**LA-ICP-MS U-(Th-)Pb data analytical details**

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| **Laboratory & Sample Preparation** |  |
| Laboratory name | CNR-Istituto di Geoscienze e Georisorse U.O. Pavia (Italy) |
| Sample type/mineral | Monazite and titanite |
| Sample preparation | Polished thin section with a thickness of 30μm and/or 50μm. |
| Imaging | BSE images with normal brightness/contrast setting and highly contrasted, MIRA3 TESCAN FE-SEM, 20kV, 16-17mm working distance |
| **Laser ablation system** |  |
| Make, Model & type | Geolas 102 from Microlas |
| Ablation cell & volume | In-house built low volume cell, volume ca. 4 cm3 |
| Laser wavelength (nm) | 193 nm |
| Pulse width (ns) | 4 ns |
| Fluence (J.cm-2) | 7 J.cm-2 |
| Repetition rate (Hz) | 3 Hz for monazite; 5 Hz for titanite |
| Ablation duration (secs) | 40 secs |
| Ablation pit depth / ablation rate | Not measured |
| Spot diameter (m) nominal/actual | 10 m for monazite; 25 or 35 m for titanite |
| Sampling mode / pattern | Static spot ablation |
| Carrier gas | 100% He in the cell, Ar make-up gas combined using a Y-piece 50% along the sample transport line to the torch. |
| Cell carrier gas flow (l/min) | 0.44 l/min |
| **ICP-MS Instrument** |  |
| Make, Model & type | Agilent 8900 ICP-MS |
| Sample introduction | Ablation aerosol (sample + He + Ar) |
| RF power (W) | 1250W |
| Make-up gas flow (l/min) | 0.44 l/min He + 0.91 l/min Ar |
| Detection system | Single quadrupole, dual detection, no-gas mode |
| Masses measured | Monazite: 202-208, 232, 238;  titanite: 27, 29, 31, 43, 44, 49, 51, 55, 57, 89, 90, 93, 139, 140, 141, 146, 149, 151, 157, 159, 163, 165, 167, 169, 173, 175, 177, 198, 202-208, 232, 238 for titanite |
| Integration time per peak/dwell times (ms); quadrupole settling time between mass jumps | Monazite: 202Hg (50), 204Pb (150), 206Pb (20), 207Pb (40), 208Pb (10), 232Th (2), and 238U (20);  titanite: Al27(3), Si29(3), P31(3), Ca43(3), Ca44(3), Ti49(3), V51(3), Mn55(3), Fe57(3), Y89(5), Zr90(5), Nb93(5), La139(5), Ce140(5), Pr141(5), Nd146(5), Sm149(5), Eu151(5), Gd157(5), Tb159(5), Dy163(5), Ho165(5), Er167(5), Tm169(5), Yb173(5), Lu175(5), Hf177(5), Hg198(5), Hg202(5), Pb204(5), Pb206(30), Pb207(45), Pb208(15), Th232(10), U238(10). |
| Total integration time per output datapoint (secs) | ~0.4secs for monazite; ~0.3secs for titanite  *(N.B. this should represent the time resolution of the data)* |
| ‘Sensitivity’ | 9000 cps of Th on NIST612 |
| IC Dead time (ns) |  |
| **Data Processing** |  |
| Gas blank | 30 second before and after ablation |
| Calibration strategy | MOACIR and MKED-1 were used as primary reference materials for monazite and titanite dating, respectively.  44069 monazite (Aleinikoff et al., 2006; Liu et al., 2012) was analysed as secondary/validation standard.  Titanite trace elements:  NIST610 was used as primary reference materials for titanite trace element characterization  MKED-1 and TTN150 (Klemme et al., 2008) were analysed as secondaries/validation |
| Reference Material info | MOACIR monazite: Cruz et al. 1996; Seydoux-Guillaume  et al. (2002a, b); considering the values, re-calibrated for  isotopic disequilibrium, reported by Gasquet et al. (2010).  44069 monazite: Aleinikoff et al. (2006) with the 208Pb/232Th values after Liu et al. (2012);  MKED-1 titanite: Spandler et al. (2016);  Bear Lake and Khan River titanite: Mazoz et al. (2022). |
| Data processing package used / Correction for LIEF | GLITTER ® (van Achterbergh et al., 2001) |
| Mass discrimination | Standard-sample bracketing with 207Pb/206Pb, 206Pb/238U and 208Pb/232Th normalized to reference material |
| Common-Pb correction, composition and uncertainty | No common-Pb correction applied to the data. |
| Uncertainty level & propagation | Ages are quoted at 2sigma absolute, propagation is by quadratic addition according to Horstwood et al. (2003). Reproducibility and age uncertainty of reference material are propagated. |
| Quality control / Validation | 44069 monazite (Aleinikoff et al., 2006): average ratio ± 1sigma; precision(%); accuracy(%)  207Pb/206Pb: 0,0538±0,0014; 2.2%;  207Pb/235U: 0,5070±0,0132; 2.1%; 2.45%(a)  206Pb/238U: 0,0683±0,0007; 1.4%; 0.33%(a)  208Pb/232Th: 0,0219±0,0002; 3.6%; 4.88%(b)  Data for the accuracy are from Aleinikoff et al. (2006) for (a) and Liu et al. (2012) for (b).  Precision: 2.2%  Wtd ave 206Pb/238U age = 338 ± 3 (2*s*, MSWD = 0.9, n=8)  GJ-1 – Wtd ave 206Pb/238U age = 602 ± 5 (2*s*, MSWD = 1.1, n=7)  Systematic uncertainty for propagation is 2% (2*s*).  Bear Lake titanite: average ratio ± 1sigma; precision (%); accuracy (%). Accuracy is measured with respect to the reference value proposed by Mazoz et al. (2022).  207Pb/206Pb: 0.11314±0.00148; 1.31%; 1.19%;  207Pb/235U: 3.08732±0.08049; 2.61%; -3.57%  206Pb/238U: 0.19792±0,00434; 2.19%; -4.94%  Khan River titanite: average ratio ± 1sigma; precision (%); accuracy (%). Accuracy is measured with respect to the reference value proposed by Mazoz et al. (2022).  207Pb/206Pb: 0.06118±0.005255; 8.59%; -1.28%;  207Pb/235U: 0.73966±0.087656; 11.85%; -6.24%  206Pb/238U: 0.08752±0.003556; 4.06%; -4.69% |
| **Other information** |  |

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