

DATA REPOSITORY

Appendix 1. Analytical methods

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APPENDIX 1. ANALYTICAL METHODS

Zircon U–Pb dating

Zircons were separated from samples B1204–1, 1201–1, and B1205–1, using the density and magnetic separation techniques, and then handpicked under a binocular stereomicroscope in the laboratory of Langfang Regional Geological Survey Institute, Hebei Province, China. They were mounted in epoxy resin and polished to expose their crystal centers in the Wuhan Sample Solution Analytical Technology Co., Ltd. Cathodoluminescence (CL), reflected and transmitted light images were obtained to ensure that the least fractured and most inclusion-free zones of the zircons were analyzed. The CL images were taken using a Mono CL4+ attached to a scanning electron microscope (Quanta 450 FEG) at the electron microprobe laboratory in the State Key Laboratory of Geological Processes and Mineral Resources (GPMR), China University of Geosciences, Wuhan.

Zircon U–Pb dating was conducted by the LA-ICP-MS at the GPMR. Sample ablation was performed using a GeoLas 2005 and an Agilent 7500a ICP-MS instrument was used to acquire ion-signal intensities. The diameter of the laser ablation craters was 32 μm . Each analysis incorporated a background acquisition of ~20–30 s (gas blank) followed by 50 s acquisitions of data from the sample. Zircon 91500 was used as external standard for U–Pb dating, and was analyzed twice every five analyses. The obtained weighted mean age $^{206}\text{Pb}/^{238}\text{U}$ age for Zircon 91500 is 1062 ± 4 Ma (2σ , $n = 40$), which is consistent with the recommended value (Wiedenbeck et al., 1995). Detailed operating conditions for the laser ablation system and the ICP-MS instrument and data reduction are the same as description by Liu et al. (2010a; 2008a; 2010b). Off-line selection and integration of background and analytical signals and time-drift correction and quantitative calibration for U–Pb dating were performed by ICPMSDataCal (Liu et al., 2008a; Liu et al., 2010a). Common Pb was corrected according to the method proposed by Andersen (2002). Concordia diagrams and weighted mean calculations were made using Isoplot/Ex ver3 (Ludwig, 2003).

Major and trace elements determination

Whole rock samples were crushed in a corundum jaw crusher then powdered in an agate mill to less than 200 meshes. Major elements geochemical analyses were measured by X-ray fluorescence (XRF) spectrometer at the ALS Mineral/ALS Chemex (Guangzhou) Co. Ltd at Guangzhou, China. Fused glass disks with lithium borate were used and the analytical precisions

were better than 0.01%, estimated from repeated analyses of the standards LAT-CS9, NCSDC73303, SARM-3, SARM-32 and SARM-45. Trace elements concentrations were determined at the GPMR. The samples were digested by HF + HNO₃ in Teflon bombs and analyzed with an Agilent 7500a ICP-MS. AGV-2, BHVO-2, BCR-2 and RGM-2 are used as reference materials during the determination. The detailed sample-digesting procedure for ICP-MS analyses and analytical precision and accuracy for trace elements are the same as description by Liu et al. (2008b).

Sr–Nd isotope analyses

Whole rock Sr and Nd isotope analyses were undertaken at the Wuhan Institute of Geology and Mineral Resources in China. MAT 261 and Triton thermal ionization mass spectrometer were used to determine Sr and Nd isotope compositions, respectively. International reference materials NBS987 (Sr), NBS607 (Sr), GBW0411 (Sr), GBW04419 (Nd), BCR-2 (Nd) and JMC (Nd) were measured with the samples. $^{88}\text{Sr}/^{86}\text{Sr}$ and $^{143}\text{Nd}/^{144}\text{Nd}$ isotope ratios were normalized against $^{88}\text{Sr}/^{86}\text{Sr} = 8.3752$ and $^{146}\text{Nd}/^{144}\text{Nd} = 0.72190$, respectively. The measured values for the NBS-987, NBS607 and GBW0411, were $^{87}\text{Sr}/^{86}\text{Sr} = 0.71021 \pm 0.00008$ (2 σ), 1.20046 ± 0.00006 (2 σ) and 0.75986 ± 0.00007 (2 σ), respectively; values for the GBW04419, BCR-2 and JMC were $^{143}\text{Nd}/^{144}\text{Nd} = 0.512717 \pm 0.000005$, 0.512633 ± 0.000003 and 0.511554 ± 0.000003 , respectively, during the period of data acquisition. These were in accordance with the recommended values within the limit of error. The precisions for $^{87}\text{Rb}/^{86}\text{Sr}$ and $^{147}\text{Sm}/^{144}\text{Nd}$ are better than 1% and 0.5%, respectively. Procedural blanks were 1×10^{-9} g and 1.4×10^{-9} g for Rb and Sr respectively; 9.6×10^{-11} g and 5.4×10^{-11} g for Nd and Sm respectively. Detailed operating conditions and procedures are the same as description by Yang et al. (2015).

In situ Hf isotope determination

Zircon Lu-Hf isotope analyses were conducted on or close to the previously U–Pb analyzed spots. Experiments were performed using a Neptune Plus MC-ICP-MS (Thermo Fisher Scientific, Germany) in combination with a Geolas 2005 excimer ArF laser ablation system at the GPMR. Zircons were ablated using laser ablation energy density of 5.3 J/cm². All data were acquired on zircon in single spot ablation mode with a beam diameter of 44 μm . Each measurement consisted of 20 s acquisition of the background signal followed by 50 s ablation signal acquisition. Zircon 91500 was measured as standard zircon and the $^{176}\text{Hf}/^{177}\text{Hf}$ was 0.282314 ± 0.000006 (2 σ , $n = 22$), similar to the commonly accepted $^{176}\text{Hf}/^{177}\text{Hf}$ ratio of 0.282308 ± 0.000006 (2 σ) (Blichert-Toft, 2008). Detailed operating conditions for the laser ablation system and the MC-ICP-MS instrument and analytical method are the same as description by Hu et al. (2012). Off-line selection and integration of analytical signals, and mass bias calibrations were performed using ICPMSDataCal (Liu et al., 2010b).

REFERENCES CITED

- Andersen, T., 2002, Correction of common lead in U–Pb analyses that do not report 204Pb: *Chemical Geology*, v. 192, p. 59–79, [https://doi.org/10.1016/S0009-2541\(02\)00195-X](https://doi.org/10.1016/S0009-2541(02)00195-X).
Blichert-Toft, J., 2008, The Hf isotopic composition of zircon reference material 91500: *Chemical Geology*, v. 253, p. 252–257, <https://doi.org/10.1016/j.chemgeo.2008.05.014>.

- Hu, Z.C., Liu, Y.S., Gao, S., Xiao, S.Q., Zhao, L.S., Gunther, D., Li, M., Zhang, W., and Zong, K.Q., 2012, A “wire” signal smoothing device for laser ablation inductively coupled plasma mass spectrometry analysis: *Spectrochimica Acta. Part B, Atomic Spectroscopy*, v. 78, p. 50–57, <https://doi.org/10.1016/j.sab.2012.09.007>.
- Liu, Y.S., Hu, Z.C., Gao, S., Gunter, D., Xu, J., Gao, C.G., and Chen, H.H., 2008a, In situ analysis of major and trace elements of anhydrous minerals by LA-ICP-MS without applying an internal standard: *Chemical Geology*, v. 257, p. 34–43, <https://doi.org/10.1016/j.chemgeo.2008.08.004>.
- Liu, Y.S., Zong, K.Q., Kelemen, P.B., and Gao, S., 2008b, Geochemistry and magmatic history of eclogites and ultramafic rocks from the Chinese continental scientific drill hole: Subduction and ultrahigh-pressure metamorphism of lower crustal cumulates: *Chemical Geology*, v. 247, p. 133–153, <https://doi.org/10.1016/j.chemgeo.2007.10.016>.
- Liu, Y.S., Gao, S., Hu, Z.C., Gao, C.G., Zong, K.Q., and Wang, D.B., 2010a, Continental and Oceanic Crust Recycling-induced Melt-Peridotite Interactions in the Trans-North China Orogen: U-Pb Dating, Hf Isotopes and Trace Elements in Zircons from Mantle Xenoliths: *Journal of Petrology*, v. 51, p. 537–571, <https://doi.org/10.1093/petrology/egp082>.
- Liu, Y.S., Hu, Z.C., Zong, K.Q., Gao, C.G., Gao, S., Xu, J., and Chen, H.H., 2010b, Reappraisal and refinement of zircon U-Pb isotope and trace element analyses by LA-ICP-MS: *Chinese Science Bulletin*, v. 55, p. 1535–1546, <https://doi.org/10.1007/s11434-010-3052-4>.
- Ludwig, K.R., 2003, *ISOPLOT 3.00: A Geochronological Toolkit for Microsoft Excel*: Berkeley, California, Berkeley Geochronology Center.
- Wiedenbeck, M., Alle, P., Corfu, F., Griffin, W.L., Meier, M., Oberli, F., Vonquadt, A., Roddick, J.C., and Speigel, W., 1995, Three natural zircon standards for U-Th-Pb, Lu-Hf, trace-element and REE analyses: *Geostandards Newsletter*, v. 19, p. 1–23, <https://doi.org/10.1111/j.1751-908X.1995.tb00147.x>.
- Yang, H. M., Liu, C. P., Duan, R. C., Gu, X. M., Lu, S. S., Tan, J. J., Cai, Y. X., Zhang, L. G., and Qiu, X. F., 2015, Rb-Sr and Sm-Nd Isochron Ages of Bokouchang Pb-Zn Deposit in Tongren, Guizhou Province and Their Geological Implication: *Geotectonica et Metallogenia*, v. 39, p. 855–865 [in Chinese with English abstract], [10.16539/j.ddgzyckx.2015.05.009](https://doi.org/10.16539/j.ddgzyckx.2015.05.009).

APPENDIX 2. SUPPLEMENTARY DATA (see top for link to Excel file)

Table DR1. LA-ICPMS zircon U–Pb dating data for the Xitieshan gabbro and granitoids

Table DR2. Major (wt.%) and trace elements (ppm) compositions of the Xitieshan gabbro and granitoids

Table DR3. Sr and Nd isotopic compositions of the Xitieshan gabbro and granitoids

Table DR4. Hf isotope compositions data for zircons from the Xitieshan gabbro and granitoids