

A Description of Sediment Cores From the Arabian Sea

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ABSTRACT

This study describes in detail the lithologic character of five sediment cores from the Arabian Sea (shelf, slope, and basins) and summarizes the distribution and occurrence of their characteristic lithofacies and biofacies in schematic stratigraphic columns.

Core no. 1 from the slope is composed of fine-grained, limy marl with oolites and a mixed fauna which includes in situ and slumped outer shelf material. Core no. 2 is mainly a pelagic ooze with intercalations of turbidites and oolites derived from the outer shelf/slope region. Although the last three cores are all from an offshore, outer neritic, low-energy environment, core no. 3 has sapropelitic sediment which probably developed within a 'closed basin' with a highly reducing environment; core no. 4 has oolitic layers with intercalations of clayey material and contains few fossils; and core no. 5 is characterized by two distinct lithologies, a definite stratigraphic break and a moderate concentration of fossils.

INTRODUCTION

Five Sediment Cores from the Arabian Sea were obtained by the R/V *Oceanographer*, U. S. Coast and Geodetic Survey, during June 13-23, 1967. These were splits and have been shared by the author and the U. S. Environmental Science Services Administration. This, the first in a series, is an account of their stratigraphy.

LOCATION

Three of the sediment cores (nos. 3, 4 and 5 at stations 66, 73 and 146) were collected from the continental shelf; one (no. 1 at sta. 29) from the slope; and one (no. 2 at sta. 43) from the Arabian Sea basin (Fig. 1 and Table 1).

Earlier workers (Olausson, 1960, 1961; Norin, 1961) described the sediment cores from the Mediterranean Sea, Red Sea and the Indian Ocean; a detailed account of the biological and sedimentological contents of the surface sediments of the Indian Ocean was given by Stubbings (1939), and the structural and geological aspects were discussed by Schott (1935), Sewell (1937) and Peppar et al., (1963).

SAMPLING AND METHOD OF STUDY

Each core was split and divided into small portions before storage, taking care to mark the top, bottom and the location of each piece. Each of these

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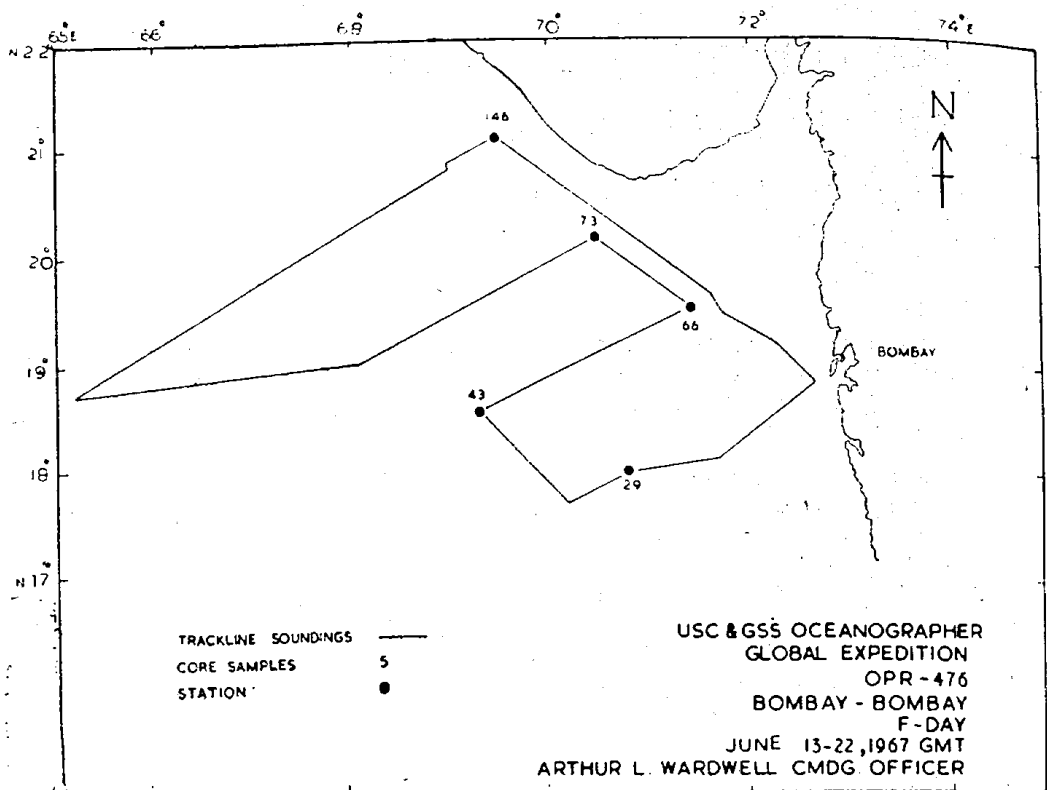


FIGURE 1--Map showing the stations where the sediment cores were collected in the Arabian Sea.

was sampled continuously in 1-inch (2.5-cm) segments, and stored in separate vials retaining, as far as possible, the orientation of the sample. The results of investigation of every segment are plotted schematically on a column which represents the log of that piece of the core. Any variation in colour, stratification or fossil content and special features noticed were recorded during study.

TABLE 1 — Station Location and Other Core Data of the Scientific Cruise of USC & GSS OCEANOGRAPHER, Bombay-Bombay Leg.

Core No.	Station	Location		Depth (meters)	Core Length (centimeters)
	Serial No. as per Oceanographer	Latitude North	Longitude East		
1	29	17°57.9'	70°46.0	649	175
2	43	18°35.2'	69°17.2	2960	190
3	66	19°32.8'	71°21.5'	64	115
4	73	20°10.0'	70°26.9'	73	50
5	146	20°04.5'	69°26.0'	63	235

A vertical shrinkage in length, as a result of loss of moisture and drying, was also noticed.

CORE No. 1. Arabian Sea — Slope (Table 1 and Figures 2 and 7a)

This core is composed of soft, light grey, calcareous clayey material with white and grey oolites. Lenses of these two types of oolites are found scattered in a mixed layer. A distinct clayey layer occurs at 0-42 cm, an oolitic layer at 130-175 cm and a mixed layer at 42-130 cm depth. Within the oolitic layer, thin bands of clustered oolites and clayey material alternate. The oolites show a variation in size, shape and colour. They are porcelaneous and iridescent, and can be small, rounded, equigranular and assorted. At some depths the whites dominate the greys or vice versa.

Palaeontologically, foraminifera are dominant, but pteropods, otoliths, fish scales and teeth with embryonic, juvenile, adult and fragmented bivalves and gastropods also occur. Planktonic foraminifera predominate at 12-42 cm and are common at 0-12, 42-80 and 135-175 cm depth. This indicates a marked fluctuation in their deposition. Foraminifera almost fade out in the mixed layer (80-135 cm depth), indicating a faunistic unconformity or an environmental hiatus in the sequence of the core. Pteropods are present rather sparingly at 50-55, 70-120 and 140-175 cm, but are characteristically absent in the clayey layer and part of the mixed layer. The embryonic and juvenile molluscs are seen intermittently throughout. The adult and fragmented forms are, however, restricted to 80-111 cm. Focal pellets are present at 58 and 117 cm depth. Carbonaceous matter is found distributed in the core (between 75-101 and 136-172 cm) as fillings in the tests of foraminifera and in cracks or cavities present in the sediment. A calcareous, longitudinal, thinly layered shelly tooth-like form (an unidentified fossil) is seen at 73-98 cm depth.

The sediment deposited *in situ* is represented in horizons at 12-42 and 80-130 cm, with oolitic inclusions at 0-12, 42-80 and 133-175 cm. Thick sediment indicates slumped outer shelf material with the most recent slump deposit being the 0-12 cm layer at the top. Figure 8a indicates a progressive increase in oolitic content with depth, whereas foraminifera show a decline.

CORE No. 2. Arabian Sea—Basin—Abyssal Plain
(Table 1 and figures 3 and 7b)

The core is composed of Globigerina ooze, limy marl, finegrained oolites, a turbidite, and other biogenic material. The occurrence of a turbidite (terrigenous material) in an otherwise calcareous sediment marks a definite stratigraphic break or unconformity (at 90-98 cm depth). Similarly, lenses of turbidite occur at 8-10, 45-47, 60-62, 82-89, 142-145 and 180-188 cm depth, although these (excepting those at 82-89) are unrelated bodies. Detrital grains exist at 58-62 cm depth.

The oolites, which are definite shelf deposits, occur as inclusions in the ooze at 8-45, and 170-185 cm, and as lenses or pockets of oolites at 10-32, 45-48 and 60-63 cm. Globigerina is abundant in the ooze at 0-12 and 97-178, common at 12-52, 57-90 and 180-190, but rare at 53-58 cm depth. A sudden fall in their number indicates a definite ecological disturbance during deposition. The carbonaceous matter is distributed as infillings, except at 65-98 and 180-190 cm, which may be attributed to the appearance of a temporary oxidizing phase induced by the influx of terrigenous material such as turbidite. Pteropods are common at 18-45 and 145-155, but rare at 170-190 cm. Embryonic, thin-walled bivalves and gastropods are found at 123-130 cm depth only. A large cone-like flat-topped, spiked calcareous fossil (an unidentified form) occurs at 145 cm

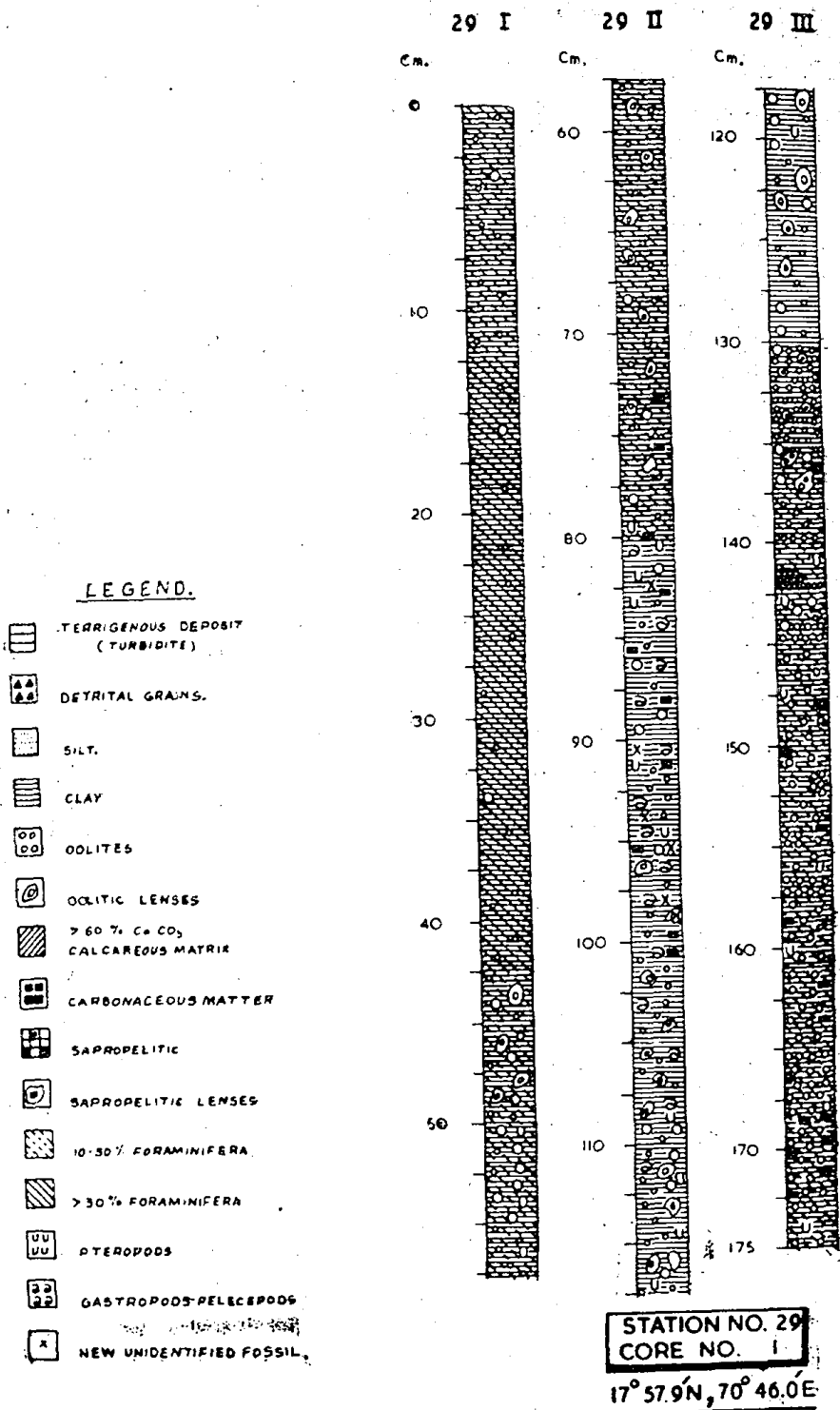
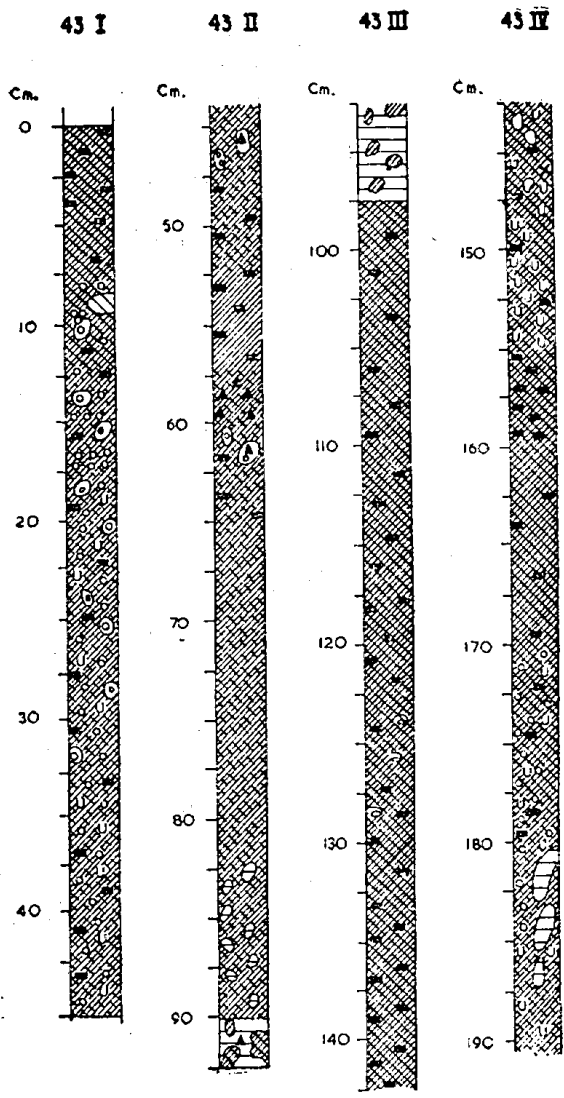


FIGURE 2—Schematic section of core No. 1

depth. The calcareous marl acts as the matrix for the ooze. The *in-situ* deposition of the ooze is represented by horizons at 0-8, and 45-170 cm, whereas the oolitic slump deposit (8-45, and 170-190 cm) was derived from the slope and/or outer shelf; the clastic detrital material found at 8-10, 90-98 and 180-188 cm (and lenses of it) was, however, derived from the basin area only (Fig. 3).



STATION NO	43
CORE NO	2
18° 35.2' N, 69° 17.2' E	

FIGURE 3—Schematic section of core No. 2 (see Fig. 2 for legend).

Figure 7b shows that the rate of ooze accumulation is very high at the present time (0–8 cm), as it was also at 98–178 cm depth, and the oolites do not seem to be associated with the deposition of the ooze. Therefore, it is clear that they were displaced and deposited in the basin. The interrupted ooze deposition continued, however, often with intrusions of turbidite.

CORE No. 3. Arabian Sea—Shelf (Table 1 and Figures 4 and 7c)

This core is chiefly composed of a very fine grained sapropelitic, dark greyish brown clayey material. The high content of organic matter throughout indicates continued reducing conditions. The second predominant material is the carbonaceous matter. Lenses of unfossiliferous, much darker and denser clayey material at 8–10 cm and small intrusions of sand or terrigenous material at 70–73, 77–80, 82–84 and 100–102 cm exist. Newly formed colourless/white fibrous mineral material (zeolite?) extrudes from the sediment on drying. In addition, rounded or oval, small, equigranular, hard grains exhibiting metallic/perlitic lustre and iridescence are found clustered in small pockets and cavities of foraminifera.

Foraminifera include planktonic and benthonic species ranging between 10–30 per cent of the fauna throughout, except at 0–10 and 95–103 cm depth, where they are rare. Pteropods are quite common at 20–28, 38–62 and 71–77 cm depth. Embryonic and juvenile molluscs, ostracods, otoliths, fish teeth and scales are also found.

Figure 7c indicates that the sapropelitic layer appears to be in equilibrium with the carbonaceous matter in the sediment. Foraminifera are rare to frequent and restricted in the core. This region, therefore, may be considered to be a 'closed basin' within the shelf.

CORE No. 4. Arabian Sea—Shelf (Table 1 and Figures 5 and 7d)

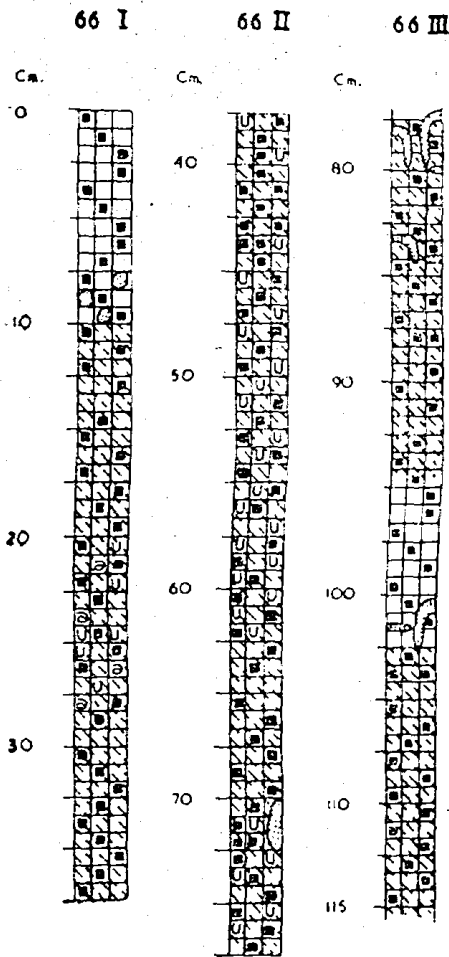
The entire core consists of an oolitic layer intercalated with soft, very fine grained calcareous clayey material. The oolites are white to grey, vary in size from very small to quite large, and vary in shape from rounded, oval and spherical to rod and roller types. This layer at times alternates with the clayey marl and interfingers with it at other depths. Otherwise, oolites together with detrital grains of quartz, muscovite and small water-worn crystalline rock fragments are found in a clayey matrix.

The clayey layer, which occurs in alternating bands at 0–17 cm, becomes discontinuous and appears as lenses at 17–35 and finally as an intercalation at 35–45 cm. The white oolites predominate at 0–8 and 22–28 cm, but the greys dominate at 10–18 and 45–50 and both white and grey alternate at 25–40 cm depth. Foraminifera are minor constituents (about 10 per cent throughout the core, except at 10–22 cm where they are very rare), however planktonic species appear to be dominant in the upper 8–3m layer. Pteropods occur sparingly throughout, but the adult and fragmented pelecypods and gastropods are common. Fragments of bryozoa, spines of echinoderms, ostracods and fish teeth occur very sparingly.

The foraminiferal and oolite content in the sediment is proportionately constant (Fig. 7d).

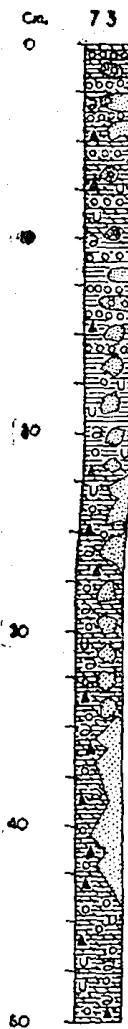
CORE No. 5. Arabian Sea—Shelf (Table 1 and Figures 6 and 7e).

This is the longest of the cores. The sediment can be divided into two layers characterised by distinct lithologies separated at a definite stratigraphic break at 65 cm depth. These are (1) a sapropelitic layer and (2) a mixed layer having lenses of sapropel and oolitic marl. The sapropelitic layer



STATION NO. 66
CORE NO. 3
19° 32.8' N, 71° 21.5' E

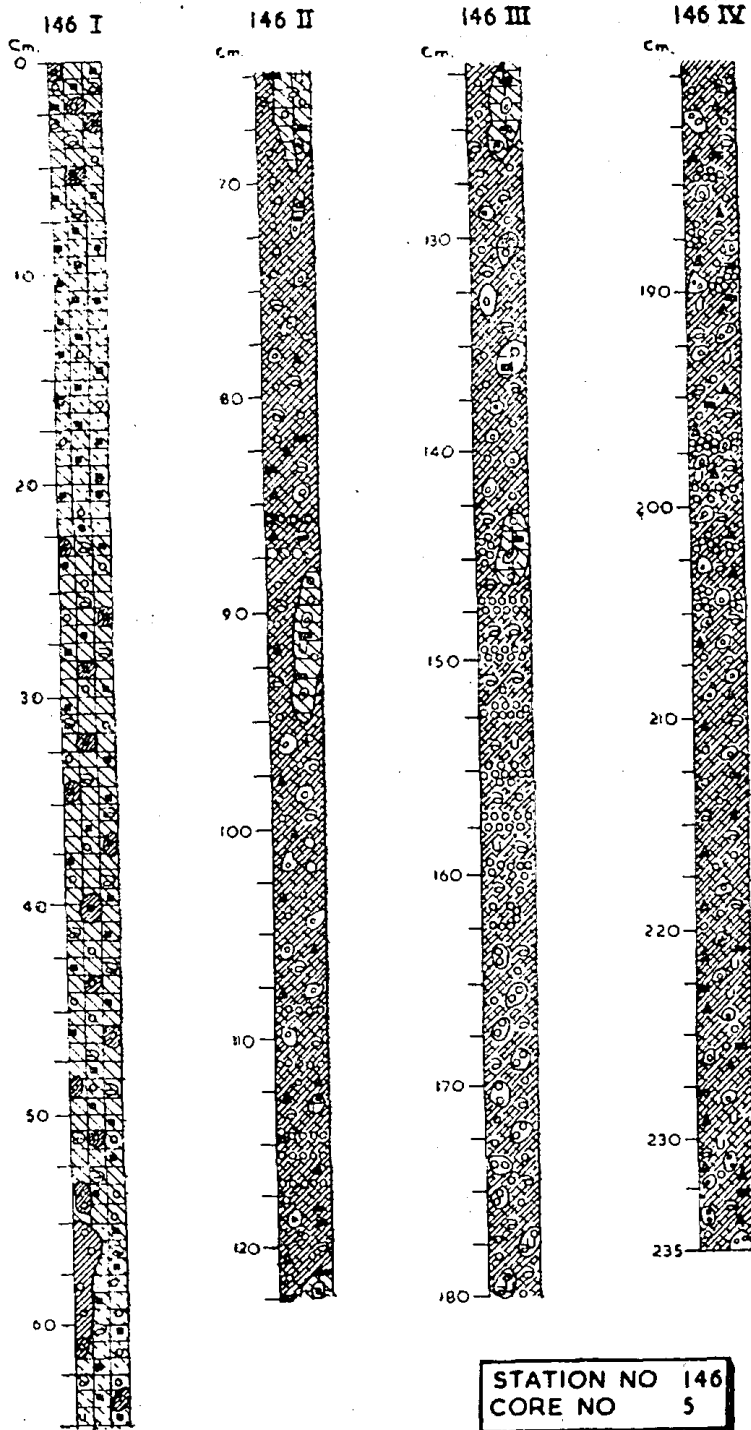
FIGURE 4 — Schematic section of core No. 3 (see Fig. 2 for legend).



STATION NO. 73
CORE NO. 4
20° 10.0' N, 70° 26.9' E

FIGURE 5 — Schematic section of core No. 4 (see Fig. 2 for legend).

is clearly marked by its lithology and extends from the top to 70 cm depth. Based on the abundance of fauna and included lenses, it can further be divided into two parts that alternate with each other : (a) the sections between 0-8 and 22-55 cm, characterised by a large number of lenses of the oolitic layer and abundant foraminifera and other fauna ; and (b) sections at 8-22 and 55-65 cm



STATION NO 146
 CORE NO 5
 20° 04.5' N, 69° 26.0' E

FIGURE 6—
 Schematic section
 of core No. 5
 (see Fig. 2 for
 legend).

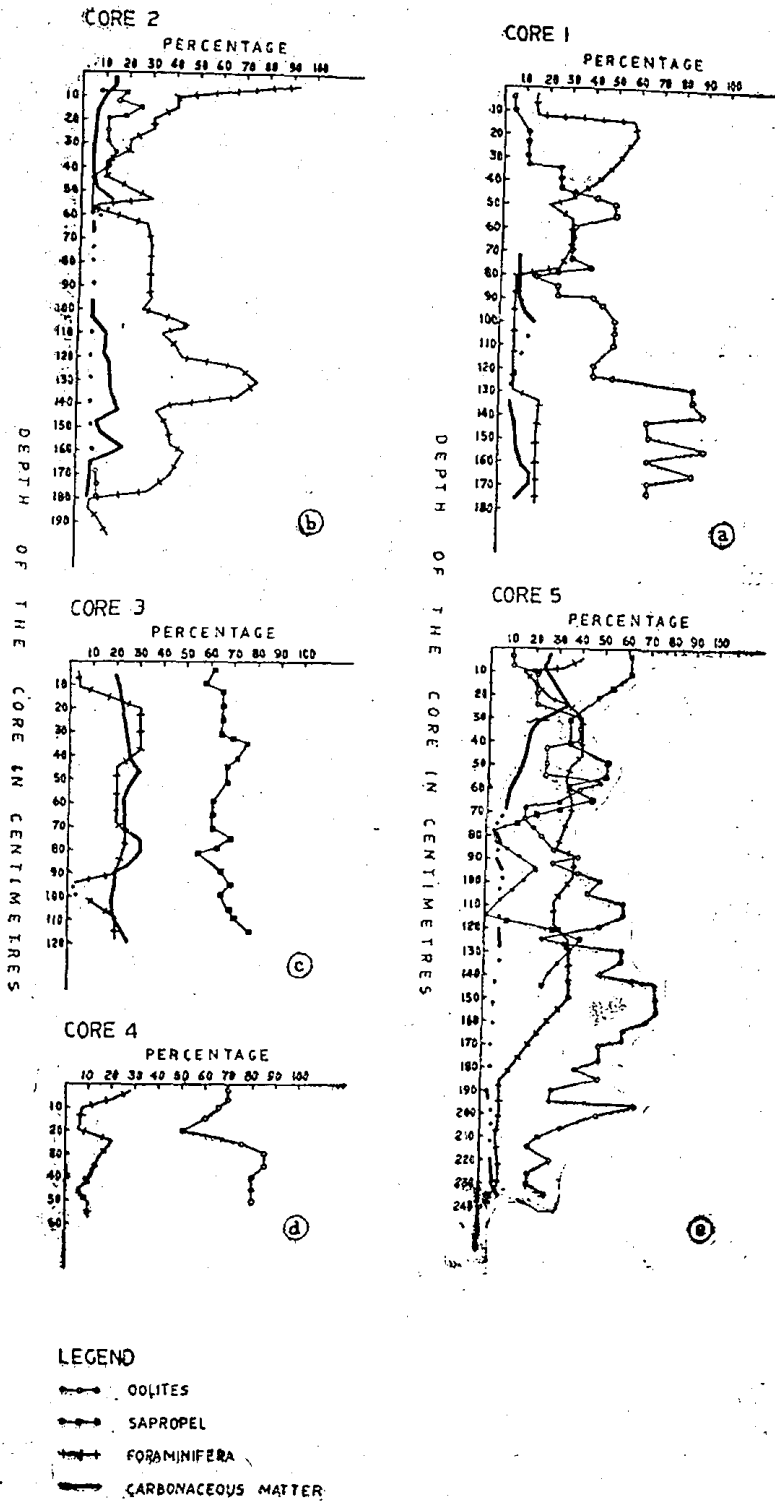


FIGURE 7—Graphic representation of distribution of lithofacies and biofacies in cores 1-5.

composed of a few lenses of oolitic marl having a low foraminiferal fauna. The mixed oolitic marl layer is composed of light grey, hard, compact oolites and marl and extends from 65 to 208 cm depth. It includes lenses of sapropel at 70-72, 88-95, 120-126, 130-137 and 142-146 cm. The white and grey oolites appear in alternate bands and also abundantly at 109-117, 142-162 and 185-205 cm. A segment of calcareous marl found at 208-235 cm is characterised by a few oolites and fossils. The detrital grains are increasingly present at 180-235 cm, but less so at 78-120 cm. The carbonaceous matter is present throughout the sapropelitic layer, but only in traces at 185-235 cm. Foraminifera are found throughout the core, but are abundant only at 0-8 and 22-55 cm; they are common at 8-22 and 55-235 cm depth. Minor amounts of pteropods, embryonic gastropods and pelecypods are also present. Mixing of sediment, due to the activities of burrowing organisms, is noticed in the top 60 cm.

A change in environmental conditions of deposition is indicated at 65 cm by a total change in lithologic character (from calcareous marl to sapropelitic material). Within the marl (70-235 cm) there is a dominant oolitic zone (142-205 cm), although oolites are present throughout the core. The lithologic character indicates that the region changed from an oxidizing environment suitable for the formation of oolites to a reducing environment conducive to the formation of a sapropelitic layer. (Fig. 7e).

COMPARISON

Of cores which are shallowest and closest inshore, two (nos. 3 and 5) have a features in common: sapropelitic sediment, colour, texture and organic matter content. Thus the entire core no. 3 is similar and equivalent in all respects to a portion of core no. 5 (0-65 cm). However, the full cores differ with respect to their concentration of oolites or oolitic lenses, and the character of their fossil assemblages.

Part of core no. 5 (147-235 cm) is similar to the entire core no. 4 insofar as both have: (1) oolites and oolitic lenses, (2) oolitic layers alternating with marl, (3) detrital grains and (4) a similar number and variety of foraminifera and other kinds of fossils. The sapropelitic layer (0-65 cm) in core no. 5 is present in the entire core no. 3, but this is not so for core no. 4. However, no. 5, differs from the other two in colour, mineral composition and sediment texture.

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REFERENCES

- Norin, Eric, 1960. Sediment cores from the Mediterranean Sea and Red Sea: the sediments of the central Tyrrhenian Sea. Rept. Swedish Deep-Sea Exped., 8, (1), p. 136.
- Olausson, Eric, 1960. Description of sediment cores from the Indian Ocean. Rept. Swedish Deep-Sea Exped. 1947-48, 9, (2), p. 88.

- _____, 1961. Sediment cores from the Mediterranean Sea and the Red Sea : studies of deep-sea cores. Rept. Swedish Deep-Sea Exped, 8, (4), p. 391.
- Peppar, J. F., and Everhart, G. M., 1963. The Indian Ocean : the geology of its bordering lands and the configuration of its floor. U. S. Geol. Surv. Publ. Dep. Int. p. 33, Map 1-380.
- Schott, 1935. Geographic des Indischen and Stillen Ozeans. Hamburg, Verlag, Boysen, p. 413.
- Sewell, R. B. S., 1937. An outline of the field sciences of India : the oceans around India. Ind. Sci. Congr. Assn., Calcutta, p. 41.
- Stubbings, H. G., 1939. The marine deposits of the Arabian Sea. The John Murray Exped. 1933-34, 3, (2), p. 31-158.
- _____, 1939. Stratification of biological remains of marine deposits. The John Murray Exped. 1933-34, 3, (2), p. 159-192.