**Appendix A. Analytical methods details**

The Zircon U–Pb analyses. We collected three samples (ZK01021, QY-2, ZK32031) for zircon grain selection. Wuhan Sample Solution Analytical Technology Co., Ltd. in Wuhan, China performed U-Pb dating and trace element analysis on these zircons using LAICPMS. The laser ablation system and ICPMS instrument operated as Zong et al. (2017) described [115]. The laser spot size was set at 32 µm, and the frequency was 5 Hz. U-Pb dating employed zircon 91500 as an external standard, while trace element calibration utilized glass NIST610 as the external standard. An initial background acquisition period of about 2030 seconds preceded 50 seconds of data acquisition from the sample for each analysis. The Excel-based software ICPMS-Data Cal performed data reduction, which included background and analyzed signal selection, time-drift correction, and quantitative calibration for trace element analysis and U-Pb dating, following Liu et al (2010) [70,116]. We used Isoplo-R to generate Concordia diagrams and weighted mean calculations for data interpretation and analysis [117-119].

Major and trace element geochemical analyses. Fourteen samples were collected from the Qiyishan granitic pluton for major and trace element analysis, including REE (rare earth elements), at Wuhan Sample-Solution Analytical Technology Co., Ltd. in Wuhan, China. The major element analysis of the whole rock was conducted using the ZSX Primus II wavelength dispersive Xray fluorescence spectrometer (XRF) manufactured by RIGAKU, Japan. The Xray tube employed was a 4.0Kw end window Rh target. The test conditions included a voltage of 50kV and a current of 60mA. The major element analysis lines were determined using the kα method. The construction of the standard curve was accomplished using the national standard material and the standard sample GBW0710114. The data were corrected using the theoretical α coefficient method, with a relative standard deviation (RSD) of less than 2%. For trace element analysis of the whole rock, the Agilent 7700e ICPMS instrument was utilized.

Nd isotopic analyses. Nd isotope analyses were conducted at Wuhan Sample Solution Analytical Technology Co., Ltd. in Hubei, China using a Neptune Plus MCICPMS instrument manufactured by Thermo Fisher Scientific, Dreieich, Germany. The Neptune Plus is a double focusing MCICPMS and is equipped with seven fixed electron multiplier ICs and nine Faraday cups, each fitted with 1011 Ω resistors. The faraday collector con-Figure ration of the mass system included an array from L4 to H4 to monitor 142Nd+, 143Nd+, 144Nd+, 145Nd+, 146Nd+, 147Sm+, 148Nd+, 149Sm+, 150Nd+. All data reduction processes for the MCICPMS analysis of Nd isotope ratios were performed using the "Iso-Compass" software, as described by Zhang et al. (2020a, 2020b) [120-121]. To monitor instrument stability and ensure accuracy, one measurement of the GSB 0432582015 standard was conducted for every seven samples analyzed. The analysis of the GSB 0432582015 standard yielded a 143Nd /144Nd ratio of 0.512440±6 (2SD, n=31), which is consistent within error with the published values (0.512438±6 (2SD)) reported by Li et al. (2017) [122]. Additionally, the USGS reference materials BCR2 (basalt) and RGM2 (rhyolite) were analyzed, yielding results of 0.512641±11 (2SD, n=82) and 0.512804±12 (2SD, n=80) for 143Nd /144Nd, respectively. These values are also in agreement within error with the published values reported by Li et al. (2012) [6].

In-situ zircon Hf isotopic analyses. The zircon Hf isotope ratio analyses were performed in situ, meaning that the analysis was conducted directly on the zircon grains in their natural state, without requiring the separation of the mineral from the rock matrix. The instrument used for the analysis was a Neptune Plus MCICPMS, which is a double-focusing mass spectrometer that is specifically designed for high-precision isotopic measurements. The instrument was coupled with a Geo-las HD excimer ArF laser ablation system, which was used to ablate the zircon grains and generate an aerosol that was then transported into the MCICPMS for analysis. The laser ablation was performed in single spot mode, meaning that a single spot on the zircon grain was ablated for each analysis. The spot size was 44 μm, and the energy density used was approximately 7.0 J cm2. During each analysis, a 20s acquisition of the background signal was followed by a 50s acquisition of the ablation signal. The detailed operating conditions for the laser ablation system and the MCICPMS instrument, as well as the analytical method, were identical to those described by Hu et al. (2012) [123], which suggests that the same or similar protocols were followed. The βYb value directly obtained from the zircon sample itself was used in Realtime during the analysis. To calculate the mass bias of Hf (βHf) and Yb (βYb), the 179Hf/177Hf and 173Yb/171Yb ratios were normalized to 179Hf/177Hf =0.7325 and 173Yb/171Yb=1.132685, respectively, using an exponential correction for mass bias [124]

**Appendix B. Table The major (wt%), trace element (ppm) results for Triassic granitoids in the Qiyishan pluton.**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Sample | QY-2 | QY4 | QY5 | QY6 | QY7 | ZK0504 | | ZK3403 | | ZK0102 | | ZK3203 | | |
| ZK050451 | ZK050452 | ZK340311 | ZK340312 | ZK010211 | ZK010212 | ZK32031 | ZK32032 | ZK32033 |
| Rock type | Albitite granitic porphyry | | | | | Biotite granitic | | | | | | | | |
| Major elements (wt.%) | | | | | | | | | | | | | | |
| SiO2 | 71.56 | 73.98 | 69.88 | 72.35 | 71.74 | 75.52 | 76.14 | 75.02 | 77.12 | 74.77 | 72.29 | 74.97 | 78.91 | 79.27 |
| TiO2 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 | 0.03 | 0.03 | 0.01 | 0.09 | 0.17 | 0.14 | 0.03 | 0.02 | 0.01 |
| Al2O3 | 16.22 | 15.68 | 18.59 | 16.51 | 16.44 | 13.65 | 13.37 | 15.06 | 11.60 | 12.82 | 14.12 | 13.45 | 11.54 | 11.31 |
| Fe2O3 | 0.07 | 0.29 | 0.38 | 0.33 | 0.50 | 0.66 | 0.72 | 0.62 | 0.98 | 1.82 | 1.35 | 0.14 | 0.13 | 0.10 |
| FeO | 0.25 |  |  |  |  |  |  |  |  |  |  | 0.75 | 0.56 | 0.53 |
| MnO | 0.05 | 0.03 | 0.05 | 0.02 | 0.05 | 0.02 | 0.02 | 0.04 | 0.04 | 0.03 | 0.04 | 0.06 | 0.06 | 0.06 |
| MgO | 0.06 | 0.06 | 0.09 | 0.12 | 0.37 | 0.06 | 0.06 | 0.03 | 0.06 | 0.17 | 0.14 | 0.02 | 0.03 | 0.02 |
| CaO | 0.34 | 0.37 | 0.45 | 0.10 | 1.13 | 0.69 | 0.58 | 0.21 | 0.87 | 0.87 | 1.14 | 0.42 | 0.38 | 0.31 |
| Na2O | 6.03 | 3.85 | 3.61 | 5.78 | 0.18 | 3.88 | 3.98 | 4.56 | 3.17 | 3.54 | 3.46 | 4.13 | 3.03 | 3.11 |
| K2O | 3.75 | 3.60 | 4.22 | 3.01 | 4.78 | 4.06 | 3.81 | 3.41 | 4.54 | 4.27 | 5.59 | 4.58 | 4.18 | 3.76 |
| P2O5 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 | 0.02 | 0.05 | 0.04 | 0.01 | 0.01 | 0.01 |
| LOI | 0.97 | 1.65 | 2.20 | 1.37 | 4.21 | 1.00 | 0.86 | 0.57 | 1.02 | 1.10 | 1.31 | 0.63 | 0.64 | 0.66 |
| TOTAL | 99.37 | 99.54 | 99.49 | 99.63 | 99.42 | 99.57 | 99.57 | 99.54 | 99.50 | 99.61 | 99.61 | 99.28 | 99.54 | 99.21 |
| TFeO | 0.31 | 0.26 | 0.34 | 0.30 | 0.45 | 0.60 | 0.65 | 0.56 | 0.88 | 1.63 | 1.21 | 0.88 | 0.68 | 0.62 |
| A/CNK | 1.11 | 1.44 | 1.64 | 1.27 | 2.19 | 1.13 | 1.14 | 1.30 | 0.99 | 1.07 | 1.02 | 1.08 | 1.14 | 1.16 |
| A/NK | 1.16 | 1.53 | 1.77 | 1.29 | 3.01 | 1.27 | 1.25 | 1.35 | 1.15 | 1.23 | 1.20 | 1.14 | 1.21 | 1.23 |
| Mg# | 0.48 | 0.47 | 0.50 | 0.67 | 0.72 | 0.34 | 0.31 | 0.17 | 0.28 | 0.39 | 0.44 | 0.11 | 0.13 | 0.12 |
| Trace elements (ppm) | | | | | | | | | | | | | | |
| La | 7.41 | 7.26 | 6.21 | 8.20 | 6.13 | 13.15 | 13.97 | 5.29 | 47.32 | 50.34 | 44.36 | 27.16 | 10.34 | 8.94 |
| Ce | 19.89 | 18.37 | 13.08 | 17.96 | 14.26 | 29.87 | 31.37 | 14.12 | 95.39 | 96.92 | 89.82 | 74.23 | 35.82 | 29.76 |
| Pr | 2.35 | 2.04 | 1.77 | 2.25 | 1.67 | 4.18 | 4.28 | 1.64 | 10.85 | 11.34 | 9.84 | 9.79 | 4.49 | 3.70 |
| Nd | 7.48 | 6.75 | 5.72 | 7.36 | 5.56 | 15.78 | 15.98 | 5.54 | 39.49 | 42.76 | 37.50 | 37.93 | 14.55 | 11.43 |
| Sm | 1.98 | 2.02 | 1.74 | 2.13 | 1.80 | 6.08 | 6.11 | 1.71 | 10.50 | 10.10 | 8.67 | 13.19 | 4.10 | 3.61 |
| Eu | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.07 | 0.07 | 0.02 | 0.18 | 0.44 | 0.56 | 0.03 | 0.01 | 0.01 |
| Gd | 1.72 | 1.72 | 1.49 | 1.84 | 1.77 | 5.82 | 5.92 | 1.53 | 9.94 | 9.76 | 8.00 | 13.19 | 3.05 | 2.47 |
| Tb | 0.42 | 0.42 | 0.35 | 0.43 | 0.41 | 1.46 | 1.48 | 0.36 | 2.02 | 1.91 | 1.61 | 2.77 | 0.71 | 0.58 |
| Dy | 2.95 | 2.83 | 2.40 | 3.02 | 2.77 | 10.39 | 10.23 | 2.41 | 13.34 | 12.22 | 10.35 | 20.72 | 5.48 | 4.30 |
| Ho | 0.61 | 0.57 | 0.50 | 0.61 | 0.57 | 2.18 | 2.08 | 0.47 | 2.80 | 2.58 | 2.12 | 4.21 | 1.03 | 0.84 |
| Er | 2.09 | 2.05 | 1.76 | 2.11 | 1.96 | 8.13 | 7.67 | 1.63 | 9.19 | 8.72 | 7.14 | 13.37 | 3.42 | 2.76 |
| Tm | 0.39 | 0.39 | 0.33 | 0.41 | 0.38 | 1.67 | 1.58 | 0.31 | 1.54 | 1.43 | 1.21 | 2.33 | 0.67 | 0.57 |
| Yb | 3.07 | 3.12 | 2.56 | 3.06 | 2.93 | 13.36 | 12.76 | 2.26 | 10.67 | 10.13 | 8.15 | 16.96 | 5.43 | 4.43 |
| Lu | 0.47 | 0.48 | 0.40 | 0.49 | 0.43 | 2.18 | 2.04 | 0.33 | 1.63 | 1.53 | 1.24 | 2.49 | 0.79 | 0.63 |
| Y | 15.92 | 15.94 | 13.25 | 16.43 | 16.77 | 72.19 | 66.24 | 12.40 | 102.42 | 89.65 | 74.92 | 111.98 | 20.29 | 15.17 |
| ∑REE | 50.85 | 48.04 | 38.35 | 49.89 | 40.68 | 114.33 | 115.53 | 37.61 | 254.87 | 260.17 | 230.58 | 238.38 | 89.87 | 74.04 |
| δEu | 0.03 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.03 | 0.04 | 0.05 | 0.13 | 0.20 | 0.01 | 0.01 | 0.01 |
| (La/Yb)*N* | 1.73 | 1.67 | 1.74 | 1.92 | 1.50 | 0.71 | 0.79 | 1.68 | 3.18 | 3.57 | 3.90 | 1.15 | 1.37 | 1.45 |
| Li | 980.87 | 618.63 | 530.69 | 93.90 | 1816.06 | 470.51 | 523.13 | 487.67 | 616.18 | 88.02 | 120.15 | 720.21 | 654.02 | 617.75 |
| Be | 6.67 | 4.79 | 5.96 | 5.74 | 6.93 | 21.62 | 8.66 | 6.21 | 6.31 | 14.66 | 9.52 | 12.42 | 6.05 | 6.20 |
| Sc | 0.14 | 3.23 | 5.51 | 5.16 | 1.74 | 4.83 | 4.76 | 4.42 | 3.87 | 5.11 | 5.00 | 0.64 | 0.46 | 0.46 |
| V | 0.84 | 0.72 | 0.62 | 1.27 | 0.83 | 0.69 | 1.14 | 1.04 | 2.57 | 3.89 | 3.41 | 2.07 | 1.34 | 1.67 |
| Cr | 0.93 | 1.05 | 0.84 | 1.65 | 1.13 | 1.28 | 1.21 | 1.26 | 2.45 | 1.36 | 2.59 | 1.06 | 1.02 | 0.99 |
| Co | 0.07 | 1.19 | 1.15 | 1.20 | 1.13 | 1.10 | 1.10 | 1.21 | 1.30 | 2.08 | 1.43 | 0.18 | 0.11 | 0.09 |
| Ni | 0.73 | 0.34 | 0.92 | 2.19 | 1.32 | 1.91 | 0.73 | 1.04 | 2.89 | 0.47 | 1.58 | 0.94 | 0.97 | 0.79 |
| Cu | 1.50 | 1.39 | 2.23 | 2.59 | 1.49 | 1.64 | 1.87 | 7.34 | 4.86 | 1.64 | 3.04 | 1.03 | 0.67 | 0.71 |
| Zn | 34.93 | 29.15 | 39.51 | 38.88 | 51.16 | 33.17 | 34.96 | 29.63 | 40.84 | 37.49 | 29.57 | 44.32 | 40.72 | 40.19 |
| Ga | 46.98 | 39.23 | 48.05 | 49.01 | 42.89 | 30.87 | 30.22 | 37.32 | 23.42 | 23.84 | 23.68 | 32.77 | 32.67 | 32.70 |
| Rb | 1511.48 | 1180.48 | 1362.90 | 925.10 | 1516.31 | 884.15 | 865.82 | 843.43 | 1116.01 | 455.53 | 632.59 | 1311.94 | 1269.60 | 1171.75 |
| Sr | 14.21 | 25.77 | 22.48 | 20.80 | 26.44 | 20.84 | 19.69 | 9.29 | 26.33 | 45.03 | 53.07 | 5.18 | 7.87 | 6.27 |
| Zr | 25.63 | 32.84 | 29.52 | 30.33 | 45.21 | 52.21 | 49.24 | 17.85 | 144.89 | 244.46 | 196.26 | 64.03 | 10.35 | 8.09 |
| Nb | 71.43 | 67.08 | 54.80 | 71.68 | 70.81 | 71.89 | 66.21 | 31.09 | 51.75 | 41.00 | 31.65 | 64.56 | 65.11 | 63.64 |
| Cs | 25.20 | 19.14 | 22.52 | 12.62 | 41.61 | 47.20 | 52.09 | 28.07 | 53.35 | 14.82 | 20.71 | 54.36 | 41.51 | 37.12 |
| Ba | 13.55 | 24.10 | 22.15 | 21.92 | 30.90 | 44.98 | 39.46 | 26.00 | 43.28 | 106.59 | 198.45 | 5.71 | 14.08 | 12.66 |
| Hf | 3.30 | 4.07 | 3.73 | 3.78 | 3.88 | 5.03 | 4.69 | 2.18 | 6.71 | 8.08 | 6.43 | 4.41 | 1.22 | 1.05 |
| Ta | 44.03 | 44.65 | 33.36 | 52.18 | 40.43 | 27.92 | 27.13 | 14.21 | 10.91 | 6.20 | 5.30 | 10.85 | 25.63 | 23.34 |
| Pb | 28.45 | 21.20 | 17.81 | 20.53 | 26.63 | 33.84 | 31.08 | 46.47 | 46.47 | 45.17 | 63.39 | 67.00 | 35.66 | 32.71 |
| Th | 17.62 | 14.66 | 16.86 | 17.08 | 8.78 | 14.42 | 14.59 | 15.04 | 70.57 | 65.88 | 54.06 | 30.29 | 12.16 | 10.53 |
| U | 1.53 | 1.51 | 1.23 | 1.29 | 0.69 | 8.14 | 5.88 | 16.91 | 19.07 | 35.44 | 18.53 | 8.09 | 3.19 | 3.00 |
| Mo | 0.43 | 0.05 | 1.22 | 0.70 | 0.76 | 0.41 | 0.05 | 7.18 | 10.75 | 1.99 | 2.33 | 0.16 | 2.16 | 1.87 |
| Sn | 13.40 | 10.67 | 20.88 | 22.26 | 122.33 | 13.83 | 10.39 | 13.29 | 10.60 | 7.99 | 9.49 | 19.12 | 21.18 | 20.63 |