American Mineralogist, Volume 84, pages 1939–1949, 1999

Novel TEM approaches to imaging of microstructures in carbonates: Clues to growth mechanisms in calcite and dolomite

JEANNE PAQUETTE,[1,*] HOJATOLLAH VALI,[2] AND ERIC MOUNTJOY[1]

[1]Department of Earth and Planetary Sciences, McGill University, 3450 University Street, Montreal, Quebec H3A 2A7, Canada
[2]Electron Microscopy Centre, McGill University, 3640 University St., Montreal, Quebec H3A 2B2, Canada

ABSTRACT

Relating microstructures imaged by transmission electron microscopy (TEM) to specific growth mechanisms requires imaging of both the surface microtopography on crystal faces and its corresponding microstructure in the bulk crystal. Pt-C replicas of as-grown surfaces are ideally suited to this task, as they provide a high-resolution, nearly three-dimensional image of surface topography that can be correlated with microstructures visible in sections at high angle to the as-grown surface. Ultramicrotomy enables the preparation of ultrathin sections more quickly than conventional ion-thinning and can be used to investigate chemical heterogeneities by analytical electron microscopy (AEM). We evaluate the potential of both techniques for the study of microstructures in calcite and dolomite. (1) TEM images were obtained from Pt-C replicas of synthetic calcite. The as-grown $(10\bar{1}4)$ face of a Mg/Mn-doped crystal growth showed growth hillocks aligned along preferred orientations. In Pb/Mn/Sr-doped calcite, sections at high angle to as-grown faces showed a uniform microstructure in $\{10\bar{1}4\}$ sectors. The $\{01\bar{1}2\}$ sectors contained concentric zones that alternated from striated to uniform microstructures, suggesting periodic variations in growth rate and possibly in the growth mechanism. An oscillatory-zoned Mn-doped calcite showed fine-scale banding (30–150 mm) and periodic roughening of $(10\bar{1}4)$ surfaces that suggest repetitive transitions between growth mechanisms. (2) In sedimentary dolomites, Pt-C replicas of surfaces cleaved parallel to a $(10\bar{1}4)$ face showed a hillocky topography or smooth $(10\bar{1}4)$ surfaces modified by non-equivalent facets. Surfaces produced by cleavage at high angle to a $(10\bar{1}4)$ face exposed sectors with fine-scale banding crosscut by sharp boundaries, suggestive of closely spaced growth hillocks intercalated with non-equivalent subsectors. Ultrathin sections prepared by microtomy showed some disruption of the crystal structure but, in some dolomite samples, domains with distinctive microstructures similar in scale and shape to those seen in the Pt-C replica were identified. (3) The growth microstructures in $\{10\bar{1}4\}$ sectors of dolomite present striking similarities to the larger scale compositional zoning patterns produced by growth spirals in calcite doped with trace elements. At this stage, Pt-C replicas and ultramicrotomy can distinguish among dolomites that are petrographically very similar.