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Original Article

Reservoir characterization of the Upper Cretaceous Abu Roash 'G' Member, using 3-D seismic data in the WON-X Oil Field, Beni Suef Basin, Western Desert, Egypt

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ABSTRACT

The WON-X field was discovered in the western area of Beni Suef Basin in Egypt, which is now being explored and exploited in the part of the northern Desert. Within this concession, the WON-X field is adopted to producing hydrocarbons successfully. The West Beni Suef basin is one of the prospective area recently added to Egypt's oil exploration strategy (WON-X). Interpolated seismic data oriented NE-SW and passed through well faults displayed the element that impacted the research area. The Lower Cretaceous Albian Kharita Fm, superimposes the foundation rocks in an unconformable form. The original Nile was at the top of the seismic section, where the sediments were eroded in a variety of methods, until they reached the Abu Roash E (A/R E) Member. It was feasible to find major lateral changes in the reservoir, such as stratigraphic barriers, as a result of many drilled wells evaluated, including pressure measurements, which differed between the southern and northern portions of the field. Through the integration of seismic and geological well log data, the WON-X oil field has obtained extensive knowledge and a deeper understanding of the potential of the Abu Roash (AR "G") reservoir. Seismic attributes such as the RMS map can be utilized, to discover various compartments in the field and the other geologic factors whose, amplitude responses allow them to be separated from the background features. In addition, the RMS map depicts the stratigraphic mud barrier that developed between the wells in the studied area. In addition to normal fault lines, the WON-X hydrocarbon oilfield is located on a doubly plunging anticline, commonly referred to as an "asymmetrical anticline." According to the maps of the AR "G" reservoir, this anticline's centre is a prime place for oil accumulation.

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1. Introduction

The field of study: WON X; is an important oil field in the north Western Desert of Egypt, located between 28º 57' 0" and 28º 59' 0" N, and 30º 53' 0" E and 30º 56' 0" E. Figure (1) depicts the WON X Field, a significant oil field in the north Western Egyptian Desert. It is located south of the Gindi basin and east of the Qarun oil field. The West Beni Suef basin (WON) is one of the most promising locations in Egypt's Western Desert for oil and gas exploration. It IS just included to the country's economic long-term hydrocarbon exploration strategy.

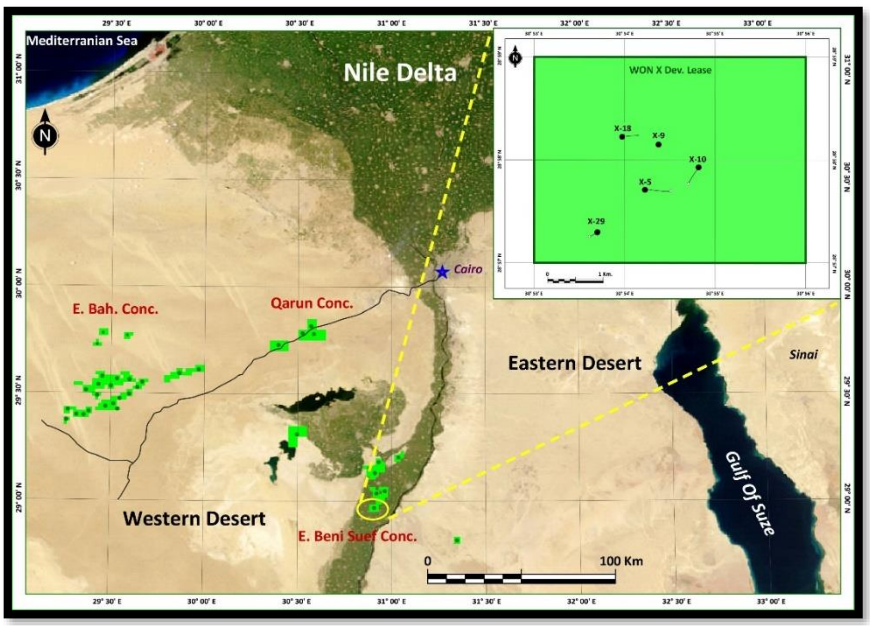

Fig. 1: Location map of WON X oil field in the Beni Suef basin (modified from Google Earth).

2. Geologic Settings

The stratigraphic review of the northern part of the Western Desert (Beni Suef basin area) shows a sedimentary succession ranging from recent to Pre- Lower Cretaceous and basement figure 2. It consists of alternating depositional cycles of clastics and carbonates. The Upper Cretaceous section is divided into three main rock units, which are from bottom to top: Bahariya, Abu Roash and Khoman formations. The Miocene or recent age is of the homogeneous "Clastic Deposits (ancestor Nil Valley) They were deposited by the former Nile River and are composed of sand, silt, shale, and reworked limestone. This would have a negative effect on the imaging of the seismic data

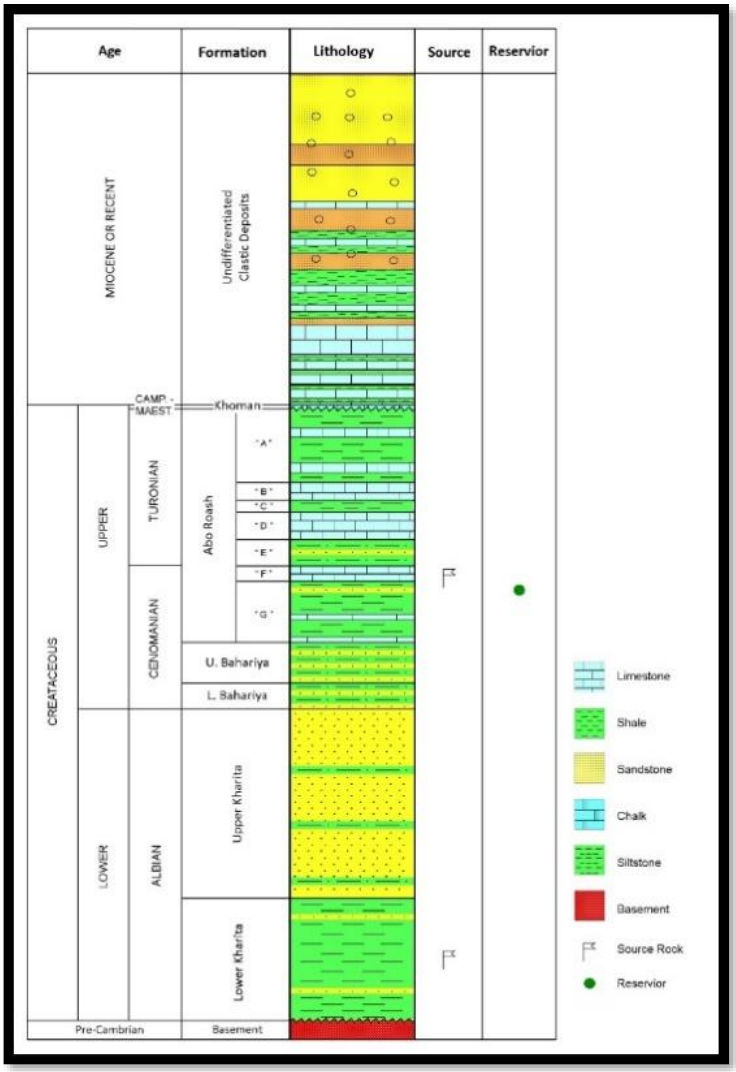

Fig. 2: Stratigraphic column of WON-X field.

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The origin of Beni Suef basin is a more obvious explanation for the change in basin orientations, during the Jurassic and Cretaceous periods. NE-SW oriented Jurassic basins are related in time and space to the opening of the Neo Tethys Ocean (Argyriadis et al., 1980), whereas the WNW-ESE to NW-SE oriented Cretaceous rifts are similar in age and orientation to the rift basins in west and central Africa, Sudan, and Libya (Sirt Basin) during the opening of the Atlantic Ocean thorough Africa's break-up during the Early Cretaceous break (Schull, 1988; and Genik, 1993)this with the exception that, the basin is controlled by the Aptian/Albian NE-SW extension movement, Zahran et al. (2011) pointed out that, the Beni Suef basin is very similar to that of the northern areas of the Western Desert figure (3). As a result of this movement, the Albian Kharita sediments were deposited directly on the Egyptian Basement Complex's crystalline rocks

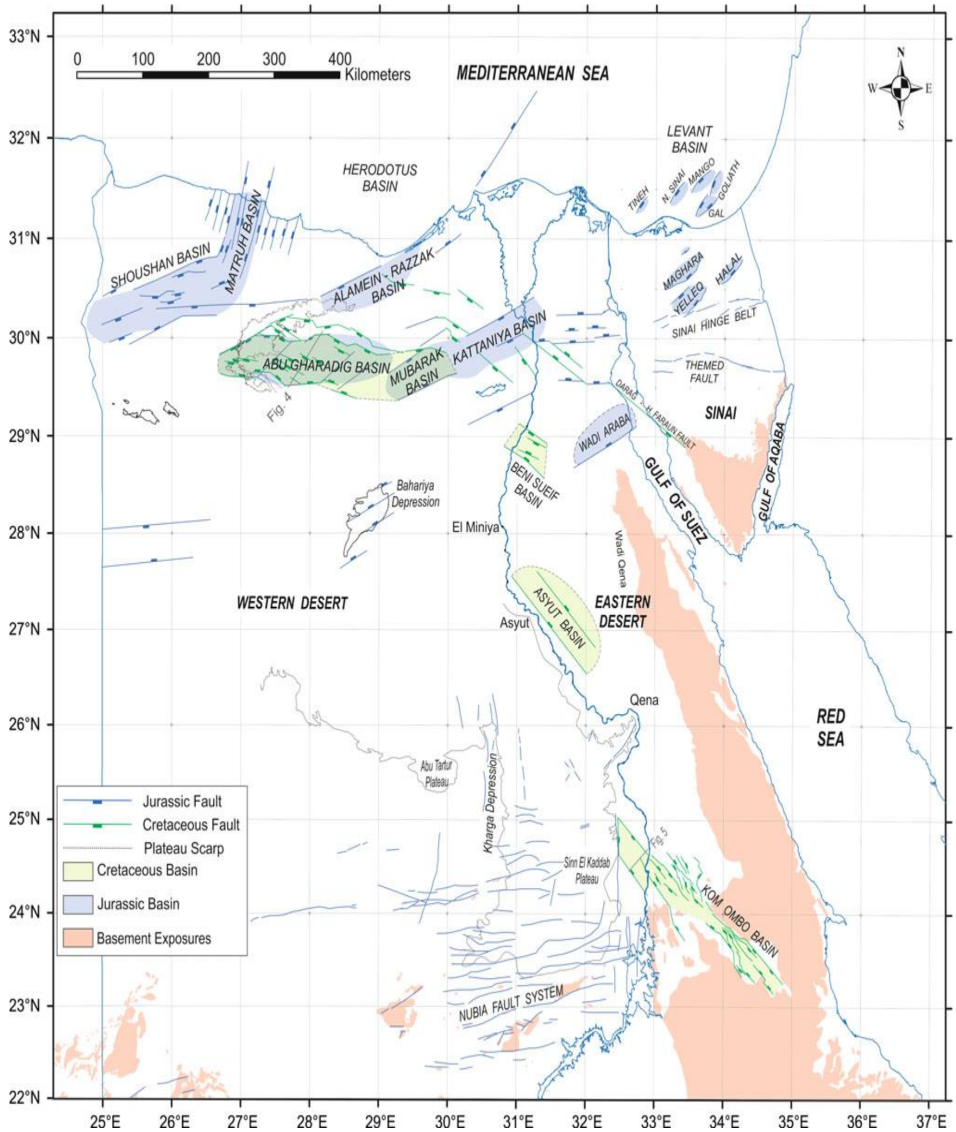


Fig. 3: Simplified tectonic map showing the main basins in the north Western Desert (after Moustafa, 2008)

3. Materials and methods

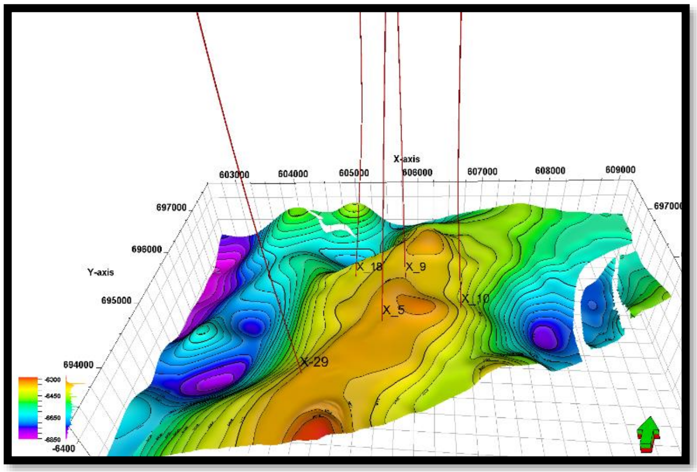
There are thirty 3D seismic lines (15 cross-line, and 15 in-line), and a complete set of well logs for five wells available for a Ph.D study. Regarding the seismic interpretation, there are two interpretation modules: Horizon interpretation, which is performed on the horizons of interest, and Fault interpretation for the section of interest; these seismic interpretations then are utilized for mapping surfaces.

Using Interactive Petrophysics software, to determine the petrophysical properties of the Abu Roash G reservoir (shale volume, net - pay thickness, porosity, water saturation, and hydrocarbon saturation), and create a separatation between the shelf mud and intertidal channel for the Abu Roash G reservoir. As a result of the analysis of the well data, the depositional environment for the upper Abu Roash "G" Member reservoir is a tidal mixed flat, which means that, there is a significant heterogeneity in the reservoir, Therefore; it is a demand to integrate the seismic and geologic data, to determine the changes in the Cretaceous reservoir.

One of the useful tools is the seismic attributes, which aims to extract as much as possible the geologic information from the seismic data. Root mean square amplitude is one of the most important seismic attributes that could help identifying the lateral continuity, hence could refer to the faices heterogeneity. The RMS attribute is calculated on a sample-by-sample basis, without regard to the waveform. It’s a phase of a seismic trace at a selected sample, in degree or radius. This is used to highlight the continuity of the weak intra-reservoir reflections.

4. Results

The study's findings improve reservoir characterization of the AR "G" sandstone facies, aid in the identification of possible hydrocarbon structural traps, and hence used in regional exploration. Seismic investigation found that, the AR "G" reservoir's horizons were chosen to depict the development of structural variables influencing the reservoir. The seismic lines that were available were interpreted to represent an asymmetrical double plunging anticline with a NE-SW axis striking the research area figure (4). The doubly plunging anticline represents the structural control for hydrocarbon buildup in the WON X oil field. The most essential interpretation activity is the structural interpretation, which requires constructing maps of multiple horizons as well as a 3D structural model (Abdel Fattah et al., 2014). A large folding event occurred near the northern limits of the Western Desert in the Late Cretaceous–Early Tertiary period (Abdel Fattah et al., 2018)



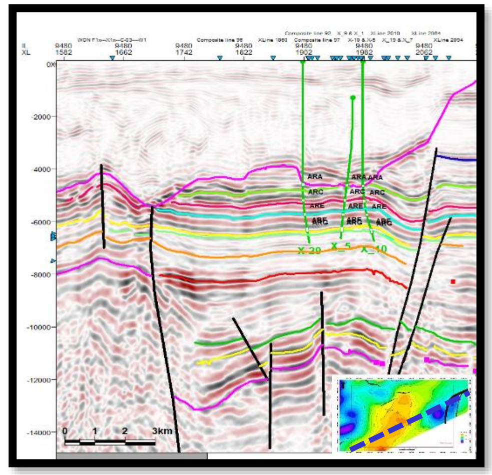


Fig. 4: AR "G" reservoir demonstrates the asymmetrical double plunging anticline that formed the WON X field and the interpreted seismic line

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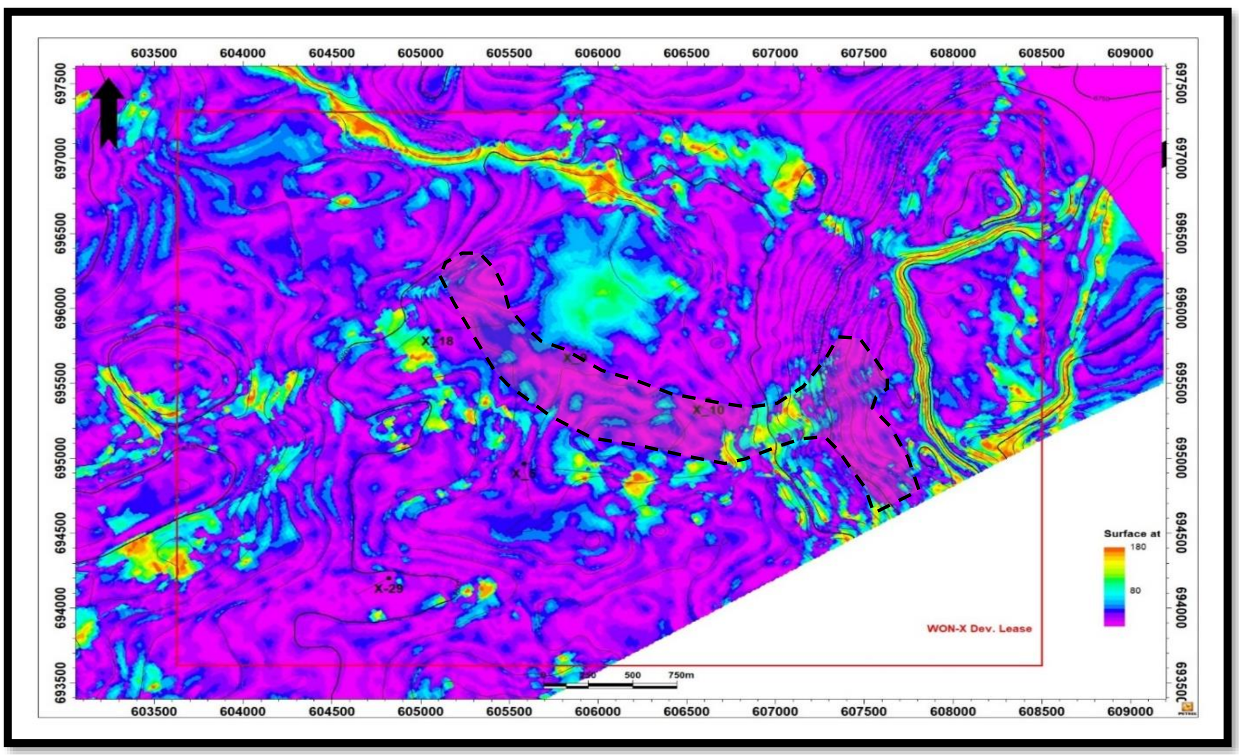

Fig. 5: RMS surface slice extracted on the top ARG reservoir, illustrating the variation in the amplitude resulted from the change in reservoir properties, as indicated by the black arrows.

X-9 Well recorded a pressure of 1900 psi, whereas X-29 well recorded a pressure of 2300 psi, indicating the presence of two separate compartments, supported by the lateral change of the reservoir sand into mud, as indicated by the well logs data of well X-5. On the other hand, the extracted RMS amplitude map of the reservoir zone showed high RMS values at certain locations, where there are faults, when compared to the structural map of the AR"G" reservoir. The RMS amplitude can, not only identify the structural elements, but also identify any lateral variation in the reservoir, such as stratigraphic barriers. There is an anomaly, which cannot respond to structural fault, but could indicate the contribution of stratigraphy in the reservoir figure (5). This can be evaluated by integrating the well and seismic data, as the well data contain a more detailed vertical description of the reservoirs. The integration draws attention to the presence of mud barriers using the well data, but the seismic RMS amplitude map helps in delineating this amplitude away from the wells.

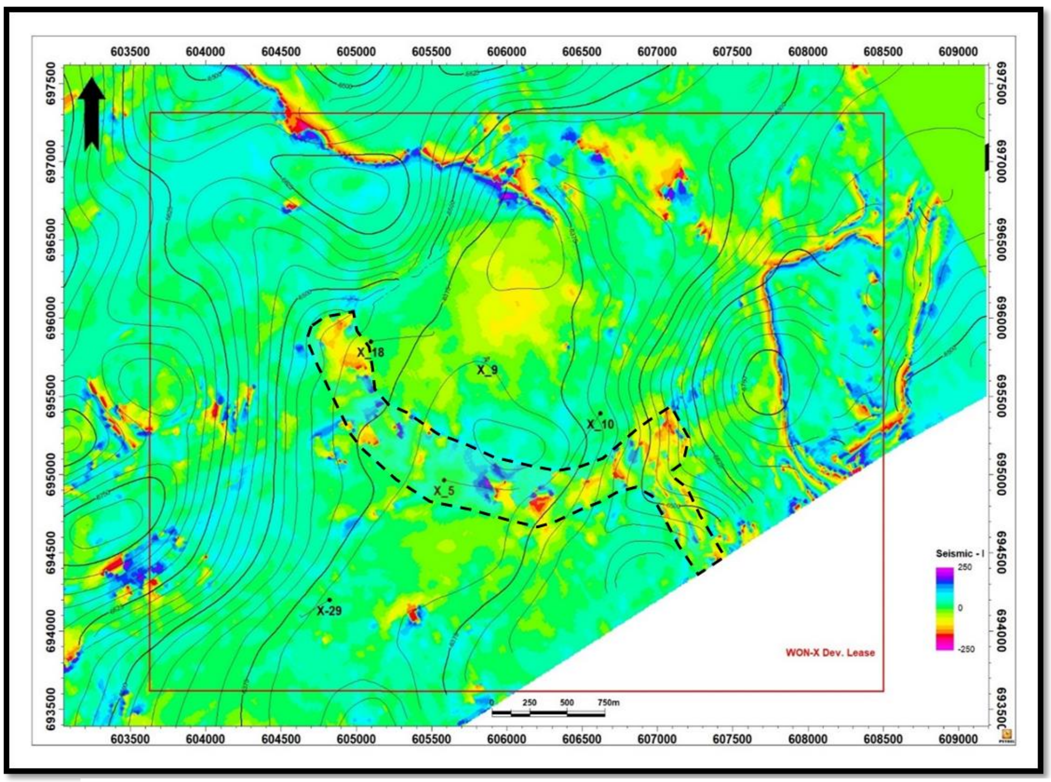

Fig. 6: instantaneous phase attribute map on top ARG+50 window illustrates the lateral variation in the reservoir that caused by structural or stratigraphic elements.

Figure 6 shows an instantaneous phase attribute map taken from the ARG reservoir, which shows the reservoir heterogeneity and it is structural elements. It indicates the reservoir's continuity as well as the faults that occurred during the leat Aptian -Albian kharita Formation phase of the rift period. It also displays the stratigraphic mud barrier that formed between the wells in the study field. The RMS results and the net - pay map in Figure (7) are in agreement.

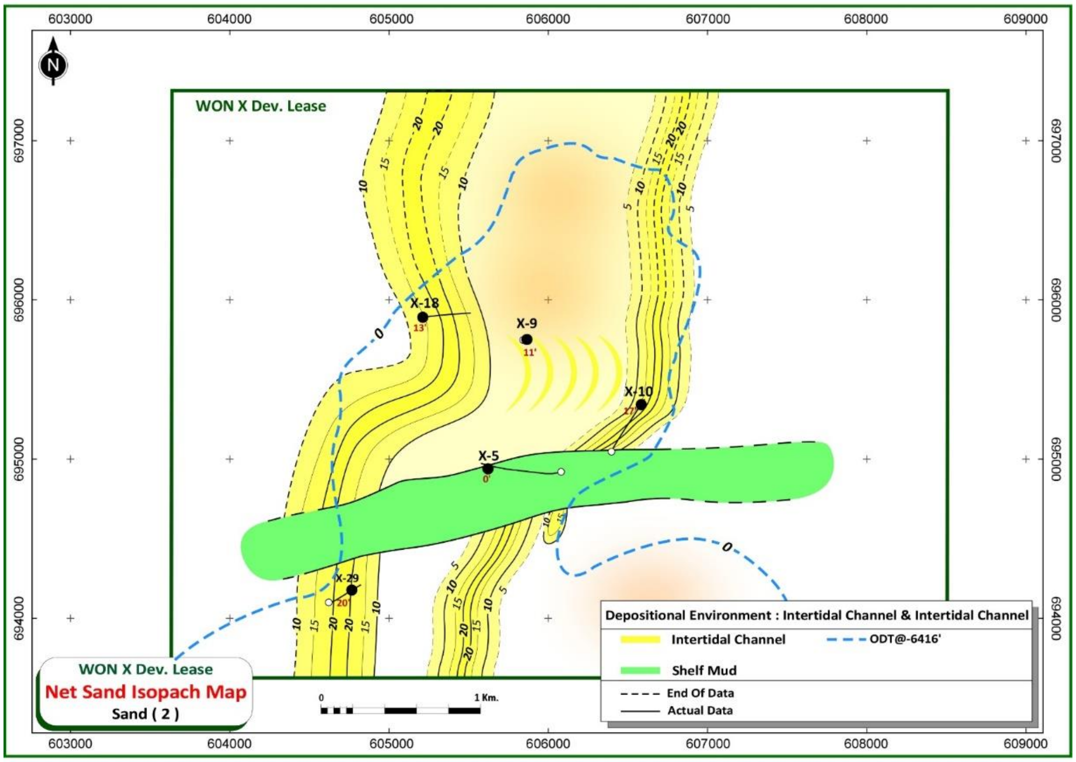

Fig. 7: Net Sand Isopach Map to integration with seismic data.

5. **Conclusion**

A three-dimensional representation of the top of the AR "G" reservoir, exhibiting the structural relationships between each grid point and the other points on its surface. The highest point in the field is located at the X-5 well, while the lowest points are located to the eastern and western sides. The interpretation of 3D seismic data helps identifying, not only the picture of the subsurface structures, which is an asymmetrical double-plugging anticline with a NE-SW axis, but also draws our intention to the lithology heterogeneity of the reservoir away from the well locations, using the seismic attribute analysis.

Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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