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The dunitic mantle/crust transition zone in the Oman Ophiolite: Residue of melt-rock interaction, cumulates from high-MgO melts, or both?

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The transition between mantle peridotite and gabbro from the lower oceanic crust, well documented in ophiolites and occasionally sampled in present-day oceans (e.g. Hess Deep), is usually underlined by a horizon of dunite (olivine + scattered chromian spinel) reaching up to several hundred meters in thickness. This "dunitic transition zone" (DTZ) is viewed either as a former lithospheric lid that was pervasively percolated by a melt under-saturated with orthopyroxene, leading to the transformation of peridotite into dunite, or as a pile of cumulus olivine from high-MgO (picritic) melts that settled on the bottom of a magma chamber. Each hypothesis involves a different model of mid-ocean ridge basalts (MORB) genesis: a residual DTZ would support the view that the MgO content of MORB parent melts and, hence, their liquidus temperature, are close to the ones of the most primitive MORB sampled along mid-ocean ridges (MgO$\sim$10%, liquidus T°$\sim$1200°C) while a cumulative DTZ would indicate that MORB are derivative melts left after abundant crystallization of olivine from much more magnesian and hotter parent melts (MgO$\geq$15%, 50 T°$\geq$1450°C).

In order to unravel the origin of the DTZ, we determined a detailed petrological profile through the 330 m-thick DTZ that developed at the top of a former mantle diapir in the Oman ophiolite. In the lowermost 280 m of the DTZ, olivine and chromian spinel present intricate but non-random compositional variations that bear witness of a complex interaction history between MORB melts and the residual mantle: variously differentiated and/or transformed MORB melts migrated, stagnated and crystallized at different levels of this horizon. Some intervals from this part of the DTZ show the highest degree of equilibration with MORB melts ever recorded in the Oman ophiolite. In the uppermost 50 m of the DTZ, all compositional trends become consistent with a simple cumulus origin of the dunite, olivine crystallization being a prelude to the one of the overlying gabbros.

Both major assumptions on DTZ origin are thus not mutually exclusive: although the DTZ developed largely in response to melt/rock reaction, it contains a significant proportion of cumulate dunite ($\sim$20%). Our observations call for MORB parent melts significantly more magnesian than the most primitive MORB sampled along present-day ridges although not reaching the extreme MgO contents (> 15%) of picritic basalts. Our results demonstrate also that the mantle/crust boundary acts as a reactive filter that buffers or, at least, influences, some of the chemical variables used in the interpretation of MORB chemistry in terms of chemical geodynamics and mantle temperature.