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STRATIGRAPHY OF THE THANETIAN ROTALIIDS LIMESTONE, NORTHERN LORESTAN, IRAN – LORESTAN, SW IRAN

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ABSTRACT – In this research, biostratigraphy of the Taleh Zang Formation, located in northern Lorestan, SW Iran, is discussed. The benthic foraminiferal contents of the upper Paleocene successions were examined in a carbonate platform setting in the context of European standard zonation (Shallow Benthic Zones). The co-occurrence of *Glomalveolina levis* (Hottinger) and *Miscellanea miscella* (d'Archiac & Haime) characterizes Zone SBZ 4, indicating a Thanetian age. Based on biofacies analysis and faunal associations, with emphasis on benthic foraminifera and coralline red algae, tidal flat and marginal marine environment exposed to salinity fluctuations (short-term salinity fluctuations or fully marine conditions), dominated by small benthic Foraminifera (*Kathina*) with slightly mesotrophic conditions, are determined for the deposition of the Poshte Jangal section. The highly translucent, shallowest part of the inner shelf dominated by representatives of *Miscellanea* and *Opertorbitolites*. The biotic assemblages representing warm tropical waters with oligotrophic conditions were observed in Palganeh and Pasan sections.

Keywords: Taleh Zang Formation, Paleocene, Foraminifera, Biostratigraphy, Thanetian.

RESUMO – Nesta investigação, discute-se a biostratigrafia da Formação Taleh Zang, localizada no norte de Lorestan, sudoeste do Irã. Os foraminíferos bentônicos das sucessões do Paleoceno superior foram examinados numa plataforma de carbonato no contexto da zonação padrão europeia (*Shallow Benthic Zones*). A coocorrência de *Glomalveolina levis* (Hottinger) e *Miscellanea miscella* (d'Archiac & Haime) caracteriza a Zona SBZ 4, indicando uma idade Thanetiana. Com base na análise de biofácies e associações faunísticas, com ênfase em foraminíferos bentônicos e algas vermelhas coralinas, ambiente marinho plano e marginal exposto a flutuações de salinidade (flutuações de salinidade a curto prazo ou condições totalmente marinhas), dominadas por pequenos foraminíferos bentônicos (*Kathina*) com condições ligeiramente mesotróficas, são determinadas para a deposição da seção Poshte Jangal. A parte mais superficial e altamente translúcida da plataforma interna é dominada por representantes de *Miscellanea* e *Opertorbitolites*. As associações bióticas representando as águas tropicais quentes com condições oligotróficas foram observadas nas seções de Palganeh e Pasan.

Palavras-chave: Formação Taleh Zang, Paleoceno, Foraminifera, biostratigrafia, Thanetiano.

INTRODUCTION

Thanetian was an age of intense global warming of sea surface temperature in less than 10 Ma (Zachos *et al.*, 2001, 2008). A steady increase in temperature contributed to the expansion of oligotrophic conditions in the global ocean, which would have facilitated the diversification of larger benthic foraminifera (BouDagher-Fadel, 2008). Hottinger (2014) proposed an oligotrophy condition usually requiring long periods of climatic stability in the environment and a permanent separation of gyral current patterns from nutrient sources produced on land by erosion, he called it "Global Community Maturation". Larger foraminifera are extreme K-strategists characterized by long individual lives and low reproductive potential (BouDagher-Fadel, 2008), thriving in a stable, typically oligotrophic environment (Hottinger, 1983). Representatives of the genera *Miscellanea* and *Ranikothalia* were common larger benthic foraminifera in the late

Paleocene on shallow circum-Tethyan carbonate platforms (Adams, 1967). Larger benthic foraminiferal taxa in the shelf sediments, especially those in the shallower water limestones of Late Paleocene, have been previously reported from Iran (James & Wynd, 1965; Maghfori Moghaddam & Jalali, 2004, Homke *et al*., 2009; Bagherpour & Vaziri, 2012; Sadeghi & Jokar, 2019), while there is no published stratigraphic information for these deposits in the north Lorestan. In this study, we focus on foraminiferal biostratigraphy of lower Paleogene Taleh Zang Formation of shallow-water carbonate in the north Lorestan basin and compare them with the other studies in the Tethys.

GEOLOGICAL SETTING

Based on the sedimentary sequence, structural setting and intensity of deformation, the Zagros Orogenic Belt of Iran has been subdivided into two continental fragments (Sherkaty & Letouzey, 2004), High Zagros Thrust Belt (**HZTB**) and Zagros Fold-Thrust belt (**ZFTB**). Bahroudi & Koyi (2004) have suggested that basement faults had a significant effect on the evolution of the ZFTB. Thickness and facies variations, as well as local and regional unconformities, have been related to the reactivation of basement faults or the migration of the foreland basin (Sherkati & Letouzey, 2004). Lorestan basin is part of ZFTB (Alavi, 2004), which is limited to Main Zagros Reverse Fault and Dezful Embayment in northeast and southeast, respectively (Figure 1A).

The Zagros Orogenic Belt, including the Lorestan Basin (**LZ**), contains a sedimentary sequence named as Jahrum, with Paleocene to lowermost Oligocene age (Motiei, 1993). The Paleogene history of the LZ commenced with an uplift of ophiolites in the northeast margin of Arabian plate and a major regression at the middle Maastrichtian age. In central and northeastern Lorestan, the uplift and then erosion of the ophiolites produced a great quantity of detritus carried southwestward and accumulated as flysh-type plus mollasic sediments, forming the present Amiran and Kashkan formations during late Maastrichtian–Eocene time, respectively (Setudehnia, 1972). These two units are separated by the carbonate of the Taleh Zang Formation. Deep water, anoxic, and basinal pelagic sedimentation continued during the Paleogene time in southern and western Lorestan which form the present day Pabdeh Formation.

MATERIAL AND METHODS

In the studied sections, the Taleh Zang Formation consists of medium bedded to massive, resistant, grey and brown, fossiliferous limestone and dolomite (Figure 1B). Three sections of the Taleh Zang Formation were measured bed by bed, and sampled in three areas (Poshte Jangal, 26; Pasan, 57; and Palganeh, 84 m thick), and paleontologically investigated. Following field inspections, 160 samples were collected from every 1 to 2 meters from (lithified) limestone beds and analyzed in thin sections. Biostratigraphic zonation is mainly based on the larger benthic foraminifera, which are very abundant and have high diversity in the study section (Figure 2). The generic classification of foraminifera follows Loeblich & Tappan (1988) criteria, updated with Hottinger (2014) for the rotaliids. The larger foraminiferal biozonal scheme by Serra-Kiel *et al*. (1998) for Paleogene platform carbonates of the Mediterranean region (Shallow benthic foraminifera = **SBZ**) is applied to the studied sections.

SYSTEMATIC PALEONTOLOGY

Phyllum FORAMINIFERA Eichwald, 1830
Class GLOBOTHALAMEA Pawlowski, Holzmann, Jaroslaw & Tyszka, 2013
Order ROTALIIDA Delage & Hérouard, 1896
Superfamily ROTALIOIDEA Ehrenberg, 1839
Family ROTALIIDAE Ehrenberg, 1839
Subfamily LOCKHARTIINAE Hottinger, 2014

Lockhartia Davies, 1932

Lockhartia haimei Davies, 1927
(Figure 3C)

1954 *Lockhartia haimei* (Davies) Smout, p. 49; pl. 2, figs. 1–14.
1962 *Lockhartia haimei* (Davies) Sander, p. 19; pl. 5, figs. 1–37.
2014 *Lockhartia haimei* (Davies) Hottinger, p. 61, 62 and 65; pl. 5.3, figs. 1-2; pl. 5.5, figs. 1–12; pl. 5.6, figs. 1–17; pl. 5.7, figs. 1–12; pl. 5.8, figs. 1–14.

Material. Nine axial sections.
Description. Our determination of *Lockhartia haimei* (Davies, 1927) is based on the internal features in axial sections. The specimen is characterized by a low-trochospiral shell. The dorsal side is highly ornamented. The maximum cone diameter and height observed are 2.25 mm and 1.2 mm, respectively. The dorsal side with a rounded apex and the ventral side are convex with an umbilicus formed by folium and filled with 5–6 piles. This species is distinguished by its distribution of piles in the ultimate and penultimate ventral side of the shell. These have equal diameters from the center to the periphery of the shell. The periphery is slightly concave, without a keel, and the proloculus is 0.2 mm in diameter.

Subfamily KATHININAE Hottinger, 2014

Kathina Smout, 1954

Kathina pernavuti Sirel, 1972
(Figure 3L)

1972 *Kathina pernavuti* Sirel, p. 289, pl. 5, fig. 7.

Material. Three axial sections and five random sections.
Description. Lamellar, lenticular tests with trochospiral chamber arrangement. The ventral side shows an umbo formed by pillars and a few vertical funnels. The dorsal side shows a few short pillars. The maximum diameter and height of the tests observed are 1.0–1.3 mm and 0.6–0.9 mm, respectively. In spite of the small size of the shell, the folia are clearly visible. No dimorphism of generations was observed.

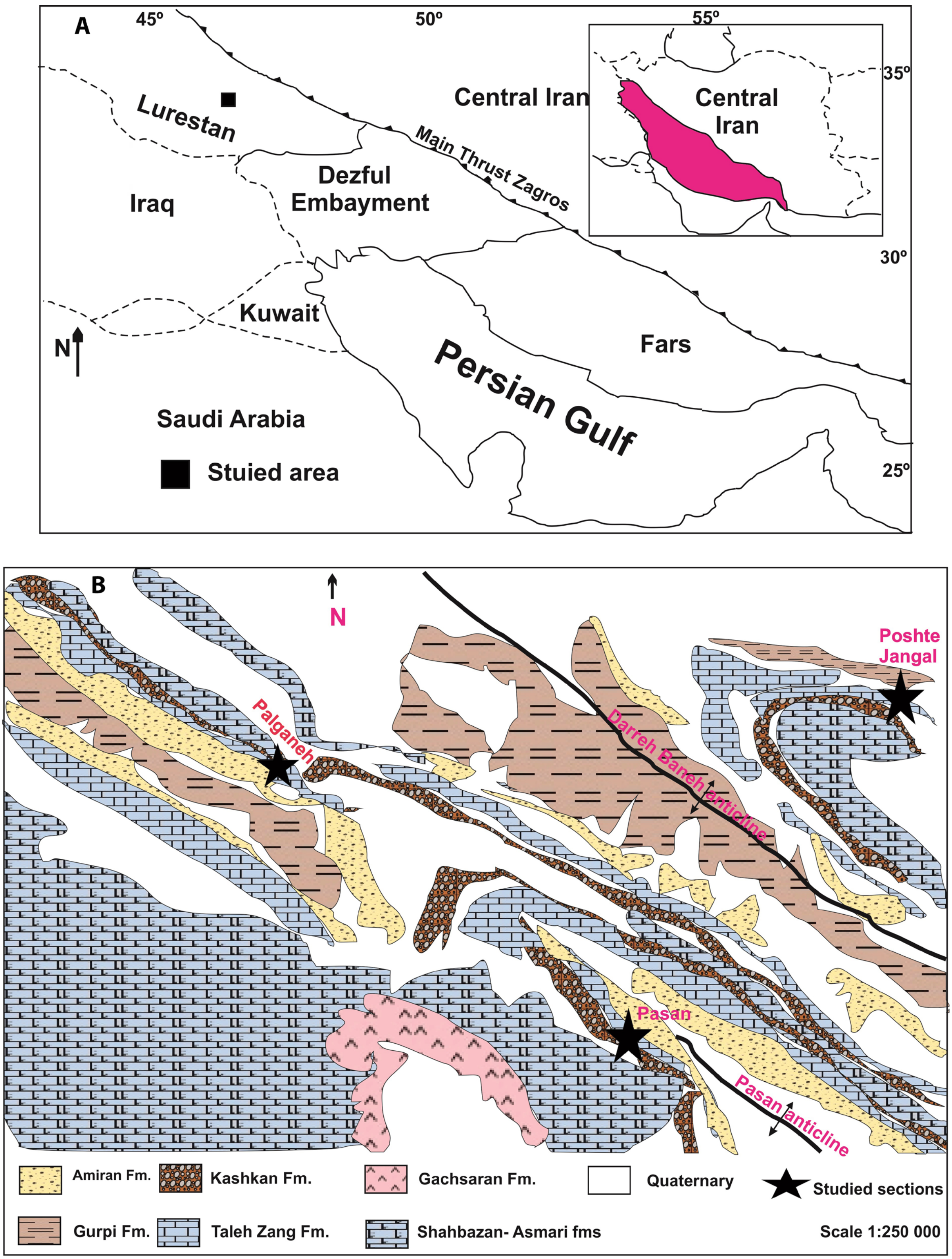

Figure 1. A, location map of the study area in the Lorestan Zone, and position of Lorestan Zone in the Zagros Orogenic belt; **B**, simplified geological map from study area (after geological map of Ilam-Kuh Dasht, 1:250,000 from Liewellyn, 1974).

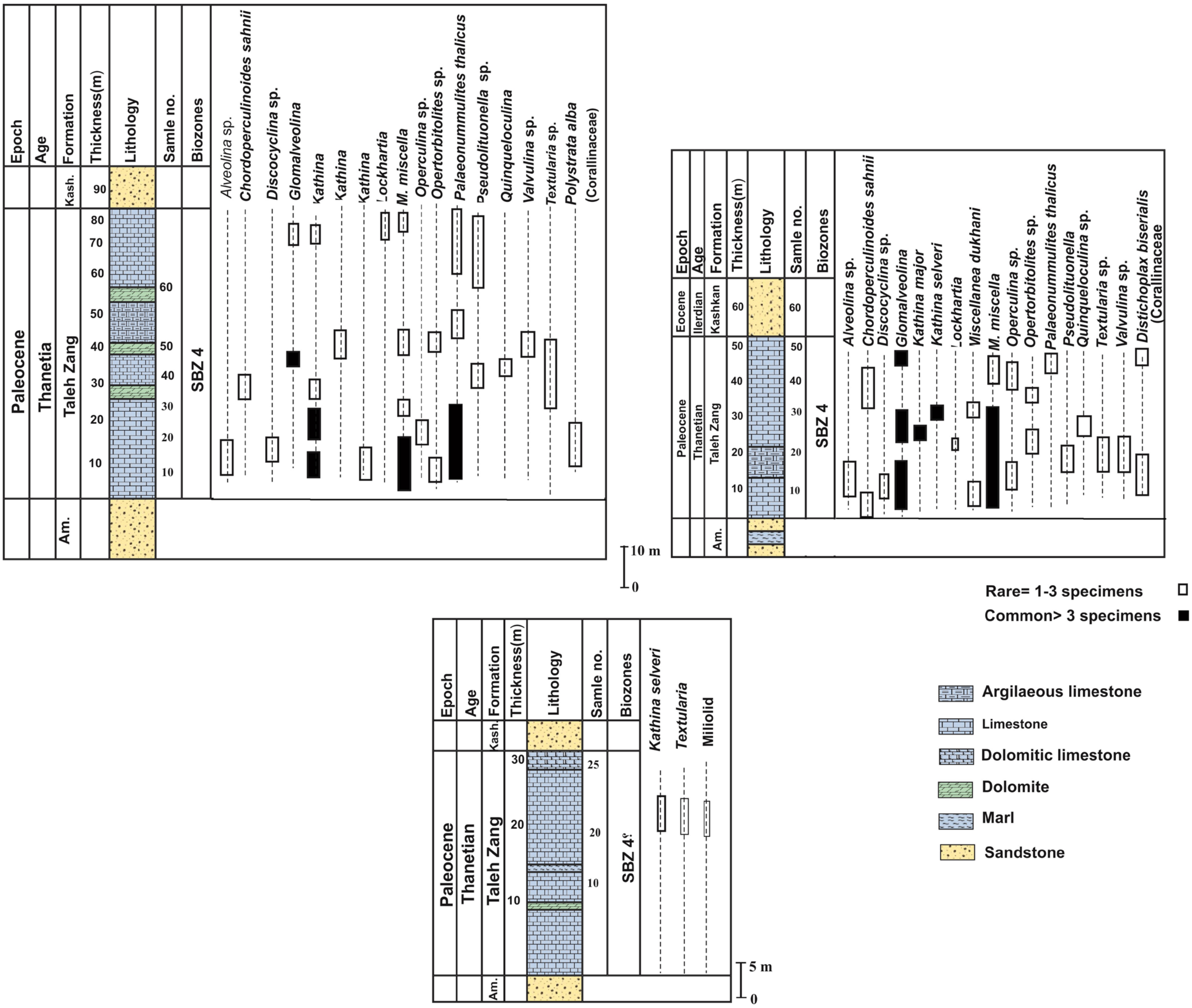

Figure 2. Lithology, biostratigraphy and vertical distribution of microfossil for the Taleh Zang Formation at the studied area, **A**, Palganeh section; **B**, Pasan section; **C**, Poshte Jangal sections.

Elazigina harabekayisensis (Sirel, 2012)
(Figure 3K)

1972 *Kathina subsphaerica* Sirel.
2012 *Elazigina harabekayisensis* Sirel, figs. 8.15–8.17.

Material. Three axial sections and seven random sections.
Description. Lamellar, lenticular tests with low trochospiral with smooth dorsal side and acute periphery, but absence of a keel. Ventral side occupied by a massive umbilical plug and surrounded by umbilical piles and funnels. The maximum diameter and height of the tests observed are 1.0–1.3 mm and 0.6–0.9mm, respectively.

Superfamily NONIONOIDEA Schultze, 1854
Family MISCELLANEIDAE Sigal in Piveteau, 1952
Subfamily MISCELLANEINAE Kacharava in Rauzer-Chernoussova & Furzenko, 1959

Miscellanea Pfender, 1935

Miscellanea dukhani Smout, 1954
(Figure 3E)

1954 *Miscellanea miscella* var. *dukhani* Smout, p. 73, ül. 14, figs. 2–6.
2008 *Miscellanea miscella* var. *dukhani* Smout; BouDagher-Fadel, p. 128, pl. 6/15, fig. 9.

Material. Seven axial and sub axial sections; six random sections.
Description. Shells flatly lenticular and have few whorls with a diameter to thickness ratio of about 1.7. The periphery is unkeeled, narrowly rounded, with lateral surfaces with light ornamentation and thin walls. The diameter of the embryonic apparatus is 0.4 mm and is composed of a protoconch and a slightly smaller deuteroconch.

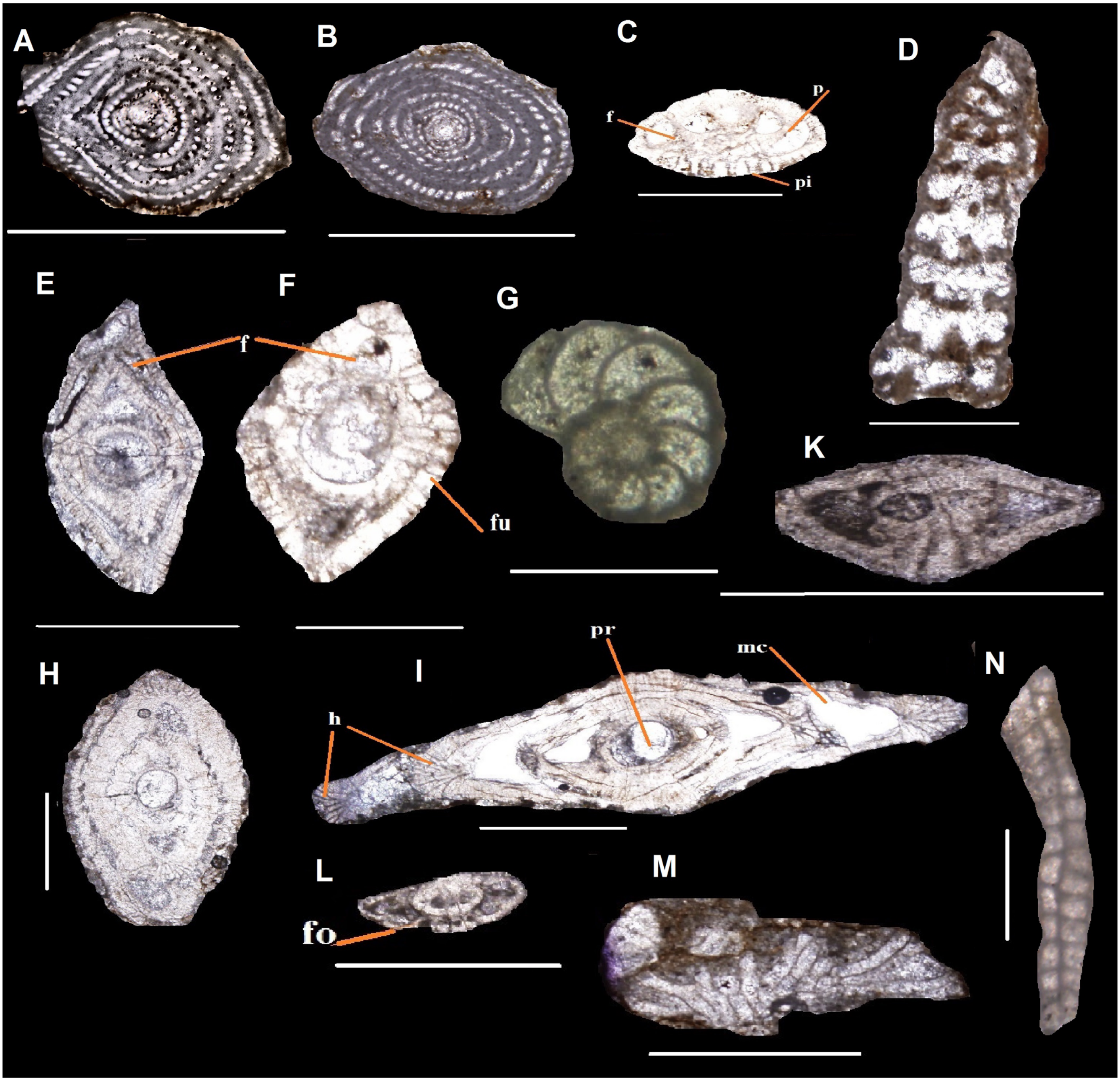

Figure 3. Photomicrographs of some foraminifera and coralline algae that are recognized in studied sections; **A**, *Alveolina* sp., sample no.7, Pelganeh section; **B**, *Glomalveolina levis* (Hottinger), sample no. 8, Pasan section; **C**, *Lockhartia haimei* (Davies), sample no. 11, Pelganeh section; **D**, *Pseudolitonella* sp., sample no. 29, Palganeh section; **E**, *Miscellanea dukhani* (Smout), sample no. 29, Pasan section; **F**, *Miscellanea miscella*, sample no.46, Pasan section; **G**, *Operculina* sp., sample no. 39, Palganeh section; **H**, *Palaeonummulites thalicus* (Davies), sample no. 36, Palganeh section; **I**, *Chordoperculinoides sahnii* (Davies), sample no. 35, Palganeh section; **K**, *Elazigina harabekayisensis* (Sirel); L, *Kathina pernavuti* (Sirel), sample no. 29, Pasan section; **M**, *Polystrata alba* (Pfender), sample no. 7, Palganeh section; **N**, *Distichoplax biserialis* (Dietrich), sample no. 29, Pasan section. **Abbreviations: f**, foramen; **fo**, folia; **fu**, funnel; **h**, horizontal canals; **mc**, Marginal cord; **p**, pore; **pi**, pile; **pr**, proloculus. Scale bars = 1000 µm.

Miscellanea miscella d'Archiac & Haime, 1853
(Figure 3F)

1853 *Nummulites miscella* d'Archiac & Haime, p. 345, pl. 35, figs. 4a–c.
1916 *Siderolites miscella* (d'Archiac & Haime). Douville, p. 38, pl. XV, fig. 5.
1937 *Miscellanea miscella* ((d'Archiac & Haime) pars. Davies & Pinfold (1937) p. 43, pl. VI,
1937 *Miscellanea stampi* (Davies). Davies & Pinfold, p. 42, ll. VI, figs. 4, 6, 9–10 and 17–18.
2008 *Miscellanea miscella* (d'Archiac & Haime). BouDagher-Fadel, p. 328, pl. 6/15, figs. 3–5.

Material. Fourteen axial and sub axial sections; seven random sections.
Description. The lenticular shells have an unkeeled, but sharp periphery narrowly rounded with lateral surfaces covered with numerous pustules. The ratio of equatorial to axial diameter of the shell is 1.2–3.1. The diameter of the embryonic apparatus is 0.7 mm. The deuteroconch embraces the proloculus in axial sections.

Family NUMMULITIDAE de Blainville, 1825
Subfamily PALEONUMMULITINAE subfam. nov.
Haynes, Racey & Whittaker, 2010

Chordoperculinoides Arni, 1965

Chordoperculinoides sahnii Davies, 1952
(Figure 2I)

1952 *Ranikothalia sahnii* Davies, p. 155, pl. 1, figs 1, 2, 4, 5, 7, 8 [B-form].
1952 *Ranikothalia savitriae* Davies, p. 155, pl. 1, figs 3, 6, 9, 10 [A-form].
1969 *Ranikothalia savitriae* Davies; Butterlin & Monod, p. 601, pl. 3, figs. 1, 5 (not 8).
1988 *Ranikothalia savitriae* Davies: Haynes & Nwabufo-Ene, p. 233, pl. 1, figs 1–4, 6–8.
1995 *Ranikothalia sahnii* Davies; Racey, p. 78, figs 13, 14, 19, 20, 22.

Material. Five axial sections and 11 random sections.
Description. Test large, exceeding 7 mm, semi-compressed lenticular with the canal system in the thickened marginal cord involute; chamber height becoming greater than twice the length; wall finely perforate and with thick, whorls irregular, increasing in diameter at about 2d.

Palaeonummulites Schubert, 1908

Palaeonummulites thalicus Davies, 1927
(Figure 3H)

1927 *Nummulites thalicus* var. *gwynae* Davies, p. 271, pl. 20, fig. 5.
1980 *Ranikothalia nuttalli* (Davies); Samanta, p. 126, pl. 2, figs 1–4; pl. 3, figs 1–5; pl. 4, figs 1–4.
1995 *Ranikothalia nuttalli* (Davies); Racey, p. 77, pl. 7, figs 6, 8.

Material. Five axial sections and eleven random sections
Description. Test compressed, planispiral, involute, with thin marginal cord; up to three and a half whorls, increasing in diameter at just below 2d; proloculus oval with maximum diameter of 250 µm, but sectioned slightly off center. *Palaeonummulites thalicus* Davies is described under the name *Nummulites nuttalli* (a taxon later (Caudri, 1944) reassigned to *Ranikothalia*) by Davies (1927). Its marginal cord is markedly thinner and chamber height markedly less. *Ranikothalia nuttalli kohaticus* and *P. thalicus gwynae* occur together both in Pakistan and in Oman (Haynes *et al*., 2010).

Operculina d'Orbigny, 1826
(Figure 3G)

Material. Three axial sections and four random sections.
Description. Involute to evolute; with moderate marginal cord; two or three whorls and high chambers, about 12 chambers by the third whorl, becoming about twice as high as long; septa falciform.

BIOSTRATIGRAPHIC INTERPRETATION AND DISCUSSION

A biostratigraphy criterion of the Taleh Zang Formation was established by James & Wynd (1965), though, it is unpublished report. James & Wynd (1965) designed *Miscellanea-Kathina* Assemblage Zone for the upper Paleocene deposits of Taleh Zang Formation. This zone could not recognize the stages of the Paleocene–Eocene as individual. Outside of the work on the Taleh Zang Formation, about three decades later, Serra- Kiel *et al*. (1998) developed foraminiferal biozonation of the peri-Mediterranean region and Europe (Western Tethys). Major events in larger benthic foraminifera evolution are isochronous datum from the Mediterranean to the Far East. The stratigraphical ranges of the foraminiferal taxa as given by Serra-Kiel *et al*. (1998) are highly applicable to the Taleh Zang material. Planktonic foraminifera and nannofossils are absent in the study sections. Thus, larger foraminifera remain the only tool for biostratigraphy and age dating of the examined successions (Figure 3). Larger foraminifera are represented by *Alveolina* sp., *Chordoperculinoides sahnii* (Davies), *Discocyclina* sp., *Elazigina harabekayisensis* (Sirel), *Glomalveolina levis* (Hottinger); *Kathina major* (Smout), *K. pernavuti* (Sirel), *K. selveri* (Smout), *Lockhartia haimei* (Davies), *Miscellanea dukhani* (Smout), *Miscellanea miscella* (d'Archiac & Haime), *Operculina* sp., *Opertorbitolites* sp., *Palaeonummulites thalicus* (Davies), *Pseudolituonella* sp., *Quinqueloculina* sp., *Rotorbinella skournesis* (Pfender), *Textularia* sp., and *Valvulina* sp.

Chordoperculinoides sahnii have been reported from the Late Paleocene age (SBZ 4) in the lower member of the Jafnayn Formation of Oman (Haynes *et al*., 2010). *Miscellanea miscella* (d'Archiac & Haime) is here described from the late Paleocene of Iran and recognized from equivalent shallow-water carbonates of Turkey, Syria, Madagascar, Iran, Pakistan, India, Tibet, and Burma (Leppig, 1988). *Miscellanea miscella* (d'Archiac & Haime) and *Miscellanea dukhani* (Smout) are dated by associated larger foraminifera (Hottinger, 2009), which belong to SBZ 3 and SBZ 4.

Palaeonummulites thalicus (Davies) is known from Pakistan and Oman (Haynes *et al*., 2010). Serra-Kiel *et al*., (2016) reported it in the SBZ 3 into the lower part of SBZ 6, in the lower member of the Jafnayn Formation of Oman.

The presence of *Glomalveolina levis* (Hottinger) is given by Serra-Kiel *et al*. (1998) to SBZ 4 and corresponding to the Thanetian. As Zhang *et al*. (2013) point out, there are differences between the eastern and western Tethys. In the east, the Paleocene carbonate ramps were rich in the larger benthic foraminifera, such as *Lockhartia*, *Kathina*, *Daviesina*, *Miscellanea*, *Ranikothalia*, and *Operculina*, during SBZ 3–5, and early differentiation between genera and species diversifications. The larger benthic foraminifera have been taken as a major carbonate producer for the construction of carbonate ramps. In contrast, carbonate platforms in the west were mainly dominated by coralgal reefs during most of the Paleocene (Scheibner & Speijer, 2008) and *Miscellanea*, *Daviesina*, *Ranikothalia*, *Assilina*, and *Glomalveolina* were some frequently reported genera with their species diversification at the beginning of SBZ 5 (Hottinger, 1997).

The set of Lorestan foraminifera is similar to Eastern Tethys. It seems that environmental factors, such as very shallow depth, have caused some genera such as *Daviesina* and *Ranikothalia* to be absent in the studied sections. The low diversity of foraminifera is far more pronounced due to hard environmental conditions in the Poshte Jangal section. The Taleh Zang Formation at this section is characterized by dolomite, dolomitic limestone and limestone, with locally recrystallized wackestone to pack-grainstone textures. Fossils are extremely scarce, they include *Kathina selveri* (Smout), *Textularia* sp., miliolid, coral and ostracoda.

Since we could not find any index microfossils in this interval, we named it Indeterminate Zone. The Thanetian age attributed to these deposits is mainly extracted of its stratigraphic position and comparison with age of the Tale Zang Formation in adjacent sections, as well as the presence of *Kathina selveri* (Smout).

Paleoecology

In eastern parts of the study area (Poshte Jangal section), except for some limestone layers (21 to 26 m thick), there are no fossils. Dolomite limestone and limestone with fenestrate structures, representative of a tidal flat environment, where trapped air between irregularly shaped deposits leads to the development of bird's eyes (Shinn, 1983). In other sections, benthic foraminifera are abundant. The larger benthic foraminifera bearing sediments show some variability resulting from the taxon composition, growth forms as well as the presence of rock-forming accompanying larger benthic foraminifera (*e.g*., algae and coral). Paleoenvironmental interpretations of the Thanetian deposits are mainly based on described benthic assemblage, the dominance of small rotaliids and the presence of red algae indicate shallow water setting, with low turbidity and high light intensity, as well as low substrate stability with abnormal salinity (BouDagher-Fadel, 2008, Brandano *et al*., 2009). Rare occurrence of larger benthic foraminifera indicates unfavorable physical conditions, such as insufficient quantity of available light for the symbiotic association between larger benthic foraminifera and algal endosymbionts. These conditions can be due to higher nutrient regime (eutrophication), which possibly did not allow sufficient light to penetrate the water column. If the nutrient input in the euphotic zone increases, transparency of the water column will be reduced, which in turn decreases the depth range for organisms relying on photosynthesis (Hallock, 1988).

The lower part of Palganeh and Pasan sections is dominated by larger hyaline and imperforated forminifera. Hyaline foraminifera were dominated by *Chordoperculinoides sahnii* (Davies), *Discocyclin*a sp., *Elazigina harabekayisensis* (Sirel), *Glomalveolina levis* (Hottinger), *Kathina major* (Smout), *K. pernavuti* (Sirel); *K. selveri* (Smout), *Lockhartia haimei* (Davies), *Miscellanea dukhani* (Smout), *Miscellanea miscella* (d'Archiac & Haime), *Operculina* sp., *Opertorbitolites* sp., *Palaeonummulites thalicus* (Davies), and *Rotorbinella skourensis* (Pfender). Porcellaneous foraminifera were dominated by *Glomalveolina levis* (Hottinger), *Opertorbitolites* sp., and *Quinqueloculina* sp. Agglutinate foraminifera were dominated by *Pseudolituonella* sp., *Textularia* sp., and *Valvulina* sp.

Luterbacher (1970) expressed that spheric alveolinids was found in lagoonal deposits. This study revealed that *Opertorbitolites* inhabit together with these *Alveolina* species under identical environmental conditions. These types of environments, where low energy conditions are dominant, are characteristic of *Alveolina* and *Opertorbitolites* assemblages (Hottinger, 1960). The abundance of porcelaneous larger foraminifera in Assemblage 2 indicates a well-lit, highly translucent, shallow part of the photic zone (Bassi & Nebelsick, 2010). The low turbidity is ascribed to the high diversity of the porcelaneous foraminiferal fauna, which develops in meso-to-oligotrophic settings at a shallow depth (Hallock, 1984, 1988).

A cursory look at the Paleocene–Eocene stratigraphy of the Lorestan basin shows the presence of a regressive sedimentary cycle separated by major unconformities (Heydari, 2008). Sedimentation of the deep-water turbidites of the Amiran Formation was followed by the deposition of the shallow-marine carbonates of the Taleh Zang Formation. The Taleh Zang Formation forms transitional facies between fluviatile siliciclastic strata of the Kashkan Formation and deep-water facies lime mudstones, calcareous shales, and marls of the Pabdeh Formation. Deposition of Paleocene to Eocene marine deposits in the central and the northwestern Zagros coincided with the establishment of a NW–SE-trending foreland basin in the Zagros region (Sherkati & Letouzey, 2004). Therefore, in addition to the relative sea-level change, the deposition of the Taleh Zang Formation was also influenced by the orogenic processes (Bahroudi & Koyi, 2004).

CONCLUSIONS

In this study paleontological investigations have been carried out on the Taleh Zang Formation, which outcrops in the north of Lorestan. Larger foraminifera are the prominent fossil components, while red algae, ostracod and coral fragments occur only locally. In the studied sections, the presence of *Glomalveolina levis* (Hottinger) allows assigning this association to SBZ4, as indicated by Serra-Kiel *et al.* (1998). Based on the occurrence of foraminifera our paleoecological interpretation shows a gradient change from tidal flat and shallow water setting with low turbidity and low substrate stability with abnormal salinity in photic zones dominated by of small rotaliids (Poshte Jangal section) to a lagoonal setting in the oligophotic zone (Pasan and Palganeh sections). The Taleh Zang formed in a foreland setting which, a priori, was rich in detrital input from erosion of an uplifted wedged top. However, during the Late Paleocene there was a gap in wedged top derived detrital input (see above) resulting in calcareous sediments in shallow water areas. Sedimentary setting of Taleh Zang Formation is a carbonate shelf which is located from below to turbidite deposits of the Amiran Formation and from above to the continental clastics of deposits of Kashkan Formation. Thus, the Tale Zang Formation is deposited in the middle of a regressive sedimentary cycle at the time of conversion of sloping facies to continental facies.

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