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FACIES ANALYSIS AND NEW DISCOVERY OF A MASTODONT FROM INJANA FORMATION (LATE MIOCENE) NEAR THARTHAR LAKE- MIDDLE OF IRAQ

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ABSTRACT

The study area comprises Injana Formation (Late Miocene), exposed on the hills nearby of Tharthar Lake and about 120 km north of Baghdad city. This study depends on sedimentologic and facies analysis to recognize paleoenvironment and recognize the kinds of vertebrate bone fossils during Late Miocene. Sedimentologic and facies analysis showed many sedimentary facies: facies (Se) of scoured erosional surface, facies of (Sp) cross-bedded sandstones, facies (Fs) of fine sandstone facies, facies of (Fc) claystone, and facies of (C) calcareous clay. Facies analysis referred to the sub environments which are: point bar, over bank and floodplain in addition to fining upward cycles of deposition, which refers to meandering fluvial depositional environment.

Large vertebrate bone fossils were collected from the study area; the studied bone fossils probably are related to Proboscidea, Mastodont of Hemrin, which is named (Hemrin Mastodont). The current study considered the studied bone fossil as a new discovery of Proboscidea, Mastodont, which can be named (Tharthar Mastodont) after the name of the collection site of Tharthar Lake, from Injana Formation (Late Miocene), middle of Iraq. It was living near meandering fluvial environment which provided also plant diversity for herbivores.

Key words: Bone fossils, Facies analysis, Injana Formation, Iraq, Proboscidea, Mastodont.

INTRODUCTION

Injana Formation (Late Miocene) comprises claystone, siltstone, mudstone and sandstone rock units (Bellen *et al*., 1959). Many authors studied its paleocurrent (Kukal and Saadallah, 1970), stratigraphy and sedimentology (Al-Naqib, 1959; Basi, 1973; Al-Mubarak and Youkhana, 1976; Al-Sammarai, 1978; Jassim *et al*., 1984; Al-Rawi *et al*., 1993; Al-Zubaidi, 2004). Facies analysis of its exposures, north Baghdad between Baiji and Sammarraa, showed many fining upward cycles of meandering fluvial system (Basi, 2007). Many sites were studied in countries of the region, such as: two species of proboscidean fossils of Late Miocene in the Axion Valley, Macedonia-Greece (Konidaris and Koufus, 2013); mammalian site in Akkasdagi in Turkey, L. Miocene (Valli, 2005.); Proboscidea in addition to many vertebrate fossils in Maragheh Formation, northwest Iran (Berner *et al*., 1996, 2001). Some vertebrate fossil sites were discovered in Iraq (Piveteau, 1935; Al-Naqib, 1959; Bellen, *et al*., 1959; Al-Zubaidi and Jan, 2015). Some mastodont species, of order proboscidea were recognized beside 20 types of vertebrate bone fossils within sandstone beds of Injana Formation (Thomas *et al*., 1981).

Occurrence and history of Proboscidea: The earliest genera of the order Proboscidea appeared at North Africa during Early Miocene, about 50 million years ago. Mastodonts were expanded, about 20 mya, from Africa into Asia, Europe, then after to North America (Haynes, 1991). Nowadays there are two living genera, locally restricted, of the order Proboscidea: the African elephant *Loxodonta africana* (Blumenbach, 1797) and the Asian elephant *Elephaus maximus* (Linnaeus, 1758), (Gohlich, 1999). Two genera of *Mammuths* (Brookes, 1828) and *Mammut* (Blumenbach, 1799), synonyms of mastodonts or gomphotheres that disappeared from Europe, North Asia and North America. Three genera of mastodonts (gomphotheres) were also extinct from the world (Haynes, 1991).

This study aims to determine the paleoenvironment, according to sedimentological facies model, and to recognize vertebrate bone fossils in L. Miocene site on the hills nearby Tharthar Lake, west Sammarraa city.

MATERIALS AND METHODS

Location: The study area is located in the hills nearby the Tharthar Lake beach, about 120 km north of the Baghdad city (Map 1). Field surveys and lithofacies descriptions included sedimentary structures and grain size were done on the rock bed units within Injana Formation (Late Miocene) exposed on the hills nearby Tharthar Lake beach. Lab and office works implicated facies analysis of lithofacies and prediction of facies model. Some large and small vertebrate bone fossils presences within cross-bedded sandstone were collected by fishermen from Tharthar Lake and were presented to the Iraq Natural History Research Center and Museum. Photos of bone fossils were taken and sent to three world authorities in vertebrate bone fossils taxonomy to confirm identification: Dr. William J. Sanders, Paleontology Museum, University of Michigan, USA. Dr. Andrea M. Valli, Vector Higo Research Centre, France and Afifi H. Abdul Gafar, Geological Museum, Egypt.

RESULTS AND DISCUSSION

Sedimentology: best exposed sections, on hills, more than 15 meters in high, nearby Tharthar Lake beach, about 50 kilometers west Sammarraa city, of Injana Formation were described; facies is a term used previously to describe grain size and sedimentary structures for rocks and sediments (Moore, 1949; Teichert, 1958). In the present study, five facies were recognized, following Miall (1977, 1978, 1988) from Injana Formation (Tab. 1, Diag. 1) as follow:

1- Facies (Se), Scoured erosional surface: this surface resulted from erosion on old sediments occurred on channel floor and coincided with high flow regime and discharge during flood and rainy season. On this surface there were coarse and very coarse sandstone, mud balls, claystone fragments in addition to large and small pieces of vertebrate bones were deposited. Involved surface formed by erosion on old bed, during fluvial flood and rainy seasons which caused high flow regime of fluvial system (stream current), (Maill, 1978; Oplustil *et al*., 2005; Basi, 2007).

2- Facies (Sp), Cross- bedded sandstone facies: this facies often overlain facies (Se) and composed of cross-bedded sandstone up to 1.2 meters in thickness, grain size range from medium to coarse grains and contains mud ball and small fragments of claystone and bone (Diag. 1). It is resulted from sand dune migration as a bed- load on channel floor or as a channel lag deposits. This facies is similar to that described by Allen (1964) and Selley (1977) and it represents the lower part of river point bar sub environment.

3- Facies (Fs), Fine sandstone: it comprises of fine sandstone with silty and clayey materials, and reaches 2.6 meters in thickness, very fine sandstone alternated with mudstone and claystone. The main sedimentary structures, in this facies, are the parallel and cross laminations; this facies is underlain by facies (Sp) and overlain by (Fc) mudstone or claystone. Facies (Fs) are deposited from suspension materials due to presence of mudstone and claystone in addition to cross and parallel laminations (Diag. 1). It represents either upper part of point bar or over- bank sub environment (Maill, 1978; Oplustil *et al.*, 2005).

4- Facies (Fc), Claystone facies: It is composed of a massive or a parallel lamination of claystone and mudstone and ranges from 1.9 – 4 meters in thickness (Diag. 1). The abundance of massive claystone and mudstone and the presence of parallel laminations refer to quite water environment of deposition (Miall, 1978). Involved facies refer to vertical accression of suspended clay materials on flood- plain basin.

5- Facies (C), Limy mud: It is composed of very fine layers of limy mud sediments, up to 0.3 meters in thickness and has gray to light gray color (Diag. 1). It reflects lakstrine- river sediments under arid climate conditions of back- swamp and/or oxbow lake, located on flood- plain sub environment (Basi, 2007).

Table (1): Lithofacies and interpretation of Injana Formation (Late Miocene).

Facies code	Lithofacies	Sedimentary structures	Interpretation
Se	Erosional scours with mud balls and large bone fragments	Crude cross-beddings	Scoured fill (high flow regime and discharge) resulted from river flood and rainy seasons
Sp	Medium- v. coarse sand with small mud ball and small bone fragments	Planar cross-bedded	Sand dune, (low flow regime), lower part of point bar
Fm	Fine sandstone with silty and clayey materials	Parallel and cross laminations	Upper part of point bar or over- bank sub environment
Fc	Claystone and mudstone	Massive or parallel lamination of claystone and mudstone	Vertical accression of suspended clay materials on flood- plain basin
C	Limy mudstone	Massive to laminated	Back- swamp and/or oxbow lake on flood plain

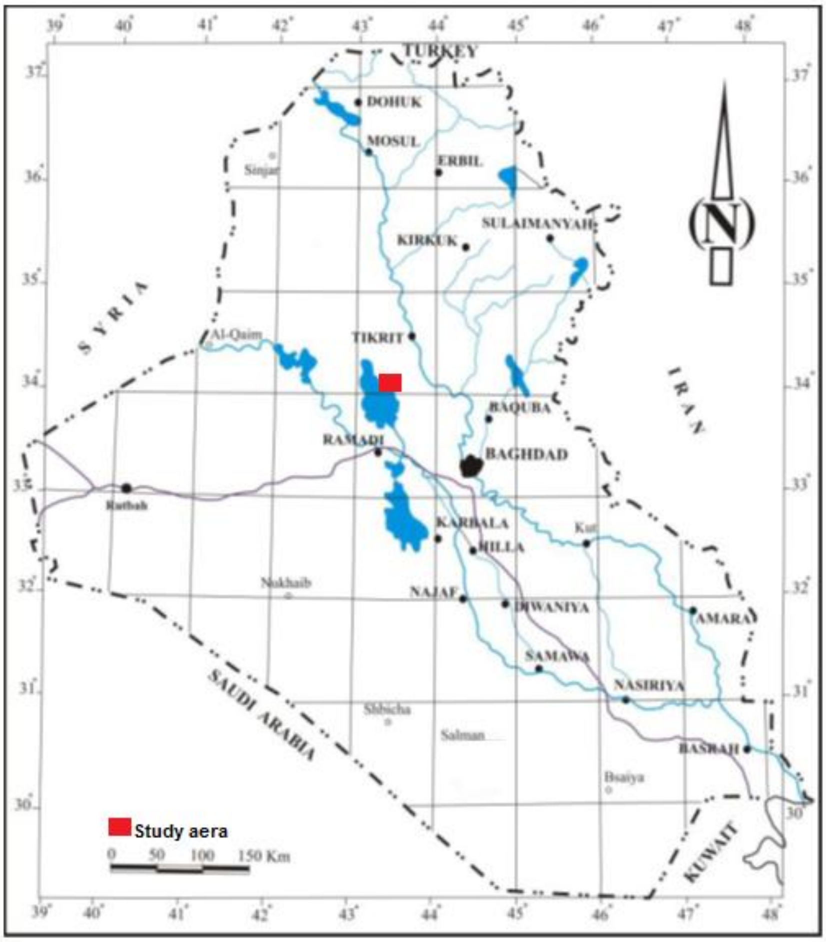
Rock bed succession of Injana Formation (Late Miocene) at studied area composed of: facies (Se) scoured erosional surface resulting during fluvial flood and rainy season to increase discharge and flow energy and transported bone of died animals and deposited on the scoured surfaces. Facies (Se) are overlain by facies (Sp) cross- bedded sand stone; the later facies are deposited on scoured surface to form lower part of point bar, followed by facies (Fs) fine sandstone of upper part of point bar and / or overbank sub environment, then facies (Fc) are claystone deposited on flood- plain basin, and facies (C) limy mud are deposited from shallow lakstrine- river of back- swamps and/ or oxbow lakes during arid climatic conditions.

Facies analysis of Injana Formation near Tharthar Lake shows three subenvironments: river channel, over bank and flood plain, that all refer to the meandering river environment (Diag. 2), resemble to the facies of the model by Allen (1964) and Miall (1977, 1978, 1988); it agrees also with Basi (2007) work on the subsurface section on Injana Formation near Sammarraa, and with Al-Banna (1982) work on the same formation in the north of Iraq, who concluded meandering or braided environment of deposition of upper part. The main direction of involved paleocurrents of fluvial system were from north east to south east (Kukal and Saadallah, 1970) which resulted from Zagros Belt uplift, and was caused by plate tectonic convergence of Arabian and Iranian plates.

Vertebrate bone fossils: small and large fragments of vertebrate bone fossils were collected from facies (Sp) exposed on the hills nearby Tharthar Lake. Large bone fossil was more than 40 cm in length and 22 cm in thickness (Pl. 1), and was presented by fishermen, near Tharthar Lake, about 50 km west Sammarraa city. It is well known that the Wooly mammuths lived in the cool and dry environments of northern hemisphere (Lister and Sher, 2001; Bravo *et al*., 2008), while the studied bone fossil was deposited from meandering fluvial system at semi dry and warm climate during Late Miocene. Bone fossils included small and large pieces which refer to medium distance of transportation during multicycle of deposition. Photos of bone were taken and sent to three world authorities of vertebrate bone fossils. W. J. Sanders and A. H. abdul Gafar who mentioned that the large bone (Pl. 1) represented Femur of order Proboscidea. Andrea M. F. Valli, who referred to some important notes on the photo of studied large fossil, *"It must be the distal part of a femur of large mammal; I think it belong to a proboscidian, but I can not specify the species; may be a mastodont; do you know kind of species you have in your country at this period"*. Litreture surveys on mastodont occurrence in Iraq showed complete skulls, some isolated molars and post cranial elements of *Choerolophodont* mastodont genus, named *Injana Mastodont*, which were discovered on the north east flanks of Hemrin Southern Anticline within rock bed unit of Mukdadiya Formation (Pliocene) (Thomas, *et al*., 1981); in addition, another bone of Mastodont was found, by H. Al-Hashimi in 1977, (Buday, 1980) within Mukdadiya Formation (Pliocene), but he did not mention the collection site. The studied femur bone fossils found within facies (Sp) cross-bedded sandstone of Injana Formation (Late Miocene) near Tharthar Lake may be related temporally and spatially to the Hemrin Mastodont, which is not far away from the studied site. According to sedimentological and facies analysis, the studied Tharthar Mastodont was lived near meandering fluvial system which includes river channel, overbank and floodplain sub environments (Diag. 2); all provide water and suitable plants for vegetarian animals particularly for mastodont. Paleocurrent of Injana rivers flow from north east high-land Zagros thrust belt toward south west low-land (Mesopotamian basin now); since the gradient increased due to uplifting, folding and thrusting which resulted from the collision of Arabian and Iranian Plates.

CONCLUSIONS

Facies analysis of Injana Formation (Late Miocene) exposed on the hills near Tharthar Lake, about 50 km west Sammarraa city, Middle of Iraq, showed meandering fluvial environment that includes: river channel, overbank and flood plain sub environments. The mentioned river flows from Zagros fold belt at the northeast, to the foreland basin at southeast (now Middle of Iraq); when the gradient was increased due to uplifting, folding and thrusting resulted from collision of Arabian and Iranian Plates and closing of Tethys Sea. Sub environments of meandering river systems contributed to enhance wide plant diversity and provide water, food and place for living and reproduction of Mastodont. During high rate rainy seasons, the above mentioned rivers flooded and increased discharge and flow energy to produce facies (Se), and the transporting bone of died Mastodont was deposited within facies (Sp) cross-bedded sandstone as a bed load on the facies (Se) to form lower part of point bar.



Map (1): Location Map of study area.

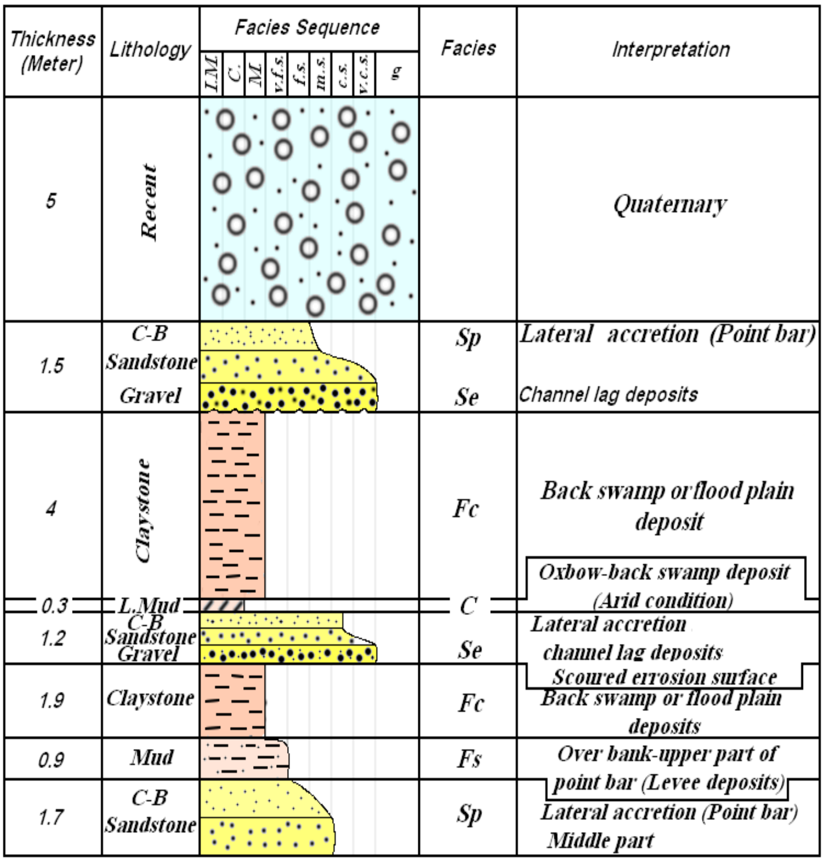


Diagram (1): Vertical facies succession of Injana Formation at study area, near Tharthar Lake, Middle Iraq.

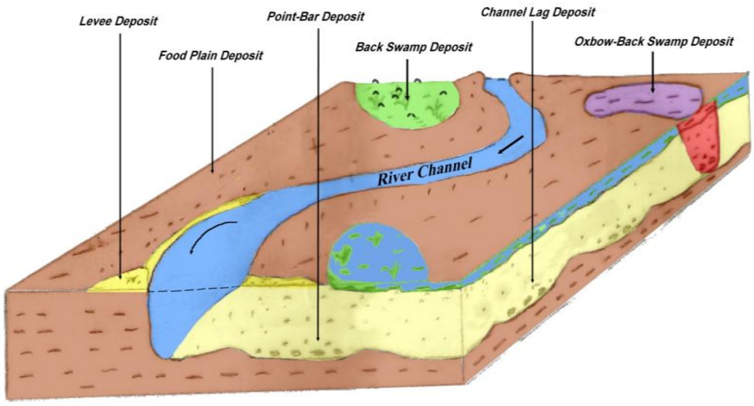


Diagram (2): Block diagram shows the paleoenvironment of Injana Formation at study area, near Tharthar Lake, Middle Iraq.

Plate (1): Bone fossil, femure of Proboscidea, mastodonts (in two views) was collected from Injana Formation near Tharthar Lake- Middle of Iraq (scale: 15 cm).

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التحليل السحني واكتشاف جديد للماستودونت من تكوين انجانة (مايوسين متأخر) قرب بحيرة الثرثار- وسط العراق

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الخلاصة

تهتم هذه الدراسة بتكوين انجانة (مايوسين متأخر) الذي ينكشف على التلال القريبة من بحيرة الثرثار التي تبعد بحوالي ١٢٠ كم الى الشمال من مدينة بغداد. وتعتمد على تطبيق علم الرسوبيات سيما التحليل السحني لتحديد البيئة الترسيبية القديمة، وتشخيص نوع الفقريات خلال المايوسين المتأخر.

اشار علم الرسوبيات والتحليل السحني الى وجود عدة سحنات رسوبية، مثل: سحنة (Se) سطح التعرية المتعرج، وسحنة (Sp) الصخور الرملية ذات التطبق المتقاطع، وسحنة (Fs) الصخور الرملية الناعمة، وسحنة (Fc) الصخور الطينية، وسحنة (C) الصخور الطينية الجيرية. وقد اشار التحليل السحني الى وجود البيئات الثانوية الاتية: الحواجز اللسانية، وفوق الضفة، والسهل الفيضي؛ الى جانب وجود دورات التناعم الى الاعلى، التي تشير الى البيئة الترسيبية للانهار الالتوائية. وتم جمع عظام متحجرات كبيرة من منطقة الدراسة، والتي تم تصويرها وارسالها الى عدد من المتخصصين في علم المتحجرات. ولوحظ بان العظام المتحجرة قيد الدراسة ذات علاقة بالماستودونت من الخرطوميات في حمرين والذي يطلق عليه (ماستودونت حمرين)؛ وبذلك فان الدراسة الحالية تشير الى ان العظم المتحجر المدروس هو اكتشاف جديد للخرطوميات، الماستودونت، والذي يمكن ان تسميته (ماستودونت الثرثار) من تكوين انجانة (المايوسين المتأخر) في وسط العراق، قرب بيئة الانهار الالتوائية التي توفر التنوع النباتي الى الحيوانات عشبية التغذية.