

Upper Cretaceous planktic foraminiferal from the Zagros basin (north-northwest Shiraz), Iran

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Abstract

The litho- and biostratigraphy of Upper Cretaceous (Gurpi Formation) has been investigated within a well-exposed section at the northern limb of Pey zard anticline, Abnow area, Southern Iran. The studied section consists mainly of grey marl, calcareous pyritic shale, and argillaceous limestones. The Formation unconformably overlies Sarvak Formation and the Tarbur Formation overlies it unconformably. The samples of the section under investigation yielded rich and various planktic foraminiferal taxa, where forty planktic species belonging to eighteen genera have been recognized, the detailed foraminiferal investigation permits the recognition of the most standard biozones defined in Mediterranean regions, especially Tethyan domain. Depending on the stratigraphic distribution and relative abundance of planktic foraminiferal faunas, the studied section is subdivided into eleven biozones, which confirm a Campanian- Maastrichtian age of the Gurpi Formation. Biozones 11 (*Globotruncanites elevata* zone), 10 (*Globotruncana ventricosa* zone) and 9 (*Globotruncanites calcarata* zone), 8 (*Globotruncanella havanensis* zone), 7 (*Globotruncana aegyptiaca* zone) represent the Early, Middle and Late Campanian, respectively. Biozone 6 (*Gansserina gansseri* zone) represent Late Campanian- Early Maastrichtian, Biozones 5 (*Contusotruncana contusa/Racemiguembelina fructicosa* zone), 4 (*Abathomphalus mayaroensis* zone), 3 (*Pseudoguembelina hariaensis* zone), 2 (*Pseudoguembelina palpebra* zone), 1 (*Plummerita hantkeninoides* zone) suggest the Early- Late Maastrichtian, respectively.

Keywords: Campanian- Maastrichtian; Foraminifera; Shiraz; Zagros; Iran.

1- Introduction

The Gurpi Formation is one of the best well-known and widespread formations in the Zagros Mountains of northwestern– southeastern Iran. This formation has been variably dated as Santonian to Paleocene. The deposition of the Gurpi Formation has been occurred at a time of broad marine transgression during the Late Cretaceous period. The shales and marls of the Gurpi Formation were deposited in a deep marine environment. In type section, (49°13' 47" E, 32° 26' 50" N) the Gurpi Formation consists of 320 meters of grey to blue marls and shales and sparse thin beds of argillaceous

limestones (James and Wynd, 1965; Setudehnia, 1972; Darvishzadeh, 1992; Motiei, 1993). The Gurpi Formation which underlies the Ilam Formation, overlies unconformably the Pabdeh Formation at the type section.

The Gurpi Formation microfauna has been studied by Jalali (1971); Kalantary (1976); Zahiri (1982) and Kalantary (1992). A biostratigraphic zonation of the formation was established by Wynd (1965) and then discussed by Wynd (1965) and Bolz (1977). A comprehensive study of stratigraphy and

geographical idea about the distribution of the Gurpi Formation is essential to refine its age and depositional setting. Here we study the planktic foraminifera from the Gurpi Formation and establish a biostratigraphic zonation enabling correlation with other standard biozones.

2- Material and methods

The section was studied in detail. Samples were taken from almost every 2 meters. Approximately 120 samples were collected. Hard samples (100) were studied by making thin sections. Eighteen genera and forty species planktic foraminifera containing eleven biozones were identified. The foraminiferal taxonomy and nomenclature followed Leoblich and Tappan (1987); Sliter (1989); Hart *et al.*,

(1989); Longoria and Von Feldt (1991); Premoli Silva and Sliter (1995), and Georgescu (1996) method.

3- Geological setting

The studied area is located 10 km to the northwest of Beyza, which is located 35 km to the northwest of Shiraz (Fig. 1). The fieldwork was concentrated at the southwest flank of Kuh-e-Pey Zard with the coordinates of $52^{\circ} 8' 22''$ E; $30^{\circ} 8' 8''$ N. The thickness of the Gurpi Formation at the southern part of the Kuh-e-Pey Zard anticline is 205.1 meters which consists of grey marl, calcareous pyritic shale, and argillaceous limestones. The Gurpi Formation conformably overlies the Sarvak Formation, and it is overlain by the Tarbur Formation.

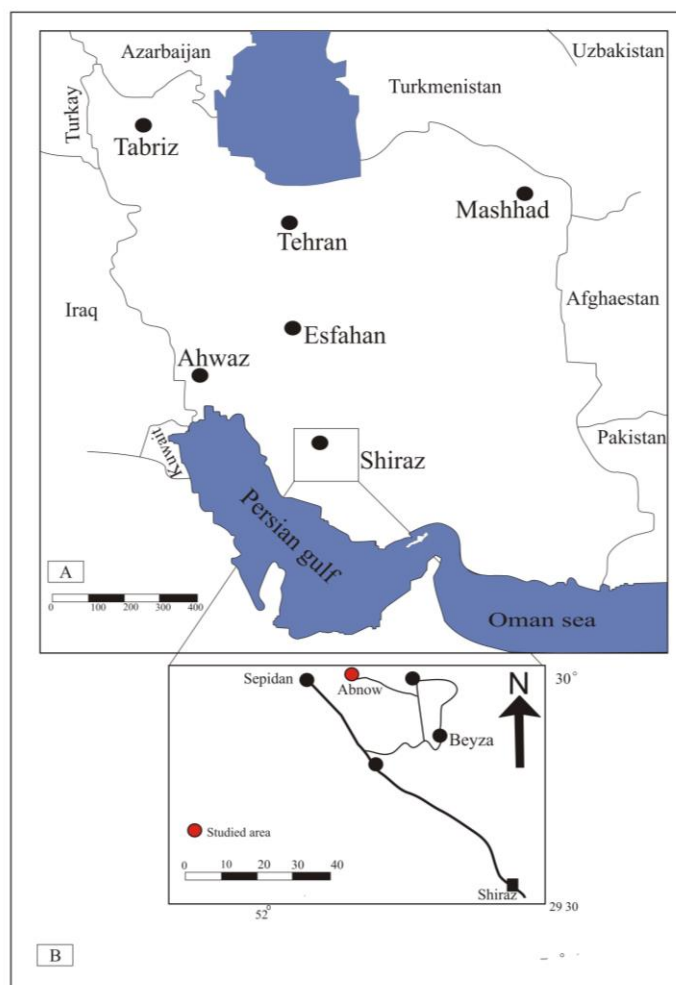


Figure 1A) Geographic map of Iran showing Shiraz situation; B) the location map of the studied area.

4- Biostratigraphy

The samples were taken from an outcrop section which provided abundant and well preserved foraminifera. These included high diversity of Globotruncanids, Rugoglobigerinids, Globigerinelloids and Heterohelicids planktic foraminifera with moderate calcareous and rare agglutinated benthonic foraminifera. The foraminifera occurred continuously in the studied succession, which generally showed continuous sedimentary sequence without any interruptions. Forty planktic foraminiferal species belonging to eighteen genera were recorded (Fig. 2). The planktic foraminifera showed the best indication for typical Tethyan fauna type. They have been used for biozonation of the sediments in tropical/subtropical regions by Li and Keller, 1998; Abramovich *et al.*, 2002; Samir, 2002; Abramovich and Keller, 2003; Keller, 2004; Obaidalla, 2005, Sharbazheri, 2007, 2008, 2010 and Farouk *et al.*, 2014, 2017. These studies have been used exclusively as the biostratigraphic framework in the present work. Li and Keller (1998) subdivided the Maastrichtian zonal scheme into eleven Cretaceous Foraminiferal (CF) zones labeled CF11 to CF1, from the base to the top. The biostratigraphic correlation of the studied section was based on planktic foraminiferal zonations (Fig. 3) which showed a correlation between the biostratigraphic zones established in this study with other equivalent areas of the commonly used planktic zonal scheme.

5- Biozones description

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

***Globotruncanita elevata* Zone (CF11)**

Author: Dalbiez (1955)

Definition: The partial range zone from the last appearance of *Globotruncanita elevata* to the first appearance of *Globotruncana ventricosa* White.

Characteristics: Within this zone numerous representatives of the genus *Globotruncana* (or *G.*): *G. lapparenti*, *G. linneiana*, *G. arca* (Cushman) and *G. bulloides* Vogler (Figs. 4a,b) are present. *Rosita fornicata*, *Globotruncanita stuartiformis* (Dalbiez) and *Rugoglobigerina rugosa* (Plummer) are also present.

Remarks: The first appearance of *Rugoglobigerina rugosa* occurs within this zone.

Age: Early Campanian. This zone was recorded from W. Tethys (Wynd, 1965), Central Tethys (Sigal, 1977), Caribbean (Grandstein *et al.*, 1978), E. Tethys (Drushtchitz *et al.*, 1979), Central Tethys (Fleury, 1980), W. Tethys (Zahiri, 1982) and Iran (Vaziri Moghaddam, 2002) from the Early Campanian.

Thickness: 76 m represented by Samples 1–16.

Correlation and Age Determination: The zone is cosmopolitan. The taxonomical composition is the same like in the zones described by Wonders (1980); Salaj (1980); Robaszynski *et al.*, (1984); Caron (1985); Abdel-Kireem *et al.*, (1995); Salaj (1997); Premo- Silva, Verga (2004), limited the range of the zone in the Lowermost Campanian only.

***Globotruncana ventricosa* Zone (CF10)**

Author: Dalbiez (1955)

Definition: The interval zone from the first appearance of *Globotruncana ventricosa* to the first appearance of *Globotruncanita calcarata* (Cushman).

Characteristics: *Globotruncana lapparenti*, *G. linneiana*, *G. arca*, *G. bulloides*, *Rosita fomicata*, *Globotruncanita elevata* (Brotzen) (Fig. 4c), *Globotruncanita stuartiformis* are the most common taxa in this zone.

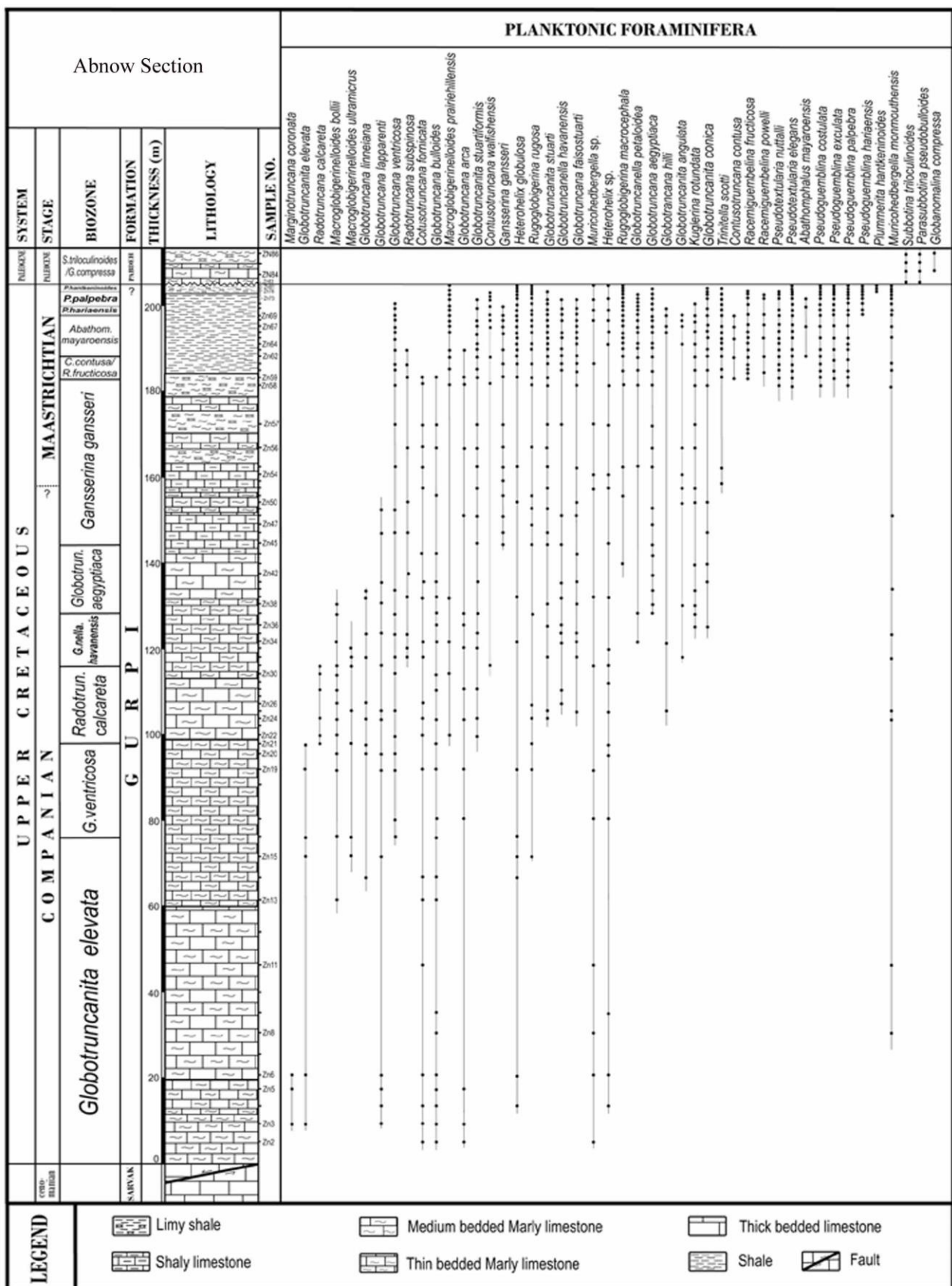


Figure 2) Stratigraphic range chart of planktic foraminifera of the Gurpi Formation, Abnow area.

	Barr (1972)	Caron (1978)	Sliter (1989)	Farouk et. al., (2017)	James and Wynd (1965)	Vazirimoghaddam	This study	
	Central Tethys	Tethys	Tethys	Iraq	Zagros	Sarvestan area	Abnow area	
65 Maastrichtian	<i>Abathomphalus mayaroensis</i>	<i>Abathomphalus mayaroensis</i>	<i>Abathomphalus mayaroensis</i>	<i>R. Hantkeninoides</i> (CF1)	<i>Abathomphalus mayaroensis</i>	-----	<i>Plummerita hantkeninoides</i>	
				<i>A. Mayaroensis</i> (CF3-CF2)			<i>Pseudoguembolina palpebra</i>	
				Hiatus			<i>Pseudoguembolina hariaensis</i>	
	<i>Gansserina gansseri</i>	<i>Gansserina gansseri</i>	<i>Gansserina gansseri</i>	<i>Pseudotextularia intermedia</i> (CF5)	<i>Globotruncana stuarti</i> + <i>Pseudotextularia various</i>	<i>Gansserina gansseri</i>	<i>Abathomphalus mayaroensis</i>	
				<i>R. Powellii</i> (CF6)			<i>Contusotruncana contusa</i> & <i>Racemiguembelia fruticosan</i>	
				<i>Gansserina gansseri</i> (CF7)			<i>Gansserina gansseri</i>	
<i>Globotruncanites stuarti</i> + <i>Globotruncana falsostuarti</i>	<i>Globotruncana aegyptiaca</i>	<i>Globotruncana aegyptiaca</i>	<i>R. Hexacamerata</i> (CF8b)	<i>Globotruncana stuarti</i>				
<i>Globotruncanella havaensis</i>	<i>Globotruncanella havaensis</i>							
70 Maastrichtian	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncana aegyptiaca</i> (CF8)	<i>Globotruncana elevata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncana aegyptiaca</i>	
							<i>Globotruncanella havaensis</i>	
	<i>Globotruncanites elevata</i> + <i>Globotruncanites stuaniformis</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncana elevata</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanella havaensis</i>	
		<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>				<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>
	78 Campanian	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncana aegyptiaca</i> (CF8)	<i>Globotruncana elevata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>
<i>Globotruncanites elevata</i> + <i>Globotruncanites stuaniformis</i>		<i>Globotruncana ventricosa</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncana elevata</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	
		<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>				<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>
<i>Globotruncanites calcarata</i>		<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncana aegyptiaca</i> (CF8)	<i>Globotruncana elevata</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>	
								<i>Globotruncanella havaensis</i>
<i>Globotruncanites elevata</i> + <i>Globotruncanites stuaniformis</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncana elevata</i>	<i>Globotruncana ventricosa</i>	<i>Globotruncanites calcarata</i>	<i>Globotruncanites calcarata</i>		
	<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>				<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>	<i>Globotruncanites stuaniformis</i>

Figure 3) Correlation chart showing the proposed biostratigraphic zones of Abnow section with the Planktic foraminiferal zonation commonly used in Iran.

Age: Middle to early Late Campanian.

Thickness: 21. 8 m represented by Samples 16-21.

Correlation and Age Determination: This zone was recorded from W. Tethys (Wynd , 1965; Zahiri, 1982) and Iran (Vaziri Moghaddam, 2002) from the Middle to early Late Campanian.

***Rudotruncana* (*Globotruncanites*) *calcareta* Zone (CF9)**

Author: Herm (1962)

Definition: The total range zone of *Globotruncanites calcareta* is defined as the interval from the first appearance datum (FAD) to the last appearance datum (LAD) of the nominate taxon.

Characteristics: The dominant taxa in this zone are: *Globotruncana lapparenti*, *G. fornicate*

(Fig. 4d), *G. area* (Fig. 4e), *G. linneiana* (Figs. 4f-g), *G. bulloides*, *G. ventricosa* (Fig. 4h), *G. falsostuarti*, *Globotruncanites stuarti*, *Globotruncanites stuartiformis*, *Globotruncanites elevate*, *Macrolobigerinelloides bollii* (Fig. 5a) *Globotruncanites calcareta* (Fig. 5b) and *Rugoglobigerina rugosa*.

Remarks: This zone contains the first appearance of *Globotruncanites stuarti* and *Globotruncana falsostuarti*. The last appearance of *Globotruncanites elevate* is recorded from the top of the zone.

Age: early Late Campanian. This zone was introduced from W. Tethys (Wynd, 1965), Atlantic realm (Premoli-Silva and Bolli 1973), W. Pacific (McNulty, 1976), Central Tethys (Sigal, 1977), Central Tethys (Fleury, 1980), W. Pacific (Silva *et al.*, 1981), W Tethys (Zahiri, 1982), and Iran (Vaziri Moghaddam, 2002) all from the Late Campanian.

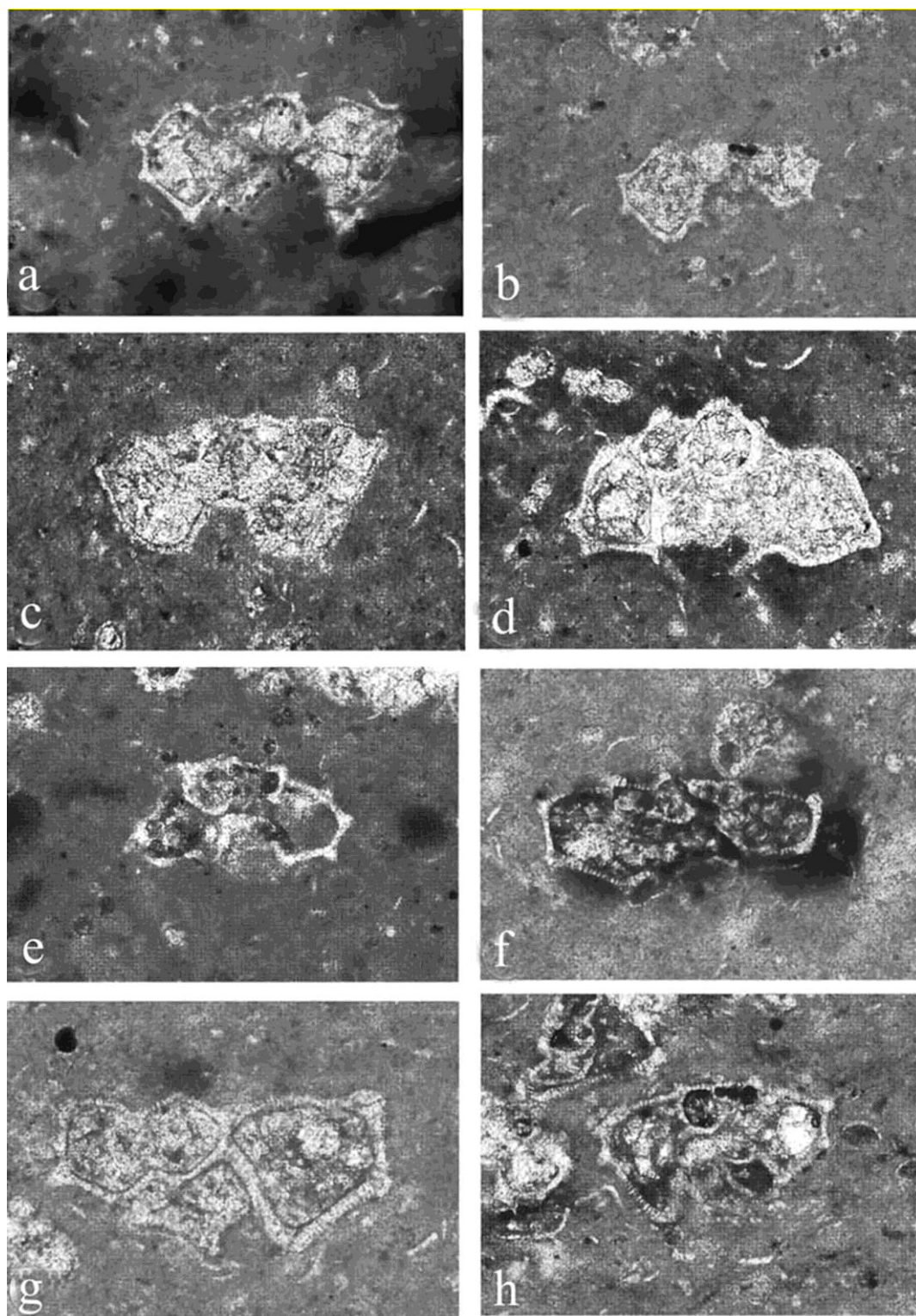


Figure 4) Planktic foraminifera observed in the Abnow (or Ab) area. (a) *Globotruncana bulloides* (Vogler, 1941), Sample no. Ab 3, Axial section, $\times 200$. (b) *Globotruncana bulloides* (Vogler, 1941), Sample no. Ab 5, Axial section, $\times 100$. (c) *Globotruncanita elevata* (Brotzen, 1934), Sample no. Ab 15, Axial section, $\times 200$. (d) *Contusotruncana fornicata* (Plummer, 1931), Sample no. Ab 30, Axial section, $\times 200$. (e) *Globotruncana arca* (Cushman, 1926), Sample no. Ab 28, Axial section, $\times 100$. (f) *Globotruncana linneiana* (d'Orbigny, 1839), Sample no. Ab 22, Axial section, $\times 200$. (g) *Globotruncana linneiana* (d'Orbigny, 1839), Sample no. Ab 24, Axial section, $\times 200$. (h) *Globotruncana ventricosa* (White, 1928), Sample no. Ab 23, Axial section, $\times 100$.

Thickness: 18. 3 m represented by Samples 21–30.

Correlation and Age Determination: The extinction of *Globotruncanita calcareta* is regarded one of the most important indicators, which has been used to delineate the Campanian–Maastrichtian boundary (Robaszynski *et al.*, 1984; Caron, 1985; and Sliter, 1989). However, Robaszynski and Caron (1995) in Sari (2006) noted that the *Globotruncanita calcareta* disappeared before the base of *Nostoeeras* (*Nostoeeras*) *hyatti* Zone (ammonite zone dating the uppermost Campanian), so the *Globotruncanita calcareta* Zone might be a little older. As noted by Premoli Silva and Sliter (1995) in Sari (2006), the Campanian–Maastrichtian boundary was equated to the Chron 32 N/Chron 31 R boundary and shifted to 71. 3 Ma by Lommerzheim and Hambach (1992) in Sari (2006), that means the *Globotruncanita calcareta* Zone does not correspond to the uppermost part of the Campanian. Furthermore, the *Globotruncanella havanensis* and *Globotruncana aegyptiaca* Zones and even the lower part of the *Gansserina gansseri* Zone, are all of late Campanian age (Sari, 2006).

The present study showed that the *Globotruncanita calcareta* Zone was equivalent to the *Globotruncana calcarata* Zone of Postuma (1971); Caron (1985); Sliter (1989) (in Circum Pacific) and Mogaddam (2002), which corresponds to latest Campanian age. The zone is also correlated to the *Globotruncanita calcareta* of Li *et al.*, (1999); Gradstein *et al.*, (2004) and Chacon and Chivelet (2005) (in Spain) which support early late Campanian, and it is also equivalent to *Radotruncana calcareta* Zone that described by (Sari, 2006), which dating the same age of this zone.

***Globotruncanella havanensis* Zone (CF8)**

Author: Voorwijk (1937)

Definition: The interval from the last occurrence of *Globotruncanita calcareta* and its upper boundary was defined by the first occurrence of *Globotruncana aegyptiaca*.

Characteristics: *Hedbergella monmouthensis*, *H. sliteri*, *Globotruncanella havanensis*, *Archaeoglobigerina australis*, *A. mateota*, and *Rugotruncana circumnodifer*.

Age: Late Campanian.

Thickness: 12. 1 m represented by Samples 30–37.

Correlation and Age Determination: The present biozone is equivalent to the lower part of the *Globotruncana stuartiformis* Zone of Postuma (1971), to the *Globotruncanella havanensis* Zone of Caron (1985) and Sliter (1989), which are considered to be early Maastrichtian in age, and to the *Globotruncanella subcarinatus* (CF9) Zone, which is described from middle late Campanian deposits by Li *et al.*, (1999). The present biozone is also correlated with the lower part of the *Globotruncanita stuarti* Zone recorded in Iran by Mogaddam (2002), and with the *Globotruncanella havanensis* Zone of Gradstein *et al.*, (2004), which correspond to the suggested age of the present biozone, and is equivalent to the *Globotruncana falsostuarti* Zone recorded in Spain and Turkey by Chacon and Chivelet (2005) and Sari (2006), respectively.

***Globotruncana aegyptiaca* Zone (CF7)**

Definition: The interval zone from the last occurrence of *Globotruncana aegyptiaca* to the first appearance of *Gansserina gansseri* (Bolli).

Characteristics: The dominant taxa in this zone are *Rugoglobigerina macrocephala*, *Radotruncana subspinosa* (Figs. 5c–d), *Globotruncanita conica*, *Contusotruncana walfishensis*, *Globotruncanita angulata* (Figs. 5e–f), *Globotruncanella petaloidea*, *Globotruncanella havanensis*, *Globotruncana*

hilli, *Rugoglobigerina rugosa*, and *Muricohedbergella monmouthensis*.

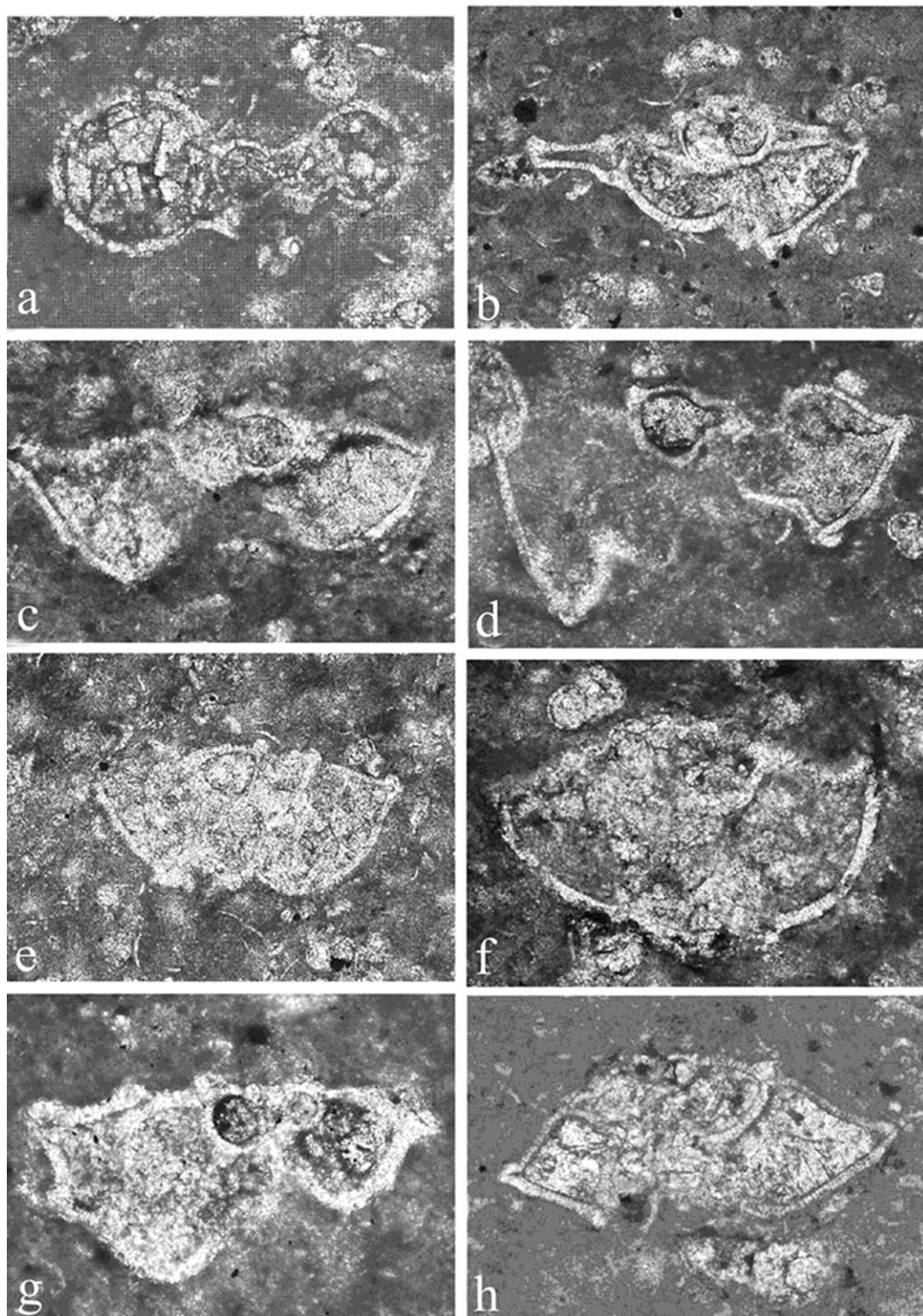


Figure 5) Planktic foraminifera observed in the Abnow area. (a) *Macroglobigerinelloides bollii* (Pessagno, 1967), Sample no. Ab 27, Axial section, $\times 200$. (b) *Radotruncana calcareta* (Cushman, 1927), Sample no. Ab 22, Axial section, $\times 200$. (c) *Radotruncana subspinoso* (Pessagno, 1967), Sample no. Ab 39, Axial section, $\times 200$. (d) *Radotruncana subspinoso* (Pessagno, 1967), Sample no. Ab 44, Axial section, $\times 200$. (e) *Globotruncanita angulata* (Tilev, 1951), Sample no. Ab 38, Axial section, $\times 100$. (f) *Globotruncanita angulata* (Tilev, 1951), Sample no. Ab 45, Axial section, $\times 200$. (g) *Globotruncana aegyptiaca* (Nakkady, 1950), Sample no. Ab 60, Axial section, $\times 200$. (h) *Globotruncana falsostuarti* (Sigal, 1952), Sample no. Ab 71, Axial section, $\times 200$.

Age: Late Campanian.

Thickness: 15. 8 m represented by Samples 37-45.

Correlation and Age Determination: The present zone is equivalent to the upper part of *Globotruncana stuartiformis* Zone of Postuma (1971) and to the *Globotruncana aegyptiaca* Zone of Caron (1985) and Sliter (1989). It is equivalent to the *Globotruncana aegyptiaca* (CF8a) Zone and the *Rugoglobigerina hexaeamerata* (CF8b) Zone of (Li *et al.*, 1999), which are considered to be of Latest Campanian-Early Maastrichtian age. This zone is equivalent to the *Globotruncana aegyptiaca* Zone of Gradstein *et al.*, (2004), which supports the same age of this zone.

***Gansserina gansseri* Zone (CF6)**

Definition: Interval zone from the first appearance of *Gansserina gansseri* (Bolli), whereas its upper boundary, in the studied area, is indicated by the first appearance of *Contusotruncana contusa*. (Cushman).

Characteristics: The dominant taxa in this biozone are: *Globotruncana linneiana*, *Globotruncana falsostuarti*, *Globotruncanella stuarti* and *Globotruncanella stuartiformis*.

Age: Late Campanian- Early Maastrichtian. This biozone was recorded from Central Tethys (Barr, 1972), Tethys (Caron, 1978; Sliter, 1989) and Iran (Vaziri Moghaddam, 2002) from the Middle-Upper Maastrichtian

Thickness: 36. 6 m represented by Samples 45-59.

Correlation and Age Determination: The present zone is equivalent to the lower part of *Gansserina gansseri* Zone of (Postuma, 1971); (Robaszynski *et al.*, 1984); (Caron, 1985); (Sliter, 1989); (Mogaddam, 2002). The present zone is equivalent to the *Gansserina gansseri* Zone (CF7) of (Li *et al.*, 1999); (Gradstein *et al.*, 2004) which they considered it of Late Campanian - Early Maastrichtian age.

***Contusotruncana contusa* / *Racemiguembelina fruticosa* Zone (CF5)**

Definition: The interval zone from the first appearance of the zonal markers to the first appearance of *Abathomphalus mayaroensis*. The lower boundary of this short zone was identified by the presence of the first of the two markers only, whereas the second marker appears just prior to the end of the zone. *Contusotruncana plummerae* and *Heterohelix rajagopalani* disappear at the end of the zone.

The presence of *C. contusa* and *R. fruticosa* also indicates a Late Maastrichtian age. The coexistence of the two species suggests the presence of the *C. contusa*-*R. fruticosa* zone (Premoli Silva and Bolli, 1973; Premoli Silva and Sliter, 1994; Premoli Silva and Sliter, 1999; Premoli Silva and Verga, 2004), which corresponds to the lowermost part of the Late Maastrichtian.

Characteristics: *Pseudoguembelina costulata*, *Pseudoguembelina exculata*, *Pseudoguembelina palpebra*, *Racemiguembelina powelli*, *Kuglerina rotundata*, *Rugoglobigerina macrocephala*, *Globotruncana aegyptiaca* (Fig. 5g), *Gansserina gansseri*, *Globotruncana angulata*, *Globotruncanella conica*, *Globotruncana hilli*, *Globotruncanella havanensis*, *Rugoglobigerina rugosa* are the most common taxa in this zone.

Age: Early- Late Maastrichtian

Thickness: 5.2 m represented by Sample 17-20.

Correlation and Age Determination: This zone is correlated with *Contusotruncana contusa* (CF6) Zone of (Li *et al.*, 1999) and (Darvishzad and Abdolalipour, 2008) of Early Maastrichtian age, it is equivalent to the lower part of *Contusotruncana contusa* Zone of (Dimitrova and Valcher, 2007) and *Contusotruncana contusa* Zone of (Rostami *et al.*, 2009) which considered it of Early Maastrichtian age.

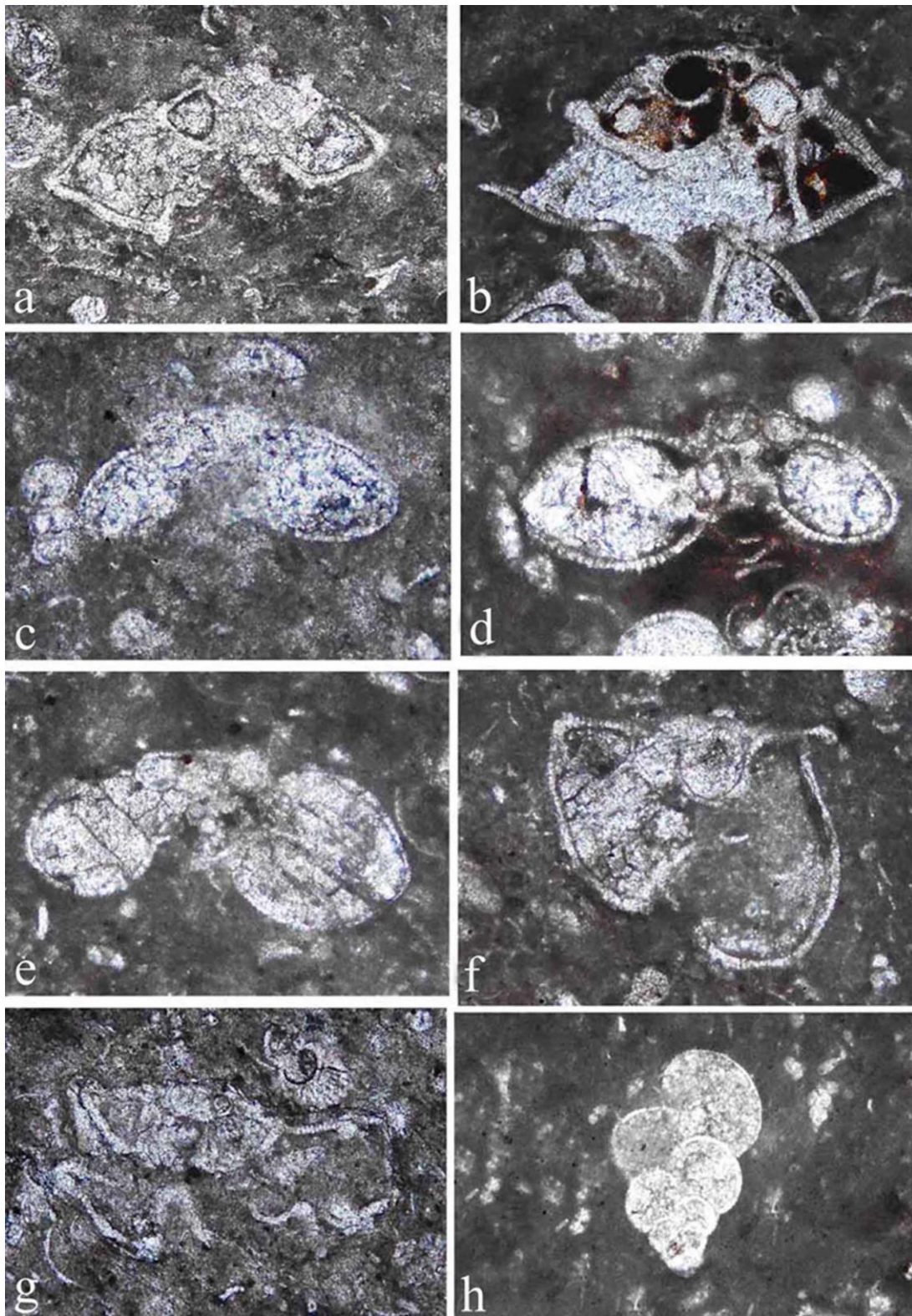


Figure 6) Planktic foraminifera observed in the Abnow area. (a) *Globotruncana falsostuarti* (Sigal, 1952), Sample no. Ab73, Axial section, $\times 100$. (b) *Globotruncanita conica* (White, 1928), Sample no. Ab 71, Axial section, $\times 200$. (c) *Globotruncanella havanensis* (Voorwijk, 1937), Sample no. Ab 72, Axial section, $\times 100$. (d) *Globotruncanella petaloidea* (Gandolfi, 1955), Sample no. Ab 73, Axial section, $\times 200$. (e) *Globotruncanella petaloidea* (Gandolfi, 1955), Sample no. Ab 70, Axial section, $\times 200$. (f) *Gansserina gansseri* (Bolli, 1951), Sample no. Ab 71, Axial section, $\times 200$. (g) *Abathomphalus mayaroensis* (Bolli, 1951), Sample no. Ab 74, Axial section, $\times 200$. (h) *Heterohelix globulosa* (Ehrenberg, 1840), Sample no. Ab79, Axial section, $\times 100$.

***Abathomphalus mayaroensis* Zone (CF4)**

Definition: Brönnimann (1952) originally defined this zone on the total range of *A. mayaroensis*. The upper and lower boundaries were drawn with the first and last occurrences of the nominate taxon.

Characteristics: *Gublerina robusta*, *Hedbergella sliteri*, *Globotruncanella petaloidea*, *Rugotruncana circumnodifer*, and *Abathomphalus intermedius*.

Age: Late Maestrichtian.

Thickness: 9.8 m that represented by Samples 62–70.

Correlation and Age Determination: The zone is cosmopolitan. It could be correlated to the zones of the same range of Barr (1972); Premoli Silva and Bolli (1973); Sigal (1977); Wonders (1980); Robaszynski *et al.*, (1984); Caron (1985), and the upper part of the zones of Vaptzarova (1976) and Premoli Silva, Verga (2004).

***Pseudoguembelina hariaensis* Zone (CF3):**

Definition: This zone was originally defined by Li and Keller (1998), the Interval zone which represented by the stratigraphic range of the index species *Pseudoguembelina hariaensis* Nederbragt between its first appearance and the last appearance of *Gansserina gansseri* (Bolli).

Characteristics: *Abathomphalus mayaroensis*, *Racemiguembelina fructicosa*, *Pseudotextularia elegans*, *Pseudotextularia nuttalli*, *Pseudoguembelina costulata*, *Pseudoguembelina exculata*, *Heterohelix globulosa*, *Trinitella scotti*, *Rugoglobigerina macrocephala*, *Gansserina gansseri*, *Kuglerina rotundata*, *Globotruncanella stuartiformis*, *Rugoglobigerina rugosa*, *Macroglobigerinellodes prairiehillensis*, *Muricohedbergella monmouthensis*, *Globotruncana hilli*. are the most common taxa in this zone.

Age: Late Maestrichtian.

Thickness: 2.2 m represented by Samples 70–71.

Correlation and Age Determination: The present zone is equivalent to the *Pseudoguembelina hariaensis* Zone which described by Li *et al.* (1999), Arenillas *et al.* (2006) and Darvishzad *et al.* (2007), who considered it to be of middle Late Maestrichtian age.

***Pseudoguembelina palpebra* Zone (CF2):**

Definition: This zone was defined by Li and Keller (1998), it represented the partial range of *Pseudoguembelina palpebra* Brönnimann and Brown between the last appearance of *Gansserina gansseri* (Bolli) and the first appearance of *Plummerita hantkeninoides* (Brönnimann).

Characteristics: *Globotruncana ventricosa*, *Globotruncana falsostuarti* (Figs. 5h, and 6a), *Globotruncanella stuarti*, *Abathomphalus mayaroensis*, *Globotruncanella conica* (Fig. 6b), *Contusotruncana walfishensis*, *Racemiguembelina fructicosa*, *Globotruncanella havanensis* (Fig. 6c), *Racemiguembelina powelli*, *Pseudotextularia nuttalli*, *Globotruncanella petaloidea* (Figs. 6d–e), *Rugoglobigerina rugosa*, *Abathomphalus mayaroensis* (Fig. 6g), *Rugoglobigerina macrocephala*.

Age: Late Maestrichtian.

Thickness: 5.3 m that represented by Samples 71–75.

Correlation and Age Determination: The present zone is equivalent to the *Pseudoguembelina palpebra* Zone of Li *et al.*, (1999); Darvishzad *et al.* (2007) which they considered it of Late Maestrichtian age.

***Plummerita hantkeninoides* Zone (CF1)**

Definition: The total range zone from the first appearance of *Plummerita hantkeninoides* (Brönnimann), while its upper boundary is

marked by last appearance of the nominate taxon.

Characteristics: *Pseudoguemblina hariaensis*, *Pseudoguemblina palpebra*, *Pseudoguemblina costulata*, *Pseudoguemblina exculata*, *Heterohelix globulosa* (Fig. 6h), *Trinitella scotti*, *Globotruncana aegyptiaca*, *Globotruncanita conica*, *Pseudotextularia elegans*, *Rugoglobigerina macrocephala*, *Rugoglobigerina rugosa*, *Macroglobigerinellodes prairiehillensis*, *Muricohedbergella monmouthensis*.

Age: Latest Maastrichtian.

Thickness: 1. 7 m represented by Samples 75–82.

Correlation and Age Determination: *Plummerita hantkenincides* is easily identified within the uppermost part of Late Maastrichtian, the range of this excellent marker species spans the youngest 300 kyr of the Maastrichtian below the Cretaceous / paleogene boundary (Keller *et al.*, 2002). The present zone is equivalent to the *Plummerita hantkeninoides* Zone (CF1) which described by Li *et al.*, 1999 and Darvishzad *et al.*, (2007), they considered it of Latest Maastrichtian age, this zone is also correlated with the upper part of *Abathomphalus mayaroensis* Zone of (Robaszynski *et al.*, 1984); (Caron, 1985); (Premoli Silva *et al.*, 1998); (Chacon *et al.*, 2005) of Late Maastrichtian age.

6- Conclusion

Planktic foraminiferal investigation of the Upper Cretaceous Gurpi Formation in Abnow area southwestern Iran yielded forty species that belonged to eighteen genera. According to their stratigraphic range, the formation was divided into eleven zones. The distribution of faunal sequence and the correlation between these zones and other zonal schemes in and outside Iran reveals the Early, Middle and Late Campanian, age for the first five zones (CF11–

CF7) and Late Campanian - Early Maastrichtian for the sixth zone (CF6), whereas the remaining five biozones (CF5– CF1) extended from Early - Late Maastrichtian.

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