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Integration Study of a New Gravity and Seismic Survey along NE- SW Profilein Al- Najaf Desert

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Abstract

A new gravity and seismic survey along a profile length (70 Km) carried out at the area of exploration Block- 11 in Al- Najaf desert, southwest Iraq. The obtained gravity and seismic value compared with the previous available data that achieved by IPC and OEC for gravity and seismic data respectively. The difference between the new gravity profile and the old one is mainly in small anomaly not more than (14 %) that related to shallow depth levels and presents through power spectrum analysis. Previously, Ghulaissan-1 well which drilled in (1960) depend on a positive gravity and magnetic anomaly interpret, which is considered as an anticline structure in sub surface. It did not indicate any hydrocarbon shows after drilling, the integration study shows, that the positive anomaly appear in gravity record may be results from extension of presence thick Ophiolites and syn- tectonic gabbro.

Keywords: Integration, Ghulaissan-1, Calibration, difference, Domination Slices and Ophiolites.

دراسة متكاملة لمسح جذبي و زلزالي على طول مقطع ممتد بإتجاه شمال شرق – جنوب غرب في صحراء النجف

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الخلاصة

إستخدمت الدراسة مسح جيوفيزيائي جديد في التسجيل الجذبي والزلزالي الإنعكاسي على مسار طوله (70كم) ضمن الرقعة الإستكشافية لبلوك- 11 في صحراء النجف جنوب غرب العراق، تمت مقارنة المعلومات المسجلة الجذبية والزلزالية مع التسجيلات القديمة من قبل شركة النفط الوطنية وشركة الإستكشافات النفطية على التوالي، التي بينت ظهور شواذ صغيرة لا تتجاوز(14%) ضمن الأعماق الضحلة، التي توضحت في التسجيل الجذبي خلال تطبيق التحليل الطيفي للسعة والتردد. تم حفر بئر غليصان- 1 عام 1960 إعتماداً على شاذة جذبية ومغناطيسية موجبة بإعتبارها منطقة تحدب تركيبي تحت سطحي، حيث لم يبين أي شواهد هايدروكربونية من نتائج الحفر، بينت الدراسة الحالية من موديل متكامل للمعلومات الجيوفيزيائية أن سبب هذه الشاذة الموجبة التي تظهر في التسجيل الجذبي قد يكون ناتجة من إمتداد إقليمي لصخور الأفيولايت ذات سماكات عالية.

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1. Introduction

In earth sciences, subsurface structures are studied by collecting large and various types of geophysical data, different geophysical attributes of the subsurface are measured by a variety of geophysical measuring techniques, [1, 2, 3], However, in recent years, many authors have considered using diverse data in geophysical inversion can reduce uncertainty, [4]. Gravity and seismic data when integrated with other give good results. The integration study provides valuable information, where seismic data alone may be difficult to interpret, [5].The integrated gravity and seismic modeling has been used to provide information about formations geometries and dip angle, [6].

Previously, in (1960) the Ghulaissan -1 well where locates in the mid of the study area, Figure-1. This well drilled at the high positive gravity anomaly, [7]. The previous seismic survey (1Gn- 32 in 1979) was showed bad quality reflectors and did not obtain clear anomaly, [8].

The Iraqi oil exploration studies was considered it an exploratory area within block- 11 as many or most blocks which are still in a state of ambiguity, [9]. To interpret the geophysics appearance to the geological & tectonically means is to take the sample profile from the study area by new geophysical survey record including seismic and gravity survey. These two methods are common used to develop the seismic record, processing and introduce more acceptable geological model.

Zubair Formation is the most important sandstone reservoir in south and SW of Iraq with 30% of Iraq's hydrocarbon reserves. Sandstones of the Zubair Formation were deposited in a delta/ pro- delta to inner shelf setting and consist of inter bedded sandstone and shale (300-400m) thick; a thickness of over (200m) of sandstone is present in Zubair field and the Karbala area of central Iraq. Porosities increase from an average of (15%) near the border with Iran to around (30%) in wells in Salman Zone such as Kifl-1 well, [10].

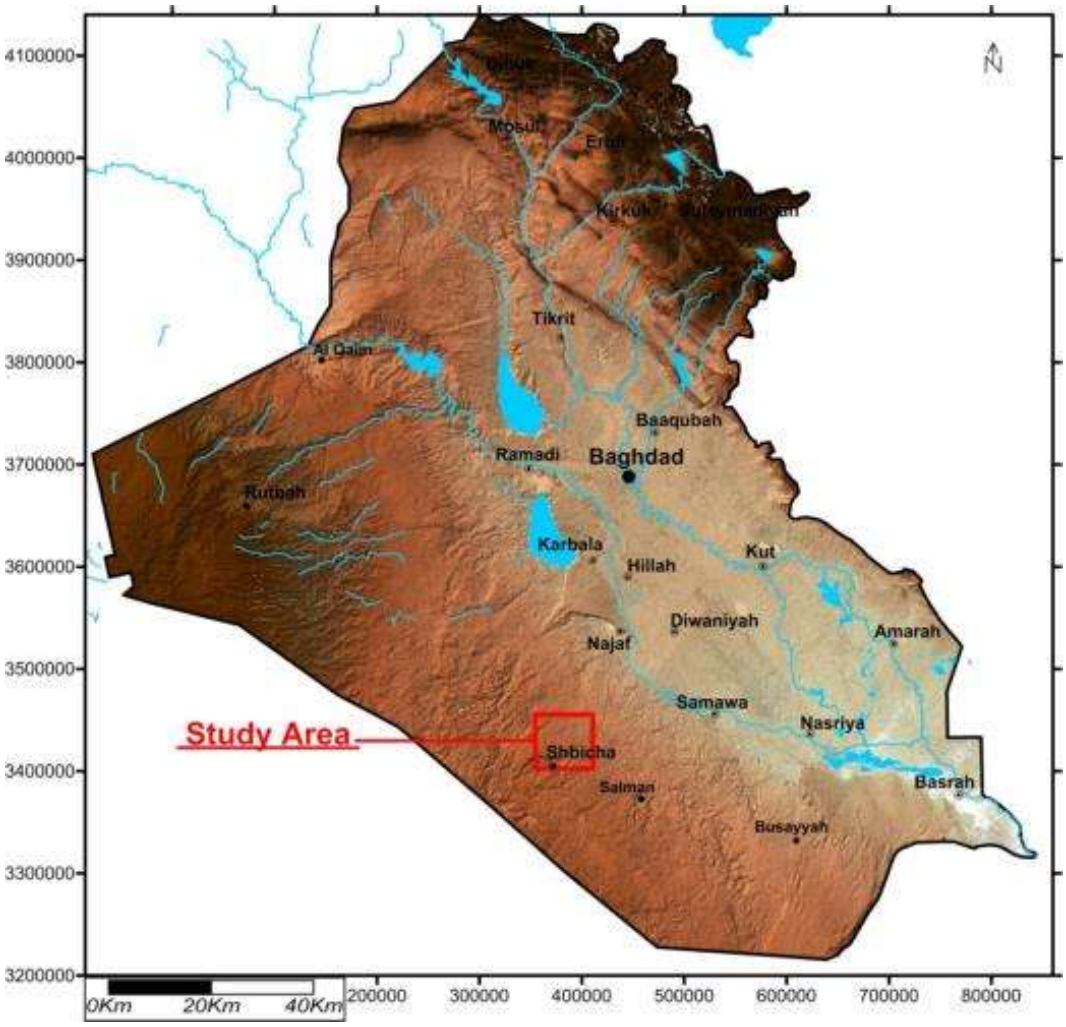

Figure 1-Study area Location in south west Iraq.

2. Old Geophysics Records

2.1 Gravity Survey

Gravity survey was carried out at the study area in 1940s by Iraq Petroleum Company (IPC), spacing distance (5Km) and all gravity stations in the full principal facts database were originally acquired using the system (Postdam 1930 datum). However the IPC data had undergone a datum correction as part of Getech's IPC Gravity & Magnetic Compilation (1995) to adjusting the data to International gravity standardization network in 1971 definition, [11].

2.2 Seismic Survey

Area of interest covered 2D seismic lines implemented of exploratory surveys by Iraqi oil exploration company in (1979) by the seismic survey program parameter Table- 1, the 2D lines designed at dip and strike of structures elements that mostly trending SW – NE and SE – NW, [8].

Table 1-Field parameter of previous seismic survey in study area, [8].

Area	Year	Km	Coverage	Source	Spread (m)	Quality
Ghulaissan 1Gn	**1979**	**1475**	**2400 %**	**Vibrators**	**3525-150-VP-150-3525m**	**Good to fair**

3. New Geophysical Field

3.1 Gravity Field Surveying

The pre planning of gravity profile survey was taken according to the interest of Iraqi oil exploration company (OEC) which planned within the program of seismic surveying at the exploration area (Block- 11) at the Najaf desert, so the gravity profile location was sequenced exactly with new seismic reflection line (7Gn- 16) at the same (X, Y coordinate) from southwest (No. 1048) to the northeast (No. 2418), passing on the location of an oil well (Ghulaissan - 1) as control point to gravity and seismic interpretation Figure-2. The gravity survey works were carried out with high resolution in monitoring; the spatial coordinates and topographic heights by satellite using the surveying apparatus (*LEICA VIVA GPS*) and the system coordinate adopted *WGS84 UTM ZONE 38*, fixed as the bench marks on the surface for each record point, Figure-3.The station spacing specified to 250m along 70 Km, The gravimeter LACOSTE & ROMBERG- G. 532 Figure-3, has been a Main stay of exploration for many years and recent improvements greatly increased the production rate and ease of use, [12]. Recording was taken in the beginning of summer season, gravity survey covered part of missing seismic record survey because the path passing on a mined area of an old military airport, which couldn't passing the heavy seismic equipment. The main steps of gravity survey include base station establishment, gravity measurements and traditional corrections.

3.2 Seismic Survey

Study area covered by gridding of 2D seismic lines survey at general trend of dip lines (NE - SW) and of axial lines (NW - SE), the dip line (7Gn-16) is locate at gravity line path, applied field parameter of the seismic line survey is as follows:

Line 7Gn-16: 1048 SW - 2408 NE, Receiver station interval: 50m, Source station interval: 50m
Number of channel: 212, Sample rate: 2mSec, Normal folds: 106
Distance between CDPS: 25m spread by 2D Symmetrical split spread (106+106)
Source type: Vibrators - Sweep length: 12Sec, Physical pattern length: 60m
Vibration pattern: 3X3X3, Movement of vibro: 30M sweep in 10HZ - 76HZ Linear Upsweep
Number of vibrator in source pattern: 3
Geophone string config: 12 Sensor (Connected) by 2 strings, Geometry of pattern: Linear
Pattern dimension: 60m, Record length correlated: 6 Sec

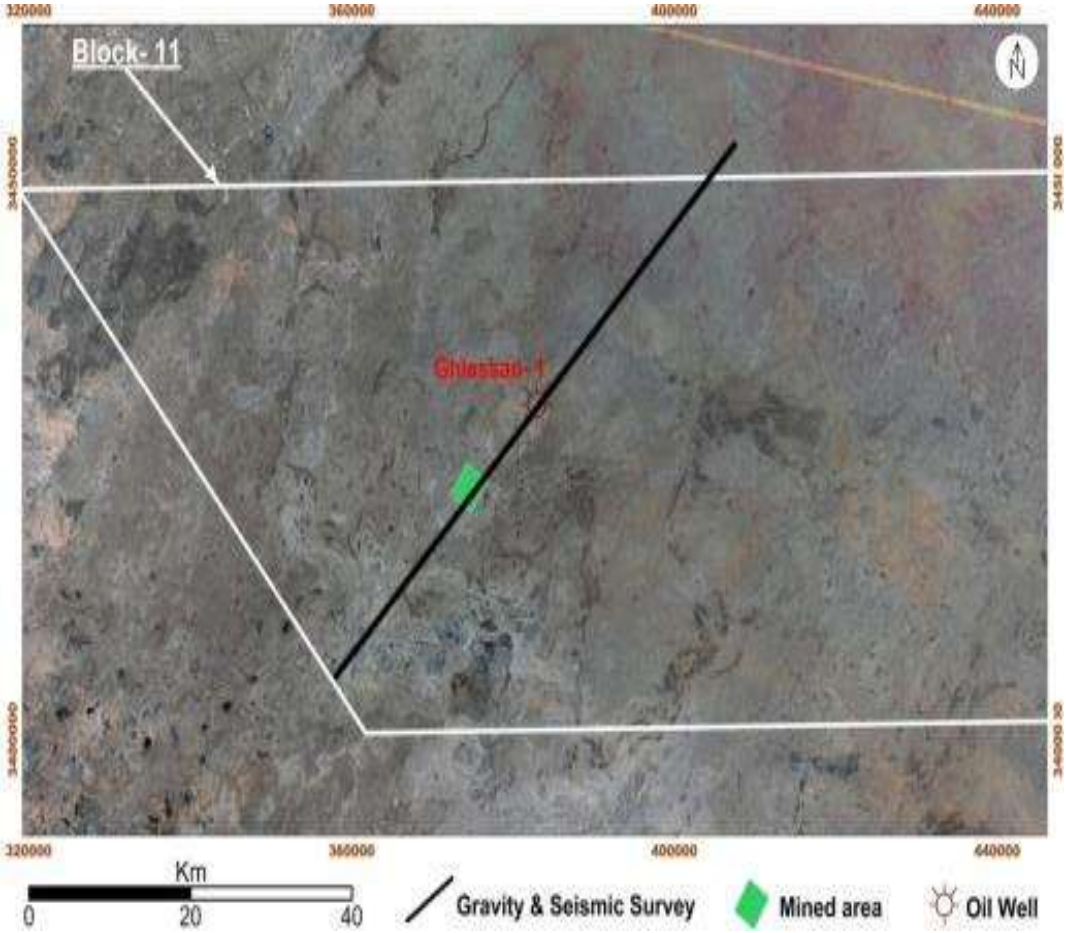

Figure 2- Location of Gravity and seismic line survey in block- 11.

Figure 3-The (LEICA VIVA GPS) and the gravimeter (LACOSTE and ROMBERG- G. 532) used in the field survey.

4. Processing Data

4.1 Gravity Processing Data

The new gravity survey using datum 200 above sea level was accredited in processing & interpretation, according to datum plane of seismic record which considered the same datum. Estimated the gravity values contrast along the profile and transform as positive and negative values to compare with previous gravity survey.

by equation:

Gravity value contrast = Absolute value - Average of absolute values ……..……. (1)

The Average of absolute gravity values along the profile is (3070.30) mGal.

It applied simple low pass filter to remove the noise Figure-4, by loading the stations data in software (*GeoSoft- Oasis Montaj version 8.4)* and it is simple to increase of the ratio (wave length/ frequency).

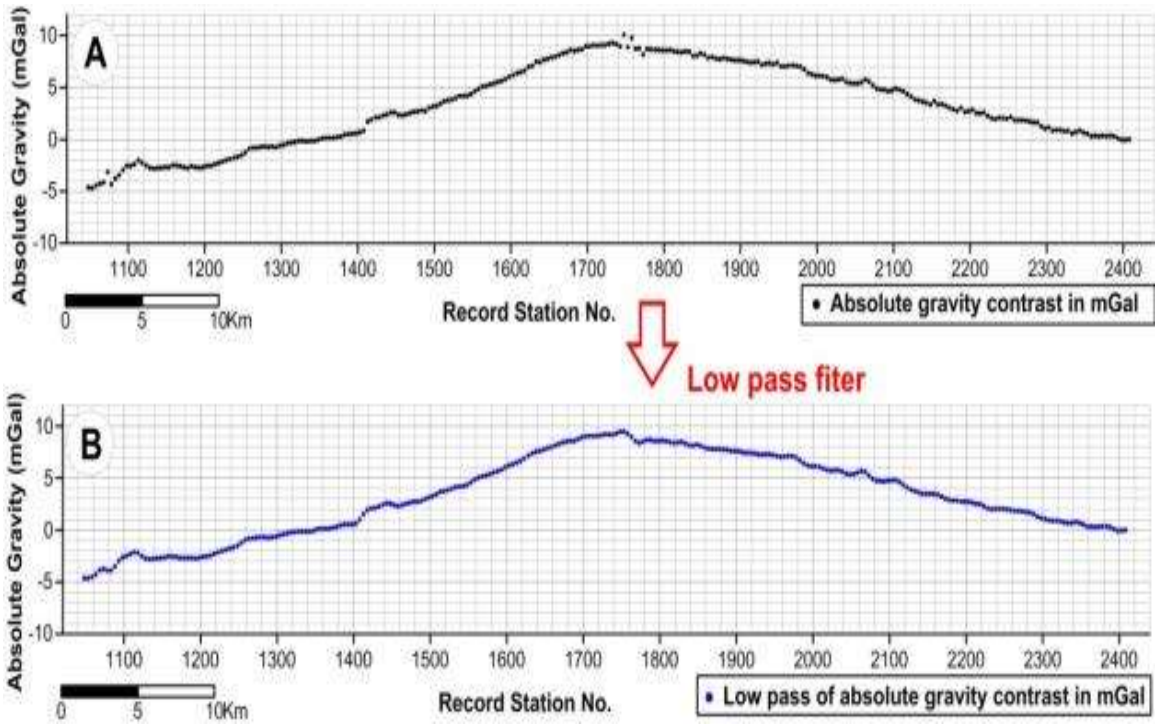

Figure 4-Applying simple low pass filter to gravity observed of datum (200m ASL), using software (GeoSoft- Oasis Montaj version 8.4). A- Profile shows some noise in start and mid of path at station. B- Profile showsremove the noise after applied simple low pass filter.

4.2 Previous Gravity Processing Data

Gravity station data gridding in a (500m) of Bouguer anomaly derived from those stations by Getech group (British Institution) in (2010), the station data are delivered in Geosoft database(.gdb) and ASCII space delimited text (.xyz) formats. Both formats contain the following table (2).

Table 2- Database and description of previous gravity station, (Getech, 2011)

Field Name	Description	Format
lon	longitude WGS84	f12.7
lat	latitude WGS84	f12.7
grav_obs	(mGal - to IGSN71)	f12.3
elevation	(m) – see elev_flag for whether measured	f11.3
grav_faa	Free air anomaly (mGal)	f9.3
grav_ba	Complete Bouguer anomaly (mGal)	f9.3
tc	Terrain correction (mGal)	f8.2
station_no	Station within camp	I10
camp_no	Camp number	I10
grav_accuracy	Gravity accuracy (mGal)	f13.2
grav_ipc_gobs	IPC observed gravity (gravity units)	f13.1
grav_ipc_ba	IPC Bouguer anomaly (gravity units)	f13.1
elev_corr_factor	(mGal/m x 10,000)	I16
elev_flag	0=measured, 1=derived from DTM	I9

After qualitative analysis of the grid derived from station data it has been give a clearer indication of the geological signals contained within the gravity data when viewed after performing grid derivatives, [11]. In current search it did cropping the Bouguer Iraqi gravity database at limit to the study area, re- projection from (Geography) to (U.T.M.) coordinate system and re- sample the cell size from (1000 * 1000) to (250 * 250), Figure- 5.

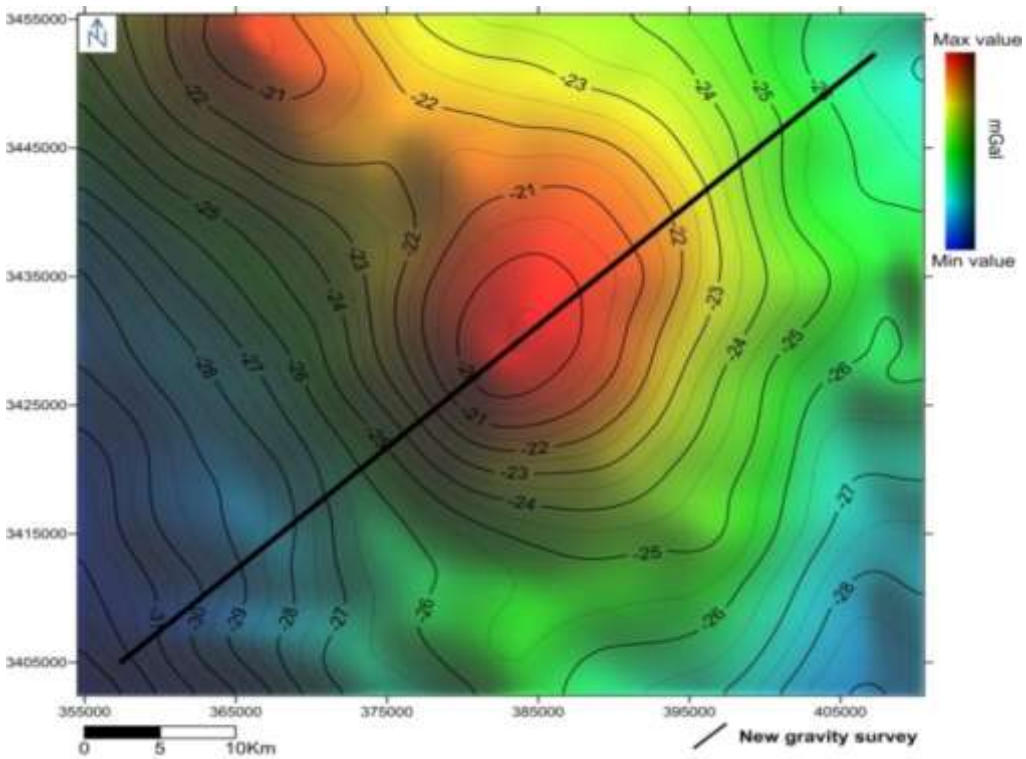

Figure 5-Gravity Bouguer map shows the positive anomaly which takes its axis N- S,the axis drift at the northwest of the study area to NW- SE , the new profile survey is passing at the dip of the general anomaly and covered it.

4.3 Calibration of the New Gravity Profile with That from Old Gravity Data

It tacked and comparing the new gravity profile (*Ngb*) with the old base station observed (*P gb*) by (IPC) in (1940s) which recorded in space interval (5 Km) on area of interest, shows low distribution due to raw base station interval (5Km). The current research been re- sample the values at the new gravity station by distance (250m) along the new profile to make the best calibration between the two profiles. Equation *(2)* applied to obtain the difference between those gradual values plus/ minus Figures-(6,7). The maximum percentage of deference found to be equal to (14%). This difference from major and minor effects; interval distance change and topography change is the major effects, the accuracy of the instrument and the person error is the minor effects.

Average of total (P gb) – Average of total (N gb) = Average of difference

(N gb)+ Average difference = Calibration new gravity value……..…… (2)

The statistical details of new gravity survey compatible with the general behavior of the previous (IPC) gravity survey, but with a detailed vision is impressed relatively somewhat anomalies that didn't appear in previous survey, these anomalies will be multiply and give details in applying the filter and divertive especially by power spectrum presentation.

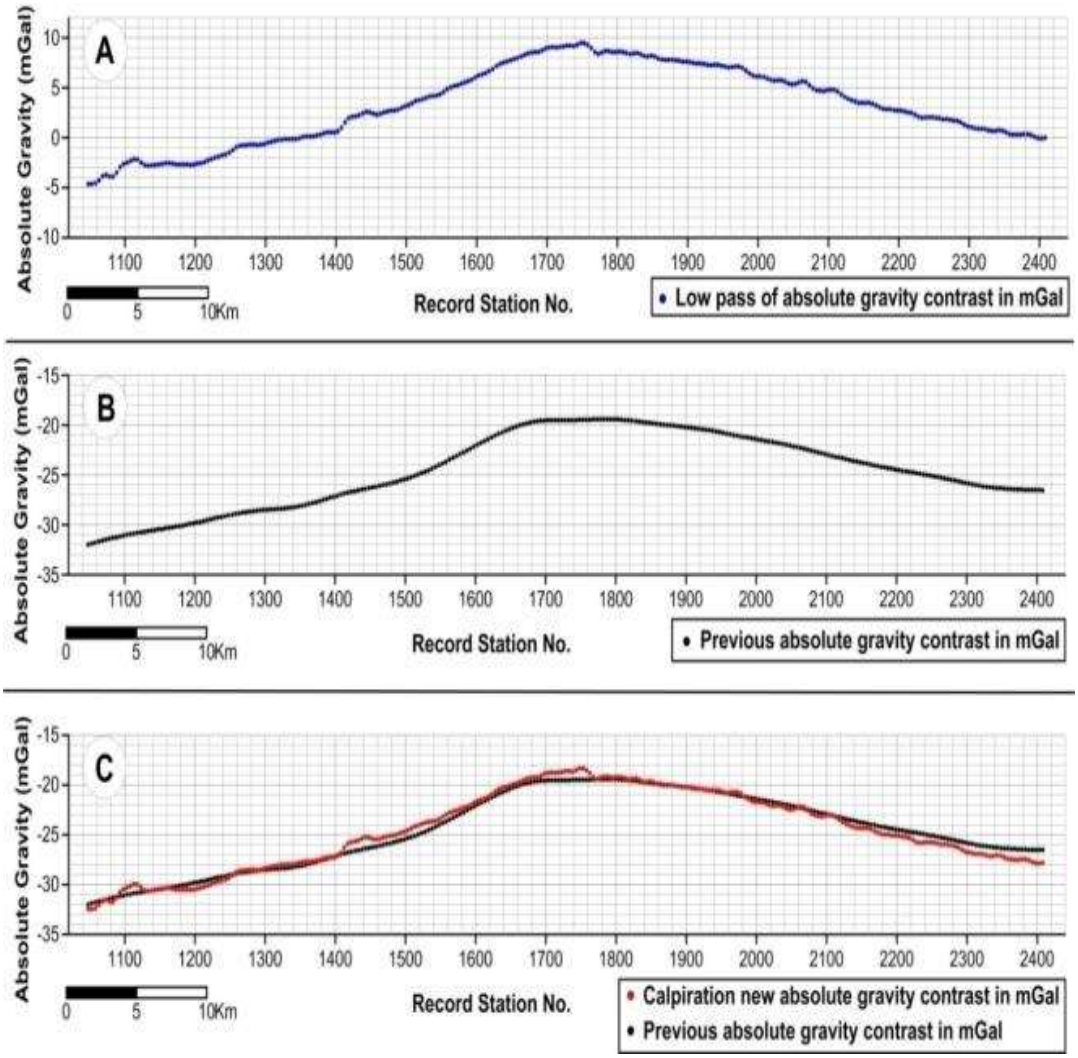

Figure 6- Shows the calibration of the gravity values between the two surveys. A- Blue profile is the new gravity values contrast, range from (-4.64 to 9.22) mGal. B- Black profile is the previous gravity values contrast, range from (-31.6 to 19.4) mGal. C- Calibration new gravity values contrast (Red profile) at the previous gravity survey.

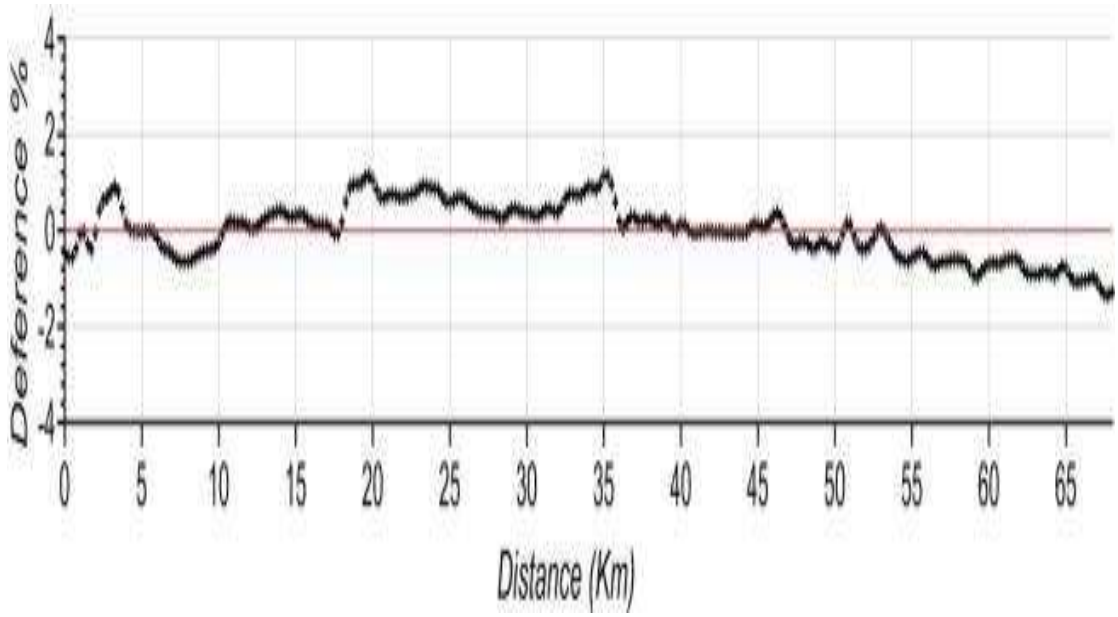

Figure 7-Shows the difference percentage between the two surveys with distance along the studied profile, which indicated that the maximum percentage is 14%.

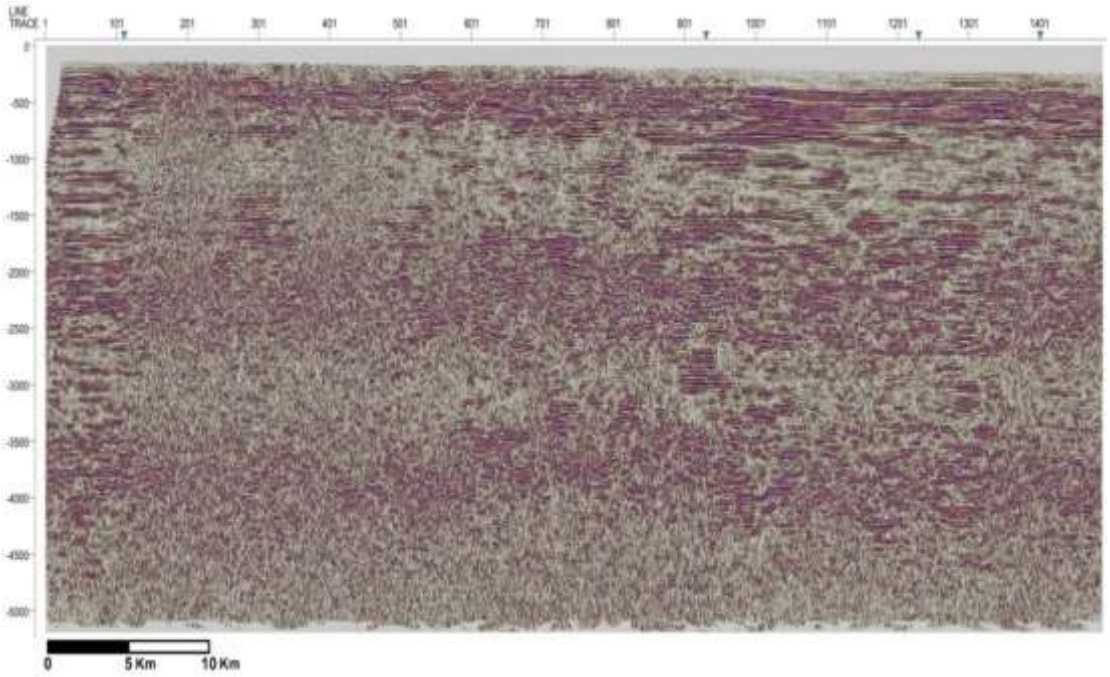

Figure 8-Previous seismic section (1979) in time domain of line 1Gn- 32 which corresponds the location of gravity survey, [8].

4. 4 Seismic Section Processing

Seismic processing sequences applied in Iraqi oil exploration using software (Omega version 2015) and exported seismic section in time domain Figure-8, the quality of the reflectors is acceptable to deteriorating in the start of the section through the shot point range (1001 to 1500) as well with the depth from (2000mSec). The quality significantly improved when compared with the previous survey in (1979) of the line (1Gn- 32) on the same font location Figure- 9.

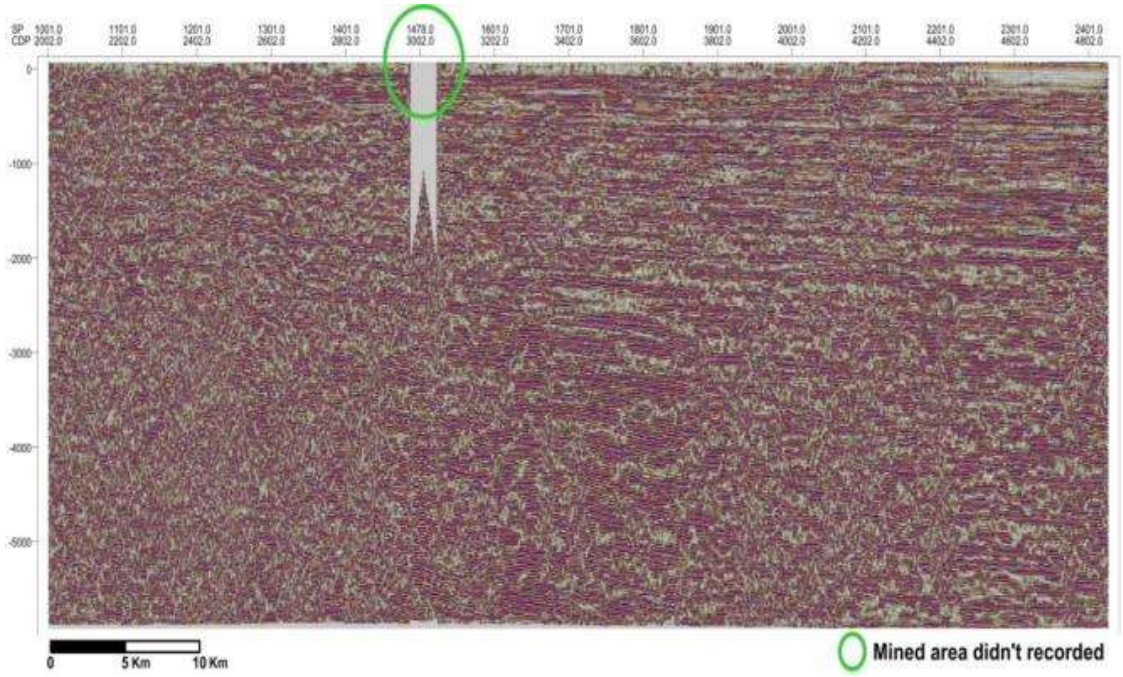

Figure 9-New seismic section in time domain of line 7Gn- 16 which coinciding with the new gravity profile survey.

The deep reflectors of the seismic section from TWT: (2000- 6000 mSec) was still bad quality and didn't recognize the general anomaly. Using an additional enhancement for integration with gravity profile in deep model, applying band pass filter by the frequency signal to noise ratio is increased, Figure-10. This kind of filter gave better determination of the features on the seismic section (7Gn-16).

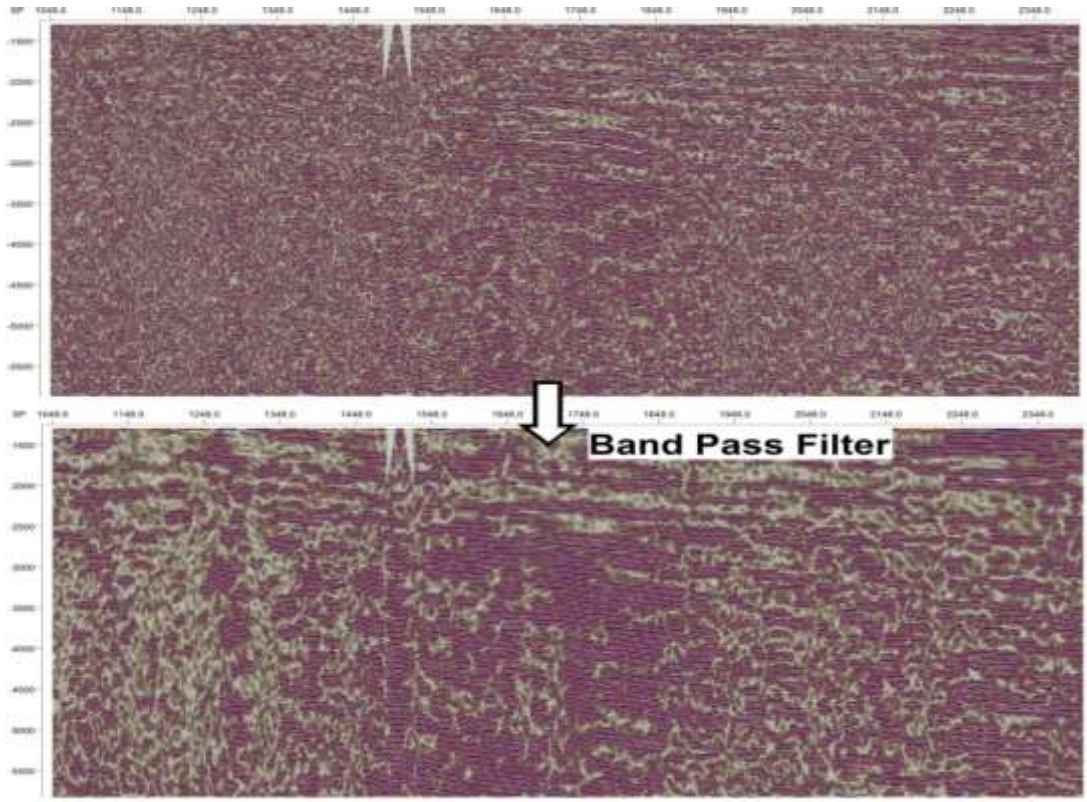

Figure 10-New Seismic section (7Gn- 16) shows the enhancement of features after applying the band pass frequency filter.

6. Data Analysis and Interpretation Considered in the Study

Executive plan of integration from data collected with their stages as field survey, processing, interpretation and supposal output model. Its basis is interpretive work experience and using software customized of geophysics interpretation. As well the theory background of each item from data is necessary to make best integration. The current study designed flow chart of geophysics integration Figure-11.

6.1 Power Spectrum Analyses of Gravity Data

Represent the gravity profile in high & low amplitude and frequency with distance, reflects the details of depth anomaly, [13]. Using *GET grid* software to input the gravity records survey and transform into two functions; Amplitude and Frequency. Taking straight trend touches the each part of spectrum curve, straight trend is the tilts of the various amplitude and frequency, each straight slices reflects depth anomaly level, the high amplitude energy with low frequency reflect deeper level and the low amplitude energy with high frequency reflect shallow level, [14]. According to this procedure; the current gravity records presents into spectral amplitude, Figure-12. Dominate anomalies effect from six depth levels interfaces; 7090m (Basement rocks), 3330m (Paleozoic), 1290m (Mesozoic), 1110m (L. Cretaceous), 373m (U. Cretaceous) and 318m (late Tertiary). Obtained through the total spectrum between slice (1110m, 373m and 318m) somewhat spike ratios to amplitude energy/ frequency due to assuming the effect of unconformity levels and/or faults systems trend, Figure-13.

In comparing the power spectrum results between the new and previous (IPC) gravity survey we find similar behavior in deep level, but did not show better anomalies details in shallow levels beside to the shallow noise effective it seems the pseudo noise, new gravity shows clear the discontinuous between the straight lines to the depth levels interfaces, Figures- (14, 15).

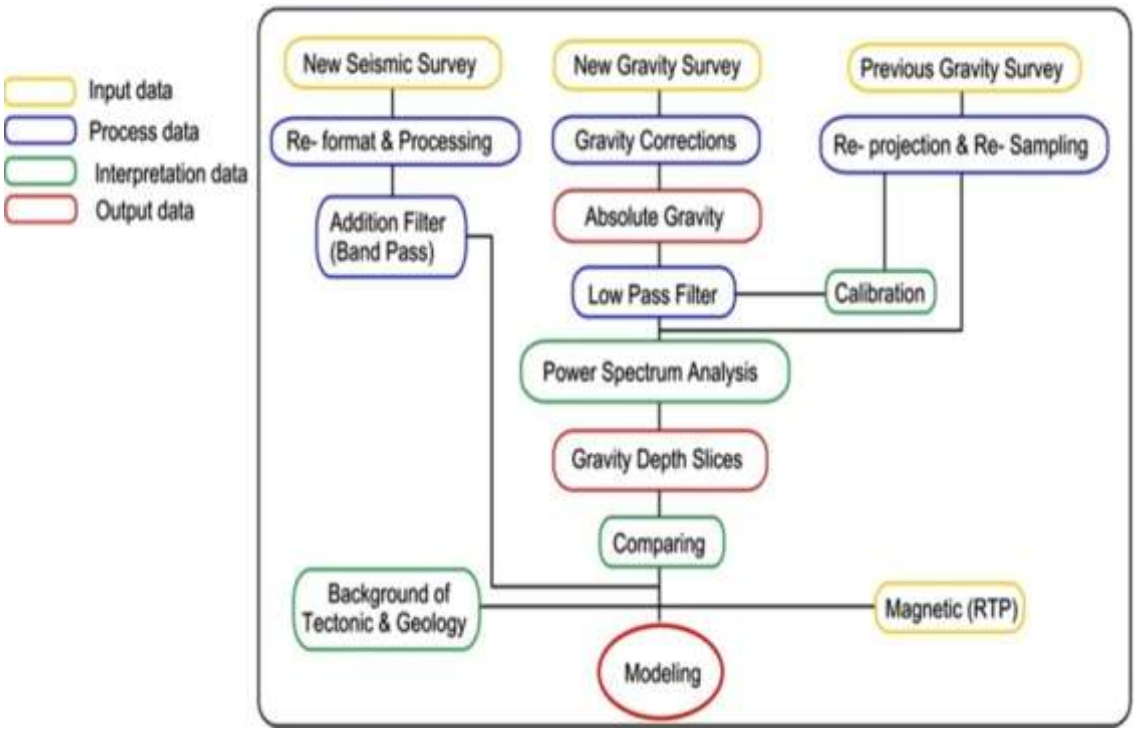

Figure 11-Flow chart of current geophysics integration based on (input data, processing, interpretation and output data).

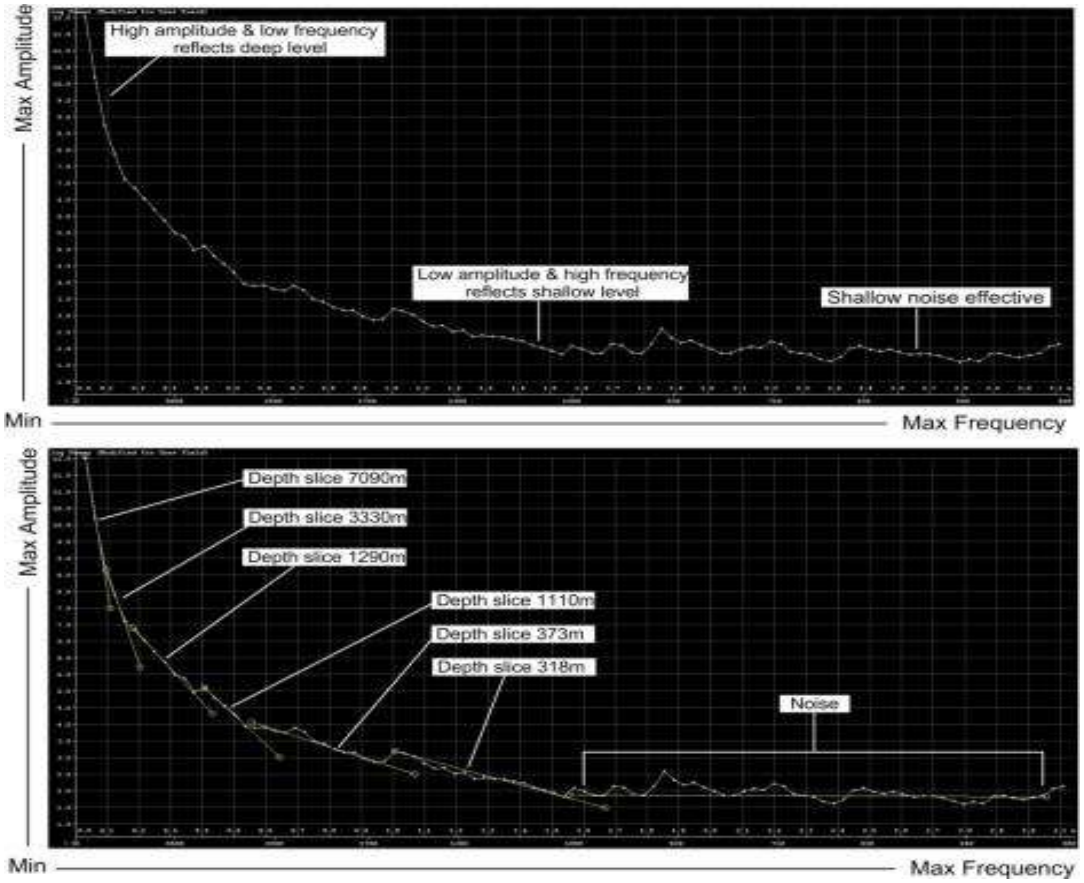

Figure 12-Power spectrum of the new gravity profile, shows the wave number of high/ low amplitude and frequency. Present in gravity depth slices levels and shallow noise effective.

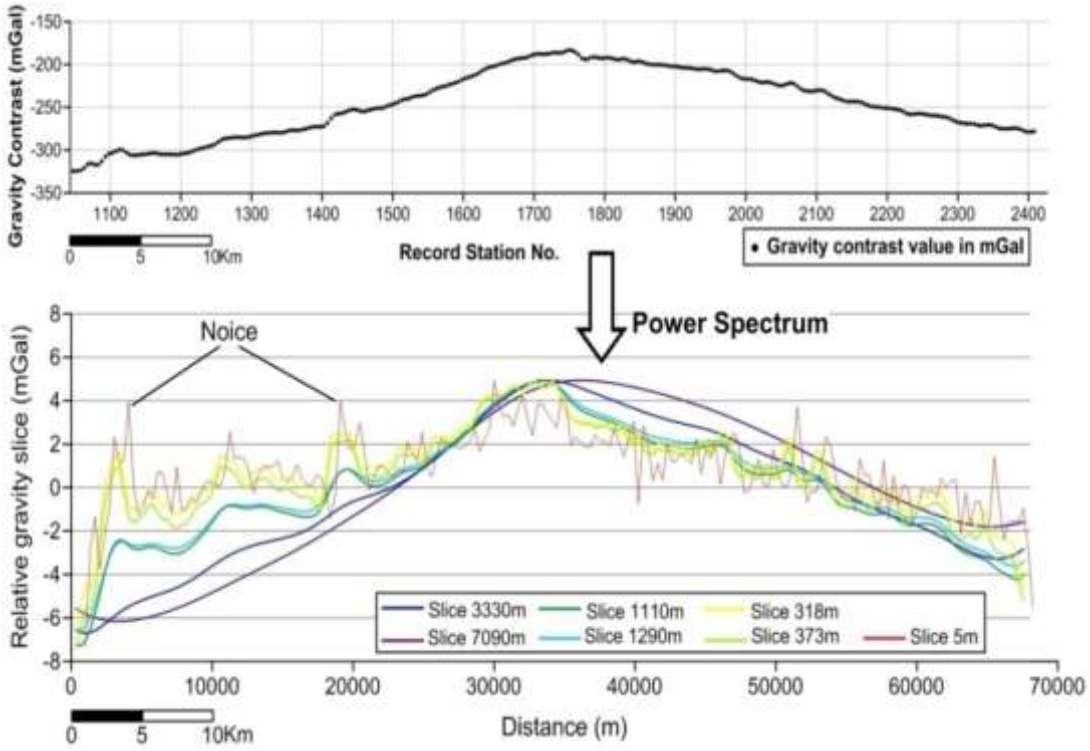

Figure 13-Showing the domination of (7) levels interference, after applying the new gravity profile in power spectrum analysis.

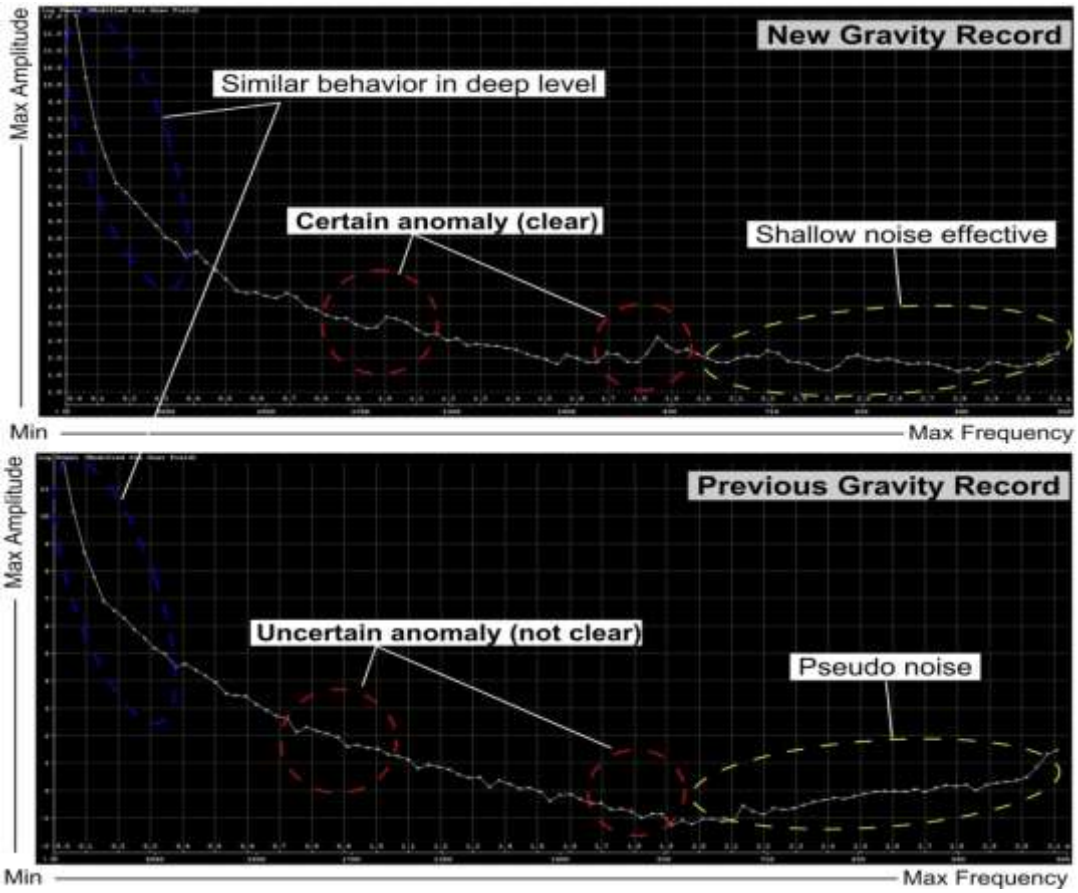

Figure 14-Comparison between the new and previous gravity profile in power spectrum domain, showing the similar behavior in deep level (indicator in blue), new gravity profile obtain better details in shallow levels (indicator in red), the shallow noise effective (indicator in yellow) seems pseudo noise in previous gravity profile.

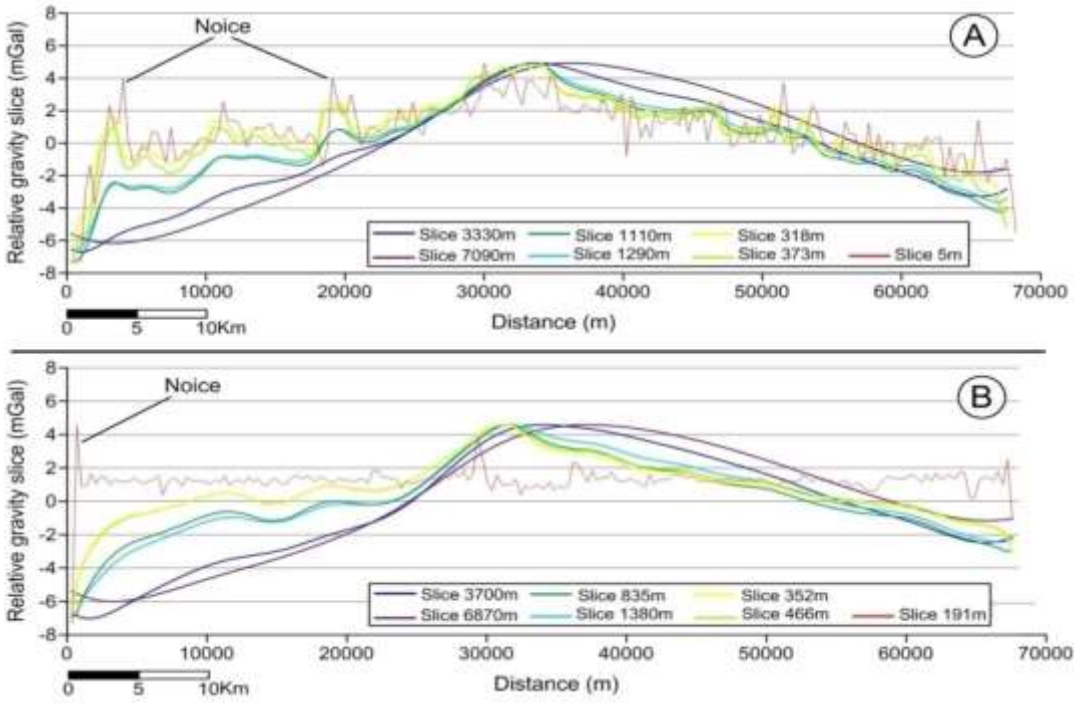

Figure 15-Compare the domination slices of new gravity (A) and previous gravity profile (B):
(A, B) are similar behavior in deep level (indicator in purple &blue curve).
(B) Shallow noise effective (indicator in light red curve) seems pseudo noise.

6.2 Deep Modeling along the Studies Profile

The gravity spectrum (higher amplitude slice), seismic section, magnetic (Reduction to pole) and tectonic geology background are the determinants of deep model supposed, [15]. Based on the background of structural geology in study area it's create the proposal depth and density of Moho discontinuity, lower crust, basement rock and sedimentary cover of geological formations. The weight of Moho level around (32Km) depth and (0.3 g/cm^3) density relatively to levels above it which proposal is be (3.00 g/cm^3) density. Applying fitness of the Moho level with gravity observe curve by change carefully of the lateral depth adjustments to gravity curve with the least percentage error. The rock basement did match with magnetic (RTP) and gravity profiles, the magnetic susceptibility supposedly about (0.02 cgs) and the density is (2.8 gm/cm3). The model required creating simple blocks vertically in deepest levels to dividing the density rocks that is almost compatible with gravity observed and enhancement of percentage error. It's compared with deep seismic reflector section after filtered in band pass frequency which shows the respect with continuity of reflectors. It's presented generally; the higher reflectivity strength in mid of the section relatively with its sides, refers the contrast relatively of higher density (3.1 g/cm^3) and magnetic susceptibility (0.022 nT), that interpret the higher gravity anomaly recorded, Figure-16.

The current supposed deep model where located at the new gravity profile, is proportional and/ or updating the theoretical of regional extension to the buried Precambrian basement model in Iraq (Figure-17), which signature based to magnetic and gravity traced and due the presence of thick highly magnetic Ophiolites and syn- tectonic gabbro, [16].

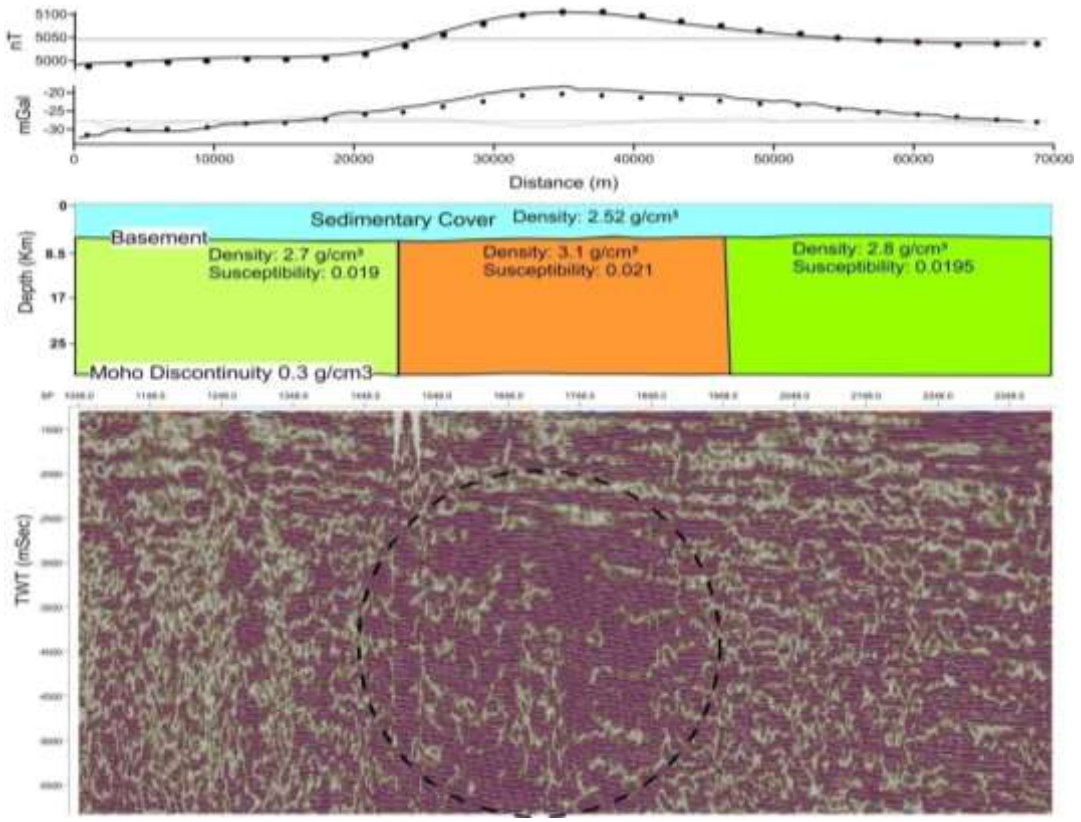

Figure 16-Supposed simple deep modeling at Moho discontinuity comparing with seismic section filtered (Band pass), shows the effective of higher gravity & magnetic anomaly due to higher density and magnetic sensitivity in deep level.

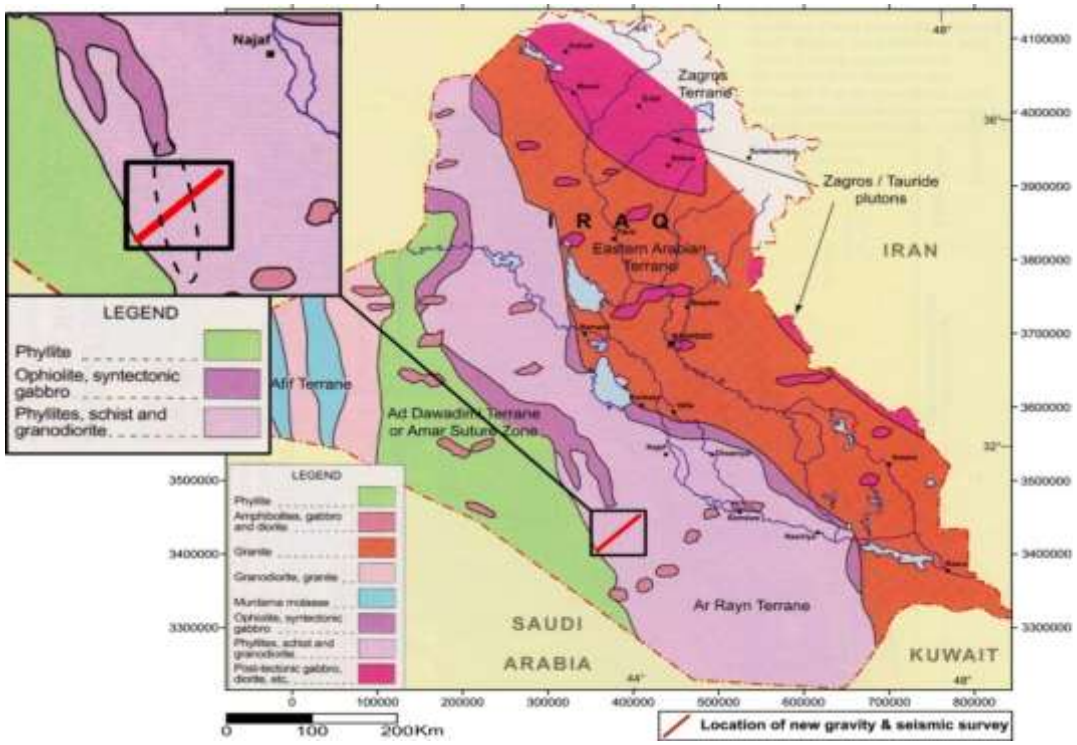

Figure 17-Showing the profile model crossing the supposed extension of the buried Precambrian basement due the presence of thick highly magnetic Ophiolites at the study area, *(Modify after Jassim and Goff, 2006).*

7. Conclusions

1- The current study concern with a comparison between the new gravity survey with the oldgravity data, shows a slight difference around (14%). The statistical details of new gravity survey compatible with the general behavior of the previous (IPC) gravity survey, but with a details division is impressed relatively somewhat anomalies in the southwest part that didn't appear in previous survey.

2- As well a new seismic section survey (7Gn- 16) achieved along the gravity profile, which showed better enhancement in the reflectors quality and continuity than the previous (1Gn-32 which is carried out in 1979), this is due to improved the survey parameters and develop of registered equipment.

3- The power spectrum which is used to analysis the main six underlying levels that reflect the dominant gravity anomaly levels (not to estimate the depth values directly).These levels shows somewhat the unconformity contact, proposal in between (U. Cretaceous – L. Tertiary) and between (U. Eocene – L. Paleocene), which is not clear through the previous gravity observes (IPC). As well power spectrum obtains the matching between the new gravity profile and the previous profile will be in deepest levels from (~ 3000m to ~ 7000m).

4- Ghulaissan-1 well which drilled in (1960) on the positive gravity and magnetic anomaly, considered as on anticline structure in sub surface. It did not indicate any hydrocarbon shows after drilling. The current integration geophysical data shows that positive anomaly appear in gravity and magnetic maps may be result from thick highly Ophiolites and syn- tectonic gabbro, which is an extension to the Ophiolites body northward, according (Geology of Iraq) the study area which mention by (*Jassim and Goff, 2006*).

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