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Zircon ages of late Palaeoproterozoic (ca. 1.72–1.70 Ga) extension-related granitoids in NE Rajasthan, India: Regional and tectonic significance

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ABSTRACT

The Khetri region forms a late Palaeoproterozoic igneous–metamorphic complex in NE Rajasthan, India. Seven granitoid plutons of the Khetri complex have been studied for zircon U–Pb and Pb–Pb dating along with whole-rock and Nd–Sr isotope geochemistry to provide new constraints on the Palaeoproterozoic magmatic activity in the Aravalli orogen of northwestern India. Most intrusives show evidence of moderate to extreme albitisation forming microcline–albite granite and albite granite, respectively. The rocks are metaluminous to weakly peraluminous, largely ferroan and intraplate A-type granites. The U–Pb zircon ages for four plutons cover a time span of 1732–1682 Ma, whereas Pb–Pb zircon evaporation data for three intrusives indicate minimum emplacement ages between 1671 and 1537 Ma. The Nd–Sr isotopic systematics suggest the involvement of Neoarchaean to Palaeoproterozoic crustal components in the petrogenesis of these granitoids. A regional survey of late Palaeoproterozoic ages in the Aravalli orogen provides evidence for a geographically widespread extension-related event in the northwestern Indian shield about 1720–1700 Ma ago. The record of comparable ages and the magmatic history reported in parts of North America and the North China Craton may indicate the significance of this event for the rift tectonics of the hypothetical supercontinent Columbia.

1. Introduction

The Palaeoproterozoic represents a significant period of continental crustal growth because this Era witnessed high production of juvenile crust, mainly in the form of continental arc systems on a global scale (e.g., Condie, 2000; Sato and Siga, 2002), which are speculated to have eventually accreted to form a supercontinent (e.g. Hoffman, 1997; Rogers and Santosh, 2002, 2009; Zhao et al., 2002, 2004; Santosh, 2010). The distribution of zircon ages suggests that 2.7 and 1.9 Ga were maxima for the production of granitoid crust, and Nd isotopic data further indicate that during Palaeoproterozoic, 1.9 and 1.7 Ga were important peaks for juvenile crust production (Condie, 1998; Condie et al., 2009). The great production of juvenile crust and the assembly of a supercontinent imply that global tectonothermal events were frequent and extensive during the Palaeoproterozoic (Zhang et al., 2006). The effect of these global magmatic events in the Aravalli orogen of northwestern India (Fig. 1) has not been fully explored because of a lack of robust geochronological data.

A large tract of Palaeoproterozoic crust (~1850–1700 Ma) is exposed in the northern and central parts of the Aravalli orogen (Fig. 1; Mukhopadhyay et al., 2000; Deb et al., 2002; Biju-Sekhar et al., 2003; Roy et al., 2005; Buick et al., 2006; Kaur et al., 2006a, 2007, 2009; Bhowmik et al., 2010). Important advances made in recent times to understand the Precambrian crustal evolution of the Aravalli orogen is the identification of a ~1711–1660 Ma phase of an A-type granitoid plutonism (Chaudhri et al., 2003; Kaur et al., 2006b, 2007) and an older pulse of ~1850–1822 Ma Andean-type granitoid magmatism (Kaur et al., 2009). These results are, however, preliminary as the studies were restricted to a limited area in the northern part of the Khetri complex, situated about 150 km SW of Delhi (Fig. 1b). We present new geochronological, geochemical and Nd–Sr isotopic data for granitoid intrusions of the southern and northern parts of the Khetri complex with an aim to delineate the existence of a widespread late Palaeoproterozoic event in the Aravalli orogen. This 1720–1700 Ma event also had significance for a rifting phase of the assumed Palaeoproterozoic supercontinent Columbia.

2. Geological background

The oldest rock unit in the Aravalli orogen is represented by a Palaeoarchaean (~3.3 Ga; Gopalan et al., 1990; Wiedenbeck and

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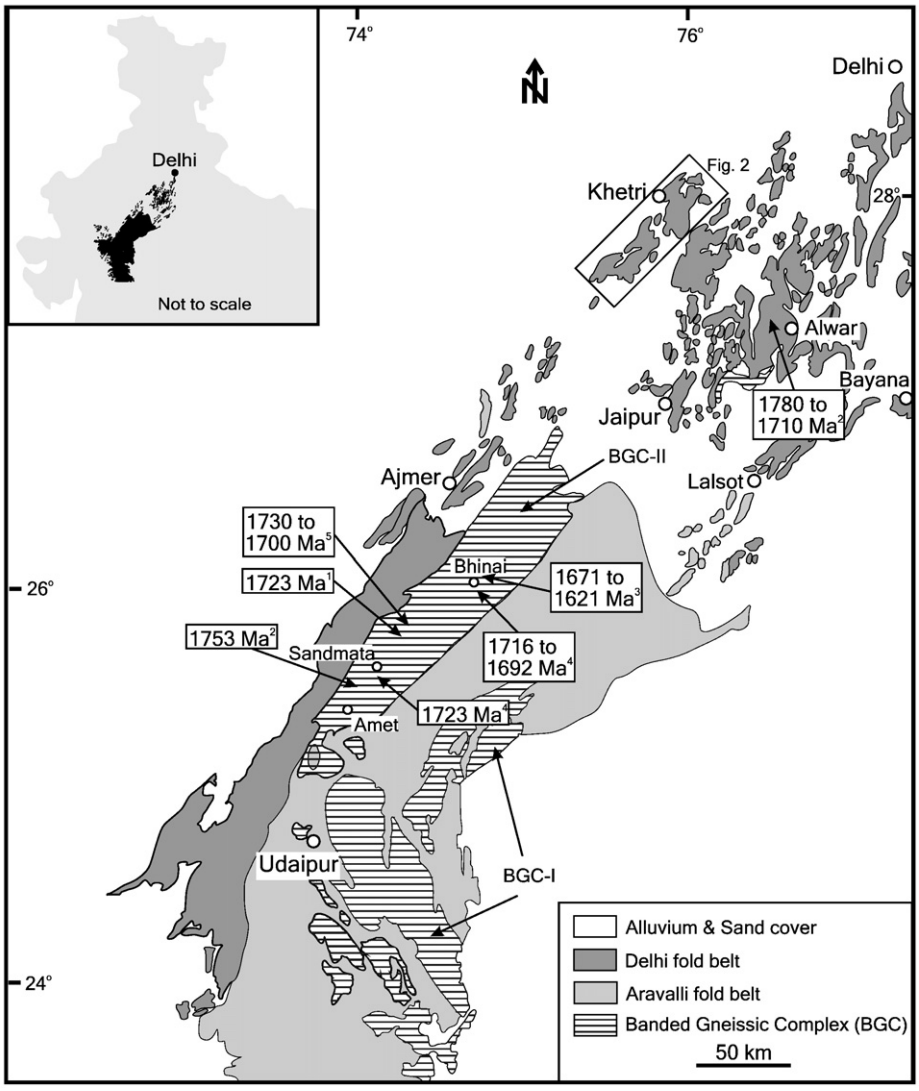

Fig. 1. Simplified geological map showing major Precambrian lithotectonic units of the Aravalli orogen, northwestern India (after Heron, 1953; Gupta et al., 1997; Roy, 1988; Roy and Jakhar, 2002) and ages for granitoids and granulites in central and northern parts. Age data sources: 1 — Sarkar et al. (1989), 2 — Biju-Sekhar et al. (2003), 3 — Roy et al. (2005), 4 — Buick et al. (2006) and 5 — Bhowmik et al. (2010). Inset map shows location of Aravalli orogen in northwestern India, and box indicates location of Fig. 2.

Goswami, 1994; Roy and Kröner, 1996) basement complex consisting predominantly of granitic gneisses with minor enclaves of amphibolites and metasediments and Neoarchaean granitoid intrusions (~2.8–2.5 Ga; Gopalan et al., 1990; Roy and Kröner, 1996; Wiedenbeck et al., 1996). This Palaeo- to Neoarchaean domain, which is characteristic of the southern Aravalli region, is traditionally known as the Banded Gneissic Complex or BGC (Gupta, 1934; Heron, 1953). It is also designated as the BGC-I (Gupta, 1934) in order to distinguish it from a similar-aged largely granulite-facies terrane (BGC-II) in the central Aravalli region (Fig. 1); however, recent zircon ages indicate that the BGC-II is largely a late Palaeoproterozoic terrane (~1.72–1.62 Ga; Roy et al., 2005; Buick et al., 2006; Bhowmik et al., 2010). The BGC is overlain by a collage of Proterozoic metasupracrustal sequences of the Aravalli fold belt (ca. 2.2–1.9 Ga?) and Delhi fold belt (ca. 1.85–0.85 Ga?).

The westernmost entity of the Aravalli orogen in its northern part is designated as the Khetri complex (Kaur et al., 2009), also known as Khetri Copper Belt or Khetri fold belt (Fig. 1); it is about 100 km in extent from Pacheri in the northeast to Sangarva in the southwest (Fig. 2). A NW–SE lineament (the Kantli lineament/fault) separates the complex into northern and southern parts. Conventionally, the area is considered to be occupied by rocks of Delhi Supergroup (Das Gupta, 1968) with a predominantly arenaceous older unit (the Alwar Group) and an argillaceous–calcareous younger unit (the Ajabgarh Group). Recent work, however, classified the rocks in terms of an apparent Archaean basement, overlain by Proterozoic cover sequences (Gupta et al., 1998). In this igneous–metamorphic complex, the igneous activity is primarily in the form of late Palaeoproterozoic (1.82–1.66 Ga) granitoid rocks (Kaur et al., 2007, 2009). The majority of these granitoids intrude into a presumed Archaean basement of metasedimentary (e.g. quartzites, metapelites, and calc-silicate rocks) and minor gneissic rocks. The region is characterised by a multiphase structural history (e.g. Naha et al., 1988), polyphase regional metamorphism of andalusite–sillimanite type in the northern and kyanite–sillimanite type in the southern domains (e.g. Lal and Ackermand, 1981; Gupta et al., 1998), and sediment-hosted workable copper mineralisation (e.g. Sarkar and Dasgupta, 1980). Besides, it also records an overprint by a Neoproterozoic thermal event (~950–910 Ma, U–Th–Pb monazite ages; Kaur et al., 2006a; Pant et al., 2008). The most notable feature of this area is that most of the granitoid rocks are albitised to varying extents, and this has been ascribed to a regional scale Na-metasomatic event (Kaur et al., 2006b).