

## Comparative Study of the Topography & Sediments of the Western & Eastern Continental Shelves around Cape Comorin

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Western and eastern continental shelves around Cape Comorin show 3 well-defined regions of depositional environments each having its own characteristic features. The environments extend from Cochin to Quilon, Quilon to Cape Comorin and Cape Comorin to Tuticorin. Topographically the region between Cochin and Quilon is smooth with sub-bottom reflections on the echogram whereas between Quilon and Cape Comorin and from Cape Comorin to Tuticorin the continental shelf is uneven and periodic bed forms (ripples/waves) are observed in the latter area. Sediments of the 1st region are characterized by a high percentage of fine grained sediments (62.4% silt and clay) whereas the 2nd and 3rd regions have 4.3 and 12.8% respectively. The carbonate content increases from 21.9% off Cochin to 37.4% off Quilon and 71.4% off Tuticorin. Differences in the 3 sedimentary environments are attributed to the variations in the depositional and erosional processes prevailing in the region.

Recent sedimentation processes on the sea bed are a function of climate, bathymetry, and hydrography. Variations in these parameters result in differing depositional environments with characteristic sediments and bed forms. In this paper an attempt is made to compare and contrast the topography and Recent sediments occurring on the western and eastern shelves around Cape Comorin. For this purpose the study area is divided into 3 regions, viz. Cochin to Quilon, Quilon to Cape Comorin and Cape Comorin to Tuticorin (Fig. 1).

### Coastal Physiography and Geology

The study area is bordered by a narrow coastal plain approximately 30-70 km wide. The coastal plain is backed by the Western Ghats. On the southwestern coast (Kerala) besides Periyar river which is the longest, there are a few small rivers. Vembanad lake near Cochin and Ashtamudi backwater near Quilon are the 2 lagoons into which the rivers discharge their sediment load. Between Cape Comorin and Tuticorin a few small streams are present and lagoons are absent.

In general the coastal plain of the study area is covered by the Recent and Sub-Recent sediments. Outcrops of the Miocene Warkalli beds are exposed as cliffs at Quilon, and the Cuddalore sandstones occur around Cape Comorin<sup>1-4</sup>.

Regarding the structure of western side Varadarajan and Nair<sup>4</sup> concluded on the basis of the lineament studies that many of the established fracture zones in the craton area extend into the coastal sedimentary basin. NW-SE to WNW-ESE trending faults have played a significant part in the structural framework for the foundering of the greater part of the offshore

basin and for shaping the present day coastline. Faults affecting laterites and Quaternary sediments are also seen in this area. They postulate that the Vembanad lake occupies a fault trough. On the southwestern side the coastal plain is composed of Recent alluvium. Beach rocks occur at Cape Comorin and Tuticorin and fringing coral reefs occur within 8 km from the mainland in the Gulf of Manaar<sup>5,6</sup>.

### Materials and Methods

Unconsolidated surficial samples (53) were collected from 10 to 50 m with a La Fond Dietz snapper/van Veen grab during the 17th cruise of *RV Gaveshani*. Navigation during the cruise was based on shore and radar fixes. Echosounding was carried out by Kelvin Hughes MS-45 echosounder. Laboratory methods were similar to those reported earlier<sup>7</sup>.

### Results and Discussion

#### Bathymetry and Bottom Topography

Prominent changes in bathymetry take place on the shelf between Cochin and Cape Comorin and between Cape Comorin and Tuticorin. Changes in the shelf gradient are most conspicuous. Shelf gradients, obtained by measuring the distance between the coastline and the 20 and 50 m isobaths on N.H.O. Chart No. 261 (Table 1), indicate that off Cochin the gradient is lower than at Quilon and Trivandrum. The gradient with respect to the 20 m isobath is greater than that with the 50 m isobath. In either case, the shelf off Quilon marks the transition from low to high gradient. Off Cape Comorin the gradient is low due to the presence of the Wadge Bank and increases off Tuticorin.

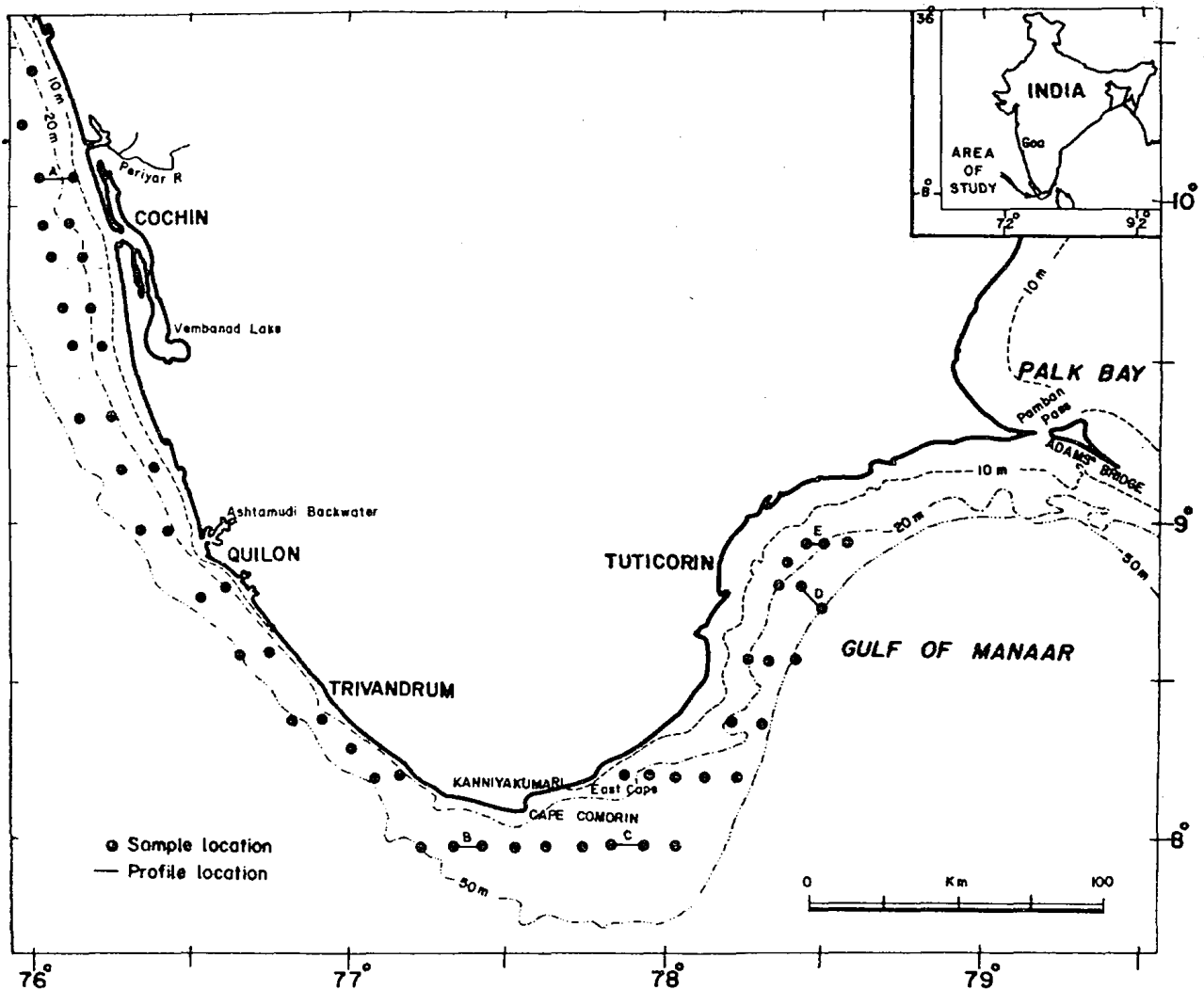


Fig. 1—Location map of samples, echograms and general bathymetry

Table 1—Shelf Gradient

Shelf off	Shore to 20 m	Shore to 50 m
Cochin	1:570	1:768
Quilon	1:322	1:414
Trivandrum	1:67	1:270
Cape Comorin	1:95	1:756
Tuticorin	1:1500	1:900

Bottom profiles taken with the MS-45 echosounder between 10 to 50 m show well defined differences for different regions. The continental shelf off Cochin, the inner parts of which are mud covered, is characterized by echograms (profiles A, Fig. 2) in which clear sub-bottom reflection is present to a depth of about 30 m. The estimated thickness of the mud overlying the calcareous sand is of the order of 2 m. On the shelf between Quilon to Cape Comorin (profile B, Fig. 2) where the sediment texture is sandy, sub-bottom reflection is absent. Within the sand textured sea bed

regions of the shelf various types of bottom profile are observed. Profile B (Fig. 2), representative of the region between Quilon and Cape Comorin shows flat topography, whereas profile C east of Cape Comorin, where the sea bed consists of calcareous sand similar in nature to that found in the region of profile B, shows the presence of periodic bed forms in water depth of 33 to 35 m. Profile D (Fig. 2) of the shelf in the Gulf of Manaar shows increasingly irregular topography beyond 39 m. The irregular topography has a relief of 5 m. Profile E in the Gulf of Manaar shows shallow water (15 to 25 m) sand waves. The wave length of the sand waves is less (250 m) and wave height greater in the shallow waters as compared to that in the deeper part which are of the order of 2,000 m in wave length. Since the texture of the sediments is largely similar on the shelf between Quilon and Tuticorin, the presence of the periodic bed form only between Cape Comorin and Tuticorin implies the action of a different hydraulic regime in this area.

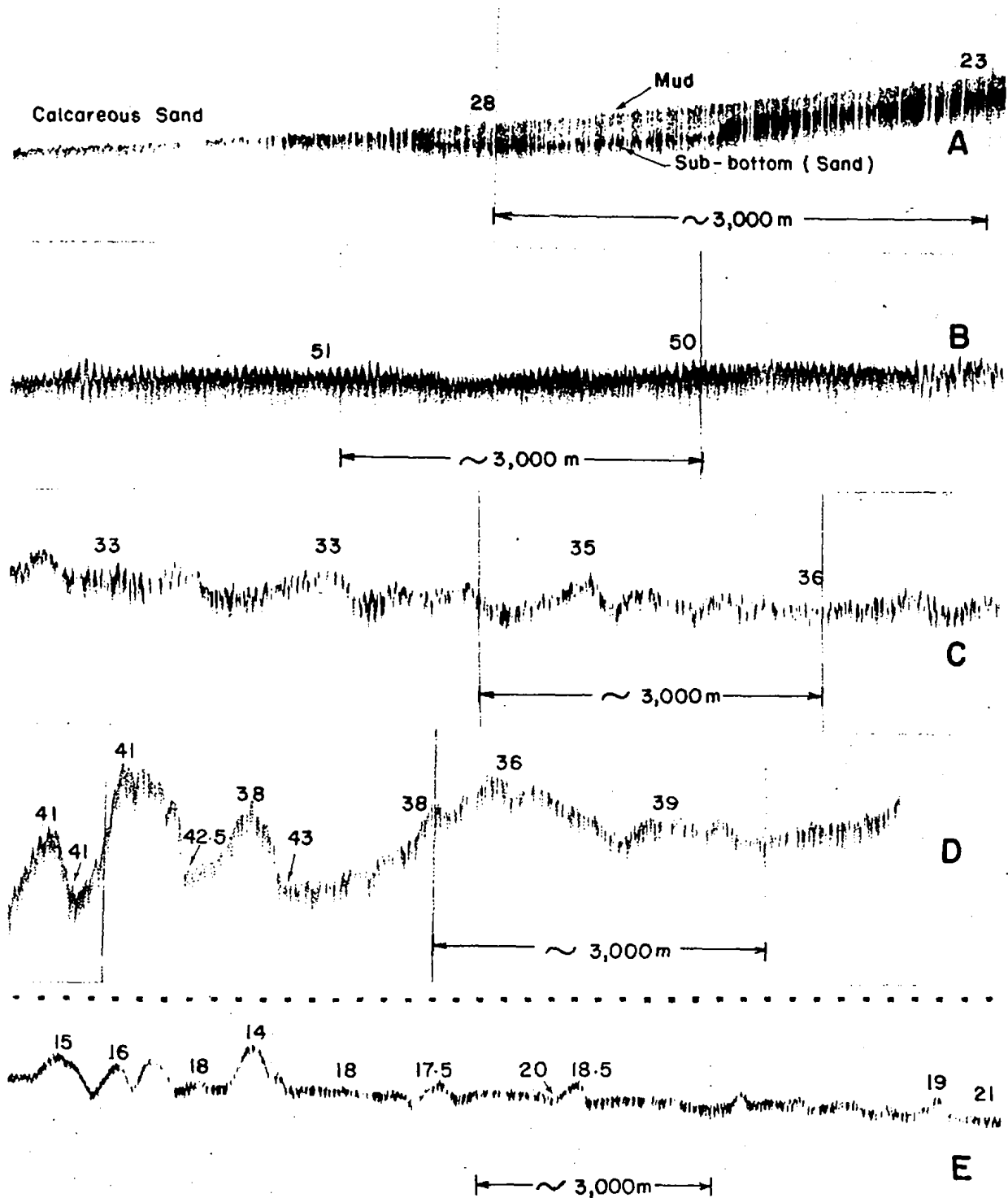


Fig. 2—Bottom profiles, depth in metres (Location in Fig. 1)

**Sediments**

The present study, though limited to 50 m depth on the shelf, presents a different picture compared to previous studies of the northern part of the western shelf of India. From Cochin to Quilon the sediments are clayey silt or sand-silt-clay to a depth of 20 m, beyond which (> 30 m) the sediment changes to sand and clayey sand (Fig. 3). From Quilon to Tuticorin the sediments are dominantly sandy in nature except patches of sandy silt at 18 m and silty sand at 25 m depth off East Cape. This distribution is in contrast to the distribution in the northern part where generally clayey silt/silty clay is dominating up to a depth of 50 m<sup>8-12</sup>.

**Distribution of sand**—Areal distribution of the sand fraction (> 62.5 μm) in the study area is shown in Fig. 4A. The area between Cochin and Quilon shows varying percentage (0.22-93.82, av. 36.92) of sand. The percentage of sand is high (av. 93.23) and consistent (91.40-98.30) between Quilon to Cape Comorin and between Cape Comorin to Tuticorin it ranges from 46.93-99.42 (av. 87.2).

The high percentage of sands on the continental shelf between Quilon and Tuticorin is attributed to (i) absence of estuaries or backwaters which trap coarse sediments and (ii) presence of the Warkalli beds and the Cuddalore sandstone on the coast which provide sources for coarse sediment.

More than 2/3rd of the area is covered with sands, hence the percentage of the carbonate was determined for this particular fraction only. The general pattern of distribution of the carbonate is shown in Fig. 4B. The area between Cochin and Quilon has low carbonate (av. 12.47, 1.26-50.63). It is intermediate (av. 37.4, 4.74-

74.95) in the area between Quilon and Cape Comorin and high (av. 71.45, 6.95-94.47) between Cape Comorin and Tuticorin. The low value of carbonate between Cochin and Quilon is due to the dilution of the shelf sediments by land derived clastics. The reduction in terrigenous contribution from Quilon to Tuticorin is reflected in the progressively higher carbonate content.

**Distribution of silt**—Next to the sand fraction the silt size dominates in all regions of the study area (Fig. 4C). The silt percentage is quite high in the area north of Cochin and north of Quilon with intermediate values (30-50%) in between them. The percentage of silt is high (av. 41.18, 5-70.42) in the Cochin and Quilon region with a patch of as less as 5%. The percentage of silt is very low (1.27-8.6, av. 4.02) in the Quilon to Cape Comorin region. In the Cape Comorin-Tuticorin region, in general, the percentage of silt (0.49-48.49, av. 9.76) is < 5%, however, off East Cape there are 2 patches with higher percentages (48.49 and 30.5).

**Distribution of clay**—Clay, in general, is the least abundant fraction of the sediments of the study area, barring an area up to 20 m isobath between Cochin and Quilon (Fig. 4D). In this area it attains a maximum of 49.65% just off Cochin, decreasing towards north and south of that location. This high percentage may be due to the fine sediments which are discharged from the Vembanad lake and the Ashtamudi backwater. From Quilon to Tuticorin, either the clay fraction is absent or present only in traces (< 2%). The scarcity of clay sized sediment is due to the absence of the rivers.

**Variation of Textural Parameters**

The sediments of the study area have compositionally a very wide range. They vary from dominantly terrigenous to dominantly calcareous (consisting of skeletal material) and both have different hydraulic characteristics. A general distribution of size parameters is given below.

**Mean size**—Fig. 5A shows the areal distribution of the mean size. Up to Quilon mean size distribution is patchy ranging from 0.83-7.87φ, i.e. from coarse sand to very fine silt with a mean 5.02φ falling in medium silt size. Between Quilon and Cape Comorin it becomes coarser towards south ranging from fine sand to coarse sand (2.47-0.34φ) with an av. of 1.53 (medium sand). From Cape Comorin to Tuticorin the mean size starts as coarse sand size and changes over to fine sand and finally changed to medium sand size. The overall range is 0.07-3.77φ with an av. of 1.79φ (medium sand).

Regions off the coast where the estuaries and lagoons are present, as on the Cochin-Quilon coast the mean size tends to be finer compared to those areas which are devoid of estuaries and lagoons. The finding in this area is similar to that reported earlier on the shelf between Vengurla and Mangalore<sup>12</sup>.

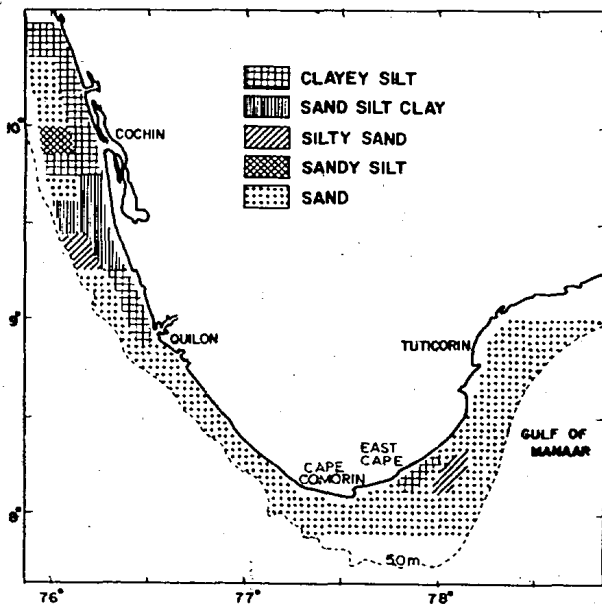


Fig. 3—Surface sediment distribution

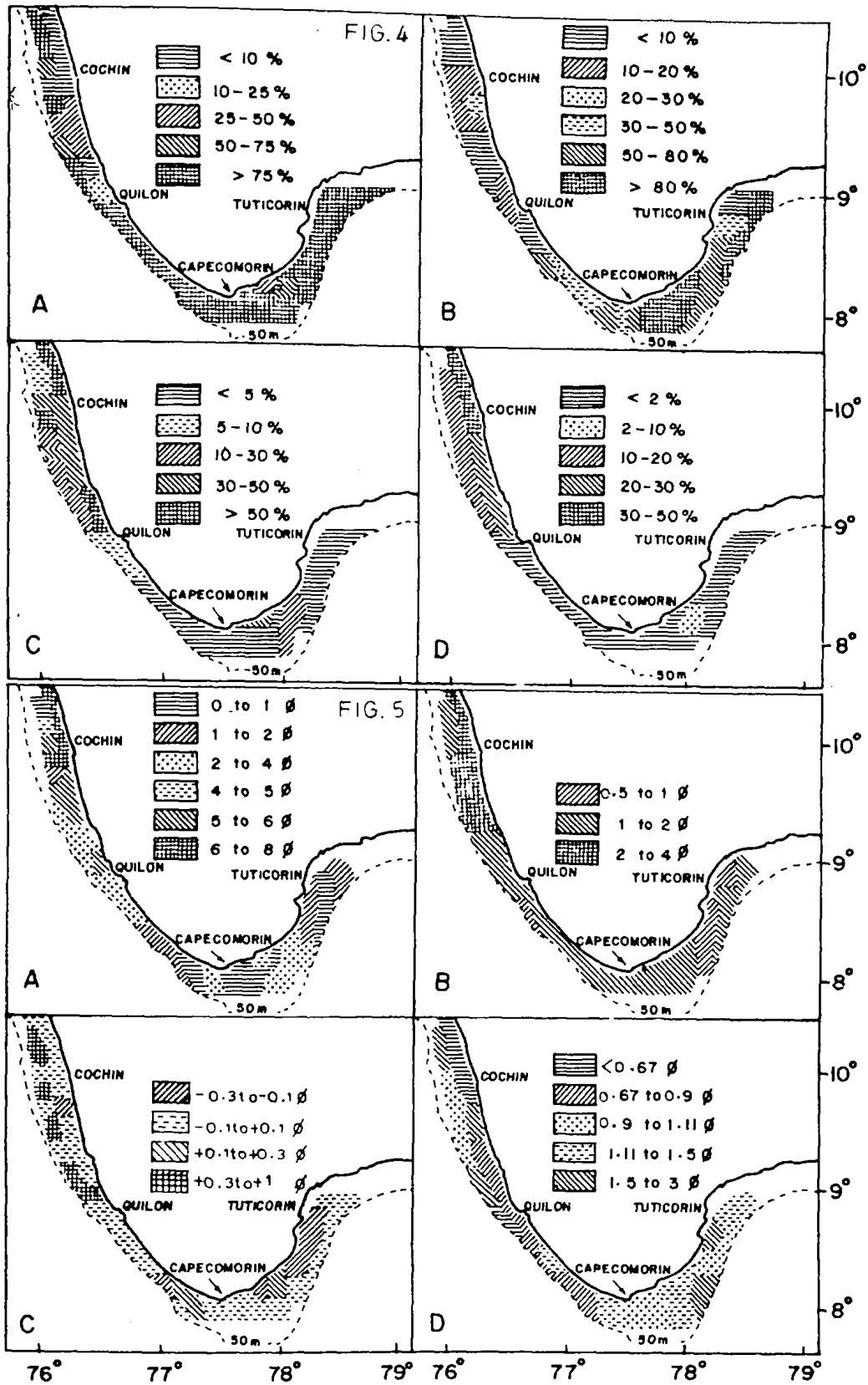


Fig. 4—Distribution of sand (A), carbonate percentage in sand size fraction (B), silt (C), and clay (D) in sediments. Fig. 5—Variation of mean size (A), sorting (B), skewness (C) and kurtosis (D)

**Sorting**—Areal distribution of sorting is shown in Fig. 5B. The area north of Quilon shows dominantly very poor to poor sorting ( $1.11-3.45\phi$ , av.  $2.23\phi$ ). Poor sorting also prevails in the area between Quilon and Cape Comorin ( $0.95-1.64\phi$ , av.  $1.26\phi$ ) with one patch of moderately sorted sediment between Quilon and Trivandrum. The area between Cape Comorin to Tuticorin shows poor sorting on either ends with moderate sorting in the centre ( $0.67-2.1\phi$ , av.  $1.16\phi$ ). Based on this distribution it can be summed up that comparatively the sorting is better in the Cape Comorin to Tuticorin region, poor in the Cochin to Quilon section and intermediate between Quilon to Cape Comorin region.

**Skewness**—In general the skewness in the area between Cochin to Quilon varies from nearly symmetrical to very positively skewed ( $-0.14$  to  $0.46\phi$ , av.  $0.25\phi$ ) sediments (Fig. 5C) showing the absence of winnowing action or winnowing at places only. The sediments between Quilon to Cape Comorin show dominantly symmetrical skewness ( $-0.6$  to  $0.28\phi$ , av.  $0.001\phi$ ) with patches of negatively and positively skewed sediments showing variable winnowing action. The sediments between Cape Comorin to Tuticorin ( $-0.31$  to  $0.33\phi$ , av.  $0.081\phi$ ) also show dominantly symmetrical skewness. However, the area covered by the number of negatively skewed sediment samples is comparatively larger than on southwestern part. This difference may be due to the fact that the origin of the fine fraction is essentially different on the 2 regions. On the southwestern shelf the fine fraction is terrigenous whereas on the southeastern side the fines are generated *in situ* by the abrasion of carbonate particles. The average content of carbonate is much lower ( $37\%$ ) on the southwestern shelf compared to the southeastern shelf ( $71\%$ ). The large carbonate thus offers a ready source material for the generation of carbonate fines.

**Kurtosis**—Variation in the kurtosis values is shown in Fig. 5D. Distribution of Kurtosis values is nearly normal in regions between Cochin to Quilon and Quilon to Cape Comorin as their average values are  $1.09\phi$  and  $0.98\phi$  respectively. The average kurtosis in the region between Cape Comorin and Tuticorin is  $1.8\phi$ .

#### Sedimentary Processes

The high percentage of fines in the Cochin-Quilon is the result of the trapping of coarse sediments by Vembanad lake near Cochin<sup>13</sup> and Ashtamudi backwaters near Quilon<sup>14</sup>. The clay sized sediments are deposited in the nearshore region by the process of

flocculation. South of Quilon rivers comparable to, for example Periyar are absent, hence the percentage of fines decrease sharply and sand becomes the prominent sediment type on the shelf. An additional reason for the predominance of sands may be due to winnowing action by waves. This is shown by the skewness values of the sediments of this region. The fine fraction of the sediments are less ( $4.27\%$ ) in the region between Quilon to Cape Comorin compared to the region between Cape Comorin to Tuticorin which is  $12.81\%$ . This difference may be due to the fact that the southwestern shelf is more exposed to open ocean conditions (including the effect of the southwest monsoon) compared to eastern region. The lack of terrigenous influx (due to lack of rainfall) to the Gulf of Manaar also results in increase in carbonate productivity, because carbonate production is usually enhanced in warm, clear and shallow waters. Profiles C and E (Fig. 2) which show periodic bed forms suggest the presence of strong bottom current. The absence of such bottom features on the shelf where the sediment texture is sandy (mean size similar on both sides but of different composition), as between Quilon and Cape Comorin, in turn means that bottom currents of sufficient strength to generate such features are absent.

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