Thirteenth Indian Expedition to Antarctica, Scientific Report, 1997
Department of Ocean Development, Technical Publication No. 11, pp. 227-236

Calc-alkaline Lamprophyres from Schirmacher Oasis, Queen Maud Land, East Antarctica

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Abstract

Several lamprophyre dykes of calc-alkaline (shoshonitic) nature are reported from Schirmacher Oasis,Queen Maud Land, in Eastern Antarctica. These dykes are characterised by high K_2O/Na_2O (avg. 5.81) ratios, high Rb,Sr,Zr and Th abundances. REE distribution patterns show a significant enrichment of LREE against HREE (avg. La_n/Yb_n=27.51) without any Eu anomaly and appears that these ultrapotassic dykes have been derived from partial melting of a thickened lithosphere.

Introduction

Elemental abundance in basic volcanic rocks has been used to identify the nature of their parental magma, the amount of partial melting of the mantle source, its differentiation and the tectonic environment of magma emplacement (Pearce and Cann 1973; Sun and Nesbitt 1978; Sun *et al,* 1979; Tatsumi and Ishizaka, 1982). The Polymetamorphosed precambrian rocks of Schirmacher Oasis (Fig. 1) is characterised by the occurrence of varied intrusive rocks (Kaul *et al.*, 1985; Kampf and Stackebrandt, 1985). Recently lamprophyre dykes of shoshonitic affinity (Wand *et al.,* 1991) and an alkaline affinity (D'Souza *et al.,* 1994) have been reported from the Schirmacher Oasis. Lamprophyres of shoshonitic affinity have also been reported from Pevikhornet and Sonste-bynuten nunataks, adjacent to the schirmacher Oasis (Singh *et al.,* 1988).

During the 13th Indian Antarctic scientific expedition, several lamprophyre dykes were noticed in the Schirmacher Oasis. The aim of this paper is to record these occurrences and describe the petrography and geochemistry of the lamprophyres.

Geology

The east-west trending Schirmacher Oasis-off Princess Astrid Coast in the Central Droning Maud Land of East Antarctica is exposed over an area of

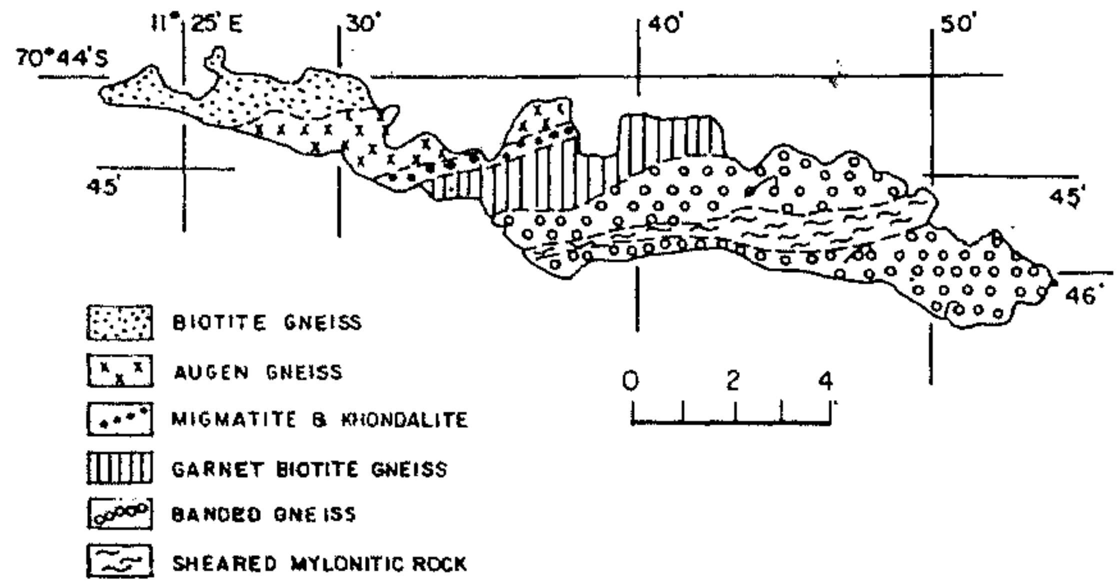

Fig.1: Generalised geological map of Schirmacher Oasis (after Singh, 1986)

approximately 35 sq kms. It lies at an altitude of 100 meters above sea level with steep cliffs towards the shelf and on the southern side it is covered by polar ice. The area is mainly comprised of garnet-biotite gneiss, pyroxene granulite, calc-gneiss, khondalite along with migmatite and augen gneiss (Singh, 1986; Sengupta, 1986; 1988). The lithological units usually have gradational contacts with one another and patches of a particular unit may occur sporadically within large outcrops of the other (Sengupta, 1988). However, other workers have suggested that the boundaries separating the different rock units are in most cases of tectonic character (Kampf and Stackebrandt, 1985; Bormann *et al.,* 1986). The rocks of Schirmacher Oasis are high-to medium-grade and are polymetamorphic in nature (Ravich and Soloviev, 1966; Ravich and Kamenev, 1972), and have suffered five generations of superposed folding and all the folds are buckling folds (Sengupta, 1988).

The area does not show any well defined mappable shear zone, although extensive mylonitisation took place throughout the area. The intensity of shearing is not uniform and it varies from place to place and these shear zones run in almost E-W direction with a moderate dip towards south. Boudinage structures are common in the Schirmacher Oasis and are mostly noticed in the bands of pyroxene granulite, calc-gneiss and amphibolites (Sengupta, 1988).

The polymetamorphosed rocks of Schirmacher Oasis are intruded by dolerite, basalt, pegmatite, lamprophyre dykes and an aplite dyke (Bormann *et al.,* 1986). The available age data (K-Ar ages), on a few of the basalt dykes of

Schirmacher Oasis range from 290 m.y. to 302 m.y. (Kaiser and Wand, 1985). The ages for the remaining intrusive rocks of the Oasis are not available and based on field observations. Wand *et al* (1991) have suggested that the lamprophyre dykes are younger than the associated pegmatite dykes and older than the basalt dykes.

Several lamprophyre dykes are noticed near DG glacier in the central part and near the Russian station (Novo) in the eastern part of the Schirmacher Oasis. Their length varies from less than 10 meters to about 500 meters and width from a few centimeters to about one meter. Lamprophyre dykes, which occur in central part of the Oasis are dark brown, lustrous rocks with dark brown coloured mica (shining porphyries). These dykes show chilled margins and are characterised by the occurrence of "ocelli" which range from a few mm to one cm in diameter.

Analytical Techniques

The mineral compositions were determined by a Cameca make Electron Probe Micro Analyser (EPMA) on polished and carbon coated thin sections, using the correction procedure of Henoc and Maurice (1978). The operating conditions were 15 KV accelerating voltage, 4 nA sample current and counting time of 10 seconds with a beam diameter of 1-5 um both in standards and the samples.

Major and minor elements were analysed by using a Phillips PW- 1400 model X-ray Fluorescence Spectrophotometer. Precision and accuracy of XRF data have been reported earlier by Govil (1985). Trace and rare earth elements (REE) were determined using an ICP- MS (VG Plasma Quad) technique (Balaram *et al.,* 1992). Using this method precision of 1 -7% relative to standard deviation and comparable accuracy were obtained.

Petrography

These lamprophyre dykes are composed of biotite and clinopyroxene microphenocrysts within a medium to fine grained matrix of biotite, clinopyroxene, alkali feldspar and chromite. In these lamprophyres, glomeroporphyritic aggregates of clinopyroxene are common (Fig.2).

Microprobe analysis show that the biotites are biotite to phlogopite in composition and their Al_2O_3 content ranges from 12.70 to 16.12 wt%. Opaques are chromite in composition. Pyroxene microphenocrysts as well as interstitial grains are augite and endiopside in composition and their Al_2O_3 and Na_2O contents range from 0.46 to 3.55 and 0.01 to 1.55 wt% respectively. Alkali feldspars show FeO range from 0.00 to 0.17 wt%.

Fig.2: Photomicrograph showing glomeroporphyritic aggregates of clinopyroxene (X250)

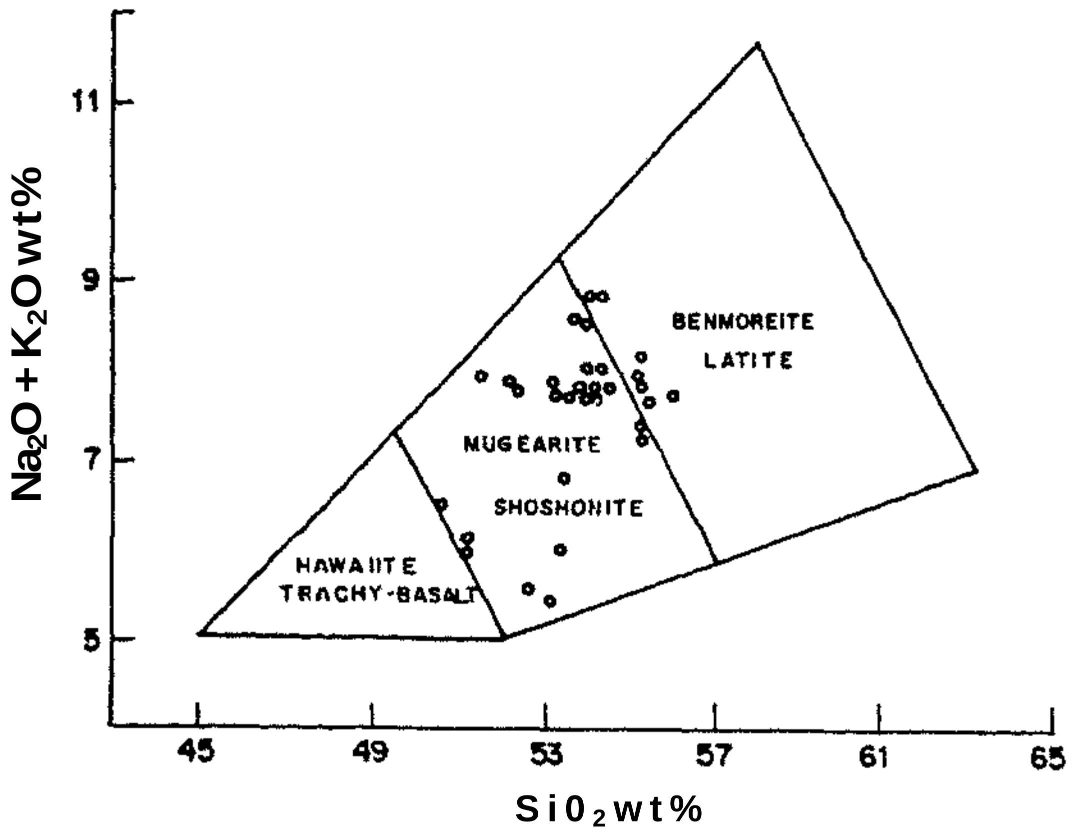

Fig.3: $Na_2O + K_2O$ versus SiO_2 diagram (after Lebas et al., 1986)

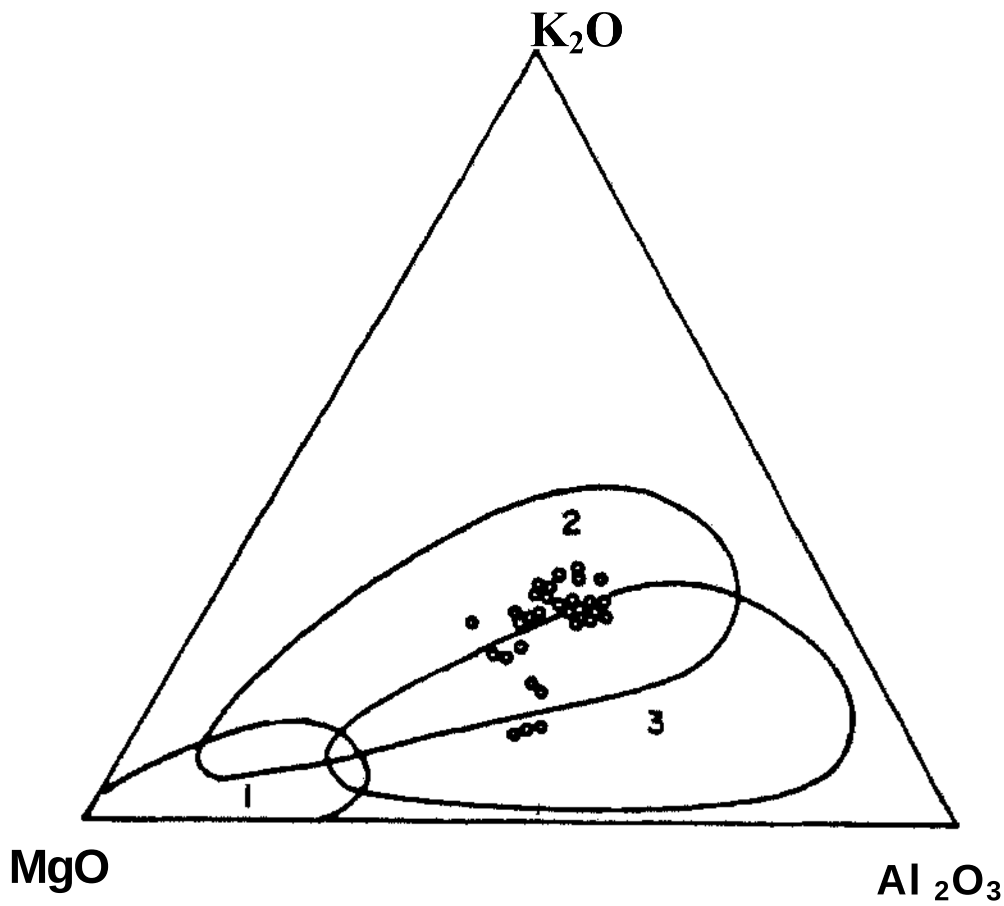

Fig.4: MgO - Al_2O_3 - K_2O diagram (1 = Kimberlites, 2 = Lamproites and 3 = Lamprophyres, after Bergman, 1987)

Table 1: Average major element composition of the lamprophyre dykes from the central and eastern parts of the Schirmacher Oasis

	Central (n =13)	Eastern (n=19)
SiO_2	53.60	53.25
TiO_2	1.28	1.25
Al_2O_3	9.45	10.39
Fe_2O_3	7.95	8.04
CaO	5.42	5.53
MgO	10.28	8.15
Na20	0.79	1.34
K_2O	6.50	6.43
MnO	1.94	2.26
P_2O_5	1.28	1.39
LOI	1.07	1.13
Total	99.56	99.16

n = number of samples analysed.

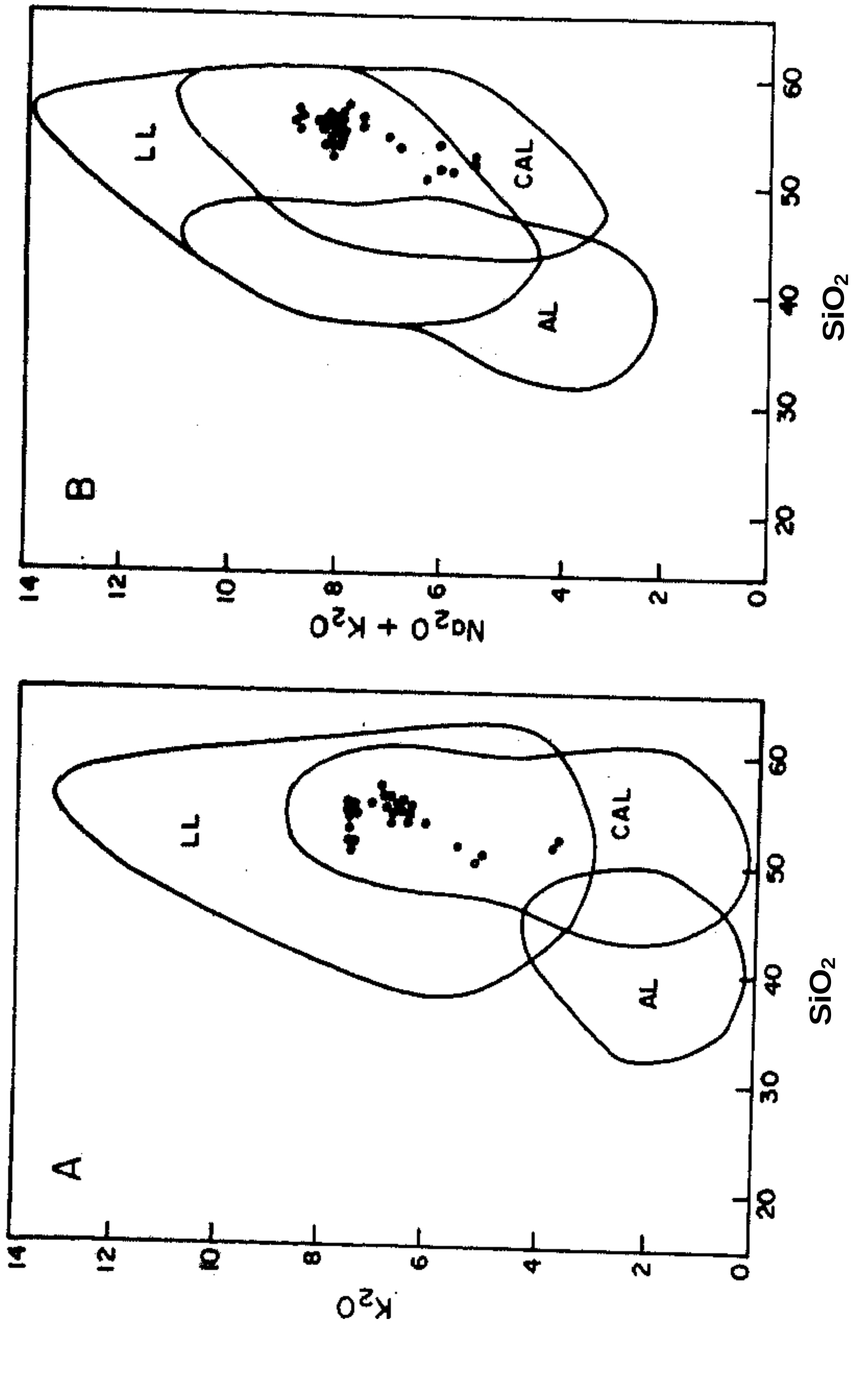

Fig.5a: K2O versus SiO2 diagram and
b. K2O + Na2O versus SiO2 diagram (Al= Alkaline, CAl= Calc- alkaline, LL= Lamproites, after Rock 1987)

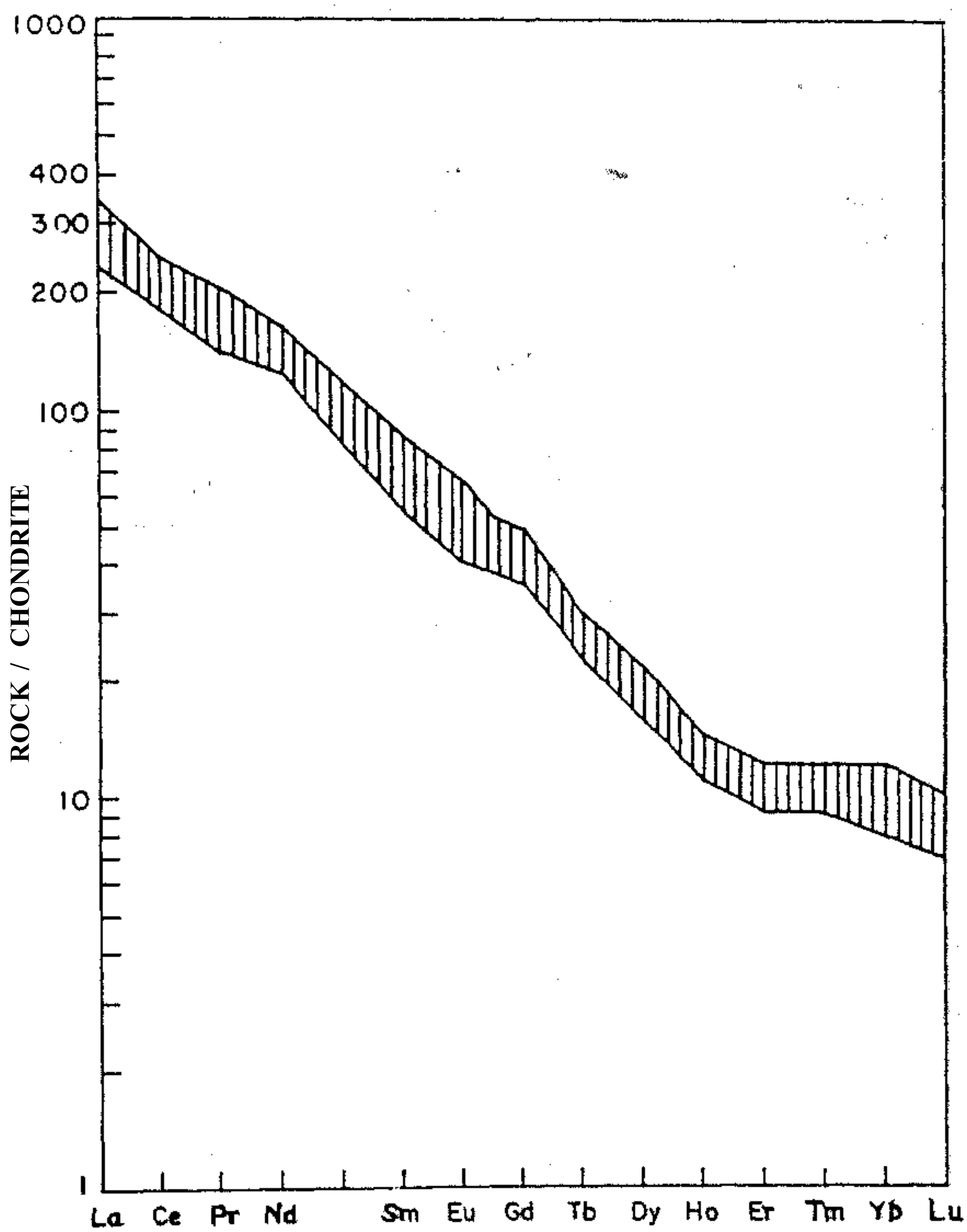

Fig.6: REE distribution pattern of lamprophyre dykes from Schirmacher Oasis.

Geochemistry

Major and minor elements of representative lamprophyre dykes from the central and the eastern parts of the Schirmacher Oasis are presented in Table 1. These lamprophyre dykes have extremely high K_2O content. The ultrapotassic nature of these dykes is also indicated by high K_2O/Na_2O and K_2O/Al_2O_3 ratios. Total alkalies and silica abundance of these samples also substantiate their ultrapotassic nature as they plot in shoshonite and latite fields (Fig.3). MgO - Al_2O_3 - K_2O plot of these samples show both lamproite as well as lamprophyre nature (Fig.4). In K_2O and $K_2O + Na_2O$ versus SiO_2 diagram, these samples show both lamproite as well as calc-alkaline nature (Fig. 5a,b). The lamproite or Calc- alkaline (shoshonitic) nature of these samples can not be efficiently differentiated by these diagrams alone. Mitchell and Bergman (1991) have suggested that lamproites should typically have the elemental abundances of Zr > 500 ppm, La > 200 ppm, Sr > 1000 ppm and Fe-rich (1-5 wt.%) sanidine and Al_2O_3-poor (5-12 wt.%) phlogopite. As the samples of these lamprophyre dykes have elemental abundance of Zr (224-458 ppm), La (69-105 ppm), and Sr (611-1844 ppm) and Fe-poor (0.00-0.17) alkali feldspar and Al_2O_3- rich (12.70 - 16.12) phlogopite, suggesting that these dykes are not lamproites and in addition as these samples plot in calc- alkaline field (Fig. 5 a,b), it is suggested that these dykes are lamprophyres of a calc-alkaline (shoshonitic) nature.

These dykes are characterised by the higher abundance of Ba (5064 to 7394 ppm), Rb (106 to 290 ppm), Sr (622 to 1843 ppm), Th (8.83 to 21.51 ppm) and Zr (205 to 458 ppm). The REE distribution of these lamprophyre dykes show strong LREE enrichment relative to HREE (average $La_n/Yb_n = 27.51$) and no Eu anomaly (Fig.6). These ultrapotassic lamprophyre dykes of Schirmacher Oasis appears to have been derived from the partial melting of an overthickened lithosphere as has also been suggested for the ultrapotassic lamprophyre dykes found in the eastern Queen Maud Land, East Antarctica (Arima and Shiraishi, 1993).

Acknowledgements

The author is grateful to Dr. H.K.Gupta, Director, N.G.R.I., Hyderabad and Dr.P.Rama Rao, Secretary, (DOD and DST), New Delhi, for sponsoring his participation in the 13th Indian Scientific Expedition to Antarctica and permission to publish this paper. The author is thankful to Dr. V. Divakar Rao for discussions and valuable suggestions. He is also thankful to Messers. M. J.Baig, R.Asthana, A.Chaturvedi and M.J.D'Souza (GSI) for help and discussions, Drs. Narayanan (PRL) and Ghosh (NEERI) for their help and company during geological traverses in the Schirmacher Oasis.

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