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In-situ trace element and U-Pb-, Sr- and Nd- isotope analysis of accessory phases in Kaiserstuhl Carbonatites

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Laser ablation ICP mass spectrometry is a fast and precise tool in age determination and the analysis of isotope ratios of rocks where minerals with suitable element contents are available. Well known and widely accepted is the use of zircon in this context for U-Pb age dating and the analysis of their Hf isotopes. The large variety of accessory phases from alkaline and carbonatite complexes with their high trace element contents have the potential to exploit more radiogenic systems. Perovskites are already in use (e.g. Heaman et al. 2009) and recently Kogarko et al. (2009) have shown that pyrochlore, loparite and eudialyte are potentially of equal use for age determination and to identify magmatic processes and crustal contamination.

Here, we apply in-situ laser ablation analysis to U, REE and Sr rich phases in carbonatites and bergalites from the Kaiserstuhl alkaline complex. We then compare these results with known age and isotope data from bulk rocks. The Kaiserstuhl is situated in the southern part of the Rhine Graben rift. It consists of olivine nephelinites, tephrites, phonolites and subvolcanics like essexites on the one hand and bergalites and carbonatites as another stream of alkaline rocks. In this study we conducted in-situ laser ablation (MC)ICP-MS Sr-, Nd-, Hf-, isotope analyses as well as U-Pb geochronology on perovskites, pyrochlores, andradites, calzirtites and zirconolites from the carbonatites (soevite and alvikitic dykes) and perovskites from the bergalites.

The εNd values of all phases in the carbonatites range between 2.7 and 3.8 except for a few of the andradites from the Brettel dike, which are lower between 2.1 and 2.7. The perovskites from the bergalites overlap with the carbonatites with εNd between 2.5 to 3.1. The known values for the phonolites are lower at around 2.1.

The $^{87}Sr/^{86}Sr$ isotope ratios of pyrochlores and perovskites from carbonatites are in the same range between 0.70356 and 0.70370 and lower on average than the perovskites from bergalites with ratios between 0.70364 and 0.70382. All these values are lower than those from the bulk rocks indicating alteration effects in the latter. Tephrites and phonolites exhibit even higher values.

As discussed in earlier work the Nd and Sr isotope compositions of the carbonatites and bergalites suggests that they are from a common magma source which may, however, be different to that for the tephrites and phonolites, both Carbonatites and bergalites plot in the OIB (Ocean Island Basalts) field in a εNd vs. $^{87}Sr/^{86}Sr$ diagram and also with respect to the Hf isotopes as determined in calzirtites from the Brettel dike ($\varepsilon Hf^{d}_{(t)}$ = 8.3 $\pm$ 0.17).

The perovskites, pyrochlores, calzirtites and zirconolites from the carbonatites give a concordant U-Pb age of 15.5 $\pm$ 0.1 Ma. Errors on U-Pb of perovskites from the bergalites are very high because of low U and high common Pb contents. A weighted average gives 15.28 $\pm$ 0.48 which indicates that the emplacement of the carbonatites was before that of the bergalites, which is consistent with field observations.