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Seismic structural study of Mishrif and Nahr Umr Formations in Huwaiza oilfield south-eastern Iraq

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Abstract
An interpretive study of two-dimension seismic data of the Huwaiza oilfield was carried out using Petrel 2015 program. Twenty seismic section were used, these seismic sections were carried out at three-time stages: HH survey in 1976, 2HH survey in 1978 and AM in 1980. Mishrif and Nahr Umr reservoirs were selected to study because they are the most important reservoirs in the neighbor fields. The study showed that the structure is an anticline trending North-South, so that the field may belong to Zubair tectonic subzone rather than Tigris subzone, which is northwest-southeast trending. A hypothetical model was drawn up showing the extension of the field in the Iraqi and Iranian territories based on information from both sides, it showed that the field is an extension of the large Iranian field called Azadegan and that Iraq has a small part of it, also the model illustrated that what is called south Huwaiza is the north-western part of Azadegan.

Keywords*:* Huwaiza oilfield, 2D seismic, border oilfield, Mishrif Formation, Nahr Umr Formation.

دراسة زلزالية تركيبية لتكويني المشرف والنهر عمر في حقل الحويزة النفطي جنوب شرق العراق

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قسم علوم الأرض، كلية العلوم، جامعة بغداد، بغداد، العراق

الخلاصة
تم اجراء دراسة تفسيرية للمعطيات الزلزالية ثنائية الابعاد لحقل الحويزة النفطي باستخدام برنامج Petrel 2015، حيث استخدمت معلومات عشرين خط زلزالي ثنائي الابعاد مقسمة على ثلاث مسوحات زلزالية اجريت بفترات زمنية مختلفة هي المسح HH في 1976 والمسح 2HH في 1978 والمسح AM في 1980، .تم اختيار مكمني المشرف والنهر عمر للدراسة كونهما اهم مكمنين في الحقول المجاورة ، اظهرت النتائج ان التركيب عبارة عن طية محدبة مضربها باتجاه شمال–جنوب ، لذا فان المنطقه لربما تعود الى نطاق الزبير الثانوي ضمن نطاق وادي الرافدين على عكس نطاق دجلة الثانوي الذي يكون فيه اتجاه التراكيب شمال غرب– جنوب شرق. كما تم رسم مجسم تخيلي يوضح امتداد الحقل في الاراضي العراقية والايرانية استناداً الى معلومات من الجانبين، حيث بيّن المجسم ان الحقل عبارة عن امتداد للحقل الايراني الكبير ازاديجان وان العراق يمتلك جزء صغير منه ، كما بين المجسم ان ما يعرف بالحويزة الجنوبي هو الطرف الشمالي الغربي لحقل أزاديجان.

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Introduction

Seismic interpretation is the art and science of inferring the geology from the processed seismic record. The process of interpretation can be subdivided into three interconnected categories: structural, stratigraphic, and lithologic. Structural seismic interpretation is directed toward the creation of structural maps of the subsurface from the observed configuration of arrival times [1]. Seismic reflections come from interfaces where the acoustic properties of the rocks change, and this fact is the key of our understanding of the nature of seismic data. The acoustic impedance of a rock layer is the product of the density and the velocity of that layer, and strictly a reflection is generated by a contrast in acoustic impedance. In fact, impedance and lithology normally follow each other, so that impedance boundaries and lithologic boundaries normally concur [2].

Location of the Study Area

The Huwaiza oilfield is situated at the Iraq-Iran border, within Missan province, southern Iraq at a distance about 63 km east of Amara city, 35 km east of Halfaya oilfield and about 70 km north of the Majnoon oil field (Figure-1), the area is elevated 3-5 m above sea level [3], with an area of 1600 km^2. The study area is appointed by five corners A, B, C, D, and E which have the following coordinates:

Table 1-Coordinates of the Study Area

Corner symbol	X (m)	Y (m)	Latitude	Longitude
A	735788.67	3534016.32	31°55'3.3625"N	47°29'37.3924"E
B	761107.75	3533997.12	31°54'42.8101"N	47°29'37.3924"E
C	771015.40	3521612.55	31°47'52.7230"N	47°51'44.8219"E
D	756420.73	3477704.84	31°24'20.3071"N	47°41'49.2567"E
E	735788.67	3477704.84	31°47'52.7230"N	47°51'44.8219"E

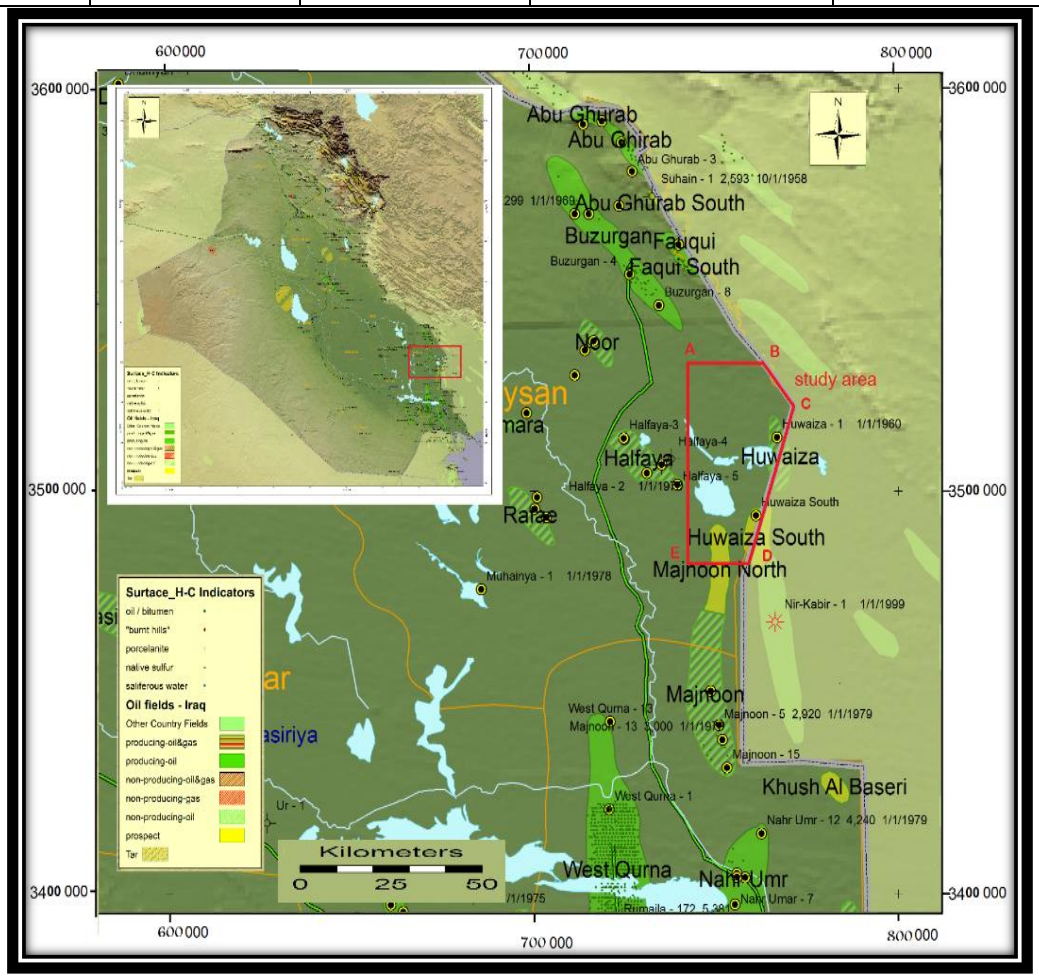

Figure 1- Location map showing the study area

Tectonic and Structural Setting

According to Jassim and Goff (2006) the Huwaiza area is tectonically located in the Tigris subzone which in turn belong to the Mesopotamian zone within the stable shelf, the Huwaiza structure is an anticline fold characterized by narrow band faults and complex at some location, extends towards (NW–SE) (Figure-2). "The Mesopotamian Zone contains buried faulted structures below the Quaternary cover separated by broad synclines. The fold structures, mainly trend NW-SE in the eastern part of the zone and N-S in the southern part; some NE-SW trending structures occur'', The Mesopotamian zone is divided into three subzones: the Zubair Subzone in the S with N-S trending structures in the S, the Euphrates Subzone in the W, and the Tigris Subzone in NE with NW-SE trending structures [4].

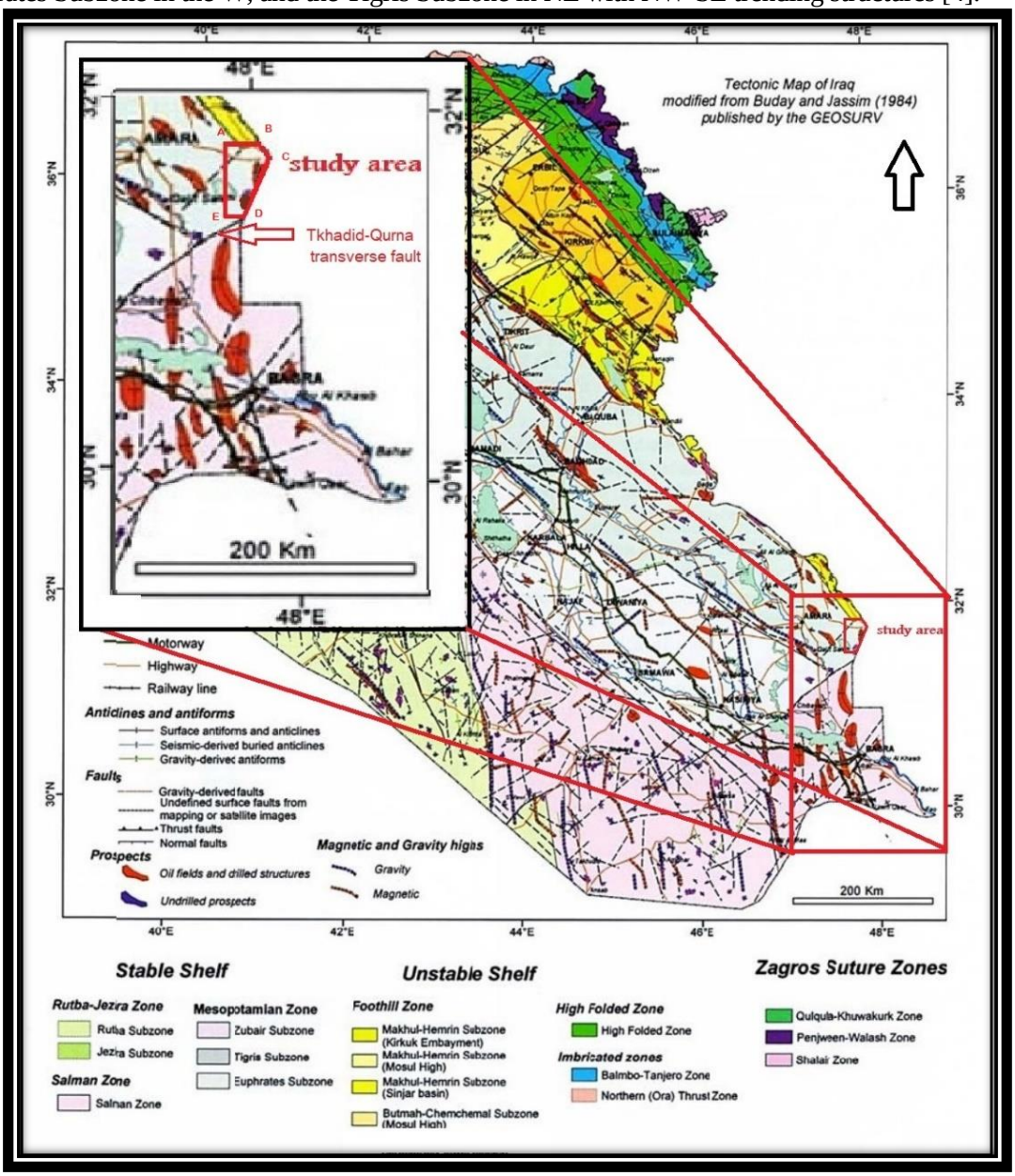

Figure 2- The tectonic map of Iraq.

Subsurface Geology

Subsurface geology can be identified by studying the geological column that is penetrated by the Huwaiza-1 well. Sedimentary conditions and deposition quality are generally similar to those in southeastern Iraq, which represent several shallow marine environments consisting of several sedimentary cycles separated by erosion surfaces caused by Epeirogenic movements which was exposed to the south-eastern part of Iraq, which led to the formation of a series of submerges and emerges by sea

water, geological column (Figure-3) illustrate the age, name, thickness and brief description of all the formations penetrated by well Hu-1[5].

The well Huwaiza -1 drilled in 1980, reaching Zubair Formation at depth of 4166 m. Many Formations such as Hartha, Sadi, Khasib, Mishrif and Nahr Umr showing good oil and gas indications [3]

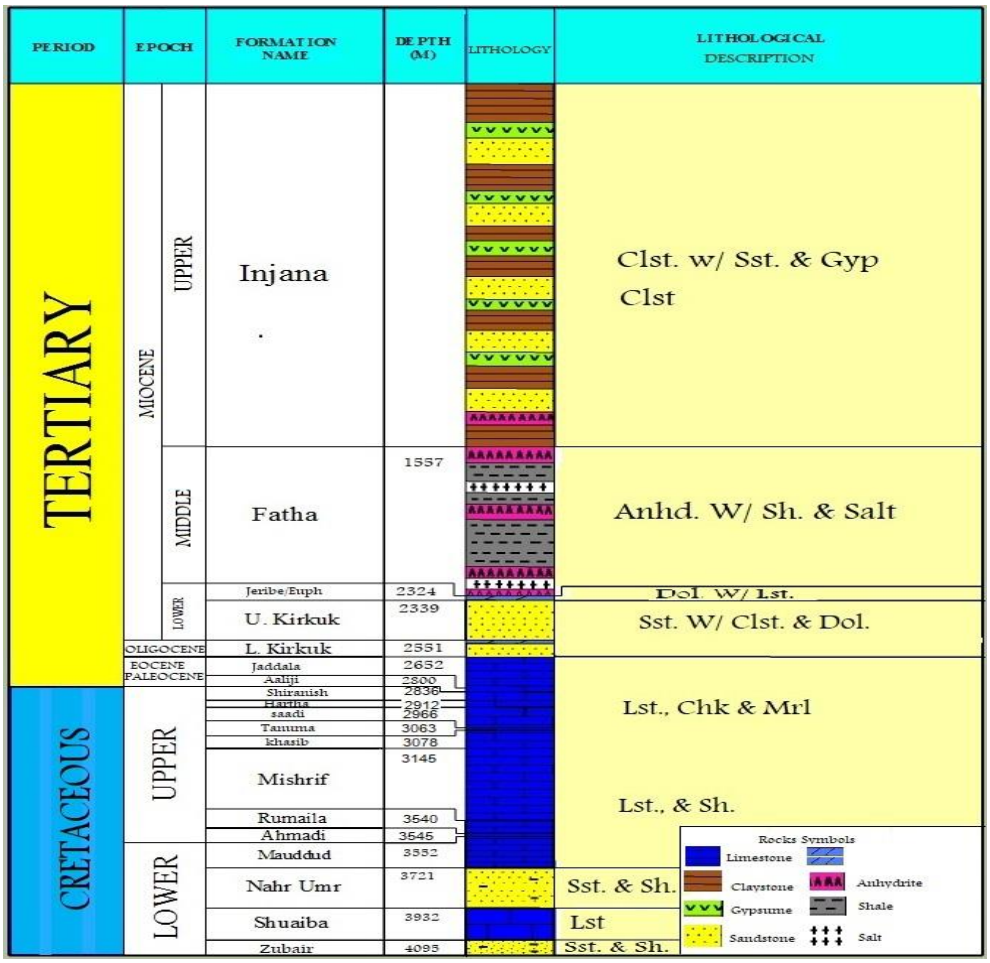

Figure 3- The geological column of the Huwaiza -1 well.

Stratigraphy

The main oil-bearing reservoirs in the field and surrounding area are Mishrif and Nahr Umr Formations which belong to the Cretaceous Period, the following is a description of each of them:

- Mishrif Formation belongs to Albian-Lower Turonian, which correspond to the tectonostratigraphic megasequence AP8 of Sharland in 2001[6]. Mishrif Formation represents a very complex sequence defined originally as complex of detrital limestones, containing sometimes algal, rudist, and coral-reef limestones; capped by limonitic freshwater limestones. This definition was given by Rabanit in 1952, who first described the formation in the Zubair area of southern Iraq [7].
- Nahr Umr Formation belongs to (upper Aptian – Albian) it comprises, at the type section in the Nahr Umr field, from black shale interbedded with sandstone containing lignite, amber, and pyrite [6]. A carbonate unit occurs locally in the upper part of the Nahr Umr Formation in SE Iraq, pinching out to the west and south, the formation is interpreted to be an alluvial to lower coastal plain to deltaic deposit with shallow-marine and aeolian influences [6].

Loading data and base map preparation

The following data were loaded to Petrel software:

1- Inserting well tops, total depths and the coordinates of the wells Halfaya-1, Noor-1, and Huwaiza-1 in the Excel program and exporting them as a space delimited extension (.prn) formula because of the used program is accepting this extension.
2- Loading well coordinates, well tops and total depth of Hf-1, No-1, and Hu-1.
3- Loading Hu-1 well logs (sonic and estimated density logs).

4- Loading vertical seismic profile (VSP) as a one-way time.
5- Loading 2D seismic lines (SEG-Y format), after that the base map was constructed (Figure-4).

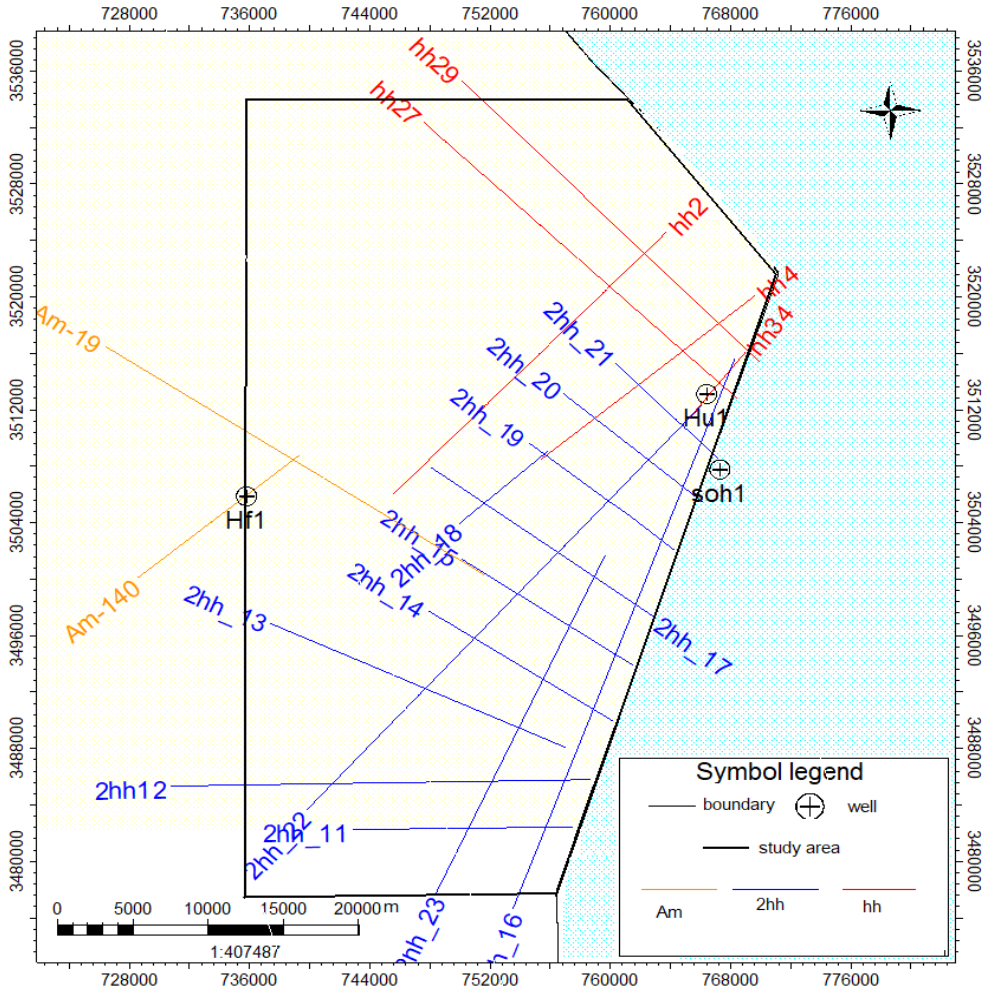

Figure 4- The base map of the study area.

Creating Synthetic Seismogram

This process consists of two steps, the first is sonic calibration by calibrating sonic log and velocity log, we used estimated check-shot from the well Sohrab-1 VSP in this study because the generated synthetic seismogram represents the best matching with the seismic section.

The calibrated sonic log multiplied with the estimated density log was used to compute the acoustic impedance then reflection coefficient calculated. The Ricker wavelet convolved with the reflection coefficient to generate synthetic seismogram. The matching between the seismic section and synthetic seismogram was good, in contrast to synthetic seismogram generated by convolving deterministic wavelet.

Synthetic seismogram was generated for the well (Hu-1) using Petrel software package, Figure-5 represents the nearest seismic sections (HH34) passing beside the well location and synthetic traces are displayed. The picked reflectors appeared as peaks and troughs on synthetic trace (positive and negative reflection) but in different intensities because it is in different frequencies. The top of Mishrif corresponds to peak while top Nahr Umr and top Zubair correspond to trough.

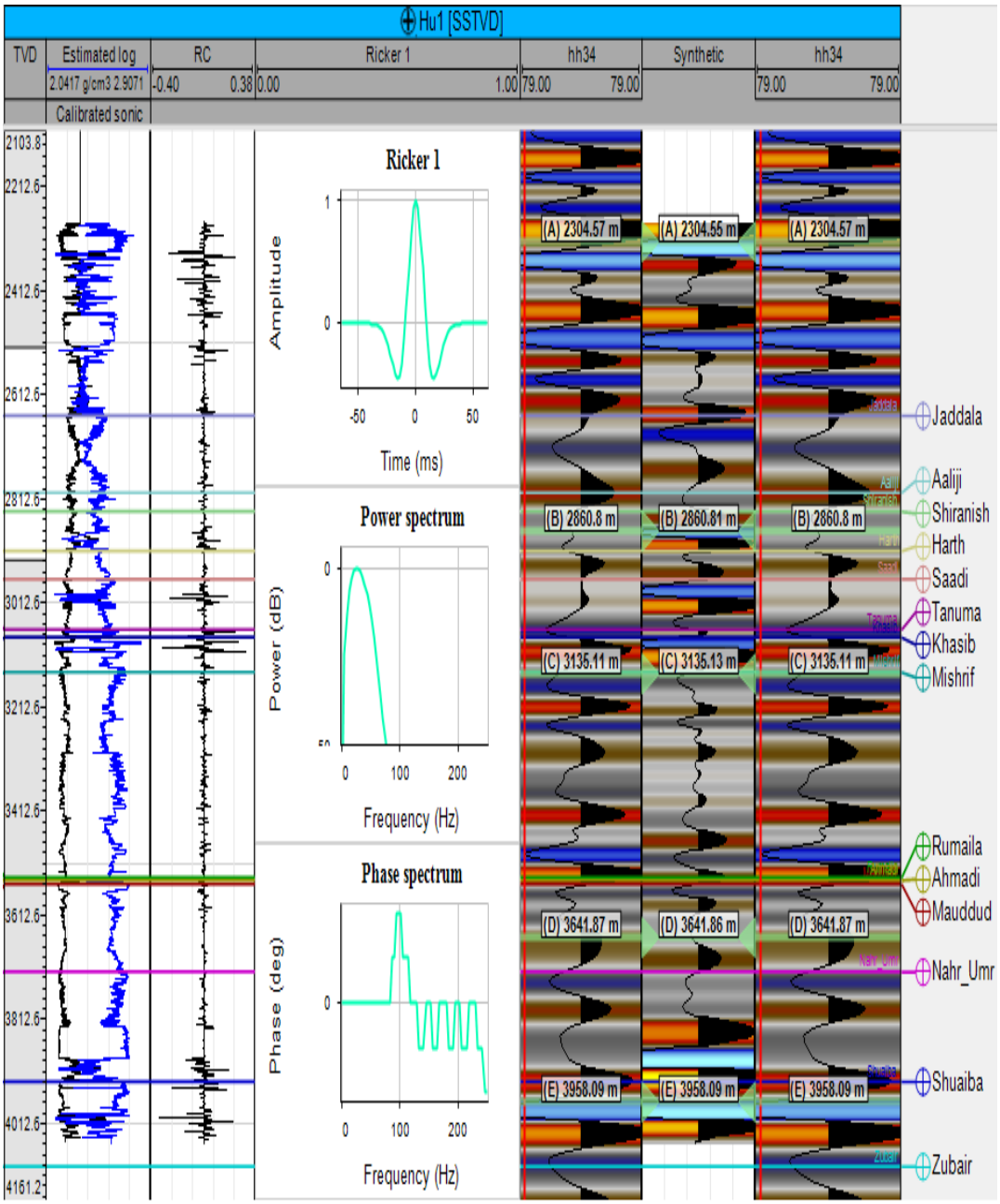

Figure 5- Synthetic seismogram and its required parameter.

Horizon Picking

Picking is marking the reflection on a seismic section. It involves deciding what wiggles from a trace to trace are from the same reflection, that is, which wiggles were reflected from the same rock layer [8].

"Conventional seismic interpretation is mechanically driven. Knowledge of the seismic wavelet's phase and polarity is not emphasized. Instead, knowledge of what particular seismic reflector to interpret is all that is required. One then simply traces that particular reflector on a series of seismic lines which intersect orthogonally in planar view, culminating with a product that correlates on every line. By correlating specific horizons on a seismic line, one may subsequently generate time data which, after conversion to depth, help generate structural maps" [9]

Three wells Hf-1, No-1, and Hu-1 were used to track and follow the reflectors, the tracking of each reflector was along the composite that is illustrated in (Figure-6).

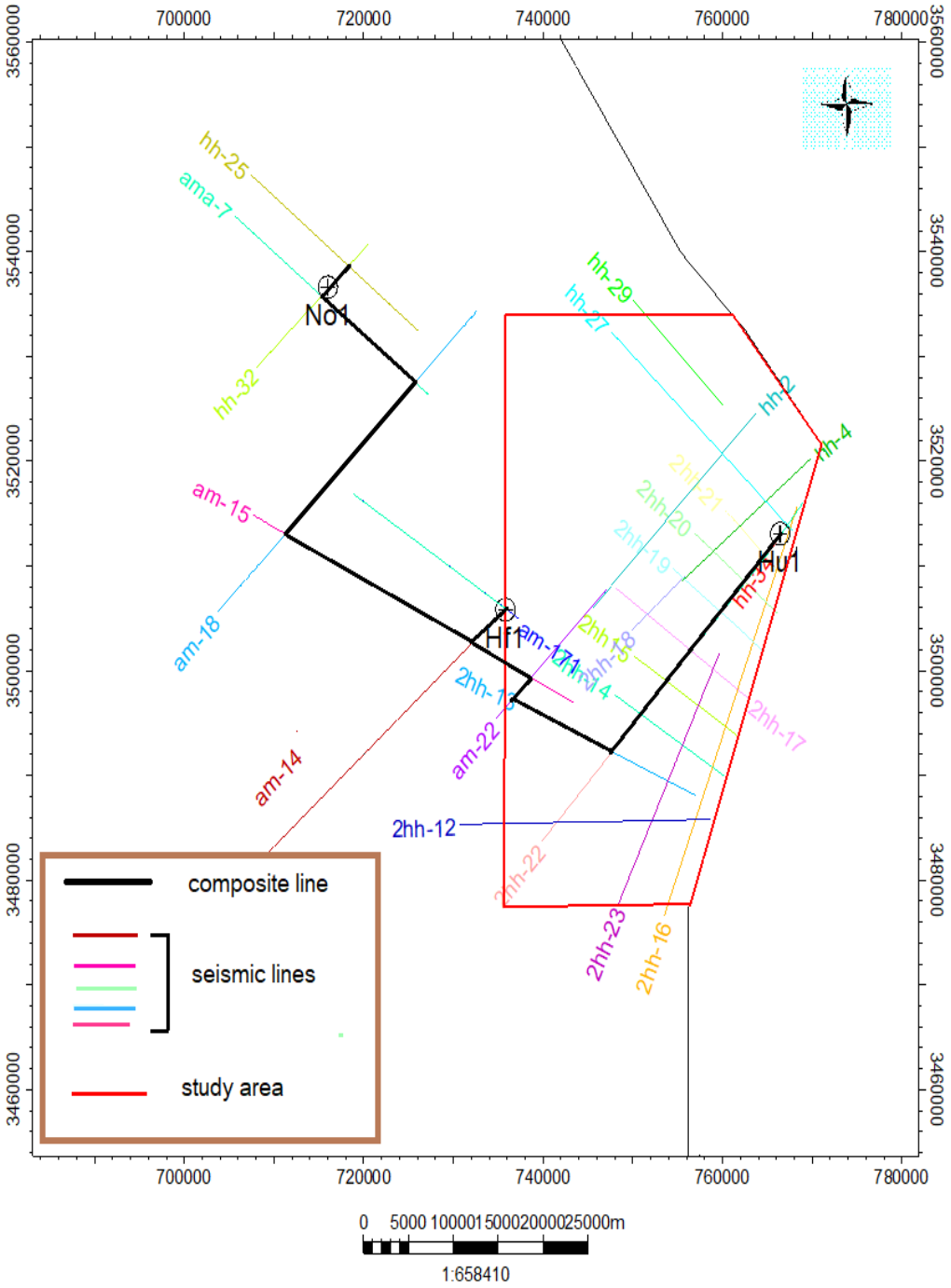

Figure 6- The base map showing the composite line.

Velocity Model Preparation

To convert two-way time map to depth map the velocity model is required (Figure-7).

The Input data including:

1- Four time surfaces which are Mishrif, Nahr Umr, Rumaila, and Zubair surface.

2- Well tops.

3- Time depth relationship (TDR) from calibrated sonic and velocity logs (study-1 of synthetic generation) for Hu-1 and Hf-1 wells.

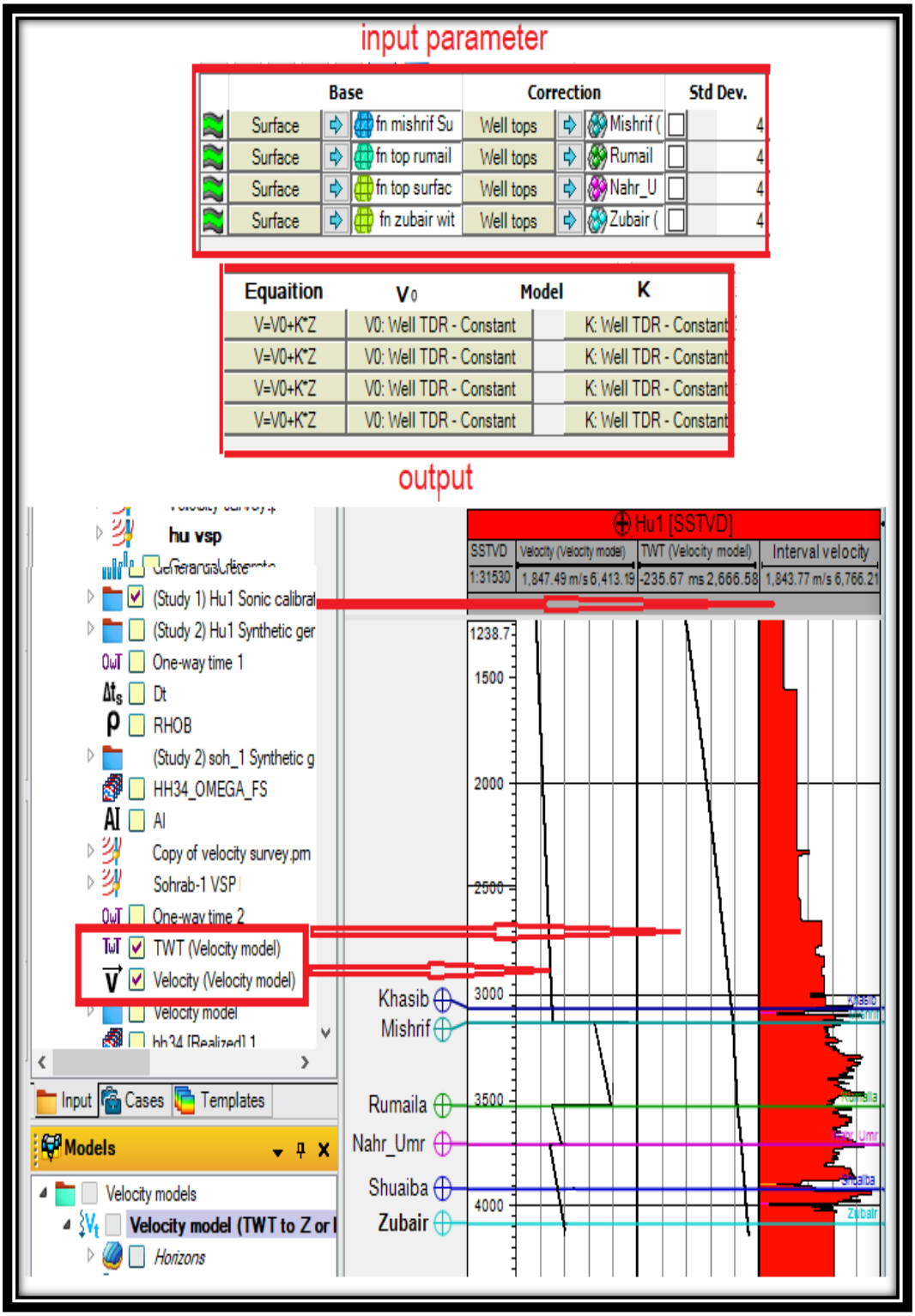

Figure 7- Input and output of the velocity model.

Description of the Picked Reflectors

This study focused on two reservoirs, Mishrif, and Nahr Umr, because they are the most important reservoirs in the region, as in the Halfaya field, which is more than thirty kilometers to the east of the Huwaiza structure. The Zubair reservoir in Huwaiza area showed a good oil accumulation (from cutting), however, it has been neglected because the lack of well logs.

The following is a brief description of each reflector considered in this study, (Figure-8) shows the picked horizons:

1- The top of Mishrif is peak because of the cover layers represented by the lower part of the Khasib Formation consists dominantly of shale which in turn have lower density compared with the limestone of Mishrif Formation.
2- The top of Rumaila Formation is an s-crossing because of the rocks above and below the reflector are all limestone and there is a slight difference between them.
3- The top of Nahr Umr, this reflector represented by sandstone interbedded with shale is a trough because its density is less than the cover layers (limestone).
4- The top of Zubair Formation is also trough as the top of Nahr Umr Formation.

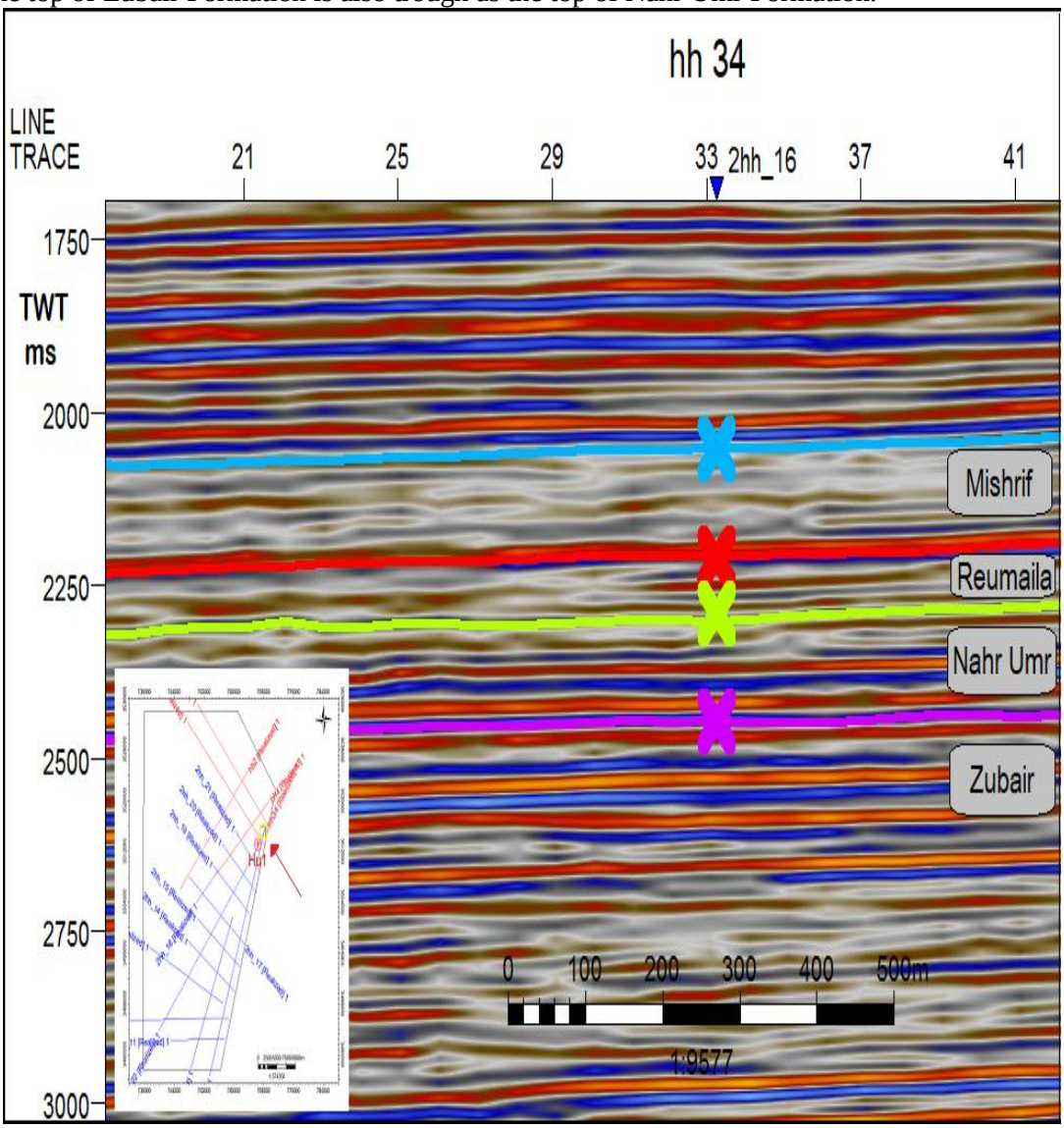

Figure 8- A- Part of the seismic line HH34 showing formations top and horizons B-base map shows the location of the line HH34 marked by the red arrow.

Two-Way Time Maps

1- Two-way time map of Mishrif Formation: The map represents the two-way time between the sea level as a reference surface and the top of Mishrif, Figure-(9A) shows the lowest value of TWT located at the west (1700 ms) with contour interval (30 ms), also the highest time is at the north of the study area (2400 ms), but Huwaiza structure offers the value of the time between the lowest time (1980 ms) and the highest time (2100 ms) and the increasing is to the north.
2- Two-way time map of Nahr Umr Formation: the map represents two-way time between sea level and the top of Nahr Umr reflector, which is a trough due to negative acoustic impedance between the limestone and Sandstone. Figure-(9B) showing the lowest value of TWT at the south (2125 ms) represent north Majnoon structure and at the west (2125 ms), while the highest value is at the north

(2600 ms), the highest value of the Huwaiza structure is at north (2375 ms) and the lowest value is in the south (2250 ms). Mishrif and Nahr Umr TWT maps are nearly identical, that means when Mishrif Formation were completely deposited the layers of Nahr Umr were almost horizontal and the folding movement happened later.

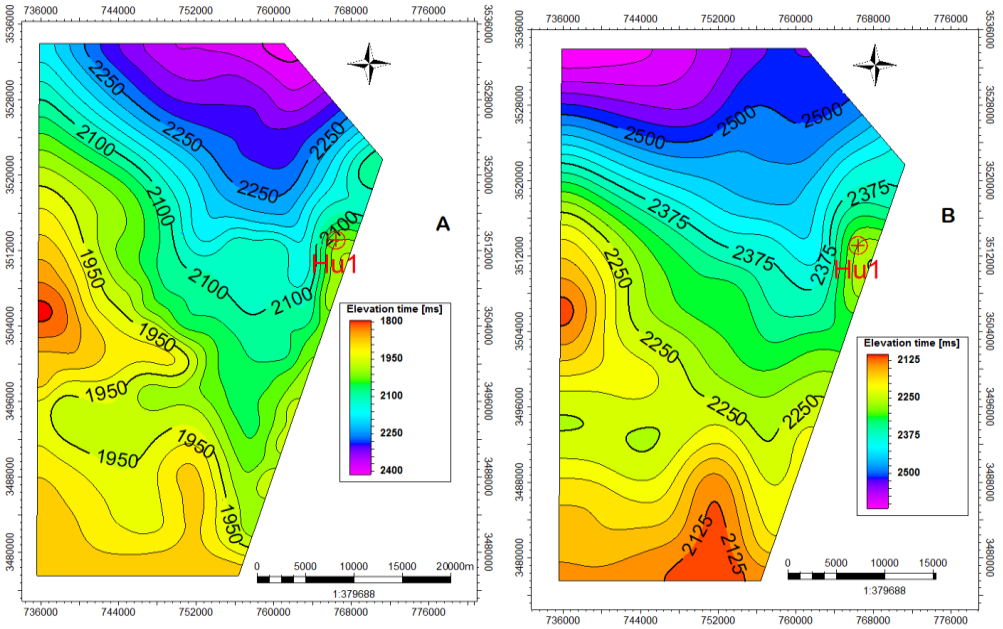

Figure 9- A-TWT map of Mishrif Formation B-TWT map of Nahr Umr Formation.

Average Velocity maps

Average velocity maps acquired from the velocity model Figure-10 (A, B) for Mishrif and Nahr Umr Formation show decreasing in the average velocity at the Hu-1 well and to the east while they show increases in velocity toward the north.

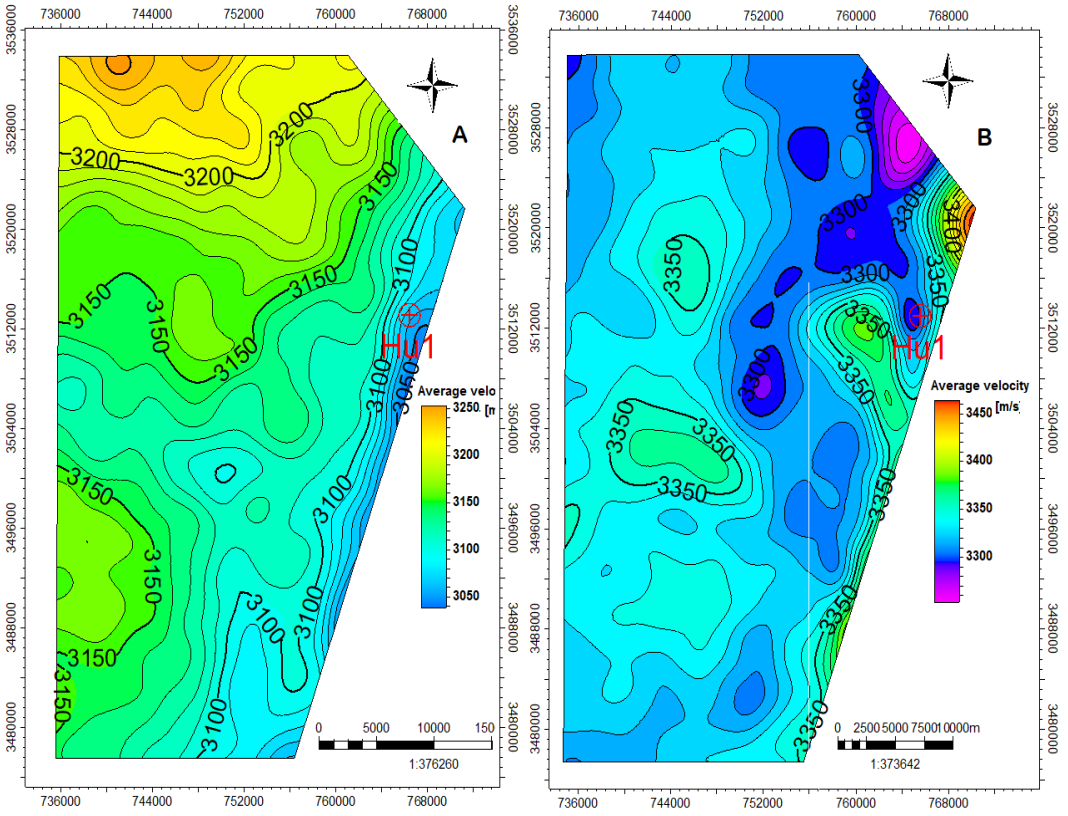

Figure 10- A-Top Mishrif average velocity map. B- Top Nahr Umr average velocity map.

Depth Maps

The depth maps are well-correlated in the Halfaya-1 and Huwaiza-1 wells. The important horizons are shown in the following figures: top Mishrif Formation Figure-(11A) and top Nahr Umr Formation Figure-(11B). Both maps show nearly the same structuring; the Halfaya structure at the west, the Huwaiza structure at the east and the north Majnoon structure at the south, the maps are deepening to the north

Depth map of Mishrif Formation was drawn between sea level, as a reference datum, and top of Mishrif with contour interval (50 m), Figure-(11A) show that the lowest depth of top Mishrif Formation is at the west of the study area, which is (2850 m), while the deepest point is at the north (3850 m), also the lowest depth of the Huwaiza structure is (3000m) south and the highest depth of the structure is at north (3250 m), the map shows that the Huwaiza structure is an anticline with nearly north-south trending and the well Hu-1 is located at its northern plunge, also what is called south Huwaiza is just an extent of the northern Huwaiza (the targeted structure). The top of Mishrif Formation is approximately 312m deeper in Huawaiza-1well than in the Halfaya-1 well.

Depth map of top Nahr Umr Formation was drawn between sea level and the top of Nahr Umr, Figure-(11B) illustrates that the lowest depth is located at the south of the study area, which is (3500 m) while greatest depth is at the north (4250 m), as well as, that the Huwaiza structure depth lies between (3745-4000 m), the map shows that the Huwaiza structure is an anticline with north-south trending, the western structure is the southern part of Halfaya anticline and the southern structure is the north Majnoon anticline.

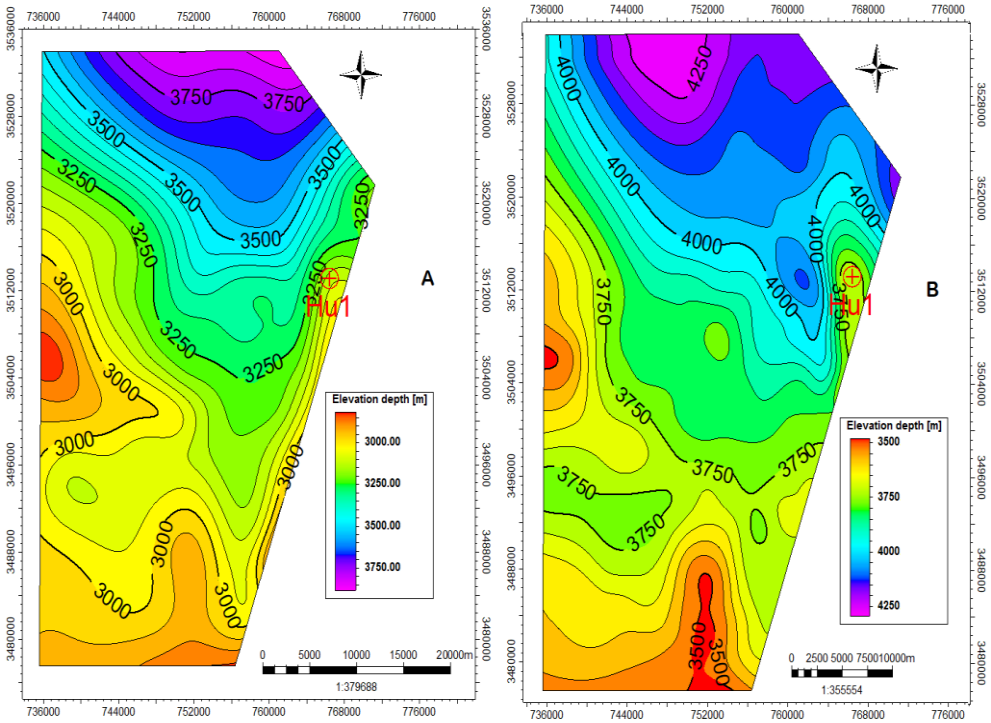

Figure 11- A-Top Mishrif depth map B- Nahr Umr depth map.

Hypothetical Model of Huwaiza and Surrounding Structures of Top Mishrif Formation

Iraq has a part of the Huwaiza structure, the other part is in the Iranian territory [5]. In bordered oilfield, the key information of the structural interpretation is to understand the extension of the structure. A model has been built depending on a document published by National Oil Iranian Company (NIOC) in its website Figure-(12A) [10]. This model was built using a simulated grid estimated from that document. Figure-(12 B) shows the hypothetical extension of top Mishrif Formation and illustrates that the Huwaiza structure is the northern extension of Azadegan anticline, also what is called southern Huwaiza is simply the northwestern part of the Azadegan structure.

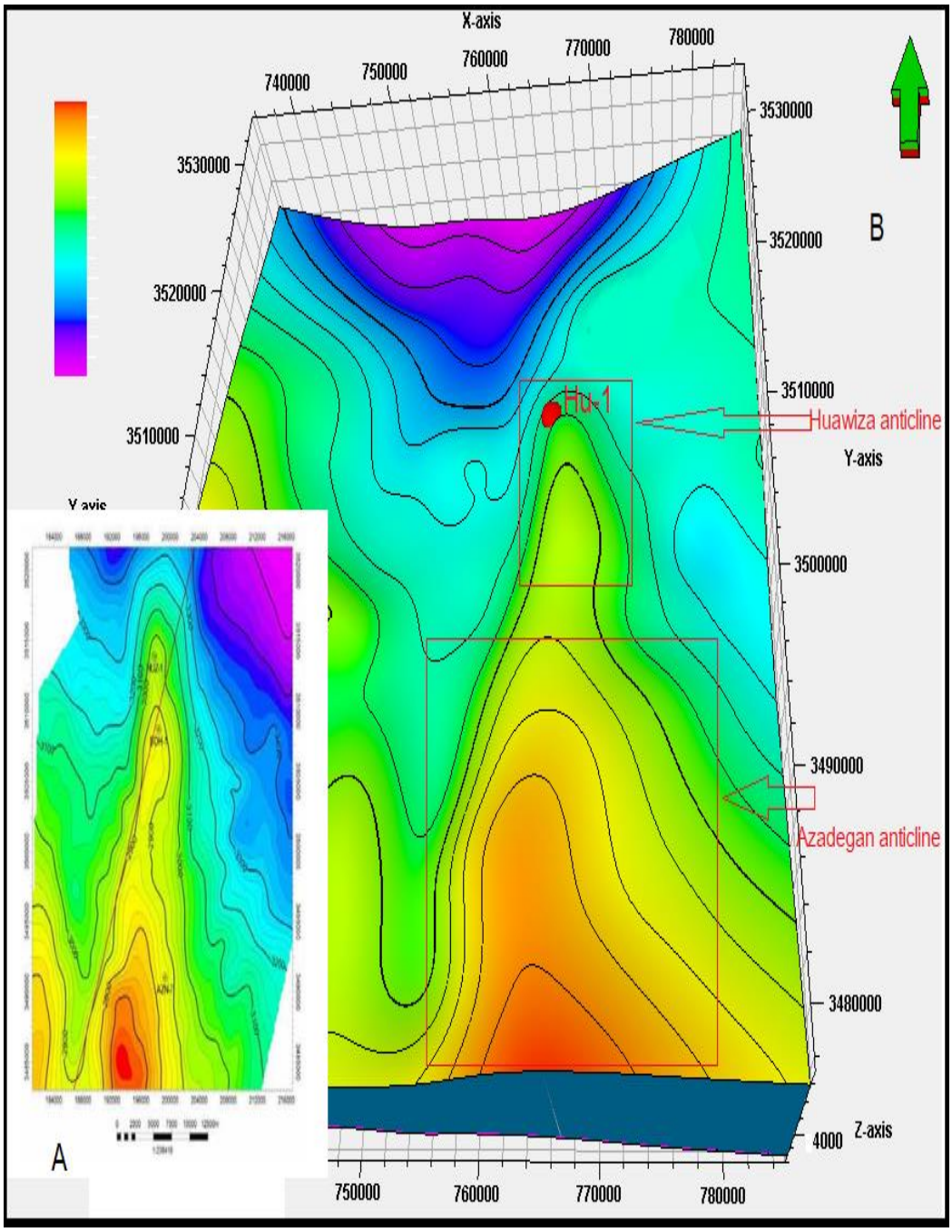

Figure 12- A- Top Mishrif depth map [10], B- Top Mishrif hypothetical depth model of Huwaiza and surrounding structures.

Modification of the Zubair subzone

The Mesopotamian tectonic zone is divided into three subzones these are Euphrates, Tigris and Zubair subzone. The Tigris subzone contains broad synclines and narrow anticlines trending predominantly NW-SE while the Zubair subzone, which bounded in the north by Takhadid-Qurna transversal fault, has a uniform structural style controlled by the underlying basement and contains prominent N-S trending structures [4]. Based on the trending of Huawiza structure which is (N-S), so the Zubair subzone can be modified to include the Huwaiza structure. Figure-(13A) shows the modification of the Zubair subzone.

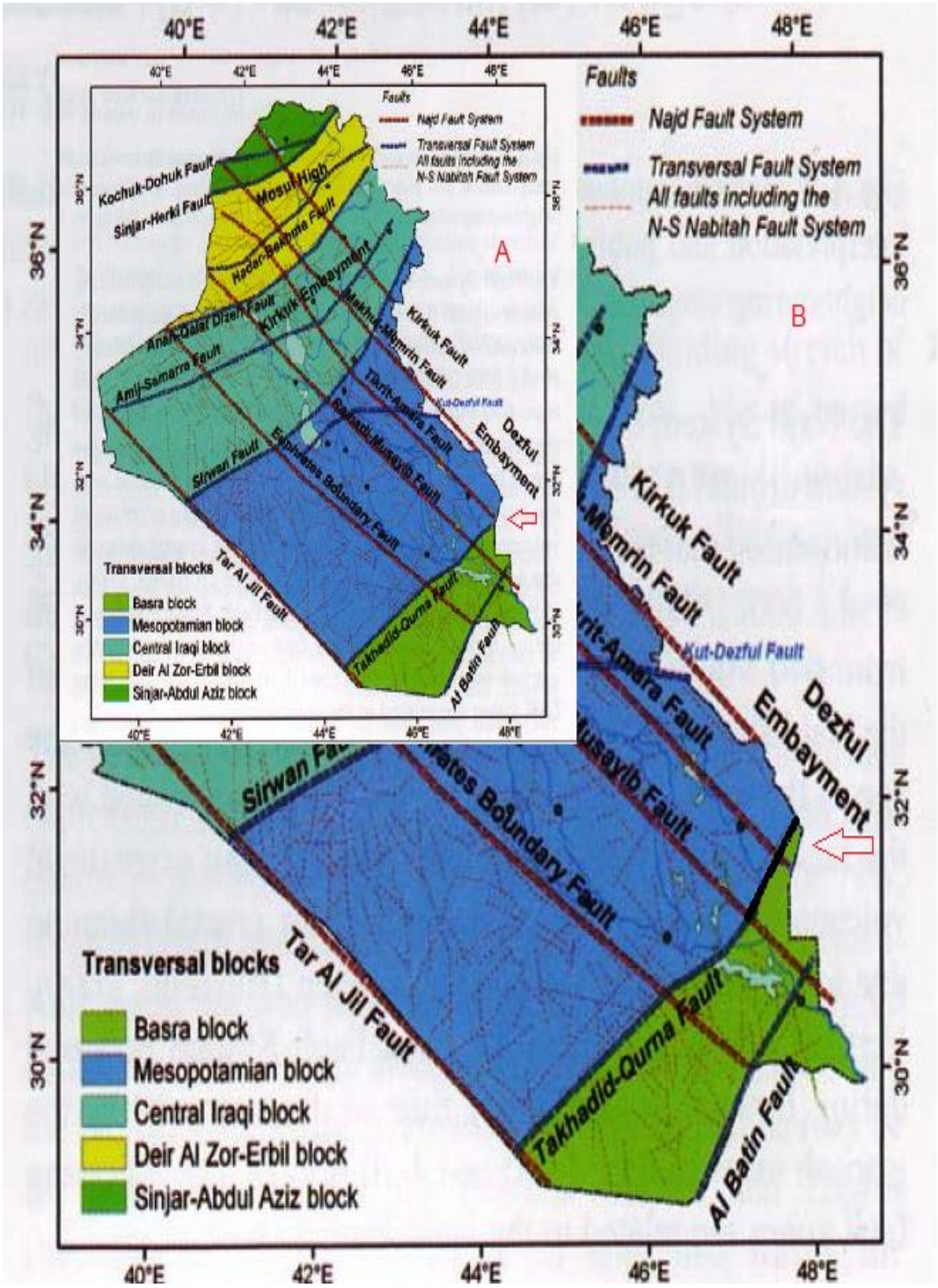

Figure 13- A- Transversal blocks of Iraq showing the main faults including Takhdid-Qurna transversal fault separating the Zubair subzone from Euphrates and Tigris subzone, B- The modified Zubair subzone after [4].

Conclusion

Based on the results from interpreting the 2D seismic sections of Huwaiza area, the study comes with the following conclusions: first of all, from depth maps, the Huwaiza structure is an anticline with north plunging and the structure orientation is north-south trending. Second, the location of Hu-1 well is not at the highest point on the structure and it may close to the oil-water contact. Third, also depending on depth maps and the structure orientation, the field may include within Zubair subzone instead of Mesopotamian subzone. Finally, the hypothetical model appears that the Huwaiza structure

is an extension of the great Iranian oilfield named (Azadegan) and what is called Southern Huwaiza is just the northeastern part of Azadegan anticline.

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