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Precambrian tectonothermal evolution of South Qinling and its affinity to the Yangtze Block: Evidence from zircon ages and Hf-Nd isotopic compositions of basement rocks

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ABSTRACT

South Qinling is a tectonic block in the Mesozoic Qinling orogenic belt, central China, which is generally believed to have had tight affinity with the Yangtze Block during Precambrian times. In recent years, it has been recognized that the South Qinling Block hosts several Precambrian basement complexes. Here we report U-Pb ages and Hf isotopic data for zircons and Sr-Nd isotopic data for whole-rocks of the Douling complex, the oldest rock unit exposed in South Qinling, to reveal the early evolution of this basement. The Douling complex mainly consists of paragneisses and granitic orthogneisses. Zircons of magmatic origin from three orthogneiss samples give U-Pb ages of *c.* 2.5 Ga, suggesting an early Paleoproterozoic magmatic activity. Zircon Hf isotopic compositions imply the growth of juvenile crust since *c.* 3.0 Ga. The magmatic activity at *c.* 2.5 Ga points to differences in the Precambrian history between South Qinling and the Archean Kongling terrene, the oldest basement of the Yangtze Block. Three paragneiss samples contain complex detrital zircons of different ages and origins. Their U-Pb ages mainly cluster around 2.5 Ga, 2.0 Ga, 1.5 Ga and 800 Ma. Zircon grains with ages of 2.0 Ga and 800 Ma have low Th/U ratios and no oscillatory zoning, implying two episodes of metamorphic overprint. Such Paleoproterozoic metamorphic event has also been traced in the Yangtze Block, confirming its close relationship with South Qinling. The record of Neoproterozoic amphibolite-facies metamorphism in detrital zircons suggest that the tectonic transition from convergent to extensional environments in the Yangtze Block must have occurred later than 800 Ma ago.

1. Introduction

The Qinling orogen, extending roughly east-west across central China (Fig. 1a), was formed by a two-stage collision process between the North China Craton and the Yangtze (or South China) Block and intervening micro-continents during the middle Paleozoic and early Mesozoic era. The orogenic belt can be tectonically subdivided into the North Qinling Block, South Qinling Block and northern Yangtze Block, which are separated by the Shangnan-Danfeng (or Shang-Dan) suture zone to the north and Mianxian-Lueyang (or Mian-Lue) suture to the south (e.g., Meng and Zhang, 2000; Ratschbacher et al., 2003; Dong et al., 2011; Wu and Zheng, 2013; Liu et al., 2015; Dong and Santosh, 2016). Although the tectonic affinity of the North Qinling Block is still in debate (Zhang et al., 1997; Dong et al., 2003; Zhu et al., 2011; Liu et al., 2013, 2016), it is generally considered that the South Qinling Block was part of the Yangtze Block of South China during Precambrian times (Ling et al., 2008; Ling et al., 2010; Wang et al., 2013a).

In sharp contrast with the Archean and Paleoproterozoic high-grade basement of the North China Craton, the basement of the Yangtze Block mainly consists of Neoproterozoic sedimentary assemblages with sparse and discontinuous outcrops of Archean and Paleoproterozoic rocks, (Zheng and Zhang, 2007; Diwu et al., 2011; Zhai, 2011; Zhao and Cawood, 2012; Zhu et al., 2013). This limited old basement, known as the Kongling complex, provides valuable information about the Archean tectono-magmatic evolution of the Yangtze Block, useful for a better comparison between South Qinling and the Yangtze Block. During recent investigations, several Precambrian basement terrenes composed of high-grade meta-igneous rocks have been discovered in the South Qinling Block (Zhang et al., 1996; Hu et al., 2013; Shi et al., 2013).

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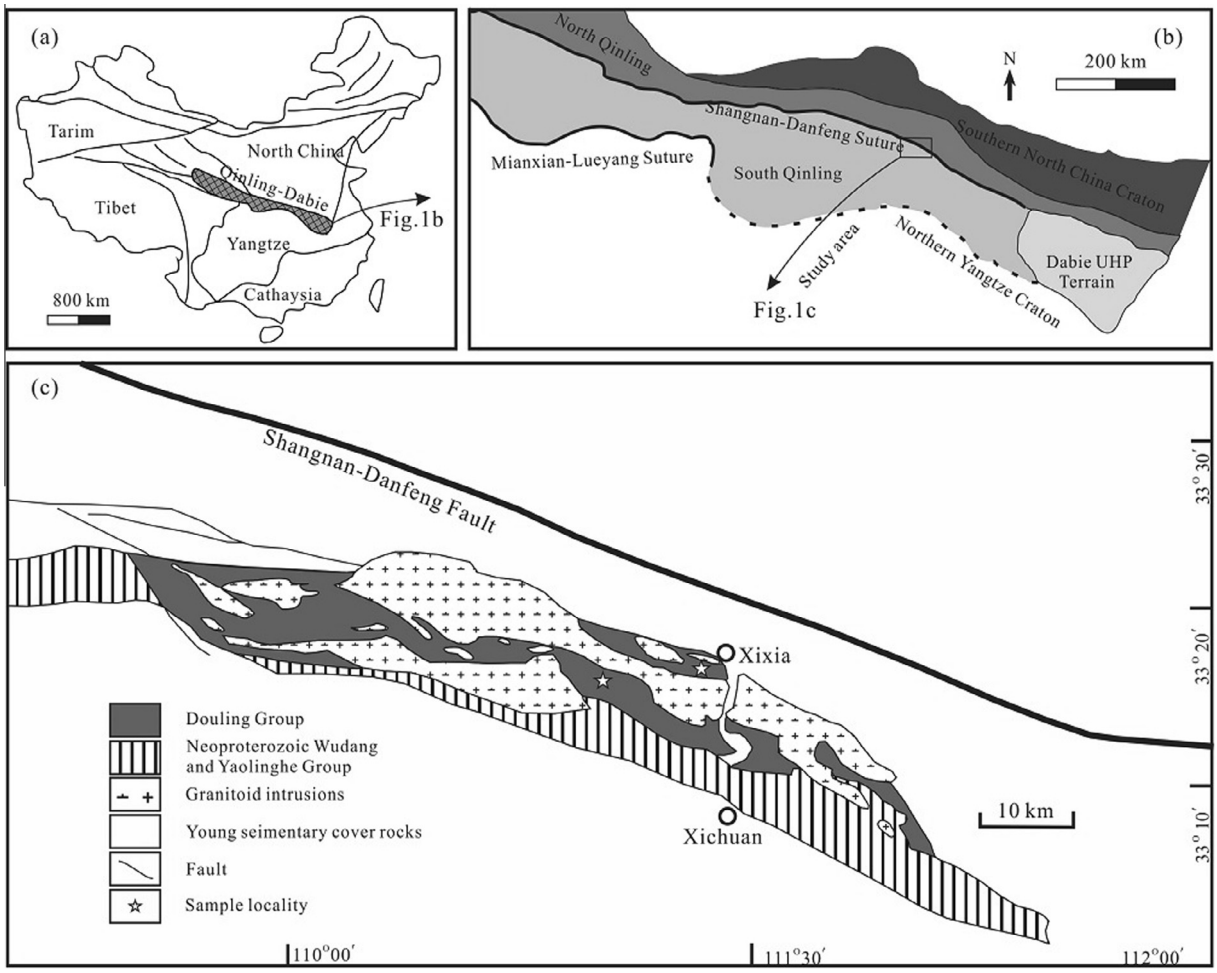

Fig. 1. Geological sketch map of South Qinling, showing sample localities.

Controversy remains about the formation ages of the protoliths, the geochemical features of the source regions, and the metamorphic history of the rocks. The old basement rocks of South Qinling are ideal objects to study the evolution of South Qinling or the Yangtze Block prior to the formation of the Qinling orogen.

In the last decades, most studies focused on the genesis of the Neoproterozoic magmatic rocks which are common in South Qinling (Ling et al., 2002b, 2008; Zhou et al., 2002; Zhang et al., 2004a; Zhu et al., 2014). In this study, we report U-Pb ages and Hf isotopic composition of zircons and geochemical and Sr-Nd isotopic data of the much older metamorphic rocks of the Douling complex exposed in the northern part of the South Qinling Block, close to the Shang-Dan suture zone. Including data from previous studies, the Precambrian crustal evolution of the South Qinling Block and its relationship with the Yangtze Block are evaluated.

2. Geological setting

The Qinling orogenic belt is composed of three blocks (Fig. 1b; Meng and Zhang, 2000). These are, from north to south, (1) the North Qinling, generally including the southern part of the North China block, (2) the South Qinling, and (3) the foreland terrene of the northern Yangtze Block. These blocks are separated by the Paleozoic Shangnan-Danfeng (or Shang-Dan) suture in the north and the Early Mesozoic Mianxian-Lueyang (or Mian-Lue) suture in the south (Fig. 1b). The suture zones formed due to the closure of the Shang-Dan and Mian-Lue oceans (e.g., Meng and Zhang, 2000).

The South Qinling Block comprises underlying Precambrian basement and a younger sedimentary cover (Meng and Zhang, 2000). The eastern South Qinling Block mainly comprises the Douling complex and the Wudang, Yaolinghe and Liuling Groups. These units are separated from each other by faults (Dong et al., 2011). Based on differences in lithology and metamorphic grade, two types of basement, crystalline and transitional, occur in the South Qinling Block. The crystalline basement is represented by the high-grade metamorphic rocks of the Douling complex, whereas the transitional basement is exposed in the low-grade metamorphic volcanic-sedimentary sequences of the Wudang and Yaolinghe Groups. Rocks of the Douling complex (also known as Douling Group) are discontinuously exposed in the Xixia-Xichuan area of the Henan Province (Fig. 1c). This rock complex consists of amphibolite-facies gneisses, schists, amphibolites and minor marbles. P-T conditions of the Douling complex were estimated at 600–700 °C by garnet-hornblende geothermometry and at 0.7–0.8 Gpa by garnet-hornblende-plagioclase-quartz geobarometry (Zhang et al., 1996). Rocks from the Douling complex were dismembered during the intrusion of voluminous Neoproterozoic granitoid rocks (Zhang et al., 2004a).

The Wudang and Yaolinghe Groups consist of clastic sediments with interbedded layers of volcanic tuff and lava (Zhu et al., 2009). The Yaolinghe Group contains more mafic igneous components while the Wudang Group is more felsic in composition. These volcanic-sedimentary sequences commonly record greenschist-facies metamorphic overprint. The Liuling Group, situated at the northern part of South Qinling, is characterized by thick flysch