Serpentinization, metasomatism and carbonate precipitation in Jurassic mafic and ultramafic sea-floor

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Several Ligurian ophiolitic units are considered to be fragments of heterogeneous Jurassic lithosphere that record 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. We present a petrological and geochemical study of deformation and fluid-rock interaction in the Bracco-Levanto ophiolite complex (BL), which documents a multiphase history of alteration and hydrothermal activity, similar to present-day hydrothermal processes in oceanic core complexes at slow-spreading ridges. A focus is on investigating mass transfer, fluid flow paths, and fluid fluxes 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 BL sequences.

Bulk rock and mineral compositional data allow us to distinguish (1) a widespread phase of Si-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. In general, the ophicalcites have higher Si, Al and Fe concentrations and lower Mg than the serpentinite basement rocks with minimal or no carbonate veins. We interpret the zones of ophicalcites to reflect paleo-pathways for hydrothermal fluids and Si-metasomatism during uplift and emplacement on the seafloor. Bulk rock major and trace element data and Sr-isotope ratios indicate a seawater source of the hydrothermal fluids, and suggest that these fluids had reacted with rocks of mafic composition. We observe regional variations in Mg, Si and Al, which suggest Si-flux towards stratigraphically higher units. Channelling of Si-rich fluids is also indicated by amphibole and talc growth in shear zones. $\delta^{18}O$-values of the carbonate veins indicate temperatures up to 150°C and document a decrease in temperature with ongoing veining and carbonate precipitation. Continued pulses of Si-rich fluids upon cooling are indicated by the formation of late-stage calcite-talc druses in the ophicalcites.

Noble gas temperature determination in fluid inclusions - method, tests, future applications

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Concentrations of dissolved atmospheric noble gases in open water bodies and ground water have successfully been used to reconstruct past climatic and hydraulic conditions [1]. We have developed a combined vacuum crushing and sieving (CVCS) device which allows application of the so-called noble gas thermometer also to samples containing water amounts in the sub-milligram range, such as speleothems [2]. During growth, speleothems trap minute quantities of drip water, whose noble gas concentrations depend on the cave temperature. CVCS enables extraction of this water and the associated dissolved noble gases for analysis without inducing elemental fractionation, and minimizes addition of noble gases from air-filled inclusions. Air-related noble gases do not carry a temperature signal and have hence hampered noble gas temperature (NGT) determination in the past.

CVCS performance has been tested on samples from a stalagmite grown at a known temperature. NGTs deduced from the sieved grain size fractions with the most suitable air/water volume ratios excellently reproduce the expected paleotemperatures [2]. Furthermore, we report NGTs deduced from a stalagmite from Borneo covering two glacial–interglacial cycles (330-460 ka; [3]). These NGTs are compared to a sea surface temperature record from a tropical West Pacific sediment core [4].

We anticipate to apply the CVCS technique also to other fluid-inclusion bearing materials such as organic shells, corals, and consolidated sediments in the future.

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