EPSC Abstracts
Vol. 12, EPSC2018-1252-2, 2018
European Planetary Science Congress 2018

Macromolecular organic compounds emerging from the Enceladus ocean

Frank Postberg[1,6], Nozair Khawaja[1], Christopher R. Glein[2], Hsiang-Wen Hsu[3], Sascha Kempf[3], Fabian Klenner[1], Lenz Nölle[1], Juergen Schmidt[4], Gabriel Tobie[5], J. Hunter Waite[2]

[1] University of Heidelberg, Heidelberg, Germany, [2] Southwest Research Institute, San Antonio, Texas, United States, [3] University of Colorado at Boulder, Boulder, Colorado, United States, [4] University of Oulu, Oulu, Finland, [5] University of Nantes, Nantes, France, [6] Freie Universität, Berlin, Germany

Abstract

We present the detection of macromolecular organic compounds in ice grains ejected by Enceladus plume into Saturn's E ring. The evaluation is based on data obtained by Cassini's Cosmic Dust Analyser (CDA) and the Ion and Neutral mass spectrometer (INMS). We infer key properties of the macromolecules and link these to possible subsurface processes in the ocean of Enceladus and its hydrothermally active rock core.

1. Introduction

Saturn's icy moon Enceladus harbors a global subsurface ocean, which is thickest (50 km) below the south polar region. There, through warm fractures in the less than 5 km thick ice crust [1,2], jets of vapor and nanometer to micrometer-sized ice grains emerge from the ocean into space. Two mass spectrometers aboard the Cassini spacecraft frequently carried out compositional in situ measurements of material emerging from the subsurface of Enceladus. These measurements were made inside both the plume and the E ring. The Cosmic Dust Analyser (CDA) showed that a large fraction of the ice grains are direct samples of subsurface alkaline ocean water with mild salinity [3,4].

The CDA also uncovered the first evidence of hydrothermal activity taking place at the interface of the moon's rocky core and its ocean [5]. The detection of molecular hydrogen in the plume by the Ion and Neutral Mass Spectrometer (INMS) provided further support for fluid-rock interactions, most consistent with exothermic serpentinization reactions [6], similar to certain alkaline hydrothermal systems of Earth's oceans, such as Lost City in the Atlantic Ocean. Because of the relatively low density (2500 kg/m3) of the moon's core it is likely porous and percolated by ocean water [7]. Hydrothermal reactions thus probably take place deep inside the core and are likely powered by tidal dissipation [8].

2. Results

Previous CDA and INMS measurements showed that the plume emits organic material of low molecular weight both, in the gas phase and in about 25% of the ice grains, so-called Type 2 grains [3,9] but complex organics emerging from Enceladus oceans have not been reported before. Here we will present spectra of emitted ice grains containing concentrated, macromolecular organic material with molecular masses clearly above 200u. The data provides key constraints on the macromolecular structure and is suggestive of thin a organic-rich film on top of the oceanic water table [10]. We suggest that it originates from Enceladus' rocky core and might be a product of hydrothermal roch/water interaction.

Furthermore, we suggest a large-scale ocean convection mechanism that, together with bubbles of volatile gases, transports these and other materials from the moon's core up to the ocean surface. There, organic nucleation cores - generated by bubble bursting and subsequently coated with ice from vapour freezing - are ejected into space [10]. This mechanism shows similarities to the formation of ice clouds from sea spray on Earth [11] and allows probing of Enceladus' organic inventory in drastically enhanced concentrations.

References

[1] Čadek, O. et al. Enceladus's internal ocean and ice shell constrained from Cassini gravity, shape, and libration data. Geophysical Research Lett. 43, Issue 11, 5653-5660 (2016)

[2] Le Gall, A. et al. Thermally anomalous features in the subsurface of Enceladus's south polar terrain. Nat. Astron. 1, 0063 (2017).

[3] Postberg, F. et al. Sodium salts in E-ring ice grains from an ocean below the surface of Enceladus. Nature 459, 1098–1101 (2009)

[4] Postberg, F., Schmidt, J., Hillier, J., Kempf, S. & Srama, R. A salt-water reservoir as the source of a compositionally stratified plume on Enceladus. Nature 474, 620–622 (2011)

[5] Hsu, S. et al. Ongoing hydrothermal activities within Enceladus. Nature 519, 207-210 (2015)

[6] Waite, Jr J. H. et al. Cassini finds molecular hydrogen in the Enceladus plume: Evidence for hydrothermal processes. Science 356, 155-159 (2017)

[7] Iess, L. et al. The Gravity Field and Interior Structure of Enceladus. Science 344, 78-80 (2014)

[8] Choblet, G. et al. Powering prolonged hydrothermal activity inside Enceladus. Nature Astronomy 1, 841 - 847 (2017).

[9] Postberg, F. et al. The E ring in the vicinity of Enceladus. II. Probing the moon's interior—the composition of E-ring particles. Icarus 193, 438–454 (2008)

[10] Postberg, F. *et al.* Macromolecular organic compounds from the depths of Enceladus. *Nature*, in press (2018)

[11] Wilson, T. W. et al. A marine biogenic source of atmospheric ice-nucleation particles. Nature 525, 234-238 (2015)