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THE EARLY-MIDDLE TRIASSIC BOUNDARY AT CHIOS (GREECE)

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Riassunto. Vengono riesaminate le sezioni di Marathovouno (Chios, Grecia), tra le quali Assereto (1974) propose quella centrale quale stratotipo per la base dell'Anisico. Inoltre viene esaminata una nuova sezione, Parthenis, presso l'abitato di Chios.

La fauna ad Ammonoidi del tardo Spathiano, piuttosto abbondante nella sezione Parthenis, appartiene alla zona a *Prohungarites/Subcolumbites* sensu Kummel (1973). Ulteriori raccolte di Ammoniti sono state fatte lungo la sezione stratotipica di Assereto, così come dalla sezione G, dove si è rinvenuto un Ammonoide dell'Egeico, *Paradanubites*, immediatamente sopra l'orizzonte condensato. Nella sezione Parthenis la parte basale dell'Anisico è assente a causa di una lacuna deposizionale. Alcuni Ammonoidi post-Egeici sono stati rinvenuti entro olistoliti di calcari rossi entro la Variegated Serie (Bunte Serie).

I Conodonti forniscono una documentazione più continua lungo tutte le sezioni misurate. Le specie più significative dal punto di vista stratigrafico sono: *Neospathodus homeri*, *Gondolella timorensis*, *Gondolella regale*. La distribuzione di *G. timorensis* è coincidente con quella di *N. homeri* per oltre un metro di successione sotto lo strato con *Egeiceras*. *G. regale* non sembra mai associata con *N. homeri* e compare dopo la fauna ad Ammonoidi tipica dell'Egeico. L'analisi delle microfacies ha messo in evidenza solo la presenza di Foraminiferi ad ampia distribuzione.

Per quanto concerne la base dell'Anisico si possono indicare i seguenti elementi. 1) La base del piano può essere tracciata in corrispondenza del FAD di *Aegeiceras*, *Paracrochordiceras*, *Paradanubites* e *Japonites*. 2) Il FAD di *G. timorensis* precede di poco il FAD degli Ammonoidi Egeici. Quindi se si da prevalenza al limite tracciato con gli Ammonoidi, il FAD di *G. timorensis* avviene nel tardo Spathiano. 3) Il FAD di *G. regale* avviene dopo il FAD degli Ammonoidi Anisici. La fauna di Chios sembra correlativa degli *Japonites welteri* beds della sezione dello Star Peak Canyon in Nevada, secondo la definizione data da Bucher (1989).

Abstract. The sections of Marathovouno hillock in Chios (Greece), proposed by Assereto (1974) as stratotype for the base of the Anisian, have been revisited. An additional new section, Parthenis, near the town of Chios, was also considered.

The ammonoid fauna of the Late Spathian, fairly rich in the Parthenis section, fully belongs to the *Prohungarites/Subcolumbites* zone, sensu Kummel (1973). Additional ammonoid collections have been made

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from the stratotype section of Assereto, as well from section G, where the Aegean *Paradanubites* has been found above the condensed horizon. In the Parthenis section the earliest Anisian is missing because of a sedimentation gap. Several post-Aegean ammonoids have been found in red limestones olistoliths within the Variegated Series (Bunte Serie).

The conodonts gave a more continuous record troughout all the sections. The most significant species to be considered are: *Neospathodus homeri*, *Gondolella timorensis* and *Gondolella regale*. The first occurrence of *G. timorensis* overlaps the *N. homeri* range for more than 1 m in thickness, below the bed with the ammonoid *Aegeiceras*. *G. regale* seems to be never associated with *N. homeri* and appears later than the typical Aegean ammonoid fauna. Microfacies analysis revealed the presence of long ranging foraminifers.

As far as the base of the Anisian is concerned, we may advance the following statements. 1) The base of the stage may be traced with the FAD of *Aegeiceras*, *Paracrochordiceras*, *Paradanubites* and *Japonites*. 2) The FAD of *G. timorensis* slightly preceeds the Aegean ammonoid FAD. Thus, if the boundary is drawn on the base of ammonoids, *G. timorensis* FAD is latest Spathian in age. 3) *G. regale* FAD occurs later than the Aegean ammonoid fauna FAD. By correlation to the Nevada Star Peak Canyon section, the Aegean fauna of Chios seems correlative to the *Japonites welteri* beds of Bucher (1989).

Foreword.

The Marathovouno section was proposed by Assereto (1974) as type-locality for the new Aegean substage, considered as the lowest substage in the Anisian. In the current stratigraphic practice (Hedberg, 1976; Cowie et al., 1986), a stage is defined by its base and by the base of the following stage. Hence, the proposed base of Aegean at Chios defines the base of the Anisian, constituting its possible basal golden spike.

Due to its critical significance, and through the kind interest of the IGME General Director, Dr. Andronopoulos, we had the opportunity to revisit the most significant sections of Chios during september 1989. New results concern especially sections A, C, D and G of Assereto et al. (1980) at Marathovouno and the Parthenis area, this last previously investigated by Tietze (1969) and briefly discussed by Jacobshagen & Tietze (1974) (Fig. 1, 2).

Field work was performed by V. Jacobshagen, A. Nicora, M. Gaetani, V. Tselepidis, with the help of the students of Milan University: L. Angiolini, R. Lazzaroni and G. Muttoni. Scythian ammonoids have been identified by D. Mertmann, Anisian ammonoids by N. Fantini Sestini, Scythian conodonts by G. Kauffmann, Anisian conodonts by A. Nicora, V. Skourtsis-Coroneou worked out the foraminifera.

History of research.

The Chios Upper Scythian rocks were firstly described by Ktenas & Renz (1928, 1931). Subsequently Renz also monographed the Lower Triassic ammonoids (Renz & Renz, 1948). The mapping of the island and a stratigraphical evaluation were done by Besenecker et al. (1968, 1971). Bender (1970) found an ammonoid and conodont fauna above the Scythian one, considering it as the lowermost Anisian. He described three sections at the Marathovouno hillock, viz. CMI, CMII, and CMIII, which in fact are the only three complete sections measurable on the spot. Following the Bender paper, Assereto resampled the section CMII in 1971. The ammonoid content was discussed in Assereto (1974), in which the Marathovouno hillock and the section CMII were indicated as type for the new proposed Aegean substage of the Anisian. The conodonts from the same section were illustrated by Nicora (1977). Jacobshagen & Tietze (1974) also discussed the problems of the Scythian-Anisian boundary at Chios.

During the summer 1975, a joint field research was carried out by German and Italian teams, remeasuring and sampling in great detail Marathovouno. The section CMIII of Bender became section F, section CMII was split into sections A + C and D, because of the presence of fractures and small covered intervals which could conceal minor faults. The field collectors preferred to emphasize possible gaps or repetitions. In fact, lab treatment of samples revealed that no significant repetitions are present and thus it is sufficiently correct to consider the section as continuous as

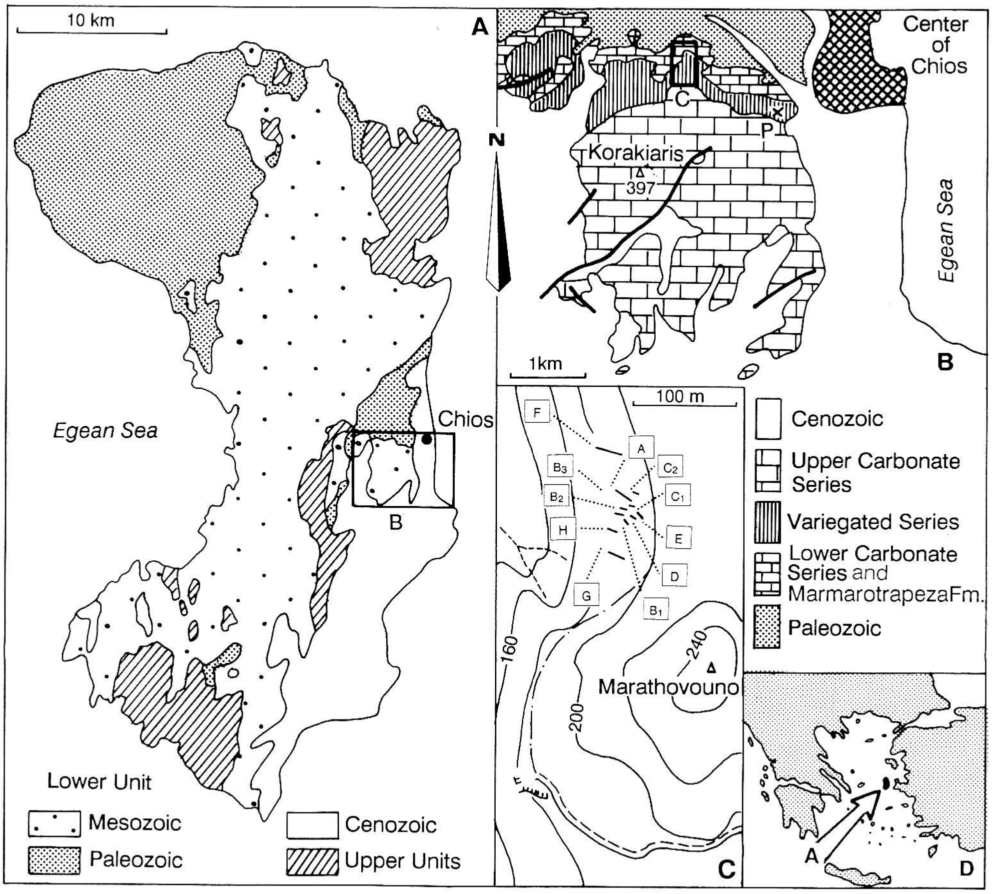


Fig. 1 - Index-map of Chios Island (Greece) and of the investigated area (A) with geological map (B), location of the measured sections (C), and location of the island in Greece (D).

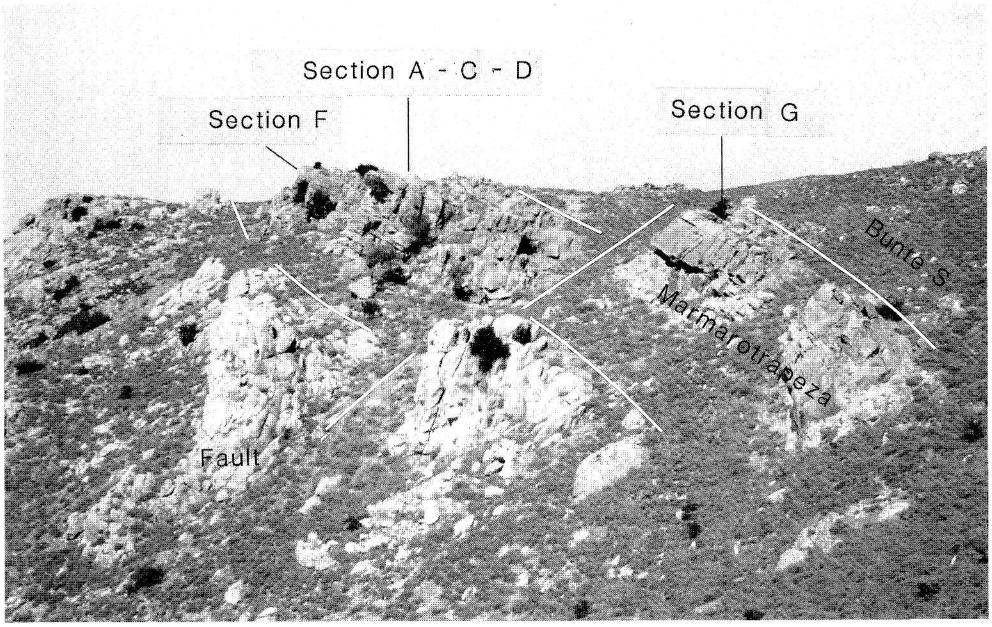


Fig. 2 - Picture of the Marathovouno outcrops, with location of the sections A, C, D, F, G.

Bender (1970) and Assereto (1974) did. Section CMI became section G. For detailed positioning of the sections see also fig. 1 in Assereto et al. (1980).

The death of Assereto in 1976 greatly affected this research project and delayed the publication of the results. At the Assereto-Pisa Symposium (1979), however, general results were published, with data from sections A (but not C and D), F and G (Assereto et al., 1980). Eventually in 1981, Fantini Sestini described the Anisian ammonoid fauna collected in 1971 and 1975 from sections C and D, i.e. the upper part of the section CMII of Bender.

The Chios sections were later discussed by Wang Yi-gang (1985) and by Bucher (1989) in their papers on the Spathian/Anisian boundary and earliest Anisian ammonoids.

Geological evolution.

Chios island is composed by two main tectonic units (Fig. 1A). The lower one (called by Besenecker et al., 1968, 1971 as "autochthonous") contains a thick succession of Triassic rocks and shows clear affinities to the Pelagonian zone of mainland Greece. The upper one, covering the previous as a nappe overthrust from the N, is now preserved in a few outliers only. It only contains a few Triassic rocks. Between these two major units, tectonic melanges or even extended scales ("parautochthonous") can be observed in limited areas. Our studies refer to the Triassic of the lower unit in the

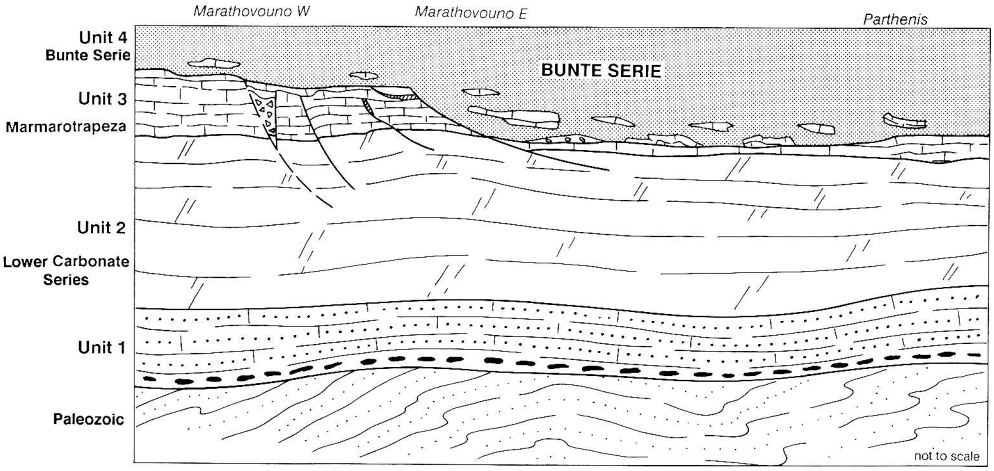


Fig. 3 - Geological evolution cartoon, emphasizing the tensional drowning of the carbonate ramp, the block faulting affecting the Marmarotrapeza Fm. and the presence of olistholites within the Variegated Series (Bunte Serie).

vicinity of Chios town, which had been investigated and mapped by Tietze (1969).

The Lower Triassic and Anisian sediments of the "autochthonous" of Chios are transgressive over the gently metamorphosed and deformed Palaeozoic greywackes (Besenecker et al., 1968). Four units may be distinguished, from bottom to top.

1) *Basal Series* (Besenecker et. al, 1968). This unit consists of polymictic conglomerates (0-40 m), followed by well bedded grey arenitic limestones, some tens to more than one hundred-meters thick. This first stack has a highly variable distribution, being thicker on the west coast of the island (Metochi bay) and thinner in the Marathovouno area (10-20 m at maximum). This terrigenous unit ends with well bedded limestones containing already a Late Scythian bivalve fauna and in the north conodonts of the Spathian *collinsoni* zone (Kauffmann, 1978).

2) *Lower Carbonate Series* (Besenecker et al., 1968). The well bedded gray wackestones/packstones upwards became massive and interfinger with gray bedded and massive dolomites. These latter, very coarse grained, eventually dominate with some oolithic phantoms still visible. This second unit, testifying to a peritidal carbonate flat, at the beginning still polluted by clastic input and then swept also by oolithic bars, is widespread in the "autochthonous" of Chios.

3) *Marmarotrapeza* Fm. (Ktenas & Renz, 1928). In the region south of Chios town with sharp contact, the Marmarotrapeza follows. The red nodular limestone (wackestones and rarely packstones, with fragments of ammonoids, filaments and rare foraminifera) usually does not exceed 15 m in thickness. It testifies to a deeper environment with reduced sedimentation rate. The downwarping was earlier at east (Spathian), whereas was younger at west (latest Spathian or earlier Anisian according to Roth, 1968). The Anisian part of the Marmarotrapeza Fm. may not exist as in the

Parthenis section or to reach 2 to 3.5 m as at Marathovouno hillock. Lithological characters do not significantly change in respect to the Scythian part. The Marmarotrapeza Fm. occurs mainly around the town of Chios, whereas to the west and to the north is absent or very reduced. In such cases, the following unit lies directly on the Lower Carbonate Series.

4) *Variegated Series* (= *Bunte Serie*). This term was introduced by Besenecker et al. (1968) to designate a succession of red to purple shales, radiolarites, and tuffitic horizons. It contains m-thick olistoliths usually with Scythian ammonoids. During 1989 field-work also two small blocks with Middle Anisian ammonoids have been found, indicating that in very small spots, possibly in the west, the reduced carbonate sedimentation of the Rosso Ammonitico facies continued upward. In the area of M. Korakaris, Tietze (1969) found evidence for a Carnian age in the cherty limestones.

Whether the recent interpretations of the Permian Chios successions (Stampfli et al., 1981; Baud et al., 1991) are accepted as evidence of an accretionary complex or not, the Early and Middle Triassic of the "Chios autochthonous" may be safely considered as linked to a very active extensional regime. It is out of the scope of the present paper to discuss its more general geodynamic meaning and thus to try to fit the extensional regime within an accretionary complex as suggested by Stampfli et al. (1981). Evidences for tensional activity are the general sedimentary trend, the intense synsedimentary block-faulting, the fissure fillings of various size, from mm to several m wide and deep (see the fig. 5 in Assereto et al., 1980), the Marmarotrapeza olistoliths into the Bunte Serie, the sudden deepening indicated by the sharp superposition of the Marmarotrapeza Fm. upon the dolomitic peritidal bank. Fig. 3 depicts the general interpretation of the geological evolution in the Marathovouno-Parthenis area.

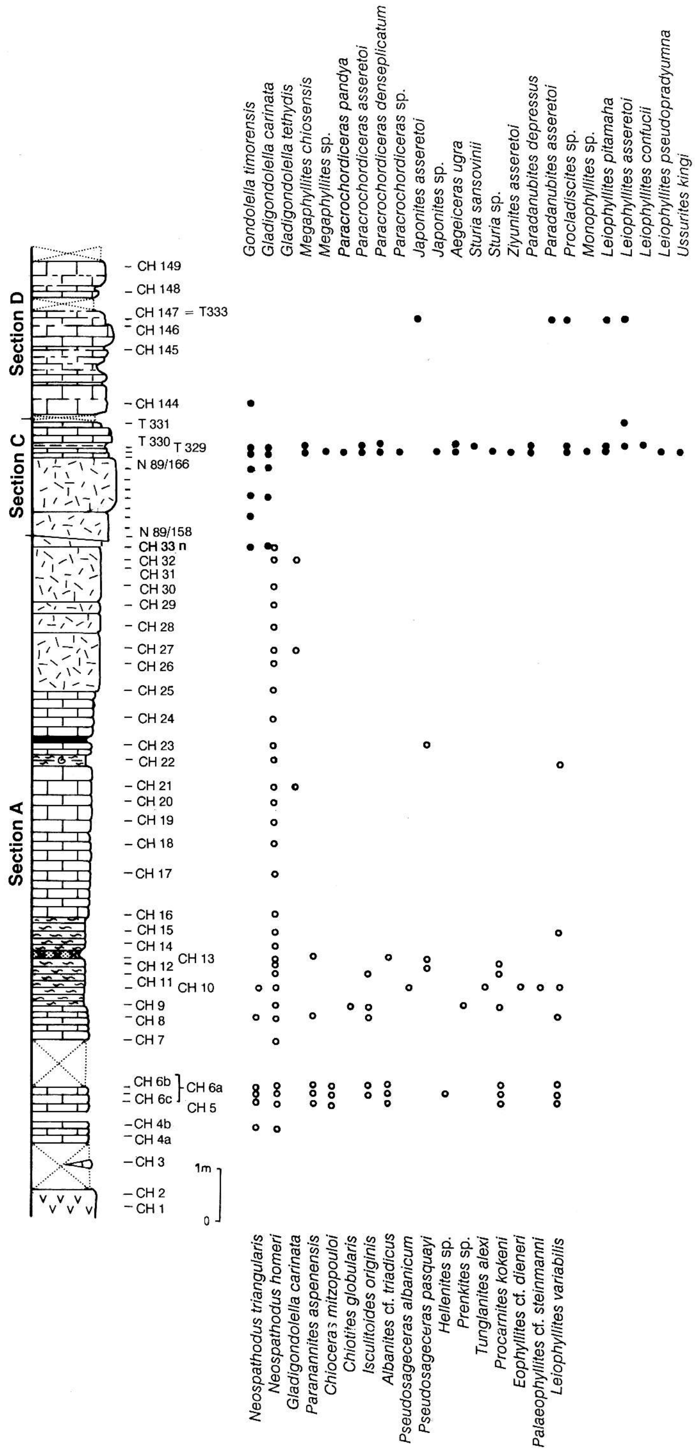
The new data.

The central section (Fig. 4).

The central section at Marathovouno comprises sections A + C + D measured by the German-Italian team in 1975, exactly on the same spot where Bender measured his CMII section. In 1980 only the lower part (section A) was published. It has been proposed as type for the base of the Anisian (Assereto, 1974).

Ammonoid resampling in 1989 has been done at m 4.10, where also the genera *Tunglanites* and *Eophyllites* have been collected. A few additional ammonoids were collected in level T 329 (*Monophyllites* sp. and *Procladiscites* sp.), while a fairly large collection was obtained by level T 330: *Leiophyllites confucii* (Diener), *L. pitamaha* (Diener), *L. asseretoi* Fantini Sestini, *Paracrochordiceras denseplicatum* Fantini Sestini, *P.*

Fig. 4 - Stratigraphic log of section A+C+D with ammonoid and conodont ranges. Both data obtained in 1975 and 1989 are plotted. Full dots refer to the top list, open circles to the bottom list.



Section D
Section C
Section A
CH 149
CH 148
CH 147 = T333
CH 146
CH 145
CH 144
T 331
T 330
T 329
N 89/166
N 89/158
CH 33 n
CH 32
CH 31
CH 30
CH 29
CH 28
CH 27
CH 26
CH 25
CH 24
CH 23
CH 22
CH 21
CH 20
CH 19
CH 18
CH 17
CH 16
CH 15
CH 14
CH 13
CH 12
CH 11
CH 10
CH 9
CH 8
CH 7
CH 6b
CH 6a
CH 6c
CH 5
CH 4b
CH 4a
CH 3
CH 2
CH 1
1m
0
Gondolella timorensis
Gladigondolella carinata
Gladigondolella tethydis
Megaphyllites chiosensis
Megaphyllites sp.
Paracrochordiceras pandya
Paracrochordiceras asseretoi
Paracrochordiceras denseplicatum
Paracrochordiceras sp.
Japonites asseretoi
Japonites sp.
Aegeiceras ugra
Sturia sansovinii
Sturia sp.
Ziyunites asseretoi
Paradanubites depressus
Paradanubites asseretoi
Procladiscites sp.
Monophyllites sp.
Leiophyllites pitamaha
Leiophyllites asseretoi
Leiophyllites confucii
Leiophyllites pseudopradyumna
Ussurites kingi
Neospathodus triangularis
Neospathodus homeri
Gladigondolella carinata
Paranannites aspenensis
Chioceras mitzopouloi
Chiotites globularis
Isculitoides originis
Albanites cf. triadicus
Pseudosageceras albanicum
Pseudosageceras pasquayi
Hellenites sp.
Prenkites sp.
Tunglanites alexi
Procarnites kokeni
Eophyllites cf. dieneri
Palaeophyllites cf. steinmanni
Leiophyllites variabilis

	Total specimens	Total platforms	N. homeri	G. timorensis, juv.	G. timorensis, evol.	Gl. carinata	Gl. tethydis
CH 148	Foraminifers						
CH 147	Foraminifers						
CH 146	3	-	-	-	-	-	-
CH145	20	1	-	-	-	-	-
CH 144	21	8	2	6	-	-	-
T 331	Foraminifers						
T 330	30	13	-	-	11	-	2
T 329	42	19	-	-	15	-	4
N 89/166	Foraminifers						
N 89/165	29	3	-	-	2	-	1
N 89/164	31	7	-	1	4	-	2
N 89/163	Foraminifers						
N 89/162	52	11	-	2	7	-	2
N 89/161	Foraminifers						
N 89/160	35	8	-	2	6	-	-
N 89/159	Foraminifers						
N 89/158	Foraminifers						
CH 33n	21	4	3	-	1	Gl.sp.	-

Fig. 5 - Section C + D. Detail of the boundary, with conodont distribution.

asseretoi Fantini Sestini, *Paracrochordiceras* sp., *Paradanubites depressus* Fantini Sestini, *Sturia sansovinii* Mojsisovics, *Megaphyllites chiosensis* Fantini Sestini, *Megaphyllites* sp., *Procladiscites* sp. Pl. 16 depicts the most relevant species.

The Marmarotrapeza Fm. is followed, 1.15 m above sample T 333, by the Bunte Serie. In this unit olistoliths of the Marmarotrapeza Fm. are frequent, most of them bearing numerous Lower Triassic ammonoids. At about 5.5 m from the base of the Bunte Serie the following ammonoids were collected: *Eophyllites dieneri* (Arthaber), *E. betilloni betilloni* Renz, *E. betilloni evolutus* Renz, *Leiophyllites georgalasi* Renz, *L.* aff. *pitamaha* (Diener), *L. praeconfucii* Renz, *Procarnites kokeni* (Arthaber). But a single specimen of a Middle Anisian species, *Platycuccoceras* cf. *yoga* (Diener), was also found in a red limestone clast, on the continuation of the section on the gentle saddle of the hillock.

The conodont sampling has been done mainly around the Early/Middle Triassic boundary. Fig. 5 gives the detailed range of the elements. *Neospathodus homeri* (Bender), which is present from near the base of the Marmarotrapeza Fm., has been found till 1.80 m below the T 329 (appearance of *Aegeiceras ugra* and other Aegean ammonoid fauna). *Gondolella timorensis* Nogami has been collected from sample CH 33n upwards, thus associated with *N. homeri* at least in a single sample. *Gondolella regale* was found in the sample CH 170, which is on the lateral continuation of the bed with the ammonoids of T 333. Thus it lies 2.10 m above the *Aegeiceras* appearance. Most significant species of conodonts are reported in Pl. 17.

Several foraminifera species have been identified within the Marmarotrapeza unit. Surprisingly enough, most of them are species previously described in Upper Anisian or Ladinian rocks. Being all long ranging species, no detailed biostratigraphic contribution may be offered. They are figured in Pl. 18, where also some specimens from the neighbouring Aghia Ana outcrop of the Marmarotrapeza Fm. are considered.

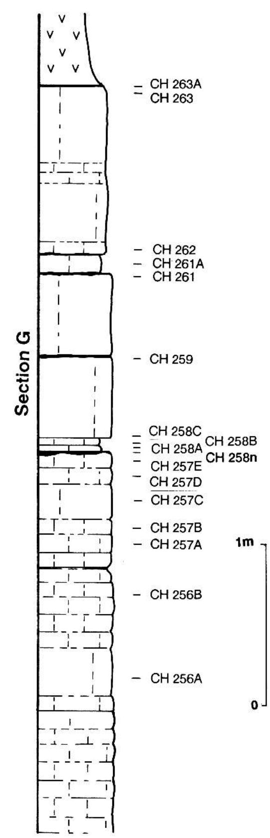


Fig. 6 - Stratigraphic log of section G.

Section G (Fig. 6).

Also this section was reconsidered mostly near the boundary.

The previous sample CH 258 was split on the field into three parts. The lower part (CH 258n) consists of the condensed horizon, containing several thin ferro-man-

	Total specimens	*Total platform*	*N. homeri*	*G. timorensis, juv.*	*G. timorensis, evol.*	*Gl. carinata*	*Gl malayensis budurovi*	*Gl. tethydis*	*G. jubata*	*G. regale*
CH 263 A	2	-	-	-	-	-	-	-	-	-
CH 263	5	1	•	-	1	-	-	-	-	-
CH 262	-	-	-	-	-	-	-	-	-	-
CH 261 A	5	2	-	-	2	-	-	-	-	-
CH 261	9	6	1	-	2	-	-	-	1	-
CH 259	6	2	-	-	2	-	-	-	-	-
CH 258 C	10	4	-	1	2	-	-	1	-	-
CH 258 B	>400	18	1	4	-	-	8	3	-	2
CH 258 A	49	14	4	5	1	4	-	-	-	-
CH 258 n	61	33	18	14	-	1?	-	-	-	-
CH 257 E	23	9	2	3	4	-	-	-	-	-
CH 257 D	3	3	1	2	-	-	-	-	-	-
CH 257	7	5	1	2	2	-	-	-	-	-
CH 257 C	3	1	-	1	-	-	-	-	-	-
CH 257 B	-	-	-	-	-	-	-	-	-	-
CH 257 A	32	11	3	4	4	-	-	-	-	-
CH 256 B	6	-	-	-	-	-	-	-	-	-
CH 256 A	1	-	-	-	-	-	-	-	-	-

Fig. 7 - Conodont abundance in section G.

ganese veneers, in which some additional ammonoids were obtained: *Pseudosageceras albanicum* Arthaber, *Procarnites kokeni*, *Procarnites* sp., *Eogymnites arthaberi*, *Leiophyllites* sp. In the old comprehensive sample CH 258 (see Assereto et al., 1980 for the complete list), also cladiscitids were found. They consist of three specimens. One may be assigned to the genus *Cladiscites* Mojsisovics, which according to Tozer (1981) spans from Scythian to Ladinian. The second specimen bears suture line and strigation like a *Procladiscites* with section of a *Sturia*, suggesting to be a new genus. The third specimen could be assigned to the genus *Psilocladiscites* Mojsisovics. 5 cm above the condensed horizon, a single specimen of *Paradanubites asseretoi* Fantini Sestini was collected (sample CH 258 A). The third level consisting of 7 cm of red marly limestone doesn't contain ammonoids.

As far as conodonts are concerned, platforms are usually rare (Fig. 7). *N. homeri* reaches just up into the condensed level. However, isolated specimens were collected in samples CH 258 A and CH 261. Should we consider them as reworked or are they testifying a sparse occurrence of *N. homeri* even higher than usual? *G. timorensis* makes its first appearance (sample CH 252) 62 cm below the condensed horizon, thus coexisting with *N. homeri* within this interval.

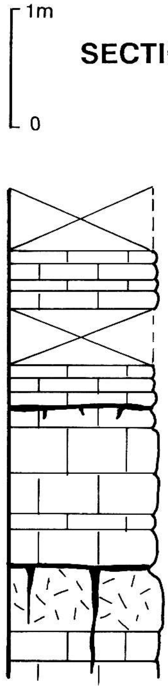
Two specimens of *G. regale* have been found in the sample CH 258 B.

Section F (Fig. 8).

This section has not delivered ammonoids. Resampling for conodonts around the boundary gave the following results.

N. homeri has been found up to the sample CH 227, whereas the appearance of *G. timorensis* is confirmed in the sample CH 221n (n = new sample). Consequently there is an overlap of these two forms for about 2 m. Most important is the appearance of *G. regale* in sample CH 228.

SECTION F



	Neospathodus homeri	*Gondolella timorensis juv.*	*Gondolella timorensis ev.*	*Gladigondolella carinata*	*Gladigondolella malayensis budurovi*	*Gladigondolella tethydis*	*Gondolella regale*
CH 229	-	1	-	-	4	-	-
CH 228	-	4	1	-	1	4	2
CH 227	2	28	3	-	2	-	-
CH 226	-	25	2	-	3	-	-
CH 225	12	67	4	-	-	-	-
CH 224	2	19	-	-	1?	-	-
CH 223	6	26	-	-	-	-	-
CH 222	-	3	-	-	-	-	-
CH 221n	4	19	6	1	-	-	-
CH 221							
CH220	-	12	-	-	-	-	-

Fig. 8 - Stratigraphic log of section F.

Section Parthenis (Fig. 9).

The area of Parthenis was described by Tietze (1969) with a section measured along the Parthenis quarry up to a small chapel on the hill. It was subsequently discussed by Jacobshagen & Tietze (1974), who recorded also some Anisian ammonoids amongst the Scythian ones. In 1975 it could not be considered because the area was not accessible for military reasons. In 1989, another section was measured in the nearby small creek, lying about 100 m S of the Parthenis quarry. Here, the Marmarotrapeza Fm., does not exceed 2 m in thickness and lies on a partly dolomitized slumped body, m-thick, of nodular limestones. It is very rich in ammonoids, especially in its last 15 cm, ending with a condensed ferro-manganesiferous horizon, 2 cm thick.

In the small creek section, folding may have caused local deformations affecting the boundary with the Variegated Series by apparent repetitions.

Within the Marmarotrapeza Fm., the following ammonoids were collected: *Pseudosageceras* sp., *Procarnites* sp., *Procarnites kokeni* (Arthaber), *Prosphingites ali* Arthaber, *Columbites* sp., *C. parisianus* Hyatt & Smith, *Subcolumbites* sp., *Chioceras* sp., *Epiceltites gentii* Arthaber, *Metadagnoceras terbunicum* (Arthaber), *Nodophiceras* sp., *Albanites* sp., *Dinarites* cf. *liatsikasi* Renz & Renz, *Hellenites* sp., *Hellenites radiatus* Renz & Renz, *H. praematurus* (Arthaber), *Leiophyllites* sp. The species *Albanites triadicus* Arthaber and

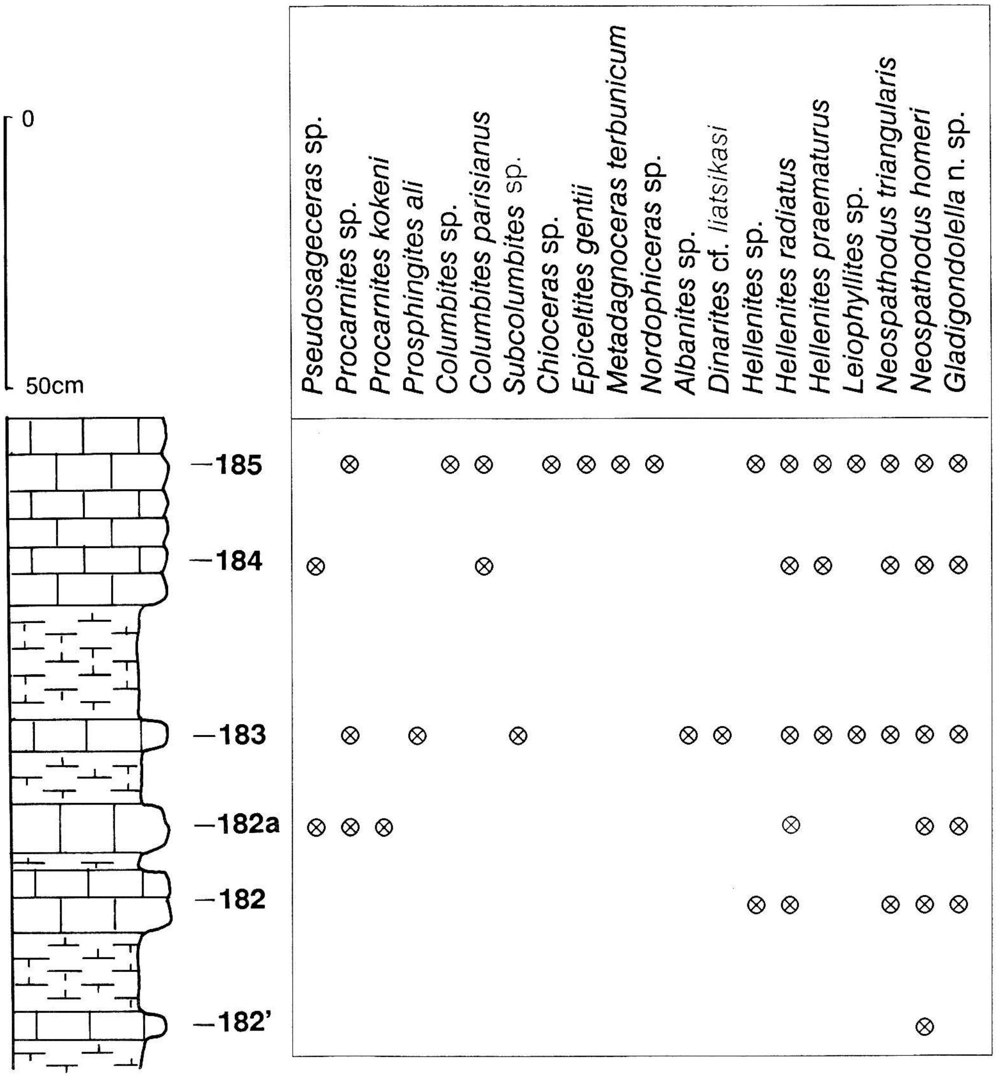


Fig. 9 - Stratigraphic log of Parthenis section, with ammonoid and conodont distribution.

Leiophyllites cf. *variabilis* (Spath) were collected along the section but in a comprehensive sample. Consequently their range has not been reported in Fig. 9. Most significant species of Spathian ammonoids are reported in Pl. 15.

This assemblage could be entirely referred to the *Prohungarites/Subcolumbites* zone of Kummel (1973).

At the base of the Bunte Serie, 16 cm above the ferro-manganesiferous crust, a single specimen of the ammonoid *Pronoetlingites* sp. of Bithynian-Pelsonian age (Parnes, 1986), has been collected.

The conodonts of the Marmarotrapeza Fm. show the assemblage *Neospathodus homeri*, *N. triangularis* and a new species of *Gladigondolella* up to the very top of the unit. A couple of meters above the lense with *Pronoetlingites*, a limestone lense delivered *N. homeri*, indicating the presence of an olistolith. The spot where Jacobshagen & Tietze (1974) reported Early Anisian ammonoids and conodonts lies about 50 m NW of the present section.

Thus the Parthenis section, being one of the richest as far as the Scythian ammonoids are concerned, is not suitable for the definition of the Anisian base. The entire ammonoid assemblage with *Aegeiceras*, *Japonites* and *Paracrochordiceras* is missing, due to a sedimentation gap at the top of the Marmarotrapeza Fm.

Bio-and chronostratigraphy.

The Chios sections are significant at least in two respects. The late Early Triassic ammonoid fauna, which will be illustrated elsewhere, and the strata related to the Early/Middle Triassic boundary. This second point is topic of the present paper.

In the modern chronostratigraphic use, a stage is described by its base and by the base of the following stage. Thus the Marathovouno sections are crucial for the definition of the base of the Anisian, as it was proposed by Assereto (1974). Moreover, to have more correlation opportunities, as numerous tools as possible should be considered. In Chios we have at present two biostratigraphic tools.

Ammonoid tool.

At Marathovouno there are two ammonoid faunas superposed. A first assemblage is given by the genera *Procarnites* and *Hellenites*. In Parthenis this assemblage is enriched also by *Columbites*, *Albanites* and *Subcolumbites*. In the central section (A +C+D = CMII) they lie at least 7.5 m below the second assemblage characterized by the appearance of *Aegeiceras*, *Japonites*, *Paracrochordiceras* and *Paradanubites*. In section G (= CMI) poorly preserved ammonoids, which could be referred to the first assemblage, are found in an horizon, which contains a fauna basically Scythian (*Praeflorianites* and *Procarnites*), together with long ranging forms (*Procladiscites*, *Eophyllites*, *Leiophyllites variabilis*) and a single specimen of the genus *Psilocladiscites*, till now found only in the Late Anisian of the Han Bulog facies in several localities of the Hellenides and Dinarides. The composition of this horizon is similar to what has been described in China, Guizhou province (Wang Yi-gang, 1978) and interpreted by Tozer (1981, p. 407) as possibly condensed. Thus we are inclined to consider also this horizon as condensed. It is directly overlain by a thin bed with a *Paradanubites* of the second assemblage. At Parthenis only the first assemblage, much richer in species and specimens, is preserved (Fig. 9).

The first assemblage is correlative to the *Prohungarites/Subcolumbites* zone of Kummel (1973). The question arises, however, whether there exists a further uppermost Spathian ammonoid zone in the Tethys realm, which might be synchronous with the arctic Subrobustus Zone including the equivalent zone of *Neopopanoceras haugi* in Nevada. For Krystyn (in Zapfe, 1983) this question remained open, whereas Wang Yi-gang (1985) supposed that the *Keyserlingites subrobustus* fauna of the arctic regions would represent only an upper part of the *Subcolumbites* zone of the Tethys. Wang pointed out that the Tethyan species of *Keyserlingites*, identified as *Durgaites* (Krystyn, 1986), are associated with typical Early Anisian forms as *Paradanubites*, *Japonites*, *Aegeiceras*, and *Procladiscites* everywhere from Central Qinghai/China over Timor to the Central and Western Himalaya. Thus he concluded that the range of the genus *Keyserlingites* would be uppermost Scythian to Lower Anisian. Following Wang's view we should suppose a normal sequence of ammonoid faunas at the Scythian/Anisian boundary in Chios.

The second assemblage is considered by Fantini Sestini (1981), Krystyn (1986) and Bucher (1989) as characterizing a very early fauna of the Anisian. So far, there are no older ammonoid faunas known, which may be considered as Anisian. However, Bucher (1989, tab. 2) introducing further ammonoid subdivisions within the Early Anisian of Nevada, states (p. 957) that the Chios fauna may be used to identify the " whole interval from the *J. welteri* beds to the Caurus Zone, without further precision." Our new collections cannot modify this statement, as far as the ammonoids are concerned. We may only stress that the distinctive species *Aegeiceras ugra* was found only in the bed T 329 of the central section. At present we neither want to identify subzones on the base of the presence or absence of *A. ugra*, nor are we inclined to establish a new biostratigraphic zone for the earliest Anisian ammonoid fauna. We prefer to wait for results of investigations now in progress within the Tethyan province and not to burden the literature.

Conodont tool.

The conodonts are present in most of the sampled strata and give a more continuous record. Three bioevents may be recognized, i.e. LAD of *N. homeri*, FAD of *G. timorensis* and FAD of *G. regale.*

Neospathodus homeri (Bender) is widely ranging in the lower part of the Marmarotrapeza Fm., where it is associated with the first ammonoid assemblage. Upward it never occurs with the second ammonoid assemblage, except for 4 specimens in the *Paradanubites* bed (CH 258 A) and two single specimens above (CH 258 B and CH 261). Is it a case of reworking or of a sparse and rare later occurrence ? *N. homeri* coexists with *G. timorensis* in all measured sections at Marathovouno (maximum for 2 m in the section F), before desappearing.

Gondolella timorensis Nogami appears before the last occurrence of the first ammonoid assemblage in section G, and 1.80 m before the *Aegeiceras* occurrence in the type-section.

Taxonomic remark. In the present paper, evolved or mature and juvenile growth-stages have been distinguished in *Gondolella timorensis* population. Evolved specimens (Pl. 17, fig. 11-13) that correspond to *Neogondolella timorensis timorensis* in Nicora (1977) are characterized by a strong lateral platform-like rib, perpendicular to the carina, that merges into a brim that surrounds the posterior end of the unit. In this form, 10-16 denticles are present. Juvenile specimens (Pl. 17, fig. 8, 9) which correspond to *Spathognathodus gondolelloides* Bender (1970), are shorter, with a very weak lateral rib that vanishes posteriorly before the last denticle. In this form 9-12 denticles are present. Furthermore, according to the Triassic Conodont Working Group, Budapest 1979, *Neogondolella timorensis benderi* Nicora, 1977, which was established because of its wider platform in respect to that of *Neogondolella timorensis timorensis*, it is here considered only a more evolved growth-stage of *timorensis timorensis* (sensu Nicora, 1977). Consequently both the previous subspecies of Nicora (1977) correspond to *G. timorensis* Nogami, 1968.

Gondolella regale (Mosher) appears in a correlative bed to sample T 333 of the central section about 2.50 m above the first appearance of the *Aegeiceras-Japonites-Paracrochordiceras-Paradanubites* fauna. In section G it is represented by two specimens in the bed just above *Paradanubites*. In section F, where ammonoids were not recovered, *G. regale* appears 30 cm above the LAD of *N. homeri*.

From these data it can be deduced:

1) There is poor evidence that *N. homeri* enters into the Anisian.

2) Though the ammonoid fauna is poorly preserved and condensation is also present, it seems that there is sufficient evidence that *G. timorensis* appears before the appearance of the first Anisian ammonoid fauna. Consequently, the FAD of *timorensis* does not coincide with the FAD of *Aegeiceras*. If prominent value is given to ammonoids, *G. timorensis* FAD cannot be used to define the beginning of the Anisian. Anyway, it is not far from this possible boundary. Moreover, it may be inferred that the coexistence of *N. homeri* and *G. timorensis* seems to characterize the latest Spathian, while the occurrence of *G. timorensis* alone could strictly approach the beginning of the Aegean.

3) *G. regale* FAD occurs after the *Aegeiceras-Japonites* appearance, and thus cannot be used to define the Anisian lower boundary.

The relevant biostratigraphic events are summarized in Fig. 10.

Correlations to other significant sections.

The matter, from the ammonoid side, has been recently discussed by Bucher (1989) and we refer to. However, using the combined tool ammonoid/conodonts, we would like to precise the position of the *Aegeiceras/Japonites* beds of Chios. In our opinion, they are correlative to the *J. welteri* beds of Nevada.

Nicora (1977, fig. 3) gave the conodont distribution in the Star Peak Canyon section, against lithology and ammonoid content studied by Silberling & Wallace

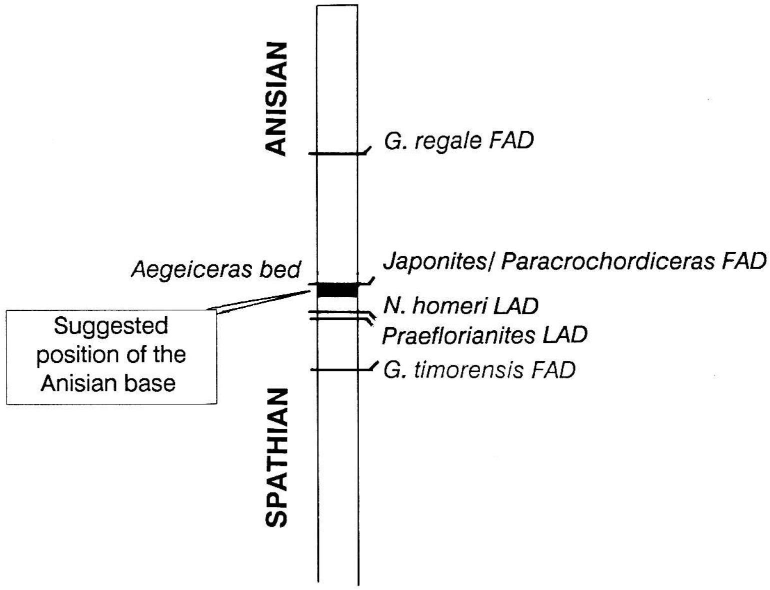


Fig. 10 - Main biostratigraphic events around the base of the Anisian discussed in the present paper.

(1967, 1969). The *Eophyllites* sp. A of Silberling & Wallace (1969) has been renamed *Japonites welteri* by Bucher (1989), who considers the Star Peak Canyon section as the type-locality of the *J. welteri* beds. From Nicora (1977) it can be deduced that *G. regale* appears above the *J. welteri* beds, exactly as it happens in Chios. Consequently we are inclined to consider the *Aegeiceras/Japonites* fauna of Chios to represent only the lower part of the interval between Haugi and Caurus Zones in Nevada.

Tozer & Calon (1990) found a short succession in Hallstatt facies in Wadi Alwa (Oman), which contains superposed representants (*Procarnites kokeni* and *Japonites subacutus*) of both ammonoid assemblages discussed here. No data on the conodont distribution are given.

Conclusions and suggestions.

In recent meetings and discussions within the Subcommission of Triassic Stratigraphy, the presence of possible gaps and condensations was considered a rather important failure for the formal acceptance of the Chios Marathovouno section as Boundary Stratotype for the base of the Anisian. From the present revision, it appears that no older ammonoid fauna are presently known that can be safely attributed to the Anisian. Moreover, thanks to the conodont cross-correlations, it can be suggested that the *Aegeiceras/Japonites* beds of Chios are correlative to the *J. welteri* beds of Nevada. The combined use of ammonoid and conodonts provide a double tool to approach the matter.

A failure is the non-continuity within the ammonoid documentation, causing an uncomplete picture of the underlying latest Lower Triassic biostratigraphy. However, this is not true for the conodonts. Moreover, it should be stressed that the first appearances are the most important events to be considered in drawing a boundary. Also in Nevada, where the conodont sequence is scanty known for the latest Early Triassic (Collinson & Hasenmueller, 1978), there is a barren Brown Calcareous Sandstone Unit of about 100 m, between the Haugi Zone and the *J. welteri* beds (Bucher, 1989).

Consequently, within the tropical seaways linked to the Tethys, the Chios sections may continue to play an important reference role.

In conclusion, from the chronostratigraphic point of view, we propose that the *Aegeiceras/Japonites* FAD should represent the base of the Anisian. Instead, *Gondolella timorensis* FAD cannot be used to define the base of the stage exactly, because its appearance approximate the beginning of the Anisian only in a broad sense. Only a change in conventions, giving more weight to the conodont tool in case of non perfect coincidence of relevant conodont and ammonoids FADs, would shift the position and hence the definition of the lower boundary of the Anisian to the FAD of *G. timorensis*, as it had been suggested by Assereto et al. (1980). The Sweet & Bergstrom (1986) zonation very appropriately puts a question mark at this point.

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PLATE 15

Scythian ammonoids (all specimens in natural size).

Fig. 1 - *Hellenites praematurus* (Arthaber). Sample 183, Parthenis section.

Fig. 2 - *Leiophyllites* sp. Sample 183, Parthenis section.

Fig. 3 - *Albanites triadicus* Arthaber. Sample XC 20 collected by V. Tselepidis in the Parthenis area near Parthenis section.

Fig. 4 - *Epiceltites gentii* Arthaber. Undivided sample 182-185, Parthenis section.

Fig. 5 - *Procarnites* cf. *kokeni* (Arthaber) Sample 182a, Parthenis section.

Fig. 6 - *Hellenites radiatus* Renz & Renz. Sample 182a, Parthenis section.

Fig. 7 - *Procarnites kokeni* (Arthaber). Sample 182a, Parthenis section.

PLATE 16

Anisian ammonoids.

Fig. 1 - *Aegeiceras ugra* (Diener). Sample T 329, section C; x 1.

Fig. 2 - *Paracrochordiceras denseplicatum* Fantini Sestini. Sample T 329, section C; x 1.

Fig. 3 - *Paracrochordiceras asseretoi* Fantini Sestini. Sample CH 169, section B1; x 1. For position of section B1 refer to Fig. 1 C and to the Assereto et al. (1980) paper.

Fig. 4 - *Paracrochordiceras pandya* (Diener). Sample T 329, section C; x 1.

Fig. 5 - *Paradanubites asseretoi* Fantini Sestini. Sample CH 258 A, section G; x 1.5.

Fig. 6 - *Paradanubites depressus* Fantini Sestini. Sample T 330, section C; x 1.

PLATE 17

Spathian and Anisian conodonts.

Fig. 1, a, b - *Neospathodus triangularis* (Bender). Sample CH 6a, section A, Spathian; x 100.

Fig. 2 - *Neospathodus homeri* (Bender). Oblique/ lateral view. Sample CH 24, section A, Spathian; x 100.

Fig. 3 a, b - *Neospathodus homeri* (Bender). Sample 183, Parthenis section, Spathian; x 80.

Fig. 4 a, b - *Neospathodus* cf. *homeri* (Bender). Sample CH 257 D, section G, Spathian; x 50.

Fig. 5 a, c - *Gladigondolella carinata* Bender. Sample CH 253, section G, Spathian; x 50. For position of sample CH 253 refer to fig. 4 of Assereto et al. (1980).

Fig. 6 a, c - *Gladigondolella malayensis budurovi* Kovacs & Kozur. Sample CH 258 B, section G, Anisian; x 50.

Fig. 7 - *Gladigondolella tethydis* (Huckriede). Lateral view. Sample N 89/ 164, section C, Spathian; x 65.

Fig. 8 a, b - *Gondolella timorensis* Nogami. Juvenile ontogenetic stage. Sample CH 257 A, section G, Spathian; x 50.

Fig. 9 - *Gondolella timorensis* Nogami. Juvenile ontogenetic stage, lateral view. Sample CH 257 D, Spathian; x 50.

Fig. 10 a, b - *Gondolella timorensis* Nogami. Medium ontogenetic stage. Sample CH 258 B, Anisian; x 90.

Fig. 11 - *Gondolella timorensis* Nogami. Evoluted ontogenetic stage, lower/oblique view. Sample CH 261, section G, Anisian; x 40.

Fig. 12 a, b - *Gondolella timorensis* Nogami. Evoluted ontogenetic stage. Sample N 89/160, section C, Spathian; x 50.

Fig. 13 a, b - *Gondolella timorensis* Nogami. Evoluted ontogenetic stage. Sample T 329, section C, Anisian; x 50.

a = Lateral view; b = lower view; c = upper view.

PLATE 18

Foraminifera.

Fig. 1 - *Tolypammina gregaria* Wendt. Aghia Ana, sample XA2; x 60.

Fig. 2 - *Endothyranella wirtzi* (Koehn-Zaninetti). Section A, sample XB15, between CH 8 and CH 9; x 100.

Fig. 3 - *Gaudryina triassica* Trifonova. Section A, sample XB19, near the sample CH 9; x 100.

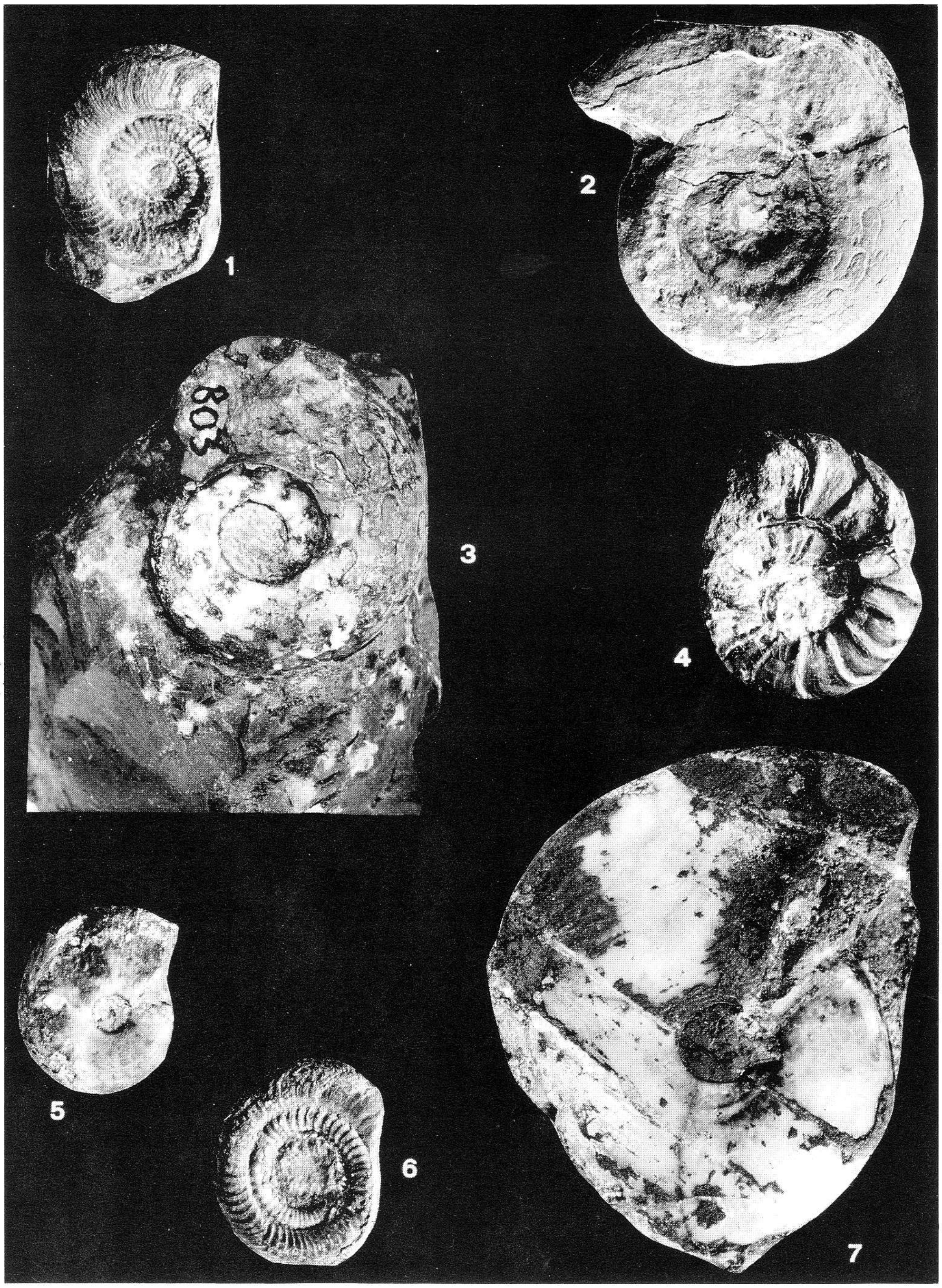
Fig. 4 - *Trochammina jaunensis* Broennimann & Page. Section A, sample XB31, near the sample CH 14; x 100.

Fig. 5, 6 - *Astacolus* sp. Section A, sample XB18, slightly below the sample CH 9; x 100.

Fig. 7 - *Nodosaria ordinata* Trifonova. Aghia Ana, sample XA1; x 100.

Fig. 8 - *Nodosariidae.* Section A, sample XB23, near sample CH 10; x 100.

Fig. 9 - *Nodosariidae.* Section A, sample XB26, near the sample CH 12; x 100.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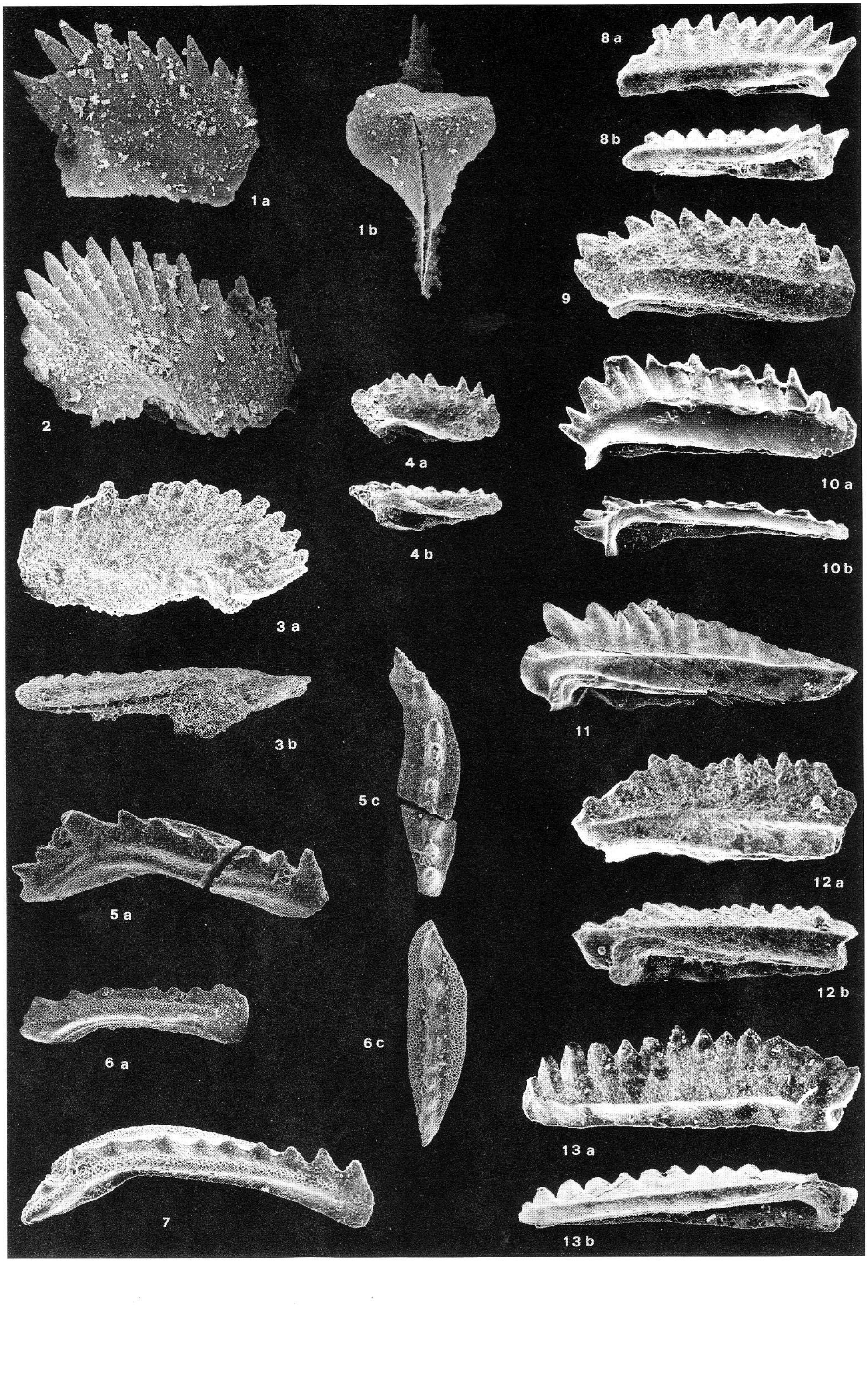
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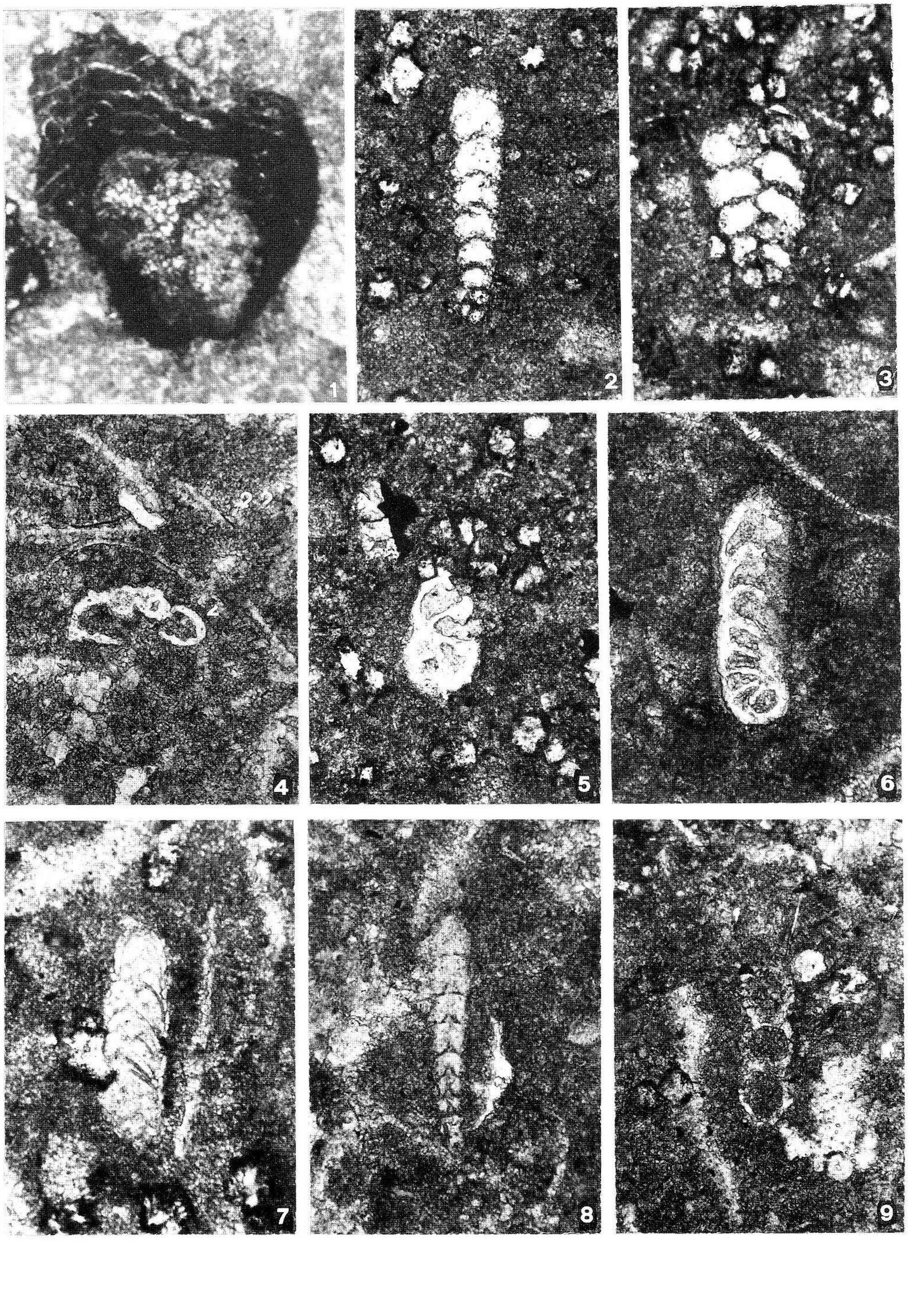
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