Synthesis and characterization of white micas in the join muscovite–aluminoceladonite

MAX W. SCHMIDT, 1 MATTIA DUGNANI, 2 AND GILBERTO ARTIOLI 2,3,*

1 CNRS, UMR 6524 Magmas et Volcans, Université Blaise Pascal, F-63038 Clermont-Ferrand, France
2 Dipartimento di Scienze della Terra, Università di Milano, I-20133 Milano, Italy
3 CNR Centro di Studio per la Geodinamica Alpina e Quaternaria, I-20133 Milano, Italy

ABSTRACT

Potassic white micas were synthesized in the K2O-MgO-Al2O3-SiO2-H2O system along the pseudobinary join muscovite–aluminoceladonite (mu-Alcel). Composition of run products as measured by electron microprobe analysis are in the range mu0.07-Alcel0.1 to mu0.1-Alcel0.9. Cell parameters were determined on powder samples by full-profile Rietveld refinement, using both a single-polytype and a multi-polytype model. The results of both analysis models are in full agreement, and show that the phengite cell parameters have a distinct dependence on the celadonite content: the c parameter shows a monotonic decrease over the full compositional range, whereas the a and b parameters both increase in the Alcel1–Alcel0 range but decrease in the Alcel0–Alcel1 range. The monoclinic b angle decreases slightly with increasing celadonite content. The overall behavior of the cell parameters indicates a decrease of the ditrigonal distortion of the tetrahedral 6-rings, and an increased trioctahedral character of the structure at high celadonite compositions. The molar volume along the solid solution join shows a maximum at about Alcel0. Molar volume vs. composition can be fitted by a symmetric function for the excess volume yielding a molar volume for end member aluminoceladonite of 13.957 ± 0.006 J/bar, for muscovite 14.076 ± 0.004 J/bar, and a symmetric positive deviation from ideal volumes of mixing with W = 0.198 ± 0.025 J/bar, and r2 = 0.941. The use of an asymmetric excess volume function does not significantly improve the fit quality (r2 = 0.945).

INTRODUCTION

Potassic white micas form a solid solution between muscovite, K(Al,Fe3+)2[Si,Al]O10(OH)2, and celadonite, K(Al,Fe3+)3(Mg,Fe2+)2[Si,Al]O10(OH)2, with the coupled heterovalent Tschermak substitution AlVIAlIV ↔ MgVII SiIV linking the end members. Common homovalent substitutions are the unlimited Mg ↔ Fe2+, and AlVI ↔ Fe3+ exchanges and the limited K ↔ Na exchange. Finally, the very limited coupled heterovalent substitution 2 AlVI ↔ 3 MgVIII links dioctahedral to trioctahedral micas. Potassic white micas are common rock-forming minerals in low to intermediate grade metamorphism but also occur magmatically in granitoids. In granitoids and during low pressure Barrow-type metamorphism, i.e., in greenschist or low to intermediate amphibolite facies, potassic white micas are mostly close to the muscovite end member with typically 3.3 to 3.3 Si atoms per formula unit (pfu). During high pressure metamorphism, i.e., at blueschist or eclogite facies, intermediate amphibolite facies, intermediate members, so-called phengites, occur having typically Si contents from 3.3 to 3.55 Si pfu. Mg-Al-phengites with higher Si-contents of up to 3.8 Si pfu rarely occur (Kardymowicz 1960; Seifert 1968; Ghent et al. 1993; Dalla Torre et al. 1996). Richer Fe2+ and Fe3+ celadonites with almost 4.0 Si pfu form together with glauconite during low-temperature hydrothermal sea floor alteration (see Odom 1984 for a review) clearly showing that Si-content by itself is not a reliable pressure indicator.

Because of the pressure sensitivity of the Tschermak exchange in white mica, phengite could be extremely useful for geobarometry in blueschists and eclogites. Any eclogite contains by definition garnet and clinopyroxene and thus buffers the Tschermak exchange according to the equation 2 pyrope + 1 grossular = tk-exchange + 3 diopside. Despite this geobarometric potential, the crystallographic and thus also thermodynamic properties of the phengite solid solution remain poorly understood. In order to progress on this issue it is necessary to establish a correct molar volume relation in the muscovite–aluminoceladonite solid solution. This is the scope of the present study.

Phengites are known to show extensive polytypism, and the characterization of the crystallographic properties is complicated by the potential simultaneous occurrence of several polytypes (1M, Md, 2M1, and 3T) in synthetic products. In nature, most phengites occur either in the polytypes 2M1 or 3T. Velde (1965) suggested that kinetics plays an important role for polytypism and that 2M1 is the most stable polype. Composition is another factor suggested to influence the stability of the 2M1 and 3T polytypes, with Fe2+ and/or Na necessary to stabilize the 3T polype. Stöckert (1985) for example observed a correlation between the Mg/(Al + Fe + Mg) value and the rec-