Precambrian Research 214–215 (2012) 28–43

Contents lists available at SciVerse ScienceDirect

Precambrian Research

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

Detrital zircon age structure within ca. 3 Ga metasedimentary rocks, Yilgarn Craton: Elucidation of Hadean source terranes by principal component analysis

Eric R. Thern[a,*], David R. Nelson[b]

[a] Department of Imaging and Applied Physics, Curtin University of Technology, GPO Box U1987, Perth, WA 6001, Australia
[b] School of Natural Sciences, University of Western Sydney, Locked Bag 1797, Penrith, NSW 2751, Australia

ARTICLE INFO

Article history:
Received 8 July 2011
Received in revised form 19 October 2011
Accepted 20 October 2011
Available online 30 October 2011

Keywords:
Multivariate
Detrital zircon
Yilgarn
Hadean
Geochronology

ABSTRACT

A multivariate approach using a similarity matrix derived from >5500 U–Pb zircon analyses was used to investigate the complex and overlapping detrital zircon age structure within ca. 3 Ga metasedimentary rocks from the Yilgarn Craton, Western Australia. Detrital zircon analyses were grouped by their $^{207}Pb/^{206}Pb$ dates using a robust Chi-square grouping method which produced 74 Yilgarn-wide age groups from a pool of >3500 analyses and that were correlated between different metasedimentary rocks. Principal component analysis (PCA) was then used on a calculated similarity matrix of >65 samples which contained these age groups. PCA indicates that the main age populations of the detrital zircons in the ca. 3 Ga metasedimentary rocks were derived in varying portions from the Narryer and Yarlarweelor Gneiss Complexes. Differences between the age structure of >3.9 Ga zircon populations within the Mt. Alfred metasedimentary rocks with those from Mt. Narryer, Jack Hills and Maynard Hills localities is best explained by their derivation from two Hadean terranes which were joined by ca. 3.7 Ga.

1. Introduction

The oldest materials that survive on Earth, >4000 Ma zircons, are found within ca. 3 Ga metasedimentary rocks throughout the Yilgarn Craton. These zircons, with ages up to ca. 4350 Ma, have been found within the metasedimentary rocks of Mt. Narryer (Froude et al., 1983; Kinny et al., 1990; Crowley et al., 2005; Pidgeon and Nemchin, 2006), Jack Hills (Compston et al., 1985; Wilde et al., 2001; Peck et al., 2001; Cavosie et al., 2004, 2006; Crowley et al., 2005), Maynard Hills (Nelson, 2002; Wyche et al., 2004) and the Mt. Alfred locality of the Illaara Greenstone Belt (Nelson, 2005; Wyche, 2007). These ancient zircons are of unknown provenance, and their distribution throughout multiple disparate metasedimentary rocks >400 km apart within granite greenstone terranes and high grade Gneiss Complexes makes their relation to one another at time of deposition difficult to assess.

Whereas much thought and study has gone into these Hadean zircons from the Jack Hills and Mt. Narryer, the source terranes of these detrital grains is still unknown. There are hints of source rock diversity from the age structures within the detrital zircon data of the Jack Hills, Mt. Narryer and Toodyay Lake Grace zircon populations (Cavosie et al., 2004; Spaggiari et al., 2007; Dunn et al., 2005; Crowley et al., 2005; Pidgeon and Nemchin, 2006; Pidgeon et al., 2010), and some similarities between the metasedimentary rocks and the Narryer gneisses have been discussed (Kinny et al., 1988; Pidgeon et al., 2010). Adding to the complexity is the metamorphosed and deformed nature of the metasedimentary rocks which has obliterated much of their original sedimentary character.

To address these issues, new detrital zircon U–Pb analyses from the ca. 3 Ga Maynard Hills and Illaara Greenstone Belt metasedimentary rocks (Thern and Nelson, submitted for publication) are combined with existing data from ca. 3 Ga metasedimentary rocks from the Yilgarn Craton in order to investigate the age structures of their detrital zircon populations. Detrital zircon studies have used many techniques to assess and match age structures within datasets—some recent examples include the use of probability density plots (for example Pidgeon et al., 2010); discussion of histograms and binning[1] of age data (Vermeesch, 2005); usage of binning or fractions separated by predefined age limits (Andersen, 2005); hierarchical dendograms and cluster trees of mostly igneous samples (Condie et al., 2009) and on detrital samples (Weislogel et al., 2010); principal component analysis (PCA) (Sircombe, 1999, 2000); and kernel functional estimation of ages prior to clustering (Sircombe and Hazelton, 2004).

* Corresponding author. Tel.: +61 4 22529477.
E-mail address: eric@thern.org (E.R. Thern).

[1] Where pre-determined intervals of certain ages or values, 'bins', are defined that consist of the original data which falls into these intervals.

0301-9268/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.precamres.2011.10.015

This paper offers a synthesis of >3 Ga detrital zircon data from the Yilgarn Craton in order to investigate sources of the Hadean zircons and the makeup of the pre-Yilgarn Craton source terranes. A multivariate statistical approach using robust age grouping of all sample data is used to produce a similarity matrix from the age groups in each sample. Principal component analysis (PCA) has then been applied to the resulting matrix, producing PCA-derived hierarchical clusters which are interpreted to define distinct provenances.

2. Geological setting

The Yilgarn Craton primarily consists of >3000 Ma gneisses (Narryer Gneiss Complex), >2900 Ma, ca. 2800 Ma and 2730–2680 Ma greenstones, and 2730–2630 Ma granites (Fig. 1). The greenstone belts are generally N–S trending 'rafts' within younger granites throughout the Yilgarn Craton. The ca. >2900 Ma greenstones are commonly associated with ca. 3 Ga clastic metasedimentary rocks,

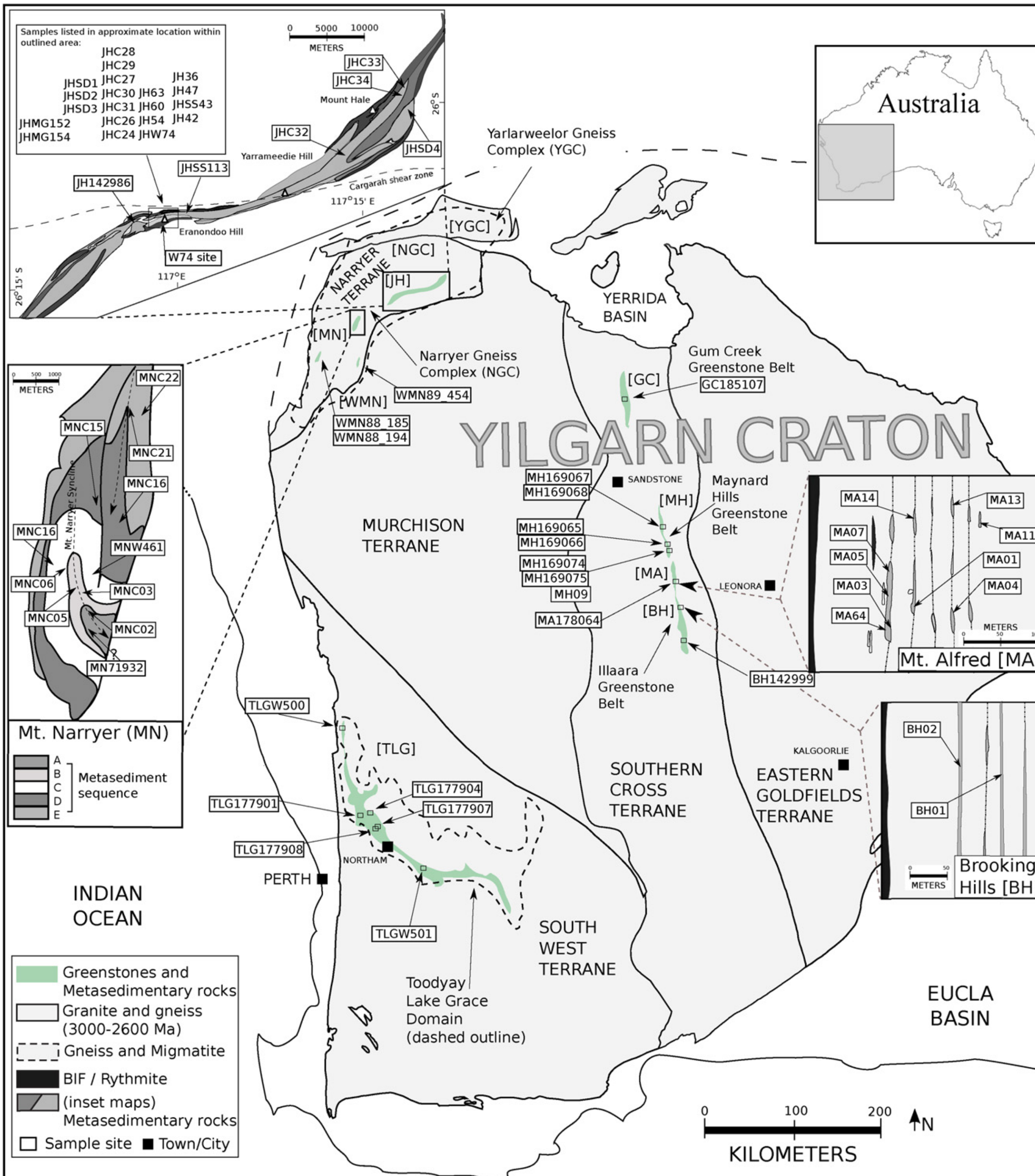

Fig. 1. Map of the Yilgarn Craton, Western Australia, showing locations of ca. 3 Ga metasedimentary rocks and of gneisses examined in this study. Inset maps are of Mt. Narryer (after Crowley et al., 2005), Jack Hills (after Spaggiari et al., 2007), Mt. Alfred and Brooking Hills. Samples used in this study have been prefixed with locality information: [JH] Jack Hills, [MN] Mt. Narryer, [WMN] West of Mt. Narryer, [TLG] Toodyay Lake Grace, [BH] Brooking Hills, [MA] Mt. Alfred, [MH] Maynard Hills and [GC] Gum Creek. See Table 1 for full reference list.