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Microfacies and sedimentary environments of Gurpi and Pabdeh Formations and the type of Mesozoic– Cenozoic boundary in Fars province, Iran

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Abstract

The Upper Cretaceous Gurpi and Lower Tertiary Pabdeh formations as units of Folded Zagros were studied in three different regions (Tang-e-Abolhayat, Tang-e-Zanjiran and Maharloo) in Fars Province. Gurpi Formation consists of thin to medium bedded gray marl and marlstone interbedded with thin layers of argillaceous limestone and shale. The dominant Microfacies in this Formation are biomicrite; Index species of Globotruncana give the age of the Formation from Lower Campanian to Upper Maastrichtian. Pabdeh Formation consists of bluish gray, thin to medium bedded shale and marl and interlayers of argillaceous limestones (with purple shales and thin cherty beds) at lower part, dark gray shales and marls with interlayers of argillaceous limestone in the middle, and alternative layers of thinly bedded argillaceous limestone, shale and marl at the upper part. The dominant Microfacies are biomicrite. Index species of *Globorotalia* and *Hantkenina* give the age of Formation from Upper Paleocene to Eocene. The sedimentary environment of both formations is a bathymetrical carbonate floored basin (deep shelf or basin margin) which has deposited its facies in transgressive stage. The contact between the two formations is disconform. In Tang-e-Abolhayat it lies at the base of purple shale. In this region and also in Tang-e-Zanjiran and Maharloo, in addition to the recognition of *Globorotalia velascoensis*, which is attributed to lower part of the Pabdeh Formation, a glauconitic-Phosphatic bed separates the two formations. This bed represents a non-depositional (epirogeny) period from the Late Maastrichtian to the end of Early Paleocene.

Key words: Upper Cretaceous, Folded Zagros, Tang-e-Abolhayat, Tang-e-Zanjiran, Maharloo.

1. Introduction

The main aim of this paper is the study of litho-and bio – facies of Gurpi and Pabdeh formations and hence identification of their sedimentary environments in three Stratigraphic sections (north – east flank of Ghareh mountain in south of Maharloo lake; Tang-e-Zanjiran, about 35 km north of Firoozabad; Tang – e – Abolhayat, some 75 km west of Shiraz to Kazerun) in Fars Province in Iran (Fig.1). The type of contact between the two formations in Mesozoic - Cenozoic boundary is also considered.

2. Structural and geomorphologic features

The three mentioned stratigraphic sections show remarkable outcrops of the two formations (Gurpi & Pabdeh; Figs. 2 and 3), which is due to structural impressions affected there and also petrological nature of the formations (Blanc et al. 2003, Ramsey et al. 2009). The effect of these two factors has formed special morphology which appears throughout the outcrops. High and elongated NW-SE trends anticlines, long strike faults which have cut the anticlines longitudinally and opened them laterally by erosion, short faults which cut them widthwise, and lineaments which are of structural and stratigraphical origins are the similar structural elements in the regions (Farzipour-Saein et al. 2009). Formations, due to low stability of their rock deposits (marl, shale, argillaceous limestone), exhibit a low morphology and more or less change in thicknesses. Since the upper and lower parts of these formations are of hard carbonate rocks of Asmari, Jahrum and Sarvak formations (James & Wynd 1965, Motiei 1994), differential erosion has caused deep strike valleys due to the alternation of hard limestones and soft marls, and dense branching drainage systems in the latter, the similar morphological elements seen in all mentioned sections (Fig. 4).

3. Microfacies

3.1. Gurpi Formation

Gurpi Formation, with a thickness of about 500 m at Tang -e-Zanjiran and 450 m at Tang-e-Abolhayat overlies Sarvak Formation disconformably and includes thin to medium bedded bluish gray marl and marlstones with

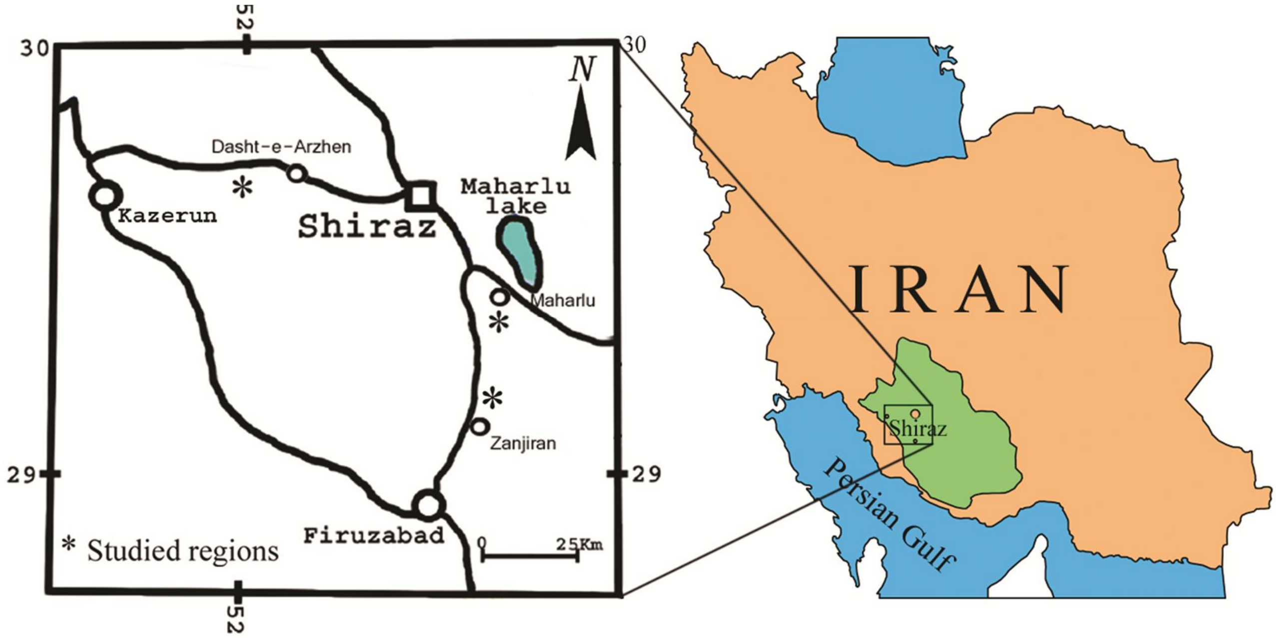

Figure 1. Location map of the studied areas.

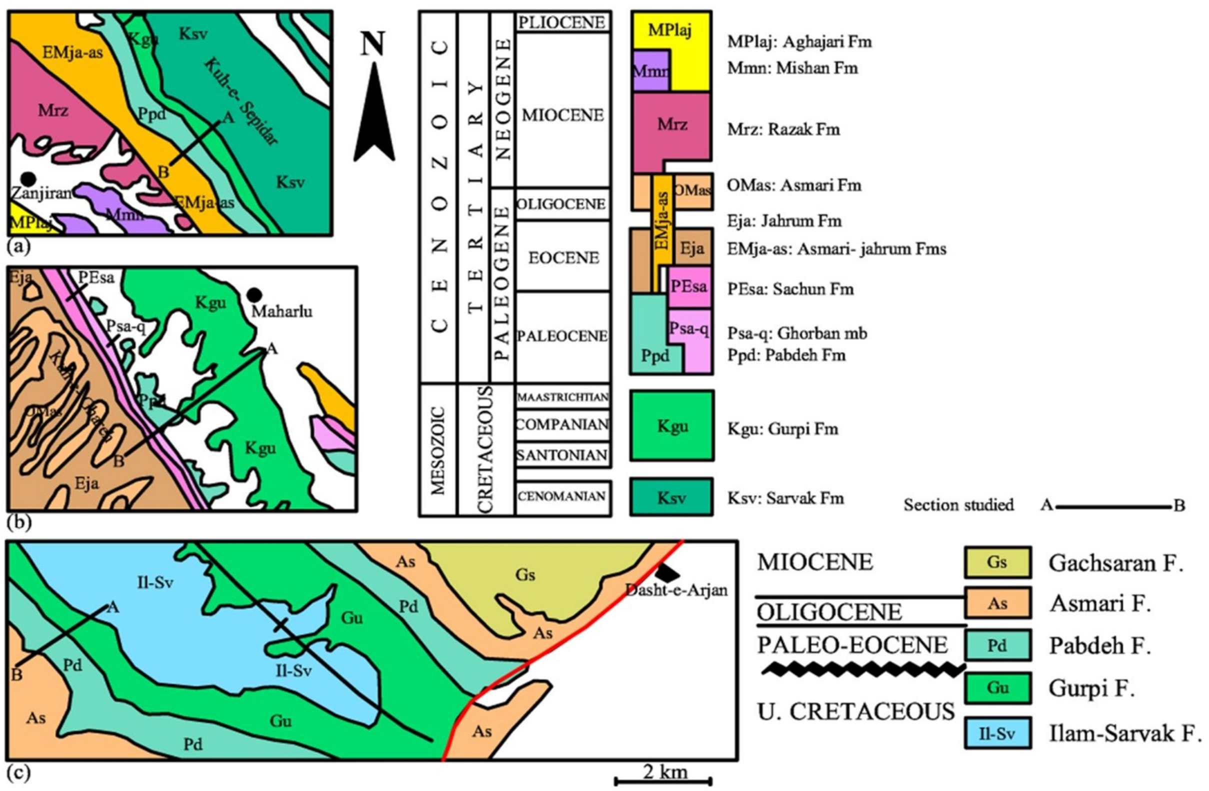

Figure 2. Geological map of the studied areas: (a): Tang–e–Zanjiran (GSI 1998), (b): Maharloo (GSI 2000), (c): Tang–e-Abolhayat (NIOC 1972)

thin interlayers of argillaceous cream limestones. Occasionally sparse silt and fine sand-sized grains within the marl form silty and sandy marls at intervals. Partly increasing of these grains forms thin layers of shale.

Studying thethin sections of provided samples shows dominantly biomicrite to biopelmicrite (wackstone) and sometimes micrite (mudstone) (Dunham 1962, Folk 1974, Wright 1992) all argillaceous to some extent.

Small and rounded microsparitic intraclasts and spary calcite cement that fill all foraminiferal chambers are dominant features seen in thin sections.

Iron oxides (opaque), glauconite and phosphate especially at upper parts, radiolarian cherts and destroyed bitumen all are seen in sparse.

Microfossils are dominantly planktonic (pelagic) foraminifera which show 5 biozones:

1- *Globotruncanaelevata* zone; associated microfossils are *G. bulloides, G. lapparenti, G. coronata,* and *Hedbergella*. This biozone is seen at lower part of the Formation in the three sections and the age is Lower Campanian.

2- *Globotruncana ventricosa* zone; associated microfossils are *G. bulloides, G. arca, G. lapparenti,G. falsostuarti, Hedbergella* and *Heterohelix* (Fig. 5–plate1). This biozone is observed at Maharloo and Tang-e-Abolhayat and the age is Lower Campanian to lower part of Upper Campanian.

3- *Globotruncana calcarata* zone*; associated microfossils are G. fornica, G. lapparenti, G. elevata, G. bulloides, G. ventricosa, G. arca, G. stuarti, G.falsostuarti, G. linniana,Hedbergella* and *Heterohelix* (Fig. 5 - plate 2). This biozone is observed at Tang-e-Abolhayat and Maharloo and belonging to Upper Campanian.

4- *Globotruncanastuarti* zone; associated microfossils are *G. bulloides, G. conica, G. lapparenti, G. falsostuarti, Hedbergella*and*Heterohelix* (Fig. 5 -plate 3). This biozone is seen in all of the three stratigraphic sections and the age is Lower Maastrichtian.

5- *Gansserina gansseri* zone; associated microfossils are *G. conica, G. gansseri, G. falsostuarti, G. gagnebini* and *Hedbergella* (Fig. 5-plate 4). This biozone is observed at Tang –e-Abolhayat and Maharloo and the age is Middle to Upper Maastrichtian.

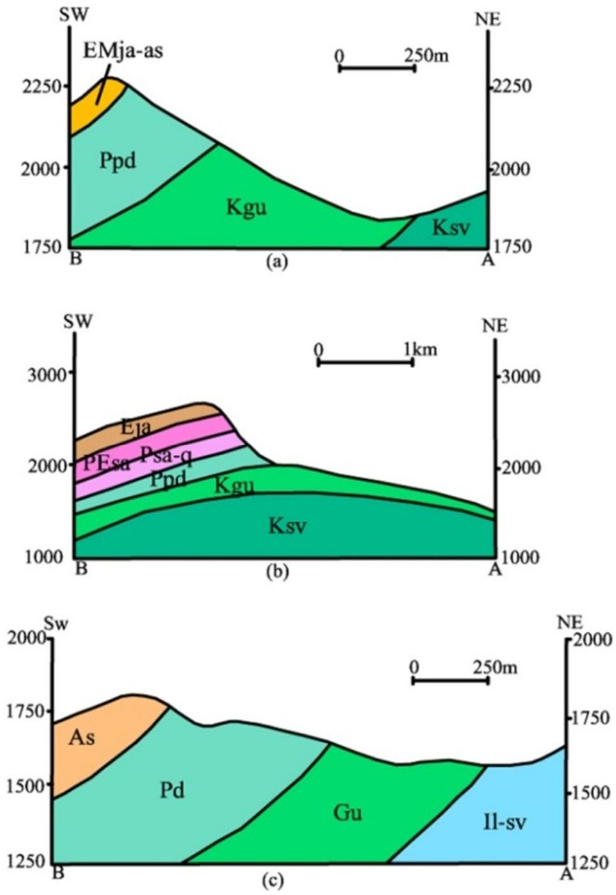

Figure 3. Geological cross sections of the studied areas: (a): Tang-e-Zanjiran, (b): Maharloo, (c): Tang-e-Abolhayat.

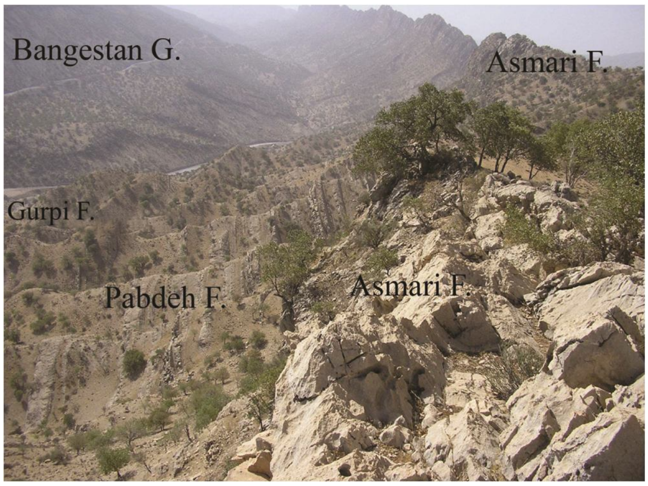

Figure 4. A SE view of Tang-e Abolhayat, showing Bangestan Group, Gurpi, Pabdeh and Asmari formations

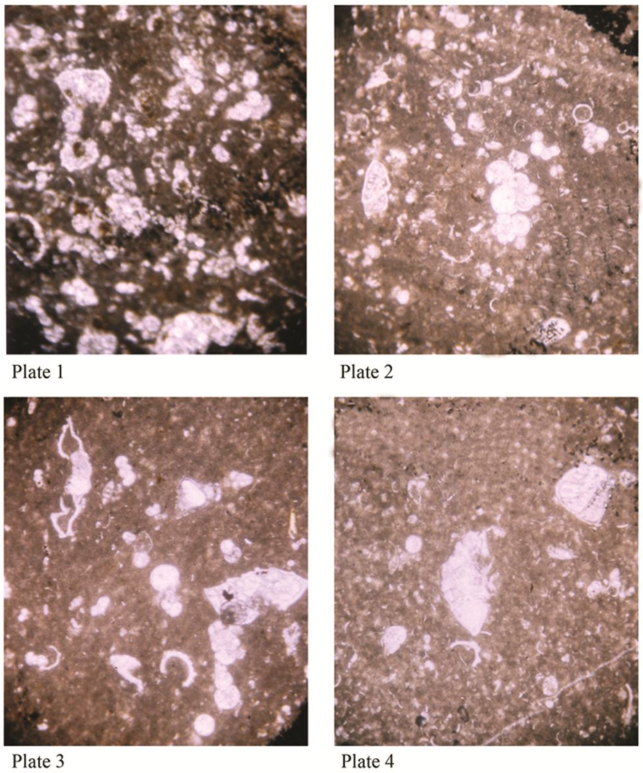

Figure 5. Plates 1- 4: Argillaceous biomicrite, with rounded and small microsparitic intraclast and sparite cement filled foraminiferal (Globotruncana) chambers; x 30.

3-2. Pabdeh Formation

Pabdeh Formation, with a thickness of 300 m at Tang-e-Zanjiran and 500 m at Tang - e- Abolhayat overlies Gurpi Formation disconformably and consists of thin to medium bedded bluish gray shale and marl and interlayers of argillaceous limestones. There exist also some beds of purple to bluish sandy shale with a thickness of about 6m overlaid by thin layers of nodular and lenticular chert (Fig. 6) and occasionally silty-sandy limestones interbedded with marls at the base of the Formation at

Tang-e-Abolhayat. Dark gray shale and marl with interlayers of thin bedded argillaceous limestone and alternative layers of gray thin to medium bedded argillaceous limestone, shale and marl at lower part which gradually change to medium to thick bedded limestone at middle and upper parts form the whole lithofacies of the Formation. Studiedthin sections of the provided samples show biomicrite and pelbiomicrite (wackestone) and in parts micrite (mudstone) with scattered small rounded microsparitic intraclasts and sparry calcite cement filled all foraminiferal chambers. Glauconite mineral and phosphate material at lower parts (Fig. 7), and some fine quartz crystals, which fills the chambers or rests irregularly, are the dominant features in thin sections.

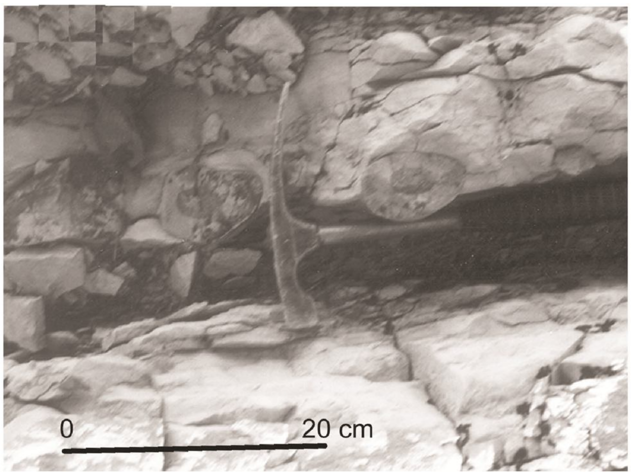

Figure 6. A bed of layered and lenticular cherts at the base of Pabdeh Formation.

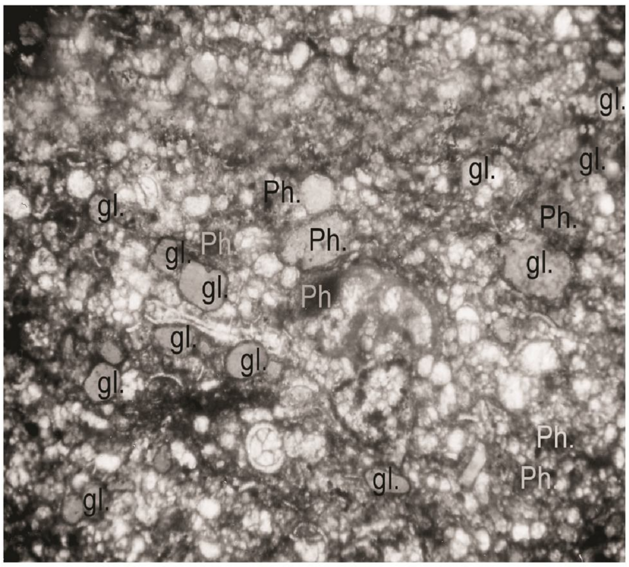

Figure 7. Phosphatic and glauconitic marl at the base of the Pabdeh Formation x 30.Ph.: Phosphate, gl.: glauconite

Microscopic studies show four biozones in this Formation in the studied areas:

1- *Globrotalia velascoensis* zone; Upper Paleocene.

2- *Globorotalia aragonensis* zone; Lower Eocene (Fig. 8-plates: 5 & 6)

3- *Globorotalia spinolusa* zone; Middle Eocene.

4-*Globorotalia centralis - Hantkenina assemblage* zone; upper Eocene (Fig. 8-plate 7).

Other microfossils such as Globigerina (Fig. 8 -plate 8) are observed likewise.

Pabdeh Formation underlies by Jahrum Formation and has an interfingering contact with it (at Tang-e-Zanjiran). Asmari Formation (at Tang-e-Abolhayat; Fig. 4), and Ghorban member of Sachun Formation (at Maharloo) overlie Pabdeh Formation.

4. Gurpi and Pabdeh formations boundary.

The boundary between Gurpi and Pabdeh Formations is of disconformity type. Considering lithological similarity of both Formations, determining of this unconformity from field observations is not possible and it is done by means of microscopic studies and microfossil recognition. The boundary between the two Formations, at Tang-e-Abolhayat, rests at the base of purple shale. At Maharloo and Tang-e-Zanjiran, in addition to the recognition of *Globotruncana velascoensis* which is referred to the lower part of Pabdeh Formation, a bed of glauconitic marl is seen in this part. This bed which distinct the two Formations (Pabdeh & Gurpi) shows a hiatus from Late Maastrichtian to the end of Early Paleocene.

5. Sedimentary Environments

The interpretation of depositional processes and sedimentary paleoenvironment is usually done by their lithofacies and biofacies and, in particular, their microfacies. The following microfacies criteria which are observed in microscopic examination of both Formations show a deep marine environment (Flügel 1982, Jenkyns 1986, Reading 1996, Einsele 2000, Raymond 2002) (Fig. 9). Micrite dominates; it is homogenous and microcrystalline and accompany with planktonic microfossils (an indication of low energy environment); sparry calcite fills all microfossils chambers; pelloids usually exist in micrite and biomicrite (fecal pellets occur in micrite); microsparitic intraclasts, due to weak sea currents, exist (intraclasts are indication of sea floor erosion and sedimentation at down slope); calcilutite with fine bioclasts and pelagic mudstone; glauconite accumulates beneath the discontinuity surface (of course, it is not an indication of deep marine; nowadays, glauconite is found in depths of 30 to 700 m); coloured layers (due to the enrichment of ferromanganese materials at sedimentary discontinuity surfaces); chert, which is an indication of deep marine environment, in the form of nodular and layered; frequent alternative layers of limestone and marl.

A marine environment with above-mentioned characteristics is also called pelagic environment (Cojan&Renard2002) (Fig. 9). Pelagic sediments are chiefly composed of microscopic skeletal remains of planktonic animals and plants, variously diluted by non-biogenic components. Such sediments may be carbonate-rich, silica-rich or clay-rich.

At the present time, pelagic environments are essentially confined to ocean basins and, locally, their margins. The factors that control sedimentation and the resulting stratigraphy in pelagic environments include tectonic history, temperature and fertility of near –surface water,

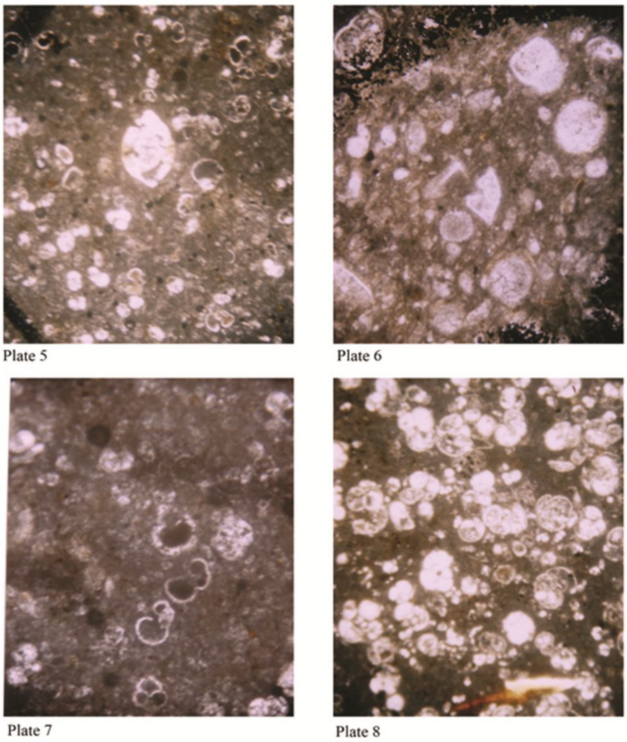

Figure 8. Argillaceous biomicrite, with rounded and small microsparitic intraclasts and sparite cement (occasionally Micrite filled foraminiferal (Globorotalia- plates 5-7 & Globigerina – plate 8) chambers; x 30.

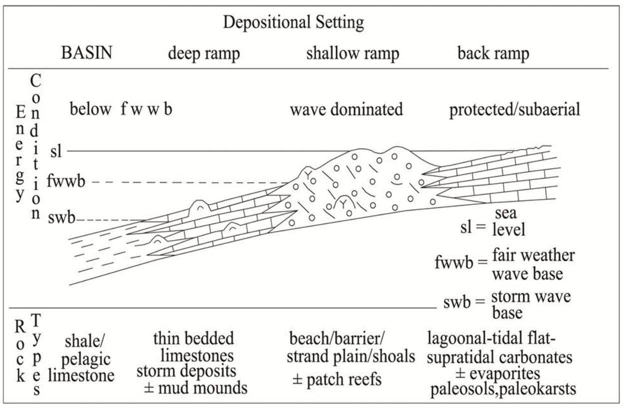

Figure 9. A carbonate ramp depositional model, showing also shale (marl) and pelagic limestone below storm wave base.

the history of the calcium carbonate compensation depth (CCD), and the paleobiology history (Raymond 2002).
The interpretation of ancient sediments as pelagic relies primarily on the recognition of included planktonic organisms. With Tertiary and Upper Mesozoic sediments, such as the Formations being studied recognition of planktonic components is relatively easy, since comparable faunas and floras may survive to the recent. Crucial to any study of pelagic sediments on land is an investigation of the nature of the basement on which they were deposited.
Epeiric or epicontinental pelagic facies, since they are deposited on stable cratons during a relative high stand of sea level will, however, remain largely undeformed. From a tectonic point of view they have the greatest preservation potential of all pelagic sediments, while ancient pelagic facies laid down in ocean will have been or will ultimately be subducted(Jenkyns 1986).
Marl, the dominant rock that makes up the two Formations, clearly marks a phase of deepening and transgression as pelagic conditions spreading over this part of the country. Gurpi marls, thus, may be attributed to Upper Mesozoic transgressions. Chalks deposited during the Late Cretaceous in the Middle East and other places have been attributed to these transgressions (Jenkyns 1986).
The absence of clay causes chalk to be deposited and presence of it causes marl. The bed of marly sea is probably anoxic and has organic carbon and this can explain local occurrence of glauconite and phosphate which their presence involves such conditions (Odin & Matter1981). Glauconite commonly forms by the interaction between kaolinite-type clays which are spatially linked to land masses and Fe^{++} ions which derive in large part (as Fe^{3+}) from continental run-off. Replacement and primary phosphate are formed from anoxic interstitial waters that contain P supplied by the dissolution of zoo-and particularly phyto - plankton that contain this element in their protoplasm. Upwelling of nutrient - rich water promotes plankton productivity. Phosphates apparently develop preferentially at the upper and lower boundaries of oxygen minimum zone (O'Brien & Veeh 1983)
Glauconite is formed by replacement of clays, skeletal carbonates and fecal pellets. The presence of bitumen suggests that parts of the environment were at times in contact with anoxic waters.
In all of the studied areas, Gurpi Formation overlies Sarvak Formation disconformable.
The subsidence of the basin in this region started at Companian and the sedimentation rate was in accordant with the rate of subsidence which is synchronous with global sea level rise and its transgression which caused a thick accumulation of deep marine marl and shale (Motiei 1994). The Late Cretaceous marl may be most simply related to the spectacular end-Mesozoic transgression which flooded cratonic areas. Phyto - and zoo - plankton could thus flourish and in the absence of clastics, produced pelagic sediments. Epeiric seas are likely to be fertile and support abundant plankton since areas close to continents are usually well supplied with nutrients.
General regression at the end of Maastrichtian (due to Laramid orogeny) and depth decreasing led to impression of an erosional phase at the boundary of Mesozoic – Cenozoic (Pabdeh & Gurpi disconformity and Lower Paleocene hiatus). The purple (sandy) shales and cherts, at the base of Pabdeh Formation, are referred to this depth decreasing. Deposition of Pabdeh marl and shale is an indication of redeepening of sea from upper Paleocene.

The lithofacies similarity of Pabdeh and Gurpi Formations indicates a similarity in conditions and sedimentary environments.

6. Conclusions

The Upper Cretaceous Gurpi and Lower Tertiary Pabdeh formations, as units of Folded Zagros Zone, consist of a series of sedimentary rocks of which marl is dominated. The dominant microfacies of both formations are biomicrite (wackstone). Gurpi Formation consists of 5 biozones of Globotruncana and Pabdeh Formation consists of 4 biozones of Globorotalia. Both formations show a deep marine environment (pelagic environment).

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