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U–Pb geochronology of detrital zircon in metasediments from Sri Lanka: Implications for the regional correlation of Gondwana fragments

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ABSTRACT

Recent tectonic models of Sri Lankan basement suggest that the Highland Complex (HC), which is dominantly composed of metasedimentary rocks, forms part of an accretionary complex developed during Neoproterozoic subduction-collision tectonics between the Wanni and Vijayan Complexes. Here we present new U–Pb geochronological data on detrital zircon in metasediments from the HC and adjacent regions to investigate the source characteristics, deposition and regional correlations with similar rocks in adjacent Gondwana fragments. Cores of detrital zircon grains in twelve metasediment samples (quartzite, pelitic gneiss, leptynite, and metamorphosed banded iron formation) characterized by higher Th/U ratios indicating derivation from magmatic protoliths yield Neoarchean to Paleoproterozoic ages (ca. 2700–1700 Ma) with minor Paleoarchean (ca. 3500 Ma), Mesoproterozoic (ca. 1200 Ma), and Early to Middle Neoproterozoic (ca. 800–600 Ma) components. The rims of most grains as well as homogeneous grains show Late Neoproterozoic ages (582–533 Ma) with lower Th/U ratios that can be interpreted as metamorphic ages. Our results constrain the depositional age of the HC sediments to be Late Neoproterozoic (ca. 600–550 Ma) based on the ages of the youngest detrital zircon grains and metamorphism. Although exposed Archean magmatic units are absent in Sri Lanka, several crustal blocks including the Dharwar Craton, Coorg Block, and Salem Block in the adjacent Gondwana fragment of India carry Archean (ca. 3400–2500 Ma) basement, which we consider to be the major source for the Sri Lankan detrital zircons. The Paleoproterozoic zircons might have been derived from the Congo–Tanzania–Bangweulu Block in East Africa that includes Archean to Paleoproterozoic blocks (e.g., ca. ~2700 Ma Tanzania Craton; ca. 2300–1800 Ma Usagaran–Ubendian belt). The Kibaran belt (ca. 1400–1000 Ma) in the Congo–Tanzania–Bangweulu Block might have served as the source of minor Mesoproterozoic zircons. Early to Mid Neoproterozoic grains might have come from the adjacent Wanni, Vijayan, and Kadugannawa Complexes in Sri Lanka (ca. 1100–750 Ma). The similarity in detrital age spectra of the metasediments in the HC and those of the northern Madurai Block in southern India suggests that they could have similar provenances (Archean cratons in India and/or East Africa). Similar age distributions of detrital zircon cores reported from the Itremo Group (central Madagascar) indicate that the metasedimentary terranes in central Madagascar, southern India, and Sri Lanka could have been juxtaposed, and with sediment source including those in the East African cratons. Similar magmatic features in central Madagascar, southern India, Sri Lanka, and eastern Antarctica also suggest a series of volcanic arcs developed through a complex subduction-accretion process in these regions before the final amalgamation of Gondwana.

1. Introduction

Recent geological, petrological, and geochronological data from the East African-Antarctic orogen suggest that the Late Neoproterozoic – Cambrian Gondwana supercontinent was formed

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through a sequence of complex subduction-accession-collision processes (e.g., Meert, 2003; Jacobs and Thomas, 2004; Collins et al., 2007a; Meert and Lieberman, 2008; Santosh et al., 2009, 2014, and references therein). Although a relatively small segment, Sri Lanka bears important significance in understanding the assembly of Gondwana due to its position in the central part of the Gondwana forming orogeny (Santosh et al., 2014; He et al., 2016a,b). The Sri Lankan basement has been subdivided into four main terranes (Cooray, 1994): the Wanni Complex (WC) to the northwest together with Kadugannawa Complex (KC), the Highland Complex (HC) exposed at the central domain, and the Vijayan Complex (VC) distributed at the southeast, largely based on Nd-model age mapping and structural data (Kröner et al., 1987; Milisenda et al., 1988, 1994). Based on available petrological, geochemical and geochronological studies, the WC, KC and VC were considered to have formed through arc-related events during Early Neoproterozoic (ca. 1.0 Ga; Kehelpannala, 2003, 2004; Kröner et al., 2003, 2013; Willbold et al., 2004). In recent studies, the WC, KC and VC are regarded as Early to Late Neoproterozoic continental arcs, and the HC is considered as the Neoproterozoic suture zone formed by double-sided subduction and final collision of the WC and VC (Santosh et al., 2014; He et al., 2016a,b).

Previous studies on meta-igneous rocks from Sri Lanka identified prominent Neoproterozoic tectonothermal events (e.g. Santosh et al., 2014; He et al., 2016a,b), which closely correlate the basement of the island with neighboring Gondwana terranes such as the Southern Granulite Terrain of India (e.g. Collins et al., 2007b; Teale et al., 2011; Kröner et al., 2012; Plavsa et al., 2014) and the Lützow-Holm Complex, Antarctica (e.g. Tsunogae et al., 2015; Kazami et al., 2016). Teale et al. (2011) correlated magmatic rocks in the WC and the HC to those in the Madurai Block, southern India. On the other hand, Kröner et al. (2012) juxtaposed the HC with the Trivandrum Block, southernmost India in the Gondwana reconstruction. The HC is also interpreted to be a part of supracrustal basin developed in a suture zone with the Lützow-Holm Complex in East Antarctica during the final amalgamation of Gondwana supercontinent (Shiraishi et al., 1994; Takamura et al., 2015; Tsunogae et al., 2015, 2016; Kazami et al., 2016). Some authors also proposed that the VC and the Lurio Belt in the Kalahari Block, southeast Africa, form the Lurio-Vijayan Peninsula (e.g., Collins and Pisarevsky, 2005). Dissanayake and Chandrajith (1999) proposed a model directly linking Sri Lanka with Madagascar.

Zircon is a common accessory mineral in crustal rocks. Since zircon possesses the properties of physical and chemical durability against weathering and metamorphism, the analyses of detrital zircons in sedimentary and metasedimentary rocks and comparison of their age spectra with those of adjacent terranes is a common approach to understand the formation of major orogens, crustal evolution, and regional correlations (e.g., Gebauer et al., 1989; Cawood et al., 2003; Tsutsumi et al., 2009; Kuznetsov et al., 2014).

Studies on detrital zircon geochronology in metasedimentary rocks from Gondwana fragments from elsewhere have attempted to elucidate the protolith origins in the Gondwana. For example, Collins et al. (2003) reported Paleoarchean to Neoproterozoic (ca. 3460, 3200–3000, ~2650, ~2500, 800, and 700 Ma) detrital zircons in metasediments from Betsimisaraka suture, eastern Madagascar, and Cox et al. (2004) reported ages of detrital zircon cores from Itremo (ca. 2500, 2300–1700 Ma) and Molo (ca. 1100–630 Ma) Groups, central Madagascar. The results suggested that zircons in Betsimisaraka suture were derived from India, whereas those in Itremo and Molo Groups were from East Africa. Detrital zircons from the Madurai Block (ca. 2800–1900 Ma), Trivandrum Block (ca. 2400–1700 Ma), and Achankovil Suture Zone (ca. 2000–1800, 1400, 650 Ma) in southern India were also considered to have been derived from East African basement, suggesting that the Itremo and Molo Groups and the Madurai Block have similar provenances (Collins et al., 2007b; Teale et al., 2011). Sato et al. (2011a) analyzed detrital zircon cores in quartzite from Kadavur, northernmost Madurai Block, and obtained Neoarchean to Paleoproterozoic ages (ca. 2600–1900 Ma). Plavsa et al. (2014) carried out analyses of detrital zircons from southern India and proposed that the zircons of the northern Palghat-Cauvery Suture Zone (ca. ~2650 to 2500 Ma), northern Madurai Block (ca. 2800–1900 Ma), and southern Madurai Block (ca. 1100–670 Ma) were derived from the Salem Block, Congo–Tanzania–Bangweulu Block, and East African orogen, respectively.

Detrital zircon core analyses from Sri Lanka in previous studies have reported Mesoarchean to Paleoproterozoic ages (e.g., Kröner et al., 1987, 2003; Hölzl et al., 1994; Sajeev et al., 2010). Sajeev et al. (2010) and Dharmapriya et al. (2015b, 2016) reported Paleoproterozoic and Late Mesoproterozoic to Middle Neoproterozoic ages from pelitic granulites. Kröner et al. (2003) identified Mesoproterozoic to Cryogenian detrital zircon cores from the WC. However, these limited data do not precisely constrain the provenances of the HC sediments and their implications on regional correlations with other Gondwana fragments. Thus, although Sri Lanka is an integral part in the center of East Gondwana and preserves important records of collision and amalgamation of Gondwana, the precise geotectonic position of Sri Lanka in East Gondwana with respect to other supercontinent fragments is still controversial (e.g., Kröner et al., 2003, 2013; Kehelpannala, 2004 and references therein). Therefore, geochronological investigations are integral to the correlation of Sri Lanka with its neighboring Gondwana terranes.

In this backdrop, we report new geochronological data on detrital zircons in metasediments collected from systematic field traverse over a wide region of Sri Lanka, with particular focus on the HC, and compare the results with those of previous studies to address regional geochronological features of Sri Lanka. We also compare our data with age spectra of detrital zircons from other Gondwana fragments and discuss the correlations and connections.

2. Geological background

2.1. General geology

The Highland Complex (HC), exposed at the central part of Sri Lanka, is dominantly composed of metasediments such as quartzite, marble, calc-silicate and pelitic gneiss with subordinate felsic to mafic meta-igneous rocks (Pohl and Emmermann, 1991; Kröner et al., 1994; Braun and Kriegsman, 2003; Santosh et al., 2014; He et al., 2016a). Some HC lithologies occur as tectonic klippens in the VC (Kataragama, Buttala, and Kuda Oya) (Fig. 1). The HC underwent granulite-facies metamorphism (e.g., Perera, 1984; Faulhaber and Raith, 1991; Schumacher and Faulhaber, 1994; Hiroi et al., 1994; Raase and Schenk, 1994), which corresponds to the highest metamorphic conditions in the Sri Lankan basement. A regional decrease in *P-T* conditions from 9–10 kbar and 830 °C (in the eastern and southeastern HC) to 5–6 kbar and 700 °C (in the northwest HC) has been reported (Faulhaber and Raith, 1991; Schumacher and Faulhaber, 1994). Sajeev and Osanai (2005) identified a similar thermal gradient from 591 to 996 °C across the southwestern to central region of the HC. Many authors reported clockwise *P-T* paths from pelitic granulites (Hiroi et al., 1994; Raase and Schenk, 1994; Mathavan et al., 1999; Kriegsman and Schumacher, 1999), whereas isobaric cooling at high pressure (first reported by Perera, 1987) before the dominant decompression stage is proposed for some meta-igneous rocks (Perera, 1987; Schumacher and Faulhaber, 1994) and a khondalite (Dharmapriya et al., 2014). Ultrahigh-temperature (UHT) peak metamorphism of