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CHARACTERIZATION OF DIOPSIDE-KAERSUTITE INTERGROWTH IN BALMUCCIA DUNITES

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INTRODUCTION

Balmuccia is one of the subcontinental mantle peridotite bodies occurring in the Southern Domain of the Western Italian Alps (Lensch, 1971; Rivalenti *et al.*, 1975; Ernst, 1978). It consists of a 4-5 km long, 0-8 km wide lens crossing the Val Sesia just East of the Insubric line. The occurrence of dunites in the spinel-facies mantle massif of Balmuccia represents a precious opportunity to investigate the mineralogical and petrochemical processes governing the dunite formation at relatively high-P conditions (*i.e*. spinel-facies conditions). Dunite lenses are 15-20 m thick and up to 60 m long and contain pods and dykes rich in amphibole, phlogopite, plagioclase and rutile. The studies dealing with this kind of dunites are currently in progress. The preliminary petrographic investigations highlight that melt escaped from gabbroic pods and/or dykes (cm to dm in thickness) into the surrounding dunite. This determined the development of reaction zones (dm-thick), characterised by segregation of newly-formed minerals, basically amphibole and clinopyroxene. However, up to certain distance (~ 8 cm) from the dunite-gabbroic pod/dyke contact, the early recrystallisation is systematically characterised by the formation of mm-large grains showing a tight intergrowth of clinopyroxene and amphibole lamellae (Fig. 1). In these sectors, amphibole crystallises in the interstices as relatively late products of the melt-peridotite interaction. Petrographic survey evidences that amphibole sometimes overgrows grains with clinopyroxene-amphibole intergrowths. The latter show the outermost rim cleaned by amphibole lamellae and formed by pure clinopyroxene, likely as a result of chemical re-equilibration (Fig. 1).

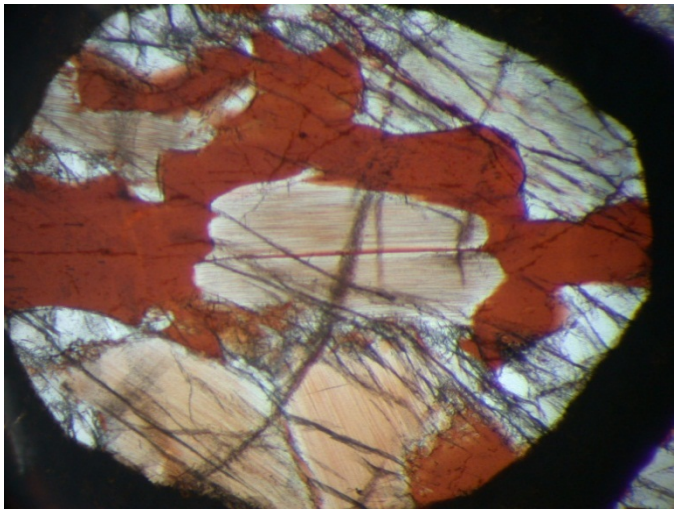

Fig. 1 - Petrographic details of dunites from Balmuccia massif showing pockets related to melt infiltration. These are characterised by early crystallisation of mm-long grains with tight clinopyroxene-amphibole intergrowth. Amphibole and clinopyroxene crystallise as late minerals, and the former locally overgrows the grains with amphibole-clinopyroxene lamellae.

Aim of this research is to reconstruct the mechanism of intergrowth formation by characterizing, in association to petrographic analysis, the two phases and their relative sizes and orientation. Such aim was pursued, during the research period spent at the Bayerisches Geoinstitut in Bayreuth (Germany) thanks to the SIMP grant, by a combined approach which makes use of scanning electron microscopy with electron backscattering diffraction (SEM-EBSD) and transmission electron microscopy (TEM).

EXPERIMENTAL

Thin sections were prepared from four samples and polished by standard methods (SiC and diamond to 0.5 μm). For the SEM-EBSD analysis, an additional step of combined etching and polishing was performed with a high-*p*H colloidal silica solution (40 nm particle size) in order to remove the surface layer damaged by previous polishing. The samples were then coated with *ca*. 4 nm of carbon to reduce charging and possible beam drift during the orientation measurements.

One sample was selected for TEM analysis and prepared from the orientated thin section normal to the **c**-axis. The sample was glued on a Mo-TEM grid and then thinned to electron transparent at 4.5 kV and 0.8 mA by a conventional Ar-milling machine (Gatan Dual milling). The TEM observation of the sample was performed in a transmission electron microscope (Philips CM20FEG), operating at 200 kV. The micro-textures of amphiboles lamellae were examined using bright field (BF) and weak-beam dark-field images and selected area electron diffraction. High resolution TEM images were recorded under some defocus conditions near the Scherzer defocus (-67 nm). The chemical analysis was also performed using a STEM-EDXS system, combined scanning TEM beam with an energy-dispersive X-ray detector.

RESULTS

Back-Scattered SEM inspection of the amphibole-clinopyroxene intergrowth confirms the occurrence of a tight (μm-scale) alternation of amphibole and clinopyroxene lamellae. In some grains, the thickness of the clinopyroxene lamellae (~ 20 μm) is around ten times that of amphiboles whereas in other cases the thickness of the two phases is comparable (2-5 μm). Semi-quantitative EDS analyses indicate that in most cases the major element composition of amphibole and clinopyroxene lamellae is virtually stoichiometric. EBSD maps allowed to determine, by indexing Kikuchi diffraction patterns, the spatial distribution and the orientation relationships between the two phases. The obtained maps show an extremely ordered phase separation in which the amphibole lamellae as well as the late kaersutite crystals are all parallel to (010) in the pyroxene, in agreement with TEM and consistent with previous studies. The topotaxial orientation of the amphibole lamellae with the matrix of clinopyroxene, as revealed by dark field TEM images, is displayed in Fig. 2.

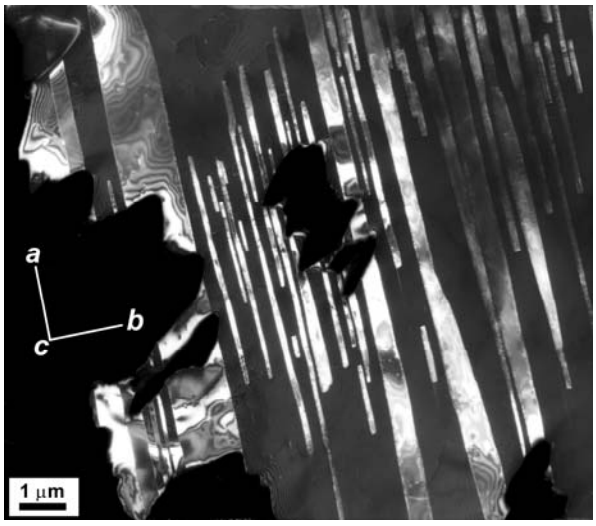

Fig. 2 - A typical texture of amphibole lamellae (white contrast) in the clinopyroxene (black matrix). The both phases share the (010) planes in the same direction. Dark field TEM image with $\mathbf{g} = 5\bar{1}0$ (in the clino-amphibole diffraction).

Diffraction contrast images showed also the presence of finer (less than 100 nm) amphibole lamellae in the diopside. The interface between the two phases contains an array of misfit dislocations due to the differences in the lengths of the **a**-axis. High resolution TEM image of the interface between clinopyroxene and clinoamphibole indicates

intercalation of a chain multiplicity fault of single chains parallel to (010) into the lattice characterized by double chains. The chemical analysis across the interface is currently under progress, to discuss the formation mechanisms of the amphibole lamellae. As far as we are aware, this is the first documentation of tight alternation of diopside and kaersutite lamellae in high-T mantle peridotites. On the basis of the preliminary observations, two hypotheses can be tentatively proposed to explain the development of this kind of crystals. The first one involves the crystallisation of a phase having composition intermediate to that of amphibole and clinopyroxene, and subsequent unmixing. The second one would consider the amphibole-clinopyroxene intergrowth as a primary feature, likely due to very special kinetic conditions of crystallisation.

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