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Silica-induced mineral self-assembly in natural geochemical environments

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Mineral self-assembly is a far-from-equilibrium precipitation process by which minerals self-organize spontaneously into complex patterns. Among these patterns, silica-induced mineral gardens are thought to be relevant for prebiotic chemistry and origin of life on early Earth when alkaline silica- and carbonate-rich oceans were widespread [1,2]. Mineral gardens are tubular mineral membranes formed via abiotic precipitation upon the interaction of metal salts with aqueous solutions such as silicate and carbonate. Particularly, iron and cobalt silica gardens are small batteries [3] that selectively catalyse the synthesis of prebiotically relevant compounds in the presence of formamide [4]. The pH gradient between the inner acidic and the exterior alkaline solution was the major contributor to the electrochemical potential. In addition to silicates, chemical (carbonate) gardens could form in synthetic carbonate solutions. Interestingly, we have shown that silica gardens could form in purely natural serpentinization-driven alkaline springs [5] whereas carbonate mineral tubes could form in natural carbonate-rich alkaline soda lake water [6], implying the geochemical plausibility of mineral self-assembly on early Earth alkaline oceans. However, unlike silica gardens, synthetic and natural calcium carbonate tubes couldn't generate a significant electrochemical potential [7] despite the high pH gradient in the case of natural calcium carbonate tubes. Here, we will compare and discuss the physicochemical and mineralogical properties of silica and carbonate tubes to reveal the possible reasons for the presence/absence of voltage. Moreover, we will shed light on the implication of these tubular minerals in catalysing chemical reactions and prebiotic chemistry on early Earth and other planets and moons.

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