Abiotic calcites: crystal morphology, zoning and microstructure

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Experimental work relating the morphology and trace element incorporation of calcite crystals grown from complex aqueous solutions is in an early stage, but it is already clear that these attributes are sensitive to saturation state, ionic strength and the presence of specific growth inhibitors.

Surface microtopography is an expression of crystal growth mechanisms that can be investigated by scanning force microscopy, during growth or on pristine as-grown surfaces. The {10.4} rhombohedron of synthetic calcite commonly displays growth spirals that vary in size, anisotropy and geometry with solution composition, sometimes with transitions from spirals to nuclei or growth islands across a single face. Other crystallographic faces appear at low supersaturation, especially in the presence of specific ions (sulfate, ammonium, divalent metals) in solution. Examined by scanning or transmission electron microscopy, after recovery from growth solutions, these other faces are often slightly curved, covered by complex arrays of facets and macrosteps, and tend to evolve within several days into planar faces with a homogeneous and subdued surface microtopography.

Pristine as-grown surfaces are rare or absent on natural and biogenic carbonate minerals. What else can we use to infer their growth mechanism? The structural anisotropy of calcite results in a different microtopography on non-equivalent faces. The crystalline structure exposed at non-equivalent steps also influences trace element incorporation. Compositional zoning therefore develops among crystalline sectors grown on arrays of non-equivalent steps and on facets seen on single faces. This zoning maps onto surface microtopography in synthetic calcite single crystals large enough (> 100 µm) to detect this pattern. Similar zoning patterns are found on gem-quality natural calcite specimens and also map on their surface microtopography. However, the scale of microtopographic features (growth hillocks, facets or macrosteps) varies widely among natural crystals. Mapping compositional zoning patterns is limited by the sensitivity and resolution of available analytical mapping techniques. With this caveat, compositional zoning patterns offer a useful proxy for certain surface microtopographic features.

Sector zoning patterns are expected in any low-temperature calcite having grown from well-defined faces or arrays of distinct steps. Their absence would suggest that crystallographic faces and non-equivalent steps were not a template for crystal growth or that these features were too small for current mapping tools to resolve zoning patterns.

The individual behaviours of trace elements in the orogenic Alpe Arami garnet peridotite (Central Swiss Alps). A detailed LA-ICPMS study

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The Alpe Arami peridotite body is one the most spectacular examples of an UHP garnet peridotite within collisional belts. Based on several major and trace element thermobarometers peak metamorphic conditions have been estimated at 1180 °C and 5.9 GPa. Due to fast subduction and exhumation this rock was not equilibrated with respect to elements with low diffusivities (Sc, V, Ca, Cr, Ti), while elements with high diffusivities (Fe, Mg, Co, Ni) were equilibrated (Paquin & Altherr 2001). In this study we performed stepscan LA-ICPMS profiles across the same grains that were investigated by electron and ion microprobes during previous studies. Porphyroclastic garnet and clinopyroxene are strongly zoned. Fluid immobile trace elements (HFSE, HREE) are higher in the grt cores and decrease continuously towards the rims. The Variation in these trace elements is most likely related to growth zoning. Strontium as a fluid mobile element is enriched in grt (~2.6µg/g) and in the rims of porphyroclastic cpx. This is symptomatic of a metasomatic overprinting, which is in accordance with the findings of strong Li enrichment in the various cpx generations and the occurrence of pyroxenitic veins (Paquin & Altherr 2002). Porphyroclastic, neoblastic and vein-hosted clinopyroxene represent different stages of crystallisation and are not in trace element equilibrium. Neoblasts are not zoned whilst vein-hosted cpx shows elevated Sr concentrations with zoning enrichment towards the cores.

References

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