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Timescale of serpentinization reactions on Enceladus

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The Cassini spacecraft demonstrated that Enceladus, a small moon on the outer edge of Saturn's rings, may harbor hydrothermal activity beneath its ice crust [1,2,3]. In particular, hydrogen production could result from water-rock interactions in a tidally-heated, water-filled porous rocky core [4]. The lifetime of such reactions is key to assess both the habitability potential of Enceladus and to constrain plausible durations of the active stage in a context where the evolution of the moon is debated [5]. A preliminary study estimated the maximum timescale of serpentinization and reported relatively brief durations (at most a few tens to a couple hundreds of million years) [6]. Here, we investigate plausible rate-limiting mechanisms governing fluid-rock interactions that could delay the completion of serpentinization of Enceladus rocky core. In particular, we consider (i) the impact of etch pit nucleation; (ii) the impact of surface layers; (iii) diffusion in nanoporous secondary assemblages; (iv) fluid flow. Our results confirm the former estimate (longest time scale : 300 Myr) and indicate that fluid flow ultimately sets the tempo for serpentinization. Possible causes to the observed rate of hydrogen emission in the jets of Enceladus will be discussed.

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