

In-situ Rb-Sr dating of beryl

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Beryl is the type example of interstitial substitution in which ions are replacing vacancies, in this case alkaline metals (in particular K, Rb, Cs) occupying the large open space within silicon tetrahedra rings; charge balance is maintained by Al³⁺ substituting for Si⁴⁺ (see Nesse, Introduction to Mineralogy).

Despite this fundamental property, attempts for direct dating of beryl by Rb-Sr are absent in the literature. With the introduction of in-situ Rb-Sr dating by laser ablation ICP-MS/MS (see e.g., Zack & Hogmalm 2016, Chem Geol 437, 120-133), beryls are becoming an attractive target for dating.

We have begun an extensive study investigating a large range of different varieties of beryl, including gem quality emerald, aquamarine, goshenite, morganite and heliodor. Of more than 50 analysed samples from around the world, 90% had Rb concentrations of between 5-50 ppm. Although significantly lower than for example most micas, this turns out to be highly suitable of our methodology, as beryls are characterized by extremely low Sr contents (usually <<1 ppm), resulting in very high ⁸⁵Rb/⁸⁶Sr ratios (often >10,000). This allows single crystal dating with measured ⁸⁷Sr/⁸⁵Rb ratios directly translated into ages (like for many ²⁰⁶Pb/²³⁸U ratios in zircon). Beryls with such suitable characteristics have been found both in all gem varieties as well as in non-gem occurrences.

Selection of reference materials is an ongoing process, as no traditionally dated beryl exists so far. In principle, several artificial glasses are suitable as primary standards, as they contain low amounts of Rb and Sr (e.g., BCR-2G). For the evaluation of the method, we are focussing on sample locations where beryl in mirolitic pegmatites occur in well-dated felsic intrusions, with the assumption that in such high-level intrusions the main magmatic and late pegmatitic crystallization are identical within the analytical uncertainty. So far, one large (1 cm³) gem quality aquamarine from the Erongo massive in Namibia (132±1 Ma) turns out to be well-behaved (ca 40 ppm Rb, no detectable ⁸⁶Sr).

These findings have far-reaching implications: they not only allow for the first time direct dating of gemstones, which facilitates more specific fingerprinting, but can be a robust tool for dating pegmatites and can also be applied in provenance analysis as they allow single crystal dating.