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BURDIGALIAN ICHNOFABRIC FROM THE GURI MEMBER, DEZFUL EMBAYMENT, SOUTHWESTERN IRAN

MEHDI GHANAVATI
Department of Earth Sciences, Science and Research Branch, Islamic Azad University (IAU), Tehran, Iran.
ghanavati708@gmail.com

IRAJ MAGHFOURI MOGHADDAM
Department of Geology, Faculty of Science, Lorestan University, Lorestan, Iran.
maghfouri.i@lu.ac.ir (Corresponding author)

MOHSEN ALEALI & MEHRAN ARIAN
Department of Earth Sciences, Science and Research Branch, Islamic Azad University (IAU), Tehran, Iran.
aleali.mohsen@gmail.com, *mehranarian@yahoo.com*

ABSTRACT – The carbonate strata of the Burdigalian Guri Member are located in the Dezful Embayment along the northern Persian Gulf shore. Ichnofabric analysis and paleoecology of the Guri Member in the Dezful Embayment are described by investigating three outcrop sections. The facies features of the Guri Member show a very shallow marine environment with high oxidation content. The Guri Member contains remarkably well-preserved specimens of *Thalassinoides suevicus*. It is mainly recorded as Y and T forms in the shallow water facies. Two ichnofabrics were recognized in the dominantly carbonate sedimentary succession. Ichnofabrics A, and B are interpreted as representing the tidal flat and lagoon environments respectively. Ichnofabric interpretation of the Miankuh section might be simply indicating more time to colonization in relation to the Parsi section.

Keywords: ichnofabric, Miocene, Dezful Embayment, Guri Member.

RESUMO – Os estratos carbonatados do Burdigaliano do Membro Guri estão localizados no Embasamento Dezful, ao longo da costa norte do Golfo Pérsico. A análise de icnofábrica e a paleoecologia do Membro Guri no Embasamento Dezful são descritas através da investigação de três secções de afloramento. As características da fácies do Membro Guri revelam um ambiente marinho muito pouco profundo, com elevado teor de oxidação. O Membro Guri contém espécimes notavelmente bem preservados de *Thalassinoides suevicus*. São registrados principalmente como formas Y e T na fácies de águas pouco profundas. Foram Reconhecidas duas icnofábricas na sucessão sedimentar predominantemente carbonatada. As icnofábricas A e B são interpretadas como representando os ambientes de planície de maré e de lagoa, respectivamente. A interpretação da icnofábrica da seção Miankuh pode simplesmente indicar mais tempo para a colonização em relação à da seção Parsi.

Palavras-chave: ichnofábrica, Mioceno, Embasamento Dezful Embayment, Membro Guri.

INTRODUCTION

The Burdigalian Guri Member is the lower member of the Mishan Formation and consists of alternating marl and limestone. It contains minor gas and oil reservoirs in SW Iran, such as the Sarkhon gas field in coastal Fars and the Sarkan oil field in the Southern Lorestan Zone (Kashefi, 1982; Fathi & Esrafili, 2020). Deposits of the Guri Member are full of fossils such as corals, mollusks, foraminifers, ostracods, and trace fossils (Motiei, 1993; Heidari *et al*., 2012). Since trace fossils are formed during sedimentation or shortly after it, they reflect their biological and non-biological conditions during the time of trace making. The fabric resulting from the activity of living organisms in the sedimentary layers is generally used to achieve information on sedimentary events (Ekdale *et al*., 2012). Despite detailed studies on the paleontology and depositional sequence of the Mishan Formation (*e.g*., Rahmani *et al*., 2010; Heidari *et al*., 2012; Yazdi *et al*., 2013), no study has investigated the trace fossils and ichnofabric of the Guri Member. Accordingly, the present study seeks to introduce the ichnofabric of the Guri Member and reconstruct its paleoenvironmental conditions.

GEOLOGICAL SETTING

The Zagros Basin is considered a section of the Alpine-Himalayan orogenic belt (Alavi, 2007) on the northeastern coast of the Tethyan Seaway (Bialik *et al*., 2019; Mohammadkhani *et al*., 2022) (Figure 1A). The Dezful Embayment in the Southwestern Zagros Basin includes the most important oil fields in Iran (Heidari *et al*., 2020).

During the Early Miocene, the Fars Group (Gachsaran, Mishan, and Agha Jari formations) was deposited conformably on the Asmari limestone in the Dezful Embayment (James & Wynd, 1965). The Fars Group represents the progressive infilling of the Zagros Basin during the continental collision between Arabia and Eurasia (Sharland *et al*., 2001). The Gachsaran Formation consists of evaporites (gypsum, anhydrite, and halite), marl, and thin-bedded limestone.

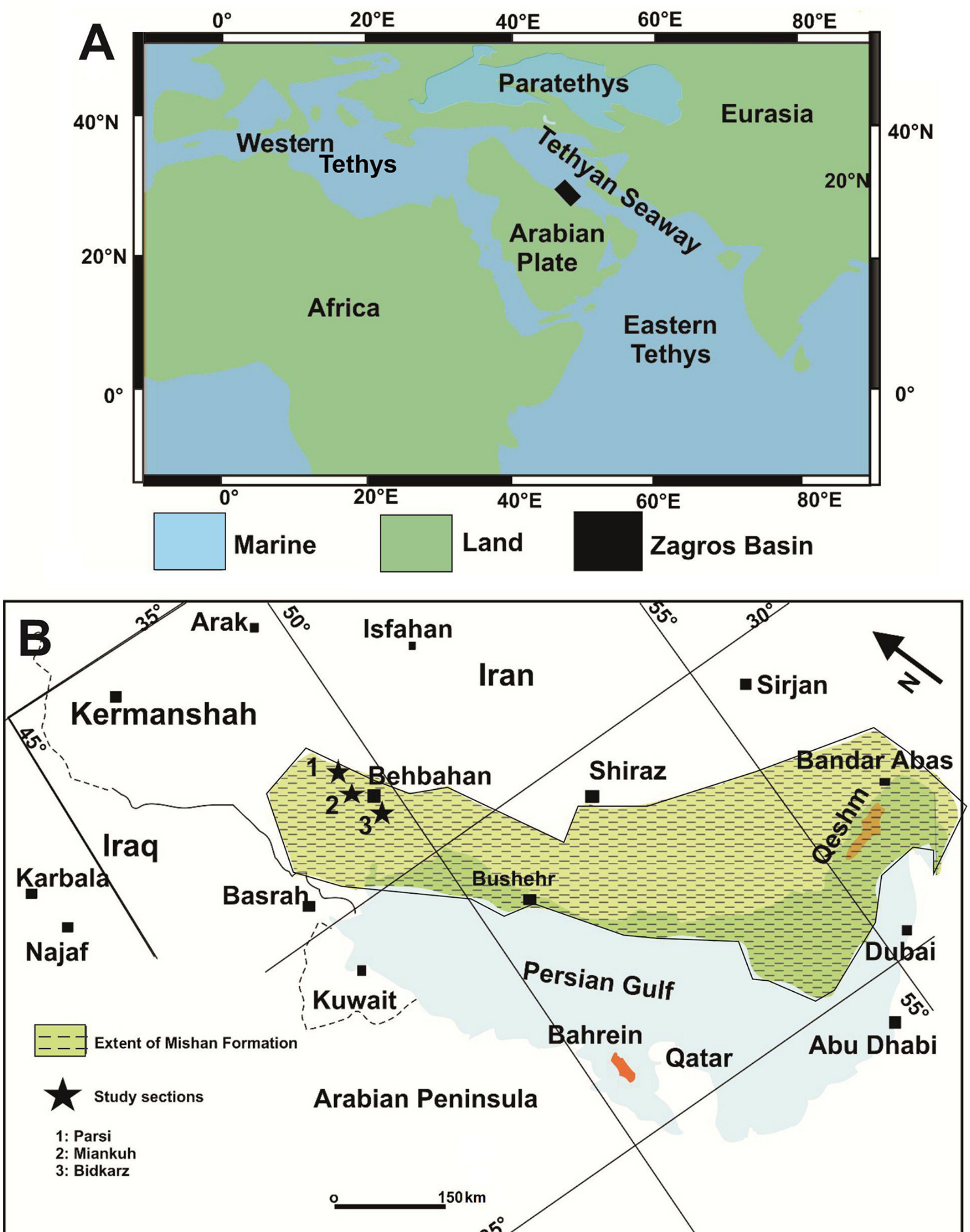

Figure 1. A, Early Miocene paleogeography of the Tethyan Seaway and location of the Zagros Basin (modified from Bialik *et al*., 2019); **B**, Distribution of the Mishan Formation in the Zagros Basin (modified from Motiei, 1993).

The widespread deposition of marine sediments of the Mishan Formation on the Gachsaran Formation was probably a response to a global rise in sea level (Ghazban, 2007). This formation was spread on the Dezful Embayment and on the northern coast of the Persian Gulf in the Early–Middle Miocene (Motiei, 1993) (Figure 1B). The Guri Member in the lower part of the Mishan Formation is underlain by the Gachsaran Formation, and its upper boundary is conformable with the marly units of the Mishan Formation. The thickest part of the Guri Member has been encountered in the northeastern part of the Persian Gulf (Motiei, 1993). For example, in the Bandar-Abbas region, the thickness of the Guri Member is 540 m (Zohdi *et al*., 2018). The thickness of the Guri Member decreases from east to west. In the Lorestan Zone, Southeastern Iraq, Kuwait, and Saudi Arabia, the clastic deposits of the Agha Jari Formation gradually replace the marls and limestone of the Mishan Formation laterally (Setudehnia, 1971).

MATERIAL AND METHODS

Three surface sections in the Dezful Embayment of the Guri Member close to the city of Behbahan (Miankuh: 63 m thick, Parsi: 60 m thick, and Bidkarz: 103 m thick) were measured bed by bed. Trace fossils were recorded in several horizons in the Miankuh and Parsi sections. Their diameter, branching angles and forms were recorded in the field. Five bioturbation indexes were recognized based on the Bioturbation Index (BI) of Taylor & Goldring (1993). The ichnofabric along with the data obtained from facies analysis were used to interpret the paleoecological conditions. We studied 126 thin sections for microfossils and microfacies characteristics.

RESULTS

Six sedimentary facies could be recognized in the study area (Figures 2–3):

Facies A. Anhydrite

This facies is composed of white to milky anhydrites and is present in the middle part of the Bidkarz section. There is no exposure of upper and lower layers of Anhydrite facies. No sedimentary structures are present (Figure 2A).

Facies B. Dolomudstone

Dolomudstone is comprised of light brown to brown massive limestones with dolomitic texture. The cristal size of dolomites are 6 to 16 μm (very fine to fine cristals).This facies is present in the Bidkarz section. Dolomudstone overlies the marl layers and is underlain by the marl beds. No sedimentary structures are present (Figure 2B).

Facies C. Medium/thick-bedded limestones with Fenestral porosity

This facies is composed of off white to cream medium/thick-bedded limestones. lamination and bioturbated layers are the sedimentary structures. There is silt-sized terrigenous particles in facies C and iron oxide is well developed (Figure 2C). The size of voids (fenestral porosities) changes from 0.25 to 1.2 mm (Figure 2C). Facies C is present in the Miankuh and Parsi sections and overlies the marl layers, massive limestones contain benthic foraminifers and thin-bedded limestones contain ooids in different parts of the Guri Member.

Facies D. Massive limestones contain benthic foraminiferans

Facies D is gray to light gray massive limestones and bioturbated layers is the only sedimentary structure. Iron oxide is also present in the sedimentary layers. The bioclastic content of facies D is predominantly benthic foraminiferans (*e.g*., *Dendritina rangi*, *Miliola* sp., *Triloculina tricarinata*, *Triloculina trigonula*, *Heterilina* sp., *Ammonia beccari*, *Elphidium* sp., *Sigmolina* sp., *Spirolina* sp., *Meandropsina* sp., *Neorotalia viennoti*), abundant bivalve and gastropod fragments, echinoid and ostracoda (Figure 2D). Facies D is present in the Miankuh and Parsi sections and overlies the marl layers, thin-bedded limestones contain ooids and medium/thick-bedded limestones with fenestral porosity in different parts of the Guri Member.

Facies E. Marl

This facies consists of gray, dark gray and greenish gray marls including bivalve and gastropod shells. Facies E alternate with carbonate facies and consists of siliciclastic sediments ranging from silt to sand (rare) (Figure 2E).

Facies F. Thin-bedded limestones contain ooids

Facies F consists of cream thin-bedded limestones contain ooids. The size of ooids vary from .150 to .430 mm. This facies is present in the Parsi section and overlies the marl beds, medium/thick-bedded limestones with fenestral porosity and massive limestones contain benthic foraminiferans in different parts of the Guri Member. No sedimentary structures are present. The facies characteristics are summarized in Table 1.

ICHNOLOGY AND ICHNOFABRIC

Thalassinoides suevicus (Rieth, 1932) is the only known ichnospecies in the studied sections. *T. suevicus* is generated by crustaceans, especially decapods (Frey & Pemberton, 1984; Knust, 2017). They can build empty tunnels up to 75 cm deep (Bromley, 1996). *Thalassinoides* is built in different sedimentary environments such as salt marshes, beaches, deltas, and outer shelves (Yanin & Baraboshkin, 2013). *T. suevicus* is distinctive from other *Thalassinoides* ichnospecies by mostly horizontal and more or less regular burrows (El-Hedeny *et al*., 2012). This species comprises ungrooved cylindrical or elliptical burrows and has three-dimensional horizontal to somewhat oblique branching network forms (Abbasi & Amini, 2005; El- Sabbagh *et al*., 2017).

Thalassinoides suevicus in the Guri Member has a horizontal to somewhat oblique burrow shape, regularly branching with Y, and T shapes, among which Y shapes are

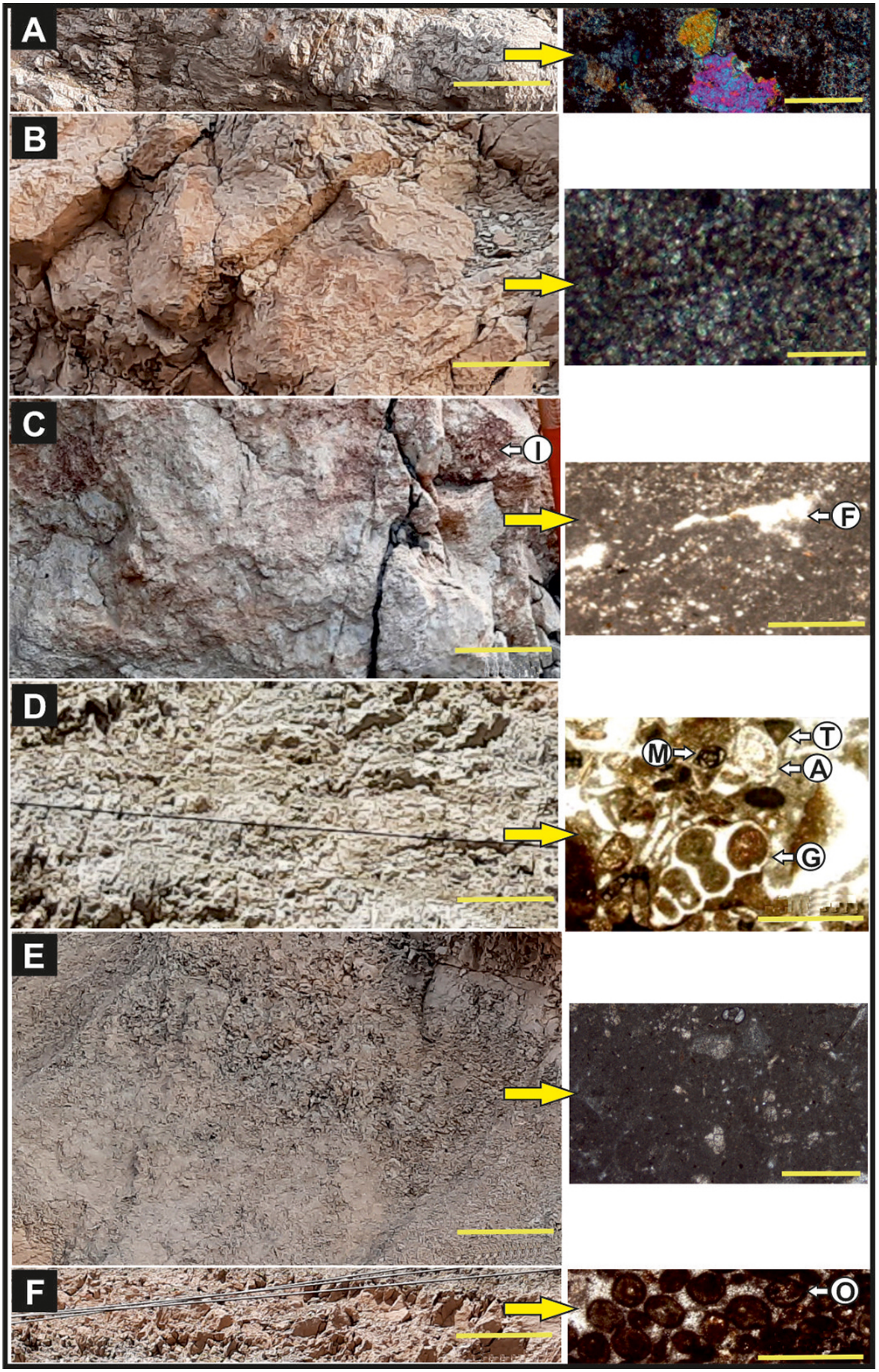

Figure 2. Sedimentary facies of the Guri Member exposed in the study area. **A**, Anhydrite; **B**, Dolomudstone; **C**, Medium/thick-bedded limestones with fenestral porosity (I: Iron oxide; F: fenestral fabric) (there are silt-sized terrrigenous particles); **D**, Massive limestones containing benthic foraminiferans (A: *Ammonia*; T: *Triloculina*; M: miliolid; G: gastropod); **E**, Marl; **F**, Thin-bedded limestones containing ooids (O: ooid). Scale bars: A = 50 cm; A' = 0.6 mm; B = 10 cm; B' = 0.5 mm; C = 20 cm; C' = 0.3 mm; D = 30 cm; D' = 0.4 mm; E = 10 cm, E' = 1 mm; F = 30 cm; F' = 0.4 mm.

more common (Figure 4). The diameter of the branches varies from 5 to 20 mm, and their length is between 44 and 150 mm in the studied area (Table 2). The Y- and T-shaped burrows show an increase in diameter at the bifurcation points, leading to bulb forms.

The link between facies and trace fossils

The bioturbated layers of the Guri Member are associated to two facies: (i) medium/thick-bedded limestones with fenestral porosity (Facies C) and (ii) massive limestones containing benthic foraminiferans (Facies D).

Table 1. Facies recognized in the Guri Member.

Facies code	Facies name	Lithology, color	Sedimentary structure	Components (Skeletal &non-skeletal)	Depositional environment
A	Anhydrite	Anhydrite, white to milky	–	–	Supratidal
B	Dolomudstone	Limestone, light brown to brown	Massive	–	Tidal flat
C	Medium /thick-bedded limestones with fenestral porosity	Limestone, off white to cream	Lamination, bioturbation	–	Tidal flat
D	Massive limestones containing benthic foraminiferans	Limestone, gray to light gray	Massive, bioturbation	Benthic imperforate foraminiferans (*Dendritina rangi*, *Triloculina tricarinata*, *Triloculina trigonula*, *Pyrgo* sp., *Miliola* sp., *Spirolina* sp., *Sigmolina* sp., *Meandropsina* sp., *Heterilina* sp.); Benthic perforate foraminiferans (*Rotalia* sp., *Neorotalia viennoti*, *Ammonia beccari*); *Tubucellaria* sp; bivalve fragment; gastropod fragment; ostracoda	Lagoon
E	Marl	Marl, gray, dark gray greenish gray	–	bivalve and gastropod	Lagoon
F	Thin-bedded limestones containing ooids	Limestone, cream	–	ooid	Shoal

Table 2. The record of well-preserved *Thalassinoides suevicus* (Rieth, 1932) in the Guri Member, including thickness, geometry, burrow diameter, burrow length, and branching angles.

Section	Bed No	Geometry	Thickness (m)	Burrows Diameter (mm)	Burrows Length (mm)	Branching Angle (degree)
Miankoh	8	Y	1	15–16	85–140	Y:15–30
Miankoh	11	Y	.70	15–15.5	86–150	Y:15–30
Miankoh	14	Y	1	14.5–15.5	90–150	Y:15–25
Miankoh	26	Y,T	1	8–8.5	52–53	Y:15–30
Miankoh	35	Y	1	5–6	65–132	Y:15–25
Miankoh	60	Y	1	15–16	80–150	Y:15–30
Miankoh	62	Y	.80	15–16	85–130	Y:15–30
Parsi	33	T	1	12–20	85–88	
Parsi	37	Y	1	10–11	61–64	Y:15–30
Parsi	39	Y	.20	11	114	
Parsi	39	T	1	14–16	63–65	
Parsi	39	Y	1	13–15	68–70	Y:25–28

Facies C and trace fossils. Lamination and bioturbated layers are the sedimentary structures. There are silt-sized terrigenous particles in the limestone layers. Furthermore, iron oxide is well developed. *Thalassinoides suevicus* has a horizontal to somewhat oblique burrow shape, regularly branching with Y and T shapes. The diameter of the branches varies from 10 to 20 mm, and their length is between 61 and 150 mm. The Y- and T-shaped burrows show an increase in diameter at the bifurcation points, leading to bulb forms. In this facies the high frequency of *Thalassinoides* burrows is relevant to the oxic environment (high frequency of iron oxide) because *Thalassinoides* are good indicators of the oxic conditions (Bromley *et al*., 1995; Villegas-Martin *et al*., 2014; El-Sabbagh *et al*., 2017).

Facies D and trace fossils. In facies D, bioturbated layers are the only sedimentary structure. Iron oxide is present in the sedimentary layers. *Thalassinoides suevicus* is regularly branched with Y and T shapes. Y forms are more frequent than T shape. The diameter of the branches varies from 5 to 16 mm, and their length is between 52 and 150 mm. The sediment infill of *Thalassinoides* burrows is consists of benthic foraminiferans (*e.g*., *Dendritina rangi*, miliolid, *Ammonia beccari*, *Neorotalia viennoti*), and bivalve and gastropod fragments. The presence of iron oxide is an indicator of oxic conditions (a favored environment for *Thalassinoides*) (Bromley, 1996; El-Sabbagh *et al*., 2017).

Ichnofabrics

Ichnofabric is all aspects of the texture and internal structure of a sediment that result from bioturhation (Ekdale *et al*., 1984). In this study two ichnofabrics were recognized:

Ichnofabric A

The burrows are preserved at the beds of off white to cream medium/thick-bedded limestones facies (Figure 5A). The lamination is the only structure in some parts of Tchnofabric A. There are silt-sized terrigenous particles in the limestone layers and iron oxide is present. Composed exclusively of *Thalassinoides* with BI 2-3 and 3-4, which occurs as a branched burrow system with horizontal to somewhat oblique components, predominating the horizontal ones and presenting a straight to lightly inclined trajectory. *Thalassinoides* is represented by the ichnospecies *T. suevicus*. The burrows were observed as T-shaped and Y-shaped forms. The burrow walls are smooth and circular or subcircular in cross section. The 10–20 mm diameter, branching *T. suevicus* have the same filling as the background sediment in terms of color and grain size (Figure 5A). Limestone beds of Ichnofabric A cut the lagoonal marl with erosive base (Figure 3). Ichnofabric A is in the lower and upper parts of the Miankuh section and is 2 to 3.5 m thick and overlies Facies D (massive limestones contain benthic foraminiferans) and Facies E (marl) (Figure 6). Ichnofabric A is in the middle part of the Parsi section, it is 1 to 3.5 m thick and overlies Facies D (massive limestones containing benthic foraminiferans) (Figure 7).

Ichnofabric B

The burrows are preserved at the beds of the gray to light gray massive limestones facies (Figure 5B). *Thalassinoides* have a bioclast-dominated filling and form a branched system within a background of structureless limestone. The BI is 1, 2-3, 3-4, and 5. In some cases the burrows were observed as independent T-shaped and Y-shaped forms. The bioclastic content (bioclast-dominated filling) of Ichnofabric B is predominantly benthic foraminiferans (*e.g*., *Dendritina rangi*, miliolids, *Ammonia beccari*, *Elphidium* sp., *Neorotalia viennoti*) and bivalve and gastropod fragments. *Thalassinoides suevicus* is regularly branched with Y and T shapes, and vertical and inclined cylindrical shafts. The diameter of the branches varies from 5 to 16 mm, and their length is between 52 and 150 mm. The Y- and T-shaped burrows show an increase in diameter at the bifurcation points, leading to bulb forms. The burrows are composed of uniform grain sizes that are similar to the texture of the surrounding matrix (Figure 5B). Iron oxide is also present in some parts of Ichnofabric B (Figure 5B). Ichnofabric B is in the lower, middle, and upper parts of the Miankuh section, it is 1.5 to 4 m thick and overlies Facies C (medium/thick-bedded limestones with fenestral porosity), and Facies E (marl) (Figure 6). Ichnofabric B is in the middle part of the Parsi section, it is 2 to 4 m thick and overlies fFcies C (medium/thick-bedded limestones with fenestral porosity) and Facies E (marl) (Figure 7).

PALEOECOLOGY

The depositional model of the Guri Member in the Dezful Embayment can be considered a carbonate ramp with a slight slope (Table 1) because of the following: a) the absence of a distinctive reef (barrier reef); and b) presence of no calciturbidite or talus. In the studied sections, the inner ramp setting is composed of shoal, lagoon, and tidal-flat environments (Figure 7).

The burrows in the Guri Member are composed of uniform grain sizes that are similar to the texture of the surrounding matrix (host sediments). The lack of linings of the Guri Member burrows may be simply a response to sediment consistency (Myrow, 1995). *Thalassinoides* is dependent on the aerated environment in soft but relatively cohesive layers (Bromley, 1996; El- Sabbagh *et al*., 2017).

Trace fossils which are assigned to *Thalassinoides* in new sedimentary environments are due to vagile to semi-vagile crustaceans, probably thalassinid decapods (Ngoc-Ho, 1981). Many researchers (*e.g*., Vega & Bahrami, 2010; Yazdi *et al*., 2013) have studied decapod crustaceans of the Mishan Formation.

The limestone beds of Ichnofabric A cut the lagoonal marl with erosive base. The lower intertidal origin is supported by subaerial exposure features and vertical association with lagoonal and proximal tidal flat facies (Shin, 1983, 1986; Mohammadkhani *et al*., 2022). Ichnofabric A is interpreted as representing the tidal flat environment due to indicators

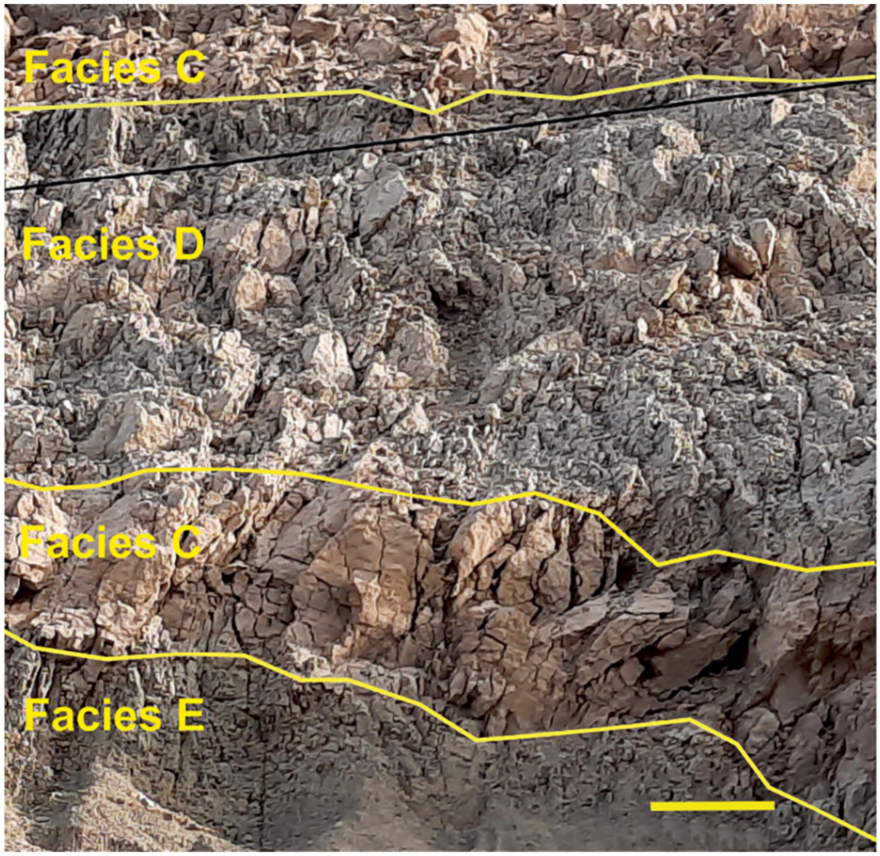

Figure 3. Erosive base of facies C and D in the study area. Scale bar = 15 cm.

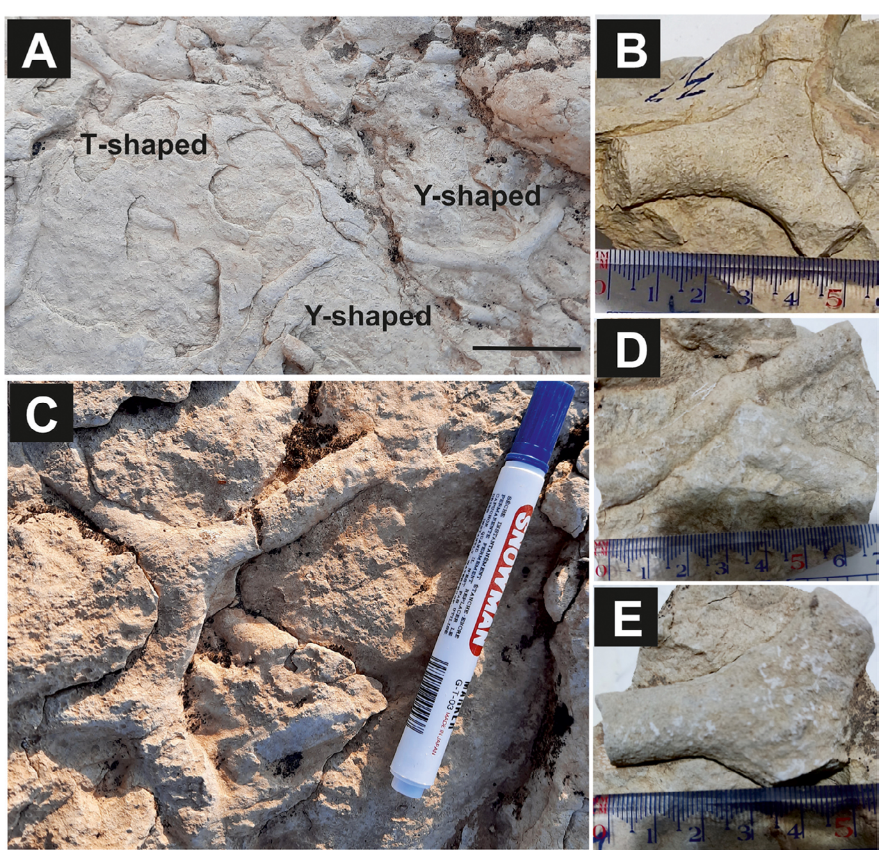

Figure 4. *Thalassinoides suevicus* (Rieth, 1932). **A**, T and Y shapes; **B**, T shape; **C**, Bifurcate Y shape; **D**, Y shape; **E**, T shape. Scale bar: A = 65 cm.

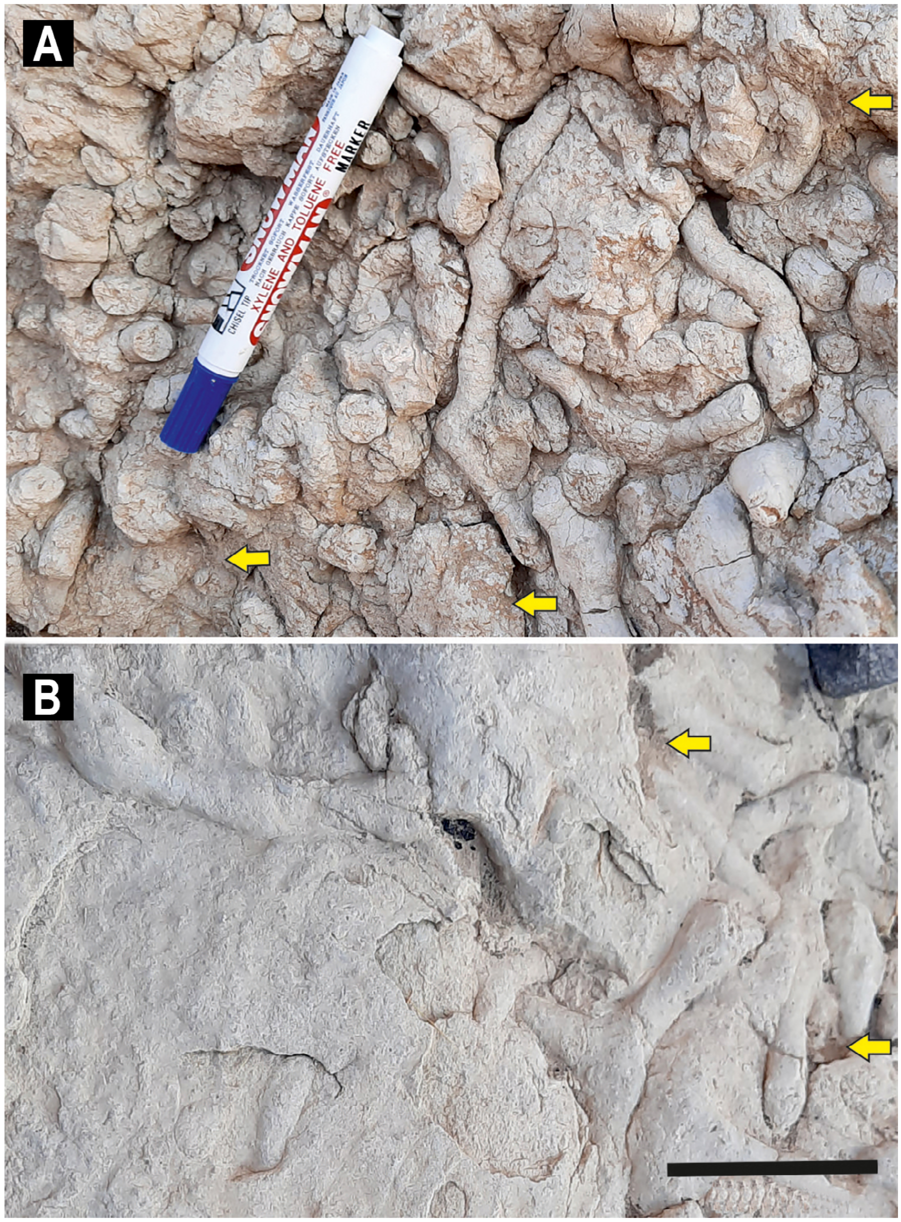

Figure 5. A, Ichnofabric A: branched burrow system (Y and T forms). The iron oxide is well developed (yellow arrows). **B**, Ichnofabric B: T and Y forms of *Thalassinoides suevicus.* The yellow arrow shows iron oxide in some parts of Ichnofabric B. Scale bar: B = 50 mm.

such as fenestral fabric (the fenestral limestone beds) (Shin, 1983; Avarjani *et al*., 2015; Mohammadkhani *et al*., 2022) and lamination. *Talassinoides* is frequently considered as an indicator of oxic environments (Ekdale *et al*., 1984; Bromley, 1990; El-Sabbagh *et al*., 2017). The frequency of iron oxide confirms the presence of *Thalassinoides* in Ichnofabric A.

Alternation of limestone layers mixed with terrigenous particles (Ichnofabric A) and thick to massive marl layers consisted of fine-grained siliciclastic-carbonate sediments indicates siliciclastic influx from adjacent highlands via rivers and deltas discharges (Mohammadkhani *et al*., 2022).

Thalassinoides is considered as a cross-facies ichnotaxa (Frey *et al*., 1978; El-Sabbagh *et al*., 2017), which are commonly reported in shallow marine facies to deep environments (*e.g*., Frey *et al*., 1978; Bromley, 1990; Uchman, 1998; El-Sabbagh *et al*., 2017). In these cases (cross-facies ichnotaxa), the benthic foraminiferans assemblages can give valuable information about facies type (El-Sabbagh *et al*., 2017).

In Ichnofabric B, *Thalassinoides* burrows have a bioclast-dominated fill. The bioclastic content (the burrows infill) of Ichnofabric B is predominantly benthic foraminiferans (*e.g*., *Dendritina rangi*, miliolids*, Ammonia beccari*, *Elphidium* sp., *Neorotalia viennoti*) and bivalve and gastropod fragments. The contemporary presence of marine organisms (*Rotalia*) and lagoonal organisms (miliolids) indicate semi-restricted lagoon environment in a carbonate ramp (Taheri *et al*., 2008; Avarjani *et al*., 2015). The assemblage of *Ammonia*, *Elphidium*, and bivalve fragments reflects an eutrophic and normal marine condition that was exposed to a short period of

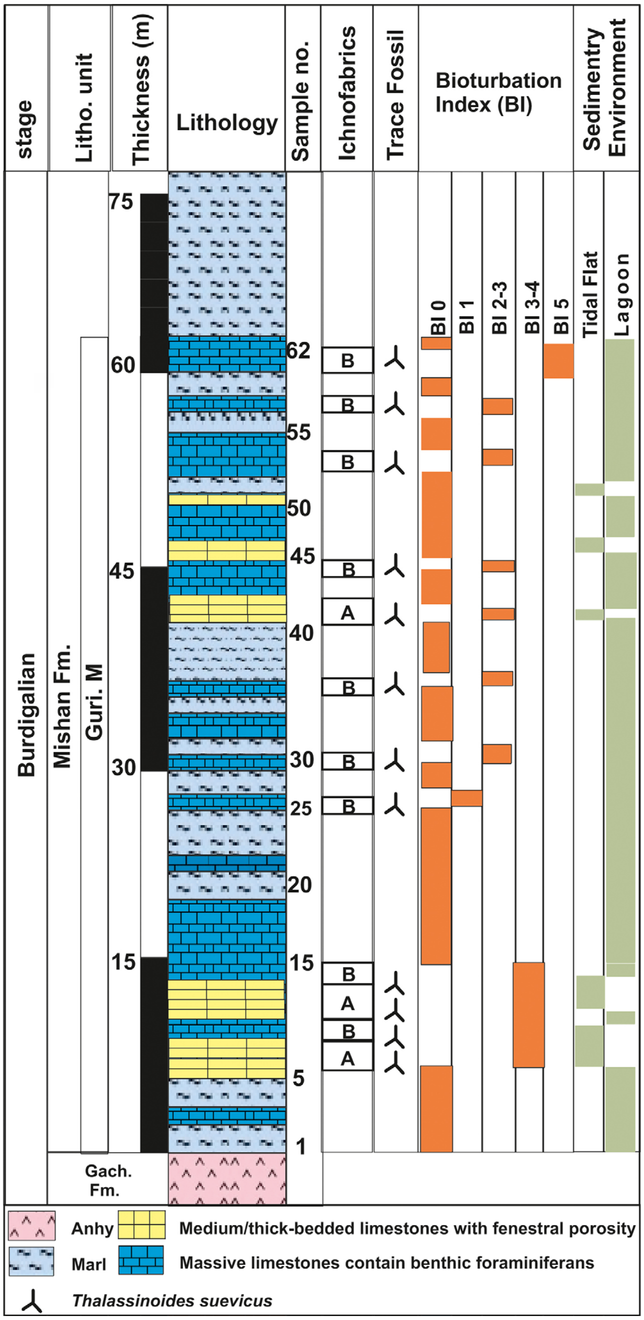

Figure 6. Ichnofabric and facies of the Guri Member in the Miankuh section.

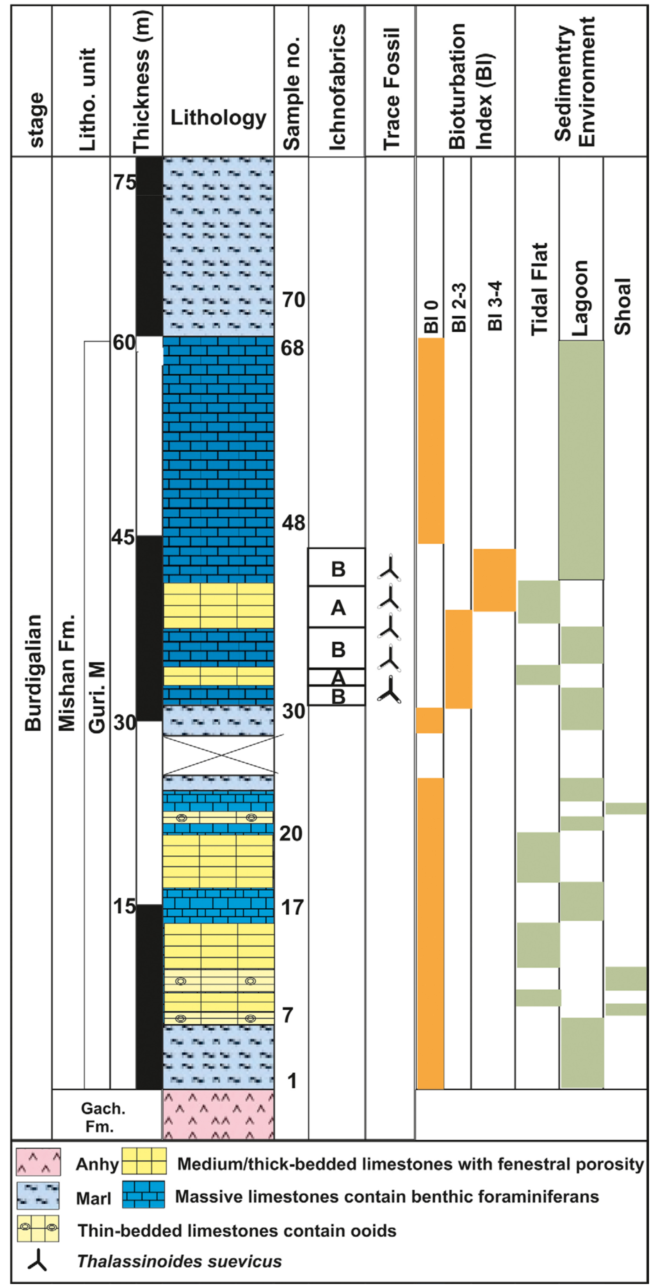

Figure 7. Ichnofabric and facies of the Guri Member in the Parsi section.

salinity fluctuation (Reuter & Brachert, 2007). The appearance of benthic foraminiferans with porcelaneous tests such as miliolid suggests low depth, fairly clear water with suitable light penetration (Bassi & Nebelsick, 2010).

Griffis & Suchanek (1991) identified six types of burrows made by thalassinidean shrimp. The criteria for distinguishing the burrows were: a) the absence or presence of sediment mounds; b) the existence of seagrass in the tunnels or the burrow lining; and c) uncomplicated U-form system, which is attributed to one of the three total trophic methods, *i.e.*, filter/suspension-feeding, drift catching, and deposit-feeding. The ichnofabric assemblage of the Guri Member in the studied sections corresponds to the type 5 burrows of Griffis & Suchanek (1991). Type 5 burrows are comprised of single or multiple U- or T-shaped tubes with tight apertures caused by swollen shafts.

Ichnofabric evolution is controlled in the first stages by the ecological factors such as the oxygen content, type of sediment, frequency of food, and environmental energy, which control colonization and deposition rate (Malpas *et al*., 2005).

Ichnofabric analysis of the Miankuh section might be simply indicating more time to colonization in relation to the Parsi section (Figure 6). *Thalassinoides* are associated with apparently less rapid rates of sedimentation (Taylor *et al*., 2003). In the first six meters of the thickness of the Miankuh section, there was no evidence of trace maker activity (BI 0), resulting from high sedimentation rates. The 8.5 m thickness of limestone has abundant trace makers' activity and a high degree of bioturbation (BI 3-4). After this stage, trace makers' activity stopped and remained steady for a large thickness, equal to about 10.5 m. BI 1 formed in the middle part of the Miankuh section. Over the thickness of 27 to 58 m, the colonization window is variable and caused an alternation of BI 2-3 and 0. There was a significant rise in bioturbation due to the very high activity of trace makers from 59 to 62 m (BI 5).

Ichnofabric analysis of the Parsi section indicate less time for colonization in relation to the Miankuh section (Figure 7). The lower part of the Parsi section (about 27 m) is made up of BI 0. In the middle part of the Parsi section (13 m), there is a significant rise in bioturbation and prevalence of BI 2-3 and 3-4. These conditions are indicative of optimal conditions for the *Thalassinoides* trace makers. The uniform bioturbation is directly related to a nearly steady agitation rate or a more extended colonization period. Finally, there is no evidence of bioturbation in the uppermost of the Parsi section (BI 0, about 17 m). Moreover, no *Thalassinoides suevicus* exist in the dark gray marls of the Parsi section. The lack of ichnofabrics in the shoal environment was perhaps due to the lack of suitable bottom conditions.

The exclusive presence of *Thalassinoides* ichnofabric in the study area suggests that they were affected by high enegy events (Villegas-Martin et al., 2014). The predominance of the monospecific ichnotaxa suggest conditions of environmental stress (Buatois & Lopez-Angriman, 1992; Uchman, 1992; Buatois *et al*., 2010; Villegas-Martin *et al*., 2014).

Overall, BI 3-4 and 5 in the Guri Member were formed under favorable conditions for *Thalasssinoides* trace makers. Meanwhile, BI 1 was constructed in nearly unsuitable conditions.

There is no *Thalassinoides suevicus* in the Bidkarz section (Figure 8). Several evaporative layers, and the small number of fossils, especially foraminiferans, in this section may indicate harsh living conditions for animals.

CONCLUSIONS

The sediments of the Guri Member contain *Thalassinoides suevicus* in Y-shaped and T-shaped forms and bifurcating burrows. The bioturbation analysis resulted in the definition of type 5 burrows in the studied area. Two ichnofabrics were recognized in the carbonate sedimentary succession representing the tidal flat and lagoon environments. The lack of ichnofabrics in the shoal environment was perhaps due to the lack of suitable bottom conditions. The absence of *Thalassinoides suevicus* in the Bidkarz section is a result of highly stressed conditions. Ichnofabric analysis of the Miankuh section shows more time for colonization in relation to the Parsi section. In the middle part of the Parsi section,

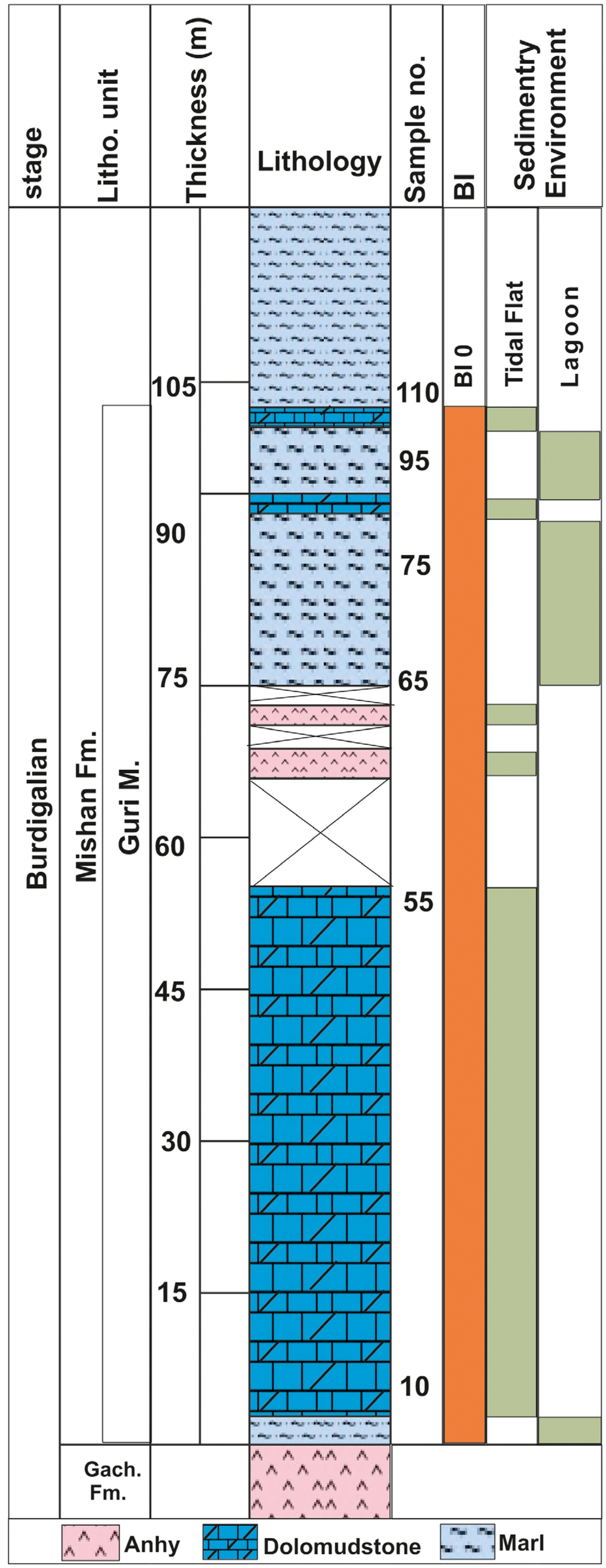

Figure 8. Ichnofabric and facies of the Guri Member in the Bidkarz section.

the abundant uniform bioturbation is indicative of nearly a steady agitation rate or a more extended colonization period. Paleoenvironmental studies of *Thalassinoides suevicus* show a very shallow marine environment with high oxidation content.

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