Alkali partitioning between beryl and hydrothermal fluids: an experimental study at 600 °C and 1.5 kbar

VALÉRIE MANIER-GLAVINAZ, PHILIPPE D’ARCO and MARTINE LAGACHE

Laboratoire de Géologie, Ecole Normale Supérieure, C.N.R.S., URA 1316, 24 rue Lhomond, 75005 Paris, France

Abstract: A natural lithian-caesian beryl was re-equilibrated with hydrothermal chloride solutions of Li, Na or Cs, at 600 °C and 1.5 kbar. The alkali elements substitute one another in the mineral, suggesting that they occupy the same structural position. Beryl composition depends on the absolute amount of alkalis present in the solution and not on the alkali concentration. Partition coefficients, Pi, are defined as follows: Pi = Xi(Bl)/Xi(fl) where Xi(Bl) and Xi(fl) are i/(Li+Na+Cs) ratios of the beryl and of the solution, respectively. i = Li, Na or Cs is expressed in μmol per 100 mg of beryl or 100 μl of solution. Average values are: P Li = 1.12, P Na = 0.51 and P Cs = 2.10. These coefficients are independent of chlorinity but in fact slightly depend on the solution (and solid) alkali composition.

Using these coefficients, and assuming equivalent crystallization conditions, the Li-, Na- and Cs-ratios of mineralizing fluids have been estimated on the basis of the compositions of several natural beryls; their relative constancy may reflect the buffering of the pegmatite system by alkali-aluminosilicates.

Key-words : experimental mineralogy, beryl, hydrothermal fluids, rare alkali elements, partition coefficients.

Introduction

Beryl is a common accessory mineral in granitic pegmatites and may crystallize at any stage of differentiation of these rocks. Early beryls, intergrown with quartz and feldspars, crystallize from the melt (Burt, 1982); late beryls, generally alkali-rich, may precipitate from late albitizing fluids (Černý and Simpson, 1977; Beus, 1966).

The crystal structure of beryl, ideally Be3Al2Si6O18, was determined by Bragg and West (1926). It has been confirmed by numerous authors, using various methods (Belov and Matveeva, 1950; Bergerhoff and Nowacki, 1955; Gibbs et al., 1968; Morosin, 1972). It consists of hexagonal rings of SiO4 tetrahedra, stacked along the c axis forming channels. The rings are cross-linked by BeO4 tetrahedra and AlO6 octahedra. Natural beryls usually depart widely from the ideal formula. They contain large amounts of impurities such as alkali metals, water molecules, iron, etc. Divalent cations are supposed to substitute for aluminium in octahedral sites (Aurisicchio et al., 1988). The structural position of alkali cations has long been a matter of controversy. It is now agreed that water molecules and alkalis, except Li, are localized in the channels as shown in Fig. 1 (Brown and Mills, 1986). According to Belov (1958) and Bakakin et al. (1969), Li replaces Be, but Hawthorne and Černý (1977) consider that some Li can also be located in the channels.

A strong relationship between the alkali content of natural beryls and the chemistry of their host pegmatite has long been pointed out. This has led Černý (1975) to suggest a geochemical control for the alkali content of beryls.

Our interest in beryls of rare-alkali-rich pegmatites (Li, Cs) led us to examine the geochemical behaviour of alkalis in beryl with respect to the alkali elements present in the hydrothermal fluids during crystallization. Pre