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AN IMPROVED SEISMIC INTERPRETATION APPROACH FOR RESERVOIR MODELING, COMPARISON OF SEQUENTIAL GAUSSIAN SIMULATION PROPERTY MODELING WITH MODEL-BASED INVERSION FOR POROSITY COMPUTATION IN STRUCTURALLY COMPLEX FOLD BELT AREA OF SOUTHERN INDUS BASIN, PAKISTAN

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ABSTRACT

3D structural maps of Late Cretaceous Pab Sandstone at reservoir level in a gas producing field of Kirthar Fold Belt Southern Indus Basin, Pakistan were generated, and Ant-Tracking attribute for fault extraction was applied for improved structural understandings. Re-interpretation reveals large north-south thrusted anticline, pattern of north-south oblique ramp thrusts on the southeast flank, and combination of easterly vergent thrusts with counter back thrust creating a local pop-up structure in the area. 3D seismic interpretation and application of Ant-Tracking for fault extraction identifies discrete structural styles and reveals that all thrusting has occurred as a result of compression in the Plio-Pleistocene. The apparent different styles are a result of reactivation of earlier extensional fault systems and probably during phased periods of compression. Integration of well and 3D seismic data interpretation along with the application of automatic fault extraction technique is highly recommended to obtain reliable structural interpretation in fold and thrust Belts with structural complexity. Structural modeling leads to the generation of static model which serves as an input to populate petrophysical properties for generating reservoir model using Sequential Gaussian Simulation algorithm. Intersection from model populates the porosity across the main fault and shows good reservoir porosity in south-western part, whereas in north-eastern part, reservoir porosities are poor at deeper levels. In order to validate porosity, Model Based Inversion which uses generalized linear inversion algorithm have been applied on the same data. Low frequency model was added in order to get the absolute acoustic impedance. Inversion analysis provides high correlation coefficient with an estimated error 0.15 illustrating the reliability of results. Direction of cross section from east to west represents acoustic impedances and high impedances are corresponds to low porosity sands. Inversion results have been used as a training data for porosity calculation. Regression analysis was performed on impedance results to get porosity distribution across the reservoir. Porosity estimated from inversion gives indication of porosity distribution over the high-resolution impedance derived seismic data. A strong correlation between porosity estimation from petrophysical modeling using Sequential Gaussian Simulation and seismic inversion derived porosity values at reservoir scale makes porosity estimation a reliable and efficient reservoir characterization in the structurally complex areas and has equal worldwide implications.

INTRODUCTION

Study area is located in Kirthar Fold belt, Sindh Province, Pakistan approximately 200 km north of Karachi. The objective reservoir belongs to late Cretaceous age. Due to condensate seepages at Moghalkot in the Central Sulaiman Fold belt Pab Sandstone has been considered as a potential reservoir. In 1974, first discovery was made from Pab by oil and gas development company limited (Humayon et al., 1991). Pab sandstone of Cretaceous age is among the major reservoirs in this area (Moghal et al., 2012). In 1950 Philji-01 and Philji-2 wells were drilled and both were abandoned. 2D seismic lines of 196 km were acquired to define the Zamzama structure. In 1998 Zamzama-1/ST1 was drilled indicating that Pab Sandstone depicts a good reservoir. Due to poor hole condition petrophysical analysis of Khadro Formation is not possible (Jackson et al., 2004). After first discovery, appraisal program involved the acquisition of new 3D and additional 2D seismic lines. In 1999, Zamzama-2 was drilled and results were encouraging to for both Pab and Khadro Formations (Karazincir and Orumwense, 2014).

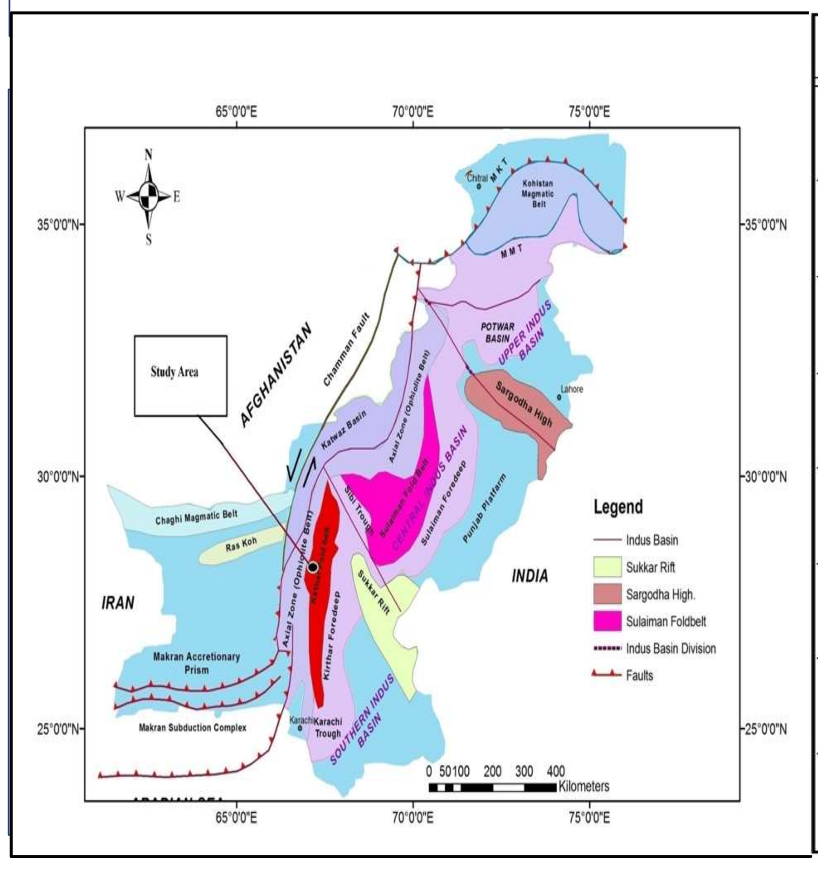


Figure 1.Tectonic map showing tectonic features, location of study area and divisions of Indus Basin (Modified after Kadri, 1995)

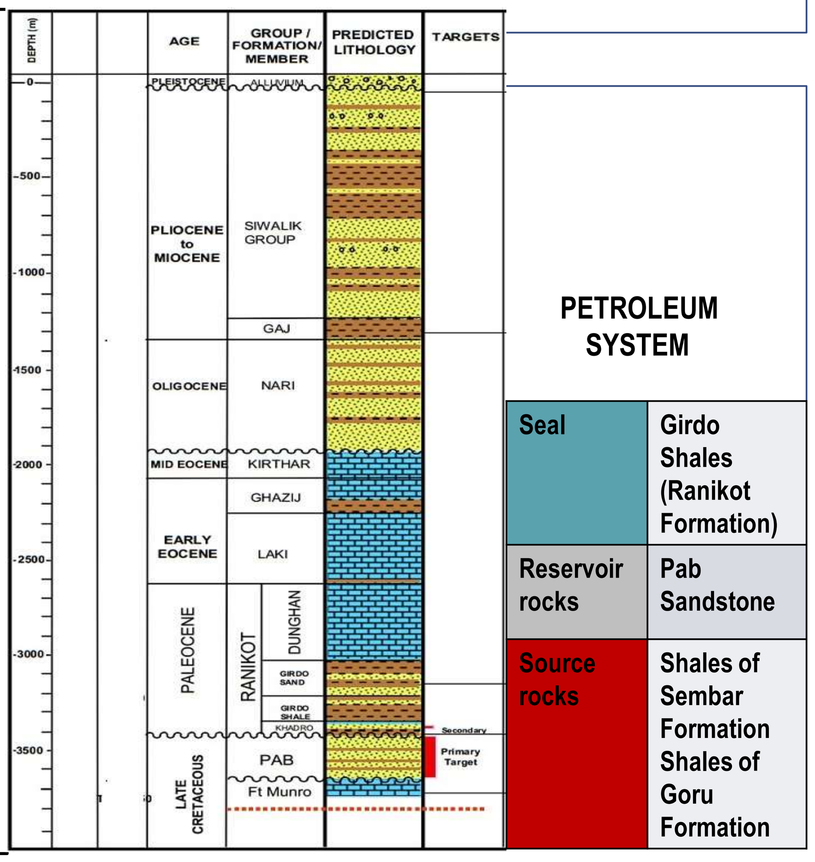
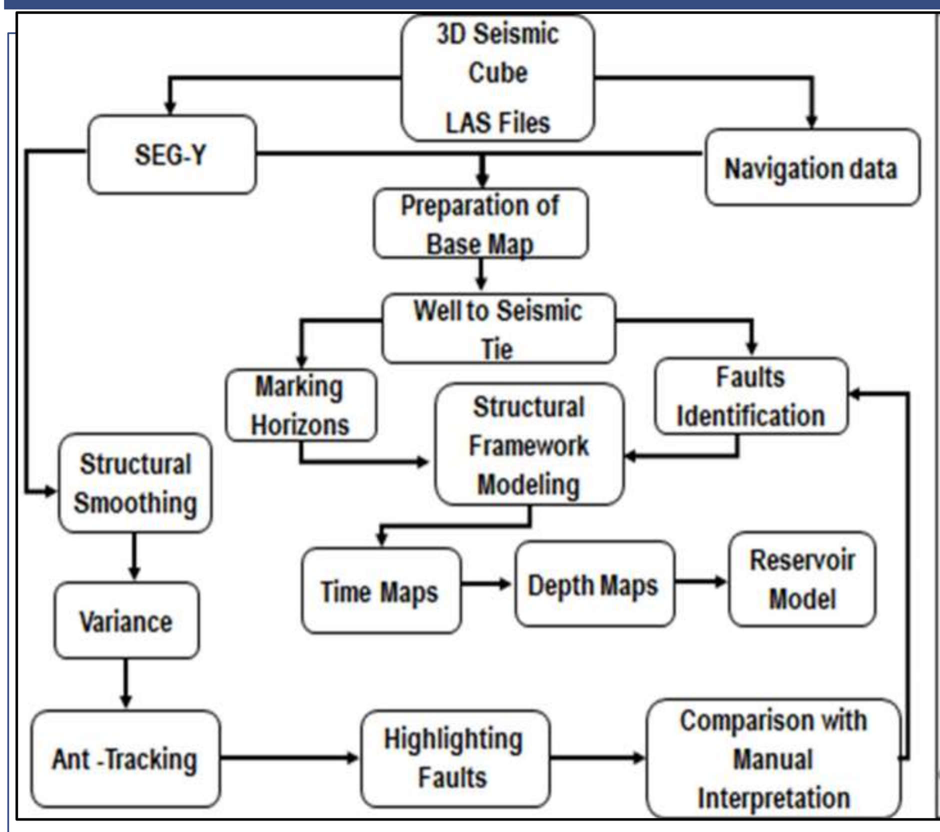


Figure 2.Stratigraphic column of Zamzama area (Jackson et al., 2004)

SEISMIC INTERPRETATION WORKFLOW



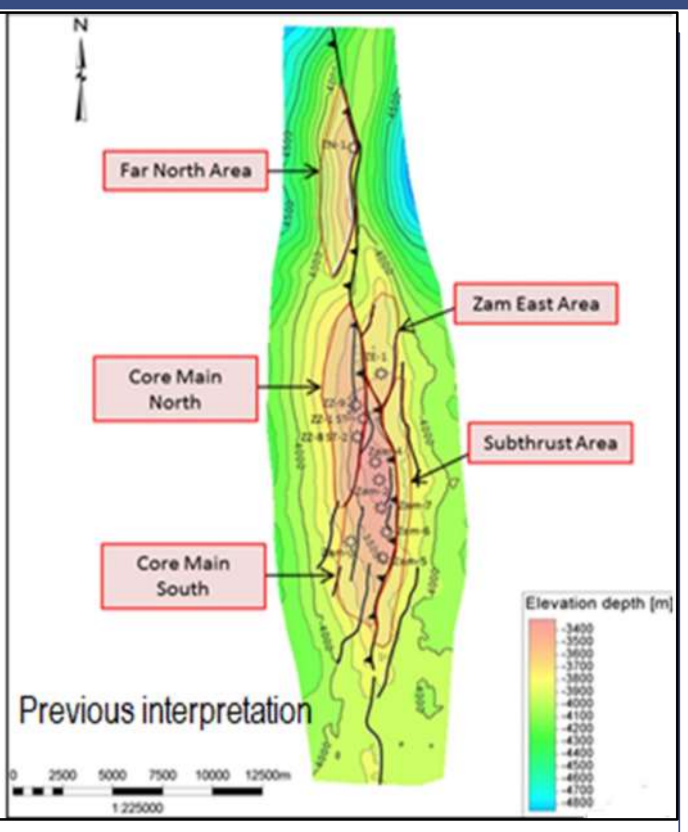


Figure.3.Workflow for current research work Figure.4.Previous seismic interpretation (Jackson et al.,2004)

OBJECTIVES

1. Seismic reinterpretation and application of Ant-Tracking attribute for improved structural understanding
2. Using Sequential Gaussian Simulation algorithm to populate reservoir properties.
3. Model Based impedance inversion for porosity computation across the study area.
4. Comparison of porosity computation techniques

RESULTS AND INTERPRETATION

Seismic interpretation identifies pattern of north-south oblique ramp thrusts on the southeast flank, and combination of easterly vergent thrusts with counter back thrust creating a local pop-up structure in the area (figure 5(a) and (b). Faults are highlighted on time slice at reservoir level after some pre-processing steps i.e smoothing and variance attributes (figure 6(a), (b) and (c). Horizons and faults are combined into a structural framework and 3D reservoir static model figure (7(a)) was build. Computed porosity was upscaled and populated using Sequential Gaussian Simulation algorithm (figure 7(b)). Model Based Inversion was applied at reservoir scale and porosity computed (figure 8(a) using regression analysis. Cross-section (figure (8)b represents porosity values at well locations.

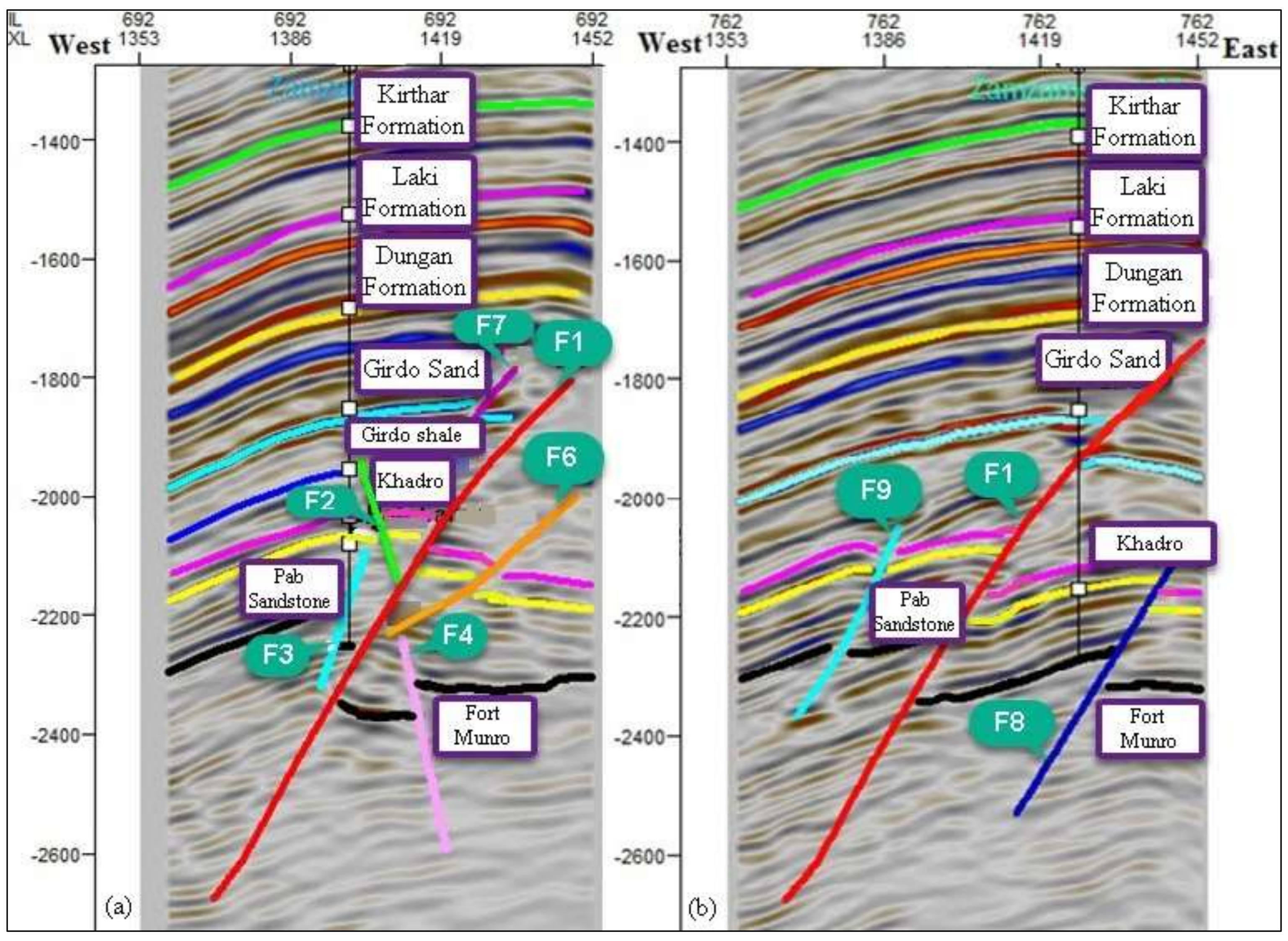


Figure .5. Interpreted seismic section (b) Interpreted seismic section inline

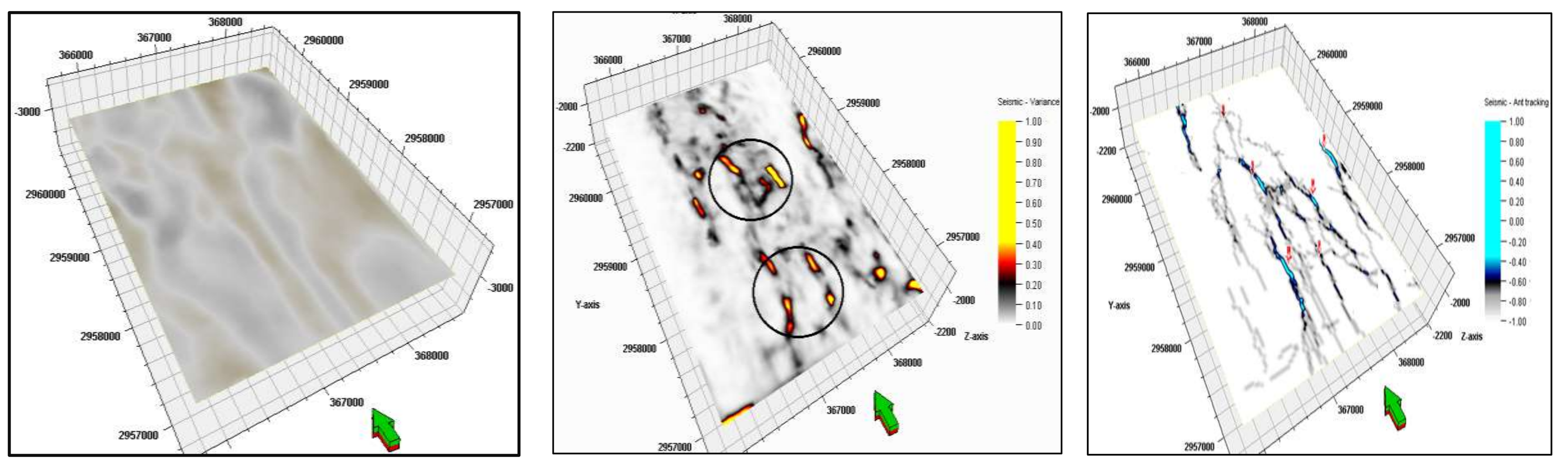


Figure.6 (a).Structural smoothing attribute (b) Variance attribute applied at time slice (c) Ant-Tracking attribute

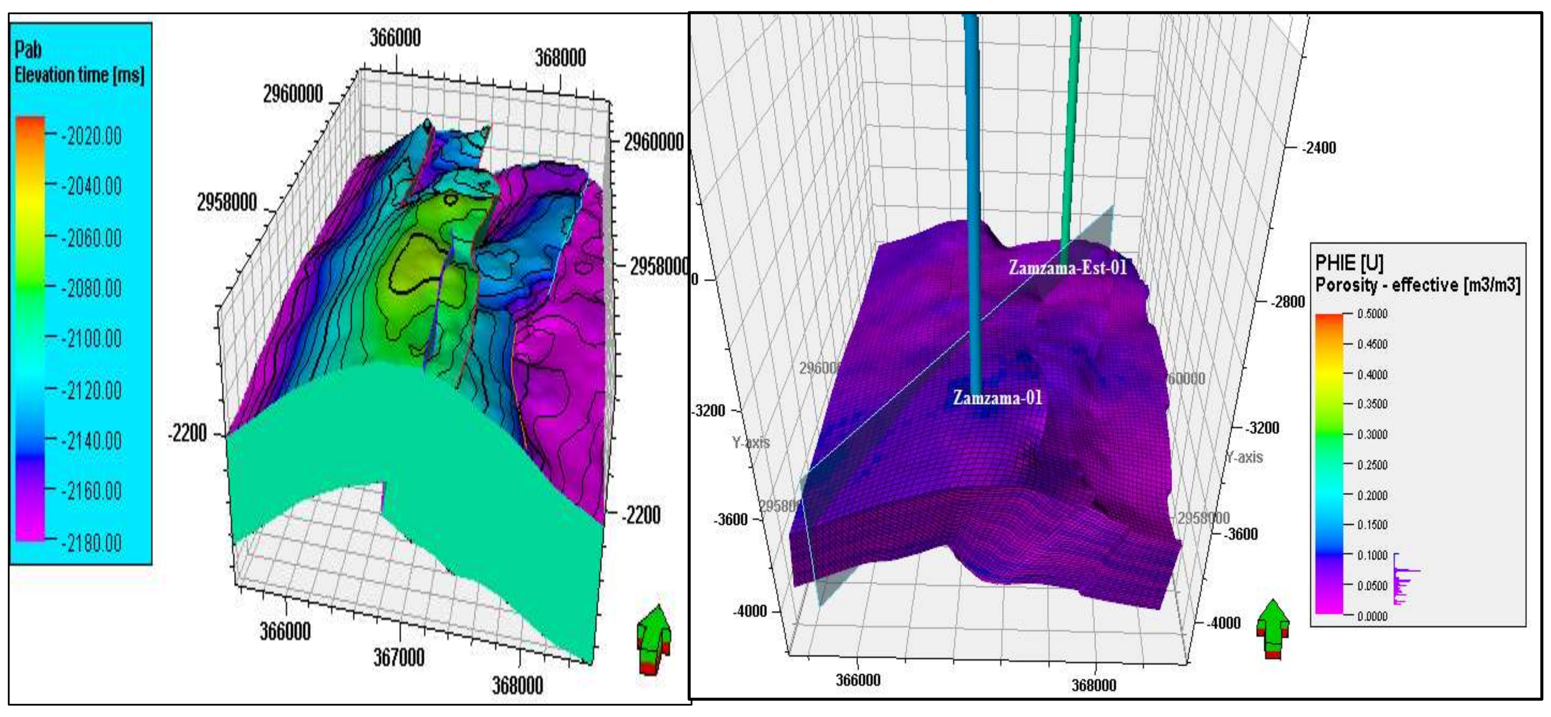


Figure 7 (a). 3D improved reservoir model (b) Model for porosity using Sequential Gaussian Simulation algorithm

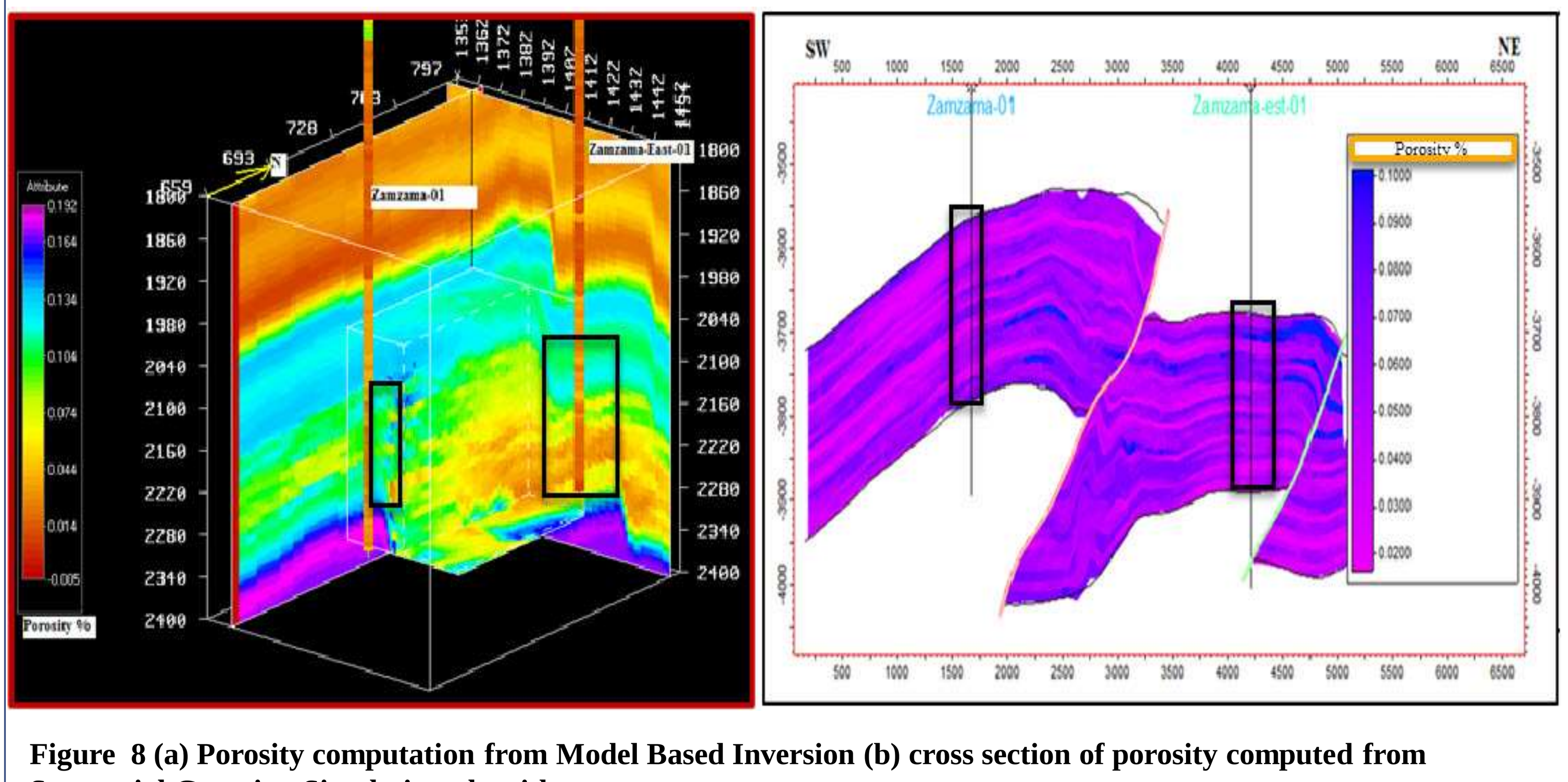


Figure 8 (a) Porosity computation from Model Based Inversion (b) cross section of porosity computed from Sequential Gaussian Simulation algorithm

CONCLUSIONS

1. 3D seismic interpretation and application of Ant-Tracking for fault extraction identifies discrete structural styles
2. Porosity computed from Model Based Inversion and from Sequential Gaussian Simulation algorithm can be correlated as both showing porosity ranges (5%-10%) and (2%-10%) respectively.
3. Low porosity corresponds to high impedance and hence impedance results are quite effective to mark tight sands intervals.

CONTACT

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REFERENCES

1. Kadri, I.B., 1995. Petroleum Geology of Pakistan, Pakistan Petroleum Limited publisher, Pakistan. 268p.
2. Khan, M.A., 2016. *Petrophysical Modeling and 3d Post-Stack Seismic Inversion for Reservoir Characterization of Pab Sandstone, Zamzama Area, Southern Indus Basin, Pakistan*(Dissertation, Bahria University Islamabad Campus).
3. *Jackson MA, Jellis RG, Hill R, Roberson P, Woodall MA, Wormald G Jafri N (2004). January. Zamzama Gas Field-Balancing Risk and Value: Asia Pacific Oil and Gas Conference and Exhibition. Society of Petroleum Engineers; Perth, Australia.doi: 10.2118/88577-MS*
4. *Karazincir M, Orumwense R (2014). Tilted orthorhombic velocity model building and imaging of Zamzama gas field with full-azimuth land data. The Leading Edge 33(9):1024-1028. doi : 10.1190/tle33091024.1*