Sr-REE rich carbonatite dyke from Sarnu–Dandali, Barmer, Rajasthan

R. K. Srivastava, F. Wall* and M. J. LeBas**

Department of Geology, M. L. Sukhadia University, Udaipur 313 001, India

*Department of Mineralogy, The Natural History Museum, Cromwell Road, London, UK

**Department of Geology, The University of Leicester, Leicester LE1 7RH, UK

A carbonatite dyke from the Sarnu–Dandali alkaline complex of Barmer has given total REE+Sr+Ba as 14 wt% and REE as 6 wt%. The main constituents of the carbonatite are strontian calcite, carbocernaite, britholite and calcian strontianite plus minor baryte, pyrrhotite, sphalerite, alabandite, allanite, monazite and iron oxides.

IN a recent paper Chandrasekaran and Srivastava[1] have described the geochemistry of the Sarnu–Dandali carbonatites. They report that some of the carbonatites of the area have high REE (> 5000 ppm La & Ce by spectrographic analysis). Further probe of these samples by XRF at Leicester University by one of us (M. J. L.) revealed that total REE+Sr+Ba in some of these carbonatites varied from 6 to 16 wt% and the REE from 3 to 6 wt%. This sets in motion detailed chemico-mineralogical investigations of these carbonatites. The present communication describes in brief the setting and nature of these rare REE-rich carbonatites.

The high Sr-REE carbonatites of Sarnu–Dandali occur as intrusive in the melanephelinites to the north of the village Kamthai. The width of these carbonatites varies from a few mm to a maximum of 20 cm, large majority, however, have width varying from 5 to 10 cm only. They are extremely penetrative in nature and show vague flowage. The forceful injection of these carbonatites has resulted into shattering of the host melanephelinites and injection of material along the fracture planes has resulted into netveined melanephelinites and carbonatites. The field disposition suggests the possibility of a central carbonatite stock lying below the melanephelinites and the sand covers.

In hand specimen the carbonatite is light grey and its contact with dark grey fenitized melanephelinite is sharp. Under an optical microscope the carbonatite appears to be composed entirely of calcite with rare isolated crystals of opaque minerals. However, back scattered electron micrograph of a polished thin section taken at the Natural History Museum, London, (By F. Wall) reveals that carbonatite consists of a strontian–calcite with exolved lamellae of carbocernaite [(Ca, Na) (Sr, Ce, Ba) $(CO_3)_2$] oriented parallel to its twin and cleavage planes. Complex (possibly cotectic) intergrowth of carbocernaite and Sr-rich calcite with late Ca-rich strontianite (13 wt% CaO) are also present[2]. Besides the strontian calcite, carbocernaite and calcian strontianite the other minerals present are britholite-(Ce), [$Ca_2Ce_3(SiO_4)_3$ (OH, F)] plus minor baryte, pyrrhotite, sphalerite, alabandite, alanite, rare monazite (Ce) and iron oxides.

In terms of its major oxide constituents (Table 1) the carbonatite has a composition transitional between that of Sövite and Ferrocarbonatite with some unusual features. (i) The MnO content is high at nearly 3%, however, MnO is known to increase with the fractionation. (ii) The high sum of Na_2O+K_2O at > 1% is abnormal because there are no feldspar, micas, amphiboles or pyroxenes in the carbonatite, carbocernaite is a possible host mineral for sodium but the host for potassium is not known. (iii) Elements usually present in low quantities are present in major proportion, viz. Ca 6% REE, 5% Sr and 1.2% Ba.

The multi-element variation diagram (Figure 1) of Sarnu carbonatite has the characters of a typical

Table 1. Whole rock analysis of Sr-REE rich carbonatite dyke from Barmer

	Wt%		ppm
SiO_2	2.27	V	1
TiO_2	0.06	Cr	6
Al_2O_3	0.35	Ni	17
Fe_2O_3(T)	4.65	Zn	3400
MnO	2.78	Ga	7
MgO	0.88	Rb	1
CaO	39.30	Sr	53000
Na_2O	0.75	Y	133
K_2O	0.63	Zr	1
P_2O_5	0.76	Nb	227
LOI	34.00	Ba	11830
Total	86.43	La	22850
Total including trace elements	101.00	Ce	27750
		Nd	4950
(T)=Total iron as Fe_2O_3		Th	34
LOI = Loss on ignition			

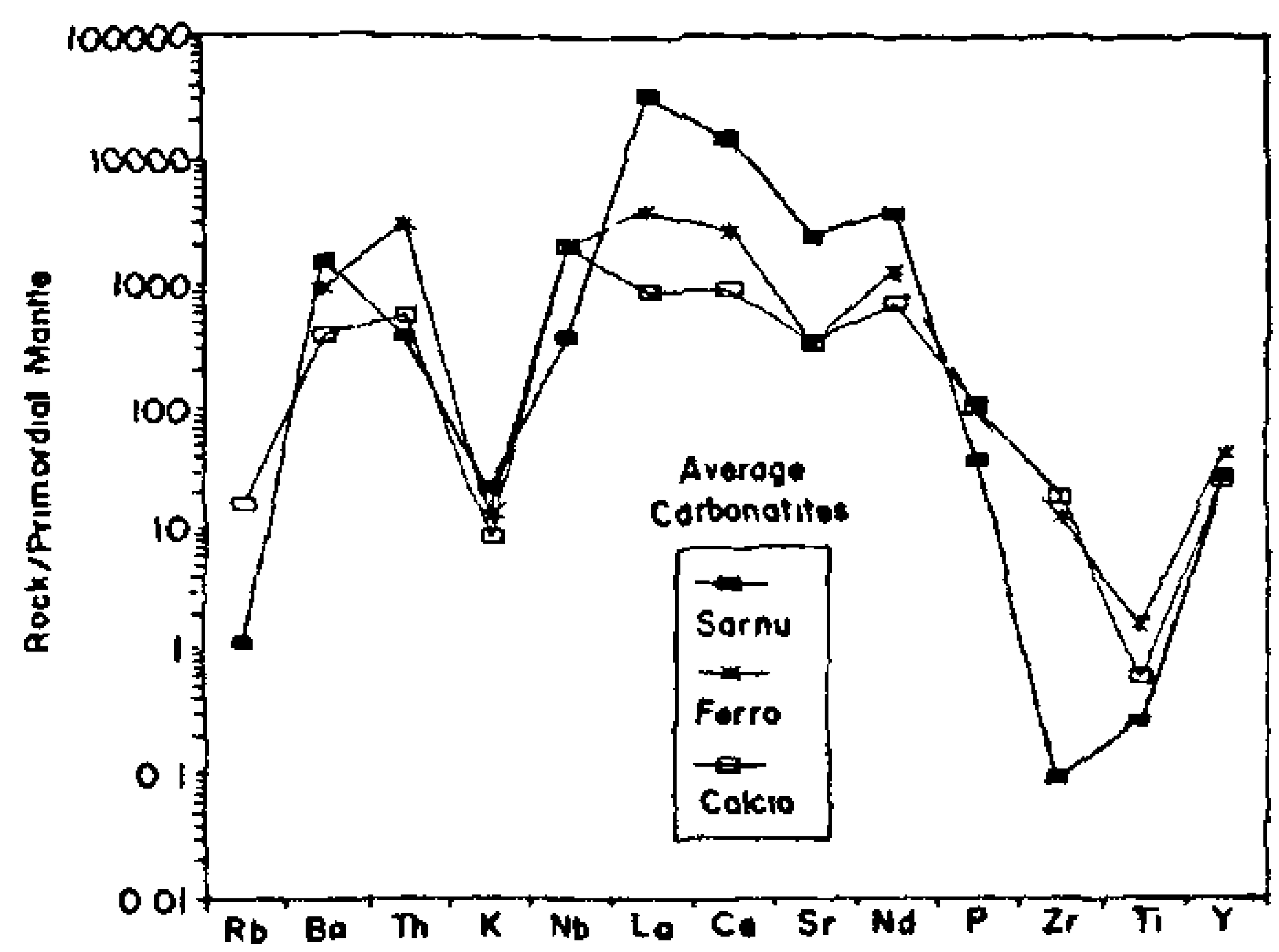

Figure 1. Spidergram to compare the Sarnu-Dandali carbonatite (Table 1) with average calciocarbonatite and ferrocarbonatite of Woolley and Kempe[4]. Primordial mantle data for normalization is from Wood *et al.*[5].

fractionated carbonatite, with relatively high normalized ratios for La, Ce, Nd and Ba but with a relatively lower ratio for Sr as shown by Clarke *et al.*[3]. Nb, Zr and Ti have smaller ratios as appropriate to elements that occur in minerals commonly fractionated early from carbonatite magma, i.e. pyrochlore, ziron and titaniferous magnetite. P is also usually much reduced in fractionated carbonatite owing to the early separation of apatite, but in Figure 1, P is only slightly lower than that of the average carbonatites plotted. This surprised us because there is no apatite in the dyke.

The P in this dyke is associated with the britholite-(Ce) (the silicate analogue of apatite which contains minor P) as well as rare monazite-(Ce) (30 wt% P_2O_5) and daquingshanite[2].

The mineral assemblage reported above and its texture has not been previously recorded. The Sr content of the strontian-calcite in the dyke reaches 13 wt% which is believed to be highest ever reported. The texture and mineral compositions indicate primary crystallization from a carbonatite magma rich in REE, Sr and Ba. The coexisting composition of the calcian-strontianite and strontian-calcite suggests subsolidus exsolution at 500° C and 2 kbar pressure.

1. Chandrasekaran, V. and Srivastava, R. K., *J. Geol. Soc. India*, 1992, 39, 321–328.
2. Wall, F., LeBas, M. J. and Srivastava, R. K., *Min. Magz. London*, 1993, in press.
3. Clarke, L. B, LeBas, M. J. and Spiro, B., International Kimberlite Conference, A. Araxa 1991, Proceedings, CRPM Brasilia, 1993, in press.
4. Woolley, A. R. and Kempe, D. R. C., *Carbonatites : Genesis and Evolution* (ed. Bell, K.), Unwin Hyman, London, 1989, pp. 1–14.
5. Wood, D. A., Joron, J. L. and Treuil, M., *Earth Planet. Sci. Lett.*, 1979, 45, 326–336.

Received 20 February 1993; accepted 17 May 1993

First record of marine macroinvertebrate from Bhuj Sandstone (Lower Cretaceous) of eastern Kachchh

U. K. Shukla and I. B. Singh*

Department of Geology, Kumaun University, Nainital 263 002, India

*Department of Geology, Lucknow University, Lucknow 226 007, India

The record of shell impressions (external moulds) of *Indotrigonia*, a marine bivalve from Bhuj Sandstone, the youngest lithostratigraphic unit of Kachchh Mesozoic, supports the marine depositional environment of Bhuj Sandstone. This finding also supports the contention that during deposition of Bhuj Sandstone a rich benthonic population was present (as evidenced by the presence of rich trace fossil assemblage). However, the highly porous nature of sand caused dissolution of shells during diagenesis, destroying the body fossils but preserving the trace fossils.

THE Mesozoic rocks of Kachchh are well-known for their fauna and flora[1–7]. Bhuj Sandstone (Bhuj Formation≃Umia Formation) is the youngest lithostratigraphic unit of Mesozoic sequence of pericratonic Kachchh basin (Table 1). It is extensively developed in the Kachchh mainland and represented mainly by sandstones with occasional silt and clay horizons. Bhuj Sandstone is mostly devoid of animal body fossils, except in western part where few horizons rich in macroinvertebrates are present[8]. Recently, trace fossils have been recorded from Bhuj Sandstone[9–12]. Absence of animal body fossils and presence of plant fossils in Bhuj Sandstone are considered as main argument to support a fluvial or continental origin of Bhuj Sandstone[8]. However, facies association and trace fossil studies suggest a coastal marine environment of deposition for Bhuj Sandstone[11–14].

During regional facies study of Bhuj Sandstone, three shell impressions of marine bivalve are recorded from a fine-grained sandstone unit of Bhuj Sandstone, exposed in the vicinity of Bhuj township along Bhuj–Mandvi road (Figures 1 and 2). This is the first record of animal body fossils from the eastern part of Kachchh mainland. These body fossils are described in the following and their significance is discussed.

Classification

Phylum: Mollusca
Class: Bivalvia Bonnani, 1681
Sub-class: Palaeohetrodonta Newell, 1965
Order: Trigonoida Dall, 1889
Superfamily: Trigoniacea Lamark, 1819
Family: Trigoniidae Lamark, 1819
Genus: *Indotrigonia* Dietrich, 1933

Indotrigonia smeei (Sowerby)
Plate I–a, b & c

Trigonia smeei Sowerby[15], 1840 Plate III, Fig. 9.
Plate IV, Fig. 1–3, Medlicott and Blandford[16] 1879
Plate XII, Fig. 11 Kitchin, 1903, p. pl. III, Fig. 9, 9a (ref. 3).

Indotrigonia smeei (Sowerby)–Dietrich[17], 1933, p. 30, pl. III, Fig. 48–51, 54–56.

Material. Three external moulds.

Diagnosis. The shells of *Indotrigonia* are characterized by an elongated oval form with well incurved and