Supplementary Material File S1

Major oxides and trace element analyses of whole-rock

Major element (Lithium metaborate alkali melt-ICP-OES internal standard method): Accurately weigh 100 mg of the sample, which has been ground to 200 mesh and dried at 105°C. Thoroughly mix the sample with 400 mg of anhydrous lithium metaborate, then transfer the mixture into a graphite crucible. Place the crucible in a muffle furnace at 1000°C for 15 minutes to melt the sample until it forms a glass bead. Remove the bead and allow it to cool. Transfer the cooled glass bead into a 250 ml beaker containing 50 ml of 5% aqua regia. Heat and stir the mixture on an 80°C water bath using a magnetic stirrer for 30 minutes until the glass bead is completely dissolved. After cooling, dilute the solution with 5% aqua regia to a final volume of 100 ml, mix well, and let it stand.

The major elements (Al, Ca, Mg, Fe, Mn, K, Na, P, Si, Ti, Sr, Ba) are determined using an ICP-OES instrument from HORIBA. Lithium (Li) is used as the internal standard during the measurement. The method ensures precision with a relative standard deviation (RSD) of less than 3%.

Trace Element Analysis (Acid Dissolution-ICP-MS with Internal Standard Method): Accurately weigh 50 mg of the sample, ground to 200 mesh and dried at 105°C, into a polytetrafluoroethylene (PTFE) digestion vessel. Add 1 ml HNO_3, 3 ml HCl, and 1.5 ml HF. Seal the PTFE digestion vessel with its cover, place it in a stainless steel sleeve, and tighten securely. Heat the sealed vessel in an oven at 190°C for no less than 36 hours to ensure complete dissolution.

After digestion, place the PTFE vessel on a hot plate at 160°C and evaporate the solution to a moist salt state. Add 1 ml of HNO_3 twice consecutively, each time evaporating the solution to a moist salt state. Finally, add 1.5 ml of HNO_3 and 2 ml of H_2O, seal the vessel again with the

stainless steel sleeve, and heat at 190°C in the oven for 12 hours. Allow the solution to cool and dilute it to 50 ml with 18 MΩ ultrapure water.

The diluted solution is analyzed for trace elements using an Agilent 7900 ICP-MS instrument. The analysis employs a wet sample introduction method and uses Rh as the internal standard. Each element is scanned five times, achieving a precision of RSD < 3%.

In-situ U-Pb dating and trace element analysis of zircon by LA-ICP-MS

Technology Service Co., The Resolution SE model laser ablation system (Applied Spectra, USA) was equipped with ATL (ATLEX 300) excimer laser and a Two Volume S155 ablation cell. The laser ablation system was coupled to an Agilent 8900 ICPMS (Agilent, USA).

Detailed tuning methods can be seen in [65]. LA-ICP-MS tuning was performed using a 50 micron diameter line scan at 3 μm/s on NIST 612 at ~3.5 J/cm2 with repetition rate 10 Hz. Adjusting the gas flow to get the highest sensitivity (^{238}U~6*105 cps) and the lowest oxide ratio(ThO/Th＜0.2%). P/A calibration was conducted on the NIST 610 using a 100 micron diameter line scan. Other laser parameters are the same as that of tuning. Detailed analytical conditions can be seen in table 1. Mass analysed were ^{29}Si, ^{31}P, ^{45}Sc, ^{49}Ti, ^{56}Fe, ^{89}Y, ^{91}Zr,^{93}Nb, ^{139}La, ^{140}Ce, ^{141}Pr, ^{146}Nd, ^{147}Sm, ^{151}Eu, ^{157}Gd, ^{159}Tb, ^{163}Dy, ^{165}Ho, ^{166}Er, ^{169}Tm, ^{173}Yb, ^{175}Lu, ^{178}Hf, ^{181}Ta, ^{202}Hg, ^{204}Pb, ^{206}Pb, ^{207}Pb, ^{208}Pb, ^{232}Th, ^{235}U and ^{238}U, with a total sweep time of ~0.23 seconds. Zircon were mounted in epoxy discs, polished to expose the grains, cleaned ultrasonically in ultrapure water, then cleaned again prior to the analysis using AR grade methanol. Pre-ablation was conducted for each spot analysis using 5 laser shots (~0.3 μm in depth) to remove potential surface contamination. The analysis was performed using 30 μm diameter spot at 5 Hz with fluence of 2 J/cm^2.

Iolite software package was used for data reduction [66]. Zircon 91500 and GJ-1 was used as primary and secondary reference materials, respectively. Triplets of 91500 and GJ-1 were

bracketed between multiple groups of 10 to 12 sample unknowns. Typically, 35-40 seconds of the sample signals were acquired after 20 seconds gas background measurement. Using the exponential function to calibrate the downhole fractionation [66]. NIST 610 and 91Zr were used to calibrate the trace element concentrations as external reference material and internal standard element respectively. Measured ages of 91500 (1061.5 ± 3.2 Ma, 2σ) and GJ-1 (604 ± 6 Ma, 2σ) are well within 1% of the accepted age.