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Short Communications (Research Advances)

Discovery of the oldest (ca. 2.87 Ga) granitic gneisses in the Qinling-Dabie Orogenic Belt: Direct evidence of Mesoarchean crust

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1. Objectives

Precambrian microcontinents (terranes) or continental fragments are generally essential components in the evolution and architecture of Phanerozoic orogenic belts. Formation of the Qinling-Dabie Orogenic Belt, a typical Paleozoic to Triassic collisional zone between the South China Block (including the Yangtze Block and the Cathaysia Block) and the North China Block (inset map in Fig. 1a), is characterized by the occurrence of several Precambrian complexes or microcontinents. These complexes or microcontinents are dominated by Neoproterozoic rocks and thought to be of Yangtze affinity, but a scarcity of the older rock record has hampered further understanding of the earlier crustal evolution and origin of the Precambrian microcontinents. There has been xenocrystic/inherited zircon evidence from granulites and gneisses at Huangtuling in the Dabie Orogenic Belt that suggests the presence of crustal remnants as old as 2.9–3.5 Ga (Wu YB et al., 2008), but no Archean rocks except some magmatic rocks of mainly 2.5–2.4 Ga ages have been identified from the Yudongzi and Douling complexes in South Qinling, and several localities of the Dabie orogen (Wang K et al., 2020; inset map in Fig. 1a).

This paper reports the first discovery of ca. 2.87 Ga granitic gneisses from the Susong Complex, a possible Precambrian microcontinent exposed in the southeastern part of the Dabie Orogenic Belt (Figs. 1a, b). The granitic gneisses are the oldest known rocks in the Qinling-Dabie Orogenic Belt, which form a rare but direct Mesoarchean rock archive that can be used as important "geologic barcodes" for terrane correlations. The new data constrain the nature and origin of Precambrian terranes in the Qinling-Dabie orogenic belt and have implications on the evolutionary history of the Archean Yangtze Block.

2. Methods

A granitic gneiss sample (DB61-1) was collected from a small elongated, near NS-trending gneiss complex at the northeastern part of the Susong Complex (Fig. 1b). The granitic gneisses exhibit steep foliations (125°∠73°; Fig. 1c), which together with the associated migmatites are outcropped as several small bodies (about 20–30 m wide) within the gneiss complex in the field. Several mafic dikes were observed to intrude on the granitic gneisses, but the contact between the granitic gneisses and migmatites is unknown. The dated sample DB61-1 is medium- to fine-grained, consisting mainly of quartz (40–50 vol.%), plagioclase (30–35 vol.%), and K-feldspar (10–15 vol.%). Biotite (about 10 vol.%) is the main mafic mineral, which shows a preferred orientation (Fig. 1d).

Zircons were separated from the rock sample using conventional heavy liquid and magnetic techniques and hand-picked under a binocular microscope. The separated zircons were then mounted in epoxy and polished to expose the center. Cathodoluminescence (CL) images of zircons were obtained using a GatanCL attached to a scanning electron microscope (SEM) (JSM-6510, Japan) at the Beijing CreaTech Testing International Co., Ltd., Beijing, China. *In-situ* zircon U-Pb isotopic dating of the samples was conducted by using an Agilent 7900 inductively coupled plasma mass spectrometry (ICP-MS) attached to a 193 nm ArF excimer laser ablation system (GeoLas HD, Coherent) (LA-ICP-MS), at the Key Laboratory of Paleomagnetism and Tectonic Reconstruction of the Ministry of Natural Resources, Institute of Geomechanics, CAGS (Chinese Academy of Geological Sciences).

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3. Results

Zircon grains from the granitic gneiss sample DB61-1 are generally transparent and colorless, euhedral to subhedral, and have generally prismatic shapes with lengths of 100–300 μm and aspect ratios between 1.5∶1 and 3∶1. CL images reveal

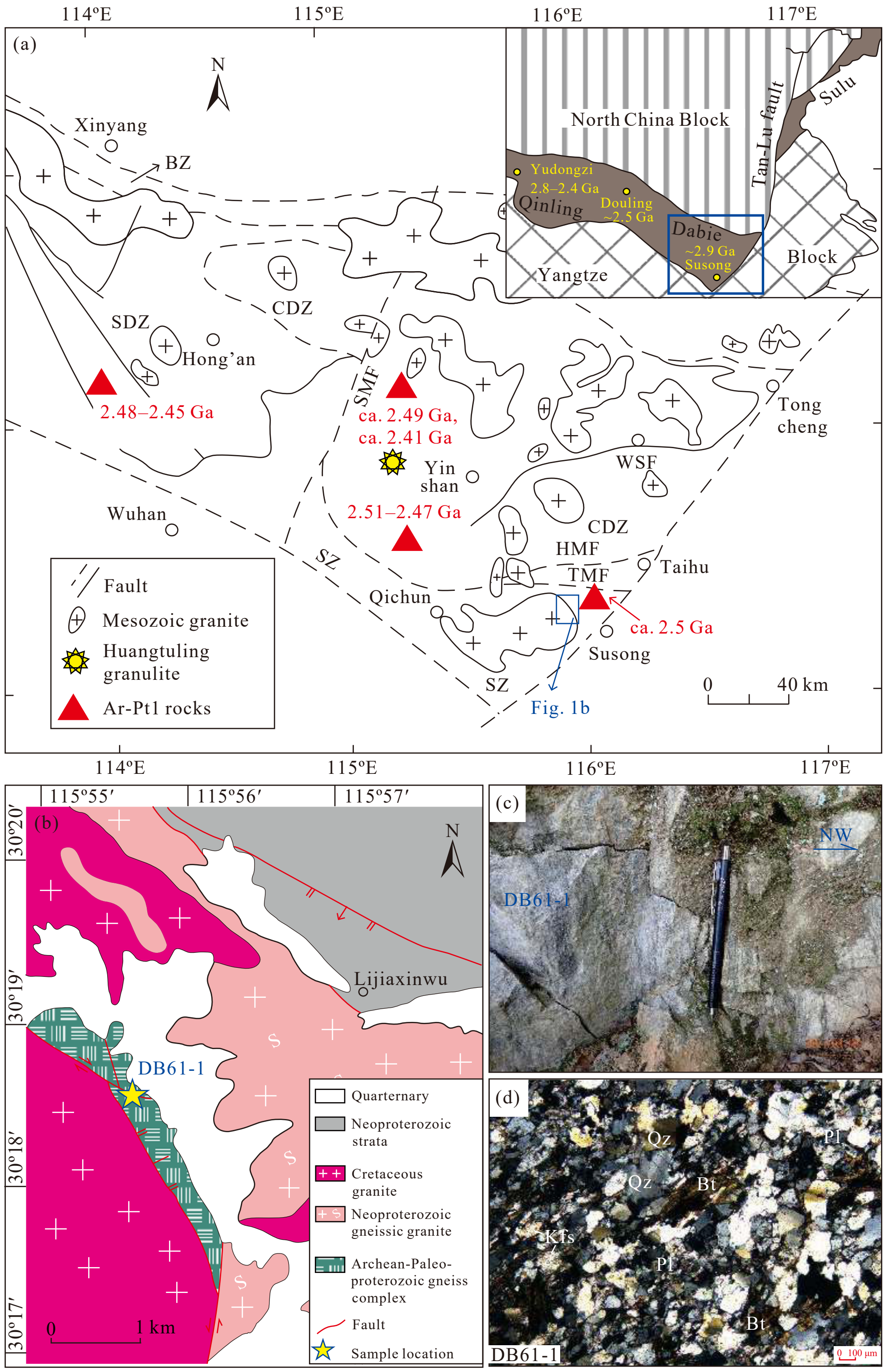

Fig. 1. a–Schematic tectonic map of the Dabie Orogenic Belt showing the main litho-tectonic units and their tectonic boundaries. Locations of published Archean and earliest Paleoproterozoic rocks and their age ranges are highlighted in red. Detailed data and references are summarized by Wang K et al. (2020). BZ–Beihuaiyang zone; NDZ–Northern Dabie zone; CDZ–Central Dabie zone; SDZ–Southern Dabie zone; SZ–Susong Complex zone. The inset map shows the locations of the Qinling-Dabie Orogenic Belt and the study area (Susong) relative to the North China Block and the Yangtze Block, and major Archean provinces in the Qinling-Dabie Orogenic Belt and their ages are highlighted in yellow. b–simplified geological map of the study area after 1∶50000 geological map of the Tingqianjie area showing sample location. c–representative field photo of the studied granitic gneiss. d–photomicrograph showing typical textures and mineral assemblages under cross-polarized light for the studied granitic gneiss. Bt–biotite; Kfs–potassium feldspar; Pl–plagioclase; Qz–quartz.

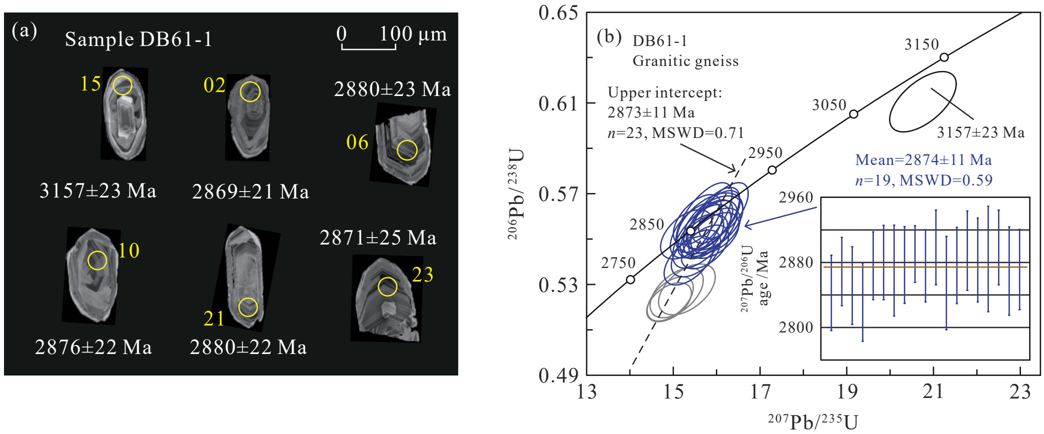

Fig. 2. CL images of representative zircons from the granitic gneiss sample (a) and their plots on the U-Pb Concordia diagram (b), respectively. Yellow circles in (a) are spots for U-Pb analyses, and yellow and white digits are spot numbers and corresponding $^{207}Pb/^{206}Pb$ ages, respectively. “*n*” in (b) represents the number of zircon analyses.

that most zircon grains have clear oscillatory zoning although some with blurry, chaotic domains, which is typical of magmatic zircon (Fig. 2a). Bright, very thin and discontinuous outer rims occur around most zircon grains, indicating they have been modified by later metamorphism. Twenty-four analyses were conducted on the magmatic domains of 24 zircons from sample DB61-1, all of which yielded ages of ≥ 96% concordance. Except for one analysis (spot #15) with an apparently older age of 3157±23 Ma ($^{207}Pb/^{206}Pb$ age), other zircon plots cluster around a younger age on the U-Pb Concordia diagram, yielding a weighted mean $^{207}Pb/^{206}Pb$ age of 2874±11 Ma (*n*=19, MSWD=0.97) for the most (≥97%) concordant analyses (Fig. 2b). Th/U is 0.20 for the older zircon, and is variably high from 0.14 to 0.62 for the younger zircons, all corresponding to an igneous Th/U of >0.1 (Supplementary Table S1). It interprets the older zircon as a xenocrystic or inherited grain and the weighted mean age of 2874±11 Ma as recording the crystallization of the granitic protolith.

4. Conclusion

The dating of granitic gneiss in the Susong Complex clearly shows that its protolith was emplaced at ca. 2.87 Ga, which is the oldest precise age obtained so far for rocks in the Qinling-Dabie Orogenic Belt. This also provides the first direct evidence for Mesoarchean crust in the Dabie Orogenic Belt, where Nd model ages as old as ca. 3.1 Ga have been obtained from felsic gneisses to indicate a Mesoarchean crustal source. The discovery of one, ca. 3.2 Ga xenocrystic or inherited zircon from the granitic gneiss further suggests a likely existence of Early Mesoarchean crustal components in this part of the Qinling-Dabie Orogenic Belt, which along with existing data (ca. 2.5 Ga amphibolite; Wang X et al, 2020) points to three major episodes of crustal growth and/or reworking at ca. 3.2 Ga, ca. 2.9 Ga, and ca. 2.5 Ga in the Susong Complex.

In combination with available data from the region, the authors conclude that some basement rocks of the Yangtze Block, dated at least back to the Mesoarchean, were extended beneath and currently preserved in the Qinling-Dabie Orogenic Belt, and Archean crust of the Yangtze Block was more widespread than previously recognized.

CRediT authorship contribution statement

Kai Wang and Tian-yu Zhao conceived the original idea. Kai Wang carried out the experiment and wrote the manuscript. Shuan-Hong Zhang verified the analytical methods and supervised the findings of this work. 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 Table S1) to this article can be found online at doi: 10.31035/cg2022084.

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