The moons of the gaseous planets: habitable zones?

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Abstract

My work is a review of the moons of the gaseous planets, primarily focused on the icy moons (Encelado and Europe). I will expose the true potential that these satellites can offer as habitats beyond Earth and as future places for exploration on site. I will raise the pros and cons that, to send missions on them, could imply. I will mention about the importance of the interplanetary contamination. Finally, I will explain, under my point of view, what mission or project should be chosen as more interesting and why.

Introduction

My approach to this work and my motivation is because these moons are my favorite places in the solar system and finding life there could be among the most important discoveries possible. In these moons, we are talking about the life potential that lives there today (Europe, Encelado) and that are not contaminated. The access to the frozen surfaces of these satellites would offer a much more powerful analysis of some worlds and I consider this one of the most tempting perspectives to find extraterrestrial life

Extended Versions

In the Jupiter system more than 60 satellites have been discovered, highlighting the Galileans (Io, Europa, Ganimedes and Callisto) as the most interesting. Io is the most volcanic object of the whole Solar System. More than 300 active and inactive volcanoes have been identified. Europe has a rocky interior and a superficial layer of viscous ice or water. It also has a smooth surface of water ice crossed by fractures and only a few impact craters (Diam: 3130 km. Dens: 3g/cm³. Temp: -163ºC). Moreover, Europe has an underground Ocean, internal energy of tidal origin, underground volcanoes and maybe… aquatic life? Ganymede and Callisto could have a subsoil of liquid oceans but they are buried under, at least, 95 km of rock. Because that I think there would be less chances that life could be sustained there. In the Saturn system have been detected more than 60 satellites. The most interesting ones are Titan and Enceladus (diam: 505 km; dens:1,12 g/cm³; Temp :-200ºC) that has the Northern Hemisphere with an old and cratered surface. The Southern Hemisphere has a younger surface with little craters and with "Tiger Stripes" (active faults). Maybe aquatic life? Titan (Diam: 5120km; Dens: 1,88 g/cm³; Temp: -180ºC Atm. pressure: 1,7at). It is composed 50% of rock and 50% of ice and its atmosphere has 95% Nitrogen, 6% of acetylene, methane and ethane. There are rivers, oceans and liquid lakes with more than 100 meters deep, located at the top of the hills and in underground caves filled with liquid methane that evaporates and rains on the surface. Some lakes appear and disappear. Titan is the only body in the solar system that we know has liquid on the surface, with an hydrological cycle very similar to the Earth. I think that, in this active chemistry, some kind of life based on methane could progress, but we still do not know where it comes from. Maybe from an warmer underground ocean?.

Europe and Enceladus would be my candidates with potential for a possible life beyond the Earth and as future places of exploration. Each of the icy moons is sprinkled with an orange-rose substance. Its composition is not clear yet. These worlds with ice water and with subsurface oceans could be compared to what happens Under the ice of Antarctica where microbial ecosystems have been found. This would open the possibility to survive in the extreme environments of other uncontaminated worlds where material has not been transferred between them and the Earth as it could have happened with Mars that is close enough to be potentially contaminated by the Earth. The life that could be found there would be ancient, dead and fossilized. It Could survive millions of years ago when it was warmer and more humid but would not tell us much about how our life began. On these icy moons we are thinking about the life potential that is there today, surviving and thriving.

In Europe the presence of water was discovered by the Galileo spacecraft plus images of the Hubble telescope. It was confirmed through the magnetometer and applying the magnetic induction system, indicating that it is a cryogeological world that has ice of water on the surface instead of rock. It has a weak magnetic field driven by Jupiter which is its driving force. The conductor of electricity to the magnetic field is the liquid water that would be below the surface. The presence of an ocean that could be 50 to 100 km deep (probably with a certain degree of salinity to form the magnetic field since pure water is a bad conductor of electricity). So, why does it offer true potential as a habitat for life beyond the Earth?. It has liquid water in contact with the rock, it is fed by tidal forces, there is chemical energy and the essential organic compounds are given for life as we know it. But there are also obstacles: we do not know the thickness of the ice that could reach 30 or 40 km; nor if it is regenerated by the cryogenesis of plate tectonics, if the cracks observed in the ice are faults where the water passes to the surface or if there are

isolated water deposits inside the ice sheet. Moreover, the radiation in Europe is extremely high because it orbits very close to Jupiter and captures many charged particles in its magnetic field. Funding to send missions is being reduced by prioritizing other projects (sending Rovers to Mars) to look for signs of water or remnants of past life while here we have a huge ocean that would be much more interesting to explore and would not be contaminated. Soon two missions will be sent: 1) JUICE (financed by the ESA) although its target will be Ganimides and not Europe that will only have overflights in approach (since it would need more propellant to enter its orbit and be more expensive). 2) The second mission is the NASA´S EUROPEAN CLIPPER for 2023 and does aim to map the subsoil to find signs of life. It will make around 40 low overflights on the surface and will be equipped with 9 instruments that (will measure the magnetic field, the temperature of the surface, a drilling radar that will analyze what minerals the surface ice contains, etc). The bad news is that ICEMAG, one of the most important instruments to drill ice, has been removed and although it is still possible that it can measure Ocean depth and salinity, it will be much more difficult whithout it. It will depend on how Europe really is once there. What would be the possible trajectories of a mission of these characteristics? Trajectory 1: Launch vehicle (Atlas V 551 or Delta IV Heavy) Transfer EVEEGA (Earth, Venus, Earth, Earth Gravity Assist) Pro´s: Low energy trajectory that acquires energy for Jupiter. Con`s: Long trip (7.5 years for a launch in 2023).
Trajectory 2: Launch Vehicle: SLS Transfer: (Earth-Jupiter Direct). Pro`s: Direct launch to Jupiter and only 2.5 years trip. Con´s: Need very large rocket! SLS is the only vehicle capable of this transit.

Enceladus is a small moon with one sixth the size of Europe and a very cold and bright surface. The Cassini space probe observed geysers or columns of dust in a bounded region of the southern area and flew over them analyzing the ejected material with its mass spectrometer (that simply collects the stuff as that it goes through, and it actually collected material from these plumes) The surprise was that there was water because since there is no continuous heat source, there was no reason to think that the ice wasn´t frozen. An abundance of Ammonia was also detected, which when mixed with water acts as an effective antifreeze. When the temperatures in the vents were measured, liquid water was detected. In addition methane, complex organic products, amino acids and a soup of organic matter were identified too. There are data of gravitational attraction confirming that between the ice layer and the rock core a pocket of water is formed that would make them come in contact forming cracks in the surface and appearing plumes of dust. With all these factors we would have a very interesting chemistry and my opinion is that it fits all the criteria we know about habitability: it has chemical energy sources and carbon to build complex molecules. But there are objections: there is no continuous source of heat. It was thought that the ocean should be frozen but the surprise was that NO. However there are doubts and theories about this point. My opinion is that Encelado was found millions of years ago in a phase of eccentricity much larger than his orbit and pumping heat into the interior. Now there would be the remains of that ocean that will freeze one day. And as a consequence, it could not have existed for a sufficient period of time to give the conditions of life.

what mission or project would be chosen as more interesting and why?

It could be Europe that has had liquid water in contact with rock and a source of abundant heat for a long period of time (so that life could be created). However, being under the ice and not being able to penetrate it would make the mission very complicated. I would choose Enceladus because is reachable; the water is constantly expelled into space and we have the necessary technology to take samples and return them to the Earth. The mission would follow the trajectory EVEEGA (Earth, Venus, Earth, Earth Gravity Assist) taking advantage of the gravitational help of several planets of the interior Solar System consuming little energy and multiplying the cruising speed to reduce arrival times. It would take 7-8 years to reach Saturn plus 2 years orbiting and making descents through the geysers and another 4 to return towards the gravity of the sun before bringing the samples to earth. It would need a source of energy that would keep working in deep space for around 16 years and a space shuttle. The budget of this mission would be about 2 billion dollars. In addition, if this or another return mission would one day bring potentially biological samples from another world of the Solar System, these would have to be managed in a secure plant designed specifically for its treatment and to avoid contamination. This type of "restricted" mission that would bring samples with the potential to harbor life, requires during the entire return phase (since they entered low Earth orbit reentry, controlled landing and reception), of a containment device for non-sterilized samples and , after the mission, a strict containment of the samples and their immediate study, using the safest techniques available in the laboratories. I think that International Space Agencies should contribute to the construction of a plant for the treatment of these samples.