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Deepwater channel levee system of Mahanadi Basin

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Summary

Deepwater channel levee system has come into focus of exploration since a number of giants pools have been discovered from the couple of decades. The significance of channels are sand conduits has been understood during this period when huge volumes of sandy deposits have been identified to occur down dip of muddy slope systems in number of basins in different parts of the world. The levee overbank areas associated with the channels albeit consists primarily of mud and thinly bedded sands sometime possess excellent porosity and good permeability to form commercial reservoirs.

In the study Area I i.e 1250 SKM of 3D on the eastern part within Mahanadi Offshore a number of channel levee systems have been identified distributed in time and space. Out of them three were Prioritized as immediate exploration targets judging from their volume and distinctive shape. Their age ranges from Early to Late Miocene. Volume visualization of three channel levee systems brought out amplitude distribution pattern in time and space. The high amplitude geo -bodies possibly indicate presence of coarser clastics within an overall mud dominating geological set up.

The oldest identified channel levee system with higher aspect ratio was possibly active in the middle fan and show more aggradational component than those of the younger channels. The younger systems with less aspect ratio reflect more erosional indicating increase in energy condition in the relatively upper part of fan and expected to have more coarser clastic in them.

Introduction

Mahanadi Offshore basin is a passive margin basin of the east coast of India. It is flanked by Bengal Basin in the northeast and Krishna-Godavari basin in the southwest. The present study area covers 1250 SKM. of 3D volume falling in the eastern part of deep water block of Mahanadi basin (Fig.1). The bathymetry in thestudy area varies from 1700 to **1800m.** A detailed work was done on the aforesaid volume to bring out the details of the channel levee systems and generation of hydrocarbon prospects.

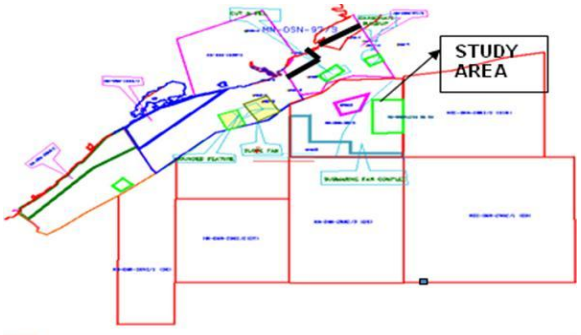

Fig.1 Map showing study area along with different blocks of Mahandi Basin

Geological Setting

Mahanadi basin along with other passive margin basins off the east coast of India came into existence during Late Jurassic-Early Cretaceous separation of Indian plate from East Gondwana assembly (Australia-Antarctica-India). The initial part of the basin history is recorded in the onland and shallow offshore areas. The pre rift Gondwana sediments are represented in the onland part along NW -SE oriented grabens. The rifting is accompanied by volcanic eruptions equivalent to Rajmahal traps along with inter-trappeans. The tensional faults created during rifting are in NE-SW direction and at right angle to former Gondwana trends. The rift stage initiated the separation of continents and creation of oceanic crust. The newly created passive margin formed a huge depocentre from Late Cretaceous to Recent.

The collision of Indian plate and Eurasian plate, consequent uplift and erosion resulted in enormous accumulation of the detrital sediments from Oligocene to Recent time created the Ganga and Brahmaputra delta systems. Interception and funneling of river delivered system and long shore drift by submarine canyons caused turbidite sedimentation in the deep waters forming Bengal submarine fan.

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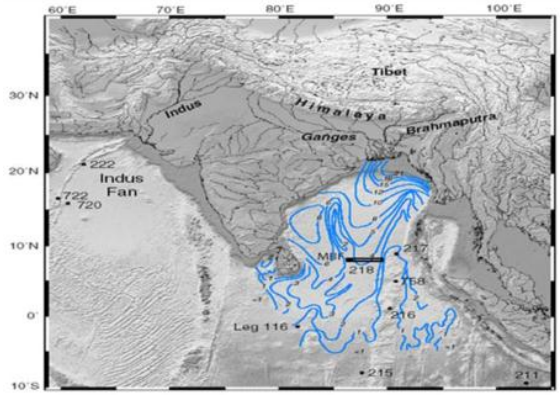
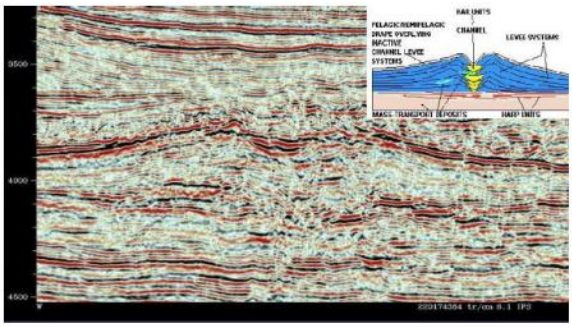
Sedimentation Pattern

The present day sediment thickness map of Bengal Fan shows a maximum thickness of 21 Km close to the mouth of Ganga - Brahmaputra delta system (Fig.2). In the study area its thickness varies from 12 to 15 Km. The Bengal Fan, which initiated in Eocene time, consists of stacks of Channel - levee systems and associated geological features. The zoomed view of channel levee system is shown in Fig. 3.

Out of a number of channel - levee systems identified in different stratigraphic levels in the study area, three of them were prioritized as immediate exploration targets. They are correlated with CLS 1, CLS 2 and CLS 4 depicted earlier in 2D study. The same nomenclature is continued in the present work also. The CLS 1 lies between reflector 3 and 4, CLS 2 between Reflector 7 and 8, whereas, CLS 4 is bounded by reflector 9 and 10 (Fig. 5). To link the identified channel-levee systems in the study area with the regional sediment dispersal pattern, an attempt has been made to trace the channels into regional perspective. The channels in CLS 1, 2 and 4 were correlated beyond the study area with the help of available 2D data to the north and northeast (Fig.4). All the three channel-levee systems could be traced towards northeast up to the mouth of the Bengal canyon (Fig. 6). This confirms sediment input from Ganges/ Ganges-Brahmaputra delta existing during Mio-Pliocene time. Those deltaic sediments were possibly redistributed by long shore drift and intercepted and funneled through Bengal canyon in to the deep-sea environment. The coarser sediment brought in to the slope were further transported in to the deeper abyssal plains through the channels by sediment gravity flow.



Fig, 2 Map showing sediment thickness of present day Bengal Fan



Fig, 3 shows zoomed view of Channel levee system

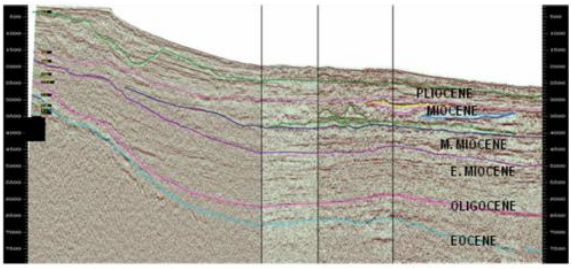


FIG 4 Regional 2D line passing through study area showing channel levee system

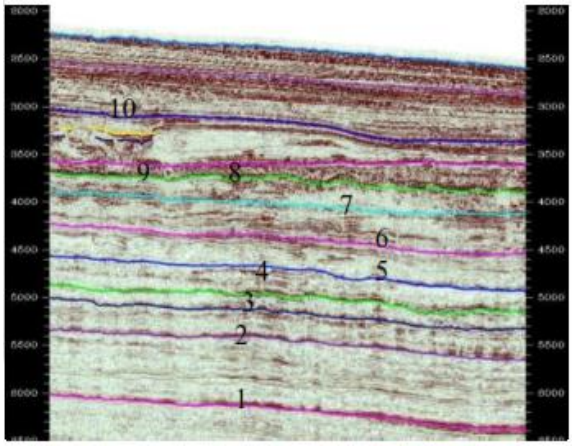


Fig 5 Seismic trace showing mapped levels in the study area

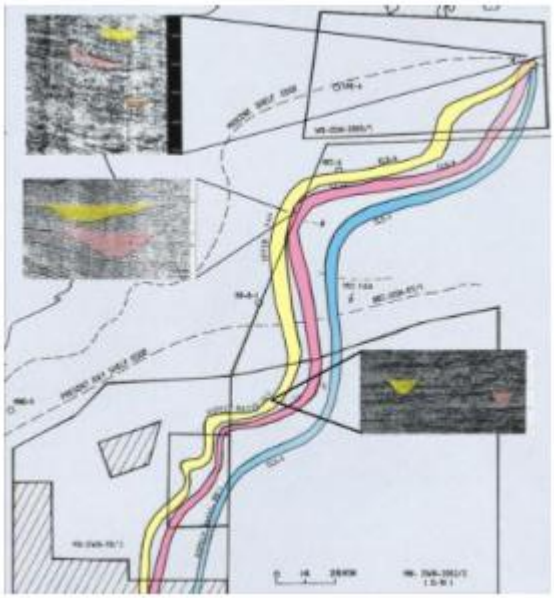


Fig.6 : Regional view of Channel levee system

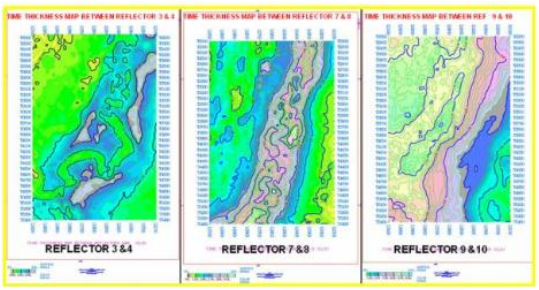


Fig.7: Time thickness map of reflectors

Attribute Analysis

The entire volume was divided into 72 proportional slices (Fig.8). Different amplitude studies (rms, average absolute amplitude etc.) were carried out along 13 reflectors and 72 proportional slices. Spectral decomposition studies were carried out on 85 levels to understand channel pattern. Out of those studies, attributes, which brought out the targeted features in the proposed locations, are discussed below.

Interval between reflectors 4 and 3: Spectral decomposition studies between the reflectors 4 and 3 shows the presence of a NNE-SSW trending meandering channel at all the levels. One such level is shown in Fig.9.

Interval between reflectors 8 and 7: This interval represents a major channel – levee system, CLS-2. Spectral Decomposition studies show entry of meandering channels from NE (Fig.9).

Interval between reflectors 10 and 9: The interval between reflectors 10 and 9 represents the major channel – levee system in the area, the CLS-4. Spectral decomposition studied on a number of proportional slices shows a NE –SW trend of a sinuous channel (Fig.9).

Major Channel Levee Systems

In the study area within Mahanadi Offshore a number of channel levee systems have been identified distributed in time and space. Out of them three were Prioritized as immediate exploration targets judging from their volume and distinctive shape. They are CLS-1, CLS-2 and CLS-4 in ascending order.

Channel - Levee System 1

This Channel - levee system is the oldest identified geological feature of purport within the studied section. The time thickness map between the reflectors 3 and 4 (Fig. 7) demonstrates the NE - SW trending channel of relatively low thickness, flanked by higher thickness of levee. The E-W seismic section (Fig.11) clearly show the various parts of the channel-levee system. The Average Absolute Amplitude map (Fig.10) as well as spectral decomposition (Fig. 9) also brings out the meandering channel. Avg. Absolute Amplitude extraction with a different colour scheme also shows the amalgamation of a number of channels within master channel of CLS 1. Voxel view of channel is shown in Fig.13. The anticipated lithology as well as seismic pattern of CLS 1 is shown in fig. 12.

Channel - Levee System 2

The CLS-2 is seen in the time thickness map between reflectors 7 and 8 (Figure 8). Trace 5000 seismic section (Fig.11) reveals the major part of the channel - levee system with HAR within the centrally located channel. Very high amplitude along the channel, on extraction of Average Absolute Amplitude (Fig. 10) indicates possible of charged reservoirs. Voxel view of channel is shown in Fig.12. The anticipated lithology as well as seismic pattern of CLS 2 is shown in fig. 12.

Channel - Levee System 4

Time thickness map between reflectors 9 and 10 (Fig. 8) shows a relatively low thickness along a NE –SW trending channel, which is flanked by high thickness contours along the levee. Seismic section trace 3100 (Fig.11) demonstrates the presence of HARP within the channel as well as on the proximal levees.. Extraction of Average A bsolute Amplitude (Fig.10) indicates possible presence of charged reservoirs in the northern part of the channel. The HAR observed on the proximal levees (Fig. 11) seem to be interesting, considering the possibility of presence of quality reservoirs and world wide examples of hydrocarbon pools within them. Extaction of average absolute amplitude (Fig. 10) and Spectral Decomposition (Fig.9) shows distribution of high amplitude along the two parallel levees.

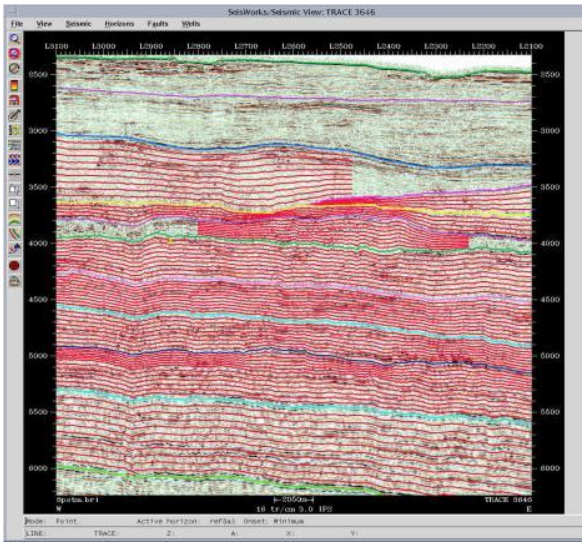


Fig. 8 : Seismic trace showing levels of slices

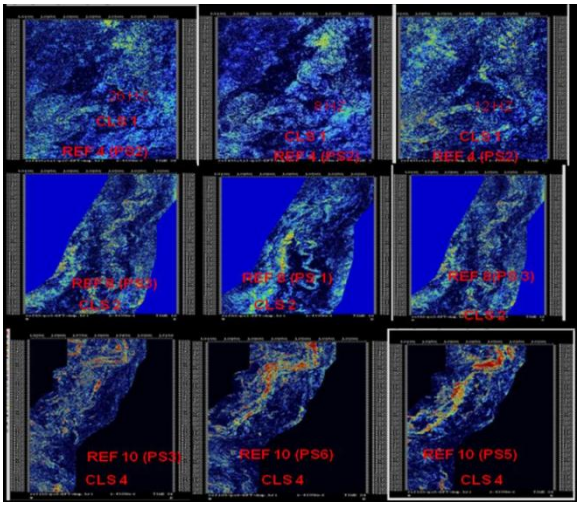


Fig.9 : Spectral Decomp of Ref4, Ref 8 and Ref 10 for showing CLS 1 ,2 and 4

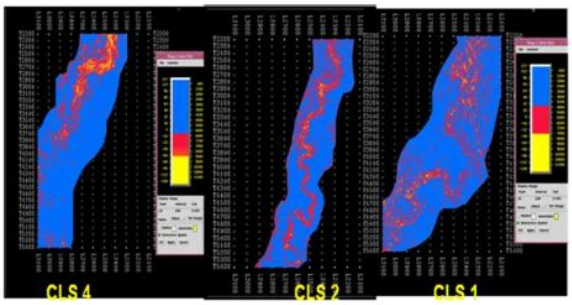


Fig.10: Average absolute amplitude between Ref10(PS 4) & Ref 9 showing high amplitude along channel (CLS 4) between Reflector 8a (PS 5) & 8 (PS 2) showing high amplitude with CLS 2 between PS 2 & 3 of Reflector 4 showing high amplitude within CLS 1

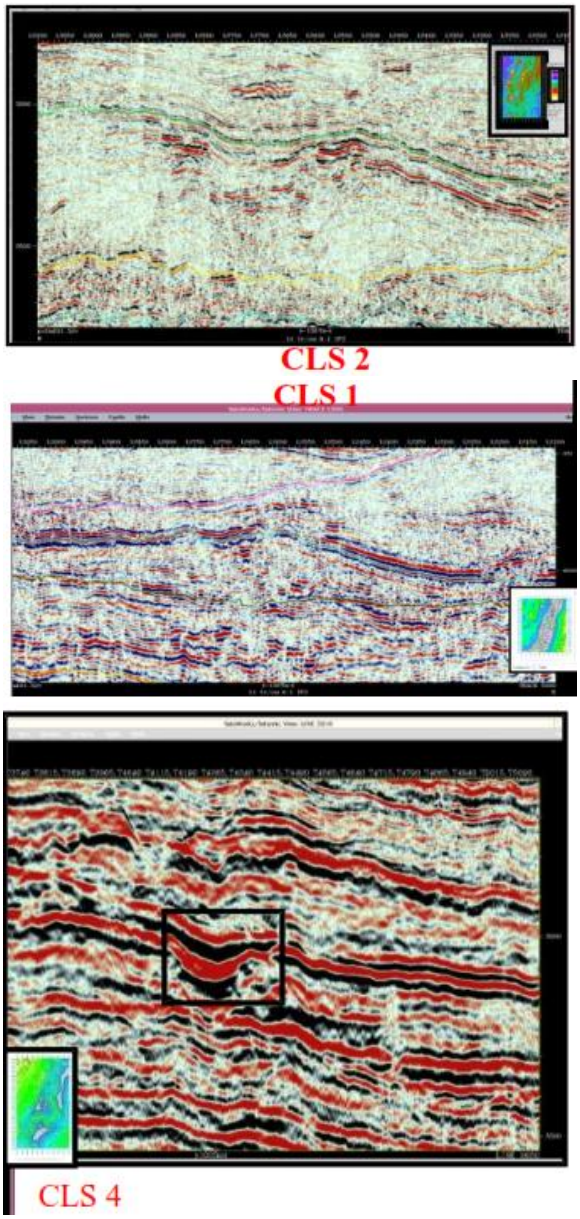


Fig. 11 Seismic Line passing through Western, Channel And Eastern Levee of CLS 4, CLS 2 and in line 2600 showing Channel Levee System of CLS

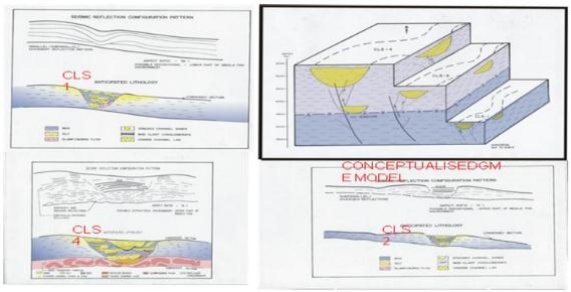


Fig. 12 Shows Seismic reflection pattern and anticipated anthology within CLS1, CLS2 and CLS4 and conceptualized GME model.

Conclusions

Out of a number of channel-levee systems brought out through attribute analysis, three were prioritized as immediate exploration targets judging from their volume and distinctive shape.

The channels in the three identified channel levee systems are mixed erosional to aggradational in nature.The oldest identified channel levee system (CLS 1) possibly was active in the mid fan and show more aggradational component than those of the younger channels. The younger CLS 2 and 4 with less aspect ratio reflect more erosion and are inferred to have operated in upper fan. This indicates an increase in energy conditions as well as erosion in the younger channel-levee systems.

The sediments below 4500m in the area is envisaged to have reached hydrocarbon maturation window

The channels brought out through different studies are expected to have good reservoir facies. The Proximal levee parts are also exected to be sand rich and potential reservoirs.

The entrapment is generally stratigraphic in nature. The hydrocarbon migration is envisaged to have been taken place through faults/micro-faults from source to reservoir.

In seismic section the youngest channel-levee system (CLS 4) show the presence of a distinct mass transport complex (MTC) at the base of it. The chaotic and Hummocky reflection pattern in the MTC is representation of slides and inverted blocks generally caused by catastrophic failure of the margins.

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