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Characterization and Interpretation of Dedicated Reservoir Interval: A 2D Seismic Structural Approach

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Abstract
In the present study, three different depth conversion methods have been used with varying equations at Mishrif Formation to determine the best method to produce better, more realistic and accurate interpretation results and to reduce the risk of future petroleum production wells drilling. Three horizons were picked (Tanuma, Mishrif and Rumaila) and converted into a two-way time grid surface. In addition, the velocity parameters (instantaneous velocity and rate of velocity change with depth) were computed and converted to the form grid surface from the well data, showing lateral velocity variation. Among the three models carried out, the Model 1 is considered the most accurate depth conversion method in this region according to the results of the geostatistical analysis. This method gave fewer errors and mistakes between actual and predicted depth with the best intra-extrapolation technique at all directions away from the well area with a standard deviation value of 13.2, and the standard deviation values of 13.6 and 13.9 for models 2 and 3, respectively.

Keywords: Depth Prediction, Geostatistical Analysis, Mishrif Formation, Reservoir Characterization

الخصائص والتفسيرات المكمنية لفترة عمقية محددة: بأستخدام التركيبية الزلزالية ثنائية الابعاد

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الخلاصة
في البحث الحالي ، تم استخدام ثلاث طرق مختلفة لتحويل العمق باستخدام معادلات مختلفة في تكوين مشرف بهدف تحديد أفضل طريقة لإستنتاج نتائج تفسير أفضل وأكثر واقعية ودقة ولتقليل المخاطر في حفر ابار الانتاج النفطي في المستقبل. تم اختيار ثلاثة سطوح (تنومة ، مشرف ، الرميلة) وتحويلها إلى سطح شبكة الزمن ثنائي المسار. كما تم حساب معاملات السرعة (السرعة اللحظية ومعدل تغير السرعة مع العمق) وتحويلها إلى سطح شبكة الشكل من بيانات البئر ، والتي تظهر التباين الجانبي للسرعة. من بين النماذج الثلاثة التي تم تنفيذها ، يعتبر النموذج (1) أكثر طرق تحويل العمق دقة في هذه المنطقة وفقًا لنتائج التحليل الإحصائي والجيوإحصائي. أعطت هذه الطريقة أخطاء وأخطاء أقل بين العمق الفعلي والمتوقع مع أفضل تقنية استقراء

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داخلية في جميع الاتجاهات بعيدًا عن منطقة البئر بقيمة انحراف معياري (13.2) ، بينما قيم الانحراف المعياري (13.6) و (13.9) النموذجين (2) و (3) على التوالي.

1. Introduction

The depth conversion is considered a vital process in seismic interpretation because all features are interpreted in the seismic section, which was in time units, the well drilling in depth units [1] [2]. The entire understanding of subsurface geology and the structural situation is more complex; therefore, this method was used to reduce the subsurface geophysical ambiguity [3] [4] [5].

There are two general sides on which the type or method to use of the depth conversion process depends on the technical and geological sides. The technical side means the availability of geophysical and geological data related to the study area, such as the drilled wells information (number, density and depth) and the field seismic survey data carried out in the study area using 2D and 3D surveying techniques. Meanwhile, the geological side means the complexity of the region structurally, lithofacies variations, and thickness/depth variation. All these factors should be considered before the depth conversion process [6].

Depth conversion must be reachable to the preferable degree of accuracy and reliability, all within the limitations of the available geophysical and geological data [7] [8]. The depth prediction significantly impacts the economic development of hydrocarbon exploration. Therefore, errors related to a vertical depth of a few meters may have a financial impact. In the oil and gas industry, challenges arise in geological modelling, especially in complex geological regions, due to rising modelling errors [9]. These challenges were addressed during the progress of acquisition data techniques, a creation velocity model, and algorithmic imaging [10] [11].

In many studies, velocity models are selected based on personal performance or depend only on the differences between the actual depth and the calculated depth at well sites (e.g. [12] [13] [14]). In addition, many authors used pseudo-depth conversion (simple method) in many fields [15]. In the pseudo-depth conversion method, all predicted depths are tied exactly to the actual depth at well sites, and the interpreter cannot evaluate the accuracy of depth conversion results outside the well locations [6]. This study applied the geostatistical analysis and some effects in A field at Mishrif Reservoir [16] [17], southern Iraq, to evaluate the depth conversion at and away from well locations by using different velocity models to determine the appropriate model that adopted in depth conversion. The main purposes of this study are to explain a general workflow for determining the optimum velocity model and to conduct a quantitative and qualitative evaluation of depth conversion uncertainties.

2. Methodology

2.1 Dataset

In the current study, the available data included to interpret of ten 2D seismic reflection sections carried out by an international oil company (INOC) in 1975 with 21 wells that cover the study area, as shown in Figure1. Only one well (H2) contains on velocity information (check shot), which was used to discern the main horizons of interest.

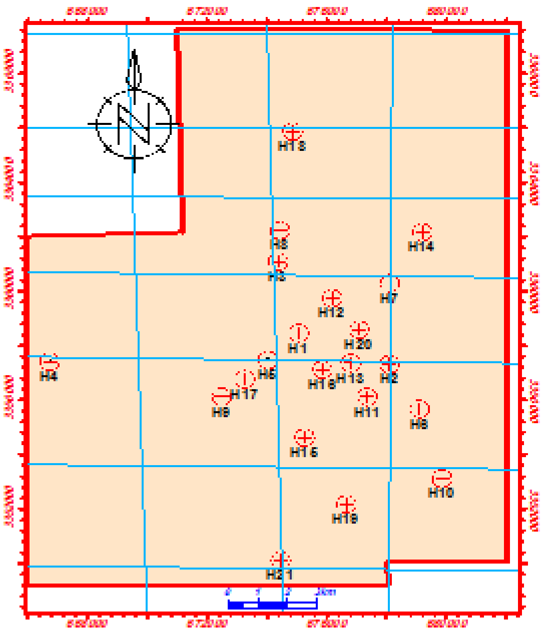
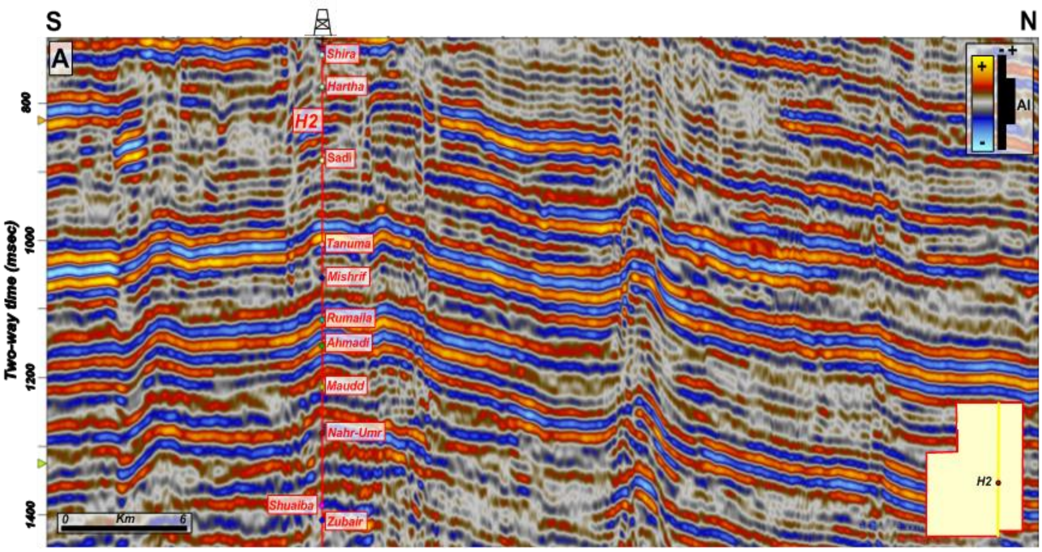


Figure 1: Base map of A-oil field shows 2D seismic reflections, well locations, and the boundary of the study area.

2.2 Fault analysis and picking horizons:

The picking horizon process precedes fault analysis to avoid misinterpretation [6]. Nine faults were recognized in 2D seismic sections with less displacement, as shown in Figure 2. All these faults were picked manually with the general strike of these faults toward the N-S direction. Three horizons (Tanuma, Mishrif and Rumaila) were picked to provide a more reliable velocity model for the interpreter. The reflector's continuity is good, with high amplitude in most cases, while the continuity and amplitude became moderate, especially in fault zones. The auto-tracking picking was applied, but manual picking was used where the reflectors with less continuity and amplitude. All these horizons represented the Lower Cretaceous epoch and were converted into maps. These maps illustrate the structure as irregularly shaped at the well coverage area with no clear structure axis showing up with a horizon surface, which dips to the eastern and northeast parts of the field. The two-way time maps show an increase in size with depth, as shown in Figure 3.



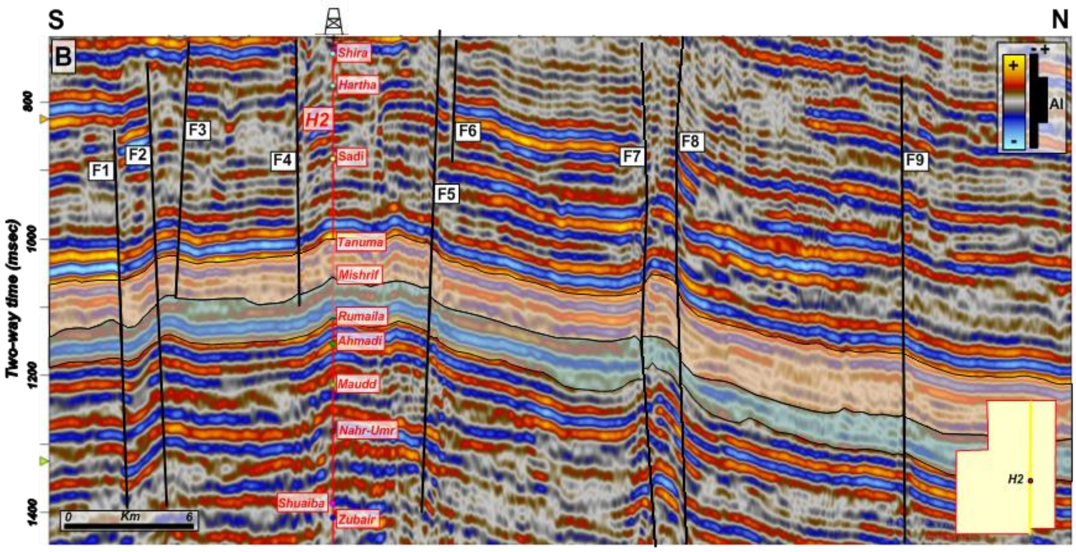


Figure 2: N - S direction, A) Seismic section before interpretation a cross H-2 well, B) interpreted seismic section shows the picked horizons with faults.

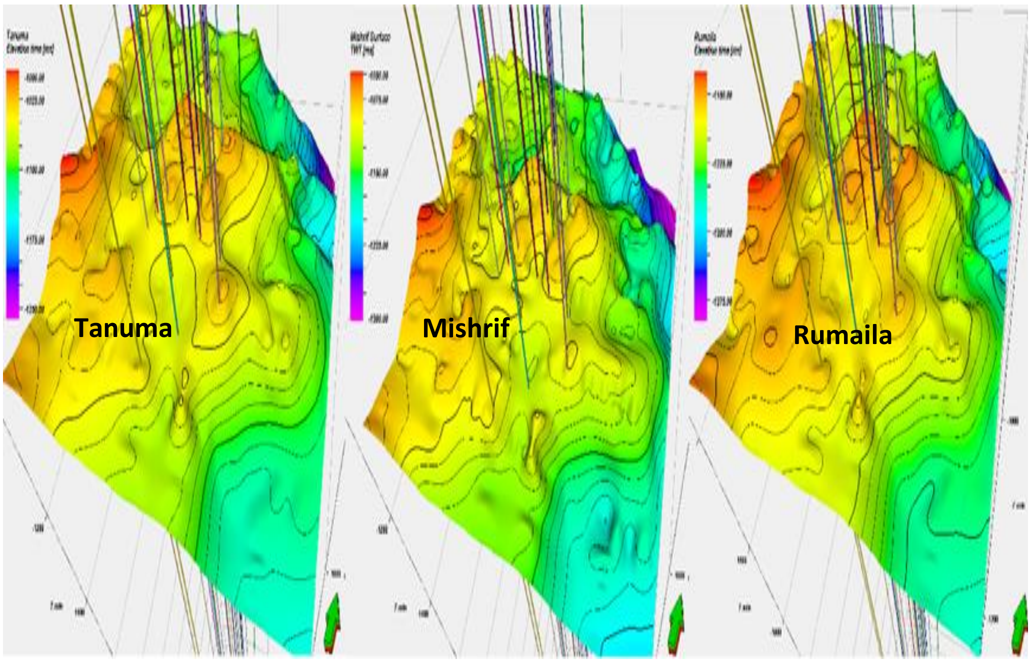


Figure 3: Two-way time grid surface of picked horizons (Tanuma, Mishrif and Rumaila) in the 3D window shows the irregular shape of the structure with drilled wells in the A field.

2.3 Velocity Parameter Estimation

Map calculated from well data by using the following equation, V0 = Vavg – kz, where Vavg [16]. The V0 (V0 represents the instantaneous velocity at the top of the key of velocity layers). In comparison, k and z (Vavg average velocity at the top of the key of velocity layers, K the rate of velocity change with depth, and Z actual depth) are computed at each well locations. Only one V0 map was generated from well data at the top of the Tanuma Formation to give a more accurate velocity model. This velocity map illustrates the trend of velocity change, and this horizon's observed instantaneous velocity variation is not almost constant. Note Figure 4a. The K-parameters were derived from each well location and gridded to produce the k-grid surface, Figure 4b.

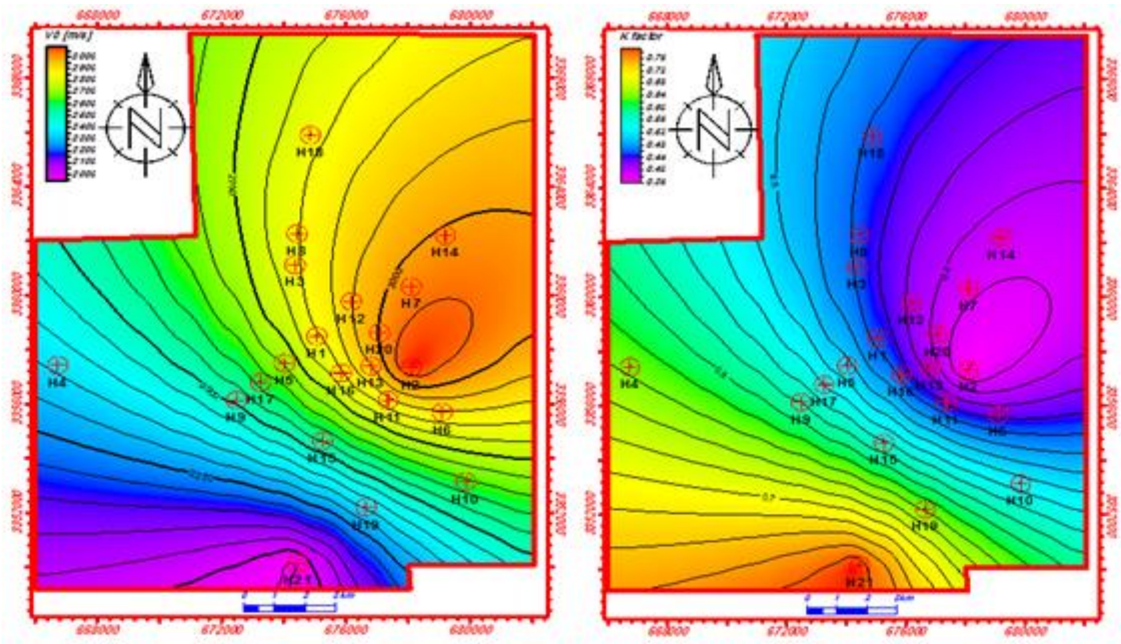


Figure 4: V_0 map and K-parameter of Tanuma Horizon.

2.4 Depth Conversion Techniques

Determining the most suitable depth conversion method is vital to generate a more accurate velocity model where the distributed velocity values among the wells and away from well locations give more accurate true depth values with reasonable geological sense. Therefore, three models were tested to find the general technique that best works intra-extrapolation away from the dataset in this field.

Model 1

Simple V0-k method versus depth for depth conversion can be carried out in uniform lithology-facies region with low tectonic history [18], this method gives good results. Nevertheless, the mistie between real and calculated depth remains existing, where applied this method in a regional area with high relief structure. Therefore, special care should be taken in consideration if high lateral change is existed [19]. This model was carried out by assuming the V0 map and K-parameter as a variable surface. Thus, the equation was applied to Model (1) is:

$$V_{av} = V_0 + K\,Z \qquad \text{........ (1) [18]}$$

Where V0 instantaneous velocity and K-parameter (the rate of velocity change with depth) that are computed earlier note Figure 4, Z depth form well top. The depth map of the Mishrif Formation is also calculated by multiplying the velocity, derived from Model 1, by one-way time surface grid of the Mishrif Horizon. The raw depth of the Mishrif Formation was corrected by computing the mistie between actual depth and predicted depth. Then converted into a grid surface to produce the residual map. This residual map was subtracted from the raw depth map to correct this map and reduce errors, Figure 5.

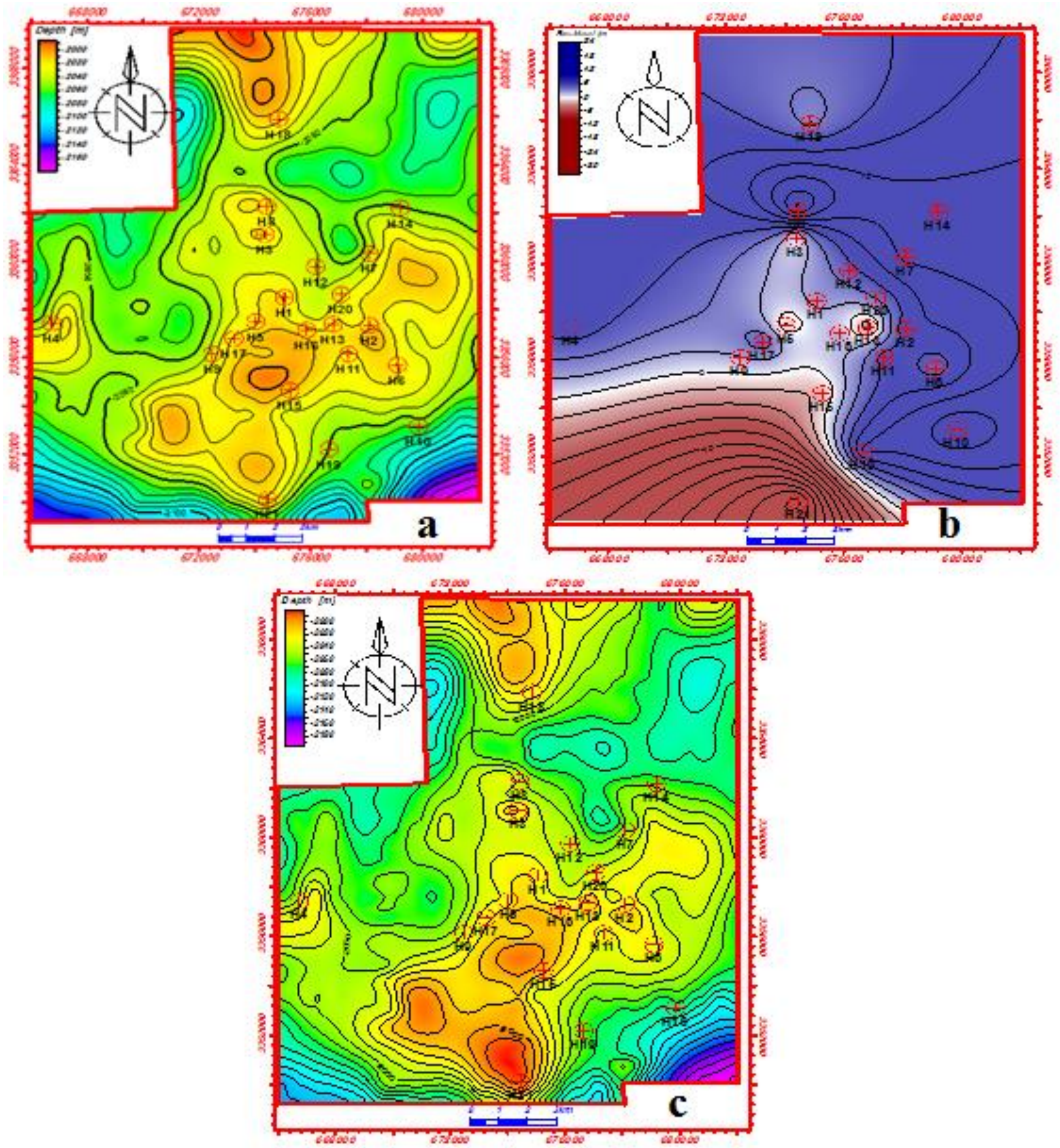


Figure 5: a) Raw depth map, b) Residual map, and c) correction depth map at the top Mishrif Formation using Model 1.

Model 2

This model was constructed by assuming the V_0 map and K-parameter as a variable surface. Thus, the equation was applied for this Model (2) is:

$$V_{av} = V_0 + K\,t \qquad \text{........ (2)}$$

Where V_0 instantaneous velocity and K-parameter that are computed earlier, note Figure 4, while t represents the TWT grid surface. The raw depth map of the Mishrif Formation, Figure 6a, is calculated by multiplying the velocity from Model 2 by the TWT surface grid of the Mishrif horizon. The residual map of the Mishrif Formation was estimated by computing the differences between real depth and predicted depth. Then, the residual values were converted into the grid surface to subtract from the raw depth map to the corrected depth map (Figure 6c).

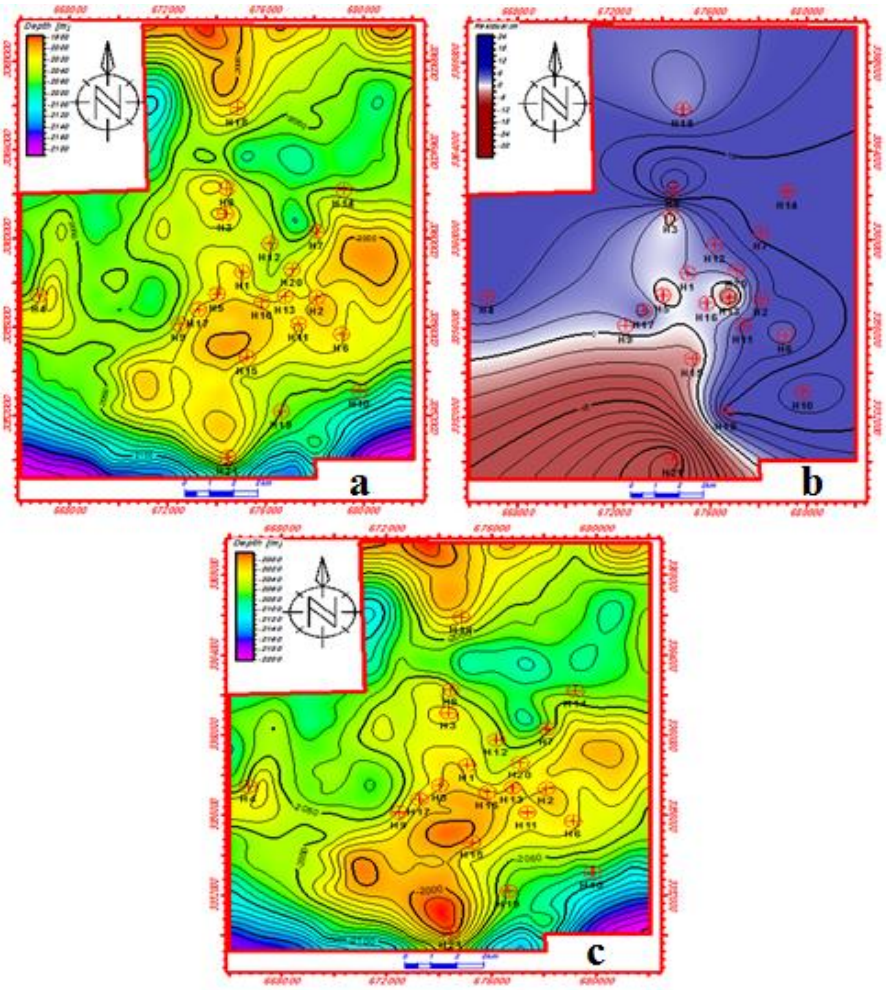


Figure 6: a) Raw depth map, b) Residual map and c) corrected depth map at the top Mishrif Formation using Model 2.

Model 3

For this model, we assume that the K-parameter is constant (K= 0). Therefore, the equation used is ($V=V_0=V_{int}$). As stated earlier, V_0 was computed for the Tanuma horizon at well positions, which was then converted into the surface grid and applied in this model. The depth conversion was done by multiplying the TWT surface by the velocity surface, resulting from ($V=V_0=V_{int}$) Model 3. In this model, we used the TWT surface grid, which has a much stronger influence on the interpolation values between well locations and extrapolation values away from well controls, see Figure7.

3. Dealing with Depth Conversion Errors and Geostatistical Analysis

The three methods that were utilized failed to tie perfectly between actual depths and calculated depths at well locations. Thus, the three raw depth maps for models 1, 2 and 3 of the Mishrif Formation must be corrected and analyzed. The shift of three depth maps between actual and predicted depths is computed, converted into the surface grid and subtracted from the depth map, which results from model 1 and model 2 see Figures 5, 6 and 7. Table 1 shows the residual value that resulted from the three models, and then a geostatistical analysis was applied by calculating the standard deviation. The standard deviation value of Model 1 is 13.2 and less than the other models, which are 13.6 and 13.9 for models 2 and 3, respectively. According to these results, Model 1 is considered the best model because it shows a lower standard deviation value.

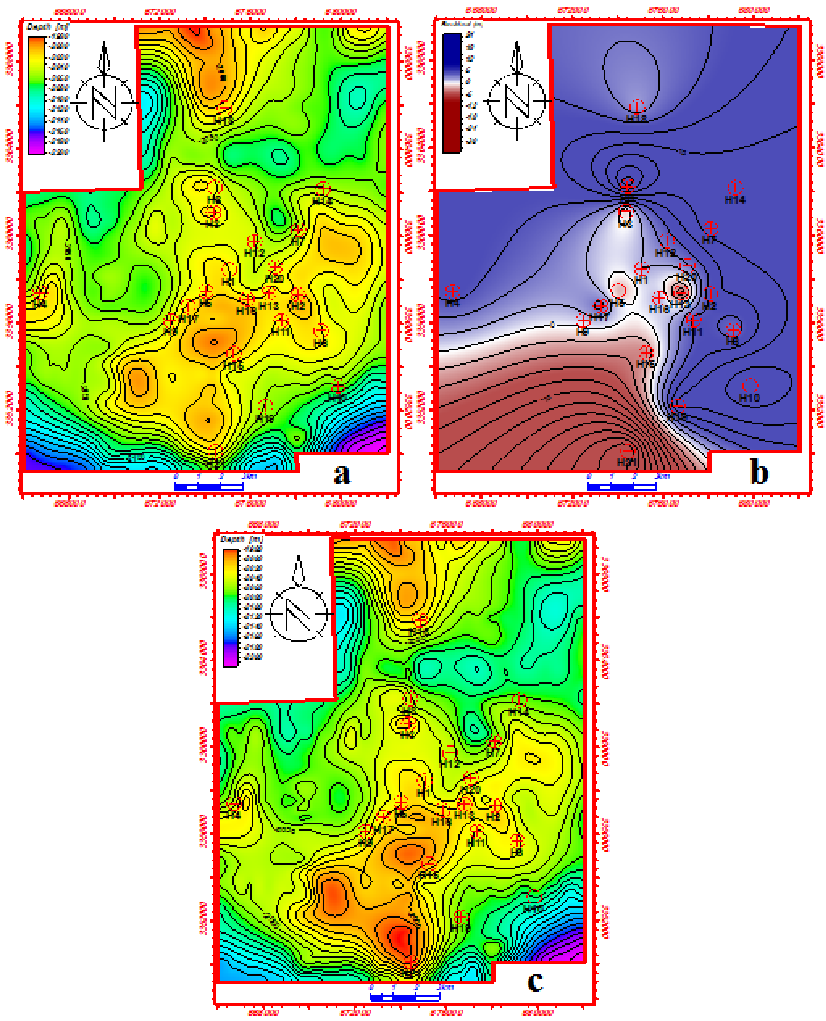


Figure 7: a) Raw depth map, b) Residual map and c) corrected depth map at the top Mishrif Formation using Model 3.

Table1: Depth conversion residual and standard deviation using three different methods.

Well	Residual (Model 1) (m)	Residual (Model 2) (m)	Residual (Model 3) (m)
H1	4.04	3.33	3.19
H6	6.59	7.26	6.77
H16	2.84	1.85	2.78
H3	0.08	-1.12	-1.37
H8	24.95	25.52	25.83
H21	-33.41	-35.45	-36.05
H11	10.05	10.46	9.9
H14	16	16.19	16.4
H20	6.3	6.98	6.03
H18	4.65	4.08	3.8
H12	7.7	8.29	7.67
H13	-5.53	-4.58	-7.75
H15	-2.81	-4.17	-5.15
H10	20.62	21.35	21.18
H7	16.06	16.52	16.67
H19	15.49	15.82	15.96
H5	-1.93	2.63	-3.12
H9	2.86	3.44	1.57
H4	11.33	10.99	10.89
H17	8.02	4.23	7.11
H2	11.34	11.01	11.3
Standard Deviation	13.2	13.6	13.9

4. Conclusion

The determination of the most suitable method of depth conversion was solved by adopting a geostatistical analysis that could be used to detect the most accurate method. According to geostatistical analysis, the most accurate time-to-depth conversion technique statistically yields less standard deviation. A clear difference in depths between depth maps were produced by observing models 1, 2, and 3.The depth map derived from Model 1 in this study area was considered the most accurate method because it gives less mistie between actual and produced depth with fewer residual values and low errors. The final corrected depth map of Mishrif Reservoir products using Model 1 illustrates the main irregular enclosures of the anticline with several miner enclosures at the center of the field with no clear axis of this anticline. Many faults can be detected in the seismic section that strikes the Mishrif Reservoir with less displacement. The depth conversion is a significant challenge, especially in areas around or outside well control position. This is because the TWT surface grid only guides the extrapolation of depth contouring values. The challenge increased as the dipping horizon depth increased. Therefore, the errors raised in the eastern and northern east parts with a dipping increase.

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