Mars

CESAR Booklet

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Overview of Mars

The red planet Mars

Mars, also known as “the Red Planet” because of the appearance of its surface, is the fourth planet from the Sun and the second-smallest planet in the Solar System after Mercury. It is one of the planets of the Solar System that is visible to the naked eye, and has been known since the first humans started to watch the sky.

The first observations of Mars using a telescope were made by Galileo Galilei in 1610. Since the beginning of the space age, starting from the NASA’s Mariner missions in the 1960s, dozens of spacecraft from different space agencies have explored Mars.

It is now known that Mars is a rocky planet with a thin atmosphere with a variety of surface features, which can also be found on other Solar System bodies (e.g. craters, deserts, valleys, volcanoes). Mars has polar ice caps, similar to those on Earth, that vary seasonally. Studying Mars helps us to better understand rocky planets like the Earth and the process of planetary evolution.

Over the years, different space missions have tried to solve the mysteries of Mars, including questions like: Has there ever been life on Mars? Was Mars once partially covered by a sea that slowly disappeared with time?

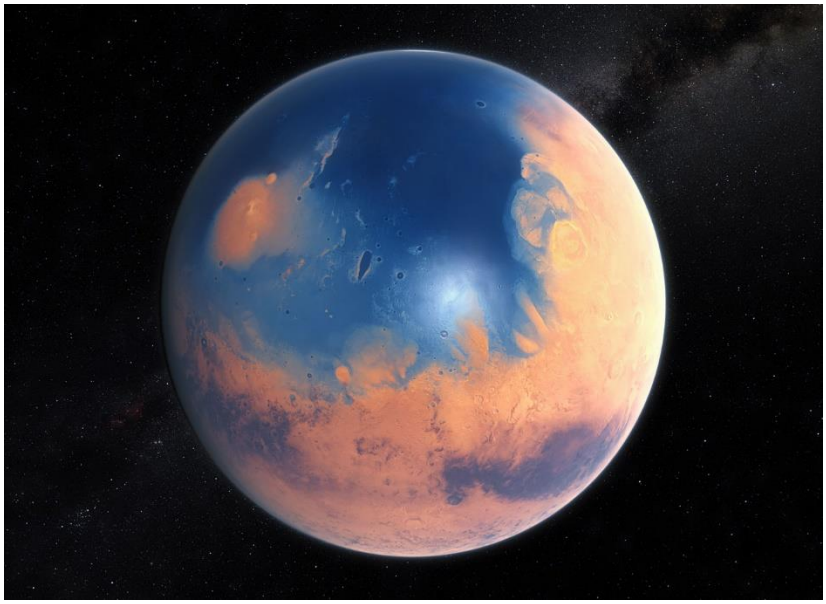


Figure 1: *Artist's impression of how Mars may have looked four billion years ago. Credit: ESO/M. Kornmesser/N. Risinger (skysurvey.org).*

Properties of Mars

Global properties of Mars compared to Earth:

- Mars is a rocky or ‘terrestrial’ planet, because it is mainly made of elements also found on Earth.
- Diameter ~0.5 of Earth diameter.
- Volume ~ 15% of Earth's volume (0.151 Earths).
- Mass ~ 11% of Earth's mass (0.107 Earths).
- Gravity ~ 38% of Earth's surface gravity, which corresponds to 3.72 m/s^2.
- Global density lower than the Earth (3.93 g/cm^3 compared to 5.51 g/cm^3 on Earth).
- The land mass on Mar is similar to that of the Earth (because Mars lacks oceans).
- Mars has a very thin atmosphere (~6 millibars compared to ~1000 millibars on Earth).
- Mars no longer has a magnetic field.

Differences between Mars and Earth:

- The orbit of Mars is more eccentric than Earth’s, therefore, it plays a more important role in the climate of Mars.
- Around 70% of the Earth is covered by water, but Mars is not. However, as channels, ravines, and valleys are found all over the surface of Mars it is thought **that liquid water flowed across the planet in the past.**
- At present, the atmospheric pressure of Mars is too low for liquid water to exist, with the exception of very low altitude areas such a Hellas Basin.
- There is a lot of dust on the Martian surface and dust storms and Mars frequently has regional and global scale dust storms, as well as local dust devils.
- Mars’s polar caps are made of a mixture of water ice and frozen carbon dioxide or “dry ice”, unlike Earth’s ice caps which consist only of water ice. On Mars, when the polar caps begin to shrink in Spring/Summer, they don't melt into an ocean but instead sublimate into the atmosphere. Carbon dioxide is the main gas in the Martian atmosphere, and Mars has carbon dioxide ice clouds.

- As there are no oceans on Mars and the atmosphere is thinner than the Earth's, this causes a faster response of the climate to solar insolation conditions (the amount of solar radiation hitting the surface). Note that on Earth the hottest month takes place two months after the summer solstice, whereas on Mars it takes place almost immediately.

Similarities of Earth and Mars:

- Both planets have a tilt in their rotational axis, which is the main cause of their seasons.
- Both planets have features and meteorological phenomena that are specific for each season and each region of the planet. For example, there is a hurricane season on Earth while on Mars there is a recurrent double vortex.
- Both planets have polar ice caps that change with the seasons.
- Both Mars and Earth have water in the form of clouds and ice.

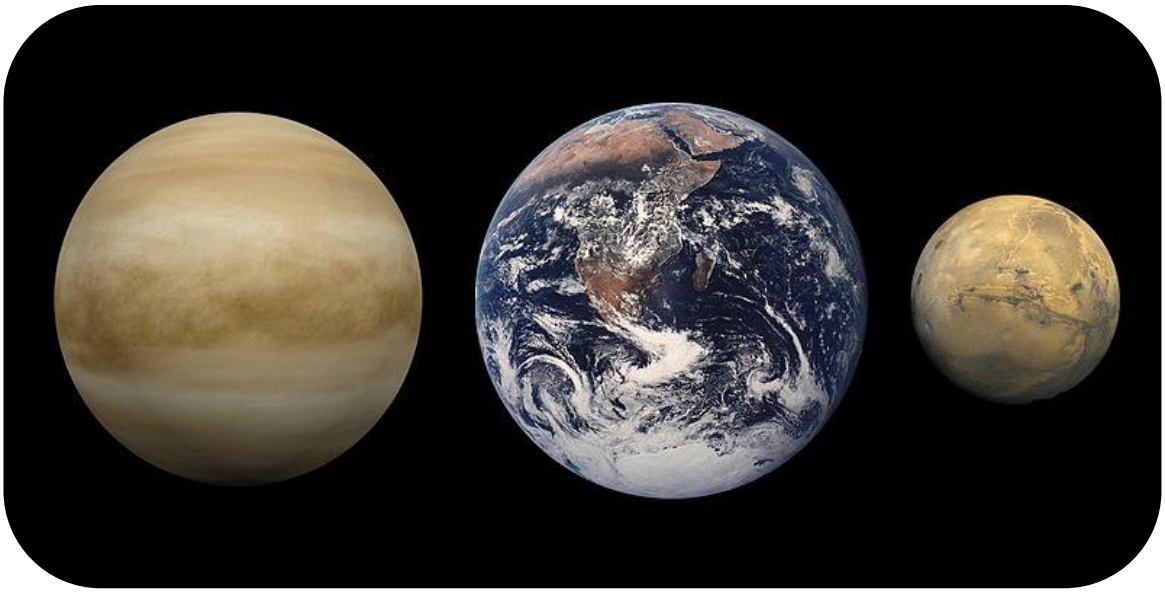


***Figure 2**: Mars compared with Venus and Earth. (Credit: NASA/ESA)*

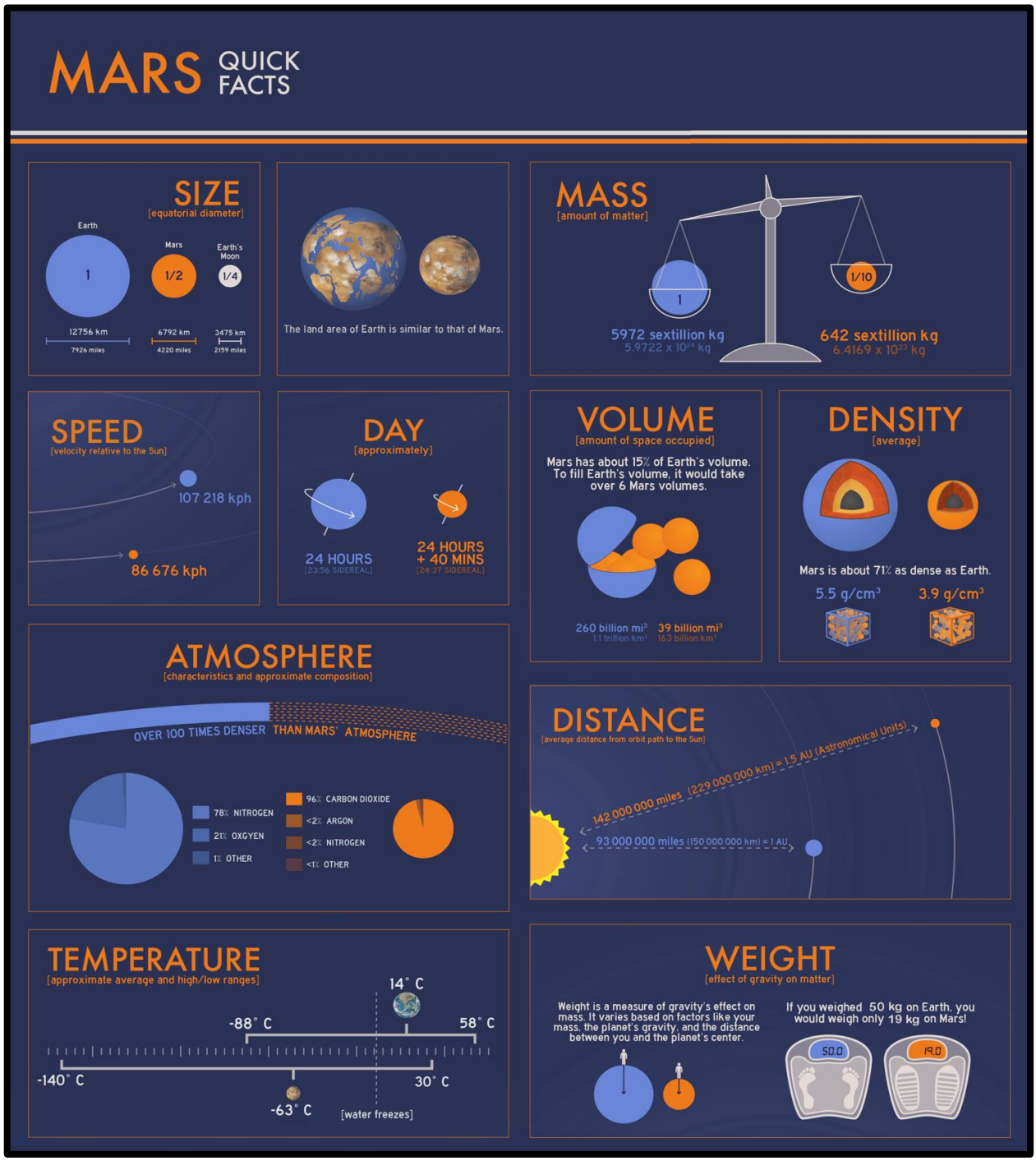
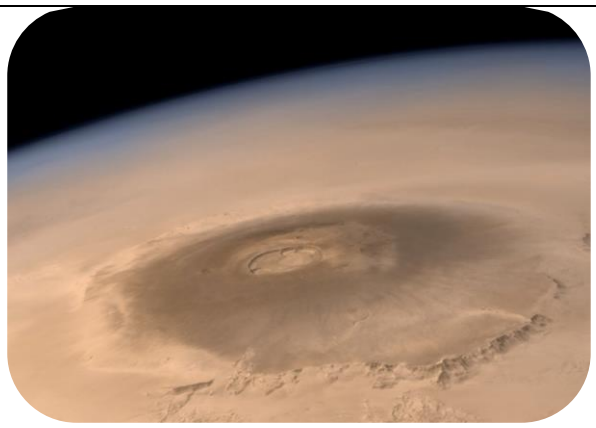
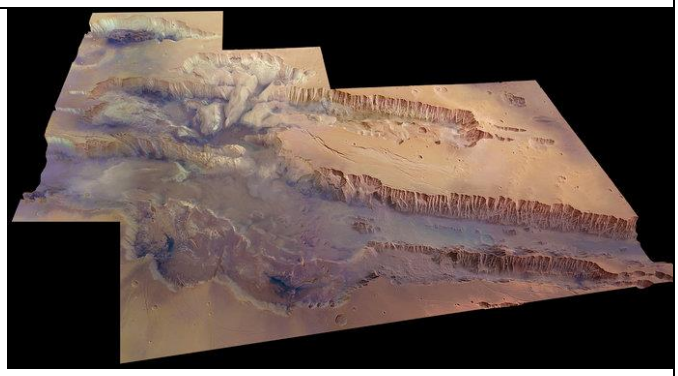
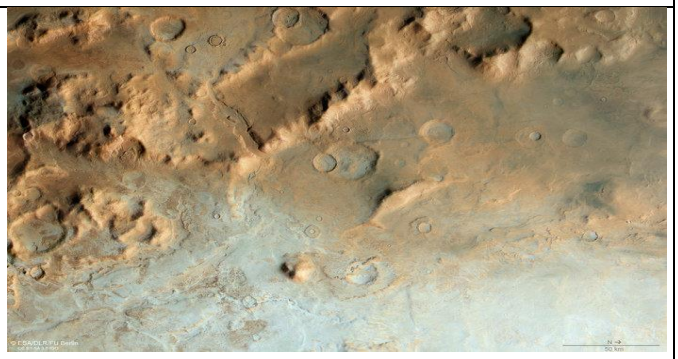


Figure 3: *Mars fast facts that are interesting for comparing Mars with Earth. Credit: ESA. (For full version of infographic visit: https://mars.nasa.gov/all-about-mars/facts/)*

Mars surface properties

Mars has a characteristic red-orange appearance mainly because of the iron oxide on its surface. Spacecraft exploring Mars have also shown other colours on its surface such as brown, tan, and greenish. The **main composition of Mars is silicon and oxygen, together with metals**.

The largest volcano in the Solar System, **Olympus Mons**, is located on Mars. At 27 km high it is also the second highest mountain in the Solar System (second only to Rheasilvia on Vesta). In addition, Mars has one of the largest canyons in the Solar System, **Valles Mariners**, that is 4000 km in length, 200 km wide, and up to 7 km deep.

Olympus Mons Credit: ESA/DLR/FU Berlin (Mars Express)	
Valles Marineris. Credit: ESA/DLR/FU Berlin (Mars Express mission)	
Hellas Basin Credit: ESA/DLR/FU Berlin (Mars Express)	

The smooth Borealis basin of the northern hemisphere covers 40% of the planet and may be a giant impact feature. Channels found in this regions can be 2000 km long and 100 km wide.

As channels, ravines, and valleys are found all over the planet it may be assumed **that liquid water once flowed across the surface of the planet in the past**.

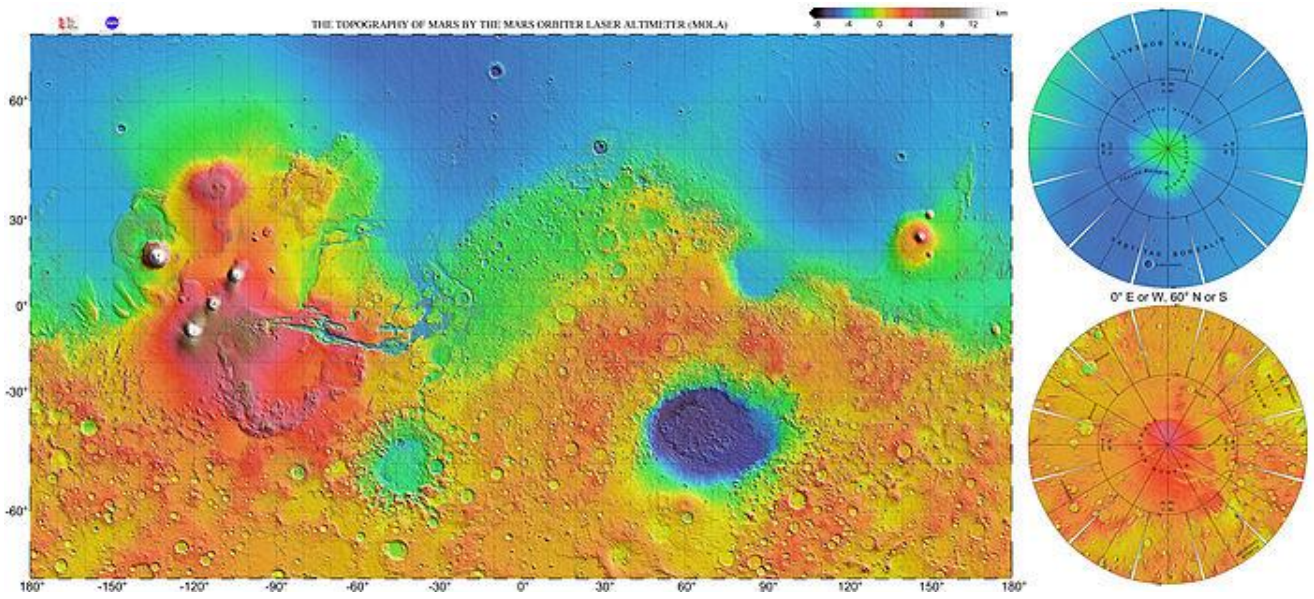


***Figure 7**: Radar image of the **smooth** Borealis basin. Credit: MOLA*

Mars is much colder than our planet, which is partly due to its further distance from the Sun but also due to its lack of atmosphere producing a warming greenhouse effect. The average temperature is around -60ºC, although this can change from as low as -125ºC near the poles (during the winter) up to 20ºC near the equator.

On Mars, just like Earth, the north and south poles do not receive any light during winter. In the cold of the winter, the carbon dioxide (CO_2) freezes and forms polar caps. When winter ends and the light of the Sun starts to heat the poles, the carbon dioxide from the caps changes from a solid to a gas state (a process known as sublimation). As time passes and temperatures increase, the polar caps melt and the carbon dioxide returns to the atmosphere, reducing the size of the polar caps, which are also made up of water ice.

Interior properties of Mars:

The interior of Mars, in some aspects, is similar to the interior of the Earth. It can be differentiated into a dense metallic core overlaid by less dense materials. The core (with a radius of about 1800 km), is mainly made of iron and nickel and is surrounded by a silicate

mantle that formed many of the tectonic and volcanic features on the planet. The thickness of the planet's crust is similar to Earth’s (approximately 50 km).

The Martian atmosphere

Originally Mars had a thicker atmosphere but it lost its magnetosphere about 4 billion years ago. Consequently, the solar wind interacts directly with the Martian ionosphere, lowering the atmospheric density by stripping away atoms from the outer layer. This erosion resulted in a mean surface pressure of only 0.6% of the Earth’s.

Mars has a thin and cold atmosphere, which means that liquid water cannot exist in most places on its surface. The composition of the Martian atmosphere consists of about 96% carbon dioxide, 1.93% argon and 1.89% nitrogen along with traces of oxygen and water. However, methane may also have been detected in the Martian atmosphere, though this remains a controversial topic of debate amongst the scientific community. Its presence tells us that an active source of this gas must be present on Mars. It could originate from volcanic activity, cometary impacts, and even the presence of methanogenic microbial life forms.

Figure 8: *Sunset on Mars. Credit: NASA*

Orbital properties

Mars's average distance from the Sun is approximately 230 million km, and it has an orbital period of 687 terrestrial days. A Martian year is equal to nearly 2 Earth years.

The duration of a "day" on Mars is really close to an Earth day, and is 24 hours and 40 minutes. Regarding the tilt of Mars, its rotational axis is tilted relative to its orbital plane at a value of 25.2 degrees, which is similar to the tilt of the Earth's rotational axis (23.5 degrees).

Seasons on Mars

Mars has seasons which are quite similar to the Earth's. The seasons are produced because of the inclination of the rotational axis of Mars. However, because Mars is at a greater distance from the Sun, the duration of the Martian seasons is about twice the length of those on Earth. Due to the higher eccentricity of the Martian orbit, summer temperatures in the southern hemisphere of Mars are higher than the summer temperatures in the northern hemisphere.

Mars has the largest dust storms in the Solar System. These storms occur on Mars regularly during the southern hemisphere summer season when the planet is closer to the Sun. A higher solar illumination causes stronger temperature contrasts, with the resulting air movements more readily lifting dust particles from the surface. The size of these storms can vary from a small area on the surface, to gigantic storms that cover the entire planet, reaching speeds of over 160 km/h.

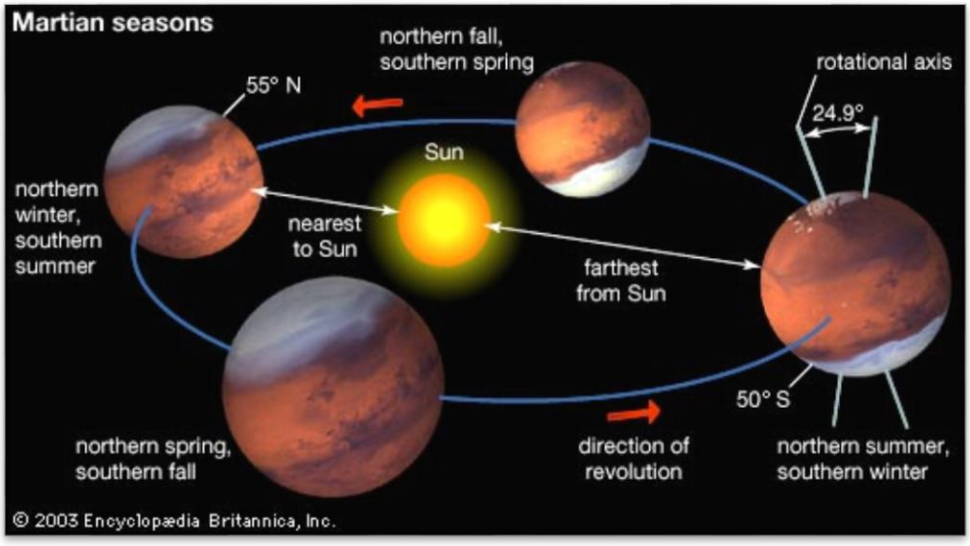


Figure 9: *Illustration of the Martian seasons. Credit: Encyclopaedia Britannica.*

Habitability

The orbital properties of Mars mean that it lies just within the boundary of the habitable zone for our Solar System, which is commonly defined as the region around a star in which a planet could maintain liquid water on its surface. The main problem for Mars is that its thin atmosphere and lack of magnetosphere prevents liquid water from existing on the surface for extended periods. This doesn't mean that Mars never had liquid on its surface. There is evidence that suggests the planet was once significantly more habitable than it is today, but whether living organisms such as microbes ever existed there remains uncertain.

What is true is that **many visible landforms on Mars suggest that liquid water was present on the Martian surface**. So far huge lakes and valleys, have been found, which appear similar to terrestrial features shaped by water or rain.