Geophysical Research Abstracts, Vol. 7, 07973, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07973

Advances in geochronology: constraints on the duration of UHT metamorphic events by in-situ U-Pb dating of zircon and rutile

A. Möller (1), R. Moraes (2), A. Kennedy (3), P.J. O'Brien (1), R.A. Fuck (4), A. Kröner (5)

(1) Inst. f. Geowissenschaften, Univ. Potsdam, 14415 Potsdam, Germany (amoeller@geo.uni-potsdam.de), (2) Inst. Geociências - Univ. São Paulo, CEP 05508-080, São Paulo, Brazil, (3) Dept. of Appl. Physics, Curtin Univ., Bentley 6102, Australia, (4) Inst. Geociências - Univ. Brasilia, CEP 70910-900, Brasilia, Brazil, (5) Inst. f. Geowissenschaften, Univ. Mainz, 55099 Mainz

Ultrahigh-temperature (UHT) metamorphism in the continental crust is recognized as a phenomenon occurring in orogenic belts throughout Earths history more frequently than previously thought. However, the heat source for UHT conditions in the middle to lower crust has not been established in most of these complexes. This is partly due to the lack of geochronological constraints on the duration of the UHT event. Such information on the timescale of metamorphic events is crucial for the interpretation of possible geodynamic settings, with short-lived events and fast cooling being indicative of local, transient heat sources.

U-Pb zircon data from metamorphic rocks have very often been simply interpreted as the age of peak metamorphism. There are some approaches by which we can improve upon this and link zircon formation or modification to particular stages of the metamorphic evolution, i.e. the P-T path: identifying zircon-forming reactions by trace analysis of zirconium in major and accessory phases contributing to zircon growth by solid-state metamorphic reactions (e.g. Degeling et al. 2001; Bingen et al. 2001); relating the Th-U-Y systematics of zircon to CL and BSE zoning patterns and ion microprobe U-Pb ages (Möller et al. 2002); establishing trace element equilibrium between zircon and major phases such as garnet (e.g. Rubatto 2002; Kelly Harley 2005, this volume); in-situ dating within thin-section to provide absolute time constraints on relative timing provided by metamorphic textures with zircon as inclusion in metamorphic minerals (e.g. Möller et al. 2003).

Two examples for the in-situ dating approach on UHT metamorphic rocks are presented. The Rogaland UHT granulites (up to T > 1000°C at 5.5 kbar) are exceptional to most UHT complexes, not only because they strictly do not fall into the pressure bracket of UHT granulites defined by Harley (1998). There is an excellent exposure situation and direct link can be provided with a local heat source, although this had been questioned for decades. The granulites formed in a thermal aureole around a large mafic intrusive complex. It had been established by thermal modelling consistent with high precision U-Pb zircon dating on the different intrusions that the observed metamorphic isograd pattern can be produced by two large intrusion events separated by no more than 3 m.y. The direct geochronological evidence for this temporal link from the granulites was provided by dating zircon from within the highest grade isograds (Möller et al. 2002). Dating of zircon included in metamorphic minerals of the peak M2 phase (927±7 Ma) and the retrograde M3 phase (908±9 Ma), directly within thin sections, was successful in providing absolute age constraints, consistent with the magmatic evolution. Rare earth element patterns of some metamorphic zircon indicate equilibrium with garnet.

The UHT granulites in the Anápolis-Itauçu Complex within the Brasília fold belt attained peak conditions of at least 1050°C, probably up to 1150°C, at more than 10 kbar (Moraes et al. 2002). The P-T path is characterized by initial decompression followed by nearly isobaric cooling path to below 900°C. Opx-bearing leucosomes intruded during cooling. Rutile and zircon were dated in thin section, within their textural context; zircon included in peak metamorphic garnet and high-Al orthopyroxene, and from the Opx-leucosomes was dated and produced results identical within error. Rutile from within garnets are slightly older, but rutile not included in peak metamorphic minerals that may be interpreted to represent cooling through c. 430°C are only slightly younger than zircon, in fact indistinguishable within robust error estimates. The combined evidence points to very fast cooling from peak metamorphic conditions, possibly close to 100°C/Ma, indicative of local heat sources. If the inherited cores that have been dated to be only c. 20 m.y. older than the earliest metamorphic age group are interpreted as detrital pre-metamorphic grains, the whole metamorphic event could be interpreted as a short-lived, highly transient thermal signal. Trace element characteristics of the different textural, morphological and zoning type groups will be used to differentiate these results further.

References: Bingen, B., Austrheim, H. Whitehouse, M., 2001. Ilmenite as a potential source for zirconium during high-grade metamorphism? Textural evidence from the Caledonides of Western Norway and implications for zircon geochronology. Journal of Petrology 42, 355-375.

Degeling, H., Eggins, S. Ellis, D.J., 2001. Zr budgets for metamorphic reactions, and the formation of zircon from garnet breakdown. Mineralogical Magazine 65, 749-758.

Harley, S.L., 1998. On the occurrence and characterization of ultrahigh-temperature crustal metamorphism. In: What drives metamorphism and metamorphic reactions? (eds Treloar, P.J. O'Brien, P.J.) Geological Society Special Publications, The Geological Society, London, pp. 81-107.

Möller, A., O'Brien, P.J., Kennedy, A. Kröner, A., 2002. Polyphase zircon in ultrahigh-temperature granulites (Rogaland, SW Norway): constraints for Pb diffusion in zircon. Journal of metamorphic Geology 20, 727-740.

Möller, A., O'Brien, P. J., Kennedy, A. Kröner, A., 2003. Linking growth episodes of zircon and metamorphic textures to zircon chemistry: an example from the ultrahigh-temperature granulites of Rogaland (SW Norway). In: Geochronology: Linking the Isotopic Record with Petrology and Textures (eds Vance, D., Müller, W. Villa, I.M.) Geological Society, London, Special Publications, 220, pp. 65-81.

Moraes, R., Brown, M., Fuck, R.A., Camargo, M.A. Lima, T.M., 2002. Characterization and P-T evolution of melt-bearing ultrahigh-temperature granulites: an example from the Anápolis-Itauçu complex of the Brasília fold belt, Brazil. Journal of Petrology 43, 1673-1705.

Rubatto, D., 2002. Zircon trace element geochemistry: partitioning with garnet and the link between U-Pb ages and metamorphism. Chemical Geology 184, 123-138.