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The possibility of life proliferation from Enceladus

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Introduction: Enceladus is a medium-sized icy satellite (MIS) of Saturn. MIS are built of mixtures of rocks and ices. Enceladus with its radius of 250 km is one of the smallest of MIS, however, it is geologically active.

According to [1]: "For life to have emerged [. . .] on the early Earth, a sustained source of chemically transducible energy was essential. The serpentinization process is emerging as an increasingly likely source of that energy. Serpentinization of ultramafic crust would have continuously supplied hydrogen, methane, [. . .] to off-ridge alkaline hydrothermal springs that interfaced with the metal-rich carbonic Hadean Ocean" (see also [2]).

We consider here conditions for origin of life in early Enceladus and possible proliferation of the life from this satellite to the rest of Solar System.

Mass of serpentinite: The serpentinization on the Earth is found in neovolcanic zones along mid-oceanic spreading centers. However, only in small part of them the hydrothermal activity really occurs.

After [3] we consider the following reaction:

$Mg_2SiO_4 + MgSiO_3 + 2H_2O \rightarrow Mg_3Si_2O_5(OH)_4$.

This reaction releases 241 000 J per kg of serpentine produced. Simple calculations (e.g. [4]) indicate that mass fraction of silicates f_{mas} in Enceladus is ∼0.646, hence the total mass of its silicate is ∼6.97 10^{19} kg.

[4] found that the early core in Enceladus was a relatively cold structure built from loosely packed grains with water between them. At that time, there was not mechanism of removing the water.

Since rocks are permeable up to the pressure of ∼300 MPa then the entire core of Enceladus was probably permeable for liquids. This could lead to formation of extensive hydrothermal convective systems.

T-p conditions in Enceladus: The pressure in the center of Enceladus is ∼2.3 10^7 Pa that corresponds to pressure on the depth 2300 m in a terrestrial ocean.

The evolution of temperature in the Enceladus interior for the first a few hundreds Myr is considered by [4]. If Enceladus accreted later than 2.4 Myr after formation of CAI then the temperature allows for existing the life even in the center of the satellite. For hundreds of Myr the conditions in the interior of Enceladus were more favorable for origin of life than on the Earth [5, 6].

Proliferation of life: We do not know the probability of life origin. The life could be a common phenomenon originating in relatively short time if conditions are favorable. However, it is possible also that the life had originated only one time in the Universe. If this option is true then the transport of primitive organism is critical.

From the core to the surface. The volcanic activity offers occasion to transport organisms from the core to the surface of early Enceladus. The form of the activity could be essentially the same as present in the South Polar Terrain (SPT).

From the surface to E-ring. The existence of E-ring is the evidence that cryo-volcanic jets could eject gas and solid particles (possibly with primitive organism) into orbit around Saturn.

From E-ring to an orbit around Sun. The mechanism of gravity assist could be responsible for acceleration of some particles from the orbit around the Saturn into orbit around the Sun. The existence of several satellites of Saturn increases the probability of this mechanism. The sequence of close encounters with these satellites could eventually transfer enough energy to the grains to leave the orbit around Saturn.

From orbit of Saturn to terrestrial planets. To reach the terrestrial planets the grain must be substantially decelerated. There are a few possible mechanisms of loosing energy: Poynting-Robertson mechanism (for grains larger than a few μm), Yarkovsky diurnal effect (if the grain is a retrograde rotator) and Yarkovsky seasonal effect (for grains of diameter of a few meters); e.g. [7].

After [6] we consider here the Poynting-Robertson effect which is effective for the grains size of E-ring particles. The time of falling from the orbit with the radius 9.5 AU to an orbit with the radius 1 AU for the grains of density 1000 kg m^{-3} and radius of 10 μm is $\sim$650 000 yr. For large grains (e.g. $\sim$1 m) other processes, like Yarkovsky effect, could be more effective than the Poynting-Robertson effect. The larger grains give better protection against the radiation.

Decelaration in the upper atmosphere. Small ratio of mass of the considered particles to their cross section makes possible to decelerate them in upper atmospheres of terrestrial planets without substantial increase of temperature – e.g. [7]. During deceleration of larger bodies the dissipation of heat could be high, but cooling effect of ablation would reduce the temperature.

The proposed mission to Enceladus (Enceladus Life Finder [8]) could solve the considered here problem. Note, that if the life in the Solar System has the common origin then Enceladus is "a better cradle" than the Earth, because high gravity and dense atmosphere makes the proliferation of terrestrial life rather difficult.

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