CHAPTER III

STRATIGRAPHIC SEQUENCE OF SAURASHTRA

CLASSIFICATION

Fedden (1884) was the first worker to give the sequence of Tertiary and Quaternary sedimentaries (Table III.1). Amongst the Quaternary deposits, he included, besides miliolite, raised beaches (Littoral concrete, Dead coral reefs, and Oyster beds), rann clays, sand dunes and freshwater alluvium and grouped them under 'Alluvium'. He, however, stated that some of the rocks incorporated under Dwarka beds might be as young as Pleistocene and must be separated on closer
Table III.1: Classification of Quaternary and Tertiary sequence of Saurashtra (after Fedden, 1884)

<table>
<thead>
<tr>
<th>Formation</th>
<th>Approximate geological position</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alluvium</strong></td>
<td></td>
</tr>
<tr>
<td>(Sand dune, tidal flat, freshwater alluvium, 'ran' clay, raised beaches and miliolite)</td>
<td>Recent and Sub-Recent</td>
</tr>
<tr>
<td><strong>Dwarka Beds</strong></td>
<td>? Higher Tertiary or Post-Pliocene</td>
</tr>
<tr>
<td><strong>Gaj Beds</strong></td>
<td>Upper Miocene (Lower Manchar in part and Gaj of Sind)</td>
</tr>
<tr>
<td><strong>Lateritic rocks</strong></td>
<td>? Lower Eocene- Sub-Nummulitic (Wynne) of Kutch and ? High-level laterite of Deccan</td>
</tr>
<tr>
<td><strong>Traps</strong></td>
<td>Cretaceous-Eocene (Deccan Traps)</td>
</tr>
</tbody>
</table>
examination. He described one of these rock types as "Coast fringing rock, which is seldom met at any great distance from the coast and forms Dwarka cliff in the type area of Dwarka beds".

Sastri & Pant (1959) who were the first to map Quaternary carbonates in detail, covered Veraval-Mangrol coast. They gave entirely a new classification in which chronostratigraphic units of Pleistocene, Sub-Recent and Recent ages were distinguished (Table III.2). Under this scheme, Miliolite limestone forms the oldest unit, followed by consolidated fossiliferous rocks, while the unconsolidated sediments and coral reefs constitute the youngest unit.

More recently, Marathe et al. (1977) have reconstructed a composite lithostratigraphic section (Table III.3) of the rock units encountered in the Hiran valley of southern Saurashtra. The stratigraphic column presented by them shows that there are two major rock-units (Rock Unit I and II), each one is characterised by fluvial sediments grading into the miliolites. They assigned Middle Pleistocene (?) and Late Pleistocene ages to miliolite I and II of the above units respectively.
Table III.2: Classification of Quaternary and Tertiary sequence of Saurashtra (after Sastri & Pant, 1959)

<table>
<thead>
<tr>
<th>Formation</th>
<th>Lithology</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent Deposits</td>
<td>Alluvium, coastal sand dunes, fringing coral reefs</td>
<td>Recent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-Recent Deposits</td>
<td>Consolidated shell sands and beach deposits, dead reefs, emerged beaches, old sand dunes etc.</td>
<td>Sub-Recent</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miliolite Limestone</td>
<td>Fine to medium grained oolitic limestone</td>
<td>Pleistocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dwarka Beds</td>
<td>Variegated, flaggy limestone of varying texture and composition and with interveening yellow marls and clays</td>
<td>Upper Miocene to Pliocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gaj Beds</td>
<td>Hard, compact, fine grained, buff, yellow or red coloured limestones</td>
<td>Lower Miocene</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deccan Traps and other Volcanics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table III.3: Composite lithostratigraphic section of Quaternary rocks of Hiran Valley, Southern Saurashtra (after Marathe et al., 1977)

<table>
<thead>
<tr>
<th>Average thickness (m)</th>
<th>Lithology</th>
<th>Probable age</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>Soil, alluvia, beaches and dunes sharp contact to (disconformity)</td>
<td>Late Holocene (4,000 B.P. to Modern)</td>
</tr>
<tr>
<td>1.0</td>
<td>Fossil soils, yellow-brown alluvial silts, gravels and aeolinite and beach rock sharp contact to</td>
<td>Late Pleistocene to Mid-Holocene (20,000 - 4,000 B.P.)</td>
</tr>
<tr>
<td>1.5</td>
<td>Miliolite-II, oyster beds, shelly gravels, beach rock and aeolinite sharp contact to</td>
<td>Late Pleistocene (30,000-20,000 B.P.)</td>
</tr>
<tr>
<td>1.5</td>
<td>Fluvial gravels and brownish moderately calcreted silts and tidal clays</td>
<td>Late Pleistocene (30,000 B.P.)</td>
</tr>
<tr>
<td>1.0</td>
<td>Calcreted fluvial gravels, and clays sharp contact to (disconformity)</td>
<td>Early late Pleistocene</td>
</tr>
<tr>
<td>1.0</td>
<td>Miliolite-I, with intercalated tidal clays, aeolinites and terrigenous sediments grades to</td>
<td>Mid - Pleistocene (?)</td>
</tr>
<tr>
<td>1.0</td>
<td>Fluvial gravels, silts and clays unconformity</td>
<td>Mid - Pleistocene (?)</td>
</tr>
<tr>
<td>1.0</td>
<td>Beach rock, limestone etc.</td>
<td>Gaj of Miocene</td>
</tr>
<tr>
<td></td>
<td>Deccan Traps</td>
<td>Eocene - Cretaceous</td>
</tr>
</tbody>
</table>
The present author (Mathur & Mehra, 1975) proposed a classification on the basis of the detailed work on the Quaternary rocks of Porbandar area and the reconnaissance of the rest of Saurashtra peninsula; and this could be considered as the most serious attempt using the Code of Stratigraphic Nomenclature of India. The same classification is followed here (Table III.4). He has given Formation status to two of the three stratigraphic units suggested by Sastri and Pant (1959). The 'Miliolite limestone' was renamed as Miliolite Formation, while "Sub-Recent Deposits" were referred as Chaya Formation (nomen novem), the two being assigned Early Pleistocene and Late Pleistocene ages respectively. The 'Coast fringing rocks' of Fedden were taken out from 'Dwarka beds' and grouped with the newly proposed Chaya Formation. The Rock Units I and II of Marathe et al. (1977) are approximate equivalents of Miliolite and Chaya Formations respectively. The present author has grouped Miliolite and Chaya Formations under Porbandar Group. The Miliolite Formation has been sub-divided into two Members viz., Dhobalia Talav and Adatiana Members.
Table III.4: Proposed classification of Quaternary and Tertiary sequence of Saurashtra

<table>
<thead>
<tr>
<th>Stratigraphic Unit</th>
<th>Lithology</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUATERNARY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ALLUVIUM AND COASTAL DEPOSITS</td>
<td>Freshwater alluvium (sands, clays), coastal deposits (Lime mud; rann clays with carbonaceous material/ marine shells; unconsolidated calcareous sands)</td>
<td>Holocene</td>
</tr>
<tr>
<td>ADATIANA MEMBER</td>
<td>Semiconsolidated to consolidated limestones (Calcirudites); shell limestones, coral reefs and oyster beds</td>
<td>Holocene to Late Pleistocene</td>
</tr>
<tr>
<td>CHAYA FORMATION</td>
<td>Alternating sequence of pelletoid limestones and fine grained limestone (micrites)</td>
<td>Early Pleistocene</td>
</tr>
<tr>
<td>MILIOLITE FORMATION</td>
<td>Flaggy, arenaceous limestones with recrystallised shells; clays</td>
<td>Middle Miocene to Lower Miocene</td>
</tr>
<tr>
<td>DWARKA FORMATION</td>
<td>Hard, compact, fine grained limestone with abundant foraminifera; variegated clays</td>
<td>Lower Miocene</td>
</tr>
</tbody>
</table>

Laterite and Deccan Trap
DESCRIPTION OF LITHOSTRATIGRAPHIC UNITS

In the following lines the nomenclature, distribution, mode of occurrence, lithology, fauna, age and correlation of various stratigraphic units of the study area has been dealt with. However, the detailed description and discussions on Miliolite and Chaya Formations have been postponed for the Chapter V on erstwhile 'miliolite' (= Porbandar Group of author).

Gaj Formation

The sediments of Gaj formation are best exposed in the stream section near Balamivav, west of Timbi, 1 km ENE of Umes and in the stream section east of Vavarda (Fig. I.6). They are also very well exposed just outside the limits of study area, on Una-Veraval road at its crossing with the road leading to Diu near the village Kesaria (20°48':70°56'). In general, the pale yellow to deep ochrous colour of Gaj marly limestones is very characteristic. The abundant foraminifera found in them make Gaj beds easily distinguishable in the field. The following species of larger foraminifera were identified:-

 Miogypsina irregularis, Miogypsina (Lepidosemicyclina) thecidaeformis, M. (L.) polymorpha, Lepidocyclina (Nephrolepidina) borneensis, L. (N) martini, L. (N.) morgani,
L. (Trybliolepidina) kathiawarensis, Austrotrillina howchini.

Besides the above forms, the echinodermata Breynia carinata, the lamellibranchs Ostrea latimarginata and O. gajensis and the gastropod Turritella angulata are also met frequently in the Gaj beds. The exposure near Umes yielded large number of corals and many other invertebrates.

From a subsurface sample of grey shale from Kadiali area (Fig. 1.6) nannoplanktons were recognised. This is the first record of Miocene nannoplanktons from western India:


The age indicated by foraminifera, nannoplanktons and invertebrates is lower Miocene.

Dwarka Formation

Formerly known in the literature as Dwarka beds, the limestones of Dwarka Formation have a distinct
lithological identity in being highly arenaceous.

Limestones contain broken shell fragments in abundance together with rounded to sub-rounded sand-size grains of smoky quartz. The barnacle *Balanus* and its broken fragments sometimes form such a predominant constituent of the fauna that the rock could be termed as *Balanus* limestone. The *Lamellibranchs* and gastropods of Dwarka Formation are difficult to be identified because of their high degree of recrystallisation. The clays associated with Dwarka limestone are highly arenaceous in composition and usually devoid of fossils.

The larger foraminifera identified from Dwarka limestones of the type area of Dwarka Formation (Mathur, 1972) in western Saurashtra indicate that the lower age limit of Dwarka Formation is lower Miocene. None of the characteristic Pliocene fossil forms has been discovered so far from Dwarka limestone. However, most of the workers put the age of Dwarka Formation as Upper Miocene to Pliocene, apparently to fill in the gap in the stratigraphical column between lower Miocene Gaj Formation and Quaternary carbonates of western India.
The main interest of Quaternary researchers in Dwarka Beds of Fedden lies in the 'coast fringing rocks'. Although described under a separate head, the 'coast fringing rocks' were included by Fedden tentatively under 'Dwarka Beds'. However, these rocks were included by the present author (Mathur & Mehra, 1975; Verma, Mathur & Misra, 1975) under the Chaya Formation. The organic remains of the 'coast fringing rocks' are in semi-fossilised state of preservation and belong to the species now living on the coasts of Saurashtra.

In the area investigated, the Dwarka limestone is best developed in the form of a ridge near Kadiali (called 'Kadiali ridge' by Verma et al., 1974) which seldom rises more than a couple of metres above the general level of the ground but forms a very conspicuous physiographic expression in otherwise flat, open surroundings. The limestone is gritty but flaggy in nature. Unidentifiable fossils and their fragments, chiefly of Balanus, are abundant in this rock but none of the larger foraminifera identified in the type area of Dwarka Formation could be found. However,
in view of the general lithological similarity and stratigraphical position of these beds with Dwarka limestones of type area, lower to Middle Miocene age has been assigned.

As stated above the separate identity of Dwarka Formation is recognised due to its arenaceous nature and fauna which consists mostly of recrystallised Balanus and molluscs. Besides, Dwarka rocks occupy the stratigraphic position just above the Gaj Formation without any visible unconformity. The identification of the larger foraminifera of Lower to Middle Miocene from Dwarka limestone clearly shows that Dwarka sediments represent the continuation of the process which commenced with the deposition of Lower Miocene Gaj sediments. Gaj rocks represent a slightly deeper water facies than the Dwarka rocks. In other words, the Dwarka sediments were deposited when the Gaj sea had started regressing from the scene of Saurashtra in Middle Miocene and left its impressions in the form of littoral sediments which now constitute Dwarka Formation. It is therefore, appropriate to place Gaj and Dwarka rocks under single chronostratigraphic unit. This should however, await
till such time when Dwarka area is more thoroughly studied in field and laboratory. When it is done, some of the area mapped by Fedden under Dwarka beds will have to be included in the older stratigraphic unit and some under Quaternary, is beyond doubt.

**PORBANDAR GROUP**

The lithostratigraphic term Porbandar Group was proposed by the author (Mathur & Mehra, 1975) for the post-Tertiary carbonate sequence of Saurashtra to include Miliolite Formation and Chaya Formation. It comprises erstwhile 'miliolite' and other consolidated and semiconsolidated carbonates of Quaternary. The rocks of the two formations were deposited in at, or near the strand line of a shallow Quaternary sea which oscillated in response to the eustatic changes in the sea levels during Quaternary. In view of the above natural relationship between them, they have been placed under one group.

**Miliolite Formation**

The term 'Miliolite'/Miliolite Formation was used till recently in a very loose sense to include all
the consolidated and semi-consolidated carbonate deposits of post-Tertiary age of Saurashtra and Kutch (Gujarat). The author has, however, redefined the term and used it in a restricted meaning to cover only the calcarenites and the associated micrites which are devoid of megafossils. The Miliolite Formation (sensu stricto) has been further sub-divided by the author (Mathur and Mehra 1975; Mathur et al., 1976) into Dhobalia Talav Member and Adatiana Member. The latter is characterised by pelletoid calcarenites and the former by an interbedded sequence of calcarenites and micrites (Plate III.1). Dhobalia Talav–Nawagam and Adatiana–Ranawao areas (Fig. I.5) expose typical sections of the two members respectively. In the study area, Dhobalia Talav Member is best developed around Una. Three bands of micrites are noticed in a well section 2 km north of Una bridge on Machhundri river. Adatiana Member is also well exposed in the investigated area. The low-level deposits of this member occur in the form of crescentic-shaped mounds and as sheet deposits in a wide area near Una (Fig. I.2). Besides, just outside the limits of the study area, the Adatiana Member is exposed about 15 km northwest of Una in the vicinity of Fareda and Jhakhiya villages. Its exposures
PLATE III.1

a. A view of the interbedded sequence of calcarenites and micrites of Dhalbilal Talav Member (Miliolite Formation). Dhalbilal Talav 'Chalk' quarry, 12 km NE of Porbandar, south-western Saurashtra.

b. An exposure showing calcarenites overlying micrites of Dhalbilal Talav Member (Miliolite Formation), just north of Una bridge on Manchhundri river, southern Saurashtra.
are seen practically all around the A254 hill upto a level of about 225 m above the mean sea level in the stream valleys radiating from the highlands.

The thickness of Miliolite Formation is highly variable ranging from a couple of metres to 60 m or so. Wherever it occurs as sheets, the thickness is not much, but at those places where it consists of piled up heaps, it shows thicknesses as much as 60 m.

In the area investigated this formation occurs in the form of crescent shaped outcrops over the peneplained surface of Deccan trap and Tertiaries. It also occurs as tongues inside the valleys of consequent streams.

The most common rock type of Miliolite Formation is pelletoid calcarenite consisting essentially of sand size pellets. The oolites and superficial oolites also enter into its composition but in a very small way. The cores of the accretionary grains are invariably made up of calcareous grains. In rare cases foraminifera forms the nucleus of the oolites.

The microfauna contained in the miliolite rocks consists of shallow water species of benthonic foraminifera,
ostracoda and calcareous algae. Most of them are the living forms.

The Miliolite limestone is as a rule thinly laminated, sub-horizontally bedded and exhibits cross bedding of varied type. The high angle, wedge planar cross stratification with long laminae of the forest beds is commonly seen in all the thick deposits. However, tabular-planar and trough type cross-lamination is more common in the valley-fill deposits. The study of the dip-azimuthal data of the typical aeolinites has shown that the prevalent wind direction has more or less not changed since the time of deposition of the Miliolite Formation.

The miliolite rocks are marine as well as aolian in origin. Both the types co-exist in the study area. A number of criteria have been advanced to distinguish aeolian from aqueous deposits. Some of these are of debatable merit when used in isolation. The ultimate decision whether a deposit is of aeolian or marine origin, therefore depends on a full critical evaluation of all the available data.
The Miliolite Formation has been assigned Lower Pleistocene age on the basis of indirect evidences.

Chaya Formation

The term Chaya Formation was proposed by the author (Mathur & Mehra, 1975) to include deposits younger than Miliolite Formation (sensu stricto). These were included by the earlier workers either under 'Miliolite' or 'Miliolite Limestone' but as will be seen, have a distinct identity of their own. Consisting essentially of calcirudites and other coast fringing, megafossil bearing rocks like oyster beds, coral reefs etc., the name Chaya Formation was proposed after a locality of the same name in Porbandar area.

Chaya Formation overlaps Tertiary sedimentaries and Miliolite Formation. In rare cases it has also been found to overlap the Deccan Trap Formation in southern Saurashtra. It occurs in the form of beach ridges which have subsequently been cut into precipitous cliffs.

Besides the megafossils, the Chaya rocks contain intrachasts of miliolite limestones and shell fragments of lamellibranchs, gastropods, hermatypic corals, echinoids and calcareous algae, etc.
The limestones of this formation are thickly bedded and as in the case of Miliolite Formation, the high angle, wedge-planar cross stratification with long foresets, is very common in the thick deposits of Chaya limestone. The palaeowind direction determined by the study of such deposits has shown that on the southern Saurashtra the wind regime has not changed since the deposition of Chaya Formation.

Some of the beds of Chaya Formation containing megafossils comprise undoubted marine deposits, but those devoid of larger fossils are sometimes marine, but mostly aeolian.

A late Pleistocene to Holocene age has been assigned to Chaya Formation on the basis of the \(^{14}C\) dating of the corals, oysters contained in Chaya rocks.

**ALLUVIUM AND COASTAL DEPOSITS**

It includes freshwater alluvium (sands and clays) and coastal alluvium, of which the latter are of relevance to the present study. Under the coastal alluvium are included the old and newer tidal flat sediments and the coastal unconsolidated beach and dune sands.
The lime mud deposits form one of the most interesting sediments because their older analogues are associated with miliolite rocks. They occupy the low ground that now forms the old tidal flats southwest of Delvada (Fig. I.2) and between Kadiali and Jafarabad. Calcilutite to calcisiltite in composition, the rock is thinly laminated—a feature which is hard to be distinguished owing to the high degree of calciretisation. The typical bedding characters of intertidal deposits (Plate III.2) were however, noticed at a locality 2 km NE of Jafarabad. The lime mud deposits of Vansoj and Kadiali areas are dirty white in colour while those of Jafarabad and Diu Island are impure with a high percentage of ferruginous content which has imparted reddish brown colour to the rock.

Besides the lime mud, carbonaceous clays were also noticed to form the old tidal flats of the study area. They are usually rich in woody matter which is not much altered. About 1 km N 10° W of Nandan, the Chaya Formation is overlain by about 2 m thick deposit of such clays under a cover of about 3 m of unconsolidated sand.
PLATE III.2

Close-up of typical inter-tidal bedding seen in the old tidal flat lime mud deposits, 2 km NE of Jafarabad, southern Saurashtra.
Similarly, about half a km south of Delvada, Miliolite Formation is overlain by 3.2 m thick zone of grey, carbonaceous clay under the cover of river alluvium. The presence of brakish water shells was recorded from the Delvada locality.

Unconsolidated beach sediments of the study area provide a fine example of carbonate beach sands consisting of mechanically deposited carbonate grains. The fragments of mollusca and pellets are the most dominant constituents. The pellets are generally of two types viz., (i) smooth, ellipsoidal or spherical ones which were derived from the miliolite rocks and (ii) micritised skeletal grains which have assumed the shape of the pellets. The latter are fresh and show various stages of micritisations and pelletisation. Some of the pellets might be faecal in origin. This impression is strengthened by the observation of pellet-forming habit of some of the burrowing crabs of the present-day coast. The coastal sands get covered during the low tide by pellets formed by the burrowing crabs in a radial pattern of linear tracks around their burrows (Plate III.4). The shape of the pellets was
PLATE III.3


b. Photomicrograph showing pellets and shell fragments in carbonate beach sand (X18). Hematpur Mandvi beach, southern Saurashtra.
Pellets formed by burrowing crabs on modern carbonate beach sands. Hematpur Mandvi beach, southern Saurashtra.
spheroidal and they were smooth and loose textured.
Unlike the ellipsoidal faecal pellets that are produced
by the passage of lime mud through the guts of the worms,
mollusca, etc., the spheroidal pellets of the study area
have resulted by a different process. The small,
burrowing crabs were observed to extract the lime mud
from the calcareous sands, put it into their mouth,
munch in the nutriants and expel the ball like pellets
from their mouth. This activity was so fast that on an
average, a crab produced one pellet every 10 seconds.

The coarser fraction which is generally concentrated
in the upper tidal limits is made up of complete shells
of gastropods, lamellibranchs, corals, Balanus, and their
large fragments. Heavy concentration of shells and
gravels of coastal limestone is found only on small
stretches of beach near the rocky cliffs such as in the
protected embayment in the rocky coast about 1.5 km
S 70° W Nawabandar. Trap fragments form common constituent
of the beach sand only near the mouth of the rivers.

Chemically, the beach sands of the area have on
an average about 55% CaCO₃. The highest percentage of
carbonates is found in the medium to fine sand size
fraction.
The unconsolidated dune deposits cover a considerable area near the coast. In Hematpur-Khada area the dune fields stretch over an area of more than 20 sq km in a 3 km wide belt in the form of detached patches, stretching 5 km or more in the direction of dominant wind. Similarly, thick pile of active dune sand cover can be seen near Vadhera and Senjalia. Occurring in the form of barchans (Plate III.5), transverse and longitudinal dunes (Plate I.5a), the unconsolidated sand overlies the limestone of Chaya Formation (Plate I.5b).

The dune sands of the study area are strikingly different from other parts of Indian coast in being dominantly calcareous in composition. On an average they contain 22% insolubles, 6% R₂O₃, 37% CaO and 2% MgO. The 60 mesh fraction, which forms about 60% of the total sand, contains as high as 43% CaO with only 14% insolubles, 4% R₂O₃ and 2% MgO.

Dune sands are obviously derived from the calcareous beach sands of the vicinity by the onshore wind transportation. The dunes are being formed by the summer and monsoonal westerly and south-westerly winds which blow for about seven months in a year and carry with them the carbonate
PLATE III.5

Active barchan dune. Nandan coast near Delvada, southern Saurashtra.
sands from the vast expense of the present day beaches. That the westerly winds play a major role in sand movement, is not only evident from the active dune morphology but also from the fact that a large part of agricultural land of Vadhera and Nawabandar area which falls in the line of the elongation of the dune fields now stands deserted because of the encroachment of active dune. Some of the palm trees falling in the line of westerly wind are seen in Nandan area to be covered under thick pile of active dune sands.

The effect of the somewhat weaker northerly wind in reshaping the active dune morphology is most sinking. The monsoon wind which blows at a speed up to 28.5 km/hour has shaped the sand into barchans (Plate III.5) having a steep up to 32° slope on the leeward side and a gentle 10° slope on windward side. But the northerly wind, is seen reshaping the barchans wings, the barchans having been modified into S-shaped plan (Plate III.6).

Fauna of the unconsolidated beach and dune sands includes a host of molluscan shells, bryozoans, echinoderms spines and small fragments of calcareous algae, ostracods
S-shaped dune plan of a partially modified active barchan dune. Jafarabad coast, southern Saurashtra.
and abundant bentonic foraminifera. Among the foraminifera, the abundance of *Streblus taiwanica*, *S. annentens* and *S. pappilosus* together with the presence of slightly smaller percentage of *Elphidium crispum*. *Eponides repandus* are the main feature of the microfauna of the sands. The remaining species are rarer. Among these the family *Miliolidae*, represented by the genera *Quinqueloculina*, *Spiroloculina* and *Triloculina* is common under the quantitative standpoint.

A point count of the beach samples show that foraminifera of the family *Rotalidae* and molluscan shell fragments constitute 48 and 46 per cent subpopulations of the total bionbiota; the miliolids are only 2 per cent and the rest 4 per cent comprise the remaining families of foraminifera, ostracoda, algae, etc.

The check list of foraminifera is given below:
BENTHONIC SPECIES

Family MILIOLIDAE Ehrenberg, 1839

Quinqueloculina contorta d'Orbigny,
Q. lamarkiana d'Orbigny,
Q. longirostra d'Orbigny,
Q. pseudoreticulatus Parr,
Q. undosa-costata Terquemum,
Q. vulgaris d'Orbigny,
Triloculina affinis d'Orbigny,
T. cf. circularis Bornemann,
T. terquemiana (Brady),
T. tricarinata d'Orbigny,
T. cf. trigonula (Lazarck),

Family NUBECULARIIDAE Jones, 1875

Sproloculina eximia Cushman,
Spiroloculina indica Cushman and Todd,

Family HOTALIIDAE Ehrenberg, 1839

Streblus annectens (Parker and Jones),
S. taiwanica (Nakanmura),
S. beccarii (Linnaeus),
S. catesbyanus (d'Orbigny),
S. dentatus (Parker and Jones),
S. papillosus (Brady).
Family \textbf{BOLIVINITIDAE} Cushman, 1927

\textit{Bolivina} sp.
\textit{Siphogenerina raphanus} (Parker and Jones),
\textit{Reusella} sp.

Family \textbf{LOXOSTROMIDAE} Loeblich & Tappan, 1962

\textit{Loxostormum} sp.

Family \textbf{UVIGERINIDAE} Haeckel, 1894

\textit{Uvigerina} sp.

Family \textbf{DISCORBIDAE} Ehrenberg, 1838

\textit{Discorbis globularis} (d'Orbigny),
\textit{D. patelliformis} (Brady),

Family \textbf{ELPHIDIIDAE} Galloway, 1933

\textit{Elphidium advenum} (Cushman),
\textit{E. craticulatum} (Fichtel & Moll),
\textit{E. crispum} (Linnaeus),
\textit{E. indicum} Cushman,
\textit{E. jensenii} (Cushman),
\textit{E. simolex} Cushman,

Family \textbf{NONIONIDAE} Schultze, 1854

\textit{Nonion scapha} (Fitchel & Moll)
Family EPONIDIDAE Hofker, 1951

*Eponides repandus* (Fichtel & Moll),
*Poroeponides lateralis* (Terquem),
*Pulvinulina* sp.,

Family CIBICIDIDAE Cushman, 1927

*Cibicides boueanus* (d'Orbigny),
*C. cf. floridanus* (Cushman),
*C. lobatulus* (Walker & Jones),
*C. cf. pseudoungerianus* (Cushman),
*C. refulgens* (Montfort).

Family AMPHISTEGINIDAE

*Amphistegina radiata* (Fitchel & Moll)

Family LAGENIIDAE

*Lagena* sp.

Family ANOMALINIDAE Cushman, 1927

*Anomalina* sp.,

**PLANKTONIC SPECIES**

Family GLOBOGERINIDAE Carpenter, Parker & Jones, 1862.

*Globigerina* sp.

*Globigerinoides trilobata* (Reuss)

Family CHILOSTROMELIIDAE

*Sphaeroidina bulloides* d'Orbigny
From the ecological point of view the foraminifera recorded from the Holocene sediments are characteristic of warm to temperate, shallow waters. The absence of agglutinated forms suggests weak terrigenous sedimentation, a point confirmed by other studies.