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Zr solubility in alkaline silica-undersaturated magmas: stability of eudialyte and element distribution between eudialyte and alkaline melts

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Eudialyte-group minerals (EGM) are complex zirconosilicate solid solutions of global interest as a potential source of Zr, Nb, Ta, and heavy rare earth elements (REE), which are critical materials for modern technologies. In petrology, EGM are unique tracers of peralkaline silica-undersaturated rocks often associating with carbonatites. Experimental studies of silicate-carbonate liquid immiscibility (e.g., [1]) have shown that Zr strongly partitions to silicate melt. Crystallization of EGM may strongly deplete silicate/carbonate magma in REE and other ore-forming elements. In this study Zr solubility was studied in peralkaline melts from the system Na_2O–CaO–Al_2O_3–SiO_2 ± H_2O at temperatures between 750 and 1000 °C and pressures of 100 and 200 MPa. We used three starting compositions with different Na/Al values: 1.37, 1.93, and 3.42. Variable amounts of natural eudialyte were added to the starting mixtures. Experiments were carried out in cold seal and internally heated pressure vessels. Run products were analysed by electron microprobe and LA ICP-MS.

Crystalline phases in run products were eudialyte (Fig. 1a), parakeldyshite (Fig. 1b) and albite. Eudialyte was found to decompose 900 and 1000 °C to parakeldyshite. Eudialyte solubility at nominally dry conditions and 750-850 °C is at about 0.2-0.22 wt.% ZrO_2 in the melt. With the additions of H_2O, the solubility greatly increases up to 1.1–2.85 wt.% ZrO_2 in the same temperature interval. REE and HFSE are strongly compatible with eudialyte as the eudialyte-melt distribution coefficients (*D*) for the elements rise from 2 to 90 (Fig. 2). The lowest *D* values are observed in experiments with the highest Zr solubility, i.e., at high temperature and in hydrated compositions. Light REEs and especially La tend to have lower *D* values than the heavy REE.

[1] Veksler, Dorfman, Dulski, Kamenetsky, Danyushevsky, Jeffries & Dingwell (2012), *Geochimica et Cosmochimica Acta*, *79*, 20-40.

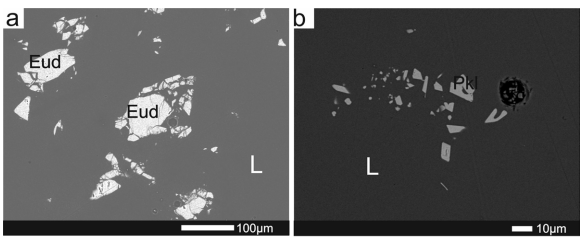

Figure 1

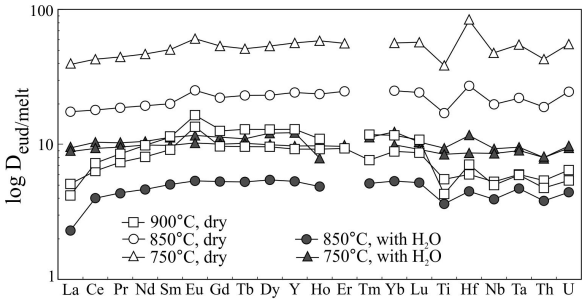

Figure 2