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Precise and Accurate U-Pb Laser Ablation ICPMS Dating of Monazite

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Laser ablation (LA) ICPMS dating of U-bearing accessory phases has recently developed into a well-established tool that can be used to decipher time scales of igneous and metamorphic processes that were not previously revealed by conventional dating techniques. To date this method has almost exclusively been used for U-Pb dating of zircons, while other geochronologically important minerals (e.g. monazite) have only been dated using $^{207}Pb/^{206}Pb$ method. Major limitations of U-Pb LA ICPMS dating are (1) availability of suitable mineral standards, (2) instrument mass bias of isotope measurements, (3) control of laser-induced elemental fractionation and (4) dynamic range limitations of secondary electron multipliers used in quadrupole instruments. Instrument mass bias of isotopes in zircon analysis can be corrected for by simultaneous aspiration of a mixed, natural thallium and enriched ^{235}U tracer solution to the plasma (Horn et al., 2000). Elemental fractionation in the laser ablation cell can be minimised by suitable cell design, laser beam defocus (Ketchum et al., in press) and/or beam rastering (Parrish et al., 1999) during the analysis. Laser-induced fractionation of isotopes is matrix-dependent, precluding the use of external standards (e.g. NIST glass) that do not match the sample matrix to correct for U/Pb elemental fractionation. A major obstacle to U-Pb dating of monazites that are younger than 100 Ma is the limited dynamic range of electron multipliers. Monazites typically contain 300 - 14000 ppm U (average ~3800 ppm U; Heaman and Parrish, 1991). The high ^{238}U and low ^{207}Pb contents of young monazites cannot be measured on the same laser spot, precluding the conventional LA ICPMS dating technique from being applied to this geochronologically important accessory phase. In addition, accurate measurement of ^{235}U (as an alternative to ^{238}U) in monazite is not possible if ^{235}U is used in tracer solution. This paper describes the use of an enriched ^{233}U tracer solution to over come these problems.

We have utilised a VG PlasmaQuad 2S+ instrument coupled to an in-house built NdYAG laser at Memorial University to measure U/Pb and Pb isotopic ratios in monazites of varying trace element compositions and ages. Monazites were exposed to a stationary 10 Hz defocused laser beam 10-15 micrometers in diameter while the sample stage was rastered, producing a 40 x 40 micron wide, 50 micron deep ablation pit in the grain. The total amount of ablated material from each site was less than 0.0005 mg, i.e. 200 times less than the amount used for a typical TIMS analysis. Using the rastering procedure and He as a carrier gas, we were able to achieve stable ^{235}U signals of more than $2x10^4$ cps for at least 180 seconds, while keeping the ^{206}Pb signal in the pulse-counting range of the electron multiplier. Rastering the sample surface during ablation suppressed the U/Pb elemental fractionation below a level that could be detected during a 3-minute acquisition period. Raw counts were corrected for the multiplier dead time and gas blank. Instrumental mass bias corrections were based on measurements of solution containing natural thallium ($^{205}Tl/^{203}Tl$=2.3871) mixed with enriched ^{233}U (>99%) that was simultaneously aspirated to the plasma. Analysis of monazites with a wide range of ages and U contents was possible by varying laser parameters, sensitivity of the instrument and by measuring ^{235}U and ^{238}U for young (typically <100 Ma) and old monazites, respectively. Using this technique, we achieved 2 sigma precisions for individual spot analyses better than 3% for $^{207}Pb/^{235}U$ ages, 2% for $^{206}Pb/^{238}U$ ages and 2.5% for $^{207}Pb/^{206}Pb$ ages for ca. 72 Ma old monazites (3500 ppm U) from the Doi Inthanon core complex in northern Thailand (Dunning et al., 1995). Similar precisions were obtained for a ca. 474 Ma in-house monazite (1300 ppm U) standard from Brazil. All U-Pb LA ICPMS analyses were within errors of previous TIMS age determinations.

The high U contents in monazite and slow laser penetration rates during rastering permit high spatial resolution U-Pb geochronological work, even on petrographic thin sections. LREE-enriched monazite inclusions can compromise or preclude conventional Sm-Nd dating of garnets and staurolites in metamorphic rocks. Previous SIMS measurements (Harrison et al., 1997) have demonstrated that ages of monazite inclusions often correspond to the age of their host garnet. Spatial resolution available via U-Pb LA ICPMS dating can provide a more affordable way to carry out such high-resolution geochronological work utilising inclusions of U-bearing phases in metamorphic minerals.

Dunning GR, Macdonald AS & Barr SM, Tectonophysics, 57, 197-213, (1995).

Harrison TM, Ryerson FJ, LeFort P, Yin A, Lovera OM & Catlos EJ, Earth Planet. Sci. Lett, 146, E1-E7, (1997).

Heaman L & Parrish R, MAC Short Course Handbook, 19, 59-102, (1991).

Horn I, Rudnick RL & McDonough WF, Chem. Geol, 131, 37-53, (2000).

Ketchum JWF, Jackson SE, Culshaw NG & Barr SM, Precam. Res, (in press).

Parrish RR, Nowell G, Noble SR, Horstwood M, Timmerman H, Shaw P & Bowen I, J. Conf. Abstr, 4, 799, (1999).