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Integrated Study of Charali field with a special emphasis on Barail sands to bring out Channel Geometry from Log Data & P-Impedance volume

R.C.P. Saxsena S. Uppal*, Md. S. Akhtar, & A. Bhardwaj

Summary

The present work is an outcome of the study carried out in the Charali field in the North Assam Shelf area. The study area covers Charali and part of Nazira low area and confined to Barail sands. These areas are known producers of hydrocarbons from multi-layered reservoirs in Tipams and Barails. The objective is to delineate the extent of the existing BCS reservoirs particularly channel sands and its geometry through reservoir characterization. Model Based P Impedance Inversion analysis has been carried out to find out the probable locales for BCS sands within the 3D volume in different windows close to BMS/BCS-I & BCS-IV, where the hydrocarbon has been encountered in some of the wells Electro-log correlation along the key wells depicts that the sands within BCS unit varies in thickness from one well to other and are discontinues in nature. The RMS amplitude slice (time) and along the BCS top horizon with different windows (time interval) has been extracted close to BMS/BCS-I & BCS-IV sands depicting the input direction of the flow of sand is from NW direction at all the sub units of the BCS deposition. From stratigraphic correlation of these sands, it is observed that HC bearing sands in wells CH-CD & CH-CF are not the same sands and same has been validated through seismic attribute studies.

Keywords: Channel geometry, P-Impedance, Charali area, Upper Assam

Introduction

The Assam & Assam Arakan basin is situated in the northeastern part of India and has an extent of around 40,000 sq. Km. of area. This is an intermontane basin surrounded on three sides by fold and thrust belts. Geographically, the area is bounded in the northwest by the eastern Himalayas, in the southeast by the Naga Hills, in the northeast by the Mishmi Hills, and in the southwest by the Mikir Massif and Shillong Plateau. Tectonically Assam-Arakan basin has been defined as a poly - history basin that evolved synchronous with the other East-Coast basins of India, concomitant with the rifting and subsequent drifting of the Indian Plate from Eastern Gondwanaland. The basin was initiated in an extensional phase and later modified by different episodes of compressional phase. Super-imposition of compressional phase over extensional regime modified the earlier extensional structures that indicate the poly-phase / poly-history nature of the basin. About 7000m of sediments ranging in age between Cretaceous to Recent are expected to be present in this part of the Assam & Assam Arakan basin.

The study area covers Charali and part of Nazira Low area from this basin (Fig-1).

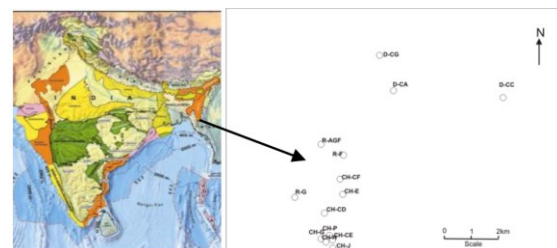


Fig.1: Location map of the study area

These areas are known producers of hydrocarbons from multi- layered reservoirs in Tipams and Barails. The Charali field is one of the oldest oil fields of Upper Assam with BMS (Barail Main Sand), BCS, TS-5A, TS-4, TS-2 are the main reservoirs. BCS sand has produced hydrocarbon from CH-A, H, P, CD & CF. The objective is to delineate the extent of the existing BCS reservoirs particularly channel sands and its geometry through reservoir characterization.

Model Based P Impedance Inversion analysis has been carried out to find out the probable locales for BCS sands



within the 3D volume in different windows close to BMS/BCS1 & BCSIV, where the hydrocarbon has been encountered in some of the wells. This analysis validates the observation in most of the wells. Electro-log correlation (N-S profile) depicts that the sands within BCS unit varies in thickness from one well to other and are discontinuous in nature.

Geology of the area

The Assam-Arakan Basin is a polyhistory basin which witnessed two major phases of development. It developed as a composite shelf-slope-basinal system under a passive margin setup during the period from Early Cretaceous to the close of Oligocene. During the post- Oligocene time, however, different parts of the mega basin witnessed different evolutionary trends, mostly under compressive tectonic forces.

During Paleocene, there was a marine transgression on the southern edge of the Shillong Plateau, depositing sediments of the Therria **Formation** consisting of limestone, sandstone and shale. The **Lakadang Formation** (Early Eocene) comprising limestone and coal bearing sandstones was deposited in shallow marine to lagoonal conditions, while the overlying **Tura Sandstone Formation** (Early Eocene) was deposited under fluvio-deltaic environment. The Tura Formation is extensively developed in the Upper Assam Shelf and is oil bearing in Lakwa, Disangmukh, Panidihing and Nahorkatiya oil fields.

During Eocene to Oligocene, due to the rise of the peripheral arc system (rise of the basement ridge) consequent upon the active oblique subduction of the Indian plate, the intervening sea became progressively narrower southward. During this period, the Assam Shelf was being evolved in a passive margin tectonic setting and under shallow marine to brackish water sedimentation conditions. Following the deposition of the Tura Sandstone, there was a wide spread marine transgression in which the **Sylhet Limestone** (Middle Eocene) was deposited almost all over the Upper Assam Shelf. Towards the close of Middle Eocene, limestone deposition ceased because of an increase in the influx of finer clastics in the shelf. These clastics, making the lower part of the **Kopili Formation**, were deposited in open marine conditions during Late Eocene, when marine transgression was waning out. Further increase in the clastic influx in the stable shelf during Late Eocene to Early Oligocene resulted in marine regression with the deposition of the

upper part of the Kopili Formation, consisting of shales, siltstone and subordinate sandstones, in shallow marine to prodelta environments. In the North Bank of the Brahmaputra River, however, environmental conditions were deltaic with the deposition of sandstones with minor shales and siltstones. During shallowing of the sea in the basinal area, the succeeding sediments of the **Barail Group** were deposited under environments ranging from moderately deep marine to deltaic.

Towards the end of the Tipam Sandstone deposition, there developed a series of N-S to NE-SW trending compressive structures in the basinal area. During the growth of these structures, the **Girujan Clay Formation** was deposited. The most prominent structural depression was formed in Kumchai – Manabhum area in front of the Mishmi uplift, where the Girujan Clay Formation attains a thickness of about 2300m. The development of the frontal foredeep in front of the rising Himalaya, during Mio-Pliocene and later times, due to tectonic loading by thrust slices was filled with coarser sediments. During this time, sedimentation of arenaceous Lower Dupitila sediments over a post-Girujan unconformity and the argillaceous Upper Dupitilas over a post-Lower Dupitila unconformity took place.

Methodology

Log correlation along the 4 profiles through key wells (16wells) covering the entire area have been carried out to know the distribution of BCS sands within the area. The rock physics analysis has been carried out in most of the wells of the area to see the feasibility of distinguishing the shale / sand and coal distribution in the zone of interest through P-Impedance. The generated cross plots of Gamma ray vs P-Impedance (from Logs) show (Fig. 2 & 3) that it is not possible to distinguish sand from shale by P-impedance alone. However, the zone of coal may be distinguished on the xplot.

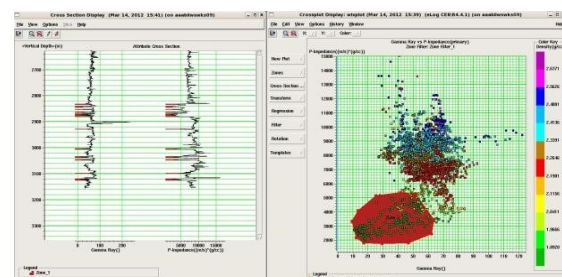


Fig.2: X plot between Gamma Ray and P- impedance at well CH-S along with density in the zone of interest. It helps to identify the coal streaks, however, unable to distinguish sand and shale

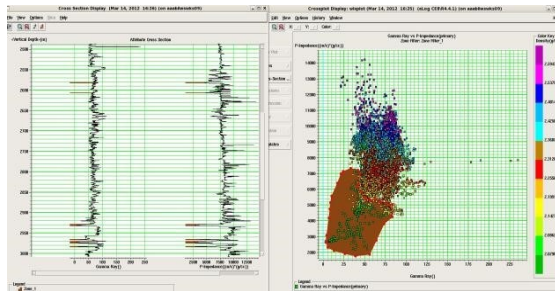


Fig.3: X plot between Gamma Ray and P- impedance at well CH-CD along with density in the zone of interest. It helps to identify the coal streaks, however, unable to distinguish sand and shale.

The seismic inversion analysis has been carried out after going through QC of the Seismic data, log data and horizons. Well to Seismic tie was carried out for all the selected wells. The statistical wavelet was extracted and a reasonable correlation was achieved (approx.65%). The synthetic seismogram correlation at different wells (Fig.4) in the area provides the true time-depth relationship along with the wavelet (close to the wavelet embedded in the Seismic) in zone of interest.

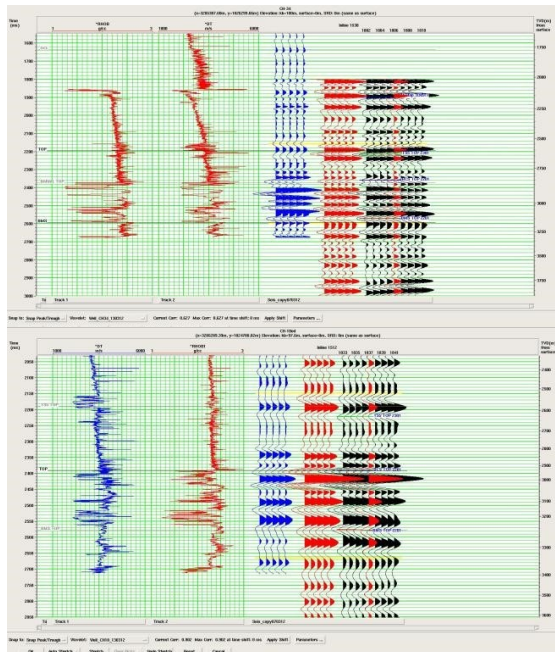


Fig.4: Synthetic Seismogram generation & correlation for wells CHCD & CH-R between TS-5 top to BMS Top.

The consistent wavelets at seven well locations were taken to generate a composite wavelet or an average wavelet, which was finally used for the inversion. It indicates that a more or less a zero phase wavelet is embedded in the data.

(Fig.5). The required horizons namely – TS-5 top, BCS top and BMS top has been mapped (Fig.6).

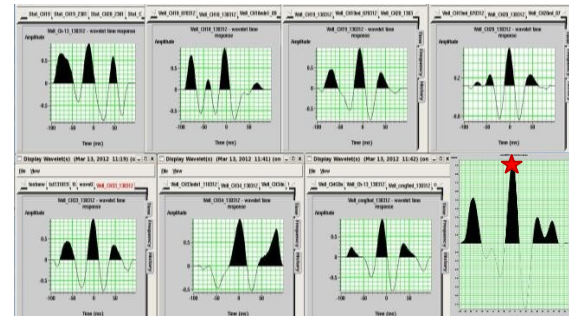


Fig.5: Full Wavelets extracted at different wells between TS-5 top to BMS Top. The composite wavelet (*) has been used for the inversion

Present studies

Electrolog Correlation

Electro-log correlation (Fig.7&8) along the wells CH-Z, CH-N, CH-L, CH-R, CH-P, CH-CD & CH-CF (N-S profile) depicts that the sands within BCS unit varies in thickness from one well to other.

The stratigraphic correlation (Fig.8) has been attempted by flattening at BMS top. It is observed that BCS sands are quite discontinuous in nature and it is difficult to correlate each sand from seismic. Broadly five depositional packs are identified within BCS in these wells whereas the sixth one is present only in few wells.

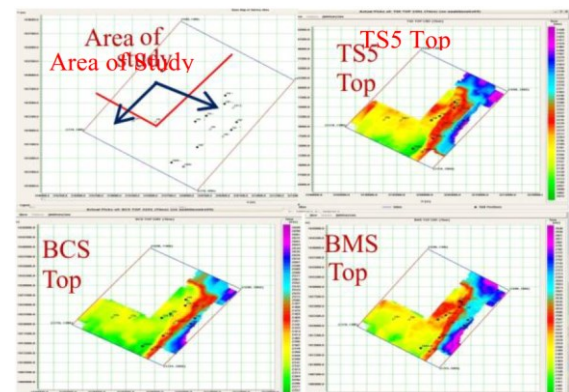


Fig.6. (a) Area of study mainly from the Charali. Mapped horizons at (b) TS-5 Top, (c) BCS Top,(d) BMS Top

The lower most pack i.e. BCS-1 mostly shaly in nature except some sandy facies developed in well. Whereas the depositional pack II, III & IV are better developed. From

the structural correlation it is found that at BCS level well CH-H is higher as compared to other wells. The oil bearing sand of CH-CD is structurally higher as compared to the gas bearing sand of CHCF. From stratigraphic correlation it is clear that both the sands are not the same which is also supported by the RMS amplitude map close to BCS IV (Fig.8).The isopach map of BCS-IV sand indicates that the input direction is from NW to SE (Fig. 9) and same is supported by seismic attribute studies.



Fig.7 N-S Structural Correlation profile along wells CH-Z, N, L, R, P, CD & CF

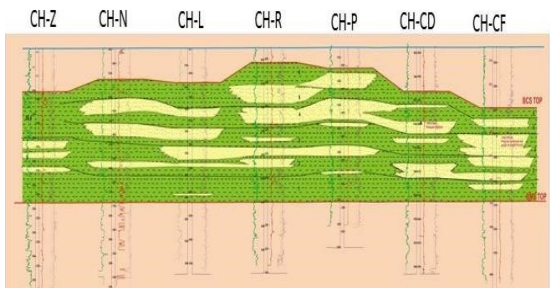


Fig.8 Stratigraphic Correlation (Flattened at BMS top) profile along wells CH-Z, N, L, R, P, CD & CF

Seismic inversion analysis

Model Based P Impedance Inversion analysis has been carried out to find out the probable locales for BCS sands within the 3D volume in different windows close to BMS/BCS-I & BCSIV, (Figs.10 & 11) where the hydrocarbon has been encountered in some of the wells. This analysis validates the observation in most of wells. As it is not possible to discriminate sand/shale parameters uniquely, it can only be used as likely indicator of occurrences of hydrocarbon bearing sands which needs to be augmented by other exploration and production data.

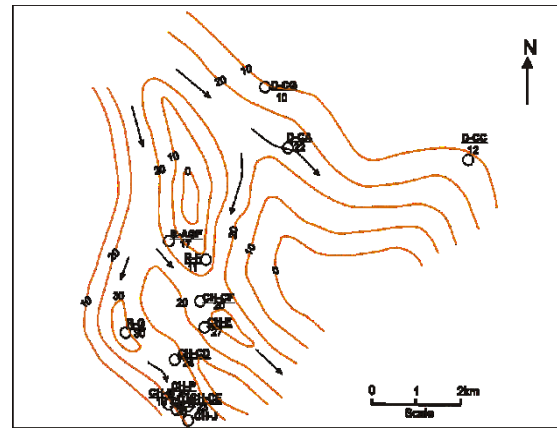


Fig.9 Isopach Map of BCS-IV Sand

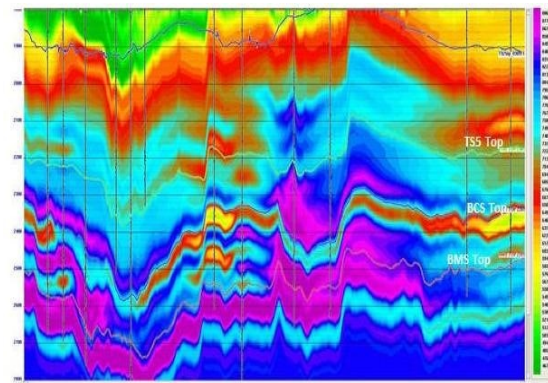


Fig.10: A low frequency P-impedance model is generated from time window of 1800 to 3000 ms.

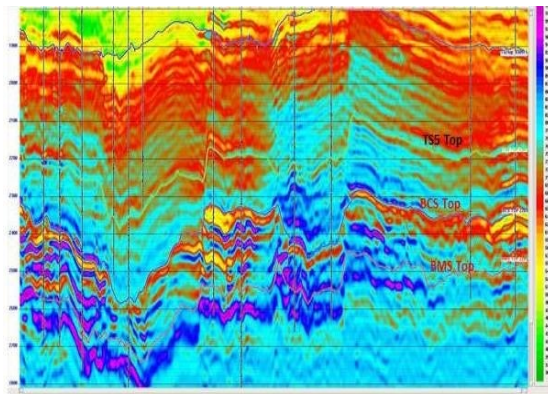


Fig.11: An arbitrary line passing through different wells from the newly generated P-Impedance volume

However, with only P-Impedance, it is not possible to distinguish oil or non-oil bearing facies.

Interpretation of Results

RMS amplitude has been extracted close to BMS/BCS -I, in the same window from Seismic (Fig.12) and from P – Impedance (Fig.13).The Amplitude attribute in Fig.12, depicts only flow of sand direction, however does not show any pattern of channel, as it depicts in the P-Impedance (Fig.13). It is due to the fact the increase in bandwidth in the P-Impedance volume.

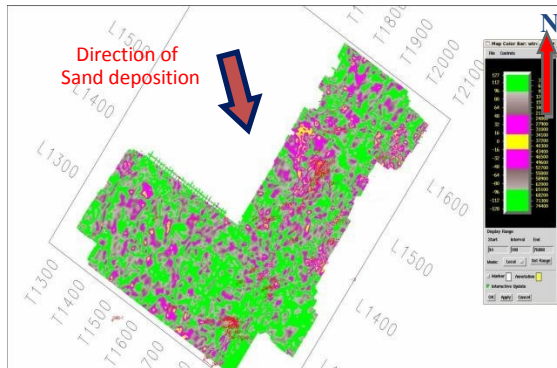


Fig.12 RMS amplitude slice extracted from the Seismic Volume in the Time window of 130 to 140ms below the BCS Top (close to BMS/BCS-I). It does not show channels, however, shows the direction of flow of sand deposits

Interpretation for BMS/BCS-I

The RMS amplitude slice (time) and along the BCS top horizon with different windows (time interval) has been extracted close to BMS/BCS-I Sand (Fig.13 &14). It shows the input direction of the flow of sand is from NW direction at all the sub units of the BCS deposition. Different channels geometry from NW to the SE and southern directions are shown along with the entry point of the sand. When river carrying sediment reaches an inland region where the water spreads out, it deposits

Moreover, when the flow enters the standing water, it is no longer confined to its channels and expands in width. This flow expansion results in a decrease in the flow velocity, which diminishes the ability of the flow to transport sediment, as a result, sediment drops out of the flow and deposits. Over time, this single channel will build a deltaic facies pushing its mouth further into the standing water (Fig.13 &14).

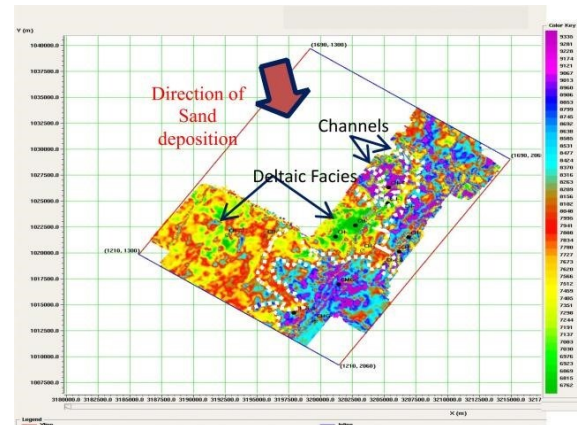


Fig.13 RMS amplitude slice extracted from the P-Impedance Volume in the Time window of 130 to 140ms below the BCS Top (close to BMS/BCS-I).

Channels, in the study areas are found to exist in various geometries. The channel development is controlled by both water and sediment movement. There is a difference between low gradient and high gradient streams. Wide variety of sand channels types are distinguished (e.g. Braided Wandering, Single Thread Sinuous etc.). The wells CH-A, H & P which has produced hydrocarbon (Oil) from BMS/BCS-I passing through the channels sand and their deltaic facies.

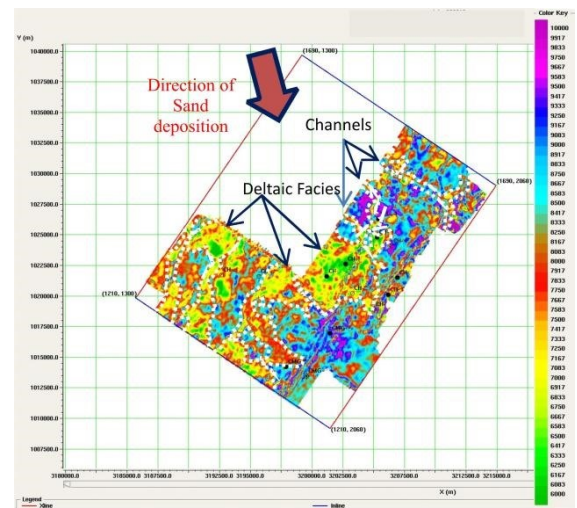


Fig.14 RMS amplitude slice extracted from the P-Impedance Volume below 130ms below the BCS Top with central window of 10ms Top (close to BMS/BCS-I).

Interpretation for BCS-IV

The only well which has produced hydrocarbon from BCS-IV is CH-CD. The same type of channel geometries (Low gradient, High gradient and Mix) are found for BCS-IV also (Fig.15 &16). On the basis of the P-Impedance value for the sand/shale formation the lithology attributes are extracted from the P-Impedance volume close to the BCS-IV (Fig. 15&16). Different channels sand along with deltaic facies are observed on the slices extracted for different windows from the P- Impedance volume.

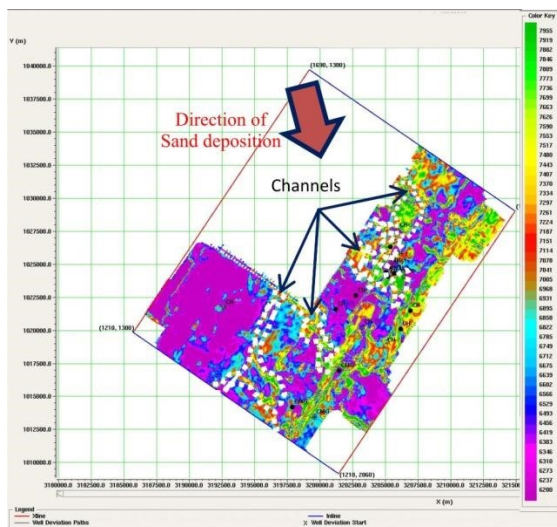


Fig. 15 RMS amplitude extracted from the P-Impedance Volume at 20ms below BCS top with central window of 10ms (close to BCS-IV).

It clearly shows the distribution of lateral impedance variation within the sequences which may be attributed to probable facies variation (Fig.15&16). RMS amplitude extracted 20ms below BCS top with central window of 10 ms close to BCS-IV sand shows that HC bearing sands encountered in CH-CD & CH-CF are different, as evident from fluid type also. The well CH-CD which is higher as compare to CH-CF has produced oil, whereas CH-CF produced mainly gas along with some.

This analysis validates the observation in most of wells except for few which could be because of non-unique rock physics behaviour of BCS. The study shows that these are discontinuous channels and the input direction of sediments is from NW direction. The RMS amplitude slice (time) and along the BCS top horizon with different windows (time interval) close to BMS/BCS-I &IV sands indicate the input direction of sand is from NW direction at all the sub units of the BCS deposition. From

stratigraphic correlation of these sands, it is observed that HC bearing sands in wells CH-CD & CH-CF are not the same sands and same has been validated through seismic attribute studies

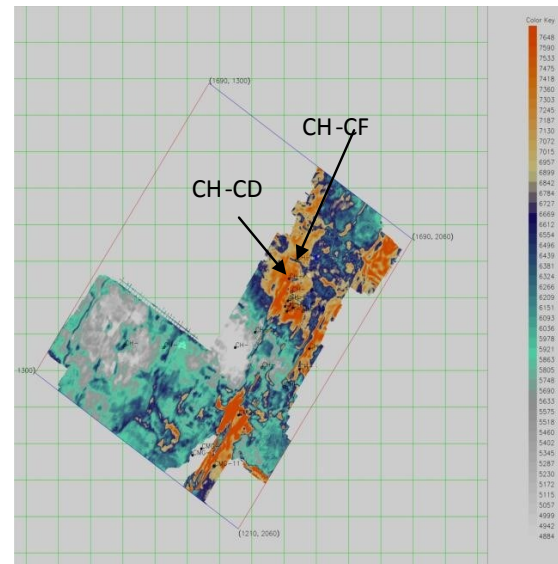


Fig. 16: RMS amplitude extracted from the P-Impedance Volume at 20ms below BCS top with central window of 10ms (close to BCS-IV).

Conclusions

- Rock physics analysis shows that reasonable discrimination is not possible between sand and shale using P-impedance. However, the x-plot between GR log and P- impedance at wells helps to identify coal facies.
- Results derived out of this analysis are only indicative and qualitative and needs to be considered together with other relevant geo-scientific data for useful decision making for prospect analysis.
- The major constraints in this kind of study are non-uniqueness in rock physics behavior which is inherent to the clastics within BCS sequence.
- Log correlation shows that BCS sands are of discontinuous nature and it is difficult to correlate all the sands from seismic. □ The stratigraphic correlation brought out that producing sands of well CH-CD &CH-CF are altogether different sands and not belong to the same pool.



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