POLLEN EVIDENCE OF LATE QUATERNARY VEGETATION AND INFERRED CLIMATIC CHANGES OF LAKE RAZZAZA, WESTERN IRAQI DESERT

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ABSTRACT

Palynological analysis of a sediment core of two meters depth from the eastern shore of Razzaza Lake (Karbala Governorate, Iraq) provides the first late Quaternary palaeoclimatic record for the western Iraqi desert region. The lake sediments contain pollen and spore taxa including *Graminidities, Palmaepollenites, Polypodium, Onobrychis, Convolusia, Artemisia, Quercus, Retitricolpites tuberosus, Alnus, Chenopodiacea, Plantago, Cuscuta, Pinus, Laevigatosporites ovatus, Laevigatosporites discordant, Littorella uniflora* and *Anthemis maritimum* as well as foraminiferal test linings, acritarch, dinoflagellates and fungi. The pollen diagram suggests eight palaeoecological zones for the late Quaternary period in this area. The palaeoclimate seems to have changed during the last 40000 years through periods of warm and wet climate with Mediterranean savanah forest, pluvial periods with summer rainfall, semi-arid cold climate with steppe vegetation and warm arid desertic climate. Dense vegetation once occupied the catchment area of this depression and at times it was filled with water to form a lake that reached a depth of 16 m. as its level stood at 32 m. (a.s.l.).

الدلائل البالينولوجية للتغيرات المناخية لبحيرة الرزازة / الصحراء الغربية العراقية خلال فترة العصر الرباعي المتأخر

المستخلص

اثبت التحليل البالينولوجي للباب رسوبي بعمق مترين من الساحل الشرقي لبحيرة الرزازة (محافظة كربلاء، العراق) سجل المناخ القديم لفترة نهاية العصر الرباعي لمنطقة الصحراء الغربية – العراق. تتميز رسوبيات البحيرة بوجود الاصناف الآتية من حبوب الطلع والابواغ:-

حبوب طلع الحشائش (*Graminae*) ، حبوب طلع اشجار النخيل (*Palmaepollenites*) ، حبوب طلع اشجار الصنوبر (*Pinus*) ، حبوب طلع الكيوركس (*Quercus*)، حبوب طلع ريتير اكولبايتيس تيوبروس (*Retitricolpites tuberosus*)، حبوب طلع ايلنوس (*Alnus*) ، حبوب طلع الكونفولوسيا (*Convolusia*) ، حبوب طلع اونوبرايجس (*Onobrychis*) ، حبوب طلع ليتوريلا يونيفلورا (*Littorella uniflora*) ، حبوب طلع الانثيمز (*Anthemis*) ، حبوب طلع كسكيوتا (*Cuscuta*) ، حبوب طلع الارتيميسيا (*Artemisia*) ، حبوب طلع اعشاب الجينوبوديشيا (*Chenopodiacea*) ، حبوب طلع بلانتكو (*Plantago*) ، وابواغ لافيكاتوسبورايت اوفاتس ودسكوردنت (*Laevigatosporites discordant*)، (*Laevigatosporites ovatus*)، والبوليبوديوم (*Polypodium*) والبوليكـونيوم (*Polygonium*) وكذلك بطانة الفورامنيفرا (*Foraminiferal test lining*) ، الاكريتارك (*Acritarch*) ، متكيسات ذوات السوطين (*Dinoflagellates*) والفطريات (*Fungi*). يبين المخطط البالينولوجي للمقطع المذكور ثمانية انطقة للبيئة القديمة لفترة نهاية العصر الرباعي في هذه المنطقة وان المناخ القديم قد تغير خلال 40000 سنة قبل الحاضر الاخير مابين مناخ دافئ ورطب مما ادى الى نمو الحشائش الى فترات مطيرة مع سقوط الامطار صيفا الى مناخ شبه بارد مع نباتات عشبية ثم الى مناخ صحراوي دافئ وجاف. شغل الغطاء النباتي منطقة حوض تصريف المنخفض في اوقات كان قد امتلئ فيها بالمياه ليكون بحيرة وصل اقصى ارتفاع للمياه فيها 32 متر فوق مستوى سطح البحر.

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INTRODUCTION

Lake Razzaza is located about 20 km. west of Karbala (Fig. 1) and occupies what used to be until recently (1940) a dry depression. Present climatic conditions are characterized by a prolonged period of summer drought and highly variable winter precipitation with a mean annual precipitation of less than 100 mm. Mean temperatures range from 8-10°C in January to 30-32°C in July. These conditions are too dry to form a lake. Filling the depression with water from the Euphrates River via Lake Habaniya formed the present lake. However, the presence of a series of ancient shorelines and some old lake sediments (Voute, 1957; Al-Tawash, 1996) indicate the presence of an old (palaeo) lake in this depression.

Available evidence suggests that the origin of Razzaza depression is primarily tectonic (down warping and down faulting) accompanied by eolian erosion (deflation) (Al-Tawash, 1996). The easterly regional dip of strata in the desert area to the west, the occurrence of the Euphrates fault system, which bounds the depression west and the elevated "desert" lands to the east point to the effects of tectonic movements. The bottom of the depression (about 16 meters a.s.l.) is

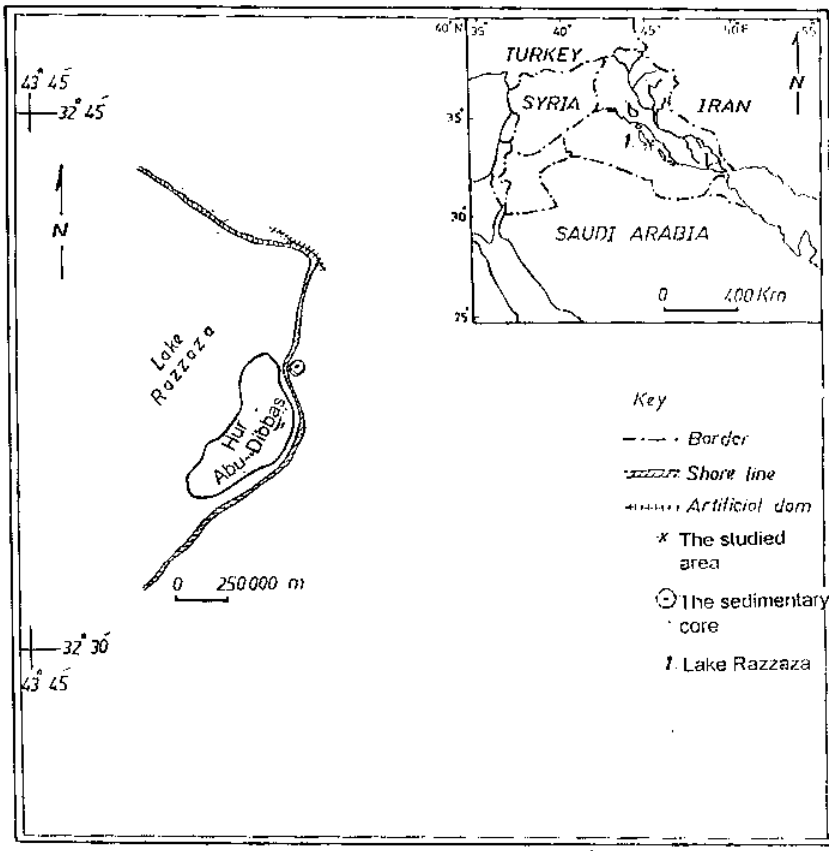

Fig. 1: Shows the studied area and the location of sedimentary core.

lower than the surrounding areas and is about 16 meters below the level of the Euphrates River in the area (32 meters a.s.l. at nearby Hindiya). This indicates that wind deflation was responsible for carrying away sediments carried into the depression by running water as well as eroding older sedimentary strata.

This work is aimed to study the late Pleistocene and Holocene history of Razzaza depression depending on the palynological evidence to infer the palaeoenvironment including the palaeovegetation which were favorable to form the palaeolake Razzaza. The work also aims to compare the palaeoclimate that prevailed in the area with the global climate in the Middle East and neighbouring countries during the late Quaternary.

COLLECTION AND SAMPLE PROCESSING

Sixteen samples were collected from a continuous core from an auger-hole which was bored at the southeastern part of the lake and penetrated two meters of Quaternary sediments before reaching older bedrock sediments of Injana Formation (Upper Miocene). This sediment column consists of alternating layers of sand, silt and clayey silt generally of light color. The sand is generally fine grained but occasionally coarse such as at the depth of 185 cm. These sediments represent near-shore lake deposits and the finer (clayey) parts probably deeper phases of the lake.

The 16 collected sediments samples were macerated for their palynomorph constituents. The procedure used is that outlined by Bars and Williams (1977) with some modifications. The samples were treated with hydrochloric and hydrofloric acids and the palynomorphs were mechanically separated (instead of using zinc bromide). The residues were dispersed and stuck on glass covers by cellosize solution and mounted on glass slides with Canada Balsam and were studied under the polarized microscope. These slides are stored at the Department of Geology, College of Science, University of Baghdad.

PALYNOSTRATIGRAPHY OF SEDIMENTS

Numerous pollen and spore taxa were identified in the sediments of the palaeolake Razzaza. These include *Graminidities, Palmaepollenites, Polypodium, Onobrychis, Convolusia, Artemisia, Quercus, Retitricolpites tuberosus, Alnus, Chenopodiacea, Plantago, Cuscuta, Pinus, Laevigatosporites ovatus, Laevigatosporites discordant, Littorella uniflora and Anthemis maritimum* as well as foraminiferal test linings, acritarch, dinoflagellates and fungi (Fig. 2 and 3). This suite characterizes the palaeovegetation of the late Quaternary period as inferred by other workers elsewhere in the world (El-Moslimany, 1986, 1987, 1990 and 1994; Horn, 1994; Barnett, 1989).

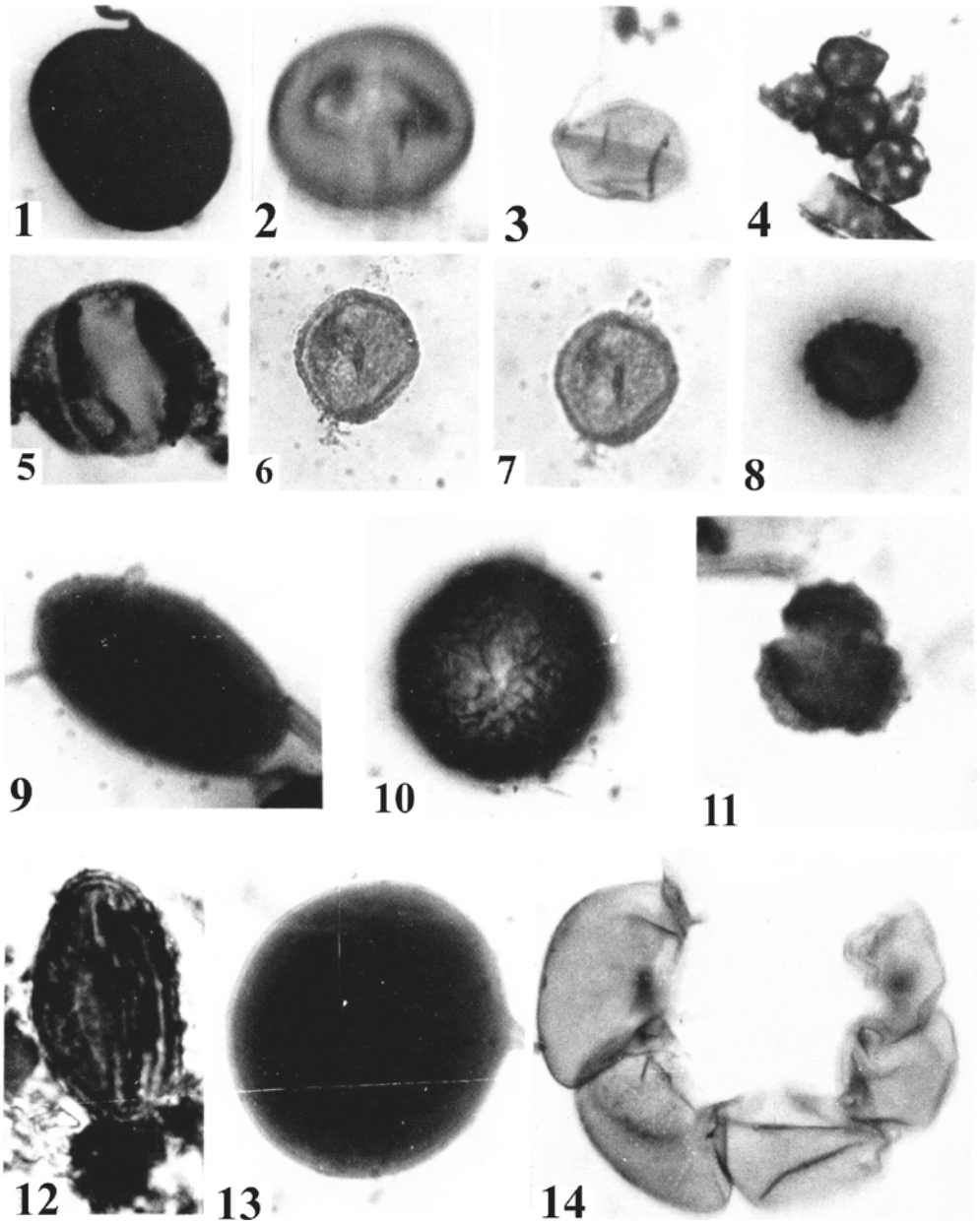
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Fig. 2

Palynomorphs of Lake Razzaza sediments. Bar scale = 20 μm.

1) *Graminae sp.*, depth 165cm, 14-115 Leitz.

2) *Psilamonocolpites riconii* Duenas 1965, depth 175cm, 16-145 Leitz.

3*) Retimonocolpites maximus* Horn 1993, 17-126 Leitz.

4) *Chenopodiacea*, depth 150cm, 23-134 Leitz.

5) *Pinus sp.*, depth 150cm., 12-116 Leitz.

6&7) *Retitricolpites tuberosus* Horn 1993, depth 15cm, 16-115 Leitz.

8) *Tricolpate sp*, depth 165cm, 21.5-125.7 leitz.

9) *Quercus sp*., depth 165cm, 7-140 Leitz.

10) *Littorella uniflora*, (in Moore & Webb, 1978), depth 175cm, 15-119 Leitz.

11) *Anthemis type* (Tripleurospermum maritimum), depth 175cm 12-133 Leitz.

12) *Retitricolpites simplex*, Horn, 1994, Enclosed rocks, 21-139 Leitz.

13) *Polygonium bistorta*, (in Moore & Webb, 1978), depth 150cm, 15-128 Leitz.

14) Foraminiferal test lining, depth 175cm, 12-129 Leitz.

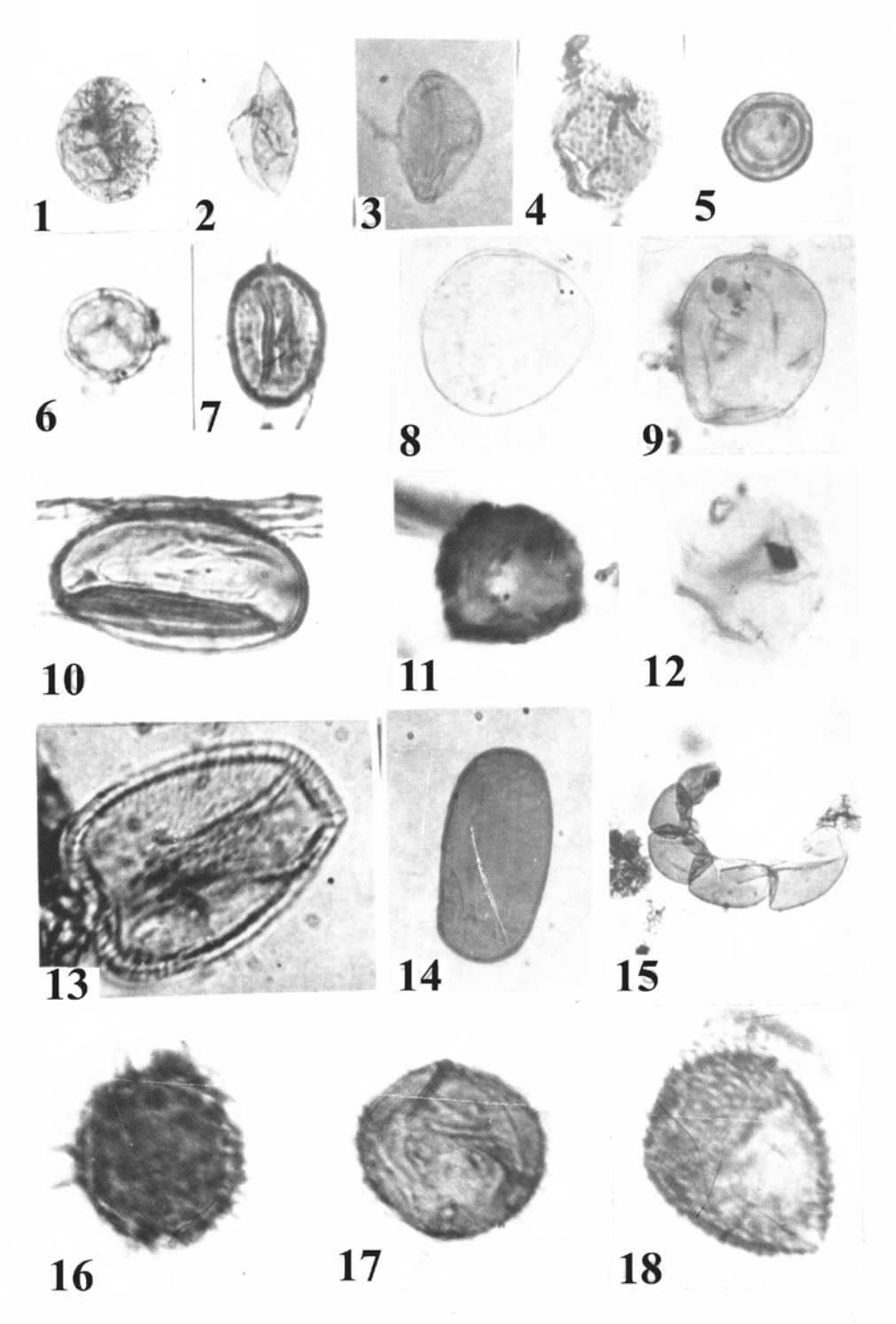
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Fig. 3

Palynomorphs of Lake Razzaza sediments. Bar scale = 20 μm

1) *Palmaepollenites sp.,* depth 165cm, 16-128 Leitz.

2)*Psilamonocolpites nanus* Horn 1993, depth 165cm, 17-129 Leitz.

3) *Psilamonocolpites amazonicas* Horn 1993, depth 45cm, 3-170 Leitz.

4) laevigatosporites discordant Thompson & Pflug, depth 165cm, 13-119 Leitz.

5) *Polygonium bistorta*, (in Moore & Webb, 1978), depth 165cm, 10-145 Leitz.

6)*Chenopodipollis sp*., Enclosed rocks, 20-138 Leitz.

7) *Quercus sp*. depth 45, 13-110 Leitz.

8) *Graminae sp.*, depth 110cm, 6-125 Leitz.

9) *Monoporites annuladus* Van der Hammer 1954, depth 165cm, 19.5-142 leitz.

10) *Quercus sp.*, depth 45cm, 12-132 Leitz.

11) *Polypodium sp*., depth 110cm, 13-117 Leitz.

12)*Trichotomosulcites sp*. of Horn 1994, depth 45cm, 6.5-135 Leitz.

13) *Artemisia sp.*, depth, 45cm, 13-140 Leitz.

14) *Onobrychis sp*., depth 165cm, 6-155 Leitz.

15) Foraminiferal test lining, depth 45cm, 12-134 Leitz.

16-18) Dinoflagellate cysts, depth 165cm.

PALAEOECOLOGICAL ZONES OF LAKE RAZZAZA SEDIMENTS

A pollen diagram of the environmentally controlled taxa is constructed from the palynological analysis of the sediments. Eight palaeoecological zones are recognized for the studied late Quaternary period in this area (Fig. 4); dating is estimated on the basis of a sedimentation rate of 5 cm/1000 years. The palaeolake levels are given in this study by correlating each palaeoecological zone with its appropriate ancient shore line cut into the slope of Razzaza depression. The ancient shorelines were delineated with the aid of aerial photographs of the region (Al-Tawash, 1996).

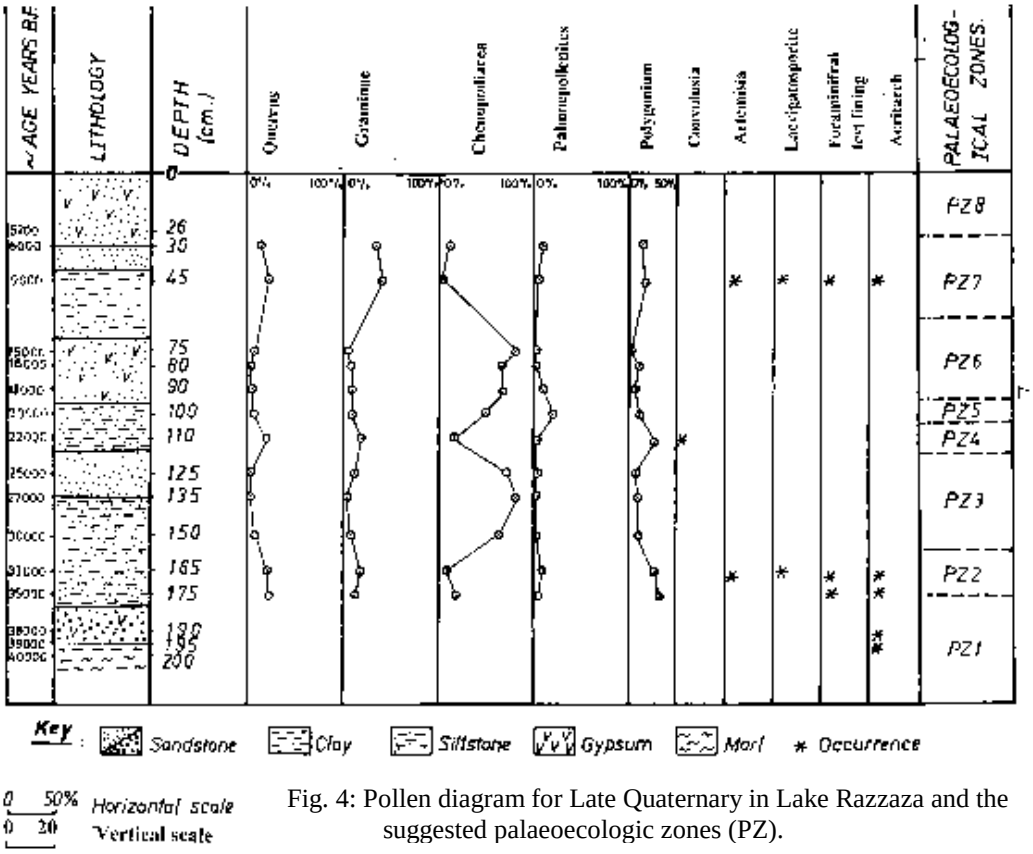

Fig. 4: Pollen diagram for Late Quaternary in Lake Razzaza and the suggested palaeoecologic zones (PZ).

1. **First Palaeoecological Zone (PZ1)**: This is the lowest zone, which is represented by the core from the depth of 195-180 cm. and may refer to the time interval of 39000-36000 years BP. The sediments are composed of coarse-grained, well sorted sand and probably indicate an ancient shoreline of the lake. The zone is poor in palynological contents but still contains some of the aquatic palynomorphs (Fig. 4), which indicate that the lake level was at

about 29 to 30 m. above sea level (a.s.l.) during this period, which is equivalent to a lake depth of 13-14 m.

2. **Second Palaeoecological Zone (PZ2)**: This zone is represented by the core from 180-155 cm. which is estimated to represent the time interval of 36000-31000 years BP. The sediments here are composed of light brown very fine silt. The silt is considered as a lake bottom sediment and probably reflects a higher water level for the lake. The palynomorphs content of this zone show an increasing percentages of *Quercus, Graminae* and *Polygonium* and low percentages, *Chenopodiacea, Artemisia* and *Laevigatosporites* (Fig. 4), which suggest a warm and wet climate with subtropical savanah forest. Aquatic palynomorphs such as acritarch, dinoflagellates and foraminiferal test linings are also present (Fig. 4) as indicators of the palaeolake, which expanded and reached higher levels of at least 31 m. a.s.l. during this time interval (more than 15 m. of water hight for the lake). Both the lake sediments and the palaeovegetation of this zone suggest favorable climatic conditions of a pluvial period prevailing in the area during this time interval.
3. **Third Palaeoecological Zone (PZ3)**: This zone is represented by the core from depth 155-116 cm. which probably represents the time interval 31000-23200 years BP. The sediments of this zone are composed of alternating light brown silt and friable fine sand. The palynomorphs of this zone are characterized by a high percentage of *Chenopodiacea,* low percentages of *Graminae, Polygonium* and *Palmae* and the disappearance of acritarchs and dinofllagelates (Fig. 4). This suggests relatively semi-arid and cold climatic conditions with drought summer; only the lower part of this zone is considered transitional between the pluvial and the semi-arid conditions. These conditions led to a contraction of palaeolake Razzaza lowering its water height to 7 m. (23 m. a.s.l.).
4. **Fourth Palaeoecological Zone (PZ4)**: This zone is represented by the core from depths 116-103 cm. probably equivalent to the time interval 23200-20600 years BP. The sediments are composed of light brown silt. The palynomorphs suite is characterized by the decrease of *Chenopodiacea* and increasing percentages of palynomorphs of the second palaeoecological zone (PZ2) (Fig. 4) suggesting a temperate climate with probable summer rainfall.
5. **Fifth Palaeoecological Zone (PZ5)**: This zone is represented by the sediments from depth 103-94 cm. of an estimated time interval of 20600-18800 years BP. The palynoflora of this zone show high percentages of *Palmae* associated with some *Chenopodiacea* and *polygonium* and rare occurrences of *Graminae.* This suggests a warm and dry climate in general with summer drought leading to increased evaporation and, hence, lowering of the lake level to 20 m. (a.s.l.).

6. **Sixth Palaeoecological Zone (PZ6)**: This zone is represented by the depths 94-60 cm. of probable time interval 18800-12000 years BP. The sediments consist of friable fine sand. The pollen diagram (Fig. 4) show a high percentage of *Chenopodiacea* and a low percentage or absence of the other types. Such a distribution of the palaeovegetation could reflect summer drought and a semi-arid cold climate with steppe vegetation. This dry and cold climate probably coincides with the last glacial maximum, which took place at about 15000-14000 years BP. The palaeoclimatic conditions of this zone might have caused lowering of palaeolake Razzaza and its gradual disappearance or even total dryness.
7. **Seventh Palaeoecological Zone (PZ7)**: This zone is represented by the depths 60-29 cm. and probable time interval of 12000-5800 years BP. Fine brown silt forms the larger part of the sediments of this zone with some alternating friable sand in its upper part. Palaeoecological conditions of this zone are similar to those of PZ2 as deduced from the increasing percentages of *Graminae, Quercus, Polygonium* and the presence of *Palmae, Artemisia and Laevigatosporites* with the aquatic palynomorphs acritarchs, dinoflagellates and foraminiferal test linings. These suggest a dense vegetational cover formed by a warm and wet climate with summer rainfall; i.e. a pluvial period in general. The peak of this pluvial period is suggested to have taken place during the time interval 9000-6000 years BP, as indicated by the sediments from depths 45-30 cm. These conditions caused precipitation rates to exceed that of evaporation and hence recharged and filled palaeolake Razzaza to a level of 32 m. (a.s.l.) and probably caused its overflow.
8. **Eighth Palaeoecological Zone (PZ8)**: This zone extends within the depth of 26 cm. to the surface and covers the time interval of 5800 years BP to the present. Its sediments consist of friable sand with some gypsum and show poor palynological contents. The indications are those of climatic conditions similar to the present desertic climate. The increased rates of evaporation led to the gradual lowering of the water level in palaeolake Razzaza and finally its disappearance leaving behind its old shorelines that mark the fluctuations of its level during the Quaternary.

DISCUSSION

On the basis of palynological evidence the climatic history of the Razzaza area has shown a good agreement with the palynological studies have been carried in Iraq (Al-Jubouri, 1997; Al-Dulaimiy, 1999 and Benni, 2001). It is compatible with palynological studies done in the Middle East by El-Moslimany (1986, 1987, 1990 and 1994) as well. The widely accepted concept of a dry glacial period in the Middle East is apparently based almost exclusively on palynology. El-Moslimany

(1987) recognized from a moisture curve of the ratio of *Chenopodiacea/Artemisia* a pleniglacial climate with wet winters and a late-glacial - early Holocene climate with periods of intense aridity. El-Moslimany (1994) also recognized the occurrence of early Holocene summer precipitation in the presently dry summer regions of the Middle East on the basis of botanical evidence.

Non-palynological studies also showed a great agreement with the results of this study. For instance, McClure (1984) defined two main periods of lake bed deposition in the Late Quaternary of Rub'al Khali, a period within the time span of the late Pleistocene from about 37000 to about 20000 years B.P. and a period within the early Holocene from about 10000 to 5000 years B.P. Yan and Petit-Maire, 1994 also recognized a humid period in the Arabian Peninsula, which occurred before the last glacial maximum at 30000-21000 years B.P. Aqrawi (1993) referred to the occurrences of peat of organic remains to suggest the presence of swamps and marshes development within the period of about 9000-8000 years B.P. at the head of the Arabian Gulf. These two humid periods may be correlated to zones PZ2 and PZ7, respectively. Furthermore, Kutzbach and Street-Perrott (1985) discussed fluctuations in the closed lakes in low latitudes during the late Quaternay and concluded that the last glacial maximum occurred at about 18000 years B.P., while lake levels in the northern tropics were low or falling. This drying trend continued until 12500 years B.P. when water levels began to rise again. During the period of about 9000-8000 years B.P., the Saharan, Arabian and Thar deserts were dotted with lakes and swamps. Water levels continued to be high until 5000 years B.P. The extent of present-day lakes is broadly comparable with that of 18000 years B.P. This sequence of climatic fluctuations is similar to that of PZ6, PZ7 and PZ8 of the present work. A similar trend was also deduced by Yan and Petit-Maire (1994) who reported a major rainfall decrease in the Afro-Asian arid/semi-arid transitional zone is everywhere associated with the last glacial maximum (21000-15000 years B.P. in most regions). They also concluded that during the Holocene, precipitation increased everywhere by 100-400 mm. per year relative to present day values, the optimum at 8500-6500 years B.P. Conditions wetter than those of today (with some dry spells) also prevailed over the Indian and African monsoon regions during the early-mid Holocene period (Gasse and Van Campo, 1994).

Harrison (1993) also deduced similar climatic successions in Australia and Papua Guinea. She provided a basis for reconstructing changes in the water balance and atmospheric circulation during the past 30000 years . These reconstructions are consistent with hydrological changes inferred from pollen analysis and palaeowind directions inferred from dunes. She concluded wetter conditions between 30000 and 24000 years B.P. as well as a general aridity at the glacial maximum and until 12000 years B.P. with higher than present lake levels

in the southern interior of Australia. A northward migration of the belt of high lake levels between 11000 and 6000 years B.P. and relaxation to modern conditions occurred after 6000 years B.P., interrupted by an unexplained dry phase (6000-5000 years B.P.) in Tasmania and Queensland.

CONCLUSIONS

It is evident in this study that the palaeoclimate of the area around Razzaza depression have changed through the last 40000 years through periods of warm and wet climate, pluvial periods with summer rainfall, semi-arid cold climate with steppe vegetation and warm arid desertic climate. Dense vegetation once occupied the catchment area of this depression and at times, it was filled with water to form a lake that reached a depth of 16 m. as its level stood at 32 m. (a.s.l.).

Eight palaeoecological zones are recognized for the late Quaternary period in this area. Pollen and spore taxa indicate that the second, fourth and seventh zones represent warm and wet climates; the third and sixth zones represent a cold semi-arid climate whereas the fifth and eighth represent a warm semi-arid climate.

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