***Frontiers in Earth Science***

Supporting Information for

New Paleomagnetic Constraint on the Early Cretaceous Paleolatitude of the Lhasa Terrane (Tibet)

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Text S1. Procedures & Methods for Zircon U-Pb Radiometric Dating

Zircon grains were selected from three radiometric dating samples of the Lower Cretaceous Zonggei Formation volcanic rocks, which were processed using standard procedures and heavy liquid, magnetic and electromagnetic separation techniques at the Langfang Center for Rocks and Minerals Separation. In total, thirty-six prismatic zircon grains were selected from each bulk sample and were hand-picked and mounted on adhesive tape, enclosed in epoxy resin and then polished to half-width of their initial size.

Before measurement, cathodoluminescence (CL) images of zircon grains were taken to study internal structures for subsequent U-Pb dating analysis using a Gatan mini-CL detector coupled to a JEOL JXA-8100 electron microprobe at the Institute of Tibetan Plateau Research, Chinese Academy of Sciences (ITPCAS) in Beijing, China. Isotopes of 204Pb, 206Pb, 207Pb, 232Th and 238U were collected using a New Wave UP 193FX Excimer laser (New Wave Instrument, U.S.A.) coupled to an Agilent 7500a inductively coupled plasma mass spectrometer (ICP-MS) at ITPCAS. We used a laser repetition rate of 8 Hz, laser energy of 5-8 J/cm2, and a focused laser beam with a diameter of 30 μm. Readers who are interested in this topic please refer to Xiong et al. (2020) for more details. We used zircon standard 91500 as our primary standard and GJ-1 as our secondary standard (Wiendenbeck et al., 1995; Jackson et al., 2004).

Offline isotope ratios and trace element concentrations were calculated using GLITTER 4.0 software (Jackson et al., 2004). Ages have been calculated from the U and Th decay constants recommended by Steiger and Jäger (1977). All reported common Pb corrections (using the ComPbCorr# routine), age calculations, and concordant ages were made using Isoplot 4.00 (Ludwig, 2012). Weighted 206Pb/238U ages of standard zircon 91500 and standard zircon GJ-1 obtained in this study are 1080±46 Ma (1 sigma, n=18), and 600±14 Ma (1 sigma, n=42), respectively, in agreement with the recommended values (Wiendenbeck et al., 1995; Jackson et al., 2004). There is very little or no Pb loss in our samples from concordant plots of three bulk samples. Individual analyses for each sample are reported in the data table and Concordant plots with 1σ error and uncertainties in calculated ages are at the 95% level (2σ) (see Table S2 below).

For the sample 2012TZ580, of 36 analyses completed, 23 of them are concordant and yielded a weighted mean age of 110.51±0.42 Ma (MSWD=1.5) (see Figure S1, Table S2 below). For the sample 2012TZ578, of the 36 spot analyses completed, 20 of them are concordant and yielded a weighted mean age of 111.16±0.71 Ma (MSWD=5.4), and for the sample 2012TZ576, of the 36 spot analyses completed, 18 of them are concordant and yielded a weighted mean age of 114.0±0.78 Ma (MSWD=3.1) (see Figure S1, Table S2 below). Thus, the age of the Zonggei Formation volcanic rocks around the Nagqu County location is at the period of 114-110 Ma.

Text S2. Paleomagnetic Data Selection and Field Tests

**S2.1 Procedures and Details for the 20 Group-Mean Directions**

The maximum angular deviations (MAD) are primarily less than 16° when the PCA method used to isolate HTC. Here we defined the HTCs as the ChRM directions for all specimens. In this study, we applied the following criteria to ChRMs and Fisherian site-means before proceeding with additional data analysis, (1) MAD values for isolated ChRMs are <16°; (2) a site-mean direction was determined by 4 consecutive steps at high temperatures; (3) a site-mean direction includes at least 2 specimens; (4) precision parameter k of a site-mean direction is of and greater than the cut-off value of 50 (Johnson et al., 2008). However, considering that the paleomagnetic sites TNZ04, TNZ05, and TNZ06 were drilled from the same lava flow, then we combined these three sites into one group and calculated a final group mean for sites TNZ04 (2 specimens), TNZ05 (6 specimens), and TNZ 06 (4 specimens). The final group mean of TNZ 04, TNZ05, and TNZ06 is D±ΔD=5.7°±4.7°, I±ΔD=33.8°±3.9°, α95=3.9°, with k=122.5 *n*=12 (D±ΔD=330.7°±6.0°, I±ΔI=48.9°±3.9°, α95=3.9°, with k=122.5) after (before) bedding correction.

**S2.2 Field Tests for the 20 Group-Mean Directions**

For the combined 20 group-mean directions, details of the field tests are as follows. The stepwise unfolding test (Watson and Enkin, 1993) shows that the precision parameter reached its maximum value (K=36.6) at the unfolding level of 81.4±16.3%, confirming a pre-folding origin of the isolated ChRMs directions (see Figure S5 below). The reversal test also exhibits “class-C” level (angles of two antipodal directions γ=10.3°, critical valueγc=18.7°) (McFadden & McElhinny, 1990), indicating a positive result (Table 1 in the main text; Figure S5 below). The correlation test (McFadden & Lowes, 1981; McFadden, 1990) shows that ξ2=1.756 (=9.156) after (before) bedding correction and the critical value ξc=5.335 and 7.483 at the 95% and 99% confidence level, respectively.

**Figures**



**Figure S1.** Stepwise unfolding test (Watson and Enkin, 1993) for selected isolated ChRMs from Lower Cretaceous Zonggei Formation volcanic rocks combined with previously published results of the Lower Cretaceous Duoni Formation volcano-sedimentary rocks. The precision parameter k reaches its maximum value of 35.76 when unfolded to 81.4±17.0% level, indicating the pre-folding nature of ChRM directions.

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| **Table S1**. Reference paleopoles used to establish paleolatitudes evolution of the Eurasian and Indian continents since 130 Ma in this study. | | | | | | | | | | |
|  |  |  |  |  |  |  |  |  |  |  | |
| **ID** | **Formation/Lithology** | **Age (Ma)** | **Plat(°N)** | **Plong(°E)** | **A95 (°)** | **Paleolat (°N)** | **Reference** |  |  |  | |
| ***Reference paleopoles for the Eurasian Continent (29.5°N, 91.0°E)*** | | | | |  |  |  |  |  |  | |
| Eur 0 | APW reference pole | 0 | 88.5 | 173.9 | 1.9 | 29.7±1.9 | Torsvik et al., 2012 |  |  |  | |
| Eur 10 | APW reference pole | 10 | 86.7 | 150 | 1.8 | 31.2±1.8 | Torsvik et al., 2012 |  |  |  | |
| Eur 20 | APW reference pole | 20 | 84.4 | 152.1 | 2.6 | 32.1±2.6 | Torsvik et al., 2012 |  |  |  | |
| Eur 30 | APW reference pole | 30 | 83.1 | 146.5 | 2.6 | 33.2±2.6 | Torsvik et al., 2012 |  |  |  | |
| Eur 40 | APW reference pole | 40 | 81.1 | 144.3 | 2.9 | 34.5±2.9 | Torsvik et al., 2012 |  |  |  | |
| Eur 50 | APW reference pole | 50 | 78.9 | 164.7 | 2.8 | 32±2.8 | Torsvik et al., 2012 |  |  |  | |
| Eur 60 | APW reference pole | 60 | 78.2 | 172.6 | 2.1 | 30.5±2.1 | Torsvik et al., 2012 |  |  |  | |
| Eur 70 | APW reference pole | 70 | 79.2 | 175.7 | 2.5 | 29.9±2.5 | Torsvik et al., 2012 |  |  |  | |
| Eur 80 | APW reference pole | 80 | 79.7 | 177.9 | 2.9 | 29.5±2.9 | Torsvik et al., 2012 |  |  |  | |
| Eur 90 | APW reference pole | 90 | 80.4 | 167.2 | 2.5 | 31.3±2.5 | Torsvik et al., 2012 |  |  |  | |
| Eur 100 | APW reference pole | 100 | 80.8 | 152.3 | 3.3 | 33.6±3.3 | Torsvik et al., 2012 |  |  |  | |
| Eur 110 | APW reference pole | 110 | 81.2 | 193.1 | 3.3 | 27.3±3.3 | Torsvik et al., 2012 |  |  |  | |
| Eur 120 | APW reference pole | 120 | 79 | 190.1 | 2.6 | 27.2±2.6 | Torsvik et al., 2012 |  |  |  | |
| Eur 130 | APW reference pole | 130 | 75 | 183.4 | 2.8 | 27.8±2.8 | Torsvik et al., 2012 |  |  |  | |
|  |  |  |  |  |  |  |  |  |  |  | |
| ***Reference paleopoles for the Indian shield (29.5°N, 91.0°E)*** | | | | |  |  |  |  |  |  | |
| Ind 0 | APW reference pole | 0 | 88.5 | 173.9 | 1.9 | 29.7±1.9 | Torsvik et al., 2012 |  |  |  | |
| Ind 10 | APW reference pole | 10 | 87.2 | 240.4 | 1.8 | 27.1±1.8 | Torsvik et al., 2012 |  |  |  | |
| Ind 20 | APW reference pole | 20 | 83.7 | 254.7 | 2.6 | 23.4±2.6 | Torsvik et al., 2012 |  |  |  | |
| Ind 30 | APW reference pole | 30 | 79.7 | 281.7 | 2.6 | 19.4±2.6 | Torsvik et al., 2012 |  |  |  | |
| Ind 40 | APW reference pole | 40 | 74.7 | 286.8 | 2.9 | 14.7±2.9 | Torsvik et al., 2012 |  |  |  | |
| Ind 50 | APW reference pole | 50 | 65.1 | 278.4 | 2.8 | 4.8±2.8 | Torsvik et al., 2012 |  |  |  | |
| Ind 60 | APW reference pole | 60 | 48.5 | 280.8 | 2.1 | -11.5±2.1 | Torsvik et al., 2012 |  |  |  | |
| Ind 70 | APW reference pole | 70 | 36.4 | 280.7 | 2.5 | -23.5±2.5 | Torsvik et al., 2012 |  |  |  | |
| Ind 80 | APW reference pole | 80 | 29 | 283.5 | 2.9 | -30.3±2.9 | Torsvik et al., 2012 |  |  |  | |
| Ind 90 | APW reference pole | 90 | 20.9 | 291.4 | 2.5 | -35.9±2.5 | Torsvik et al., 2012 |  |  |  | |
| Ind 100 | APW reference pole | 100 | 19.7 | 293 | 3.3 | -36.4±3.3 | Torsvik et al., 2012 |  |  |  | |
| Ind 110 | APW reference pole | 110 | 11.1 | 295.9 | 3.3 | -42.8±3.3 | Torsvik et al., 2012 |  |  |  | |
| Ind 120 | APW reference pole | 120 | 8.6 | 296.4 | 2.6 | -44.7±2.6 | Torsvik et al., 2012 |  |  |  | |
| Ind 130 | APW reference pole | 130 | 1 | 297.1 | 2.8 | -50.6±2.8 | Torsvik et al., 2012 |  |  |  | |

Notes, abbreviations are as follows, **ID,** reference paleomagnetic poles which were derived from Torsvik et al., 2012 used in this study; **Plat. (°N), Plong. (°E)**, latitude and longitude of reference paleomagnetic poles which were derived from Torsvik et al., 2012; **Paleolat (°N),** paleolatitude calculated at reference point (29.5°N, 91.0°E).

**Table S2.** Corrected U-Pb isotopic compositions and ages for bulk samples of the Zonggei Formation volcanic rocks in the Nagqu area of central Tibet.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Analysis** | **CORRECTED RATIOS** | | | | | | | | | | **CORRECTED AGES (Ma)** | | | | | | | | **Ages (Ma)** | **1** |
|
| ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** | ***238U/232Th*** | **1** | ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** |
| **2012TZ580, Zonggei Formation volcanic rocks, Nagqu area** | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2012TZ580-01** | 0.04832 | 0.00244 | 0.11641 | 0.0057 | 0.01749 | 0.0002 | 0.00547 | 0.0001 | 0.99 | 0.01 | 115 | 89 | 112 | 5 | 112 | 1 | 110 | 2 | **112** | **1** |
| **2012TZ580-02** | 0.04884 | 0.00344 | 0.11699 | 0.0081 | 0.01739 | 0.00022 | 0.00555 | 0.00012 | 1.08 | 0.01 | 140 | 132 | 112 | 7 | 111 | 1 | 112 | 2 | **111** | **1** |
| **2012TZ580-03** | 0.0485 | 0.00235 | 0.11567 | 0.0054 | 0.01732 | 0.0002 | 0.00538 | 0.00011 | 1.36 | 0.01 | 124 | 85 | 111 | 5 | 111 | 1 | 108 | 2 | **111** | **1** |
| **2012TZ580-04** | 0.04831 | 0.00331 | 0.11494 | 0.0077 | 0.01728 | 0.00023 | 0.00542 | 0.00013 | 1.08 | 0.01 | 114 | 125 | 110 | 7 | 110 | 1 | 109 | 3 | **110** | **1** |
| **2012TZ580-05** | 0.04858 | 0.00596 | 0.11751 | 0.0143 | 0.01757 | 0.00029 | 0.0053 | 0.00015 | 1.27 | 0.01 | 128 | 236 | 113 | 13 | 112 | 2 | 107 | 3 | **112** | **2** |
| **2012TZ580-06** | 0.04866 | 0.00242 | 0.11493 | 0.0055 | 0.01715 | 0.00021 | 0.00523 | 0.0001 | 0.99 | 0.01 | 131 | 87 | 110 | 5 | 110 | 1 | 105 | 2 | **110** | **1** |
| **2012TZ580-07** | 0.04894 | 0.00624 | 0.11641 | 0.0145 | 0.01727 | 0.00047 | 0.00489 | 0.0002 | 0.83 | 0.01 | 145 | 226 | 112 | 13 | 110 | 3 | 99 | 4 | **110** | **3** |
| **2012TZ580-08** | 0.04798 | 0.00315 | 0.11357 | 0.0073 | 0.01719 | 0.00025 | 0.0051 | 0.00012 | 0.87 | 0.01 | 98 | 115 | 109 | 7 | 110 | 2 | 103 | 2 | **110** | **2** |
| **2012TZ580-09** | 0.04924 | 0.00215 | 0.11827 | 0.005 | 0.01744 | 0.00016 | 0.00503 | 0.00006 | 0.77 | 0.01 | 159 | 82 | 114 | 5 | 111 | 1 | 101 | 1 | **111** | **1** |
| **2012TZ580-10** | 0.04868 | 0.00215 | 0.1165 | 0.005 | 0.01738 | 0.00018 | 0.0052 | 0.00009 | 1.08 | 0.01 | 132 | 79 | 112 | 5 | 111 | 1 | 105 | 2 | **111** | **1** |
| **2012TZ580-11** | 0.04859 | 0.00943 | 0.11714 | 0.0225 | 0.0175 | 0.00045 | 0.00529 | 0.00028 | 1.02 | 0.01 | 128 | 314 | 112 | 20 | 112 | 3 | 107 | 6 | **112** | **3** |
| **2012TZ580-12** | 0.04849 | 0.00333 | 0.11501 | 0.0077 | 0.01722 | 0.00026 | 0.00557 | 0.00016 | 1.36 | 0.01 | 123 | 122 | 111 | 7 | 110 | 2 | 112 | 3 | **110** | **2** |
| **2012TZ580-13** | 0.04841 | 0.00528 | 0.11634 | 0.0125 | 0.01745 | 0.00032 | 0.00498 | 0.00018 | 1.05 | 0.01 | 119 | 207 | 112 | 11 | 112 | 2 | 100 | 4 | **112** | **2** |
| **2012TZ580-14** | 0.04917 | 0.00846 | 0.11624 | 0.0195 | 0.01717 | 0.00066 | 0.00524 | 0.00035 | 1.22 | 0.01 | 156 | 274 | 112 | 18 | 110 | 4 | 106 | 7 | **110** | **4** |
| **2012TZ580-15** | 0.04787 | 0.00364 | 0.11199 | 0.0083 | 0.01699 | 0.00027 | 0.00535 | 0.00013 | 0.86 | 0.01 | 93 | 135 | 108 | 8 | 109 | 2 | 108 | 3 | **109** | **2** |
| **2012TZ580-16** | 0.04901 | 0.00543 | 0.11558 | 0.0126 | 0.01713 | 0.00032 | 0.00526 | 0.0002 | 1.23 | 0.01 | 148 | 211 | 111 | 12 | 109 | 2 | 106 | 4 | **109** | **2** |
| **2012TZ580-17** | 0.04858 | 0.00392 | 0.11633 | 0.0092 | 0.01739 | 0.00031 | 0.00534 | 0.00017 | 1.08 | 0.01 | 128 | 143 | 112 | 8 | 111 | 2 | 108 | 3 | **111** | **2** |
| **2012TZ580-18** | 0.04774 | 0.00299 | 0.11193 | 0.0068 | 0.01703 | 0.00023 | 0.0053 | 0.00013 | 1.28 | 0.01 | 86 | 110 | 108 | 6 | 109 | 1 | 107 | 3 | **109** | **1** |
| **2012TZ580-19** | 0.04838 | 0.00478 | 0.11477 | 0.0112 | 0.01722 | 0.00025 | 0.00622 | 0.00016 | 1.08 | 0.01 | 118 | 191 | 110 | 10 | 110 | 2 | 125 | 3 | **110** | **2** |
| **2012TZ580-20** | 0.04879 | 0.00381 | 0.11427 | 0.0088 | 0.01701 | 0.00025 | 0.00519 | 0.00014 | 1.15 | 0.01 | 138 | 144 | 110 | 8 | 109 | 2 | 105 | 3 | **109** | **2** |
| **2012TZ580-21** | 0.04743 | 0.00304 | 0.11337 | 0.0071 | 0.01736 | 0.00024 | 0.00526 | 0.00012 | 0.97 | 0.01 | 71 | 111 | 109 | 6 | 111 | 2 | 106 | 2 | **111** | **2** |
| **2012TZ580-22** | 0.04807 | 0.00401 | 0.11245 | 0.0092 | 0.01699 | 0.00027 | 0.00532 | 0.00017 | 1.3 | 0.01 | 103 | 152 | 108 | 8 | 109 | 2 | 107 | 3 | **109** | **2** |
| **2012TZ580-23** | 0.04924 | 0.00523 | 0.11748 | 0.0123 | 0.01732 | 0.00028 | 0.00514 | 0.00017 | 1.01 | 0.01 | 159 | 206 | 113 | 11 | 111 | 2 | 104 | 3 | **111** | **2** |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Analysis** | **CORRECTED RATIOS** | | | | | | | | | | **CORRECTED AGES (Ma)** | | | | | | | | **Ages (Ma)** | **1** |
|
| ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** | ***238U/232Th*** | **1** | ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** |
| **2012TZ578, Zonggei Formation volcanic rocks, Nagqu area** | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2012TZ578-01** | 0.04857 | 0.00179 | 0.11942 | 0.0042 | 0.01785 | 0.00017 | 0.00694 | 0.00018 | 4.18 | 0.04 | 127 | 64 | 115 | 4 | 114 | 1 | 140 | 4 | **114** | **1** |
| **2012TZ578-02** | 0.04962 | 0.00144 | 0.11655 | 0.0032 | 0.01705 | 0.00014 | 0.00632 | 0.0001 | 2.63 | 0.03 | 177 | 48 | 112 | 3 | 109 | 0.9 | 127 | 2 | **109** | **0.9** |
| **2012TZ578-03** | 0.04868 | 0.00562 | 0.11597 | 0.0131 | 0.0173 | 0.00044 | 0.00675 | 0.00037 | 1.94 | 0.02 | 132 | 205 | 111 | 12 | 111 | 3 | 136 | 7 | **111** | **3** |
| **2012TZ578-04** | 0.0487 | 0.00201 | 0.1153 | 0.0046 | 0.01719 | 0.00019 | 0.00593 | 0.00021 | 2.4 | 0.02 | 133 | 72 | 111 | 4 | 110 | 1 | 120 | 4 | **110** | **1** |
| **2012TZ578-05** | 0.04805 | 0.003 | 0.11538 | 0.0071 | 0.01744 | 0.00019 | 0.00672 | 0.00024 | 6.18 | 0.06 | 102 | 116 | 111 | 6 | 111 | 1 | 135 | 5 | **111** | **1** |
| **2012TZ578-06** | 0.04934 | 0.00264 | 0.1174 | 0.0061 | 0.01728 | 0.00022 | 0.00699 | 0.00021 | 2.85 | 0.03 | 164 | 95 | 113 | 6 | 110 | 1 | 141 | 4 | **110** | **1** |
| **2012TZ578-07** | 0.04835 | 0.00634 | 0.11908 | 0.0153 | 0.01788 | 0.00045 | 0.00803 | 0.0004 | 1.32 | 0.01 | 116 | 235 | 114 | 14 | 114 | 3 | 162 | 8 | **114** | **3** |
| **2012TZ578-08** | 0.0492 | 0.00286 | 0.11728 | 0.0067 | 0.01731 | 0.0002 | 0.0063 | 0.00012 | 1.37 | 0.01 | 157 | 108 | 113 | 6 | 111 | 1 | 127 | 2 | **111** | **1** |
| **2012TZ578-09** | 0.04838 | 0.002 | 0.11685 | 0.0047 | 0.01754 | 0.00018 | 0.00582 | 0.0001 | 1.17 | 0.01 | 118 | 73 | 112 | 4 | 112 | 1 | 117 | 2 | **112** | **1** |
| **2012TZ578-10** | 0.04858 | 0.0036 | 0.11677 | 0.0084 | 0.01745 | 0.00028 | 0.00607 | 0.00017 | 1.29 | 0.01 | 128 | 132 | 112 | 8 | 112 | 2 | 122 | 3 | **112** | **2** |
| **2012TZ578-11** | 0.04701 | 0.0029 | 0.11344 | 0.0068 | 0.01752 | 0.00023 | 0.00626 | 0.00025 | 2.56 | 0.03 | 50 | 106 | 109 | 6 | 112 | 1 | 126 | 5 | **112** | **1** |
| **2012TZ578-12** | 0.04908 | 0.00363 | 0.11976 | 0.0086 | 0.01772 | 0.0003 | 0.00613 | 0.00021 | 1.64 | 0.02 | 152 | 130 | 115 | 8 | 113 | 2 | 124 | 4 | **113** | **2** |
| **2012TZ578-13** | 0.04894 | 0.00187 | 0.11829 | 0.0043 | 0.01755 | 0.00018 | 0.00643 | 0.00013 | 1.65 | 0.02 | 145 | 67 | 114 | 4 | 112 | 1 | 130 | 3 | **112** | **1** |
| **2012TZ578-14** | 0.04885 | 0.00254 | 0.11467 | 0.0058 | 0.01705 | 0.00022 | 0.0059 | 0.00012 | 1.15 | 0.01 | 141 | 91 | 110 | 5 | 109 | 1 | 119 | 2 | **109** | **1** |
| **2012TZ578-15** | 0.04872 | 0.00296 | 0.11534 | 0.0068 | 0.01719 | 0.00025 | 0.00644 | 0.00023 | 2.52 | 0.03 | 134 | 106 | 111 | 6 | 110 | 2 | 130 | 5 | **110** | **2** |
| **2012TZ578-16** | 0.04852 | 0.0035 | 0.11724 | 0.0083 | 0.01754 | 0.00023 | 0.00626 | 0.00019 | 1.72 | 0.02 | 125 | 134 | 113 | 8 | 112 | 1 | 126 | 4 | **112** | **1** |
| **2012TZ578-17** | 0.04794 | 0.00609 | 0.11255 | 0.014 | 0.01705 | 0.00045 | 0.00698 | 0.00051 | 3.54 | 0.04 | 96 | 223 | 108 | 13 | 109 | 3 | 141 | 10 | **109** | **3** |
| **2012TZ578-18** | 0.04856 | 0.00183 | 0.11813 | 0.0043 | 0.01766 | 0.00016 | 0.00547 | 0.00011 | 2.11 | 0.02 | 127 | 68 | 113 | 4 | 113 | 1 | 110 | 2 | **113** | **1** |
| **2012TZ578-19** | 0.04871 | 0.00384 | 0.11877 | 0.0091 | 0.0177 | 0.00031 | 0.00601 | 0.0002 | 1.36 | 0.01 | 134 | 139 | 114 | 8 | 113 | 2 | 121 | 4 | **113** | **2** |
| **2012TZ578-20** | 0.04793 | 0.00144 | 0.1139 | 0.0032 | 0.01725 | 0.00015 | 0.00559 | 0.0001 | 2.42 | 0.02 | 96 | 50 | 110 | 3 | 110.3 | 1 | 113 | 2 | **110.3** | **1** |

**Table S2**. Continued.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Analysis** | **CORRECTED RATIOS** | | | | | | | | | | **CORRECTED AGES (Ma)** | | | | | | | | **Ages (Ma)** | **1** |
|
| ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** | ***238U/232Th*** | **1** | ***207Pb/206Pb*** | **1** | ***207Pb/235U*** | **1** | ***206Pb/238U*** | **1** | ***208Pb/232Th*** | **1** |
| **2012TZ576, Zonggei Formation volcanic rocks, Nagqu area** | | | | | | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **2012TZ576-01** | 0.04748 | 0.00208 | 0.11514 | 0.0049 | 0.01761 | 0.00017 | 0.00562 | 0.00012 | 2.65 | 0.03 | 73 | 76 | 111 | 4 | 113 | 1 | 113 | 2 | **113** | **1** |
| **2012TZ576-02** | 0.04866 | 0.00534 | 0.12028 | 0.013 | 0.01795 | 0.00035 | 0.0058 | 0.0002 | 1.22 | 0.01 | 131 | 206 | 115 | 12 | 115 | 2 | 117 | 4 | **115** | **2** |
| **2012TZ576-03** | 0.0482 | 0.00276 | 0.11757 | 0.0065 | 0.01771 | 0.00024 | 0.00919 | 0.0005 | 10.55 | 0.11 | 109 | 99 | 113 | 6 | 113 | 2 | 185 | 10 | **113** | **2** |
| **2012TZ576-04** | 0.04804 | 0.00565 | 0.11717 | 0.0135 | 0.01771 | 0.00043 | 0.00613 | 0.00039 | 2.22 | 0.02 | 101 | 209 | 113 | 12 | 113 | 3 | 124 | 8 | **113** | **3** |
| **2012TZ576-05** | 0.0482 | 0.00411 | 0.1164 | 0.0097 | 0.01753 | 0.00032 | 0.00584 | 0.00019 | 1.06 | 0.01 | 109 | 151 | 112 | 9 | 112 | 2 | 118 | 4 | **112** | **2** |
| **2012TZ576-06** | 0.04911 | 0.00185 | 0.12313 | 0.0044 | 0.0182 | 0.00018 | 0.00546 | 0.00014 | 3.42 | 0.03 | 153 | 66 | 118 | 4 | 116 | 1 | 110 | 3 | **116** | **1** |
| **2012TZ576-07** | 0.04903 | 0.01206 | 0.11844 | 0.0285 | 0.01754 | 0.00091 | 0.00614 | 0.00067 | 1.48 | 0.01 | 149 | 357 | 114 | 26 | 112 | 6 | 124 | 13 | **112** | **6** |
| **2012TZ576-08** | 0.04823 | 0.00486 | 0.11806 | 0.0117 | 0.01777 | 0.00036 | 0.00572 | 0.00026 | 1.82 | 0.02 | 111 | 182 | 113 | 11 | 114 | 2 | 115 | 5 | **114** | **2** |
| **2012TZ576-09** | 0.04805 | 0.00333 | 0.1167 | 0.0079 | 0.01763 | 0.00027 | 0.00728 | 0.0003 | 2.87 | 0.03 | 102 | 122 | 112 | 7 | 113 | 2 | 147 | 6 | **113** | **2** |
| **2012TZ576-10** | 0.04824 | 0.00579 | 0.11461 | 0.0135 | 0.01725 | 0.00044 | 0.00686 | 0.00035 | 1.15 | 0.01 | 111 | 211 | 110 | 12 | 110 | 3 | 138 | 7 | **110** | **3** |
| **2012TZ576-11** | 0.04879 | 0.00359 | 0.12195 | 0.0087 | 0.01815 | 0.00031 | 0.00518 | 0.00018 | 1.98 | 0.02 | 138 | 129 | 117 | 8 | 116 | 2 | 104 | 4 | **116** | **2** |
| **2012TZ576-12** | 0.04923 | 0.00165 | 0.11899 | 0.0038 | 0.01755 | 0.00016 | 0.00616 | 0.00007 | 0.89 | 0.01 | 159 | 57 | 114 | 3 | 112 | 1 | 124 | 1 | **112** | **1** |
| **2012TZ576-13** | 0.04858 | 0.00858 | 0.11885 | 0.0206 | 0.01776 | 0.00058 | 0.00596 | 0.00049 | 2.3 | 0.02 | 128 | 291 | 114 | 19 | 113 | 4 | 120 | 10 | **113** | **4** |
| **2012TZ576-14** | 0.04778 | 0.00411 | 0.11667 | 0.0098 | 0.01773 | 0.00031 | 0.00618 | 0.00024 | 1.86 | 0.02 | 88 | 154 | 112 | 9 | 113 | 2 | 125 | 5 | **113** | **2** |
| **2012TZ576-15** | 0.04884 | 0.0052 | 0.11952 | 0.0125 | 0.01777 | 0.0004 | 0.00563 | 0.00033 | 2.37 | 0.02 | 140 | 191 | 115 | 11 | 114 | 3 | 113 | 7 | **114** | **3** |
| **2012TZ576-16** | 0.04828 | 0.00168 | 0.11994 | 0.004 | 0.01804 | 0.00017 | 0.00586 | 0.00009 | 1.27 | 0.01 | 113 | 60 | 115 | 4 | 115 | 1 | 118 | 2 | **115** | **1** |
| **2012TZ576-17** | 0.04857 | 0.00229 | 0.12042 | 0.0055 | 0.018 | 0.0002 | 0.00603 | 0.00016 | 2.48 | 0.02 | 127 | 84 | 115 | 5 | 115 | 1 | 122 | 3 | **115** | **1** |
| **2012TZ576-18** | 0.04966 | 0.0038 | 0.1246 | 0.0094 | 0.01821 | 0.00027 | 0.00721 | 0.00024 | 2.86 | 0.03 | 179 | 142 | 119 | 8 | 116 | 2 | 145 | 5 | **116** | **2** |

### Cited References in Supporting Information

Andersen, T., 2002. Correction of common lead in U-Pb analyses that do not report Pb-204. Chem. Geol. 192, 59-79.

Dunlop, D.J., Özdemir, Ö., 1997. Rock Magnetism: Fundamentals and Frontiers. Cambridge University Press, Cambridge, pp. 74-76.

Huang, W.-T., van Hinsbergen, D.J.J., Dekkers, M., et al., 2015. Paleolatitudes of the Tibetan Himalaya from primary and secondary magnetizations of Jurassic to Lower Cretaceous sedimentary rocks.Geochem. Geophys. Geosyst. 16, 77-100, doi: 10.1002/2014GC005624.

Jackson, S.E., Pearson, N.J., Griffin, W.L., Belousova, E.A., 2004. The application of laser ablation-inductively coupled plasma-mass

spectrometry to in situ U–Pb zircon geochronology. Chem. Geol. 211, 47-69.

Johnson, C.L., Constable, C.G., Tauxe, L., Barendregt, R., Brown, L.L., Coe, R.S., Layer, P., Mejia, V., Opdyke, N.D., Singer, B.S., Staudigel, H., Stone, D.B., 2008. Recent investigation of the 0-5 Ma geomagnetic field recorded by lava flows. Geochem. Geophys. Geosyst. 9(Q04032), 1-31, doi:10.1029/2007GC001696.

Ludwig, K.R., 2003. Isoplot 3.00: Berkeley Geochronology Center Special Publication, 4, pp. 70.

Ludwig, K.R., 2012. Isoplot 3.75: A Geochronological Toolkit for Microsoft Excel. Berkeley Geochronology Center Special Publication No. 5, 1-75.

Steiger, R.H., and Jäger, E., 1977. Subcommission on geochronology: convention on the use of decay constants in geo-and cosmochronology. Earth Planet. Sci. Lett. 36, 359-362.

Torsvik, T.H., Van der Voo, R., Preeden, U., Niocaill, C.M., Steinberger, B., Doubrovine, P.V., van Hinsbergen, D.J.J., Domeier, M., Gaina, C., Tohver, E., Meert, J.G., McCausland, P.J.A., Cocks, L.R.M., 2012. Phanerozoic polar wander, palaeogeography and dynamics. Earth-Sci. Rev. 114, 325-368.

Xiong, Z.-Y., Ding, L., Spicer, R. et al., 2020. The Early Eocene Rise of the Gonjo Basin, SE Tibet: From Low desert to High Forest. Earth Planet. Sci. Lett. 543, 116312.

Watson, G.S., Enkin, R.J., 1993. The fold test in paleomagnetism as a parameter estimation problem. Geophys. Res. Lett. 20, 2135-2137. doi: 10.1029/93GL01901.

Wiedenbeck, M., Alle, P., Corfu, F., et al., 1995. Three natural zircon standards for T-Th-Pb, Lu-Hf, trace element and REE analyses. Geostandards Newslett. 19.