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Interactions between high-T hydrothermal fluids and mantle lithologies: evidence from the Oman fossilised spreading centre

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Dykes are omnipresent features in the mantle section of the Oman ophiolite. They are considered as the fossilized melt migration structures that fed the oceanic crust. Nevertheless all the dykes present in the Omanese mantle are not of magmatic origin and about 2% of them show petrological characteristics (textures, mineralogy, chemistry, etc.) that may be explained in the frame of a high-T hydrothermal circulation within the mantle. These hydrothermal dykes (or diopsidite dykes) are composed mainly of pure diopside (Mg#>0.95) highly depleted in Fe, Al, Cr, Ti and other trace and minor elements. We interpreted them as the result of very high-T hydrothermal activity in the upper mantle (see Python et al., Earth Planet. Sci. Letters, 2007 and Python et al., J. Mineral. Petrol. Sci., 2007).

In the Northern part of the Oman ophiolite, the diopsidite dykes are abnormally abundant and their effect is observable in the lithologies (peridotites, gabbroic and pyroxenitic dykes) located in their immediate vicinities. In the field, some diopsidites dykes are crosscut by magmatic dykes, showing that these two features formed more or less contemporaneously and may have interact to some extent. At the contact with a diopsidite dyke, the chemistry of the primary minerals in harzburgites or magmatic dykes is modified. Chromian spinels, olivines and plagioclases showing respectively exceptionally high Cr# (up to 0.85), forsterite (to 0.98) and anorthite (to 0.99) contents. The process leading to the genesis of the diopsidites affect a region larger than the dyke itself, and a few millimetres to few tens of centimetre wide reaction zone is observed between the diopsidite dyke and its host rock. Two types of reaction zones are observed according to the lithology in contact with the diopsidite:

1. In the absence of any magmatic dyke, the reaction zone occurs between the mantle harburgites and the diopsidite dyke. It is very rich in hydrous phases (tremolite and antigorite) and contains low amount of forsterite, diopside and high Cr# chromian spinels. The textures shows that the diopside and the forsterite are not in equilibrium and reacted to form a mixture of antigorite and tremolite. Chromian spinel progressively decompose into pure chromite and chlorite, and the total absence of magnetite suggest a reducing chemical environment.
2. When a mafic dyke is present, the diopsidite dyke react with the magmatic lithology as well as with the peridotite. In this case, these so called "diopsidites" actually contain 40 to 50 Vol.% of anorthite (An%>0.98) and the reaction zone, composed of fine grained diopsides and anorthites which chemical composition is intermediate between the composition of the magmatic dyke and that of the diopsidite. Hydrous phases are very scarce and represented by amphiboles in equilibrium with highly calcic plagioclase.

The diopsidite dykes themselves present large chemical heterogeneities, which probably result from their metamorphic origin. On the other hand, when not included in the reaction zone, their host rocks are relatively homogeneous. Out of the active magmatic zones (absence of any mafic dyke), the mantle probably reacted with a Ca-rich hydrous fluid leading to the formation of antigorite and tremolite in the reaction zone. In an active magmatic zone, the hydrothermal fluid reacted with the magma at very high-T, leading to the formation of the observed assemblage of diopside and anorthite with low amount of amphibole. The chemical composition of the minerals in the reaction zone is intermediate between the magmatic and the hydrothermal compositions, showing that there is a very narrow mixing zone where hydrothermal and magmatic processes interacted.