

# **PS Reservoir Fairway Analysis of a Barail Interval of Deohal Area in Upper Assam Basin Using High Resolution Sequence Stratigraphy and Seismic Attributes\***

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## **Abstract**

The heterogeneity of Oligocene Barail 3 reservoir in Deohal area of Upper Assam is a challenge for delineation and optimum development for oil and gas. The effective porosity varies between 6% and 23%, and, net to gross fraction varies from 0.15 to 0.97 in the reservoir. One well on the northern part of the area was abandoned because of the absence of this reservoir. An integrated analytical approach is undertaken for understanding of the reservoir heterogeneity and sand body architecture using high resolution stratigraphy based on 3-D seismic and well data.

The gross thickness of Barail 1-3 (Upper Barail) is about 160-180m in Deohal area. Barail 3 is the bottommost and thickest reservoir of the sequence. The log motifs for the Barail 1-3 interval indicate a fining and thinning upward trend on both larger and smaller scale. High resolution stratigraphic correlation across wells has helped in understanding the sand body stacking pattern and juxtaposition.

Integrated seismic amplitude which is physically related to logarithm of acoustic impedance contrasts have been extracted from the zone of interest in the Deohal area. Analysis of integrated seismic attribute revealed prominent channel belts. Cross-plots of integrated seismic amplitude vs. reservoir properties from drilled wells indicate fairly positive correlation ( $R^2=0.5739$  to  $0.7478$ ). Spectral decomposition analysis of 3-D seismic data has further enhanced the channel belt geometry in 18, 24 and 30 Hz frequency cubes. The absence of Barail 3 in the abandoned well may be correlated to its location beyond limit of the observed channel belt.

Two major channel belts have been identified around the area. The observed braided pattern in the channel belts is possibly the result of composite seismic response of multi-storied channels. In regional context it appears that the channel belts may be part of a

distributary channel system. The widths of the channels were estimated from the seismic attribute maps. The width/thickness (W/T) ratios of the individual channel bodies in the Deohal area range between 8 and 32. For composite channel belt W/T ratio ranges between 68 and 84. These channels may be classified as broad ribbons and narrow sheets.

Guided reservoir property maps and depositional model generated based on the integrated analysis is expected to optimise placement of delineation and development wells in the area.

### **Reference**

Gibling, M.R., 2006, Width and thickness of fluvial channel bodies and valley fills in the geological record; a literature compilation and classification: *Journal of Sedimentary Research*, v. 76/5-6, p. 731-770.



# Reservoir Fairway Analysis of a Barail Interval of Deohal Area in Upper Assam Basin using High Resolution Sequence Stratigraphy and Seismic Attributes

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## Abstract

The heterogeneity of Oligocene Barail 3 reservoir in Deohal area of Upper Assam is a challenge for delineation and optimum development for oil and gas. The effective porosity varies between 6% and 23%, and net to gross fraction varies from 0.15 to 0.97 in the reservoir. One well on the northern part of the area was abandoned because of the absence of this reservoir. An integrated analytical approach is undertaken for understanding of the reservoir heterogeneity and sand body architecture using high resolution stratigraphy based on 3D seismic and well data.

The gross thickness of Barail 1-3 (Upper Barail) is about 160-180m in Deohal area. Barail 3 is the bottom-most and thickest reservoir of the sequence. The log motifs for the Barail 1-3 interval indicate a fining and thinning upward trend on both larger and smaller scale. High resolution stratigraphic correlation across wells has helped in understanding the sand body stacking pattern and juxtaposition. Integrated seismic amplitude which is physically related to logarithm of acoustic impedance contrasts have been extracted from the zone of interest in the Deohal area. Analysis of integrated seismic attribute revealed prominent channel belts. Cross-plots of integrated seismic amplitude vs. reservoir properties from drilled wells indicate fairly positive correlation ( $R^2=0.5739$  to  $0.7478$ ). Spectral decomposition analysis of 3D seismic data has further enhanced the channel belt geometry in 18, 24 and 30 Hz frequency cubes. The absence of Barail 3 in the abandoned well may be correlated to its location beyond limit of the observed channel belt. Two major channel belts have been identified around the area. The observed braided pattern in the channel belts is possibly the result of composite seismic response of multi-storeyed channels. In regional context it appears that the channel belts may be part of a distributary channel system. The widths of the channels were estimated from the seismic attribute maps. The width/thickness (W/T) ratios of the individual channel bodies in the Deohal area range between 8 and 32. For composite channel belt W/T ratio ranges between 68 and 84. These channels may be classified as broad ribbons and narrow sheets.

Guided reservoir property maps and depositional model generated based on the integrated analysis is expected to optimise placement of delineation and development wells in the area.

## Geologic Setting



- The study Area is situated in the east central part of Upper Assam Foreland Basin within the curve of the Assam Syntaxis of the Himalayan Orogenic Belt (Figure-1).
- The basin has thrusted margins on three sides: Naga Thrust Belt to the south, Mishmi Thrust to the east and Main Boundary Thrust of the Himalayas to the north.

- The basin has evolved from passive margin setting during Paleocene/Eocene to an active margin setting during Miocene.

- The Stratigraphic succession, major Tectonic events, Lithostratigraphy and Chronostratigraphic divisions are presented in Figure-2.

- The Barail 1-3 deposition took place during the Oligocene wherein extensive deltaic environment prevailed in major part of Upper Assam with gradual sea level fall.

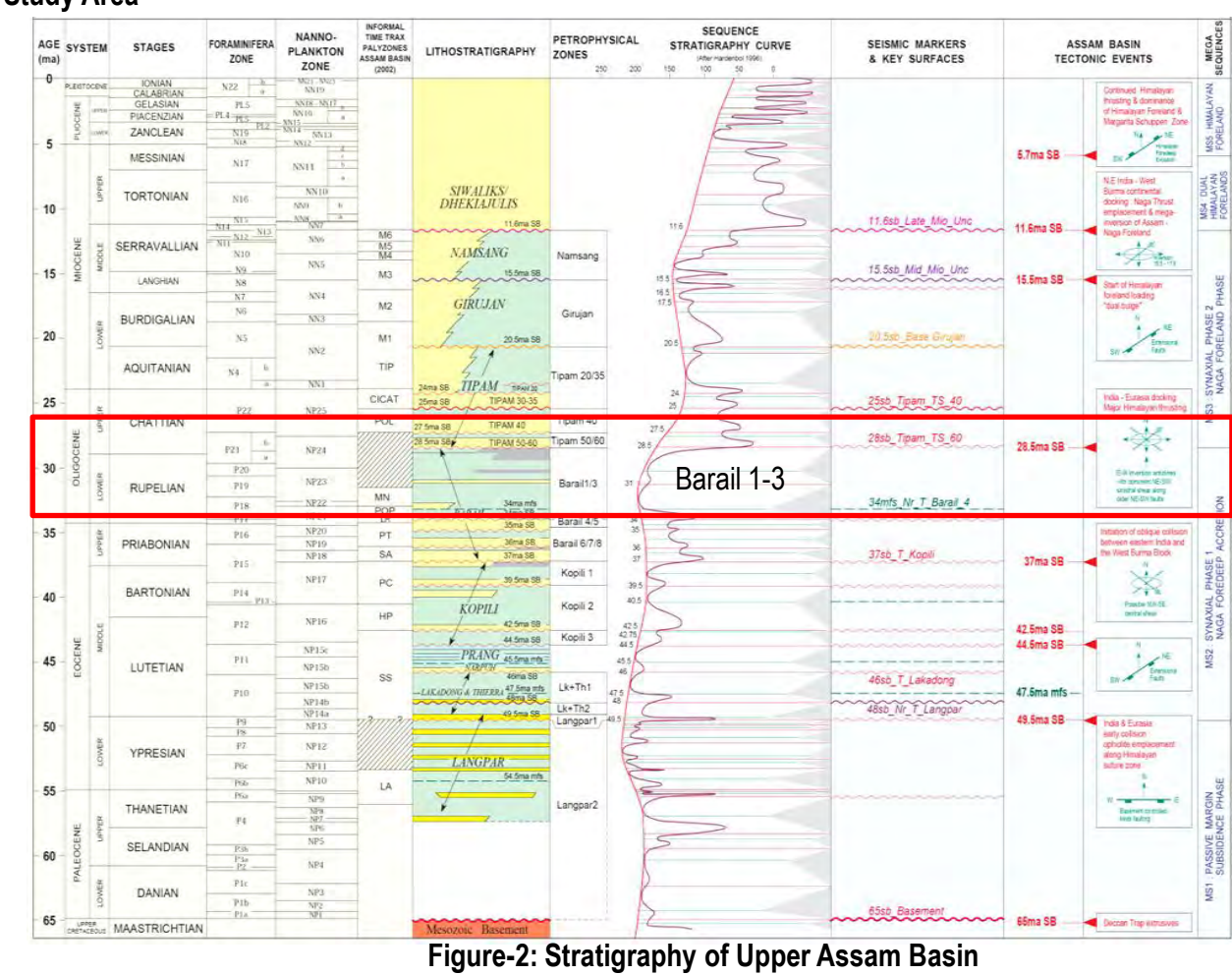


Figure-2: Stratigraphy of Upper Assam Basin

## Structure

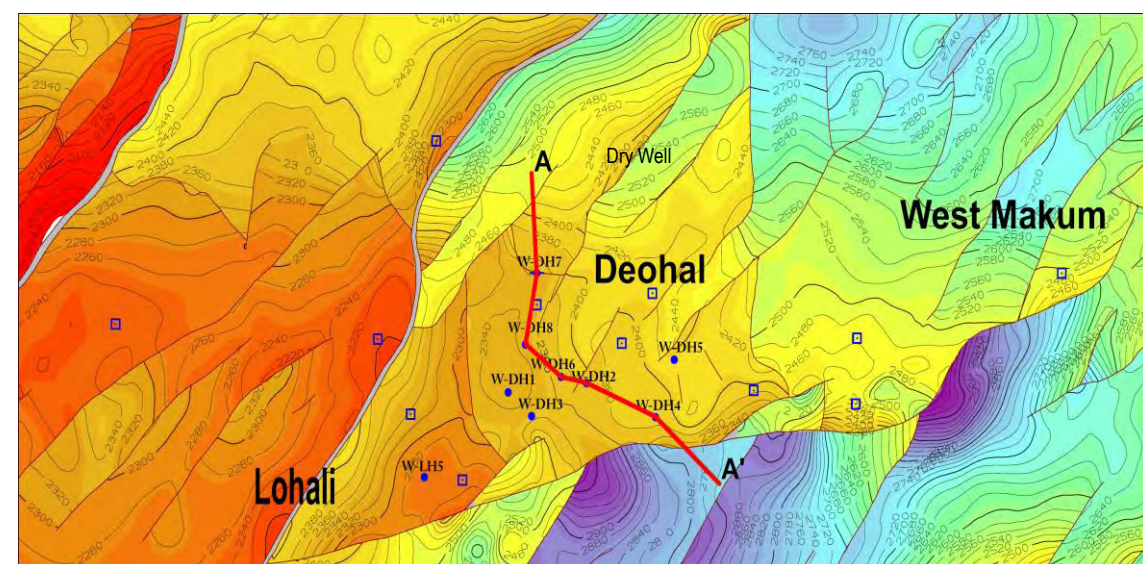


Figure-3: Top Barail 3 (34mfs) Depth Contour Map

A composite faulted anticlinal structure compartmentalised by NE-SW trending faults and bounded by a common major E-W trending fault to the south.

## Barail 1-3 Sequence

- The Barail 1-3 sequences in the study area have a gross thickness of 160-180 m in the drilled wells.
- Overall log motif for the Barail 1-3 interval indicate a fining upward trend
- Depositional Environment - Upper delta plain with fluvial influence
- Two main assemblages – channel sandstone bodies (Facies 1) and surrounding delta/floodplain deposits (Facies 2).
- Floodplain proportion varies between 60 to 75%.

- The thickest sandstone interval is Barail 3 (upto 32m) - interpreted as multi-storey sand body.

- Barail 2 & Barail 1 deposition is characterised by dominance of floodplain muddy system occasionally frequented by highly sinuous meandering channels where floodplain deposits are laterally extensive and the sands occur as isolated bodies within mudstone.

Well Derived Reservoir Characteristics			
Sub-zone	Net to Gross (NTG) (fraction)	Average Effective Porosity (%)	Net Reservoir Thickness (m)
Barail 1	0.09 - 0.73	11 - 20	1.5 - 3.0
Barail 2	0.00 - 0.87	17 - 20	0 - 15.0
Barail 2A	0.05 - 0.97	10 - 25	0.6 - 17.5
Barail 3	0.15 - 0.97	6 - 23	11.0-31.0

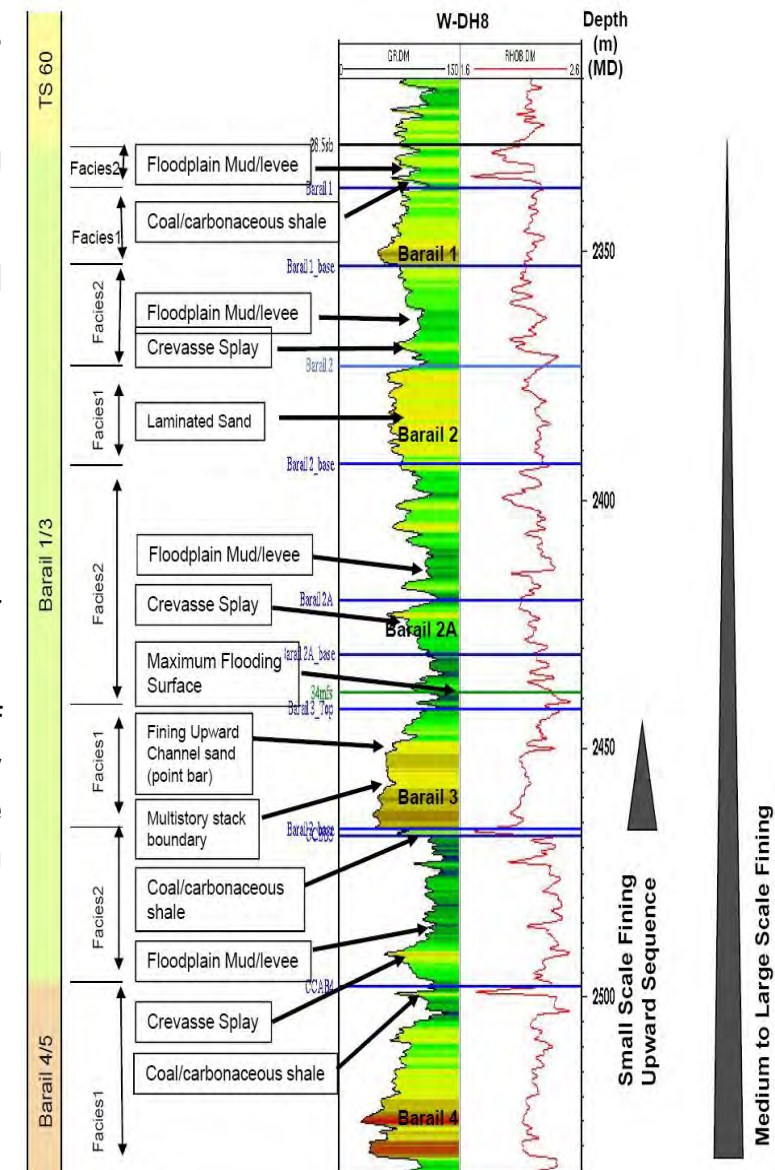


Figure-4: Facies and Zonation in a well in Deohal

## Correlation

Two locally persistent coal/carbonaceous horizons (CCBB3 and CCAB4) - one below Barail 3 and another above Barail 4 has guided in drawing a well-to-well correlation scheme with confidence and thereby understanding the sand body architecture.

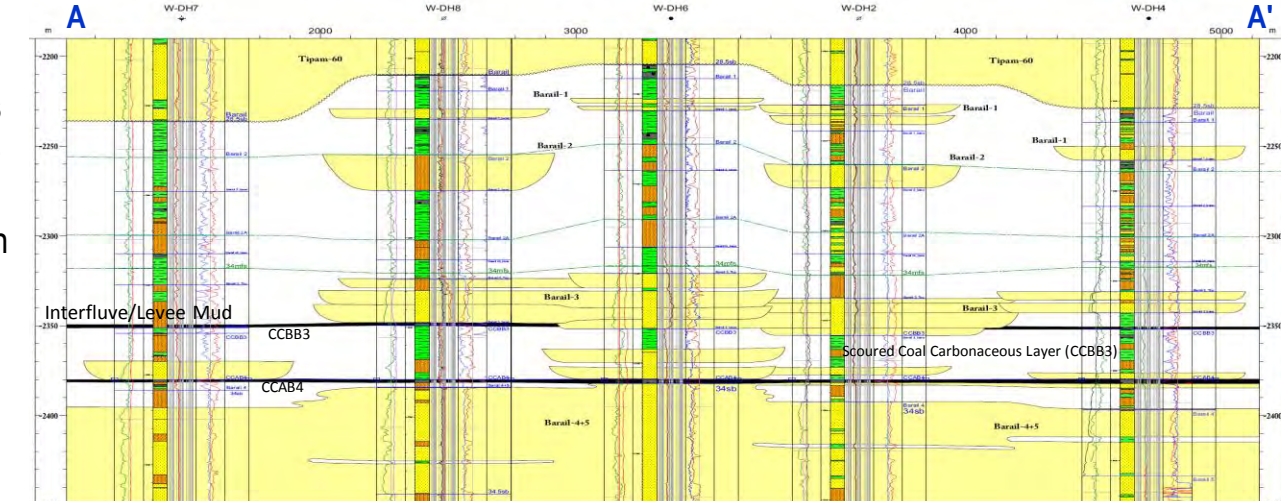


Figure-5: NW-SE Stratigraphic Correlation through Wells DH7, DH8, DH6, DH2 and DH4, DH7 (Across the Channel Belt). Note the coal/carbonaceous layer (CCBB3) scoured by Barail 3

## Seismic Attributes

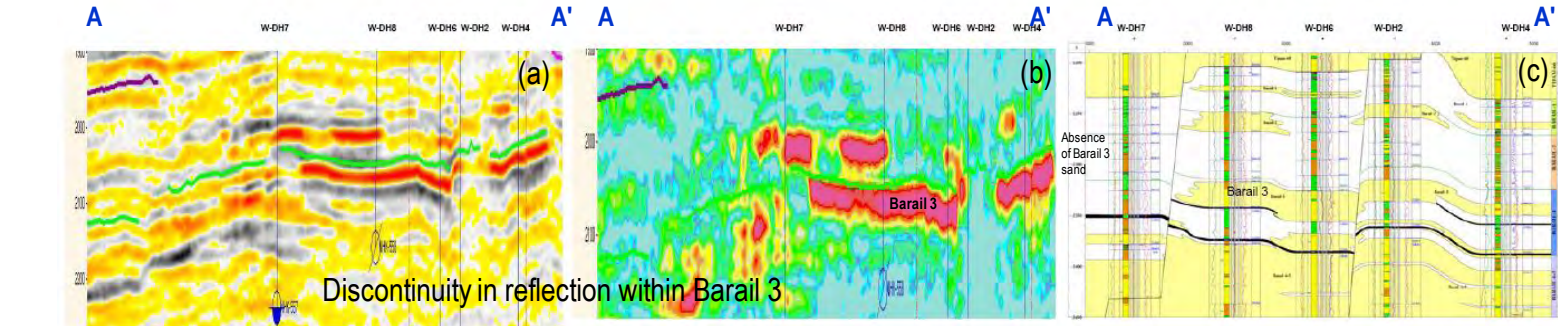


Figure-6: NW-SE Cross Section (AA') -- (a) VI Display, (b) Reflection Strength and (c) Seismo-geological Cross-section

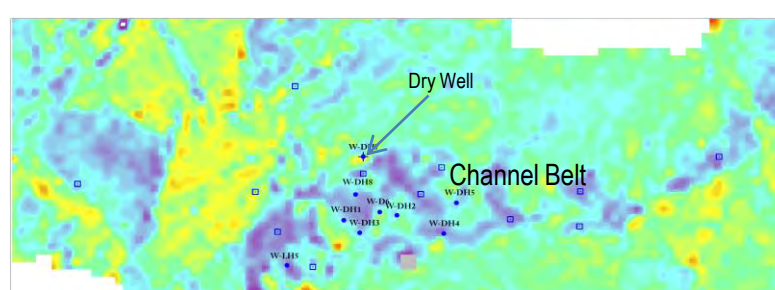


Figure-7: Barail 3 Integrated Seismic Amplitude. Note the location of dry well outside the low integrated amplitude area (channel belt)

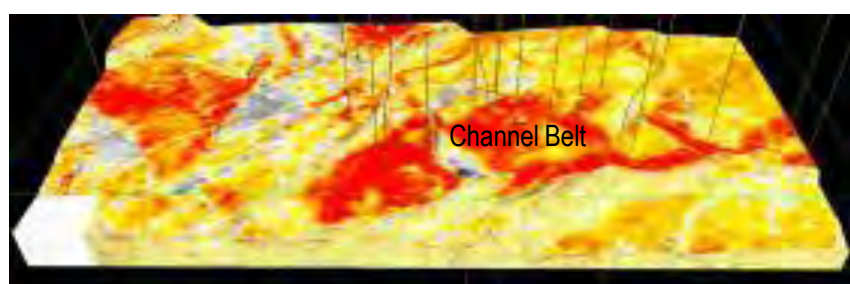


Figure-8: Horizon Slice within Barail 3

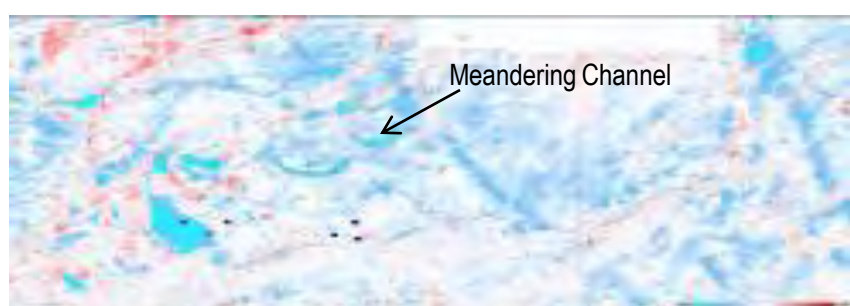


Figure-9: Barail 2 Seismic Amplitude

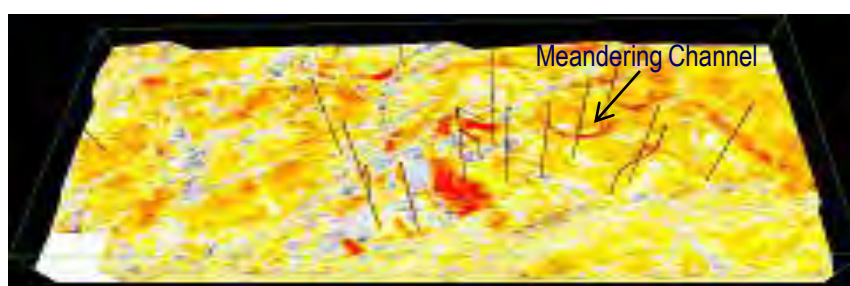


Figure-10: Horizon Slice within Barail 2

- Spectral decomposition suggests the dominant frequency to be around 18 - 24 Hz where the Barail 3 shows clearly describable bed juxtaposition.
- At the Barail 3 depth range the seismic resolution is estimated at 20 m.
- The horizon slices of Barail 3 at 18, 24, 30, and 50 Hz frequencies are shown in Figures 11(a) – 11(d).
- Low frequency slices illustrate the channel features prominently while it is feeble in 50 Hz slice.

- The variation in seismic signature around Barail 1-3 sequence can well be correlated with change in facies (Figure-6).

- Integrated seismic amplitude (20 ms volume window) and horizon slice for Barail 3 interval (Figures-7 & 8) indicate a prominent E-W trending contrasting features akin to a channel belt.

- Similarly, within the Barail 2, well defined NW-SE to NS trending meandering channel pattern with abandoned channels and point bar build-ups were prominent (Figures- 9 & 10).

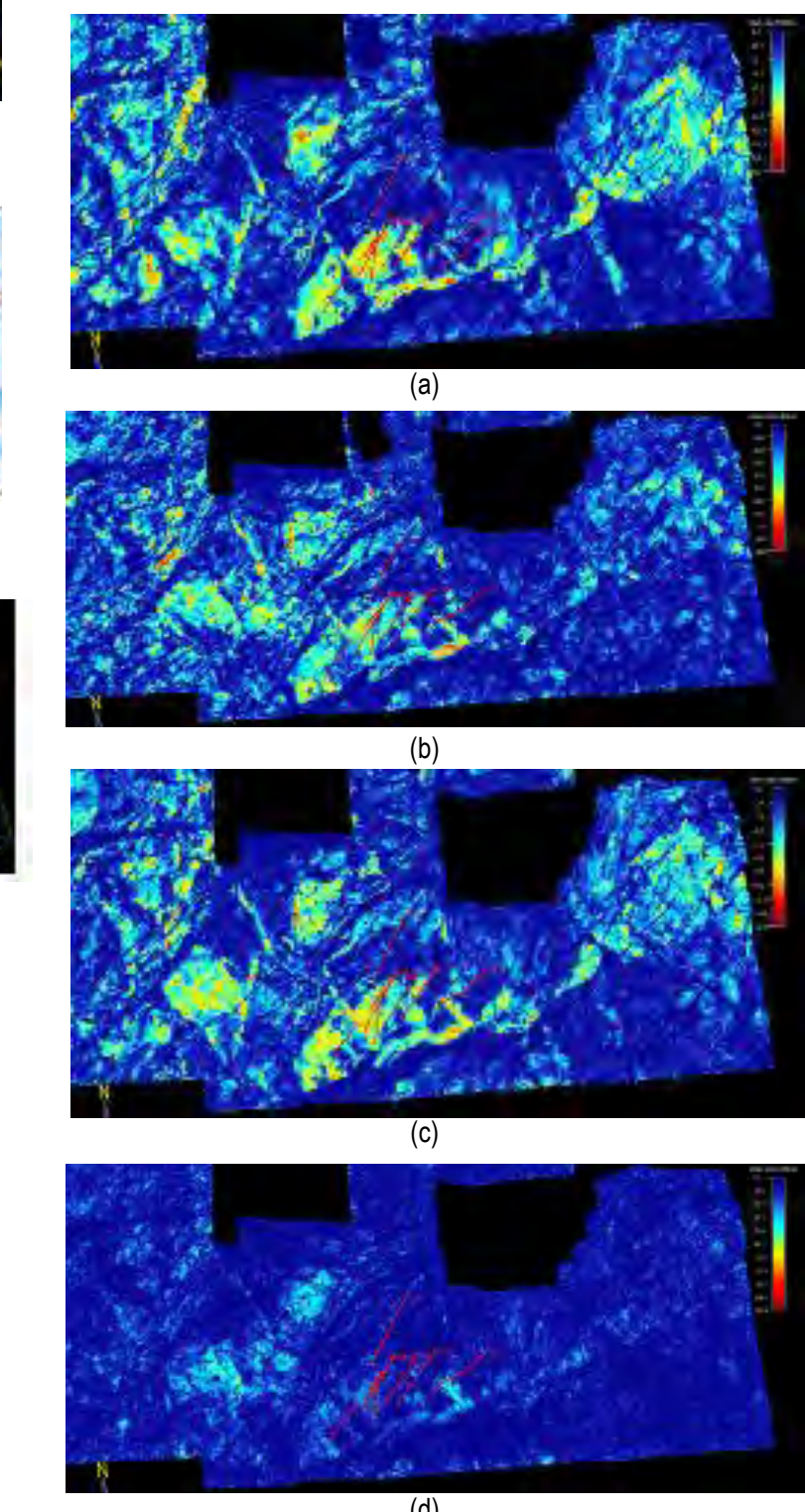


Figure-11: Horizon Slices within Barail 3 (a) 18 Hz, (b) 24 Hz, (c) 30 Hz and (d) 50 Hz Frequency

## Attributes vs. Reservoir Properties

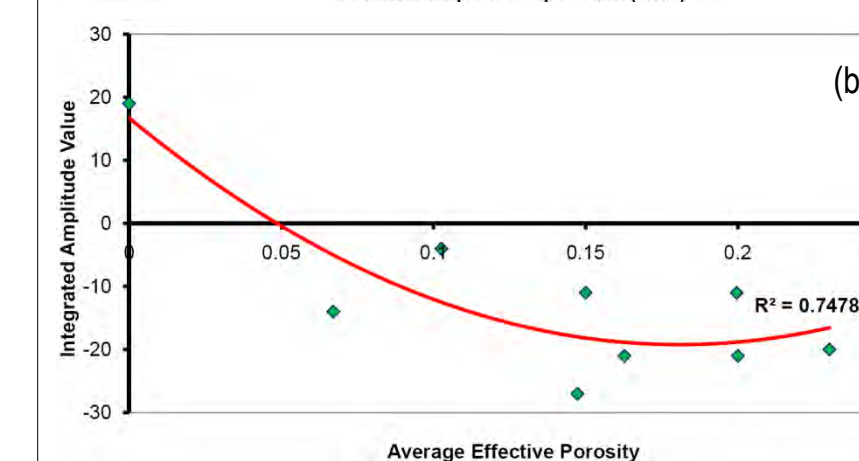
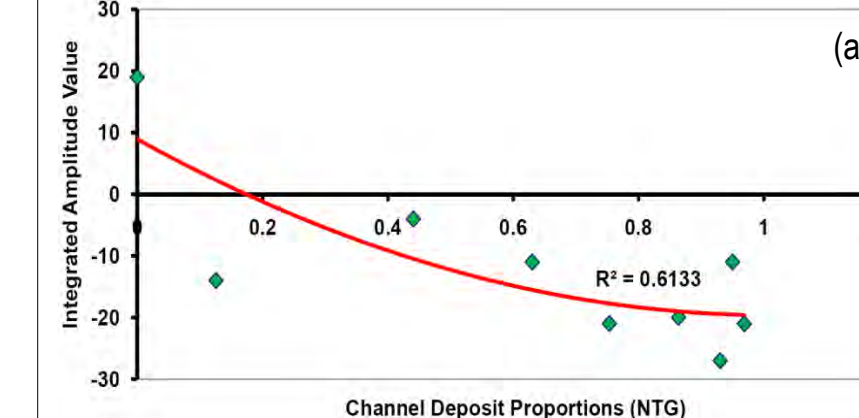
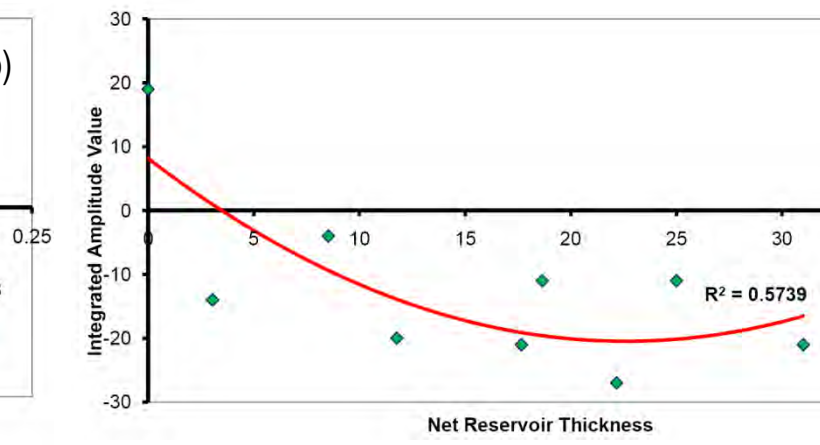


Figure-12: Integrated Seismic Amplitude vs a) Net to gross (NTG), b) Effective Porosity and c) Net Reservoir Thickness from well data

The seismic attribute especially the integrated seismic amplitude correlates fairly well with basic reservoir properties for Barail 3 unit. These are :

- NTG with  $R^2=0.6133$  (Figure-12a)
- $\Phi_{eff}$  with  $R^2=0.7478$  (Figure-12b)
- NRT with  $R^2=0.5739$  (Figure-12c)



## Seismic Guided Reservoir Properties

Positive correlation between integrated seismic amplitude and reservoir properties gave confidence to generate seismic guided reservoir property maps for Barail 3 interval (Figure-13).

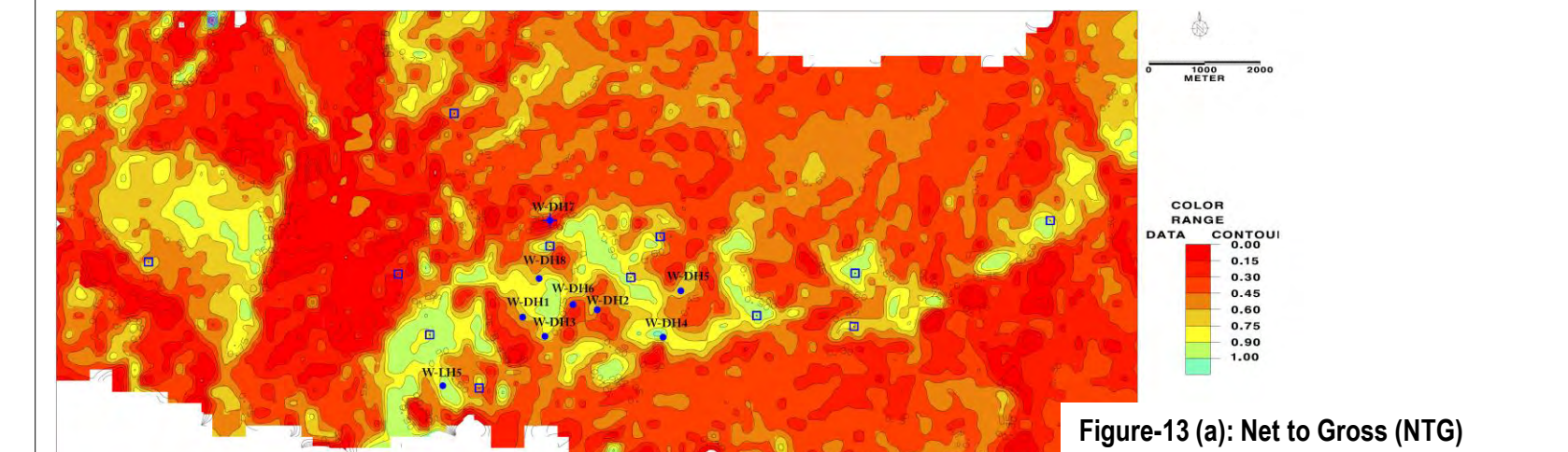


Figure-13 (a): Net to Gross (NTG)

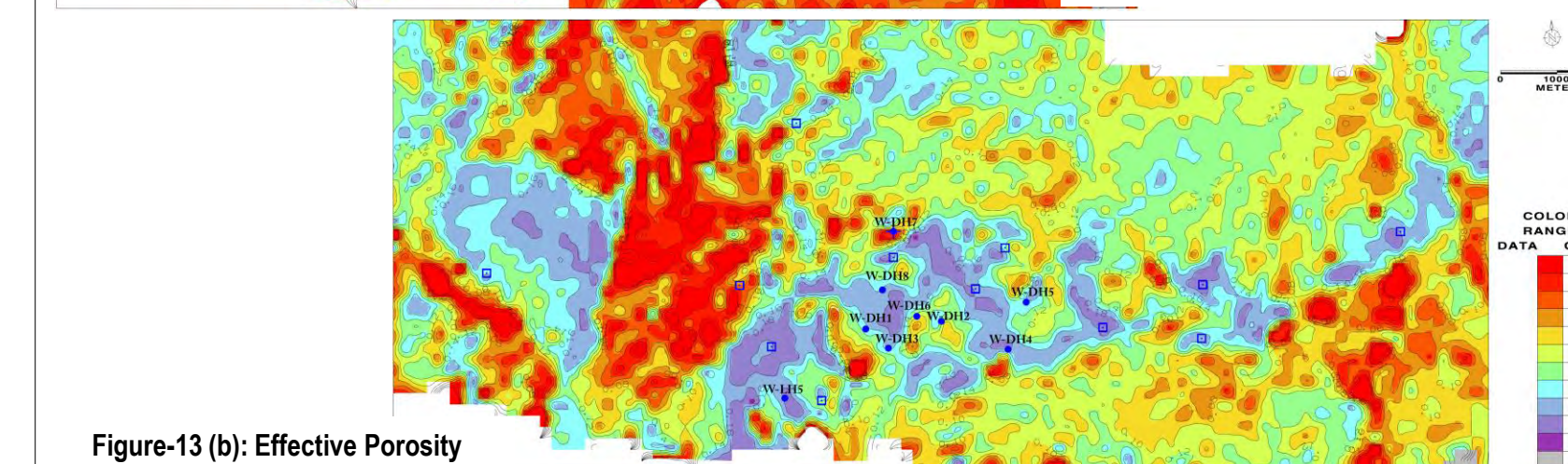


Figure-13 (b): Effective Porosity

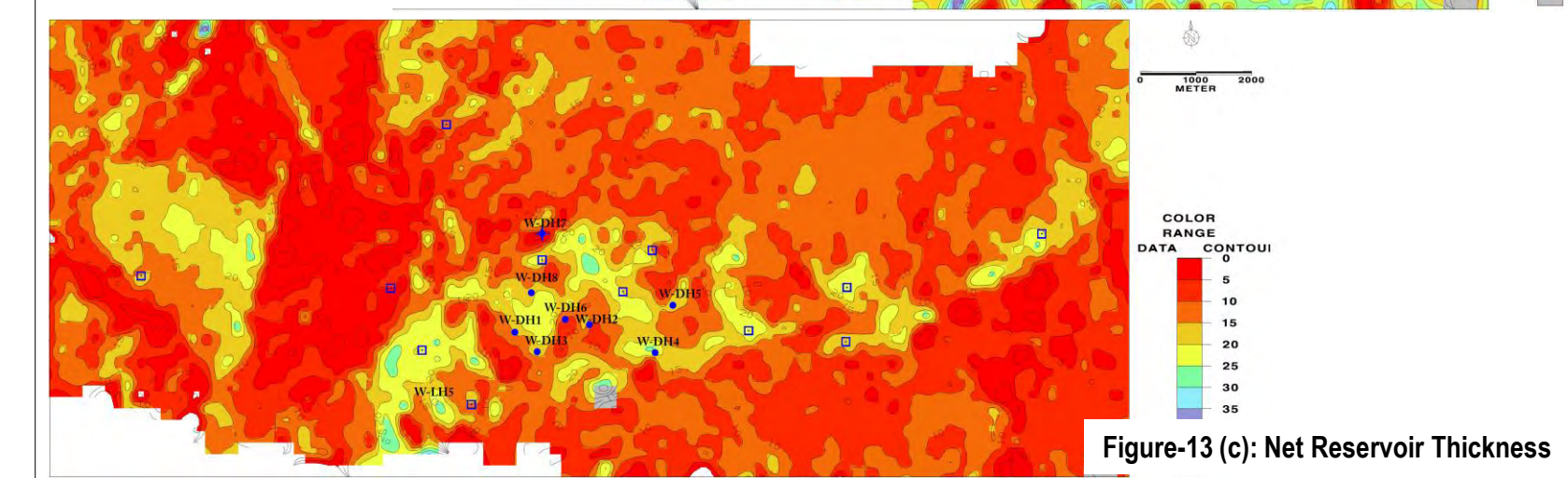


Figure-13 (c): Net Reservoir Thickness

## Channel Geometries

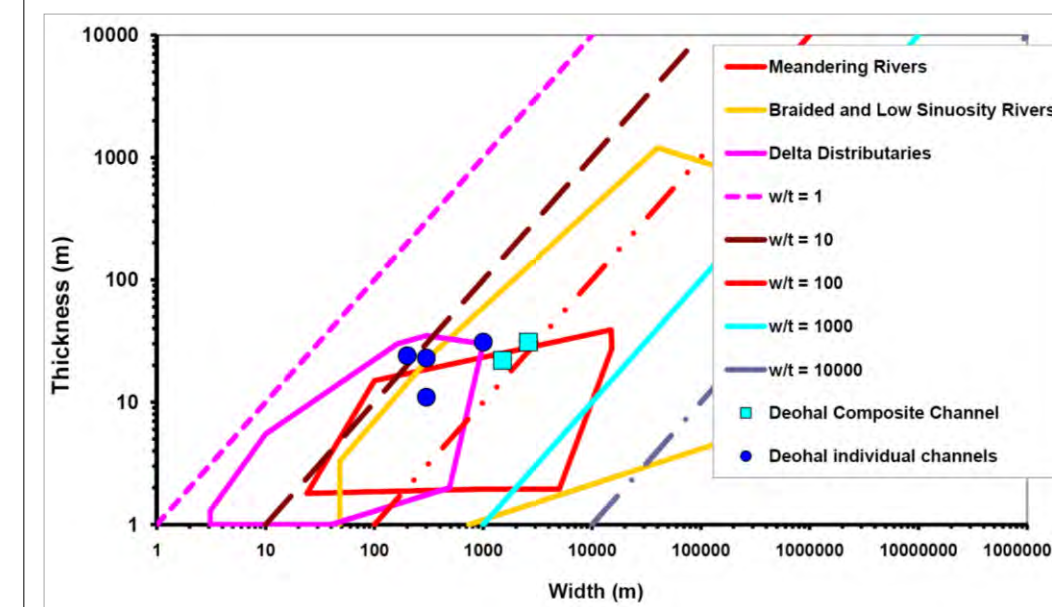


Figure-14: W/T Ratios of individual and composite channels

The W/T ratio of the individual and composite channel bodies in the study area ranges between 8 and 84 and may be classified as broad ribbons and narrow sheets (after Gibling 2006).

The individual as well as the composite channels lie at the transition of meandering, delta distributary and braided river data envelopes proposed by Gibling (Figure-14).

## Reservoir Distribution

- The study has led to delineation of reservoir distribution pattern in the area (Figure-15). Two major channel belts - one running NE-SW and the other running almost E-W are mapped.
- The channel running E-W could be identified with confidence from integrated seismic amplitude
- Channels identified in western part are mapped based on integration of patterns in horizon slices from spectral decomposition.
- The observed channels are inferred to be part of a bigger basin scale delta distributary system.

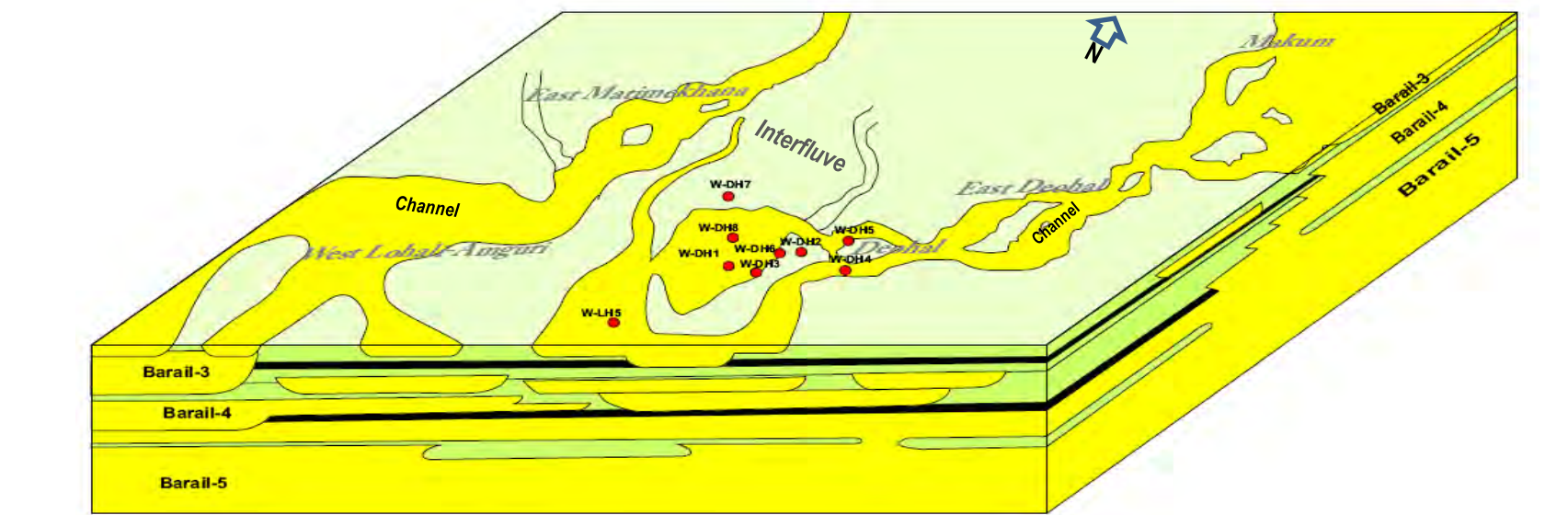


Figure-15: Reservoir Distribution in Lohali, Deohal, West Makum Areas

## Conclusion

- The study has resulted in establishing a reasonable correlation scheme for Barail 1-3 interval in the area. This correlation scheme may further be extended to adjoining areas.
- The observed cross-correlation between integrated seismic amplitude and the basic reservoir properties gave confidence for generation of seismic guided reservoir properties maps for Barail 3 interval in the study area.
- An integrated approach has allowed identification of two major channel belts and hence the reservoir distribution pattern in the area.
- The identified channels are inferred to be part of a basin scale delta distributary system.
- The study is expected to give fair confidence in locating future extension and development wells.
- Additionally, extension of similar studies in the neighbouring areas is expected to provide better understanding of the target reservoirs from local to basinal perspective.