Int. J. Econ. Environ. Geol. Vol. 8 (3) 40-46, 2017

Journal home page: www.econ-environ-geol.org

Open Access

ISSN: 2223-957X

Seismic Interpretation and Reservoir Evaluation Utilizing 2-D Seismic Data and Wireline Logs of Bijnot-01 Well, Fort Abbas Field, Central Indus Basin, Pakistan

Muhammad Adnan Khan[1], Hamad-ur-Rahim[2, 3*], Syed Waqas Haider[1], WaqarAhmad[1]

[1]Department of Earth and Environmental Sciences, Bahria University, Islamabad, Pakistan
[2]Earth Sciences Division, Pakistan Museum of Natural History, Islamabad, Pakistan
[3]Department of Earth Sciences, Quaid-i-Azam University, Islamabad, Pakistan

*Email: hamadrahim@gmail.com

Received: *19 June, 2016* ***Accepted:*** *30 August, 2017*

Abstract: Present study attempts to decipher the subsurface structure and reservoir characterization of Fort-Abbas field, located in Punjab platform, Central Indus Basin utilizing 2-D seismic and wireline logs data. Four seismic lines, 944-FABS-42, 944-FABS-43, 944-FABS-48, 944-FABS-49 and wireline logs of Bijnot-01 well have been used for this research work to delineate subsurface structures and demarcation of zone having fair potential of hydrocarbon accumulation. Formation evaluation for hydrocarbon potential using the reservoir properties is also the foremost objective of this research work. Based on the results of seismic data interpretation of Fort-Abbas field and integrating it with formation tops and wireline logs data, three prominent reflectors have been marked i.e. Eocene Sui Main Limestone, Cretaceous Lower Goru and Jurassic Chiltan Limestone. The structure of the area is interpreted as gently dipping monocline. Based on the breakup of reflectors on seismic section, one normal fault is marked. Time and depth contour maps are generated to demarcate lateral extension and closure of the reservoir. Based on interpretation of wireline logs, a zone has been marked from depth of 504 m to 594 m (Datta Formation) as a favorable zone having good potential for hydrocarbon accumulation. Saturation of hydrocarbon (S_h) in this zone is calculated as 57%.

Keywords: 2-D Seismic, Punjab platform, Fort Abbas field, petrophysics, wireline logs.

Introduction

The study area lies in Tehsil Fort Abbas, District Bahawalnagar of Punjab Province (Fig.1a). Geographically the area is situated at 28°49'42" N and 71°52'14"E. Geologically, it is the component of Central Indus Basin, Pakistan. The exploration license of Fort Abbas field was granted to OGDCL in June 1992. Acquisition and processing of 2-D Seismic data was done on Fort Abbas field by Oil and Gas Development Company Limited (OGDCL) in 1994.Exploratory wellsFort-Abbas-01 and Bijnot-01 were drilled in 1994 and 1996 respectively on Punjab platform to discover the petroleum potential of Infra Cambrian reservoir rocks (Zaidi et al., 2012).

Tectonics of area

Central Indus Basin has three subdivisions. From east to west these are Punjab platform, Sulaiman depression and Sulaiman fold belt (Quadri et al., 1986) (Fig.1b). Punjab platform is west ward dipping monocline, covered with unconsolidated Quaternary deposits with the maximum thickness of about 500m (Raza et al., 2008). It is mostly a desert area with no surface

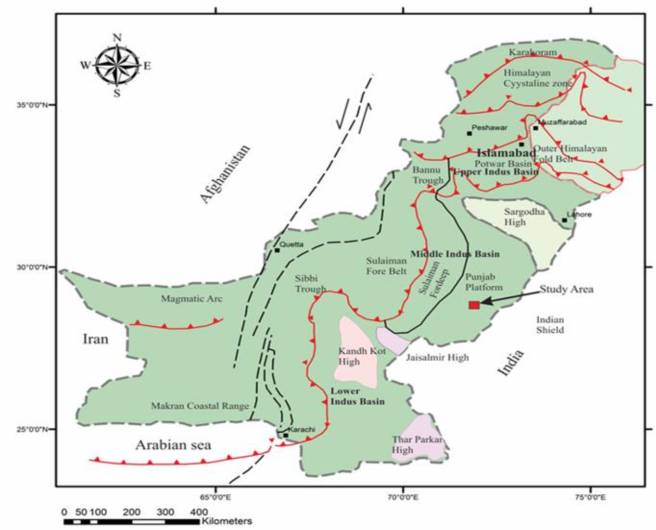

Fig.1a Tectonic Map of Pakistan showing study area (modified after Kadri, 1995).

outcrops (Kadri, 1995). The basin configuration of Central Indus Basin is as follows. In north there is Sargodha high, in east there is Indian Shield, in west there is Axial Belt and in south, there is Sukker Rift (Kadri, 1995) (Fig. 1a, 1b). Punjab Platform is least affected during Himalayan orogeny therefore, it possesses non-tectonic origin structures (Hasany et al., 2007). Punjab platform has no exposure of bed rocks. Most of bed rocks are covered with thick alluvium (clay, silt and sand) deposits. The oldest rock present in the basin is of Triassic age. Due to lack of active tectonic elements in the Central Indus Basin, it is very stable (Kazmi, 1997)

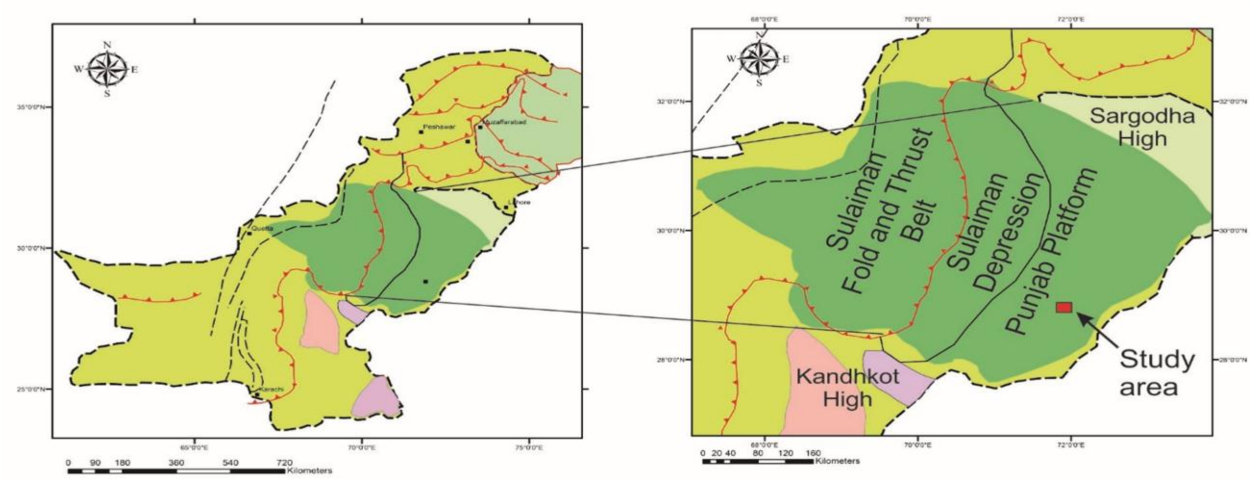

Fig.1b Generalized tectonic map of Pakistan and location of the Central Indus Basin (modified after Kadri, 1995).

Methodology

Seismic Data Interpretation

The analysis of seismic data includes stratigraphic and structural analysis. It is the conversion of seismic reflection data into a useful structural picture to reveal the structure and stratigraphy of the subsurface (Dobrin, 1976). Seismic interpretation includes conversion of velocity and time into the depth of subsurface reflecting interfaces to convert seismic data in to useful image (Dobrin, 1976). For present research work Kingdom software version 8.6 has been used to interpret seismic data. The data of well Bijnot-01 has been incorporated for the study. Table 1

Table 1 Seismic lines information.

LINE NAME	944-FABS-42	944-FABS-43	944-FABS-48	944-FABS-49
Line	Strike	Strike	Dip	Dip
Line Direction	East-West	East-West	North-South	North-South
SP Range	101-1218	101-1015	101-1099	101-597

Shows the properties of four seismic lines used for interpretation. Base map of study area (Fig. 2) shows the orientation of seismic lines and the corresponding points on which seismic data are acquired. The quality of seismic lines of Fort Abbas field is fair to good. On interpretation of seismic data, three prominent reflectors are marked on seismic section. Well Tops of Bijnot-01 well are used for correlation. The marked horizons are Eocene Sui Main Limestone, Cretaceous Lower Goru and Jurassic Chiltan Limestone (Fig. 3, 4). Time read of these interpreted sections at an interval of 50 shot points and referred to the seismic base map (Fig. 2). By contouring points of equal time value, time contour maps of all three horizons are prepared (Fig. 5a, 6a, 7a). Taking the average stacking velocities and smoothing of the velocities with the depths encountered in Bijnot-01, the depth structure maps are also prepared for three horizons (Fig. 5b, 6b, 7b). The seismic line S944-FABS-42, which is a strike line, taken as control line for correlation. Well is not exactly located on the seismic line rather it is at some offset from it (Figure 2).

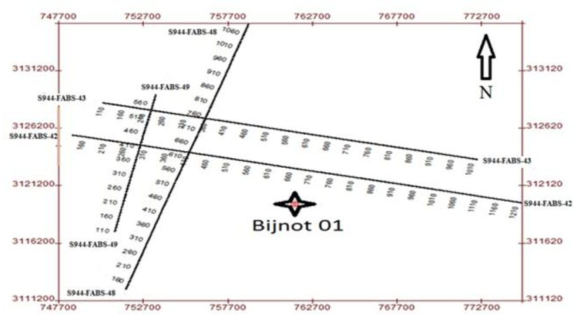

Fig. 2 Base map of the study area.

Seismic Time and Depth Sections

Seismic Time section is a plot in a time frame against the shot points. Seismic section is in time (sec) units therefore, the interpretation has been carried out in units of two way travel time. To determine the depth,

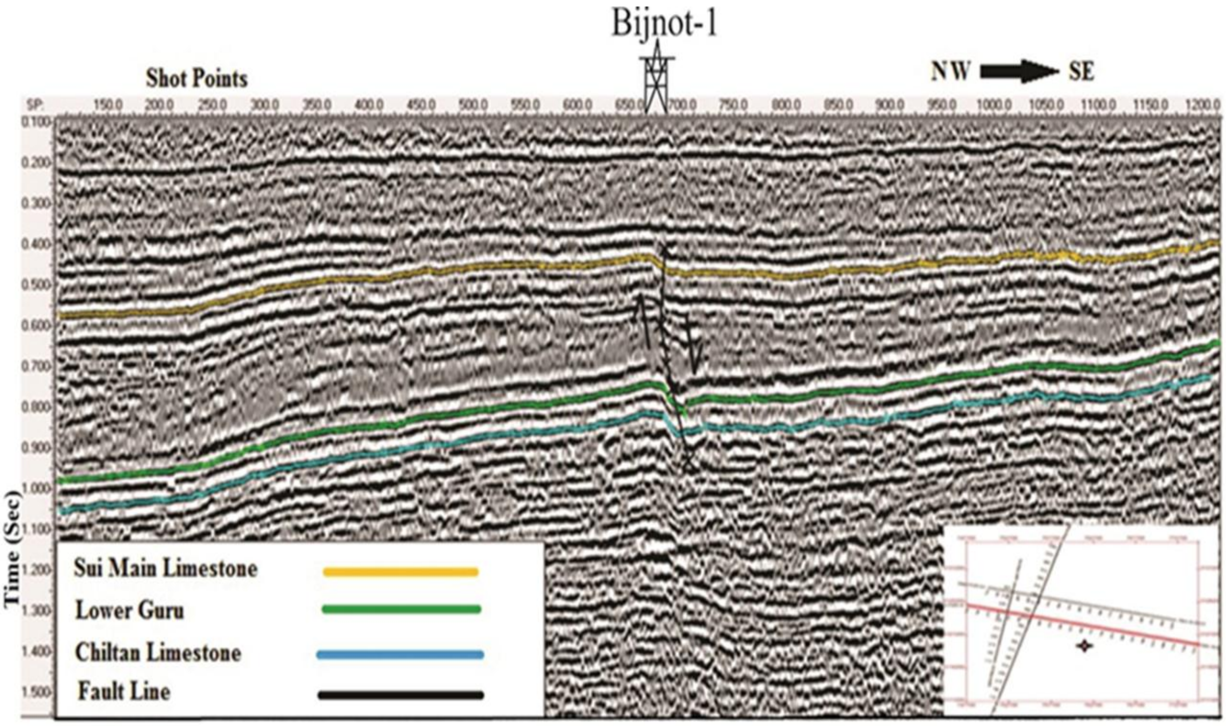

Fig. 3. Interpreted Seismic Section of strike line 944-FABS-42 showing horizons and fault with well location.

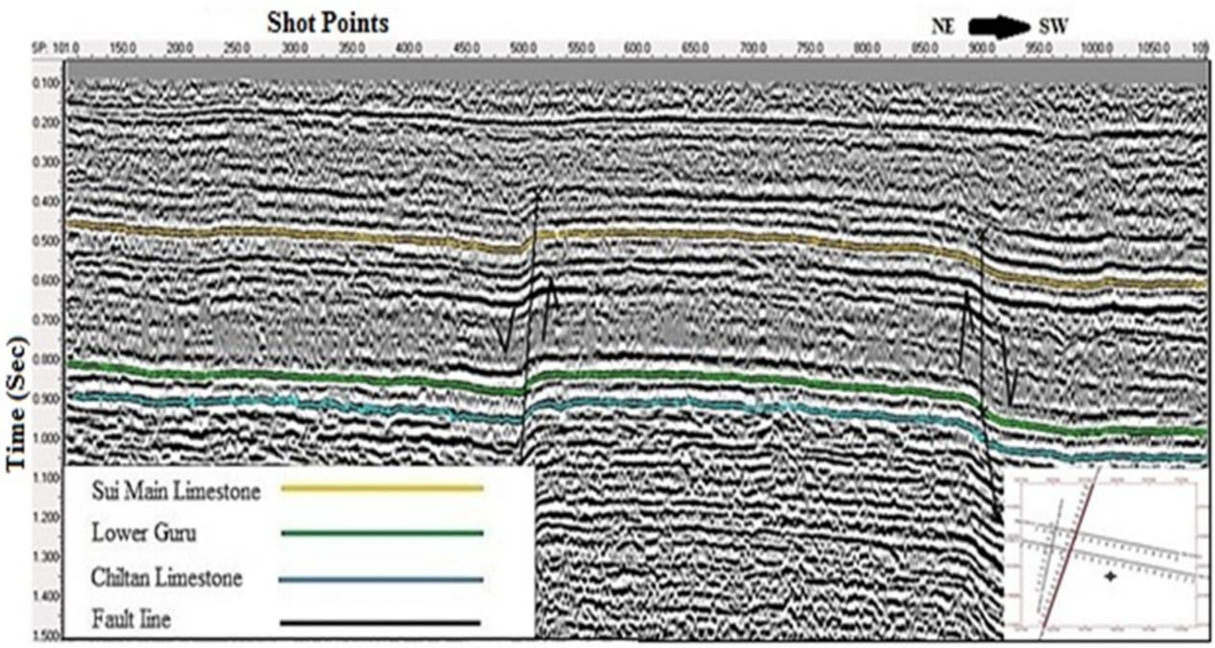

Fig. 4 Interpreted seismic section of dip line 944-FABS-48.

read the time of each reflector from seismic section. By using the appropriate velocity values and time, the depth of each reflector is calculated by the following relation.

Depth (S) = (V x T) / 2

Where: V = Velocity of reflector in (m/s) and T = Two-way travel time of each reflector in (sec).

Time and Depth Contour Maps

Time contour map correspond to contour lines which have the same time value and represents the time taken by a seismic wave to travel through subsurface and after reflection coming back to the receivers. The depth of the stratigraphy i.e. Sui Main Limestone, Lower Goru and Chiltan Limestone and the structures such as faults and folds are marked onthe base map. They are contoured to make depth contour map. The contours show the precise depths of the structure present in the area. The contour values representing the shapes of the subsurface features.

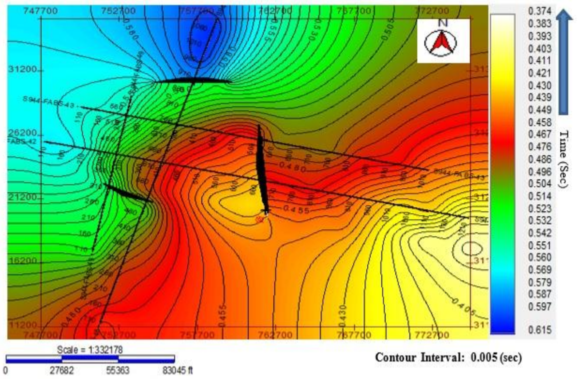

Fig.5a. Time contour map of Sui Main Limestone.

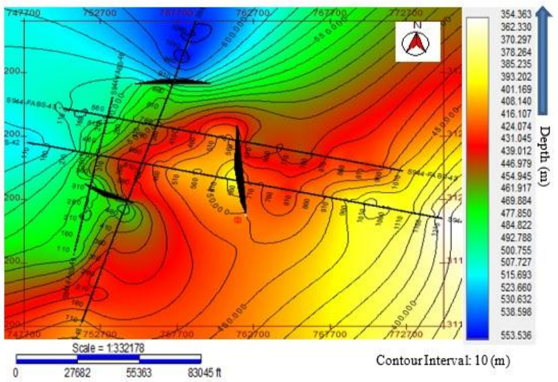

Fig. 5b. Depth Contour map of Sui Main Limestone.

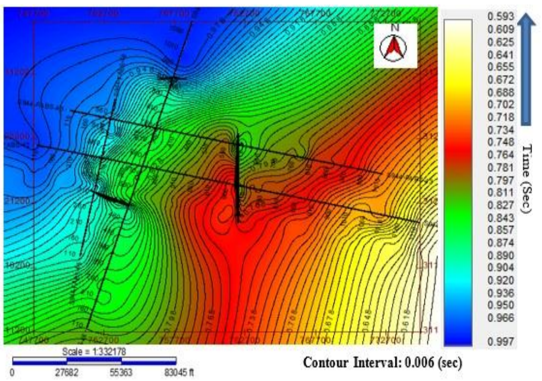

Fig. 6a. Time contour map of Lower Goru

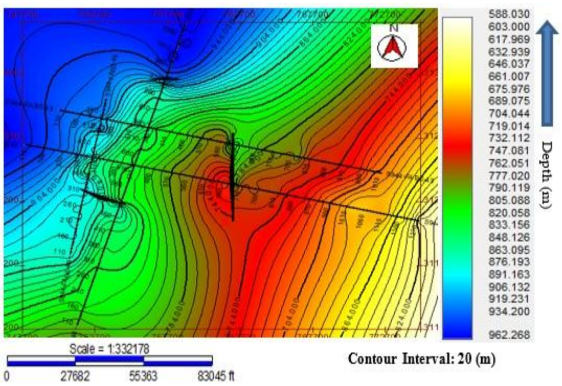

Fig. 6b Depth contour map of Lower Goru.

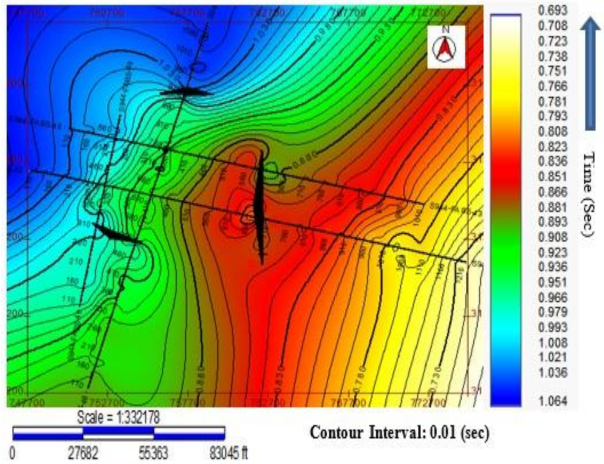

Fig.7a. Time contour map of Chiltan Limestone.

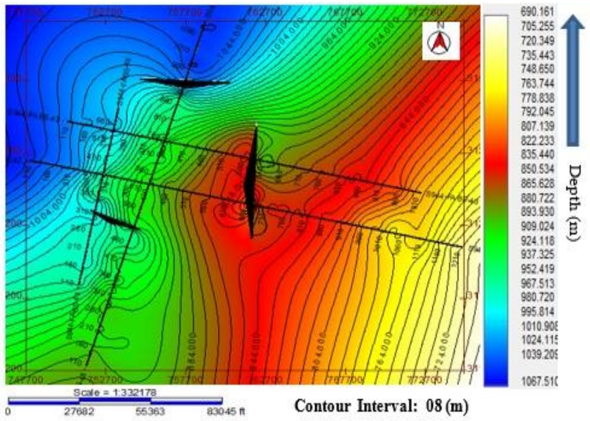

Fig.7b Depth Contour map of Chiltan Limestone.

Results of Time Depth Contour Map

As it is obvious from Time / Depth Contour Maps that at Sui Main Limestone, Lower Goru and Chiltan Limestone level, there are westwards dipping monocline, which is a typical characteristic of the area. Normal faults of subtle throw are present in this area. There is a very small three-way dip and one way fault bounded closure.

Petrophysical Analysis:

The objective of petrophysical analysis is to attain information from the well, i.e. Bijnot-01. The data used for this study comprises of the log curves. The logs used are Gamma Ray Log, Neutron Log, Density Log, and Resistivity Log. A procedure adopted for this study is shown below (Table 2). The clean zone is marked using the Gamma Ray Log. Separation in resistivity curves (LLS, MSFL and LLD) and higher values of resistivity confirm the presence of hydrocarbons. The cross over between Neutron and Density logs indicate the presence of hydrocarbons in selected clean zone. Following zone of interest is marked (Table 3) and the methodology adopted is given below (Table 2).

Table 2 Procedure adopted for wireline log interpretation.

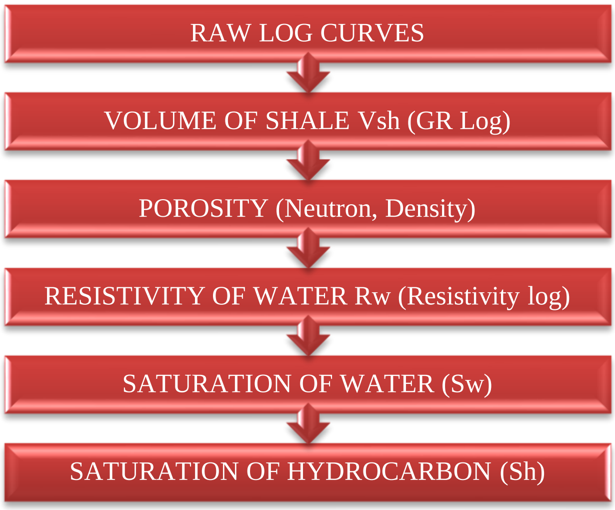

Table 3 Marked zone of interest encountered.

Formation	Starting Point	Ending Point	Total Thickness
Datta Formation	504m	594m	90m

Calculation of Volume of Shale:

Volume of shale is also called dirtiness of reservoir. Figure 8 represents Vsh calculated in our zone of interest. It is calculated by using following equation.

Vsh = (GR log - GR min) / (GR max - GR min)

Where:

GR_{log} = *Gamma ray log reading.*

GR_{max} = *Maximum Gamma ray value.*

GR_{min} = *Minimum Gamma ray value.*

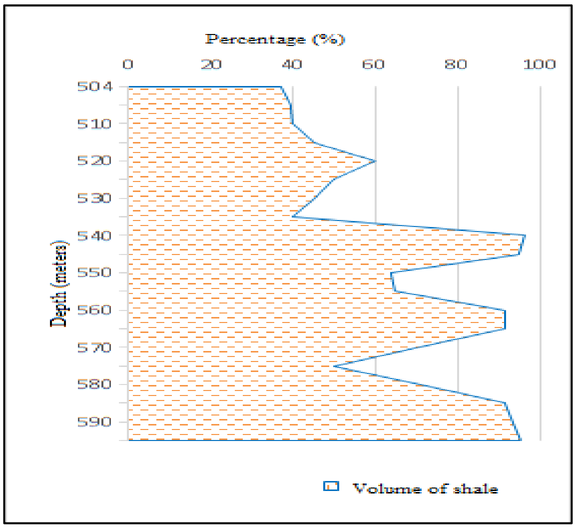

Fig. 8 Volume of shale for selected zone.

Net to Gross Ratio (NTG)

Net to gross ratio is the cleanliness of a reservoir. It is also known as V clean or V sand. It is calculated by subtracting shale volume from 1(Rider, 2002).

Net to Gross Ratio (NTG) = 1-V_{sh}

Where: V_{sh} = Volume of shale.

Porosity Calculations

For a reservoir evaluation, porosity "φ" calculation is an important parameter. For the present research work porosity is calculated using porosity logs i.e. neutron log and density log (Schlumberger, 1997, Rider, 2002).

DPHI (Density Porosity) = (RHOM-RHOB)/(RHOM-RHOF)

Where: RHOM= *density of matrix (constant values).*

RHOF= *density of fluid (on log header).*

RHOB= *Bulk Density (density log values).*

Neutron Porosity is directly calculated from neutron log curve.

Average Porosity= (Neutron Porosity + Density Porosity) / 2

Effective porosity= (NTG)*Average Porosity.

Where: NTG = 1-$V_{sh.}$

Effective porosity and total porosity curve for our zone of interest is shown in Figure 9.

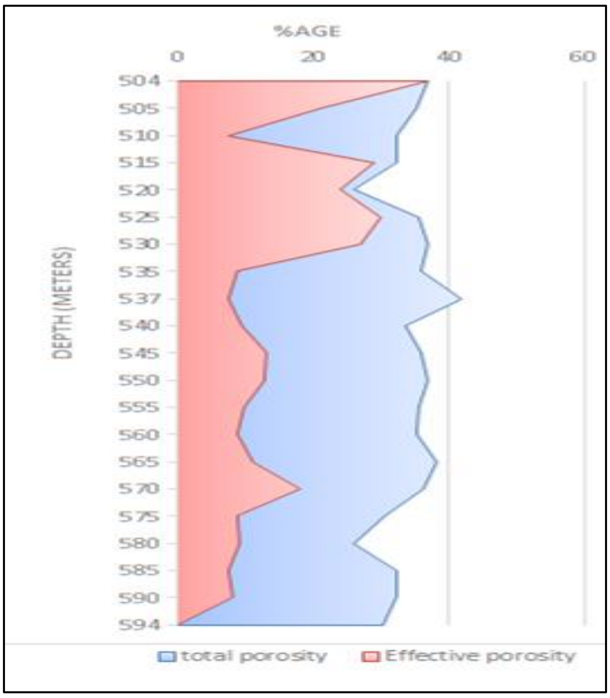

Fig. 9 Effective porosity as compared to total porosity.

Saturation of water

Sw is calculated by using Archie's equation (Archie, 1942).

Archie's Equation:

$$Sw = \sqrt{(Rw / (Rt * Øe^2))}$$

Where: Sw = Saturation of water

Rw = Resistivity of water

Rt= Resistivity of true zone

Øe= Effective porosity

Saturation of Hydrocarbon

Hydrocarbon's saturation determination is most important factor because it shows the potential of reservoir to produce hydrocarbons. Saturation of hydrocarbons results are shown in Figure 10. Formula for calculation of hydrocarbons is:

$$Sh = 1 - Sw$$

Where: Sh: *Saturation of hydrocarbons.*

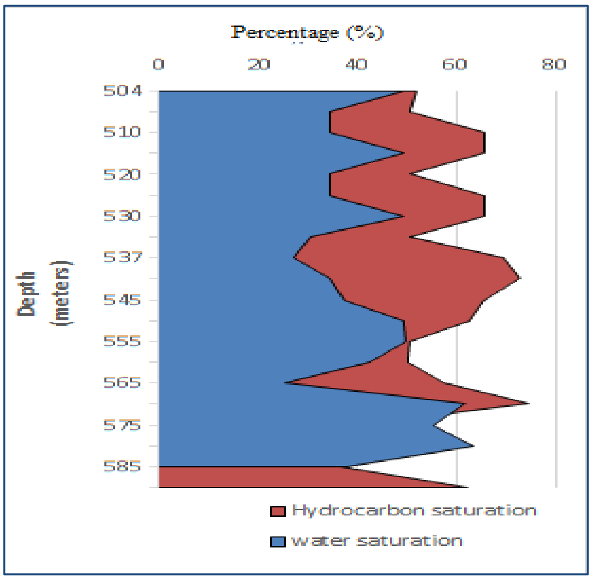

Fig. 10 Saturation of hydrocarbons.

Results and Discussions

The study area lies in Punjab Platform. This area is least effected by tectonic activity, so normally faulting is common behavior observed here. Horst and graben structures are generally present in this area. These structures favor the accumulation of hydrocarbons. Seismic interpretation shows that the area is comprised of monocline structures that have one limb gently dipping in north-west direction. Punjab Platform further extends towards east in India, where it is called Bikaner-Nagaur Basin, where significant quantity of hydrocarbons has been discovered. Good reservoir quality sands and dolomite are present in Cambrian sequence. The well was drilled on basement involved high with a sufficient structure closure. The geothermal gradient of the area is very low and as such oil window lies much below the Salt Range Formation. Petrophysical analysis of Bijnot-01 well indicates good potential of Hydrocarbons in Datta Formation and Salt Range Formation. Bijnot-01 well is drilled downdip that makes it unsuccessful.

Acknowledgement

The authors are grateful to the Faculty of Department of Earth and Environmental Sciences, Bahria University, Islamabad for their guidance and moral support and especially thankful to Director General Petroleum Concession for giving approval to LMKR to provide data for this research work.

References

Archie, G. E. (1942). Electrical resistivity Log as an aid in determining some Reservoir characteristics. *Transaction of American Institute of Mining, Metallurgical and Petroleum Engineers* (*TAIME*), **146**, 54-62.

Dobrin, M. B., Savit, C. H. (1976). *Introduction to Geo-Physical Prospecting*. 2nd edition, Mc Graw-Hill, New York, USA, 286-327.

Hasany, S. T., Aftab, M., Siddiqui, R. A. (2007). Refound exploration opportunities in infraCambrian and Cambrian sediments of Punjab Platform, Pakistan. In: *Proceedings PAPG-SPE Annual Technical conference 2007*, Islamabad, Pakistan, 31-62.

Kadri, I. B. (1995). *Petroleum Geology of Pakistan*. Pakistan Petroleum Limited, Karachi, Pakistan, 275 pages.

Kazmi, A. H., Jan, M. Q. (1997). *Geology and Tectonics of Pakistan*. Graphic publishers, Karachi, Pakistan, 500 pages.

Quadri, V. N., Shuhaib, S. M. (1986). Hydrocarbon Prospects of southern Indus Basin, Pakistan. *Bull. Amer. Assoc. Petrol. Geol*., **70**, 730-747.

Raza, H. A., Ahmad, W., Ali, S.M., Mujtaba, M., Alam, S., Shafeeq, M., Iqbal, M., Noor, I., Riaz, N. (2008). Hydrocarbon prospects of Punjab Platform, Pakistan with special reference to Bikaner-Nagaur Basin of India, *Pak. J. Hydrocarbon Res*., **18**, 1-33.

Rider, M. (2002). *The Geological Interpretation of Well Logs*, 2ndedition, Suthernland, Rider-French Consulting, 291 pages

Schlumberger (1997). *Log Interpretation Charts*, Gen-9, SP-1, SP-2 Charts, 19-20.

Zaidi, S. N. A., Brohi, I. A., Ramzan, A., Ahmad, N., Mehmood, F., Brohi, A. U. (2012). Evaluation of Infra-Cambrian Plays in Punjab Platform. *Sindh Univ. Res. Jour. (Sci. Ser.)* **44** (4), 549-554.

Mujtaba, M. (2006). Petroleum prospects of Punjab Platform, Middle Indus Basin, Pakistan, through personnel communication.