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# Studies on Coastal Geomorphology along Visakhapatnam to Bhimunipatnam, East Coast of India

**M. Jagannadha Rao, Greeshma Gireesh A.G., P. Avatharam[1], N.C. Anil[2] and T. Karuna Karudu**
Delta Studies Institute, [1]Dept of Geology, [2]Dept. of Geo-Engineering,
Andhra University, Visakhapatnam.

**ABSTRACT**
An attempt has been made to study and record the diverse coastal geomorphic features along Visakhapatnam – Bhimunipatnam coast. The study area is marked by geomorphic features resulted from various coastal and land ward processes. The geomorphic units under different heads namely, features formed by present day wave action, features formed due to sea level oscillations and features formed by rock and sea water interaction have been presented. The influence of sea level oscillations and land and sea interaction forms a diverse coastal geomorphology along the coast. The details of features such as beach, dune system, inter tidal deposits, red sediments, wave cut platform, marine terrace, sea stack, sea cave, serpent hood structures, promontories, wind gap and natural bridge have been recorded and the formation as well as significance of their occurrence are presented. The coastal geomorphology of the study area clearly established not only the sea level oscillations but also variations in climatic conditions in this part of the coast.

## INTRODUCTION

Coastal geomorphology by definition is the study of the morphological development and evolution of the coast as it acts under the influence of winds, waves, currents and sea level changes.

The Visakhapatnam - Bhimunipatnam coast is known for diverse coastal geomorphic features. The environments namely beach, dune system, rocky promontories, red sediments, beach rock, Precambrian hillocks resulted in characteristic and significant coastal geomorphology because of land sea interaction, besides fluviatile and aeolian activity since Pleistocene to recent times. The work has been taken up with the following objectives.

1. To map the coastal features along Visakhapatnam-Bhimunipatnam coast.
2. To record the significance and processes that influenced their formation.

## LOCATION

The area lies between North Latitudes 17° 39′ and 17° 54′ & East Longitudes 83° 40′ and 83° 27′, which includes Visakhapatnam city and Bhimunipatnam town (Fig. 1).

## PHYSIOGRAPHY

The study area is characterized by Eastern Ghat mobile belt. This area covered with denudational hills of range between 30 to 594m above mean sea level. Kailasa range and Yarada range are two important hill ranges. Kailasa hill range limits the Visakhapatnam city in the northern boundary where as the Yarada range is located in the southern side. These two ranges are being separated from each other by a vast tidal basin, a few scattered hillocks and portions of low land. The above mentioned two hill ranges attaining a maximum height of 506 and 356m respectively are extending nearly east to west, and thus deviate from the general NE – SW trend of Eastern Ghats. These two hill ranges typically end their extremities into the sea as promontories. The Dolphin's nose, one such promontory formed by Yarada range, is famous for its shape similar to the fish Dolphin.

## GEOLOGY OF THE AREA

The study area geologically belongs to Precambrian age and is characterized by the occurrence of metasediments and intrusive meta igneous bodies. Apart from meta sediments the area is also marked

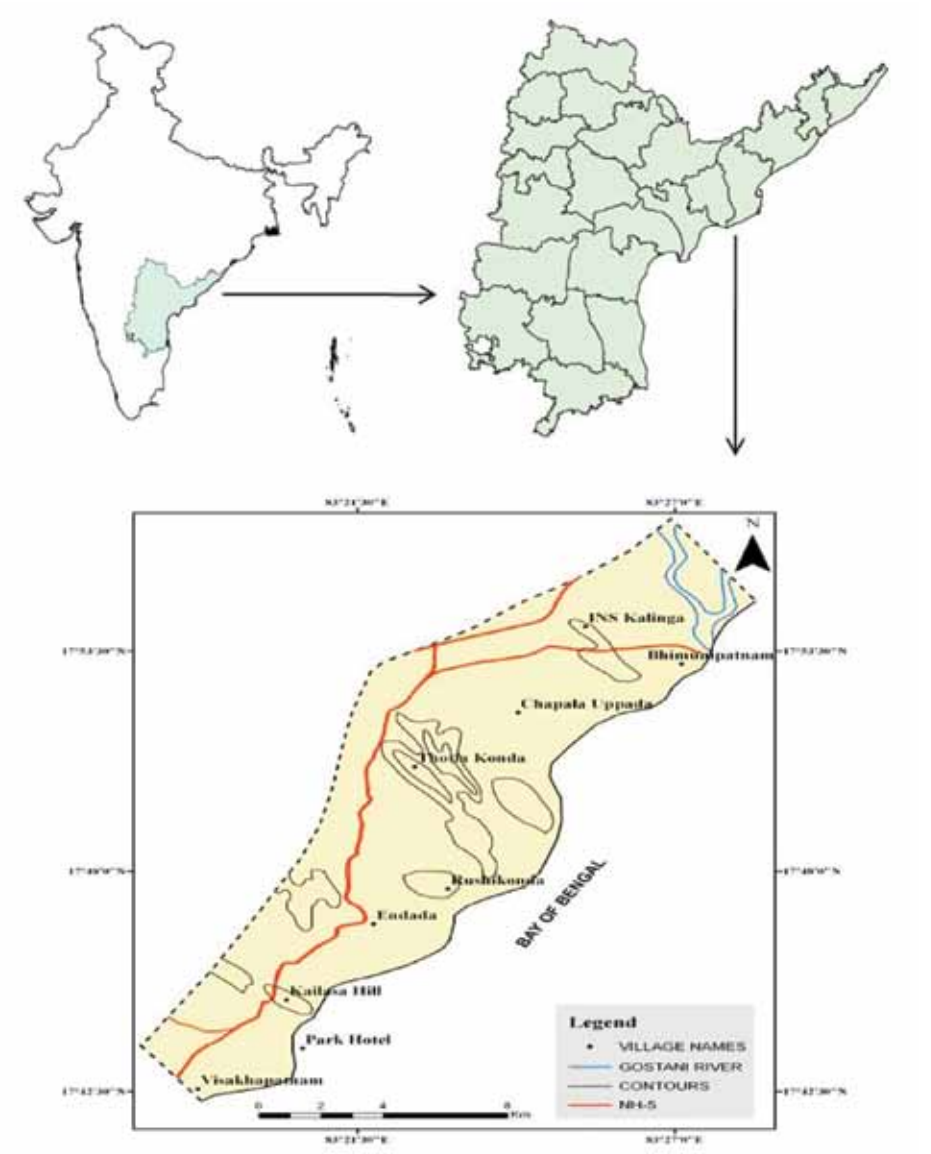


**Figure 1.** Location Map of Study Area

by the occurrence of recent sediments such as red sediments with calcium carbonate calcretes, dune sands and beach sands with economically important black sand concentrations. All these rocks and sediments characteristically exhibit a variety of geomorphic features distributed from deepest hinterland to near coastal plains.

King (1886) gave the geological sketch of Visakhapatnam district. Narasimha Rao (1945) studied the geology and petrology of the Kailasa range. Mahadevan and Sathapathi (1949) described the origin of Waltair high lands. Anjaneyulu (1950) studied the geology of the coastal strip between Anakapalle and Vizianagaram. Srinivasa Sastry (1952) studied the geology of the western part of the toposheet No's 65 O/6, 65 O/9. Murthy (1961) studied the structure, mineralogy and petrology of the charnockite series of Visakhapatnam district. Natarajan et.al (1979) studied the geology and its influence on physical environments of Visakhapatnam city and its neighbourhood. Nookaraju and Vaidyanadhan (1971) carried out Geomorphological studies. Bhaskara Rao and Vaidyanadhan (1975) studied the coastal features between Pudimadaka and Visakhapatnam.

Garnet – sillimanite – biotite gneisses (Khondalites), hypersthene granites (Charnockites), garnetiferous granites (Leptynites), quartzites and pegmatites are the chief rock types that occur as

bedded and banded as well as massive formations in the study area. Natarajan and Nanda (1979) studied the structures of this area. According to them this area can be classified in to a large scale basin coupled with a dome structure near Madhuravada. This area can be termed as Archean high grade metamorphic migmatite complex of the Eastern Ghat mobile belt.

## METHOD OF STUDY

In this study an attempt is made to record exclusively the coastal geomorphic features. Study area between Visakhapatnam and Bhimunipatnam has been investigated for recording geomorphological variability. The features formed by present day coastal process, features formed due to sea level oscillations and features formed by rock and sea interaction have been identified at different places and descriptions of individual features have been recorded. The features were confirmed using field data as well as the earlier investigations carried out in this part of the coast (Jagannadha Rao 1985), (Prudviraju and Vaidyanadhan 1978), (Vasudevu 1982).

## GEOMORPHOLOGY OF THE STUDY AREA

The area under investigation forms a coastal strip between Visakhapatnam to Bhimunipatnam, a length of 24 km. the entire area is marked by varied and geologically significant Geomorphological features. The extensive construction activity due to rapid urbanization is resulting in the destruction of these beautiful features day by day. As such these features are recorded for the benefit of future researchers. All the significant features have been studied for scientific documentation.Geomorphological map of this area is prepared (Fig. 2). The detailed description of individual features is presented below. For the

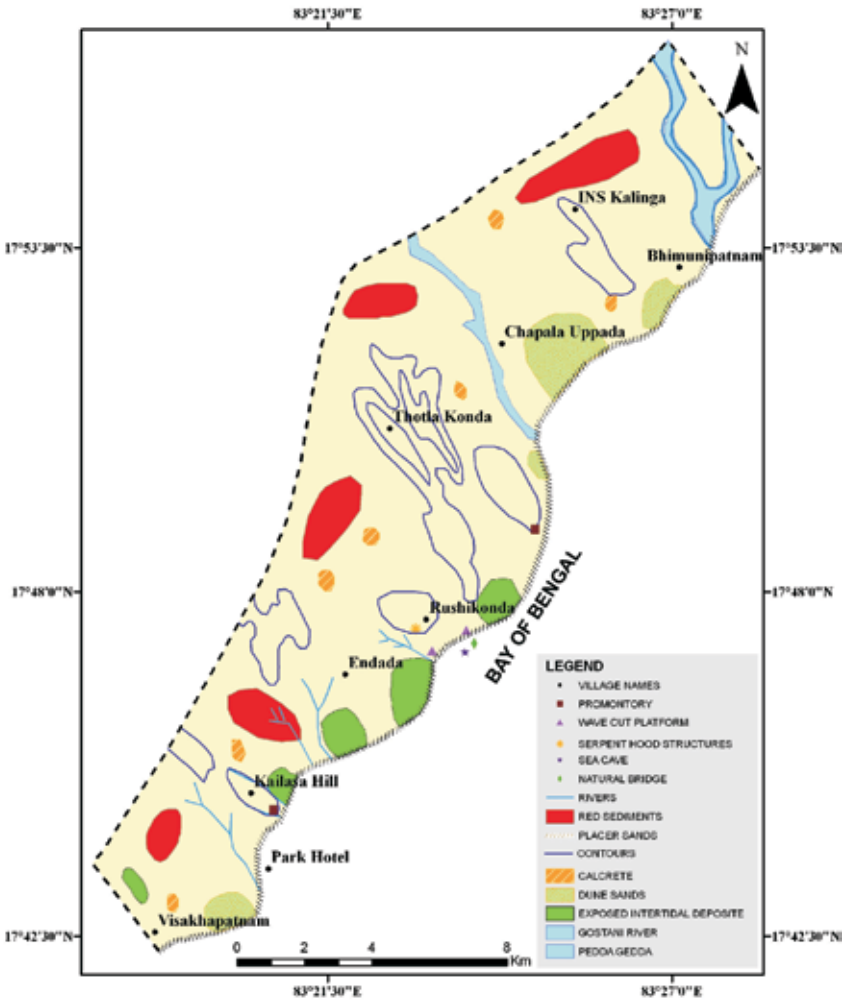


**Figure 2.** Coastal Geomorphological Map of Study Area

convenience of presentation the features have been classified into three types.

**1. Features Formed by Present Day Wave Action**

Waves, currents and wind are the important physical parameters, which give raise to form different geomorphologic features along Visakhapatnam – Bhimunipatnam coast. Beach and coastal sand dunes are the important geomorphologic features along the coast.

**a. Beach**

The sediment in motion along the shore is the beach (Bloom 2003). The shape of the beach from Visakhapatnam to Bhimunipatnam is cuspate and mainly sandy, apart from some locations which are covered with rocks (wave cut terraces). The width of the beach varies from 45 to 60 mts. The fore shore slopes are steeper ($4^0$ to $5^0$) (Jagannadha Rao,1985). The maximum beach width is observed in the area around Rushikonda, Kapula Uppada and Bhimunipatnam, where as the beach between coastal battery and Appugarh recorded minimum beach widths. Black sand concentrations containing minerals like garnet, sillimanite, zircon, ilmenite and monazite are observed along the coast. Wave cut section /face of the berm reveals the alternate layering of black sands and white sands (Fig. 3). Thickness of the individual layers varies from a few mm to a few cm. The stratification is best developed on the foreshore of the beach and usually slopes parallel to the surface slope. White sand layers are thicker than black sand layers. It is observed that the concentration of the black sand is more in the back shore area, where white sand is thin. As this zone is beyond the approach of normal waves, the white sand layers on this zone are thinner and less significant. So the concentration on the head of the fore shore and the immediate back shore part are more voluminous than on the foreshore part of the beach.

**b. Dune System**

One of the most important processes presently active on Visakhapatnam – Bhimunipatnam coast is formation of coastal sand dunes (Figs. 4 & 5). The material for the formation of these dunes is essentially derived from the present day beach extending from foreshore to backshore.

The most characteristic feature of these dunes is the vegetative cover. The dunes that are much inland are more vegetated than those near the sea. The vegetation is mainly of grassy variety. It has an important effect in helping to bind together the sand by their complex root system and thus help to protect the dunes from erosion. If the vegetation by any reason is removed, sand is exposed to the wind and blown away causing further migration of dunes. At most places dunes get stabilized by the vegetation.

Along the coast different types of coastal dunes are observed, which are mainly fore dunes and rear dunes. As per the classification of Smith (1954) dunes are transverse, crescent shaped and parabolic. Even though dune formation is noted all along the coast, it is dominantly localized in the northern side near Bhimunipatnam, where extensive dune formation is observed covering 6 to 9 sq. kms (Fig. 5). All the dunes especially that are adjacent to the beach are characterized by the presence of ripples formed by the alternate white and black sand layers. The ripple formation can be ascribed due to the oscillatory flow of wind (Fig. 6).

**2. Features Formed due to Sea Level Oscillations**

The study area is marked by sea level oscillations as evidenced from resultant geomorphology. Based on the available field data it can be established that the sea level rise to as much as 60m from the present day sea level. The features indicating the sea level oscillations are described below.

**a. Intertidal Deposits**

Intertidal deposits are characterized by the occurrence of consolidated and unconsolidated sediments. Beach rock, armoured mud balls and conglomeratic beach rock are the consolidated deposits. Rounded and flat pebbles mark the unconsolidated deposits. These deposits are mainly found beneath the red sediment cover and exposed at places where the sediment is removed or washed off. The extensive construction activity along the coast is causing the removal of red sediments. These intertidal deposits are exposed in some places (near Rushikonda and Ramakrishna beach) (Fig. 7). The area of exposure of these sediments varies from 200 sq. mts to 4000

**Figure 3.** Beach

**Figure 4.** Coastal sand dune.

**Figure 5.** Coastal sand dune.

**Figure 6.** Ripples on the sand Dunes.

**Figure 7.** Beach rock.

**Figure 8.** Red sediments.

sq.mts. They are exposed at a distance of few meters to as much as 500 mts from the present day sea water mark.

Beach pebbles, which are flatty in shape, are well rounded. They vary in size from 1 cm to 30 cm. The pebbles are mainly quartzitic in composition. Some pebbles of khondalitic composition are also observed. Some small pebbles are wedged to large boulders by the intertidal cement. The presence of carbonate content in this cement is revealed by the acid test. The presence of intertidal deposits indicates the sea level oscillation in this part of the coast.

**b. Red Sediments**

Red sediments are prominent features of the study area. Some times they attain a height of 30 mts above the mean sea level. They exhibit typical badland like topography. These sediments are homogeneous in nature, unfossiliferous and exhibit characteristic reddish colour, which gives the name red sediments.

Red sediment is formed in a highly oxidizing environment, so that the iron is present in the form of red ferric hydroxide. The mineralogy of the sand containing red sediment is almost similar to the present day dune sand, except for minerals like garnet that are absent in red sediments. This is due to leaching of these unstable minerals that contribute to the red colour. Garnet and the other unstable minerals convert into iron oxide contributing to the red color of the sand. Some believe that the red dunes had formed during the quaternary era; i.e.1.8 Ma ago when sea level oscillations and subsequent rapid climatic changes contributed to arid conditions leading to formation of the dunes. Red beds are formed due to headward erosion of uplifted land present at INS Kalinga, which is traversed by Peddagadda River. Here rill marks, gully erosion and calcretes are observed (Fig. 8). Texturally the sand content in red sediment confirms their dunal affinity.

**c. Calcretes**

These features are part of red sediments and mainly formed by the deposition of calcium carbonate and attain different forms. These are like root like systems, corn stone like forms etc. It is believed that these forms are resulted due to intake of calcium rich groundwater by the plants system resulting the deposition of calcium within the roots of the plant (Fig. 9) (Jagannadha Rao, 1985).

**3. Features Formed by Rock and Sea Water Interaction**

Rock and sea water interaction forms different morphologic features during geologic times to present time. These morphologic features gave clues to the sea level oscillations. Wave - cut platform, Marine platform/terrace, Sea stack, Sea cave, Serpent hood structures, Promontories, Wind gap and Natural Bridge are the important geomorphic features along the Visakhapatnam – Bhimunipatnam coast.

**a. Wave cut Platform**

It is a gently sloping surface produced by wave erosion and extends outward into the sea from the base of a sea cliff. It is also called the wave cut bench. These platforms occur at some height above MSL in this area. This wave cut platform is a result of constant wave action on the rocky cliffs of the head land. Wave cut platforms have been observed in the study area near places like Rushikonda, Ramadri and Thotlakonda area. In fact the wave cut platforms are the modified sea promontories where the perpendicularly running hillocks are flattened by the continuous wave erosion (Fig. 10).

**b. Marine Platform / Terrace**

It is a gently sloping (sea-ward) platform/terrace above the present sea level. These terraces are now exposed to sub-aerial weathering and erosion and are often covered by rubble. These marine platforms are fairly open and wide. A remanent of marine terrace occurs at 10 mts. above MSL on a hill called Merakametta close to the sea near Gangavaram, 12 kms SW of Visakhapatnam. Similar terraces also occur close to the sea SW of Rushikonda. These well preserved rocky terraces (in Khondalite) perhaps indicate higher sea-levels of the past around 10 to 12 mts above present MSL. These are probably of quaternary period/era.

**c. Sea Stack**

A sea stack is a small isolated usually steep sided rocky mass or island near cliffy shore often detached from the head land by wave erosion assisted by sub – aerial weathering ( Bloom 2003). Sea stacks are remanents of retreated sea cliff. A number of sea cliffs can be noted all along the coast. They also indicate submergence along the east coast of India. This is observed near Park Hotel along Visakhapatnam coast.

**d. Sea Cave**

It is a cavity or opening in the base of a sea cliff excavated by wave action along the weak zones in an easily weather able rock (Bloom 2003). This is formed as a result of scooping of rock material by constant attack of waves on the khondalite out crops (Fig. 11). Being at the sea level it is frequently affected


**Figure 9.** Calcretes in red sediments.

**Figure 10.** Wave cut terrace.

**Figure 11.** Sea cave.

**Figure 12.** Serpent hood Structure.

**Figure 13.** Promontory.

**Figure 14.** Natural Bridge

by tides. It is often filled with beach sand. Some sea caves have been observed at places like Rushikonda and Thotlakonda where these hills are exposed to wave action during earlier times of higher sea levels.

**e. Serpent Hood Structures**

These structures are formed by the continuous battering of sea waves causing concave snake hood

like structures (Garner 1974). These structures are noted along this coast in Gangavaram, Rushikonda etc. These are 15 to 16 m above present day mean sea level. The sea caves and the serpent hood structures are obvious indicators of past higher sea levels (Fig. 12).

**f. Promontories**

A promontory is a prominent mass of land which overlooks lower lying land or a body of water (Garner 1974). Most promontories are formed either from a hard ridge of rock that has resisted the erosive forces that have removed the softer rock to the sides of it, or the high grounds that remain between two river valleys where they form a confluence. Number of promontories is observed in Kailasa hill, Yarada hill and Thotla konda hill (Fig. 13).

**g. Wind Gap**

It is a narrow to deep gorge or valley across a mountain ridge formed by a stream. Wind gap is a former water gap presently abandoned by a stream. Most wind gaps are produced by one of the four mechanisms: 1. River capture; 2. glacial breaching; 3. Accidental diversion, e.g. land slides; 4. climatic changes (Thornbury 2002). About 1.5km wide wind gap is observed along the Kailasa hill range at venkojipalem. This gap is believed to be formed by a river that some time back lost its waters to a stream flowing east, probably by headward erosion.

**h. Natural Bridge**

A natural bridge or natural arch is a natural geological formation where a rock arch forms, with an opening underneath (Bloom, 2003). Most natural arches form as a narrow ridge, walled by cliffs. They become narrower from erosion, with a softer rock stratum under the cliff-forming stratum that is gradually eroding out until the rock shelters thus formed, meet underneath the ridge. A beautiful small natural bridge is observed at Thotlakonda (Fig. 14).

## CONCLUSIONS

The study area between Visakhapatnam and Bhimunipatnam is marked by diverse geomorphic features which signify dynamic coastal process during pleistocene to recent. The coastal geomorphic features clearly established the sea level oscillations and variations in climatic conditions along this study area.

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**Prof. M. Jagannadha Rao** has been working as Professor of Geology, Andhra University, Visakhapatnam for the last 25 years. Presently he is heading a research institute- Delta Studies Institute within A.U Campus which has focus on research activities with emphasis on Modern and Ancient Deltas. He has research interest in the fields including Coastal Geology, Mineral Deposits, Environmental studies, GIS & RS applications, Fuels etc. Fifteen students got Ph.D s′ under his guidance. He has published about 70 scientific papers in various National and International Journals. He has visited University of Alaska (USA) for advanced study and research related to Coal Science & Technology. He is member in various National and International scientific bodies. He has undertaken a number of funded research projects.

**Ms. A.G. Greeshma Gireesh** is presently working as a Research Scholar in the Delta Studies Institute, Andhra University, Visakhapatnam. She has completed her M.Sc in Geology from Andhra University (2009 – 2011). She is working for her Ph.D on the "Global Technotic Controls of Oil and Natural Gas Genesis – A Model of Hydrocarbon Evolution", under the guidance of Prof. M. Jagannadha Rao, Director, Delta Studies Institute. She is interested in the areas of research work including Sedimentary environments, Petroleum Geology, Micro Faunal studies, Geomorphology etc.

**Mr. P. Avatharam** is presently working for his Ph.D on the topic "A Study on Coastal Geomorphological and Neotechtonics controls on the Placer mineral deposits along the Bhimunipatnam to Itchapuram, North Coastal Andhra Pradesh, India", under the guidance of Prof. M. Jagannadha Rao, Director, Delta Studies Institute. He did his M. Sc in Geology from Andhra University (2003 – 2005). He has undergone specialized training in the field of Photogrammetry, Remote Sensing and GIS applications. His research interests are in the areas of Sedimentary environments, Geomorphology and Remote sensing applications.

**Mr. N. C. Anil** did his B.Tech (Civil Engineering) from Acharya Nagarjuna University (1998 – 2002) and M.Tech (Remote Sensing) from Andhra University (2005 – 2007). Presently he is working as a senior research fellow in the department of Geo-Engineering, Andhra University and pursuing his Ph.D. His topic of research is "Studies on Geomorphology and Land use/Land cover patterns related to Aquaculture with Particular reference to possible impact on Environment using Remote Sensing techniques and Field studies", under the guidance of Prof. G.Jai Sankar and Prof. M.Jagannadha Rao. He is actively involved in teaching and research programmes of the department and regularly takes up class work for B.Tech and M.Tech students. He has attended IGU conference 2007, held at CMRI-Dhanbad.

**Mr. T. Karuna Karudu** is presently working as a Teaching Assistant for M.Tech Petroleum Exploration Programme of Delta Studies Institute, Andhra University, Visakhapatnam. He has recently submitted his Ph.D. thesis to Andhra University on the topic "Textural and Heavy mineral characteristics of different sub-environments of Mahanadi Delta, East Coast of India". He did his M. Sc (Tech) in Applied Geology from Andhra University (2001 – 2004). He worked as a project fellow in ONGC sponsored projects on Mahanadi Delta and Krishna Delta. He has undergone specialized training in the field of Remote Sensing and GIS applications. His research interests are in the areas of Sedimentary environments, Geomorphology and Remote sensing applications.