Dispersal pattern of clay minerals in the sediments of Nizampatnam bay, east coast of India

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Constituent minerals of the clays were (from X-ray diffraction) montmorillonite, illite, kaolinite and chlorite. Montmorillonite is the predominant mineral which constitutes > 80% of the clay minerals in most of the sediments. Illite is the next abundant mineral varying from 5-22%. Kaolinite and chlorite are least abundant with concentrations well below 10%. Lateral distribution pattern of the clay minerals shows an increase in smectite with concomitant decrease in illite and kaolinite from the coast to the shelf. A greater contribution of the clay fraction appears to have been derived from the erosion of alkaline rich rocks in the upper reaches of Krishna drainage basin.

Very limited data exist on the clay mineral distribution of marginal/continental shelf sediments off the east coast of India\(^1\). The purpose of this investigation was to identify the source and to study the distribution of clay minerals in the area.

The Nizampatnam bay is an embayment, adjoining the Krishna delta in the western Bay of Bengal. The Krishna and Gundlakamma rivers are the main source of sediments to the Nizampatnam bay. The Krishna drainage basin includes a large variety of rock types: the Deccan volcanics and Archaean granites and gneisses, precambrian sediments and khondalite group of rocks in the coastal region.

Fifty six sediment samples were selected from the Nizampatnam bay for the present study (Fig. 1). Sediment samples were collected by Peterson grab along 12 profiles during Jan.-Feb.1987. Approximately 5 g of sample was added in 50 ml of 1M sodium acetate-acetic acid buffer (pH 5) and disaggregated mechanically and ultrasonically. The resulting suspension was digested (at 80°C for 30 min) to remove carbonates, and later 5 ml of 30% H\(_2\)O\(_2\) was added to remove organic matter. Suspension was again digested for 2 to 4 h. To the evaporated residue, 20 ml of 0.3 M Na\(_2\)C\(_6\)H\(_5\)O\(_7\) 2H\(_2\)O and 5 ml of 1M NaH\(_2\)CO\(_3\) solution was added. The temperature was brought to 80°C in a water bath and 1g of Na\(_2\)S\(_2\)O\(_4\) was added. This treatment was meant to dissolution of amorphous silica, reduced iron oxides and hydroxides and chelated the dissolved iron.

The treated samples were then suspended in 25 ml of 1 M calgon (sodium hexametaphosphate) solution and separated by sieving and gravity settling. The 2 to 0.2 fraction (equivalent to settling diameter) was removed by centrifugation, dried and preserved for X-ray diffractometry.

Oriented slides were prepared of all the fractions by the pipette-on-to glass slide technique\(^2\). The slides were exposed under Phillips XRD system (PW 1730/PW 1390) as untreated and glycolated from 3° to 30° at 2°2θ min\(^{-1}\) using Ni filtered Cu Kα radiation. To detect chlorite from kaolinite, sediment samples were slow scanned from 23° to 26° at 0.25° speed with the interval of 2θ. min\(^{-1}\). Clay mineral identification\(^6\) and quantification\(^8\) were also made.

Clay minerals montmorillonite, illite, kaolinite and chlorite were identified in the bay sediments (Figs 1,2). Montmorillonite is dominant with 70 to 93%...
Illite ranges from 5 to 22%. Kaolinite and chlorite are least abundant and does not exceed 10% of the total clay mineral content. High content (> 90%) of montmorillonite is present, around the Krishna river mouth and in the centre of the bay. Illite is more concentrated (15-22%) in the south western part of the bay (off Gundlakamma river).

The montmorillonite dominant clay assemblage of the Nizampatnam bay sediments is almost similar to that of the Krishna river sediments, indicating a source from the drainage basin of the river. However, it seems that calcium favours the formation of montmorillonite and retards the development of kaolinite, even in the middle parts of the drainage basin. In the lower reaches of the Krishna river, laterite soils formed under humid conditions contribute kaolinite to the sediment load. A minor part of the kaolinite present in the sediments may be attributed to red soils derived mainly from the khondalite suite of rocks.

The closeness in the clay mineral composition of the soils in the drainage basin and the bay sediments substantiates the inference, that the sediments are mainly contributed by the Krishna river. Eventhough the clay minerals in the Nizampatnam bay reflects the composition of the soils in the drainage basin, the regional distribution patterns of the clay minerals recorded in the bay are considered to be due to differential transport and flocculation.

In the light of the above it is considered that, during the transportation process more and more fine material is carried offshore giving higher montmorillonite contents. On the otherhand coarse kaolinite and illite are deposited in the nearshore region, because wind and wave induced current velocities are decreased towards the central bay. Low energy and calm conditions also favour the settling of montmorillonite in the central bay. Fine (clay/mud) and coarse (sandy silt, clayey sand) fractions are deposited in the central and adjacent parts of the bay respectively. Size sorting during transport thus seems to represent a significant factor in the clay mineral distribution pattern of the bay sediments. A similar processes has been ascribed to account for the montmorillonite and kaolinite distributions in the innershelf sediments off Cochin and west coast of India.

Relative suspension stability of the clay minerals might have also contributed to the observed clay mineral variation in the bay. The source material consists of montmorillonite, degraded (depotassicated) illite produced by preferential stripping of $K^+$ from illite by plants or partial leaching during weathering and degraded chlorite. Illite and chlorite minerals are upgraded to their original structure in the estuarine environment by adsorption of $K^+$ and $Mg^+$ respectively. Then these minerals undergo differential flocculation and sedimentation/size segregation. Illite, kaolinite and chlorite because of their coarse size and quick flocculation capacity settle relatively fast in the estuarine and open sea nearshore environments. Contrastingly, montmorillonite being smallest in particle size and of low flocculation ability, is carried farther offshore and a sediment enriched in montmorillonite is finally deposited there.

The high content (15-22%) of illite (Fig. 2) in the southwestern part of the bay is due to an additional source of illite from Gundlakamma river. The river sediments contain 30-40% montmorillonite, 20-57% illite and 7-28% kaolinite. The Gundlakamma river flows through the geological formations of Cuddapahs and Kurnools, mainly illite is considered to have been derived from these rock formations of the river drainage basin.

Therefore it may be concluded that the origin of montmorillonite occurring in the Krishna river drainage basin may possibly be related to the high magnesium and calcium contents of the source rocks and to the semi-arid climatic conditions of the drainage basin. The differential transport and flocculation plays a major role for the deposition of clays in the bay environment.

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References
5 Stanley D J & Liyanage A N, Mar Geol. 73 (1986) 263.