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EFFECTS OF TEMPERATURE AND PRESSURE IN SUBSURFACE OCEANS OF ENCELADUS AND EUROPA ON MACROMOLECULAR BIOSIGNATURES

Abstract

Icy moons with a subsurface ocean, such as Enceladus or Europa, are prime candidates in the search for extraterrestrial life. Identification of biosignatures with mass spectrometers (MS) onboard future spaceflight missions is essential. NASA's Cassini-Huygens spacecraft, passing nearby to Enceladus and sampling ice grains from the icy moon's cryovolcanic plume with low resolution MS, has already identified a variety of organic material originating from the moon's subsurface ocean. The Planetary Sciences group at Freie Universität Berlin, through laboratory experiments, simulates mass spectra obtained by these MS space instruments. Such experiments have been proven capable of accurately identifying biomolecules such as amino acids, peptides, sugars, and fatty acids from within cells. However, there are still many gaps in our knowledge of how MS readings may be affected by fluctuating environmental factors, such as temperature and pressure shifts, relevant in the subsurface oceans of icy moons. Previous research indicates that the hydrophobicity of amino acids becomes weaker when cells experience low temperatures, which has a direct and measurable influence on protein structure. Likewise, it has also been shown that moving cells from high to low pressure can significantly modify the structure and function of certain amino acids, and can even lead to protein denaturation. Such shifts in pressure and temperature are highly relevant for ocean moons, where potential biosignatures will move from hot hydrothermal sites at the bottom of the subsurface oceans upwards to cold near-surface ocean waters where they would be entrained into ice grains that are ejected into space by its cryovolcanic plume. This research project will study how changes to amino acid structure and function caused by extreme temperature and pressure shifts may affect mass spectral biosignature readings. To achieve this, various species of extremophiles will experience a shift in temperatures and pressures to varying degrees over varying time scales, while situated in an environment analogous to Enceladus and Europa's subsurface oceans. Then, hydrophilic cell compounds will be extracted, and their mass spectral data will be measured with MS laboratory instruments to see if there is a variation between the amino acid abundances across a temperature and pressure gradient. Understanding the way in which amino acid and peptide cell compounds behave in extreme environments is key to understanding how they will be presented in mass spectral data, and with that, the capability of human-made space instruments to identify the presence or absence of biosignatures with high confidence.