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Alkaline hydrothermal systems on Enceladus inferred from laboratory experiments

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The discovery of water-rich plumes with sodium salts erupting from warm fractures near the south pole of Enceladus suggest the presence of an interior ocean interacting with the rock components. The recent findings of silica nano-particles in Saturn's E-ring derived from the plumes imply the possibility of active geochemistry in the ocean. It is however highly uncertain the particular conditions of temperature, pH, and mineral compositions under which the reactions occur in the ocean. Here we report laboratory experiments of hydrothermal reactions between aqueous solution containing primordial volatiles with cometary compositions and primitive minerals simulating Enceladus' interior. Our results indicate that redox reactions of primordial volatiles, such as NH3 dissociation and conversion of CO2 to CH4, are highly inhibited kinetically even at high temperatures. These volatiles in turn would keep pH of the solution alkaline (i.e., pH 8-11). To generate silica nano-particles in Enceladus, we suggest that temperature should be at least ˜100 degree in C or above with the presence of secondary minerals of serpentine and talc. These secondary mineral assemblages imply that the initial rock compositions of building block of Enceladus were CI chondritic. Our experimental results together with the findings of silica particles in Saturn E-ring suggest the presence of hydrothermal activities (temperature $>$ 100 degree in C) with alkaline fluids in Enceladus' ocean in the recent past or even today.

Keywords: icy satellite, hydrothermal activity, astrobiology, planetary science