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A Note on the Petrochemical Characteristics of a Nodular Basalt Dyke from Schirmacher Hills, East Antarctica

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Abstract

The basaltic dyke containing nodules, *insitu* occurrence of which was located during the present expedition, lies in the central part of the Schirmacher range. Some samples from this were further studied from petrochemical point of view and a few interpretations made. Chemical parameters indicate that the basaltic magma has originated by partial melting at great depth and the magma rose rapidly intruding the country rock. More detailed field and laboratory investigations on this rock will contribute to the knowledge on the origin and evolution of this occurrence.

Introduction

The second Indian Expedition to Antarctica reported the occurrence of nodular basaltic boulders in the central part of Schirmacher hills, north of the snout of Dakshin Gahgotri glacier. These erratics were reported to occur in the form of few individual nodules and as agglomeration of nodules within the parent rock. However, *insitu* outcrop of this nodular basalt could not be located although location of these 'erratics' was plotted on the geological map (Kaul et a/., 1985). A re-examination of this area by the geologists of the Fifth Indian Expedition team to Antarctica revealed the occurrence of a small nodular basaltic dyke in the vicinity of these boulders further north (Fig. 1) and thus led to the source of the 'erratics' found earlier. The dyke is about 0.50m in width, on an average, and has transgressed the gneisses.

Megascopically the dyke rock under discussion is fine-grained and dark grey in colour. Well rounded nodules are embedded in the host rock giving it a distinctive appearance. Both, the host rock and the nodules have small vesicular pits on the exposed surface. Smooth, conchoidal grooves are noticed in the host rock presumably caused by the removal of nodules (Fig. 2).

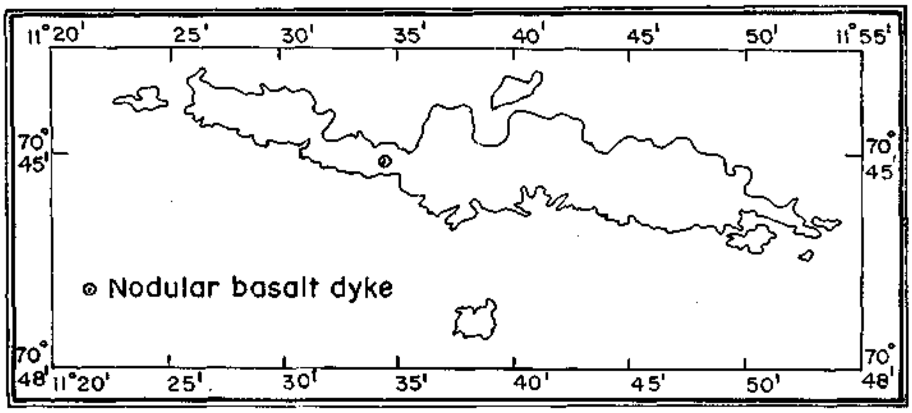


Fig. 1. Location of Nodular basalt dyke, Schirmacher hills, Antarctica

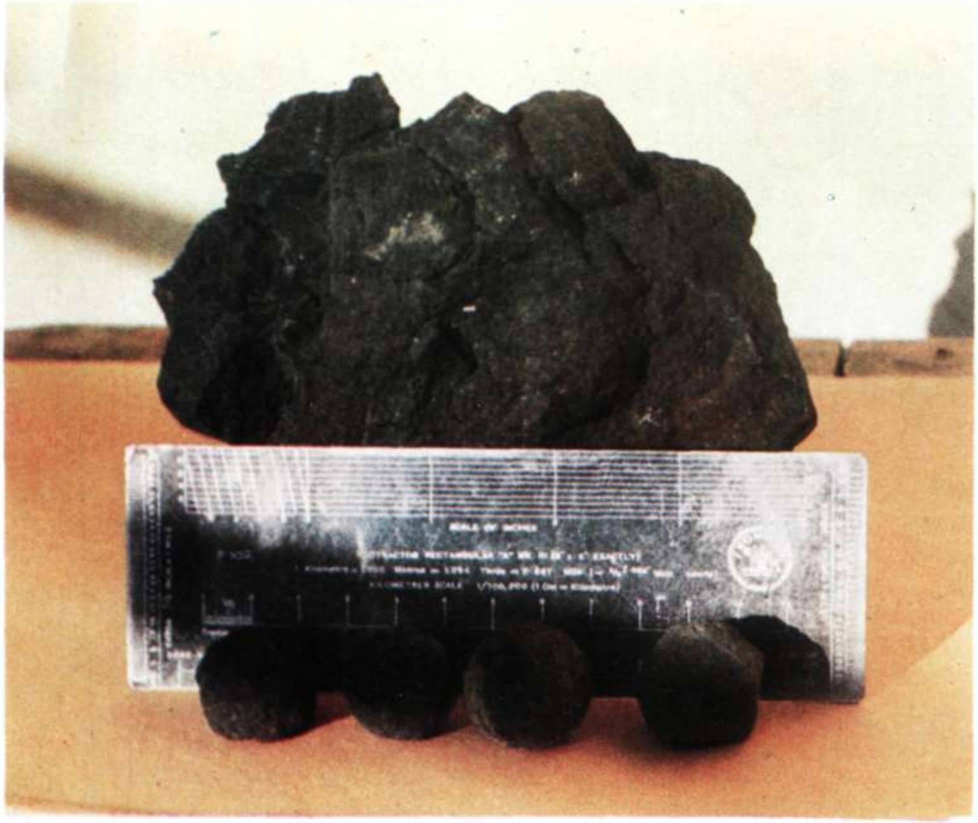


Fig. 2. Typical megascopic appearance of the dyke rock (Individual nodules are in the foreground)

Petrochemical Interpretations

Petrochemical studies carried out on the 'erratics' during the second Indian Expedition to Antarctica have already been described (Raina *et* al., 1985) which identified these rocks as olivine-basalts. Further studies on the samples collected during the present expedition have revealed the formation of clusters by olivine phenocrysts (Fig. 3). Intersertal texture is very common and as a whole it appears as if the phenocrysts are floating in the highly glassy groundmass (Fig. 4).

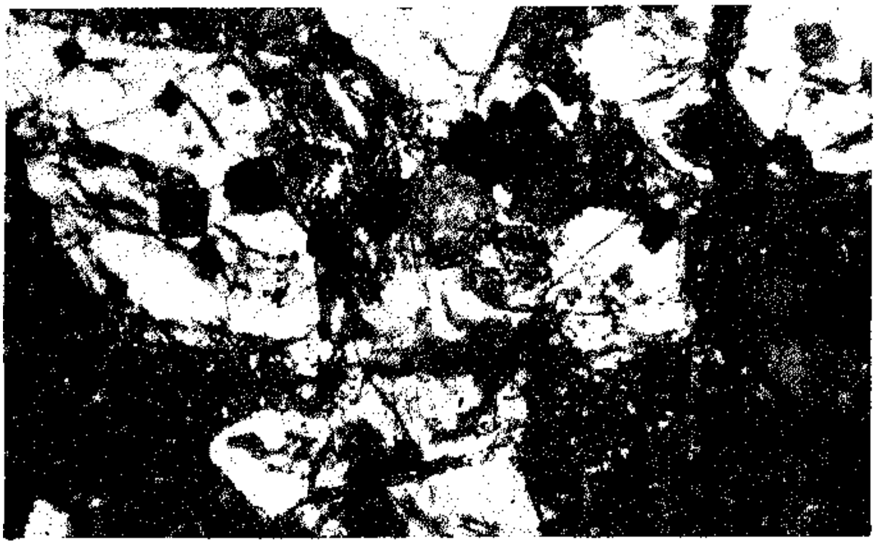


Fig. 3. Photomicrograph showing clustering of olivine in the basaltic rock (CN X 61).

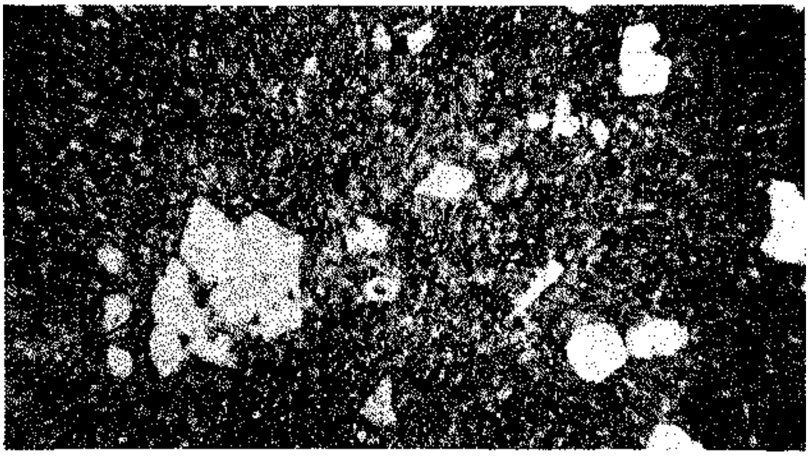


Fig. 4. Photomicrograph showing phenocrysts "floating" in the glassy groundmass (CN x *20).*

The major element oxides of the samples collected during the present expedition, alongwith those of the second expedition, and available representative analyses of the basaltic rocks from different parts of the world are presented in Table **I.**

Table I. Oxide weight percentages of basaltic host rock and nodules, Schirmacher hills, E. Antarctica and of basalts from some other world occurrences.

Oxides	1	2	3	4	5	6	7	8
SiO_2	45.18	44.65	45.05	44.55	50.14	53.30	45.20	48.78
TiO_2	2.16	2.24	1.32	1.34	1.55	1.00	0.67	2.44
Al_2O_3	12.22	10.42	12,98	13.30	15.47	15.20	7.05	13.78
Fe_2O_3	1.65	4.42	13.08^T	13.80^T	—	1.60	1.40	4.03
FeO	9.95	8.80	—	—	11.20	8.30	6.84	9.28
MnO	0.19	0.18	0.19	0.19	0.20	0.10	0.14	2.21
MgO	10,03	11.15	10.40	9.05	6.65	6.30	4.16	6.26
CaO	11.70	12.05	10.21	10.54	10.62	10.10	6.98	10.45
Na_2O	3.01	2.94	3.10	3.68	2.94	2.00	1.13	1.93
K_2O	0.72	0.66	0.98	1.07	0.57	0.90	0.38	0.44
P_2O_5	0.29	0.23	0.31	0.31	0.22	0.10	0.07	0.23
CO_2	1.52	0.70	—	—	—	—	—	—
H_2O	1.04	1.66	—	—	—	0.90	—	—
LOI	—	—	1.51	1.63	—	—	—	—
Total	99.66	100.10	99.13	99.46	99.56	99.80	74.02	99.83

T total iron as Fe_2O_3
1 & 3 nodules
2 & 4 host rock (matrix of the above nodules)
1 & 2 after Raina *et al,* (1985)
3 & 4 present sample analyses
5 High magnestan Picture Gorge-basalt (Wright *et al,* 1973)
6 Average of chilled margins of Ferrar (Antarctica), Tasmania, Karroo, Palisade and Whin Sill dolerites (Wilkinson, 1981; Table I, No. 4),
7 Major elements for Siberian basalt (Viswanathan and Chandrasekharan, 1981; Table 3).
8 Basalt vein in tholeiite, western Dronning Maud Land (Von Brunn, 1964; Table I, No. 8).

The normative values of the samples from present area only are given in Table'II. (The normative values of samples 1 & 2 were calculated from chemical analysis data in Raina *et al,* 1985).

In the study outlined below, graphical method has been utilised to compare the chemical behaviour of the present samples with some of the geochemical aspects of basalt magmatism. The few interpretations made thus, are given as under:—

(i) The dyke is an alkali-basalt dyke as indicated by their plots in the

Table II. Normative values **of basaltic host rock and nodules, Schirmacher hills, E. Antarctica.**

Normative mineral	1	2	3	4
Or	4.45	3.89	5.79	6.32
Ab	19.39	16.24	24.05	21.31
An	17.51	13.34	18.61	16.61
Ne	3.41	4.54	1.18	5.32
Di	23.67	32.03	20.37	23.14
Ol	19.80	15.56	11.53	8.27
Mt	2.32	6.50	—	—
11	4.10	4.26	0.41	0.41
Ap	0.67	0.67	0.72	0.72
Ca	3.50	1.60	—	—
Hm	—	—	13.08	13.80
Per	—	—	1.88	1.92

alkali-silica diagram (Fig. 5) of Macdonald and Katsura (1964) and Irving and Baragar (1971).

(ii) Green and Poldervaart (1958) used two ternary diagrams Mg-Fe$_t$-Alk and Ca-Na-K (atomic weight percent) to illustrate differentiation in basaltic rocks. Plots of the present data in such diagrams indicate that they form cluster near the Ca apex (Fig. 6) and this might be representing the original composition of the magma. Fig. 7 indicates that these basalts are different from the trend of the average igneous rocks. Their moderate to high Fe$_t$, points to a slightly advanced stage in the general differentiation sequence.

(iii) Plots of the present data in the normative pyroxene-plagioclase-olivine diagram (Fig. 8) show that the specimens tend to fall in the olivine rich side of a boundary line that represents an olivine-plagioclase co-tectic (Miyashiro et al., 1970, Shido *et* al., 1971). It thus becomes clear that there is an early separation of olivine and plagioclase and that the order of crystallization in the early stage is controlled mainly by the relative amounts of olivine, plagioclase and pyroxene in the magma.

(iv) Jamieson and Clarke (1970) considered the relation between MgO and K O content as the most suitable differentiation index and thought that the dominant differentiation process is crystal-liquid fractionation. Plots of the data (Fig. 9) indicate that the magma has **a** different differentiation trend showing a significant departure from that of other basalts from different parts of the world.

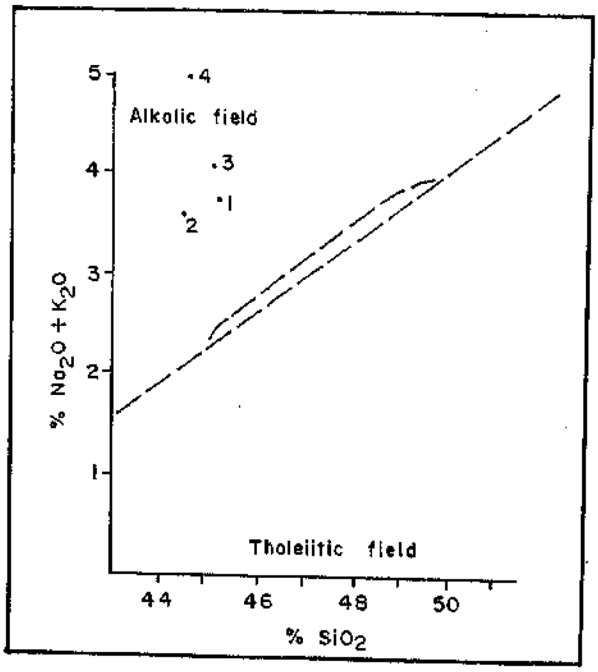


Fig. 5 Plots of the samples in the alkali-silica diagram of Macdonald and Katsura 1964. (curved dashed line after Irving and Bar agar, 1971)

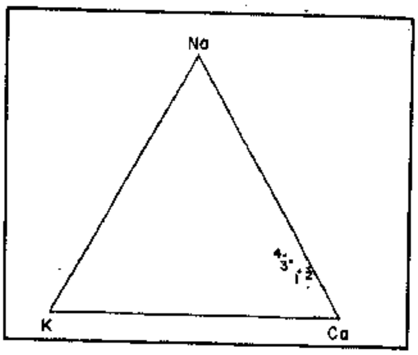
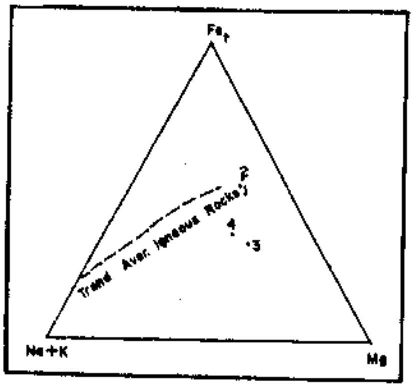
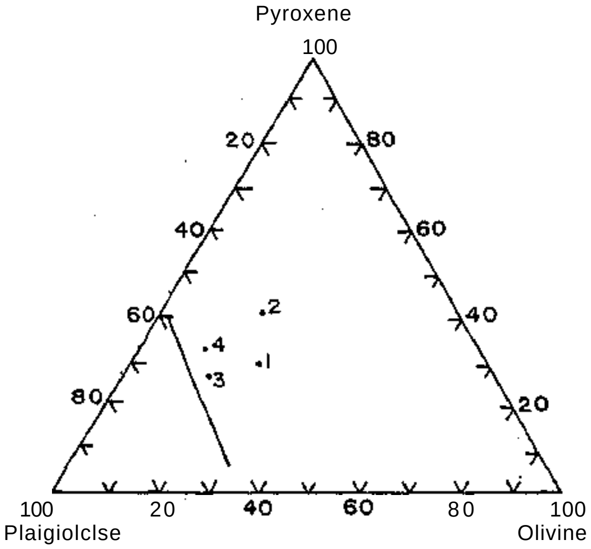


Fig. 6. Plots of the analyses on Ca - Na — K diagram



Fig, 7 Plots of the analyses on Mg - Fe, - Alk, diagram



Pig 8. Analyses plotted on the normative Olivine—Plagioclase— Pyroxene diagram

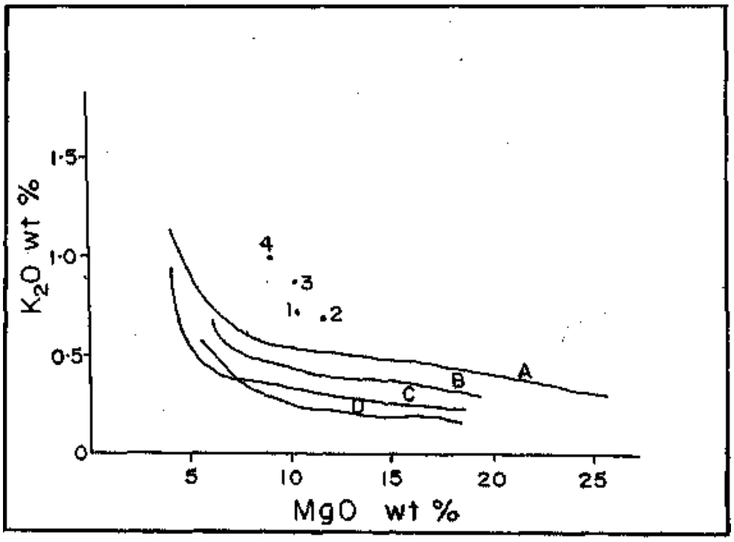


Fig 9. Plots of K_2O *versus MgO of the samples} trend A—Kilauea Iki; trend B—Makaopuhi Lava Lake; trend C— Tbingmuli; trend D—Skaergaard*

(v) An interesting point is noticed when the present analyses are plotted in a TiO_2 — K_2O — P_2O_5 diagram (Fig, 10) of Pearce er a/. (1975). It is seen that they fall" close to and on either side of the oceanic-basalt — continental basalt boundary. Similar nature of the samples is reflected when their TiO, values are plotted against K.,0 in a semi-log paper (Baragar, 1977) where they lie (Fig. 11) evenly distributed both within and outside the field of Ocean ridge basalts.

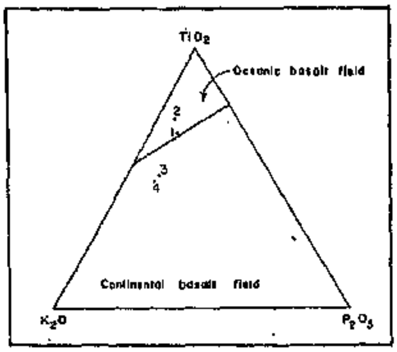


Fig. 10 TiO_2 - K_2O -P_2O_3 *plots of the analyses*

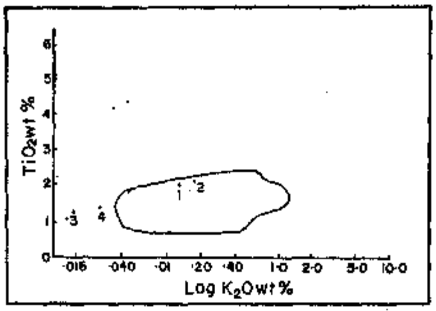


Fig. 11 Plots of the $Ti0_2$ *versus log* K_2O *of the samples, field of ocean ridge basalt*

The trace element values of four samples from this dyke are given in Table **III.**

Table III. Trace element analyses of nodular basaltic **rock, Schirmacher Hills, E. Antarctica (in ppm)**

	. **1***	2*	3	4
Cu	580	670	100	100
Pb	250	280	<5	<5
Zn	:670	690	100	100
Ni	1600	1640	150	150
Co	500	540	35	35

* from Raina *et al,* (1985)
3 & 4 Present sample analyses.

The samples 1 & 2 show a marked variation in the results obtained from those of samples 3 & 4. Confirmation of these values by further analyses on more samples is necessary before any interpretation is made, based on trace element geochemistry.

Conclusions

Basaltic dykes are reported from the western Dronning Maud Land also (Von Brunn, 1964; Wolmarans and Kent, 1982) and they are considered to be Triassic to Jurassic in age. These dykes are notable for containing phenocrysts of olivine (chrysolite) as well as bronzite, glomeroporphyritic augite and phagioclase. The groundmass contains grains or shafts of feathery pyroxene microlites, laths or sub-radiating crystals of plagioclase and olivine or pseudomorphs after olivine.

Petrographically these dyke rocks are similar to the Schirmacher occurrence, but to what extent they can be correlated in time cannot be speculated at this stage. Further, the basalt of the persent area is significant by virtue of its nodular occurrence, a phenomenon requiring further study.

The content of titanium is directly related to the depth of magma generation (McGregor, 1969). The titanium content in the samples studied indicates that the magma might have generated by partial melting at great depths within the mantle followed by rapid rise of the fluid from the chamber to higher level.

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