Integrated Sequence Stratigraphy of the Cretaceous Lower Goru Deposits, Lower Indus Basin, Pakistan*

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Abstract

The area southwest of the Badin gas-producing trend in South Pakistan is under-explored, especially within the Lower Goru Play. Few recent discoveries indicate a gas-rich petroleum system within this under-explored area. The present study resulted in establishment of the chronostratigraphic and paleogeographic framework of the Lower Cretaceous Lower Goru Formation within the Lower Indus Basin. This, in-turn, has resulted in a better understanding of the distribution of petroleum system elements in time and space, with the most prospective parts of the study outlined as a result. Eight depositional paleoenvironments and twenty-two high-order depositional sequences were identified. Several sharp-based forced-regressive sands were observed throughout the study area after the integration of well, seismic sequence, and seismic facies analysis using seismic stratigraphic approaches. Several regional structural and isochron and isochore maps were constructed, each representing an interpreted depositional sequence, aiding in the prediction of hydrocarbon traps, including possible subtle traps. Areas of erosion or non-deposition were outlined at each sequence level, resulting in the reduction of uncertainties.

Eighty-eight discontinuity surfaces were identified, interpreted, and used in aiding the interpretation of sequences and systems tracts. Twenty-two systems tracts, belonging to four types, were identified and interpreted, including the falling stage systems tract (FSST), lowstand normal regressive (LNR), transgressive (TST), and highstand normal regressive systems tracts (HNR). Absolute ages, in millions of years from the present, were assigned to depositional sequences after tying to global sea cycle charts. Reservoir and source rocks were interpreted from indicative well log suites. Sand distribution through the play fairway was mapped, highlighting the most prospective parts of the study area for further prospecting and 3D seismic acquisition. Eight types of stratigraphic traps were identified, each with the likely reservoir and seal rock occurrence. Depositional models were predicted for sequence intervals, outlining potential areas of sand-prone reservoirs. Seismic inversion was applied within the established sequence stratigraphic framework, resulting in the identification of lower-risk targets.

References Cited

Galloway, W.E., 2001, The many faces of submarine erosion: theory meets reality in selection of sequence boundaries: AAPG Hedberg Research Conference on “Sequence Stratigraphic and Allostratigraphic Principles and Concepts”, Dallas, August 26-29, Program and Abstracts Volume, p. 28-29.

Hardenbol, Jan, Jacques Thierry, Martin B. Farley, Thierry Jacquin, and Peter R. Vail, 1998, Mesozoic and Cenozoic sequence chronostratigraphic framework of European basins: SEPM Special Pub. no. 60.

Helland-Hansen, W., and J.G. Gjelberg, 1994, Conceptual basis and variability in sequence stratigraphy; a different perspective: Sedimentary Geology, v. 92/1-2, p. 31-52.

Hunt, D., and M.E. Tucker, 1992, Stranded parasequences and the forced regressive wedge systems tract: deposition during base-level fall: Sedimentary Geology, v. 81, p. 1-9.

Hunt, D., and M.E. Tucker, 1995, Stranded parasequences and the forced regressive wedge systems tract: deposition during base-level fall-reply: Sedimentary Geology, v. 95, p. 147-160.

Plint, A.G., 1988, Sharp-based shoreface sequences and "offshore bars" in the Cardium Formation of Alberta: their relationship to relative changes in sea level, *in* C. K. Wilgus et al., eds., Sea-level changes: an integrated approach: SEPM Special Publication 42, p. 357-370.

Sloss, L.L., W.C. Krumbein, and E.C. Daples, 1949, Integrated facies analysis, *in* C.R. Longwell, ed., Sedimentary facies in geologic history: Geological Society of America Memoir 39, p. 91-124.

Van Wagoner, J.C., R.M. Mitchum, K.M. Campion, and V.D. Rahmanian, 1990, Siliciclastic sequence stratigraphy in well logs, cores, and outcrops: AAPG Methods in Exploration Series, no. 7, 55 p.

INTEGRATED SEQUENCE STRATIGRAPHY OF THE CRETACEOUS LOWER GORU DEPOSITS, LOWER INDUS BASIN, PAKISTAN

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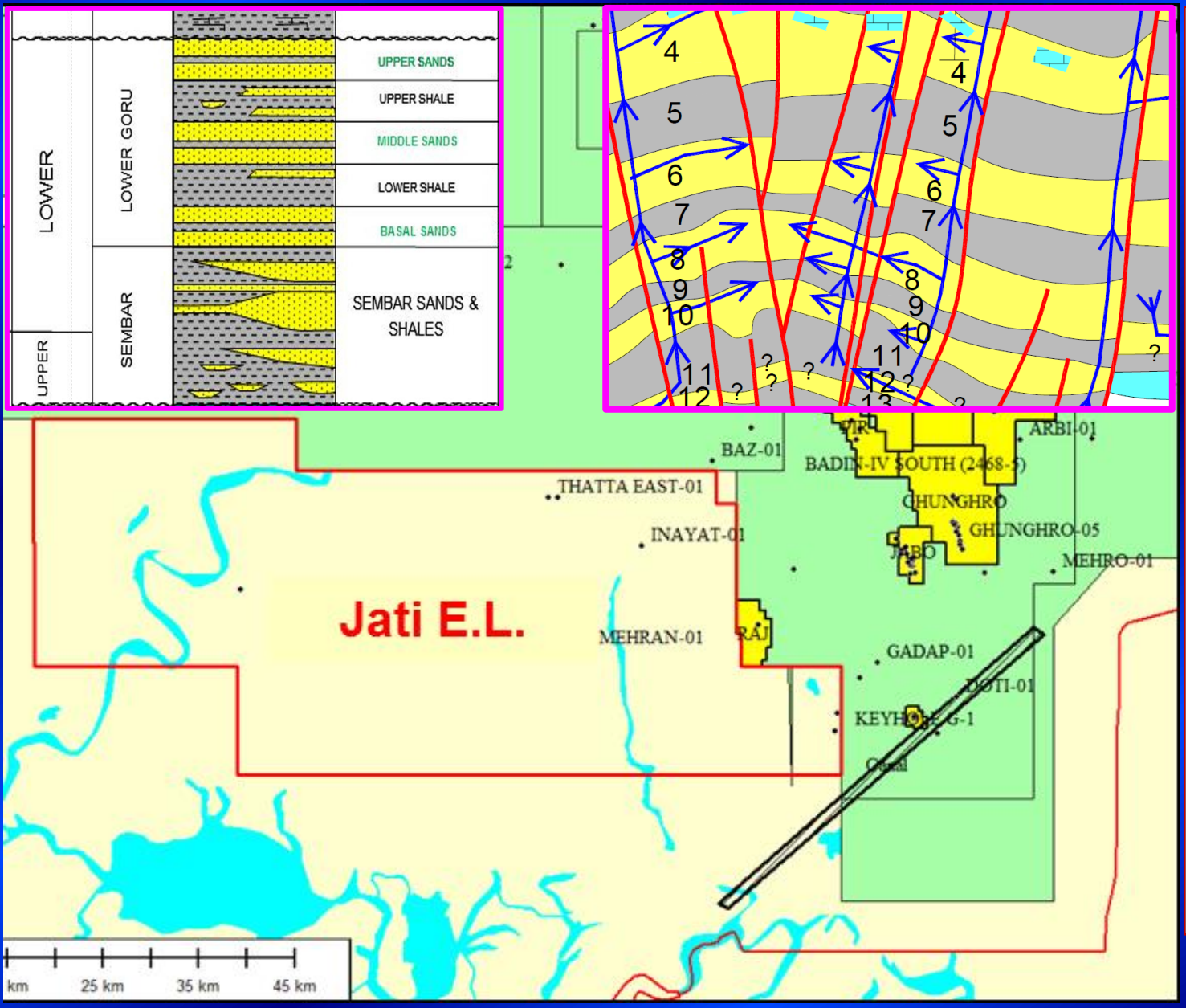
1. INTRODUCTION

LOCATION



The Jati Block is located in the Lower Indus Basin and covers an area of 2465.33 KM^2.

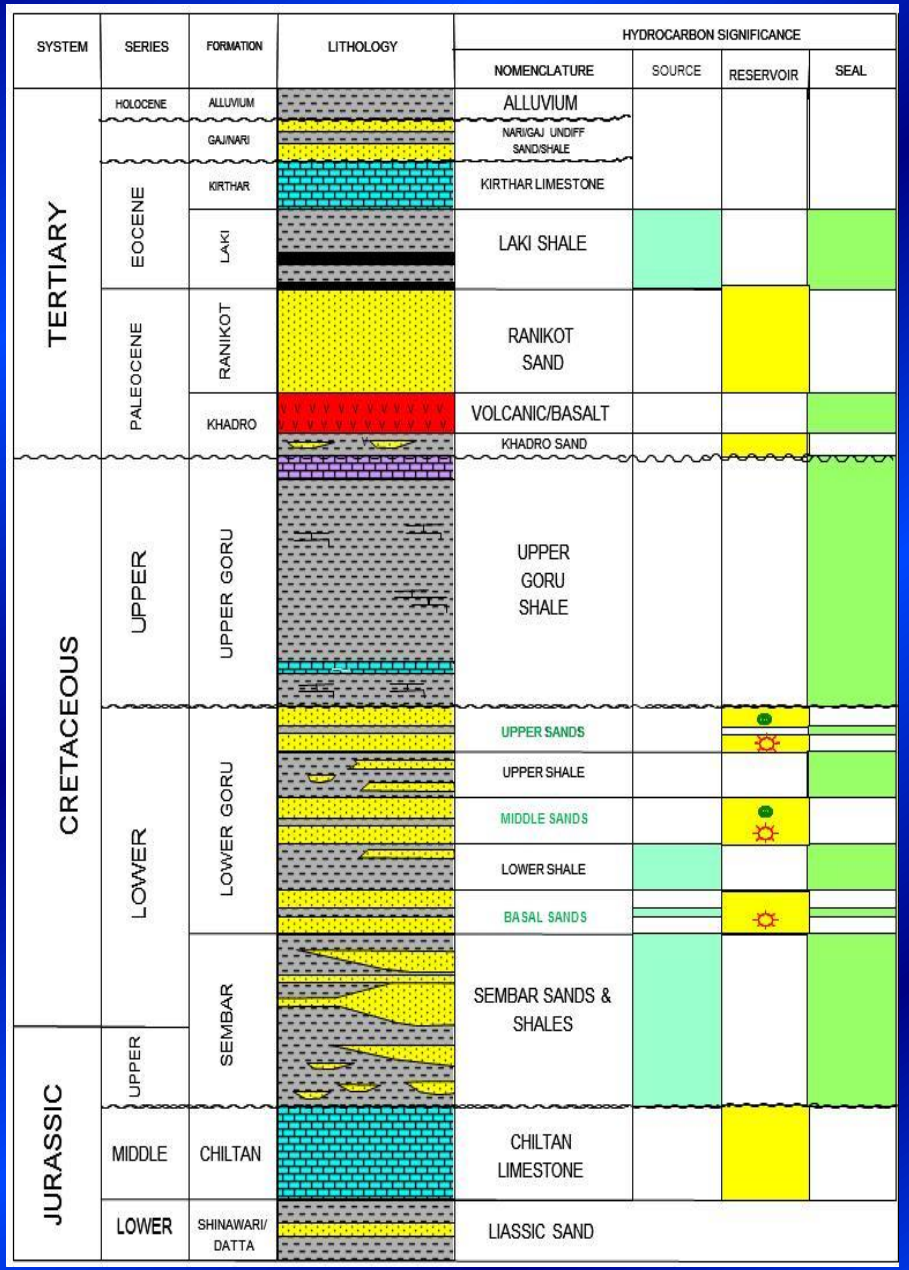
The Lower Goru Sands are the main reservoirs, while the Upper Guru, & intra-Lower Guru shales & marls are the main seal.

The Sembar and intra-Lower Guru shales form the main source.

The area was subject to extensive faulting, resulting in migration pathways along fault planes.

JATI BLOCK STRATIGRAPHY

- **SOURCE**
  - Sembar
  - Lower Goru Shales
- **RESERVOIR**
  - Lower Goru Sands
- **SEAL**
  - Upper Goru
  - Intra-formational Lower Goru shales
- **TRAP**
  - 3-Way dipping fault bounded structures
  - Crotch trap
- **MATURATION / MIGRATION**
  - Adjacent Grabens horizontal, vertical and through faults

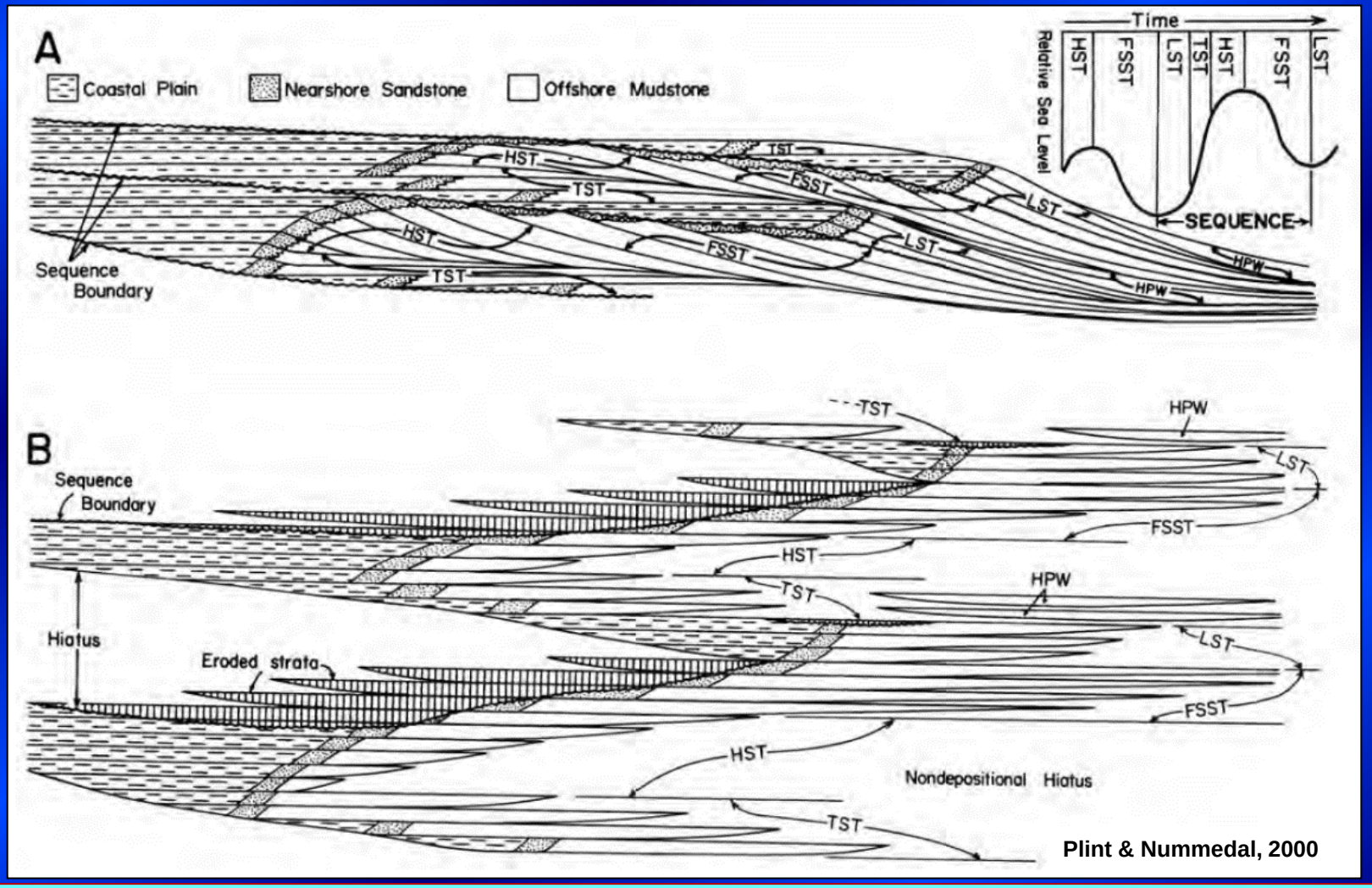


2. METHODOLOGY

APPROACH

1. Gathering well & seismic data from 2D & 3D vintages.
2. Seismic-well tie.
3. Well-based sedimentology & sequence analysis from 17 wells.
4. Sequence analysis on key seismic lines.
5. Well sequence correlation.
6. Seismic facies analysis.
7. Seismic sequence age-dating.
8. Sequence mapping.
9. Interpret remaining types of discontinuity surfaces.
10. Integration:
    a. Define systems tracts.
    b. Define chronostratigraphic framework
    c. Predict petroleum system elements.
    d. Define trap types.
    e. Prospect delineation.

APPLIED SEQUENCE STRATIGRAPHIC MODEL



Plint & Nummedal, 2000

- It is following "**Depositional Sequence IV**" approach in the sense of Hunt & Tucker (1992, 1995) and Helland-Hansen & Gjelberg (1994).
- With this approach, the sequence boundary is placed above the FSST "Falling Stage Systems Tract" (synonymous to "early lowstand", "late highstand", "forced regressive wedge" in various literature) since it is marking the termination of one depositional cycle.
- It realistically predicts the depositional processes and settings, especially in case of forced regressive deposits.

3. INTERPRETATION

SEISMIC SEQUENCE ANALYSIS ON KEY SEISMIC LINES

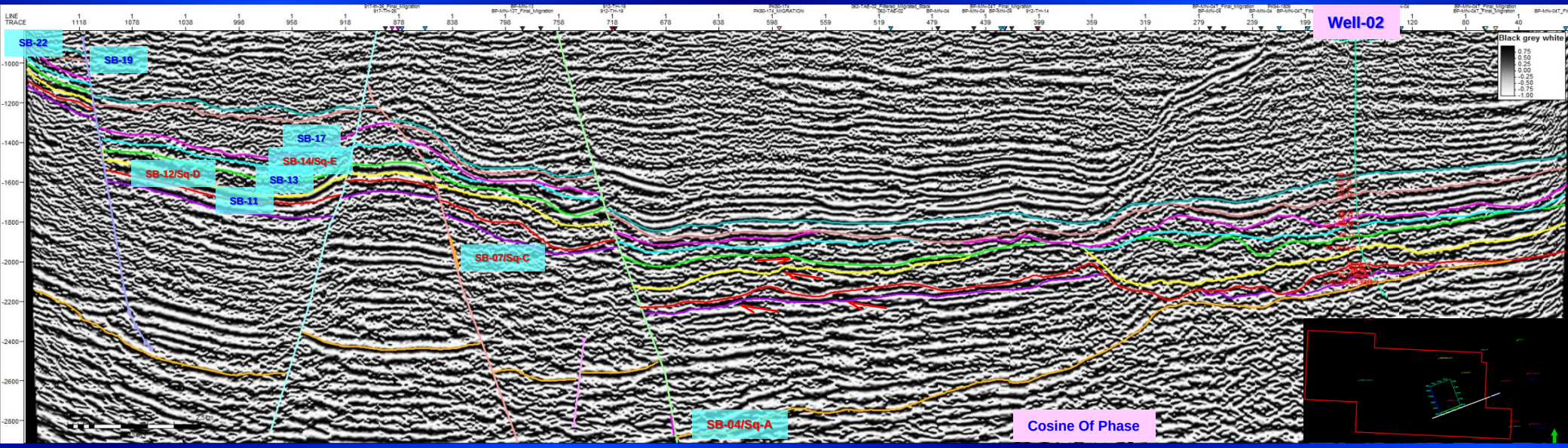
1. Seven third-order seismic depositional sequences were identified and interpreted in the present study.

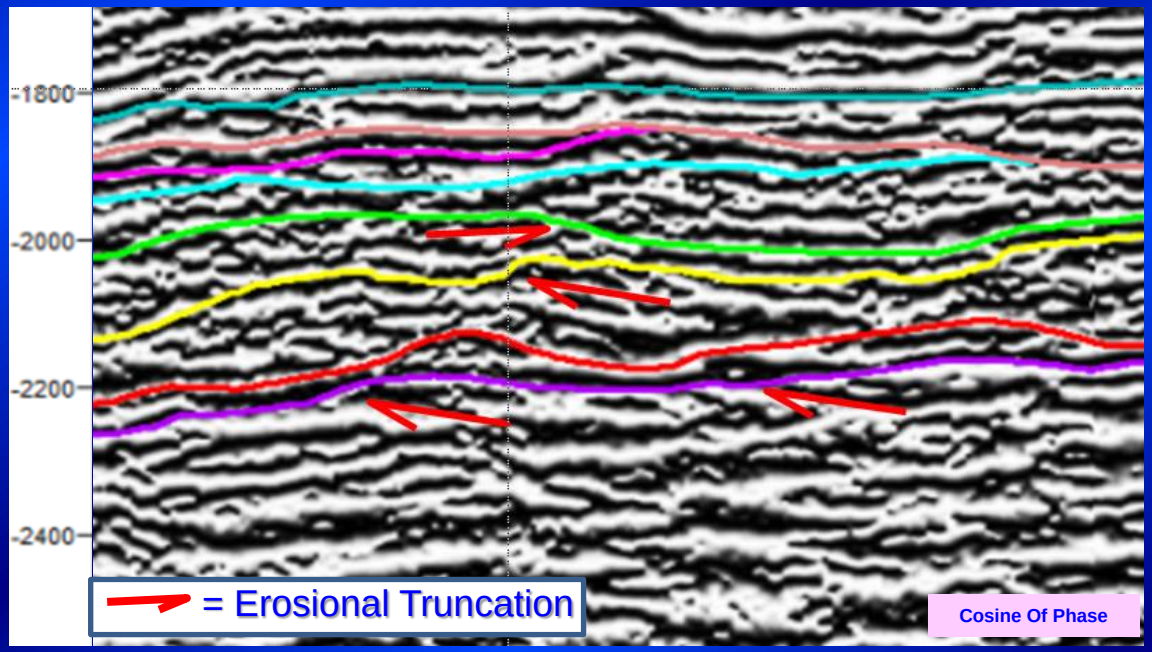
2. Depositional sequences were recognized by picking their lower and upper boundaries based on reflection terminations.

3. These depositional sequences, named Sq-A to Sq-G, are identified with the aid of stratigraphic-indicator attributes, such as Cosine of Phase, in order to better identify reflection terminations and lateral stratal changes.

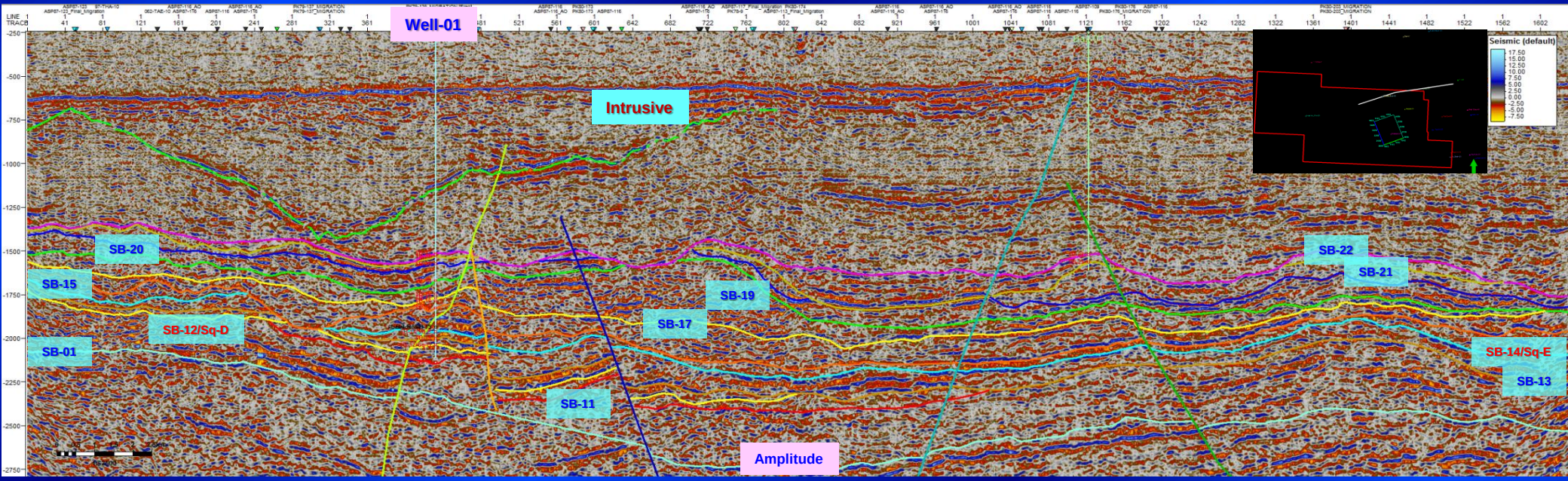
4. Interpreted sequences are used as the main framework for more detailed sequence stratigraphic interpretation.

Line-02


SB-22
SB-19
SB-17
SB-14/Sq-E
SB-12/Sq-D
SB-13
SB-11
SB-07/Sq-C
SB-04/Sq-A
Well-02
Black grey white
Cosine Of Phase


-1800
-2000
-2200
-2400
= Erosional Truncation
Cosine Of Phase

Line-01



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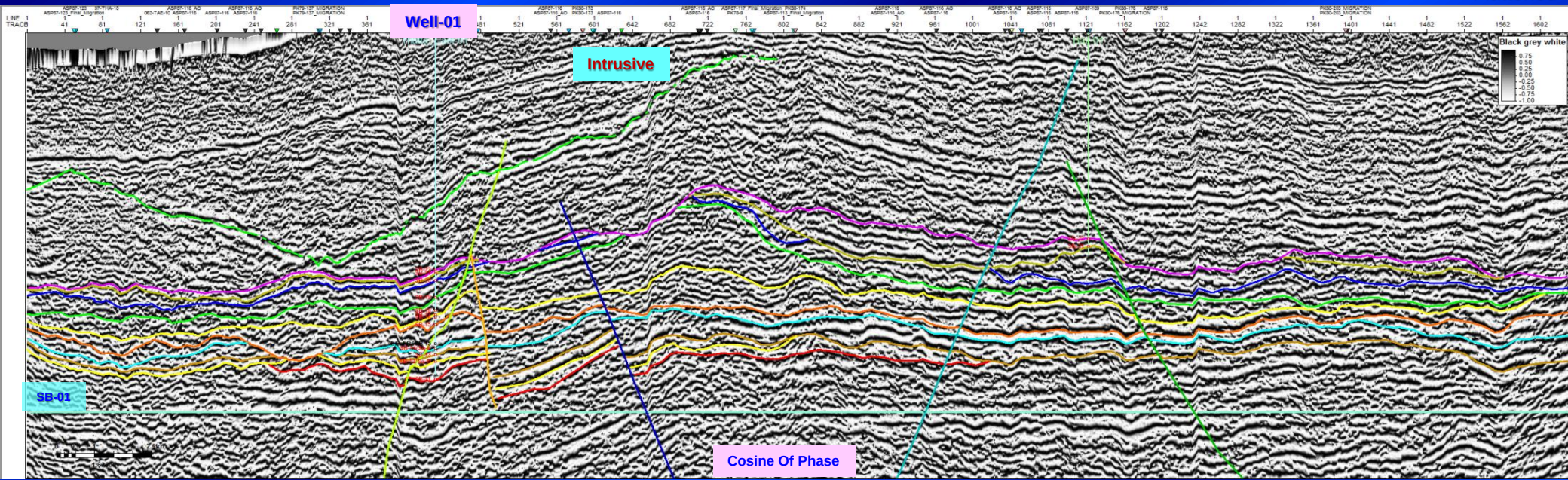
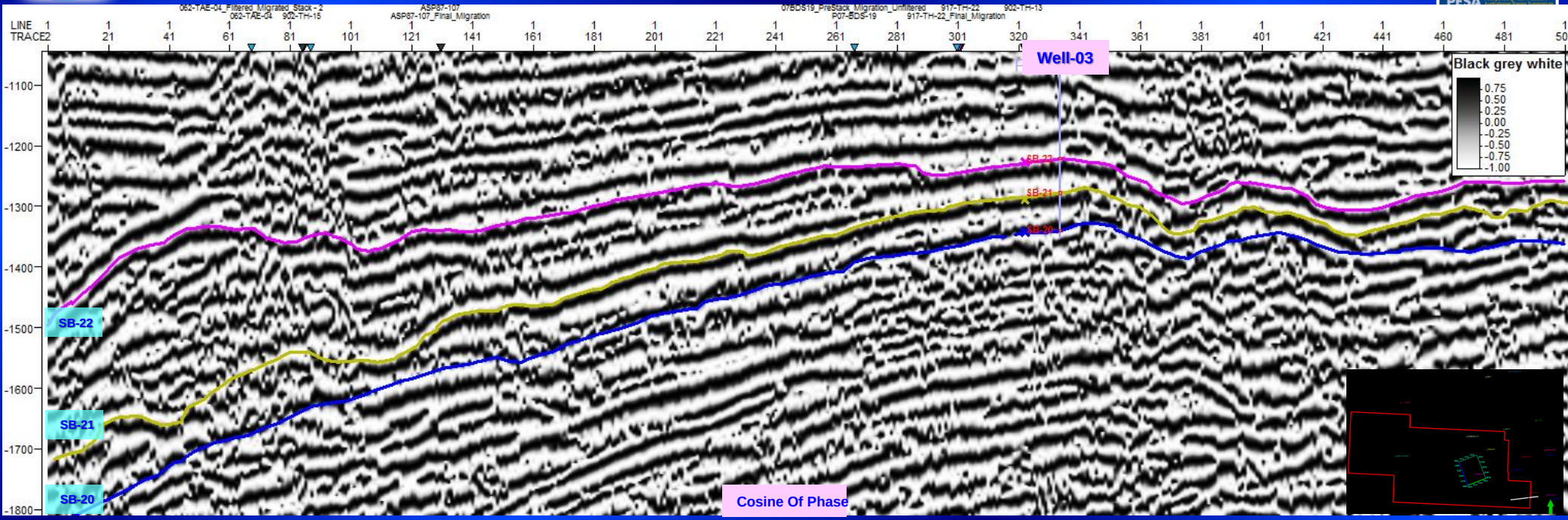


Line-03



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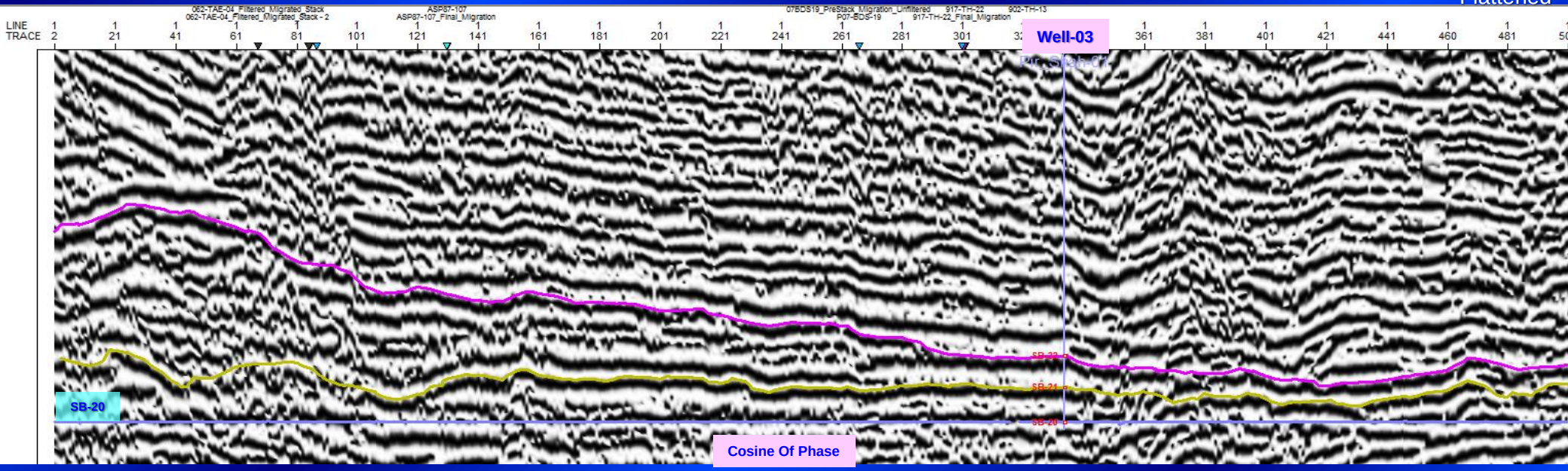
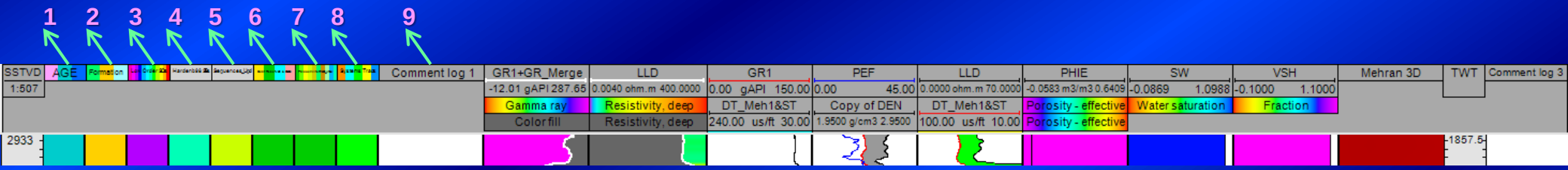


HIGH-RESOLUTION SEQUENCE STRATIGRAPHY - ABBREVIATIONS



1. Geological Age
2. Formation
3. Sequences
4. Hardenbol, 1998 et al., Sequence Boundaries
5. High-Order Sequences
6. Reservoir/Source
7. Depositional Paleoenvironment
8. Systems Tract
9. Absolute Age

KEY TO LOG HEADERS

DEPOSITIONAL PALEOENVIRONMENTS

BSD=Beach Sands

CHS=Channel

DBS=Distal Bar/Shoal & Storm Sands

SBB=Strandplain/Shoreface

SBS=Stacked Offshore Bar/Shoal Sand

SMS=Shelf Mudstones/Siltstones

STB=Stacked Beach Sand

TCH=Tidal Channel

SYSTEMS TRACTS

LNR = Lowstand Normal Regressive Systems Tract.

T = Transgressive Systems Tract.

HNR = Highstand Normal Regressive Systems Tract.

FSST = Falling Stage Systems Tract

CHRONOSTRATIGRAPHIC SURFACES

107.14 Ma — Sequence Boundary (SB)

Transgressive Surface (TRS)

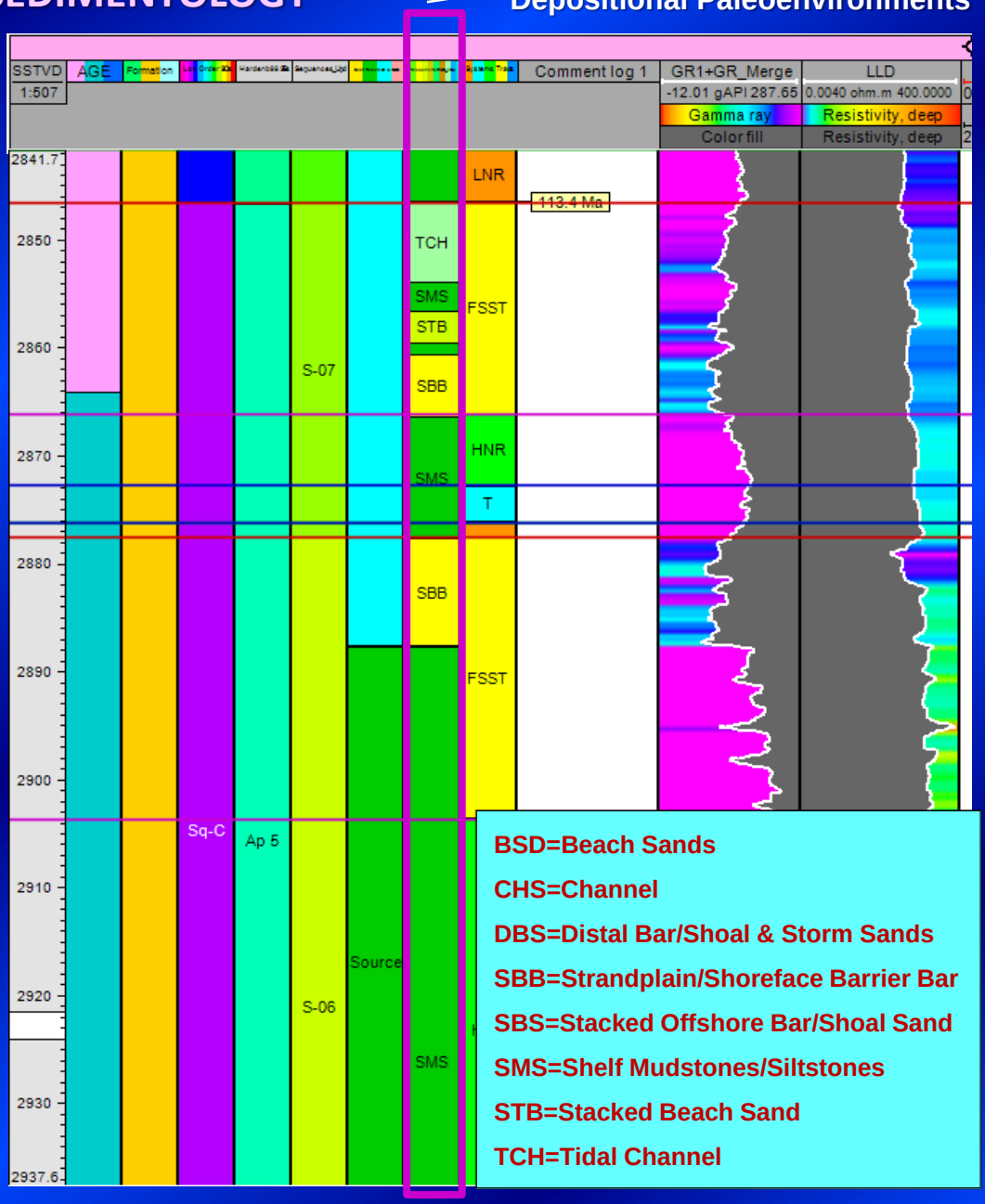
Flooding Surface (FS)

Regressive Surface of Marine Erosion (RSME)

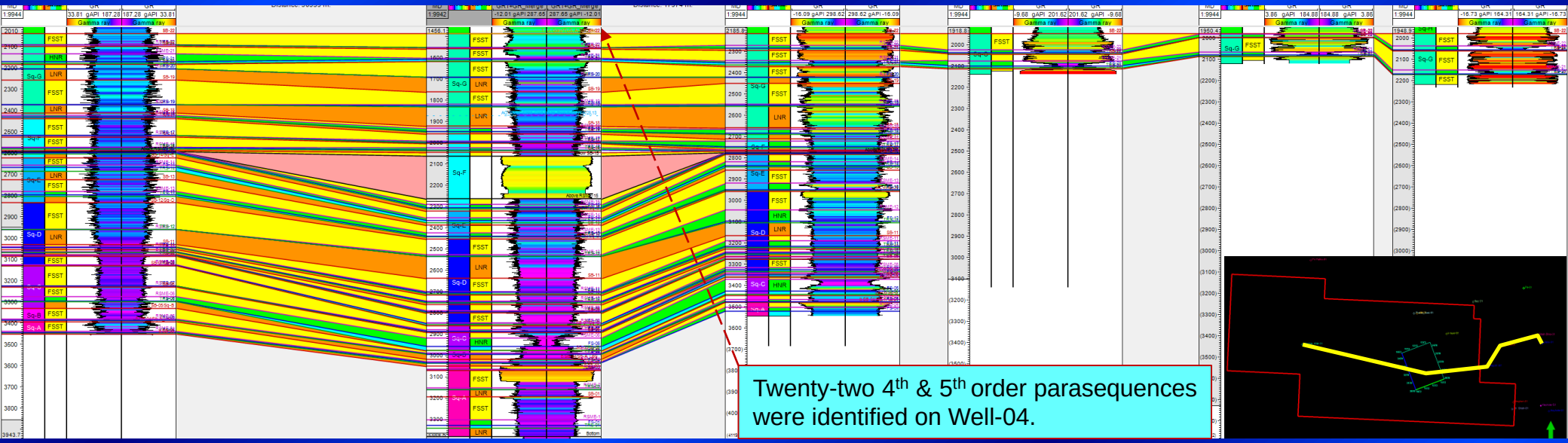
HIGH-RESOLUTION SEQUENCE STRATIGRAPHY

WELL-04 LOG SEDIMENTOLOGY

- Detailed sedimentological interpretation of depositional paleoenvironments was carried out on Well-04.
- Eight depositional paleoenvironments were interpreted from Gamma Ray and Resistivity well log motifs after tying to core data.
- Interpreted depositional paleoenvironments are:
    1. Beach Sands
    2. Channel
    3. Distal Bar/Shoal & Storm Sands
    4. Strandplain/Shoreface Barrier Bar
    5. Stacked Offshore Bar/Shoal Sand
    6. Shelf Mudstones/Siltstones
    7. Stacked Beach Sand
    8. Tidal Channel

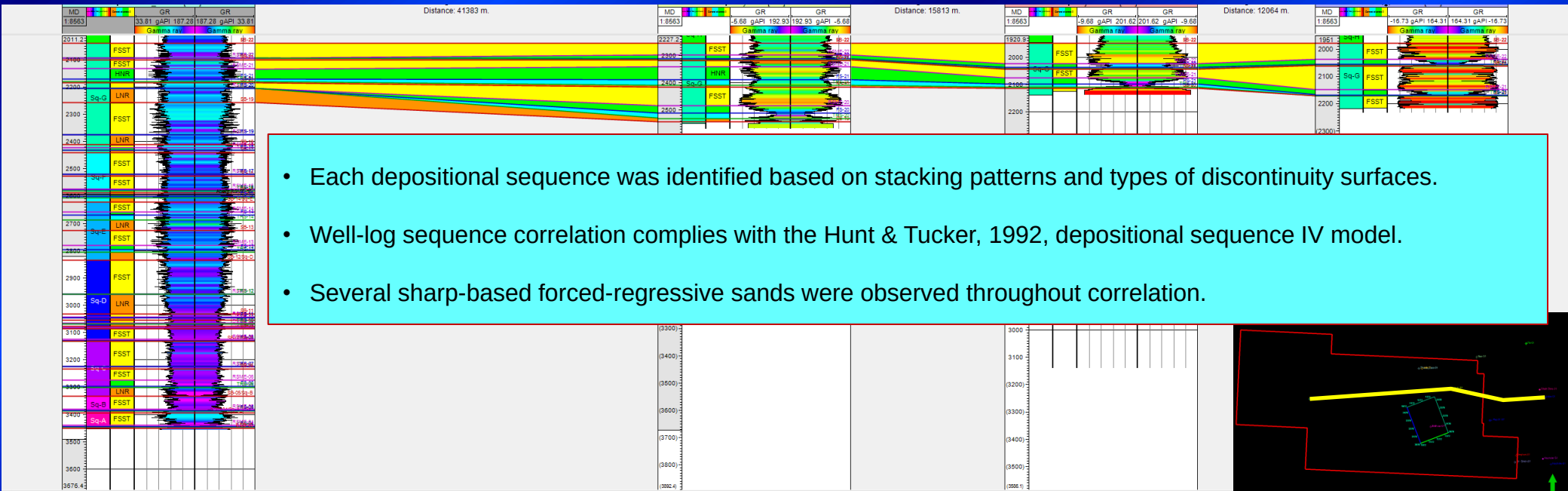


SEQUENCE CORRELATION # 1



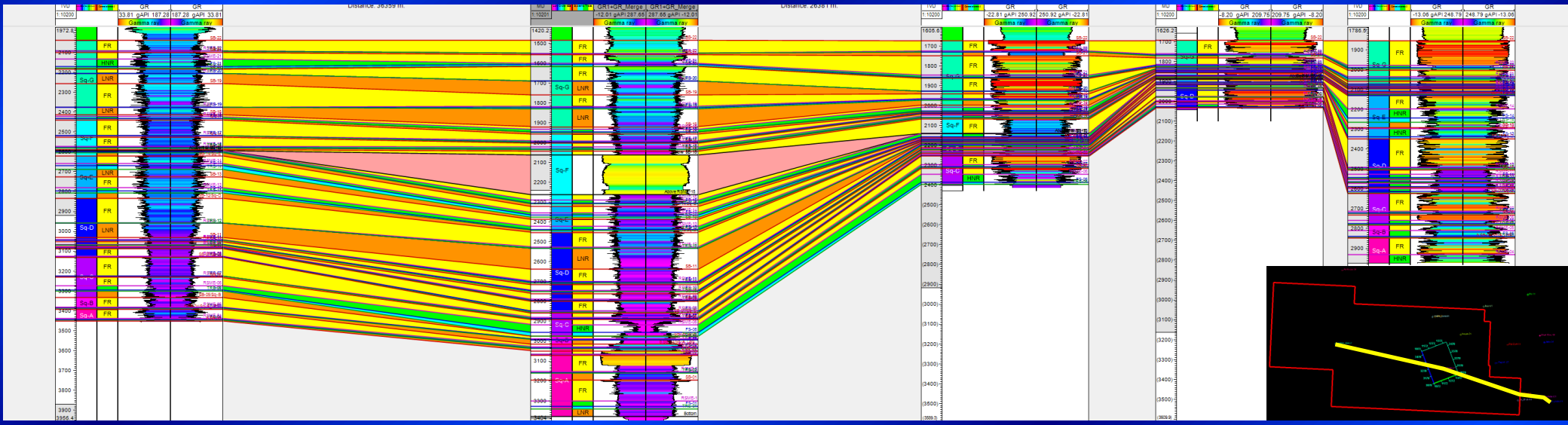
Twenty-two 4th & 5th order parasequences were identified on Well-04.

SEQUENCE CORRELATION # 2

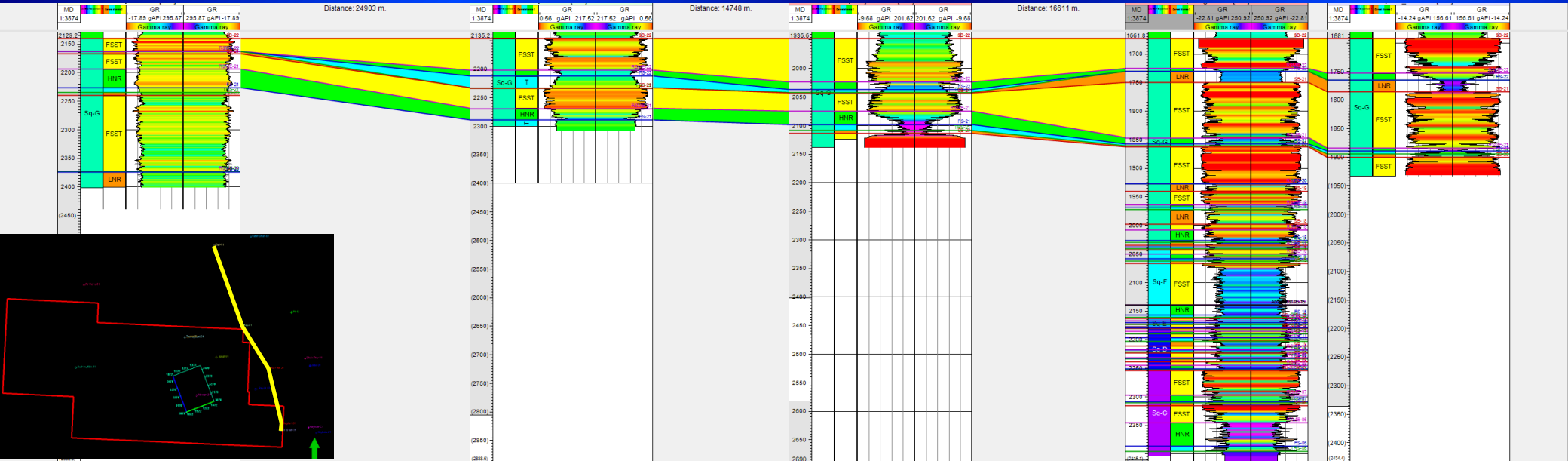


- Each depositional sequence was identified based on stacking patterns and types of discontinuity surfaces.
- Well-log sequence correlation complies with the Hunt & Tucker, 1992, depositional sequence IV model.
- Several sharp-based forced-regressive sands were observed throughout correlation.

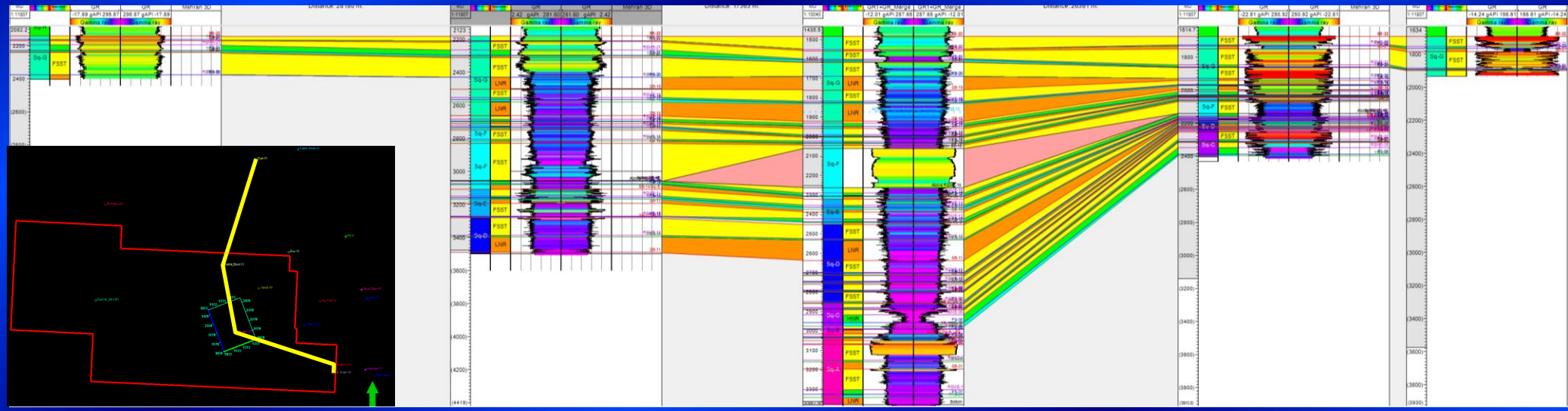
SEQUENCE CORRELATION # 3



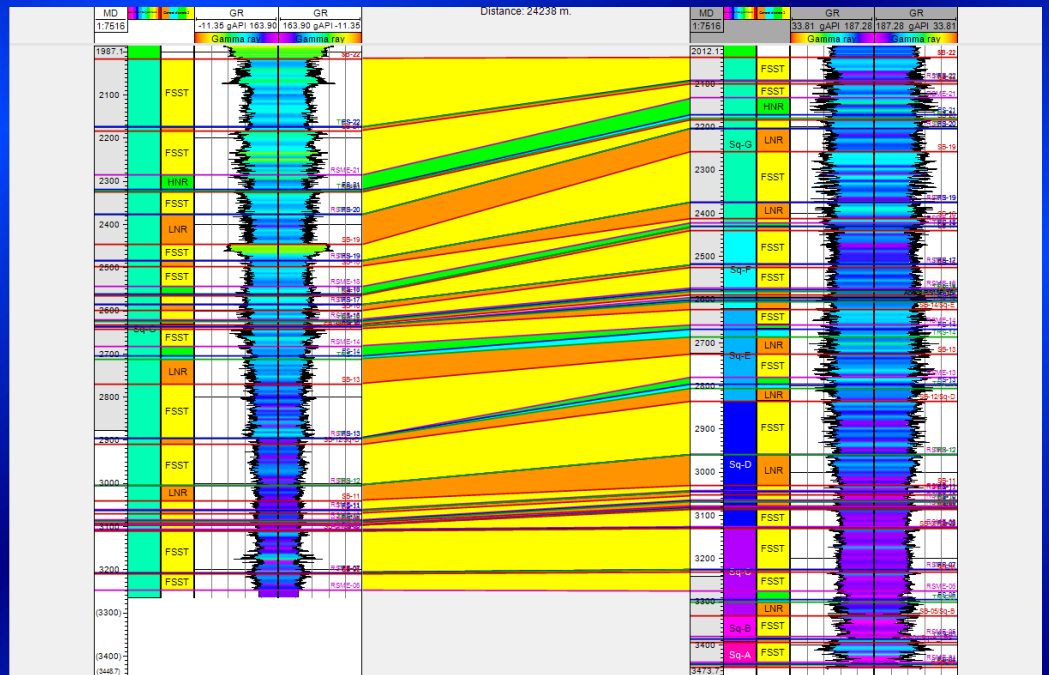
SEQUENCE CORRELATION # 4

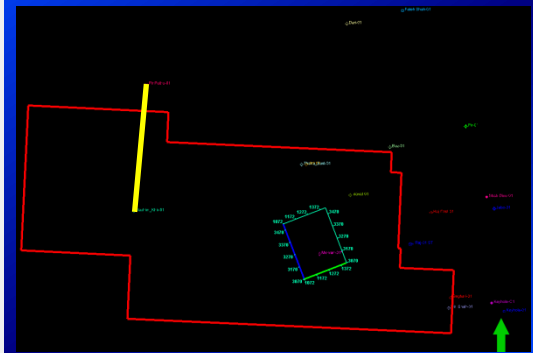


SEQUENCE CORRELATION # 5



SEQUENCE CORRELATION # 6





EXAMPLES

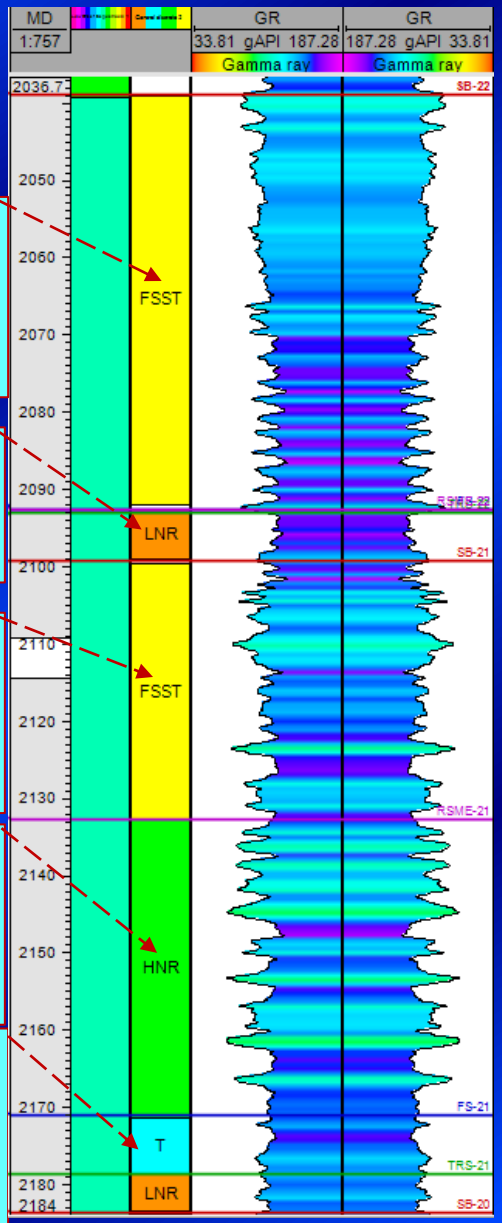
Moderately distal parts of FSST dominated by progradational offshore mudstones & siltstones.

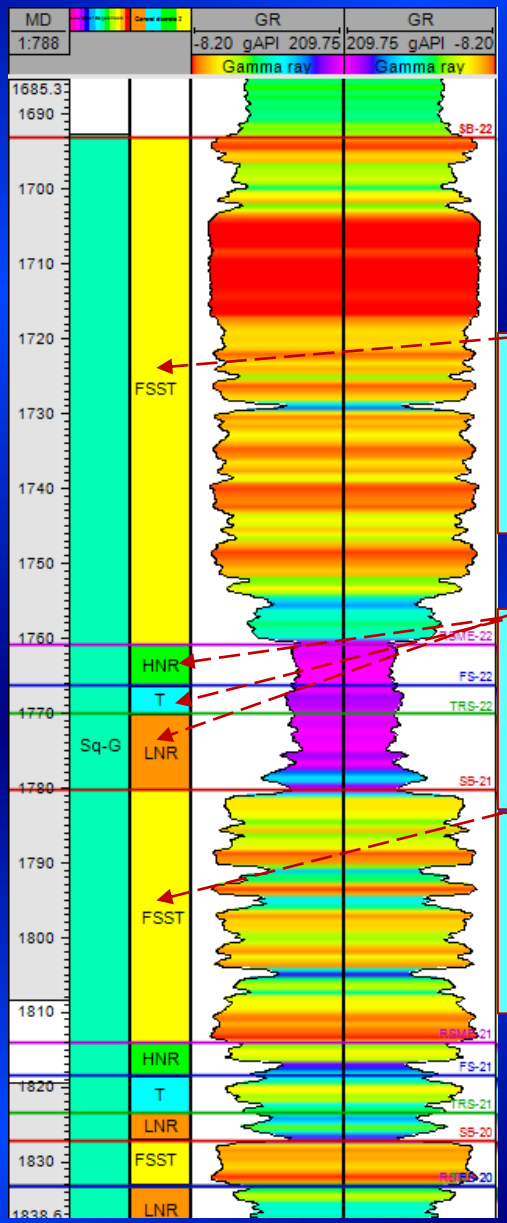
Distal parts of LNR dominated by offshore mudstones.

Moderately distal parts of FSST dominated by offshore mudstones & siltstones.

Moderately distal parts of HNR dominated by offshore mudstones & siltstones.

Moderately distal thin parts of TST dominated by offshore mudstones & siltstones.





Proximal parts of FSST dominated by sharp-based, forced regressive, reservoir sands.

Distal parts of LNR, TST, & HNR dominated by offshore mudstones & siltstones.

Proximal parts of FSST dominated by sharp-based, forced regressive, reservoir sands.

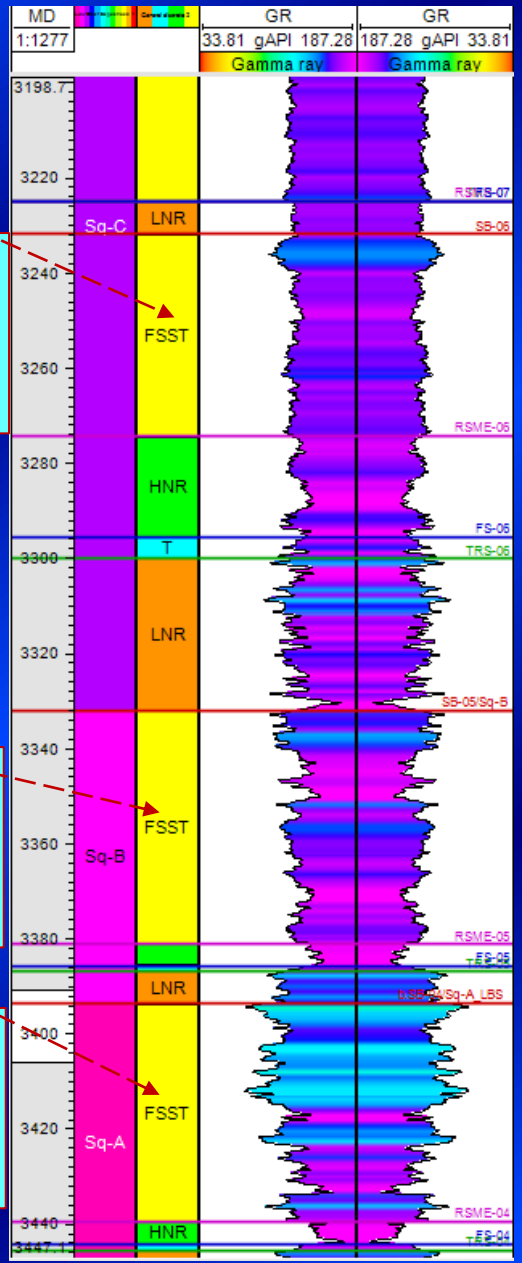
From Sequence Correlation # 3

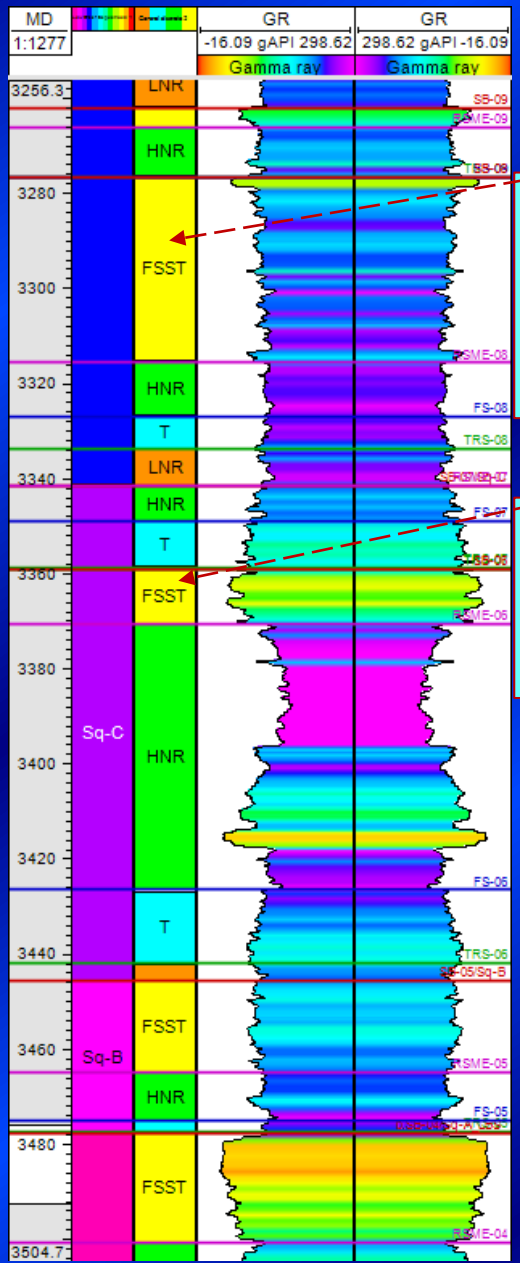
EXAMPLES "cont."

Distal parts of FSST dominated by progradational offshore mudstones & siltstones.

Distal parts of FSST dominated by progradational offshore mudstones & siltstones.

Moderately distal parts of FSST dominated by progradational offshore mudstones & siltstones.





Distal parts of FSST dominated by progradational offshore mudstones, siltstones, and thin shoreface sands.

Moderately proximal parts of FSST dominated by thin, sharp-based, forced regressive, sands.

From Sequence Correlation # 1

SEISMIC FACIES

1. Depositional setting, sedimentary processes and lithofacies distribution are predicted after integration with well data within a chronostratigraphic framework.

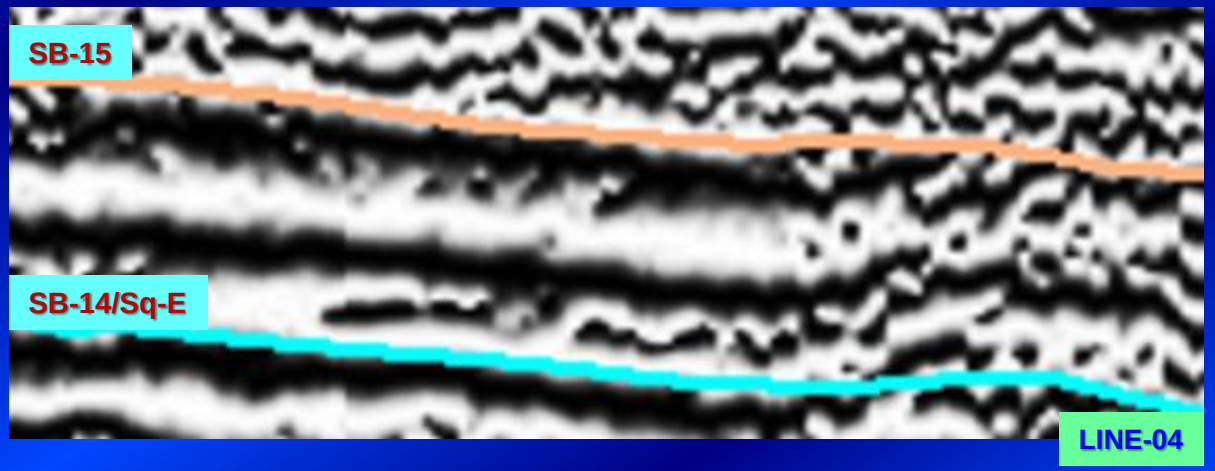
2. Reflection configuration revealed the gross stratification pattern which is governed by geometry and position of the layers that are linked to depositional processes.

3. Reflection continuity indicated the spatial spreading of homogeneous depositional processes.

4. External geometry and areal association of seismic facies units indicated the depositional environments, as well as the location and the direction of sediment supply.

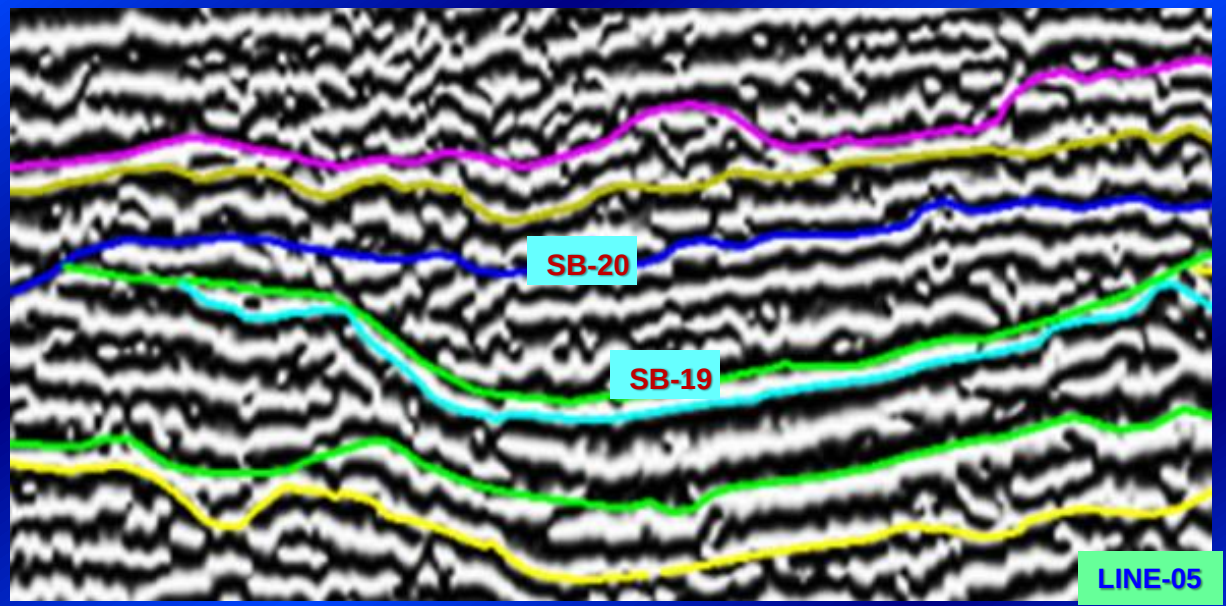
SEISMIC FACIES-01

- Sheet to wedge external geometry.
- Parallel to wavy internal reflection configuration.
- High reflection continuity.
- Moderate to high amplitude strength (amplitude sections).



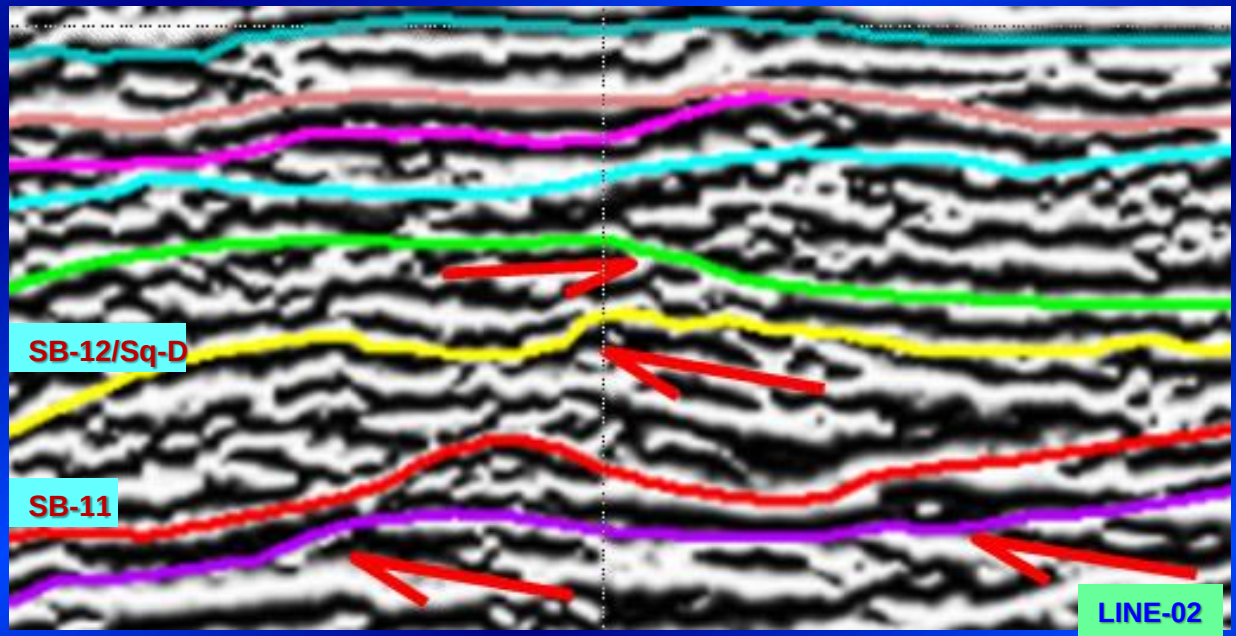
SEISMIC FACIES-02

- Sheet to wedge external geometry.
- Parallel to wavy internal reflection configuration.
- Sub-continuous to high reflection continuity.
- Moderate to high amplitude strength.
- Indicates uniform sedimentation conditions.
- It may indicate cross bedding and prograding bar delta system.
- High-amplitude parts indicate sand/shale acoustic impedance contrasts.
- Low-amplitude parts indicate interfaces of more similar lithology, such as sand/silty shale.
- High-continuity parts indicate high lateral extent of similar sedimentation conditions, in contrast to low-continuity reflections.



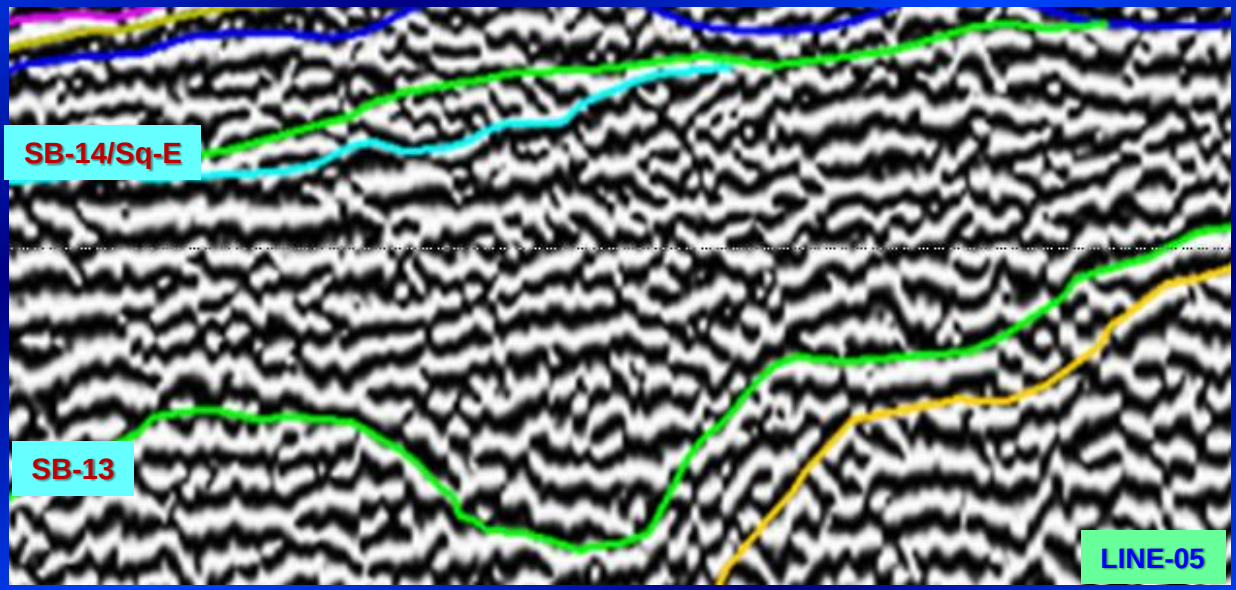
SEISMIC FACIES-03

- Sheet to mounded external geometry.
- Wavy to hummocky internal reflection configuration.
- Disrupted to discontinuous reflection continuity.
- Moderate to high amplitude strength.
- May indicate presence of cut-and-fill geometries (mostly resulting from channelized deposits) and/or contorted bedding.



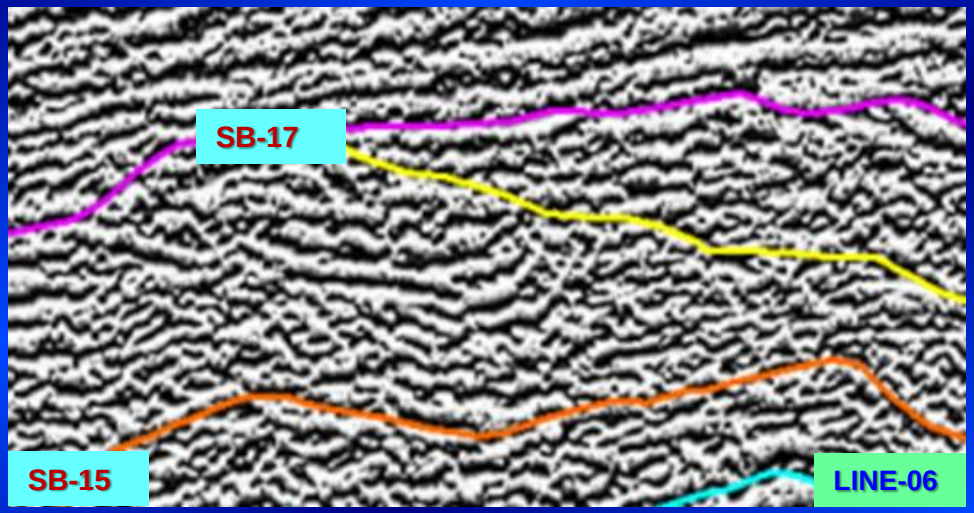
SEISMIC FACIES-04

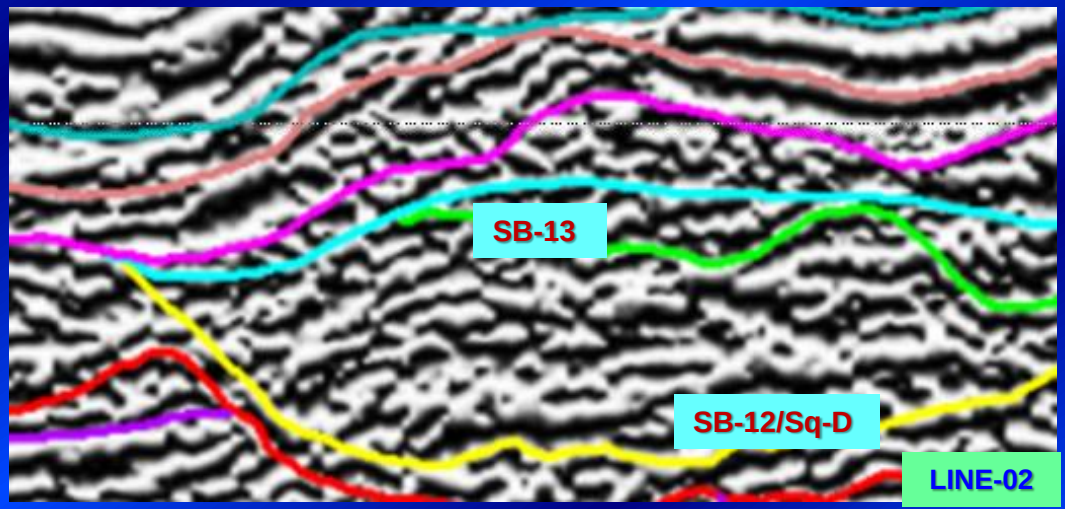
- Sheet to wedge external geometry.
- Parallel to sub-parallel reflection configuration.
- Sub-continuous to disrupted reflection continuity.
- Low to moderate amplitude strength.



SEISMIC FACIES-05

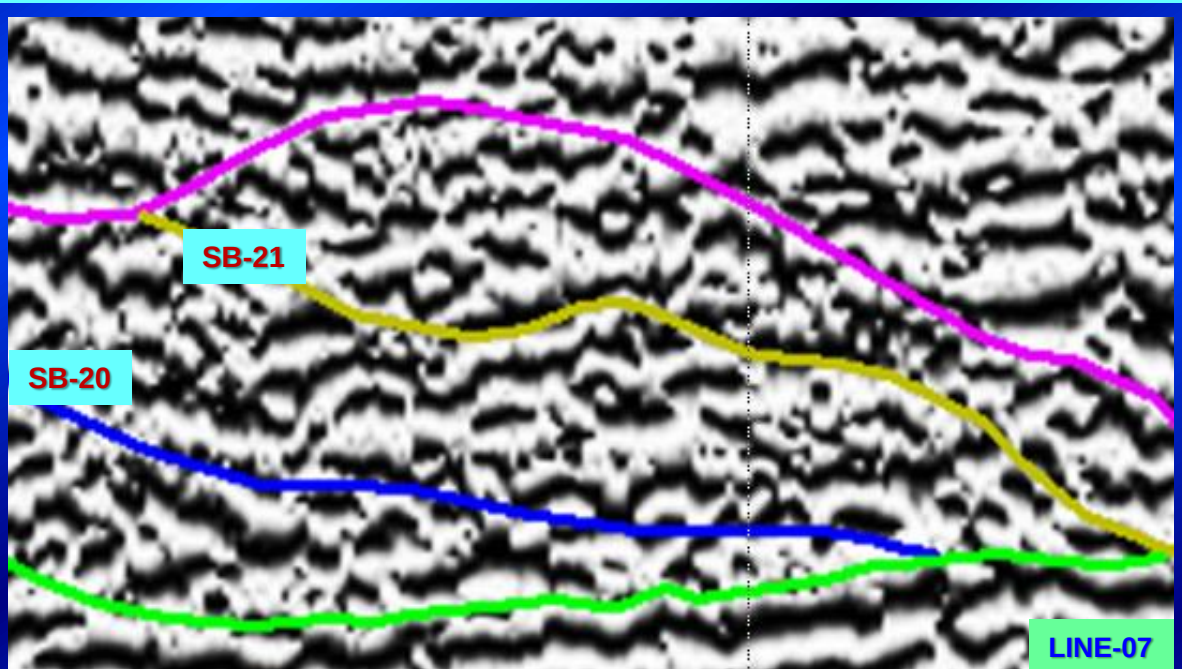
- Lens to wedge external geometry.
- Sub-parallel to convergent to oblique reflection configuration.
- Sub-continuous to continuous reflection continuity.
- Low to moderate amplitude strength.
- Shows asymmetric sediment thickness distribution with a wedge-shaped sediment body, which may be due to changes in rate of sediment supply, subsidence rate, and/or differential compaction.
- Syn-depositional tectonic movements may be indicated by the divergent geometry.





SEISMIC FACIES-06

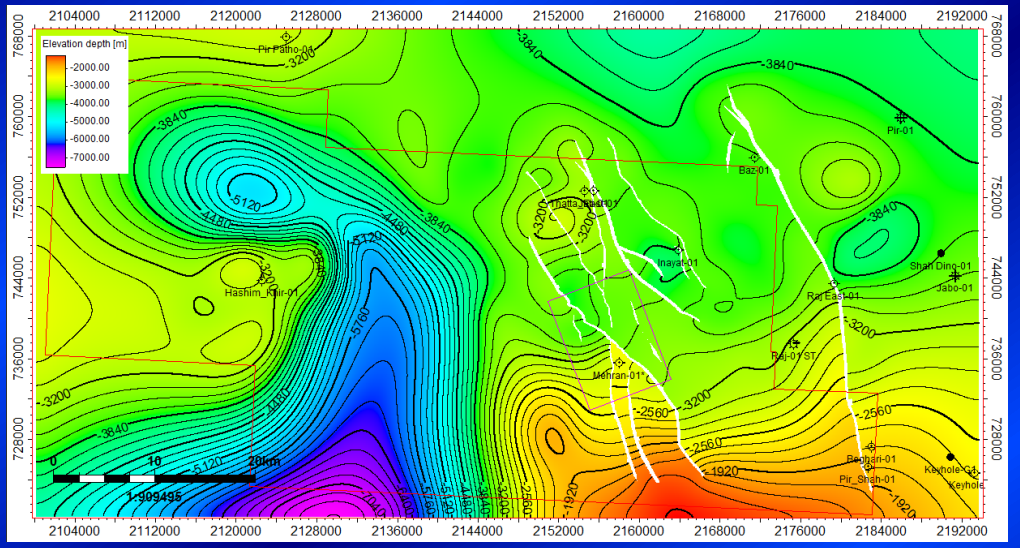
- Lens to concave external geometry.
- Wavy to chaotic reflection configuration.
- Discontinuous reflection continuity.
- Low to moderate amplitude strength.
- The discontinuous character indicates highly disordered internal organization of the deposits that may be associated with channel fills or over-pressured shales.



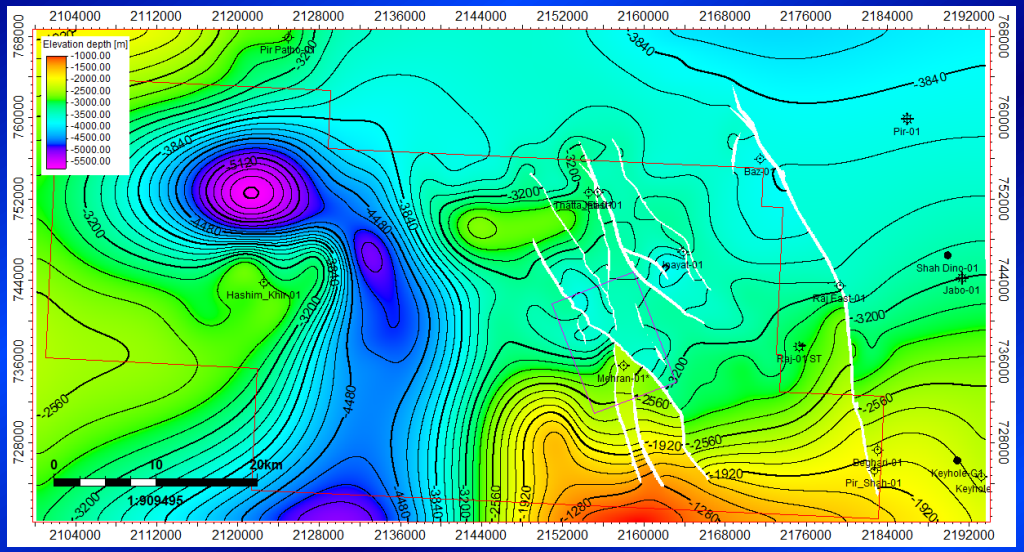
SEQUENCE MAPPING

- Mapping was carried out on amplitude and phase attributes that gave better definition for stratigraphic and structural features than the reflectivity lines alone.
- Regional sequence structural maps were created, each represents an interpreted sequence.
- Isochore maps between interpreted sequences were created to outline parts of thickening, some of which are associated with differential compaction associated with forced-regressive sand reservoirs.
- Color-corded isochore maps were created, with overlays of structural contours for outlining possible subtle traps.
- Areas of erosion or non-deposition were outlined at each sequence level, resulting in the reduction of uncertainties.

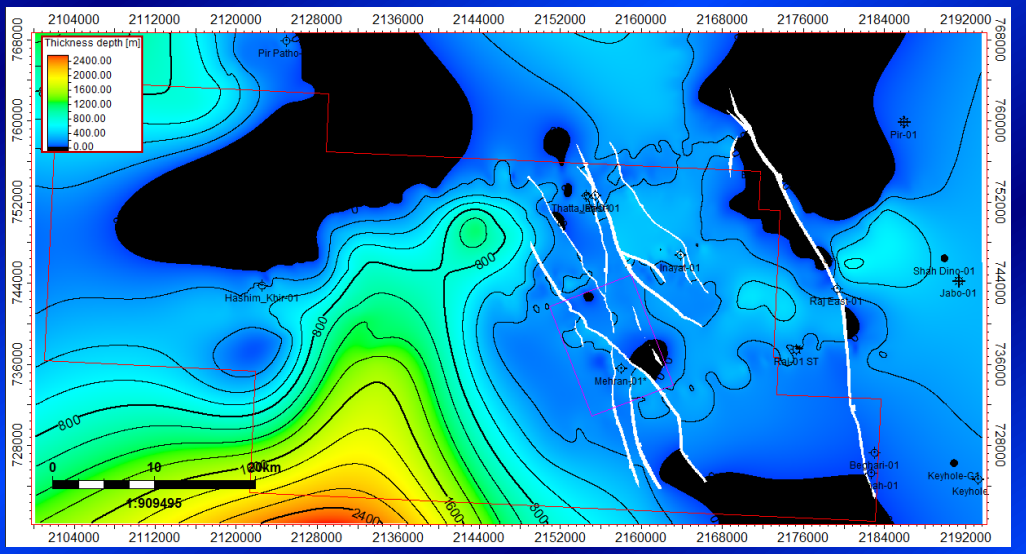
SB-11 SEQUENCE STRUCTURAL MAP



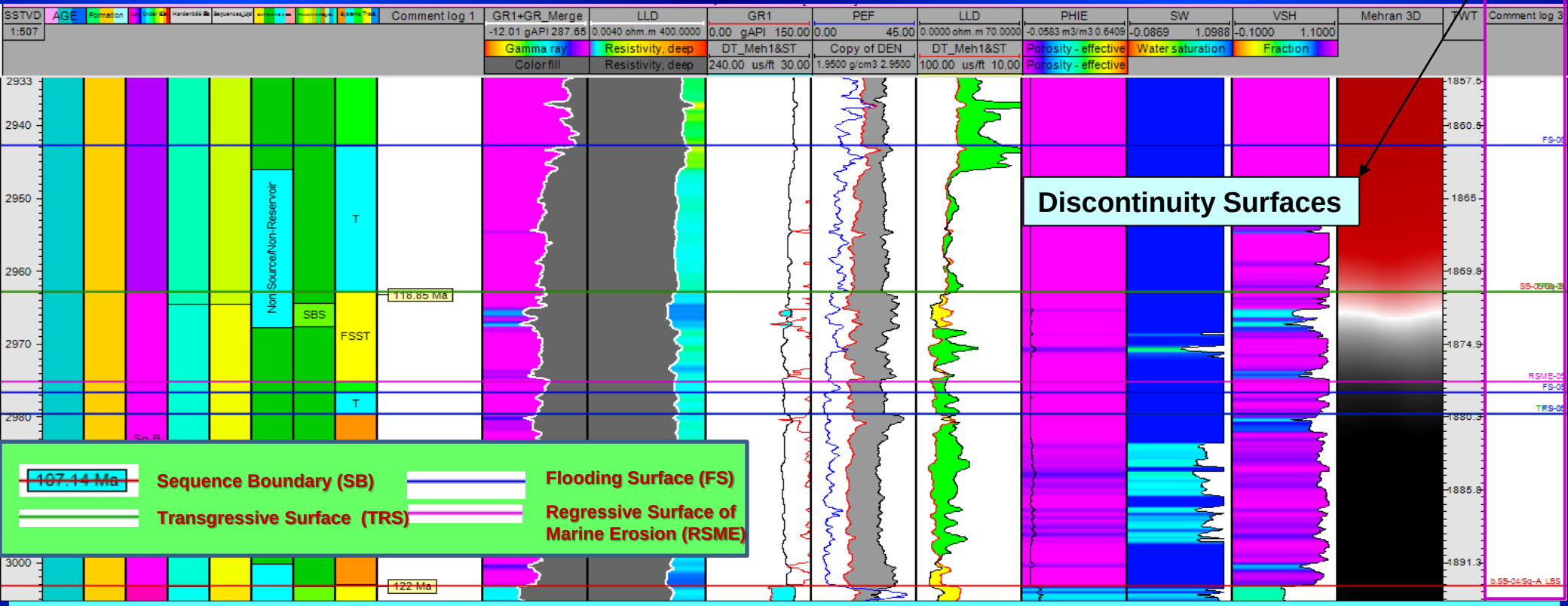
SB-12/Sq-D SEQUENCE STRUCTURAL MAP



SB-11 to SB-12/Sq-D SEQUENCE ISOCHORE MAP



INTERPRETED DISCONTINUITY SURFACES, WELL-04



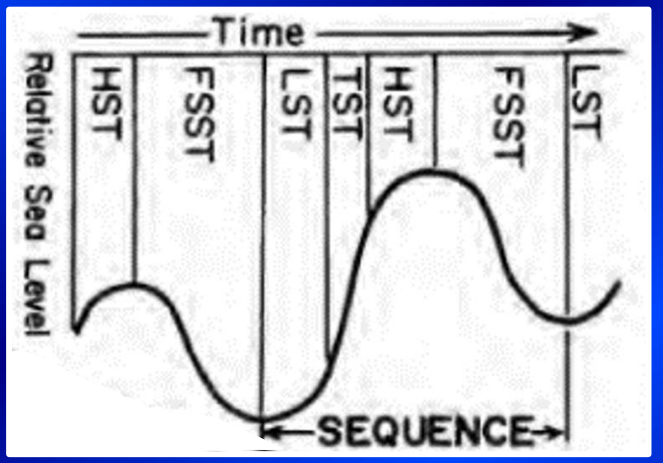
1. Subaerial Unconformities/Sequence Boundaries (SB) “of Sloss et al., 1949”.
   - Underlain by a falling stage systems tract and overlain by normal regressive lowstand systems tract.
2. Regressive Surfaces of Marine Erosion (RSME) “of Plint, 1988”.
   - Underlain by a normal regressive highstand systems tract and is overlain by a falling stage systems tract.
3. Transgressive Ravinement Surfaces (TRS) “Galloway, 2001”.
   - Underlain by a normal regressive lowstand systems tract and is overlain by a transgressive systems tract.
4. Flooding Surfaces (FS) “of Van Wagoner et al., 1990”.
   - Underlain by a transgressive systems tract and is overlain by a normal regressive highstand systems tract.

4. RESULTS INTEGRATION

IDENTIFIED SYSTEMS TRACTS

A. Falling Stage Systems Tract (FSST):

- Resulting from relative sea-level fall (negative accommodation), forcing the coast line to regress independently from sediment supply effects.
- During this negative accommodation time, where subaerial exposure & erosion occurred, progradation occurred in the basinward direction of the depositional system, resulting in the forced regressive deposits.
- Characterized by sharp-based shoreface deposits.



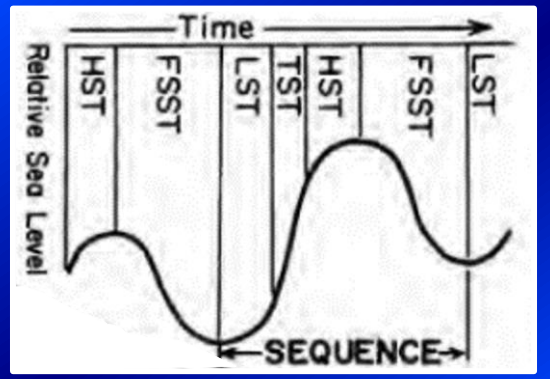
- The stratigraphic succession is foreshortened (Posamentier & Morris, 2000).
- Forced regressive clastics are known to be attractive exploration targets in the study area.
- The interplay between rate of relative sea-level fall, rate of sediment supply, and depositional profile gradient play an important role in whether the resultant deposits will be of an attached or detached architecture.

B. Lowstand and Highstand Normal Regressive Systems Tracts (LNR "LST"/HNR "HST"):

- Resulted from positive and overfilled accommodation, with sediment supply as the main driver during relative sea-level rise, either before or after transgression.

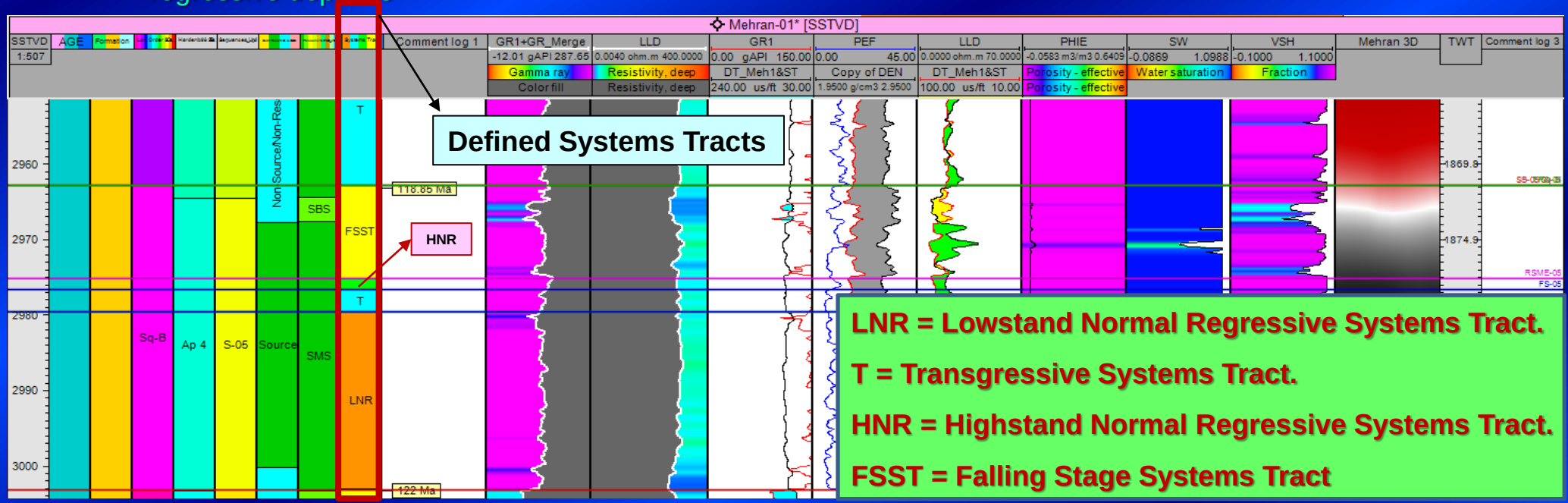
IDENTIFIED SYSTEMS TRACTS "CONT."

- In case of LNR "LST", progradation rate decreased with time, while aggradation rate increased with time, resulting from acceleration of rate of accommodation creation.
- In case of HNR "HST", progradation rate increased with time, while aggradation rate decreased with time, resulting from deceleration of rate of accommodation creation.

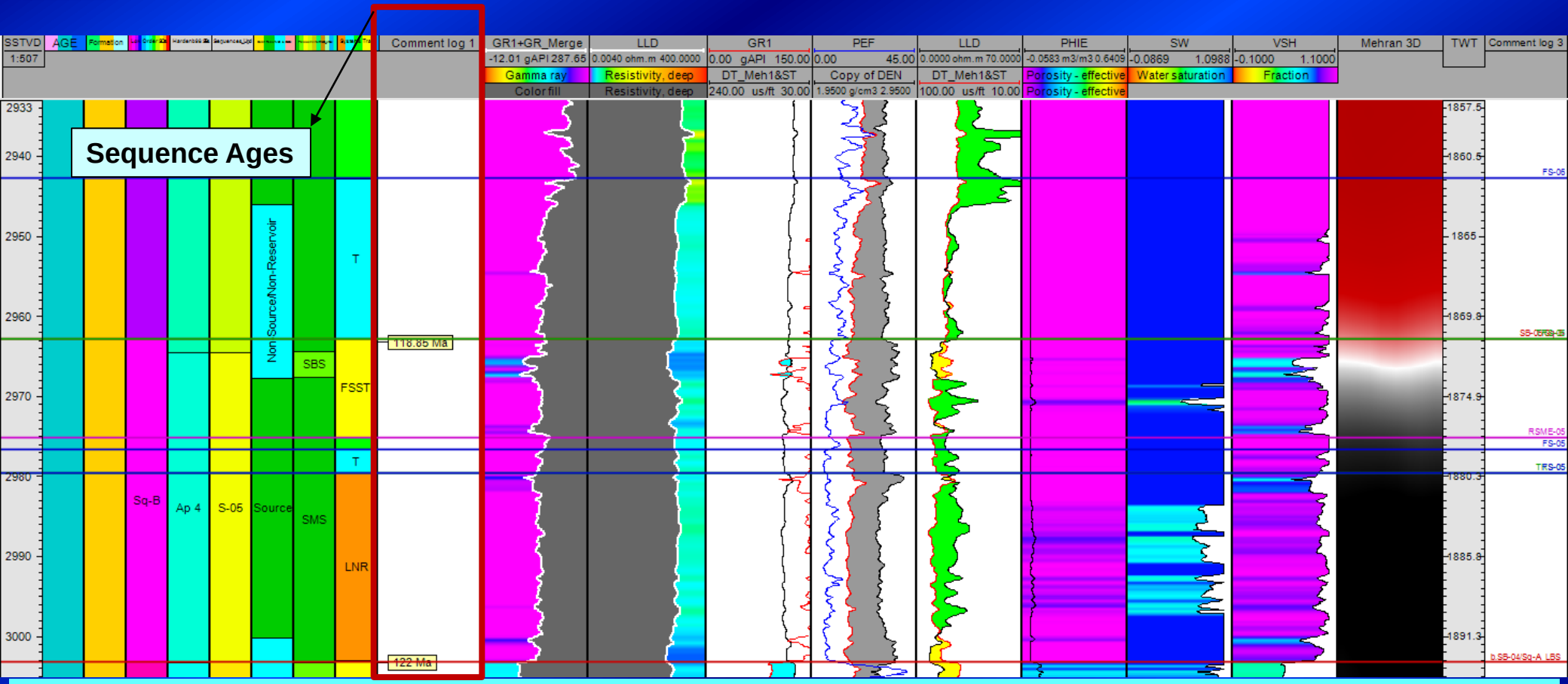


C. Transgressive Systems Tract:

- Resulted from relative sea-level rise (positive and underfilled accommodation).
- Sediment starvation occurred in the shallow marine environment (Loutit et al., 1988; Van Wagoner et al., 1990), resulting in the accumulation of fine-grained clastics over relatively longer time than equivalent regressive deposits.

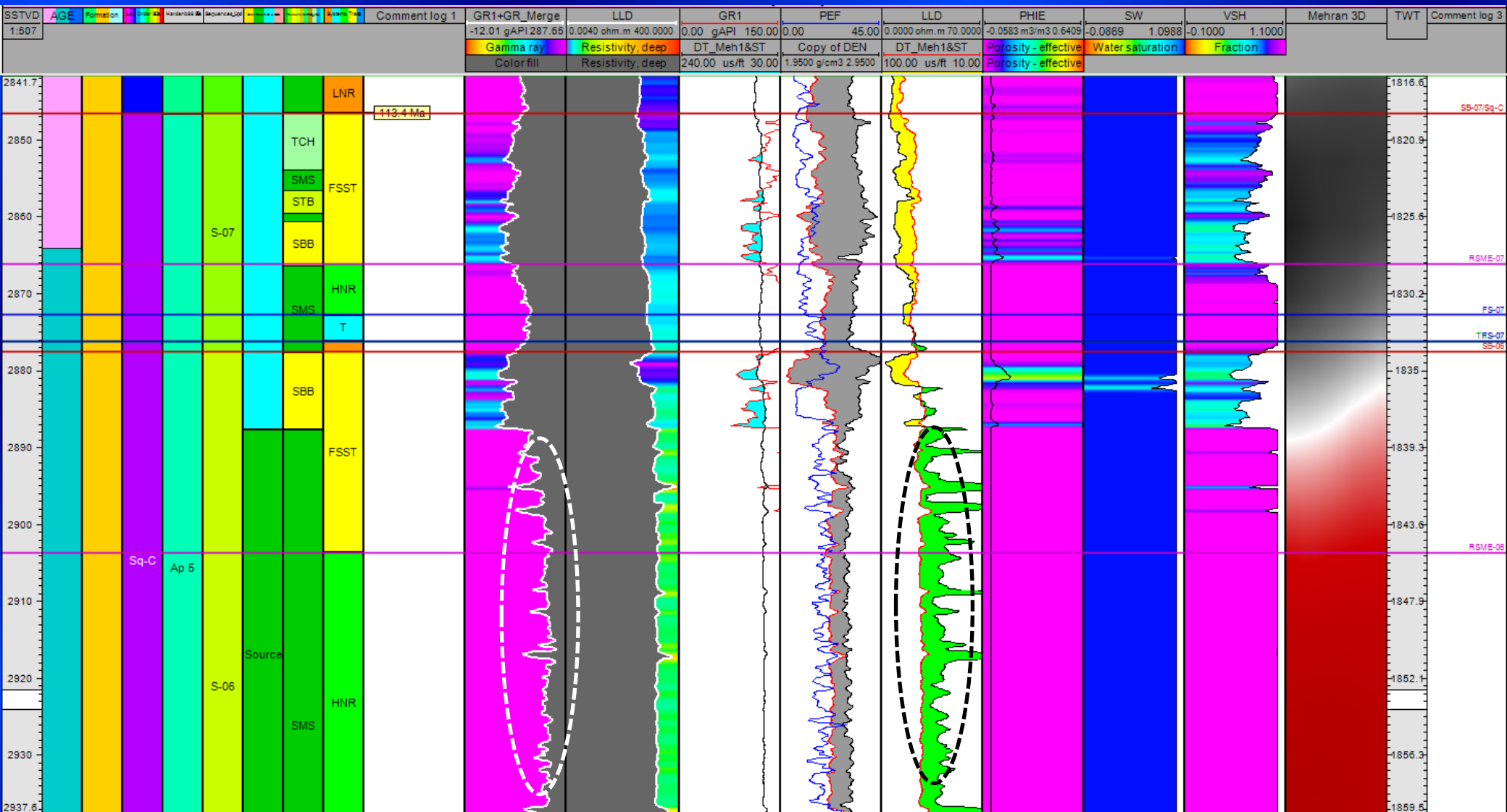


SEQUENCE AGE-DATING, WELL-04

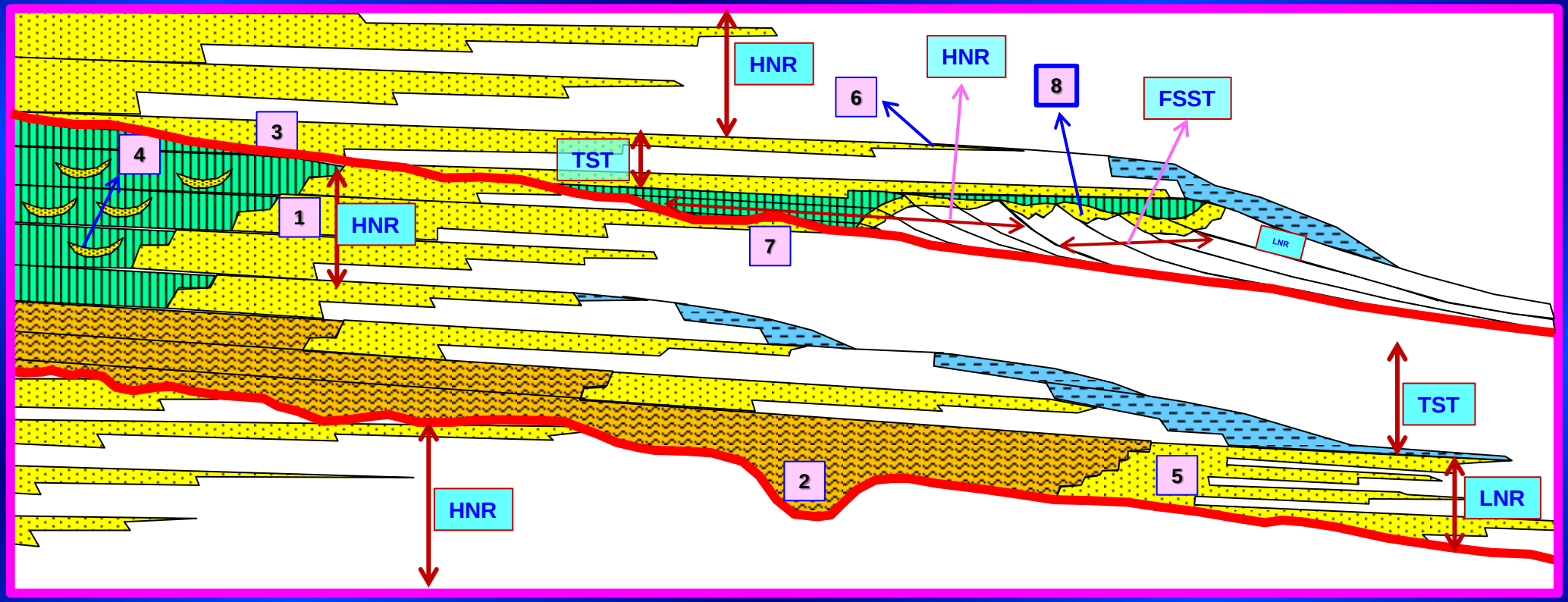


- Absolute ages, in millions of years from the present, were assigned to depositional sequences.
- Approximate age-dating was based, in part, on available biostratigraphic reports, and in part, on tying interpreted sequence boundaries to global sequences of Hardenbol et al., 1998.
- Sequence age-dating constitutes a critical part of the establishment of chronostratigaphic history of the study area.
- Amount of time gaps between interpreted sequences laterally vary throughout the study, but these gaps are less common basinwards as indicated from correlation and seismic sequence analysis.

WELL-04 SOURCE & RESERVOIR ROCK INTERPRETATION FROM WELL LOGS



DEPOSITIONAL MODEL WITHIN SEQUENCE STRATIGRAPHIC FRAMEWORK, with IDENTIFIED STRATIGRAPHIC TRAP TYPES



Sequence Boundary

1 Stratigraphic Trap Type

Shallow Marine Sandstones

Shelf Mudstones

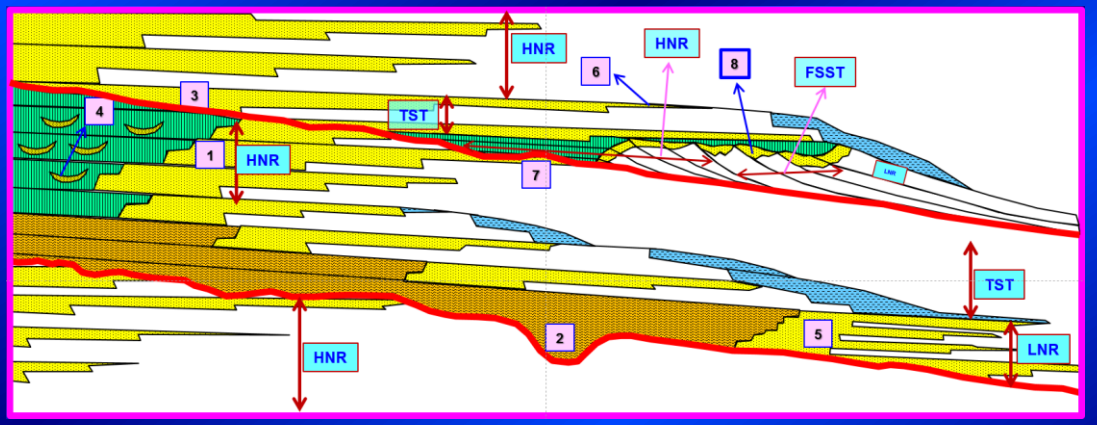
Fluvial/Estuarine Incised Valley Sandstones & Mudstones

Coastal Plain Sandstones & Mudstones

Organic-Rich Shales & Carbonates

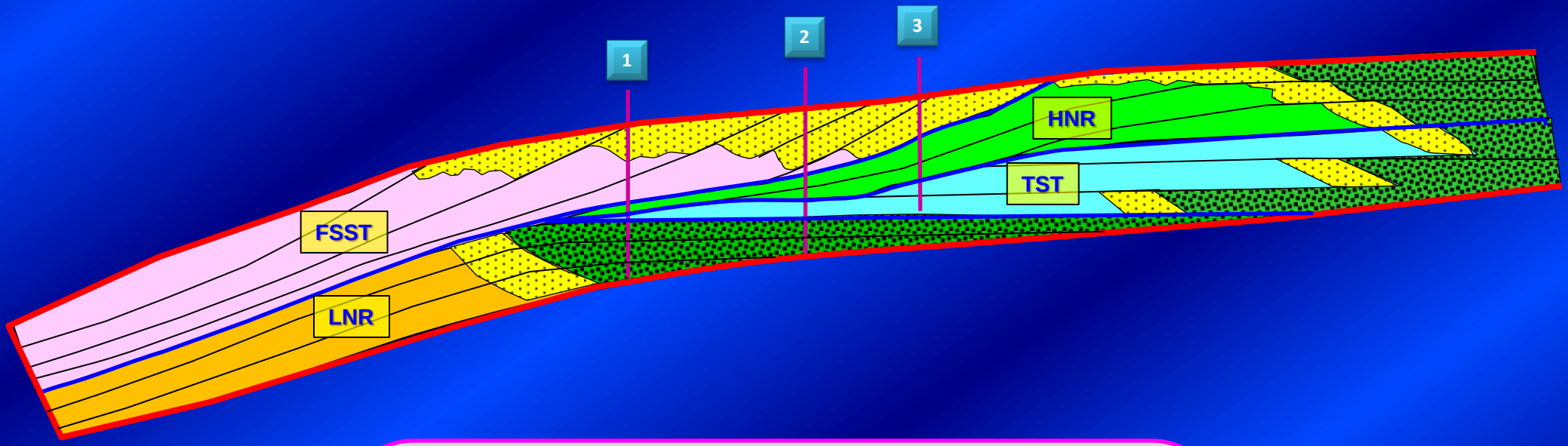
PREDICTIVE DEPOSITIONAL MODEL WITHIN SEQUENCE STRATIGRAPHIC FRAMEWORK, with IDENTIFIED STRATIGRAPHIC TRAP TYPES

1. HNR Updip Pinchout:
   - Beach to deltaic sandstone reservoirs.
   - Coastal plain mudstone seals.
2. Incised Valley:
   - Braided stream to estuarine sandstone reservoirs.
   - Shelf mudstone seals.
3. Onlap:
   - Beach, deltaic, estuarine, or sub-tidal to tidal flat sandstone reservoirs.
   - Shelf mudstone seals.
4. Isolated Channels:
   - Distributary channel sand reservoirs.
   - Coastal/delta plain mudstone seals.
5. LNR Updip Pinchout:
   - Estuary mouth sand plug reservoirs.
   - Central basin estuarine mudstone seals.
6. Downdip Pinchout:
   - Deltaic, beach, or sub-tidal sandstone reservoirs.
   - Shelf mudstone seals.
7. Erosional Truncation:
   - Beach or deltaic sandstone reservoirs.
   - Shelf mudstone and coastal/deltaic plain mudstone seals.
8. Detached Sand Bodies:
   - Detached, sharp-based sand reservoirs of the Falling Stage Systems Tract.
   - Shelf and coastal plain mudstone seals.



PREDICTIVE DEPOSITIONAL SEQUENCE MODEL SECTIONS WITHIN THE STUDY AREA

Depositional Sequence Model and Facies Architecture of SB-04 Sequence

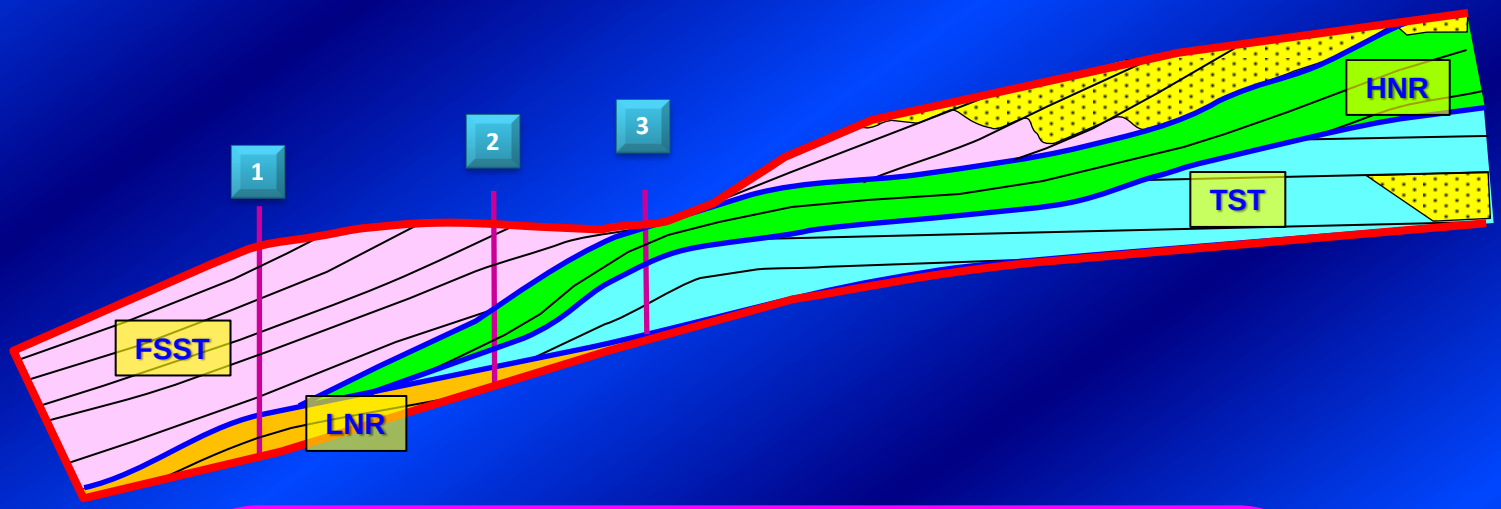


- Sequence Boundary
- Systems Tract Boundary
- Lowstand Normal Regressive Systems Tract (LNR) Shelf Mudstones
- Transgressive Systems Tract (TST) Shelf Mudstones
- Highstand Normal regressive systems Tract (HST) Shelf Mudstones
- Falling Stage Systems Tract (FSST) Shelf Mudstones
- Shallow Marine Sandstones
- Shelf Mudstones
- Coastal Plain Sandstones & Mudstones

1. Well-05
2. Well-04
3. Well-02

PREDICTIVE DEPOSITIONAL SEQUENCE MODEL SECTIONS WITHIN THE STUDY AREA

Depositional Sequence Model and Facies Architecture of SB-07 Sequence

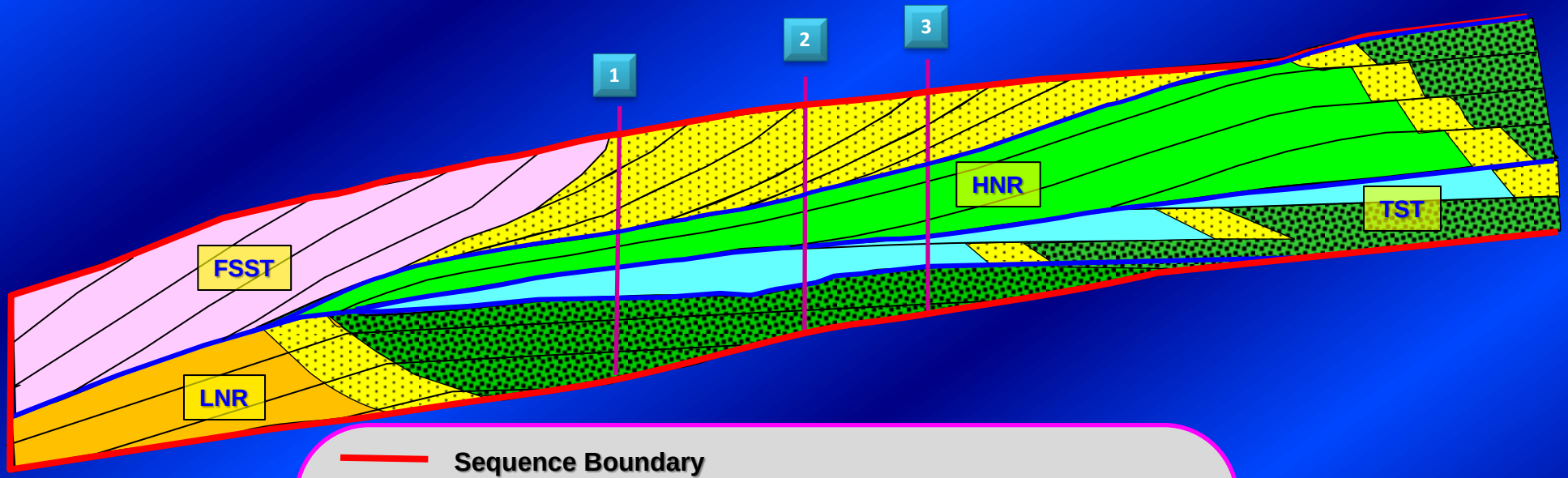


- Sequence Boundary
- Systems Tract Boundary
- Lowstand Normal Regressive Systems Tract (LNR) Shelf Mudstones
- Transgressive Systems Tract (TST) Shelf Mudstones
- Highstand Normal regressive systems Tract (HST) Shelf Mudstones
- Falling Stage Systems Tract (FSST) Shelf Mudstones
- Shallow Marine Sandstones
- Shelf Mudstones
- Coastal Plain Sandstones & Mudstones

1. Well-05
2. Well-04
3. Well-02

PREDICTIVE DEPOSITIONAL SEQUENCE MODEL SECTIONS WITHIN THE STUDY AREA

Depositional Sequence Model and Facies Architecture of SB-14 Sequence



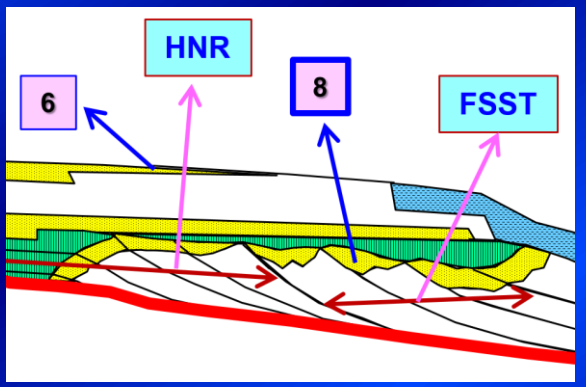
- Sequence Boundary
- Systems Tract Boundary
- Lowstand Normal Regressive Systems Tract (LNR) Shelf Mudstones
- Transgressive Systems Tract (TST) Shelf Mudstones
- Highstand Normal regressive systems Tract (HST) Shelf Mudstones
- Falling Stage Systems Tract (FSST) Shelf Mudstones
- Shallow Marine Sandstones
- Shelf Mudstones
- Coastal Plain Sandstones & Mudstones

1. Well-05
2. Well-04
3. Well-02

PROSPECT DELINEATION

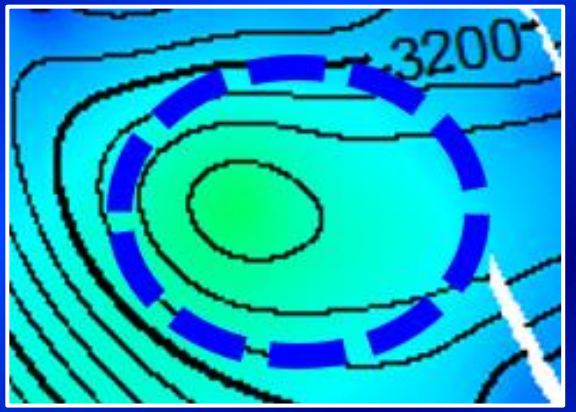
- Mainly achieved though using the resulting predictive depositional model within sequence stratigraphic framework, with identified stratigraphic trap types, together with sequence maps (structural on isochore overlays).

- Sequence stratigraphic interpretation & correlation outlines the significance of the falling stage systems tract (FSST) for new exploration opportunities.



- Parts of the FSST with reservoir-quality, sharp-based forced regressive sands are proven to be attractive sites for drilling, giving the successful discoveries around the block.

- These forced regressive sands are attractive due to high quality of the shoreface/barrier bar sands and encasement in shelf and coastal plain mudstones, constituting good seal.

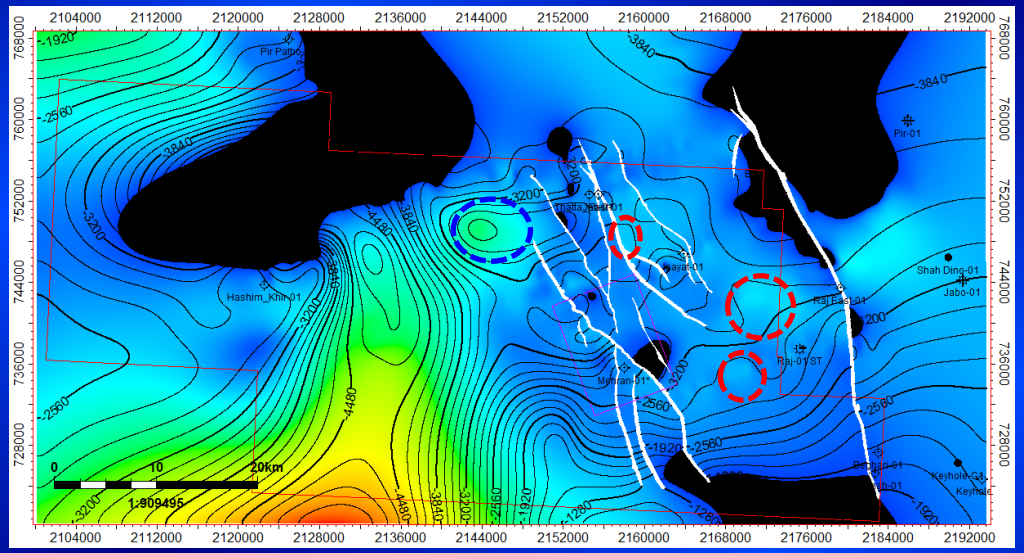


- Differential compaction between forced regressive sands and surrounding mudstones and shales resulted in thickness anomalies that can be detected on seismic sections and isochore maps.

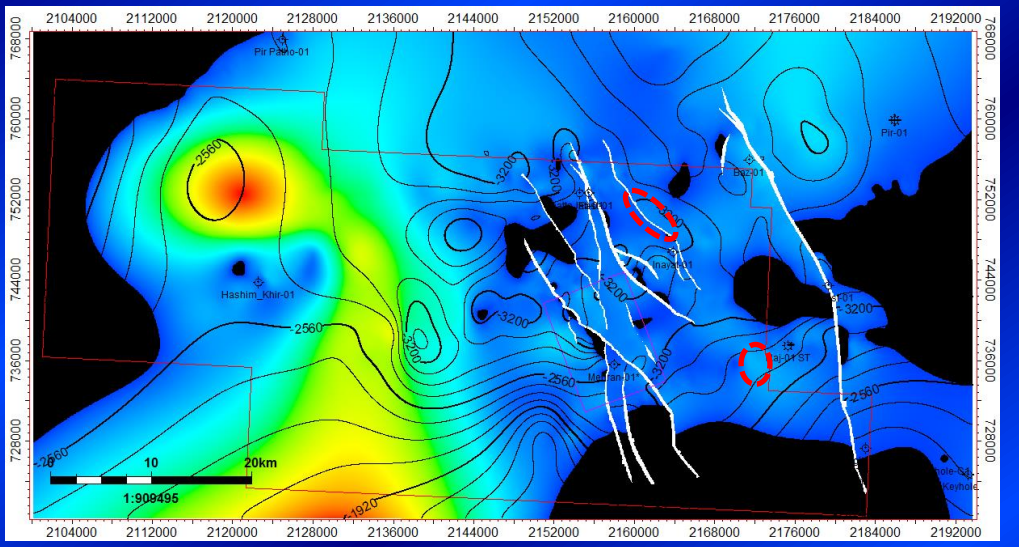
- Furthermore, highlighting these thickness anomalies on isochore maps, with overlaying structural contours, could outline attractive areas for further prospecting.

SEQUENCE STRUCTURAL ON ISOCHORE OVERLAY MAPS

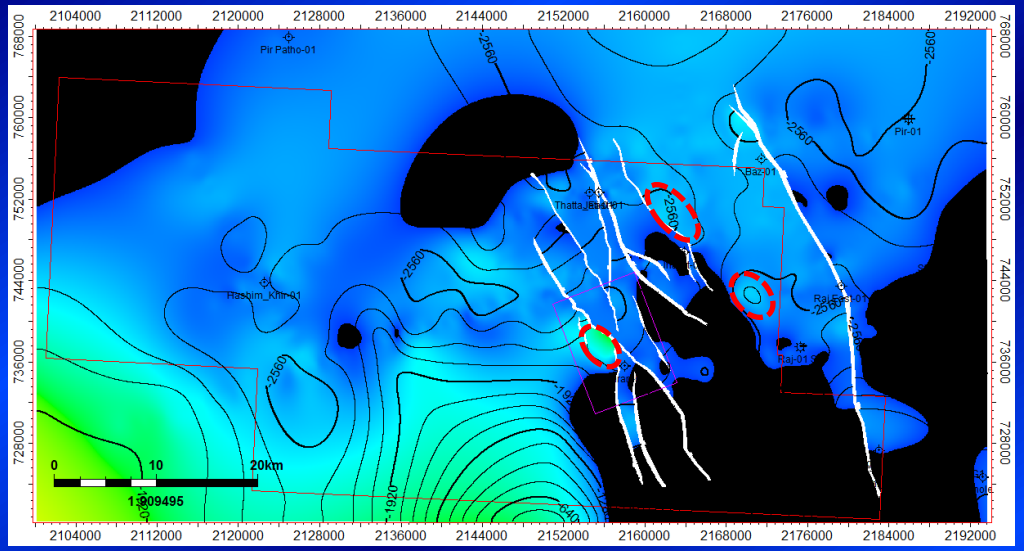
SB-11 to SB-12/Sq-D



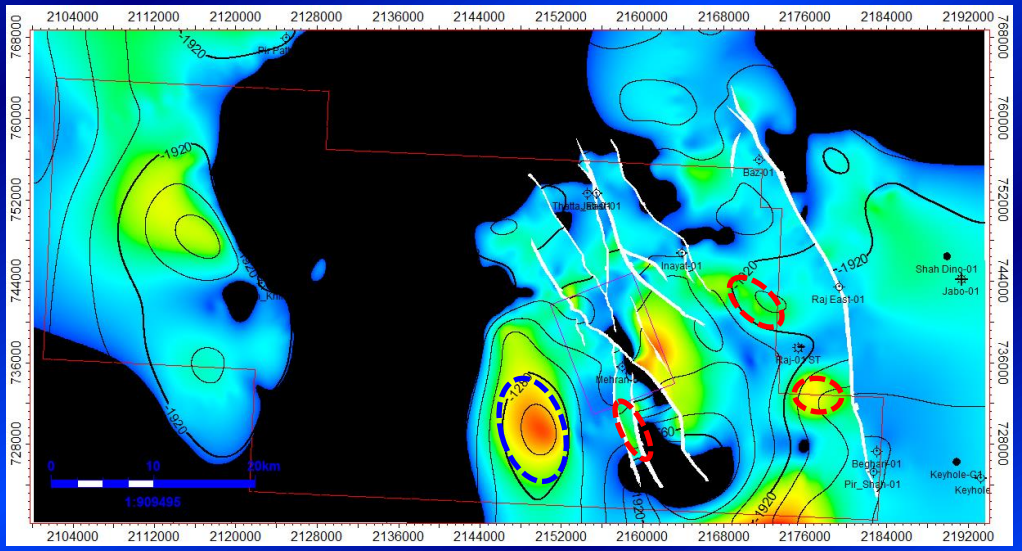
SB-12/Sq-D to SB-13



SB-15 to SB-17



SB-21 to SB-22



5. CONCLUSIONS

1. Seven third-order sequences (A-G) were identified and interpreted, with the aid of stratigraphic-indicator seismic attributes.
2. Eight depositional paleoenvironments were identified from well logs.
3. Twenty two high-order depositional sequences were identified.
4. Several sharp-based forced-regressive sands were observed throughout the study.
5. Six seismic facies were identified in the study area in terms of external geometry, reflection configuration, reflection continuity, and amplitude strength.
6. The use of structural and stratigraphic seismic attributes have proven to be of high significance in improving seismic sequence and seismic facies analysis interpretability of existent seismic data.
7. Eleven regional sequence structural maps were created, each represents an interpreted depositional sequence.
8. Areas of erosion or non-deposition were outlined at each sequence level, resulting in the reduction of uncertainties.

CONCLUSIONS "CONT."

9. Eighty eight discontinuity surfaces of four types were identified, interpreted, and used in aiding the interpretation of sequences and systems tracts.

10. Twenty two systems tracts, belonging to four types, were identified and interpreted, including the FSST, LNR, TST, and HNR.

11. Approximate age-dating was based, in part, on available biostratigraphic studies, and in part, on tying interpreted sequence boundaries to global sequences of Hardenbol et al., 1998.

12. Reservoir and source rocks were interpreted using innovative techniques of interpreting source and reservoir rocks from indicative well log suites.

13. Eight types of stratigraphic traps were identified, each with the likely reservoir and seal rock occurrence.

14. Twenty three attractive stratigraphic exploration opportunities were highlighted after mapping thickness anomalies on isochore maps, with overlaying structural contours. These opportunities are good candidates for further prospecting.

6. ACKNOWLEDGEMENTS

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- KUFPEC Center of Excellence.
- Pakistan Petroleum Limited (PPL).