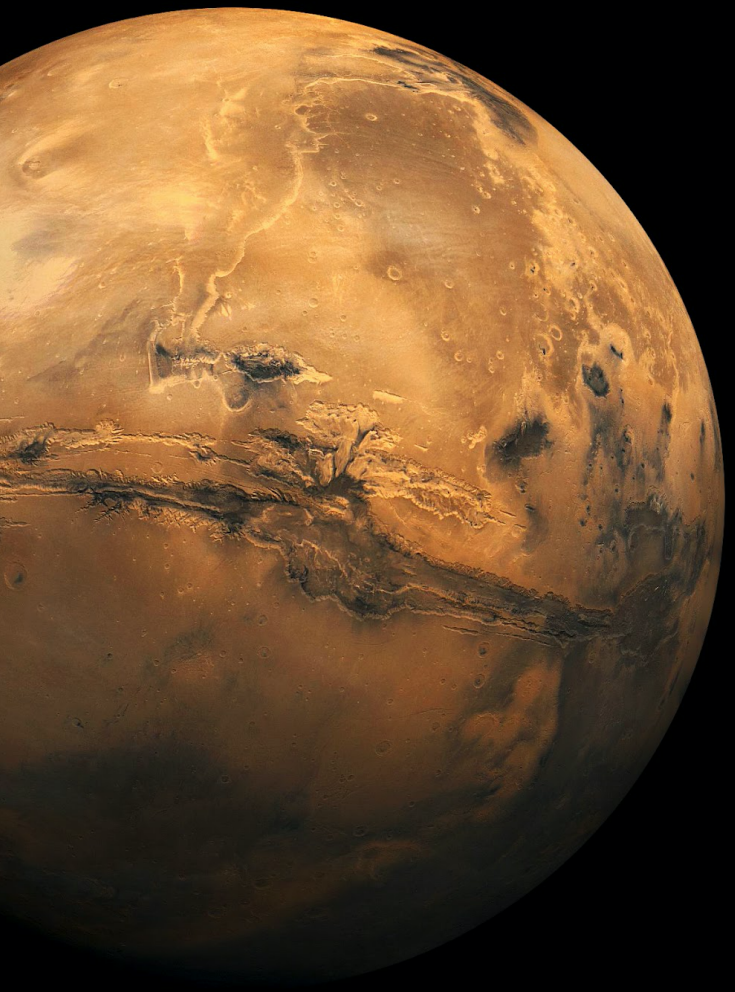

MODERN-DAY SUBSURFACE HABITABILITY ...
... AND HOW TO EXPLORE IT.

Dr. Vlada Stamenković,
Jet Propulsion Laboratory, California Institute of Technology

Michael Mischna (JPL), Woody Fischer (Caltech), Lewis Ward (Harvard)
...and the TH_2OR & VALKYRIE Teams.

MARS

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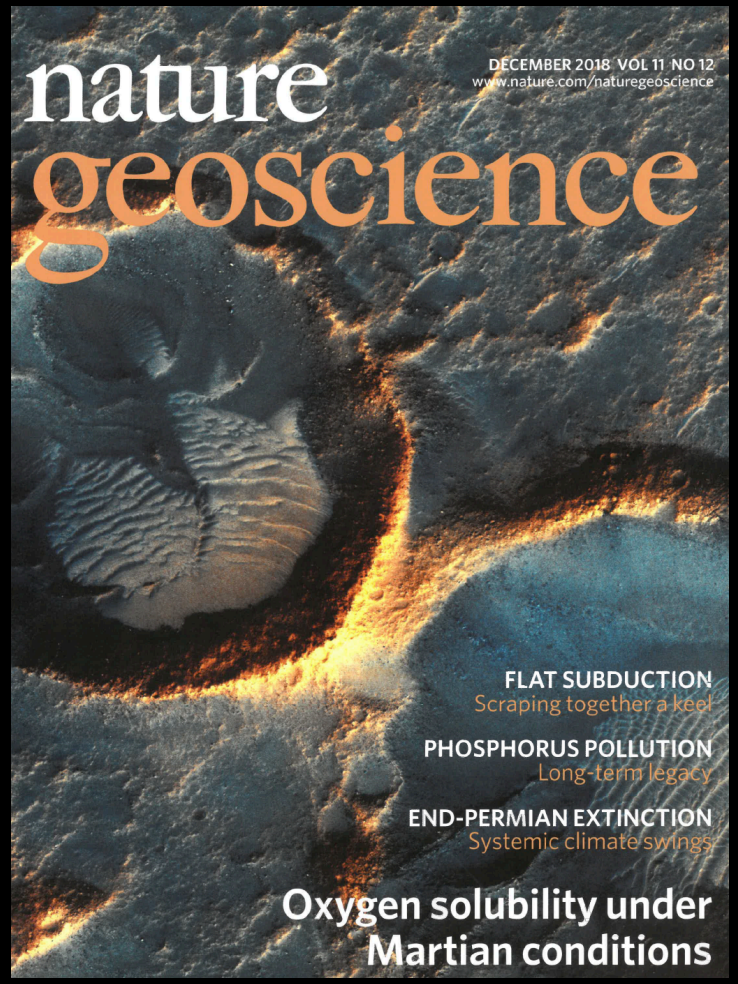
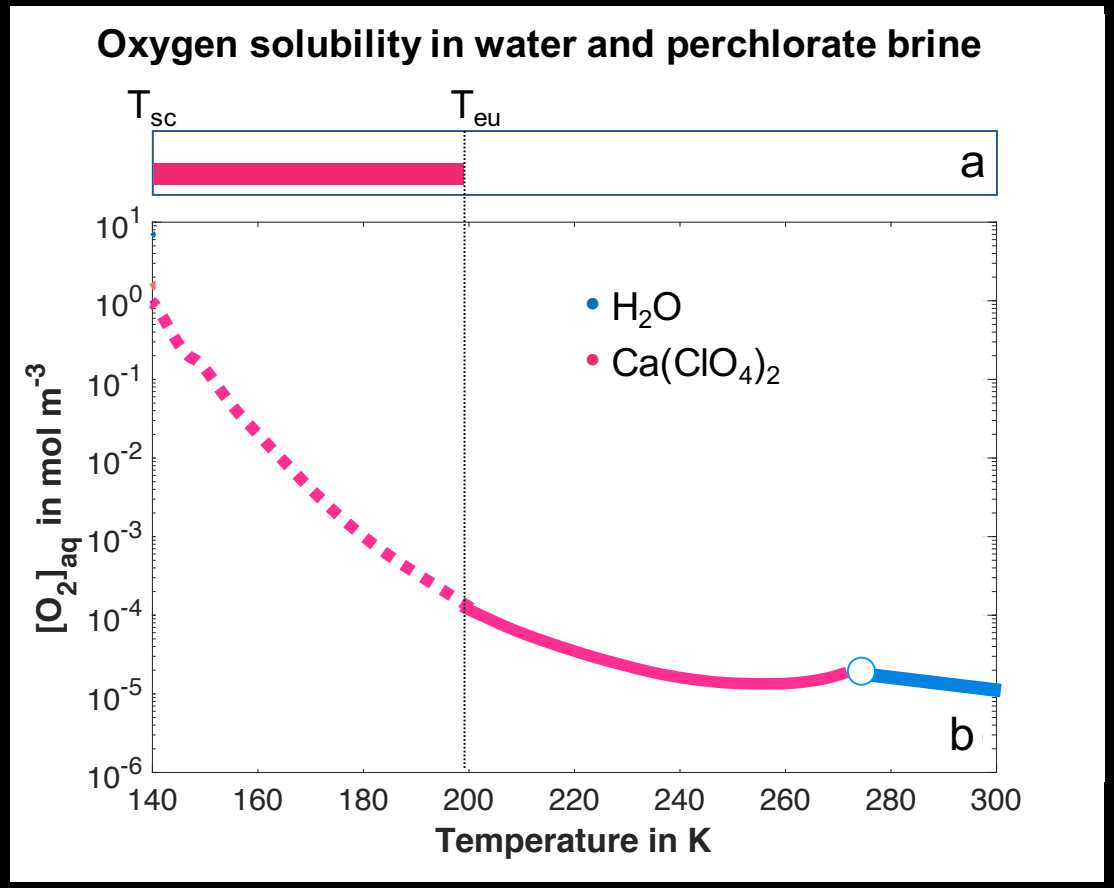
Jet Propulsion Laboratory
California Institute of Technology

Brines and O_2

- Liquid brines on modern and geologically recent Mars can contain very large amounts of dissolved O_2—sourced either from the atmosphere or radiolysis.
- The amounts are orders of magnitude greater than aerobes need on the Earth for breathing.
- We see evidence of this in the rock record.
- The potential for <u>aerobic</u> life on Mars?



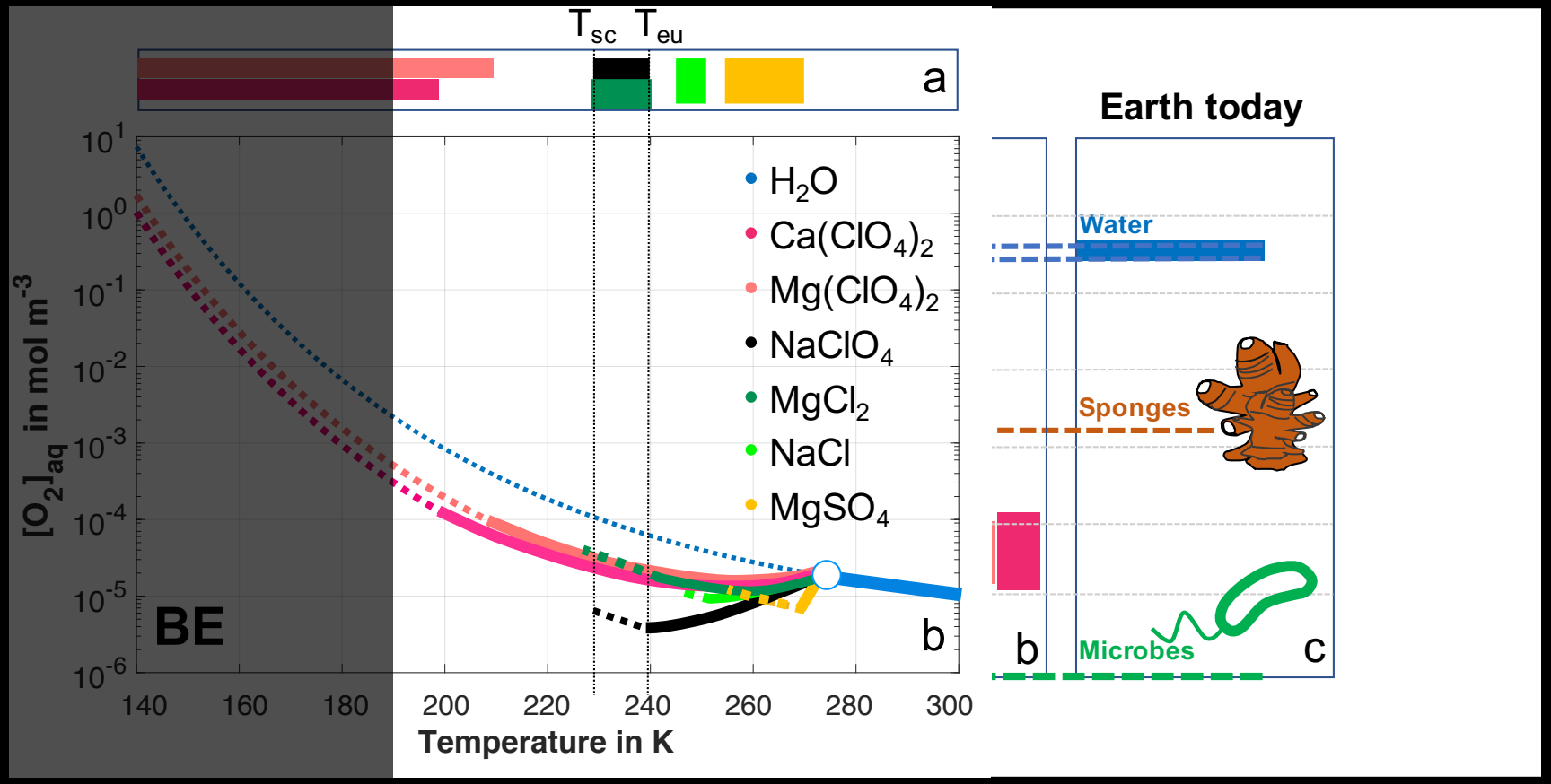
Brines and O_2: Solubility as a function of temperature



Stamenković + (2018)

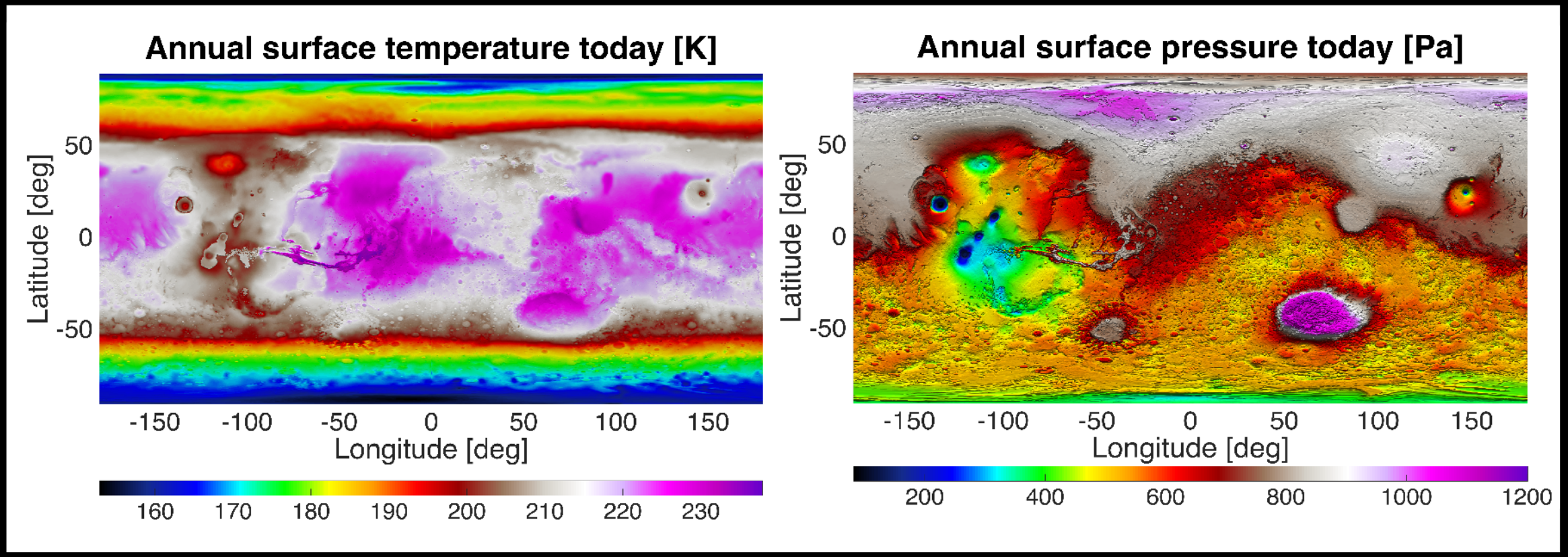
- P = 6 mbar
- f_{O_2} = 0.146 %
- T = 140-300 K

Brines and O_2: Implications for aerobic life



Stamenković + (2018)

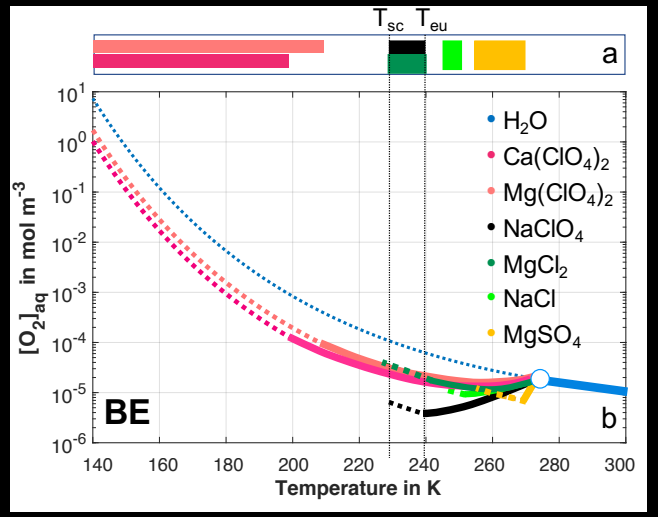
Brines and O_2: TODAY in 3D



Stamenković + (2018)

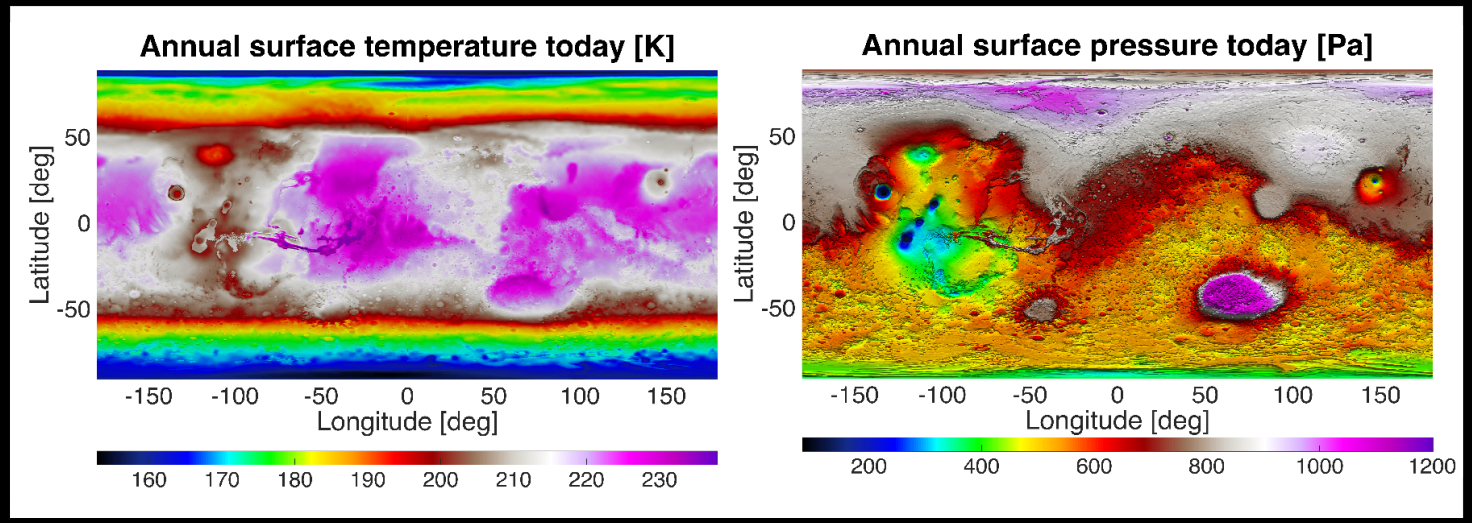
Brines and O_2: TODAY in 3D

Solubility(T,P)



+

T,P (3D)

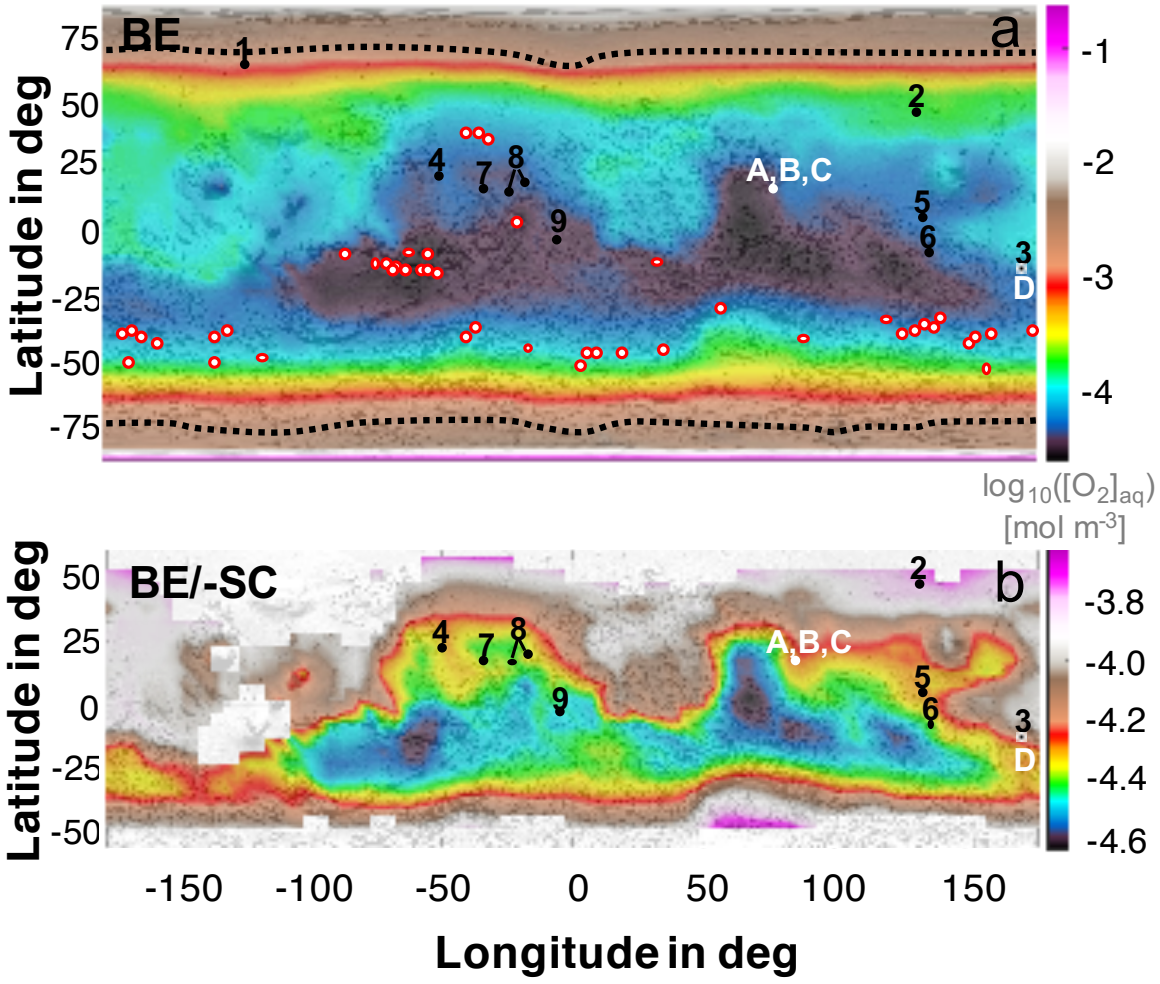


=

Brines and O_2: TODAY in 3D

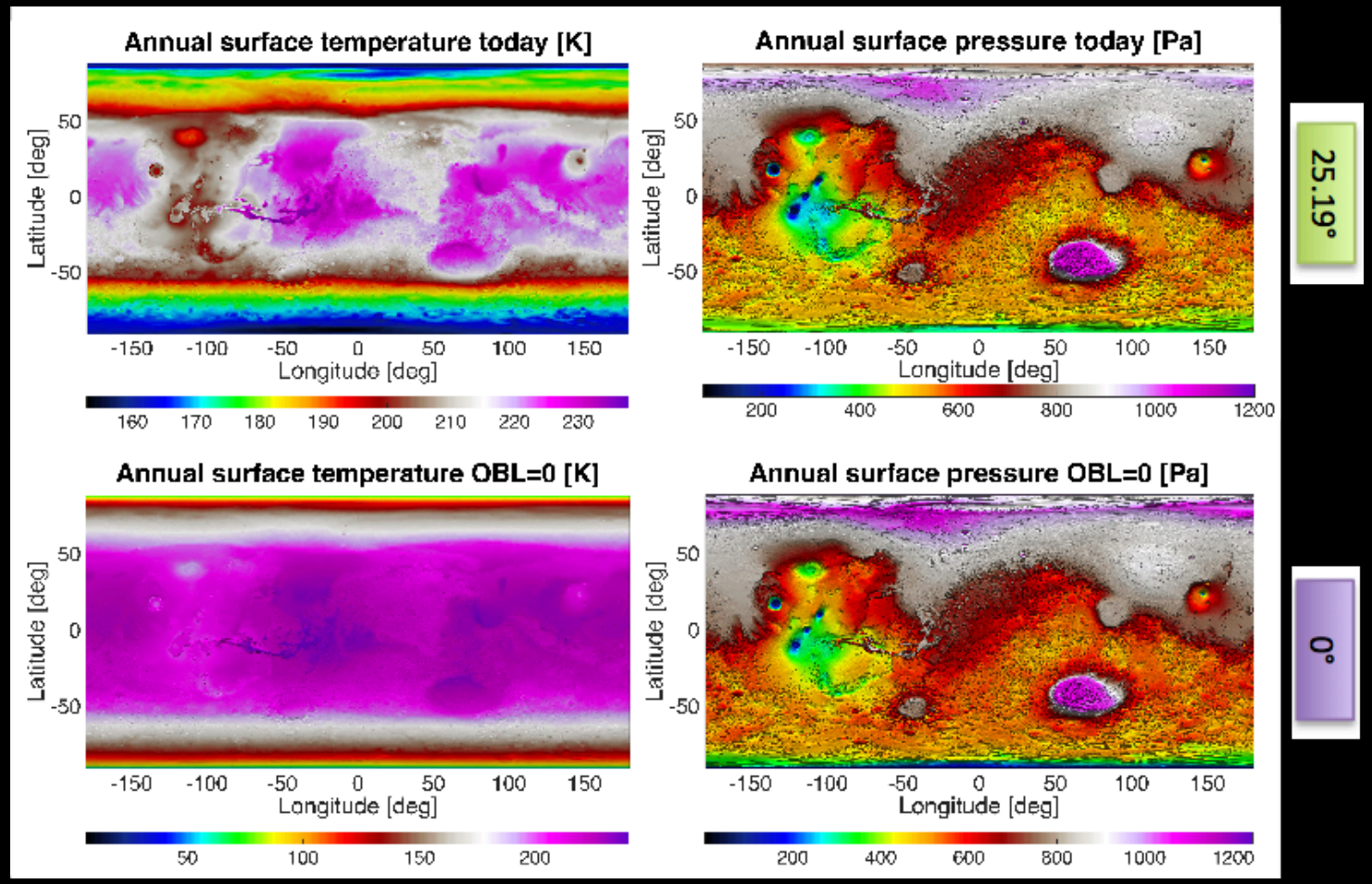
=

1 Phoenix
2 Viking 2
3 Spirit
4 Viking 1
5 InSight
6 Curiosity
7 Pathfinder
8 ExoMars
9 Opportunity
A Jezero
B Midway
C NE Syrtis
D Columbia Hills
RSL[13]



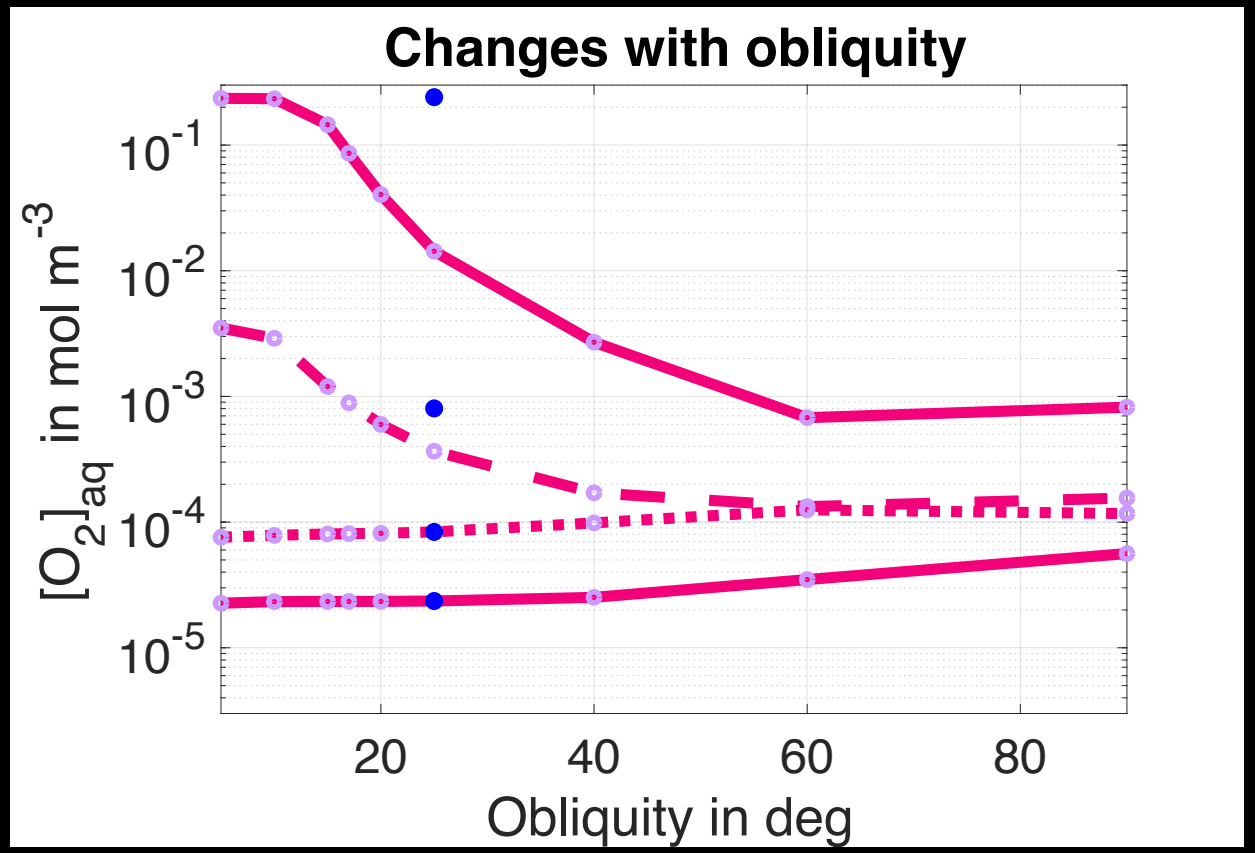
Stamenković + (2018)

Brines and O_2: With Obliquity Change



Stamenković + (2018)

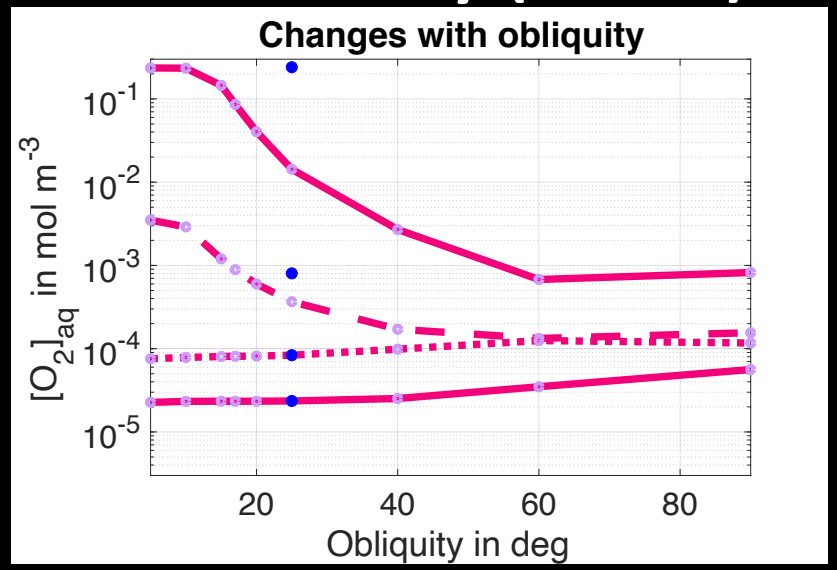
Brines and O_2: With Obliquity Change



Stamenković + (2018)

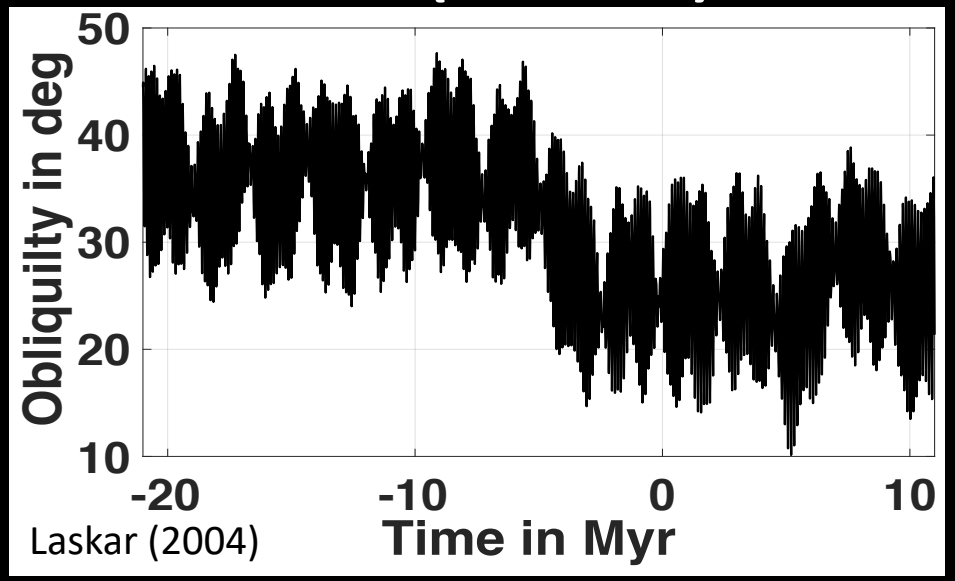
Brines and O_2: in 4D (3D + Time)

Solubility(OBL)



+

OBL(Time)



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Brines and O_2: in 4D (3D + Time)

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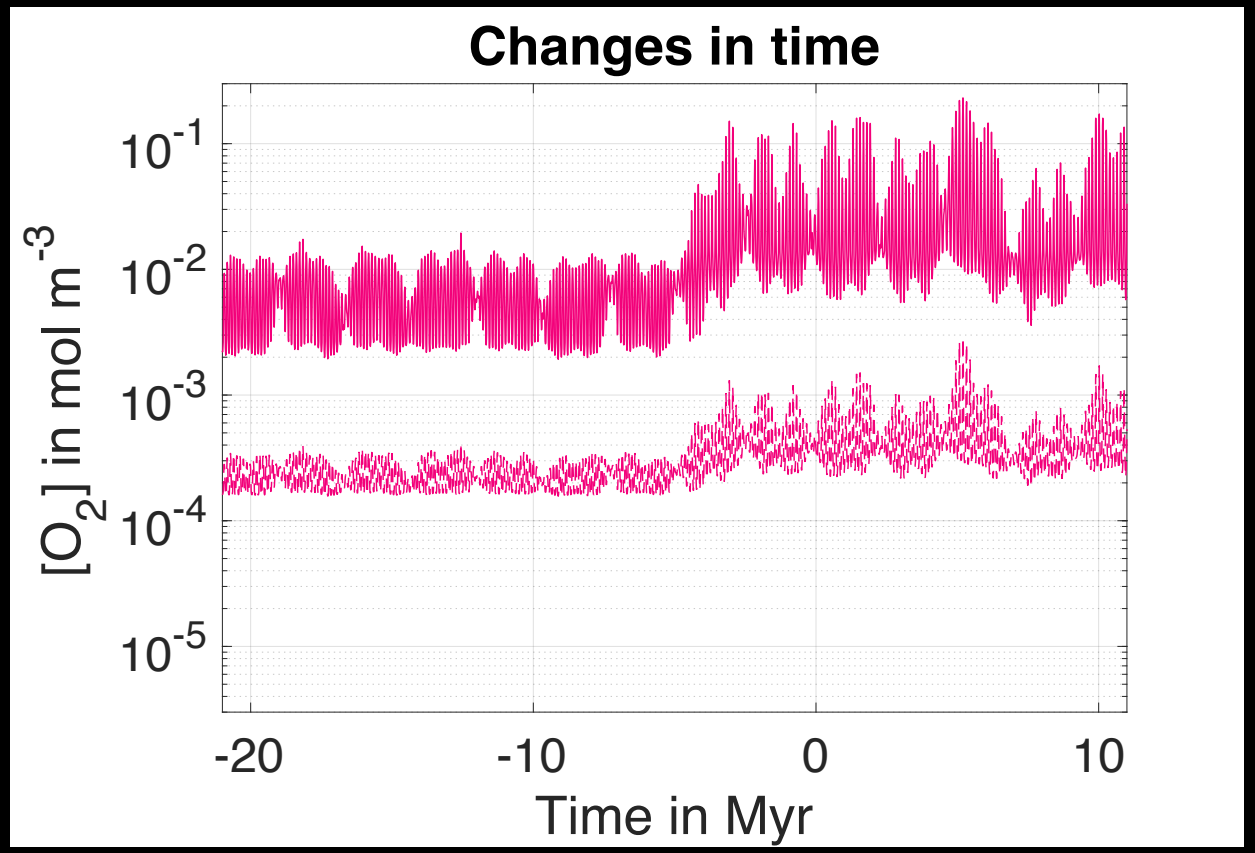


Stamenković + (2018)

Brines and O_2: Evidence in the rock record

Evidence of large $[O_2]_{aq}$ from MnO_2

Brines and O_2

- Liquid brines on modern and geologically recent Mars can contain very large amounts of dissolved O_2—sourced either from the atmosphere or radiolysis.
- The amounts are orders of magnitude greater than aerobes need on the Earth for breathing.
- We see evidence of this in the rock record.
- The potential for aerobic life on Mars?
- **But are there water/brines at all today?**
- **How to explore subsurface habitability and the potential for extant life?**

nature astronomy

The next frontier for planetary and human exploration

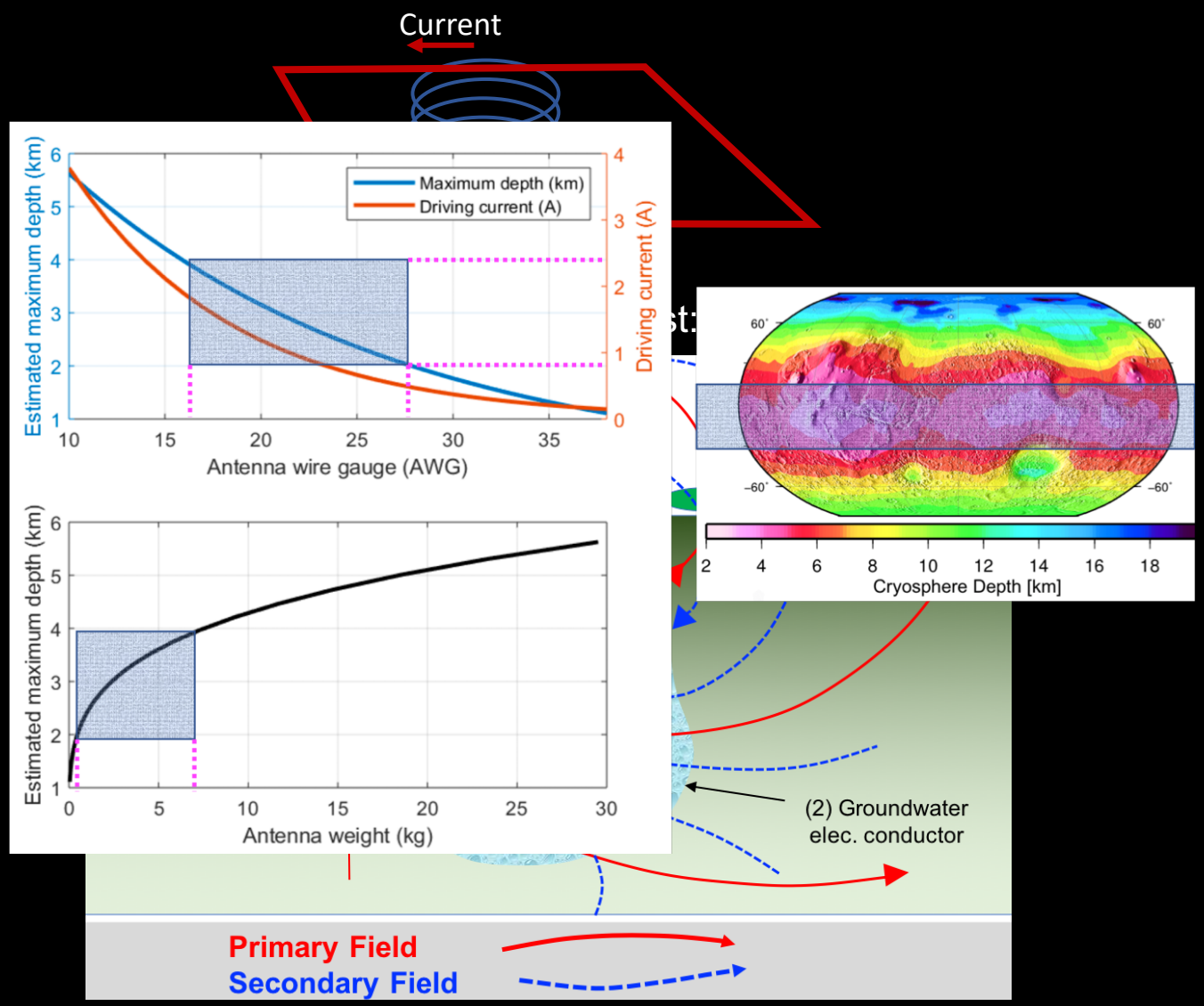
The surface of Mars has been well mapped and characterized, yet the subsurface — the most likely place to find signs of extant or extinct life and a repository of useful resources for human exploration — remains unexplored. In the near future this is set to change.

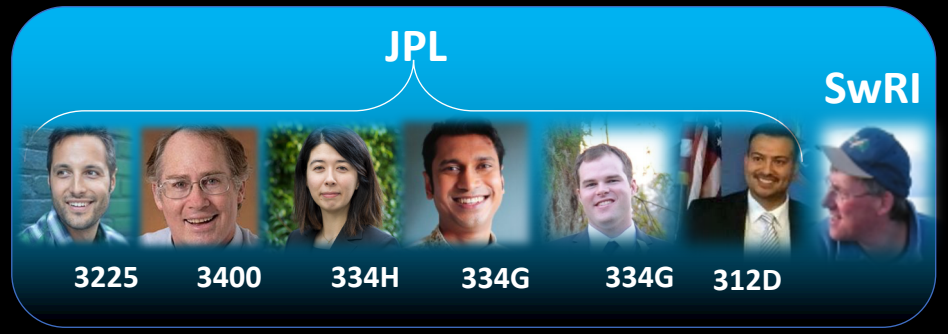
V. Stamenković, L. W. Beegle, K. Zacny, D. D. Arumugam, P. Baglioni, N. Barba, J. Baross, M. S. Bell, R. Bhartia, J. G. Blank, P. J. Boston, D. Breuer, W. Brinckerhoff, M. S. Burgin, I. Cooper, V. Cormarkovic, A. Davila, R. M. Davis, C. Edwards, G. Etiope, W. W. Fischer, D. P. Glavin, R. E. Grimm, F. Inagaki, J. L. Kirschvink, A. Kobayashi, T. Komarek, M. Malaska, J. Michalski, B. Ménez, M. Mischna, D. Moser, J. Mustard, T. C. Onstott, V. J. Orphan, M. R. Osburn, J. Plaut, A.-C. Plesa, N. Putzig, K. L. Rogers, L. Rothschild, M. Russell, H. Sapers, B. Sherwood Lollar, T. Spohn, J. D. Tarnas, M. Tuite, D. Viola, L. M. Ward, B. Wilcox and R. Woolley

TH_2OR Concept (Transient H_2O Reconnaissance)

Objectives

Demonstrate that we can uniquely sound from the Martian surface for groundwater, expected to be at depths as large as 1-10 km, using a low-mass (<5 kg) and low-power (<10 W average) EM system and to determine its salinity.





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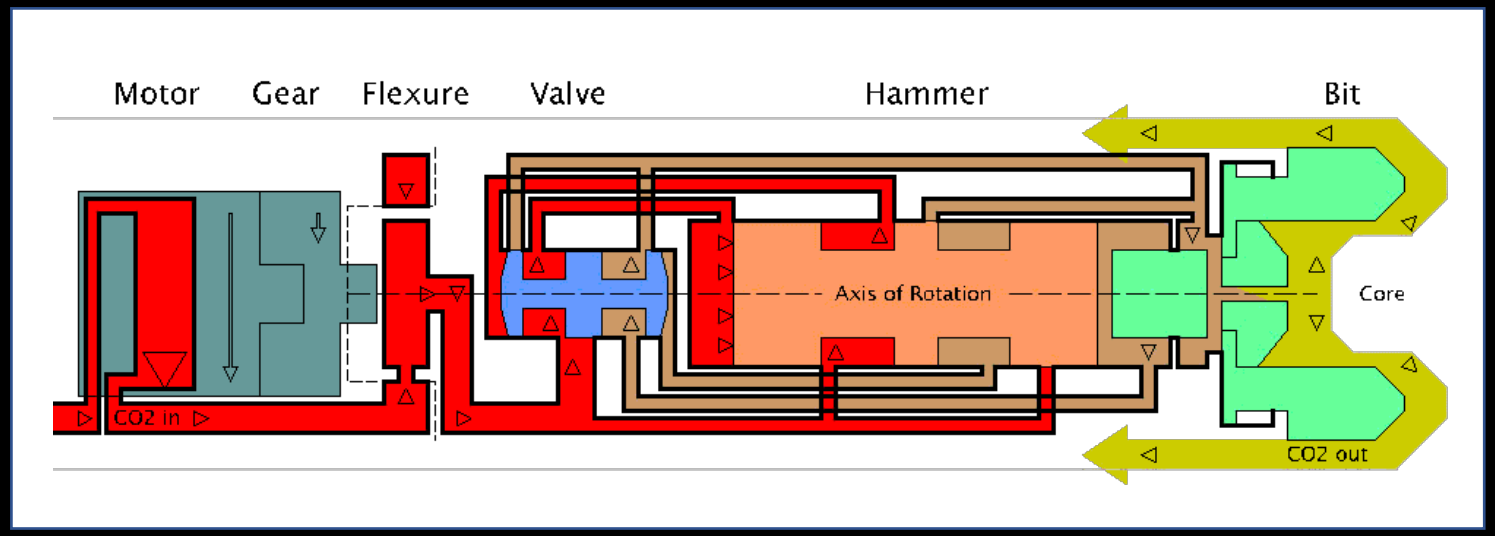
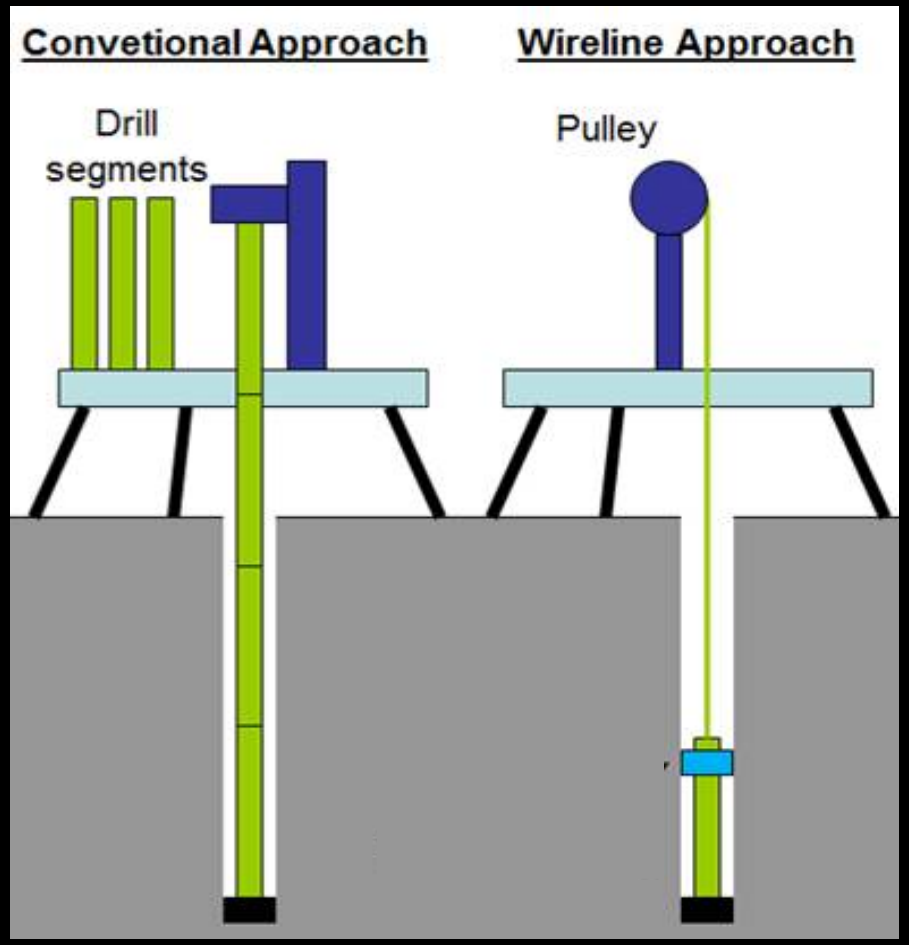
ASGARD Concept (Ares Subsurface Great Access Research Drill)

- Downhole assembly is all-mechanical, powered by compressed liquid CO_2 driven down hole through a sub-mm fused silica capillary tube that is also used as a wireline to raise and lower the downhole assembly in and out of the hole once or more per Mars day.
- Downhole assembly has a rotary-percussive mechanism powered by progressive depressurization of the liquid CO_2, culminating in the liquid flashing to vapor where it is used to flush the cuttings away from the drill bit and up the annulus between the mechanism and the hole where they settle into a bailing bucket in approximately the reverse stratigraphic order that they were drilled (e.g., first-drilled is at the bottom).





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The Roses C.30 VALKYRIE* Mission Concept Study

*Volatiles And Life: Key Reconnaissance & In-Situ Exploration

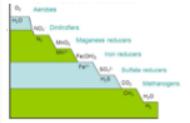
WHY?

- The Martian Subsurface is, if not the only, the most likely place to find evidence of extant life on Mars.
- Exploration has been limited to 2D and it's time to "go deep" into 3D.
- Training ground for Europa/Enceladus exploration.

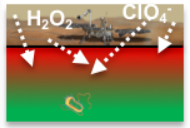
DRIVERS

Quantify **(1)** the modern Martian subsurface habitability **(2)** search for signs of extant life by following:

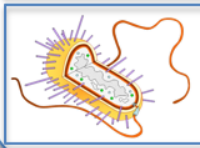
- **A. Liquid Water**



- **B. Energy & Nutrients**



- **C. Cellular Stability**



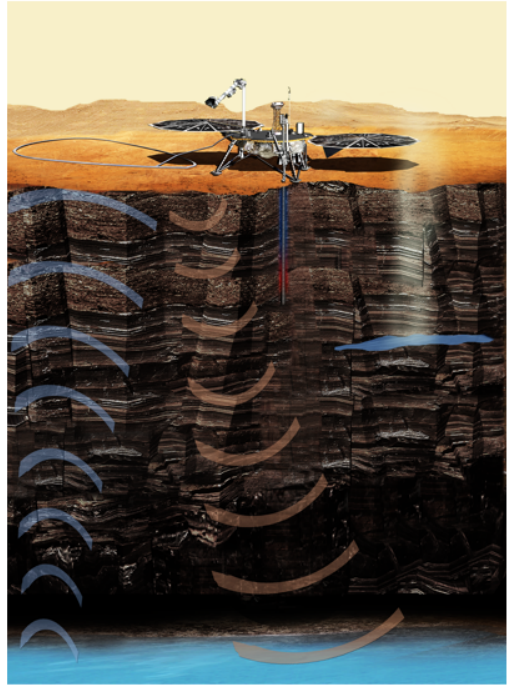
- **D. Biomarkers & Signs of Metabolic Activity**

1. HABITABILITY
2. LIFE

HOW?

Baseline: Insight type lander with EM sounder, drill > 10 m, in-borehole and on ship biogeochemical analysis focused on habitability.

Enhancements: two landers, mobility, drill depth ~100 m, towards life detection instruments.



Team Member
1. PI (US): Vlada Stamenkovic *(JPL)*
2. Co-I (US): Jennifer Stern *(GSFC)*
3. Co-I (US): Nina Lanza *(Los Alamos Nat. Lab)*
4. Co-I (US): Bob Grimm *(SwRI)*
5. Co-I (US): Jack Mustard *(Brown University)*
6. Co-I (US): Victoria Orphan *(Caltech)*
7. Co-I (US): Karyn Rogers (Rensselaer Uni.)
8. Co-I (US): Kris Zacny *(Honeybee Robotics)*
9. Co-I (US): Michael Mischna *(JPL)*
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11. (F): Joe Michalski *(Uni of Hong Kong)*
12. (F): Tilman Spohn *(ISSI)*
13. (F): Ana Plesa *(DLR)*
14. (F): Barbara Sherwood Lollar *(Uni. Toronto)*
15. *(US) Maggie Osburn,* Northwestern

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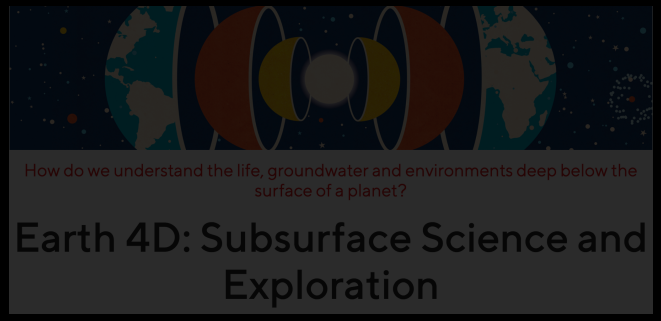
Community

- NAI Workshop Without Walls: Searching for Signs of Subsurface Life on Mars (Extinct and Extant)
  - 4 virtual m
    meeting a
    Penny Bo
- Mars Extan
  - 5-8 Nov 2
- **AGU Session "New Mars Underground 2.0"**
  - Session ID: 83347 → *Nina Lanza, Jack Mustard, Kris Zacny, Vlada S.*
- AGU Session Earth 4D – a Deep Dive into the Habitability of the Blue Planet
  - → *Jack Mustard, Barbara Sherwood Lollar, Magdalena Osburn.*

THANK YOU ☺!



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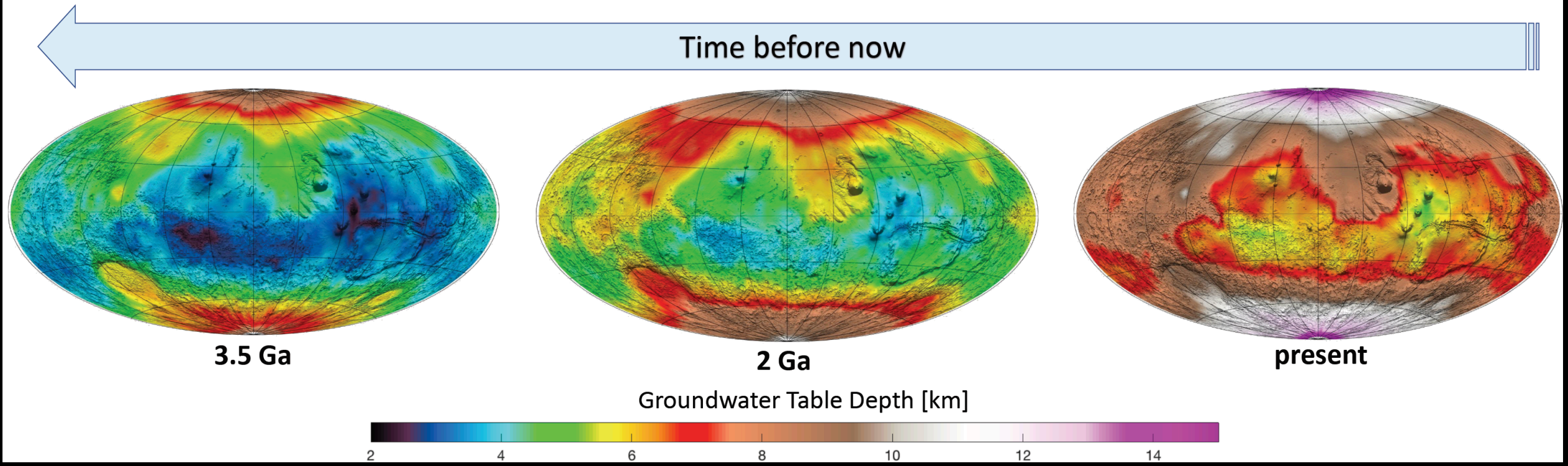
Ad Ares: Where is the water with Mars$_X$-4D?