Original Research Paper

IJES *Iranian Journal of Earth Sciences*
Vol. 16, No. 1, 2024, 59-71.
DOI: 10.57647/j.ijes.2024.1601.05

Biostratigraphy and paleoecology of the Cenomanian – Coniacian succession in the Chenareh Anticline, West of Iran

Iraj Maghfouri Moghaddam[1*], Mehdi Farahpour[1], Ghamar Naz Darabi[1], Mostafa Dolatsha[1], Parvin Hassan Zaded[1]

1. Department of Geology, Faculty of Science, Lorestan University, Iran

Received: 19 March 2023; Revised: 29 May 2023; Accepted 3 November 2023

Abstract

In this study, a foraminiferal biozonation scheme for the Late Cenomanian – Coniacian deposits for the Lorestan basin, is proposed. Five successive biozones are recognized within the Sarvak, Surgah and Ilam formations, which in stratigraphic arrangement are Nezzazata – Alveolinids Assemblage Zone (Late Cenomanian- Early Turonian), Helvetoglobotruncana helvetica Total Rang Zone (Early- Middle Turonian), Marginotruncana schneegansi partial Range Zone (late Turonian), Diacarinella concavata Interval Zone (Coniacian), and Diacarinella asymetrica Total Zone (Santonian). Assemblages of Turonian planktonic foraminifera followed assemblages of the late- Cenomanian- early Turonian benthic foraminifera. The paleoecology of the larger benthic foraminifera suggests very shallow water (10 to 50m water depth) and oligotrophic conditions. A sharp decrease in the diversity of foraminifera, inferring an period with dysoxic situation at the sea bottom that was found in the upper part of the Sarvak Formation. The occurrence of planktonic foraminifera associated with opportunistic taxa such as the hemipelagic calcisphaerulids at early Turonian refers to a bioevent that appears to equate with the Bonarelli Cenomanian-Turonian Oceanic Anoxic Event. Commonly, the planktonic foraminiferal morphotype suggests that the depth of the basin was often more than 200 m in the Turonian to late Santonian. In the middle Santonian, biserials and non-keeled forms of the shallow water fauna (0 to 50 m) dominate foraminiferal assemblages.

Keywords: *Cenomanian, Santonian, Biostratigraphy, Foraminifera, Lorestan*

1. Introduction

The Lorestan zone, in Zagros Basin, is an important petroleum basin that hosts the giant Maleh Kuh and Sarkan oil fields (Motiei 1998). The upper Cretaceous Bangestan Group Formation contains some of the hydrocarbon source, reservoir, and cap rocks (Ghazban 2007). Commonly, sea surface fluctuation are the most significant factor in the formation and distribution of oil reserves. The highest global sea level in Cenozoic was reported in the Cenomanian- Turonian periods (Sharland et al. 2001). Rising global sea surface and the beginning of anoxic conditions in the oceans have caused drastic changes on some benthic and planktonic foraminifera (Boudagher-Fadel 2013). Major bioevents in foraminiferal evolution are isochronous from the Mediterranean to the Far East. The stratigraphical spans of the foraminiferal taxons in the Mediterranean region are highly similar to the Bangestan Group. Except in some conditions where fossil diversity is very low. By studying the microfossils of the Bangestan Group, a chronostratigraphic framework can be drawn for it and its geological record can be compared with global events. however there have been some biostratigraphical investigations in the Cenomanian – Coniacian deposits of the Southern Zagros (e.g., Ghabeishavi et al. 20009, 2010; Hajkarimi et al. 2012; Afghah et al. 2014; Agahah and Fadei 2015; Reza 2020; Dehghanian and Afghah 2021; Dousti Mohajer et al. 2021a ; Dousti Mohajer et al. 2021b; Shapourikia et al. 2021), there are only a few published stratigraphic information for the Lorestan Zone (e.g. Maghfouri Moghaddam 2017).

----

*Corresponding author.
E-mail address (es): irajmmms@yahoo.co.uk

This paper deal with on the litho-biostratigraphy and bioevents of the Late Cenomanian – Coniacian successions outcropping in the Chenareh anticline, southwestern Iran.

2. Methods

The studied section of the Bangestan Group is located 108 km southwest of Khorram Abad,32° 53′ 22″ N/ longitude 48° 7′ 25 ″E. For this research, 175 hard surface samples were treated and investigated for foraminifera taxons. The foraminifera were identified by their morphological characteristics in thin sections. Following the identification of the microfauna in each sample, a range chart was developed. Wynd (1965) introduced the first assemblage zones for the Zagros Basin, which was based mainly on benthic foraminifera. The biozone of the lower part of Bangestan group in Chenareh anticline was offered on the wind biozone (1965). The herin classification of planktonic foraminifera follows Caron 1985; Robaszynski and Caron 1995 and Premoli Silva and Verga 2004.

3. Regional stratigraphy

The Zagros basin lies along the northeastern edge of the Arabian plate, extends over nearly 1600 km from northeastern Syria and northeastern Iraq through northwestern Iran, and carry on into southeastern Iran (Fig 1a). The Lorestan Zone is a northwest part of the Zagros basin. The Chenareh anticline is 65 km long by 6 km wide, trending NW-SE direction, situated at southeastern Lorestan Zone (Fig 1b).

The Chenareh anticline is a gentle symmetrically shaped anticline. The northwestern end of this anticline is called

Kialu (Fakhari et al. 1998). It contains Sarvak, Surgah, and Ilam formations. The Bangestan Group is exposed in the central axial portion of the structure.

The Sarvak Formation in the center of the Chenareh anticline consists of 195m light grey medium to thick-bedded limestone. The lower limit of the Garau Formation is not exposed in this section. Its upper boundary with the Surghah Formation is conformable. The thickness of the Surghah Formation in this section is up 15 m and contains of light grey thin- to medium-bedded argillaceous limestone. Its upper limit with the Ilam Formation is conformable. The thickness of the Ilam Formation in the Chenareh section is 42.20 m and consists of white and light grey medium to thick - bedded limestone. The Gurpi Formation (140 m) lies conformably on the Ilam Formation (Fig1c).

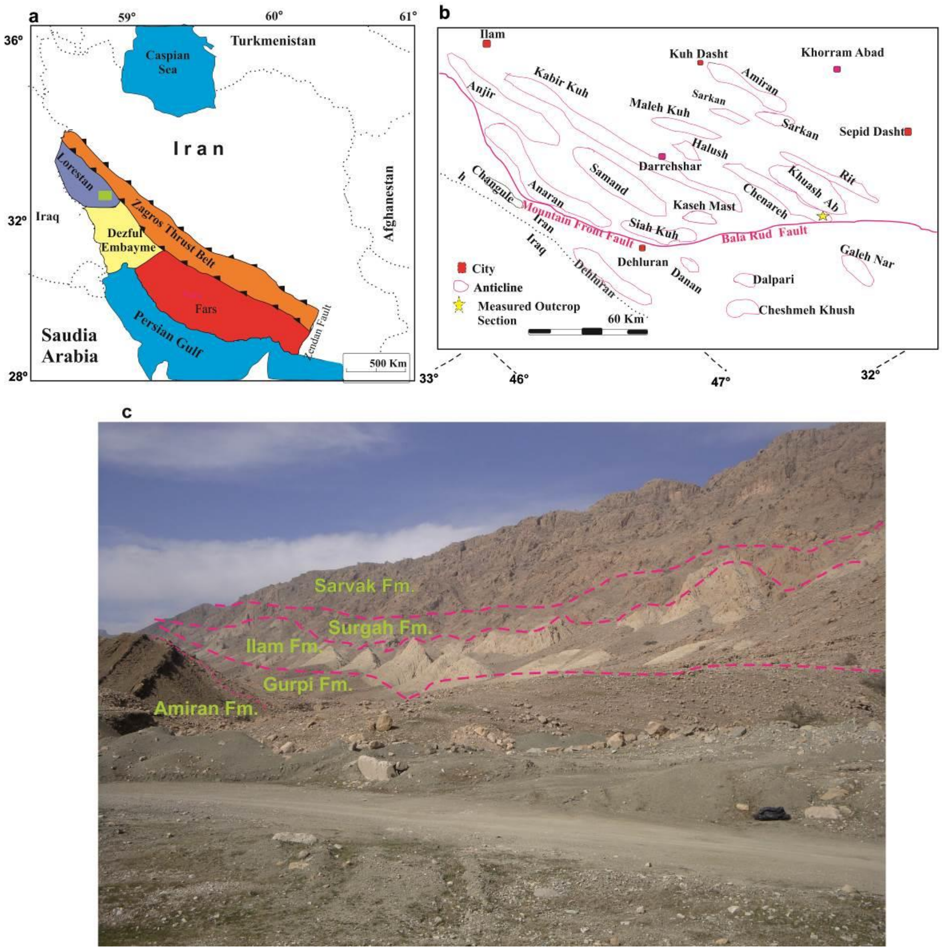

Fig 1. a) Divisions of the Zagros Basin (modified after Heydari 2008).; b) Location map of the Chenareh anticline in the Zagros Basin (modified after Farzeipour-Saein et al. 2009); c) Outcrop photograph of the Chenareh anticline (View to the NE)

4. Biostratigraphy

Biostratigraphic subdivisions of the late cretaceous deposits in the Zagros Basin are mainly based on planktonic and benthic foraminifera. Bed-by-bed sampling at the Chenareh anticline for biostratigraphic studies direct to the distinction of 23 genera and 17 species of benthic foraminifera (Fig 2), with 12 genera and 41 species of planktonic foraminifera (Fig 3). Vertical stratigraphic ranges of the foraminifera have led to the distinction of five combined benthonic and planktonic foraminiferal biozones (Fig 4). The proposed foraminiferal biozones are correlated with their equivalents inside Zagros and outside Zagros especially in the Mediterranean realm (Table 1). The biostratigraphic zones are briefly described below:

***Nezzazata* – Alveolinids Assemblage Zone**

Representatives of the benthic foraminifera characterize this biozone in lower portion of the Sarvak Formation, which extends for about 190 meters. Lithology this biozone comprises of light grey medium-bedded limestone. Microscopic researchs present the periodicity of bioclastic wackestone – packstone and pellet bioclast wackestone as main sub- facies of this biozone. Rarely bioclastic rudist grainstone occurs. The most characteristic microfossils associated with this biozone are as follows:

Biplanata sp., *Cisalveolina frassi* (Gumbel 1872), *Chrysalidina gradata* (D'orbigny 1839), *Dicyclina schlumbergeri* (Munier– Chalmas 1887), *Edomia* sp., *Mangoshtia viennoti* (Henson 1948), *Nezzazata concava* (Smout 1956), *Nezzazata conica* (Smout 1956), *Nezzazata simplex* (Omara 1956), *Nezzazatinella picardi* (Henson 1948), *Nummoloculina heimi* (Bonet, 1965), *Nummoloculina reularis* (Philips 1846), *Praechysalidina* infracretacea (Lupertosinni 1979), *Peneroplis turonicus* (Said & Kenawy 1957), *Praealveolina* sp., *praetaberina bangsitani* (Henson 1948), *Psedolituonella reicheli* (Marie 1955), *Simplalveolina simplex* (Reichel 1937), *Spiroloculina cretacea* (Reuss 1854), *Triloculina trigonula* (Lamarck 1804) , *Dictyocouns* sp., *Textulaia* sp., *Quinqueolina* sp. These benthic foraminifera are introduced in Cenomanian deposits of other stratigraphic sections in the Zagros Basin by many paleontologist (e.g., Khosrow Tehrani and Fonooni,1994 and Afgah et al. 2014. Filikon and Scott (2011) documented *Nummoloculina heimi* (Philips 1846) and *Nezzazata conica* (Smout 1956) as upper Cenomanian index taxon, from southern Mexico. In the studied section, vanishing of *Nezzazata conica* (Smout 1956) and *Nezzazata simplex* (Omara 1956) is contemporaneous with the first emersion of planktonic foraminifers likewise *Helvetoglobotruncana* and *Marginotruncana.* Furthermore, Orabi et al. (2012) documented *Nummoloculina heimi* (Philips 1846) in Middle - Upper Cenomanian association of Mexico. Similar data was documented from in a central Italy succession by Chiocchini et al. (2004) and by Sari et al. (2009) in the Middle to Upper Cenomanian sdeposits in southwestern Turkey.

Table 1. Correlation scheme of the recorded foraminiferal biozones for the peri-Mediterranean Upper Cretaceous limestone with the fixed Upper Cretaceous foraminiferal biozonation for the Chenareh anticline (Time measure is adapted from Gradstein et al. 1994).

Age (Ma)	Stage	Tethys (Hardenbol et al., 1998) Zones	Tethys (Hardenbol et al., 1998) Datums	Paris basin Robaszynski & Caron (1995)	Tethys Caron (1985)	Tethys Premolisilva & Verga (2004)	Central Anatolia Sariaslan (2017)	NW Iraq Jeff et al. (2015)	Fars Vaziri Moghaddam et al. (2002) Dehghanian & Afgah (2021)	SE Lorestan This study
82; 83.5	Campanian	*G.elevata*	*G.elevata* 83.5	*G.elevata*	*G.elevata*	*G.elevata*	*G.elevata*	*G.elevata*	*G.elevata*	*G.elevata*
84; 85.8	Santonian	*D.asmetrica*	*D.asmetrica D.concavata*; *D.asmetrica* 84.9	*D.asmetrica*	*D.asmetrica*	*D.asmetrica*	*D.asmetrica*	*D.asmetrica*	*D.asmetrica*	*D.asmetrica*
86; 88; 89.0	Coniacian	*D.concavata*	*w. archaeocretacea* 89.59	*D.concavata*	*D.concavata*; *D. primitiva*	*D.concavata*	No Coniacian species were observed	*D.concavata*	*D.concavata*	*D.concavata*
90; 92	Turonian	*D.concavata*; *M. sheenganzi*; *H.helvetica*	*D.concavata* 90.65; *H.helvetica* 91.31; *H.helvetica* 93.29	*M. sheenganzi*; *H.helvetica*	*M.sigali*; *H.helvetica*	*M.sigali*; *H.helvetica*	*H.helvetica*	*D. primitiva*; *M. sheenganzi*; *H.helvetica*	Hiatus	*M. sheenganzi*; *H.helvetica*
93.5; 94	Cenomanian	*w.archaeocretacea*							*Pseudolituonella reicheli*	*Nezzazata* – Alveolinids

Nezzazata – Alveolinids Assemblage Zone is similar to upper *Pseudolituonella reicheli – Pseudorhapydionina dubia* Zone in Western Taurides , Turkey (Sari et al., 2009), the upper part of the *Pseudorhapydionina dubia – Biconcava bentori* Zone in the Bolkar Mountains, south Turkey (Tasli et al. 2005), the middle part of the *Vidalina radoicicae– Chrysalidina gradata* Concurrent-Range Zone in the Adriatic region (Vellic 2007), the middle part of the *Chrysalidina gradata – Pseudolituonella reicheli* Zone in Italy (Mancinelli and Chiocchini 2006), the upper part of the *Nummofallotia apula- Pseudorhapydionina- Nummoloculine* Zone in Tunisia (Gargouri and Razgallah,1983), the upper part of the *Praealveolina cretacea* of Spain-France (Bilotte 1985), and the upper part of the *Nezzazata conica - Chrysalidina* sp. Assemblage Zone and the *Nummoloculina heimi* Zone in the Fars area (Afgah et al, 2014).

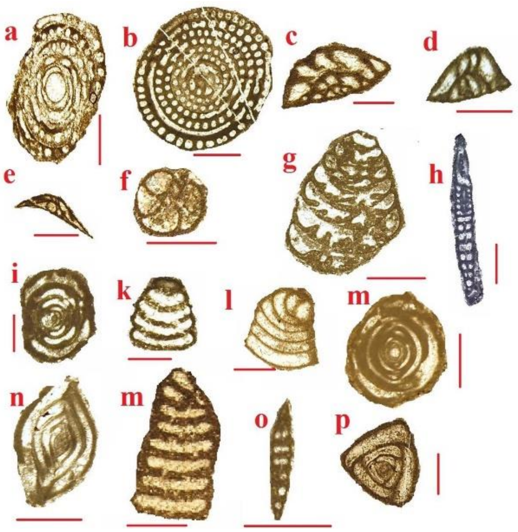

Fig 2. Benthic foraminifera recognized in the studied section, Scale bars represent 0.1 mm. a) *Simplalveolina simplex* (Reichel 1937), Axial section, sample no. 70; b) *Cisalveolina frassi* (Gumbel 1872), Axial Section, sample no. 72; c) *Nezzazata simplex* (Omara 1956), Axial section, sample no. 98; d) *Nezzazata conica* (Smout, 1956), Axial section, sample no. 98; e) *Nezzazata concava* (Smout 1956), Axial section, sample no. 56; f) *Nezzazatinella picardi* (Henson 1948), Axial Section, sample:35; g) *Chrysalidina gradata* (D'orbigny 1839), Axial section, sample no. 86; h) *Mangashtia viennoti* (Henson 1948), Axial section, Sample no. 36; i) : *Nummoloculina reularis* (Philips 1846), Axial section, sample no. 66; k) *Praechrysalidina infracretacea* (Lupertosinni 1979), Axial section, sample no. 66; l) *Peneroplis turonicus* (Said and Kenawy 1957), Axial Section, sample no. 73; m) *Nummoloculina heimi* (Bonet 1965), Axial section, sample 37; n) *Spiroloculina cretacea* (Reuss 1845), Axial section, sample no. 67; 0) *Psudolituonella reicheli* (Marie 1955), Axial section, sample no. 99; p) *Biplanata* sp., Axial section, sample no. 89; q) *Triloculina trigonula* (Lamarck 1804), sample no. 89, Axial Section.

Helvetoglobotruncana helvetica Total Range Zone (Sigal 1955)

This biozone is 7 m-thick in the Sarvak Formation and possess of mudstone and, and characterized by mudstone and argillaceous limestone with cherty nodules (Fig. 4). The emersion of large and robust planktonic foraminifera, like *Marginotruncana coronata* (Bolli 1945), *M. marginata* (Reuss 1845), *M. renzi* (Gandolfi 1942), falls within this zone. The non-foraminifera community possesses *Calcisphaerula innominata* (Bonet 1956) and *Pithonella ovalis* (Kaufmann) and rudist fragments. The total range of the zonal markers *Helvetoglobotruncana helvetica* (Reiss 1957) defines this biozone. The lower limit of this biozone in the Chenareh anticline and NE Iraq (Kurdistan area) concurrent with the facies variation with the underlying *Nezzazata* – Alveolinids Assemblage Zone, and the unconformable boundary with the Balambo and Qamchuqa formations, respectively. The late Cenomanian- early Turonian period was one of the widespread regression, non-deposition or erosion associated with major inversion in most if not all the Zagros Orogenic Belt, with a marked disconformity. It is unknown, hence, if the lower part of the biozone in the studied section and NE Iraq as determined level out to the global Lower occurrences of *H. helvetica* (Jaff et al. 2015). According to Sariaslanan (2017), the Cenomanian- Turonian border is not coincident with a main lithology variation in the Haymana- Polatli basin (Central Anatolia), and placed at the lowest occurrence of *Helvetoglobotruncana helvetica*. The *H. helvetica* total-range zone is assigned to the early to middle Turonian (Caron et al. 2006; Ogg , Huber and Petrizzo, 2014; Vahidinia et al. 2014).

Marginotruncana scheengansi partial Range Zone (Robazynski and Caron 1995)

This biozone is known in the upper fragment of the Sarvak Formation, which is investigated by the partial range zone of *Marginotruncana scheengansi* (Sigal 1952) from the last occurrence of *Helvetoglobotruncana* to the first occurrences of *Diacarinella concavata* (Brotzen 1934). This interval is also known in the literature as the *Marginotruncana sigali* Zone (Barr 1972), and the *Diacarinella primitiva* — *Marginotruncana sigali* Zone (Premoli Silva and Sliter 1981). This biozone is made of 7.5 m of brown medium-bedded limestone in upper part of the Sarvak Formation, which is combined alternately of intraclast and bioclast wackestone. The investigated foraminifera associations of this biozone comprise: *Diacarinella primitiva* (Delbiez 1955), *Gublerina* sp., *Marginotruncana scheengansi* (Sigal 1952), *Marginotruncana coronata* (Bolli 1945), *M. marginata* (Reuss 1845), *M. renzi* (Gandolfi 1942). The non-foraminifera assemblages include *Calcisphaerula innominata* (Kaufmann 1865) and *Pithonella ovalis* (Kaufmann 1851). This biozone is attributed to the Late Turonian (Caron 1985).

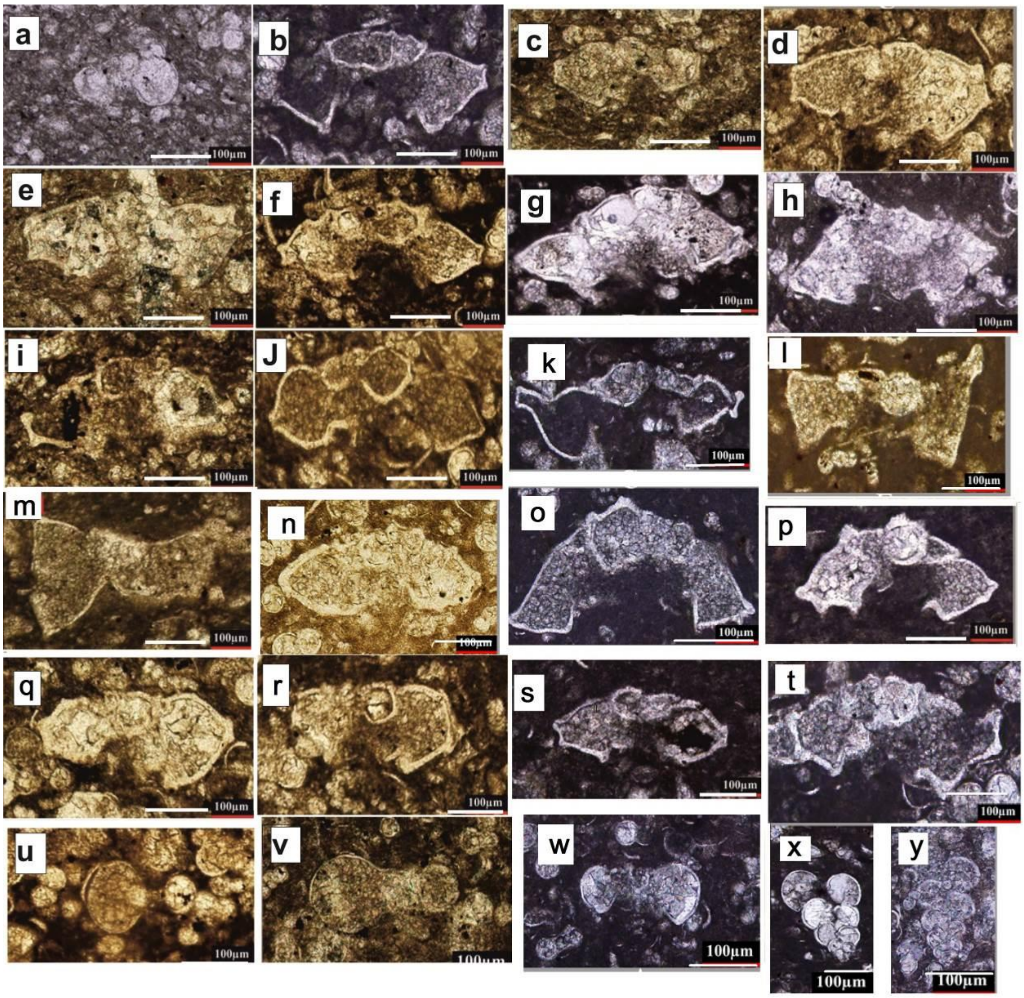

Fig 3. Planktonic foraminifera recognized in the Chenareh anticline. a) *Helvetoglobotruncana helvetica* (Bolli 1945), sample no. 122, x75; b) *Marginotruncana coronata* (Bolli 1945), Sample no. 150, x75, c) *Marginotruncana marginata* (Reuss 1845), sample no. 139, x75; d) *Marginotruncana pseudolinneiana* (pessagno 1967), sample no. 138, *Dicarinella asymetrica* x7, e) *Marginotruncana paraconcavata* (Porthault 1970), sample no. 137,x75, f) *Marginotruncana renzi* (Gandolfi 1942), sample no. 134 x75; g) *Marginotruncana schneegansi* (Sigal 1952), sample no. 155, x75, h) *Marginotruncana sigali* (Reichel1950), sample no. 142, x75; i) *Marginotruncana sinousa* (Porthault 1970), sample no. 131, x75, k) *Dicarinella primitiva* (Dalbiez 1955), sample no. 150, x75, l) *Dicarinalla concavata* (Brotzen 1934), sample no. 138, x75; m) *Dicarinella asymetrica* (Sigal 1952), sample no. 150,x75; n) *Praeglobotruncana algeriana* (Caron 1966), sample no. 138, x75, o) *Contusotruncana patelliformis* (Gandolfi 1955), sample no. 171, x75 ; p) *Contusotruncana fornicata* (Plummer 1931), sample no. 170, x75; q) *Globotruncana bulloides* (Vogler 1941), sample no. 154, x75; r) *Globotruncana linneiana* (d` Orbigny 1839),sample no.137, x75; s) *Globotruncana mariei* (Banner and Blow 1960), sample no. 142, x75, s) *Globotruncana lapparenti* (Brotzen 1936), sample no.153, x75; t) *Globotruncana arca* (Cushman 1926), sample no.156, x75, u) *Globigerinelloides bollii* (Pessagno, 1967), sample no. 135, x75, v) : *Globigerinelloides ultramicrus* (Subbotina 1949), sample no. 136, x75; w) *Muricohedbergella holmdelensis* (Olsson 1964), sample no.141, x75; x) *Heterohelix globulosa* (Ehrenberg 1840), sample no.31, x75, y) *Heterohelix moremani* (Cushman 1938), sample no. 144, x75, measure bars represent 1000µm

***Dicarinella concavata* Interval Zone (Premoli Silva and Verga, 2004)**

This biozone extends in the Surgah Formation and it is characterized by 15.5 thick meters grey medium-bedded limestone. Facies considerations provided the frequency of bioclastic wackestone and lithoclast wackestone–packstone. The interval zone from the first outbreak of *Dicarinella concavata* (Brotzen 1934) to the first outbreak of *Diacarinella asymetrica* (Sigal 1952) marks this biozone. The main taxons are *Contusotruncana fornicata* (Plummer 1931), *Dicarinella concavata* (Brotzen 1934), *D. primitiva* (Delbiez, 1955), *Globigerinelloides bentonensis* (Morrow, 1934) *G. bollii* (Pessagno 1967), *G. prairiehillensis* (Pessagno,1967), *Globigerinelloides ultramicrus* (Subbotina 1949), *Globotruncana linneiana* (d'Orbigny 1839), *G. lapparenti* (Brotzen 1936), *Heterohelix globulosa* (Ehrenberg, 1840) *H.* (Cushman, 1938), *Marginotruncana coronata* (Bolli, 1945), *M. pseudolinneiana* (Pessagno 1967), *M. renzi* (Gandolfi 1942), *M. scheengansi* (Sigal 1952), *M. sigali* (Reichel 1950), *M. sinuosa* (Porthault in Donze et al. 1970), *M. tarfayaensis* (Lehmann 1963) and *Muricohedbergella holmdelensis* (Olsson 1964). This biozone assigned to the Late Turonian to Early Coniacian (Premoli Silva and Verga 2004).

***Dicarinella asymetrica* Total Range Zone (Postuma 1971)**

This biozone extends in the Ilam Formation and it is characterized by 30 meters thick light grey medium-bedded limestone. Facies considerations provided the frequency of bioclastic wackestone to packstone. It is distinguished as span between the first occurrence *Dicarinella asymetrica* (Sigal 1952).

The investigated foraminifera associations of this biozone include: *Anomalina* sp., *Archaeoglobigerina blowi* (Pessagno 1967), *A. cretacea* (d'Orbigny 1840), *Diacrinella* sp., *Dorothia* sp., *Globotruncana arca* (Cushman 1926), *G. hilli* (Pessagno 1967), *G. mariei* (Banner and Blow 1960), *G. stuartiformis* (Dalbiez 1955) *G.*sp., *Heterohelix globulosa* (Ehrenberg 1840), *Heterohelix moremani* (Cushman 1938), *Praeglobotruncana algeriana* (Caron 1966). This biozone was assigned to the Santonian (Premoli Silva and Verga 2004).

The *Globotruncanita elevata* Partial Range Zone (Postuma 1971) extends over *Dicarinella asymetrica* Total Range Zone and it consist of thin-bedded foraminifera mudstone, as measured in lower part of the Gurpi Formation. The *Globotruncanita elevata* (Brotzen 1934) Partial Range Zone shows the stratigraphical interval with *Globotruncanita elevata* (Brotzen 1934), from the last development (LA) of *Dicarinella asymetrica* (Sigal 1952) and the first development (FA) of *Globotruncana ventricosa* (White 1928). It is Early Campanian in age (Caron1985; Premoli Silva and Verga 2004).

5. Benthic foraminifera paleoecology

Foraminifera are the most numerous amoeboid protozoans in the marine environments. The paleoecological conditions are important factors (Geel 2000).

Pursuant the Late Albian, the early Cenomanian is signed by the highest benthic foraminifera turnover in the Cretaceous (Boudagher Fadel 2008). In lower part of the chenare section, the benthic foraminifera association in the upper Cenomanian deposits is dominated by *Nezzazata simplex* (Omara 1956), *Nezzazatinella picardi* (Henson 1948), and *Chrysalidina gradata* (D'orbigny 1839), which have wide paleogeographic distribution (Shahin and Elbaz 2013). These huge agglutinated foraminifera and rare calcareous benthic foraminifers lived in the inner ramp and shoals (10 to 50m water depth in the photic zone, Gräfe 2005). The abundance and diversity of benthic foraminifera showed that there was a better water circulation, along with the presence of more oxygen and nutrient during deposition of lower sector of the Sarvak Fm., as Van Der Zwaan et al. (1999) stated it.

Diminution of benthic foraminifera, echinoids and calcispheres in the upper part of the Sarvak Formation replaces an association of benthic foraminifera, coral and rudist. This transition can also be a signal of nutrient moving from oligotrophic to mesotrophic conditions. As Hallock (1987) showed, the rate of nutrient supply by terrestrial runoff or marine upwelling is the first qualifying system for benthic communities in shallow tropical seas.

A sharp reduction in the variety of foraminifera was also found in the upper part of Sarvak Fm. Scant variety foraminiferal associations inferring a period with dysoxic situation in the sea bottom were showed in several sections in Italy (Coccioni and Luciani 2004; GhasemShirazi et al. 2014) and Japan (Kaiho 1994).

In the studied section, the upper Cenomanian extinction has happened in two successive stages.

In the first stage, the K-extreme benthic foraminifera as the alveolinds disappeared while in the second stageall the soritoideans and many agglutinate foraminifera disappeared. Parente et al. (2008) showed at that least in southern Italy, where shallow- water carbonate sedimentation was continuous through the Cenomanian-Turonian border transition , the extinction occurred in two successive phases phases separated by 150ky.

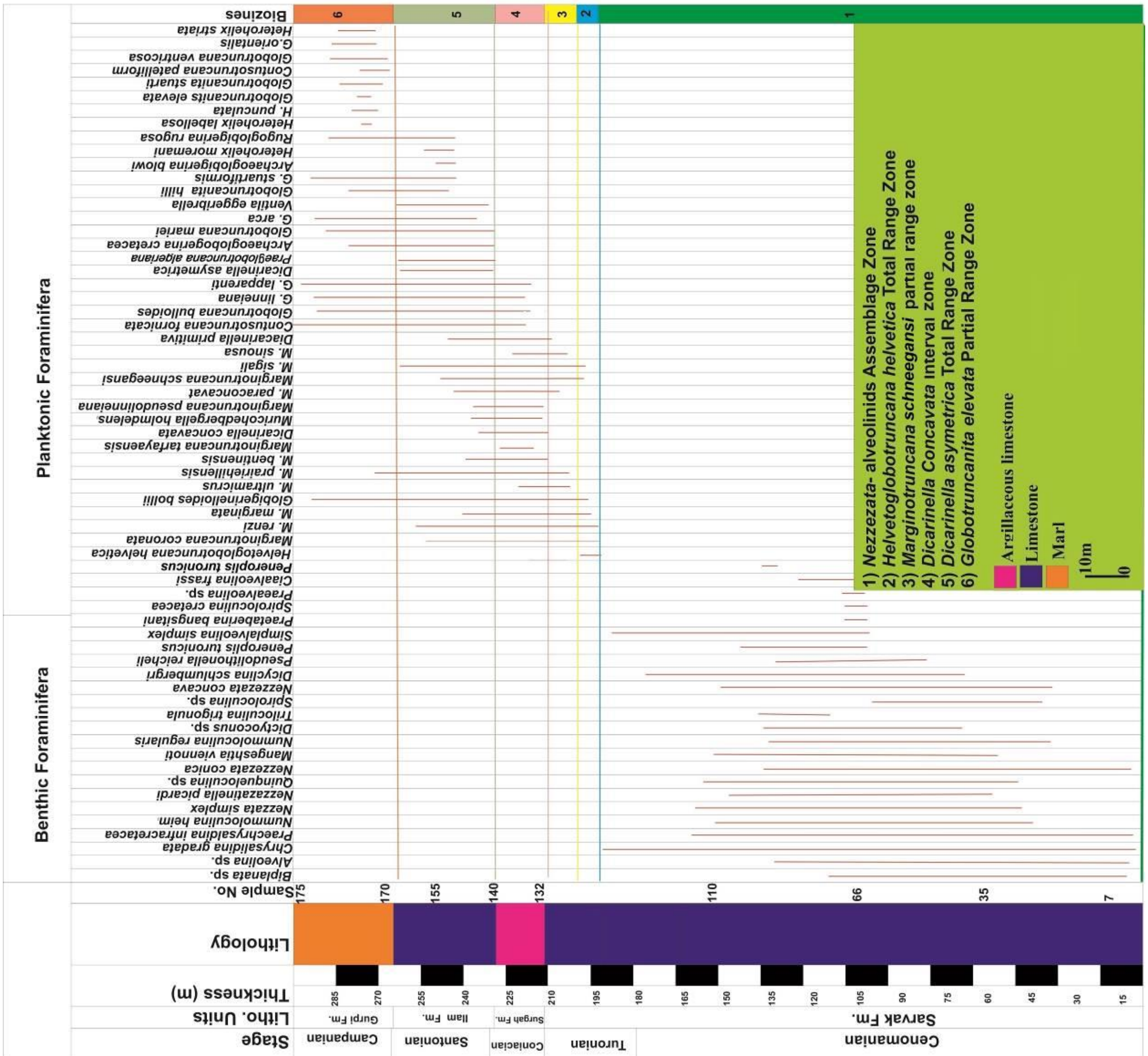

Fig 4. Biostratigraphic column of the Chenareh anticline

6. Planktonic foraminifera paleoecology

Previous studies of pelagic morphological groups by Sliter and Baker (1972) showed that the Cretaceous planktonic foraminifera were distributed in the upper water column as follows: the inflated, simple morphotypes generally inhabited the shallowest waters (> 100m) while the keeled, specialized morphotypes inhabited the deepest waters (>100 m).

The planktonic foraminiferal assemblage of the Bangestan Group in the Chenareh anticline allowed distinguishing three different morphotypes:

1) The first morphotype opportunist foraminifera indicating shallow waters (0 to 50 m). They have a upright test such *Heterohelix* and *Hedbergella*, and/or a trochospiral test with spherical chambers such as *Globogerinelloides* (Abramovich et al. 2003).

2) The second morphotype consists of taxa with trochospiral genera and compressed chambers an initial keel, such as *Archaeoglobigerina*, which lived from 50 to 100 m below the water surface.

3) The third morphotype comprises genera, which generally lived in water depths from 100 to 200 m. They have keeled trochospiral tests with compact chambers such as *Marginotruncana*.

The species of the morphotype 2 are less abundant in Chenareh anticline; thus, this morphotype cannot be used to determine sea level fluctuations. Instead, the ratios of species belonging to morphotypes 1 and 3 ratio were used (Fig 5).

Planktonic foraminiferal habitats change by geological activities, such as obduction of ophiolite and large igneous province volcanism (Boudagher-Fadel, 2013). They commonly have two types of strategy in their life, the R strategy and the K strategy, respectively. These strategies are r and K-strategy. R- Strategy species, such as belonging to the Hedbergellids and Heterohelicids, are modest ecological opportunists, which principally operate to maximize reproductive rates in an unstable environment, where only modest competition exists.

K- strategy species are highly diverse, well-ornamented, such as *Marginotruncana*, *Contusotruncana*, *Globotruncana* and *Globotruncanita*. These taxonomically complex taxa become more stable and diverse under optimum such as enough food supply, oligotrophic environments, etc. Important changes in the ecosystem cause their decline in normal environmental conditions; K-strategists could not adapt to these hostile conditions, starting to decline, while a sudden increase of opportunistic species, the r- strategist, is noted.

There are also intermediate strategists with tendency towards both K- and R-strategists (R/K strategists). They are observed in low-oxygen environments and optimum conditions assemblages (Premoli Silva & Sliter 1994). The more K-selected of the K/R intermediates include trochospiral, keeled *Dicarinella* and *Helvetoglobotruncana*. The more r-selected R/K intermediates include semitrochospiral *Archaeoglobigerina*. The R/k intermediate morphotypes typify mesotrophic environments, chiefly in mid-latitudes, with the most complex morphotypes (more K-selected R/K intermediates) holding the most oligotrophic portion of the mesotrophic spectrum, and the least complex (more R-selected R/K intermediates) living closer to the eutrophic end of the spectrum. (Petrizzo 2002).

Species of the more r-selected R/K intermediates showed low plenty in the Chenareh section; thus, this morphotype cannot be used for the sea- level changes. To determine the sea level changes in the studied area, the species of K, R, and K/R strategies were used.

Through the Turonian to early Campanian deposits in the studied area, the following four separate period have been perceived as being linked to periodic steps of instable situation to well-stratified level waters as investigated next sections for each of them.

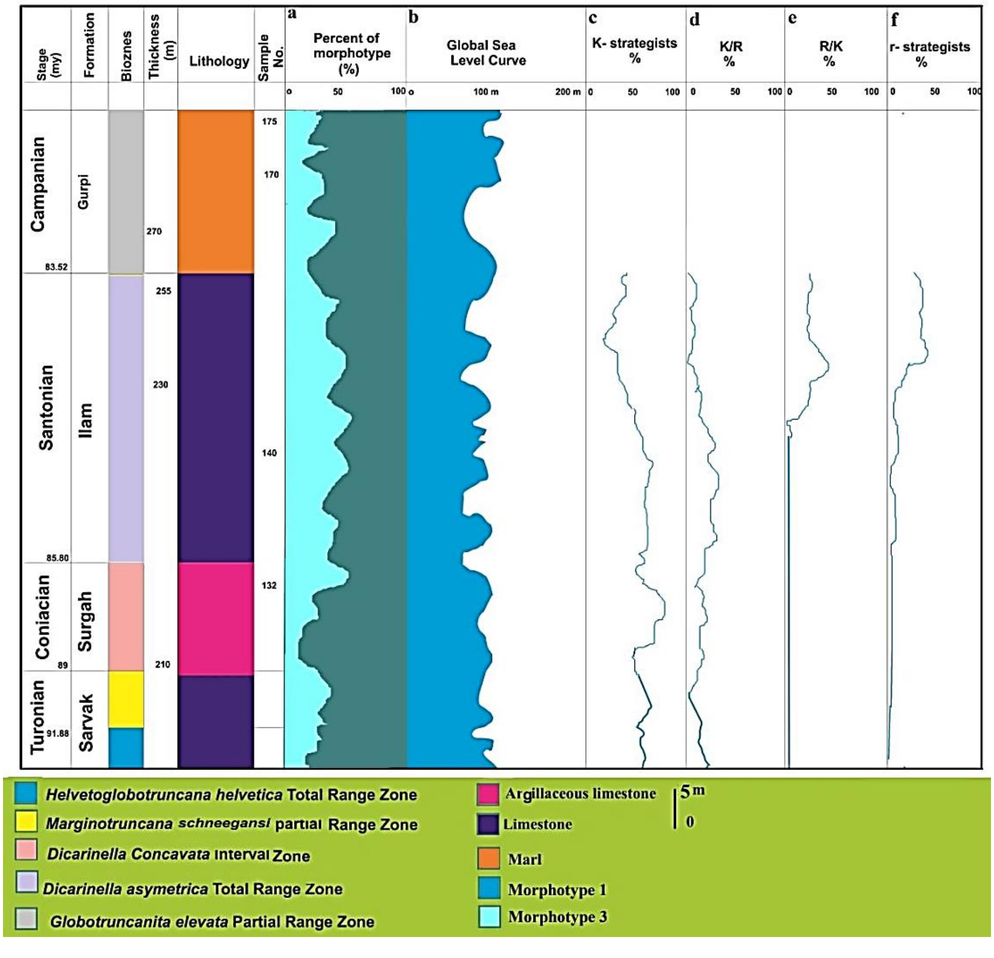

Fig 5. rRepresentations used for the assessment of sea-level fluctuations in the Chenareh anticline. a: amount of morphotype 3; b Eustatic curves (after Haq et al. 1987); c : Planktonic foraminifera variety of the total k-strategists; d: Planktonic foraminifera diversity of the total r/k intermediates; e: Planktonic foraminifera diversity of the total k/r intermediates; f: Planktonic foraminifera diversity of the total r-strategists.

Period one

From the *Helvetoglobotruncana helvetica* Zone to the basal part of the *Marginotruncana schneegansi* partial range zone. Assemblages are dominated by the k-strategists and the more k-selected k/r intermediates throughout (Fig. 6).

Strongly developed keels and compact chambers characterize Helvetoglobotruncanids and Marginotruncanids, which first appear in the Turonian. The planktonic foraminiferal assemblages that occupy depths from 100 up to 200 m show a lengthy lifetime and a little reproductive possible pattern of a more firm oligotrophic conformation.

The occurrence of planktonic foraminifera associated with opportunistic taxa such as the hemipelagic calcisphaerulids in upper part of Sarvak and Surgah formations refers to a bioevent related to the Cenomanian-Turonian Oceanic Anoxic Event, called in Europe as the “Bonarelli Event” (Boudagher Fadel 2013). It is concerning to the earliest stages of platform submerging in the latest Cenomanian (Walliser 1996). This event can have been generated by basaltic eruptions (Courtillot and Renne 2003), which would have been attached with a high releasing of CO_2 contributing to the global warming (Boudagher 2008). In northeastern Iraq, the lower Turonian pelagic sediments include the oligosteginal Dokan Fm. deposited on top of the Qamchuqa reefal margin and in basinal positions to the northeast, on the uppermost Balambo Fm. (Sharland et al. 2001).

Period two

From the upper sector of the *Helvetoglobotruncana helvetica* Zone to the basal sector of the *Dicarinella concavata* Interval Zone. Expanding k-strategists characterize the interval. The quick variegation and increment in the number of specimens of *Marginotruncana* may be explained in respect of a rise in temperature, associated with a low improvement in stratification of waters outcoming in the development a fix oligotrophic condition (Petrizzo 2002).

Period three

From the basal part of the *Dicarinella concavata* Interval Zone to the middle part of the *Dicarinella concavata* Interval Zone. Planktonic foraminifer diversity increases from the basal part of the Surgah Fm. This signal is global, related to an extensive transgression of the sea. This transgression reached in the study area in the earliest Santonian. To the southeast (i.e., Fars Zone and the northern Persian Gulf), Santonian shales of the Laffan Member overlie the eroded surface of the Sarvak Fm. The latest Turonian regional unconformity records the initiation of the ophiolites obduction onto Arabian plate (Alavi 2007). In the Chenare anticline, the Turonian unconformity is not expressed, but raising of the ophiolites source areas caused a renovated influx of colloidal sediments over large parts of the Lorestan basin in the Turonian (Farzeipour-Saein et al. 2009).

The periodis characterized by the multipling of species and plenty of the more K-selected K/R intermediates (Dicarinellids). Presences of assembled morphotypes (K-strategists in addition the more K-selected K/R intermediates) suggest the presence of a separate blended layer, and a more oligotrophic environment in the mesotrophic spectrum.

Period four

From the middle part of the *Dicarinella concavata* Interval Zone to the *Globotruncanita elevata* Partial Zone. The k-strategists and more k-selected k/r intermediates (Dicarinellid) slowly enhancement in quantity throughout. This affirmative summit is linked to the variegation of *Marginotruncana* with the emersion of *Contusotruncana fornicata* (Plummer 1931) and *Globotruncana bulloides* (Vogler 1941). The rapid diversification of *Marginotruncana* and the increasing abundance of globotruncanids, could have been linked to an increment in temperature outcoming in a fix oligotrophic condition. On the other hand, the abundance of *Archaeoglobigerina cretacea* (Pessagno, 1967) offers that near-surface waters practiced high nutrient levels concurrently.

A signed shift in planktonic foraminiferal association composition on in middle part of the Ilam Fm. is attributed to paleoecological changes in the upper water column. Assemblages dominated by biserials and non-keeled forms of *Archaeoglobigerina cretacea* (d’Orbigny 1840) and *Heterohelix moremani* (Cushman 1938), component of the shallow water fauna (0 to 50 m, Abramovich et al. 2003) succeeded assemblages dominated by trochospiral morphotypes. *Heterohelix* was a eurytopic surface- dweller, tolerant of the variable mixed surface- layer in epicontinental areas (Leckie 1987).

7. Discussion

In the studied sections, the Sarvak, Surgah and Ilam formations showed continuous upper Cenomanian – Coniacian series, without any gap of characteristic biozones. The upper Cenomanian indicated by *Nezzazata* – Alveolinids Assemblage Zone. This biozone is defined as the interval from the local first occurrence of *Nezzazata* to the last occurrence of alveolinids (James & Wynd 1965). However, the first occurrence of *Nezzazata* in the Fars Zone is recorded in a lower level (Afgah et al. 2014; Dousti Mohajer et al., 2021a, b and Dehghanian and Afghah, 2021), probably due to missing interval(s) in the lower Sarvak Fm. in the Chenareh anticline.

The lower and middle Turonian were indicated by *Helvetoglobotruncana helvetica* Total Range Zone and *Marginotruncana scheengansi* partial Range Zone, respectively. Following the deposition of upper Sarvak in the Late Cenomanian, the Fars zone was uplifted and eroded during a coincident Turonian relative decline in the sea level. This uplift resulted of the ophiolite obduction on the northeast Zagros Zone (James and

Wynd 1965). Simultaneously the abrupt shift of shallow facies to deep marine deposits in the upper Sarvak Fm. in the Chenareh anticline shows sinking of the carbonate platform in the Zagros Orogenic Belt, in the late Cenomanian. This transgression is represented by pelagic sediments in the upper part of the Sarvak Fm., in the Surgah and Ilam formations, deposited on top of lower part of the Sarvak Fm.

The Surgah Fm. contains *Dicarinella concavata* Interval Zone in the studied section. Outside of Lorestan Zone, Fars and Dezful Embayment Zones, this bizone is the first deposits identified above the major middle Turonian unconformity, which marks the base of the Ilam Fm. During this period, a significant shift in the sedimentation scheme on the Arabian plate happen, so the Arabian plate marked a change from an extensional passive to a compressional active margin in the neo-Tethys ocean (Sharland et al 2001). A foreland basin created between the Arabian and Iranian plates (Piryaei et al. 2010). This time defined by the increasing number of Diacarinids, and it was deposited in deepnvironment within the Coniacian.

The latest Coniacian - Santonian Ilam Fm. was indicated by Dicarinella concavata Interval Zone. The Ilam Fm. has been traced through a significant part of the Zagros Basin. It is consists of two different facies: in Lorestan it is mainly represented by a deeper – water facies while in Fars and Dezful Embayment both the Shallow – water and deeper – water facies may be found (Setudehnia 1972). Its shallow – water facies are typically wackstone and packstone dominated by benthic foraminifera.

Facies analysis in southern parts of the Dezful Embayment indicated that the Ilam Fm. has been deposited in four facies belts: inner ramp (containing shoal facies and open to restricted lagoons), mid-ramp (including channels and patch reef talus facies), outer ramp and basin (Mehrabi et al. 2013).

In the Lorestan Zone, the Ilam carbonate represents forebulge deposits onlaping back-bulge deposits during prograde south- westward migration of proforeland depozones (Alavi, 2007). In the Chenareh section, the middle Santonian is defined by the coexistence of Dicarinellids, Globotruncanids, and Heterohelicids. The disappearance of the genus *Marginotruncana* coincided with the progressive increase in diversity of the keeled forms (*Globotruncanita* and *Contusotruncana*) , and a slight increase of the genus *Heterohelix*. This assemblage suggests that water masses were unstable and characterized by a predominant mesotrophic regime ranging from relatively eutrophic during seasonal bloom to oligotrophic when upwelling (or runoff) decline (Petrizzo 2002). Keeled trochospiral test with compact chambers such as *Diacariinella asymetrica* (Sigal 1952) are dominant in the Illam Fm., which represents a eutrophic deep marine environment.

8. Conclusions

Precise studies of the various associations of late Cenomanian- Coniacian foraminifera recovered from the Chenareh section provided biostratigraphic and paleoenvironmental conclusions to be drawn as follows from older at the base:

5- *Diacarinella asymetrica* Total Zone (Santonian)

4- *Diacarinella concavata* Interval Zone (Coniacian)

3- *Marginotruncana schneegansi* Partial Range Zone (Late Turonian)

2- *Helvetoglobotruncana helvetica* Total Rang Zone (Early- Middle Turonian)

1- *Nezzazata* – Alveolinids Assemblage Zone (Late Cenomanian- Early Turonian)

Based on the faunal elements, carbonate sediments of the Sarvak Fm. were deposited in an inner ramp environment. Benthic foraminifer suggests a sharp decrease in the diversity trend in the Sarvak Fm. in the Late Cenomanian. The upper Cenomanian extinction occurred at two consecutive phases in the studied section. In the first phase, alveolinids disappeared while in the second phase all the soritoideans were eliminated. Furthermore, the very manifold planktonic associations (Biozone 2 to 5) with many K-selected taxons indicate that the Lorestan Zone was a deep oligotrophic to mesotrophic basin during the early Turonian and the late Coniacian. A significant sea-level regression occurred near the middle part of the Coniacian for a short period.

Acknowledgement

This article is part of a M.S study by A Mostafa Dolatsha and Parvin Hassan Zadehat Lorestan University. We are thankful to Mostafa Sedaghat for his help during the fieldwork. The authors wish to thank the Deputy of Research and Technology of Lorestan University for their financial support. We are thankful to Mostafa Sedaghat for his help during the fieldwork. In addition, we appreciate the IJES referees for their constructive remarks.

References

Abramovich S, Keller G, Stuben D, Berne, Z (2003) Characterization of late Campanian and Maastrichtian planktonic foraminiferal depth habitats and vital activities based on stable isotopes, Palaeogeography, Palaeoclimatology, *Palaeoecology 202: 1-29.*

Afgah M, Fadaei HR (2015) Biostratigraphy of Cenomanian succession in Zagros area (southwest of Iran), *Geosciences Journal 19: 257 – 271.*

Afghah M, Yousef Zadeh A, Shirdel S (2014) Biostratigraphic Revision of Middle Cretaceous Succession in South Zagros Basin (SW of Iran), *Earth Science & Climatic Change's 5: 2-10.*

Alavi M (2007) Structures of the Zagros fold–thrust belt in Iran, American, *Journal of Science 307: 1064-1095.*

Bilotte M (1985) Le Crétacé supérieur des plates-formes est-pyrénéennes, Strata.2: 438 p.

Boudagher Fadel MK (2008) Evolution and Geological Significance of Larger Benthic Foraminifera, Elsevier.

Boudagher-Fadel M.K (2013) Biostratigraphic and Geological Significance of Planktonic Foraminifera, Elsevier.

Caron M (1985) Cretaceous planktonic foraminifera, In: Bolli HM, Saunders JB and Perchnielsen, K (eds.): Planktonic Stratigraphy, Cambridge University Pres.

Caron M, Dall' Angnolo S, Accrie H, Barrera E, Kauffman E, G, Amedro F, Robaszynski F (2006) High-resolution stratigraphy of the Cenomanian-Turonian boundary interval at Pueblo (USA) and Wadi Bahloul (Tunisia): stable isotope and bioevents correlation, *Geobios 39: 171-200*.

Chiocchini M, Coccia B, Mancinelli A, Romano A, Urgera A, (2004) Microbiostratigrafia ed evoluzione paleogeograficadel Mesozoico del Monte Cairo e di Vallerotonda(Lazio meridionale, Italia), *Studi Geol Camerti,NuovaSerie 2: 1-18.*

Coccioni R, Luciani V, (2004) Planktonic foraminifera and environmental changes across the Bonarelli event (OAE 2, latest Cenomanian) in its type area: A high resolution study from the Tethyan reference Bottacione section (Gubbio, central Italy), *Journal of Foraminiferal Research 34: 109–129.*

Courtillot V E, Renne P R (2003) On the ages of flood basalt, *Comptes Rendus Geoscience, 335: 113-14.*

Dehghanian M, Afghah M (2021) Foraminiferal paleoecology of Sarvak Formation (Cenomanian) in the east of Shiraz, interior Fars, Zagros Basin, Iran, *Carbonates and Evaporites 36:37* DOI: 10.1007/S13146-021-00690-0

Dousti Mohajer M, Afghah M, Dehghanian, Abyat A (2021a) Evolutionary trend of Cenomanian alveolinids from Zagros Basin, SW of Iran, *Geological Journal 57: 24-36*

Dousti Mohajer M, Afghah M, Dehghanian, Sheikh SJ (2021b) Biostratigraphy, Microfacies and Depositional Environment of the Sarvak Formation at Pyun Anticline (Zagros Basin, Southwest of Iran), *Acta Geologica Sinica, 95: 1647-1667*

Fahkari M, Housseini MH, Goudarzi MG, Souleimani B, Voussoghi M, Sherkati S (1998) Structural geology of the Khosh Ab, Rit, Chenareh and Marab anticlines, , Exploration Div. Iooc. *Geological Report No.1897*.

Farzeipour-Saein A, Yassaghi A, Sherkati S, Koyi H (2009) Basin evolution of the Lurestan Region in the Zagros Fold- and-Thrust belt, Iran, *Journal of Petroleum Geology,32(1):5-20.*

Filikon HF, Scott RW (2011) Microfossils, paleoenvironments and biostratigraphy of the Mal Paso Formation. (Cretaceous, upper Albian), State of Guerrero, Mexico. *Revista Mexicana de Ciencias Geológicas 28: 175-191.*

Gargouri- Razgallah, S., 1983. Le Cenomanien de Tunisie centrale: étude paléoécologique, stratigraphique, micropaléontologique et paléogéographique, Thése Docteur dés-Sciences, Univérsité Claude Bernard, Lyon.

Geel T (2000) Recognition of stratigraphic sequences in carbonate platform and slope deposits: empirical models based on microfacies analysis of paleogene deposits in southeastern Spain, Palaeogeography, Palaeoclimatology, *Palaeoecology 155: 211-238.*

Ghabeishavi A, Vaziri- Moghaddam H, Taheri A (2009) : Facies distribution and sequence stratigraphy of the Coniacian–Santonian succession of the Bangestan Palaeo-high in the Bangestan Anticline, SW Iran, *Facies 55:243–257.*

Ghabeishavi A, Vaziri- Moghaddam H, Taheri A, Tatti, F (2010) Microfacies and depositional environment of the Cenomanian of the Bangestan anticline, SW Iran, *Journal of Asian Earth Sciences 37: 275–285.*

GhasemShirazi B, Bakhshandeh L, Yazdi A (2014) Biozonation and Paleobathymetry on Foraminifera Upper Cretaceous Deposites of Central Iran Basins (Isfahan, Baharestan Section), *Open Journal of Geology*, 4 (8): 343-353.

Ghazban F (2007) Petroleum Geology of the Persian Gulf, Tehran University and National Iranian Oil Company.

Gradstein, F N, Agterberg FP, Ogg JG, Hardenbol J, Van Veen, P, Thiery J, Huang Z (1994) A Mesozoic Time Scale, *Journal of Geophysical Research 99: 051−24,074.*

Gräfe KU (2005) Late Cretaceous benthic foraminifers from the Basque–Cantabrian Basin, Northern Spain, *Journal of Iberian Geology 31: 277– 298.*

Hajkarimi E, Al-Aasm IS, Coniglio, M (2012) Cemostratigraphy of Cenomanian- Turonian carbonates of the Sarvak Formation, southern Iran, *Journal of Petroleum Geology 35: 187-206.*

Hallock P (1987) Fluctuations in the trophic resource continuum: a factor in global diversity cycles, *Paleoceanography 2:457–471.*

Haq B, Hardenbol J, Vail P (1987) Chronology of fluctuating sea level since the Triassic, *Science 235 1156–1167.*

Heydari E (2008) Tectonic versus eustatic control on supersequences of the Zagros Mountains of Iran, *Tectonophysics 451:56–70.*

Huber B, Petrizzo M, R (2014) Evolution and taxonomic study of the cretaceous planktic foraminiferal genus Helvetoglobotruncana reiss, 1957, *The Journal of Foraminifera Research 44: 40-57.*

Jaff R B N, Wilkinson IP, Lee S, Zalasiewicz j, Lawa F, Williams M (2015) Biostratigraphy and palaeoceanography of the early Turonian–early Maastrichtian planktonic foraminifera of NE Iraq, *Journal of Micropalaeontology 34: 105– 138.*

James G , Wynd J (1965) Stratigraphic nomenclature of Iranian oil consortium agreement area, *American Association of Petroleum Geologists 49(12): 2182-2245.*

Kaiho K (1994) Benthic foraminiferal dissolved-oxygen index and dissolved-oxygen levels in the modern ocean, *Geology 22(8): 719-722.*

Kohsrow Tehrani K, Fonooni B (1994) New Investigations in Microbiostratigraphy of Sarvak formation in Fars and Khuzestan region. Geological Survey of Iran, *Geoscience Journal 3: 2–15.*

Leckie R M (1987) Paleoecology of Mid-Cretaceous Planktonic Foraminifera: A Comparison of Open Ocean and Epicontinental Sea Assemblages, *Micropaleontology 33: 164-176.*

Maghfouri Moghaddam I (2017) The Microbiostratigraphy and Depositional History of the Turonian–Santonian Surgah Formation at the Northern Flank of the Kuh-e Sepid Anticline, Lorestan Basin, *Iranian Journal of Earth Sciences 9: 73-81.*

Mancinelli A Chiocchini M (2006) Cretaceous benthic foraminifers and calcareous algae from Monte Cairo (southern Latium, Italy), *Bollettino della Società Paleontologica Italiana 45: 91-113.*

Mehrabi H, Rahimpour-Bonab H, Enayati-Bidgoli AM, Navidtalab A (2013) Depositional environment and sequence stratigraphy of the Upper Cretaceous Ilam Formation in central and southern parts of the Dezful Embayment, SW Iran, Carbonates Evaporites DOI 10.1007/s13146-013-0168-z

Motei, H., 1998. Geology of Iran, petroleum geology of Zagros. *Geologial survey of Iran. 589 p.*

Orabi OH, Osman RA, El Qot GM, Afify AM (2012) Biostratigraphy and stepwise extinctions of the larger foraminifera during Cenomanian (Upper Cretaceous) of Gebel Um Horeiba (Mittla Pass), west-central Sinai, *Egypt Revue de Paléobiologie 31: 303-312.*

Parente M, Frijia G, Di Lucia, M, Jenkyns, HC, Woodfine R.G, Baroncini F (2008) Stepwise extinction of larger foraminifers at the Cenomanian–Turonian boundary: a shallow-water perspective on nutrient fluctuations during Oceanic Anoxic Event 2 (Bonarelli Event), *Geology 36 (7), 715–718.*

Petrizzo M R (2002) Palaeoceanographic and palaeoclimatic inferences from Late Cretaceous planktonic foraminiferal assemblages from the Exmouth Plateau (ODP Sites 762 and 763, eastern Indian Ocean), *Marine Micropaleontology 45: 117-150.*

Piryaei A, Reijmer JJG, Van Buchem FSP, Yazdi-Moghadam M, Sadouni J, Danelian T (2010) The influence of Late Cretaceous tectonic processes on sedimentation patterns along the northeasternArabian plate margin (Fars Province, SW Iran). In: Leturmy, P. & Robin, C. (eds) Tectonic andStratigraphic Evolution of Zagros and Makran during the Mesozoic-Cenozoic, Geological Society,London, *Special Publications 330: 211-251.*

Postuma J (1971) Manuel of planktonic foraminifera, Amesterdam , Elsevier.

Premoli Silva I, ERGA D (2004) Practical manual of cretaceous planktonic foraminifera. In: Verga D. and Rettori R (EDS.), International School on Planktonic Foraminifera, Universities of Perugia and Milano.

Premoli Silva I, Sliter WV (1994) Cretaceous planktonic foraminiferal biostratigraphy and evolutionary trends from the Bottacioni section, Gubbio, Italy, *Paleontographica Italica 82, 1–8*

PremoliI Silvia I, Sliter W V (1981) Cretaceous planktonic foraminifers from the Nauru Basin, Leg 61, Site 462, Western equatorial Pacific, *Initial Reported Deep Sea Drilling Project 61: 423-37.*

Reza M M (2020) Sequence stratigraphy of Albian–Campanian carbonate deposits (Sarvak and Ilam formations) in Shiraz area, Fars, SW Iran, *Carbonates and Evaporites 35:92.*

RobaszynskiI F, Caron M (1995) Foraminifers planctoniques du Crétacé: commentaire de la zonation Europe-Méditerrané, *Bulletin de la Société Géologique de France 6: 681–692.*

Sari B, Tasli K, Özer S (2009) Benthonic foraminiferal biostratigraphy of the Upper Cretaceous (Middle Cenomanian−Coniacian) sequences of the Bey Dağları carbonate platform, Western Taurides, Turkey, *Turkish Journal Earth Science 18: 393-425.*

Sariaslan N (2017) Planktonic foraminiferal biostratigraphy and microfacies analysis of the cenomanian-campanian succession in the Haymana-Polatlı Basin (Ankara, Turkey), A thesis submitted to the Graduate School of Natural and Applied Sciences of Middle East Technical.

Setudehnia A (1972) Stratigraphic Lexicon of Iran. Union International des Sciences Geologiques, 3., ASIE, southwest Iran.

Shahin AM, Elbaz S (2013) Foraminiferal biostratigraphy, paleoenvironment and paleobiogeography of cenomanian-lower turonian shallow marine carbonate platform in west central sinai, Egypt, *Micropaleontology 59: 249–283*.

Shapourikia R, Afghah M, Parvaneh-Nejad Shirazi M, Dehghanian MS (2021) Microbiostratigraphy of the Sarvak Formation (Cenomanian) in the Aghar and Homa wells in sub-coastal and coastal Fars, (south of Iran), *Carbonates and Evaporites 36: 1*-16

Sharland PR, Archer R, Casey D, Davies RB, Hall SH, Heward AP, Horbury AD, Simmons MD (2001 Arabian Plate Sequence Stratigraphy. GeoArabia Special Publication.f

SigalL J (1955) Notes micropaleontologyiques nord-africaines, l. Du Cenomanian au Santonian: zoneset limites en facies pelagiques CRSomn, *Société géologique de France 8:157-160.*

Sliteer WV, Baker RA (1972) Cretaceous bathymetric distribution of benthic foraminifers, *Journal of foraminiferal Research 2(4): 167-183.*

Tasli K, Ozer E, Koc H (2005) Benthic foraminiferal assemblages of the Cretaceous platform carbonate su ccession in the Yavca area (Bolkar Mountains, S Turkey): biostratigraphy and aleoenvironments, *Geobios 39: 521–533*.

Vahidnia M, Youssef M, Ardestani MS, Sadegh, A, Dochev D (2014). Integrated biostratigraphy and stage boundaries of the Abderaz Formation, east of the KopehDagh sedimentary basin, NE Iran, *Journal of African Earth Sciences 90: 87-104*.

Van Der Zwaan GJ, Duijnstee IAP, Den Dulkm Ernsts SR, Kouwenhoven NT (1999) Benthic foraminifers: proxies or problems? A review of paleoecological concepts, *Earth Science Review 46: 213-236*.

Vellic I (2007) Stratigraphy and Palaeobiogeography of Mesozoic Benthic Foraminifera of the Karst Dinarides (SE Europe), *Geologica Croatica* 60: 1–113.

Walliserm OH (1996) Global events and event stratigraphy in the Phanerozoic. In: Walliser, O.H. (EDS.), Global Events and Event Stratigraphy, Berlin (Springer),

Wynd J (1965) Biofacies of the Iranian Consortium agreement Area, Iranian Oil Corporation Companies, Geological and Exploration Division, unpublished.