Remote Sensing Analysis of Valles Marineris: Insights into the Red Planet's History

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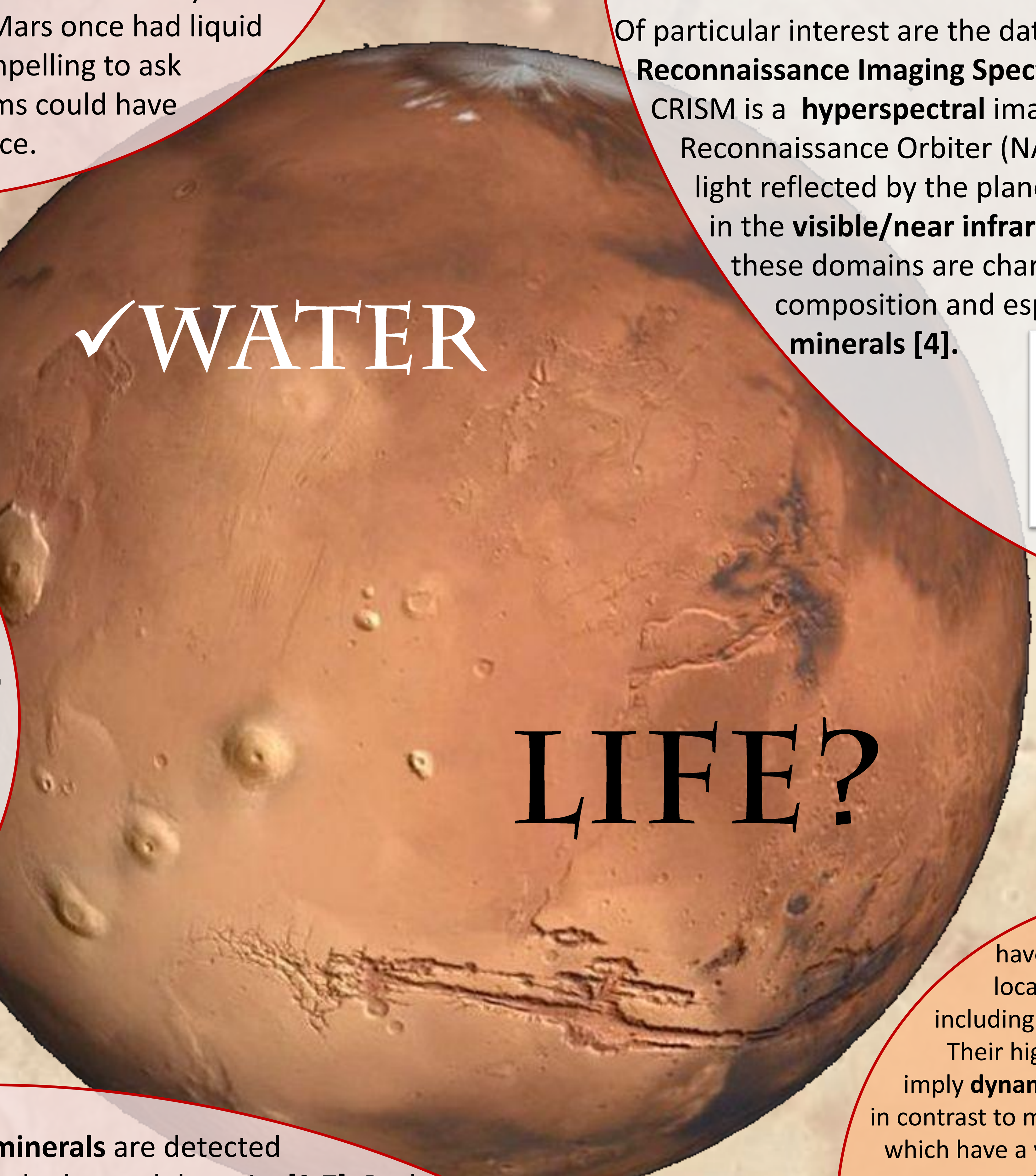
WHY?

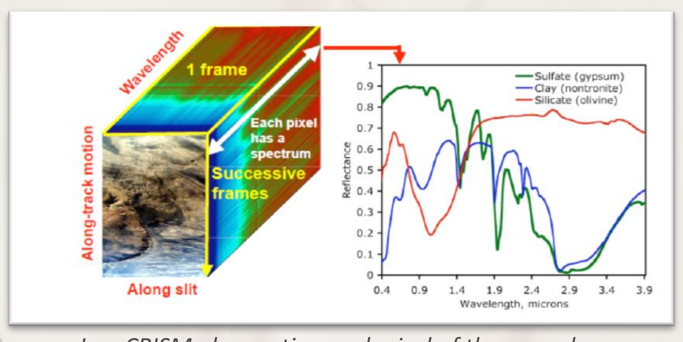
Although the first spacecrafts that flew over Mars showed **the planet is rocky, cold, and sterile** beneath its hazy, pink sky, today's Martian wasteland hints at **a formerly different world** where volcanoes once raged, and flash floods rushed over the land [1]. Among our discoveries about Mars, one stands out above all others: the **possible presence of liquid water on Mars**, either in its ancient past or preserved in the subsurface today. **Water is key** because almost everywhere we find water on Earth, we find **life**. If Mars once had liquid water, or still does today, it is compelling to ask whether any microscopic life forms could have developed on its surface.



HOW?

A wide array of data (visible imagery, spectroscopy, laser altimetry, gravity) from different missions are used in order to **identify, map and characterize geologic features and units** at the surface of Mars. These data are collected, processed and gathered into a **Geographic Information System (GIS) [2].**

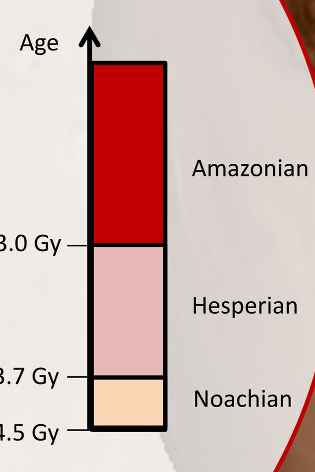
Of particular interest are the data from the **Compact Reconnaissance Imaging Spectrometer for Mars (CRISM).** CRISM is a **hyperspectral** imaging spectrometer onboard Mars Reconnaissance Orbiter (NASA, 2005) which analyzed the light reflected by the planet's surface thanks to 2 detectors in the **visible/near infrared domains [3].** Absorptions in these domains are characteristic of the surface composition and especially the **presence of hydrated minerals [4].**



In a CRISM observation each pixel of the scene has a associated spectrum. Minerals are identified thanks to their diagnostic absorptions in that spectrum.

WHEN?

Crater counts (which are commmonly used in planetary science for relative dating of surfaces) performed in Valles Marineris (VM) suggest that **the layered deposits were formed about 3. 5 Gy ago, after the canyon's opening**, but were repeatedly **eroded by outflows until 2 Gy ago [2].**



Mars geologic eras.

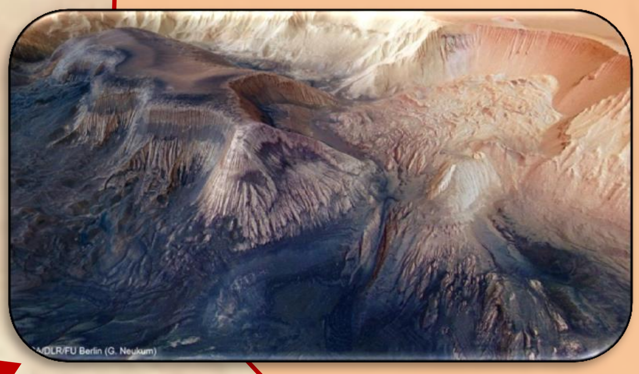
These results suggest that VM is an unique area of Mars where liquid water persisted, as least episodically, until late in its history.

VM KEY FACTS:

- *Length: 4000 km*
- *Width: 400 km*
- *Depth: up to 10 km*
- *The largest fault in the Solar System*
- *Connected to Tharsis, the largest volcano in the Solar System (26 km)*

WHERE?

Layered Deposits have been observed in different locations at the surface of Mars, including crater floors and canyon systems. Their high interest relies on the fact they imply **dynamic conditions** of deposition. Indeed, in contrast to most of the rocks on the martian surface, which have a volcanic origin, bright layered deposits seems to be **sedimentary outcrops [5].**

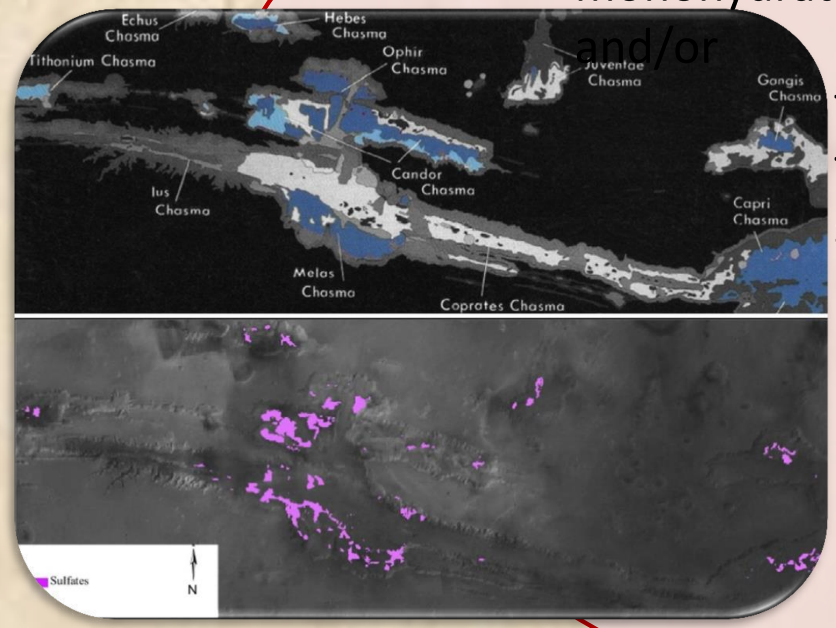


HRSC stereo camera image of a layered mound in Hebes Chasma, Valles Marineris.

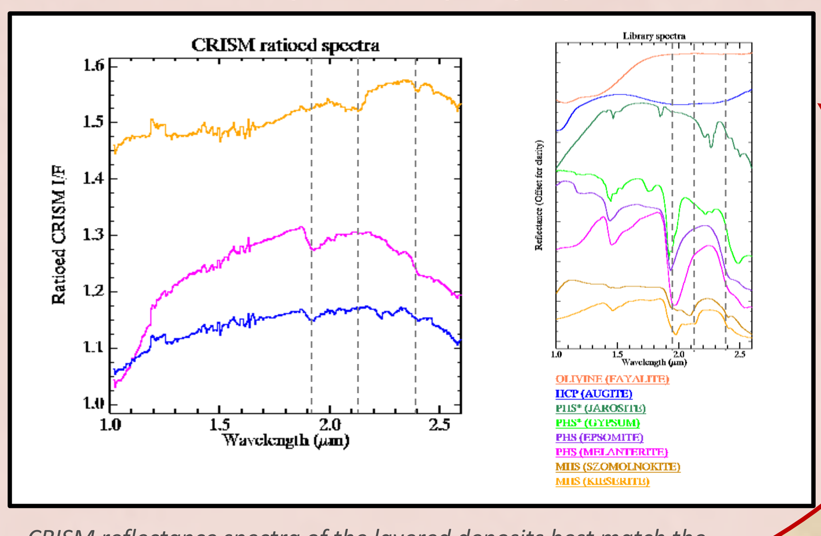
Such deposits are found in **Valles Marineris**, Mars' unique giant canyon system, where they form kilometer thick mounds of unknown origin [6].

WHAT?

Hydrated sulfate minerals are detected in association with the layered deposits [2,7]. Both monohydrated Mg-rich sulfate (MHS, kieserite) and Mg and/or Fe-rich polyhydrated sulfates (PHS) are identified thanks to their absorptions at 1.6; 2.13 and 2.4 µm for kieserite and 1.4; 1.9 and 2.4 µm for polyhydrated sulfates [2,8].



Sulfates are hydrated minerals that required liquid water and sulfur to form, usually in acidic conditions.



CRISM reflectance spectra of the layered deposits best match the MHS (kieserite) and PHS spectra in the reference library (comparison with terrestrial samples).

CONCLUSIONS and PERSPECTIVES

- Observations in Valles Marineris confirm **the presence of large amounts of liquid water** until 2 Gy
- As liquid water is not stable under present day Mars conditions (P=6 hPa, T=-63°C), this suggests that liquid water was transient and/or that **conditions on Early Mars were different**
- A lot more areas **remain to be explored** with newly available high resolution datasets – especially since most places remain inaccessible by rover missions.

References: [1] Carr and Head (2010), EPSL; [2] Flahaut (2011), PhD thesis; [3] Murchie et al. (2007), JGR; [4] Clark et al. (1990), JGR; [5] Malin et al., (2000), Science; [6] Lucchitta et al. (1994), JGR; [7] Bibring et al., (2006), Science [8] Gendrin et al. (2005), Science.

MISSIONS TO MARS