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FACIES DISTRIBUTION AND PALAEOECOLOGY OF THE GURI MEMBER OF THE MISHAN FORMATION, IN LAR AREA, FARS PROVINCE, SW IRAN*

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Abstract – This research is focused on facies distribution, palaeoecology and palaeoenvironment of the Guri Member of the Mishan Formation in Kuh-e Shur and Kuh-e Kurdeh sections at the Lar area, Fars province. The Guri Member is composed of limestone, marly limestone and marl and the thickness at Kuh-e Shur and Kuh-e Kurdeh is about 72 and 110 meters, respectively. Based on petrographical studies of 120 thin sections, 8 microfacies have been identified that are deposited in open shelf environment (inner and middle shelf). Palaeolatitudinal reconstructions based on skeletal grains suggests that carbonate sedimentation of Guri Member took place in tropical waters under oligotrophic conditions, a typical environment for photozoan assemblages. These biotic assemblages of the Guri Member belong to foralgal association and may be broadly defined as comprising heterozoan assemblages. An important factor controlling the spread of heterozoan assemblages during the Early Miocene in the study areas seem to be related to the palaeoecology and evolution of zooxanthellate corals.

Keywords – Guri member, Mishan formation, microfacies, palaeoecology, benthic foraminifera, Kuh-e Shur, Kuh-e Kurdeh

1. INTRODUCTION

The Guri Member of Mishan Formation takes its name from Tang-e Guri, Kud-e Herangin, in Fars Province, where it consists of 113 m of hard, creamy and fossiliferous limestone interbedded with rubbly limestone and marl [1]. The basal 61 m limestone of the Mishan Formation laterally changes into a limestone facies named the Guri Member [1]. The basal contact with the gypsum of the underlying Gachsaran Formation is sharp. The upper contact with the Mishan Formation is conformable. This member is best developed in the central part of south- eastern Fars Province. In the Sarkhum Field, it is a small gas reservoir.

The study area is located in Fars Province (SW Iran), which is part of the Zagros fold-and-thrust belt (Fig. 1) ([2-4]).

The Guri Member in the studied section conformably overlies the Gachsaran Formation. The contact with the overlying marl of the Misahn Formation is conformable. Most of the researches so far focused mainly on the lithostratigraphy, biostratigraphy and paleontology of the Guri Member ([5]), therefore less attention has been given to the interpretation of microfacies and palaeoenvironmental reconstruction. In this research, a microfacies analysis and palaeoecological approach is used to interpret the relationship between palaeoenvironmental parameters and change of sedimentary facies.

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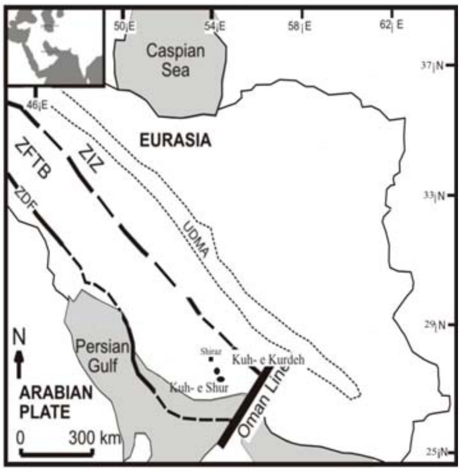

Fig. 1. Map showing regional structural units and position of outcrop sections. Abbreviation for structural units: UDMA, urumieh - Dokhtar Magmatic Arc; ZIZ, Zagrose Imbricate Zone; ZFTB, Zagrose Fold Thrust Belt; ZDF, Zagrose Deformational Front (modified from [4])

2. MATERIAL AND METHODS

This study is based on two measured and sampled outcrop sections in the Kuh-e Shur and Kuh-e Kurdeh areas. The total thickness of Guri Member of the Mishan Formation is about 72 m and 110 m in Kuh-e Shur and Kuh-e Kurdeh sections, respectively.

The rocks were classified in the field using the depositional fabric of Dunham [6] and Embry and Klovan [7]. More than 120 thin sections were prepared and examined in the lab. Facies were determined for each palaeoenvironment according to carbonate grain types, textures and interpretation of functional morphology of larger foraminifers.

3. STUDY AREA

This research involves two stratigraphic sections from the Guri Member in the Zagros fold belt (Fig. 1) in the Fars area in southwest Iran (Fig. 2). The study area in the Kuh-e Shur section is located about 300 Km southeast of Shiraz (Fars Province) and 50 Km southeast of Lar city (Fig. 2). The section was measured in detail at 27° 34' 49'' N and 54° 49' 21'' E. The study area in the Kuh-e Kurdeh section is located about 300 Km southeast of Shiraz (Fars Province) and .30 Km northeast of Lar city (Fig. 2). The section was measured in detail at 27° 49' 26'' N and 54° 40' 09'' E.

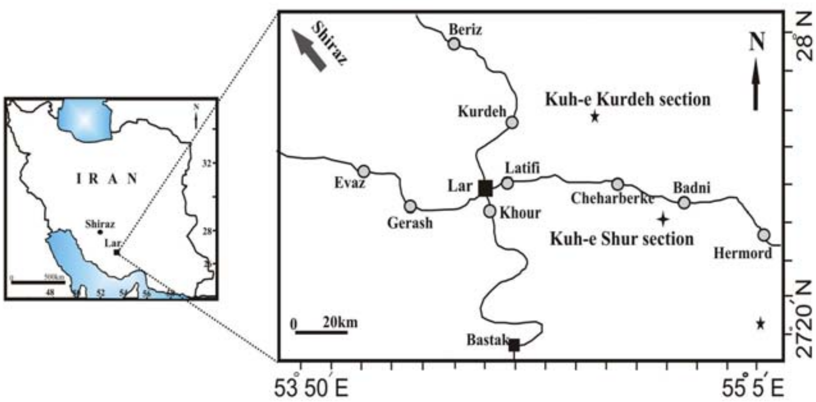

Fig. 2. Location of the studies area in Southwestern Iran

4. FACIES

Facies analysis of the Guri Member of Mishan Formation in the study areas resulted in the definition of thirteen facies types which characterize platform development. Each of the microfacies exhibits typical skeletal and non-skeletal components and textures. The general environmental interpretations of the microfacies are discussed in the following paragraphs.

4.1. MF.1. Operculina Bioclastic Packstone

The main characteristic feature of this facies is the abundance of large and flat epifauna benthic foraminifera *Operculina*. Other components of this facies include corallinaceans, echinoids, bryozoans, bivalves and *Amphistegina*. The matrix is fine-grained micrite (Fig. 3a). Grains are poorly sorted and are medium to coarse sand. The rocks of this microfacies are composed of medium bedded marly limestone.

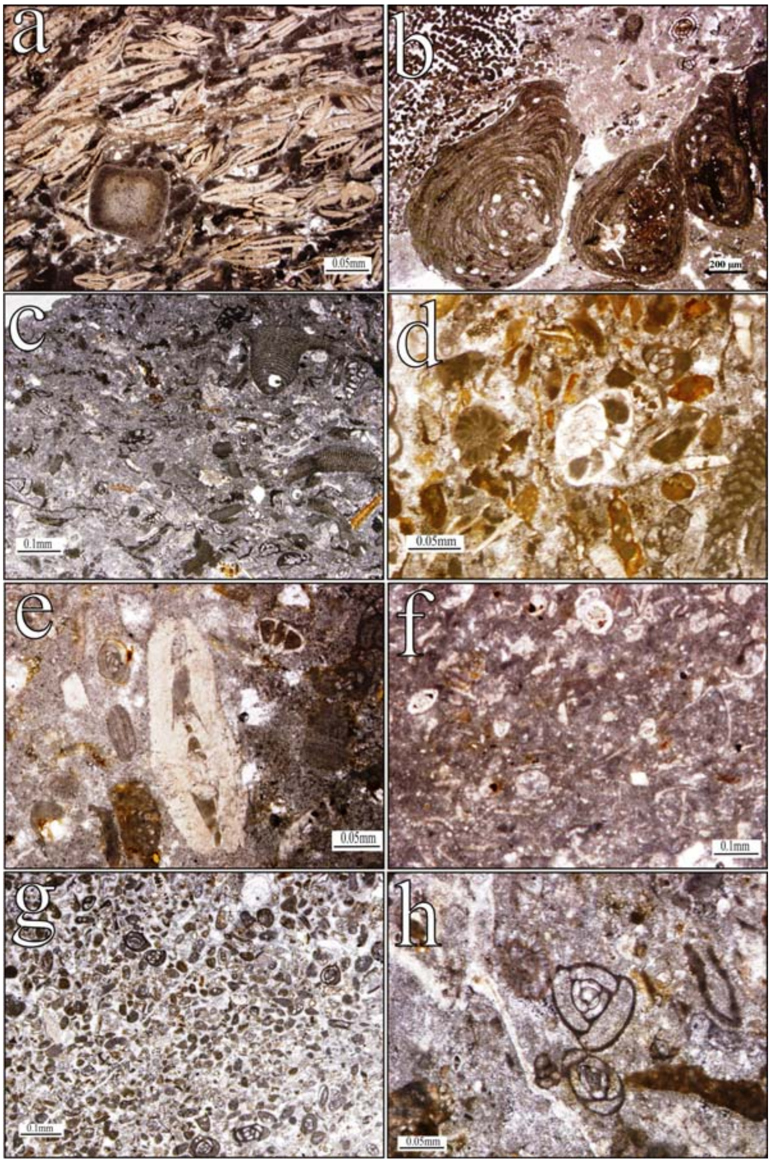

Fig. 3. General view of some selected microfacies of the Guri Member in the study areas (a) MF. 1, Operculina Bioclastic Packstone (sample no. H558). (b) MF.2, Imperforate foraminifera corallinacea coral rudstone (sample no. J3293). (c) MF.3, Miliolids corallinacea bioclastic wackestone-packstone (sample no. J3301). (d, e) MF.4. Foraminifera (perforate and imperforate) bioclastic wackestone-packstone(sample no. H495, H518). (f) MF.5, Neorotalia Bioclastic wackestone (sample no. H497). (g) MF. 7, Miliolids peloids bioclastic packstone (sample no. J3288). (h) MF.8, Miliolids bioclastic wackestone (sample no. H451)

4.1.1. Interpretation

The presence of high diverse stenohaline fauna such as red algae, bryozoan, echinoid and larger foraminifera (*Operculina* and *Amphistegina*) indicate that the sedimentary environment was situated in the oligophotic zone in a shallow open marine environment or near a fair-water wave base on the proximal middle shelf [8-11]. Present day larger foraminifera are in fact restricted to the photic zone, since all of them house symbiotic algae [12-14]. They also need to protect themselves from very high degrees of illumination causing damage by ultraviolet light [15]. Nummulitids with transparent and hyaline walls protect themselves in deeper water from uv-light by producing large and flat walls [15].

4.2. MF.2. Imperforate foraminifera corallinacea coral rudstone

This microfacies is characterized by a high diversity of benthic biota, including foraminifers (neoalveolinids, miliolids, rare rotaliids and *Amphistegina*), bryozoans, echinoderms and coralline algae, particularly *Lithophyllum* and *Lithothamnion* and corals. Typically, it has a rudstone texture with wackestone-packstone matrix (Fig. 3b). Megascopically, it is medium-bedded to thick-bedded limestone.

4.3. MF.3. Miliolids corallinacea bioclastic wackestone-packstone

Miliolids and corallinacea red algae are dominate components in this microfacies. Other bioclasts are rare but include *Neorotalia*, bryozoa and echinoid fragments. The textures are wackestone-packstone (Fig. 3c).

4.3.1. Interpretation

Both MF2 and MF3 represent low to medium-energy open lagoon shallow subtidal environments, but differ from each other by their grain composition.

Depositional textures, fauna and flora and stratigraphic position reflects sedimentation may have taken place in warm, euphotic and shallow water, with low to moderate energy conditions, in a semi-restricted lagoon, within inner carbonate platform setting.

The presence of well-preserved coralline algal indicates a relatively quiet-water environment with stable substrate and low sedimentation rates [16]. The associations of miliolids within this facies support the additional interpretation of a relatively protected environment, probably the inner part of a platform [17]. A similar facies was reported from the inner ramp of the Oligocene-Miocene sediments of the Zagros basin [18].

4.4. MF.4. Foraminifera (perforate and imperforate) bioclastic wackestone-packstone

Skeletal grains consists of diverse fauna, including benthic foraminifera (miliolids, rotalids) echinoid, corallinacean and bivalve fragments. Textures are wackestone-packstone. Perforate foraminifera are represented by *Operculina* and *Neorotalia*. Imperforate foraminifera are common with miliolids and *Borelis* (Fig. 3d, e).

4.4.1. Interpretation

The co-occurrence of normal marine biota such as rotaliids, corallinaceans and echinoids with lagoonal biota such as miliolids indicates that sedimentation took place in an open shelf lagoon. A similar facies with imperforate foraminifers and perforate foraminifers was reported from the inner ramp of the Oligo-Miocene sediments of the Zagros Basin [18], Miocene sediments of the central Apennines [19] and from Early Oligocene deposits of the Lower Inn Valley [20].

4.5. MF.5. Neorotalia Bioclastic wackestone

This facies is dominated by *Neorotalia* with subordinate components such as echinoid debris and bryozoan. This facies has a fine grained matrix (Fig. 3f).

4.5.1. Interpretation

The presence of environment was situated in the shallow open lagoon environment. stenohalyn fauna such as bryozoan, echinoid and *Neorotalia* and stratigraphic position below lagoonal facies indicate that the sedimentary.

4.6. MF-6 Marl facies

This facies occurs in the lower and upper parts of the succession. They are gray to green and are intercalated between facies 7 and 5. Washed samples contain miliolids, *Neorotalia*, *Elphidium*, *Operculina*, *Amphistegina* and textularids.

4.6.1. Interpretation

The feature of fauna and stratigraphic relationships with the other microfacies suggest that marl facies were deposited in an open lagoon environment.

4.7. MF. 7. Miliolids peloids bioclastic packstone

The most frequent skeletal components of this microfacies are benthic foraminifers with imperforate walls such as miliolids and *Dendritina* and fragments of bryozoan. Non skeletal components consist of poloid and intraclst. Peloids occur abundantly while intraclsts are subordinate (Fig. 3g). The foraminifera are generally well-preserved and show no abrasion.

4.7.1. Interpretation

This facies was deposited in restricted circulation condition in a protected lagoon environment. The abundance of peloids, miliolids and the low diversity of fauna support this interpretation. The oligotypic fauna (such as miliolids) and the presence of a low-diversity foraminiferal association indicate a very shallow subtidal environment with low to moderate energy [21] and low water turbulence [22] as well as high salinity. Moreover, an abundance of peloids with a low diversity of fossils suggests deposition in a restricted shallow subtidal water and slow sedimentation rate ([23-25]).

4.8. MF.8. Miliolids bioclastic wackestone

This facies is characterized by the dominant presence of small benthic foraminifera (miliolids). Other components such as bryozoa, echinid fragments, and *Neorotalia* are rare. The matrix is fine grained micrite (Fig. 3h).

4.8.1. Interpretation

This facies was deposited in restricted low energy lagoonal environments as indicated by low-diversity skeletal fauna, lack of subaerial exposure and the stratigraphic position. The low biotic diversity of fauna indicates a high-stressed habitat in very shallow restricted areas, where great fluctuations in salinity and temperature probably occurred.

5. DEPOSITIONAL ENVIRONMENT

Two major depositional environments are identified in the Miocene succession in the Lar area, on the basis of the distribution of the foraminifera and vertical facies relationships (Figs. 4, 5). These include inner shelf and middle shelf environments (Fig. 6). These two environments are represented by 8 microfacies types (MF-1: middle shelf, MF-2-8: inner shelf). Inner shelf deposits represent marginal marine deposits indicative of open lagoon and protected lagoon. In the restricted lagoon environment, faunal diversity is low and normal marine fauna are lacking, except for imperforate benthic foraminifera (miliolids, *Dendritina*, borelisids), which indicate quite sheltered conditions. A large number of porcellaneous imperforates points to somewhat hypersaline waters [22].

Today, porcelaneous larger foraminifera thrive in tropical carbonate platforms within the upper part of the photic zone ([26-28]). Some biogenic components such as miliolids indicate stress conditions within restricted environments. Miliolids-dominate benthic foraminifer assemblages reflect decreased circulation and probably reduced oxygen contents or euryhaline conditions. Miliolids are found in a variety of very shallow, hyposaline to hypersaline environments, or are even common in the sand shoal environments of normal salinities ([29, 30]), and are generally taken as evidence of restricted lagoon [31]. Open lagoon shallow subtidal environments are characterized by microfacies types that include mixed open marine bioclasts (such as red algae, echinoids and corals) and protected environment bioclasts (such as miliolids). The diversity association of skeletal components represents a shallow subtidal environment, with optimal conditions as regards salinity and water circulation.

Deposition within a middle-shelf setting is supported by foraminiferal-bioclast wacke-packstone, dominated by an assemblage of large perforate foraminifera (*Operculina* and *Amphistegina*) and fragments of echinoid and corallinacean. The change in larger foraminiferal fauna from porcelaneous imperforated to hyaline perforated forms point to a decrease in water transparency [32].

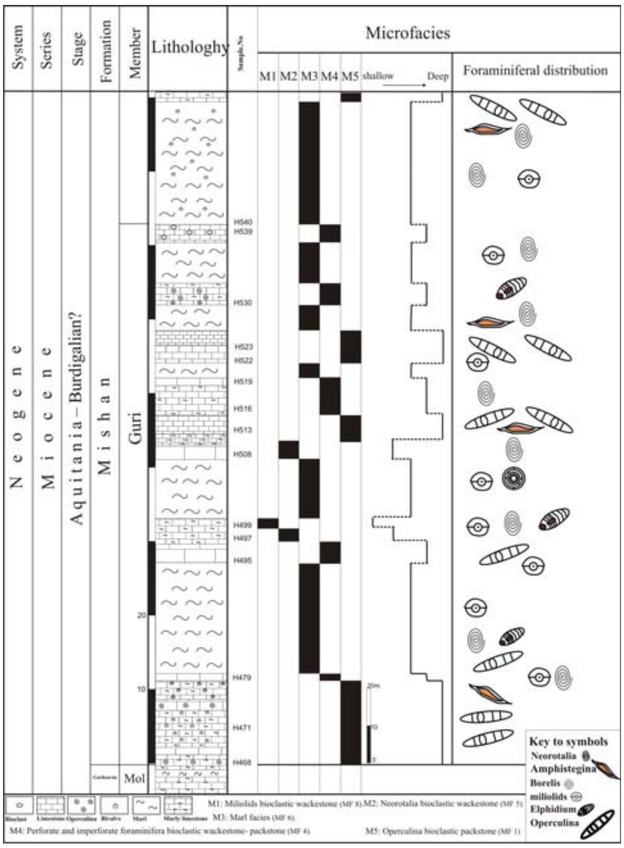

Fig. 4. Distribution of microfacies of the Guri Member of Mishan Formation in the Kuh- e Shur section

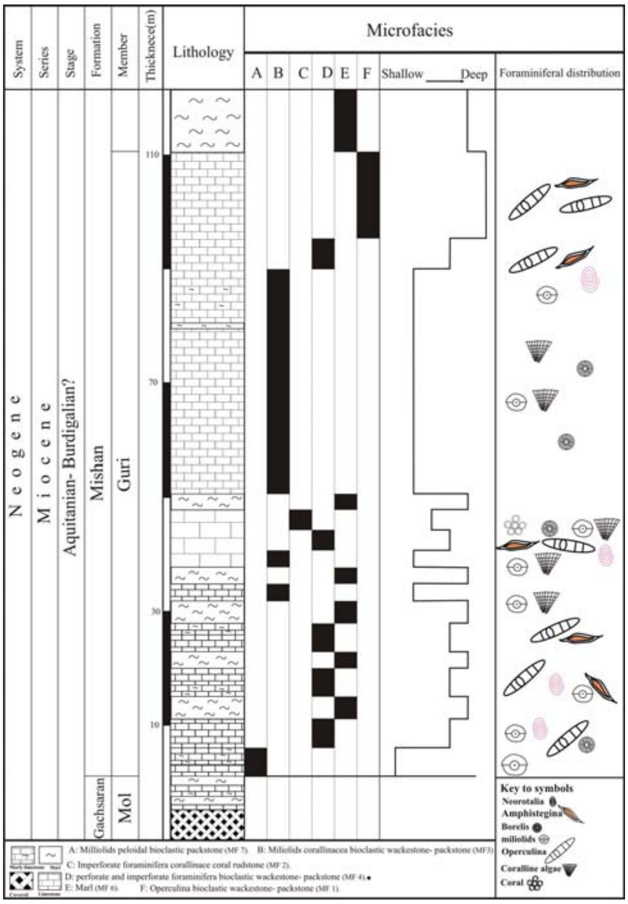

Fig. 5. Distribution of microfacies of the Guri Member of Mishan Formation in the Kuh- e Kurdeh section

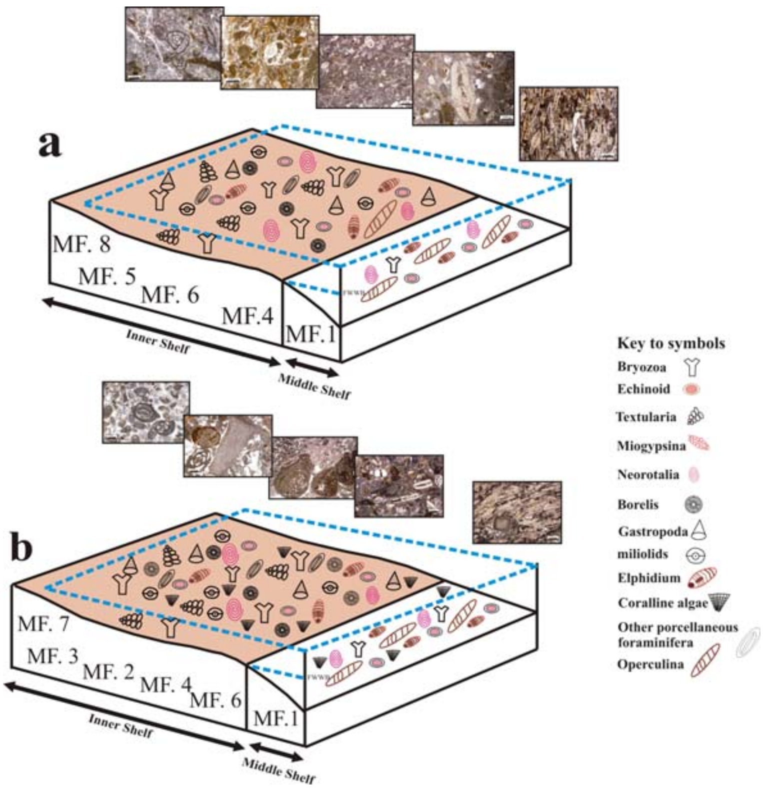

Fig. 6. Depositional model for the platform carbonates of the Guri Member in Lar area, Zagros Basin, S. W. Iran. (a) Kuh-e Shur section, (b) Kuh-e Kurdeh Section

6. ENVIRONMENTAL FACTORS AND SKELETAL GRAIN ASSOCIATIONS

The skeletal grains and palaeolatitudinal reconstructions [33] suggest that carbonate sedimentation of Guri Member took place in tropical waters under oligotrophic conditions, a typical environment for photozoan assemblages. The compositional analysis of the Guri Member shows that the main carbonate producing skeletal grains are represented by benthic foraminifera (*Operculina, Amphistegina* and *Borelis*) and red algae.

Foraminifera are commonly used as indicators of water temperature ([34-36]). The occurrence of larger benthic foraminifera is not only limited by the annual minimum temperature, but also by nutrient contents, very much like zooxanthella corals, larger benthic foraminifera are usually restricted to oligotrophic environments [36].

The abundance of larger benthic foraminifera (*Borelis*, *Archias*, *Peneroplis*, nummulitide, lepidocyclinidae) and zooxanthellate corals on many of the platforms, however, are in contrast to the persistently high nutrients, since these foraminifera thrive in oligotrophic [36] to possibly slightly mesotrophic [37] waters. These biotic assemblages of the Guri Member belong to foralgal association and may be broadly defined as comprising heterozoan assemblages. Heterozoan carbonates are also well-developed in the Late Oligocene of Malta [38].

According to [39], until the Late Miocene zooaxanthellate corals did not build framework structures in the Mediterranean and lived in the middle-lower part of the photic zone. Therefore, the spread of heterozoan assemblages in the Guri Member was related to the palaeoecology of zooaxanthellate corals. The interpretation used here may be confirmed by the interpretation of the Late Oligocene carbonate platform of Malta [38]. Here, the authors interpreted where the spread of heterozoan assemblages related to the low capacity of corals to thrive in high-light conditions and to form a wave-resistant reef promoted the diffusion of heterozoan assemblages.

7. CONCLUSIONS

Miocene carbonates of the Guri Member in the Lar area were deposited in an open carbonate shelf. Eight microfacies have been identified within this carbonate platform. Deposition of MF-2-8 may have taken place in marginal marine such as open lagoon and protected lagoon (inner shelf). Deposition within a middle-shelf setting is characterized by foraminiferal-bioclast wacke-packstone, dominated by the assemblage of large perforate foraminifera (*Operculina* and *Amphistegina*) and fragments of echinoid and corallinacean (MF-1).

Based on skeletal grains, palaeolatitudinal reconstructions suggest that carbonate sedimentation of the Guri Member took place in tropical waters under oligotrophic conditions. In modern carbonate platforms, water temperatures and trophic resources generally promote the development of a photozoan association; nevertheless, the biotic assemblages of the Guri Member belong to foralgal association and may be broadly defined as comprising heterozoan assemblages. The spread of heterozoan assemblages in the Guri Member was related to the palaeoecology of zooaxanthellate corals. It seems that the low capacity of corals to thrive in high-light conditions and to form a wave-resistant reef promoted the diffusion of heterozoan assemblages by large benthic foraminifera and coralline algae.

REFERENCES

1. James, G. A. & Wynd, J. G. (1965). Stratigraphic nomenclature of Iranian Oil consortium agreement area. *AAPG Bulletin, 49,* 2182-2245.
2. McQuarrie, N. (2004). Crustal scale geometry of the Zagros fold thrust belt, Iran. *J Struct. Geol., 26,* 519-535.

3. Alavi, M. (1994). Tectonics of the Zagros Orogenic belt of Iran, new data and interpretation. *Tectonophysics, 229,* 211-238.
4. Alavi, M. (2004). Regional stratigraphy of the Zagros Fold-Thrust Belt of Iran its proforeland evolution. *American Journal of Sciences, 304,* 1535-1541.
5. Motiei, H. (1993). *Stratigraphy of Zagros.* Geological Survey of Iran (in Persian), 536p.
6. Dunham, R. J. (1962). Classification of carbonate rocks according to their depositional texture, In Ham, W. E. (ed.), Classification of Carbonate Rocks. *A Symposium AAPG, Memo., 1,* 108-121.
7. Embry A. F. & Klovan, J. E. (1971). A late Devonian reef tract on Northeastern Banks Island. NWT, Can. *Petroleum Geol. Bull., 19,* 730-781.
8. Pomar, L. (2001a). Types of carbonate platforms, a genetic approach. *Basin Res., 13,* 313-334.
9. Pomar, L. (2001b). Ecological control of sedimentary accommodation, evolution from a carbonate ramp to rimmed shelf, Upper Miocene, Balearic Islands. *Palaeogeography, Palaeoclimatology, Palaeoecology, 175,* 249-272.
10. Brandona, M. & Corda, L. (2002). Nutrients, sea level and tectonics, constrains for the facies architecture of a Miocene carbonate ramp in central Italy. *Terra Nova, 14,* 257-262.
11. Cosovic, V., Drobne, K. & Moro, A. (2004). Paleoenvironmental model for Eocene foraminiferal limestones of the Adriatic carbonate platform (Istrian Peninsula). *Facies, 50,* 61-75.
12. Hottinger, L. (1997). Shallow benthic foraminiferal assemblages as signals for depth of their deposition and their limitation. *Bull. Soc. Geol. France, 168,* 491-505.
13. Hohenegger, J. (2000). Coenoclines of larger foraminifera. *Micropaleontology, 4,* 127-151.
14. Hohenegger, J. (2004). Depth coenoclines and environmental considerations of western Pacific larger foraminifera. *J. Foram. Research, 34,* 9-33.
15. Rasser, M. W., Scheibner, C. & Mutti, M. (2005). Paleoenvironmental standard section for early Ilerdian tropical carbonate factories (Corbieres, France; Pyrenees, Spain). *Facies, 51,* 217-232.
16. Nebelsick, J. H. & Bassi, D. (2000). Diversity, growth forms and taphonomy, Key factors controlling the fabric of coralline algae dominated shelf carbonates, In Insalaco E., P. W. Skelton, T. J. Palmer (eds.) Carbonate platform system: components and interaction. *Geol. Soc. Lond, Special Publication, 178,* 89-107.
17. Fournier, F., Montaggioni, L. & Borgomano, J., (2004). Paleoenvironments and high-frequency cyclicity from Cenozoic southeast Asian shallow-water carbonates, a case study from the Oligo-Miocene buildups of Malampaya (offshore Palawan, Philippines). *Mar. Petrol. Geol., 21,* 1-21.
18. Vaziri-Moghaddam, H., Kimiagari, M. & Taheri, A. (2006). Depositional environment and sequence stratigraphy of the Oligocene-Miocene Asmari Formation in SW Iran, Lali area. *Facies, 52,* 41-51.
19. Corda, L. & Brandano, M. (2003). Aphotic zone carbonate production on a Miocene ramp central Apenninnes, Italy. *Sedimetary Geology, 61,* 55-70.
20. Nebelsick, J. H., Stingl, T. V. & Rasser, M. (2001). Autochthonous Facies and Allochthonous Debris Flows compared: Early Oligocene carbonate facies patterns of the lower Inn valley (Tyrol, Austria). *Facies, 44,* 31-46.
21. Ghobeishavi, A., Vaziri-Moghaddam, H. & Taheri, A. (2009). Facies distribution and sequence stratigraphy of the Coniacian-Santonian succession of the Bangestan Paleo-high in the Bangestsn Anticline, SW Iran. *Facies, 55,* 243-257.
22. Geel, T. (2000). Recognition of stratigraphic seguences in carbonate platform and slope deposits: empirical models based on microfacies analysis of Paleogene deposits in southeastern Spain. *Palaeogeography, Palaeoclimatology, Palaecology, 144,* 211-238.
23. Wilson, J. L. (1975). *Carbonate facies in geological history.* Springer, 471p.
24. Flugel, E. (1982). *Microfacies analysis of limestone*. Springer, 633p.
25. Wanas, H. A. (2008). Cenomanian rocks in the Peninsula, Northeast Egypt, Facies analysis and sequence stratigraphy. *J. of African Earth Sciences, 5,* 125-138.

26. Leuttenger, S. (1984). Symbiosis in benthic foraminifera: specificity and host adaptations. *J. Foram. Research, 14*, 16-35.
27. Romero, J., Caus, E. & Rossel, J. (2002). A model for the paleoenvironmental distribution of larger foraminifera based on Late-Middle Eocene deposits on the margin of the south Pyrenean basin. *Palaeogeography, Palaeoclimatology, Palaeoecology, 179*, 43-56.
28. Reiss, Z. & Hottinger, L. (1984). *The Gulf of Aqaba: Ecological micropaleontology. Berlin.* Springer, 354p.
29. Brasier, M. D. (1975a). Ecology of Recent sediment- dwelling and phytal foraminifera from the lagoons of Barbuda, West Indies. *J. of Foram. Research*, 5, 42-46.
30. Brasier, M. D. (1975b). The ecology and distribution of Recent Foraminifera from the reefs and shoals around Barbuda, West Indies. *J. of Foram. Research, 5,* 193-210.
31. Murray, J. W. (1991). *Ecology and paleoecology of Benthic Foraminifera.* London, Wiley, 397p.
32. Barattolo, F., Bassi, D. & Romero, R. (2007). Upper Eocene larger foraminiferal-coralline algal facies from the Klokova Mountain (south continental Greece). *Facies, 53,* 361-375.
33. Alavi, M. (2007). Structures of the Zagros Fold-Thrust Belt in Iran. *American Journal of Sciences., 307,* 1046-1095.
34. Betzler, C., Brachert, T. C. & Nebelsick, J. (1997). The warm temperate carbonate province, A review of the facies, zonation and delimitations. *Courier Forshungs-Institut Senckenberg, 201,* 83-99.
35. Hollaus, S. & Hottinger, L. (1997). Temperature dependance of symbiontic relationship, Evidence from depth range of Mediterranean Amphistegina truncated by the thermocline Eclogae geological Helvetica. *Basel., 90,* 591-597, 2figs.
36. Langer, M. & Hottinger L. (2000). Biogeography of selected 'larger' foraminifera. *Micropaleontology, 46*, 105-126.
37. Halfar, G., Godinez-Orta, L., Mutti, M., Valdez-Holguin, J. E. & Borges, J. M. (2004). Nutrient and temperature controls on modern carbonate production: an example from the Gulf of California. Mexico. *Geology, 32,* 481-484.
38. Brandona, M., Frezza, V., Tomassetti, L. & Cuffaro, M. (2009). Heterozoan carbonates in oligotrophic tropical water, The Attard Member of the lower coralline limestone formation (Upper Oligocene, Malta). *Palaeogeography, Palaeoclimatology, Palaeoecology, 56,* 1138-1158.
39. Pomar, L. & Hallock, P. (2007). Changes in coral- reef structure through the Miocene in the Mediterranean province, adaptive vs. environmental influence. *Geology, 35,* 899-902.