Lithos 123 (2011) 176–187

Contents lists available at ScienceDirect

Lithos

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

The India and South China cratons at the margin of Rodinia — Synchronous Neoproterozoic magmatism revealed by LA-ICP-MS zircon analyses

M. Hofmann [a,*], U. Linnemann [a], V. Rai [b], S. Becker [a], A. Gärtner [a], A. Sagawe [a]

[a] c/o Senckenberg Naturhistorische Sammlungen Dresden, Museum für Mineralogie und Geologie, Sektion Geochronologie, Königsbrücker Landstraße 159, D-01109 Dresden, Germany
[b] University of Lucknow, Department of Geology, Centre of Advanced Study in Geology, Lucknow 226007, U.P., India

ARTICLE INFO

Article history:
Received 2 July 2010
Accepted 26 January 2011
Available online 2 February 2011

Keywords:
Lesser Himalaya
Yangtze block
U–Pb zircon age
LA-ICP-MS
Neoproterozoic
Rodinia

ABSTRACT

The palaeogeographic position of South China in relation to India in the Neoproterozoic is controversial. Resolution of this controversy constrains the reconstruction of Rodinia during its breakup and contributes to our understanding of Snowball Earth. This work compares the Neoproterozoic histories of the Lesser Himalaya in northern India and the Yangtze block in southern China. We present U–Pb LA-ICP-MS ages of detrital zircon grains from six Indian and three Chinese siliciclastic sedimentary rocks, such as sandstones or diamictites/tillites. In total, 1148 grains were analysed from which 833 measurements gave ages with a degree of concordance between 90 and 110%. The correlation of the Indian and the Chinese sections is possible using the tillites of both areas purportedly deposited during the Snowball Earth time interval: the Blaini tillite from India and the Nantuo tillite from China. The U–Pb ages confirm the Marinoan age of the Chinese Liantuo tillite. Although the youngest zircon age for the Indian Blaini tillite is about 678 Ma, the Marinoan age is indicated by the presence of a typical Marinoan white to bright yellowish overlying cap carbonate.

In addition to the tillites, representative detrital zircon ages from over- and underlying clastic rocks were determined. The Chinese samples are dominated by zircons with Neoproterozoic ages with a main peak between ca. 750 Ma and ca. 950 Ma and are characterised by the absence of Archaean ages. The Indian samples contain abundant Neoproterozoic zircon grains, but also contain Mesoproterozoic to Archaean zircons. For all samples, a local source area that provided the Neoproterozoic zircons is likely. A synchronous Neoproterozoic magmatic event in both cratons probably reflects the breakup of the supercontinent Rodinia and therefore the same tectono-magmatic event. Our results indicate a similar history for India and South China which both underwent at least one synchronous episode of crustal growth during the Neoproterozoic. In addition, our data set shows that both passive margin clastic sequences had the same source area for all zircons older than Neoproterozoic. Therefore we infer that India and South China were close to each other and along the same passive margin during the breakup of Rodinia in the Late Neoproterozoic.

1. Introduction

The palaeogeographic positions of India and South China during the Neoproterozoic are controversial (e.g. Duan et al., 2011; Jiang et al., 2003a; Li and Powell, 2001; Torsvik et al., 2001; Yu et al., 2008). Modern palaeomagnetic data permit a reconstruction in which the two continents are positioned together along the western margin of the Rodinia supercontinent (e.g. Duan et al., 2011; Jiang et al., 2003a; Li et al., 2004; Torsvik et al., 2001). This paper presents and compares detrital zircon grains of various samples from Neoproterozoic to Cambrian strata of the Lesser Himalaya in northern India with the Neoproterozoic of the Yangtze craton in South China.

The ages of zircon grains in sedimentary rocks reflect the age of the source area rocks that were exposed to weathering and erosion at the time of their deposition. By determining the detrital zircon age record of the sedimentary rocks, it is possible to constrain the absolute ages of the source area and the episodes of crustal growth. The data reflect the different episodes of secular magmatism and can therefore be used as a tracer for tectonic activity. It is possible to compare different sedimentary rocks regarding their zircon age record to see if they had a connection with the same geological hinterland.

1.1. India and South China as a part of Rodinia supercontinent

The supercontinent Rodinia formed at about 1100–1000 Ma and lasted approximately until 750 Ma ago (final breakup, e.g. Pisarevsky et al., 2003). The positions and drift directions of India and South China during the Neoproterozoic and early Cambrian were recently discussed by various authors (e.g. Duan et al., 2011; Evans, 2009; Jiang et al., 2003a; Li and Powell, 2001; Pisarevsky

* Corresponding author. Tel.: +49 351 795841 4419; fax: +49 351 795841 4404.
E-mail address: mandy.hofmann@senckenberg.de (M. Hofmann).

0024-4937/$ – see front matter
doi:10.1016/j.lithos.2011.01.012

et al., 2003; Torsvik et al., 2001; Yu et al., 2008). There is considerable discussion concerning how close these cratons were to each other and their position relative to Antarctica and Australia. Pisarevsky et al. (2003) propose a model in which India was not part of Rodinia and the South China craton was situated north of Laurentia. In contrast, the data of other authors (e.g. Evans, 2009, and others) suggest that the two cratons were neighbours along the Rodinia margin.

Around ca. 825–800 Ma, India was at high latitudes (e.g. Evans, 2009; Li et al., 2004; Pisarevsky et al., 2003; Radhakrishna and Mathew, 1996; Torsvik et al., 2001) but its location relative to the South China craton is not clear. According to the Apparent Polar Wander Path, South China was also situated at relatively high latitudes (between 55 and 70°) at ca. 800 Ma (Evans, 2009; Li et al., 2004), and therefore could have been close to India.

At ca. 780 Ma, rifting events began which led to the final breakup of the Rodinia supercontinent between 750 and 725 Ma (Evans, 2009; Torsvik et al., 2001; Zheng et al., 2008). For the ca. 750 to 755 Ma time period, Torsvik et al. (2001) see two possibilities for the position of India: (1) along the western margin of Australia at ca. 30° N or (2) closer to the equator along the western margin of East Antarctica. As the palaeomagnetic reconstruction for the South China craton points to a location north of Australia (ca. 34° N) around 750 Ma, possibility (1) for India would fit very well with the idea of a close proximity between the two cratons (also proposed e.g. by Duan et al., 2011; Evans, 2009; Jiang et al., 2003a; and others). An equatorial position for South China during the Ediacaran was also proposed by Macouin et al. (2004). Evans (2009) holds the view that South China and India were neighbours at ca. 780 Ma.

The movement of both cratons from relatively high latitudes at ca. 800 Ma to positions close to the equator at ca. 750 to 725 Ma would require very fast velocities (up to 20 cm/year) for India and South China. The proposed 90° rotation of Rodinia (axis near Greenland) that placed the whole supercontinent close to equatorial latitudes at ca. 750 Ma, is attributed to a subequatorial superplume (Li et al., 2004) which may explain these fast velocities.

The Neoproterozoic was characterised by extreme climatic variations. The location of such a big landmass along the equator resulted in (1) an increase in albedo and (2) increasing chemical weathering that reduces the abundance of CO_2 in the atmosphere (Li et al., 2004). The global cooling effect may have triggered the Sturtian glaciation at ca. 750–720 Ma (e.g. Li et al., 2004). Today Sturtian tillites can be found on the Yangtze craton (South China), for example within the Chang'an Formation. There are no glacial deposits from that time in the Lesser Himalaya sections of northern India.

The Rodinia-breakup (around 750 Ma) and accompanying magmatic events resulted in an increase of atmospheric CO_2 and led to a greenhouse effect after the Sturtian glaciation. As the breakup of the supercontinent proceeded, newly developed small continents with rift basins and new passive margins formed around 650 Ma. The increasing evaporation from the newly formed oceans and the rising rainfall again increased the weathering of exposed rocks and further reduced the atmospheric greenhouse gas levels that induced the second global glaciation, the Marinoan Snowball Earth at ca. 635 Ma (e.g. Hoffman et al., 1998). Both, the Indian and the South China craton, preserve tillites within their sections that are clearly Marinoan in age (Figs. 1, 2 and 3). Based on the occurrence of these strata the correlation of both Neoproterozoic sections is possible.

The post-Marinoan palaeogeographic position of India and South China was close to the equator (Macouin et al., 2004). For the early Cambrian time (at ca. 535 Ma), Torsvik et al. (2001) placed India along the western margin of Gondwana between East Antarctica in the east and Madagascar and the Seychelles in the south at latitudes around 10–15° S. By that time, South China had drifted away towards northwestern Australia (Duan et al., 2011; Jiang et al., 2003a; and others) and was no longer close to India.

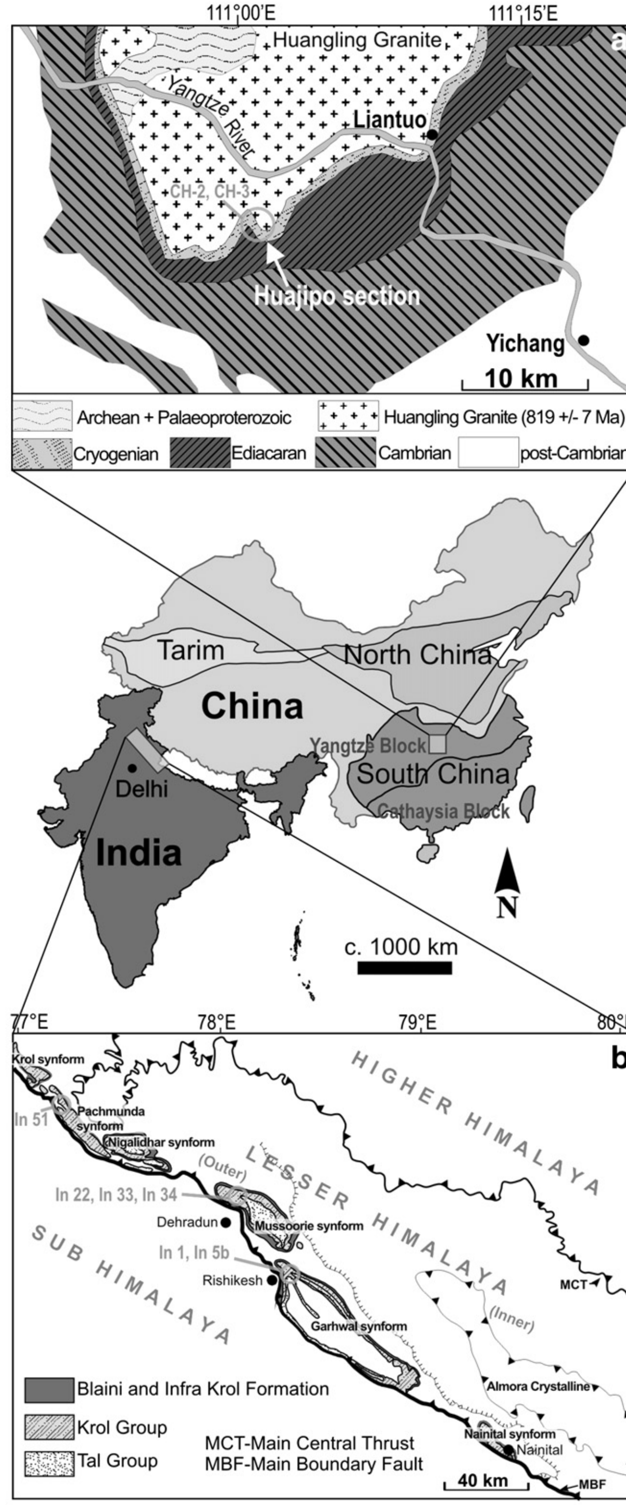

Fig. 1. Location and geological setting for the Indian and Chinese samples. The Indian samples In-1, -5b, -22, -33, -34 and -51 represent Neoproterozoic to Cambrian clastic rocks from the Garhwal, Mussoorie and Pachmunda synclines. They are a part of the Lesser Himalaya that contains different synforms and the outer and inner sedimentary belts of Neoproterozoic to Cambrian age. The Neoproterozoic Chinese samples CH-2 and -3 are from the Huajipo section west of the Yangtze Gorges area within the Yangtze block of the South China craton.
Geological map of the Indian Lesser Himalaya region modified after Jiang et al. (2003b); geological map of the Chinese southern Huangling Granite area modified after Dong et al. (2009); age of the Huangling-Granite after Zhu et al. (2006), and others.