Mapping of Ancient River Courses by Remote Sensing Techniques and Geophysical Investigation in Northern Arabian Gulf Region

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Abstract

The Northern Arabian Gulf region is important because it have many morphological and landscape, the most important of these landscape are the rivers. So, the present study applied satellite imagery integrating with sub bottom profilers survey to analysis and detect paleoachannel courses for many river and lagoons (Khors) in this region, includes Khor Al-Zubair , Khor Shaitana, Khor Abdulla and Shatt Al-Arab river.

Satellite imagery analysis revealed of many traces of discontinued ancient river streams such as Al-Fayeed and Al-Ma'aqel, as well as many ancient courses of presented rivers such as Euphrates, Tigris and Bahamshir. These results were confirmed by sub bottom profilers results which completed in some river channels and that revealed many buried old channels underneath the current river bottoms. Analysis all method depicted that most of these water system sites are exposed to neotectonic indicators affected on the region in

general.These morphotectonic activity impacted on the alteration and

discontinuity of the river courses in the area under study.From the present study, it seems that the subsidence process is predominant in the region, particularly in the eastern part, and in order to reach a state of equilibrium, this was accompanied by locally uplifting sub-surface structures in Nahr Umr, Al- Zubair, Siba, and Sanam plug sites, as well as the proposed sites between Shatt Al-Arab and Bahamshir rivers.

Keywards: Ancient River Courses; Remote Sensing; Sub Bottom Profilers

الكشف عن مجاري الانهار القديمة بأستخدام تقنيات الاستشعار عن بعد والتحريات الجيوفيزيائية لمنطقة شمال الخليج العربي

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المستخلص

تمتلك منطقة شمال الخليج العربي أهمية كبيرة لأنها تحتوي على العديد من الخصائص المورفولوجية والمظاهر لطبيعية المميزة، وتمثل الأنهار أهم تلك المظاهر. تتضمن الدراسة الحالية تطبيق تقنيات معالجة وتحليل الصور الفضائية بالتكامل مع المسوحات الجيوفيزيائية البحرية متمثلة بتقنية رسم المقاطع للقيعان (Sub Bottom Profiler) للكشف عن المجاري النهرية والقنوات القديمة في عدة مواقع تشمل مناطق خور الزبير وخور عبد الله وشط العرب وما حولها .

أظهرت نتائج معالجة وتحليل الصور الفضائية عن العديد من مجاري الأنهار القديمة المندثرة مثل انهار الفيض غرب منطقة الدراسة والمعقل في الجزء الوسطي من المنطقة، فضلا عن العديد من القنوات القديمة المتغيرة للأنهار الحالية مثل الفرات ودجلة وبهمشير في الجانب الايراني. وأكدت هذه النتائج بتقنية رسم المقاطع للقيعان التي أنجزت في بعض القنوات النهرية والتي كشفت عن العديد من القنوات القديمة المدفونة تحت قيعان الأنهار الحالية. وبينت النتائج تأثر المنطقة بالانشطة التكتونية الحديثة والتي سببت بدورها الى انقطاع وتغير العديد من مجاري الانهار في المنطقة قيد الدراسة. ويبدو ان التأثير التكتوني السائد يتمثل بعملية الهبوط ، لا سيما في الجزء الشرقي من المنطقة، وبغية التوصل إلى حالة من التوازن، صاحب ذلك حدوث عملية رفع محلية لعدد من التراكيب الجيولوجية تحت السطحية في مناطق نهر عمر والزبير والسيبة ، وجبل سنام ، فضلا عن التراكيب الجيولوجية تحت السطحية المحتملة بين نهري شط العرب وبهمشير.

Introduction:

The discontiuity and migration of river channels with the time are a significant mechanism which changes the geomorphological of the river channels. Many recent geological indications refer to that the Northern Arabian Gulf region is influenced by neotectonics activation, these processes affected on the presence of the subsurface geological structures that influenced later on the changing of the river courses and interruption to some ancient courses (Al- Sakini, 1986 ; Al-Sakini, 1993; Jassim and Goff, 2006; Al-Hawi, 2014; Al-Kubaisi and Hussein, 2014). River channel migration phenomenon is well recognized in the low elevation areas of the delta plain, particularly in the area covered by diversified sediments (Al-Azzawi, 1996; Al-Mulla, 2005).

Because of the large thickness of the sedimentary column in the region, the impact of this activation on the surface it may not be obvious and cannot be traced using only one technique. But the integration of information that can be obtained from many techniques be more significant and gives more detail results about the effect of this activation, especially if these techniques are applied in the river systems, which consider sensitive to any variations which caused by tectonic effects where it are closely associated with active structures (Holbrook and Schumm,1999), which in turn are responsible for changings in channel morphology, hydrological characteristics and fluvial processes of a river system (Vikrant and Sinha, 2005). So, the present study aims to redraw the ancient river channels with a new vision using the recent satellite images and confirm it by

geophysical information using Sub Bottom Profilers technique (SBP) .

The study area:

The study area is located in the Northern Arabian Gulf region between Latitude (29° 50´00" N- 31°0´0" N) and Longitude (47° 20´0" E- 48° 45´ 00" E), figure (1). It is considered a part of the Mesopotamia Plain (Buday and Jassim ,1987), and within Inner Platform and Mesopotamia Foredeep according of (Fouad, 2015). it is distinguished by low elevation, not exceeding a maximum height of 3m above sea level (Al-Mulla, 2005) . The Quaternary sediment extends to cover most of the study area, it is characterized by the presence of some prominent geomorphological features such as rivers, such as Shatt Al-Arab and Bahmshir rivers, the flood plains ,sabkha as well as the tidal flats covering the Khor Al-Zubair area and the Arabian Gulf coasts (yacob , 2011).

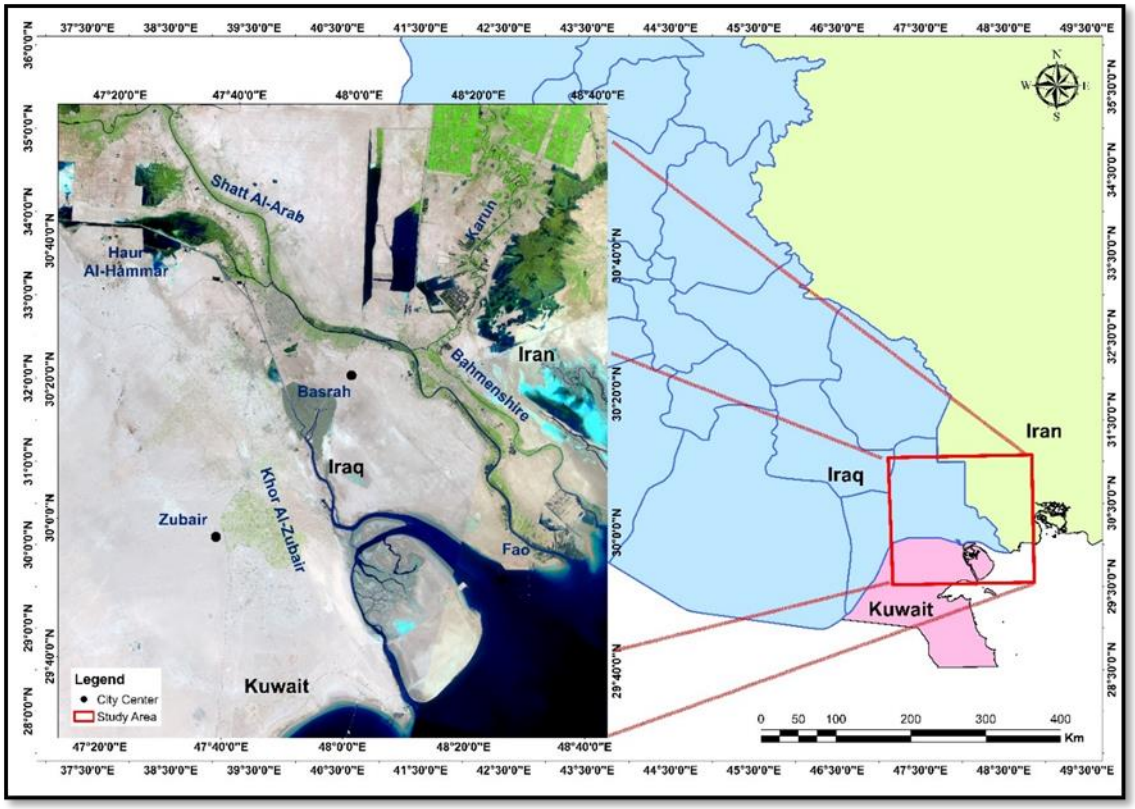

Figure (1) . Oli Landsat stallite Image (2017), shows the study area.

Methods :

To achieve the objective of this study, many different satellite images are used to verify the extensions of the old river channels. Quickbird Satellite images used high-resolution reached to 0.6m, planet satellite images have resolution of 3.125 m, the sentinal-2 satellites images of resolution 10 m, and free Landsat MSS, TM, ETM+ and OLI scenes with spatial resolutions 30 meters which have been taken in period 2017 and 1973. The Image enhancements techniques have been made in the bands of satellites images such as radiometric enhancements (Histogram Equalization and Brightness Inversion) Spectral Enhancements (RGBI Shaded Relief Image, IHS to RGB and bands combinations) and Spatial Enhancement (Convolution) using Erdas Imaging 2014 software and anlyzing these images by Arc map 10.2 software. To acquire detailed results and proving the derived results from the digital analysis of satellite images, marine geophysical survey is carried out using SBP technique. SBP is an acoustic investigation technique that maps the sub-bottom by attaching the probe (transducer) to a boat and dragging it through the water. The acoustic pulses generated may be described as a single-beam, the acoustic pulse travels through the water column at a rate determined by water temperature, suspended material concentration, salinity, and penetrates the sea-floor, figure (2).

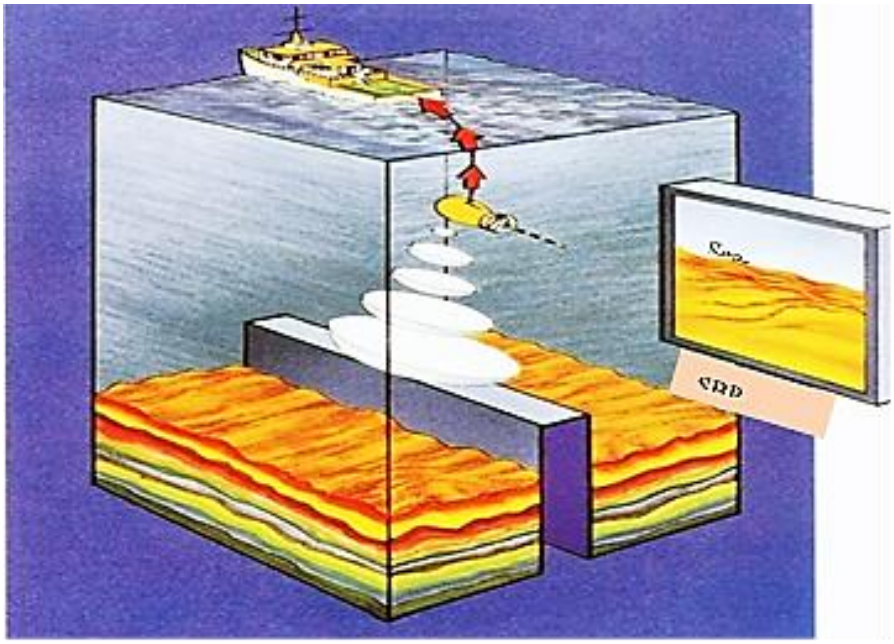

Figure (2). Deployment of sub bottom profiling system.

Seven of SBP transverse profilers were carried out by 10 kHz of Strata Box transducer in eight stations over the study area, one transverse profilers is selected in Khor Abdulaah, as well

as one longitudinal profiler is also completed in west of the study area (Khor Al-Zubair), figure (3). Table (1) illustrates the numbers and coordinates station, with the lengths and locations of the SPB profilers.

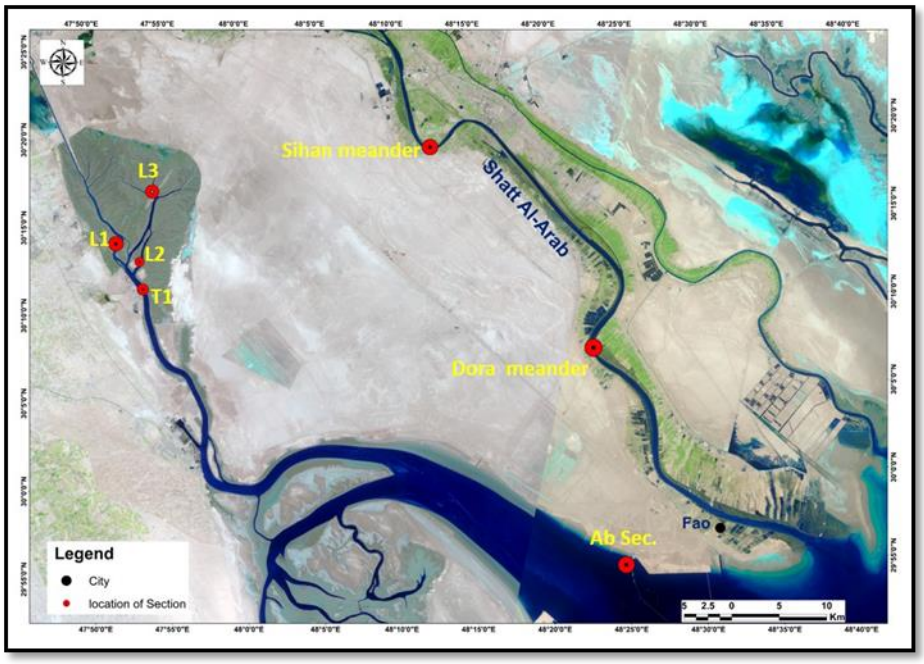

Figure (3): Map of the study area for the stations of SBP profilers.

Table (1). The stations, locations, lengths and their coordinates that are done by SBP profilers and selected GPR profilers.

St.	Site	Length(m)	Coordinates	
SBP profilers				
1	Tributary of Khor Al-Zubair (L3)	1200	3353471.77 m N	780033.48 m E
2	longitudinal profiler in tributary of Khor Al-Zubair(L2)	1800	3345829.44 m N	776924.77 m E

3	Khor Al-Zubair channel vicinity of Khor Al-Zubair port(T1)	550 m	3344350.72 m N	777624.59 m E
4	Tributary of Khor Al-Zubair (L1)	1100	3346942.56 m N	775521.72 m E
5	Inlet of Khor Abdullah (Ab)	4000	3306187.00 m N	256149.00 m E
6	Sihan meander	280	3356982.00 m N	231953.00 m E
7	Doraa meander	305	3335022.78 m N	247671.33 m E

Results and Discussion :

The image processing and the analysis techniques are used to develop the interpretation of the images, and to extract prospective information from the satellite images. Appropriate processing techniques are used to achieve the aims of the current study. Some common procedures have utilized to recognize and to identify the significant features from the satellite images. In this study, enhancement techniques were used by ERDAS IMAGINE software, in order to access for the optimal interpretation of all the morphotectonic and other terrestrial features under investigation.

Satellite imagery analysis revealed of many traces of discontinued ancient river streams such as Al-Fayeed and Al-Ma'aqel, as well as many ancient courses of presented rivers such as Euphrates, Tigris and Bahamshir. These results were confirmed by sub bottom profilers results which completed in some river channels and that revealed many buried old channels underneath the current river bottoms.

The figures (4,5,6,7,8) show the ancient rivers courses West the Study Area (Euphrates, Abo Al-Khaseeb, Al-Fayeed and Al- Ma'aqel) .

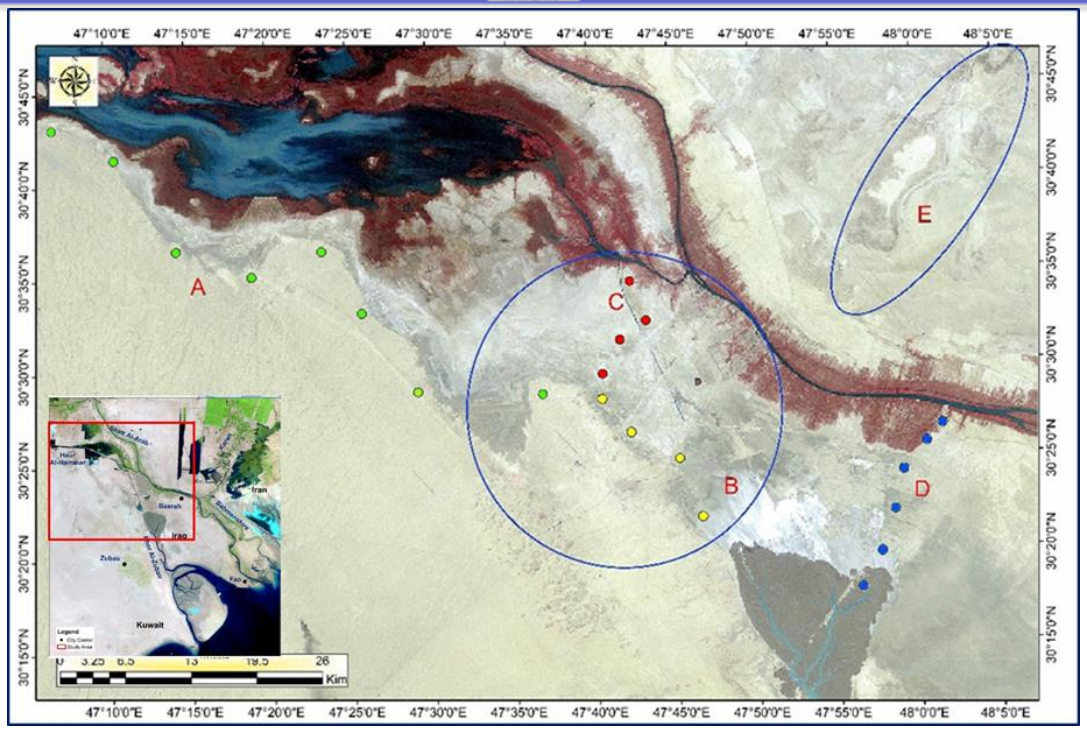

Figure (4): MSS Landsat 1973, layer stack (432), shows clearly the traces of the old Basra channels. A old Euphrates, B, Al-Fayeed, C, Ma'aqel, D , Abo-Al-Khasib .E, The old channels.

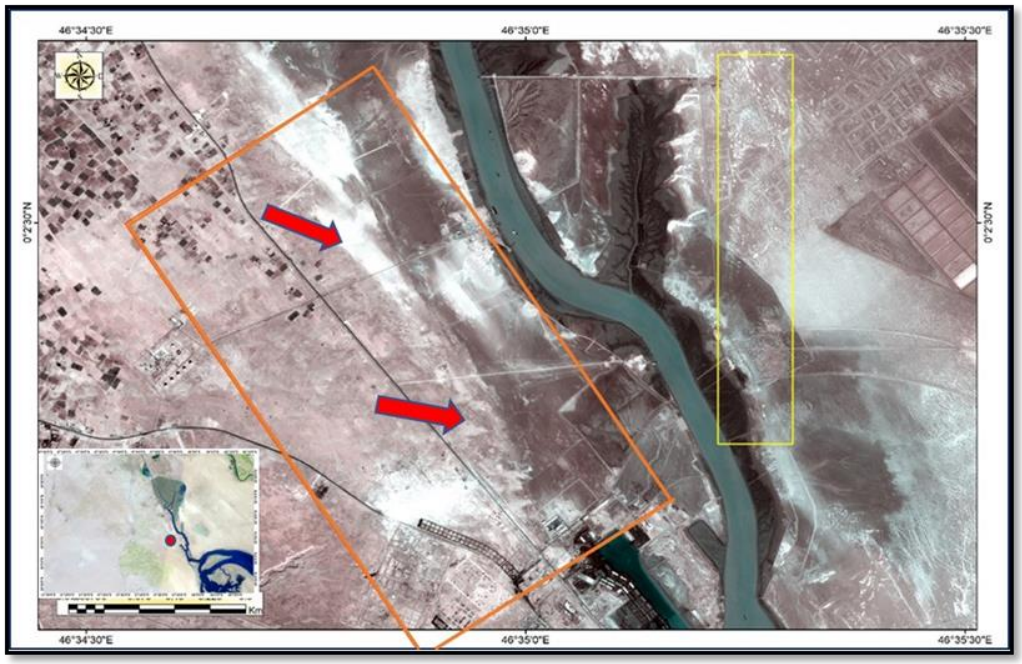

Figure (5). Sentinel satellite (345 bands), illustrates the old Euphrates estuary near Um Qasir in the left, and buried channels into Khor Al-Zubair in the right.

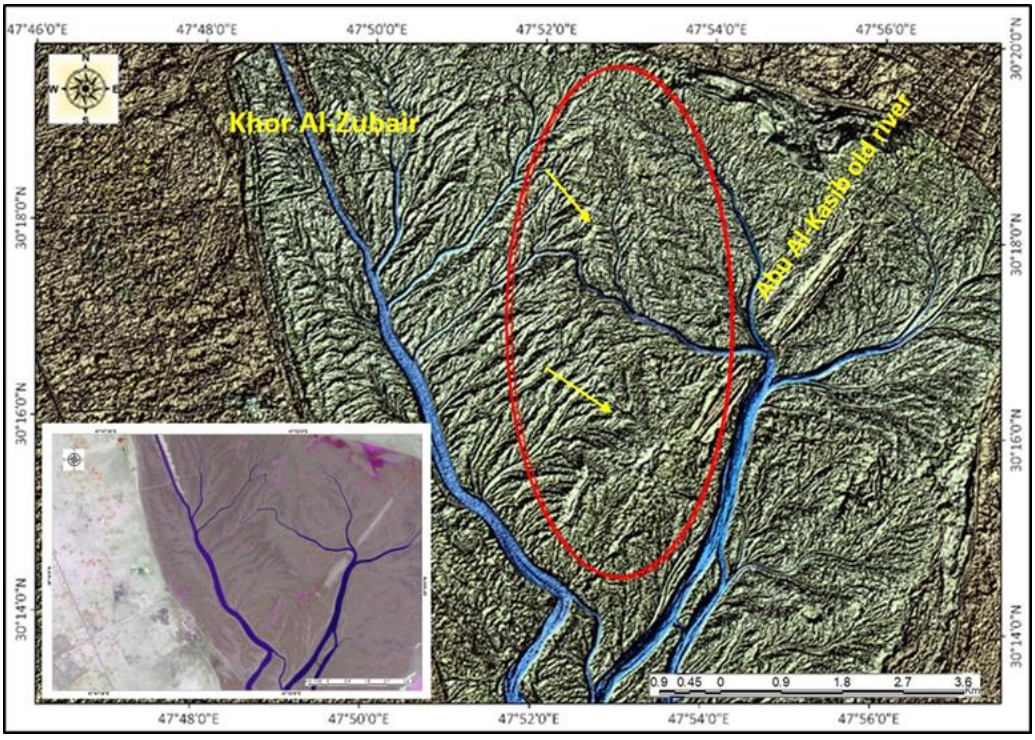

Figure (6). Applying the RGBI Shaded Relief Technique in sentinel 2 MSI satellite Image to clarify unknown eroded features beneath the tidal drainage basin of Khor Al -Zubair

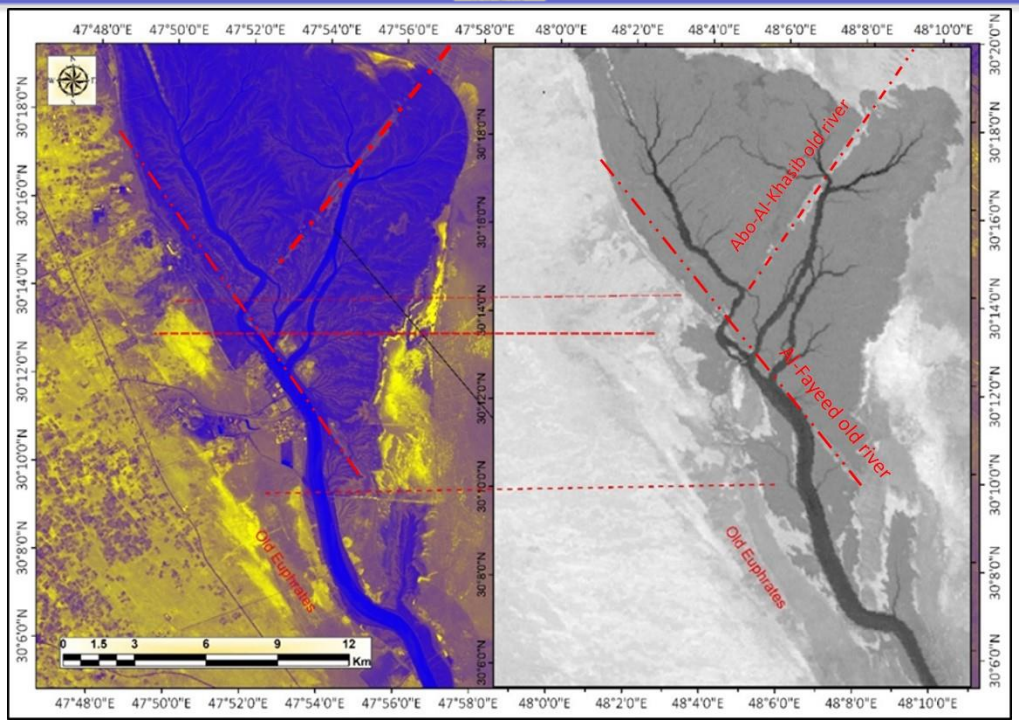

Figure (7). IHS to RGB clarify the old Euphrates Channels migration , Abo-Al-Khaseeb Old River, and Al-Fayeed Old River

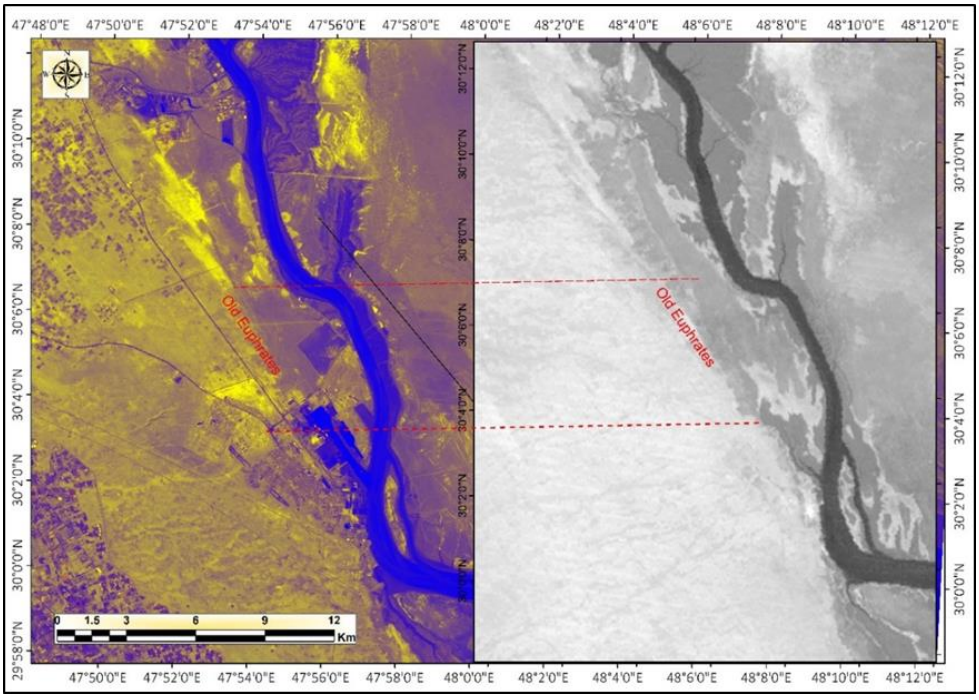

Figure (8). IHS to RGB clarify the old Euphrates Channels migration and flows to northern Arabian Gulf Compared with the Landsat MSS satellite image of 1973.

During the period of neotectonics activity, which occurred in Khor Al-Zubair area and after period marine regression before 3750 years, the region exposed to a tectonic activity led to exist of many subsurface structures such as , Al-Zubair and Al- Rumaila anticlines, these structures were affected by uplift movement led to an increase relative uplifting in the anticline arises and limbs of these structures (Karim, 1998; Al-Hawi, 2014). Where the course of the Euphrates river passes through those areas, the rise of the river bottom and its low slope, led to an increase in the sedimentation rate at the bottom and thus increase the height of the bottom and the lack of drainage. This result to shifting of Euphrates River toward the east (figures 7,8) and joined finally with Tigris River then discontinuity of the old Euphrates River in the area between Hour Al- Hummar and Khor Al-Zubair (Al-Mussawy, 1993) . The same case is happened to the old Abu Khaseeb, Al -Fayeed and Ma'aqel rivers (figures 4 ,6), this led to the change of Khor Al-Zubair from estuary to a longitudinal lake (Al-Katib, 1971; AL-Sakini,1986), (figure 5). In the (figurs 9,10,11,12) it can be shown the ancient river courses in the east of the study area (Tigris and Bahamshir rivers).

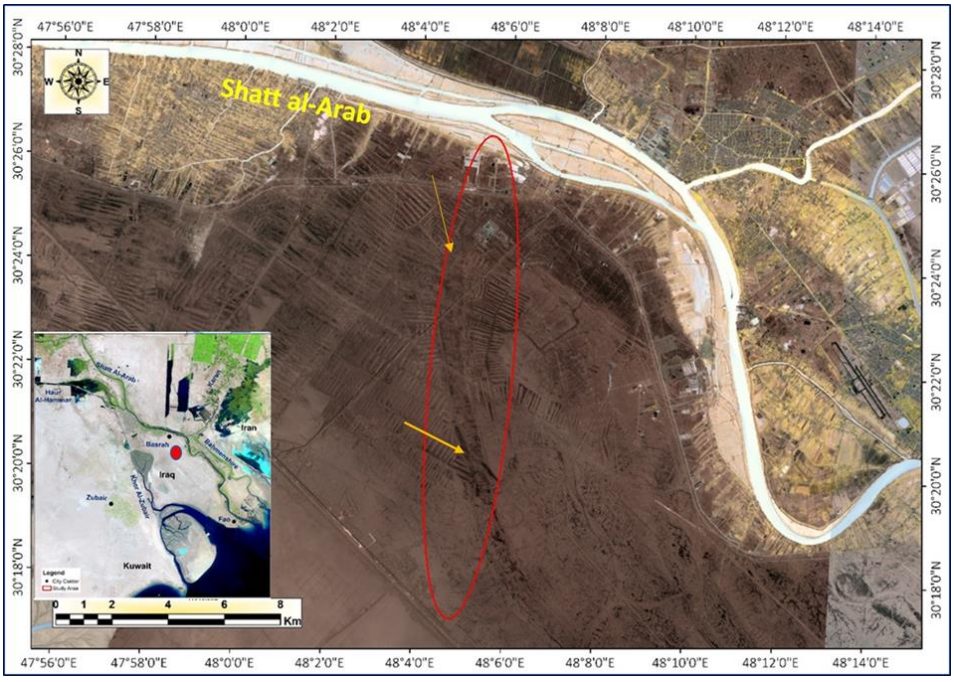

Figure (9) : OLI Landsat shows the main successive migrations of the old Tigris channels to the eastward.

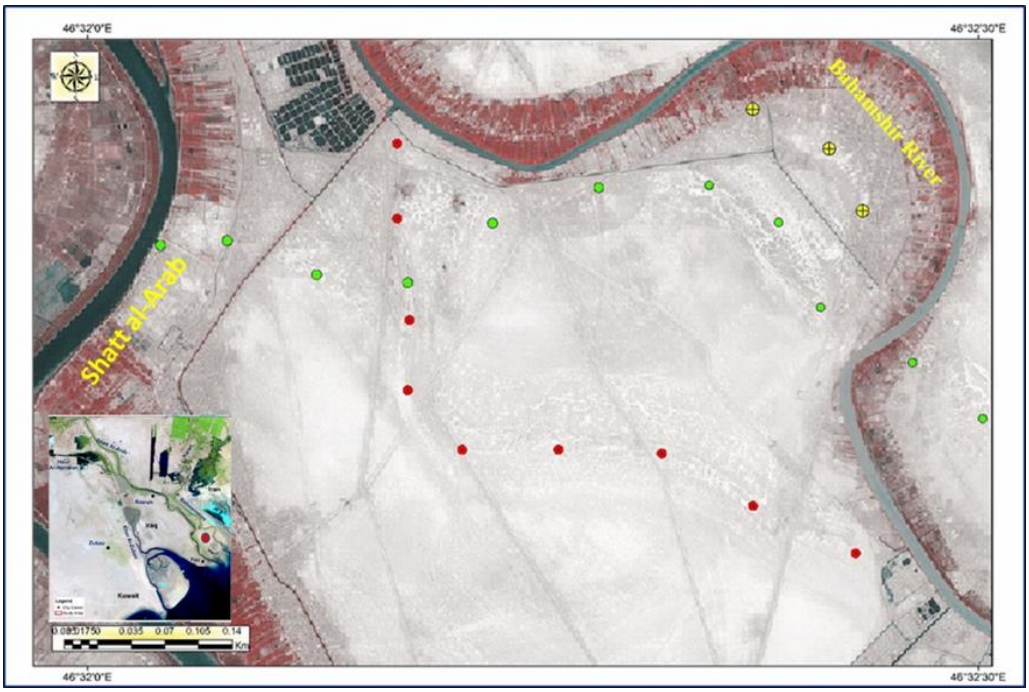

Figure (10): Shaded map of RGB, OLI Landsat shows the successive migrations of old Tigris channels beneath the sediments of the Sabkha.

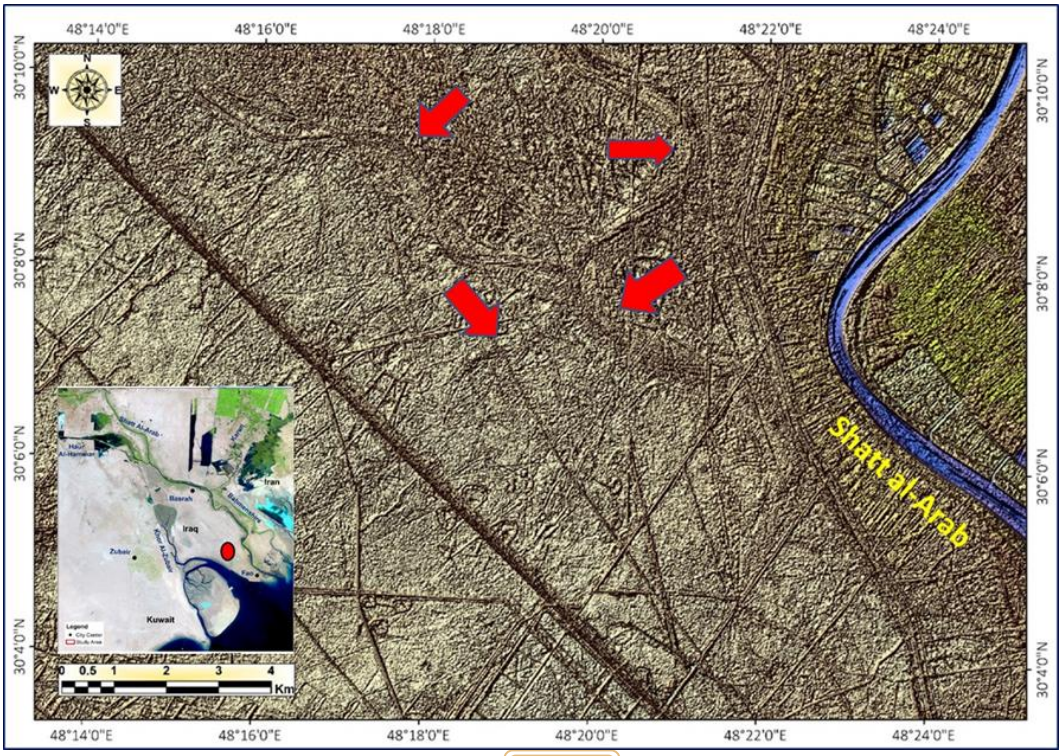

Figure (11). Sentinel satellite image (567 bands) shows the migration of Bahamshir River channel to the eastward in the Iranian side

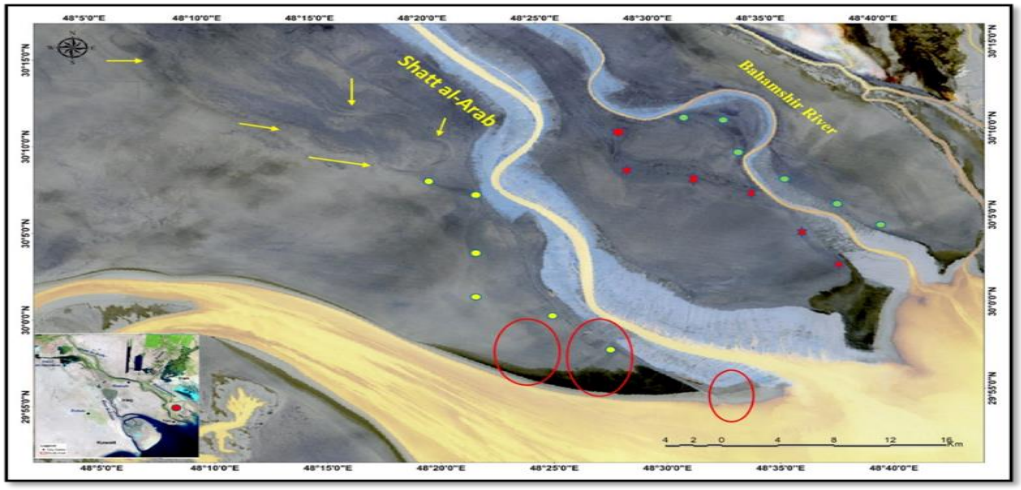

Figure (12). MSS Landsat 1973, shows the old Tigris and Bahamshir rivers with their estuaries.

The historical sources indicated that many sub-rivers and tributaries were established for using in agricultural purposes in the west of the Shatt Al-Arab area at the beginning of the Islamic period,these channels fed water from the Tigris, which was called the Tigris Al-Awara (Shatt Al-Arab now) (Al-Katib, 1971; AL-Sakini,1993), so the hydrogeometric changes of Tigris river in this area due to tectonic uplift of the Siba structure coused exsit of some islands in the channel of Shatt Al-Arab.Moreover, local uplift movements of the subsurface anticlinal structures results in dryness and discontinuity of many old river channels (fig.7, 8). The shifting toward the east not appears in Tigris river in the Iraqi side just, but also in Bahamshir River in the Iranian side (figure. 11), and this change includes their esturites also.

To detection the ancient channels by geophysical sections, SBP sections were depicted the existence of ancient channels buried under and in the bottom of Khor Al-Zubair, such as the old Al-Fayeed river, a tributary in Khor Al-Zubair channel and the old Abo Al-Khaseeb river (fig. 13, 14, 15).

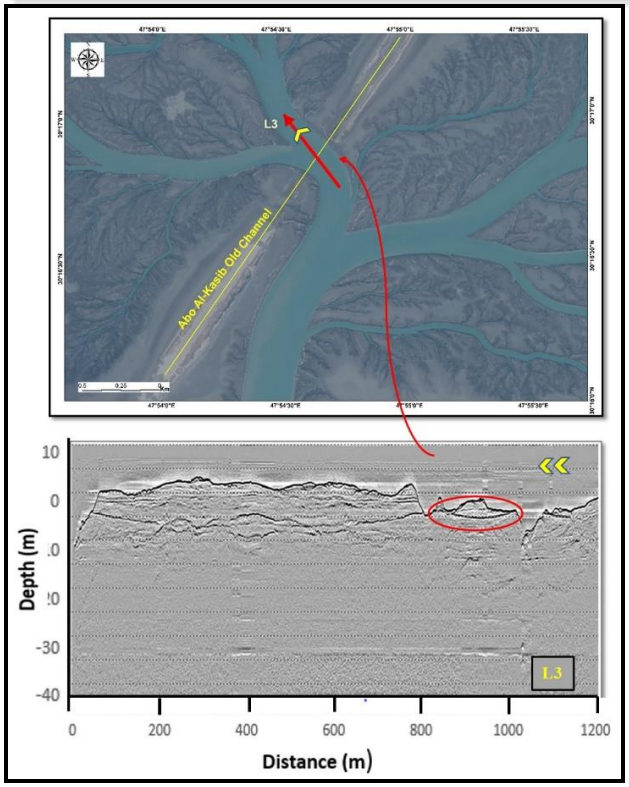

Figure (13). SBP section (L3) depicts the trace of the old Abo Al-Khasib river in the bottom of Khor Al-Zubair channel of Khor Al-Zubair

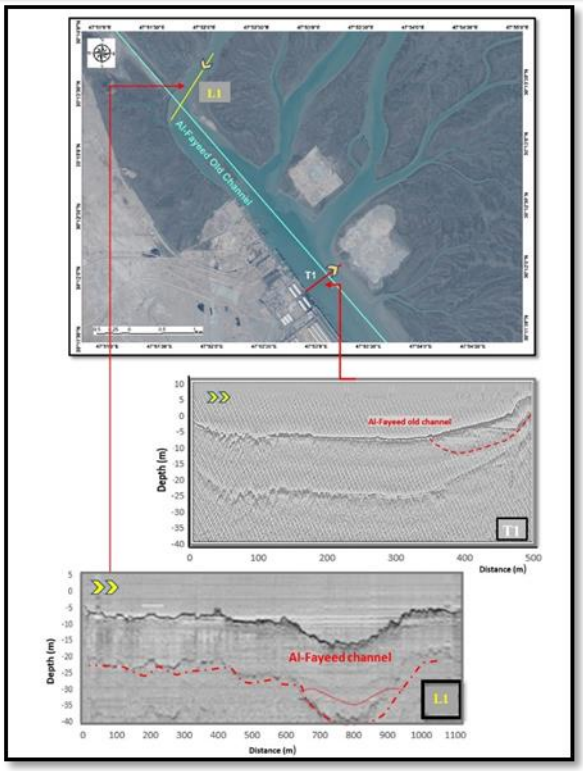

Figure (14). SBP section depicts the trace of the old Al- Fayeed river is buried under the bottom of Khor Al-Zubair

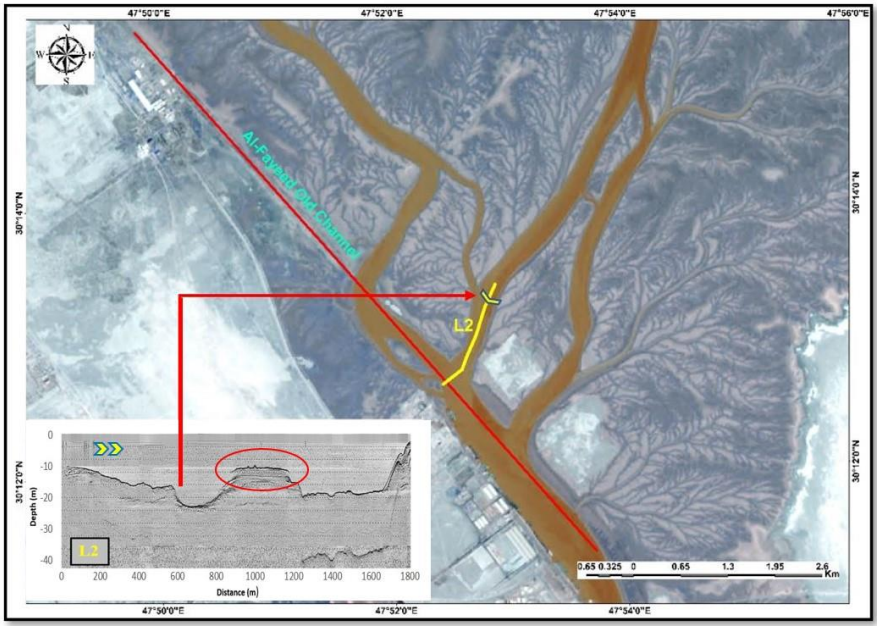

Figure (15). Longitudinal SBP section (L2) shows the trace of the old Al- Fayeed river and a tributary in Khor Al- Zubair channel.

SBP section of Khor Abdullah appeared there is a buried channel underneath the the Khor's bottom, this channel represents the old Tigris estuary into Khor Abdullah northern Arabian Gulf (fig.16)

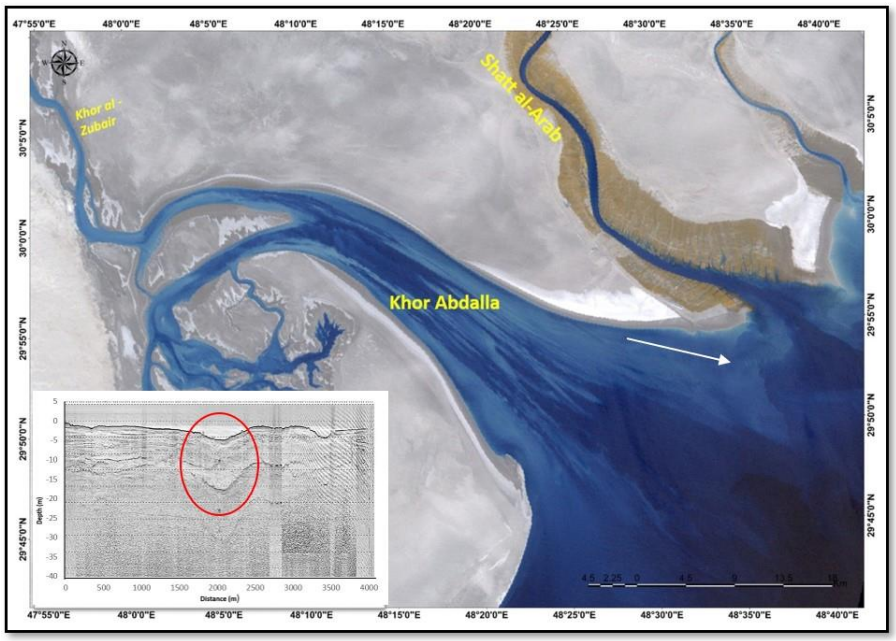

Figure (16). SBP section shows the old Tigris estuary into Khor Abdullah.

By making an analysis of SBP sections of Shatt Al-Arab in Sihan and Doraa cross sections, the results show a buried paleochannel beneath the River bottom at the depth of 30 m from water surface. this channel may represent an old course of the River, this buried channel is closed to the Iranian side (fig. 17).

The SBP section in Doraa site (fig. 18) revealed of a buried paleochannels under the River bottom in the middle part of the River cross-section, it may be an ancient stream of the River, this phenomena and presence the meander as well as the variation in the depth may be an imprint of structural activity similar to Sihan site.

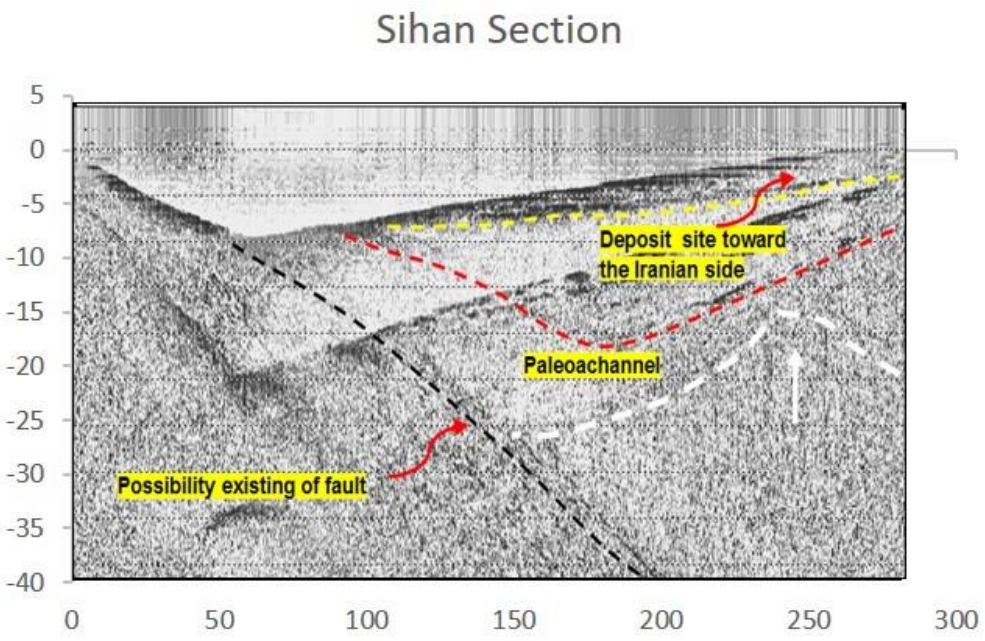

Figure (17). SBP section of Shatt Al-Arab in Sihan meander.

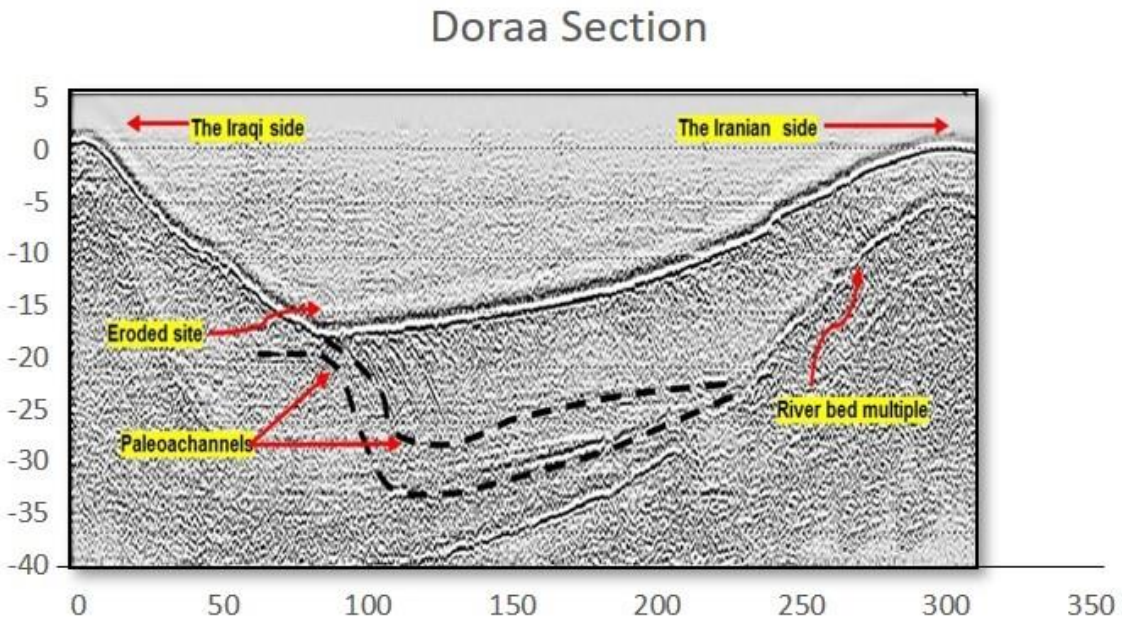

Figure (18). SBP section of Shatt Al-Arab River in Doraa meander.

To summarize the result of the paleochannels analyses and detection that have distinguishable after applying numbers of enhancements by satellite images integration with geophysical investigation.. The detectable Palochannels are showing in (fig. 19)

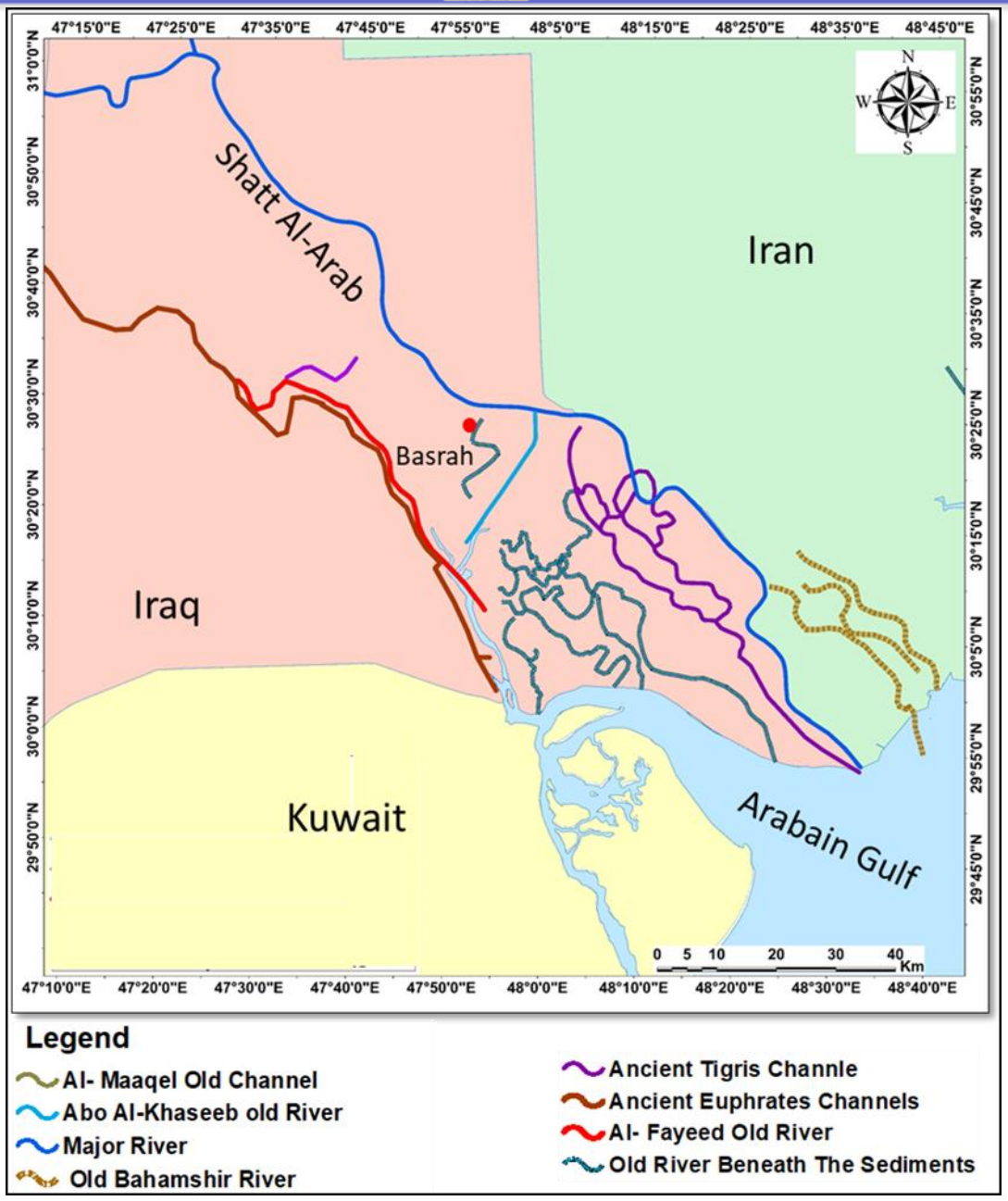

Figure (19). All paleochannle in Northern Arabian Gulf that extracted by satellite images integration with geophysical investigation

Regarding of the tectonic influence, it seems that the subsidence process is predominant in the region, particularly in the eastern part, so most of sub-surface features are covered, as well as the area affected by deposits of the ancient Tigris and Euphrates basin, and by progressing and regressing of sea level. To reach a state of equilibrium, this was accompanied by locally uplifting sub-surface structures in Nahr Omer, Al- Zubair, Siba, and Sanam plug sites, as well as the proposed sites between Shatt Al-Arab and Bahamshir rivers, (fig. 20)

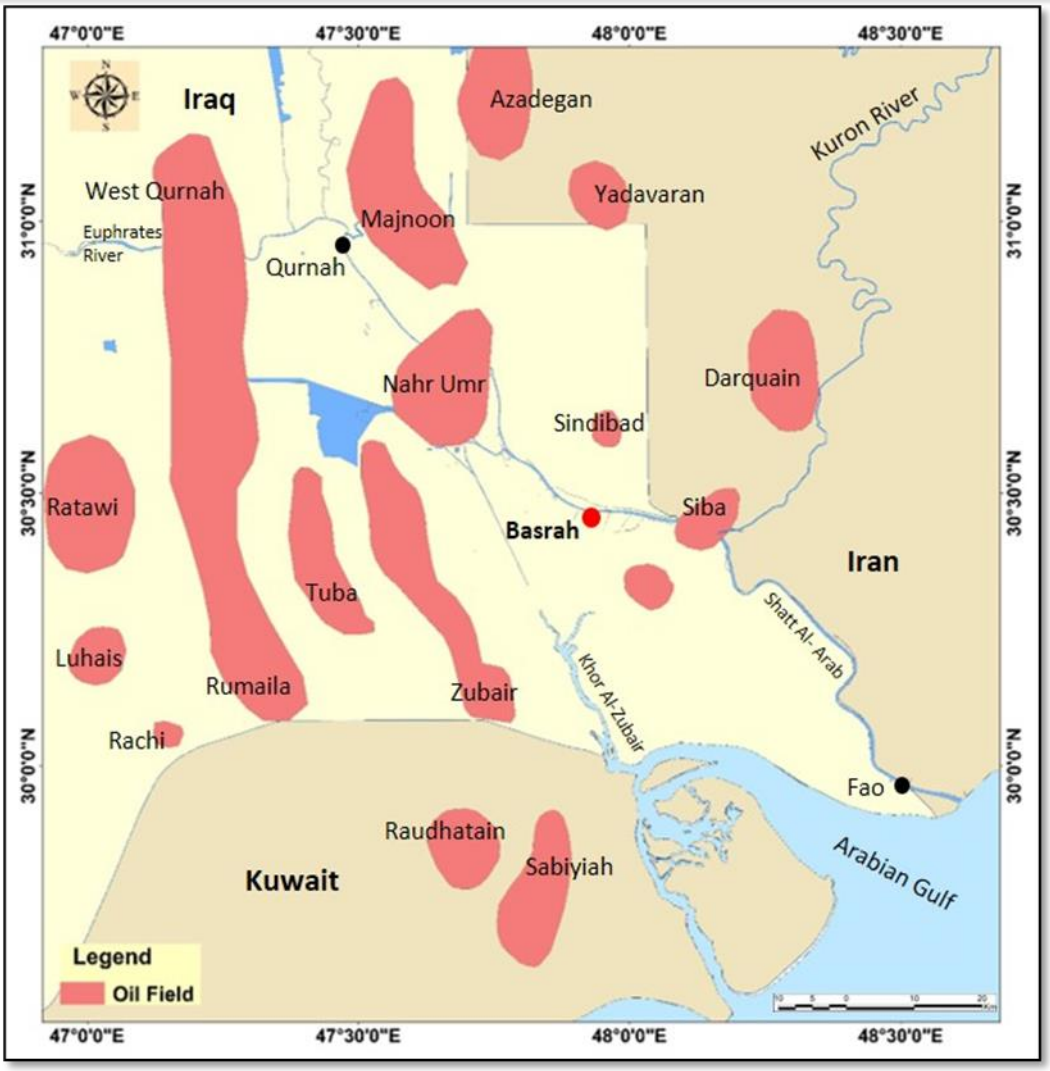

Figure (20). Structural subsurface anticline of the study area, modified after (Carman,1996; Aqrawi and Badics, 2015).

Counclusion :

In the present study, integration of satellite imagery sub bottom profilers survey have been used to analysis of river and lagoon (Khor) courses and detection paleoachannels of its in North Arabian Gulf. Analysis all the gathered data led to obtain the following conclusions:

1- Satellite imagery analysis combination with marine geophysical survey using sub bottom profilers technique are active methods to be employed to identify the paleoachannels and ancient courses of the rivers as well as evaluate the tectonic setting and its effect on morphological landscapes of an area.

2- Satellite imagery analysis revealed of many traces of discontinued ancient river streams such as Al-Fayeed and Al-Ma'aqel, as well as many ancient courses of presented rivers such as Euphrates, Tigris and Bahamshir. These results were confirmed by sub bottom profilers results which completed in some river channels and that revealed many buried old

channels underneath the current river bottoms.

3- Satellite imagery analysis and marine geophysical surveys which have been applied in many Khor sites such as Al-Zubair and it's dendritic part, Shaitana and Abdullah, as well as Shatt Al-Arab, are depicted that most of these sites are exposed to neotectonic indicators affected on the region in general. These morphotectonic activity impacted on the alteration and discontinuity of the river courses in the area under study.

4- The subsidence process is predominant in the region, particularly in the eastern part. In order to reach a state of equilibrium, this was accompanied by locally uplifting sub-surface structures in Nahr Omer, Al- Zubair, Siba, and Sanam plug sites.

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