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The effect of Cr on chlorite stability and the appearance of a new Al-rich silicate

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Chlorite is an important water carrier which transfers and potentially releases H_2O deep into the Earth´s Mantle. Chlorite stability field does not exceed 760-780˚C at 4 GPa in a model NCFMASH peridotite, but chlorite was found to extend to more than 850˚C, at approx. 3 GPa, in a more complex chemical systems, in which the addition of Cr_2O_3 stabilizes Cr-chlorite with up to 1.4 wt % Cr_2O_3. To understand the influence of minor components on breakdown reactions, we experimentally investigated chlorite in the Cr_2O_3-MgO-Al_2O_3-SiO_2-H_2O system. Assuming that Cr is substituting for Al in the octahedral site of a clinochlore stoichiometry of $Mg_{10}Al_2(Si_6Al_2)O_{20}(OH)_{16}$, three different bulk compositions A, B and C with Cr/(Cr+Al) = 0.15, 0.5 and 1.0 have been considered. Gels have been used as starting materials and run between 1.5-6.5 GPa, 650-900˚C in piston cylinder and multi anvil apparatus. All experiments were fluid saturated. All run products have been inspected by SE/BSE images and were analyzed by EMPA.

Cr-chlorite was found only in bulk A. It coexists with enstatite up to 3.5 GPa, 800˚C; at 5.0 GPa, 750˚C it coexists with forsterite, pyrope and spinel. At 900˚C, 3.5 GPa, the anhydrous phase assemblage pyrope, forsterite and spinel has been found. At 5.5 GPa, 670˚C and 6.0 GPa, 650˚C Mg-sursassite (with a= 8.532 Å, b= 5.735 Å, c= 9.673 Å, α= 90˚, β= 108˚ and γ= 90˚) was observed. Bulk B and C show a chromite, enstatite and forsterite phase assemblage; no pyrope was detected up to 6.5 GPa, 700˚C. Cr-chlorite synchrotron diffraction patterns show the following cell parameters for the synthesis in the range 2.0-5.0 GPa, 750-800˚C. (a=5.3237 Å, b= 9.2215 Å, c=14.3785 Å, α=89.88˚, β= 97.08˚ and γ= 89.99˚). Chromium strongly partitions into spinel (X_{Cr}=0.8806), followed by orthopyroxene (X_{Cr}=0.1428), Cr-chlorite (X_{Cr}=0.0815) and garnet (X_{Cr}= 0.0339).

Cr affects the stability of chlorite by shifting its breakdown reactions towards higher T and P, but Cr solubility at high P results to be reduced as compared with low P occurrence in hydrothermal environments.

Furthermore we discovered in the experiment at 5.4 GPa, 720˚C a until now unknown hydrous phase coexisting with pyrope, forsterite and spinel. Diffraction pattern taken with TEM suggest a C-centered monoclinic unit cell for the new phase having: a= 9.9 Å; b= 11.8 Å and c= 5.12 Å with β = 109˚. The extinction conditions are compatible with space groups Cc or C2/c. At the moment reproducing experiments are in progress to proof this detection.