CHAPTER-III

GEOLOGY, STRUCTURE AND GEOMORPHOLOGY

3.0 INTRODUCTION

The details on geology, structure, landforms and drainage networks of the terrain forms one of the basic data requirement for any geological application. Obtaining these details, are being carried out for several decades through traditional-conventional ground based surveying and mapping methods. Later, the aerial photo interpretation has been added to aid geological mapping. It has been realised that the systematic approach of understanding the terrain at the regional scale and then going for required target areas not only improve the quality of information being obtained, but also to save considerable time, cost and manpower. Towards this satellite based remote sensing technique has become the most effective tool for mapping, geological, structural and landform details. Due to its synoptic viewing, multispectral, multitemporal and resist capabilities, the remote sensing technique is being widely employed in geological and geomorphological applications.

In the present study, attempts have been made to demonstrate the capabilities of remote sensing technique in geological and geomorphological mapping of Ramanathapuram District.
3.1 GEOLGY

Foote, R.B. (1883) from Geological Survey of India traversed through this area and has carried out extensive mapping of geological formation and structures. But, however, with proper approach, mapping of geological formations has started only in 1940. Only a few exposures of Archean rocks reported from Ramnathapuram district. Most of the area are covered by alluvial sands and beach sands. The general stratigraphy of the study area is as given in the Table-3.1. Apart from this with the information collected from various state, central government agencies, a geological map had been prepared using aerial photographs on 1:50,000 scale and digitally enhanced IRS IA LISS I data, and the informations were incorporated in the base map prepared from Survey of India toposheet on 1:50,000 scale with limited field checks (Fig.3.1).

The crystalline rocks are exposed only in the northwestern part of the district around Kamudhi. The granite gneisses show a regional trend of NNW-SSW with varying dips. The Quarzites are exposed near Kamudhi as elevated ridges and it is sheared by joints of 3 or 4 sets. Course feldspathic gneisses are found SE of Ellayirampannadai with the strike of ENE-WSW. The dip is ranging from 60° to 75° South. The gneisses are mostly covered with thick soils, along the stream courses, due to the removal of sands by running water, they are found to be exposed. The veins of pegmatites are also noticed along the foliation planes of the gneisses in the stream sections of Ellayirampannadai and Manjalodaipatti.
Table-3.1: General Stratigraphy of the Study area

<table>
<thead>
<tr>
<th>Era</th>
<th>Period</th>
<th>Age</th>
<th>Stage</th>
<th>Morpho stratigraphic units</th>
<th>Lithology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quaternary</td>
<td>Pleistocene to Recent</td>
<td>Devipattinam formation</td>
<td>Beach, barrier dune, tidal flat, estuary, lagoonal, strand plain</td>
<td>Medium to fine sand, clay, silt, laterites, alluvium</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Holocene to late Pleistocene</td>
<td>Pallamorkulam Pullangudi formation</td>
<td>Mud flat deposits</td>
<td>Clay</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Holocene</td>
<td>Vaigai, Gundar formation</td>
<td>Channel bar and bedload deposit</td>
<td>Sand silt clay</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>point bar deposit</td>
<td>Silt and sand</td>
<td></td>
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<td></td>
<td></td>
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<td>levee deposit</td>
<td>Silt</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>terrace deposit</td>
<td>Sand and silt</td>
<td></td>
</tr>
<tr>
<td>Tertiary</td>
<td></td>
<td></td>
<td>paleochannel deposit</td>
<td></td>
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</tr>
</tbody>
</table>

Unconformity

Proterozoic Pre-cambrian Archean

Gneisses, granites, pegmatite veins and associated basic intrusive
GEOMORPHOLOGICAL MAP

RAMANATHAPURAM DISTRICT

SCALE

FIG. 3.3

37
The eastern portion of the Ramnathapuram consist of consolidated sedimentary rocks overlying the crystalline basement rocks. These rocks are formed in beds of shallow levels and coastal back waters where the silt, mud and sand, brought by rivers from the west are deposited. The sedimentary rocks extends into the whole of Thiruvadanai and Mudukaluthur taluk. The sediments, consisting mainly of clays and sandstone, must have been deposited continuously for several million years from Gondwana period to the present day. They also contain some useful types of clays and limestones and the possibility of the occurrence of coal in them cannot be ruled out. The sandstones are brown to white in colour highly friable and weathered. At places, laterite capping is seen above the Tertiary formations. Mottled sand, friable sandstones is associated with brown coloured clay. Gravel beds form as junction between the crystalline rocks and sandstones.

Quaternary deposits are confined to the coastal area and flood plains of major rivers. Quaternary deposits are exposed widely to a width of about 25 to 30 km from Mandapam to Disayanvillai coastal tract (Loveson, 1993). The Quaternary sediments have resulted from the erosive action of various natural agents like wind, wave and river, the sediments consist of clay, silt and sand. The sedimentation had taken place under fluvial, fluvio-marine, marine and aeolian environments. As a result, typical deltaic and coastal landforms with distinct difference in composition leading to the recognition of various morpho-stratigraphic units have been developed (Muralidharan 1985).
and Janardhan 1988). Red soil occurs on small patches in the southern part of the district. Sub-Recent calcareous sandstones forms the base of the present day coral reef. Red sand occurs about 1.6 km north west of Tirupullani.

3.2 STRUCTURE

The lineaments are concealed by a thick cover of alluvium. Geophysical studies carried out by Geological Survey of India, and Oil and Natural Gas Commission have given fairly good picture of the type, extensions and nature of the sedimentary basins. These studies as well as the drilling data have confirmed the presence of basement ridge in Sarguni -Devakottai area as well as the deepening of the basin in the eastern part and the maximum thickness of sediments on the western side of Ramnathapuram. There is a rise in the basement near Mandapam indicating a "Graben" structure, as revealed from seismic explorations, the thickness of sedimentary formations is found to range upto 2,000 near Ramnathapuram. The basement ridge is probably located near Uchipuli and thickness of sediments at Mandapam is 1640 m.

3.2.1 COASTAL TECTONICS

The Indian coast frequently has been subjected to tectonic movements in Quaternary periods. Through out the coast line of India, presence of tectonic activities are shown by the E-W block movements and some times the same with a tilt. The resultant effects
are reflected in the disposition and complex configuration of the
geological formation along the coast line (Dhundial, 1987). It is
suggested that the Quaternary movements in Coastal areas are mainly
of epirogenic type with vertical uplifts and subsidence throughout the
coast lines of India (Biswas et.al.1971). In many occasions, one can
see the off set of coastal sedimentation due to such vertical
movements. An attempt is made here to bring out the evidences of
possible tectonism along this part of Tamil Nadu coast.

The identification of coastal transformation as due to the neo
tectonics is difficult due to the thick cover of sands and sand dunes.
However, it can be recognised in the field by observing the disposition
of features like beach ridges, terraces, cliffs, offset of sediments,
change of soils, abrupt absence of linear features and the presence of
lineaments. Such a study is possible with the satellite pictures.

In addition an attempt has been made to recognise various
lineament systems so as to understand the neotectonic activities
prevailing in the study area. As the imagery is synoptic and covers a
large aerial extent, the regional features, especially, lineaments,
fractures could be traced easily (Seigel and Gillespie, 1979).
Particularly, for lineament mapping, imagery is considered to be has an
unparallel and replacable tool.
3.2.2 LINEAMENTS

It is generally accepted that the term "Lineament" was originally used by Hobbs (1904,1912) to describe linear features that are "Significant lines of Landscape." Since the 1800's (Hodgson, 1974) with the advent of high altitude earth observation, the term "Lineament" has assumed a greater significance. O'Leart et.al., (1976) defined "Lineament" as "a mappable, simple or composite linear feature of a surface, whose parts are aligned in a rectilinear or slightly curvilinear relationship. Which differ distinctly from the patterns of adjacent features and which presumably reflects a sub surface phenomenon". Lineament studies have their greatest application in consolidated rocks of a low primary permeability, where groundwater occurrence is primarily a function of a fracture induced secondary permeability.

Based on the analyses of IRS IA data a lineament map has been prepared (Fig.3.2). These lineaments have also been confirmed by the aerial photographs of 1972 obtained for the coastal belts of the district. Among all the systems, NE-SE and NW-SE trending lineaments are the most prominent.

The lineaments are classified as follows:

i. Lithological lineaments and

ii. Structural lineaments
LINEAMENT MAP

RAMANATHAPURAM DISTRICT

--- LINEAMENT
--- LINEAMENT CONJUNTURED
--- FRACTURE
--- FAULT

SCALE

FIG. 3.2

33
In the study area, lithological boundaries have been identified clearly. Generally most of the lithological lineaments are found to trend either NW-SE or NE-SW. Around Kamudi area, the contact zone of deltaic land with gneissic rocks is represented by a lineament trending a N-S trend. A three series of conjectured lineament trending NE-SW extends from Chinna Eravadi to Tondi along the junction of Tertiary and Quarternary boundary, two prominent lineaments along the Devipattinam area marking the beach ridges are identified.

In the study area, the structural lineaments are represented by lineaments systems trending mostly of NW-SE. The Vaigai river follows the lineament (Fault) trending due NW-SE. Aeromagnetic study also reveals the basement break at SW of Ramnathapuram. The Gundar basement break might have aided the subsidence of the northern block, (Photo-1) enabling the formation of vast Vaigai deltaic plain, whereas the southern block must have been lifted up, compactly (Photo-1).

3.3 GEOMORPHOLOGY

The present landforms are expected of both fluvial and marine origin. The various landforms resulted from both marine and fluvial are discussed below:
Photo-1: Section showing the basement break near Valinokam
3.3.1 MARINE ENVIRONS

The present landforms are the product of the processes of erosion and deposition. The coast, in total is considered as emerging type on the basis of different classifications as shown below. The classification of any coastline helps to evaluate and understand the relationship between nature of landforms and various geomorphic processes (Pethick, 1983). According to Johnson's (1919) classification, the coastal strip is denoted as emerged one on the basis of sea level variation. As per Valentine (1952) the area falls under prograding type of coast. Ahmed (1972) and Krishnan (1956) classified the study area as depositional plain coast type. In short the study area can generally be considered as emerging type, because of the impressions registered by the characteristics landform like beach ridges, spits, beach, swale, sanddunes, marine terrace, cliffs, sea arches, deltaic plain, inter distributary basin and palaeo channels. Each landforms explicitly describes the type of natural processes involved in shaping its formation and the causes responsible for their present disposition. In order to study the morphogenetic set up of the landforms and their evolution, Coastal geomorphology map of the study area has been prepared (Fig.3.3). Special attention is devoted to the identification and classification of landforms. Geomorphic units are deduced from aerial photographs of 1:50,000 scale through visual interpretation using tonal variation also from satellite data of IRS IA LISS I data, various landforms are mapped. By duly integrating all the information a final map is prepared by incorporating the details into the base map prepared from toposheet of 1:50,000 scale.
A. Beach ridges

In the study area beach ridges of varied nature are found to be distributed far away from the coast line. In aerial photographs beach ridges are identified by medium grey tone and in imagery it appears as yellow tone. The beach ridges are produced mainly by wave action and lie parallel to the shoreline. On the basis of the nature and disposition of beach ridges, the study area is grouped into (i) northern and (ii) southern sides of Vaigai river basin. In the northern region between Devipattinam and Attangari two series of beach ridges are identified. These ridges are arranged in curvilinear pattern trending towards NNE to SSW direction with parallel disposition towards the shoreline.

The southern side of the Vaigai river region can be further classified into two sectors one extending from Vaigai river mouth to Mandapam tip (ii) Mandapam to Periyapattinam (Photo-2 and 3). The development of beach ridge has been in general assigned to the migration of lower reach of river like Godavari, Mahanadi, Cauvery, Pennar etc. (Sambasiva Rao and Vaidyanathan, 1979). Some beach ridges occur with thin lenses of sands near the tank in Periyapattinam. In some ridges coconut, palmtrees and paddy fields are located.
Photo-2: Digital output of satellite imagery IRS-1A depicting the beach ridge patterns in Periyapatnam area

Photo-3: Digital output showing the alternate beach ridges and swales near Vedalai
B. Spits

A spit is a small point of low tongue or narrow embarkment and commonly consisting of sand or gravel. The accumulation of enormous amount of sediments has caused the development of sand spits in east coast (Agarwal and Satyaprakash 1986). The spit, in Devipattinam is inhabited by Mangroves under swampy conditions. Agarwal, (1988) opined that in the East coast of India, the area between Mandapam and Pamban Island is attributed to a sandspit, later emerging as a high water land. The spit formation near Periyapatinam as a hooked nature trending towards southeast direction and having link with mainland in southwest direction (Photo-4).

C. Beach

Beach is a temporary or short lived deposits on the shore, it consists partly of unconsolidated materials. On the basis of beach characteristics the study area can be divided into two type in (i) sandy beaches (ii) rocky beaches.

i. Sandy beach

Sandy beaches are extremely developed along the northern coastal area between Devipattinam and Mandapam, covering for about a total length of 30 km. In the southern part of coastal area sandy beaches are noticed between Mandapam camp region and east of Ramasamymadam (Photo-5).
Photo-4 : A panoramic view of Periyapatnam spit
Photo-5: Sandy beach near Mandapam coast
ii. Rocky beach

Rocky outcrops of varying nature represent this type of beach. The outcrops of marine calcareous sandstones are noticed in the Valinokam region (Photo-6). The erosional features like wave cut terraces, sea caves, stacks and cliffs are found in the Mandapam region. Calcareous sandstone are also noticed in Pudumadam to Talaitoppu region.

D. Swales

Swales are the depressions located normally between the beach ridges. Swales are comprised of silt, clay and sand materials. During monsoon times, the swales are flooded with water and water stagnation persists for some time. A well developed swale system sand witched between Devipattinam and Muthuregunathapuram. From Nochiyuranai to Periyapattinam, a net work of swales of 4 series is located in between the complex beach ridges (Photo-3). If the swale system, located, near the shore, has any direct conneetion with sea it is called back water. The typical sight being seen near Noichyurni and Pillaimadam.

E. Sand dunes

A dune consisting of loose sands piled up by the wind action, commonly found along the low lying sea shores above high tide level. Coastal dunes cover only small areas are defined as topographical
Photo-6: Marine calcareous sandstone near Valinokam region
feature of aeolian origin composed of sand grains deposited down by wind from a natural source of sand (Fairbridge, 1968).

In the study area, dunes are scarcely distributed. However, their distribution is restricted to 1 km of the shoreline. Inland stabilised dunes are observed in Chitrarakottai region and longitudinal dunes with long round and circular types. The southern coastal region is characterised by prominent partially stabilised inland longitudinal dunes especially at Mandapam and Vedelai. Their height shows a meteoric rise of 15 to 30 meters and 75 metres length (Photo-7). These dunes are migratory in nature as there is no vegetation cover over them.

F. Sand sheets

Sand sheet is a sandy area marked by an extremely flat surface and absence of any topographic relief other than small ripples (Bagnold 1931). They cover an aerial extent of southern part between south of Vaigai river and north of Periyatharuvai tank. This region has three strandline of palaeo shoreline and they are covered by sand sheets. In the northern part of the Vaigai river, area between Devipattinam and Attangari has a swale system filled with sand sheets.

G. Deltaic plain

The level or nearby level surface comprising the landward part of a large delta strictly an alluvial plain characterised by repeated channel bifurcation and divergence, multiple distributary channels and
interdistributary flood basins. Younger Deltaic plain is recognised by deep red tone in the imagery. Older deltaic plain is identified by reddish brown coloured tone. Deltaic plain is well marked in the Vaigai delta region (Fig.3.3). Older deltaic plains are noticed in the Agricultural practising areas, Thiruvallur, Tedakkottai, Villangulam, Vattakudi, Madhavnur and Nariyanendal. Numerous tanks are noticed in NW of Devipattinam. Younger deltaic plains are developed in the lower reaches, of main Vaigai river tributary. The younger deltaic plains are dominantly uninhabitated.

H. Mud flat

Mudflat is distinguished by smooth surface which are formed by deposits of clay, silt and ooze (King 1972). Mudflats result from inundation of sea water, mudflat is identified by dark grey tone with smooth and irregular, texture and shape respectively from the imagery. Mudflat is well developed in the Devipattinam spit region. Another large mud flat is noticed in the western part of Chittarakottai (Photo-8). Limited occurrence of water in mud flats which are saline in nature.

I. Back waters

Back water is a creek, arm of the sea or series of connected lagoons usually parallel to the coast, separated from sea by a narrow strip of land but communicating with it through based outlines. The Vaigai river mouth is containing the back water extending up to 10 km
from the coast (Photo-9). A small creek having a back water is noticed at Uchipuli and a zone of back water is located in Pillaimadam near and parallel to the coast.

J. Mangroves

Mangroves are trees of various species of several families which grow only where they can come into permanent contact with sea water or brackish water. They occur at the edges of the tropical or subtropical areas, in bays, lagoons and estuarine region (Gerllech 1973). The well developed mangroves are noticed in Devipattinam spit area and in some parts of Valinokkam bay and areas north of Vaippar estuary.

3.2.2 FLUVIAL ENVIRONS

A. PALAEOCHANNELS

Palaeochannels occur in the deltaic region south of Vaigai river and a few in the northern part (Fig.3.3). Those are identified by their characteristic tonal variation. In the upper part of the palaeo channels, tanks predominate and occur across them, and in the lower parts are saline water tanks. Two patterns of palaeo channels trending NW-SE and WNW-ESE are identified. At present, the Vaigai river is flowing from northwest to south east. But based on the disposition of Palaeo - channels, there is every reason to believe that, Vaigai river might have been flowing NNW and SSE and discharging into the Gulf of Mannar.
Photo-7: Partially stabilised longitudinal sand dune near Mandapam
Photo-8: Mud flat near Chittarakottai
Photo-9: Vaigai river mouth containing the back water near Periyatharuvai
This inference is based on the longest palaeochannel recognised around Periyapatnam area. The presence of salt water tanks and there in the lower reaches of the palaeochannels can be attributed to the regression of the sea in stages, leaving the salt water tanks to be filled with the fresh water from the extended distributaries. Most of the palaeochannels are found to get terminated at the ridge zone itself, and did not cross over the present ridges in the coastal plain. It suggests that the palaeochannels must have been old and they must have been formed before the formation of those ridges. The palaeo channels have more sedimentation and due to their buried nature and their thickness of sediments is attributed through electrical logging and geo electrical surveys show that they have definite control over ground water.

3.4 CONCLUSION

The present study has brought out clearly the details of the geology of the study area through the use of aerial photographs, satellite images and with limited field checks. The crystallines are exposed only in the northwestern part of the district around Kamudhi. The eastern part of the Ramanathapuram consist of consolidated sedimentary rocks. The sediments consist mainly of clays and sandstones. Quaternary deposits are confined to the coastal area and flood plains of major rivers. It is exposed widely to a width of about 25 to 30 kms.
The lineament are classed as lithological and structural lineament. In the study area the lithological boundaries are identified clearly and a three series of conjectured lineament trending NE - SW marking the junction of Tertiary, Quaternary. In the study area the structural lineament are represented by NW - SE trends one follows the Vaigai river and another Gundar river.

The Geomorphology has been classed into (1) Marine environs, (2) Fluvial environs depending on their origin. The landform are further classified into Depositional and Erosional features. Generally the coast is of emerging type. Beachridges, spit, sand sheets, swales, back water, mangrove swamps, deltaic plain were mapped and their area of occurrence were discussed.

The palaeochannels and interdistributory plains were mapped and the occurrence of the palaeochannels and their thickness of sedimentation attributed with reference to ground water were discussed latter (Chapter-V).