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Constraining timing and tectonic implications of Neoproterozoic metamorphic event in the Cathaysia Block, South China

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ABSTRACT

The Cathaysia Block of the South China Craton includes a Proterozoic basement that experienced a prolonged Precambrian crustal evolution but to date lacks evidence of Proterozoic metamorphic ages. At Lichuan and Jianning, in the Wuyi Domain of the eastern Cathaysia Block, Proterozoic rock units include migmatized paragneiss of the Wanyuan Group and minor amphibolite of the Tianjingping Formation, which are enveloped by schist of Mayuan Group, and all are intruded by Paleozoic and Mesozoic igneous rocks. Detrital zircon grains from the Wanyuan paragneiss display metamorphic rims that yield concordant weighted average $^{206}Pb/^{238}U$ ages of 860 ± 6 Ma and 435 ± 5 Ma, along with variably disconcordant ages with lower intercept ages of 442 ± 41 Ma. The zircon core ages range from 3015 Ma to 851 Ma, with three major age populations at 930–865 Ma, 1850–1200 Ma and 2650–2400 Ma. Detrital zircon grains from Mayuan schist samples at Jianning generally lack core-rim structures and yield three main age populations at 860–736 Ma, 1835–1775 Ma and 2720–2500 Ma. Metamorphic ages of ca. 860 Ma and ca. 435 Ma for the Wanyuan paragneiss along with the youngest detrital zircon constrain the depositional age of the protolith to ca. 865–860 Ma, whereas the Mayuan Group is younger and probably deposited after ca. 736 Ma. Characteristics of detrital zircon age populations along with regional geological data suggest accumulation of the Wanyuan Group in a convergent and/or collisional setting. Metamorphism and a possible subduction-collision process within the Cathaysia Block at around 860 Ma suggest it was not a unified block in early Neoproterozoic. The growth of ca. 440 Ma metamorphic rims is likely related to granitic magmatism, such as that exposed in the Lichuan region. The sparse evidence for early Neoproterozoic metamorphism likely reflects widespread overprinting by the Paleozoic tectonothermal event at around 440 Ma.

1. Introduction

Regional metamorphism and tectonothermal events associated with orogenesis are generally ascribed to subduction or collision zone settings and their timing provides important constraints on the crustal evolution of the resultant mountain belts. In regions that have undergone multiple metamorphic events, recognition of the earliest events and their tectonic setting can be difficult to determine due to overprinting by younger events including the resetting of mineral systems. Advances in micro-analysis along with the stability of the U–Th–Pb isotopic system in zircon and its ability to record multiple igneous and metamorphic events have made it an important phase in unravelling complex geological histories in orogenic belts (Vavra et al., 1999; Corfu et al., 2003; Harley et al., 2007).

The Cathaysia Block of the southeast South China Craton contains the geographically restricted Paleoproterozoic Wuyi domain, and the early Neoproterozoic Yunkai and Southern Jiangxi – Nanling domains, overlain by widespread middle Neoproterozoic to early Paleozoic sedimentary and igneous units (Fig. 1; Shu, 2006; Zhao and Cawood, 1999, 2012; Li et al., 2011a,b; Wang et al., 2014). Early Neoproterozoic subduction related igneous suites (Shu et al., 2008; Li et al., 2011b; Zhang et al., 2012; Wang et al., 2013) and S type granitic gneiss (Wang et al., 2014) are exposed in various localities of the Cathaysia Block. Due to a lack of evidence of Neoproterozoic metamorphism, whether the Cathaysia Block constituted a single unified block or a series of microblocks assembled in the Neoproterozoic is debated, as is the

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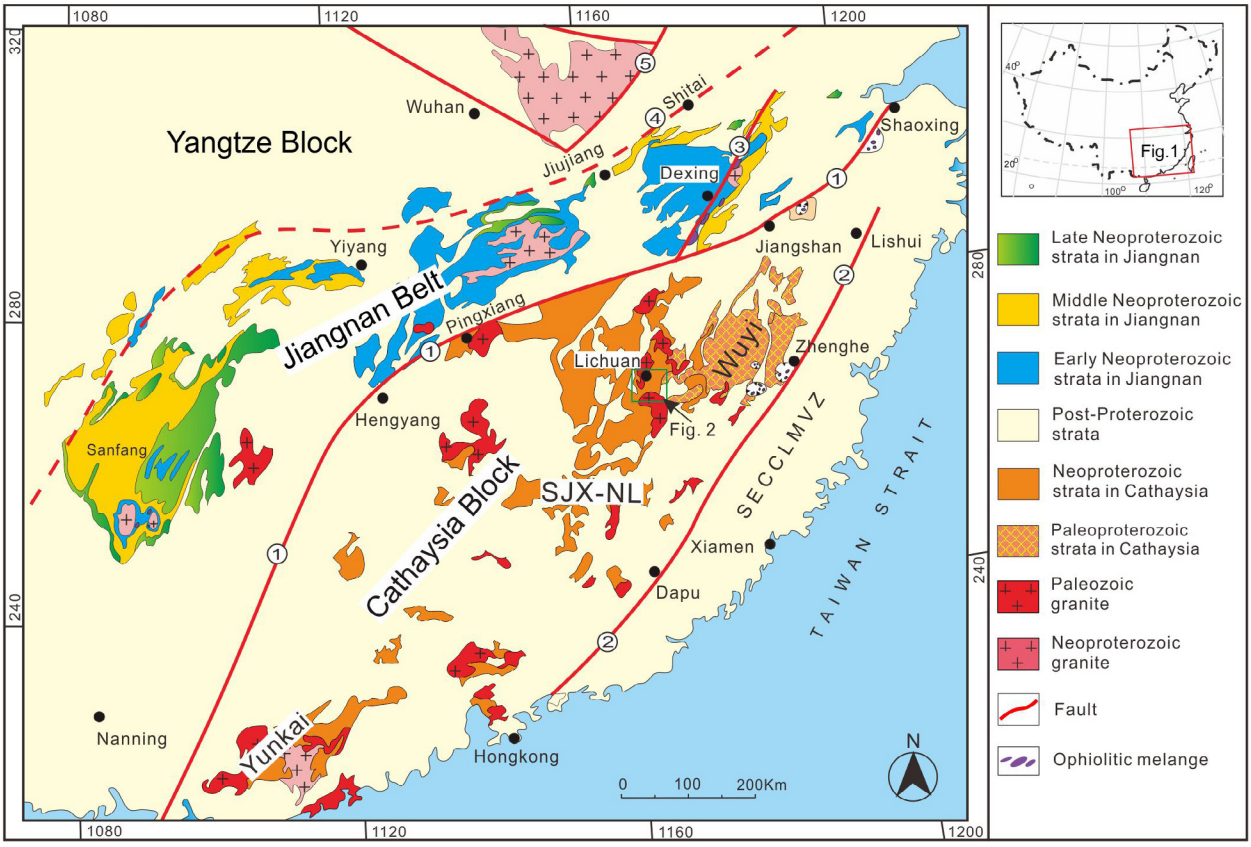

Fig. 1. Geological sketch map of the Cathaysia Block, South China Craton (1: Jiangshan-Shaoxing fault; 2: Zhenghe-Dapu fault; 3: Northeast Jiangxi fault; 4: Jiujiang-Shitai fault; 5: Tanlu fault; SECCLMVZ: Southeast China costal late Mesozoic volcanic zone; SJX-NL: southern Jiangxi – Nanling).

number and direction of subduction zones, and the timing of final suturing with the Yangtze Block (Shu, 2012; Wang et al., 2013, 2014; Yao et al., 2014, 2015; Zhao, 2015). These uncertainties are reflected in the controversy as to the position of South China in the Rodinia supercontinent (Cawood et al., 2013; Wang et al., 2013).

In this study, we outline U-Pb zircon age data from migmatized paragneiss from the Cathaysia Block of the South China Craton, which provide the unequivocal age data for early Neoproterozoic metamorphism of the block. The studied rock units preserve a spectrum of detrital zircon ages that are variably overprinted by early Neoproterozoic and early Paleozoic metamorphic events, providing insight into the assembly of the Cathaysia Block that we relate to subduction-collision related tectono-thermal events.

2. Geological setting and litho-stratigraphic structures

2.1. Geological setting

The Cathaysia Block accreted with the Yangtze Block to the northwest in the early-middle Neoproterozoic, involving a series of arc systems along the intervening Jiangnan accretionary orogenic belt (Cawood et al., 2013 and references therein; Yao et al., 2015, 2016). These are overlain by Nanhua rift basin succession and Sinian to Phanerozoic strata (Shu et al., 2011; Shu, 2012).

In the period ca. 440–410 Ma, the pre-Devonian (>ca. 410 Ma) rock units in Cathaysia were variably metamorphosed and deformed, and intruded by S-type granites (Charvet et al., 2010; Shu et al., 2014; Song et al., 2015). Coeval metamorphism of early Paleozoic strata reached greenschist facies in the Cathaysia Block, and locally amphibolite to granulite facies (BGMRFJ, 1985; Zhao and Cawood, 1999; Yu et al., 2003, 2005), but the precise age of metamorphism is not well constrained. Zhao and Cawood (1999) identified four stages of metamorphism from the Mayuan Group in Wuyi Domain that display a clockwise P-T path. The Yangtze Block generally lacks evidence for an early Paleozoic tectonothermal event (Fig. 1; Shu, 2012; Zhao and Cawood, 2012).

2.2. Lithology and related structures in Lichuan and Jianning regions

In the Lichuan region of the western Wuyi Domain, the Wanyuan Group is the oldest exposed unit and is unconformably overlain by the middle to late Neoproterozoic Sinian Group (Fig. 2; BGMRJX, 1984). The former consists of variably migmatized gneiss and leptynite pods or lenses interlayered within schist and minor amphibolite (BGMRJX, 1984). The Sinian Group contains variably migmatized mica schist and phyllite. Both the Wanyuan and Sinian groups are intruded by deformed S-type granite dated at 436 ± 6 Ma and 457 ± 6 Ma (LA–ICP–MS, Zhang et al., 2011; Song et al., 2015 and references therein) and undeformed Mesozoic plutons dated at 189 ± 5 Ma (LA–ICP–MS, Jiang et al., 2015). Exposures of paragneiss and migmatized paragneiss ranging in size from tens of centimeters to kilometers occur within the Paleozoic granitic plutons (Figs. 2 and 3a).

To the south of Lichuan, at Jianning, plagioclase amphibolite of the Tianjingping Formation is enveloped by kyanite schist and biotite quartz schist of the Mayuan Group (BGMRFJ, 1985; Figs. 2 and 4). The Tianjingping Formation is dated at 1766 ± 19 Ma (zircon SHRIMP U–Pb, Li, 1997) and the Mayuan Group is likely Neoproterozoic (Wan et al., 2007). Both units have experienced multiple episodes of deformation and metamorphism (Fig. 3b; Zhao and Cawood, 1999) and are intruded by Paleozoic S-type granite dated