Future explorations of Mars and the importance of sample return

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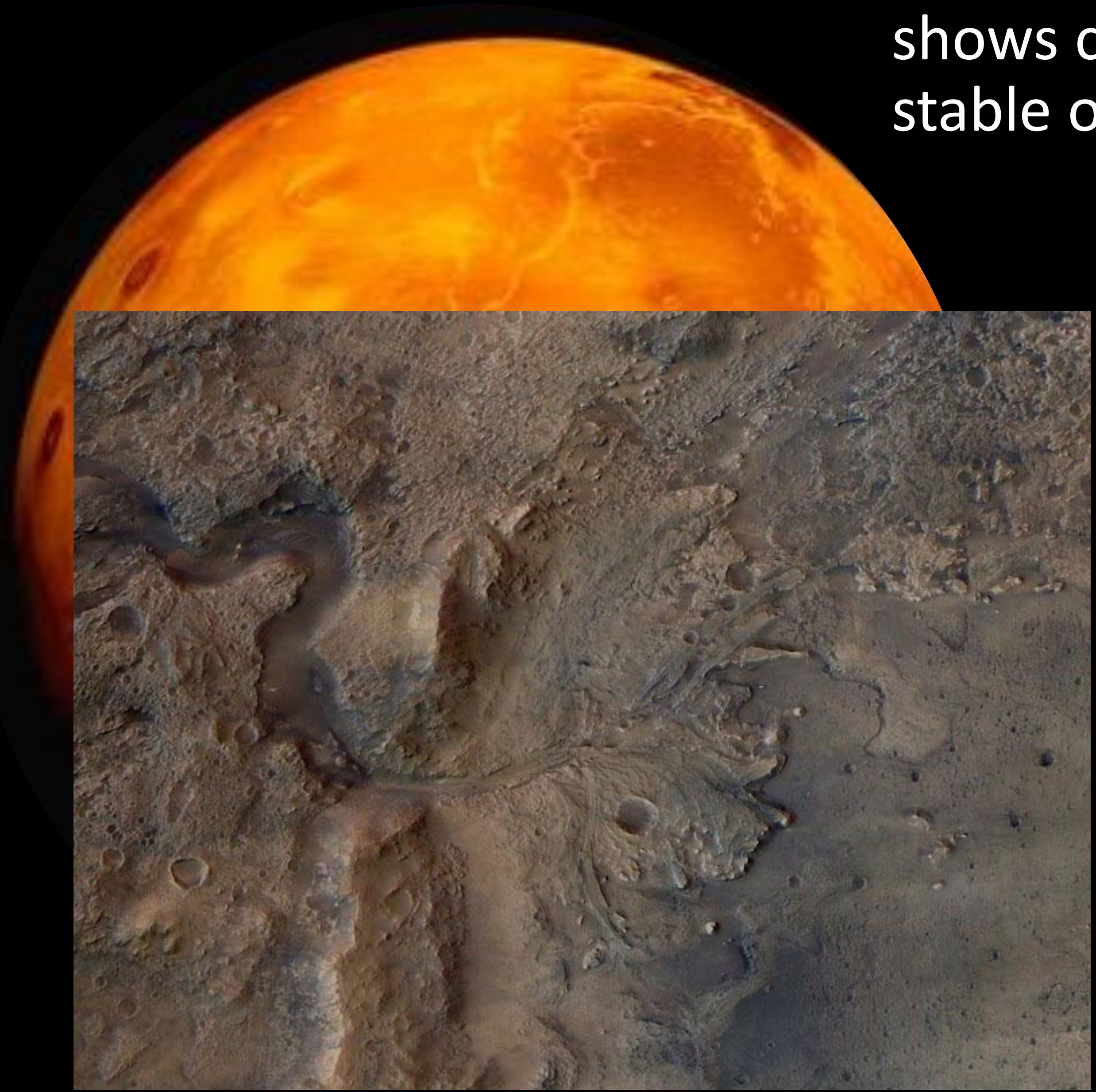

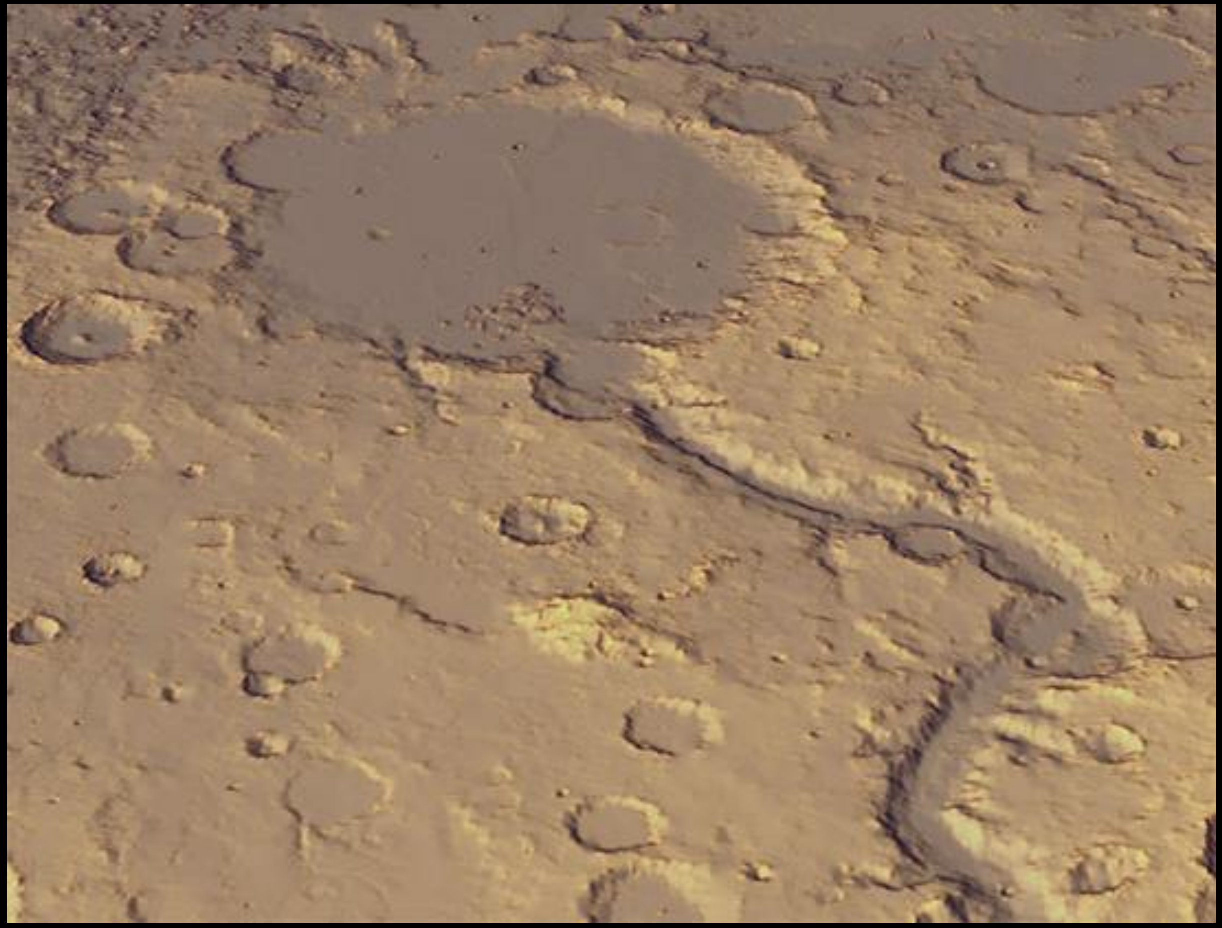

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→ Thicker atmosphere → warm climate? → life?

Results from current missions have provided clear evidences that:

- ✓ Early Mars hosted habitable oases, more than 3.5 billion years ago when bacteria populated the Earth.
- ✓ There is a salty subglacial lake close to the South Pole at a depth of 1.5 km.
- ✓ Methane is present in trace in the atmosphere with a variability that the current models are not able to explain. Methane is a very interesting molecule as it can be produced by biogenetic activity.

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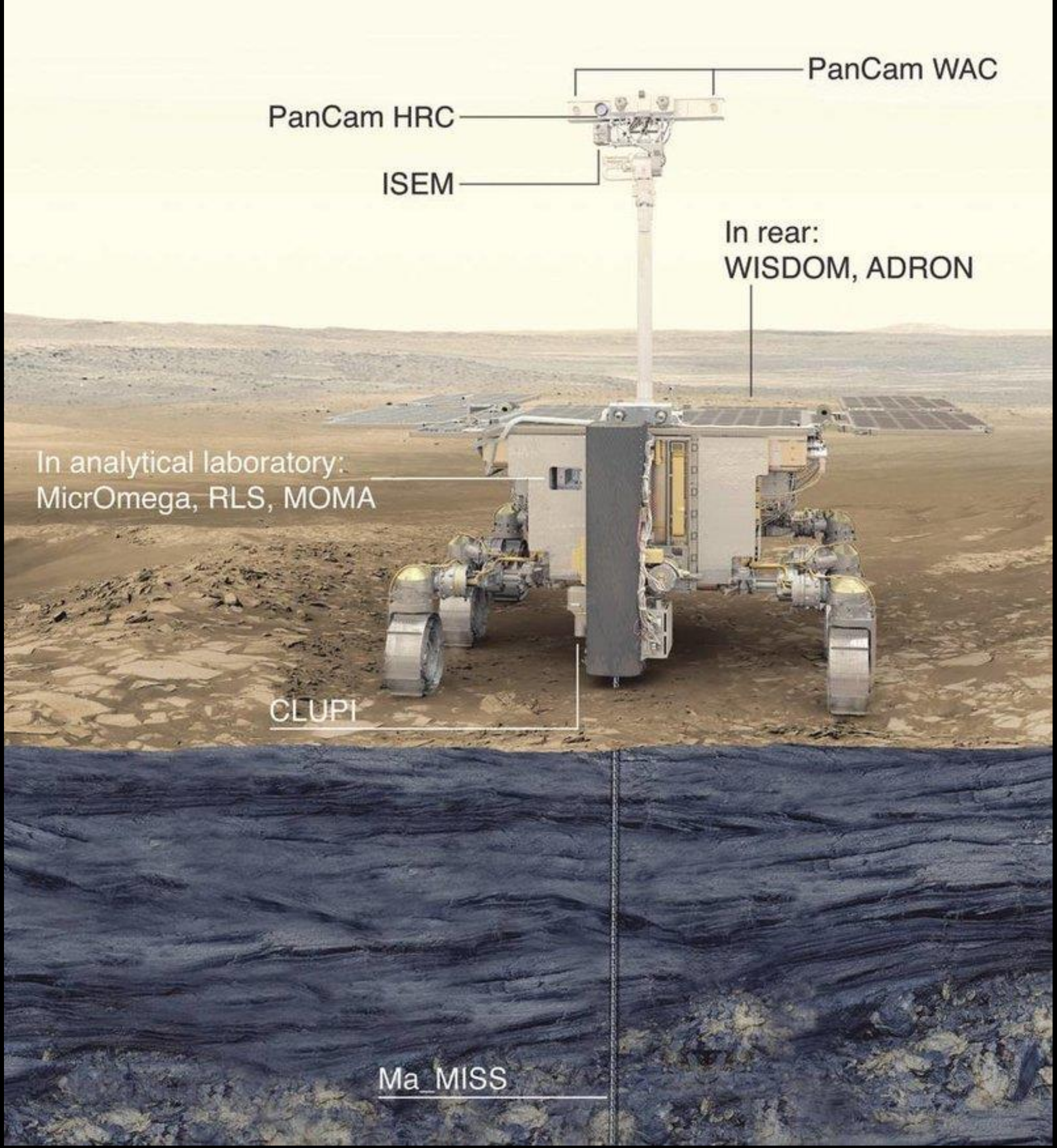
Target of future explorations is the search for signs of life on ancient terrains.



The uniqueness of the ExoMars Rover

Launch date: 2028

- A drill able to collect for the first time on Mars sample down to a depth of 2 m.
- A payload suitable to search for signs of life and properly characterize the environment.
- A landing site (Oxia Planum) very ancient location (4 Gyr) covered by large amount of water for a long time.

Mars Sample Return (MSR)

Why MSR and the Value of the Returned Samples

Mars is the most Erath-like planet in terms of geologic history and the planet in the solar system most likely to have hosted life when microbes gained a foothold on the young Earth.

Samples returned from Mars will be the most precious specimen ever collected.

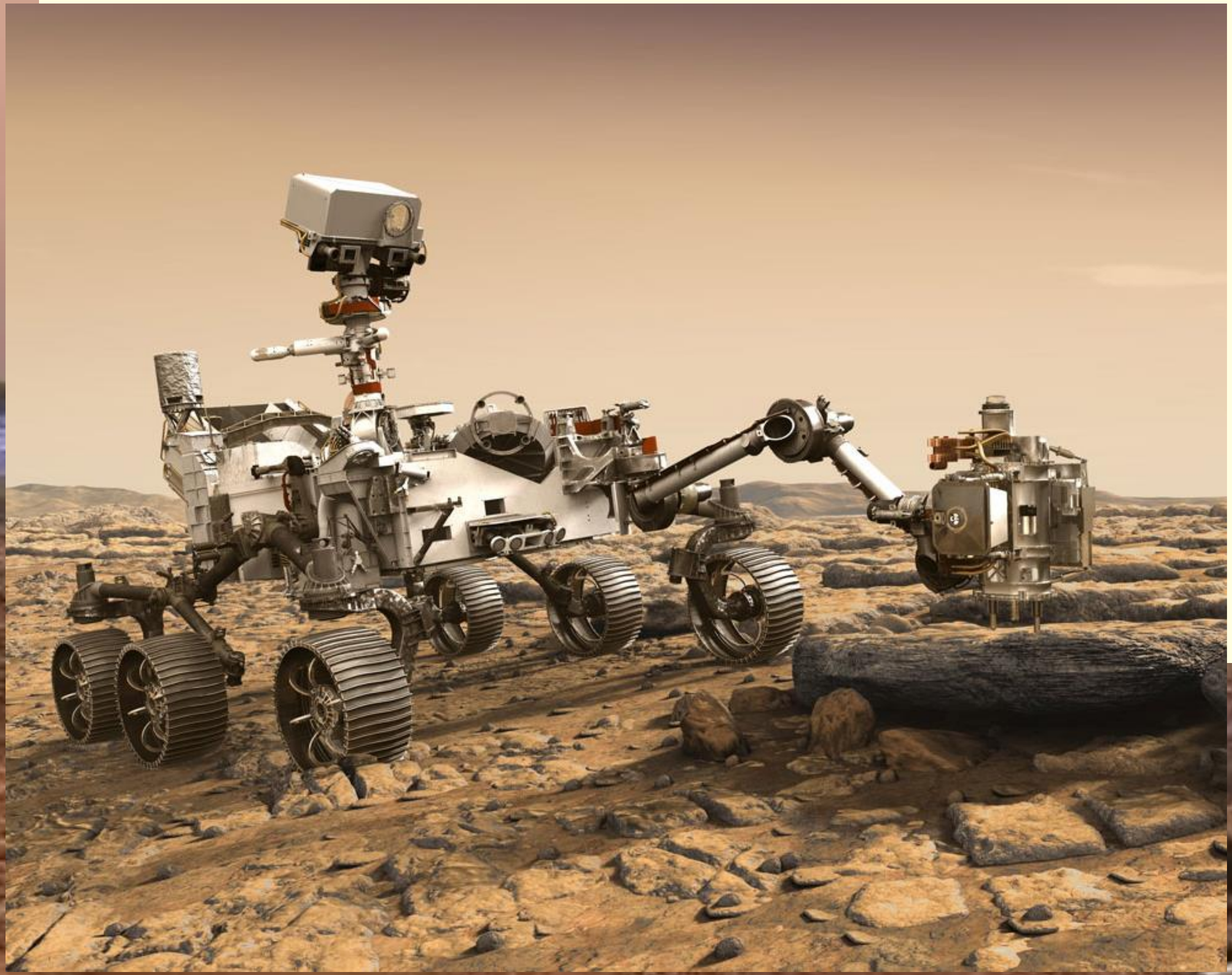
The broadest, most rigorous investigations of potential biosignatures can only be achieved in Earth-based laboratories.

The MSR Campaign status

- ✓ **NASA mission Mars2020 is identifying and gathering the samples; sample-related objectives were defined by an international team.**
- ✓ **NASA/ESA joint campaign (with IT indusrty contribution) will bring the samples back to Earth by 2033.**
- ✓ **Management Plan Milestones:**
  - **Finalize in 2024 the science input for the Sample Receiving Project (SRP) to account for sample curation, safety assessment, as well as time and sterilization critical objective driven science.**
  - **Issue the first competitive Announcement of Opportunity (AO) in 2026 for MSR objective driven science investigations on the samples.**

Perseverance

Mars 2020 Perseverance rover was launched on 30 July 2020, and landed on Mars on 18 February 2021. Surface operations last at least one Mars year (about 687 Earth days).



Landing Site: **Jezero Crater**, a large impact crater (45 kilometers wide) just north of the Martian equator that **once contained a lake**. Several evidences indicate that Jezero is one of the most ideal places to find traces of ancient microbial life.

Sample caching: Perseverance rover will gather samples from Martian rocks and soil using its drill. The rover will then store the sample cores in tubes on the Martian surface.

- **43 Sample Containers**
- **Collected and sealed 18 samples**

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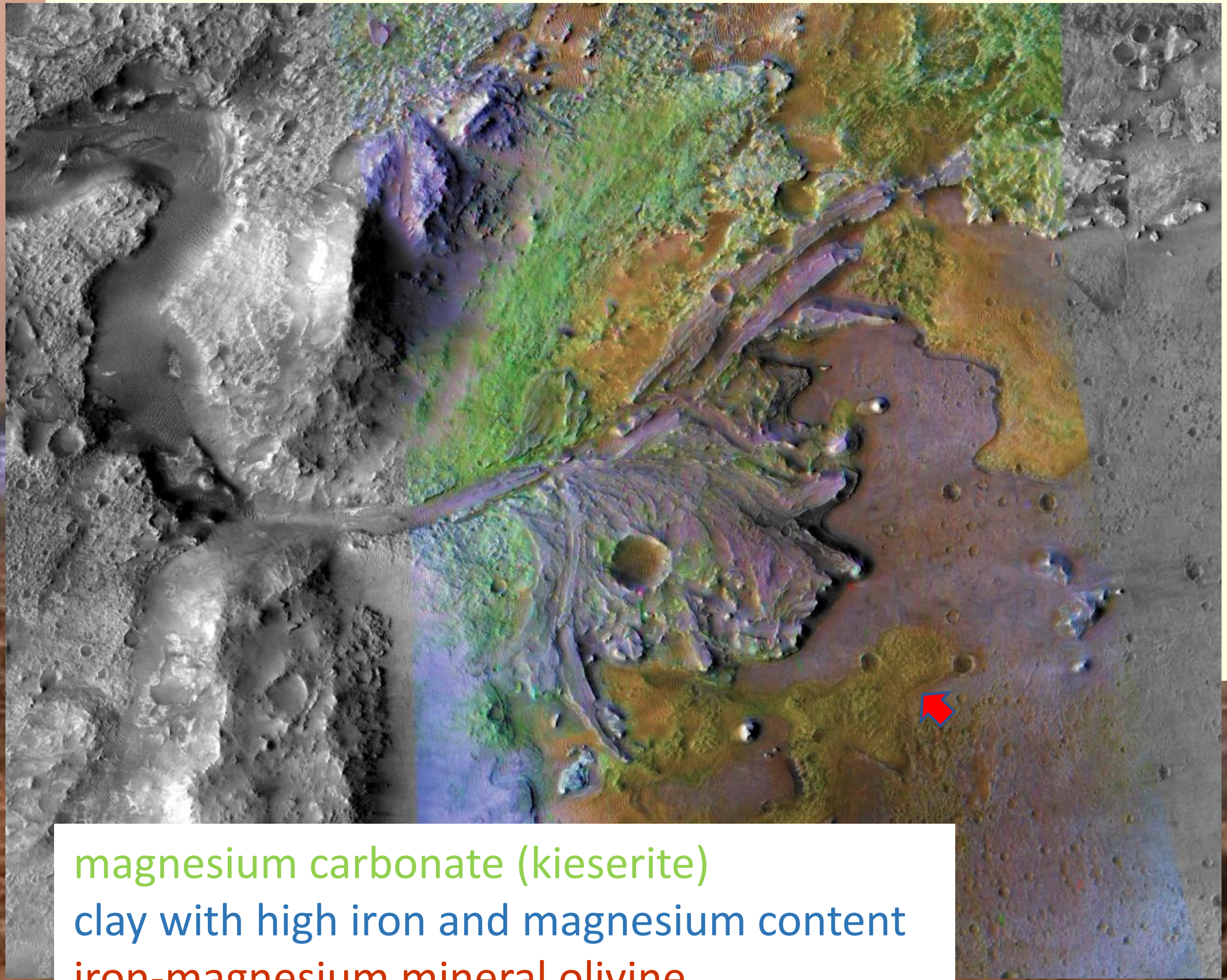

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Credit: NASA/JPL-Caltech/MSSS/JHU-APL

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Sample-related Objectives and the science of Mars Samples

Life

- Assess and Interpret the Potential Biological History of Mars, Including Assaying Returned Samples for the Evidence of Life.

Geologic Processes/Role of Water

- Interpret the Primary Geologic Processes and History that Formed the Martian Geologic Record, with an Emphasis on the Role of Water.

- Quantitatively Determine the Evolutionary Timeline of Mars.

- Reconstruct the Processes That Have Affected the Origin and Modification of the Interior, Including the Crust, Mantle, Core and the Evolution of the Martian Dynamo – Interior.

Volatiles

- Constrain the Inventory of Martian Volatiles as a Function of Geologic Time and Determine the Ways in Which These Volatiles Have Interacted with Mars as a Geologic System.

Prepare for Human Exploration: Hazards and *In Situ* Resources

- Understand and Quantify the Potential Martian Environmental Hazards to Future Human Exploration and the Terrestrial Biosphere.

- Evaluate the Type and Distribution of *In Situ* Resources to Support Potential Future Mars Exploration.

Sample-related Objectives and the science of Mars Samples

Life

- Assess and Interpret the Potential Biological History of Mars, Including Assaying Returned Samples for the Evidence of Life.

Kye Questions:

What processes are key for preserving, altering and destroying any martian biosignatures? …

What physical, chemical and isotopic patterns can be interpreted as biosignatures? …

Do life on Mars and Earth share a common ancestor? What are life's universal requirements?

Investigation Strategies:

Environment characterization.

Develop as complete an inventory as possible of the organic molecules present in the samples.

Determine isotopic fractionation between organic matter and carbon-bearing minerals such as carbonates.

Assess the possibility of metabolism and respiration.

Exclude the possibility of contamination with terrestrial life or terrestrial organics.

Sample-related Objectives and the science of Mars Samples

Life

- Assess and Interpret the Potential Biological History of Mars, Including Assaying Returned Samples for the Evidence of Life.

Role of Water/Geologic Processes

- Interpret the Primary Geologic Processes and History that Formed the Martian Geologic Record, with an Emphasis on the Role of Water.

- Quantitatively Determine the Evolutionary Timeline of Mars.

Kye Questions:

What was the history (timing, quantity, and chemistry) of surface/near-surface water and how is the record of ancient climate of Mars preserved in the sediments? What was the relationship of aqueous systems to atmospheric processes? How does the impact flux on Mars compare to that on the Moon?...

Investigation Strategies:

Investigate sediment diagenesis, including the processes of cementation, dissolution, authigenesis, recrystallization, oxidation/reduction, and fluid-mineral interaction; understand the weathering and eolian processes; calibrate cratering chronology.

→ *Quantitative comparison of the histories of Earth, Mars, and the Moon is a key input to understanding the origin and evolution of the inner solar system, including the history of habitability.*

Final Remarks

- In the next decade most of the INAF Solar System community will work on the MSR programme. A long-term vision is mandatory for properly identify, evaluate and plan the future activities.
- The overall Italian community interested in MSR, led by INAF, has a big potentiality for conducting scientific analysis on the samples that will be returned to the Earth. More focused activities and technological equipment are needed to consolidate this potentially and overcome the gaps to be worldwide competitive for the next milestones.
- To be ready, a series of activities needs to start soon to consolidate the Italian community, discussing the appropriate protocols and laboratory environments where to manipulate and analyze the samples.
- The MSR objective is in its intimate nature interdisciplinary. It will be crucial to train a new generation of Italian scientists and to be ready with the necessary technological equipment.

Future strategies

- Investing in education and training of a new generation of scientist
- Investing in instruments and facilities to get ready to the analysis of the Mars Samples
- Creating an Italian facility to analyze the samples, depending on future international agreements

3rd Italian Workshop on MSR: 25-26 May 2023
ASI - Rome

https://indico.ict.inaf.it/event/1169/

Topics:

- Terrestrial analogues and martian meteorites
- Investigation Techniques
- Sample management and Planetary Protection
- Infrastructures

SOC: F. Altieri (co-chair, INAF), J.R. Brucato (co-chair, INAF), E. Ammannito (ASI), F. Capaccioni (INAF), M.C. De Sanctis (INAF), F. Esposito (INAF), R. Mugnuolo (ASI), A. Rotundi (Università Parthenope, Napoli).

Goal: build solid collaborations among national scientific and technologic communities interested in MSR to be internationally competitive for the next frontier in the exploration of Mars.

Achieving MSR would represent one of humankind's greatest technical accomplishments, with a two-part measure of success—one engineering and one scientific. In addition to the remarkable engineering accomplishments that are required to deliver samples safely from Mars to Earth, the world's scientific community stands to make historic discoveries.
We believe that the Italian community should play a crucial role in such a big leap towards the exploration of Mars and the search for signs of life beyond Earth.