

Tectono-stratigraphy, Structural Development and Hydrocarbon Potential of Khairpur-Jacobabad High (KJH), Lower Indus Basin, Pakistan – An Overview Based on Seismic and Well Data

Muhammad Akram¹, Zahoor Ahmad Khan¹, Rana Faisal Shahzad¹, Shabeer Ahmed¹, Shakeel Ahmed¹, Imran Khan¹, Uzair Hamid Awan¹

Affiliation

1– Basin Study and Exploration Research, Oil and Gas Development Company Limited, Pakistan

Summary

Indus Basin located on the northwestern corner of the Indo-Pak Plate; and it has been subdivided in to three segments i.e Upper, Middle and Lower Indus Basin which are separated by highs between them (**Fig.1**). Study area lies within Lower Indus Basin. A number of discoveries have been made within the study area, however, the western part of the Foredeep is a major concern. So far 3 plays are proven within the study area. Lower and Middle Indus is separated by Mari-Kandhkot high which is believed to be a paleo high. North-south oriented Jacobabad high is located in South-West of Mari-Khandhkot high, and known to have more than one culminations. Kandra High, being the shallowest, is one of culmination of Jacobabad high, has been properly mapped and covered by adequate seismic data. Rest of the culminations are covered by dispersed seismic, and has not been properly evaluated and mapped as a whole.

Geologically, Kirthar Foredeep is considered as the segment of Lower Indus Basin (LIB) with exposures at exceptional locations (e.g. Kandra/Kandhkot high) and/or no surface outcrops of sedimentary rocks. Well data and Time sections show stratigraphy ranging from Basement to Recent with the evidences of major five tectonic events i.e. Pre-Cambrian, Permian (related to intra-Gondwana rifting). Triassic and Jurassic (related to breakup of Gondwana) while Late Cretaceous (related to separation into Indian and Madagascan Plate) and Eocene/Oligocene (related to collision of Indian and Eurasian Plate).

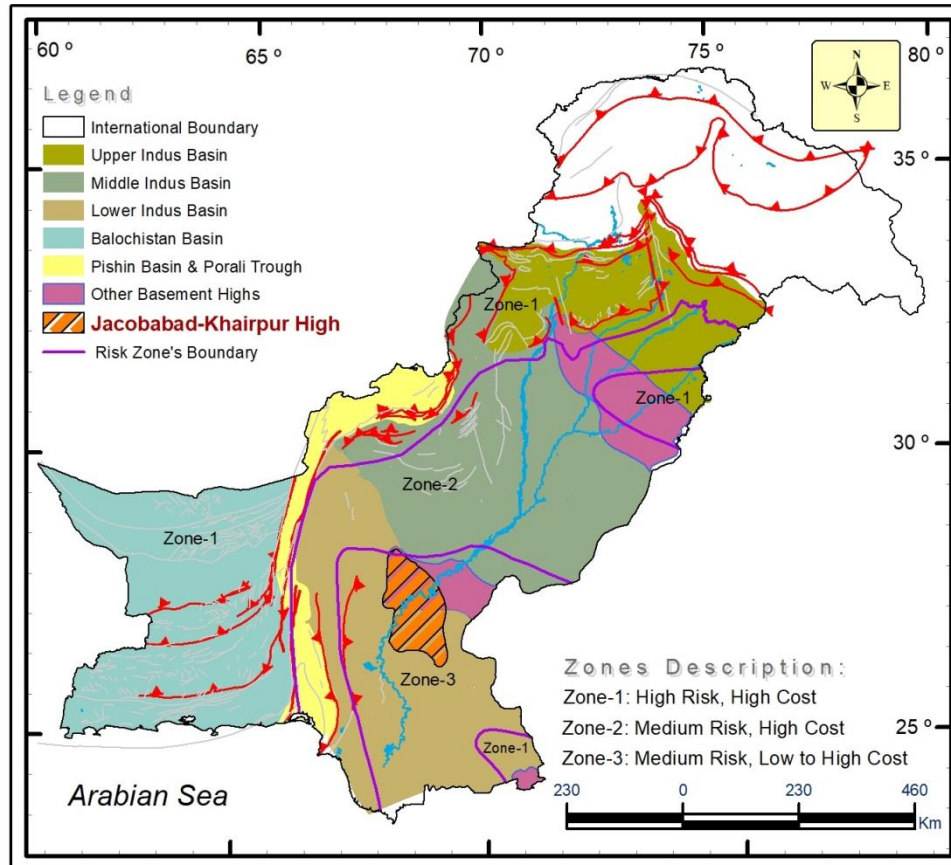


Fig. 1 - Map showing the location of study area

Lower Indus Platform is gently westward sloping monocline controlled by basement topography. The basin is bounded by Indian Shield to the east and highly folded mountains of Axial Belt to the west. The general west directed dip of Platform is interrupted by gentle arch of north to south oriented Khairpur High which previously was interpreted as a large basement induced structure.

The main aim and scope of this study is to find the timing of development of Jacobabad high by integrating all the available seismic data, after getting the complete subsurface picture then to evaluate hydrocarbon potential.

Keeping in view the main aim of the study, it was inevitable to demarcate the tentative area of Jacobabad-Khairpur high by using the existing available data and literature, correlations of wells drilled in the area to understand the subsurface geology and geometry of the high; and with the help of well data, identification of the possible source, reservoir and seal formations. Preparation

of regional cross sections, to identify the possible structural and stratigraphic geometries favorable for entrapping the migrating hydrocarbons in the area.

The G&G data interpretations carried out during the course this study suggests that the sediments are as old as Paleozoic; and top Cambrian or base Permian has been picked on seismic. Permian and Triassic sequence is thicker at core of the high as compared with flanks.

Theory / Method / Workflow

Seismic data is widely used for the interpretation of structure, stratigraphy and traps with hydrocarbon potential. Seismic data 2D/3D has been used for the current study to interpret the geometry of the Khairpur- Jaccobabad High. Four transects have been prepared in order to interpret the geometry of the high.

Results, Observations, Conclusions

East-west oriented regional transects show a continuous deposition of Permian to Jurassic strata and having almost uniform thickness rejecting idea of presence of any Paleo high at that time. However, there are some deep rooted faults related with Pre-Jurassic rifting events with minor throws which have displaced the Basement, Paleozoic and Mesozoic Strata. There is no evidence of any fault with large throws may contribute in development of Paleo basin.

Jurassic sequence is quite a layer cake deposit and maintaining its thickness from east to west across the high. Lower Cretaceous strata getting down-lapped on Chiltan platform from east to west in the fore-deep and pertains to basinal environment near Khairpur-Jaccobabad High. The Early Cretaceous sediments (Sembar Formation) were sourced from the east and successively prograding to west and thinning out towards the shallowest point of the high at Chiltan level. The deposition of sediments over this part (Khairpur High), had previously been interpreted as controlled by Paleo-High; but the current study shows the case was not so, instead it is the end points of the progrades which is well demonstrated by flattening the top Chiltan Formation surface, it portrays the point of zero deposition is a condensed section for the sediments of Sembar Formation (Top Jurassic), which is actually controlled by the influx of sediments. Moreover, above the Sembar Formation, Cretaceous sediments strata of Goru Formation also show wedging and downlapping on top of Chiltan, westward in the fore-deep passing through Khairpur High. It is also noteworthy, dips of Intra horizons within Cretaceous also follow the shape of rollover and thinning out progressively in the west crossing shallowest point of high,

advocating the idea of no existence of any paleo high till Late Cretaceous. During Early Tertiary, transpressional or wrench tectonics induced an event of uplift in eastern part of Indus Basin, developed small scale structural highs like Khairpur and largely eroded upper Cretaceous sediments. The majority of the deep basement and shallow wrench tectonics related faults terminate close to this unconformity. This was probably the first event, when the Khairpur structure attained some degree of high, but feasibly not of a larger scale. Paleocene (Ranikot Formation) is well developed in the depression, south of high and relatively less in the north but is thinning at Khairpur High. Depocenter for Cretaceous is developed in the east and north of high, seems to shift in south of high for Paleocene. Seismic supports that, it is again actually the quantity of input flux of sediment, controlling the thickness variation across the basin. However, seismic also shows an erosional event above Top of Ranikot, which hints second phase of uplift, which is actually not of a big scale. Some rollover features associated with this tectonic event also be preserved on seismic and those are consistent with Base Tertiary Unconformity surface. Depocenter for Early Eocene shifts towards north of the high at Sui location. The area of present day Khairpur High, again received basinal sediments from Lower Eocene onwards to Middle Eocene. Interestingly, Eocene seems to be have more thickness at core point of high in contrast to eastern and western flanks, which is not possible, if a high already exists. Eocene and Paleocene dip in the same direction as the rest of the older foreland basin sequence, reflecting the pre-collisional configuration. Variations in Paleogene deposits around the Khairpur feature suggesting number of small scale unconformities (uplift/subsidence) during Late Eocene-Oligocene. The final uplift of Khairpur High took in the post Eocene (Oligocene) as a result of the India-Eurasia collision. The resultant fold belt, may have generated enough load on lithosphere to develop a fore-bulge, which also have contributed in the development of high. Miocene to Recent, sediments dips gently, and thickens westwards towards to the axis of the fore deep and getting on-lapped against Eocene sediments. The synclinal part of the fore deep is covered by Quaternary alluvium.

Acknowledgements

Authors are highly thankful to the ED (Exploration) and management for permission to submit the paper for oral as well as poster presentation.

References

All references will be incorporated in full length paper and presentation