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At what conditions does zircon grow/dissolve during high-T metamorphism? Relating zircon textures to PT-conditions

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A key question in ziconology is when and how zircon grows during metamorphism. To shed light on zircon forming processes and the corresponding PT-conditions during high-T metamorphism a case study was undertaken. The Ivrea Zone (N-Italy) exposes a lower continental crustal section in which a continuous metamorphic field gradient from amphibolite to granulite facies is documented. This field gradient is thought to reflect protracted heating during late Paleozoic times, with a probable high-T peak in the Permian.

We present first results from a primarily textural study supported by U-Pb ages, Th/U ratios and Ti-in-Zrn thermometry. Four types of zircon were identified based on their overgrowth proportions and the preservation of detrital cores. Zircon grains were thus classified as
Type1 – detrital grains with no overgrowth or very narrow rims (<5 μm);
Type2 – prominent detrital core with variable (10–40 μm) overgrowths;
Type3 – small/relic detrital core with prominent overgrowths;
Type4 – newly grown zircon only, no core present/visible.
Based on zircon textures in CL-images four overgrowth stages were distinguished
Rim1 – CL-bright, messy texture, inclusion-rich;
Rim2 – Cl-dark, uniform texture or sector zoning or planar growth banding, at lower grade often inclusion-rich whereas at higher grades mostly inclusion-free;
Rim3 – CL-light grey, oscillatory zoning, mostly inclusion-free;
Rim4 – CL-bright, uniform texture, mostly inclusion-free.

Rim1 shows textures typical for low-grade fluid related growth, presumably grown during a pre-Permian event. Rim2 comprises two varieties (2a/2b) that show essentially the same textural characteristics, indicative of metamorphic dehydration. Rim2a yields late Carboniferous ages (>300 Ma) and appears to reflect an early dehydration phase. Rim2b has Permian ages (median 275 Ma), is by far the most common overgrowth type, found in a wide PT-range. Its development appears related to biotite breakdown. Rim3 is texturally indicative of magmatic zircon, occurs only in diatexites. Rim4 is the latest overgrowth and is locally found at all metamorphic grades. Textural features suggest late fluid-related recrystallization of existing zircon.

At lowest grade (675$\pm$35°C, 6$\pm$2 kbar) zircons show type1 only, overgrowths are too thin to clearly identify the rim type. Further upgrade ($\sim$700°C, 7 kbar) type1 and type2 dominate. Type2 zircons show rim1, rim2a and occasionally rim4. At the Mu-out isograd (750$\pm$50°C, 8.2$\pm$1.4 kbar) most zircons are of type2, now with rim2b instead of 2a, in addition to rim1 and rim4. Near and in granulite facies (to 800°C, 8$\pm$2 kbar) mostly zircon type2 and type4 are present. While rim1 gets more narrow with increasing metamorphic grade, rim2b grows significantly thicker. Occasionally rim2a and rim4 occur. Close to the Bt-out isograd ($\sim$860°C, 9.2$\pm$1.7 kbar), mostly type3 and type4 are found. Rim1 is absent, and rim2b is commonly overgrown by rim3. Above the Bt-out isograd (>870°C, 9.5 kbar) zircon types3 and type4 dominate. Rim1 is missing, while Rim2b is the most common type, often with a thin rim4.
Detailed textural features alone often are not sufficient to relate zircon growth zones to PT-conditions. In combination with U-Pb ages, Th/U ratios and Ti-in-Zrn thermometry, however it is possible to link spot ages to PT-conditions.