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Stability of Titanian-Clinohumite and Olivine at the High Pressure Breakdown of Antigorite-Serpentinite to Chlorite-Harzburgite: Evidence from the Almirez Ultramafic Massif (S. Spain)

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Subduction of serpentinite is an important process in transporting water to depths critical for the generation of arc magmatism (Scambelluri et al. 1995; Ulmer and Trommsdorff 1995). In hydrated subduction zones, antigorite serpentinite may occur in large portions of the mantle wedge and the incoming subducting slab. A potentially significant dehydration reaction in subduction settings is the high-pressure breakdown of antigorite serpentinite to chlorite harzburgite (olivine + orthopyroxene+ chlorite). There is increasing evidence showing that serpentinite subduction may be a suitable source or sink for geochemically significant elements for arc volcanism such as F, Cl, B, Be, Sr and Li and HFSE (Scambelluri et al., 2004; Garrido et al. 2005). Some of these geochemical characteristics of high-pressure antigorite serpentinite dehydration have been accounted for by stabilization of clinohumite.

We present a study of Ti-clinohumite in rocks of the Cerro del Almirez ultramafic massif (Sierra Nevada, Betic Cordillera, S. Spain) that record the high-pressure antigorite-serpentinite dehydration to form chlorite harzburgite (ol + opx +chl). This allows us to investigate the composition and stability of Ti-clinohumite during high-pressure breakdown of antigorite-serpentinite. Titanian clinohumite and olivine show textural and compositional differences depending on rock type. OH-Ti-clinohumite

occurs in the serpentinite as disseminated grains and in veins. F-OH-Ti-clinohumite is observed exclusively in the chlorite harzburgite, where it occurs as porphyroblastic grains and within prograde olivine as irregular and lamellar, planar intergrowths at microscopic and submicroscopic scales. Petrological evidence of partial to complete breakdown of Ti-clinohumite to olivine + ilmenite is preserved in both rock types. Chlorite harzburgite is characterized by a brown pleochroic olivine with abundant oriented microscopic to submicroscopic oxide particles. The mean Ti-content of bulk brown olivine is 144 ppm. Brown olivine preserves Ti-clinohumite lamellae that sometimes grade into ghost lamellae outlined by oxide trails. This observation suggests that some of the oxide inclusions in brown olivine are derived from the breakdown of Ti-clinohumite intergrowths.

Thermodynamic modelling for selected Almirez bulk rock compositions indicates a temperature increase from 635 to 695 ^0C, at pressures ranging from 1.7 to 2.0 GPa, as the cause for the compositional adjustment of Ti-clinohumite between the Almirez antigorite serpentinite and chlorite harzburgite. These P-T estimates are in good agreement with the sequence of phase relations as observed in the field. The computed phase diagrams in conjunction with geothermal conditions envisaged for different subduction settings indicate that Ti-clinohumite is stable in the vicinity of the antigorite serpentinite / chlorite harzburgite phase boundary in some subduction settings. In these circumstances clinohumite-olivine intergrowths in chlorite harzburgite may act as sink for HFSE, and probably other, elements that are present in mantle-wedge fluids.

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