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Chemical and petrological aspects of magma-mantle interactions. Examples from the Oman and Trinity ophiolites.

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The large scatter in the composition of mantle derived peridotites exposed in ophiolites is generally considered to reflect source heterogeneity and variability in the conditions of decompression melting. Magma migration through the shallow mantle is another process that may influence the composition of ophiolitic peridotites. The real impact of magma/mantle interaction is poorly constrained by direct observations, and, consequently, may have been underestimated or overestimated in models of magma genesis below spreading centres (mid-ocean ridges and marginal basins). Accordingly, we performed a petrological and geochemical study on samples (veins + wall rocks) collected in twenty sites representative of different types of magma/rock interaction, i.e. various magmas (boninites, andesites and MORB) percolating through peridotites displaying different modal compositions.

Using the electron microprobe (on pyroxenes, Cr-spinel and olivine) and LA-ICP-MS (on cpx), we quantified mineral chemistry as a function of the distance from the veins. Several different patterns of variation were observed. In most cases, a gradient of concentration in incompatible elements (such as Ti in pyroxenes and Cr-spinel, Al, REE in pyroxenes, etc…) is present. An important conclusion is that variations in mineral chemistry are not necessarily related to variations in mineral proportions, i.e. the interaction can be entirely cryptic. This shows that a marked petrological desequilibrium resulting in consumption or precipitation of minerals at the vein walls, is not a prerequisite for chemical exchange between mantle peridotites and percolating melts.

The profiles have the shape of a more or less open “V” or “inverted V”. In other words, both situations of “refertilization” and “defertilization” of the mantle by the percolating melt are observed, and the degree of refertilization or defertilization is more or less pronounced depending on the relative concentration of a given element in the vein relative to the host mantle. The thickness of the reaction zone, defined by the distance at which the concentration level in the mantle rock reaches its “pristine” value, ranges from a few centimetres to one decimetre. In most situations, the concentrations in the wall rock immediately adjacent to the vein reach the concentration levels observed in the vein itself. In some cases, a step is observed, i.e. the concentration of a given element in a mantle mineral evolves towards the vein but does not reach the concentration level of the vein, suggesting incomplete reaction. Other samples do not show clearly developed chemical interaction profiles : either the values in the wall rock and the vein are levelled or no interaction occurred.

We conclude that geochemical interaction is the rule rather than the exception in peridotites hosting magmatic veins whatever their nature and even in the absence of obvious reaction criteria that can be tracked in the field (dunitic margins, etc...). The geochemical effects can be drastic (changes in concentration by up of a factor of 5 for some elements) when the percolating melt has a composition that contrasts markedly with that of the peridotite. The linearity of the geochemical profiles is best accounted for by re-equilibration of mantle minerals with an infiltrating melt whose concentration linearily decreases from 100% in the vein to 0% in the far field peridotite.