Enceladus, Europa, Mars, and what they have in common

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Abstract. Astrobiologists have always been preoccupied with the detection of extraterrestrial life. Two satellites - Enceladus, Europa – and one planet – Mars - seem to share the same precious compound: water. Knowledge based on the study of some extremophiles on Earth showed that the organisms have succeeded in conquering almost all biotopes in which water exists. Such organisms can provide us with important information about how life could work on other planets. Although water is not the only condition of the emergence of life, whether we consider abiogenesis, or we are supporters of panspermia, in both cases life should exist on some planets that have, or have ever had, abundant water on their surface. This paper explains the most important reason why Enceladus, Europa, and Mars are believed to hold significant chances to be life-bearing planets.
Key Words: water, extremophiles, abiogenesis, ocean, extraterrestrial life.

Introduction. Astronomers and astrobiologists have always been preoccupied with the detection of extraterrestrial life (Engel & Macko 1997; Petrescu-Mag et al 2011). Enceladus, Europa, and Mars seem to share the same precious compound: water (Tosca et al 2008; Waite et al 2009; Horne 2018; Smith 2018). Most scientists consider that water is at the origin of life formation on Earth and very likely on other planets the situation would be similar (Westall & Brack 2018). We will see in this paper why Enceladus, Europa, and Mars are believed to hold significant chances to be life-bearing planets.

Enceladus. Enceladus is the sixth largest satellite of Saturn (Lunine et al 2015). In fact, it is a small satellite, having 504 km in diameter. Although its surface is completely frozen, liquid water was observed at the surface of this planet. Recent knowledge about Enceladus comes from interplanetary spaceprobes Voyager 2 (received in 1982) and Cassini (received in 2004-2005). Cassini was launched in 1997 and needed 7 years of interplanetary space travel to reach Saturn.

The data sent by the spaceprobes revealed that giant geysers of water sprang out of Enceladus's surface. The ice particles are sputtered at heights of hundreds of kilometers. These geysers may come from huge underground seas or oceans (Wall 2015, Figure 1). The sea water enhancers also amplify the caloric effects exerted by the tides. Clouds have also been observed on this planet.

On Enceladus there are also relatively hot formations (temperature: 150 instead of 70 K) called "tiger stripes", which consist of very deep and very long trenches (up to 130 km), parallel, full of snow and water steam. These formations emit huge amounts of energy. The area where they are located is a round area around the southern pole, without craters. The causes of this unusual activity are not clear (Waite et al 2009).

Enceladus is one of three candidates for extraterrestrial life search. More specifically, the reason for this suspicion is the presence on Enceladus of all three factors necessary for living organisms: energy, molecules containing carbon (organic substances), water (Waite et al 2009).

In addition to water vapor, in March 2008 the Cassini probe also detected nitrogen, carbon dioxide, methane, acetylene and cyanogen in various proportions, as well as traces of ethane, propane, benzene, formaldehyde (NASA 2014; ESA 2014).

On April 3, 2014, NASA and ESA announced that Cassini's measurements indicate the presence of a vast ocean of liquid water under the surface of the satellite. According to the data, the ocean could have a depth of 10 km and would be under an ice crust of between 30 and 40 km. NASA believes that the presence of the ocean includes Enceladus among the most likely places in the Solar System where microbial life might exist (NASA 2014; ESA 2014).

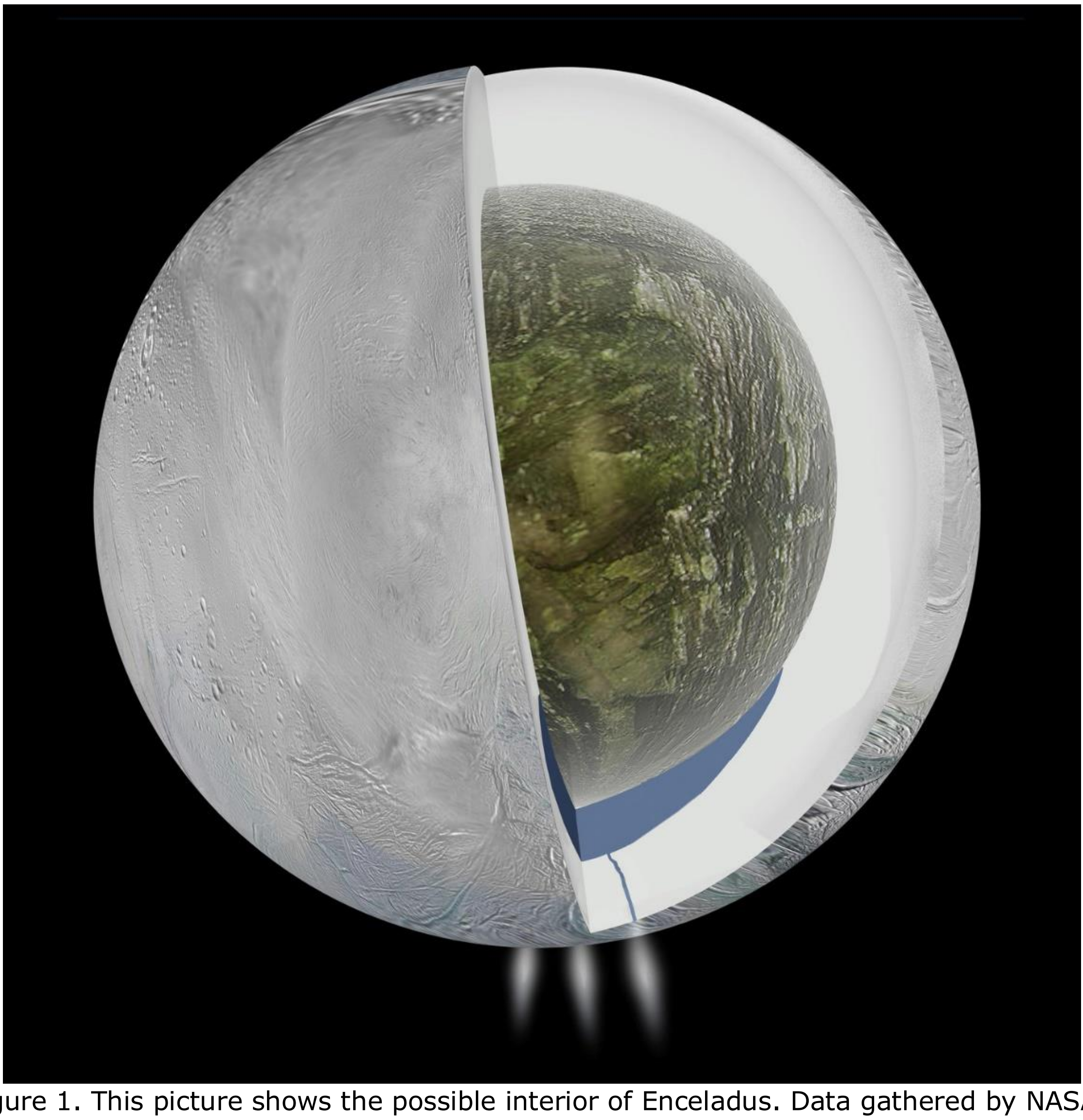

Figure 1. This picture shows the possible interior of Enceladus. Data gathered by NASA's Cassini probe suggests Enceladus has an ice outer shell and a rocky core with a regional water ocean sandwiched in between at high southern latitudes. Credit: NASA/JPL-Caltech/SSI/PSI.

The information gathered until now has awakened NASA's interest in designing Enceladus Life Finder (ELF) project. ELF is a proposed astrobiology mission concept for a NASA spacecraft intended to assess the habitability of the internal aquatic ocean of Enceladus, which is seemingly similar in chemical makeup to comets (Battersby 2008). The spaceprobe would orbit Saturn and fly through Enceladus's geyser-like plumes multiple times. It would be powered by energy supplied from solar panels on the spacecraft (Lunine et al 2015).

Europa. Europa is Jupiter's sixth satellite and fourth largest in size, being among the largest satellites in the solar system. Europa is a bit smaller than the Moon. Europa's observation has taken place over the centuries with telescopes on Earth and space probes that have been sent since the 1970s.

The surface of Europa is completely frozen (Figure 2) like that of Enceladus. Scientists believe under the frozen surface to find liquid water and perhaps even frozen prehistoric beings. In this sense, a space mission is being prepared to verify these assumptions.

Life may exist on Europa under ice, in the ocean of the satellite where there is probably a similar environment to deep oceans with hydrothermal springs on Earth or Vostok Antarctic Lake (Hoover et al 1999). Life in such an ocean could be similar to the microbial life of the Earth in the depths of the oceans.

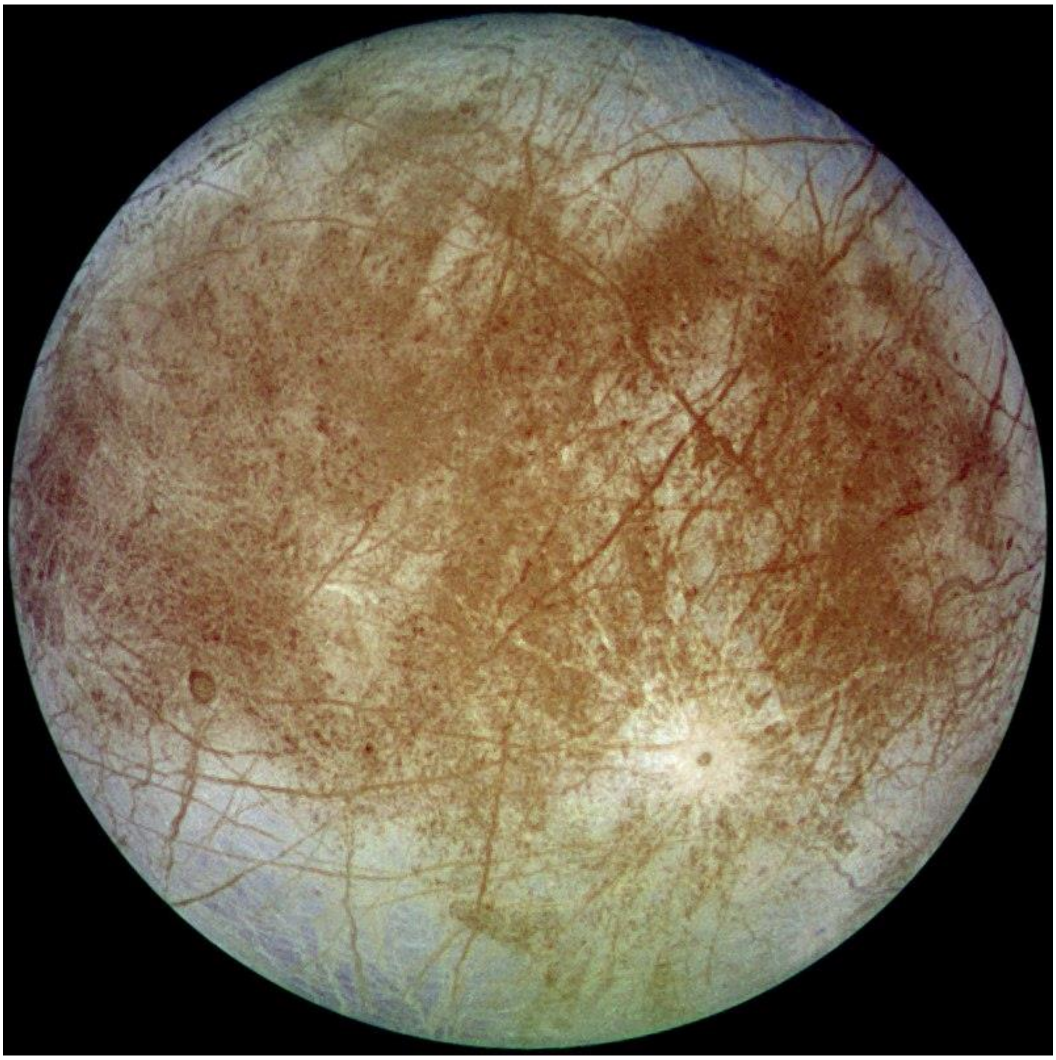

Figure 2. This image shows a view of the trailing hemisphere of Jupiter's ice-covered satellite, Europa, in approximate natural color. Long, dark lines are fractures in the crust, some of which are more than 3,000 kilometers (1,850 miles) long. The bright feature containing a central dark spot in the lower third of the image is a young impact crater some 50 kilometers (31 miles) in diameter. This crater has been provisionally named "Pwyll" for the Celtic god of the underworld. Europa is about 3,160 kilometers (1,950 miles) in diameter, or about the size of Earth's moon. This image was taken on September 7, 1996, at a range of 677,000 kilometers (417,900 miles) by the solid state imaging television camera onboard the Galileo spacecraft during its second orbit around Jupiter. The image was processed by Deutsche Forschungsanstalt fuer Luftund Raumfahrt e.V., Berlin, Germany.

Mars. Mars, the Red Planet (Figure 3), is the fourth planet of the solar system. The surface of Mars is not as rich in water or ice as the two planets previously discussed. The most common ice/snow encountered on Mars is carbon snow (solidified CO_2) (Manning et al 2019; Petrescu-Mag 2009). However, "water on Mars" is not an unusual topic among scientists (Michalski et al 2018; Citron et al 2018). Astronomers have found many evidences that the Red Planet was much wetter and warmer, with a dense atmosphere, billions of years ago (Ramirez & Craddock 2018).

Few traces of Earth's geologic record are conserved from the time of life's emergence, over 3,800 million years ago. For this reason, what little we understand about the origin of life on Terra is primarily due to laboratory experiments and theory. On one side, the best geological lens for understanding early Earth might actually come from Mars, a planet with a crust that's overall far more ancient than our own (Michalski et al 2018). On the other side, the abundant hydrothermal environments on Mars might provide more valuable insights into life's origins (Michalski et al 2018).

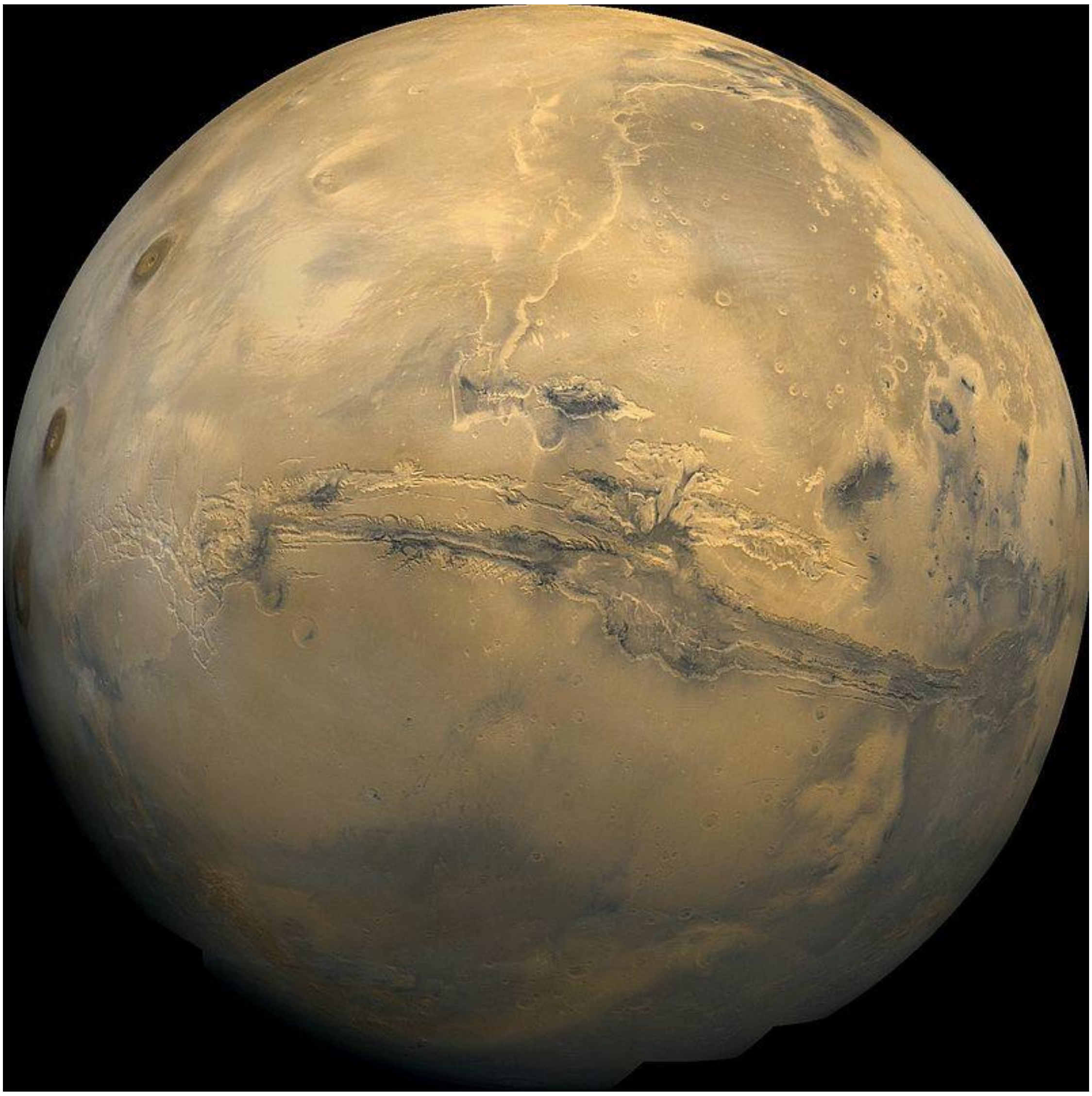

Figure 3. Global mosaic of 102 Viking 1 Orbiter images of Mars taken on orbit 1,334, 22 February 1980.

Discussion. Knowledge based on the study of some aquatic (Bharudin et al 2018; Villarreal et al 2018; Petrescu-Mag et al 2007ab, 2016; Petrescu-Mag & Rasiga 2009ab) or terrestrial extremophilic organisms (Pricop & Negrea 2009) on Earth shows that the organisms have succeeded in conquering almost all biotopes in which water exists

(Gagyi-Palffy & Stoian 2011). These extremophiles can provide us with important information about how life could work on other planets.

Although water is not the only condition of the emergence of life, whether we consider abiogenesis, or we are supporters of panspermia, in both cases life should exist on some planets that have, or have ever had, abundant water on their surface. One planet – Mars – and two natural satellites - Europa and Enceladus - are the most important candidates for life-bearing from this point of view.

However, while nature is a great architect, water should not be mandatory for the quality of life-bearing planet (see an opinion presented in Petrescu-Mag & Gavriloaie 2018).

Conclusions. Knowledge based on the study of some extremophilic organisms on Earth shows that the organisms have succeeded in conquering almost all biotopes in which water exists. Such organisms can provide us with important information about how life could work on other planets. Although water is not the only condition of the emergence of life, whether we consider abiogenesis, or we are supporters of panspermia, in both cases life should exist on some planets that have, or have ever had, abundant water on their surface. Mars, Europa and Enceladus are the most important candidates from this point of view.

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