Nanometrical study of polyphasic and discordant monazites

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Electron microprobe (EMP) U-Th-Pb dating on polyphasic discordant monazites from poly-metamorphic Ultra High Temperature (UHT) granulites, (Andriamena unit, Madagascar) revealed inconsistent chemical ages [1]. This appeared by a spreading of EMP U-Th-Pb apparent ages ranging between 790 and 2500 Ma. In order to explain this drastic variation, a nanometric study was done using the Transmission Electron Microscope (TEM). For that, TEM-foils were prepared using the Focused Ion Beam (FIB) technique [2]. Thanks to this technique it is possible to prepare 15 µm x 10 µm x 100 nm samples in specific areas, directly from thin section. This allowed preserving entirely the textural information from the thin section. The combination of these techniques allowed to show up nanometric domains (~ 50 nm) enriched in Pb within areas that show large variation in ages [2], and the presence of nanometric hydrous phases along grain boundaries (monazite/quartz, monazite/garnet), evidence of fluid activity. The present study demonstrates the potential of the combined use of different methods and scales for the interpretation of geochronological data.

References

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[2] Seydoux-Guillaume A. M., Goncalves P., Wirth R., and Deutsch A. (2003) *Geology,* **31**, 973-976.

U-(Th)-Pb dating of monazite and xenotime by EMPA, LA-ICPMS, and IDTIMS: Examples from the Yilgarn Craton and Himalayas

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Monazite and xenotime geochronology is important for understanding the timing of metamorphic reactions and leucogranite crystallization. Key to extracting meaningful data is establishing a well-defined history of crystallization, dissolution, and recrystallization. We present two case studies that illustrate the power of combining the high-spatial resolution of x-ray chemical mapping by electron microprobe analysis (EMPA) with U-(Th)-Pb isotopic dating by inductively coupled plasma mass spectrometry (LA-ICPMS) and isotope dilution thermal ionization mass spectrometry (IDTIMS). When comparing techniques, the main variables are analytical precision, speed of analysis, and spatial resolution. EMPA identifies growth domains and provides U-Th-Pb dates from small (10 µm), Pb-rich domains. LA-ICPMS dates larger domains (20 µm) in a short timeframe (~15 analyses per hour), and IDTIMS provides high precise dates from moderate-sized fragments (>40 µm) of grains.

Metasedimentary rocks at Mount Narryer (Yilgarn Craton, Western Australia) contain twenty-two monazite domains and two xenotime domains that were identified based on chemistry, age, and texture. All methods yielded relatively high precision monazite dates due to the Pb-rich nature of the grains (0.4-3.5 wt. %); 2σ errors from multiple dates on homogeneous domains are as low as 0.5% for EMPA, 0.2% for LA-ICPMS, and 0.02% for IDTIMS. IDTIMS dates were used to assess the accuracy of the EMPA and LA-ICPMS dates. EMPA was the only method capable of showing that monazite formed (i) as inclusions in detrital zircon at 3670 and 3130 Ma, (ii) with xenotime during diagenesis at 3000 Ma, and (iii) with garnet and xenotime during granulite facies metamorphism at 2640 Ma. LA-ICPMS was the only practical method for showing that 100 detrital monazite grains were derived exclusively from source rocks of two ages, 3300 and 3130 Ma. Leucogranites from Rongbuk Valley (Nepal) have three monazite domains that were dated by IDTIMS. Monazite that formed during igneous crystallization of the protolith at 23.5 Ma was overgrown by secondary monazite at 19.0 Ma. Discrete monazite grains grew at 16.5 Ma from late fluids or small volume melts.