Zeitschrift: Eclogae Geologicae Helvetiae

Herausgeber: Schweizerische Geologische Gesellschaft

Band: 69 (1976)

Heft: 3

Artikel: Stratigraphy and radiolarian fauan in a Late Jurassic - Early Cretaceous section near Achladi (Evvoia, Eastern Greece)

Autor: Baumgartner, Peter O. / Bernoulli, Daniel

DOI: https://doi.org/10.5169/seals-164528

Eclogae geol. Helv.	Vol. 69/3	Pages 601-626	12 figures in the text	Basle, November 1976

Stratigraphy and Radiolarian Fauna in a Late Jurassic - Early Cretaceous Section near Achladi (Evvoia, Eastern Greece)

By PETER O. BAUMGARTNER and DANIEL BERNOULLI[1])

RÉSUMÉ

Le Calcaire à Cladocoropsis (Jurassique supérieur) de la zone pélagonienne de l'Eubée est surmonté près d'Achladi par une série de turbidites calcaires grossières et de sédiments pélagiques redéposés, à grain fin. Ceux-ci passent graduellement à des grès, des siltites et des radiolarites contenant beaucoup de détritus ophiolitique («Diabase-Chert Formation»). Au sommet, cette formation contient des olistostromes avec des blocs ophiolitiques qui annoncent le charriage de la nappe ophiolitique sur la zone pélagonienne. Datées par une faunule à radiolaires, les radiolarites de la «Diabase-Chert Formation» appartiennent soit au Jurassique terminal soit au Crétacé basal, probablement à la période Berriasien à Valanginien (zone à *Sphaerostylus lanceola* de RIEDEL & SANFILIPPO 1974; zone RK 2 de MOORE 1973). La datation des radiolarites confirme l'âge de la mise en place de la nappe ophiolitique pendant le Jurassique terminal ou le Crétacé basal comme on peut le déduire du fait que les flyschs béotiens du Crétacé basal, situés plus à l'Ouest, sont chargés de détritus ophiolitique (CELET et al. 1976).

ABSTRACT

In a section near Achladi, eastern Evvoia, the Late Jurassic Cladocoropsis Limestone of the Pelagonian zone of Evvoia is overlain by a transitional unit of coarse turbiditic limestones and fine-grained redeposited pelagic sediments. This unit in turn passes upwards into graded lithic arenites, silt- and radiolarian mudstones with abundant ophiolitic detritus (Diabase-Chert Formation). In its upper part, the formation contains olistostromes with blocks of ophiolitic rocks heralding the overthrust of the overlying ophiolite nappe. The radiolarian mudstones of the Diabase-Chert Formation have been dated by a small radiolarian fauna as latest Jurassic to Early Cretaceous, most probably Berriasian to Valanginian (*Sphaerostylus lanceola* zone of RIEDEL & SANFILIPPO 1974; Zone RK 2, MOORE 1973). This confirms the emplacement of an ophiolite nappe during the latest Jurassic or earliest Cretaceous as also indicated by ophiolite detritus in the Early Cretaceous Beotian flysch to the west (CELET et al. 1976).

CONTENTS

[1]) Geological Institute, University of Basel, Bernoullianum, CH-4056 Basel.

Introduction

In the frame of the new global tectonics Alpine-type ophiolites are generally interpreted as remnants of oceanic crust and lithosphere tectonically emplaced on former continental margins. For the Tethyan ophiolites of the Dinaride and Hellenide mountain system this view seems now widely accepted. More ambiguous, however, are the age of formation of this oceanic crust, the width and palinspastic arrangement of the oceanic areas, their origin (spreading ridge versus back-arc basin), and the time and mode of the tectonic emplacement on the continental margins.

In the Hellenides and Dinarides several authors have argued for two ocean basins separated by a Pelagonian microcontinent, one originally external to the Pelagonian axis (Subpelagonian zone of AUBOUIN 1957, 1958, 1959, 1960), the other originally occupying the area of the present-day Vardar zone (MOORES 1969, SMITH 1971, DIMITRIJEVIĆ & DIMITRIJEVIĆ 1973). The alternative solution is a central Tethyan ocean occupying what is now known as the Almopias subzone of the Vardar zone (MERCIER 1966) from which have issued the great ophiolite nappes now lying far to the south-west (DERCOURT 1972, BERNOULLI & LAUBSCHER 1972, ZIMMERMAN 1972). For a thorough review of the stratigraphic data the reader is referred to AUBOUIN (1973), for a clear exposition of the palinspastic and paleotectonic problems to DÜRR (1976).

In the first model, the Subpelagonian ocean appears to form a continuous sedimentary basin with the Beotian (Bosnian) flysch zone and, north of the Sperchios River, also with the Pindos zone (HYNES et al. 1972, CELET et al. 1976). Tectonic emplacement of ophiolites on the Pelagonian microcontinent occurred along the north-eastern margin of this ocean with a vergence of thrusting towards the north-east, before the transgression of the Upper Cretaceous sediments, possibly in Late Jurassic to Early Cretaceous times (HYNES et al. 1972, SMITH et al. 1975) as suggested by the presence of Late Jurassic - Early Cretaceous ophiolitic flysch in the Beotian zone (CELET & CLÉMENT 1971, CELET et al. 1976).

According to the second interpretation, the ophiolites have been thrust from the east onto the Pelagonian continental margin which belonged to the southern margin of the central Tethys (cf. LAUBSCHER & BERNOULLI 1976); in this view the Beotian and Pindos zone appear as deeper troughs within a general continental margin setting.

In either hypothesis the tectonic emplacement of ophiolites on the Pelagonian margin occurred between the Late Jurassic and the Early Cretaceous. From Late Triassic to Early Jurassic this margin was characterized by a thick sequence of shallow-water limestones. During the Jurassic this carbonate platform was disintegrated by extensional faulting; parts of it were submerged and received pelagic sediments from the Middle to Late Liassic onwards (Argolis, AUBOUIN et al. 1970); in other places sedimentation of shallow-water limestones kept pace with subsidence up to the Late Jurassic (Locris, Evvoia, BASSOULET & GUERNET 1970). Both shallow-water limestones and pelagic sediments are generally overlain by a sequence of turbiditic lithic sandstones, siltstones, and shales with occasional radiolarian cherts, redeposited carbonate material, and intercalations of basaltic pillow-lavas (PARROT

& GUERNET 1972). In its higher parts this formation contains olistoliths of ophiolitic rocks which are obviously linked with the emplacement of the ophiolite nappe overlying the formation, and at places typical mélange formations of sedimentary and/or tectonic origin are present below the ophiolite nappe (CELET 1975, ZIMMERMAN 1972). The whole formation is known as Diabase-Chert Formation in Yugoslavia (AMPFERER & HAMMER 1921, ĆIRIĆ & KARAMATA 1960), in Greece it is known as Serpentin-Schiefer-Hornstein-Gruppe (including the overlying ophiolite nappe, RENZ 1955), Diabas-Hornstein-Tuffit-Serie (BANNERT & BENDER 1968) or as «Série détritique infra-ophiolitique» (AUBOUIN et al. 1970). Although in Greece this formation is not clearly defined we shall informally refer to it as "Diabase-Chert Formation". The formation contains hardly any fossils; it has been roughly dated as latest Jurassic by scarce fossils (ALBANDAKIS 1968) and by the age of the underlying carbonate sequence (Kimmeridgian to ? Early Tithonian, BASSOULET & GUERNET 1970). This age, however, is in good agreement with the age of the Beotian flysch which also contains abundant ophiolitic detritus derived from the ophiolite nappe and which has been dated as Late Tithonian(?) to Early Cretaceous (Berriasian) (CELET et al. 1976).

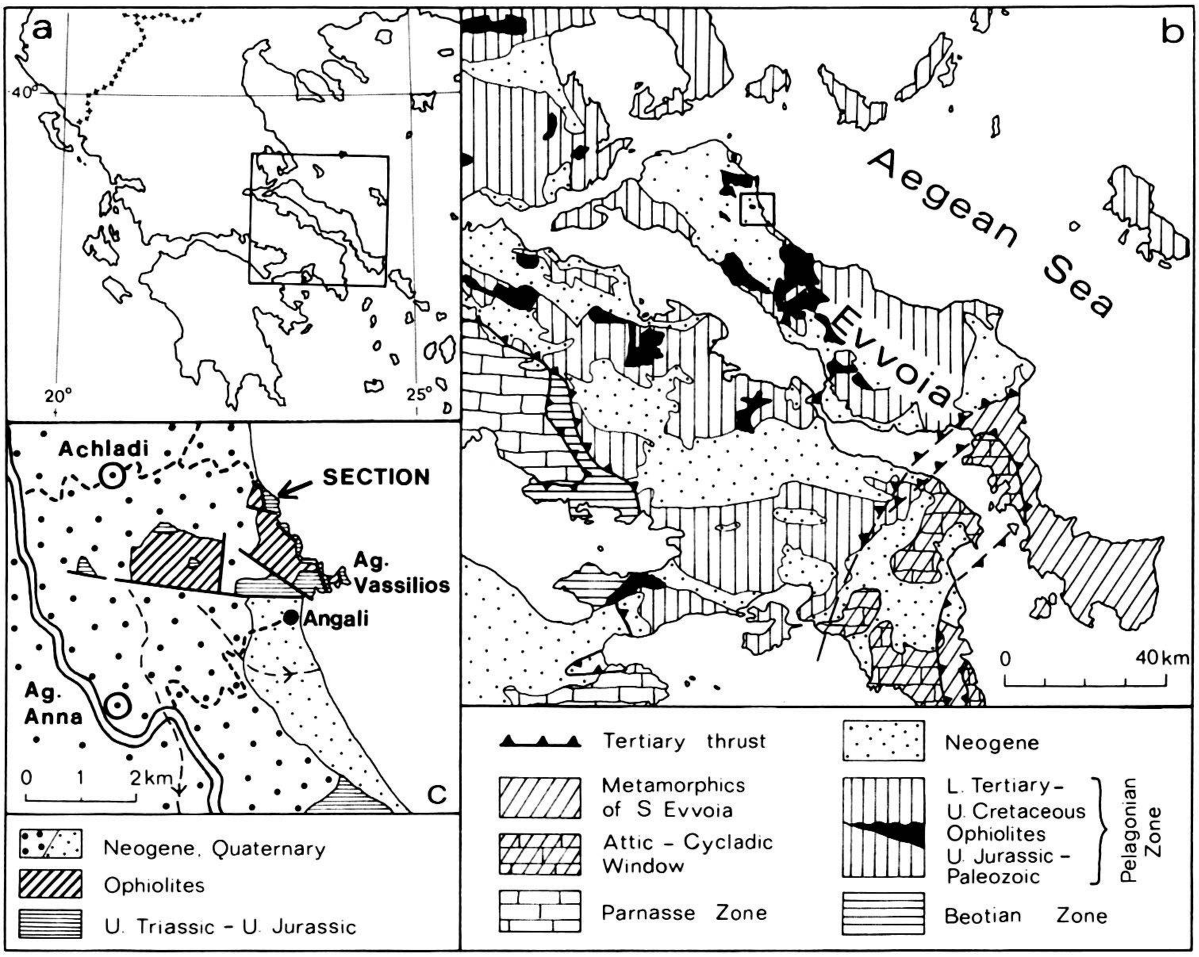

Fig. 1. Index map (a) and generalized tectonic map (b) of central eastern Greece, mainly after CELET (1962), CELET et al. (1976), DÜRR (in press), GUERNET (1974) and KATSIKATSOS (1969). Location of section (c), geology after GUERNET (1974).

The deeply eroded ophiolite nappe and its substratum are transgressively overlain by thick lateritic crusts, conglomerates and shallow-water limestones. In Argolis (DECROUEZ 1976) and in Locris and Evvoia (BIGNOT & GUERNET 1968) the age of the transgression is Albian to Cenomanian; in southern Yugoslavia, however, transgressive «Neocomian» strata seal the thrust of the ophiolites on the Diabase-Chert Formation (AUBOUIN 1973). Additional tectonic transport of the ophiolites and their Pelagonian substratum in a composite nappe towards the west occurred in Late Eocene times (overthrust of the "Subpelagonian" zone onto the Beotian and Pindos zones, cf. BERNOULLI & LAUBSCHER 1972).

In this preliminary paper we shall present some observations on 1. the passage from shallow-water limestones to pelagic and turbiditic sediments in the sequence underlying the ophiolite nappe in the Pelagonian sequence of central Evvoia, and 2. present some biostratigraphic data on the age of these sequences. The section illustrated here has been investigated earlier by GUERNET (1971) and GUERNET & PARROT (1972); they describe an alternation of shallow-marine limestones and radiolarites, which leads them to the conclusion that radiolarites may be deposited in shallow water of some hundred meters only. As this question bears on the

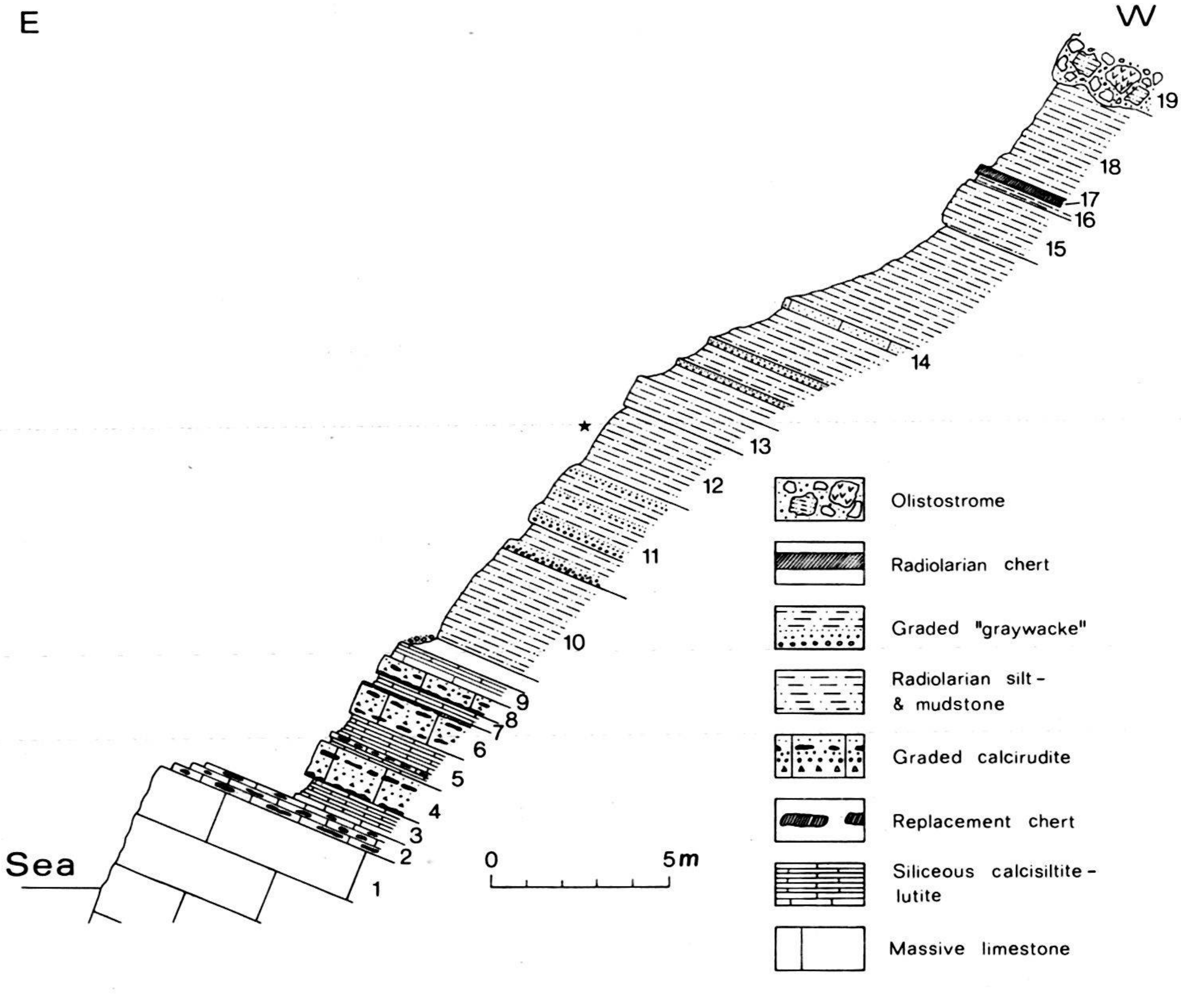

Fig. 2. Stratigraphic section in the top of the Cladocoropsis Limestone and the base of the Diabase-Chert Formation, beach of Achladi, Evvoia. Description in the text. *Radiolarian fauna.

paleobathymetric interpretation of many Tethyan sequences we have drawn special attention to this problem.

Field work and sedimentological analysis have been carried out by P.O. Baumgartner and D. Bernoulli; the paleontological part has been worked out by P.O. Baumgartner.

Location of section

The section is situated on the east-coast of Evvoia at the southern end of the beach of Achladi (Fig. 1). Additional observations have been made in the section of Cap Ajios Vassilios which has also been described by GUERNET & PARROT (1972).

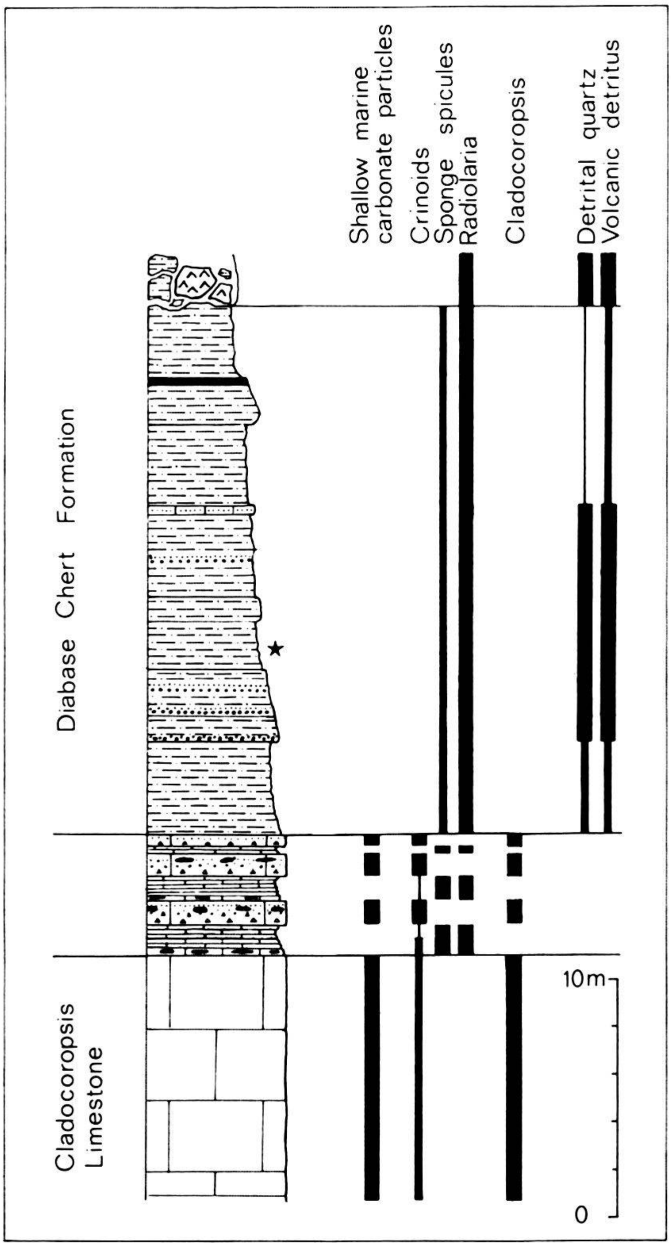

Fig. 3. Columnar section in the top of the Cladocoropsis Limestone and the base of the Diabase-Chert Formation, beach of Achladi, Evvoia. For explanation of lithological symbols see Figure 2. *Radiolarian fauna.

Stratigraphy and sedimentology

The section is illustrated in Figures 2 to 4. Four major lithologic units can be recognized: The lowermost unit exposed is a massive bioclastic limestone of unknown thickness (1); it is overlain by an alternation of thin-bedded, graded, fine calcarenites to calcisiltites, radiolarian limestones and meter-bedded, graded, coarse bioclastic calcirudites to calcarenites (2-9). Above this transitional unit, there is a sequence of radiolaria-rich green mudstones and siltstones with interbedded lithic sand- and siltstones containing mainly volcanic detritus (10-18), and finally a boulder bed of at least some meters thickness (19) occurs below the postorogenic deposits. At this point the section of GUERNET & PARROT (1972) indicates Neogene conglomerates; however, the latter usually can be clearly distinguished from preorogenic deposits; and the occurrence of a similar boulder bed of identical stratigraphic position and composition in the nearby section of Cap Ajios Vassilios leaves little doubt about the Mesozoic age of this horizon.

Some 50 m to the north of the profile, a lenticular body of fine-grained limestone rich in calcitized sponge spicules, several meters thick, is intercalated in the radiolarian mud- and siltstones. This limestone mass which occurs about 15 m above the base of the mudstone unit is interpreted by us as an olistolith.

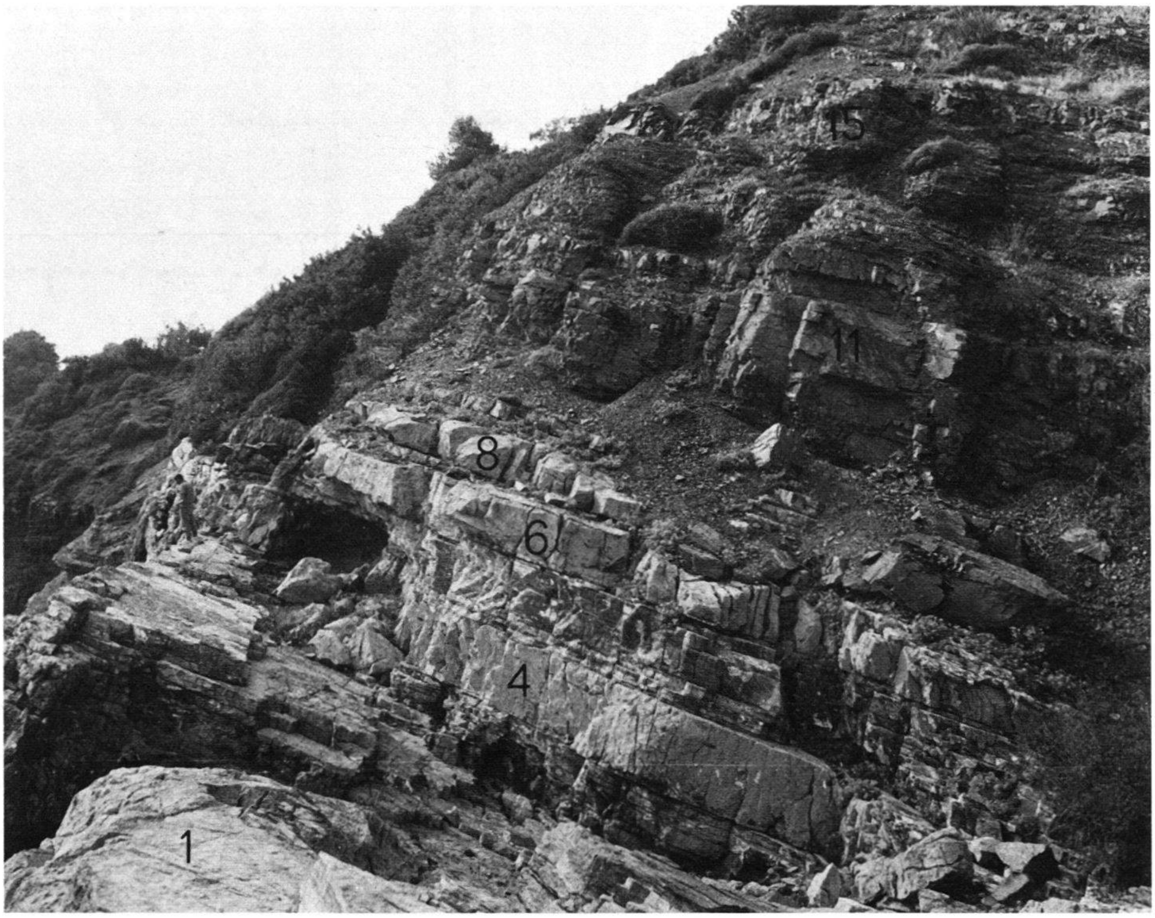

Fig. 4. General view of the section at beach of Achladi, Evvoia. Numbers refer to Figure 2 and to the description in the text.

The section comprises from bottom to top (Fig. 2–4):

1. Cladocoropsis Limestone: dark grey, massive, unsorted calcirudite to calcarenite, which in a micritic to finely calcarenitic matrix contains bioclastic and intraclastic fragments. These fragments are of cm- to dm-size, they include hydrozoa, calcareous algae, *Cladocoropsis* and corals. Visible thickness 10 m.
2. dark grey, dm-bedded calcisiltite to calcilutite with small irregular nodules of replacement chert. These limestones show faint current bedding and convolution. Thickness 0.75 m.
3. to 9. light grey to pink and yellowish, cm-bedded calcisiltites and calcilutites. The sediment is generally fine-grained, but often the basal part of the beds displays faint grading and current lamination whereas the upper part of the beds appears to be burrowed (Fig. 6a). The matrix of these limestones has been recrystallized to microspar, it contains badly preserved coccoliths, calcite-filled molds of sponge spicules, radiolarians, undeterminable microbioclastic hash and questionable calcispherulids. Silicification in the form of megaquartz occurs selectively in burrows or in irregular patches.
   Intercalated are three thick beds of dark grey, bioclastic calcirudite to calcarenite (Fig. 5). These beds are distinctly graded with components some cm across along the base of the bed and arenitic fragments in the upper part. The lower, graded, interval shows imbrication of the fragments and in the upper part parallel lamination can be observed. The components are mainly bioclasts, neritic particles and fragments of shallow-water limestones; they include hydrozoa (*Cladocoropsis* sp.), calcareous algae [*Bačinella irregularis* RADOIČIĆ, *Lithocodium aggregatum* ELLIOTT, *Thaumatoporella parvovesiculifera* (RAINERI), dasyclad algae, *Cayeuxia* sp.], corals, molluscs, echinoderms, various coated indeterminable fossils, foraminifera, ooids, onkoids, fragments of pelletal and ooidal grainstones and of micritic limestones (determinations of fossils by E. Flügel). The fragments are closely packed, and the sparse matrix and the rims of the components are often replaced by silica (megaquartz with sometimes euhedral bipyramidal crystals rich in calcite inclusions). Such concentrations of silica often occur along the base (Fig. 6b) or the top of the beds or as irregular nodules along certain levels (Fig. 5).

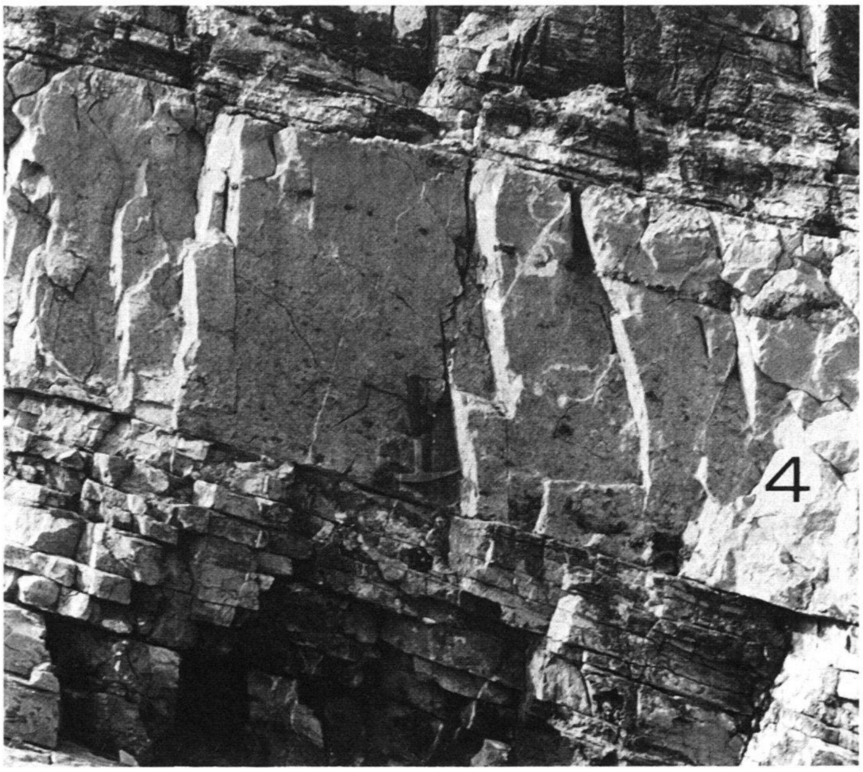

Fig. 5. Graded, coarse bio- and lithoclastic calcirudite to calcarenite with bands and nodules of replacement chert, intercalated between thinly-bedded calcisiltites and calcilutites. Upper Jurassic, beach of Achladi, Evvoia.

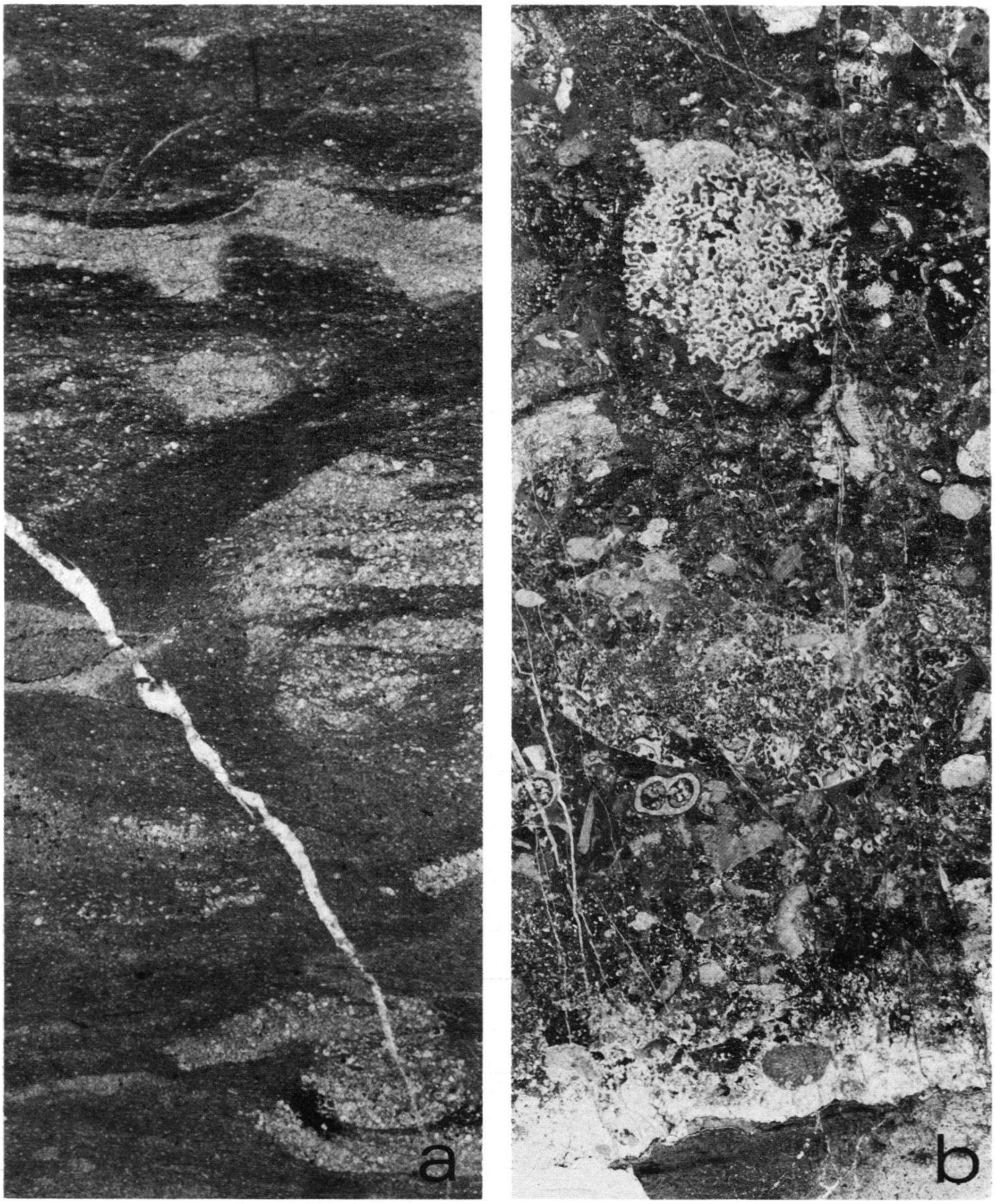

Fig. 6a. Burrowed calcisiltite to calcilutite with calcite-filled molds of sponge spicules and Radiolaria. Burrows are partly replaced by silica. Unit 5, uppermost Jurassic, beach of Achladi, Evvoia. DB4565, thin-section, ×4.35.

Fig. 6b. Bio-lithoclastic calcirudite overlying fine calcisiltite to calcilutite, partially replaced by silica. The calcirudite contains bio- and lithoclasts of carbonate platform origin, mainly hydrozoa, calcareous algae, molluscs and benthonic foraminifera. Along the base of the calcirudite the sediment is largely replaced by silica. Base of Unit 8, uppermost Jurassic, beach of Achladi, Evvoia. DB4561, thin-section, ×3.45.

10. to 18. Diabase-Chert Formation: radiolaria-rich, green, brownish weathering mudstones and siltstones with intercalated graded lithic arenites. The mud- and siltstones are very fine-grained throughout, they consist of various proportions of clay minerals, radiolarians, very fine-grained detrital material and minor amounts of carbonate. The state of preservation of the radiolaria varies considerably from relatively well preserved skeletons (Fig. 7b-c, 10-12) to silica- and calcite-filled molds without skeletal structure. At places faint grading and a fine lamination can be observed. Intercalated within the mud- and siltstones, up to 10 cm thick beds and thin laminae of graded and laminated lithic arenites occur (Fig. 7a, d). They are composed of closely packed fine-grained lithic fragments - mainly altered volcanics -, some angular quartz, rare altered feldspars, coarsely crystalline carbonate fragments, and occasional radiolaria. Minor lithologies in this succession consist of siliceous claystone with only occasional radiolaria (17) and of laminated argillaceous limestones with calcitized radiolaria.

19. boulder bed with blocks and pebbles (Fig. 8, 9). This unsorted deposit contains in a muddy to sandy matrix fragments of mm- to dm-size of widely varying lithologies. These comprise fragments of serpentinite, altered gabbro, mafic volcanic rocks, lithic sandstones and radiolarian silt- to mudstones as in the underlying sequence, coarsely crystalline limestones including skeletal limestones with pelagic bivalves, quartzose cherts and quartzarenites (Fig. 9).

Radiolarian assemblages in the Diabase-Chert Formation

General remarks

During the last few years the biostratigraphy of Mesozoic Radiolaria has been greatly improved and stratigraphic zonations have been extended as far back as to the Early Cretaceous and Late Jurassic (FOREMAN 1971, 1973; MOORE 1973; RIEDEL & SANFILIPPO 1974). These zonations are mainly based on material recovered by deep ocean drilling; when calibrated with other fossils, they should provide a valuable tool for dating otherwise unfossiliferous deep-sea sediments in orogenic belts. However, application to such deformed "oceanic" sequences still meets with considerable difficulties: oceanic sequences in orogenic belts usually occur in highly deformed, sometimes metamorphosed zones, and therefore well-preserved and determinable radiolarian faunas are rather an exception and may be expected only in particular lithologies. An additional difficulty arises from the present stage of radiolarian taxonomy: systematic descriptions on a supra-specific level have not been done or are in progress for most of the radiolarian groups and therefore many new forms can only tentatively be assigned to genera. Thus we restrict ourselves to a preliminary inventory of some radiolarians in the Diabase-Chert Formation of the described section in order to evaluate its possible chronologic position.

Methods

In thin sections some of the samples of the Diabase-Chert Formation showed very well-preserved radiolarians embedded in a fine clayey and siliceous matrix; they are predominantly filled by a greenish authigenic mineral of chloritic composition (Fig. 7b-c). The samples containing well-preserved specimens were treated with dilute hydrofluoric acid following the method described by DUMITRICA (1970) and by PESSAGNO & NEWPORT (1972). Among these samples, one (DB 4575; Unit 12, Fig. 2-3) contained an assemblage sufficiently preserved for systematic description. The material was examined both with the Stereoscan electron microscope and with the light microscope; the well-defined forms were determined with the help of the

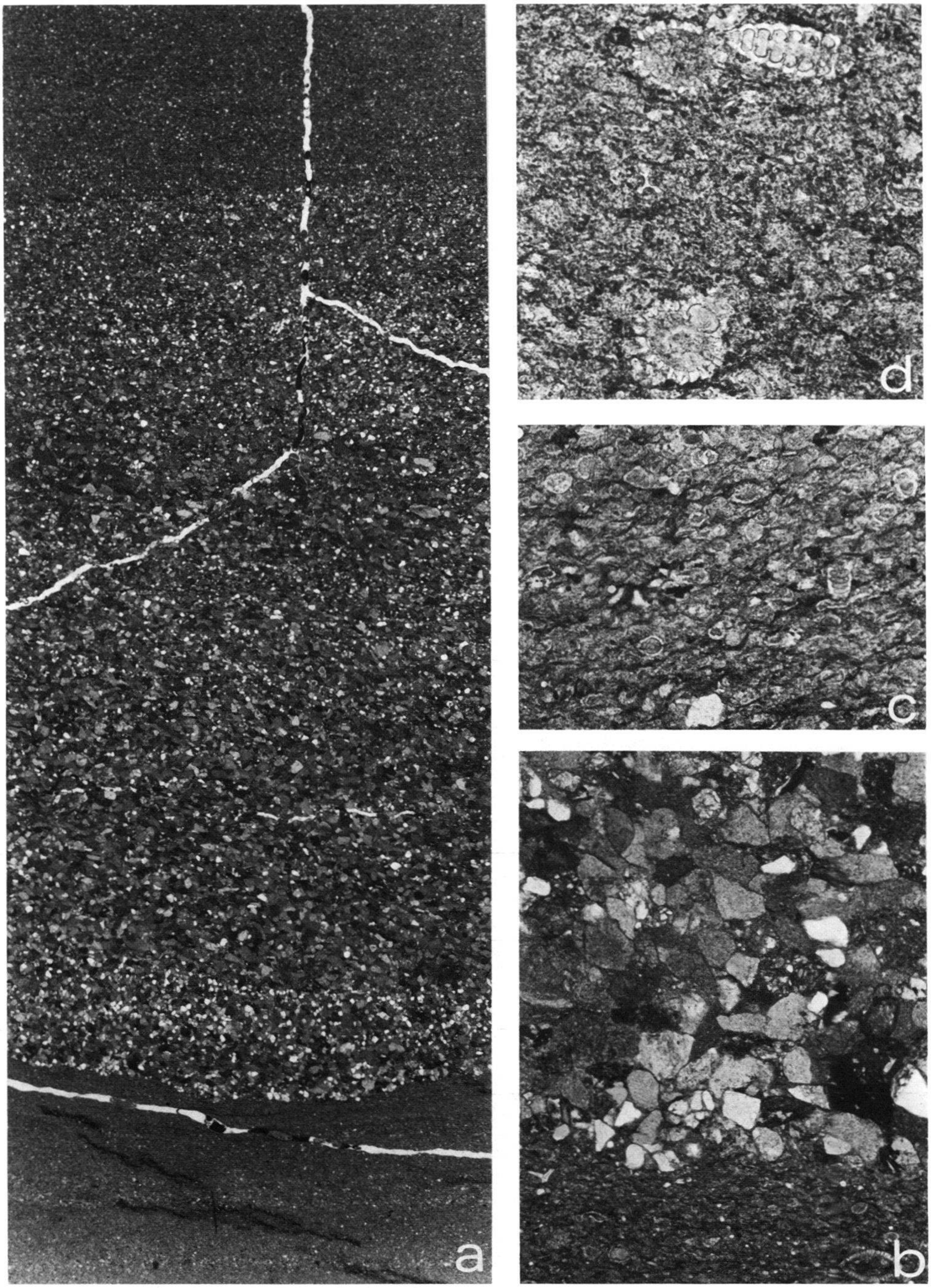

Fig. 7. Explanations on the opposite page.

existing literature; taxonomical assignments were made as conservatively as possible.

Taxonomic descriptions

The following taxonomic listing is intended to provide 1. references to described taxa, 2. descriptions of well-defined forms which could not be assigned to specific taxa, 3. dimensions for comparison with earlier work and 4. known ranges and occurrences.

We have mainly followed the generic and specific assignments applied by the cited authors and therefore neglected classification.

Acaeniotyle sp. aff. *A. umbilicata* (RÜST 1898)

Fig. 10i

FOREMAN 1973, p. 258, Pl. 1, Fig. 12–14, 16.

Xiphosphaera umbilicata RÜST 1898, p. 7, Pl. 1, Fig. 9.
Xiphosphaera tuberosa TAN SIN HOK 1927, p. 35, Pl. 5, Fig. 8.

Dimensions. - Diameter 120 μ; spine length 133 μ.

Remarks. - Recovered specimens are poorly preserved with broken spines. The figured specimen shows a slightly curved spine and a poorly preserved spongy internal structure.

Range and occurrence. - *Acaeniotyle umbilicata* is reported from DSDP Sites 194, 195, 195B and 196, ranging from Late Jurassic to Early Cretaceous; *Xiphosphaera umbilicata* is reported from the Upper Jurassic of Cittiglio, Northern Italy; *Xiphosphaera tuberosa* is reported from the Turonian or Early Senonian of Roti.

Amphipyndax FOREMAN 1966 sp.

Fig. 12e, i, m

FOREMAN 1966, p. 355, Fig. 7–9.

cf. *Dictyomitra nassa* PARONA 1890, p. 170, Pl. 6, Fig. 10.
cf. *Lithocampe fasciata* RÜST 1898, p. 63, Pl. 18, Fig. 3.
cf. *Stichocapsa fasciata* RÜST 1898, p. 65, Pl. 18, Fig. 6.
cf. *Lithocampe ananassa* RÜST 1885, in MOORE 1973, p. 828, Pl. 4, Fig. 7–9.
cf. *Amphipyndax* (?) spp., in FOREMAN 1973, p. 263, Pl. 9, Fig. 3–5.
cf. *Dictyomitra boesii* PARONA 1890, in RIEDEL & SANFILIPPO 1974, p. 778, Pl. 4, Fig. 5–6.

Description. - Shell more or less spindle-shaped, with seven to eight, sometimes ten segments, of which the fifth to seventh are the widest. All species are apparently

---

Fig. 7a. Graded lithic arenite overlying radiolaria-bearing silt- to mudstones. The turbidite contains fine-grained lithic fragments - mainly altered volcanics -, some angular quartz, rare altered feldspars and occasional Radiolaria. Unit 11, Diabase-Chert Formation, ? lowermost Cretaceous, beach of Achladi, Evvoia. DB 4574, thin section, × 4.

Fig. 7b. Detail of base of turbidite illustrated in Figure 7a, × 30.

Fig. 7c and 7d. Well-preserved radiolaria in a clayey-siliceous mudstone matrix. Thin sections. *7c* = DB4573, Unit 10, × 48; *7d* = DB4575, Unit 12, × 120. Diabase-Chert Formation, ? lowermost Cretaceous, beach of Achladi, Evvoia.

broken at their distal end. The basal constriction may be strong or rather slight, the latter forms having more segments. Cephalis divided into a larger upper spherical or hemispherical, and a lower cylindrical chamber. No apical horn was observed. Cephalis and thorax together conical, thorax and abdominal segments each bearing three rows of round pores, arranged hexagonally and forming diagonal rows over the shell. The segmental divisions, except the one between cephalis and thorax, are accentuated externally by a broad transverse ridge, which produces a rippled silhouette.

Dimensions (6 specimens). - Length of longest specimen of 10 segments 205 μ, of 7 segments 130-150 μ; greatest width 83-97 μ; length of cephalis 20-26 μ; diameter of upper chamber of cephalis 17-20 μ; diameter of pores on largest segment 3-5 μ.

Remarks. - This is one of the abundant, better preserved nassellarians in the assemblage. It has similarities to the above cited species, but we assign it on account of its cephalic structure to the genus *Amphipyndax*.

Occurrence. - *Lithocampe fasciata, Stichocapsa fasciata* and *Dictyomitra nassa* are reported from the Upper Jurassic of Cittiglio, Northern Italy. *Lithocampe ananassa* is reported by MOORE (1973) from DSDP Site 167, ranging from Tithonian

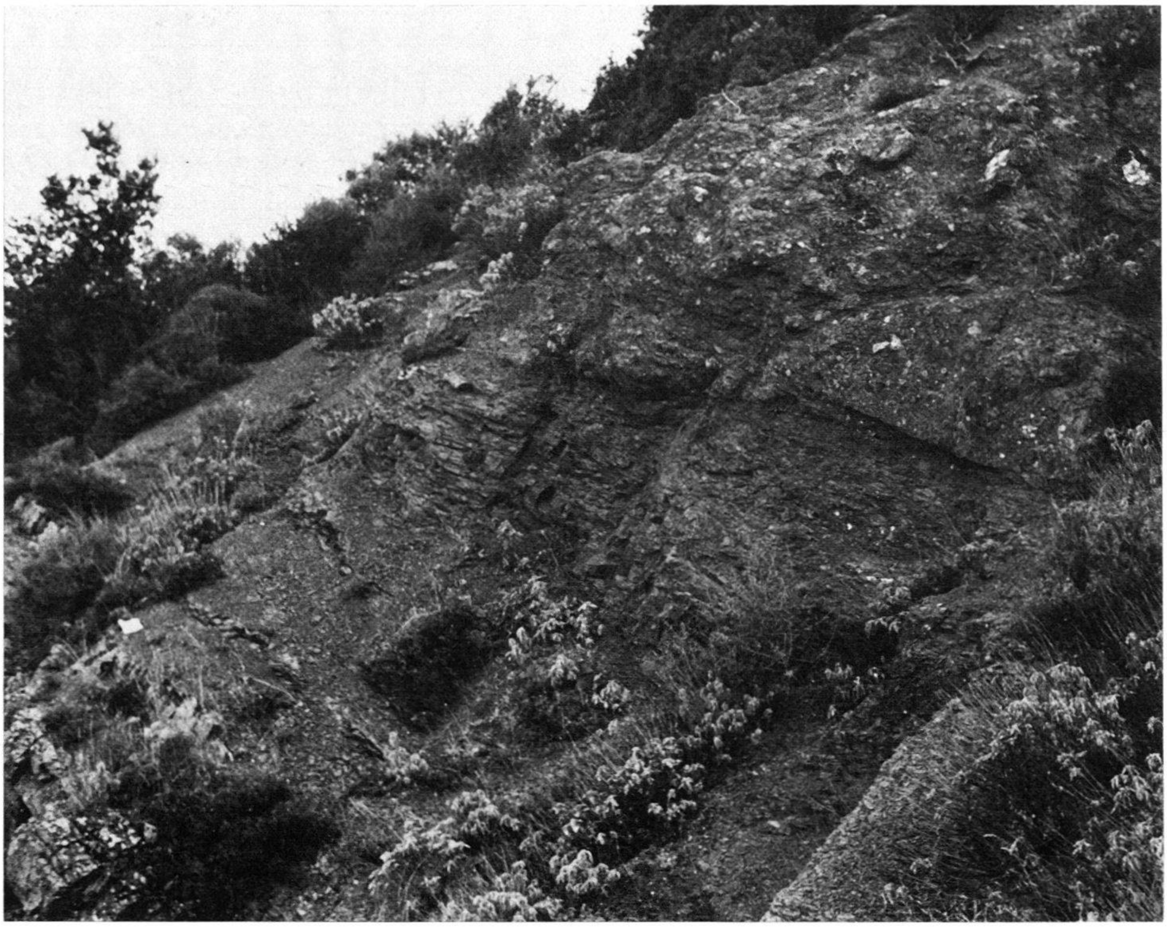

Fig. 8. Thinly bedded radiolaria-bearing silt- to mudstones overlain by boulder bed (debris flow) containing boulders and pebbles of ophiolitic rocks.
Unit 19, Diabase-Chert Formation, ? lowermost Cretaceous, beach of Achladi, Evvoia.

to Cenomanian. *Amphipyndax* (?) spp. are reported by FOREMAN (1973) from DSDP Sites 195 and 196, ranging from ? Late Jurassic to Early Hauterivian. *Dictyomitra boesii* is reported by RIEDEL & SANFILIPPO (1974) from Santa Anna (Sicily), Pt. Sal, California, and DSDP Site 167, ranging from Late Jurassic to approx. Albian-Barremian.

Archaeospongoprunum PESSAGNO 1973 sp.

Fig. 10a, b

PESSAGNO 1973, p. 57.

Description. - A coarsely spongy form with elongated-ellipsoidal shape, medially slightly constricted, with two sturdy four- (or five-) bladed polar spines. Twisted spines were not found.

Dimensions (5 specimens). - Length of shell in polar plane 115-130 μ; maximal aequatorial width 60-70 μ; length of preserved spines 75-105 μ; width of spine base 27-37 μ; width of pores 5-7 μ.

Remarks. - The form cannot be assigned to any of the described species.

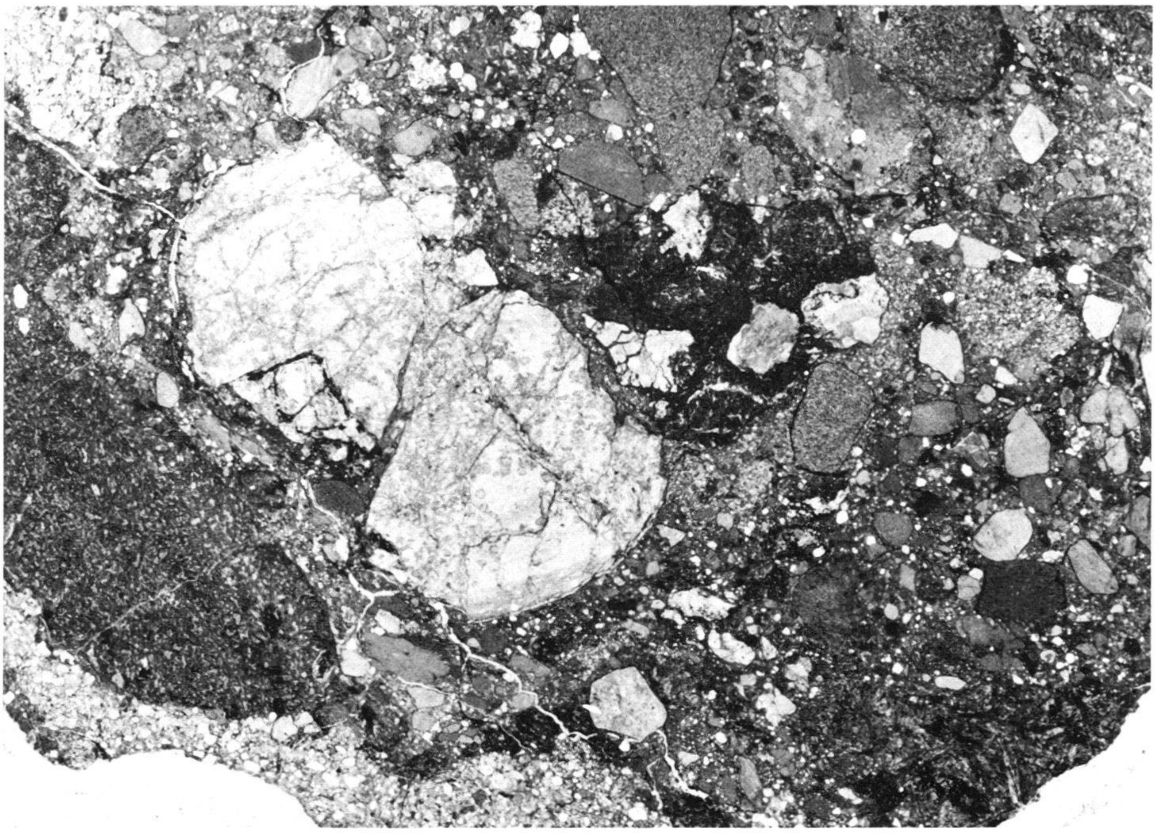

Fig. 9. Matrix of boulder bed (Unit 19), contains in sandy to clayey matrix lithic fragments of altered volcanics, silt- and mudstones, radiolaria-bearing mudstones, sandstones and rare silica-replaced carbonate rocks.

Diabase-Chert Formation, ? lowermost Cretaceous, beach of Achladi, Evvoia. DB 4579, thin section, ×4.5.

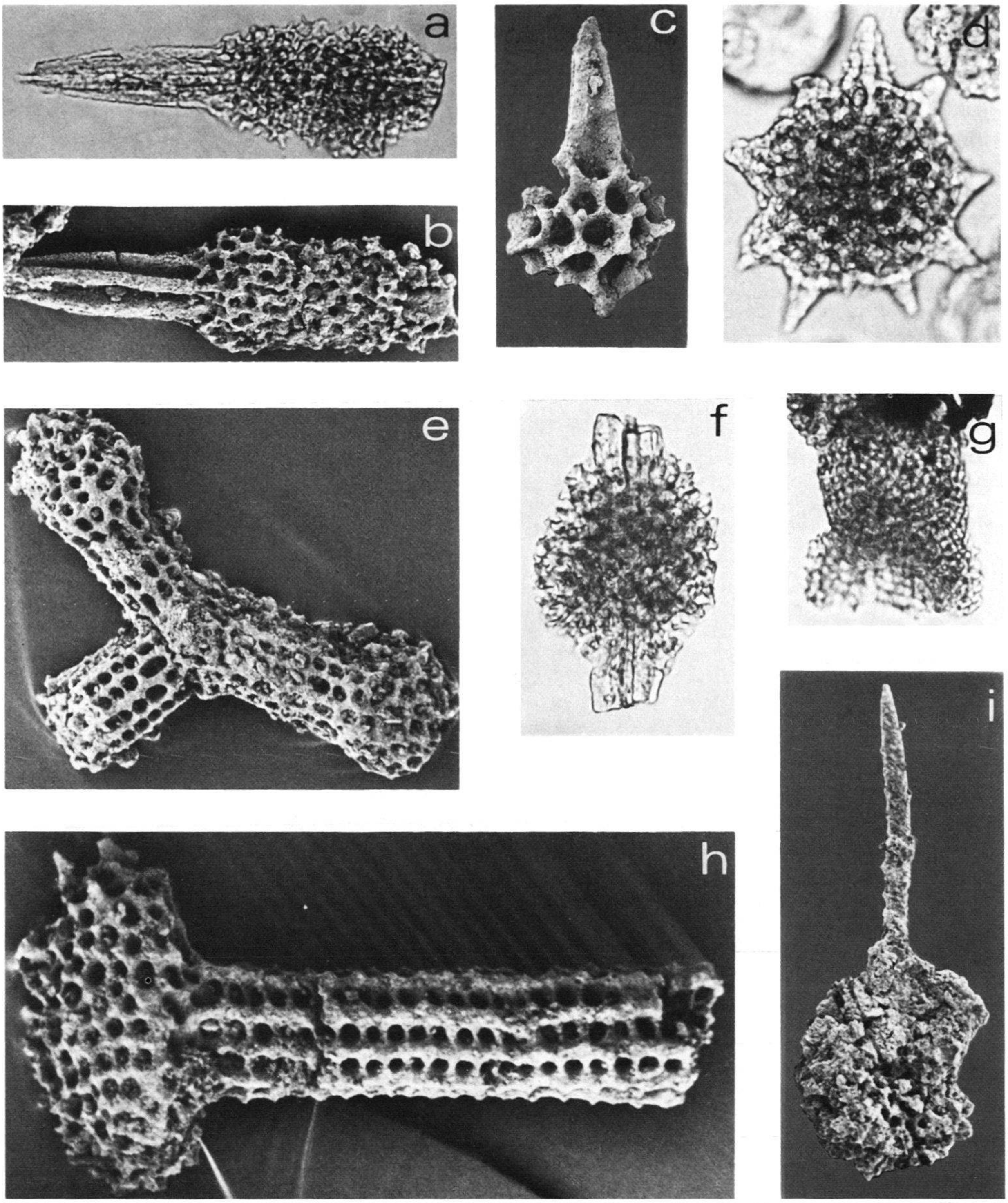

Fig. 10. Radiolaria *(Spumellaria)* from the Diabase-Chert Formation, sample DB4575, Unit 12, Achladi, Evvoia, Eastern Greece. All specimen ×250.

a, b	*Archaeospongoprunum* sp.	f	Spongodiscid gen. et sp. indet.
c	*Sphaerostylus lanceola*	g	*Spongopyle insolita* group
d	Pseudoaulophacid gen. et sp. indet.	h	Hagiastrid cf. *Amphibracchium* sp.
e	*? Patulibracchium* sp.	i	*Acaeniotyle umbilicata*

Cyrtocapsa molengraaffi TAN SIN HOK 1927 group

Fig. 11o

TAN SIN HOK 1927, p. 66, Pl. 14, Fig. 114-116.
MOORE 1973, p. 828.

Remarks. - Several forms with sub-spherical fourth or fifth terminal segment, with large circular pores and ridges between them are common in the assemblage. Some of them certainly belong to *C. molengraaffi*.

Range and occurrence. - *C. molengraaffi* is reported from Roti, Timor (probably Turonian or Senonian) and from DSDP Site 167, ranging from Upper Tithonian/Berriasian to Upper Albian/Lower Cenomanian.

Dictyomitra excellens (TAN SIN HOK 1927)

Fig. 12k

RENZ 1974, p. 791, Pl. 8, Fig. 7, 8; Pl. 11, Fig. 35.
Lithomitra excellens TAN SIN HOK 1927, p. 56, Pl. 11, Fig. 85.
L. excellens in MOORE 1973, p. 827, Pl. 4, Fig. 3, 4.

Dimensions (2 specimens). - Total length (9 segments) 225 μ; maximal width (seventh segment) 115 μ; thickest shell wall 18 μ.

Remarks. - The thickening of the shell wall, which forms a cylindrical shape beyond the fifth segment, is typical and well seen in TAN's and RENZ's illustrations.

Range and occurrence. - The species is reported from Roti, (Timor), probably of Turonian to Senonian age; from DSDP Site 167, ranging from Upper Berriasian - Lower Valanginian to Upper Albian - Lower Cenomanian; and from DSDP Sites 259-261, Senonian to Aptian and older.

Dictyomitra ZITTEL 1876 spp. group A

Fig. 12a-c

cf. *Eucyrtidium brouweri* TAN SIN HOK 1927, p. 57-58, Pl. 11, Fig. 89-93
cf. *D. lacrimula* FOREMAN 1973, p. 263, Pl. 10, Fig. 11.
cf. *D. brouweri* in RENZ 1974, p. 790, Pl. 8, Fig. 9-16; Pl. 11, Fig. 26, 27.

Description. - Small spindle-shaped forms with four or more segments. Externally smooth or sometimes with rarely visible segmental divisions. Longitudinal ribs, about 10 per half a circumference from thorax to aperture. A single vertical row of small rounded pores is placed between adjacent ribs, sometimes ordered into three transverse rows per segment.

Dimensions. - Length of 4 segments 90-110 μ, of 7 segments 170 μ; width 55-75 μ.

Remarks. - The general description is in good agreement with FOREMAN's description of *D. lacrimula*, however, all our specimens are distinctly smaller.

Dictyomitra ZITTEL 1876 sp. B

Fig. 12d, g, h

cf. *Dictyomitra* sp., FOREMAN 1973, Pl. 16, Fig. 7.

Description. - Small, slender form with conical shape, tending to be cylindrical or slightly constricted distally, with nine to eleven segments. The segments are

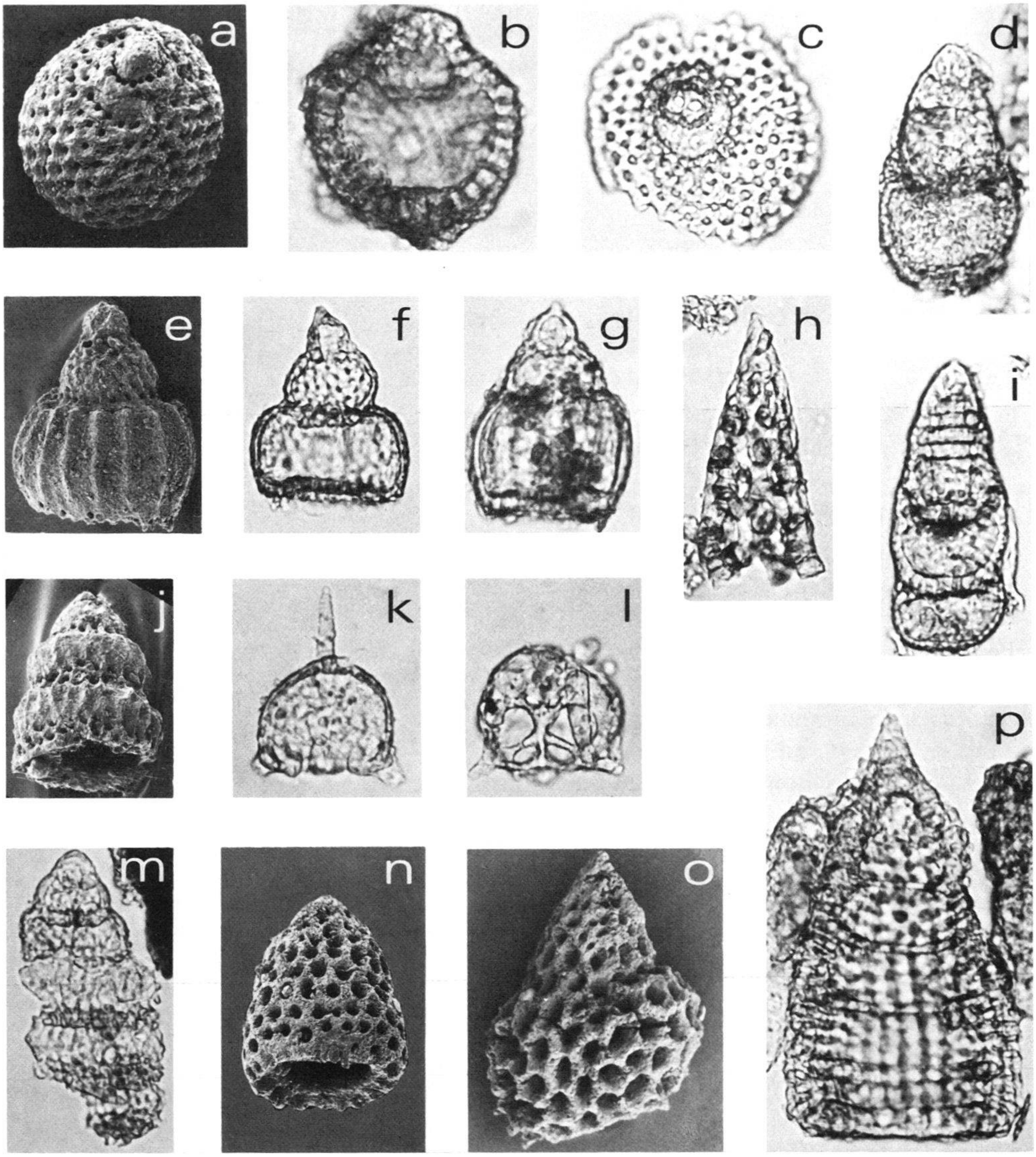

Fig. 11. Radiolaria *(Nassellaria)* from the Diabase-Chert Formation, sample DB 4575, Unit 12, Achladi, Evvoia, Eastern Greece. All specimen $\times 250$.

a–c	*Hemicryptocapsa* spp. cf. *H. capita*
d, i	*Solenotryma* sp.
e–g	*Eucyrtidium ptyctum*
h	Theoperid gen. et sp. indet.
j, m	Nassellariid sp. A
k, l	? Spyrid gen. et sp. indet.
n	Nassellariid sp. group C
o	*Cyrtocapsa molengraaffi*
p	*Lithostrobus erectus ?*

slightly inflated and, apart from cephalis and thorax, nearly equal in length. The segmental divisions are only distally marked by a slight constriction. The shell bears characteristic fine longitudinal costae which bifurcate next to the segmental constriction to surround the pores. A single row of small elliptic pores is thus placed at the segmental constriction.

Dimensions (6 specimens). - Length of 9 segments 145-160 μ, of 11 segments 180 μ; greatest width 63-77 μ; length of a distal segment 20 μ.

Remarks. - Common form, but in most cases badly preserved.

Dictyomitra ZITTEL 1876 sp. C

Fig. 12 l

cf. *Dictyomitra* sp., FOREMAN 1973, Pl. 10, Fig. 5.

Remarks. - Only one specimen found. Probably related to *Dictyomitra* sp. B but with twelve segments, rather conical shape and more accentuated segmental divisions. One pore row in the lower part of each segment.

Dictyomitra ZITTEL 1876 sp. D

Fig. 12j

cf. *Dictyomitra* sp. C, MOORE 1973, p. 830, Pl. 14, Fig. 3, 4.

Remarks. - Only one specimen found. Stout conical form with nine segments, bearing strong costae with pores irregularly distributed between them.

Eucyrtidium ptyctum RIEDEL & SANFILIPPO 1974

Fig. 11e-g

RIEDEL & SANFILIPPO 1974, p. 778, Pl. 12, Fig. 14, 15.

Dimensions (10 specimens). - Total length of three segments (excluding horn) 73-110 μ; maximum breadth 60-95 μ.

Remarks. - This is one of the common and well preserved forms in the assemblage. Some specimens show a row of small pores placed at the segmental constriction between thorax and third segment (cf. Fig. 11e). The third segment of our specimen is generally flatter and more inflated than illustrated by RIEDEL & SANFILIPPO.

Range and occurrence. - Tithonian or lowermost Berriasian of Santa Anna, Sicily; Pt. Sal, California, approx. Tithonian-Valanginian.

Hagiastridae RIEDEL, emend. PESSAGNO 1971 spp.

Fig. 10h

PESSAGNO 1971, p. 19.

Remarks. - Numerous fragments of Hagiastrids are present in our assemblage. Some rare three-rayed forms with distinct linearly rowed rectangular pores and several spines on ray tips were found in the freshly sieved material, but were

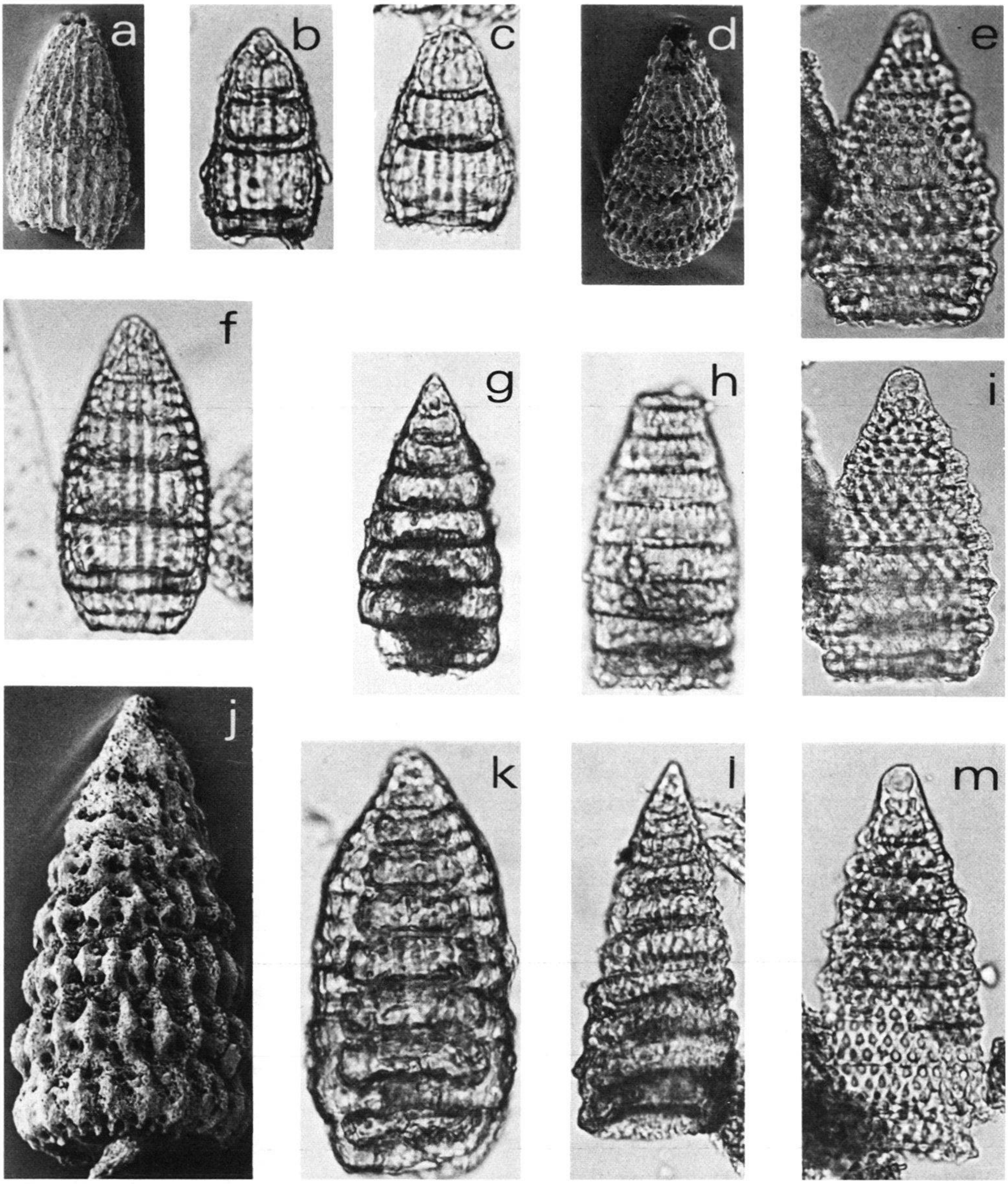

Fig. 12. Radiolaria *(Nassellaria)* from the Diabase-Chert Formation, sample DB 4575, Unit 12, Achladi, Evvoia, Eastern Greece. All specimen $\times 250$.

a–c	*Dictyomitra* spp. group A	j	*Dictyomitra* sp. D
d, g, h	*Dictyomitra* sp. B	k	*Dictyomitra excellens*
e, i, m	*Amphipyndax* sp. (*e* and *i* = same specimen)	l	*Dictyomitra* sp. C
f	Nassellariid sp. B		

probably broken by further treatment. They may belong to the genus *Paronaella*. The figured fragment may belong to the genus *Amphibracchium* because of its several linear pore rows, and the shape and size of its ray tip.

Occurrence. - *Amphibracchium* seems to be restricted to strata of Jurassic and Early Cretaceous age. Forms of ?*Paronaella* occur in Late Jurassic assemblages.

Hemicryptocapsa spp. cf. *H. capita* TAN SIN HOK 1927

Fig. 11a-c

TAN SIN HOK 1927, p. 50, Pl. 9, Fig. 67.
RIEDEL & SANFILIPPO 1974, p. 779, Pl. 6, Fig. 1-4.

Remarks. - Many specimens with spherical abdomen and partly hidden thorax are found in the assemblage. They may belong to the group of *Hemicryptocapsa* but belong certainly to several species.

Range and occurrence. - The group is reported from Roti, Timor; from Santa Anna, Sicily; Pt. Sal, California, and from DSDP Site 167, ranging from Late Jurassic to approx. Barremian-Albian.

Lithostrobus erectus TAN SIN HOK 1927?

Fig. 11p

TAN SIN HOK 1927, p. 53, Pl. 10, Fig. 76.

Remarks. - We have found one specimen and several fragments which match well TAN's description. They differ from the form illustrated by RENZ 1974, p. 796, Pl. 7, Fig. 12, 13, Pl. 11, Fig. 19a, b, under this name, in having pores arranged in transverse and longitudinal rows.

Nassellariid sp. A

Fig. 11j, m

Description. - The form is broadly conical, and has six (or more ?) segments, usually broken after the fourth. Cephalis is relatively large, simple, spherical, without horn but thickened apically. Thorax and abdominal segments are inflated-annular, gradually increasing in length and width, bearing smooth costae. Thorax bears one or two, abdominal segments two or three irregular transverse rows of small round pores, placed above the segmental stricture. The costae, about twelve per half a circumference, grade into ridges between the pores.

Dimensions. - Length of 6 segments (2 specimens) 150-170 μ, of 4 segments (8 specimens) 85-95 μ; diameter of cephalis 17-22 μ; width of fourth segment 65-85 μ.

Remarks. - Common form, systematic position not clear.

Nassellariid sp. B

Fig. 12f

Remarks. - Only one apparently complete specimen found. The shell is externally very similar to *Dictyomitra* spp. group A, but the internal structure of the cephalis makes the assignment to another systematic group more appropriate.

Nassellariids spp. group C

Fig. 11n

Remarks. - There is a common group of forms with thick shell, dome-like or inflated conical shape, smooth surface wearing large pores arranged in transverse rows, forming a rough hexagonal pattern. The internal structure has not been recognized, and the taxonomical position is thus not clear.

? *Patulibracchium* PESSAGNO 1971 sp.

Fig. 10e

PESSAGNO 1971, p.26, Pl. 1, Fig. 1, 2.

Dimensions (one specimen). - Angle between primary and secondary ray 90°, between secondary and tertiary ray 148°, between tertiary and primary ray 122°; length of primary ray (to center of test) 90 μ, of secondary ray 133 μ, of tertiary ray 143 μ.

Remarks. - Compared with measurements given in the original description our specimen is relatively small. However, pore arrangement, unequal length of rays and different angles between them are typical for the genus *Patulibracchium.*

Range. - Late Cretaceous, ? Early Cretaceous, ? Late Jurassic.

Pseudoaulophacid gen. et sp. indet.

Fig. 10d

PESSAGNO 1963, p.200, Pl. 2, Fig. 1-9.
RIEDEL 1967, p. 148.

Description. - The shell is a biconvex lens with a coarse spongy internal structure. The surface bears numerous protrusions which develop in the equatorial plane into short sturdy three-bladed spines. Six to nine of them are irregularly placed around the equator. The circular pores fill the place between the protrusions.

Dimensions (7 specimens). - Diameter in equatorial plane 85-110 μ; width in axial plane 35-45 μ; length of longest equatorial spine 33 μ; width of pores 6-10 μ.

Solenotryma FOREMAN 1968 sp.

Fig. 11d, i

FOREMAN 1968, p.33.
RIEDEL & SANFILIPPO 1974, p.780, Pl. 13, Fig. 11.
? *Tricolocapsa parvipora* TAN SIN HOK 1927, p.48, Pl. 9, Fig. 59, 60; in: RENZ 1974, p.798, Pl. 6, Fig. 8-12; Pl. 11, Fig. 3.

Remarks. - Very similar forms as in RIEDEL & SANFILIPPO's sample WRE 67-74 (Santa Anna, Sicily) are found in our assemblage.

Range and occurrence. - *Solenotryma* spp. are reported from Late Jurassic to approx. Albian by RIEDEL & SANFILIPPO (1974). *?Tricolocapsa parvipora* is reported from DSDP Site 261 and others, Aptian-Senonian and older.

Sphaerostylus lanceola (PARONA 1890)

Fig. 10c

FOREMAN 1973, p.258, Pl. 1, Fig. 7-11.
Stylosphaera lanceola PARONA 1890, p. 150, Pl. 1, Fig. 19.

Stylosphaera squinaboli TAN SIN HOK 1927, p. 35, Pl. 6, Fig. 9.
Stylatractus ovatus HINDE, in: MOORE 1973, p. 823, Pl. 2, Fig. 1.

Dimensions (4 specimens). - Width of shell in polar plane 70–90 μ; width of shell in equatorial plane 73–95 μ; length of long polar spine 80–105 μ; length of short polar spine (1 specimen) 60 μ.

Remarks. - Only a few poorly preserved specimens of this species could be obtained, but they definitely belong to the species *S. lanceola* and not to the ancestral form mentioned by RIEDEL & SANFILIPPO (1974).

Range and occurrence. - *Stylosphaera lanceola* is reported from the Upper Jurassic of Cittiglio, Northern Italy; *Stylatractus ovatus* is reported by MOORE (1973) from DSDP Site 167 from Tithonian-Berriassian to Lower Cenomanian; *Stylosphaera squinaboli* from the Turonian or Lower Senonian of Roti; *S. lanceola* is reported by RIEDEL & SANFILIPPO (1974) from approximately Tithonian-Valanginian to approximately Barremian-Albian and not found in their oldest sample from Santa Anna, Sicily, of Tithonian or lowermost Berriasian age.

Spongopyle insolita KOZLOWA 1966 group

Fig. 10g

RIEDEL & SANFILIPPO 1974, p. 780, Pl. 2, Fig. 7–11.

Remarks. - Rare and poorly preserved.

Range and occurrence. - Santa Anna, Sicily, Pt. Sal, California, DSDP Site 167 and others. Ranging from Late Jurassic to approximately Campanian.

? Spyrid gen. et sp. indet.

Fig. 11k, l

RIEDEL & SANFILIPPO 1974, p. 780, Pl. 3, Fig. 4–8.

Dimensions (3 specimens). - Largest diameter of shell 65–75 μ.

Remarks. - The forms found in our assemblage match very well with the description of a ? Spyrid given by RIEDEL & SANFILIPPO (1974). Spines are almost all broken.

Range and occurrence. - Tithonian or lowermost Berriasian of Santa Anna, Sicily; Pt. Sal, California, and DSDP Site 167, ranging from Late Jurassic to approximately Valanginian-Hauterivian.

Theoperid gen. et sp. indet.

Fig. 11h

RIEDEL & SANFILIPPO 1974, Pl. 9, Fig. 1, 2; Pl. 13, Fig. 6–7.

Remarks. - According to W.R. Riedel (personal communication) the figured fragment could be a broken off distal end of a theoperid. One large theoperid has been discovered in freshly sieved material, but was broken by further treatment.

Discussion

Age of the radiolarian assemblage

Despite of the small number of well defined species, the assemblage can definitely be assigned to the time-span between Late Jurassic and Early Cretaceous. All the forms which can be compared to already described taxa are reported from this interval.

The presence of *Eucyrtidium ptyctum* and *Sphaerostylus lanceola* would place our assemblage into the *Sphaerostylus lanceola*-zone as defined by RIEDEL & SANFILIPPO (1974). This zone ranges approximately from Tithonian p.p. to Valaginian p.p. It is based on material from Site 167 of DSDP, where its age has been demonstrated by calcareous nannofossils, and on outcrop samples from Sicily (Santa Anna, Tithonian to lowermost Berriasian indicated by calcareous nannofossils) and California (Pt. Sal). Besides the two species mentioned, some other species occurring in the *S. lanceola*-zone are found in our assemblage; they comprise Spyrid (?) gen. et sp. indet., *Hemicryptocapsa* spp. cf. *H. capita, Amphypindax* sp. (cf. *Dictyomitra boesii*), *Spongopyle insolita* group. Still other forms of the zone as *Haliodictya hojnosi* and *Acanthocircus* spp. seem to occur as fragments, however, some forms usually found in the zone have not been encountered. This could be due to the primary distribution of the species or, more likely, to bad preservation or destruction during the preparation.

The presence of *Dictyomitra excellens* would place the assemblage into Zone RK2 as defined by MOORE (1973) on the basis of material from Leg 17 DSDP, especially from Site 167. According to associated calcareous nannofossils, this zone ranges from the Late Berriasian to Early or Late Valanginian. Other species reported from this zone comprise *Amphipyndax* sp. (cf. *Lithocampe ananassa*), *Cyrtocapsa molengraaffi, Sphaerostylus lanceola, Paronaella ewingi,* and *Crucella* spp., the two latter occurring as questionable fragments in our assemblage. On account of these comparisons the assemblage is probably of Berriasian to Valanginian age.

Sedimentary and paleotectonic evolution

The thick Jurassic carbonate sequences of eastern continental Greece (Parnasse zone substratum of Beotian flysch, CELET et al. 1976; Pelagonian zone s.l.) were deposited on a continental margin of Atlantic type (BERNOULLI & JENKYNS 1974). Subsidence in this margin was differential and accompanied by extensional faulting: in the Argolis region the margin was submerged to subphotic depth during Middle to Late Liassic times (AUBOUIN et al. 1970), whereas to the north the change from carbonate platform to pelagic sedimentation occurred during different stages of the Late Jurassic (BASSOULET & GUERNET 1970; CELET et al. 1976) or even later.

The Cladocoropsis Limestone which generally underlies the ophiolite nappe in the Pelagonian realm of central eastern Greece is attributed to the Late Jurassic. In Beotia, BASSOULET & GUERNET (1970) have dated this limestone unit by a rich microfauna as Kimmeridgian to Early Tithonian. Although the hydrozoans and calcareous algae determined in our sections have much longer stratigraphic ranges, they are particularly frequent in the Upper Jurassic. For the massive Cladocoropsis

Limestone at the base of the section a shallow-water origin was assumed by GUERNET & PARROT (1972). However, the facies of this limestone differs somewhat from the dark-colored, well-bedded, micritic Cladocoropsis limestones of restricted shallow marine origin (e.g. SARTONI & CRESCENTI 1962, FLÜGEL 1974) and it cannot be safely excluded that already this limestone is redeposited. This, at least, is suggested by the occurrence of calcitized radiolaria and sponge spicules in the topmost part of the massive limestone; however, our present data do not allow a definite conclusion.

The transitional unit overlying the massive Cladocoropsis Limestone is composed of coarse redeposited skeletal and lithoclastic calcirudites and finer-grained graded and current-bedded calcisiltites to calcilutites. At least some of the fine material is pelagic as shown by the radiolarian molds and the badly preserved coccoliths and calcispherulids. For this unit a Late Jurassic (Tithonian) age and a deeper marine depositional environment is most likely.

The lower part of the Diabase-Chert Formation has been dated by us as latest Jurassic to Early Cretaceous, very probably Berriasian to Valanginian. This is in good agreement with the age of the Beotian flysch which has been dated by CELET et al. (1976) as Late Tithonian (?) to Early Cretaceous (Berriasian) and which similarly contains abundant ophiolitic detritus. In Evvoia and in the eastern Argolis the upper part of the Diabase-Chert Formation contains olistostromes with blocks of ophiolitic material and is generally overlain by the ophiolite nappe, emplaced during the latest Jurassic (?) or earliest Cretaceous. In the Beotian zone s.str. no remnants of such a Cretaceous ophiolite nappe, but only ophiolitic detritus is present. CELET et al. (1976) explain the facies distribution in the Upper Jurassic and the Lower Cretaceous of the Beotian and the "Subpelagonian" and Pelagonian zones by a complicated sequence of Late Jurassic thrusting of an ophiolite nappe towards the west and subquent back-thrusting of the oceanic sequences onto the Pelagonian margin during the Early Cretaceous. From our limited data in Evvoia we cannot decide if the ophiolite nappe has been thrust from the east or from the west. However, Late Jurassic ophiolite emplacement, granitization and postorogenic uplift in the Vardar zone to the east (BORSI et al. 1966, MERCIER 1966*a* and *b*, KOCKEL et al. 1971) seem to indicate that orogenic movements and emplacement of ophiolites proceeded from east to west. Then ophiolite nappes would have reached the Pelagonian realm of Evvoia during the latest Jurassic or Early Cretaceous delivering ophiolitic detritus into a fore-deep situated in the Beotian zone to the west. We are, however, well aware how fragmentary our knowledge on Mesozoic orogenies in the Mediterranean region still is and expect that our simple working hypothesis may have to be changed drastically in the light of new data.

Acknowledgements

This study is part of a research programme on the sedimentary and paleotectonic evolution of the southern Tethys at the Geological Institute of the University of Basel. Support of this programme by the Swiss National Science Foundation (grants 2.421.70 and 2.1620.74) is gratefully acknowledged. We also thank the National Institute of Geology and Mining Research, Athens, for helpful assistance.

The authors are very much indebted to H. Laubscher for cooperation in the field, stimulating discussions and reading of the manuscript. W.R. Riedel gave helpful advise in problems of radiolarian paleontology and read drafts of the manuscript. E. Flügel and L. Hottinger determined various fossils. R. Guggenheim provided facilities at the SEM-Laboratory of the University of Basel; Mrs. L. Luginbühl operated the SEM, she also carried out the photographic work and drafted the text-figures.

REFERENCES

A. Regional geology

ALBANDAKIS, S.N. (1968): *Nuovi dati stratigrafici sulla regione di Locrida (Grecia)* (Comunicazione preliminare). - Boll. Soc. geol. ital. *87,* 733-741.

AMPFERER, O., & HAMMER, W. (1921): *Ergebnisse der geologischen Forschungsreisen in Westserbien.* II: *Die Diabashornsteinschichten von W. Hammer.* - Denkschr. Akad. Wiss. Wien, math.-natw. Kl. *98,* 45-56.

AUBOUIN, J. (1957): *Un profil tectonique d'ensemble de la Grèce septentrionale moyenne.* - Bull. Soc. géol. France (6), *7,* 1135-1155.

— (1958): *Essai sur l'évolution paléogéographique et le développement tecto-orogénique d'un système géosynclinal: le secteur grec des Dinarides (Hellénides).* - Bull. Soc. géol. France (6), *8,* 731-749.

— (1959): *Contribution à l'étude géologique de la Grèce septentrionale: les confins de l'Epire et de la Thessalie.* - Ann. géol. Pays hellén. *10,* 1-403.

— (1960): *Essai sur l'ensemble italo-dinarique et ses rapports avec l'arc alpin.* - Bull. Soc. géol. France (7), *2,* 487-526.

— (1973): *Des tectoniques superposées et de leur signification par rapport aux modèles géophysiques: l'exemple des Dinarides; paléotectonique, tectonique, tarditectonique, néotectonique.* - Bull. Soc. géol. France (7), *15,* 426-460.

AUBOUIN, J., BONNEAU, M., CELET, P., CHARVET, J., CLÉMENT, B., DEGARDIN, J.M., DERCOURT, J., FERRIÈRE, J., FLEURY, J.J., GUERNET, C., MAILLOT, H., MANIA, J., MANSY, J.L., TERRY, J., THIÉBAULT, F., TSOFLIAS, P., & VERRIEZ, J.J. (1970): *Contribution à la géologie des Hellénides: le Gavrovo, le Pinde et la zone ophiolitique subpélagonienne.* - Ann. Soc. géol. Nord *90*/4, 277-306.

BANNERT, D., & BENDER, H. (1968): *Zur Geologie der Argolis-Halbinsel (Peloponnes, Griechenland).* - Geologica et Palaeontologica *2,* 151-162.

BASSOULLET, J.P., & GUERNET, CL. (1970): *Le Trias et le Jurassique de la région des lacs de Thèbes (Béotie et Locride, Grèce).* - Rév. Micropaléont. *12*/4, 209-217.

BERNOULLI, D., & JENKYNS, H. (1974): *Alpine, Mediterranean, and Central Atlantic Mesozoic facies in relation to the early evolution of the Tethys.* In: DOTT, R.H. Jr., & SHAVER, R.H. (Ed.): *Modern and ancient geosynclinal sedimentation.* - Spec. Publ. Soc. econ. Paleont. Mineral. *19,* 129-160.

BERNOULLI, D., & LAUBSCHER, H. (1972): *The Palinspastic Problem of the Hellenides.* - Eclogae geol. Helv. *65*/1, 107-118.

BIGNOT, G., & GUERNET, C. (1968): *L'âge de la transgression du Crétacé supérieur dans la région de Larymna, au nord des lacs Thébains (Grèce).* - Rév. Micropaléont. *10*/4, 261-270.

BORSI, S., FERRARA, G., MERCIER, J., & TONGIORGI, E. (1966): *Age stratigraphique et radiométrique jurassique supérieur d'un granite des zones internes des Hellénides (Granite de Fanos, Macédoine, Grèce).* - Rev. Géogr. phys. Géol. dyn. (2), *8*/4, 279-287.

CELET, P. (1975): *A propos de mélange de type «volcano-sédimentaire» de l'Iti (Grèce méridionale)* [Abstr.]. - V[e] Colloque sur la géologie des régions égeennes, Orsay.

CELET, P., & CLÉMENT, B. (1971): *Sur la présence d'une nouvelle unité paléogéographique et structurale en Grèce continentale du sud: L'unité du flysch béotien.* - C.R. Soc. géol. France *17,* 43.

CELET, P., CLÉMENT, B., & FERRIÈRE, J. (1976): *La zone béotienne en Grèce: Implications paléogéographiques et structurales.* - Eclogae geol. Helv. *69*/3, 577-599.

ĆIRIĆ, B., & KARAMATA, S. (1960): *L'évolution du magmatisme dans le géosynclinal dinarique au Mésozoique et au Cénozoique.* - Bull. Soc. géol. France (7), *2,* 376-380.

DECROUEZ, D. (1976): *Etude stratigraphique et micropaléontologique du Crétacé d'Argolide (Péloponnèse septentrional, Grèce).* - Thèse Univ. Genève (Impr. Sect. Phys., Genève).

DERCOURT, J. (1972): *The Canadian Cordillera; the Hellenides and the sea floor spreading theory.* - Canad. J. Earth Sci. *9,* 709-743.

DIMITRIJEVIC, M.D., & DIMITRIJEVIC, M.N. (1973): *Olistostrome mélange in the Yugoslavian Dinarides and late Mesozoic plate tectonics.* - J. Geol. *81,* 328-340.

DÜRR, ST. (1976): *Über Alter und geotektonische Stellung des Menderes-Kristallins/SW-Anatolien und seine Aequivalente in der mittleren Aegaeis.* - In press.

FLÜGEL, E. (1974): *Fazies-Interpretation der Cladocoropsis-Kalke (Malm) auf Karaburun, W-Anatolien.* - Arch. Lagerstforsch. (Ostalpen), Sonderbd. *2* (Festschr. O.M. Friedrich), 79-94.

GUERNET, C. (1971): *Etudes géologiques en Eubée et dans les régions voisines (Grèce).* - Paris.

— (1974): *Carte géologique d'une partie de l'Eubée et des régions voisines, 1:200000.* - Impr. Louis-Jean, Gap.

GUERNET, C., & PARROT, J.F. (1972): *Le cortège ophiolitique de l'Eubée moyenne (Grèce): position et relations avec les séries mésozoiques.* - Cah. ORSTOM, Sect. Géol. *4*/1, 67-75.

HYNES, A.J., NISBET, E.G., SMITH, A.G., & WELLAND, M.J.P. (1972): *Spreading and emplacement ages of some ophiolites in the Othrys region (eastern central Greece).* - Z. dtsch. geol. Ges. *123*, 455-468.

KATSIKATSOS, G. (1969): *L'âge du système métamorphique de l'Eubée méridionale et sa subdivision stratigraphique* [in Greek]. - Prakt. Acad. Athènes *44*, 223-238.

KOCKEL, F., MOLLAT, H., & WALTHER, H.W. (1971): *Geologie des Serbo-Mazedonischen Massivs und seines mesozoischen Rahmens (Nordgriechenland).* - Geol. Jb. *89*, 529-551.

LAUBSCHER, H., & BERNOULLI, D. (1976): *Mediterranean and Tethys.* In: NAIRN, A.E.M., STEHLI, F.G., & KANES, W. (Eds.): *The Ocean Basins and Margins.* IV.: *Mediterranean.* - Plenum Publ. Corp. New York.

MERCIER, J. (1966a): *Mouvements orogéniques et magmatisme d'âge jurassique supérieur - éocrétacé dans les zones internes des Hellénides (Macédoine, Grèce).* - Rev. Géogr. phys. Géol. dyn. *8*, 265-278.

— (1966b): *Paléogéographie, orogenèse, métamorphisme et magmatisme des zones internes des Hellénides en Macédoine (Grèce): Vue d'ensemble.* - Bull. Soc. géol. France (7), *8*, 1014-1017.

MOORES, E.M. (1969): *Petrology and Structure of the Vourinos Ophiolite Complex, Northern Greece.* - Spec. Pap. geol. Soc. Amer. *118*.

PARROT, J.F., & GUERNET, C. (1972): *Le Cortège ophiolitique de l'Eubée Moyenne (Grèce): Etude pétrographique des formations volcaniques et des roches métamorphiques associées dans les monts Kandilis aux radiolarites.* - Cah. ORSTOM, Sect. Géol. *4*/2, 153-161.

RENZ, C. (1955): *Die vorneogene Stratigraphie der normalsedimentären Formationen Griechenlands.* - Inst. Geol. Subsurface Res., Athens.

SARTONI, S., & CRESCENTI, U. (1962): *Ricerche biostratigrafiche nel Mesozoico dell'Appennino meridionale.* - G. Geol. (2a), *29*, 161-302 (1960-1961).

SMITH, A.G. (1971): *Alpine deformation and the oceanic areas of the Tethys, Mediterranean and Atlantic.* - Bull. geol. Soc. Amer. *82*, 2039-2070.

SMITH, A.G., HYNES, A.J., MENZIES, M., NISBET, E.G., PRICE, I., WELLAND, M.J., & FERRIÈRE, J. (1975): *The Stratigraphy of the Othris Mountains, Eastern Central Greece: a Deformed Mesozoic Continental Margin Sequence.* - Eclogae geol. Helv. *68*/3, 463-481.

ZIMMERMAN, J. (1972): *Emplacement of the Vourinos ophiolitic complex, Northern Greece.* In: SHAGAM, R., HARGRAVES, R.B. et al. (Ed.): *Studies in earth and space sciences.* - Mem. geol. Soc. Amer. *132*, 225-239.

B. Radiolaria

DUMITRICA, P. (1970): *Cryptocephalic and Cryptothoracic Nassellaria in some Mesozoic deposits of Romania.* - Rev. roumaine Géol. Géophys. Géogr., Sér. Géol. *14*/1, 45-124.

FOREMAN, H.P. (1966): *Two Cretaceous radiolarian genera.* - Micropaleontology *12*/3, 355-359.

— (1968): *Upper Maestrichtian Radiolaria of California.* - Spec. Pap. Palaeont. *3*.

— (1971): *Cretaceous Radiolaria.* - Init. Rep. Deep Sea Drill. Proj. *7*, 1673-1693.

— (1973): *Radiolaria from DSDP Leg 20.* - Init. Rep. Deep Sea Drill. Proj. *20*, 249-305.

HINDE, G.J. (1900): *Description of fossil Radiolaria from the rocks of central Borneo.* In: MOLENGRAAF, G.A.F.: *Borneo-expeditie: geologische verkenningstochten in central Borneo (1893-1894).* - Brill, Leiden.

MOORE, T.C. Jr. (1973): *Radiolaria from Leg 17 of the Deep Sea Drilling Project.* - Init. Rep. Deep Sea Drill. Proj. *17*, 797-869.

NIGRINI, C. (1967): *Radiolaria in pelagic sediments from the Indian and Atlantic Oceans.* - Bull. Scripps Instn. Oceanogr. *11*, 1-125.

PARONA, C.F. (1890): *Radiolarie nei noduli selciosi del calcare giurese di Cittiglio presso Laveno.* - Boll. Soc. geol. ital. *9*/1, 132-175.

PESSAGNO, E.A. Jr. (1963): *Upper Cretaceous Radiolaria from Puerto Rico.* - Micropaleontology *9*/2, 197-214.

— (1971): *Jurassic and Cretaceous Hagiastridae from the Blake-Bahama Basin (Site 5A, JOIDES Leg 1) and the Great Valley Sequence, California Coast Ranges.* - Bull. amer. Paleont. *60*/264.

— (1973): *Upper Cretaceous Spumellariina from the Great Valley Sequence, California Coast Ranges.* - Bull. amer. Paleont. *63*/276, 45-102.

PESSAGNO, E.A. Jr., & NEWPORT, R.L. (1972): *A technique for extracting Radiolaria from radiolarian cherts.* - Micropaleontology *18*/2, 231-234.

RENZ, G.W. (1974): *Radiolaria from Leg 27 of the Deep Sea Drilling Project.* - Init. Rep. Deep Sea Drill. Proj. *27*, 769-841.

RIEDEL, W.R. (1967): *Some new families of Radiolaria.* - Proc. geol. Soc. London *1640*, 148-149.

— (1971): *Systematic classification of polycystine Radiolaria.* In: FUNNEL, B.M., & RIEDEL W.R. (Eds.): *The Micropaleontology of Oceans* (p. 649-661). - Cambridge Univ. Press, Cambridge.

RIEDEL, W.R., & SANFILIPPO, A. (1974): *Radiolaria from the Southern Indian Ocean, DSDP Leg 26.* - Init. Rep. Deep Sea Drill. Proj. *26*, 771-813.

RÜST, D. (1885): *Beiträge zur Kenntnis der fossilen Radiolarien aus Gesteinen des Jura.* - Palaeontographica *31* (3/7), 269-322.

— (1898): *Neue Beiträge zur Kenntnis der fossilen Radiolarien aus Gesteinen des Jura und der Kreide.* - Palaeontographica *45*, 1-67.

TAN SIN HOK (1927): *Over de samenstelling en het ontstaan van krijt- en mergelgesteenten van de Molukken.* - Jb. Mijnwezen nederl. Oost-Indie [Verh.] *1926*.