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Serpentinization and fluid-rock interaction in Jurassic mafic and ultramafic sea-floor: constraints from Ligurian ophiolite sequences

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The Bracco-Levanto ophiolitic complex (Eastern Liguria) represents one of the largest and better-exposed ophiolitic successions in the Northern Apennines. It is considered to be a fragment of heterogeneous Jurassic lithosphere that records tectono-magmatic and alteration histories similar to those documented along the Mid-Atlantic Ridge, such as at the 15°20'N area and the Atlantis Massif at 30°N. Structural and petrological studies on these rocks provide constraints on metamorphic/deformation processes during formation and hydrothermal alteration of the Jurassic oceanic lithosphere. We present a petrological and geochemical study of deformation processes and fluid-rock interaction in the Bracco-Levanto ophiolitic complex and compare these to modern oceanic hydrothermal systems, such as the Lost City Hydrothermal Field hosted in ultramafic rocks on the Atlantis Massif.

A focus is on investigating mass transfer and fluid flow paths during high and low temperature hydrothermal activity, and on processes leading to hydrothermal carbonate precipitation and the formation of ophicalcites, which are characteristic of the Bracco-Levanto sequences. Major element and mineral compositional data allow us to distinguish a multiphase history of alteration characterized by: (1) widespread SiO_2 metasomatism during progressive serpentinization, and (2) multiple phases of veining and carbonate precipitation associated with circulation of seawater and high fluid-rock ratios in the shallow ultramafic-dominated portions of the Jurassic seafloor. We observe regional variations in MgO, SiO_2 and $Al2O_3$, suggesting Si-flux towards stratigraphically higher units. In general, the ophicalcites have higher Si, Al and Fe concentrations and lower Mg than the serpentinite basement rocks or serpentinites with minimal carbonate veins. Bulk rock trace element data and Sr isotope ratios indicate seawater reacting with rocks of more mafic composition, then channeled towards stratigraphically higher units, leading to Si metasomatism in the serpentinites and ophicalcites. Channelling of Si-rich fluids is also indicated by amphibole and talc growth in shear zones and wall rock around the ophicalcites. δ18O-values of the carbonate veins indicate temperatures up to 150°C and document a decrease in temperature with ongoing serpentinization. Comparison with serpentinites from the Atlantis Massif and 15°20'N indicates a similar degree of Si enrichment in the modern seafloor and suggests that Si-metasomatism may be a fundamental process associated with serpentinization at slow-spreading ridge environments.