Use of the Laser Ablation ICP-MS Technique for U-Pb Zircon Dating

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U-Pb dating of accessory phases is one of the most commonly used geochronological tools for obtaining protolith and magmatic ages of rocks. It is mostly the slow diffusion rates of both U and Pb in common accessories that make this isotopic system robust to subsequent resetting. Range of various U-Pb techniques (conventional isotope dilution, single zircon grain evaporation, SHRIMP, electron microprobe) has been recently extended by laser probe coupled to an ICP mass spectrometer (LA ICP-MS, Feng et al. 1993, Fryer et al. 1993, Hirata and Nesbitt 1995, Jackson et al. 1996). Like the ion microprobe, the laser ablation sampling has the advantage of (1) spatial resolution of several spot analyses within a single grain of an accessory mineral that is often less than 200 - 300 microns in size, (2) potential to date accessory phases in situ, i.e. within the context of petrological and structural information present in the rock and (3) small or zero Pb blank introduced to the sample during the analysis.

Instrumentation

The analytical setup at the Charles University is a commercially available high-sensitivity quadrupole ICP-MS system which is coupled to a UV probe with a frequency quadrupled NdYAG laser emitting at 266 nm. The analysis of accessory phases (e.g. zircons) is usually performed on polished samples whose composition was previously examined using an electron microscope. Each analysis (60 seconds) consists of blank measurement (20 s) and measurement of the ablated sample (40 s). Signal of mases 202, 204, 206, 207, 208 and 238 is collected sequentially on the secondary electron multiplier. The calculation of U-Pb ages is preceded by blank correction, Hg interference correction, common lead correction and U/Pb fractionation correction. Although the correction for decoupling of U and Pb during the ablation represents the major source of error in the age calculation, we are able to achieve accuracy of mean $^{206}Pb/^{238}U$ age data of ca 5% with the internal age precision better than 2%.

LA ICP-MS dating of zircons

In order to test this technique on natural samples we have analysed zircon grains from three samples for which conventional U-Pb age data were available.

Zircons from a calc-alkaline, amphibole- and biotite-bearing Stráž gneiss that is a part of a discontinuous belt of similar bodies separating the Ostrong and Drosendorf (and Gföhl) units of the Moldanubian Zone in southern Bohemian Massif has been previously dated using U-Pb population zircon technique and yielded an upper intercept age of four zircon fractions at 537 ± 8 Ma (Košler et al. 1996). This has been confirmed by a single zircon grain evaporation age of ca 550 Ma (Wendt, pers. comm.) We have analysed 6 spots (craters 20 microns in diameter, ca. 30 microns deep) within two zircon grains. The compositions of all of them (except one) cluster near the concordia and they yield discordant mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ages of 505 ± 7 and 583 ± 18 Ma, respectively, mean $^{206}Pb/^{238}U$ age of all six samples is 510 ± 7 Ma. There is no obvious relation between the discordance of the analysed points and their BSE and CL images.

Two other samples come from the Mt. Mucrone meta-granite in the Sesia - Lanzo Zone of the Italian western Alps. The meta-granite is considered as a part of subducted continental crust that has been subject to various stages of deformation and metamorphism (cf. Oberhansli et al. 1985). Conventional U-Pb zircon dating yielded a lower concordia intercept at 286 ± 2 Ma (Paquette et al. 1989). Two additional zircon fractions define a lower concordia intercept at 292 ± 1 Ma (Košler unpubl. data). We have measured 14 laser spots in two zircon grains from undeformed granite which has preserved the original igneous assemblage and from a pyroxene- and garnet-bearing granitic gneiss. The mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ages for the first sample are 213 ± 3 and 237 ± 5 Ma, respectively. Data points from the second sample form a discordant array with lower concordia intercept at ca. 200 Ma and yield mean $^{206}Pb/^{238}U$ and $^{207}Pb/^{235}U$ ages of 226 ± 3 and 253 ± 5 Ma, respectively. Back-scattered electron and cathodoluminiscence study of the zircons has not revealed any visible inheritance. The inherited Pb must be therefore dispersed within the grains and the shift to younger laser ablation ages compared to the conventional TIMS data probably results from different sampling modes of the two techniques.

U-Pb laser ablation ICP-MS data from zircons clearly show the potential of this technique to arrive to ages that are comparable to those obtained by the conventional methods. In terms of its spatial resolution, LA ICP-MS can compete with the more laborious (and also more expensive) SHRIMP dating (e.g. Schaltegger et al. 1998).

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