

Today's Topics

Monday, October 5, 2020 (Week 7, lecture 20) – Chapters 10.

Mars

A. Basic properties

B. Moons

C. Surface features

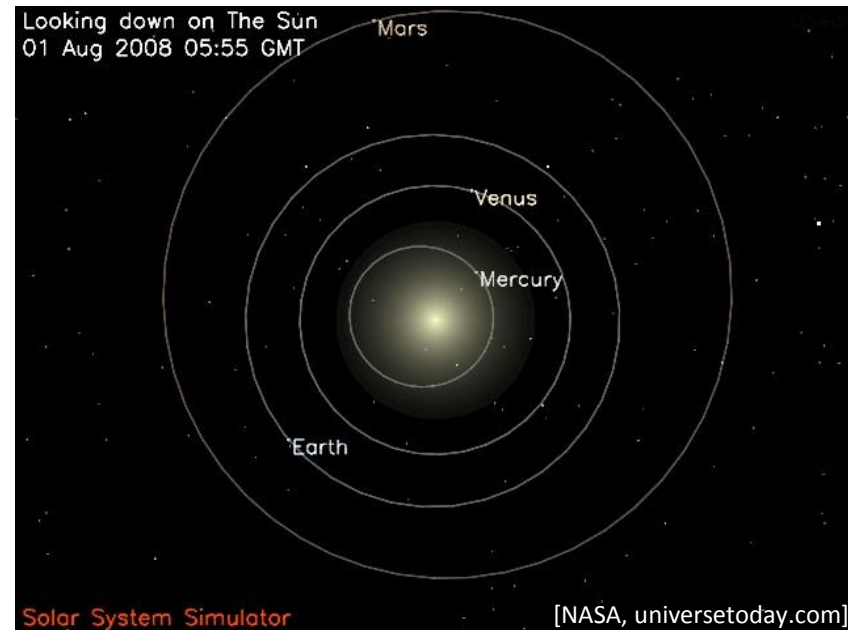
D. Internal structure

E. Atmosphere

F. Water

Mars

- Fourth planet from Sun.
- Second closest planet to Earth.
- 687 day orbit, somewhat eccentric $\epsilon = 0.093$.
- Receives ~40 % of the sunlight that Earth does, i.e. 60 % less sunlight than Earth.
- Martian day is 24.6 hrs, very similar to Earth's.



Mars

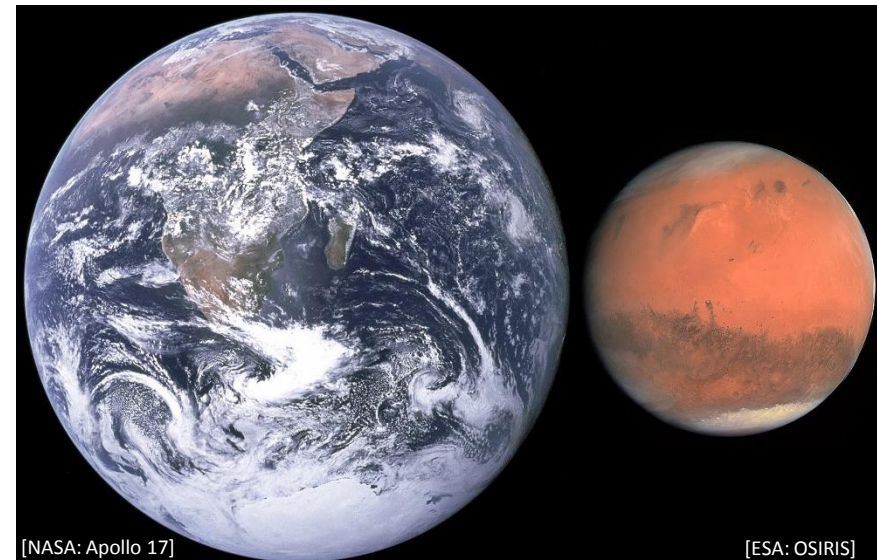
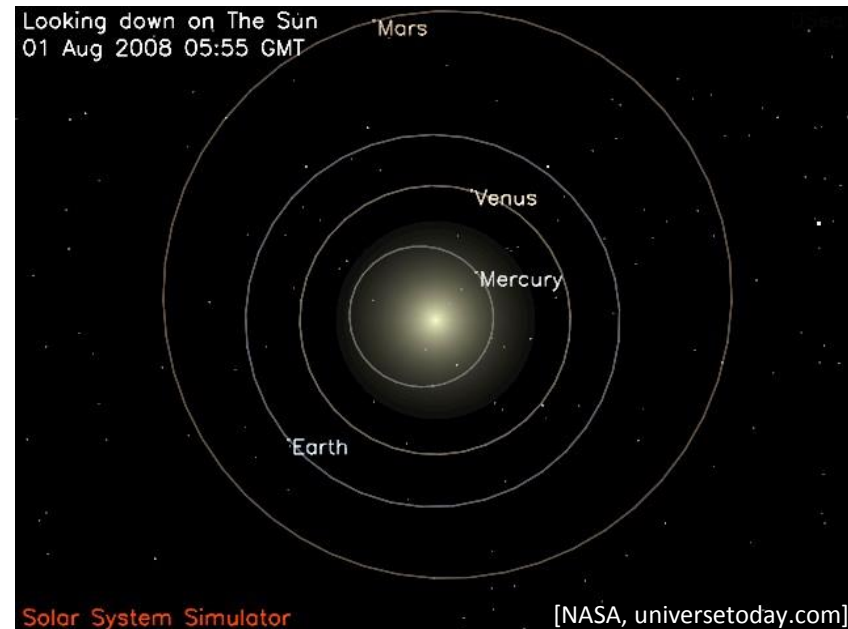
- Fourth planet from Sun.
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➤ Physical features

- $R_{\text{Mars}} = 53\%$ of Earth's.
- $M_{\text{Mars}} = 11\%$ of Earth's.
- $g_{\text{Mars}} = 38\%$ of Earth's.
- Density: 3.9 g/cm^3 .

➤ Temperature range: -143° to 35° C .

➤ No magnetosphere.



Martian Moons

Phobos & Deimos



Phobos, diameter \approx 22 km.
(11 hour orbit)



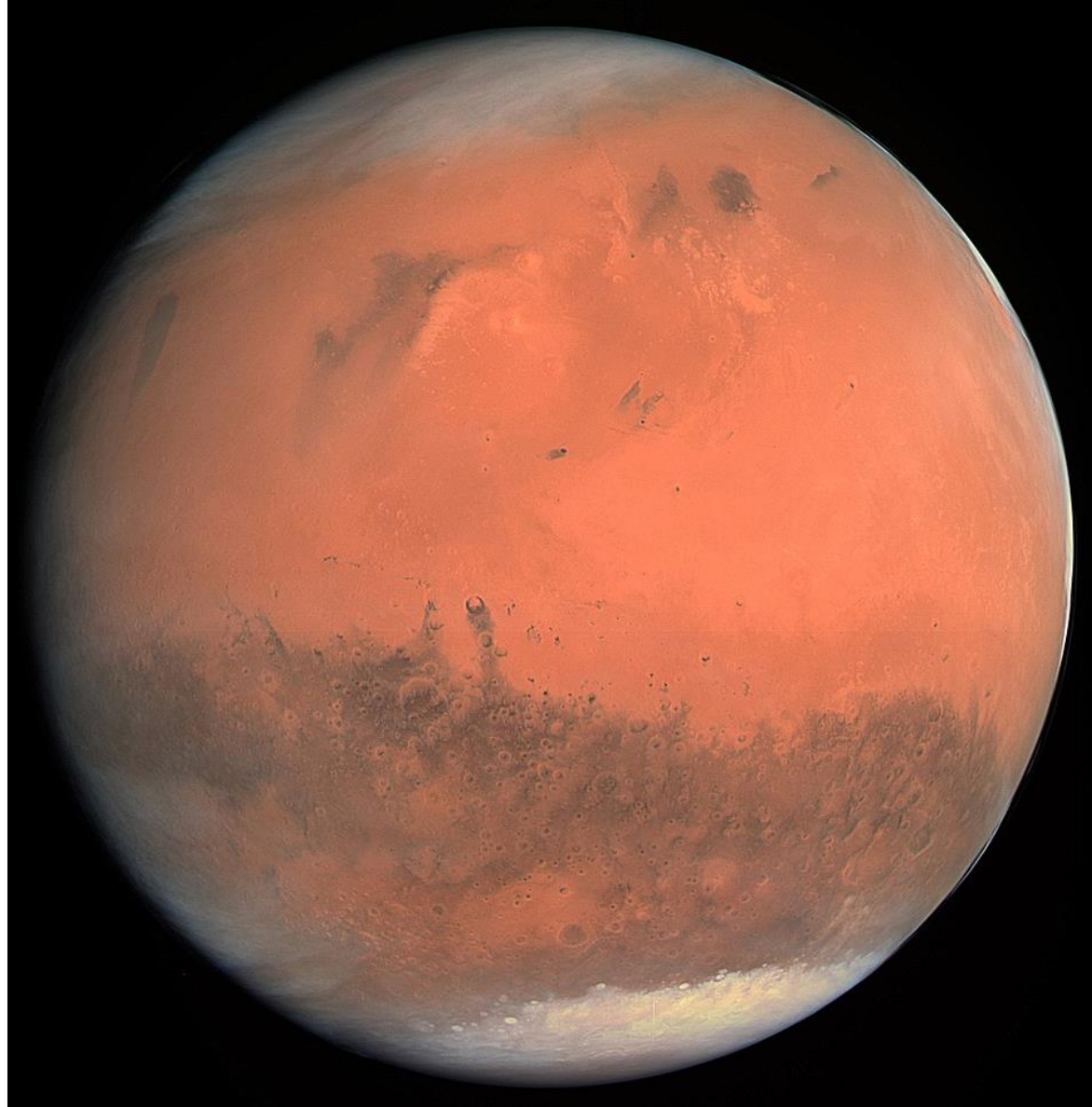
Deimos, diameter \approx 12 km.
(30 hour orbit)

Origin hypotheses: orbital capture of asteroids ... accretion after collision with Mars.

Mars: first glance

Data collection

- Visited by many landers (2 active).
- Several permanently orbiting spacecraft (6 active).
- The surface is clearly visible from space.



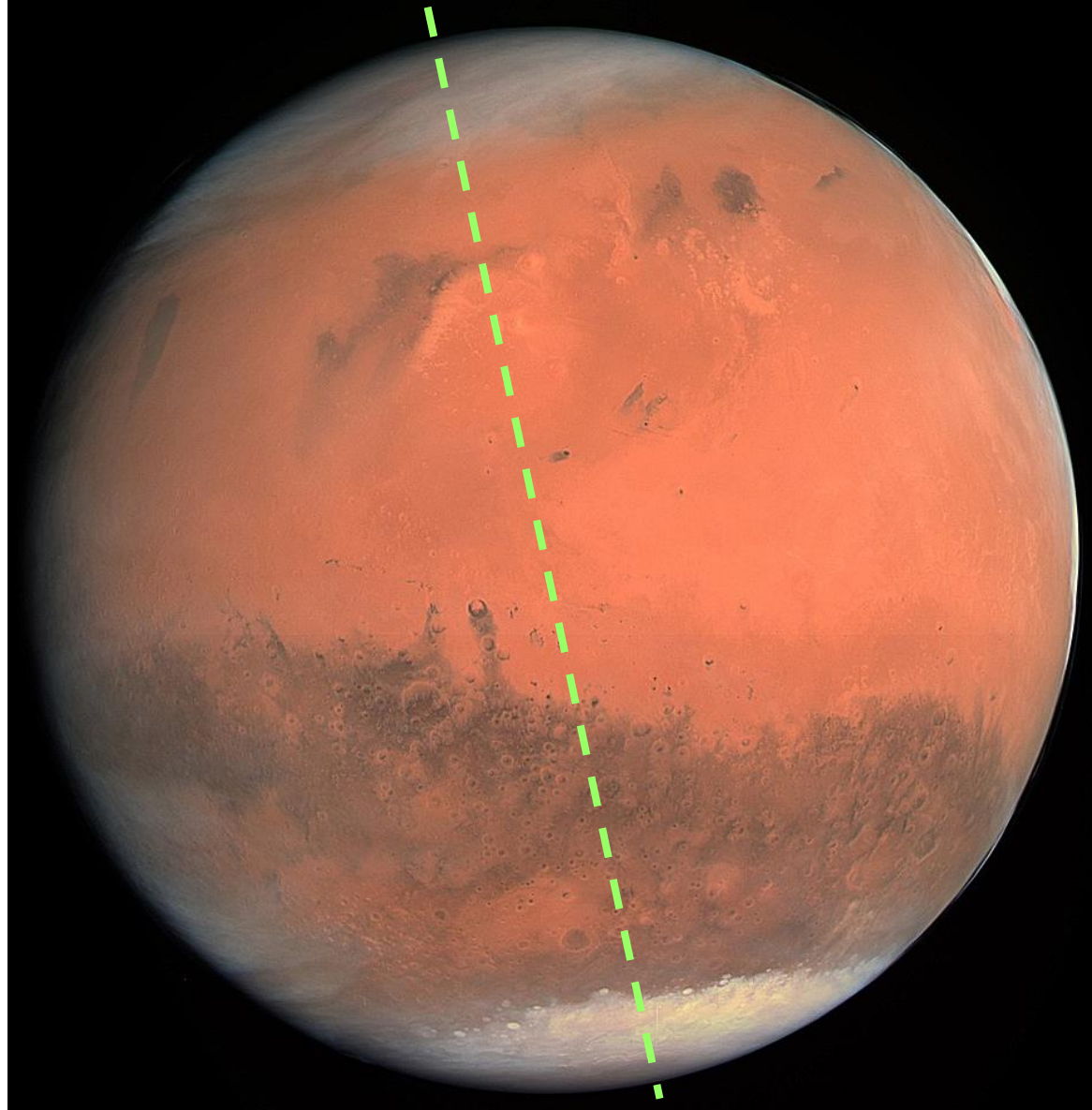
Mars: first glance

Data collection

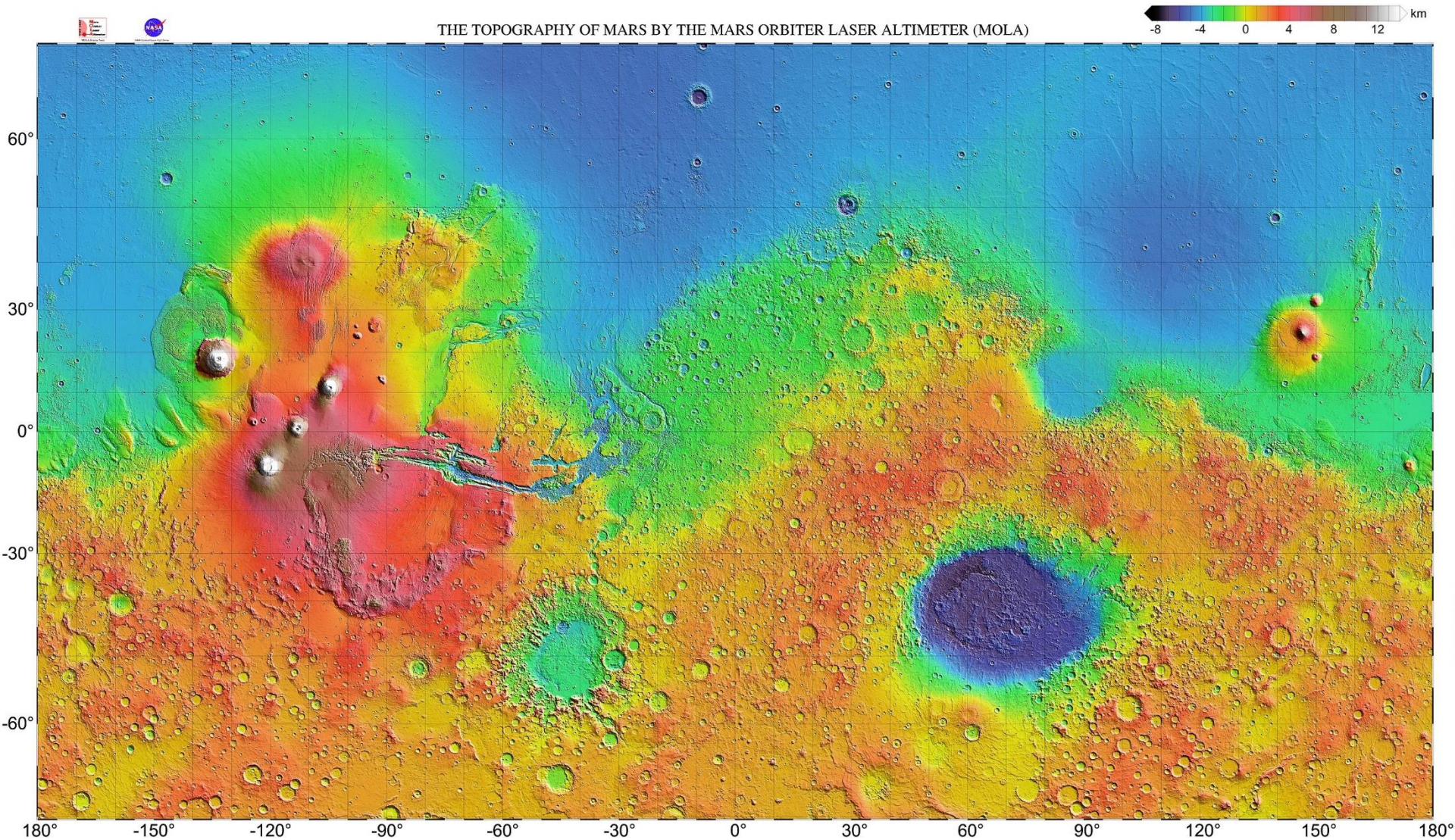
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Major surface features

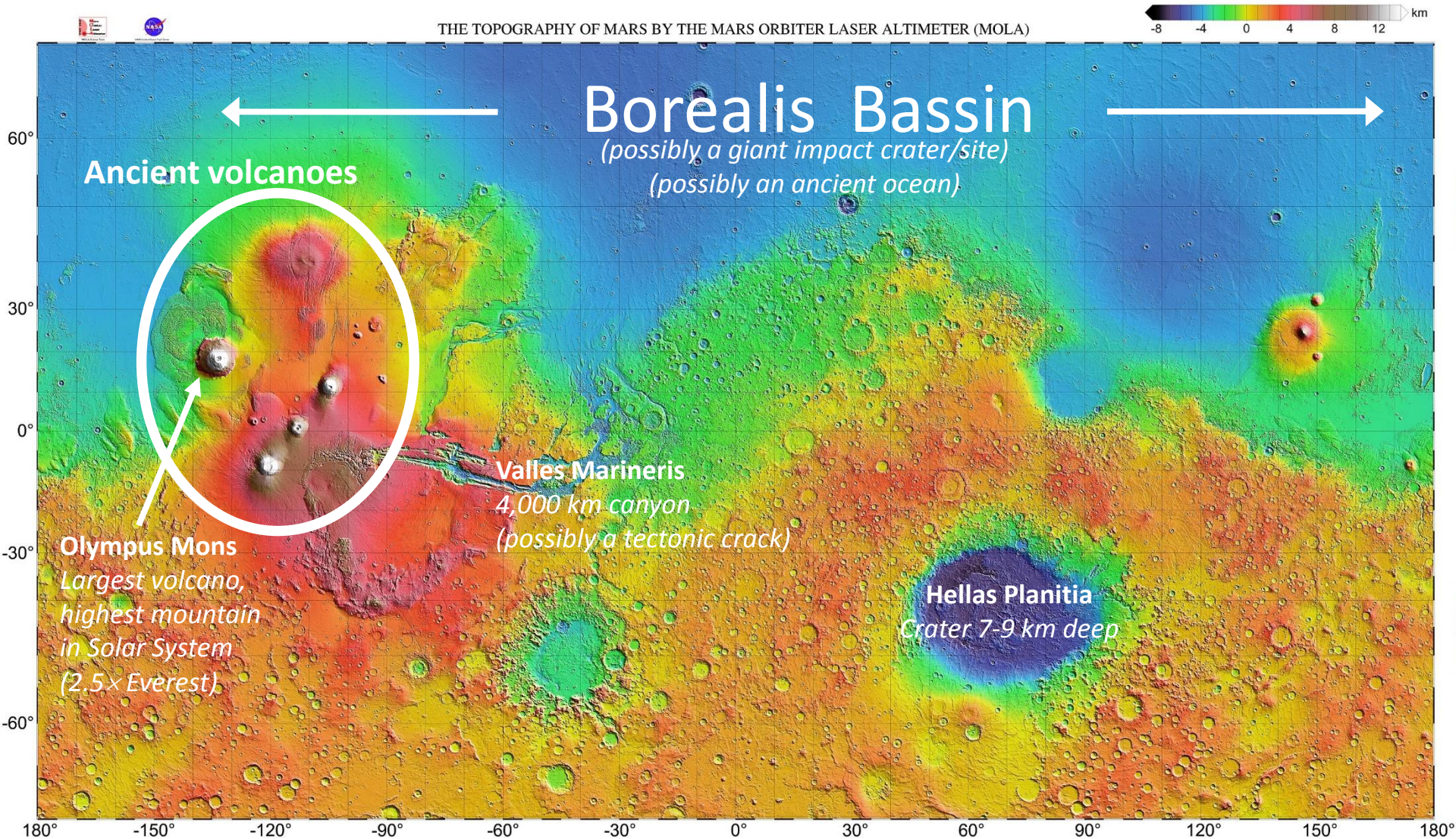
- **Seasons:** rotation axis is at 25° (similar to Earth's 23°).
- Polar **ice caps** (CO_2 & H_2O).
- **North hemisphere** is smoother and 1-3 km lower.
- **South hemisphere** is bumpier, older, and 1-3 km higher.



Mars: topology

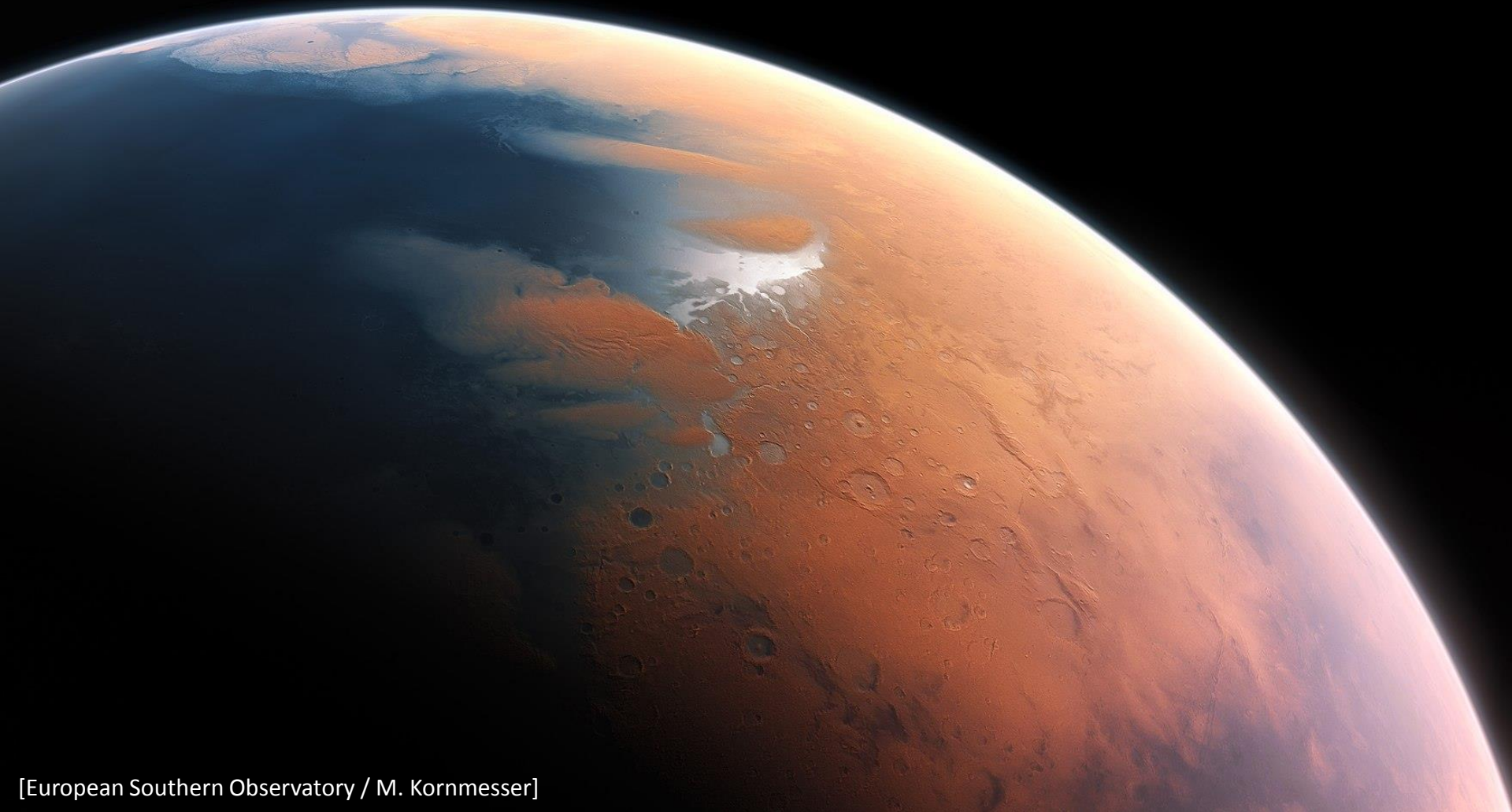


Mars: topology



Mars: ancient ocean ?

Artist's depiction of a possible ancient ocean (water)
4 billion years ago.



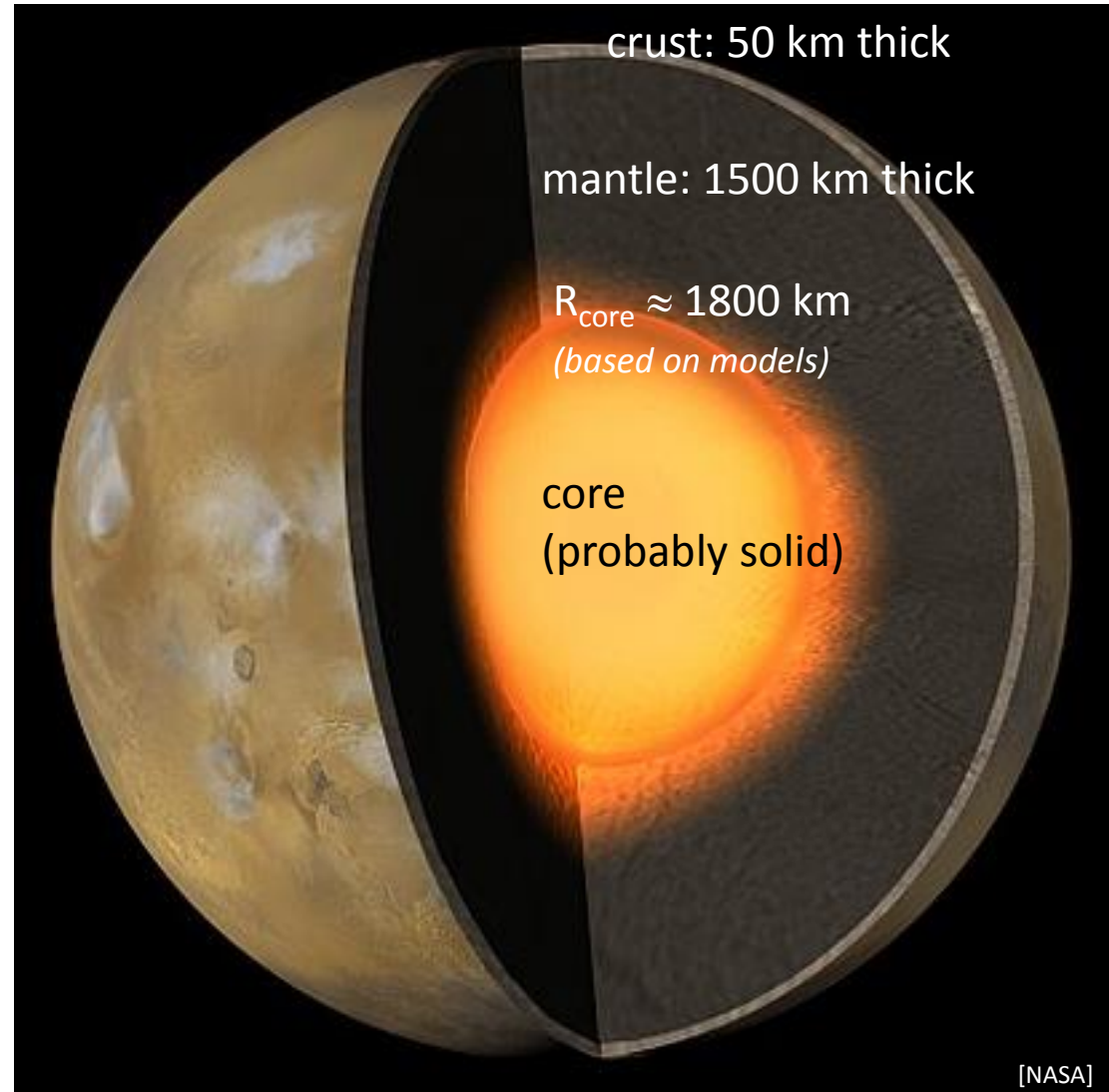
Mars: internal structure

Composition

Crust: Silicon, oxygen, iron, magnesium, calcium, potassium.

Mantle: Silicates.
(model based)

Core: Iron, nickel, and some sulfur.
(model based)



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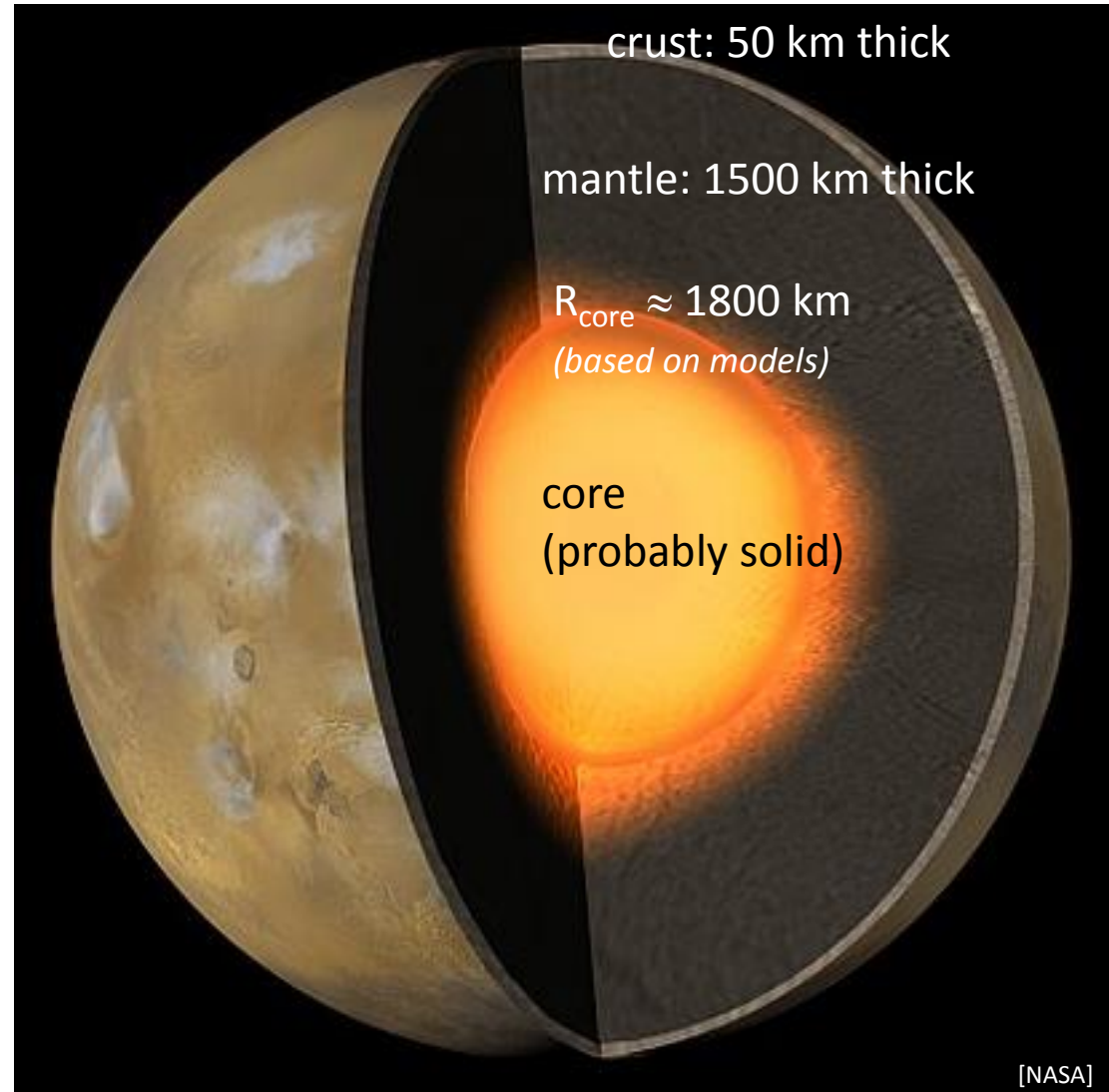
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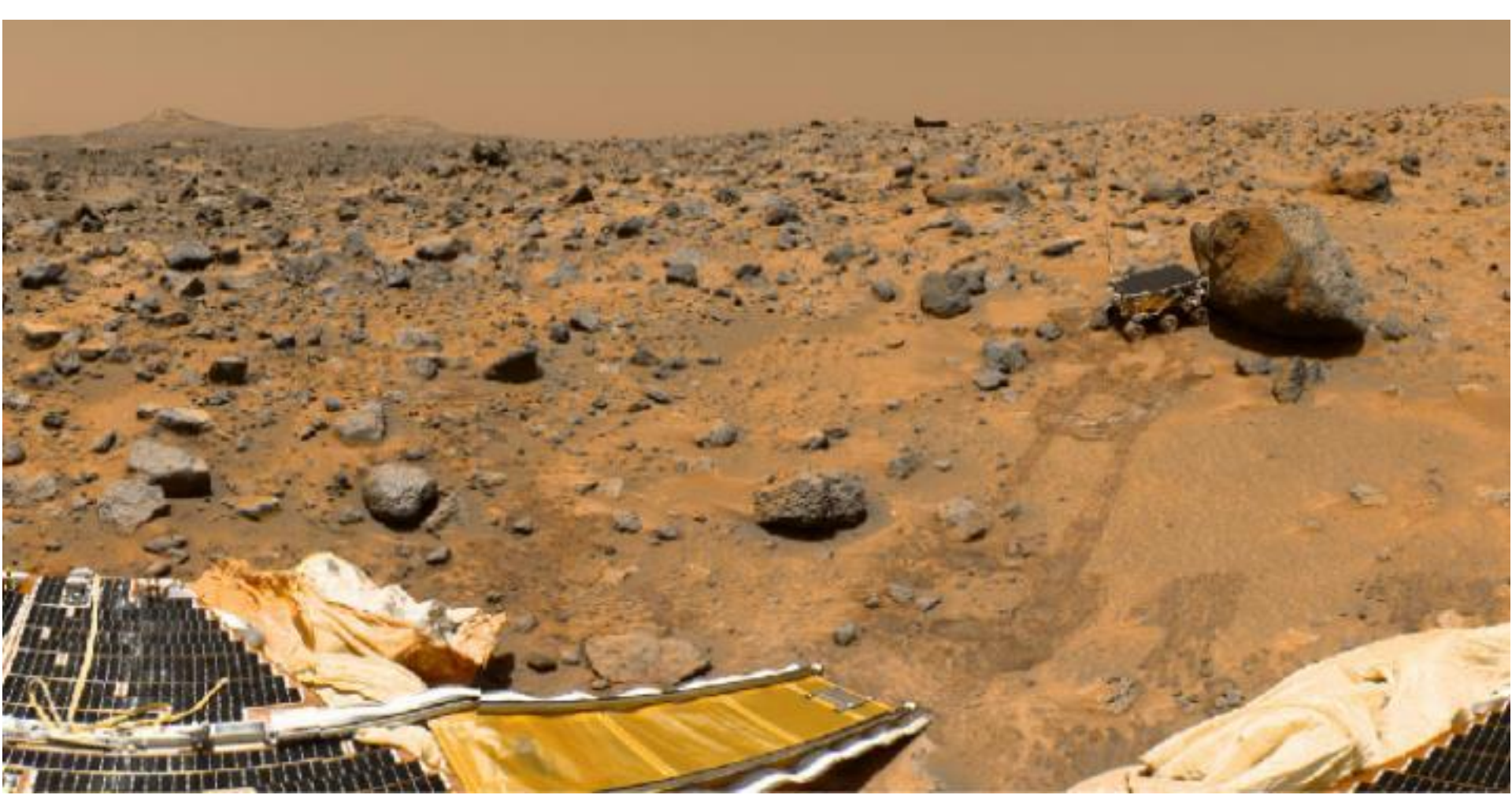
Q: Why is Mars red-ish?

A: Martian soil has a lot of iron oxide dust in it (rust-like particles).

*This **dust** is often in the atmosphere as well.*



Martian sky with dust



[NASA:Pathfinder mission + sojourner]

Clear Martian Sky



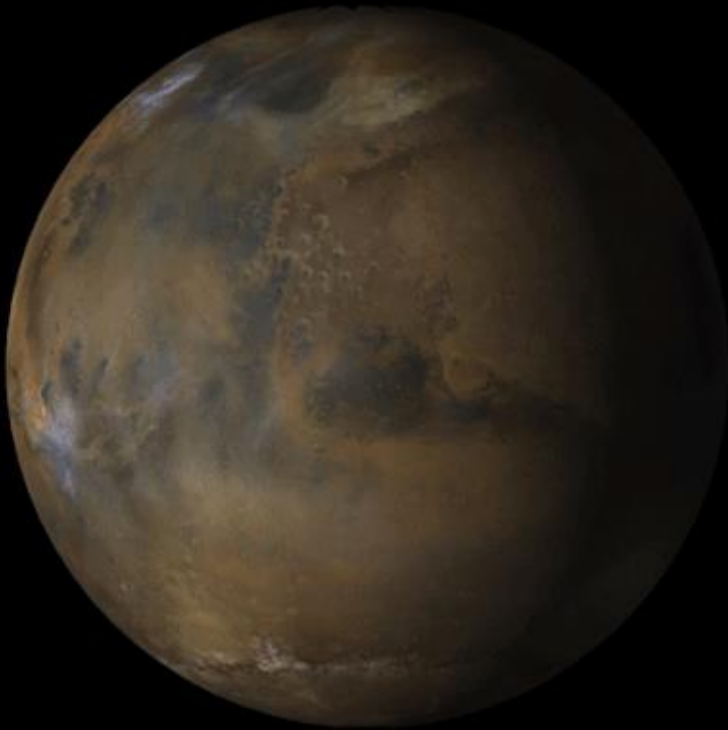
[NASA: Curiosity rover, Gale crater]

Mars: global dust storms

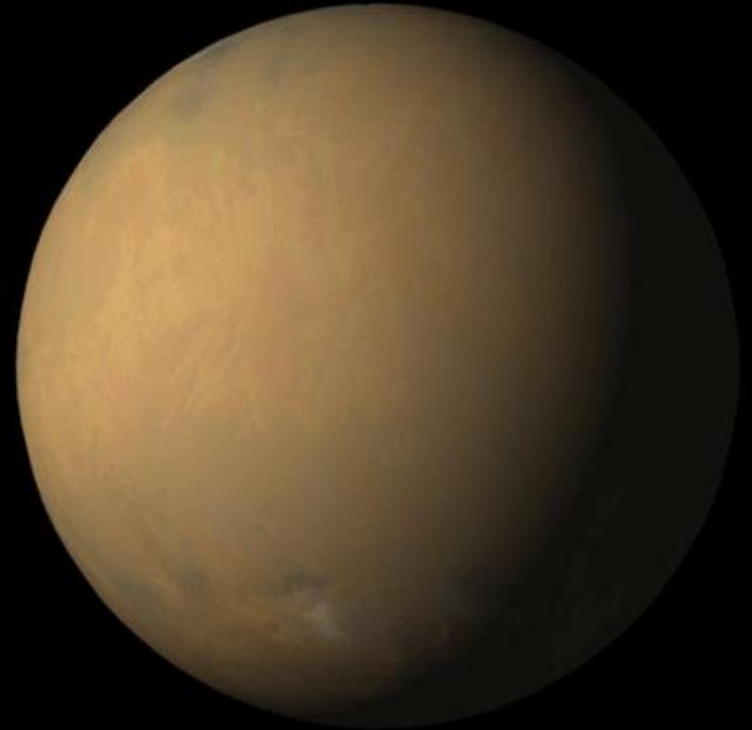
Mars has the biggest dust storms in the Solar System.

→ They can be planet-wide with winds up to 160 km/h.

clear sky



global dust storm



Martian Atmosphere

Pressure

Mars has a very dilute atmosphere.

→ Pressure is **0.6 %** of Earth's.

→ **Greenhouse effect is weak.**

Composition

Carbon dioxide (CO₂): 95.3 %

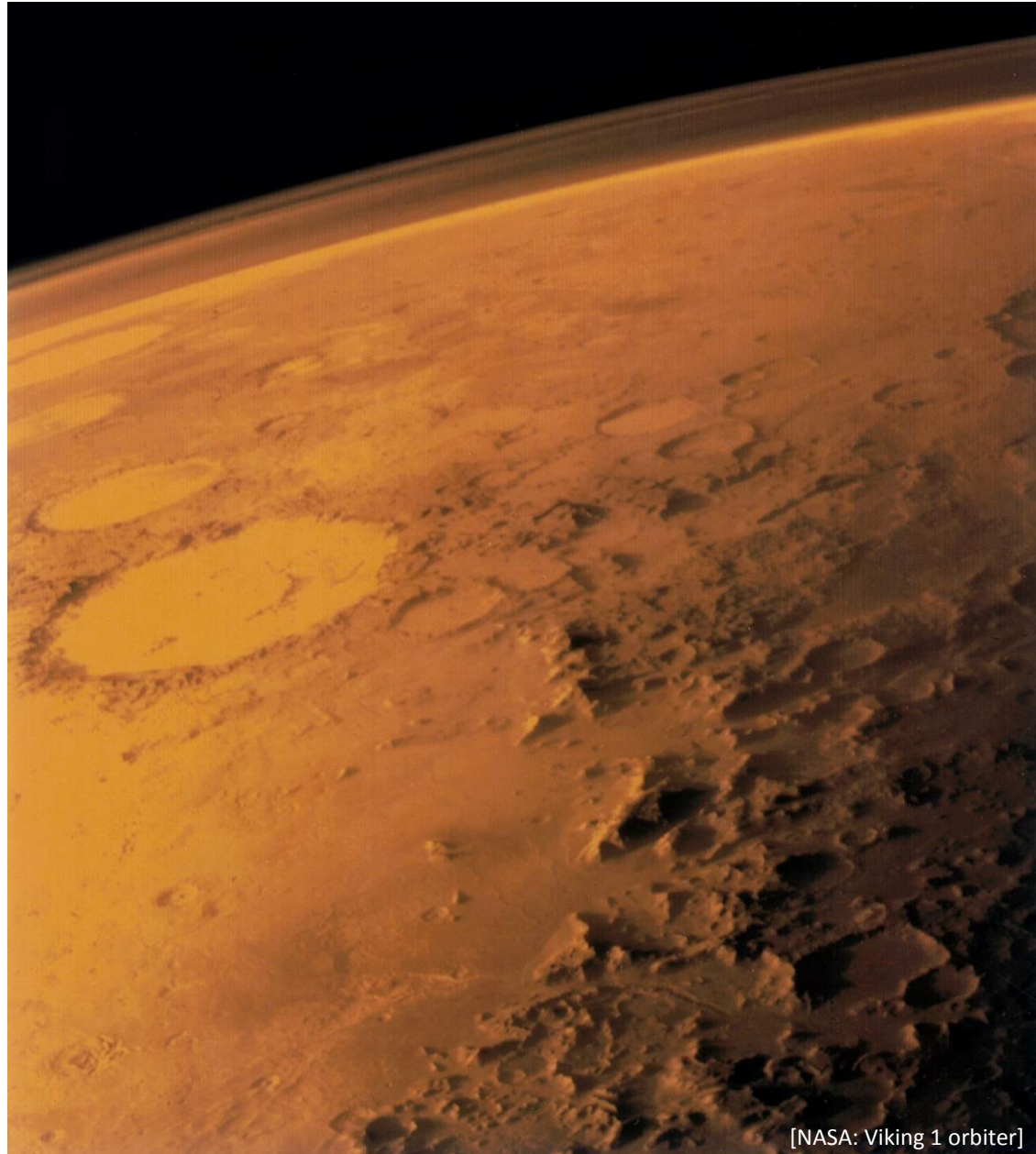
Nitrogen (N₂): 2.7 %

Argon (Ar): 1.6 %

Oxygen (O₂): 0.15 %

Water (H₂O): trace

(occasional water ice clouds)



[NASA: Viking 1 orbiter]

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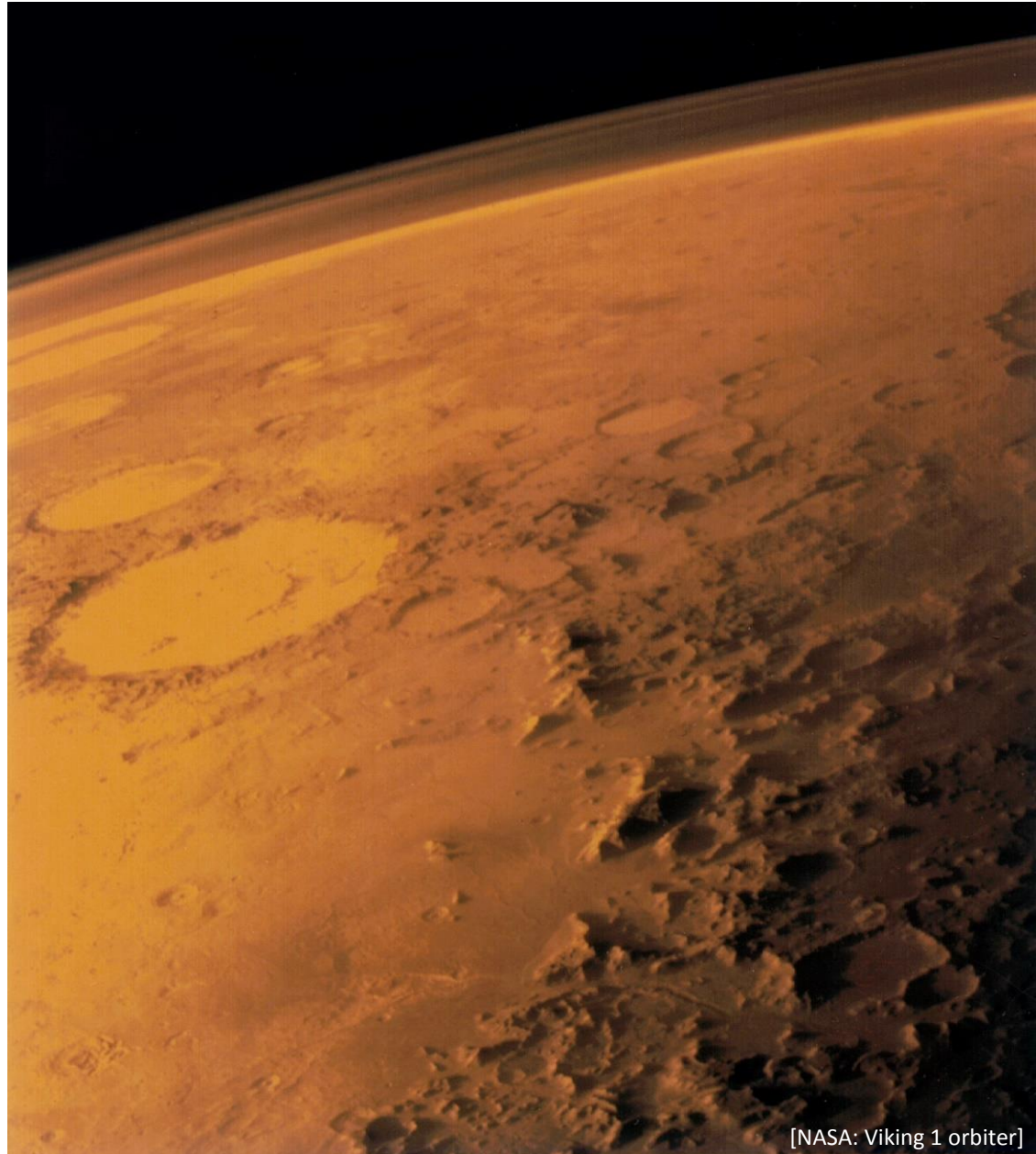
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Water in atmosphere

Water ice sublimates in low pressure atmosphere.

Note: Water vapor escapes Mars into space.



[NASA: Viking 1 orbiter]

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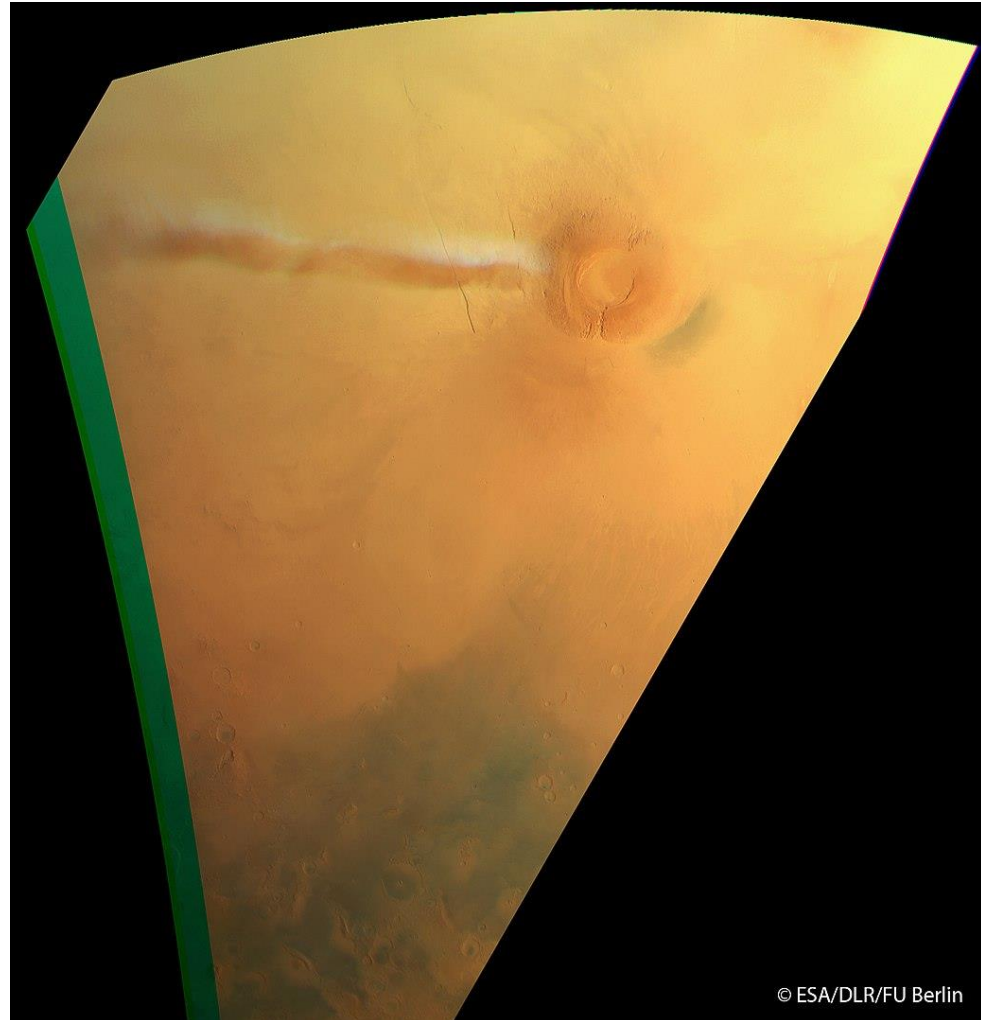
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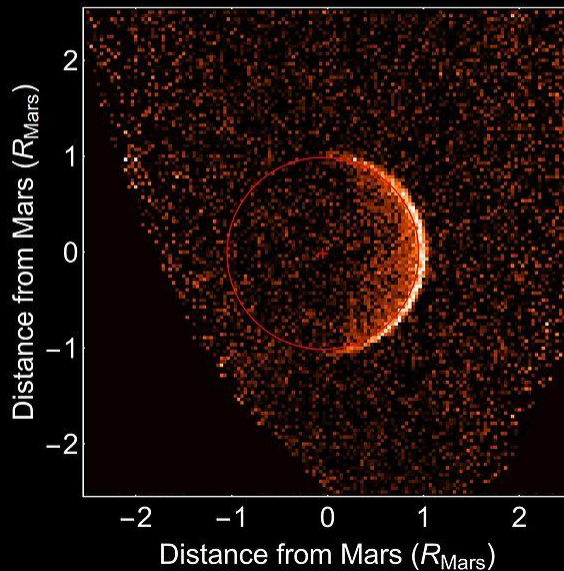
© ESA/DLR/FU Berlin

Water ice clouds above Arsia Mons volcano, 2018.

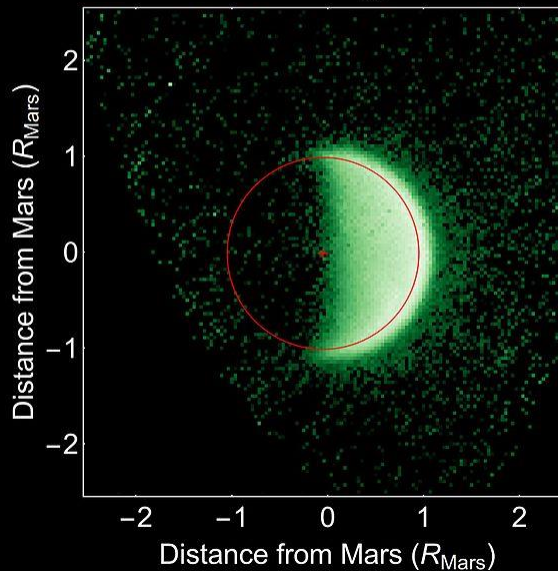
Why can't Mars keep its water?

- **Solar wind & UV radiation** from the Sun break up water molecules high in the atmosphere:
- **Mars's gravity is not sufficient** to hold onto the resulting hydrogen atoms (and oxygen atoms).

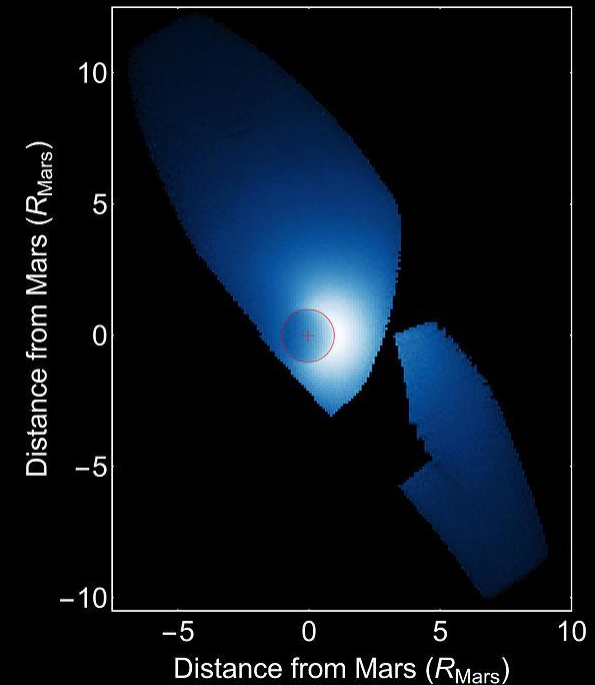
Atomic Carbon



Atomic Oxygen



Atomic Hydrogen



[NASA: MAVEN probe]

→ Mars is constantly losing its atmosphere.

Water Ice on Mars



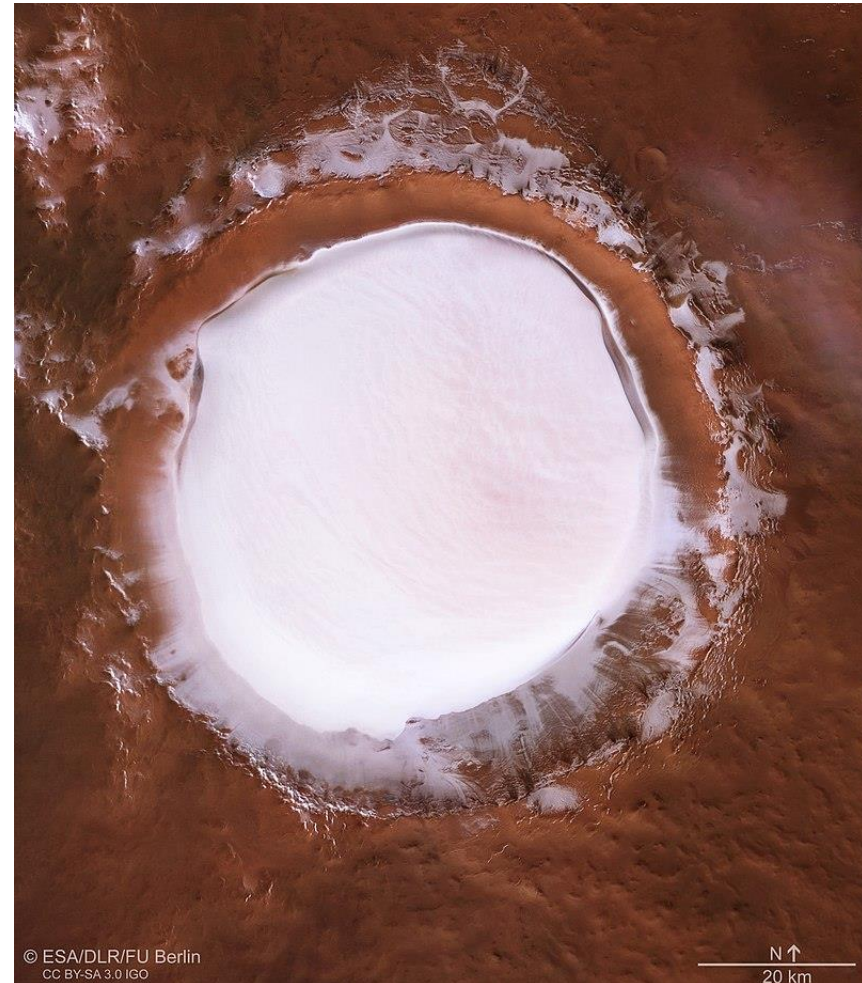
[NASA – false color image]

Water frost from the atmosphere (northern hemisphere) as seen by Viking 2 lander (1979).

Water Ice on Mars



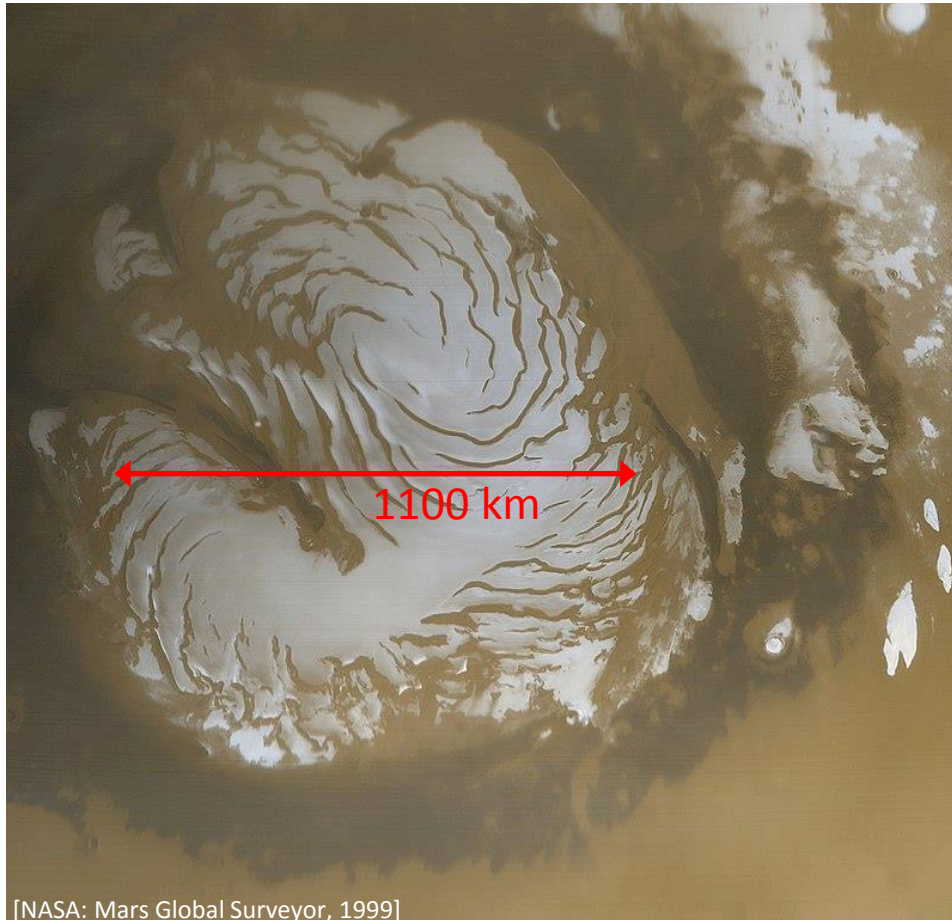
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Korolev crater filled with water ice (cold trap) as seen by Mars Express orbiter (2018).

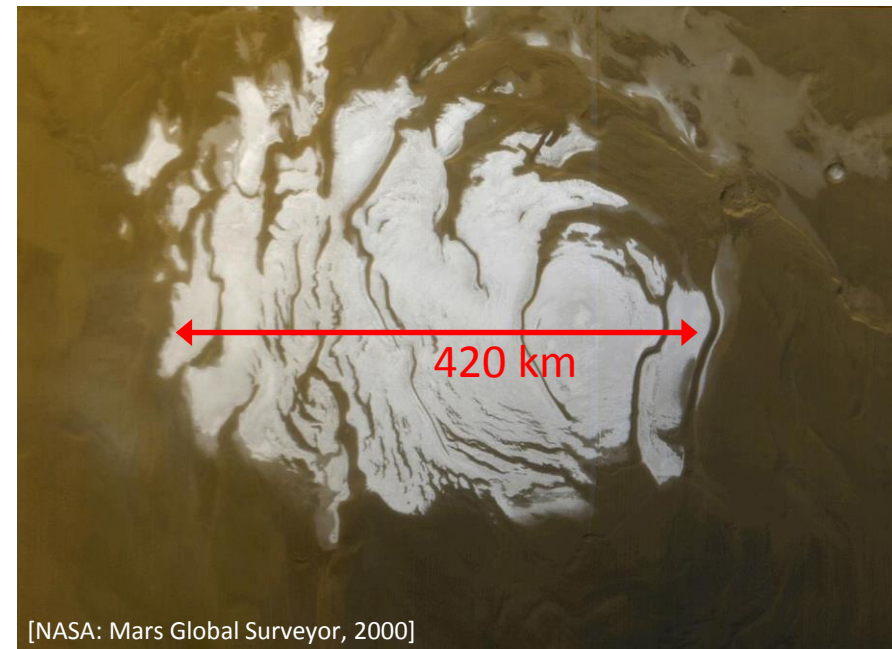
Water Ice on Mars: Polar Caps

Polar ice caps acquire a dry ice (CO_2) layer in the winter, but in the summer they are primarily water ice.



Northern ice cap, summer 1999.

→ Water ice, 2-3 km thick.

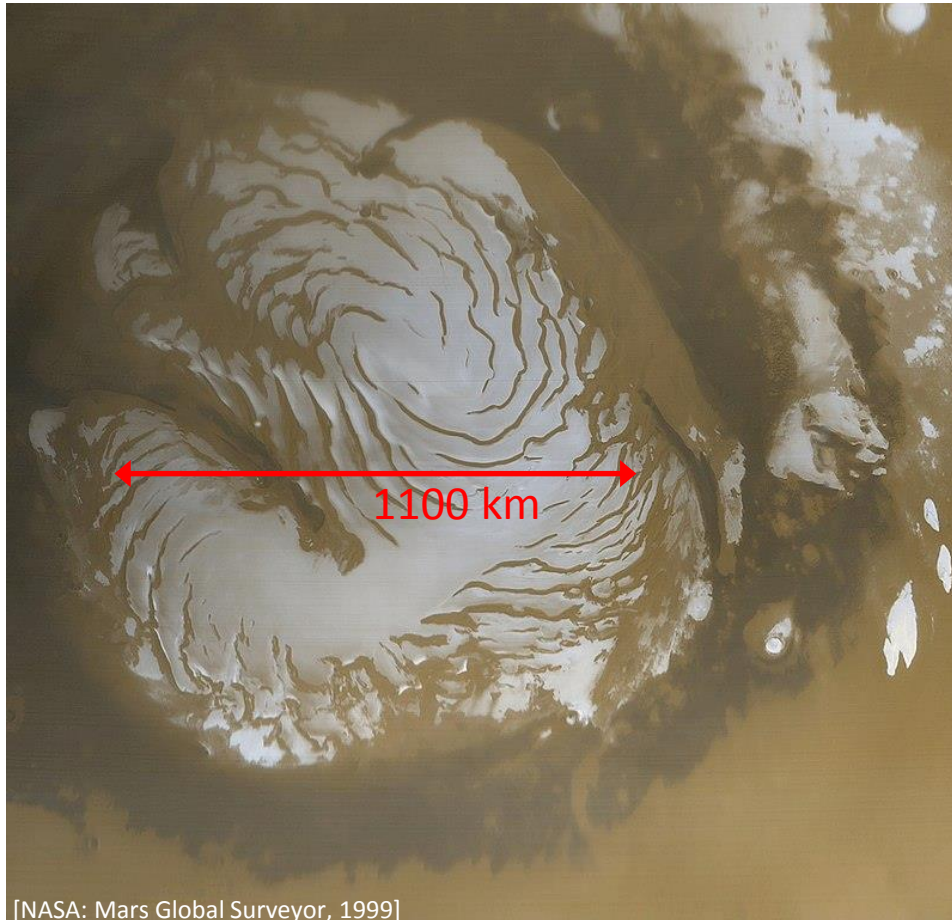


Southern ice cap, summer 2000.

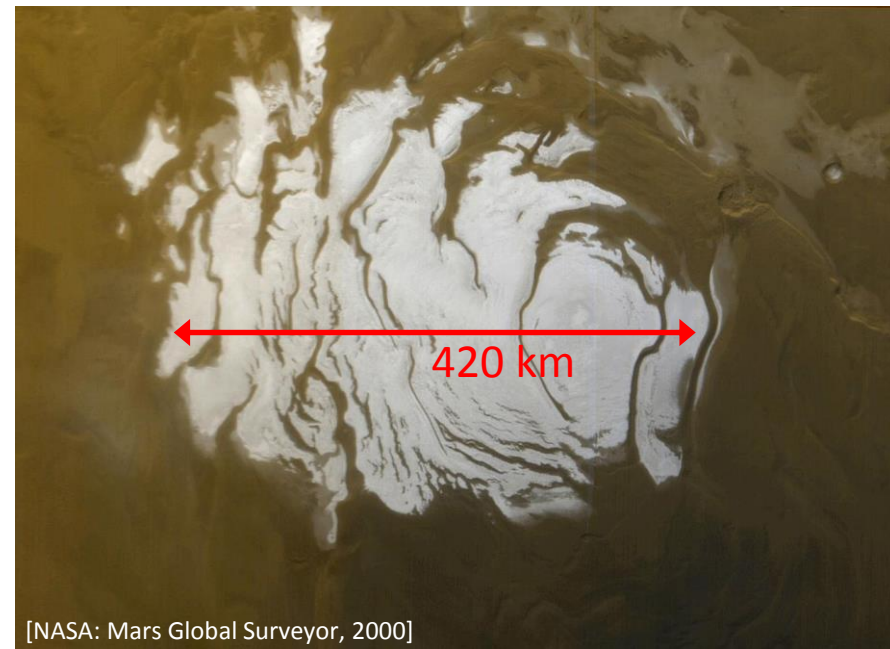
→ Water ice with some CO_2 ice.

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→ Water ice with some CO_2 ice.

Mars Reconnaissance Orbiter radar measures $820,000 \text{ km}^3$ of water ice ... other estimates put it at $1.6 \times 10^6 \text{ km}^3$.

Life on Mars ?

TBD: To Be Determined ...