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Biostratigraphy and Lithostratigraphy of Pabdeh Formation Sediments (Middle Paleocene–Upper Eocene) in the Zagros Basin, Southwest Iran

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ABSTRACT

The 530 thin sections from the Farashband region were investigated to study the Pabdeh Formation sediments in the Fars region. The 210 meters thick Pabdeh Formation is located in the Farashband fold section. The Pabdeh Formation's geology consists mostly of thin to medium-bedded limestone, argillite lime, shale and marl. The Pabdeh Formation's lower boundary is in disconformity with the Gurpi Formation (Campanian–Middle Maastrichtian), while its upper boundary is in conformity with the Asmari Formation (lower oligocene). The 14 species belonging to 31 planktonic and benthic Foraminifera types and 5 planktonic Foraminifera biozones (*Morzovella unicinata* zone–*Morzovella velascoensis* Zone–*Morzovella formosa Morzovella aragoensis* Assemblage zone–*Morzovella lehneri* zone–*Turborotalia cerroazulensis*, Hantkenina Assemblage zone) were obtained in biostratigraphy analysis. The Pabdeh Formation's approximate age is upper Paleocene-Eocene according to identified fossilized content and biozones.

Keywords Pabdeh Formation, Biostratigraphy, Planktonic, Benthic Foraminifera, Biozone.

INTRODUCTION

The Pabdeh Formation, with Paleocene, Eocene, Oligo-Miocene age and marl, shale and marly limestone lithology, is seen in various parts of Zagros. The Pabdeh Formation is a shale-marl unit related to the sea environment that has developed in the Southwestern regions of Lorestan, Khuzestan and the South Fars region. It has two unofficial parts, namely purple shale and chert limestone. The Pabdeh Formation is widespread in Khuzestan and is replaced in the Western and Northwestern ends with the Jahrom Formation. The Pabdeh Formation continues toward Southwestern regions from Khuzestan to Fars and then to Firuzabad.

A stratum mixture is observed from Pabdeh and Jahrom toward the Southwestern regions. The

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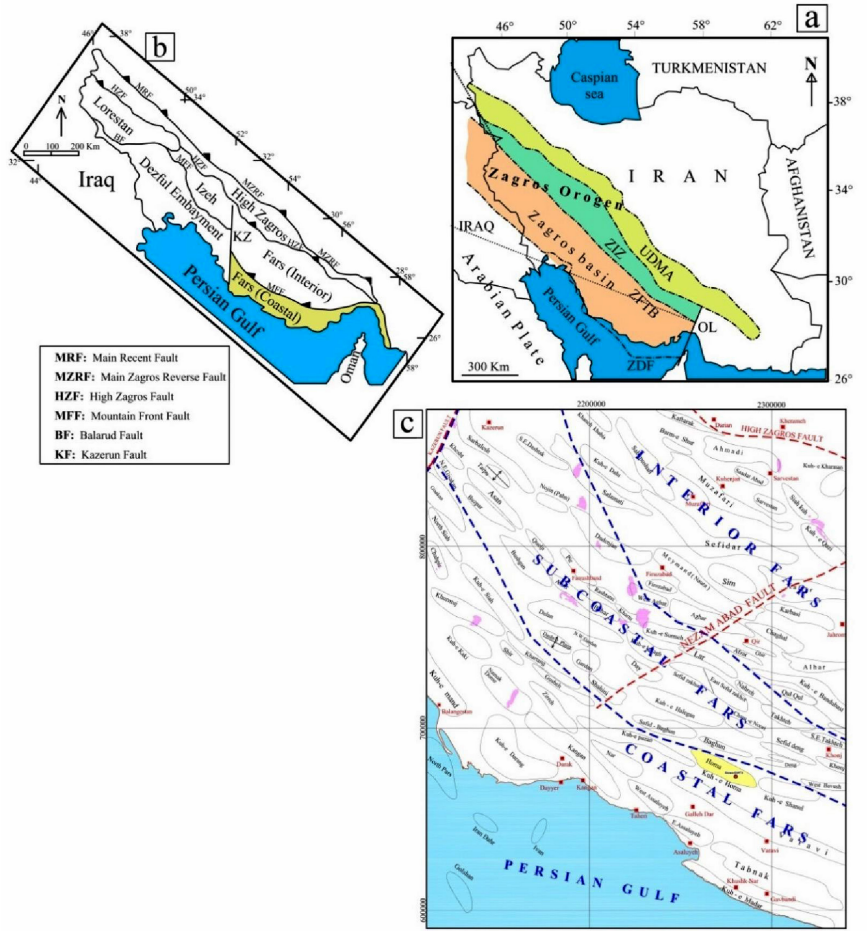

Fig. 1. (a) The Zagros basin's most important tectonic units. (b) Structural regions including high Fars, Lorestan, Izeh, the Dezful embayment and interior and coastal Fars. (c) The region's geographic location.

Pabdeh Formation is finally replaced in internal Fars regions with the Jahrom Formation. From a geological perspective, the sections under study are located in the folded Zagros region. This formation's age in the Fars region ranges from Paleocene to Oligocene, according to studies by stratigraphers. The exact age of this formation appears to be Miocene in Fars. This formation's age is considered to be late Paleocene to Miocene in Lorestan. The Pabdeh Formation contains significant amounts of pelagic microfossils in general. This Formation's shale base belongs to the late Paleocene period in Khuzestan and Fars (Khosrotehrani 1998, 2003, 2005, 2007), although for this Formation, lower Paleocene was also observed in recent studies in Fars, so Pabdeh appears to be older in Fars (Aghanabati 2006, Dervishzadeh 1991, Puciat 2007).

MATERIALS AND METHODS

The geology of the area

From early Cretaceous period until now, the Zagros biosphere was affected by the Zagros sedimentary basin located on the Africa-Arabian continent's Northeastern border. These events shaped the Zagros fold-thrust belt, which is one of the most important tectonic units in Iran from an economical standpoint (Fig. 1a). Earlier it was categorized that Zagros fold-thrust belt (ZFTB) according to its structural style and sediments into six regions, including high Zagros, Lorestan, Izeh, the Dezful embayment, interior Fars and Coastal Fars (Fig. 1b). This study's stratigraphy section is located to the North of Farashband town

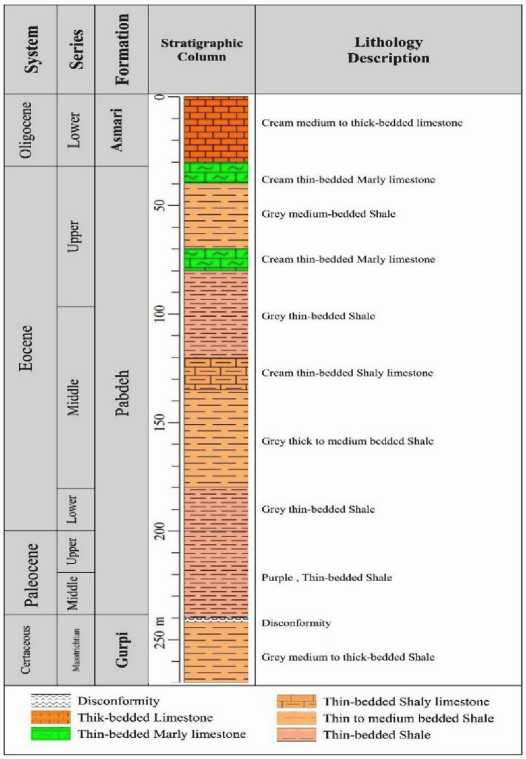

Fig. 2. The Pabdeh Farashband Formation's stratigraphic column.

(Fars province) in Southern Iran. Farashband's stratigraphy section is near the symmetrical articline region, which is a part of Coastal Fars on Southwestern Fars basin located on the Southern frontier of the Zagros Mountain next to the Persian Gulf (Fig. lc).

Lithostratigraphy

The shale Pabdeh Formation's cross section in Gurpi Mountain's Pabdeh valley located to the North of Lali oil field (Wynd 1967). Formation cross section was obtained from the Pabdeh valley at the very end of Pabdeh Mountain's Southeast section. This Formation consists of shale and gray limestone and consists of two parts, the lower purple shale part and the upper Talleh Zang section consisting of silica shale, red to gray gravel and thin-bedded limestone. The purple shale region includes shale and purple marl, which are considered to be the Pabdeh Formation's lowest lithostratigraphic units. They are considered an indicating row for distinguishing the Pabdeh and Gurpi Formations wherever they exist. This section has spread in central and Southwest Lorestan and has even been seen regionally in Fars.

From a lithostratigraphic perspective, sections of the Pabdeh Formation being studied includes limestone and purple, cream and gray shale and marl, where the thickness of the Pabdeh Formation's

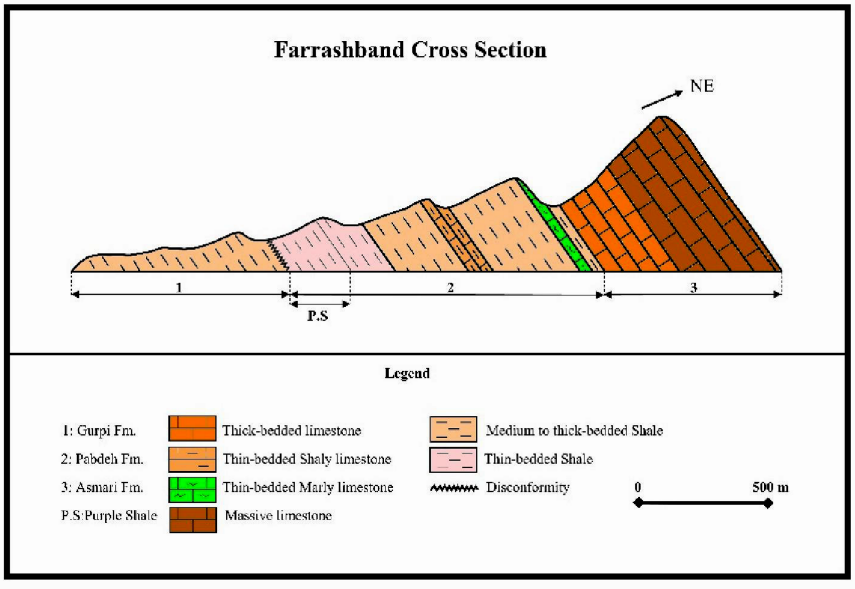

Fig. 3. Pabdeh Formation's vertical section and the Farashband section's lower and upper boundaries.

Fig. 4. Purple shale image in the Pabdeh Formation basin and the stratigraphic Farashband section.

stratigraphic section in Farashband is 210 meters (Figs. 2 and 3). From a structural standpoint, these sections have been folded in the Zagros region and are located on the interior Fars region. This Formation's lower boundaries are in erosional disconformity with the Gurpi Formation. The presence of iron oxide and gravel horizons in the Pabdeh Formation's purple-shale basin (Figs. 4–6), as well as the lack of lower Paleocene sediments is indicative of discontinuity, which can be equated with the Laramide orogeny phase. This Formation's upper boundary is a continuation of the Asmari Formation's limestone.

Biostratigraphy

The 22 types and 12 species of planktonic Foraminifera, 9 types and 2 species of benthic Foraminifera, as well as sponge beriozonas, aligosteginides, radiolar and espigol were identified in biostratigraphic analysis of the Pabdeh Formation. Seven biozones were identified according to plankton Foraminifera and

Fig. 5. A view of the Pabdeh and Gurpi Formations' boundaries as well as the regional boundaries berween Pabdeh and Asmari (View toward southwest).

Premoli Silva biozones (Ardestani et al. 2009, Vaziri 2002, Asgharian et al. 2008, Loeblich and Tappan 1987). Images of identified Foraminifera are shown in Fig. 7, (Table 1). The distribution of planktonic and benthic Foraminifera is also presented in Figs. 8 and 9. The biozones presented in this study from low to high are as follows: *Morzovella unicinata* zone. *Morzovella velascoensis* zone. *Morzovella formosa*, *Morzovella aragoensis* Assemblage zone. *Morzovella lehneri* zone. *Turborotalia cerroazulensis*, Hantkenina Assemblage zone.

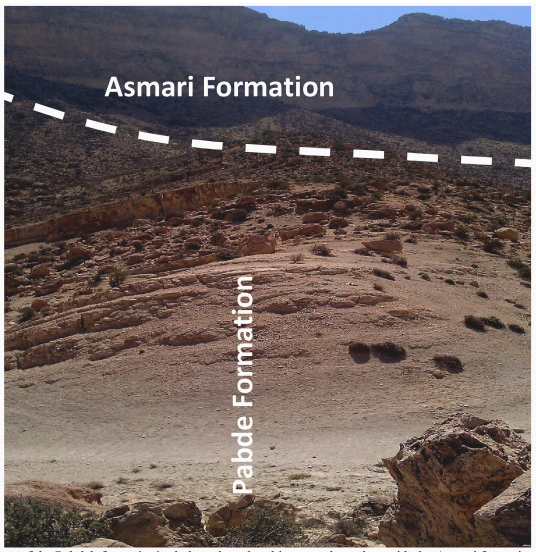

Fig. 6. View of the Pabdeh Formation's shale and marl and its upper boundary with the Asmari Formation in the stratigraphic section under study (View toward southwest).

Table 1. Comparing the biozones presented in the section with other biozones.

Age	Wynd (1967)		Bolli (1985 a.b 1966) Premoli silva and Bolli (1973)		Kord (2019)
Upper Eocene	*Globorotalia cerroazulensis, Hantkenina, G. centralis, Globigerinatheka* sp., *Globigerinita accatapsis Drax* sp., *Pseudohasti gerina*, *Uvigerina bulimina* Assemblage zone	5 2	*Turborotalia cerroazulensis* S.L.	Pl-6	*Turborotalia cerroazulensis* S.L.
Middle Eocene	*Turborotalia porticulasphas, Globorotalia spinulosa, G. lehneri, G. aragoensis, G. centralis, G. palmera, Globigerina theka, Hantkenina* sp. Assemblage zone	4 7	*Globigerina thekaseminvoluta* *Truncorota loidesrohri*	Pl-5 Pl-4	*Morzovella lehneri* zone
Middle Eocene	*Globorota liarex, G. formosa, G. aragoensis, G. formosa, G. vilicoxensid, G. palmera, G. quetra,* Assemblage zone	4 5	*Orbulinoides beckmani* *Morzovella lehneri* *Globigerina thekasubcongl obata* *Hankenina muttalli* *Acarinapenta camerata*	Pl-3 Pl-2 Pl-1 Pl-0 P9	*Morzovella formosa*, *Morzovella aragoensis*
Lower Eocene			*Morzovella aragoensis*	P8	Assemblage zone
Upper Paleocene	*Globorotalia velascoensis, Globorotalia pseudomenardi, G. velascoensis, G. elongata*, *G. vilcoxensid, G. palmerea, G. rex, G. formosa, G. aequa* Assemblage zone	4 2	*Morzovella edgari* *Morzovella velascoensis*	P6 P5	*Morzovella velascoensis* *Planorotalites pseudomenardi* Assemblage zone
Lower to Middle Paleocene			*Planorotalites pseudomenardi*	P4 P2	*Morzovella unicinata* zone

RESULTS AND DISCUSSION

Biozone 1:

Morzovella unicinata zone

This is the first biozone present in the lower part of the section under study. It is *Morzovella unicinata,* until the first appearance of *Morzovella angulata*. This interval zone matches the biozone (Bolli 1985). This zone's dominant species is *Morzovella unicinata*, along with other types of *Globonomalina compressa*, *Planorotalia pseudomenardi*, *Globoconusa daubjerjensis* and *Morzovella trinidadensi.* This zone's age is lower to middle Paleocene.

Biozone 2:

Morzovella velascoensis zone

This biozone is located on the upper section of biozone 1. The beginning of this biozone coincides with the appearance of the *Planorotalites pseudomenardi*, *Morzovella velascoensis*, *Globoconusa daubjergensis, Morzovella trinidadensis*, *Globonomalina compressa* and *Morzovella abondocamerata* pelagic species (Bolli 1985). This biozone's age is upper Paleocene.

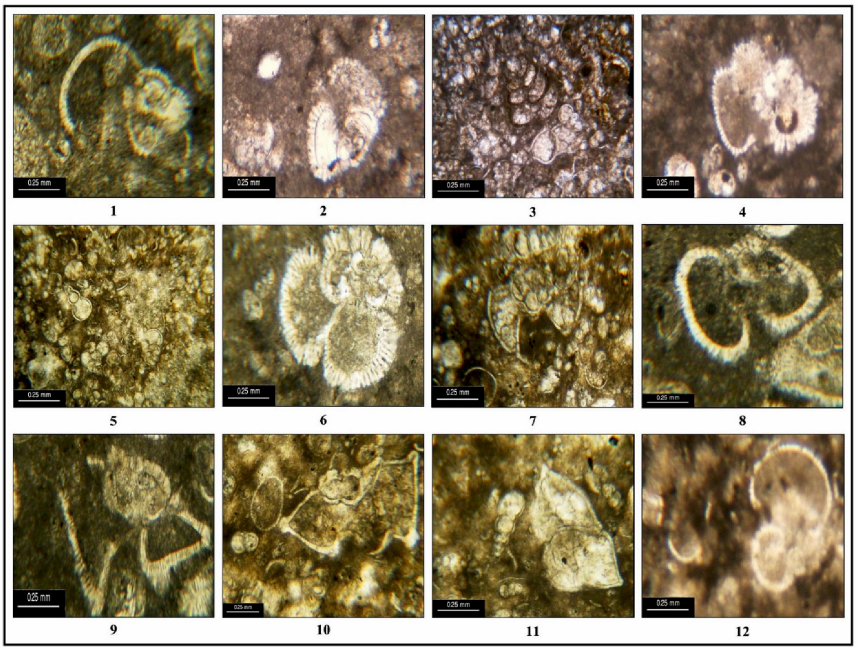

Fig. 7. 1. *Globoconusa daubjergensis* (Bronnmiann 1952) ; Layer age: Lower Paleocene / Pabdeh Formation, Axial Section/Sample No: Gt23. 2. *Globigerina gravelli* (Kushman 1956) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section/Sample No: Gt47. 3. *Textularia* sp. ; Layer age: Upper Eocene/ Pabdeh Formation, Trangential Section/Sample No: Gt50. 4. *Globonomalina primitive* (Bolli 1957) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section/Sample No: Gt50. 5. *Globigerina thekasenni* (Modified from Seni et al. 1995). Layer age: Middle Eocene/Pabdeh Formation, Axial Section/ Sample No: Gt80. 6. *Pseudotextularia elegance* (Cushman 1957) ; Layer age: Campanian/Gurpi Formation, Trangential Section/Sample No: Gt10. 7. *Morzovella formosa* (Bolli 1957) ; Layer age: Lower Eocene/Pabdeh Formation, Axial Section/Sample No: Gt55. 8. *Morzovella unicinata* (Bolli 1957) ; Layer age: Middle Paleocene/Pabdeh formation, Axial Section/Sample No: Gt30. 9. *Morzovellaaff abundocamerata* (Bolli–Postuma 1971) ; Layer age: Middle Paleocene/Pabdeh Formation, Axial Section/Sample No: Gt27. 10. *Morzovella aequa* (Cushman and Renz 1942) ; Layer age: Upper Paleocene–Lower Eocene/Pabdeh Formation, Axial Section/Sample No: Gt25. 11. *Morzovella* sp. ; Layer age: Lower Eocene/ Pabdeh Formation, Oblique Section/Sample No: Gt20. 12. *Morzovellaaff. bolivariana* (Petters) of Bolli (1957b) ; Layer age: Middle Eocene/Pabdeh Formation, Sub-axial Section / Sample No: Gt90.

Biozone 3:

Morzovella formosa, *Morzovella aragoensis* Assemblage zone

This biozone is located on the upper section of biozone 2. This biozone is 20 meters thick. The beginning of this biozone coincides with the appearance of *Morzovella gracilis*, *Morzovella graveli*, *Morzovella formosa, Morzovella aragoensis*, *Hastigerina bolivariana*, and *Globigerina aspensis* Foraminifera (Bolli 1985). This biozone's age is lower Eocene.

Biozone 4:

Morzovella lehneri zone

This biozone is located on the upper section of zone 3. This biozone is 72 meters thick. Species such as *Morzovella soldadoensis, Globigerina primitiva* and *Morzovella formosa* became extinct at the beginning of this zone, but species such as *Pseudohasti gerinamicra*, *Morzovella aragoensis*, *Globigerina aspensis, Truncorota loidestopilensis, Morzovella lehneri* and *Hastigerina bolivariana* were also observed. Analysis of pelagic microfossils in this boundary, however, shows that this zone's beginning coincided with the appearance of *Globigerina senni, Globigerina boweri, Morzovella spinulosa, Has-*

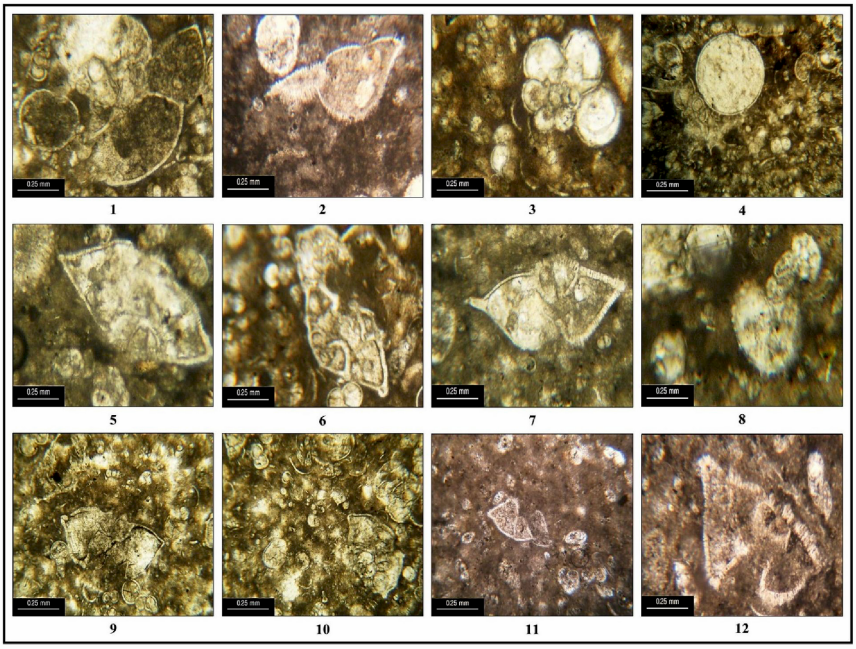

Fig. 8. 1. *Planorotalites* cf. *pseudomenardi* (Washborni 1955) ; Layer age: Lower Eocene/Pabdeh Formation, Sub-axial Section/Sample No: Gt45. 2. *Planorotalites* cf. *pseudomenardi* (Washborni 1955) ; Layer age: Lower Eocene / Pabdeh Formation, Sub-axial Section / Sample No: Gt47. 3. *Globanomalina compressa* (Bronman 1933) ; Layer age: Upper Paleocene / Pabdeh Formation, Trangential Section/ Sample No: Gt32. 4. *Orbulina* sp. ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt50. 5. *Morzovella gracilis* (Bolli 1957) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt46. 6. *Morzovella lehneri* (Bolli 1957) ; Layer age: Middle Eocene / Pabdeh Formation, Axial Section / Sample No: Gt92. 7. *Morzovella spinulosa* (Cifelli 1972) ; Layer age: Middle Eocene / Pabdeh Formation, Axial Section / Sample No: Gt85. 8. *Morzovella trinidadensis* (Bolli 1957) ; Layer age: Middle Paleocene / Pabdeh Formation, Axial Section / Sample No : Gt21. 9. *Morzovella* cf. *aragoensis* (Bolli 1957) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt60. 10. *Morzovella* cf. *formosa* (Bolli 1957) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt57. 11. *Morzovella* sp. ; Layer age: Lower Paleocene / Pabdeh Formation, Axial Section / Sample No: Gt23. 12. *Morzovella Formosa* (Bolli 1957) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt50.

tigerina bolivariana and *Acarina bulbruki* species. The *Trancorotaloides topilensis* became extinct at the end of this zone. This zone matches the (p12) biozone (Bolli 1985). This biozone's age is middle Eocene.

Biozone 5 :

Turborotalia cerroazulensis, Hantkenina Assemblage zone

This biozone was known for the spread and abundance of *Turborotalia cerroazulensis*, *Hantkenina* sp. (Bolli 1985) and the *Hastigerina* sp. Fossil. This biointerval zone matches zone 52 (Wynd 1967). *Turborotalia* have many subspecies and Bolli (1985) has identified various upper Eocene zones accordingly.

CONCLUSION

The Pabdeh Formation in 208 meters thick at the Dehbin section. This formation's lower boundary is in disconformity with the Gurpi Formation due to having iron oxide horizons, but there are no signs of disconformity with the Asmari Formation at the Pabdeh Formation's upper boundary. The best evidence for introducing the discontinuous upper Cretaceous - Paleocene boundary is the lack of the specific upper Maastrichtian *Abathomphalus mayaorensis* species. The Gurpi Formation's end is specified with the *Glo-*

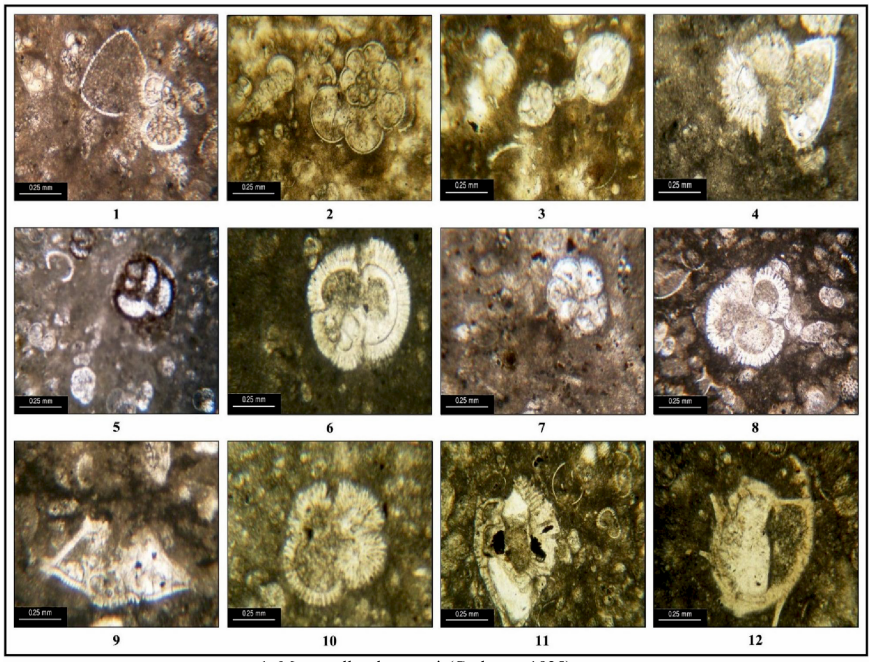

Fig. 9. 1. *Morzovella velascoensis* (Cushman 1925) ; Layer age: Upper Paleocene / Pabdeh Formation, Trangential Section / Sample No: Gt45. 2. *Acarina wilcoxensis* (Cushman 1925) ; Layer age: Lower Eocene / Pabdeh Formation, Axial Section / Sample No: Gt54. 3. *Pseudohastigerina* cf. *micra* (Cole 1927 from : Bolli HM 1957) ; Layer age: Upper Eocene/Pabdeh Formation, Axial Section /Sample No: Gt100. 4. *Truncorota loidestopilensis* (Bronnmiann 1952) ; Layer age: Middle Eocene / Pabdeh Formation, Axial Section / Sample No. Gt80. 5. *Globigeria theka* of Index (Bronman 1933) ; Layer age: Middle Paleocene / Pabdeh Formation, Axial Section / Sample No : Gt21. 6. *Minuxia* sp. ; Layer age: Upper Paleocene/Gurpi Formation, Trangential Section/Sample No: Gt35. 7. *Globigerina theka* cf index (Bronman 1933) ; Layer age: Middle Eocene / Pabdeh Formation, Trangential Section / Sample No: Gt70. 8. *Globigerina theka* sp. ; Layer age: Middle Paleocene / Pabdeh Formation, Axial Section / Sample No: Gt34. 9. *Globigerina theka* sp. ; Layer age: Middle Eocene / Pabdeh Formation, Axial Section / Sample No: Gt90. 10. *Morzovellas pinulosa* (Cifelli 1972) ; Layer age: Middle Eocene / Pabdeh Formation, Axial Section / Sample No: Gt85. 11. *Lenticulina* sp. ; Layer age: Lower Eocene / Pabdeh Formation, Oblique Section / Sample No: Gt53. 12. *Hantkenina* cf. *alabamensis* (Cushman 1957) ; Layer age: Upper Eocene / Pabdeh Formation, Oblique Section / Sample No. Gt110.

botruncanitas tuartiformis species, which is related to Campanian. The presence of lower Paleocene fossils, such as *Morzovella unicinata, Planorotaloides pseudomenardi* and *Globoconusa daubjerjensis* indicates the Pabdeh Formation's beginning in lower Paleocene. Therefore, cretaceous tertiary boundary was not observed for the Maastrichtian sediments in the region, which indicates discontinuity.

The beginning of Paleocene coincides with the appearance of the *Globoconusa daubjergensis, Morzovella trinidadensis*, *Globonomalina compressa*, *Morzovella unicinata* and *Morzovella abondocamerata* pelagic species. The extinction of species such as *Morzovella velascoensis* and *Morzovella aequa* was observed in the upper Paleocene-lower Eocene boundary. The appearance of species such as *Globigerina graveli* and *Morzovella gracilis* was also observed. The Pabdeh and Asmari boundary has no signs of disconformity. According to studies on the section, this boundary is in complete conformity and is identified with the presence of lower Oligocene Foraminifera, such as *Nummulites fabiani*, small globigerinelloides and *Nummulites intermedius*.

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