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Early to Middle Triassic sedimentary records in the Youjiang Basin, South China: Implications for Indosinian orogenesis

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ABSTRACT

The Indosinian orogeny marks the termination of marine deposition and the accumulation of lower Permian to Late Triassic clastic sediments in the Youjiang Basin, South China Block. Major and trace element compositions of Early to Middle Triassic sedimentary clastic rocks from Youjiang Basin were analysed to constrain their provenance and tectonic setting. Argillaceous samples have low SiO_2 (average 56.95 wt.%), Al_2O_3 (average 15.15 wt.%), and $Fe_2O_3^T$ + MgO (average 11.54 wt.%) contents, and high K_2O/Na_2O (average 15.61) and Al_2O_3/SiO_2 (average 0.27) ratios, similar to mudstones from continental arc basins. Arenaceous samples have moderate SiO_2 (average 76.98 wt.%), Al_2O_3 (average 8.41 wt.%), and $Fe_2O_3^T$ + MgO (average 5.29 wt.%) contents, and moderate Al_2O_3/SiO_2 (average 0.11) and K_2O/Na_2O (average 15.26) ratios, identical to those of graywackes from continental island arcs or active continental margins. Both the argillaceous and arenaceous samples have low CIA values (57–85) and relatively high ICV values (0.69–2.11), indicating that the source rocks experienced weak chemical weathering and the sedimentary detritus was derived from an immature source. Compared with late Permian to Early Triassic South China granitoids and upper crust, the samples have lower contents of high-field-strength elements (e.g., Zr, Hf, Nb, and Ta) and large ion lithophile elements (e.g., Rb, Sr, Ba, Th, U, and Pb). However, their relatively high Rb concentrations (>51 ppm), and low Rb/Sr (0.16–4.19) and Th/U (2.66–5.21) ratios, are indicative of an igneous source from a continental arc that underwent weak chemical weathering. Both the argillaceous and arenaceous samples are moderately enriched in light rare earth elements and show relatively flat chondrite-normalized heavy rare earth element patterns (La_N/Yb_N = 6.61–17.35; average 10.61) with strong negative Eu anomalies (Eu/Eu^* = 0.54–0.89; average 0.73). In tectonic discrimination diagrams, including Th–Sc–Zr/10 and La–Th–Sc plots, the geochemical data suggest that the clastic rocks were deposited in a continental arc or margin setting. Thus, we infer that Early to Middle Triassic sediments in the Youjiang foreland basin record the transition from late Permian and Early Triassic subduction to Middle Triassic collision at the southwestern margin of the South China Block.

1. Introduction

Sedimentary sequences record significant information on their depositional environment and tectonic setting, as well as continental growth (e.g., Najman, 2006; Lehrmann et al., 2007; Long et al., 2008; Wang et al., 2012; Verma and Armstrong-Altrin, 2016). Chemical and mineral compositions of sedimentary rocks are used to reveal their potential provenance, the tectonic settings of sedimentary basins (Zimmermann and Bahlburg, 2003; Hu et al., 2014, 2015a,b), and the evolution of orogens (Bhatia, 1983; Gu, 1994; Yang et al., 2012; Painter et al., 2014). Due to their homogeneity and relatively high trace element contents, clastic rocks (i.e., mudstone and sandstone) are ideal for geochemical reconstructions of provenance and tectonic setting (e.g., Long et al., 2008; Wang et al., 2016a,b).

The Triassic tectonic history of the southwestern South China Block (SCB) is marked by the Indosinian orogeny (e.g., Deprat, 1914; Fromaget, 1932, 1941) that records amalgamation of the Indochina and South China blocks during the late Permian to Triassic as a result of closure of the eastern branch of the palaeo-Tethys Ocean (e.g., Lepvrier et al., 2011; Wang et al., 2013a,b; Faure et al., 2014, 2016a, 2016b; Cao et al., 2015; Halpin et al., 2016). This orogeny is characterized by a Late Triassic unconformity, large-scale granitic magmatism, fold-and-thrust belts, and depositional basins (Wang et al., 2007a, 2007b, 2013a,b; Zhang et al., 2011; Yang et al.,

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2012; Qiu et al., 2014, 2016). However, the tectonic evolution of the Indosinian orogeny is controversial and the tectonic setting of associated sedimentary basins is poorly constrained (Metcalfe, 2002; Zhou et al., 2008; Wang et al., 2013a,b). During the Triassic, formation of the Youjiang Basin (also termed the Nanpanjiang Basin) has been attributed to various processes, such as formation as a back-arc extensional basin (Hou and Huang, 1984) or as the foreland basin of an arc at the northern Song Ma suture (Xia et al., 1993). In particular, Enos et al. (1998) suggested that the Middle–Late Triassic succession was a classic flysch to molasse sequence of a foreland basin. However, there is no consensus on the provenance of the clastic sediments in the basin, and the sediment source areas and siliciclastic flux are poorly constrained. For example, palaeocurrent data, sandstone petrology and heavy mineral data (Chaikin, 2004) of Middle Triassic flysch in the northern part of the basin (Bianyang Formation) suggest that the provenance is the Jiangnan orogen at the southeastern margin of the Yangtze Block. In contrast, detrital zircon data and the geochemistry of the Middle Triassic turbidites indicate a source from the Indosinian orogeny at the southwestern margin of the Yangtze Block (Yang et al., 2012). Furthermore, the magnetic fabric of the Middle Triassic siliciclastic rocks reveal a NE palaeoflow direction and support a southern origin from the collision of Indochina–South China (Cai et al., 2014). Moreover, the Early Triassic clastic record is not well studied and it lacks a continuous reconstruction from the Early to Middle Triassic.

This contribution uses geochemical data to further investigate the provenance and tectonic setting of these Early to Middle Triassic siliciclastic rocks. The results are compared with previously published geochronological and geochemical data, which allows us to constrain the erosional, depositional, and tectonic conditions of the Youjiang Basin during the Indosinian orogeny. The significance of our results is discussed in the framework of the evolution of palaeo-Tethys tectonism.

2. Geologic setting

The SCB formed as a result of the Neoproterozoic amalgamation of the Yangtze and Cathaysia blocks (Fig. 1a; e.g., Zhou et al., 2002; Zhao et al., 2011; Wang et al., 2013a,b; Zhao, 2015), and subsequently was affected by early Palaeozoic and Mesozoic tectonic events (e.g., Lin et al., 2008; Faure et al., 2009; Charvet et al., 2010; Li et al., 2010; Wang et al., 2013a,b; Qiu et al., 2014). The SCB comprises folded and metamorphosed Proterozoic basement (e.g., Wang and Zhou, 2014; Wang et al., 2016a,b) and a folded Phanerozoic sedimentary sequence (Fig. 1; Charvet et al., 1996;

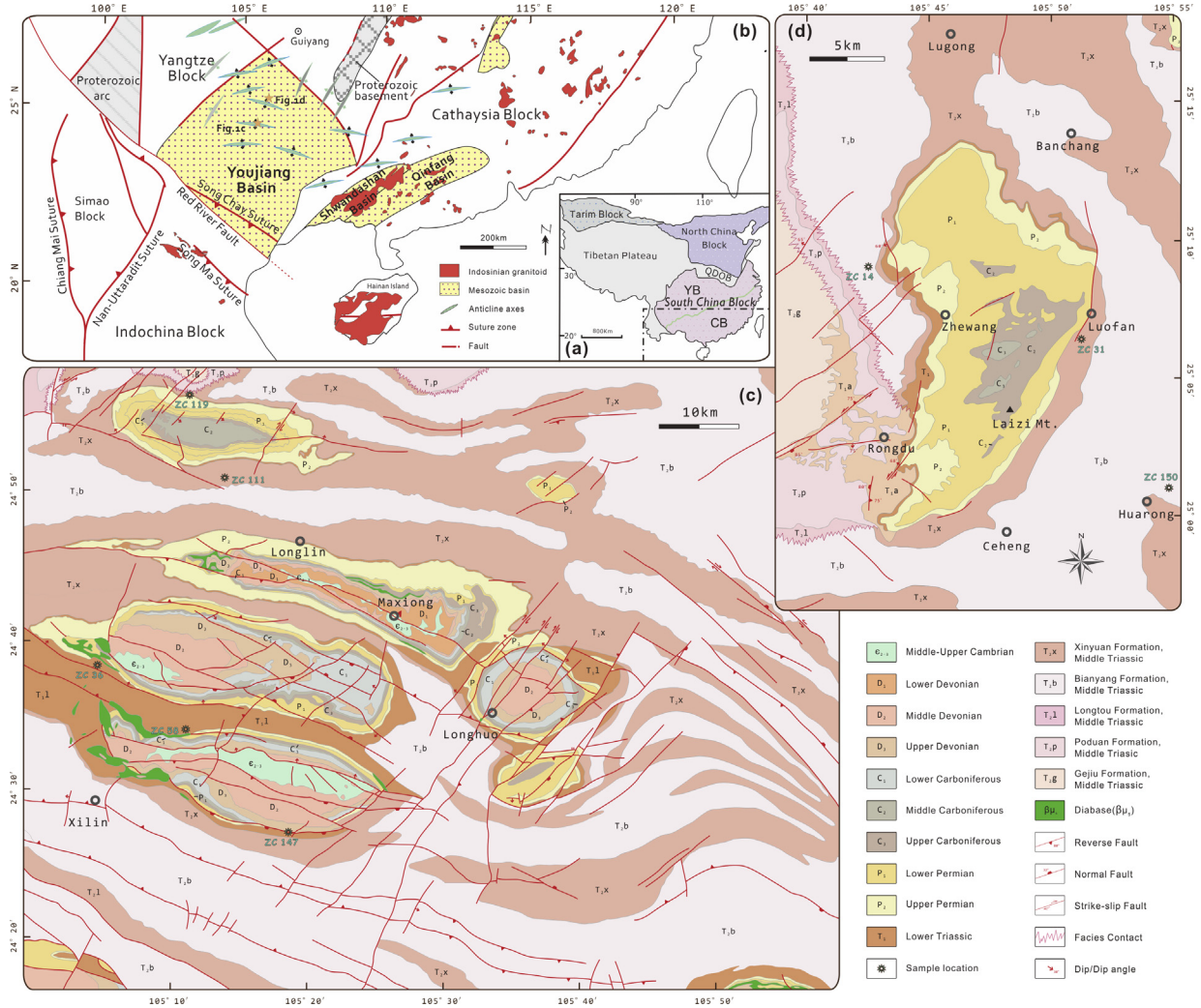

Fig. 1. Geological map of the Youjiang Basin in the South China Block. (a) Inset shows the location of the South China Block. (b) Sketch tectonic map of the Youjiang Basin and adjacent areas (modified from Yan et al., 2003; Qiu et al., 2014). (c) Geological map of the Longlin area in the northern Youjiang Basin. (d) Geological map of the Laizishan dome in the northern Youjiang Basin (BGMRGX, 1985).