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DISTRIBUTION OF SURFACE SEDIMENTS OFF INDUS DELTA ON THE CONTINENTAL SHELF OF PAKISTAN

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ABSTRACT: Surface sediments from the continental shelf area off Indus delta were analysed for their textural characteristics and carbonate content. The sediments are largely silt, silty clay and clayey silty sand. Sandy fraction is dominant in the outer region with relatively high carbonate content. The study shows that distribution of carbonate in sediments off Indus delta continental shelf is controlled by the dilution of terrigenous material and its distance from source area.

KEY WORDS: Sediments - textural characterstics - carbonate - Indus delta

INTRODUCTION

The Oceanographic studies of the continental shelf between Cape Monze and Indus canyon were carried out by National Institute of Oceanography on board S/V Behr Paima during April-May 1984. The area covered lies between latitude 22°47' 20" and 24°43' 57" North and longitude 65°58' 19" and 67°51' 1" East (Fig. 1). In this study surface sediments from 40 stations were analysed for their sand, silt and clay content and also the carbonate content. Sediments of inner shelf (water depth 20-50 m) are fine grained ranging in size 4-8ϕ and are lower in carbonate content. Grain size and carbonate content of sediments from outer shelf increases westward. Here sediments are relatively coarse grained i.e. $\leq 2\phi$ and carbonate content ranges 60 to 70%.

GEOLOGY OF THE SURROUNDING AREA:

The onshore geology of the area adjacent to the investigated area comprises of deltaic flood plain deposits in the upper part and tidal deltaic deposits, tidal mud flats and coastal sand dunes in lower parts (Kazmi, 1984). Deltaic deposits are interlayered fine sand, silt and clay containing abundant molluscan shells. A thick sequence of Tertiary sedimentary rocks mainly composed of limestone, shale, mudstone and sand stone ranging in age from Eocene to Pleistocene is exposed along the Northern margin of the present delta (Hunting Servey Ltd., 1960). The rock types of the coastal area from Korangi creek to Clifton and westward up to Cape Monze are limestone, sandstone and shale of Nari (Oligocene) and Gaj Formation (Miocene) and conglomerate and sandstone of Manchar Formation (Pliocene-Pleistocene). Subrecent sand and gravels have also been found in the area. At Churna Island, south of Cape Monze, rocks of Kirthar Formation (Middle Eocene) are exposed and a few reefs at a depth of 10-11 meters have been found to the south of Churna Island. (Islam, 1966).

BATHYMETRY:

The general bathymetry of the study area is shown in Fig. 1. In the area of study the continental shelf is characterized by broad flat terraces with a width of about 100-150

Km. The average slope of shelf is 1° per mile. The shelf breaks at an average depth of about 100 m. The Indus submarine canyon with bell shaped mouth is the most striking feature of continental shelf. The average width of the canyon is about 8 Km and its depth is 800 m. The canyon is 170 Km long extending from about 20-30 m water depth to about 1400 m depth where it is 20 Km wide with a relief of about 325 m (Islam, 1959).

MATERIALS AND METHODS

SAMPLING OF SEA BOTTOM:

The sampling stations are shown in Fig. 1. These stations lie on a quadratic grid with about 18 Km wide length. Sediment samples were collected with the help of Peterson grab. Sand, silt and clay fractions were separated by wet sieving. Bulk samples were ground to powder and homogenized. The dry powder sample was used for the analysis of carbonate.

DETERMINATION OF CARBONATE:

Calcium carbonate content was determined with the help of monocalcimeter. This is obtained by treating one gram powdered dry sample with HCl in a chamber of constant volume and recording the CO_2 pressure produced. Determinations were made for the whole sample. The accuracy of the carbonate analysis is $\pm$ 1 %.

RESULTS

SEDIMENTS:

Sediments description and carbonate content are given in Table I. The surface sediments samples are grey to light grey and brown in colour. Nature of sediments and their distribution pattern are shown in Fig. 1. The texture of the sediments range from coarse to fine sand, silt, clay and silty clay. Sediments from near shore stations and from the stations proximal to the contour of 100 m depth in the eastern part of study area are clayey silt with few shell fragments and abundant mica flakes. These are fine grained mostly have medium diameter of 4ϕ. Sediments in and around the Indus canyon are fine silt and clay with less shell material. Further westward of the canyon the shelf sediments change from silt to fine sand ranging from 2-4ϕ in size with abundant skeletal material. In deeper water towards outer continental shelf and continental slope, biogenous sediments consisting of foraminiferal ooze and skeletal components of pelecypods, gastropods, pteropods etc. are found.

CARBONATE:

The aerial distribution of calcium carbonate in surface sediments of the study area is shown in Fig. 2. Calcium carbonate content increases towards offshore. In near-shore clayey sediments carbonate content is 5-20% whereas in offshore sandy sediments it is more than 60%. In clay-silt fraction lithic carbonate fragments are common. The sediments near the Indus canyon are low in calcium carbonate content, but westward in the outer shelf the high values of carbonate content (60-80%) is due to shells of various molluscs as well as tests of foraminifera which are predominant in the outer shelf and slope regions. A very high percentage of carbonate, 76% and 85%,

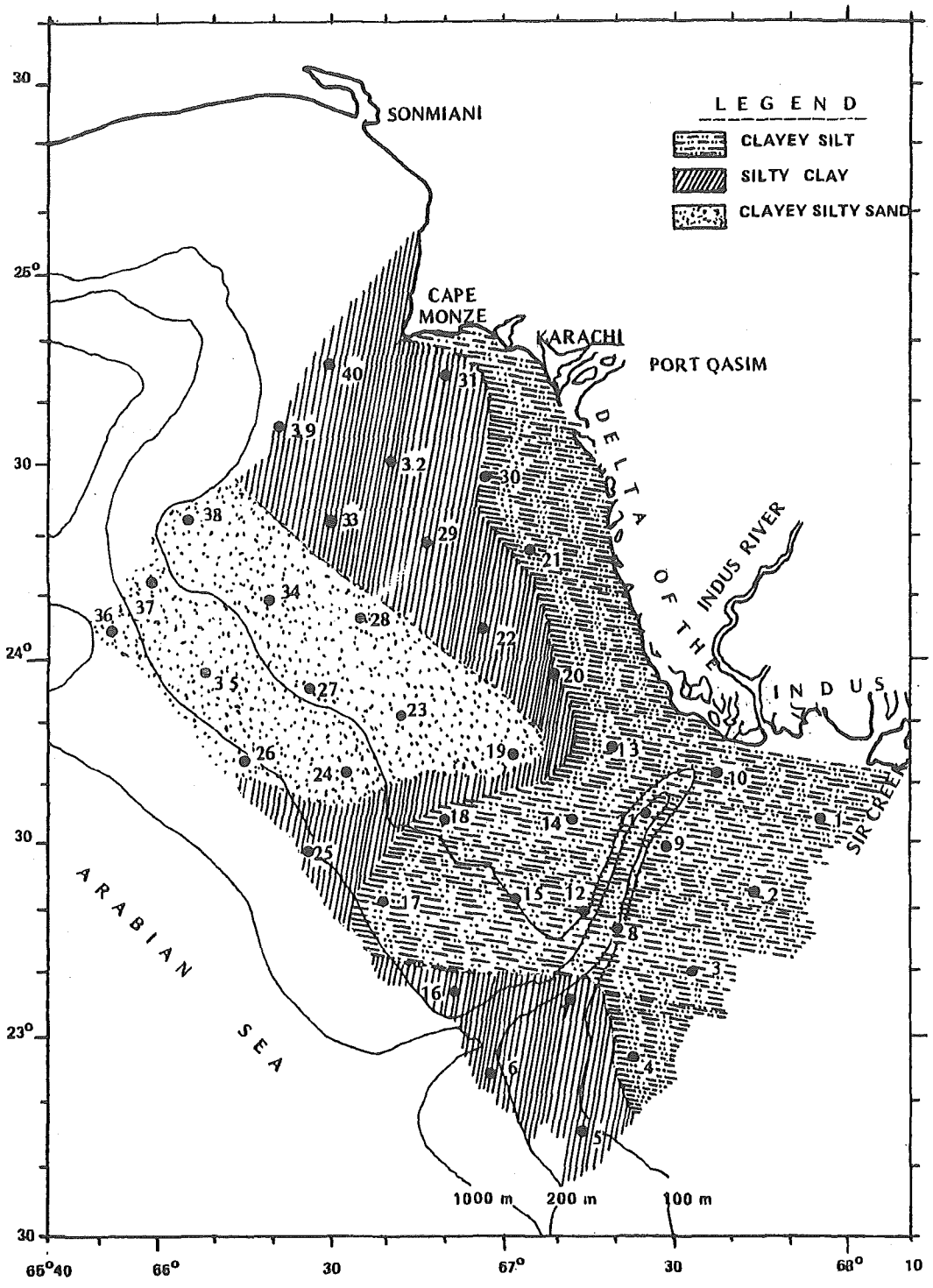

Fig. 1. General bathymetry and sediments distribution map of the study area. Circles indicate sampling stations.

Table.I. Sampling stations and sediments description

Station No.	Depth (m)	Lithology	Colour	Sand% 2-4ϕ	Silt% 4-8ϕ	Clay% >8ϕ	Carbonate %
1	13	Clay-silt	Dark grey	7.16	77.96	14.88	8.43
2	25	Clay-silt	Dark grey	11.05	77.26	10.42	6.25
3	26	Clay-silt	Dark grey	15.46	70.76	9.53	6.5
4	51	Clay-silt	Grey	9.16	73.74	4.30	10.70
5	113	Silty-clay	Grey	12.06	43.16	44.60	17.30
6	270	Clay-silt	Dark grey	2.88	19.00	78.12	10.40
7	112	Clay-silt	Dark grey	1.65	36.78	62.13	6.52
8	49	Clay-silt	Dark grey	1.72	70.00	29.00	12.00
9*	-	-	-	-	-	-	-
10	295	Clay-silt	Grey	1.85	49.23	48.92	8.50
11	712	Clay-silt	Light-grey	4.20	64.40	30.60	9.00
12	25	Clay-silt	Brownish-grey	1.20	60.10	38.40	10.40
13	80	Clay-silt	Dark-grey	1.00	65.00	33.00	14.40
14	96	Clay-silt	Dark grey	8.00	56.00	34.00	18.20
15	126	Clay-silt	Brownish grey	8.00	50.00	32.00	35.60
16	137	Clay-silt	Brownish-grey	9.72	49.18	41.38	31.00
17	90	Clay-silt	Brownish-grey	22.80	43.13	34.06	33.10
18	59	Clay-sand	Brownish-grey	57.70	18.70	23.44	58.15
19	23	Clay-silt	Brownish-grey	50.00	18.21	30.11	66.30
20	23	Clay-silt	Greenish-grey	9.30	70.20	18.80	10.20
21	30	Sandy-silt	Grey	12.00	75.50	4.50	10.20
22	22	Silty-clay	Grey	2.10	46.80	50.20	10.80
23*	-	-	-	-	-	-	-
24	104	Silty-sand	Brownish-grey	64.30	32.19	3.50	70.90
25	222	Sandy-clay	Brownish-grey	18.50	7.40	73.30	29.10
26	216	Silty-sand	Grey	46.23	45.19	9.42	49.10
27	102	Silty-sand	Grey	63.11	33.34	6.00	60.70
28	80	Clay-sand	Brownish-grey	70.04	11.19	18.60	70.10
29	79	Sandy-silt	Grey	17.18	78.70	4.02	21.60
30	30	Clay-silt	Brown	2.00	70.69	27.28	12.70
31	27	Silty-clay	Grey	2.40	44.48	49.88	19.30
32	60	Silty-clay	Grey	1.20	46.44	50.96	17.00
33	60	Silty-clay	Grey	3.57	49.61	46.14	23.00
34	93	Clay-sand	Grey	42.50	27.40	30.10	57.50
35	174	Silty-clay	Brownish-grey	19.00	30.40	50.60	23.50
36*	-	-	-	-	-	-	-
37	157	Silty-sand	Dark-brown	71.04	17.10	11.70	76.00
38	87	Silty-sand	Brown	73.16	23.85	2.84	85.50
39*	-	-	-	-	-	-	-
40*	-	-	-	-	-	-	-

*Sample not taken

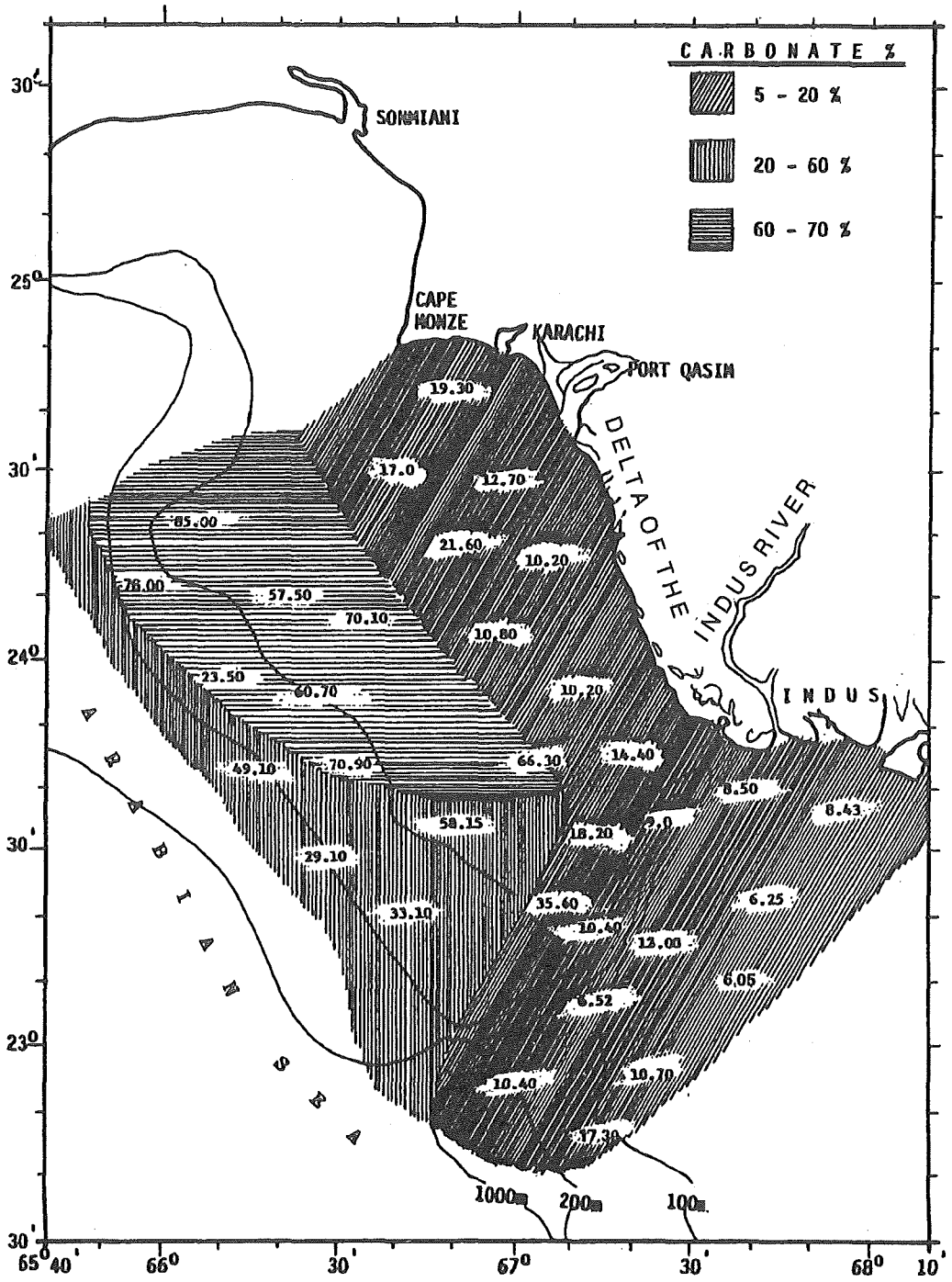

Fig.2. Carbonate distribution in surface sediments off the Indus continental shelf.

was observed at stations 37 and 38 respectively. The sediments at these stations are silty-sand with coral fragments. Some calcareous oolitic sand of various colour yellow, pale brown, dark grey, and greenish black resembling glauconite have also been identified in the samples of stations 6, 19, 24, 28, 29. These carbonate pellets are authegenic in origin formed by the physico-chemical changes in the environment.

DISCUSSION

Surface sediments and their carbonate content shown in Figs. 1 and 2 suggest that bathymetry of the area and the sediments texture are the main controlling factors in sediments distribution and their carbonate content off Indus delta continental shelf Sediments distribution and their nature also reflects the sources of their contributors. Sediments in the inner shelf and in the adjoining areas of Indus canyon are predominantly terrigenous. Towards outer shelf and particularly in western part, terrigenous content decreases and the biogenic content increases. Sediments in the southwest corner of the outer continental shelf are silty-sand and in nature largely composed of coarse skeletal material of calcareous organisms. The coarsness of the sediments in this zone is owing to the presence of abundant biogenic remains of carbonate secreting organism. Nearly all calcium carbonate in the sediments on the outer continental shelf between Cape Monze and Indus canyon is derived from biogenic matter. Visual inspection shows tests of forams ranked to be first in abundance followed by shells of molluscs, crustaceans and of echinoderms. Few corals fragments have been found at stations 33 and 38. Foraminiferal tests are significantly abundant in the outer continental shelf and continental slope. The higher percentage of carbonate (more than 70%) in the extreme west at stations 37 and 38, may be due to presence of coral fragments observed in the sediments at these stations. The outcrops of limestone along the coast might also have contributed a significant amount of carbonate to the seafloor by weathering. This connotation appears to be limited mostly in the shallow, nearshore, stations where lithic carbonate fragments have been observed. The relatively low value of calcium may also be accounted for by the greater dilution of the sediments by the Indus river discharging 100×10^6 metric tons/year (Milliman and Meade, 1983) of fresh terrigenous material in the sea. The carbonate content of the sediment is largely biogenous in origin. However, presence of some calcareous oolites show that authigenic carbonate is also contributing to a less extent.

Arrhenius (1963) correlated the fertility of the seawater to the carbonate content of the sediment. In the light of this correlation the source and distribution pattern of calcium carbonate in the area of study indicates that the carbonate content may be related to the biogenic productivity of the overlying water. Generally it is accepted that the high carbonate occurs in the area where conditions are favourable for animal community (Hulsemam, 1967). During International Indian Ocean Expedition about 1000 specimens of planktonic foraminifera were estimated in one gram of sediment sample from the Arabian Sea (Geol. Geopy. Atlas, 1975). Although the offshore Indus shelf is one of the most fertile region (Quraishee, 1988), it is difficult to correlate the productivity of the area with the carbonate content of sediments. More data of the phytoplankon distribution and detailed studies of biological phenomenon are required. However, this study clearly reveals that sediments distribution and their carbonate content in the offshore Indus delta shelf are linked with biogenous and

terrigenous sources. Carbonate content is largely biogenic in origin and nearshore sediments are largely terrigenous. Low carbonate content (5-20 %) near the inner shelf and in the Indus canyon area may be due to the dilution of sediments by non carbonate detritus washed into the Indus canyon by the Indus river. (Kolla, *et al.* 1918). It is likely that the abundance of terrigenous content in the near sediments is suppressing the carbonate content in the investigated sediments. However, the off-shore sediments rich in carbonate content appears to be less effected by the terrigenous input.

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