Journal of Asian Earth Sciences 91 (2014) 252–262

Contents lists available at SciVerse ScienceDirect

Journal of Asian Earth Sciences

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

Contributions of zircon U–Pb geochronology to understanding the volcanic and sedimentary history of some *Purāna* basins, India

Abhijit Basu[a,*], Marion. E. Bickford[b,1]

[a] Department of Geological Sciences, Indiana University, 1001 East 10th Street, Bloomington, IN 47405, USA
[b] Department of Earth Sciences, 204 Heroy Geology Laboratory, Syracuse University, Syracuse, NY 13244, USA

ARTICLE INFO

Article history:
Received 27 February 2013
Received in revised form 20 May 2013
Accepted 27 June 2013
Available online 6 July 2013

Keywords:
Zircon geochronology
Proterozoic
Sedimentary basins
India

ABSTRACT

In this century, U–Pb ages of magmatic and detrital zircons, together with a few less accurate but fairly robust ages determined on monazite and baddeleyite, in the *Purāna* successions in India have established a few firm timelines that constrain the opening, closure, inversion, and provenance of the *Purāna* basins. The Cuddapah basin opened shortly before ca. 1900 Ma, the Vindhyan basin opened before ca. 1630 Ma, the Khariar basin likely opened ca. 1500 Ma, and the Chhattisgarh basin opened ca. 1400 Ma. The Marwar basin opened after ca. 750 Ma. The Chhattisgarh basin began to invert at ca. 1000 Ma and closed shortly thereafter. The Indravati and the Vindhyan basins closed ca. 1000 Ma. There are no other defensible geochronologic data to adequately constrain the opening and closure of other *Purāna* basins (e.g., Kaladgi, Badami, Bhima, Kurnool, Mallampalli, Albaka, Ampani, Sabari, and Kolhan). Neither the fossil record nor the biostratigraphy of these basins necessarily correspond to the chronology determined through radiometric measurements.

The discovery of ca. 1000 Ma volcanic events in the Indravati and Chhattisgarh basins adds to the growing list of ca. 1000 Ma thermal disturbances in the Indian shield. Most of these events were likely the far field effects of the final assembly of Rodinia.

1. Introduction

The Indian shield is composed of six ancient cratons that are >3.0 Ga. Within the shield, the Aravalli and the Bundelkhand cratons occur in the northern part, the Bastar craton is in the central part, the Eastern Dharwar and Western Dharwar cratons are in the southern part, and the Singbhum craton occurs in the eastern part (Fig. 1). These cratons were stabilized by 2.5 Ga and consist mostly of granitic rocks and TTG gneisses, with minor occurrences of greenstone belts, mafic LIPs, and felsic volcanics (Pascoe, 1950; Wiedenbeck et al., 1996; Jayananda et al., 2000, 2013; Srivastava et al., 2001; Ghosh, 2004; Raza et al., 2010; Manikyamba and Kerrich, 2012; Ram Mohan et al., 2012; Sarma et al., 2012). Successions of virtually unmetamorphosed sedimentary rocks, devoid of body-fossils and mostly undeformed, occur in numerous large and small basins and their outliers; all are floored by the ⩾ca. 2.5 Ga cratonic basement. These basins have been called *Purāna* (≈ancient in Sanskrit) basins (Holland, 1913).

The *Purāna* basins are thus, by definition or through consensus, understood to be Proterozoic. They opened and closed at different times during the approximately 2000 Ma duration of the Proterozoic Eon. The absolute ages of the lifespans of these basins, and the major unconformities within the sedimentary successions, are very poorly constrained. Older geochronologic data, including K–Ar ages of authigenic glauconite, have been taken as or used to constrain, depositional ages (e.g., Mathur, 1982; Chaudhuri et al., 1989). These older data (e.g., Vinogradov et al., 1964; Aswathanarayana, 1964; Tugarinov et al., 1965; Clark and Subbarao, 1971; Ikramuddin and Stueber, 1976; Kreuzer et al., 1977), some of which persist in the literature (e.g., Sreenivasa Rao, 2001; Patranabis-Deb, 2004; Dayal and Murthy, 2006; Upadhyay and Raith, 2006; Patranabis-Deb and Chaudhuri, 2007; Conrad et al., 2011; Yellappa et al., 2012), have been confusing. Lithostratigraphic and biostratigraphic correlations of the sedimentary successions among these basins are not necessarily compatible with recent isotopic data. Ages assigned to some strata on the basis of biotic and isotopic evidence are also not compatible with each other, as is common in many Proterozoic basins (e.g., Basu, 2009; Bengtson et al., 2009). The purpose of this short note is to examine critically the geochronologic record, identify reliable ages, and discuss the time-lines of igneous and depositional histories of these basins. Our motivation comes not only from the desire to discard relatively unreliable geochronologic data and identify robust depositional ages for the *Purāna* basins, but also from the inspiration provided by the paleontologic community in explicit identification of dubiofossils,

* Corresponding author. Tel.: +1 812 855 6654; fax: +1 812 855 7899.
E-mail addresses: basu@indiana.edu (A. Basu), mebickfo@syr.edu (M. E. Bickford).
[1] Tel.: +1 315 443 9290; fax: +1 315 443 3363.

1367-9120/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jseaes.2013.06.018

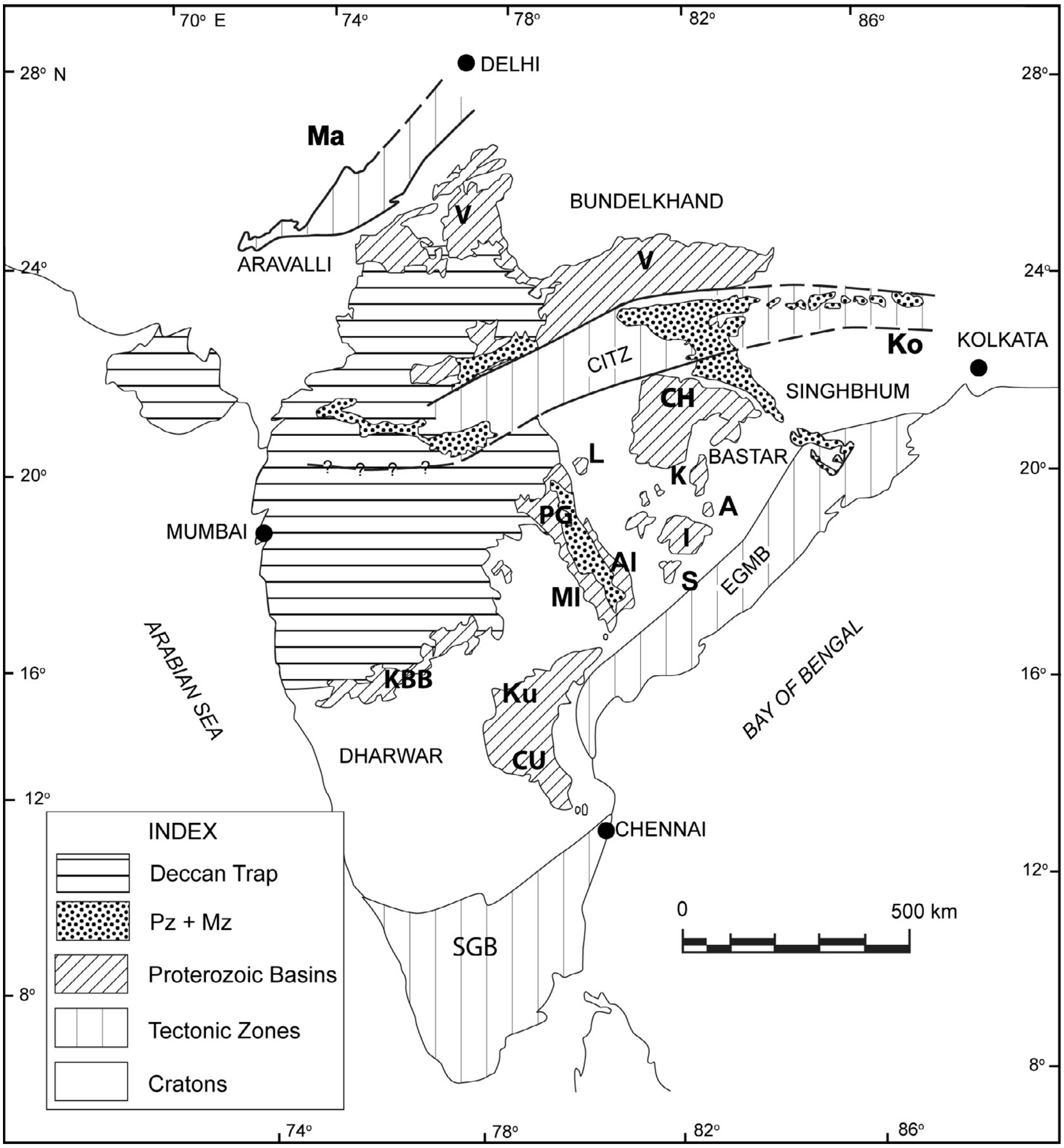

Fig. 1. Map of India with the locations of the principal *Purāna* basins and tectonic belts (A = Ampani; Al = Albaka; CH = Chhattisgarh; CITZ = Central Indian Tectonic Zone; CU = Cuddapah; EGMB = Eastern Ghats Mobile Belt; I = Indravati; K = Khariar; KBB = Kaladgi–Badami–Bhima; Ko = Kolhan; Ku = Kurnool; L = Lohara; Ma = Marwar; Ml = Mallampalli; S = Sabari; V = Vindhyan; and, Pz = Paleozoic; Mz = Mesozoic). After Holmes (1955), Mahadevan (2008) and Bickford et al. (2011b).

pseudofossils and even nonfossils (e.g., Chakrabarti, 1990; Sharma et al., 1992; Kumar, 1995 Kulkarni et al., 2004; Brasier et al., 2005; Hofmann, 2005; De, 2006; Sharma and Shukla, 2009).

2. Radioisotope geochronology

In recent years, crystallization ages of single mineral grains in crystalline rocks associated with *Purāna* basins have provided the bulk of geochronologic knowledge. Igneous rocks are quite diverse. They may occur as tuffs, intercalated with sedimentary rocks; their ages can constrain the timing of sedimentary deposition. Or, they may occur as intrusions, such as sills and dykes; their ages constrain the minimum age of the intruded sedimentary rocks. Others, including metamorphic rocks, may form the basement of a succession of sedimentary rocks; their ages provide the maximum age of the succession. The most robust ages are obtained by the U–Pb method from zircon ($ZrSiO_4$) and baddeleyite (ZrO_2) because they are usually closed systems to parent and daughter elements, even at high temperatures. Monazite ((Ce, La, Th)PO_4) most commonly occurs in metapelites. It can be dated by electron microprobe methods because it's very high abundances of Th ensure that essentially all Pb is radiogenic. However, because it is a phosphate, monazite is susceptible to dissolution and reprecipitation during hydrothermal events (e.g., Williams et al., 2011). Thus, grains should be mapped, by X-ray methods with the probe, to determine compositional regions, which may yield differing ages.

Micas, including muscovite, biotite, and phlogopite, as well as amphiboles like common hornblende, may be dated through analysis of the ^{40}K–^{40}Ar system. In modern analysis the sample is irradiated so that ^{39}K is converted quantitatively to ^{39}Ar, and becomes a proxy for ^{40}K. Then, when the $^{39}Ar/^{40}Ar$ ratio is measured the age can be calculated. It must be understood that K–Ar and Ar–Ar ages are cooling ages, i.e., they record the time at which the mineral being analyzed cools through the "blocking temperature", i.e., the temperature below which radiogenic Ar is quantitatively retained. These temperatures range from about 500 °C for hornblende to about 300 °C for biotite. The cooling age is necessarily less than the crystallization age, and, depending on the cooling or metamorphic history of the rock, may be much less. However, in rapidly