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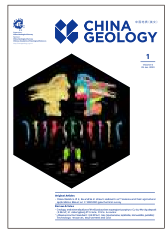

Short Communications (Research Advances)

Zircon U-Pb age evidence of the Mesoarchean (2.9–3.2 Ga) crustal remnant in the Southern Dabie Orogen, South China

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1. Objective

Unlike the North China Plate where Archean and Paleoproterozoic crustal rocks are widely distributed, Early Precambrian basement rocks in the Yangtze Block of South China are locally exposed (Fig. 1a), such as in the Kongling Complex, the Zhongxiang Complex, and the Douling Complex (Zhao GC and Cawood PA, 2012). The Dabie Orogen is the eastward extension of the Qinling Orogen, which formed during the northward subduction of the Yangtze Block beneath the North China Plate in the Triassic. Archean rocks are only locally exposed in the Northern Dabie Orogen, such as the 2.77 Ga Huangtuling granulites within a granitic migmatitic gneiss (Wu YB et al., 2008) and the 2.85 Ga Tuanfeng migmatites (Qiu XF et al., 2020), suggesting the presence of ancient crustal rocks in the Northern Dabie Orogen. In this study, the authors present the results of a combined study of zircon U-Pb ages, trace elements, and Lu-Hf isotope compositions for a newly discovered Paleoproterozoic granitic gneiss with Mesoarchean remnants from the Qichun area in the Southern Dabie Orogen. The research results will provide a new constraint on the Precambrian crustal evolution of the Northern Yangtze Block.

2. Methods

Zircons from the granitic gneiss sample (D966–1) were separated by standard heavy-liquid and magnetic techniques, followed by handpicking under a binocular microscope. After polishing and carbon coating, the internal structure of the zircon grains was evaluated by cathode luminescence (CL) imaging conducted at the Nanjing Hongchuang Geological Exploration Technology Service Co. Ltd. Zircon U-Pb dating and trace element analyses were conducted using an icapQ ICP-MS connected to a RESOlution laser-ablation system at the Laboratory of Isotope Geochemistry, Wuhan Center of China Geological Survey. Zircon 91500 was used as a U-Pb standard and NIST610 was used to calibrate U, Th, and Pb contents. A laser spot diameter of 29 μm was used with a repetition frequency of 4 Hz. *In-situ* Lu-Hf isotope analyses of zircons were measured at the same laboratory using a Neptune Plus MC-ICP-MS combined with a RESOlution laser-ablation system. The laser spot was 44 μm in diameter with an ablation frequency of 8 Hz. The detailed analytical conditions and procedures are the same as those described by Qiu XF et al. (2020).

3. Results

The Dabie complex in the Southern Dabie Orogen is mainly composed of metamorphosed supracrustal rocks and granitic gneisses. A sample (D966–1) was collected from an outcrop of granitic gneiss which is over thrust onto a mica schist (Fig. 1c). They predominantly consist of quartz, plagioclase, and biotite, with minor zircon and apatite as accessory minerals, and show a gneissic texture (Fig. 1d). Zircon grains from the granitic gneiss sample are subhedral to euhedral in morphology, 70–120 μm in length with aspect ratios of 1∶1 to 3∶1, and commonly show clear oscillatory zoning (Fig. 2a), typical of an igneous origin. A total of 25 zircon domains were analyzed for U-Pb dating and/or Lu-Hf

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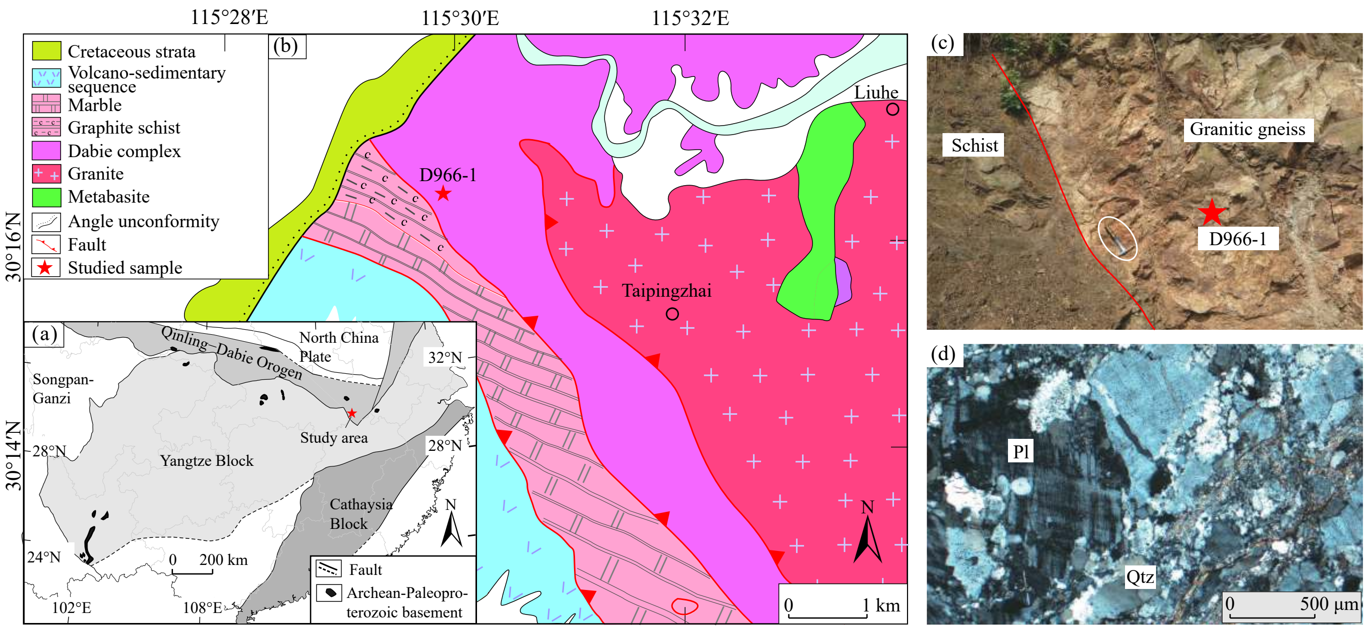

Fig. 1. Geological map of South China showing the distribution of Early Precambrian rocks in the Yangtze Block (a, modified from Zhao GC and Cawood PA, 2012), simplified geological map (b), field outcrop (c), and microscope photograph (d) of the discovered granitic gneiss in the Qichun area. Qtz–quartz, Pl–plagioclase.

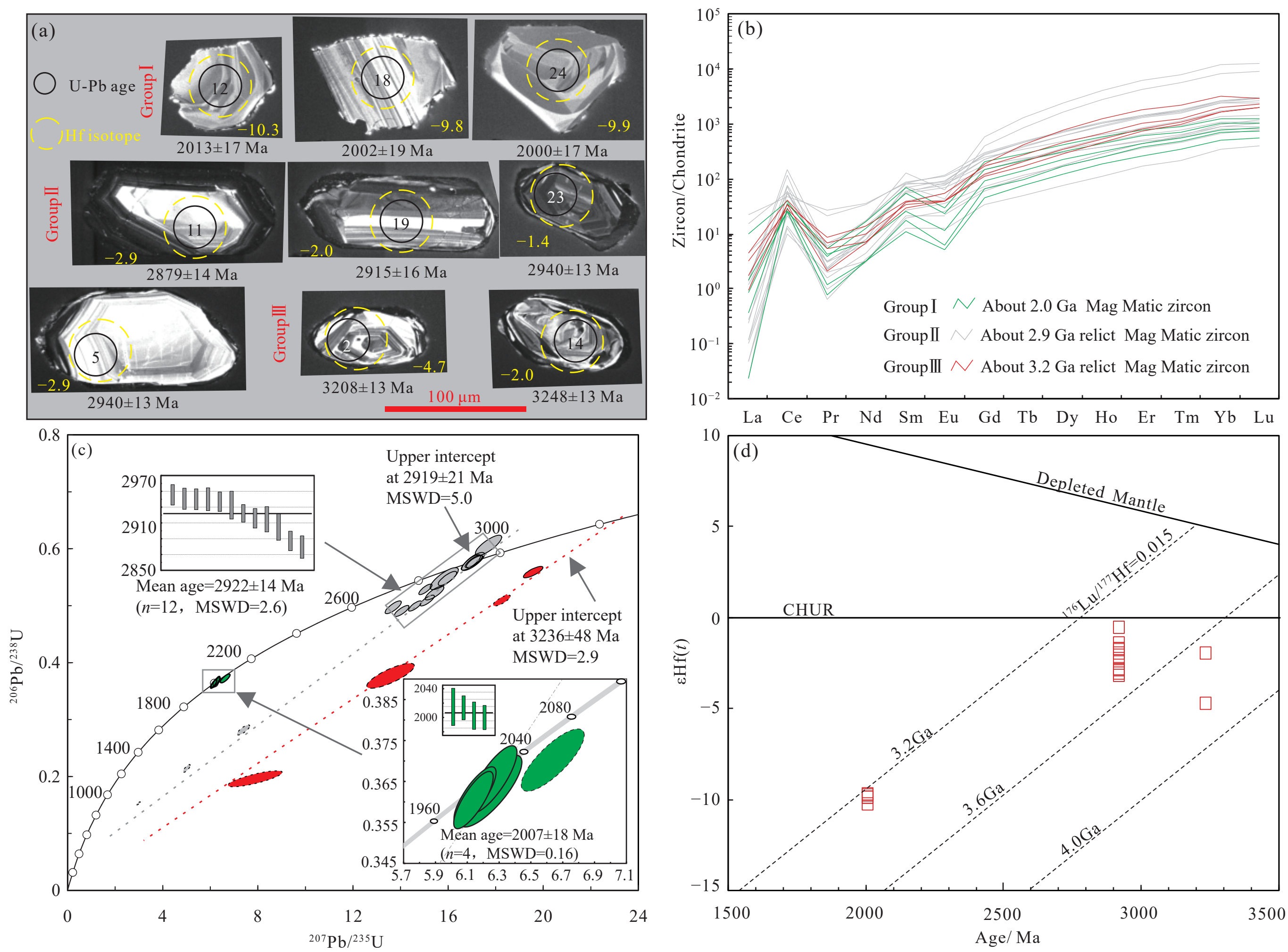

Fig. 2. CL images (a), chondrite-normalized REE patterns (b), U-Pb age diagrams (c), and U-Pb age versus εHf(t) values (d) of representative zircons from granitic gneiss (D966-1) in the Qichun area.

isotope (Supplementary Tables S1–S2), and they yielded apparent $^{207}Pb/^{206}Pb$ ages that varied from 3276 ± 93 Ma to 2000 ± 17 Ma. Based on CL images, trace element compositions, and U-Pb ages, the zircon domains can be categorized into three groups (Fig. 2), as follows.

Group I zircon domains yielded similar U (72×10^{-6}–114×10^{-6}) and Th (89×10^{-6}–148×10^{-6}), higher Th/U ratios (1.02–1.54), negative Eu anomalies (Eu*=0.18–0.26), and steep HREE patterns with small ranges in $(Yb/Gd)_N$ ratios of 6.2–11.2. They show apparent $^{207}Pb/^{206}Pb$ ages of 2000±17 Ma to 2015±26 Ma (Supplementary Table S1), with a weighted mean of 2007±18 Ma (MSWD=0.16), indicative of the emplacement age of the magmatic protolith. The zircon domains (n=5) have $^{176}Hf/^{177}Hf$ ratios of 0.281225–0.281245 and $^{176}Lu/^{177}Hf$ ratios of 0.000304–0.000500. Their $\varepsilon Hf(t)$ values range from −9.7 to −10.3 with two-stage depleted mantle Hf model ages (T_{DM2}) of 3222–3258 Ma (Supplementary Table S2).

Group II zircon domains are relict magmatic zircons. They yielded variable U (31×10^{-6}–373×10^{-6}) and Th (15×10^{-6}–224×10^{-6}) contents, lower Th/U ratios (0.22–0.74), negative Eu anomalies (Eu*=0.59–0.82), and steeper HREE patterns with $(Yb/Gd)_N$ ratios of 4.4–13.3. The $^{207}Pb/^{206}Pb$ ages for these domains ranged from 2945±13 Ma to 2828±16 Ma (Supplementary Table S1), with an upper intercept of 2919±21 Ma (MSWD=5.0) and a weighted mean of 2922±14 Ma (MSWD=2.6) (Fig. 2c). Group II domains (n=10) exhibit lower $^{176}Hf/^{177}Hf$ ratios of 0.280838–0.280944 and variable $^{176}Lu/^{177}Hf$ ratios of 0.000214-0.001472. Their $\varepsilon Hf(t)$ values range from −0.6 to −3.2 with T_{DM2} ages of 3377–3534 Ma (Supplementary Table S2).

Group III zircon domains are also relict magmatic zircons. They are discordant, likely due to later metamorphic or alteration events, and have apparent $^{207}Pb/^{206}Pb$ ages of 3276±93 to 3208±13 Ma (Supplementary Table S1). Four zircons define an upper intercept ages of 3236±48 Ma (MSWD=2.9) (Fig. 2c). These domains show variable contents of U (248×10^{-6}–704×10^{-6}) and Th (133×10^{-6}–189×10^{-6}), with Th/U ratios of 0.19–0.77. They exhibit negative Eu anomalies with Eu*=0.53–0.68 and steep HREE patterns with small ranges in $(Yb/Gd)_N$ ratios of 11.7–16.7. These domains (n=2) have low $^{176}Hf/^{177}Hf$ ratios of 0.280637–0.280700 and $^{176}Lu/^{177}Hf$ ratios of 0.000942–0.001011. Their $\varepsilon Hf(t)$ values are −2.0 to −4.7 with T_{DM2} ages 3705–3848 Ma (Supplementary Table S2).

4. Conclusion

Relict magmatic zircons with Mesoarchean U-Pb ages of about 2.9 Ga and about 3.2Ga were discoverd for the first time from a granitic gneiss in the Qichun area in the Southern Dabie Orogen. They show negative $\varepsilon Hf(t)$ values ranging from −0.6 to −3.2 and −2.0 to −4.7, with two-stage depleted mantle Hf model ages (T_{DM2}) of 3.3–3.5 Ga and 3.7–3.8 Ga, respectively, indicating the existence of Mesoarchean crustal remnants in the Southern Dabie Orogen and the growth of juvenile crust during the Eoarchean to Paleoarchean. The final emplacement age for the protolith of the studied granitic gneiss is about 2007 Ma, which is consistent with the Paleoproterozoic magmatic events in the Kongling and Zhongxiang complexes of the Yangtze Block, with a possible link to the assembly of the supercontinent Columbia (Zhao GC and Cawood PA, 2012). Their two-stage depleted Hf model ages of 3.2 Ga suggest derivation through the episodic reworking of the Archean crust. This study demonstrates the presence of Mesoarchean crustal remnants in the Southern Dabie Orogen and the reworking of Archean crust during the Paleoproterozoic.

CRediT authorship contribution statement

Da-liang Xu, Lian-hong Peng and Xin Deng conceived of the presented idea. Da-liang Xu and Chao-ran Liu carried out the experiment. All 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 S1–S2) to this article can be found online at doi: 10.31035/cg2022056.

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