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Quartz and feldspar distribution in continental shelf sediments of east coast of India

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Coarse fractions of 57 sediment samples from the eastern continental shelf of India between the Hoogly mouth and Krishna mouth have been analysed for quartz and feldspar distribution. Highest concentrations (80-90%) of quartz are in the sediments between Kalingapatnam and Chilka lake and in the area north of the Mahanadi. It is lowest (50-60%) in the sediments off the Krishna and Godavari and in the outer continental shelf off Visakhapatnam. Plagioclase feldspar concentrations are high (20-40%) in the clayey silt sediments off the Krishna and Godavari and low (< 10%) in the sandy sediments which occur in the northern part. Alkali feldspar to quartz ratios range from 0.05 to 0.27 in the inner shelf and 0.4 to 0.9 in the outer shelf sediments off Visakhapatnam. Variations in the distribution of quartz and feldspar have been attributed to coastal geology and rock formations in the drainage basins of the rivers. It is further suggested that the feldspar quantity cannot be regarded as a climatic indicator in all the regions.

Several workers have investigated the continental shelf sediments of the east and west coasts of India and established that the inner shelf consists of modern sediments in equilibrium with the present day environment and relict sediments characterise the outer shelf and are not in equilibrium with the environment[1,2]. It is generally accepted that an arid to semi-arid climate dominated large portions of the low latitude regions during the Holocene[3] in contrast to the present day humid tropical climate. Hashimi and Nair[4] have studied the quartz and feldspar distributions in the west coast shelf sediments and used their relative abundance to recognise the Holocene arid to semi-arid climate influence on the sediment depositional history on this shelf. Similar studies are lacking in the east coast. The objectives of the present study are (i) to determine the areal distributions of quartz and feldspar, (ii) to check whether the Holocene arid climate had left its imprint in east coast shelf sediments too like in the west coast shelf and (iii) to shed light on the provenance of the sediments.

Materials and Methods

Fifty seven samples were selected from the sediments collected during the 76 (7-13 June 1980) and 77 (15-20 June 1980) cruises of *R V Gaveshani* which represent both the inner and the outer shelf between the Hoogly mouth and Krishna mouth (Fig. 1A). Coarse material (> 62 μm) was separated from each sample, treated with 10% HCl solution to eliminate $CaCO_3$, washed with distilled water, dried and powdered to very fine size. These powders were scanned from 25° to 30° 2 θ at 1° 2 θ.min^{-1} on a Philips X-ray diffractometer using nickel filtered CuKα radiation. Selected samples (11) were scanned from 10° to 60° 2 θ to distinguish alkali feldspar and plagioclase feldspar, based on peak positions of (201), (002), (113), (006) and (204) reflections[5]. Relative abundance of the minerals were estimated based on principal peak heights. The study area is in proximity to the source rocks and the $CaCO_3$ percentage of the inner shelf sediments is < 20%. Therefore it is assumed that quartz and feldspar are the predominant minerals and their variation may reflect their provenance and depositional environment of the study area.

Results and Discussion

Quartz is the most abundant mineral in every segment of the shelf under study, varying from 50 to 90% (Fig. 1B). It is 80 to 90% in the shelf area from the north of Kalingapatnam to south of the Chilka lake mouth and also in the area north of the Mahanadi mouth. It is least abundant (50-60%) at the mouth of the Krishna river (Figs 1B, 2) and in a small patch off Pentakota. It is of intermediate abundance (60-80%) elsewhere. Highest concentrations of quartz are located in the sandy sediments and also where plagioclase concentrations are lowest. Lowest concentrations of quartz are found in the outer shelf off Visakhapatnam.

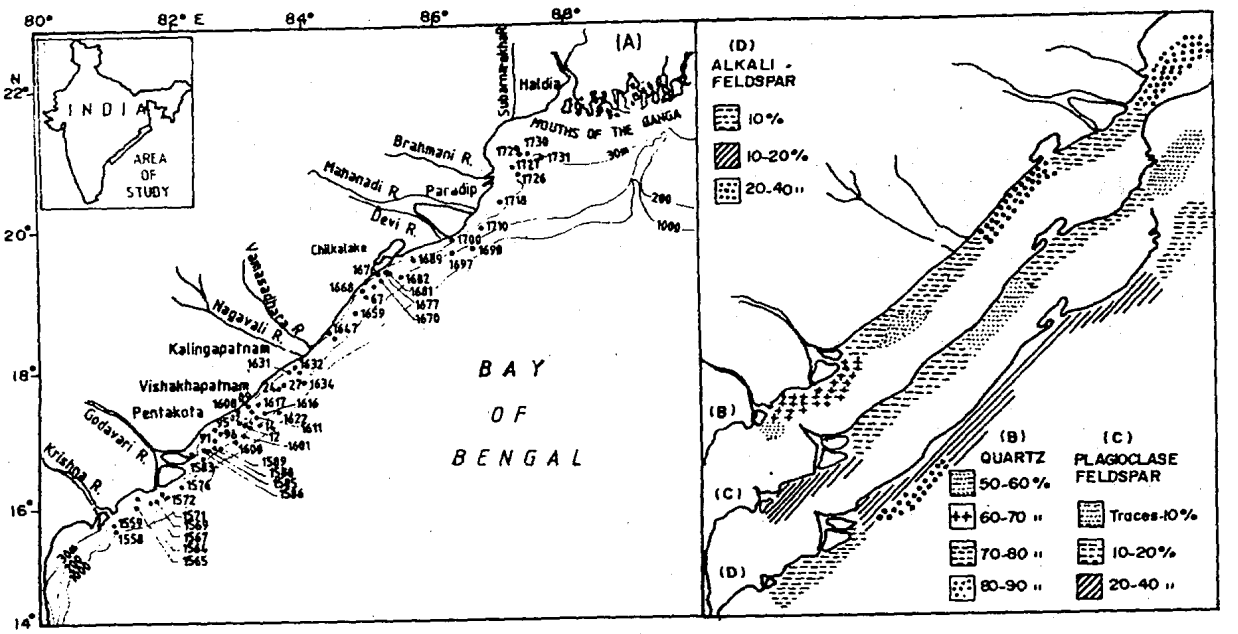

Fig. 1—Sample location and bathymetry (A), and distribution of quartz (B), plagioclase feldspar (C) and alkali feldspar (D)

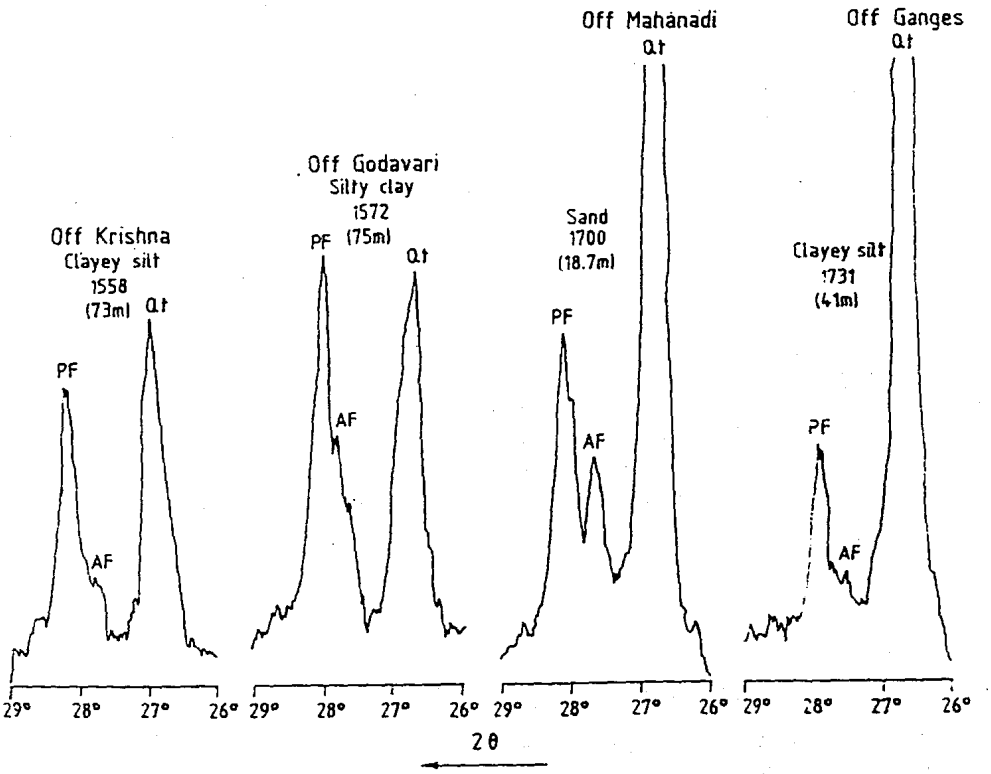

Fig. 2—Representative X-ray diffractograms showing quartz and feldspar in sediments off major rivers (QT—quartz; PF—plagioclase feldspar; AF—alkali feldspar)

Plagioclase feldspar ranges in abundance from traces to 40% (Fig. 1C). It is 20 to 40% in the shelf area fronting the Krishna and Godavari delta (Figs 1C and 2). It occurs in 10% concentration in those areas of the shelf where quartz is 80-90%. It is 10 to 20% in the shelf from north of the Godavari delta to Kalingapatnam and in the shelf part from Gopalpur to the Mahanadi mouth (Fig. 1C).

Alkali feldspars have lowest abundance (10%) in the shelf areas off the Krishna and Godavari delta and north of the Mahanadi mouth (Fig. 1D). The entire shelf area from north of the Godavari to the Mahanadi mouth is characterised by 10-20% alkali feldspar. Significantly no major rivers enter this part of the shelf. However, in deeper water sediments off Pentakota, alkali feldspar is 20-40% over a small area (Fig. 1D). Thus alkali feldspars are poor in abundance in the sediments derived from the Krishna, Godavari, Mahanadi and Ganges rivers. They are also poor in near shore samples (samples 1595 and 1608 in Fig. 3). Alkali feldspars dominate plagioclase feldspars in seaward samples of the inner shelf (for example, samples 1627 and 1633 in Fig. 3, and 1604 in Fig. 4) and also in the outer shelf off Visakhapatnam where relict calcareous sediments are abundant (Fig. 4). Alkali feldspar to quartz ratio is <0.3 (range: 0.05 to 0.27) all over the shelf except in the outershelf off Visakhapatnam where it ranges from 0.4 to 0.9.

There are distinct trends in the quartz and feldspar distribution in the sediments of east coast shelf. The mineral abundances are related with the coastal geology and rock formations in the drainage basins of the rivers. Reworked Quaternary sediments occupy the coastal regions between north of Mahanadi and Ganges[6], and thus relatively resistant quartz should be seen as an abundant mineral. The Eastern Ghats consisting of Khondalites (gneissic rocks) and charnockites are the major source of minerals in the region between Paradeep in the north and Nizampatnam in the south. Khondalites are of high grade, metamorphic origin and highly felspathic. Charnockites vary in their composition widely from acidic to ultramafic, and are characterised by the invariable presence of orthopyroxene. These charnockites have undergone postmagmatic changes like albitisation and myrmekitisation[6]. Since feldspar is an abundant component of these coastal rocks, the nearshore sediments of the neighbouring continental shelf have shown the presence of plagioclase as well as alkali feldspar. The seaward samples of the inner shelf region show only alkali feldspar. It can be due to differential weathering of these feldspars as plagioclase feldspar weather more easily than the alkali feldspars[7]. Furthermore, the outer continental shelf off Visakhapatnam consists of relict carbonate sands, as evidenced by the occurrence of oolites of late Pleistocene period[1], and

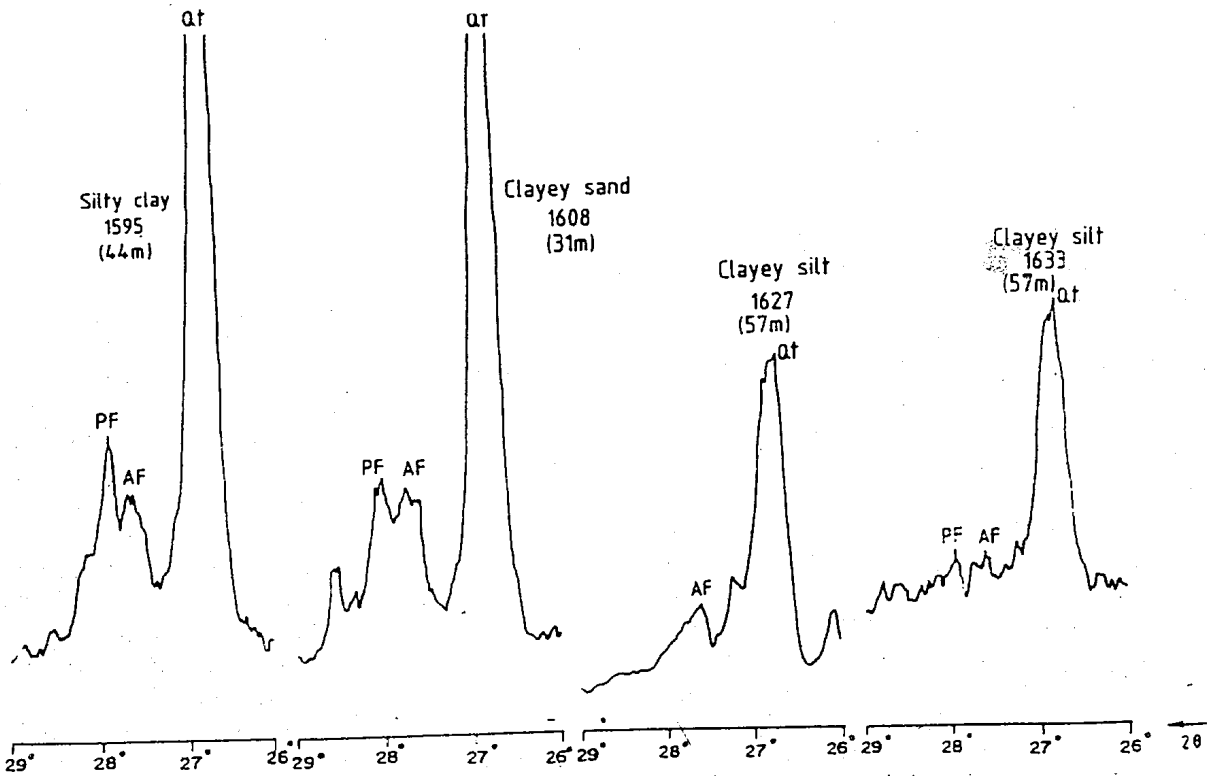

Fig. 3—Representative X-ray diffractogramms showing quartz and feldspars in the sediments of inner shelf

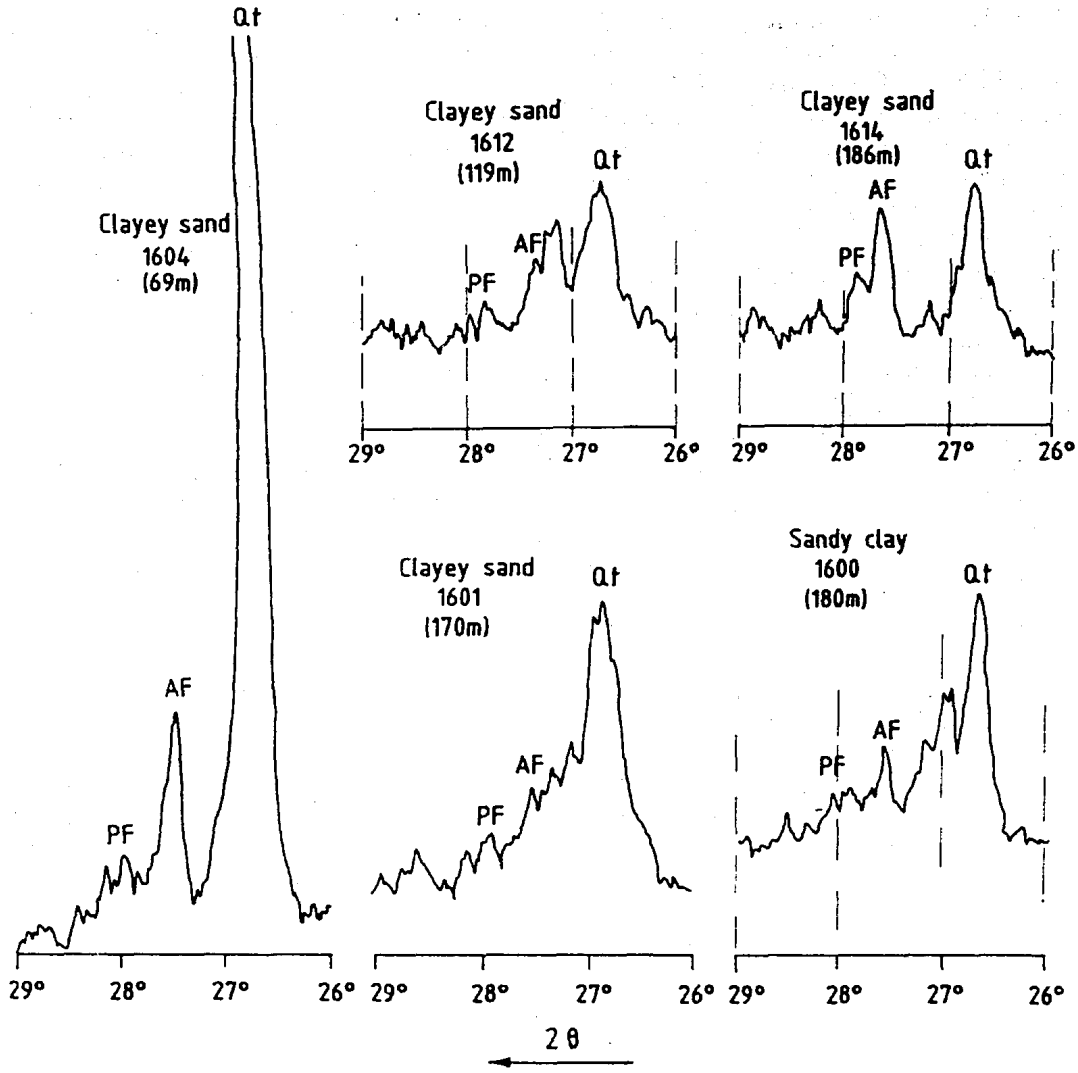

Fig. 4—Representative X-ray diffractogramms showing quartz and feldspars in sediments of the outer shelf off Visakhapatnam

these sediments are characterised by higher proportions of alkali feldspars than plagioclase and the alkali feldspar to quartz ratio varies from 0.4 to 0.9. The differences in the feldspar type and abundance can be explained by 2 interrelated processes. The outer continental shelf sediments were originally formed at relatively shallow depths during low stands of sea level in late Pleistocene. Therefore the feldspars that are associated with these sediments can be attributed to climatic conditions prevailing at that time. Feldspars are sensitive indicators of climate[8] and high content of feldspar may indicate climatic conditions either hot and dry or cold and dry[9]. Therefore high ratios of alkali feldspars to quartz may be resultant of an arid climate. High content of alkali feldspars as compared to plagioclase may indicate the influence of depositional environment and weathering rate of feldspars. Oolites and shell fragments associated with alkali feldspars indicate the existence of a shallow turbulent environment. As a consequence of turbulent conditions the more chemically stable alkali feldspars could be preserved while the easily degraded plagioclases might have been weathered to fine size. It is therefore concluded that the greater abundance of alkali feldspar in the outershelf relict sediments is a result of arid climate and a nearshore high energy environment.

The continental margin sediments off the Krishna-Godavari delta consist of highest concentrations of feldspars and relatively low quartz contents. Plagioclase feldspar is more predominant of the 2 feldspars in all samples. Both the Godavari and Krishna rivers originate in the western ghats where the bed rocks are composed of basic volcanic rocks (Deccan traps) and flow through acidic volcanic rocks (Precambrian metamorphics) and bring the sediment material to the continental shelf from both the rock types. Plagiocl-

ase is the dominant feldspar in the soils of Deccan traps and K-feldspar is abundant in gneissic rocks. From the feldspar distributions, it appears that the sedimentary material brought from the Deccan trap terrain is extremely high as compared to the material from other rocks in the lower reaches of the rivers. High relief of the Deccan trap terrain could also have favoured the high plagioclases in the shelf. Clay mineral distribution also indicates abundant montomorillonite (up to 70%) characteristic of the Godavari and Krishna sediment loads[10] which indicate that the weathering products of basic volcanic rocks dominated this part of the shelf region. Both clay minerals and feldspar distributions demonstrate that the shelf sediments off the Godavari-Krishna delta are essentially derived from the Deccan traps.

It appears that the texture of the sediments also has a role in determining the feldspar type. For example, the sediments off Krishna, Godavari, Mahanadi and Ganges are silty clay/clayey silts and consist of plagioclase feldspar as the dominant mineral. It may suggest that plagioclases which weather easily to clay size particles, get transported along with other finer size particles and thus enriched in clayey sediments.

The continental margin sediments between Visakhapatnam and Paradip on the east coast of India and between Goa and Mangalore on the west coast of India[4] are compared. The coastal rocks in both the regions consist of Precambrian gneisses and charnockites. The inner continental shelf sediments of both the east and west coast of India show similarities in feldspar and quartz distributions and in their ratios. However, along west coast of India only plagioclase is reported whereas in the east coast of India both plagioclase and alkali feldspars are present in the nearshore sands, and only alkali feldspars in the seaward samples. These differences can be due to differences in environmental conditions prevailing on either continental margin. For example the west coast of India is a sea dominated environment. The estuaries in this region are dominated more by the salt water intrusion resulted due to the lesser fresh water discharges compared to the east coast of India and partially due to north east blowing winds. As a consequence coarse fraction trapped in estuaries does not reach the shelf, thus feldspar content is low in the inner shelf. In the eastern shelf of India, being a river dominated environment, the coarse fraction is flushed out of estuaries as evidenced by the nearshore sand zone on the continental shelf. The nearshore sands show relatively sharp reflections of feldspars as compared to the sediments of the west coast of India. The outer shelf sediments on both the eastern and western shelf consist of only stable alkali feldspars which indicate that peninsular India and the adjacent shelves were under a spell of arid climate during late Pleistocene. It may be mentioned here that equal proportions of feldspar and quartz found in the sand fraction of the inner shelf sediments off the Krishna, Godavari and Mahanadi river mouths may indicate that transporting agent is the prime factor in distribution of sandy material.

Acknowledgement

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