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## *Chapter 5*

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# **Influence of Geomorphological and Tectonic Control in the Mineralization of the Western Shelf of India**

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The west coast of India extends for a distance of about 1400 km. from Tapti estuary in Gujarat to Cape Comorin in Tamilnadu. The coast is more or less straight running in NNW-SSE direction. It is interesting to observe the convex nature of the topography, with vertical scarp right on the coast, leaving very narrow strip of plain area, beaches, marshy grounds or cultivable lands. Though lot of small rivers are found to cut across the coast, estuary formations are scarce. At the same time, all the rivers, whether big or small, support the formation of offshore sand bars or shoal. The rivers, however small they may be, are carrying lot of sediment load due to heavy rainfall and high relief in the catchment.

Earlier workers have identified different stages of emergence and submergence which were responsible for carrying out the present coastline. However, most of the supports and evidences are drawn from the coastal geomorphological features and surmised offshore features, with very little information of sediments. In spite of its popularity for its mineral deposits by way of monazite placers in the Kerala coast, ilmenite placers in the Konkan coast and hydrocarbons in the shelf off Bombay, the amount of scientific contributions are not cumulative and contiguous but of are independent and limited in nature. So, it is highly impossible to generalize the cause of the disputable factors like the scarp formation, convex topography etc. The west coast has two kinds of coastal rocks predominantly of Deccan basalts in the north and granitic and gneissic in the south, each similar

in bulk composition. It is indeed peculiar to notice only two types of placers from these coastal rocks. One in the southern tip of the coast and the other in the middle of the coast, each occupying a characteristic coastal provenance. From the available data on the various aspects of these placers, one can easily notice the differences in their content and possible mode of accumulation. Taking into account that the placers in the Maharashtra coast, where the catchment is mainly of basalts, one can expect similar deposits throughout the entire basaltic coastal belt, that too in a zone north of Bombay, where thick flows are present. Instead, placers are found to be accumulated neither in the northern bounds of the basalts nor in the southern portions of the same. So, an attempt is being made in this paper to arrive at a possible solution for such localization by assuming tectonic and geomorphological controls from the available existing additional data on the west coast.

#### **GEOLOGY OF THE WEST COAST OF INDIA**

West coast is mainly made up of older metamorphic and peninsular gneisses as the basement rocks (Fig. 1). In the central west coast Dharwarian sediments and metamorphics are noticed. A major portion of the west coast is covered by Kaladgi series consisting of conglomerates, quartzites, sandstones and shales. The oldest marine sediments in the west coast is represented in Kutch by Jurassic sediments, comprised chiefly of limestones, marls and oolites. Ahmednagar sandstones and coral line limestone of Bagh beds represent the Cretaceous sedimentation in this coast. The northern part of the west coast is completely carpeted by Deccan Traps while the southern part is not covered by any rocks of similar nature or of same age. Over the traps the coast is seen to have been covered by Tertiary sediments primarily of Khar series in Kutch Piran beds in Kathiawar, oil bearing sands of Gujarat, Gaj beds of Ratnagiri and Quilon limestones and Warkali beds of Kerala. These early Tertiary succession are followed by miliolitic laterites, limestones, phosphatic muds and the recent beach-dune sands and alluvium.

#### **GEOMORPHOLOGY**

The coastal zone is highly variable to an extent from 5 to 40 km in Saurashtra. A little south in the Cambay region, it is slightly wider reaching even 60 km from the shoreline, whereas, further down south,

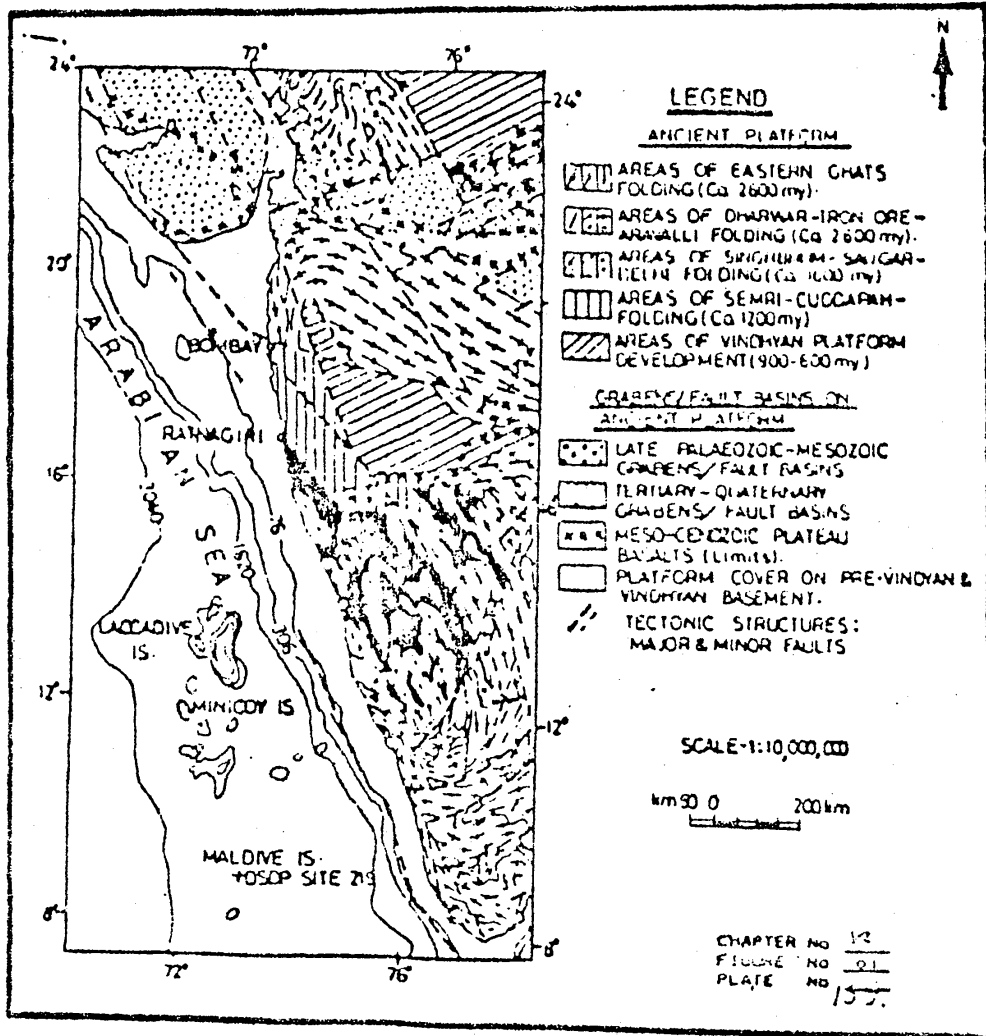


Figure 1

a very narrow coastline with 0 to 15 km. from the water line along the Maharashtra and Goa coast and 15 to 20 km. coastal zone from the shoreline in Karnataka and Kerala is observed. The coastal zone of Kutch and Cambay is marked by few cliffs but of wider coastal alluvial tract and a green belt of casuarina, palm, coconut palmyra followed by broad marshes and cultivable lands. The slopes of the ghats in the region is very low. It is followed upto Karwar in the South, by a highly crenulated, dissected coastal zone with very narrow coastal plain, often with cliffed headlands directly in contact with waterline. Further south of Karwar the coastal zone appears streamlined parallel to the shore with narrow and long belts of cultivation. The area is marked by dissected coastal zones with pronounced and entrenched meanders of the streams with steep rocky bluffs in the interior.

The topography of the western shelf varies from smooth to rugged relative relief with amplitude of 2 to 20 m above the bed. The inner shelf extending from Kathiawar to Cape Comorin is found to be smooth probably due to carpeting of recent sediments, whereas the middle shelf is invariably found to be uneven with relief variations between 2 to 5 m. and the outer shelf predominantly of relief nature is noticed to have rugged topography. The wider shelf is observed off Bombay to an extent of 220 km with the shelf break at about 140 m depth. South of Bombay, the width of the shelf is gradually reduced to about 60 km off Kerala.

The shelf indicates the presence of submerged terraces of Holocene age at depths of 110, 92, 85, 75 and 55 m and the same is attributed to the former low stands of sea-level changes (Nair, 1971). The outer reefs of the Lakshadweep islands also mark the existence of such submerged terraces but at depths of about 7, 25 and 40 m (Siddique, 1975).

### EVOLUTION OF THE COAST

Based on their extensive field observations, the pioneer geologists like Blanford (1872), Foote (1876), Fedden (1884) and Lak (1890), have described the west coast as a zone of interest and suggested its existence as a result of many orogenic activities. However, subsequent workers on this region have been different views. From the detailed geomorphological and geological studies on the coast du Toit (1937), Pascoe (1950), De Souza (1965), Radhakrishnan (1967), Krishnan

(1968) and Ahmad (1972) have suggested faulting as mainly responsible for the present coastal features. From the studies of satellite imagery and geophysical data, Dessai and Peshwa (1978) and Naina (1980) have supported their views. Feio (1956), Guilcher (1964) and Shepard (1973) have suggested this coast as the remnant of an erosional margin in the geological past. Johnson (1972) was of the view that the coastal margin was the result of the submergence in the infant stage, whereas Wagle and Misra (1975), Vaidyanadhan (1976), Kumar and Subramana (1978), Sriram and Prasad (1979), Wagle (1982) and Rajamanickam (1983) have strongly considered the possibilities of both tectonic and subsequent denudational activities, in carving the present coastline. When all these are pooled, together with the various field observations on the coast and offshore data collected in the recent years by the authors there is every probability that the present coast owes its existence to combined effects of gradual submergence in the beginning and later frequent upheaval with simultaneous denudational processes in each stage. In addition to the above, they are not ruling out the appreciable contribution of sea-level changes and recent intrusions in shaping the present coast line.

#### NATURE OF SEDIMENTS

The inner shelf is mainly comprised of quartz and heavy mineral sands whereas the middle shelf (15 to 60 m) is covered by recent terrigenous silts and clay with low calcium carbonate and high organic matter, and the outer shelf beyond 60 m consists of relict carbonate sand and carbonate rocks in the form of algal and oolitic limestones of Holocene age, formed when the sea had its lowest level at the end of Pleistocene [Rao, 1968; Nair and Pylee 1968; and Murty 1968]. The extensive sand zones on the western continental shelf is considered to be of relict sediments (Nair, 1969; Kidwai and Rao et al (1978) and Murty et al (1968) have divided the shelf into three zones on the basis of phosphate content i.e. Kerala coast (100 to 430  $\mu\text{g/g}$ ), Mangalore coast (40 to 430  $\mu\text{g/g}$ ) and Bombay coast (190 to 540  $\mu\text{g/g}$ ). Nair et al (1982) and Rao et al (1983) have recorded four clay mineral provinces in this shelf i.e. (i) montmorillonite and minor amount of kaolinite, illite and chlorite province of Gulf of Kutch, (ii) rich montmorillonite province of Gulf of Cambay, (iii) a transition province on the central part of the shelf and (iv) a relatively montmorillonite poor gibbsite province off Kerala coast. They have also indicated

the influence of parent rocks on the clay mineral composition and their differences. Hashimi (1981) has reported the marked difference in the grain sizes of sediments between the inner and outer shelves. Nair and Hashimi (1981) have indicated that the heavy mineral assemblage both in the sediments and limestones are similar and do not show any diagenetic change in them. Bhattacharya (1984) has concluded that the recent clay sediments and those with hydrocarbons in the shelf are found to have independent source rocks.

#### MINERALOGY OF THE SEDIMENTS

Kidwai et al (1981) have observed the heavy mineral assemblage in the outer continental shelf sediments between Vengurla and Mangalore constituted chiefly of opaques, hornblende epidote, garnet, zircon, monazite kyanite and tourmaline and attributed their derivation from a mixed metamorphic and igneous suite of rocks. Krishnan and Roy (1945) and Roy (1958) have reported heavy mineral concentrations in the inner shelf of Kerala and Maharashtra. Rao and Rao (1965) have suggested the possibility of a pre-existing provenance for the ilmenites of Kerala beaches from a detailed account of the intergrowth pattern of ilmenites. Prabhakar Rao (1968) attempted to correlate the heavy mineral assemblage with monazite and their possible mode of origin from the nearby coastal rocks. He was of the opinion that the monazite deposits are not being replenished today. Roy (1958) and Subbaraju and Rao (1978), after studying the mineralogy of the sediments of Konkan coast, have indicated the Deccan basalt as the major source rocks for these sediments. Siddiquie et al (1979) after investigating the distribution of mineral placers in some of the bays of Konkan coast, have proposed more than one provenance for the sediments. Rajamanickam and Gujar (1982 & 1984) from the grain size studies have found the heavy minerals not related to those and the rocks in the neighbourhood. Rajamanickam (1983) has attributed the Kaladgi's and the older gneisses as the source rocks for these inner shelf sands of the Konkan coast and also has proved the separate identity of these placer sands from those in the existing coastal rocks. Siddiquie and Mallik (1972) have reported the presence of zircon, kyanite, augite, hornblende, sillimanite etc. in the inner shelf sediments off Mangalore. has recorded the presence of hornblende, actinolite, augite, zoilite, zircon, monazite, topaz, sillimanite, kyanite, andalusite, etc. in the sediments of the shelf covering from Mangalore to Kochin

and assigned a possible mixed source rocks from both igneous and metamorphic suite of rocks. Mallik (1972) after noticing the presence of opaque minerals of magnetite, ilmenite, hematite, goethite, lepidocrocite and pyrite in the Mangalore sediments, has concluded that they are derived from the existing drainage basin underlain by high temperature igneous and metamorphic rocks. Siddiquie and Mallik (1972) on analyzing the non-opaque heavy minerals have opined their derivation from a mixed metamorphic and igneous terrain with the predominant contribution from the metamorphics because of the dominant presence of tremolite- actinolite, garnet, sillimanite, kyanite, epidote, etc.

### DISCUSSIONS

From the views of the earlier workers on the evolution of the west coast, it is evident that the coastal margin is a zone of a typical representation of the last phase of its tectonic movements (Kumar, 1975; Closs et al 1974 and Kaila, 1972) and subsequent denudation. The evidence for both emergence (Setty and Wagle, 1972 and Rao, P., 1968) like raised beach, beach rocks, etc., and submergence like the drowned river valleys (Vaidyanadhan, ria, etc., (Nair and Fero, 1956) are present. Tectonically, because of the presence of growth faults and step faults (Siddiquie et al 1982), the extension of the lineaments in the Dharwar and the Tapti region into the offshore (Ramana) frequent intrusions like dykes on the coast (Rajamanickam, 1983), the area is found to be active. So, one can not rule out the possibilities of significant changes in the geomorphology of the area even in the recent past.

When one looks upon the characteristics of the sediments the west coast is prominent in having a wider shelf with the maximum off Bombay and gradually getting reduced to the south (Siddiquie and Rajamanickam, 1974 and Closs, et al, 1970). Throughout the west coast presence of a narrow sandy belt is common between the shore and place to phosphatic, the inner shelf clay except in the southern portion (Nair, 1976) where this gains clayey sediments in the inner shelf. This sandy sediments within a distance of 1 to 4 km from the shore, is covered by clay. Beyond 30 m water depth calcareous coarse sand and oolitic sand is found to be present in the middle shelf and the same is considered to be the relict sediments (Hashimi and Nair; Kidwai and Almeida, 1975). Kidwai stated that an extensive sandy



deposits in the western shelf, mainly beyond 80 to 200 m is comprised of relict sands. They also added that recent clay sediments are covering the already existing relict sediments. Siddiquie, et al., (1981) have recorded the presence of relict topography under the cover of recent clayey sediments even upto the shore. Rajamanickam and Gujar (1982 and 1984) have reported the presence of a mixture of relict and recent sands in the bays of Konkan coast. Rao (1968) has attributed the possibility for the existence of pre-glaciation relict sediments in the inner shelf due to sudden change in the conditions of deposition and their difference to the composition of modern sediments. Wagle (1979) recorded the presence of exposed relict topography even inside the Gulf of Kutch.

When the composition of sands in the inner shelf is reviewed by taking much studied area like Konkan shelf, it draws the attention of everyone. The narrow sandy belt in the inner shelf is dominantly comprised of crystalline quartz (Veerayya et al., 1981; Rajamanickam, 1983; Siddiquie, et al. 1979 and Rajamanickam and Gujar, 1982 and 1984) where the coastal rocks are mainly of Deccan basalts. The whole coast is comprised of only Deccan basalts but for a few beach rocks and quartz veins. All the rivers drain through only basaltic terrain. In that case, is it possible to derive this free crystalline coarse-sized quartz from the basalts? Over and above, the heavy minerals show the presence of tourmaline, topaz, kyanite, zircon, epidote, rutile, staurolite, garnet etc. (Siddiquie, et al. 1979; Subbaraju and Rao, 1978 and Rajamanickam, 1983). Krishnan and Roy (1945), Siddiquie, et al. (1975), Subbaraju and Rao (1978), Kidwai and Wagle (1975) and Kidwai (1971) have attributed the Deccan basalts as the major contributor for these placers and heavy minerals in the inner shelf sediments. Siddiquie, et al. (1979) have placed an iota of doubt over the provenance of these placers by suggesting more than one source. Rajamanickam and Gujar (1982 and 1984) have assigned, after studying the textures of these sands, the mixing of two environmental characteristics 1) the existing and 2) the fresh coming in the depositional basin. While interpreting the CM pattern of the same sands, Rajamanickam and Gujar (1984) have noticed the presence of dominant graded suspension sediments which was a common feature in the ancient seas. Rajamanickam (1983) has shown the presence of relict sands on the basis of mineralogical and chemical characteristics. Rao (1968) also suggested the possibility of relict origin for monazite

placers of Kerala.

It is rather difficult to assimilate the findings of the presence of crystalline quartz, typical granitic suite of heavy minerals like tourmaline, topaz, zircon, rutile etc., and metamorphic index minerals like kyanite, staurolite and garnet in the basaltic area by stating them to be the derivatives of Deccan basalts. When one scans through the coastal rocks, basalts do not show such minerals. Wagle and Rajamanickam (1980) have noticed such minerals in quartzites off Goa coast. Kelkar (1959) has reported such assemblage in Kaladgi sediments and gneissic basements in the south Konkan area. If one proposes such a source, then the sands present in the nearshore areas have to be considered as pre-Deccan derivations, probably equivalent to Mesozoic sediments recorded below Deccan basalts throughout the Cambay basin and further south (Kaila, et al, 1981 and Kaila). It also implies that there is no addition to the type of assemblage that has been in existence, on the other hand height, now only minuses from the Deccan provenance, are being added. If so, what are the materials that are being brought by the present rivers? Siddiquie, et al (1979 & 1982) and Rajamanickam (1983) have clearly noticed a difference in the pattern of accumulations in front of the rivers and away from the rivers on either sides. They found magnetite rich sediments in the river mouths and ilmenite rich in the rest of the bays. Najati, et al. (1981) and Krishnamurty and Udas (1981) have noticed titano-magnetite domination in the basalts. Rajamanickam (1983) and Rajamanickam, et al (1984) have recognized ferro-basalts completely made up of fine grained titanomagnetite and poor in ilmenite. Present day contribution to the shelf is surmised to the magnetite rich fine grained materials and clayey sediments in the northern part of the west coast. If ilmenites are the palaeo-sediments, where were they during the period of Deccan activities? A probable oscillatory trend as model, is proposed by pooling up the data already available in the diagrams shown:

Figure 2 depicts the status of Pre-Cretaceous (Pre-Deccan flows) in the Konkan coast, with older sediments in a narrow basin having Kaladgi's or gneisses on both the sides of the same. During this period, the rivers in these areas were draining through Kaladgi's which is found rich in minerals like ilmenite, tourmaline, topaz, zircon and quartz (Kelkar, 1955 and Sowani, 1961) and gneissic rocks containing minerals like kyanite, staurolite, chlorite, epidote, hornblende, etc.,

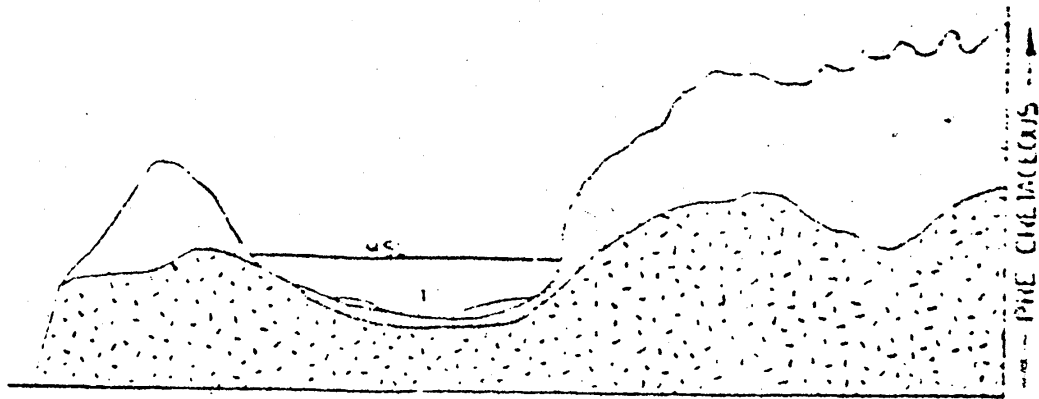


Figure 2

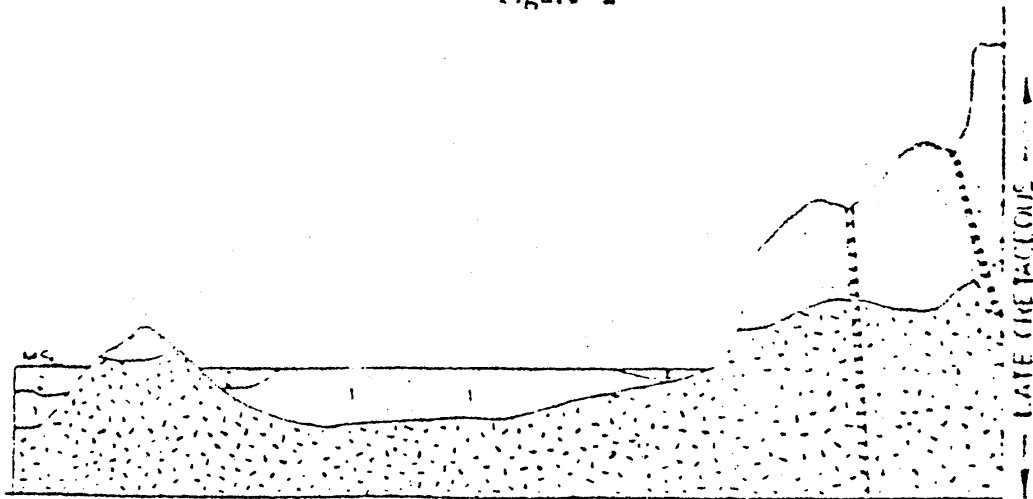
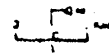


Figure 3

LEGEND

1	ILMENITE, TOURMALINE, TOPAZ, ZIRCON, QUARTZ, KYANITE, SAUROLITE ETC. RICH SEDIMENTS
2	ALBITE, OLIVINE, TITANO MAGNETITE, QUARTZ, RICH SEDIMENTS
3	TITANO MAGNETITE, QUARTZ, RICH SEDIMENTS
—	FAULT
∇	BASIC DYKES
•••	DECCAN TRAP BASALT
□	KALADGIS
▨	PRECAMBRIAN GNEISSES



and getting deposited in a basin engulfed by these rocks both on the western and eastern sides. Data collected from the recent boreholes in the western shelf established the presence of palaeo-highs on the western side of the depositional basins (Agarwal, et.al., 1981; Basu, et.al., 1981; Ramasamy and Rao, 1980; Rao and Srhivastava, 1984). Kaladgis are found to be of loose unconsolidated sand stone, pebble bed and quartzite with minor conglomerates, shales and limestones (Anon, 1976). Hora (1947) has reported the past erosion and removal of thousands of feet deposits from the Konkan coast, mainly due to high relief and heavy rainfall. The sedimentation in the area was expected to be in the nature of dumping of material consisting of both stable and unstable minerals with high angularity and lack of roundness and sorting (Rajamanickam and Gujar, 1984). The dumping was on in front of the high hills and mouths of the rivers with heavy siltation in the tidal channel. Even today sedimentation rate is found to be 2.4 cm/y (Gujar, et.al, 1986).

The heavy sedimentation in this period was causing gradual subsidence in addition to the impact of the NW margin of Indian plate with the Sind-Baluchistan axial belt. The Western India witnessed lot of tectonical deformities leading to a subsidence in this area as well as the beginning of the outpouring of Deccan volcanism (Ramanathan, 1981). Figure 3 depicts the coast at this period (Late Cretaceous). It is presumed that the basin at that period was receiving sediments mainly from Kaladgis and Archeans in the east and only from Archeans in the west, but of reduced quantity compared to the earlier occasions. Because of the heavy sedimentation and the volcanic activities lot of structural disturbances are noticed in this basin, leading to the formation of graben or otherwise making the basin locally deeper enabling the burial of older sediments. Such graben have been observed in Konkan coast (Rao, 1934). During this period what ever Deccan flow was existing on the drainage basin was sparingly contributing sediments due to its lack of weathering. Because of the subsidence caused due to the structural disturbances and the subsequent formation of graben, the earlier sediments were (1) trapped in the graben and removed away from the active sedimentation center, giving way to the deposition of another type of sediments (2) in the coastal basin, brought under the deposition caused by the transgression. Above all the coast had a low relief due to the past removal of the Kaladgis in the previous period and so the supply of sediments to the offshore was very limited

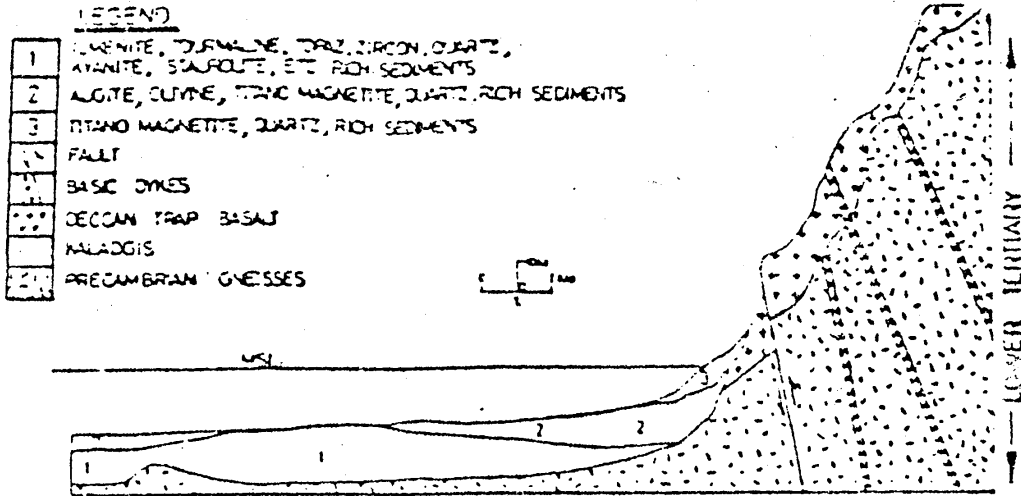


Figure 4

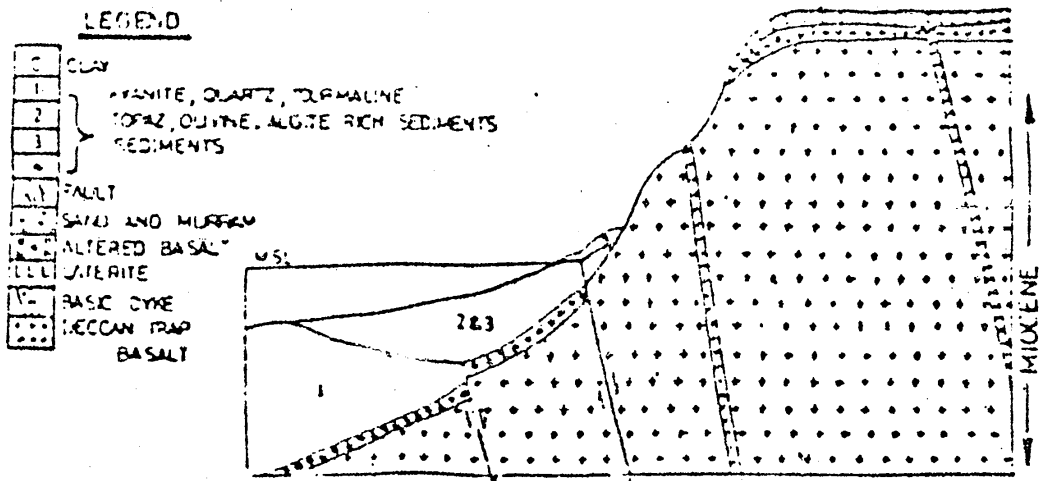


Figure 5

compared to the previous occasion.

At the close of Cretaceous, world wide transgression was a marked feature (Krishnan, 1963). Figure 4 indicates the status of the coast after the transgression. Whatever islands or low lying continents supplying little sediments to the coastal basins were completely brought under the submergence. The sediments deposited during the late Cretaceous (2) were brought under submergence introducing a new status to No.2 sediments, in par with No. 1 sediments in Late Cretaceous times. No.1 sediments were taken still deeper or quite away from the deposition. At this period, the drainage was bringing a different type of sediment mainly constituted by the supply of Deccan basalts which was occupying the depositional basin bed as well as the catchment. Because of their compactness and freshness one can not expect much debris to the depositional basin, which is receiving No.3 sediments. Instead one can surmise that the weathering of basalts to a stage of only mechanical disintegration or rather formation of boulders, which will not reach the place of No. 2 and No. 1 sediments in the offshore, forming coarser nature of sediments along the coast No. 3. These sediments were expected to contain the minerals derived from Deccan basalts and deprived of free quartz supposed to be supplied from Kaladgis and Archaean, which were buried deep due to the overlying thick massive basalts, producing a high relief to the coast. At this stage, seabed was found to consist of some Deccan basaltic sheets (Ramanathan, 1981; Sastri, 1981). In the offshore areas and the previous continental islands calcareous deposits of fine grained nature were formed straight over the pre Cambrian basement. This sort of deposition may be attributed to the existence of sediments obtained straight overlying the gneisses without basalts in certain boreholes (Rao, 1984).

The coastline after the Miocene upheaval, which brought the complete withdrawal of Tethys and the major portion of the pre sent west coast (Radhakrishna, 1967), is shown in figure 5. Due to the orogenic activities, along with the rise of Himalayas, the western coast of India also had uplift which brought the No. 3 sediments in recycling and the catchment elevation to a sharp scarp formation. The sediments of No. 3 along with the sediments derived out of the Deccan basalts and its newly formed thin lateritic caps are found to mix with No. 2 sediments which are brought nearer to the coast to receive the new type of sediments dominated by titanomagnetite, augite and olivine. These sediments were found to be little coarser because of its nearness

to the source and high relief of the catchment. This type of material was not that much appreciable so as to dilute the composition of No. 1 & 2 sediment which was dominantly constituted by the mineral assemblages, derived out of Kaladgis and Archeans.

The status of the coast at the close of Pliocene after the completion of fourth upheaval (Krishnan, 1968) is presented in Figure. 6. In this period the coast consisted of thick pile of basalt with an appreciable lateritic cover. The coast due to the uplift has shown sharp scarp with step like features which are the remnant of earlier upheavals. This has introduced back the No. 2 sediments in the active depositional basin and the sediments of No. 2 and 3 in the coast under active erosion leading to the formation of No. 4 sediments a mixture of No. 2 and 3 and fresh supplies. Wherever the river drainage is present these sediments are completely eroded off and the rest of the places some remnants of these sediments buried under a cover of recent sands are noticed. The river mouths were getting, in addition to the sediments of 2 and 3, the sediments derived directly from the basalts. The older sediments, different to the adjacent coastal rock types, may be considered as the remnants of 2 and 3. In the depositional basins near the coast the sediments, already deposited (as per Fig. 2) and preserved in the offshore due to subsequent submergence and transgression, are slowly being diluted in their characters. Banerji (1973) has reported from the heavy mineral studies the possibilities of the existence of the basins which were getting sediments without the admixture of the Deccan basalts even in the post Miocene period.

The existing coastal zone, as depicted in figure.6, shows the presence of sharp escarpment with step like topographical features developed in basalts out of the uplift and subsequent denudation and a very narrow plain surface, in between the sea-level and the escarpment. In this plains, however narrow it is, some remnants of earlier depositions (2) beach rocks and some lignitic beds are preserved. The structures like current bedding, preserved in the berm positions below the dune sands indicate the activities of the different ice-ages. The depositional basins are characterized by the superfluous mixing of basaltic sediments off the river mouths and a diluted ancient sediments away from the river mouths. The characteristic absence of sediments of No. 1 is due to the enormous supply from the rivers to the basin. The river capturing and the lack of lateritic cover in many of drain age areas are indicative of active erosion in the coastal belt off river mouths. The depositional

basin is characterized by the extension of river channel and presence of dykes. Beach rocks along the beaches may be attributed to the cause of sea level changes in Pleistocene. The coast is marked by number of intrusions which may be of Quaternary ages.

If the sediments have undergone recycling as shown in the figures, do they have the evidences for the same? When some of the highly resistive heavy minerals like zircon, rutile, tourmaline and kyanite are examined, they are found to be highly rounded. Though the distance of transportation is very much restricted, due to the proximity of the parent rocks, such roundness indicate the recycling and to and fro motions as in the case of surf deposits. Rajamanickam (1983) has shown the rounded overgrowths in zircon which is indicative of the transportation of the overgrown zircons from the source which may be far from the source i.e. the earlier depositional basins. The same heavy mineral with rounded, semi-rounded and angular nature is suggestive of multi-cycling, single cycle and direct deposition from the source rocks.

During the survey of offshore ilmenite exploration, for a stretch of 130 km, it is observed that the river mouths are characterized by the magnetite concentration with complete ferruginous coated sediments, whereas all the bays which either away from the river source or devoid of ferruginous source are noticed to contain superficially white quartzitic sediments with lack of ferruginous coating even in the heavier grains.

The studies of Reddy (1976) and Rajamanickam, et al., (1986) on wave refraction indicates the presence of convergence in many places. Such convergence affects very much the littoral transport to presume the possibility of northerly transport of these minerals to the existing depositional basins. Rajamanickam, et al., (1986) have shown a complete interruption among the adjacent bays in mixing of sediments and have proposed a drift of sediments only within the two convergence points. One may consider the possibility of transporting to deeper portions and transmission to a different bay in each stage but heavy minerals like magnetite, zircon can not be transported so easily like that. So such stage movement also is ruled out to obtain roundness and mixing of sediments.

Today they are found overlying the Deccan traps in the inner shelf. Shallow seismic records of this area indicate the presence of Deccan immediately below the sand, but within a distance of 3 to 4



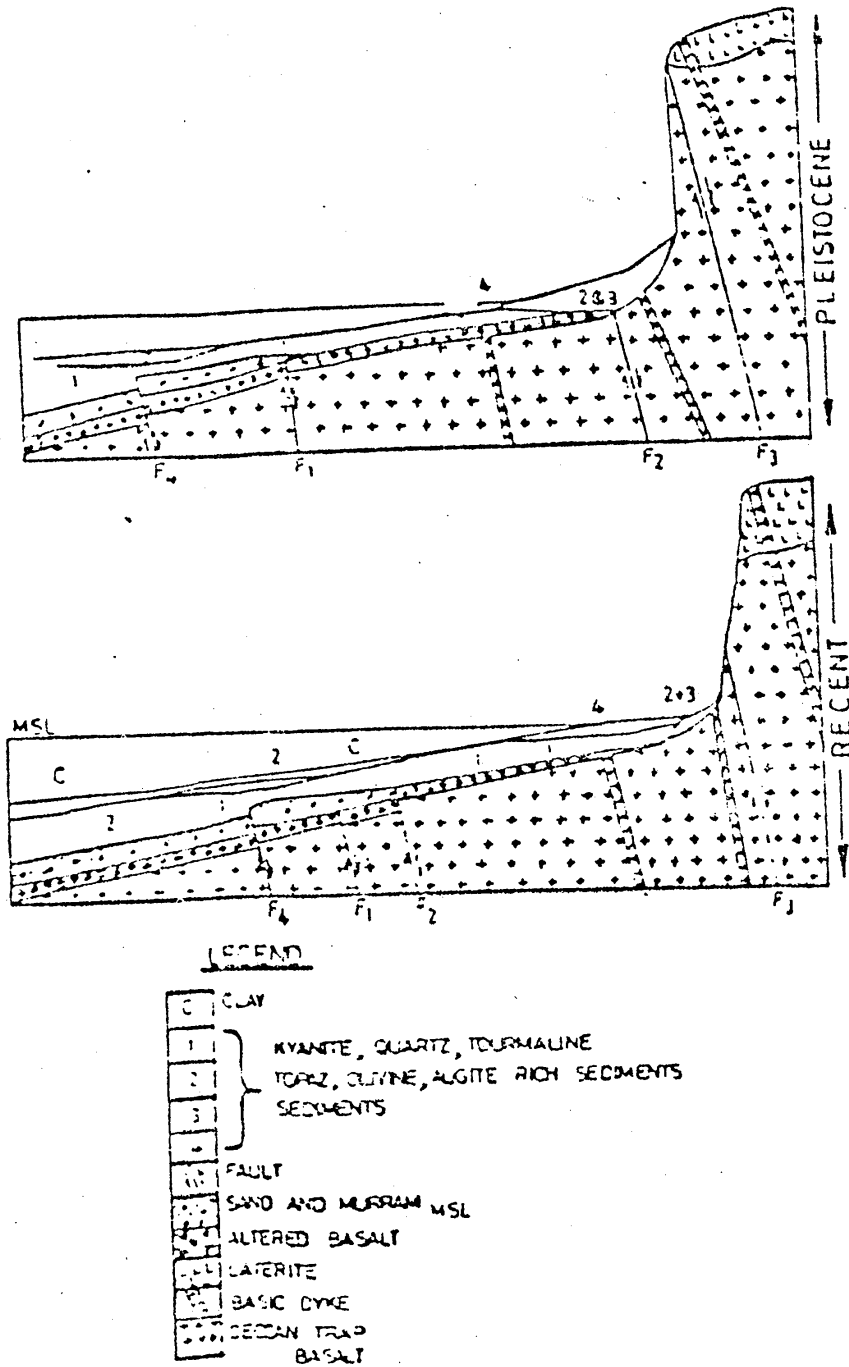


Figure 6

km, one finds a sudden plunge in the basement records. On continuous shallow seismic recording, it is highly impossible to get the basement record without break. If Deccan basalt is considered as continuous, when the recording conditions are not changed, one should expect such strong reflectors without fail. So, it is presumed that these flows in the shelf are not carpeted throughout seabed. Instead one can expect the flows during Deccan eruptions, even directly below the sands as patchy extrusions and the same later covered up by the offshore transportations of the nearby sands. Such patchy occurrences have been noticed in the Bombay high during the oil well drillings. There they could not get Deccan basalts in certain wells immediately below the sediments. Instead they noticed in certain places gneissic basement and certain other places some weak acidic type of rocks (Sastri, 1981; Ramanathan, 1981). Such patchy appearances of the basalt is also shown in the model 2. One would expect under these circumstances contact metamorphic effects in the sediments or at erupting point. One can not rule out this possibility but, in case, we can obtain cores of the basement through the sediments, it may throw some light on this aspect. Though a vast flow is recorded throughout the coast, such contact rocks are not noticed so far. One has to consider this aspect also. This may be due to the lack of high temperature eruption. Over and above the sudden cooling, caused by the cold water in the seabed, might have retarded the contact effects on the sediments around the eruption.

Siddiquie, et.al (1982), Rajamanickam (1983) and Rajamanickam, et.al. (1981) have shown a series of structural deformities leading to the assumption of an active margin in this area. The number of dykes existing in the offshore areas and exposed upto the seabed also support the frequent tectonic disturbances in this area. The sudden increase of clay thickness beyond 15 m at a distance of about 5 km from the shore, deep burial of basement at this point (and in certain places beyond), detecting limits of continuous shallow seismic profiler, buried channels giving rise to sand lens are some of the evidences which are indicating the tectonically active zones in this coast.

Because of the presence of entirely different behaviours of the nearshore sands to the immediate coastal rocks and their constituents, it is surmised that the sands containing a peculiar heavy mineral assemblage must have been the palaeo-sands or remnants of the palaeo-sediments. These sands are being covered by the recent clay beyond

the zone of wave activities and littoral movements. These sands are being affected by the recent coarse natured sediments in getting diluted from their original characteristics specially in the river mouths where fine silt to coarse sands are profusely made available. Since the near-shore sands in the west coast are the representative of the palaeo-sediments, one is noticing placer accumulation contrary to the nature of coastal rocks and finds lack of replenishment in the placer sands as the mining progresses, like the monezite sands of Travencore. When the various properties of the sands are analyzed, it is clear that they are not mainly supplied by the basaltic rocks but brought in juxtaposition with them. It cannot be presumed to retain the palaeo-sands in contact with eruptive masses in the palaeo-times. It may not be feasible to think about transportation of these sediments along the coast from down south due to the wave refractive and littoral transport patterns. So, one can agree that basaltic basements are continuing below the sediments upto the outer shelf. From the present day shelf topography, one is able to make out many terraces of 85, 75, 55, 35, 25, 11 m water depths. These terraces may be the boundary limits of earlier sea-level stands. So, from these earlier shelves, the sediments might have been transported shoreward in stages which must have given time to develop even the overgrowths in some stages and later transported further. Even today, one finds shoreward transport commonly in the coast. Such long time transportation in the oscillatory zones of different terraces, supports satisfactorily the roundness noticed, in the high resistive minerals. On these, the recent ice-ages introduced the formation of raised beaches, terraces, beach rocks, etc. So, ancient sediments deposited in the nearshore prior to the capping of the Deccan flow in the coastal margins, were shifted slowly by shoreward transportation in stages on the active support and aid provided by the coastal down warping and subsidences caused during the various tectonic movements associated with the volcanic activities and heavy sedimentation in the ancient times.

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