

Trace element distribution between richteritic amphiboles and silicate melts, and contrasts to their behaviour in calcic amphiboles

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Potassic richterites occur as primary magmatic phases in lamproites and are also known from xenoliths in lamproites and kimberlites believed to be formed by the high-pressure crystallisation of similar melts. The partitioning of trace elements between K-richterites and silicate melts has, however, been neglected other than a few measurements on mineral-mineral partitioning in natural rocks. Here, we present the first results of high-pressure partitioning experiments which were performed as part of a more comprehensive study aimed at understanding the crystal-chemical control of trace-element partitioning in a variety of amphibole structures. These studies consist of experimental synthesis of amphibole-melt pairs at high pressures, analysis of the trace element partitioning by SIMS, and the determination of

crystal structures and site sizes. Experiments were performed on a synthetic bulk composition based on partial melts of mica pyroxenites, which are similar to silica rich lamproites (SiO_2 : 52 wt.%; Al_2O_3 : 3 wt.%; K_2O : 9.6 wt.%).

Partitioning results have been obtained to date for amphibole-melt pairs from pressures of 10–15 kbar and temperatures between 850° and 1050°C. The bulk composition has also been systematically varied in three series of experiments, in each of which one of Mg/Fe ratio (0.2–0.8), K/Na ratio (0.125 to 2) or TiO_2 -concentration (1.5–10 wt.%) was varied whilst the others were held constant. Fig.1 illustrates the trace element partitioning patterns for 26 elements for a selection of potassic richterites which differ in TiO_2 content. The pattern for a typical kaersutite from a basanite with $\text{Mg}\# = 0.6$ (TiO_2 : 5.6%) is

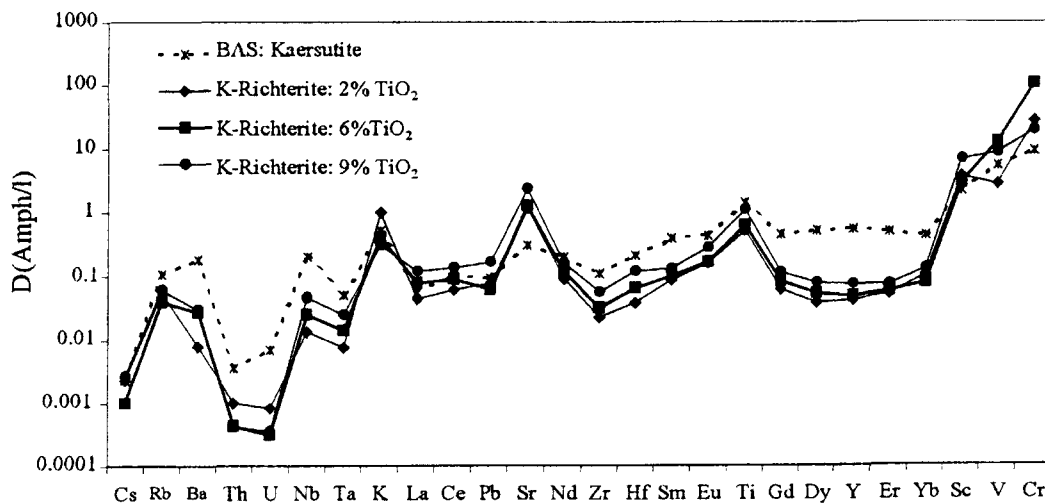


FIG. 1. Trace element partitioning patterns for K-richterite with different TiO_2 contents and one kaersutite occurring in a basanite (BAS).

shown for comparison. The general pattern for potassic richterite shows some systematic differences from that of kaersutite and a significant correlation of increasing $D(\text{Am}/\text{Lq})$ with increasing TiO_2 content. A similar decrease in $D(\text{Am}/\text{Lq})$ is seen with decreasing Mg/Fe , whereas variation of K/Na does not produce a systematic change in the level of partition coefficients. The principle characteristics of the trace element partitioning pattern for potassic richterite are generally lower values for most elements, including all the rare earth elements (*REE*), significant positive spikes in the pattern for Sr, Rb and Ba (K and Ti are major elements) and a curved pattern in the heavy *REE*. Variation in temperature between 850° and 1050°C does not cause appreciable change in the partition coefficients other than for the compatible trace elements Sc, Cr and V. These increase by more than an order of magnitude with decreasing temperature, in keeping with their behaviour in other silicate minerals and spinels. The concave-upward pattern in the *HREE* can be demonstrated from the crystal structure analysis to be due to the incorporation of the heaviest *REE* Yb and Er at the M2 site (Tiepolo *et al.* 1998, this issue) The decrease of $D(\text{REE})$ relative to calcic amphiboles can be explained by the variation of Ca-Na occupancy on M4. The K-richterites are similar to the kaersutites in that Ti on the octahedral sites is distributed between the M1 site, where it is

associated with the oxy-component, and the M2-site where it is charge balanced by higher Na contents in the neighbouring M4 site. However, Ti occurs also in the tetrahedral double chain (Oberti *et al.*, 1998, this issue). The higher Sr partition coefficient in K-richterite is due to enlargement of the M4 site by the higher Na occupancy relative to that in kaersutite, making the M4 site more convenient for the ionic radius of strontium. Despite the positive spikes in the pattern for Ba and Rb, the partition coefficients for K-richterite are lower than for kaersutite. In the case of Ba, this can be explained by the higher Si occupancy in the tetrahedral sites working to prevent incorporation of the divalent Ba in the A-site. The trace element occupancy of the A-site confirms the counter-intuitive observation from natural K-richterites that Rb and Cs are less abundant in alkali than in calcic amphiboles (Foley *et al.*, 1995).

References

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