U-Pb geochronology revealing different monazite generations in the polyphase paragneisses of the Teplá Barrandian Unit, Northwestern Bohemian Massif: Implications for the processes involving monazite formation

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For the understanding and quantification of tectono-thermal processes in crustal rocks it is necessary to determine the exact timeframe, and the temperatures prevailing during the respective events. Radiogenic decay of isotopes in accessory minerals thereby serves as a tool for the determination of ages for crystallisation, metamorphism, and cooling. Although geochronology using various isotope systems is widely and successfully used for several decades, questions still remain as to the concept of closure temperatures in accessory minerals and to the systematics of the isotope system used. U-Pb geochronology on monazites has become a widely applied technique for dating regional high grade metamorphism, as closure temperatures in excess of 750 °C, with respect to diffusional loss of radiogenic Pb, results in concordant analyses even in polymetamorphic areas (Parrish 1990, Spear and Parrish 1996). However, recent studies show that monazites – more often than previously thought – reflect a complex evolution similar to zircon, with inheritance, Pb-loss, or recristallisation causing discordant ages (e.g., Vavra und Schaltegger 1999, Foster et al. 2002). Furthermore, in complexly metamorphosed areas, (relict) monazite of several generations reflect growth through different processes, one example being the presence of hot metamorphic fluids that easily dissolve early monazite and reprecipitate minerals of differing trace element concentrations (e.g., Finger et al. 2002).

This study presents U-Pb monazite data from the Teplá Barrandian unit (TBU) in the central part of the Bohemian Massif in the Variscan terrane collage of Central Europe. The initial objective was to precisely constrain the age of Cadomian and Variscan regional metamorphism by conventional isotope dilution thermal ionisation mass spectrometry (ID-TIMS) and comparative chemical dating by in-situ electron microprobe analyses (EMPA).

We discovered different generations of monazites that have formed during different tectono-thermal events in the TBU: The oldest TIMS monazite ages derived in this study are max. 520 Ma in the southern TBU, possibly the result of heat or fluid flow associated with the intrusion of the various, ca. 523 Ma plutons into transtensive shear zones (Dörr et al. 2002). More common in this area, however, are monazites with ID-TIMS ages around 500 Ma. These are possibly due to fluid-related dissolution of the older (Cadomian or 520 Ma-) monazites and subsequent reprecipitation, as indicated by numerous pegmatites in the entire TBU that are only slightly younger in age (Glodny et al. 1998).

In the the northern TBU, the area of strongest Variscan overprint onto Cadomian metamorphism and deformation, U-Pb monazite ages are mainly 380 Ma. Here, P-T conditions typical for the staurolite zone (≥ 500 °C) were sufficient to completely reset the U-Pb systematic in monazite. P-T conditions in the Variscan garnet zone (ca. 500 °C, 5–6 kbar; Zulauf 1997) were still high enough to completely reset U-Pb systematics in small monazites (≤ 100 μ) and wipe out any record of previous events. The temperatures in the staurolite and garnet zone of the northern TBU are much lower than T_{max} of 750 °C, at which monazite is still supposed to be stable (Spear and Parrish 1996). This points to the fact that other mechanisms are just as important as the opening of the chronometer within a certain temperature range for the resetting of the U-Pb systematic in monazite.

Especially notable is a generation of Pb-poor monazite giving young, discordant ages. These remind of monazite decomposition and rhabdophane formation during alpine, fluid-dominated low-grade metamorphism in Crete (Finger et al. 2002, Krenn – Finger 2002).

The important implication for monazite as a chronometer is that different events or processes influence monazite growth and/or lead to resetting or disturbance of their U-Pb systematic. Finally, the nature of the disturbance or resetting is revealed by backscatter imaging and chemical dating; these shows a mixing of different age domains, thus indicating that resetting is due to dissolution and re- or new crystallisation (or reprecipitation), and plays a more important role than Pb loss.

References

Dörr, W. – Zulauf, G. – Fiala, J. – Franke, W. – Vejnar, Z. (2002): Neoproterozoic to Early Cambrian history of an active plate margin in the Teplá Barrandian unit – a correlation of U-Pb Isotopic-Dilution-TIMS ages (Bohemia, Czech Republic). Tectonophysics, 352, 65–85.

Finger, F. – Krenn, E. – Riegler, G. – Romano, S. – Zulauf, G. (2002): Resolving Cambrian, Carboniferous, Permian and Alpine monazite gen-

erations in the polymetamorphic basement of eastern Crete (Greece) by means of the electron microprobe. Terra Nova, 14, 233–240.

Foster, G. – Gibson, H. D. – Parrish, R. R. – Horstwood, M. – Fraser, J. – Tindle, A. (2002): Textural, chemical and isotopic insights into the nature and behaviour of metamorphic monazite. Chemical Geology, 191, 183–207.

Glodny, J. – Grauert, B. – Fiala, J. – Vejnar, Z. – Krohe, A. (1998): Metapegmatites in the western Bohemian massif: ages of crystallisation and metamorphic overprint, as constrained by U-Pb zircon, monazite, garnet, columbite and Rb-Sr muscovite data. Geologische Rundschau, 87, 124–134.

Krenn, E. – Finger, F. (2002): Zur Stabilität von Monazit bei der Metamorphose. Erlanger Geologische Abhandlungen, Sonderband 3, TSK9.

Parrish, R. R. (1990): U-Pb dating of monazite and its application to geological problems. Canadian Journal of Earth Sciences, 27, 1431–1450.

Spear, F. S. – Parrish, R. R. (1996): Petrology and cooling rates of the Valhalla Complex, British Columbia, Canada. Journal of Petrology, 37, 733–765.

Vavra, G. – Schaltegger, U. (1999): Post-granulite facies monazite growth and rejuvenation during Permian to Lower Jurassic thermal and fluid events in the Ivrea Zone (Southern Alps). Contributions to Mineraloy and Petrology, 134, 405–414.

Zulauf, G. (1997): Von der Anchizone bis zur Eklogitfazies: Angekippte Krustenprofile als Folge der cadomischen und variscischen Orogenese im Teplá-Barrandium (Böhmische Masse). Geotektonische Forschungen 89.