**Appendix A. Analytical methods**

**Zircon U‒Pb dating and Lu‒Hf isotopic analytical methods**

Zircon grains were separated using standard heavy liquid and magnetic separation techniques. They were selected, mounted in epoxy resin, polished, and finally coated with gold. The internal texture of these grains was examined using cathodoluminescence (CL) imaging by a scanning electron microprobe at Sun Yat-sen University (SYSU). In-situ zircon U‒Pb and trace elemental determinations were undertaken using an iCAP RQ ICP-MS coupled with a 193 nm ArF Geolas HD laser-ablation system at the Guangdong Provincial Key Lab of Geodynamics and Geohazards (GLGG) of SYSU. The spot size of 32 µm with a laser repetition rate of 5 Hz was used for ablation zircons. Standard zircons Plešovice and 91500 were used as external isotopic calibration standards, and NIST SRM 610 as the external trace elemental calibration standard. Helium was invoked as the carrier gas to enhance the transport efficiency of the ablated material. Raw data processing was carried out by GLITTER 4.4.5 (e.g., Griffin et al., 2008). Detailed analytical methods were described by Wang et al. (2020). The Concordia diagrams and weighted average calculations were conducted by the Isoplot program (e.g., Ludwig, 2001). The results are shown in Supplementary Table S1.

In-situ zircon Lu‒Hf isotope analyses were performed using a Neptune Plus multi-collector inductively coupled plasma mass spectrometer (MC-ICP-MS) in combination with a Geolas HD excimer 193 nm ArF laser ablation system at GLGG, SYSU. To transport ablated materials, Helium and Argon gas were used as carriers. The spot size of 44 μm with a laser repetition rate of 6 Hz was utilized for ablating zircons. Standard zircon 91500 was utilized as an external standard. Data were normalized to 176Hf/177Hf = 0.7325. εHf (t) values were calculated by the chondrite ratios of 176Hf/177Hf = 0.282772 and 176Lu/177Hf = 0.0332 (e.g., Blichert-Toft and Albarede, 1997). Hf model ages (TDM1) and two-stage Hf model ages (TDM2) were calculated on basis of the depleted mantle of 176Hf/177Hf = 0.283250 with 176Lu/177Hf = 0.0384 and average continental crust of 176Lu/177Hf = 0.015, respectively (e.g., Griffin et al., 2000, 2002). The Lu‒Hf isotopic data are shown in Supplementary Table S2.

**Whole-rock elemental and Sr–Nd-Pb isotopic analytical methods**

Fresh whole-rock samples were crushed in a steel mortar and then pulverized to 200-mesh for elemental and isotopic analyses. An ARL-Perform’ X 4200 X-ray fluorescence spectrometer analyzed major oxides contents at GLGG, SYSU. The relative standard derivation for major oxides is lower than 5%. Trace elemental and Sr‒Nd isotopic analyses were performed at the GLGG, SYSU, using an iCAP RQ ICP-MS. Detailed analytic methods were described by Wang et al. (2020).

Sr‒Nd‒Pb isotopic separation and purification were performed at Guizhou Tongwei Analytical Technology Co. Ltd. Details of analytical methods are presented in Wang et al. (2020). The Sr–Nd‒Pb isotopic analysis was finished at the GLGG, SYSU, using a Neptune Plus MC-ICP-MS. The mass fractionation corrections were based on 86Sr/88Sr = 0.1194 and 146Nd/144Nd = 0.7219. The measured standard materials are NIST SRM 987 and ALFA-Nd for the Sr and Nd isotopic analyses. The measured 207Pb/206Pb and 206Pb/204Pb ratios of the (NIST) NBS 981 standard are 0.9145–0.9146 and 16.926–16.934, respectively. The whole-rock elemental and Sr–Nd‒Pb isotopic data are shown in Supplementary Table S3.

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