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Systematic study of high field strength elements during liquid immiscibility between carbonatitic melt and silicate melt

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Abstract

Natural carbonatites exhibit a wide range of high field strength elements (HFSEs) and the highest Nb/Ta and Zr/Hf ratios among various rock types. However, primitive carbonatitic melts derived from carbonated peridotite do not display significant fractionation of Nb-Ta and Zr-Hf. To investigate this further, we conducted liquid immiscibility experiments to comprehend the differentiation of these HFSEs. Our experiments revealed substantial changes in partition coefficients for Nb, Ta, Zr, and Hf between carbonatite and silicate melts. We identified a positive correlation between the partition coefficients of these elements and Si, indicating that Si determines the differentiation of Nb-Ta and Zr-Hf during liquid immiscibility. The partition coefficients of Si increase as temperature increases and pressure decreases, resulting in higher HFSE concentrations during the early stages of liquid immiscibility. Liquid immiscibility is crucial in differentiating HFSEs in carbonatitic melts, explaining the association between super large carbonatite-related Nb deposits and Si-undersaturated silicate rocks.

Keywords: High field strength elements (HFSE), liquid immiscibility, carbonatitic and silicate melt, piston-cylinder experiments