

Anhydrite formation in planetary surface environments – The case of the Atacama Desert

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Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), bassanite ($\text{CaSO}_4 \cdot 0.5\text{H}_2\text{O}$), and anhydrite (CaSO_4) are essential evaporite minerals for the evolution of hyper-arid surface environments on Earth and Mars (Voigt et al. 2019; Vaniman et al. 2018). The formation mechanism of especially anhydrite has been a matter of scientific debate for more than a century (van't Hoff et al. 1903). To date, there exists no model that can reliably predict anhydrite formation at earth's surface conditions. While thermodynamics favor its formation, it is hardly achieved on laboratory time scales at conditions fitting either the Atacama Desert on Earth, or the surface of Mars (Wehmann et al. 2023, *subm.*). In light of most recent developments (e.g. Stawski et al. 2016), that advocate for a complex, non-classical nucleation mechanism for all calcium sulphates, we present an analysis of natural samples from the Atacama Desert to identify key features that promote the nucleation and growth of anhydrite under planetary surface conditions. Our analyses reveal at least three distinct anhydrite facies, with differing mineralogy and micro- to nano-structures. The facies are (1) aeolian deposits with sub- μm grain sizes, (2) (sub-)surface nodules that formed from aeolian deposits and (3) selenites with secondary anhydrite rims. Possible mechanisms of their formation will be discussed.

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