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Late Pleistocene - Holocene Paleoecology of Southern Mesopotamia, Iraq

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Abstract

The distributions of rivers, back swamps, delta, and ancient marine shore line of Southern Mesopotamia during Late Pleistocene – Holocene have been studied depending on the ostracoda and foraminifera assemblages as ecological indicators to determine the ecofacies and paleosalinities, which diagnose different depositional environments. The data are collected from 86 boreholes (including 12 deep boreholes), covering almost the entire Southern Mesopotamia.

Rates of sedimentation are calculated and corrected for compaction in this study, relative to previously measured C^{14} dating by some authors, for the marine and non-marine (Ur Flood) deposits.

Those rates of sedimentation found in this study are varies from a borehole to another, according to the environment of deposition; fluvial, back swamps, deltaic or marine environments.

The base of the Ur Flood bed is considered as a marker for correlations between the studied boreholes, and to distinguish the successive depositional cycles basing on their faunal content of ostracoda and foraminifera.

Accordingly, nine paleoecological maps for the Southern Mesopotamia are made to represent the age intervals between 22000 B.P. to 1000 B.P., showing the distribution of ancient rivers, back swamps, delta and ancient marine shore line.

Keywords: Mesopotamia, Ostracoda, Paleoecology, Pleistocene, Holocene.

البيئة القديمة لحوض الرافدين الجنوبي خلال البلايستوسين المتأخر – الهولوسين في العراق

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الخلاصه

أن توزيع الأنهار والمستنقعات الخلفية والدلتا وخطوط الساحل القديمة لحوض الرافدين الجنوبي قد تمت دراسته للفترة بين البلايستوسين المتأخر – الهولوسين، بالأعتماد على تجمعات الأوستراكودا والفورامينفيرا كدلائل بيئية لتحديد السحنات البيئية والملوحة القديمة، والتي هي بدورها تشخص العديد من بيئات الترسيب.

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ولقد جمعت المعلومات من دراسة 86 بئراً (من ضمنها12 بئراً عميقاُ) لتغطي تقريباً معظم حوض الرافدين الجنوبي.

أن معدلات الترسيب قد تم احتسابها وتصحيحها وفقاً لمقدار الأنضغاط في هذه الدراسة نسبةً لقياسات سابقة لعمر عنصر الكاربون 14 قام بها بعض الباحثين للترسبات البحرية وغير البحرية لترسبات (فيضان أور). أن ما وجد من معدلات للترسيب في هذه الدراسة تختلف من بئر لآخر بالأعتماد على طبيعة بيئات الترسيب التي تتدرج من الفيضية الى المستنقعات الخلفية الى الدلتا ثم الى البيئة البحرية. ولقد تم أعتبار قاعدة طبقة (فيضان أور) كمؤشر للمضاهاة بين أبار هذه الدراسة لتميز الدورات الترسيبية المتعاقبة بالأعتماد على محتواها الحياتي من الأوستراكودا والفورامينفيرا.

أستنادا الى ذلك، تم وضع تسعة خرائط بيئية قديمة لحوض الرافدين الجنوبي للأعمار بين 22000 الى 1000 قبل الحاضر، حيث ان هذه الخرائط توضح توزيع مجاري الأنهار القديمة والمستنقعات الخلفية والدلتا وخط الساحل البحري القديم.

Introduction

The ancient river system plays a rule in the distribution of the ancient civilizations of Southern Mesopotamia. Most of the archaeologists draw maps of the ancient rivers basing on a principle that any archaeological site was lying on a river bank or beside it. They are not taking into consideration the presence of marshes and swamps on the area, because most of the studied archaeological sites are in desertified areas nowadays.

Archaeologists lose sight of the idea that the ancient populations of Mesopotamia were lived away from the flooding danger of Tigris and Euphrates Rivers. They preferred the flooding plains, lakes, marshes and swamps, where those areas provided them with the principle living needs of their life and cattle, such as food (birds and fishes), fresh water, and fertilized soil. [1]

There are a lot of studies dealing with the new tectonism of the Mesopotamian Plain such as Lees & Falcon [2], Mitchell [3], Al- Faraji [4], Al- Sakini [5], and Al- Mossawi [6].

Hudson *et al.* [7] studied marine ostracods and bivalves of the Hammar Formation near Basrah area. Dance and Eames [8] studied marine bivalves of the Hammar Formation of Basrah and Amarah areas. While MacFadyen and Vita-Finze [9] studied the foraminifera, ostracoda and bivalves of subsurface boreholes in Amarah and Garmet Ali areas.

Raja and Salman [10] discussed the depositional environment and fauna of the Mesopotamian Plain of Samawa and Naseriah areas. Karim *et al.* [11] studied the Quaternary foraminifera of Basrah area to determine the paleoecology. Al- Jumaily [12] discussed the Quaternary ostracods and its paleoecology in Southern Iraq. Al- Sharifee [13] studied recent ostracods of Khor Al- Zubair, Southern Iraq. Owen [14] studied the pollens and ostracoda of Eastern Iraq. Al- Ka'abi [15] and Al- Shehmany [16] discussed the ostracoda distribution and its paleoecological indications in central and west of Southern Mesopotamia and east of Southern Mesopotamia, respectively.

There were many studies dealing with the paleoecology and paleoclimate of the Quaternary deposits of Southern Iraq and Western Iran, such as Al- Azzawi [17], El- Moslimany [18, 19], Salman [20], Al- Tawash [21], Al- Jumaily and Al- Sheikhly [22], Al- Jubouri [23], Owen [14], Al- Ka'abi [15], and Al- Shehmany [16].

Other studies dealing with the sedimentation of Quaternary and Recent deposits are; Larsen and Evans [24], Yacoub *et al.* [25, 26], Jassim *et al.* [27], Domas [28], Baltzer and Pursen [29], and Aqrawi [30].

Methodology

To cover most of the Southern Mesopotamia, there are 1478 core samples being collected from 86 subsurface bore holes (including 12 deep bore holes), which were chosen from the collection of GEOSURV Iraq, as the best fully documented data. (Figure- 1)

For ecological purposes, the weight of each sample used in this study is 50 gm, the samples prepared by washing on 0.063 mm sieve in order to retain all the juvenile stages of ostracods. The counting of specimens, which are more than 300 have been quartered for better statistical presentations of different variables concerning adults / juveniles, full carapaces / dis- articulate valves, left / right valves and nodded / non- nodded ratios. Individuality counted to cover the adults and juveniles stages by considering every left and right valves as on individual, while the remaining single valves treated as one individual too.

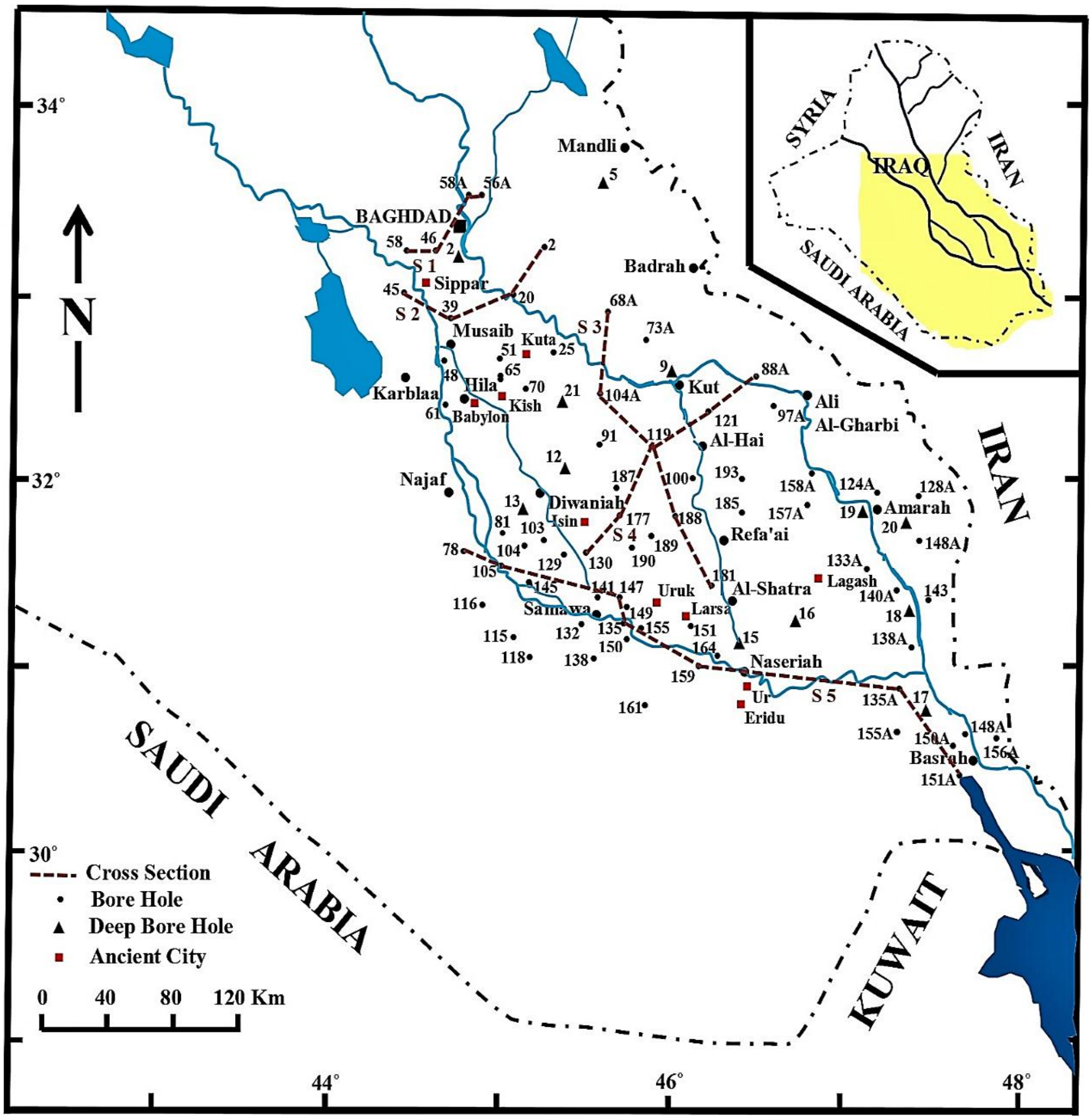


Figure 1 - Location map for studied boreholes and sections.

Geological setting

Tectonically, Jassim and Goff [31] stated that “The Mesopotamian Zone is the easternmost unit of the Stable Shelf. It is bounded in the NE by the folded ranges of Pesh-i-Kuh in the E, and Hemrin and Makhul in the N. The SW boundary is controlled by faults. The zone was probably uplifted during the Hercynian deformation but it subsided from Late Permian time onwards. The sedimentary column of the Mesopotamian Zone thickens to the east. It comprises up to 1500 m of Infracambrian, 2500-5000 m of Paleozoic, 1500-2200 m of Triassic, 1100 m of Jurassic, 500-700 m of Lower Cretaceous, 700-1400 m of Upper Cretaceous, 200-900 m of Paleogene, and 150-1500 m of Neogene and Quaternary section. Quaternary sediments alone are up to 300 m thick”.

Al- Sakini [5] considered the tectonic formation of some subsurface structures is responsible for the drifts present in the course of Tigris and Euphrates Rivers during the Quaternary in central and southern Iraq.

The Quaternary deposits in the Southern Mesopotamian Basin consists of complicated interbedded sequences of sands, silts and clays (sometimes rich in organic materials). Jassim and Goff [31] considered these sediments to cover more than one third of the surface area of Iraq, mostly within the Mesopotamian Plain, where they comprise fluviatile, lacustrine, deltaic, and aeolian sediments that replace each other both horizontally and vertically.

Those Quaternary deposits comprise two formations:

The Hammar Formation which was described by Hudson *et al.* [7] from Zubair well-13 as a Recent marine deposits reaching the thickness of 6.5m and consisting of sand and silt in the lower part and clay in the upper part. This formation could be considered to represent the last transgression of the Quaternary, which recorded world widely during the M. Holocene. [32- 39]. It is extended to the north reaching Amarah City and to the northwest reaching Naseriah City, where it's intertounging with its equivalent Maymouna Formation.

The Maymouna Formation was introduced by Al-Sheikhly [40] from the Deep Borehole -19, near Maymouna Town southwest of Amarah City. Representing alternations of fresh to brackish water deposits, consisting of sands, silts and clays in different proportions depending on their depositional environments, such as fluvial, swamps or deltaic. It extends over the southern Mesopotamian Basin reaching Diwaniya and Samawa Cities in the west, Kut area in the east and extending to Baghdad and Babylon areas in the northwest. It underlain by the Mahmodia unit (proposed by Domas [28] for Pliocene age) in the center of the basin, Injana Formation in the northwestern part and Dibdiba Formation farther to the west and south of the basin. There is a clear Quaternary / pre- Quaternary boundary NW of Samawa City, where the Maymouna Formation is underlain by the M. Miocene Fat'ha Formation.

What's more, Parsons [41], Buday [42] and Foda *et al.* [43] recorded aeolian deposits along the western margin of the study area.

Paleoecology

The Ostracode distribution patterns and their associations are extremely sensitive to the environmental conditions; and could provide an important paleo-environmental information.

Ostracod assemblages showing in many cases depth – related changes in the diversity, density, shape and size of carapace; although, the depth as a factor does not directly affect the ostracod assemblages distribution but it is relating to the turbulence, turbidity, temperature, hydrostatic pressure and oxygen levels [44 - 57].

Temperature controls the ostracod assemblages distribution, vertically with depth, and geographically (latitudinally) with respect to the shallow marine ostracodes [58 - 61].

In the current study, the salinity is the more important factor controlling the ostracod distribution, among which *Cyprideis torosa* (comprising 90- 95% of the total Ostracod fauna in this study) is the best known example for the development of nodes on their shells, where it is found within salinities ranging from oligohaline to Euhaline. In the oligohaline environment, they have large, thick and reticulate carapaces, almost nodded with few occurrences of non-nodded forms, which might be controlled genetically. While, in the mesohaline environment, the carapaces are smaller in size, slightly thinner and reticulate or punctate, almost non-nodded, the nodded forms are very few (about 3%) and the nodosity if present, are either some faint nodes in different sites or general occurrence of faint nodes. Whilst, from the polyhaline to the Euhaline environments, the carapaces become smallest, thinnest, pitted to smooth and non-nodded.

The increase in size, thickness, nodded reticulations toward the oligohaline environment, is not due to the decrease in salinity, but could be attributed to the great increased quantities of dissolved organic nutrients, and the interaction between organic molecules and heavy metals produces toxic compounds, causing a physiological reaction in the ostracods [62, 63].

On the other hand, the salinity may affect the type of plant dominating the area and indirectly the amount and type of organic nutrients, stimulating the epidermal cells responsible for carapace construction, ornamentation and nodding [22].

The size differences could be additionally ascribed to the salinity as a main ecological factor, substrata and thermal changes, due to the glacial and intraglacial impacts during the Late Quaternary in Southern Iraq.

There is high nodded / non-nodded ratio within the juvenile stages in respect to a low ratio in the adults of a similar population. This distinction cannot be clarified unless the genetic factor and ecological factors are taken into consideration.

According to the ostracod assemblage's distribution within the southern Mesopotamian Basin, six ecofacies could be distinguished representing ranges of salinities in different environments.

Eco-facies A: (Oligohaline, 0.5 - 5‰) Fresh Water. Silt and clay sediments with sand intercalations.
Fossils; *Advenocypris alpherovi* Schneider,1956, *Candona altoides* Petkviski, *Candona compressa* (Koch), *Candona neglecta* Sars,1887, *Candona paionica* Glozanj, *Candona* spp., *Candoniella albicans* (Brady), *Candoniella simpsoni* (Sharpe), *Candoniella suzini* Schneider, 1956, *Candoniella wanlessi* (Staplin), *Cypretta globulus* (Sars), *Cyprideis torosa* (Jones) Jones,1857 (nodded, reticulate, and thick walled specimens), *Cypris subglobosa* Sowerby, 1840, *Cypris trigonella* Brady, 1868, *Darwinula cylendrica* Straub, 1952, *Darwinula stevensoni* (Brady and Robertson), *Eucypris pigra* (Fisher), *Gomphocythere capensis* (G.W. Muller), *Hemicypris dentatomarginata* (Baird), *Ilyocypris bradyi* Sars, 1890, *Ilyocypris gibba* (Ramdohr), *Ilyocypris monstrifica* (Norman), *Ilyocypris quinculminata* Sylvester – Bradley, *Limnocythere floridensis* Keyser,1976, *Limnocythere inopinata* (Baird), *Limnocythere pleistocenica* (Krstic), *Limnocythere* sp., *Paracypria* sp., Gastropods (shells and operculum) and huge occurrence of Charophytes.

Eco-facies B: (Mesohaline, 5 - 18‰) Brackish Water. Silt and clay sediments with few sand intercalations.
Fossils; *Cyprideis torosa* (Jones) Jones, 1857 (non-nodded, slightly thick walled and reticulate, instars and adults specimens), *Leptocythere* sp., *Paracyprideis rarefistulosa* (Lienenklaus), with rare occurrence of fresh water species and less dominant Charophytes.

Eco-facies C: (Oligo – Mesohaline, 0.5 - 18‰). Mixed Fresh and Brackish Water. Clay, silt and few sand sediments with some evaporates.
Fossils; *Cyprideis torosa* (Jones) Jones, 1857 (smooth specimens exceeded the nodded specimens).

Eco-facies D: (Polyhaline 18 - 30‰). Mixed Brackish and Marine Water. Silt and clay sediments.
Fossils; *Cyprideis torosa* (Jones) Jones, 1857, *Loxoconcha babazananica* (Livental), *Tyrrhenocythere amnicola* (Sars), sometimes with very rare occurrence of one or two fresh water species, and rare occurrence of *Limnocythere inopenata* or *Carinocythereis indica* Jain, 1978, and *Hemicytheridea paiki* Jain, 1978.

Complete disappearance of Charophytes, and the first good appearance of benthic foraminifera such as *Ammonia beccarii parkinsoniana, A. b. sorbina, A. b. tepida, A. b. pauciloculata, Elphidium articulatum, E. excavatum, E. gunteri and E. tumidum.*

Eco-facies E: (Meso to Polyhaline 15 - 25‰). Mixed facies of Ecofacies C and D. The sediments are mostly silt with few clay.
Fossils; *Loxoconcha babazananica* (Livental), *Tyrrhenocythere amnicola* (Sars), Gastropods (shells and operculum) and Charophyta.

Eco-facies F: (Euhaline 30 – 40‰) Marine Water. Only silty clay sediments.
Fossils; *Alocopocythere reticulate* (Hartmann), *Carinocythereis indica* Jain, 1978, *Cushmanidea guhai* Jain, 1978, *Haplocytheridea keyseri* Jain, 1978, *Hemicytheridea reticulate* Kingma, 1948, *Hemicytheridea paiki* Jain, 1978, *Hemikrithe peterseni* Jain, 1978, *Neomonoceratina iniqua* Kingma, 1948, *Loxoconcha babazananica* (Livental) and *Tyrrhenocythere amnicola* (Sars). With rare existence of small size, very thin, non- nodded, and smooth specimens of *Cyprideis torosa* (Jones) Jones, 1857.

There are high individuality and high diversity of benthic foraminifera such as; *Ammonia beccarii parkinsoniana, A. b. pauciloculata, A.b. sobrina, A. b. tepida, Biloculina irregularis, Buccella frigida, Elphidium articulatum, E. excavatum, E. gunteri, E. poeyanum, E. tumidum, Ophthalmidium arabiansis, Pyrgo inornata, Quinqueloculina oblunga, Spiriloculina excavate, S. nitida and Triloculina laevigata.*

Aqrawi [64] used C^{14} dating to determine the rate of sedimentation of the marine sediments of Southern Mesopotamia. The rate of sedimentation was calculated and corrected for compaction by Aqrawi [65] for the marine, brackish and fresh water sediments to be 1.3 cm / 1000 yrs. after the last marine transgression, and 2.2 cm / 1000 yrs. before the last marine transgression.

In addition, Paepe *et al.* [66] used C^{14} dating to measure the age of the Ur Flooding Bed in the area of Sippar Ancient City and modern Tell ed-Der (near Al-Mahmmodia Town). The ages of the Ur flooding Bed is 5550 yrs. B.P, Kish flooding bed is 4850 yrs. B.P. and ed-Der flooding bed is 3950 yrs. B.P. in coincidence with sandy beds.

Webb [67] mentioned that most core samples of Late Quaternary are dated by traditional radiocarbon dates of bulk sediments, which is giving the dates for the sediment matrix and not for the fossils embedded within the sediments. That is causing uncertainties of the age model, and variations in the sediment accumulation rate.

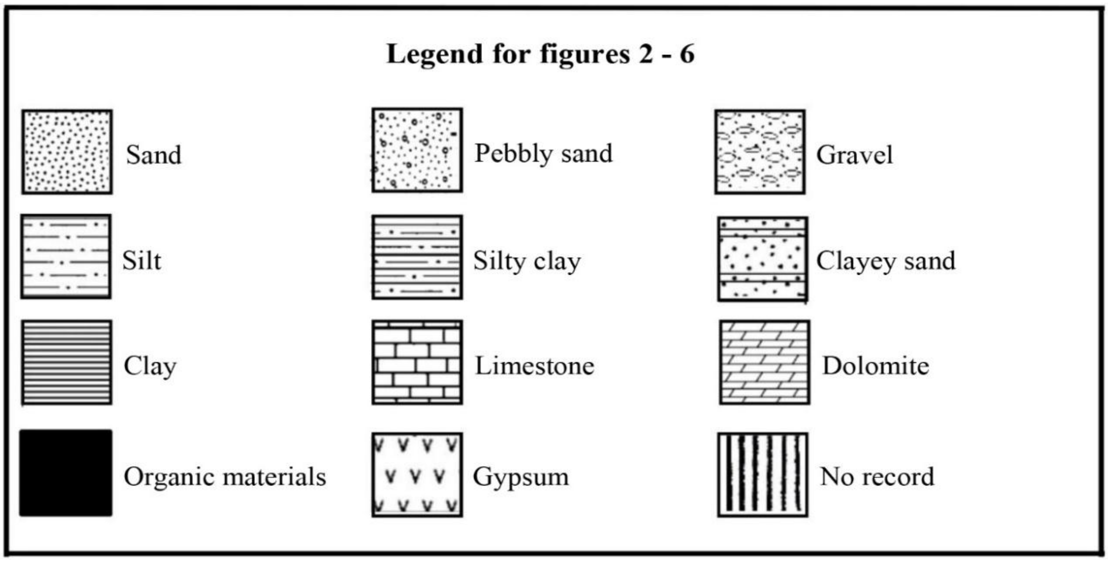
So, there are uncertainties in the work of many authors, who considered the rate of sedimentation as constant as for the marine environment as done by Aqrawi [65]. Those rates of sedimentation differs from a bore hole to another depending on the depositional environments (fluvial, back swamps, deltaic to marine) as shown in Table -1. The differences in rates of sedimentation could be noticed by the changing in depth of the marine transgression bed at about 10000 years B.P., which was recorded by Al- Jubouri [23] on the deep borehole (D.B.H.-18) near Amarah City at 48-55m., and she noticed the depth of the Ur- flooding bed at 5.4-5.7 m. depth; whilst Owen [14] recorded the marine transgression bed on (D.B.H.-9) near Kut City at 51.5-53m. depth, and on (D.B.H.-5) near Mandli City at 32-34m. depth.

In this study, the successions of the fluvial depositional cycles are considered for each borehole depending on their sedimentary facies and sometimes their faunal content to determine the cycle contacts.

The nearest borehole to Tell ed - Der ancient site which was studied by Paepe *et al.* [66] is (B.H.-46). This borehole have been chosen to locate the age of the depositional cycles, where the sandy bed are coincide with Ur flooding, and it is considered as a datum plane for correlations among the study boreholes, to determine the depositional cycles (in addition to the faunal content), and to calculate and correct for compaction the relative rate of sedimentation of the study bore holes Figures- (2, 3, 4,5 and 6).

Table 1 - Rate of sedimentation corrected for compaction of some studied boreholes (BH) and deep boreholes (DBH).

Bore hole Number	Depth of key bed in meters (Beginning of Ur flood)	Rate of Sedimentation (m. / 1000 yrs.)
BH-2	7.13	1.28
BH-20	8.45	1.52
BH-25	7.45	1.33
BH-39	6.85	1.23
BH-45	8.15	1.46
BH-46	7.20	1.29
BH-48	8.47	1.52
BH-51	7.00	1.26
BH-56A	12.10	2.18
BH-58	8.10	1.45
BH-58A	9.50	1.71
BH-61	9.80	1.76
BH-65	7.65	1.37
BH-68A	6.80	1.20
BH-70	9.33	1.68
BH-73A	3.16	0.56
BH-78	8.50	1.80
BH-88A	6.80	1.20
BH-91	9.00	1.60
BH-104A	7.66	1.38
BH-105	8.00	1.80
BH-119	8.50	1.50
BH121	9.00	1.60
BH-130	8.60	1.50
BH-135	9.50	2.00
BH- 135A	10.80	2.20
BH-147	8.85	1.80
BH-151	5.80	1.04
BH-151A	10.25	2.17
BH-159	9.75	2.00
BH-177	8.80	1.58
BH-178	8.50	1.50
BH-181	5.80	1.04
BH-188	10.00	1.80
BH-189	11.50	2.07
BH-190	9.80	1.70
DBH-2	9.70	1.74
DBH-12	12.50	2.20
DBH-21	9.30	1.68



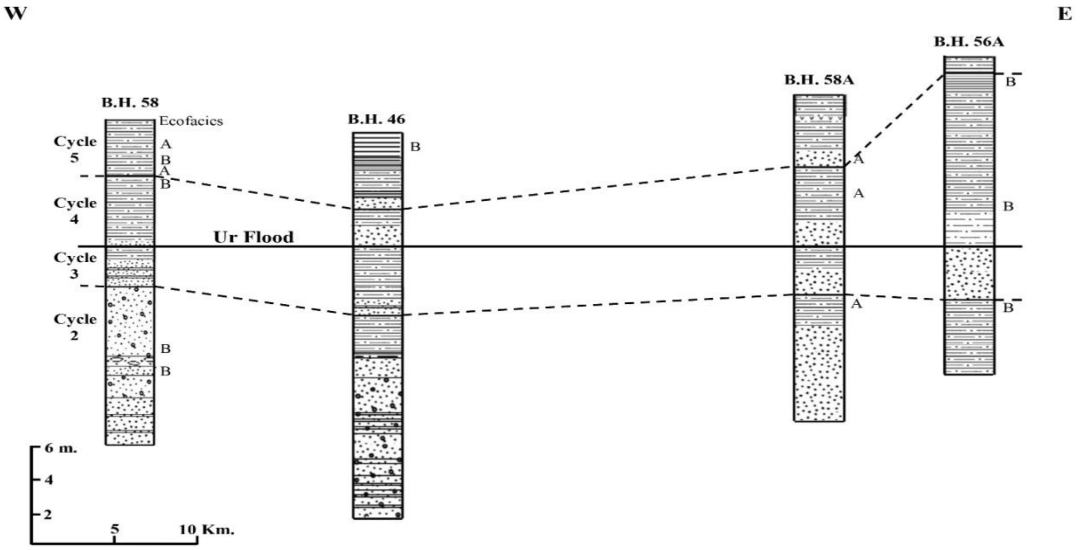


Figure 2 - East – west Cross section of southern Mesopotamian Basin (S 1) showing the depositional cycles and the ecofacies distribution.

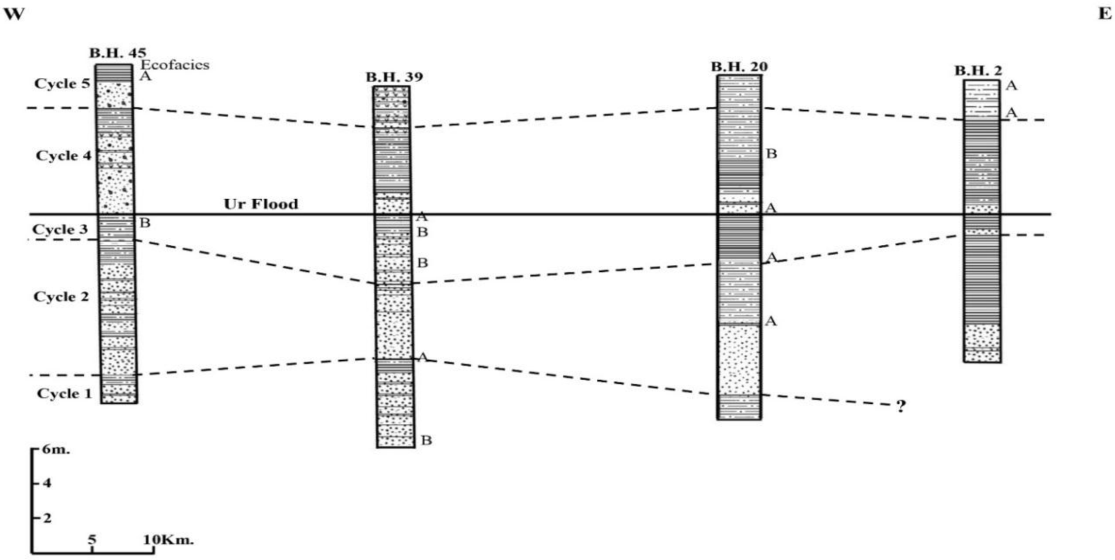


Figure 3 - East – west Cross section of southern Mesopotamian Basin (S 2) showing the depositional cycles and the ecofacies distribution.

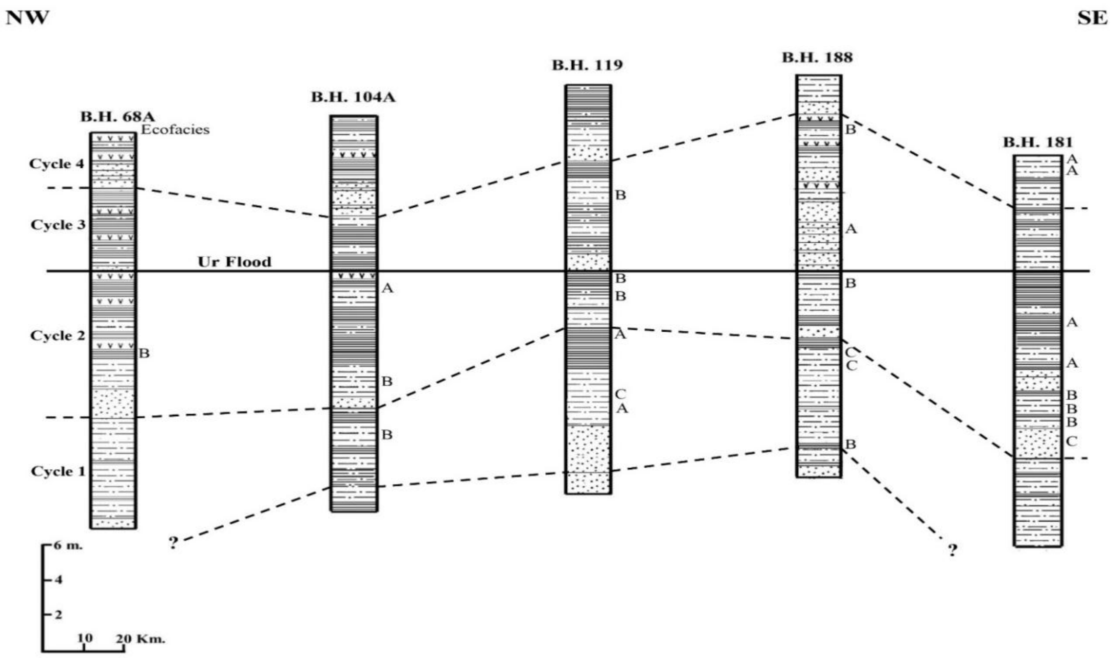


Figure 4 - NW – SE Cross section of southern Mesopotamian Basin (S 3) showing the depositional cycles and the ecofacies distribution.

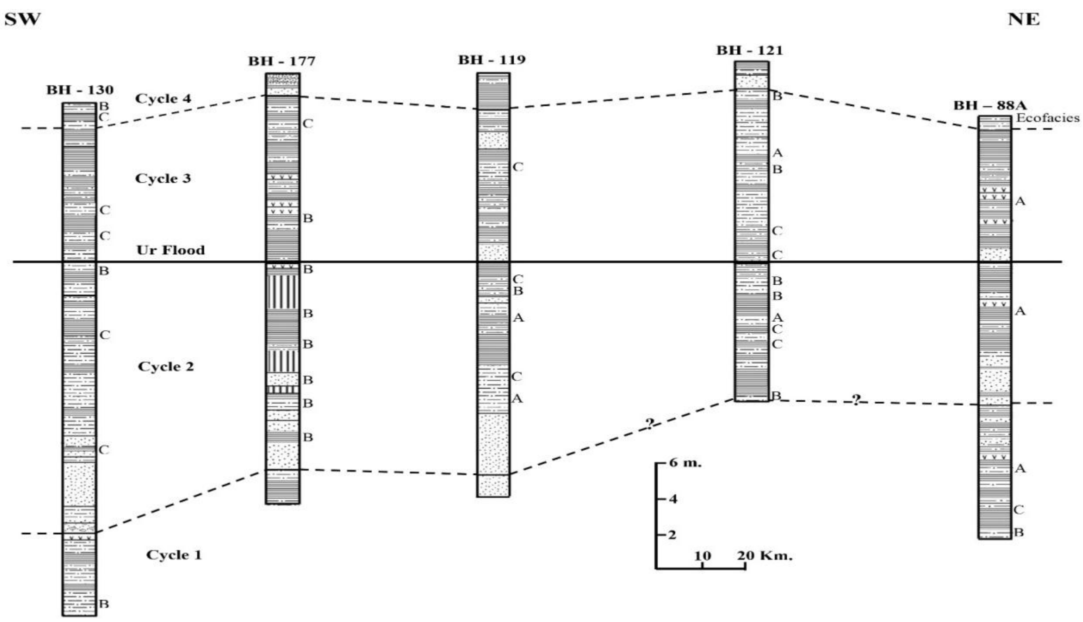


Figure 5 - NE – SW Cross section of southern Mesopotamian Basin (S 4) showing the depositional cycles and the ecofacies distribution.

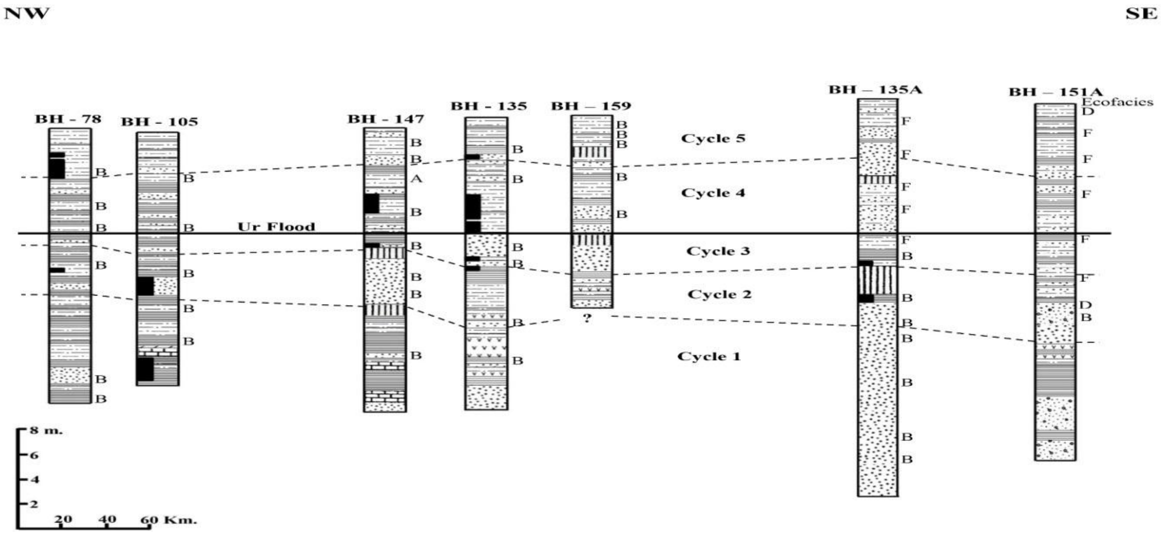


Figure 6 - NW – SE Cross section of southern Mesopotamian Basin (S 5) showing the depositional cycles and the ecofacies distribution.

Discussions and Conclusions

The studies of ostracods and foraminifera within the Southern Mesopotamia Basin, shows that this area was suffered from different environmental changes throughout the Pleistocene- Holocene, among which was the most effect climatic changes due to the temperature rise by the end of Pleistocene, causing the sea level rise worldwide, where the Arabian Gulf in particular, reaches the vicinity of Naseriah City, north of Amarah City [12, 30] and the proximity of Kut City [14]. This is demonstrated by the deposition of the marine Hammar Formation, whereas the areas covered by non-marine deposits of the Maymouna Formation [40], represented by fluvial and back swamp deposits.

Godwin *et al.* [1958, in: Al-Jubouri 23] mentioned that there were swamp (Ahwar) deposits rich with organic matter and reed remains, are deposited within a hot and dry climatic conditions prevailing during 6000 – 9000 yrs. B.P. The same climatic conditions was recorded by Paepe *et al.* [66] for the same time interval at Tell ed- Der archaeological site. Whereas, there were wet and temperate conditions prevailed during 8000 – 9000 yrs. B.P. in Southern Iraq [23].

Figures- (7, 8, 9, 10 and 11) show an estimation of the paleoecology of Southern Mesopotamia throughout nine time intervals extending from 22000 to 1000 years B.P., where there are different depositional environments could be recognized ranging from fluvial, back swamps, delta to marine.

Southern Mesopotamia effected by three distinguished sea transgressions; the first was during the time interval 22000 – 20000 yrs. B.P., represented by deltaic environment in D.B.H. - 21 and that is coincides with the marine transgression recorded by Al- Jumaily [12] and correlated with a period of humidity and sea level rise during Late Pleistocene (37000 – 20000 yrs. B.P.) as mentioned by McClure [68]. The second transgression registered during the time interval 16000 -14000 yrs. B.P., it is distinguished by deltaic environment recorded from D.B.H.-21 and marine environment in B.H.-181. The closure of Würm Glacial Cycle at 16000 yrs. B.P. which was distinguished by global climatic changes toward warmer conditions, which was registered by the distribution of fresh water-fluvial and back swamps environments in Southern Mesopotamia during the time interval 13000 – 11000 yrs. B.P. So by the end of Pleistocene (10000 yrs. B.P.) the third sea transgression was recorded by the presence of deltaic and shoal back swamps environments in the B.H.- 189 and B.H. -190 respectively. This transgression continued during 9000 yrs. B.P. and represented by the deltaic environment in B.H. -190 and B.H. – 151, in addition to the back swamps and fluvial environments where the climate was wet with low temperature [66]. The influence of the third transgression continued during the time interval 8000 -7000 yrs. B.P. by the presence of deltaic environment in the B.H. - 149, B.H. - 151, B.H. - 189 and B.H. – 190., in addition to the distribution of back swamps and fresh water – fluvial environments.

During the interval 7000 – 6000 yrs. B.P. the fresh water fluvial environment was prevailed among the studied boreholes, indicating an ancient river passing through the boreholes 58, 39, 51 and 70, which was coincides with the assumption of Adams [69] about the presence of a river during

Ubaid Period (Writing Period 7000 – 6000 yrs. B.P.), and that is coincide with the presence of the Ancient Cities of Sipper, Kuta and Kish which were lying on this river [1]. This ancient river might be a branch of the Euphrates River, called by the archaeologists as Arahtu River [1]. It is worth to mention, that the swamp environments of most boreholes were changing with time to fresh water-fluvial environment, and that was assumed by Al-Sakini [5] in explaining the mechanism of forming new river courses within Mesopotamia.

The time interval 6000-5000 yrs. B.P. represents the Post – Glacial Climatic Optimum, where the sea level and humidity were changed worldwide. So, the Back Swamps environment was prevailed over the Southern Mesopotamia during 5500 - 4500 yrs. B.P. which indicates the flooding of most rivers, where the dominance of the Ecofacies- A means rainy -wet climate. Paepe *et al.* [66] recorded Ur Flood by the end of Ubaid Period (5550 – 5450 yrs. B.P.), and Kish Flood (4850 – 4300 yrs. B.P.). Al-Jubouri [23] mentioned that both floods were correlated with the global climatic changes, where there were two sea level rises dominated during Late Holocene of West Europe at 5000-4700 yrs. B.P. and 4500-4200 yrs. B.P. respectively.

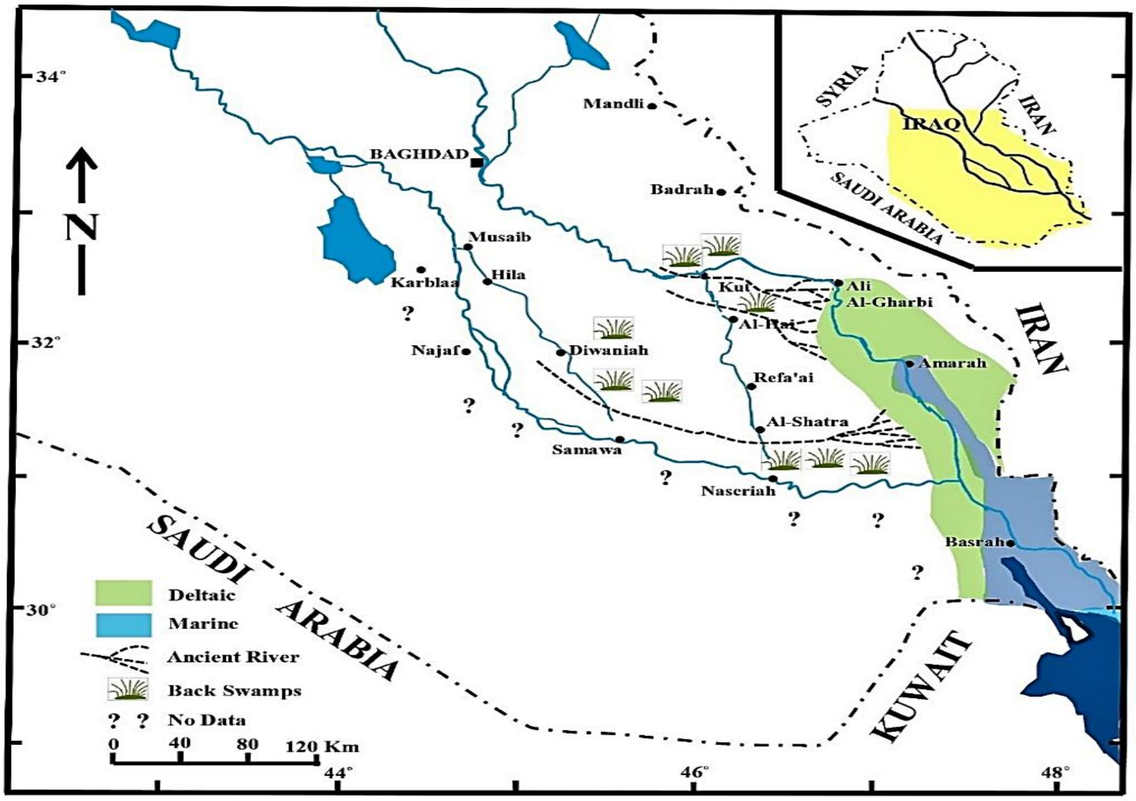
By the end of 5000 yrs. B.P., the Climate was cold and wet (Weiss *et al.* [70], and that is recorded in Southern Mesopotamia by increasing rains fall and widening of rivers during 4000 – 3000 yrs. B.P. Nützel [71] mentioned that that there was a decrease in temperature (2-3 degrees) in Southern Mesopotamia during 3500 yrs. B.P., causing colder climate and rising of sea level (3 meters above nowadays level).

Throughout the time interval 3500- 3000 yrs. B.P., the fresh water- fluvial environment were present in B.H.-51 and B.H.-70 and extended to the B.H. - 48 and D.B.H. – 2. The fresh water environment in B.H. - 48 may indicates the changing of Euphrates River to its present course during that time, or there was a bisect of the Euphrates River at that site. Susa [1965, in: 5] mentioned that Ancient Euphrates River had changed its course during the Babylonian Period from Kuta Ancient City to the west towards Babylon river, due to a man-made dam done to elevate the old water level, which was in turn lead to prosperity of Babylon Civilization at that time. But the Euphrates River had changed its course tectonically because of the effect of Falloja Subsurface Structure [5].

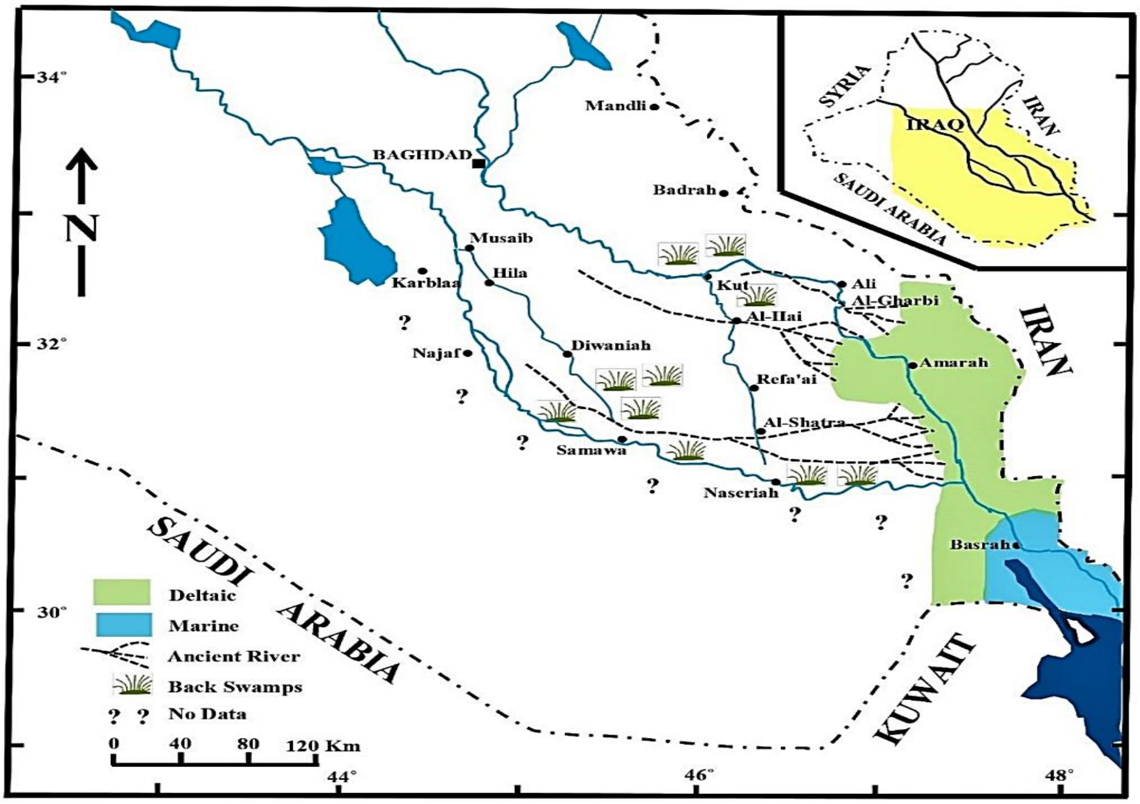
Rivers Activity increased during the time interval 2300- 2000 yrs. B.P. causing floods, called Greek Floods [72]. While the last time interval 1500- 500 yrs. B.P. distinguished by the high distribution of fresh- water environment in most of the studied boreholes, with less distribution of fluvial environment. Fairbridge [72] recorded global rise in sea level for about 2 meters during the time interval 1650- 950 yrs. B.P., causing sea transgression in Northern Europe. Also, he recorded an increase in seasonal rainfall in Central and North Africa during the time interval 1650 – 1350 yrs. B.P., causing the Nile Flood.

The climate of Southern Mesopotamia during the time interval 2000 – 1000 yrs. B.P. distinguished by the changing between dry and wet conditions, and that is recorded by the distribution of back swamps and fluvial environments, in addition to huge river systems covered the area.

The Fluvial environment appeared at B.H.-58A and D.B.H.-2 at the last time intervals may represent the old Tigris River Course, and not the effect of the closeness of those boreholes from the river because there was not any fresh water fluvial environment recorded from the nearest B.H. - 20. Al- Sakini [5] recorded the preliminary phase of Tigris River during Middle Pleistocene, running near the Ancient City of Ctesiphon toward Al-Suwaira Town, it is evidenced by the presence of subsurface river sands and gravels.

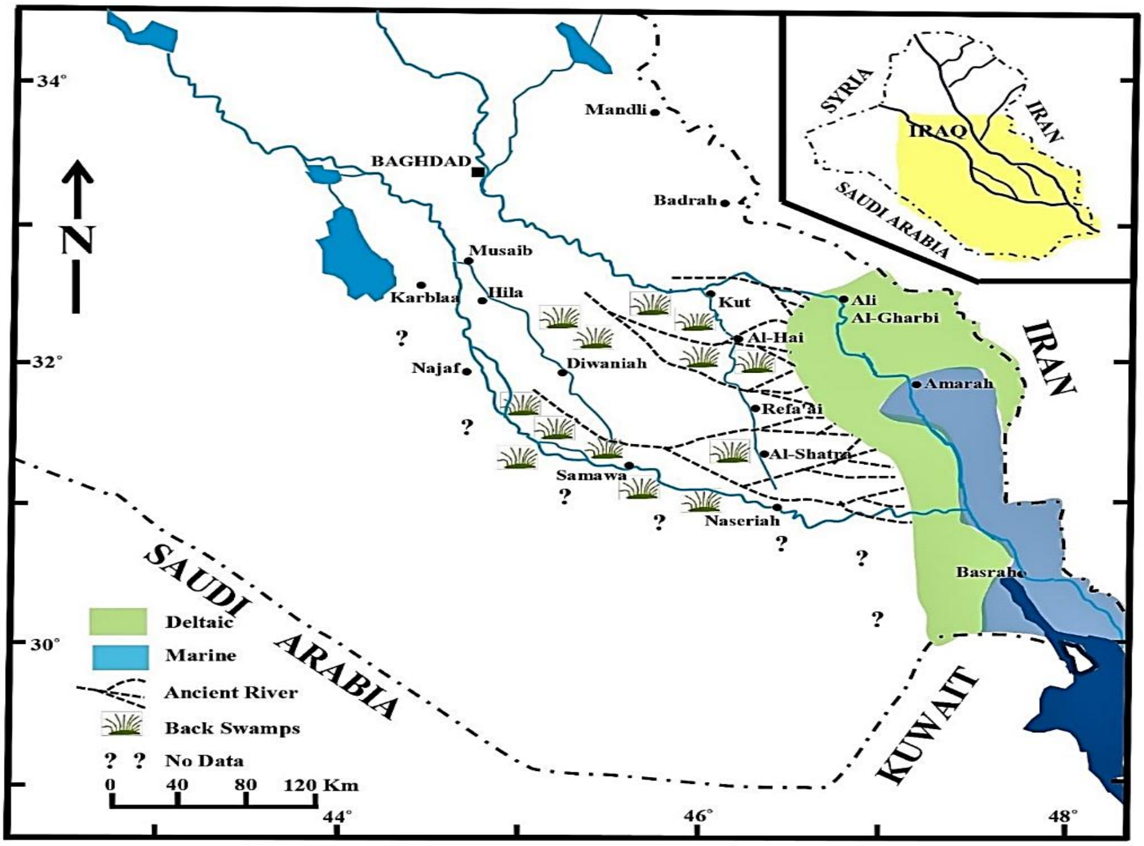


22000 – 20000 B.P.

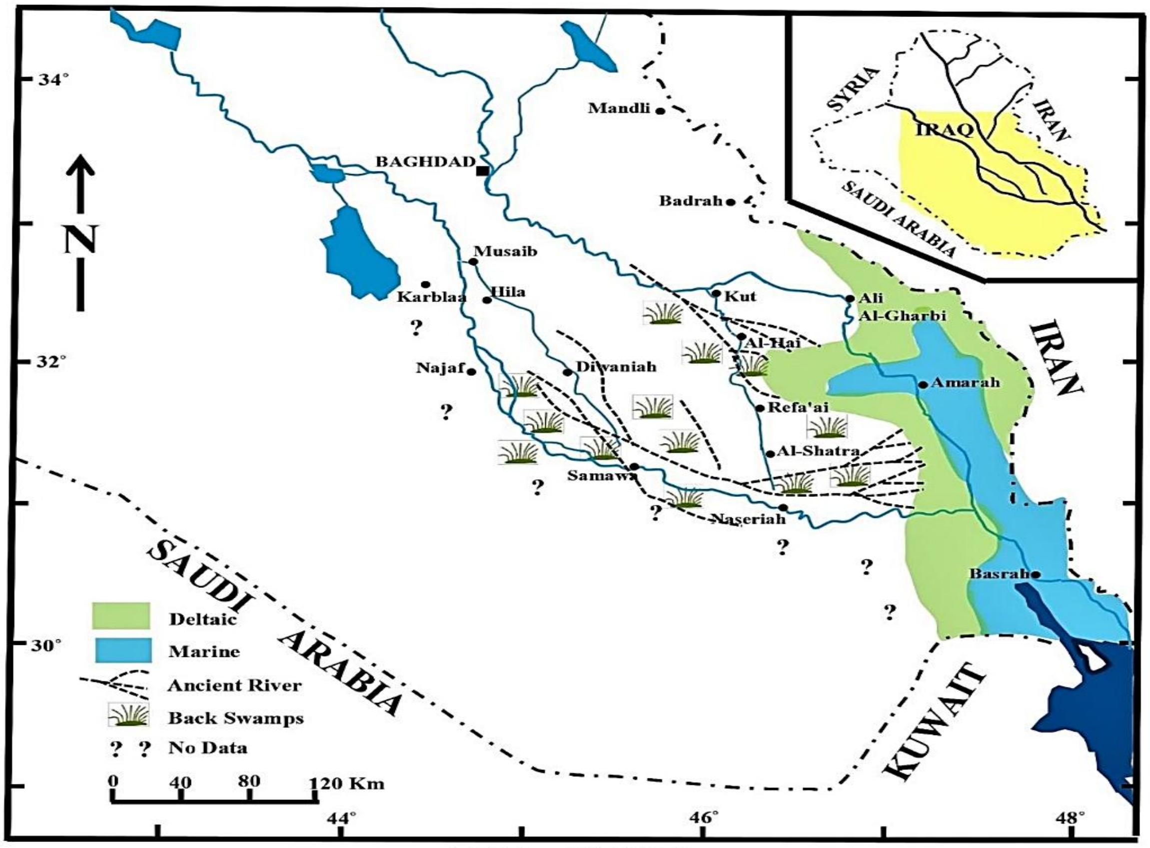


18000 – 14000 B.P.

Figure 7 - Estimated paleoecological maps for Southern Mesopotamia during 22000 yrs. B.P. – 14000 yrs. B.P.



13000 – 11000 B.P.



10000 – 9000 B.P.

Figure 8 – Estimated paleoecological maps for Southern Mesopotamia during 13000 yrs. B.P. – 9000 yrs. B.P.

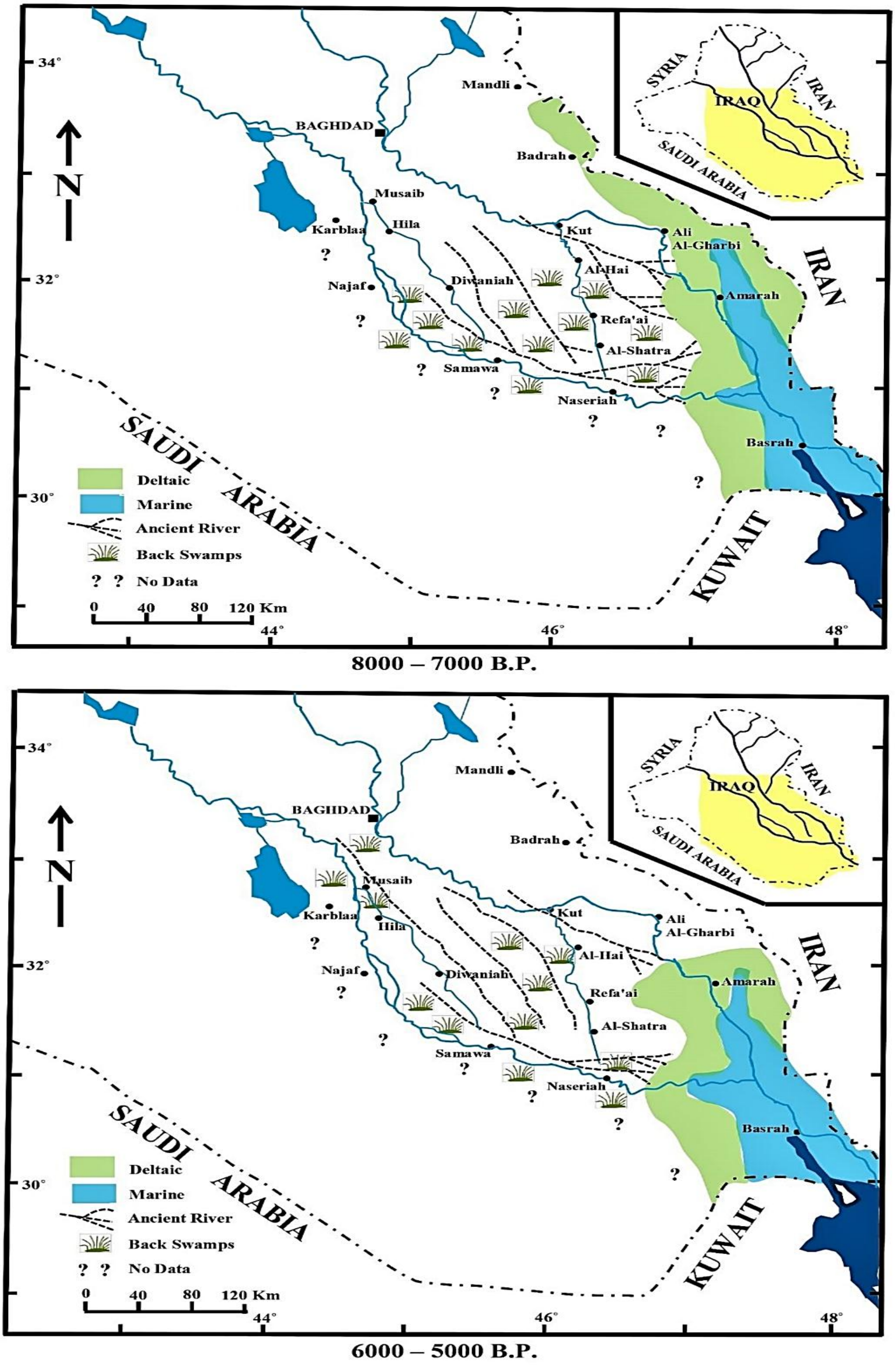
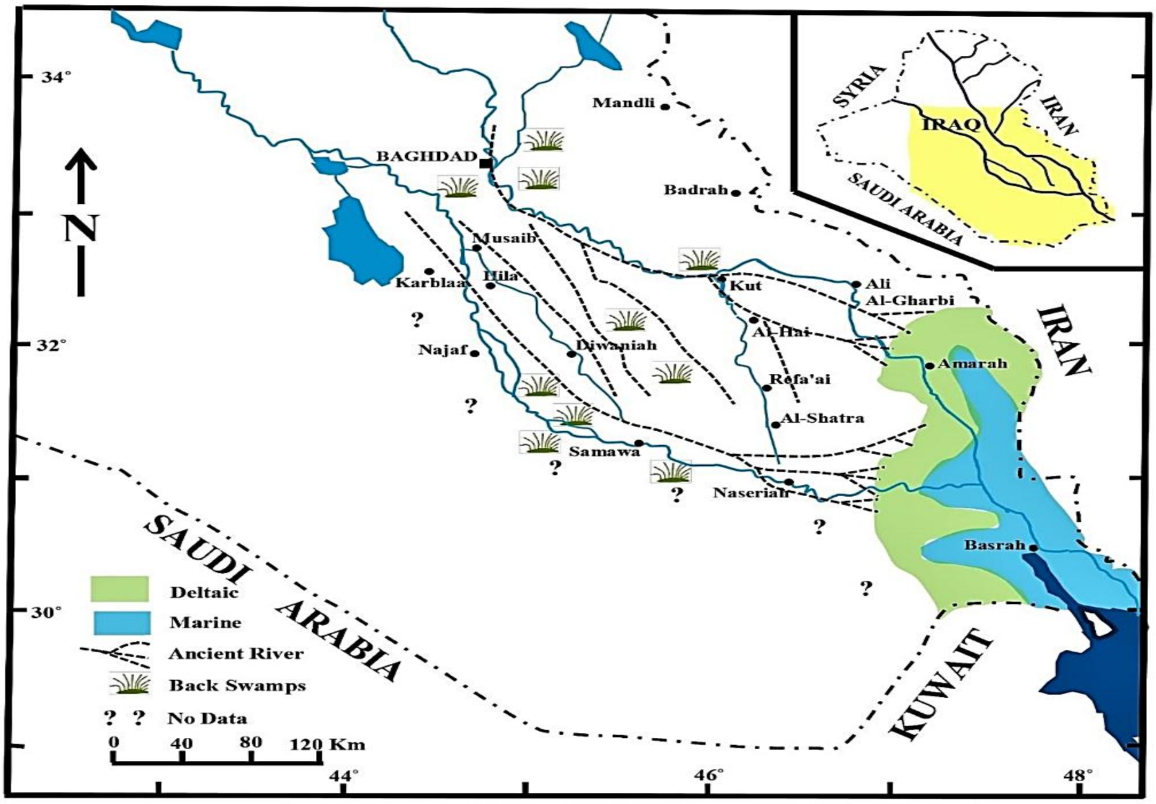
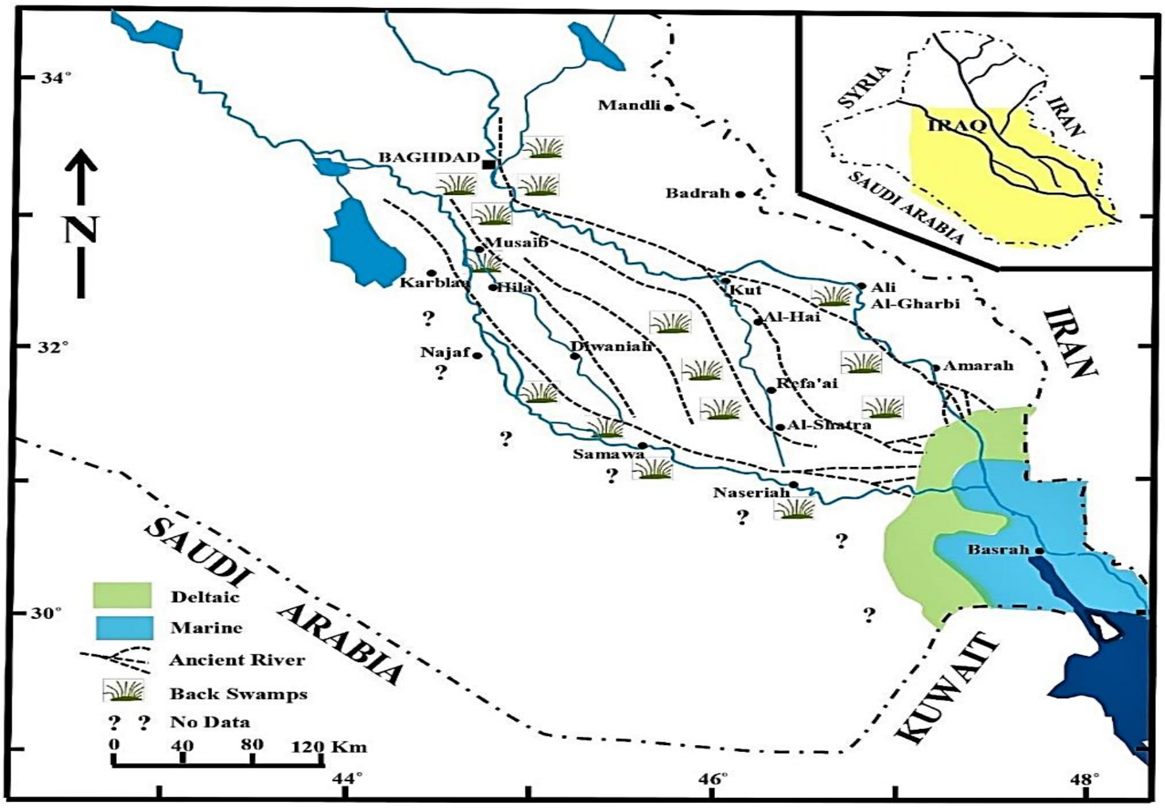


Figure 9 – Estimated paleoecological maps for Southern Mesopotamia during 8000 yrs. B.P. – 5000 yrs. B.P.



4000 – 3000 B.P.



2000 B.P.

Figure 10 – Estimated paleoecological maps for Southern Mesopotamia during 4000 yrs. B.P. – 2000 yrs. B.P.

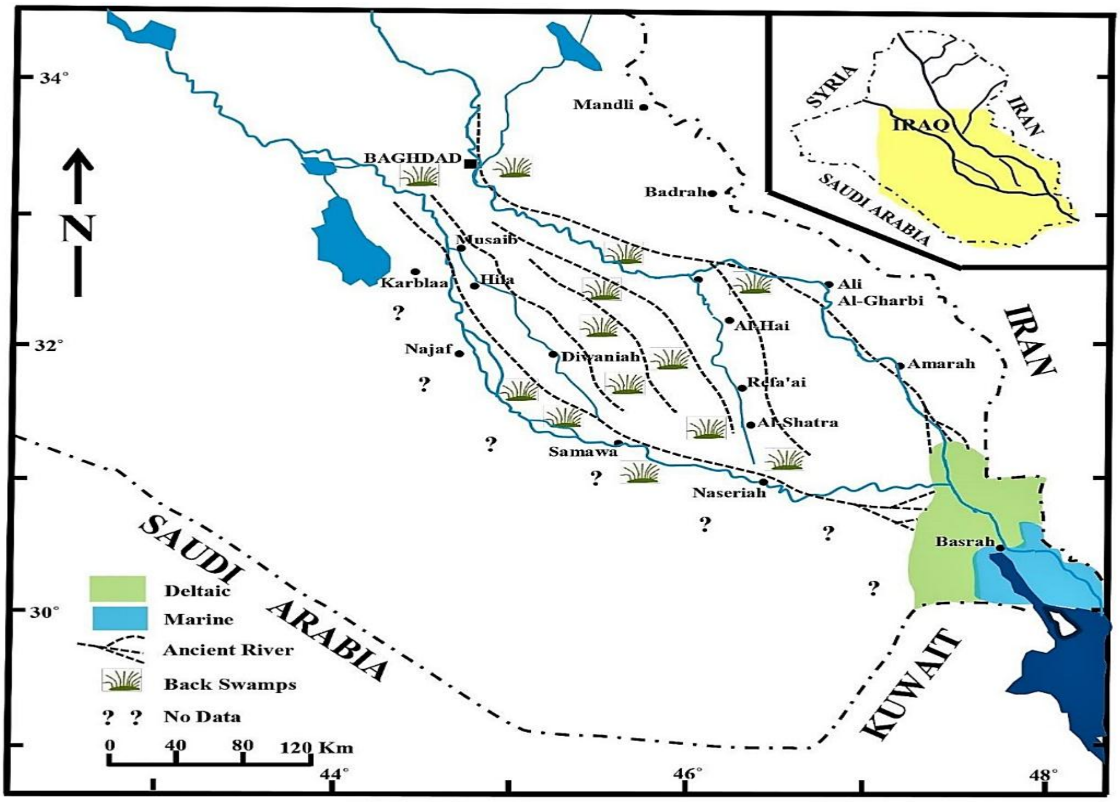


Figure 11 – Estimated paleoecological maps for Southern Mesopotamia during 1000 yrs. B.P. (1000 yrs. A.D.).

Recommendations

- Drilling more of the boreholes, within the Southern Mesopotamia, nearby the archaeological sites, for more detailed paleoecological mapping.
- Using C^{14} dating and O^{16} / O^{18} ratio for more precise dating and accurate climatological and paleoecolgical studies for the Southern Mesopotamia.
- Detailed macro-paleontological and palynological study and their ecological implications, for more knowing about the paleoecology of the Southern Mesopotamia.
- It is worthy to do new archaeological excavations within the deserted areas nowadays, which might be lakes, back swamps or ancient rivers, with a possibility of the present of undiscovered ancient cities.

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