Gondwana Research xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

Gondwana Research

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

Detrital zircon U–Pb geochronology, trace-element and Hf isotope geochemistry of the metasedimentary rocks in the Eastern Himalayan syntaxis: Tectonic and paleogeographic implications

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ARTICLE INFO

Article history:
Received 29 April 2015
Received in revised form 19 July 2015
Accepted 22 July 2015
Available online xxxx

Keywords:
Detrital zircon
Eastern Himalayan syntaxis
Greater Himalayan Sequence
South Lhasa terrane
Paleogeography

ABSTRACT

The origin of the Greater Himalayan Sequence in the Himalaya and the paleogeographic position of the Lhasa terrane within Gondwanaland remain controversial. In the Eastern Himalayan syntaxis, the basement complexes of the northeastern Indian plate (Namche Barwa Complex) and the South Lhasa terrane (Nyingchi Complex) can be studied to explore these issues. Detrital zircons from the metasedimentary rocks in the Namche Barwa Complex and Nyingchi Complex yield similar U–Pb age spectra, with major age populations of 1.00–1.20 Ga, 1.30–1.45 Ga, 1.50–1.65 Ga and 1.70–1.80 Ga. The maximum depositional ages for their sedimentary protoliths are ~1.0 Ga based on the mean ages of the youngest three detrital zircons. Their minimum depositional ages are ~477 Ma for the Namche Barwa Complex and ~499 Ma for the Nyingchi Complex. Detrital zircons from the Namche Barwa Complex and Nyingchi Complex also display similar trace-element signatures and Hf isotopic composition, indicating that they were derived from common provenance. The trace-element signatures of 1.30–1.45 Ga detrital zircons indicate that the 1.3–1.5 Ga alkalic and mafic rocks belt in the southeastern India is a potential provenance. Most 1.50–1.65 Ga zircons have positive $\varepsilon_{Hf}(t)$ values (+1.2 to +9.0), and most 1.70–1.80 Ga zircons have negative $\varepsilon_{Hf}(t)$ values (−7.1 to −1.9), which are compatible with those of the Paleo- to Mesoproterozoic orthogneisses in the Namche Barwa Complex. Provenance analysis indicates that the southern Indian Shield, South Lhasa terrane and probably Eastern Antarctica were the potential detrital sources. Combined with previous studies, our results suggest that: (1) the Namche Barwa Complex is the northeastern extension of the Greater Himalaya Sequence; (2) the metasedimentary rocks in the Namche Barwa Complex represent distal deposits of the northern Indian margin relative to the Lesser Himalaya; (3) the South Lhasa terrane was tectonically linked to northern India before the Cambrian.

1. Introduction

The Himalaya-Tibetan orogen was built upon a complex tectonic collage resulting from several continental collision events since the Early Paleozoic (Allègre et al., 1984; Yin and Harrison, 2000; Zhu et al., 2013). From north to south, it consists of the Kunlun–Qaidam, Songpan–Ganzi, Qiangtang, Lhasa terranes and Himalaya (Fig. 1a), which are separated by the Anyimaqen–Muztagh suture, Jinshajiang suture, Bangong–Nujiang suture, and Indus–Tsangpo suture, respectively. Reconstruction of the Neoproterozoic–Paleozoic paleogeography for different terranes, such as the Himalaya, Lhasa and Qiangtang terranes, is therefore of critical importance to our understanding of the formation and evolution of the Himalaya-Tibetan orogen (Allègre et al., 1984; DeCelles et al., 2000; Yin and Harrison, 2000; Myrow et al., 2003; Gehrels et al., 2011; Zhu et al., 2011a, 2013; Zhang et al., 2012a, 2014; McQuarrie et al., 2013).

The paleogeographic position of Lhasa terrane within Gondwanaland remains a matter of dispute. Traditionally, the Lhasa terrane was sandwiched between the Indian plate and Qiangtang terrane (Metcalfe, 1996; Yin and Harrison, 2000; Dong et al., 2010; Gehrels et al., 2011; Burrett et al., 2014). However, recent studies argued that the Lhasa terrane was located adjacent to Northwest Australia (Ferrari et al., 2008; Zhu et al., 2011a; Ran et al., 2012). The Lhasa terrane can be divided into the South and North Lhasa terranes by the Permian North Gangdese suture (Fig. 1b) (Yang et al., 2009; Zhang et al., 2014). Zhang et al. (2012a, 2014) proposed that the North Lhasa terrane might have been derived from the northern segment of the East African Orogen, and the South Lhasa terrane might be related to Northwest Australia or northern India. The evidence supporting the Australian affinity is that detrital zircon age spectra of Carboniferous–Permian sedimentary rocks in the North Lhasa terrane are similar to those of Northwest Australia, but different from those of Tethyan

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http://dx.doi.org/10.1016/j.gr.2015.07.013
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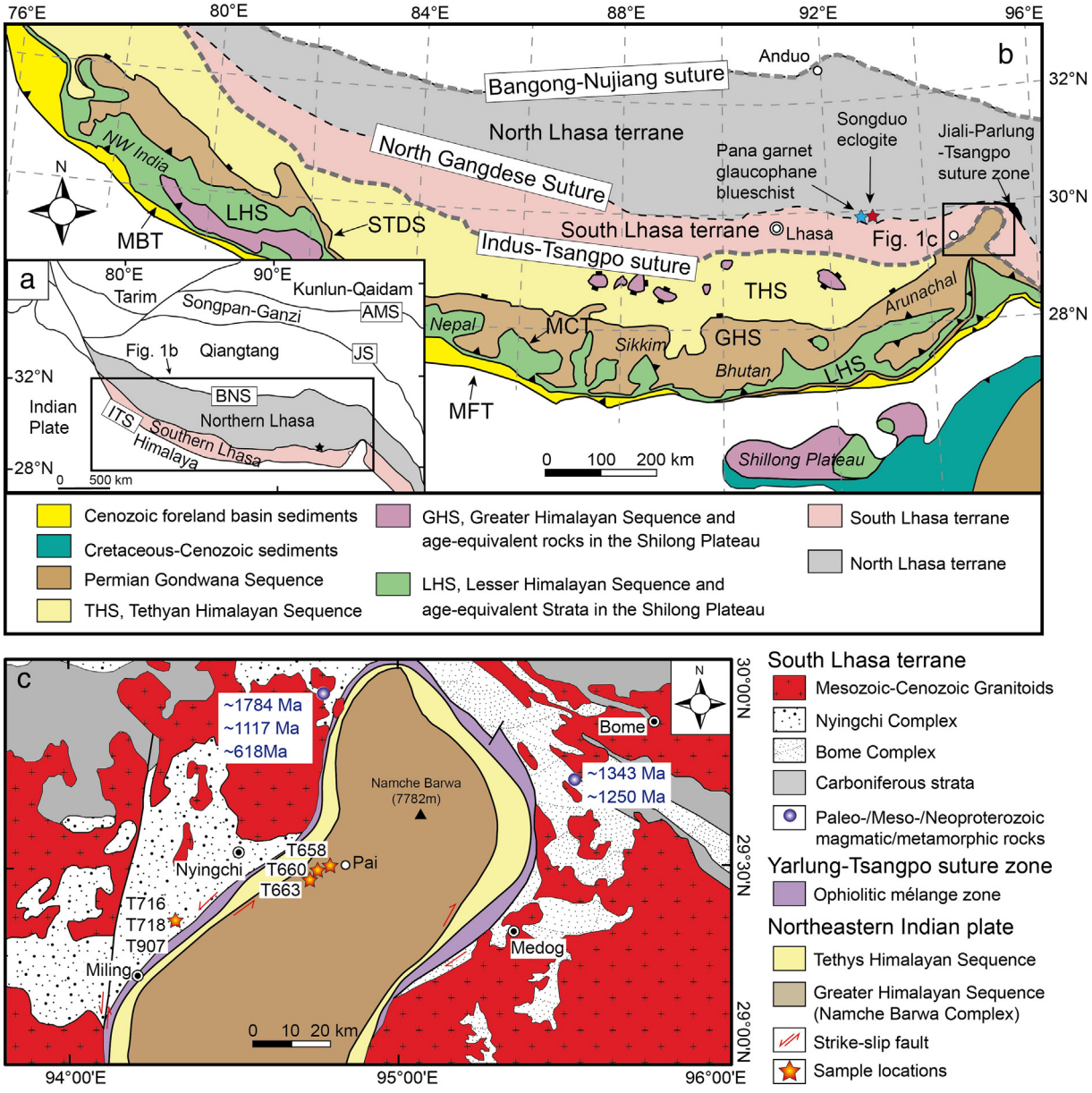

Fig. 1. (a) Tectonic outline of the Himalayan–Tibetan Plateau. AMS = Anyimaqen–Muztagh suture; BNS = Bangong–Nujiang suture; JS = Jinshajiang suture; ITS = Indus–Tsangpo suture. (b) Tectonic framework of the Himalayan orogen and Lhasa terrane (modified from Yin et al. (2010a); Zhu et al. (2011b) and Yang et al. (2009)), showing the location of this study area in the Eastern Himalayan syntaxis. The locations of Songduo eclogite belt (Yang et al., 2009), Pana garnet glaucophane blueschist (Liu et al., 2009) and Jiali–Parlung–Tsangpo suture zone (Geng et al., 2006) are also displayed. Abbreviations: STDS = South Tibet detachment system; MCT = Main Central thrust; MBT = Main Boundary thrust; MFT = Main Frontal thrust. (c) Simplified geological map of the Eastern Himalayan syntaxis (modified from Xu et al. (2012) and Zhang et al. (2015)), showing the locations of the studied samples and Paleoproterozoic–Neoproterozoic magmatic/metamorphic rocks (Lin et al., 2013; Xu et al., 2013b).

Himalaya (Zhu et al., 2011a, 2013). The South Lhasa terrane is the key connection between the Indian plate and the North Lhasa terrane (Fig. 1b), thus constraining its paleogeographic position is essential for reconstructing the paleogeography of the northern East Gondwana. In the Eastern Himalayan syntaxis, the metamorphic basement complexes of the northern Indian plate (Namche Barwa Complex) and the South Lhasa terrane (Nyingchi Complex) can be studied to explore this issue.

In this study, our new data show that the Namche Barwa Complex is likely the northeastern extension of the Greater Himalayan Sequence. The metasedimentary rocks in the Namche Barwa Complex represent the distal deposits of northern Indian margin. The similar detrital zircon U–Pb age spectra, trace-element signatures and Hf isotopic compositions between the Namche Barwa Complex and Nyingchi Complex indicate that their sedimentary protoliths were derived from common provenance, and that the South Lhasa terrane was linked to the northern Indian plate before the Cambrian.

2. Geological background and sample descriptions

2.1. Geological background

The Himalayan orogenic belt is separated from the Lhasa terrane by Indus–Tsangpo suture (Fig. 1b). It has been divided into four tectono-stratigraphic units from south to north: Sub-Himalayan, Lesser Himalayan Sequence (LHS), Greater Himalayan Sequence (GHS), and Tethyan Himalayan Sequence (THS), separated by the Main Front thrust, Main Boundary thrust, Main Central thrust, and South Tibetan detachment series, respectively (Fig. 1b) (Yin, 2006, and references therein). The

Please cite this article as: Guo, L., et al., Detrital zircon U–Pb geochronology, trace-element and Hf isotope geochemistry of the metasedimentary rocks in the Eastern Himala..., Gondwana Research (2015), http://dx.doi.org/10.1016/j.gr.2015.07.013