Enabling Mars excellence in the Moon-Mars program

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NASA

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Mars as the goal

- **Mars is unparalleled destination for planetary science and continued exploration**

Policy opportunities now

- **Keep the cadence and the leadership by a science-driven Mars robotic program**
- **Activate all the stakeholders: international, commercial, academic**
- **Develop and practice human+agent science at the Moon and Mars**

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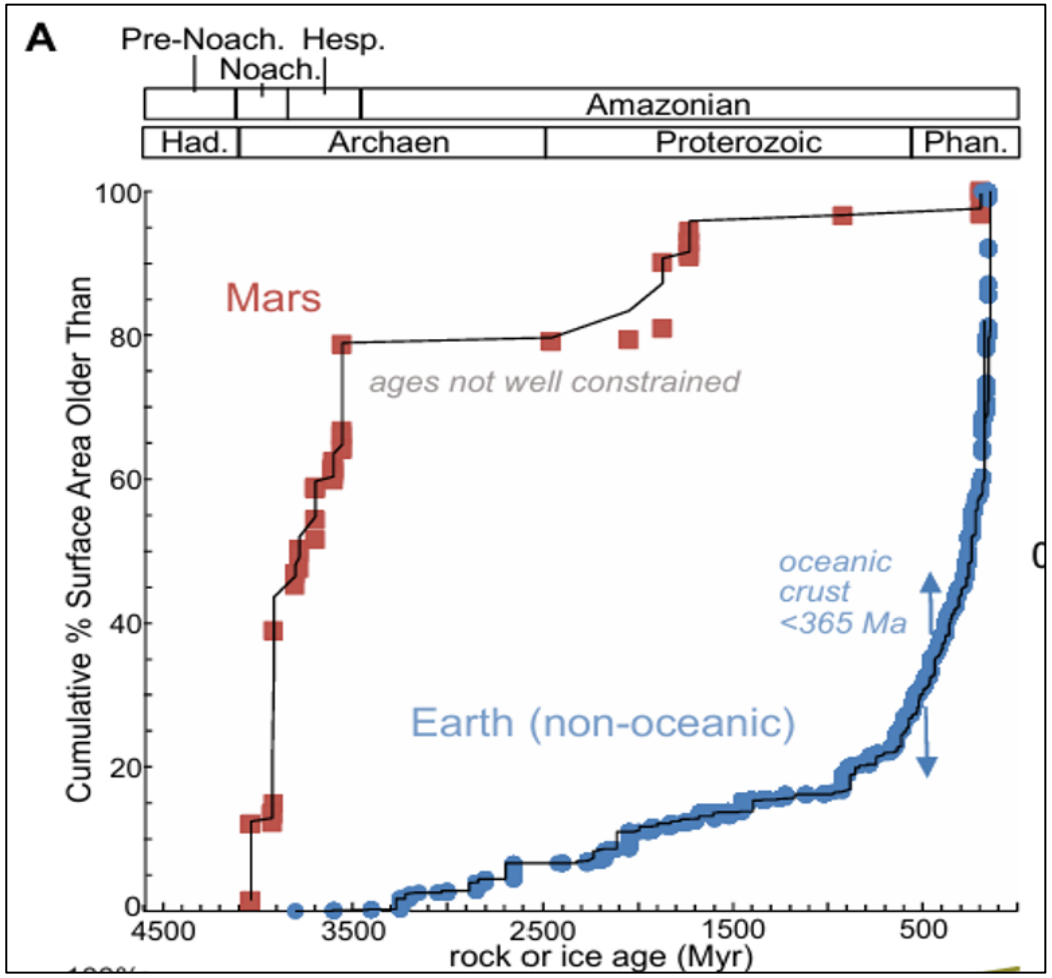
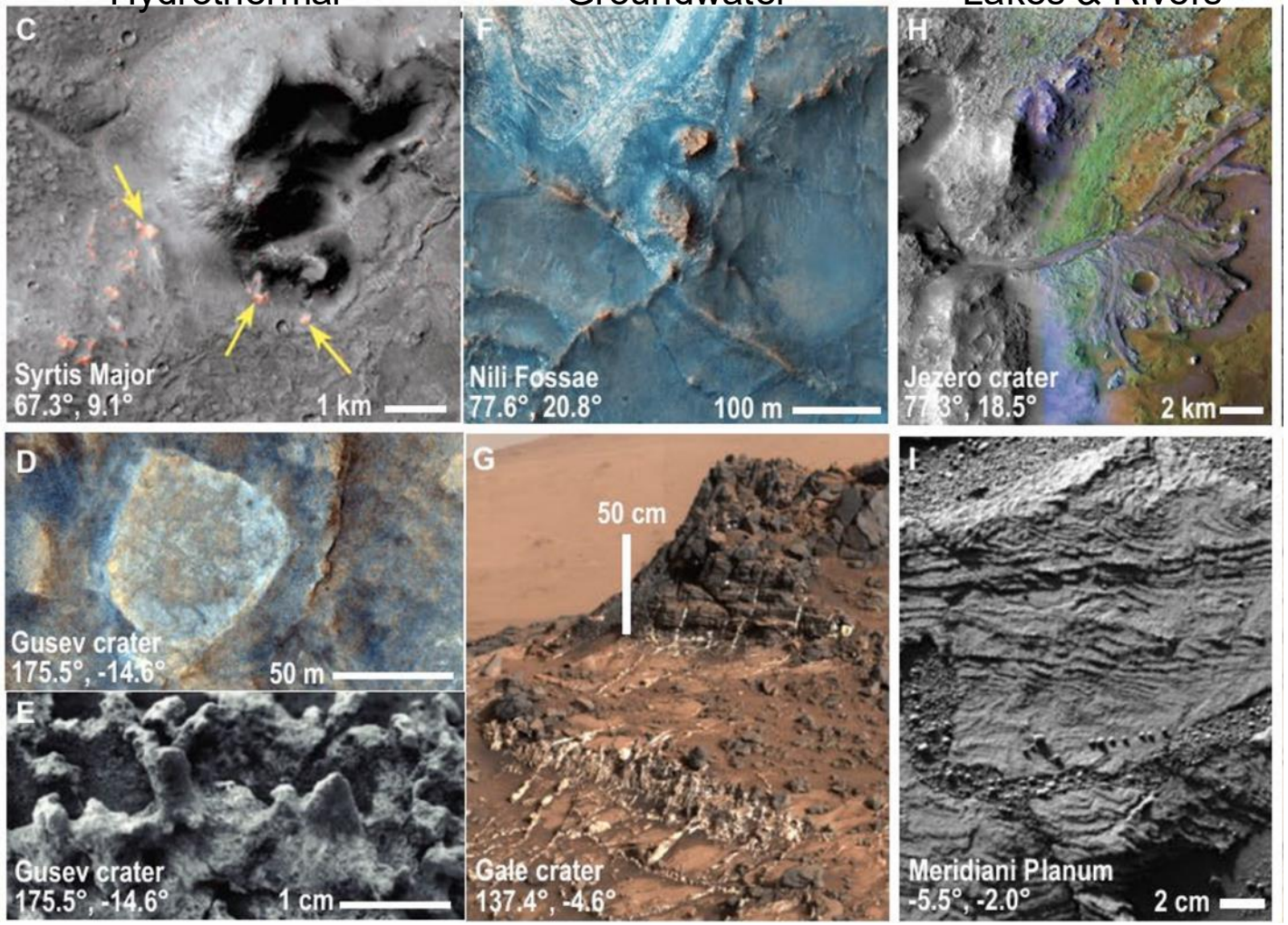
Key Finding #1: Exquisite record of 4 billion years of water on an Earth-like world

Mars is the only full, detailed record of an Earth-like planet with an atmosphere and habitats over long time



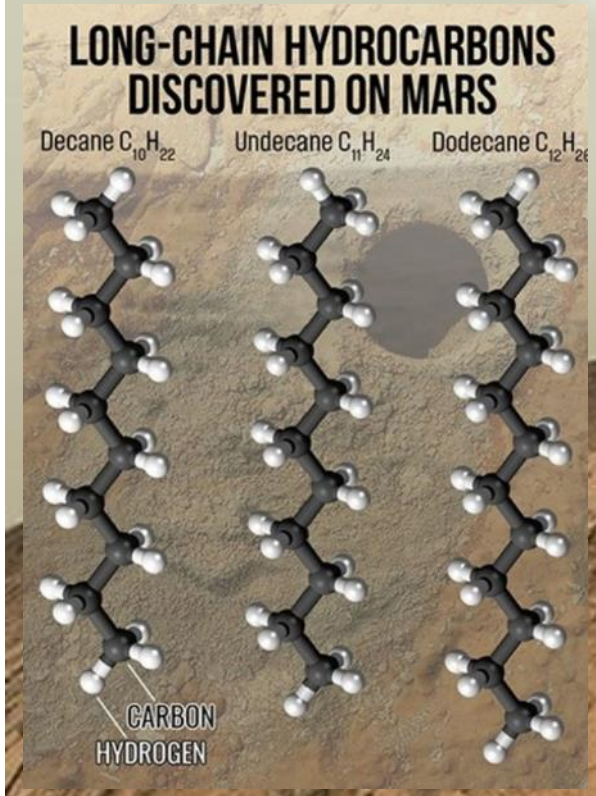
Hydrothermal | Groundwater | Lakes & Rivers



Ehlmann & Wordsworth, submitted, Science

Key Finding #2:
Organics-bearing rocks from ancient habitats

We know we can and should look for life on Mars in samples (this is special and we cannot do this with Moon rocks)



Curiosity rover finds complex carbon

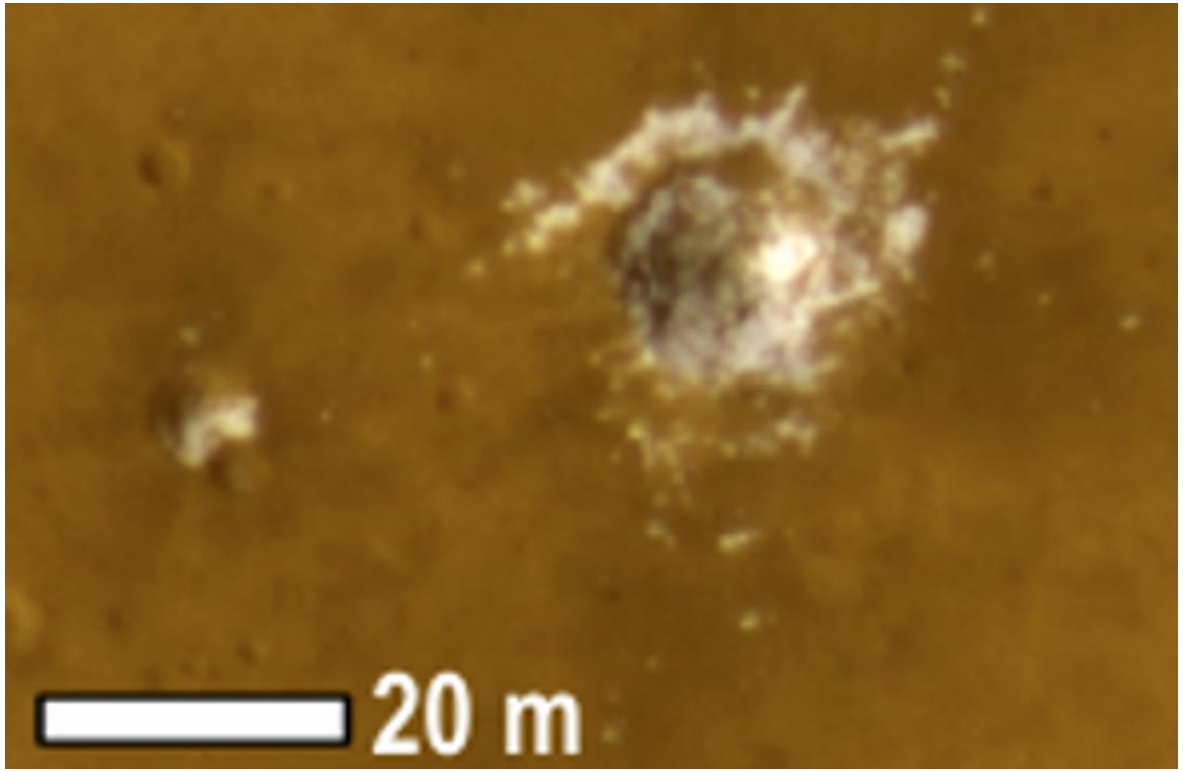
Eigenbrode et al., 2018, Science; Freissinet et al., 2025, PNAS

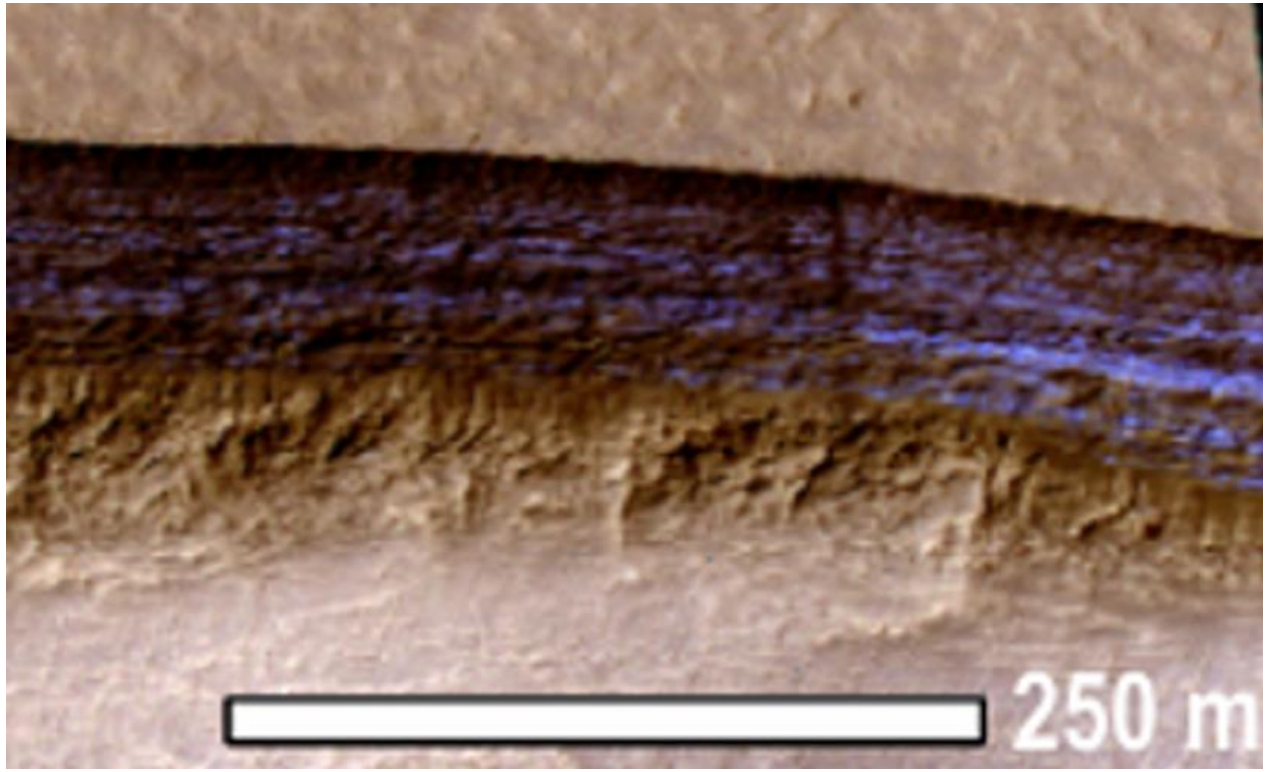
Perseverance rover finds organics and life-favorable chemistry around phosphate grains. Sample awaiting return now

Hurowitz et al., 2025; Murphy et al., in press

Key Environments Finding #3: Ground Ice

Now that we see at small-scale, we know Mars has recent thick, buried ice (a surprise)
We don't (yet) know why, how old, how much





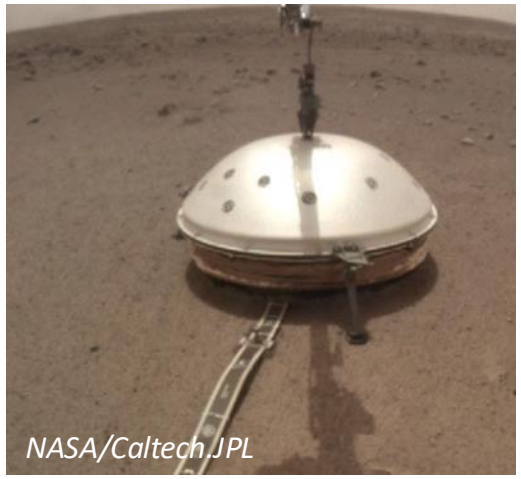
NASA/JPL-Caltech/U Arizona

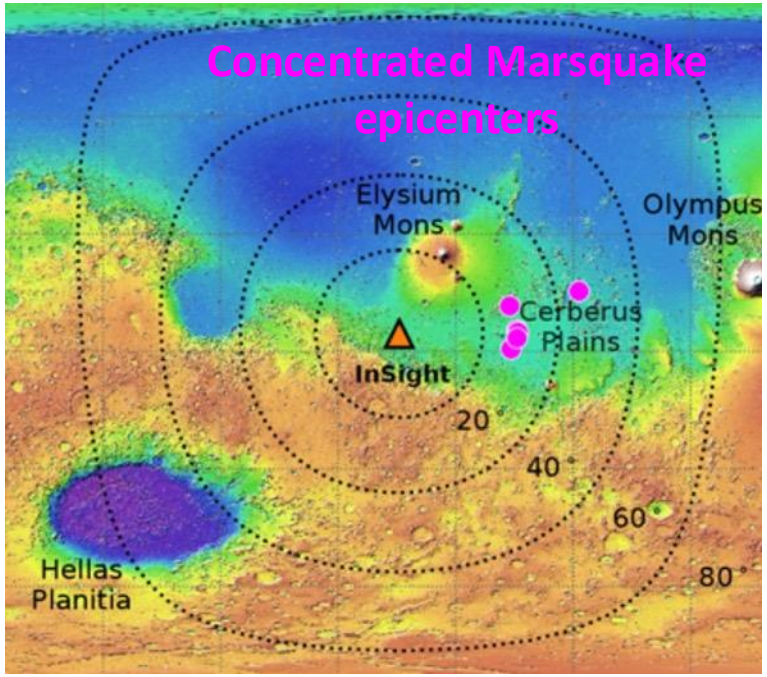
Morgan et al., 2024 Nat Astro
Dundas et al., 2021, Science
Byrne et al., 2009, Science

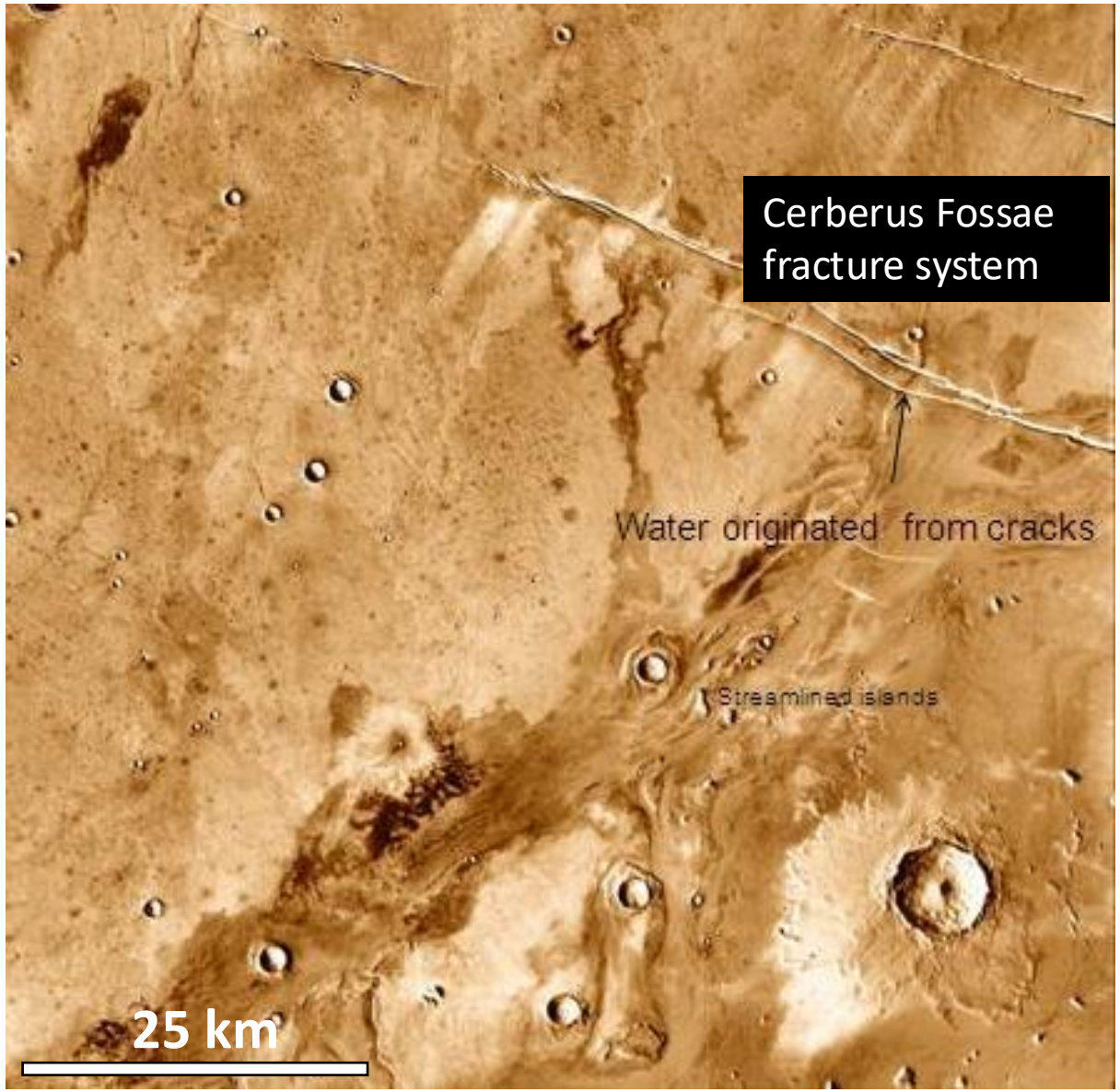
Key Finding #4: Mars is Active Underground Now

Many Mars-quakes are near relatively the most recent volcanoes and recent water outflows
Is there lava moving underground? Is there an aquifer?

InSight seismometer
2018-2022



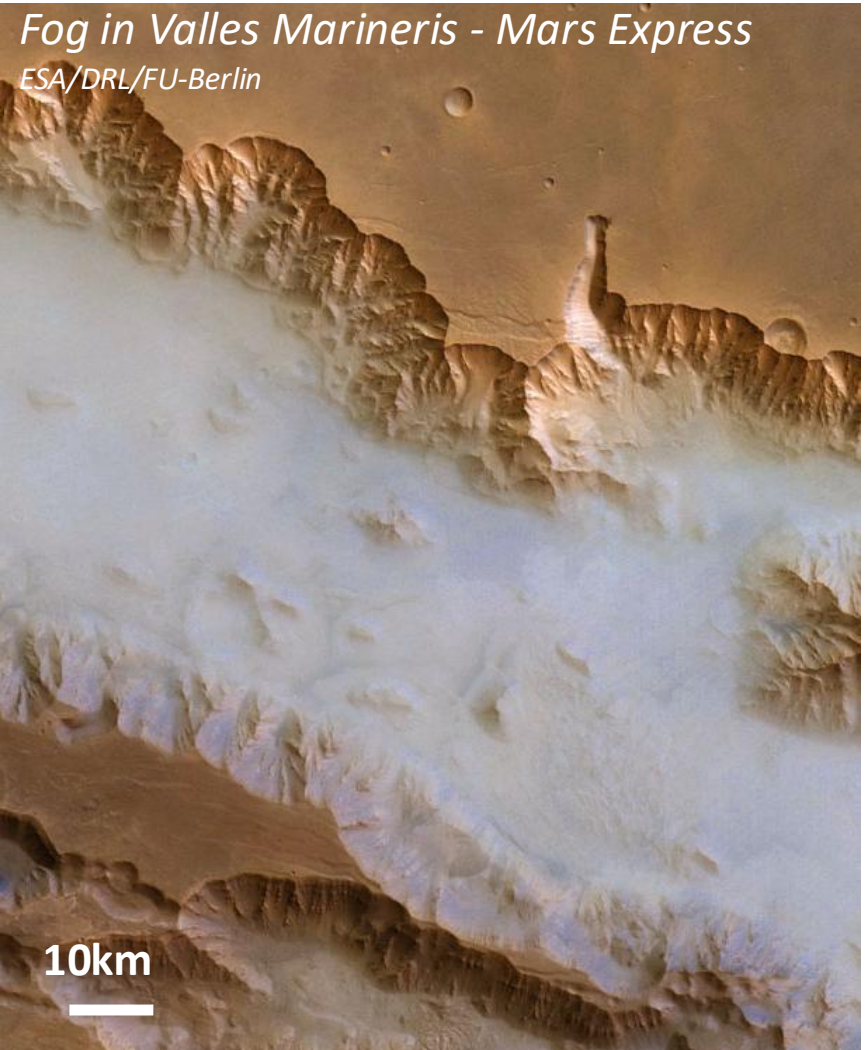


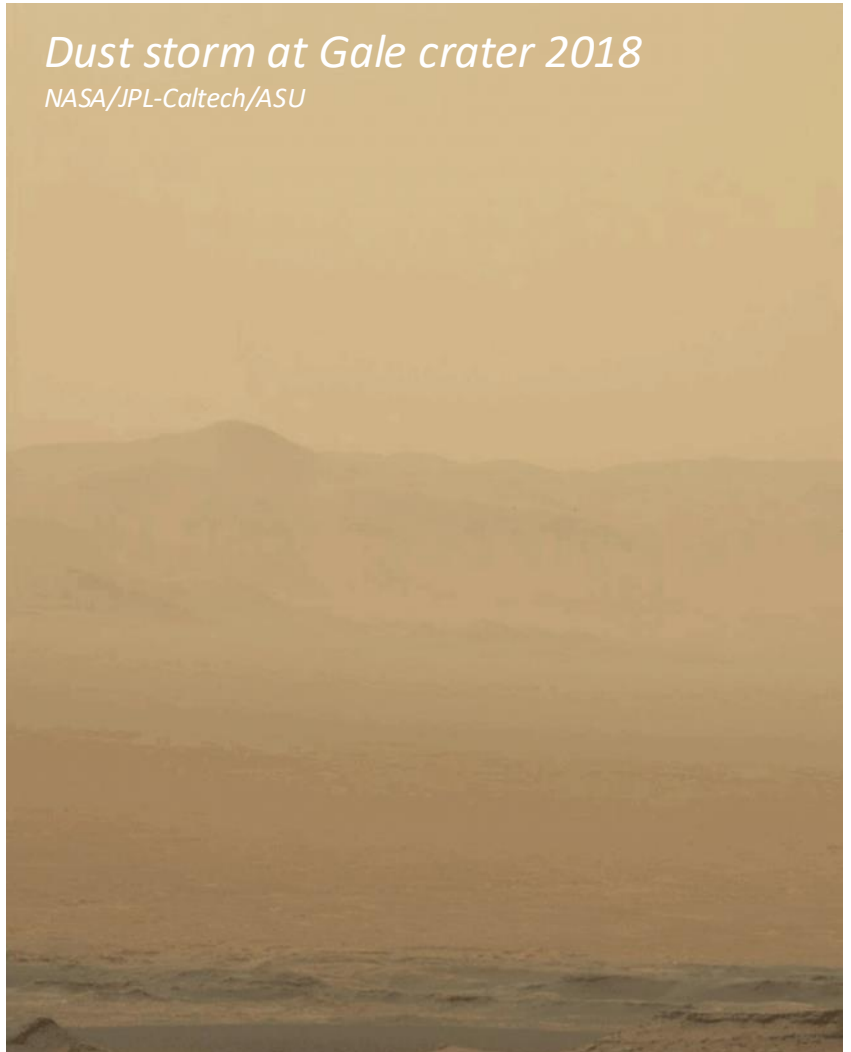


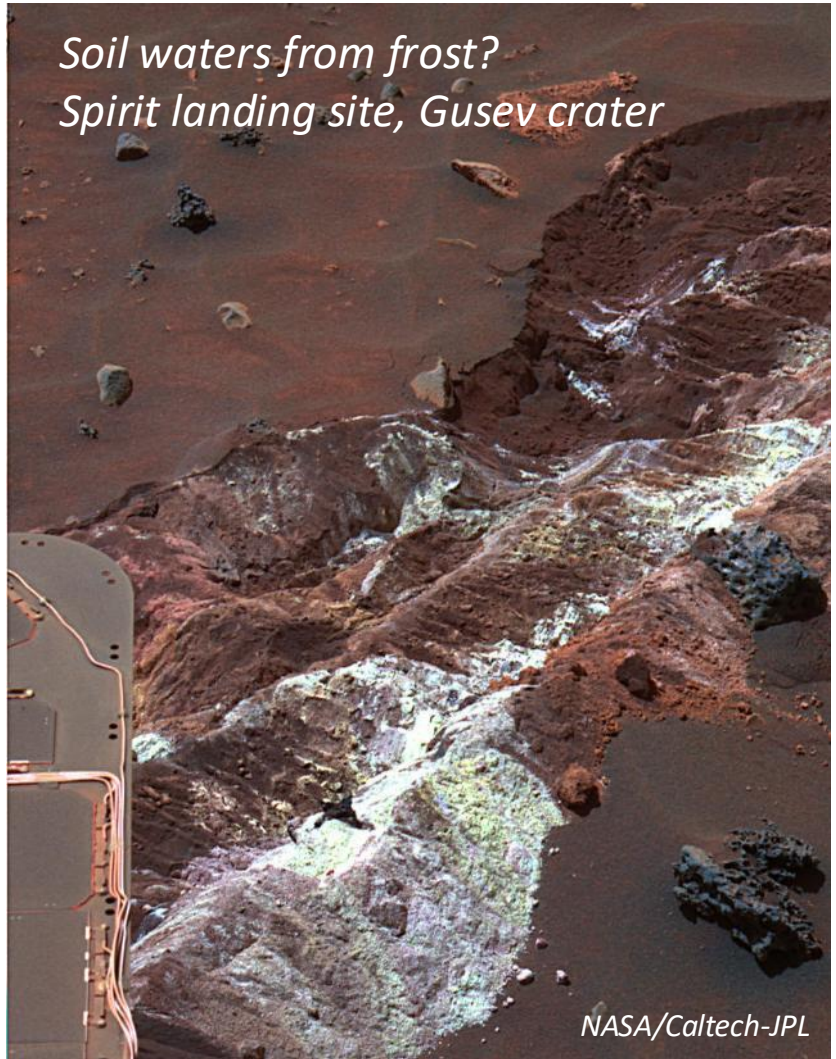
Horelston et al. (2022) TSR

Key Finding #5: Mars' Environment is Dynamic

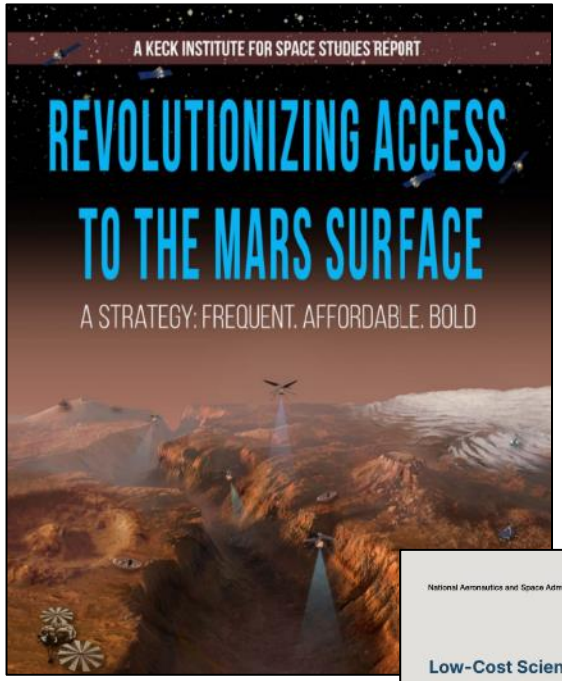
Morning water fogs, global dust storms, water frosts, recent melt (?) are observed
Additional information from unmade measurements are needed for *prediction*







So, what next? We know what to do



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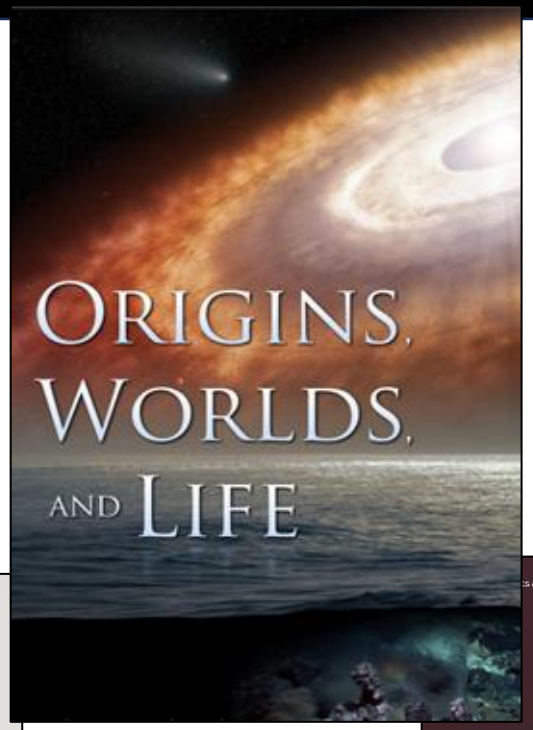

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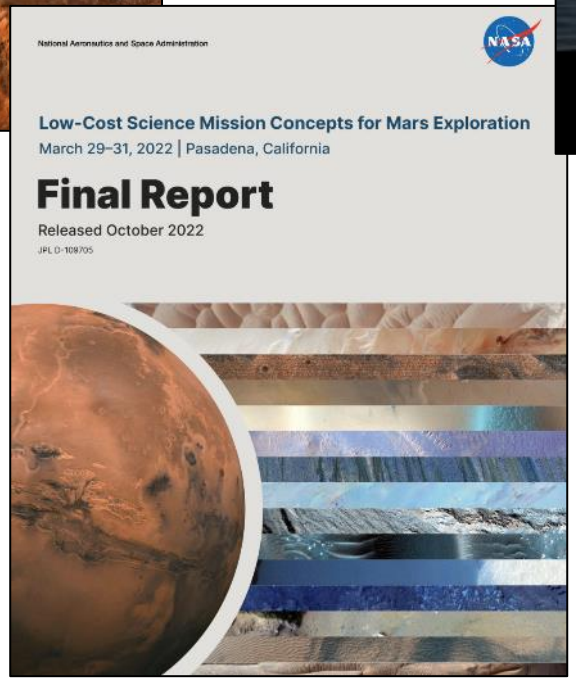

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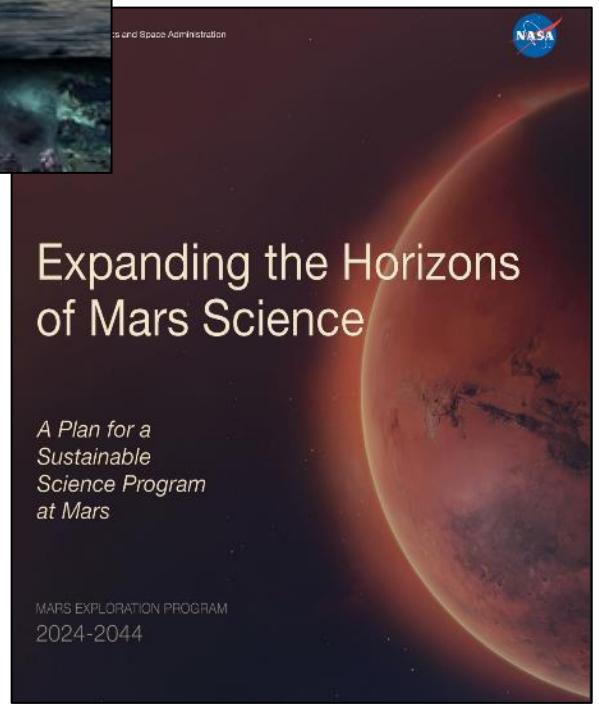


2024

2025

So, what next? We know what to do

Habitable environments explored, breakthrough samples collected → Complete Mars Sample Return

Mars ice discovery and questions → Mars Ice Mapper

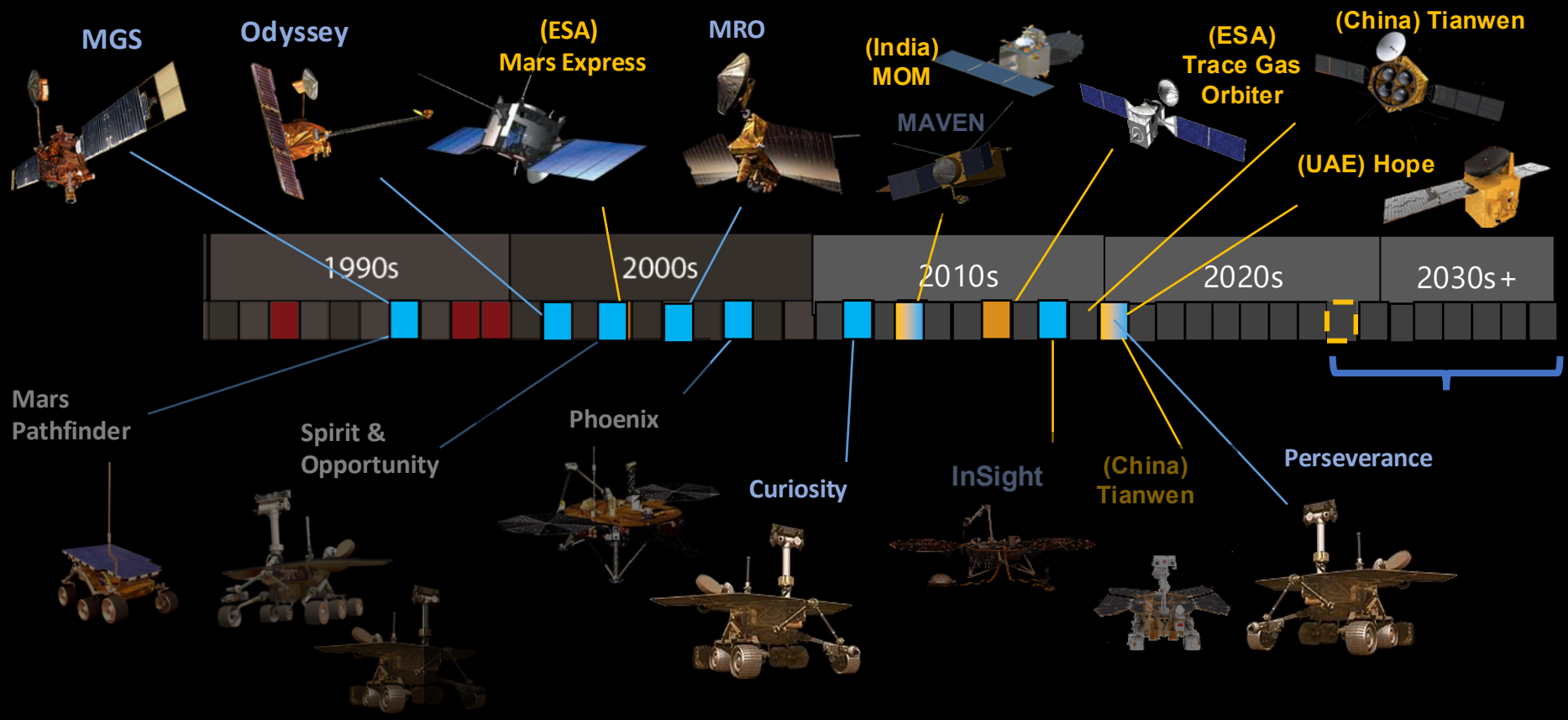
Diversity of priority science and exploration topics

Growing international capabilities (and Artemis partner nations)

Growing commercial capabilities, interest in CLPS-like program at Mars

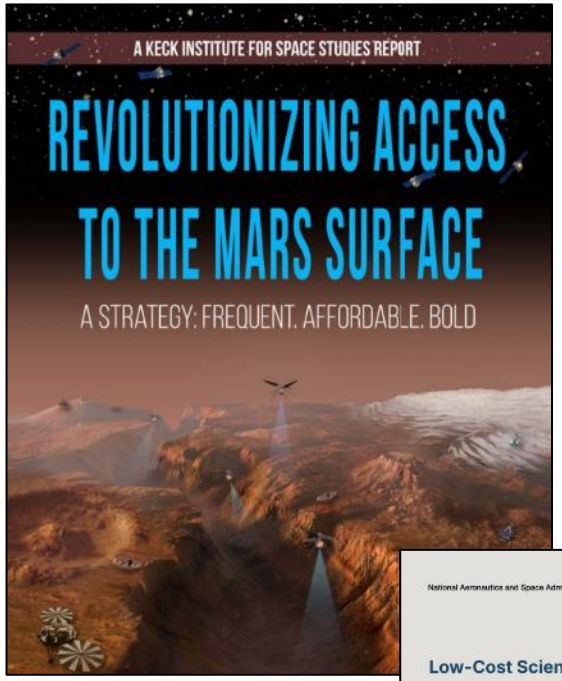
→ High-cadence mission program, every 2-years

The Fleet at Mars Now and Launch Date



This is the future of new NASA leadership at Mars that we must lay out now

What next? We know what to do



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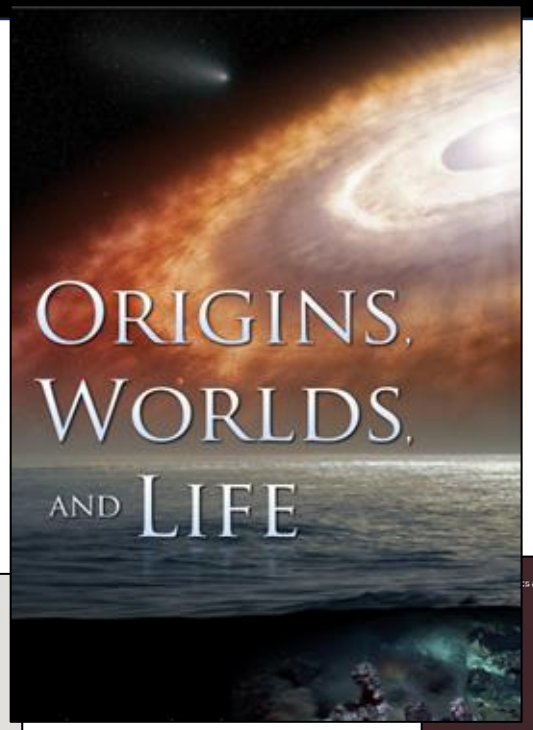

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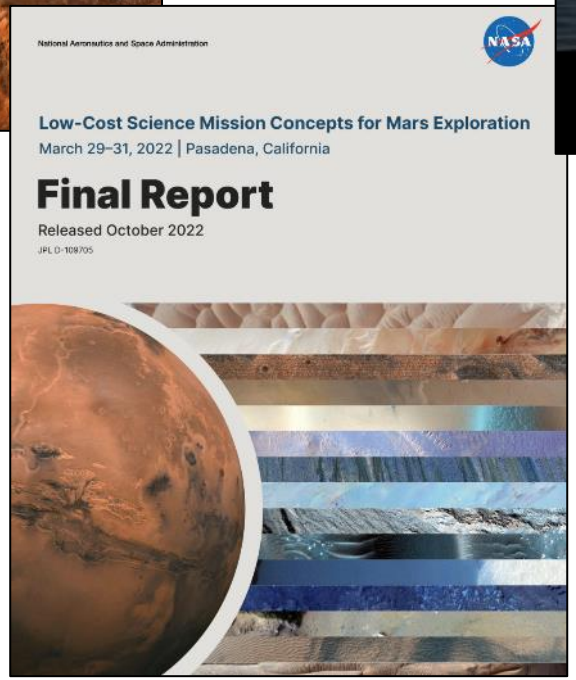

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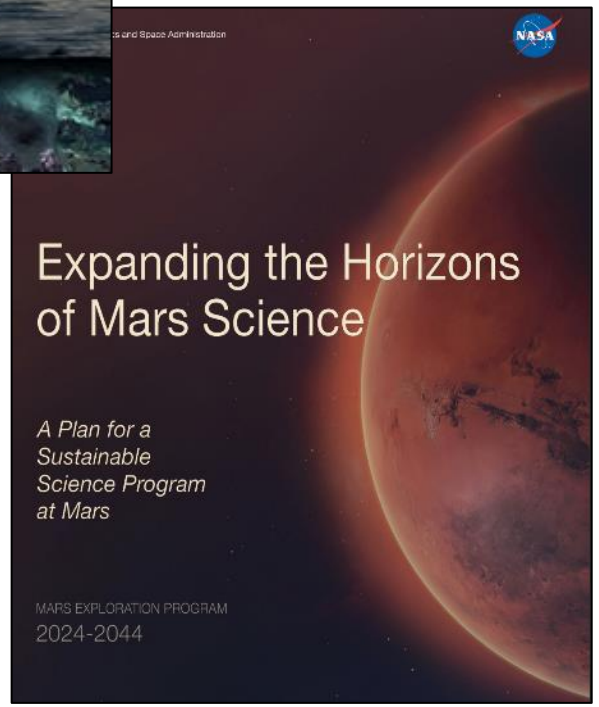


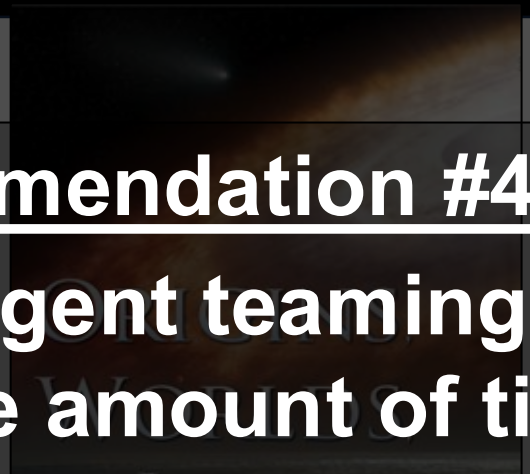
2024

What next? We know what to do

2022

Recommendation #4:

"Human-Agent teaming…to maximize the amount of time on Mars available for astronauts to perform scientific research, and to maximize the quality of that science"



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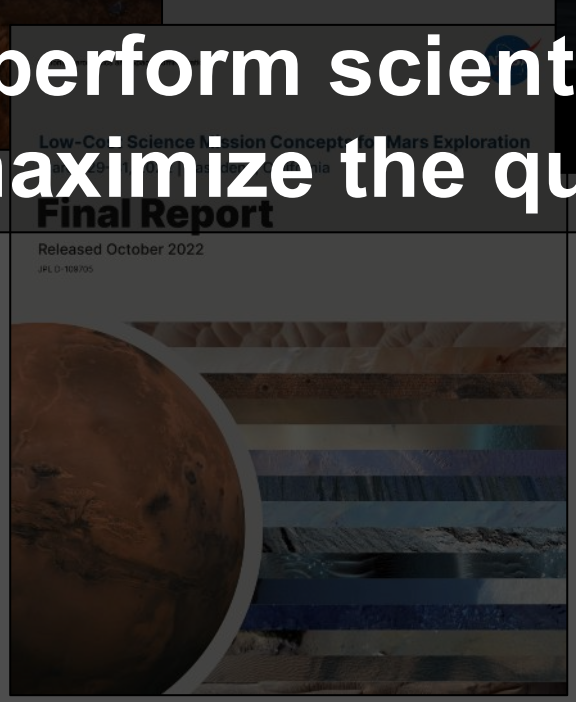

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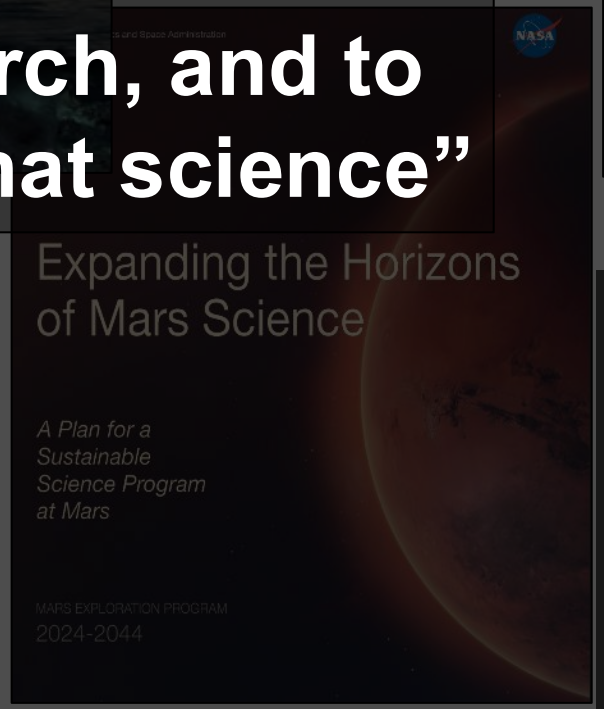


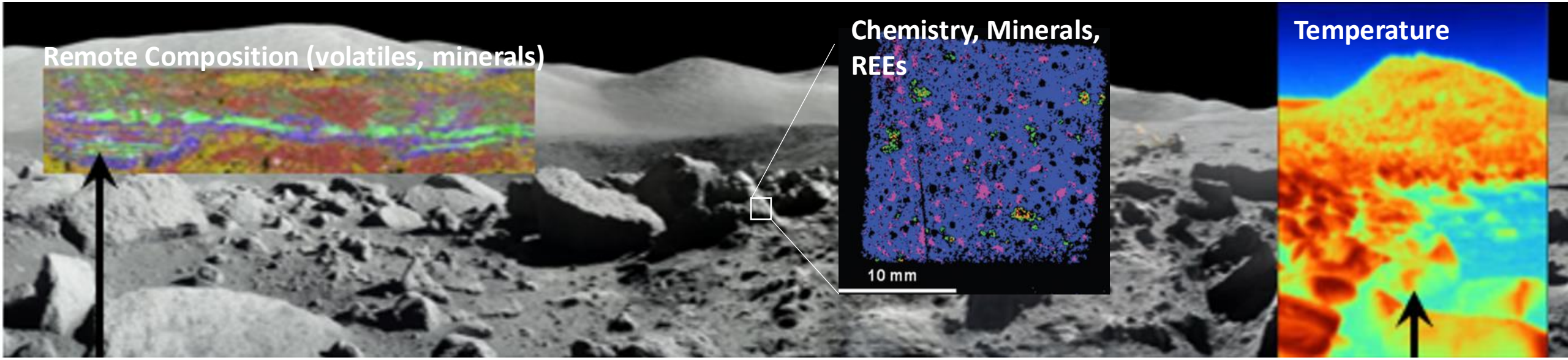
2024

2025

As we learn from the Moon, let's go 21st century

Toolkit for the modern astronaut:

- Orbital recon (radar, IR, and optical)
- Vehicle with IR and thermal mapper display
- Arm/glove-based tools for sub-mm composition
- Autonomy, on-board processing aids ('go-to' spot)
- Robots in advance of humans



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Extras

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- **Mars is unparalleled destination for planetary science and continued exploration**
  - *Life:* Nearest, best target for search for life
  - *Environments & Water:* Mars has water resources, is *dynamic* (and we can't yet predict how)
  - *Planet Evolution:* Long record for understanding Earth-like planets and habitability
- **Keep the cadence – and the leadership with science-driven Mars robotic program**
  - NASA has led the world because of Mars Program integration and timely science
  - Sample return is important for science and paving the way for human return
  - New low-cost opportunities now, with careful teaming
  - Workforce training, "living and working on Mars" with robots
- **Activate all the stakeholders – international, commercial, academic**
- **Develop and practice human+agent science at the Moon and Mars**
  - Cameras and sensors beyond visible: IR, sub-mm, radar
  - Handheld tools for astronauts to triage in seconds
  - Develop sample handling for rocks and ices

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