

Laser ablation ICP-MS dating of complex magmatic and metamorphic zircon

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Zircon belongs to the key minerals for unravelling many processes during earth history. The U-Th-Pb systematic in most zircon grains is complex due to alteration processes, such as dissolution, recrystallization and new zircon growth. A spatial resolution of 10 to 40 μm are commonly needed to resolve the different age pattern in complex grains. Only few LA-ICP-MS studies have shown so far that they are capable to analyse 30 μm areas and precisely detect low Pb contents, which are relative common e.g. for younger and detrital zircon grains.

The U-Th-Pb zircon dating technique was developed in our lab using a 213 Merkantek laser systems attached to a Thermo-Finnigan Element II. A spot-size of 25–30 μm is used as the best compromise between spatial resolution and acceptable internal precision of the $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{206}\text{Pb}/^{238}\text{U}$ ratios. A teardrop-shaped, low volume laser cell with a washout time below 1 s (Horstwood *et al.*, 2003) enables precise detection of a sampled material, which is heterogeneous with time. A relative simple approach is used to correct for within-run U-Pb fractionation before normalisation to a repeatedly analysed reference zircon. The typical internal precision of $^{206}\text{Pb}/^{238}\text{U}$ is 0.6 % (1 s.e.). Frequent analyses of zircon with known (GJ-1, 91500, CS3 and Temora) and unknown U–Pb ages using 91500 or GJ-1 zircon as references show that an external precision (1σ) and an accuracy of 1–2 % can be achieved routinely for crack-less grains with a homogeneous U–Pb composition. This is comparable to or even better as precision reported by other laboratories. All errors are propagated with the reproducibility of the standard over the session taken into account.

A common lead correction is usually not possible or necessary as total counts of $^{204}\text{Hg} + \text{Pb}$ were similar ($\pm 10\%$) to the ^{204}Hg counts. Applying such a correction to individual ratios would have increased the $^{207}\text{Pb}/^{206}\text{Pb}$ error 2–10 times. The main controlling factor for the error is counting statistic in case of the $^{207}\text{Pb}/^{206}\text{Pb}$ and the reproducibility of the ablation process and sample heterogeneity for the $^{206}\text{Pb}/^{238}\text{U}$. We will present data of different studies currently completed. Analysed grains spanning a wide range of magmatic, metamorphic and detrital zircon, demonstrating their natural complexity. The results of the studies are encouraging and illustrate the ability but also the limits for LA ICP-MS dating of complex zircon.

Time of flight secondary ion mass spectrometry (ToF-SIMS) use in sedimentary geochemistry

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A relatively new instrument, Time of Flight Secondary Ion Mass Spectrometry (ToF-SIMS) has recently become available to the sedimentary geochemical community. ToF-SIMS is basically a mass spectrometer capable of acquiring microanalytical data on solid surface samples at the micron or submicron levels. It provides simultaneous detection of all elemental, isotopic and chemical element abundances via molecular and cluster ions. The device has high lateral resolution (<50nm), high surface sensitivity (>1 nm) and high depth resolution (> 1 nm). Detection limits are ppm of a monolayer for elements and sub-fmol for molecules.

We studied elements and isotopes across a black shale with layers composed mainly of FeS₂. About 30 elements and isotopes were observed, and we were able to ratio S34/S32. This ratio produced an ion picture, and an intensity vs distance graph; we used a backscattered electron microscope photograph to pinpoint the area being analyzed. This permitted us to follow the ratio across a 50x50 micron area.

With further refinement and the growing need for very high resolution in situ chemical analyses of geological materials, this may become the instrument of choice to address many geological problems where textural context and two and or three dimensional chemical information is critical.