Geological evolution of Mahanadi delta, Orissa using high resolution satellite data

The Mahanadi basin is one of the five sedimentary basins occurring along the east coast of India. The sediments are mostly deposited by the rivers Mahanadi, Brahmani, Baitarani and their tributaries. The delta is arcuate in shape indicating wave-dominated delta-front. Floods and cyclones affect this area regularly. Hence, a better geomorphological understanding of the basin will help in better disaster-mitigation planning. The present study is aimed to understand processes operating in the sub-aerial portion of the delta using high-resolution satellite data.

The study area is located between lat 20 and 21°N, and long 85 and 87°E. This area is well-connected by a road network. Mahanadi Deltaic Plain falls under tropical climate characterized by high temperature, and medium to high rainfall. Indian Remote Sensing (IRS-1C) satellite data were used to understand the processes operating in this dynamic environment. This satellite platform has LISS-3 sensor with better spatial resolution (23 m) compared to the earlier generation of IRS satellites.

The Mahanadi delta is a complex delta formed due to the coalescence of three sub-deltas formed by Brahmani–Baitarani river in the north, Mahanadi river in the central part and Devi river in the south. It is a typical arcuate delta with its apex near Cuttack. The Brahmani and Mahanadi rivers form the arcuate delta in the central part, whereas the Devi river forms an estuarine-type of delta in the south. The age of the delta is Early Miocene to Quaternary period[1]. The high-resolution satellite data and digital enhancement techniques facilitate classifying the delta system into systematic groups. The active and abandoned components of the deltaic system are shown in Figure 1. The delta-building processes being highly dynamic, such shifting of delta-building is common in all the important deltas in the world[2]. The shifting of deltaic-building process may be related to tectonic upheavals in the area. The active or the abandoned delta can further be divided into upper and lower delta, based on the limits of the present-day tide. The present-day tide is seen to affect a narrow strip of land near the sea, but a major portion of this delta is away from the tide. The apex of the delta is in Cuttack, which is 50 km from the present-day coast. Hence, it is appropriate to further classify this plain by taking into consideration the tidal limits. The lower delta is within the present day tidal limits, whereas the upper delta is away from the tides. The Upper Deltaic Plain is the active zone of the delta-building process, and it is mostly affected by the fluvial action. Hence, it would be appropriate to classify this plain further based on the river system responsible for the deposition (Figure 1). This active delta is further classified based on the active river system, like Brahmani, Baitarani, Mahanadi and Devi rivers. These active, deltaic, distributary plains consist of mostly fluvial landforms.

The deltaic plain is characterized by a number of ENE–WSW trending basement faults which were reactivated during Tertiary and Quaternary periods. The delta is tectonically active as seen by many circular anomalies and lineament-controlled behaviour of the river (Figure 2). This basin appears to have been created due to rifting in the Cretaceous period. Subsidence of this basin was recorded from Cretaceous onwards, resulting in the varied thickness of Quaternary sediments[3].

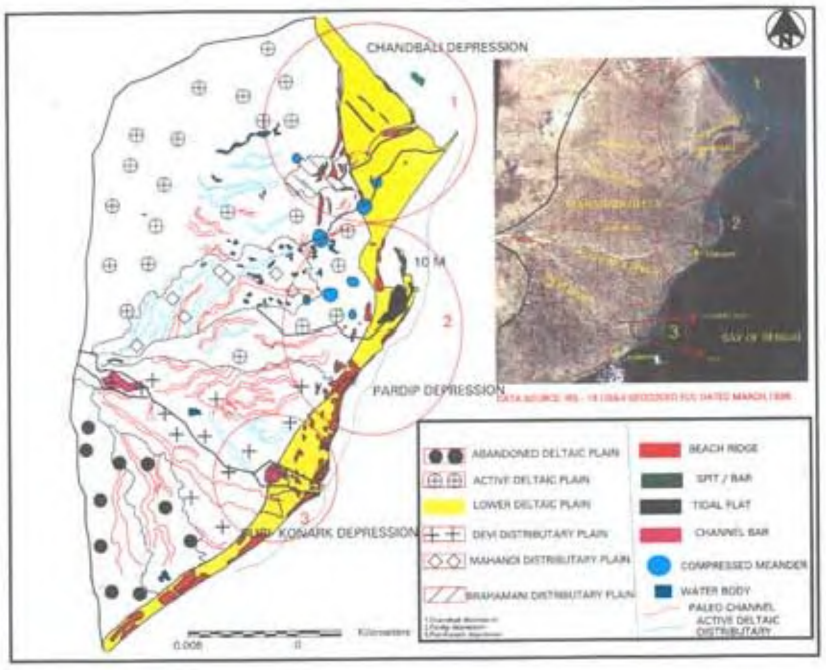

Figure 1. Geomorphic features of the Mahanadi delta.

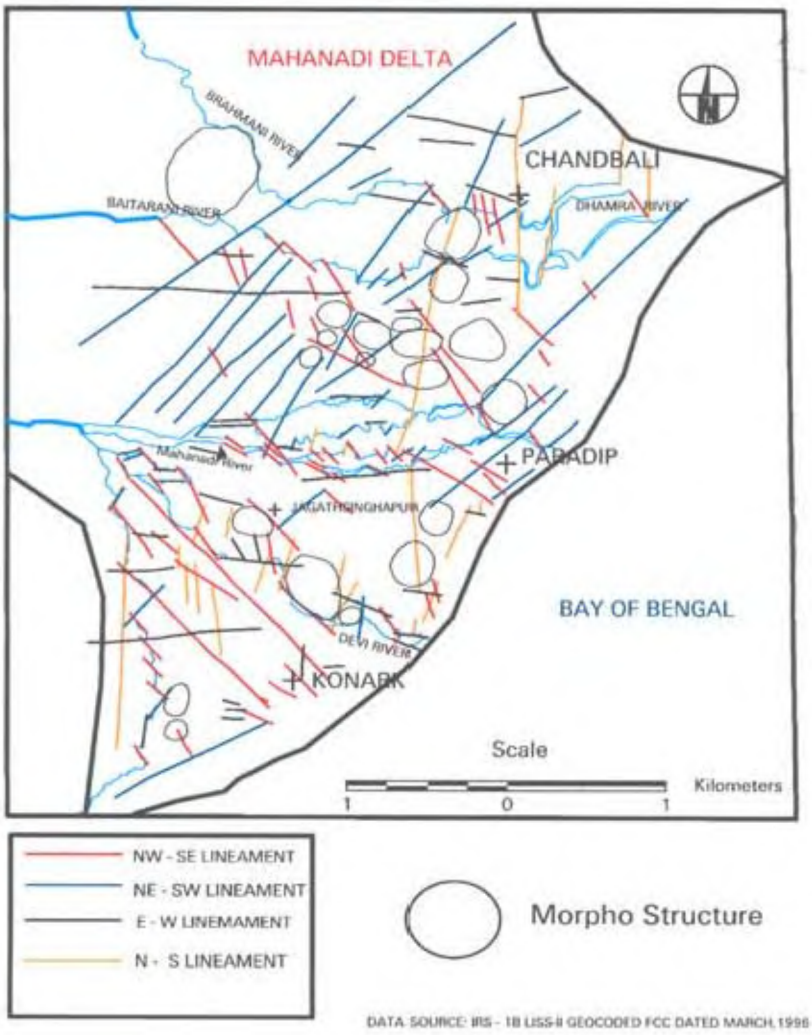

Figure 2. Lineaments and morphotectonics of Mahanadi delta.

Lineament analysis indicates NE–SW, E–W, N–S trending lineaments. These trends match well with the observed gravity and magnetic trends of the basin[1]. Many morphostructures are seen at this depression (Figure 2). The active deltaic distributary in the Mahanadi interdistributary plain shows alignment in the direction of NE–SW lineament (Figures 1 and 2). The courses of the Brahmani and Baitarani rivers are seen to deviate because of a major morphostructure (extreme NE of Figure 2). In the Lower Deltaic Plain of Chandbali depression, the N–S trend dominates. Both the river courses are seen to be controlled by this lineament when they enter the Lower Deltaic Plain. Two sets of lineaments, NE–SW and NW–SE, control the coast in the Chandbali depression. The older generation of beach ridges has NE–SW trend compared to the younger generation of beach ridges which have NW–SE trend. Many of the NW–SE trending beach ridges seem to be displaced by NE–SW trending lineaments, indicating reactivation in recent times. The orientation of the Dhamra river mouth is controlled by E–W trending lineament, along which a linear channel bar has developed. The compression of meanders is seen to be controlled by these lineaments. Along the morphostructure zone in this depression, the density of the lineament is high (Figure 2). The trend of lineament north of the Mahanadi river is typically different from the south of this river. It is NE–SW in the northern region and NW–SE in the southern region. The NE–SW trend corresponds to the Precambrian trend, whereas the NW–SE trend corresponds to the Mahanadi graben trend. The NE–SW trend seems to be the oldest, with other trends cutting across it (Figure 2). The NE–SW trending lineament controls the growth of spit near the Devi river mouth (satellite image at location 3, inset, Figure 1). Most of the depositional activities within the Devi river, especially the estuarine islands are controlled by this lineament trend. A major morphostructure is observed near the Devi river where anomalous channel bar activity is seen (Figure 1).

Four stages of the delta progradation were identified based on the strandlines and palaeo-deltaic lobes (Figure 3). The present-day coastline forms the fourth strandline. In the Chandbali depression, new sets of beach ridges are seen between the third strandline and the present-day coast (Figure 3). The nature of the present-day delta progradation in three

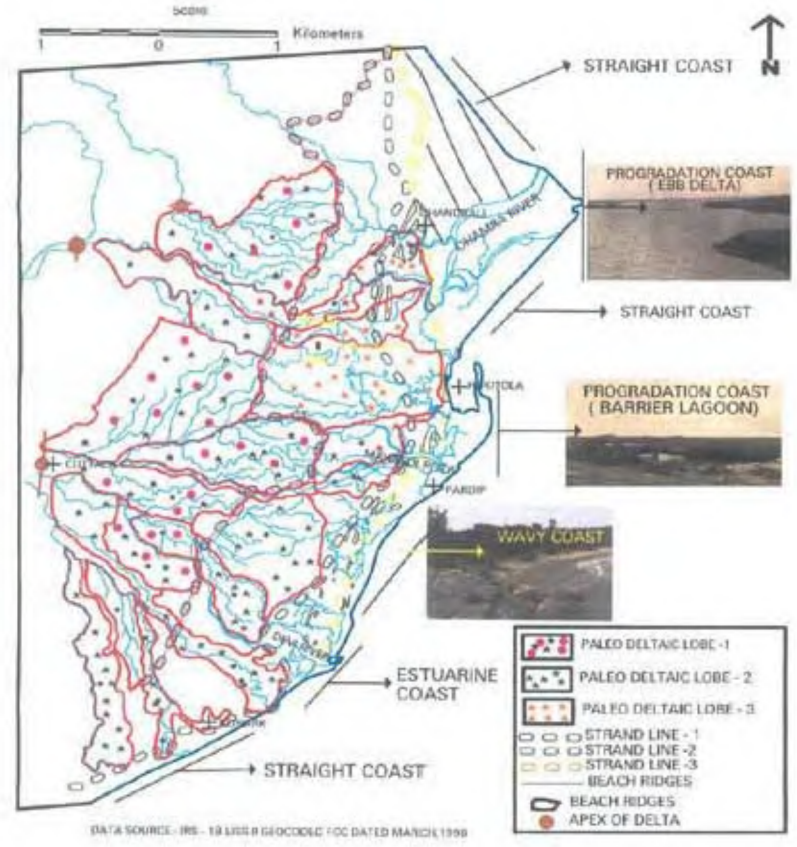

Figure 3. Palaeogeomorphological map of Mahanadi delta.

river mouths is different (Figure 3). In the Chandbali depression, delta-building is by ebb delta. The configuration of the coast is straight near the Chandbali depression, wavy near the Paradip depression and wavy-to-straight near the Puri–Konark depression. In the case of the Jambu river mouth, it is by barrier-lagoon type. No delta-building activity is seen in the Devi river mouth. The abandoned deltaic plain lies south of the Devi river. The delta-building activity is seen towards the north, especially in the Chandbali and Paradip depressions. The delta-building processes of the existing set of rivers continued throughout the Quaternary and all the rivers that have cut across the Eastern Ghats and Palaeozoic rift trend to flow in the southeasterly direction[4]. The presence of abandoned deltaic elements like the palaeo-deltaic lobe suggests more than one major stage of delta-building activity controlled by the palaeo-strandlines. The three tectonic depressions controlled the sedimentation pattern in the Lower Deltaic Plain.

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