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Microbiostratigraphy and Sequencestratigraphy of the Gurpi Formation in central part of Lorestan zone, SW Iran

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Abstract

Gurpi Formations is well distributed along Zagros Foreland Basin particularly in the north west of the Zagros (Lurestan Province). For Microbiostratigraphy and Paleobathymetric studies of the Gurpi Formation in the central part of Lurestan two stratigraphic sections including Soltan and Amiran sections were selected. In this study, 48 foraminiferal species belonging to 25 genera were identified, and 7 biozones were recognized; *Globotruncanita elevata* Taxon Range Zone, *Globotruncana ventricosa* Interval Zone, *Radotruncana calcarata* Taxon Range Zone, *Globotruncanella havanensis* Partial Range Zone, *Globotruncana aegyptiaca* Interval Zone, *Gansserina gansseri* Interval Zone, *Contusotruncana contusa* Interval Zone. Planktonic foraminiferal morphology was studied in order to assign paleobathymetry and the sequences stratigraphic course of the Gurpi Formation. Three third-order sequences were identified, on the basis of deepening and shallowing patterns in the morphological changes and the distribution of the Gurpi Formation planktonic foraminifers and planktic/benthic (P/B).

Keywords: *Lurestan, Gurpi Formation, Planktic foraminifera, Paleobathymetry*

1. Introduction

The unit previously called the "Dezak marl" or "*Globigerina* marl" is now divided into the Gurpi and the Pabdeh Formations (Motei 1992). The type section of the Gurpi Formation, measured in the Tange-Pabdeh out crop, north of Lali oil field in Dezful Embayment zone, by James and wynd (1965) is about 320 m thick and consists of marl and shale. The Gurpi Formation was deposited across the elongated Zagros foreland basin and constitutes the source rock for petroleum in the oil-rich southwest Iran. Based on biostratigraphic data, the Gurpi Formation is Santonian-Late Maastrichtian in age in Fars and Khuzestan zones, whereas it was deposited in Santonian-Early Paleocene in Lurestan zone James and Wynd (1965). The main purpose of this research was to identify a biostratigraphic zonation of Gurpi Formation in central part of Lurestan zone and to investigate the relationship between widespread morphological changes in planktonic foraminifera and sea level changes.

2. Geological setting

The Zagros foreland basin, as a part of the Alpine-Himalayan mountain chain, extends for about 2000 km in a NW-SE direction from the East Anatolian fault of eastern Turkey to the Oman line in southern Iran (Alavi 2004). The Gurpi Formation consists of two members: The Emam Hassan member and Lopha limestone Member. The Emam Hassan Member occurs in the middle portion of the Lorestan Zone and is composed of deep marine limestone. The Lopha limestone Member is located in the south western (SW) of the Lorestan Zone and along the Kabir Kuh anticline.Lithologically, it consists of limestones and marls.

Based on the sedimentary sequence, structural setting and intensity of deFormation, the Zagros has been subdivided into Six continental For micropalaeontological and biostratigraphic study of the Gurpi Formation two stratigraphic sections Amiran and Soltan were studied. The study sections are located 50 and 80 km from the south of Khorram Abad city, respectively (Fig 1). In these areas, the Gurpi Formation uncomfortably overlies the Ilam Formation and is overlain by a sharp boundary with the Amiran Formation (Fig 2).

3. Material and Methods

Two stratigraphical sections of the Gurpi Formation were measured bed by bed, and sampled in two areas in the central part of Lurestan zone (northwest flank of Soltan anticline, 270 m; north flank of Amiran anticline, 275 m thick). A number of 320 specimens were examined to investigate the Campanian - Masstrichtian successions at this two sections. Sampling intervals were generally between 1/5 and 2 m. the number of 18 and 25 specimens of the Ilam Formation and Amiran Formation were examined. The selection of samples was primarily based on changes in colour, lithology, and other sedimentary parameters.

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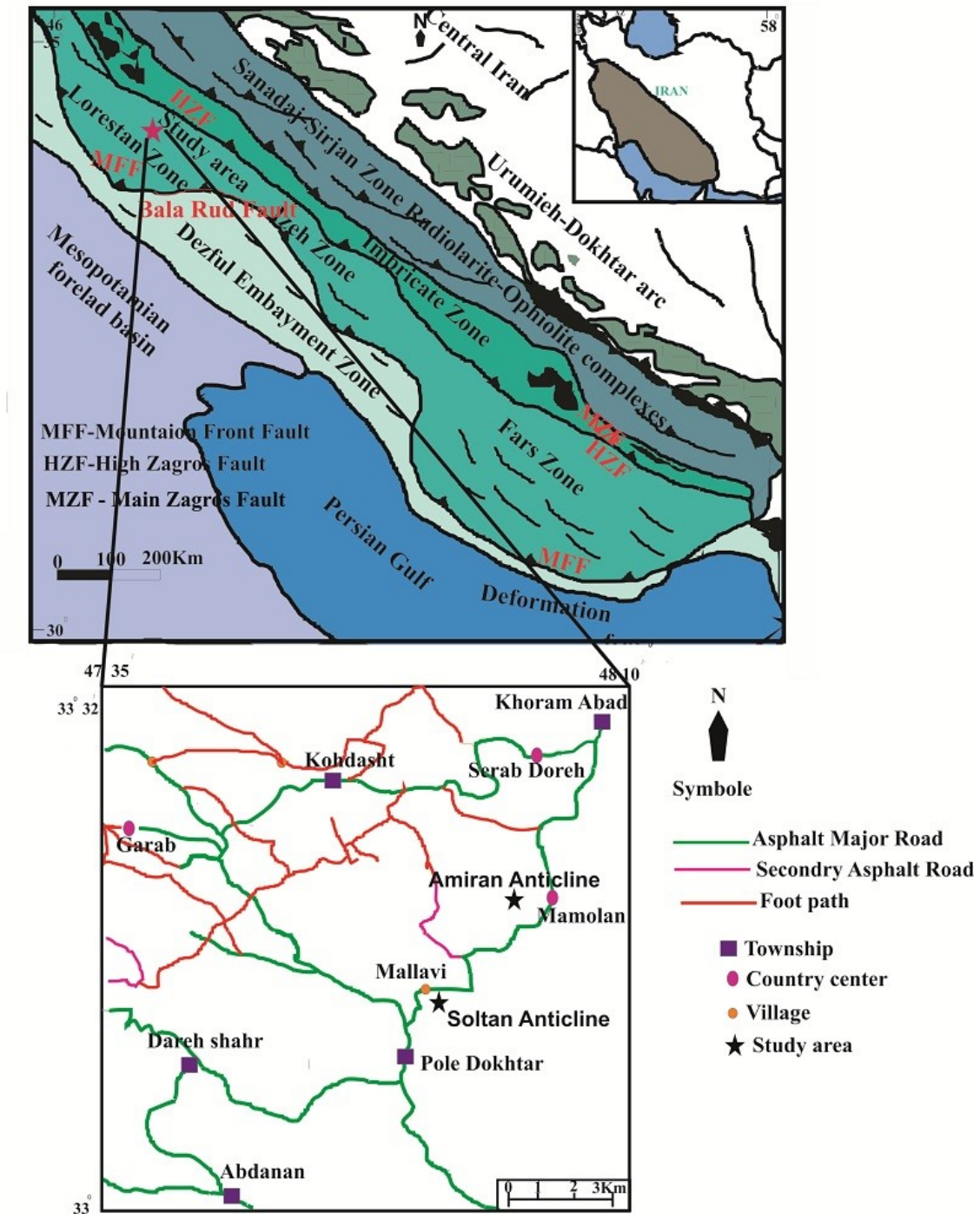

Fig 1. Location of the study area in south of Lurestan zone.

All samples were processed for foraminiferal analysis following the standard method of Keller et al. (1995). A number of 120 thin sections were provided for harder lithologies whilst 200 soft samples were disaggregated and the foraminifera were picked and analyzed. The samples were disaggregated by being soaked in water for several days and then being washed through 200, 120, 63 mm sieve series with tap water. Sediment infilling of foraminiferal tests was removed by repeated sonic agitation of the residues for about 15 minutes. The best-preserved specimens of planktonic foraminiferal species were picked identified and mounted on micro slides for a permanent record and for taking SEM microphotographs. Test shapes of the small planktonic

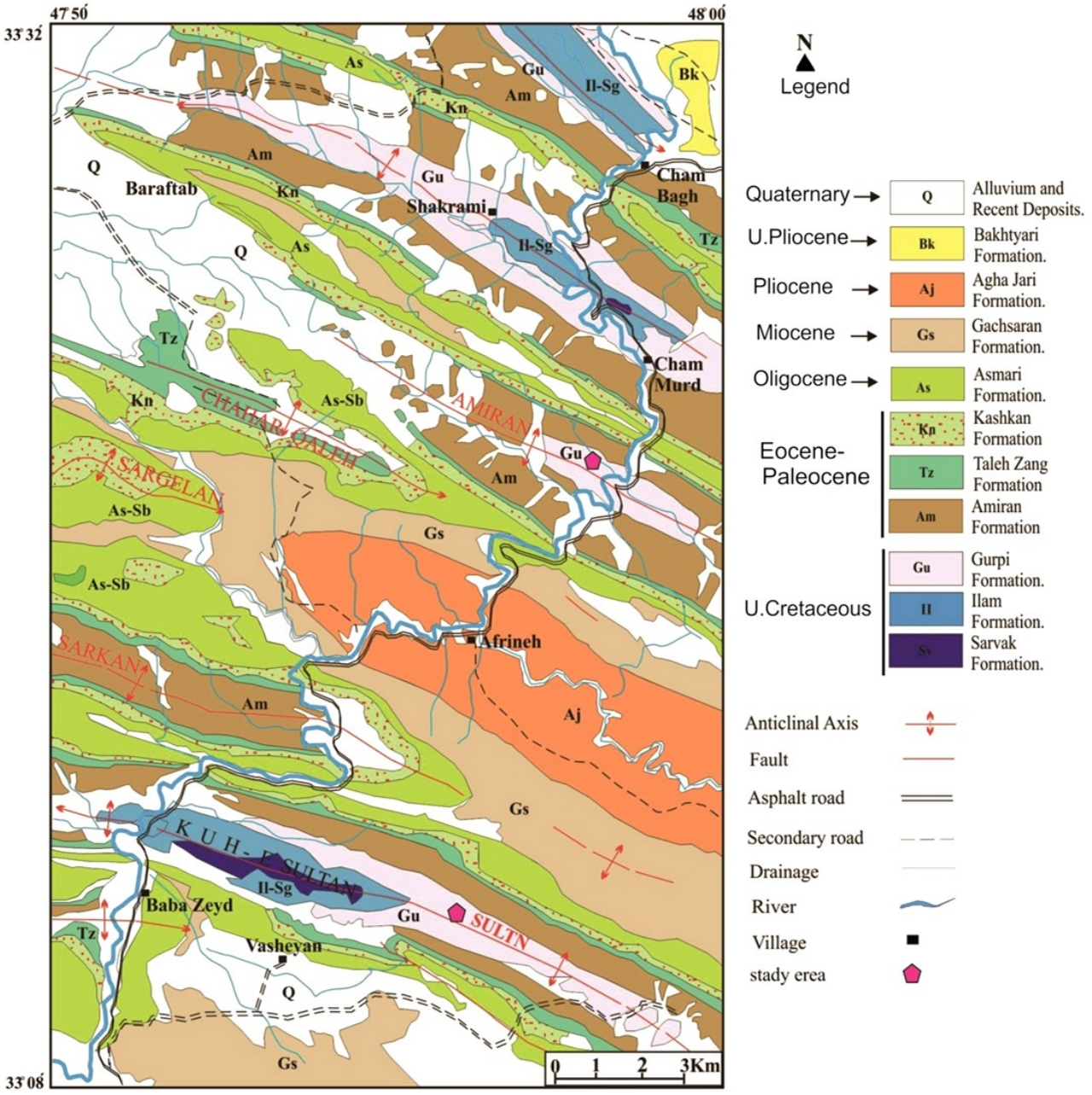

Fig 2. Geological map of Amiran and Soltan anticlines.

were taken into account for the paleobathymetric interpretation, as their differences depend on the depth. Recognition and identification of Cretaceous planktonic foraminiferal were based on (Bolli et al. 1957; Leoblich and Tappan 1964 and 1987; Sliter 1989; Robaszynski et al. 1984; Premoli Silva and Bolli 1973; Loeblich and Tappan 1988; Premoli silva and Verga 2004; Boudagher–Fadel 2013).

4. Results and Discussione

4.1. Biostratigraphy

On the basis of micropalaeontological and biostratigraphic studies of the Gurpi Formation in the Amiran and Soltan stratigraphycal sections, 48 species belonging to 25 genera of planktonic foraminifera were recognized and eventually 7 biozones were introduced (Figs 3,4,5). Correlation of the proposed biostratigraphic zonal scheme in this study was shown with other accepted standard biozones of other parts of the world (Table1).

Tabel 1. Correlation of the proposed biostratigraphic zonal scheme at this study with other accepted standardbiozones of other parts of the world.

Stage My 65	James and Wynd (1965)	Caron (1985)	Sliter (1989)	Vaziri - Moghadam (2002)	Robaszynski and Caron (1995)	Premoli Silva (2004)	This study
	Zagros	Tethys	Tethys	Sarvestan Area	Tethys	Tethys	Lorestan Area
Maastrictian	*Abathomphalus mayaroensis* Zone	*Abathomphalus mayaroensis* Zone	*Abathomphalus mayaroensis* Zone		*Abathomphalus mayaroensis* Zone	*Abathomphalus mayaroensis* Zone	
	Globotruncanita stuarti + *Pesudotextularia varians* Zone	*Gansserina gansseri* Zone	*Gansserina gansseri* Zone	*Gansserina gansseri* Zone	*Contusotruncana contusa* + *Racemiguembelina fructicosa* Zone	*Contusotruncana contusa* + *Racemiguembelina fructicosa* Zone	*Contusotruncana contusa* Zone
		Globotruncana aegyptiaca Zone	*Globotruncana aegyptiaca* Zone	*Globotruncanita stuarti* Zone			
713		*Globotruncanella havanensis* Zone	*Globotruncanella havanensis* Zone		*Gansserina gansseri* Zone	*Gansserina gansseri* Zone	*Gansserina gansseri* Zone
Campanian	*Globotruncanita elevata* Zone	*Radotruncana calcarata* Zone	*Radotruncana calcarata* Zone	*Radotruncana calcarata* Zone	*Globotruncana aegyptiaca* Zone	*Globotruncana aegyptiaca* Zone	*Globotruncana aegyptiaca* Zone
					Globotruncanella havanensis Zone	*Globotruncanella havanensis* Zone	*Globotruncanella havanensis* Zone
					Radotruncana calcarata Zone	*Radotruncana calcarata* Zone	*Radotruncana calcarata* Zone
835		*Globotruncana ventricosa* Zone	*Globotruncana ventricosa* Zone	*Globotruncana ventricosa* Zone	*Globotruncana ventricosa* Zone	*Globotruncana ventricosa* Zone	*Globotruncana ventricosa* Zone
		Globotruncanita elevata Zone	*Globotruncanita elevata* Zone	*Globotruncanita elevata* Zone	*Globotruncanita elevata* Zone	*Globotruncanita elevata* Zone	*Globotruncanita elevata* Zone
Santonian	*Globotruncana cocavata* + *carinata* Zone	*Dicarinella asymetrica* Zone	*Dicarinella asymetrica* Zone	*Dicarinella asymetrica* Zone	*Dicarinella asymetrica* Zone	*Dicarinella asymetrica* Zone	
855							

The biostratigraphic zones are briefly described as follow:

4.1.1. *Globotruncanita elevata* Taxon Range Zone

Definition: Total range zone of *Globotruncanita elevata*.

Characteristics: Within this zone numerous representatives of the genus *Contusotruncana fornicata* (Fig 6.5a-5c), *Globuncotrana mariei* (Fig 6.3a-3c), *Globotruncanita stuartiformis* (Fig 6.5a-5c), *Globotruncanita elevata* (Fig 7.3a-3c), *Globotruncana bulloides* (Fig 7.6a-6c), *Globotruncana bulloides* (Fig. 8. 6a-6c), *Globotruncana hilli* (Fig 9.5a-5c, *Lenticulina* sp. (Fig 9.11a-11b), *Ventilabrella* sp. (Fig 9.12), *Ventilabrella austinana* (Fig 9.13), *Palmula jarvisi* (Fig 9.6.14), are also present.

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

Age and Occurrence: Early Campanian. *Globotruncanita elevata* Zone is recorded from 25 and 26 meters of the thick grey marly limestone in Amiran and Soltan sections, respectively. This biozone was recorded from Zagros (James and Wynd 1965) and Tethys (Caron 1985; Sliter 1989). This biozone is characterized by Planktonic foraminiferal species.

4.1.2. *Globotrnucana ventricosa* Interval Zone

Author: Dalbiez (1955)

Definition: Interval zone from the first appearance of *Globotruncana ventricosa* to the first appearance of *Globotruncanita calcarata*.

Characteristics: Within this zone numerous representatives of the genus *Globotruncana lapparenti, Pseudotextularia elegans* (Fig 6.10), *Globotruncana hilli, Macroglobigerinelloides alvarezi, Contusotruncana fornicata* (Fig 7.7a-7c), *Globotruncana mariei, Globotruncanita stuartiformis, Globotruncana falsostuarti, Rugoglobigerina rugosa, Gavelinella pertusa, Globotruncana orientalis, Muricohedbergella holmdelensis, Dentalina multicostata* (Fig 9.1a-1b), *Gaudryina pyramidata* (Fig 9.2), are also present.

Remarks: The first appearance of *Globotruncana atlantica* approximates the base of the zone which also

contains the first appearance of *Contusotruncana plummerae* in the middle part and *Radotruncana subspinosa* occurs at the top of this zone.
Age and Occurrence: Middle to Late Campanian. *Globotruncanita ventricosa* Zone is recorded from 35 and 34 meters of the thick grey marly limestone in Amiran and Soltan sections, respectively. This biozone was recorded from Tethys by (Caron 1978; Sliter 1989).

4.1.3. *Radotruncana calcarata* Taxon Range Zone
Author: Herm (1962)
Definition: Total range zone of *Radotruncana calcarata*
Characteristics: Whitin this zone numerous representatives of the genus *Globotruncana ventricosa, Globotruncana hilli, Macroglobigerinelloides alvarezi, Ventilabrella eggeri* (Fig 8,4.8a-8b), *Dentalina catenula* (Fig 9.9), *Lagena hispida* (Fig 9.10), *Contusotruncana fornicata, Globotruncanita stuartiformiz, Gaudryina pyramidata, Rugoglobigerina rugosa, Frondicularia undulosa, Gavelinella pertusa, Ventilabrella eggeri* (Fig 6.8). *Globotruncana orientalis, Radotruncana calcarata* (Fig 8.2a-2c), *Radotruncana subspinosa,Globotruncana linneiana* (Fig 8. 1a-1c), are also present. Remarks: The first appearance of *Globotruncana stuarti* and *Globotruncana falsostuarti* occurs within this zone.
Age and Occurrence: Late Campanian. *Radutruncana calcarata* Zone is recorded from 20 and 40 meters of the thick grey marly limestone in Soltan and Amiran sections, respectively. This biozone was recorded form Tethys by (Caron 1978; Sliter 1989).

4.1.4. *Globltruncanella havanensis* Partial Range Zone
Author: Caron (1978)
Definition: Partial range zone from the Last appearance of *Radotruncana calcarata* to the First appearance of *Globotruncana aegyptica*.
Remarks: The first appearance of *Globotruncanella petaloidea, Ventilabrella multicamerata* and *Globotruncana pettersi* occurs within this zone.
Characteristics: Within this zone numerous representatives of the genus *Globotruncana ventricosa, Contusotruncana fornicata, Globotruncana mariei, Heterohelix punctulata, Globotruncanita stuartiformis, Globotruncanella havanensis* (Fig 7.4a-4c), (8a-8c), *Globotruncana falsostuarti* (Fig 7.2a-2c), *Ammodiscoides cretaceus* (Fig 9.15a-15b-15c) *Gaudryina faujasi* (Fig 9.16), *Gavelinella pertusa, Radotruncana subspinosa, Globotruncana orientalis, Muricohedbergella holmdelensis,* are also present.
Age and Occurrence: Late Campanian; *Globotruncanella havanensis* Zone is recorded from 25 and 45 meters of the thick grey marly limestone and shale in Soltan and Amiran sections, respectively. This biozone was recorded from Tethys (Caron 1978; Sliter 1989).

4.1.5. *Globotruncana aegyptica* Interval Zone
Author: Caron (1985)
Definition: Interval zone from the first appearance of *Globotruncana aegyptica* to the first appearance of *Gansserina gansseri*.
Remarks: The first appearance of *Pseudoguembelina costulata* and *Pseudoguembelina excolata* occurs within this zone.
Characteristics: Within this zone numerous representatives of the genus *Globotroncana aegyptiaca* (Fig 6.5a-5c), (7a-7c), *Dentalina multicostata, Globotruncanella havanensis, Globotruncana lapparenti, pseudotextularia elegans, Lagena hispida, Radotruncana subspinosa, Archaeoglobigerina cretacea, Heterohelix planata*, are also present.
Age and Occurrence: Late to latest Campanian. *Globotruncana aegyptica* zone is recorded from 70 and 30 meters of the thick limestone in Soltan and Amiran sections, respectively. This biozone was recorded from Tethys by (Caron 1978; Sliter 1989).

4.1.6. *Gansserina gansseri* Interval Zone
Author: Bronniman (1952)
Definition: Interval zone from the first appearance of *Gansserina gansseri* to the first appearance of *Contusotruncana contusa* and *Racemiguembellina fructicosa*.
Remarks: The first appearance of *Pseudoguembelina acervulinoides, Pseudoguembelina palpebral* and *Contusortuncana walfishensis* occurs within this zone.
Characteristics: Within this zone numerous representatives of the genus *Globotruncana mariei, Globotruncanita pettersi* (Fig 7.1a-1c). *Gansserina gansseri* (Fig 8.1a-1c), (3a-3c), *Globotruncanita conica* (Fig 8. 4a-4c), *Globotruncana ventricosa* (Fig 9.7a-7c), *Globotruncanita stuartiformis, Globotruncanita stuarti* (Fig 9.8a-8c).*Globotruncana hilli, Globotruncana arca, Globotroncana aegyptiaca, Frondicularia undulosa* (Fig 9.3a-3b), *Bolivinoides draco* (Fig 9.4), *Palmula rugosa* (Fig 9.5a-5b), *Globotruncanella havanensis, Globotruncana arca, Muricohedbergella monmouthensis, Rugotruncana subcircumnodifer, Archaeoglobigerina cretacea, Rugoglobigerina macrocephala,* are also present.
Age and Occurrence: Latest Campanian to Early Maastrichtian**.** *Gansserina gansseri zone* is recorded from 55 and 60 meters marly limestone in Soltan and Amiran sections, respectively. This biozone was recorded from Tethys by (Caron 1978; Sliter 1989).

4.1.7. *Contusotruncana contusa* Interval Zone
Author: Premoli Silva and Bolli (1973)
Definition: Interval zone from the First appearance of *Contusotruncana contusa* to the extinction of most of Cretaceous biozone.

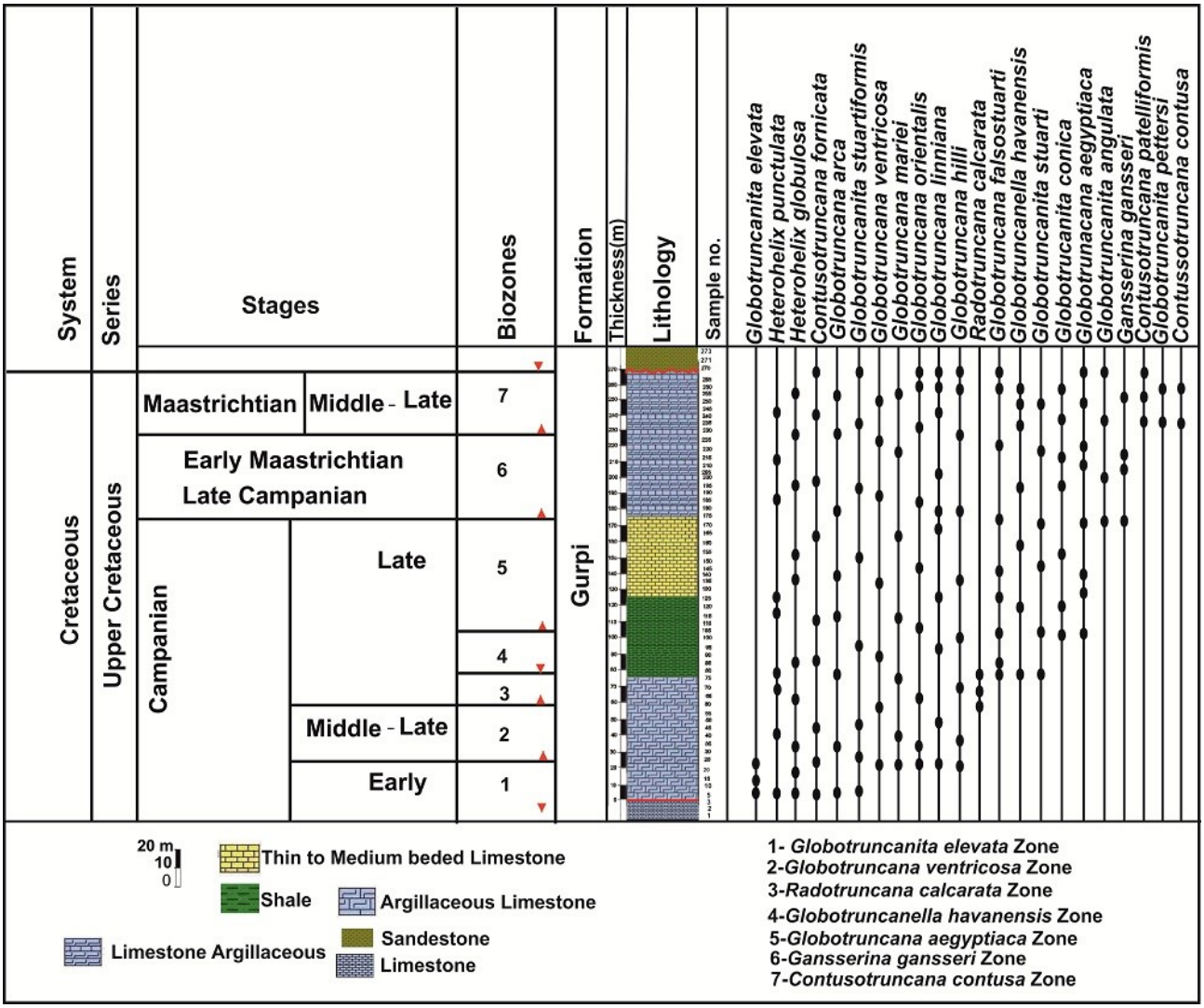

Fig 3. Biostratigraphic Colum of the Gurpi Formation in section Soltan Anticline

Remarks: The first appearance of *Contusotruncana contusa* occurs within this zone.

Characteristics: Within this zone numerous representatives of the genus *Contusotruncana walfishensis, Contusotruncana contusa* (Fig 7.6a-6c), *Contusotruncana fornicata, Globotruncana mariei, Globotruncanita pettersi* (Fig 9.1a-1c), *Gansserina gansseri, Globotruncana ventricosa, Globotruncanita stuarti, Globotruncana hilli, Globotruncana arca, Globotrucanita angulata, Globotroncana aegyptiaca, Globotruncanella havanensis, Macroglobigernelloides prairiehillensis, Contusotruncana contusa, Globotruncanita conica, Rugotruncana subcircumnodifer, Trinitella scotti, Rugoglobigerina macrocephala,* are also present.

Age and Occurrence: Early to Late Maastrichtian. *Contusotruncana contusa zone* is recorded from 40 and 40 meters of the thick marl and limestone in Soltan and Amiran sections, respectively. This biozone was recorded from Tethys by (Caron 1978; Sliter 1989).

4.2. Paleobathymetry

Various case studies on different kinds of Planktonic foraminifera show that each of the unicellular taxa is congruent with a specific depth of water column. According to the models for the development of planktonic foraminifera, based on depth, some researches have been done (Hart 1980b; Caron 1983). Accordingly, based on the various forms of planktonic foraminifera, we can determine three different morphotypes:

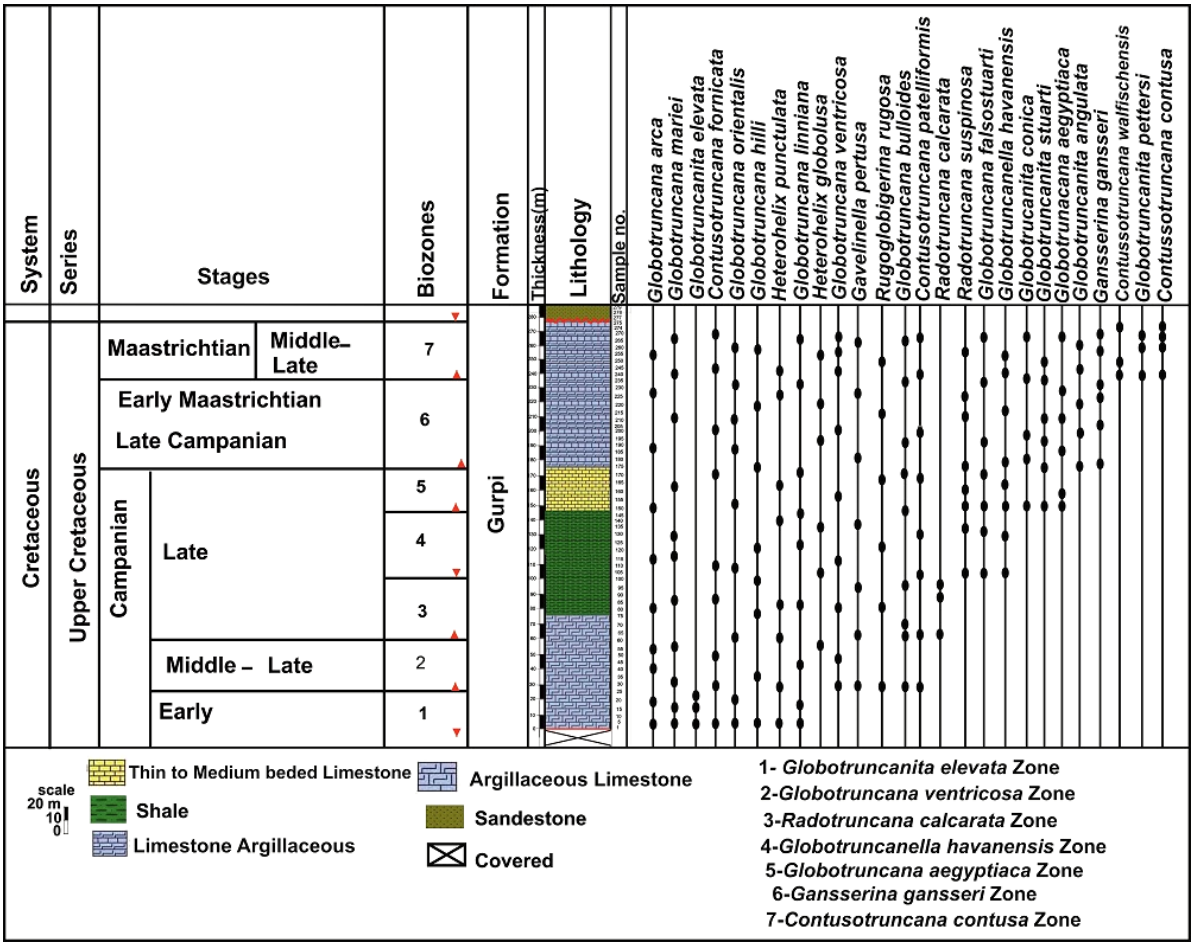

Fig 4. Biostratigraphic Colum of the Gurpi Formation in section Amiran Anticline.

A) Morphotype Type 1 or fauna of shallow waters (0 to 50 m). The species of this group have a direct or trochospiral test with spherical chambers, without karren and with low ornamentation which include: *Heterohelix* sp. *Globogerinelloides* sp. *Hedbergella* sp. *Pseudotextularia* sp. (Martinez 1989; Abramovich et al. 2003).

B) Morphotype Type 2 or intermediate fauna (50 to 100 m). The examples of this morphotype have the trochospiral test, compact chambers and primary karrens which include: *Preglobotruncana* sp. *Rugoglobigerina* sp. *Archeoglobigerina* sp.

C) Morphotype Type 3 or fauna of deep waters (more than 100 m). The examples of this group have trochospiral test with compact chambers and karren which include: *Globotruncana* sp. *Globotrucanita* sp. and *Gansserina* sp. The abundance of the keeled taxa indicates deep marine environments (Bandy 1953; Bandy and Arnal 1960; Abramovich et al. 2003; Gallalal et al. 2010; Filkorn et al. 2011).

In the studied sections, Planktonic foraminifera are the most common microfossils. Benthic foraminifera are extremely rare throughout all samples. Based on morphological variations of planktonic foraminifera and Planktonic to benthic ratio (P/B). Tabels (2 and 3), three depositional sequences have been recognized (Figs 10, 11 and 12).

The Early Campanian to Late Maastrichtian sequences of the Lurestan zone are similar to the global sea level curve of Haq (2014). Sequence stratigraphy studies accompanying with paleontological evidences (especially foraminiferals and palynomorphs) indicate four complete sequences of the Gurpi Formation (Campanian–Paleocene) in southwest of Zagros (Zarei and Ghasemi Nejad 2014).

4.2.1. Sequence 1

This sequence is Early Campanian in age and is present in Amiran section (110 m thick) and in Soltan section (78 m thick). At Amiran and Soltan sections, the TST and HST comprise a 60, 39 and 50, 39 m-thick, respectively and is indicated by planktonic foraminifer

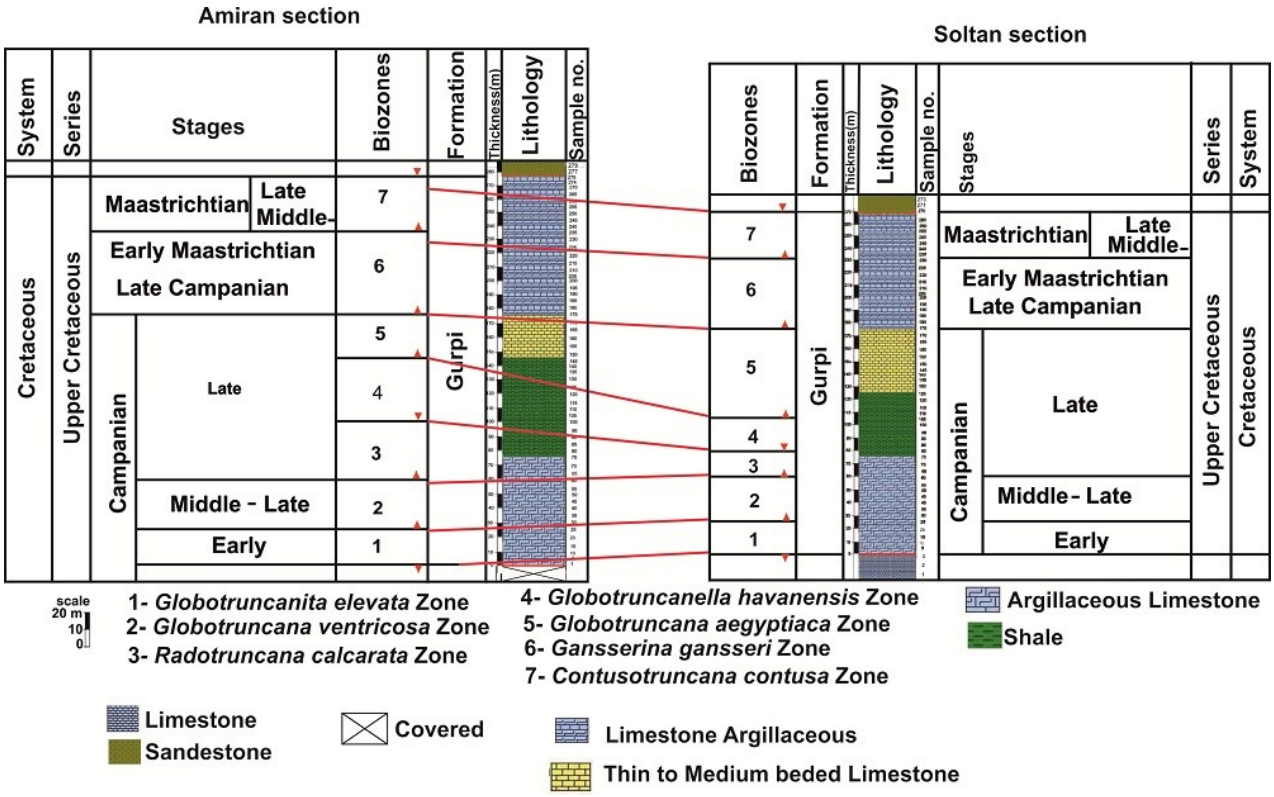

Fig 5. Correlation between planktonic biozones showing in the two sections (Soltan Anticline and Amiran Anticline).

wackestone/ mudstone facies and increase in relative abundance of morphotype 3. Wackestone with abundant planktonic foraminifers and high ratio of P/B and glauconite represent deep-water facies in sample # 60 of Amiran section and # 39 of Soltan section; this is, therefore, interpreted as the MFS. An upward-shallowing facies trend (HST) is indicated by the reduction of morphotype 3 as well as the P/B ratio. The sequence boundary (SB) is characterized by maximum decrease in the P/B ratio as well as the percentage of morphotype 3.

4.2.2. Sequence 2

This sequence is Late Campanian in age and is present in Amiran section (109 m thick) and in Soltan section (97 m thick). At Amiran and Soltan sections, the TST and HST comprise a 62, 47 and 47, 50 m-thick, respectively and is indicated by planktonic foraminifer wackestone/mudstone facies and increase in relative abundance of morphotype 3. Wackestone with abundant planktonic foraminifers and high ratio of P/B and glauconite represent deep-water facies in sample # 172 of Amiran section and # 129 of Soltan section; this is, therefore, interpreted as the MFS. An upward-shallowing facies trend (HST) is indicated by the reduction of morphotype 3 as well as the P/B ratio. The sequence boundary (SB) is characterized by maximum decrease in the P/B ratio as well as the percentage of morphotype 3.

4.2.3. Sequence 3

This sequence is Early Campanian in age and is present in Amiran section (56 m thick) and in Soltan section (95 m thick). At Amiran and Soltan sections, the TST and HST comprise a 41, 50 and 15, 45 m-thick, respectively and is indicated by planktonic foraminifer wackestone/mudstone facies, and increase in relative abundance of morphotype 3. Wackestone with abundant planktonic foraminifers and high ratio of P/B and glauconite represent deep-water facies in sample # 260 of Amiran section and # 223 of Soltan section (Fig 9); this is, therefore, interpreted as the MFS. An upward-shallowing facies trend (HST) is indicated by the reduction of morphotype 3 as well as the P/B ratio. The sequence boundary (SB) is characterized by maximum decrease in the P/B ratio as well as the percentage of morphotype3.

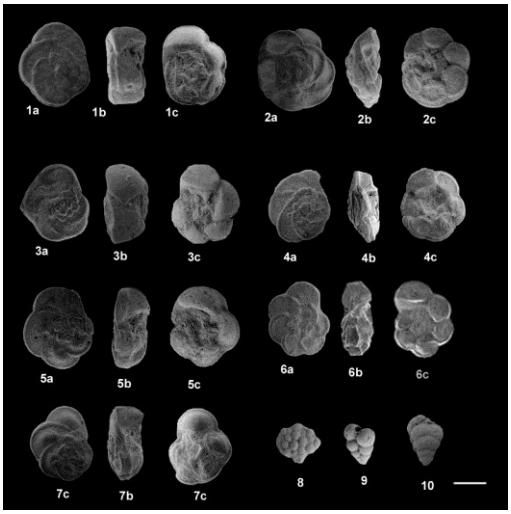

Fig 6. selected assembelage Planktonic Foraminifers of the Gurpi Formation in study area. Scale bar: 100µ m. 1a-spiral side, 1b-axial side, 1c-umbilical sid: *Gansserina gansseri* (Bolli, 1951)., 2a-spiral side, 2b -axial side, 2c-umbilical sid: *Globotruncana arca*., 3a-spiral side, 3b-axial side, 3c-umbilical sid: *Gansserina gansseri* (Bolli, 1951)., 4a-spiral side, 4b-axial side, 4c-umbilical sid: *Globotruncana arca* (Cushman, 1927)., 5a-spiral side, 5b - axial side, 5c-umbilical sid: *Globotruncana aegyptiaca* (Nakkady, 1950)., 6a-spiral side, 6b-axial side, 6c-umbilical sid: *Globotruncana bulloides* (Vogler, 1941)., 7a-spiral side, 7b-axial side, 7c-umbilical sid: *Globotruncana aegyptiaca* (Nakkady, 1950)., 8: *Ventilabrella eggeri* (Cushman, 1938) ., 9: *Heterohelix globolosa* (Ehrenberg, 1840)., 10: *Pseudotextularia elegans*(Rzehak, 1891).

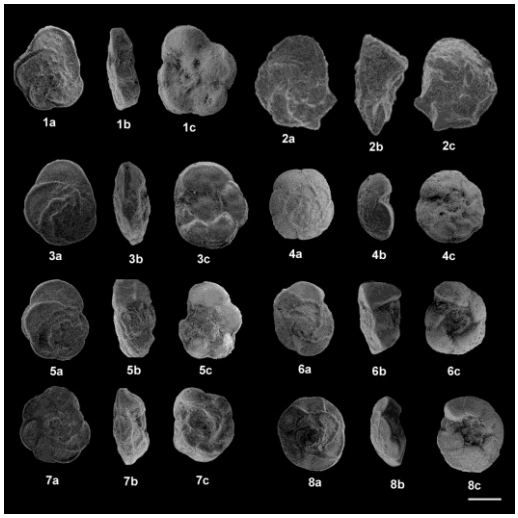

Fig 8. selected assembelage Planktonic Foraminifers of the Gurpi Formation in study area. Scale bar: 100µ m. 1a-spiral side, 1b-axial side, 1c-umbilical sid: *Globotruncana linneiana* (d' Orbigny, 1839)., 2a-spiral side, 2b-axial side, 2c-umbilical sid: *Radotruncana calcarata* (Cushman, 1928)., 3a-spiral side, 3b-axial side, 3c-umbilical sid: *Globotruncana mariei* (Banner and Blow, 1960)., 4a-spiral side, 4b-axial side, 4c-umbilical sid: *Globotruncanita conica* (White, 1928)., 5a-spiral side, 5b-axial side, 5c-umbilical sid: *Globotruncana hilli* (Pessagno, 1967)., 6a-spiral side, 6b-axial side, 6c-umbilical sid: *Globotruncana angulata* (Tilev, 1951)., 7a-spiral side, 7b-axial side, 7c-umbilical sid: *Globotruncana ventricosa* (White, 1928) .

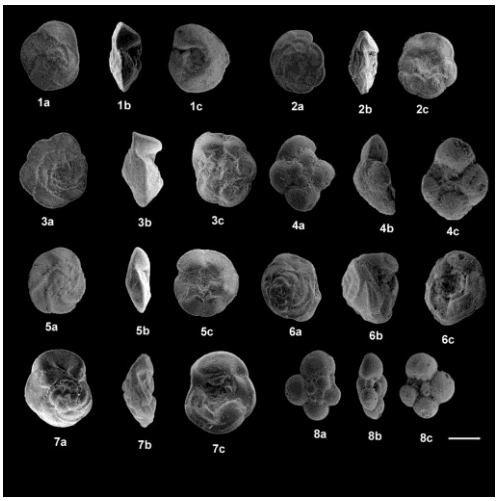

Fig 7. selected assembelage Planktonic Foraminifers of the Gurpi Formation in study area. Scale bar: 100µ m. 1a-spiral side, 1b-axial side, 1c-umbilical sid: *Globotruncana pettersi* (Gandolfi, 1955)., 2a-spiral side, 2b-axial side, 2c-umbilical sid: *Globotruncana falsostuarti* (Sigal, 1952)., 3a-spiral side, 3b-axial side, 3c-umbilical sid: *Globotruncanita elevate* (Brotzen, 1934)., 4a-spiral side, 4b-axial side, 4c-umbilical sid: *Globotruncanella havanensis* (Voorwijk, 1937)., 5a-spiral side, 5b-axial side, 5c-umbilical sid: *Globotrunita stuartiformis* (Dalbiez, 1955)., 6a-spiral side, 6b-axial side, 6c-umbilical sid: *Contusotruncana contusa* (Cushman, 1926)., 7a-spiral side, 7b-axial side, 7c-umbilical sid: *Contusotruncana fornicata* (Plummer, 1931)., 8a-spiral side, 8b-axial side, 8c-umbilical sid: *Globotruncanella havanensis*(Voorwijk, 1937).

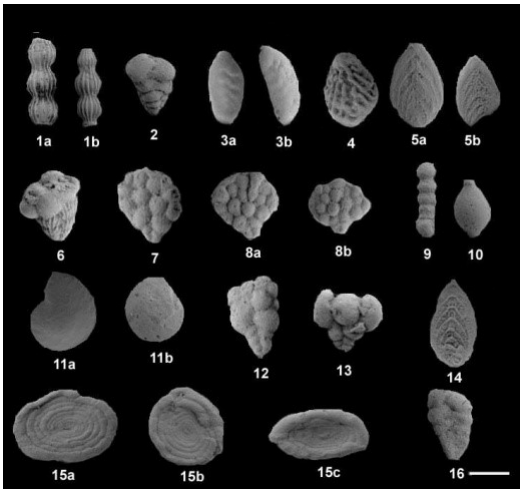

Fig 9. selected assembelage Planktonic Foraminifers of the Gurpi Formation in study area. Scale bar: 100µ m. 1a-spiral side, 1b-axial side: *Dentalina multicostata* (d'Orbigny, 1840)., 2.*Gaudryina pyramidata* (Cushman, 1926)., 3a-spiral side, 3b-axial side: *Frondicularia undulosa* (Cushman, 1936)., 4, *Bolivinoides draco* (Marsson, 1878)., 5a-spiral side, 5b-axial side: *Palmula rugosa* (Cushman, 1944)., 6: *Racemiguembelina powelli* (Smith & Pessagno, 1973)., 7, 8a-spiral side, 8b-axial side: *Ventilabrella eggeri* (Cushman, 1938) ., 9*: Dentalina catenula* (Reuss, 1860)., 10. *Lagena hispida* (Russ, 1858)., 11a-spiral side, 11b-axial side: *Lenticulina* sp., 12, 13*Ventilabrella* sp., 14*: Palmula jarvisi* (Cushman, 1935)., 15a-spiral side, 15b-axial side, 15c-umbilical sid: *Ammodiscoides cretaceous* (Chushman, 1835)., *16: Gaudrina pyramidata* (Cushman, 1926).

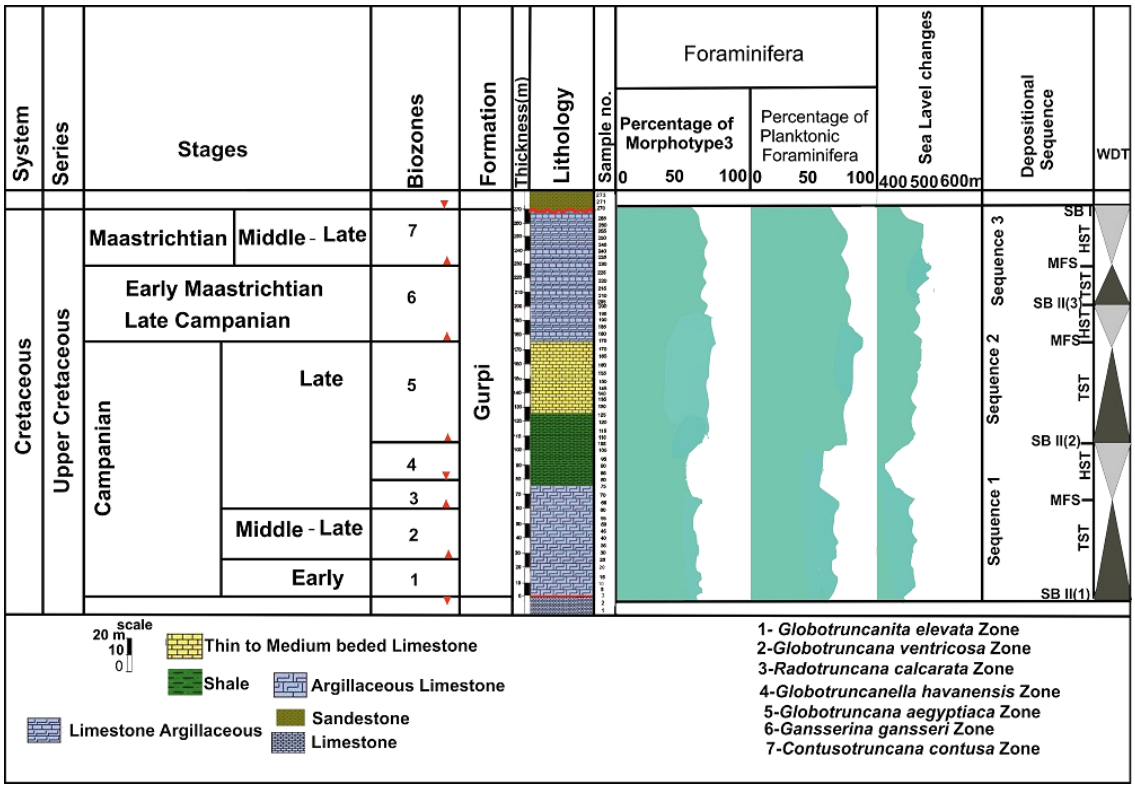

Fig 10. Percentage of morphotype 3, rtio (P/B), Palaeobathymetry and Depositional sequence of the Gurpi Formation in the section Soltan

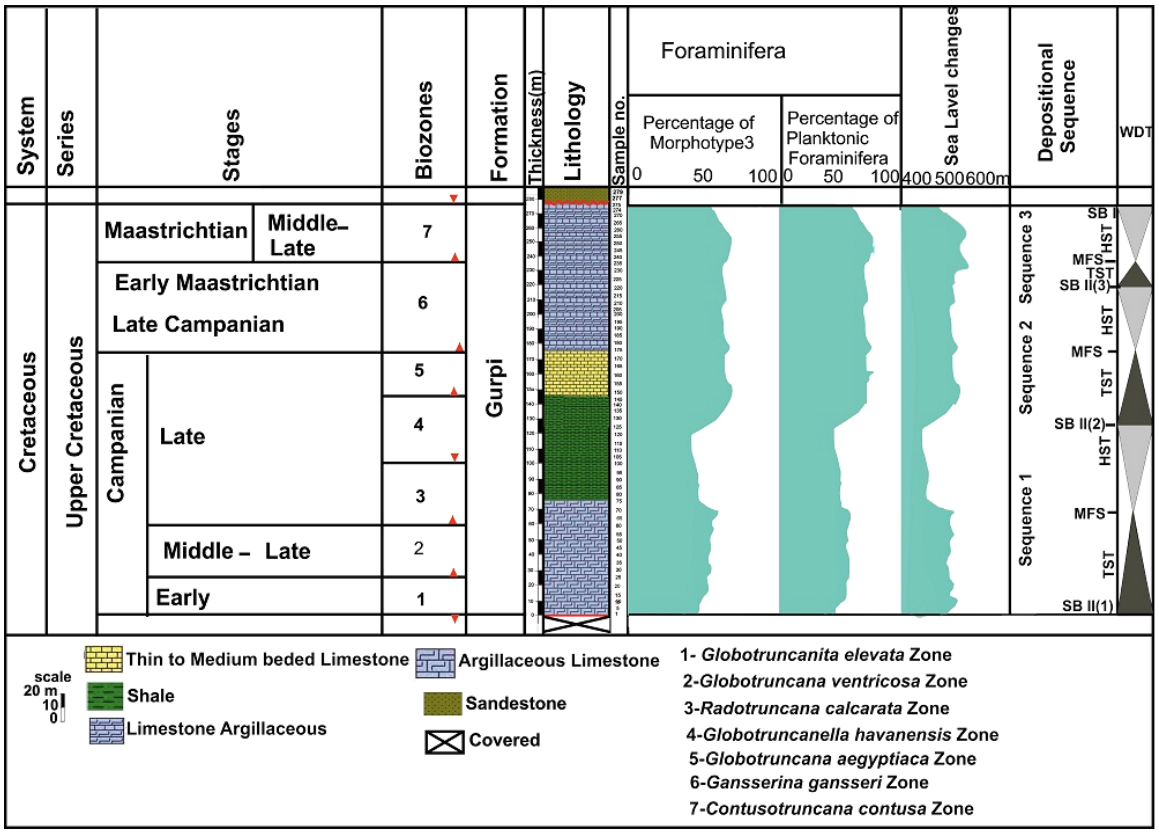

Fig 11. Percentage of morphotype 3, rtio (P/B), Palaeobathymetry and Depositional sequenceof the Gurpi Formation in the section Amiran.

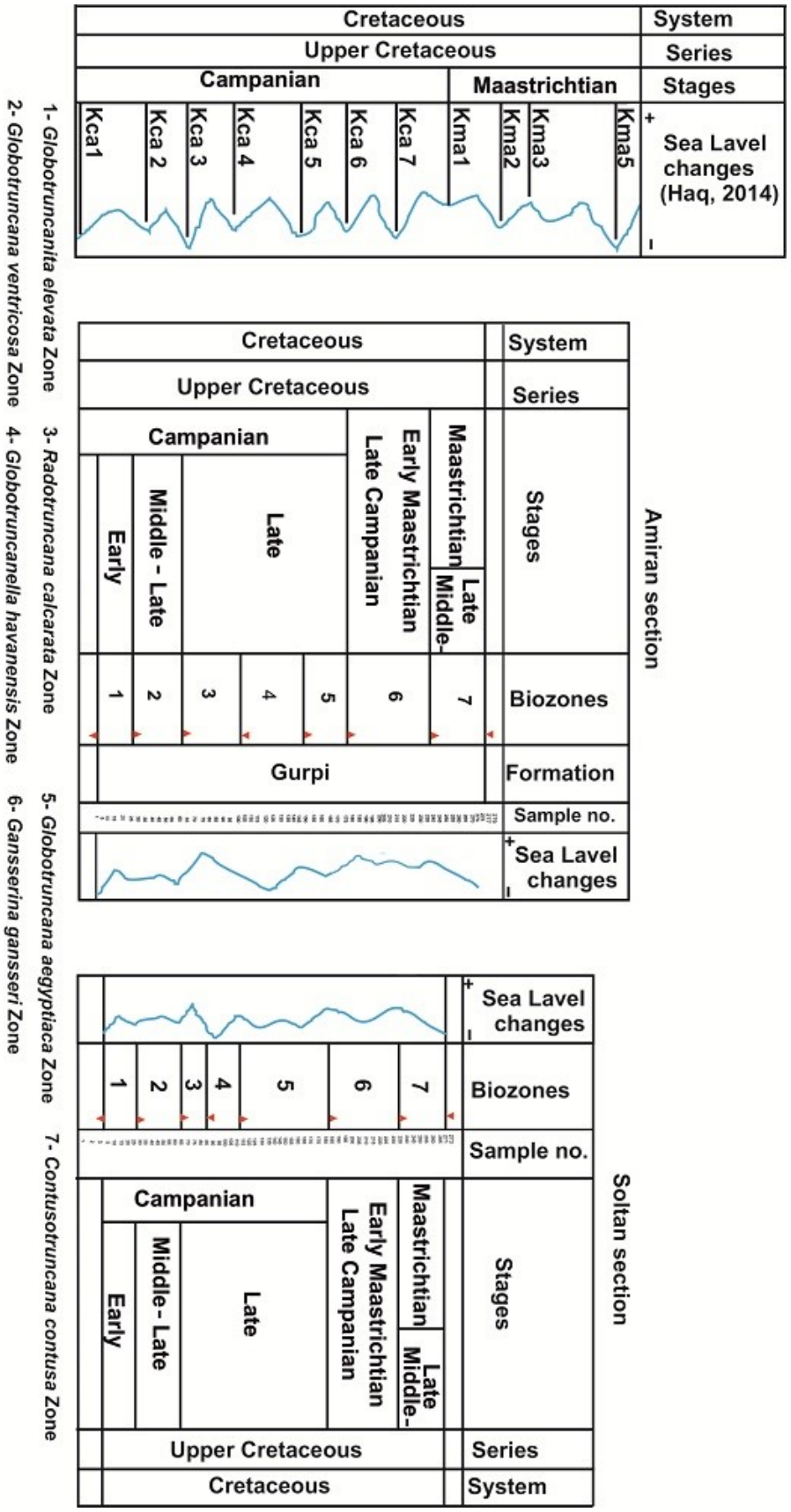

Fig 12. Comparison ofchange palaeodepth sediments of the Gurpi Formation in this study with those of Haq (2014).

Tabel 2. Percentage of planktinic foraminifera, rtio (P/B), Palaeobathymetry of the Gurpi Formation in the section Soltan.

Sample no.	Number of Foraminifera	Percentage of Morphotype 3	Number of Planktonic Foraminifera	Number of Benthic Foraminifera	Percentage of Planktonic Foraminifera	Palaeodepth	Sample no.	Number of Foraminifera	Percentage of Morphotype 3	Number of Planktonic Foraminifera	Number of Benthic Foraminifera	Percentage of Planktonic Foraminifera	Palaeodepth
1	200	68	151	49	75/5	518	139	200	72	153	47	76/5	539
3	200	68	152	48	76	528	141	200	73	154	46	77	544
5	200	67	152	48	76	528	143	200	73	155	45	77/5	555
7	200	70	154	46	77	544	145	200	72	154	46	77	544
9	200	71	153	47	76/5	539	147	200	71	156	44	78	566
11	200	71	154	46	77	544	149	200	72	154	46	77	544
13	200	72	156	44	78	566	151	200	73	157	43	78/5	578
15	200	73	157	43	78/5	578	153	200	72	153	47	76/5	539
17	200	73	157	43	78/5	578	155	200	73	154	46	77	544
19	200	72	155	45	77/5	555	157	200	73	155	45	77/5	555
21	200	70	153	47	76/5	539	159	200	72	154	46	77	544
23	200	70	152	48	76	528	161	200	71	156	44	78	566
25	200	69	152	48	76	528	163	200	72	154	46	77	544
27	200	69	153	47	76/5	539	165	200	73	157	43	78/5	578
29	200	67	154	46	77	544	167	200	74	159	41	79/5	595
31	200	66	155	45	77/5	555	169	200	73	159	41	79/5	595
33	200	68	156	44	78	566	171	200	75	160	40	80	607
35	200	67	156	44	78	566	173	200	75	161	39	80/5	620
37	200	70	157	43	78/5	578	175	200	74	162	38	81	626
39	200	71	156	44	78	566	177	200	74	162	38	81	626
41	200	73	154	46	77	544	179	200	71	156	44	78	564
43	200	73	153	47	76/5	539	181	200	71	154	46	77	544
45	200	71	154	44	78	566	183	200	70	151	49	75/5	518
47	200	70	153	47	76/5	539	185	200	68	148	52	74	492
49	200	70	153	47	76/5	539	187	200	66	145	55	72/5	464
51	200	67	154	46	77	544	189	200	65	145	55	72/5	464
53	200	66	155	45	77/5	555	191	200	55	144	56	72	459
55	200	71	156	44	78	566	193	200	56	145	55	72/5	464
57	200	71	156	44	78	566	195	200	57	144	56	72	459
59	200	71	156	44	78	566	197	200	56	147	53	73/5	482
61	200	66	155	45	77/5	555	199	200	55	148	52	74	492
63	200	66	155	45	77/5	555	201	200	55	144	56	72	459
65	200	75	160	40	80	607	203	200	73	155	45	77/5	555
67	200	75	160	40	80	607	205	200	72	156	44	78	566
69	200	75	160	40	80	607	207	200	73	156	44	78	566
71	200	74	159	41	79/5	595	209	200	72	154	46	77	544
73	200	71	156	44	78	566	211	200	74	154	46	77	544
75	200	71	155	45	77/5	555	213	200	74	153	47	76/5	539
77	200	67	154	46	77	544	215	200	72	153	47	76/5	539
79	200	62	155	45	76/5	539	217	200	69	151	49	75/5	518
81	200	62	155	45	76/5	539	219	200	68	150	50	75	507
83	200	55	148	52	74	492	221	200	67	154	46	77	544
85	200	56	147	53	73/5	482	223	200	70	155	45	77/5	555
87	200	56	147	53	73/5	482	225	200	71	156	44	78	566
89	200	56	145	55	72/5	464	227	200	71	156	44	78	566
91	200	57	144	56	72	459	228	200	74	157	43	78/5	578
93	200	58	150	50	75	507	229	200	75	160	40	80	607
95	200	59	150	50	75	507	231	200	74	161	39	80/5	620
97	200	60	151	49	75/5	518	233	200	74	160	40	80	607
99	200	61	151	49	75/5	518	235	200	74	160	40	80	607
101	200	61	154	46	77	544	237	200	67	153	47	76/5	539
103	200	62	155	45	77/5	555	239	200	72	154	44	78	566
105	200	63	152	48	76	528	241	200	73	154	44	78	566
107	200	65	153	47	76/5	539	243	200	74	157	43	78/5	578
109	200	66	148	52	74	492	245	200	72	156	44	78	564
111	200	67	148	52	74	492	246	200	71	156	44	78	564
112	200	67	149	51	74/5	502	247	200	71	154	46	77	544
115	200	68	150	50	75	507	249	200	72	153	47	76/5	539
117	200	69	152	48	76	528	251	200	72	153	47	76/5	539
119	200	70	153	47	76/5	539	253	200	70	151	49	75/5	518
121	200	71	155	45	77/5	555	255	200	70	151	49	75/5	518
123	200	72	150	50	75	507	257	200	68	150	50	75	507
125	200	72	154	46	77	544	259	200	68	150	50	75	507
127	200	73	154	46	77	544	261	200	68	148	52	74	492
129	200	72	151	49	75/5	518	263	200	66	145	55	72/5	464
131	200	71	153	47	76/5	539	265	200	65	145	55	72/5	464
133	200	72	153	47	76/5	539	267	200	64	142	58	71	421
135	200	73	155	45	77/5	539	269	200	63	142	58	71	421
137	200	74	153	47	76/5	539	271	200	62	142	58	71	421

Tabel 3. Percentage of planktinic foraminifera, rtio (P/B), Palaeobathymetry of the Gurpi Formation in the Amiran section.

Sample no.	Number of Foraminifera	Percentage of Morphotype 3	Number of Planktonic Foraminifera	Number of Benthic Foraminifera	Percentage of Planktonic Foraminifera	Palaeodepth	Sample no.	Number of Foraminifera	Percentage of Morphotype 3	Number of Planktonic Foraminifera	Number of Benthic Foraminifera	Percentage of Planktonic Foraminifera	Palaeodepth
1	200	66	149	51	74/5	502	139	200	65	147	53	73/5	482
3	200	67	150	50	75	507	141	200	67	150	50	75	507
5	200	68	152	48	76	528	143	200	66	150	50	75	507
7	200	68	153	47	75/5	518	145	200	68	152	48	76	528
9	200	65	154	46	77	544	147	200	68	152	48	76	528
11	200	69	154	46	77	544	149	200	70	155	45	77/5	555
13	200	65	155	45	77/5	555	151	200	71	155	45	77/5	555
15	200	66	153	47	76/5	539	153	200	72	153	47	76/5	539
17	200	69	155	45	77/5	555	155	200	73	154	46	77	544
19	200	67	153	47	76/5	539	157	200	70	152	48	76	528
21	200	64	151	49	75/5	518	159	200	75	156	44	78	566
23	200	65	151	49	75/5	518	161	200	74	155	45	77/5	555
25	200	66	152	48	76	528	163	200	71	153	47	76/5	539
27	200	68	155	45	77/5	555	165	200	74	152	48	76	528
29	200	69	154	46	77	544	167	200	73	157	43	78/5	578
31	200	66	152	48	76	528	169	200	74	158	42	79	584
33	200	70	156	44	78	566	171	200	73	158	42	79	584
35	200	71	157	43	78/5	578	173	200	73	158	42	79	584
37	200	72	156	44	78	566	175	200	76	161	39	80/5	620
39	200	75	158	42	79	584	177	200	74	157	43	78/5	578
41	200	73	152	48	76	528	179	200	74	157	43	78/5	578
43	200	74	155	45	77/5	555	181	200	75	158	42	79	584
45	200	70	156	44	78	566	183	200	72	155	45	77/5	555
47	200	70	156	44	78	566	185	200	70	155	45	77/5	555
49	200	66	152	48	76	578	187	200	75	156	44	78	544
51	200	69	154	46	77	544	189	200	70	155	45	77/5	555
53	200	74	155	45	77/5	555	191	200	73	154	46	77	544
55	200	74	155	45	77/5	555	193	200	74	157	43	78/5	578
57	200	72	157	43	78/5	578	195	200	75	158	42	79	584
59	200	69	155	45	77/5	555	197	200	72	155	45	77/5	555
61	200	69	153	47	76/5	539	199	200	70	155	45	77/5	555
63	200	72	157	43	78/5	578	201	200	75	156	44	78	544
65	200	72	160	40	80	607	203	200	74	154	46	77	544
67	200	73	162	38	81	621	205	200	70	152	48	76	528
69	200	75	160	40	80	607	207	200	66	151	49	75/5	518
71	200	75	157	43	78/5	578	209	200	73	154	46	77	544
73	200	73	154	46	77	544	211	200	72	154	46	77	544
75	200	68	155	45	77/5	555	213	200	73	153	47	76/5	539
77	200	73	154	46	77	544	215	200	74	155	45	77/5	555
79	200	72	153	47	76/5	539	217	200	71	152	48	76	528
81	200	72	153	47	76/5	539	219	200	72	152	48	76	528
83	200	70	152	48	76	528	221	200	67	151	49	75/5	518
85	200	68	151	49	75/5	518	223	200	67	151	49	75/5	518
87	200	67	151	49	75/5	518	225	200	71	152	48	76	528
89	200	59	143	57	71/5	450	227	200	73	154	46	77	544
91	200	59	143	57	71/5	450	229	200	73	155	45	77/5	555
93	200	59	143	57	71/5	450	231	200	73	155	45	77/5	555
95	200	59	143	57	71/5	450	233	200	74	157	43	78/5	578
97	200	58	141	59	70/5	432	235	200	75	158	42	79	584
99	200	58	141	59	70/5	432	237	200	74	157	43	78/5	578
101	200	58	141	59	70/5	432	239	200	74	157	43	78/5	578
103	200	58	141	59	70/5	432	241	200	72	155	45	77/5	555
105	200	58	141	59	70/5	432	243	200	70	155	45	77/5	555
107	200	58	141	59	70/5	432	245	200	72	156	44	78	566
109	200	60	142	58	71	421	247	200	76	156	44	78	564
111	200	60	142	58	71	421	249	200	75	156	44	78	564
112	200	60	142	58	71	421	251	200	72	154	46	77	544
115	200	60	142	58	71	421	253	200	74	154	46	77	544
117	200	60	142	58	71	421	255	200	71	155	45	77/5	555
119	200	60	142	58	71	421	257	200	73	153	47	76/5	539
121	200	64	142	58	71	421	259	200	72	153	47	76/5	539
123	200	64	142	58	71	421	261	200	70	152	48	76	528
125	200	64	142	58	71	421	263	200	68	151	49	75/5	518
127	200	61	144	56	72	459	265	200	67	151	49	75/5	518
129	200	66	143	57	71/5	450	267	200	66	149	51	74/5	502
131	200	64	143	57	71/5	450	269	200	67	148	52	74	492
133	200	63	144	56	72	459	271	200	65	148	52	74	492
135	200	62	146	54	73	473	273	200	66	145	55	72/5	464
137	200	62	145	55	72/5	464	275	200	66	145	55	72/5	464

5. Conclusion

Micropalaeontology and biostratigraphical studies of the Gurpi Formation led to identification of 48 species belonging to 25 genera of planktonic foraminifera and to establish of 7 biozones. On the basis of the recognized planktonic foraminifera, the Gurpi Formation in the central part of the Lurestan province ranges from the Early Campanian to Late Maastrichtian. On the basis of analysis and the distribution of morphotype groups of the planktonic foraminifera, three third-order sequences were identified.

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