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Supplemental Material

Supporting Information S1. Details of analytical methods

Table S1. Zircon U-Pb dating, whole-rock geochemical, and Sr–Nd–Hf isotopic data of Cambrian mafic–intermediate–felsic rocks from the North Lhasa terrane

Table S2. Magma mixing modeling of the Cambrian magmatic rocks from the North Lhasa terrane

SUPPORTING INFORMATION S1. DETAILS OF ANALYTICAL METHODS

1. Zircon U-Pb analyses

Zircons were separated at the Special Laboratory of the Geological Team of Hebei Province, Langfang, China, by crushing, sieving, shaking, heavy-liquid separation, and Franz Magnetic separation. Cathodo-luminescence (CL) images were obtained using a HITACH S-3000N scanning electron microscope fitted with a Gatan Chroma CL imaging system at the Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China.

U-Pb isotopic analyses on zircons from a gabbro sample 16T079 were performed using the SHRIMP-II instrument at the Beijing SHRIMP Center. The diameter of the ion beam was 30 μm , and the data were collected in sets of five scans through the masses with a 2 nA primary O_2 beam. Instrument conditions and measurement procedures were as described by Compston et al. (1992) and Song et al. (2002). Standard zircon sample SL13 (572 Ma) was measured to calibrate U, Th, and Pb concentrations, and standard zircon TEMORA was used for the isotopic fractionation correction (details in Black et al., 2003). Analyses of the TEMORA standard zircon were interspersed with unknown sample grains. The data were processed with SQUID and ISOPLOT software of Ludwig (2003). Measurements on TEMORA yielded a weighted $^{206}\text{Pb}/^{238}\text{U}$ age of 416.0 ± 7.2 Ma (2σ , $n = 23$), which is consistent with the standard age (416.8 ± 0.2 Ma; Black et al., 2003).

U-Pb zircon analyses of the other samples were performed at the Beijing Createch Test Technology Co. Ltd., Beijing, China, using laser-ablation–inductively coupled plasma–mass spectrometry (LA–ICP–MS). Laser sampling was performed using an ESI NWR 193 nm laser-ablation system, and an AnlyitikJena PQMS Elite ICP–MS instrument was used to acquire ion-signal intensities. The analyses were conducted with a beam diameter of 25 μm , a repetition rate of 10 Hz, and an energy of 4 J/cm^2 . U–Th–Pb isotopic compositions were calibrated using zircon GJ-1 (Jackson et al., 2004) and NIST610 (^{29}Si) as the reference and internal standards, respectively. During the analyses, the obtained mean $^{206}\text{Pb}/^{238}\text{U}$ age for zircon standard GJ-1 was 600.3 ± 1.1 Ma (2σ , $n = 140$), consistent with the reported or recommended values (Jackson et al., 2004).

2. In situ zircon Hf-isotope analysis

In situ zircon Hf-isotope analyses were performed on the same zircons used for U-Pb analyses, with analysis at the same sites, or in the same age domains (identified using CL images) as for U-Pb. Analyses were performed using a Neptune multi-collector (MC)–ICP–MS equipped with a GeoLas 200M ArF excimer 193 nm laser-ablation system (MicroLas, Germany) at the Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China. The detailed analytical technique is described in Wu et al. (2006). A 44 μm laser spot size was selected during the ablation, with a repetition rate of 8 Hz at 15 J/cm². A ¹⁷⁵Lu/¹⁷⁶Lu of 0.02655 was used for elemental fractionation correction (Xie et al., 2008). Isobaric interference of ¹⁷⁶Yb on ¹⁷⁶Hf was corrected using the mean fractionation index proposed by Iizuka and Hirata (2005) and a ¹⁷⁶Yb/¹⁷²Yb ratio of 0.5886 (Chu et al., 2002). Repeated measurements on the Mud standard yielded a mean ¹⁷⁶Hf/¹⁷⁷Hf ratio of 0.282506 \pm 11 (2 σ , n = 177), which is consistent (within error) with the standard reference value of 0.282500 (Wu et al., 2006).

3. Major and trace element analyses

Whole-rock geochemical analyses were performed at the National Research Center for Geoanalysis, Beijing, China. Major elements were determined using X-ray fluorescence (XRF model PW 4400), with analytical uncertainties ranging from 1% to 3%. LOL (loss on ignition) was obtained using \sim 1 g of sample powder heated at 980 $^{\circ}\text{C}$ for 30 min. Trace elements were analyzed with ICP–MS on an Agilent 7500ce. About 50 mg of powder was dissolved for \sim 7 days at \sim 100 $^{\circ}\text{C}$ using HF–HNO₃ (10:1) mixtures in screw-top Teflon beakers, followed by evaporation to dryness. The material was dissolved in 7N HNO₃, taken to incipient dryness, and then re-dissolved in 2% HNO₃ to a sample/solution weight ratio of 1:1000. Rare-earth elements (REE) and trace elements were analyzed with analytical uncertainties of 10% for elements with abundances of <10 ppm, and \sim 5% for those of >10 ppm. The analyses of international standards (GSR-3 and AGV-2) were in good agreement with recommended values (http://georem.mpch-mainz.gwdg.de/sample_query.asp).

4. Whole-rock Sr–Nd isotopic analyses

Eighteen samples were selected for subsequent whole-rock Sr–Nd isotopic analysis. Mass analyses were measured in Beijing Createch Testing Technology Co., Ltd. All chemical preparations were conducted on class 100 work benches within a 1000 clean laboratory. About 150 mg of sample powder was weighted into a 15mL SavillexTM PFA screw-top beaker. Concentrated HNO₃ and HF (1 ml and 2 ml) were added to the samples and the sealed beakers were heated on a hotplate at 150 $^{\circ}\text{C}$ for 1 week. After digestion, acids were evaporated on the hotplate and residues were dissolved in 1 ml of concentrated HCl. This procedure was then repeated 3 times. Finally, the samples were dissolved in 1.5 ml of 3.5 M HNO₃ or 3 M HCl for Sr or Nd purification, respectively.

Sr was separated and purified from samples using Sr-Spec (Triskem, 100–150 μm) resin. For Nd purification, REEs (Rare Earth Elements) were first rinsed by 6 M HCl using the cation exchange resin (AG50W-X12, 200–400 mesh). Then Nd was purified from REEs by 0.25 M with LN resin (Triskem, 100–150 μm).

Isotopic compositions of Sr and Nd analyses were undertaken using a Thermo Fisher Scientific Neptune Plus MC–ICP–MS. ⁸⁷Sr/⁸⁶Sr ratios were corrected for instrumental mass

fractionation using the exponential fractionation law and assuming $^{88}\text{Sr}/^{86}\text{Sr} = 8.375209$. $^{143}\text{Nd}/^{144}\text{Nd}$ ratios were corrected for instrumental mass fractionation using the exponential fractionation law and assuming $^{146}\text{Nd}/^{144}\text{Nd} = 0.7219$. The methods were modified from Yang et al. (2010).

In addition, the Sr isotope international standard NBS987 was repeatedly tested for accuracy monitoring, yielding an average $^{87}\text{Sr}/^{86}\text{Sr}$ of 0.710248 ± 13 (2 SD, $n = 54$). The stability assessment for $^{143}\text{Nd}/^{144}\text{Nd}$ was conducted with the in-house standard GSB-Nd, yielding a value of 0.512185 ± 8 (2 SD, $n = 68$). The $^{143}\text{Nd}/^{144}\text{Nd}$ results for international basalt standard BHVO-2 and BCR-2 were 0.512970 and 0.512614 , respectively.

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