PLANKTONIC FORAMINIFERAL BIOSTRATIGRAPHY OF THE REDDISH TO PALE BROWN TRANSITIONAL SUCCESSION (UPPER CRETACEOUS) IN SMAQULI AREA, NORTHEAST IRAQ (KURDISTAN REGION)

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Key words: Biostratigraphy, Planktonic foraminifera, Upper Cretaceous, Shiranish Formation, Kurdistan

ABSRTACT

The Upper Cretaceous reddish to pale brown transitional succession (Shiranish – Tanjero transition unit) in the Smaquli area; northeast Iraq was studied to document the nature of the reddish brown unit within the studied section, which comprises three lithostratigraphic units; upper part of Shiranish Formation (Late Campanian), Reddish to pale brown unit (Early Maastrichtian) and lower part of Tanjero Formation (lower – middle Late Maastrichtian). Sixty seven planktonic foraminiferal species that belong to nineteen genera are recorded and six Planktonic Foraminiferal Biostratigraphic Zones have been detected in the studied section. They represent *Globotruncana aegyptiaca* Interval Zone (CF8), *Gansserina gansseri* Interval Zone (CF7), *Contusotruncana contusa* Interval Zone (CF6), *Pseudotextularia intermedia* Interval Zone (CF5), *Racemiguembelina fructicosa* Interval Zone (CF4), *Pseudoguembelina hariaensis* Interval Zone (CF3). They display Late Campanian – Middle to Late Maastrichtian age. They are discussed and correlated with their equivalents in and outside of the studied area. The age of this succession is estimated to be more than 2.150 My. The planktonic foraminiferal biozones of the studied section display continuous sedimentary succession; they show incessant in sedimentary sequence without any interruption.

الطباقية الحياتية للفورامنيفيرا الطافية للتتابعات الصخرية الانتقالية البنية المائلة الى الاحمرار (الكريتاسي الأعلى) فى منطقة سماقولي، شمال شرق العراق، إقليم كردستان

خالد محمود إسماعيل الشارباژيرى

المستخلص

أظهرت الدراسة الحالية تواجد تتابعات صخرية بنية مائلة إلى الاحمرار لعصر الكريتاسي الأعلى فى منطقة سماقولي شمال شرق العراق والتى تقع بين تكويني شيرانش وتانجرو. وأجريت لها دراسة طباقية حياتية للفورامنيفيرا الطافية حيث تم تحديد الأنطقة الحياتية التالية:

Globotruncana aegyptiaca Interval Zone (CF8), *Gansserina gansseri* Interval Zone (CF7), *Contusotruncana contusa* Interval Zone (CF6), *Pseudotextularia intermedia* Interval Zone (CF5), *Racemiguembelina fructicosa* Interval Zone (CF4), *Pseudoguembelina hariaensis* Interval Zone (CF3).

وتعود هذه التتابعات الى عصر الكامبانيان المتأخر – والماسترختي الأوسط الى المتأخر، وقد قدر العمر الجيولوجي لهذه التتابعات الصخرية بفترة زمنية مقدارها 2.150 مليون سنة. ومن خلال هذه الدراسة تبين إن الترسيب مستمر بدون أي انقطاع. وأمكن التعرف على سبعة وستين نوعاً من الفورامنيفيرا الطافية العائدة الى تسعة عشرة جنساً، وتم إجراء عملية المقارنة والتعاقب مع الأنطقة الحياتية الأخرى داخل وخارج العراق. إن المكشف الجيد لهذه التتابعات فى منطقة الدراسة ووضعها وصفاتها الصخرية المميزة والمختلفة تماماً عن تكويني شيرانش وتانجرو الواقعة بينهما وامتدادها الجغرافي والعمودي يجعلها تكون وحدة صخرية مستقلة.

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INTRODUCTION

The Late Campanian – Maastrichtian sequence; in the north and northeastern Iraq is well exposed and represented by six subsequences. Two diagnostic subsequences (facies) of them, in the studied area represent the outer shelf – basinal facies (Shiranish Formation) and isolated basin of the Balambo – Tanjero (Tanjero Formation) (Jassim and Goff, 2006).

This study deals with the field observation and detailed planktonic biostratigraphic zonation of "reddish to pale brown succession", which represents transitional facies change between Shiranish and Tanjero formations. Henson (1940) in Buday (1980) defined the Shiranish Formation from the High Folded Zone in north Iraq near Shiranish Islam village, northeast of Zakho. The Tanjero Formation was first defined and described under the name of Tanjero Clastic Formation by Dunnington (1952) in Bellen *et al*. (1959) from the Sirwan Valley, southeast of Sulaimaniyah, 2 Km to the south of Kani Karweshkan village, near Halabja town and located at the right bank of Sirwan River (upstream of Diyala River). Now, most of the type section is inundated by Darbandi Khan Dam reservoir.

The studied section is located in Sulaimaniyah Governorate, Smaquli area, at latitude 36° 10′ 51″ and longitude 44° 36′ 40″, about 25 Km northeast of Koy Sanjaq town, (Fig.1) and 5 Km southeast of Gali village. It is located southwest of Zagros Thrust Belt, along the distal margin of the Tanjero Foreland Basin, which is developed from the basin fill of the Neo-Tethys Sea and colliding of Iranian and Arabian Plates (Karim, 2004). Structurally, the studied area is located within the High Folded Zone near the boundary of the Low and High Folded Zones (Buday and Jassim, 1987).

The main objective of this study is concerned with the age determination of the "reddish to pale brown succession" (Shiranish – Tanjero transition unit), which represents transitional facial change from basinal sediments, of Shiranish Formation to flysch type foreland basin, of Tanjero Formation. Moreover, to investigate in detail, the vertical distribution of planktonic foraminifera in this unit at Awagird Mountain in Smaquli area, based on the available and the inferred evidences of planktonic foraminiferal biostratigraphic study of "reddish brown succession" (Shiranish – Tanjero transition unit) in the studied area. Furthermore, the present study deals; for the first time with the field observation of lithology, stratigraphic position and geographic distribution of the involved succession. No previous studies are available about the involved succession in the studied area; except the sedimentological study of Karim (2004), which deals with the red sandstone beds within Tanjero Formation.

LITHOLOGY AND STRATIGRAPHY

The studied "reddish pale brown succession" (Shiranish – Tanjero transition unit) consists of 66 m of alternation of thin bedded fossiliferous reddish to pale brown claystone and marl alternated with thin red shale, intercalated by thin pale brown; some times pale grey marly limestone of (5 – 10) cm thickness form the base and the top of this interval (Fig.2). Throughout the studied area, the "reddish to pale brown succession" (Shiranish – Tanjero transition unit) is underlain by Shiranish Formation (Fig.3). It is likely forming a normal stratigraphic boundary of conformable gradational contact, from bluish white marl and marly limestone of Shiranish Formation to the first appearance of reddish to pale brown claystone or marl beds of the transitional unit. The upper contact is marked by the presence of olive green and dark grey lithology with the first appearance of 20 cm hard well bedded sandstone, at the base of Tanjero Formation (Figs.2 and 4).

It is worth mentioning that the main lithologic constituents of Shiranish – Tanjero transition unit has the same lithologic character of monotonous and similar repetition in all studied sections of the studied area, with exception that there are few sandstone layers at the base of this interval at Hizop area, 20 Km southeast of the studied section .

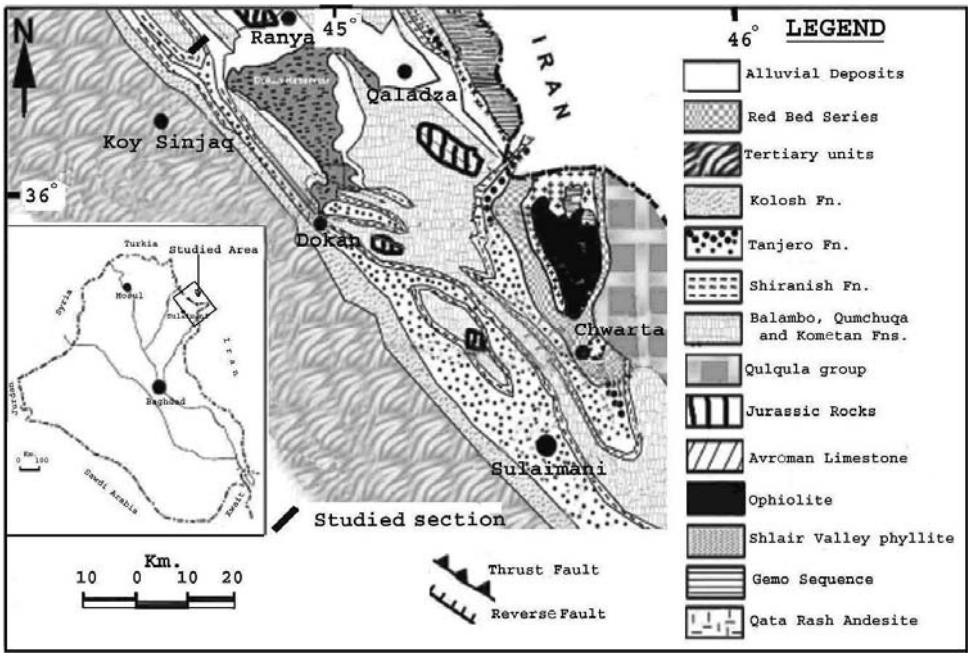

Fig.1: Location and geological map of the studied area
(modified from Sissakian, 2000)

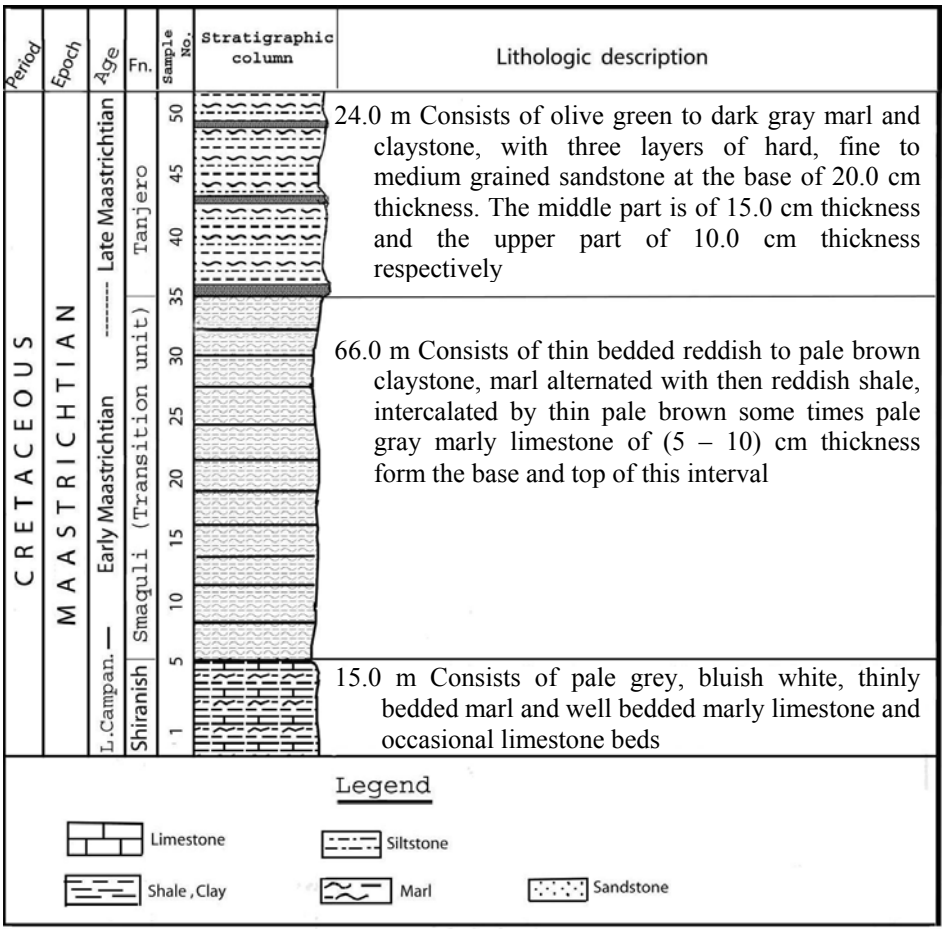

Fig.2: Stratigraphic column of Awagird section in Smaquli area,
northeast of Koy Sanjaq city (not to scale)

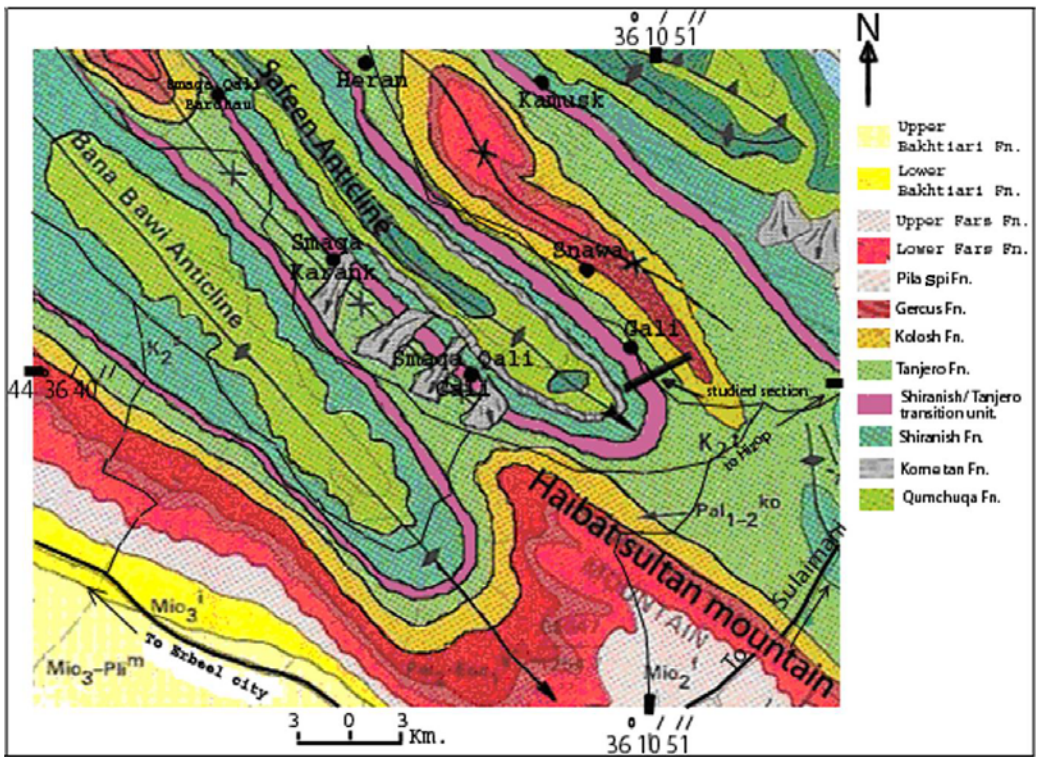

Fig.3: Geological map of the studied area showing the new formal stratigraphic unit (Reddish to pale brown succession) representing transitional facies between Shiranish and Tanjero formations (modified from Sissakian, 1997)

The involved succession geographically manifested excellent exposure that extends for 75 Km in length, with general southeast – northwest trend from Girda Sura village, southeastern limb of Kosrat anticline, when it is plunging down under Dokan Lake (northwestern side of the Dokan Dam). The name of Girda Sura village reveals the lithologic colour of this unit, where it is exposed, to the south of Shaqlawa city, which is vanishing there. It extends continuously from Girda Sura village (15 m thick) throughout the southwestern limb of Kosrat anticline at Merga Pasha, Girda Baru village and Khalakan city (20 – 25 m thick), Badawan village (10 m thick), Bestana (27 m thick), Hizop (20 m thick) and to Smaquli region along the northeastern limb of Safeen anticline, at the studied section (66 m thick) and reaches maximum thickness (72 m thick) at the gorge of Gali village, it also extends to Snawa, Nazanin and Heran villages, with thickness of 25 m between Heran and Nazanin. Along the southwestern limb of Safeen anticline, the unit extends from Smaqa Qali Gali, Smaqa Qali Karank to Smaqa Quli Barchau where it terminates (Figs.3 and 4).

The main structural unit in the studied area is Awgird Mountain (Fig.5), which represents the southeastern part of Safeen anticline. The general lithostratigraphic sequence in Smaquli area consists of the following formations (Fig.4):

1- Gercus Formation (Eocene)
2- Kolosh Formation (Paleocene – Early Eocene)
3- Tanjero Formation (Late Maastrichtian)
4- Shiranish – Tanjero Transition Unit (Early Maastrichtian)
5- Shiranish Formation (Campanian – Early Maastrichtian)
6- Kometan Formation (Turonian – Santonian)
7- Qumchuqa Formation (Albian – Cenomanian)

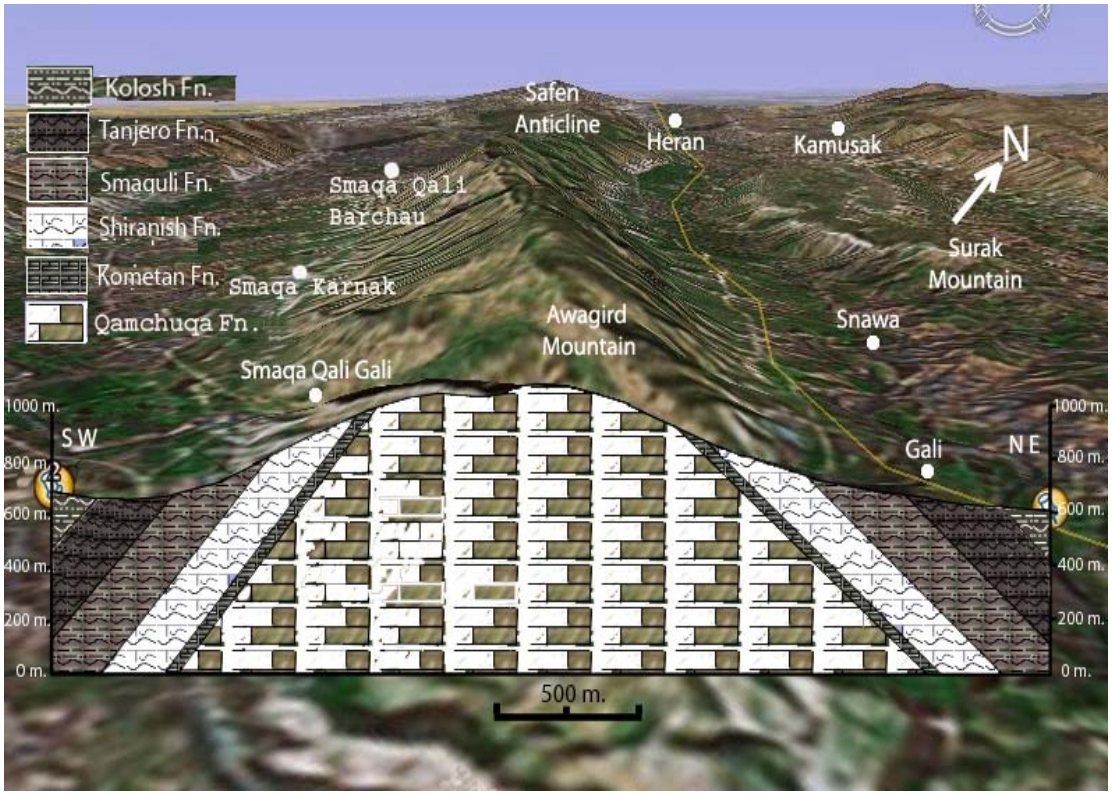

Fig.4: Geological cross section along Awagird Mountain showing different rock units in the studied area from the core of the anticline to both limbs (modified from Google Earth morphological feature of the studied area)

Fig.5: Geologic cross section of the "reddish to pale brown succession" (Shiranish – Tanjero transition unit) in Awagird anticline, which is underlain by the Shiranish Formation and overlain by the Tanjero Formation

MATERIALS AND METHODS

Fifty samples were collected at (1 – 3) m interval from the studied section, including fife samples from the upper part of Shiranish Formation and fifteen samples from the lower part of Tanjero Formation (Fig.2).

Samples were treated (soaked) with the Ethanoic acid solution (CH_3COOH) made up of 80% acetic acid and 20% H_2O for the duration time of (1 – 5) hours, the technique proposed here, is based on cold-disaggregation with acetic acid. The acetic acid causes a very slow reaction that disaggregates the rocks without destroying and corroding fossil content. This method firstly was used by Lirer (2000). The disaggregated samples were washed with tap water through a 63-µm sieve until clean foraminiferal residues were recovered. The washed samples were oven-dried at 40^{o}C and sieved through a 150-µm sieve (after drying). A laboratory procedure and scanning electron microscope photo was processed in the Institute for Paleontology, University of Bonn, Germany.

PREVIOUS STUDIES

Bellen *et al.* (1959) described briefly the distribution, age, lithology, fossils content, and stratigraphy of the Shiranish and Tanjero formations, in different localities. Kassab (1972, 1975a, 1975b, 1975c and 1976) and Kassab *et al*. (1986) studied the biostratigraphy of the Shiranish and Tanjero formations at their type localities and in other six locations in north and northeast Iraq. They deducted Late Campanian – Maastrichtian age for the both formations in Iraq and recognized two planktonic foraminiferal zones and five sub-zones; from base to the top; as follows:

1- *Globotruncana fornicata – stuartiformis-elevata-roseta- ventricoza* Zone
   a- *Globotruncana calcarata – elevata-aegyptiaca* Subzone (Late Campanian)
   b- *Globotruncana arca – tricarinata -subcircumnodifer* Subzone (Early Maastrichtian)
2 - *Globotruncana contusa-esnehensis-duwi* Zone
   a- *G. gansseri-bahijae – Gublerina cuvillieri* Subzone (Middle Maastrichtian)
   b- *Abathomphalus mayaroensis* Subzone (Late Maastrichtian)
   c- *Globotruncana falsocalcarata* Subzone (Late Maastrichtian)

Abawi *et al.* (1982) and Abdel Kireem (1986a and b) included both formations within stratigraphy of Late Cretaceous of northeast Iraq. Also they recognized five planktonic foraminiferal subzones under two zones, as follows from the base to the top:

   a- *Globotruncana fornicate-arca-stuarti* Assemblage Zone
      Globotruncana calcarata Subzone (Late Campanian)
   b- *Globotruncana aegyptiaca – lapparenti-stuarti* Assemblage Zone
1-*Rugotruncana subcircumnaodifer* Subzone (Early Maastrichtian)
2-*Globotruncana gansseri* Subzone (Middle Maastrichtian)
3-*Globotruncana contusa* Subzone (Middle Maastrichtian)
4-*Abathomphalus mayaroensis* Subzone (Late Maastrichtian)

Al-Mutwali and Al-Jubouri (2005) described the age of Shiranish Formation as Late Campanian – Late Maastrichtian based on the biostratigraphy of the following biozones**:**

1**-** *Globotruncana calcarata* (Late Campanian)
2**-** *Globotruncanella havanensis-Roseta fornicata* Zone (Early Maastrichtian)
3- *Globotruncana aegyptiaca* Zone (Early Maastrichtian)
4- *Globotruncana gansseri* Zone (Late Maastrichtian)

BIOSTRATIGRAPHY

The collected samples from the studied section, which contain microfossils provided predominant to extremely abundant well preserved forms, they reveal as the radiation stage of biotic evolution and high diversity of Globotruncanids, Rugoglobigerinids, Globigerinids and Heterohelicids planktonic foraminifera with rare to moderate calcareous and agglutinated benthonic forams (Fig.6). The foraminifera occur continuously in the studied succession indicating incessant in sedimentary sequence without any interruptions.

Sixty seven planktonic foraminiferal species belonging to nineteen genera were recorded (Fig.6). The planktonic foraminifera of Globotruncanids, Heterohelicids, Rugoglobigerinids, Globigerinelloidids and Globigerinids are the most prevalent planktonic forams and they show the best indication for typical Tethyan fauna type.

The planktonic foraminiferal zonation of the sediments in tropical – subtropical regions, like Li and Keller (1998a); Keller (2002 and 2004); Abramovich *et al.* (2002); Abramovich and Keller (2003); Samir (2002); Obaidalla (2005) and Sharbazheri (2007) were used exclusively as the biostratigraphic framework in this study.

Li and Keller (1998a) subdivided the Maastrichtian zonal scheme into nine Cretaceous Foraminiferal (CF) zones; labeled CF9 to CF1, from the base to the top. They calibrated their ranges to the paleomagnetic time scale in the DSDP Site 525A, and on Tunisian sections (Li and Keller, 1998b).

The recognizing and genetic classification used in this study follows that of Postuma (1971); Kassab (1975b, 1975d and 1976); Masters (1977); Ramsay (1977); Jenkins and Murray (1981); Caron (1985); Loeblich and Tappan (1988); Georgescu (1996 and 2002) and Bou Dagher-Fadel *et al*. (1997). The biostratigraphic correlation of the studied section that is based on planktonic foraminiferal zonations (Figs.7 and 8) shows a comparison between the biostratigraphic zones established in this study with other equivalents of the commonly used planktonic zonal scheme.

The biostratigraphic zones are described from the bottom to the top as follows:

▪ *Globotruncana aegyptiaca* Interval Zone (CF8)

The *Globotruncana aegyptiaca* or CF8 zone was originally established and described by Caron (1985). It is marked by the interval from the First Appearance Datum (FAD) of the nominate species to the FAD of *Gansserina gansseri*. In the studied section, it is defined by the first appearance (FA) of index taxon (*Globotruncana aegyptiaca* Nakkady) within the first sample collected from the upper part of Shiranish Formation at the base to the FAD of *Gansserina gansseri* (Bolli) (Figs.6 and 9e – g) within the involved unit; at the top. This zone is covered with frequent occurrence of the nominate species for 15 m interval in the upper part of the Shiranish Formation and 5 m of the lower part of the unit. This zone indicates Early Maastrichtian and corresponds to that of Caron (1985); Shahin (1992), Li and Keller (1998a); Abramovich *et al*. (2002); Al-Mutwali and Al-Jubouri, (2005) and Sharbazheri (2007 and 2008) (Figs.7 and 8). This interval zone is characterized by a well diversified planktonic foraminiferal species, e.g. *Heterohelix navarroensis* Loeblich, *H. globulosa* (Ehrenberg), *H. Striata* (Ehrenberg), *H. reussi* (Cushman), *H. nauttalli* (Voorwijk), *H. punctulats* (Cushman), *H. pulchra* (Brotzen), *Planoglobulina carseyae* (Plummer), *P. brazoensis* Martin *P. acervulinoides* (Egger), *Rugoglobigerinarugosa* (Plummer), *R. Scotti* (Bronnimann), *R. hexcamerata* Bronnimann, *R. macrocephala* Bronnimann, *R. macrocephala* Bronnimann, *R. rotundata* Bronnimann, *R. milamensis* Smith and Pessa, *Globotruncanita stuarti* (de Lapparent), *Globotruncanita stuartiforms* Dalbez, *Rugotruncana subcircumnodifer* (Gandolfi), *Globotruncana aegyptica* Nakkady, *Glt. orientalis* El-Naggar,

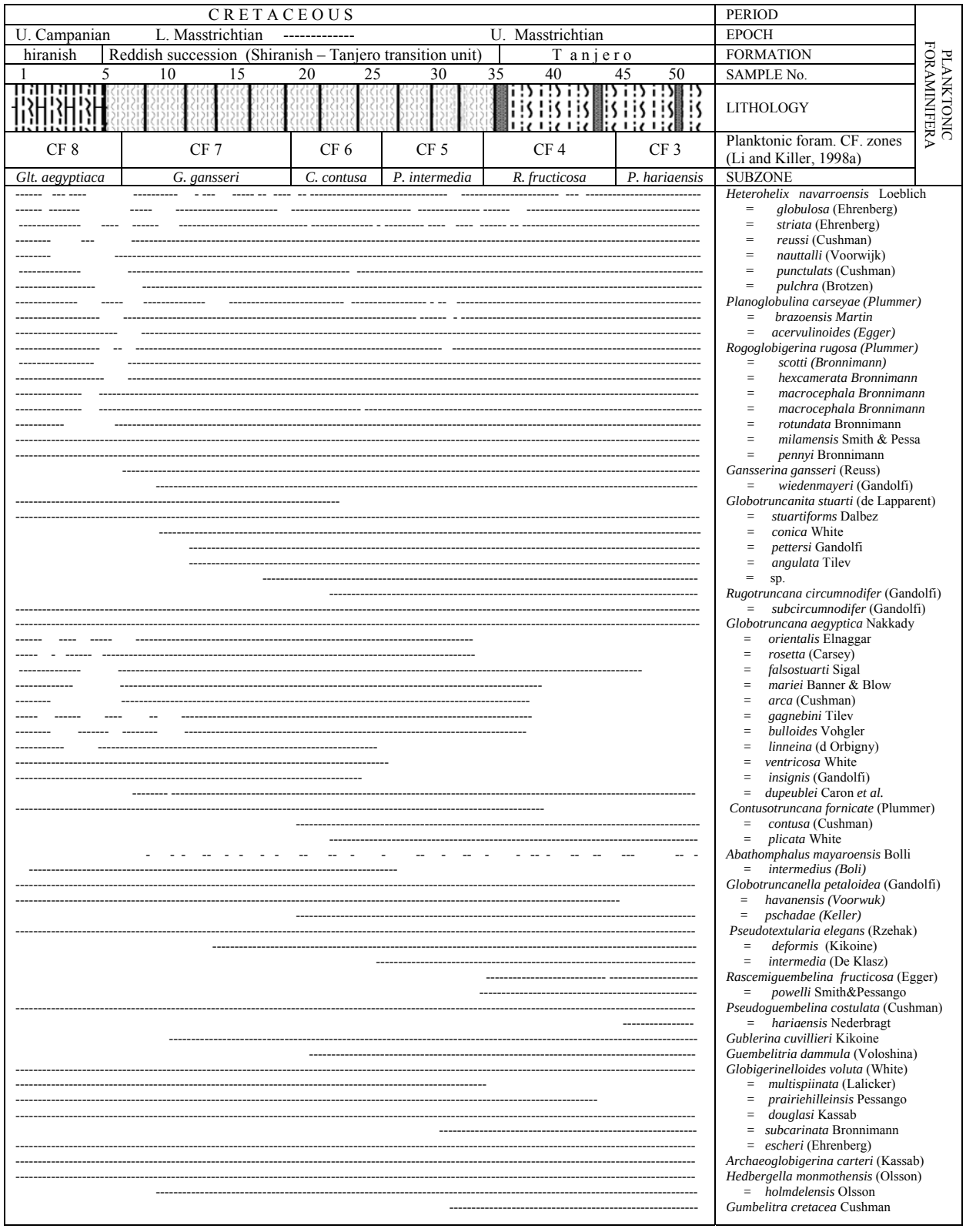

Fig.6: Stratigraphic range chart of planktonic foraminifera of the Shiranish – Tanjero transition unit at Awagird section, Smaquli area

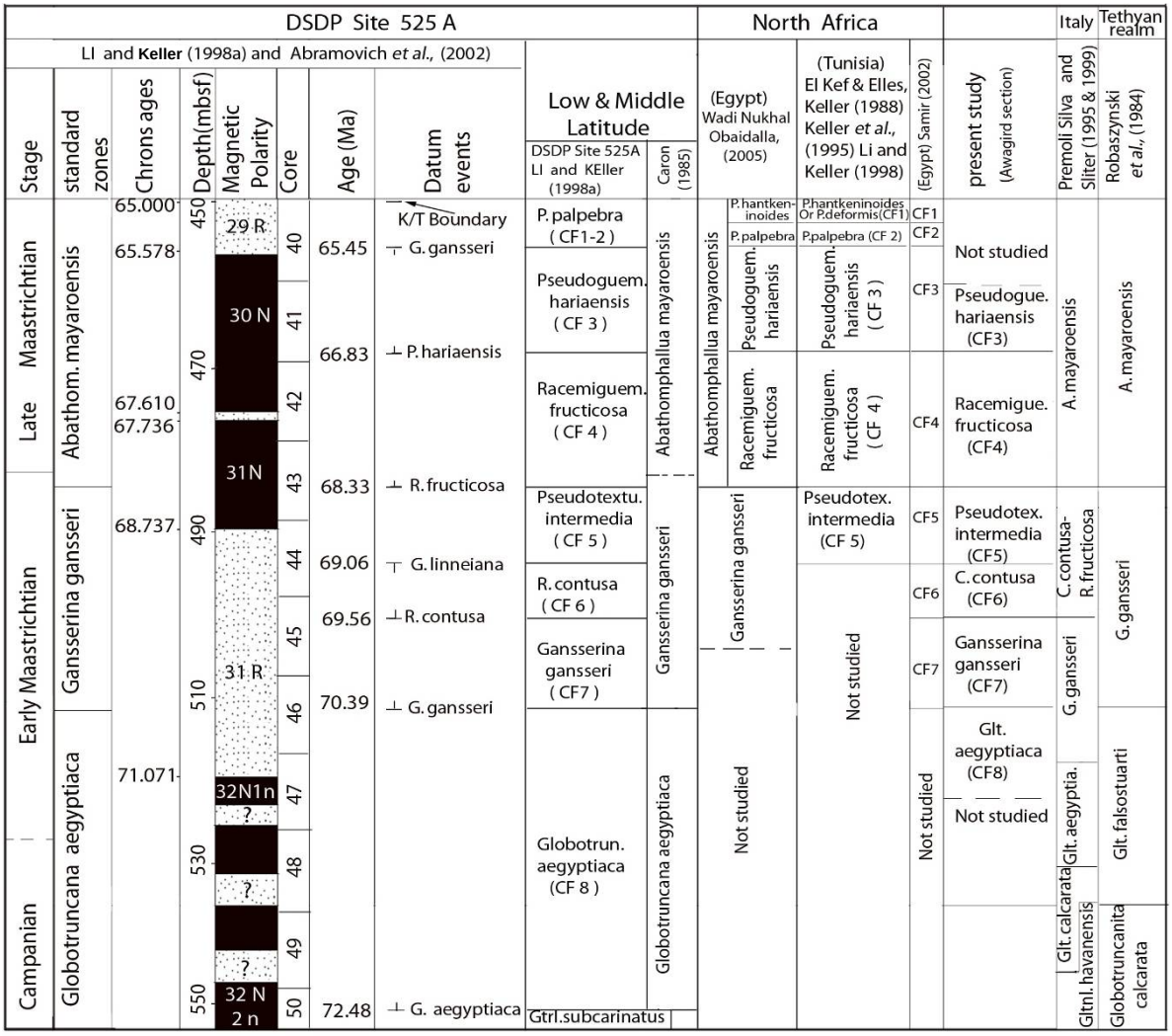

Fig.7: Correlation chart showing the proposed biostratigraphic zones of Awagird section (Smaquli area) with the Planktonic foraminiferal zonation commonly used in low, middle and high latitudes, and new zonation proposed based on DSDP Site 525A, by Li and Keller (1998a) and Abramovich *et al*. (2002) in the new zonal scheme. The age of planktonic foraminiferal datum events is shown (Modified from different authors)

Glt. Rosetta (Carsey), *Glt. falsostuarti* Sigal, *Glt. mariei* Banner and Blow, *Glt. arca* (Cushman), *Glt. gagnebini* Tilev, *Glt. Bulloides* Vohgler, *Glt. Linneina* (d'Orbigny), *Glt. ventricosa* (White), *Glt. insignis* (Gandolfi), *Abathomphalus intermedius* (Bolli), *Globotruncanella petaloidea* (Gandolfi), *Globotruncanella havanensis* (Voorwuk), *Pseudotextularia elegans* (Rzehak), *Pseudoguembelina costulata* (Cushman), *Globigerinelloides voluta* (White), *Globigerinelloides multispiinata* (Lalicker), *Globigerinelloides prairiehilleinsis* Pessango, *Globigerinelloides douglasi* Kassab, *Globigerinelloides escheri* (Ehrenberg), *Archaeoglobigerina carteri* (Kassab) and *Hedbergella monmothensis* (Olsson). Beside these planktonic foraminiferal assemblages rare benthonic foraminiferal species were recorded.

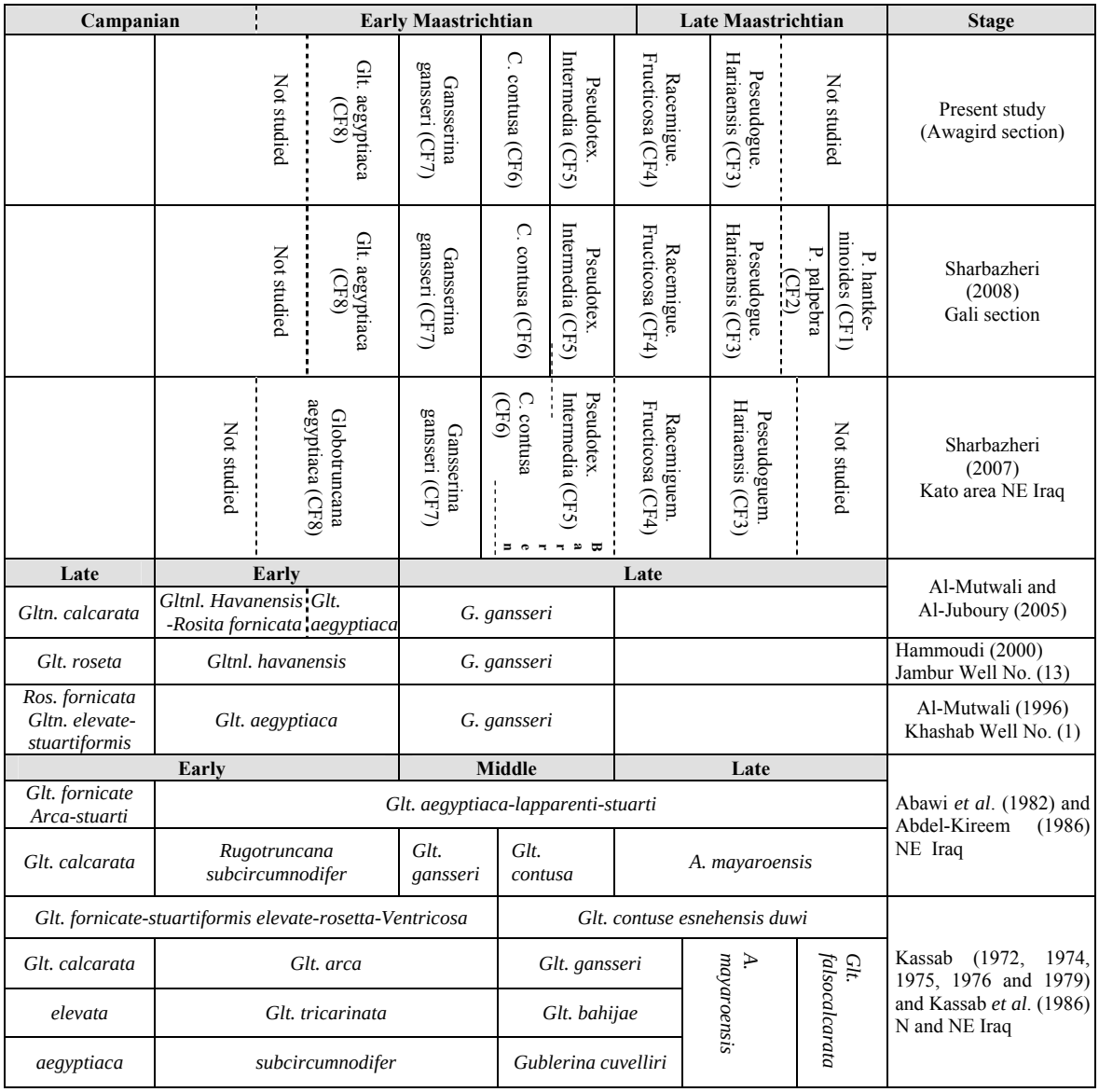

Fig.8: Correlation chart showing the proposed biostratigraphic zones of Awagird section (Smaquli area) with the Planktonic foraminiferal zonation; commonly used in Iraq

According to the aforementioned authors and Faris (1984); Martines (1989); Abdel Kareem and Samir (1995); Al-Mutwali (1996); Elnady and Shahin (2001) and Khalil and Mashaly (2004), the age estimation of this biozone indicates Early Maastrichtian. Li and Keller (1998a) recorded the time span of this biozone from (72.48 – 70.39) Ma estimated by absolute ages based on magnetochron ages, while Premoli Silva *et al*. (1998) in their study of bio-isotope stratigraphy on eastern Mediterranean and Maestas *et al*. (2003) recorded the *Globotruncana aegyptiaca* Zone from the Late Campanian age. The Geologic Time Scale (GTS2004) by Gradstein *et al*. (2004) and the accompanying International Stratigraphic Chart, issued under auspices of the International Commission of Stratigraphy (ICS) shows the current chronostratigraphic scale and ages with estimates of uncertainty for all stage boundaries, placed this span of time (72.48 – 70.39 Ma) under the upper limit of Campanian. The chronostratigraphic duration age was estimated on different techniques and methods to construct a GTS (2004) placed the Maastrichtian stage between time intervals of ($70.6 - {}^{+}0.6$) Ma; at the base and ($65.5^{+} - 0.3$) Ma at the top.

▪ ***Gansserina gansseri* Interval Zone (CF7)**

The *Gansserina gansseri* or CF7 Zone was introduced by Bronnimann (1952) in Samir (2002) as *Globotruncana gansseri* Zone and placed into the Early Maastrichtian of Trinidad. In the present study, this biozone is defined by the interval between the FAD of nominate species *Gansserina gansseri* (Bolli) and the FAD of *Contusotruncana contusa* (Cushman) (Figs.9h – i). Most of the workers in the zonal scheme placed *Gansserina gansseri* Zone informally at the Middle – Lower Maastrichtian (Kassab, 1975a, 1975b, 1975c and 1976; Abawi *et al*., 1982; Faris, 1984; Kassab *et al.*, 1986; Abdel Kireem, 1986a and b; Abdel Kireem and Samir, 1995; Al-Mutwali, 1996; Li and Keller, 1998a; Luning *et al*., 1998; Premoli Silva *et al.*, 1998; Elnady and Shahin, 2001; Abramovich *et al*., 2002; Samir, 2002; Maestas *et al*., 2003; Al-Mutwali and Al-Jubouri, 2005; Chacon and Martin, 2005 and Sharbazheri, 2007 and 2008) (Figs.7 and 8), while Obaidalla (2005) placed this zone at the base of Late Maastrichtian and Maestas *et al*. (2003) placed this zone at Late Campanian – Early Maastrichtian. This zone covers abundant occurrence of the nominate species for 28 m.

In addition to the index species, the planktonic assemblages of this zone include: *Heterohelix navarroensis* Loeblich, *H. Globulosa* (Ehrenberg), H. *Striata* (Ehrenberg), *H. reussi* (Cushman), *H. nauttalli* (Voorwijk), H. *punctulats* (Cushman), *H. pulchra* (Brotzen), *Planoglobulina carseyae* (Plummer), *P. Brazoensis* Martin *P. Acervulinoides* (Egger), *Rogoglobigerina rugosa* (Plummer), *R. Scotti* (Bronnimann), *R. Hexcamerata* Bronnimann, *R. Macrocephala* Bronnimann, *R. Rotundata* Bronnimann, *R. Milamensis* Smith and Pessa, *Gansserina gansseri* (Reuss), *G. Wiedenmayeri* (Gandolfi), *Globotruncanita stuarti* (de Lapparent), *Globotruncanita stuartiforms* Dalbez, *Globotruncanita conica* White, *Globotruncanita pettersi* Gandulfi, *Globotruncanita angulata* Tilev, *Rugotruncana subcircumnodifer* (Gandolfi), *Globotruncana aegyptica* Nakkady, *Glt. Orientalis* Elnaggar, *Glt. Rosetta* (Carsey), *Glt. Falsostuarti* Siga,l *Glt. Mariei* Banner and Blow, *Glt. arca* (Cushman), *Glt. Gagnebini* Tilev, *Glt. Bulloides* Vohgler, *Glt. Linneina* (d Orbigny), *Glt. Ventricosa* White, *Glt. Insignis* (Gandolfi), *Glt. dupeublei* Caron *et al*., *Contusotruncana fornicate* (Plummer), *Abathomphalusmayaroensis* (Bolli), *Abathomphalus intermedius* (Bolli), *Globotruncanella petaloidea* (Gandolfi), *Globotruncanella havanensis* (Voorwuk), *Pseudotextularia elegans* (Rzehak), *Pseudotextularia deformis* (Kikoine), *Pseudoguembelina costulata* (Cushman), *Gublerina cuvillieri* Kikoine, *Globigerinelloides voluta* (White), *Globigerinelloides multispiinata* (Lalicker), *Globigerinelloides prairiehilleinsis* Pessango, *Globigerinelloides douglasi* Kassab, *Globigerinelloides escheri* (Ehrenberg), *Archaeoglobigerina carteri* (Kassab), *Hedbergella monmothensis* (Olsson) *and Hedbergella holmdelensis* Olsson.

The age estimation of this biozone by Li and Keller (1998a) recorded the time span of (70.39 – 69.56) Ma (830 Ky) estimating absolute ages based on magnetochron ages with 30 Ky/m moderate rate of deposition (Fig.7).

▪ ***Contusotruncana contusa* Interval Zone (CF6)**

Dalbeiez (1955) in Samir (2002) proposed the *Globotruncana contusa* Zone for the Late Maastrichtian of Tunisia. Biostratigraphic interval from the FAD of *Contusotruncana contusa* (Cushman), at the base and last appearance (LAD) of *Globotruncana linneniana* (d Orbigny) at the top (Fig.9c, d and u). In the present study, this Zone **(CF6)** covers an interval of 13 m and provided an assemblage of planktonic foraminifera, which totally resembles that of the underlying *Gansserina gansseri* Zone **(CF7)**, except for the first appearance of *Contusotruncana contusa* (Cushman), *Contusotruncana plicata* White, *Rugotruncana circumnodifer* (Gandolfi), *Globotruncanella* pschadae (Keller) and *Guembelitria dammula* (Voloshina).

Explanations of Fig. (9):

a and b: *Globotruncanita stuartiformis*. (Dalbiez). **a)** spiral view, **b)** umbilical view. Sample from *G*, *gansseri* Zone

c, d and u: *Contusotrancana contuse (Cushman)*. **c)** spiral view, **d)** umbilical view, **u)** side view. Sample from *C. contoza* Zone

e, f and g: *Globotruncana aegyptiaca* Nakkady. **e)** side view, **f)** spiral view, **g)** umbilical view. Sample from *R. fructicusa* Zone

h and i: *Gansserina gansseri* (Bolli). **h)** umbilical view, **i)** spiral view. Sample from *G*., *gansseri* Zone

j and k: *Gansserina wiedenmayeri* (Gandolfi). **j)** side view, **k)** umbilical view. Sample from *G*. *gansseri* Zone

l and m: *Contusotrancana plicata* White. **l)** spiral view, **m)** umbilical view. Sample from *G*. *gansseri* Zone

n and o: *Globotruncana ventricosa* White. **n)** spiral view, **o)** umbilical view. Sample from *G*. *gansseri* Zone

p and r: *Contusotruncana fornicate* (Plummer). **p)** umbilical view, **q)** side view, **r)** spiral view. Sample from *G. gansseri* Zone

s and t: *Globotruncanita pettersi* Gandolfi. **s)** Umbilical view, **t)** side view. Sample from *G*. *gansseri* Zone

v: *Globotruncana dupeublei* Caron, Gonzalez, Donoso, Robaszynski and wonders. spiral view. Sample from *G.gansseri* Zone

w and x: *Rugoglobigerina rugosa* (Plummer), **w)** umbilical view, **x)** side view. Sample from *R*. *fructicusa* Zone

Explanation of Fig. (9)

All planktonic foraminifera are from the "reddish to pale brown succession" of Upper Cretaceous (Maastrichtian) of Awagird section, Smaquli area.
Scale bar represents magnification on the specimens.

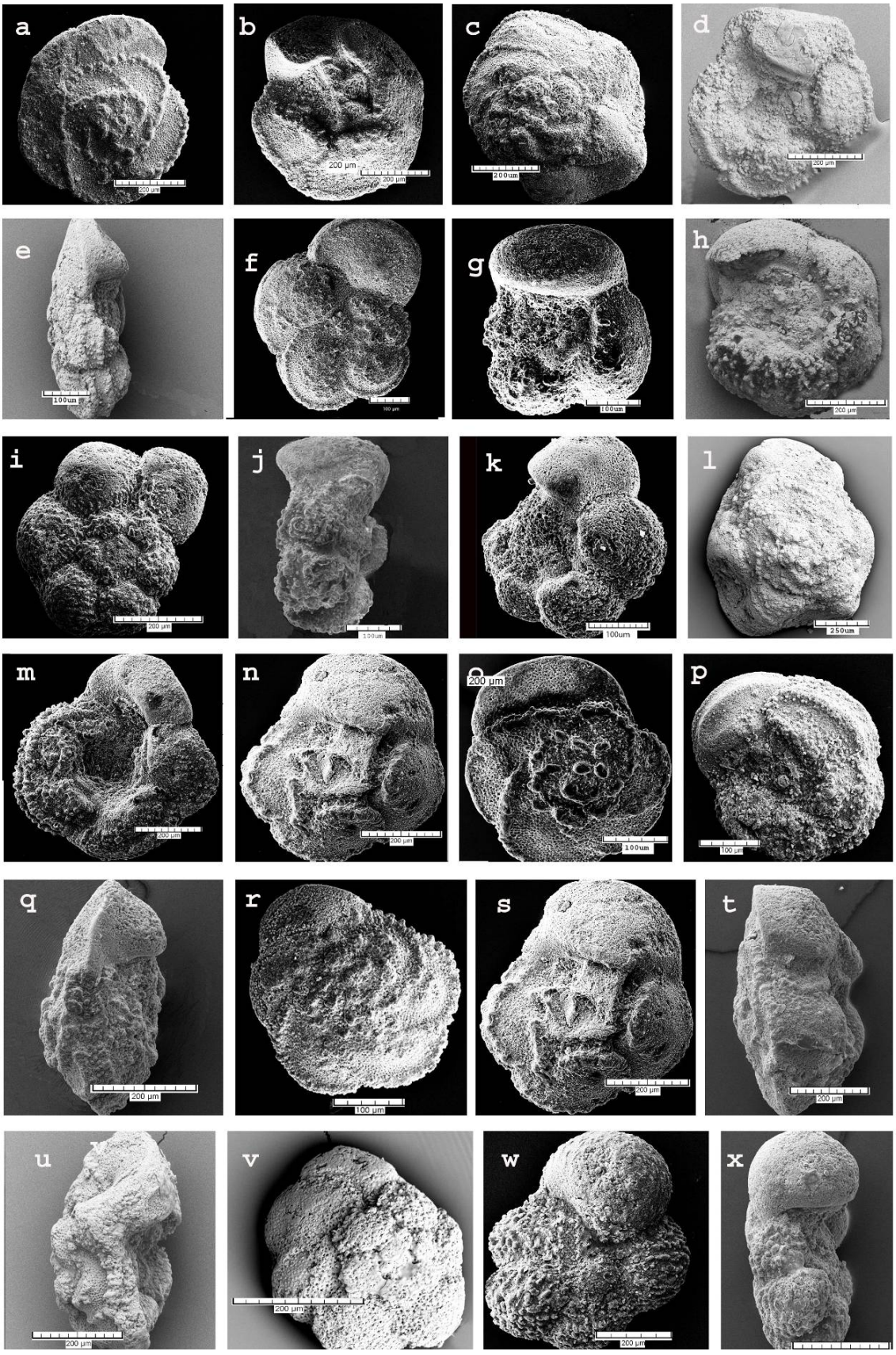

Fig.9

As defined herein, the present biozone (CF6) is correlatable with the zone recorded by Li and Keller (1998a and b); Abramovich *et al*. (2002); Samir (2002) and Sharbazheri (2008), to the lower part of *Rosita contusa* Zone recorded in the Northeast of Iraq (Abawi *et al*., 1982 and Abdel-Kareem, 1986a and b), in Italy Premoli Silva and Sliter (1995 and 1998) and Premoli Silva *et al*. (1998), Abdel-Kareem and Samir (1995) in Egypt**,** and it is correlated with middle part of *Gansserina gansseri* Zone of Al-Mutwali (1996); Hammoudi (2000); Al-Mutwali and Al-Jubouri (2005) and Chacon and Martin (2005) in Iraq, and other different localities of the world Robaszynski *et al.* (1984); Caron (1985); D'Hont and Keller (1991); Maestas *et al*. (2003) and Obaidalla (2005) (Figs.7 and 8).

Magnetochron records of this biozone by Li and Keller (1998a) shows the age estimation of the time span from (69.56 – 69.06) Ma 500 Ky/13m; estimating absolute ages based on magnetochron ages with 38 Ky/m moderate rate of deposition (Fig.7).
Age: late Early Maastrichtian.

- ***Pseudotextularia intermedia* Interval Zone (CF5)**

In the present study *Pseudotextularia intermedia* Zone or CF5 is defied by the LAD of the *Globotruncana linneiana* (d'Orbigny) at the base and the FAD of *Racemiguembelina fructicosa* (Egger) at the top (Fig.10f). Nederbragt (1991) originally introduced this biozone as the interval from the FAD of *Planoglobulina acervulinoides* at the base and the FAD *Racemiguembelina fructicosa* at the top. In the present study, the definition is constrained according to Li and Keller (1998a and b). The interval of this zone is 18 m thick, besides the planktonic foraminiferal species enduring from the underlying biozones; some species show their first appearance, e.g. *Pseudotextularia intermedia* (De Klasz), *Globigerinelloides subcarinata* Bronnimann, and *Gumbelitra cretacea* Cushman.

Due to high similarities of the foraminiferal occurance, the present zone (CF5) is equivalent to that of Li and Keller (1998a and b); Abramovich *et al*. (2002); Samir (2002) and Sharbazheri (2008), it is mostly equivalent to the upper part of *Gansserina gansseri* Zone recorded in the north and northeast of Iraq and different regions of the world (Al-Mutwali and Al-Jubouri, 2005; Al-Mutwali, 1996; Hammoudi, 2000; Caron 1985; Obaidalla, 2005; Robaszynski *et al*., 1984 and D' Hont and Keller, 1991) and it is equivalent to the upper part of *Glt. contusa* Zone of Abawi *et al*. (1920) and Abdel Kareem (1986b) and *Glt. Contuse – R. fructicosa* Zone of Premoli Silva and Sliter (1995 and 1999) and Abdel Kareem and Samir (1995) (Figs.7 and 8).

The *Pseudotextularia intermedia* Zone spans about 0.73 Myr, (69.06 – 68.33) Ma; 730 Ky/18m; estimating absolute age based on magnetochron ages with 40.5 Ky/m of moderate rate of deposition (Fig.7).
Age: late Early Maastrichtian.

- ***Racemiguembelina fructicosa* Interval Zone (CF4)**

Racemiguembelina fructicosa Zone or CF4 is introduced by Li and Keller (1998a and b) as a biostratigraphic interval between FAD of *Racemiguembelina fructicosa* (Egger) at the base and the FAD of *Pseudoguembelina hariaensis* at the top. The FAD of *Racemiguembelina fructicosa* (Egger) in the studied section is recorded from the upper most part of the reddish layers of Shiranish – Tanjero transition unit and covers the basal part of the Tanjero Formation (sample no.33) to the FAD of *Pseudoguembelina hariaensis* Nederbragt within Tanjero Formation (sample no.45) (Fig.10c), attaining a thickness of 18 m.

It is worth mentioning that the zonal scheme of Cretaceous foraminifera (CF) proposed by Li and Keller (1998a and b) replaces the *Abathomphalus mayaroensis* Zone with four zones (*R. fructicosa* Zone, *P. hariaensis* Zone, *P. palpebra* Zone and *P. hantkeninoides* Zone), for

a much improved age estimation at the Late Maastrichtian (Fig.7). The total range zone of *A. mayaroensis* Zone characterizes the Late Maastrichtian in low latitude regions as well as the Tethyan paleogeographic realm. However, it has been found that *A. mayaroensis* is very rare or absent in high latitude regions (Blow, 1979) and in the studied section also, consequently it is more accurate to use the new zonal scheme.

Most of the workers in the zonal scheme placed *Racemiguembelina fructicosa* Zone at the Early – Late Maastrichtian (Keller *et al*., 1995; Li and Keller, 1998a and b; Premoli Silva, 1999; Abramovich *et al*., 2002; Samir, 2002 and Obaidalla, 2005 and Sharbazheri, 2007 and 2008). As defined above, the present biozone (CF4) is correlatable with the lower part of *A. mayaroensis* of Abawi *et al*. (1982); Robaszynski *et al*. (1984); Caron (1985); Abdel-Kareem (1986) and Premoli Silva and Sliter (1995 and 1999) (Fig.7).

This zone covers abundant occurrence of the nominate species along 18 m thick succession. In addition to the index species, *Racemiguembelina fructicosa* (Egger), the planktonic foraminiferal assemblages of this zone include well preserved: *Heterohelix navarroensis* Loeblich, *H. Globulosa* (Ehrenberg), *H. Striata* (Ehrenberg), *H. reussi* (Cushman), *H. nauttalli* (Voorwijk), H. *punctulats* (Cushman), *H. pulchra* (Brotzen), *Planoglobulina carseyae* (Plummer), *P. Brazoensis* Martin *P. Acervulinoides* (Egger), *Rogoglobigerina rugosa* (Plummer), *R. Scotti* (Bronnimann), *R. Hexcamerata* Bronnimann, *R. Macrocephala* Bronnimann, *R. Rotundata* Bronnimann, *R. Milamensis* Smith and Pessa, *Gansserina gansseri* (Reuss), *G. Wiedenmayeri* (Gandolfi), *Globotruncanita stuartiforms* Dalbez, *Globotruncanita conica* White, *Globotruncanita pettersi* Gandolfi, *Globotruncanita angulata* Tilev, *Rugotruncana subcircumnodifer* (Gandolfi), *Globotruncana aegyptica* Nakkady, *Glt. Falsostuarti* Sigal, *Glt. Dupeublei* Caron *et al*., and *Glt. Mariei* Banner and Blow. In the lower part, *Contusotruncana contusa* (Cushman), *C. plicata* White, *Abathomphalus mayaroensis* (Bolli) *Globotruncanella petaloidea* (Gandolfi), *Globotruncanella havanensis* (Voorwuk), *Globotruncanella pschadae* (Keller), *Pseudotextularia elegans* (Rzehak), *Pseudotextularia deformis* (Kikoine), *Pseudotextularia intermidia (De Klasz)*, *Rascemiguembelina powelli* Smith and Pessango, *Pseudoguembelina costulata* (Cushman), *Gublerina cuvillieri* kikoine, *Guembelitria dammula* (Voloshina), *Globigerinelloides voluta* (White), *Globigerinelloides prairiehilleinsis* Pessango, *Globigerinelloides douglasi* Kassab, *Globigerinelloides subcarinata* Bronnimann, *Globigerinelloides escheri* (Ehrenberg), *Archaeoglobigerina carteri* (Kassab), *Hedbergella monmothensis* (Olsson), *Hedbergellaholmdelensis* Olsson and *Gumbelitra cretacea* Cushman.

The age estimation of this biozone by Li and Keller (1998a), records the time span of (68.33 – 68.83) Ma (500 Ky) estimating absolute age based on magnetochron ages with 26.3 Ky/m moderate rate of deposition (Fig.7).

- ***Pseudoguembelina hariaensis* Interval Zone (CF3)**

The *Pseudoguembelina hariaensis* Zone is defined by Li and Killer (1998a) as a partial range of the nominate species between the FAD of *Pseudoguembelina hariaensis* Nederbragt and the last appearance LAD of *Gansserina gansseri* (Bolli). In the studied section, this zone also is marked by the FAD of the nominate species, but the last occurrence of *Gansserina gansseri* (Bolli) was not figured out, therefore the top of CF3 was not recorded herein the studied section. This zone shows reliable abundance of *Pseudoguembelina hariaensis* Nederbragt and other assemblages of planktonic foraminifera, which totally resemble that of the underlying *Racemiguembelina fructicosa* zone (CF4), except for the termination of *Globosotruncana falsostuarti* Sigal, *Globotruncanella havanensis* (Voorwuk) and *Globigerinelloides prairiehilleinsis* Pessango.

Explanations of Fig. (10):

a and b: *Globotruncanita conica* (White). **a)** spiral view, **b)** umbilical view. Sample from *C. contoza* Zone

c: *Racemiguembelina fructicusa* (Egger). Sample from *R. fructicusa* Zone

d: *Racemiguembelina powelli* Smith and Passango. Sample from *R. fructicusa* Zone

e: *Pseudotextularia elegans* (Rzehak**).** Sample from *R. fructicusa* Zone

f : *Pseudotextularia intermedia* (De Klasz). Sample from *P. intermedia* Zone

g and h: *Globotruncanita stuarti*. (De Lapparent). **g)** spiral view, **h)** umbilical view. Sample from *R. fructicusa* Zone

i and j: *Globotruncana orientalis* Elnaggar. **i)** umbilical view. **j)** spiral view. Sample from *P. hariaensis* Zone

k: *Globotruncana arca* (Cushman), side view. Sample from *R. fructicusa* Zone

l: *Globotruncanita angulata* Tilev. umbilical view. Sample from *G. gansseri* Zone

m: *Globigerinelloides volutes* (White). umbilical view. Sample from *G. gansseri* Zone

n and o: *Rugoglobigerina rugosas* (Plummer), **n)** umbilical view, **o)** spiral view. Sample from *R. fructicusa* Zone

p: *Rugoglobigerina milamensis* Smith and Passango, umbilical view. Sample from *R. fructicusa* Zone

q: *Globotruncana mariei* Banner and Blow, umbilical view. Sample from *G. gansseri* Zone

r: *Rugoglobigerina macrocephala Bronnimann,* umbilical view. Sample from *R. fructicusa* Zone

s: *Globotruncana falsostuarti* Sigal, side view. Sample from *R. fructicusa* Zone

t: *Globotruncanella havanensis* (Voorwuk), umbilical view. Sample from *R. fructicusa* Zone

u: *Globotruncanella pateloidia* (Gandolfi), spiral view. Sample from *R. fructicusa* Zone

v: *Pseudotextularia deformis* (Kekoine). Sample from *G. gansseri* Zone

w: *Rugoglobigerina pennyi* (Gandolfi), side view. Sample from *R. fructicusa* Zone

x: *Rugotruncana circumnodifer* (Gandolfi), spiral view. Sample from *R. fructicusa* Zone

Explanation of Fig. (10)

All planktonic foraminifera are from the reddish to pale brown succession of Upper Cretaceous (Maastrichtian) of Awagird section, Smaquli area.
Scale bar represents magnification on the specimens.

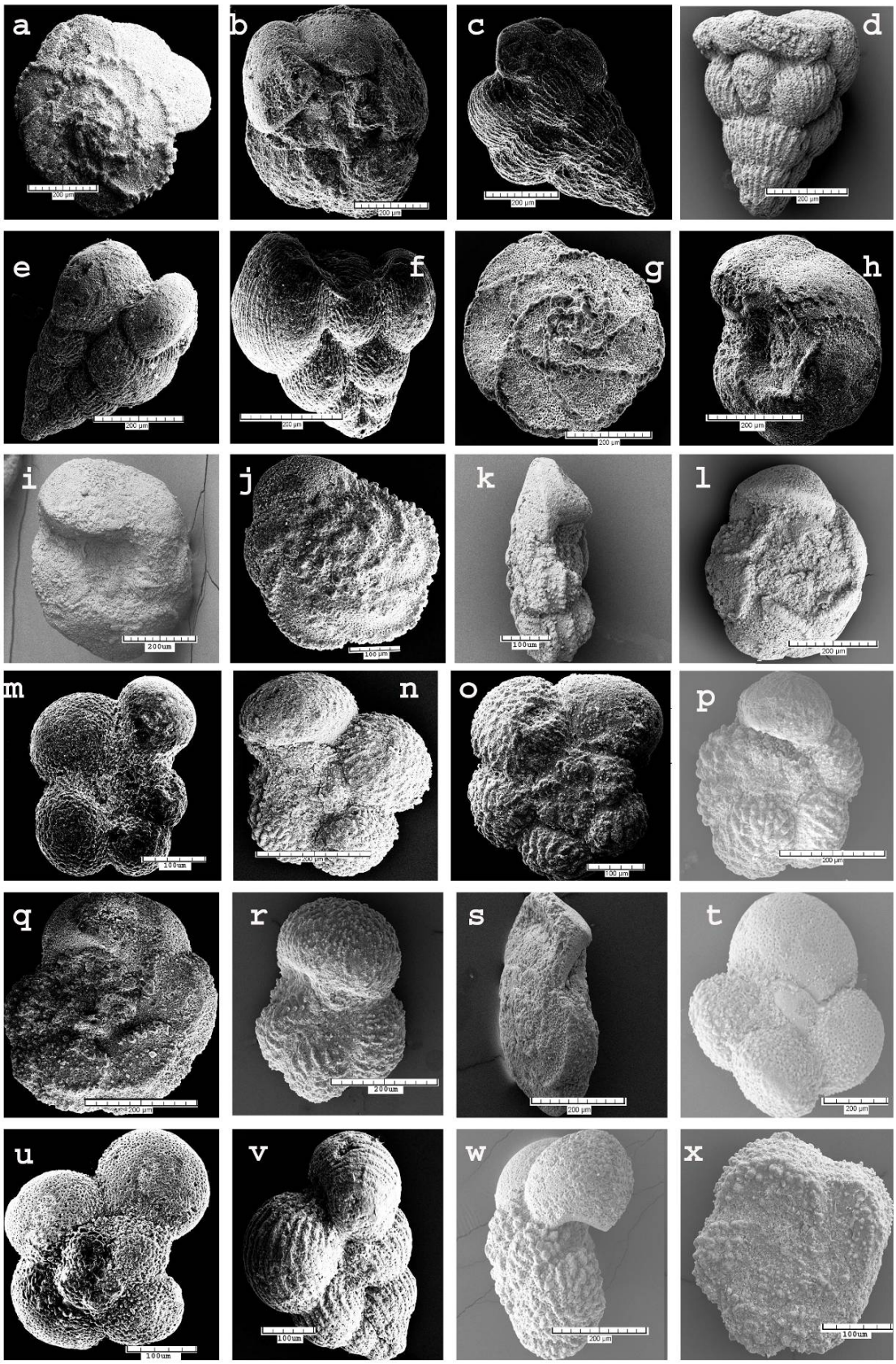

Fig.10

As defined herin, the present biozone (CF3) is correlatable with the zone recorded by Li and Keller (1998a, b); Keller (2002 and 2004); Abramovich *et al*. (2002); Samir (2002); Abramovich and Keller (2003); Obaidalla (2005) and Sharbazheri (2008) and it is correlated with the middle part of *Abathomphalus mayaroensis* Zone recorded in the Northeast of Iraq by Abawi *et al*. (1982) and Abdel Kareem (1986), in Italy Premoli Silva and Sliter (1995 and 1999) and Premoli Silva *et al*. (1998), Abdel Kareem and Samir (1995) in Egypt, and Robaszynski *et al*. (1984) and Caron (1985) (Fig.7).

The age estimation of this biozone by Li and Keller (1998a) is recorded as Middle – Late Maastrichtian, with the time span of (66.8 – 65.45) Ma; estimating absolute ages based on magnetochron ages (Fig.7).

CONCLUSIONS AND RECOMMENDATION

- The duration of the "reddish to pale brown succession" (Shiranish – Tanjero transition unit) of the studied section in the Smaquli area is estimated to be more than 2.150 My.
- Sixty seven planktonic foraminiferal species belonging to nineteen genera have been recorded.
- Six Planktonic Foraminiferal biostratigraphic zones have been detected in the studied section representing *Globotruncana aegyptiaca* Interval Zone (CF8), *Gansserina gansseri* Interval Zone (CF7), *Contusotruncana contusa* Interval Zone (CF6), *Pseudotextularia intermedia* Interval Zone (CF5), *Racemiguembelina fructicosa* Interval Zone (CF4), *Pseudoguembelina hariaensis* Interval Zone (CF3), and they display Late Campanian – Middle – Late Maastrichtian age.
- The planktonic foraminifera occur continuously in the sedimentary succession of the studied section show incessant in sedimentary sequence without any interruption.
- The lateral and vertical relations of the "reddish to pale brown succession" are quite conformable with both underlying Shiranish and overlying Tanjero formations.
- The well exposed "reddish to pale brown succession" (Shiranish – Tanjero transition unit) has special monotonous, conventional lithologic character that differs from the both underlying Shiranish Formation and overlying Tanjero Formation, geographically extends for more than 75 Km and it has mapable thickness, which reaches 72 m in Smaquli Gali Gorge. With relevant feasible geologic age of Early Maastrichtian, about 2 My duration.
- Consequently, the author recommends the name of "Smaquli Formation" as a new formal lithologic unit to display an incipient effort of formation rank according to international stratigraphic nomenclature code.

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