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Enceladus as a place of origin of the life in Solar System

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Abstract

We consider the core of early Enceladus as a cradle of the life. The model of core origin indicates that for dozens of Myr there were conditions preferable for the origin of life. The simple organisms could be ejected in icy grains into space by the volcanic jets. A few mechanisms could be responsible for transport the grains to the early Earth.

1. 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, contrary to the rest of them, it is geologically active. [2] considered the process of differentiation and core forming in Enceladus. He found that the result of differentiation is a relatively cold core of loosely packed grains with water between them. At that time, there was not mechanism of removing the water. The water and silicates make the process of serpentinization possible. After [4] the reaction of serpentinization could be:

Mg_2SiO_4 (forsterite) + $MgSiO_3$ (enstatite) + $2H_2O$ --> $Mg_3Si_2O_5(OH)_4$ (antigorite).

This reaction releases 241 000 J per kg of serpentine produced. A simple calculations (e.g. [2]) indicate that mass fraction of silicates f_{mas} in Enceladus is ~0.646, hence the total mass of its silicate is ~6.97 $\times 10^{19}$ kg. The serpentinization is believed to be a possible source of energy for primitive life. According to [1]: "For life to have emerged […], 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 [3]).

2. Conditions in the early core

The pressure in the center of Enceladus is ~2.3 10^7 Pa that correspond to pressure on the depth 2300 m in the terrestrial ocean.

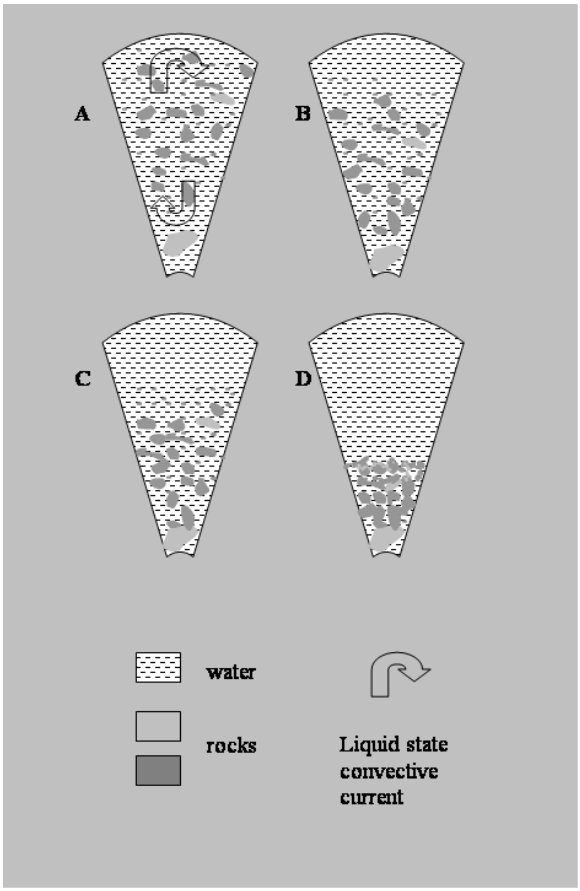

Fig. 1 A scheme of differentiation and formation of the core in Enceladus: A – silicate grains (typical size 0.1-1 mm) are suspended in liquid water. LSC mixing does not allow for setting the grains with exception of the largest ones (e.g. over 10 cm). B. LSC stops. The grains are setting. C – grains in hydrodynamic contact. D – grains in the physical contact. Further compaction requires significant pressure gradient. The core is permeable, so

hydrothermal convection could operate. The sizes of the grains are highly exaggerated.

The model of evolution of temperature in the Enceladus interior for the first a few hundreds Myr is calculated by [2]. It is found that for hundreds of Myr the conditions in the interior of Enceladus were favorable for origin of life. Presently, the life could exist in the underground sea just above the core

Since terrestrial rocks are permeable up to the pressure of ~300 MPa then the entire core of Enceladus was probably permeable for liquids and gases. This could lead to formation of extensive hydrothermal convective systems. Note that in Enceladus most of silicate could be serpentenized (contrary to the Earth). It suggests that total mass of serpentenized silicate in Enceladus could be even larger than on the Earth.

3. Proliferation of the life

3.1 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 this activity could be essentially the same as present.

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

3.3 From E-ring to 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.

3.4 Deceleration of particle: On the orbit around the Sun the small grains could decelerate as a result of Poynting-Robertson mechanism. Deceleration leads the particle to move closer to the Earth and other terrestrial planets.

3.5. Deceleration in the upper atmosphere: Small ratio of considered particles mass to their cross section makes possible to decelerate in upper atmospheres of terrestrial planets without substantial increase of temperature

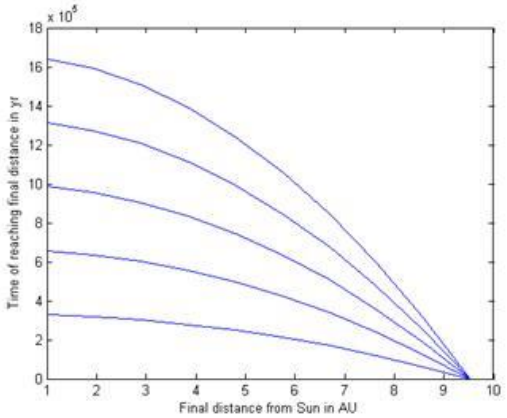

Fig. 1 Time of reaching a given orbit from the orbit at 9.5 AU from the Sun as a result of Poynting-Roberstson effect. The grains' radius: 5μm (the lowest line), 10 μm, 15μm, 20 μm, 25 μm (the uppermost line).

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3.6. Evolution in terrestrial condition: The primitive organism could evolve into present forms of life.

4. Summary and Conclusions

We indicate that the proliferation of life from Enceladus is possible [5]. Note that similar proliferation from the Earth is less probably because of high escape velocity from the Earth.

Acknowledgements

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References

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