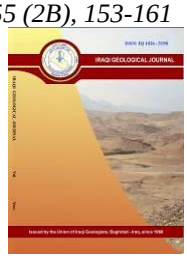
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Islands of the Tectonic Origin in the Shatt Al-Arab River, Southern Iraq

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Abstract

Several factors control the formation of river islands, such as tectonic factors, sedimentation, erosion, and human activities. This research is concerned with islands in the Shatt Al-Arab channel, which are likely to be traced back to tectonic factors in their formation. The islands of the Shatt Al-Arab River are distributed along its axis starting from the islands of Sindbad and Muhammadiyah, 15 km to the north of the city center of Basra, to the islands of Shatit, Al-Dawasir and Minauhi, 70 km south of the city center of Basrah. This study area is part of the Mesopotamia Plain, southern Iraq. The fieldwork period extended from the beginning of September 2012 to June 2013, which included making subsurface sections (longitudinal and transverse) of the bottom of the Shatt Al-Arab channel using the Sub-bottom profile Strata box device, imaging the topography of the river bottom in a side scan sonar, collecting the bottom sediments by a grab sampler. The volumetric analysis method uses the Master Sizer device based on the Folk classification to calculate the volumetric gradient of sediments. The study showed that the tectonic factor has a prominent role in the growth island Maino and as a result of the presence of sub-surface structures for the structure of the Siba, which appeared to affect the subsurface layers of the river bed near the island as it appeared in the survey sections of the Strata box device. There are some islands that more than one factor emerged as a reason for their formation and development, as in the islands of Muhammadiyah and Umm al-Rasas, where tectonic and sedimentary factors interfered in their formation and development due to the influence of sub-surface structures as well as the influence of nearby rivers such as the Karma and Karun Rivers.

Keywords: Shatt Al-Arab; Channel; River; Tectonism; Islands; Iraq

1. Introduction

The study of river patterns in general and the study of river islands in particular are among the most important topics in fluvial geomorphology, which have aroused the interest of various researchers in geology, structural geology, geomorphology, sedimentology and geography, in the past and present. The study area begins at the north of Muhammadiyah Island (Fig. 1), 15 km north of the city center of Basrah, that is, after a distance of 65 km from the confluence of the Tigris and Euphrates Rivers in the Qurna and the formation of the Shatt Al-Arab River. The Shatt Al-Arab River is characterized by the presence of many islands and subsidiary irrigation channels on both sides of the river channel. The Shatt Al-Arab channel forms the southern and southeastern part of the Mesopotamia Basin. There are a number of

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islands in this part, some of which are located on the Iraqi side and the other on the Iranian side. The study area ends at the city of Faw, 80 km south of Basrah. The present study aims to know the islands of tectonic origin and distinguish them from the rest of the islands that could formed by the action of other factors, including sedimentation and by the human factor and erosion.

2. Stratigraphic Setting

Description of the stratigraphic sequence of the Shatt Al-Arab Basin was a subject by many geological studies (Owen and Naser, 1958; Al-Naqib, 1967; Al-Saddiki, 1978) from the Paleozoic Era to Recent. However, all layers that appear on the surface in the study area are limited within Quaternary Period. The tectonic division of the Outer Platform Western Zagros Fold-Thrust Belt and Mesopotamia Foredeep, The Mesopotamian Basin is the terrestrial remains of the Zagros Basin, which extends to the southeast to its marine counterpart, the "Arabian Gulf". It is located between the stable continental part (the inner plate) and the Zagros mountain front to the northeast. It is essentially flat terrain, covered with Miocene to Holocene sediments and continental sediments. The anterior segment contains many buried structures including the neotectonics active structures. Based on its different movement and activity, the front Rafidain region is divided into the Jazirah and Basrah regions in the north and south, respectively (Fouad, 2015).

The Quaternary period sediments consist of the Pleistocene and Holocene sediments in the alluvial plain in Iraq. The climatic fluctuations and the periodic change in sea level during the Pleistocene epoch greatly affected the nature of the sediments of this epoch, as the stages of sedimentation and erosion have been repeated, so we do not find a continuous stratigraphy. In the Quaternary period, the development of the facies and the quality of sediments were also strongly influenced by the geomorphological conditions of the region, and its life span ranged from 2 million years until now (Al-Kaaby, 2019). The Mesopotamia Basin is characterized by the deltaic and fluvial sediments that are characterized by the change of facies and their exchange horizontally and vertically, and then the marine deposits represented by the Hammar Formation and brackish lacustrine deposits. Aqrawi (1995), Polservice (1980) and Albadran and Al-badran (1997) mentioned that the upper part of it is a mixture of fluvial flood silts and aeolian deposits that are naturally mixed. In the study area, the Quaternary sediments have thickness reaches 100 m, and cohesionless that cover areas extending from the Shatt Al-Arab and the Euphrates Rivers as far as the Shatt of Al-Basrah canal and to the Saudi border, represented by the coarse-grained sediments (Hussein et al., 1991). Many studies have been conducted on the Hammar Formation in the region, the most important of which is Polservice (1980). The Hammar Formation appears at a depth of 7-14 m at the confluence of the Tigris and Euphrates Rivers and the southeastern parts of the Hammar lake, while its thickness reaches 20 m at Al Faw, mainly lime clay, sand and silt. divided the Hammar Formation in the Khor Al-Zubair region from top to bottom into three parts: the upper one, which consists of soft gray silty clay with a thickness of 20 meters, and the middle, of soft gray sand clay interbedded with Soft gray sandy clay with loose sand, with a thickness of 12 meters, followed by the lower part consisting of strong gray clay interbedded with sand (Stiff gray clay with sand) with a thickness of 10 meters. It is bounded from the bottom, unconformable by the Dibdibba Formation, and at the top by modern riverine sediments consisting of red silt with some sand and gravel (Karim, 1991). The formation age is determined by the Holocene epoch (Aqrawi, 1995). A change took place at the entrance to the Shatt Al-Arab due to the continuous erosion, especially to the banks from the western side of the river, which is the Iraqi side. At the same time, sedimentation occurred on the eastern side of the river represented by the Iranian side (Khalifa, 2019), indicated that there are three main movements that clearly affected the region, including the pre-Pliocene movement, 5-6 million years ago. These movements occurred at separate and irregular periods, in some they were regular, and in general they were very slow movements that created anticline structures with gentle slopes. These

developing anticline structures are clearly visible in the stratigraphic column through changes in thickness of rocks. The current shape of the Gulf is due to the presence of many folds in the south and southwest of Iran that were formed by these movements. In addition to the Quaternary movements, these movements had a much lesser impact than the Plio-Pleistocene movements, and the influence of these latter movements took a local scope on the pre-existing appearances and structures. One of the most important movements of the Quaternary period is the penetrating salt domes movement. Al-Mousawi (1993) and Karim (1991) indicated that the region witnessed tectonic activity that caused the occurrence of a tectonic depression to the east of the Al-Zubair high and another tectonic depression northwest of Bubiyan Island, which caused the separation of Warba Island and the emergence of Khor Boubyan, and the connection of Khor Al-Zubair to Khor Abdullah. These movements affected the subsurface structures and then affected the geomorphology of the region, as the course of the Euphrates River changed and the rise in the Siba area led to the drying up of the ancient Abu al-Khasib River and the same thing happened to most of the ancient river channels coming from the Shatt Al-Arab channel (Al-Sakini, 1986).

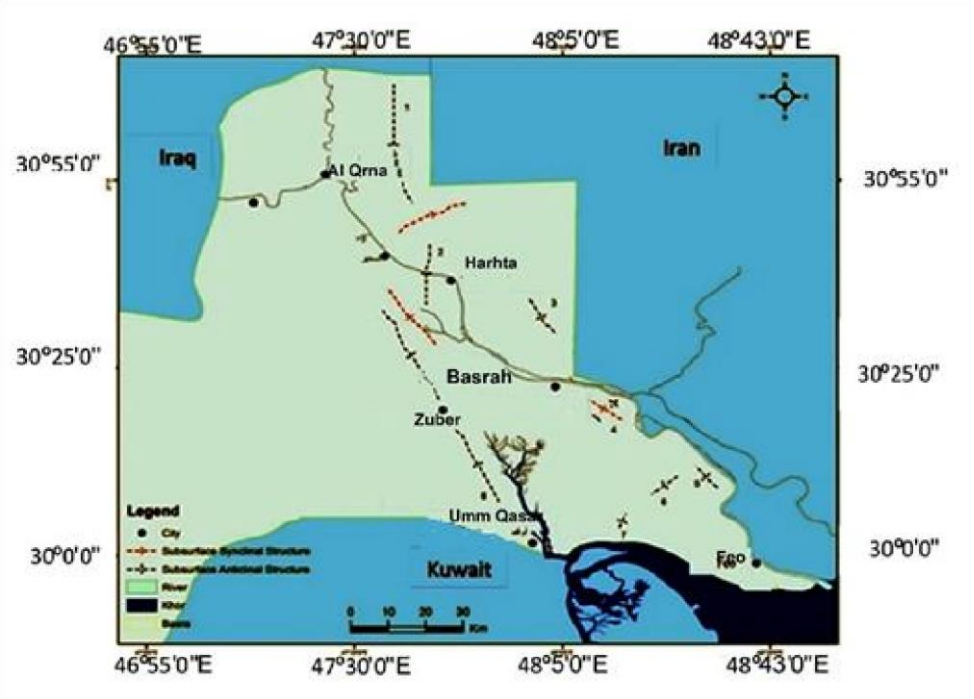


Fig. 1. A map of the subsurface structures in the Shatt al-Arab Basin (after Hussein, 2011)

The Shatt Al-Arab stream is considered in the last stage of the river's emergence and according to the Davies's cycle classification, whom divided the river into three phases depending on the velocity of the currents, the slope of the river and the width of the channel. The widening of the channel increases, as for the third stage, which is the preservative stage of the last stage of the stream, in which the gradient is significantly reduced and the cross-section of the river is widened while the depths are somewhat shallower, and the erosion rate is Less than the deposition rate. The Shatt Al-Arab stream can be classified as being in the last part of the river cycle (the preservative stage), however in it rejuvenation occurs when the Karun channel flows into it, whom used to contribute around than half of the Shatt Al-Arab stream water revenues and was spending big quantities of sediment loads (Al-Mansouri, 1996). The width of the Shatt Al-Arab River varies according to the areas it passes through, as its width ranges between 200m near the confluence with the Karun River and more than 2000 m at its mouth in the northern Gulf, while the width of the channel near Basrah City is about 500 m (Al-Whaely et al., 2013).

The gradient of the Shatt Al-Arab River channel is 1.5 cm per kilometer (Hussein et al., 1991). As for the depths of the Shatt Al-Arab River, they change from one place to another as well. At the meeting point in Qurna, the depth does not exceed 10m. As for the port of Maaqal and al-Ashar, it reaches more than 15m, while it returns to 6m north the Karun River Mouth and then returns to more than 10m at Faw and returns to less than 8m at the external bar at the entrance to the Shatt Al-Arab River, according to field surveys of the Marine Sciences Center (2005).

The texture of the bed sediment types in the Shatt Al-Arab channel is muddy with some places covered by sand. All of these sediments are reworked from the tidal flats, the channel discharges, and the surrounding areas (Albadra, 2021). It also does not forget that there are large wrecks on the river beds that have an effect on changing the shape of the river, and finally there is a clear difference in the shape of river sections due to the difference in areas of erosion and sedimentation.

3. Materials and Methods

The study area includes the course of the Shatt Al-Arab River from North of Muhammadiyah Island to the estuary northwest of the Arabian Gulf (Fig. 1). The field work continued from the beginning of September 2012 to June 2013, with two trips per month, and each trip included field work and measurements. In this survey, a Strata box was used, type SYQWEST at a frequency of 10 kHz. The marine subsurface section mapping technique was adopted in the study and identification of marine sedimentary layers and their depths. It was also adopted in the study of marine geological structures as well as its use in mapping the seabed (Yaacob & Mustapa, 2010). Therefore, this method was used in this study in detecting the extension and continuation of sedimentary layers, or the presence of uplifting, as well as knowledge of the subsurface situation. Side Scan Sonar was used, or what is known as a bottom scanner, type IMAGENEX MODEL 872 with the interpretation program YellowFin_v2014 at a frequency of 800 kilohertz and a radius of width of 100 meters. The van veen grab sampler was used to take the bottom sediments and at different locations of the river channel, the samples were saved in well-marked plastic bags until they reached the laboratory.

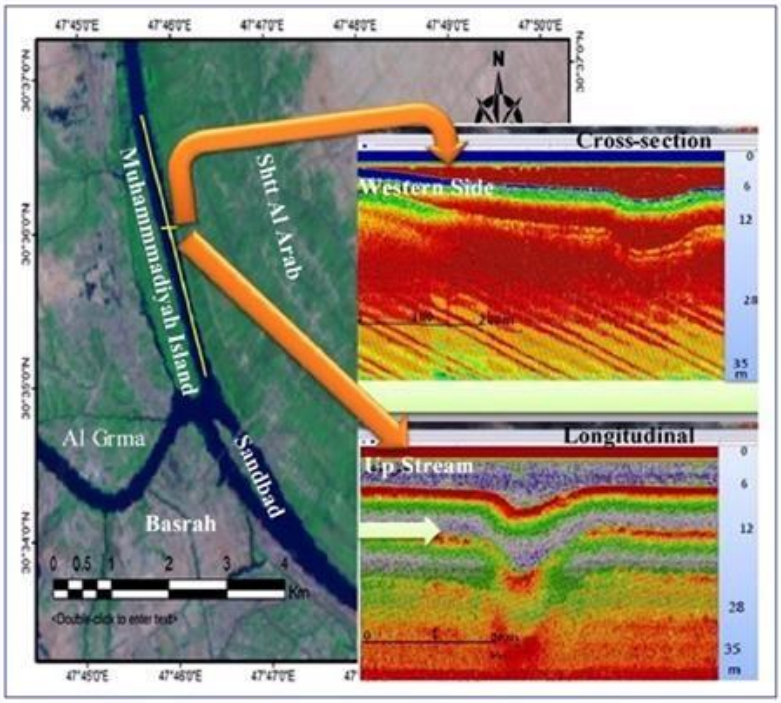


Fig. 2. Cross-and longitudinal sections on Muhammadiyah Island using Sub-Bottom Profile Strata Box

4. Results and Discussion

Islands arise and develop under the influence of several natural or human factors. Natural factors are either tectonic or sedimentary and erosive. In this research, we will deal with islands that are expected, according to field evidence and the results of the information that have been deduced, to be of tectonic origin only. The process of tectonic activation is one of the geological phenomena that has increased interest in geological studies because it gives an explanation for many of the geomorphological features spread over the earth's surface. The development and growth of surface and subsurface geological structures such as faults and folds and their growth in their simple or relatively limited movement affects the surface geomorphic processes. The most important changes involved in modern tectonics (Neotectonics) are the uplift, or subsidence, for large parts of the earth, or the change and variation in the degree of gradient. Such Neotectonic movements are difficult to record and feel because they are relatively slow, long-term, and extend to large areas of the Earth (Al-Qayim, 2006). Therefore, caution must be exercised in choosing methods of analysis commensurate with the nature of the geologically and tectonically studied area. A change affecting its steepness or grade due to tectonic motions (Holbrook and Schumm, 1999). In particular, ground patterns such as river patterns, river cycles, channel form and river terraces can be used as geomorphological evidence of the presence of tectonic activation in the area. This is done by using topographical and geomorphological maps and satellite visualizations (Goudie, 2004). In addition, the subsurface structures that intersect with the course of the river channel over hundreds of years led to the rise of the area and then to the bottom of the channel, this made the channel go to new areas, less elevated than the previous one, to drain its water, and its slope decreased. From previous geophysical studies of the region, such as the study of Karim (1991), during which the subsurface structures of the region indicate the presence of positive and negative residual gravitational anomalies, including those of Nahr Omar, Al-Zubair, the southern and northern Rumaila, and Basra Depression, with negative anomalies, which indicates the subsistence of the light core because of the layers of salt and positive anomalies like the subsurface structure of Siba and the structure of Jabel Sanam, which represents a salt dome (Karim, 1991). The structure of the Nahr Omar River is an anticline fold located under the Shatt Al-Arab River, at the city of Al-Hartha, and the effect of this structure is directly evident on the Shatt Al-Arab channel in the Al-Hartha area, especially with regard to the deviation of the Shatt Al-Arab River in the area of Nahr Omar, as shown by the study of Al-Mayahi (2011), and Hussein (2011).

Through field surveys using the Sub-Bottom Profile (Strata-Box) device, in this study the effect of subsurface structures has been revealed and identified and can be reviewed as follows: in front of Muhammadiyah Island by three cross-sections in the north, center and south of the island as well as for the longitudinal section from the north to the south of the island, the presence of an effect of subsurface structure at the bottom of the river (Fig.2), and it is possible to notice a decrease in the bottom of the channel extending to the lower layer of it, which can be interpreted as subsidence or differential subsidence at the bottom of the channel. A detailed survey of the area was conducted by an Echo-Sounder, so the shape of the bottom was a longitudinal groove that crossed the channel crosswise. North of Sindbad Island: a cross section in the area where the Karma River meets the Shatt Al-Arab channel. For the southern part of Umm Al-Rasas Island, a sub-surface layer uplifted, similar to a dome (Fig. 3), which indicates that Umm Al-Rasas Island formed from a sub-surface movement due to the uplifted of a dome, and then it became a barrier at the bottom of the channel.

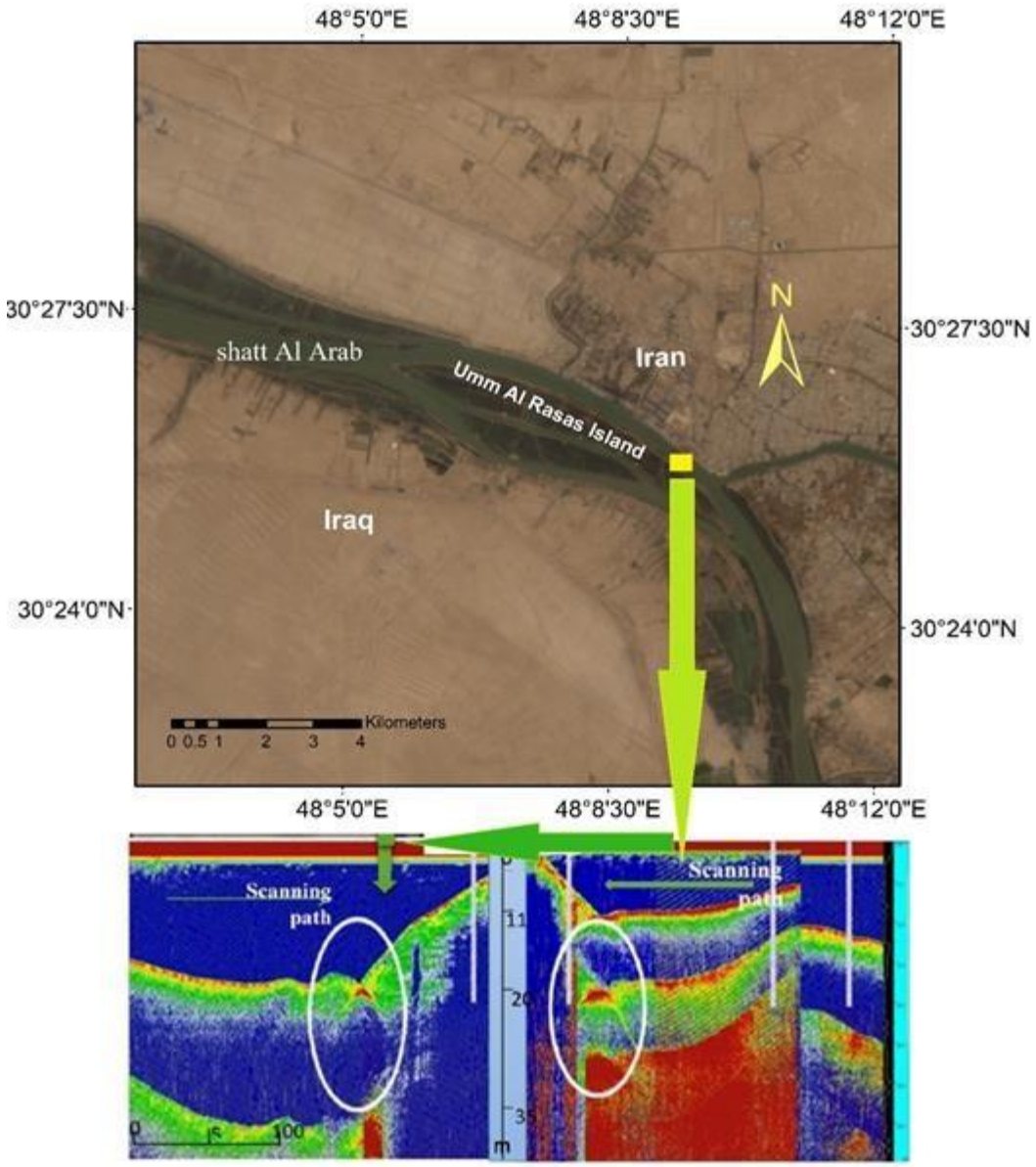


Fig. 3. A sub-surface, round-trip side section to the bottom of the canal, south of Umm Al-Rasas Island, marked by the location of the subsurface layer eruption

This uplift can be observed (Fig. 3), knowing that two sections were taken to the same structures. The Sihan area in front of the island of Maino, which is located on the Iranian side, and it is noticed through the survey of the subsurface layers in the Strata Box that there is a clear uplift of the subsurface layers, which led to the deviation of the channel from south-west to north-east, and the shape of the channel became arc, and the difference in depth is observed in this section, which is more than 11 meters for a cross-section distance not exceeding 50 meters (Fig. 4).

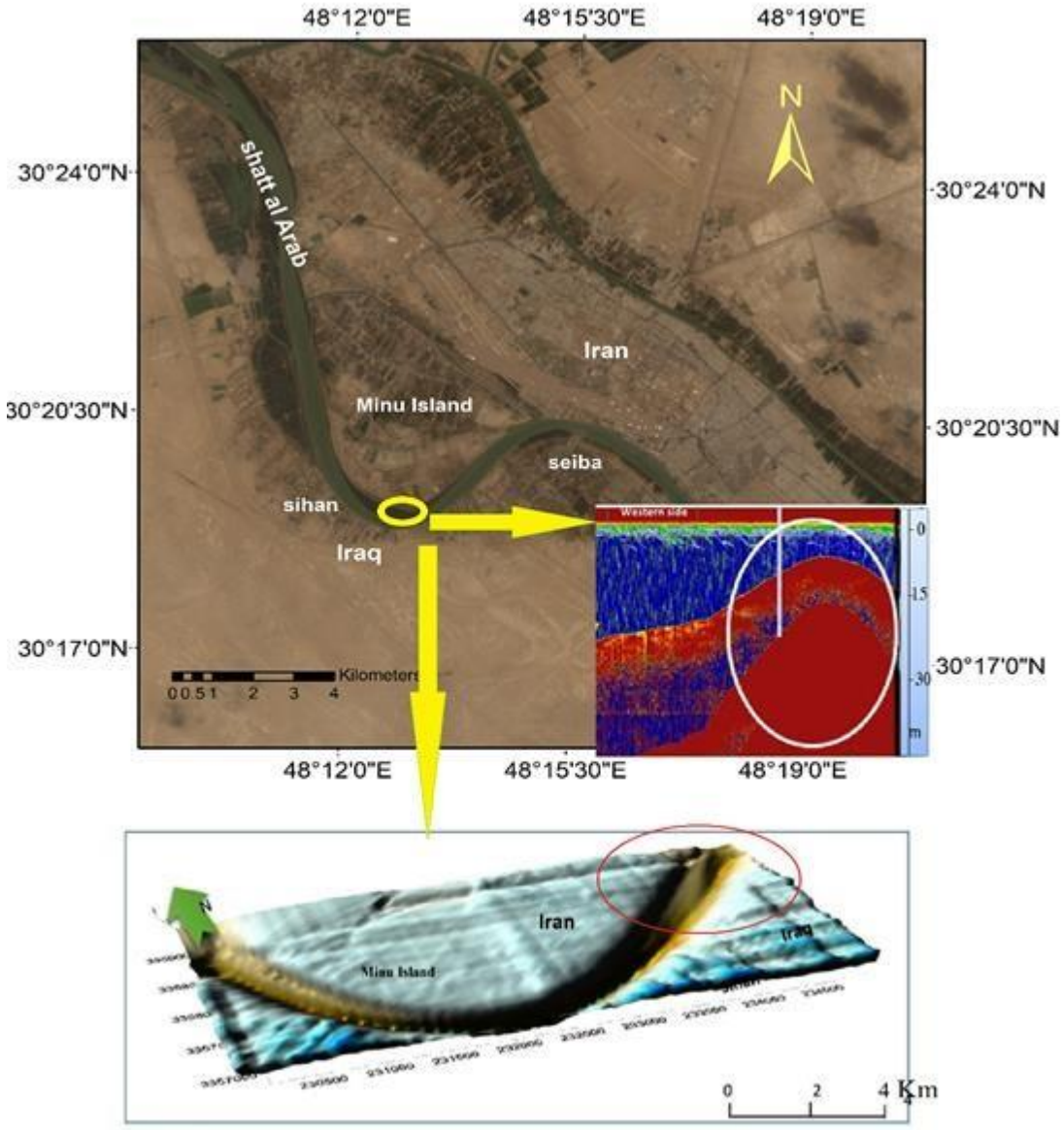


Fig. 4. The eruption at the bottom of the channel opposite the Iranian island of Minu and the Iraqi Sihan region and a three-dimensional drawing of the curvature of the Shatt Al-Arab in the Sihan area opposite to Minu Island from a detailed survey

It appears from Fig.4, which was taken from the middle of the channel to the Iraqi bank in front of Sihan, in which there is a clear uplift of the sub-surface layers, and this is consistent the suggestion of Al-Mulla (2005) in her study that the island could be tectonic in origin, as well as the presence of studies concerning by oil exploration indicating the existence of a sub-surface structure called the structure of the Siba. The Siba area is located on the convexity of the Shatt Al-Arab channel and the direction of the channel is from northeast to southwest, and from the section it appears that there is an end to the effect of the Siba structure due to which the channel deviated towards the southwest and from the observation of the section and due to a change in the degree of steepness of the layers as in Fig. 4. This indicates the existence of a subsurface structure in the area, and this is almost agreed upon due to the presence of the subsurface structure, so the channel tries to return to its original path after bending.

In the north of the Dora (Fig. 5), in which a sudden change of depths appears, and this is evidence of the existence of a subsurface fault as suggested by Hussein (2011), which caused a sudden deviation

in the course of the Shatt Al-Arab River towards the west and changed the meandering. This fault is an extension of the fracture referred to by Al-Mousawi (1993), due to which the islands of Warba and Bubiyan separated from the Iraqi coast (Fig. 5).

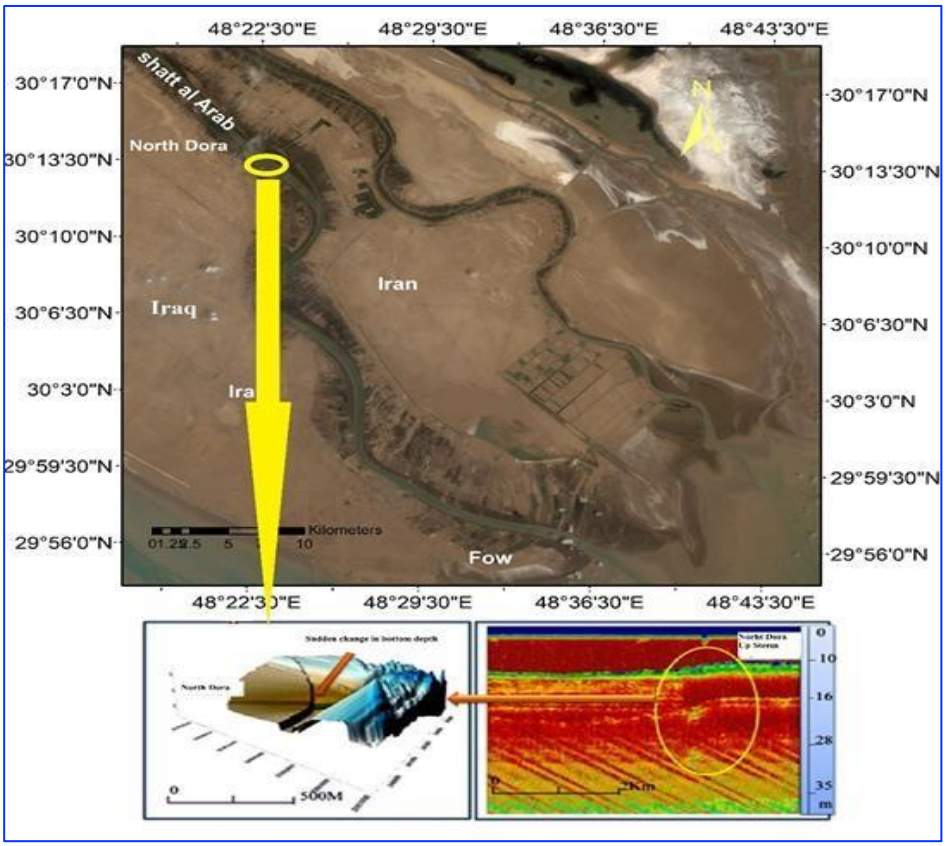


Fig. 5. A 3D drawing of the Dora area, showing the effect of the fault in the north of the session with a subsurface section using Strata-Box**.**

5. Conclusions

The island of Muhammadiyah has been affected by the tectonic factor and the sedimentary factor in its formation, as the tectonic factor is most evident through the degradation of the subsurface layers of the channel bed, which is located opposite the island. The results obtained from the fieldwork showed that the Umm Al-Rasas Island was affected by the structural factor through what showed the survey of the subsurface sections that indicate the presence of a sub-surface uplift, and the sedimentary factor is distinctively clear. The Maino Island is affected by an uplift at the bottom of the channel.

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References

Albadran, B. N. 2021. The Geology of Iraqi Territorial Waters, Northwest of the Arabian Gulf. The Arabian Seas: Biodiversity, Environmental Challenges and Conservation Measures, 196-213.

Albadran, B. N. Al-badran A.A., 1997. Distribution of bearing strata and their engineering properties in Basrah Region, South of Iraq. Basrah Journal of Science,15(1), 95-104.

Al-Mayahi, D. S., 2011. A quantitative analysis of transverse river profiles and its applications for morphotectonics: A case studying, Shatt Al-Arab River, Southern Iraq, Mesopotamia. Journal Marine Science, 26 (1),15-24.

Al-Mousawi, S. N., 1993. The evolution of the Khor Al-Zubair region and its surroundings through recent geological history. The Iraqi Geological Journal, 26 (3), 1-17.

Al-Mulla, S. T., 2005. Geomorphology of the Shatt Al-Arab River with the help of remote sensing techniques. Ph. D. Thesis, College of Arts, University of Basrah, 268p.

Al-Naqib, K.M., 1967. Geology of Arabian Peninsula, southwestern Iraq. USGS, 54p.

Al-Qayim, B.,2006. Morphotectonism of Diyala River, Iraq. Journal of the College of Arts, University of Baghdad, 78, 230-250.

Al-Sakani, J. A., 1986. Drought and interruption of the ancient rivers of Basra and their relationship to the Khor Al-Zubair Channel and the subsurface geological structures that constitute the current Basra oil fields. Proceedings of the first symposium on the marine nature of Khor Al-Zubair and the adjacent surfaces - Marine Sciences Center - Basra University, 146-145.

Al-Whaely, U., Albadran, B. N., and Al-Mulla, S. T., 2013. Geomorphologic study of Umm Al Raşā ş Island and its surrounding channels, Shatt Al-Arab River, Southern Iraq. Journal of Science and Technology, 3(4), 408-414.

Aqrawi, A. A., 1995 Brackish - Water evaporitic Ca – Mg Carbonate in the Holocene lacustrine, deltaic deposits of Southern Mesopotamia. Journal of the Geology of Society, London, U.K., 152, 259- 268.

Goudie, A. S., 2004. Encyclopedia of Geomorphology. Routledge, Taylor & Francis, London and New York.

Holbrook, J., and Schumm, S.A., 1999. Geomorphic and sedimentary response of rivers to tectonic deformation: a brief review and critique of a tool for recognizing subtle epeirogenic deformation in modern and ancient settings. Tectonophysics, 305, 287–306.

Hussein, M. A., 2011. Morphotectonic of Shatt Al-Arab River South of Iraq. Unpublished M.Sc.Thesis, College of Science, University of Baghdad, 119.

Hussein, N. A., Karim, H.H., Al-Saad, H. T., Youssef, O. H., and Ali, A., 1991. Shatt Al-Arab River- Basic Scientific Studies, Center for Marine Sciences, University of Basrah.

Jassim, S.Z., and Goff, J.C., 2006. Geology of Iraq. Dolin, Prague and Moravian Museum, Brno, 341.

Karim, H. H., 1991. Structural nature of lower Mesopotamian region from geophysical observations. Proceeding of third symposium, Oceanography of Khour Al-Zubair, Basra, Research, 15-25.

Khalifa, U. Q., 2019. Hydrodynamic of the sediment's movement in the Southern Part of the Shatt Al-Arab and North-Western of the Gulf. Basrah Journal of Science, 37 (2), 237-251.

Marine Sciences Center, 2005. Shatt Al Arab Survey Project, Basrah University, 223

Numan, N.M.S., 1997. A Plate Tectonic Scenario for The Phanerozoic Succession in Iraq. Journal Geological Society, Iraq, 30 (2), 85-110.

Owen, R.M.S. and S.N. Nasr 1958. Stratigraphy of the Kuwait-Basrah area. In Weeks L.G. ed., Habitat of Oil. American Association of Petroleum Geologists Symposium,1252-1278.

Polservice Co. 1979. GESD, Shatt Al-Arab Project, Feasibility Report Draft, Part A, Basrah, Iraq, 25-26.

Yaacob, R., and Mustaa, M. Z., 2010. Grain-size distribution and subsurface mapping at the Setiu wetlands, Seitu, Terengganu. Environmental Earth Sciences, 975-984.