**Whole-rock major and trace elements, and Sr-Nd-Pb isotopes**

The major elements were measured by X-ray fluorescence spectrometry (XRF) on fused glass disks, using a Shimadzu XRF-4400 at the National Research Center of Geoanalysis (NRCGA). The analytical precisions were ~1–3% for elements at >10 wt% concentration and ~10% for elements <1.0 wt%. Trace elements were determined by inductively coupled plasma mass spectrometry (ICP-MS) using an Agilent 7500a system (PE300D) at the NRCGA. The precisions are better than 5% for most trace elements according to the replicate analyses of Chinese national standard (GSR1). The analytical results for whole rocks are listed in Table S1.

Strontium (Sr), neodymium (Nd) and lead (Pb) were separated using conventional ion exchange procedures and then analyzed followed procedures similar to those described by Li et al. [106]. Whole rock powders for Sr and Nd isotopic analyses were dissolved in Savillex Teﬂon screw-top capsule after being spiked with the mixed 87Rb-84Sr and 149Sm-150Nd tracers prior to HF + HNO3 + HClO4 dissolution. Rb, Sr, Sm and Nd were separated using the classical two-step ion exchange chromatographic method and measured using a Thermo Fisher Scientific Triton Plus multi-collector thermal ionization mass spectrometer at IGGCAS. The whole procedure blank was lower than 250 pg for Rb-Sr and 100 pg for Sm-Nd. The isotopic ratios were corrected for mass fractionation by normalizing to 88Sr/86Sr=8.375209 and 146Nd/144Nd = 0.7219, respectively. The international standard samples, NBS-987 and JNdi-1, were employed to evaluate instrument stability during the period of data collection. The measured values for the NBS-987 Sr standard and JNdi-1 Nd standard were 87Sr/86Sr =0.710245 ± 0.000021 (n=8, 2 SD) and 143Nd/144Nd = 0.512111 ± 0.000011 (n=9, 2 SD), respectively. USGS reference material BCR-2 was measured to monitor the accuracy of the analytical procedures, with the following results: 87Sr/86Sr = 0.705010 ±0.000013 and 143Nd/144Nd = 0.512625 ±0.000010. The 87Sr/86Sr and 143Nd/144Nd data of BCR-2 show good agreement with previously published data by TIMS and MC-ICP-MS techniques [106,107]. Measured Pb isotopic ratios were corrected for instrumental mass fractionation of 1.2 ‰ per atomic mass unit by reference to repeated analyses of the NBS-981 Pb standard. Repeated analyses of NBS-981 gave 204Pb/206Pb = 0.05894 ± 0.00013, 207Pb/206Pb = 0.91393 ± 0.00070, 208Pb/206Pb = 2.1612 ± 0.0018 (2σ) [42,108]. The analytical results for whole rocks are listed in Table S2.

*Zircon U -Pb and Hf isotope analyses*

U-Pb dating and trace element analyses of zircon were conducted synchronously by LA-ICP-MS at the State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry Chinese Academy of Sciences. Laser sampling was performed using a GeoLas Pro 193 nm ArF excimer laser. An Agilent 7500x ICP-MS instrument was used to acquire ion-signal intensities. Helium was applied as a carrier gas which was mixed with Argon via a T-connector before entering the ICP-MS. Each analysis incorporated a background acquisition of approximately 30 s (gas blank) followed by 60 s of data acquisition from the sample. Off-line selection and integration of background and analyte signals, and time-drift correction and quantitative calibration for trace element analyses and U-Pb dating were performed by ICPMSDataCal [101,109]. Zircon 91500 was used as external standard for U-Pb dating, and was analyzed twice every 6-8 analyses (i.e., 2 zircon 91500 + 6–8 samples + 2 zircons 91500). Uncertainty of preferred values for the external standard 91500 was propagated to the ultimate results of the samples. Concordia diagrams and weighted mean calculations were made using Isoplot [110]. Trace element compositions of zircons were calibrated against multiple-reference materials (NIST 610) combined with Si internal standardization. Zircon U-Pb age results are listed in Table S3, and representative zircon CL images of selected zircon crystals and U-Pb Concordia and weighted average diagrams are displayed in Figures. 8 and 9.

Zircon Hf isotopic analysis were conducted using a Neptune Plus MC-ICP-MS from Thermo Fisher Company equipped with a Geolas 2005 excimer ArF laser ablation system from Lambda Physik Company at the GPMR. The detailed analytical procedures can be found in Hu et al. [111]. Ablations were carried out with a 44 μm beam with 5.3 J/cm2 energy density. Helium was used as the carrier gas within the ablation cell and was merged with argon after the ablation cell. Each measurement consisted of 20s of acquisition of the background signal followed by 50s of ablation signal acquisition. The standard zircon 91500 yielded a recommended 176Hf/177Hf ratio of 0.282306 ± 10 [112] was analyzed to maintain the accuracy of the laser-ablation results. Off-line selection and integration of analyze signals, and mass bias calibrations were performed using the ICPMSDataCal [109]. In the calculation of εHf (0) values, present-day chondrite values: 176Hf/177Hf=0.282772 and 176Lu/177Hf=0.0332[113] was used. The observed zircon U-Pb age and the decay constant for 176Lu (1.865×10-11year-1; [114]) were used to calculate εHf (t) for zircon. Single-stage Hf model ages (TDM) were calculated relative to the present-day depleted mantle values of 176Hf/177Hf=0.28352 and 176Lu/177Hf=0.0384 [115]. We also calculated a crustal model age (TDM; two-stage model age) for the zircon, based on the assumption that the magma was derived from a continental crust (176Lu/177Hf=0.015; [116]) that was originally derived from depleted mantle. The zircon Lu-Hf isotopic data are listed in Table S4.

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