Data Acquisition and Processing of Hartha Formation in the east Baghdad oil field, Central of Iraq

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***Abstract*—*A three-dimensional survey was carried out to Eastern Baghdad oil field, which consist three parts, the area of (EB South- 2) approximately 179,875 km^2 and (EB South-1) is about (602.03) km^2, while the space segment (EB South-3) is approximately to (419.095) km^2. In this research, was focused on Hartha Formation only. Based on many tests to designation of pre-planning of the survey to get good signal to noise ratio for receivers in addition to the best suit for vibrators distribution and also getting the best signal source where spread of a 60-line impact and the distance between the point of receive and the other are (2 meters), also using (5) vibrators Type (NOMAD 65) with a maximum capacity of (62000 LB) for each shock. Where all processes work such as enhancing signal at the expense of noise, correction CDP gather for Normal Move Out (NMO) and stack them, correction for influence of near-surface time delays (static correction), filtering processes, providing velocity information, increasing resolution and collapsing diffractions and placing dipping events in their correct subsurface locations (migration) This processes are achieved using computers, they include many mathematical processes depend on physical fundamentals. The main processes in seismic data processing include : stacking, deconvolution, and migration. By using the information of EB-1 Well, and making the relationship time-depth curve of EB-1 then following up on getting synthetic to be linked later with seismic data and sections to obtain a real subsurface image.*

***Keywords*— Data Acquisition , Processing of Hartha Formation, upper Cretaceous age-East Baghdad oil field.**

I. INTRODUCTION

There are several seismic surveys covered the entire area East of Baghdad, carried out by foreign and Iraqi seismic parties . Oil exploration company in 2009 began planning to survey southern part of east baghdad field by using 3D seismic technique. The study area divided into three parts (S1,S2 and S3) . The second seismic party has carried out the work in two stages: the first stage South-2 (S2) survey in 2010 (O.E.C., 2010) , and the second stage S1 and S3 survey in 2011 [2]. The area of (EB South- 2) is approximately (179.875) km ^{2} and (EB South-1) is about (602.03) km ^{2} , while the space segment (EB South-3) amounted to approximately (419.095) km ^{2}, and this zone which forms part of a flat land interspersed irrigation channels and agricultural areas . The interests in this research are (S1 ,S2).

II. THE PRE-PLANNING OF THE SURVEY

The designation of pre-planning of the survey area was as in (Table 1) (O.E.C., 2010) :-

Table 1 : Shows the designation of pre-planning of the survey area (O.E.C., 2010).

1	The number of recording channels activated	1920 channel spread over 16 registration line by 120 channel / line
2	Number of receiver lines	92 lines
3	The number of source lines	45 lines
4	Distance between receiver lines	300 m.
5	Number of source points in SALVO points .	6
6	Distance between source lines	500 m.
7	Fold	48
8	Bin	25 x 25.
9	Line Roll	4.
10	Receiver Interval	50m.
11	Source Interval	50m.

III. Field tests

Forteen field tests used in the study area to get good signal to noise ratio for receivers in addition to the best suit for vibrators distribution.

3.1 SIGNAL TEST

It has been installed and the spread of a 60-line impact and the distance between the point of receive and the other are (2 meters) as shown in Figure (1) (O.E.C. 2010).

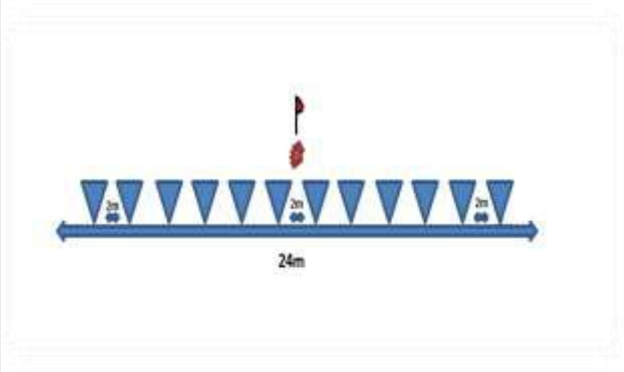

Fig.1: Shows the distribution of receivers.

3.2 Source Test (Vibro pattern)

Several modes for power source test were done using (5) vibrators Type (NOMAD 65) with a maximum capacity (peak force) of (62000 LB) for each shock , four shocks (vibrators) are in work and one vibrators as reserve, and the geometry of the vibrators are shown in Figure (2) , (O.E.C., 2010). The recording below shows on of the seismic record in the field at the study area Figure (3) .

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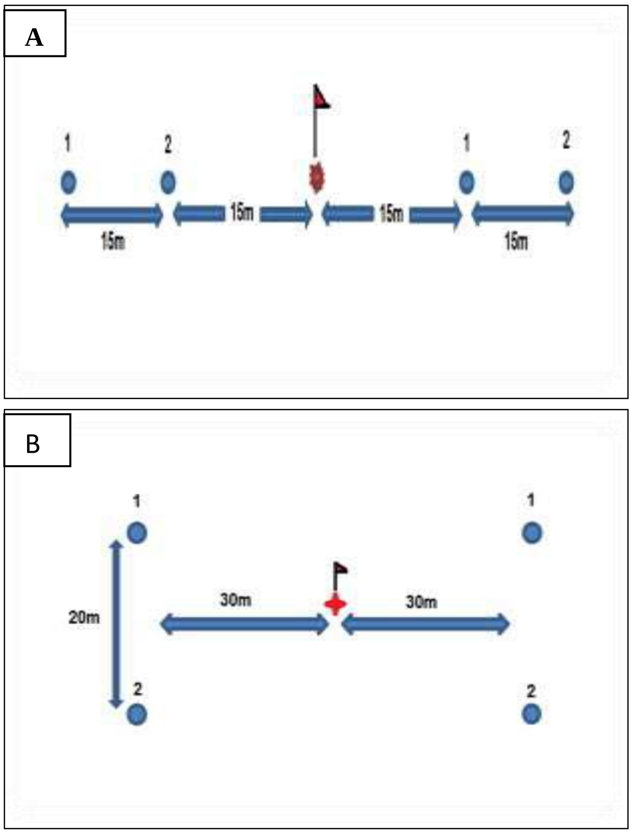

Fig.2: Shows the distribution of vibrators (A) inline and (B) cross line .

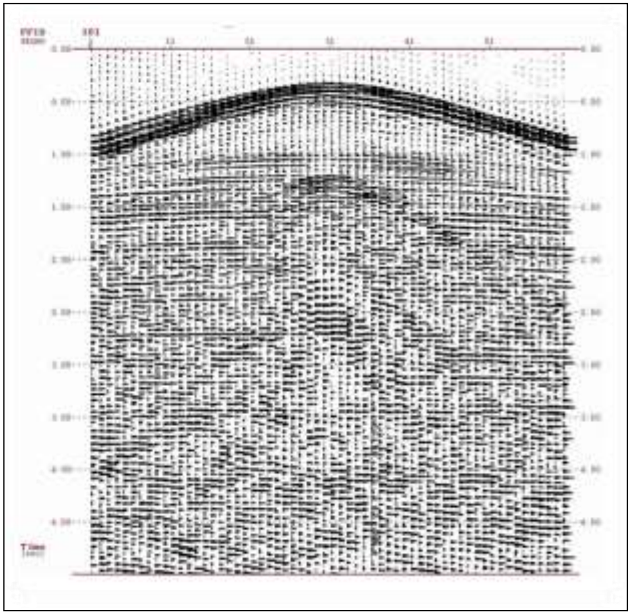

Fig.3: Shows one of the field record in the study area [2].

IV. PROCESSING OF SEISMIC DATA

The seismic data were processed at the processing center of Oil Exploration Company. The primary objective is to enhance the quality of the recorded data with special regard to the 3-D data (O.E.C., 2011). Basically, this improvement is essential to facilate the structural and stratigraphic seismic interpretation. Noise attenuation process leads to improve reflection continuity and enhance our ability to compute seismic attributes. To convert the field recording into a usable seismic section requires a good deal of data manipulation. The purpose of seismic processing is to manipulate the obtained data into an image that can be used to indicate the sub-surface structure and stratigraphy. Only minimal processing would be required if any one had a perfect acquisition system (Yilmaz, 1987) . Processing consists of the application of a sets of computer routines to the acquired data planned by the hand of the processing geophysicist. The interpreter should be interested at all stages to check that processing decisions in order not to take the interpretations of the incorrect direction. Processing routines generally fall into one of the following categories: Enhancing signal at the expense of noise, correction CDP gather for Normal Move Out (NMO) and stack them, correction for influence of near-surface time delays (static correction), filtering processes, providing velocity information, increasing resolution and collapsing diffractions and placing dipping events in their correct subsurface locations (migration). This processes are achieved using computers, they include many mathematical processes depend on physical fundamentals. The main processes in seismic data processing include : stacking, deconvolution, and migration. The processing stages are divided into pre-stack and post-stack processing (Hatton et al., 1986) .

V. LOADING OF 3D SEISMIC DATA

Processed seismic data are loaded in the interacting workstation of interpretation in SEG-Y format and before beginning; special subprograms must be operated to define the required data for loading. This process is called (project creation) for obtaining the interpretation process on an active workstation, loading of 3D seismic data in pre- stack and post stack time migrated format. After that, the base map of the study area is constructed with global coordinate's browser WG 1984 UTM system. This process involves entering the first and last inline number, the first and last cross line number, the divided space between bin size along inline direction and cross line direction is shown in Figure (4).

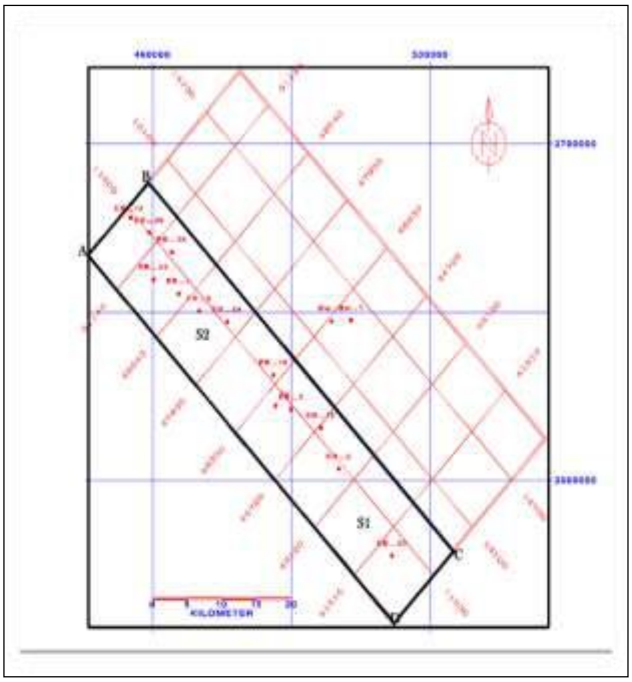

Fig.4: Base map of East Baghdad oil field (south-1 and south-2).

VI. ELEVATION STATIC CORRECTION CALCULATION AND APPLYING

The static correction is so-called because it is a fixed time correction applied to the entire trace (Silvia, and Robinson, 1979). Elevation static was primarily calculated using (elevation information, replacement velocity =2300 m/sec, datum = 0) (O.C.E., 2010) static correction is shown in Figure (5).

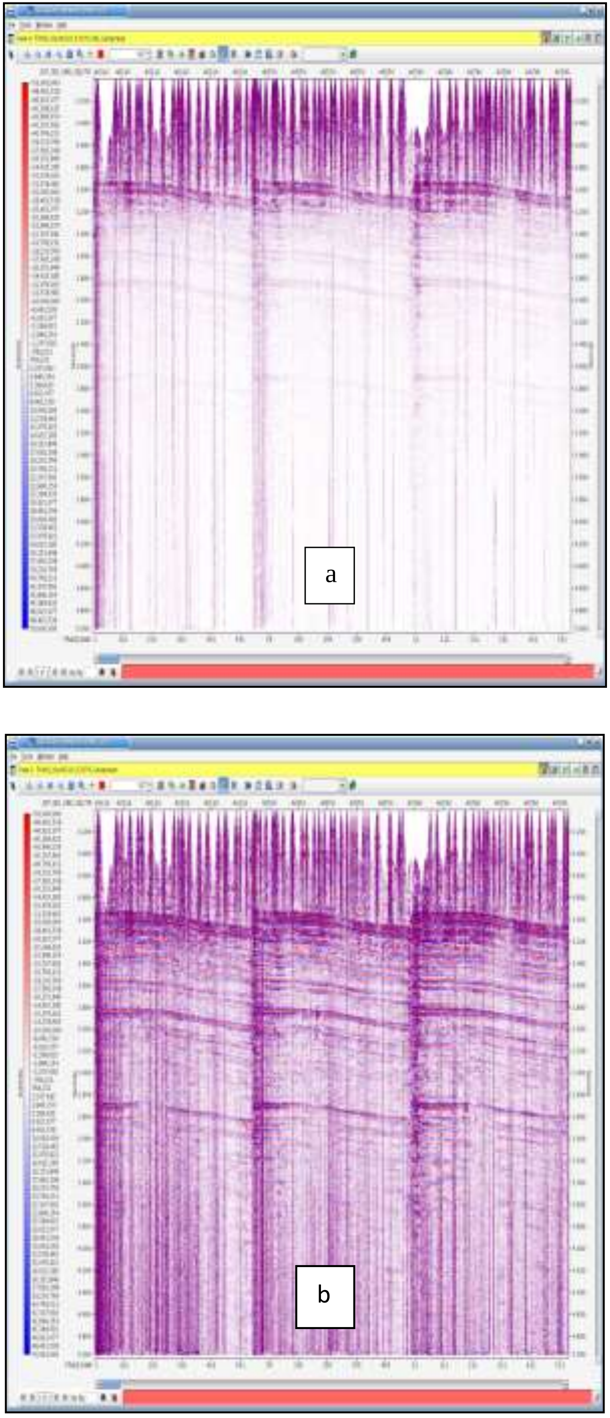

Fig.5: a- before and b- after applying elevation static correction.

VII. DECONVOLUTION

Deconvolution is mathematical processing applied to inverse the effects of convolution on recorded data. Deconvolution improves the temporal resolution of seismic data by compressing the basic seismic wavelet and removes the range character or the reverberating energy. The removal of the frequency-dependant response of the source and the instrument. The instrument response is normally known and can be removed exactly. The source shape can be estimated from the signal itself under certain assumptions. Spiking deconvolution, wavelet deconvolution, gapped deconvolution, signature deconvolution, predictive deconvolution, maximum entropy deconvolution, and surface consistent deconvolution are different appearances of the try to remove the source width from the observed reflections (Deregowski, 1986). The producing reflection sequence always has some smoothing function left, usually called the residual wavelet. Attempting to be too accurate about deconvolution usually conclusions in a very noisy section (Yilmaz, 1987). The effect of deconvolution is shown in Figure(6).

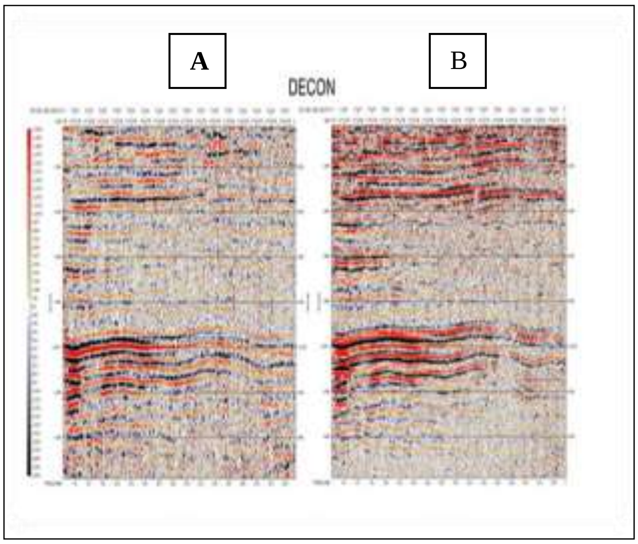

Fig.6: Shows deconvolution A- before deconvolution B- after deconvolution (http:// inter- geo.org /Services /Processing3d /Parameters .php?lang=en) .

VIII. COMMON-MIDPOINT STACKING

CMP stacking is probabiy the most important application of data processing for improving data quality. The component data are sometimes displayed as a gather: a CMP gather has the components for the same midpoint arranged side by side and a common-offset gather has the components for which the offset is the same arranges side by side . after correcting for normal moveout , the data are stacked into single output trace for each midpoint . If reflectors dip , the reflecting point is not common for CMO traces and consequently the stacking result involved smearing and degradation of data quality. The degradation can be avoided by migration before stacking . Somtime partial stacks, each of traces over a limited offset range , are made and migrated to cut down on the amount of data to be migrated. Dip-moveout(DMO) processing transforms a set of pre-stack common-point gathers so that each gather contained events from the same reflecting point (Telford et al., 1990). If the velocity is constant, the locus for equal travel times is an ellipse with the source and receiver locations as foci; all reflectors, dipping as well as horizontal, are tangent to such an ellipse . DMO uses the difference between the mid-point and the points where perpendiculars to the ellipse intercept the surface to create common-reflecting point gathers . These gathers can then be stacked and migrated without reflecting point smear . The constant-velocity assumtion provides a reason ably satisfactory approximation where velocity varies (Stolt and Benson, 1986).

IX. STACKING AND MIGRATION

Migration is one of the main steps in seismic data processing it is the step which try to move the recorded data so that events lie in their right spatial location rather than their recorded location (Bacon and Redshaw , 2003). Once more there are a large number of options ranging from migrating all the pre-stack data to stacking data in a CMP followed by post-stack migration.There is also the issue of whether to use time or depth migration and also the type of algorithm (Kirchoff, implicit finite difference, explicit finite difference, F- K filter, phase shift, etc.). In recent years the choice has become even wider with the ability of some algorithms to incorporate the effects of velocity anisotropy. The option of whether to migrated at a before or after stacking is in general dependent on the velocity regime and the subsurface dips present in the data. An assumed velocity-depth model is used, the data are migrated pre-stack using this model, and the images across the migrated CMP gather are compared. If the velocity model is nearly correct will the events appear flat. Events will only be flat if they have been fully migrated in a 3-D sense and it is expensive to repeat this for the entire section. Since lateral velocity variations also give rise to stacking problems most depth migration benefit is gained from working pre-stack. After the final velocity analysis and Move Out Correction (MOC) the data are stacked. Stacking together traces that include the same reflection information both get better the signal to (random) noise content (by the square root of the number of traces stacked) and reduces any residual coherent noise such as multiples which stack at velocities different from the primary events. During stacking , mutes (zeroing the data within specified zones) are used to the data to ensure that NMO is not a problem and that any residual multiples left on the near-offset traces do not mess the stacked section. There may be some amplitude difference with offset (AVO) effects in the data,which can be inducted as hydrocarbon indicators (Drijkoningen and Verschuur , 2003).

X. POST-STACK TIME/DEPTH MIGRATION

In a number of these steps some assumptions have been made that are not valid for general inhomogeneous earth models (Hagedoorn, 1954) such as :

A- **CMP sorting:** If the earth is inhomogeneous and reactors have complex shapes and the reaction events within a CMP gather do not belong to one subsurface reactors point .

B- **NMO correction:** In complex subsurface media the moveout in a CMP gather is not hyperbolic, so a perfect moveout correction cannot be achieved.

C- **DMO:** If strong lateral velocity and/or reactor geometry variations are present, the DMO procedure still will not resolve the reaction point smear within a CMP gather.

D- **Stack:** As the events within a CMP gather do not belong to the same subsurface reaction point, stacking of these events will mix subsurface information.

E- **Poststack time/depth migration:** Given the approximations in the previous steps, a stacked section does not represent a true zero offset section and migration of this stack will therefore not result in an exact image. Furthermore, some poststack migration algorithms have limitations due to the assumed simple velocity field or limitation in the maximum dip that can be handled. Figure (7) shows the Shot gather with MUTE.

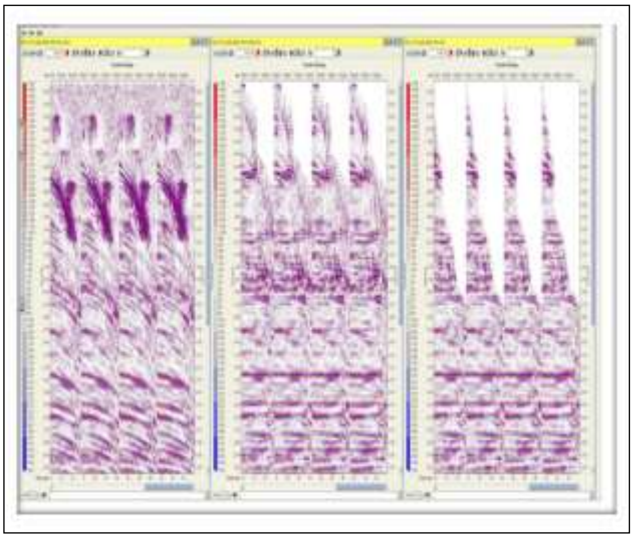

Fig.7: shows the Shot gather with MUTE.

XI. MIGRATION OF SEISMIC DATA

Migration is the process of propagating waves observed on the surface of the ground backward in time into the earth to the subsurface structures. In a geographical region where all the subsurface stratums are quite horizontal, such depropagation would take place on perfectly vertical paths. However, if the undergraond stratums are dipping, the depropagation would take place on curved paths turning away from the vertical. The reason for proceeding migration or depropagation is that it discover the present spatial positions of the subsurface reflection points at depth, where as the unmigrated seismic data observed on the surface of the ground only gives the apparent reflecting positions. Thus migration can be described as the conversion of data observed at the surface to data that would have been observed at depth. That is, migration is the process of mathematically pushing the data back into the ground so as to detect the true spatial locations of the subsurface structure (Stolt , 1978). The common mid-point (CMP) stack record section is works on assembling all the CMP stacked traces along the survey line. The CMP stack section has approximately the properties of a record section in which each trace has the same source and receiver position (Schlumberger. 2004). Recents seismic reflection data possibly processed to approximate closely the reflection coefficient sets of a sedimentary section. Inversion of the groups will result a low-cut filter impedance log. Extension of the technique to involve density relationship and replacement of missing low-frequency components leads to generation of a synthetic sonic log having dimensions and advantages like to a conventional borehole sonic log.

XII. COMPUTER INTERPRETATION AND USED PROGRAMS

The interactive workstation (GeoFrame) available in O.E.C was used to perform interpretation. It is an electronic computer uses (Red hat) as operating system, the later is a copy of UNIX (operating system). There are several specialized programs operating with this interactive workstation such as geology, seismic, reservoir engineering and petrophysics programs (Dobrin and Savit, 1988). The GeoFrame software is a part project database capable of managing tens of thousands of wells, hundreds of 3D seismic surveys, and thousands of 2D seismic lines. Advanced workflow techniques—such as AVO (Amplitude Verses Offset) interpretation, volume interpretation and GIS—give geoscientists an advantage in prospect generation and field development. Coupled with easy arrival to the Petrel E&P software platform, interpretation rise Connected with easy arrival to the Petrel E&P software platform, interpretation dangers are reduced even further (Dobrin and Savit, 1988) The use of workstations for 3D interpretation was therefore welcomed by interpreters. They offered several advantages:

1- The ability to view sections through the data in any orientation.

2- Automatic book-keeping of manually selected horizon: picks made on one line would automatically be ransferred to another lines or to map views.

3- Semi-automated horizon picking.

4- Calculation of pick attributes that can be used to extract additional information.

5- Capability to see the data volume in 3D not just as sections, to obtain all this requires that use of completely powerful workstations (Drijkoningen and Verschuur , 2003).

The GeoFrame software system includes several windows and will be explained windows that have been working out that includes Figure (8) :

12.1 Seismic interpretation: including ((IESX (Interpretation Extracts Seismic Xtrem)) and Charisma)) that work on the interpretation of 2D/3D pre- and post stack seismic interpretation with data versioning for multiple users.

12.2 Mapping and gridding: including (Base map Plus and CPS3 (Control point Sections)) working on quality maps for geological and geophysical interpretation data, and data management functionality in one mapping canvas.

12.3 Depth conversion: Including (in depth and synthetics)

-In depth Domain conversion of 2D/3D seismic and interpretation data by creating velocity models with access to QC (Quality Control) tools.

-Synthetics: Synthetics bridges the gap between geology and geophysics, creates accurate time to depth relationships for the wells in the field.

- Analysis: including (Seismic Attribute ToolKit Bundle) get more detail on the subtle lithological variations of the reservoir.

- LPM (Log Property Mapping) Creates rock property maps guided by seismic attributes (Dobrin, and Savit, 1988).

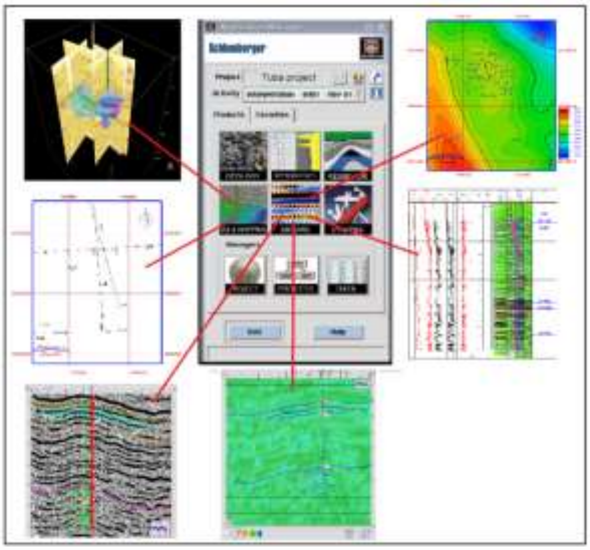

*Fig.8***:** *Shows The GeoFrame software system windows.*

XIII. CHECK – SHOT SURVEY

Is used to determine interval velocities to geologic marker horizons. The typical check shot survey involves lowering a geophone/hydophone into a well to a selected position and measuring the time it takes for an acoustic pulse generated at or near the well head to travel to the receiver. Most often explosive source is used. Unlike it’s VSP, the receiver locations are often placed hundreds or thousands of meters apart and the recording windows are only long enough to record the directly arriving signals (Khorshid, 2015). The data can then be correlated to surface seismic data by correcting the sonic log and generating a synthetic seismogram to confirm or modify seismic interpretations (Sheriff and Geldart, 1995). (Table 2) extracted from IESX system shows the dependent depth and time values from upper formation logs, field survey velocity, and the processing of depth field values to the depth of penetrating formations of sea level which considered a reference surface for three dimensional data of the study area. For the purpose of obtaining accurate synthetic seismogram of good matching with seismic data by using available tools and possibilities in the window of creating synthetic seismogram within IESX program of interactive work station (Geoframe) according to the following steps:-

-The process of loading sonic log, velocity log and upper formations of wells.

-A process of calibration of time curve with depth for sonic and velocity logs for the purpose of correcting time values of sonic log according to the field velocity survey. Figures (9) shows the time-depth curve of EB-1 .

- Using of seismic data that cover the well area to extract the wavelet shapes which dependent in the process of convolution to convert reflection coefficient values to seismic signal in amplitude.

Table.2: Shows the marker informations of two wells EB-1.

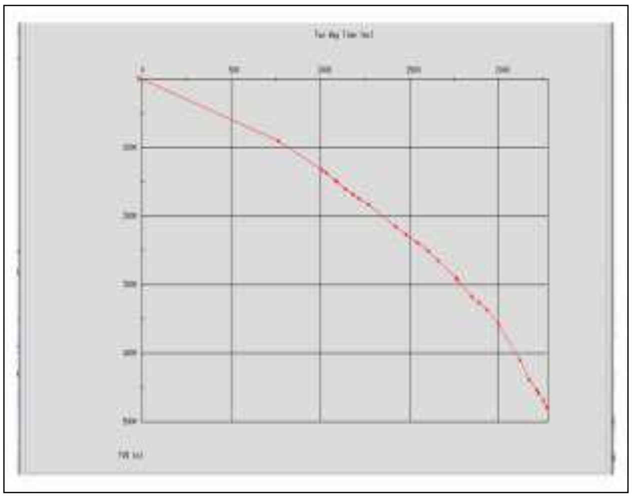

Fig.9: Shows time-depth curves for East Baghdad well-1.

XIV. GENERATION OF SYNTHETIC SEISMOGRAM

Synthetic seismograms was generated for East Baghdad well-1 using GeoFrame software package . (Sheriff and Geldart, 1995) referred to the main steps for generation of the synthetic seismogram which they are :

a- finding the acoustic impedance (= $\rho \times v$)
Where:
v: Is seismic velocity.

ρ: Is density measured from density logs.

b- calculating the reflection coefficients (RC) of the vertical incident wave on reflector separating two groups of time intervals such (i) and (i+1) that have values of acoustic impedance (ρi vi) and (ρi+1, vi+1) respectively (Khorshid, 2015) .

$$\mathrm{RC} = \frac{\mathrm{V_2\rho_2 - V_2\rho_2}}{\mathrm{V_2\rho_2 + V_2\rho_2}} = \frac{\mathrm{A_r}}{\mathrm{A_i}} \ldots\ldots\ldots\ldots..\ldots\ldots (1)$$

Experimentally choice wavelet is made to result the synthetic seismogram. The sonic log data are compared with the wellhole velocity survey which symbolizes the direct method to measure the geological velocity (average velocity) of geological strata. The synthetic seismogram traces of the East Baghdad well for EB-1 were generated using programs within the IESX (synthetic programs). These have ability to extract the relation between the time and depth functions in the well location. This relation is very important in determining the reflection on a time axis of seismic section and synthetic trace against the require bed in the well. The sonic logs were transformed from the depth to the time domain using the check shots that were provided and used to make synthetics from the computed reflectivity series convolved with a Ricker and extraction wavelet to match the dominant frequency of reprocessed 2D seismic data. After that calibration must be done on seismic section of the synthetic as shown in Figure (10).

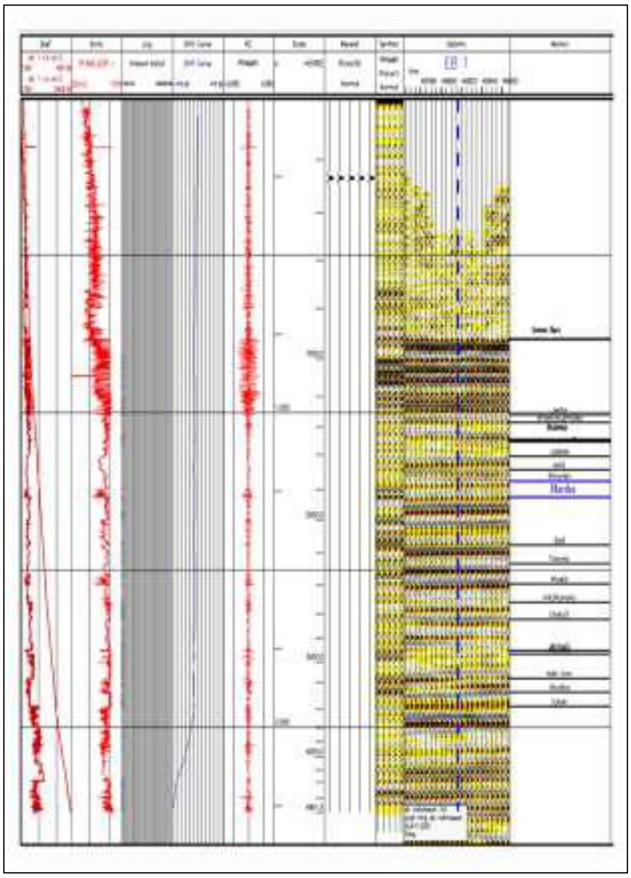

Fig.10: Shows the seismic sections with synthetic seismogram of EB-1.

CONCLUSIONS

The following conclusions are the resultant of this research:-

1. Through the implementation of several field tests, a major action plan was adopted as shown in Table -1
2. Best arrangement have been reached through installed and the spread of a 60-line impact and the distance between the point of receive and the other are (2 meters).
3. The best signal source represent by four shocks (vibrators) are in work and one vibrators as reserve Type (NOMAD 65) with a maximum capacity (peak force) of (62000 LB) for each shock.
4. By using the information of EB-1 Well, and making the relationship time-depth curve of EB-1 then following up on getting synthetic to be linked later with seismic data and sections to obtain a real subsurface image
5. Through the use of the interactive workstation (GeoFrame) to get a good applications and interpretation.

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