Precambrian Research 283 (2016) 50–67

Contents lists available at ScienceDirect

Precambrian Research

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

Late Palaeoproterozoic depositional age for khondalite protoliths in southern India and tectonic implications

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ARTICLE INFO

Article history:
Received 17 March 2016
Revised 14 July 2016
Accepted 23 July 2016
Available online 29 July 2016

Keywords:
Khondalite
Zircon geochronology
Pb isotopic inhomogeneity
Trivandrum Block
India

ABSTRACT

SHRIMP dating of detrital zircons from garnet–sillimanite–cordierite paragneisses (khondalites) of the Trivandrum Block, southern India, revealed nanometer-scale Pb isotopic inhomogeneity in most grains that we ascribe to annealing processes during ultra-high-temperature metamorphism at ca. 570 Ma.

Our age data for zircons from six representative khondalite samples do not document any Neo- or Mesoproterozoic detrital grains, and we conclude from the concordant ages and discordant minimum $^{207}Pb/^{206}Pb$ ages that the khondalite precursor sediments were deposited more than 2.1 Ga ago and were subsequently intruded by granitoid rocks at ca. 1765–2100 Ma. Some detrital zircons in the khondalites contain late Palaeoproterozoic metamorphic domains, suggesting that these grains are derived from an unknown crustal source that most likely experienced late Palaeoproterozoic high-grade metamorphism. Both the metasedimentary assemblage and granitoids were severely ductilely deformed, metamorphosed and migmatized during the pervasive Pan-African event at ca. 550–580 Ma. This caused many detrital zircons in the khondalites to become variably recrystallized and to develop metamorphic rims. Proper interpretation of cathodoluminescence images and zircon morphology is important in interpreting detrital populations.

The southern Indian khondalites were part of an extensive Palaeoproterozoic metasedimentary assemblage that may have extended from southern Madagascar via the Trivandrum Block to the Highland Complex of Sri Lanka and seems to reflect a continental margin sequence that was deposited on an Archaean to early Palaeoproterozoic continental terrane, possibly the southern margin of the Indian Dharwar craton. The tectonic history of this terrane remains obscure due to the pervasive overprint during the Pan-African event.

1. Introduction

Granulite-facies metapelites (locally named khondalites) are widespread together with granitoid-derived charnockites in the Trivandrum Block of southern India (Fig. 1). They have been the focus of several investigations concerning their composition, metamorphic evolution, age and tectonic significance (for reviews and literature see Santosh et al., 2006; Sato et al., 2011). These cordierite-, sillimanite- and spinel-bearing metapelite assemblages have provided important clues on the pressure–temperature conditions and exhumation history of the region and also yielded critical geochronologic information on source characteristics, tectonothermal histories and timing of high grade metamorphism (for review and literature see Santosh et al., 2006).

Santosh et al. (2006) provided a comprehensive review of the mineral composition and P–T evolution of the khondalite suite and reported electron-probe (EPMA) $^{207}Pb/^{206}Pb$ ages for zircon and monazite from five key metapelite localities in the Trivandrum Block. From these data the above authors concluded that the khondalite sedimentary precursors were derived from Archaean to Proterozoic sources and were deposited after 569 Ma ago. This was deduced from what Santosh et al. (2006) interpreted as abraded grains that apparently underwent fluvial transportation pror to deposition. This interpretation led to widespread supposition of a late Neoproterozoic depositional age for the precursor sediments of khondalite suite (e.g., Collins et al., 2007, 2014; Santosh et al., 2009) and to tectonic models that interpreted the

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http://dx.doi.org/10.1016/j.precamres.2016.07.015
0301-9268/

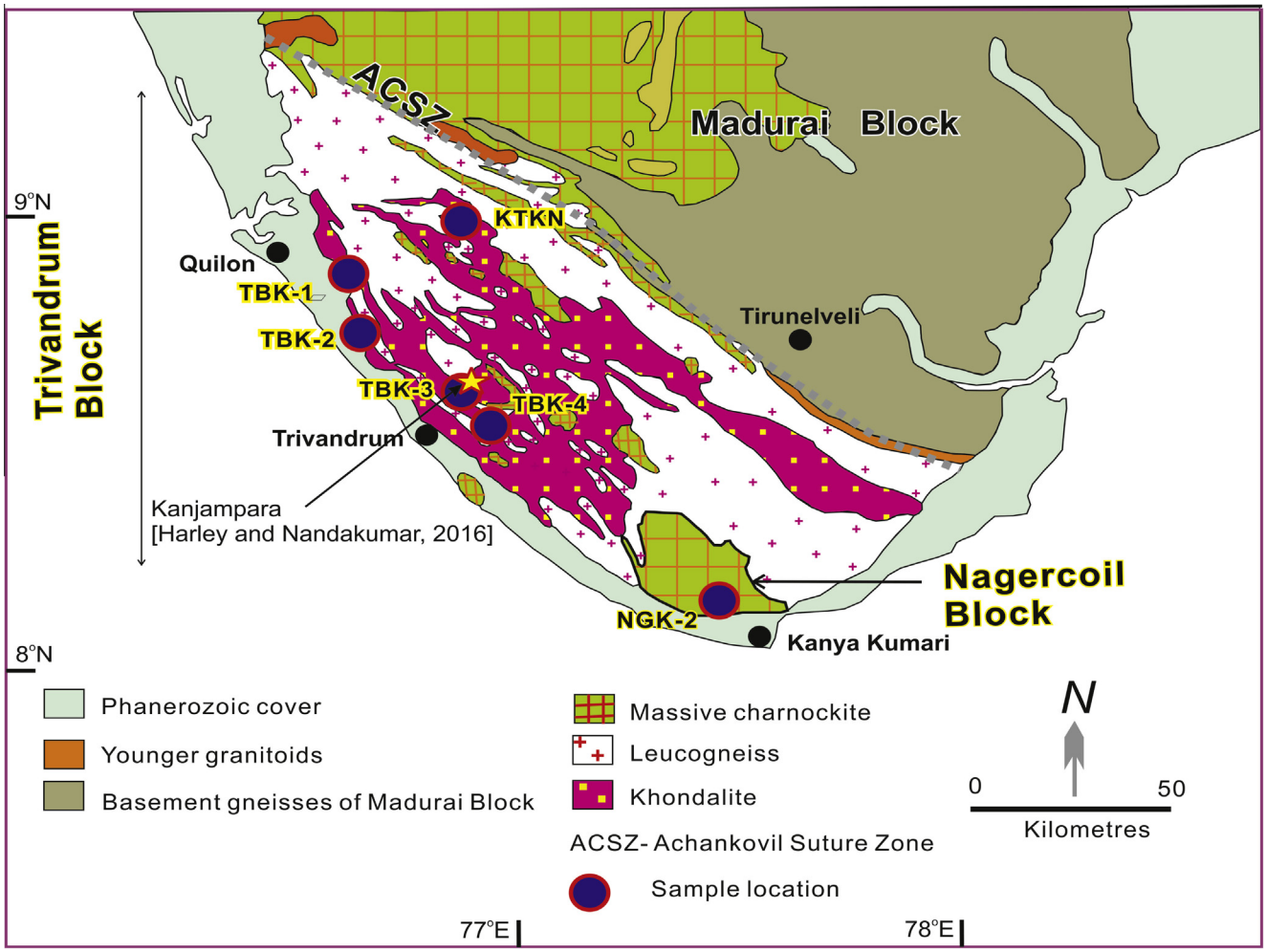

Fig. 1. Simplified geological map of the southern part of Kerala and Tamil Nadu, showing the various Proterozoic granulite blocks and rock types as well as sample localities of khondalites dated in this study (compiled after Geological Survey of India (1995), modified from Kröner et al. (2015a)).

metapelitic assemblage as part of a Neoproterozoic (Pan-African) accretionary belt in a subduction environment (Santosh et al., 2009; Rajesh et al., 2013).

Doubt about a late Neoproterozoic depositional age for the khondalite precursors comes from rare intrusive contacts with adjacent and frequently interlayered charnockitic gneisses of granitoid origin, as documented by Whitehouse et al. (2014) and Kröner et al. (2015a) and for which magmatic emplacement ages between 1765 and ca. 2100 Ma were determined. However, the above intrusive relationships are often difficult to establish and, at most localities, the khondalites and charnockites have parallel contacts due to intense ductile deformation which brought them into parallelism. Furthermore, detailed single zircon analysis combined with cathodoluminescence imaging revealed very complex crystallization-recrystallization phenomena and Pb-loss in the charnockites, probably caused by fluid-assisted high-grade metamorphism, metasomatism, and anatexis during ca. 550–580 Ma granulite-facies metamorphism and subsequent fluid-related retrogression (Whitehouse et al., 2014; Kröner et al., 2015a). Such processes have also been documented in high-grade rocks of Madagascar (Ashwal et al., 1999; Tucker et al., 2011). They are also likely to have affected the khondalite zircons, and the interpretation of well rounded grains to be of detrital origin may therefore be incorrect, and some of the young EPMA ages reported by Santosh et al. (2006) are likely to be the result of severe Pb-loss or may reflect high-grade metamorphism during the 550–580 Ma Pan-African event.

The purpose of this study was to re-investigate and date detrital zircons from typical khondalites of the Trivandrum Block, since a previous field-based survey has shown that these rocks were intruded by ca. 1765–2106 Ma old granitoids (Kröner et al., 2015a). We have therefore analyzed single zircons from six representative khondalite samples (Table 1), using a SHRIMP II high-resolution ion-microprobe, combined with cathodoluminescence imaging.

The sample localities are shown in Fig. 1, and a brief petrographic characterization of the samples is provided in Table 1.

2. Brief geological setting and petrological characterization and PT conditions of the dated samples

The Trivandrum Block (Fig. 1) consists predominantly of granulite–facies granitoid leucogneisses and garnetiferous metasediments (collectively referred to as leptynites and khondalites, respectively, in the literature), in association with minor charnockites and mafic granulites. Details on the regional geology and field relationships were recently summarized by Collins et al. (2014), Whitehouse et al. (2014) and Kröner et al. (2015a). Pelitic metasediments constitute a major part of the supracrustal sequences, and six samples were collected for zircon geochronology from six different quarries as summarized in Table 1, and representative field photographs are shown in Fig. 2. These metasediments were intruded by light grey, fine- to medium-grained and equigranular