

# Microstructural and microchemical characteristics of dolomite in Ryugu regolith particles

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**Introduction.** Previous studies of Ryugu material have reported that the regolith particles record extensive aqueous alteration as the result of water activity in the original parent body [1,2]. The aqueous alteration finally resulted in the almost complete overprint of the primary mineralogical composition and the precipitation of secondary minerals, i.e. phyllosilicates, carbonates, phosphates, sulfides, and oxides. The isotopic  $^{18}\text{O}/^{16}\text{O}$  and  $^{13}\text{C}/^{12}\text{C}$  signatures of carbonates were recently studied in great detail to obtain information on the conditions of aqueous alteration [3]. Here, we focus on the characterization of the defect microstructures and nanoscale element distributions in dolomite of Ryugu samples to obtain further insights into the formation history and mechanisms of carbonates.

**Samples and methods.** In the context of the Hayabusa2 initial analysis phase, we have mainly studied polished sections prepared from larger particles recovered in the C chamber, i.e. C0033-01 and C0033-04, and C0055-01 [detailed in 1]. Eleven slices of carbonate-bearing regions were cut from the thin sections by focused ion beam (FIB) preparation on a scanning electron microscope (SEM). Subsequent analytical transmission electron microscopy (TEM) were performed according to the procedure described by [4].

**Results and discussion.** TEM observations reveal numerous curled dislocations as the most dominant lattice defect in almost all dolomite grains. This shape of dislocation lines indicate that dislocations are not in glide configuration and thus may have been incorporated during imperfect growth from the aqueous fluid. In the vicinity of fractures, sample C0055-01 contains also straight glissile dislocations, which were previously assigned to mild shock [5]. Deformation twins, which are generally regarded as typical for shock-metamorphosed carbonates, are however absent in C0055-01. An explanation for their absence could be that deformation twinning in dolomite requires enhanced temperatures [6], which do not prevail during low shock metamorphism [6].

Mapping of elemental distributions in scanning mode using energy-dispersive X-ray emission spectroscopy show complex and variable zoning of dolomite grains. Many grains show sharp, non-concentric, up to 1  $\mu\text{m}$  thin rims with a significant enrichment in manganese (up to 8 wt% MnO). This observation points, at least, to a second precipitation event, when the fluid became apparently enriched in manganese. A preferential mobilization of manganese might be explained by a (localized) change in the reduction potential. In addition, manganese-enriched dolomites with continuously decreasing manganese concentration from core to rim exist and monitor a gradual change in the fluid chemistry controlled by carbonate growth.

Most interesting is the observation of nanoscale modulations in the rims of dolomite. Such microstructures have also been observed in sedimentary calcian dolomites and are interpreted as growth microstructures [7]. The modulations appear as almost parallel lamellae with regular alternating light and dark contrast, resembling microstructures known for spinodal decomposition. A periodical variation of the fluid composition at the mineral-solution interface during progressing growth is a plausible explanation for this microchemical peculiarity [8].

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## References

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