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Late Triassic paleogeographic reconstruction along the Neo–Tethyan Ocean margins, southern Tibet

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ABSTRACT

Sandstone petrographic and U–Pb detrital zircon analyses of Upper Triassic sedimentary rocks from the northern margin of India (Tethyan Himalaya Sequence) and southern margin of Eurasia (Lhasa terrane) provide new constraints on the Mesozoic paleogeography of Neo–Tethyan Ocean basins. The Upper Triassic Nieru Formation of the Tethyan Himalaya Sequence (THS) near Lazi city (∼29°N, 87.5°E) is dominated by Indian-affinity, Precambrian detrital zircons, which are typical of the majority of the THS. However, the Upper Triassic Langjiexue Formation of the THS exposed to the east (at 90–93°E longitude) includes significant populations of Permian to Early Jurassic (291–184 Ma) detrital zircons for which there is no known Indian source. In addition, the Upper Triassic Nieru Formation near Kangma town (∼28.5°N, 90°E), located ∼200 km to the southeast of Lazi city, yielded detrital zircon age spectra that are similar to those of Langjiexue Formation. Based on detrital zircon age spectra comparisons, we propose that both the Langjiexue and Nieru formations were derived from continental crustal fragments that were adjacent to the northwestern margin of Australia. Furthermore, we suggest that these THS units, and age-equivalent strata in Northwest Australia, West Sulawesi, Timor and West Papua, comprised a Late Triassic submarine fan along the northern Australian shelf. The Upper Triassic Mailonggang Formation in the southern Lhasa terrane (35 km northeast of Lhasa city, ∼30°N, 91.5°E) is dominated by Permian detrital zircons, which were likely derived from proximal Lhasa terrane sources. The Mailonggang Formation differs from all age-equivalent strata in the Tethyan Himalaya; therefore we interpret that it was separated from Greater India by the Neo–Tethyan Ocean.

1. Introduction

Constraining the early Mesozoic paleogeography of the Neo–Tethyan Ocean margins is crucial for understanding the opening history of the Neo–Tethyan Ocean and the paleoposition of the southern margin of Eurasia (the Lhasa terrane) and the northern margin of India (the Tethyan Himalaya). Upper Triassic strata are well exposed in the Tethyan Himalaya (Liu and Einsele, 1994; Aikman et al., 2008; Dai et al., 2008; Li et al., 2010), the Lhasa terrane (Li et al., 2014), northwest Australia (Lewis and Sircombe, 2013) and southeast Asia (Gunawan et al., 2012; Zimmermann and Hall, 2014; Sevastjanova et al., 2015). At present, however, there is little consensus about the paleogeography of these assemblages during Late Triassic time.

Several tectonic models have been proposed to explain the provenance and paleogeographic relationships between the Upper Triassic Langjiexue Formation in the Tethyan Himalaya and age-equivalent units deposited in the Lhasa terrane (Fig. 1). One class of models argues that the Langjiexue Formation was derived from India, similar to the vast majority of previously investigated Tethyan Himalaya strata (Liu and Einsele, 1994; Searle et al., 1987). Another class of models argues that the Langjiexue Formation is allocthonous with respect to the Tethyan Himalaya and was derived from the Lhasa terrane (Dai et al., 2008; Li et al., 2010, 2015). These opposing models result in paleogeographic reconstructions that place the Langjiexue Formation on opposite sides of the Neo–Tethyan Ocean during the Late Triassic.

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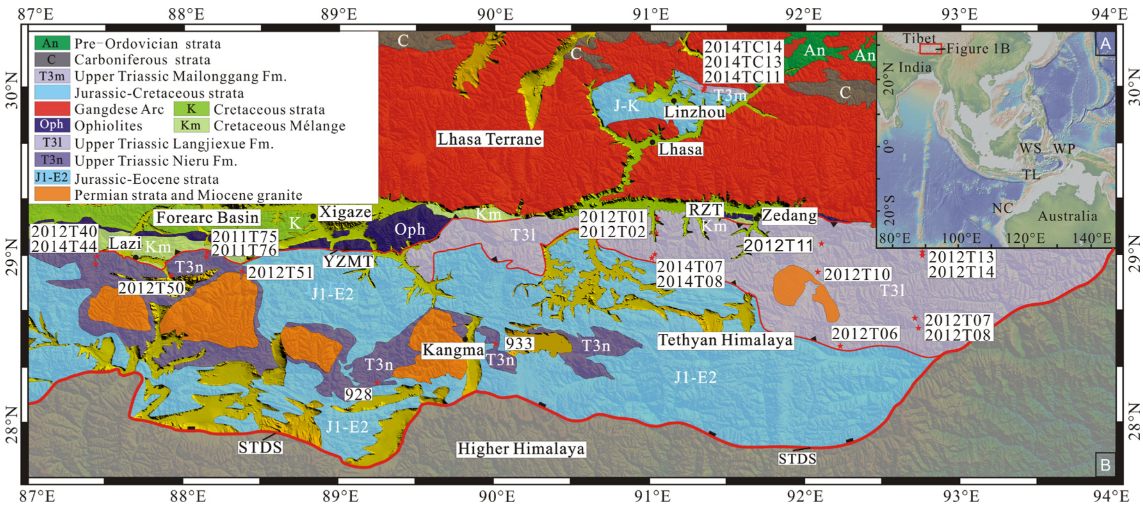

Fig. 1. Simplified geological map of south-central Tibet. YZMT = Yarlung–Zangpo mantle thrust, STDS = South Tibetan detachment system, RZT = Renbu–Zedang thrust, NC = North Carnarvon basin, TL = Timor–Leste, WS = West Sulawesi, WP = West Papua.

Models favoring an allochthonous origin were proposed to explain the presence of Permian–Triassic detrital zircons and high whole-rock εNd(t) values in the Langjiexue Formation (Dai et al., 2008; Li et al., 2010). These models invoke a number of explanations that fall into three broad categories (Webb et al., 2013). (1) Rift-fill: detritus was derived from the Lhasa terrane and deposited across both the southern Lhasa terrane and northern Indian margin during the initiation of Neo–Tethyan rifting (Dai et al., 2008; Li et al., 2014). This model requires that India–Lhasa terrane rifting initiated during the Late Triassic. (2) Lhasa forearc: detritus was shed from a Triassic arc that developed along the southern Lhasa terrane and was deposited in a forearc basin (Li et al., 2010). This model requires northward subduction of Neo–Tethyan oceanic lithosphere during the Triassic and an oceanic suture zone between the Langjiexue Formation and Indian-affinity Tethyan Himalya strata to the south (Li et al., 2010). (3) Intra-oceanic forearc: detritus was derived from a south-facing intra-oceanic arc within the Neo–Tethyan Ocean (Li et al., 2010). This model requires that Neo–Tethyan oceanic lithosphere was subducted northward beneath at least one Neo–Tethyan intra-oceanic arc, in addition to beneath the Lhasa terrane during Triassic time.

In an effort to discriminate among the contrasting models of early Mesozoic paleogeography, we conducted sandstone petrologic and U–Pb detrital zircon geochronologic studies on Upper Triassic strata exposed in the Tethyan Himalaya Sequence and southern Lhasa terrane of southern Tibet. Integration of our new, and previously published data indicate that the Langjiexue and Nieru formations (Fig. 1) were deposited on Greater India's passive margin and were derived from West Papua. In contrast, the Nieru Formation exposed to the west near Lazi city exhibits an Indian affinity and the Mailonggang Formation north of the Yarlung–Tsangpo suture zone near Lhasa city exhibits a proximal Lhasa terrane affinity. We propose that the northeast Greater Indian shelf and northwest Australian shelf were contiguous during Late Triassic time and accommodated deposition of a submarine fan complexes that were deposited in the Neo–Tethyan Ocean between West Papua to the east and India–Australia to the south.

2. Tectonic setting

Our study area consists of three major tectonic units from north to south: the Lhasa terrane; the Yarlung–Tsangpo (India–Asia) suture zone (YZSZ); and the Tethyan Himalaya Sequence (Fig. 1). The Lhasa terrane is composed of Neoproterozoic to Lower Cambrian basement, Paleozoic to Cenozoic cover strata and igneous rocks, and Gangdese continental margin arc rocks (e.g., Gehrels et al., 2012). The Gangdese arc mainly consists of Cretaceous to early Cenozoic calc–alkaline granitoids (Chu et al., 2006) and coeval volcanic sequences (He et al., 2007). The presence of diamictites and cool-water faunas in Carboniferous–Lower Permian strata suggest that the Lhasa terrane was located along the margin of Gondwana during this time (Ji et al., 2005; Yuan et al., 2015). Warm-water faunas have been identified in Middle–Upper Permian strata (Yuan et al., 2015). This faunal change is attributed to either palaeoclimate change or northward drift of the Lhasa terrane into a warm-water regime (Yuan et al., 2015). The Cretaceous to Eocene Xigaze forearc basin is exposed along the southern margin of Lhasa terrane and was derived from the southern Lhasa terrane continental margin (Fig. 1; Dürr, 1996; Orme et al., 2015). In the eastern Himalaya, the Xigaze forearc basin is absent and the Gangdese arc was thrust southward over the Yarlung–Tsangpo suture zone (YZSZ) in the hanging wall of the Gangdese thrust during Oligocene–Miocene time (Yin et al., 1994).

The YZSZ defines the boundary between Indian- and Asian-affinity assemblages. Supra-subduction zone ophiolitic rocks exposed between the Zedang and Yungbwa areas formed during the Early Cretaceous (Fig. 1; Hébert et al., 2012 and references therein). A chert-rich mélange to the south consists of chert–pebble conglomerate, limestone, and pillow basalt blocks surrounded by a matrix of radiolarian–chert and mudstone. Radiolarian assemblages in chert sequences range from late Middle Triassic to Early Cretaceous in age (Matsuoka et al., 2002; Ziabrev et al., 2004; Zhu et al., 2005). To the south is a trench–fill basin composed of strongly-cleaved Cretaceous sandstone, shale and conglomerate in a highly sheared mudstone matrix (Cai et al., 2012). These units comprise a southward-younging accretionary complex that developed during the northward subduction of Neo–Tethyan Ocean beneath Lhasa terrane during Cretaceous time (Cai et al., 2012).

The northern Tethyan Himalaya Sequence (THS) includes Paleozoic to Eocene carbonate and clastic sedimentary rocks that were deposited on the distal passive continental margin of India (Searle et al., 1987; Liu and Einsele, 1994). Tethyan Himalaya Sequence strata were predominately derived from Gondwanan sources based on numerous stratigraphic and detrital zircon studies (e.g. Liu and Einsele, 1994; DeCelles et al., 2004; Gehrels et al., 2012). Emplacement of continental flood basalts in various areas of the Indian passive margin suggests the Neo–Tethys Ocean began to form during early Permian time (Garzanti et al., 1999).