The radiolarian age and petrographic composition of a block of the Lower Jurassic volcaniclastic breccia and chert of the Mamonia Complex, SW Cyprus

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1. INTRODUCTION

The geology of southwestern Cyprus is characterized by extensive occurrences of Mesozoic allochthonous rock assemblages that were grouped together as the Mamonia Complex (GASS, 1960; LAPIERRE, 1975; ROBERTSON & WOODCOCK, 1979; SWARBRICK & ROBERTSON, 1980; MALPAS et al., 1992). The Mamonia Complex is divided in two major sub-groups, the Ayios Photios Group and the Dhiarizos Group, including extensive zones of tectonic mélangé known as the Mamonia Mélange (Fig. 1). The Ayios Photios Group (SWARBRICK & ROBERTSON, 1980) consists of Upper Triassic to Upper Cretaceous sedimentary units (BRAGIN & KRYLOV, 1996; 1999; BRAGIN et al., 2000; BRAGINA & BRAGIN, 2016), while the Dhiarizos Group (SWARBRICK & ROBERTSON, 1980) is composed of Upper Triassic to Lower Cretaceous basic volcanic rocks and their sedimentary cover. The Mamonia Mélange consists of a sedimentary matrix of highly tectonized siltstones and mudstones of the Ayios Photios Group, mixed with different-sized blocks from various lithologies of the Mamonia Complex and to a lesser extent from the Troodos Ophiolite (GEOLOGICAL SURVEY DEPARTMENT OF CYPRUS, 2008; 2015).

The age determination of the Mesozoic sedimentary sequences of the Mamonia Complex is estimated from the presence of radiolarian chert and cherty mudstone layers within these deposits, indicating that the radiolarian biostratigraphy is of significant importance for the dating of these deep-water lithologies, which lack other macrofossils or foraminifers.

This article presents new petrographic and palaeontological data from a sedimentary-volcaniclastic breccia block that presumably represents the lower part of the sedimentary cover of the Dhiarizos Group. This work represents the first time that this type of Lower Mesozoic sedimentary-volcaniclastic breccia, of southwestern Cyprus, is studied from a micropalaentological/biostatigraphical perspective.

2. GEOLOGICAL SETTING

Two main Mesozoic rock complexes are widespread in southwestern Cyprus: the Troodos Ophiolite Complex and the Mamonia Complex (Fig. 2A). Both are allochthonous and form systems of nappes, the relationship between them is strictly tectonic. The Mesozoic complexes of Cyprus reflect the history of the southern branch of Neotethys. The Mamonia Complex represents the Upper Triassic to Cretaceous deposits and Upper Triassic volcanics of the northern margin of Gondwana, whereas the Troodos Complex constitute Cretaceous oceanic formations. Both complexes became juxtaposed in the Late Cretaceous with the development of the nappe system with chaotic assemblages (mélanges andolistostomes).

The Troodos Ophiolite Complex is a fully developed fragment of oceanic lithosphere that consists of lithologies ranging from upper mantle harzburgites to pillow lavas, overlain by umberr (hydrothermal sediments) with radiolarian cherts of the upper Turonian to uppermost Santonian Perapedhi Formation (WILSON, 1959; SWARBRICK & ROBERTSON, 1980; BLOME & IRWIN, 1985; BRAGINA & BRAGIN, 1996; BRAGINA, 2012; 2016). The latter are locally capped by a sedimentary sequence consisting of Campanian to middle Maastrichtian bentonitic clays and volcaniclastic sandstones and siltstones of the Kannaviou Formation (ROBERTSON & HUDSON, 1974; ROBERTSON, 1977).

The Mesozoic lithologies of the Mamonia Complex are mainly grouped into the Ayios Photios Group (sedimentary) and the Dhiarizos Group (volcano-sedimentary), (ROBERTSON & WOODCOCK, 1979; SWARBRICK & ROBERTSON, 1980), which are subdivided into a number of sub-units (Fig. 1). The Ayios Photios Group consists of the following sub-units: the Vlampouros Formation (Upper Triassic siliciclastics and micritic limestones with minor chert interlayers) (SWARBRICK & ROBERTSON, 1980; BRAGIN & KRYLOV, 1996; TORLEY & ROBERTSON, 2018) and the Episkopi Formation (Middle Jurassic to...
middle Cretaceous, Albian–Turonian, alternating layers of cherts, mudstones, limestones, sandstones, siltstones and clays) (SWARBRICK & ROBERTSON, 1980; BRAGIN & KRYLOV, 1999; BRAGIN et al., 2000). The thick Lower Cretaceous sandstones within the Episkopi Formation are referred to as the Akamas Member or the Akamas Sandstone (SWARBRICK & ROBERTSON, 1980). Several authors in previous studies have included within this group another sub-unit, referred to as the Marona Formation to describe blocks of Upper Triassic hemipelagic limestones (SWARBRICK & ROBERTSON, 1980; TORLEY & ROBERTSON, 2018).

The Dhiarizos Group consists of the following sub-units: the Phasoula Formation (Upper Triassic basic volcanics with interlayers of limestones and cherts) (SWARBRICK & ROBERTSON, 1980; BRAGIN, 2007; 2010), the Loutra tis Aphroditis Formation (Upper Triassic lava breccias and volcaniclastic breccias with interlayers of volcaniclastic siltstones and radiolarian mudstones) (SWARBRICK & ROBERTSON, 1980), the Petra tou Romiou Formation (detached blocks of Upper Triassic reefal limestones) (HENSON et al., 1949; SWARBRICK & ROBERTSON, 1980; MARTINI et al., 2009), and the Mavrokolympos Formation (Jurassic to Cretaceous alternating layers of limestones, cherts, mudstones, siltstones and calcilutites) (SWARBRICK & ROBERTSON, 1980). The sedimentary interlayers within and above the Phasoula and Loutra tis Aphroditis formations are referred to as the Kholetria Member and are represented by chert-limestone alternations (SWARBRICK & ROBERTSON, 1980). Furthermore, the greenschist- to amphibolite-facies metamorphic rocks are termed the Ayia Varvara Formation (metasediments and metavolcanics of various Dhiarizos lithologies, metamorphosed during the Cretaceous) (MALPAS et al., 1992; CHAN et al., 2007; 2008).

For the purposes of this study, field work was conducted in the southwestern part of the Akamas Peninsula (Fig. 2). This area is characterized by the extensive distribution of the Ayios Photios Group lithologies and the Mamonia Melange. Furthermore, seve-
ral big blocks of the Dhiairizos Group (mainly the Phasoula For-

mation) are also observed within the Mamonia Mélange. These
blocks are mainly composed of basic volcanics commonly with
interbeds of limestone and radiolarian chert. One of these blocks
is composed of sedimentary-volcaniclastic breccia consisting
mainly of fragments of basalts, diabases and gabbro, with inter-
layers of limestones and cherts that yield abundant radiolarian
assemblages.

This roughly rounded block is located 2.5 km east-northeast
of the northern Lara Bay (Fig. 2) and has an extent of 270 x 200
m, with an elongated axis along a SW – NE direction (Fig. 3, Fig.
4A, B). The studied breccia block is in tectonic contact with the
surrounding matrix of the Mamonia Mélange, that yields
numerous small blocks of Lower Cretaceous Akamas Sandstone
of the Episkopi Formation (SWARBRICK & ROBERTSON,
1980) (Fig. 4C), Upper Triassic limestones of the Petra tou Ro-
mioi Formation or the Kholetria Member (SWARBRICK &
ROBERTSON, 1980), as well as basic volcanics of the Upper Tri-
assic Phasoula Formation. The matrix of the mélangé consists of
reddish-grey to brownish-grey mudstones and siltstones. Further-
more, another, smaller block of similar breccia was identified near
the NW boundary of the studied breccia block (Fig. 3, sampling
location 18-19).

From the detailed survey of the large breccia block, from the
northwestern boundary (point 18-18, coordinates 34° 58’ 22,4”
N, 32° 20’ 13,4” E) towards its southern edge (point 18-15, coor-
dinates 34° 58’ 17,5” N, 32° 20’ 19,9” E) (Fig. 3, 4, 5, 6), various
individual units of the block were recognized and described:
1. Greenish-grey hard cemented breccia mainly consisting
of small (3-5 up to 15-20 cm in size) diabase and subor-
2. Greenish-grey and reddish-brown hard cemented breccia
of metabasalt, diabase and metagabbro clasts with rare
small fragments of red recrystallized limestone in a
coarse-grained to gravelly matrix of metabasalt, diabase
and metagabbro. Lenses (1-2 m thick) of breccia within a
pinkish matrix of highly brecciated limestone, occur in the
upper part of the unit. The thickness of the unit is 100 m.
3. Pink to greenish-brown hard cemented breccia of diabase
and metabasalt clasts within a matrix of highly brecciated
pink to white limestone (Fig. 4F). The thickness of the
unit is 4 m.
4. Greenish-grey hard cemented breccia with lenses (1,5 m
thick) of breccia within a matrix of highly brecciated
pink to white limestone (Fig. 4E). The thickness of the
unit is 20 m.
5. White to pink, hard, thin-bedded recrystallized lime-
stones with calcite veins (Fig. 5F). The thickness of the
unit is 2 m.
6. Greenish-grey hard cemented breccia consisting of met-
basalt, diabase and metagabbro fragments and blocks
(Fig. 4G, H) in a coarse-grained to gravelly matrix of the
same composition. The thickness of the unit is 5 m.
7. Brick-red and crimson-red, thin-bedded radiolarian
cherts (Fig. 5D) with interbeds (0,5 – 1 m) of pink and
white hard recrystallized limestones (Fig. 5E). The thick-
ness of the unit is 20 m.
8. Greenish-grey to reddish-brown, hard cemented breccia
consisting of diabase and metagabbro fragments and
blocks as well as rare fragments of siltstones in a coarse-
grained to gravelly matrix of the metabasalt, metagabbro
and diabases. The thickness of the unit is 5 m.
9. Brick-red, thin-bedded radiolarian cherts intercalated
with red cherty mudstones. Interbeds (up to 1 m) of dark-
Figure 4. Volcaniclastic breccia of the Akamas Peninsula. Outcrops of breccia. A – Block of the breccia, view from the south; B – Same block, view from the east; C – Contact between the breccia (left) and the Mamonia Mélange (right, with scattered blocks of Akamas Sandstone); D – Breccia composed of small diabase and metabasalt clasts in a volcaniclastic matrix (unit 10); E – Breccia with carbonate (calcite) matrix (unit 4); F – Breccia with well-developed carbonate matrix represented by pink micritic limestone (unit 3); G – Block of metagabbro (unit 6); H – Blocks of diabase (unit 6).
greenish-grey breccia with fragments of metabasalt and metagabbro and lenses of pink recrystallized brecciated limestone are observed in the middle part of this unit. The contact between the chert and breccia layers is clearly sedimentary (Fig. 5A-C). The thickness of the unit is 5 m.

10. Dark-greenish-grey hard cemented breccia composed of unsorted diabase and metabasalt fragments in a coarse-grained to gravelly matrix of the same composition (Fig. 4D). The thickness of the unit is 6 m.

It is herein assumed that this fragmentary section is the lower part of the sedimentary cover of the Upper Triassic volcanics of the Diarizos Group, which consists of breccia, while the upper part of the succession is characterized by the presence of limestone and radiolarian chert layers that become more and more abundant towards the top.

3. MATERIALS AND METHODS

Twenty-five samples of various rock types including metavolcanics, limestones and cherts were collected during fieldwork in 2018 and 2019. The petrography of the acquired rock samples was studied in standard thin-sections using a light microscope Olympus BS51. Radiolarians were extracted from chert samples using diluted (5%) hydrofluoric acid (HF) for twelve (12) hours and the residues were rinsed with water and dried. The residues were studied using a light microscope LOMO-MBS-10. The microfos-
Sills were collected, mounted, studied in detail and photographed with scanning electron microscopes: TESCAN 2300 in the Geological Institute RAS, Moscow, and TESCAN VEGA-II XMU in the Palaeontological Institute RAS, Moscow. Thin sections and radiolarian assemblages are stored in the Geological Institute RAS, Moscow, Russia.

4. PETROGRAPHY

4.1. Breccia with carbonate matrix

The breccia consists of metabasalt, diabase and metagabbro blocks and clasts that are irregularly shaped, sub-angular and poorly sorted. These rock fragments vary from a few centimetres to 10-15, rarely 20-30 cm in size. The matrix is represented by micritic limestone or recrystallized calcite.

4.1.1. Breccia clasts

Metabasalts are represented by amygdaloidal aphyric, plagioclase- and clinopyroxene-plagioclase porphyric varieties (Fig. 7A, B, 8A, B). Phenocrysts of clinopyroxene are represented by short-prismatic crystals (0.4-0.9 mm) and are partly replaced by amphibole. Phenocrysts of plagioclase are tabular and often elongated tabular zoned crystals (0.2 mm); plagioclase is completely altered pseudomorphs of albite, epidote group mineral and chlorite creating a very fine-grained aggregate. The groundmass exhibits hyaloplitic and interstratified textures. The interstratified groundmass is composed of altered plagioclase, altered pyroxene and opaque minerals; the hyaloplitic groundmass is composed of elongated, needle-shaped, often skeletal plagioclase and altered glass replaced by a black opaque substance.

Diabase (Fig. 7C) is composed of pseudomorphs after the alteration of plagioclase and pyroxene crystals, Fe-Ti oxides, quartz and micrographic intergrowths of quartz with feldspar. Plagioclase pseudomorphs are nearly euhedral in form, elongated tabular grains of a microcrystalline aggregate of epidote, colourless chlorite and albite in cores or rims. Pyroxene pseudomorphs are nearly euhedral and anhedral grains, represented by light-green to colourless amphibole with tiny inclusions of titanite. Fe-Ti oxides, which are abundant in the rock, comprise euhedral crystals with lacy edges. Minor quartz (<1%) and its intergrowths with feldspar (<1%) fill interstices. The rock texture is doleritic.

4.1.2. Carbonate matrix

The matrix is represented mainly by pink to white micritic limestone which is often strongly brecciated and cut by calcite veins (Fig. 8A, B). This matrix yields small non-sorted clasts of metabasalts and chlorite (formed supposedly after volcanic glass). Sometimes, the matrix is represented by highly recrystallized calcite. There is no visible layering of the matrix. Rare epidote group minerals are present in the carbonate matrix between clasts (Fig. 7B).

4.2. Breccia with sandstone-gravel matrix

This type of breccia is composed of metabasalt, diabase and metagabbro blocks, altered volcanic glass, quartz-albite-chlorite-epidote aggregates and rarely siltstone clasts. Blocks and clasts are irregularly shaped, sub-rounded and poorly sorted rock fragments from predominantly few centimetres up to 20-30 cm in size. The matrix is represented by sandstone-gravel that has the same composition with the large (both rock and mineral debris) clasts.

Breccia clasts

Metabasalts and diabase are represented by the same lithologies as clasts of the breccia with carbonate matrix.

Metagabbro (Fig. 7D) is composed of clinopyroxene, pseudomorphs after the alteration of plagioclase and an accessory opaque mineral. Clinopyroxene is preserved only in relics and is largely replaced by green to light-yellow amphibole with lamellae of an opaque mineral (<100 µm in size) and chlorite with interference in a blue colour. Plagioclase pseudomorphs form euhedral tabular grains, composed of a microcrystalline aggregate of albite, an epidote group mineral and chlorite. The opaque mineral is anhedral. Metagabbro is a fine- to medium-grained rock exhibiting a primary hypidiomorphic-granular texture.

Some clasts exhibit no primary textures. Intensively fractured clasts of presumably altered volcanic glass (Fig. 7E) consist of pale-green and colourless chlorite with minor hydrogarnet and fine- to medium-grained aggregates of quartz, albite, epidote group mineral and chlorite which are produced from an unidentified rock.
Figure 7. Clasts typical of breccia. A – plagioclase-pyroxene porphyric basalts with intersertal groundmass (sample 18-17-6, unit 4); B – clasts of amygdaloidal aphyric basalt with a hyalopilitic groundmass and chlorite presumably after volcanic glass in carbonate matrix (sample 18-17-3, unit 4); C – diabase (metadolerite), enriched by ore minerals (sample 18-16-2, unit 8); D – metagabbro with plagioclase replaced by albite, zoisite and chlorite, and with clinopyroxene replaced by amphibole (sample 18-20-2, unit 1); E – fractured clast of chlorite with minor hydrogarnet presumably after volcanic glass in sandstone matrix dominated by quartz and plagioclase (sample 18-15-2, unit 10); F – clasts of siltstone and aggregate of quartz, albite, epidote group mineral and chlorite (sample 18-15-3, unit 10); G – detail of siltstone clast, polarized light (sample 18-15-3, unit 10); H – detail of siltstone clast (sample 18-15-3, unit 10).
Siltstone clasts (sample 18-15-2, unit 10, Fig. 7F-H) are composed of quartz and feldspar (albite). The supporting matrix is composed of chlorite and an epidote group mineral. Thin fractures are filled by carbonate minerals.

Sandstone-gravel matrix
Sandstone-gravel matrix is represented by the same lithologies as in the blocks and clasts. The matrix exhibits no layering or sorting. Occasional veins of calcite are present.

4.3. Limestone and radiolarian chert beds and lenses within the breccia succession
Limestones and radiolarian cherts form interbeds and lenses within the breccia. Limestones are represented by micrites which are commonly brecciated, and sometimes contain recrystallized radiolarian remains. Stylolites and fractures filled by calcite are common; these fractures are commonly confined to limestone clasts (Fig. 8C, D).

Red radiolarian cherts usually yield abundant, moderately, to poorly preserved radiolarian assemblages. Fractures are filled by quartz (Fig. 8E, F).

5. RADIOLARIAN ASSEMBLAGE AND AGE OF BRECCIA
Abundant radiolarians are present in the chert beds of the upper part of the studied section (Plate 1, 2, localities 18-15 and 18-16). The systematic composition of the radiolarian assemblages re-
covered from units 7 and 9 (Fig. 6) is similar (Table 1). The presence of several characteristic taxa within the radiolarian assemblages is used to determine the age of the radiolarian cherts (Fig. 9). Primary attention was given to well-preserved radiolarians determined to the species level useful for dating. Taxa described in open nomenclature are of secondary importance.

**Sample 18-15-6**

This sample yielded an abundant and diverse assemblage that allowed successful dating (Fig. 9, Table 1).

Bagotum maudense PESSAGNO & WHALEN is present in the upper Sinemurian – lower Toarcian of Canada (PESSAGNO & WHALEN, 1982; CARTER ET AL., 2010) and in the lower Toarcian of Japan (YAO, 1997), and in the upper Pliensbachian of Oman (BLEICHSCMIDT et al., 2004). The presence of this species in the upper Sinemurian is documented on Kunga Island (Haida Gwaii) in the Sinemurian part of the Sandilands Formation together with the ammonite *Tetraspidoceras* sp. (see fig. 3 in CARTER et al., 2010). The range of species according to the present data is upper Sinemurian – lower Toarcian.

Beatricea argescens (CORDEY) is known from the Pliensbachian of British Columbia, Canada (CORDEY, 1998; GORIČAN et al., 2006) and from the Lower Jurassic of Japan and New Zealand (GORIČAN et al., 2006).

**Table 1. Taxonomic composition of studied samples of radiolarian cherts. A – abundant, C – common, R – rare.**

| Radiolarian taxa                          | Samples          |
|------------------------------------------|------------------|
|                                          | 18-15-6 | 18-15-7 | 18-15-8 | 18-16-7 |
| Bagotum maudense PESSAGNO & WHALEN       | R       |
| Beatricea sp. cf. B. christovalensis WHALEN & CARTER | R       |
| Beatricea sp.                             | C       | R       | R       |
| Bipedis hannai WHALEN & CARTER           | R       |     |
| Bipedis patricki WHALEN & CARTER         | R       | R       | C       |
| Canoptum sp. cf. C. anulatum PESSAGNO & POISSON | R       |
| Canoptum sp. cf. C. artum YEH             | R       |
| Charlottea weedensis WHALEN & CARTER     | R       |
| Gorgansium gongyloideum KISHIDA & HSADA  | A       | C       | C       | C       |
| Gorgansium morganense PESSAGNO & BLOME   | R       |
| Katroma sp. cf. K. irving WHALEN & CARTER| R       | R       | C       |
| Katroma ninintisi CARTER                 | C       | R       | C       |
| Lantus sp.                               | R       |
| Pantanellium sii WHALEN & CARTER         | A       | R       | R       |
| Paronaella grahamensis CARTER            | C       | C       |
| Paronaella sp. cf. P. notabilis WHALEN & CARTER | R       |
| Prahecasaturnalis tetraradatus KOZUR & MOSTLER | R       |
| Pseudoeucyrtis busungaensis (YEH & CHENG) | R       | C       |
| Pseudoeucyrtis sp. cf. P. busungaensis (YEH & CHENG) | R       | C       |
| Udalia primaeva WHALEN & CARTER          | R       |

Figure 9. Stratigraphic ranges of selected radiolarian taxa and proposed dating of the breccia unit.
**Geologia Croatica**

**6. THE ORIGIN AND SIGNIFICANCE OF BRECCIA**

The studied block of volcaniclastic breccia represents a new undescribed unit of the Dhiarizos Group. It differs from other units of the Dhiarizos Group by its composition and origin. The breccia consists of fragments of metabasalts, diabases and metagabbros with minor fragments of silstones. The supporting matrix of the breccia can vary – from sandy consisting of grains of diabase and other igneous rocks to recrystallized micritic carbonates. Several beds of micritic limestone and radiolarian chert are present within the breccia. The presence of silstone fragments and sedimentary contacts between the breccia, limestone and chert beds are an indication of the sedimentary origin of the breccia.

The volcaniclastic breccia is closely related with the volcanic units of the Dhiarizos Group, such as the Phasoula and Loutra tis Aphroditi formations, which could be the source of the clastic material. The breccia may have originated via underwater erosion of previously formed basic volcanics. The breccia is characterized by the irregular, poorly rounded character of the rock.
fragments, and by the absence of any sorting or stratification. The deposition of the breccia was probably local – along steep slopes or in narrow depressions triggered by tectonic movements. The formation of the breccia took place simultaneously with deep-water carbonate-chert sedimentation. The beds of micritic limestone and radiolarian chert within the breccia display a close affinity with the Upper Triassic – Lower Jurassic Kholoetria Member of the Dhiarizos Group.

Similar Mesozoic volcaniclastic sedimentary breccias are known in various regions of the Mediterranean, either related to the upper part of plutonic and intrusive sequences of ophiolite complexes or formed within volcanic sequences (KNIPPER, 1978). The latter type is characterized by the predominance of clastic material consisting of dolerites, basalts and altered gabbro, while serpentinites are rare. These breccias can occur within or at the top of volcanic sections and they usually have sedimentary relationships with chert layers. Such breccias were studied in detail in the Ligurian Alps (GIANELLI & PRINCIPI, 1974).

Thus, the Lower Jurassic breccia in the Akamas Peninsula represents the lower part of the Dhiarizos Group sedimentary section. The presence of radiolarian cherts related with volcaniclastic breccias is of significant interest as according to many studies the Rhaetian to Toarcian (Liassic) cherts are very rare in the Mediterranean Region, and, if present, they can be related to breccias, as in the lesser Caucasus (KNIPPER et al., 1987) and Greece (CHIARI et al., 2013).

7. CONCLUSIONS

Volcanoclastic breccia of sedimentary origin, composed mainly of blocks and clasts of metabasalts, diabase and metagabbro, has been described from the Akamas Peninsula, western Cyprus.

Interbeds of radiolarian cherts within breccia yield radiolarian assemblages that allow dating of the breccia as Lower Jurassic, Sinemurian – Pliensbachian. The Triassic volcanics of the Phasoula Formation can be the source of the clastic material of the breccia. The breccia represents a previously unknown lower part of the sedimentary cover of the Triassic volcanics (Phasoula Formation, Mamonia Complex).

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REFERENCES

BAUMGARTNER, P.O., BERNOULLI, D., STAMPFLI, G.M. & CHIARI, M. (2003): Stratigraphic architecture of the northern Oman continental margin – Me- sozoic Hadramut Dau Group, Hawasina complex, Oman. – GeoArabia, 9, 2, 1-12. BLOME, C.D. & IRWIN, W.R. (1985): Equivalent radiolarian ages from ophiolitic terranes of Cyprus and Oman. – Geology, 13, 6, 401–404. doi: 10.1130/0091-7613(1985)13<401:EERA3>2.0.CO;2 BORTOLOTTI, V., CARRAS, N., CHIARI, M., FAZZUOLI, M., MARCUCCI, M., PHOTIADIES, A. & PRINCIPI, G. (2003): The Argolis peninsula in the palaeo-geographic and geodynamic frame of the Hellenides. – Ophiolite, 28, 79-94. BRAGIN, N.Y. (2007): Late Triassic radiolarians of southern Cyprus. – Palaeontological Journal, 41, 951-1029. doi: 10.1134/S0303301007100002 BRAGIN, N.Y. (2010): Stratigraphy of Mesoovic (Upper Triassic–Lower Cretaceous) volcanogenic-sedimentary deposits of the Dhiarizos Group, the Allochthonous Mamonia Complex of Cyprus. – Stratigraphy and Geological Correlation, 18/2, 118-132. doi: 10.1134/S0869593810020024 BRAGIN, N. & BRAGINA, L. (2017): Early and Middle Jurassic (Plenuschian to Bas- jocian) Radiolaria from cherts of Kiselevka-Manoma accretionary complex (Amur River, Eastern Russia). – Ophiolite 42, 1-19. BRAGIN, N.Y. & KRYLOV, K.A. (1996): Stratigraphy and lithology of the Upper Triassic deposits of southwestern Cyprus (Vlambourou Formation). – Stratigraphy and Geological Correlation, 4/2, 132-140. BRAGIN, N.Y. & KRYLOV, K.A. (1999): Stratigraphy and formation conditions of the Jurassic silicous and terrigenous deposits in southwestern Cyprus. – Stratigraphy and Geological Correlation, 7/4, 333-342. BRAGIN, N.Y., BRAGINA, L.G. & KRYLOV, K.A. (2000): Albian-Cenomanian de- posits of the Mamonia Complex, Southwestern Cyprus. – In: PANAYIDES, I., XENOPHONTHOS, C. & MALPAS, J. (eds.): Proceedings of the Third Interna- tional Conference on the Geology of the Eastern Mediterranean, Nicosia, 1998, 309-315. BRAGIN, L.G. (2012): Radiolarian biostatigraphy of the Perapedi Formation (Cy- prus): implications for the geological evolution of the Troodos Ophiolite. – Bulletin de la Société Géologique de France, 183/4, 347–353. doi: 10.2113/gsge- bull.183.4.343 BRAGIN, L.G. (2016): Radiolarian-based zonal scheme of the Cretaceous (Alban- Santonian) of the Tethyan regions of Eurasia. – Stratigraphy and Geological Correlation, 24/2, 141-166. BRAGINA, L.G. & BRAGIN, N.Y. (1996): Stratigraphy and radiolarians from the type section of Perapedi Formation (Upper Cretaceous Cyprus). – Stratigraphy and Geological Correlation, 4/3, 246-253. BRAGINA, L.G. & BRAGIN, N.Y. (2016): Cretaceous (Albian to Turonian) radiolarians from chert blocks of Moni Mèlange (Southern Cyprus). – Revue de micropaléo- tologie, 59/4, 311–338. doi: 10.1016/j.revmip.2016.05.002 CARTER, E.S., CAMERON, B.E.B. & SMITH, P.L. (1988): Lower and Middle Jurassic radiolarian biostatigraphy and systematic, paleontology, Queen Charlotte Islands, British Columbia. – Bulletin Geological Survey Canada, 386, 1–109. CARTER, E.S. & HORI, R.S. (2005): Global correlation of the radiolarian faunal change across the Triassic-Jurassic boundary. – Canadian Journal of Earth Sciences, 42, 777–790. doi: 10.1139/e05-050 CARTER, E.S., WHALEN, P.A. & GUEX, J. (1998): Biochronology and paleontology of Lower Jurassic (Hettangian and Sinemurian) radiolarians, Queen Charlotte Islands, British Columbia. – Bulletin Geological Survey Canada, 496, 1–162. CARTER, E.S., GORIČAN, Š., GUEX, J., ODOGHERTY, L., DE WEVER, P., DUMITRICA, P., HORI, R.S., MATUSUKA, A. & WHALEN, P. (2010): Global ra- diolarian zonation for the Plenuschian, Toarcian and Aalenian. – Palaeo., 297, 401–419. doi: 10.1142/paleo.2010.08.024 CHAN, G.H.-N., MALPAS, J., XENOPHONTHOS, C. & LO, C.-H. (2007): Timing of subduction zone metamorphism during the formation and emplacement of Troo- dos and Baèr-Bassit ophiolites: Insights from 40Ar-39Ar geochronology. – Geo- logical Magazine, 144, 797–810. doi: 10.1017/S0016756807003792 CHAN, G.H.-N., MALPAS, J., XENOPHONTHOS, C. & LO, C.-H. (2008): Magma- tism associated with Gondwanaland rifting and Neo-Tethyan oceanic crust develop- ment: evidence from the Mamonia Complex, SW Cyprus. – Journal of the Geological Society, 165, 699–709. doi: 10.1144/0016-76492007-050 CHIARI, M., BAUMGARTNER, P.O., BERNOULLI, D., BORTOLOTTI, V., MARCUCCI, M., PHOTIADIES, A. & PRINCIPI, G. (2013): Late Triassic, Early and Middle Jurassic radiolaria from ferromanganese-chert “nodules” (Angelokastron, Argolis, Greece): evidence for prolonged radiolarite sedimentation in the Malac- Vardar Ocean. – Facies, 59, 391-424. doi: 10.1007/s10347-012-0314-4 CIFER, T., GORIČAN, Š., GAWLIK, H.-J. & AUER, M. (2020): Plenuschian, Early Jurassic radiolarians from MountRettenstein in the Northern Calcareous Alps, Austria. – Acta Palaeontologica Polonica, 65/1, 167–207. doi: 10.4202/app.00618.2019 CORDEY, F. (1998): Radioîles des complexes d’accrétion de la Cordillère Canadienne (Colombie-Britannique).– Commission Géologique du Canada, Bulletin 183, 125. GASS, I.G. (1966): The petrography, structure and evolution of the Troodos Massif, Cy- prus. – Unpubl. PhD Thesis – University of Leeds, 279 p. GAWLIK, H.-J., SUZUKI, H. & MISSONI, S. (2001): Nachweis von unterlialischen Beckensedimenten in Hallstätter Fazies (Dürrenberg-Formation) im Bereich der Hallin-Berchesgadener Hallstatt Zone und des Lammer Beckens (Hettangium-Sinemurium).– Mitteilungen Ges. Geol. Bergbaustud Osterr., 45, 39–55.

GEOLOGICAL SURVEY DEPARTMENT OF CYPRUS (2008): Geological map of Paphos–Kalypotia area, Nicosia, sheet 16 III–IV. Scale 1:25000. GEOLOGICAL SURVEY DEPARTMENT OF CYPRUS (2015): Geological map of the Pegeia–Steni area. Nicosia, sheet 16 H–I. Scale 1:25000.
GIANELLI, G. & PRINCIPI, G. (1974): Studies on maflc and ultramaflc rocks. 4. Breccias of the ocholitic suite in the Monito Bocco area (Ligurian Apenine). – Bollettino Societa Geologica Italiana, 93, 277–308.

GORIĆAN, Š., CARTER, E.S., DUMITRICA, P., WHALEN, P.A., HORI, R.S., DE WEVER, P., O’DOGHERTY, L., MATSUOKA, A. & GUEX, J. (2006): Catalogue and Systematics of Plensibachian, Toarcian and Aalenian Radiolarian Genera and Species. – ZRC Publishing, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, 446 p.

HENSON, F.R.S., BROWN, R.V. & MCCINTY, J. (1949): A synopsis of the stratigraphy and geological history of Cyprus. – Quarterly Journal of the Geological Society of London, 105, 1–41. doi: 10.1144/GSL.JGS.1949.105.01-04.03

HORI, R. (1990): Lower Jurassic radiolarian zones of SW Japan.– Trans. Proc. Palaeont. Soc. Japan, N. S., 159, 562–586.

HORI, N. (2004): Jurassic radiolarians from chert and clastic rocks of the Chichibu Belt in the Toyohashi district, Aichi Prefecture, Southwest Japan.– Bulletin of the Geological Survey of Japan, 55, 335–388.

KNIPPER, A.L. (1978): Ophicalcites and some other types of breccia accompanying pre-orogenic formation of ocholitic assemblage. – Geotectonics, 2, 50–66 (in Russian).

KNIPPER, A.L., SATIAN, M.A. & BRAGIN, N.Y. (1997): Upper Triassic-Lower Jurassic volcanogenic and sedimentary deposits of the Old Zod Pass (Transcaucasia). – Stratigraphy, Geological Correlation, 3, 58–65. (in Russian).

KOZUR, H. & MOSTLER, H. (1990): Saltanilaceae DEFLANDRE and some other stratigraphically important radiolaria from the Hettangian of Lenggries/Isar (Bavaria, Northern Calcareous Alps). – Geol. Paläontol. Mitt. Innsbruck, 17, 179–248.

LAPIERRE, H. (1975): Les formations sédimentaires et éruptives des nappes de Mamoni and some other types of breccia accompanying pre-orogenic formation of ocholitic assemblage. – Geotectonics, 2, 50–66 (in Russian).

MALPAS, J., CARTER, E.S., DUMITRICA, P., WHALEN, P.A., HORI, R.S., DE WEVER, P., O’DOGHERTY, L., MATSUOKA, A. & GUEX, J. (2006): Catalogue and Systematics of Plensibachian, Toarcian and Aalenian Radiolarian Genera and Species. – ZRC Publishing, Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Ljubljana, 446 p.

MARTINI, R., PEYBERNÉS, B. & MOIX, P. (2009): Late Triassic foraminifera in ree-fal limestones of SW Cyprus. – Journal of Foraminiferal Research, 39/3, 218–230. doi: 10.2113/gsjfr.39.3.218

MALPAS, J., XENOPHONTOS, C. & WILLIAMS, D. (1992): The Ayia Varvara Formation of SW Cyprus: volcaniclastic sedimentation of a probable Late Cretaceous volcanic arc. – Journal of the Geological Society London, 134, 269–292. doi: 10.1144/gjs.134.3.0269

ROBERTSON, A.H.F. (1977): The Kannaviou Formation, Cyprus: volcaniclastic sedimentation of a probable Late Cretaceous volcanic arc. – Journal of the Geological Society London, 134, 269–292. doi: 10.1144/gjs.134.3.0269

ROBERTSON, A.H.F. & HUDSON, J.D. (1974): Pelagic sediments in the Cretaceous and Tertiary history of Cyprus.– In: HSU, K.J. & JENKYNS, H.C. (eds.): Pelagic Sediments: On Land and Under the Sea. – Special Publications International Association Sedimentologists, 12, 177–205. doi: 10.2113/48.2.177

TEKIN, U.K., KRYSTYN, L., OKUYUCU, C., BEDI, Y., SAYIT, K. (2020): Late Triassic to Early Jurassic radiolarian, conodont and ammonite assemblages from the Tavuscayiri block, Mersin Mélange, southern Turkey: Time constraints for the T/J boundary and sedimentary evolution of the southern margin of the northern Neo-tethys. – Geodynamics, 2, 493–537. doi: 10.5252/geodynamics2020v242e27

TORLEY, J.M. & ROBERTSON, A.H.F. (2018): New evidence and interpretation of facies, provenance and geochemistry of late Triassic–early Cretaceous Tethyan deep-water passive margin-related sedimentary rocks (Ayios Photos Group), SW Cyprus in the context of eastern Mediterranean geodynamics. – Sedimentary Geology, 377, 82–110. doi: 10.1016/j.sedgeo.2018.09.001

WHALEN, P.A. & CARTER, E.S. (1998): Systematic Paleontology.– In: CARTER, E.S., WHALEN, P.A. & GUEX, J. (1998): Bioschronology and paleontology of Lower Jurassic (Hettangian–Sinemurian) Radiolarians, Queen Charlotte Islands, British Columbia. Geological Survey of Canada Bulletin, 496, 147–147.

WHALEN, P.A. & CARTER, E.S. (2002): Plensibachian (Lower Jurassic) radiolaria from Baja California Sur, Mexico.– Micropaleontology 48/2, 97–151. doi: 10.2307/1485228

YEH, K.-Y. (1987): Taxonomic studies of Lower Jurassic Radiolaria from east-central Oregon.– National Museum of Natural Science, Special Publication 2, 1–169.

YEH, K.-Y. (2009): A Middle Jurassic radiolarian fauna from Southfork member of Snow- shoe Formation, east-central Oregon. – Memoirs Geological Survey Cyprus 1, 1–136.

YEH, K.-Y. & CHENG, Y.-N. (1998): Radiolarians from the Lower Jurassic of the Bu-sanga Island, Philippines. – Bull. Nat. Mus. Nat. Sci. (Taiwan) 11, 1–65.
Plate 1. Lower Jurassic Radiolaria (Spumellaria)
A, B – Pantanellium sixi WHALEN & CARTER; C, D – Gorgansium gongyloideum KISHIDA & HISADA; E – Gorgansium morganense PESSAGNO & BLOME; F – Charlottea weedensis WHALEN & CARTER; G – Paronaella grahamensis CARTER; H – Praehexasaturnalis tetraradiatus KÖZUR & MOSTLER; I – Beatricea? argescens (CORDEY); J – Paronaella sp. cf. P. notabilis WHALEN & CARTER; K – Udalia primaeva WHALEN & CARTER; L, M – Udalia spp.
Magnification – 1-5, 8 – 1; 6, 7, 9-13 – 2. Scale 100 μm. Figs. A, B, C, G, I, K, L, M – sample 18-15-6; figs. D, E, F, H, J – sample 18-16-7
Plate 2. Lower Jurassic Radiolaria (Nassellaria)

A, B – Bipedis japonicus Hori; C, H – Bipedis hannai WHALEN & CARTER; D – Pseudoeucyrtis busuangaensis (YEH & CHENG); E – Pseudoeucyrtis sp. cf. P. busuangaensis (YEH & CHENG); F, G – Katroma niinintsi CARTER; I – Bagotum maudense PESSAGNO & WHALEN; J – Canoptum? megathelus CORDEY; K, L – Canoptum sp. cf. C. anulatum PESSAGNO & POISSON; M – Katroma sp. cf. K. irvingi WHALEN & CARTER; N – Lantus sp. cf. L. obesus (YEH). Scale 100 μm. Figs. A, B, F, I, K, L, N – sample 18-15-6, fig. E – sample 18-15-5; figs. C, D, G, H, J, M – sample 18-16-7