Phase formation in the system (Ca,Sr)Al_{2}O_{4}

JACQUES BARBIER and JÖRG NEUHAUSEN

Department of Chemistry, McMaster University, 1280 Main Street West, Hamilton, Ontario, L8S 4M1, Canada

Abstract: The phase relations in the system (Ca,Sr)Al_{2}O_{4} have been studied by powder X-ray diffraction and electron microscopy on products quenched from 1400 and 1600°C. Three structure-type have been identified including the CaAl_{2}O_{4} beryllonite structure (0-30 at% Sr), a pseudo-hexagonal twinned orthorhombic structure (40-70 at% Sr). The quenched phases containing 40-100 at% Sr are room-temperature distortions of an unquenchable high-temperature hexagonal kalsilite phase. Strong structural analogies existing between the (Ca,Sr)Al_{2}O_{4} and (Na,K)AlGeO_{4} systems are discussed in terms of the dependence of the topologies of the tetrahedral frameworks on the size of the alkali and alkaline-earth atoms.

Key-words: (Ca,Sr)Al_{2}O_{4} system, phase relations, tridymite-derivative compounds, powder X-ray diffraction, electron microscopy.

1. Introduction

The aluminates MAI_{2}O_{4} (M = Ca,Sr,Ba) crystallize with tridymite derivative structures consisting of a three-dimensional framework of corner-connected AlO_{4} tetrahedra, the cavities of which are filled with alkaline-earth metal atoms (Fig. 1). As such, these compounds are structurally related to the mineralogically important nepheline-kalsilite series, (Na,K)AlSiO_{4} (e.g. Merlino, 1984; Liebau, 1985), and the study of their crystal chemistry is of interest to solid-state chemists and mineralogists (e.g. Taylor, 1983, 1984 and references therein). CaAl_{2}O_{4} crystallizes with a beryllonite (NaBePO_{4})-type structure (Hörkner & Müller-Buschbaum, 1976) while both SrAl_{2}O_{4} (Schulze & Müller-Buschbaum, 1981) and BaAl_{2}O_{4} (Hörkner & Müller-Buschbaum, 1979) crystallize with kalsilite (KAlSiO_{4})-type structures. The crystal chemistry of the mixed compounds (Sr,Ba)Al_{2}O_{4} has also been investigated in detail with respect, in particular, to their structural behaviour at high temperature (Henderson & Taylor, 1982; Taylor et al., 1985) and the results have been used to obtain new insights into the complex polymorphism of the (Na,K)AlSiO_{4} mineral system.

The present paper reports on the investigation of phase relations in the related (Ca,Sr)Al_{2}O_{4} system using powder X-ray diffraction and transmission electron microscopy. The results are discussed in terms of the structure-types identified in this system and their relative stabilities as a function of composition and temperature and, also, in terms of clearly apparent structural analogies with the (Na,K)AlGeO_{4} system studied recently (Barbier & Fleet, 1988).

2. Experimental procedure

The (Ca,Sr)Al_{2}O_{4} compounds were synthesized by high-temperature sintering of stoichiometric mixtures of CaCO_{3}, Al_{2}O_{3} and Sr(CH_{3}COO)_{2}·1/2H_{2}O powders. A series of eleven compositions, (Ca_{1-x}Sr_{x})Al_{2}O_{4}, were prepared with x varying from 0.0 to 1.0 in steps of 0.1.