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Microbial component detection in Enceladus

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Introduction

Enceladus is particularly attractive place in the outer Solar System where life can thrive It's very spectacular that such a small astronomical object with a diameter of less than 500 km is thermally active. The origin of this activity is still unknown. Tidal heating from Saturn is being considered and resulting from the existence of the orbital resonance of Enceladus with another moon of Saturn, Dione. As a result of these interactions, the ice-cold surface of Enceladus bursts and forms gaps in it that, as in the case of gaps called „Tiger Stripes", begin to exhibit activity in contact with the vacuum. The warm interior of Enceladus due to the tidal processes and radioactive decay heats the outer ice layer, releasing from the "Tiger Stripes", also water vapor with ice crystals. For the moment, Enceladus activity and the reason why cryo-volcanism occurs only on the south pole of the moon remain unexplained. Under the surface of the ice crust there is 10-50 km deep ocean which is the source of the material escaping to the space through "Tiger Stripes".

We applied kinetic particle-in-cell (Fig.1) simulation to estimate cell concentration and parameters on the ocean surface, than we used kinetic particle-in-cell simulation to plume shape and density modelling and finally cells density distribution in plume and during snowing process were calculated. We applied spectral data of the four types of microbial strains to estimate possible reflectance difference between plumes with and without microbial component.

Methods

Tiger stripes consist of 5 gaps spaced about 35 km apart, and the ice crust under them is only 5 km [1] Scientists suggests that the brackish ocean of Enceladus (-Na, -Cl, -CO_3) has alkaline pH from 11 to 12 [2]. This allow us to make important conclusions about geochemical processes inside Enceladus. Such a high pH may be a consequence of the serpentinization of olivine. As a result of serpentinization, such products are created, among others as H_2 and CH_4 [3], which are considered as potential places where life could thrive.

Temporal variations in the plume's gas content and matter fluxes from individual sources were observed [4]. Plume's main component is water in two states: solid and vapor also, the other organic and biologically significant compounds were detected during previous missions. Cassini during its closest approach to Enceladus' surface in July 2005 collected data using the Ion and Neutral Mass Spectrometer. The best estimation of the composition gives us: 91 (±3)% H_2O, 3.2 (±0.6)% CO_2, 4.0 (±1.0)% N_2/CO and 1.6 (±0.4)% CH_4. H_2 was also discovered in the plume's vapor [5]. Multiple stellar and solar measurements of the vapor column density done by ultraviolet and mass spectrometer data suggests multiple gas jets of different gas emissions: 1) high-speed gas (i.e. thermal expansion of gas through narrow channels, pressure driven acceleration) and 2) low-speed thermal (like solid or liquid near surface sublimation) [6]. The data suggests quite total plume H_2O output between 180 kg/s and 250 kg/s. INMS data in the contrast suggests spatially more varied H_2O stream ranging from 200 kg/s to 1000 kg/s [7]. All these data show that the structure of the plume itself and the structure of geological formation from which it originates may be varied.

In recent years, many researchers have been interested in the possibility of the existence of habitable for microorganisms places in those diverse forms [8] [9] [10]. We may distinguish four main types of theoretically habitable areas near Enceladus' south pole:

1- the ocean in the area of volcanic activity and around it,

2- surface of the ocean inside rift-like forms, 3- ice surface around plumes sources where the heavier particles fall from the interior of the subsurface ocean and finally

4- geysers themselves.

According to [10] we assumed the presence microbial ecosystem at the ultramafic, alkaline, hydrothermal vents on the ocean bottom with cell concentrations analogous to the Lost City Hydrothermal Field ~ 105/mL [11].

Results

This result showed that proposed for Enceladus Orbiter biological activity technique – mass spectrometer and orbiter altitude ~ 50 km – may be not appropriate in this case. Also potential usage of multispectral camera for this purpose should be focused on the area near plume source where higher concentration of the 2 um wide and 6.6 pg mass Methanosarcinales particles should be found with higher concentration.

Spectral measurements of the four example microbial strains showed the difference between cells reflectance between visible light and near infrared. However, this difference is too small (~0.05 for concentration ~ 107 cells/mL) for standard microbial remote sensing detection techniques. Our estimates are only a few photons of reflected light per every 400 square meters for 80 km altitude and a few thousands for 5 km altitude (~10-7 – 10-8 reflectance difference according to Cassini medium angle camera acquisition parameters). This value would be a big challenge for multispectral image analysis and an average distance of the falling microbes < 1km from the plume source compared to the range from 6 to 7 km of falling ice and water 1um particles may be good reason to focus on this particular area in future remote sensing investigations.

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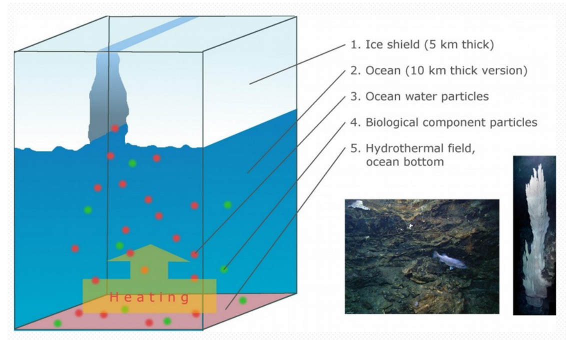

Figure 1. Particle-In-Cell kinetic model.

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