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Provenance change from the Middle to Late Triassic of the southwestern Sichuan basin, Southwest China: Constraints from the sedimentary record and its tectonic significance

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ABSTRACT

The formation of the Sanjiang and Qinling orogens caused by closure of Paleo-Tethys Ocean along the western and northern margins of the Yangtze block during the early Mesozoic created a unique basin-mountain system. Petrology, geochemistry, geochronology, sedimentary facies and paleocurrent data are integrated in order to investigate the changing provenance of Middle-Late Triassic successions from the southwestern Sichuan region, SW China. The detrital compositions from the Middle Triassic successions indicate low mature sediments of mafic and intermediate rocks origin, which derivation mainly from recycled orogenic and secondarily from the Emeishan Large Igneous Province (ELIP). The detrital zircon U-Pb age distribution pattern of the Middle Triassic sandstone samples exhibits four major age Groups at ~257 Ma, 650–500 Ma, 880–710 Ma, and 1000–900 Ma. Combined with the geochemical characteristics, an interior Yangtze block source including the Khamdian uplift and ELIP is suggested. The Late Triassic sedimentary rocks yield seven U-Pb age Groups at 245–210 Ma, 290–260 Ma, 460–410 Ma, 650 Ma, 880–710 Ma, 1900–1600 Ma, and 2600–2400 Ma, which are consistent with the data reported from the Sichuan basin, Songpan Ganzi basin and the southern Yidun terrane, and are partly similar to those of the south Qinling orogen, Jiangnan Xuefeng thrust belt. In contrast to the Middle Triassic successions, the sandstone composition modals and whole-rock geochemistry of the Late Triassic samples denote mature deposits and of intermediate and acid rocks origin. Therefore, during the Late Triassic, the southwestern Sichuan basin received materials from the Songpan Ganzi folded belt and Yidun arc complex dominantly, and from the Qinling orogen and Jiangnan Xuefeng thrust belt subsidiarily. The Sanjiang orogen and the Songpan Ganzi folded belt should have controlled the formation of the southwestern Sichuan basin, while the development of the Qinling orogen and the western Jiangnan-Xuefeng orogen may also influenced the formation of the southwestern Sichuan basin. The southwestern Sichuan region evolved from the passive continental margin basin in the Middle Triassic into a foreland basin in the Norian age of the Late Triassic.

1. Introduction

The formation, fill and deformation of sedimentary basins are important processes along convergent margins. Based on the provenance signature, sedimentary basins can be used to track their tectonic formation and evolution of craton margins through their passive and compressional phases (Peter-Jon et al., 2015). The coupling between basins and mountain ranges received extensive attentions from geologists who treated the two units as an integral unit since the latter part of the 20th Century (e.g. Heller et al., 1988; Posamentier and Allen, 1993; Van Wagoner, 1995; Currie, 1997; Liu et al., 2005).

The Yangtze block is surrounded by the North China block with the Qinling Orogenic belt to the north, the Qiangtang block with Sanjiang Orogenic belt to the southwest (Pan et al., 2001; Xu et al., 2013) and by the Jiangnan-Xuefeng orogen to the southeast (Fig. 1a). During the Late Paleozoic to early Mesozoic, the North China block and the northern Yangtze block collided diachronously from east to west along the Mianlue suture zone (Zhao and Coe, 1987; Yin and Nie, 1993; Hacker et al., 2006), resulting in the development of the Qinling orogenic belts and the northern Yangtze peripheral foreland basins (Liu et al., 2005; Zheng et al., 2009); Meanwhile, the tectono-magmatic thermal event of the Emeishan Large Igneous Province (ELIP) and the formation of the Sanjiang Orogen caused by the closure of Paleo-Tethys ocean along the western margin (Zi et al., 2012; Zhu et al., 2011; Wang et al., 2014a 2014b) of the Upper Yangtze area, shaped the diverse basins in southwestern Yangtze region during the Middle and Late Triassic,

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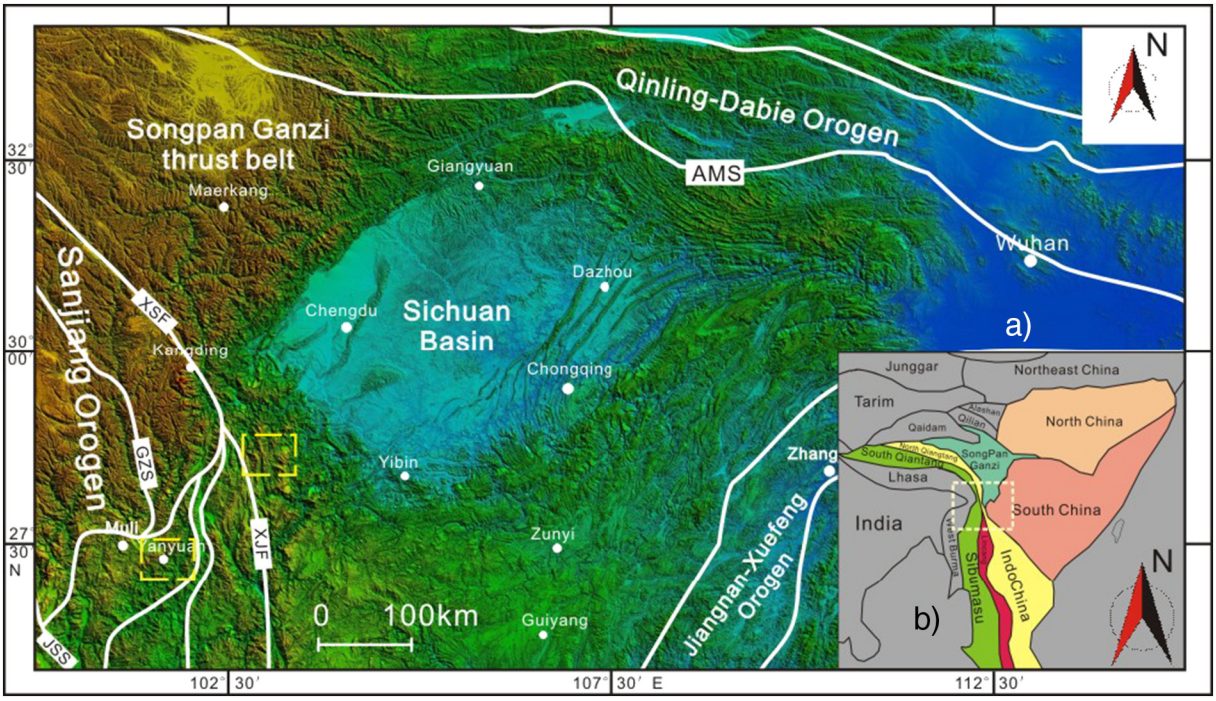

Fig. 1. Tectonic Upper Yangtze area (a) and (b) simplified geological map of the East Asia, modified from Metcalfe (2013); AMS = Animaqin-Mianlue suture; XJF = Xiaojiang fault; XSF = Xianshuihe fault; JSS = Jinshajiang suture; GZS: Ganzi Litang suture.

resulted in the transform from passive continental basin to foreland basin (Liu et al., 2005; Lin et al., 2006; Zheng et al., 2009).

Detrital zircons in sedimentary basins are derived from the weathering of rocks in the provenance and their subsequent transportation in fluvial systems (Luo et al., 2013). Geochemistry of sedimentary rocks can provide insight into the principal chemical signatures of source rocks (Bhatia and Crook, 1986; McLennan et al., 2003). Thereupon the analyzed zircons and geochemical immobile elements from the sediments in basins could provide important information of their potential sources, tectonic processes and paleogeographic environments of the basins (Cawood et al., 2007; Yang et al., 2012a). Abundant researches based on the traditional sedimentology (e.g. Cui et al., 1991; Xie et al., 2006; Shi et al., 2011; Dai et al., 2014), as well as petrology, geochronology, geochemistry, and paleogeography analyses has focused on the detrital records of the Late Paleozoic to Mesozoic sedimentary basins in the South China Block (Deng et al., 2008; Li et al., 2010b; Chen et al., 2011; Du et al., 2013a, 2013b; Luo et al., 2013; Yang et al., 2012a; Hu et al., 2014; Zhang et al., 2015), the Songpan-Ganzi terrane (Weislogel, 2006; Weislogel et al., 2010; Ding et al., 2013) and the Yidun terrane (Wang et al., 2011, 2013). All these studies indicated that the Sichuan basin located in the central Yangtze block had a remarkable high correlative provenance with its adjacent Sanjiang orogen (Deng et al., 2008), Qinling-Dabie orogen, Jiangnan-Xuefeng orogen, Longmen thrust belt and Songpan-Ganzi turbidite complex during the Late Triassic. The reported data based on traditional sedimentary methods suggest that the Middle Triassic strata were deposited primarily in carbonate platform marine environments, overlain by Late Triassic terrestrial dominated sediments in the Yangtze block (BGMRSP, 1991; Wei et al., 2014). However, systematic studies of the provenance and depositional environments of the southwestern Sichuan basin, such as the major sources for the Middle and Late Triassic sediments respectively, the time when the basin received materials from the western orogen exterior Yangtze block, and the tectonic process that led to the formation of the basins from Middle to Late Triassic, are still rare. In this paper, we first present systematic sandstone petrology, detrital zircon geochronology, geochemistry, and paleogeography from the Middle-Late Triassic successions in the southwestern Sichuan region. Combined with other published data, the provenance and tectonic processes of the southwestern Sichuan sedimentary basin is constrained, and the framework of the southwestern Sichuan basin and its adjacent regions during Middle-Late Triassic is reconstructed.

2. Geological background

The southwestern Sichuan basin is bounded by the Sanjiang orogen to the west, Songpan Ganzi complex to the north, and extends to the Yangtze block to the east (Figs. 1a, 2c). Of which the Sanjiang orogen generally consists of Yidun arc complex, Zhongza massif, Qiangtang-Changdu block and three sutures of Jinshajiang, Ganzi-Litang and Lancangjiang (Metcalfe, 2013). The Zhongza Massif in the Sanjiang orogen is mainly composed of meta-igneous rocks of Neoproterozoic basement and weakly metamorphosed Paleozoic sedimentary strata with minor mafic volcanic rocks (BGMRSP, 1991). The Yidun arc complex (also known as the eastern Yidun Terrane) mainly comprises Triassic flysch-volcanic successions named the Yidun Group and the arc-related granitoid plutons (Hou et al., 2001) that formed during the Late Triassic (230–202 Ma) (Wang et al., 2011), which is believed to be related to the westward subduction of the Ganzi-Litang Ocean (Reid et al., 2007; Wang et al., 2013). The Late Triassic Yidun Group includes the Qugasi, Tumugou and Lanashan formations that uncomfortably overlie on the Middle Triassic Lieyi Formation. The Qugasi Formation of the Yidun Group in the southern Yidun Terrane received detritus shed from the Zhongza massif. The Tumugou Formation received mixed sediments from the Zhongza Massif and local Triassic magmatic arc rocks (Wang et al., 2013).

The Songpan-Ganzi turbidite complex is bounded by Eastern Kunlun orogen to the north, Yidun arc complex to the west, and the Longmenshan thrust belt to the east. The complex formed as a basin that mainly filled by continental slope-abyssal turbidites namely Xikang Group during the Middle to Late Triassic (BGMRSP, 1991; Yang et al.,