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Late Paleoproterozoic to early Mesoproterozoic Dongchuan Group in Yunnan, SW China: Implications for tectonic evolution of the Yangtze Block

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ABSTRACT

The Dongchuan Group including the Yinmin, Luoxue, Etouchang, and Luzhijiang Formations from the base upward has extensive outcrops in the western Yangtze Block. It was previously thought to be the lower part of the late Mesoproterozoic to early Neoproterozoic Kunyang Group, but there was a lack of precise age determination. The whole sequence is more than 4 km in thickness and consists of conglomerate, sandstone, slate, dolostone, carbonaceous slate, and minor tuffaceous volcanic rocks. The basal unit, the Yinmin Formation, is a continental red-bed deposit thought to have been formed in an intra-continental rift basin.

Zircons from the sandstone and volcanic rocks of the Yinmin Formation are analyzed for U–Pb and Lu–Hf isotopes in this study. Detrital zircons from the sandstone have U–Pb age populations at 1.8–1.9 Ga, 2.25–2.35 Ga, ~2.5 Ga, and 2.7–2.9 Ga with the oldest age of ~3.7 Ga. Most zircons have high Th/U ratios (>0.1) and were probably derived from igneous rocks, whereas a few 2.05–1.95 Ga grains with low Th/U ratios (<0.1) may have a metamorphic origin. The age groups are roughly consistent with those of known tectonothermal events in the northern Yangtze Block. The youngest detrital zircons of the Yinmin Formation have $^{207}Pb/^{206}Pb$ ages of ~1780 Ma and dolerite dykes intruding the formation have a zircon $^{207}Pb/^{206}Pb$ age of 1690 ± 32 Ma (2σ). A zircon $^{207}Pb/^{206}Pb$ age of 1742 ± 13 Ma (2σ) was obtained from a tuff sample of the Yinmin Formation and is considered to represent the deposition age. In combination with other age data of the Dongchuan Group, the newly obtained U–Pb age data thus constrain the deposition of the Dongchuan Group to the period between ~1.7 Ga and 1.5 Ga, significantly older than previously thought. Presence of late Paleoproterozoic continental rift in the western Yangtze Block is contemporaneous with the break-up of the Columbia supercontinent, and provide further evidence to support the idea that the Yangtze Block was likely part of the supercontinent.

Detrital zircons of the Yinmin Formation mostly have Hf continental modal ages (T_{DM}^{C}) between 3.5 Ga and 2.6 Ga with the oldest T_{DM}^{C} of 3.9 Ga, indicating that the western Yangtze Block experienced significant continental crustal growth during the Paleo- to Neo-archean and contains Eoarchean crustal rocks. In combination with data from others, our results suggest that the Yangtze Block have a widespread Archean basement. The Archean zircons have both positive and negative $\varepsilon_{Hf}(t)$ values (−10.1 to +6.5) suggesting both juvenile crustal growth and reworking of older materials. In contrast, the Paleoproterozoic zircons have highly variable but mostly negative $\varepsilon_{Hf}(t)$ values implying episodic crustal reworking of Archean crustal rocks. Unlike the Paleoproterozoic detrital zircons, igneous zircons from the tuff and dolerite dyke samples mostly have positive $\varepsilon_{Hf}(t)$ values (−0.8 to +10.1), indicating contributions of juvenile materials from a depleted mantle source due to continental rifting.

1. Introduction

The Yangtze Block consists predominantly of Meso- to Neoproterozoic rocks with sparse exposure of Archean to Paleoproterozoic rocks (Huang, 1945; Qiu et al., 2000; Wan, 2004). Despite the paucity of outcrops, U–Pb and Lu–Hf isotopic studies of detrital zircons from Neoproterozoic strata in the northern part of the block have revealed juvenile crustal growth in the Archean and episodic crustal reworking in the Paleoproterozoic (Zhang et al., 2006b; Liu et al., 2008). The 2.03–1.97 Ga granulites and 1.85 Ga mafic dykes have been identified in the northern Yangtze Block, and have been genetically linked to the recently proposed Columbia supercontinent (Zhang et al., 2006a; Sun et al., 2008; Xiong et al., 2009).

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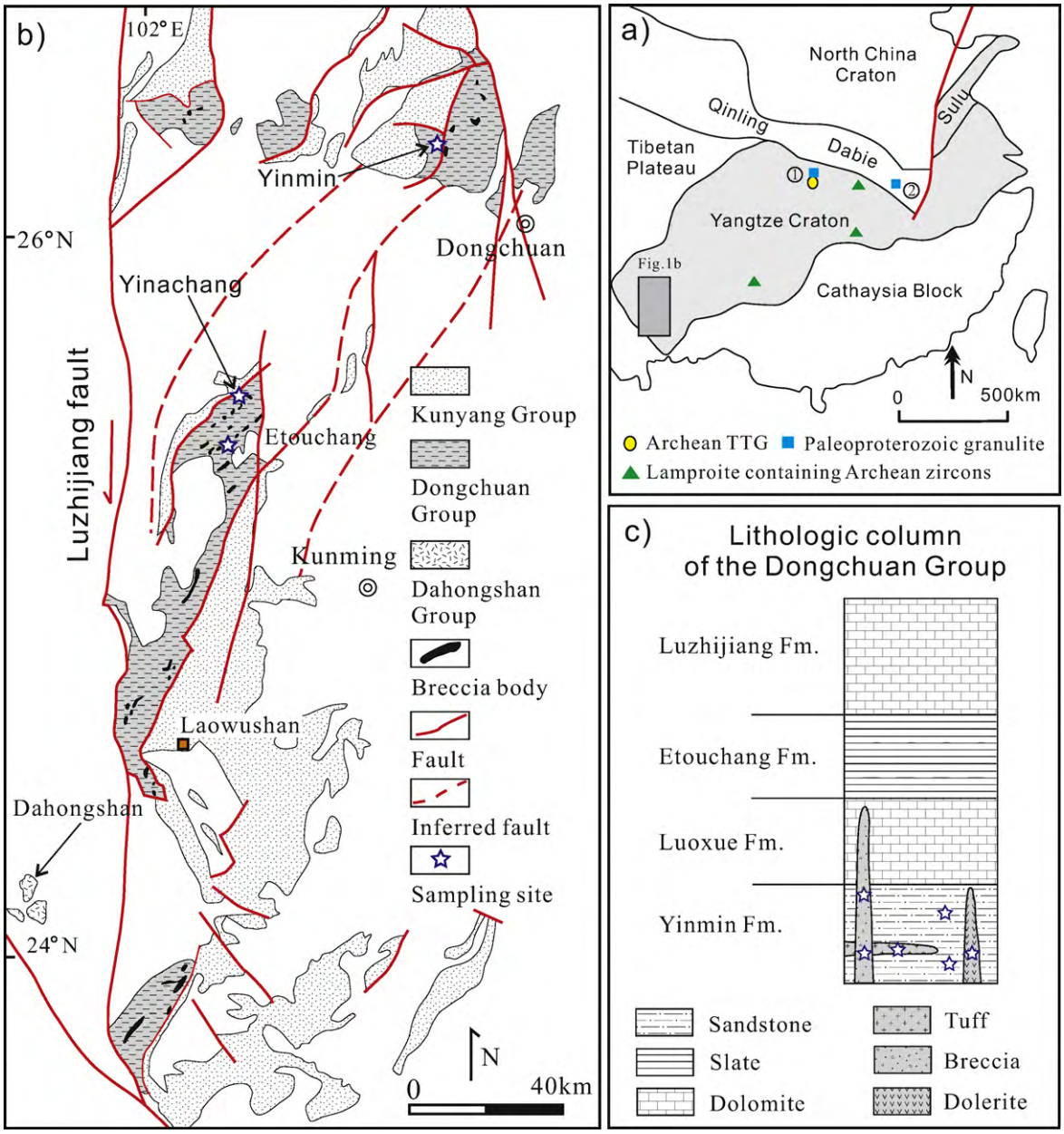

Fig. 1. (a) Simplified tectonic map showing the study area in the Yangtze Block. Locations of Archean TTG, Paleoproterozoic granulite and Paleozoic lamproites are also shown. Numbers 1 and 2 indicate Kongling and Huangtuling granulites, respectively. (b) Simplified geological map showing the distribution of Proterozoic strata in the SW Yangtze Block (modified from Wu et al., 1990). The sizes of the breccia bodies are not to scale. (c) Simplified lithologic column of the Dongchuan Group showing relative positions of selected samples.

However, such rocks have not been identified in the western part of the Yangtze Block and the Archean to Paleoproterozoic crustal and tectonic evolution remains poorly understood. Sparse outcrops and paucity of geochronological data of the Paleoproteorzoic rocks have also hampered the understanding of the tectonic evolution of the Yangtze Block.

Sedimentary rocks are natural samples of eroded continental crust and they record valuable information about their sources. Detrital zircon U–Pb and Lu–Hf isotopic data of siliciclastic rocks have been used widely to identify sediment provenance and major magmatic events in the source region, and hence help to decipher regional tectonomagmatic events and crustal evolution (e.g. Iizuka et al., 2005; Yang et al., 2006; Liu et al., 2008). The Dongchuan Group, which has been traditionally called the Lower Kunyang Group (Wu et al., 1990), is believed to be late Mesoproterozoic to early Neoproterozoic supracrustal succession in the western Yangtze Block (Greentree et al., 2006; Zhang et al., 2007). However, new geochronological data from this and other recent studies suggest that it is late Paleoproterozoic to early Mesoproterozoic strata, much older than the upper Kunyang Group. Thus, the Dongchuan Group provides an excellent opportunity to examine the Paleoproterozoic crustal evolution of the western Yangtze Block.

In this paper, we present zircon U–Pb and Lu–Hf isotopic data of the Dongchuan Group and associated intrusive rocks. The new dataset places tight constraints on the age of deposition and, combined with stratigraphic data, suggest that the Dongchuan Group was deposited in a late Paleoproterozoic continental rift setting. Thus, our study provides important insights into the Precambrian crustal evolution of the Yangtze Block with implications for the configuration of the Yangtze Block in the Columbia supercontinent.