Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.17867

Evaluating the potential for abiotic synthesis of organic compounds in the subsurface ocean of Enceladus

JIHUA HAO

University of Science and Technology of China

Presenting Author: hao@ustc.edu.cn

Apart from the Earth, extraterrestrial oceans of liquid water exist beneath the icy shells of some moons in the solar system. One notable example is Enceladus, a moon of Saturn. The Cassini spacecraft discovered a cryovolcanic plume erupting from the south pole of Enceladus, and also found geophysical evidence of a subsurface ocean that is global in extent. Further analyses of the ice particles and gases revealed a complex chemistry of the plume, including various minerals (NaCl, NaHCO3, SiO2), gases (H2, NH3, CO2, CH4), as well as a variety of organics (C1 to C7 with O- or N-bearing functional groups). These observations render Enceladus as one of the hottest targets in the search for extraterrestrial life. However, we still have very few constraints about the detailed structure of most organics detected by the Cassini, not alone their origin, evolution, and distribution in the subsurface ocean.

Here, we applied thermodynamic calculations to assess the abiotic synthesis affinities of various groups of organics (hydrocarbons, alcohols, aldehydes, ketones, carboxylic acids, amines, nitriles, and amino acids) under the simulative Enceladus ocean water (0 °C) and hydrothermal (50-300 °C) conditions. Our preliminary results suggested that most of the studied organics are thermodynamically favorable to form with positive affinities under the neutral to weakly alkaline pHs and oceanic conditions. However, HCHO and HCN, as the key building blocks of life, are thermodynamically unfavorable to form or stabilize under a wide range of pHs. Abiotic synthesis of organics become less favorable under the hydrothermal conditions, suggesting that hydrothermal activity may threaten the stability of some organics in the Enceladus. Based on our results, we will discuss possible organic speciation, distribution, and evolution stories in the Enceladus subsurface ocean.