

## **Geomorphological Evolution of River Terraces and Indicators of Climatic Change in Dry Environments Euphrates River in Anbar Governorate a Case Study**

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### **Abstract :**

The research deals with the river terraces. These terraces are located in Euphrates River between Haditha and Fallujah city in Anbar Governorate at the west part of Iraq. The analyzed data based on modern technologies by relying on a number of criteria which determined the river terraces in study area. The Euphrates extended in the plain lands. These lands are among the regions that most affected by climate change, because of the activity of the erosion processes associated with those changes that accompany the process of regenerating the river terraces. The river terraces represent the remainder of the ancient flood plains. These river terraces consist of gravel, mud and sand deposits. Moreover, these river terraces are formed as a result of the succession of river sculpture processes, due to the climatic changes that contained low water levels on rivers graded stages along the banks of the Euphrates River. So, as to increase its ability to sculpture and erosion. The above factors affected the Euphrates river stream to change. Climate change also have affected the formation of asymmetric river terraces. When the stream of the river turns or diverges from one side to the other, the bottom sediments remain in its first stream and are counted as sub-terraces. The research problem indicates that there are geomorphological factors and processes that result from river terraces in Euphrates river. While the main objectives of the research are making a geomorphological survey of the study

area, and then identifying the most important natural characteristics of the form of the river terraces in study aream. The researcher adopted, in order to determine the river terraces, the analytical approach, Arc Map v 10.4.1, 9.2 v Erdas Imagine, v 12 Global mappers, Google Earth and the quantitative method were relied upon using modern technologies and filed work. The researcher reached number of results, the most prominent one is that the study area has natural characteristics that directly affected the formation of the river terraces shapes, including the river terraces between Haditha and Fallujah. The researcher found eight river terraces within the Euphrates river sections in the study area.

Keywords: (climate change, dry environments, river terraces, Euphrates river, Anbar Governorate).

## التطور الجيومورفولوجي لمصاطب الأنهار ومؤشرات التغير المناخي في البيئات الجافة نهر الفرات في محافظة الأنبار دراسة حالة

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### المخلص:

يتعامل البحث مع مصاطب النهر. وتقع هذه المصاطب في نهر الفرات بين حديثة ومدينة الفلوجة في محافظة الأنبار في الجزء الغربي من العراق. تم تحليل البيانات بالاعتماد على التقنيات الحديثة بالاعتماد على عدد من المعايير التي حددت المصاطب النهرية في منطقة الدراسة. امتد نهر الفرات في السهل. وتعتبر هذه الأراضي من أكثر المناطق تأثراً بالتغير المناخي ، وذلك بسبب نشاط عمليات الانجراف المصاحبة لتلك التغيرات المصاحبة لعملية تجديد مصاطب النهر. تمثل مصاطب النهر ما تبقى من سهول الفيضانات القديمة. تتكون مصاطب النهر هذه من رواسب من الحصى والطين والرمل. علاوة على ذلك ، تتشكل هذه المصاطب النهرية نتيجة لتعاقب عمليات النحت النهرية ، بسبب التغيرات المناخية التي احتوت على انخفاض منسوب المياه على مراحل متدرجة من الأنهار على ضفاف نهر الفرات. وذلك لزيادة قدرتها على النحت والتعرية. العوامل المذكورة أعلاه أثرت على مجرى نهر الفرات للتغيير. أثر تغير المناخ أيضاً على تكوين مصاطب الأنهار غير المتكافئة. عندما يتحول مجرى النهر أو يتباعد من جانب إلى آخر ، تظل الرواسب السفلية في مجرى النهر الأول وتُحسب على أنها

مصاطب فرعية. تشير مشكلة البحث إلى وجود عوامل وعمليات جيومورفولوجية ناتجة عن مصاطب النهر في نهر الفرات. بينما تتمثل الأهداف الرئيسية للبحث في إجراء مسح جيومورفولوجي لمنطقة الدراسة ، ومن ثم تحديد أهم الخصائص الطبيعية لشكل المصاطب النهرية في منطقة الدراسة m. اعتمدت الباحثة ، من أجل تحديد مصاطب النهر ، المنهج التحليلي ، Arc Map v 10.4.1 ، 9.2 v ، Erdas Imagine ، 12 v مصممي الخرائط العالمية ، Google Earth والطريقة الكمية تم الاعتماد عليها باستخدام التقنيات الحديثة والعمل الميداني. توصلت الباحثة إلى عدد من النتائج أبرزها أن منطقة الدراسة تتمتع بخصائص طبيعية أثرت بشكل مباشر على تشكيل أشكال المصاطب النهرية بما في ذلك المصاطب النهرية بين حديثة والفلوجة. ووجدت الباحثة ثمانية مصاطب نهرية ضمن أقسام نهر الفرات بمنطقة الدراسة.

الكلمات المفتاحية: (تغير المناخ ، البيئات الجافة ، المصاطب النهرية ، نهر الفرات ، محافظة الأنبار).

## 1- Introduction

The study of river terraces shows the clear effect of the succession of different climates on the region, which ranged between humid and dry climates. It coincides with the vertical and lateral erosion processes of the bottom and sides of the river which are active at the same time. The vertical erosion is dominant in most stages of the river's life

Meanwhile, lateral erosion is increasing with the near reaching of the river to the equilibrium stage. The river terraces in the study area are represented by longitudinal extensions on both sides of the river as they appear in the form of successive terraces, one on top of the other, and in most cases there are several pairs. The channel of the Euphrates River is determined between the pair below it, and each pair of these terraces represents a stage of the lifting movements that renewed the activity of the Euphrates River.

As the pair of higher terraces represents the level of the valley floor during one of its first stages of its maturity, and after that it led to the rejuvenation of the river to dig a new valley in the sediments that make up these river terraces in the sediments that make up these high river terraces.

When the river returns to the stage of aging, it begins with deposition of materials carried in the new valley, which it dug in the first high river terrace.

New sediments form a new level of river terraces lower than the level of the river terraces less high than the previous level of river terraces, and by repeating this process, levels of several river terraces may be formed.

#### Problem of Research

There are geomorphological factors and processes that result from river terraces in Euphrates river . Is it possible to The impact of climate change on these river terraces.

#### Hypothesis of Research

climate change have a clear effect on river terraces in the study area. Is there a possibility of determining the degrees of this impact

#### objectives of the Research

Make a geomorphological survey of the study area, and then identifying the most important natural characteristics of the from river terraces in study area

#### Reasons for Choosing the Topic

the river terraces in Euphrates river was chosen as it is located in the Anbar governorate between Haditha and Faluja, which is a promising area for investment, as it includes the largest cites in governorate.

#### The Methodology

The analytical approach and the quantitative method were relied upon using modern technologies and filed work in order to determine the river terraces in study area

#### Data References and methods used in the research

- 1- Climatic data for the period 1980–2020 for the stations of Anah, Haditha and Al–Ramadi, issued by the Iraqi Directorate of Meteorology and Seismic Monitoring.
- 2- Digital Height Model (DEM) with distinctive accuracy (30 × 30) meters, for the year 2000.
- 3- Application of Arc Map v 10.4.1, 9.2 v Erdas Imagine, v 12 Global mapper, Google Earth.

4- Iraq topographic map, scale 1: 100,000 for the year 1990, issued by the General Commission for Survey.

5- A satellite image of the (landsat-8 OLI) satellite captured on 5/6/2021.

#### Previous Geomorphological studies

There are a number of previous studies of the river terraces in the world. but most of them concentrated on the bedrock geology. these studies showed that the study area belonged to the stable shelf of the Arabian platform which was consolidated at the end of the Precambrian. This section reviews some of the literature on hot dry environments in general. An overall appreciation of the nature of landforms, processes and landscape evolution in hot deserts is provided by Cooke et al. (1993), Cooke et al. From that time and even today some reports were published on hot desert such as Palmer (2013). In 1980, important progress had been made in the scientific studies of geomorphological in the dry environments, e.g. parson (1994). . These studies had a profound influence on the empirical work in dry environments. Tuncer, et al., (2007) studied the terrace staircases of the River Euphrates in southeast Turkey, northern Syria and western Iraq. Tyracek, J., 1987. Nash, (2006) looked at the relationships between the effects of the wind and the water in the geomorphology and longer – term landscape of arid regions of the world. Nash (2012) refers the arid geomorphology he is studies the Desert surfaces and duricrusts in the desert

#### acknowledgements

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## 1-1- Study Site

The study area is located within the administrative borders of Anbar Governorate, between Haditha and Fallujah dams, 60 km west of Baghdad, and lies between longitudes ( $42^{\circ}21'18.5''E - 43^{\circ}46'21.1''E$ ) east and latitudes ( $34^{\circ}12'25.5''N - 33^{\circ}18'31.6''N$ ) north. figure 1

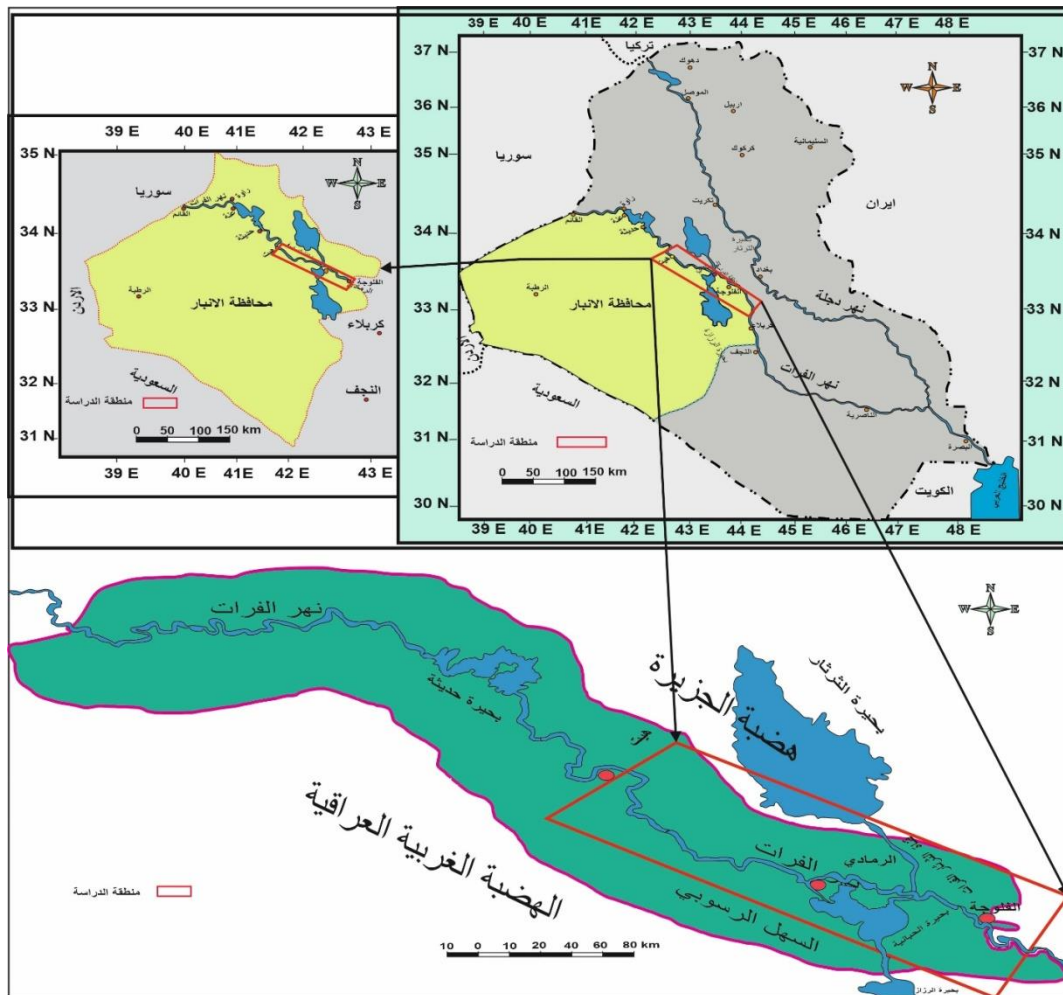


figure (1) location of study area in Iraq

## 2- Geological Setting

Several geological formations spread in the study area, ranging in age from the Eocene to the Pliocene, with the spread of the Quaternary age deposits in parts of the study area (Al-Hadithi, 1994, p. 5). The most important geological formations are: figure 2

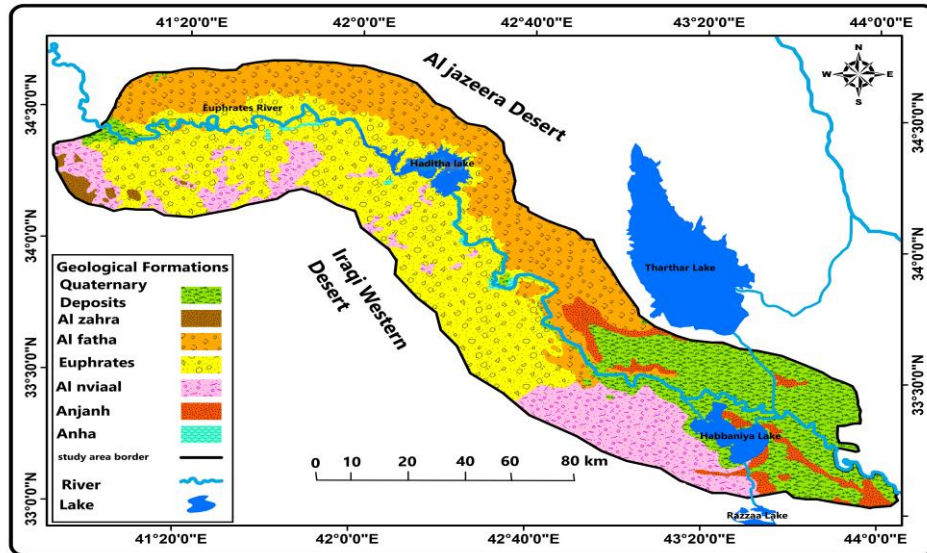


figure (2) Geological setting at the study area

٢-١- Formation of the Euphrates (the lower Miocene).

This formation is exposed along the banks of the Euphrates River and appears in several areas within the study area along the Euphrates within the section studied.

٢-٢- The Composition of Anaa (the superior Oligocene)

This formation is exposed in several areas within the channel of the Euphrates River within the study area, and this formation consists mainly of limestone, (Al-Balani 2003, p. 12).

٢-٣- Formation of AlFathaa (upper Miocene)

The presence of this formation on the left bank of the Euphrates River in an area of Anah is revealed in the form of a belt, which soon becomes of less thickness towards the east of the study area.

٢-٤- Formation of the higher myosin nugget

This formation is exposed on the banks of the Euphrates River in the study area, and among the most important components of this rock formation are AlGareni stone, mudstone, sandstone, limestone and lamellar clay (Al-Dulaimi, 2013, p.11)

٢-٥- Quaternary deposits

The deposits of this age are found in many places in the study area and are found along the Euphrates River and on both sides of it, and those deposits are divided into:

٢-٥-١- Pleistocene deposits and the two most important ones

٢-٥-1-1- Terraces sediments

٢-5-2- Holocene deposits and their most important forms appear in

٢-٥-2-1- Sedimentary plain sediments

These deposits were formed by the frequent floods of the Euphrates River on varying lengths of time and consist of sand, mud and silt with a small percentage of fine gravel.

٢-٥-٣- Valleys filling sediments

These sediments collect by river erosion of valleys and are mainly composed of sand, gravel and silt, and the gravel in these sediments is characterized by being coarse-grained (Al-Balani, 2003, p. 18).

٢-٥-٤- Precipitates filling depressions

These deposits are formed from materials that are washed by rain and torrents into the depressions, and the form of these deposits from clay materials rich in aluminum oxides and alluvial materials resulted from the gathering of wind deposits in the region.

٢.٥-٥- Slope sedimentation

The sediments of the slopes consist of clay materials and pieces of dolomite stone. These sediments are spread along the rocky ridges and the banks of the valleys that flow into the Euphrates River within the boundaries of the study area.

٢-٥-٥-١- Structural Geology

The structural phenomena affecting the formation of river terraces within the study area are divided into folds and splits as follows:

٣-١- The terrain affecting the riverbed

The study area varies in its extension between the desert plateau and the sedimentary plain, as the area is characterized by its high terrain in general,



and the limited diversity may be due to the nature of the geomorphological structure of the region characterized by the riverine overflow sediments. (Al-Dulaimi, 2013, p.20).

#### 4- The Natural Plant

The quality of natural plants in the study area varies from one place to another depending on the natural conditions of soils, climatic elements, proximity and distance from water sources. In general, natural plants are concentrated in riverine islands of high density that have affected the river water drainage processes affecting the formation of river terraces in the channel of the Euphrates River. (Al-Dulaimi, 2011, p. 45)

#### 5- Geographical distribution of soils

The soils in the study area between Haditha and Fallujah are distinguished by their disparity in terms of their composition, nature of origin, fertility and productive viability, and the most important soils in the area are sedimentary and desert soils (Al-Balani, 2003, p. 23) figure 3

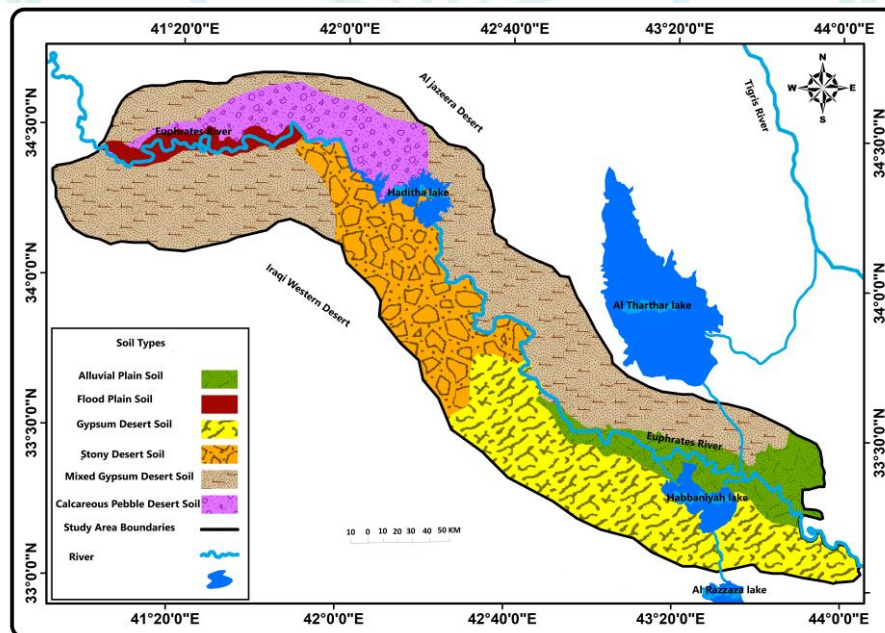


figure (3) Soil types of the study area

The sedimentary soils are distributed on both sides of the Euphrates River, along with the extension of the flood plain from Haditha to Fallujah, and these

soils were formed as a result of the sediments that were transported by the river terraces brought by the valleys to the Euphrates River, either from the western plateau or from the island plateau. Whereas, desert soils prevail, which are dry soils, not because they originated in areas with a dry climate. They are disjointed soils characterized by a lack of vegetation cover, as erosion of all kinds played a role in the erosion present in the study area (Al-Dabbagh 1993, p15).

#### 6- The climatic history of the region

The study of climate on a specific place on the surface of the earth during a certain period of time, taking into account the medium and extreme changes that fall under the heading of the state of the atmosphere in time and place, and this definition, which is considered to have a geographical meaning, is inferred from the temporal changes of climate during the history of the earth (Al-Fahdawi, 2003, p 52).

The importance of climatic differences studies has emerged on the different types of shapes of the surface of the earth, as the extremes of ice, humid or dry climatic conditions give rise to distinct ground forms, including river terraces as ground shapes formed in the study area and that the geomorphological processes take place at different rates under different climatic conditions if climate control is not limited. In the work on the evolution of earth forms, but its effect on the emergence of certain ground forms under specific climatic conditions, for example, the formation of river terraces in the Euphrates River valley, as well as many terraces in the upper sectors of the valleys, is due to the change in loads and rates of drainage (Al-Hasani, 1978, p. 376).

It is more than affected by the change in the base level. Accordingly, the land shapes, including the river terraces in the study area, are affected by the climatic changes during the Pleistocene period, including the river terraces on the basis that all these forms are multi-origin because they illustrate the influence of climates, so the land shapes in desert areas, for example, reflect

the impact of dry periods. Various methods have been used to build a perception of the climate of Iraq, including the study area through the geological ages. These sources and methods ranged between geomorphological wastes and various weather activities such as heat and rain and analysis of pollen samples discovered on the surface

#### 7- The current climate of the study area

In this research, the data of Haditha and Ramadi weather stations were reported on

Table (1) show the location stations.

Station	Heights	longitude	latitude
Haditha	139	34° 40'	41°
Ramadi	48	33° 25'	42°

The climate of the current study area is described, based on reliable recording data, as a continental climate, hot dry in summer, moderate to cold, and humid winter.

Despite the specificity of this description on the study area, it can be generalized to all parts of Iraq due to the location of Iraq north of the Tropic of Cancer and its distance from marine influences (Al-Samarrai, 2000, p 116).

Therefore, the periods that prevailed during the Pleistocene era had a great role in the very high drainage of the Euphrates River and the valleys that descend towards it from the two plateaus of the island and the western plateau. Thus the activity of the process of erosion and formation of terraces in addition to the dry periods that followed, the water of the Euphrates River became unable to carry large quantities of gravel, leading to the formation of gravel layers within the river terraces in the study area, which we will discuss in detail later in this research.

#### 2-2- River terraces:

The studies that are made by researchers (Al-Dulaimi, 1996, Al-Dulaimi, 2013) for the channel of the Euphrates River in Anbar Governorate on the

presence of river terraces within the boundaries of the study area. figure (4): show The River Terraces in study area

The river terraces in the study area are formed by many overlapping factors, so there is a difficulty facing researchers in determining the causes of their formation and determining their numbers, levels and ages, especially since they are ground forms that have been formed for long periods which made them exposed to the erosion factors that the study area is exposed to, as there is a network of dry valleys that ends in the channel of the Euphrates River. It cut the study area and changed its height by means of retrograde erosion, so the researcher found a difficulty in defining the terraces based on maps of equal elevations (Al-Jumaili, 1990, p. 111). In addition, the influence of the wind and water erosion factors that worked to level the area and remove the edges of river terrace, as well as the influence of the human factor represented by the removal of terraced sediments from gravel and sand during road laying operations. figure (4) show the River terraces with slope in study area.

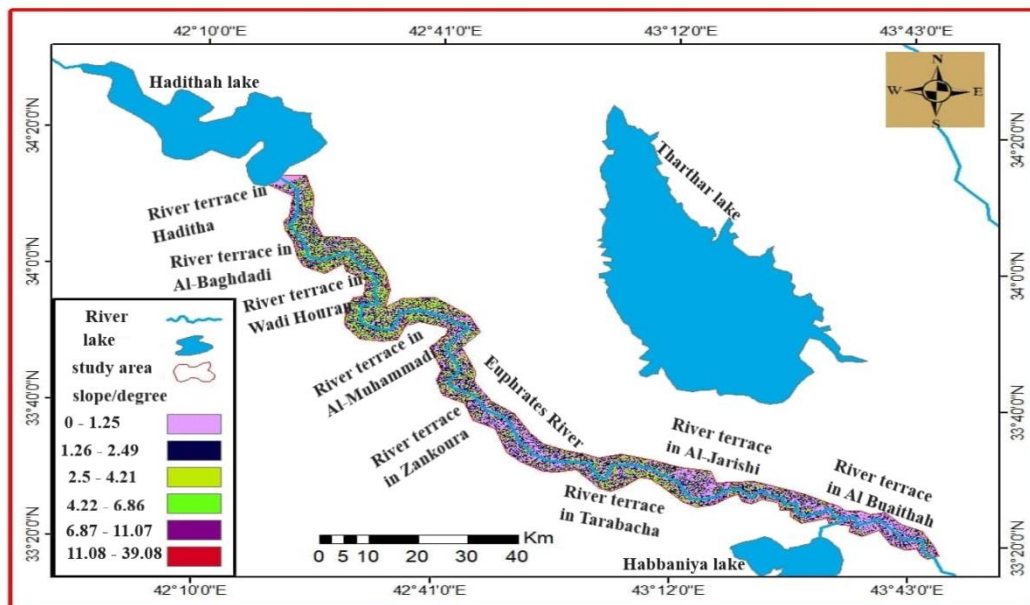


figure (4) show the River terraces with slope in study area.

They can be used as raw materials in the construction process, which leads to the distortion of the image that the river terraces were on. The study area

between Haditha and Heet contained four numbers and levels of river terraces, while the section between Heet and Ramadi contained three levels. The section between Ramadi and Fallujah contained four levels of river terraces. The researcher will study the characteristics of these terraces, respectively.

#### 2-2-1- The terraces of the first section: between Haditha and Heet

Four numbers and levels of river terraces were determined in this section between Haditha and Heet by determining the remains of river terrace sediments and confirming the locations of these river terraces through the field study. These terraces were named according to the areas in which they appear (Al-Jumaili, 1990, p. 113). These terraces are:

##### 2-2-1-1- The River terrace in Haditha:

The sediments of this terrace appear near Haditha, and it is the oldest river terrace in the study area and is located at an altitude of (50-60) m above the level of the flood plain. The terrace varies in its level from one section to another depending on the conditions of the terrace and the effect of erosion factors on it as most of the sediments of this terrace have been removed. Nothing remains of its effects except for scattered parts in the study area. The thickness of this terrace ranges between (2-8) m and consists of sand and gravel with a small percentage of silt and clay and the presence of secondary gypsum.

The proportions of sediments ranged between coarse gravel with a diameter between (64-256) mm and a rate of 50% in addition to the presence of intermediate gravel between (32-64) mm and a rate of 34%. The proportions of sand on the first, second and third three layers reached 16%. The reason can be attributed to the decline the ratio of soft materials to light materials that can be transported by water to places further towards estuaries, especially in the rainy ages, where the Euphrates River is characterized by high drainage of water, while heavy coarse materials such as gravel and boulders precipitate in the event of a decrease in the velocity and amount of water. Symmetric in.

map (2) on both sides of the riverbed while it is symmetric in other sections of the river (Al-Jumaili, 1990, p. 120)

#### 2-2-1-2- The River terrace in Al-Baghdadi

This terrace appears to the south from Al-Baghdadi side on the right bank of the channel of the Euphrates River and appears opposite Al-Faliwi island in the channel of the Euphrates River on the left side of the channel of the Euphrates, at a height of (100-110) meters above sea level. The terrace rises by 45 meters from the level of the flood plain in both places (Al-Jumaili, 1990, p. 120). This terrace is characterized by being not symmetry on both sides of the Euphrates in some sections, as it appears on one side and disappears on the other side, it has a map (1) while it is symmetric in the other sections. As for the sediments of this terrace, it consists of four layers whose thickness varies between (0.5-1) m and the size of the sediment components is less than the size of the components of terraces of Haditha. This terrace is made of boulders and the diameter of sediments ranges between (32-64) mm and by 27% of the total research sample size. The percentage of gravel with a diameter between 16 - 32 mm increases by 37%, while the percentage of sand is 51% in the first layer of the terrace with other percentages In the rest of the classes. picture No (1 )

picture No (1 ) River Terraces in Al Baghdadi area



Resource: field work in study area in date 28- 6- 2021

#### 2-2-1-3- The River terrace in Wadi Houran

The sediments of this terrace appear on both sides of the Wadi Horan along the two banks of the Euphrates River in the area into which the Wadi Houran flows into the Euphrates River at a height ranging between 25–40 m above the level of the floodplain (Hamed ٢٠١٥ p188) . The sediments of the terraces are also shown off ALous Island on the left bank of the Euphrates River. The thickness of the terrace sediments is 6 m, and the terrace sediments include gravel, sand, silt, and clay. The terrace is characterized by being not symmetry on both sides of the channel in some river sections figure (4) The size of the sediments in the terrace ranges between 32–64 mm and constitutes 60% as for silty deposits and clay, they constitute 4%. figure (5) and figure (6).

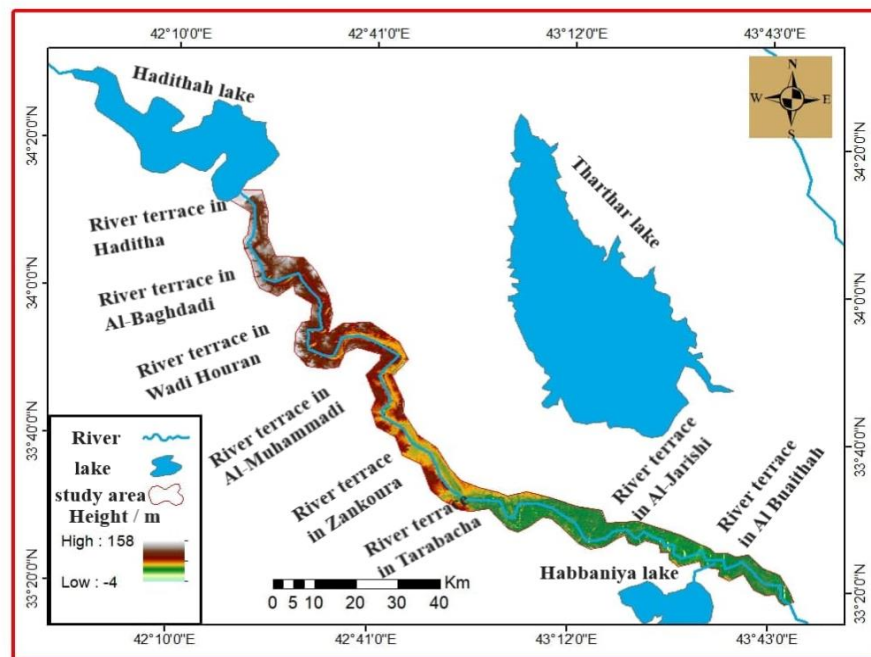


figure (5): The River Terraces in study area

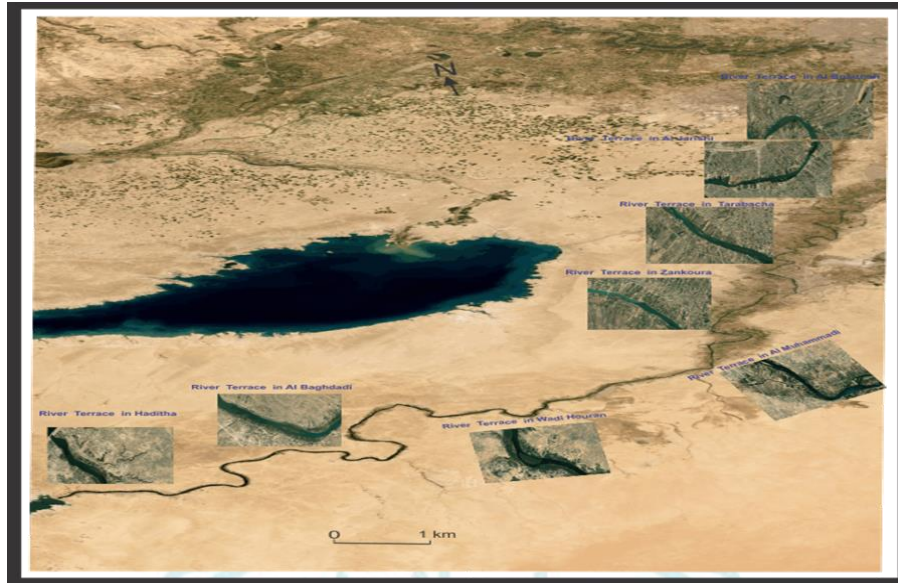


figure (6): The River Terraces in study area

#### 2-2-1-4- The River terrace in the Al-Muhammadi Area

The sediments of the al-Muhammadi terrace appear in the al-Muhammadi area south of the city of Heet and in three regions in that region, as well as other places with the extension of the river channel. The Al-Muhammadi terrace consists of five sedimentary layers that vary in the sizes of their components, as sediments ranging in diameter from 64 to 256 mm appear in the second and fifth layers. It is high, reaching 85% for the two aforementioned layers in a row, and this terrace is characterized by symmetry on both sides of the stream and asymmetry in other sections, as it appears most often on the concave sides of the turns and disappears on the opposite convex side. Therefore, the characteristic of asymmetry was caused by the effect of river bends. Picture No (2)

#### 2-2-2Section Two Terraces: Between Al-Muhammadi area and the city of Ramadi:

The terraces of this section include ancient valley levels formed in periods when vertical erosion operations stopped and lateral erosion began, which led to the expansion of the valley and the floodplain. The height of the oldest terraces from the current flood plain represents the level at which the river was able to deepen its channel after the renewal of youth (Al-Dulaimi, 1996, p.



40). The study section included three levels of sedimentary river terrace, two on the left side and one on the right side

It represents the first level, which is the Zankorah terrace, while the second level is represented by the Tarabsha terrace. The third level represents the al-Jarashi terrace, while the other levels that are located within the floodplain, they have no clear traces of exposing them to continuous floods and human exploitation, which led to the obliteration of their features, especially as they have low levels and consist of fragile deposits that are easy to remove. The three terraces may differ in terms of location, layers and components. We will study these terraces in some detail.

#### 2-2-2-1- The River terrace in the Zankoura Area

This terrace is located northwest of Ramadi, about 18 km, at a distance of 1350 m west of the current channel of the Euphrates River, and it rises about 50 m from the level of the current flood plain. The Zankoura terrace consists of six distinct layers up to about 4.50 m thick and these layers consist of gravel of all kinds and sand, while fine gravel and sand constitute the highest percentage of its components, which led to its exploitation in economic fields. The areas that were removed from the terrace were widely used for the construction of housing units, and only the traces of the Zankoura terrace remained that were used as cemeteries used for burial operations, which kept the terrace from being removed. The sizes of the joints and their proportions are included in the terrace, as the size of the separations reached 64 – 256 mm is the lowest percentage, then the joints from 16 to 32 mm, the joints from 8 to 16 mm, and the joints from 2 to 8, the highest percentage in the joints of the terrace components. picture No (2)

picture No (2) River Terraces in the Zankoura area



Resource: field work in study area in date 28- 6- 2021.

#### 2-2-2-2- The River terrace in the Tarabacha Area

This terrace is located northwest of the city of Ramadi, about 20 km, away from the channel of the Euphrates River, up to 1500 m and a height of 5.5 m above the level of the flood plain. This terrace consists of fine gravel with sandy soil mixed with pebbles. A large area has been removed from this terrace by residents to be used in the construction operations taking place in the areas near this terrace

#### 2-2-2-3- The River terrace in Al-Jarishi Area

This terrace is located north of the city of Ramadi to the southeast of the Tarabsha terrace and it is 5 km away from the channel of the Euphrates River, and the height of the terrace from the floodplain is about 10 m. Sand constitutes the largest percentage of separations, at 94%, distributed by 5%, fine sand, 55% gravel, 19%, large gravel, 22%, medium gravel, 11%. Small gravel. Very fine gravel 12% and very fine sand 17%. The thickness of this layer was large, up to 1.60 m, and the sediments of this terrace were exploited for construction purposes on a large scale. Several laboratories have been established for this purpose, especially as it is located near the city of Ramadi, the largest urban center that witnesses a wide urban growth, which requires large quantities of gravel and sand, therefore high levels turned into low lands (Al-Dulaimi, 1996, p. 70).

### 2-2-3- The terraces of the third section between Ramadi and Fallujah

The Euphrates River enters in this section the stage of equalization, and some terraces may be formed in the valleys of rivers that have reached the stage of equilibrium and formed in their hearts the flood plains. The water of the Euphrates River may continue to carry its load of coarse materials due to the steepness of the channel, which gradually decreases until it becomes insignificant at the area of the flood plain.

The sedimentation of the coarse load increases, while the fine materials that the river deposits part of over the low slopes continue to be carried. if this process is coupled with a lateral migration of the stream, it forms on both sides of the valley river terraces of varying levels i.e. non-double and the most important terraces that appear in the area between Ramadi and Fallujah are:

#### 2-2-3-1- The River terrace in Al Buaitah Area

This terrace is located north of Ramadi, towards the area between Tharthar lake and the Euphrates River, at a distance of 2500 m and is located at a height of 3 m from the level of the flood plain. The terrace consists of various kinds of pebbles and sand, as only a small area remains of this terrace that was used as a cemetery for the residents of the region.

The third topic: the factors of formation of river terraces

The river terraces in the study area are due to two main factors

#### 3-1- Climate change

The climatic changes that affected Iraq and the Arabian Peninsula as well as large areas of the world during the Quaternary era, which had a fundamental role in the sedimentation process and then the renewal of rivers to their youth, which in turn formed river terraces in the study area between Haditha and Fallujah.

During the four glacial periods that occurred in the Ice Age, which affected large areas of the world, including Europe, North America and Asia, which were matched by rainy periods in sub-tropical shows, including Iraq, where the

amount of water and sediments that reached the rivers, including the Euphrates River in the study area increased.

It is noticed through the field study on geomorphological indications indicating the link between climate changes and river terraces in the presence of very clear layers that vary in the size of their components, as there are layers consisting of boulders, gravel and sand, while other layers consist of fine gravel, silt and mud

This is evidence of the occurrence of climatic fluctuations, as the river brings coarse materials during the rainy ages, while it brings soft materials in dry periods that separate them according to the variation in the amount of drainage. In addition to that each of these layers consists of secondary layers that also vary in the sizes of their components (Al-Jumaili, 1990), P. 128.

### 3-2- Changes in the channel of the Euphrates River

The changes in the channel of the Euphrates River, which are related to many factors, lead to the formation of asymmetric river terrace, when the channel of the river turns or diverges from one side to the other, and the bottom sediments remain in its first channel. They are calculated as subordinate to it, and it appears that the channel of the Euphrates River is diverted south of the city of Heet and towards the northwest Southeast down to the east of Habbaniyah Lake.

Which led to the deviation of the channel in its current direction in the study area, leaving the sediments of its ancient hall on the right bank, south of the city of Heet.

By studying the cross sections of the Euphrates Valley, we notice that the number of terraces on both sides is not equal, meaning that they are asymmetric, and this makes us explain the existence of some terraces as related to changes in the channel of the river resulting from the interception of some rock formations of the stream or the presence of joints and faults that have a role in this aspect.

### 3-3- Factors affecting the nature of river terraces

There are influencing factors that affect the river terraces with time, as the water and wind erosion removed part of it or added a new layer to it. Therefore, the presence of aerobic sediments in the form of sand transported in the upper layer of some river terraces was observed. Dry valleys with seasonal water drainage that descend the western plateau and the island plateau cut into these terraces.

They are located near the estuaries of these valleys, or remove a large part of them, or add a new layer to them in some sections, if taking into account that the region contains a dense network of dry valleys that end in the Euphrates River within the studied section. The river bends play a clear role in the formation of the river terraces by removing some of them on the side that the stream moves towards, so river terraces may appear on one side and disappear on the other side. It is meant that they are asymmetric.

### 3-4- Characteristics of the water system of the Euphrates River

The study of the analysis of the water characteristics of the channel of the Euphrates River within the study area is one of the most influential factors in the formation of the ground shapes in a continuous succession of the processes of erosion and sedimentation. The study of the distribution of flow rates in the river according to the years of high and low drainage as an indicator to clarify the characteristics of the general system in the flow process in order to reach the extent of The relationship of this in the formation of different ground shapes, The river section within the study area, including the river terraces. The study relied on analyzing the meteorological data of hydrological stations within the boundaries of the study area, such as Haditha Hydrological Station and Heet Station, and the data of Ramadi Dam station, which is located in the middle of the study area towards the city of Fallujah.

It became clear that the water system in the Euphrates River differs from one water year to another over long stretches of time, it had a clear effect on the

variation in the extent of the water drainage effect of the river on the formation of the land features within the channel.

### 3-5 The economic importance of river terraces to humans

The river terraces have a clear impact on the economic activities of the population in the study area. Among the most prominent activities that are related to this geomorphological phenomenon are:

### 3-6- Results and Discussion

The study area has natural characteristics that directly affected the formation of the terrestrial shapes in it, including the river terraces between Haditha and Fallujah . These River terraces are 8 river terrace within the Euphrates River sections in the study area 3 river terrace in the section between Haditha and Heet, which is Haditha, Al-Baghdadi, Horan, Al-Muhammadi, and 3 river terrace between Al-Muhammadi and Al-Ramadi, which is Zankoura, Al-Tarabsha, and Al-Jarashi terrace, and one terrace between Ramadi and Fallujah, which is Al-Bouaitha terrace .The study of river terraces is of importance within the channel of the river, as it is one of the most important ground forms within the river channel, which can be used as a means to compare the stages of river channel development for any stage of the river's development within its channel. The layers that make up these terraces vary in terms of thickness, number of layers and the type of sediments in each layer due to the variation in the level of river drainage, which is related to climatic conditions and precipitation that prevailed in the upper sources of the river.

### Conclusions

- 1- The sediment volumes in the section of the Euphrates River that have been studied vary between coarse gravel deposits and fine sandy deposits.
- 2- The river terraces are characterized by their asymmetry, their contrast and their discontinuous spread in the study area due to their exposure to erosion processes.
- 3- The changes and developments to which the river was exposed occurred as a result of the influence of a group of natural and human factors, the most

important of which are the geological structure of the area, tectonic activation, water drainage, climate factors, natural plant distribution, slope and the nature of water drainage of the valleys network that ends in the Euphrates River within the boundaries of the study area

4- The human factors affecting the construction of the dam and reservoirs such as the Ramadi dam, the Warar dam and the Fallujah dam, in addition to the construction of the dam and lake of Haditha.

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