American Mineralogist, Volume 92, pages 735–747, 2007

High-temperature phase relations and topological constraints in the quaternary system MgO-Al_2O_3-SiO_2-Cr_2O_3: An experimental study

Cristiano Brigida,[1] Stefano Poli,[1,2,*] and Massimiliano Valle[2]

[1]Dipartimento di Scienze della Terra, Università di Milano, Via Botticelli 23, 20133 Milano, Italy
[2]Petroceramics Srl, Via Botticelli 23, 20133 Milano, Italy

Abstract

Phase relationships in the system MgO-Al_2O_3-SiO_2-Cr_2O_3 (MASCr) were investigated experimentally from 1250 to 1560 °C using a 1-atm vertical quench furnace on 12 oxide mixtures covering a wide range of chemical compositions. Spinel, corundum, mullite, and sapphirine were found to display a wide range of solid solutions toward CR-rich end-members, whereas enstatite, cordierite, forsterite, and glasses were always Cr-poor. Glasses formed in relatively MgO-rich bulk compositions from 1250 °C, in assemblage with cordierite, enstatite, forsterite, and spinel, suggesting a lowering of the eutectic minimum in MASCr compared to available melting relationships in the model system MAS. Although unexpected, the relatively low-temperature melting of Cr-bearing mixtures is supported by topological constraints in the subsystems SACr and MSCr. The extent of Cr solubility in mullite has been found to reach ~14 wt% at 1560 °C, and 33 wt% in sapphirine at 1340 °C, which are the highest Cr values reported so far for these minerals. Liquidus surfaces are constrained by glass compositions that are displaced systematically toward silica compared to corresponding liquids in the ternary system MAS. As a consequence, the primary crystallization fields of Cr-spinel, Cr-sapphirine, and Cr-mullite are found to face the cristobalite/tridymite primary fields. A tentative liquidus diagram for the system MgO-Al_2O_3-SiO_2-Cr_2O_3 is proposed, which could serve as a basis for the interpretation of the high-temperature evolution of planetary materials as well as for the development of new ceramic materials.

Keywords: Mullite, spinel, sapphirine, chromium, glass, liquidus phase diagram