Precipitation of self-organized Fe-silica membranes on early Earth: Friend or Foe?

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Fe-silica self-organized membranes, so-called Fe-silica gardens, are film-like or twisted hollow filamentous structures that form upon reaction of an alkaline silica-rich solution/salt with an Fe-rich acidic solution/salt [1]. These membranes exhibit a series of interesting properties relevant for prebiotic chemistry [2,3], life detection studies and material science [4]. It was shown recently that Fe-silica membranes can precipitate from natural alkaline, silica-saturated water deriving from a serpentinization setting, placing their formation in a geological context relevant for early Earth [5].

Despite these interesting findings, we lack information on the actual structure of the membrane that controls its properties, and we don't know if these can be extended to the natural membranes as well. Here, we reveal the nanostructure and the textural and mineralogical characteristics of the Fe-silica membranes at the nanoscale (FESEM-EDS/FIB, HRTEM/HAADF/STEM/EELS) and compare the model membranes with those made with natural solutions. Our results show that both the model and natural membranes are composed of amorphous silica and Fe-nanoparticles with nanosized channels, responsible for their excellent catalytic potential and help us to better distinguish them from their biologic counterparts. Given their potential function as prebiotic catalysts and their morphological and mineralogical resemblance to putative biogenic Fe-filamentous structures found in cherts, we will also discuss the geochemical conditions for the precipitation of the Fe-silica membranes during the Hadean-Early Archean.

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