Presence and zoning of hydrous components in leucite from the Alban Hills volcano, Rome, Italy

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ABSTRACT

This paper reports a single-crystal FTIR spectroscopic study of leucite, a nominally anhydrous mineral (NAM). Several transparent, inclusion-free samples from different occurrences and localities in the Alban Hills volcanic area (Latium, Italy) were analyzed. The FTIR spectra collected in the 4000–3000 cm⁻¹ H₂O-stretching region show a broad absorption consisting of overlapping components at 3604, 3500, and 3245 cm⁻¹. The occurrence of a well-defined combination band at 5225 cm⁻¹ indicates that almost all the examined samples contain hydrous components in the form of structurally bound water molecules. Using the integrated molar absorption coefficient from the working curve of Libowitzky and Rossman (1997), a water content up to >4000 ppm was obtained for the studied specimens. Detailed microspectroscopy mapping shows significant zoning of water in some samples, typically consisting of an anhydrous core mantled by a hydrous rim. The collected data suggest that careful study of the distribution of the volatile content of leucite (and associated volcanic NAMs) may provide a tool to monitor the evolution of the magmatic system where these minerals occur.

Keywords: Leucite, Latium, single-crystal FTIR spectroscopy, microchemical composition, H₂O mapping

INTRODUCTION

The study of magmatic volatiles is essentially based on the determination of the amount of H₂O and CO₂ in the glass (assumed to represent almost the total gas phase dissolved in the melt). However, it is now well known that several nominally anhydrous minerals (NAMs) from volcanic rocks may contain trace but significant amounts of molecular hydrous species (Beran 1986; Beran and Rossman 1989; Farver and Yund 1990; Balassone and Beran 1995; Johnson and Rossman 2003, 2004; Johnson 2005, 2006; Balassone et al. 2006). Therefore, the study of these minerals may offer the possibility to monitor the partition behavior of hydrogen between mineral and melt is known (Johnson 2006).

Leucite is a characteristic mineral of K-rich basic magmas, such as leucite-basanite, leucite-tephrite, and leucite-mellilite basalts; it typically occurs in these rocks as an early formed phenocryst. It is also an essential constituent of the K-rich ultrabasic volcanic rocks, ugandite and katungite (Deer et al. 2004). In Latium (central Italy), leucite is a widespread constituent of lava flows, pumice flows, and pyroclastic deposits; it also occurs in ejected blocks of various types and can be a major constituent in some particular xenoliths (“italite,” Washington 1927; Federico et al. 1994).

The composition of natural leucite does not deviate significantly from the ideal stoichiometry KAlSi₃O₈; replacement of K by Na rarely exceeds 10% (Deer et al. 2004). At room T, leucite is tetragonal (pseudo-cubic), but it gradually changes on heating to cubic at ~625 °C (e.g., Mazzi et al. 1976). The structure of leucite is based on an (Si,Al)-O tetrahedral framework, isotypic with that of analcime (NaAlSi₂O₆·H₂O) and of the rare Cs-rich zeolite pollucite (CsAlSi₃O₈·xH₂O). In all these minerals, (Si,Al)-tetrahedra are linked to form six- and four-membered rings as “secondary building units” (Barea laocher et al. 2001). The center of each six-membered ring is occupied by K in leucite and Cs (or H₂O) in pollucite, as extraframework constituent, and by water molecules in analcime. Analcime is a zeolite-type hydrous mineral; its stoichiometric water content is >8.0 wt%, and Cs-analcime (pollucite) is also a hydrous mineral with H₂O contents up to 7.5 wt% (Černý 1974; Teertstra et al. 1994). In contrast, leucite is essentially anhydrous, in agreement with its origin as an early crystalizing volcanic mineral. However, minor but significant amounts of a hydrous component have been detected (Balassone et al. 2006) in leucite from Vesuvius and Roccamonfina, two volcanic centers south of Rome (Italy).

During a recent systematic FTIR spectroscopic study of minerals from the volcanic region of Latium (Italy), we observed (Della Ventura et al. 2005, 2007; Piccinini et al. 2006) that water is a widespread component in leucite from all volcanic products of central Italy. In those papers, we described the data collected on some samples from the Alban Hills volcanic complex (Rome) with particular emphasis on the zoning of water in leucite, a feature that has possible applications in igneous petrology, especially for monitoring the evolution of volatile systems in still active volcanic areas. The main goal of the present paper

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