Small volume U-Th-Pb geochronology of accessory minerals by laser ablation quadrupole ICP-MS

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Small volume U-Th-Pb isotope analysis of accessory minerals is a major aim of modern geochronology. Analytical techniques are constantly developed to try and date ever smaller features, such as metamorphic rims and inclusions, and more recently produce age maps. Improvements in laser ablation ICP-MS technology and methodology offer great potential in this regard, but only a few laboratories are routinely operating with laser beam diameters ≤10 μm, mostly using *mutli-collector* ICP-MS instruments. Here we present analytical developments using a high-sensitivity *quadrupole* ICP-MS instrument (Analytik Jena PQ Elite), coupled with a 193 nm ArF excimer laser (ASI RESOlution-SE), which allow for rapid *small volume* geochronology of minerals including zircon, monazite and baddeleyite.

The smallest achievable ablation volume for precise and accurate laser ablation U-Th-Pb geochronology is largely controlled by ablation efficiency, the degree of laser induced elemental fractionation (LIEF), signal stability and the sensitivity of the mass spectrometer. We present the results of a range of tests designed to optimize ablation parameters at beam diameters ranging from 9 to 15 microns, and ablation pit depths <5 microns using zircon, monazite and baddeleyite reference materials. These include testing ranges in fluence (1-4 Jcm^{-2}), repetition rate (1-4 Hz) and the use of a signal smoothing device. As a result, laser induced elemental fractionation in zircon at 9 μm beam diameters can be modelled/corrected using simple linear or exponential regressions, whilst yielding >150 cps/ppm of ^{238}U.

U-Th-Pb isotope ratio data collected using these ablation conditions for zircon reference materials GJ-1, Temora2, and 91500 (normalized to Plesovice) are accurate with 2σ errors of 2-3% and 4-6% on $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ratios respectively. These developments are opening up exciting new applications, including the dating of mineral inclusions, multiple age domains in single crystals, and thin metamorphic rims on zircon and monazite.