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Porosity Prediction from Seismic Inversion for Yamama Formation in (Abu-Amoud) Oil Field in Southern of Iraq

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Abstract

The study is an attempt to predict reservoir characterization by improving the estimation of petro-physical properties (porosity), through integration of wells information and 3D seismic data in early cretaceous carbonate reservoir Yamama Formation of (Abu-Amoud) field in southern part of Iraq. Seismic inversion (MBI) was used on post- stack 3 dimensions seismic data to estimate the values of P-acoustic impedance of which the distribution of porosity values was estimated through Yamama Formation in the study area. EMERGE module on the Hampson Russel software was applied to create a relationship between inverted seismic data and well data at well location to construct a perception about the distribution of porosity on the level of all units of Yamama reservoir. Instantaneous frequency attribute is used to confirm the distribution of low value of acoustic impedance, which in turn indicates the location of high porosity values.

Keywords: Porosity, Seismic Inversion, Yamama Formation, and Abu- Amoud oil field, Iraq

استنباط المسامية باستخدام المعكوس الزلزالي لتكوين اليمامة في حقل ابو عامود النفطي في جنوبي العراق

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الخلاصة

البحث هو محاولة لاستنباط الخواص المكمنية والمتمثلة بحساب خاصية المسامية من خلال تكامل معلومات الابار الستة المحفورة في المنطقة والبيانات الزلزاليه الثلاثية الابعاد لتكوين اليمامة (العصر الطباشيري المبكر) في حقل ابو عامود الواقع في الجزء الجنوبي من العراق . ولقد تم استخدام تقنية المعكوس الزلزالي لحساب قيم الممانعة الصوتية للمكعب الزلزالي (المنضد) ومن ثم استنتاج توزيع قيم المساميه على طول تكوين اليمامه في منطقة الدراسه. استخدمت تقنية (EMERGE) المتوفره على منظومة (Hampson Russell) لبناء العلاقة ما بين المعكوس الزلزالي ومعلومات الابارفي منطقة الابار لبناء تصور عن توزيع المساميه على مستوى كل الوحدات الطباقيه لمكمن اليمامه . كما تم استخدام ملمح التردد الآني في هذا البحث لتاكيد اماكن توزيع القيم الواطئة للممانعة الصوتية والتي بدورها تشير الى مواقع قيم المسامية العالية.

Introduction

The understanding of the relationship between the wells information and those taken from observed seismic data is the key of exploration and interpretation [1]. Acoustic seismic amplitude is inverted to generate physical rock properties like impedance and by using of rock physics; it is possible to

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generate reservoir parameters that are directly used in flow simulation like porosity, layer depth and fluid saturation [2].

The current study is an attempt to predict reservoir characterization by improving the estimation of petro-physical properties (porosity) through integration of 6 wells information in (Abu-Amoud field) in southern part of Iraq, and 3D post- stack seismic cube of early cretaceous carbonate Yamama Formation. Seismic inversion techniques (Model Based Inversion) used to estimate Acoustic Impedance (AI) values and their distribution over seismic cube. Seismic attribute (Instantaneous Frequency) was used to confirm the low (AI) values existence. Finally EMERGE module on Hampson Russell software applied to create a relationship between inverted seismic data and wells data at (2) wells location (AAM1 and EAA1) to construct a perception about the distribution of porosity on the level of all reservoir units of Yamama Formation

Location and area of the study area

The study area is located in the south eastern part of Iraq in (Dhiqar) province between the Dujela and Garraf field, Abu-Amoud field is located about (16 Km) north east of (Qalat Sukkar) and (26 Km) away from Rifai district, while eastern Abu Amoud field is located within administrative boundaries of (Maysan) province, about (45 Km) west of Amara city and it is about (40 Km) to the southeast of Abu-Amoud [3] Figure-1.

3D seismic survey area is 1534.88 Km^2 and six wells were drilled, five of them in Abu- Amoud and one in east Abu-Amoud, Figure-2.

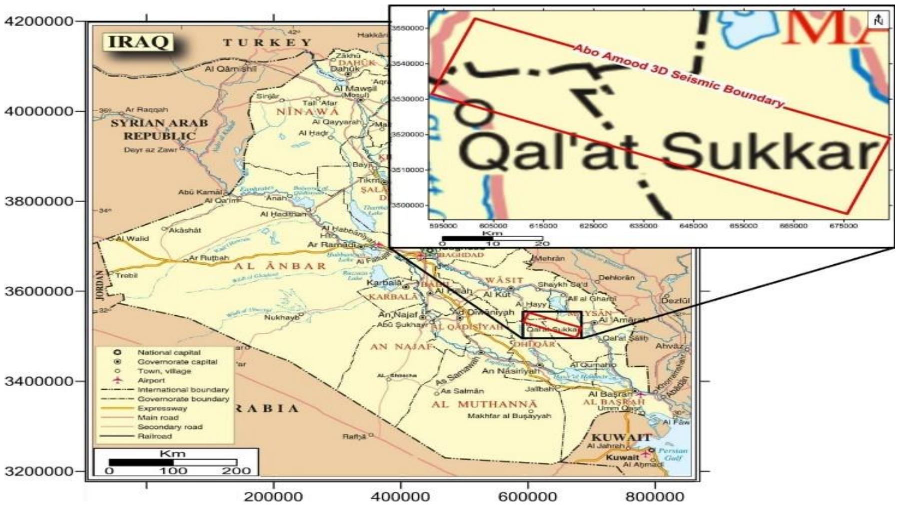

Figure 1-location map of study area

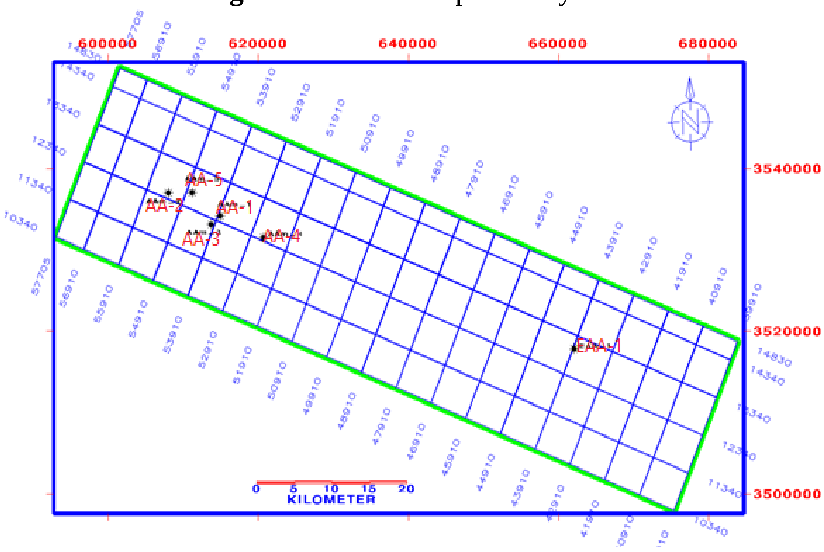

Figure 2 -3D seismic survey area and six wells

Seismic Inversion

Seismic inversion is used to transform a seismic trace into density and sonic logs, and the inverse of transforming of these two logs into a synthetic seismic at wells[4].

Seismic inversion helps in removed the peculiarities of wavelets and then estimates reservoir properties with a better resolution and may be considered in several ways[5].

3D seismic cube of Abu- Amoud field was loaded on the Hampson Russell software and the following steps were followed to reach to the use of seismic inversion technique (Model Based Inversion) on the post stack seismic data to obtain the acoustic impedance model of the study area.

Synthetic Seismogram

The building of synthetic seismogram is considered as the basic work in the seismic interpretation process for the comparison between the seismic trace built from seismic data and the other (synthetic seismogram) which is come from the real data of wells, to identify the corrected reflectors location in order to reach to more realistic interpretation of seismic data. [6] In the study area the synthetic seismograms of two wells were built (AAm1 and EAA1) after the check correction was made. The check shot correction in the AAm1 well which has been applied in all wells (AAm1, 2, 3, 4, and 5) and EAA1 well, Figure-3.

Wavelet

The success in estimating of the seismic wavelet may be considered the most important step in creating of the synthetic seismogram by convolution process as well as applying the concept of seismic inversion by calculate the value of the wavelet and then removed it by deconvolution process to obtain the reflection coefficient (RC) values which is lead to calculate of acoustic impedance values[7].

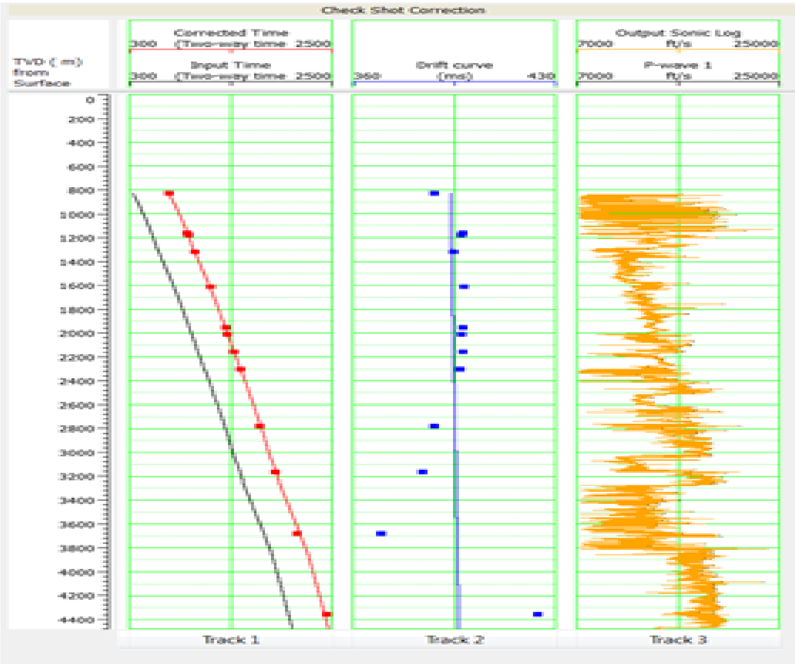

Figure 3-check shot correction calibration AAm-1 well polynomial method.

The value of wavelet was calculated in this study by using the wells information and it gives a good estimated of both the amplitude and the phase spectra of the wavelet. The best extracted well wavelets for all wells in the study area is AAm wavelet which represents an average wavelet (brown color) for 6 wells (AAm1, 2,3,4,5 and EAA1), Figure-4.

Figure 4-average wavelet of six wells

Synthetic Trace

Synthetic seismogram was generated for two wells (AAm1) & (EAA1) by using Hampson Russell software package.

The ratio of the matching between synthetic seismogram and the seismic trace at the site of AAm1 well is about 93% and at the EAA1 well is 81%. The corrected synthetic seismogram is displayed in (AAm1 and EAA1) wells location through 3D seismic data to optimize depth to time conversion and picking the main horizons in Yamama Formation, Figures-(5&6).Low frequency model (LFM) (initial model)

Inversion of seismic data alone leads to band-limited (AI) estimation.[8]Therefore, the low frequency content must be compensated by build 3D geological model of (AI) from well logs to obtain absolute rather than relative band – limited inverted property values [9]. In current study the Low Frequency Model (LFM) built from filtered well impedance guided by 7 interpreted horizons through the study area.

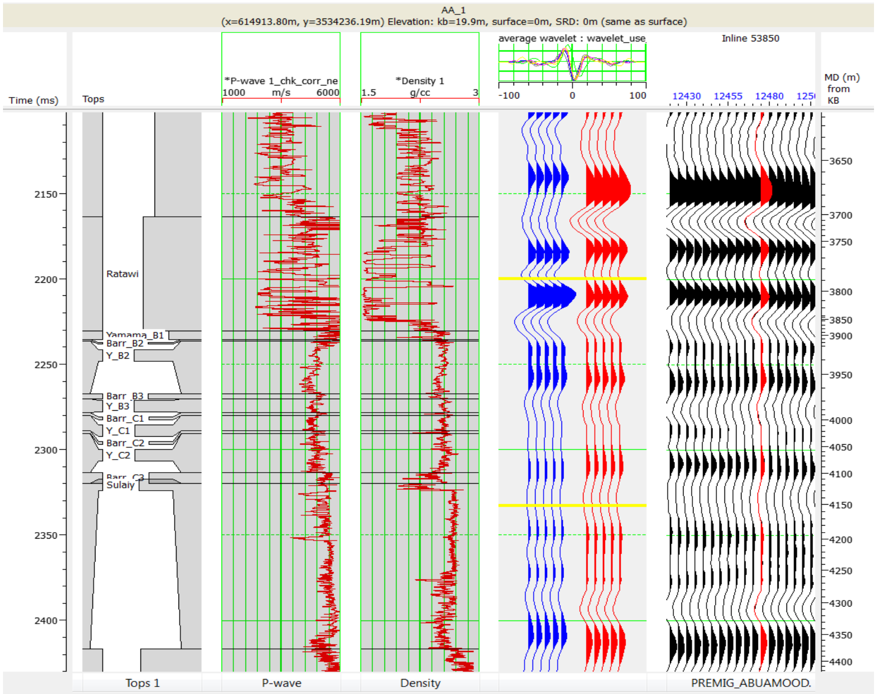

Figure 5-Synthetic seismogram of AAM_1

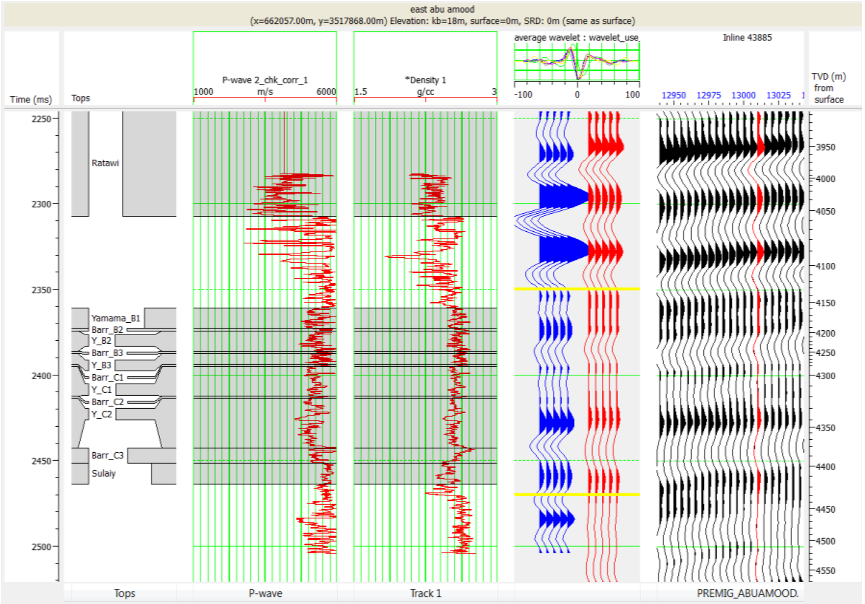

Figure 6-Synthetic seismogram of EAA_1

The final (LFM) ranges from (12 – 55) HZ used in the final inversion model as shown in Figure-7

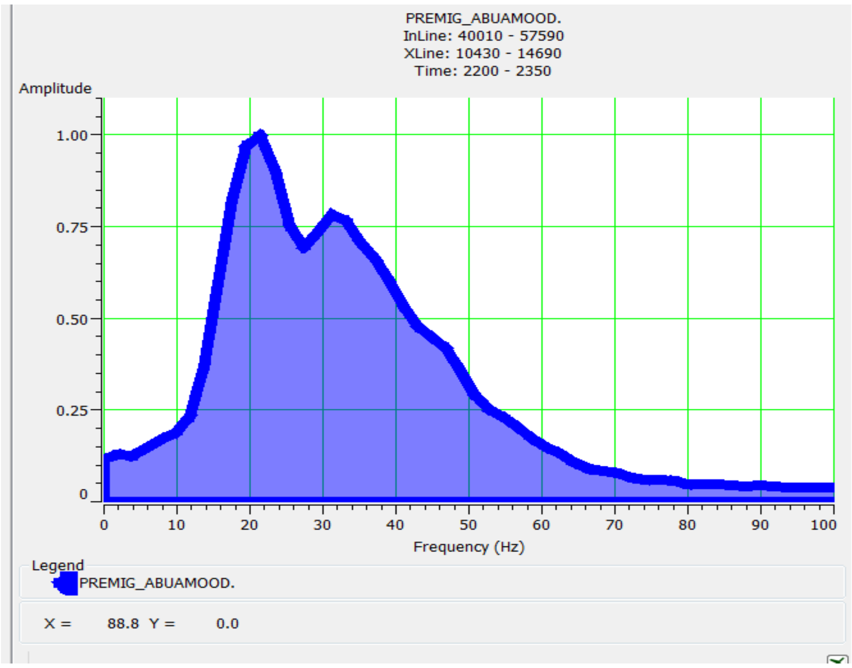

Figure 7-final low frequency model

Inversion Analysis

The model based inversion algorithm is run through all post stack seismic cube of the study area by using (STRATA) program (one of HRS applications) , to calculate the values of acoustic impedance of carbonate Yamama Formation between the sites of (AAm5 ,1,4 and EAA1) wells to cover all study area Figure-8.

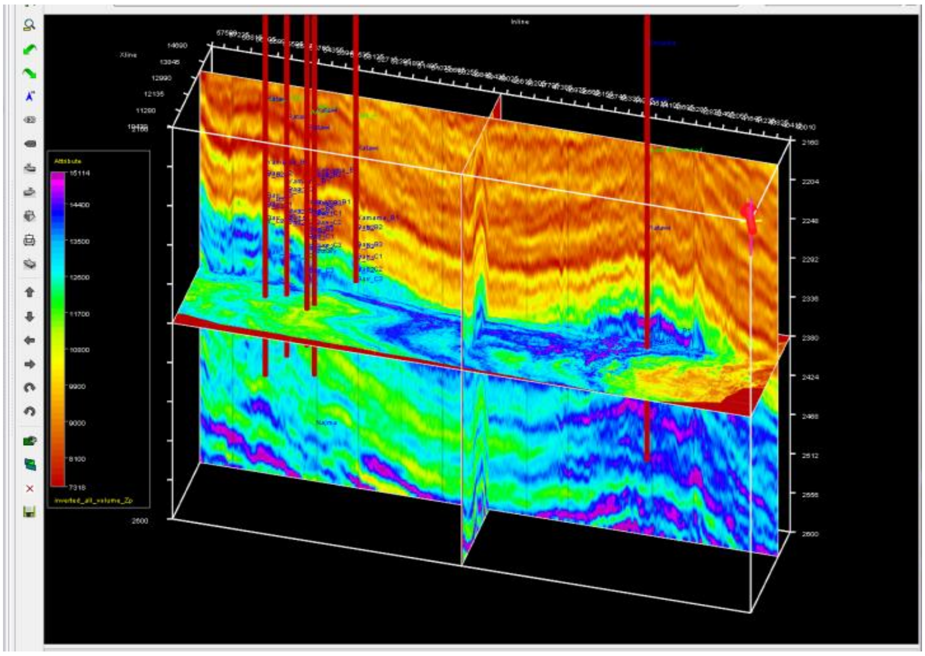

Figure 8-inverted seismic cube of AAm & EAA field

Two main reflectors (top and bottom) of Yamama reservoir were picked in addition to the reflectors that represent seven reservoirs unit existence Figure-9.

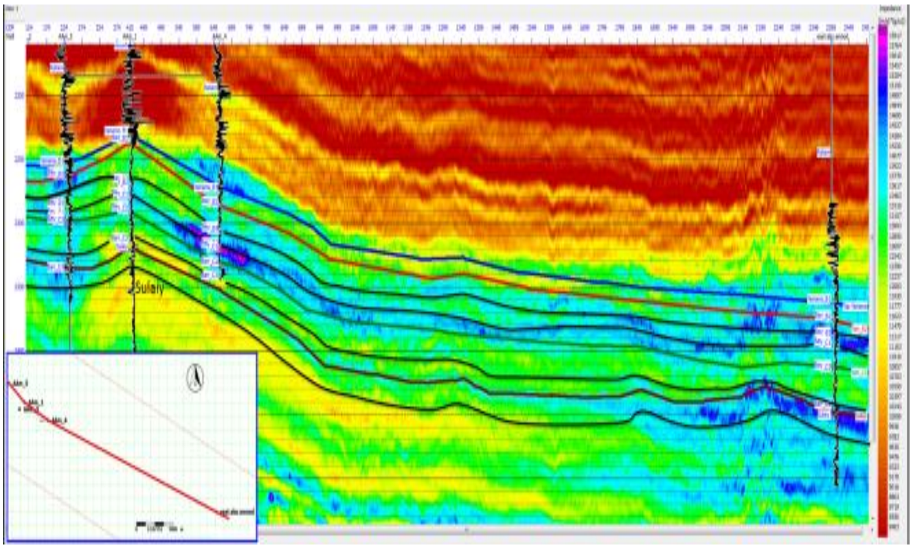

Figure 9- inverted seismic section within arbitrary line through AAm-(5, 1, 4) & EAA-1

The following observations were made from the distribution of the acoustic impedance values on the inverted seismic section.

There is a clear decrease in acoustic impedance values in (Abu-Amoud) wells area from the top to the bottom of Yamama formation.

In Eastern (Abu-Amoud) area the decreasing in (AI) values starting almost in the (C2) unit, but it's not encouraged in the upper part of this region (B1, B2, B3, C1) units. While in the central part of the study area which lies between the sites of (Abu-Amoud) wells the values of (AI) are clearly decreased along (top Yamama and B1) units and less in (B2) units and returns to record lower values again in (C2) unit. Three horizon slices were taken within three units (B1, B2, C2) as shown in Figures- (10, 11, 12) (where red circle refer to AAm & EAA field low AI values and rectangles refer to low AI values in central part of study area) which conformed more accurately the existence of lower values of (AI) in the (Abu-Amoud) wells area which are considered as the best results than east (Abu-Amoud).

Seismic Attribute

Instantaneous frequency is the time derivative of the phase, i.e., the rate of change of the phase [10]

$$F(t) = \frac{d(Q(t))}{dt}$$

The values of instantaneous frequency could indicate the thicknesses of layers; therefore, it used to compare (AI) values of (Abu-Amoud) wells area and its confirmation with low frequency value. A clear matching between low (AI) and low frequency values were indicated, Figure-13

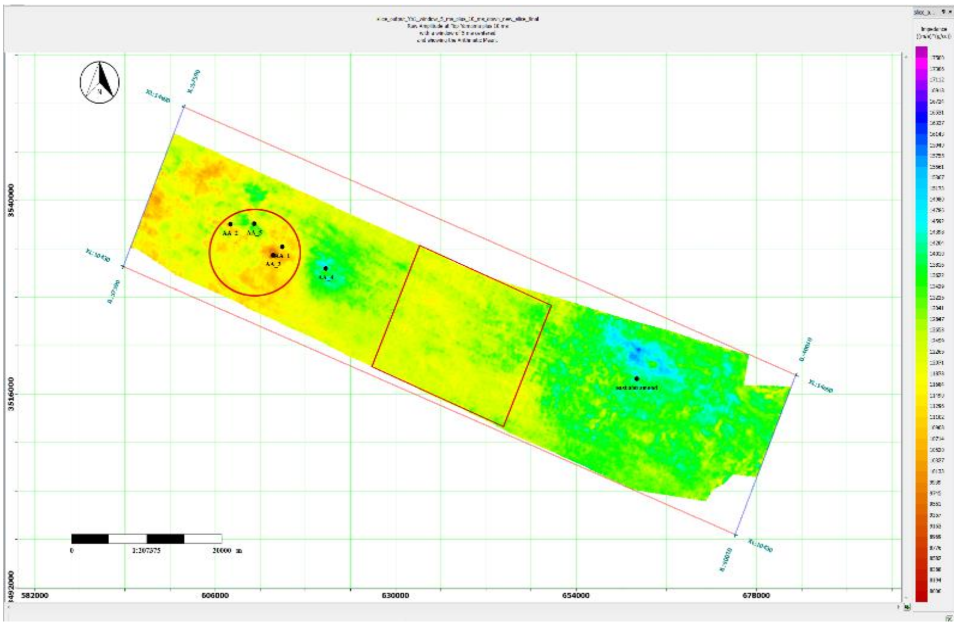

Figure 10-horizon slice within YB1 10 ms down top Yamama

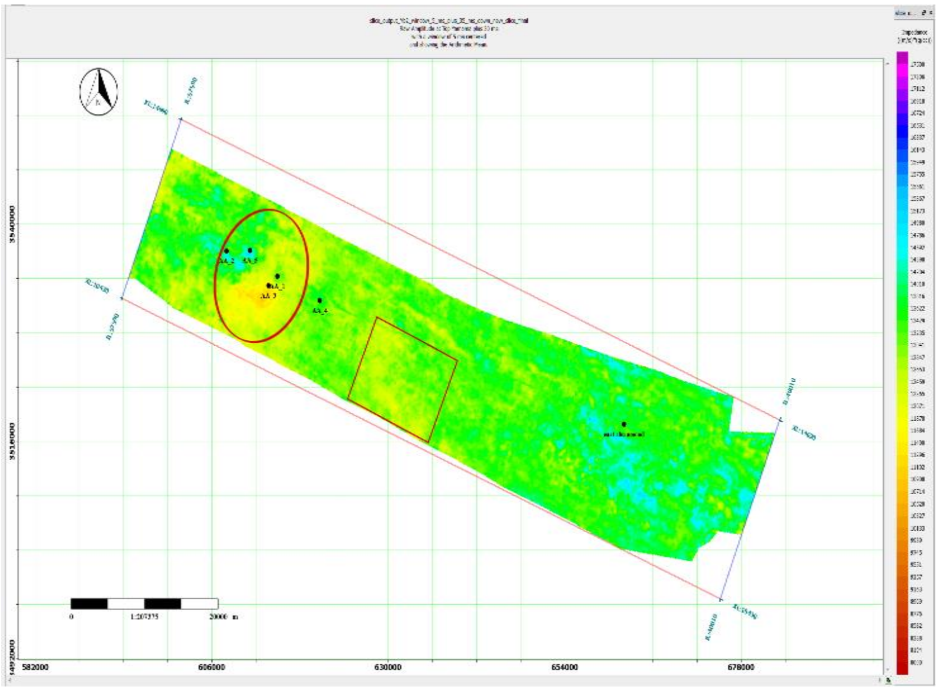

Figure 11-horizon slice within YB2 35 ms down top Yamama

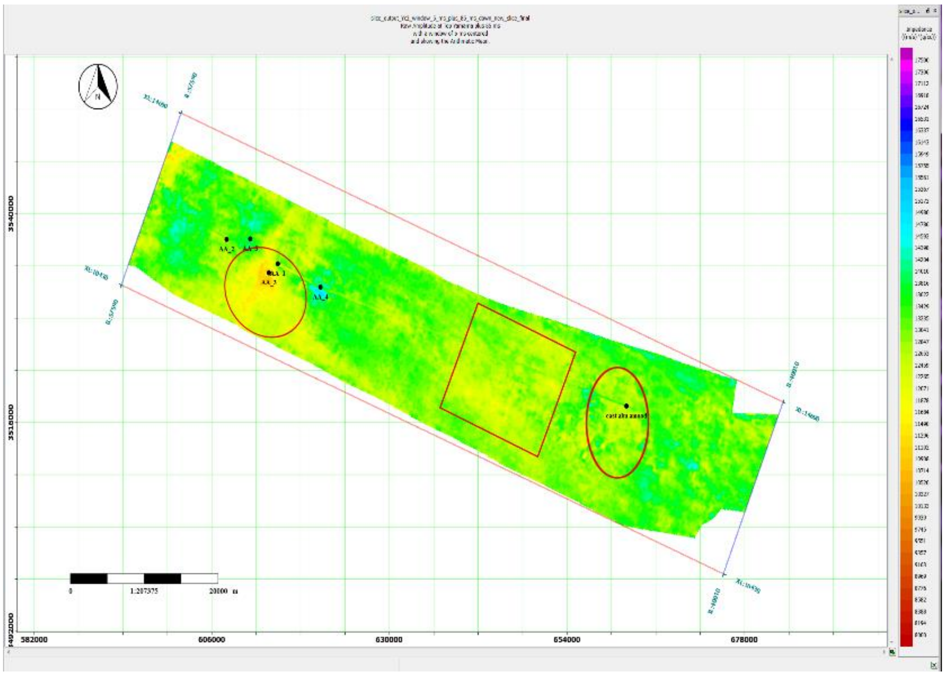

Figure 12-horizon slice within YC 2 85 ms down top Yamama

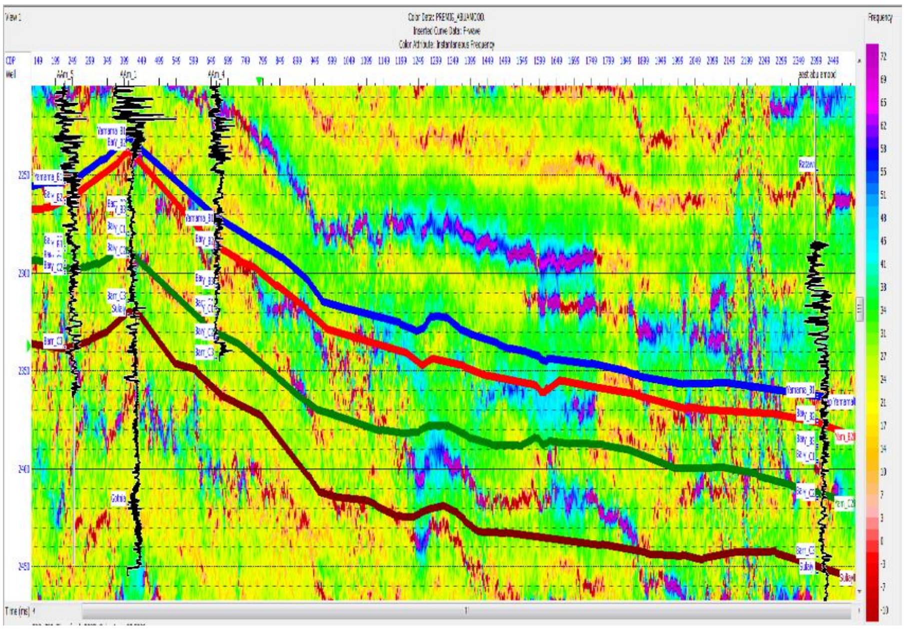

Figure 13-Arbitrary instantaneous frequency within AAm-(5, 1, 4) & EAA-1

Porosity

Quantitative evaluation of the porosity of carbonate rock is often as difficult as it is important. The main problems arise in the presence of dispersed shale or when the reservoir rock exhibits several types of porosity because of diagnosis processes. [11] The porosity was estimated from acoustic impedance values by using (EMERGE) module on the (Hampson Russell) software. The module is applied by using the inverted 3D (AI) data as external attribute and compares it with 3D seismic data and the well data to create a relationship at well location through internal algorithm provided in it.

The distribution of porosity at AAm (1, 2, 4, 5) was between (0.03 – 0.12) m^3 / m^3 which is very encouraging at all levels of Yamama Fn. units, Figure-14.

While the porosity distribution at (EAA1) well location is concentrated in the deeper Yamama Fn. (C1 – C2) units and its values ranging from (0.025 – 0.05) m^3 / m^3 Figure-15.

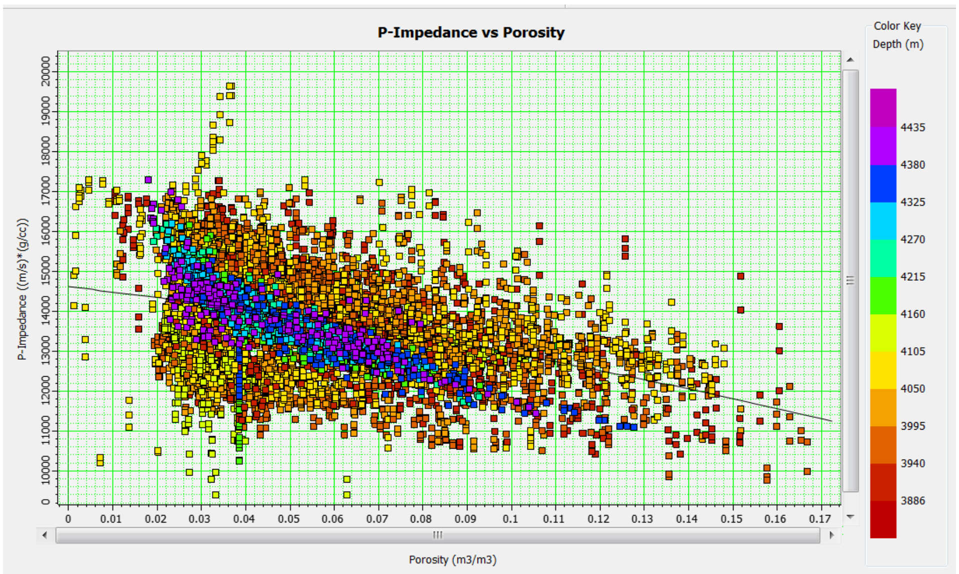

Figure 14-porosity and (AI) crossplot at AAm-(1, 2, 4, and 5)

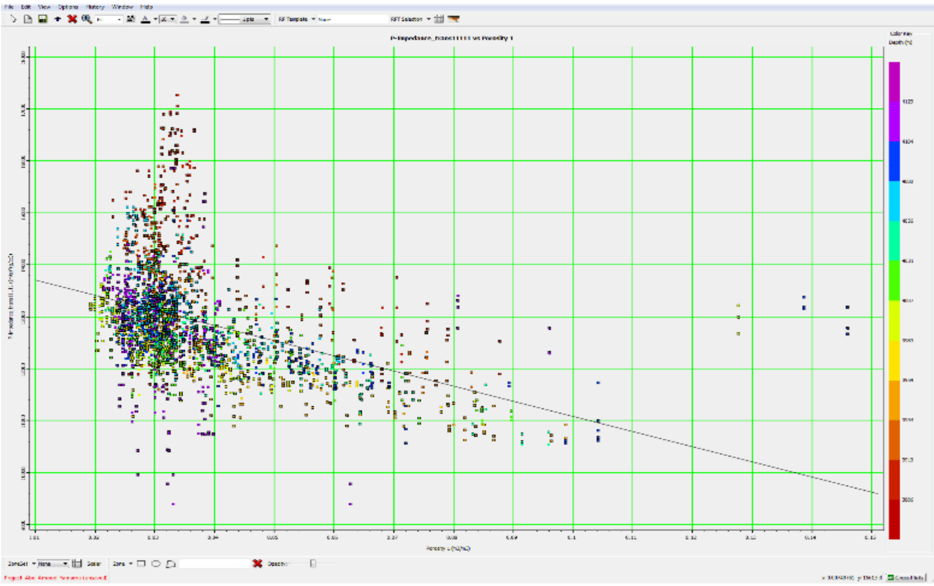

Figure 15-porosity and (AI) crossplot at EAA-1

Conclusions

1. Two main reflectors (top and bottom) of Yamama reservoir were picked in addition to the reflectors that represent seven reservoirs unit existence.
2. There is a clear decrease in acoustic impedance values in (Abu –Amoud) wells area from the top to the bottom of Yamama Formation.
3. In eastern (Abu-Amoud) area decreasing in (AI) values starting in (C2) unit but it is not encouraging in (B1, B2, B3, C1) units.
4. Acoustic impedance value in central part of the study area are clearly decreased along (top Yamama and B1) units and less in (B2) and returns to low values in (C2) unit .

There is a good matching between low (AI) values and low frequency values with the distribution of encouraging porosity which showed values range from (0.03 - 0.12) m^3/m^3 at all levels of Yamama Formation units at (AAm1) well and from (0.025 - 0.05) m^3/m^3 which is concentrated in (C1 and C2) units at (EAA1) well.

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