American Mineralogist, Volume 97, pages 184–196, 2012

Implications of ferrous and ferric iron in antigorite

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Abstract

Microprobe analyses of antigorite show that (Al+Cr) and inferred Fe^{3+} correlate inversely with Si apfu in a Tschermaks substitution. This observation suggests that the uptake of Fe^{3+} is not simply related to f_{O_2}. For Si = 1.95 apfu estimated Fe^{3+} = 0.032 apfu (or 0.95 wt% Fe_2O_3). Such estimates of Fe^{3+} require high analytical accuracy and precision, and assume a fixed polysomatic formula (e.g., m = 17) and freedom from interlayer sheet-silicate impurities. In many cases the estimates appear to be high. An alternative measure of Fe^{3+} is provided by the partitioning of total Fe and Mg between antigorite and olivine in well-equilibrated natural antigorite-olivine-magnetite parageneses. Extrapolation of Nernst and Roozeboom partition plots to Fe-free olivine permits an estimate of the Fe^{3+} content of the average antigorite in this paragenesis, namely 0.42 or 0.64 wt% Fe_2O_3.

The partition estimates are in good agreement with the results of Mössbauer spectroscopy performed here on 14 antigorites from metaperidotites, together with four from the literature. These spectra reveal a range of 0.16 to 1.94 in wt% Fe_2O_3 in metaperidotite antigorite, with an average of 0.83. In two olivine-bearing rocks, antigorite has $Fe^{3+}/\Sigma Fe$ ratios of 0.13 and 0.15, which corresponds to wt% Fe_2O_3 = 0.47 and 0.54, respectively. Larger amounts of Fe_2O_3 occur in some, but not all, vein antigorites. The prograde formation of antigorite in serpentinite from lizardite is accompanied by loss of some cronstedtite component and the precipitation of additional magnetite.

The Roozeboom Mg/Fe partition plot is concave down rather than up; in other words the partition coefficient K_D is a function of the X_{Mg} of olivine. This behavior has been found in other olivine-mineral pairs. It can be interpreted to reflect strongly non-ideal solution behavior of MgFe-olivine at low temperatures, viz. $W_G \approx 8.5$ kJ assuming a symmetrical solution. MgFe-brucite appears to be similarly non-ideal.

Keywords: Antigorite, Mössbauer spectroscopy, microprobe, ferrous/ferric ratios, cronstedtite component, non-ideal olivine