Geochemical and isotopic (C, S, Sr, Nd) compositions of serpentinized peridotites and gabbros at the Atlantis Massif and Lost City Hydrothermal Field, 30°N MAR

*Delacour Adélie, *Früh-Green Gretchen L., **Bernasconi Stefano M., *Boschi Chiara, ***Frank Martin & ****Kelley Deborah S.

* ETH Zurich, Institute for Mineralogy and Petrology, Zurich, Switzerland (adelie.delacour@erdw.ethz.ch, frueh-green@erdw.ethz.ch)
** ETH Zurich, Geological Institute, Zurich, Switzerland
*** IFM-Geomar, Leibniz Institute for Marine Sciences, Kiel, Germany
**** School of Oceanography, University of Washington, Seattle, USA

Serpentinization of oceanic peridotites is a fundamental process that greatly affects the physical properties and geochemical cycles of the oceanic lithosphere, and has important consequences for microbial activity above or within the oceanic crust. The newly discovered Lost City Hydrothermal Vent Field (LCHF; Kelley et al., 2001), located at 30°N along the Mid-Atlantic Ridge, is an active hydrothermal system hosted by peridotite and driven by serpentinization processes. The LCHF is located on a terrace of the southern wall of the Atlantis Massif (AM) and is composed of numerous active and inactive carbonate chimneys, which vent low-temperature (<90°C) fluids with high concentrations of methane and hydrogen (Kelley et al., 2005). Microbial activity is associated with the carbonate chimneys or with carbonate filling fractures in the basement rocks. The Atlantis Massif is a dome-shaped massif with corrugations and striations on its top, which are considered as surface expressions of a long-lived low-angle detachment fault that led to the uplift and exposure of the massif. The southern AM is mainly formed by serpentinized peridotites interspersed with lesser gabbroic rocks, overlain by a 100 m-thick detachment shear zone (DSZ, Karson et al., 2006), which is composed of highly deformed and metasomatized serpentinites and gabbros, defined as talc-rich and amphibole-rich rocks (Boschi et al., 2006). On top of the massif, a carbonate layer and sedimentary breccias cap this mylonitic detachment zone. The altered peridotites record multiple phases of serpentinization and metasomatism, as well as carbonate veins related to the exhumation history of the massif and the formation of the LCHF.

Samples of peridotite, collected by submersible, show high degrees of serpentinization (70-100%), with replacement of olivine and orthopyroxene by serpentine ± talc ± chlorite ± tremolite + magnetite. Sr- and Nd-isotopic compositions of the serpentinites are close to seawater values, attesting to significant interactions between circulating seawater and the basement rocks of the AM. High seawater fluxes have consequences on the geochemical compositions of the serpentinites and have particularly affected the sulfur geochemistry of the rocks. Sulfur content of the serpentinites is predominantly present as sulfate phase, with high SO_4/S_{total} ratios. The $\delta^{34}S$ values for the sulfate are similar to that of seawater, indicating that serpentinization at the AM is an important sink of seawater sulfate. The sulfides have positive $\delta^{34}S$ values that are consistent with partial oxidation and loss of sulfides. Some samples, however, have negative $\delta^{34}S$ values for sulfides and/or sulfate attesting to bacterial sulfate reduction and/or bacterial sulfide oxidation. Carbon contents and carbon isotopes have been measured from serpentinized peridotites and gabbros in the basement of the LCHF with the goal to better understand carbon sources and carbon cycling during serpentinization. The serpentinites contain total carbon content (TC) with a wide range of carbon isotopic composition. Positive $\delta^{13}C_{TC}$ values are related to serpentinites with calcite veins indicating a marine carbon input. Total organic carbon (TOC) represents a significant amount of the total carbon content with negative $\delta^{13}C_{TOC}$ values. The gabbros have a wider range of TC content and $\delta^{13}C$ values, and similar $\delta^{13}C_{TOC}$ values than those of the serpentinites. The highly negative $\delta^{13}C_{TOC}$ may be related to the occurrence of methane or due to the presence of organic compounds within the samples.

Collectively, our data indicates that the Atlantis Massif has undergone a long history of fluid-rock interaction and that serpentinization processes have important consequences for sulfur and carbon cycles in near-ridge environments. Furthermore, the ultramafic rocks of the LCHF may represent a significant reservoir of both abiogenic and biogenic carbon, and may support much larger microbial populations than has been previously recognized.

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