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2.1–1.85 Ga tectonic events in the Yangtze Block, South China: Petrological and geochronological evidence from the Kongling Complex and implications for the reconstruction of supercontinent Columbia

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ABSTRACT

This paper presents petrography, zircon U–Pb ages and Hf isotopic data as well as whole-rock Sm–Nd isotopic data for mafic granulites, metapelitic rocks and high-grade marble from the Kongling Complex in the Yangtze Block, South China. Petrographic observations indicate that these three types of rocks experienced high-pressure metamorphism. Their mineral assemblages and P–T conditions define a clockwise P–T path involving isothermal decompression following the peak high-pressure metamorphism, which is considered to record a continent–continent collisional event. This is systematic documentation of the tectonic evolution of the Kongling Complex from 2.1-2.0 Ga deposition (constrained by youngest detrital zircon and metamorphic zircon) through ~2.0 Ga collision (high-pressure metamorphism) and syn-collisional partial melting (S-type granite and migmatization of TTG gneiss) to ~1.85 Ga post-collisional extension (A-type high-K granite and mafic dyke). These ages are broadly coincident with global collisional events (2.1–1.8 Ga) that led to the assembly of the Palaeo-Mesoproterozoic Columbia (or Nuna) supercontinent. Therefore, this study provides strong evidence that the Yangtze Block in South China was a component of the Columbia supercontinent.

1. Introduction

The Yangtze Block in South China is a major cratonic block that is believed to have been involved in the assembly of many ancient supercontinents such as Columbia, Rodinia and Pangea (Cawood et al., 2013; Evans, 2009; Li et al., 2008; Veevers, 2004; Yu et al., 2008, 2012; Zhao et al., 2002, 2004; Zhang et al., 2012a,b,c). Therefore, its formation and evolution can provide significant insights into crustal accretion and amalgamation of the supercontinents. However, our attention has mainly been focused on the younger supercontinents Pangea and Rodinia (Bader et al., 2013; Condie, 2002; Dalziel et al., 2000; Meert and Powell, 2001; Torsvik, 2003). In contrast, understanding of the earlier, Palaeo-Mesoproterozoic Columbia supercontinent has been more tenuous. Columbia contained almost all of the world's continental blocks that were amalgamated along global 2.1–1.8 Ga collisional orogens (Zhao et al., 2002). However, it remains controversial whether the South China was part of the Columbia supercontinent and, if so, where it was located within this supercontinent (Evans, 2009; Zhang et al., 2012a; Zhao et al., 2002). A main reason for this controversy is that no typical 2.1–1.8 Ga continent–continent collision has been identified in South China.

The Kongling Complex, located in the north of the Yangtze Block in South China and composed of Mesoarchean TTG basement rocks and the Palaeoproterozoic Kongling Group (metamorphic sedimentary rocks), is considered to have been involved in global collisional events (2.1–1.8 Ga) that led to the assembly of the Columbia supercontinent (Wu et al., 2009; Zhang et al., 2006b,c; Zhao et al., 2002). However, tectonic setting and evolution of the Kongling Complex remain unknown or controversial, due to the absence of high-pressure granulite and the lack of precise constraints on timing of deposition and metamorphism in the Kongling Group. In this paper, we report high-pressure mafic granulite in the Kongling Complex and determine depositional and metamorphic timing of the Kongling Group based on petrography, zircon U–Pb ages and Hf isotopic data, and whole-rock Nd isotopic data on high-pressure mafic granulites, metasedimentary rocks and high-grade marble from the Kongling Complex. The results of this study provide strong evidence that the South China is a

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component of the Palaeo- to Mesoproterozoic Columbia supercontinent and provide significant insights into understanding the reconstruction of the supercontinent.

2. Geologic setting

The South China Craton is separated from the North China Craton by the Qinling–Dabie–Sulu orogen in the north, from the Songpan–Ganze Terrane by the Longmenshan Fault in the west, and is bounded by the Pacific Ocean to the southeast (Fig. 1; Zhao and Cawood, 2012). It is conventionally subdivided into the Yangtze Block to the northwest and the Cathaysia Block to the southeast (Fig. 1). The Archean and Palaeoproterozoic basement of the South China Craton has only been exposed in the northern and western parts of the Yangtze Block, represented by the Kongling Complex, Huangtuling granulites, Yudongzi Group and Houhe Complex in the north, and by the Dahongshan and Dongchuan groups in the southwest (Fig. 1; Chen et al., 2013a,b; Wang et al., 2013; Wu et al., 2008, 2012; Zhao and Cawood, 2012; Zheng et al., 2004, 2006), and in the northeastern part of Cathaysia (Xia et al., 2012; Yu et al., 2008, 2012). The dominant Precambrian rocks in the South China Craton are Neoproterozoic rocks (Dong et al., 2012; Wang et al., 2012a, b,c,d; Zhang et al., 2012b,c, 2013).

The Kongling Complex, covering an area of ~360 km^2 (Fig. 1; Gao et al., 1999), consists predominantly of Archean tonalitic–trondhjemitic–granitic (TTG) gneisses and Palaeoproterozoic Al-rich metasedimentary rocks (supracrustal rocks), with minor amphibolite, mafic granulites and S-type garnet-bearing granites (Fig. 2; Gao et al., 1999, 2011). Traditionally, these Al-rich supracrustal rocks and the associated amphibolite and mafic granulites are together called the 'Kongling Group'. It is intruded by ~1.85 Ga Quanyishang K-feldspar granite in the north and the early Neoproterozoic (850–826 Ma) Huangling granitoids in the south, and surrounded by the unmetamorphosed late Neoproterozoic and Palaeozoic sedimentary cover (Fig. 2; Peng et al., 2012; Xiong et al., 2008; Zhang et al., 2008, 2009; Zhang and Zheng, 2013; Zhao and Guo, 2012; Zhao et al., 2013a,b,c).

The Kongling Group can be subdivided into three "formations": the bottom formation is composed predominantly of graphite–sillimanite–garnet gneiss and staurolite–sillimanite–garnet gneiss, with minor garnet–biotite schist and amphibolite; the middle formation consists mainly of graphite–biotite schist, olivine–diopside marble, calc–silicate rock and quartzite; and the top formation is dominated by banded fine-grained biotite–plagioclase gneiss, locally including BIFs, calc–silicate, mafic granulite and amphibolite lenses and/or boudins.

Available geochronological data show that major TTG gneisses from the Kongling Complex were emplaced in the period of 3.3–3.2 Ga and 3.0–2.9 Ga and metamorphosed at 2015–1891 Ma (Gao et al., 1999, 2001, 2011; Jiao et al., 2009; Peng et al., 2009, 2012; Qiu et al., 2000; Wu et al., 2009; Zhang et al., 2006a,b; Zheng and Zhang, 2007). The previously-documented youngest detrital zircon from the metasedimentary rocks in the Kongling Complex constrained the maximum depositional age at ~2.87 Ga (Qiu et al., 2000). The Hf isotopic data reveal that the 3.3–3.2 Ga and 3.0–2.9 Ga zircons from the TTG gneisses and metasedimentary rocks in the Kongling Complex are characterized by negative εHf(t) values and 3.5–4.0 Ga Hf model ages (Gao et al., 2011; Jiao et al., 2009; Liu et al., 2008; Zhang et al., 2006a; Zheng and Zhang, 2007).

3. Petrography

The protoliths of mafic, pelitic and carbonate-bearing rock-types from the Kongling Complex underwent high-grade metamorphism. In this paper, representative samples of high-pressure mafic granulite (11YC01-6, Fig. 3a), garnet–sillimanite gneisses (11YC02-2, Fig. 3b) and olivine–diopside marble (11YC05-7, Fig. 3c) were selected for petrographic analyses.

3.1. High-pressure mafic granulite (sample 11YC01-6)

Sample 11YC01-6 (Fig. 3a) consists of garnet (g), diopsidic clinopyroxene (cpx), plagioclase (pl), ilmenite (ilm) and minor quartz

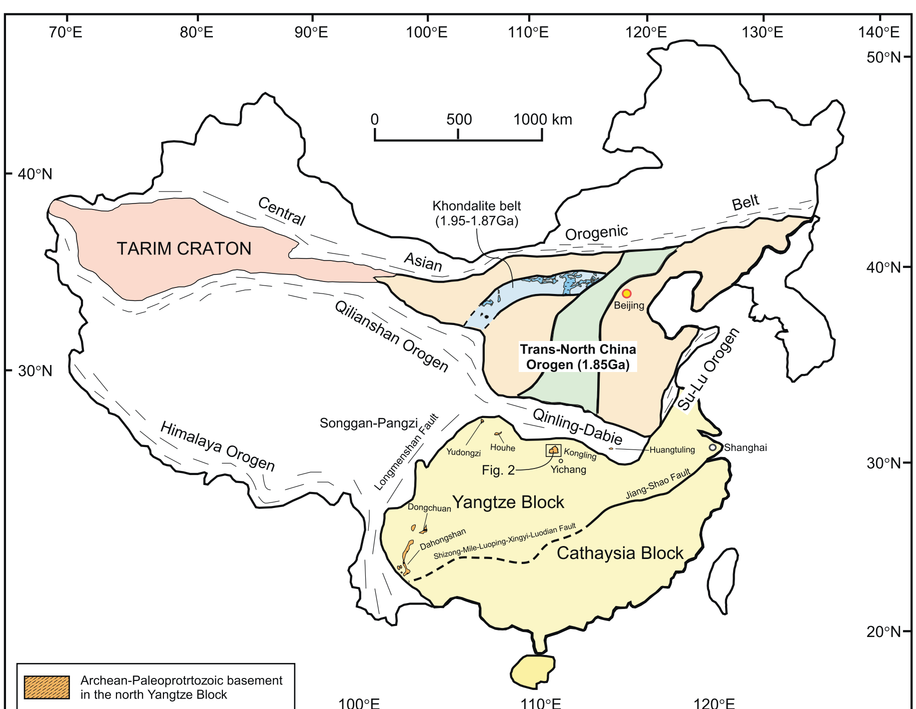

Fig. 1. Schematic tectonic map of China showing major Precambrian blocks connected by Phanerozoic fold belts. After Zhao and Cawood (2012).