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Depositional Model and Facies Distribution of Hazad Sands, South Cambay Basin.

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Abstract

Hazad Member of Middle Eocene is a TST part of second order sequence i.e.**"Middle Eocene to Late Eocene sequence"**. It unconformably overlies the Early Eocene sequence and underlies the Maximum Flooding Surface (Kanwa Shale) which relates to Late Eocene upliftment. The Paleo-geographic reconstruction based on faunal and floral evidences, lithological associations, sand dispersal pattern, seismic and electro facies analysis suggest delta model for deposition of Hazad sands through Proto Narmada and Dadhar river system flowing from east to west direction. Time thickness map prepared for Middle Eocene TST suggest paleoslope to the west during the deposition of Hazad sediments. The main depocentre of Hazad Member was in Gandhar-Dahej area in Broach Block and Ankleshwar area in Narmada Block. Sand isolith map suggests drainage from ENE to east direction which leads to deposition of deltaic sand lobes in Gandhar, Dahej and Ankleshwar areas separated by inter-distributary bays. Hazad sands gradually shale out towards the west in Broach Block however shale out towards south in Narmada Block. Prospectivity analysis suggest up dip shale out of Hazad Member west of Nada, Gandhar, Dahej , east of Aliabet in Broach Block and area towards north of Anklehwar may be future hydrocarbon targets.

Introduction

In the Narmada - Broach Block, Hazad reservoirs are the major producers of Hydrocarbons. So far about 28 oil & gas fields have been discovered within Hazad reservoirs. “Gandhar” and “Ankleshwar” are two giant oil and gas fields having accumulation in multiple Hazad reservoirs. The other smaller hydrocarbon fields are Nada, Pakhajan, Dahej, Jambusar, Dabka, Gajera, N.Sarbhan, Kural, Matar, Palej, Padra, Karjan, Karvan, Vemardi, Gulf-A, Gulf-D, Andada, Kim, Katpur, West Motwan, Motwan, Sisodra, Kosamba, Elao, Kudara and recently discovered Aliabet field. An attempt has been made to decipher the depositional model of Hazad reservoir with the aim to identify additional prospective areas in Broach-Narmada block between Mahi River in north and Tapti River in south (Fig.-1). The Hazad Member of Middle Eocene age is a TST part of second order sequence “**Middle Eocene to Late Eocene sequence”**. It unconformably overlies the Early Eocene sequence and underlies the Maximum Flooding Surface, represented by Kanwa shale and relates to Late Eocene uplift.

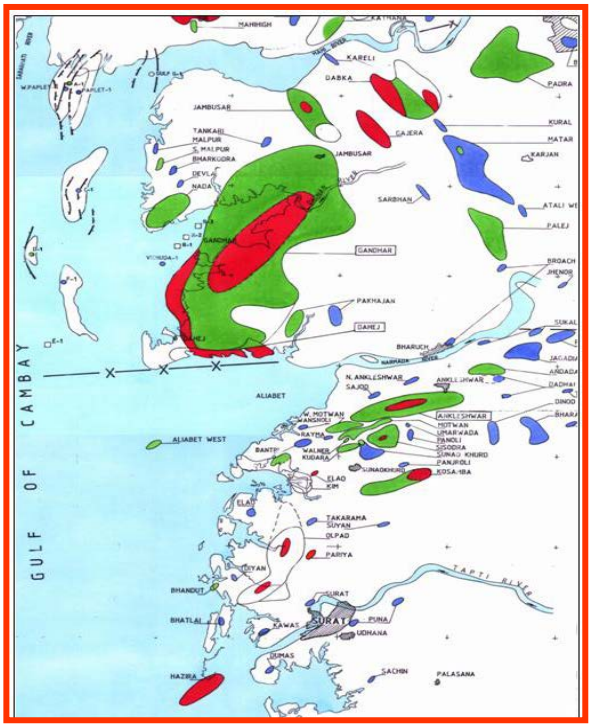


Fig.-1: Prospect Map of south Cambay Basin

Seismically, one MFS i.e. Kanwa shale over which progadations are down lapping (Fig.- 2) and top lapping surface which is a major erosional surface is well evident in seismic. A number of progradation cycles and corresponding horizontal seismic events corroborating to condense section of Late Eocene HST (prodelta shale) can also be seen. The Paleo-geographic reconstruction based on faunal floral evidences and lithological associations suggest well spread transgression (TST) during Middle Eocene.

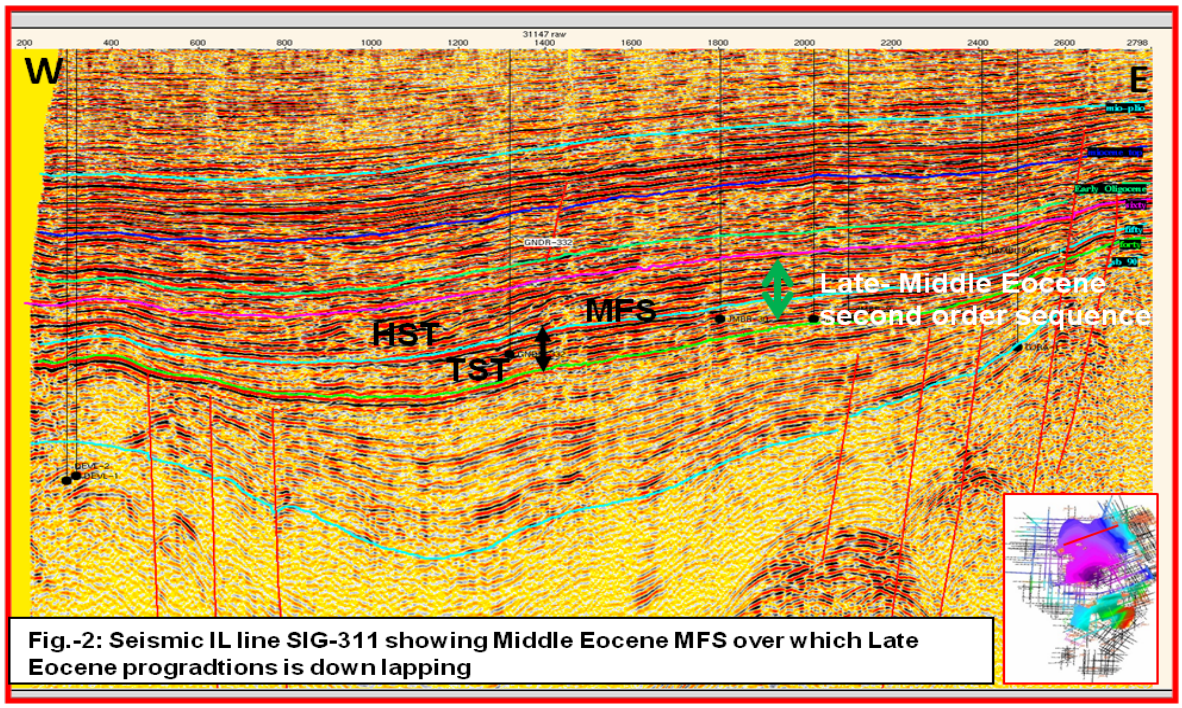


Fig.-2: Seismic IL line SIG-311 showing Middle Eocene MFS over which Late Eocene progradtions is down lapping

Based on the litho facies analysis & fossil assemblage, a neritic environment has been inferred in Broach-Narmada block. The delta model depicted here in is predominantly the arenaceous facies Hazad Member, which is overlaid by deposition of MFS represented by marine shale known as Kanwa Shale. The presence of planktonic foraminifera in this shale indicates a transgressive activity during Middle Eocene time.

The petroleum system identified in South Cambay Basin has a multiplicity of source rocks in Paleocene and Early to Middle Eocene age (Older and Younger Cambay Shales). The principal reservoirs are Middle Eocene TST (Hazad reservoirs). The Kanwa shale of Middle Eocene is a main seal in the study area. Hydrocarbon accumulations are mainly Strati-structural in the Gandhar, Jambusar, S.Dahej, Aliabet, Kim, Katpur, Motwan, Sisodara, Elao and Kosamba fields towards the basinal areas. However, it is mainly structural towards the eastern margin areas, in Gajera, Kural, Palej, Matar and Karvan areas because of fault closures.

Tectonic setting:

The Broach - Narmada Block lies between Mahi River in north and Tapti River in south. The block has several NNE-SSW to N-S trending listric normal faults and ENE-WSW trending transfer faults. The listric normal faults controlled the subsidence and deposition during the synrift phase. Inversion across listric faults due to reverse activation is also seen, resulted in the formation of Gandhar, Jambusar, Ankleshwar, Kosamba, kim, Katpur & Olpad structures.

Methodology:

- Identification and correlation of Early Eocene unconformity (Y-Marker) and Middle Eocene maximum Flooding Surface (MFS) Kanwa shale throughout the study area including the Gulf.
- Preparation of E-W and N-S log correlation profiles covering the entire study area to understand lateral and vertical facies variation.
- Preparation of time structure maps to understand present day structural pattern.
- Preparation of Ishochronopach and isopach maps to understand depositional pattern.
- Preparation of sand isolith maps to understand sand dispersal pattern and likely depositional model.
- To build depositional model for the Hazad reservoirs from electro facies analysis, sand dispersal pattern and integrating with laboratory data.
- Prospectivity analysis.

Electro log correlation:

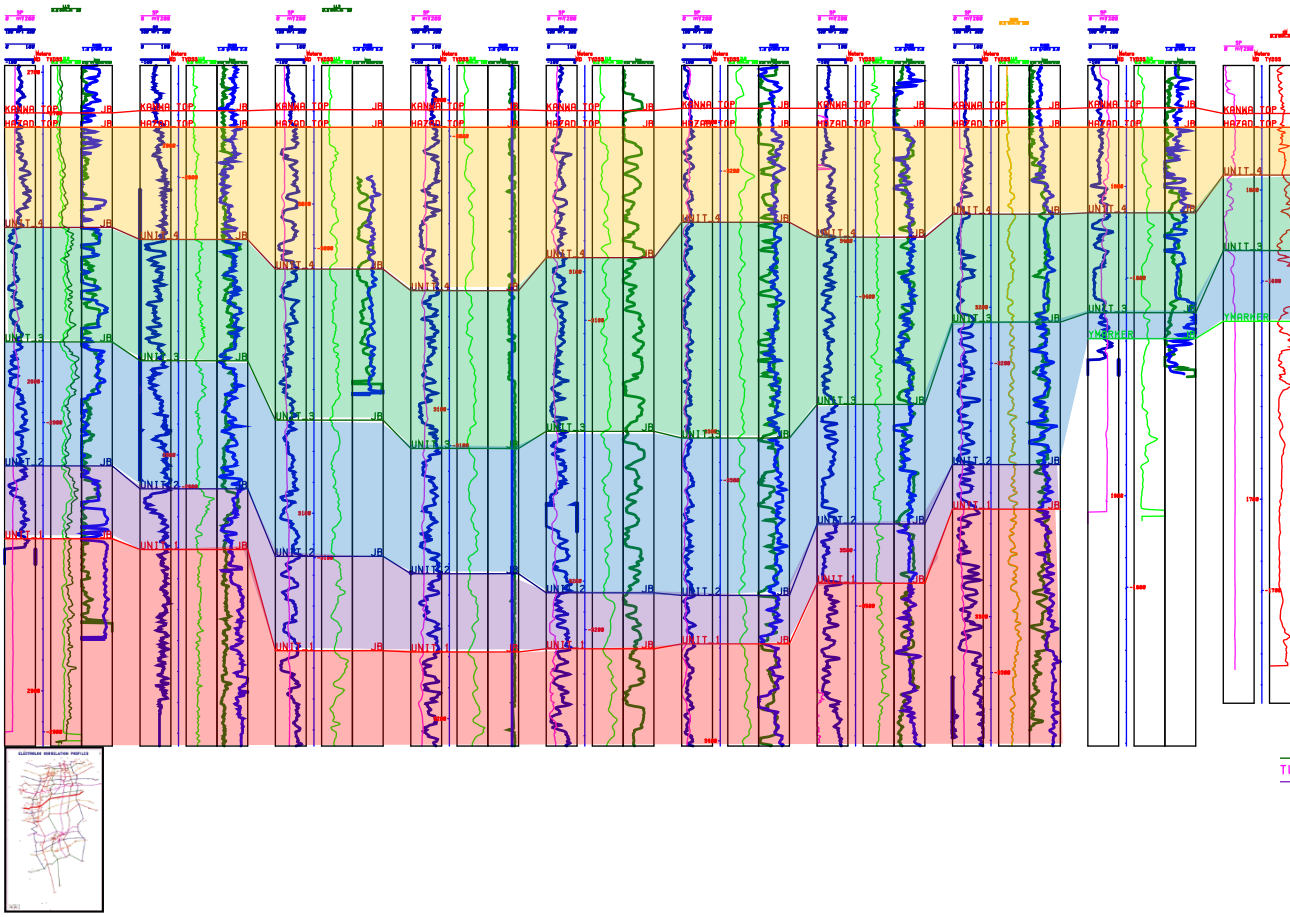
Number of East–West and North–South electro log correlations has been generated to understand the facies distribution and depositional model (Fig.3 a, b, c).

On the E-W log correlation profiles, shale out of various Hazad units is clearly seen from east to west direction suggesting sand entry from east direction. In Dahej, Gandhar, Nada, Aliabet, Katpur, Kim and Kosamba fields, coarsening up log signature is seen within the various Hazad units also suggest delta front regime for their deposition. West of Aliabet, Dahej, Gandhar and Nada areas Hazad sands gradually shale out suggesting pro-delta regime during deposition. South of Kim, Elao, Kosamba Hazad sand gradually shale out suggesting pro-delta regime during deposition of Hazad Member.

ELECTROLOG CORRELATION PROFILE

← W

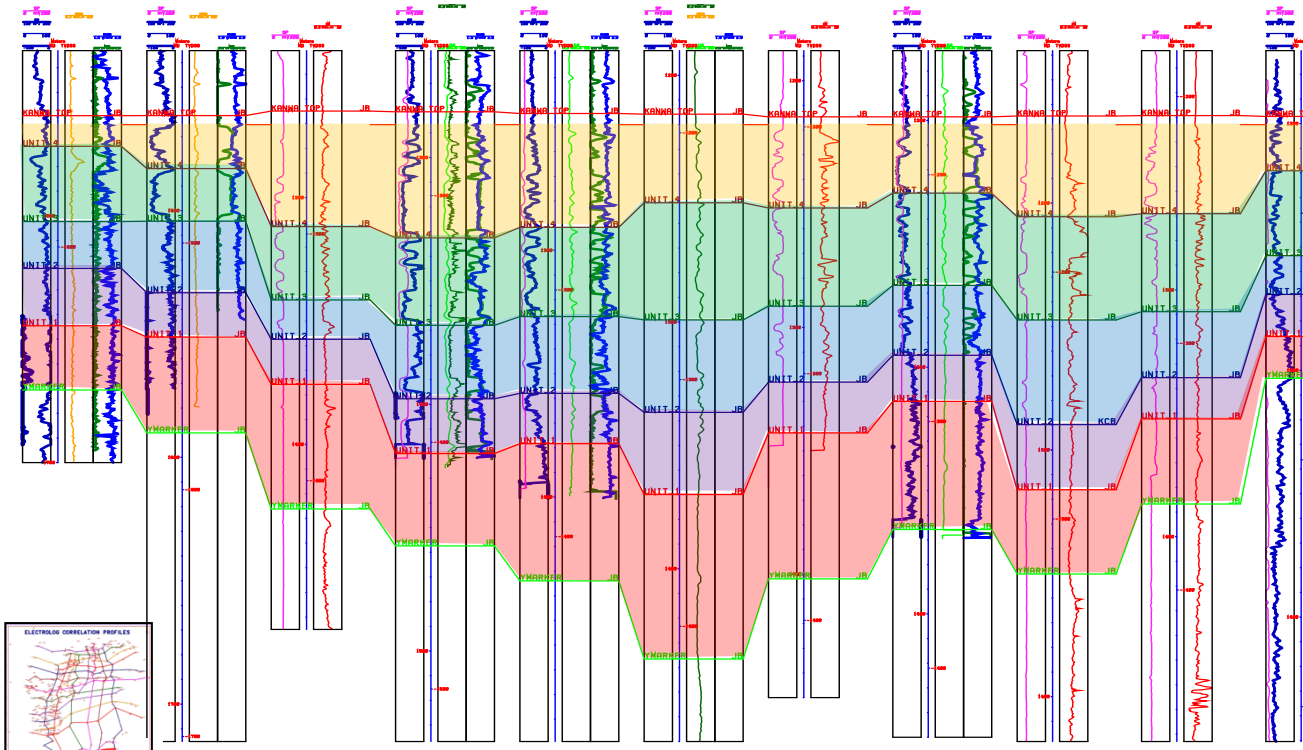
GN-329 GN-388 GN-160 GN-170 GN-37 GN-358 GN-122 GN-526 PJ-4 PJ-3



W

ELECTROLOG CORRELATION PROFILE

KT-1 KIM-14 MT-8 MT-20 SI-19 AN-1SD AN-46 AN-292 AN-135 AN-78 AD



← N

ELECTROLOG CORRELATION PROFILE

JM-37 JM-36 JM-46 JM-14 GN-520 GN-566 GN-14 GN-259 GN-253 GN-455 GN-607 GN-526 GN-172 PK-12 F.. . SJ-1 AN-63 M
2

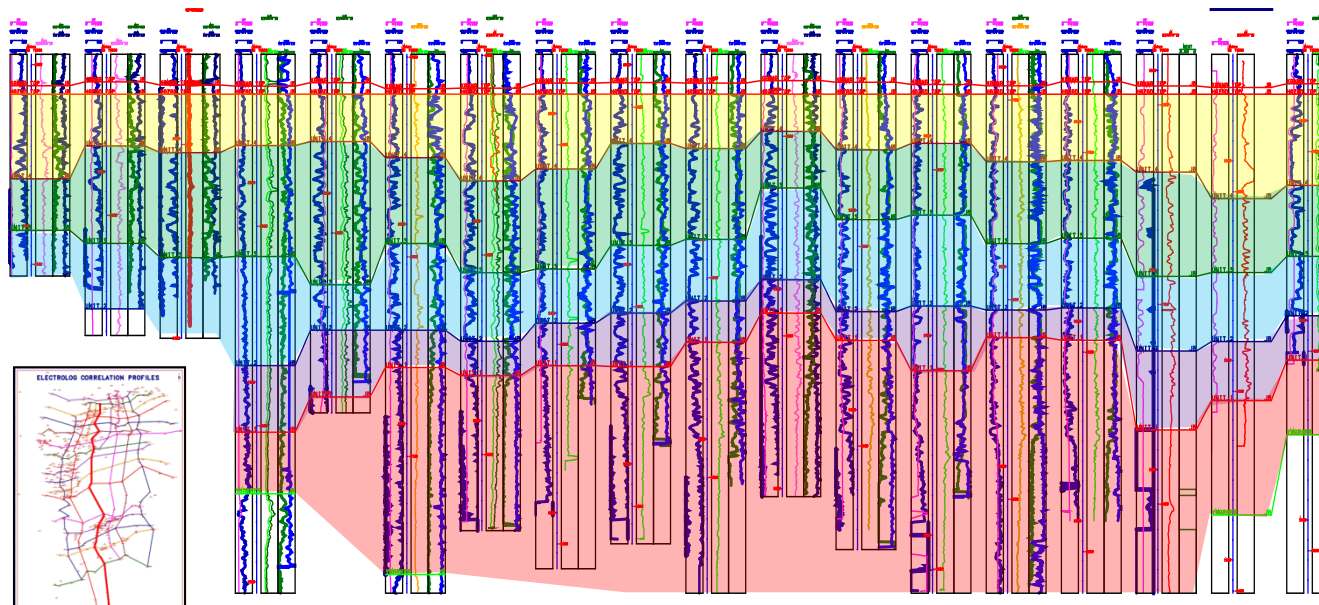


Fig. : 3 a, b, c.

Time Structure Map at Middle Eocene Top (Hazad Top):

Time map has brought out a nosal feature in Gandhar & Jambusar area, anticlinal structures in Ankleshwar & Kosamba, major depression on the western flank of Gandhar nose i.e. Tankari and Broach depression south of Gandhar nose (Fig.-4).

Two set of normal faults trending NW-SE & NE-SW, few normal faults heading down to the eastern margin area making the half graben structure along eastern margin area and several E-W trending reverse & normal faults has been mapped. South of Narmada fault, number of NE-SW trending reveres faults have been mapped which bound major hydrocarbon bearing structures like Ankleshwar, Kosamba, Kim, Katpur, Aliabet & Olpad. Structures in Broach Block (Gandhar, Jambusar, Dabka etc.) are trending in N-S direction where as structures in Narmada Block (Ankleshwar, Kosamba, Kim, Katpur, Aliabet) are trending in E-W direction (Satpura trend) except Olpad structure which trends in NE-SW direction. Structures in Narmada Block are mainly inversion structures bounded by the reverse faults which have formed because of compressional activity during Miocene Himalayan orogeny.

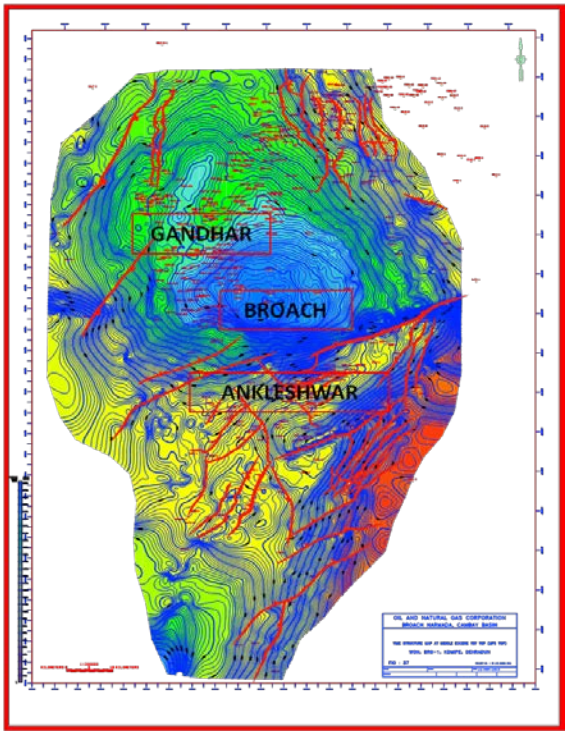


Fig. 4: Time Structure Map at Middle Eocene Top (Hazad Top)

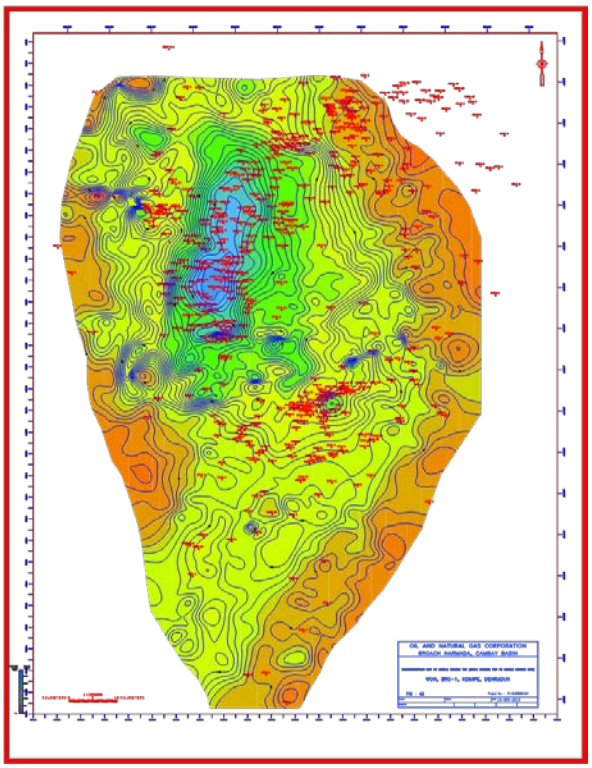


Fig. 5: Iso chronopach of Middle Eocene

Iso chronopach of Middle Eocene:

The deepest part the basin during “Middle Eocene TST” is in Broach block (Broach depression) with contour value of 2800 m.sec (Fig.-5). The “Broach depression” is aligned in E-W direction whereas the “Gandhar nose” & “Tankari depression” is seen to be trending in NE-SW direction. The basin is shallowing towards south (Tapti Block), eastern margin and west of Gulf area along western margin.

Paleostructural analysis suggests “Broach depression” has been formed during post Miocene time, whereas “Gandhar nose”, “Ankleshwar & “Olpad structures” are inversion structures formed during Lower Miocene compressional activity related to Himalayan Orogeny which has also resulted in formation of “Tankari low” west of Gandhar nose. “Kosamba structure” is a paleohigh (Fig.-6). Inversion across listric faults due to reverse activation has resulted in the formation of Gandhar, Ankleshwar, Aliabet, Katpur, Kim & Olpad structure and Tankari low.

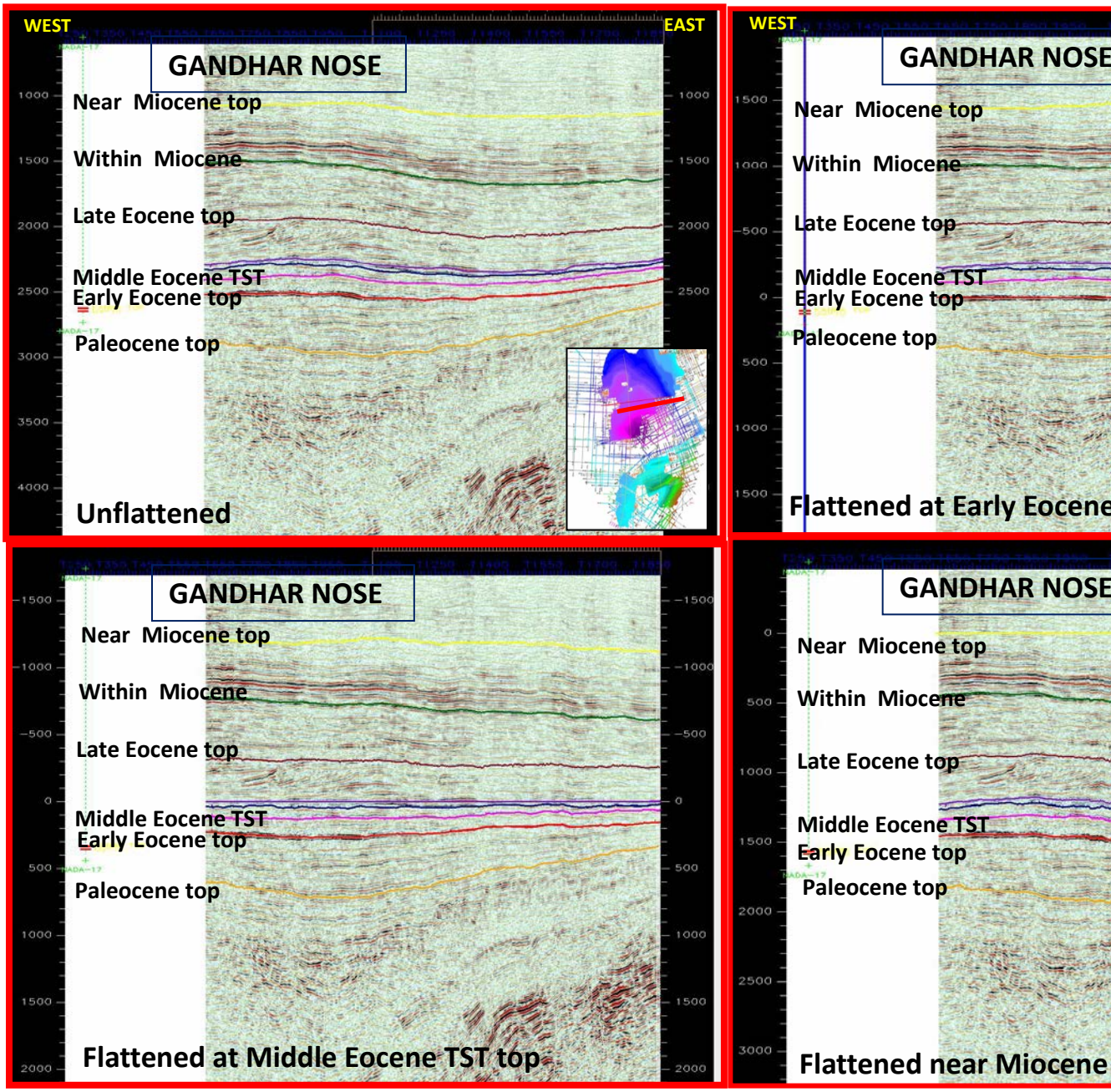


Fig.: 6 Paleo-structural analysis (W – E) Passing through Gandhar nose

Sand Isolith map of Hazad Member:

Sand isolith map (Fig.-7) clearly suggests the paleo-drainage system flowing from ENE to WSW direction and depositing various units of Hazad Member during normal regression. Sediment input is envisaged from East and North-East direction and gradual shale out of the unit is seen towards west of Gandhar, Dahej and Nada areas.

The Sand maxima of 170m can be seen in Pakhajan and Gandhar areas. In Narmada block maximum thickness is seen in Ankleshwar, Motwan & West Motwan areas (70-80m). In Kim, Katpur, Elao & Kosamba the sand thickness is 10-20m.

Paleogeographic reconstruction further suggests existence of proto Narmada and proto Dadhar delta during Middle Eocene time (Fig.- 8).

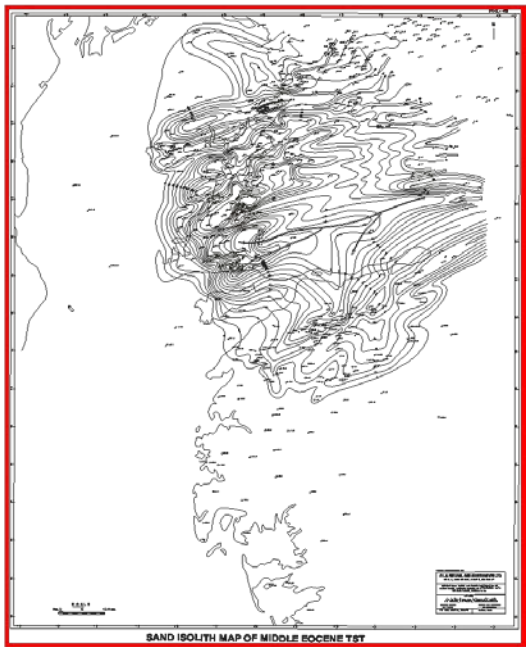


Fig.7: ***Sand Isolith map of Hazad Member***

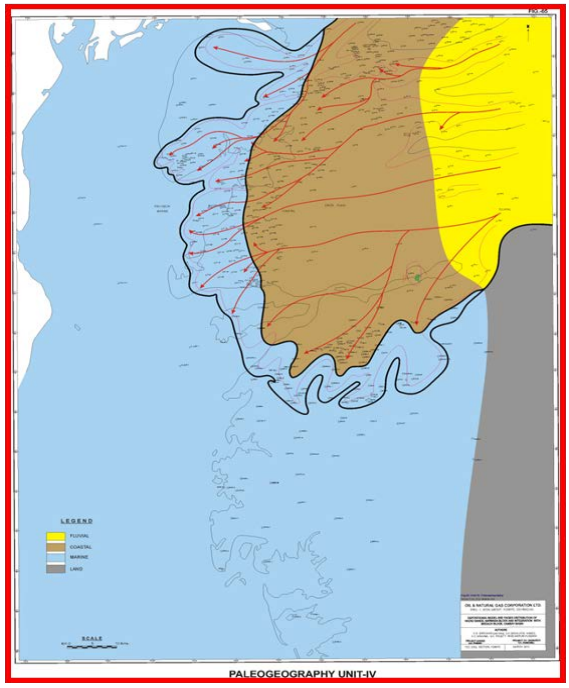


Fig. : 8 Paleogeography at Middle Eocene top

Conclusion:

The Paleo-geographic reconstruction based on faunal floral evidences and lithological associations suggest well spread transgression (TST) during Middle Eocene. The delta model for Hazad Member is envisaged, which is followed by deposition of MFS represented by marine shale “Kanwa Shale”. Time thickness map prepared for Middle Eocene TST suggest paleoslope to the west during the deposition of this system tract. The main depocentre of Middle Eocene TST is in “Gandhar-Dahej area” in Broach Block, trending north to south direction and “Sajod-Wasnoli area” in Narmada Block trending east to west, the maximum thickness of 360m (280 m.sec) of Middle Eocene TST is seen in Gandhar area. On the E-W log correlation profiles, shale out of various Hazad units is clearly seen from east to west direction suggesting sand entry from

east direction. Sand isolith map of Hazad Member suggest distributary channel system flowing from ENE to east direction and depositing deltaic lobes in Gandhar – Dahej areas, separated by inter distributaries bay under normal regression. Sands gradually shale out towards the west of Dahej, Gandhar, Nada in Broach Block. In Narmada Block the channel takes swing to north south direction and depositing deltaic lobes in Ankleshwar, Sisodara & Motwan area. Hazad reservoirs gradually shale out south of Kim, Katpur and Elao areas. The Kosamba reverse fault is a depositional limit for Hazad reservoirs towards south in Narmada Block .Paleogeographic reconstruction further suggests existence of proto Narmada and proto Dadhar delta during Middle Eocene time.

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