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Towards a morphology diagram for terrestrial carbonates: Evaluating the impact of carbonate supersaturation and alginic acid in calcite precipitate morphology

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Ancient and recent terrestrial carbonate-precipitating systems are characterised by a heterogeneous array of deposits volumetrically dominated by calcite. In these environments, calcite precipitates display an extraordinary morphological diversity, from single crystal rhombohedral prisms, to blocky crystalline encrustations, or spherulitic to dendritic aggregates. Despite many decades of thorough descriptive and interpretative work on these fabrics, relating calcite micro-morphology with sedimentary hydrogeochemical conditions remains a challenge. Environmental interpretations have been hampered by the fact that calcite morphogenesis results from the complex interaction between different physico-chemical parameters which often act simultaneously (e.g., carbonate mineral supersaturation, Mg/Ca ratio of the parental fluid, organic and inorganic additives). To try to experimentally address the sedimentological causes of calcite morphogenesis, an experimental approach yielding a first attempt at a calcite growth-form phase diagram is presented here. The initial aim was to account for the carbonate products experimentally nucleated in alkaline, saline lake settings. These are the result of at least two competing calcite precipitation ‘driving forces’ that affect morphogenesis: the calcite supersaturation level of the parental fluid, and the concentration of microbial-derived organic molecules (alginic acid). A key finding of this study is that common naturally-occurring calcite products such as calcite floating rafts, rhombohedral prismatic forms, di-pyramid calcite crystals, spherulitic calcite grains, or vertically stacked spheroidal calcite aggregates, can be related to specific hydrogeochemical contexts, and their physical transitions pinpointed in a phase diagram. By exploring binary or ternary responses to forcing in morphological phase-space, links between calcite growth forms and (palaeo)environmental conditions can be determined. This provides a truly process-oriented means of navigating questions around carbonate precipitate morphogenesis for the future.