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Zebra textures in fault-controlled, hydrothermal dolomite bodies: coupled mechanisms of replacement, deformation, and cementation

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Fault-controlled, hydrothermal dolomitization involves the interaction of high pressure (P), high temperature (T) fluids with the surrounding host-rock. A striking feature of hydrothermal dolomite bodies is the pattern development and periodicity of zebra textures, whereby alternating units of replacement dolomite (RD) and saddle dolomite (SD) form symmetrical RD-SD/SD-RD patterns. Zebra textures are often considered to be diagnostic of these elevated P/T conditions, but the roles of mechanical deformation and the localization of strain during dolomitization have received limited attention. Here we evaluate the effect of P/T perturbations on the genesis of zebra textures, and how strain-hardening mechanisms promote their characteristic pattern development. Published fluid inclusion homogenization and carbonate clumped isotope temperatures were compiled from the literature and the offset between these data were used as a geobarometer. Based on these pore pressures, a series of rock deformation experiments were conducted to reproduce zebra textures in the laboratory. Cylindrical samples were held in an annealed copper jacket and deformed in axisymmetric extension. As the rock underwent tensile failure, the jacket deformed by intracrystalline plasticity, strain-hardened, and stabilized each opening-mode fracture. As a result, a succession of closely spaced fractures formed along the length of the sample. In natural settings, an analogous process is inferred, whereby dilatancy hardening, precipitation hardening, and the stress shadow effect promote the rhythmicity of zebra textures. Lastly, the effects of P/T perturbations on the solubility of dolomite were evaluated using the Pitzer aqueous model in PHREEQC. This interdisciplinary study presents novel insights into the geomechanical and hydrochemical interaction between metasomatic fluids and carbonate rocks, which are of critical importance to the understanding of carbonate-hosted ore deposits in sedimentary basins worldwide.

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