Aegean and Bithynian: Proposal for Two New Anisian Substages

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8 Figures

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Abstract

Three ammonoid zones are recognized in unusually complete sections of early Middle Triassic marine pelagic rocks exposed on the Kokaeli Peninsula (Turkey) and on the Island of Chios. These zones are grouped into two substages named in ascending order Aegean and Bithynian. Superposition of the Aegean Substage on the Lower Triassic is well proven on the Island of Chios where beds with Aegean ammonites conformably overlie beds with a late Lower Triassic *Subcolumbites* fauna. The relationship between Bithynian and the overlying Pelsonian are well displayed by superposition of fossiliferous beds on the Kokaeli Peninsula. The new substages represent a stratigraphic interval that has been improperly known in the literature as "Hydaspian", a chronostratigraphic unit much older, of Lower Triassic age. Their introduction therefore fills the need for named subdivisions and provides a standard for rocks of early Middle Triassic age throughout the world. On the basis of the new data it is proposed to enlarge the scope of the Anisian Stage to include the new substages and to divide it into two parts: an Upper Anisian based on the Illyrian and Pelsonian substages, and a Lower Anisian founded on the new Bithynian and Aegean substages. The lower boundary of each Anisian substage is defined in terms of beds at a type locality.

Introduction

Unusually complete and fossiliferous sections of marine early Middle Triassic beds have been found near Gebze on the Kokaeli Peninsula (Turkey) (ASSERETO, 1972) and on the Island of Chios (Greece) (BENDER, 1970; BESENECKER et al., 1968) (fig. 1). These sequences represent an unnamed stratigraphic interval younger than Lower Triassic, but older than the Anisian, as originally defined by WAAGEN and DIENER (in MOJSISOVICS et al., 1895), with which the Middle Triassic begins. This chronostratigraphic interval, for which no unquestioned ammonites have been known in the Mediterranean province, has traditionally been named "Hydasp" in the European literature. But this name is inappropriate because the strato-type of the Hydaspian is much older, of Lower Triassic age.

The objects of this paper are: (i) to show that Gebze and Chios sections provide a record for the unnamed interval; (ii) to illustrate how these sequences may constitute a basis for distinction of standard zones useful in expressing age relations and in defining higher rank chronostratigraphic units that fill the need of named subdivisions for the interval; (iii) to review the chronostratigraphic nomenclature of the Anisian in the light of the new data.

The author is deeply grateful to friends and colleagues Drs. M. GAETANI, N. SILBERLING, W. SWEET and T. TOZER for the stimulating discussions had on the problems dealt with in this paper, during the last years and for reading and criticising early drafts of this work. Thanks are due to Prof. JACOBSHAGEN who kindly put the BENDER collection at the writer's disposal and discussed with him the generic and specific determinations

given by that author, and the stratigraphic problems of the Island of Chios. The author also wishes to thank all colleagues who kindly replied to the questionnaire on the problems dealt with in this work. Financial support to this research was given by the "Centro Studi per la Stratigrafia delle Alpi" of the Italian "Centro Nazionale delle Ricerche".

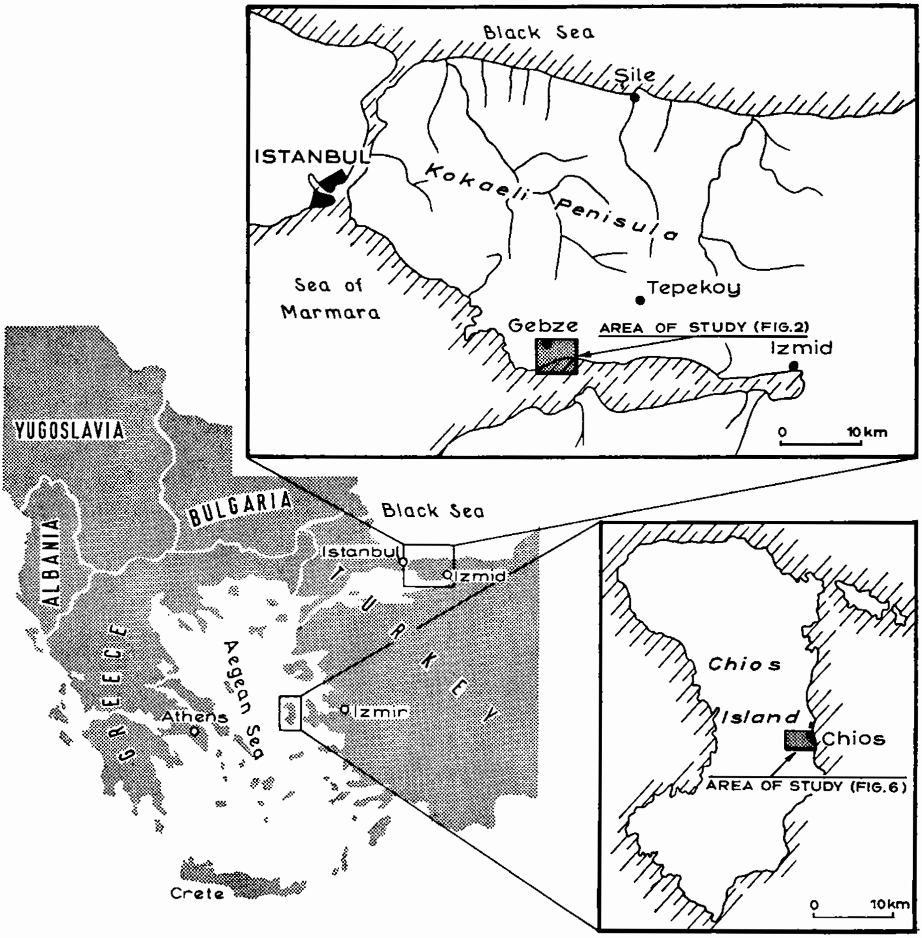

Fig. 1. Index map of the eastern Mediterranean region showing location of the studied areas.

Analysis of the Sequences

Kokaeli Peninsula

In the Kokaeli Pensula, Turkey (figs. 1, 2) richly fossiliferous localities with early Middle Triassic ammonoids occur along the Istanbul-Izmid railway line, east of the Gebze station (Toula, 1896; Arthaber, 1914).

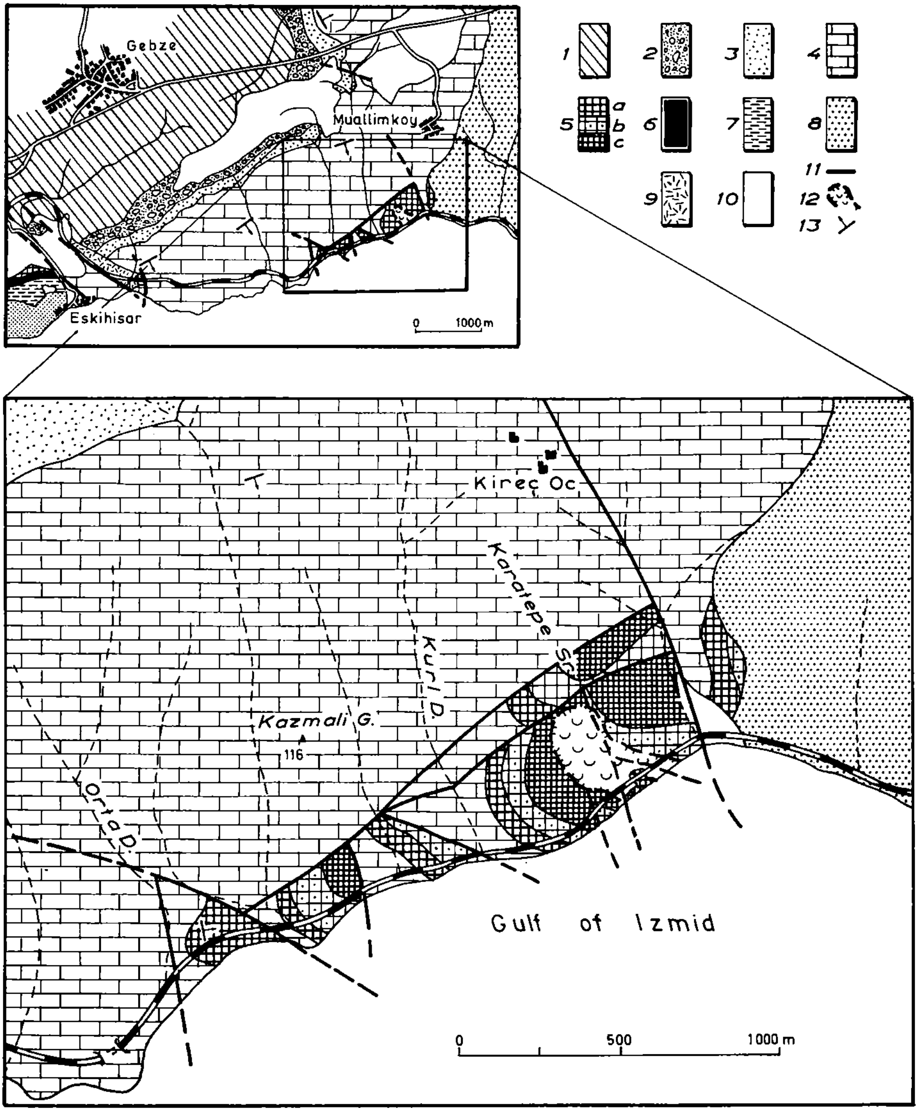

Fig. 2. Geologic map of the type locality of the Bithynian substage in Gebze area (Kokaeli Peninsula, Turkey). (1) Devonian and Carboniferous formations; (2) Basal Conglomerate (probable Permian); (3) Variegated Sandstone and Marl (Lower Triassic); (4) Grey Limestone and Dolomite (Upper Spathian—Lower Anisian); (5) Nodular Limestone (Anisian), (a) Lower Member, (b) Middle Member, (c) Upper Member; (6) „Ammonitico Rosso" (Upper Anisian—Ladinian); (7) Grey-Green Marl (Carnian); (8) Cretaceous formations; (9) andesites; (10) Neogene and Quaternary cover; (11) faults; (12) landslides; (13) strike and dip of beds.

Recent studies (Assereto, 1972) have shown that the faunas are contained in six superimposed horizons the location of which is given in figs. 3, 4. The upper fossiliferous beds (c, d, e, and f in figs. 3, 4) include assemblages with respectively: *Flexoptychites* and

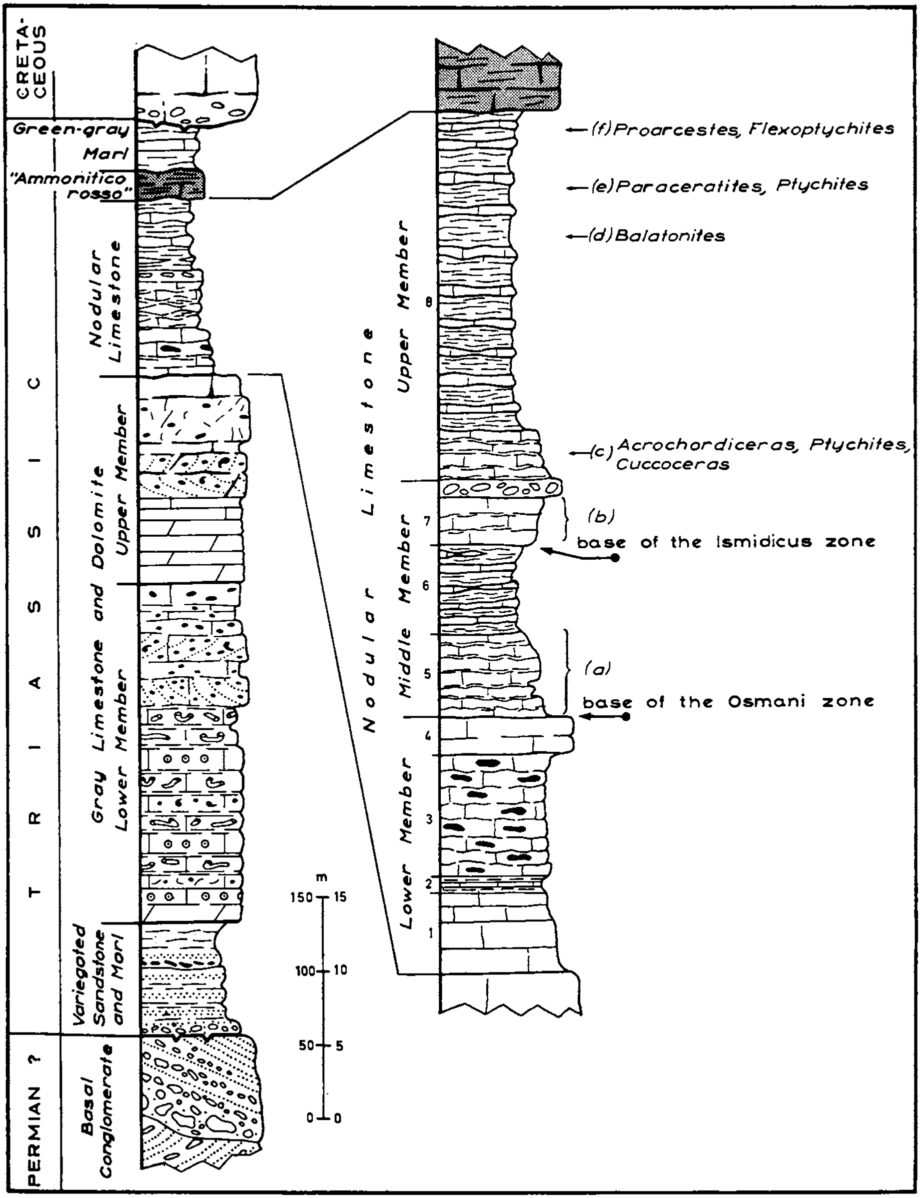

Fig. 3. Generalized stratigraphic section of the Triassic rocks in Gebze area and location of ammonite faunas (indicated by letters) in the Nodular Limestone. The Ismidicus and Osmani Standard Zones are based respectively on faunas (b) and (a).

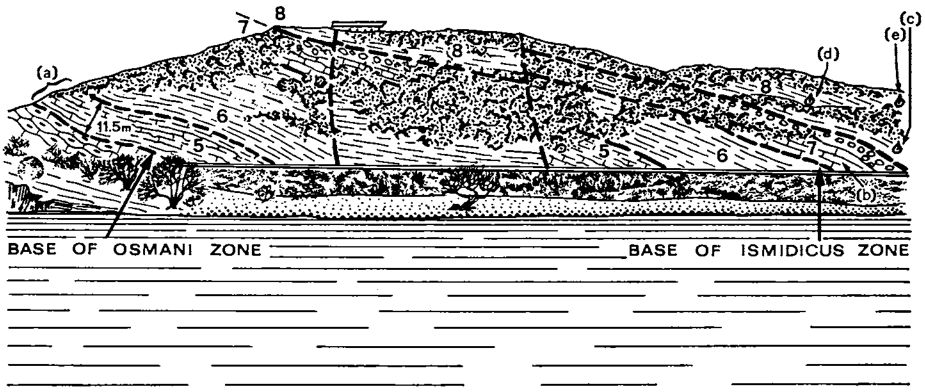

Fig. 4. Sketch from a photo of the railway cutting between Km 49,920 and Km 51,120 of the Istanbul—Izmid line seen from the sea. The letters show the location of the ammonite faunas, while numbers refer to lithic units (see text for discussion and fig. 3).

Proarcestes (f); *Ptychites* and *Paraceratites* (e); *Balatonites* (d); *Acrochordiceras*, *Ptychites* and *Cuccoceras* (c) that enable correlations with the *trinodosus* and *binodosus* zones (sensu Mojsisovics) of the Alps (Assereto, 1972, p. 440—442). The faunas immediately underlying bed (c) (faunas [b] and [a] in figs. 3, 4) have independent features and cannot be referred to any standard zone recognized in the Tethys. Fauna (b) is characterized by *Anagymnotoceras*, *Ismidites*, *Acrochordiceras*, *Cuccoceras*, *Sturia* and Gymnitids, while fauna (a) is represented by an abundance of *Nicomedites* associated with "*Hungarites*" (perhaps *Grambergia*), *Procladiscites*, *Epacrochordiceras*, *Hollandites*, etc. Faunas (b) and (a) underlie correlatives of the *binodosus* Zone (sensu Mojsisovics), with which the Anisian stage was begun, and overlie by about 350 m beds with late Lower Triassic conodonts of the lower *homeri* Zone *sensu* Bender (1970) (A. Nicora and W. Sweet, personal communication) and therefore provide a record for at least part of the unnamed chronostratigraphic interval that exists between the top of the Lower Triassic and the base of the type Anisian.

It is proposed therefore to base on these faunas two standard zones named, in descending order, the Ismidicus and Osmani Zones, whose type-locality limits, content and correlations are given in the paragraph "Proposals" on page 36—39.

Chios Island

Red limestones in "Ammonitico Rosso" facies, with rich late Lower Triassic *Subcolumbites* faunas, have long been known in the island of Chios (Greece) (Renz and Renz, 1947, 1948). Recently Bender (1970) found ammonite faunas with "Anisian" affinities at M. Marathovouno (fig. 1, 5), in the upper part of the "Ammonitico Rosso", above the Lower Triassic faunas (fig. 6). Subsequent research by the writer along Bender's CM II section permitted the duplication of almost all the fossiliferous material of the above author. The revised list of Bender's species and the determinations in the new material are given below.

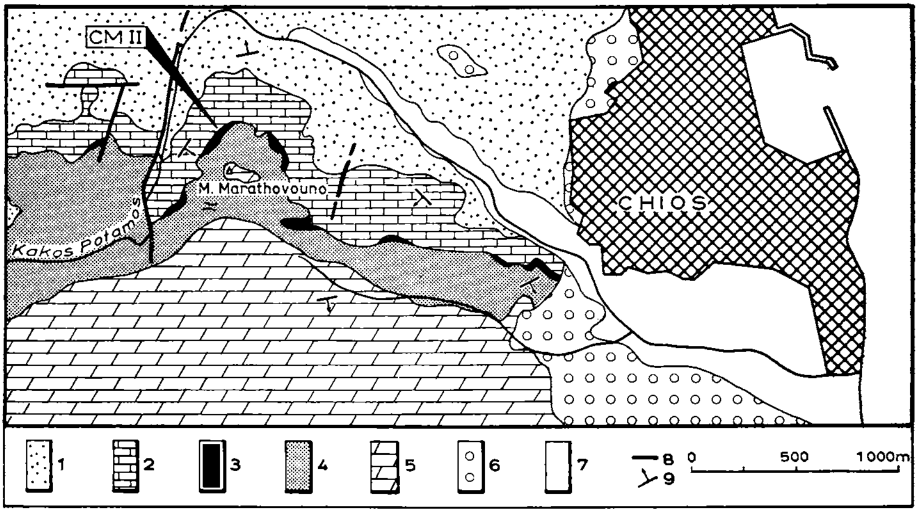

Fig. 5. Geologic map of the type locality of the Aegean substage in Chios Island Greece), showing location of section CM II. (1) Paleozoic formation; (2) Massive limestone (Lower Triassic); (3) Marmarotrapeza Kalk (Ammonitico rosso) (Spathian—Lower Anisian); (4) "Bunte Serie" (conglomerates, tuffs, cherts) (Anisian); (5) Stratified limestone and dolomite (Ladinian); (6) Miocene sandstones; (7) Quaternary cover; (8) faults; (9) strike and dip of beds.

m 10.5 (fig. 6)

Bender material[1]: "*Megaphyllites*" *evolutus* WELTER, *Paracrochordiceras* n. sp. A. aff. *P. americanum* McLEARN (2), *Paracrochordiceras* n. sp. B. (3), ? *Paracrochordieras* n. sp. C (4), *Japonites ugra* (DIENER) (5), *Procladiscites* n. sp.? (6), *Leiophyllites* ex. gr. *confucii* (DIENER) (7), *L. pitamaha* (DIENER) (8).

New material (T 329): "*Megaphyllites*" *evolutus* WELTER, *Paracrochordiceras* n. sp. B, *Procladiscites* sp. ind., *Sturia* sp. ind., *Leiophyllites* ex gr. *confucii* (DIENER).

[1]) The original determinations of BENDER (1970), when different, are given below in notes 2—10. (2) *Florianites alternecostatus* (pl. 3 fig. 2, non pl. 3 fig. 3) in BENDER. (3) *Sibirites pandya* (pl. 3 fig. 1) and *Acrochordiceras* ex aff. *anodosum* (specimen not figured) in BENDER. (4) *Acrochordiceras* ex. aff. *anodosum* (pl. 2 fig. 9) in BENDER. (5) *Japonites ugra* (pl. 3 figs. 5—6, pl. 4 fig. 2) and *J. meridianus* (pl. 2 fig. 10) in BENDER. (6) *Sturia* cf. *mongolica* in BENDER 1970. (7) *Xenaspis laevis* (pl. 2 fig. 8) in BENDER 1970. (8) *Xenaspis indoaustralica* (pl. 2 fig. 7) in BENDER 1970. (9) *Japonites raphaelis-zojae* (pl. 4 fig. 1) in BENDER 1970. (10) *Florianites* cf. *alternecostatus* (pl. 3 fig. 3, non fig. 2) in BENDER 1970.

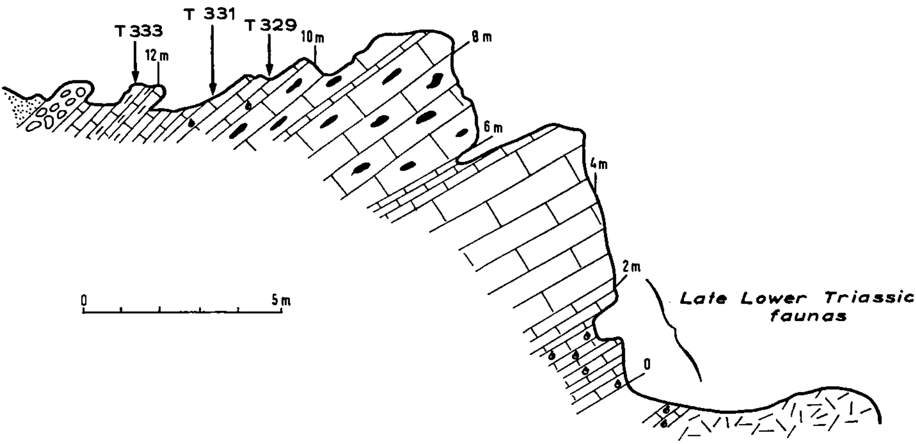

Fig. 6. Section CM II (from Bender 1970) near M. Marathovouno (Chios Island) showing location of ammonite faunas.

m 11

Bender material: *Japonites* n. sp. A (= *J. raphaelis-zojae* in WELTER 1915; non *J. raphaelis-zojae* TOMMASI, 1899) (9), *Danubites* cf. *alternecostatus* (WELTER) (10).

New material (T 331): *Japonites* sp. ind. cf. *ugra* (DIENER), *Leiophyllites pitamaha* (DIENER).

m 12.20

New material (T 333): *Japonites* n. sp. A (= *J. raphaelis-zojae* in WELTER, 1915), *Danubites* cf. *alternecostatus* (WELTER), *Leiophyllites* aff. *L. visendus* SHEVYREV.

From the above list it appears that some disagreement in the measurements exists, for what is listed by BENDER at m 11 seems equivalent to what the writer has in T 333 (m 12.20) in the new collection. Further some of the species found by the writer in beds contiguous, but clearly distinct (T 329 and T 331) are listed by BENDER in the same bed (m 10.5). At present we are not in a position to establish if this depends on a composite collecting by BENDER or on an insufficiently large collection from the basal bed (m 10.5) on the writer's part. There is an element, nevertheless, that suggests that the first alternative is the more probable one; in the new collection from m 11 there is a fragment of *Leiophyllites pitamaha*, whose missing piece is represented by the specimen Mbg 753 (pl. 2, fig. 2) listed by BENDER (1970) from m 10.5.

In any case, even considered as a whole, this fauna has a very characteristic generic assemblage, different from that of any standard zone known in the Tethys, which correlates with numerous Asiatic and American faunas. The above characters and the superimposition in one single section above late Lower Triassic ammonites recommend this fauna as the basis for at least one, but perhaps two, standard zones. The discrepancy between BENDER's stratigraphic data and mine and the delicate problems connected with collecting in the "Ammonitico Rosso" facies, have led to the postponement of formal designation of standard zones to new studies, planned in collaboration with Prof. JACOBSHAGEN for next summer. For the moment the zone in question will be informally indicated as *Paracrochordiceras-Japonites* beds.

MOJSISOVICS 1874

Bunt-Sandstein	ALPINER MUSCHELKALK	
	T. balatonicum Z.	*A. studeri Z.*

MOJSISOVICS 1882

Bunt-Sandstein	ALPINER MUSCHELKALK	
	C. binodosus Z.	*C. trinodosus Z.*

MOJSISOVICS ET AL. 1895

Skythisch	DINARISCH		
Jakutisch	Hydaspisch	Anisisch: Balatonisch	Anisisch: Bosnisch
	S. superbus Z.	*C. binodosus Z.*	*C. trinodosus Z*

ARTHABER 1906

Skythisch	ANISISCH		
	D. gracilis Z.	*Rh. decurtata Z.*	*C. trinodosus Z.*

PIA 1930

Skyth	Grenzbildungen	ANIS unter		ANIS ober		
		Hydasp unter	Hydasp ober	Pelson	Illyr unter	Illyr ober
	N. stanensis	*Ph. pauciforata*	?	*C. binodosus*	*D. sturi*	*Diplopora annulatissima*

SPATH 1934

Upper Eo-Trias	LOWER MESO-TRIAS (ANISIAN)		
Prohungarithan	Beyrichitan	Paraceratitan	
		binodosus Z.	*trinodosus Z.*

ROSENBERG 1952-1959

Skyth	ANIS unter			ANIS ober		
	Hydasp unter		Hydasp ober	Pelson	Illyr unter	Illyr ober
	N. stanensis	*Ph. pauciforata*	*Voltzia recubariensis*	*P. binodosus*, *Rh. decurtata*	*P. trinodosus*, *D. sturi*	*Diplopora annulatissima*

SHEVYREV 1968

Olenekian	ANISIAN			
	Beyrichitan		Paraceratitan	
	haugi Z.	*osmani Z.*	*binodosus Z.*	*trinodosus Z.*

SILBERLING & TOZER 1968

Spathian	ANISIAN					
	Lower Anisian	Middle Anisian		Upper Anisian		
	Caurus Z.	*Varium Z.*	*Shoshonensis Z.*	*Rotelliformis Z.*	*Meeki Z.*	*Occidentalis Z.*

TOZER 1971

Spathian	ANISIAN					
	Lower Anisian	Middle Anisian		Upper Anisian		
	Caurus Z.	*hyatti beds*	*Shoshonensis Z.*	*Rotelliformis Z.*	*Meeki Z.*	*Occidentalis Z.*

KOZUR 1973a

Spathian	ANIS			
	Unter Anis		Pelson	Illyr
	Caurus Z	*Varium Z.*	*(Shoshonensis Z.)*	*trinodosus Z*

KOZUR 1973b

Olenekian	ANIS			
	Unter Anis		Pelson	Illyr
	A. anodosum Z.	*A. varium Z.s.st.*		*P. trinodosus Z*

PISA 1973

Skyth	ANIS		
	Unter Anis (Hydasp)	Ober Anis: Pelson	Ober Anis: Illyr

Fig. 7. Comparative table of the chronostratigraphic nomenclatures applied to the lower Mesotriassic. This table is just a comparison between different nomenclatures and not a correlation-table.

Discussion

In his pioneering and classical studies on the Alpine Trias, above the late Lower Triassic *cassianus* Zone, MOJSISOVICS (1872) recognized two ammonitic horizons, which he at first (1873, 1874) named *balatonicum* and *studeri* Zones, and later (1882) *binodosus* and *trinodosus* Zones respectively. These zones provide, according to MOJSISOVICS, a basis for the distinction of the Alpine Muschelkalk. In substitution of the name Alpine Muschelkalk, some years later WAAGEN and DIENER (in MOJSISOVICS et al., 1895) introduced the Anisian Stage, from the Latin name (*Anisus*) of the river Enns (Austria), where both *binodosus* and *trinodosus* Zones are represented (ASSERETO, 1971; SUMMESBERGER and WAGNER, 1972). In the original definition Anisian was the upper subdivision of the Dinarian Serie (fig. 8); the lower subdivision was represented by the Hydaspian, an independent stage based on the Upper Ceratite Limestone of the Salt Range (Pakistan). The definition of the Anisian was subsequently enlarged by ARTHABER (1906) who did not used the term Hydaspian and in the Alps considered as "Anisian" the calcareous beds without ammonites lying below the *binodosus* zone and above the late Lower Triassic *cassianus* zone. This enlargement was subsequently accepted by PIA (1930) who divided the Anisian into two parts: an Upper Anisian, equivalent to the original Anisian of Waagen and Diener and a Lower Anisian or Hydaspian equivalent to the Lower Anisian of Arthaber, for which he claimed no ammonite faunas were known. The use of the term Hydaspian for this interval was inappropriate because, as noted by SPATH (1934), the type Hydaspian in the Salt Range is Lower Triassic and therefore much older than the Lower Anisian rocks of the Alps.

In spite of SPATH's remarks PIA classification and the term "Hydasp" have been widely used in succeding years in Europe in the stratigraphic nomenclature of the Mediterranean region. Only recently have various authors felt the need to substitute a new name for the inappropriate term "Hydaspian" (ASSERETO, 1972; TOZER, 1972; SUMMESBERGER and WAGNER, 1972; KOZUR, 1973a, 1973b). The introduction of a new chronostratigraphic unit was however considered problematic due to the supposed lack in the Tethys of complete ammonitiferous sections representative of the interval (SILBERLING and TOZER, 1968; SUMMESBERGER and WAGNER, 1972; KOZUR, 1973). Data reported in the preceding paragraphs show that in the eastern Mediterranean there are sections that provide a basis for definition of standard zones and higher rank chronostratigraphic units.

At this point arises the problem, clearly focused by SUMMESBERGER and WAGNER (1972, p. 534) and ASSERETO (1972), of determining whether these sequences should provide (a) a basis for a new stage or rather if (b) they should be used to amend the original definition of the Anisian by amplification (see fig. 8).

Priority and the long chronological interval represented by the sequences in question favour the first alternative. However, very often in chronostratigraphic nomenclature tradition prevails over priority, and undoubtedly from the time of ARTHABER (1906) the chronologic interval represented by the Gebze and Chios sequences has always been included in the Anisian. Moreover, the ammonite faunas of this interval have also been considered Anisian, even if they have often been inappropriately correlated with *trinodosus* zone (TOULA, 1896; ARTHABER, 1914; SHEVYREV, 1968 etc.). Therefore, in order to disturb as little as possible a "well established" stratigraphic nomenclature, the writer (ASSERETO, 1972) suggested that it would be more suitable to consider the interval in question as part of the Anisian and not a new stage. This resolution was recently supported by replies to a questionnaire on the problem from numerous colleagues active on the Triassic; 100% supported inclusion in the Anisian of the interval represented by the Chios and Gebze sections.

The acceptance of this solution raises the problem of the redefinition and the most appropriate subdivision of the enlarged Anisian stage. As chronostratigraphic subdivisions are essentially a matter of convention, it would be better to introduce new data or eventually improvements as far as possible in the traditionally used schemes, in order to avoid too sudden charges in the established nomenclature.

In this case two principal tendencies can be recognized in the literature (fig. 7): (a) the traditional school, based on the works of Mojsisovics et al. (1895) and Pia (1930), who divide the chronologic interval included between the Lower Triassic and the Ladinian into two parts, an upper one which includes the Pelsonian (=Balatonian) and the Illyrian (=Bosnian) substages, and a lower one inappropriately named Hydaspian; (b) the American school, based on recent works of Tozer (1967, 1971) and Silberling and Tozer (1968) which divides this interval into three parts, a Lower Anisian equivalent to the lower part of Pia's Hydaspian, a Middle Anisian, which corresponds to the late Hydaspian, plus the Pelsonian of Pia, and an Upper Anisian equivalent to the Illyrian. The classification used in America would be justified according to Tozer (personal communication) by the affinity existing between the faunas of the uper part of the so-called "Hydaspian" and those of the Pelsonian, especially by the common stamp given by *Acrochordiceras* and *Cuccoceras*. However, the appearance at the base of the Pelsonian of important genera such as *Balatonites* and *Ptychites* s. st. and the disappearance of equally important groups such as *Anagymnotoceras*, *Ismidites* and *Isculites*,

<table>
<tr><th colspan="2">A</th><th colspan="3">B</th><th colspan="3">C</th></tr>
<tr><td rowspan="2">ANISIAN</td><td>Illyrian</td><td rowspan="4">ANISIAN</td><td rowspan="2">Upper</td><td>Illyrian</td><td rowspan="4">ANISIAN</td><td rowspan="2">Upper</td><td>Illyrian</td></tr>
<tr><td>Pelsonian</td><td>Pelsonian</td><td>Pelsonian</td></tr>
<tr><td rowspan="2">"ANATOLIAN"</td><td>Bithynian</td><td rowspan="2">Lower</td><td rowspan="2">"Anatolian"</td><td rowspan="2">Lower</td><td>Bithynian</td></tr>
<tr><td>Aegean</td><td>Aegean</td></tr>
</table>

Fig. 8. Possible nomenclatures that can be applied to the lower Mesotriassic on the basis of the new data from Chios Island and Kokaeli Peninsula. Alternative A is based on priority and maintains the original scope of the Anisian, while B and C are possible alternatives in which the Anisian is considered in the enlarged sense proposed by Arthaber (1906) and traditionally accepted. For reasons explained in the text (p. 35) it is proposed in this paper the adoption of alternative C.

in my opinion discount the other similarities. In particular the appearance at the base of the Pelsonian of *Ptychites*, a very abundant and characteristic element of the Anisian faunas of the Tethys, supports the subdivision into two parts proposed by Mojsisovics et al. (1895) and Pia (1930).

Remaining to be considered are the most appropriate nomenclature and definition to be applied to the Lower Anisian for which no formal names are available, as the widely used Hydaspian is based on a Lower Triassic stratotype. On the basis of the data available, two theoretical alternatives are possible (fig. 8): (a) to replace the inappropriate name by a new one based on the grouping of Kokaeli and Chios sequences or (b) to introduce two new substages, based respectively on the Ismidicus and Osmani Zones of the Kokaeli Peninsula and on the *Paracrochordiceras-Japonites* beds of Chios. The first alternative is favoured by traditional use, for the Lower Anisian has always been treated in European literature as an unicum. The second alternative is supported by paleontological facts for there are obvious differences between the fauna of the *Paracrochordiceras-Japonites* beds and the faunas of the Ismidicus and Osmani Zones. The writer, probably a conservative, favoured the first alternative and proposed, in the oral presentation of this paper at the Vienna Meeting (May 1973), the name "Anatolian" for the whole interval of the Lower Anisian. This alternative was supported also by a majority of the colleagues who replied to a questionnaire on this problem. However, Dr. E. T. Tozer, who is well acquainted with these problems because of his world-wide experience with Triassic rocks, pointed out, during a series of stimulating conversations (May 1973), that the differences between the fauna of *Paracrochordiceras-Japonites* beds and those of the Ismidicus and Osmani Zones are actually similar to those existing between the latter and the Pelsonian faunas or between Pelsonian faunas and Illyrian ones. For these reasons Dr. Tozer felt it would be inappropriate to lump into a single substage the Turkish and Chios faunas. Rather, he supported designation of two substages. This also to favour the use of substages in boreal regions where, due to the well-known faunistic provincialism, it is possible to distinguish correlatives of the *Paracrochordiceras-Japonites* beds from correlatives of the Bithynian faunas, but it is more difficult to separate the latter from the Pelsonian faunas. Analogous suggestions were made to the writer by Prof. V. Jacobshagen.

As the distinction of two substages seems to correspond with the available facts and to be useful in facilitating intercontinental correlations, it is proposed to introduce the following two new substages, in descending order: (2) *Bithynian*, based on Kokaeli Peninsula sequences, and (1) *Aegean*, based on the Chios sequence. Type-localities, boundaries and contents of the new substages are fixed in the paragraph "Proposals" on p. 36–39.

When the proofs of this paper had already been delivered Dr. Tozer kindly sent me a copy of the reports of the meeting for the unification of the stratigraphic schemes of the marine Mesozoic of Siberia and the Far East, held at Novosibirsk in March, 1972 (Geologica i Geofisika 1972, №. 7, p. 136). In table 1 of the report summarising the final proposals the Anisian stage is considered in the enlarged sense proposed in this paper. However, in note 4 of p. 138, it is specified that according to Arkhipov "the two lower Anisian zones, whose equivalents are unknown in the Alpine stratotypic localities, may be grouped in the new Kular stage". Thus, the Kular stage should be more or less equivalent to the Lower Anisian of Pia (1930) and of this paper. However, as in the report of the Novosibirsk meeting no mention was made either of the sequences or of the faunistic assemblages on which Arkhipov intends to base the new stage, it is not possible at present to establish the exact chronostratigraphic significance of the Kular, nor its boundaries.

Proposals

As a conclusion to the discussions in the preceding paragraphs the following proposals are made.

Anisian Stage

It is formally proposed to enlarge the original definition of the Anisian Stage of Waagen and Diener (in Mojsisovics et al. 1895) to include the stratigraphic interval between the top of the Lower Triassic and the base of the Pelsonian (= Balatonian), which is represented by the two new substages, the Bithynian and the Aegean. The lower boundary of the new Anisian coincides with that of the Aegean. In agreement with Pia (1930) it is proposed to subdivide the Anisian, as above defined, into two parts, the Upper Anisian, defined by the Illyrian and Pelsonian substages and the Lower Anisian, defined by the Bithynian and Aegean substages.

Upper Anisian

Equivalent to the original Anisian of Waagen and Diener (in Mojsisovics et al. 1895) and to the Upper Anisian of Pia (1930); characterized in the Tethys by two ammonite assemblages. The upper, dominated by *Paraceratites* and *Flexoptychites*, provided the basis for the Bosnian Substage (Waagen and Diener in Mojsisovics et al. 1895), later named Illyrian by Pia (1930). The lower assemblage including *Balatonites, Acrochordiceras, Ptychites* and *Cuccoceras* provided a basis for the definition of the Balatonian Substage (Waagen and Diener, in Mojsisovics et al., 1895), subsequently renamed Pelsonian by Pia (1930). Bosnian and Balatonian have priority but have never been used, while on the contrary Pelsonian and Illyrian are well—established names. For this reason it is proposed that they continue to be used.

Illyrian Lower Boundary

Assereto (1971), discussing the significance of the *binodosus* Zone of Mojsisovics, stressed how the zonal index was confined to the upper part only of the zone and added that if the initial appearance of new taxa is used for the biostratigraphic limits, then the horizon in which *P. binodosus* occurs already belongs to the following *trinodosus* Zone, on which Illyrian substage is based. This opinion was supported by Kozur (1973a, 1973b) who proposed to fix the Pelsonian-Illyrian boundary at the base of Tiefengraben fauna in Grossreifling (Austria). The choice is unhappy as the Tiefengraben locality is no longer known exactly (Assereto, 1971; Summesberger and Wagner, 1972). It seems more suitable to establish the boundary stratotype in the continuously fossiliferous section of Dont (Southern Alps) (Assereto, 1971) at the base of the bed where *P. binodosus* first appears. Naturally the name *binodosus* Zone cannot be maintained for the older faunas of the Pelsonian, that might be grouped under the name Balatonicus Zone, with which these faunas were originally defined by Mojsisovics (1873, 1874).

Pelsonian Lower Boundary

Creates some problems as (a) neither Waagen and Diener nor Pia fixed the base of the substage in terms of beds and (b) a section is not known where continuous faunas provide a basis for fixing the actual first appearance of typical Pelsonian fossils. As an ideal boundary stratotype has not yet been found it is proposed that the base of the Pelson, for priority reasons (Mojsisovics et al., 1895; see also Summesberger and Wagner, 1972), is placed at the base of the bed with Rahnbauerkogel fauna, at the type locality of the Anisian in Grossreifling. However the possibility of lowering this boundary should be left open, in case typical Pelsonian faunas be found in the apparently unfossiliferous lower beds.

Lower Anisian

Defined by the new Bithynian and Aegean Substages; more or less equivalent to the Lower Anisian of ARTHABER (1906), PIA (1930), ROSENBERG (1952, 1959) and KOZUR (1973a, b). Lower boundary coincides with that of the Aegean substage; upper boundary is fixed by the base of Upper Anisian, that is by the base of the Pelsonian.

Bithynian Substage

Derivation of the name

From *Bithynia* the ancient Latin name given to the Kokaeli Peninsula.

Type Locality

Kokaeli Peninsula, near the town of Gebze, along the Istanbul-Izmid railway line, from km 49,780 to km 51,500 (figs. 1, 2, 4).

Lower Boundary

Is fixed by the base of Osmani Zone.

Upper Boundary

Defined by the base of the Pelsonian, the next contiguous substage. The superposition is proved in the type area.

Contents

The Bithynian is based on the grouping of the next lower rank chronostratigraphic units, the Ismidicus and the Osmani Standard Zones.

Ismidicus Zone

Zonal Index: *Anagymnotoceras ismidicus* (ARTHABER) 1914, p. 126, pl. XII, fig. 6.
Type Locality: at km 51,080 of the Istanbul-Izmid railway line (see fig. 4).
Lower Boundary: base of the bed 7 in which the zonal index first appears (figs. 3, 4).

This zone is marked by an abundance of *Anagymnotoceras* which exhibits large variations, associated with representatives of *Acrochordiceras, Ismidites, Beyrichites, Isculites, Cuccoceras, Sturia,* Gymnitids etc. Among the specimens figured by ARTHABER (1914) the following are certainly from this zone: pl. I figs. 3—4, pl. II figs. 4, 5, 6; pl. III fig. 8; pl. V figs. 9, 10.

Equivalents of the Ismidicus Zone appear to be widely distributed in central and eastern Tethys and in America, but the lack of detailed stratigraphic data makes correlations often difficult. Certainly to be referred to this zone are the *Anagymnotoceras* beds of the Anarak region (Iran) (TOZER, 1972), the Lower Gymnites Layer of Kashmir (DIENER, 1913) and the Varium fauna of Nevada (SILBERLING and WALLACE, 1969). Equivalents may also be present in the Anisian fauna of the Caucasus described by SHEVYREV (1968), in the *Hollandites*—bearing beds of Japan (SHIMIZU, 1930; BANDO, 1964) and perhaps in some forms of the *Phyllocladiscites basarinensis* Zone of Primor'ye (ZACHAROV, 1968). Among the Anisian ammonoids from Canada described by TOZER

(1967) and McLearn (1969) those of the Varium Zone are evidently related to the fauna of the Ismidicus Zone as suggested by the presence of *Anagymnotoceras, Hollandites, Ismidites* and *Gymnites*.

Osmani Zone

Zonal Index: *Nicomedites osmani* (Toula), 1896, p. 182, pl. XXII figs. 7, 8.
Type Locality: at km 50,210 of the Istanbul-Izmid railway line (see fig. 4).
Lower Boundary: base of bed 5 in which *Nicomedites osmani* (Toula) and "*Hungarites*" *solimani* (Toula) first appears (figs. 3, 4).

A fairly large ammonoid fauna from this zone was described by Toula (1896). The zone is characterized by abundant *Nicomedites* associated with "*Hungarites*" (perhaps *Grambergia*), *Procladiscites, Hollandites, Sturia, Leiphyllites* etc. This zone may eventually be subdivided in subzones on the basis of the appearance of primitive *Epacrochordiceras* in the upper portion. Among the specimen figured by Arthaber (1914) the following are certainly from this zone: pl. I figs. 1—10; pl. III figs. 4—7; pl. IV figs. 1, 3, 4.

The Osmani Zone probably has close correlatives in the *Beyrichites* Zone of Siberia (Kiparisova, 1937; Popov, 1961), in the *Leiophyllites* beds of Anarak region (Iran) (Tozer, 1972) and in "Maizuru Zone" of Japan (Nakazawa et al., 1954), as suggested by the occurrence of "*Hungarites*" *solimani* and *Nicomedites*. Equivalents may also be present in the *Leiophyllites pradjumna* beds of Primor'ye (Zacharov, 1968).

Representativity of the faunas

The faunas of the Ismidicus and Osmani Zones of the type locality represent in all probability almost all the chronologic interval of the Bithynian. Only for the uppermost part of this substage is a faunistic correspondent unknown, due to the presence of a conglomerate bed in the type area (see fig. 3).

Aegean Substage

Derivation of the name

From *Aegeum* the ancient Latin name given to the sea in which Chios Island is located.

Type Locality

Section CM II of Bender (1970) at Mount Marathovouno, west of the town of Chios in Chios Island (Greece) (fig. 5, 6).

Lower Boundary

Provisionally fixed at the base of *Paracrochordiceras-Japonites* beds, that is at m 10.5 of Bender's CM II section. In this section between the beds with late Lower Triassic faunas and the *Paracrochordiceras-Japonites* fauna there are about 8.5 m in which no ammonites have been found. It is suggested leaving open the alternative to place the apparently unfossiliferous beds in the Aegean, if further studies show characteristic Aegean ammonoids in them.

Upper Boundary

Is defined by the base of the Bithynian, the next contiguous substage. The superposition is proved in Anarak region (Iran) (Tozer, 1972) and in Nevada (Silberling & Wallace, 1969) where correlatives of *Paracrochordiceras-Japonites* beds are overlain by correlatives of the Osmani and Ismidicus Zones, and also by geometrical reasons, considering that while the Aegean fauna in Chios directly overlies a late Lower Triassic, *homeri* conodont fauna, the same fauna is found in Bithynia about 350 m below the Osmani Zone.

Contents

Recognition of the Aegean Substage is facilitated by the typical faunistic assemblage present in the type locality. This assemblage, provisionally called *Paracrochordiceras-Japonites* fauna, is characterized (see pag. 31) by different species of *Paracrochordiceras, Japonites, Leiphoyllites* and by *Sturia Procladiscites* and primitive *Megaphyllites*.

Equivalents of *Paracrochordiceras-Japonites* beds are widely distributed all over the world. These are the fauna of bed nº 2 of Nifeokoko (Timor) (WELTER, 1915), the fauna of Middlemiss Crag near Chitichun nº 1 (DIENER, 1895) and the Lower Muschelkalk fauna from Lilang, Spiti (DIENER, 1907). It is possible that equivalents of this zone are also present in the Anarak region (Iran) in *Ussurites* and *Procladiscites* beds (TOZER, 1972) in Nevada in the faunas of Caurus Zone (SILBERLING and WALLACE, 1969) and in the faunas of Kitakami Massif in Japan (MOJSISOVICS, 1888; SHIMIZU, 1930) as suggested by the presence of *Danubites* cf. *kansa, Leiophyllites pseudopradyumna* and *Japonites*. In the boreal province *Paracrochordiceras-Japonites* beds have probably correlatives in Siberia as indicated by the occurrence of *Japonites olenekensis* (KIPARISOVA, 1937), a species very similar to *Japonites "raphaelis-zojae"* of WELTER (1915) (non TOMMASI, 1899), and in Canada in the Caurus Zone as suggested by *Paracrochordiceras americanum*, a species very close to *Paracrochordiceras* n. sp. A of Chios.

Representativity of the faunas

As the beds above *Paracrochordiceras-Japonites* beds have no ammonites, as those below Osmani Zone, we are not in a position to state how much of the Aegean Chronostratigraphic interval is represented by fauna. The faunistic differences betwen these faunas suggest that they may be separated by a long time interval of which we have at the moment no fossil record. In this hypothesis *Paracrochordiceras-Japonites* fauna would represent only the lower part of the Aegean.

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