

## Discussion

# Clay mineralogy of Visakhapatnam shelf sediments, east coast of India: comment

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In Murty and Rao's recent study of the clay mineralogy of the shelf sediments off Visakhapatnam (*Marine Geology*, 88: 153–165) I have noticed contradictory statements, analytical drawbacks, peculiar results which disagree with other studies from the same area, and inferences not supported by the data.

On p. 155, in the section "Earlier Studies" it was stated that "the easterly flowing rivers of the peninsula contribute detritus from humid tropical weathering to the western part of the bay". Under humid tropical conditions, chemical weathering results in high leaching of alkalis and alkaline earths and the dominant clay mineral that forms is the kaolinite. The peninsular rivers mentioned by the authors contribute abundant illite, chlorite and smectite-dominated clays.

In the X-ray diffraction techniques, the procedures adopted to identify and confirm the presence of chlorite and kaolinite were not mentioned. Further, the method used to calculate the chlorite percentage was not given. The procedure for semi-quantitative estimation refers only to the three clay minerals, but the percentages of chlorite were presented in table 3.

In the results section, the statement that illite is the dominant clay mineral in the shelf sediments is not supported by the data presented in table 1. Indeed, no mineral has a characteristically high abundance. Critical observation of the table shows that more than 30% of the surface samples, 35% between 10 and 20 cm, 60% between 30 and 40 cm

and 35% between 50 and 60 cm, have more smectite than illite. Further, kaolinite is dominant in some surface sediments. Further, the data presented in the table also contradict the statement that "the concentration of illite is dominant over kaolinite and smectite at the various depths" (page 164, second column, second paragraph). The authors report the absence of chlorite in the shelf sediments, but earlier investigations (Kolla and Biscaye, 1973) reported chlorite in these sediments. Purnachandra Rao et al. (1988) have also observed chlorite in shelf sediments off Visakhapatnam. In addition, the river sediments (tables 3 and 4) which ultimately reach the sea contain chlorite too. Therefore, the absence of chlorite reported by the authors seems to be an analytical lapse. They neither tried a slow scan nor other procedures to identify chlorite.

In a semi-quantitative analysis a variation of a few percent does not make any difference. Therefore, the decreasing order of abundance of the clay minerals given by the authors simply based on the average values is not justified. An anomalous value in a sample can tilt the whole picture when only averages are considered.

In explaining the results, more stress was given to the regional distribution of clay minerals in the surface and subsurface sediments of the shelf. Such patterns provide information on the differences in the nature of the transport of the various clay minerals. Further, regional vertical variations throw some light on the diagenetic and the climatic variations in the source regions with geological time. The authors did not discuss these two points, although they did present many figures depicting

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the distribution patterns of the clay minerals at various depths in the shelf. Attributing the observed regional variations to the circulation pattern (no pattern was given, incidently) over the shelf is baseless. Vertical variations in the clay minerals were not properly explained.

In the absence of diagenesis, the significant vertical variations in the clay minerals observed in the shelf sediments should have been produced by differences in the sources. There are no reported drastic climatic changes in the Holocene that could produce different clay minerals in the source regions within a short time interval.

The reported abundance of smectite in the near-shore sandy sediments contradicts the observation of Purnachandra Rao et al. (1988) who report abundant illite and kaolinite in the sandy sediments and smectite in the finer outer shelf sediments. Further, Reddy and Mohan Rao (1989) recorded high concentrations of kaolinite+chlorite in the nearshore sandy sediments of Visakhapatnam. The predominant kaolinite was considered to have been derived from the coastal red sediments, which are rich in kaolinite (Durga Prasad Rao and Srihari, 1980). Purnachandra Rao et al. consider that high energy conditions in the sandy zone prevent the deposition of relatively finer smectite, which will be carried to and deposited in the low energy regions along with finer sediments. Further, the larger particle size of kaolinite and illite and early flocculation of these minerals (Whitehouse et al., 1960) in saline conditions result in the enrichment of these minerals in the nearshore zone. In the light of the above, the abundant smectite reported by the authors in the nearshore sandy sediments needs a reasonable explanation.

In discussing the source of the clays (p. 161) Murty and Rao state that the khondalites are frequently covered by thick laterite and bauxites and the weathered products of these rocks are transported to the study area. Laterization is a product of intense chemical weathering under humid tropical climates and under these conditions the clay mineral that is ultimately produced is kaolinite. Durga Prasad Rao and Srihari (1980) reported abundant (>60%) kaolinite in the red soils of the Visakhapatnam coastal region. These

red soils occupy large tracts of the coastal region and contribute significant amounts of kaolinite to the shelf. Even in the Gostani and Sarada rivers, which are the sources of sediments to the shelf, kaolinite constitutes a considerable proportion of the clay minerals. It is surprising that Murty and Rao record kaolinite as the least abundant clay mineral in the shelf sediments. In order to justify their results, the fate of kaolinite should have been explained.

As stated by the authors (p. 164), kaolinite is not impoverished in the Sarada, Gostani, Vamsadhara and Nagavali river sediments. In none of the samples, less than 30%. In Gostani River kaolinite has almost the same abundance as illite. Further, in two samples from the River Vamsadhara it is almost equal in abundance to illite (42% kaolinite, 46% illite). In the River Nagavali, many of the samples contain more kaolinite than illite (table 4).

Proposing a northward transport of the sediments along the Visakhapatnam coast (p. 164), the authors simultaneously consider a source of illite and kaolinite from rivers joining the bay to the north of the study area. Because of the absence of chlorite (doubtful) and the general decrease in kaolinite, they inferred that the influence of the northern rivers is negligible. Does the kaolinite decrease mean a southward movement? Does the north-flowing current terminate at Visakhapatnam and does not carry illite and kaolinite-suspended loads of the study area northwards? Added to the confusion, table 4 shows that the Mahanadi sediments have more smectite than illite, and this does not preclude a southern source for the smectite.

In addition, as stated by the authors, if Godavari River smectite-rich sediment is diluted by the Sarada and Gostani River sediment load containing about 85% kaolinite and illite, the more than 67% smectite in the nearshore shelf sediments must be an analytical error.

Conclusion (3) is rather drastic. The outer-shelf illite-dominant clays are contributed by the rivers (Sarada and Gostani) and streams draining the Eastern Ghats. In the first place, all these rivers and streams are ephemeral and their contribution to the shelf is minimal. Further, sediments from

these sources will be subjected to northward drift like those of the Godavari River. Even if it is assumed that somehow these clays escaped the northerly currents, they should instead be deposited on the inner shelf. However, the high smectite contents there show no such deposition. On bypassing the inner shelf, the clays should reach the outer shelf and be deposited there. The authors should have provided evidence in support of such a sedimentation type on the shelf. If the inner sand zone is considered to be a high-energy environment which prevents clay deposition, the same should apply for the smectite-dominant clay of the Godavari River.

Conclusion (5) states that "Provenance is the main controlling factor on the clay mineralogy of the shelf sediments". On the basis of this conclusion, the regional variations would be due to different sources through geological time. However, at one location regional variations were attributed to the surface circulation patterns in the shelf, while at another a mixing (dilution) of clays from one source with another is postulated. These two attributions contradict conclusion (5).

I conclude that the authors have not acquired their data properly and have misinterpreted the results, in particular ignoring previous investigations carried out in the area.

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## Reply to comment on "Clay mineralogy of Visakhapatnam shelf sediments, east coast of India"

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From the comments offered by Mr. N.V.N. Durga Prasada Rao it appears that he may not be fully aware of the different types of investigations carried out on the sea bed sediments in the Bay of Bengal. The comments appear to be mostly based on his limited knowledge of the coastal landforms and adjoining lagoons, and the physico-chemical environments in the different domains (terrestrial and marine) have not been properly evaluated by him before putting forth his comments. We offer below our reply to the comments made:

(1) The contention of Mr. Rao that Kolla and Biscaye (1973) reported chlorite in the shelf sediments is factually incorrect since their study was confined to deep Bay of Bengal sediments, which are dominated by illite and chlorite. There is no mention of shelf sediments at all anywhere in Kolla and Biscaye's paper.

(2) The clay mineral distribution maps of Kolla

and Biscaye (1973) and Goldberg and Griffin (1970) indicate that Godavari River-borne smectite has been transported as far north as off Kalingapatnam by surface currents.

(3) The statement that Purnachandra Rao et al. (1988) and Reddy and Mohan Rao (1989) have studied the nearshore sandy sediments is also incorrect as all their samples are from the area beyond the sand zone (more than 30 m deep). They have not studied any samples of nearshore sandy sediments (below the 30 m depth), where the smectite domination was reported by us.

(4) It was pointed out that we have not given the procedure followed for X-ray diffraction study. On p. 156, it is clearly stated that the procedures adopted for X-ray diffraction are after Biscaye (1965). The analysis was carried out at Scripps Institution of Oceanography, La Jolla, California by the junior author (K.S.R. Rao) himself.