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Geochemistry and Sm–Nd geochronology of the metasomatised mafic rocks in the Khetri complex, Rajasthan, NW India: Evidence of an Early Cryogenian metasomatic event in the northern Aravalli orogen

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ABSTRACT

The mafic magmatic rocks associated with 1720–1700 Ma albitised A-type granites in the northern segment of the Aravalli orogen, NW India show evidence of metasomatism. It is, however, not clear whether the metasomatism of mafic rocks is related to the cooling of these associated granites or whether it took place much later after the emplacement of the granites on a regional scale. For this, we have investigated the mafic magmatic rocks, which occur in close association with these granites. In the Biharipur intrusive, the mafic rocks are intensely commingled with the A-type granites, whereas in the vicinity of the Dosi intrusive, the mafic rocks (clinopyroxenite) do not show any evidence of granite mingling. The commingled and metasomatised Biharipur mafics occur in contact with the albitised granites instead of original granite, indicating that the mafics were metasomatised along with the granites. This is supported by the similarity in REE and spider patterns of the intermixed mafic rocks and the albite granites. On the other hand, the Dosi mafic rocks, free from granite commingling, are scapolitised where the original diopside has been partly transformed to chlorine-rich marialites with a meionite component ranging from Me14.0 to Me16.0. The scapolite, occurring as anastomosing veins, within these rocks is also of similar composition, and the undeformed nature of these veins suggests that the scapolitisation postdates regional metamorphism in the region. Mineralogical, geochemical and Nd isotopic characteristics of the mafic rocks indicate that originally, these were clinopyroxenites, which have been altered to a monomineralic actinolite-bearing rock. The immobile incompatible trace element ratios indicate a continental tholeiite affinity for the mafics, which is in consonance with the A-type nature of the associated granites. During this metasomatic event, the mafic magmatic rocks experienced albitisation and scapolitisation, although the dominance of these processes varied on a local scale depending on the fluid composition.

A whole-rock-mineral (clinopyroxene and scapolite) Sm–Nd isochron of the scapolitised clinopyroxenite at Dosi yields an age of 831 ± 15 Ma. Synthesis of this age data along with previously published geochronological data indicate an important Early Cryogenian (850–830 Ma) metasomatic event in the northern Aravalli orogen, which is also synchronous with the Erinpura granite event in the southern Aravalli orogen.

1. Introduction

Metasomatism is a common metamorphic phenomenon that affects a wide spectrum of rock types in the Earth's upper crust, such as granitoids, alkali-carbonatite complexes, basaltic rocks, siliciclastic and calcareous sedimentary rocks and metamorphic sequences (e.g. Oliver et al., 1994; Aslund et al., 1995; Perez and Boles, 2005; Kaur et al., 2012a). The metasomatic alteration varies spatially from local to (often selectively) pervasive, depending on the supply and the compositional contrast between the rock and the infiltrating fluid. At times, the metasomatic rocks are so severely altered that it is difficult to resolve a regional metasomatised assemblage from a regional metamorphic assemblage, leading to incorrect interpretations of the results (e.g. Putnis and Austrheim, 2010 and references therein). Therefore, it is essential to discriminate between a metasomatic and a metamorphic mineral assemblage for a meaningful interpretation.

In the northern Aravalli orogen of NW India, the majority of late Palaeoproterozoic (1720–1700 Ma) A-type granite intrusives are variably albitised (Kaur et al., 2006a, 2011a, 2012a). Kaur et al.

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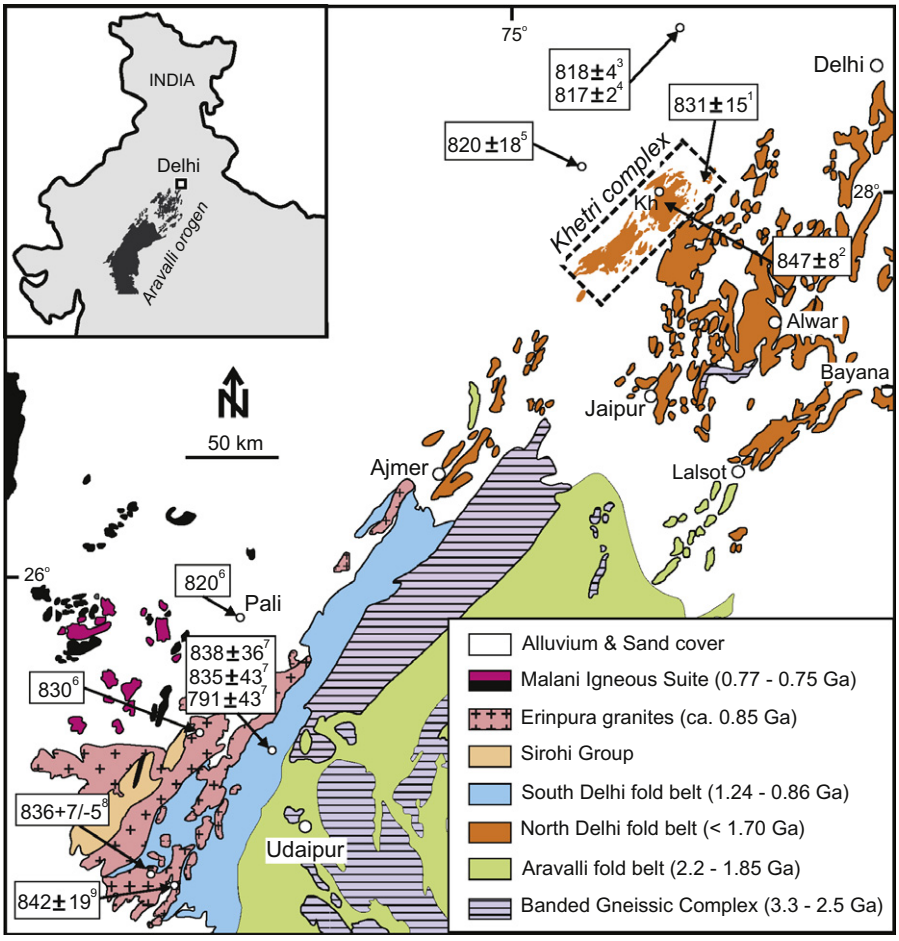

Fig. 1. Simplified geological map of the Aravalli orogen showing various Precambrian lithotectonic units (modified after Roy, 1988; Roy and Jakhar, 2002) and age locations of Early Cryogenian event. Age data sources, (1) – this study; (2) – Knight et al. (2002); (3) – Murao et al. (2000); (4) – Deb and Thorpe (2004); (5) – Sastry, 1992; (6) – Choudhary et al. (1984); (7) – Volpe and Macdougall (1990); (8) – Deb et al. (2001) and (9) – Singh et al. (2010). Kh: Khetri. The inset shows the extent of Aravalli orogen in northwestern India.

(2012a) presented a model for the mechanism of albitisation in these A-type granites and demonstrated that this metasomatic event in the northern Aravalli orogen has taken place on a regional scale. These workers also provided a rough age estimation for the albitisation to the extent that it occurred at least 300 Myr after the emplacement of the A-type granites. A SHRIMP U–Pb titanite age of 847 ± 8 Ma from this region is thought to indicate the timing of regional metasomatism (Knight et al., 2002). In situ EPMA U–Th–Pb monazite ages between 952 ± 16 Ma and 945 ± 15 Ma from an adjoining area are interpreted to represent timing of regional metamorphism (Pant et al., 2008). Monazite from the metasomatically altered mafic rocks of the region yielded an EPMA chemical age of 910 ± 10 Ma (Kaur et al., 2006b). This age is difficult to correlate either with a metasomatic or a metamorphic event because separated fractions of the monazite were dated and thus there is no textural control on the analysed monazite. Despite these geochronological data, no adequate time constraints are available for this metasomatic event in the northern Aravalli orogen, which is critical to understand the crustal evolution of this segment of NW India.

In this regard, we have evaluated the mineralogical, chemical and isotopic changes in the metasomatised mafic rocks of the Khetri complex that are either commingled with the albitised granites or occur in close association with these rocks. The main question is whether the metasomatism of mafic rocks, associated with granite intrusions, is driven by the heat of the cooling magmatic body, or it may be an unrelated, more regional phenomenon that occurred at a much later time. We present a new Sm–Nd whole-rock-mineral isochron age of a scapolitised mafic rock to provide evidence of an Early Cryogenian regional metasomatic event in the northern Aravalli orogen.

2. Geological background and field relationship

A predominantly gneissic basement of ~3.3 Ga intruded by 2.9–2.5 Ga granitoids (Gopalan et al., 1990; Roy and Kröner, 1996; Wiedenbeck et al., 1996; Dharma Rao et al., 2011; Roy et al., 2012), the Banded Gneissic Complex (BGC), forms a cratonic nucleus in the Aravalli orogen (Fig. 1). The BGC is uncomformably overlain by two supracrustal belts, the older one is known as the Aravalli fold belt, whereas the younger cover sequence is called the Delhi fold belt. The former is deposited between 2.2 and 1.85 Ga (Roy, 2000; Bhattacharya and Bull, 2010), while the latter constitutes a relatively older terrane (north Delhi fold belt; deposition age <1.70 Ga; Kaur et al., 2011b) to the area north of Ajmer, and a younger terrane (south Delhi fold belt; deposition age 1.24–0.86 Ga; Singh et al., 2010) to the south of Ajmer (Fig. 1). A synthesis of important tectonothermal events in the Aravalli orogen is presented elsewhere (see Kaur et al., 2011b and references therein).

The Khetri complex, comprising metasedimentary and igneous rocks, forms the northwestern domain of the Aravalli orogen in the north Delhi fold belt (Fig. 1). The metasedimentary rocks