BIOSTRATIGRAPHY OF THE LATE CRETACEOUS/EARLY PALEOCENE SUCCESSIONS AT K.H 5\6 AND K.H 5\8 CORE INTERVAL, WESTERN DESERT OF IRAQ

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ABSTRACT

The core interval at the K.H5\6 and K.H5\8 wells in the west of Rutba province reveals a significant succession across the Late Cretaceous-Early Paleocene transition. The sampled interval encompasses a series of carbonates belong to Digma Formation of Latest Cretaceous age, which underlies the Akashat Formation of Danian age. Fifty-five species belong to thirty-five genera were recognized. Based on the distribution of these species, eight biozones were distinguished, three biozones are recorded from the K.H 5\6 studied section and two biozones are documented from the K.H 5\8 studied section which refers to Late Maastrichtian age of Digma Formation. Five biozones are recorded from Akashat Formation in the K.H 5\6 studied section and only one biozone is documented from the K.H 5\8 studied section which refers to Danian age. The depositional environment of the studied successions proposed it accumulated in the outer ramp environments.

Keywords: Cretaceous; Paleocene; Maastrichtian; Danian; Foraminifera; Digma Formation; Akashat Formation

INTRODUCTION

One of the most important stratigraphic boundaries in the world is the K/Pg boundary (synonymous with the K/T boundary). It expresses one of the main biological extinction catastrophes in the life history which is described by the largest Phanerozoic mass extinctions (Smit and Hertogen, 1980; Alvarez *et al.*, 1980; MacLeod and Keller, 1996). This extinction crisis corresponds with a large asteroid impact at Chicxulub, Mexico, the Deccan flood basalt volcanism in India (Schulte *et al.*, 2010). Lippard (1986) and Farouk *et al.* (2014) regarded dramatic tectonic events occurs in the Arabian and African Plate history at the time of the K/Pg boundary. The Late Cretaceous-Early Paleocene succession in the Western desert of Iraq is exemplified by Digma and Akashat formations. Akashat Formation regarded as a

source of phosphate. Bellen *et al.* (1959), and Kassab (1972&1976) mentioned the break between the Maastrichtian and Palaeocene showed that sediments of the latest Maastrichtian and Early Palaeocene (Danian) age are absent in the shelf areas of Iraq. However, Jassim and Karim (1986) proved the presence of Danian in Western Iraq by record the presence of *Globigerina daubgerhensis* and other associated planktonic fauna that belongs to Danian age. Jassim *et al.* (1984) mentioned to the Early Paleocene succession in the Western desert of Iraq represented by Akashat and Umm Er Radhuma formations. The main objective of this study is to determine planktonic foraminiferal zonation of the Late Maastrichtian-Early Paleocene succession in the subsurface sections of K.H 5\6 and K.H 5\8 to improve the existence of the latest Maastrichtian - Early Palaeocene (Danian) sediments in the studied area and to interpret the depositional environment of the studied succession. The biostratigraphic zonation of the present study is correlated with the regional zonation.

HISTORY OF DIGMA AND AKASHAT FORMATIONS

The youngest Cretaceous rocks in the Western Desert of Iraq is the Digma Formation, it was first defined as an independent stratigraphic unit by (Dunnington, 1953 in Bellen *et al.*, 1959), in well Anah-1 in Western Iraq. It comprises 50 m of phosphatic, glauconitic, locally silicified marls. Buday (1980) recognized and mapped the succession of this Formation. But, the sequence claimed by (Buday and Hak, 1980) as the Digma Formation represents the sequence of Hartha Formation with the lower part of the Tayarat Formation. Sattran and Mansour (1975) in (Buday and Hak, 1980) are the first who mentioned the presence of the Digma Formation in the western desert. (Hassan, 1998) identified the Digma Formation (Maastrichtian) in the Western Desert, and then adopted by Iraq Geological Survey (GEOSURV). Jassim *et al.* (1984) introduced the name Jeed for the phosphatic development of Tayarat, the Jeed Formation claimed for the sequence involved the Digma Formation and part of the Tayarat Formation. Then, the name “Jeed Formation” is abandoned and used the name Digma Formation as a replacement. (Al-Mutwali, 1992) discussed the distribution and facies of Tayarat and Digma formations. (Mohammed, 1993) concluded that the Jeed Formation is mixed carbonate-phosphorite-shale –marl-sandstone and porcelanite facies which deposited from tidal environment in east and southwest to deep marine realm in western. (Sissakian, 2005) defines the Digma Formation in the Western part of the Western desert as a succession of yellow marl and shale topped by shelly limestone, and mentioned to the upper part of the Tayarat Formation is interfingering with Digma Formation. (Bellen *et al.*, 1959; Buday and Hak, 1980; Jassim *et al.*, 1984; Amer 1977; Al-Mutwali, 1992; Mohammed, 1993;

Hassan, 1998; Sissakian, 2005; Jassim and Goff 2006) assigned the Upper Cretaceous (Upper Maastrichtian) age of Digma Formation. (Al-Mutwali, 1992; Mohammed, 1993) concluded that the deposition environment of Digma Formation is deep marine. The Digma Formation conformably overlying Tayarat Formation, and the upper contact is also conformable with the overlying Akashat Formation (Jassim *et al.*, 1984; Amer, 1977; Al-Mutwali, 1992; Mohammed, 1993; Hassan, 1998; Sissakian, 2005; Jassim and Goff, 2006). (Jassim *et al.*, 1984) mentioned to the Early Paleocene succession in the Western desert of Iraq represented by Akashat and Umm Er Radhuma formations and named the phosphatic facies of Umm Er Radhuma Formation, as Akashat Formation and was announced officially by (Al-Bassam and Karim, 1997) and the Akashat Formation (M-U Palaeocene part only) phosphorites are restricted to the north, west and south flanks of the Hauran anticlinorium. The Akashat Formation overlies the phosphatic Digma Formation of Maastrichtian age. It is overlain by the phosphatic Ratga Formation of Eocene age. (Karim and Jassim 1985) Founded Danian planktonic foraminifera in the lower part of Akashat Formation and concluded that Cretaceous- Paleocene contact is conformable in the Western. (Al-Bassam *et al.*, 1990) did the detailed geological survey of the Upper Cretaceous – Lower Tertiary phosphorite bearing sequence in the Western Desert and divided the Akashat Formation (Paleocene) into three mappable members: The lower member is named Traifawi Member (Early Paleocene) overlying by Hirri Member (Middle Paleocene), and the upper member is Dwaima Member (Late Paleocene). (Al-Jibouri, 2003) concluded that the Paleocene succession represented by Umm Er Radhuma and Akashat Formation deposited in steepened ramp in the western desert. (Al-jibouri and Gayara, 2015) referred to Akashat Formation is developed through six third order cycles which is subdivision into several cycles due to Local tectonism and eustasy, and they mentioned to The K/T boundary is represented by a transgressive surface and the Early Paleocene succession was mainly controlled by the eustatic component and the resultant of eustatic subsidence.

MATERIALS AND METHODS

This study is based on a subsurface Upper Cretaceous –Paleocene stratigraphic succession at the Western part of Rutba province, western desert. The K.H5\6 section is situated in 38° 56'13"E, 32° 42' 15"N and the K.H5\8 section is situated in 39° 29' 52"E, 33° 11' 11"N) (Fig.1). 184 samples were collected at a spacing interval of almost 1 m, and in some intervals the spacing takes 0.5 m. Hard carbonate rocks of the samples were studied by making thin

sections. The thin sections were studied in detail to define and recognize the paleontological content, age dating and the paleo environmental evaluation.

Fig. 1. Location map of the study area (modified after Sissakian, 2000)

BIOSTRATIGRAPHY AND BIOZONES

The Cretaceous foraminiferal zones marked (CF8) to (CF1) from the Lower Cretaceous to Upper Cretaceous. The Maastrichtian zonal scheme subdivided by (Li and Keller, 1998a and b) and (Keller *et al.*, 2002); the latest biozonation gives detailed and more significant biostratigraphic analysis than earliest biozonation. (Li and Keller, 1998a and b) and (Keller *et al.*, 2002) adjusted the ranges of this zone to the paleomagnetic time scale in Tunisian sections (Li and Keller, 1998a and b) and on Egypt (Keller *et al.*, 2002) their estimation age was also compared with ages by (Berggren *et al.*, 1995), and subsequently, the biostratigraphic relationship can be determined estimation age. The description and discussion biozones of the studied succession is exhibited below:

A. Biostratigraphy and Biozone of Late Maastrichtian Succession (Digma Formation)

Digma Formation in K.H 5/6 to describe 64 m thick of limestone and marly limestone interbedded with shale and dolomitic shale overlying the dolomite units of Tayarat Formation and underlying the Akashat Formation. Whereas the Digma Formation in K.H 5/8 to describe 51m thick of limestone overlying the dolomite units of Tayarat Formation and underlying the Akashat Formation. Through the detailed biostratigraphic study of Digma Formation and depending on the presence of planktonic foraminifera, three biozones are recorded from the K.H 5/6 studied section and two biozones are documented from the K.H 5/8 studied section.

The biozones of Digma Formation in studied sections are defined from the lower part to the upper part of formation as below:

I. *Pseudoumbilical hariaensis* partial range zone (CF 3)

- A. Definition: This zone is marked by the first occurrence of the *Pseudoguembelina hariaensis* Nederbragi (Pl.1, Fig. Q), to the last occurrence of *Gansserina gansseri*.
- B. Occurrence: This biozone is recorded in the lower part of the Digma Formation in K.H5\6, and covers the intervals of 53 meter and depth intervals ranging 45–198 m. This zone is recorded only in K.H 5\6 section.
- C. Assemblages: This zone is related to occurrence of the *Pseudoguembelina hariaensis* Nederbragi, additionally to the planktonic foraminifera distinguished in K.H 5\6, e.g.:- *Abathomphalus intermedius* Bolli (Pl.1, Fig. A), *Abathomphalus mayaroensis* Bolli (Pl.1, Fig. B), *Archaeoglobigerina carteri* kassab (Pl.1, Fig. C), *Globotruncana aegyptiaca* Nakkady (Pl.1, Fig. D), *Globotruncana arca* Cushman (Pl.1, Fig. E), *Globotruncanabulloides* Vogler (Pl.1, Fig. F), *Globotruncana dupeblei* Caron *et al* (Pl.1, Fig. G), *Globotruncana elevate* Brotz(Pl.1, Fig. H), *Globotruncana gansseri gansseri* Bolli (Pl.1, Fig. I), *Globotruncana orientalis* El-Naggar (Pl.1, Fig. J), *Globotruncanella pschadae* Keller (Pl.1, Fig. K), *Globotruncanella petaloidea* Gandolfi (Pl.1, Fig. L), *Globotruncanita stuarti* De Lapparent (Pl.1, Fig. M), *Globotruncanita stuartiformis* Dalbiez (Pl.1, Fig. N), *Globotruncana trinidadensis* Gandolfi (Pl.1, Fig. O), *Hedbergella monmouthensis* Olsson(Pl.1, Fig. P), *Heterohelix globulosa* Ehrenberg(Pl.1, Fig. Q), *Heterohelix punctulatus* Cushman (Pl.1, Fig. R), *Rugoglobigerina hexacamerata* Bronnimann (Pl.2, Fig. A), *Rugoglobigerina rugosa* Plumme (Pl.2, Fig. B). The common benthic foraminifera which are associated with mentioned biozone are comprised by: *Anomalinoides pinguis* Jennings (Pl.2, Fig. C), *Bolivina incrassata* Reuss (Pl.2, Fig. D), *Bulimina aspera* Cushman & Parker (Pl.2, Fig. E), *Cibicides* sp. (Pl.2, Fig. F), *Cibicides excavate* Brotzen, *Citharina recta* Reuss (Pl.2, Fig. G), *Gavelinella pertusa* Marsson (Pl.2, Fig. H), *Siphogenerinoides plummerae* Cushman (Pl.2, Fig. I), *Valvalabamina lenticular* Reuss (Pl.2, Fig. J), *Valvulinoides* sp.(Pl.2, Fig. K).
- D. Remarks and Correlation: According to the *Pseudoguembelina hariaensis* zone which reported from late Maastrichtian sediment of Tunisia by (Li and Keller, 1998a and b) and from late Maastrichtian sediments of Egypt(Keller *et al.*, 2002), the present Biozone (CF3) is equivalent to the *Pseudoguembelina hariaensis* (CF3) partial range

zone which is recorded from the late Maastrichtian sediments of South Atlantic DSDP Site 525A (Li and Keller, 1998a) and Tunisia (Li and Keller, 1998b) and on Egypt (Keller *et al.*, 2002), In Mahajanga Basin (Abramovich *et al.*, 2002), from South Atlantic (Abramovich and Keller, 2003), Eastern Tethys (Keller, 2004), in Egypt (Samir, 2002), (Keller *et al.*, 2002), (Obaidalla, 2005); and in NE Iraq (Sharbazheri, 2007& 2008); Iran (Rostami and Balmaki 2018). In the Northeast of Iraq, this zone is compared with the middle part of *Abathomphalus mayaroensis* zone described by (Abdel-Kireem, 1986), (Abawi *et al.*, 1982), in Italy (Premoli Silva & Sliter, 1995 & 1999), in Egypt (Abdel-Kireem & Samir, 1995), Eastern Mediterranean (Silva *et al.*, 1998), and is comparable to the upper part of *Gansserina gansseri* in Egypt (El-Younsy *et al.*, 2017)

- E. Age: M-Late Maastrichtian, the time span of this zone is from 66.83Ma to 65.45Ma.
- F. Lithology and paleoenvironment: The lithology of this biozone is limestone and marly limestone interbedded with shale and dolomitic shale. (Planktonic mudstone/wackestone to packstone) with few of phosclast indicates accumulation in outer ramp depositional settings (Pecimotika *et al.*, 2014)

II. *Pseudoumbilical palpebra partial range zone (CF 2)*

- A. Definition: This Zone describes the interval between the latest occurrence of *Gansserina gansseri* at the base and the first occurrence of *Plummerita hantkeninoides* at the top.
- B. Occurrence: The Zone covers spans 7 meters in K.H 5\6 (Fig. 3) and covers spans 34 meters in K.H5\8 (Fig. 2).
- C. Assemblages: The common fossils taxa which are associated with *Pseudoguembelina palpebra* (Pl.2, Fig. L) are the same recognized in the previous biozone in addition to the occurrence of *Globotruncana falsocalcarata* Kerdany and Abdelsalam (Pl.2, Fig. M), *Praeglobotruncana havanensis* Voorwijk (Pl.2, Fig. N), *Archaeoglobigerina carteri* kassab and *Globotruncana trinidadensis* Gandolfi presence in the previous biozone and not recorded in this biozone. The common benthic foraminifera which are associated with mentioned biozone are comprised by *Bolivina incrassata* Reuss, *Bulimina aspera* Cushman & Parker, *Bulimina ovulum* Reuss (Pl.2, Fig. O), *Cibicides* sp., *Cibicides excavate* Brotzen, *Gavelinella pertusa* Marsson, *Valvulinoides* sp., *Valvalabamina lenticular* Reuss. The Zone (CF2) covers extents (34) meters in K.H5\8 (Fig. 2). The common fossils taxa which are associated with *Pseudoguembelina palpebra* represented

by *Abathomphalus intermedius* Bolli, *Abathomphalus mayaroensis* Bolli, *Globotruncanella pschadae* Keller, *Hedbergella monmouthensis* Olsson, *Praeglobotruncana havanensis* Voorwijk, *Rugoglobigerina hexacamerata* Bronnimann, *Rugoglobigerina rugosa* Plumme. Benthic foraminifera recognized in K.H 5\8 section

D. represented by *Cibicides* sp., *Lenticulina* sp.

Plate 1. All figures are from Digma Formation (Late Maastrichtian) A-*Abathomphalus intermedius* Bolli; tangential section; K.H 5\6 (133 m). B-*Abathomphalus mayaroensis* Bolli; tangential section; K.H 5\8 (116m). C-*Archaeoglobigerina carteri* Kasser; tangential section; K.H 5\6 (192m). D-*Globotruncana aegyptiaca* Nakkady; Axial section; K.H 5\6; (133m). E-*Globotruncana arca* Cushman; Subaxial section; K.H 5\6 (133m). F-*Globotruncana bulloides* Vogler; Axial section; K.H 5\6 (136m). G- *Globotruncana dupeublei* Caron et al.; tangential section; K.H 5\6 (135m). H-*Globotruncana elevata* Brotzen; Axial section; K.H 5\6 (138m). I-*Globotruncana gansseri gansseri* Bolli; Axial section; K.H 5\6 (145m). J- *Globotruncana orientalis* El-Naggar; Axial section; K.H 5\6 (138m). K-*Globotruncanella pschadae* Keller; Axial section; K.H 5\8 (116m). L-*Globotruncanella petaloidea* Gandolfi; Subaxial section; K.H 5\6 (138m). M-*Globotruncanita stuarti* De Lapparent; Axial section; K.H 5\6 (136m). N-*Globotruncanita stuartiformis* Dalbiez; Axial section; K.H 5\6 (133m). O-*Globotruncana trinidadensis* Gandolfi; Axial section; K.H 5\6 (135m). P- *Hedbergella monmouthensis* Olsson; Subaxial section; K.H 5\6 (133m). Q-*Heterohelix globulosa* Ehrenberg; Axial section; (164m). R-*Heterohelix punctulatus* Cushman; Axial section; (142m).

Plate 2. All figures are from Digma Formation (Late Maastrichtian) K.H 5/6. A- *Rugoglobigerina hexacamerata* Bronnimann; sub equatorial section; (184m). B- *Rugoglobigerina rugosa* Plumme; Axial section; (133m). C- *Anomalinoides pinguis* Jennings; equatorial section; (192m). D- *Bolivina incrassata* Reuss; Axial section; (144m). E- *Bulimina aspera* Cushman & Parker 1940; (144m). F- *Cibicides* sp. in organic material shale; Equatorial section; (155m). G- *Citharina recta* Reuss; Axial section; (159m). H- *Gavelinella pertusa* Marsson; Equatorial section; (135.8m). I- *Siphogenerinoides plummerae* Cushman; Axial section; (165m). J- *Valvalabamina lenticular* Reuss; Equatorial section; (140m). K- *Valvulinoides* sp.; Equatorial section; (145m). L- *Pseudoguembelina palpebea*; Axial section; (140m). M- *Globotruncana falsocalcarata* Kerdany & Abdelsalam; Axial section; K.H 5/6; (135m). N- *Praeglobotruncana havanensis* Voorwijk; Subaxial section; (133m). O- *Bulimina ovulum* Reuss, 1844; Axial section; (133m). P- *Plummerita hantkeninoides* Bronnimann; Axial section; (133m). Q- *Pseudoguembelina hariaensis* Nederbragi; Axial section; (184m). R- *Globotruncanita conica* White; Axial section; K.H 5/6 (135m).

E. Remarks and correlation: The *Pseudoumbilica palpebra* Zone of studied sections is equivalent to the comparable zone of the *Pseudoumbilica palpebra* Zone of South Atlantic DSDP Site 525A (Li and Keller, 1998a); and in Tunisia (Li and Keller, 1998b); In Mahajanga Basin, Madagascar (Abramovich *et al.*, 2002); in Tunisia (Arenillas *et al.* 2000); in Egypt (Obaidalla 2005); and in NE Iraq (Sharbazheri, 2007 and 2008); Eastern Tethys (Keller, 2004); Iran (Rostami and Balmaki 2018). The present *Pseudoumbilica palpebra* zone is equal to *Abathomphalus mayaroensis* zone documented from several countries ; Spain (Canudo *et al.*, 1991); (Premoli Silva and Sliter, 1995&1999) in Italy; Mediterranean (Silva *et al.*, 1998); in Mexico (Maestas *et al.*, 2003); (Elnady and Shahin 2001) and (Samir 2002) in Egypt. The *Pseudoumbilica palpebra* zone is comparable to *Abathomphalus mayaroensis* zone registered in many locations of Iraq (Kassab, 1972, 1974, 1975&1976), (Kassab *et al.*, 1986), (Abawi *et al.*, 1982), (Abdel-Kireem, 1986), (Al-Mutwali, 1996), (Hammoudi, 2000) and (Al-Mutwali and Al-Jubouri 2005); and in Syria (Pecimotika *et al.*, 2014). The *Pseudoguembelina palpebra* zone can be equal to the *Kassbiana falsocalcarata* zone documented in North Iraq (Kassab, 1976)(Kassab *et al.*, 1986). And is comparable to the upper part of *Gansserina gansseri* in Egypt (El-Younsy *et al.*, 2017).

F. Age: The age of this zone is Upper Late Maastrichtian.

G. Lithology and paleoenvironment: In K.H 5\6 section, this biozone is recorded in planktonic packstone, limestone, marly limestone with few phosclast and little benthic foraminiferal assemblage, the abundant planktonic foraminifera (85%) indicates outer ramp depositional environments. This biozone in K.H5\8 section occurs in planktonic packstone, limestone with phosclast in the lower part and the upper part the percentage of the component decreases to represent mudstone.

III. *Plummerita hantkeninoides* total range zone (CF1)

A. Definition: The *Plummerita hantkeninoides* (Pl.2, Fig. P) zone is marked by the total range of the nominate taxon, in addition to the last occurrence of all tropical species that indicate mass extinction at the K\T boundary.

B. Occurrence: In the studied sections, this zone includes the top (5) meters in K.H 5\6 section (Fig. 3) and covers 17 meters in K.H5\8 section (Fig. 2).

C. Assemblages: The planktonic foraminiferal association of this biozone is abundant and much diversified. Most planktonic foraminifera continue from the underlying biozone CF2, in addition to recognize the *Globotruncanita conica* White (Pl.2, Fig. R).

Fig. 2. The correlation among the biostratigraphic zones recognized in this study depended on planktonic foraminiferal zonations with other planktonic zonal documented in the Maastrichtian/Danian boundary in Iraq and other countries

Also some benthic foraminifera are associated with mentioned biozone. It is reliable to give notice that the *Plummerita hantkeninoides* zone can also record in K.H 5\8 (Fig. 2). The common fossils taxa which are associated with *Plummerita hantkeninoides* in K.H 5\8 represented by *Abathomphalus intermedius* Bolli, *Abathomphalus mayaroensis* Bolli, *Globotruncanella pschadae* Keller, *Hedbergella monmouthensis* Olsson, *Praeglobotruncana havanensis* Voorwijk, *Pseudoguembelina palpebra*, *Rugoglobigerina hexacamerata* Bronnimann, *Rugoglobigerina rugosa* Plumme. Benthic foraminifera recognized in K.H 5\8 section represented by *Cibicides* sp., *Lenticulina* sp.

D. Remarks and correlation: The total Range of *Plummerita hantkeninoides* (CF1) of studied area and depending on the associated planktonic foraminiferal species is comparable to the similar zone registered from Tunisia (Li and Keller, 1998b); in Tunisia (Arenillas *et al.* 2000); and Egypt (Obaidalla 2005),(El-Younsy *et al.* 2017), (Pardo *et al.*, 1996),(Samir 2002),(Keller *et al.*, 2002); Eastern Tethys (Keller, 2004). The *Plummerita hantkeninoides* zone is equal to the upper part of zone (CF 1-2)

recorded in South Atlantic in DSDP Site 525A (Li and Keller, 1998a); In Mahajanga Basin, (Abramovich *et al.*, 2002); (Abramovich and Keller, 2003) in DSDP Site 525A; recorded in USA by (Stinnesbeck *et al.* 2004); In Northeastern Iraq (Sharbazheri, 2008 and 2010). The *Plummerita hantkeninoides* Zone is corresponding to the highest part of *Abathomphalus mayaroensis* zone documented in several parts of the countries: In Spain (Canudo *et al.*, 1991), (Smit, 2005), (Chacon and Martin-Chivelet 2005); (Premoli Silva and Sliter, 1995 and 1999) in Italy; (Silva *et al.*, 1998) in the Mediterranean; (Govindan *et al.*, 1996) in India; (Maestas *et al.* 2003) in Mexico; and in Syria (Pecimotika *et al.*, 2014); The *Plummerita hantkeninoides* zone is comparable to the *Kassbiana falsocalcarata* zone reported in Kassab *et al.* (1986) and Kassab (1976).

E. Age: Latest Maastrichtian, the time span of this zone is from 65.30Ma to 65.00Ma.

F. Lithology and Paleoenvironment: In K.H 5\6 section this biozone documented in high organic material shale\marl with (up to 90%) of planktonic species and less than 10% phosclast suggest continuous deepening of this marine realm and deposition in outer ramp environments (Pecimotika *et al.*, 2014). This biozone in K.H 5\8 section occurs in limestone and represented by planktonic mudstone in the lower part and in the upper two meters the percentage of planktonic with phosclast increases to represent packstone, the latest seven meters is crystalline limestone. The top of this biozone matches to the abruptly disappeared of great diversities planktonic foraminiferal assemblages of Maastrichtian.

B. Biostratigraphy and Biozone of Early Paleocene Succession (Akashat Formation)

The Akashat Formation belongs to the Paleocene age, this formation have three subdivisions members (Al-Jibouri, 2003). This study includes only the lower member. In the studied section the Traifawi Member was introduced to describe 34m in K.H 5\6 section and in K.H 5\8 section the Traifawi Shale Member was introduced to describe seven meters. The Planktonic and benthic foraminifera analysis shows 19 species including zonal index marker species which led to recorded five biozones in K.H 5\6 (Fig. 3) and one biozone in K.H 5\8 (Fig. 2) within the studies area.

I. *Guembelitra cretacea* interval zone (P0)

A. Definition: The *Guembelitra cretacea* (P0) biozone denotes the Cretaceous\Paleocene boundary and described as a biozone between the latest appearance of Maastrichtian planktonic and benthonic foraminifera, the Latest presence of (CF1) *Plummerita*

hantkeninoides zone and the first presence of *Parvularugoglobigerina eugubina* (Ioterbacher and Premoli Silva).

Fig. 3. Biozones and Biostratigraphic distribution of Foraminifers of Digma and Akashat formations in K.H 5\8 section

B. Occurrence: In the studied sections, the P0 Subzone reaches a thickness of 1.2 meters in K.H 5\6 section and 2 meters in K.H 5\8.

C. Remarks and correlation: According to the foraminiferal association, the *Guembelitra cretacea* (Pl. 3, Fig. A) zone corresponds with the similar zone documented in Tunisia (Li, L., Keller, 1998b); and in Egypt (Keller *et al.*, 2002)(El-Younsy *et al.* 2017); general (Berggren *et al.*, 1995)and (Berggren and Norris, 1997), also recorded by (Olsson *et al.*, 2000); Eastern Tethys (Keller, 2004); documented in DSDP Site

(Abramovich and Keller, 2003); in Spain (Canudo *et al.*, 1991), (Pardo *et al.*, 1996), (Smit, 2005); Northern Iraq (Sharbazheri, 2008). The *Guembelitra cretacea* biozone is also corresponding to the *Guembelitra cretacea* zone in the lower part, recorded in Tunisia (Arenillas *et al.* 2000) ; recorded in Egypt by (Obaidalla 2005).

D. Age: The age of this biozone is Earliest Paleocene (Danian).

E. Lithology and paleoenvironment: In K.H 5\6 section, this biozone is documented in brownish shale\ marl rich in organic material with medium proportions of planktonic species (up to 50%) and few phosclast. this indicated the continuous deepening and deposition in outer ramp. This biozone in K.H5\8 section occurs in 2 meters in limestone and represented by planktonic wackestone, contain index planktonic foraminifera which overlying by five meters of crystalline limestone. The *Guembelitra cretacea* interval zone is conformably overlain by the *Parvularugoglobigerina eugubina* total range zone in K.H 5\6 section, and unconformably overlain by shelly floatstone of Hirri Member in K.H 5\8 section.

II. *Parvularugoglobigerina eugubina* total range zone (Pa)

A. Definition: The biostratigraphic interval is delineated by the total range of the *P. eugubina* Luterbacher and Premoli Silva. (Luterbacher, 1964), (Alvarez *et al.* 1977), (Blow 1979), (Bang 1979), (Liu and Olsson 1992), (Luterbacher 1964) applied the zone of *Parvularugoglobigerina eugubina* for the Danian age which recorded in Italy.

B. Occurrence: This zone covers the interval of 5.8 meters in K.H 5\6 section.

C. Assemblages: The planktonic foraminiferal association of this biozone, that expressed by *Parvularugoglobigerina eugubina* Luterbacher and Premoli Silva (Pl.3, Fig. B), *Chiloguembelina midwayensi* Cushman (Pl.3, Fig. C), *Chiloguembelina morsei* Kline (Pl.3, Fig. D), *Eoglobigerina simplicissima* Blow (Pl.3, Fig. E), *Globoconusa daubjergensis* Bronnimann (Pl. 3, Fig. F), *Parasubbotina pseudobulloides* (Pl.3, Fig. G). Also, benthic foraminifera which are associated with mentioned biozone are comprised by *Gavelinella danica* Brotzen (Pl.3, Fig. H), *Lenticulina* sp. (Pl.3, Fig. I).

D. Remarks and correlation: The present *Parvularugoglobigerina eugubina* Zone is comparable to the similar zone registered by (Li, L., Keller, 1998b) and (Arenillas *et al.* 2000) in Tunisia; in Egypt recorded by (El-Younsy *et al.* 2017), (Shahin 1992), (Tuning *et al.*, 1998), (Elnady and Shahin 2001) also documented from Egypt by (Samir 2002), (Keller *et al.*, 2002), (Keller, 2002); Spain (Smit 2005); in DSDP Site 525A from South Atlantic (Abramovich & Keller, 2003); the *Parvularugoglobigerina*

eugubina Zone equivalent to (P α) recorded in Eastern part of Tethys (Keller, 2004); (Berggren *et al.*, 1995), (Keller, 1996), (Berggren & Norris, 1997) and (Olsson *et al.* 2000) in general studied ; in Northeastern Iraq (Sharbazheri, 2008); Western Iraq (Al-Jibouri , 2003) and equivalent to P1a of (Pardo *et al.*, 1996).

- E. Age: The age of this biozone is Earliest Paleocene (Danian). The estimation age was registered by Olsson *et al.* 2000 and in the studied accomplished by Li and Keller, 1998, and by Keller in 2002, 2004. The *P. eugubina* zone is conformably superimposed by the *Parasubbotina pseudobulloides* zone in K.H5\6 section.
- F. Lithology and paleoenvironment: This biozone recoded only in K.H 5\6 section, it documented in brownish grey to grey shale\ marl rich in organic material with medium proportions of planktonic species (up to 50%), and this indicated the continuous deepening and deposition in outer ramp environments.

III. *Parvularugoglobigerina eugubina* - *praemurica uncinata* interval zone (P1)

The Lower Paleocene portion of the studies section are subdivided depending on (Berggren and Norris, 1997) and (Olsson *et al.* 2000). The P1 zone is divided into three subzones depending on the occurrences of *Parasubbotina pseudobulloides* (P1a) / *Subbotina triloculinoides* (P1b) and the *Subbotina triloculinoides* (P1b) / *Globanomalina compressa* or *Praemurica inconstans* (P1c). In this studies section P1a Subzone, P1b Subzone and P1c Subzone encountered only in K.H5\6. And this biozone not recorded in K.H 5\8.

IV. *Parasubbotina pseudobulloides* interval subzone (P1a)

- A. Definition: *Parasubbotina pseudobulloides* subzone is specified depending on the description of Berggren *et al.*, 1995 between the latest occurrence of *P. eugubina* Luterbacher and Premoli Silva and the first occurrence of *Subbotina*.
- B. Occurrence: The P1a Subzone reaches a thickness of four meters in K.H 5\6 section.
- C. Assemblages: The dominant species in this zone are: *Chiloguembelina midwayensi* Cushman, *Chiloguembelina morsei* Kline, *Eoglobigerina simplicissima* Blow, *Globoconusa daubjergensis* Bronnimann, *Woodringina hornerstownensis* Olsson (Pl.3, Fig. J). The common benthic foraminifera which are associated with mentioned biozone are: *Cibicides* sp., *Gavelinella danica* Brotzen, *Textularia* sp. (Pl.3, Fig. K).
- D. Remarks and correlation: Depending on foraminiferal relationships, the P1a subzones comparable to the lower part of *Morozovella pseudobulloides* zone were recorded by (Bolli 1966), P1a subzone documented by (Blow 1979); in Tunisia (Arenillas *et al.*

2000); (Elnady and Shahin 2001) in Egypt; *Parasubbotinapseudobulloides* subzones are equivalent to P1a recorded by (Berggren and Miller, 1988); (Samir 2002) and (Keller, 2002) from Egypt; (Keller, 2004) from Eastern Tethys; in Madagascar (Abramovich *et al.*, 2002); in SE Spain (Smit, 2005); from standard studied by (Berggren *et al.*, 1995), (Berggren and Norris, 1997) and (Olsson *et al.* 2000). also it is equivalent to the P1b in the El Kef of Tunisia (Keller, 1988); in general (Keller, 1996); in Spain (Pardo *et al.*, 1996); this subzone is correlatable with the lower part of *P.pseudobulloides* SE Spain (Canudo *et al.*, 1991), general (Liu and Olsson 1992); and correlatable with *P.pseudobulloides* in Italy (Luciani 1997), Egypt (Obaidalla 2005), (El-Younsy *et al.* 2017); Western Iraq (Al-Jibouri, 2003); equivalent to (P1a) *Parvularugoglobigerina eugubina* – *Subbotina triloculinoides* interval subzone in Northeastern Iraq (Sharbazheri, 2008).

- E. Age: The age of this subzone is Early Paleocene (Early Danian). The estimation age was registered by Olsson *et al.* 2000 and the studies were demounted by Li and Keller, 1998, and by Keller 2002 and 2004. The P1a subzone is conformably superimposed by the P1b subzone in the K.H5\6 section.
- F. Lithology and palaeoenvironment: It documented in grey shale\marl rich in organic materials with medium amounts of planktonic species (up to 50%), and this indicates that the subzone was deposited in the outer ramp environments.

V. *Subbotina triloculinoides* interval subzone (P1b)

- A. Definition: This subzone was defined by Berggren *et al.*, 1995 as the biostratigraphic interval between the first occurrence of *Subbotina triloculinoides* and the first occurrence of *Globanomalina compressa* and/or *Praemurica inconstans*.
- B. Assemblages: The planktonic foraminifera association of this subzone is characterized by appearance of the *Subbotina triloculinoides* Plummer (Pl.3, Fig. L), in addition to the following like: *Chiloguembelina midwayensi* Cushman, *Chiloguembelina morsei* Kline, *Globoconusa daubjergensis* Bronnimann, *Woodringina hornerstownensis* Olsson, and absent of *Eoglobigerina simplicissima* Blow. The benthic foraminifera of this biozone is represented by: *Cibicides* sp., *Gavelinella danica* Brotzen, *Lenticulina* sp., *Marssonell oxycona* Reuss (Pl.3, Fig. M), *Protelphidium hofkeri* Haynes (Pl.3, Fig. N), *Valvalabamina* sp. (Pl.3, Fig. O).
- C. Occurrence: This subzone reaching a thickness of 3 meters in K.H 5\6 section.

- D. Remarks and correlation: Depending on faunal comparisons, the P1b subzones could be comparable to the upper part of the *Morozovella pseudobulloides* zone which is recorded by Bolli 1966 (P1b) subzone is documented by Blow 1979; from Egypt (Elnady and Shahin 2001); (Arenillas *et al.* 2000) recorded in Tunisia; it is equivalent to the P1c documented by (Keller, 1988) in Tunisia; it is equivalent to the P1b of (Berggren *et al.*, 1995) and (Berggren and Norris, 1997), in Egypt (Keller *et al.*, 2002), (Keller, 2004), (Samir 2002); in SE Spain (Smit, 2005); in general (Olsson *et al.* 2000); in Northeastern Iraq (Sharbazheri, 2008); this subzone correlatable with the upper part of *P.pseudobulloides* SE Spain (Canudo *et al.*, 1991); (Liu and Olsson 1992); and correlatable with the *S. triloculinoidea* (Obaidalla 2005), (El-Younsy *et al.* 2017).
- E. Age: The age is estimated as Early Paleocene (Early Danian).
- F. Lithology and palaeoenvironment: It occurs in limestone and represented by planktonic wackestone\ packstone, this indicates deposition in outer ramp environments. This biozone is overlying by six meters of dolomitic limestone.

VI. *Globanomalina compressa/praemurica inconstans- praemurica uncinata interval subzone (P1c)*

- A. Definition: This subzone is determined by Berggren *et al.*, 1995 as a biozone includes the biostratigraphic interval Zone which is recorded between the first occurrence of the *Globanomalina compressa* Plummer (Pl.3, Fig. P), and/or *Praemurica inconstans* Subbotina (Pl.3, Figs. Q) and the first occurrence of the *Praemurica uncinata* Bolli at the topmost.
- B. Occurrence: At studied sections this subzone gets a thickness of 13 meters in K.H 5\6 section.
- C. Assemblages: The planktonic species of this subzone include the same species that are recognized in the previous biozone. The benthic foraminifera of this biozone are exemplified by: *Cibicides sp*, *Gavelinella danica* Brotzen, *Marssonell oxycona* Reuss, *Nodosaria sp.* (Pl.3, Fig. R).
- D. Remarks and correlation: According to the foraminiferal assemblage, the P1c Subzones in this study could be matching to *Morozovella trinidadensis* (Bolli 1966); and are equivalent to *Morozovella compressa* (Blow 1979); from Egypt (Elnady and Shahin 2001); this subzones equivalent to P1c of (Berggren *et al.*, 1995); of Egypt (Samir 2002); SE Spain (Smit, 2005); to the P1d of Tunisia (Keller, 1988), (Li and Keller,

1998); in high latitudes (Keller *et al.*, 1993); in addition it correlatable with the *P. inconstans* of Egypt (Obaidalla, 2005), (El-Younsy *et al.* 2017).

E. Age: The age is estimated as Early Paleocene (Early Danian)

F. Lithology and palaeoenvironment: It occurs in the limestone and represented by planktonic wackestone\ packstone, indicates deposition in the outer ramp environments.

Cretaceous	Paleocene		Period
Maastrichtian	Danian		Age
<i>P. hartiensis</i> (CF3)	<i>A. mayaroensis</i> (P0)	<i>G. gansseri</i> (CF2)	Bergeron event (Lakkel, 1998a,b) (Obaidalla, 2005) (Keller, 2002 & 2004)
<i>P. hartiensis</i> (CF3)	<i>P. hartiensis</i> (CF3)	<i>P. hartiensis</i> (CF3)	Egypt (Wadi Naktul, Obaidalla, 2005)
<i>P. hartiensis</i> (CF3)	<i>P. hartiensis</i> (CF3)	<i>P. hartiensis</i> (CF3)	Tunisia (El Kel & Elles, 1995)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Standard zonation (Bergeron <i>et al.</i> , 1995)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Caravaca, SE Spain (Smit, 2005)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Egypt (Samir, 2002)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	NE Iraq (Shahzadeh, 2008)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Present study (El-Younsy <i>et al.</i> , 2002)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Egypt (Kazakhstan, 1999)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Italy (Luciani, 1997)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Texas (Keller, 1989)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Spain (Camudo <i>et al.</i> , 1999)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Alabama (Millers Ferry, Lin & Olsson, 1992)
<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	<i>A. mayaroensis</i>	Antarctic Ocean (ODP Site 738C, Keller, 1993)

Fig. 4. A comparison between the biostratigraphic zones around the Cretaceous/Tertiary boundary in and outside of Iraq

Plate 3. All figures are from K.H 5\6 & K.H 5\8; Akashat Formation(Early Paleocene) A-*Guemblitria cretacea* Cushman;Axial section;K.H 5\8;(107m).B-*Parvularugoglobigirina eugubina* Luterbacher & Premoli Silva;Equatorial section;K.H 5\6;(131.6m). C-*Chiloguembelina midwayensi* Cushman; Axial section; K.H 5\6; (103m). D-*Chiloguembelina morsei* Kline; Axial section; K.H 5\6; (103m). E-*Eoglobigerina simplicissima* Blow; Equatorial section; K.H 5\6; (129m). F-*Globoconusa daubjergensis* Bronnimann;Equatorial section; K.H 5\6 (131.2m).G-*Parasubbotina pseudobulloides* plummer;Equatorial section; K.H 5\6 (124m). H- *Gavelinella danica* Brotzen; Equatorial section; K.H 5\6;(108m). I-*Lenticulina*sp.; Equatorial section; K.H 5\6 (118m). J- *Woodringina hornerstownensis* Olsson; Axial section; K.H 5\6; (105m). K- *Textularia* sp.; Axial section; K.H 5\6; (122.6m). L-*Subbotina triloculinoides* Plummer; Equatorial section; K.H 5\6 (120m). M- *Marssonell oxycona* Reuss; Axial section;K.H 5\6 ;(119m). N-*Protelphidium hofkeri* Haynes; Subequatorial section; K.H 5\6 ; (119m). O-*Valvalabamina* sp.; Equatorial section; K.H 5\6 (119m). P- *Globanomalina compressa* Plummer; K.H 5\6 (119m). Q- *Praemurica inconstans* Subbotina; Axial section; K.H 5\6 (104m). R-*Nodosaria* sp.; Axial section; K.H 5\6 (105m).

CONCLUSIONS

Detailed study of the Late Maastrichtian-Early Paleocene planktonic and benthic foraminiferal associations gives the basis for biostratigraphic and palaeoenvironmental interpretations of the studied successions. A sum of 55 foraminiferal species related to 35 genera are recognized. Moderately, common to abundant and completely preserved or partially preserved foraminifera assemblages allowed biozonation and establishing of the resulting biozones: (1): *Pseudoguembelina hariaensis* Partial Range Zone (2): *Pseudoguembelina palpebra* Partial Range Zone (3): *Plummerita hantkeninoides* Total Range Zone. Three biozones are documented from the K.H 5\6 studied section and the latest two biozones are documented from the K.H 5\8 studied section, these biozones refer to the Late Maastrichtian age of Digma Formation. Five biozones of the Early Paleocene are recorded in the K.H 5\6 studied section represented by (1) *Guembelitra cretacea* interval Zone (2) *Parvularugoglobigerina eugubina* Total Range Zone (3) *Parasubbotina pseudobulloides* interval Subzone (4) *Subbotina triloculinoides* Interval Subzone (5) *Globanomalina compressa/Praemurica inconstans- Praemurica uncinata*. Only the first biozone is documented in the K.H 5\8 studied section. Each biozone of Paleocene refers to the early Danian age of Tirfawi Member, the first member of Akashat Formation. The Maastrichtian/Danian contact in the studied regions is concluded as conformable surface indicated by the lack of any sediment interruption, or unconformity surface and continuous in the biostratigraphic record. The latest Maastrichtian planktonic zone (*Plummerita hantkeninoides* Zone) and the oldest Paleocene (*Guembelitra cretacea* Zone) are present. In K.H 5\8, the contact between the Danian and Selandian is unconformable. So, the Early- Late Danian not recorded in this K.H 5\8 section, because the *Guembelitra cretacea* Cushman of Danian age directly overlying by the Earliest Selandian Mollusca shell fragment and it is probable stratigraphic gaps in the Paleocene successions in K.H5\8 section, magnitude of the gap is great as the Earliest Danian P0 subzone is being directly underlying the Earliest Selandian. The successions of the studied area were deposited in the outer ramp environments.

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