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Mineral crystallization in deep-sea alkaline hydrothermal vents: brucite formation pathways and chemical energy conversion

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White chimneys in deep-sea alkaline hydrothermal vents have received increasing attention because of their potential relevance to chemosynthetic ecosystems. Our recent work has shown that the white chimney precipitated in the depths of the Mariana Trench—composed mainly of brucite and carbonates—has surprisingly well-organized structures ranging from sub-nanometers to hundreds of micrometers, capable of osmotic energy harvesting just like cells [1]. Such a functional structure has formed spontaneously despite the fact that the solution chemistry is highly variable in both time and space: the intermittent flow of alkaline vent fluids seeps out of the Earth's crust and contacts the surrounding seawater, creating steep gradients in temperature, pH, ion concentrations and composition. While the intricate structure suggests nonclassical crystal growth processes such as oriented aggregation, the precise mechanisms remain elusive. This preliminary study will investigate brucite nucleation and crystallization pathways using synchrotron X-ray scattering, by mimicking the hydrothermal environment with a particular focus on liquid-liquid interfaces with contrasting physicochemistry and the presence of flow.

[1] Lee, H.-E. et al. Osmotic energy conversion in serpentinite-hosted deep-sea hydrothermal vents. Nat. Commun. 15, (2024).