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MIOCENE BRYOZOANS FROM JABAL ZALTAN, NORTHEAST SIRT BASIN, LIBYA

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ABSTRACT

A taxonomic study has been performed for the thirty-two retrieve bryozoan species from the measured Serravallian Maradah Formation section at Z138, Jabal Zaltan, northeastern Sirt Basin, Libya. Among this unique assemblage only two new species *Calpensia spinosa* and *Thalamoporella zaltaniensis* have been established. The *Cubitostrea* shells provide the most attachments of the encrusting bryozoans.

The reported species are of Mediterranean/Atlantic distributional affinity. However the new species are considered as an endemic species. The limestones and marls are rich in erect flexible and encrusting forms which indicate inter-subtidal (10-50m) environments with moderate rate of sedimentation and relatively strong wave actions. Highly agitated environment is specially recognized from the investigated assemblages in the lower part of Ar Rahlah Member of Maradah Formation as suggested on taphonomical basis.

***Keywords*:** Mediterranean, Miocene Bryozoa, Libya, Maradah Formation, Jabal Zaltan

INTRODUCTION

Jabal Zaltan area is located in the vicinity of the Marada Oasis in north-central Sirt Basin (Longitudes 18° 45' to 20° 10' E and latitudes 28° 20' to 29° 25' N. The studied locality Z138 is indicated by solid circles (Fig. 1). Maradah Formation (Middle Miocene) was introduced and described by Desio (1935) from 80 meters thick section at Garet al Mazzala, near Marada Oasis. It consists mainly of siliciclastics with minor carbonates at the lower half of the Formation resembling Qarat Jahanam Member changed upwards to mainly carbonate with interbeds of siliciclastics containing marine invertebrates at some levels. This formation is unconformably underlain by the Oligocene Bu Hashisha Formation of Rupelian age, while the upper boundary is not present. According to Mastera (1985) this formation has been subdivided into two members, the lower siliciclastic Qarat Jahannam Member of Burdigallian-Aquitanjan age and the upper carbonate – siliciclastic Ar Rahlah Member (Aquitanian – Serravallian). The type locality of Ar Rahlah Member is situated 25km northeast of the Maradah oasis, with about 150m thick sequence. Ar Rahlah Member resembles the marine facies with several fossiliferous horizons. It is gradually changed to Qarat Jahannam Member by depth, but unconformably overlain by Wadi Yunis Member of Al Khums Formation (Mastera, 1985). El Hawat (2008) studied the sequence stratigraphy architecture of the Maradah Formation and attributed it to the interplay of steady eustatic sea level change overprinted by spasmodic tectonic activity of Sirt rift complex during Middle Miocene.

LOCATION OF THE Z138 (CAMP SECTION)

Coordinates: Latitudes (28º 55' 00.5" N) and Longitudes (19º 45' 54.6" E). The measured thickness of this section is about 87 meters, representing Ar Rahlah Member of Maradah Formation (Figs. 1, 2). The section consists mainly of invertebrate-bearing carbonates with minor interbeds of non-fossiliferous siliciclastics.

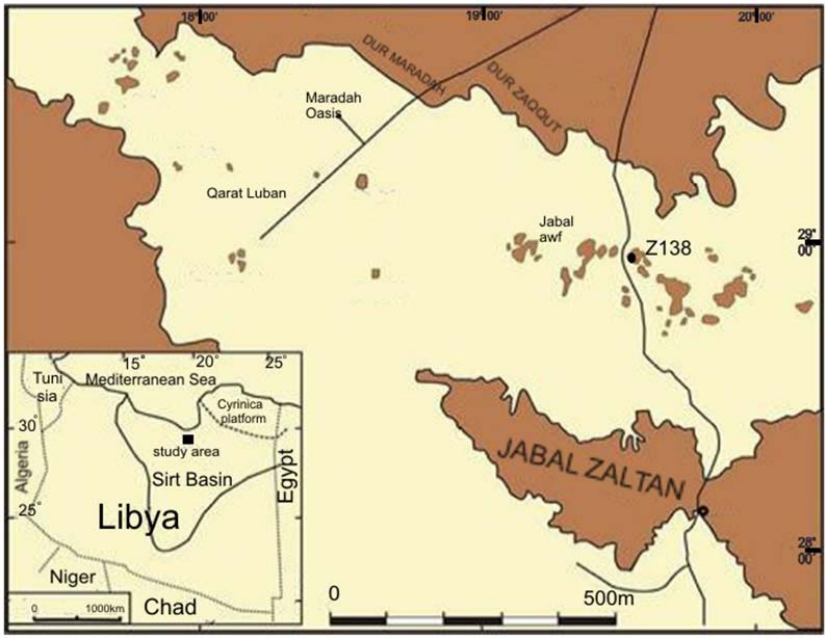

Fig. 1: Location map of Jabal Zaltan area, showing the studied Z138 section.

Fig. 2: Zaltan Oil Field, and the studied Z138 section of the Maradah Formation (Ar Rahlah Member).

MATERIAL AND METHODS

The raw material of this chapter has been collected during the field trip of the season 2010 by ELNRP team. During which one section (Z138) in Jabal Zaltan area (Figs. 1, 2) have been measured, sampled and described. This section mainly represented by the older siliciclastic deposits of the carbonates with siliciclastic alternation of Ar Rahlah Member. Fifty-five samples have been collected from the Z138 at Jabal Zaltan (Figs. 2, 3). Well preserved and abundant bryozoan specimens were picked form the processed microfossils-bearing samples by aid of Kruss stereo zoom binocular microscope, selected species are also examined using a Jeol JSM 6360 Scanning Electron Microsope, at the University of Athens, Department of Historical Geology and Paleontology, for taxonomic and illustrative purposes. All materials (samples and micropaleontological slides) are stored at the micropaleontological section of the Earth Sciences Department of Benghazi University, Benghazi-Libya.

LITHOSTRATIGRAPHY OF AR RAHLAH MEMBER OF MARADAH FORMATION

Ar Rahlah Member of Maradah Formation at locality Z138 yielded 88m thick sequence, out of which a total of 55 samples have been collected. Neither the upper boundary, nor the lower were observed in this section. The sedimentological details are illustrated in Figure 3. Lithological nature, sedimentary structures, biological contents and ichnofossils are utilized in the recognition of the microfacies and depositional paeoenvironment. The collected samples have been processed petrographically and micropaleontologically, in order to assist in reaching the goals of this study. The studied facies generally reflect gradual changes from siliciclastic dominated intervals to fossiliferous carbonates, with rhythmic sedimentary pattern locally reported. They are formed in response the

climatic change during deposition. The highly fossiliferous horizons of mostly bryozoans-bearing sediments are repeatedly reported, indicating low sedimentation rate within the section. The presence of *Echinolampas* in two major horizons is also recorded. Two distinct hard grounds have also been documented, reflecting eustatic sea level fall accompanied with slow rate of sedimentation.

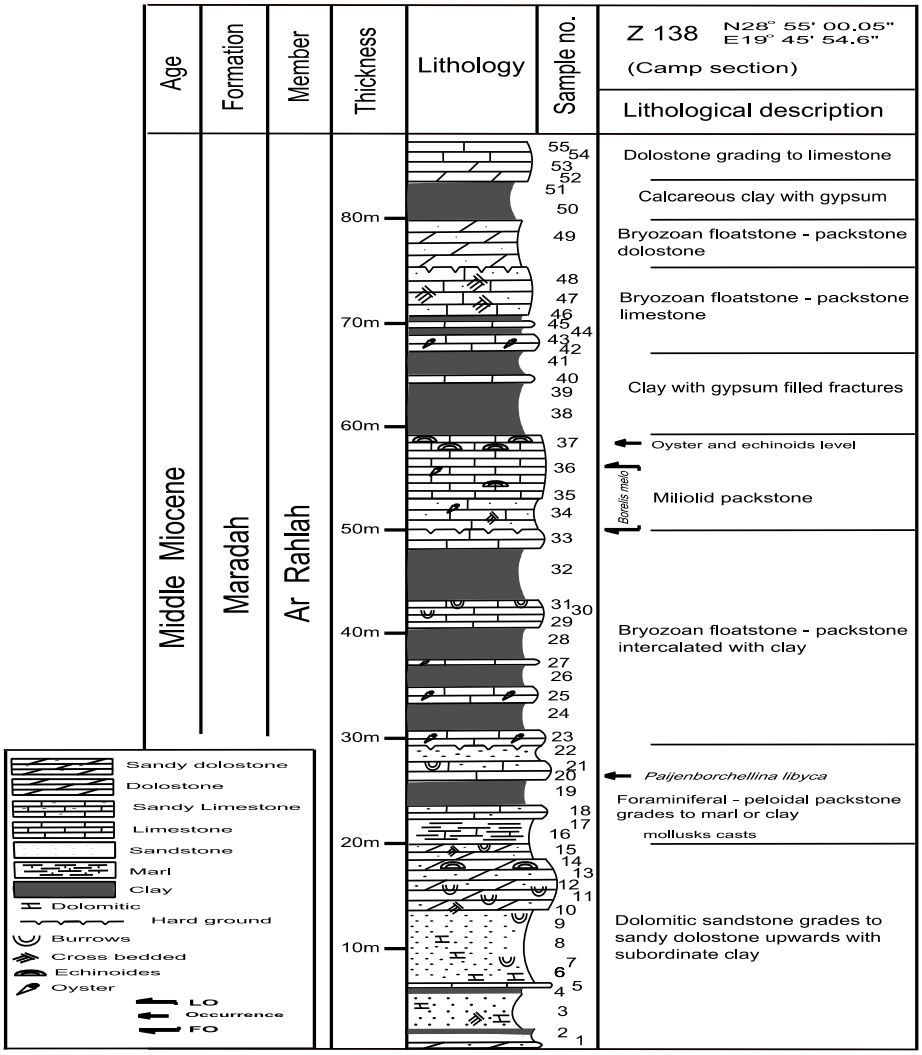

Fig. 3: Lithological columnar section of Z138 at Jabal Zaltan.

FAUNAL ASSOCIATION

Among the other microfossils common group in the studied mateials are foraminifera and ostracods

Foraminifera

The microfossils retrieved from Ar Rahlah Member of Maradah Formation at Z138 in Jabal Zaltan area are represented by Foraminifera, Ostracoda and Bryozoa, (All samples were processed for calcareous nannofossils and found to be completely barren. In some horizons, however, foraminifers and/or ostracodes may exist, poorly preserved and of very low diversity. Bryozoans (the scope of this paper) on the other hand are found to be abundant, and moderately divers. The foraminifera are represented by sparsely benthic representatives. These include *Elphidium macellum, E. minutum, Ammonia beccarii, Lobatula lobatulus, Discorbis cf. perlexus, Tritaxia tricarinata, Borelis melo, Pyrgo sp., Quinqueloculina spp., Bolivina cf. fastigia, Amphistegina sp., Pararotalia serrata* and *Rotalia viennesis*. Planktonic foraminifers are rare, including *Globorotalia cf. opima* and *Globigerina praebulloides.* The distribution of these foraminifers is vertically discontinuous, interrupted by non-fossiliferous clays or sandy dolostone (Fig. 4).

Ostracods

Ostracods on the other hand are mainly represented by common *Paijenborchellina libyca* associated with very rare of *Loculicytheretta* sp. which are retrieved from the lower part of the studied Z138 (Fig. 4). The presence of *Paijenborchellina libyca* in the lower part of the section is an indicative of shallow warm marginal marine.

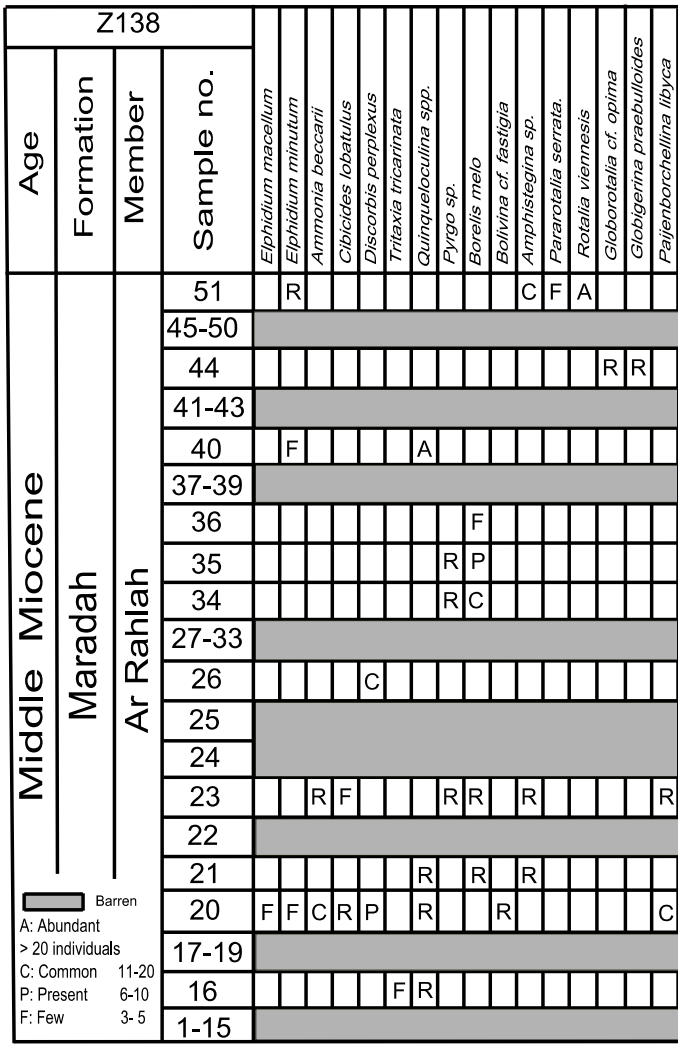

Fig. 4: Foraminifers and ostracodes distribution chart of Ar Rahlah Member of Marada Formation at P138, Jabal Zaltan

Bryozoa from Maradah Formation

The measured section Z138 at Jabal Zaltan (Figs. 1, 2) was studied in detail using Bryozoan assemblages, as this macrofossils group is predominant at several horizons (Fig. 3). The only attempts to document the bryozoans in Maradah Formation have been conducted by El-Hawat (1975). He identified *Idmonea* spp., *Haloporella* sp. and *Trigonopora moniliferum* in petrographic thin sections from the exposed rocks at Zabal Zaltan area.

Z138 Bryozoan analysis

Out of 32 studied bryozoan species from Maradah Formation (Fig. 5), 15 are encrusting (48%) and the rest 16 are erecting. The encrusting species are represented by Membraniporiforms and Celleporifors. The erect bryozoans (52%) are represented by erect rigid growth form (56%), and erect flexible growth form (44%). In the study area, oyster shells provide the most attachments for the encrusting bryozoans. The limestones and marls contained erect forms, which indicate inter-subtidal (10-50m) environments characterized by moderate rate of sedimentation and relatively strong wave actions.

Age	Formation	Member	Sample number	*Crisia eburnea*	*Crisia elongata*	*Crisia haueri*	*Crisia hornesi*	*Crisia suezensis*	*Exidmonea atlantica*	*Exidmonea undata*	*Plagioecia patina*	*Tretocycloecia dichotoma*	*Disporella hispida*	*Ybseloseocia typica*	*Biflustra savartii*	*Conopeum lacroixi*	*Rosselina rosselii*	*Smittipora sp*	*Steginoporella iberica reussi*	*Calpensia gracilis*	*Calpensia calpensis*	*Calpensia spinosa*	*Thalamoporella neogenica*	*Nellia tenella*	*Scrupocellaria elleptica*	*Mucropetraliella plana*	*Dakaria bitubeculata*	*Eschrella peachi*	*Schizoporella longirostris*	*Porella cervicornis*	*Margretta ceroides*	*Metrarabdotos moniliferum*	*Celleporaria polythele*	*Celleporina tubifera*	*Turbicellepora coronopus*
Late Miocene (Serravallian)	Maradah	Ar Rahlah	51	C	C																		F							R		C	
			50																												R		F	
			49	C	F	C	A	C															C				C			C	F	C	F	R
			47					C	C																					C	F	C		
			46																				C	R							R			
			43	R	C	C	C	C		C			R	R												C	R	R			R	R			
			40	R	R		R																F	C						R	C			
			35																								R							
			31		R																		F	R					F					
			29		R					F													R	C		C		C	C		R			
			27	R	R			R	R	R													R	R	R			R			F			
			26																				C	C										
			25												R	R	R	R	R	R	R								C		F		R	
			23		R		R	R	R	R	R	R					C					R	R	C	C	R	R	R	R			F	R	R
			21							R													R	R								R		
			20	R	R		C			R													R	R	R							R		
			17																												R			
			16																				R	R							F		R	

Fig. 5: Bryozoan distribution chart of Ar Rahlah Member, Maradah Formation at Z138 section in Jabal Zaltan area. (R: Rare 1-2; C: Common 3-5; F: Frequent 6-10; A: Abundant 10)

Systematic Paleontology

Thirty-two bryozoan species are taxonomic studied of all recorded species (Fig. 5). The study is based primarily on the classification of Bassler (1953) with modifications. In addition to the morphologic description of two new species, micrometric measurements, distribution, and habitat for each species are given. The illustrated types are deposited in the Department of Earth Sciences, Faculty of Science, University of Benghazi. The used parameters, statistics and abbreviations, as well as the form in which are presented, are as follows:

Parameter	No. of measured Zoaria, Zooecia	Range	Standard deviation	Mean
X*	(4, 8)	0.125-0.301 mm	(0.021)	0.332 mm

Dz= Zoarial diameter; Dt= Diameter of the zooecial tubes; Dp= Peristomes diameter; Do= Orifice diameter; Df= Fascicles diameter; Lz= Zooecial length; lz= Zooecial width; Lo= Apertural or Opesial length; lo= Apertural or Opesial width; Lov= Ovicell length; Iov= Ovicell width; Lav= Avicularian length; Iav= Avicularian width.

Class Stenolaemata Borg, 1926

Order: Cyclostomata Busk, 1852

Family: Crisidae Johnston, 1847

Crisia eburnea (Linnaeus, 1758)

(Fig. 6/ 1)

1758 *Sertularia eburnea* Linnaeus: 810.

1982 *Crisia. eburnea* Winston, p. 155, fig. 91.

Measurements: Dz (3) 0.2646-0.266 (0.083) 0.259mm; Lz (1, 3) 0.351-0.389 (0.083) 0.365mm; Do (1, 10) 0.064-0.070 (0.024) 0.068mm; Dp (1, 10) 0.079-0.089 (0.102) 0.087mm.

Material: Maradah Formation, Z138, Sample nos. 20, 27, 40, 43, 49, 51.

Distribution: Common in the cold waters of Europe and America, also in western Atlantic, Mediterranean Sea and West Africa.

Habitat: It is always dominant at 50 m, with a maximum depth of 300 m (Hayward and Ryland, 1985).

Remarks: The present species has a close relation to *Crisia denticulata*, but differs in having only smaller size ranges and not-wedged basis rami.

Crisia elongata Milne-Edwards, 1838

1838 *Crisia elongata* Milne-Edwards, p. 203, pl. 7, fig. 2.

1995 *Crisia elongata* Ziko and El-Sorogy, p. 82, figs. 3: 1-2.

Measurements: Dz (5) 0.215-0.270 (0.028) 0.260mm; Lz (1, 10) 0.410-0.473 (0.019) 0.455mm; Do (2, 10) 0.064-0.070 (0.022) 0.068mm; Dp (2, 10) 0.076-0.086 (0.015) 0.083mm; Lov (2, 5) 0.491-0.500 (0.022) 0.495mm; Iov (2, 5) 0.298-0.313 (0.012) 0.305mm.

Material: Maradah Formation, Z138, Sample nos. 20, 23, 27, 29, 31, 40, 43, 49, 51.

Distribution: Eocene (France, and North America); Oligocene (France, Germany, and Italy); Miocene (Egypt, CSSR, France, Hungary, Italy, and Austria); Pliocene (Italy), Pleistocene (Egypt).

Habitat: Atlantic, Mediterranean, Red Sea, Japan, with a depth range of 0-59m (Vavra, 1977).

Crisia hauri (Reuss, 1848)

(Fig. 6/ 2)

1848 *Crisia hauri* Reuss, p. 54, pl. 7, figs. 22-24.

2002 *Crisia hauri* El Safori, p. 426, pl. 2, fig. 2.

Measurements: Dz (5) 0.184-0.200 (0.023) 0.192mm; Lz (1, 10) 0.152-0.167 (0.017) 0.166mm; Do (2, 10) 0.060-0.063 (0.062) 0.062mm; Dp (2, 10) 0.086-0.094 (0.075) 0.090mm.

Material: Maradah Formation, Z138, Sample nos. 43, 49.

Distribution: Eocene (Egypt, and Italy); Oligocene (Germany); Miocene (Egypt, France, Italy, Austria, Morocco) .

Habitat: Common in the cold waters of Europe and America, also in western Atlantic, Mediterranean Sea and West Africa.

Crisia hornesi Reuss, 1848

(Fig. 6/ 3)

1848 *Crisia hornesi* Reuss, p. 54, pl. 7, fig. 21.

2002 *Crisia hornesi* El Safori, p. 426, pl. 2, fig. 3.

Measurements: Dz (3) 0.489-0.522 (0.023) 0.510mm; Lz ((1, 3) 0.351-0.389 (0.013) 0.365mm; Do (2, 10) 0.064-0.070 (0.004) 0.068mm; Dp (2, 10) 0.076-0.086 (0.009) 0.081mm.

Material: Maradah Formation, Z138, Sample nos. 20, 23, 40, 43, 49.

Distribution: Eocene (France, Italy, and North America); Oligocene (Germany, France, Italy, and USA); Miocene (Egypt, CSSR, Greece, Italy, Poland, Romania, Hungary, and Portugal); Pliocene–Pleistocene of Italy.

Habitat: Red Sea, Philippines, at depth from 100 to 300m, temperature: 11.2ºC.

Crisia suezensis El Safori, 1994

(Fig. 6/ 4)

1994 *Crisia suezensis* El Safori, p. 109, pl. 9, figs. 7, 8.

2010 *Crisia suezensis* Ziko et al., p. 67, pl. 1, figs. 8-9.

Measurements: Dz (3) 0.520-0.669 (0.023) 0.605mm; Lz (1, 10) 0.232-0.320 (0.022) 0.284mm; Do (2, 10) 0.058-0.086 (0.014) 0.073mm; Dp (2, 10) 0.083-0.100 (0.012) 0.095mm.

Material: Maradah Formation, Z138, Sample nos. 23, 27, 43, 47, 49.

Distribution: Miocene of Egypt.

Family: Tubuliboridae Johnston, 1838

Exidmonea atlantica (Forbes in Johnston, 1847)

(Fig. 6/ 5)

1847 *Idomnea atlantica* Forbes in Johnston, 278, pl. 48, fig. 3.

2002 *Exidmonea atlantica* El Safori, p. 427, pl. 2, fig. 7.

Measurements: Dz (5) 0.641-0.769 (0.023) 0.727mm; Dp (2, 10) 0.111-0.134 (0.014) 0.126mm; Df (2, 6) 0.387-0.410 (0.010) 0.390mm.

Material: Maradah Formation, Z138, Sample nos. 23, 27, 47.

Distribution: Eocene (Italy, Hungary, Romania, USA? and Argentina?); Oligocene (Germany, Italy, and USA?); Miocene (Egypt, France, Italy, Austria, Poland, and Morocco); Pliocene (Tunisia, Morocco, Mexico?); Pleistocene (Italy, Canada?).

Habitat: Cosmopolitan, variable depth (0-850m), with an optimum depth range of 40-100m in the Mediterranean Sea (Moissette, 1988).

Exidmonea undata (Reuss, 1851)

(Fig. 6/ 6)

1851 *Idmonea undata* Reuss, p. 172, pl. 9, fig. 20

2010 *Exidmonea undata* Zagoršek, p. 29, pl. 7, figs. 1-4.

Measurements: Dz (5) 0.435-0.476 (0.024) 0.456mm; Dp (1, 10) 0.110-0.129 (0.014) 0.117mm; Df (1, 6) 0.354-0.362 (0.010) 0.358mm.

Material: Maradah Formation, Z138, Sample no. 23 (Fig. 5).

Distribution: Eocene (Italy, Hungary, Romania, USA?, and Argentina?); Oligocene (Germany, Italy, and USA?); Miocene (Egypt, France, Italy, Austria, Poland, and Morocco); Pliocene (Tunisia, Morocco, Mexico?); Pleistocene (Italy, Canada?).

Habitat: Cosmopolitan, variable depth (0-850m), with an optimum depth range of 40-100m in the Mediterranean Sea (Moissette, 1988).

Family: Cerioporidae Reuss, 1866

Tretocycloecia dichotoma Canu, 1919

1848 *Heteropora dichotoma* Reuss, p. 35, pl. 5, fig. 20.

2010 *Tretocycloecia dichotoma* Ziko, et al., p. 92, pl. 4, fig. 12, pl. 5, fig. 1.

Measurements: Dz (2) 1.300-1.510 (0.083) 1.387mm; Do (1, 10) 0.064-0.085 (0.024) 0.076mm; Dp (1, 10) 0.088-0.129 (0.108) 0.116mm.

Material: Maradah Formation, Z138, Sample no. 23.

Distribution: Miocene (Egypt, Austria); Tertiary (France).

Family: Lichenoporidae Smitt, 1867

Disporella hispida (Fleming, 1828)

(Fig. 6/ 7)

1828 *Discopora hispida* Fleming, p. 530.

2010 *Disporella cf. hispida* Zágoršek, p.39, pl. 36, figs. 2-5.

Measurements: Dz (5) 0.464-0.640 (0.043) 0.587mm; Do (1, 10) 0.075-0.108 (0.054) 0.098mm; Dp (1, 10) 0.133-0.144 (0.054) 0.136mm; Df (1, 6) 0.197-0.209 (0.075) 0.201mm.

Material: Maradah Formation, Z138, Sample no. 43.

Distribution: Eocene (Egypt); Oligocene (Italy, Germany); Miocene (Egypt, France, Italy, Austria, Hungary, and CSSR); Pliocene (England and Italy); Pleistocene (USA and Italy). It inhabits the Mediterranean Sea, Arctic, Atlantic and Pacific Oceans (Vavra, 1974).

Family Diaperoeciidae Canu, 1918

Ybselosoecia typica (Manzoni, 1878)

(Fig. 6/ 8)

1878 *Filisparsa typica* Manzoni p. 10, pl. 8, fig. 30.

2010 *Ybselosoecia typica* Zagoršek p. 31,pl. 15, fig. 1-5.

Measurements: Dz (2) 1.250-1.610 (0.023) 1.330mm; Lz (2, 10) 0.456-0.487 (0.012) 0.466mm; Do (2, 10) 0.133-0.1455 (0.014) 0.143mm; Dp (2, 10) 0.157-0.188 (0.012) 0.170mm..

Material: Maradah Formation, Z138, Sample no. 43.

Distribution: Eocene Europe (Poland, France, Romania); Oligocene (USA); Miocene Austria, Poland, France, Italy); Quaternary and Recent (Italy).

Order Cheilostomata Busk, 1852

Suborder Malacostegina Levinsen, 1909

Family: Membraniporidae Busk, 1852

Biflustra savartii (Audouin, 1826)

1826 *Flustra savartii* Audouin: 240, pl. 10, fig. 10.

1988 *Biflustra savartii* Moissette: 73, pl. 11, figs. 6, 9.

Measurements: Lz (2, 10) 0.468-0.546 (0.124) 0.513mm; Iz (2, 10) 0.260-0.312 (0.125) 0.297mm; Lo (1, 10) 0.234- 0.312 (0.143) 0.260mm; Io (2, 10) 0.208-0.260 (0.137) 0.223mm.

Material: Maradah Formation, Z138, Sample nos. 23, 25.

Distribution: Eocene (France, Spain, Egypt, Italy, and USA); Oligocene (Germany, USA and Italy); Miocene (France, Egypt, Austria, Czechoslovakia, Poland, Italy, Tunisia, Libya, USA, and Portugal); Pliocene (England, Spain, Netherlands, Portugal, Italy, Tunisia, Venezuela, and Australia); Pleistocene (Italy, Algeria, USA, china, and Argentina).

Habitat: Cosmopolitan in Atlantic, Indian and Pacific Oceans. It survives in Equatorial hot waters to a depth of 100m (Moissette, 1988).

Family Electridae d'Orbigny, 1851

Conopeuim lacroixii (Audouin, 1826)

(Fig. 7/ 1)

1826 *Flustra lacroixi* Audouin: 240, pl. 10, fig. 9.

1912 *Membranipora lacroixi* Canu: 195, pl. 10, fig. 5, 6.

Measurements: Lz (2, 10) 0.475-0.550 (0.024) 0.515mm; Iz (2, 10) 0.275-0.375 (0.020) 0.340mm;Lo (2, 10) 0.225- 0.256 (0.023) 0.238mm; Io (2, 10) 0.199-0.249 (0.014) 0.218mm.

Occurrence: Maradah Formation, Z138, Sample no. 25 (Fig. 5).

Distribution: Eocene (France, Belgium, Egypt and USA); Miocene (Egypt, USA Tunisia, Italy, Austria, and Hungary); Pliocene (England); Quaternary (England, and Argentina).

Habitat: Atlantic, Pacific and Indian Oceans, Mediterranean and Red Sea. Shore depths (Canu and Bassler, 1920).

Family Antroporidae Vigneaux, 1949

Rosselina rosselii (Audouin, 1826)

1826 *Flustra rosselii* Audouin, p. 240, pl. 10, fig.1.1.

2002 *Rosselina rosselii* El Safori, p. 437, pl. 4, fig. 6.

Measurements: Lz (2, 10) 0.375-0.427 (0.074) 0.394mm; Iz (2, 10) 0.275-0.303 (0.060) 0.289mm; Lo (2, 10) 0.100- 0.124 (0.053) 0.109mm; Io (2, 10) 0.100-0.126 (0.050) 0.113mm; Lav (2, 3) 0.127-0.153 (0.063) 0.138mm, Iav (2, 3) 0.075-0.087 (0.020) 0.081mm.

Material: Maradah Formation, Z138, Sample no. 25.

Distribution: Miocene (Egypt, France, Spain, and Portugal); Pliocene (Tunisia); Pleistocene (Italy).

Family Onychocellidae Jullien, 1882

Smittipora sp.

(Fig. 7/ 2)

Figured material: Maradah Formation, Z138, Sample no. 25.

Description: Zooecia encrusting unilamellar, hexagonal with mainly regular alternating rows of zoeecia, separated by fine furrows. Cryptocyst is finely granulated, slightly convex. Opesia is large oval to elliptical. Fertile zooecia have the same size with larger opesia and rounded anter. Avicularian zooecia with wide and salient proximal part, and straight narrow rostrum.

Measurements: Lz (2, 10) 0.450-0.540 (0.024) 0.544mm; Iz (2, 10) 0.295-0.340 (0.020) 0.320mm; Lo (2, 10) 0.140- 0.194 (0.013) 0.169mm; Io (2, 10) 0.140- 0.176 (0.015) 0.155mm; Lav (2, 3) 0.487-0.520 (0.025) 0.508mm; Iav (2, 3) 0.335-0.348 (0.010) 0.340mm.

Family: Steginoporellidae Bassler, 1953

Steginoporella iberica reussi Pouyet and David, 1979.

1979 *Steginaporella iberica reussi* Poyet and David, 780, pl. 4, fig. 3, text fig. 3.

Measurements: Lz (1, 10) 0.985-1.009 (0.017) 0.998mm; Iz (1, 10) 0.655-0.610 (0.008) 0.600mm; Lo (1, 10) 0. 124-0.256 (0.022) 0.245mm; Io (1, 10) 0.379-0.400(0.010) 0.386mm

Material: Maradah Formation, Z138, Sample no. 25.

Distribution: Miocene (Vienna Basin-Austria, Rhone Basin-France).

Family: Calpenciidae Canu and Bassler, 1923

Calpensia calpensis (Busk, 1854)

1854 *Membranipora calpensis* Busk: 60 pl. 104, figs. 5-6.

2002 *Calpensia calpensis* El Safori, p. 437, pl. 5, fig. 1.

Measurements: Lz (1, 10) 0.598-0.702 (0.064) 0.657mm; Iz (1, 10) 0.390-0.464 (0.085) 0.438mm; Lo (1, 10) 0.090-0.110 (0.040) 0.104mm; Io (1, 10) 0.130- 0.200 (0.030) 0.148mm.

Material: Maradah Formation, Z138, Sample no. 25.

Distribution: Miocene (Egypt, France, and Portugal); Pliocene (Italy, Tunisia); Pleistocene (Italy); Quaternary (Italy). It is of Mediterranean range (David et al., 1972).

Calpensia gracilis (Münster in Goldfuss, 1826)

(Fig. 7/ 3)

1847 *Membranipora gracilis* Münster, p. 93, pl. 11, fig. 12

2010 *Calpensia gracilis* Zagoršek, p. 47, pl. 3, figs. 1-4.

Measurements: Lz (1, 10) 0.598-0.702 (0.024) 0.657mm; Iz (1, 10) 0.390-0.464 (0.015) 0.438mm; Lo (1, 10) 0.090- 0.110 (0.010) 0.104mm; Io (1, 10) 0.130- 0.200 (0.010) 0.148mm.

Material: Maradah Formation, Z138, Sample no. 25.

Distribution: Miocene (France, Austria, Morocco, Algeria, Poland, and Romania).

Calpensia spinosa n. sp.

(Fig. 7/ 4)

Material: Holotype**,** Maradah Formation, Ar Rahlah Member, Z138 section Serravallian, Z138, Sample no. 23.

Etymology: The species is named after the specific criteria of mural spine occurrences.

Diagnosis: *Calpensia* having zooecia with one or two spines at proximal cadre.

Description: Zoarium encrusts membraniporiform. Zooecia distinct, lozenge, arranged in alternating longitudinal rows, separated by thin furrows. Mural rim thin, convex, slightly salient, granulated, basal part isoften pierced by two and rarely one small spine with thick base and abraded shaft. Cryptocyst shallow, slightly convex to flat, finely granulated and perforated, grooved by two small symmetrical rounded opesiuels placed just below the proximal border of opesia. Opesia elliptical with rounded distal and concave to slightly concave proximal border; peristome thin, salient. Ovicells are not observed.

Measurements: Lz (1, 10) 0.423-0.452 (0.014) 0.432mm; Iz (1, 10) 0.273-0.334 (0.021) 0.329mm; Lo (1, 10) 0.062- 0.072 (0.009) 0.065mm; Io (1, 10) 0.086- 0.097 (0.010) 0.093mm.

Affinity: This species is close to *C. calpensis*, but its mural rim is often pierced by two and rarely one small spine.

Family Thalamoporellidae Levinsen, 1902

Thalamoporella zaltaniensis n. sp.

(Fig. 7/ 5, 6)

Material: Holotype**,** Maradah Formation, Serravallian, Ar Rahlah Member, Z138 section, Sample no.

Etymology: The species is named after Jabal Zaltan.

Diagnosis: *Thalamoporella* having flat cryptosyst with two mediun opesiules situated at the middle part of the cryptocyst.

Description: Zoarium encrusts and membraniporiform. Zooecia distinct, arranged in alternating longitudinal rows and separated by thin furrows. Mural rim thin, convex, slightly salient, granulated, basal part pierced by two and rarely one small spines with thick base and abraded shaft. Cryptocyst shallow, little convex to flat, finely granulated and perforated, grooved by two small symmetrical rounded opesiuels, placed just below the proximal border of the opesia. Opesia elliptical with rounded distal and concave to little concave proximal border; peristome thin, salient. Ovicells are not observed.

Measurements: Lz (2, 7) 0.391-0.492 (0.036) 0.449mm; Iz (2, 7) 0.187-0.282 (0.042) 0.253mm; Lo (2, 7) 0.043- 0.057 (0.013) 0.050mm; Io (2, 7) 0.101- 0.108 (0.006) 0.104mm; Lav (1, 2) 0.558- 0.565 (0.013) 0.561mm; Iav (1, 2) 0.276- 0.284 (0.006) 0.280mm.

Affinity: This species is close to *Th. neogenica* but it has lager opesules, more flattened cryptocyst, opesia with typical elliptical shape.

Family Scrupocellariidae Levinsen, 1909

Nellia tenella (Lamarck, 1816)

(Fig. 7/ 7)

1816 *Cellaria tenella* Lamarck: 135.

1974 *Nellia tenella* David and Pouyet, p. 132.

Measurements: Lz (2, 10) 0.373-0.452 (0.014) 0.397mm; Iz (2, 10) 0.123-0.164 (0.010) 0.252mm; Lo (2, 10) 0.242- 0.262 (0.013) 0.254mm; Io (2, 10) 0.086- 0.117 (0.010) 0.103mm.

Material: Maradah Formation, Z138, Sample nos. 16, 20, 21, 23, 26, 27, 29, 31, 40, 46, 49, 51.

Distribution: Eocene (France); Eocene-Oligocene (USA); Miocene (Egypt, Jamaica, Austria); Pliocene-Pleistocene (USA).

Family Scrupocellariidae Levinsen, 1909

Scrupocellaria elleptica (Reuss, 1848)

1848 *Bactridium elleptica* Reuss, p. 148, pl. 11, figs. 1-9.

1996 *Scrupocellaria elleptica* Haddadi-Hamdane, p. 73, pl. 5, fig. 5.

Measurements: Lz (2, 5) 0.368-0.437 (0.035) 0.410mm ; Iz (2, 5) 0.138-0.184 (0.016) 0.176mm; Lo (2, 5) 0.189-0.253 (0.018) 0.228mm; Io (2, 5) 0.069-0.119 (0.010) 0.103mm.

Material: Maradah Formation, Z138, Sample nos. 16, 20, 21, 23, 26, 27, 29, 31, 40, 46.

Distribution: *Eocene (France, Italy, Hungary, and France); Oligocene (Italy and France); Miocene (Egypt, Libya, France, Iran, Portugal, Austria, and Belgium); Pliocene (Portugal, Spain, Italy, and Tunisia); Pleistocene (Egypt, Algeria, and Italy).*

Infraorder: Ascophorina Levinsen, 1909

Family: Mucronellidae Levinsen, 1902

Mucropetraliella plana Moissette, 1988

(Fig. 8/ 1)

1988 *Mucropetraliella plana* Moissette, p. 121, pl 20, figs. 1-3.

Measurements: Lz (4, 10) 0.840-0.920 (0.024) 0.820mm, Iz (4, 10) 0.420-0.570 (0.030) 0.440mm, Lo (4, 15) 0.201- 0.224 (0.023) 0.214mm, Io (4, 10) 0.223-0.265 (0.016) 0.240mm, Lav (4, 7) 0.103-0.113 (0.006) 0.108mm, Iav (4, 7) 0.007- 0.008 (0.006) 0.007mm,

Material: Maradah Formation, Z138, Sample nos. 20, 23, 27, 43 (Fig. 5).

Distribution: Miocene (Egypt, Italy, Germany, Austria, France); Pliocene (Italy, England, Belgium, Pays-Bas); Pleistocene (England); Quaternary (Italy).

Watersiporidae Vigneaux, 1949

Watersipora bitubeculata (Canu and lecointre, 1928)

(Fig. 8/ 2)

1928 *Dakaria bitubeculata* Canu and lecointre, p. 68, pl. 12, figs. 3-6.

1988 *Dakaria cf. bitubeculata* Moissette, p. 129, pl. 21, figs. 1-2.

Measurements: Lz (2, 10) 0.561-0.625 (0.042) 0.590mm; Iz (2, 10) 0.283-0.323 (0. 040) 0.308mm; Lo (2, 10) 0.154- 0.160 (0.013) 0.158mm; Io (2, 10) 0.152- 0.162 (0.012) 0.156mm.

Material: Maradah Formation, Z138, Sample nos. 23, 29, 43.

Distribution: Miocene (France and Algeria).

Romancheinidae Jullien, 1888

Eschrella peachi (Johnston, 1847)

1847 *Eschrella peachi* Johnston, 315, pl. 55, fig. 5.

1988 *Eschrella peachi* Moissette, p. 155, pl. 24, fig 122, pl. 13, fig. 6.

Measurements: Lz (1, 10) 0.325-0.346 (0.014) 0.~~338mm;~~ Iz (1, 10) 0.283-0.323 (0.024) 0.308mm; Lo (1, 10) 0.081-0.094 (0.0093) 0.092mm; Io (1, 10) 0.090- 0.096 (0.004) 0.092mm; Lav (1, 10) 0.161-0.173 (0.007) 0.171mm; Iav (1, 10) 0.173-0.232 (0.014) 0.210mm.

Material: Maradah Formation, Z138, Sample nos. 23, 35, 43, 49 (Fig. 5).

Distribution: Mediterranean, Arctic and East Atlantic range. Miocene (France); Pliocene (Italy, England); Pleistocene (England); Pleistocene (Italy).

Schizoporellidae Jullien, 1883

Schizoporella longirostris (Canu and Bassler, 1930)

1930 *Schizoporella longirostris* Canu and Bassler, 43, pl.4, figs.15-20, pl.5, figs.1-19.

1989 *Schizoporella longirostris* Schmidt, p. 39, pl. 11, figs. 5-8.

Measurements: Lz (2, 10) 0.393-0.452 (0.074) 0.422mm; Iz (2, 10) 0.232-0.374 (0.060) 0.353mm; Lo (2, 10) 0.082- 0.094 (0.053) 0.089mm; Io (2, 10) 0.012- 0.014 (0.050) 0.013mm; Lav (2, 10) 0.135-0.193 (0.074) 0.182mm; Iav (2, 10) 0.060-0.130 (0.060) 0.094mm.

Material: Maradah Formation, Z138, Sample nos. 23, 27, 29 (Fig. 5).

Distribution: Miocene (Italy, Rhone Basin-France, Algeria); Pliocene (Italy); Pleistocene (Italy).

Habitat: East Atlantic, Mediterranean, Red Sea. The present species range from 0.5 to 150m with 20-60m optimum range, Canu and Bassler (1930).

Bryocryptellidae Vigneaux, 1949

Porella cervicornis (Pallas, 1766)

(Fig. 8/ 3)

1766 *Millepora cervicornis* Pallas. p. 252.

1989 *Smittina cervicornis* Bishop and Hayward, p. 30, figs.. 114-118.

Measurements: Lz (2, 10) 1.750-1.960 (0.032) 0.795mm; Iz (2, 10) 0.348-0.454 (0.036) 0.374mm; Lo (2, 10) 0.164- 0.243 (0.023) 0.193mm; Io (2, 10) 0.147- 0.162 (0.022) 0.145mm.

Material: Maradah Formation, Z138, Sample nos. 25, 29, 31.

Distribution: Oligocene (Italy); Miocene (Egypt, Morocco, France, Italy, Portugal, Austria); Pliocene (Bays-Bas, Portugal, Spain, Italy, Tunisia, Algeria); Pleistocene (Italy).

Habitat: Mediterranean, 30-120m depth range, 40-60m optimum depth Atlantic (30-400m depth range); Red Sea (Gautier, 1961).

Family: Margarettidae Harmer, 1957

Margaretta cereoides (Ellis and Solander, 1786)

(Fig. 8/ 4)

1786 *Cellaria cereoides* Ellis and Solander, p. 26, pl. 5, figs. B-E.

2002 *Margaretta cereoides* El Safori, p. 450, pl. 7, fig. 6.

Measurements: Lz (2, 10) 1.430-1.560 (0.030) 1.495mm; Iz (2, 10) 0.468-0.49 (0.026) 0.481mm; Lo (2, 10) 0.130- 0.153 (0.023) 0.147mm; Io (2, 10) 0.172- 0.182 (0.012) 0.180mm.

Material: Maradah Formation, Z138, Sample nos. 40, 43, 47, 49 (Fig. 5).

Distribution: Eocene (Spain, Italy, France, and Egypt); Oligocene (Italy, Germany, Austria, Poland, and USA); Miocene (Italy, France, Egypt, Austria, Poland, Romania, Libya, Algeria, and Morocco); Pliocene (Italy, North Africa, and Central America).

Habitat: Adriatic, Mediterranean, Pacific, and Red Sea; Atlantic in tropical and subtropical regions (Schmid, 1989).

Metrarabdotosidae Vigneaux, 1949

Metrarabdotos moniliferum (Milne-Edwards, 1836)

(Fig. 8/ 5, 6)

1836 *Eschara monilifera* Milne-Edwards, 27, pl. 9, fig. 1.

1989 *Metrarabdotos moniliferum* Bishop and Hayward, p. 84, figs. 184-185.

Measurements: Lz (4, 6) 0.743-0.792 (0.024) 0.7848mm; Iz (4, 6) 0.283-0.323 (0.020) 0.318mm; Lo (4, 6) 0.132- 0.143 (0.023) 0.134mm; Io (4, 6) 0.125- 0.132 (0.013) 0.131mm; Lav (4, 4) 0.284-0.321 (0.015) 0.306mm; Iav (4, 4) 0.132-0.149 (0.016) 0.142mm; Lov (4, 3) 0.821-0.943 (0.012) 0.886mm; Iov (4, 3) 0.621-0.742 (0.028) 0.653mm.

Material: Maradah Formation, Z138, Sample nos. 17, 25, 27, 29, 40, 43, 46, 47, 49, 50, 51.

Remarks: According to Cheetham, (1968), the *M. moniliferum* species has non-costulate ovicell. Canu and Bassler (1920), however, mentioned the change of degree of ovicell costulation among the English, French and American specimens, and its non-specific importance.

Distribution: Miocene (Egypt, Italy, Germany, Austria, France); Pliocene (Italy, England, Belgium, Pays-Bas); Pleistocene (England); Quaternary (Italy).

Family Lepraliellidae Vigneaux, 1949

Celleporaria polythele (Reuss, 1848)

1848 *Cellepora polythele* Reuss, p. 77, pl. 9, fig. 18.

2002 *Celleporaria polythele* El Safori, p. 451.

Measurements: Lz (3, 10) 0.325-0.346 (0.054) 0.338mm; Iz (3, 10) 0.283-0.323 (0.060) 0.308mm; Lo (3, 10) 0.081- 0.094 (0.053) 0.092mm; Io (3, 10) 0.090- 0.096 (0.054) 0.092mm.

Material: Maradah Formation, Z138, Sample nos. 16, 20, 21, 23, 47, 49.

Remarks: *C. polythele* is characterized by the absence of advetitous avicularia and the presence of mammelar interzooecial projections.

Distribution: Miocene (Italy, France, Egypt, Austria, Netherlands, CSSR, Hungary).

Family Celleporidae Johnston, 1838

Celleporina tubifera Moissette, 1988

(Fig. 8/ 7, 8)

1988 *Celleporina tubifera* Moissette, p. 187, pl. 30, figs. 1-3.

Measurements: Lz (2, 10) 0.333-0.427 (0.034) 0.370mm; Iz (1, 10) 0.338-0.386 (0.023) 0.372mm; Lo (2, 10) 0.147- 0.174 (0.033) 0.163mm; Io (1, 10) 0.165- 0.187 (0.040) 0.152mm; Lav (2, 3) 0.359- 0.390 (0.018) 0.378mm; Iav (2, 3) 0.123- 0.143 (0.026) 0.133mm.

Material: Maradah Formation, Z138, Sample nos. 23, 25, 49, 50, 51.

Distribution: Miocene (Egypt, and Libya).

Turbicellepora coronopus (Wood, 1844)

(Fig. 8/ 9)

1844 *Cellepora coronopus* Wood, p. 18.

1992 *Turbicellepora coronopus* Pouyet and Moissette, p. 79, pl. 12, fig. 7.

Measurements: Lz (1, 10) 0.381-0.472 (0.074) 0.445mm; Iz (1, 10) 0.363-0.390 (0.020) 0.382mm;

Lo (1, 10) 0.072- 0.109 (0.094) 0.098mm; Io (1, 10) 0.090- 0.118 (0.075) 0.109mm; Lav (1, 10) 0.358-0.418 (0.093) 0.409mm. Iav (1, 10) 0.098-0.116 (0.029) 0.110mm.

Material: Maradah Formation, Z138, Sample nos. 16, 23, 49.

Distribution: Miocene (Egypt, and Libya).

PALEOGEOGRAPHIC DISTRIBUTION

Most of the Neogene bryozoans are preserved in Miocene and Pliocene basins in south Europe (Spain) and North Africa (Tunisia, Algeria, Morocco, Egypt and Libya), with additional occurrences in Germany, France, Austria and Poland, (Fig. 6). This distribution pattern suggests that bryozoans preferred low latitudes in the Mediterranean region. The Plio-Pleistocene bryozoan record, however, is restricted to Tunisia in North Africa and to Spain and Portugal in South Europe. Pouyet and David, (1987) concluded that the biogeography of the Neogene and Recent bryozoans in East Mediterranean (Aegean Sea) and West Mediterranean (Tyrhenian Sea) are paleogeographically united. The newly introduced in this study locality Z138, Jabal Zaltan, Northeastern Sirt Basin, (i.e. locality) is an important addition to the previous distribution of Pouyet and David (1987).

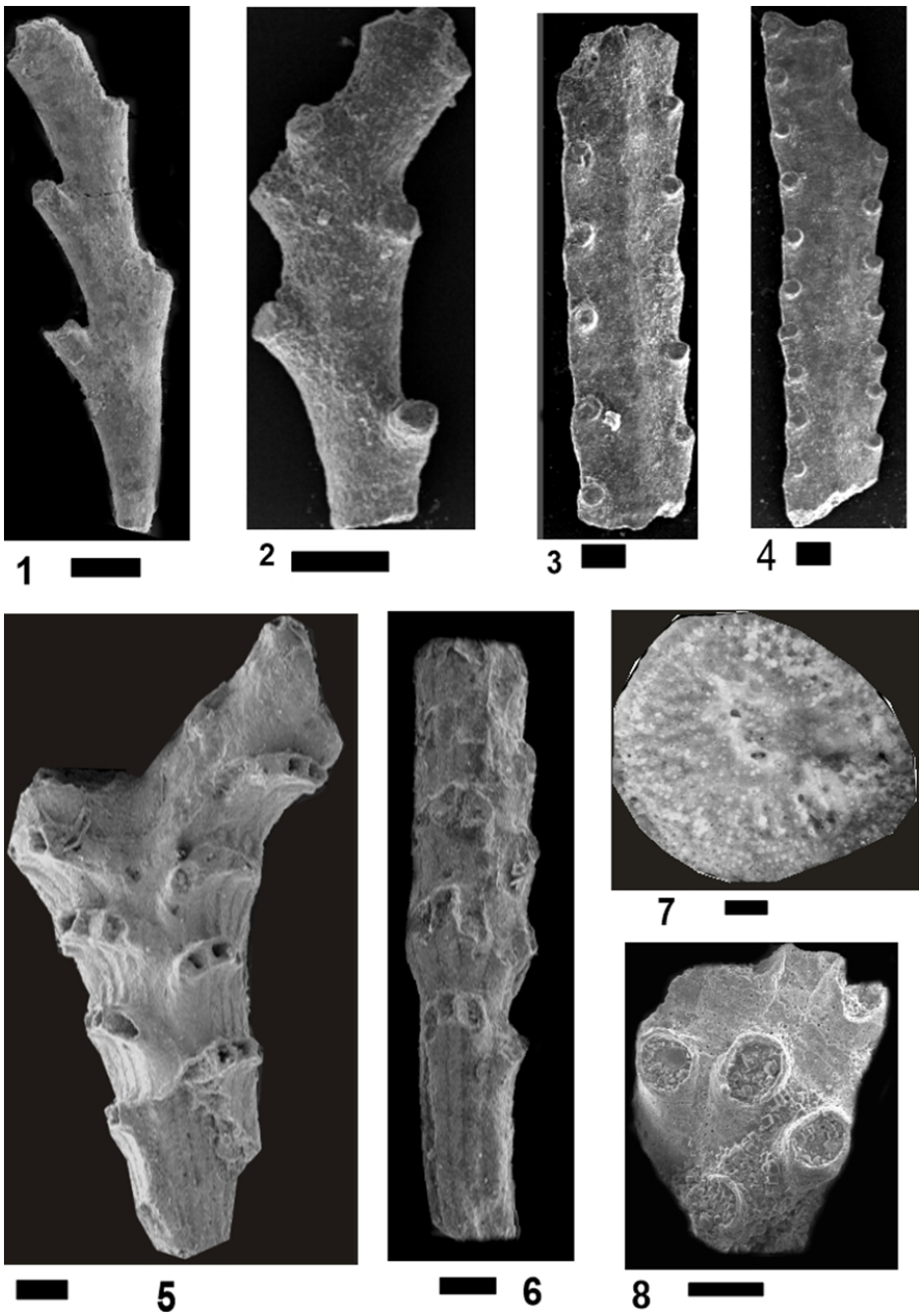

Fig. 6: 1. *Crisia eburnea* (Linnaeus, 1758), 2. *Crisia hauri* (Reuss, 1848), 3. *Crisia hornesi* Reuss, 1848, 4. *Crisia suezensis* El Safori 1994, 5. *Exidmonea atlantica* (Forbes in Johnston, 1847), 6. *Exidmonea undata* (Reuss, 1851), 7. *Disporella hispida* (Fleming, 1828), 8. *Ybselosoecia typica* (Manzoni, 1878). Scale bar = 200µm.

TAPHONOMY

It is true that bryozoans can be easily mixed with other sediments before the final burial, fact which can obscure some environmental signals. When, however, bryozoans are deposited in situ in life position, they are highly accurate in determining the paleoenvironment. Moreover, the different taphonomical features are very useful in interpreting depositional environments (i.e. bottom current, type of substrate, shell transportation and rate of sedimentation). The abrasion, dissolution, and encrustation are the three taphonomical signs recognized in the investigated assemblages of Ar Rahlah Member of Maradah Formation at Z138 section.

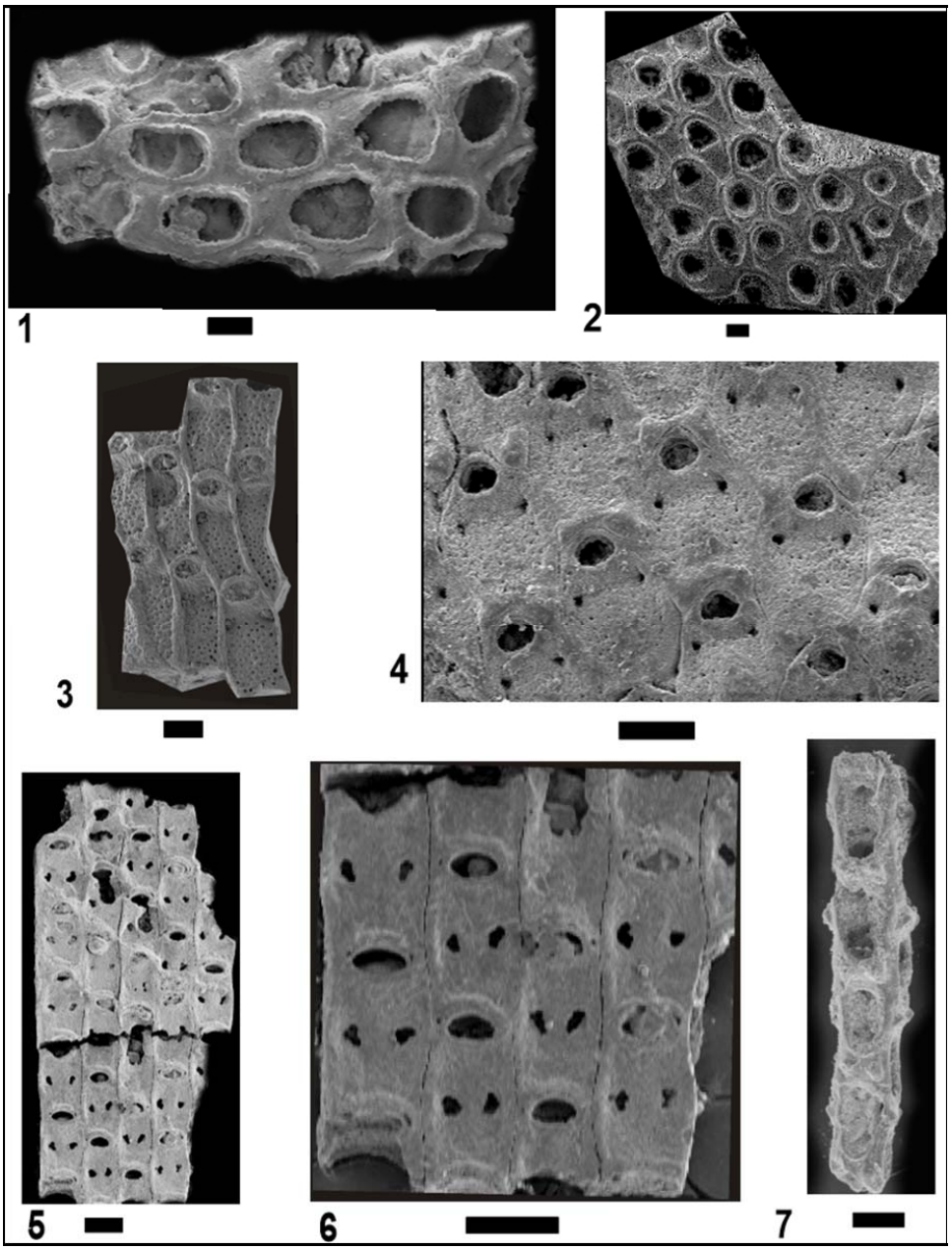

Fig. 7: 1. *Conopeuim lacroixi* (Audouin 1826), 2. *Smittipora sp.,* 3. *Calpensia gracilis* (Münster, 1826), 4. *Calpensia spinosa* n. sp., 5, 6. *Thalamoporella zaltaniensis* n. sp., 7. *Nellia tenella* (Lamarck, 1816). Scale bar = 200µm.

CONCLUSIONS

The productive carbonate deposits of Ar Rahla Member of Maradah Formation (Serravallian) at the studied locality Z138 in Jabal Zaltan, Sirt Basin yields common bryozoan remains. A descriptive taxonomy has been performed with illustrations for twenty-one species from this measured Serravalian Maradah Formation. The identified taxa consist of 48% encrusted forms (which are represented by Membraniporiform and Celleporiform) and 52% erecting forms (which are representing by rigid growthform and erect flexible growth form). Among this unique assemblage only two new species namely *Calpensia spinosa* n. sp. and *Thalamoporella zaltaniensis* n. sp. have been described in this paper. Shells of *Cubitostrea* mostly provide the most attachments of the encrusted bryozoan forms.

The reported species are of Mediterranean/Atlantic distributional affinity. However the new species are considered endemic. The limestones and marls are rich in erect flexible and encrusting forms which indicate inter-subtidal (10-50m) environments with moderate rate of sedimentation and relatively strong wave actions. Highly agitated environment is specially recognized from the investigated assemblages of the lower part of Maradah Formation (Ar Rahlah Member) as suggested on taphonomical basis.

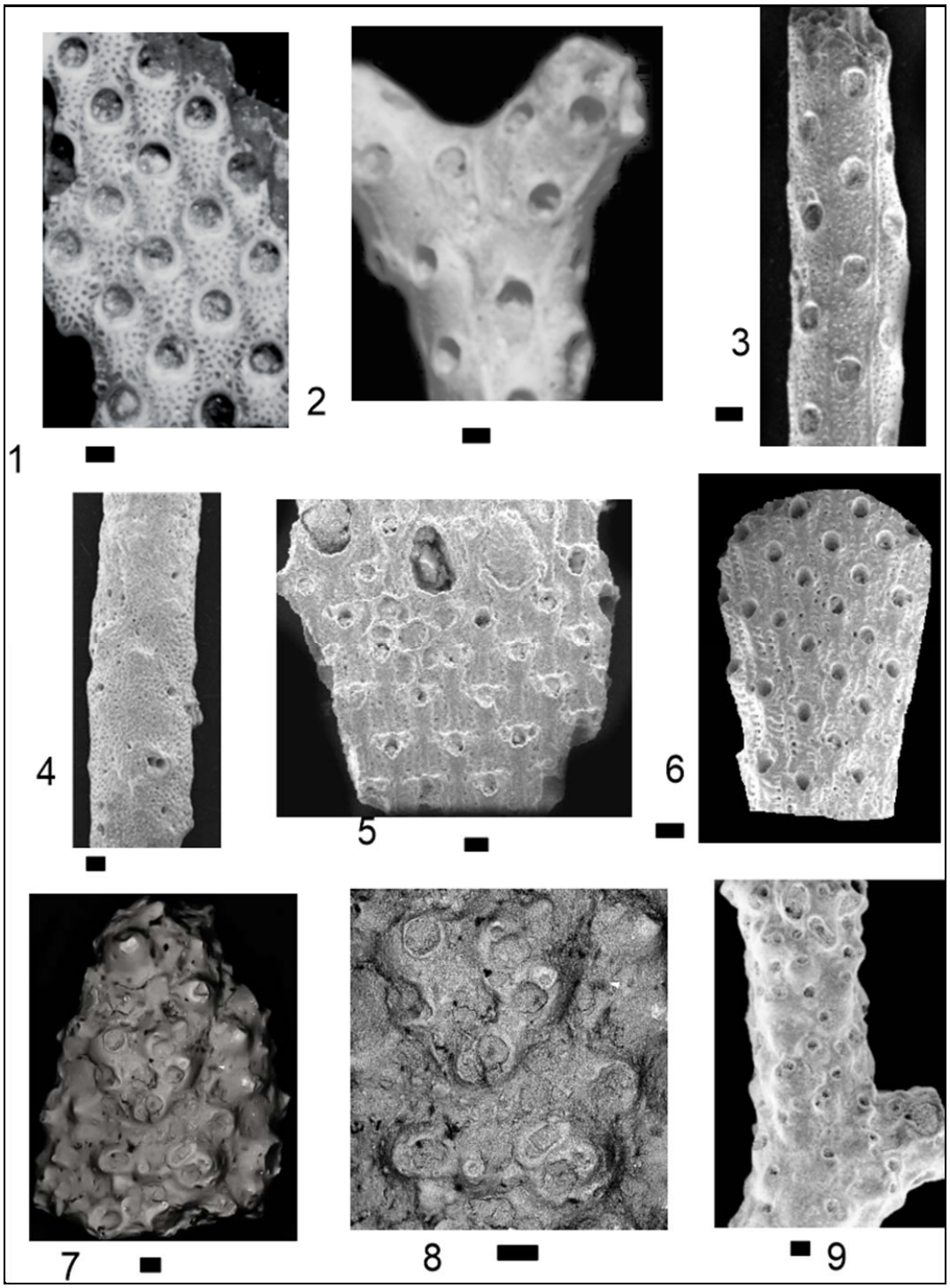

Fig. 8: 1. *Mucropetraliella plana* Moissette (1988), 2. *Dakaria bitubeculata* (Canu and lecointre, 1928), 3. *Porella cervicornis* (Pallas, 1766), 4. *Margaretta cereoides* (Ellis and Solander, 1786), 5, 6. *Metrarabdotos moniliferum* (Milne-Edwards, 1836), 7, 8. *Celleporina tubilifera* Moissette, 1988, 9. *Turbicellepora coronopus* (Wood, 1844). Scale bar = 200µm.

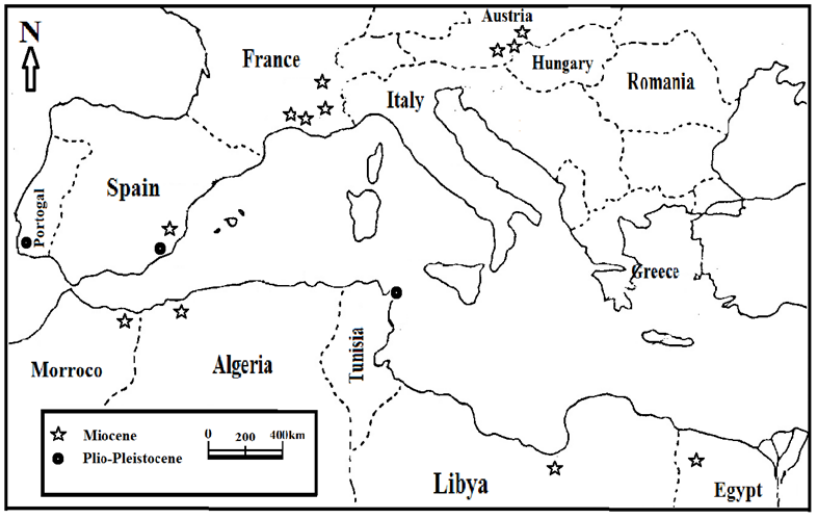

Fig. 9: Geographical distribution of main Neogene bryozoans deposits from Mesogean realm (modified after Pouyet and David, 1987).

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Miocene bryozoans from Jabal Zaltan, Northeast Sirt basin

جماعيات الميوسين من جبل زلطن، شمال شرق حوض سرت ، ليبيا

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الخلاصة

تم تصنيف اثنين وثلاثين نوع من مستعمرات احافير الجماعيات من تكوين مردة لعصر الميوسين الاوسط (السرافاليان) والمجمعه من قطاع مردة "Z138 "، جبل زلطن، شمال شرق حوض سرت ، ليبيا. من بين هذا التجمع لاحافير الجماعيات تم التعرف على نوعين من المستعمرات المستوطنه وتم دراستهم كنوعين جديدين وهما *Calpensia spinosa* و *Thalamoporella zaltaniensis*. وقد وفر السطح الداخلى لمحاريات Cubitostrea معظم الاسطح المناسبه لالتصاق مستعمرات احافير الجماعيات.

تشير الأنواع المسجلة فى تلك الدراسة الى تبعيتها للتوزيعات الحيويه للمتوسطي–الأطلسي فى حين تعتبر الأنواع الجديدة فى الدراسة الحالية من الأنواع المستوطنة. كذلك توفرت انواع الجماعيات ذات نمطى النمو القشرى السطحى و مرن الانتصاب فى صخور الحجر الجيري والمارل فى الجزء العلوى من تكوين مردة و تشير تلك المستعمرات الى بيئات تتراوح اعماقها ما بين ١٠ و ٥٠ متر وتتميز بمعدل معتدل للترسيب وتاثيرات موجية قوية نسبيا. فى حين يتميز الجزء السفلي من تكوين مردة بالترسيب تحت تاثيرات موجية قوية كما هو مقترح من زيادة الجماعيات ذات نمط النمو مرن الانتصاب.