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Biostratigraphy of the Gurpi Formation in Sepidan section, Interior Fars basin based on planktonic foraminifera

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Abstract

In this study biostratigraphy of the Upper Cretaceous deposits (Gurpi Formation) in Sepidan section located in the Interior Fars basin (SW Iran) was studied. The Gurpi Formation in this section consists of 360 m lime shale, argillaceous limestone and shale laid continuously on the Ilam Formation and with a paraconformity under the Pabdeh Formation. Nine genera and 27 species of planktonic foraminifera have been identified in the section. On this basis, the Gurpi Formation here includes nine biozones with an age of Santonian to Maastrichtian. The biozones identified resemble considerably those of the other parts of the world.

Keywords: *Biostratigraphy, Gurpi Formation, Interior Fars basin, Upper Cretaceous.*

Introduction

The Zagros fold-and-thrust belt is a section of the Alpine Himalayan system formed along the Arabia–Eurasia collision zone (Berberian & King, 1981; Golonka, 2004). Zagros basin is one of the greatest and most important oil-rich basins (Alavi, 1994). Gurpi Formation is one of the lithostratigraphic units of the basin from Cretaceous. The type section of the formation consists of 320 m argillaceous limestone and gray shale in Pabdeh strait north of Lali oil field located in the Northeast of Masjedsoleiman; the thickness and age of the Formation is different in different parts of Zagros in a way that the age of the base from Fars towards Khuzestan and Lurestan belongs to Santonian to Campanian and the top belongs to Maastrichtian to Paleocene (Motiei, 1993). Some stratigraphy studies include Vaziri-Moghaddam (2002), Hemmati-Nasab *et al.* (2008), Hadavi & Senemari (2010), Abrari *et al.* (2011), Asgharianrostami (2012), Esmaeilbeig (2012), Bieranvand & Ghasemi-Nejad (2013), Parvaneh-Nejad Shirazi *et al.* (2013), Fereydoonpour et al. (2014, 2015), Rahimi *et al.* (2015), Sadeghi & Darabi (2015), Zarei & Ghasemi-Nejad (2014, 2015).

The main purpose of this study is to examine lithostratigraphy and biostratigraphy of Gurpi Formation in the Internal Fars basin and compare it with some other sections of this formation in Zagros basin.

The Geographical and Geological Setting

Iran is divided structurally into eight tectonic units (Fig. 1-b) including Zagros, Alborz, Central Iran, Makran, Kopeh-dagh, Lut block, Sanandaj-Sirjan and Urumieh-Dokhtar magmatic arc (Aghanabati, 2004; Heydari *et al.*, 2003).

The Zagros Basin consists of a thick sedimentary sequence that covers the Precambrian basement formed during the PanAfrican orogeny (Al-Husseini, 2000). The total thickness of the sedimentary column deposited above the Neoproterozoic Hormuz salt before the Neogene Zagros folding reaches over 8-10 km (Alavi, 2004; Sherkati & Letouzey, 2004). Three parallel zones can be distinguished in the Zagros mountain chain (Fig. 1-c): the Uromiah–Dokhtar magmatic assemblage (UDMA; Alavi, 1980; 1994), the Zagros Imbricate Zone (ZIZ) and the Zagros Fold-Thrust Belt (ZFTB; Alavi, 2007). This belt is subdivided into different structural zones including the Interior Fars, Coastal Fars, Izeh, Dezful Embayment and the Lurestan zones. They are separated by strike slip faults known as Balarud, Hendijan and Kazeroun faults (Fig. 1-c; Motiei, 1993; Berberian & King, 1981). The study area is located in the Interior Fars and on latitude 30° 24′ 53″ N and 51° 53′ 6″ E (Fig. 2).

Materials and methods

150 samples of Gurpi Formation were taken from Sepidan section in order to identify and present Gurpi Formation biozones based on the Planktonic Foraminifera dispersion. For the preparation of isolated form, the process of preparing for a number of samples was carried out but because of hard rock, isolated forms were obtained without the necessary features for identification. Therefore the study was done only through thin sections.

Having provided microscopic thin sections, the microfossils with completely axial sections were photographed; and then based on different sources such as Postuma (1971), Caron (1985) and Premoli Silva & Verga (2004) the Planktonic Foraminifera were identified and biozones were determined by Premoli Silva & Verga (2004); then the studied section were compared with some parts of Zagros basin.

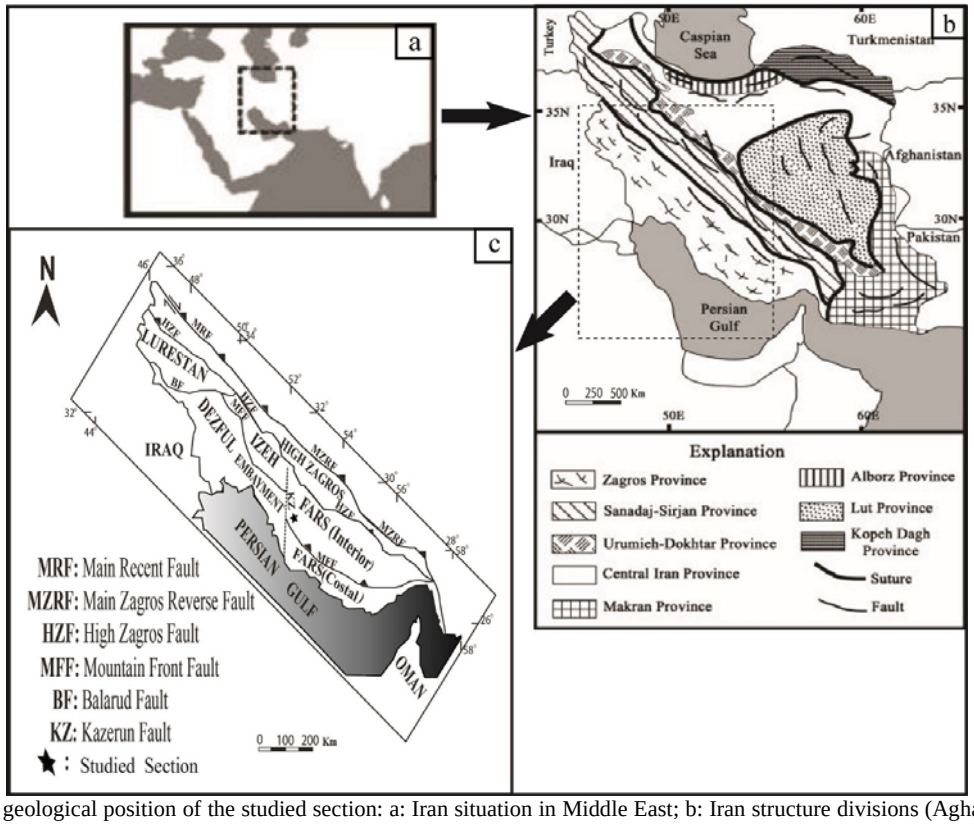

Figure 1. The geological position of the studied section: a: Iran situation in Middle East; b: Iran structure divisions (Aghanabati, 2004; Heydari et al., 2003) and c: Zagros construction divisions (Motiei, 1993) with geological situation of the studied section.

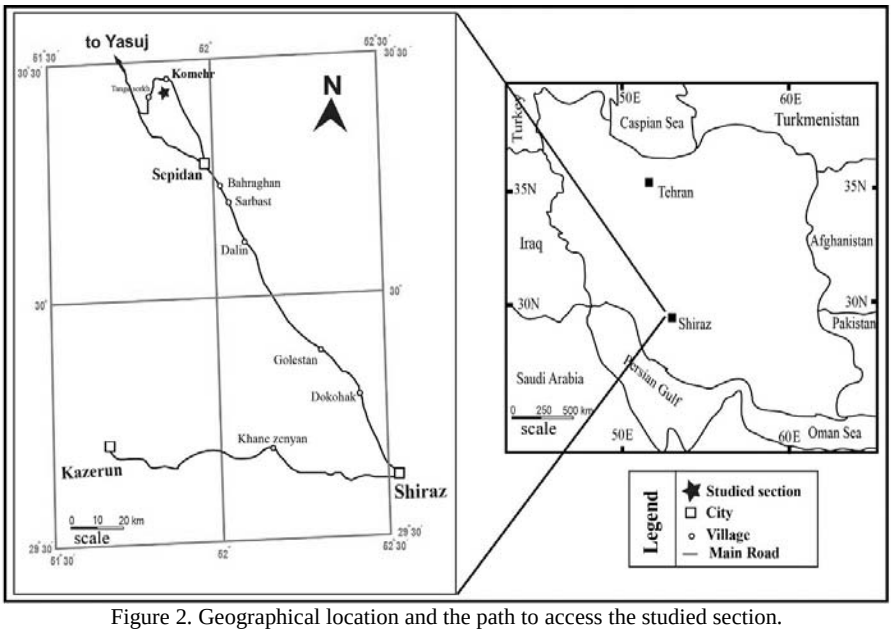

Figure 2. Geographical location and the path to access the studied section.

Lithostratigraphy of Gurpi Formation in Sepidan section

The Gurpi Formation was laid on Ilam Formation continuously and upper boundary was paraconformity to Pabdeh Formation. Because continuity in the fossil process and there is no evidence of disconformity is considered lower boundary of Gurpi formation continuously with Ilam Formation. Upper boundary of Gurpi Formation with the Pabdeh Formation due to fissure in the fossil process, the existence of Gluconite in primary part of the Pabdeh Formation and lack of any sign in the field operation indicate paraconformity. The above of the boundary the purple shale of the Pabdeh Formation as a key layer is clear. Lithologically, the Gurpi Formation in the section consists of three separated units:

Unit a: this unit consist of 135 m lime shale seen in the primary part of the Gurpi Formation in the section.

Unit b: this unit consist of 185 m argillaceous limestone with lime shale internal layers.

Unit c: this unit consist of 40 m shale and was studied at the end of the section ended by the Pabdeh Formation shales by a paraconformity.

Biostratigraphy of Gurpi Formation in Sepidan section

In this study, 9 genera and 27 species of planktonic foraminifera were identified in the Sepidan section and 9 biozones were presented according to their dispersion.

***Dicarinella asymetrica* Zone**

This zone is of total range zone including 38 m of the primary section and is defined by the appearance and disappearance of the genus: *Dicarinella asymetrica*.

Other species identified in this biozone include: *Dicarinella concavata, Marginotruncana coronata, Globotruncana bulloides, Globotruncana lapparenti, Marginotruncana sinusa, Marginotruncana renzi, Marginotruncana sigali,* and *Contusotruncana fornicata.*

This biozone was seen in primary part of the Gurpi Formation and by presence of *Globotruncanita elevata* above it the age of Santonian was taken into consideration for it.

***Globotruncanita elevata* Zone**

This biozone is of partial range zone and its lower and upper limits are defined by the appearance of *Dicarinella asymetrica* and *Globotruncana ventricosa*, respectively; it is of 33 m thickness and includes 38 – 71 m thickness of the section.

The predominant planktonic foraminifera are: *Globotruncana lapparenti, Globotruncana bulloides, Globotruncana arca,* and *Globotruncana hilli.*

The biozone is on the biozone No. 1 and it seems to be of the Early Campanian age.

***Globotruncana ventricosa* Zone**

It is an interval zone characterized by the appearance of *Globotruncana ventricosa* to *Globotruncana falsostuarti*. The other species of Globotruncanidae in this biozone include: *Globotruncana lapparenti, Globotruncana arca, Globotruncana bulloides, Globotruncanita elevata, Globotruncana hilli, Globotruncanita stuartiformis, Globotruncana linneiana*, and *Globotruncanita stuarti*.

The thickness of the zone is 71 m and 71 to 142 m section thickness; this biozone is on biozone No. 2 considered with the age of Middle Campanian.

***Radotruncana calcarata* Zone**

This zone is a total range zone characterized by the appearance to disappearance of *Radotruncana calcarata*. The other fossils with this biozone include: *Globotruncana bulloides, Globotruncana hilli*, and *Globotruncanita stuarti*.

This biozone is on biozone No. 3 considered with the age of Middle Campanian; section thickness of 142 – 162 m and thickness of 20 m.

***Globotruncanella havanensis* Zone**

This zone is a partial type and is between the disappearance of the genus *Radotruncana calcarata* in the lower limit and appearance of the genus *Globotruncana aegyptiaca* in the upper limit; its thickness is 56 m in addition to 162 – 218 m thickness of the section. The genera with this zone include: *Globotruncana bulloides, Globotruncanita stuarti, Globotruncana ventricosa, Globotruncana falsostuarti*, and *Globotruncana hilli*. The age of Late Campanian is considered as its age.

***Globotruncana aegyptiaca* Zone**

It is an interval zone, too and its lower and upper limits are defined by the appearance of *Globotruncana aegyptiaca* and *Gansserina gansseri*, respectively. The predominant planktonic foraminifera are: *Globotruncana bulloides, Globotruncana ventricosa, Globotruncanella havanensis, Globotruncana lapparenti, Globotruncana*

arca, Globotruncana orientalis, Globotruncana falsostuarti, Globotruncanita stuartiformis, Globotruncanita stuarti, and *Globotruncana rosetta.*
This biozone is on biozone No. 5 with its considered by the age of Middle Campanian; its thickness is 50 m in addition to 218 – 268 m thickness of the section.

***Gansserina gansseri* Zone**
It is an interval zone characterized by the first appearance of *Gansserina gansseri* to the first appearance of *Contusotruncana contusa*. The other fossils with it include: *Globotruncana lapparenti, Globotruncanita stuartiformis, Globotruncana arca, Globotruncana bulloides, Globotruncanita angulata, Globotruncana falsostuarti, Globotruncana ventricosa, Globotruncana aegyptiaca, Globotruncana orientalis, Globotruncana insignis,* and *Globotruncanita stuarti.*
This biozone is on biozone No. 6 and the latest part of Late Campanian to the lower part of Maastrichtian is taken into consideration for it; its thickness is 46 m while its section thickness is 268 – 314 m.

***Contusotruncana contusa* Zone**
This is of total range zone and is defined by the appearance to disappearance of *Contusotruncana contusa;* its thickness is 28 m while section thickness is 314 – 342 m. The other fossils with it include: *Globotruncana lapparenti, Globotruncanita stuartiformis, Globotruncana arca, Globotruncana bulloides, Globotruncanita angulata, Globotruncana falsostuarti, Globotruncana ventricosa, Globotruncana aegyptiaca, Globotruncanita stuarti, Globotruncana orientalis, Globotruncana insignis,* and *Globotruncanita stuarti.*

This biozone is on biozone No. 7 and its age is determined by the age of Early to Late Maastrichtian.

***Abathomphalus mayaroensis* Zone:**
It is of interval zone; its lower and upper limits are defined by *Abathomphalus mayaroensis* appearance and disappearance of all genera of Globotruncanidae family.
This biozone is 18 m in thickness in addition to 342 m section thickness. Other species identified in this biozone include: *Globotruncanita angulata, Globotruncanita stuarti, Globotruncana aegyptiaca, Gansserina gansseri, Globotruncanita conica, Globotruncanita pettersi, Globotruncana insignis,* and *Globotruncana falsostuarti.*

This biozone is on biozone No. 8 and the age of Late Maastrichtian is considered in its age. Thus, the age of the deposits of Gurpi Formation in Sepidan section is Santonian to the end of Maastrichtian.

Table 1 compares the biozones in the region with some biozonation of worldwide standard include James & Wynd (1965), Sigal (1977), Caron (1985), Sliter (1989), Premoli Silva & Verga (2004) and Ogg et al. (2008). As can be seen considerable compliance between biozones of Gurpi Formation in Sepidan section and biozones provided by Premoli Silva & Verga (2004) and Ogg et al. (2008).

Comparing Gurpi Formation in Sepidan section with some regions in Zagros basin
Planktonic foraminifera are useful fossil groups used to define the relative age of the Upper Cretaceous layers. By distribution and dispersion of the planktonic foraminifera and present biozones definition, it is possible to define the Gurpi Formation sediment beginning at different parts of the Zagros basin. In this section we compare the Gurpi Formation with some Zagros parts (Fig. 5) namely:

Type section- The Gurpi Formation is of 320 m thickness in the section as 8 lithostratigraphy units that consists of marly limestone, marly limestone and shale, shale marl and limestone, marly limestone with shale interbedding, limestone and shale and shale with limestone and marl. The Gurpi Formation in this section lies in disconformity with the IIam Formation and with a paraconformity under basely purple shales of the Pabdeh Formation. The Gurpi Formation in this section includes 7 biozones at the age of Early Campanian to Late Maastrichtian (Vaziri-Moghaddam *et al.,* 2006).

Sepidan section- The Gurpi Formation in the Sepidan region with 360 m thickness has 3 lithostratigraphy units that Including calcareous shale, argillaceous limestone with interbedding of calcareous shale and shale and the lower boundary is continuous to the Ilam Formation and the upper boundary is in paraconformity with Pabdeh Formation. Gurpi Formation in this section includes 9 biozones at the age of Santonian to Maastrichtian.

Dashtak section- This section in Dashtak anticline in the North of Kazerun is of 343 m thickness and consists of thin to medium bedded argillaceous

limestone and shale and the lower boundary lies in disconformity on the Sarvak Formation and the upper one with a paraconformity is under Pabdeh Formation. 7 biozones were found in the studied section and the age of Gurpi Formation in this section is Santonian to Late Maastrichtian (Esfandyari Bayat, 2014). Having compared the Gurpi Formation in Sepidan region in view of biostratigraphy and lithostratigraphy with some other Zagros parts, we conclude that:

Due to the presence *Dicarinella asymetrica* biozone, age of the base Gurpi Formation in Sepidan and North Kazerun sections is Santonian. Accordingly, sedimentation of Gurpi Formation in North Kazerun and Sepidan sections of the Santonian started, while at the same time Gurpi Formation in type section of lack of sedimentation have been seen. With the progress of the sea level in the Campanian, conditions for deposition of Gurpi Formation in Lali region is provided and the presence *Globotruncanita elevata* biozone, age of the base Gurpi Formation in Lali region is showed. The sedimentation in the North Kazerun to late Maastrichtian has been continued and latest biozone in Gurpi Formation is *Contusotruncana contusa* biozone.

Table 1. Comparing the biozones in the region with some biozones of worldwide standard

<table>
<tr><th>Age / stage</th><th>James & Wynd (1965)</th><th>Sigal (1977)</th><th>Caron (1985)</th><th>Sliter (1989)</th><th>Premolisilva & Verga (2004)</th><th>Ogg et al. (2008)</th><th>This study</th></tr>
<tr><td>65 M.Y.</td><td>Zagros</td><td></td><td>Tethys</td><td>Tethys</td><td></td><td></td><td>Sepidan</td></tr>
<tr><td rowspan="6">Maastrichtian
71.3</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td><td>Abathomphalus mayaroensis</td></tr>
<tr><td rowspan="2">G.stuarti + Pseudotextularia</td><td>Gansserina gansseri</td><td>Gansserina gansseri</td><td>Gansserina gansseri</td><td>contusa R.fructicosa</td><td>contusa R.fructicosa</td><td>contusotruncana contusa</td></tr>
<tr><td rowspan="2">G.stuarti + Globotroncana falsostuarti</td><td>Globotruncana aegyptiaca</td><td>Globotruncana aegyptiaca</td><td rowspan="3">Gansserina gansseri</td><td rowspan="3">Gansserina gansseri</td><td rowspan="3">Gansserina gansseri</td></tr>
<tr><td>Globotruncanella havanensis</td><td>Globotruncanella havanensis</td></tr>
<tr><td rowspan="5">Campanian
83.5</td><td rowspan="5">G.elevata elevata</td><td>Radotruncana calcarata</td><td>Radotruncana calcarata</td><td>Radotruncana calcarata</td></tr>
<tr><td rowspan="4">Globotroncanita elevata + Globotroncanita stuartiformis</td><td rowspan="3">Globotroncana ventricosa</td><td rowspan="3">Globotroncana ventricosa</td><td>G. aegyptiaca</td><td>G.aegyptiaca</td><td>G.aegyptiaca</td></tr>
<tr><td>Globotruncanella havanensis</td><td>Globotruncanella havanensis</td><td>Globotruncanella havanensis</td></tr>
<tr><td>R. calcarata</td><td>R. calcarata</td><td>R. calcarata</td></tr>
<tr><td>Globotroncanita elevata</td><td>Globotroncanita elevata</td><td>G. ventricosa</td><td>G.ventricosa</td><td>G. ventricosa</td></tr>
<tr><td rowspan="2">Santonian
85.8</td><td rowspan="2">G.concavata + carinata</td><td>G. concavata + carinata</td><td>Dicarinella asymetrica</td><td>Dicarinella asymetrica</td><td rowspan="2">Dicarinella asymetrica</td><td>Dicarinella asymetrica</td><td rowspan="2">Dicarinella asymetrica</td></tr>
<tr><td rowspan="2">Dicarinella concavata</td><td rowspan="2">Dicarinella concavata</td><td rowspan="2">Dicarinella concavata</td><td rowspan="2"></td></tr>
<tr><td>Coniacian</td><td></td><td>Dicarinella concavata</td><td></td><td></td></tr>
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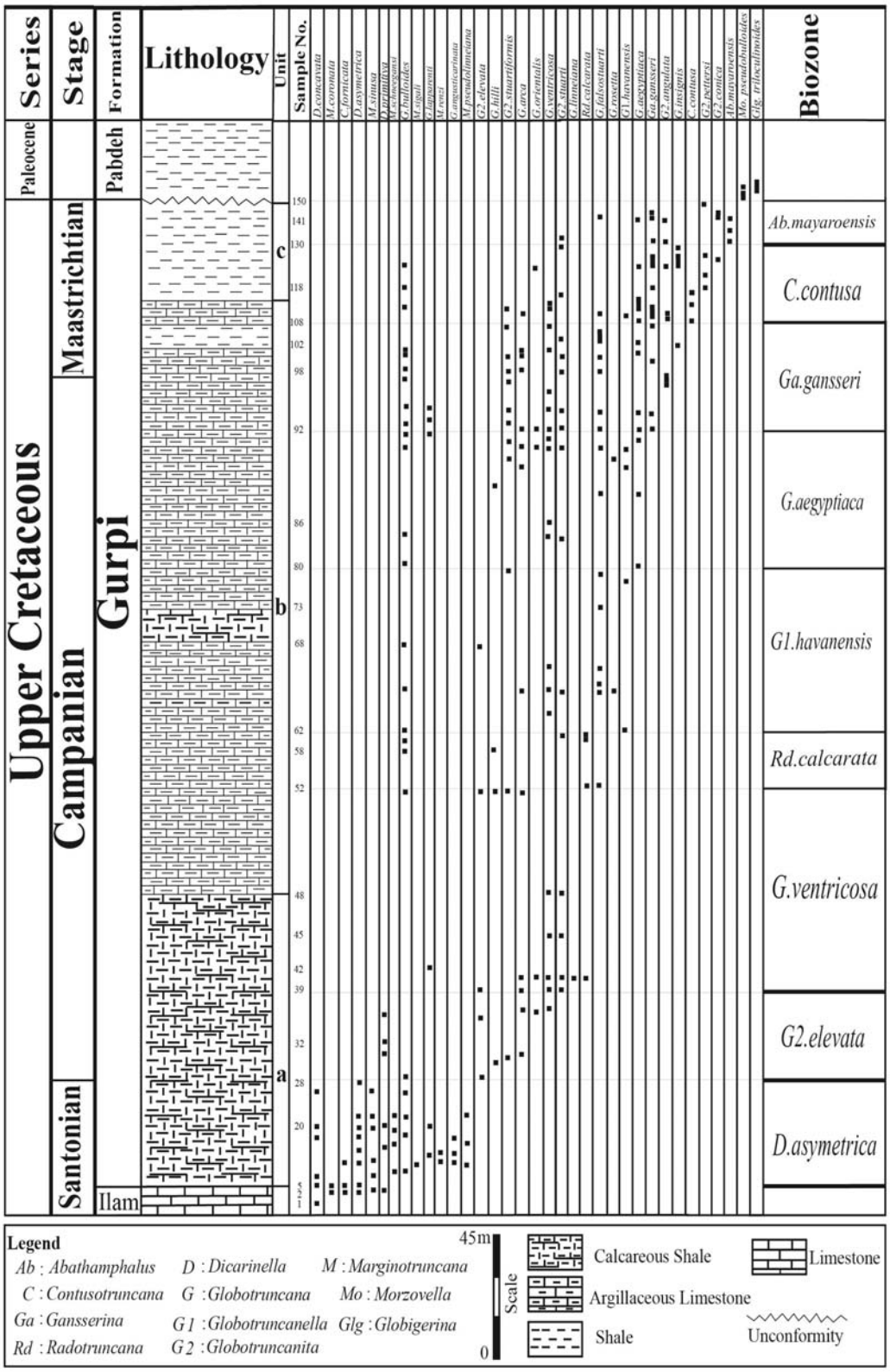

Figure 3. The column of biostratigraphy of Gurpi Formation in Sepidan section.

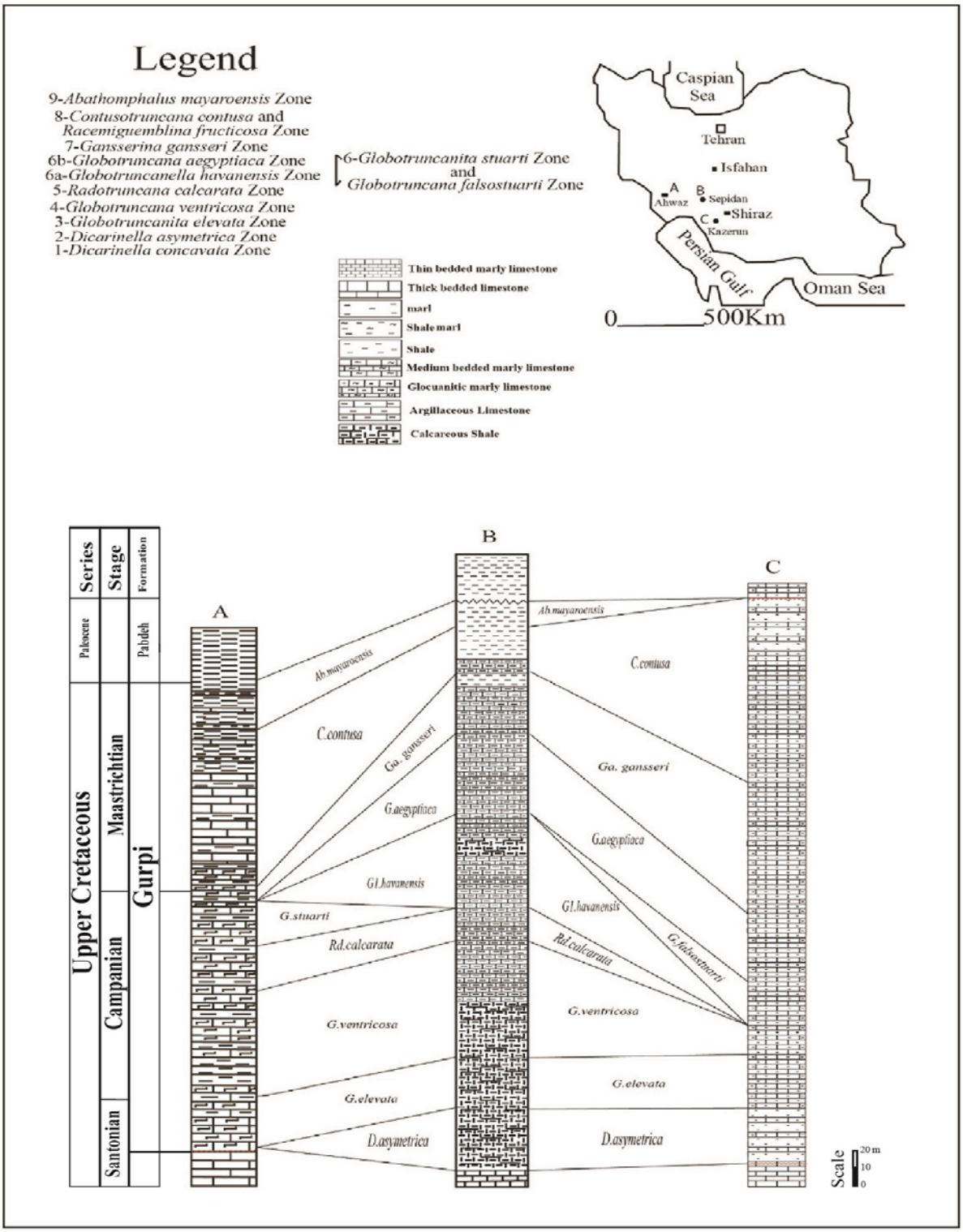

Figure 4. Biostratigraphy correlation of Gurpi Formation in Sepidan section with some regions in Zagros basin; A: Lali section, type section (Vaziri-Moghaddam *et al.*, 2006); B: Sepidan section and C: Dashtak section (Esfandyari Bayat, 2014).

The lack of *Abathomphalus mayaroensis* biozone in the North Kazerun region that indicates the highest limit of Maastrichtian, is due to the reduced depth in this region. Afterward, in the North

Kazerun region the Pabdeh Formation of pelagic facies by a paraconformity placed on Gurpi Formation, while the presence *Abathomphalus mayaroensis* biozone shows that Gurpi Formation in Lali and Sepidan sections has been continued to the latest late Maastrichtian. Then, in this regions as North Kazerun region, the Pabdeh Formation of pelagic facies by a paraconformity placed on Gurpi Formation. As can be seen from the comparison results are consistent with the general trend of Gurpi Formation from Fars province towards Lurestan and Khuzestan provinces.

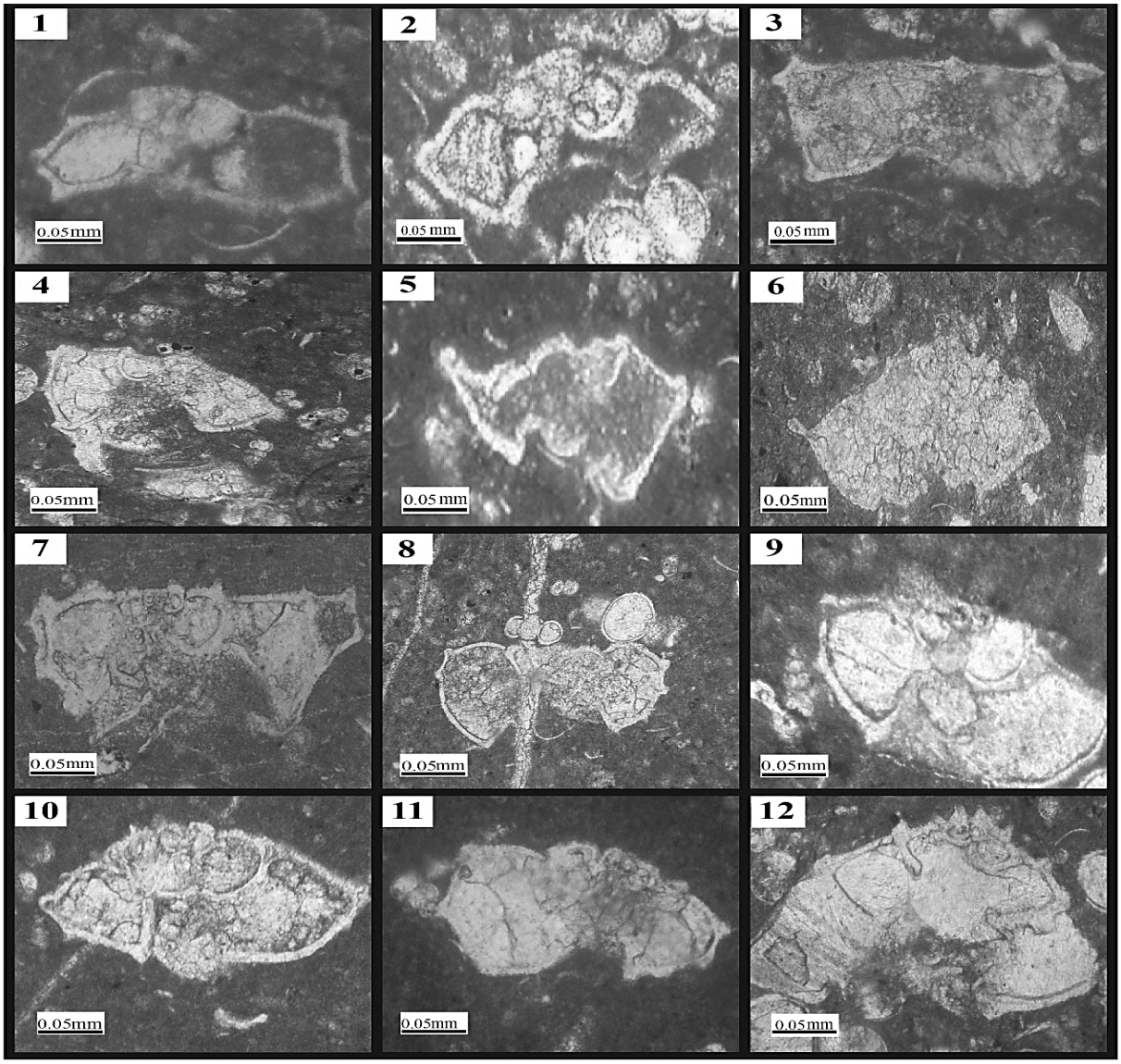

Plate 1. 1. *Abathomphalus mayaroensis*, (Bolli, 1951); 2. *Globotruncanella havanensis*, (Voorwij, 1937); 3. *Dicarinella asymetrica*, (Sigal, 1952); 4. *Globotruncanita elevata*, (Brotzen, 1934); 5. *Radotruncana calcarata*, (Cushman, 1927); 6. *Globotruncanita stuarti*, (De lapparent, 1918); 7. *Globotruncana ventricosa*, (White, 1928); 8. *Globotruncana aegyptiaca*, (Nakkady, 1950); 9. *Gansserina gansseri*, (Bolli, 1951); 10. *Globotruncana falsostuarti*, (Sigal, 1952); 11. *Globotruncana lapparenti*, (Brotzen, 1936); 12. *Globotruncanita conica*, (White, 1928).

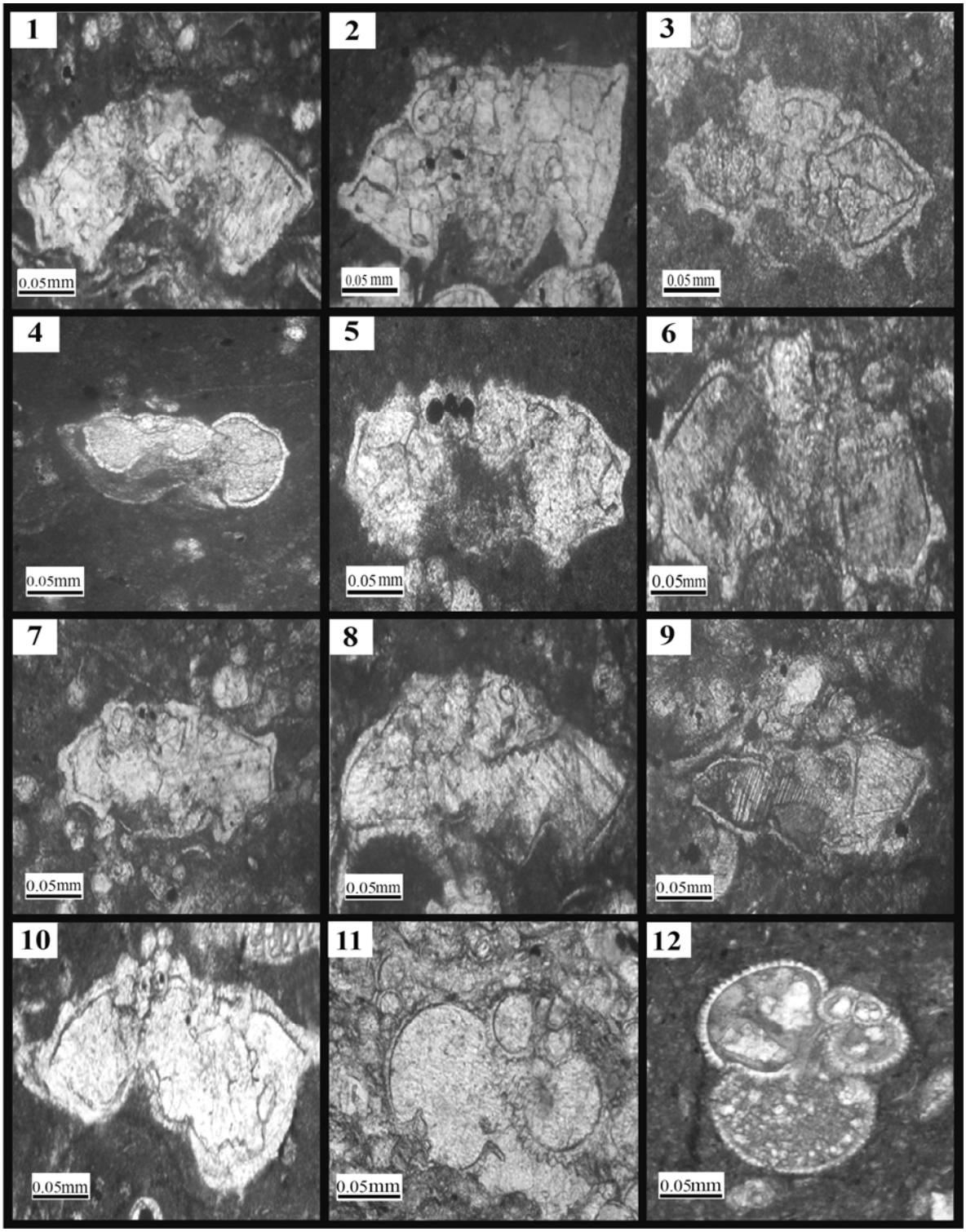

Plate 2. 1. *Marginotruncana renzi*, (Gandolfi, 1949); 2. *Globotruncanita angulata*, (Tilev, 1951); 3. *Globotruncana orientalis*, (El-Naggar, 1966); 4. *Globotruncana hilli*, (Pessagno, 1951); 5. *Globotruncana bulloides*, (Vogler, 1941); 6. *Contusotruncana fornicata*, (Plummer, 1931); 7. *Marginotruncana pseodolinneiana*, (Pessango, 1967); 8. *Marginotruncana schneegansi*, (Sigal, 1952); 9. *Marginotruncana sinusa*, (Porthalat, 1970); 10. *Globotruncanita stuartiformis*, (Dalbiez, 1955); 11. *Morzovella pseudobulloides*, (Plummer, 1926); 12. *Globigerina triloculinoides*, (Plummer, 1926).

Conclusion

The results of the stratigraphic study of the Gurpi Formation based on Globotruncanidae show that:

Gurpi Formation in the Sepidan section consist of 360 m lime shale, argillaceous limestone and shale laid continuously on Ilam Formation and with a paraconformity under Pabdeh Formation.

Studying the biostratigraphy of Gurpi Formation showed that 9 genera and 27 species of planktonic foraminifera and 9 biozones are present in the Sepidan section.

The studied section biozones is comparable with the Upper Cretaceous biozones presented in worldwide standard scale.

The lower layers of Gurpi Formation in Sepidan section, considering the presence of *Dicarinella asymetrica* has the age of Santonian. The last biozone of the Gurpi Formation in Sepidan section is *Abathomphalus mayaroensis* Zone. On this basis, the age of Gurpi Formation in this section is Santonian to the end of Maastrichtian.

Comparing biozones of Sepidan section with some other parts of the Zagros basin indicates that the Gurpi Formation sediment had begun more rapidly in Sepidan and Kazerun sections and later ended in type section and Sepidan section.

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