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Earliest Campanian – latest Maastrichtian sequence stratigraphy based on planktonic foraminifera, Fars province, Zagros (Iran)

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Abstract
The Gurpi, Tarbur and Sachun formations have been investigated in the studied section in the Fars Province, in order to determine their sequence stratigraphy. On the basis of done studies on the cores of borehole, four main microfacies have been recognized in four stratigraphic sequence deposited during the Campanian to Maastrichtian. The lowermost sequence, was deposited in the early Campanian-early late Campanian which include wackestone to packestone texture with *Globotruncanita elevata* Zone and *Globotruncana ventricosa* Zone that representative of the deep marine and outer ramp. The intermediate and uppermost sequences (sequences two, three and four) display well developed deposits formed in the end of the Campanian (*Radotruncana calcarata* Zone and *Globotruncanella havanensis* Zone), formed during the Maastrichtian (*Globotruncana aegyptiaca* Zone and *Gansserina gansseri* Zone) and the end of the Maastrichtian (*Omphalocyclus macroporus - loftusia* sp assemblage Zone) on pelagic, hemipelagic, outer and middle ramp. On the basis of the sequence stratigraphic chart, the transgression of the upper Cretaceous sea started since the early Campanian and continued gradually until the early Maastrichtian. Then, until the end of Maastrichtian, the area has been emerged. The sequence stratigraphic architecture of Campanian/ Maastrichtian Gurpi, Tarbur and Sachun formations model is in a good agreement with global sea level changes.
Keywords: *Campanian, Maastrichtian, Sequence stratigraphy, Zagros, Fars.*

1. Introduction
The Zagros belt is extending for about 2000 km from eastern Turkey to the Makran in southern Iran (Motiei 2003). Zagros belt is a part of the Alpine / Himalayan orogenetic system, and is the largest basin with hydrocarbon reservoir in the world (Alavi 2004; Kamali et al. 2006; Bordenave 2010). This basin is located at the collisional zone of the Arabia and Eurasia blocks and includes very thick marine sedimentary sequence that covers Precambrian basement (Al-Husseini 2000; Lacombe et al. 2006). The Gurpi Formation as one of the source rocks in this basin has received the attention of most geologists from the past decades (Motiei 2003; Amirkhani et al. 2015). This formation is developed in the Lurestan, Khuzestan and Fars Provinces, southwest Iran. The Gurpi Formation in the Fars Province is considered as one of the poor source rocks. The Gurpi Formation overlies the Santonian Ilam Formation and overlain by the Tarbur and Sachun formations with the late Maastrichtian age at the studied section. The type section of Gurpi Formation is chosen in the north oil field Lali in north-east Masjed-Soleiman with 320 m thickness of argillaceous limestone, shale and marl which covered by the Pabdeh Formation. The stratigraphy, microfacies, petroleum geology and sedimentology of the Gurpi Formation were studied by James and Wynd (1965), Setudehnia (1972,1978), Vaziri-Moghaddam (2002), Ghasemi-Nejad et al. (2006) Darvishzadeh et al. (2007), Hadavi and Senemari (2010), Beiranvand et al. (2014) and Zarei and Ghasemi Nejad (2014). The type section of Tarbur Formation is chosen in the Gadvan Mountain in north Tarbur village with 527.3 m thickness of limestone and less amount shales, which are covered by the Sachun Formation. The microfacies, biostratigraphy and lithostratigraphy of the Tarbur Formation were studied by Maghfouri-Moghadam et al. (2009), Pirbalouti and Abyat (2013), Afghah and Yaghmour (2014). The type section of Sachun Formation is chosen in the Sachun Mountain in north Sachun village with 1415 m thickness include dolomite, gypsum and marl. The age of this formation have been reported Paleocene-early Eocene (James and Wynd 1965). The sedimentology, lithostratigraphy, facies analysis and sequence stratigraphic of the Sachun Formation were studied by Mahboubi et al. (2010), Shabafrooz et al. (2010), Shabafrooz et al. (2013), Bahrami et al. (2013), Arzaghi and Afghah (2014). In this study, the Gurpi Formation with 460 m thick is composed of argillaceous limestone, which conformably overlies Ilam Formation limestone and it is covered by the Tarbur Formation with an erosional disconformity. The Tarbur Formation with 90 m thick is determined of dolomitic limestone and limestone, which overlies argillaceous limestone of the Gurpi Formation and it underlies the Sachun Formation. The Sachun Formation with 275 m thick is formed of dolomitic limestone, anhydrite and dolomite succession. The main purpose of this study, is to examine biostratigraphy, facies analysis

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and sequence stratigraphy of the Gurpi, Tarbur and Sachun formations in a chronostratigraphic and sequence stratigraphic framework in the studied section, located in Fars Province, southwestern Iran.

2. Geographical and geological setting

The Zagros Basin structurally is one geologic units in Iran. Often, the units are delineated by major boundary faults (Fig 1) (Motiei 2003; Alavi 2007). The basement faults of the Zagros Basin have been recorded by many geologists previously (Dehbozorgi et al. 2010; Burberry 2015). The major tectonic events in the geological history of the Zagros took place in the Late Cretaceous to Pliocene time interval (Alavi 2004). The Zagros Basin is the result of at least two main tectonic events, the first time was beginning of the Neo-Tethys closure, which lead to thrusting in the late Cretaceous, and the second being the final collision, which caused the closure of the Neo-Tethys in the Miocene – Pliocene (Glennie 2000; Alavi 2004; Piryaei et al. 2010). Therefore, tectonic factors play a role in creating a stratigraphy pattern. Three zones can be distinguished in the Zagros Basin: the Zagros fold-thrust belt, the Zagros imbricate Zone (High Zagros) and the Uramieh-Dokhtar Zone (Alavi 2007). The Folded Zagros is divided into subzones: Dezful Embayment, Lurestan, Izeh and Fars. The study area, geologically is located in the Fars, about 30 km northeast of Jahrum city, southwestern Iran. The section was measured in detail at 28° 42´ 34" N and 53° 46´ 45" E.

3. Material and methods

The examination of sequence stratigraphy the studied section, was investigated using planktonic foraminifera and samples collected at a distance of 0.5 meters. References of European Colloque on Cretaceous planktonic foraminifera by Caron (1985), Premoli Silva and Verga (2004) and benthic foraminifera by Wynd (1965) are the basis for the identifications in this study. The microfacies characteristics were described from thin sections in about 1990 rocky samples that were rich in planktonic foraminifera. In the laboratory, thin sections of all limestones and hard samples were prepared for the study of microfossils and to aid in sedimentological explanations. In fact, the interpretations are based on thin sections, as well as the textural analysis such as grain size, grain composition and fauna assemblages reveal microfacies specifications. The classification of microfacies textures is basis on the nomenclature of Dunham (1962). The relative abundance of species as: abundant (>10%); common (5-10%); few (2-5%) and rare (<2%) was distinguished (Fig 2).

4. Lithology changes

Lithologycally, the studied succession can be divided into three distinctive parts: the lower Campanian to upper Maastrichtian argillaceous limestone in the lower part of succession (named Gurpi Formation/ with 460 m thick) which conformably overlies limestone of the Ilam Formation, upper Maastrichtian dolomitic limestone interlayered with limestone of the second formation (named Tarbur Formation/with 90 m thick), and upper Maastrichtian dolomitic limestone, anhydrite and dolomite (lower part of Sachun Formation/with 275 m thick) in the upper part of the studied section (Fig 3). Therefore, the formations in the studied section include a sedimentary succession of 825 m that extends from the lower Campanian to the upper Maastrichtian.

5. Results and Discussion

5.1. Microfacies analysis

The interpretation of depositional environments of the Gurpi, Tarbur and Sachun formations is done by microfacies analysis. The microfacies analysis of all thin sections, was performed by microscopic examination. Based on the textural, allochemical and orthochemical characteristics four microfacies types were recognized in formations of this succession. In classical facies models, there is a carbonate ramp divided into the inner, middle and outer ramp (Burchette and Wright 1992) along with a deep marine environment with pelagic and hemi-pelagic sediments. Microfacies analysis from the studied section of the Gurpi, Tarbur and Sachun formations, shows deep marine, outer and middle ramp environments. Reconstruction of the palaeoenvironmental for the studied section based on the microfacies resulted in the detection of the homoclinal carbonate ramp (middle ramp) and deep marine environment (Fig 2). The description of microfacies in the present study is as a mixture of the description of lithofacies, biofacies and environmental characteristics:

5.1.1. Microfacies pelagic (MF1):

Only planktonic foraminifera, wackestone to packstone (Gurpi Formation)

This facies is dominated by planktonic foraminifera. The existence of only planktonic foraminifera and abundant gray micrite matrix indicates the deposition of this group in deep sea environment (Fig 2). In fact, the specific faunal assemblage and presence of mud supported textures with high amount of planktonic foraminifera in this facies suggests pelagic environment. Depositional textures are represented by wackestone to packstone.

5.1.2. Microfacies hemi-pelagic (MF2):

Planktonic, small benthic foraminifera and Oligostegenid wackestone to packstone (Gurpi Formation)

The Hemi-pelagic facies consist of bioclasts of planktonic foraminifera, *oligostegenid* and small benthic foraminifera fragments which indicates hemi-pelagic sediment.

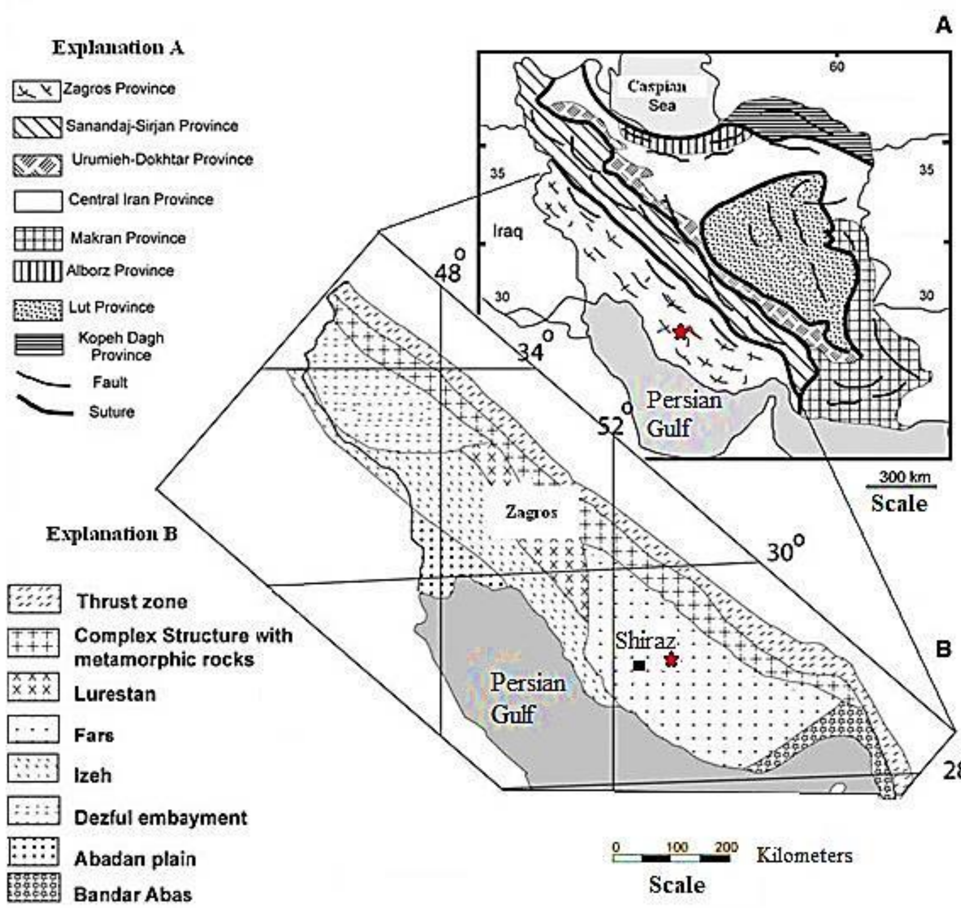

Fig 1. a. Location map of the studied area in Zagros Basin, SW Iran (Heydari et al. 2003). b. The location of the studied section in northeast Shiraz is marked by a star.

5.1.3. Microfacies outer ramp (MF3):

Planktonic, small benthic foraminifera, wackestone to packstone (Gurpi Formation)

This microfacies is mainly belongs to outer ramp bioclasts consisting of small benthic foraminiferal without *oligostegenid* which suggest an outer ramp environment.

5.1.4. Microfacies middle ramp (MF4):

Large and small benthic foraminifera, rudist and echinoid debris grainstone to boundstone (Tarbur and Sachun formations)

The facies consists of benthic foraminifera, rudist and echinoid debris. This facies is generally formed from grainstone which are associated with boundstone (Fig 2). In fact, this facies is characterized by medium grained grainstone to boundstone, dominated by large and small benthic foraminifera and other skeletal constituents include bioclasts derived from rudist and echinoids.

5.2. Sedimentary model

Microfacies analysis of the Gurpi, Tarbur, and Sachun formations in the studied section allows for the characterization of the development of a carbonate ramp (middle and outer ramp) and deep marine environments in the early Campanian-late Maastrichtian. The facies model presented here shows decrease of depth from the pelagic, hemipelagic to the middle ramp with distribution of large and small benthic foraminifera, and other important components (Fig 2). The wackestone to packstone texture with abundant planktonic foraminifera represents predominating types in the microfacies (MF1). The presence of micrite texture and the apparent absence of current structures suggest a low energy environment (Burchette and Wright 1992). In the pelagic and hemi pelagic environments (MF1 and MF2), faunal diversity (especially planktonic foraminifera) is high and marine fauna are such as *Globotruncana, Globotruncanita, Rugoglobigerina, Muricohedbergella, Macroglobigerinelloides, Heterohelix* and small foraminifera such as *Minouxia* sp., *Marssonella* sp., *Miliolid* sp., *Bolivina* sp. The middle ramp setting is represented by grained foraminifera and bioclastic grainstone to boundstone, dominated by assemblages of larger foraminifera such as *Loftusia, Orbitoides, Ompholocyclus, Lepidorbitoides, Siderolites (S. calsitrapoides)* and small foraminifera such as *Rotalia* sp ‹*Bolivinoides* sp ‹*Bolivina* sp., *Cibicides* sp.

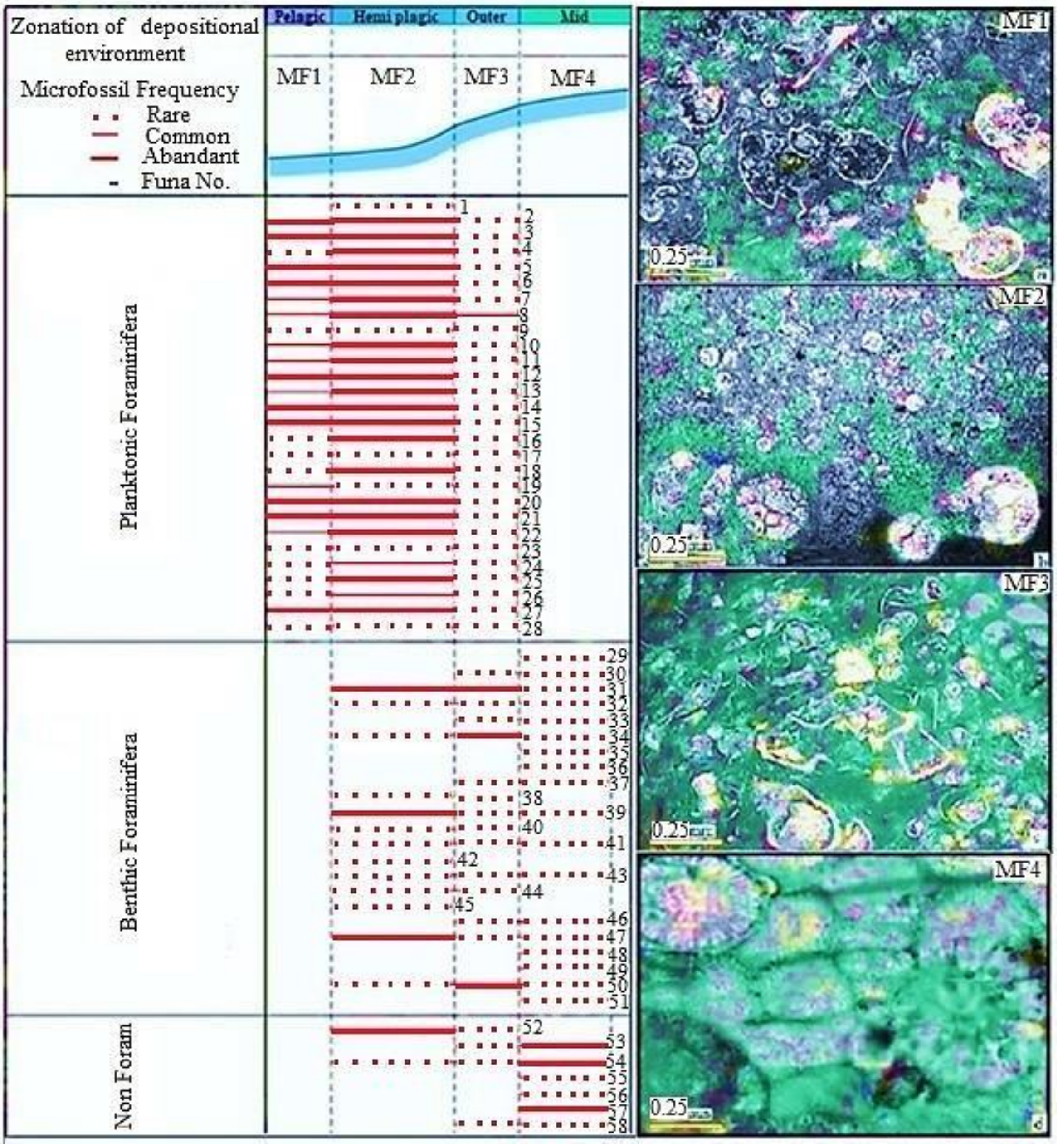

Fig 2. General distribution of planktonic and benthic foraminifera for Campanian-Maastrichtian in studied section. Microfacies type: a. Microfacies type 1 (MF1), Gurpi Formation b. Microfacies type 2 (MF2), Gurpi Formation c. Microfacies type 3 (MF3), Gurpi Formation d. Microfacies type 4 (MF4), Tarbur and Sachun formations. (Explaination the numbers of the species in figure are: 1. *Dicarinella asymetrica,* 2. *Macroglobigerinelloides bollii*, 3. *Globotruncanita stuartiformis*, 4. *Globotruncanita elevata*, 5. *Muricohedbergella holmdelenis,* 6. *Marginotruncana* sp., 7. *Heterohelix striata,* 8. *Macroglobigerinelloides ultramicrus,* 9. *Rugoglobigerina rugosa*, 10. *Heterohelix globolusa,* 11. *Globotruncana ventricosa*, 12. *Macroglobigerinelloides prairiehillensis,* 13. *Globotruncana bulloides,* 14. *Spiroplecta* sp., 15. *Contusotruncana fornicata*, 16. *Archaeoglobigerina blowi*, 17. *Muricohedbergella monmouthensis,* 18. *Globotruncana arca,* 19. *Radotruncana calcarata,* 20. *Pseudotextularia elegans,* 21. *Globotruncanita stuarti,* 22. *Globotruncanella havanensis,* 23. *Globotruncana falsostuarti*, 24. *Globotruncana aegyptica*, 25. *Globotruncana lapparanti,* 26. *Globotruncanita conica*, 27. *Contusotruncana contusa,* 28. *Gansserina gansseri,* 29. *Gavellinella* sp., 30. *Marssonella* sp., 31. *Bolivinoides* sp., 32. *Quinquelolina* sp., 33. *Rotalia* sp., 34. *Minouxia* sp., 35. *Bolivina* sp., 36. *Bolivinoides darco*, 37. *Siderolites calcirapoides,* 38. *Loftusia* sp., 39. *Omphalocyclus macroporus,* 40. *Raphydionina* sp., 41. *Calcisphaerula innominate lata,* 42. Rudist debris, 43. Echinoderm debris).

5.3. Planktonic and benthic foraminifera bio zones of the studied borehole

Planktonic foraminifera are abundant and diverse in samples of the Gurpi Formation at the studied section. In this study, 15 genera and 28 species of planktonic foraminifera were recognized (Fig 3). Some important species in this study are illustrated in the Plate. The benthic foraminifera were twelve species in samples of the Tarbur and Sachun formations at the studied section. Besides foraminifera, non foraminiferal are

Calcisphaerula innominata lata, rudist debris and echinoderm debris are also present. The zonal scheme includes six Caron bio zones (1985) in the Gurpi Formation and one Wynd bio zone (1965) (No. 37) for the Tarbur and Sachun formations based on the distribution of planktonic foraminifera. Caron (1985)'s identified zones of the Gurpi Formation are:

5.3.1. *Globotruncanita elevata* Partial Range Zone

The *Globotruncanita elevata* Partial Range Zone defines the interval from the last occurrence of all *Dicarinella* and the first occurrence of *Globotruncana ventricosa*, and corresponds to the early Campanian (Fig 3). The thickness of the bio zone is 53 m. This zone was recorded from Zagros Basin as a part of the Tethys (James and Wynd 1965; Caron 1985). The assemblage includes: *Heterohelix striata, Heterohelix globolusa, Globotruncanita stuartiformis, Rugoglobigerina rugosa, Muricohedbergella holmdelenis, Macroglobigerinelloides bollii, Globotruncanita elevata, Macroglobigerinelloides ultramicrus, Marginotruncana* sp., *Bolivinoides* sp., *Gavellinella* sp., *Marssonella* sp.

5.3.2. *Globotruncana ventricosa* Interval Range Zone

This zone defines the stratigraphical interval from the first occurrence of *Globotruncana ventricosa* to the first occurrence of *Radotruncana calcarata,* and corresponds to the late early Campanian to early late Campanian (Fig 3). The thickness of the biozone is 172 m. This zone was recorded from Tethys (Caron 1985; Sliter 1989), and is characterized by foraminifera species like *Heterohelix globolusa, Heterohelix striata, Globotruncana bulloides, Globotruncanita stuartiformis, Globotruncana ventricosa, Rugoglobigerina rugosa, Globotruncanita elevata, Muricohedbergella holmdelenis, Macroglobigerinelloides prairiehillensis, Contusotruncana fornicata, Macroglobigerinelloides bollii, Muricohedbergella monmouthensis, Globotruncanita elevata, Macroglobigerihelloides ultramicrus, Globotruncana arca, Archaeoglobigerina blowi, Spiroplecta* sp., *Quinqueloculina* sp., *Bolivinoides* sp., *Rotalia* sp., *Marssonella* sp. and *Minouxia* sp.

5.3.3. *Radotruncana calcarata* Total Range Zone

This zone defines by the total range of *Globotruncanita calcarata* and corresponds to the latest Campanian (Fig 3). The thickness of the bio zone is 30 m. This zone was recorded from Tethys (Caron 1985; Sliter 1989), and is characterized by foraminifera species following: *Heterohelix globolusa, Heterohelix striata, Globotruncana bulloides, Globotruncanita stuartiformis, Rugoglobigerina rugosa, Globotruncana ventricosa, Muricohedbergella holmdelensis, Contusotruncana fornicata, Archaeoglobigerina blowi, Pseudotextularia elegans, Macroglobigerinelloides prairiehillensis, Macroglobigerinelloides bollii, Muricohedbergella monmouthensis, Quinqueloculina* sp., *Spiroplecta* sp., *Bolivinoides* sp., *Rotalia* sp., *Marssonella* sp., *Minouxia* sp.

5.3.4. *Globotruncanella havanensis* Partial Range Zone

The zone is defined as an interval from the last occurrence of *Radotruncana calcarata* to the first occurrence of *Globotruncana aegyptiaca,* and corresponds to the earliest Maastrichtian (Fig 3). The thickness of the bio zone is 42 m. This zone was recorded from Tethys (Caron 1985; Sliter 1989), and is characterized by foraminifera species following: *Heterohelix globolusa, Globotruncana falsostuarti, Globotruncanita stuarti, Heterohelix striata, Globotruncana bulloides, Globotrunconita stuartiformis, Rugoglobigerina rugosa, Globotruncana ventricosa, Globotruncana arca, Macroglobigerinelloides prairiehillensis, Muricohedbergella holmdelensis, Globotruncanella havanensis, Contusotruncana fornicata, Archaeoglobigerina blowi, Muricohedbergella monmouthensis, Pseudotextularia elegans, Bolivinoides* sp., *Marssonella* sp., *Minouxia* sp.

5.3.5. *Globotruncana aegyptiaca* Interval Range Zone

The *Globotruncana aegyptiaca* Zone, is defined as interval from the first occurrence of *Globotruncana aegyptiaca* to the first occurrence of *Gansserina gansseri*, and corresponds to the early Maastrichtian (Fig 3). The thickness of the bio zone is 134 m. This zone was described from Tethys (Caron 1985; Sliter 1989) being characterized by foraminifera species: *Heterohelix globolusa, Globotruncana falsostuarti, Globotruncanita stuarti, Heterohelix striata, Globotruncana bulloides, Globotruncanita stuartiformis, Rugoglobigerina rugosa, Globotruncana ventricosa, Globotruncana aegyptica, Muricohedbergella holmdelensis, Muricohedbergella monmouthensis, Pseudotextularia elegans, Quinqueloculina* sp., *Macroglobigerinelloides prairiehillensis, Contusotruncana fornicata, Globotruncana lapparanti, Macroglobigerinelloides bollii, Gavellinella* sp., *Bolivina* sp., *Bolivinoides* sp., *Bolivinoides darco, Rotalia* sp., *Cibicides* sp., *Marssonella* sp., *Minouxia* sp.

5.3.6. *Gansserina gansseri* Total Range Zone

This zone defines by the total range of *Gansserina gansseri*, and corresponds to the late Maastrichtian (Fig 3). The thickness of the bio zone is 28 m. This zone was described from Tethys (Caron 1985; Sliter 1989), and is characterized by foraminifera species following: *Globotruncanita stuarti, Heterohelix globolusa, Gansserina gansseri, Globotruncanita conica, Contusotruncana contusa, Minouxia* sp., *Siderolites calcirapoides, Bolivinoides darco, Bolivina* sp., *Quinqueloculina* sp., *Bolivinoides* sp., *Marssonella* sp., *Rotatia* sp.

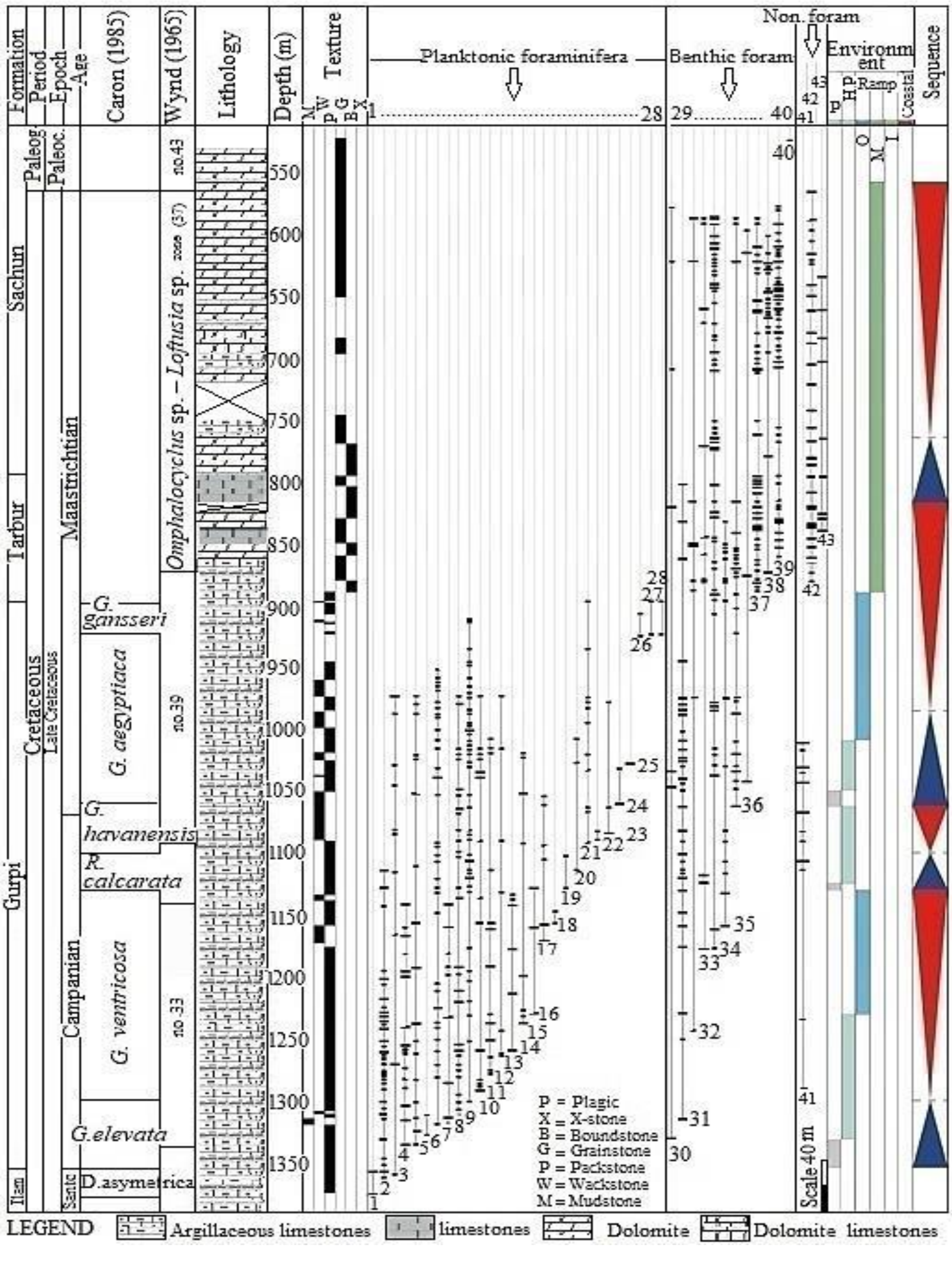

Fig 3. Gurpi, Tarbur and Sachun formations sequence stratigraphy in studied section, Zagros Basin (Fars Province), Iran. The lithology of the formations is as follows: limestone of the Ilam Formation, argillaceous limestone of the Gurpi Formation, dolomitic limestone and limestone of the Tarbur Formation, dolomitic limestone, anhydrite and dolomite of the Sachun Formation. (Explaination the numbers of the species in figure are: 1. *Dicarinella asymetrica,* 2. *Macroglobigerinelloides bollii,* 3. *Globotruncanita stuartiformis,* 4. *Globotruncanita elevata,* 5. *Muricohedbergella holmdelenis*, 6. *Marginotruncana* sp., 7. *Heterohelix striata,* 8. *Macroglobigerinelloides ultramicrus,* 9. *Rugoglobigerina rugosa,* 10. *Heterohelix globolusa,* 11. *Globotruncana ventricosa,* 12. *Macroglobigerinelloides prairiehillensis,* 13. *Globotruncana bulloides,* 14. *Spiroplecta* sp., 15. *Contusotruncana fornicata,* 16. *Archaeoglobigerina blowi,* 17. *Muricohedbergella monmouthensis,* 18. *Globotruncana arca,* 19. *Radotruncana calcarata,* 20. *Pseudotextularia elegans,* 21. *Globotruncanita stuarti,* 22. *Globotruncanella havanensis,* 23. *Globotruncana falsostuarti,* 24. *Globotruncana aegyptica,* 25. *Globotruncana lapparanti,* 26. *Globotruncanita conica,* 27. *Contusotruncana contusa,* 28. *Gansserina gansseri,* 29. *Gavellinella* sp., 30. *Marssonella* sp., 31. *Bolivinoides* sp., 32. *Quinquelolina* sp., 33. *Rotalia* sp., 34. *Minouxia* sp., 35. *Bolivina* sp., 36. *Bolivinoides darco,* 37. *Siderolites calcirapoides,* 38. *Loftusia* sp., 39. *Omphalocyclus macroporus,* 40. *Raphydionina* sp., 41. *Calcisphaerula innominate lata,* 42. Rudist debris, 43. Echinoderm debris).

5.3.7. *Omphalocyclus* sp. – *Loftusia* sp. assemblage Zone (no.37)

Wynd's identified zone of Tarbur and Sachun formations is *Omphalocyclus* sp. – *Loftusia* sp. assemblage Zone (no.37). Abyat et al. (2007) introduced the zone for Tarbur Formation as: *Omphalocyclus macroporus*– *Loftusia* sp. assemblage zone. The thickness of this bio zone is 366 m. The most important assemblage fossils in the bio zone are: *Gavellinella* sp., *Bolivina* sp., *Bolivinoides* sp., *Rotalia* sp., *Cibicides* sp., *Marssonella* sp., *Minouxia* sp., *Dicyclina* sp., *Marsonella oxycona*, *Siderolites calcirapoides*, *Bolivinoides darco*, *Dictyoconus* sp., *Quinqueloculina* sp., sponge spicules, rudist debris. The age of Zone is late Maastrichtian (Fig 3).

5.4. Sequence stratigraphic

A sequence stratigraphic framework include unites, that resulting from the interplay of accommodation and sedimentation (Catuneanu et al. 2009). These are unites of TST (Transgressive System Tract), MFS (Maximum Flooding Surface) and HST (Highstand System Tract), which are bounded by sequence boundary SB1 (a type one of sequence boundary) or SB2 (a type two of sequence boundary). SB1 is an unconformity, and SB2 is a conformity boundary. The study of vertical variations in the microfacies of formations has shown four sedimentary sequences. In this succession, the lower boundary of sequence, Gurpi Formation is identified by argillaceous limestone from Ilam Formation by SB2, and upper boundary of Sachun Formation, the end of succession, is recognized by SB1. The sequences stratigraphic are as below:

5.4.1. Sequence 1

The first sequence is 231 m thickness. This sequence can be divided into TST (57 m) and HST (174 m).

The TST is characterized by microfacies 1 and 2 (MF1-MF2) with wackestone to packstone textures. The deep marine fauna show a rising sea level which equivalent to the TST. The microfacies 2 continuing in the HST. The wackestone to packstone of the microfacies three (HST) with planktonic and small benthic foraminifer overlies the microfacies two. In fact, these sediments (TST and HST) are mostly pelagic and hemipelagic. The upper part of the HST indicate possibly outer ramp with a conformity boundary (SB2). This sequence of Gurpi Formation has been deposited in interval bio zones of *Globotruncanita elevata* (early Campanian) and *Globotruncana ventricosa* (late early Campanian to early late Campanian) of zonation of Caron (1985) equivalent to bio zone no.33 (*Globotruncanita elevata/* Campanian) of zonation of Wynd (1965). In the case of study, Maximum Flooding Surface (MFS) is located between *Globotruncanita elevata* Zone and *Globotruncana ventricosa* Zone. The age of sequence is early Campanian-early late Campanian.

5.4.2. Sequence 2

The second sequence is about 78 m in thickness. The sequence can be divided into TST (34 m) and HST (44 m). This depositional system includes argillaceous limestone rocks of the microfacies 1 and 2 are interpreted as deposits formed during a period of sea level rise (TST). The wackestone to packstone textures of the microfacies 2 is continuing until end of HST. These sediments were mostly deposited in hemi-pelagic and are interpreted as deposition of the HST with sequence boundary SB2. This sequence of Gurpi Formation has been deposited in interval bio zones of *Radotruncana calcarata* (latest Campanian) and *Globotruncanella havanensis* (earliest Maastrichtian) of zonation of Caron (1985). In second sequence, MFS is located inside *Radotruncana calcarata* Zone. The age of sequence is latest Campanian to earliest Maastrichtian.

5.4.3. Sequence 3

The thickness of the third sequence is 242 m and its microfacies can be divided into TST (75 m) and HST (167 m). There is a conformity boundary (SB2: type 2 of sequence boundary) at the start of sequence. The microfacies 1, 2 and 3 in the basal part of the sequence are interpreted as TST. This microfacies includes sediments that are related to the pelagic, hemi-pelagic and outer ramp. The microfacies 3 continue in HST with planktonic and small benthic foram wackestone to packstone. The upper part of the HST indicate middle ramp (microfacies 4) with large and small benthic foram, rudist and echinoid grainstone to boundstone. There is an unconformity (SB1) at the end sequence. This sequence of Gurpi and Tarbur formations has been deposited in interval bio zones of *Globotruncana aegyptiaca* and *Gansserina gansseri* of zonation of Caron (1985) equivalent to bio zones no.39 (*Globotruncanita stuarti- Pseudotextularia varians*) and lower part of no.37 zone (*Omphalocyclus macroporus-loftusia* sp.) of zonation of Wynd (1965). In this sequence, MFS is located inside *Globotruncana aegyptiaca* Zone. The age of sequence is early Maastrichtian.

5.4.4. Sequence 4

The thickness of sequence four is 274 m and can be divided into TST (58 m) and HST (216 m).

The basal part of the sequence is interpreted as the TST. This sequence includes limestone, dolomitic limestone, argillaceous limestone and anhydritic dolomite deposits of the microfacies 4, deposited in the middle (ramp/shelf) environment. This microfacies includes large and small benthic foram, rudist and echinoid with grainstone to boundstone textures. The microfacies 4 in the basal part of the sequence interpreted as TST, and is continues until the end sequence (HST). There is an unconformity or SB1 (type one of sequence boundary). This sequence of Sachun Formation has been deposited in interval bio zone of *Omphalocyclus macroporus-loftusia* sp. assemblage zone (no.37) of zonation of Wynd (1965). In fact, in this sequence, MFS is located inside *Omphalocyclus* sp. – *Loftusia* sp. assemblage Zone (no.37). The age of sequence is late Maastrichtian.

6. Conclusions

The studied borehole in the Fars Province consists of three formations. In this study, the lower Campanian-upper Maastrichtian deposits of the Gurpi, Tarbur and Sachun formations at the evaluated section in the interior Fars in Iran were studied in detail with regard to microfacies and sequence stratigraphy. Depth and sea level changes were the main controls on the distribution of these microfacies. The evaluation of microfacies in this study is a combination of lithofacies, biofacies and environmental characteristics (deep marine and middle ramp). Planktonic foraminifera which are suitable tool of biozonation were used for biostratigraphy leading to accurate time scale of each formation. Based on the obtained planktonic and benthic foraminifera, seven bio stratigraphic zones (six bio zones of zonation of Caron (1985) of Gurpi Formation and one bio zone of zonation of Wynd (1965) for Tarbur and Sachun formations) are proposed for the early Campanian to late Maastrichtian interval in the studied borehole. The following zones are proposed: *Globotruncanita elevata* (early Campanian), *Globotruncana ventricosa* (late early Campanian to early late Campaninan), *Radotruncana calcarata* (latest Campanian), *Globotruncanella havanensis* (earliest Maastrichtian), *Globotruncana aegyptiaca* **(**early Maastrichtian), *Gansserina gansseri* (late Maastrichtian) of zonation of Caron (1985) for Gurpi Formation, equivalent to bio zones no.33 (*Globotruncanita elevata/* Campanian), no.39 (*Globotruncanita stuarti-Pseudotextularia varians/* Maastrichtian) of zonation of Wynd (1965) and also no.37 zone (*Omphalocyclus macroporus- loftusia* sp.) of zonation of Wynd (1965) for Tarbur and Sachun formations. On the basis of thin section studies of the formations, four main microfacies have been recognized. On the basis of the microfacies, four sequences have been recognized in the upper Cretaceous in the studied section of Gurpi, Tarbur and Sachun formations. Accordingly, the Gurpi Formation has been deposited in a deep marine, the Tarbur Formation on the outer and middle ramp, as well as the Sachun Formation in the middle ramp environment.

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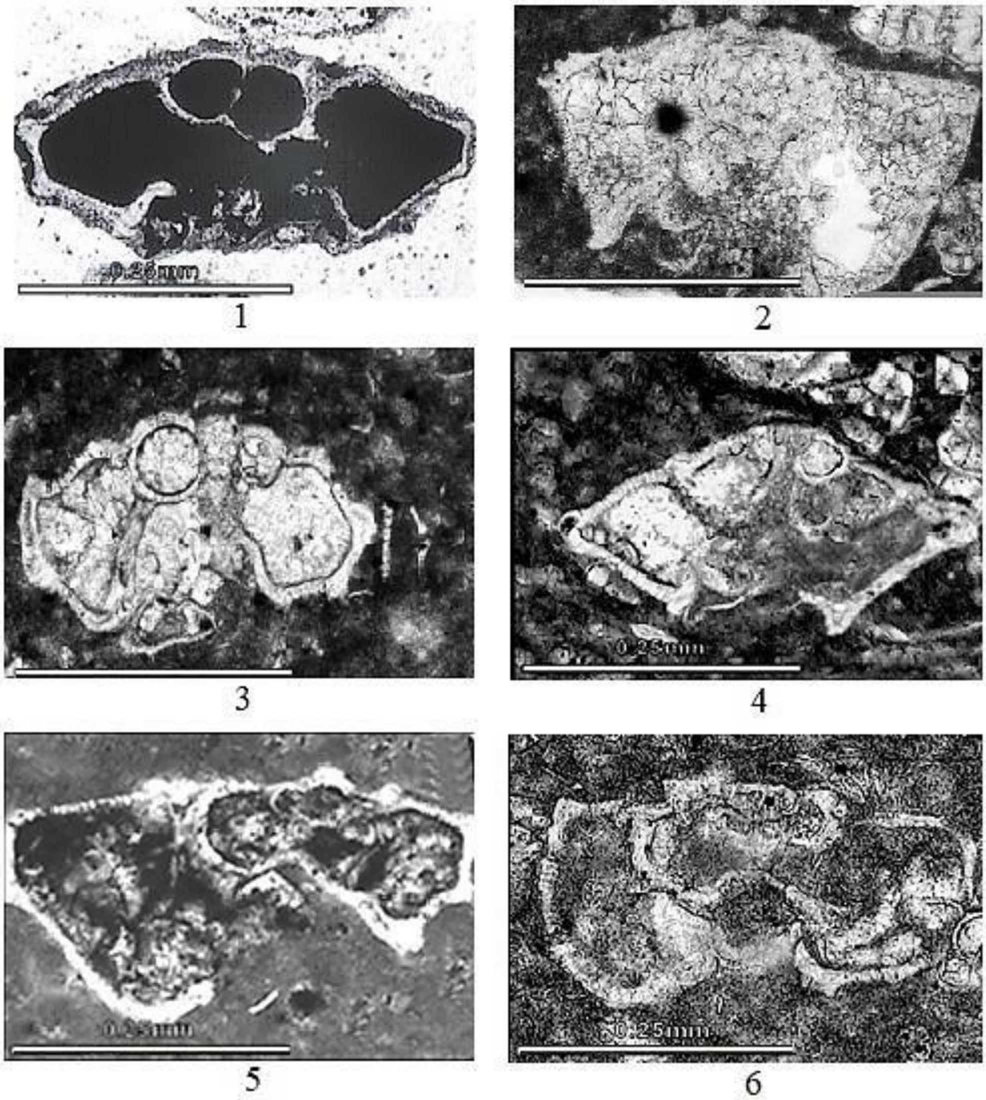

Plate: All figures are light micrographs (PL) with scale 25mm. 1. *Globotruncanita ventricosa* (White 1928); 2. *Globotruncanita elevata* (Brotzen 1934); 3. *Globotruncana bulloides* (Vogler 1941); 4. *Globotruncanita stuarti* (De lapparent 1918); 5. *Globotruncana aegyptica* (Nakkady 1950); 6. *Gansserina gansseri* (Bolli 1951).