Magmatism-hydrothermalism interaction along the crust-mantle transition below oceanic spreading centres

*Mathieu Rospabe[1,2], Mathieu Benoit[1], Georges Ceuleneer[1]

1. GET, OMP, Univ. of Toulouse, CNRS, IRD, F-31400 Toulouse, France, 2. JAMSTEC, Yokosuka 237-0061, Japan.

Beneath oceanic spreading centres, the transition from the upwelling and partially molten peridotitic mantle and the accreting gabbroic lower crust appears as a major chemical, thermal and rheological interface. In most ophiolites worldwide, it is underlined by a dunitic horizon whatever the paleo-tectonic setting (mid-ocean ridges vs. supra-subduction zone). Since dunite is observed in present-day oceans in different geodynamic environments, in association with mantle harzburgite and with troctolitic-gabbroic veins and sills, it is reasonable to suppose that ophiolitic dunitic transition zone (DTZ) formed prior to the intra-oceanic thrusting leading to obduction.

As a matter of fact, the understanding of the petrological processes occurring in the mantle-crust transition zone beneath oceanic ridges can be studied in the Oman ophiolite. Particularly, the Maqsad area (Sumail massif) evolved in a MORB-like magmatic environment and presently exposes a >300 m thick DTZ above a paleo-mantle diapiric structure. It has been attributed to peridotite reactional melting or to the accumulation of olivine from Mg-rich melts, whether a combined origin is more likely. Following the reactional origin, a partially molten harzburgite reacts with interstitial melts, enhancing the orthopyroxene dissolution and the crystallization of secondary olivine, resulting in a rock essentially made of olivine. Interstitial mineral fractionation during melt migration between olivine grains (or melt-rock reaction) is partly responsible of the extensive petrological and geochemical variability observed at Moho level.

Recent studies evidenced a large interstitial mineral variety in dunites from the DTZ with, in addition to plagioclase and clinopyroxene expected in a MORB magmatic environment, the presence of orthopyroxene and amphibole among others. These minerals are also observed, together with mica, as silicate inclusions in chromite grains scattered in the dunite. This calls for the early involvement of hydrated, Si- and alkali-rich melts in the formation of dunite and chromitite ore bodies at Moho level beneath oceanic ridges. Since the presence of this peculiar mineralogy is ubiquitous within the DTZ and absent in mantle harzburgite, this distribution supports that the hydrated component originated from above, probably seawater in origin. These fluids interacted with surrounding rocks and with the variably evolved MORB issued from the Maqsad diapir, allowing to generate the hybrid melts, i.e. a blend between supercritical hydrothermal fluids rich in silica or trondhjemitic melts issued from hydrous melting of the country rocks.

The chemical variations observed along the Maqsad DTZ define trends with a characteristic vertical scale of few tens of meters. The chemical variation patterns are spatially correlated to the distribution of ridge-related faults or fracture zones (i.e. active at an early, high temperature magmatic stage), not only for fluid-mobile elements but also for immobile elements (e.g. REE, HFSE). These faults seem to have enhanced (i) melt migration and extraction, from the mantle to the crust, and (ii) deep hydrothermal fluids introduction down to the Moho level. In other words, they are the main vectors for upwelling melt modification by hybridization, with hydrothermal fluids and/or silicic hydrous melts, and crystallization. In this context, the DTZ appears as a reactive interface that developed by the combination of three primary processes: tectonics, magmatism and deep, high temperature hydrothermal circulations. Fluid-melt-rocks reactions occurring at Moho level may have a significant impact on the MORB variability surveyed along present-day mid-ocean ridges and may contribute to part of the signatures observed at hydrothermal vents.

Keywords: Oman ophiolite, dunitic transition zone, melt-rock reactions