

CRYSTAL CHEMISTRY OF TITANIAN-CLINOHUMITE: A REPOSITORY FOR HFSE IN ANTIGORITE SERPENTINITES

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The crystal chemistry of titanian clinohumite (ticl) is of considerable interest as it is a stable phase in ultramafic rocks from low pressure (TROMMSDORFF & EVANS, 1980) to (ultra)-high pressure (SCAMBELLURI et al. 1995; OKAI, 1994) conditions. In the Alps, titanian clinohumite has been known as a vein and/or accessory rock-forming mineral in serpentinites from greenschist to eclogite and garnet peridotite facies conditions (Malenco, Saas-Zermatt, Erro-Tobbio, Cima Lunga). In the Malenco serpentinite ticl-bearing veins occur in several metamorphic generations concordant and discordant to the main Alpine schistosity. They consist of variable amounts of ticl, diopside, olivine, magnetite, chlorite, antigorite and calcite. Minor phases are perovskite, ilmenite and apatite. In almost undeformed parts of the Malenco ultramafic rocks northeast of Mte Braccia field relations show that ticl growth essentially occurs at or near the contacts between clinopyroxenite and dunite. The clinopyroxenite still contains relics of Al- and Ti- rich cpx, ilmenite and sometimes apatite. Along cracks and small veins an alpine paragenesis of olivine, ticl, diopside, antigorite and chlorite developed. Rarely, also ti-chondrodite has been found. With increasing deformation the clinopyroxenites are boudinaged and often discordant to the main foliation. The magmatic assemblage of the clinopyroxenite has been replaced by diopside, olivine, antigorite, chlorite and ticl, giving rise to an apparent development of discordant ticl bearing veins. In this study, such discordant veins have been analysed.

Major element abundances and some trace elements (Ni, Cr, Co, Sc, V) were analyzed by XRF. REE and other trace elements were analyzed by inductively coupled plasma mass spectrometry (ICP-MS). Bulk rock analyses of ticl-bearing veins are extremely variable in major and trace elements and highly depend on modal amounts of the phases present. In many veins the modal amount of apatite can be as high as 5 percent. In these veins the P, Y, LREE and MREE are dominated by apatite. REE show a flat pattern with a slight depletion in the LREE. Apatite- and diopside- free veins show low REE contents with an increase in the HREE.

The composition of ticl is rather homogeneous in terms of major element composition (i.e. $X_{Mg} = 0.87-0.90$, $X_{Ti} = 0.456$, $X_{OH} = 1$). Carefully handpicked ticl mineral separates from several veins from Val Malenco (purity > 99%) have been analysed by ICP-MS and in situ PIXE. The chondrite normalized REE abundance of ticl is relatively uniform. Ticl has low REE content ($0.1 < REE/chondrite < 1$) and they show a flat REE pattern with a strong increase in the HREE from Dy to Lu ($(Dy/Yb)_n$: 0.01–0.24). Furthermore both weak positive and negative Eu anomalies occur. In a normalized trace element abundance diagram ticl shows positive Zr, Hf and Nb, Ta anomalies. Nb, Ta abundance is unrelated to Zr, Hf and may vary almost two orders

of magnitude (from less than 0.5 ppm to more than 25 ppm for Nb). In addition ticl is characterized by a distinct fractionation of U compared to Th (U/Th)_n: 5–12.

These results indicate that ticl can be an important host not only for Ti, but also for other HFSE as Nb, Ta, Zr and Hf as well as for HREE. However field evidence, the highly variable HFSE content and the relatively homogeneous REE distribution strongly indicates that the chemical composition of Ticl (and ticl bearing veins) is most probably controlled by the host rock.

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