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Detrital record of Indosinian mountain building in SW China: Provenance of the Middle Triassic turbidites in the Youjiang Basin

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ABSTRACT

Sandstone petrology, geochemistry, and detrital zircon U–Pb ages and trace elements are integrated to investigate the provenance of Middle Triassic strata from the Youjiang Basin, SW China. Variations in abundance of volcanic lithic fragments and ratios of Th/U, Zr/Sc and Th/Sc suggest that sandstones from the southwestern portion of the basin display less sedimentary recycling and have a lower felsic average source composition than time-equivalent strata from the central, eastern and northern portions of the basin. All sandstones exhibit an overall similar detrital zircon U–Pb age distribution pattern with major age groups at 1200–900 Ma, 480–420 Ma and 300–240 Ma together with some Devonian–Carboniferous and Neoproterozoic grains. Combined with the compiled paleocurrents, the detrital zircon ages suggest multiple-sourced components. Pre-Devonian detrital zircons were likely derived from the recycled late Neoproterozoic–early Paleozoic clastic rocks and from magmatic and metamorphic rocks related to the early Paleozoic orogeny in the southeastern segment of the South China Craton. Late Paleozoic–Triassic detrital zircons together with the presence of well preserved volcanic lithic fragments were considered to indicate first-cycled detrital input from a subduction–collisional mountain belt to the southwest of the craton. These provenance data argue for an Indosinian mountain building event following the closure of a Paleo-Tethys branch ocean rather than for a thermotectonic reactivation event as recently proposed for the Indosinian orogeny in the southwestern China. In association with this orogeny the Youjiang Basin evolved into a foreland basin.

1. Introduction

The South China Craton (SCC) was assembled and accreted onto East Asia through a series of Neoproterozoic to Mesozoic orogenic cycles (Li et al., 2010; Metcalfe, 1994, 2011; Wang and Mo, 1995). The Late Permian to Triassic was a critical period in the amalgamation of the region and is marked by widespread tectonothermal activity, referred to as the Indosinian orogeny (Carter et al., 2001; Lepvrier et al., 2004; Li and Li, 2007; Wang et al., in press-b; Zhou et al., 2006). Tectonic drivers for Indosinian magmatic and metamorphic events remain elusive. Some researchers have suggested that orogenic activity is an outcome of continental collision of the SCC with the Indochina and North China blocks along with intracontinental contraction (e.g., Cai and Zhang, 2009; Lepvrier et al., 2008; Wang et al., 2007b, in press-b; Yan et al., 2006; Zhou et al., 2006). Alternatively, others have argued that orogenesis reflects a tectonothermal reactivation event to the southwest of SCC and an active margin accretion due to the subduction of Paleo-Pacific oceanic plate along the southeastern segment of the craton (Carter and Clift, 2008; Li and Li, 2007; Li et al., 2006, 2012, in press).

The Youjiang Basin (also termed the Nanpanjiang Basin) lies close to the southwestern margin of South China (Fig. 1). It has been interpreted as a retro-arc foreland basin corresponding to the northwestward subduction of the Paleo-Pacific plate beneath the SCC (Li and Li, 2007), or as a peripheral foreland basin (Cai and Zhang, 2009; Qin et al., 1996) related to the closure of the Paleo-Tethyan ocean and subsequent collision of bounding continents to the southwest of SCC during Indosinian orogeny. The basin contains a thick, Middle Triassic deep-water turbidite sequence (Du et al., 2009; Qin et al., 1996; Zeng et al., 1995) and provides a unique detrital record of tectonic activity in the orogenic hinterland (e.g., Carter and Clift, 2008; Li and Li, 2007). In this paper we look in detail at the provenance of the Middle Triassic strata by combining sandstone detrital composition, whole-rock geochemistry, and detrital zircon U–Pb ages and trace element analyses. These data are used to constrain the nature and tectonic setting of Indosinian events in East Asia.

2. Regional geology

The SCC was formed by amalgamation of the Yangtze and Cathaysia blocks along the Jiangshan–Shaoxing fault zone prior to the mid-Neoproterozoic, forming the Jiangnan Orogen (Li et al., 2002, 2007,

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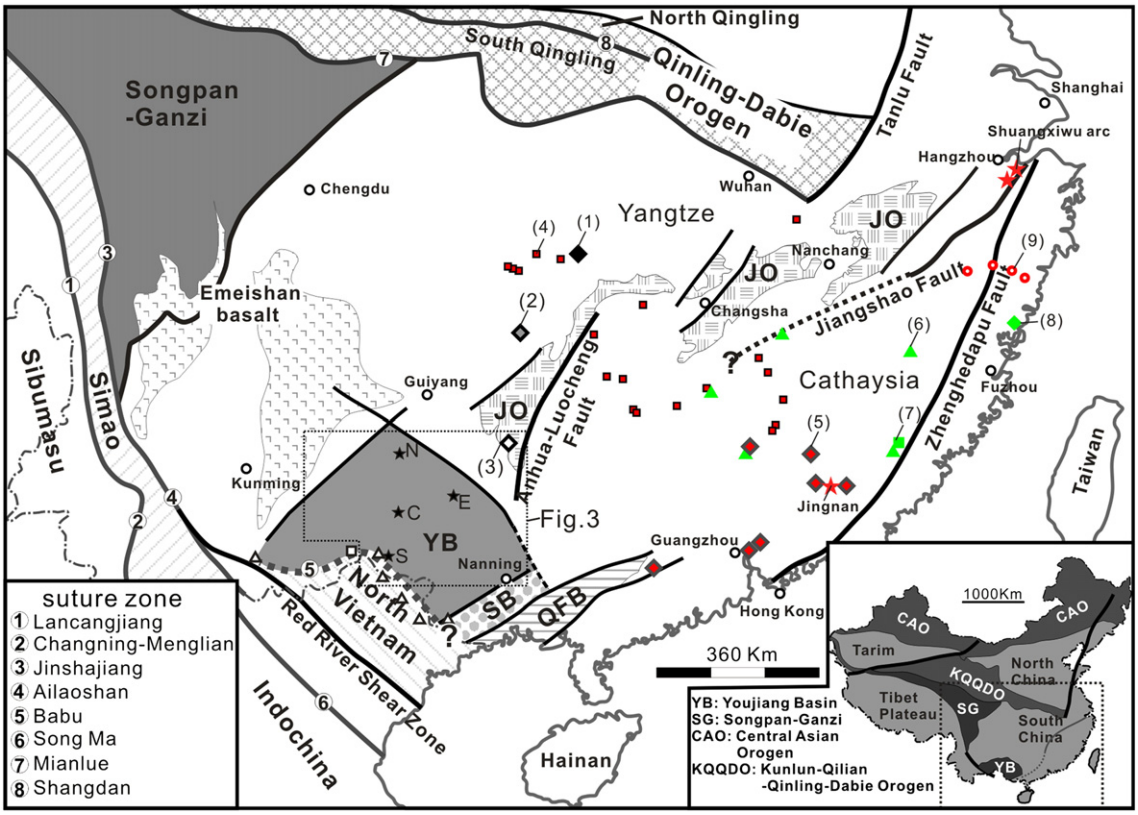

Fig. 1. Major geological features of South China and adjacent tectonic units with the inset showing the constructive components of China (1:12000000 tectonic map of China). Also shown are the ophiolites (marked as square) and the volcanoplutonic rocks (triangle) of arc geochemical characters along the inferred Babu suture zone, and locations of four sampled composite sections (S, Napo; C, Tianlin; N, Ziyun; E, Tian`e). Out of the Youjiang Basin, the locations of the Neoproterozoic (1, 2, 3 and 5), early Paleozoic (4), Middle–Late Permian (6), Late Triassic (7) and Jurassic (8) sedimentary rocks and modern river sands (9) in east South China Block used for comparison with the Youjiang sandstones in detrital zircon ages are marked as different symbols with numbers (Li et al., in press; Wang et al., 2007a, 2009, 2010a,c, 2012a,b; Xu et al., 2007; Yu et al., 2010). Abbreviations: YB, Youjiang Basin; SB, Shiwandashan Basin; JO, Jiangnan Orogen; QFB, QinFang Fold Belt.
After Wang and Mo (1995).

2009; Wang and Mo, 1995; Wang et al., 2007a; Zhao and Cawood, 1999). During the late Neoproterozoic to early Paleozoic the Nanhua rift basin developed in the vicinity of the assembly zone (Wang and Li, 2003) whereas a carbonate dominated platform developed across the northwest portion of the craton (Liu and Xu, 1994; Wang and Li, 2003; Wang et al., 2010c). During the early Paleozoic the thick shallow to abyssal marine carbonate/clastic sequence in the rift basin was uplifted, deformed, metamorphosed and intruded by granitic magmas in the southeastern SCC (Fig. 2A; Charvet et al., 2010; Liu and Xu, 1994; Li et al., 2010, 2011; Wang et al., 2010c). At the same time, the western carbonate platform of South China recorded a sedimentary hiatus and a change from carbonate to clastic sedimentation (Liu and Xu, 1994).

The SCC was involved in the Paleo-Tethys orogenic cycle as represented by the Jinshajiang–Ailaoshan, Babu and Mianlue suture zones and the Songpan–Ganzi belt (Figs. 1 and 2B,C; Dong et al., 2011; Jian et al., 2009; Wang and Mo, 1995; Wu et al., 1999). Opening and spreading of these Paleo-Tethys branch oceans since the Devonian, expressed as transgression and rebuild-up of the carbonate platform, resulted in regional subsidence across the craton (Liu and Xu, 1994). The Triassic Indosinian orogeny was manifested by termination of the carbonate platform build-up in the Early–Middle Triassic separated from Late Triassic–Jurassic terrestrial clastic sedimentation by a regional unconformity and widespread deformation, metamorphism and granitoid magmatism (Fig. 2A; Liu and Xu, 1994; Wang et al., 2007b,c; Xu et al., 2011 and references therein).

3. The Youjiang Basin and Middle Triassic turbidites

The Youjiang Basin is bounded by the Shizong–Mile fault to the northwest, by the Ziyun–Danchi fault to the northeast, and separated from the Shiwandashan Basin to the southeast by the Pingxiang–Nanning fault, and from the North Vietnam terrane to the southwest by the Babu suture zone (Fig. 1). This suture zone is delineated by Permian–Triassic mafic to silicic volcanic rocks with arc geochemical signatures and MORB-like ophiolitic mafic–ultramafic rocks (Fig. 2C; Wu et al., 1999, 2002; Zhong et al., 1999). It is considered as the western segment of the Dian–Qiong suture, which is thought to be connected with the Jinshajiang–Ailaoshan suture zone to the northwest as defined by Cai and Zhang (2009). The North Vietnam terrane is currently sandwiched between the SCC and Indochina Block with its northeastern and southwestern boundaries being the Babu suture and the Red River shear zone, respectively (Fig. 1, e.g., Cai and Zhang, 2009). This terrane consists of Neoproterozoic meta-sedimentary and igneous basement intruded by Silurian granitoids, and Paleozoic–Mesozoic sedimentary–volcanic strata (Carter et al., 2001; Guo et al., 2009; Hoa et al., 2008; Liu et al., 2006; Roger et al., 2000; Yan et al., 2006). Permian–Triassic magmatism, metamorphism and deformation have been reported from this terrane (Hoa et al., 2008; Roger et al., 2012; Yan et al., 2006).

The Early–Middle Devonian strata in the Youjiang Basin consist of sandstone, siltstone and shale, along with rifted-related basalt and diabase that unconformably overlie Cambrian–Ordovician calcareous rocks and shales (BMGRGR, 1985; Du et al., 2009; Zeng et al., 1995). They are in turn conformably overlain by a late Paleozoic–Early Triassic succession including isolated shallow-marine platform carbonates and deep-sea basinal calcareous/siliceous/volcanic rocks, and pelites, interpreted as a passive continental margin sequence (BMGRGR, 1985; Qin et al., 1996; Yang et al., 2012a; Zeng et al., 1995).

The Middle Triassic succession in the Youjiang Basin consists of thick siliciclastic turbidites of interbedded sandstone and shale.