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Reasons of well failure in Jherruck block Lower Indus Basin, Pakistan using 2D seismic and well data

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Abstract

The Jherruck block is located in Lower Indus Basin in district Thatta, Sindh province, Pakistan, which is a hydrocarbon producing province. Lower Indus Basin is underlain by infra-Cambrian to Recent clastics and carbonates. On the basis of seismic data (2 dip lines and 1 strike line) and well data (well tops) subsurface structure has been interpreted. Due to extensional regime normal faulting is present in the area, various horizons and faults have been identified and marked. The proven reservoir in the region is C-Sand which is also present in Jherruck block and has been interpreted. The interpretation of composite lines shows that Jherruck-B1 well has targeted the C-Sand horizon, as a targeted reservoir at a depth of 2454m which undergone gas-water contact level due to which the well had discovery and flowed for a day or more and then flowed water unexpectedly which is because the well was drilled in the gas water contact level, which is below 82 m from proposed well location as according to time and depth contour map closure and seismic composite line, hence this study suggests that the Jherruck block may have the potential to produce hydrocarbons but C-Sand should be targeted on the place where there is a closure present (at shallower depth), as there is a high probability of success rate.

Keywords:

1. Introduction

This study is an attempt to interpret Jherruck Block using well tops data and seismic data for subsurface structure geology, hydrocarbon potential and to explain the possible reasons of well failure in this block which is located in a proven hydrocarbon province of the region. The area of research is located in district Thatta Sindh Province, Pakistan (Kadri, 1995; Rana and Asrarullah, 1982; Shah, 2009) (Fig 2.). Tectonically the region is located in the south-eastern boundary of Lower Indus Basin, where normal faulting and strike-slip tectonic are present, and no any particular imprints of deformation on surface of the earth. (Kadri, 1995; Kazmi and Jan, 1997). The main aim of this research is to understand Jherruck Block subsurface structural style along with reasons of well failure and subsurface structure that has contributed to the accumulation of hydrocarbons.

The present study makes an attempt to interpret seismic data for subsurface structural geometry of the area as well as to mark major faults present in the block, marking target horizons, to find out the reason of well failure and propose a new well location where fault acts as barrier of hydrocarbon flow. In this study depth of horizons was confirmed by well to seismic tie (Fig. 6) for enhancing the seismic interpretation and afterwards to construct time and depth surface maps of the target reservoir. In the seismic acquisition dynamite was used as a source, and other parameters are, source interval 50m, receiver interval 25m, source hole depth 21m and number of channels were 500.

For structural and stratigraphic interpretation of subsurface horizons the geophysical and geological data that has been incorporated are as follows:

- Base map (generated using Petrel Interpretation software)
- Well tops of Jherruck B-1 well
- Seismic dip line NJ08-14, NJ08-22 and strike line BDN-11

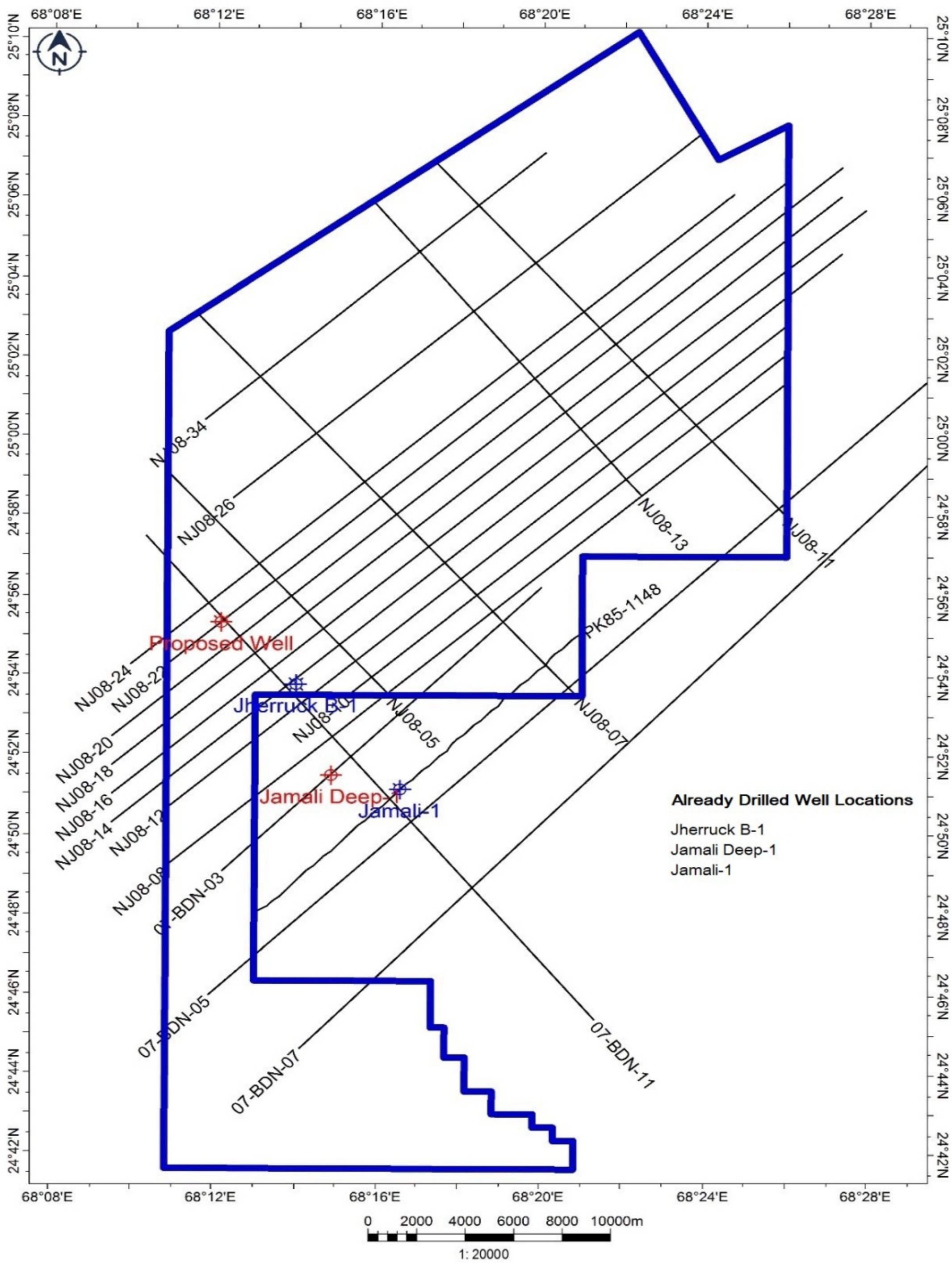

Fig. 1. Base map of study area displaying seismic dip and strike lines along with drilled well and proposed well location.

2. Geological Setting

Lower Indus basin extends between latitude 23° to 28° N and longitude between 66° to 72° E (Kadri, 1995; Kazmi and Jan, 1997). Lower Indus Basin is bounded by the Indian Shield on its east, in its west it is bounded by highly folded and thrust mountains of axial belt (Kirthar Fold Belt), southern border is marked by Dabboo Creek Anticline, which shows the boundary with the Offshore Indus Basin, whereas Jacobabad high define the northern boundary of lower Indus Basin, which separates the lower Indus Basin from central Indus Basin (Kadri, 1995; Kazmi and Abbassi, 2008; Kazmi and Jan, 1997). Main producing reservoir in the region is C-Sand, which is proven reservoir in other wells (Kadri, 1995; Kazmi and Jan, 1997).

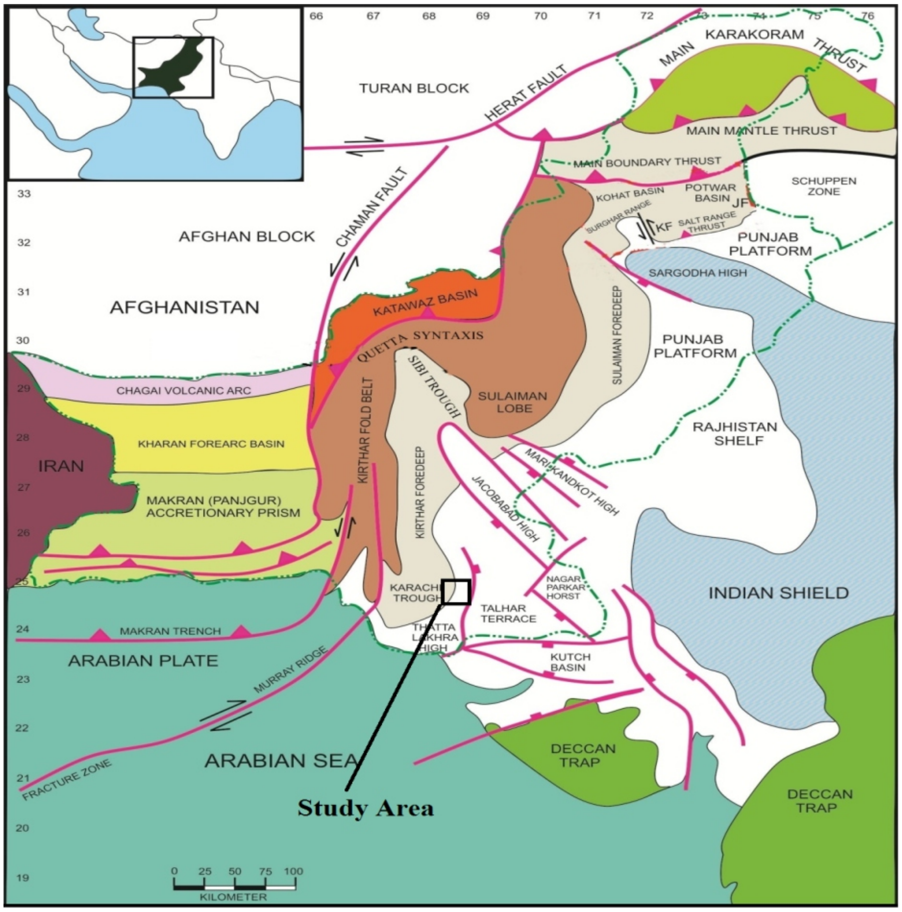

Fig. 2 Generalized geological map of Lower Indus Basin (Wakefield and Monteil, 2002).

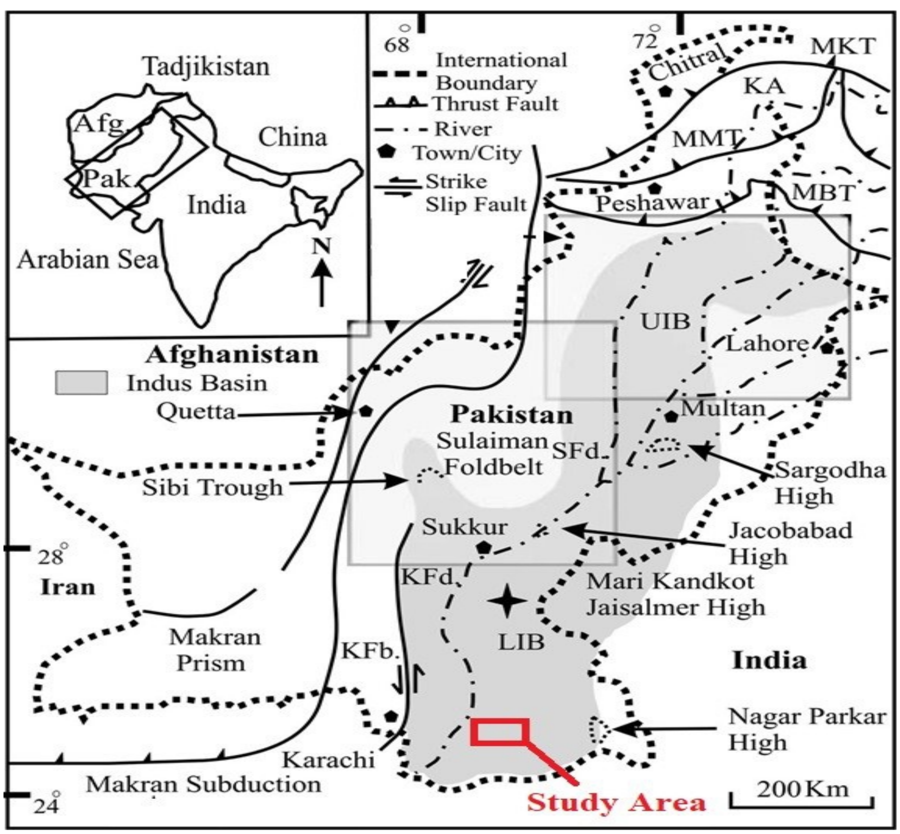

Fig. 3 Tectonic map of Lower Indus Basin displaying major tectonics present in Pakistan (Kadri, 1995; Shah and Ahmed, 2018; Shah et al., 2019).

3. Stratigraphy

The lower Indus Basin is underlain by infra-Cambrian to Recent clastics and carbonates. It was passive margin up to the Late Cretaceous, while then it is sutured between the Indian Plate and the Afghan Block. The stratigraphic thickness varies in east-west direction (Shah, 2009; Tahirkheli, 1979). Precambrian basement rocks have been exposed in the southeast corner of the basin. Stratigraphyically, Lower Indus Basin is composed of exposed Triassic to recent rock sequence (Raza and Asrarullah, 1989; Shah, 2009). Description of the stratigraphy from bottom to top is discussed below (Fig. 4).

4. Methods

4.1 Seismic Interpretation

The aim of seismic interpretation is to identify and mark horizons of interest, depth of horizons, structural style, faults present and crest of the fault bounded structure where well needs to be drilled for exploration (Shah and Abdullah, 2017). The interpretation mainly relies on the reflections identification and placing them at their true positions (depth) in the section, geometry of the structure (style and trend), identification of potential prospect, reasons of well failure and correlating the interpretation with already drilled well data for validation and enhancing interpretation procedure. The interpreted seismic section is a dip line (NJ08-14) used as a reference line because already drilled well is on this seismic line, by using well to seismic tie the targeted horizons were picked and marked (Fig. 5 and 6), the dip lines in this block are perpendicular to the major structures present in the subsurface of this block and are considered most suitable for geological interpretation.

4.2. Time and Depth Contouring

These maps play important role in understanding of prospects (Shah and Abdullah, 2016; Shah and Abdullah 2017). It also tells us about the structural closures and assists to estimate the size of the reservoir. For time and depth contour maps Petrel Interpretation software has been used. For contouring interpretation of 2D seismic data and velocity analysis, the depth of targeted horizon below all shot points were utilized to develop time and depth contour maps of C-Sand horizon. Which is the proven reservoir in the region. (Fig. 11)

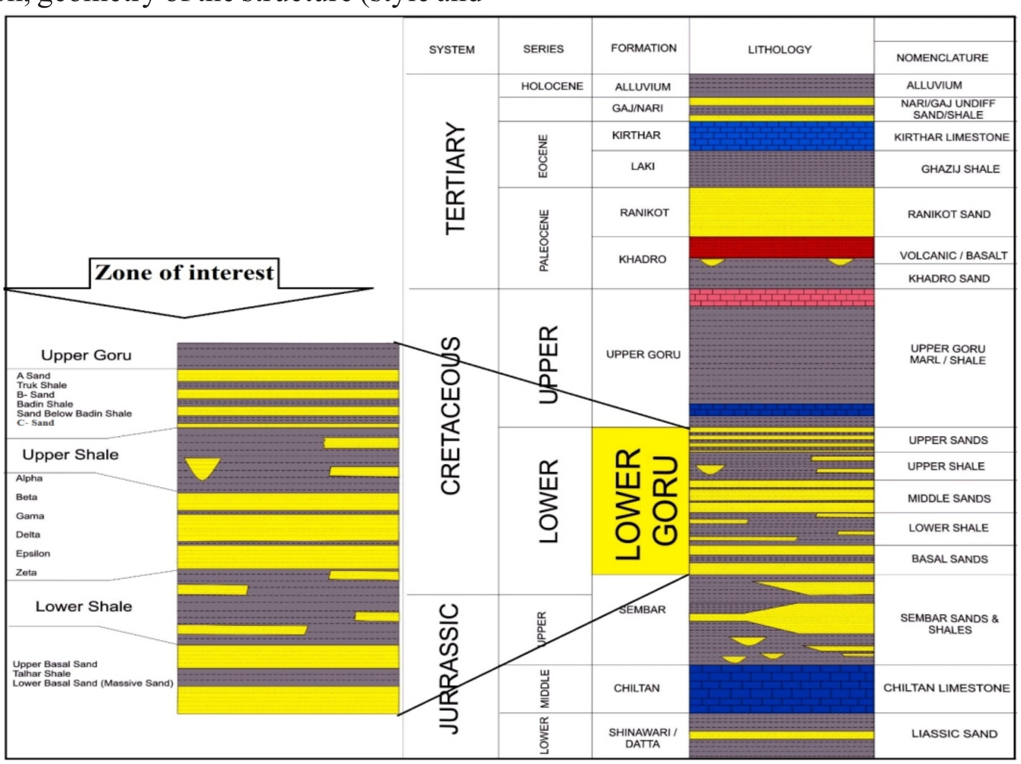

Fig. 4 Generalized Stratigraphic column of Lower Indus Basin, Pakistan (modified after Kazmi and Abbasi. 1997; Shah and Ahmed, 2018; Shah, 2009; Nawaz et al, 2019).

5. Results

Jherruck Block is located in Lower Indus Basin and it is mostly characterized by normal faults. Most of these faults cut the strata from Jurassic to Cretaceous, which included from Chiltan to Top Lower Guru (TLG). The trend of these faults is NW-SE, having planer and Horst and Graben structural geometry considered as a Domino or Book shelf style of deformation. Horizons and Faults are mapped in the research area while according to analysis few of the leads have been identified (Fig. 9, 11). As these play types are fault closures, it is very important to evaluate the fault seal risk involved in it.

The study area consists of blind Normal faults, no any imprints of these faults are found on the exposed surface. Most of these faults are interpreted to cut the strata from Jurassic to Cretaceous rocks. Some faults are dipping towards west while the rest are found to eastward dipping (Horst and Graben). Fault-01 and Fault-02 are the main prospective faults of the study area.

Fault-01 is westward moderate dipping fault, with the development of planer fault geometry (Fig. 6 & 7) it has maximum fault throw of about 250 ms on line of NJ08-18. While Fault-02 is eastward steep dipping fault. It has fault throw of about 15ms along seismic line NJ08-14. These are the two faults which may have sealed the hydrocarbons from escaping the reservoir from C-Sand horizon, as also according to Davies et al. (2014) there can be high probability of hydrocarbons discovery if any failed well is present and had the discovery for a shorter time and then it get depleted, which made us think again about our interpretation and the reasons of well failure, because there are hydrocarbons but the targeted depth and well location may have led to the failure.

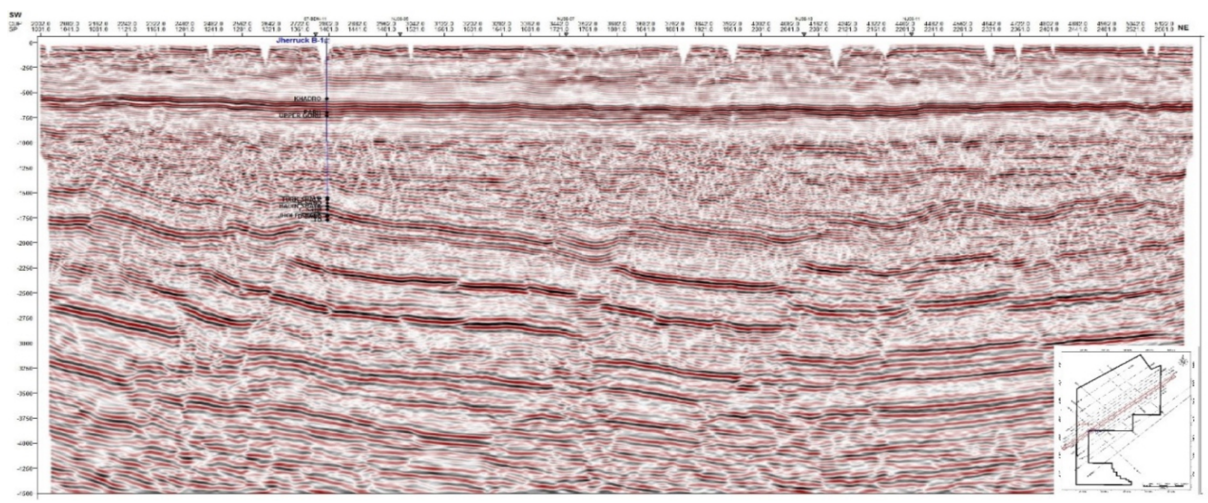

Fig. 5 Dip line NJ08-14 without interpretation with well tops of Jherruck-B1 well.

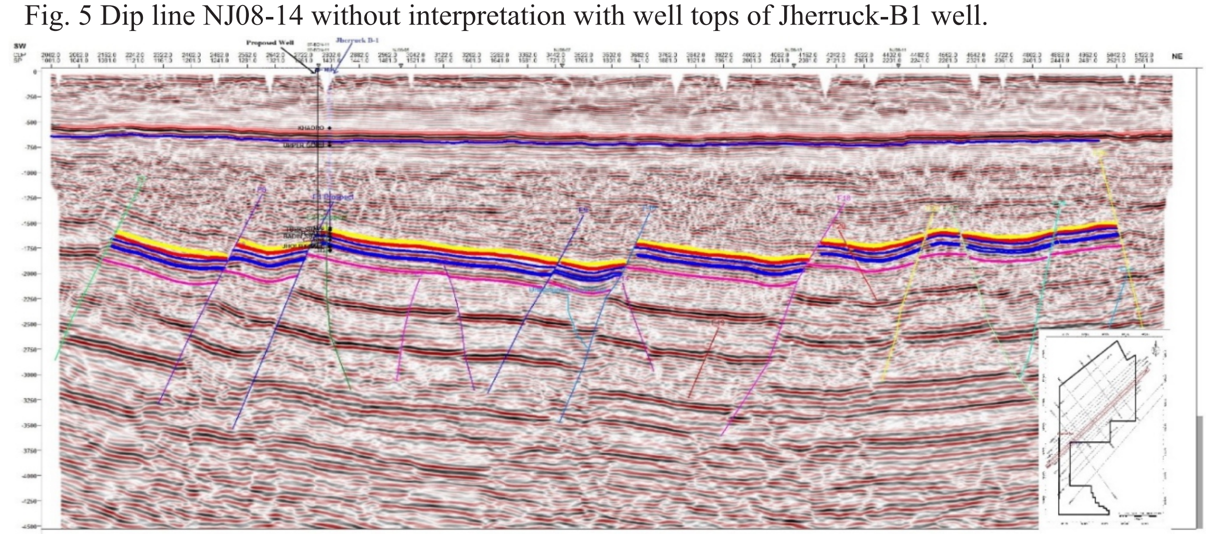

Fig. 6. Dip line NJ08-14 with interpretation, well tops of Jherruck-B1 well and proposed new well location.

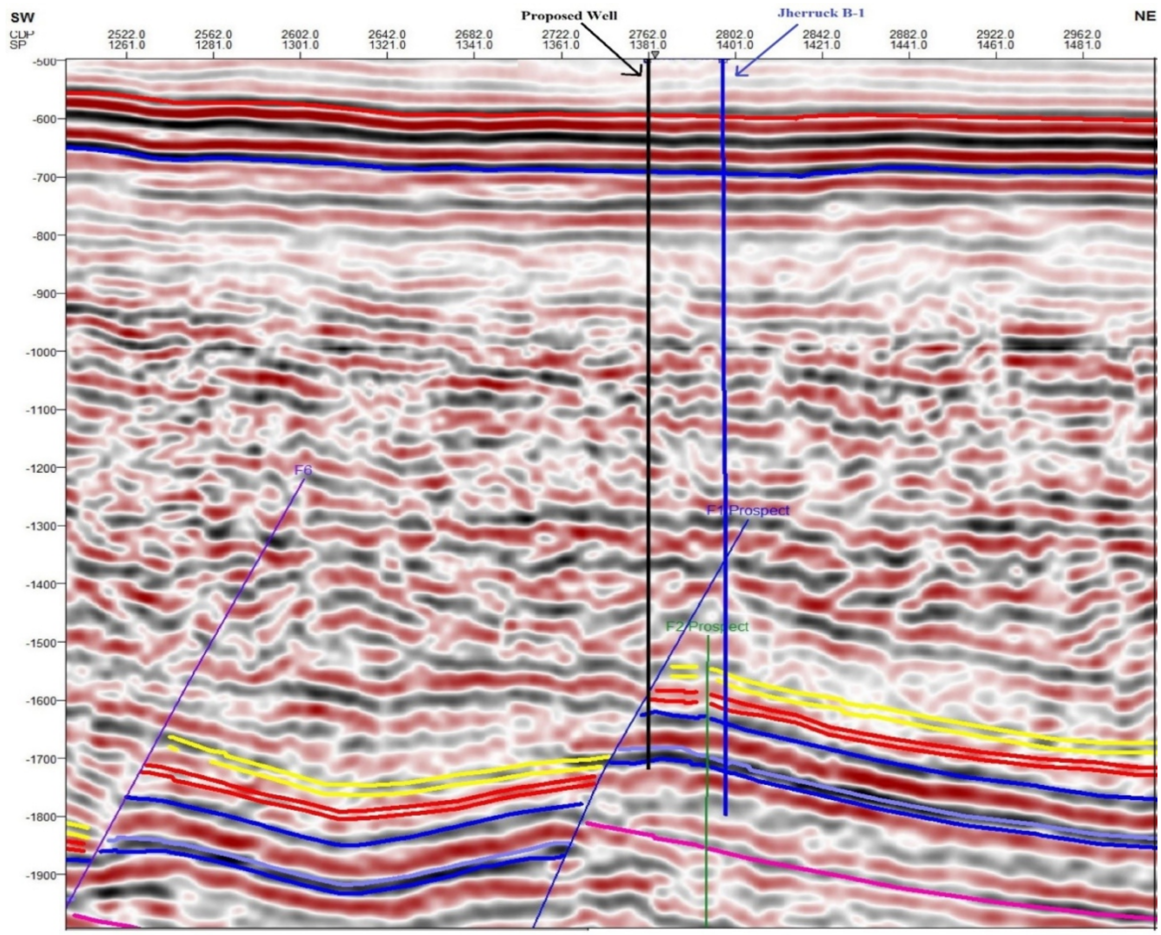

Fig. 7. Enhanced/zoomed image of Dip line NJ08-14 with interpretation and location of existing well Jherruck-B1 and proposed new well location (Projected on this line).

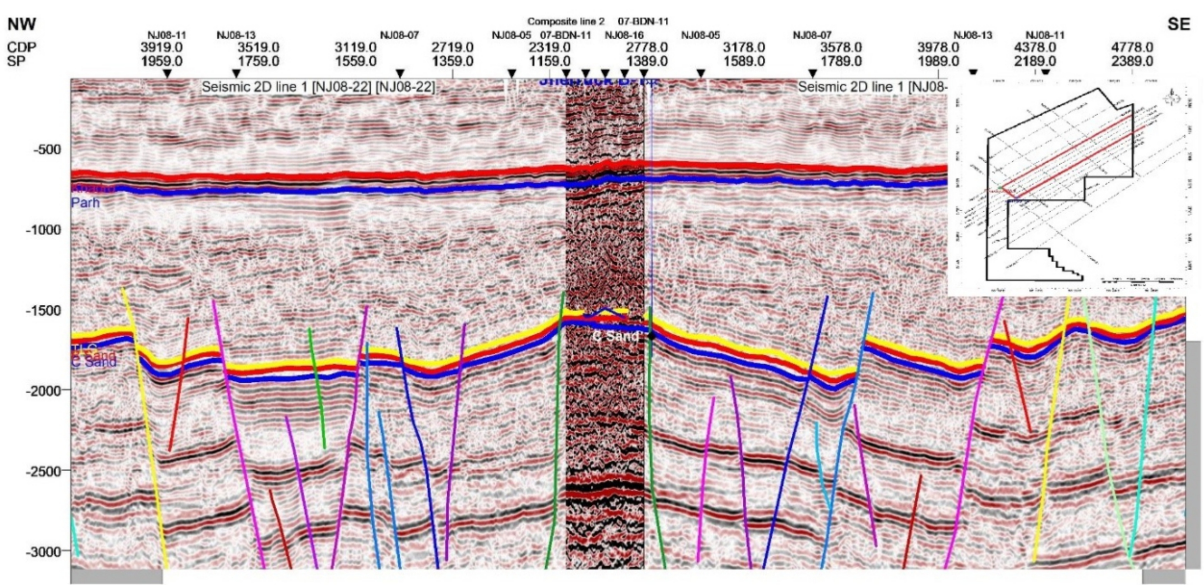

Fig. 8. Composite of Seismic lines NJ08-14, BDN-11 and NJ08-22.

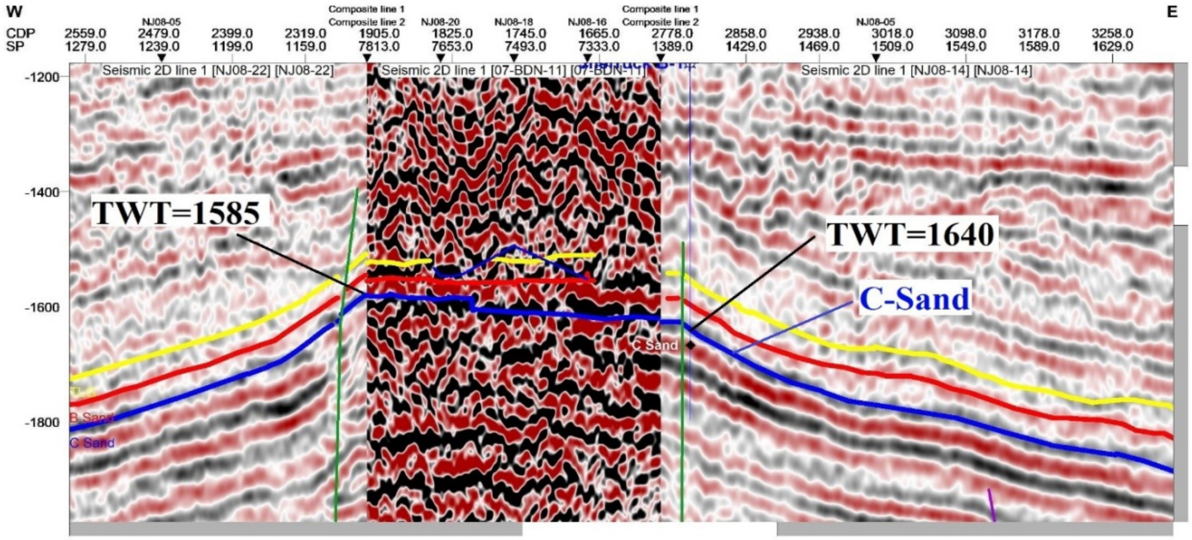

Fig. 9. Enhanced/zoomed composite of seismic lines NJ08-14, BDN-11 and NJ08-22.

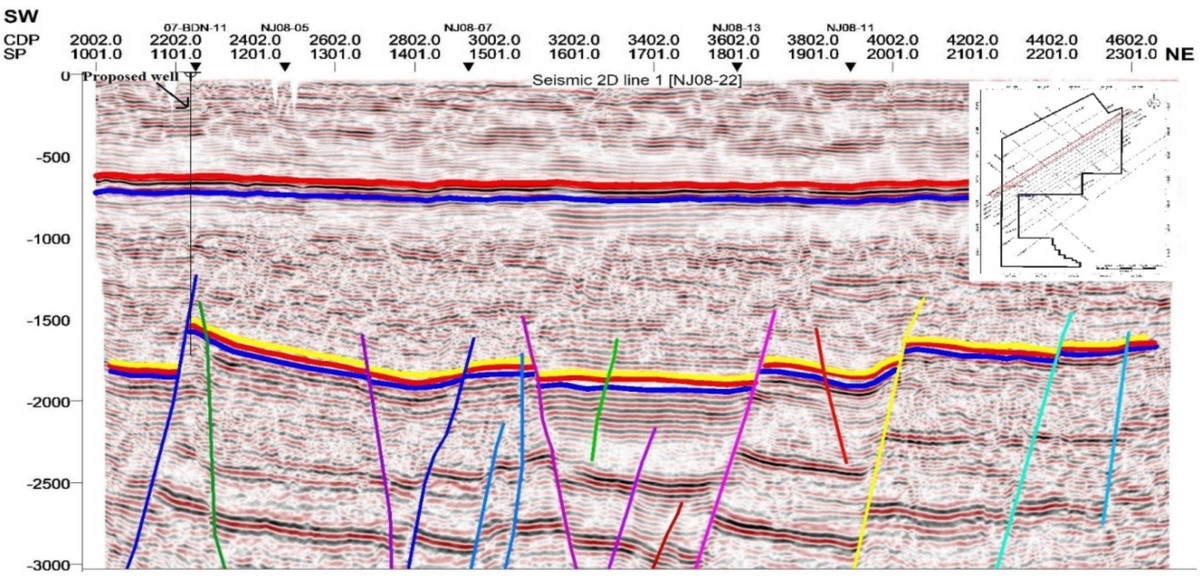

Fig. 10 Interpreted Seismic line NJ08-22 with proposed well location.

Jherruck B-1 well targeted the C-Sand horizon at depth 2454 m which appears on seismic line NJ08-14 at TWT 1640 ms (Fig. 9) while the time contour map (Fig. 11) shows that crest of C-Sand is further shallowest towards North-western side and makes closure at the line NJ08-22 having TWT of 1585 ms (2372 depth), with a total difference of 55 ms which is equal to 200 meters shallow from already drilled well (Jherruck B-1) (Fig. 9). As the drilled well (Jherruck B-1) which had the discovery flowed for a day or more and then flowed water unexpectedly which is because the well was drilled in the gas water contact level, which is below 200 m from proposed well location as according to time contour map closures and seismic composite (Fig. 1, 8, 9, 11). The composite comprise of seismic lines NJ08-14, BDN-11 and NJ08-22 respectively (Fig.8, 9).

5.1 Time and Depth Contouring

3D time and depth contour map (Fig. 13, 14) displays that contours are closed and makes a shallows point of the structure where the new well is proposed while the contours at Jherruck –B1 well shows deeper contour values, whereas faults present in the C-Sand horizon does not makes any closure on contour map. As closure is elongated in direction of north-west south-east therefore well failure risk increases while moving away from closure in any direction along fault dip, as this is considered to be the reason of failure of Jherruck-B1 well.

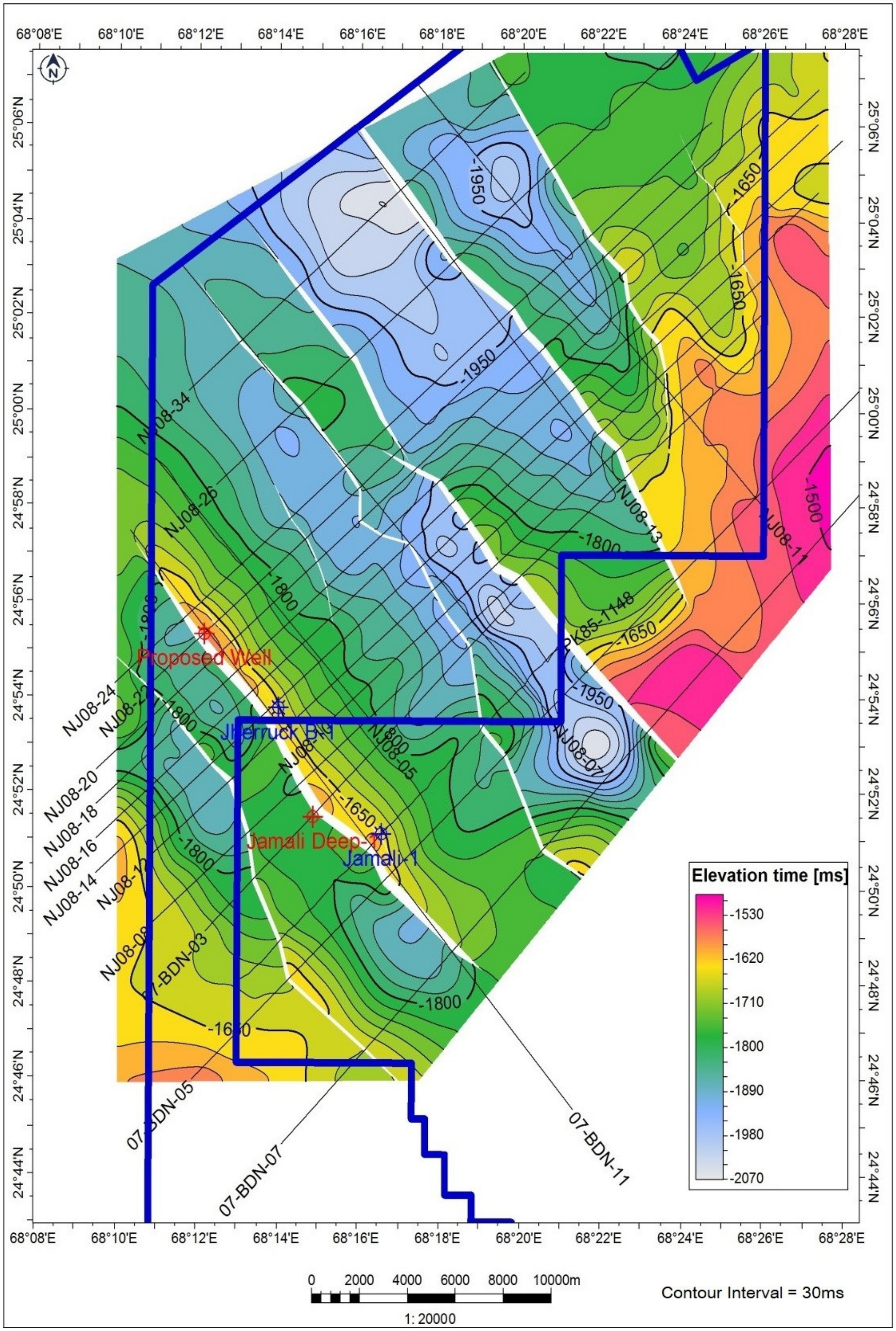

Fig. 11. Time contour map of C-Sand.

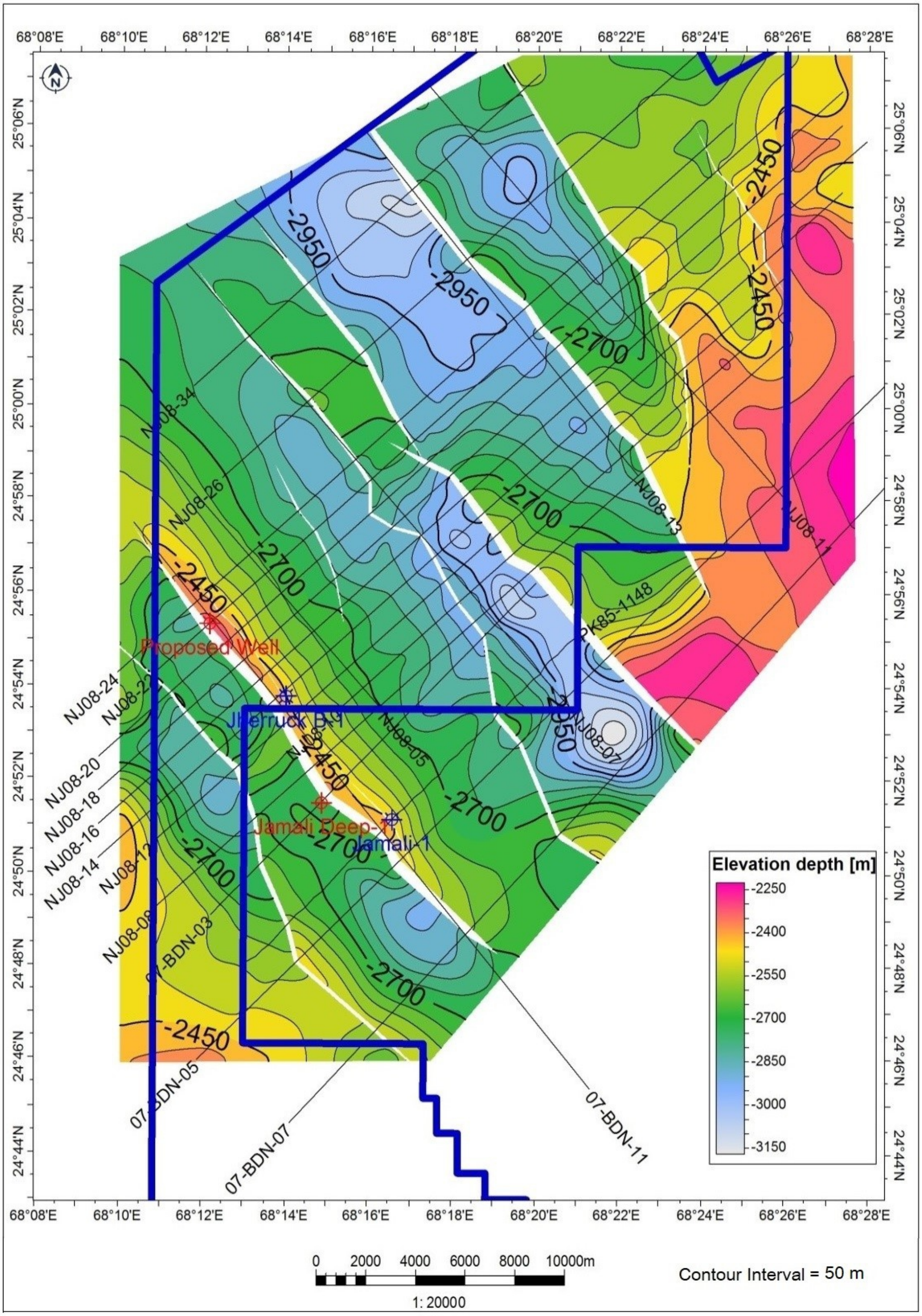

Fig. 12. Depth contour map of C-Sand.

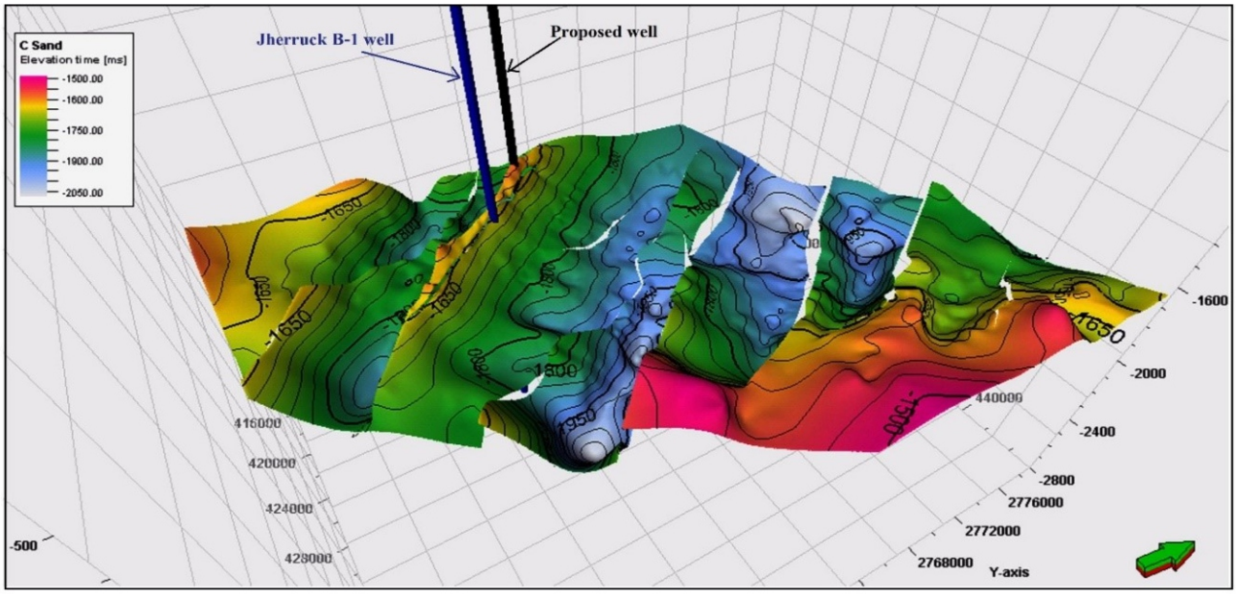

Fig. 13. Time contour map of C-Sand along with location of drilled well Jherruck-B1 and proposed well.

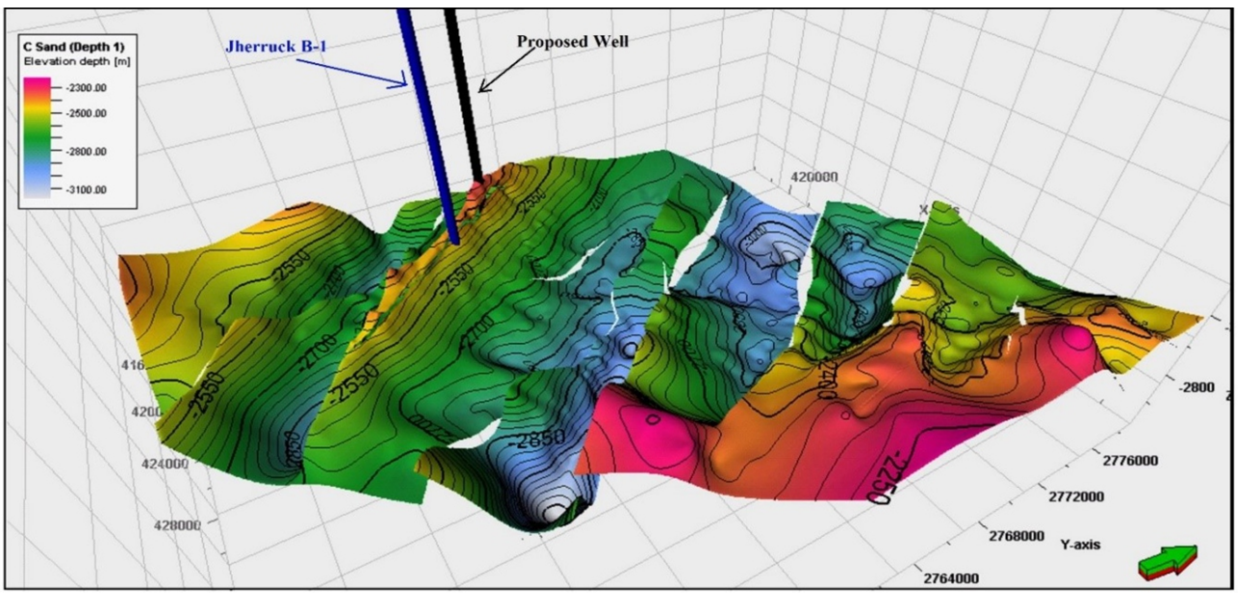

Fig. 14. Depth Contour map of C-Sand along with location of drilled well Jherruck-B1 and proposed well.

6. Conclusions

The investigation of the study area was done using well tops and three seismic lines. The interpretation of the study area reveals several leads and important information of the structure. The Jherruck Block is located in Lower Indus Basin and it is mostly characterized by normal faults, trend of these faults is NW-SE, along with planer and Horst and Graben structural geometry. The study area consists of several blind Normal faults, no any imprints of these faults are found on the exposed surface. Most of the faults present in the study area bisect the strata from Jurassic to Cretaceous age rocks. The main reason that is highlighted by this study is that the Jherruck B-1 well was drilled in the gas water contact level due to which the well had flowed and suddenly depleted. However, a new proposed well should be above the depth of Jherruck B-1 well to have a discovery and C-Sand horizon should be targeted as a reservoir-bearing horizon, as also suggested by contour maps which show a potential closure.

Acknowledgments

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Author's Contribution

Mudasser Nawaz proposed the main concept and write-up of the manuscript, and Muhammad Rustam Khan was involved in the results interpretations plots preparation. Jabir Nazir provided the relevant literature and was also involved in manuscript formatting. Syed Bilawal Ali reviews and proofreading of the manuscript.

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