FORAMINIFERA, ALGAE AND CARBONATE MICROPROBLEMATICA FROM THE LATE WUCHIAPINGIAN/DZHULFIAN (LATE PERMIAN) OF PELOPONNESUS (GREECE)

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Abstract. The origin of late Permian olistoliths found in the Glypia Cenozoic flysch must be sought in regions located to the east of the Parnon Mountain and in units that were more internal to Pindos Unit, especially in the islands of Karavia in the Argolis Gulf, and the Episkopi Formation in Hydra Island, that display probably the largest outcrops of this age.

The most interesting olistolith is a bioclastic grainstone. It yields about forty taxa of algae, microproblematica, smaller foraminifera and fusulinids, that are briefly described.

Three markers generally not co-occurring are locally associated: Paradunbarula (Shindella) shiudellii, Hemigordiopsis cf. Iniquensis and Codinella ssp. minimum. The age of the Paradunbarula (Shindella) biozone is most probably late Wuchiapingian/Dzhulfian, although other datings have been proposed from late Capitanian to late Changhsingian. Due to this dating of the Shindella zone, the coexistence of the first Codinella with the last Hemigordiopsis are not late Capitanian/Midian, but late Wuchiapingian.

The similarities of the Greek microfauna with that of South China and southeastern Pamirs, are incompatible with a larger Paleotethys but support the paleogeographic reconstructions which indicate a close location of these geographic units (Pangea B).

Riassunto. L'origine degli olistoliti di età permiana superiore rinvenuti nel flysch cenozoico di Glypia deve essere ricercata in regioni situate ad est delle Montagne del Parnon ed in unità che erano più interne all'Unità Pindos, in particolare nelle isole di Karavia nel golfo dell'Argolide e nella Formazione Episkopi nell'Isola di Hydra, dove affiora il più vasto affioramento di rocce di questa età.


Le affinità della microfauna greca con quelle della Cina meridionale e del sud-est Pamir sono ritenute incompatibili con una Paleotetide estesa, ma sono indicative di posizioni più vicine tra queste aree, formando argomenti per le ricostruzioni paleogeografiche secondo la configurazione Pangea B.

Introduction

On the Parnon mountain range (central eastern Peloponnese, Greece) the Glypia Unit overlies the Alpine units of Tripolis and Pindos (Skourtso et al. 2001) (Fig. 1). The Glypia Unit corresponds to a wild flysch of Cenozoic age including a great number of volcanic and carbonate exotic blocks.

There are four types of carbonate olistoliths: (1) large blocks (up to 50 m$^3$) of pelagic, micritic, reddish or yellowish limestone with alternations of dark-colored, clastic limestone with Globotruncanidae; (2) grey, medium to thick-bedded, microbrecciated limestone, very rich in Orbitolinidae and fragments of rudists, pelcycopods, algae and corals; (3) elongate bodies of dolomitic breccia of unknown age; (4) the small, up to 1.5 m$^3$, gray to whitish, very fossiliferous late Permian olistoliths studied here (Fig. 1c). Their geological importance was previously emphasized by Skourtso et al. (2002). The description of the micropaleontological assemblage, systems of the microfossils, biostratigraphy and consequences for the late Permian Tethyan paleobiogeography, are presented.

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Previous work

Several outcrops of wild flysch have been described in the general area of the Peloponnese. These outcrops correspond to early Cenozoic clastic series sandwiched between the Gavrovo-Tripolitza unit carbonate platform below and overlying deep-water allochthonous Pindos Unit (Dercourt 1964; Richter & Mariolakis 1973; Fleury 1976; De Wever 1976; Lekkas 1978; Degnan & Robertson 1994). The Ermioni Complex on the Argolis Peninsula (Aranitis 1960a, 1960b; Clift & Robertson 1989; Clift 1996), the Beotic flysch (Clément 1971; Richter et al. 1996) in central continental Greece, the Arvi and Miamou nappes on the island of Crete (Bonneau 1973, 1976), represent similar examples of wild flysch formations that are internal to the Pindos Unit.

The Parnon mountain chain in the central eastern Peloponnese consists of a number of imbricated tectonic nappes, that from bottom to top, are (Bassias 1984; Skourtos et al. 2001) (Fig. 1b): the Plattenkalk Unit, a metamorphic carbonate series of Mesozoic-Cenozoic age with a flysch cover of Oligocene age; the Phyllites-Quartzites Unit, a metapelite-Permo-Triassic series with metavolcanics bodies; the Gavrovo-Tripolitza Unit that consists of a volcano-sedimentary formation at the base, followed by a Late Triassic carbonate platform with a Late Cenozoic flysch at the top; the Pindos Unit formed in an oceanic basin that rifted in the early-Mid Triassic and the uppermost Glypia Unit.

The occurrences of the Glypia Unit were formerly attributed by Thiebault (1982) to the Paleochora Unit, that was defined as the uppermost member of the Gavrovo-Tripolitza Unit (Lekkas 1978). Detailed mapping of the studied area showed that the Glypia Unit overlying tectonically the Pindos Unit (Skourtos et al. 2001), whereas the Paleochora Unit is overthrusted by Pindos Unit (Lekkas 1978).

Middle and late Permian foraminifers of Greece are rather poorly known and poorly illustrated, except for the Wordian, i.e. Murgabian (Baud et al. 1991; Grant et
imbrication of the nappes was the result of a westward movement, it is suggested that the origin of the limestone blocks rich in Permian assemblages should be sought in regions located to the east of the Parnon Mountain, and in units that were more internal to Pindos Unit nappes. Rocks from which the Permian limestone blocks could have been derived are located on the Hydra island and on the Karavia islets in the Argolicum Gulf (Fig. 1a). In these places Permo-Triassic series have been described. These series constitute the base of the Subpelagonian Unit (Renz 1955; Römermann 1968; Fig. 1b). Another more internal unit to the Pindos nappe is mentioned in southeastern Peloponnessus close to Monemvasia, by Brauer et al. (1980), Gerolymatos et al. (1982) and Danielan et al. (2000). At this outcrop first Brauer et al. (1980) described relics of the Pelagonian terrain, e. g. crystalline limestone of Anisian age, accompanied by mafic and ultramafic rocks. Within the lavas Gerolymatos et al. (1982) observed lenses of limestone that were very rich in Permian fossils. These lithoclasts must be re-examined.

The nature of the Glypia Unit shows that this unit was formed in a frontal basin along an active margin. This active margin was constituted of several imbricated nappes. According to the lithology of the exotic blocks, we consider that the nappes were consisting of rocks of different origin and age. The presence of Permian blocks, derived from the base of the Subpelagonian Unit, means that already in the early Cenozoic the base was exhumed to the Earth surface. The subsequent deformation of the Glypia Unit is due to a later shearing of the unit during the late Cenozoic when the Pelagonian terrain was overthrust onto the Pindos Unit.

The principal candidates to the origin of late Permian olistoliths of the Glypia Unit are the Potami Formation on the Argolis Peninsula (Vachard et al. 1993a), Hydra island (Renz 1955; Römermann 1968; Baud et al. 1991; Grant et al. 1991) and the Karavia islets in the Argolicum Gulf (Tataris 1969, 1988) (Fig. 1a).

Skourotsos et al. (2001) have also mentioned the similarity of some components of the Glypia Unit with the Erioni Complex (Aranitis 1960a, 1960b; Bannert & Bender 1968; Bachmann & Risch 1979; Gaitanakis & Pottadis 1991; Clift & Robertson 1989; Clift 1996), and the Arvi and Miamou nappes, described from Crete by Bonneau (1973, 1976). Nevertheless, olistoliths of late Palaeozoic age have not been mentioned within the above units: the oldest determined age is Kimeridian by corals in the Miamou nappe (Bonneau 1973, 1976), and, among the middle-late Permian stages, only the Murgabian yields foraminifera in Crete (Vachard et al. 1995).

On the Karavia islets, Tataris (1988) described whitish, thick-bedded, middle Permian limestone, very rich in fossils, such as Neoschwagerina sp., Parafusulina sp., Pachyphloba sp., Plavatoxularia sp., Schwagerina sp. and Lasiodesuc sp. This limestone is older than the investigated material, and is probably Murgabian or early

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**Origin of the late Permian olistoliths**

As the Glypia Unit represents the uppermost tectonic unit in the central eastern Peloponnessus and, as the

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**Fig. 2** - The late Permian-early Triassic Formations of Hydra (Greece), and the origin of the blocks and olistoliths re-worked in the Mesozoic and Cenozoic series. (without scale).
Midian in age. However, Tataris (1988) mentioned that because of an abrupt cliff, it was not possible to sample the entire section.

The assemblages of the lichicolasts described by Vachard et al. (1993a) in the Potami Formation (Argolis Peninsula) are almost similar, but a little older, because their microfauna with are more primitive (see below).

On Hydra island, Römermann (1968), Grant et al. (1991) and Baud et al. (1991) described a series of thick-bedded, bioclastic limestone and carbonate breccia that are very rich in fossils such as algae, small foraminifers and fragments of gastropods, bryozoans and corals (Episkopi Formation). Baud et al. (1991) mentioned similar sequences on Aegina island in the Saronic Gulf, where there is an occurrence of poorly stratified bioclastic packstone with some chert and silicified corals, bryozoans and calicospawns. Consequently an outcrop of the Episkopi Formation or its equivalents, is probably at the origin of the olistoliths of the Glyfia Unit, as well as the carbonate blocks of Argolis Peninsula (Fig. 2). Therefore the erosion and reworking of the Episkopi Fm. and its equivalents is active during all the Mesozoic (Potami Formation, Argolis Peninsula) and the Cenozoic eras (Glyfia Unit, Parnon Mountain). Due to the existence of numerous lichicolasts or olistoliths in the Dorashamian (Baud et al. 1991; Altiner & Özkan-Altiner 1998: fig. 1), the reworking of the Episkopi Fm. can begin as soon as the latest Permian.

Microfacies and assemblages

The most interesting microfacies in the investigated Permian olistoliths (sample Phi 38) is a bioclastic grainstone with two generations of cements (palisadic and coarsely granular). The assemblage is rich in algae, corresponding to an agitated environment in the photic zone, at a depth of 5-10 m, in a tropical carbonate shallow shelf (Fig. 3).

The carbonate microfossils, occurring together in the sample Phi 38 (thin sections Phi 38a to 38f), are as follows (R= rare; RC = relatively common; VR = very rare):

Metazoan remains: gastropods (RC) (including Bellerophontoidae), bivalves (R), crinoids (R), bryozoans (R), calcisponges (R).

Algae: Parachaeetetes sp. (VR), Permocalculus sp. (R), Gymnocodium bellerophontis (Rothpletz, 1894) Pia, 1920 (R) (Pl. 4, fig. 6), Eugonophyllum sp. (VR), Mizizia cf. yabei (Karpinsky, 1928) (R), Macroporella apachena Johnson, 1951 (VR) (Pl. 5, fig. 2), Salopekksiella sp. (VR), Likanella (?) sp. (VR) (Pl. 5, fig. 3), Atracothylo sp. lasts Accorci, 1956 (VR) (Pl. 4, fig. 2).

Pseudo-algae: Tabiphytes ex gr. obscurus Maslov, 1956 (R) (Pl. 3, fig. 5; typical morphotypes, Pl. 4, fig. 1, 4-5; atypical morphotypes similar to the foraminifer Nodophthalimidum), Pseudoceramiporella ex gr. nipponi-ca (Endo in Endo & Kanuma, 1954) (R) (Pl. 4, fig. 3), Clararostula calamistrata Vachard, 1980 (VR), Effugella johnsoni (Flügel, 1966) Massa & Vachard, 1979 (VR), Ungavaella (?) sp. (R).

Smaller foraminifers: Spiritiolina conspecta (Reitlinger, 1950) (R), Neovendobrya sp. (VR), Terrataxis contica (Ehrenberg, 1854) (R), Abadebela sp. (VR) (Pl. 5, fig. 9), Palavotexularia sp. (VR), Cllamacumina cf. textuloides Lange, 1925 (RC) (Pl. 5, fig. 1), Cribrigerina sp. (RC), Globorotalia graeca Reichel, 1945a (R), G. quadernschmitti Reichel, 1945a (VR), Sengoena aff. argaudi Altiner, 1989 (VR) (Pl. 4, fig. 6), Neodiscus sp. (R) (Pl. 1, fig. 5), Multidiscus padagades (Lange, 1925) (Pl. 1, fig. 4, Pl. 3, fig. 5, Pl. 4, fig. 2, 6, Pl. 5, fig. 6-8), Hemigordiopsis cf. tiquensis (Wang & Sun, 1973) (RC) (Pl. 1, fig. 7, Pl. 2, fig. 6-7, Pl. 3, fig. 1-5), Ag athammina sp. (VR), Nodosaria (?) sp. (VR) (Pl. 5, fig. 5), Geinitzina sp. (VR), Calvezina (?) sp. (VR) (Pl. 5, fig. 4), Pachyphloia sp. (VR), Colaniella aff. minima Wang, 1966 (R) (Pl. 1, fig. 3, 6).

Fusulinids: Sphaerolina zosonzengensis Sheng, 1963 (RC) (Pl. 1, fig. 2, Pl. 3, fig. 5), Reibelina ex gr. media Miklukho-Maklay, 1954 (VR), Schubertella sp. (VR), Codonofusiella ex gr. turnissima Sheng, 1963 (VR), Paradunbarula (Shindella) shindensis Chediya in Kotlyar et al., 1983 (RC) (Pl. 1, fig. 1, 7, Pl. 2, fig. 1-5), Nan lingella (?) sp. (VR) (Pl. 1, fig. 3), abraded Neoschwegerina sp. (VR).

Biostratigraphy

The datation of the sample Phi 38 depends on the datation of the Shindella biozone. The age of this biozone is controversial. The biozone of Shindella pamirica-S. simplicata was defined in the Takhbatubul Formation of southeastern Pamirs, by Kotlyar et al. (1983), and firstly dated as latest Capitanian/Midian, but this age was completely modified by Kotlyar et al. (1999), and the formation was assigned to the late Changhsingian.

Nevertheless, an intermediate age, i.e. late Wuchiapingian/Dzhulfian dating is more justified for six reasons (Skourtos et al. 2002): (1) the Shindella biozone is placed in the late Dzhulfian by Davydov et al. (1996, fig. 4); (2) the beds containing Shindella in the southeastern Pamirs, are located between lower Midian and lower Triassic deposits, and are not typically lower Midian nor later Changhsingian in age; (3) no true Palaofusulinida has been found in our assemblage, and two taxa: Nanlingella (?) and Sengoena aff. argaudi might be phylogenetically directly related to true Nanlingella and to Paradunbarula Rabeliformis Zaninetti et al., 1981, both considered as early Changhsingian microfossils; (4) in Greece a relatively similar assemblage dated early Dzhulfian (Vachard et al. 1993a), is actually more primitive because it includes Pseudodunbarula and Pseudowanganiella and not Paradunbarula (Shin
Microfauna from late Permian of Greece

Schematic profile and foraminiferal and algal biotopes during the middle/late Permian (according to Vachard, 1980 and unpublished data). Abbreviation - C.M.: Central Mountains of Afghanistan.

della) and Colaniella, phylogenetically more advanced (Fig. 4); (5) the upper part of the Episkopi Fm., probable origin of the Glypta olistoliths, is clearly late Wuchiapingian/Dzhulfian - early Changhsingian/Dorashamian, dated by conodonts (Nestell & Wardlaw 1987; Grant et al. 1991), whereas its foraminifera seem to be late Changhsingian in age, due to the presence of Colaniella ex gr. lepida and Palaeofusulina ex gr. sinensis identified by Baud et al. (1991, pl. 2, fig. 2-3) and Grant et al. (1991, fig. 6D); (6) the Episkopi Formation is separated of the early Triassic Eros Formation by the Miras Formation, which correspond consequently to the late Chianghsingian (Fig. 2).

Three principal biostratigraphic markers are associated in this local late Wuchiapingian: Paradunbarula (Shindella) shindensis, Hemigordiopsis cf. luquensis and Colaniella aff. minima. Data concerning the evolution of the three groups are summarized into Fig. 4, based on various data from Afghanistan (Vachard 1980, completed), Greece (Vachard et al. 1993a), Oman (Montenat et al. 1977; Vachard et al. 2001) and the late Midian of the former USSR (Kotlyar et al. 1983, 1989).

The proposed attribution of the Shindella biozone to the late Wuchiapingian in Greece has two important implications, that might explain some misinterpretations of the biostratigraphic literature on the late Permian: (a) the genus Hemigordiopsis survives in the late Dzhulfian, contrary to the opinion of Pronina (1995); many of these Dzhulfian Hemigordiopsis were probably named Kamwra or Pseudobaisalina, two poorly known genera; (b) the first appearance of Colaniella occurs in the late Dzhulfian, contrary to previous proposals indicating an appearance in the latest Midian (Chediy & Davydov 1982; Jenny-Deshusses & Baud 1989).

Paleobiogeography

The assemblage is also paleobiogeographically significant, and it confirm similarities between Greece,
Southeast Pamir and South China.

The genus *Paradunbarula* has been described in Anatolia (Turkey) (Skinner 1969), the subgenus *Shindiella* is identified in southeastern Pamirs and South China (Kotlyar et al. 1983), but absent in Transcaucasia (Kotlyar et al. 1989). *Hemigordiopsis liuquensis* (Wang & Sun, 1973) is a species from South-China. Its probable synonym, *Hemigordiopsis orientalis* (Wang & Sun, 1973), exists also in Transcaucasia (Pronina 1988; Kotlyar et al. 1989).

Our investigated material contains *H. cf. liuquensis*. This taxon is relatively different of the Chinese material, because it displays less whors (4-5 versus 5-7) for the same diameter, but it is similar to a taxon from Montenegro (Pantic 1965, pl. 5, fig. 1-4, cited under the erroneous name of *H. renzi*).

The most ancient *Colaniella* were mentioned in Pamir, South China and Salt Range, Pakistan (Wang 1966; Chediya & Davydov 1982; Okinura 1988; Jenny-Deshusses & Baud 1989).

The identity of the Greek and South-Chinese fusulinds is also documented by the early Changhsingian genus *Baudiella* (Altiner & Özkan-Altiner 1998), that is only known from two localities: in Greece (Salamis Island) and South China (Nanjing area).

Consequently, the similarities of the Greek microfauna with that of South China and southeastern Pamirs

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**PLATE 1**

Fig. 1 - *Paradunbarula* (*Shindiella*) *obtdens*: Chediya in Kotlyar et al., 1983. Axial section. Slide Phí 38b. x 40.
Fig. 2 - *Sphaerulina* sp. *zhejiangensis*: Sheng, 1963. Oblique section. Slide Phí 38d. x 30.
Fig. 3 - *Colaniella* sp. *zulma*: Wang, 1966, 3 - Oblique section (bottom) with a subtransverse section of *Nanlingella* (*?*) sp. (top). Slide Phí 38a. x 75. 6 - Oblique section. Phí 38a. x 75.
Fig. 4 - *Multiidiscus* *padangensis*: Lange, 1925. Axial section. Slide Phí 38d. x 40.
Fig. 5 - *Neodiscus* sp. Axial section. Sample Phí 38b. x 40.
Fig. 7 - *Hemigordiopsis* cf. *liuquensis* (Wang & Sun, 1973). Transverse section (bottom) with a subtransverse section of *Paradunbarula* (*Shindiella*) *obtdens* (top). Slide Phí 38b. x 30.
are great, and confirm the paleogeographic reconstructions that indicate a close location of the three geographic units (Besse et al. 1998; Crasquin-Soleau et al. 2001), i.e. the Pangea B models.

The Paleotethys of the time was probably narrow and its southern shallow carbonate shelf extended in continuity from Greece to southeastern Pamirs and South China, via Turkey and southern Iran, and was situated in the same latitudinal band.

**Systematic paleontology**

**Algae**

*Gymnocodium bellerophontis*

Rothpletz, 1894

Pia, 1920

1894 *Gyroporella bellerophontis* n. sp. Rothpletz, p. 24, fig. 4.

1912 *Macroproporella bellerophontis* (Rothpletz) - Pia, p. 34-35, text-fig. 3, pl. 2, fig. 7-12.

1937 *Gymnocodium bellerophontis* (Rothpletz) - Pia, p. 832-833, pl. 95, fig. 1-6.

1965 *Gymnocodium bellerophontis* (Rothpletz) - Pantic, p. 159, pl. 7, fig. 1-4.

1993a *Gymnocodium bellerophontis* (Rothpletz) - Pantic, p. 138-139, pl. 1, fig. 1 (syn. syn.).

Remarks. Well known since the work of Pia (1912, 1920, 1937), Elliott (1955) and Roux (1991), this species is classical. Of interest are the discoveries of fertile (Vachard et al. 1993a) or bifurcate (Pl. 4, fig. 6) thalli, confirming the belonging to the red algae proposed by Pia, admitted by all the authors, although recently contested by Mamet & Préat (1994).

Dimensions. Length: up to 2.50 mm; outer diameter: 0.47-0.73 mm; inner diameter (medullar zone?); 0.20-0.40 mm; cortical zone thickness: 0.10-0.15 mm; pores: 0.05-0.10 mm.

**Dasycladaceae variae**

Pl. 5, fig. 2-3

Remarks. Dasyclads are rather rare in the microfacies and the generic determination of the remains is generally questionable. We identify a subaxial section of *Macroporella apachena* Johnson, 1951 (Pl. 5, fig. 2), and a possible oblique section through a verticille of *Likanella* (?) sp. (Pl. 5, fig. 3) illustrated here. The other remains belong to *Mizizia* (five oblique sections) probably *M. yabei* (Karpinsky, 1908), separated recently as a distinct genus *Yabeiella* Chuvashev, 2001, not accepted here; and to *Salopekiella* sp. (three very incomplete and abraded sections). These algal microfloras of dasyclads have equivalents in Italy (Accordi 1956) and Croatia (Pantic 1965).

**Atractyliopsis lastensis** Accordi, 1956

Pl. 4, fig. 2

1937 *Atractyliopsis* n. sp. Pia, pl. 97, fig. 5-6.

1956 *Atractyliopsis lastensis* n. sp. Accordi, p. 82-82, pl. 8, fig. 1-3, pl. 10, fig. 1-12.

1966 *Acicularia* sp. (?) - Gуйенч, p. 102-103, pl. 3, fig. 5.

1968 *Atractyliopsis darariensis* n. sp. Elliott, p. 24-25, pl. 2, fig. 3-5.

1988 *Atractyliopsis lastensis* Accordi - Sartorio & Venturini, text-fig. p. 39.

1993a *Atractyliopsis lastensis* Accordi - Vachard et al., pl. 1, fig. 9.

Remarks. The illustrations of Pia (1937) and Accordi (1956) show probably incomplete specimens, compared with the various sections presented by Sartorio & Venturini (1988). Consequently, the true morphology of the thallus looks probably more like *Acicularia* (?) sp. (Gуйенч 1966) or *Atractyliopsis darariensis* Elliott, 1968. In this case, Permian *Atractyliopsis* are probably more related to choristosporace dasyclads than endospore ones.

**Dimensions.** Length: 4.00 mm; width: 1.50 mm; diameter of cavities: 0.20-0.25 mm.

**Microproblematica**

Remarks. Two groups are present: (a) questionable consortiums of porcelaneous foraminifers and cyanobacteria: *Tubiphytes* and *Pseudoverticellaria*, and (b) rare Algospongia (Témier et al. 1977) belonging to the genera *Eflugletia*, *Claracrusta* and *Ungdarella* (?)

**Tubiphytes ex gr. obscurus** Maslov, 1956

Pl. 5, fig. 5; Pl. 4, fig. 1, 4-5

1956 *Tubiphytes obscurus* n. sp. Maslov p 82-84, text-fig. 22, pl. 25, fig. 1, 3, pl. 26, pl. 27, fig. 1-2.
Class Foraminifera d’Orbigny, 1826

Subclass Fusulinita Wedekind, 1937

Order Endothyrida Brady, 1884

Remarks. Although the most common smaller foraminifer are porcelaneous (Miliolata) and byaline (Lagenida), some rare survivals of the microgranular foraminifer Endothyrida and Fusulinita are present. The Endothyrida belong to the super-families: Paleotextulariidae especially Climaclimina valvulinae Lange, 1925 (Pl. 5, fig. 1), Tetrataxidae, e.g. Abadebella sp. (Pl. 5, fig. 9) and Globovalvulinoids, particularly Sengoerina aff. argandi (Pl. 4, fig. 6). The latter taxon, that is very poorly represented in our material, and seems by wall structure to be the direct ancestor of Paradagmarita flabelliformis Zaninetti, Altiner & Catal, 1981.

Order Fusulinita Wedekind, 1937

Superfamily Staffelloidea A.D. Mikluko-Maklay, 1949

Family Staffellidae A.D. Mikluko-Maklay, 1949

Pseudovermiporella ex gr. nipponica
(Endo in Endo & Kanuma, 1954)

1954 Vermiporella (?) nipponica n. sp. Endo in Endo & Kanuma, p. 191-192, pl. 13, fig. 2-5.
1965 Pseudovermiporella nipponica (Endo) - Param, p. 160-161, pl. 12, fig. 1-3.
1966 Vermiporella nipponica Endo - Flügel, p. 43-45, pl. 8, fig. 1-2 (non fig. 3 = Tubiphytes?) (cum syn.).
1993a Pseudovermiporella ex gr. nipponica (Endo) - Vachard et al., pl. 6, fig. 9, pl. 7, fig. 1.

Remarks. This other “algae incertae sedis” is more exactly a particular porcelaneous foraminifer and/or foraminifer/algal symbiosis (Vachard et al. 2001). The foraminiferal nature was correctly interpreted by Henbest (1963), supported by Loeblich & Tappan (1964), and remains controversial (Granier & Deloffre 1994). Specimens of the investigated material are long-pitted forms and belong to the group P. nipponica or longipora (Vachard et al. 2001).

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Sphaerulina zisonzhengensis Sheng, 1963

Pl. 1, fig. 2, Pl. 3, fig. 5

1963 Sphaerulina zisonzhengensis n. sp. Sheng, p. 153-154, pl. 2, fig. 6-7.
1967 Staffella zisonzhengensis (Sheng) - Leven, p. 125-126, pl. 1, fig. 6-8.
1977 non 1977 Staffella zisonzhengensis (Sheng) - Lys in Montenet et al., pl. 18, fig. 10-12 (all this material corresponds in fact to the genus Samaia).
1991 Staffella zisonzhengensis (sic) (Sheng) - Baud et al., pl. 2, fig. 4.

Remarks. The variability of the species is great: (a) typical spherical form (Pl. 1, fig. 2), nankinellid-form (Pl. 3, fig. 5) and (c) fusiform leiolloid-tests (not illustrated; corresponding more or less to Jiuszhangia Ueno, 2001 or Leella armenica Rozovskaya, 1965).

Superfamily Schubertelloidea Skinner, 1931

Family Dunbarulidae Vachard, Clift & Decrouez, 1999a nom. transl. herein pro Dunbarulinae
Microfauna from late Permian of Greece
Genus Paradunbarula Skinner, 1969
Subgenus Shindella Chediya in Kotlyar et al., 1983

Remarks. Paradunbarula (Paradunbarula) Skinner, 1969 was initially described in an olistolith of Cercaezhuyu, Anatolia (Turkey). The unique associated species is Bouliota erki Skinner, 1969, that might belong to Pseudodunbarula. Due to the absence of large fusulinids: Neoschwagerinoids or Schwagerinoids in the assemblage, and the biostratigraphical value of Pseudodunbarula, the holotype of Paradunbarula (Paradunbarula) is probably early Dzhulfian in age.

As the resorption of the juvenile is an evolutionary character among the Schubertellidae: Dunbarulinae and Palaeofusuliniinae of the middle/late Permian (Rui & Sheng 1981). Paradunbarula (Shindella) is more advanced than P. (Paradunbarula). Therefore, P. (S.) is at least late Dzhulfian (Fig. 5).

Leven (1993) indicates a Dzhulfian age for Paradunbarula, but the taxonomy of this author is not clear, since Leven & Okay (1996) describe three species of “Palaeofusulina (Paradunbarula)”. Chediya in Kotlyar et al. (1983) dated Paradunbarula (Shindella) as late Midian. An attribution of the Shindella simplicata-S. panirica zone to the late Dzhulfian was then indicated by Davydov et al. (1996, fig. 4), and we agree with this conclusion (see above). Interestingly, Kotlyar et al. (1999) consider the biozone as late Changhsingian, especially because Shindella simplicata (Sheng, 1963) was described in the Changhsing Limestone from South-China.

In conclusion, if Shindella is alone, it can be considered as indicative of the late Wuchiapiangian, if it is accompanied by Palaeofusulina it can be Changhsingian in age.

Paradunbarula (Shindella) shindensis
Chediya in Kotlyar et al., 1983
Pl. 1, fig. 1, Pl. 2, fig. 1-5

1983 Paradunbarula (Shindella) shinidensis n. sp. Chediya in Kotlyar et al., p. 135-136, pl. 9, fig. 2-4.
1996 Paradunbarula (Shindella) shindensis Chediya - Rauzer-Chernousova et al., p. 2, fig. 6.
? 1996 Palaeofusulina (Paradunbarula) cf. panirica Leven - Leven & Okay, pl. 10, fig. 23.
? 1996 Palaeofusulina (Paradunbarula) okuyi n. sp. Leven in Leven & Okay, p. 171, pl. 9, fig. 4-5, 7.
1999 Paradunbarula (Shindella) shinidensis Chediya - Kotlyar et al., p. 20 (no figuration).
2002 Paradunbarula (Shindella) shinidensis Chediya - Skourtsos et al., fig. 2. 1-2.

Remarks. Our material is identical to P. (S.) shinidensis, by the dimensions and the number of whorls.

Dimensions. Diameter: 1.50-1.75 mm (diagnosis: 1.68-2.13), width: 2.40-2.65 mm (diagnosis: 2.60-3.30), width/diameter: 1.4-1.5 (diagnosis: 1.4-1.6), proloculus diameter: 0.07-0.08 mm (diagnosis: 0.11-0.20), whorls: 4 (diagnosis: 4), wall thickness: 0.03 (diagnosis: 0.03).

Nanlingella (?) sp.
Pl. 1, fig. 3

Remarks. Rare forms correspond to atypical Paradunbarula, but show some characters of Nanlingella: septa more numerous and more regular, indicating probably the true lineage between Dunbarulidae and Palaeofusuliniidae. The figured specimen measures 0.64 mm in diameter.

Subclass Miliolata Delage & Hérouard, 1896
Order Hemigordiopsida Nittikina, 1969
Family Hemigordiopsidae Nittikina, 1969

Neodiscus sp.
Pl. 1, fig. 5
Remarks. Rare, this Neodiscus shows internal whorls of the group N. milliloboides Mikhailko-Maklay, 1953 but the last semi-evolute whorl allows also some comparisons with an immature Graecodiscus. An apparent pseudo-septum at the extremity of the central glomus, seems to be also a character of the genus Pseudodiscella, recently described by Pronina-Nestell & Nestell (2001).

Multidiscus padangensis (Lange, 1925)
Pl. 1, fig. 4, Pl. 3, fig. 5, Pl. 4, fig. 2, 6, Pl. 5, fig. 6-8

1925 Nannobulostegnaspadangensis n. sp. Lange, p. 271, pl. 4, fig. 77a-b.
1953 Multidiscus padangensis (Lange) - Mikhailko-Maklay, p. 130, pl. 6, fig. 7.
1988 Multidiscus padangensis (Lange) - Pronina, pl. 1, fig. 18-19.
1990 Multidiscus padangensis (Lange) - Lin et al., p. 207, pl. 23, fig. 11-12.
1993a Multidiscus padangensis (Lange) - Vachard et al., pl. 2, fig. 2, pl. 6, fig. 5.
1993b Multidiscus padangensis (Lange) - Vachard et al., pl. 8, fig. 16-18.
1996 Multidiscus padangensis (Lange) - Leven & Okay, pl. 9, fig. 24-26 (may be M. obtusus Lin et al., 1990).

Remarks. Relatively abundant, this species exhibits: (a) typical specimens planispirally coiled (Pl. 1, fig. 4; Pl. 4, fig. 2); (b) broken individuals (Pl. 4, fig. 6); (c) specimens with some deviations of coiling (Pl. 3, fig. 5; Pl. 5, fig. 6); (d) specimens with a last whorl evolute (Pl. 5, fig. 6), and comparable to Multidiscus (?) tausidianus Okuyucu, 1999; (e) presence of pseudo-septation (Pl. 5, fig. 8). This tendency, which can be interpreted as a generic character, is probably comparable with a Sigal spectrum (Sigal, 1966); i.e. rare specimens of a species showing a character of a different genus. Strictly interpreted, this generic character led to the creation of Septaghammina, Nikititella, Pseudodiscella, and various false “Balsamina” of the literature. This pseudo-septation appears independently in several lineages of porcellaneous foraminifers, with various types of coiling, such as Agathammina, Neodiscus, Multidiscus, Hemigordius, Hemigordiopsis, from the Capitanian to the Changhsingian.

Dimensions. Diameter: 1.30-1.70 mm (diagnosis: 1.25), width: 0.55-0.73 (diagnosis: 0.32 in the text, but more or less 0.80 on the photomicrograph), width/diameter: 0.42-0.63 (emended diagnosis: 0.64), whorls: 5-5.5 (diagnosis: 5.5), proloculus: 0.20 mm (diagnosis 0.15 x 0.22), wall thickness: 0.01-0.03 mm (diagnosis: 0.02).

Hemigordiopsis cf. luquensis (Wang & Sun, 1973)
Pl. 1, fig. 7, Pl. 2, fig. 6, Pl. 3, fig. 1-5

1965 Hemigordiopsis renzi Reichel - Pantic, p. 156, pl. 5, fig. 1-4.
1973 Gazsdicus luquensis n. gen. n. sp. Wang & Sun, p. 157, 176-177, pl. 4, fig. 5-9, 14-15.
1973 Gazsdicus orientalis n. gen. n. sp. Wang & Sun, p. 158, 177-178, pl. 4, fig. 10-12.

1977 Hemigordiopsis renzi Reichel - Lim Montenat et al., pl. 17, fig. 9, cf. 1988 Hemigordiopsis luquensis (Wang & Sun) - Leoblach & Tappan, pl. 32, fig. 21-22.
1988 Hemigordiopsis orientalis (Wang & Sun) - Pronina, pl. 1, fig. 9-10.
1989 Hemigordiopsis orientalis (Wang & Sun) - Kotlyar et al., pl. 4, fig. 4.
1997 Hemigordiopsis orientalis (Wang & Sun) - Nestell & Pronina, text-fig. 2-3.
2002 Hemigordiopsis cf. luquensis (Wang & Sun) - Skouros et al., fig. 2.1.

Description. Test nautiloid to subquadrate, of medium size for the genus. Proloculus spherical followed by 2 or 3 initial glomospirid whorls, and 2-3 adult whorls. Wall thin in the proloculus, increasing in thickness at each whorl, and finally double than the height of the chamber. Irregularities of the inner and outer surfaces of the tubular chamber are obvious (Pl. 1, fig. 7, Pl. 2, fig. 6).

Dimensions. Diameter: 2.00-3.10 mm (diagnosis of H. luquensis: 2.10), width: 1.60-1.90 mm (diagnosis: 1.90), width/diameter: 0.73-1.15 (diagnosis: 0.90), number of volutions: 4-5 (diagnosis: 5-7), diameter of proloculus: 0.20-0.30 mm, height of the tube: 0.07-0.12 mm (diagnosis: 0.05-0.09), wall thickness: 0.20-0.40 mm (diagnosis: 0.21-0.31).

Remarks. Hemigordiopsis renzi Reichel, 1945b, whose type locality is situated in Cyprus, is well represented in Greece (Baud et al. 1991), but our specimens are more comparable with H. luquensis (Wang & Sun, 1973) and its probable synonym H. orientalis (Wang & Sun, 1973), by the relatively big proloculus, the small number of glomospirid inner whorls, and few outer planispirally whorls. The total whorl number of our specimens is finally smaller 4-5 versus 5-7 for H. luquensis, for the same diameter.

Range. According to some authors, Hemigordiopsis disappears at the end of the Midian (Pronina 1995) and can be limited to the late Midian (Nestell & Pronina 1997). In the investigated material it is closely co-occurring with Spinella (Pl. 1, fig. 7) and consequently late Dzhulfian. Hemigordiopsis of this age are also present in Montenegro (Pantic 1965) and Oman (Jebel Safra, Vachard, Martini & Zaniutetti, unpublished). Moreover, the presence of “Hemigordiopsis” was signalized up to the Do-rashamian in Turkey (Altiner 1984, fig. 4).

Subclass Rotaliata Delage & Herouard, 1896
Order Lagenida Reuss, 1862
Superfamily Nodosarioidea Ehrenberg, 1838

Remarks. A robust Nodosaria (?) with finely and acutely costulate periphery (Pl. 5, fig. 5), only one section of Calvezzina (?) sp. with curved axis of coiling and oval uniseriate chambers (Pl. 5, fig. 4), and a few Colaniella have been found.
Colaniella aff. minima Wang, 1966
Pl. 1, fig. 3, 6

aff. 1966 Colaniella minima n. sp. Wang, p. 211, 219, pl. 1, fig. 1-9.
p. 1989 Colaniella ex gr. minima Wang - Jenny-Deshusses & Baud, p. 881-882, tabl. 1, fig. 2a, fig. 5c, pl. 1, fig. 117.
aff. 1992 Colaniella minima Wang - Lin et al., p. 248, pl. 33, fig. 13-16.
v. 1993b Colaniella cf. minima Wang - Vachard et al., pl. 8, fig. 13-14.
2000 Colaniella ex gr. minima Wang - Jenny-Deshusses et al., fig 3.1-2, 4a.
2002 Colaniella aff. minima Wang - Skoutstolo et al., fig. 2, 3-4.

Remarks. The material of this taxon consists of three oblique specimens, up to 0.30 mm. The relative simplicity of the internal subdivisions and small size are similar to those of Colaniella minima. Our taxon belongs probably to a primitive species of the group (see the descriptions of Okttyucu 1988), but the acme and specific differentiation of Colaniella occurs probably only in the Changhsingian, as compiled by Lin et al. (1990).

Conclusions
In the Parnon Mountain chain, central eastern Peloponnesus, the Glyphia Unit represents the uppermost tectonic unit. A wild flysch (mélange) unit of Cenozoic age contains several Cretaceous and late Permian exotic blocks floating in the matrix. The olistoliths were deposited within the Glyphia Unit during the sedimentation of the clastic series of the unit, when the latter was part of an active margin.

The origin of late Permian olistoliths must be sought to regions east of the Parnon Mountain range and to units that were more internal to Pindos Unit. The islets of Karavia in the Argolis Gulf, yield a thick carbonate sequence, but little known (Tataris 1969, 1988). The Episkopi Formation, on Hydra (Baud et al. 1991; Grant et al. 1991), although only preliminary studied, may be the largest outcrop of this age, and the most probable origin of the olistoliths.

A sample of an olistolith reveals a microfacies of bioclastic grainstone, that yields more or less forty taxa of algae, microproblematica, smaller foraminifera and fusulinids.

These assemblage is remarkable, because three markers, generally not co-occurring, are here associated: Paradobathra (Shindella) sbindensis, Hennigoidopsix cf. laquensis and Colaniella aff. minima. The appearance of Shindella is hypothetically attributed to the late Wuchiapingian/Dzhulfian (but latest Capitanian and late Changhsingian ages are also suggested). Consequently, in the late Wuchiapingian, the first Colaniella coexist with the last Hennigoidopsix (Fig. 4). This assemblage is generally indicated as late Median in the literature.

The similarities of the Greek microfauna with that of South China and southeastern Pamirs confirm the paleogeographic reconstructions which indicate a close location of the two geographic units (Besse et al. 1998, Crasquin-Soleau et al. 2001).

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Microfauna from late Permian of Greece

R E F E R E N C E S


Ehrenberg C.G. (1854) - Zur Mikrogeologie. Verlag von Leo


Endo R. & Kanuma M. (1954) - Stratigraphical and palaeontological studies of the later Palaeozoic calcareous algae in Japan; VII. Geology of the Mino mountainland and southern part of Hida plateau with description of the algal remains found in those districts. Saitama Reports of the Saitama University, series B, 1 (3): 177-255, Saitama.


Reitlinger E.A. (1950) - Foraminifery srednekamenogoloykh otloshennii tsentralnoloi chastii Rosskoi platformy (isklyucheney semeistvo Fusulinidae) [Foraminifers from the Middle Carboniferous of the central part of the Russian Platform (excepting the family Fusulinidae)]. *Akademiya Nauk SSSR, Trudy Geol. Inst.,* 126, geologicheskaya seria, 47: 1-127, Moskva (in Russian; French translation BRGM no 1456).


Tataris A. (1969) - Geological observations on the islands Dia-
Paximadi-Petalidi (Sea of Crete) and Ananes-Makra-
Pachneia-Karavia-Falconera-Vélopoula (S. Aegean Sea). 

Tataris A (1988) - The Paleozoic of the Karavia islets, east of 
21-38, Athens.

Termier G., Termier H. & Vachard D. (1977) - Etude com-
parative de quelques Ischyrospanges. Géologie Méditer-
ranéenne, 4 (2): 139-182, Marseille.

Thiébault F. (1982) - Evolution géodynamique des Héllé-
nides externes en Péloponnèse méridional (Grèce). Soc. 
Géol. Nord. Publication 6, 2 volumes: 1-593, Villeneuve 
d’Ascq.

Trifonova E. (1985) - Upper Permian foraminifers from south-
eastern Lakonia (Peloponnesus, Greece). Geologica Bal-

Ueno K. (2001) - Jinzhangua, a new staffellid fusulinoida from 
the middle Permian Daozai Formation of the Baoshan 
233-243, Fredericksburg, VA.

Vachard D. (1980) - Thébys et Gondwana au Paléozoïque 
supérieur ; les données afghanes : biostratigraphie, micro-
paléontologie, paléogéographie. Documents et Travaux 

Vachard D., Clift P. & Decrouez D. (1993a) - Une association 
à Pseudodunbarula (fusulinoida) du Permien supérieur 
(Djouftien) remaniée dans le Jurassique d’Argolide (Pé-
Genève.

Vachard D., Fontaine H. & Caridroit M. (1992) - Foraminife-
ra, algae and pseudo-algae from Carboniferous and Per-
min of Northwest Thailand. Revue Paléobiol., 11 (1): 
137-147, Genève.

Vachard D., Hauser M., Martini R., Zaninetti L., Matter A. 
& Peters T. (2001) - New algae and problematica of 
algal affinity from the Permian of the Aseelah Unit of 
the Batain Plain (East Oman). Geobios, 34 (4): 375-
404, Lyon.

Vachard D., Martini R., Zaninetti L. & Zambetakis Lekkas A. 
(1993b) - Révision micropaléontologique (foraminifères, 
algues) du Permien inférieur (Sakmarien) et supérieur 
(Dorashamien) du Mont Beltsi (Attique, Grèce). Boll. 

fusulinoides des îles d’Hydra, Crète et Mytilène (Permien 

Vennin E., Vachard D. & Proust J.N. (1997) - Taphonomic and 
syneologic study of Taphiphytes. Examples from Tratau 
and Nizhni-Irginsk buildups from lower Permian of the 

Wang K. (1966) - On Colaniella and its two allied new ge-
Chinese).

Wang K.L. & Sun X.F. (1973) - Carboniferous and Permian 
foraminifera of the Chinling Range and its geologic sig-
nificance. Acta Geologica Sinica, 2: 137-178, Beijing (in 
Chinese).

biostratigraphie dans le Permien supérieur du Taurus 