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Litho-biostratigraphic correlation, paleoenvironmental analysis and depositional modeling of Hazad sands in Pakhajan- Dahej - South Gandhar area, Broach Block, Cambay Basin

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Introduction

The Paleogene sequence in Jambusar-Broach block have a number of hydrocarbon bearing pays in Hazad Member of Ankleshwar Formation, that form NE-SW and E-W prograding delta lobes. Due persistent sediment supply and changing coast line especially during deposition of Hazad member under a normal regressive set up, the overall geometry of sand lobes has wide lateral spread. Towards S and E of main Gandhar field and in Pakhajan and Dahej area, a number of Hazad pays are inconspicuous due to poor development and fluctuating coast line. A biostratigraphic approach to map the persistent biochronohorizons (bounding surfaces) within Ankleshwar Formation has been adopted for correlation and depositional modeling of the GS units in the area covering south Gandhar, Dahej and Pakhajan fields.

Objective

The main objective is dating and demarcation of litho-biofacies to establish the correlatibility of payzones in Hazad sediments of Ankleshwar Formation covering South Gandhar, Dahej and Pakhajan fields.

Material and Method

The laboratory and electrolog data from 65 wells (Fig.1) have been considered to establish biostratigraphy and paleodepositional environments. Basic principles of sequence stratigraphy have been applied for depositional setup, distribution patterns and process response models of the pay sands. Geological Times Scale of Gradstein 2004 and Cambay Basin biochoronostratigraphy (Aswal et al., 2009, Fig. 2) has been followed.

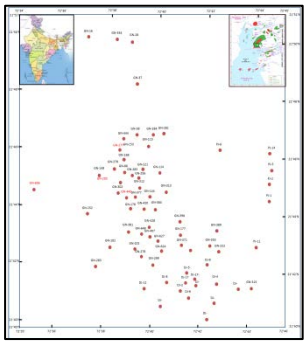

Fig. 1 Location Map

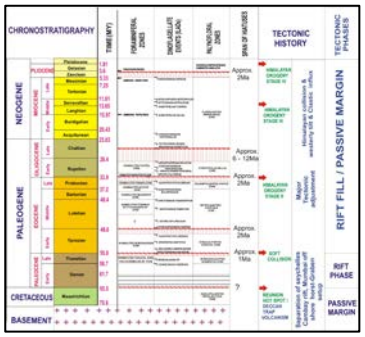

Fig.2 Biochronostratigraphy (after Aswal et al. 2009)

Geology of Broach Depression

The Tertiary sedimentary cover in Broach depression, mainly comprising clastics, is >7Km thick in the deepest part in Gandhar field (Prashad et al., 1987). The pays are represented by Gandhar sands (GS1-13). The subsurface stratigraphic classification proposed by Pandey et al., (1993) has been followed.

Biostratigraphic and Sedimentological Studies

Two foraminiferal zones representing Middle (N. fabianii- N. chavannessi Zone) and Late Eocene (N. acutus- N. staminus zone) have been recognized. Palynological studies, based on LADs of age diagnostic dinoflagellate cyst species have divided the Hazad and Kanwa Member in to three interval zones.

H. tubiferum – M. fimbriatum Interval Zone: Lutetian (49 – 44 Ma).
M. fimbriatum – A. homomorphum Interval Zone: Lutetian (44 – 42 Ma).
A. homomorphum – A. multispinosum Interval Zone: Bartonian (42 – 39.4 Ma).

Lithofacies, texture, Sequence Stratigraphy and depositional model of Hazad Sands

The Hazad member classified in to GS-0 to GS-12 sand units in ascending orders and variation in their development, distribution and depositional setup has been observed. In the present area the GS units and their equivalent are well developed. The underlying Younger Cambay shale (YCS) Formation is mostly argillaceous and distinguishable from the overlying arenaceous Hazad sands (GS-0 to GS-12) are discussed. Based on integrated data sets, the correlation of pay sands has been standardized and identification of flooding surfaces has been attempted within biochronostratigraphic framework. The top of Early Eocene has been identified as a diachronous

hiatus spanning 2 MY i.e. C II 30, an IInd sequence boundary (Parakh et al., 2007). This hiatus in some wells lies at the bottom of GS-0, while in others at the bottom of GS-1, GS-2 and GS-3, conforming its diachronous nature. The correlation of various units suggests uneven development across the study area. For understanding their depositional pattern, sequence stratigraphy has been applied. The Hazad sands are deposited over the Cambay Shale Formation with an unconformable relationship (C II 30), while the top/upper contact of the Hazad Member is marked by a transgressive event known as Kanwa Shale Member (MFS). The Hazad sands are deposited on this unconformity surface. The overview of the correlation profiles suggest on-lapping on the Cambay Shale top in the updip direction and the unconformity (C II 30) represents end of forced regression and on this surface the Hazad sediments are deposited as Low Stand Normal Regressive aggradation followed by a transgression (Kanwa Shale). Lithologically surface is contact of Shale overlain by sandstone facies of Hazad member. On electro logs the change in the facies is marked by Y-marker. For the start of forward modeling, this surface has been taken as top of YCS, MSL at time i.e. Time step-1 has been taken has Sea Level 1 and the initiation is represented in (Fig. 5 (I- XII)

Gandhar Sand Unit – 0 (GS-0): This sand unit has limited distribution and is poorly developed in the area. The maximum thickness is recorded in DJ#14 (4.5m). The lithofacies comprises of sandstone, silty in nature where clay content is applicably high, and has discontinuous laminations of carbonaceous matter, also corroborated by serrated log signature and high gamma values. The depositional model suggests input is mainly from N-NNE and start of delta building process and three separate lobes formed by different tributaries. One tributary descend in the area represented by GN#114, 144, 312, 313, and 377, the second tributary by PK#6, GN#177, 381, 389, 398, and reaches up to DJ#3. The third tributary represented by PK#11, GN#315, and DJ#4, 10, 14, and reaches up to DJ#18. The sand characters suggest mouth bar and bar cut by channel and channel deposits. The integrated interpretation suggests that this unit is deposited in delta front regime under tidal influence in subtidal conditions. The forward modelling suggests initiation of the deposition on the top of YCS Fig. 5(i) and MSL as sea level 2 and Time step-2. The overall characters suggest deposition in pro delta setup with frequent tidal influence (Fig. 5(ii), 6(i)

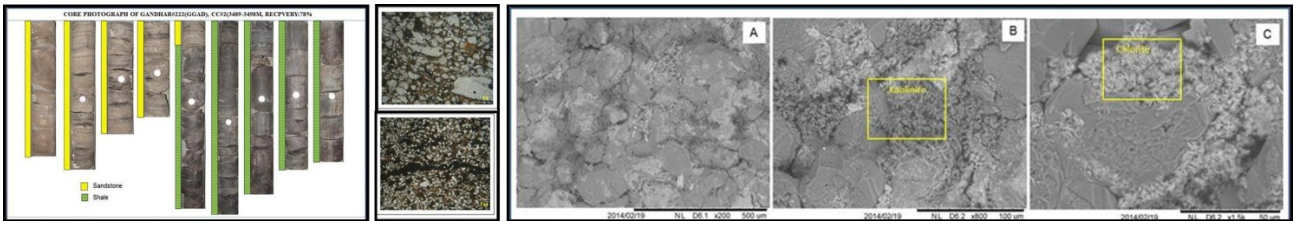

Fig. 3. Core photographs, photomicrographs and SEM images of CC-2(3489-3498m) of Gandhar#222.

Gandhar Sand Unit – 1(GS-1): The unit is white-dirty white, hard, mod sorted, medium grained, subrounded to subangular quartz grains bounded by argillaceous matrix, having discontinuous lamination of carbonaceous matter. The top part of sandstone show brownish colour and is silty in nature. Presence of grain coating chlorite and pore filling kaolinite attributed to the deposition in a relatively shallow deltaic environment as part of large fluvial system and appears to be mouth bar. Funnel shaped GR curve and CU trend is typical of bar sand and characteristic of shore line deposits and deltaic environment. Dominant med-fine and mod sorted nature, presence of substantial amount of clays, gradational basal contact and CU sequence indicate the GS-1 sand in GN#222 (Fig. 3) and GN#177 was deposited as distributary mouth bar under moderate energy condition. High argillaceous content suggests tidal influenced environment. On the electro log motifs this unit in some wells is characterized by CU sequence with frequent tidal effects and in other wells the sand is characterized by mouth bar and bar cut by channel. The maximum thickness has been recorded in DJ#5 (15m) and GN#278 (8m). This variation in the thickness suggests that during the deposition the sediment influx was max in eastern lobe toward DJ#5 though the delta prograded up to DJ#18 (1.5m thick), while in western lobe the delta prograded only up to GN#381(6m). The delta progradation begins from G-281, PJ-6, and PJ-11 in SW towards G-381, G-146 and SSW towards DJ-18, D-5. In the centre towards G-398, DJ-11 the sand is less developed. The wells lying further SW show no development of the unit. The prograding delta lobe at G-381 during GS-1 moves further SW to GN#102. In comparison to GS-0, depositional model of GS-1 suggest that the second and third lobe of GS-0 merged as the delta prograded down S and laterally. During GS-1 the input direction changes to NNE – NE (Fig. 5(iii) and 6(ii).

Gandhar Sand Unit-2(GS-2): The unit comprises grey to light brownish grey, compact, mainly fine, medium to coarse, mod to well sorted sandstone. Towards bottom becomes silty and changes to carbonaceous shale. The upper - middle parts of sand are massive with carbonaceous clay. The lower part exhibits sub horizontal**,** wavy laminations and occasional burrows. Petrographic studies suggest lower part is quartzwacke (15-35% clay matrix) and middle-lower portions of upper part are quartzarenite with patches of calcareous cement and rare pellets of Glauconite. The upper part is quartzwacke (increasing matrix % upwards). The grains are in line and point contacts, fair to good inter-granular porosity. The CC-2 (GN#177) and CC-1(GN#168) Fig. 4 (i-iii) is deposited as mouth bar. The funnel shaped, decreasing GR value depicts bar sands cut by channel (deltaic environment). The channel fill is in form of gritty sandstone at the bottom. Fine and well sorted sands, presence of suspension population; gradational basal contact and CU suggest that sand was deposited as distributary mouth bar (moderate energy condition). In others (GN-144, DJ-8, DJ-5) indicate distributary mouth bar deposit cut by channel. The electro log

motifs suggest mouth bar sands with tidal effects and where GS-0 and 1 are absent is suggestive of CU patterns. The two deltaic lobes developed during GS-1 reinforced during GS-2. The maximum thickness is recorded in GN#144(19m), and GN#222(12m). The western lobe further prograded to GN#102(6m) developing mouth bar. The eastern lobe remains as in GS-1. In the centre towards G-398, DJ-11 the sand is less developed and further SW shows no development. The prograding delta lobe at G#381 during GS-1 moves further SW to G#102. The sand distribution suggests input from NNE–NE (Fig. 5(iv) and 6(iii).

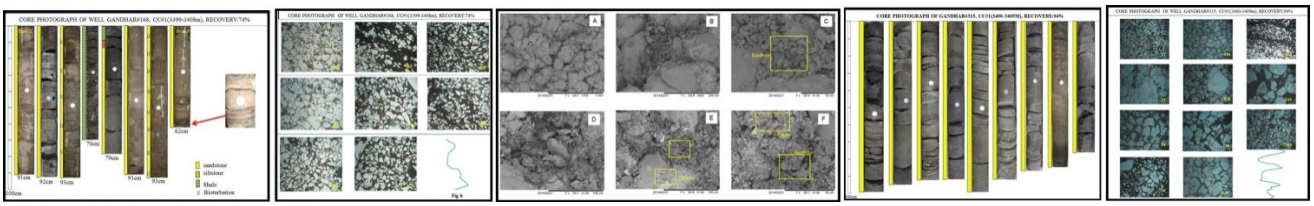

Fig. 4(i-iii) Core photographs, photomicrographs and SEM images of CC-1(3399-3408m) GN#168 and CC-1 (3400-3409m) GN#315 (Fig. iv-v).

Gandhar Sand Unit-3(GS-3): This sand unit has been recorded in all the studied wells except in GN#686, 146 and 152. The sand is fine grained, and moderately sorted, moderately hard, subrounded to sub-angular, quartz grains transparent to translucent are bounded by argillaceous matrix. The bottom most siltstone is mod hard and non-calcareous, upwards grades into grey to dark grey, moderately indurated, fissile, carbonaceous and non-calcareous shale. There is change in lithology from siltstone and to sandstone with intermittent shale. The CC-2(GN#168), suggest initiation of deposition in channel which becomes dirtier at later stage (High argillaceous content). The CC-1 (GN#315, Fig. 4(iv-v), lithofacies suggests FU of facies in a relatively reducing and low energy environment. Prominent bioturbation at the base suggest a shore face/ foreshore phase of deposition. The CC-1(GN#222) shows bar cut by channel indicating progradation of deltaic facies under moderate to high energy conditions. The CC-1 (GN#221) shows bottom part deposited as channel fill followed on top by fluvial channel within delta plain. The CC-2 (GN#221) suggest channels cut bar, suggesting delta progradation under moderate energy conditions. Presence of channel lag (DJ-6), coarser size, reduced matrix (GN-221), occasional cross bedding and FU trend suggest deposition under relatively higher energy condition in distributary channel in the proximal part of delta front. Gradual increase in bioturbation and % of clay matrix, decrease in surface creep population towards W and SW suggest direction of progradation. In GN#102, 263, DJ#12, 16, it is dominantly deposited by tidal channels and in others, channel, mouth bar and bar cut by channel deposits, at places tidally influenced. The deltaic lobes envisaged in GS-2 merge. The depositional model suggests destruction of delta lobes and aggradation in delta front and delta plain area. The maximum thickness (24m) has been recorded in GN#315, 399, 353, 222, 221, 258, and 313, PK#6 and PK#1(21m). The thickness, log shape and lithofacies suggest a gradual progradation in SSW direction starting from G#313, G#114 towards G#152, G#146 and G#144. Log motifs suggest that they are mainly deposited as mouth bar cut by channel and channel deposits. The prograding delta lobe developed at G-176 during GS-3 moves further W up to G-152. To SWS, in GN#102, 201, 263, the reservoir facies is poor and overall sand: shale ratio is low. The depositional model suggests input from NE (Fig.5 (v), 6(iv).

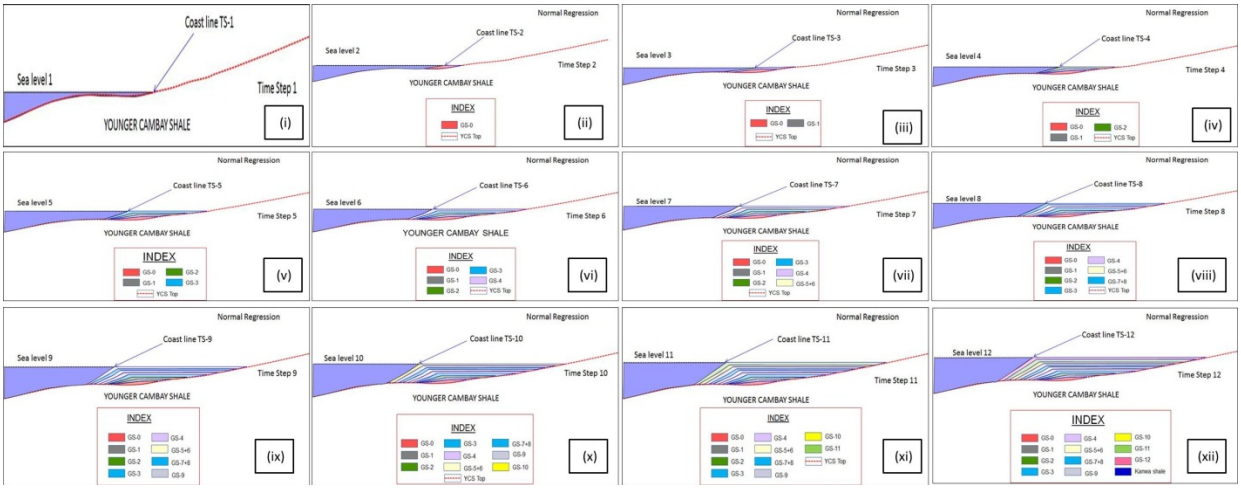

Fig. 5. Conceptualised sequence stratigraphic forward modelling of time step – 1 to 13,

Gandhar Sand Unit- 4 (GS- 4): The upper part of GS-4 is light grey, compact, medium to fine, moderately sorted, bioturbated with specks and scales of carbonaceous matter, at times, coarse to very coarse represent channel lag. The lower part is fine, rarely cross bedded. The basal contact is gradational. It is characterized by CU and FU sequences, wavy laminations and ripple bedding, disturbed due to bioturbation suggest rapid rate of sedimentation. The degree of bioturbation decreases towards E and NE. Petrographically; it is mainly quartzwacke with 15-35% carbonaceous clay matrix, grain contacts are mostly line and point. Subordinate quartzarenite; contains few pellet of

glauconite. There is increase in matrix % in the lower part and laterally increases towards E and NE. Medium to fine size, and moderate-well sorting, intense bioturbation, dominant saltation and subordinate suspension populations, gradational basal contacts and CU suggest distributary channel under moderate energy conditions. Presence of channel lag, relatively coarser, reduced amount of matrix, occasional cross bedding and FU suggest deposition in fairly higher energy condition in distributary channel in the proximal part of delta front area (PK#2). At places, the channels cut across the bar suggesting progradation and deposition under constructive phase. This sand unit is absent in GN#686 (shale) and in GN#263 (1.5m, tidal sands). The maximum thickness has been recorded in DJ#14(17m), GN#315(16m), GN#221(15m) and GN#265(14m). The thickness, log shape and lithofacies suggest a gradual progradation in S, SSW and SW direction starting from G-313, G-114 towards GN-152,146,144, 315, DJ#14. The prograding delta lobe developed at GN#176 during GS-3 moves further W up to G-152(10m), and represented by mouth bar cut by channel suggest further progradation. Also in the direction of GN#102 from GN#381(2m) characterized by bar cut by channel. In GN#102, 201 and 263, the reservoir facies is poor and overall sand: shale ratio is low. In Dahej area the unit is characterized by mouth bar cut by channel, suggest further progradation and deposition in prodelta, delta front and delta plain area and suggest input from NE (Fig. 5(vi), 8(i).

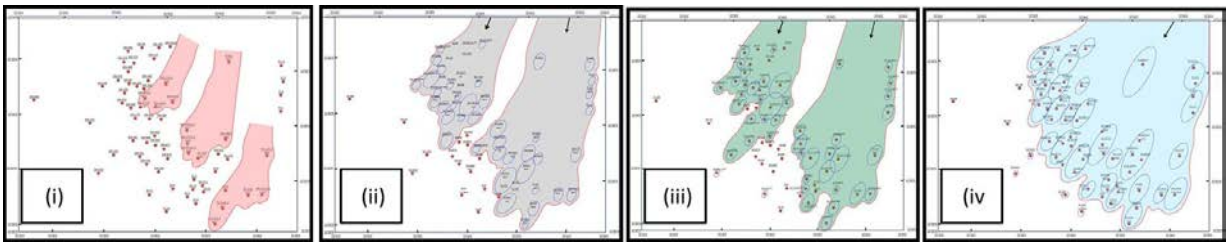

Fig.6 (i-iv) Depositional Models of Gandhar Sand Unit – 0, 1, 3 and GS-3

Gandhar Sand Unit-5+6 (GS-5+6): The unit comprises light grey, compact, fine to very fine, moderately well to well sorted, bioturbated, occasional specks and scales of carbonaceous matter. Petrographically, GS-5A is quartzwacke comprising of fine to coarse, moderate to poorly sorted grains, embedded in argillaceous matrix. The matrix is calcareous in G#144. The lower part is quartzarenite. GS-5B and lower part of GS-5C sands are quartzwacke with (20-30%) carbonaceous clay matrix. There is a slight decrease in clay matrix (15-20%) in the lower part of GS-5C as compared to GS-5B. The top most part of GS-5 sand is relatively finer. Fine to very fine and moderately to well sorted nature of sands, intense bioturbation and dominance of saltation population with minor but consistent suspension population and CU of GS-5B and suggest the upper portion of GS-5C sand as distributary mouth bar in delta front area, under moderate energy condition. Relatively coarser, poorly sorted fine to coarse grained sands, with shell fragments and fining up trends suggest the presence of tidal channel in the upper part of the sand. The maximum thickness of GS 5+6 has been recorded in GN#221(25m) and DJ#18(24m). Its presence in GN#686 as mouth bar deposits cut by channel suggest delta progradation to W and the sediment supply to GN#686 is probably from GN# 444, 153, 278, 168, 276, and 146 and further N. The deposition of the sandstone has taken place as distributary channel mouth bar sands (GN#302), at times cut by channel (GN#144) indicate an overall prograding lower delta plain towards S conforms to sand distribution model envisaged by Pandey et al. 1989 in the N in GN#36, 39, 52. The overall log characteristics, in the central part show CU as mouth bar and stacked pattern due to aggradation. Occasional increase in argillaceous matrix, presence of siderite, rare carbonaceous laminae and burrows suggest that area had been subjected to tidal action at periodic interval and input is from NE – E (Fig. 5(vii), 8(ii).

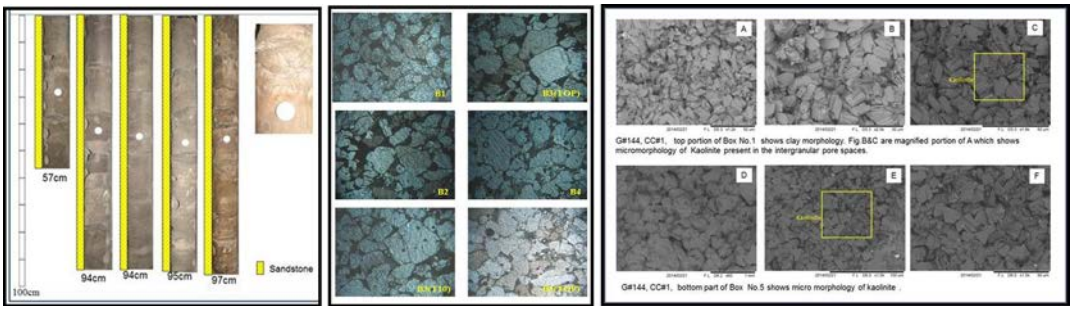

Fig. 7 Core photographs, photomicrographs and SEM images of CC-1(3431-3436m) of Gandhar#44.

Gandhar Sand Unit – 7+8 (GS – 7+8): The sand comprises light to medium grey, compact, fine to very fine, occasionally medium to coarse, moderate to well sorted sandstone with dark grey shale inter beds. The GS-7 unit is predominantly very fine to fine poorly sorted and bioturbated. The GS-8 is mainly quartzwacke having clay matrix up to 30%, contains specks of carbonaceous matter. The middle part is quartzarenite. The grain contacts are point to line. The petrographic characters of GS-8 sand are more or less similar to GS-7. The CC#1(GN#102), belongs to GS-7+8, shows grey to dark grey, moderately hard, poorly sorted, fine to coarse sandstone, sub angular-sub rounded, transparent-translucent quartz grains, bounded by argillaceous matrix. Petrographically shows gritty nature with poor sorting. The bioturbation increases in SW direction. FU have been observed in channel sand

deposited in G-428, G-427, DJ-9 and DJ-8 as mouth bar in G-146, G-152, G-648 and G-627. Overall it is deposited in delta front regime as mouth bar, cut by channel, under tidal effect. The maximum thickness in Dahej area is in DJ#6(28.5m) and GN#313(24m). In GN#686(14m) it is represented by bar cut by channel. The sand distribution pattern of this unit also suggest input to well GN#686 is from GN# 444, 153, 278, 168, 276, and 146. The pattern also suggests sediment aggradation in prodelta area. It appears that the overall spread of the prograding delta lobe has increased as compared to GS-5+6. The bay mapped close to DJ#12 in GS-5+6 has become prominent. The characteristic CU and log motif in DJ-16, DJ-18 and DJ-6 suggest both aggradation and progradation of mouth bar sands. The overall trend remains NE-SW with progradation of lobes due S (Fig. 5(viii), 8(iii).

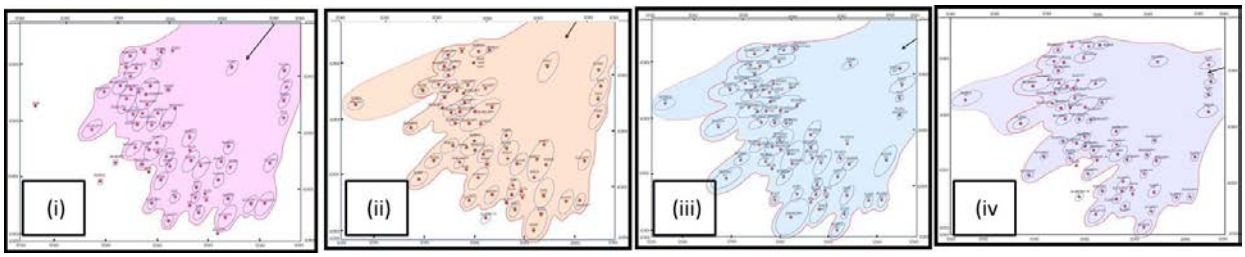

Fig. 8 (i-iv) Depositional Models of Gandhar Sand Unit – 4, 5+6, 7+8 and GS-9

Gandhar Sand Unit- 9(GS- 9): This unit is divisible into three, 9A, 9B and 9C subunits and is light to medium grey, at places dirty white, compact, medium to coarse, occasionally very coarse, moderate to poorly sorted, weakly bioturbated with thin, irregular laminations of carbonaceous clay. The GS-9C sand is bioturbated and the intensity of bioturbation increases in the lower part and also towards W and NW. The GS-9A is quartz wacke in the upper and lower parts having carbonaceous clay matrix, the middle part is quartzarenite. The quartz grains are subangular-subrounded show point sutured and line contact in quartzarenite. The GS-9B is mainly quartzwacke with 15-30% carbonaceous clay matrix and Glauconite pellets in upper part. The GS-9C is quartzwacke (upper and lower) and quartzarenite (middle part). GS-9A sand was deposited as mouth bar under moderate energy condition, GS-9B as channel sands under moderate to low energy condition; the GS-9C is deposited as channel sand. The maximum thickness is represented in GN#686 and DJ#6 i.e.12m. This unit is absent in GN#378. The depositional pattern suggests development of two bays and in DJ#12(6m) is characterizes by tidal channel deposits. The thickness in GN#686 also suggests the sediment input from wells GN# 444, 153, 278, 168, 276, and 146. On the basis of typical lithofacies distribution pattern it appears that the overall spread of the prograding delta lobe has been reduced as compared to GS-7+8. The deposition of GS-9 taken place in a series of prograding channel and mouth bars often punctuated by thin shale in between. The development of GS-9 as prograding lobes is better evident in Dahej area, whereas there is poor development in fields dominated by thin sandstone and shale deposited in probably lower delta plain around the northern region of studied area. The prominent lobes culminating at GN#263, DJ-16, and DJ-18 show progradation to SSW and S. The distributary channel feeding the delta passes through G#648 and G#4 (Fig. 5(ix), 8(iv).

Gandhar Sand Unit- 10(GS-10): The unit is greyish brown-light grey, medium, occasionally coarse, mod to well sorted. Thin wavy laminations of clay and burrows are common within the sand. Inter bed of dark grey shale, at times sideritic showing abundant kaolinite filled desiccation cracks. The lower part of GS-10 is quartz wacke with 20-25% clay matrix. The lower portion of upper part is quartzarenite, rarely sideritic and calcitic cements and is bimodal at times, upper portion is quartzwacke and quartz grains are subangular-subrounded, and show line and point contacts with rare sutured contact. Presence of wavy lamination, desiccation cracks, siderite and calcite cements, bimodal nature and FU suggest tidal channel sand. The sand distribution suggest base level rise taken over the sediment supply results in retrogradation of deltaic facies and the maximum thickness has been recorded in PK#11(6.5m). The study suggest two sedimentary sequences, represented by mouth bar sediments and other a CU followed by FU sequence having high tidal influence. The overall lithofacies suggests a prograding distributary channel from E to SSW in conformity to the GS-9, however, its distribution and extent is limited and is absent towards NW and SW part in GN-278, 146, 152, 102, 263, DJ-12 and DJ-16. The unit in central part exhibit FU, distributary channels in lower delta plain with better development in G#222. Further SW and SSW (DJ-6, 18, 10, GN-315) show good development and prograding delta lobe forming mouth bar. The study suggests input from E (Fig. 5(x), 10(i).

Gandhar Sand Unit- 11(GS- 11): The GS-11 sand is divisible into GS-11A and 11B. The GS-11A is dirty white to light grey, compact, fine-coarse grained, moderate - poorly sorted, feebly bioturbated with thin wavy laminations of carbonaceous matter and is mainly quartzwacke, containing 20-25% carbonaceous clay matrix. The quartz grains are mostly subangular to subrounded showing line and point contacts, while the GS-11B is light grey to brownish grey, fine to very fine, very well to well sorted and in some wells is represented by quartzarenite comprising mainly of monocrystalline, subrounded to rounded quartz grains showing dominantly line contact with subordinate percentage of point and sutured contacts. The GS-11 sand is characterized by presence of moderately well sorted, saltation and suspension population and minor amount of surface creep populations. The sand characteristics of GS-11A suggest mouth bar deposit and GS-11B as mouth bar cut by channel. Presence of carbonaceous matter and pyrite encrustations suggests tidal influence. The maximum thickness is represented in GN#115(19m)

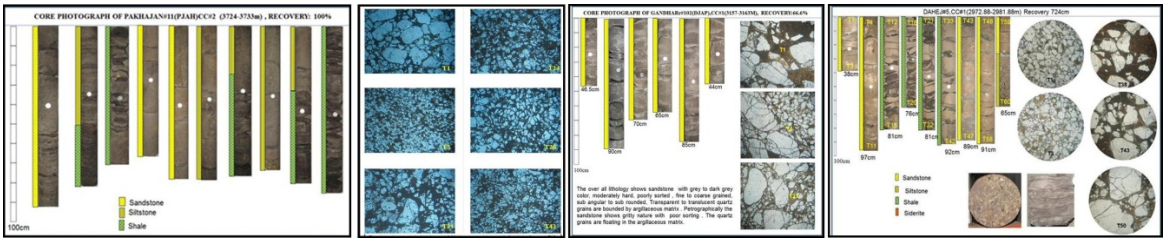

Fig. 9. (i-iv) Core photographs and photomicrographs of CC-2 (3724-3733m) of Pakhajan#11. CC-1 (3489-3498m) of Gandhar#102 and CC-1 (2972.88-2981.88m) of Dahej#5.

and PK#6(14m) and is absent in GN#38, 444, 102, 263. The bay developed between GN#152 and DJ#12 further widens during the deposition of GS-9. The deltaic progradation has been observed in the vicinity of DJ#12 and 16 in the S and towards the W in the vicinity of GN#146, 152 to GN#686. The distribution suggest SWS distribution pattern of the prograding delta front lobe having best development in G#152, 263, 146, DJ#16, 12 18 and PJ#1, 2, 5 and reappear in G-152, 102, 263, DJ-12 and DJ-16, suggest lower delta plain. The distribution suggest segmented coastline to SW and S and gradual shrinking from the northern part (G-444, 264, 281, PJ-6) and input from E to W (Fig. 5(xi), 10(ii)..

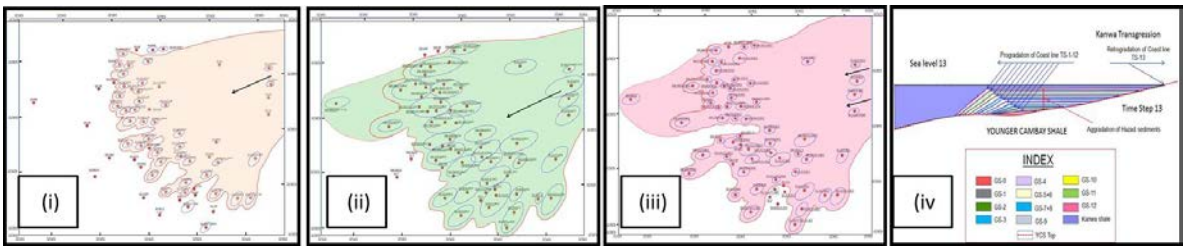

Fig.10 (i-iv) Depositional Models of GS – 10, 11, 12 and Conceptual SS forward modelling of time step 14.

Gandhar Sand Unit – 12(GS – 12): Lower part of GS-12 is grey, fine to very fine, compact, moderately sorted, intensively bioturbated with thin discontinuous carbonaceous clay laminae, lenticular bedding and sideritic mud laminations are common. Petrographically quartzwacke and quartzarenite are in sub equal proportion. In quartzwacke, matrix is carbonaceous clay ranges between 15-25% and occasional pyrite crystals and siderite cement. In lower part, ferruginised ooliths are observed. Grain size distribution patterns indicate repeated cycles (2 cycles) of CU and FU in PK#5 and DJ#2 supported by log motif. Middle part of GS-12 is light grey to light brown, compact, fine to very fine, well to moderately sorted, with thin irregular laminae, scales and specks of carbonaceous clay and disseminated pyrite. Flaser bedding, lenticular bedding and intense bioturbation are common. The depositional environment indicates sedimentation in a relatively tide influenced environment, however, the upper part suggest proximity to distal part of a channel (bar). The overall characteristic suggests deposition in tidal channels and ridges in delta front regime. The overall thickness is much reduced in comparison to other GS units. The maximum thickness has been recorded in GN#389(11m), in delta plain area. In some wells the unit represents bar cut by channels, however, in most of the wells higher tidal effect has been noticed. The unit marks the end of delta building activity and represent the lowermost event of the subsequent basin wide transgression (Fig. 10(iv) evidenced by the development of three bays as suggested in the depositional model of this unit. The sediment input direction still persisted from E. The sequence stratigraphic forward modelling concept suggest gradual rise of base level (Fig. 5(xii), 10(iii).

Conclusion

The integration of laboratory studies along with electro log motifs has brought out the depositional models and process response models for various pay sands (GS-0 to GS-12) of Hazad Member of Ankleshwar Formation in South Gandhar-Pakhajan – Dahej area. The models suggest shifting in put direction from N-S to E-W. These sands are deposited dominantly under deltaic regime in under pro delta to delta plain area.

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