

Fluid-rock interactions and sulphur mobility during carbonation of the Point-Rousse ophiolite complex: implications for carbon and sulphur cycling in forearc settings

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INTRODUCTION

The interaction of CO₂-bearing fluids with hydrated mafic and ultramafic rocks results in the replacement of minerals such as serpentine and brucite by dolomite and magnesite. This carbonation process is of significant scientific interest as a natural analogue of carbon sequestration (Andreani et al., 2009). In addition, at forearc conditions of subduction zones, it modulates the budget of the deep carbon cycle by establishing the transfer of CO₂ and other volatiles from the slab to the mantle wedge (Kelemen and Manning, 2015; Vitale-Brovarone et al., 2020). Carbonation may favour either the trapping or release of redox-sensitive volatiles such as sulphur (e.g. Albers et al., 2019), affecting the redox potential of the incoming slab. Thus, carbonated peridotites, such as soapstone or listvenite, are evidence of extensive fluid flow that trace the mobility and speciation of carbon and sulphur in metamorphic fluids (Menzel et al., 2024). However, the specific physicochemical conditions of this process are not well understood. Here, we investigate carbonated mafic and ultramafic rocks from the Point-Rousse ophiolite complex (Newfoundland, Canada). The area of study is affected by ductile deformation and hydrothermal fluid circulation at moderate P-T conditions, related to the Baie Verte Line, a major regional shear zone (Escayola et al., 2009), which can be an analogue for carbon and sulphur cycling in forearc settings.

PRELIMINARY OBSERVATIONS

The Point-Rousse ophiolite complex includes massive and foliated carbonated serpentinite, talc-carbonate rocks, albite-carbonate rocks, and carbonated, pyrite-bearing green-schists. Preliminary field and petrography observations and EDX-SEM analyses show a variety of replacement and dissolution/precipitation textures occurring during carbonation. Massive carbonated serpentinite shows the replacement of serpentine by magnesite and dolomite in pseudomorphic textures (bastite and mesh, Fig. 1a), while serpentine in foliated serpentinite is replaced by large crystals of talc (> 500 µm) and magnesite (> 2 mm, Fig. 1b). In massive talc-carbonate rocks, corona-shaped reaction rims of quartz and talc around dolomite are very prominent (> 200 µm, Fig. 1c). Coarse-grained magnesite (> 4 mm) is chemically zoned and characterized by a decreasing amount of magnetite inclusions from the core to the rim (Fig. 1c). Foliated talc-carbonate rocks show zoning of Fe-content in deformed magnesite crystals (up to 2 mm, Fig. 1d). Massive albite-carbonate rocks, composed mainly of dolomite, albite and muscovite are cross-cut by wide (up to 2 cm) veins of albite (Fig. 1e). Dolomite also exhibits zoning with increasing Fe content towards the rims (Fig. 1e). Carbonated green-schist, composed of albite, dolomite, chlorite and pyrite, exhibits dissolution/precipitation structures related to the formation of wide albite (> 1 mm) and carbonate veins (up to 1 cm). Pyrite appears to be related to the albite veins and commonly concentrates along and close to the wall of the veins (Fig. 1f).

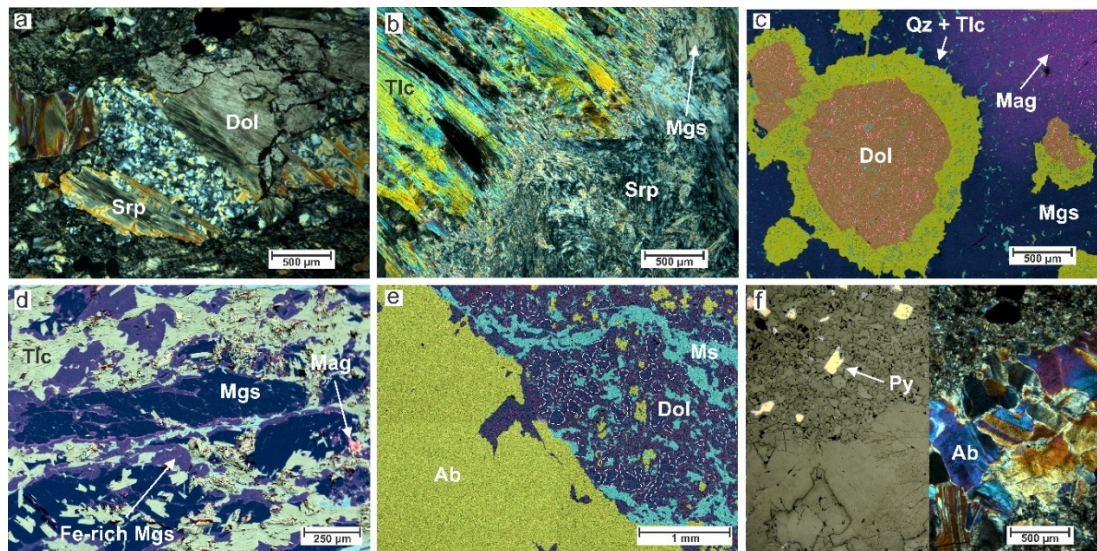


Fig 1. Replacement and dissolution–precipitation structures in samples of the Point-Rousse ophiolite. *a*) Bastite texture composed of serpentine (Srp) replaced by dolomite (Dol). *b*) Serpentine in foliated serpentinite replaced by large crystals of talc (Tlc) and magnesite (Mgs). *c*) EDS-SEM false-colour phase map of a corona-shaped reaction rim of quartz (Qz) and talc around rounded dolomite, and coarse-grained magnesite chemically zoned (reddish area) with magnetite (Mag) inclusions. *d*) EDS-SEM false-colour phase map of deformed magnesite with Fe-content zoning. *e*) EDS-SEM false-colour phase map of massive albite–carbonate rock composed of zoned dolomite (white dashed lines), albite (Ab) and muscovite (Ms) crosscut by albite vein. *f*) Pyrite (Py) in carbonated green-schist related to albite vein.

RESEARCH IMPACT

The investigated rock sequence is an ideal natural laboratory to improve our understanding of carbonation processes and massive reactive fluid flow at conditions of forearc settings, in particular concerning: 1) how much CO₂ can be trapped in different lithologies; 2) the conditions that enhance or inhibit the carbonation in mafic and ultramafic rocks; 3) the sources of CO₂-rich fluids in nature, and their carbon and sulphur speciation; and 4) how changes in the fluid speciation induced by carbonation affect the mobility of fluid mobile elements and metals of economic interest.

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