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STEM investigation of exsolution lamellae and "*c*" reflections in Ca-rich dolomite from the Platteville Formation, western Wisconsin

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Abstract

Dolomite crystals in partially dolomitized limestone from the Platteville Formation are both compositionally and microstructurally heterogeneous. A single dolomite crystal usually contains three phases: the host Ca-rich dolomite [$Ca_{1.14}Mg_{0.86}(CO_3)_2$], an Fe-bearing dolomite [$Ca_{1.06}Mg_{0.80}Fe_{0.14}(CO_3)_2$], and calcite inclusions. These three phases show similar orientations. The Ca-rich dolomite exhibits modulated microstructures with wavelength ranging from 7 to 30 nm. The modulated microstructures are not evident in Fe-bearing dolomite.

Modulations in the Ca-rich dolomite have three predominant orientation ranges in the studied sample: from (205) to (104), from (001) to ($\bar{1}$01), and ~(110), which are consistent with previous studies. Bright-field (BF) and high-angle annular dark-field (HAADF) images confirm that these modulations are due to chemical variation rather than strain or diffraction contrast. The Ca-rich lamellae are Mg-rich calcite with compositions ranging from $Ca_{0.85}Mg_{0.15}CO_3$ to $Ca_{0.70}Mg_{0.30}CO_3$. The observed results indicate that these Ca-rich exsolution lamellae formed during diagenesis. In this study, three kinds of "*c*"-reflections, which are weak spots in the halfway position between the principal reflections along the (104)*, ($\bar{1}$12)*, and (110)* directions, have been found in the diffraction patterns of some Ca-rich dolomite. Mg-Ca ordering in *x*-*y* planes was not observed directly in Z-contrast images. FFT patterns from the Z-contrast images do not show "*c*"-reflections. STEM images confirm that the "*c*"-reflections could result from multiple diffraction between the host dolomite and twinned Mg-calcite nano-lamellae under TEM imaging and diffraction modes.

Keywords: Dolomite, Z-contrast imaging, Ca-Mg ordering, TEM, twinning, high magnesian calcite, *c*-reflection, exsolution