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MIDDLE JURASSIC-EARLY CRETACEOUS RADIOLARIAN BIOCHRONOLOGY OF TETHYS: IMPLICATIONS FOR THE AGE OF RADIOLARITES IN THE HELLENIDES (GREECE)

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ABSTRACT

This paper revises the age assignment of previously published radiolarian assemblages form the Ionian Zone and the Pelagonian Argolis Peninsula, based on a preliminary new radiolarian biochronology in preparation by the INTERRAD JURASSIC-CRETACEOUS WORKING GROUP.

The radiolarites of the Ionian zone were deposited since the latest Bajocian or lower Bathonian in basinal sequences, where sedimentation was continuous until the Tithonian. In swell sequences, important hiatuses can now be dated.

The onset of radiolarite sedimentation in Pelagonian basinal sections of Maliac affinity started in the middle or early late Bajocian. Assemblages associated with the lowest ophiolite debris are dated as early as middle to late Bathonian in the internalmost Pelagonian units. The emplacement of marginal sequences is now dated as middle or early late Oxfordian to Kimmeridgian or earliest Tithonian in the external Argolis Peninsula.

1. ATLAS AND BIOCHRONOLOGY

After three meetings (Lausanne 1989, Munich 1990, Paris 1991) held by the members of the Working Group, we have agreed on the systematics of about 600 taxa to be used for the creation of a Middle Jurassic to Lower Cretaceous radiolarian biozonation for the Tethyan realm. A Radiolarian Atlas is in preparation; it will include all taxa used in biostratigraphy, with illustrations, including the holotype, original and subsequent definitions as well as an up-to-date synonymy.

Taxa difficult to identify in poorly preserved material have preferentially been placed at subspecies level, whereas our species represent a more broadly defined group of morphotypes determinable even in poorly preserved samples. In that way, the

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resulting zonation is based on, and can be applied to a wide range of preservational stages, typical for Mesozoic radiolarians.

Individual chapters (authored by each contributor) will contair details concerning the geology, stratigraphy and radiolarian occurrences from each region:

1. Geographic and geologic location of sections, regional and local geology.
2. Lithostratigraphy of the studied sections including a description of the rocks and discussion of sedimentology, and environment of deposition. Figures representing lithostratigraphic columns based on measured sections with sample levels, and original sample numbers will be included.
3. Biostratigraphy. Besides the radiolarian occurrences, special attention will be paid to other fossil groups (ammonites, nannos, calpionellids, etc.) that are important to the chronostratigraphic calibration of radiolarian assenblages.
4. Biochronology: A discussion and comparison of old and new zonations is included.

Our data base consists of radiolarian occurrence data from over 1100 samples from 130 measured sections of the Middle Jurassic to Early Cretaceous time interval, recovered from the Tethyan - Circumpacific low paleolatitude realm. Sample localities include the Alpine Mediterranean area, Central and Eastern Europe, Oman, Japan, parts of Western North America, Central America and low paleolatitude DSDP - ODP sites in the Oceans.

The contributors agreed on using the Unitary Associations method (Guex 1991) to integrate individual data sets into a common zonation. Unitary Associations (U.A.) are calculated with the program BIOGRAPH (Savary & Guex, 1991). The U. A. method creates a synthesis of the co-occurrences of taxa observed in all samples from all sections. The program BIOGRAPH produces a co-occurrence chart of chronologically ordered U. A., in which the maximum range of each species is displayed with respect to the maximum ranges of all other species. In general, several U.A. are grouped to define a biochronozone, to insure the optimum of lateral reproducibility and superpositional control of zones in as many sections as possible.

The large number of included taxa and studied sections results in a good temporal resolution (about 80 U.A. for the Middle to Upper Jurassic and 35 U.A. for the Lower Cretaceous). We will create about 20 zones for the Aalenian - Aptian interval. Chronostratigraphic calibration was principally obtained by correlation to ammonite zones defined by ammonites which co-occur with radiolarians in the sections studied for the database. Furthermore, co-occurring calpionellids, nannofossils and magnetostratigraphy previously established in the same sections were used to tie radiolarian U.A. to the stages.

Since 1984, the calibration of our radiolarian zonation has been improved, especially by the inclusion of data from sections in the Subbetic realm (Spain, Baumgartner 1987, O'Dogherty et al. 1989) and the Trento Plateau (Northern italy), where ammonites co-occur with radiolarians in the middle and upper Jurassic. The increased number of taxa included with the database and better calibration to ammonites allow to precise the age of Greek radiolarites to the substage level.

It should be noted that the numbers indicating Unitary Associations given in parenthesis are preliminary and do not represent anything like zones. These numbers, as well as the faunal contents of U.A. are likely to change once our dataset is finalized as a result of better resolution. However, the age statements made in this chapter depend on the calibrations discussed above and are made with sufficient allowance to account for possible imprecisions in correlation and should not change, but may be refined by our further work.

2. AGE OF RADIOLARITES IN THE IONIAN AND PELAGONIAN ZONES (HELLENIDES, GREECE)

2.1 IONIAN ZONE (T. Danelian)

New Unitary Associations were calculated for a combined radiolarian database of Danelian (1989) and the Jurassic-Cretaceous Working Group. They have resulted in the refinement of the chronostratigraphy in the middle to upper Jurassic sediments of the Ionian zone in Epirus (north-western Greece).

Eightytwo species of the Ionian material are represented in the atlas of taxa of the Working Group and were used in the calculations. They are present in 39 samples, collected from seven

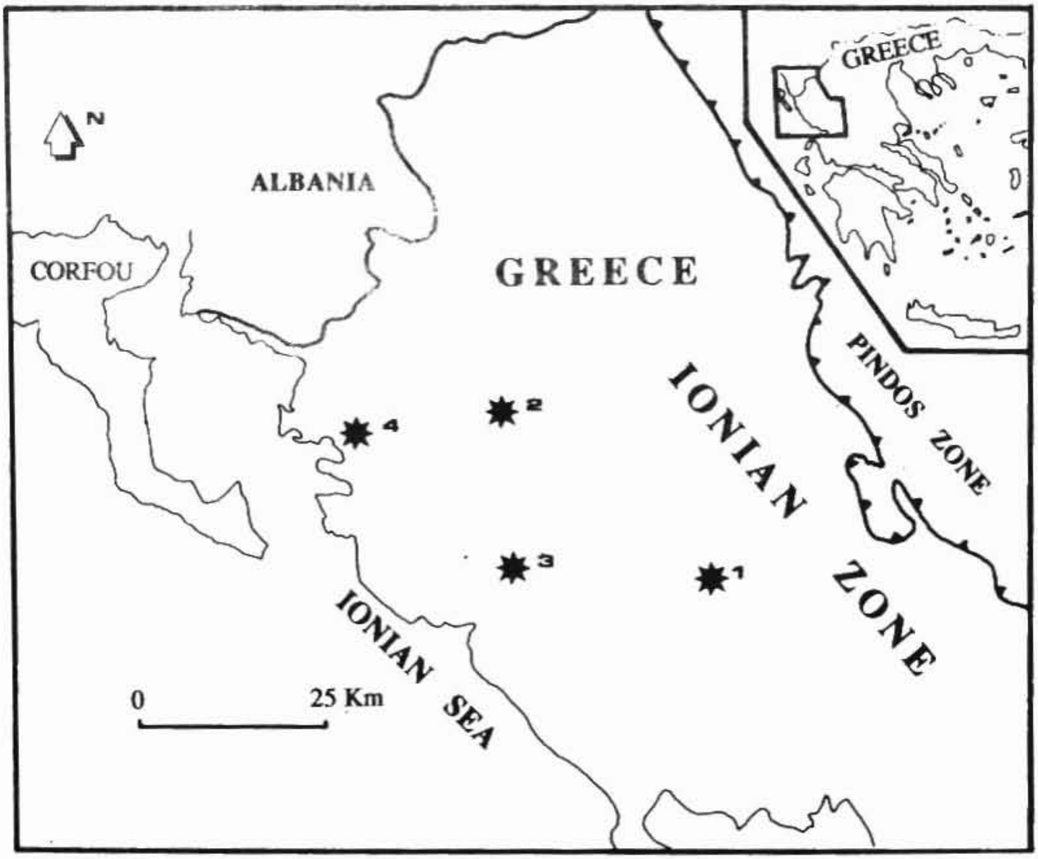


Figure 1.- Location of the studied areas: (1) Louros, (2) Khionistra, (3) Skandhalon, (4) Varathi. For geological details see Danelian (1989).

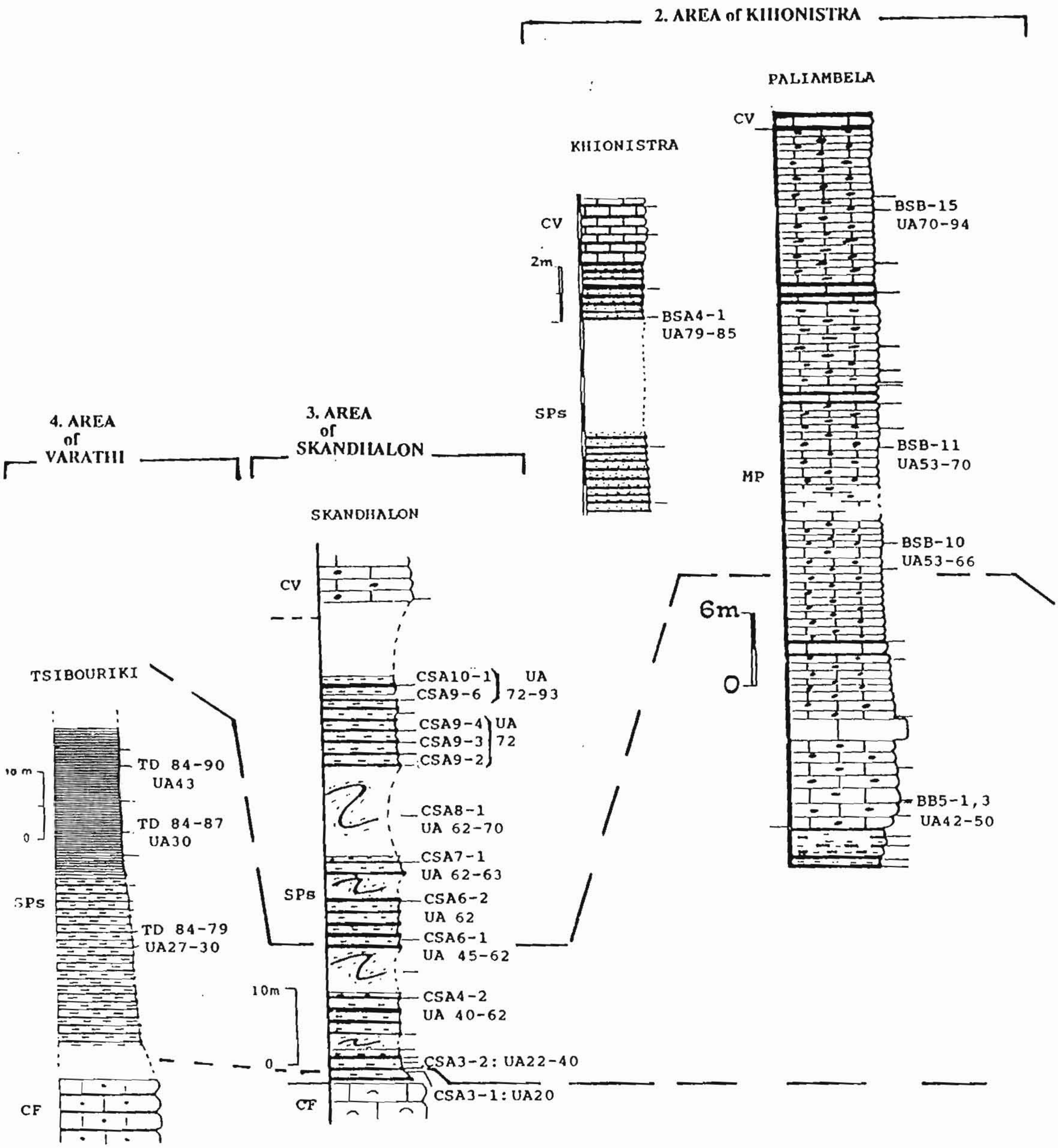
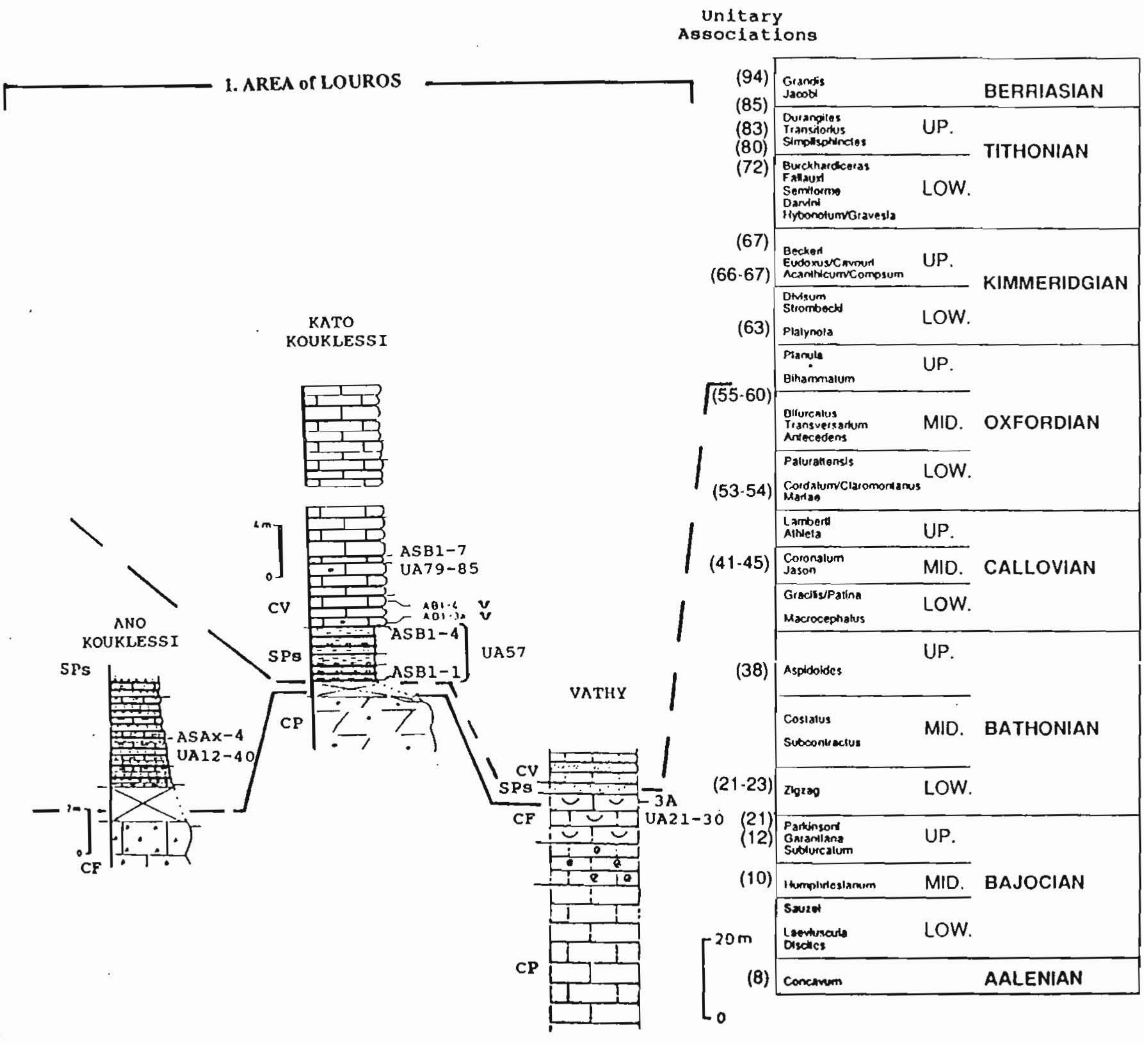


Figure 2.- Representative samples in the studied sections of the Ionian zone and age calibration of the Unitary Associations (U.A.) relative to the chronostratigraphical scale and standard Ammonite zones.
CP : Pantokrator Limestone, CF : Calcaire à filaments,
SPs : Upper Posidonia Beds. They correspond to a radiolaritic sequence.
CV : Vigla Limestone, MP : Member of Paliambela.


Unitary Associations
1. AREA of LOUROS
KATO KOUKLESSI
ANO KOUKLESSI
VATHY
SPs
CV
CP
CF
ASB1-7
UA79-85
ASB1-4
ASB1-1
UA57
ASAx-4
UA12-40
3A
UA21-30
20m
0
(94) Grandis Jacobi
BERRIASIAN
(85) Durangites
(83) Transitorius
(80) Simplisphinctes
UP.
TITHONIAN
(72) Burckhardiceras Fallauxi Semiforme Darwini Hybonotum/Gravesia
LOW.
(67) Beckeri Eudoxus/Cavouri
(66-67) Acanthicum/Compsum
UP.
KIMMERIDGIAN
Divisum Strombecki
(63) Platynota
LOW.
Planula Bihammatum
UP.
(55-60) Bifurcatus Transversarium Antecedens
MID.
OXFORDIAN
Paturattensis
(53-54) Cordatum/Claromontanus Mariae
LOW.
Lamberti Athleta
UP.
(41-45) Coronatum Jason
MID.
CALLOVIAN
Gracilis/Patina Macrocephalus
LOW.
UP.
(38) Aspidoides
Costatus Subcontractus
MID.
BATHONIAN
(21-23) Zigzag
LOW.
(21) (12) Parkinsoni Garantiana Subfurcatum
UP.
(10) Humphriesianum
MID.
BAJOCIAN
Sauzei Laeviuscula Discites
LOW.
(8) Concavum
AALENIAN

sections separated into four groups based on their geographic locations (fig.1). The results are presented in figure 2. The formations and membres discussed herein were defined by I.G.R.S. & I.F.P. (1966) and Danelian & Baudin (1990).

The results are summarized in the following.

Radiolarians recovered from the top of "Calcaire à filaments" Formation in the Vathy section allow to determine a latest Bajocian-middle Bathonian age (U.A.21-30).

The Upper "Posidonia" Beds are dated in two basinal sequences: the latest Bajocian-early Bathonian (U.A. 20, sample CSA3-1, Skandhalon section) is clearly recognised in the base of this Formation. Various levels can be attributed to either Bathonian, Callovian, Oxfordian, Kimmeridgian or lower Tithonian in the Skandhalon and Tsibouriki sections. The uppermost levels of this Formation are of late Tithonian to early Berriasian in age (U.A. 79-85; Sample BSA4-1, Khionistra section).

Concerning the Member of Paliambela, present in the homonyme section, its base (sample BB5-1,3) is now attributed with certitude to the Callovian (U.A. 42-50).

The 4-5 meters of the Upper "Posidonia Beds in the Kato Kouklessi section (samples ASB1-1 to ASB1-4) can now be dated more precisely as middle to late Oxfordian (U.A. 57). One major hiatus exists in the Kimmeridgian and Tithonian of this section, since just above the last "Posidonia" bed, dated as Oxfordian, the first level of Vigla Limestone is dated as early Berriasian by calpionellids (determination of *Remaniella ferasini* by Azema *in* Danelian, 1989).

Conclusions

The radiolarites of the Ionian zone were deposited since the latest Bajocian or lower Bathonian in basinal sequences, where sedimentation was continuous until the Tithonian. An important sedimentary hiatus has been detected in the reduced upper Jurassic sequence of Kato Kouklessi section, thanks to the good biochronological resolution presently achieved by Radiolaria. The change from radiolaritic to calcareous sedimentation (Vigla Limestone) took place in the Ionian basin during the late Tithonian to early Berriasian.

2.2. PELAGONIAN ZONE (P. O. Baumgartner)

The radiolarite Formations of the Argolis Peninsula (Figure 3) were described and dated by Baumgartner (1985), based on the radiolarian zonation proposed in Baumgartner (1984). For the first time, the Dhimaina and Potami Formations, both characterized by siliceous, radiolarian bearing mudstones and ophiolite debris, were clearly dated as Kimmeridgian. Younger ages in the more external Adhami Basal Sequence permitted to date the interval of westward progradation of the clastics derived from the ophiolite nappe and the Asklipion Unit, both emplaced during the Late Jurassic onto the pelagonian margin. In this paper, we would like to precise [illegible] Argolis

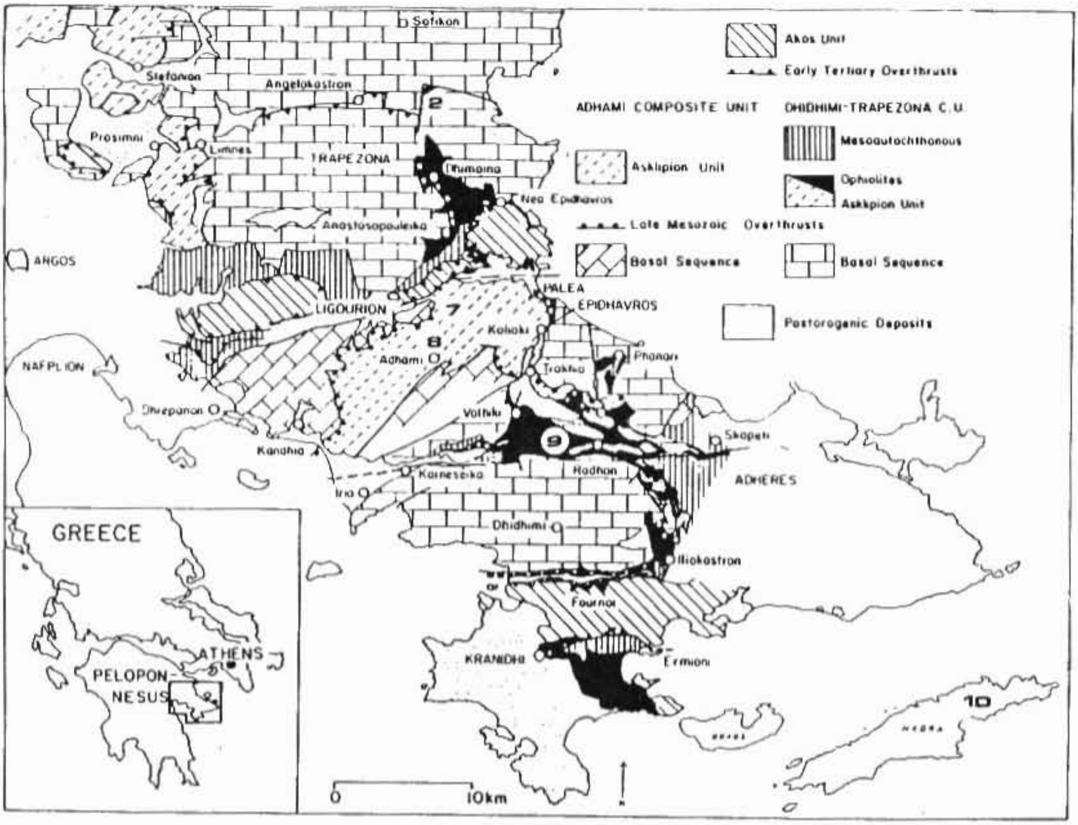
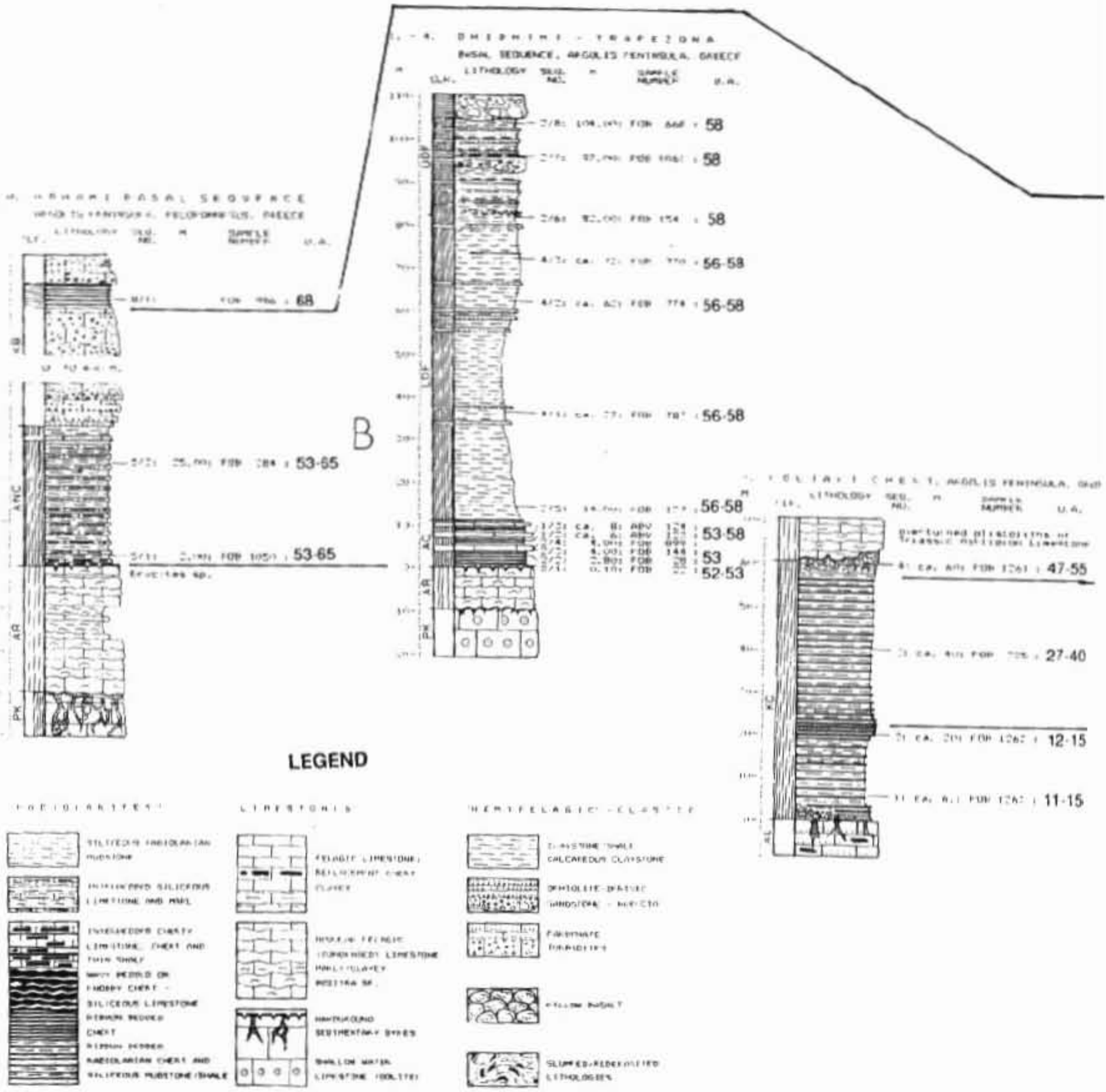


Figure 3.- Geologic map of the Argolis Peninsula (after Baumgartner, 1985) with numbers locating the sections illustrated in Figure 4 and discussed in the text. 1, 4 Dhimaina, 2 Angelokastron, 5 Kandhia, 7 Koliaki, 8 Theokafta, 9 Radhon, 10 Hydra.

Peninsula and on Hydra Island, based on preliminary results of the Jurassic-Cretaceous Working Group.

The internalmost sequences of the Argolis Peninsula and Hydra Island (Figure 3, No. 10) have Maliac affinities (Ferriere 1982, Vrielynck 1982). Deep water cherty limestones of Lower Jurassic age (Adhami Limestone) are overlain by resedimented Ammonitico Rosso lithologies, which in turn are overlain by radiolarites and siliceous mudstones (Koliaki Chert). The base of the Koliaki Chert is now dated as late middle to early late Bajocian (U.A. 11-15) in the Argolis Peninsula (Figure 4, see also Baumgartner, 1985, Plate 6, Section A). On Hydra Island, several samples at the base of the Koliaki Chert in the Klimaki Unit (Ernst et al. 1992, pp. 75-83) have yielded radiolarian assemblages assignable to the late middle to early late Bajocian (U.A. 10-12).

In the Basal Sequences of the Argolis Peninsula, radiolarite sedimentation started much later in the early Oxfordian (U.A. 52-53, Figure 4), which is typical for Tethyan "seamount" sequences (like the Trento Plateau in Northern Italy). In the external Adhami sequence, basal radiolarites could be even younger (U.A. 53-65, Figure 4), the age is, however, poorly constrained.


B
68
53-65
53-65
58
58
58
56-58
56-58
56-58
56-58
53-58
53
52-53
47-55
27-40
12-15
11-15
KB
ANC
AR
PK
UDF
LDF
AC
AR
PK
KC
AL
LEGEND

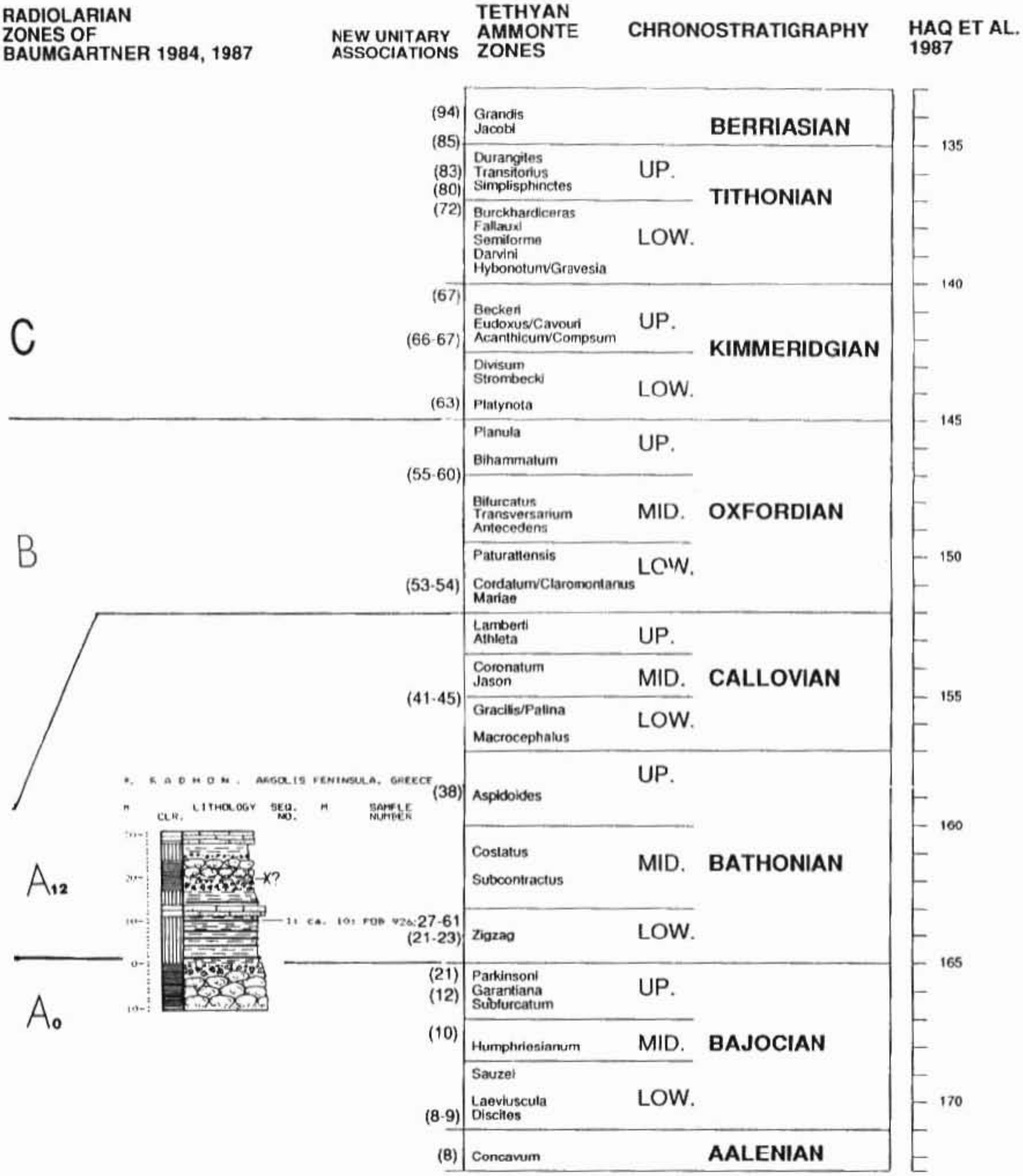


Figure 4.- Synthetic sections of radiolarite Formations in the Argolis Peninsula, after Baumgartner (1984), with new age calibration. PK: Pantokrator Limestone. AR: Ammonitico Rosso, ANC: Ayos Nikolaos Chert, KB: Kandhia Breccia, AC: Angelokastron Chert, LDF: Lower Dhimaina Formation, UDF: Upper Dhimaina Formation, AL: Adhami Limestone, KC: Koliaki Chert.

Radiolarites associated with the Ophiolites (Migdhalitsa Ophiolite Unit) near Radhon in the Argolis Peninsula can now be dated as middle Bathonian or younger (U.A. 27-61, Figure 4). This sample, however, has to be reexamined in order to better constrain its age.

The age of the first occurrence of ophiolite detritus along the eastern Pelagonian Margin is critical to the history of emplacement of the ophiolites during the Eohellenic Phase. The earliest ophiolitic detritus occurs in radiolarites (Koliaki Chert) of the Klimaki Unit on Hydra Island (Ernst et al. 1992, p. 80) The radiolarian assemblages associated with a dm-thick bed of ophiolite breccia (cm-sized pebbles of serpentinite and altered volcanics) can be dated as middle to late Bathonian (U.A. 29-37). In the Argolis peninsula, the oldest ophiolite detritus is found in the Asklipion Nappe, associated to olistoliths of Asklipion Limestone (Figure 4, Baumgartner 1985, Plate 6, Section A). The radiolarian assemblage can now be dated as late Callovian to early Oxfordian (U.A. 47-55, Figure 4). In the Basal Sequence of the Dhidhimi-Trapezona Composite Unit, coarse ophiolitic breccias certainly occur since the middle or late Oxfordian (U.A. 58). These breccias, attributed to the Potami Formation record the emplacement of the ophiolites onto the Pelagonian margin. In the more external Adhami Basal Sequence, the onset of ophiolite detritus could be quite younger, but its age is poorly constrained for the moment (U.A. 53-65, Figure 4). The youngest age associated with coarse debris derived from the ophiolites and the Asklipion Nappe (Kandhia Breccia) is Kimmeridgian or earliest Tithonian. It was found on the Theokafta hill (POB 986, U.A. 68, Figure 4 and Baumgartner, 1985, Plate 2, Section F).

Conclusions

The new calibrations presented in this chapter allow the conclusion that the onset of radiolarite sedimentation in Pelagonian basinal sections of Maliac affinity started in the middle or early late Bajocian, at the same time as in other Tethyan basins (e.g. Lombardy Basin, Umbria). However, preliminary results of the Working Group indicate that radiolarite (s.str.) sedimentation seems to start earlier in the Pindos-Budva Zone (early Bajocian or Aaalenian ?).

New calibrations of assemblages associated with the lowest ophiolite debris, imply that the Eohellenic orogenic phase emplacing Ophiolites of the Vardar Ocean onto the Pelagonian margin was recorded by the arrival of ophiolitic detritus as early as middle to late Bathonian in the internalmost Pelagonian units, while ocean floor was still forming. The main phase of emplacement of ophiolites and of the Asklipion Nappe onto the margin itself is now dated as middle or early late Oxfordian to Kimmeridgian or earliest Tithonian in the external Unit of the Argolis Peninsula.

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REFERENCES

BAUMGARTNER, P. O. (1984): A 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).- Denkschr. Schweiz. Nat. Ges., 99, 1-111.

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

DANELIAN, T. (1989): Radiolaires jurassiques de la zone ionienne (Epire, Grèce). Palontologie, Stratigraphie, Impliations paléogéographiques. - Thèse de Doctorat de l'Univ. Paris VI, Mém.Sc.Terre Univ.Curie, Paris, no 89-25, 260 p., 10 pl.

DANELIAN, T. & BAUDIN, F. (1990): Découverte et signification d'un horizon carbonaté, riche en matière organique, au sommet des radiolarites d'Epire : le Membre de Paliambela. - Comptes Rendus de l'Académie des Sciences, Paris, t.311, II, pp.421-428.

FERRIERE, J. (1982): Paléogéographies et tectoniques superposées dans les Hellénides internes: les massifs de l'Othrys et du Pelion. - Soc. Géol. Nord, publ. n°8, 2 vol., 970 p.

ERNST, B., GILBERT, C., PHILIPPOSSIAN, F. & RICHARDS, M. (1992): La géologie d'Hydra.- Unpubl. Diploma volume, Inst.Géol.Paleont., Univ. Lausanne, 207 p.

GUEX, J., (1991): Biochronological correlations.- Springer-Verlag, Berlin. 252 p.

HAQ, D.W., HARDENBOL, J. & VAIL, P. R., (1987): Chronology of fluctuating sea levels since the Triassic. Science, 235: 1156-1166.

I.G.R.S. & I.F.P. (Institut de Géologie et Recherches du Sous-sol, Athènes et Institut Français du Petrole, mission Grèce) (1966): Etude géologique de l'Epire (Grèce nord-occidentale). - Edit. Technip, Paris, 306 p., 9 pl.

O'DOGHERTY, L., SANDOVAL, J., MARTÌN-ALGARRA, A., & BAUMGARTNER, P.O.(1989): Las facies con radiolarios del Jurasico subbetico (Cordillera Betica, sur de Espana).- Rev. Soc. Mex. Paleont. Vol. 2, No. 1, pp. 70-77.

SAVARY, J, & GUEX, J., (1991): BioGraph, un nouveau programme de construction de corrélations biochronologiques basées sur les associations unitaires. Bull. Geol. Lausanne. 313: 317-340.

VRIELYNCK, B. (1982): Evolution paléogéographique et structurale de la presqu'île d'Argolide (Grèce).- Rev. Géogr. phys. Géol. dyn., 23, 4, pp.277-288.