

**Basalt Microlapilli in deep sea sediments of  
Indian Ocean in the vicinity of Vityaz Fracture Zone**

**B. NAGENDER NATH AND S. D. IYER**

*Reprinted from*

*The Journal of the Geological Society of India, Vol. 34, No. 3, 1989*

**GEOLOGICAL SOCIETY OF INDIA  
BANGALORE  
1989**

## Basalt Microlapilli in deep sea sediments of Indian Ocean in the vicinity of Vityaz Fracture Zone

B. NAGENDER NATH AND S. D. IYER

National Institute of Oceanography, Dona Paula, Goa 483 004

### Abstract

Two cores recovered from the flanks of Mid-India oceanic ridge in the vicinity of Vityaz fracture zone consist of discrete pyroclastic layers at various depths. These layers are composed of coarse-grained, angular basaltic microlapilli in which labradorite is the major mineral set in a glassy mesostasis. Chemically the microlapilli are similar to Mid-Indian oceanic ridge basalts. The microlapilli are suggested to have been formed by the process of granulation, transportation and deposition, during Late Quaternary when lava of low viscosity erupted from small vents on a segment of Vityaz fracture zone.

### INTRODUCTION

Reports on basaltic microlapilli in pelagic sediments are rare compared with those of terrestrial microspherules, microtektites, and lunar glassy particles (Vallier *et al.* 1977).

Basaltic microlapilli consisting of glassy particles and rock fragments were recovered during the Indo-German collaborative cruise (GEMINO-I) SO-28, during 1983. The sedimentology, petrography and chemistry of the basaltic microlapilli is attempted to ascertain their genesis and mechanism of formation.

For the present study, two cores 37 KL and 40 KL of 2.48 and 1 m in length were recovered from water depths of 4452 and 4563 m respectively. The stations (5°53'S; 68°11'E and 5°54'S; 68°8'E) are located between Vityaz and Vema fracture zones (Fig. 1) but nearer to the western end of the Vityaz fracture zone on the Mid-Indian Oceanic Ridge (MIOR).

### MATERIALS AND METHODS

Distinct volcanoclastic layers resembling black rock fragments were noticed in both cores at various depths (Fig. 2). In the core 37 KL these layers were noticed at 50–58 cm, 149–180 cm and at 160–169 cm; and in the core 40 KL at depths of 38–52 cm and 52–56 cm, with abundant foraminifera. These pyroclastic layers were separated, washed with distilled water and dried in an oven at 60°C. After wet sieving through 230 mesh sieve, they were passed through 14, 16, 45 and 120 ASTM mesh sieves. A part of the sample was mounted onto glass slides for textural and mineralogical studies. For the separation of the foraminifera, the samples were treated with acetone so as to make them float. After air drying and washing with distilled water, they were studied for species identification. Chemical analyses for

calcium carbonate content, major and minor elements were determined (Anon, 1983). To identify the mineral phases, samples were crushed to a fine powder and mounted on aluminium holders and analysed by Phillips X-Ray Diffractometer. The physical conditions of operations were 40 kv, 20 mA, Cu  $K\alpha$  target, rotation speed of 20/minute from  $8^\circ$  to  $64^\circ$ .

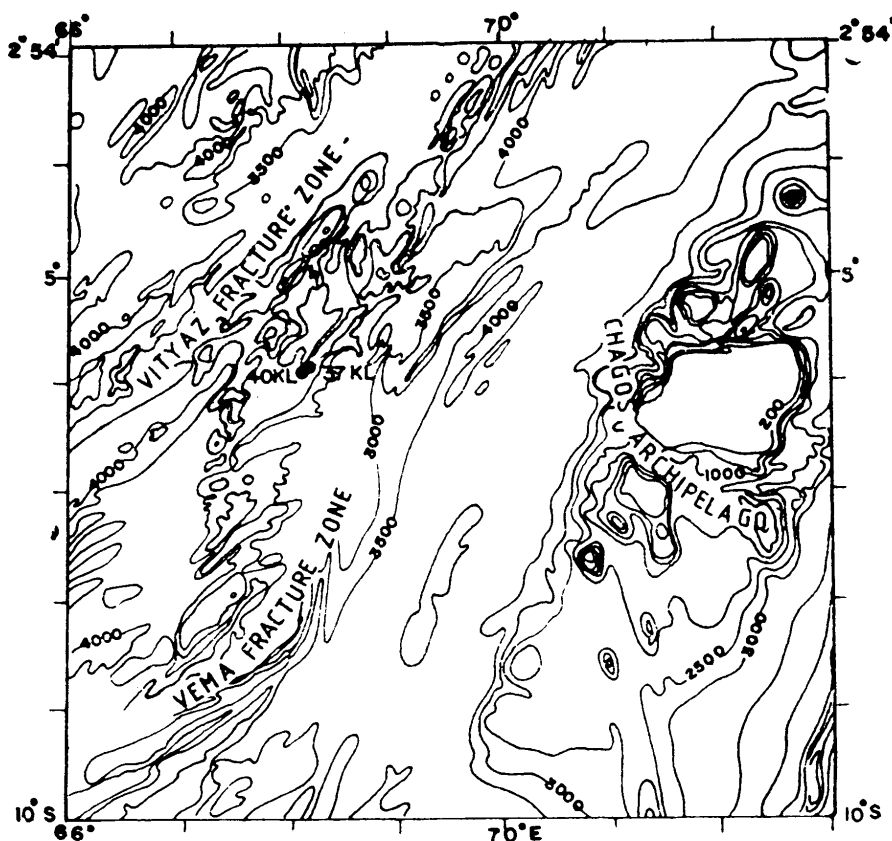


Figure 1. Sample location map.

#### RESULTS AND DISCUSSION

Core 37 KL consists of silty clay with intermittent silty sand, sand and sand-silt-clay textured layers at 52-55, 75-77, 149-157, 160-164, 173-176 and 179-180 cms. In core 40 KL the sediment is composed of silty clay with foraminiferal sand layers at 38-52 and 62-68 cm depths. Black pyroclastic layer was observed at 52-56 cm. The pyroclastic grains are mostly dark in colour except for few that are buff coloured. The size ranges from very fine sand (0.125 mm) to very coarse sand (>1.41 mm). The grains are sub-angular to sub-rounded in habit (Fig. 3). X-ray diffractogram revealed labradorite to be the dominant mineral species with minor amounts of fayalitic olivine and chlorite:

Palaeontological observations indicated radiolarians to be abundant in 37 KL and in 40 KL *Globigerina menardi* and to a lesser extent *G. ruber* dominates. Deep water benthic fauna were seen in lesser proportion. Based on the faunal assemblage, the age of the sediment is assigned to Late Quaternary (Gupta, personal

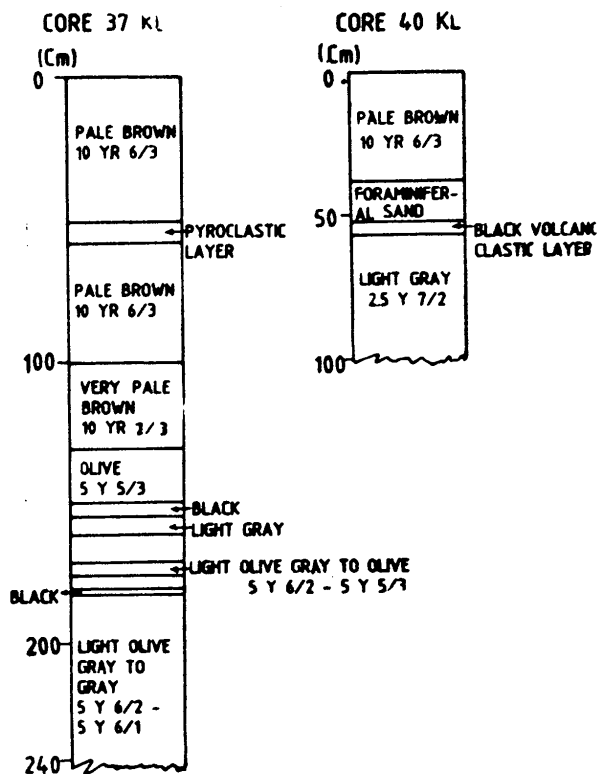


Figure 2. Figure showing the colour logs of the cores.

communication). The chemistry (Table I) of the rock fragments indicates their derivation from a tholeiitic magma with typical values of  $\text{SiO}_2$ ,  $\text{FeO}$ ,  $\text{CaO}$  and  $\text{K}_2\text{O}$ . The trace element values of Sr, Zr and Y also lie within the reported ranges of oceanic tholeiites (Subbarao *et al.* 1979). The triangular plot of  $\text{Ti}/100\text{-Zr-Sr}/2$  (Fig. 4) following Pearce and Cann (1973), shows these rock fragments to lie within the domain of ocean-floor basalt (OFB). The OFB being a major group, it was found necessary to plot the elemental values on binary plots, proposed by Bass *et al.* (1973) and Ridley *et al.* (1974). The plots of Sr vs Zr (Fig. 5a) and  $\text{P}_2\text{O}_5$  vs.  $\text{TiO}_2$  (Fig. 5b) helped to define the rock fragments as being of ocean ridge origin. This is corroborated by the fact that the samples are angular to subangular indicating less transportation. The possibility of these grains being microtektites is ruled out since the latter have much higher  $\text{SiO}_2$  and  $\text{K}_2\text{O}$  and are depleted in the other major oxides (Table I).

As regards the origin of basaltic microlapilli, very few works exist, the notable ones being that of von der Borch (1970, 1971) and Vallier *et al.* (1977) from Site 32

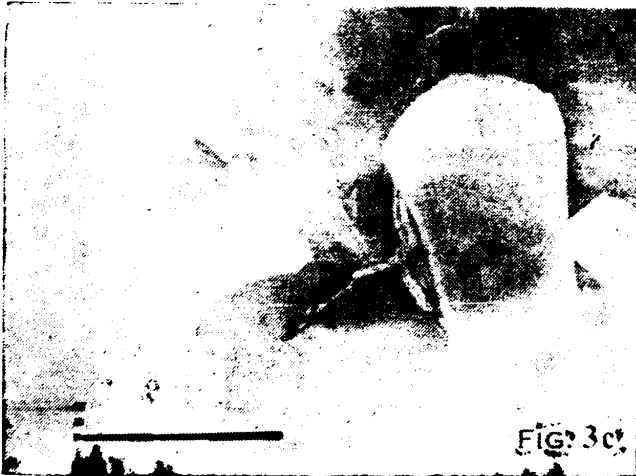
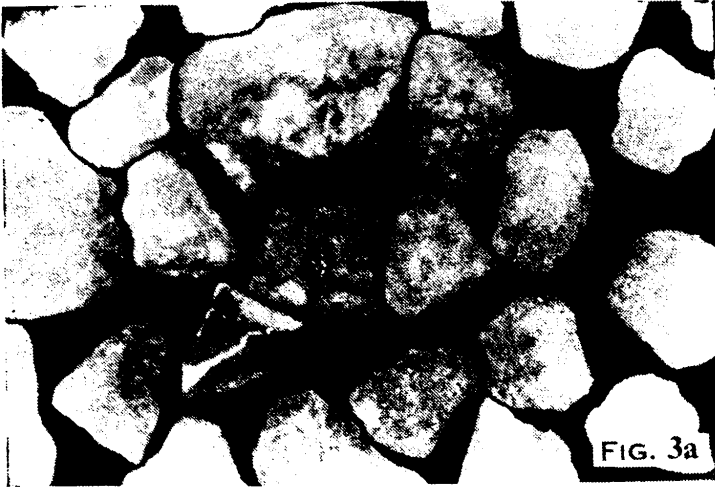


Figure 3. Morphology and characteristics of the basalt microlapilli. Equant shapes of fragments (a  $\times 10$  and b  $\times 7$ ) with the presence of glassy rind (b). c. SEM photograph of glassy particles (bar = 100  $\mu\text{m}$ ).

TABLE I Chemical analyses of microlapilli, MIOR basalts and microtektites.

(in %)	37KL*	40KL	MIOR ~	Microtektites # (Wharton Basin)
SiO <sub>2</sub>	44.96	48.58	48.17	71.10
TiO <sub>2</sub>	1.12	1.20	1.63	N.D.
Al <sub>2</sub> O <sub>3</sub>	11.82	16.20	16.67	13.50
Fe <sub>2</sub> O <sub>3</sub>	9.33	9.07	3.55	3.50
FeO			7.46	
MgO	10.47	7.45	6.39	1.90
CaO	12.68	13.60	11.74	2.60
Na <sub>2</sub> O	N.D.	N.D.	2.93	0.70
K <sub>2</sub> O	00.46	0.40	0.31	2.60
Mno	00.15	0.25	0.16	0.00
P <sub>2</sub> O <sub>5</sub>	00.10	0.11	0.19	N.A.
(in ppm)				
Sr	199	172	N.A.	N.A.
Zr	89	97	N.A.	N.A.
Y	25	27	N.A.	N.A.

\* : Average of 3 samples

~ : Average of 6 Basalts from the MIOR (Hekinian, 1968)

# : Cassidy *et al.* 1969

N.A. : Not available

N.D. : Not determined.

of the DSDP in the northeastern Pacific ocean. von der Borch (1970, 1971) suggested a submarine origin for the microlapilli whereas Vallier *et al.* (1977) proposed a subaerial eruption from an island volcano, within about 100 km of Site 32.

The origin of such basaltic microlapilli is still an enigma. Various views have been put forward such as mechanical destruction of the erupted and solidified basaltic lavas, by erosion and by new volcanic eruptions (Bezrukov *et al.* 1975). In the present instance, the near non-vesicular nature of the fragments and their equant shapes indicate the process of granulation to have been predominant within the ridge segment. The process of granulation was invoked first by Thoulet (1904, 1922) and subsequently applied by other workers (Fisher and Schmincke, 1984 and the references therein). The prerequisites for the granulation process are small vent dimensions, large volumes of water and low viscosity basaltic lavas. These conditions seem to have prevailed in a segment of the Vityaz fracture zone during Late Quaternary volcanic episodes.

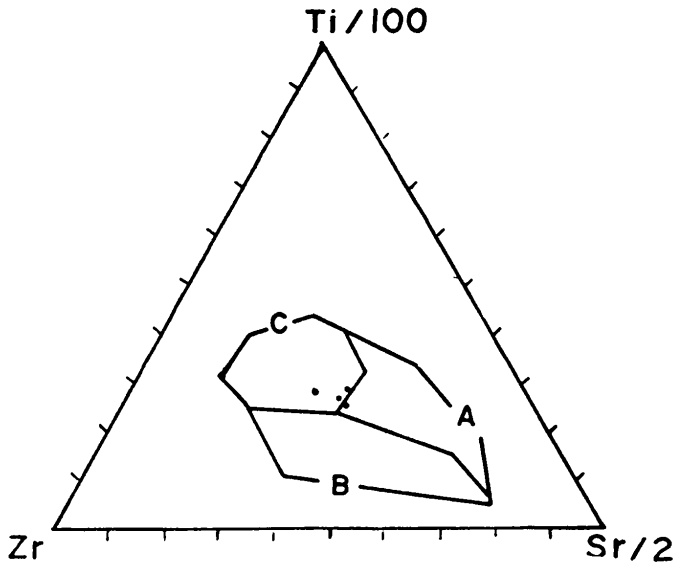


Figure 4. Triangular plot Ti/100-Zr-Sr/2.  
A - Low K-tholeiite, B - Calc-alkali basalt, C - Ocean floor basalt  
(after Pearce and Cann, 1973).

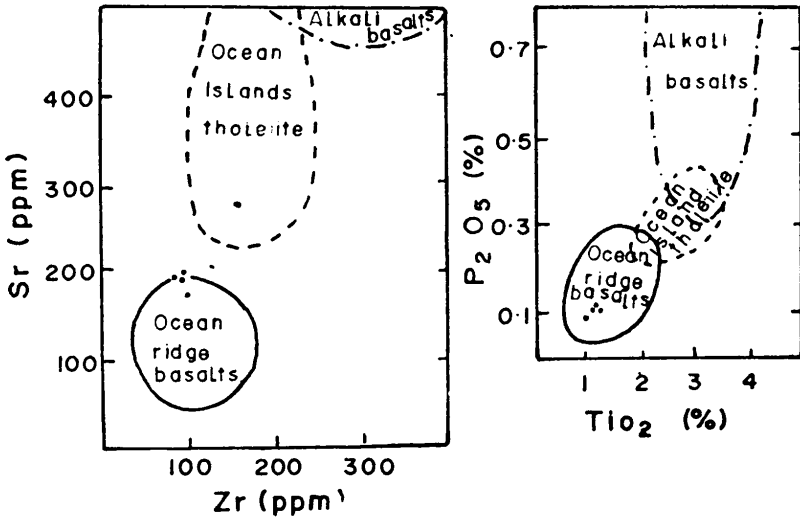


Figure 5. Binary plots of (a) Sr-Zr and (b)  $P_2O_5$ - $TiO_2$  showing the fields of Bass *et al.* (1973 and Ridley *et al.* (1974).

## ACKNOWLEDGEMENTS

Thanks are due to our colleagues M. Shyam Prasad for photomicrographs, V. Purnachandra Rao for XRD analyses and M. V. S. Gupta for palaeontological data. The work would not have been possible if Dr. W. L. Pluger, RWTH, Aachen and Prof. P. Stoffers, Kiel had not provided the interesting samples. CSIR is thanked for the deputation of B. N. to participate in this cruise.

## References

- ANON (1983) Fahrtbericht SO-28 und Wissenschaftlicher Bericht GEMINO-1: Geotherma Metallogenesis Indian Ocean.
- BASS, M. N., MOBERLY, R., RHODES, M. J. and SHITI, C. (1973) Volcanic rocks cored in the Central Pacific, Leg 17, DSDP. *In*: E. L. Winterer, J. J. Ewing *et al.* (eds.). Initial Reports of Deep Sea Drilling Project, U.S. Govt. Printing Office, Washington, D.C., v. 17, pp. 429-503.
- BEZRUKOV, P. L., BOGDANOV, YU. A., MURDMAA, J. O. and ROMANKEVICH, E. A. (1975) Bottom sediments of the Indian Ocean rift zone. *In*: A. P. Vinogradov and G. B. Udinstev (eds.). Rift zones of World Ocean. John Wiley, New York, pp. 205-230.
- CASSIDY, W. A., GLASS, B. and HEEZEN, B. C. (1969) Physical and chemical properties of Australasian microtektites. *Jour. Geophys. Res.*, v. 74, pp. 1000-1025.
- FISHER, R. V. and SCHMINCKE, H. U. (1984) Pyroclastic rocks. Springer-Verlag, Heidelberg.
- HEKINIAN, R. (1968) Rocks from the Mid-oceanic ridge in the Indian Ocean. *Deep Sea Res.* v. 15, pp. 195-210.
- PEARCE, J. A. and CANN, J. R. (1973) Tectonic setting of basic volcanic rocks determined using trace element analysis. *Earth Planet. Sci. Lett.*, v. 19, pp. 290-350.
- RIDLEY, W. I., RHODES, J. M., REID, A. M., JAKES, P., SHIH, C. and BASS, M. N. (1974) Basalts from Leg 6 of the Deep Sea Drilling Project. *Jour. Petrol.*, v. 15, pp. 140-159.
- SUBBARAO, K. V., KEMPE, D. R. C., REDDY, V. V., REDDY, G. R. and HEKINIAN, R. (1979) Review of the geochemistry of Indian and other oceanic rocks. *In*: L. H. Ahrens (ed.) Origin and distribution of the elements. Pergamon, Oxford, pp. 367-399.
- THOULET, J. (1904) L'Océan, ses lois et ses problèmes. Hachette, Paris.
- (1922) Eruptions volcaniques sous-marines profondes. *C.R. Acad. Sci.*, v. 14, pp. 1068-1070.
- VALLIER, T. L., BOHRER, D., MORELAND, G. and MCKEE, E. H. (1977) Origin of basalt microlapilli in lower Miocene pelagic sediment, Northeastern Pacific Ocean. *Bull. Geol. Soc. America*, v. 88, pp. 787-796.
- VON DER BORCH, C. C. (1970) Glassy objects in deep sea clays. *In*: D. A. McManus, R. E. Burns *et al.* (eds.). Initial reports of the Deep Sea Drilling Project 5. U.S. Govt. Printing Office, Washington, D.C., pp. 525-529.
- (1971) Glass objects in Tertiary deep sea clays cored by the Deep Sea Drilling Project. *Mar. Geol.*, v. 10, pp. 5-14.

( Received: July 16, 1988; Revised form accepted: Oct. 14, 1988 )