

## Distribution of Strontium in Sediments of the Minicoy Atoll, Lakshadweep

A MASCARENHAS, H N SIDDIQUIE & R S TOPGI

National Institute of Oceanography, Dona Paula, Goa 403 004

Received 23 January 1980; revised received 1 August 1980

Sr content in 67 sediment samples collected from the Minicoy reef and lagoon varies from 3960 to 7000 ppm (av. 5630 ppm). The concentration increases from the reef (*c.* 4,000 ppm) in the north and west to the centre of the lagoon (*c.* 7,000 ppm) while it is lower near the island. Distribution of Sr indicates an inverse relation with magnesium ( $r = -0.37$ ). Sr:Ca  $\times$  1000 ratios on the reef and lagoon range from 4.9 to 8.7; being higher in the lagoon and lower on the reef. Low Sr values on the reef and higher values in the lagoon are possibly related to greater contribution of calcareous algae (calcite and rich in Mg and low in Sr) to the reef sediments, luxuriant coral (aragonite and higher in Sr) growth and greater contribution from corals to the lagoonal sediments. Sr:Ca  $\times$  1000 ratios seem to indicate that the reef is not very active while the coral knolls in the lagoon are active.

Lakshadweep comprise a group of coral atolls, banks and submerged reefs located in the southeastern Arabian Sea (8° to 14° N lat.; 71° to 74° E long.) off the west coast of India. Most of the islands are aligned in a NNE-SSW direction with islands on the east and lagoons on the west. Minicoy forms the southern most atoll of the group and the lagoon covers an area of about 26.5 km<sup>2</sup> with a maximum depth of about 11 m. The central portion of the lagoon is deep (5-11 m) and is marked by a number of coral knolls some of which rise almost to the surface.

Gardiner<sup>1</sup> visited the Maldives and his description of lagoons and reefs included Minicoy also. The IBM<sup>2</sup> explored the phosphate deposits in the Lakshadweep. The coral fauna from Minicoy and Chetlat atolls have also been reported<sup>3</sup>. Siddiquie and Mallik<sup>4</sup> made detailed surveys (echosounding and sampling) which indicate that the Lakshadweep atolls are marked by shallow lagoons with depths ranging from 1 to 16 m. The sediments in the lagoons largely consist of fragmented coral with minor pelecypods, gastropods, halimeda and foraminifera, etc. The sands in the lagoons are largely the result of mechanical processes (break-up of the reef by waves during the monsoon and storms, though feeding by fishes and boring by sponges may also contribute to the disintegration of corals).

A detailed study of the marine geology of the islands is in progress at the Institute as a part of a major multidisciplinary study of the oceanography of these islands. This includes a comprehensive geochemical study of the sediments of the lagoons and offshore areas of these islands. Though partial analyses (Ca and Mg) of 664 samples and complete chemical analyses of 66 samples have been carried out, no analyses for trace elements have been carried out. Therefore, a study of

trace elements in sediments has been initiated with Sr which is considered as an important trace element in carbonate sediments and rocks. Distribution of Sr in biogenic carbonates is known to be controlled by mineralogy, phylogenetic level and temperature of waters. Concentration of Sr has been used to interpret the contribution of corals to calcareous sediments<sup>5</sup>, proximity of reefs<sup>6</sup> and comparison of recent with older Pleistocene sediments<sup>7</sup>. The paper presents distribution of Sr in sediments of the Minicoy lagoon and reef. An attempt has been made to relate its distribution to the composition of the sediments and in turn the environment of deposition.

Samples (67) from the lagoon and reef collected by Siddiquie<sup>4</sup> were analysed for Sr. A representative portion of the sediment sample was washed, dried and powdered to an appropriate size in a porcelain mortar. Each powdered sample (250 mg) was leached in 0.6 *N* acetic acid<sup>8</sup> till complete digestion of sample. This was made to 100 ml volume and the concentration of Sr was determined on a Hilger and Watts Atomspek-Model 1550 atomic absorption spectrophotometer by comparison with standard solutions of known concentration. The relative mean deviation of the analyses was 1.23 and SD 0.407.

Analyses of sediment samples from the Minicoy lagoon (Fig. 1) indicate that the Sr content varies from 3960 to 7000 ppm (av. 5630 ppm; Table 1). At Minicoy the Sr concentration increases from the reef (*c.* 4,000 ppm) in the north and west to the centre of the lagoon (7000 ppm) while near the island lower values are encountered. A comparison of the distribution of Sr with Mg (ref. 4) shows that in samples with high Mg, Sr is low and vice versa (Table 1). The scatter plot for Sr and Mg and the regression analyses indicate an inverse relation ( $r = -0.37$ ). A similar inverse relation has been observed between Mg and Sr on the Alacran reef<sup>9,10</sup>

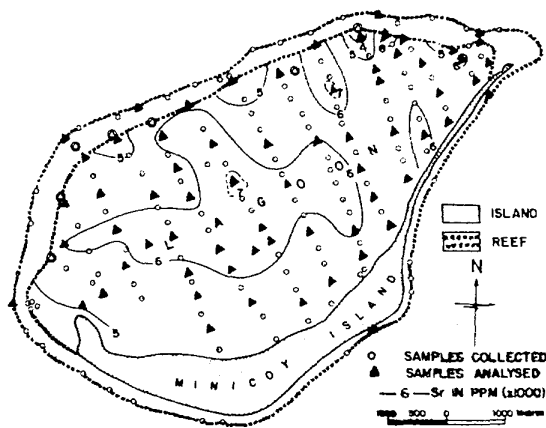


Fig. 1 Distribution of Sr in the sediments of the Minicoy lagoon and reef, Lakshadweep

Table 1—Partial Chemical Analyses of Samples from Minicoy Lagoon and Reef, Lakshadweep

Sample No.	CaO (%)*	Mg (%)*	Sr (ppm)
M1	52	0.54	5000
M4	52.56	0.46	6000
M6	52.2	0.78	5380
M10	52.2	0.78	5268
M11	51.46	0.54	5260
M13	52.92	0.54	5200
M15	52.56	0.62	6160
M17	52.56	0.78	5740
M19	51.46	1.09	—
M20	51.83	0.78	6860
M21	51.83	0.91	4740
M24	52	0.78	5780
M25	52	0.51	—
M27	52.2	0.7	6260
M29	52.20	0.7	5960
M31	51.83	0.91	5940
M33	51.1	0.99	5660
M39	51.59	0.46	6360
M41	52.19	0.46	5620
M43	51.83	0.93	5920
M46	52.19	0.62	6140
M47	52.92	0.39	6100
M49	52.56	0.46	5880
M52	51.83	0.93	6160
M53	52.56	0.31	6060
M55	52.19	0.31	6860
M57	51.46	0.46	7000
M60	52.56	0.31	6020
M61	52.19	0.31	6320
M63	52.56	0.46	—
M65	52.56	0.62	5300
M67	51.83	0.93	4580
M71	52.37	0.46	5400
M74	52.56	0.54	6260
M77	52.19	0.33	5680
M80	52.36	0.37	5780
M90	51.83	0.93	4560
M99	51.46	0.78	4480
M110	51.83	0.93	4740
M123	51.46	1.24	—
M129	51.83	1.09	4480
M137	51.19	0.31	6260
M143	52.56	0.23	5200
M146	52.56	0.23	—
M148	52.56	0.54	6000
M154	51.83	0.7	6240
M156	52.19	0.23	5200
M159	51.46	0.39	6840
M162	51.83	0.78	7000
M165	51.83	0.54	5460
M167	51.83	0.62	5560
M169	52.19	0.46	5120
M171	51.64	0.78	5220
M173	51.10	1.17	3960
M175	52.92	0.39	5300
M176	51.46	1.09	5160
M179	52.92	0.33	5220
M182	51.83	0.93	5560

Contd

Table 1—Partial Chemical Analyses of Samples from Minicoy Lagoon and Reef, Lakshadweep—Contd

Sample No.	CaO (%)*	Mg (%)*	Sr (ppm)
M183	51.1	0.93	6640
M185	52.56	0.33	5100
M190	52.92	0.33	6340
M192	51.46	0.78	5480
M194	52.92	0.23	5760
M196	52.02	0.31	5020
M198	51.46	0.85	5100
M199	51.64	1.01	4520
M200	52.37	0.46	6540
M202	52	0.7	5500
M205	52.37	0.54	5240
M206	51.46	0.62	5460
M215	51.46	1.01	5020
M241	50.23	1.24	5200

\* Values from Siddique and Malik\*

and Florida<sup>11</sup>. Among the factors which are reported to influence the distribution of Sr, contribution of temperature may be ruled out because of the unlikely large variations in a small area over the reef and lagoon. Kinsman<sup>12</sup> reported a higher concentration of Sr in lagoonal muds than reef corals in Persian Gulf which he attributed to non-skeletal origin but such an explanation may not be applicable to Minicoy lagoon sediments. The distribution may, therefore, be related to the mineralogy and phylogenetic level of the organisms. The samples taken for this study represent the comminuted skeletons of different organisms and hence the mineralogy and chemistry of any sample would be the mixture of carbonate of different biological origins. In the Minicoy lagoon the highest Sr concentration of 7000 ppm is observed in corals. In comparison, the average Sr concentration in corals from Mandappam<sup>13</sup> is reported as 7163 ppm; Florida Keys<sup>14</sup> 10,600 ppm; fresh corals from the Gulf of Aqaba<sup>15</sup> 8200 ppm; British Honduras<sup>5</sup> 7200 ppm; Bahamas<sup>12</sup> 7980 ppm and Persian Gulf<sup>12</sup> 7740 ppm.

Sr content is lower in the sediment on the reef and higher in the lagoon while Mg shows reverse trend. Most of Mg in sediments of the coral reefs and in the lagoons is derived from calcareous algae which are prolific on the reef and dominantly consist of calcite. Because of their mineralogy and chemistry the calcareous algae are lower in Sr<sup>5,6</sup>. Sediments in the lagoons are derived from corals which largely consist of aragonite. These differences in the sediment composition and the mineralogy largely explain the differences in distribution of Sr in the lagoon and reef. A similar explanation has been given by Friedman<sup>15</sup> for the variation of strontium in the corals of the Gulf of Aqaba.

In addition to the distribution of Sr and Mg the Sr/Ca  $\times$  1000 ratios have been utilized to infer the history of the reef. In recent coral sand from Bikini<sup>11</sup> Sr/Ca ratio is 10.89 and in living corals it is 12.65. Siegel<sup>11</sup> distinguished pleistocene and living reefs in Florida Keys and shoals based on Sr/Ca ratios. He stated that the reef is in a process of alteration from aragonite to calcite<sup>14</sup>; lower Sr/Ca ratios and high Mg values are observed<sup>11</sup>. Sr/Ca  $\times$  1000 ratios on the reef and lagoon at Minicoy range from 4.9 to 8.7; the ratios are generally higher in the lagoon and lower on the reef. The ratios seem to indicate that the reef at Minicoy is not very active and may in part be in a state of alteration. The Indian Naval Hydrographic Chart of Minicoy shows that the lagoon is deeper in the centre with a number of coral knolls. Visual observations also indicate a luxuriant coral growth in the knolls and patchy reefs in the lagoon. Pillai<sup>3</sup> has recorded 70 species of hermatypic corals from Minicoy atolls and indicated a luxuriant growth of certain corals in the lagoon. Some of the species were non-existent or not reported by Gardiner<sup>3</sup> but are flourishing now and according to Pillai<sup>3</sup> these colonies have grown during the last 70 yr. However, it is difficult at this stage to conclude on the basis of Sr/Ca  $\times$  1000 ratios alone the activeness or relative ages of the reef or coral knolls in the lagoon.

The authors are grateful to Dr S.Z. Qasim, Director and Shri P.S.N. Murty, Scientist, for critically going through the manuscript and Shri C.V.G. Reddy, head, COD for facilities for Chemical Analyses.

## References

- Gardiner J.S. *The fauna and geography of the Maldivic Laccadive Archipelagoes* (Cambridge, New York) 1903, 1079.
- Mukherjee N K & Dhruva Rao, *West commemoration volume* (1970) 628.
- Pillai C S G, in *Regional variation in Indian Ocean coral reefs*, edited by D.R. Stoddart and M. Yonge (Academic Press, London) 1971, 584.
- Siddiquie H N & Mallik T K. *Unpublished report* (Geological survey of India) 1973, 35.
- Matthews R K, *J Sed Petrol.* 36 (1966) 428.
- Maiklem W R, *J Sed Petrol.* 40 (1970) 55.
- Stehli F G & Hower J, *J Sed Petrol.* 31 (1961) 358.
- Angino E & Billings G K, *Atomic absorption spectrometry in geology* (Elsevier, Amsterdam) 1967, 144.
- Hoskin C M, *J Sed Petrol.* 36 (1966) 1058.
- Hoskin C M, *Am Ass Petrol Geol.* 52 (1968) 2170.
- Siegel F R, *J Sed Petrol.* 31 (1961) 336.
- Kinsman D J, *J Sed Petrol.* 39 (1969) 486.
- Sreekumaran C & Gogate S S, *Curr Sci.* 41 (1972) 241.
- Siegel F R, *J Sed Petrol.* 30 (1960) 297.
- Friedman G M, *J Sed Petrol.* 38 (1968) 895.

## Concentrations of Few Trace Metals in Coastal & Offshore Regions of the Bay of Bengal

ANALIA BRAGANCA & SUJATA SANZGIRY

National Institute of Oceanography, Dona Paula, Goa 403004

Received 16 January 1980; revised received 30 May 1980

Cu, Fe, Mn, Zn, Co and Ni in dissolved and particulate fractions of sea water at different depths were estimated from 9 stations in the Bay of Bengal. Concentrations of dissolved and particulate Fe were fairly high at coastal stations, specially at the river mouths. Cu at the nearshore stations was high but there was no marked difference between the nearshore and offshore concentrations, so as to reflect the possibility of river input. Dissolved Zn and Ni were low at the surface than in deeper layers contrary to Mn. Particulate fractions of Fe and Zn were significant, while Co and Ni were not significant; Cu and Mn showed intermediate values.

As a part of the ongoing project on 'Protection of marine environment and monitoring of pollutants in the seas around India', studies were carried out on some of the heavy metals in dissolved and particulate form. The main interest has been in the transition group metals which are necessary for the life cycle of marine organisms but which can be cumulative poisons as well. Concentrations of heavy metals were estimated along 2 transects in the Arabian Sea<sup>1</sup> and later in the sea around the Laccadive islands<sup>2</sup>. In the present paper results of estimations carried out during the 35th and 36th cruises of *RV Gaveshani* in the Bay of Bengal are presented. During the 36th cruise, sampling was mainly done at some river mouths, to study the influence of river input, if any.

Samples were collected at 9 stations (Fig. 1), using van Dorn PVC water samplers. Collection of samples was done at 10 m depth instead of surface in order to avoid contamination due to the 3.5 m deep metallic hull of the ship. Samples were transferred to acid-washed jerry cans and filtered through 0.45  $\mu$ m membrane filters (Millipore HA). The water samples were then stored in acid-washed polyethylene carboys and acidified to pH 3-4 with 1 N HCl. Filter papers with the particulate matter were stored under refrigeration, in prewashed plastic containers. Samples, both dissolved and particulate fractions, were returned to the shore laboratory for analyses. The samples were analysed for Cu, Fe, Mn, Zn, Co and Ni using atomic absorption spectrophotometry. The procedure used for the analysis of dissolved metals was same as given by Brewer *et al.*<sup>3</sup>.

Dissolved Mn could not be extracted with ammonium pyrrolidine dithiocarbamate and methyl isobutyl ketone at the pH at which other metals were analysed. It was therefore chelated with sodium-diethyl dithiocarbamate and extracted in methyl