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ABSTRACT – The northeastern part of Algeria is characterized by Meso–Cenozoic fossiliferous deposits. All the previous studies have been focused on invertebrate and vertebrate body fossils from this region. In the present paper we provide the first ichnological study from the region of Ouenza, Tebessa Wilaya (northeastern Algeria). An ichnoassemblage composed of eight ichnotaxa, namely cf. Archaeonassa isp., Arenicolites isp., Diplocraterion isp., Helminthopsis isp., Palaeophycus tubularis, Skolithos cf. linearis, cf. Taenidium isp., and Thalassinoides isp., reported from the lower Langhian (Miocene Médio) of Aïn Sidi Salah locality (Tebessa Basin) is discussed. These trace-fossils belong to the Skolithos and proximal Cruziana ichnofacies indicating deposition within a shallow marine (littoral). The large size of Thalassinoides suggests well oxygenated setting, under moderate- to high-energy conditions, with occasional storm events.

Keywords: trace-fossils, paleoenvironments, shallow marine, Middle Miocene, Tebessa.


Palavras-chave: icnofósseis, paleoambientes, mar raso, Mioceno Médio, Tebessa.
INTRODUCTION

In the west Mediterranean Miocene marginal basins, thick marine mixed siliciclastic-carbonate sediments, characterized by abundant ichnofauna, have been deposited (Naimi et al., 2020a). During the last decade, these deposits have been the subject of several ichnological studies particularly in Spain and Italy (Uchman & Hanken, 2013; Monaco & Trecci, 2014; Belaústegui et al., 2016). In a shallow marine setting, they contain diverse and spectacular trace-fossil assemblages. However, both bioturbation and bioerosion patterns were sparsely recorded (Doyle et al., 1998; de Gibert & Robles, 2005).

During the Miocene, several basins have been individualized in the northern part of Algeria, as well as the lower Chelif (Benzina et al., 2019; Naimi, 2019; Naimi et al., 2020a,b; Naimi & Cherif, 2021), Tafna (Naimi et al., 2021a), Tiaret (Cherif et al., 2021a; Naimi et al., 2021b), and Tebessa basins (Benkhedda et al., 2021). In the lower Chelif, the Tafna and Tiaret Neogene basins, several studies identified Burdigalian to Messinian shallow- to deep-marine trace-fossil assemblages (Naimi et al., 2020a, 2021a,b; Cherif et al., 2021a; Naimi & Cherif, 2021). Unfortunately, ichnological studies have not been carried out on the Tebessa Basin.

This paper aims to present the first description of lower Langhian trace-fossils from the Ouenza area (Tébessa, eastern Algeria) in the Tebessa Basin.

LOCATION AND GEOLOGICAL BACKGROUND

The study area belongs to Tebessa Mounts, which constitute the easternmost part of the Algerian Atlasic domain, consisting of the southern part of the Algerian alpine chain (Durand-Delga, 1969; Halamski & Cherif, 2017).

Tebessa Mounts are characterized by Triassic strata, cropping out as diapirs and composed of gypsum, clays, anhydrite and dolomite (Dubourdieu, 1956). The overlying Cretaceous deposits are characterized by shallow to deep marine limestones and marls. Their infill mainly consists of marine limestones and marls, composed of eight ichnotaxa, most of them identified at the ichnogenus level. This study reveals that several new species were also described in this locality. The marine Lower Miocene series is characterized by shallow marine or deltaic sediments that unconformably overlie the Cretaceous strata (Hamided & Kowalski, 2001). During the Middle–Late Miocene, the marginal part of this basin was characterized by shallow marine siliciclastic sedimentation (Benkhedda et al., 2021).

The studied outcrop is located at Ain Sidi Salah locality, to the east of Ouenza city, in the vicinity of the Algerian-Tunisian border, in the northern part of the Tebessa Basin (Figure 1). It consists of a succession of yellowish, 2 to 11 m-thick quartz-dominated fine- to coarse-grained sandstones, with sharp erosive bases, showing low-angle cross-stratifications, parallel laminations, ripple marks and bivalve bioclasts intercalated by greyish marls (Figure 2).

They contain hematite, goethite, muscovite and glauconitic grains. The sandstone beds are intercalated with greenish to grayish clayey marls, 0.5–39 m thick, represented essentially by smectite, chlorite, kaolinite and illite clay minerals (Mazouz, 2009). The Table 1 summarizes the main facies (F1–F5) with their principal lithological, sedimentological and ichnological features. This succession is underlined by Triassic claystones and gypsum, and overlain by Laghian-Serravalian conglomerates, which have been assigned previously to the Burdigalian (Dubourdieu, 1956) (Figure 3). The planktonic foraminifera identified are dominated by Globigerina dissimilis Cushman & Bermúdez, 1937; Globigerinoides trilobus (Reuss, 1850); Globorotalia mayeri Cushman & Ellisor, 1939; Gyroidinoides girardanus (Reuss, 1851) and Planulina renzi Cushman & Stainforth, 1945, indicating the early Langhian age.

MATERIAL AND METHODS

The analyzed material comes from a unique stratigraphic section, measured, and sampled at Ain Sidi Salah locality, Tebessa Basin. The trace-fossil samples were studied and photographed during the bed-by-bed descriptive observation of the lithological and paleontological aspects of the exposed sequence, as well as their stratigraphic relationships pending on the specificities of the study area. The material was not collected. All photos correspond to field specimens that were not collected and were photographed in situ.

SYSTEMATIC ICHNOLOGY

The trace-fossil assemblage is poorly diversified, composed of eight ichnotaxa, most of them identified at the ichnogenus level. This study reveals that Skolithos cf. linearis are abundant, Diplocraterion isp., and Thalassinoides isp. are common, whereas cf. Archaeonassa isp., Arenicolites isp., Helminthopsis isp., Palaeophycus tubularis and cf. Taenidium isp. are rare. In addition, most of specimens are preserved as epichnia and endichnia (Table 2).
Figure 1. Location of the study area: A, location of northeastern Algeria in the western Mediterranean region and B, geological map of eastern Algeria; C, geological map of Aïn Sidi Salah locality.

**Archaeonassa** Fenton & Fenton, 1937

cf. *Archaeonassa* isp.

(Figure 4A)

**Description.** Subhorizontal, unbranched, cylindrical and rarely meandering trail, preserved as convex hyporelief, composed of concave central zone bounded by two convex parallel lateral ridges. It is found in the top of fine-grained sandstone with ripple marks. No evident ornamentation is seen inside the trail. The trails are 94 mm length in average, axial groove is 0.5–1 mm wide and the trail width is 3 to 5 mm.

**Remarks.** *Archaeonassa* is a molluscan-type trail (Netto et al., 2012) ranging from the Ediacaran to the Recent (Buckman, 1994). It is considered as a crawling trail of predatory gastropods (Fenton & Fenton, 1937; Buckman, 1994; Stanley & Feldmann, 1998), crustaceans (Yochelson & Fedonkin, 1997; Mángano & Buatois, 2003), trilobites or echinoids (Buckman, 1994). Yuanyuan et al. (2019) also suggested nereidid polychaetes as probable trace makers. This
Figure 2. Stratigraphic column and trace-fossils distribution of the Ain Sidi Salah section (Tebessa, northeastern Algeria).
Table 1. Distribution of the main facies, ichnogenera and depositional settings.

<table>
<thead>
<tr>
<th>Facies</th>
<th>General description</th>
<th>Trace-fossils</th>
<th>Sedimentary structures</th>
<th>Sedimentary processes</th>
<th>Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1: Marls</td>
<td>2.5–8.3 m thick, massive, grey to green in color, containing benthic foraminifera and ostracods, with intercalations Sandstone beds (0.15 m mean)</td>
<td>/</td>
<td>/</td>
<td>Decantation processes mainly post-storm or tide current</td>
<td>Storm-dominated siliciclastic platform</td>
</tr>
<tr>
<td>F2: Claystones</td>
<td>0.8–5.5 m thick, massive, reddish sandy claystones, intercalated by thin sandstone levels</td>
<td>cf. Taenidium isp.</td>
<td>/</td>
<td>Decantation processes and possibly related to pedogenic processes</td>
<td></td>
</tr>
<tr>
<td>F3: Rippled fine sandstones</td>
<td>Yellow to grey fine sandstones, 0.6–1.3 m thick, intercalated within marlstone facies, channelized, and showing ripple marks</td>
<td>cf. Archeanassa isp. Diplocraterion isp. Helminthopsis isp. Skolithos cf. S. linearis Thalassinoides isp.</td>
<td>Wavy cross-laminated, wavy/ripple-marks</td>
<td>Weather wave or tide current in littoral zone</td>
<td></td>
</tr>
<tr>
<td>F4: Laminated sandstones</td>
<td>Brown to yellow, fine to medium-grained, 0.05–0.4 m thick, highly channelized, with sharp erosive bases</td>
<td>Arenicolites isp. Palaeophycus tubularis Skolithos cf. S. linearis</td>
<td>Horizontal and planar stratification</td>
<td>Deposition under high and rapid energy related to storm event</td>
<td></td>
</tr>
<tr>
<td>F5: Storm-dominated sandstones</td>
<td>Brown in color, fine to medium-grained sandstone beds, 0.2–0.45 m in thickness, channelized, showing sometimes calcareous debris</td>
<td>Skolithos cf. S. linearis Thalassinoides isp.</td>
<td>Hummocky cross-stratification (HCS), horizontal lamination</td>
<td>Middle term of the tempest sequence from storm-dominated platform (middle offshore)</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Main characteristics of the studied ichnoassemblage.

<table>
<thead>
<tr>
<th>Ichnotaxa</th>
<th>Toponomy</th>
<th>Abundance</th>
<th>Ethology</th>
<th>Main producers</th>
</tr>
</thead>
<tbody>
<tr>
<td>cf. Archeanassa isp.</td>
<td>Epichnia</td>
<td>Rare</td>
<td>Repichnia, praedichnia</td>
<td>Gastropods, crustaceans</td>
</tr>
<tr>
<td>Arenicolites isp.</td>
<td>Endichnia</td>
<td>Rare</td>
<td>Domichnia</td>
<td>Worms</td>
</tr>
<tr>
<td>Diplocraterion isp.</td>
<td>Epichnia</td>
<td>Common</td>
<td>Domichnia</td>
<td>Crustaceans, polychaetes</td>
</tr>
<tr>
<td>Helminthopsis isp.</td>
<td>Epichnia</td>
<td>Rare</td>
<td>Pascichnia, repichnia</td>
<td>Polychaetes</td>
</tr>
<tr>
<td>Palaeophycus tubularis</td>
<td>Epichnia</td>
<td>Rare</td>
<td>Domichnia</td>
<td>Worms</td>
</tr>
<tr>
<td>Skolithos cf. S. linearis</td>
<td>Endichnia</td>
<td>Abundant</td>
<td>Domichnia</td>
<td>Worms, crustaceans</td>
</tr>
<tr>
<td>cf. Taenidium isp.</td>
<td>Endichnia</td>
<td>Rare</td>
<td>Pascichnia</td>
<td>Arthropods</td>
</tr>
<tr>
<td>Thalassinoides isp.</td>
<td>Endichnia</td>
<td>Common</td>
<td>Domichnia</td>
<td>Decapod crustaceans</td>
</tr>
</tbody>
</table>

trace-fossil is common in the Cruziana ichnofacies (Knaust et al., 2012) but it is also an accessory component of the Skolithos ichnofacies (Melchor et al., 2012). Mesozoic forms occur generally in intertidal zones (Knox & Miller, 1985; Bryant & Pickett, 1990; Buckman, 1992a,b; Chen et al., 2013), offshore environments (Cherif et al., 2018) and deep marine settings (Mángano & Buatois, 2016).

Arenicolites Salter, 1857

*Arenicolites* isp.

(Figure 4B)

**Description.** Incomplete unbranched U-shaped burrows, at least 125 mm long, having a pair of closely spaced circles with subvertical orientation, and preserved as endichnia. Tube diameter is 3–6 mm. The distance between the two tube parts is up from 15 mm to 45 mm. The burrow shows no spreiten. It is filled with brown-grayish fine material.

**Remarks.** The studied specimen closely resembles the trace-fossil *Ancorichnus* described from the Carboniferous of the Carnic Alps (Baucon & De Carvalho, 2008; Figure 4). *Arenicolites* is interpreted as resulting from the dwelling activity (domichnia) of suspension-feeding organisms (Wilson, 1971; Knaust, 2017), which correspond to holothurians, sipunculans and echiurans (Smilek & Hembree, 2012; Baucon & Felletti, 2013; Baucon et al., 2014). In modern marine settings, incipient *Arenicolites* burrows have been referred to polychaete worms and amphipod crustaceans (Gingras et al., 2008; Bradshaw, 2010; Baucon et al., 2014). *Arenicolites* burrows are known from continental to deep-marine environments, commonly occurring in deposits of high-energy (Mángano & Buatois, 2016; Knaust, 2017). This trace-fossil constitutes with *Skolithos, Ophiomorpha* and *Diplocraterion*, the most common ichnogenera of the Skolithos ichnofacies, but can also occurs locally in the Cruziana ichnofacies (Knaust, 2017). Its stratigraphic
distribution ranges from the Cambrian (Crimes et al., 1977) to the Recent (Baucon & Felletti, 2013).

*Diplocraterion* Torell, 1870

*Diplocraterion* isp.  
(Figures 4C, D)

**Description.** U-shaped, vertical burrow, preserved as epichnia at the top of fine-grained sandstone beds, and no specific characteristics are shown. The burrow diameter varies from 1.5 to 6 mm and the distance between the two limbs of the U-shaped burrow is 12–13 mm. Due to the plan view; the studied specimens closely resemble the U-shaped trace-fossils *Arenicolites* and *Tisoa*. The studied burrows were attributed to *Diplocraterion* isp. due to the presence of twin funnel-shaped craters characterizing their openings.

**Remarks.** This domichnion trace is produced in carbonate and siliciclastic settings, within soft- and firmgrounds, by polychaetes and crustaceans (Knaust, 2017). It is characterized...
by a spreite which can be retrusive or protrusive, or both (Goldring, 1962, 1964) and fecal pellets can be also present (Knaust, 2017). *Diplocraterion* isp., known from Cambrian to the Recent (Mángano & Buatois, 2016), is generally documented in shallow marine settings (Knaust, 2017; Palma-Ramírez et al., 2019) and constitutes an important component of the *Skolithos* ichnofacies (Knaust, 2017).

*Helminthopsis* Heer, 1877

* Helminthopsis * isp.

(Figure 5A)

**Description.** Horizontal simple, smooth, and meandering string, 3 mm in diameter and 160 mm in length, preserved as a concave epichnial ridge in fine-grained sandstone.

**Remarks.** *Helminthopsis* is a pre-depositional graphoglyptid ichnotaxon, occurring within a sediment rich in nutrients of shallow and deep marine deposits (Uchman, 1995, 1998; Wetzel & Bromley, 1996; Wetzel et al., 2007; Cherif et al., 2021a). It is commonly interpreted as a pascichnion trace-fossil (Buatois & Mángano, 2011), probably made by grazing activity of polychaete annelids (Książkiewicz, 1977). In shallow marine setting, *Helminthopsis* ichnospecies are common in the *Cruziana* ichnofacies (MacEachern et al., 2007; Belaid et al., 2020). They have been recorded from Ediacaran (Narbonne & Aitken, 1990) to Recent strata (Gingras et al., 2008) deposited below storm wave base.

*Palaeophycus* Hall, 1847

* Palaeophycus tubularis * Hall, 1847

(Figure 5B)
Description. Epichnial convex, simple, straight, unbranched, cylindrical to subcylindrical burrow, horizontal to bedding. Diameter is 15 mm, and the maximum length is 104 mm. The burrow lacks ornamentation and is filled with identical material to that of the host rock.

Remarks. The studied burrow has been assigned to Palaeophycus tubularis due to the presence of unornamented walls (Pemberton & Frey, 1982). It occurs in soft- to firmgrounds of both siliciclastic and carbonate deposits (Knaust, 2017). Palaeophycus ichnospecies reflect the dwelling activity (domichnion) of a predaceous or suspension-feeding animal (Pemberton & Frey, 1982). However, its trace-makers consist of vermiform animals, so other groups of organisms such as arthropods may produce it (Knaust, 2017). Modern Palaeophycus are produced by nereid polychaetes (Dashtgard & Gingras, 2012; Gingras et al., 2012), and the co-occurrences with large burrows, in marginal-littoral environments indicate that the trace-maker was euryhaline (Knaust, 2017). Palaeophycus is common in shoreface and offshore deposits of the Cruziana ichnofacies, and occurs subordinately in the Skolithos, Zoophycos and Nereites ichnofacies (Knaust, 2017). Palaeophycus has been reported from the Precambrian (Narbonne & Hofmann, 1987) to the Pleistocene (Dashtgard & Gingras, 2012; Gingras et al., 2012).

Skolithos Haldeman, 1840

Skolithos cf. linearis Haldeman, 1840 (Figures 4A, 5A, C)

Description. Preserved as endichnia straight, simple, elongated, vertical to subvertical, cylindrical and unbranching tube, with lined walls and passive filling. The burrows are 55 mm long on average and 5–12 mm wide.

Remarks. In siliciclastic setting, Skolithos ichnospecies occur in soft- to firmgrounds (Knaust, 2017). They are domicnial (dwelling) traces, produced by suspension-feeding worms (Fenton & Fenton, 1934; Emig, 1982; Sundberg, 1983; Dashtgard & Gingras, 2012; Vinn & Wilson, 2013), crustaceans (Dashtgard & Gingras, 2012) and sea anemones in marine setting (Hertweck, 1972). Skolithos is the namesake for the Skolithos ichnofacies, commonly used as indicator of high energy conditions of shallow marine (littoral) environments (Knaust, 2017). Its stratigraphic record ranges from the Cambrian to the recent (Mángano & Buatois, 2016).

Tænidiæ, Heer, 1877

cf. Tænidiæ isp. 
(Figure 5D)

Description. cf. Tænidiæ isp. is winding, unbranched, and thinly lined burrow, vertical to the bedding plane, preserved as endichnial in sandy-claystone facies, up to 100 mm long and about 5 mm in diameter. The single specimen is moderately preserved, but in some segments, it is possible to see active meniscate-shaped filling.

Remarks. Tænidiæ is regarded as deposit-feeding, locomotion, and dwelling trace-fossil (Hembree & Hasiotis, 2008), produced probably by arthropods (Rodriguez-Tovar et al., 2016). It is recorded in shallow to deep-marine deposits (D’Alessandro et al., 1987), considered as characteristic element of the Scoyenia ichnofacies (Buatois & Mángano, 2011; Melchor et al., 2012). ichnospecies of Tænidiæ occur also in the Cruziana ichnofacies (Bromley et al., 1999; Cherif et al., 2018). This trace-fossil is known from the Cambrian to the recent (Mángano & Buatois, 2016).

Thalassinoides Ehrenberg, 1944

Thalassinoides isp. 
(Figure 5E)

Description. Straight or slightly curved, oblique, large, mostly with Y- to T-shaped branched burrowing network, 10–30 mm wide and 50 to 150 mm long. Thalassinoides isp. has been found in endichnia in the internal face of the storm-dominated sandstones (Facies F5).

Remarks. Thalassinoides is considered as fodinichnion- domicnial trace of decapod crustaceans (Frey et al., 1984). It represents the main component of the Cruziana ichnofacies (Knaust, 2017) and is often documented from shallow marine to deep-sea environments (Kim et al., 2002; Cherif et al., 2015b), supporting high energy conditions (Cherif et al., 2015), and occurring in soft- to firmgrounds, but rarely in hardgrounds (Knaust, 2017). In shallow marine setting, the abundance and the developed size of Thalassinoides suggest well-oxygenated deposits (Naimi et al., 2020a; Naimi & Cherif, 2021). This trace-fossil is frequently reported from the Ordovician (Ekdale & Bromley, 2003) to the Holocene (Nickell & Atkinson, 1995), especially in the Mesozoic and Cenozoic deposits (El-Sabbagh et al., 2017).

DISCUSSION

Ichnological analysis

The trace-fossils were recorded from claystones, rippled fine sandstones, laminated sandstones and storm-dominated sandstones which show densely packed bioclast-supported shell layers. The trace-fossil assemblage is characterized by sub-horizontally to sub-vertically burrows belonging to cf. Archaeaennassa isp., Arenicolites isp., Diplocraterion isp., Helminthopsis isp., Palaeophycus tubularis, Skolithos cf. S. linearis, cf. Tænidiæ isp., and Thalassinoides isp. The most abundant trace-fossil is S. cf. linearis. The low ichnodiversity observed could be the result of stress factors such as high energy (Buatois & Mángano, 2013).

The ichnoassemblage in subject is dominated by post-depositional dwelling (domicnial) traces attributed essentially to suspension- or deposit-feeding organisms (e.g. Thalassinoides isp.). Shallow marine trace-fossils show more ethological variations than that of other environments (Joseph et al., 2020), which is the main characteristic of the
Figure 5. Trace-fossils from the lower Langhian of Ain Sidi Salah: A, *Helminthopsis* isp. (*He*) associated with *Skolithos cf. S. linearis* (*Sk*); B, *Palaeophycus tubularis* (*Pa*); C, sandstone bed rich in *Skolithos cf. S. linearis* burrows (*Sk*), with probably pipe structures of *S. cf. S. linearis* burrows (*Sp*), and its lost traces (*Sl*); D, *cf. Taenidium* isp. (*Ta*) (the possible meniscate fill is indicated by white arrow); E, sandstone bed showing abundant *Thalassinoides suevicus* (*Th*). Scale bars: A–B = 2 cm; C = 5 cm; D = 1 cm.
proximal and archetypical Cruziana ichnofacies, within an upper offshore-lower shoreface environment (Pemberton et al., 2001). Mazouz (2009) suggested for the Tebessa Basin a shallow marine environment under moderate to high energy conditions based on a sedimentological approach. Thereby, the occurrence of vertical structures indicates opportunistic colonization of the storm-dominated sandstones (post-event community); whereas the presence of horizontal structures (laminated sandstones) is related to fair weather conditions (Pervesler & Uchman, 2004). The preservation of the post-depositional trace-fossil Arenicolites and Skolithos in the sandstone beds could indicate a storm-related high-energy environment of the lower to middle shoreface (MacEachern et al., 2012). Furthermore, the debris of bivalve shells could be related to storm events (tempestite-deposits) and suggest a shoreline depositional environment. Thalassinoides characterizes softgrounds (Myrow, 1995) and its co-occurrence with large and open burrows, as well as Palaeophycus, indicates a shallow marine environment with well-oxygenated water above the sea floor (Naimi et al., 2020a; Naimi & Cherif, 2021). The worms (polychaetes and phoronids) are the most common producers of the studied trace-fossils, but crustaceans and arthropods are also probable tracemakers of these structures. The studied ichnoassemblage together with the paleontological data as well as the recorded bivalves are suggestive of adequate food resources both in substrate and water column under normal salinity conditions (Fürsich, 1973; Wilson & Rigby, 2000; Mángano et al., 1999; 2005; Gurav et al., 2014).

Water with relatively strong currents, irregular rates of sedimentation and a high flux of food particles is conducive to the occurrence of suspension feeders (Buatois & Mángano, 2011). Gingras et al. (2011) also regarded the abundance of permanent U-shaped burrows and vertical tubes as indicative of shallow-marine areas with shifting sandy substrates, moderate-to high-energy conditions and food in suspension. From an ichnological point of view, the sequence shows a shift in environmental conditions, from the nearshore to the offshore zone. The colonization occurred in fully oxygenated shallow-marine waters, in a high-energy setting.

The trace-fossil assemblage of Aïn Sidi Salah is intimately related to shallow marine ichnofacies and typically shows development of Skolithos, which is the diagnostic of Skolithos ichnofacies type conditions.

Paleogeography

During the Early–Middle Miocene, a significant marine transgression began across the expanse of epicontinental Algeria (Bessedik et al., 2002). A patch reef indicating the maximum flooding has been discovered in the Langhian–Serravalian transgressive detrital strata of the Lower Chelif Basin (Belkebir et al., 1994). This transgression has been recorded from the entire western Mediterranean Basin, as result of the opening of the Algero-Provençal Basin, occupying the western part of the Mediterranean Sea (de Gibert & Robles, 2005). These transgressive deposits are overlain by continental reddish detrital sediments attributed to the Serravalian (Bessedik et al., 2002). The Miocene series ends by Late Miocene (Tortonian–Messinian) marine transgressive deposits (Benzina et al., 2019; Naimi et al., 2020a).

The attribution of the studied deposits to the lower Langhian on the basis of planktonic foraminifera allows correlating the Tebessa basin with the other marginal basins of the southwestern Mediterranean as well as the Lower Chelif Basin. The bioturbated sandstones (Facies F3–F5) have been deposited within a transgressive context related to a significant transgression recorded in the other peri-Mediterranean basins. Also, they are overlain by reddish conglomerates which are similar to that of the Lower Chelif Basin, indicating the Middle Miocene regression phase. The latter are surmounted by Upper Miocene marine siliciclastic deposits as well as in the case of the Lower Chelif and the Tafna basins (Benkhedda et al., 2021). Thus, it confirms the similarities between the Tebessa and the Lower Chelif basin, which presents the reference Miocene series of Algeria.

CONCLUSIONS

Ichnological analysis of the Aïn Sidi Salah lower Langhian sequence revealed low ichnodiversity represented by sub-horizontally to sub-vertically oriented burrows belonging to eight ichnotaxa of Skolithos and proximal Cruziana ichnofacies. Thus, these trace-fossils are cf. Archaeonassa isp., Arenicolites isp., Diploceratiner isp., Helminthopsis isp., Palaeophycus tubularis, Skolithos cf. linearis, cf. Taenidium isp., and Thalassinoides isp. The Skolithos ichnofacies suggests high hydrodynamic energy reflecting foreshore-shoreface environment with occasional storm events, while proximal Cruziana ichnofacies represents moderate energy condition of shoreface. This ichnoassemblage suggests that suspension- or deposit-feeding organisms, represented essentially by worms (polychaetes and phoronids), crustaceans and arthropods, occurred within these deposits, despite the absence of their body fossils.

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