Experimental constraints on the stability of baddeleyite and zircon in carbonatite melts

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Carbonatites are uncommon carbonate-rich igneous rocks, that may play an important role in upper mantle metasomatic processes, and also form important ores for REE, and many other metals. As many carbonatites are coarse grained plutonic inclusions, it is often difficult to establish meaningful bulk compositions. Furthermore, as many carbonatites may be cumulates or contain significant amounts of cumulate minerals, it is even more difficult to constrain the actual melt composition from which the carbonatite rock was formed. Here we aim to use accessory minerals in carbonatite to better constrain (primary) carbonatite melt compositions: Since carbonatites are silica-undersaturated rocks, their predominant zirconium accessory mineral is baddeleyite (ZrO_2). However, in many carbonatites both zircon and baddeleyite are found. In this study, we present experimental data of the stability of zircon and baddeleyite in carbonatite melts with different bulk compositions, ranging from Si-free carbonatite to carbonatite compositions with 40% (wt.) SiO_2.

All experiments were performed in a piston-cylinder apparatus at 0.7 GPa and temperatures of 1000°C and 1200°C. The quenched carbonatite melts were analyzed using an electron microprobe with an acceleration voltage of 15 kV, a beam current of 15nA, and a defocused beam of 15-20 μm.

Our results show that carbonatites need high ZrO_2 and SiO_2 concentrations to saturate in baddeleyite and/or zircon. The stability of both minerals in these melts also strongly depends on temperature. Our preliminary data shows that low silica calciocarbonatites cannot crystallize zircon but melts require about 20-30 % SiO_2 to saturate in zircon. This can be achieved by contamination from the silicate rocks normally associated with carbonatites (e.g. phonolite, melilite, or syenite). Alternatively, zircon may crystallize from a near-primary carbonatite magma with high silica activity [1].

[1] Barker, S.D. 2001. Calculated silica activities in carbonatite liquids. *Contrib Mineral Petrol*, **141**: 704-709