Definitions and Limits of Triassic Stages and Substages: Suggestions Prompted by Comparisons Between North America and the Alpine-Mediterranean Region

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1 Tab.

Abstract

Suggestions are made regarding the conventions that govern the scope and interpretation of Triassic stages and substages. Different interpretations of the Anisian-Ladinian and Carnian-Norian boundaries are discussed. It is suggested that a twofold rather than threefold division of the Carnian be adopted on the grounds that there seems to be insufficient evidence that the Jul ("Middle Carnian") is younger than the Cordevol ("Lower Carnian"). Pelson, Illyr, Fassan, Longobard, Cordevol (or Jul), Tuval, Alaun and Sevat substages are more or less adequately defined and will be useful for expressing correlations provided that agreement is reached regarding the definition of their boundaries. Intervals deserving formal designation for which no names are available are Lower Anisian and Lower Norian (*sensu* Silberling and Tozer, 1968). Interpretation of Rhaetian in terms of the Marshi Zone, rather than the whole of the Kössen Beds, is recommended.

Introduction

North America is well endowed with stratigraphic sections in which the sequence of Triassic ammonoid faunas can be objectively observed without the imposition of serious difficulties from tectonism, abrupt facies change, condensation etc. Most of the faunas known in the Alpine-Mediterranean region occur. Also present are significant faunas first discovered in India and Siberia which are at present unknown in Europe. The North American sequences have recently been summarized by Tozer (1967) and Silberling and Tozer (1968) and this had led to the introduction of a Standard Stratigraphic Scale for the Triassic (Table I). The American sequence is probably at least as significant as any other for the purpose of establishing a Triassic Standard Scale based on ammonoid faunas. It is perhaps particularly significant because within the last 10 years various shortcomings in alternative schemes have become apparent to workers in both Europe and North America. For the Middle and Upper Triassic most of the alternative schemes stem from the work of Mojsisovics, Waagen and Diener (1895) and are based on data derived from western Europe. The shortcomings of these schemes fall into three categories: (1) some zones were arranged in the wrong order, owing to insufficient stratigraphic data [e.g. some in the Middle Triassic (Assereto, 1969) and Norian (Tozer, 1965)]; (2) the faunas believed to represent some zones are based on collections from condensed or mixed deposits and contain fossils of more than one age; (3) significant time intervals have been found to exist for which there was no accommodation in the standard schemes. This last problem relates to the fact that although the Middle and Upper Triassic faunas of Europe include representatives of most known elsewhere, many are known only in isolated situations where their position in the sequence cannot be objectively demonstrated.

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TABLE 1. Triassic time scale (Silberling and Tozer 1968)

SERIES	STAGES & SUBSTAGES	ZONES (Standard Zones)	
UPPER TRIASSIC	RHAETIAN	Choristoceras MARSHI	
	UPPER NORIAN	Rhabdoceras SUESSI	
	MIDDLE NORIAN	Himavatites COLUMBIANUS Drepanites RUTHERFORDI Juvavites MAGNUS	
	LOWER NORIAN	Malayites DAWSONI Mojsisovicsites KERRI	
	UPPER CARNIAN	Klamathites MACROLOBATUS Tropites WELLERI Tropites DILLERI	
	LOWER CARNIAN	Sirenites NANSENI Trachyceras OBESUM	
MIDDLE TRIASSIC	UPPER LADINIAN	Frankites SUTHERLANDI Maclearnoceras MACLEARNI Meginoceras MEGINAE	
	LOWER LADINIAN	Progonoceratites POSEIDON Protrachyceras SUBASPERUM	
	UPPER ANISIAN	*Gymnotoceras OCCIDENTALIS *Gymnotoceras MEEKI *Gymnotoceras ROTELLIFORMIS	Frechites CHISCHA Gymnotoceras DELEENI
	MIDDLE ANISIAN	*Balatonites SHOSHONENSIS *Acrochordiceras hyatti beds	Anagymnotoceras VARIUM
	LOWER ANISIAN	Lenotropites CAURUS	
LOWER TRIASSIC (SCYTHIAN)	SPATHIAN	*Neopopanoceras HAUGI *Subcolumbites beds *Columbites & Tirolites beds	Keyserlingites SUBROBUSTUS Kazakhstanites PILATICUS
	SMITHIAN	Wasatchites TARDUS Euflemingites ROMUNDERI	
	DIENERIAN	Vavilovites SVERDRUPI Proptychites CANDIDUS	
	UPPER GRIESBACHIAN	Proptychites STRIGATUS Ophiceras COMMUNE	
	LOWER GRIESBACHIAN	Otoceras BOREALE Otoceras CONCAVUM	
PERMIAN			

* = Recognized only in Western U.S.A.

Comparisons with North America suggest that this has led faunas of some European localities to be considered as correlative when in fact they are heterochronous. Difficulties of this sort apply particularly in the Ladinian and Carnian (TOZER, 1971, p. 1018).

All the zones recognized in North America have type localities (TOZER, 1967, p. 10; SILBERLING & TOZER, 1968, p. 21). They therefore satisfy the prime requirement of the "Standard Zone" of CALLOMON (1965) and the "Chronozone" of HARLAND *et al.* (1972, p. 300) and form a suitable foundation for a Standard Scale. Being provided with stratotypes as well as faunal characteristics they are thus different from the kind of zone advocated by, for example, SCHINDEWOLF (1970) and WIEDMANN (1970), who consider that the zones of such a Scale should be defined solely in palaeontological terms without any reference to a type locality[1]). The principal objection to the kind of zone supported by SCHINDEWOLF and WIEDMANN is that they are not amendable to stable definition and unambiguous interpretation. In terms of the distinction made in the "International Guide to Stratigraphic Classification, Terminology and Usage" (HEDBERG, Ed., 1972) Standard Zones are thus chronostratigraphic, not biostratigraphic units.

The zones recognized in North America are shown on Table I. Work on the zonal subdivision in Canada is continuing and it now seems probable that some 50 divisions will be discriminated by the breakdown of zones into subzones (e.g. the Varium and Columbianus Zones, TOZER, 1971, pp. 1017, 1019). The zones are grouped into 16 larger divisions, some ranked as stages, some substages. Except for the Lower Triassic, for which no suitable stage names are available from the Old World, the stage names used are those defined in the Alpine-Mediterranean region. The Middle and Upper Triassic stages and the Lower Triassic Series have long been recognized in North America and this has undoubtedly been useful for expressing intercontinental correlations. But it is clear that more divisions than the six[2]) traditionally employed may be significant and useful. It is with the question of defining and naming the stages and substages that this paper is mainly concerned.

The ideal Standard Stratigraphic Scale would be one in which all divisions, down to the smallest (subzone) would be of world-wide application. It seems unlikely that this ideal will ever be attained because it is usually possible on any one continent, or in a more restricted area, to devise a scheme, with subzones and zones as the smallest divisions, which proves too refined for world-wide application. A single universal scale, using everywhere the same smallest divisions, seems an unattainable ideal. Europe and Asia, like North America, may eventually have 50 or more significant divisions within the Triassic but it seems unrealistic to suppose, or anticipate, that all will correlate exactly with one another, even within one continent. At some levels the zones may be of world-wide application, a notable example being the Tardus Zone which is correlative with the *Stephanites superbus* Zone (Salt Range) and the *Anasibirites nevolini* Subzone (Primor'ye). But more commonly the zones, although not recognizable everywhere else, lend themselves to form groups with adjacent zones, and the resultant groups (substages) do prove widely recognizable. This of course has long been recognized; e.g. by ARKELL (1956, p. 7). For example two zones in Canada (Concavum and Boreale) evidently correlate with one (Woodwardi) in the Himalayas; the two form a substage—Lower Griesbachian. Similarly three zones in Nevada (Rotelliformis, Meeki, Occidentalis) form a group correlative with two in Canada, the correlation being based on many lines of evidence: range of ammonoid genera, of *Daonella* species etc. Here then is another significant substage: the Upper Anisian. Most

[1]) KOZUR (1972c, p. 365) has evidently misunderstood the stratigraphic procedure advocated by SILBERLING & TOZER for he indicates that our approach conforms with that of SCHINDEWOLF. In fact it does not.

[2]) Scythian Series, Anisian, Ladinian, Carnian, Norian and Rhaetian Stages.

or all of the 16 North American divisions (stages and substages) seem to be recognizable world-wide. If an acceptable scheme of nomenclature for divisions of this scale can be devised it will prove a valuable medium for expressing intercontinental correlations. As regards the names, not a few for substages (Pelson, Illyr, Tuval, Alaun, Sevat etc.), based on Alpine-Mediterranean occurrences, are available. Most have not yet found much application outside Europe. But they probably have the potential to do so provided that their definitions are clarified and in some cases emended. Obviously more work is necessary before all the problems can be resolved. Resolution of not a few questions, however, is not dependent upon more research but upon agreement concerning conventions. For example, everybody seems to accept the reality and significance of the Kerri Zone which was shown, from North American data, to lie between the Macrolobatus Zone (undisputed Carnian) and the Dawsoni Zone (undisputed Norian). Arbitrarily it was placed in the Norian (SILBERLING, 1959; TOZER, 1965, 1967; SILBERLING & TOZER, 1968). This arrangement was accepted by KRYSTYN (1973). But ARCHIPOV *et al.* (1971) and SAKS *et al.* (1972) treat it as Carnian. There are other similar questions, requiring not more research, but merely agreement to convention. In the interests of promoting international stratigraphic communication these questions should be settled. Recommendations regarding such arbitrary questions should perhaps be a responsibility of the proposed Subcommission on Triassic Stratigraphy.

Specific questions regarding the Triassic will now be considered. In the discussion that follows, substages, where designated "Lower Anisian" etc. are used as defined by SILBERLING & TOZER (1968) (See Table I). This has been done to avoid ambiguity and does not necessarily indicate commitment to placing all Triassic substages boundaries as in Table I. But the boundaries were proposed with the European substages in mind, and the zones were grouped in such a way that, subject to clarification in definition there was a good prospect that Pelson, Illyr, Fassan, Longobard, Cordevol (or Jul), Tuval, Alaun and Sevat might eventually replace, respectively, Middle Anisian, Upper Anisian, Lower Ladinian, Upper Ladinian, Lower Carnian, Upper Carnian, Middle Norian and Upper Norian. Lower Anisian and Lower Norian were recognized as substages for which no appropriate names are available.

Lower Triassic

Most workers (listed in TOZER, 1972, p. 645) accept the base of the *Otoceras woodwardi* Zone to define the base of the Triassic. This zone correlates with the Lower Griesbachian (Table I). Recent proposals (e.g. by KOZUR, 1973) to place the Lower Griesbachian (=Gangetian) Substage in the Permian represent no more than a change in convention and as such merely a contribution to nomenclatural instability.

Of the four stages recognized in the Lower Triassic of North America, Griesbachian is recognizable in the Alpine-Mediterranean region from occurrences of *Claraia*, but representatives of the distinctive Griesbachian ammonoid faunas have not yet been found. Dienerian and Smithian correlatives are not clearly recognizable owing to the near or complete absence of ammonoids in the Alpine-Mediterranean strata that presumably represent this interval. Occurrences in Idaho, Utah and Nevada (summarized in SILBERLING & TOZER, 1968) show that the *Tirolites cassianus* Zone is early or mid-Spathian, particularly if one regards the faunas with *Subcolumbites* etc. in Albania and Chios as representative of this zone. Occurrences in Nevada and Mangyshlak suggest that the Spathian may be amenable to division into several zones, but such subdivision must await further work. But the sections in Nevada described by SILBERLING & WAL-

LACE (1969) seem to justify the conclusion that the *Tirolites-Subcolumbites* faunas are older than the Haugi and Subrobustus Zones and are thus not latest Lower Triassic.

So many alternative schemes of classification for the Lower Triassic are now available that it is impossible to discuss their respective merits within the scope of this paper. Despite the nomenclatural differences there seems to be fairly widespread agreement regarding the correlation of Lower Triassic strata. Hopefully this will soon be reflected in the adoption of a universally acceptable scheme of nomenclature. The scheme based on the North American sequence, being unambiguously defined and widely applicable (TOZER, 1971, p. 1013—1017) seems to offer this potential. If any of the four stages are to be reduced to substages I would suggest uniting the Dienerian and Smithian, the faunas of which are more intimately related than formerly believed, making it difficult, in some parts of the world, to recognize the Dienerian-Smithian boundary. But the base of the Dienerian, and that of the Spathian, are readily recognized throughout the world.

Middle Triassic

During the present century most authors have followed ARTHABER (1905) who treated the Anisian as the basal Middle Triassic stage. Thanks to ASSERETO (1971), ZAPFE (1971) and SUMMESBERGER & WAGNER (1972) the stratigraphic situation at the Anisian type locality has recently been clarified. In these works it is shown that in terms of the stratotype Anisian should be restricted to include only the Binodosus and Trinodosus Zones (*sensu* MOJSISOVICS). As will be mentioned below a correlative of the Binodosus Zone as represented at Gross Reifling can be recognized in the Shoshonensis Zone of Nevada (Table I). Between the Shoshonensis Zone and the highest beds assigned to the Lower Triassic (Haugi Zone) there are fossiliferous beds that pose a number of nomenclatural problems.

The Shoshonensis Zone has been classed as late Middle Anisian in North America (Table I). Since publication of SILBERLING & TOZER (1968) more work has been done on the Middle Anisian of North America both in Nevada (by SILBERLING) and in Canada (by the writer). The Varium Zone of the type area (British Columbia) has now been divided into three subzones (TOZER, 1971, p. 1017). In the Favret Formation of Nevada Silberling (personal communication) has shown that the Shoshonensis Zone overlies beds with *Acrochordiceras hyatti* (= Varium Zone of Nevada, SILBERLING & TOZER, 1968), a relationship previously anticipated but not until recently proved in a stratigraphic succession. It would now appear that the stratotype Varium Zone is correlative with both the *Acrochordiceras hyatti* beds and Shoshonensis Zone, not merely with the former, as originally suggested (TOZER, 1971, p. 1017). The ammonoid faunas of the *A. hyatti* beds and the Shoshonensis Zone, in my opinion, have a common stamp (*Acrochordiceras*, *Cuccoceras*, Beyrichitidae) and the beds form a group best regarded as one substage, the Middle Anisian of Table I.

Between the Middle Anisian and the highest beds of the Lower Triassic is the Caurus Zone with a significant ammonoid fauna permitting the recognition of correlatives, not only throughout North America and the Arctic but also in Timor, the Himalayas and also, from BENDER's recent discovery (1970), in Chios. Everybody who has studied the ammonoids from these beds has considered them Anisian. SILBERLING and TOZER (1968) called the interval Lower Anisian for want of an alternative. Clearly this is a significant interval for which a substage, or even stage name is desirable, but unavailable. The problem has not been overlooked in the past. It was recognized, for example, by PIA (1930). But it is only recently that ammonoid faunas have been fitted into the gap.

The name Hydasp, used as a lower division of the Anisian to embrace this interval by Pia is wrong (SPATH, 1934, p. 32). Kularian, recently proposed by ARCHIPOV et al. (1971, p. 313) on the basis of the Siberian sequence includes the Caurus Zone but is more comprehensive than Lower Anisian of Table I because it also includes at least part of the Varium Zone.

Dr. R. ASSERETO is much concerned with these problems, from his studies in the Anisian of both the Alps and Turkey (ASSERETO 1971, 1972). In his interpretation the Shoshonensis Zone correlates with the lowest ammonoid fauna at Gross Reifling, i.e. the lowest fauna at the type locality. If he is correct it follows that not only the Caurus Zone but also the *A. hyatti* beds (=Lower and Middle Subzones, Varium Zone) have ammonoid faunas older than any at the type locality for the Anisian. KOZUR (1972a, p. 20; 1972b, Table I) has also considered this question. His solution is to employ the term "Unteranis" to embrace the Caurus Zone plus the Varium Zone of Nevada (i.e. the *A. hyatti* beds). Kozur's Unteranis would thus include the beds between the top of the Lower Triassic and the beds with the lowest ammonoids at Gross Reifling.

Despite the fact that the ammonoids of the *A. hyatti* beds and the lower and middle subzones of the Varium Zone may be older than the lowest fauna at Gross Reifling I submit that these beds with these faunas should not be united with the Caurus Zone to form one substage or stage. There is an obvious affinity between the fauna of the *A. hyatti* beds with that of the Shoshonensis Zone, and between the faunas of the three subzones of the Varium Zone. There is an equally obvious difference between the faunas of these divisions with those of the Caurus Zone. Whatever solution he suggested, the Caurus Zone, correlatives of which are recognizable in both the Arctic and Tethys (TOZER, 1971, p. 1017), should be segregated as an independent division, preferably a substage of the Anisian. The boundary between the Caurus and Varium Zones, marked by the appearance of Beyrichitidae (true *Hollandites* probably being the first), *Acrochordiceras* (s. s.), *Intornites* and *Cuccoceras* seems to be one of the more significant and easily recognized in the Triassic succession and thus warrants characterization as a stage or substage boundary. The name Balatonian (=Pelson) is appropriate for at least the Shoshonensis Zone and its correlatives. I suggest that the scope of Pelson be increased to include the beds between the Caurus Zone and the Shoshonensis Zone, i.e. as an equivalent to Middle Anisian (Table I). A Pelson base defined in this way would have the advantage of being recognizable in both the Arctic and Tethys. In a higher position, at the base of the Shoshonensis Zone, this would not be so. For the Lower Anisian (Table I) a new name seems to be required.

Nomenclature of the younger Anisian beds also presents problems. PIA (1930) classed the younger Anisian beds as Illyr, divided into Lower Illyr (more or less Trinodosus Zone) and Upper Illyr (represented, for example, by the Grenzbitumenzone).[1] SILBERLING (1962; see also SILBERLING and TOZER, 1968, p. 36) has shown that the Rotelliformis Zone is the main level for *Paraceratites* of the *trinodosus* group and that *Daonella* cf. *elongata* MOJSISOVICS (a species of the Grenzbitumenzone) is in the Meeki Zone. Faunal similarities of this sort suggest that these two zones correlate with the Lower and Upper Illyr respectively.

But before Illyr becomes useful for international purposes it will be necessary to adopt a precise convention concerning both the lower boundary (with the Pelson) and

[1]) It is regretted that the important data on the ammonoids of the Grenzbitumenzone provided by Dr. H. RIEBER (*Schweiz. Paläont. Abh., 93*, 1973) are not taken into account here. Unfortunately his monograph was published after the completion of this paper.

the upper, with the Ladinian. According to ASSERETO (1971) the *Paraceratites binodosus* beds of Dont are the highest in the Binodosus Zone (*sensu* MOJSISOVICS), and are thus the youngest in the Pelson. But KOZUR (1972a, b) puts the *Paraceratites binodosus* beds in the Illyr, drops the Binodosus Zone from the Standard Scheme and thus gives a different interpretation of the Pelson-Illyr boundary. Agreement of this conventional question is necessary.

Regarding the Upper boundary of the Illyr, ASSERETO (1969) has shown that the Alpine Avisianus Zone correlates with the Meeki Zone (Nevada) and the Upper Illyr of PIA. Traditionally, following MOJSISOVICS *et al.* (1895), the Avisianus Zone had been placed in the Ladinian, between the Curionii and Archelaus Zones, but ASSERETO has shown that there is no evidence for this placement. KOZUR (1972a, b), while accepting ASSERETO's correlation, regards the Avisianus Zone as Ladinian, claiming that it belongs there on the basis of priority. But when BITTNER defined the Ladinian in 1892 he did so in terms of the Buchenstein and Wengen Beds. The Avisianus Zone was introduced later, in MOJSISOVICS *et al.* (1895). Consequently KOZUR's claim cannot be substantiated. Retention of the Avisianus and Meeki Zones in the Anisian is advocated here.

In both Nevada and British Columbia more or less uninterrupted sequences in uniform facies cover the late Anisian-early Ladinian interval, probably with a more continuous faunal record than known anywhere else. *Protrachyceras* makes its appearance in the Subasperum Zone and this has been taken to mark the Anisian-Ladinian boundary (SILBERLING and TOZER, 1968, p. 12).

The Lower-Upper Ladinian boundary (Table I) probably more or less corresponds with the Fassan-Longobard boundary. The Ladinian beds of British Columbia have rich ammonoid faunas with *Daonella* species in association. More work remains to be done of the Daonellas before their significance can be assessed. However *Daonella* species close to *D. lomelli* (Wissmann) are in the Meginae and Maclearni Zones, and *Anolcites* close to *A. doleriticum* (MOJSISOVICS) are in the Maclearni Zone. These occurrences suggest correlation with the Wengen beds, stratotype for the Longobard Substage. *Protrachyceras* species close to *P. longobardicum* MOJSISOVICS and *P. archelaus* LAUBE have a long range in North America; certainly through the Poseidon, Meginae, and Maclearni Zones, probably into the Sutherlandi Zone. Occurrences of species of this group, as presently known, do not seem to contribute much towards a refined chronology.

The Sutherlandi Zone, placed at the top of the Ladinian in North America, is one that may have particular significance for worldwide correlation. Correlatives are almost certainly widely distributed in the Alpine-Mediterranean region (TOZER, 1971, p. 1018). Some are in beds attributed to the Ladinian, others are in so-called Carnian. The North American sequence shows that this zone lies between correlatives of the Longobard and the Cordevol. Conventionally it has been assigned to the Ladinian rather than Carnian.

Upper Triassic

In North America two substages are recognized in the Carnian, compared with the three (Cordevol, Jul, Tuval) of the MOJSISOVICS *et al.* (1895) scheme. KOZUR (1972a) treats these as synonymous with Lower Middle and Upper Carnian. KRYSTYN (1973, p. 124) divides the Carnian into two: the Lower includes Cordevol and Jul; the Upper, Tuval. Lower Carnian (Table I) is similarly interpreted as including correlatives of both Cordevol and Jul, but with the suggestion that the two may be more or less con-

temporaneous, there being insufficient evidence to prove that the Jul is younger than the Cordevol (TOZER, 1967, p. 32). Typical Jul comprises *Trachyceras* beds at Raibl; typical Cordevol the Aon Zone of St Cassian. In practice the Jul has been interpreted in terms of the Aonoides Zone of the Hallstatt Limestone. According to KRYSTYN (1973, p. 125) the Aonoides Zone has both *Trachyceras* and *Sirenites*, unlike the Aon Zone and Raibl beds in which *Sirenites* is unknown. Provided that this association is not due to condensation the Aonoides Zone could correlate with the Obesum Zone or the Nanseni Zone. So although *Sirenites* appears above *Trachyceras* in Canada (in the Nanseni Zone), and apparently also in the Balaton Highlands (KOZUR, 1972a), the two may also be contemporaneous, judging from occurrences in the Aonoides Zone and at Painkhanda in the Himalayas. As regards Painkhanda, the statement to the contrary in TOZER (1971, p. 1019) is incorrect. The close similarites between *Trachyceras* of the Aon and Aonoides Zones, and the probable overlap in age of *Trachyceras* and *Sirenites*, seems to justify the conclusion that the Aon, Aonoides, Obesum and Nanseni Zones are close enough in age to be regarded as divisions of no more than one substage, which could be called Cordevol or Jul. Occurrence of *Sirenites* above *Trachyceras* (Canada, Hungary) cannot be considered a vindication of the Cordevol-Jul separation, as by KOZUR (1972a), *Sirenites* being unknown in the stratotype Jul.

KRYSTYN (1973) treats the three Upper Carnian zones (Dilleri, Welleri, Macrolobatus) as representative of the Tuval. This seems an entirely satisfactory interpretation of that substage.

Coming to the Carnian-Norian boundary: KRYSTYN (1973) follows the convention suggested by SILBERLING & TOZER (1968) by treating the Kerri Zone as basal Norian. KOZUR (1973) now does the same. In contrast ARCHIPOV *et al.* (1971) and SAKS *et al.* (1972) put it in the Carnian, on the grounds that the Paulckei Zone (more or less correlative with the Dawsoni Zone) defines the basal Norian. This argument may be questioned. Stratotype Norian is the "Bicrenatus-Lager des Sommeraukogels" (ZAPFE, 1971; KRYSTYN *et al.* 1971). The Paulckei Zone is not known at the Sommeraukogel. When DIENER named the Paulckei Zone (1921, 1925) and recognized it to be older than the Bicrenatus Zone, he arbitrarily included it in the Norian. His conclusion has been verified and accepted by later workers. The convention he adopted increased the scope of the Norian in relation to the stratotype, but not at the expense of the Carnian. When evidence was found that the Kerri Zone occupied a position between the Subbullatus and Paulckei Zones, SILBERLING and the writer, like DIENER, were faced with the necessity for making another arbitrary decision. We chose to put the Kerri Zone in the Norian, further increasing the scope of that stage, but still (as in DIENER's case) without eroding the Carnian. ARCHIPOV, SAKS *et al.* do not question the correlation of Kerri Zone; they merely adopt a different convention. I submit that this is the sort of case in which the decision of the first reviser should be upheld. DIENER's decision was accepted; why not that of SILBERLING & TOZER?

For the Carnian, in summary, I suggest that the evidence supports a twofold, not threefold division of the stage; the lower should be called Cordevol (or Jul); the upper, Tuval. The Kerri Zone should be regarded as Norian, not Carnian.

The Norian sections of British Columbia are particularly illuminating and contribute much to the problems of classifying this stage. Here occur many ammonoids more or less identical with those from Salzkammergut, where the stratotype Norian is situated. In British Columbia there are several sections in which the sequence of faunas can be readily determined, unlike Salzkammergut, where it is only in the last few years, thanks

to the work of KRYSTYN, SCHÄFFER & SCHLAGER (1968, 1971 etc.) that the problems introduced by fissure fillings, condensation etc. have been understood, and the results applied to elucidating the true faunal sequence.

There now seems to be general concensus that three substages can be recognized within the Norian. MOJSISOVICS, of course, had three (Lac, Alaun, Sevat) but his understanding of the sequence was imperfect, for it is now known that the true Lac faunas are younger, not older than those of the Alaun, and more or less the same age as some of the Sevat faunas.

For the lower substage we encounter differences concerning both scope and nomenclature. Regarding scope: in Table I and in KOZUR's (1973) most recent scheme it is Kerri and Dawsoni Zones; to KRYSTYN (1973), Kerri, Dawsoni and Magnus Zones. KRYSTYN's proposal to include the Magnus Zone in the Lower substage may have much to recommend it. His choice of name ("Lac") seems questionable, however, because Lac, as originally defined (MOJSISOVICS *et al.*, 1895, p. 1279) included only the *Cladiscites ruber* and *Sagenites giebeli* Zones, which are almost certainly correlative with part of the original Sevat (TOZER, 1965, p. 225). The complications introduced by MOJSISOVICS' (1902, p. 345) subsequent inclusion of the *Discophyllites patens* Zone in the Lac further confuse its interpretation. Lac seems best abandoned; here I agree with KOZUR (1972a, p. 21).

Alaun (based on the Bicrenatus Zone) seems a potentially useful name for the middle substage, provided that agreement can be reached regarding definition of the base. Sevat, as originally proposed, included the Metternichi and Argonautae Zones but there now seems to be general agreement that the Argonautae Zone deserves no place in a Standard Scheme; certainly not at the top of the Norian, it being, in all probability, more or less correlative with the Columbianus Zone (TOZER, 1971a, p. 1020). KRYSTYN (1973) abandons both the Metternichi and Argonautae Zones and recognizes the Suessi Zone in Salzkammergut as equivalent with Sevat. This convention seems preferable to that of KOZUR (1973, p. 12) in which the Columbianus Zone is included in the Sevat.

To summarize the Norian questions: Alaun and Sevat seem useful for the middle and upper substages. A decision regarding the base of the Alaun is required, namely whether or not the Magnus Zone is included. Lac should presumably be suppressed as a synonym of Sevat and a new name found for the lower substage. Also, inclusion of the Kerri Zone in the lower substage and retention of the Columbianus Zone in the Alaun is recommended.

The relationship between the beds assigned to the Rhaetian in North America to those in Europe has been clarified with the discovery by URLICHS (1972) of *Rhabdoceras suessi* in the type section of the Kössen Beds, with *Choristoceras marshi* HAUER at a higher level in the same formation. URLICHS assigns the beds with *Rhabdoceras* to the Norian; those with *Choristoceras marshi* to the Rhaetian. Beds with *Rhaetavicula contorta* (Portlock) underly those with *Rhabdoceras* and are also assigned to the Norian. The Kössen Beds thus include a correlative of the Upper Norian, as anticipated by ZAPFE (1968, p. 22). The ammonoid sequence closely parallels that known in North America. Rhaetian in the sense of URLICHS, SILBERLING & TOZER (i.e. for the Marshi Zone alone) is an appreciably smaller division (only the upper part) of a Rhaetian Stage interpreted from the whole of the Kössen Beds, as by, for example, MOJSISOVICS *et al.* (1895). Definition of the Rhaetian base at the base of the Marshi Zone is evidently acceptable to PEARSON (1970, p. 142), KRYSTYN (1973, p. 123) and KOZUR (1973, Table 2) as well as to URLICHS. WIEDMANN (1972), in contrast, recognizing that Rhaetian (*sensu* MOJSI-

SOVICS *et al.*, 1895) includes correlatives of at least part of the Suessi Zone, would include the whole Suessi Zone (*sensu* SILBERLING & TOZER, 1968; KRYSTYN, 1973 etc.) in the Rhaetian. Although WIEDMANN's proposal may have some historical justification, in that the name Rhaetian predates Norian; its acceptance would necessitate drastic and confusing changes in nomenclature throughout the world. Some Russian workers have made similar proposals (see PEARSON, 1970, p. 144; TOZER, 1967, p. 41) but they do not seem to have been favourably received, in their own land or elsewhere. WIEDMANN's further proposal to divide the Suessi Zone (as originally defined) into an earlier *Phyllytoceras zlambachense* Zone (I) and a later *Rhabdoceras suessi* Zone (II) (of restricted scope) reflects only the sequence in the Kössen Beds and has not yet been shown to have chronological significance. As already mentioned, the evidence from other parts of the world indicates that *Rhabdoceras suessi* ranges throughout the Upper Norian (=Sevat, =Zones I and II of WIEDMANN's Rhaetian). There seems to be insufficient evidence, at present, to warrant introducing a Zlambachense Zone between the Columbianus and Suessi Zones.

The sequence of ammonoid faunas between the Carnian and the Jurassic is now fairly well known. *Choristoceras* makes its appearance in the Suessi Zone. The differences between the *Choristoceras* of the Suessi and Marshi Zones are not easily appraised owing to the imperfect or fragmentary preservation of most specimens apart from those of *Choristoceras marshi* Hauer from the type locality. In terms of ammonoid faunas the Marshi Zone is not well characterized. The fauna is intimately related to that of the Suessi Zone. Starting anew the Marshi Zone would probably be grouped in the same substage as the Suessi Zone. To place the Suessi and Marshi Zone in one and the same stage would place their relationship, both biological and stratigraphical, in better perspective. But to assign the Suessi Zone to the Rhaetian would cause only confusion. It would necessitate, for example, describing many of the *Monotis* beds, long assigned to the Norian in North America, Eurasia, New Zealand etc., as Rhaetian. A more acceptable and practical solution would be the suppression of Rhaetian as a chronostratigraphic division and to extend the Norian to the top of the Triassic. But in the meantime the practice of KOZUR, KRYSTYN, SILBERLING, TOZER & URLICHS seems more acceptable than that of WIEDMANN, and not seriously in conflict with the principles of priority in that the Marshi Zone comprises some of the beds originally assigned to the Rhaetian; Suessi Zone some originally assigned to the Norian.

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