

Visualization of elemental uptake by individual calcite crystals

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Heterogeneous distribution of trace elements (impurities) within individual calcite crystals is a phenomenon commonly observed in natural and laboratory systems. Although changes in thermodynamic intensive parameters (mostly chemical potential and temperature) cannot always explain the inhomogeneous impurity patterns in calcite crystals, it has been suggested that growth rate and crystallographic orientation may have strong effects on elemental incorporation into calcite. There are a number of experimental studies on micro-scale element (E) distribution between non-equivalent pairs of calcite vicinal faces; however, information about the variability of partition coefficients (e.g. $K^E = (E/Ca)_{\text{calcite}} / (E/Ca)_{\text{fluid}}$) within individual crystals remains unknown.

In this study, large calcite crystals (~1 mm in size) were grown via CO₂ diffusion in a Ca-bearing solution. Growth rates of individual crystals were determined by labelling calcite growth layers with rare earth elements (REE), which were sequentially introduced into the growth medium. Chemical mapping with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) allowed evaluation of crystal growth rate and heterogeneous distribution of Li, B, Mg, and Sr within polished sections of calcite crystals. K^E values were derived by combining these data with E/Ca in the fluid obtained by sampling of the solution during the experiment. Spatial interpolation of the obtained results allowed 2D visualization of quantified K^E values within the polished sections of two individual calcite crystals.

Our study demonstrates heterogeneous distribution of Li, B, Mg, and Sr between sectors of individual calcite crystals grown at similar rates. Decoupling of crystallographic and growth rate effects reveals that crystallographic control plays a more significant role. More specifically, in different calcite sectors grown at similar rates, K^B varies by up to one order of magnitude, K^{Li} varies by a factor of four, K^{Mg} varies by a factor of three, and K^{Sr} varies by 15%. This behaviour reflects different mechanisms of incorporation of various elements into calcite.