Nucleation pathways of sulfate minerals

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Sulfate minerals are abundant materials both on Earth and Mars [1]. Despite their significant role in both natural and engineered environments, MSO_4-H_2O systems have received surprisingly little attention in the recent flurry of studies addressing alternative (i.e. non-classical) mechanisms of solution-mediated mineral formation [2]. One exception is $CaSO_4$, where extensive experimental work has revealed a rather complex mineralization process, involving different stages and precursor species [3,4].

Spurred by those findings, we have now extended our research using a broad variety of experimental techniques (e.g. *in situ* SAXS/WAXS, powder-XRD, (cryo)-TEM, potentiometric titration, induction time measurements, etc.) to other sulfate phases such as celestite ($SrSO_4$) and barite ($BaSO_4$). We found that these sulphate phases also undergo a multi-step formation pathway involving transient precursor species under certain physiochemical solution conditions. In particular, we present the effects of supersaturation, ionic strength, and solution hydrodynamics on the precipitation dynamics and stability/persistence of the different precursor phases. Based on the obtained experimental evidence, we construct a tentative unified model for sulfate crystallization from solution.

Finally, the key questions that still need to be resolved before a holistic model of the nucleation pathway of solid phases in the MSO_4-H_2O system is attained will be highlighted.

[1] Alpers et al., (2000) Reviews in Mineralogy and Geochemistry, 40.
[2] Van Driessche et al. (2017) *New Perspective on Mineral Nucleation and Growth*, Springer-verlag.
[3]Van Driessche et al (2012) *Science*, 336, 69-72.
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