*Supplementary material*

# Zircon (U-Th)/He closure temperature lower than apatite thermochronometric systems: Reconciliation of a paradox

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We present hereafter the data files corresponding to the recounting of the AFT for the samples AB-17-68 and AB-17-69 (binomfit; Figures S1 and S2). We provide also the binomfit output files and the radial plots corresponding to the ZFT analysis for samples AB-17-64, AB-17-67 and AB-17-68 (Figures S3 to S5 respectively).

*janvier 12 2021 16:14* *BinomFit for Windows ver.1.2* *Page 1*
Datafile: C:\Users\balvaym\Desktop\AB 17 68.fta
Title: AB 17 68- Irr 1-2018-24

**NEW PARAMETERS - ZETA METHOD**

EFFECTIVE TRACK DENSITY FOR FLUENCE MONITOR (tracks/cm^2): 1,49E+06
RELATIVE ERROR (%): 1,37
EFFECTIVE URANIUM CONTENT OF MONITOR (ppm): 15,00
ZETA FACTOR AND STANDARD ERROR (yr cm^2): 270,90 9,61
SIZE OF COUNTER SQUARE (cm^2): 6,39E-07

**GRAIN AGES IN ORIGINAL ORDER**

| Grain no. | RhoS (cm^-2) | (Ns) | RhoI (cm^-2) | (Ni) | Squares | U+/-2s | | Grain Age (Ma) Age | --95% CI-- | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3,48E+05 | ( 4) | 3,13E+06 | ( 36) | 18 | 32 | 10 | 23.2 | 5.8 | 62.3 |
| 2 | 6,57E+05 | ( 21) | 6,76E+06 | ( 216) | 50 | 68 | 9 | 19.7 | 11.9 | 30.7 |
| 3 | 8,35E+05 | ( 8) | 9,29E+06 | ( 89) | 15 | 93 | 20 | 18.5 | 7.6 | 37.2 |
| 4 | 1,25E+06 | ( 8) | 1,42E+07 | ( 91) | 10 | 143 | 30 | 18.1 | 7.4 | 36.4 |
| 5 | 4,79E+05 | ( 15) | 6,13E+06 | ( 192) | 49 | 62 | 9 | 15.9 | 8.6 | 26.6 |
| 6 | 4,35E+05 | ( 5) | 4,26E+06 | ( 49) | 18 | 43 | 12 | 21.2 | 6.4 | 51.2 |
| 7 | 2,87E+05 | ( 9) | 1,85E+06 | ( 58) | 49 | 19 | 5 | 31.7 | 13.6 | 63.4 |
| 8 | 1,74E+05 | ( 1) | 1,74E+06 | ( 10) | 9 | 18 | 11 | 22.7 | 0.5 | 140.4 |
| 9 | 1,10E+06 | ( 7) | 1,11E+07 | ( 71) | 10 | 112 | 27 | 20.3 | 7.7 | 43.1 |
| 10 | 0,00E+00 | ( 0) | 2,44E+06 | ( 39) | 25 | 25 | 8 | 3.6 | 0.1 | 20.0 |
| POOLED | 4,82E+05 | ( 78) | 5,26E+06 | ( 851) | 253 | 53 | 4 | 18.5 | 14.5 | 23.5 |

CHI^2 PROBABILITY (%): 69.4
>>> Beware: possible upward bias in Chi^2 probability due to low counts <<<

POOLED AGE W/ 68% CONF. INTERVAL(Ma): 18.5, 16.3 -- 20.9 ( -2.2 +2.4)
95% CONF. INTERVAL(Ma): 14.5 -- 23.5 ( -4.0 +5.1)

CENTRAL AGE W/ 68% CONF. INTERVAL(Ma): 18.5, 16.3 -- 20.9 ( -2.2 +2.4)
95% CONF. INTERVAL(Ma): 14.5 -- 23.6 ( -4.0 +5.1)
AGE DISPERSION (%): 0.2

**Figure S1.** binomfit output file for sample AB-17-68 (AFT dating).

*janvier 12 2021 16:17* *BinomFit for Windows ver.1.2* *Page 1*
Datafile: C:\Users\balvaym\Desktop\AB 17 69.fta
Title: AB 17 69- Irr 1-2018-25

**NEW PARAMETERS - ZETA METHOD**

EFFECTIVE TRACK DENSITY FOR FLUENCE MONITOR (tracks/cm^2): 1,49E+06
RELATIVE ERROR (%): 1,42
EFFECTIVE URANIUM CONTENT OF MONITOR (ppm): 15,00
ZETA FACTOR AND STANDARD ERROR (yr cm^2): 270,90 9,61
SIZE OF COUNTER SQUARE (cm^2): 6,39E-07

**GRAIN AGES IN ORIGINAL ORDER**

| Grain no. | RhoS (cm^-2) | (Ns) | RhoI (cm^-2) | (Ni) | Squares | U+/-2s | | Grain Age (Ma) Age | --95% CI-- | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4,89E+04 | ( 1) | 1,86E+06 | ( 38) | 32 | 19 | 6 | 6.1 | 0.1 | 31.4 |
| 2 | 6,26E+04 | ( 1) | 2,25E+06 | ( 36) | 25 | 23 | 8 | 6.4 | 0.1 | 33.3 |
| 3 | 0,00E+00 | ( 0) | 2,70E+06 | ( 62) | 36 | 27 | 7 | 2.3 | 0.1 | 12.4 |
| 4 | 0,00E+00 | ( 0) | 2,54E+06 | ( 26) | 16 | 26 | 10 | 5.5 | 0.2 | 30.8 |
| 5 | 0,00E+00 | ( 0) | 1,59E+06 | ( 71) | 70 | 16 | 4 | 2.0 | 0.1 | 10.8 |
| 6 | 0,00E+00 | ( 0) | 4,07E+05 | ( 13) | 50 | 4 | 2 | 11.1 | 0.4 | 66.0 |
| 7 | 1,12E+05 | ( 2) | 2,01E+06 | ( 36) | 28 | 20 | 7 | 12.0 | 1.3 | 43.5 |
| 8 | 0,00E+00 | ( 0) | 1,65E+06 | ( 38) | 36 | 17 | 5 | 3.7 | 0.1 | 20.6 |
| 9 | 5,22E+04 | ( 1) | 2,30E+06 | ( 44) | 30 | 23 | 7 | 5.2 | 0.1 | 26.9 |
| 10 | 7,82E+04 | ( 3) | 2,61E+06 | ( 100) | 60 | 26 | 5 | 6.4 | 1.2 | 18.2 |
| 11 | 0,00E+00 | ( 0) | 2,27E+06 | ( 58) | 40 | 23 | 6 | 2.4 | 0.1 | 13.3 |
| POOLED | 2,96E+04 | ( 8) | 1,93E+06 | ( 522) | 423 | 19 | 2 | 3.2 | 1.3 | 6.2 |

CHI^2 PROBABILITY (%): 45.2
>>> Beware: possible upward bias in Chi^2 probability due to low counts <<<

POOLED AGE W/ 68% CONF. INTERVAL(Ma): 3.2, 2.0 -- 4.6 ( -1.1 +1.5)
95% CONF. INTERVAL(Ma): 1.3 -- 6.2 ( -1.8 +3.0)

CENTRAL AGE W/ 68% CONF. INTERVAL(Ma): 3.1, 2.2 -- 4.4 ( -0.9 +1.3)
95% CONF. INTERVAL(Ma): 1.5 -- 6.3 ( -1.6 +3.2)
AGE DISPERSION (%): 13.6

**Figure S2.** binomfit output file for sample AB-17-69 (AFT dating).

Datafile: C:\Fission-track Lab\irradiations\2019\1-2019_zircon\Peru\AB_17_64_1-2019-52.ftz
Title: AB_17_64_1-2019-52

**NEW PARAMETERS - ZETA METHOD**

```
EFFECTIVE TRACK DENSITY FOR FLUENCE MONITOR (tracks/cm^2): 3.92E+05
                                        RELATIVE ERROR (%): 1.45
              EFFECTIVE URANIUM CONTENT OF MONITOR (ppm): 50.00
                ZETA FACTOR AND STANDARD ERROR (yr cm^2): 131.49   5.30
                             SIZE OF COUNTER SQUARE (cm^2): 6.39E-07
```

**GRAIN AGES IN ORIGINAL ORDER**

| Grain no. | RhoS (cm^-2) | (Ns) | RhoI (cm^-2) | (Ni) | Squares | U+/-2s | Grain Age (Ma) Age | --95% CI-- | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.13E+06 | ( 36) | 7.07E+06 | ( 226) | 50 | 903 123 | 4.1 | 2.8 | 5.9 |
| 2 | 7.20E+05 | ( 23) | 2.72E+06 | ( 87) | 50 | 348 75 | 6.8 | 4.1 | 10.9 |
| 3 | 1.04E+06 | ( 20) | 8.61E+06 | ( 165) | 30 | 1099 174 | 3.1 | 1.9 | 5.0 |
| 4 | 7.82E+05 | ( 20) | 6.34E+06 | ( 162) | 40 | 809 129 | 3.2 | 1.9 | 5.1 |
| 5 | 1.37E+06 | ( 14) | 7.14E+06 | ( 73) | 16 | 912 214 | 5.0 | 2.6 | 8.8 |
| 6 | 1.41E+06 | ( 36) | 5.59E+06 | ( 143) | 40 | 715 121 | 6.5 | 4.4 | 9.4 |
| 7 | 1.13E+06 | ( 29) | 5.59E+06 | ( 143) | 40 | 715 121 | 5.2 | 3.4 | 7.8 |
| 8 | 1.56E+06 | ( 40) | 8.14E+06 | ( 208) | 40 | 1039 147 | 5.0 | 3.4 | 7.0 |
| 9 | 1.35E+06 | ( 43) | 5.35E+06 | ( 171) | 50 | 684 106 | 6.5 | 4.5 | 9.1 |
| 10 | 2.47E+06 | ( 79) | 1.40E+07 | ( 448) | 50 | 1791 177 | 4.5 | 3.5 | 5.8 |
| 11 | 8.87E+05 | ( 17) | 3.65E+06 | ( 70) | 30 | 466 112 | 6.3 | 3.4 | 10.7 |
| 12 | 3.68E+06 | ( 47) | 1.41E+07 | ( 180) | 20 | 1799 273 | 6.7 | 4.8 | 9.3 |
| 13 | 1.06E+06 | ( 27) | 4.69E+06 | ( 120) | 40 | 600 111 | 5.8 | 3.7 | 8.9 |
| 14 | 2.05E+06 | ( 21) | 8.31E+06 | ( 85) | 16 | 1062 232 | 6.4 | 3.7 | 10.4 |
| 15 | 9.00E+05 | ( 23) | 3.52E+06 | ( 90) | 40 | 450 95 | 6.6 | 4.0 | 10.5 |
| 16 | 1.51E+06 | ( 29) | 6.99E+06 | ( 134) | 30 | 893 156 | 5.6 | 3.6 | 8.4 |
| 17 | 1.56E+06 | ( 16) | 3.91E+06 | ( 40) | 16 | 500 158 | 10.4 | 5.4 | 18.8 |
| 18 | 1.37E+06 | ( 14) | 5.97E+06 | ( 61) | 16 | 762 196 | 6.0 | 3.0 | 10.7 |
| 19 | 2.27E+06 | ( 29) | 1.09E+07 | ( 139) | 20 | 1389 239 | 5.4 | 3.5 | 8.1 |
| 20 | 1.25E+06 | ( 24) | 5.53E+06 | ( 106) | 30 | 706 138 | 5.9 | 3.6 | 9.1 |
| POOLED | 1.38E+06 | ( 587) | 6.72E+06 | ( 2851) | 664 | 858 41 | 5.3 | 4.7 | 6.0 |

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CHI^2 PROBABILITY (%): 10.1

 POOLED AGE W/  68% CONF. INTERVAL(Ma):    5.3,    5.0 --    5.6 ( -0.3  +0.3)
                95% CONF. INTERVAL(Ma):            4.7 --    6.0 ( -0.6  +0.7)

CENTRAL AGE W/  68% CONF. INTERVAL(Ma):    5.4,    5.0 --    5.8 ( -0.4  +0.4)
                95% CONF. INTERVAL(Ma):            4.7 --    6.2 ( -0.7  +0.8)
                    AGE DISPERSION (%):   11.9
```

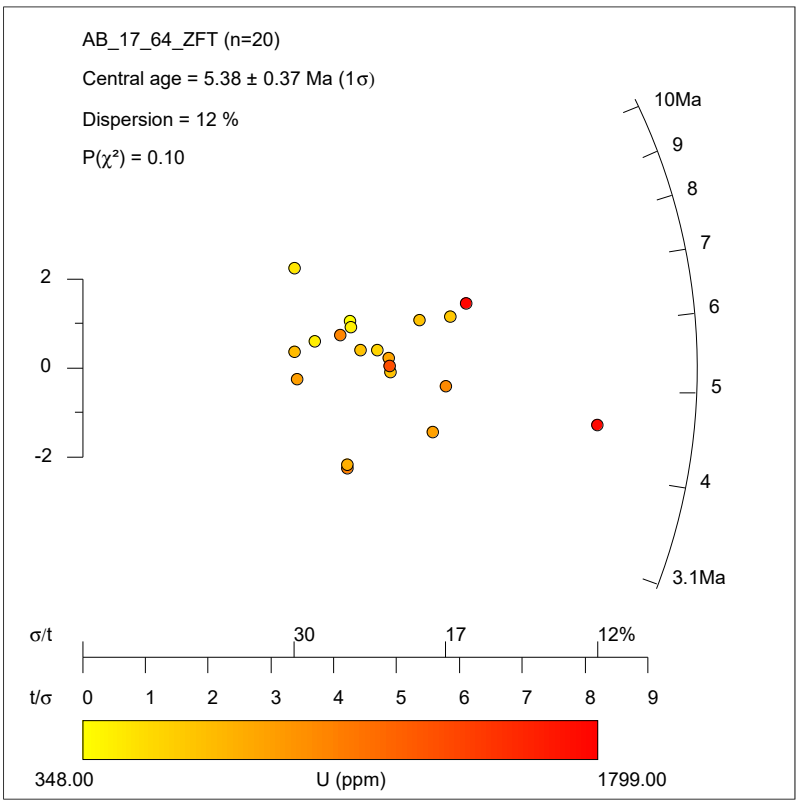


**Figure S3.** binomfit output file for sample AB-17-64 (ZFT dating).

Datafile: C:\Fission-track Lab\irradiations\2019\1-2019_zircon\Peru\AB_17_67_1-2019-53.ftz
Title: AB_17_67_1-2019-53

**NEW PARAMETERS - ZETA METHOD**

EFFECTIVE TRACK DENSITY FOR FLUENCE MONITOR (tracks/cm^2): 3.91E+05
RELATIVE ERROR (%): 1.47
EFFECTIVE URANIUM CONTENT OF MONITOR (ppm): 50.00
ZETA FACTOR AND STANDARD ERROR (yr cm^2): 131.49 5.30
SIZE OF COUNTER SQUARE (cm^2): 6.39E-07

**GRAIN AGES IN ORIGINAL ORDER**

| Grain no. | RhoS (cm^-2) | (Ns) | RhoI (cm^-2) | (Ni) | Squares | U+/-2s | Grain Age (Ma) Age | --95% CI-- | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.10E+06 | ( 21) | 3.86E+06 | ( 74) | 30 | 493 115 | 7.3 | 4.3 | 12.0 |
| 2 | 9.39E+05 | ( 24) | 5.20E+06 | ( 133) | 40 | 665 117 | 4.7 | 2.9 | 7.2 |
| 3 | 6.26E+05 | ( 20) | 2.25E+06 | ( 72) | 50 | 288 68 | 7.2 | 4.1 | 11.9 |
| 4 | 6.85E+05 | ( 7) | 1.17E+06 | ( 12) | 16 | 150 85 | 15.1 | 5.0 | 41.3 |
| 5 | 1.04E+06 | ( 20) | 4.12E+06 | ( 79) | 30 | 526 119 | 6.6 | 3.8 | 10.8 |
| 6 | 5.63E+05 | ( 18) | 2.35E+06 | ( 75) | 50 | 300 70 | 6.2 | 3.5 | 10.4 |
| 7 | 1.08E+06 | ( 11) | 4.69E+06 | ( 48) | 16 | 600 173 | 6.0 | 2.8 | 11.5 |
| 8 | 1.25E+06 | ( 24) | 5.63E+06 | ( 108) | 30 | 720 140 | 5.7 | 3.5 | 9.0 |
| 9 | 1.06E+06 | ( 27) | 3.44E+06 | ( 88) | 40 | 440 94 | 7.9 | 4.9 | 12.3 |
| 10 | 1.19E+06 | ( 38) | 5.23E+06 | ( 167) | 50 | 668 105 | 5.9 | 4.0 | 8.4 |
| 11 | 6.78E+05 | ( 13) | 2.71E+06 | ( 52) | 30 | 347 96 | 6.5 | 3.2 | 12.0 |
| 12 | 1.66E+06 | ( 53) | 6.51E+06 | ( 208) | 50 | 832 118 | 6.6 | 4.7 | 8.9 |
| 13 | 9.70E+05 | ( 31) | 2.88E+06 | ( 92) | 50 | 368 77 | 8.7 | 5.6 | 13.2 |
| 14 | 1.80E+06 | ( 23) | 4.62E+06 | ( 59) | 20 | 590 154 | 10.1 | 5.9 | 16.5 |
| 15 | 1.15E+06 | ( 22) | 5.69E+06 | ( 109) | 30 | 726 140 | 5.2 | 3.1 | 8.3 |
| 16 | 1.25E+06 | ( 32) | 3.91E+06 | ( 100) | 40 | 500 101 | 8.3 | 5.3 | 12.4 |
| 17 | 7.82E+05 | ( 10) | 3.91E+06 | ( 50) | 20 | 500 141 | 5.2 | 2.3 | 10.3 |
| 18 | 1.00E+06 | ( 16) | 4.44E+06 | ( 71) | 25 | 568 135 | 5.8 | 3.1 | 10.1 |
| 19 | 1.02E+06 | ( 26) | 3.05E+06 | ( 78) | 40 | 390 89 | 8.6 | 5.3 | 13.5 |
| 20 | 3.03E+06 | ( 31) | 9.88E+06 | ( 101) | 16 | 1262 253 | 7.9 | 5.1 | 11.9 |
| POOLED | 1.09E+06 | ( 467) | 4.13E+06 | ( 1776) | 673 | 528 29 | 6.8 | 5.9 | 7.7 |

CHI^2 PROBABILITY (%): 59.2
>>> Beware: possible upward bias in Chi^2 probability due to low counts <<<

POOLED AGE W/ 68% CONF. INTERVAL(Ma): 6.8, 6.3 -- 7.2 ( -0.4 +0.5)
95% CONF. INTERVAL(Ma): 5.9 -- 7.7 ( -0.8 +1.0)

CENTRAL AGE W/ 68% CONF. INTERVAL(Ma): 6.8, 6.3 -- 7.2 ( -0.4 +0.5)
95% CONF. INTERVAL(Ma): 5.9 -- 7.7 ( -0.8 +1.0)
AGE DISPERSION (%): 0.7

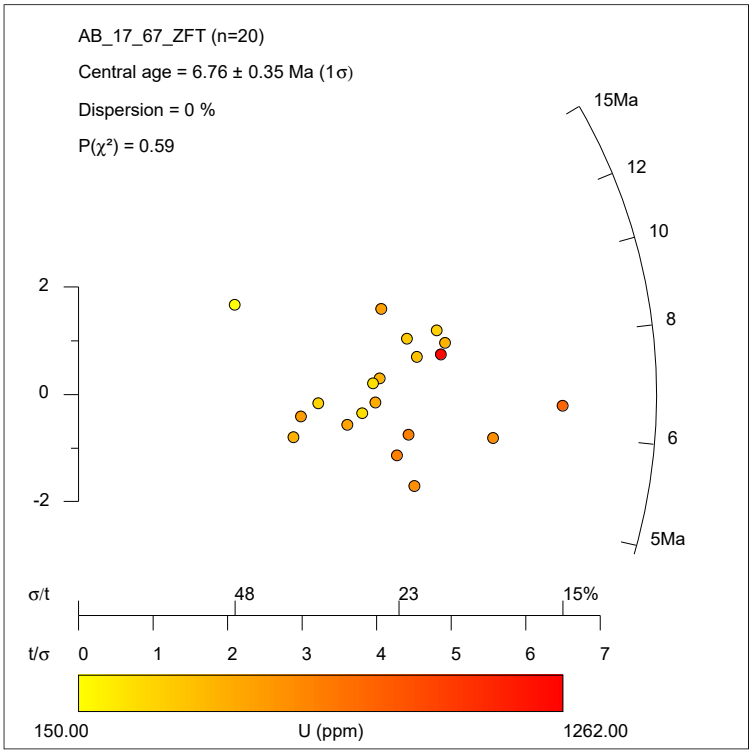


**Figure S4.** binomfit output file for sample AB-17-67 (ZFT dating).

Datafile: C:\Fission-track Lab\irradiations\2019\1-2019_zircon\Peru\AB_17_68_1-2019-54.ftz
Title: AB_17_68_1-2019-54

**NEW PARAMETERS - ZETA METHOD**

EFFECTIVE TRACK DENSITY FOR FLUENCE MONITOR (tracks/cm^2): 3.91E+05
RELATIVE ERROR (%): 1.50
EFFECTIVE URANIUM CONTENT OF MONITOR (ppm): 50.00
ZETA FACTOR AND STANDARD ERROR (yr cm^2): 131.49 5.30
SIZE OF COUNTER SQUARE (cm^2): 6.39E-07

**GRAIN AGES IN ORIGINAL ORDER**

| Grain no. | RhoS (cm^-2) | (Ns) | RhoI (cm^-2) | (Ni) | Squares | U+/-2s | Grain Age (Ma) Age | --95% CI-- | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.00E+06 | ( 23) | 3.04E+06 | ( 70) | 36 | 389 93 | 8.5 | 5.0 | 13.7 |
| 2 | 9.39E+05 | ( 12) | 4.69E+06 | ( 60) | 20 | 600 155 | 5.2 | 2.5 | 9.7 |
| 3 | 5.74E+05 | ( 11) | 3.18E+06 | ( 61) | 30 | 407 104 | 4.7 | 2.2 | 8.9 |
| 4 | 1.37E+06 | ( 14) | 4.21E+06 | ( 43) | 16 | 537 164 | 8.4 | 4.2 | 15.6 |
| 5 | 1.66E+06 | ( 17) | 3.91E+06 | ( 40) | 16 | 500 158 | 11.0 | 5.8 | 19.7 |
| 6 | 5.59E+05 | ( 5) | 2.01E+06 | ( 18) | 14 | 257 120 | 7.3 | 2.1 | 20.0 |
| 7 | 8.22E+05 | ( 21) | 2.39E+06 | ( 61) | 40 | 305 78 | 8.9 | 5.1 | 14.8 |
| 8 | 1.60E+06 | ( 41) | 5.95E+06 | ( 152) | 40 | 760 125 | 7.0 | 4.8 | 9.9 |
| 9 | 9.39E+05 | ( 18) | 4.02E+06 | ( 77) | 30 | 513 118 | 6.1 | 3.4 | 10.1 |
| 10 | 1.56E+06 | ( 20) | 5.24E+06 | ( 67) | 20 | 670 164 | 7.7 | 4.4 | 12.8 |
| 11 | 1.72E+06 | ( 22) | 5.32E+06 | ( 68) | 20 | 680 166 | 8.4 | 4.9 | 13.6 |
| 12 | 1.76E+06 | ( 18) | 5.87E+06 | ( 60) | 16 | 750 194 | 7.8 | 4.3 | 13.3 |
| 13 | 1.33E+06 | ( 34) | 6.03E+06 | ( 154) | 40 | 770 126 | 5.7 | 3.8 | 8.3 |
| 14 | 1.51E+06 | ( 29) | 4.59E+06 | ( 88) | 30 | 587 126 | 8.5 | 5.4 | 13.0 |
| 15 | 1.66E+06 | ( 17) | 7.24E+06 | ( 74) | 16 | 925 216 | 6.0 | 3.3 | 10.1 |
| 16 | 1.64E+06 | ( 21) | 5.79E+06 | ( 74) | 20 | 740 173 | 7.3 | 4.3 | 12.0 |
| 17 | 8.09E+05 | ( 31) | 3.29E+06 | ( 126) | 60 | 420 76 | 6.4 | 4.1 | 9.4 |
| 18 | 1.66E+06 | ( 17) | 3.72E+06 | ( 38) | 16 | 475 154 | 11.6 | 6.1 | 20.9 |
| 19 | 1.25E+06 | ( 16) | 5.63E+06 | ( 72) | 20 | 720 170 | 5.8 | 3.1 | 9.9 |
| 20 | 1.21E+06 | ( 31) | 4.19E+06 | ( 107) | 40 | 535 104 | 7.5 | 4.8 | 11.2 |
| POOLED | 1.21E+06 | ( 418) | 4.38E+06 | ( 1510) | 540 | 559 33 | 7.1 | 6.2 | 8.2 |

CHI^2 PROBABILITY (%): 78.6
>>> Beware: possible upward bias in Chi^2 probability due to low counts <<<

POOLED AGE W/ 68% CONF. INTERVAL(Ma): 7.1, 6.6 -- 7.6 ( -0.5 +0.5)
95% CONF. INTERVAL(Ma): 6.2 -- 8.2 ( -0.9 +1.0)

CENTRAL AGE W/ 68% CONF. INTERVAL(Ma): 7.1, 6.6 -- 7.6 ( -0.5 +0.5)
95% CONF. INTERVAL(Ma): 6.2 -- 8.2 ( -0.9 +1.0)
AGE DISPERSION (%): 0.3

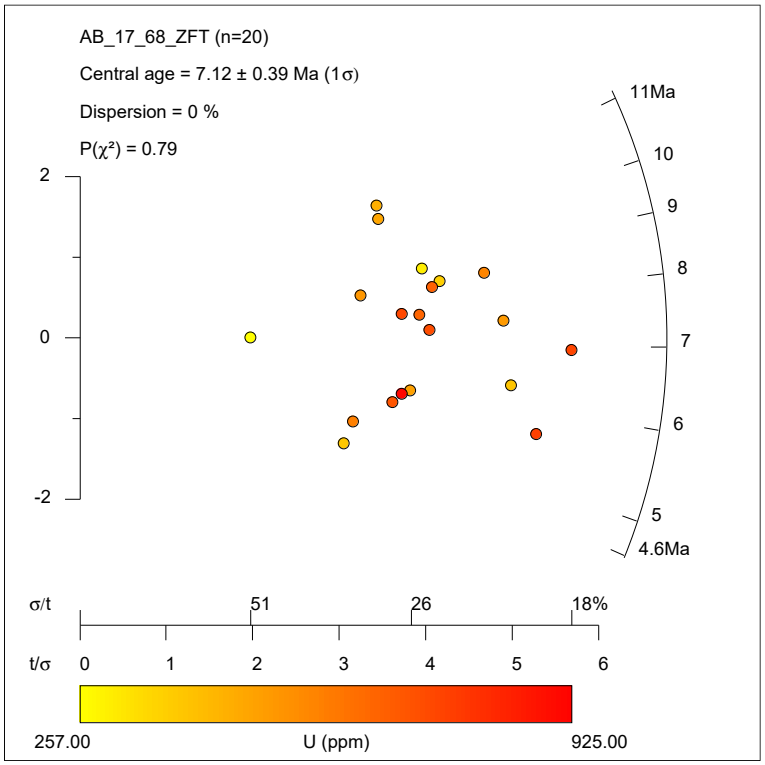


**Figure S5.** binomfit output file for sample AB-17-68 (ZFT dating).