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# On the effect of carbonate on barite growth at elevated temperatures

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## Abstract

The effect of carbonate on the growth of barite {001} surfaces from aqueous solutions supersaturated with respect to barite ($\Omega_{barite}$ ~ 12) was studied by hydrothermal atomic force microscopy (HAFM) and Raman spectroscopy at temperatures ranging from 25 to 70 °C. The experiments showed that the effects of carbonate depend on the specific location of growth. For mono-layers growing on pristine barite, the carbonate-additive promotes growth and the spreading rate of two-dimensional islands increases with temperature. However, growth is inhibited in layers growing on surfaces, which grew in carbonate-containing solution. The threshold carbonate concentration necessary to completely inhibit growth is inversely correlated with temperature. Raman spectroscopy revealed the presence of carbonate within crystals, which grew in carbonate-containing solution. Judging by these findings, incorporation of carbonate into the structure of growing barite as a thermally activated process likely is a controlling factor, which inhibits barite growth. Thus the study shows that additives can exert opposing effects on growth not only depending on additive concentration but also depending on the specific growth location. The implication of this work, therefore, is that bimodal effects of additives on crystal growth occur more frequently than generally recognized. The insights into the mechanisms of such bimodal effects of additives can significantly contribute to the understanding and predictability of the kinetics of macro-scale processes such as barite scale formation or the behavior of barium sulfate in $CO_2$-sequestration fluids.

**Keywords:** Barite, hydrothermal atomic force microscopy, impurity, growth inhibition, growth promotion, carbonate, Raman spectroscopy