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Laboratory experiments on primordial organic degradation at conditions relevant to ocean worlds interiors

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Recent interpretations of space observations suggest that the icy moons of Jupiter and Saturn and the dwarf planet Ceres formed by accreting silicates, sulfides, ices and primordial organics. During accretion and differentiation of these icy bodies, the primordial organics reacted with water. We have carried out laboratory experiments at (P,T) conditions relevant to the interiors of icy moons and dwarf planets to investigate the degradation of the organics with water. The goal is to determine the ions that are eventually dissolved in the ocean and the chemical composition and structure of the refractory organics that mix with silicates and sulfides to form the core of these bodies. The primordial organics are analogs made in the Nebulotron. A recent analysis (Lévêque et al., 2024) demonstrated that these organics have elementary and chemical composition close to that of the organic matter found in the Paris meteorite, which is a carbonaceous chondrite, one of less altered CM chondrites. These organic molecules were mixed with water and placed in three different pressuring devices covering a large domain of pressures (up to 2 GPa) and temperatures (at 200°C and 400°C) conditions relevant to the interior of icy bodies.

Gas chromatography has been carried out on sealed capsules reacted in internally heated pressure vessel. *In situ* Raman spectroscopy and *in situ* XRD have been carry out on samples pressurized in a Diamond Anvil Cell (DAC). Each device provides complementary information on the evolution of the organic matter solid residues and its byproducts. Gas analyzes and *in situ* Raman demonstrate that N_2 and CO_2 are released when OM:H_2O mixtures are heated up to 200°C, and CH_4 appears at 400°C. Organic matter (OM) evolves towards very condensed PAHs. Being denser than the ocean, that should mix with silicates and sulfides to form a refractory core that further evolves as the temperature raises due to the decay of the long-lived radioactive elements. The primordial OM reacts with water to produce ions which may form carbonates, as observed by our XRD analyzes. These experiments provide potential explanations for the presence of N_2 and CH_4 in Titan's atmosphere and for the presence of carbon-rich regions observed at the surface of Ceres, Europa and Ganymede.