

## Short Communications (Research Advances)

## Zircon U-Pb dating of metagabbro masses from the Liwu Group Complex within the Taka dome: Geochronological constraints on the Indosinian–Yanshanian tectonic events in western Sichuan, China

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The Songpan–Ganze terrane is a key region for understanding the tectonic evolution of the Tibetan Plateau and the Yangtze Craton. The Songpan–Ganzi complex comprises a thick succession of deformed Ladinian–Norian turbidites (ca. 230–203 Ma), covering about 200000 km<sup>2</sup> of the eastern Tibet Plateau with a volume of approximately  $2.0 \times 10^6$  km<sup>3</sup> (Fig. 1a). Furthermore, this complex has over 100 Permian–Cenozoic felsic plutons.

Previous research has identified a group of domal metamorphic bodies, including the Taka, Jianglang, Changqiang, Qiasi, and Tangyang metamorphic complexes, in the southern Songpan–Ganze Block (Fig. 1b). The Liwu Group Complex is located in the core of the Taka, Changqiang, and Jianglang metamorphic complexes in the southern Songpan–Garze Block. The formation of the Liwu Group Complex was dated as Ordovician. The Liwu copper deposit is composed of several ore deposits, such as the Liwu, Heiniudong, Zhongzui, Wajingou, Baixianglin, and Sunyelin orebodies, which were developed in the Liwu Group Complex within the Jianglang dome (Fig. 1c; Yuan HL et al., 2023). However, no Cu deposits were found in the Taka Dome. There are many occurrences of metagabbro in the Liwu Group Complex within the dome. Here, the authors present an integrated study of field geology, zircon U-Pb geochronology, and Hf isotopes of the metagabbro mass (Fig. 2). Together with compiled published data, the authors constrain the

magmatic age of the metagabbro mass, and discuss the formation and evolution of the Liwu Group Complex and the Paleozoic tectonic evolution of the Songpan–Garze and western Yangtze Block.

**2. Methods**

According to the geological profile observation and mapping, two metagabbro samples (PM044-67 and PM044-91) were collected from the Liwu Group Complex within the Taka dome (Fig. 1c). LA-ICP-MS zircon U-Pb dating was performed at the State Key Laboratory of the Continental Dynamics, Northwest University (Xi'an, China). Detailed operation conditions for the laser ablation system and the MC-ICP-MS instrument and data reduction processes were the same as those described by Yuan HL et al. (2008). Offline raw data selection, integration of background and analyte signals, time-drift correction, and quantitative calibration for U-Pb dating were performed using Glitter4.0. Zircon 91500 and NIST610 were used as the external standards for U-Pb dating and were analyzed twice every 5–10 sample analyses. Isoplot (ver2.49) was used to construct concordia plots and calculate weighted mean age.

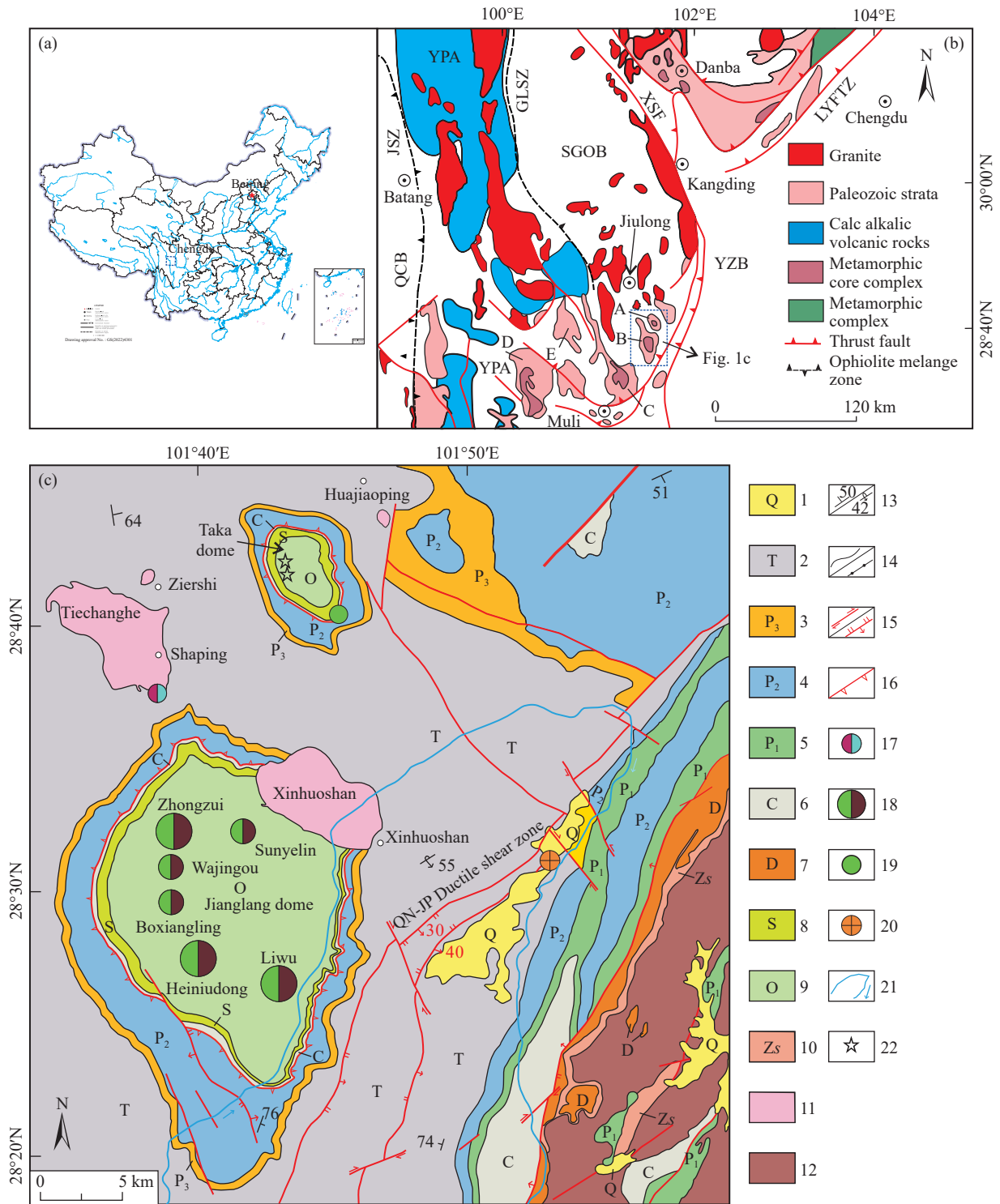
*In situ* zircon Hf isotopes were analyzed on a Neptune MC-ICP-MS instrument using the following parameters: Laser repetition rate, 6 Hz; energy, 100 mJ; and spot size, 30 μm. The obtained Hf isotopic compositions were  $0.282016 \pm 20$  (2σ,  $n = 84$ ) for the GJ-1 standard and  $0.282735 \pm 24$  (2σ,  $n = 84$ ) for the Monastery standard, consistent with the recommended values (within 2σ error) (Yuan HL et al., 2008). Detailed analytical techniques have been depicted in the study of Yuan HL et al. (2008).

**3. Results**

Zircon grains from samples PM044-67 and PM044-91

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**Fig. 1.** a–Location of the Songpan–ganzi orogenic belt within China (basemap from the China National Bureau of Surveying and Mapping Geographical information); b–geological map of the eastern margin of the Qinghai–Xizang Plateau, showing the Longmenshan–Yanyuan foreland thrust zone (LYFTZ) and the distribution of tectonic domes. c–geological sketch map of the Taka dome and its adjacent areas in western Sichuan, China. 1–Quaternary sediments; 2–Triassic schist and slate; 3–Upper Permian sandstone and slate; 4–Middle Permian basalt; 5–Lower Permian limestone; 6–Carboniferous chert bands and quartzite; 7–Devonian chert and slate; 8–Silurian chert and quartzite; 9–Ordovician schist and quartzite; 10–Suxiong Group tuff; 11–Jurassic granite; 12–Neoproterozoic granite; 13–normal and reverse fault; 14–observed geological boundary and angular unconformity; 15–measured strike-slip and reverse faults; 16–denudational faults; 17–tungsten-molybdenum deposit; 18–copper-zinc deposit; 19–copper deposit; 20–gold deposit; 21–Yalong River and its flow direction; and 22–sampling site. JSZ–Jingshaji suture zone; GLSZ–Ganzi–Litang suture zone; XSF–Xianshuihe sinistral strike-slip fault. The major metamorphic domes are the Taka dome (A); Jianglang dome (B); Changqiang dome (C); Qiasi dome (D); and Tangyang dome (E).

were mostly euhedral or subhedral, with a length of 50–110  $\mu\text{m}$  and an aspect ratio of 2 : 1–3 : 1. Internal oscillatory

zoning was observed in cathodoluminescence (CL) images, indicating a magmatic origin.

Zircon grains from sample PM044-67 contained  $141 \times 10^{-6}$ – $597 \times 10^{-6}$  Th and  $314 \times 10^{-6}$ – $1156 \times 10^{-6}$  U, with Th/U = 0.12–0.61, indicating that they were magmatic zircons. Group 1 zircon data were plotted on or close to the concordia line, with a  $^{206}\text{Pb}/^{238}\text{U}$  age of 205–208 Ma (Table S1), yielding a weighted mean  $^{206}\text{Pb}/^{238}\text{U}$  age of  $206.2 \pm 1.7$  Ma ( $n = 7$ , mean sum weighted deviation (MSWD) = 0.12; Fig. 3). Group 2 zircon data were plotted on or close to the concordia line, with

a  $^{207}\text{Pb}/^{206}\text{Pb}$  age of 1838–1890 Ma (Table S1), yielding a weighted mean  $^{207}\text{Pb}/^{206}\text{Pb}$  age of  $1857 \pm 32$  Ma ( $n = 5$ , MSWD = 0.35; Fig. 3). Eleven Hf spot analyses were performed on 11 zircon grains. The zircon grains had  $^{176}\text{Lu}/^{177}\text{Hf} = 0.000170$ – $0.001167$ ,  $^{176}\text{Hf}/^{177}\text{Hf} = 0.281342$ – $0.282679$ , and  $\epsilon\text{Hf}(t) = -10.07$  to 2.05, yielding a mean Hf model age ( $T_{\text{DM}}$ ) of 0.79–2.52 Ga (Table S2; Fig. 4).

Zircon grains from sample PM044-91 had (131–457)

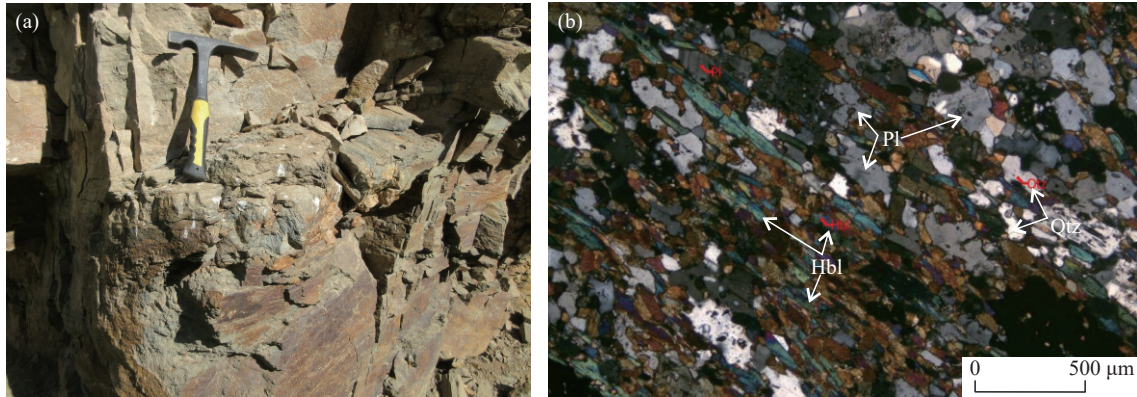


Fig. 2. a–Field photograph of the metagabbro mass in the Taka dome; b–microscopic photograph of the metagabbro mass in the Taka dome. Qtz–Quartz; Pl–Plagioclase; and Hbl–Hornblende.

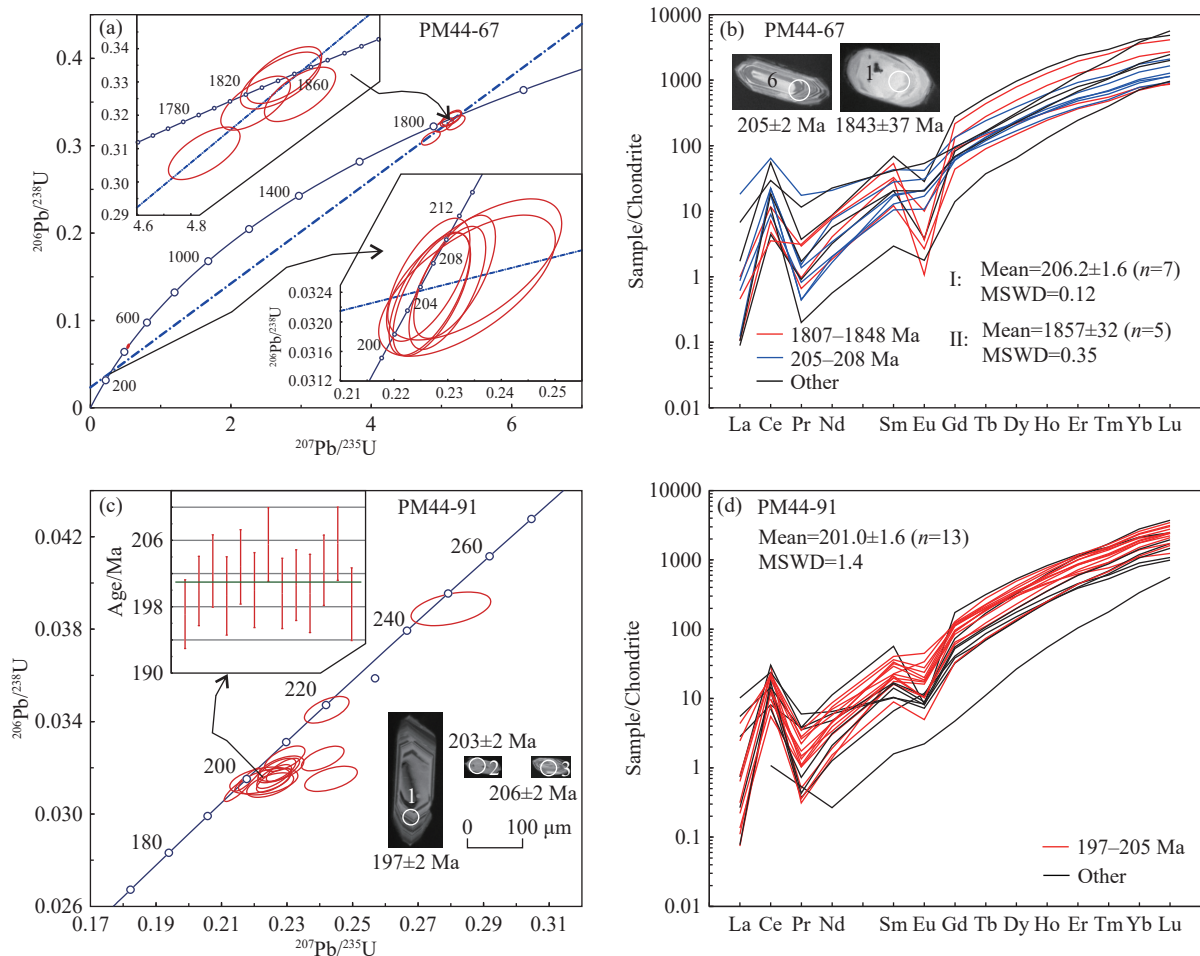
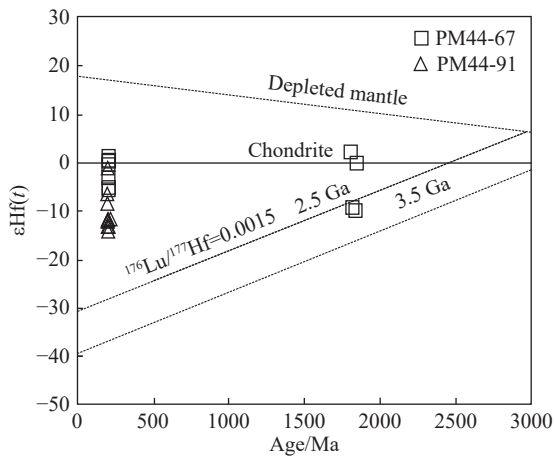


Fig. 3. a, c–Zircon U-Pb concordia plots of the metagabbro mass (Nos. PM44-67 and PM44-91) in the Taka dome; b, d–Rare-earth element chondrite-normalized patterns for the zircons from the metagabbro mass (Nos. PM44-67 and PM44-91) in the Taka dome. Chondrite-normalized values are from Sun SS and McDonough WF (1989).



**Fig. 4.**  $\varepsilon\text{Hf}(t)$  vs. U-Pb age plot for zircon grains from the metagabbro mass in the Taka dome.

$\times 10^{-6}$  Th and  $(286\text{--}1656) \times 10^{-6}$  U, with Th/U = 0.12–0.78, indicating that they were magmatic zircons. The zircon data ( $n = 13$ ) were plotted on or close to the concordia line with a  $^{206}\text{Pb}/^{238}\text{U}$  age of 197–206 Ma (Table 1), yielding a weighted mean  $^{206}\text{Pb}/^{238}\text{U}$  age of  $201.0 \pm 1.6$  Ma (MSWD = 1.4; Fig. 3). Ten Lu-Hf spot analyses were performed on 10 zircon grains. The zircon grains had  $^{176}\text{Lu}/^{177}\text{Hf} = 0.000402\text{--}0.001016$ ,  $^{176}\text{Hf}/^{177}\text{Hf} = 0.282271\text{--}0.282615$  (Table S2), and  $\varepsilon\text{Hf}(t) = -14.34$  to  $-1.30$ , yielding a  $T_{\text{DM}}$  value of 0.86–1.35 Ga (Table S2; Fig. 4).

Considering the regional tectonic background, the 220–200 Ma ages are related to the magmatic activity caused by the late Indosinian (Triassic) west-dipping Ganzi–Litang Ocean subduction and collision, consistent with the findings of previous studies. The closure of the Ganzi–Litang Ocean and the associated magmatism likely peaked at about 216 Ma. Recently, the emplacement of the metagabbro mass in the Jianglang dome has been LA-ICP-MS zircon U-Pb dated to be ca. 220–200 Ma. In this study, the authors obtained consistent ages for the metagabbro mass in the Taka dome (i.e.,  $206.2 \pm 1.7$  Ma and  $201.0 \pm 1.6$  Ma), which are largely coeval with the metamorphosed mafic dykes (206–201 Ma), the Riluku pluton (about 207 Ma), and the Dichishan pluton (about 201 Ma) (Tan HQ et al., 2022) in the Taka dome. Given the low MSWD value of these ages, after excluding the ages of inherited zircons, we suggest that the formation of the two metagabbro samples analyzed in this study was coeval with the metagabbro mass in the Jianglang dome (within error).

In this study, zircon U-Pb dating of the metagabbro mass from the Liwu Group Complex within the Taka dome yielded ages of 206–201 Ma, which represents the magmatic age of the metagabbro, offering insight into the magma evolution on the eastern margin of the Tibetan plateau.

## 4. Conclusion

The metagabbro mass is dated to 206–201 Ma, placing it in the early Late Triassic. This age is consistent with the diagenetic and metallogenetic events of the region, offering insight into the magma evolution on the eastern margin of the Tibetan plateau.

## CRedit authorship contribution statement

Hong-chao Zhang, Hong-bing Zhou, Bo Yan, and Hong-qi Tan conceived the presented idea and prepared the manuscript and figures. Hong-qi Tan, Chong-bo Sun, Yue-zhong Wang, Yun-chuan Zhao, Wen Yao, Ren-liang Cao, and Yang Qin conducted fieldwork and collected samples. All of the authors discussed the results and contributed to the final manuscript.

## Declaration of competing interest

The authors declare no conflicts of interest.

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## Supplementary dataset

Supplementary data (Supplementary Tables) to this article can be found online at doi: [10.31035/cg2023126](https://doi.org/10.31035/cg2023126).

## References

- Sun SS, McDonough WF. 1989. Chemical and isotopic systematics of ocean basalts: Implications for mantle composition and process. In: Saunders AD and Norry MJ (eds), *Magmatism in ocean basins*. Geological Society of London Special Publications, 42, 313–345.
- Tan HQ, Lü FQ, Li C, Zhou X, Zhou Y, Liu YD, Hu JL, Zhu ZM. 2023. Genetic linking between pegmatite-type veined molybdenum deposit and Dichishan highly differentiated granite in western Sichuan. *Earth Science*, 48(11), 3978–3994 (in Chinese with English abstract). doi: [10.3799/dqkx.2022.027](https://doi.org/10.3799/dqkx.2022.027).
- Yuan HL, Gao S, Dai MN, Zong CL, Günther D, Fontaine G, Liu XM, DiWu CR. 2008. Simultaneous determinations of U-Pb age, Hf isotopes and trace element compositions of zircon by excimer laser ablation quadrupole and multiple collector ICP-MS. *Chemical Geology*, 247(1–2), 100–118. doi: [10.1016/j.chemgeo.2007.10.003](https://doi.org/10.1016/j.chemgeo.2007.10.003).
- Yuan HY, Zhou Q, Song YB, Zhang W, Zhang HH, Li TZ, Yin T, Wang CN, Tang GL. 2023. Mineralization of the Liwu large-scale stratiform copper deposits in Sichuan Province, China: Constraints from fluid inclusions. *China Geology*, 6, 252–268. doi: [10.31035/cg2023034](https://doi.org/10.31035/cg2023034).