

Ophiolite carbonation: Constraints from listvenite core BT1B, Oman Drilling Project

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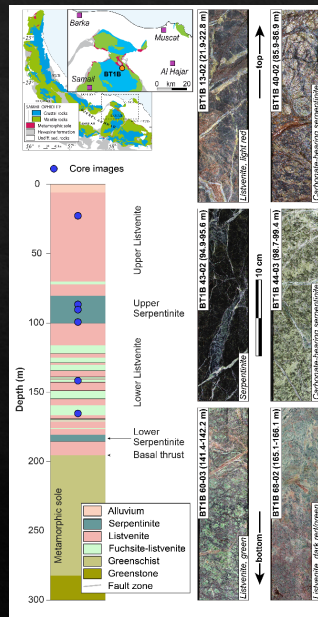
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Intro & geological setting

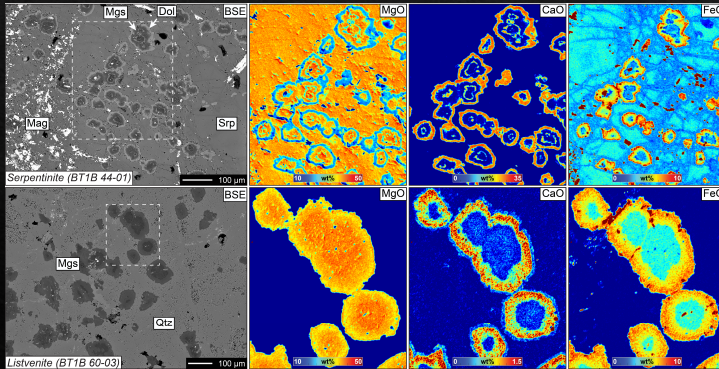
The widespread occurrence of the quartz-carbonate alteration assemblage (listvenite) in ophiolites indicates that ultramafic rock represents an effective sink for dissolved CO_2 . However, the **understanding of the carbonation mechanisms** is almost exclusively based on surface samples, which adds significant uncertainty to the interpretation of fossil hydrothermal systems. Here we present novel insight into the reaction textures and mechanisms of ultramafic rock carbonation obtained from the 300 m deep BT1B drill hole, ICDP Oman Drilling Project. Hole BT1B recovered continuous drill core intersecting surface alluvium, 200 meters of altered ultramafic rock comprising serpentinite and listvenite, and 100 meters of the underlying metamorphic sole. The ultramafic part of BT1B is dominated by listvenite with only two thin intercalated serpentinite bands at 90 m and 180 m depth.



Geological map showing location of BT1B; downhole stratigraphy of BT1B; photographs of listvenite and serpentinites

Results: Microstructures

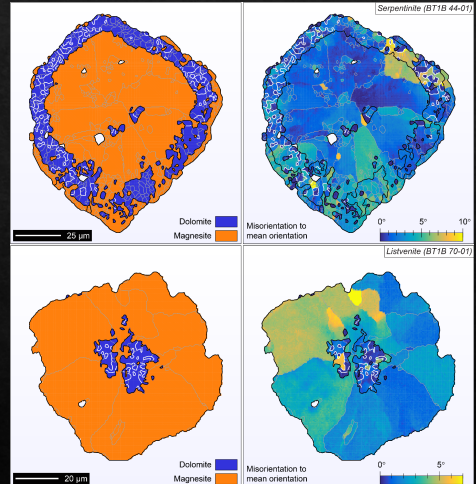
Microstructural analyses indicate an evolution beginning with **non-equilibrium growth of spheroidal carbonate** composed of interlayered magnesite and dolomite in the completely serpentinized harzburgite, and magnesite and Ca-magnesite in the listvenite. Carbonate spheroids are characterized by sectorial zoning resulting from radially oriented low-angle boundaries. In the listvenite spheroidal carbonate is overgrown by euhedral magnesite indicative of near-equilibrium growth.



Back-scattered electron (BSE) images and quantitative element distribution maps of carbonate in serpentinite and listvenite.

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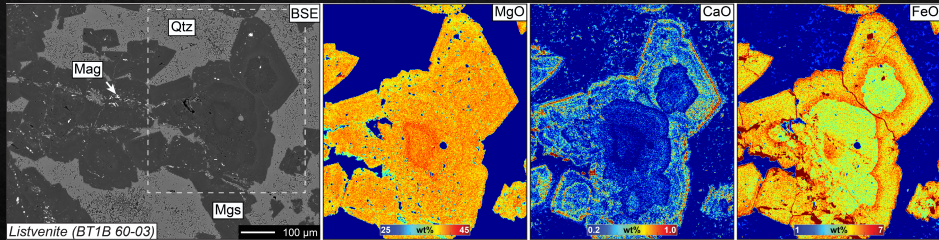


Beirlich et al. (2020), JGR

Electron backscatter diffraction
(EBSD) of spheroidal carbonate

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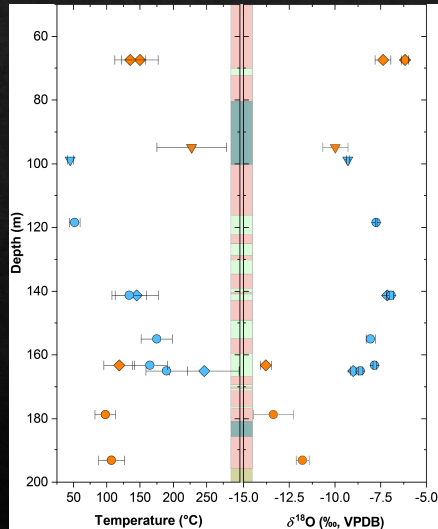


Back-scattered electron (BSE) images and quantitative element distribution maps of carbonate in listvenite.

Results: Clumped isotopes thermometry

Carbonate clumped isotope thermometry indicates carbonate crystallization predominantly between 100°C and 200°C.

The strong macroscopic brecciation and veining of listvenite indicate that carbonation was facilitated by significant tectonic deformation allowing for infiltration of reactive fluids over an extended duration.



Beinlich et al. (2020), JGR

'Take home messages'

- Large-scale carbonation resulted in pervasive replacement of serpentinite by a magnesite-quartz-fuchsite (listvenite) assemblage.
- Carbonation textures indicate a transition from non-equilibrium spheroidal growth to near-equilibrium euhedral growth.
- Clumped isotope thermometry indicates carbonation temperatures between 50°C and 250°C.