Gondwana Research xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Gondwana Research

journal homepage: www.elsevier.com/locate/gr

The evolution of Yarlung Tsangpo River: Constraints from the age and provenance of the Gangdese Conglomerates, southern Tibet

Shun Li [a,b,*], Lin Ding [a,c], Qiang Xu [a,c], Houqi Wang [a,b], Yahui Yue [a], Upendra Baral [a,b]

[a] Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] Center for Excellence in Tibetan Plateau Earth Sciences, Chinese Academy of Sciences, Beijing 100101, China

ARTICLE INFO

Article history:
Received 12 October 2014
Received in revised form 28 May 2015
Accepted 29 May 2015
Available online xxxx

Keywords:
Gangrinboche conglomerates
U–Pb age
Provenance analysis
Yarlung Tsangpo River
Tibet

ABSTRACT

Cenozoic conglomerates are exposed discontinuously along the length of the Yarlung Tsangpo suture zone on the southern margin of the Gangdese arc. These conglomerates (the "Gangdese Conglomerates" herein) record a crucial stage in the uplift and erosion histories of the southern Tibet after the initial India–Asia collision. In the Mt. Kailas area, the Gangdese Conglomerates strata consist of multiple sedimentary cycles and each cycle is a fining-upward sequence that was deposited by alluvial fan, braided-river and delta systems. Whereas in the Xigaze area, the Gangdese Conglomerates strata comprise a coarsening-upward sequence that was deposited by delta, braided-river and alluvial fan systems. Based on the detrital and igneous zircon U–Pb ages, the depositional ages of the Gangdese Conglomerates are late Oligocene to early Pliocene (ca. 26–5 Ma) in the Mt. Kailas area, late Oligocene to middle Miocene (ca. 26–15 Ma) in the Xigaze area, and late Oligocene to early Miocene (ca. 26–19 Ma) in the Zedong area. Paleocurrent measurements and provenance data (i.e., conglomerate clast composition, sandstone petrology and detrital zircon age) indicate that the initial detritus of the Gangdese Conglomerates were entirely derived from the north (mainly from the Gangdese arc). Sediment resulting from denudation to the south (the Xigaze forearc basin, the Yarlung Tsangpo suture zone and the northern margin of the Indian plate) first appeared by the early Miocene (ca. 19 Ma) and subsequently increased in abundance gradually. Our new results, together with previous data from the Xigaze area, reveal 3 major stages in the evolution of the Yarlung Tsangpo River system: (1) the southward-flowing stage (ca. 26–19 Ma) featured southward-draining transverse rivers that transported materials from the Gangdese arc southward. Southward paleocurrents in the Gangdese Conglomerates indicate a northern source. (2) The westward-flowing stage (ca. 19–15 Ma) developed due to the uplift of the suture zone and Tethys Himalaya to the south. Northward-draining rivers began to develop, and lakes resembling a string of beads formed and finally connected together, initiating the westward-flowing paleo-Yarlung Tsangpo River. Westward paleoflows were recorded in the Gangdese Conglomerates. (3) The eastward-flowing stage (ca. 15 Ma–present) resulted from differential uplift and denudation of the southern Tibet, which reversed the direction of the young Yarlung Tsangpo River by ca. 15 Ma. The deposition of the Gangdese Conglomerates was controlled by eastward paleoflows. At this point, the modern eastward-flowing Yarlung Tsangpo River system was established.

1. Introduction

A narrow elongate zone of Cenozoic conglomerates (~1300 km) is exposed discontinuously along the length of the Yarlung Tsangpo suture zone (YTSZ) on the southern flank of the Gangdese arc, extending from the Mt. Kailas in the west to the Langxian (Nyingchi area) in the east (Fig. 1). These conglomerates, known by a variety of local geographic names (e.g., Kailas, Qiuwu and Luobusa conglomerates), are correlated herein as the "Gangdese Conglomerates", which was also referred to as the "Gangrinboche conglomerates" by Aitchison et al. (2002). The term "Gangdese Conglomerates" (GC) was commonly used by Chinese geologists to describe this Cenozoic conglomerate belt (e.g., Liu et al., 1988; Yin et al., 1988). The GC records the evolving uplift and erosion histories of the Gangdese arc and Tethys Himalaya, and may provide crucial constraints for the evolution of the Yarlung Tsangpo River (Aitchison et al., 2002; DeCelles et al., 2011; Wang et al., 2013).

The depositional age of the GC is of great tectonic significance. Because the GC is the oldest unit that records the detritus sourced from both sides of the YTSZ, its age has long been regarded as a key minimum limit on the timing of the India–Asia collision (e.g., Searle et al., 1987; Aitchison et al., 2007). Previous biostratigraphic age estimates of the GC were imprecise, ranging from early Cretaceous to early Miocene

* Corresponding author at: Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China.
E-mail address: lishun@itpcas.ac.cn (S. Li).

http://dx.doi.org/10.1016/j.gr.2015.05.010
1342-937X/

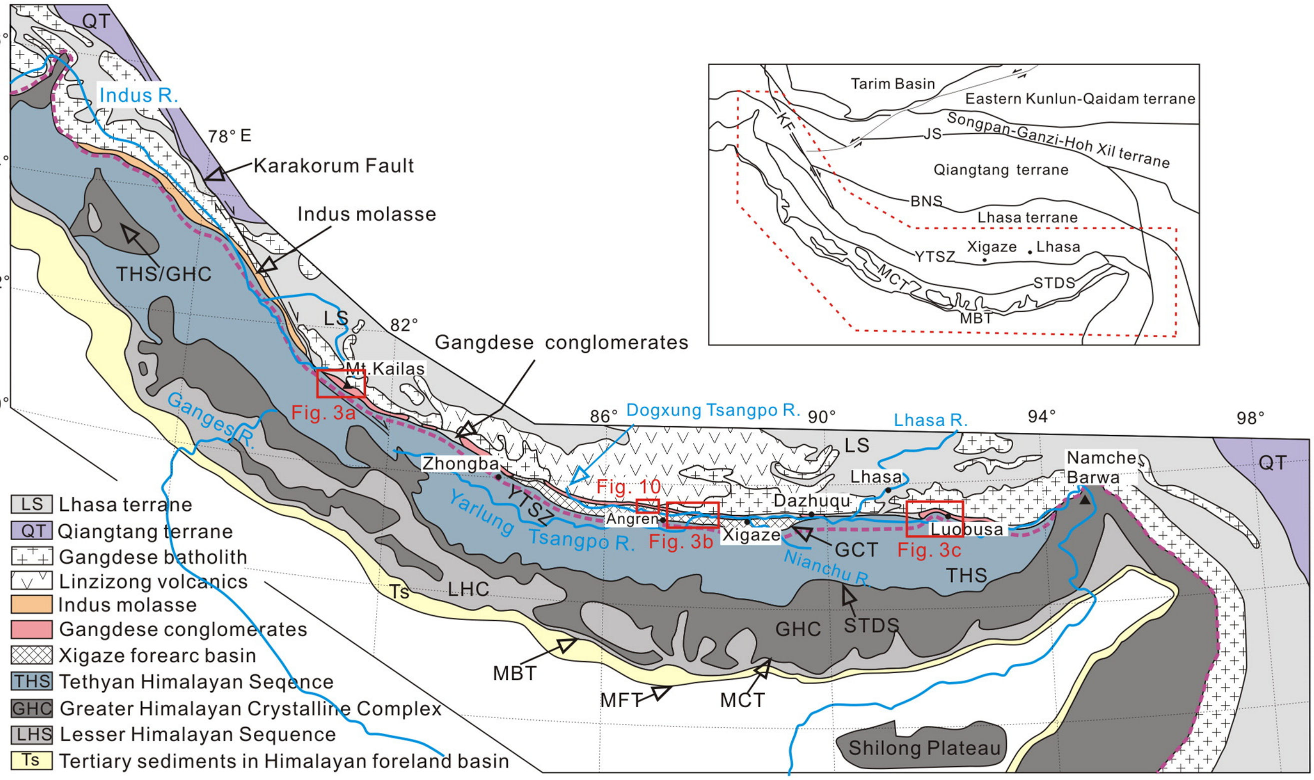

Fig. 1. General geologic map of the Southern Tibet, modified after Yin (2006). Major faults: MFT, main frontal thrust; MBT, main boundary thrust; MCT, main central thrust; STDS, South Tibetan detachment system; GCT, great counter thrust. Major sutures: YTSZ, Yarlung Tsangpo suture; BNS, Bangong–Nujiang suture; JS, Jinshajiang suture.

(Guo, 1975; Geng and Tao, 1982; Qian, 1985; Liu et al., 1996; Wang et al., 1999; Li, 2004; J.G. Li et al., 2010). Recent studies have significantly improved the age constraints on the GC. Zircon U–Pb dating results of tuff and sandstone samples indicate that the GC was deposited during late Oligocene–early Miocene (DeCelles et al., 2011; Wang et al., 2013; Carrapa et al., 2014).

The origin of the GC remains a fundamental problem in understanding the post-collisional tectonics of the southern Tibet, therefore, various tectonic models have been proposed to explain the deposition of GC (Searle et al., 1987; Yin et al., 1999; Wang et al., 2000; Aitchison et al., 2002; DeCelles et al., 2011). Particularly, based partly on interpretation of the GC, Aitchison et al. (2002, 2007) proposed that the India–Asia collision did not occur until mid-Cenozoic time (ca. 34 Ma), which differs greatly from the currently prevailing views of ca. 65–50 Ma (e.g., Garzanti et al., 1987; Rowley, 1996; Searle et al., 1997; Ding et al., 2005; Zhu et al., 2005; Cai et al., 2011).

The Yarlung Tsangpo suture zone forms the headwater catchment of the two largest river systems in Asia, the Indus River in the west and the Yarlung Tsangpo River in the east (Fig. 1). In the Xigaze area, the GC is preserved along the present-day course of the Yarlung Tsangpo River and may record the sedimentation of the fluvial paleo-Yarlung Tsangpo River system (Wang et al., 2013). New paleocurrent measurements as well as age and provenance data from the GC are presented here to illustrate the evolution of the Yarlung Tsangpo River, and its relationship with the uplift and erosion of the Gangdese arc and Tethys Himalaya.

In this study, we carried out field investigations of 10 sections at 3 well-exposed locations along this conglomerate belt (Fig. 2), i.e., Mt. Kailas (Fig. 3a), Xigaze (Fig. 3b) and Zedong (Fig. 3c), and present new sandstone petrologic data and U–Pb ages of zircons from tuff beds and sandstones. The objective here is to better constrain the depositional age of the GC, provide new insights into the origin of this unit, and further discuss implications for the evolution of the Yarlung Tsangpo River.

2. Geological setting

The study area is situated in southern Tibet, which features the juxtaposition of 5 tectonic units: the Gangdese arc, Xigaze forearc basin, Yarlung Tsangpo suture zone, Liuqu conglomerate and Tethys Himalaya from north to south. The geology and bedrock ages of each unit are summarized as follows.

The Gangdese arc, located in the southern Lhasa terrane, was formed during Mesozoic to Cenozoic time due to the continuous northward subduction of the Neo-Tethyan Ocean and early stage of the India–Asia collision (e.g., Tapponnier et al., 1981; Mo et al., 2007; Ji et al., 2009; Zhang et al., 2010; Jiang et al., 2014; L. Chen et al., 2015; Wang et al., 2015). This magmatic belt mainly consists of late Triassic–Miocene intrusions (ca. 205–10 Ma; Debon et al., 1986; Chung et al., 2005; Ji et al., 2009; Guan et al., 2012; L. Chen et al., 2015), early to middle Jurassic volcanics of the Yeba Formation (190–174 Ma; Zhu et al., 2008; Dong et al., 2006), Cretaceous volcanics of the Sangri Group (136.5–95.4 Ma; Zhu et al., 2009; Y. Chen et al., 2015), and the famous Linzizong volcanic successions (68–43 Ma; He et al., 2007).

The Xigaze forearc basin developed along the southern flank of Gangdese arc, and comprises the Albian–Maastrichtian flysch-dominated Xigaze Group (Einsele et al., 1994; Dürr, 1996; Wan et al., 1998) and the Paleocene to early Eocene shallow marine Tsojiangding Group (Ding et al., 2005). The Xigaze Group consists of the Chongdui, Angren, Padana and Qubeiya Formations from bottom to top, with detrital zircon ages dominated by populations of 80–130 Ma and 150–190 Ma (Wu et al., 2010; Aitchison et al., 2011). Notably, significant pre-Mesozoic zircons are present in the younger sequences, i.e., the upper Angren, Padana and Qubeiya Formations (Wu et al., 2010; An et al., 2014). The Tsojiangding Group, unconformably overlying the Xigaze Group, was further subdivided into the basal Quxia Formation and the overlying Jialazi Formation (Ding et al., 2005). The detrital zircon age patterns of the Tsojiangding Group are similar to the Xigaze Group; only a younger

Please cite this article as: Li, S., et al., The evolution of Yarlung Tsangpo River: Constraints from the age and provenance of the Gangdese Conglomerates, southern Tibet, Gondwana Research (2015), http://dx.doi.org/10.1016/j.gr.2015.05.010