

Spatial and temporal variations of carbonate content in the beach and nearshore environments off Goa, west coast of India

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Sediment samples collected from dunes, beaches (Calangute, Baina and Colva) and nearshore environments along the coast of Goa, have been analysed for their carbonate content. The results show the presence of very high carbonate content (60-90%) in the foreshore regions of individual beaches whereas low CaCO_3 (< 20%) in the dune and backshore areas of these beaches and adjoining nearshore environs up to 10 m isobath. The observed spatial distribution shows the occurrence of modern carbonate sediments of skeletal origin. Carbonate content of the beaches shows marked seasonal variations and closely follows the seasonal cyclic changes in beach morphology.

Textural, mineralogical and chemical aspects of sediments of western continental shelf of the Indian subcontinent, beyond 10 fm (~ 18 m) isobath have been studied in great detail¹⁻⁵. Except for studies on nearshore sediments (up to 10 fm isobath) at some selected locations⁶⁻¹², no information is available on these aspects of the beach and nearshore sediments from the west coast of India. This paper presents spatial and temporal variation of CaCO_3 content in the beach and nearshore environs off Goa and provides data useful in understanding the significance of modern carbonates from a tropical region.

Materials and Methods

The study area includes 3 sandy beaches — Calangute, Baina and Colva — the adjoining dune field along this coast and the nearshore region up to approximately 11 m depth contour (Fig. 1). Each one of these beaches is located between rock promontories. Calangute and Colva beaches are more exposed to wave action than Baina beach. Calangute beach is composed of very coarse to fine sand grade, moderate to well sorted sediments while the other 2 beaches are characterised by medium to fine sand grade, and moderate to very well sorted sediments. Sediments in the offshore regions of these beaches are characterised by sands and silts below 7.5 m water depth and clays beyond that depth^{13,14}.

In all, 13 profile stations — 5 each on Calangute and Colva beaches and 3 on the Baina beach — were established (Fig. 1). Sand samples were collected periodically along profile sections from dunes, backshore and foreshore environments. A near

synoptic sampling of each beach was carried out once during the fair weather season to study the areal distribution of CaCO_3 content. Sediment samples were collected from offshore areas of the 3 beaches to about 11 m contour using a van Veen grab (Fig. 1). Table 1 shows sampling details. The total carbonate content (which includes the carbonates of Ca and Mg) in the samples was determined¹⁵.

Results and Discussion

Dunes, backshore and nearshore portions of Calangute area (Fig. 2) are very poor in CaCO_3 (< 10%). Southern half of foreshore is characterised by 10 to 15% CaCO_3 while northern half by 15 to 50%. In the entire foreshore, however, lower reaches of foreshore show higher CaCO_3 concentration than middle or upper reaches. In Baina area (Fig. 3), nearshore region as well as northern half of foreshore is poor in CaCO_3 (< 20%) while southern half of

Table 1—Details of samples used in the study

Area	Sampling frequency	Date of sampling	No. of samples			
			FS	BS	D	NS
Calangute	A	Sept '69-Aug '70	391	40	14	—
	B	April '73	40	15	14	31
Baina*	A	May '72-Jan '74	52	—	—	—
	B	Dec '72	34	—	—	4
Colva	A	Jan '72-Feb '73	225	18	—	—
	B	April '73	129	11	20	21

*—well developed dunes are absent; A—monthly/periodic sampling; and B—synoptic sampling. FS—foreshore, BS—backshore, D—dune; and NS—nearshore

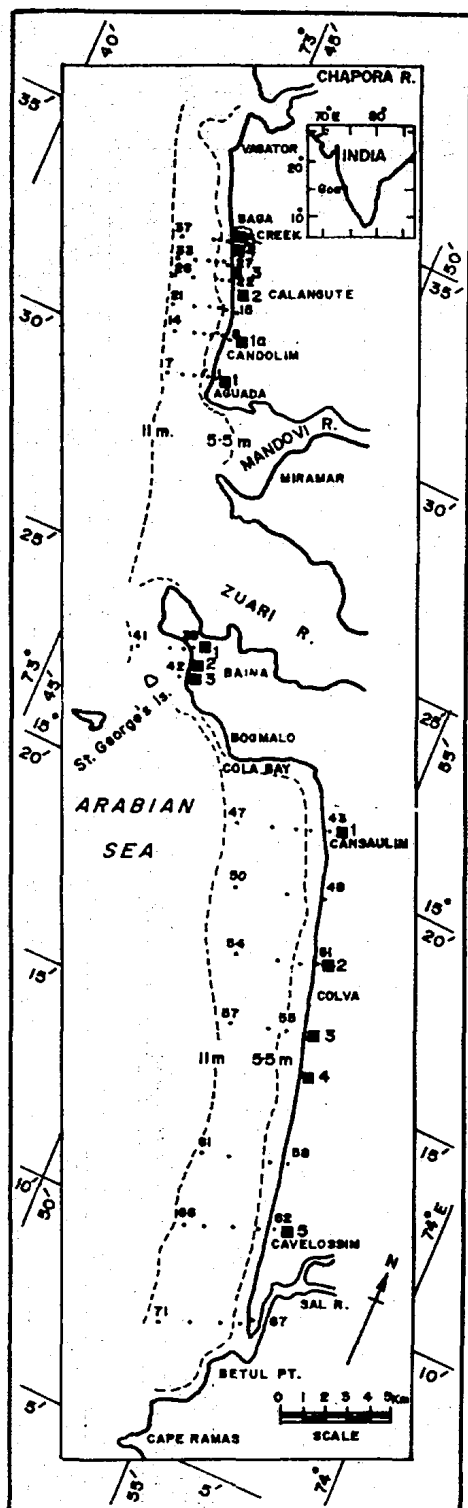


Fig. 1—Map of the study area showing locations of beach profile stations (■) and sampling stations in nearshore areas of Calangute, Baina and Colva [Detailed sampling patterns in beach, foreshore, backshore and dune environments of these regions are shown in Fig. 2 to 4]

foreshore is very rich (80-90%). In Colva area (Fig. 4), northernmost 3.5 km stretch of the beach records high CaCO_3 (20 to 70%). The rest of the beach (including the dunes and the backshore) and the entire offshore area record < 10 to 20% CaCO_3 . Further, northern carbonate-rich beach shows much higher CaCO_3 content in upper and lower foreshore than in middle foreshore.

Seasonal variation in average CaCO_3 content of foreshore samples along different sections of Calangute area (Fig. 5) shows that the carbonate content is always higher in northern 2 sections than in southern 3 sections. It is lowest at any section from June to September and shows an increasing trend from September onwards, of course, with low values at northernmost section during January, and along southern 4 sections in February-March. Table 2 gives average carbonate content of Baina foreshore samples at 3 sections for different months. At section 1, CaCO_3 content ranges from 10 to 25% except the isolated (abnormal) value of 73.5% in May 1972. At other 2 sections it is consistently high (50 to 84%). It is low at sections 2 and 3 in 1973 relative to 1972. Along Colva beach, in general, carbonate content is higher in northernmost section than in southern 4 sections (Fig. 6). The values are relatively low in southernmost section. The carbonate concentration is markedly low in April-July and November at southern 4

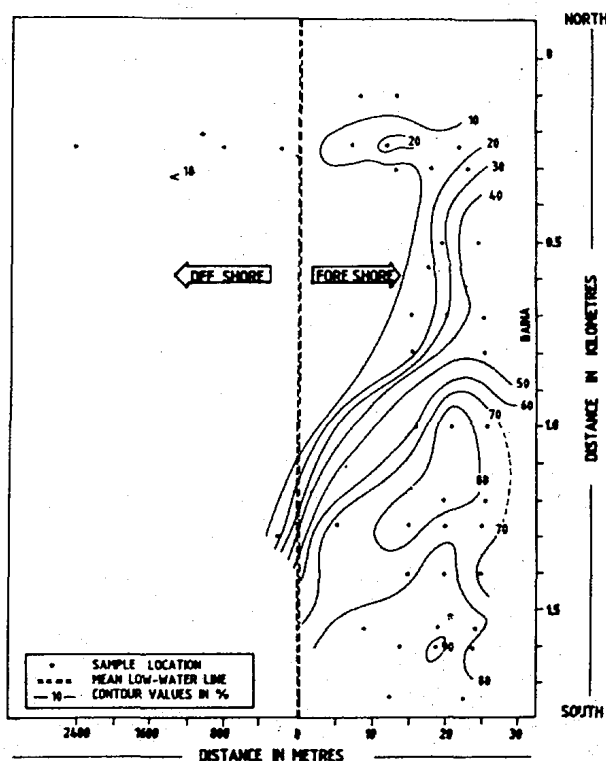


Fig. 3—Areal distribution of CaCO_3 in Baina beach

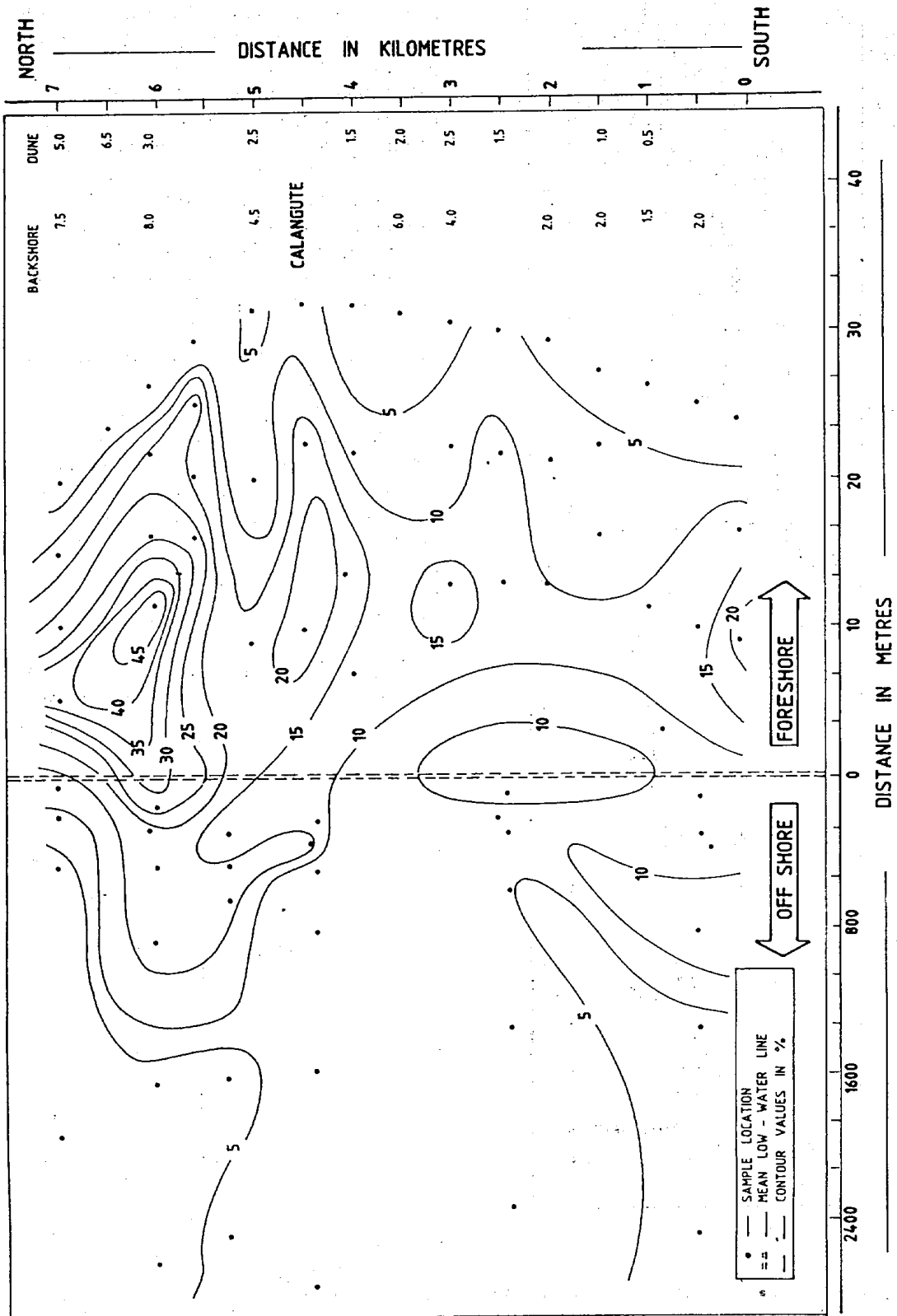


Fig. 2—Areal distribution of CaCO₃ in Calangute beach

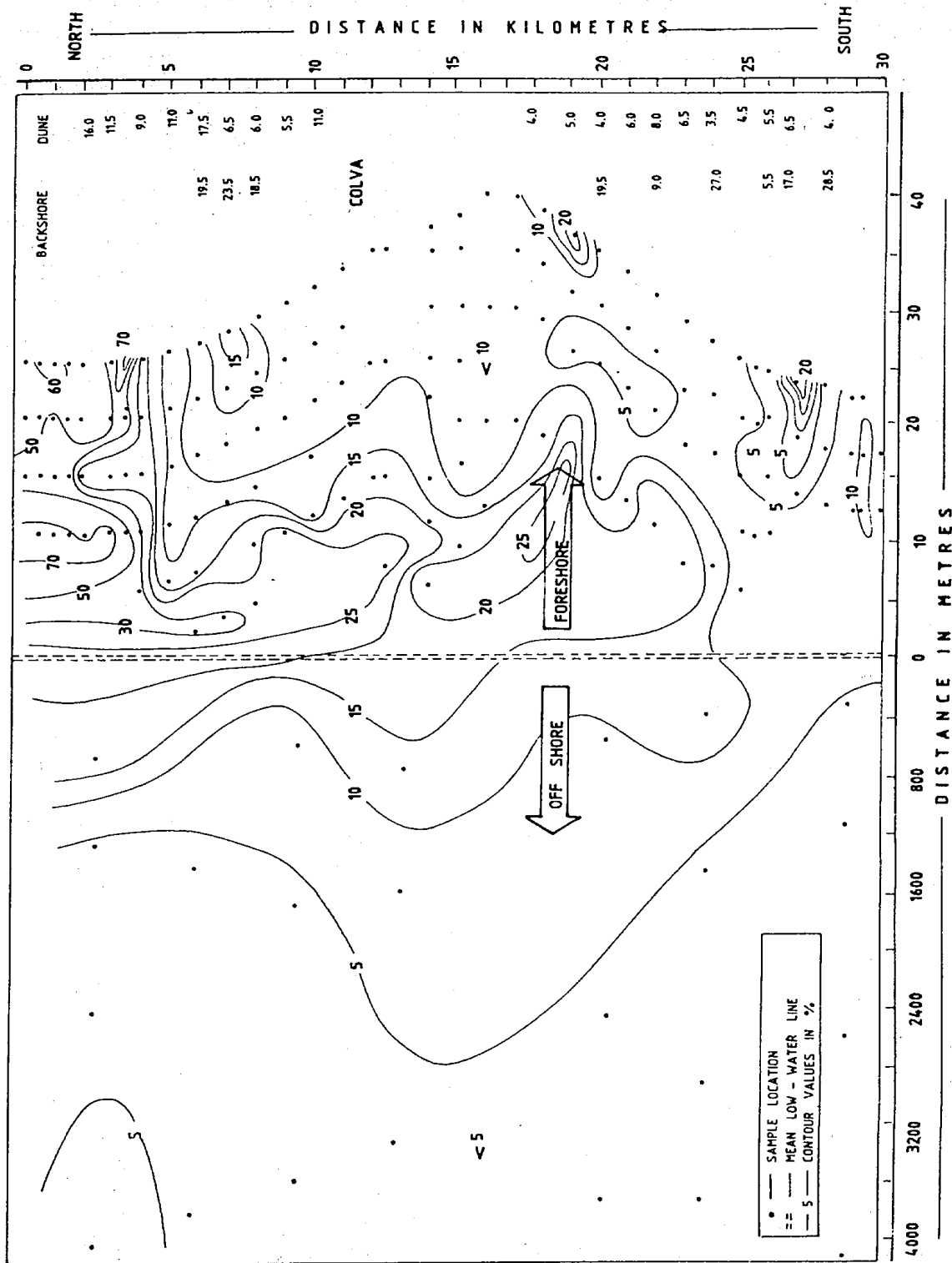


Fig. 4—Areal distribution of CaCO₃ in Colva beach

sections and in June-July at northernmost section. At the latter transect, 25 to 40 m wide foreshore records consistently high carbonate content (av. 66%).

Thus it can be seen that variations in CaCO_3 content occur from time to time along all 3 beaches investigated apart from marked variations observed

Table 2—Monthly average values of CaCO_3 (%) in Baina area

Date of collection	Section 1	Section 2	Section 3
10.05.1972	73.50	81.40	66.40
30.09.1972	11.35	83.60	74.90
02.12.1972	18.00	79.65	74.25
28.12.1972	16.55	77.60	83.50
30.01.1973	11.10	76.00	68.30
24.03.1973	—	48.30	63.90
26.10.1973	25.35	66.25	54.45
24.01.1974	25.55	60.20	59.15

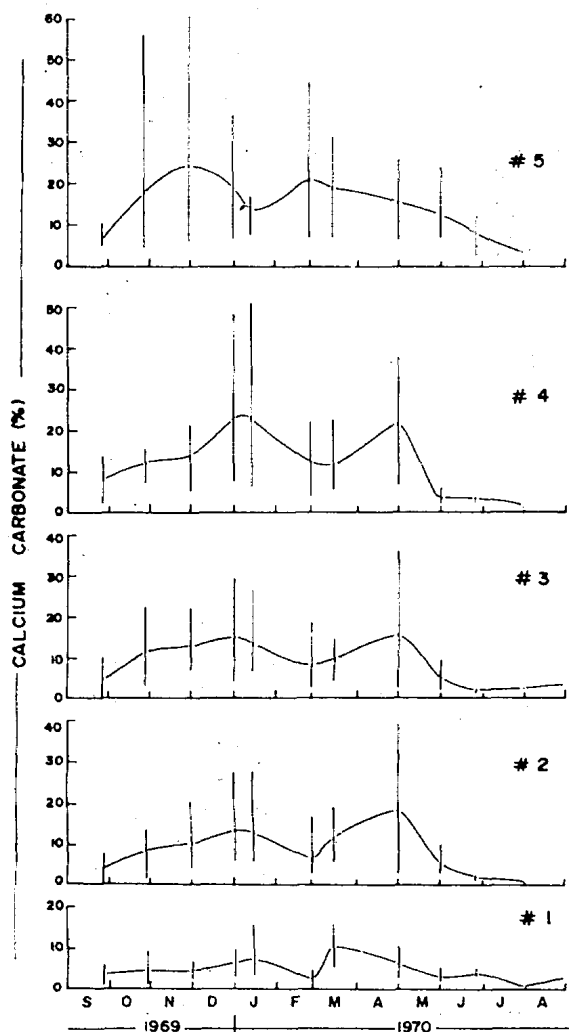


Fig. 5—Monthly variation of CaCO_3 content in foreshore sediments along profile sections 1-5 of Calangute

within the individual beaches. A correlation of carbonate content with morphological variations of the beaches reveals that carbonate content of sediments of beaches is linked up with erosional and accretional cycles of beaches¹⁶⁻¹⁹, high carbonate being associated with build up and low concentrations with erosion of the beach material. These high and low carbonate content closely correspond to seasonal variations in benthic production.

It has been observed that the average CaCO_3 content of offshore sediments of the study area is < 8% (values range from 3 to 30%). Marine sediments from depths < 10 fm (~ 18 m) from other parts of west coast^{3,6,7,9,11,12} and east coast of India^{20,21} contain CaCO_3 content not exceeding 10% by weight of dry sediments. This shows that nearshore environments along either of the coasts of India are not depositories of calcareous sediments in the Recent, probably with the exception of coral island areas off the southeastern and southwestern regions of southern end of the Indian Peninsula.

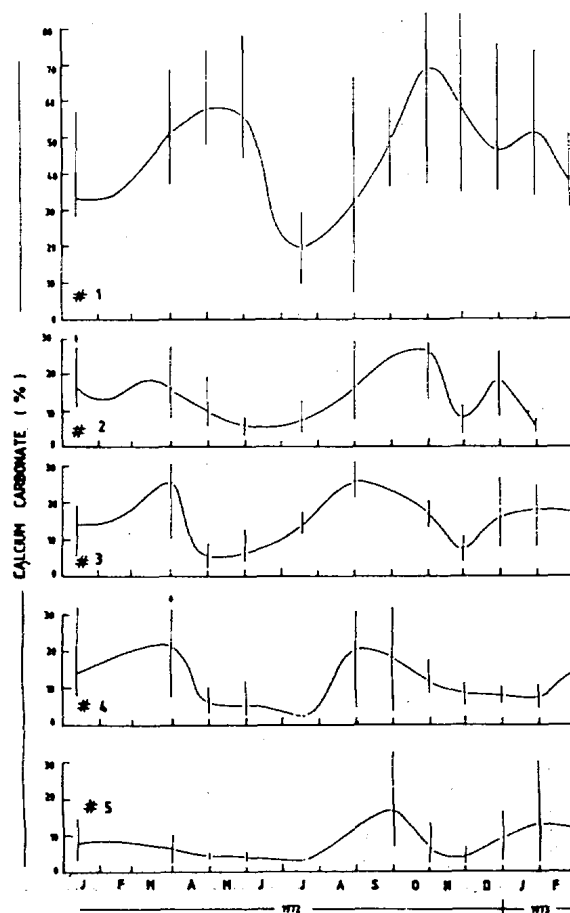


Fig. 6—Monthly variation of CaCO_3 content in foreshore sediments along profile sections 1-5 of Colva

A detailed binocular microscopic study of various sieved fractions of representative samples from beaches reveals that skeletal material preponderates the coarse fraction while terrigenous minerals (quartz and feldspar) the fine fractions. No carbonate minerals are recognised, even in the heavy mineral concentrates. Thus skeletal material appears to be the sole source of CaCO_3 in the beach sediments. Unbroken molluscan shells dominate the -1 to 0ϕ and 0 to 1ϕ size material; molluscan shell fragments and foraminiferal tests account for the bulk of the skeletal material in the 1 to 2ϕ size material, and to a considerable extent in the 2 to 3ϕ size material. Ostracods, echinoid spines and other types of biogenic material are present but they are insignificant as contributors to CaCO_3 content of beach sediments.

The reasons for accumulation of biogenic shelly material in this part of the Goa coast are: beach and nearshore sediments support rich benthic fauna²²⁻²⁴; sediment transport processes are such that dead shells are washed ashore and concentrated under the influence of prevailing northerly littoral flows along northern sectors of Colva and Calangute beaches^{25,26} and weakly southerly flows along Baina beach²⁷; inorganic sediments supplied from the shore destruction or by major rivers do not reach these strips of beaches, thus keeping calcareous material undiluted.

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