Δελτίο Ελληνικής Γεωλογικής Εταιρίας τομ. XXX/2, 167-175, 1994
Πρακτικά 7ου Επιστημονικού Συνεδρίου, Θεσσαλονίκη, Μάιος 1994

Bulletin of the Geological Society of Greece vol. XXX/2, 167-175, 1994
Proceedings of the 7th Congress, Thessaloniki, May 1994

PALAEO-OCEANOGRAPHIC SIGNIFICANCE OF MID-JURASSIC RADIOLARITES FROM THE MALIAC (SUB-PELAGONIAN) MARGIN OF OTHRIS (GREECE)

T. Danelian*

ABSTRACT

Radiolarites at the top of carbonate sequences of the Pelagonian and Maliac (Sub-Pelagonian) zones of Othris can no longer be considered as a relatively synchronous siliceous event. Lime-free ribbon radiolarites were sedimented during the late Middle Jurassic (late Bajocian - middle Callovian) in marginal Maliac units (Pirgaki and probably Garmeni-Rachi). The main cause of the change from calcareous to siliceous sediments in these basins is considered to be high radiolarian productivity, established at that time throughout Western Tethys. Diachronism of siliceous sedimentation throughout the Maliac-Pelagonian areas is very likely, with ages becoming younger (Late Jurassic) at the top of Pelagonian sequences.

INTRODUCTION

The Othris area is a suitable place to study the Triassic-Jurassic evolution of a Tethyan continental margin, as it displays a complete spectrum of sedimentary sequences from a continental platform, at a passive margin to ocean floor. There is also evidence of its destruction during the Mid-Late Jurassic tectonic phase of the "internal" Hellenides, associated with ophiolite emplacement.

The aim of the present work was to elucidate the time frame of radiolarite sedimentation on this continental margin, by studying the radiolarian fauna within the passive margin succession, and also of the overlying detrital sediments, which are related to the "eo-hellenic orogenesis".

Smith *et al.* (1975) have proposed, in a formal way, a stratigraphic framework for the Othris Mountains. They have defined sixteen formations, divided into three Groups. The Othris Group is the one which we shall be concerned with here and more precisely the **Anavra Chert** Formation of the Poulia and Karolina sequences. These authors mentioned Radiolaria extracted from the Anavra Chert; these were studied by Riedel and Pessagno and considered indicative of an upper Tithonian to Valanginian age.

Ferrière (1982) and Ferrière *et al.* (1988) coined the term "formations **pré-ophiolitiques**" for the uppermost sediments of the Jurassic sequences of Othris and Euboea (Pelagonian and Maliac or Sub-Pelagonian zones) and correlated them with equivalent formations of the Argolis Peninsula, studied by Baumgartner (1985). They have distinguished the "formation **pré-ophiolitique de base**", represented by radiolarites and shales, overlain stratigraphically by the

---

* Department of Geology and Geophysics, University of Edinburgh, Grant Institute, West Mains Road, Edinburgh EH9 3JW, Scotland, U.K.

"formation **volcano-détritique**", which displays siliciclastic sediments of chaotic aspect, containing resedimented blocs of diverse nature, some of which were derived from ophiolitic units (i.e. gabbros and peridotites). The development of this latter formation is closely related to paleotectonic compressional events of the Hellenides and the obduction of ophiolites onto the Pelagonian microcontinent (Ferrière, 1982; Baumgartner, 1985; Ferrière *et al.*, 1988; Robertson, 1991; Robertson *et al.*, 1991). Ferrière (1982) and Ferrière *et al.* (1988) considered the age of the "formations prê-ophiolitiques" of Othris and Euboea as Late Jurassic, based on Foraminifera and the calcareous algae *Cladocoropsis* identified in the uppermost calcareous levels of the Maliac and Pelagonian sequences, respectively, and mainly Kimmeridgian-Tithonian, based on extracted Radiolaria.

Baumgartner (1985) obtained detailed biostratigraphic results for Radiolaria for the Pelagonian and Maliac sequences of the Argolis Peninsula and has recently revised the chronostratigraphic significance of these assemblages (Baumgartner *et al.*, 1994). He has demonstrated major diachronism in the onset of siliceous sedimentation in Argolis, radiolarites having been sedimented mainly during the late Middle Jurassic (Middle/Late Bajocian to Late Callovian/ Early Oxfordian) for basinal sequences of Maliac affinity, and during the Late Jurassic for Pelagonian sequences.

As few data for the Othris area are available, it was decided to undertake detailed biostratigraphic studies using Radiolaria in this area. This paper will present preliminary data, focusing on the radiolarites of the Pirgaki unit of Ferrière (= Poulia sequence *pro parte* of Smith *et al.*, 1975).

THE STRATIGRAPHIC FRAMEWORK

The Pirgaki unit crops out in southern and central Othris (central Greece, Fig.1). During Late Triassic - Jurassic time the Pirgaki unit represented the proximal part of a slope which was situated between the Pelagonian platform and the abyssal Maliac (Sub-Pelagonian) units (Ferrière, 1982). Its sedimentary sequence comprises Anisian platform carbonates, overlain by Late Triassic-Jurassic siliceous limestones. The latter were intercalated, during the Jurassic, by clastic carbonates of shallow-water derived material (calcarenites, calcirudites, see Meterizia Formation of Smith *et al.*, 1975). These limestones are overlain by red ribbon radiolarites, which then pass upwards into the "volcano-detritic" formation.

No previous data exist on the radiolarites of the Pirgaki unit. Ferrière (1982, p.252) assumed that they are of Late Jurassic age, based on Foraminifera (Trocholines and *Protopeneroplis striata* WEYNSCHENK), identified in the underlying limestones, and indicating a Middle to Late Jurassic age. Nevertheless, the radiolarian data of the present work suggest an earlier age.

The studied section is situated at the margin of the western flank of the Mount Migdalia (Fig.1) and corresponds to the upper part of the Migdalia section described by Ferrière (1982, p.229, the northern section only; his fig.92A). The outcrop shows a reasonably good stratigraphic continuity from the limestones to the siliciclastic chaotic formation, with good exposure of the intervening radiolarites (Fig. 2). The beds show a constant dip to the NW.

RADIOLARIAN ASSOCIATIONS - CHRONOSTRATIGRAPHIC SIGNIFICANCE

Reasonably well preserved Radiolarian faunas have been extracted from ribbon cherts in the radiolarite sequence discussed earlier. The assemblages are quite diverse, but are dominated by Nassellaria. The taxa identified are shown on Table I.

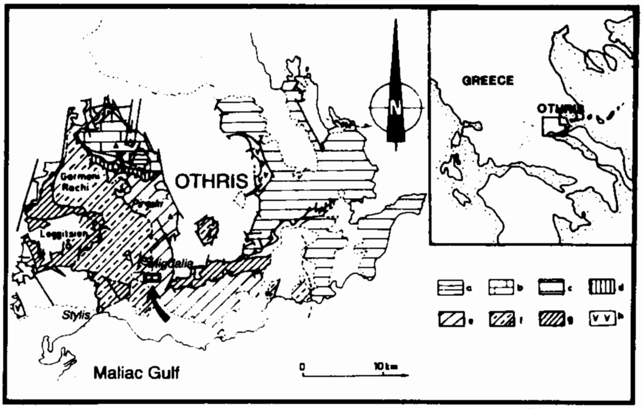


Fig. 1: Geological map of the main structural units of Othris (after Ferrière, 1982). Inset: Map of Greece with location of area. (a - c)Q Pelagonian units. - a) of Prosilia, b) of Messovouni, c) of Oriental Othris. (d - g): Maliac units. - d) of Chatala, e) of Pirgaki, f) of Garmeni Rachi, g) Loggitsion lower unit. h) ophiolites. The highlighted area shows the location of the studied section.

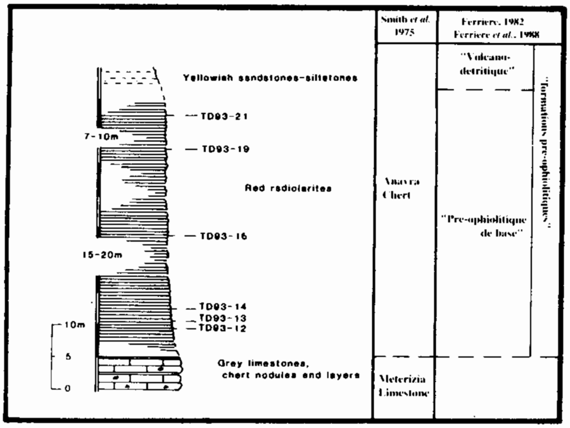


Fig. 2: Lithostratigraphic log of the studied Migdalia section

Table II presents the age range of some well known species, based on the biozonations of Baumgartner (1984), Matsuoka & Yao (1986) and Aita (1987). Baumgartner's biozonation is based on good chronostratigraphic control, which was recently revised by O'Dogherty *et al.* (1989). Yao (1986) and Aita (1987) have correlated their zones to the Unitary Associations of Baumgartner's biozonation. Thus, the biostratigraphic data of the species represented by the biozonations of Matsuoka & Yao and Aita are presented here in terms of Baumgartner's biozonation.

Only two samples are shown in the Table II, representing the lower and upper levels of the radiolarite sequence that yielded radiolaria (Fig. 2). Sample TD93-12 is regarded as late Bajocian-Callovian (earliest Oxfordian ?), based on the age range of *D.(?) kamoensis* (Zones A1-A2 of Baumgartner's biozonation). The sample TD93-21 is regarded as late Bajocian-middle Callovian, based on the age range of *B.cristatus* (Zone A1 of Baumgartner's biozonation).

Following Pessagno's *et al.* (1993) biozonation *B.cristatus* could be an exclusively Oxfordian species (Zone 2, Subzone 2 delta to upper part of Subzone 2 gamma). Nevertheless, there are significant differences in the chronostratigraphic assignement of their biozonation compared to that of Baumgartner. In fact, all the Middle Jurassic Zones of Baumgartner's biozonation are assigned to the lower-middle Oxfordian by Pessagno *et al.* (1993). The reasons for this discrepancy could be multiple; for further discussion on this subject see Baumgartner (1987, p.849-854) and Pessagno *et al.* (1993, p.104-106). In the present study we have adopted Baumgartner's biozonation.

DISCUSSION OF PREVIOUS RADIOLARIAN DATA IN OTHRIS

As discussed in the introduction, two publications have mentioned Radiolarian

Table I

Identified species \ Sample	TD-12	TD-13	TD-14	TD-16	TD-19	TD-21
Archaeodictyomitra exigua BLOME				+		
Archaeodictyomitra primigena PESSAGNO & WHALEN	+					
Bernoullius cristatus BAUMGARTNER						+
Dictyomitrella (?) kamoensis MIZUTANI & KIDO	+		?			?
Eucyrtidiellum unumaense (YAO)	+	+	+	+		+
sp.cf. Guexella nudata (KOCHER)						+
Napora sp.		+				
sp.cf. Ristola altissima (RUST)	+					
Parvicingula dhimenaensis BAUMGARTNER	+					
Saitoum sp. cf. S.trichylum DE WEVER					+	
Sethocapsa dumitricai WIDZ & DE WEVER						+
Stichocapsa convexa YAO						+
Stichocapsa robusta MATSUOKA	+				+	+
Theocapsomma cordis KOCHER	+	+	+	?		+
Theocapsomma sp.aff. T.cordis KOCHER	+					
Transhsuum maxwelli (PESSAGNO)						+
Tricolocapsa conexa MATSUOKA						+
Tricolocapsa plicarum YAO						?
Tritrabinae	+		+			

Table II: (1) Baumgartner (1984), (2) biostratigraphic data given by Matsuoka (1988) in terms of Matsuoka & Yao's (1986) biozonation, (3) Aita (1987)

Species \Baumgartner's Zones	A0	A0	A1	A1	A1	A2	A2	B	B	C1	C2
Species \ Unitary Association	0	1	2	3	4	5	6	7	8	9	10
TD93-12			===	===	===	===	===				
Dictyomitrella (?) kamoensis..(3)			+	+	+	+	+				
Eucyrtidiellum unumaense......(1)	+	+	+	+	+	+	+	+	+		
Eucyrtidiellum unumaense......(3)	+	+	+	+	+	+	+	+			
Parvicingula dhimenaensis.....(1)		+	+	+	+	+	+	+	+	+	
Parvicingula dhimenaensis.....(3)	+	+	+	+	+	+	+				
Sticocapsa robusta...........(2)			+	+	+	+	+				
Stichocapsa robusta..........(3)				+	+	+	+	+			
Theocapsomma cordis..........(1)		+	+	+	+	+	+	+			
TD93-21			===	===	===						
Bernoullius cristatus.........(1)			+	+	+						
Eucyrtidiellum unumaense......(1)	+	+	+	+	+	+	+	+	+		
Eucyrtidiellum unumaense......(3)	+	+	+	+	+	+	+	+			
Stichocapsa convexa..........(1)	+	+	+	+	+	+	+	+	+	+	+
Stichocapsa convexa..........(3)		+	+	+	+	+	–	–			
Stichocapsa robusta..........(2)			+	+	+	+	+				
Stichocapsa robusta..........(3)				+	+	+	+	+			
Theocapsomma cordis..........(1)		+	+	+	+	+	+	+			
Transhsuum maxwelli..........(1)			+	+	+	+	+	+	+		
Transhsuum maxwelli..........(2)			+	+	+	+	+	+	+	+	
Transhsuum maxwelli..........(3)			+	+	+	+	+	+			
Tricolocapsa conexa..........(2)		+	+	+	+	+	+	+			
Tricolocapsa conexa..........(3)				+	+	+	+	+			

ages at a time when the systematics and biostratigraphy of Mesozoic Radiolaria **were** in their infancy.

Riedel and Pessagno studied the radiolaria mentioned by Smith *et al.* (1975). Riedel proposed a lowest Cretaceous age (Berriasian or Valanginian), because the assemblage was thought to be indicative of the lower *Sphaerostylus lanceola* Zone (referring most probably to the biozonation of Riedel & Sanfilippo, 1974) and Pessagno an upper Tithonian or, more probably, Berriasian age. However, this work does not mention any specific taxa, or exact locations where these faunas were collected. Moreover, it has become obvious since the early eighties that the *S.lanceola* Zone covers most of the Late Jurassic and the earliest Cretaceous (Baumgartner *et al.*, 1980).

Subsequently, Ferrière (1982, annexe A, determ. Origlia-Devos) has presented a list of Radiolaria extracted from two samples from the Othris area, considered to suggest a Kimmeridgian-Tithonian age (Ferrière *et al.*, 1988). Nevertheless, confidence cannot be placed on this age, because some species whose age ranges are now well known and are listed, in fact should not exist together in the same sample (e.g. *Parvicingula cosmoconica* (FOREMAN) and *Hsuum maxwelli* PESSAGNO). A more accurate taxonomic identification of this material might resolve this problem. For instance, Danelian (1989) pointed out that Origlia-Devos (1983) has used *P. cosmoconica* in a broad sense, including forms which are conical through their whole test. These latter morphotypes have been found in the Ionian zone in older sediments (Oxfordian) than the age range of *P.cosmoconica sensu stricto*. Moreover, the presence of *Unuma echinatus* ICHIKAWA & YAO in the sample JF1-118 of Ferrière (1982) suggests a Middle Jurassic age (Bajocian?).

TIME AND CAUSES OF THE JURASSIC SILICEOUS SEDIMENTATION IN OTHRIS

In the marginal Maliac units of Othris (Pirgaki and Garmeni-Rachi) pelagic sedimentation was established during the Late Triassic (Smith *et al.*, 1975; Ferrière, 1982). During the Jurassic, calciclastic sediment-gravity-flow deposits of shallow-water derived material accumulated on a submarine fan (Price, 1977), intercalated with background calcareous pelagic sediments. A major change of the sedimentary record from calcareous to siliceous then took place, as noted earlier, during the late Middle Jurassic. However, calciturbidites continued to reach the basins occasionally, even during radiolarite deposition (Ferrière, 1982).

An accurate chronostratigraphy of the sedimentary sequences of the continental margin is crucial to interpret its tectono-sedimentary evolution. As we discussed earlier, Ferrière (1982) thought of the lime-free radiolarites deposited in the Maliac and Pelagonian zones as accumulations below the Calcium Compensation Depth (CCD), of approximately the same age (Late Jurassic). He attributed their genesis to the same cause; accelerated subsidence of these realms, due either to rapid creation of oceanic crust at the border of the Maliac-Pelagonian margin, or to compression related to the obduction of the ophiolites. In the model of Robertson (1991), the radiolarites were able to accumulate in the Pelagonian realm because of flexured subsidence of the carbonate platform and the creation of depositional space for pelagic sedimentation related to ophiolite emplacement.

The onset of lime-free ribbon radiolarites during the Middle Jurassic (Bajocian-Bathonian) has been established in many basins of Western Tethys (Baumgartner, 1984, 1987; De Wever & Dercourt, 1985; De Wever, 1989) and has stimulated discussions about the genesis of Tethyan radiolarites. Recent ideas have emphasized palaeo-oceanographic conditions which could have resulted in ages at a time when the systematics and biostratigraphy of Mesozoic Radiolaria were in their infancy.

Riedel and Pessagno studied the radiolaria mentioned by Smith *et al.* (1975). Riedel proposed a lowest Cretaceous age (Berriasian or Valanginian), because the assemblage was thought to be indicative of the lower *Sphaerostylus lanceola* Zone (referring most probably to the biozonation of Riedel & Sanfilippo, 1974) and Pessagno an upper Tithonian or, more probably, Berriasian age. However, this work does not mention any specific taxa, or exact locations where these faunas were collected. Moreover, it has become obvious since the early eighties that the *S.lanceola* Zone covers most of the Late Jurassic and the earliest Cretaceous (Baumgartner *et al.*, 1980).

Subsequently, Ferrière (1982, annexe A, determ. Origlia-Devos) has presented a list of Radiolaria extracted from two samples from the Othris area, considered to suggest a Kimmeridgian-Tithonian age (Ferrière *et al.*, 1988). Nevertheless, confidence cannot be placed on this age, because some species whose age ranges are now well known and are listed, in fact should not exist together in the same sample (e.g. *Parvicingula cosmoconica* (FOREMAN) and *Hsuum maxwelli* PESSAGNO). A more accurate taxonomic identification of this material might resolve this problem. For instance, Danelian (1989) pointed out that Origlia-Devos (1983) has used *P. cosmoconica* in a broad sense, including forms which are conical through their whole test. These latter morphotypes have been found in the Ionian zone in older sediments (Oxfordian) than the age range of *P.cosmoconica sensu stricto*. Moreover, the presence of *Unuma echinatus* ICHIKAWA & YAO in the sample JF1-118 of Ferrière (1982) suggests a Middle Jurassic age (Bajocian?).

TIME AND CAUSES OF THE JURASSIC SILICEOUS SEDIMENTATION IN OTHRIS

In the marginal Maliac units of Othris (Pirgaki and Garmeni-Rachi) pelagic sedimentation was established during the Late Triassic (Smith *et al.*, 1975; Ferrière, 1982). During the Jurassic, calciclastic sediment-gravity-flow deposits of shallow-water derived material accumulated on a submarine fan (Price, 1977), intercalated with background calcareous pelagic sediments. A major change of the sedimentary record from calcareous to siliceous then took place, as noted earlier, during the late Middle Jurassic. However, calciturbidites continued to reach the basins occasionally, even during radiolarite deposition (Ferrière, 1982).

An accurate chronostratigraphy of the sedimentary sequences of the continental margin is crucial to interpret its tectono-sedimentary evolution. As we discussed earlier, Ferrière (1982) thought of the lime-free radiolarites deposited in the Maliac and Pelagonian zones as accumulations below the Calcium Compensation Depth (CCD), of approximately the same age (Late Jurassic). He attributed their genesis to the same cause; accelerated subsidence of these realms, due either to rapid creation of oceanic crust at the border of the Maliac-Pelagonian margin, or to compression related to the obduction of the ophiolites. In the model of Robertson (1991), the radiolarites were able to accumulate in the Pelagonian realm because of flexured subsidence of the carbonate platform and the creation of depositional space for pelagic sedimentation related to ophiolite emplacement.

The onset of lime-free ribbon radiolarites during the Middle Jurassic (Bajocian-Bathonian) has been established in many basins of Western Tethys (Baumgartner, 1984, 1987; De Wever & Dercourt, 1985; De Wever, 1989) and has stimulated discussions about the genesis of Tethyan radiolarites. Recent ideas have emphasized palaeo-oceanographic conditions which could have resulted in proliferation of Radiolarians (i.e. high fertility of surface waters), rather than carbonate dissolution in the water culomn (De Wever *et al.*, 1986; Baumgartner, 1987). The Middle Jurassic Western Tethys has been regarded as an area of high radiolarian productivity, reflecting a major, basin-wide, palaeo-oceanographic event, which was probably related to the palaeotectonic evolution of Western Tethys.

Such a palaeo-oceanographic event might have been the cause of radiolarite sedimentation in the marginal Maliac units (Pirgaki and Garmeni Rachi). This could have been the result of changes in the water mass circulation pattern and current distribution, causing high radiolarian productivity in the surface waters. Radiolaria were thus able to dominate the relatively scarce calcareous plankton community.

It is noteworthy that major faunal changes can be infered from the pelagic record of the Bajocian. The Schizospheres, which were the dominant calcareous nannoplankton during the Lower Jurassic were replaced by small and oligospecific coccoliths, approximately at the Aalenian/Bajocian boundary, somewhat earlier than the profound faunistic change within the Ammonites during the middle / upper Bajocian limit (Noel *et al.*, 1991).

The existing biostratigraphic data on the higher carbonate levels of Pelagonian sequences suggest that the radiolarites there are mainly Late Jurassic in age (Ferrière, 1982). Thus, it is very likely that siliceous sedimentation was diachronous across the Maliac-Pelagonian margin, with younger ages at the top of the Pelagonian sequences, as is the case in Argolis. However, more radiolarian data are still needed to see if this, in fact, is the case.

CONCLUSIONS

Radiolarites at the top of carbonate sequences of the Pelagonian and Maliac (Sub-Pelagonian) zones of Othris cannot be considered, any longer, as a relatively synchronous siliceous event. The biostratigraphic data of the present study establish that radiolarite sedimentation took place during the late Middle Jurassic (late Bajocian - middle Callovian) on the marginal Maliac units of Othris (Pirgaki and probably Garmeni-Rachi), more or less at the same time as equivalent sediments in basinal sequences of Maliac affinity in the Argolis Peninsula. Detrital material, derived from the erosion of the emergent (?) ophiolitic and associated sedimentary nappes (Ferrière, 1982), probably arrived after the latest Middle Jurassic in these basins and diluted the siliceous plankton record.

However, the biostratigraphic data on the higher carbonate levels of Pelagonian sequences of Othris suggest that radiolarites are mainly Late Jurassic in age there. In other words, it is very likely that siliceous sedimentation throughout the Maliac-Pelagonian realm was diachronous in Othris, with the younger ages on the top of the Pelagonian sequences, as is the case in Argolis.

AKNOWLEDGMENTS

The fieldwork was financially supported by the Commission for Travelling Grants of the Swiss Academy of Natural Sciences. Part of this work has been carried out in Switzerland. The 450th Anniversary Foundation and the Institut de Géologie et Paléontologie of the University of Lausanne are gratefully aknowledged. This work was completed and written up with the financial support of the European Union (HCM programme, contract no ERBCHBICT930370). I am grateful to Dr. A.H.F. Robertson for providing many helpful comments.

REFERENCES

AITA, Y. (1987). Middle Jurassic to Lower Cretaceous Radiolarian Biostratigraphy of Shikoku with Reference to Seleceted Sections in Lombardy Basin and Sicily. - *Tohoku Univ., Sci.Rep., Ser2*, Sendai, 58, 1, 1-91.

BAUMGARTNER, P.O. (1984). Middle Jurassic-Early Cretaceous low-latitude radiolarian zonation based on Unitary Associations and age of Tethyan radiolarites. - *Eclogae Geol. Helv.*, 77/3, 729-837.

BAUMGARTNER, P.O. (1985). Jurassic Sedimentary Evolution and Nappe Emplacement in the Argolis Peninsula (Peloponnesus, Greece). - *Mem. Soc. Helv. Sciences Naturelles*, 99, 1-111.

BAUMGARTNER, P.O. (1987). Age and genesis of Tethyan Jurassic radiolarites. - *Eclogae Geol. Helv.*, 80/3, 831-879.

BAUMGARTNER, P.O., DANELIAN, T. DUMITRICA, P., GORICAN, S., JUD, R., O'DOGHERTY, L., CARTER, B., CONTI, M., DE WEVER, P., KITO, N., MARCUCCI, M., MATSUOKA, A., MURCHEY, B. and URQUHART, E. [INTERRAD Jurassic - Cretaceous Working Group] (1994). Middle Jurassic - Early Cretaceous Radiolarian biochronology of Tethys: implications for the age of radiolarites in the Hellenides (Greece). - *Bull. Geol. Soc. Greece*, in press.

BAUMGARTNER, P.O., DE WEVER, P. and KOCHER, R.N. (1980). Correlation of Tethyan Late Jurassic-Early Cretaceous events. - *Cah. Micropaleont.*, 2, 23-85.

DANELIAN, T. (1989). Radiolaires jurassiques de la zone ionienne (Epire, Grece). Paléontologie - Stratigraphie - Implications paléogéographiques. - *Mem. Sci. Terre, Univ. P. et M. Curie*, 89-25, 1-260.

DE WEVER, P. (1989). Radiolarians, Radiolarites, and Mesozoic Paleogeography of the Circum-Mediterranean Alpine Belts. *In*: HEIN J.R. & OBRADOVIC J. Eds., Siliceous Deposits of the Tethys and Pacific Regions. - Springer-Verlag, 31-49.

DE WEVER, P. and DERCOURT, J. (1985). Les radiolaires triasico-jurassiques marquers stratigraphiques et paléogéographiques dans les chaines alpines periméditerranéennes: une revue. - *Bull. Soc. Geol. France*, 8/I/5, 653-662.

DE WEVER, P., RICOU, L.-E. and FOURCADE, E. (1986). La fin brutale de l'optimum radiolaritique au Jurassique terminal: l'effet de la circulation océanique. - *C. R. Acad. Sci. Paris*, 302/II/9, 665-670.

FERRIERE, J. (1982). Paléogéographies et tectoniques superposées dans les Hellénides internes: les massifs de l'Othrys et du Pelion. - *Soc. Geol. Nord*, publ. no8, 2 vol., 1-970.

FERRIERE, J., BERTRAND, J., SIMANTOV, J. and DE WEVER, P. (1988). Comparaison entre les formations volcano-détritiques ("mélanges") du Malm des Hellénides internes (Othrys, Eubée); implications géodynamiques. - *Bull. Geol. Soc. Greece*, XX, 223-235.

MATSUOKA, A. (1988). Jurassic Radiolarian Succession in Japan. *In* : SCHMIDT-EFFING R. & BRAUN A. Eds., First International Conference on Radiolaria (EURORAD V) - Abstracts. - *Geol. Palaeontol.*, Marburg, 25-26.

MATSUOKA, A. and YAO, A. (1986). A newly proposed radiolarian zonation for the Jurassic of Japan. *In* : DE WEVER P. Ed., Eurorad IV. - *Mar. Micropaleontol.*, 11, 91-105.

NOEL, D., BUSSON, G. and CORNEE, A. (1991). Les calcaires fins pélagiques du Jurassique moyen-supérieur sont essentiellement construits d'une nannoflore calcaire oligospécifique (coccolithes en "boutons de manchette"). - *C. R. Acad. Sci. Paris*, 313/II, 1455-1462.

O'DOGHERTY, L., SANDOVAL, J., MARTIN-ALGARRA, A. and BAUMGARTNER, P.O. (1989). las facies con radiolarios del Jurasico subbetico (Cordillera Betica, sur de Espana). - *Rev. Soc. Mex. Paleont.*, 2/1, 70-77.

ORIGLIA-DEVOS, I. (1983). Radiolaires du Jurassique supérieur - Crétacé inférieur : Taxonomie et révision stratigraphique (Zone du Pinde-Olonos, Grece; Zone de Sciacca, Italie; Complexe de Nicoya, Costa Rica et forages du D.S.D.P.). - *Mem. Sci. Terre, Univ. P. et M. Curie*, 83-53, 1-328.

PESSAGNO, E.A.Jr., BLOME, C.D., MEYERHOFF HULL, D. and SIX, W.M. (1993). Jurassic Radiolaria from the Josephine ophiolite and overlying strata, Smith River subterrane (Klamath Mountains), northwestern California and southwestern Oregon. - *Micropaleontology*, 39/2, 93-166.

PRICE, I. (1977). Deposition and derivation of clastic carbonates on a Mesozoic continental margin, Othris, Greece. - *Sedimentology*, 24, 529-546.

RIEDEL, W.R. and SANFILIPPO, A. (1974). Radiolaria from the southern Indian Ocean, DSDP Leg 26. *In* : DAVIES T.A., LUYENDYK B.P. *et al.*, *Init. Rep. of Deep Sea Drilling Project*, XXVI, 771-813.

ROBERTSON, A.H.F. (1991). Origin and emplacement of an inferred late Jurassic subduction-accretion complex, Euboea, eastern Greece. - *Geol. Mag.*, 128/1, 27-41.

ROBERTSON, A.H.F., CLIFT, P.D., DEGNAN, P.J. and JONES, G. (1991). Palaeogeographic and palaeotectonic evolution of the Eastern Mediterranean Neotethys. - *Palaeogeography, Palaeoclimatology, Palaeoecology*, 87, 289-343.

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

YAO, A. (1986). Geological age of Jurassic radiolarian zones in Japan and their international correlations. *In* : Recent Progress of Research on Radiolarians and Radiolarian Terrannes of Japan. - *News Osaka Micropaleontologists*, Spec. Vol., 7, 63-74.

PLATE CAPTION

Scanning electron micrographs of Middle Jurassic Nassellaria from the radiolarites of the Pirgaki unit. Numbers in mm in all figures refer to the same scale line (upper right).

Fig. 1.- *Stichocapsa robusta* MATSUOKA, TD93-21; 1a - 62μm; 1b - view of the distal part, 57μm.

Fig. 2 - *Eucyrtidiellum unumaense* (YAO), TD93-21, 60μm.

Fig. 3 - *Tricolocapsa conexa* MATSUOKA. TD93-21, 3a - 60μm; 3b - view of the distal part, 60μm.

Fig. 4 - *Theocapsomma cordis* KOCHER, TD93-12, 50μm.

Fig. 5 - *Theocapsomma* sp.aff. *T.cordis* KOCHER, TD93-12, 48μm.

Fig. 6 - *Archaeodictyomitra primigena* PESSAGNO & WHALEN, TD93-12, 50μm.

Fig. 7 - *Archaeodictyomitra exigua* BLOME, TD93-16, 48μm.

Fig. 8 - *Archaeodictyomitra* sp. K, TD93-12, 64μm.

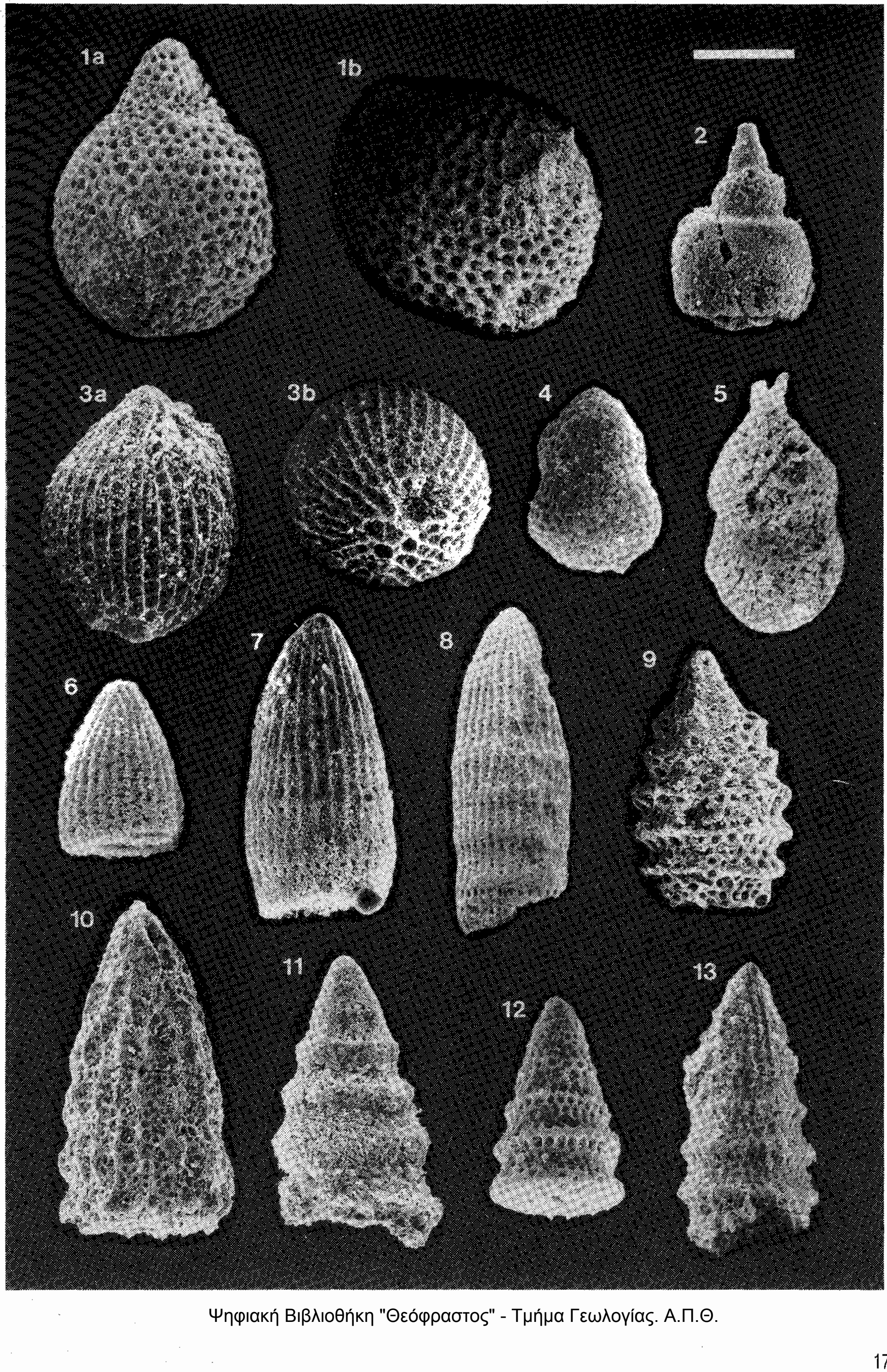
Fig. 9 - *Parvicingula* sp. M, TD93-21, 63μm.

Fig.10 - *Transhsuum maxwelli* (PESSAGNO), TD93-21, 62μm.

Fig.11 - *Sethocapsa dumitricai* WIDZ & DE WEVER, TD93-21, 60μm.

Fig.12 - *Dictyomitrella (?) kamoensis* MIZUTANI & KIDO, TD93-12, 61μm.

Fig.13 - *Dictyomitrella (?) kamoensis* MIZUTANI & KIDO, TD93-12, 65μm.


1a
1b
2
3a
3b
4
5
6
7
8
9
10
11
12
13