U-Pb shrimp dating and trace element investigations on multiple zoned zircons from a South-Bohemian granulite

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High-pressure-temperature granulites are a conspicuous feature of the Variscan orogenic belt of Europe (e.g. Pin and Vielzeuf, 1983). They record a complex multi-stage evolution history and have been the focus of intensive research over the past years, due to their importance in terms of Variscan orogenesis (Vielzeuf and Pin, 1989; O'Brien and Carswell, 1993, Cooke et al. 2000).

For many of the Variscan HP-HT granulites and especially those of the Bohemian Massif, calc-alkaline granitoid protoliths have been inferred (Fiala et al., 1987). After the formation of these granitoid protoliths, possibly in a magmatic arc setting (Carswell, 1991), the rocks experienced subduction-related high-pressure-temperature granulite-facies metamorphism with subsequent exhumation, resulting in high-temperature retrograde metamorphic overprints. Resolving the exact time-frames of the individual evolution stages preserved in the granulites is a great challenge for geochronologists and a pre-requisite for understanding the evolution of the Variscan orogen.

It has been shown already that zircons from the south Bohemian granulites can have a complex multi-phase internal growth zoning (e.g. Pöschl-Otrel, 1995; Finger et al., 1996, Kröner et al., 2000). Apart from abundant early remnant cores, considered to be derived from the granitoid protoliths, two chemically distinct outer growth shells have been recognised using BSE imaging. A U-rich shell around the inherited cores with bright BSE-signal is followed by a distal U-poor shell which is dark in BSE. Conventional zircon dating techniques which utilise whole grains, may not resolve potentially small, but distinct age differences between such growth shells. Therefore, the SHRIMP method was applied in an attempt to individually date single stages of zircon growth and to better constrain the timing of granulite evolution in south Bohemia.

The sample used in this study is a typical leucocratic, medium-grained and weakly foliated Moldanubian granulite from the Dunkelsteiner Wald granulite massif, S of Krems (Gföhl unit). The peak metamorphic assemblage of garnet + kyanite + ternary feldspar + quartz is remarkably preserved in this sample.

Many zircons of the rock show the typical threefold zoning patterns mentioned above.

Inherited cores are mostly euhedral to subhedral and generally show strong oscillatory magmatic zoning. Some cores are composite and seem to contain in turn an inherited core. SHRIMP analyses carried out in the protolithic zircon domains produced strongly scattering, although concordant ages. Most fall in the time range between 450 und 400 Ma. We assume that the granitic protolith formed at that time. A concordant Cadomian age of c. 580 Ma has been measured in one core. A further generation of inherited cores records an age of ca. 480–500 Ma. In one case a discordant $^{207}Pb/^{206}Pb$ age of ca. 2.3 Ga has been detected.

Analyses in the U-rich growth shells around the cores yielded concordant to subconcordant ages of around 340 Ma. Analyses from the U-poor outermost growth zones give slightly younger ages with a mean average $^{206}Pb/^{238}U$-age of 333 ± 3 Ma. The results are tentatively interpreted as dating two distinct stages in the metamorphic evolution of the rock. The age of 333 ± 3 Ma (zircon rims) probably dates the exhumation of the granulite to mid crustal levels. The older age may represent granulite facies zircon growth at higher PT-conditions. Magmatic zoning patterns in the zircons show that a melt phase was present in both cases.

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