CORRESPONDENCE

Crustal Source for a Syenite Complex in the High-grade Eastern Ghats Belt, India: Sm-Nd Isotopic Evidence

S. Bhattacharya[1]*, Ashit K. Swain[2] and W. Teixeira[3]

[1] *Indian Statistical Institute, Calcutta - 700 035, E-mail: samar@isical.ac.in*

[2] *Geological Survey of India, Chennai*

[3] *University of Sao Paulo, Brazil*

* *Corresponding author*

(Manuscript received November 15, 2003; accepted January 4, 2004)

Abstract

Several plutonic alkaline complexes have been reported from the high-grade Eastern Ghats belt, India and these are thought to have been derived from the mantle. The field features of the syenite complex around Rairakhol in Orissa indicate progressive deformation during emplacement and could be related to the latest deformation/folding in the host granulitic country rocks. Presence of some mafic granulite xenoliths could suggest a crustal source for this syenite complex.

Negative epsilon value is a strong indication of crustal source. The long crustal residence ages and $^{143}Nd/^{144}Nd$ values less than 0.5120, definitely indicate a crustal source.

Key words: Mafic syenite, Sm-Nd isotopes, crustal source.

Introduction

Several exposures of alkaline complex have been reported from the high-grade Eastern Ghats belt, India (Fig. 1 here and Leelanandam, 1998 and references therein). Tectonic setting of continental complexes is commonly modeled from geochemical constraints in relation to the well-studied East African Rift volcanic (Macdonald et al., 1994). However, for the plutonic complexes such as those in the Eastern Ghats belt, tectonic setting should be deciphered from field structural data. Leelanandam (1998) considered the Eastern Ghats belt as a fault-bounded ensialic linear rift-zone, and the alkaline complexes, mostly along the boundary between Bastar Craton and the Eastern Ghats Mobile Belt, were thought to represent post-tectonic alkalic magmatism signifying very deep melting (Rogers, 1986). However, Bhattacharya and Kar (2003) argued against a rift zone setting for the convergent Eastern Ghats orogen and further noted that many of the reported alkaline complexes occur far away from the cratonic margin. On the other hand, on the evidence of collisional features at this cratonic margin, Bhattacharya and Kar (2003) argued that the rift-valley model for the alkalic magmatism in this high-grade belt appears untenable.

For the Rairakhol alkaline complex, Panda et al. (1993, 1998) considered a rift setting, north of but not far from the Mahanadi Graben. On the evidence of low initial Sr ratio of 0.70330, Sarkar et al (1994) proposed a mantle derivation of the melt with no crustal contamination.

Our detailed field observations for the Rairakhol syenite complex together with Sm–Nd isotopic results would rather suggest tectonic deformation during emplacement and a crustal source for this syenite complex.

Field Relations

Tectonic deformation is prominently displayed by folding of the banded rocks. The regular geometry of the folds with variable axial plane but a constant subhorizontal hinge-line could have resulted from progressive deformation. These folds and some small-scale shear bands within the complex, could be broadly

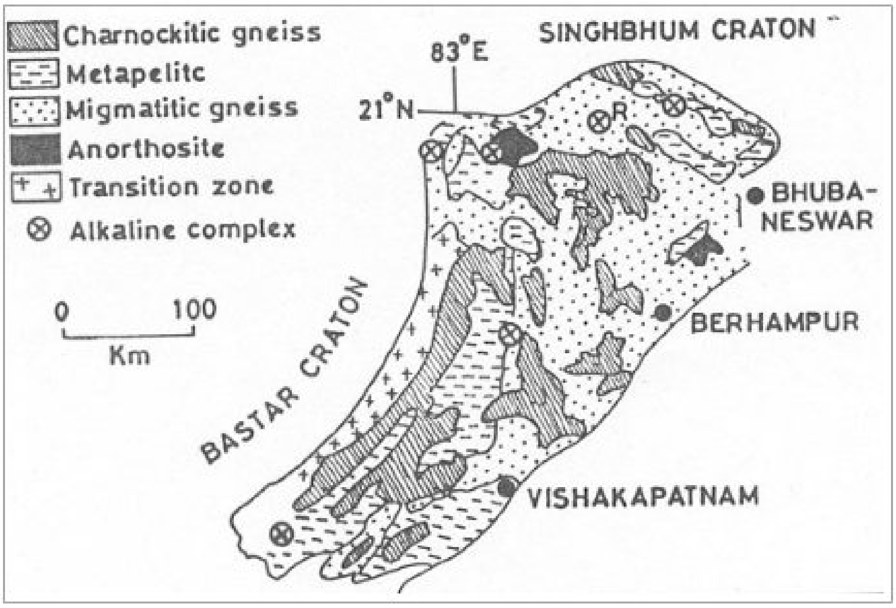

Fig. 1. Simplified geological map of the Eastern Ghats belt, India, modified after Ramakrishnan et al., 1998, showing the locations of the reported alkaline complexes, including the Rairakhol complex, marked R.

correlated to the latest deformation and mylonitic shear zones developed in the country rocks (Swain, 2003, submitted). Another important feature is the presence of some mafic granulite xenoliths within the complex.

Mineralogy and Petrography

Petrographically three broad groups could be recognized namely, mafic syenite, felsic syenite and nepheline syenite. The first two are gradational with a prominent gneissic banding. Mafic minerals are hornblende and biotite and mafic minerals typical of alkaline complexes, such as sodic amphibole, sodic pyroxene or annite are notably absent and hence this complex should be described as a syenite complex. Panda et al. (1993) described this complex as alkaline, but found hornblende and biotite as the only mafic minerals.

Geochemistry

A very important geochemical signature is a strong positive Nb anomaly (Fig.2) and this is inconsistent with a mantle-derived melt with little or no crustal contamination as proposed by Sarkar et al. (1994). It is important to note contrasting Nb signatures, strong negative Nb anomaly, in the mantle-derived Yelagiri and Sevattur syenite complexes of South India (Kumar et al., 1998).

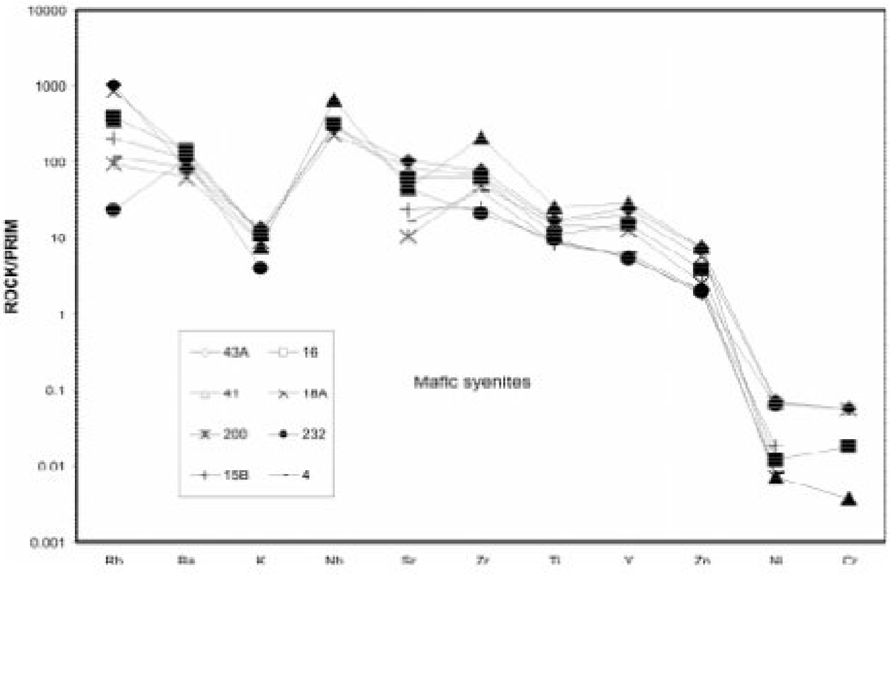

Fig. 2. Multi-element spider plot of the mafic syenites of the Rairakhol complex. Normalization after Sun and McDonough, 1989.

Table 1. Sm–Nd isotopic analytical data of mafic syenites of the Rairakhol syenite complex, Orissa, India.

Rock; Sample no.	Sm (ppm)	Nd (ppm)	$^{147}Sm/^{144}Nd$	Erro	$^{143}Nd/^{144}Nd$	Erro	$f_{Sm/Nd}$	T_{DM} (Ma)	Erro	$\varepsilon_{(0)}$
Mafic syenite; 232	7.111	32.025	0.1343	0.0008	0.511904	0.000011	–0.32	2190.0	27.9	–14.32
Mafic syenite; 15B	8.699	51.355	0.1024	0.0008	0.511767	0.000008	–0.48	1746.8	15.5	–16.99
Mafic syenite; 200	23.139	127.325	0.1099	0.0007	0.511810	0.000010	–0.44	1797.2	17.6	–16.97
Mafic syenite; 45	20.307	90.484	0.1357	0.0009	0.511914	0.000011	–0.31	2193.1	29.7	–14.71

Isotopic Signature

Four samples of the mafic syenite variety with the assemblage: hbl-plg-bio-perth-mgt± ne, were analyzed for the Sm-Nd isotopic compositions and the results are given in table 1. This analytical work was carried out at the Geoscience Institute of Sao Paulo University, Brazil, and the details of the analytical procedure are described in Bhattacharya et al., 2003.

Although no meaningful isochron could be derived, negative epsilon values between –14 and –17, is a strong indication of crustal source. Also, long crustal residence ages between 1747 and 2193 Ma and $^{143}Nd/^{144}Nd$ values less than 0.5120, definitely indicate a crustal source for this syenite complex.

References

Bhattacharya, S., Kar, Rajib, Teixeira, W. and Basei, M. (2003) High-temperature crustal anatexis in a clockwise P-T-t path: isotopic evidence from a granulite-granitoid suite in the Eastern Ghats belt, India. J. Geol. Soc. London, v. 160, pp. 39-46.

Bhattacharya, S. and Kar, Rajib. (2003) Alkaline intrusion in a granulite ensemble in the Eastern Ghats belt, India: shear zone pathway and a pull-apart structure. Proc. Ind. Acad. Sci., Earth Planet. Sci. (in press.)

Kumar, A., Charan, S.N., Gopalan, K. and Macdougall, J.D. (1998) A long-lived enriched mantle source for two carbonatite complexes from Tamil Nadu, southern India. Geochim. Cosmochim. Acta, v. 62, pp. 515-523.

Leelanandam, C. (1998) Alkaline magmatism in the Eastern Ghats belt– a critique. Geol. Surv. India, Spec. Pub., v. 44, pp. 170-179.

Macdonald, R.L., Williams, A.J. and Gass, I.J. (1994) Tectonomagmatic evolution of the Kenya rift valley: some geological perspectives. J. Geol. Soc. Lond., v. 151, pp. 879-888.

Panda, P.K., Patra, P.C., Patra, R.N. and Nanda, J.K. (1993) Nepheline syenite from Rairakhol, Sambalpur district, Orissa. J. Geol. Soc. India, v. 41, pp. 144-151.

Panda, P.K., Patra, P.C. and Nanda, J.K. (1998) Petrochemistry of the alkaline rocks of Rairakhol-Kankarkhol belt, Sambalpur and Deogarh districts, Orissa. Geol. Surv. India, Spec. Pub., v. 44, pp. 307-314.

Ramakrishnan, M., Nanda, J.K. and Augustine, P.F. (1998) Geological evolution of the Proterozoic Eastern Ghats Mobile belt. Geol. Surv. India, Spec. Pub., v. 44, pp. 1-21.

Rogers, J.J.W. (1986) The Dharwar craton and the assembly of peninsular India. J. Geol., v. 94, pp. 129-143.

Sarkar, A., Nanda, J.K., Panda, P.K., Patra, P.C., Bishui, P.K. and Gupta, S.N. (1994) Rairakhol alkaline complex, Orissa sector, Eastern Ghats belt: A Rb–Sr isotopic study. Extended Abst., Workshop on Eastern Ghats Mobile Belt, Visakhapatnam, pp. 75-76.

Sun, S.S. and McDonough, W.F. (1989) Chemical and isotopic systematics of oceanic basalt: implications for mantle composition and processes. In: Saunders A.D and Norry M.S. (Eds.), Magmatism in ocean basins. Geol. Soc. London, Spec. Pub., v. 42, pp. 313-345.