Biostratigraphy of the Gurpi Formation (Zagros Basin, western Iran) based on planktonic foraminifera

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Abstract. Micropalaeontological and biostratigraphic studies of the Gurpi Formation were carried out at the Kuhe-Surgah section (Zagros Basin, Iran). In this research, 62 species of planktonic foraminifera, belonging to 23 genera, were recognized and used to describe the following zones: 1) Contusotruncana plummerae Interval Zone; 2) Radotruncana calcarata Total Range Zone; 3) Globotruncanella havanensis Partial Range Zone; 4) Globotruncanana aegyptiaca Interval Zone; 5) Gansserina gansseri Interval Zone; 6) Contusotruncana contusa Interval Zone; 7) Abathomphalus mayaroensis Interval Zone; 8) Pseudoguembelina hariensis Interval Zone; 9) Pseudotextularia elegans Interval Zone; 10) Parvularugoglobigerina eugubina Total Range Zone; 11) Parasubbotina pseudobulloides Interval Zone; and 12) Praemurica unicinata Interval Zone. Based on the ranges of planktonic foraminifera, the age of the Kuhe-Surgah section was estimated to be middle Campanian–late Danian.


Keywords: Gurpi Formation, Kuhe-Surgah section, planktonic foraminifera, Zagros Basin, Iran.

INTRODUCTION

The Zagros Fold–Thrust Belt, which extends for about 1800 km through Iraq and SW Iran, is a continent–continent, NW–SE trending, collisional orogenic belt between the African–Arabian plate and the Iranian block (Berberian and King, 1981; Koyi, 1988). This long mountain range constitutes a section of a folded belt of the Alpine-Himalayan orogenic system and spreads from the East Anatolian fault, in eastern Turkey, to the Makran range in southern Iran (Mouthereau, 2011). The Lorestan Province, which geographically takes part of this belt, has a long history of hydrocarbon exploration and production. The first hydrocarbon exploration and drilling activities in the Middle East started in this area (Motiee, 1994). The Upper Cretaceous marine sediments occur in different sedimentary basins in Iran, but one of their main outcrops can be found in the Zagros Basin of Lorestan. The Gurpi Formation is an important part of oil source rocks in the Zagros Basin, with variable age, ranging from the Santonian to the Paleocene (Aghanabati, 2004). The type section for this formation is in the Lali oil field in the northeast of Masjed Soleiman, and the dominant lithology consists of grey shales/marlstones and clayey limestones, with a total thickness of 320 m. The Gurpi Formation is underlain by the limestones of the Ilam Formation and covered by the shales of the Pabdeh Formation (James and Wynd, 1965). For this study, we selected the Kuhe-Surgah section of the Gurpi Formation and report planktonic foraminiferal zonation from this succession. The latter is correlated with four other successions of the Lorestan Province. To date, numerous studies on the Gurpi Formation in the Zagros Basin have been presented, including biostratigraphic studies based on planktonic foraminifera: Vaziri-Moghadam et
al. (2013), in the Gardbishe Area; Hemmati-Nasab et al. (2008), in the Kavar section; Daneshian et al. (2009), in the east Kangan Port and Ivan well; Asgharian Rostami (2012), at the Mish-Khas section; Fereydoonpoor et al. (2014), at the sections of the Kuh-e Siah, Tang-e Bulfares and Aghar anticlines; Bakhshandeh et al. (2015), at the Banroshan section (Fazli, 2015) at the Kuh-e Heram and Kuh-e Nargh sections; Sadeghi and Darabi (2015), at the Maroon oil fields; Biranvand and Qaseminejad (2013), at the Daniel section; and Rahimi et al. (2018), at the Gandab Section. Relatively diverse and well-preserved planktonic foraminiferal assemblages were found in this study. These assemblages provide more precise biostratigraphic subdivision of the studied succession than the previously made attempts.

LITHOLOGICAL BACKGROUND

The studied stratigraphic section is located in the Kuhe-Surgah Anticline, E of the town of Ilam (46°19′12.96″ E; 33°35′38.53″ N) (see Fig. 1). The rock units that constitute the Gurpi Formation consist of the following elements: 1) alternation of shales and limestones; 2) light grey shales with rare limestone interbeds, 300 m thick; 3) light brown limestones, 45 m thick (Seymare Limestone); 4) shales, 75 m thick; 5) light brown limestones, 88 m thick (Imam Hassan Limestone); 6) shales and limestones in alternation, 38 m thick; and 7) shales with a thickness of 66 m. The entire succession corresponds to a total thickness of 612 m. The lower boundary of the Gurpi Formation is conformable with the limestones of the Ilam Formation, whereas the upper boundary is marked by the first appearance of purple shales of the Pabdeh Formation (see Fig. 2).

MATERIAL AND METHODS

Three hundred and eleven samples, from both the soft sediments (shales) and the intercalated lime-

Fig. 1. a, b) Location maps of the Kuhe-Surgah section (Iran); c, d) Field photographs of the lower and upper boundaries of the Gurpi Formation in the Kuhe-Surgah section.
Fig. 2. Lithological column and planktonic foraminifer biostratigraphy of the Gurpi Formation in the Kuhe-Surgah section.
stone layers of the Gurpi Formation, were collected at the Kuhe-Surgah section. The sampling density between the base of the Gurpi Formation and the upper part of the Abathomphalus mayaroensis Zone is 4 m; up-section, it was increased to 5 m. Samples were transferred to the lab and about 200 g of each sample was crushed into small particles and placed in pure water for 2 days. Following the methodology of Zapeda (1998), 10% solution of hydrogen peroxide was also added. Washing was performed on 70 μm, 150 μm and 230 μm mesh. After the separation of microfossils under the optical microscope (Sa-Iran ZSM1001), the planktonic foraminifera were placed in special cells, and then they were taxonomically identified. Taxonomic concepts follow those of Postuma (1971), Caron (1985), Robaszynski and Caron (1979, 1995), Premoli Silva et al. (2003), and Premoli Silva and Verga (2004). Finally, washed residues were picked and micrographs of selected foraminiferal taxa were taken with a Scanning Electron Microscope (SEM) (Leo 1450VP) in the Central Laboratory of Ferdowsi University of Mashhadand.

FORAMINIFERAL BIOSTRATIGRAPHY

In this study, 23 genera and 62 species of planktonic foraminifera were identified. On this basis, a continuous succession of 12 Upper Cretaceous–Paleogene foraminiferal zones, from the Campanian to the Danian, is herein described (see Fig. 2; see also Figs 3, 4). The definitions of the zones follow those of Caron (1985), Sliter (1989), Abdel-Kireem et al. (1995), Robaszynski and Caron (1995), Yıldız and Özdemir (1999), Robaszynski et al. (2000), Dimitrova and Valchev (2007), Darvishzad et al. (2007) and Premoli Silva and Verga (2004). The biozoneation used in this study is also similar to those of Premoli Silva et al. (2003) and Coccioni and Premoli Silva (2015).

Contusotruncanita plummerae Interval Zone

This zone spans the uppermost part of the Ilam Formation and the lower part of the Gurpi Formation, and its thickness is 120 m. The zone was defined as the interval between the first occurrence (FO) of Contusotruncanita plummerae and the FO of Radotruncanita calcarata. It corresponds to the middle Campanian. We follow the opinion of Petrizzo et al. (2011), who replaced the Globotruncanita ventricosa Zone with the Contusotruncanita plummerae Zone based on studies of the Bottaccione section (Italy) and Site 146 (central Atlantic Ocean). The most important species in the Contusotruncanita plummerae Zone include: Archaeoglobigerina blowi (Pessagno, 1967); A. cretacea (d’Orbigny, 1840); Contusotruncanita fornicata (Plummer, 1931); C. patelliformis (Gandolfi, 1955); Globotruncanita arca (Cushman, 1926); G. bulloides (Vogler, 1941); Globotruncanita hilli (Pessagno, 1967); Globotruncanita linneiana (d’Orbigny, 1839); G. lapparenti (Brotzen, 1936); G. mariei (Banner & Blow, 1960); G. orientalis (El Naggar, 1966); G. ventricosa (White, 1928); Globotruncanita stuartiformis (Dalbiez, 1955); G. elevata (Brotzen, 1934); Macroglobigerinelloides bollii (Pessagno, 1967); M. multispinus (Lalicker, 1984); M. prairiehillensis (Pessagno, 1967); and Pseudotextularia nuttalli (Voorwijk, 1937).

Radotruncanita calcarata Total Range Zone

This zone occurs in the light grey shales of the lower part of the Gurpi Formation, and it is 56 m thick. It corresponds to the total range of Radotruncanita calcarata, which is late Campanian in age. We follow the zonal definition of Herm (1962). The planktonic foraminiferal assemblages in this zone are similar to those from the previous zone. The most important species include: Archaeoglobigerina cretacea (d’Orbigny, 1940); Contusotruncanita fornicata (Plummer, 1931); C. patelliformis (Gandolfi, 1955); Globotruncanita arca (Cushman, 1926); G. linneiana (d’Orbigny, 1839); G. mariei (Banner & Blow, 1960); Globotruncanita stuartiformis (Dalbiez, 1955); Macroglobigerinelloides bollii (Pessagno, 1967); M. prairiehillensis (Pessagno, 1967); M. multispinus (Lalicker, 1948); Planoheterohelix globulosa (Ehrenberg, 1840); Rugotruncanita subcircummodifer (Gandolfi, 1955); and Rugoglobigerina macrocephala (Bromnimann, 1952).

Fig. 3. Representative foraminifer species from the Gurpi Formation. 1a–c Globotruncanita bulloides (Vogler,1941); 2a–c Contusotruncanita contusa (Cushman,1926); 3a–c Contusotruncanita fornicata (Plummer, 1931); 4a–c Macroglobigerinelloides prairiehillensis (Pessagno 1967); 5a–c Contusotruncanita plummerae (Gandolfi,1955); 6a–c Globotruncanita neotricarinata (Petrizzo, Falzoni & Premoli Silva 2011); 7a–c Globotruncanita aegyptiaca (Nakkady,1950). Scale bar same for all images.
Globotruncanella havanensis Partial Range Zone

This zone occurs in the light grey shales of the lower part of the Gurpi Formation. It is 84 m thick. The zone represents an interval, with Globotruncanella havanensis, between the last occurrence (LO) of Radotruncana calcara and the FO of Globotruncanca aegyptiaca. It corresponds to the upper Campanian (pars.). We follow the zonal definition of Caron (1978). The most important foraminiferal species in the zone include: Archaeoglobigerina cretacea (d’Orbigny, 1840); Contusotruncana fornicata (Plummer, 1931); C. patelliformis (Gandolfi, 1955); Globotruncanca arca (Cushman, 1926); G. linneiana (d’Orbigny, 1839); G. ventricosa (Whit, 1928); Globotruncanita stuartiformis (Dalbiez, 1955); Globotruncanella havanensis (Voorwijk, 1937); Macroglobigerinelloides prairiehillensis (Pessagno, 1967); M. multispinus (Lalicker, 1948); Pseudotextularia nuttalli (Voorwijk, 1937); Rugotruncanca subcircumnodifer (Gandolfi, 1955); Rugoglobigerina macrocephala (Broennimann, 1952); and R. rugosa (Plummer, 1926).

Gansserina gansseri Interval Zone

This zone occurs in a 106-m thick interval of the Gurpi Formation, which is comprised of shales and limestones. We follow the definition of Brönnimann (1952), according to which the zone spans the interval between the FOs of Gansserina gansseri and Contusotruncanca contusa. This interval includes the Campanian/Maastrichtian boundary. The most important foraminifera include: Globotruncanca arca (Cushman, 1926); G. linneiana (d’Orbigny, 1839); Globotruncanita stuartiformis (Dalbiez, 1955); Globotruncanita stuarti (de Lapparent, 1918); Pseudotextularia nuttalli (Voorwijk, 1937); P. elegans (Rzehak, 1891); Rugoglobigerina macrocephala (Brönnimann, 1952); R. rugosa (Plummer, 1926); and Trinitella scotti (Brönnimann, 1952). In this zone, the FOs of Contusotruncanca walfichensis, Globotruncanella minuta and Trinitella scotti were also recognized. These bioevents, which were detected in the middle part of the zone, indicate the Campanian/Maastrichtian boundary.

Contusotruncanca contusa Interval Zone

The zone corresponds to a 40-m thick interval of the Gurpi Formation, which consists of limestones (Imam Hassan Limestone). Following the definition of Li and Keller (1998a, b), the zone was identified by the FOs of Contusotruncanca contusa and Abathomphalus mayaroensis. The diagnostic foraminifera are: Gansserina gansseri (Bolli, 1951); Globotruncanca linneiana (d’Orbigny, 1839); Globotruncanita stuartiformis (Dalbiez, 1955), G. stuarti (de Lapparent, 1918); Pseudotextularia nuttalli (Voorwijk, 1937); P. elegans (Rzehak, 1891); Rugoglobigerina macrocephala (Brönnimann, 1952); R. rugosa (Plummer, 1926); and Racemiguembelina powelli (Smith and Pessagno, 1973). Amongst them, G. gansseri is particularly abundant in the upper part of the zone. The LO
of Globotruncanella petaloidea was recorded near the base of the zone.

**Abathomphalus mayaroensis Interval Zone**

This zone corresponds to a 30-m thick limestone interval in the upper parts of the Gurpi Formation. It was recognized according to the definition of Brönnimann (1952), i.e., between the FOs of Abathomphalus mayaroensis and Pseudoguembelina hariaensis. The zone is late Maastrichtian in age, following the definition of Li and Keller (1998a, b). The zonal assemblage includes: Contusotruncana contusa (Cushman, 1926); Gansserina gansseri (Bolli, 1951); Globotruncana aegyptiaca (Nakkady, 1950); G. arca (Cushman, 1926); G. linneiana (d’Orbigny, 1839); Globotruncanella havanensis (Voorwijk, 1937); Pseudoguembelina palpebra (Brönnimann & Brown, 1953); Pseudotextularia elegans (Rzehak, 1891); P. nuttalli (Voorwijk, 1937); Racemiguembelina fructicosa (Egger, 1899); R. powelli (Smith and Pessagno, 1973); Rugoglobigerina hexacamerata (Brönnimann, 1952); R. macrocephala (Brönnimann, 1952); and R. rugosa (Plummer, 1926). The most important event in this biozone is the FO of Racemiguembelina fructicosa, which was recorded near the base of the zone.

**Pseudoguembelina hariaensis Interval Zone**

This zone corresponds to a 16-m thick interval of the Gurpi Formation, which consists of alternating shales and limestones. It is an interval between the FO of Gansserina gansseri and the LO of Gansserina gansseri (Brönnimann & Brown, 1953); Pseudotextularia elegans (Rzehak, 1891); P. nuttalli (Voorwijk, 1937); Racemiguembelina fructicosa (Egger, 1899); R. powelli (Smith and Pessagno, 1973); Rugoglobigerina hexacamerata (Brönnimann, 1952); R. macrocephala (Brönnimann, 1952); and R. rugosa (Plummer, 1926). The zonal association includes: Abathomphalus mayaroensis (Bolli, 1951); Contusotruncana contusa (Cushman, 1926); Gansserina gansseri (Bolli, 1951); Globotruncana aegyptiaca (Nakkady, 1950); G. arca (Cushman, 1926); G. mariei (Banner & Blow, 1960); and Pseudotextularia elegans (Rzehak, 1891); P. nuttalli (Voorwijk, 1937); Planohe terohelix globulosa (Ehrenberg, 1840); and Pseudoguembelina hariaensis (Nederbragt, 1991).

**Parvularugoglobigerina eugubina Total Range Zone**

This zone occurs in the shale-limestone alternation of the upper part of the Gurpi Formation. It is 24 m thick. As defined by Luterbacher and Premoli Silva (1964), the zone corresponds to the total range of Parvularugoglobigerina eugubina, which is earliest Danian in age. In our section, the zone was defined by the occurrence of Subbotina triloculinoides (Plummer, 1926) and S. cancellata (Blow, 1979).

**Parasubbotina pseudobulloides Interval Zone**

This zone occurs in the dark grey shales of the uppermost part of the Gurpi Formation and has a total thickness of 26 m. It was defined by Premoli Silva et al. (2003) as framed by the LO of Parvularugoglobigerina eugubina and the FO of Praemurica uncinata and corresponds to the earliest Maastrichtian. In our section, the zonal association includes Parvularugoglobigerina eugubina (Luterbacher & Premoli Silva, 1964); Subbotina triloculinoides (Plummer, 1926); Subbotina cancellata (Blow, 1979); and Subbotina spp.

**Praemurica uncinata Interval Zone**

This zone occurs in the black shales of the uppermost part of the Gurpi Formation. It is 30 m thick. We follow the definition of Bolli (1957), according to which the zone is defined between the FOs of Praemurica uncinata and Morozovella angulata. It corresponds to the uppermost Danian. The most important foraminifera of the zone include Subbotina
triangularis (White, 1928) and Subbotina triloculinoi- 

des (Plummer, 1926).

CORRELATION WITH OTHER SECTIONS IN IRAN

The following paragraphs represent a biocorrelation 
between the Kuhe-Surgah stratigraphic section and a few other sections of the Gurpi Formation in Lorestan, namely Banroshan (Bakhshandeh et al., 2015), North Kabir-Kuh Anticline (Ghouchayi et al., 2009); Amirani (Darabi et al., 2017); and Ka- 

var (see also Fig. 5). The number of the biozones 
recognized in each section is compared with their correlates in the other sections and their ages were 
interpreted. This allows us to determine changes in 
the thickness of the biozones from the northwest to 
the southeast in Lorestan. Those variations in thick-

ness can be due to sea level changes and/or tectonic 
fluence in the Zagros basin and they will be the 
subject of another paper.

Banroshan section

Bakhshandeh et al. (2015) recognized 10 foraminif-

eral zones in this section, in the following order: 1) 
Globotruncanita elevata Partial Range Zone; 2) Glo- 
boteconch and a few other sections of the Gurpi Formation in 
Lorestan, namely Banroshan (Bakhshandeh et al., 2015), North Kabir-Kuh Anticline (Ghouchayi et al., 2009); Amirani (Darabi et al., 2017); and Ka-

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Banroshan section

Bakhshandeh et al. (2015) recognized 10 foraminif-

eral zones in this section, in the following order: 1) 
Globotruncanita elevata Partial Range Zone; 2) Glo- 
botruncanana ventricosa Interval Zone; 3) Globotrunc-

ana calcarata Interval Zone; 4) Globotruncanella 
havanensis Partial Range Zone; 5) Globotruncanana 
eygypica Interval Zone; 6) Gansserina gansseri 
Interval Zone; 7) Contusotruncanana contusa Interval 
Zone; 8) Abathomphalus mayaroensis Interval 
Zone; 9) Parasubbotina pseudobulloides Interval 
Zone; 10) Globanomalina pseudomenardii Interval 
Zone. This zonal succession corresponds to a total 
extent from the middle Campanian to the Paleocene 
(pars.).

North Kabir-Kuh section

According to Ghouchayi et al. (2009), 15 zones 
were defined in this section, as follows: 1) Globo-

truncanana elevata Partial Range Zone; 2) Globo-

truncanana ventricosa Interval Zone; 3) Globotruncan-

ana calcarata Interval Zone; 4) Globotruncanella 
havanensis Partial Range Zone; 5) Globotruncanana 
eygypica Interval Zone; 6) Gansserina gansseri 
Interval Zone; 7) Abathomphalus mayaroensis 
Interval Zone; 8) Parvularugoglobigerina eugubina 
Total Range Zone; 9) Parasubbotina pseudobullo-

ides Interval Zone; 10) Morozovella trinidadensi- 
sis Interval Zone; 11) Morozovella uncinita 
Interval Zone; 12) Morozovella angulata Interval 
Zone; 13) Planorotalites pusila Interval Zone; 14) Pla-

norotalites pseudomenardii Total Range Zone; and 
15) Morozovella velanscoensis Interval Zone. This 
zonal succession corresponds again to a total extent 
from the Campanian to the Paleocene.

Amiran section

Darabi et al. (2017) recognized seven zones in the 
Amiran section: 1) Globotruncanita elevata Partial 
Range Zone; 2) Globotruncanana ventricosa Interval 
Zone; 3) Radotruncanana calcarata Total Range Zone; 4) Globotruncanella havanensis Partial 
Range Zone; 5) Globotruncanana aegyptica Interval 
Zone; 6) Gansserina gansseri Interval Zone; and 7) 
Contusotruncanana contusa Partial Range Zone. The 
zonal succession suggests early Campanian–middle 
late Maastrichtian age for this section.

Kavar section

This section, which was also studied by the present 
authors, and the results will be published in detail 
elsewhere, has similar biozonation to the Kuhe-

surgah section. Comparing the Gurpi Formation 
in the Kuhe-Surgah section with the four other sec-

tions indicates that the base of the Gurpi Formation 
is time-transgressive between the middle and late 
Campanian in these sections. However, in the Ka-

var section, unlike the North Kabir-Kuh Anticline 
section, sediments of late Paleocene age have not 
been observed. At the Amiran section, lower Cam-

panian sediments have also been observed. In all 
five sections, there is an increased presence of more 
calcareous lithologies (i.e., Imam Hassan and Sey-

mare Limestones).

DISCUSSION

Planktonic foraminifera have proved to be vital in 
intercontinental biostratigraphy of the Upper Cre-
taceous and Paleogene (e.g., Bolli and Krashenin-

nikov, 1966; Gardin et al., 2001; Petrizzo, 2003; 
Cocioni and Premoli Silva, 2015). As plankton 
organisms have extensive geographical distribution 
and abundance in marine sediments, they are very 
useful for the purposes of correlation. Upper Creta-

ceous foraminifer biostratigraphy in the Tethys has 
been performed by various authors. One of the most 
important works in this regard is Caron’s (1985), 
which was later revised by Robaszynski and Caron 
(1995). The latter two authors also correlated their 
zonation scheme with the stratigraphic distribution of heterohelicids established by Nederbragt (1990). 
Li and Keller (1998) divided the Maastrichtian in 
the Tethys realm into eight zones. Recently, Upper
Fig. 5. Correlation of the Gurpi Formation in the Kuhe-Surgah section with four sections of Lorestan (Iran).
Cretaceous foraminifer biozones in the Tethys domain were reviewed by Coccioni and Premoli Silva (2015) (see Fig. 6).

In this study, we indicate the presence of the *Contusotruncana plummerae* Zone, based on Coccioni and Premoli Silva’s (2015) definition. Many previous studies in the Tethyan realm, such as Caron (1985) and Li and Keller (1998), used the *Globotruncanella ventricosa* Zone. However, Petrizzi et al. (2011), based on studies of the Bottaccione section (Italy) and Site 146 in the central Atlantic Ocean, replaced this zone with the *Contusotruncana plummerae* Zone. Fang et al. (2020) recorded the FO of *Contusotruncana plummerae* in the late Campanian.

In the past, Caron (1985) and Sliter (1989) proposed the base of the *Radorotruncana calcarata* Zone to define the Campanian/Maastrichtian boundary. In this research, however, the *R. calcarata* Zone is only late Campanian in age and does not contain the C/M boundary.

Razmjooei et al. (2018) placed the C/M boundary near the FO of *Gansserina gansseri* and the LO of *U. trifidus* (calcareaous nannofossil) at the Shahneshin section (Zagros Basin, Iran). However, we recorded the FOs of *Contusotruncana wallichensis*, *Globotruncanella minuta* and *Trinitella scotti* in the middle part of this zone and used these events to indicate the C/M boundary.

According to Coccioni and Premoli Silva (2015), the *Plummerita hantkeninoides* Total Range Zone contains the extinctions of most of the Cretaceous planktonic foraminfera, and thus indicates Cretaceous/Paleogene boundary. However, in our research this zone was not detected.

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**Fig. 6.** Comparison of Campanian–Danian standard planktonic foraminifer biozonations.

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<th>Stage</th>
<th>Caron</th>
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<th>Premoli Silva and Verga</th>
<th>Huber et al.</th>
<th>Pérez Rodríguez et al.</th>
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Fig. 6. Comparison of Campanian–Danian standard planktonic foraminifer biozonations.
CONCLUSION

Analysis of the planktonic foraminifera in the Kuhe-Surgah section shows that the age of the Gurpi Formation here is middle Campanian–late Danian. Based on the presence of 62 planktonic foraminifer species belonging to 23 genera, we recognized the following zones: 1) *Contusotruncanana plumeriae* Interval Zone; 2) *Radotruncanana calcarata* Total Range Zone; 3) *Globotruncanella havanensis* Partial Range Zone; 4) *Globotruncanana aegyptiaca* Interval Zone; 5) *Gansserina gansseri* Interval Zone; 6) *Contusotruncanana contusa* Interval Zone; 7) *Abathomphalus mayaroensis* Interval Zone; 8) *Pseudoguembelina hariaensis* Interval Zone; 9) *Pseudotextularia elegans* Interval Zone; 10) *Parvularugoglobigerina eugubina* Total Range Zone; 11) *Parasubbotina pseudobulloides* Interval Zone; and 12) *Praemurica uncinata* Interval Zone. The *Plummerita hankeninoides* Total Range Zone in the top of the Maastrichtian was not detected. Comparisons with five other sections in Lorestan show that the lower boundary of the Gurpi Formation is diachronous within the Campanian. The chronostratigraphic extent of this lithostratigraphic unit spans the lower Campanian to lower Paleocene, except for in the Amiran section, where only Cretaceous sediments have been reported so far.

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