

Clay mineralogy of innershelf sediments off Cochin, west coast of India

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Kaolinite, montmorillonite and illite are the clay minerals occurring in decreasing order of abundance in the holocene sediments of inner shelf and adjacent coastal environments of Cochin region. Southern part of Vembanad lake, estuarine part of Periyar river and outer parts of inner shelf have relatively more kaolinite (> 60%) than in sediments of northern part of lake and near inner shelf. In Vembanad lake, kaolinite concentration shows a gradual decrease with concomitant increase in smectite from south to north. Such a variation from the source indicates size sorting of clay minerals with coarser kaolinite depositing closer to the source than finer montmorillonite. In the inner shelf, sediments from outer parts have significantly more kaolinite than nearshore sediments. Higher proportion of kaolinite in sediments of outer parts of inner shelf are considered to have been deposited during a lowered sea level in Holocene.

Clay mineral studies on modern sediments have clearly demonstrated that they are not only sensitive indicators of their environment of formation but also of the processes of transportation and deposition. Clay mineral distribution patterns in recent sediments indicate a transport differentiation based on size sorting¹⁻³.

Size sorting during transport plays a prominent role in the differentiation of clay minerals. On the west coast of India shifting Holocene sea levels⁴ caused the migration of sediment depositories on the shelf. Such shifting coastlines changed the position of estuaries and transport distances of the land-derived material to sea from time to time. In order to understand whether such shifts in sea level and attendant variations in environmental conditions have any effect on the clay minerals, modern sediments of the Cochin region were investigated.

The study area includes inner continental shelf of Cochin, Vembanad lake, an estuarine system and Periyar river. The 45 km wide continental shelf is relatively smooth with shelf break⁵ occurring between 80 and 110 m. Mud banks are characteristic topographic features on the inner shelf off Cochin. However, they are seasonal and disappear after the monsoon period. An elongate barrier complex separates the shelf from adjacent Vembanad lake

through which the river borne material is carried to the sea. In the northern part of the study area Periyar river is a major contributor of sediments to the shelf.

Sediment samples from inner shelf of Cochin were collected with van Veen and Peterson grab. Sediments were desalted and treated with H₂O₂ and acetic acid to remove organic matter and carbonates respectively. From these sediments, clay fraction (< 2 μ m size) was separated using sedimentation technique based on settling velocities. Oriented specimens were obtained by sucking a well dispersed clay on to a membrane filter.

A Philips X-ray diffractometer fitted with Ni filtered Cu K α -radiation source was used to analyse the samples. Both untreated and glycolated specimens were scanned from 2° to 30° at 2° 2 θ per minute. Clay mineral percentages were determined following weighted peak area method⁶.

Kaolinite (87%), montmorillonite (59%) and illite (24%) are clay minerals present in sediments of the study area (Table 1). In Vembanad lake and Periyar river, kaolinite is the predominant mineral constituting more than 59% of total clay minerals. Further kaolinite dominates (81%) clay assemblage of sediments in the outer parts of inner shelf (Fig. 1). In the rest of the shelf kaolinite is either equal or relatively lower than smectite. Illite is least abundant

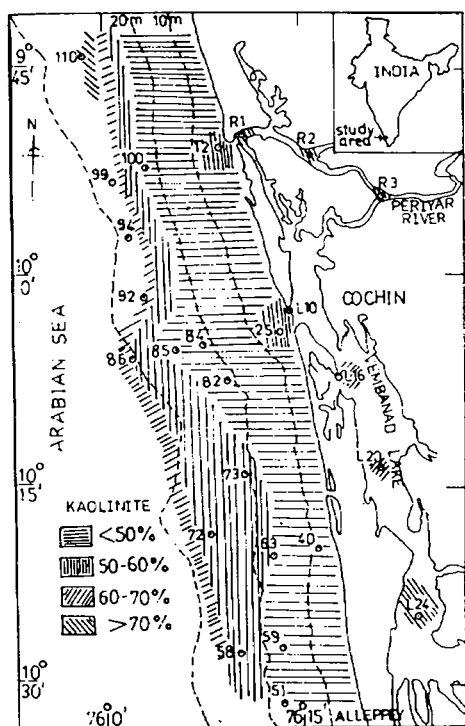


Fig. 1—Sample locations and kaolinite abundance

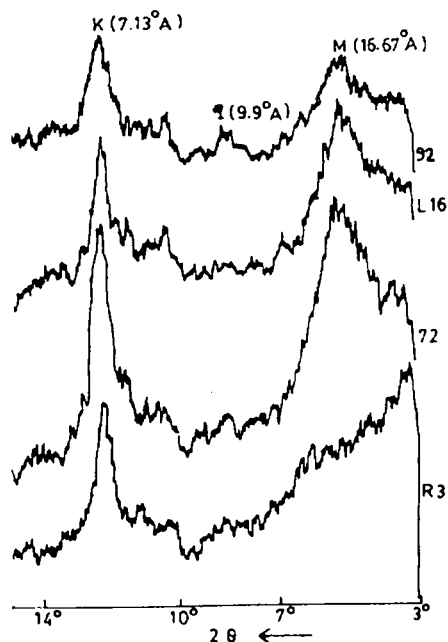


Fig. 2—X-Ray diffractograms of representative samples from each of the environments

Table 1— Percentages of clay minerals in the sediments of inner shelf, Vembanad lake and Periyar river

Sample No.	ϕ mean size M_r	Kaolinite	Illite	Montmorillonite
Inner shelf				
12	5.67	53	8	39
25	9.3	50	17	33
40	6.7	48	6	46
51	6.0	46	8	46
58	3.3	61	14	25
59	5.5	49	24	27
63	7.0	50	12	38
72	2.7	40	4	56
73	5.3	65	5	30
82	4.7	39	2	59
84	6.9	38	23	39
85	6.2	41	19	40
86	2.5	55	21	24
92	0.9	72	16	12
94	3.3	78	16	6
99	1.2	72	17	11
100	8.0	44	8	48
110	2.9	81	7	12
Vembanad lake estuary				
L10	4.87	59	19	22
L16	3.0	65	12	23
L20	4.0	70	13	17
L24	4.4	73	17	10
Periyar river				
R1	2.9	81	16	3
R2	3.3	80	16	4
R3	3.8	75	18	7

clay mineral with concentrations rarely exceeding 20%. X-ray diffractograms of representative samples from each of the environments is given in Fig. 2. Eventhough the clay assemblage is same, abundance of kaolinite is somewhat greater and exhibits a significant regional variability than that observed earlier^{5,7}. Similarly, concentration of montmorillonite is also lower than reported values. This may be due to poor representation of sediment samples from inner shelf as a whole. The general predominance of kaolinite in shelf sediments is in accordance with Nair and Murthy⁸ and Nair⁹ who reported kaolinite rich mud banks in the inner shelf of Cochin.

While illite distribution is erratic, kaolinite and smectite exhibit distinct lateral and regional variations in the study area. In Vembanad lake there is a characteristic increase in montmorillonite concentration (10 to 23%) from the source to seaward. Such an increase in montmorillonite content is accompanied by a concomitant decrease in kaolinite from 73% at the head to 59% at the mouth of

the lake. In the inner shelf also montmorillonite constitutes considerable proportions except in outer parts, where there is an enrichment of kaolinite.

In general it is recognised that coarse grained sediments contain more kaolinite, whereas fine grained sediments more montmorillonite (Table 1, Fig. 3).

Similar clay assemblage (kaolinite, montmorillonite and illite) with rich kaolinite content in sediments of shelf and river, indicate detrital origin of clays from the hinterland. A large portion of the drainage basin of rivers is covered with lateritic and red soils. This may be the main source of kaolinite. Black soils and peaty soils which cover a small proportion of the hinterland are enriched with montmorillonite and illite. Chamely¹⁰ describes continental environments favourable to montmorillonite formation as they are hot and monsoonal in character. Thus, the relative proportions of kaolinite and montmorillonite/illite in river sediments, to a great extent, reflect regional distribution of their source soils in the drainage basin.

In the absence of marked variation in source material, observed abundance and occurrence of kaolinite and montmorillonite in Vembanad lake and adjacent shelf are considered to be due to transport differentiation and flocculation. Size sorting during transport thus represent a significant factor in bringing about decrease in kaolinite with concomitant increase of montmorillonite in Vembanad lake. In inner shelf sediments also higher montmorillonite concentrations may be correlated with high contents of fine clay grade material. In fact in the inner shelf mean grain size of sediments show an inverse relation with that of kaolinite and a positive correlation with montmorillonite (Fig. 3). Johnson and Kelly¹¹ have also observed an increasing smectite abundance with decreasing size, particularly at size finer than 0.49 μm , in the suspended load of the Mississippi river.

Relative suspension stability of clay minerals might have also contributed to the observed clay mineral variations. Clays which are relatively stable in waters of low salt content are destabilized to a great degree in waters of higher salinity¹². Kaolinite, which is abundant in hinterland soils flocculate earlier in estuaries, whereas montmorillonite is carried further and gets deposited on the shelf.

Kaolinite enrichment at -30 m water depth is perhaps due to the shifting sediment discharge points

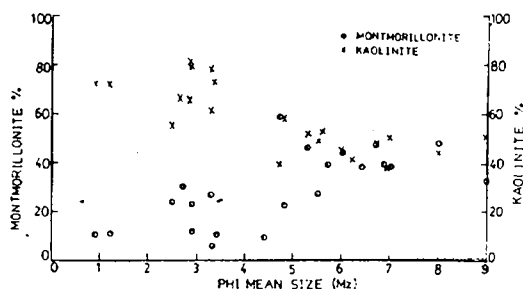


Fig. 3—Kaolinite and montmorillonite relation with ϕ mean size of the sediments

of rivers due to Holocene sea level changes. Reddy and Durgaprasada Rao¹³ report an old strandline at -30 m based on the occurrence of coarse sediments comparable in textural characteristics with those of modern beach sands. During this mid-Holocene lowered sea level, the rivers might have deposited sedimentary load directly onto the shelf giving rise to kaolinite rich sediments. The sediments appear to have been practically undisturbed during subsequent rise in the sea level probably due to low wave energy and lack of modern sediment transport across the shelf⁷. Thus the offshore kaolinite may be representing fluvial debris deposited on the shelf at the time of lowered sea level.

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