APPENDIX 1: ANALYTICAL DETAILS FOR LA-MC-ICP-MS

Zircon

The New Wave Research 193 nm ArF excimer laser was operated in 20-sec bursts at 32 mJ, a repetition rate of 8 Hz and spot sizes of 35 or 50 µm to ablate ~15 µm deep pits in zircon; monazites were analyzed at a repetition rate of 4 Hz and a spot size of 10 µm. The ablated material was transported to the ICP using a mixture of Ar and He carrier gases where it underwent ‘dry’ nebulization. The carrier gases have sufficiently low Hg abundance that any Hg in the 204 mass position was subtracted by measuring on-peak backgrounds prior to sample analysis. Mass 204 was measured using an ion-counting channel whereas masses 206, 207, 208, 232 and 238 were measured with Faraday detectors; all analyses were conducted in static mode. Each blank measurement was a 20-second count and each unknown measurement consisted of 20 separate 1-second counts. Because the measured isotopic ratios generally varied as a function of increasing laser pit depth, their values corresponding to a ‘zero pit depth’ were determined by regression of the ratio-vs.-time data. The regression was iterative, with ratios differing from their expected value by more than 3 sigma being rejected sequentially until the line was a good fit to all data. Fits that showed no statistically significant slope with respect to pit depth were recomputed with the slope forced to zero.

Mass fractionation on the Isoprobe was established by analyzing zircon and monazite standards of known ages after every few unknowns. We used a 564-Ma Sri Lankan zircon standard with 461 ppm U and 457 ppm Th, obtaining typical counting-measurement errors (2σ) of ±206/238 = 1.8%, ±206/207 = 8%, and ±208/232 = 6%. The expected/measured fractionation factors (2σ) for the zircon standard are 206/238: 1.276 ±
0.072, 206/207: 1.016 ± 0.034, and 208/232: 0.802 ± 0.128. These two sources of measurement error for the 206/238 ratio, 1.8% and 5.6%, respectively, dominate the internal error of the $^{238}\text{U}/^{206}\text{Pb}$ age (the common-Pb correction contributes only ~0.18% uncertainty, as measured 206/204 ratios are typically 3500). The choice of common-Pb correction, the 0.107% uncertainty in the $^{238}\text{U}$ decay constant, and the 0.7% uncertainty in the age of the standard lead to ~0.82% (2\(\sigma\)) additional error in the absolute $^{238}\text{U}/^{206}\text{Pb}$ age. The two sources of measurement error for the 206/207 ratio, 8% and 6.6%, respectively, dominate the internal error of the $^{207}\text{Pb}/^{206}\text{Pb}$ age (the common-Pb correction contributes ~1.2% uncertainty, as measured 207/204 ratios are typically 300). The choice of common-Pb correction, the 0.136% uncertainty in the $^{238}\text{U}$ decay constant, and the 0.7% uncertainty in the age of the standard lead to ~0.8% (2\(\sigma\)) additional error in the absolute $^{207}\text{Pb}/^{206}\text{Pb}$ age. Thus, a single analysis of our 564-Ma zircon standard typically has a precision of ±33.2 Ma (2\(\sigma\)) and an accuracy of ±33.5 Ma (2\(\sigma\)) in the $^{238}\text{U}/^{206}\text{Pb}$ age, and ±58.8 Ma (2\(\sigma\)) and ±59.1 Ma (2\(\sigma\)) in the $^{207}\text{Pb}/^{206}\text{Pb}$ age. Ten analyses of the same zircon grain leads to improvements in the accuracy of the $^{238}\text{U}/^{206}\text{Pb}$ age to ±11.5 Ma and of the $^{207}\text{Pb}/^{206}\text{Pb}$ age to ±19.1 Ma (2 standard errors of the mean).

**Monazite**

For a 425-Ma monazite standard (provided by John Aleinikoff and Sandra Kamo) typical counting-measurement errors are (2\(\sigma\)) ±206/238 = 2.6%, ±206/207 = 14%, and ±208/232 = 2.4%. The expected/measured fractionation factors (2\(\sigma\)) for the monazite standard are 206/238: 1.35 ± 0.066, 206/207: 0.75 ± 0.10, and 208/232: 0.96 ± 0.03. These two sources of measurement error, 2.4% and 3.2%, respectively for the 208/232 ratio,
dominate the internal error of the Th/Pb age (the common-Pb correction contributes only
~0.24% uncertainty as measured 208/204 ratios are typically 1500–2000). The choice of
common-Pb correction, the 0.1% uncertainty in the $^{232}$Th decay constant, and the 0.7%
uncertainty in the age of the standard lead to ~0.74% (2σ) additional error in the absolute
age. Thus, a single analysis of our monazite standard typically has a precision of ±17.0
Ma (2σ) and an accuracy of ± 17.3 Ma (2σ). Ten analyses of the same monazite grain
leads to improvements in the precision to ± 5.4 Ma and in the accuracy to ± 6.2 Ma (2
standard errors of the mean).
Appendix 2. Complete ⁴⁰Ar/³⁹Ar data

T, temperature; ⁴⁰(mol), moles ⁴⁰Ar corrected for blank and reactor-produced ⁴⁰Ar; ∑³⁹Ar, cumulative ³⁹Ar; ⁴⁰Ar*, fraction of radiogenic ⁴⁰Ar; TFA, total fusion age; WMPA, weighted mean plateau age; WMA, weighted mean age

IA, inverse isochron age. Ratios are corrected for blanks, decay and interference. First age uncertainty is intralaboratory uncertainty; uncertainty in parentheses includes error in decay constant and standard age.

* indicates steps used to calculate WMPA, WMA and IA.

<p>| Release T Dwell Time 40(mol) 39(mol) 40Ar/39Ar 39Ar/38Ar 38Ar/37Ar K/Ca ∑39Ar 40Ar* Age (Ma) Renne98 |
|----------------------------------|------------|--------|--------|--------|--------|-------|--------|--------|---------------|---------------|
| (°C) (min) | | | | | | | | | | ± 1 sigma ± 1 sigma |
| sample e9810e, UTM 0366285 6855030: J = 0.133712; TFA = 396.9 ± 0.5 (3.1) Ma; WMA = 399.4 ± 1.5 (3.4) Ma |
| 500 | 13 | 4.20E-15 | 2.00E-16 | 20.9611 | 9.10E-03 | -0.0841 | 0.0074 | &lt;0.001 | 0.00265 | 0.896 | 404.1 ± 5.9 | 409.6 ± 5.9 |
| 550 | 13 | 1.00E-14 | 5.14E-15 | 19.4539 | 1.50E-03 | -0.0606 | 0.0035 | &lt;0.001 | 0.00947 | 0.948 | 397.4 ± 2.5 | 402.8 ± 2.5 |
| 600 | 13 | 2.10E-14 | 1.08E-15 | 19.5295 | 5.20E-04 | -0.0129 | 0.0030 | &lt;0.001 | 0.02370 | 0.955 | 401.7 ± 1.3 | 407.2 ± 1.3 |
| 650 | 13 | 3.60E-14 | 1.88E-15 | 19.1694 | 0.00E+00 | -0.0113 | 0.0018 | &lt;0.001 | 0.04813 | 0.973 | 401.6 ± 0.9 | 407.1 ± 0.9 |
| 700 | 13 | 6.20E-14 | 3.21E-15 | 19.3303 | 0.00E+00 | -0.0034 | 0.0030 | &lt;0.001 | 0.09100 | 0.954 | 397.6 ± 0.7 | 403.0 ± 0.7 |
| 750 | 13 | 1.60E-13 | 8.47E-15 | 18.8666 | 0.00E+00 | -0.0017 | 0.0023 | &lt;0.001 | 0.20367 | 0.964 | 393.0 ± 0.6* | 398.3 ± 0.6* |
| 800 | 13 | 3.20E-13 | 1.72E-14 | 18.6272 | 0.00E+00 | -0.0005 | 0.0011 | &lt;0.001 | 0.43038 | 0.983 | 395.0 ± 0.5* | 400.4 ± 0.5* |
| 850 | 13 | 1.20E-13 | 6.49E-15 | 18.5036 | 0.00E+00 | -0.0015 | 0.0006 | &lt;0.001 | 0.51761 | 0.990 | 395.4 ± 0.6* | 400.8 ± 0.6* |
| 900 | 13 | 1.50E-13 | 8.10E-15 | 18.5099 | 0.00E+00 | -0.0019 | 0.0010 | &lt;0.001 | 0.62119 | 0.985 | 393.4 ± 0.6* | 398.8 ± 0.6* |
| 950 | 13 | 3.00E-12 | 4.15E-14 | 18.5123 | 0.00E+00 | -0.0027 | 0.0013 | &lt;0.001 | 0.71143 | 0.979 | 392.9 ± 0.6* | 398.2 ± 0.6* |
| 1000 | 13 | 6.00E-12 | 1.52E-14 | 18.4493 | 0.00E+00 | -0.0025 | 0.0010 | &lt;0.001 | 0.82892 | 0.984 | 391.8 ± 0.6 | 397.1 ± 0.6 |
| 1050 | 13 | 1.00E-11 | 1.70E-14 | 17.9054 | 0.00E+00 | -0.0015 | 0.0005 | &lt;0.001 | 0.97200 | 0.992 | 384.5 ± 0.6 | 387.9 ± 0.6 |
| 1100 | 13 | 7.00E-12 | 4.15E-14 | 18.5123 | 0.00E+00 | -0.0027 | 0.0013 | &lt;0.001 | 0.71143 | 0.979 | 392.9 ± 0.6* | 398.2 ± 0.6* |
| sample e9730g1, UTM 0531470 6908563: J = 0.0133759; TFA = 412.1 ± 0.8 (3.3) Ma; WMA = 410.5 ± 1.3 (3.4) Ma; IA = 409.0 ± 1.9 (3.7) Ma (MSWD = 4.6) |
| 560 | 13 | 6.40E-15 | 2.97E-16 | 21.5395 | 0.00E+00 | 0.3230 | 0.0089 | 1.50 | 0.05367 | 0.878 | 406.9 ± 3.5 | 412.4 ± 3.5 |
| 630 | 13 | 1.50E-14 | 7.80E-16 | 19.2205 | 0.00E+00 | 0.2654 | 0.0024 | 1.80 | 0.19568 | 0.963 | 399.0 ± 1.5 | 404.4 ± 1.5 |
| 690 | 13 | 2.50E-14 | 1.31E-15 | 19.1570 | 0.00E+00 | 0.3010 | 0.0096 | 1.60 | 0.43021 | 0.986 | 406.5 ± 1.1* | 412.0 ± 1.0* |
| 730 | 13 | 1.80E-14 | 9.36E-16 | 19.2271 | 0.00E+00 | 0.3437 | 0.0016 | 1.40 | 0.60300 | 0.975 | 403.8 ± 1.2* | 409.3 ± 1.2* |
| 760 | 13 | 9.00E-15 | 4.61E-16 | 19.5339 | 0.00E+00 | 0.4158 | 0.0023 | 1.20 | 0.68585 | 0.965 | 405.7 ± 2.1* | 411.2 ± 2.1* |</p>
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<th>Temperature of Maximum Post-Depositional Loss (°C)</th>
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Sample e9818b, UTM 0438451 6863002: J = 0.0133824; TFA = 393.5 ± 0.5 (3.1) Ma; WMPA = 392.9 ± 0.5 Ma (3.1); IA = 392.9 ± 0.9 (3.1) (MSWD = 0.85)
sample e9804j1, UTM 0412007 6908063: J = 0.0133849; TFA = 391.8 ± 0.6 (3.1) Ma; WMPA = 391.2 ± 0.5 (3.0) Ma; IA = 390.8 ± 0.7 (3.1) Ma (MSWD = 0.70)

sample e9731d2, UTM 0492058 6896386: J = 0.0133872; TFA = 399.9 ± 0.6 (3.1) Ma; WMPA = 399.1 ± 0.5 (3.1) Ma; IA = 398.6 ± 0.9 (3.2) Ma (MSWD = 0.18)
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Sample e9809g3, UTM 0372629 6876228: J = 0.0133892; TFA = 391.2 ± 0.5 (3.0) Ma; WMPA = 390.3 ± 0.4 (3.0) Ma; IA = 389.6 ± 0.7 (3.1) Ma (MSWD = 0.32)
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**Sample e9804c7**

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**Sample e1627i**

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**Sample e1704c**

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