Quantative Analysis of Reservoir Characterisation Through Seismic Attributes In Bassein Formation, Bombay Offshore Basin.

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ABSTRACT : This paper presents the interpretation of 3-D seismic data by integration of bore hole data and application of seismic attributes to the carbonate reservoir of Bassein Formation (Middle to late Eocene) in the southern extension of Bombay High field of Bombay offshore basin in the west coast of India. Producing reservoirs are found in carbonates of Middle to Late Eocene. In this study seismic attributes were extracted and analysed through cross-plots in association with well data. Seismic attributes calibrated with log derived porosity have helped in generating map depicting porosity pattern for the carbonate reservoirs.

INTRODUCTION

3D seismic data yields considerably more detailed information about the reservoir and its content than conventional interpretation. Seismic reflections are caused by the acoustic impedance contrast between adjacent layers. The strength of seismic reflection depends on three principal effects, (a) change in cap rock properties (density, velocity and lithology), (b) changes in reservoir properties caused by change in porosity, mineralogy or fluid content and (c) changes in geometry of the interface such as steep dip, fault and fracturing. Cap rocks generally have relatively constant properties over the large distances thus change in reflection amplitude are most likely caused by variation within reservoir and geometry or both. Seismic amplitude data can thus yield valuable information on the reservoir (Ruijtenberg et al, 1997). Seismic attributes are specific measurements of geometric, kinematic, dynamic, or statistical features derived from seismic data. Some are more sensitive than others to specific reservoir environments, some are better at revealing subsurface anomalies not easily detectable; and some have been used as direct hydrocarbon indicators (Chen et al, 1997). In the recent years, much attention has been given to the extraction of seismic attributes to enhance the value of seismic interpretation (Rijks et al, 1991). Practical application of seismic attributes for prediction of reservoir properties was documented by TongSan et al, (1996), Reddy et al, (1999).

Once the basic correlation of the intended horizons made, a large number of seismic attributes are extracted from 3D seismic data volume. The use of seismic attribute is mainly to predict reservoir properties by establishing a justifiable relationship between seismic attributes and reservoir properties obtained from well logs. The seismic attribute maps obtained after calibration can help in prediction of characteristic of the reservoir.

The present study involves analysis of seismic data with well data in the southern extension of Bombay high field where hydrocarbon potential has been established in carbonate of Bassein Formation (Mid. Late Eocene) with lateral reservoir heterogeneity. Seismic attributes, instantaneous and within a window were extracted and cross-plot analysis was carried out for similarities between them. The interpretation of attributes suggests that the Hydrocarbon distribution pattern is controlled by the reservoir quality. The seismic attribute map provides quantitative prediction of good porosity areas in the widely distributed carbonates of Bassein Formation.

GEOLOGY OF THE AREA

Study area includes southern extension of Bombay high platform and adjoining slopes Fig-1. Exploratory drilling in the area suggests that basaltic trap forms the floor for the Tertiary sediments in most part. Clastics of Panna Formation form the oldest sedimentary unit in Bombay offshore basin and unconformably overlie the Decan Trap/Archean basement. The unit is constituted of trapwash, sandstone, siltstone, shale and coal deposited during Paleocene to Early Eocene time. The broad depositional environment varies from fluviatile to the inner neritic. Maximum thickness of these sediments is around 300m in the basinal lows and wedges out against subdued ridges. Panna Formation is overlain unconformably by carbonates of Bassein Formation. The thickness of these carbonates ranges from a few meters in wedge outs of platform area to more than 250m in the depositional lows. These carbonates were deposited in shallow open shelf to restricted shelf with occasional high energy

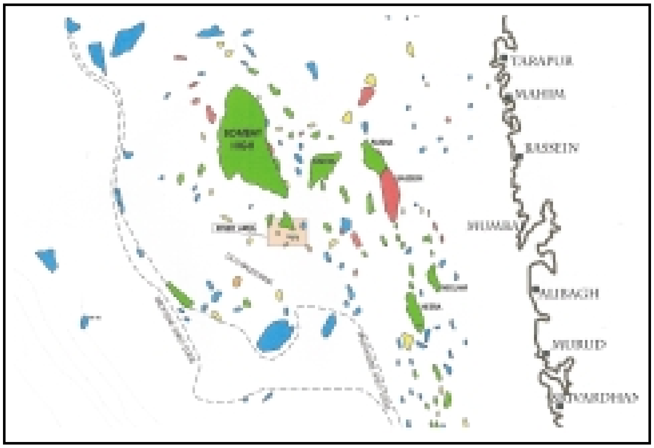

Figure 1 : Index Map.

shoals during Middle to late Eocene time. Synsedimentary tectonism and sea level changes have played major role in deposition of different type of carbonate facies in the area. Mukta Formation is unconformably underlain by Bassein Formation and overlain by Panvel Formation. The base of Mukta Formation is characterised by presence of radioactive shale, which varies in thickness from 15 to 20m. The post Mukta sediments in the area are classified into Panvel, Ratnagiri and Chinchini Formation in ascending order. The generalised stratigraphy of the area is shown in Table-1.

Table - 1 :

Age	Formation
Post Mid Miocene	Chinchini Formation
~~	~~~~~~~~~~~~~
Early to Mid Miocene	Ratnagiri Formation
~~	~~~~~~~~~~~~~
Late Oligocene	Panvel Formation
~~	~~~~~~~~~~~~~
Early Oligocene	Mukta Formation
~~	~~~~~~~~~~~~~
Mid - Late Eocene	Bassein Formation
~~	~~~~~~~~~~~~~
Paleocene – Early Eocene	Panna Formation
~~	~~~~~~~~~~~~~
Pre Tertiary	Basaltic trap/ Granite

The study area is in the vicinity of DCS paleosink in which thick sediments of carbonaceous shale of Panna Formation was deposited in fluvial to shallow marine condition and acted as good source for hydrocarbon generation (Goel et al, 2002). Hydrocarbon potential has been established chiefly from Panna, Bassein and Mukta Formations. Bassein Formation has been divided into three sub units as lower, middle and upper Bassein. The present study involves extensive analysis of upper Bassein Formation as it is good producer of gas in most of the drilled wells in the area.

METHODOLOGY

- Integration of seismic and well data using VSP data and by synthetic seismogram.
- Identification of reflectors corresponding to key horizons for mapping of time structure.
- Extraction of seismic attributes with in reservoir zone.
- Generation of cross plots between log derived acoustic impedance and porosity for individual well and also for the wells together in the reservoir zone.
- Validation of seismic attributes with log derived acoustic impedance and porosity.
- Identification of porous areas by analysis of calibrated seismic attribute map.

INTEGRATION OF SEISMIC WITH BORE HOLE DATA AND STRUCTURE MAPPING

Areal grid of study area, along with location of wells used for validation exercise is shown in Fig-2. 3-D seismic data was integrated with well data by using VSP data and generating synthetic seismogram. Fig-3 shows calibration of seismic with synthetic seismogram of well-L. Top of unit B (Bassein Formation) is represented by trough and base by peak which is corresponding to top of unit C (Panna Formation).

Time structure map Fig-4 near top of unit B shows that well A to W are located on the periphery of subdued ridges extending from Bombay High platform. Map shows the unit B is much shallower in North West and north east region with gentle gradient and is deeper in the SW and SE area with steep gradient from platform to basinal part. Limit of deposition of unit B in the area shown by dotted lines. Major fault trends are N-S, NW-SE and NE-SW related to synrift stage of Tertiary sedimentation. Time thickness map Fig-5 indicates, thickness varies from 10-40ms in NW and NE of platform and 60-110msec in the periphery of subdued ridges in southwestern and southeastern part of study area.

VALIDATION OF SEISMIC ATTRIBUTES WITH WELL DATA THROUGH CROSS PLOTS

Attempts have been made to predict the distribution of physical properties e.g., porosity within the layer by extracting seismic attributes from 3D-seismic data. RMS

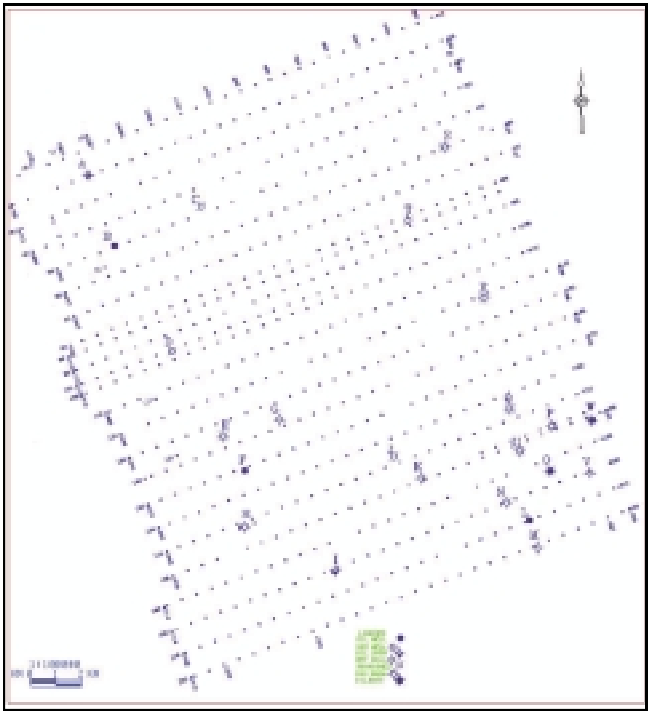

Figure 2 : Areal grid of study area; letter refers to wells which were used in the validation exercise.

absolute amplitude and average instantaneous frequency was extracted over the area with in a window of 50 ms from top of unit B and correlated with bore hole data. RMS absolute amplitude Fig-6 and average instantaneous frequency Fig-7 overlaid with time structure of unit B reflects the alignment of high value of RMS absolute amplitude with structure trends. Similarly isochronopach thickness shows alignment of high value of RMS absolute amplitude with high thickness Fig-8.

The cross plot between log derived acoustic impedance (from DT and RHOB) and porosity (NPHI) for individual wells and the wells together indicate the inverse relationship between them (Fig-9 & 10). Porosity data was taken from report by Rawat N.S, May-2000. To establish significant relationship between seismic attributes and log derived physical properties, cross plot was drawn between values of contoured seismic attribute and log derived acoustic impedance. RMS absolute amplitude indicates linear relationship with acoustic impedance Fig-11. Analysis of crossplots indicates that RMS absolute amplitude in the range of 35-65 is representative of porosity in the range of 15-10% and are depicted by light yellow to yellow color (Fig. 6).

Gas reservoir attenuates high frequencies more than rocks without gas saturation. Following this principle Tanner et al, (1979) have shown that low instantaneous frequency

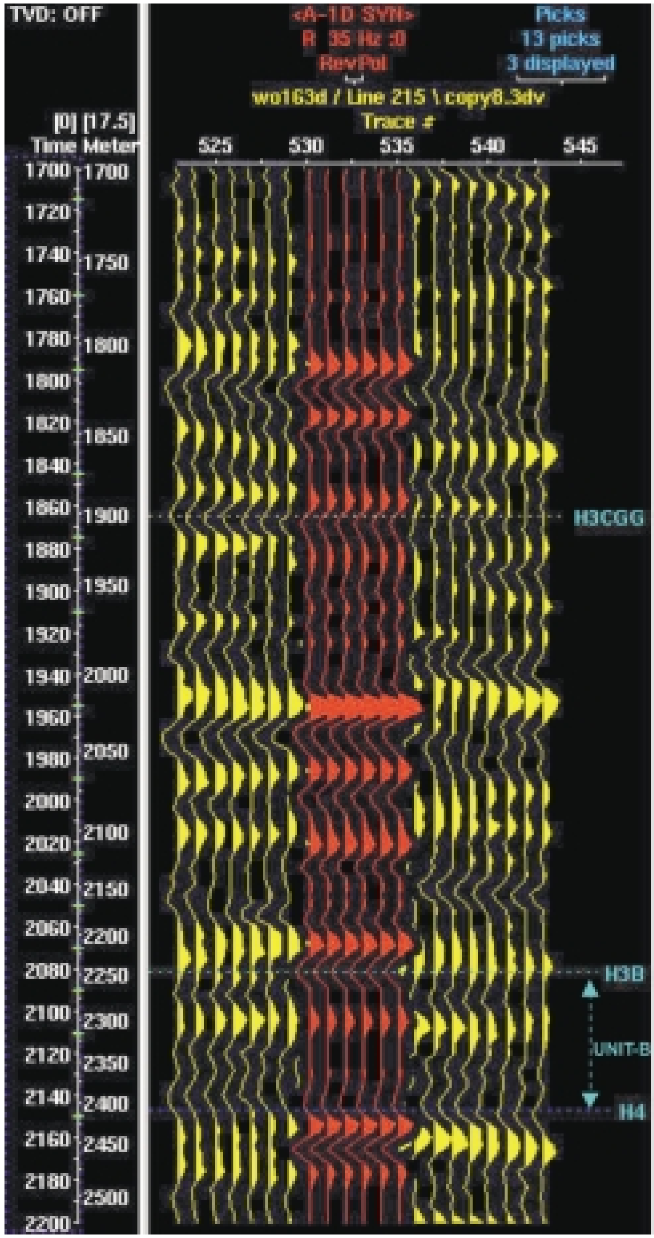

Figure 3 : Correlations of synthetic seismogram (light blue color) with seismic traces (dark blue color) on inline 215 passing through well-L.

immediately below probable reservoir can be a good indicator of gas reservoir. Upper Bassein reservoir has indicated gas entrapment in number of wells. Average thickness of upper Bassein is 83m and average TWT thickness is 38msec.Window considered for extracting seismic attributes is 50msec to include pay zones of upper Bassein reservoir and to give cumulative effect of lowering of frequency below the gas reservoir due to presence of gas. Average instantaneous frequency extracted

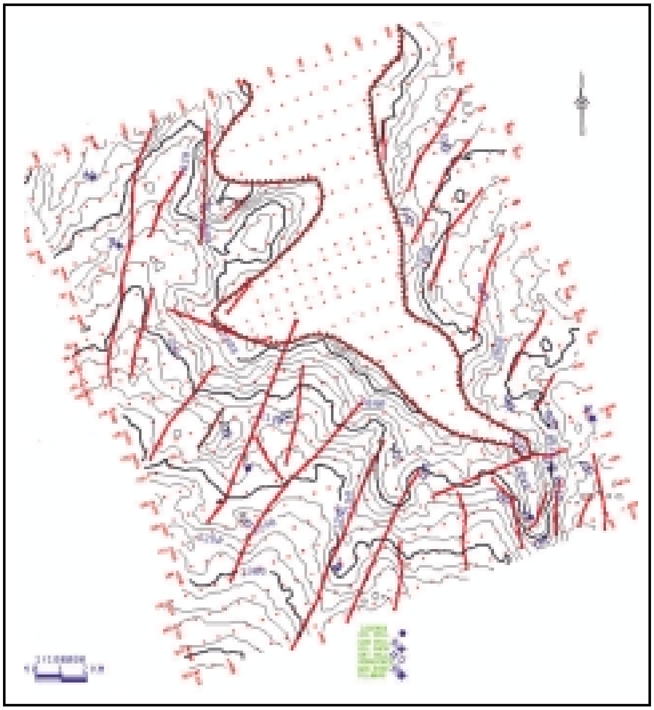

Figure 4 : Time structure map near top of Bassein Formation.

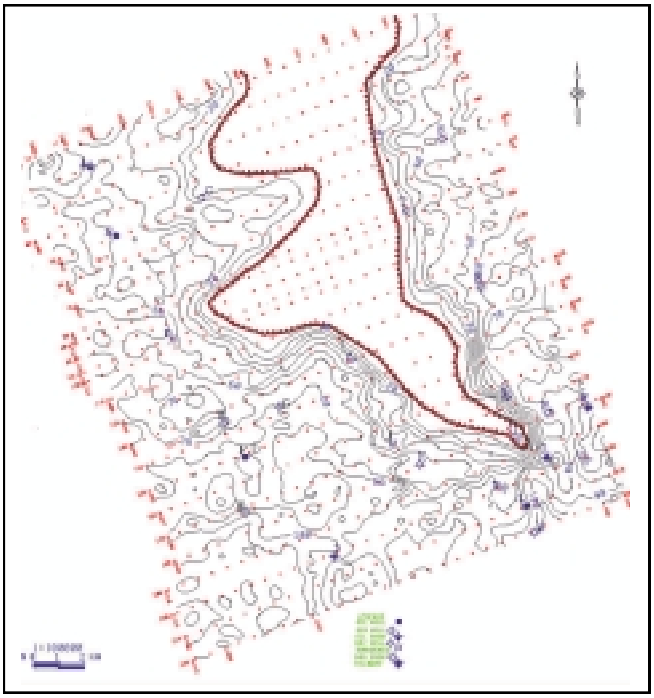

Figure 5 : TWT Thickness map of Bassein Formation.

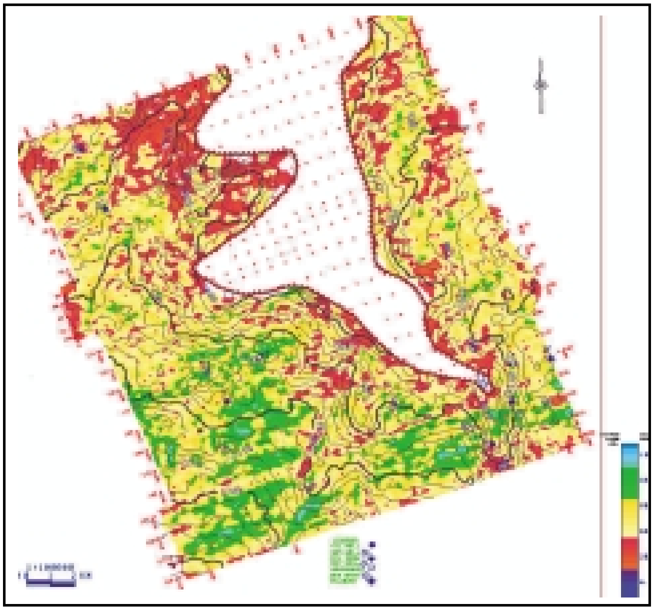

Figure 6 : RMS amplitude of 0-50ms window from top of Bassein Fm. overlaid with time structure contours of Bassein Top.

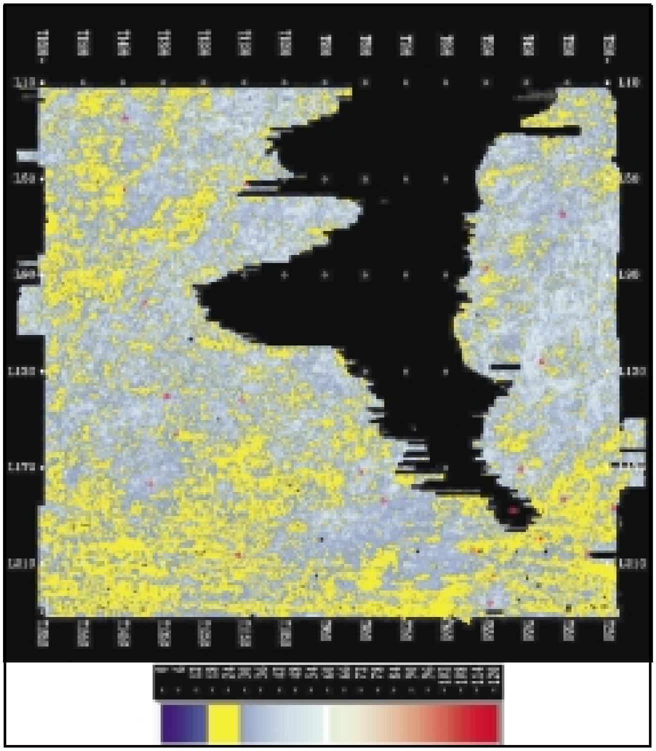

Figure 7 : Average Instantaneous frequency of 50 msec window from Bassein Top. Areas shown with yellow colour represent frequency in the range of 18-28 Hertz.

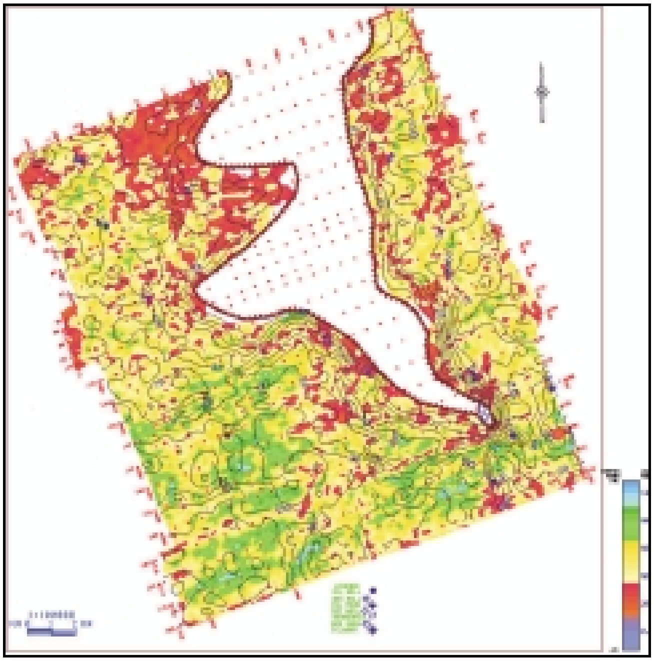

Figure 8 : RMS absolute amplitude of 50 msec window from Bassein Top overlaid with TWT thickness contours of Bassein Formation.

for the same window and displayed on the map Fig-7. Average instantaneous frequency observed within 50msec window is in the range of 10-45 Hz and average instantaneous frequency observed at well location where hydrocarbon has been found is in the range of 18-28 Hz shown by yellow color.

DISCUSSION AND CONCLUSION

Thickness of Bassein carbonate is extensive in the basinal part and wedges out against platform. So far drilling targets were subdued ridges in the periphery of Bombay High platform for testing hydrocarbon potential of Bassein reservoir. Calibration of seismic attributes with well data shows excellent relationship between them. Seismic attributes were extracted for 50ms window from top of Bassein Formation. Wells A, T and C are situated in the area where thickness of Bassein Formation is very less and are thus not considered for analysis. Wells B, D,E,F,N,L,O,P,Q,W and R are located where RMS absolute amplitude is in the range of 65-35 shown by yellow to light yellow color (Fig-6) and porosity is found in the range of 10 to 15%. Low frequency anomaly is shown by yellow color on the average instantaneous frequency map Fig-7. These wells have been good producer of gas. Wells G, H, I, J, L and V fall in the area where RMS absolute amplitude is marginally higher and are wet, on instantaneous frequency map indicate high frequency on these locations. Similarly wells

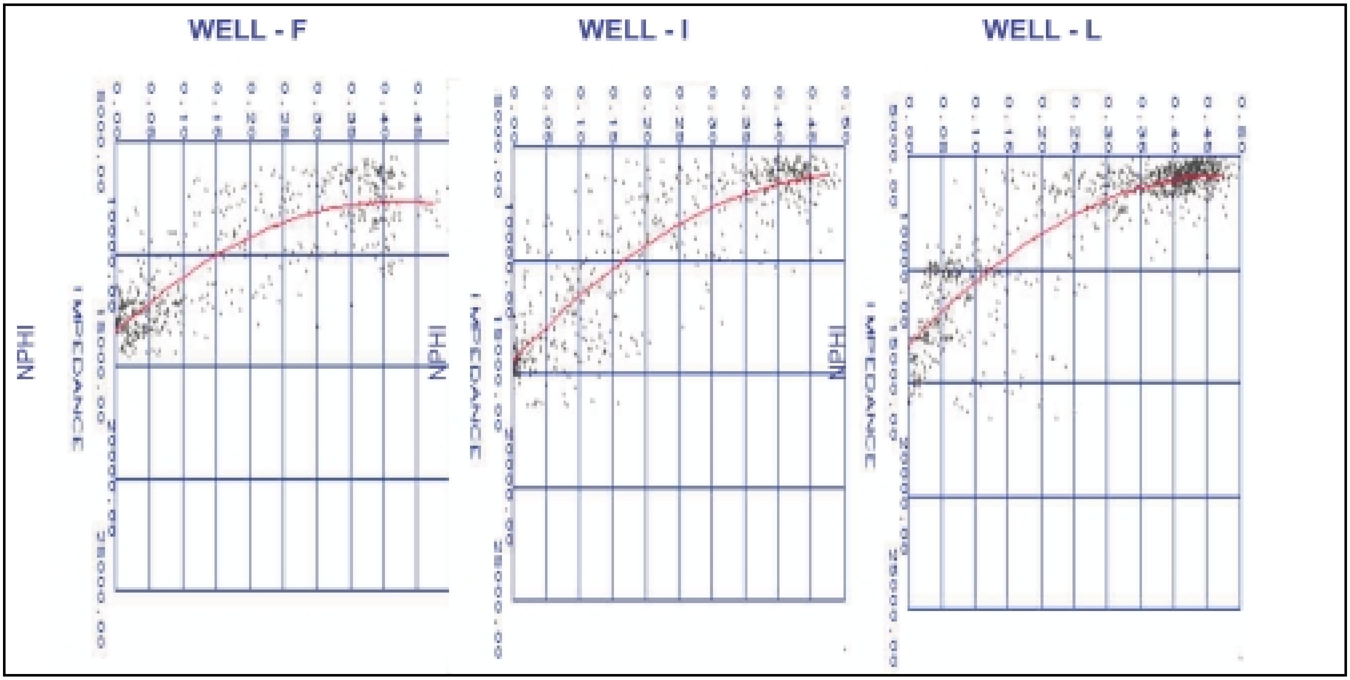

Figure 9 : Cross plots between NPHI and log drive acoustic impedance.

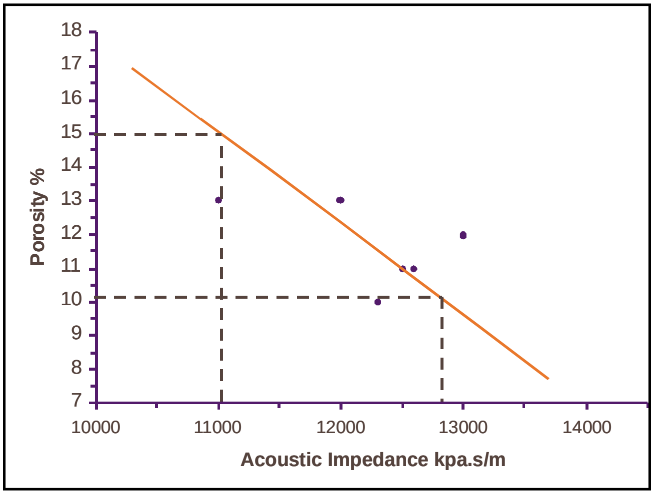

Figure 10 : Crossplot Porosity verses Acoustic Impedance. Porosity range observed 10 to 15% corresponding range of Acoustic Impedance from crossplot is 12800 to 11100 kpa.s/m respectively.

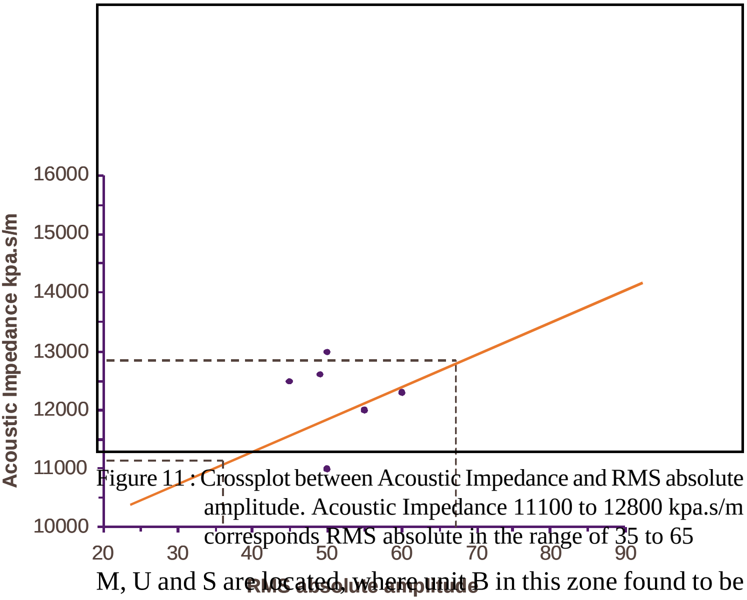

Figure 11 : Crossplot between Acoustic Impedance and RMS absolute amplitude. Acoustic Impedance 11100 to 12800 kpa.s/m corresponds RMS absolute in the range of 35 to 65

M, U and S are located, where unit B in this zone found to be devoid of porosity and falls out side the range of favourable RMS absolute amplitude value and having high instantaneous frequency at these locations.

Analysis of multiple seismic attribute together and by calibration with well data essentially provide information about the reservoir rock properties by extrapolating from known location to other areas, where no other information is available other than seismic data. Seismic attribute maps provide good information between good and poor reservoir properties from hydrocarbon point of view. Although there exists risk in this process but a large number of case histories are reported where successful application of seismic attribute for reservoir characterization is made.

ACKNOWLEDGEMENTS

The authors are thankful to Dr.D.Ray, Head KDMIPE for providing an opportunity, encouragement, infrastructure and technical support. Thanks are due to Shri N.K.Lal, GGM (Geol.) and Shri B.K.Verma, GM (Geophy.) for their keen interest and valuable guidance.

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