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Chemical gardens as laboratory analogs to clay minerals formation on early Mars

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The detection of various kind of clay minerals by Chemin, the XRD instrument on board the Curiosity rover, has provided new insights on the aqueous evolution and the potential habitability of the surface and subsurface environments of early Mars. However, the geochemical mechanisms that led to the transformation of primary basalt silicates into clay minerals at Gale during the Nochian are not yet well characterized [1].

On Earth, it is commonly accepted that the formation of clays at low temperatures by reverse weathering requires the initial precipitation of amorphous precursors, also detected on Mars, which evolve into ordered structures. This process implies order-disorder transformations and is undoubtedly the worst characterized, although it can offer important information about the past geochemical conditions prevailing on early Mars.

Previous experiments with hybrid hydroxide-silica gels showed that the mixing process is one of the determining factors leading to the formation of amorphous silicate multi-oxides (i.e., Allophane, imogolite). 'Molecular mixing', facilitates the further evolution toward more ordered clays. Here we analyzed the formation of microscopic precursor layers of clay minerals in chemical gardens (ChG) from the nanostructural scale using HREM and SAED (figure 1). This procedure serves as an analog of the formation of secondary minerals through silicate weathering under anoxic conditions. The development of tubular structures also called as 'silica garden', controls the size of compositional inhomogeneities within the range of the "spinodal decomposition" (1 nm or less) providing the intercalation of hydroxide and silica layers that characterize the clay structure. Furthermore, the process of formation of the silica garden involves the existence of an extreme pH gradient -between the internal and external walls- which drives the rate of oxidation of Fe^{+2} as well as on the simultaneous polymerization of silica, providing a way to analyze the mutual influence of Si-Fe stoichiometry, pH and oxidation rate on the evolution toward the formation of clay minerals or oxide phases.

References.

[1] Losa-Adams, E., Gil-Lozano, C., Fairén, A.G. *et al.* Long-lasting habitable periods in Gale crater constrained by glauconitic clays. *Nat Astron* **5**, 936–942 (2021). https://doi.org/10.1038/s41550-021-01397-x

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