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# The long Journey of Organic Material from Enceladus Hydrothermal Core into the Plume

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## Introduction

Enceladus emits subsurface ocean material from its south polar crustal cracks in the form of a plume of gas and ice grains. Two mass spectrometers on the Cassini spacecraft — the Cosmic Dust Analyzer (CDA) and the Ion and Neutral Mass Spectrometer (INMS) sampled this material. The INMS measured the composition of the gas/plasma component of the plume whereas the CDA measured that of ice grains in both the E ring and the plume. Both instruments detected a variety of organic compounds in substantial concentrations (Postberg et al. 2008, 2018; Waite et al. 2006, Magee & Waite 2017). Here we review the different detected organic compounds and investigate how they find their way from Enceladus' deep interior into the plume.

## Results and Discussion

The most volatile organic molecules are detected in the gas phase, mostly containing one or two carbon atoms. By contrast, a few percent of the ice grains emitted by Enceladus bear refractory organics made of large organic molecules that could be polymers with molecular weights often above 200u that must have been in the solid state when they where still part of the moon's subsurface ocean. However, a much larger fraction of the emitted ice grains contain organic materials of molecular weight below 100u. Volatile and refractory organic material, exhibits both aromatic and aliphatic constituents as well as oxygen-bearing and nitrogen-bearing functional groups (e.g. carbonyl & amine) (Postberg et al. 2018, Khawaja et al. 2019). Many of the observed organic compounds might originate from synthesis (Postberg et al. 2018a, Khawaja et al. 2019) in Enceladus' potentially hydrothermally active rocky core (Choblet et al., 2017). Thermal ocean convection together with bubbles of volatile gases like $H_2$ can transport these and other materials from the moon's core up to the oceanic surface lying more than 50 km above the hydrothermal vents.

The transport process through the ocean is relatively straightforward for the most volatile organic species. If present in sufficient concentration, they exsolve from the ocean with decreasing pressure and will further rise in the form of bubbles. When reaching the water surface situated inside Enceladus' south polar cracks, the bubbles would burst and the organic gases are entrained in the flow of water vapor to continue their journey through the icy cracks towards the outlets on the moon's surface. They cool during that ascent and depending on condensation temperature and binding energies to water ice, some of the initially volatile organics are adsorbed and freeze onto ice walls or icy grains which are likewise entrained in the upward vapor flow (Bouquet et al. 2019). Due to their condensation onto ice, these mostly polar organic molecules (e.g. carbonyls and amines) show up in mmolar concentrations in ice grains (Khawaja et al., 2019). Less polar volatile constituents, however, can be detected at barely altered concentrations in the gas phase (Magee &Waite 2017, Postberg et al. 2018b).

The generation, mobilization and transport of macromolecular organic species are quite different from the volatile organics. The Cassini mass spectra hint at hydrophobic characteristics and indicate that they are a product of polymerization and thermal processing inside the core rather than of decomposition (Postberg et al. 2018). We hypothesize that these refractory species after mobilization in the core ascend through the ocean as small particulates by thermal convection and/or on the surfaces of gas bubbles. When reaching the water surface they drastically enhance in concentration compared to the bulk ocean. The bursting of bubbles can help to aerosolize this material. In analogy to similar processes above Earth's oceans (e.g. Wilson et al. 2015), the organic aerosols can then serve as condensation cores for water while they are entrained in the vapor flow through Enceladus' ice vents and are released into the plume at high concentration with just a coating of water ice.

## References

Postberg et al. (2008), *Icarus 193, 438 - 454*
Postberg et al. (2018), *Nature 558*, 564 - 567
Waite et al. (2006), Science 311, 1419 - 1422
Magee & Waite (2017), LPSC 48, Abstract 2974

Khawaja et al. (2019), *MNRAS,* in review
Choblet et al. (2017), *Nat. Astron. 1*, 841 - 847
Bouquet et al. (2019), *ApJ*, in press
Postberg et al. (2018b), Univ. of Arizona Press,
*Enceladus and the icy moons of Saturn*, 129 – 162
Wilson et al. (2015), *Nature 525*, 234-238