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Transfer of lithophile and siderophile elements during high-pressure dehydration of antigorite in subduction settings: new insights from the Cerro del Almiréz (Betic cordillera, S. Spain)

Claudio Marchesi (1), Carlos J. Garrido (1), José Alberto Padrón-Navarta (2), María Teresa Gómez-Pugnaire (2), and Vicente López Sánchez-Vizcaíno (3)

(1) Instituto Andaluz de Ciencias de la Tierra, CSIC-UGR, Granada, Spain, (2) Departamento de Mineralogía y Petrología, UGR, Granada, Spain, (3) Departamento de Geología, Universidad de Jaén, Jaén, Spain

We present new geochemical data on high-P antigorite (Atg) serpentinites and chlorite (Chl) harzburgites from the Cerro del Almiréz complex, southern Spain. Here, the transition between the hydrous protolith (antigorite serpentinite) and its prograde dehydration product (chlorite harzburgite) is exceptionally well preserved and can be studied in detail. The peak conditions of the antigorite stability have been experimentally determined at 680-710°C and 1.6-1.9 GPa. Antigorite dehydration was accompanied by release of high amounts of high–P water-rich fluids.

Whole rock trace element patterns of Chl harzburgite normalized to precursor Atg serpentinite display marked positive spikes of Nb, Ta, Zr and Hf indicating that they strongly fractionated high field strength elements (HFSE) relative to light (LREE) and middle (MREE) rare earth elements. Chl harzburgites show statistically significantly higher Nb/La, Ta/La, Zr/Sm and Hf/Sm than precursor Atg serpentinites. This indicates that fluids released during the formation of prograde Chl harzburgites had complementary low Nb-Ta/LREE and Zr-Hf/MREE ratios. Our data show that the Zr and HREE concentrations of most Chl harzburgites are similar to those of precursor Atg serpentinites, and these elements were hence effectively immobile during deserpentinization. The high Zr/Sm and Hf/Sm ratios of Chl harzburgites are therefore due primarily to the preferential mobility of MREE into fluids. In contrast, relative gains of Nb, Ta, and U observed in Chl harzburgites relative to Atg serpentinites require high fluid/rock ratios as well as preferential LREE partitioning into fluids, implying that formation of Chl harzburgite by dehydration occurred in an open system. These data indicate that Chl harzburgite behaved as a sink of HFSE (notably Nb and Ta) during open-system dehydration of Atg serpentinite.

Atg serpentinites have elevated average H_2O (10 wt%), S ($\sim$1000 ppm), and variable C (180-1280 ppm) contents. Lower average H_2O (5.7 wt%) and S (610 ppm) in Chl harzburgites strongly support that high-P dehydration of Atg serpentinites resulted in loss of about half of their H_2O and S abundances. The δ^{34}S (-5.1 to 10.2‰) and δ^{18}O (6.4-9.5‰) of Chl harzburgites coincide with those of Atg serpentinites; on the other hand, hydrogen isotopes fractionated probably during dehydration (δD = $\sim$ 55‰ in Atg serpentinite and from $\sim$ -90 to -70‰ in Chl harzburgite).

In summary, our results mainly indicate that dehydration of serpentinites at high P-T in subduction zones produces flux of S, H_2O and possibly C to the sub-arc mantle, as well as a sink for HFSE. Residual sulfur, water and carbon in the products of serpentinite dehydration can be recycled into the deep mantle and contribute to its isotope heterogeneities.