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An Overview of Structural Style and Hydrocarbon Potential of Jabo Field, Southern Sindh Monocline, Southern Indus Basin, Pakistan.

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Abstract: This paper presents the study over the structural style and hydrocarbon potential of Jabo field located in Southern Sindh Monocline, Southern Indus Basin of Pakistan with the help of integration of seismic data and wireline logs. Seismic interpretation reveals that the structure Jabo field and in surroundings there are tilted normal fault which are collectively forming the Horst and Graben type of structures. Wire Line Log interpretation and TOC calculation shows that Turk and Badin shale are prolific source rock in the southern Sindh Monocline.

Keywords: Structure, Tilted Normal Faults, Hydrocarbon Potential, Jabo Field and Southern Sindh Monocline.

1. INTRODUCTION

Lower Cretaceous Goru Formation sandstone play was discovered by Union Texas Pakistan from Lower Indus Basin Khaskeli #1 in 1981, the first commercial discovered from Southern Sindh Monocline, Pakistan. Although the Jaisalmer Basin (Rajasthan), hydrocarbons had been known in Lower Cretaceous reservoirs since ONGC had drilled Khara Tar #1 in 1964m across the Indian border to the east of Pakistan. Extension of the play northwards into the Middle Indus Basin was proven with Lasmo's Kadanwari #1 Lower Goru gas discovery in 1989, followed by several other gas discoveries including OMV's early 1998 Sawan #1 in Central Indus Basin of Sindh Monocline. Dewan-1 & Dewan 5-A (2005 and 2007) encountered hydrocarbons in Sembar/ Lower Goru and Chiltan formations that prove the existence of active petroleum system in the deeper Middle Jurassic–Early Cretaceous rocks.

Southern Sindh Monocline **(Fig.1)** is prolific hydrocarbon producing basin of Pakistan contributing 28% of the country's total recoverable oil reserves and 90% of Sindh total recoverable reserves, according to Pakistan Energy Year Book 2013, published by Hydrocarbon Development of Pakistan, Islamabad. Similarly Southern Sindh contribute 13% of the country's total gas and 24% of Sindh total gas reserves as of Energy Year Book 2013-2013.

Field size distribution in Southern Sindh Monocline also carried out for more than 100 fields of oil and results shows that most of oil field are smaller in size **(Fig.2).** More than 50 % of oil filed in Southern Sindh are less than 1 Million of Barrel (US) as original recoverable size. Lower Goru sands is common reservoir southern Sindh Monocline with proved Sembar Goru Play.

Khaskheli field discovery was the first big discovery by Union Texas. South Mazari Field was discovered in 1985 by British Petroleum (Pakistan) Exploration & Production Inc. from a large Crotch trap, a trap formed by two faults culminating at one point. Zaur field was discovered in 1993 by BP Pakistan Exploration and Production Inc. on a structural closure on a narrow horst block, later on more wells were discovered on nearby fault blocks of the Horst structure (Alam S.M. Mozzaffar *et al.,* 2003). Later on many other major fields like Jabo, Zaur, Ghunghro and many other Exploration and Production Companies have discovered hydrocarbons from and nearby study area. Recently in 2013 more discoveries have been successful from the fault closures of Jabo as well as Nur and Bagla fields.

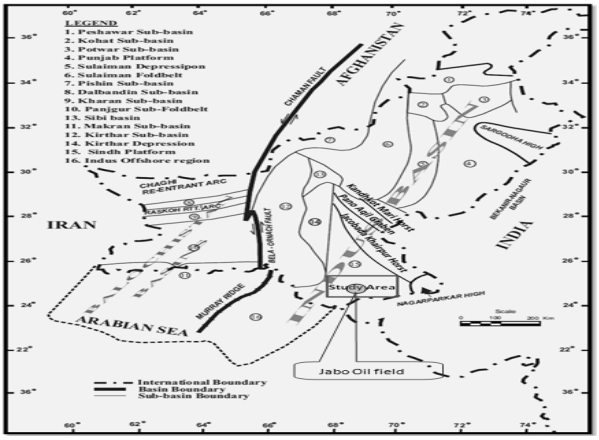

Fig.1. Location Map of Southern Sindh Monocline and Jabo Field (Modified after Nazeer et al, 2012-2013)

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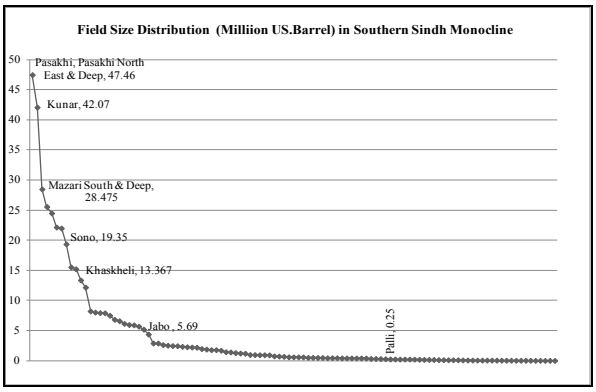

Fig.2. Filed Size Distribution of Oil Field in Southern Sindh Monocline as of Energy year Book 2012-2013.

EXPLORATION HISTORY OF JABO

The Jabo Field is located in Southern Sindh Monocline (Fig.1). The Jabo-01 exploratory well was drilled by UTP and completed in 1986 at TD of 2228m TD at the top of Lower Goru and Gas was discovered. The Jabo-02 and Jabo-03 were completed in 2000 by UTP at TD of 2103m at the top of Lower Goru. Jabo-04 was drilled by BP** in 2002 at TD of 2103 m up to the Top of Lower Goru and produced Oil, Jabo-05 was drilled by British Petroleum in 2003 at TD of 2077m up to top of Lower Goru and oil was discovered, Jabo-06 was completed BP in 2005 at TD of 2636m at the top of Lower Goru and Oil/ Gas was discovered, Jabo-07 was completed in 2007 by BP at TD of 2143 m and was decalared as abandoned, Jabo-08 was completed by BP in 2007 at TD of 2066 m up to top of Lower Goru and produced oil, Jabo-09 was drilled by BP in 2008 at TD of 2114 m up to top of Lower Goru and was declared as oil well, Jabo-11 and 12 wells were completed by BP in 2009 at TD of 2129 m and 2159m respectively and were declared as oil and gas wells, Jabo-13 was completed by BP in 2010 up to TD of 2082m to the top of Lower Goru and declared as oil and gas well, Jabo-14 was completed by UEPL*** in 2012 at TD of 2155 m up to the top of Lower Goru and was declared as oil well and according to Pakistan Energy Year Book 2013, Jab-15 was drilled by United Energy Pakistan Limited. Annual Production chart of Jabo Field **(Fig. 3, 4)** and annual production of Gas and Oil is given below **(Fig.4 and 5).**

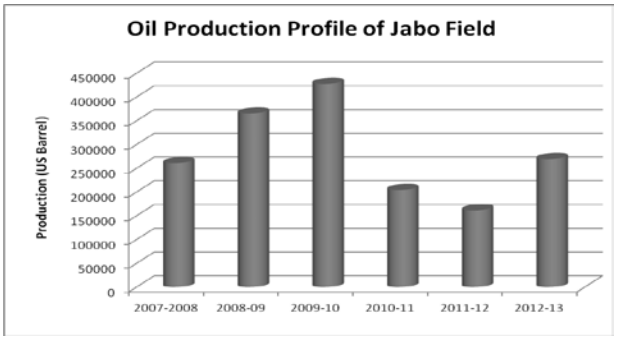

Fig.3. Annual oil production of Jabo field (Source: Energy Year Book 2012-2013)

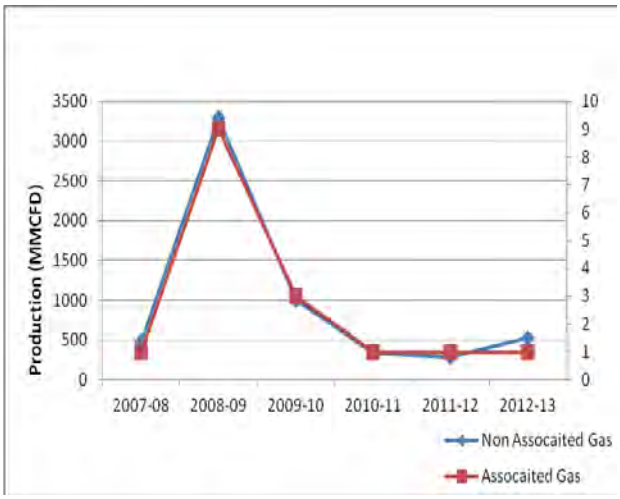

Fig.4. Annual Gas production of Jabo field (Source: Energy Year Book 2012-2013)

TECTONIC SETTING OF STUDY AREA

According to (Malick *et al.,* 1988 and Raza *et al.,* 1990) described that "the Sindh monocline came into existence when Indian plate in Early Cretaceous age started separating away from the Madagascar about 130 million year ago and began moving northward. The northward movement of Indian plate generated compression while accompanying anticlockwise rotation produced tension. Resultantly Sindh Monocline was split into Horsts, Grabens type of Structures".

Sindh monocline is now believed to be the continuation of oil and gas producing rift basin of Indian plate narrated by Kadri, (1995).

Copestake *et al.,* (1995) worked on the deposition of the reservoir sandstones and interbedded source rocks during the rifting of the Indian plate from the Gondwanaland (Fig.6. Adopted from Ph.D Research Project, Adeel Nazeer, 2015).

Memon , *et al.,* (1999), "The occurrence of oil and gas in Sindh Monocline seems to be due to the extensional tectonics"

Khan (2010) described this tectonic setting as proved and ideal for the formation of main entrapment mechanism and the source rock Sembar Formation of Lower Cretaceous and the reservoir rock Lower Goru.

Sahito, *et al.,* described Upper sands of Lower Goru Formation based on well cuttings, (Abbasi *et al.,* Munir, *et al.,* 2014 and Abbasi, *et al.,* 2015) interpreted seismic data of study area and identified the tilted Normal faults collectively forming horst and graben type of structures. From above studies it is clear that normal faulting, tilted fault blocks, crotch, horsts and grabens type of structures are commonly formed in extensional settings.

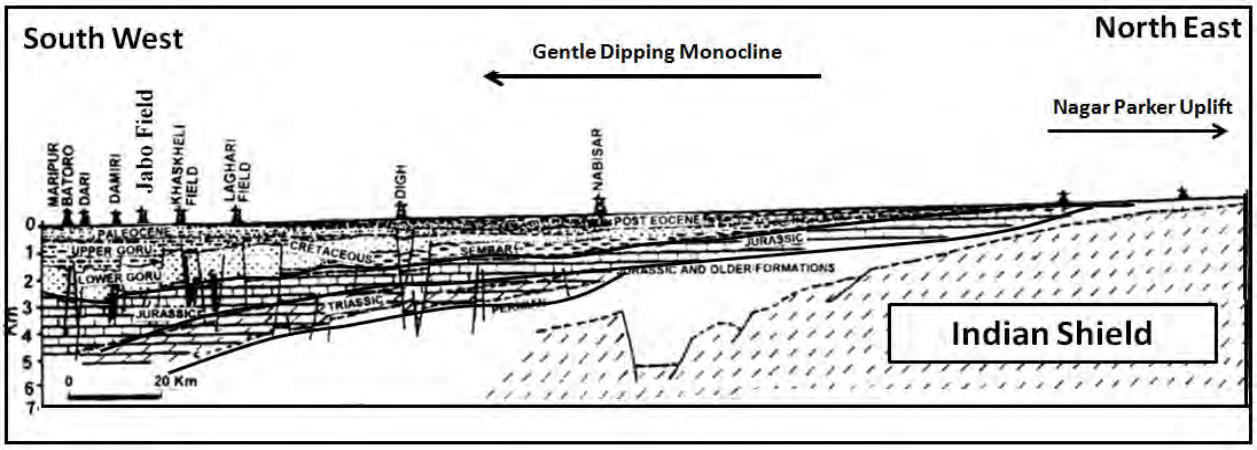

Fig.5. Configuration of Southern Sindh Monoclines with Horst and Graben structures toward basinal setting (Modified after Zaigham et al. 2012).

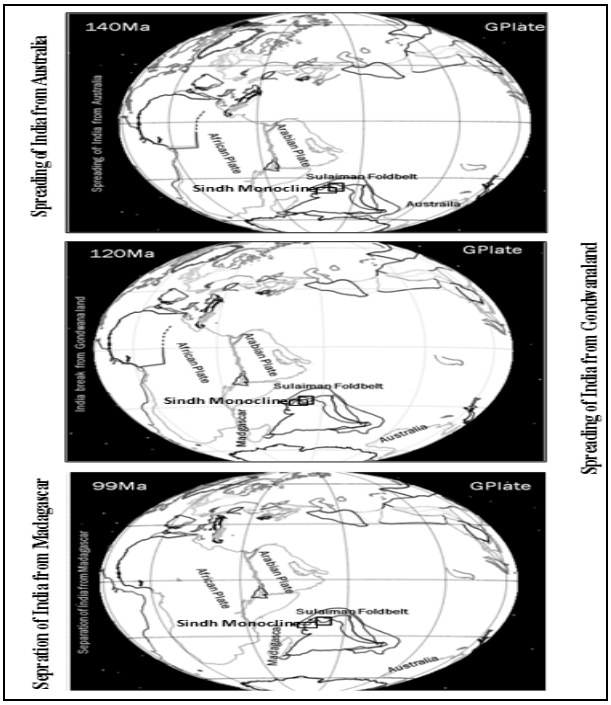

Fig.6. Reconstruction of Indian Plate (Source: Adopted from Nazeer. A , PhD Project, CPAG, UoS, Jamshoro)

2. MATERIALS AND METHODS

Jabo is producing oil field with production profile located in most prolific part of Indus Basin, called as Southern Sindh Monocline. Therefore Jabo structure carries active petroleum system. As data is limited for this research project, therefore with the help of published literature, interpretation of seismic data, integrated wireline logs are used to discuss structural style and existing hydrocarbon potential of Jabo Field, Southern Sindh Monocline, Pakistan.

DATA SET

Data set consist of twelve 2D seismic lines and wireline logs of Jabo-06 well. Energy Year Book 2012-2013 is used to understand the existing hydrocarbon potential of Jabo field and with in surroundings of study area. Published literature is thoroughly investigated to study the overall petroleum system of Southern Sindh Monocline because Sembar-Goru is common petroleum play in study area.

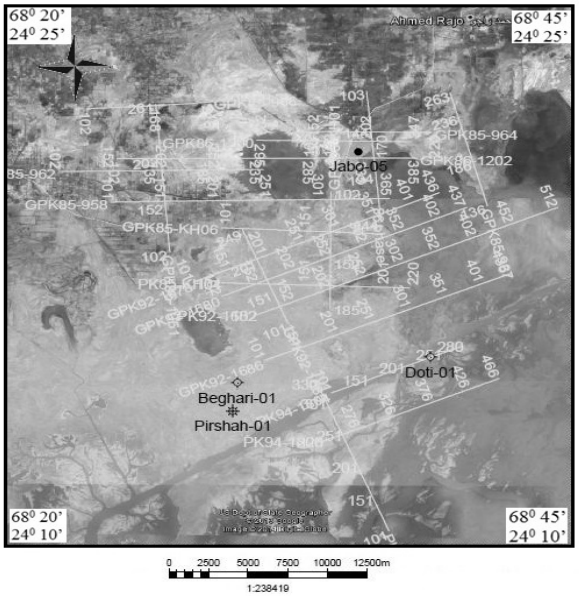

Fig.7. Base map showing location of seismic lines and Jabo Field

OBJECTIVES OF THE STUDY

Main objective is study to discuss the hydrocarbon potential of Jabo Oil field. Structuration style of Jabo Field has been assessed using seimic data. Source rock is evaluated by using Passey Methods (1980). Wireline correlation pannel is showing reservior seal pair of study area.

GENERALIZED STRATIGRAPHY

Sembar - Goru Formation is most important stratigraphic package of study area. The Formation is divided into seven members namely; youngest Upper Sands , Upper Shale, Middle Sands, Lower Shale, Upper Basal Sands, Talhar Shale and oldest Lower Basal Sands (Siddiqui *et.al,* 2012). Inter formation shales act as seal. Upper Sand , Middle Sand , Basal Sand and Massive Sand are proved reserrvior of Southern Sindh Monocline. Upper Sand is furthar divided into fours sand bodies with interbedded shales in Badin. Siddiqui *et.al.,* (2012) discussed source potential in Upper Shale , Lower Shale and Talhar Shale. Sembar is proved rock of study area (Wandrey 1995) and overlay the Goru Formation. Chiltan formation underlie the Sembar formation with unconformable contact. The generalized stratigraphy of Southern Sindh Monocline is shown in **(Fig.8).**

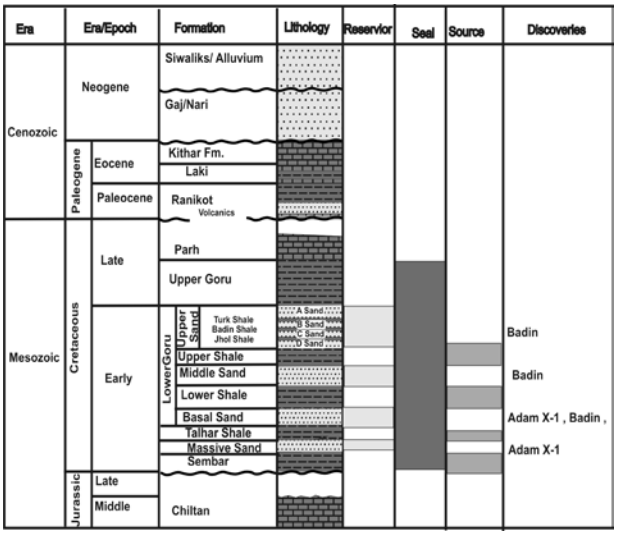

Fig.7. Generalized stratigraphy of Southern Sindh Monocline.

STRUCTURAL STYLE

The Seismic interpretation of seismic lines PK85-964 and PK86-1202 have been carried out in order to identify the structure of Jabo field. Over all interpretation of structure of Jabo field could not be possible due to limitation of seismic data available for research purpose and public domain. However, the interpretation of available Seismic Line of Jabo-01 and nearby disclose that study area consist tilted normal faults collectively forming horsts and graben type of structures **(Fig.9 and 10).** Latest published literature on the structure of study and nearby area (Munir *et al.,* 2014 and S.A. Abbasi et al, 2014 and S.A. Abbasi et al, 2015) also supports this interpretation and reveals that Jabo structure is located on upthrown side of major tilted fault block.Three dimensional view of Jabo-06 have been shown in **(Fig.10**)

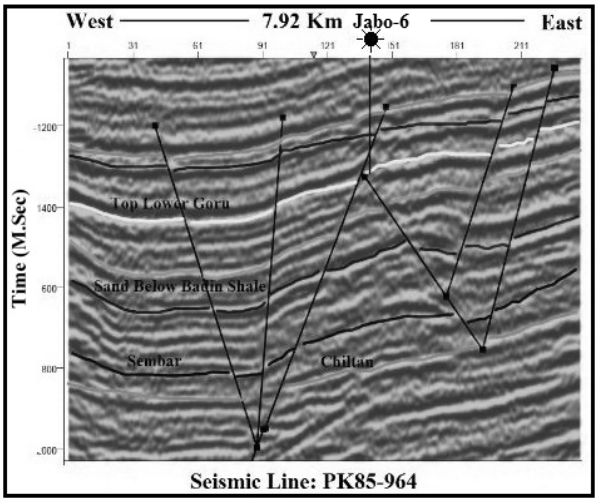

Fig.9. Structural cross section along interpreted in PK85-964

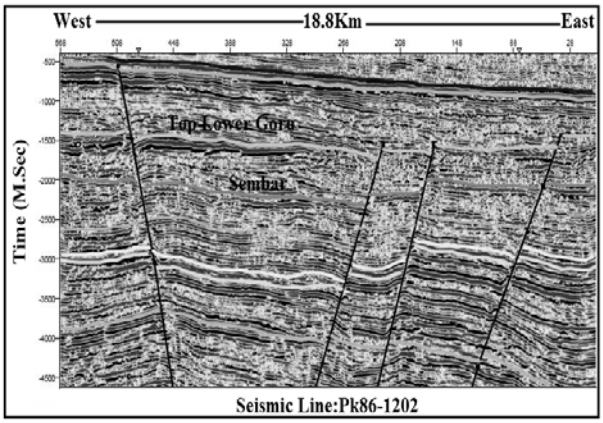

Fig.10. Structural cross section along interpreted in PK86-1200

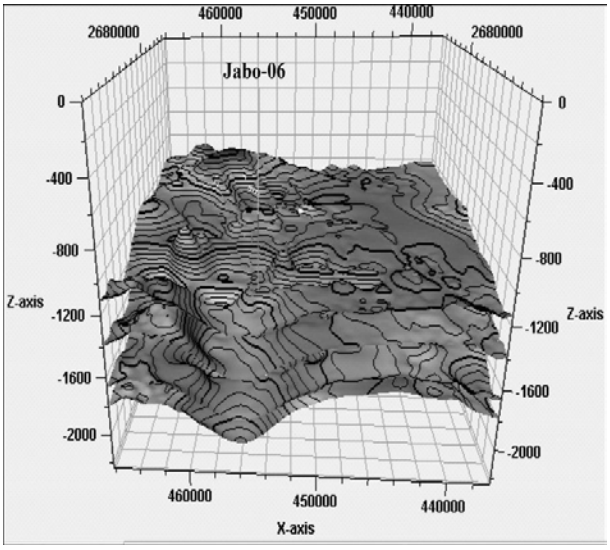

Fig.11. 3D view of interpretation at Sand below Badin Shale (SBBS)

HYDROCARBON POTENTIAL

Sembar- Goru Play

Hydrocarbons had been known in Lower Cretaceous reservoirs of Rajasthan beyond eastern border of Pakistan since ONGC had drilled Khara Tar #1 in 1964 but Khaskeli #1 was first discovery Lower Cretaceous Goru Formation sandstone play which was discovered by Union Texas' in Southern Sindh Monocline in 1981 (Ahmad, *et al*, 1998). By 1997 the operator had made a total of 49 Lower Goru - Sembar discoveries in the area, followed by indigenous company OGDCL with discoveries (Copestake *et al.,* 1995). The Lower Goru play discoveries are located within the platform parts of the Middle and Southern Indus Basin, from near the Mari High all the way down to the Badin area, Sindh Monocline (Ahmed, *et al.,* 2004).

Fig.11 is showing stratigraphic frame work of Sembar Goru in Indus Basin summarizes the nomenclature used by others in the industry. R-T (Regressive-Trangress) cylcles of Gredstein et. al., (2012) has been used to correlate the sequence stratigraphic sequence of Ahmed N., *et al.,* 2004) and I.E.D.S zones (1995) and biostratigraphic zones (Nazeer A., et al. 2012-2013). Study shows that Sembar-Goru are fluvial deltaic facies with varying lithology of sili-clastic dependent on its position in basin from shelf to slope. Intra formational shale's are providing seals to sand facies of Early Cretaceous.

Reservoir Seal Pair

Wireline correlation of various wells of Jabo field **(Fig. 12)** that effective reservoir is present with interbeded shales as reservoir seal pair. Porosity data, gross sand, net pay sand and average water saturation is given in the **(Table I**). Wireline correlation show that the effective reservoir rock and seal-pair is present in Goru Formation. Average porosity ranges from 8-20 % in Upper Sand.

Table I: Calculated parameters for Reservoir.

Depth Interval (m)	Gross Sand (m)	Net Pay Sand (m)	Average Porosity (%)	Average Sw (%)	Remarks
1953-1958	5	5	20.1	11.4	Upper B Sand-Gas
1958-1978	21	11	12.7	11.9	Upper B Sand- Oil
1990-2000	10	7	12.1	17.5	Lower B Sand-Gas
2000-2008	8	8	15.2	20.1	Lower B Sand- Oil

Effective Source Rock

Published data of IEDS (1995) and literature was used to understand the source rock of Southern Sindh Monocline, Southern Indus Basin, Pakistan. Data is limited and pyrolysis data of Jabo is not present. Results show that source rock is associated both with Sembar Formation and Goru Formation.

Regional studies shows that 0.6 -1.3% Vitrinite Reflectance is present in study area (Wandrey *et al.* , 1995). Fig. 13 is showing Iso Maturity Map of Sembar-Goru Composite Petroleum System in Southern Sindh Monocline.

The tectonic events of Indus Basin initiated with the intra-cratonic rifting of Gondwana land Super Continent in Late Protozoic followed by Permian-Triassic rift event, remain continue in Cretaceous with deposition of Sembar-Goru (Kemal *et al.,* 1991).

Pyrolysis data of Jabo field is not avaialable therefore TOC is calculated in Jabo-6 , and Key Hole-1 wells by using Passey Method. All these well were drilled in southern Sindh Monocline.

Calculation of TOC from wireline log is known as the "D log R" or "Δ log R" method. This method was based on various log motif curves. Most common technique of Δ log R is determining the shale line by using sonic logs (DT) and log (natural logarithm) of resistivity data.

GeoScinces Software (USA) is used for calculation of TOC and wireline correlation. As Jabo 6 and Key Hole is oil producing well, LOM (Level of Maturity) is taken 0.9. However values of TOC is required to be calibrated with Lab values which are not present. However these values shows that Badin Shale has source potential in Jabbo 6.

Sembar Shale is proved source rock in Southern Sindh Monocline (Ahmad, N. et.al 2014). %age of TOC are highest at 0.5 in Sili-clastics and decreases with rise of maturity because TOC is converting into hydrocarbons. %age of Jabo-6 at 0.9 LOM is less than 5 , and less than 4% in Jabo-6 at 0.9 LOM and consumed to produce hydrocarbons. Although data is limited but results shows that the Source rock is associated with Sembar Shale, Turk Shale and Badin Shale at the various level of maturity.

Composite log showing gamma ray, volume of shale, sonic and density, synthetic and with TOC (Total organic Content) value calculated at 0.9LOM in Jabo- 6 is shown in **(Fig 14)**

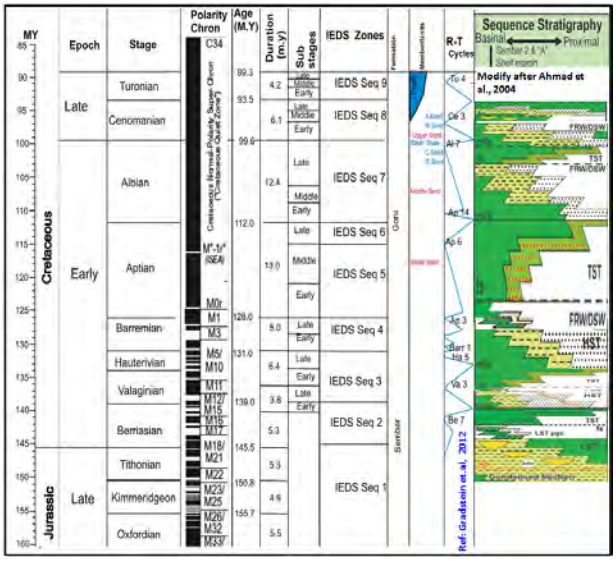

Fig.12. Plate Reconstruction of Indian Plate during the deposition of Sembar – Goru Sequences in Cretaceous (Source: Adopted from Nazeer. A, PhD Research Project, CPAG, UoS, Jamshoro)

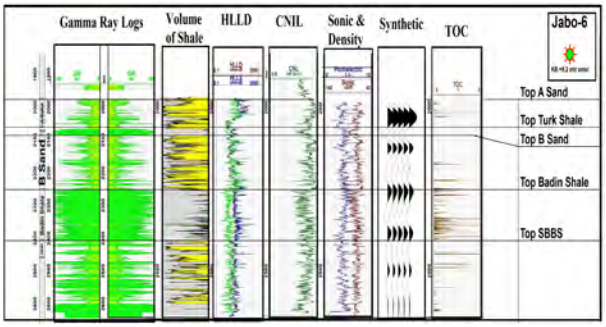

Fig.13. Fig is showing composite log with TOC value calculated at 0.9LOM in Jabo- 6

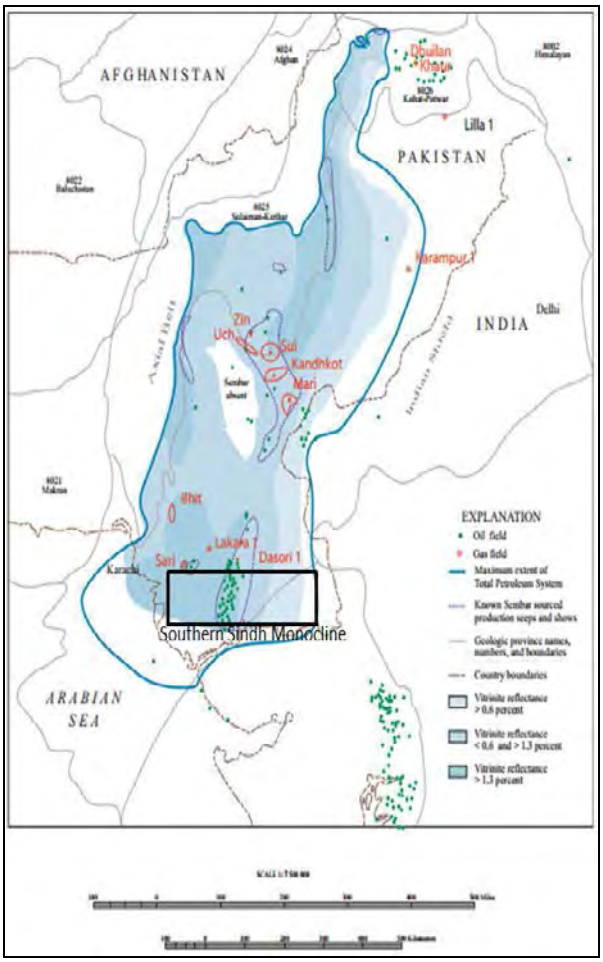

Fig.14. Fig is showing Iso Maturity Map of Sembar-Goru Composite Petroleum System in Southern Sindh Monocline (After Wandrey et al , 1995)

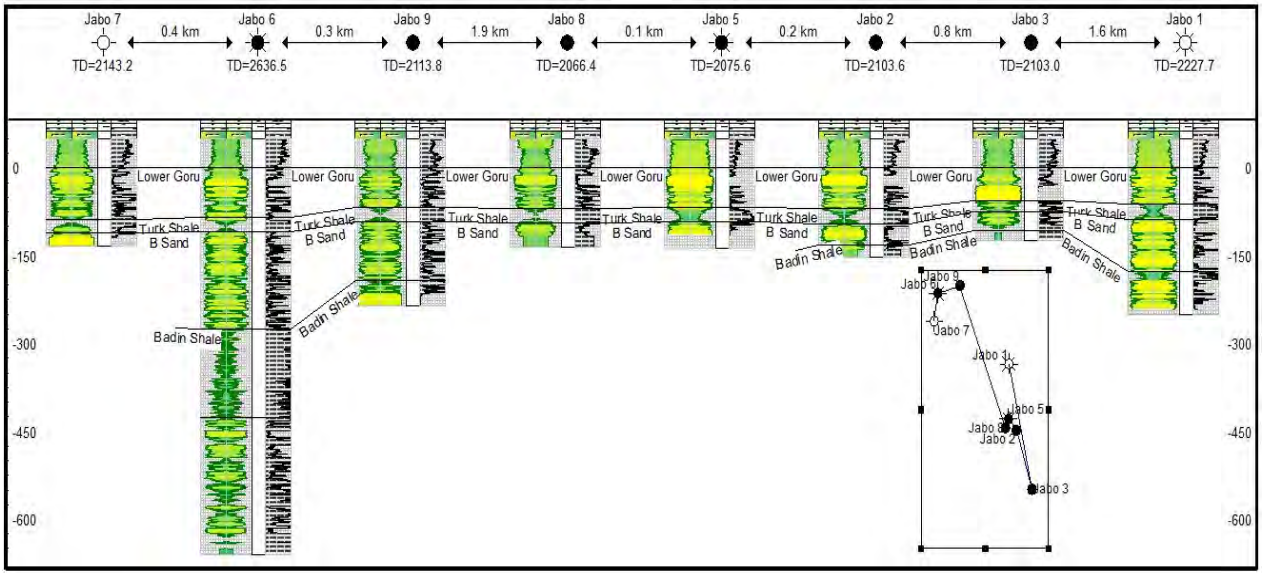

Fig.15. Fig is showing well correlation of Jabo field

3. RESULTS AND DISCUSSION

The Seismic interpretation of seismic lines PK85-964 and PK86-1202 have been carried out in order to identify the structure of Jabo field. Over all interpretation of structure of Jabo field could not be possible due to limitation of seismic data available for research purpose and public domain. However, the interpretation of available Seismic Line of Jabo-01 and nearby disclose that study area consist tilted normal faults collectively forming horsts and graben type of structures. Wireline correlation of various wells of Jabo field that effective reservoir is present with interbeded shales as reservoir seal pair. Porosity data, gross sand, net pay sand and average water saturation is given in the Table I. Wireline correlation show that the effective reservoir rock and seal-pair is present in Goru Formation. Average porosity ranges from 8-20 % in Upper Sand. As disscussed earlier that pyrolysis data of Jabo field is not avaialable. Therefore TOC is calculated in Jabo-6 well by using Passey Method.

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4. CONCLUSIONS

Jabo structure is located in Southern Sindh Monocline in 8 km southwest of Raj-1 and 18km southwest of Tajedi Field. The Seismic interpretation reveals that Jabo field consist tilted normal faults collectively forming horsts and graben type of structures.

Wire line log interpretation results show that Turk shale and Badin Shale has source potential shown in composite log of Jabbo 6.

Wireline correlation of various wells of Jabo field that effective reservoir is present with interbeded shales as reservoir seal pair. Values of porosity, gross sand, net pay sand and average water saturation have been calculated.

Wireline correlation show that the effective reservoir rock and seal-pair is present in Goru Formation. Average porosity ranges from 8-20 % in Upper Sand. Results shows that source rock is associated both with Sembar Formation and Goru Formation. Regional studies shows that 0.6 -1.3% Vitrinite Reflectance is present in study area (Wandrey *et al.* , 1995).

Study shows that Sembar-Goru are fluvial deltaic facies with varying lithology of sili-clastic dependent on its position in basin from shelf to slope. Intra formational shale's are providing seals to sand facies of Early Cretaceous.

5. ACKNOWLEDGEMENTS

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REFERENCES:

Ahmad, N., J. Mateen, K. Shehzad, N. Mehmood, and F. Arif, (2011), Shale Gas Potential of Lower Cretaceous Sembar Formation in Middle and Lower Indus Sub-Basins, Pakistan, Society of Petroleum Engineers (SPE)/Pakistan Association of Petroleum Geoscientists (PAPG) Annual Technical Conference, Islamabad, Pakistan

Alam S. M., M. Mozzaffar, S. M. Wasimuddin and S. Ahmad (2003), " Zaur Structure A Complex trap in a Poor Seismic data Area", Proceedings SPE/ PAPG ATC 2003, 146-163.

Ahmad S. M. and K. L. Malick (1998), "Khaskheli Field- An Explanation of Structural Complexity By Field Performance", Proceedings SPE/ PAPG ATC 1998, 176-213.

Ahmed, S.., S. H. Solangi, I. A. Brohi, Q. D. Khokhar, R. A. Lashari, (2014), Study of Stratigraphy and Structural Styles in the Subsurface of Southern Sindh Monocline, Pakistan: Using Seismic and Well Data", Sindh Univ. Res. Jour. (Sci. Ser.) Vol.46 (4):439-446.

Ahmad N., P. Fink, S. Sturrock, T. Mahmood1, and M. Ibrahim (2012) "Sequence Stratigraphy as Predictive Tool in Lower Goru Fairway, Lower and Middle Indus Platform, Pakistan"., Adapted from oral presentation at PAPG Annual Technical Conference 2004, Islamabad, Pakistan, October 8-9, 2004, AAPG Search and Discovery Article #10404.

Abbasi, S.A., S. H. Solangi, A. Ali, (2015). Seismic Data Interpretation: A Case Study of Southern Sindh Monocline, Lower Indus Basin, Pakistan, Mehran University Research Journal. Vol. 34. No.2,. 107-115.

Copestake, P., B.A. Cooper, M. Slatford, S. Vanstone, T. Maqsood, and M. Ashraf, (1995) Sequence sratigraphy of the Upper Jurassic-Mid Cretaceous of the Indus Basin, Pakistan and Rajhasthan Area of India, Proceeding of International Symoosium on Sequence Stratigraphy in SE Asia.

Energy Year Book, (2012-2013), Hydrocarbon Development of Pakistan, Goverenment of Pakistan

Gredstein , F. M., J. G. Ogg, M. Schmitz, and G. Ogg (2012), Geological Time Scale 2012 , 2-volume Set , Elsevier.

G-Plate, www.gplate.com

Integrated Exploration and Development Services, (1995), A Sequence Stratigraphic Study of Lower Goru-Sembar Formations of Lower and Middle Indus Basin of Pakistan and Rajisthan. Multi-client study

Kemal, A., (1991), Geology and new trends for petroleum exploration in Pakistan, New directions and strategies for accelerating petroleum exploration and production in Pakistan: Proceedings, International petroleum seminar, Ministry of Petroleum and Natural Resources, Islamabad, Pakistan, November, 22-24, 16-57.

Kadri I. B. (1994). Petroleum Geology of Pakistan. Pakistan Petroleum Limited. Karachi.

Malick, Z. A., M. Kamal, A. Malik and J. W. Bodenhausen., (1988) Petroleum Potential and Prospects in Pakistan: Proceedings of the Petroleum for the Future Symposium held in Islamabad, Pak. 71-99.

Nazeer, A., S. H. Solangi, I. A. Brohi, P. Usmani, L. D. Napar, M. Jhangir, S. Hameed and S. M. Manshoor, (2012-2013), Hydrocarbon Potential of Zinda Pir Anticline, Eastern Sulaiman Foldbelt, Middle Indus Basin, Pakistan, Pakistan Journal of Hydrocarbon Research,Vol. 22 and 23, 124-138.

Muhammad F. K., (2010) Separation, Northward Drift and Collision of Indian Plate is Responsible for the Present Petroleum System in Pakistan: Enlighten the Idea “Present is the Key to the Past”, AAPG Search and Discovery Article #90108©2010 AAPG International Convention and Exhibition, September 12-15, Calgary, Alberta, Canada. Soft

Raza, H. A., S. M. Ali and R. Ahmed., (1990), Petroleum Geology of the Kirthar Sub-basin and part of the Kuch Basin, Pakistan, Pakistan Journal of Hydrocarbon Research, Vol.2, No.1,29-73.

Memon, A. D., I. Siddiqui, and A.A. Memon, (1999), “Tectonic of Sindh Monocline, Pakistan and Their Effects on Hydrocarbons”, Mehran University Research Journal of Engineering & Technology, Volume 18, No 10, 38-39, 87-94.

Munir A., S. Asim, S. A.Bablani and A.A Asif (2014),” Seismic Data Interpretation and Fault Mapping in Badin Area, Sindh, Pakistan”, SURJ (Sci. Series), Vol 46 (2), 133-142.

.Sahito, A. G., S. H. Solangi, P. Usmani, I. A. Brohi, L. D. Napar, Q. Khokhar, 2013, Sedimentologic studies of Upper sands of Lower Goru Formation based on well cuttings and wireline logs from wells of X Field in the subsurface of Sindh Monocline, Southern Indus Basin, Pakistan

Siddiqui, F.I., Adhami, A., Asghar, A., Hussain, A., and Khan, M., W. , 2014, Shale Gas Potential of the Lower Goru Formation over the Lakhra High in Lower Indus Basin, Pakistan

Wandrey, C. J., Law, B. E., and H. A. Shah, 1995, Sembar Goru/Ghazij Composite Total Petroleum System, Indus and Sulaiman-Kirthar Geologic Provinces, Pakistan

Ziagham, N. A, A. Ahmad, and H. Hisam, (2012), Thar Rift and its Significance for Hydrocarbons, Search and Discovery Article #20146 (2012)** .