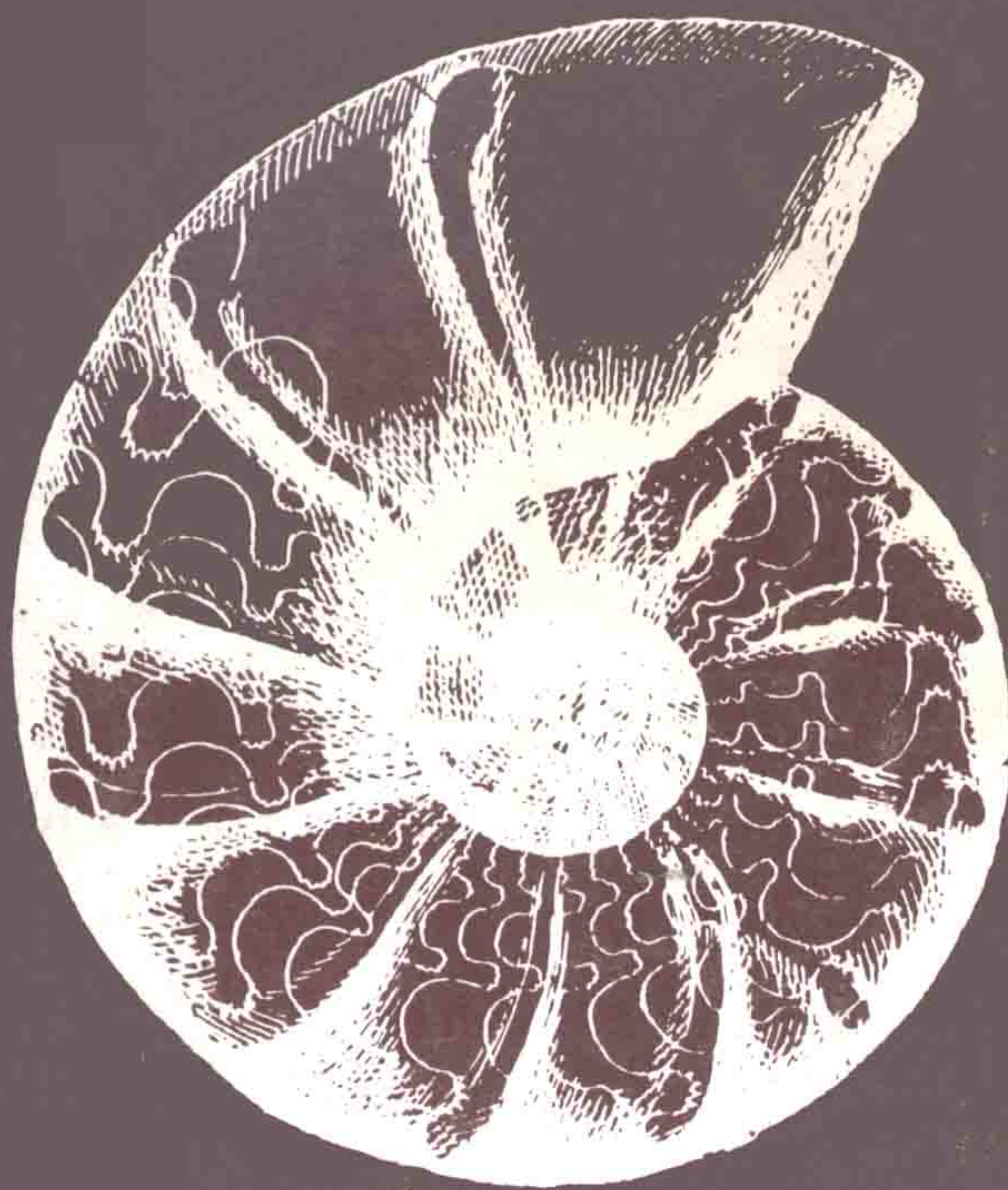


ALBERTIANA



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ALBERTIANA

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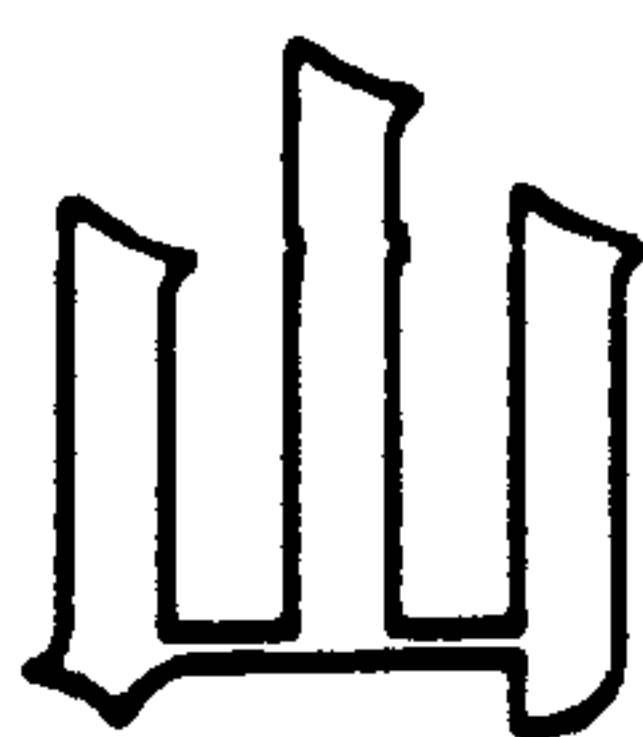
The primary intention of ALBERTIANA is to promote the interdisciplinary collaboration and understanding among the members of the I.U.G.S. Subcommittee on Triassic Stratigraphy. Within this scope ALBERTIANA serves both as a newsletter for the announcement of general information and as a platform for discussion of developments in the field of Triassic stratigraphy. ALBERTIANA thus encourages the publication of announcements, literature reviews, progress reports, preliminary notes etc. - i.e. those contributions in which information is presented relevant to current interdisciplinary Triassic research.

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REPORT 1989-1990

H. Visscher

There has been considerable delay in the production of the present issue of ALBERTIANA. This is primarily due to changes in the staff of the Laboratory of Palaeobotany and Palynology in Utrecht.

Both Miente BOERSMA, who acted as editor of ALBERTIANA since the first issue, as well as Pim BRUGMAN, who gave continuously background advice with respect to a wide variety of 'Triassic affairs', have left the University of Utrecht. In their present position, they cannot continue their work for our newsletter. On behalf of STS, I thank them for their successful efforts in creating a Triassic newsletter, which has become highly appreciated by STS members as well as other experts in the field of Triassic research.

The new editor of ALBERTIANA is Hans KERP. He is a specialist in palaeobotany and organic petrology. His main research activities have so far been in the continental Permian of Europe, but he is well-introduced in the general problems with respect to Triassic stratigraphical classification and correlation. Correspondence, including manuscripts and reprints of articles to be included in the 'Annotated Triassic Literature', should be mailed to the new editor.

In 1989 a new STS-Board was elected. This Board was formally presented during the STS-meeting organized in conjunction with the 28th International Geological Congress in Washington (see report in present issue). Aymon BAUD has succeeded Carmina VIRGILI as chairman. As a third vice-chairman, Maurizio GAETANI, was added to the Board. STS is grateful to Carmina Virgili for all the work she has done to promote interdisciplinary research in the Triassic. Fortunately she will remain a member of the new Board.

During 1989-1990 the principal issues of the STS were still the Permian-Triassic boundary, the subdivision of the Lower Triassic and the problem of the status of the Rhaetian. Especially with respect to the Rhaetian controversy, ALBERTIANA still serves as a platform for animated discussion (see contributions in the present issue). In addition, initiatives are now being developed to concentrate part of the STS activities on other Triassic stages and stage boundaries. ALBERTIANA awaits your contributions !



MEETING OF THE SUBCOMMISSION ON TRIASSIC STRATIGRAPHY

Washington DC, July 12, 1989

The meeting was held at the Convention Center, during the 28th International Geological Congress, with A. Baud as Chairman of the Subcommittee. The agenda was the following.

- 1 - Presentation of the New Bureau.
- 2 - Membership: voting and non-voting members.
- 3 - Past activities of the STS and working groups.
- 4 - Planned activities of the STS. Nomenclature (stage names). Boundaries (boundaries of Middle and Late Triassic). Time Scales. Collaboration with other institutions and working groups.
- 5 - Planned activities of the P/T boundary working group and joint meeting with the Subcommittee on Permian Stratigraphy.
- 6 - Next meeting: proposals.
- 7 - Other suggestions and free discussion.

1. The chairman introduces the new Board, as resulted from the poll between the STS voting members. Carmina VIRGILI, Madrid, acts as Past-president, Aymon BAUD, Lausanne as Chairman, Tim TOZER, Ottawa, Algyrdas DAGYS, Vilnius, and Maurizio GAETANI, Milano, as Vice-chairmen, Henk VISSCHER, Utrecht as Secretary.

2. The chairman reads the list of voting and corresponding members, as was prepared by the past Board. In the Discussion, it was formally asked to include amongst voting members also stratigraphers of continental deposits. He suggests M. Morales, (Flagstaff, Arizona), M.A. Shiskin (Moscow) and S.G. Lucas (Albuquerque, New Mexico).

3. The chairman lists the official meetings of the STS held in the past 5 years. They were: Moscow 1984, dedicated to the problems of Rhaetian and Early Jurassic. Field-meeting in Turkey, 1986. Field-meeting in China, 1987. Lyon 1988 meeting on the Rhaetian, together with the WG on the Triassic/Jurassic boundary. Also the Early Triassic was debated.

4. The chairman introduces the problems still facing the STS, i.e. the stage nomenclature for the Early Triassic, a final decision on the Rhaetian (stage or substage), and a definition of the lower boundary for Middle and Late Triassic.

4A. *Subdivision of the Early Triassic.* The chairman remembers the existence of four different proposals, i.e. a single stage (Scythian), two stages (Induan and Olenekian), three stages (Griesbachian, Nammalian, Spathian), four stages (Griesbachian, Smithian, Dienerian, Spathian). J. Remane, Neuchâtel, explains the origin of the "yellow scale" prepared by Cowie and Remane in the ICS, with the aim to have "at the moment best solution". Krystyn, considers the Tozer scale on the Arctic the better established. However, the low faunal diversity in the Arctic causes problems with correlations to the Tethys. A lot of work is still to be done.

4B. *Other stage subdivisions*. J. Remane recommends to focus the work on the stage boundaries. Baud confirms that this will be one of the targets of the STS.

4C. *Rhaetian*. Krystyn introduces the new results obtained in the Kössen and Zlambach areas by Golebiowski and himself. It is possible to distinguish two ammonite zones, each of them with two subzones. Also other fossils, like conodonts, brachiopods and bivalves are considered. He claims the existence of a true possibility to identify a chronostratigraphic subdivision, the rank of which, stage or substage, is a matter of convention. Baud and Tozer congratulate Krystyn with this improvement.

5. Tozer, as chairman of the P/T WG, reports on past activities, especially the most recent visit to the Selung section in South Tibet, reported also in Episodes, v. 11, n. 3, September 1988. He prepared a memorandum on the P/T boundary on which two comments from Newell and Sweet were received. Dickins, Canberra, on behalf of the Permian Subcommittee says that the Kashmir sequence should be favoured more than the Chinese sections. Baud reads a letter from Newell, who reinforces his statement that *Otoceras* has a Permian character and that the base of the Triassic should be drawn where new genera make their mass-appearance, i.e. at the base of the *Gyronites* Zone. Sweet, Columbus, remembers that the WG agreed in considering the base of the Triassic at the base of the *Otoceras* Zone, and he stresses the fact that the base of the Triassic should be defined and not be equated with the end of the Permian. Sweet illustrates also the correlation based the method of graphic correlations. Kozur considers the Kashmir sequence not fully suitable because of the possible presence of a gap, the span of which is unknown, at the top of the Permian. A very lively discussion follows between Sweet, Kozur, Tozer and Glenister. A very interesting contribution is given by M. Steiner, who demonstrates that the base of the Triassic as measured on Tozer's Arctic sections is characterized by a normal interval. No final decisions are taken.

6. No proposals have been made for the next meeting.

7. Morales announces his intention to propose a new IGCP Project: "Global Correlations on the Continental Triassic".

The Meeting is closed at 10.00 p.m.

M. Gaetani (as secretary) and A. Baud

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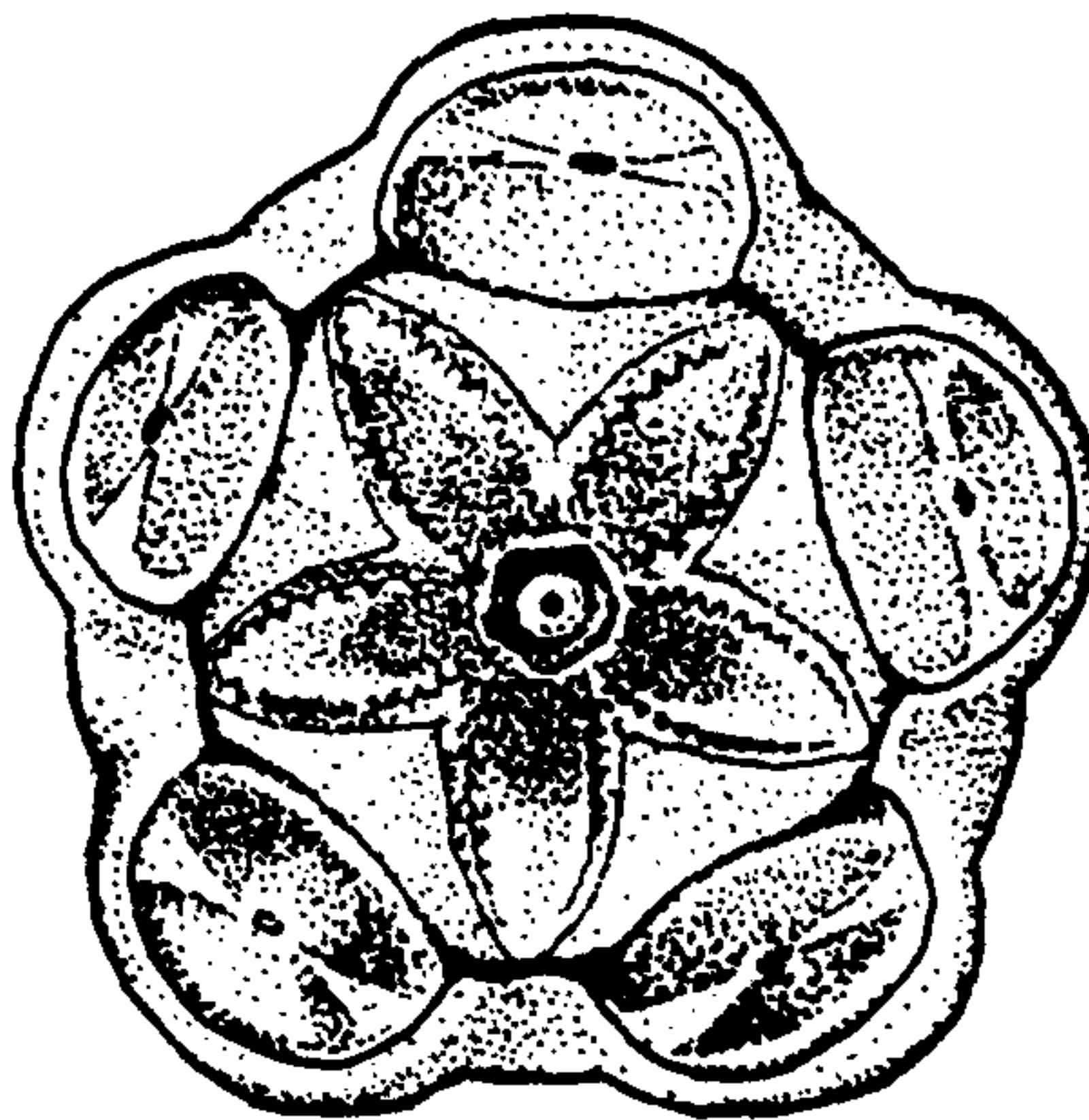
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IGCP 272 - LATE PALEOZOIC AND EARLY MESOZOIC CIRCUM-PACIFIC EVENTS**AUSTRALIAN AND NEW ZEALAND MEETING****J.M. Dickins - Project Leader****Newcastle, NSW, 30/1/90-2/2/90**

This part of the meeting was attended by 10 scientists from Australia, USSR, China and Thailand. It comprised three days field activities and one day discussion. The field geology was shown to us by Professors B.A. Engel and C.F.K. Diessel and Dr. Noreen Morris of the Department of Geology of the University of Newcastle. Examination was made of the Carboniferous sequence in the southern part of the New England Fold Belt. A variety of sedimentary types from shallow to deep water were seen, composed predominantly of intermediate and acidic detritus and including much pyroclastic volcanic material. The rocks are very different in appearance from the Permian. Various Lower and Upper Permian localities were examined and considerable time spent on the Newcastle Coal Measures, illustrating their tectonic and volcanic provenance. Main features of interest to the project were the major regression of the Upper Carboniferous and the Lower Permian, the character of the sedimentary changes and the tectonic activity at the boundary of the Lower and Upper Permian and the Permian-Triassic boundary sequence. Formal papers were held over until the New Zealand meeting.

New Zealand, 9/2/90-14/2/90

The group with the exception of the Newcastle University scientists moved on to New Zealand. A formal scientific and business meeting was held in association with the International Brachiopod Congress and sponsored by the University of Otago on the 9th February 1990. This meeting was attended by eighteen scientists from twelve countries from different parts of the Circum-Pacific region. Formal papers given at this meeting are to be published. In addition to the meeting already proposed for the project, a meeting in Thailand, probably in 1991, was discussed and plans put in hand. In addition, a meeting in the Soviet Far East is being considered.

IGCP participants then took part in the Southland excursion, 10th-14th September with Drs J.D. Campbell, H.J. Campbell and D.A.B. MacFarlan as leaders. Features of interest to the project included examination of the Upper Permian and its possible relationships with the Lower Permian, the Middle and Upper Triassic sequences and their relationships with Jurassic. Marked changes, apparently, associated with the ophiolites, occur in the Mid-Permian. The nature of the Permian to Triassic boundary sequences remains obscure. Important events are associated with the Triassic-Jurassic boundary.

RHAETIAN RECONCILIATION

Derek V. Ager

I am sorry if somewhat light-hearted remarks about the Rhaetian have irritated some people, but I believe - as Oscar Wilde might have said: "Geology is too important a matter to take it seriously". That's why I said that it was all good clean fun. But when I used terms such as "ridiculous" I meant it. Thus saying that there was a bit of Norian at the top of the Rhaetian is like saying that there is a little bit of Tuesday at the end of Wednesday. Norian and Rhaetian are sequential time-rock terms and cannot, by definition overlap. There can be no overlaps or gaps in time.

Tim Tozer seems to believe that there is some absolute truth about stages and sub-stages. But there were no fanfares of heavenly trumpets. I cannot accept arguments that "this is a stage" and "this is a sub-stage". These terms are merely words invented by man for his own convenience. The one criterion I use for all these things is one of usefulness. In this case if I use the term "Rhaetian" to almost any geologist world wide, then even the hardest rock types among them will know roughly what I mean. On the other hand if I use the term "Sevatian" or "Upper Norian" or worse still "Upper Upper Norian", a glazed look is likely to come into his crystal eye and lack of understanding will be complete.

I do not like stratotypes. It is very rare for one section to represent a whole unit such as a "stage". I remember when the international arguments got rather lively about this, that we challenged a French stratigrapher to define a stratotype, since they are very popular in Gallic lands. He thought for a moment and then said, sacrilegiously, "it is a fragment of the true cross". That is a very good definition, the critical word being "fragment". I know of no stratotype, indicated by a "golden spike" if possible and defining the base of the unit concerned. Anything found thereafter, below the "golden spike", automatically goes into the unit below.

So far we seem reasonably in agreement. The practical side of the approach is a much more difficult matter. We will never find a section representing all, or even many, of the stratigraphical units preserved one above the other. Even a super Grand Canyon with incredible thicknesses of sediment will not do that. The present one has huge gaps in the succession.

So far as Tozer's question "How many Rhaetians?" is concerned, I would say that I do not know of any stratigraphical junction anywhere on earth about which there have never been uncertainties or arguments. That goes for the Precambrian-Cambrian junction and it goes for the base of the Quaternary. Would one expect anything else? In the strata I worked on first and with which I am most familiar, I know of Toarcian ammonites in the top beds of the Pliensbachian and Pliensbachian brachiopods in the base of the Toarcian. If we believe in evolution this is inevitable. We cannot expect new forms to appear without mothers and fathers! If Tozer is telling us that ammonites must have priority over everything else, then surely he must concede that in the absence of ammonites we must use other forms. In fact he admits himself that the brachiopod fauna of the Rhaetian is distinctive.

What exactly are we arguing about? We both say that the Rhaetian brachiopod fauna is distinctive, so why cannot we recognize it as such? Tozer seems to be saying that we cannot do this because it

does not fit with a mystic concept of a "stage" which has some abstract reality. We seem almost close to agreement about the Kössener Schichten as some kind of stratotype, but Tozer objects in that it "does not permit placing the Rhaetian base in the Triassic zonal hierarchy". May I suggest that we accept the base of the Kössener Schichten as the boundary stratotype of the Rhaetian? I deliberately say "Rhaetian" rather than "Rhaetian-Norian" as I am a firm believer in boundary stratotypes to define the base of units (what has been called "topless" approach to stratigraphy). We should not concern ourselves with what lies below. Then we can get on with our real business, that is geology, and not waste our time on what is merely semantics?

Tozer places great faith in his sections in the American west. It so happens that I have recently been studying further collections made by George Stanley of the University of Montana from the Luning Formation of south-west Nevada. We hope to publish a paper on these shortly. They include forms such as *Rhaetina* cf. *gregaria* (Suess), *Zugmayerella uncinata* (Schafthautl) and *Austrirhynchia?* sp. which are characteristic of the Rhaetian and other forms which are longer ranging, but I was influenced particularly by the absence of typically Norian forms such as *Halorella* which are found almost world-wide, including Cordilleran North America. I cannot pretend to know the relevant sections in the far west, but from what I have seen of them (thanks to the guidance of a graduate student, Andrew Arthur of the University of Vancouver) and from what I have seen in the literature, most of the successions would seem to be in what we would call a "boreal" facies, with thick shale sequences and lacking much in the way of carbonates, which we would associate with the "Tethyan" facies and the south. I know very well that there are typically "Tethyan" forms in this part of the world (*Halorella* for example) and I wonder if our disagreement is no more than a contrast in facies, with the migration of forms in both directions.

However, I might point out in conclusion that by far the greatest part of the stratigraphical column does not have the benefit (?honour) of ammonite zonation? In the absence of ammonites in particular successions, one can say "hard luck" and suggest that we turn to ? humbler creatures such as brachiopods, conodonts, spores or what have you. I have never pushed brachiopods as good stratigraphical material (that is not why I study them) but I can line them up with ammonites down to "stage" level, sometimes to "substages" and sometimes even to ammonite biozones. The Rhaetian fauna happens to be a distinctive one, which I got involved in this argument, but please let us be excused the dogmatism about what is what is not a "stage".

HOW MANY RHAETIANS?

E.T. Tozer

Abstract

The classical definition for the Rhaetian, founded on the Koessen beds, does not permit placing the Rhaetian base in the Triassic zonal hierarchy. By using the Koessen as a stratotype it is impossible to define a Norian-Rhaetian boundary. In addition to the Koessen stratotype definition there are at least three others. These are defined in terms of standard zones. One certainly has a lesser scope than classical Rhaetian. The relationship of the other two to the Koessen stratotype is uncertain.

It is still recommended that Rhaetian be accepted as originally defined, and ranked as a provincial substage of the Norian, useful only for expressing relatively imprecise correlation of the Alpine and Extra-Alpine Triassic rocks of western Europe. This Rhaetian has no place in the hierarchy of international Triassic stages.

The debate on the Rhaetian prompted by Professor Ager's article (Ager, 1987) continues (Tozer, 1988). Ager defended Rhaetian as the ultimate Triassic stage, younger than the Norian. He continues to do so (Ager, 1988), claiming that Rhaetian is a useful, meaningful uppermost Triassic stage. I have repeatedly insisted that Rhaetian defined by the Koessen Formation, the classical definition, lacks the attributes of a recognizable world-wide stage. The essential attribute for any chronostratigraphic division is a base that can be recognized far afield. This is not provided by the Koessen. This definition does not place a Norian-Rhaetian boundary in a sequence of standard zones, the prerequisite for defining a boundary of more than local or provincial significance. Also, it has long been known that the time span of the Norian overlaps that of the classical Rhaetian, but the extent of this overlap is unknown. The situation is not nearly as straightforward as Ager seems to think. It is necessary to continue the discussion.

Ager was shown the MS of my article and replied in the same issue of "Albertiana" (Ager, 1988). I did not see Ager's reply until it was published so my rejoinder has had to wait.

Ager regards the problem as "good clean fun" and my suggestion that Rhaetian be ranked as a substage instead of a stage as ridiculous. To specialists concerned with Triassic biochronology it is not a funny matter. A few words below will counter his charge that my suggestion is ridiculous.

Some of Ager's remarks make me wonder if he really understands the nature of the problem.

First: "It is nonsense ... to say that we have Norian above the Rhaetian". Here Ager seems to be referring to what I described as the Norian-Rhaetian-Norian sandwich (Tozer, 1988, p.13). This was my description of the highly significant relationship documented by A.S. Dagys in the Caucasus, where Norian ammonoids are found stratigraphically above Rhaetian brachiopods. This is an important relationship which must be accommodated in our biochronological system. It indicates that Norian and Rhaetian faunas are intimately associated and can be justifiably regarded as representing one and the same stage. It cannot be swept away as nonsense.

Second: "Of course the Rhaetian is wholly younger than the Rhaetian if we define it as such. I would drive in a spike at the bottom of the Koessener Schichten or whatever level might be agreed internationally. We can then say that everything above this and its correlatives is by definition Rhaetian until we come to the next golden spike ... marking the base of the Hettangian". I agree with the "golden spike" approach. But a golden spike is only useful if it is placed at a level where a fauna of bio-chronological significance appears. In his first article Ager considered that the base of the Koessen met this requirement. He seemed to think that a Rhaetian Stage defined in this way is an "easily recognizable ... useful division at the top of the Triassic" (Ager, 1987, p.4). The Koessen base marks the appearance of the *Rhaetavicula contorta* fauna and as such permits at least an approximate correlation with the Extra-Alpine Rhaetian beds. But the Koessen **base does** not mark the appearance of a fauna that can be applied to the definition of recognition of a Norian-Rhaetian boundary.

For the Upper Triassic there is a sequence of standard zones in North America based on simple uncontroversial stratigraphy with faunas that permit the recognition of correlatives world-wide. When considering the interval between the start of the Norian and the end of the Triassic this zonal sequence is better documented than any other and provides the best chronology to cover the whole of the late and latest Triassic (Table I, column 1). Columns 2-5 of Table I illustrate most of the recent Rhaetian proposals and interpretations and their relationship to the North American standard zones. In column 1 there is no Rhaetian. In column 2, Norian is the ultimate Triassic stage, with Rhaetian as a substage. This was the only scheme acceptable to all five authors in Wiedmann et al., (1979). It shows that some European authors agree with my proposal that the Norian should be considered the ultimate Triassic stage. The Table also shows that Krystyn, Tollmann and Dagys advocate three different scopes for the Rhaetian. In this table the comparisons are made at the level of standard zones, the only level at which golden spikes can be really useful. These three Rhaetians can be interpreted in relation to the Norian because they are related to zonal schemes. Where is the classical Rhaetian, defined by the Koessen beds and favored by Ager? It is not there. Why? Because its position cannot be expressed in terms of standard zones. It is **probably** about equal to Tollmann's Rhaet Stage (column 4) and the Rhaet Substage of Wiedmann et al. (1979) (column 2), but this cannot be proved. This is not just my opinion. It is also that of most specialists on marine Triassic faunas, and is clearly expressed by Krystyn (1988). Forgive the repetition, but it must be stressed again that the base of the Koessen Formation is a useless level for a golden spike to define a Norian-Rhaetian boundary. This is why the Koessen based Rhaetian cannot be accurately placed in the Table.

Table I, with three Rhaetians, provides more detail than I gave in my previous article, which mentioned only two (s.s. and s.l.). The three Rhaetians defined in terms of standard zones form a basis for accurate comparisons. But objections can be levelled at all three. The scope advocated by Krystyn (column 3), is based on ammonoid biochronology in the Zlambach beds. It has the advantage of being properly defined but the disadvantage, in his own interpretation, of excluding the Schwaebische Facies of the Koessen (i.e. the *Rhaetavicula contorta* beds). This is not likely to be acceptable to those working with the Extra-Alpine *Rhaetavicula contorta* beds that lie below the Hettangian (Figure 1). The Dagys scope (column 4) necessitates inclusion of the Zlambach *Cochloceras* marl in the Rhaetian. The Tollmann scope (column 4) would include the world-wide *Monotis* beds. Until now the *Cochloceras* and *Monotis* beds have always been regarded as Norian and so should be.

1			2			3			4			5		
Tozer, 1979, 1980, 1984			Wiedmann et al. 1979 (compromise)			Krystyn, 1980, 1988			Tollmann, 1985			Dagys. 1988		
Stage	Substage	Zone	NORIAN			Stage	Substage	Zone	Stage	Substage	Zone	Stage	Substage	Zone
			LOWER NORIAN	MIDDLE NORIAN	UPPER NORIAN									
		Kerri						Jandianus						
		Dawsoni						Paulckeï						
		Magnus						Magnus						
		Rutherfordi						Bicrenatus						
		Columbianus						Hogarti						
		Cordilleranus						Macer						
		Amoenum												
		Crickmayi												

Ager insists that Rhaetian is useful and that it "means what I choose (it) to mean". He is living in a paradise with his useful, meaningful Rhaetian. But is Rhaetian useful to anybody if it means one thing to Ager, another to Krystyn, and has yet other meanings for Tollmann and Dagys?

I still maintain that a Rhaetian, even with an adequate, agreed upon definition, is unnecessary in the international stratigraphic hierarchy. Even if considered necessary it is impossible to accommodate a Rhaetian Stage ranked with and placed above the Norian, as Ager would have it. without an agreed Norian-Rhaetian boundary defined by a standard zone. Ager finds my emphasis on rank ridiculous but I suggest in making this judgement *ex cathedra* he reveals that he does not understand the problem.

I consider that Rhaetian is best accepted as originally defined, i.e. by the Koessen beds. This is Ager's preference. As such it is a provincial substage of the Norian, which includes the youngest beds of that stage (Silberling and Nichols, 1988). Although this Rhaetian is a chronostratigraphic division with an imprecisely defined base it remains useful, but only for expressing the rough correlation of beds between Alpine and Extra-Alpine Europe. But owing to the imprecision of its base it has no place in an international stratigraphic hierarchy.

The debate will probably continue but let it be a serious attempt from informed contributors striving to accommodate all the data and address all the problems. Let us have no more *ex cathedra* pontification.

To readers of my previous article I wish to apologize for an error. Line 11 from bottom, page 12 (Tozer, 1988, p. 12) should read "Both the Lower and **Middle** Members contain typical Upper Norian ammonoids."

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Krystyn, L., 1988. Zur Rhät-Stratigraphie in den Zlambach-Schichten (vorläufiger Bericht). Sitz.-Ber. Öster. Akad. Wiss., Math.-naturwiss. Kl., Abt. I, Bd. 196(1/4): 21-36.



Fig. 1.

Triassic schoolmaster: Bad boy! Do you realise what you have done? You have treated the *Contorta* beds as Norian! The beating I will administer will prepare you for the wrath of those who have always included the Extra-Alpine *Contorta* beds in the Rhaetian.

A RHAETIAN STAGE - CHRONOSTRATIGRAPHY, SUBDIVISIONS AND THEIR INTERCONTINENTAL CORRELATION

L. Krystyn

With respect to the Mesozoic stratigraphic procedure and not because of the "tyranny of ammonoids" (Ager, 1987), a Rhaetian stage is only justified and to be correlatable if it is defined at least at its base in an ammonoid-bearing facies of LPL or MPL position (sensu Tozer, 1982b). This cannot be provided by the Alpine Koessen Formation which starts with shallow-water beds above the inter- to subtidal lagoon of the Plattenkalk Formation (Golebiowski, 1986). Since time-stratigraphic significant fossil groups are missing in the latter, the Koessen base as the stratotype or "golden spike" level for the base of the Rhaetian (Tollmann, 1985; Ager, 1987) is completely meaningless. In this I fully agree with Tozer (this volume).

Within the Alps - the type area of all Upper Triassic stages - only the Hallstatt facies can fulfill the above required task. Here, topmost Upper Norian beds with *Cochloceras* and *Epidondolella bidentata* are followed by about 150 m of basinal sediments with ammonoids, pelagic bivalves and conodonts (Krystyn, 1988), but also with rich faunas of foraminifers (Kristan-Tollmann, 1960) and ostracods (Bolz, 1971) as well as a sparse but distinct nannoflora (Moshkovitz, 1982). On the basis of their choristoceratid ammonites, this sequence has been subdivided into two successive zones named for *Vandaites stuerzenbaumi* and *Choristoceras marshi*. Since the two units are recognizable within the Tethys as well as in North and South America (Fig. 1), they are ranked as standard zones and may serve as a biochronological Rhaetian standard. Additional choristoceratids allow a twofold subzonal division of each zone. The established sub-units in ascending order are called *Haueri* and *Stuerzenbaumi* subzones for the *Stuerzenbaumi* zone, *Ammonitiforme* and *Marshi* subzones for the *Marshi* zone. The subzones are defined at their base by the FOD of its guides and seem to correspond closely to range zones. The base (= beginning) of the Rhaetian is by this proposal defined by the first occurrence of "*Choristoceras haueri*" with a reference section in the Hallstatt region (Salzkammergut) near Bad Goisern (Kleiner Zlambachgraben; Rossmoosgraben).

In the Hallstatt facies this boundary can be further correlated by other groups such as conodonts (LOD of *Epigondolella bidentata*, FOD of *Misikella rhaetica* and *M. koessenensis*) and by pelagic bivalves (LOD of *Monotis salinaria*, FOD of alpine *Otapiria*), and is additionally marked by the LOD of *Heterastridium*. Mojsisovics (1869) has defined the Norian stage on the basis of the "Schichtgruppe des *Ammonites metternichi*" of the Alpine Hallstatt Limestone. This level is now known as a correlative of the *Cochloceras* fauna which for a long time served as the topmost Norian ammonoid standard and would remain in this position in the future too. The Norian-Rhaetian boundary as here defined, has also been used for a long time with conodonts. The importance of this group for detailed correlations across the boundary interval has just recently been underlined (Golebiowski, 1986; Krystyn, 1988).

The following chapters will deal firstly with worldwide correlatives of the new Rhaetian zonal classification in ammonoid-bearing environments, and secondly with the question of the Norian-Rhaetian mixed faunas, i.e. the "Norian-Rhaetian sandwiches" of Tozer (1988). The role of benthic

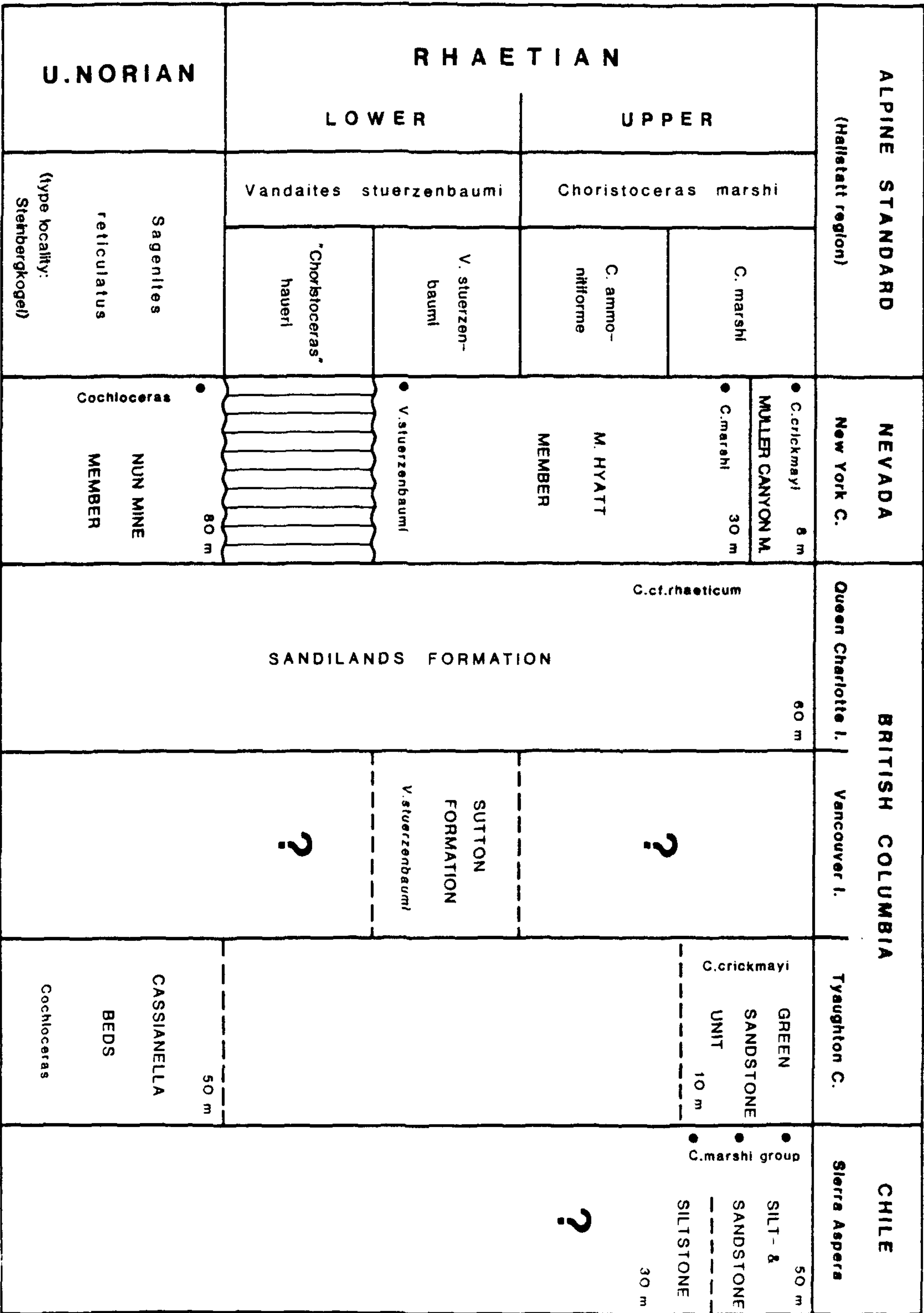


Fig. 1

invertebrate fossil groups for recognizing the Norian-Rhaetian boundary within the Alpine top-Triassic shallow-water sequences (Koessen) is discussed in detail by Golebiowski (this volume). Depending on a sequence stratigraphic approach, he offers very logic arguments for a diachrony of the "Contorta Beds" and their chronostratigraphic classification as partly Norian (Alpine) and partly Rhaetian (Northwestern Europe). This strongly contrasts with the picture drawn by E.T. Tozer who, mistakenly has come to the conclusion that I want to classify the Swabian Facies (the biofacial expression of the *Contorta* Beds) everywhere as contemporaneous and as Norian based on the new conodont data from the Swabian facies of the Koessen Formation (Golebiowski, 1986); seen from the figured cartoon in this volume obviously a question of prime importance for him.

Worldwide Correlations

Before proposing a faunal sequence as a global standard, certain requirements should be met. One of the other prerequisites should be its worldwide recognition in adequate facies, e.g. in basinal sediments of low and middle palaeolatitude (*sensu* Tozer, 1982b). Unfortunately, due to the regressive trend of the final Triassic, such rocks are not common; they are missing in cratonic areas and are restricted to the relatively narrow mobile zones of the Tethys and the Americas.

Detailed sequential data are practically lacking for major parts of the Central (Nayband, Iran) and Eastern Tethys (Timor). A different situation is present in its Northern parts. For example, sections containing rich brachiopod and ammonoid faunas are known from the Caucasus and the Pamyr (Dagys, 1983). The latter, however, are dominated by leiostraceans (such as are arestids), whereas short-lived biochronologically significant choristoceratids are missing. There, the Norian-Rhaetian boundary may, only and very tentatively, be drawn above the LOD of *Pinoceras*. This date should further be supported by the LOD of the widespread hydrozoan genus *Heterastridium* and by the study of, the until now undescribed, conodont faunas. Of further stratigraphic significance might be the range of the bivalve genus *Indopecten* hitherto known from Norian rocks only. A much better situation is recorded from North America with several instructive sections in Nevada as well as in British Columbia (see Tozer, 1988) and from South America with a newly described sequence in Chile (Chong and Hillebrandt, 1985).

As far as known, the New York Canyon section in Nevada has the highest biostratigraphic resolution for the topmost Triassic in North America. A set of the available data has been summarized recently by Tozer (1988) and the reader may be referred to this review. As the section is currently under investigation by D. Taylor from Oregon University, I will restrict myself to items of prime importance for the proposed correlations (see Fig. 1). The new observations are primarily the result of a study of the ammonoid collections made by H.S. Muller in the 1930s and now stored in the U.S. Geological Survey in Denver (Col.); and secondly they are based on field evidence and some samples taken on account of an excursion to New York Canyon in the summer of 1989 guided by Dr. Taylor.

The top-Triassic sequence of the New York Canyon is formed by the Gabbs Formation which is subdivided into three members, a lower or Nun Member, a middle or Mount Hyatt Member and an upper or Muller Canyon Member (Taylor et al., 1983). The Nun Mine contains an undisputed Norian ammonite fauna with *Cochloceras* till at least 5 m below its top, and with Upper Norian conodonts (*Epigondolella bidentata*) right to the top. The medium-bedded rocks are relatively fine-grained wackestones originally formed under calm conditions below the wave base. The Mount Hyatt

Member starts with thick-bedded coarse-grained bioclastic wackestones with densely packed lumachelles of benthic organisms, dominated by bivalves and brachiopods, Laws' (1982) so-called "*Tutcheria* Assoziation". The ammonoid fauna of this level is fairly large and identical with the one published by Muller and Ferguson (1939). Beside a large amount of leiostracan forms, those authors as well as Laws (1982) mention a specifically undetermined *Choristoceras*. According to my studies it is a fairly uncoiled, relatively large species with external nodes, an external furrow on the phragmocone, and with twisted whorls which are roundish in cross section and show a partly ribbed dorsal side. By the last-mentioned features, I feel confident to identify this form with a *Vandaite*s close to or identical with *Vandaite*s *stuerzenbaumi* (Mojs.). Compared with the Alpine standard, the basal Mount Hyatt therefore should represent the upper Lower Rhaetian *Stuerzenbaumi* Subzone with the lowermost part of the Rhaetian (*Haueri* Subzone) missing. The biochronologically indicated gap seems to be supported by the sedimentological parameters. The basal Mount Hyatt has been deposited in agitated water above the wave base and therefore in more shallow water than the under- and overlying rocks. Taylor et al. (1983) also mention a short-termed but well-defined regressive peak in this particular part of the sequence. Another indication of the presumed gap is the possible reworking of older fossils which is pointed out by the unexpected presence of the Upper Norian conodont *Epigondolella bidentata* in the basal Mount Hyatt (Orchard, oral comm.). Finally, Laws' (1982, p. 143) suggestion "that this association may represent a transported assemblage" can be interpreted as further support of the above reached conclusion.

Tozer (1988, p. 12) describes the ammonite fauna of the (basal) Mount Hyatt as typically Upper Norian. This is definitely wrong, but does otherwise explain his latter conclusion that the "genus (i.e. *Choristoceras*) is present both with and above Norian ammonoids". As far as I have learned from worldwide comparisons, *Choristoceras* s.str. is not represented in Norian times and - by further revision - may already turn out to be restricted to the Upper Rhaetian. Tozer's error may have been backed by the reported occurrence of *Pinacoceras metternichi* in Muller and Ferguson's faunal list. The presence of this genus (and species) would, by comparison with the Tethyan data, indeed point to an Upper Norian age. I could, however, identify *Pinacoceras metternichi* neither in Muller's original collection nor in within the newly collected rich material of Taylor. The upper part of the Mount Hyatt Member is according to D. Taylor relatively rare in ammonoids. In Taylor's collection I have seen only one well preserved *Choristoceras* which has been collected by Laws in the top part of the member. This specimen seems, by its long lasting ammonoid coiling and by the incised lateral lobe, conspecific with *Choristoceras marshi*. Within the Muller Canyon Member a distinct *Choristoceras* level is equally described by Muller and Ferguson (1939), Guex (1982) and Laws (1982) containing flattened specimens of the *Choristoceras marshi/crickmayi* group. This level is definitely top Rhaetian and I obviously was wrong when I denied its presence in North America (Krystyn, 1980, p. 75). About one meter above, the first psiloceratid ammonites occur, thus underlining the importance of the New York Canyon as a candidate for the reference section for the Triassic/Jurassic boundary.

Thanks to the work of H.L. McLearn and especially E.T. Tozer, British Columbia has produced a world famous Triassic faunal record including the world's most complete Norian ammonoid succession. On the contrary, topmost Triassic faunas are rare and poor all over the area for several reasons. One is the drastic facies change by the spread of terrigenous and clastic sediments over the former carbonate-rich basin rocks (Pardonet Formation etc.). The other one may be seen in a widespread pre-Liassic regression and hiatus in major parts of British Columbia as has been described by Tozer (1982a). It may therefore not be surprising to find that all sections described

U.NORIAN	RHAETIAN
SAGENITES RETICULATUS	VANDAITES STUERZENBAUMI
	CHORISTOCERAS MARSHI
<i>Pinacoceras</i>	
	<i>Placites</i>
	<i>Arcestes</i> , <i>Stenarcestes</i>
	<i>Cladiscites</i> , <i>Paracladiscites</i>
	<i>Megaphyllites</i>
	<i>Rhacophyllites</i>
	<i>Tragorhacoceras</i> ?
	<i>Rhabdoceras</i>
	<i>Cycloceltites</i> ?

U.NORIAN	RHAETIAN
(Caucasus & Pamyr, DAGYS 1963)	(Koesen F., GOLEBIEWSKI 1986)
MONOTIS BEDS with <i>M. caucasia</i>	VANDAITES STUERZENBAUMI
	CHORISTOCERAS MARSHI
	<i>Zelleria (norica)</i>
	<i>Rhaetina pyriformis</i>
	<i>Rhaetina gregaria</i>
	<i>Sinuocosta (emmrichi)</i>
	<i>Laballa (suessi)</i>
	<i>Zugmayerella</i>
	<i>Oxycolpella (oxycolpos)</i>
	<i>Fissirhynchia (fissicostata)</i>
	<i>Austrirhynchia</i>

Fig. 2 (above) and Fig. 3 (below)

until now, are faunistically or stratigraphically incomplete (see Fig. 1) when compared with the Alpine standard. Two of the three better known British Columbia sections need special attention. The first one is Tyaughton Creek in southern British Columbia, designated as the type locality of the *Crickmayi* Zone by Tozer in 1979. The other one is Cowichane Lake on Vancouver Island containing *Choristoceras suttonense* together with *Rhabdoceras*. *Choristoceras suttonense* was originally interpreted to be older than *Choristoceras crickmayi* by Tozer (1967). Later he changed this view in favour of direct correlation of the two localities because "the close similarities between specimens (of *Choristoceras*) from these two localities is now taken to justify regarding the beds with *Choristoceras suttonense* as correlative with those bearing *C. crickmayi*" (Tozer, 1980, p. 858). This correlation extended the range of *Rhabdoceras* to the top of the Triassic and has caused a 10 year long correlation controversy between Europe (Wiedmann et al., 1979; Krystyn, 1980) and North America (Tozer, 1979, 1980, 1982, 1988) on the exact position of the Crickmayi Zone. In the summer of 1989, I visited E.T. Tozer in Ottawa, and through his help I could study all his choristoceratid material from British Columbia. By this I have come to the conclusion that *Choristoceras suttonense* is not a true *Choristoceras* (Krystyn, 1988) but is a *Vandaite*s, more or less inseparable from *V. stuerzenbaumi*. Hence an age difference of one ammonite zone or at least of one million years is now calculated between the Sutton and the Crickmayi fauna (Fig. 1). Tozer's and to some extent also my 1988 correlation of the two faunas is definitely wrong, but it may explain at least in part Tozer's rejection of a too small-sized Rhaetian stage. Another possible explanation may be seen in the earlier described widespread regression in British Columbia (as in many parts of the world), causing an incomplete or often missing record of topmost Triassic rocks and fossils in Tozer's favourite working area.

A recently and only preliminary described section on Queen Charlotte Island seems to promise the first complete Rhaetian sedimentary record from British Columbia. It consists of about 60 m of sandstones and minor siltstones identified as the Sandilands Formation by Tipper (1989). For the moment, unfortunately, only one ammonoid-bearing level has been found somewhere in the middle of the section containing *Choristoceras* cf. *rhaeticum*. If the identification is correct this would mean an Upper Rhaetian age. There are about 20 m of unfossiliferous rocks below and the Hettangian ammonites are following 25 m above.

Whereas Upper Norian ammonoids from South America have been described long ago (Jaworski, 1921), the first record of their Rhaetian counterparts is fairly young. Chong and Hillebrandt (1985) have found them in close association with Lower Liassic ammonites in a section in northern Chile. They report a sequence of three successive and different *Choristoceras* species overlying *Peripleurites* and *Arcestes* from the Sierra Aspera. All the specimens of figures 1 - 7 in Chong and Hillebrandt (1985) and all the specimens of their plate 1 (except for pl. 1, fig. 4 which is in my opinion too badly preserved) are in my opinion representatives of the *Choristoceras marshi/crickmayi* group and should define the topmost Triassic. The underlying *Peripleurites* may be identical with *Rhabdoceras peruvianum*. Chong and Hillebrandt (1985, p. 195) proposed for the latter a basal Upper Norian age, what would indicate a major break between the two faunal horizons, with topmost Norian and basal Rhaetian missing in the section. Otherwise, *Rhabdoceras peruvianum* as *Rhabdoceras suessi* might be less time-diagnostic and, under the assumption of an uninterrupted sequence at Sierra Aspera, could represent basal Rhaetian too.

Any correlation with the Boreal "Rhaetian" (Days, 1988) is preliminary and extremely uncertain. The fauna of the Siberian Supramonotis Beds is poor in ammonites, lacking all time-diagnostic genera; furthermore conodonts as well as pelagic bivalves seem to be missing. The shelly fauna is practically endemic and also poor. The strong faunal change at the top of the *Monotis* beds (see

Dagys, 1988, p. 6), however, offers the possibility of a sedimentary break either in the top of Norian time or around the Norian-Rhaetian boundary. The same may be true for New Zealand where only the bivalve genus *Otiparia*, if it is identic with the alpine *Otiparia*, (B. Gruber is doubting it; pers. comm.), would allow a distinct correlation of the upper part of the Otiparian with the Alpine Rhaetian (Campbell, 1985).

The "Norian-Rhaetian-Sandwiches"

Under this headline I will refer to the stratigraphic "hamburgers" of Tozer (1988): his Norian-Rhaetian-Norian sandwich from the Caucasus and his Norian-Rhaetian-Norian sandwich from the Koessen beds. Both are stale and not very delicious as many sandwiches. They are used by Tozer (this issue) to express that "Norian and Rhaetian faunas are intimately associated and can be justifiable regarded as representing one and the same stage". I disagree with him in this. A critical re-evaluation (see below) shows example 1 as the result of a rather old-fashioned and, in my mind, inadequate biochronological interpretation; the second case is based on a single long-ranging faunal element without the asserted time-diagnostic relevance.

Concerning the Caucasus sandwich, I doubt very much the Rhaetian age of the middle brachiopod-bearing level. Because it includes the genus *Majkopella* known until now only from Norian deposits, so they are well-dated. On the other hand, the ammonite-based Norian age of the top of the sequence is unrealistic because it bears exclusively stratigraphically insignificant ammonoid genera besides a brachiopod fauna with many elements like *Euxinella*, *Worobievella*, *Pseudoregiteella* etc. (see Dagys, 1963) unknown from Rhaetian beds elsewhere. At best, the Caucasus case may be seen as a fully Norian sequence starting with *Monotis caucasica* overlain by brachiopod-bearing rocks which contain some Koessen ("Rhaetian") forms but otherwise are dominated by many Norian genera never found within the Koessen.

The Rhaetian-Norian-Rhaetian sandwich in the Weißloferbach section (Koessen Formation) is rather theoretical and practically useless in its meaning. The unusual Norian horizon faced by a Rhaetian base and top is determined by the occurrence of *Rhabdoceras suesii* whose long-believed Upper Norian range was extended far into the Rhaetian by Tozer himself in 1979! According to Mostler et al. (1978) there are three levels with *Rhabdoceras* in the section (A22b, A85 and A86), of which at least the two upper ones are definitely dated as Rhaetian by Golebiowski (1986, figs. 3-4) on the basis of *Choristoceras ammonitiforme* and the conodont *Misikella rhaetica*.

I otherwise agree with E.T. Tozer on the close similarity of many Upper Norian and Rhaetian invertebrate faunas if they are viewed only by means of leiostracean ammonites (Fig. 2) or selected brachiopods (Fig. 3). This is a fact and should not be neglected, but for me it does not imply that the "Rhaetian is unnecessary in the international stratigraphic hierarchy" (Tozer, this issue). Triassic leiostracean ammonoids commonly are long-ranging and they extend more or less unchanged through other stage boundaries too as, for example, the Ladinian-Karnian boundary. There is also no doubt that practically all Koessen brachiopod genera with exception of Ager's beloved *Austrirhynchia* do occur in the Norian (see Fig. 3). Again, however, a careful examination of Dagys' 1963 brachiopod monograph shows an overwhelming number of other genera which are unknown from the Alpine Rhaetian and may therefore represent true Norian faunal members in the Caucasus, the Pamir and elsewhere.

Conclusions

If one accepts the necessity of a hierarchical structure of our chronostratigraphic scale, then its basic working unit - the stage - should be formed by more than one zone. To me this is the only significant limitation - an two zones therefore might be regarded as a minimal but sufficient time span for ranking a stratigraphic unit as a stage. Stages may be further subdivided in substages or not. Their use is not mandatory and is obviously a matter of convention as may be seen from a comparison of Triassic and Jurassic subdivisions. Since Mesozoic biochronology is based on ammonite zones, the kind of zones, as used in my contribution, is that of Standard zones sensu Callomon and Donovan which roughly correspond to the Assemblage zones of the Hedberg Code.

By defining the Rhaetian as proposed in this paper, the minimal requirements in the size of a stage are fulfilled. The two discriminated zones have distinct subdivisions, are by their fauna recognizable worldwide and can therefore claim the status of standard zones. Moreover, basically similar subdivisions are indicated by conodonts and are expected to be available in the near future by radiolarians too (Carter et al., 1989). Finally, as has been shown on the preceding pages, Norian and Rhaetian beds may often be distinguished purely on the basis of brachiopod and bivalve faunas if the analysis is done carefully.

Thus, when a corresponding number of Rhaetian "lovers" exist, and this seems to be the case in Western Europe, I am against the further suppression of the Rhaetian stage. This, however, under the condition that no hitherto Norian center pieces like the *Cochloceras* beds and their time equivalents (e.g. *Metternichi* Zone of Mojsosovics) are included. This seemingly new Rhaetian would be of course a short-ranging stage, placed clearly among the shorter ones throughout the Phanerozoic. But does the superstage Norian represent the better alternative? Well, the discussion can go on!

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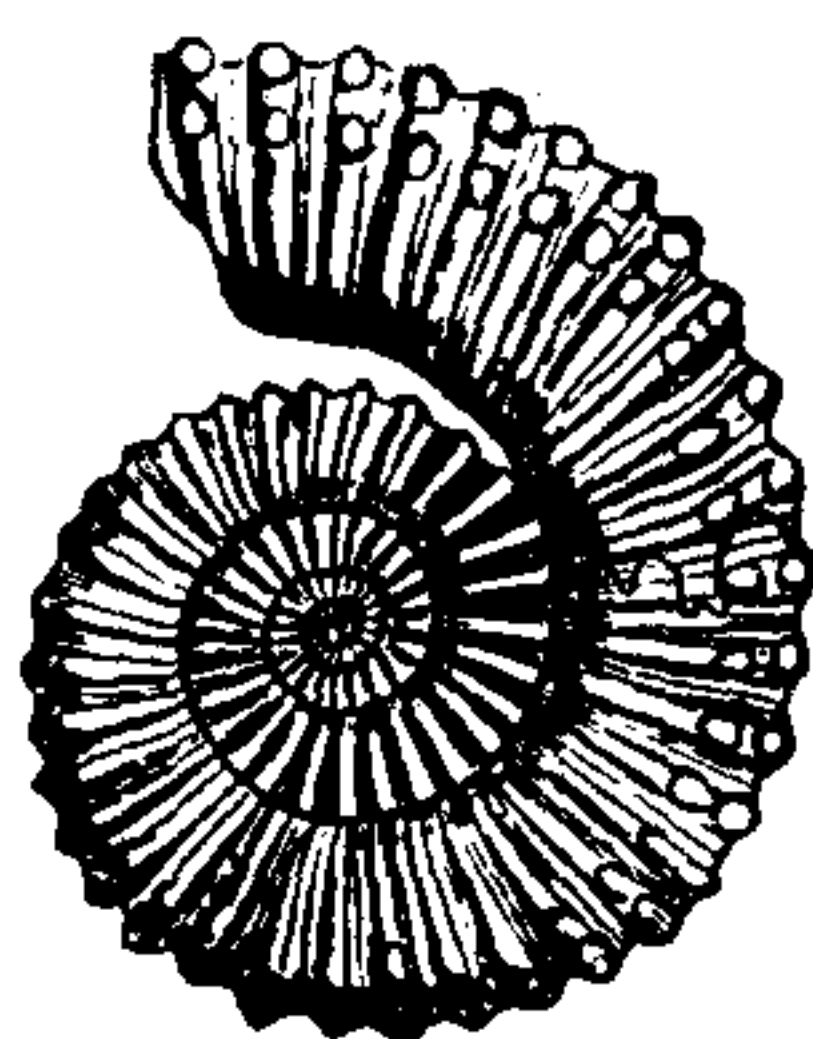
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**THE ALPINE KÖSSEN FORMATION,
A KEY FOR EUROPEAN TOPMOST TRIASSIC CORRELATIONS**
A Sequence- and Ecostratigraphic Contribution to the Norian-Rhaetian Discussion

R. Golebiowski

Introduction

Once upon a time in 1895 Gümbel established the Rhaetian "between the Triassic and Jurassic Formation". More than one hundred years later, Tozer (1967) started the discussion about the Rhaetian stage again. Since Kittl (1903), the unsolved question exists whether or not the Rhaetian is the topmost stage of the Triassic or only a time equivalent facies of the Norian. By considering the stratigraphic relationship between the Norian and the Rhaetian, this is, because the alpine Kössen Formation was originally used as the stratotype of the Rhaetian with the zonal index *Rhaetavicula contorta* (sensu Suess & Mojsisovics, 1868). The discussion continues up to now and the past issues of Albertiana have become a battlefield of the Rhaetian. Ager (1987) defended the Rhaetian as a stage and confessed that he loves the Rhaetian. Tozer (1988, p. 9), however, was afraid that Ager might have been "seduced by the two-faced creature Rhaetian, because love", he argued, "has once more proved blind". Tozer (1988, p. 14) himself created the delicious "Rhaetian-Norian-Rhaetian sandwich", because there exists the Norian *Rhabdoceras suessi* (after the important, but unfortunate discovery of two specimens of *Rhabdoceras* by Wiedmann (1973) in the Weißloferbach section of the Kössen Formation - see Fig. 1) between the so-called Rhaetian *Rhaetavicula contorta* below and the Rhaetian *Choristoceras marshi* in the upper part of the Kössen Formation. Tozer (1988, p. 14), however, knows something even more atrocious. *Austrirhynchia cornigera*, according to Pearson (1970, 1977) and Ager (1987, p. 8), the only diagnostic Rhaetian brachiopod, now occurs together with *Rhabdoceras suessi*. Tozer is really upset to see "the most distinctive Rhaetian brachiopod in bed with a Norian *Rhabdoceras*!".

Now let us stop the Norian-Rhaetian soap opera (otherwise our Rhaetian mistress will take an active part in a popular TV series) and talk seriously.

Besides the Norian-Rhaetian sections of the Hallstatt Region (Krystyn, 1988 and this volume) or of North America (e.g. New York Canyon, Muller and Ferguson, 1939; Silberling and Tozer, 1968; Hallam, 1981; Laws, 1982; Taylor et al., 1983) the Kössen Formation is also provided with new facts, which contribute to the recent discussion.

Though the Kössen Formation has been studied for more than one hundred years, only local data based on isolated sections or individual animal groups were considered (Urlichs, 1972; Wiedmann, 1973; Kozur and Mock, 1974; Morbey, 1975; Pearson, 1977; Mostler et al., 1978; Gazdzicki et al., 1979; Krystyn, 1980). It was, and still is however, impossible to subdivide the Kössen Formation using only biostratigraphic methods, because of the high diversity of facies, due to the varying

The Kössen Formation is subdivided lithostratigraphically into a lower Hochalm Member and an upper Eiberg Member. Both members are additionally subdivided into four units each. The Hochalm Member, following shallow water carbonates (Hauptdolomit and "Plattenkalk" or Dachstein Limestone), represents a partly restricted, bivalve dominated shallow water environment with rhythmic transgressive/regressive cycles (shallowing upward cycles comparable to the German Muschelkalk, Aigner, 1985). Shales, partly laminated mudstones and storm-generated lumachelles alternate with horizons of shallow-water carbonates (comparable to the lithofacies of "Plattenkalk" and Dachstein Limestone) yielding frame-building organisms and ecologically adapted foraminifera (*Aulotortus* div. sp., *Triasina hantkeni* - Kuss, 1983). In the basal part of the Hochalm Member (Unit 1) eurytrophic bivalve species characterise a high-stress environment (*Placunopsis* - *Bakevella* biofacies). Higher up (Unit 2), the diversity of infaunal and especially epifaunal bivalve species increases (*Gervillia-Atreta* biofacies). In addition to *Rhaetavicula contorta* there exists a monospecific brachiopod fauna of *Rhaetina gregaria*. In spite of this unique brachiopod species, the other faunal elements represent the Swabian Facies (in the sense of biofacies).

The succeeding transgressive trend of the Hochalm Member is displayed by the lack of tempestites and shallow water carbonates in the upper third part (Units 3-4). During the lithostratigraphic period of Unit 3, a far-reaching transgressive event takes place. At the southern rim of the sedimentary area, terrigenous and bioclastic sediments of the Kössen Formation intercalate the Dachstein Limestone and trace an important sequence stratigraphic marker. The lithofacial change of Unit 3 is subsequently indicated by a significant change of the biofacies. Rhynchonellid and spiriferid (*Austirhynchia cornigera* and *Zugmayerella* div. sp.) as well as terebratulid brachiopods, forming the *Zugmayerella* biofacies, occur jointly with a modified bivalve assemblage (*Pleuromya* biofacies). In terms of biofacies, this faunal assemblage is now designated as the Carpathian Facies of the alpine Kössen Formation. In the sense of Suess and Mojsisovics (1868) the Swabian, Carpathian and Koessen Facies are biofacial terms and have no lithofacial, furthermore also no lithostratigraphic value.

The Hochalm Member is terminated by a nearly monospecific coral limestone with a micritic matrix (Kuss, 1983). This conspicuous horizon (Unit 4) of coral limestone ("Hauptlithodendronkalk" - Suess and Mojsisovics, 1868) has been deposited below the wave base. It is the most useful lithostratigraphic marker bed within the Kössen Formation and can be traced about 300 km in the approximately E-W striking basin.

The Eiberg Member represents an E-W striking intraplatform basin rimmed by carbonate platforms in the south (Dachstein Limestone) as well as in the north ("Oberhät" Limestone - Fabricius, 1966). The basal unit (Unit 1) and the topmost beds (Unit 4) of the Eiberg Member consist of bioclastic limestones rich in echinoderm detritus. The Units 2-3 are dominated by alternating shales and mudstones. Due to its basinal facies, the Eiberg Member is comparatively rich in relevant biostratigraphic dates of ammonites - *Choristoceras ammonitiforme* and *Ch. marshi* - and conodonts - *Misikella* div. sp. (Golebiowski, 1986), see Fig. 1. Compared with the Hochalm Member, the bivalve assemblage (*Oxytoma* biofacies) of the intraplatform basin is qualitatively and quantitatively poor. Contrary to the bivalve biofacies, the brachiopod fauna is diverse yielding terebratulids as well as spiriferids and rhynchonellids (*Oxycolpella* biofacies). The biofacies of the Eiberg Member, characterized by brachiopods, ammonites and only a few bivalve species, is comprehensively designated as the Koessen Facies. The Salzburg Facies (sensu Suess and Mojsisovics, 1868) has been eliminated (sensu Urlichs, 1972), because this biofacies is only distinguished in the Osterhorn Mountains. It is not present elsewhere.

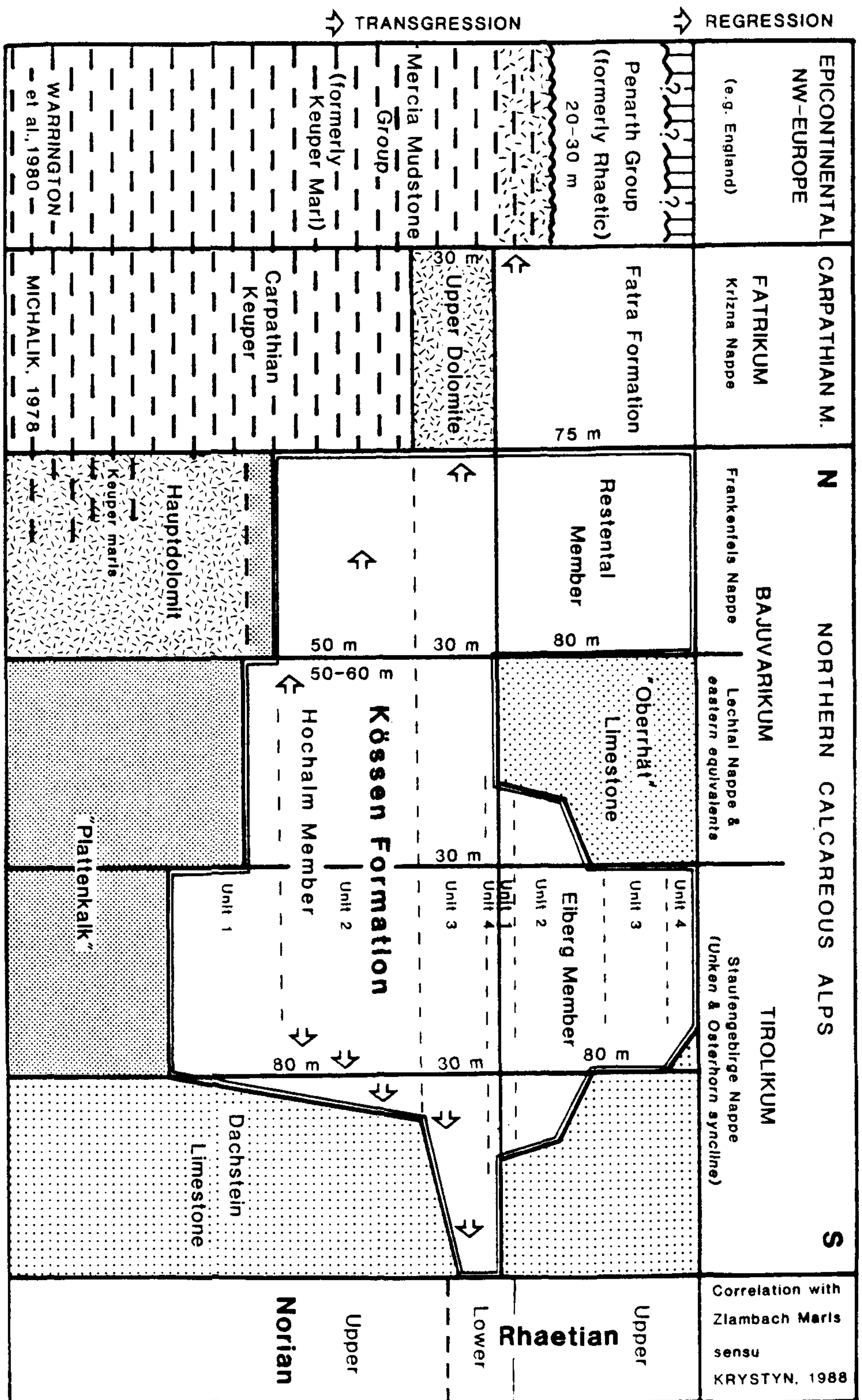


Fig. 2

This brief survey of lithostratigraphy and facies of the alpine Kössen Formation is applicable to the sections which are located in the tectonic units of the Tirolikum (Staufengebirge Nappe, e.g. Unken or Osterhorn Syncline) and the Bajuvarikum (Lechtal Nappe and eastern equivalents), A different (Frankenfeld Nappe and most probably Allgäu Nappe) of the Northern Calcareous Alps.

The Hochalm Member in this region similarly develops from the Hauptdolomit with intercalated layers of lithofacial development of the Kössen Formation exists in the most northern tectonic parts Keuper marls and with intercalations of shallow water carbonates in the topmost part. The litho- as well as the biofacies of the Hochalm Member are also similar to those of the southern tectonic units. Only the upper part of the Kössen Formation is different. Instead of the Eiberg Member the Restental Member (see Fig. 2) represents a comparably shallow and restricted basin with a monotonous, fine-grained terrigenous sedimentation. The fossil content is rather poor and uniform. A few, mostly epifaunal bivalve species (e.g. *Rhaetavicula contorta*) and a previously mentioned brachiopod assemblage (*Zugmayerella* biofacies) are indicative of the Carpathian facies (see Fig. 2, 3). Due to the unfavourable lithofacies, biostratigraphic relevant organisms like ammonites are lacking. Only one bed within the Restental Member yielded a few specimens of *M. posthernsteini*.

Biostratigraphy Of The Kössen Formation (see Fig. 2)

The biostratigraphic framework is based on the lithostratigraphy and incorporates new as well as previously known scattered and range data of ammonites and conodonts (see Fig. 1).

22 Profiles yield a unique conodont fauna, distributed among the entire Kössen Formation, composed exclusively of one genus, namely *Misikella*, sometimes associated by ramiform elements. The long standing discussion about the basal age of the Kössen Formation (e.g. Mostler et al., 1978, p. 194, Fig. 1) has been resolved by the new finding of *Misikella hernsteini* in several sections. Thus the base of the Kössen Formation is most probably dated as uppermost Norian. Time diagnostic fossil groups are missing in the underlying formations ("Plattenkalk" or Dachstein Limestone). Within Unit 2 of the Hochalm Member, *M. posthernsteini* appears and occurs together with the quantitatively dominating *M. hernsteini*. In accordance with all well known sections in the Hallstatt Region, the dominance of *M. hernsteini* in the conodont samples compared to *M. posthernsteini* is diagnostic for uppermost Norian age (Krystyn, pers. comm.). Due to the increasing terrigenous input within the Hochalm Member (Units 3), conodonts become very rare and are restricted to scattered occurrences of *M. posthernsteini* (Golebiowski, 1986). Concerning ammonites, the shallow-water character of the Hochalm Member is also unfavourable. The biofacial change between the Swabian and the Carpathian Facies (as newly defined) in the Hochalm Member (Unit 3) corresponds with the first occurrence of *Austrirhynchia cornigera*, the only distinctive Rhaetian brachiopod (see above), within the Kössen Formation. Immediately above this layer Urlichs (1972) found one of the few specimens of *Rhabdoceras suessi* in a microfossil sample (Bed: A22b) of the Weißloferbach section.

The diagnostic conodont species *Misikella rhaetica* and *M. koessenensis* first occur in the lowermost beds of the Eiberg Member. These beds (Unit 1) additionally yield the last occurrence of *M. hernsteini* in the Kössen Formation (Golebiowski, 1986). and *Vandaites* sp. (Krystyn, pers. comm.). Above, in the basal part of Unit 2, other diagnostic ammonite species occur. *Choristoceras ammonitiforme* is followed by *Choristoceras marshi*, which ranges up to the

top of the member and to the Triassic/Jurassic boundary. Excluding Unit 1 (which presumably belongs to the *Vandaïtes stuerzenbaumi* zone sensu Krystyn, 1988), the Eiberg Member coincides with the *Choristoceras marshi* zone (sensu Krystyn, 1988). It can be additionally subdivided in a *Ch. ammonitiforme* - and a *Ch. marshi* subzone. *M. rhaetica* and *M. koessenensis* disappear. Their end may have been controlled by ecological fluctuations in the intraplatform basin. Only *M. posthernsteini* accompanied by ramiform elements reaches to the top of the Eiberg Member.

It can be briefly summarized that the Kössen Formation includes Norian and Rhaetian beds, by accepting the boundary definition of Krystyn (1988 and this volume). The base of the Kössen Formation is situated somewhere within the Upper Norian without time-significant fossils below. Therefore it is not suitable as a chronostratigraphic boundary. The Kössen Formation is correlative to the Upper Sevatian *Sagenites reticulatus* zone, the Lower Rhaetian *Vandaïtes stuerzenbaumi* zone and the Upper Rhaetian *Choristoceras marshi* zone (sensu Krystyn, this volume) - see Fig. 1. This subdivision corresponds with recent lithostratigraphic results, together with biostratigraphic data from the Zlambach Marls in the Hallstatt Region (Krystyn, 1988 and this volume). Due to the poor evidence of biostratigraphically significant fossil groups, the Norian-Rhaetian boundary within the Hochalm Member, Unit 3 has been defined by a prominent transgressive event of the whole sequence (see Fig. 2). The first occurrence of the brachiopod *Austrirhynchia cornigera* corresponds to this conspicuous biofacial change between the Swabian and Carpathian Facies (see above). The sediment thickness of the Rhaetian part of the Kössen Formation corresponds to the Zlambach Marls sections (Krystyn, 1988). Indications are present for a reduced sedimentation rate in the basal Eiberg Member (Unit 1), at the beginning of the basinal development. This might explain, similar to the Zlambach Marls, the comparatively short-time interval of the Lower Rhaetian in the Kössen Formation.

Correlation with the Extra-Alpine Topmost Triassic (Fig. 2-4)

Topmost Triassic beds which are faunistically comparable to the alpine Kössen Formation also exist in the western Carpathian Mountains (Goetel, 1917). The Fatra Formation (Michalik, 1978; Gazdzicki et al., 1979), which is a litho- as well as biofacial equivalent of the Kössen Formation, is useful in correlating the epicontinental European uppermost Triassic beds with their Tethyan counterparts. The Fatra Formation follows over the "Upper Dolomites", which is the topmost part of the Carpathian Keuper Group (Fig. 2). The Fatra Formation itself consists of dark bioclastic limestones, rich in bivalves and distinct brachiopods (Fig. 3) as well as marls, which alternate cyclically with shallow water carbonates (most probably comparable with the "Oberrhät" Limestone (Michalik, 1982). The sequence yields several species which indicate a Swabian as well as a Carpathian Facies (Fig. 3, 4) and seems to consist of a mixture of both biofacies (according to Goetel, 1917, p. 176, 181). The so-called "Rhät Keuper" or "Kössen Beds" (above "Keuper" and a dolomitic horizon) of the Semmering Serie in the Unterostalpin (Tollmann, 1977) might be correlated with the Carpathian Keuper Group and the Fatra Formation, in the sense of sequence stratigraphy and therefore be regarded as isochronous. Besides the lithofacies, the thicknesses of both sections are more or less the same. In spite of the poor outcrops and knowledge, the "Kössen Beds" in the Unterostalpin might have been isochronically deposited in a similar palaeogeographical position as the Fatra Formation of the Carpathian Mountains. Both regions represent something like a key connecting link between the alpine and the epicontinental sections (Fig. 2-4).

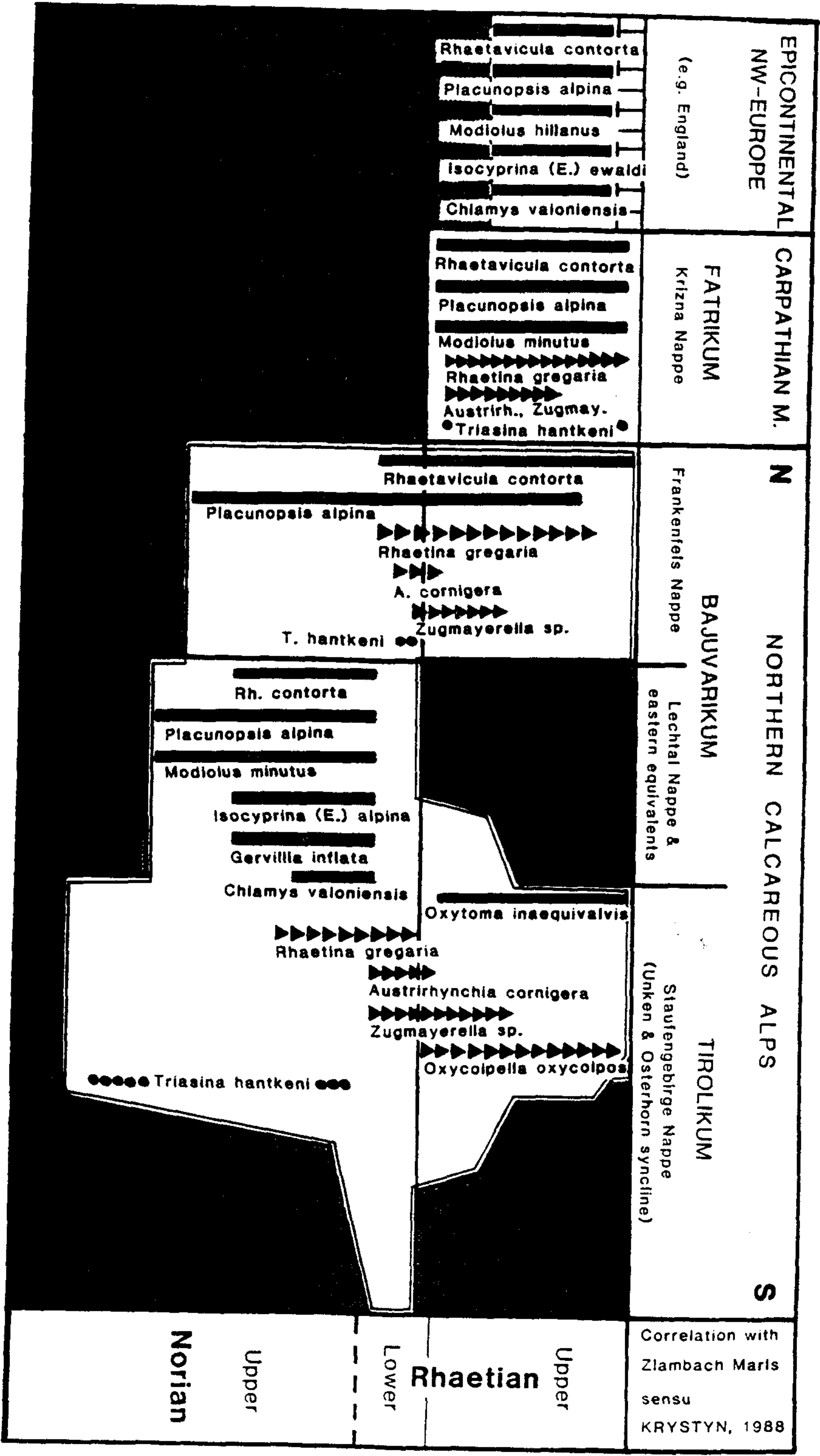


Fig. 3

There seems to be no doubt that the marine epicontinental topmost Triassic beds of NW Europe are a result of the uppermost transgressive event. By the succeeding transgression for a longer interval Tethyan faunas, as known in the alpine and West Carpathian region, had been exported only laterally via the Préalpes (Megard-Galli and Baud, 1977), the Burgundy Trough and the Paris Basin (see Ziegler, 1982). Because of the rather restricted shallow water environments only ecologically unspecialized Tethyan bivalve species (Hallam, 1981) were able to immigrate. Due to this fact, the bivalve fauna of the Penarth Group in England (Warrington et al., 1980) yields species which are diagnostic to the Swabian Facies of the Kössen Formation (Fig. 3, 4). Kössen type brachiopods (even *Rhaetina gregaria*) are missing in the epicontinental realm (Germany: Schmith, 1928; England: Pearson, 1970). Its restricted environment was something like a filter for more stenotrophic organisms. In the absence of biostratigraphic significant groups, the epifaunal bivalve *Rhaetavícula contorta* was up till now used as a diagnostic Rhaetian fossil of the epicontinental European sections.

How to turn the Rhaetian-Norian-Rhaetian Sandwich (Tozer, 1988, p. 14) into a Norian-Rhaetian Pizza

The Norian-Rhaetian-Norian sandwich (Tozer, 1988, p. 13), based on the brachiopod fauna from the Caucasus Mountains (Dagys, 1963, 1974) is discussed by Krystyn (this volume). It is the task of the brief survey to contribute to the recent discussion using stratigraphic data. I think the Rhaetian-Norian-Rhaetian sandwich should be also accepted as joke based on a careless mistake. In my opinion, *Rhaetavícula contorta* is no longer a distinct Rhaetian species in the Tethyan Realm. According to the correlation with the Zlambach Marls (Krystyn, 1988), the Norian-Rhaetian boundary in the Kössen Formation is approximately found in the basal Unit 3 of the Hochalm Member. The boundary is situated above the dominance of *Misikella hernsteini* (see above) and below the first occurrence of *Austrirhynchia cornigera* together with a conspicuous transgressive event (see Fig. 2, 3). For this reason, the laterally widespread Hochalm Member (shallow-water facies with epicontinental features, Swabian Facies) of the alpine Kössen Formation contains an uppermost Norian *Rhaetavícula contorta*. Extra-alpine sections, however, still yields *Rh. contorta* of Rhaetian age (see Fig. 3). By using a sequence stratigraphic approach (Fig. 2), there exists no doubt about the diachrony of the occurrence of *Rh. contorta*. It is partly Norian in the Tethys, though Rhaetian in NW Europe ("Contorta Beds"). In the upper part of the alpine Kössen Formation (Eiberg Member - basinal facies, Kössen Facies - see Fig. 2, 4) there is a lack of *Rh. contorta*. This conspicuous bivalve, however, seems to emigrate from the intraplatform basin to the fringing shallow-water carbonates. It is common in the lumachelles at the rim of the Rhaetian Dachstein Limestone. Unfortunately, there exist no indications about the age of *Rh. contorta* in the Napeng Beds, Burma (Healey, 1908) in the eastern Tethys, though an Upper Norian would also be plausible.

The scattered occurrence of the long-ranging species *Rhabdoceras suessi* (see Tozer, 1979) in the Weißloferbach section (Urlichs, 1977, fig. 3; Mostler et al., 1978, tab. 1) is accompanied by the occurrence of *Austrirhynchia cornigera* in the Hochalm Member, as well as *Misikella rhaetica* and *Choristoceras ammonitiforme* in the Eiberg Member (Golebiowski, 1986) - see Fig. 1. In spite of the occurrence of *Rh. suessi*, there exists no reason to accept an Upper Norian age of this middle part of the Kössen Formation and any comparison with a sandwich is rather useless. If we need allusions, then let us try a pizza. This pizza consists of a uniform Norian base, found in the alpine Kössen Formation (Hochalm Member, Units 1-3) and a rather diverse

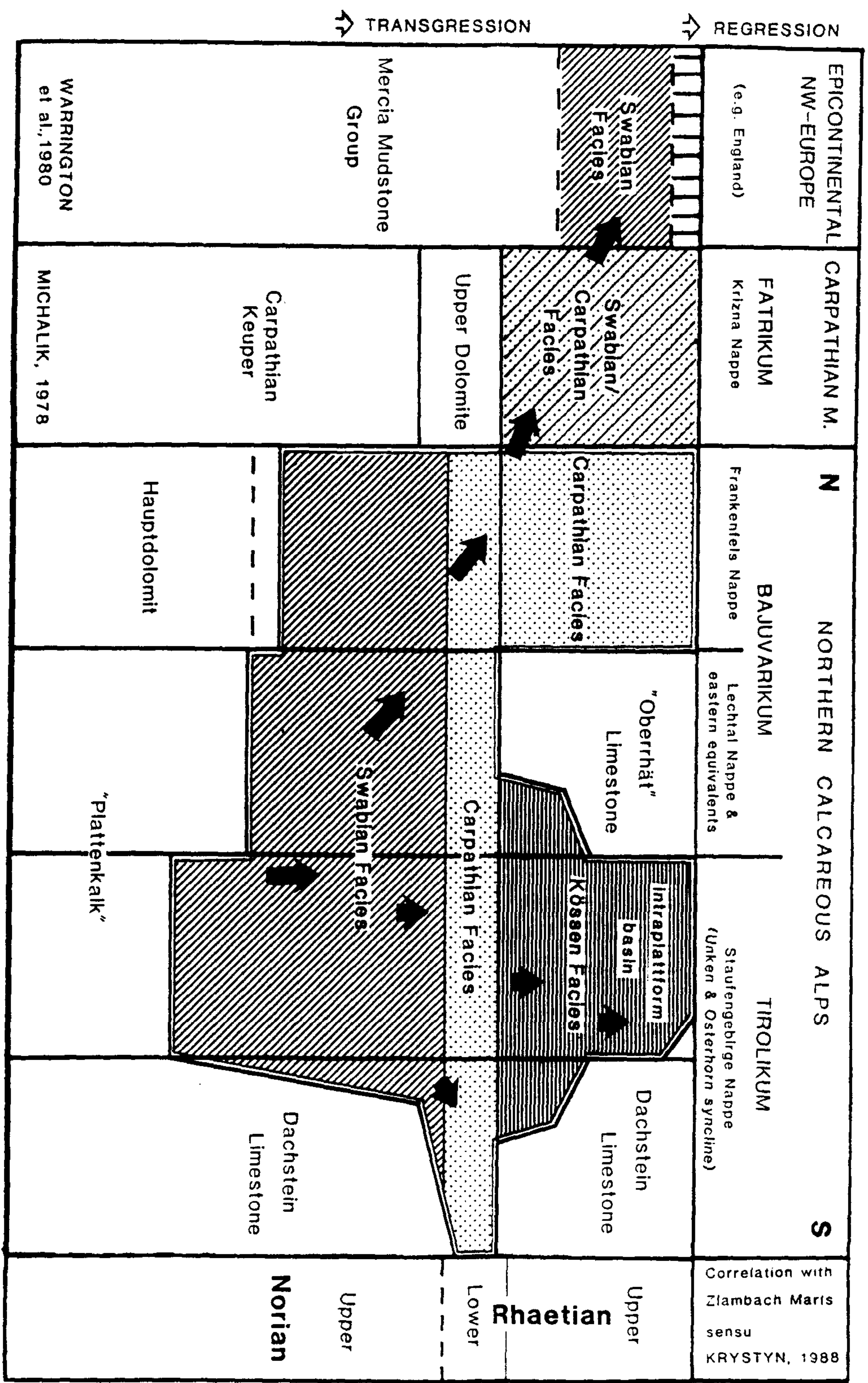


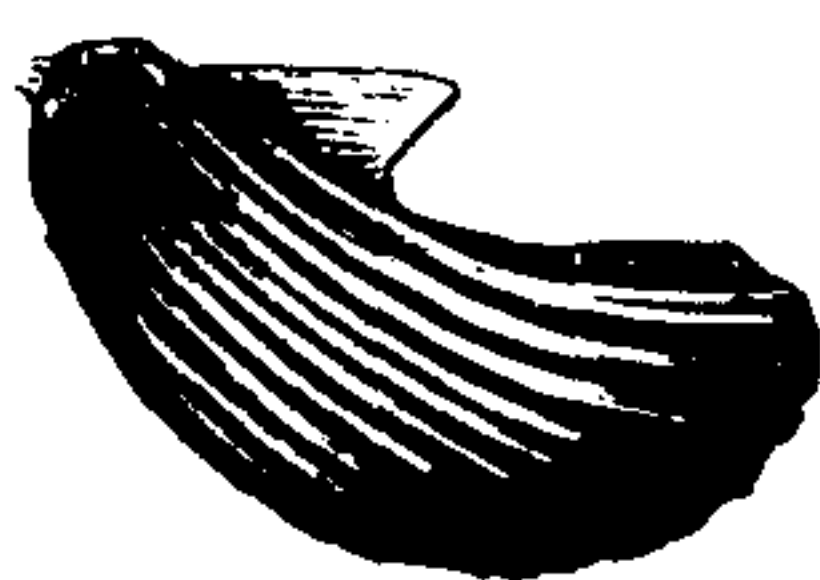
Fig. 4

accumulation of lithostratigraphic as well as biostratigraphic features in the Rhaetian top (see Fig. 2-4). Today the sandwich is out and the pizza is in.

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TOWARD A VERTEBRATE BIOCHRONOLOGY OF THE TRIASSIC

Spencer A. Lucas

Abstract

Vertebrate biochronological subdivision of the Triassic is both feasible and a desirable activity of the STS. This subdivision will best begin with the creation of provincial biochronologies.

Introduction

The efforts of the STS have focussed primarily on the delineation of the Triassic timescale in the marine realm. This is in accord with the goals and procedures of IUGS and the international stratigraphic community to develop a standard global stratigraphic scale based on marine facies. However, there is a significant rock and fossil record in the nonmarine realm, especially during the Triassic, when the Pangean supercontinent was the site of deposition of vast belts of red beds. This realm must eventually be integrated into the correlation web rooted in the marine record, and fossil vertebrates, widely distributed in Triassic continental deposits, will be critical to this integration.

However, continued attempts to build Triassic vertebrate biochronology on the shifting sands of marine stages/ages strike me as relatively unproductive. Not only is the definition and characterization of the Triassic marine stages in flux, but most Triassic terrestrial sequences can only be correlated in a general with the marine time scale. As in the *International Stratigraphic Guide* (Hedberg, 1976, p. 81) so aptly put is, "it is better to refer strata with accuracy to local or regional units rather than to strain beyond the current limits of time-correlation in assigning these strata to units of a global scale". Certainly, it ultimately will be desirable to integrate a terrestrial biochronology with the marine biochronology, but we first need a terrestrial biochronology! And, I believe one can be constructed using vertebrates.

Some Premises

In this article, I do not intend to present a comprehensive review of existing vertebrate biochronology of the Triassic nor do I formulate a new biochronological scheme. Instead, I support two premises. First, that vertebrate biochronological subdivision of the Triassic is feasible, useful and should be of concern to the STS. The second concerns how this subdivision should be attempted. I advocated the creation of provincial biochronologies for Triassic vertebrates. I thus follow the lead provided by the North American land-mammal "ages" proposed by Wood et al. (1941). The provincial biochronology has proven its utility by providing a precise, vertebrate-based chronology for Cenozoic continental deposits in Western North America (1987). Similar chronologies now exist on other continents, and work is well underway to integrate provincial biochronologies into continent-wide and intercontinental correlation webs. So impressive is the

success of this effort, that I urge following suit in the Triassic. However, other approaches are possible, though I believe less effective for the reasons stated below.

Chronofaunas

The best accepted, though very general and variously nomenclatured, scheme for subdividing Triassic time using terrestrial vertebrates recognizes a threefold division that corresponds well with the classic tripartite (Early, Middle, Late) scheme used in the standard global stratigraphic scale. Whether the divisions (Fig. 1) are termed A, B and C (Romer, 1975), or the proterosuchian, kannemeyeroi and dinosaurian epochs (Ochev and Shishkin, 1984) or the lystrosaurid, kannemeyeriid/demadodontoid and plateosaurid/melanosaurid empires (Anderson and Cruickshank, 1978), these subdivisions are more paleoecological than biochronological.

Early Triassic terrestrial vertebrate faunas, especially in Gondwana, are generally dominated by the dicynodont *Lystrosaurus* and proterosuchian "thecodonts". A renewed diversification of therapsids marks the Middle Triassic and is followed by a major extinction (Benton, 1986; Olsen and Suess, 1986) that ushers in the archosaur-dominated faunas of the Late Triassic. This threefold subdivision of the Triassic thus recognizes long-lasting chronofaunas (sensu Olson, 1952) that, despite local variation in taxonomic composition, retained their "ecological integrity" for millions of years. This scheme of subdivision thereby produces rather monolithic ("monobiochronologic"!?) entities not easily subdivided. Recent attempts to breakdown the three divisions either: (1) continue in an avowedly paleoecological vein as in Zawiskie's (1986) recognition of a "phytosaur-metoposaur community type" of early- to late-Late Triassic age and a "prosauropod community type" of mid-Late Triassic to Early Jurassic age, or (2) controvert the ecologically-based units into an explicitly biochronological scheme as in Cosgriff's (1984) division of the Early Triassic into an older, "A1" interval characterized by lystrosaurids, proterosuchids and distinctive temnospondyls and a younger, "A2" interval typified by cynognathids, kannemeyeriids, erythrosuchids and different temnospondyls.

I am not convinced that we can achieve much more refinement of Triassic vertebrate biochronology using chronofaunal divisions. Their goal clearly is to discern ecological associations regardless of their duration, not short-lived taxa and assemblages that are the groundmass of precise biochronologies. The chronofauna schemes have divided the Triassic from "the top down", producing three broad divisions of Triassic time that are difficult to subdivide further. Biochronologies are best built from "the bottom up", with short intervals of time and later aggregated into longer units based on larger scale, faunal turnover.

Large Vertebrate Zones

The most longstanding and best known divisions of the Triassic using terrestrial vertebrates are the large-vertebrate zones of the upper part of the Beaufort Group in the Karoo Basin of South Africa (Fig. 1). Originally developed by Broom (1906) and Watson (1914), the three original Triassic zones have now been reduced to two, with alternative terminologies (Kitching, 1977; Keyser and Smith, 1977-78). The zones are recognized principally by the distinctive fossils of the large *Lystrosaurus* and *Kannemeyeria*.



SOME DIVISIONS OF TRIASSIC TIME BASED ON FOSSIL VERTEBRATES

Per.	Sub-Period	Romer (1975)	Ochev & Shishkin (1984, 1988)	Kitching (1977) South Africa	Keyser & Smith (1977-78) South Africa	Cooper (1982)	Bonaparte (1966) Argentina	Lucas & Hunt (1989) western U.S.
TRIASSIC	Late	C	dinosaurian epoch			Plateosaurus zone		Informal biochrons based on phytosaurs & aetosaurs
						Placerias zone	Coloradian	
						Stahleckeria zone	Ischigualastian	
	Middle	B	kannemeyeroidean epoch	Cynognathus zone	Kannemeyeria- Diademodon assemblage zone	Dinodontosaurus zone	Chanarian	
						Tetragonias zone		
	Early	A	proterosuchian epoch	Lystrosaurus zone	Lystrosaurus- Thrinaxodon assemblage zone	Kannemeyeria zone	Puestoviejian	

Attempts to correlate other sequences with these zones have had varied success. Fossils of *Lystrosaurus* are so widespread - they are known from South Africa, the U.S.S.R., India, China, Antarctica and possibly Laos - that correlation with the oldest Triassic zone in the Karoo is rather straightforward. In the Gondwana terranes, for example in India (e.g., Bandyopadhyay, 1988) and western Argentina/southern Brazil (e.g., Bonaparte, 1982), both zones are readily correlated. However, although correlations have been presented for Laurasia (e.g., Sun, 1980; Kalandadze et al., 1968), there are problems with the age and correlation of the upper, *Cynognathus* zone. Some of these are surely the result of what Cooper (1982) has so aptly termed "provincial taxonomy". However, also at the crux of the problem are real differences that reflect paleoprovinciality (Battail, 1980, 1984) as well as a conflict between correlations suggested by amphibians as opposed to reptiles (Shishkin and Ochev, 1989).

Cooper (1982) recently made a laudable effort to extend the concepts embodied in the Karoo large-vertebrate zonation by proposing a sequence of assemblage zones (with large-vertebrate taxa as name bearers) for all of Pangea from the Permian to the Middle Jurassic. Although there are some problems with the ages Cooper assigns some of his zones (Cosgriff, 1984), his effort finds good precedent in the last century when Marsh, Cope, Matthew and Osborn successfully used large-mammal zones to subdivide the Cenozoic of the American West (cf. Tedford, 1969). However, like those schemes, the level of temporal resolution provided by large Triassic vertebrates is rather coarse; Cooper (1982) only identifies six intervals of Triassic time. Parts of his two younger Triassic zones, however, can be divided into five biochrons in the western United States using phytosaurs and aetosaurs (Fig. 1).

Not only do the large vertebrates have a limited temporal resolution, but they also lack a Pangea-wide distribution. For example, *Placerias* is known only from North America (although I suspect that *Moghreberia* from Morocco is a synonym). How do we identify a *Placerias* zone in other parts of Pangea?

Problems encountered in correlating large-vertebrate zones outside of their type areas, whether it be Karoo zones or Cooper's (1982) assemblage zones, suggest to me that Pangea was a more provincial place with respect to tetrapod distribution than we have been lead to believe. Certainly there was little climatic diversity across the supercontinent during the Triassic (Parrish et al., 1986), and many large vertebrates (viz. *Lystrosaurus*) lived over vast areas. But, there is a growing amount of evidence of provinciality among many taxa throughout the Triassic (e.g., Battail, 1980, 1984; Buffetaut and Martin, 1984; Thulborn, 1984). It is this provinciality coupled with the rather low rates of evolutionary turnover of large vertebrates that ultimately makes it difficult for a scheme of global, large-vertebrate zones to provide us with the highest biochronological resolution across Triassic Pangea.

Provincial Biochronologies

In the light of this provinciality and given the experience of mammalian paleontologists, I favor a program of Triassic vertebrate biochronology that begins with the creation of provincial biochronologies. Bonaparte (1967, 1982) has already done this in a formal way for the Triassic of western Argentina, and Lucas and Hunt (1989) have proposed an informal biochronology of the Late Triassic of the western United States (Fig. 1). Such local/regional biochronologies once

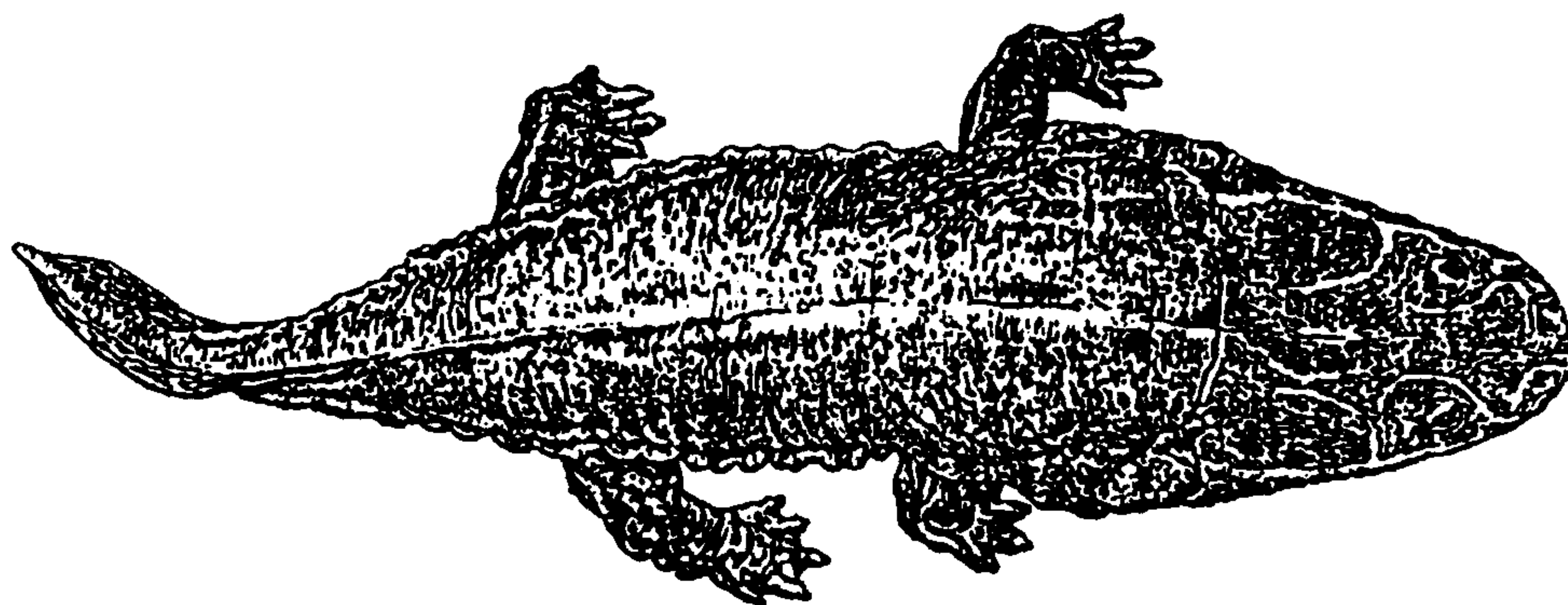
formulated, tested and well established can then be compared with each other to arrive at a unified and refined vertebrate biochronology of the terrestrial of Triassic Pangea.

In so advocating this approach to Triassic vertebrate biochronology, I recognize it is not a panacea for what ails us. Certainly, it will lead to a proliferation of stratigraphic nomenclature, and certainly it is subject to the welter of problems that always dog us when using fossils to correlate strata. However, I believe it is the way to begin building a detailed vertebrate biochronology of the Triassic that one day will be integrated with the standard global stratigraphic scale for the Triassic. For now, we need not wait for that joyous day, nor do we need to subordinate terrestrial correlations to a little agreed on Triassic timescale rooted in marine facies. Instead, we can begin a program of detailed vertebrate biochronology across the vast expanses of terrestrial red beds of Triassic Pangea.

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BRITISH TRIASSIC PALAEONTOLOGY: SUPPLEMENT 13

G. Warrington

Since the completion of the writer's previous supplement (No. 12, *Albertiana*, 7: 17-20) on British Triassic palaeontology, the following works related to aspects of that subject have been published or have come to his notice:

- Ainsworth, N.R., O'Neill, M. and Rutherford, M.M.**, 1989. Jurassic and Upper Triassic biostratigraphy of the North Celtic Sea and Fastnet Basins. In: Batten, D.J. and Keen, M.C. (eds.) 1989, *Northwest European Micropalaeontology and Palynology*, pp. 1-44. Ellis Horwood, Chichester.
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This contribution is published with the approval of the Director, British Geological Survey (N.E.R.C.).

COMMENTS ON THE RHAETIAN AND EARLY TRIASSIC

H.M. Kapoor

Summary

In this contribution the Rhaetian and Early Triassic are dealt with from an Indian point of view.

Rhaetian

With the exception of some contributions by Prof. V.J. Gupta on bivalves, and records of *Monotis salinaria* not too many contributions have appeared in India with regard to the youngest Triassic. Recently, a find has been made of *Choristoceras* sp. indet. from a tectonically disturbed area in the Lahul-Spiti belt, but its relation with over- and underlying biota is not clear. Therefore, from the available knowledge, the Himalayan sections are not suitable to add much to this issue. Our possibilities to work in the inner belt are limited, although it is known that these sections might provide a solution of the problem. Easily accessible sections are known to exist in Kashmir, but although most of the exposures are fossiliferous they have not yet yielded fossils worth studying.

Early Triassic

Indian stratigraphers working on the Lower Triassic can use the Griesbachian, Dienerian, Smithian and Spathian Stages since they are easily recognizable. Most of the work is based on Nakazawa et al. [1975, Mem. Kyoto Univ., 46(1)]. Much work has been done in the Kashmir and Spiti Basins by a number of workers from India and abroad, e.g., K.J. Budurov, V.J. Gupta, R.K. Kachroo, D.K. Bhatt, V.K. Joshi, R.K. Arora, K. Nakazawa, H.M. Kapoor and R.K. Goel. The above mentioned stages have been recognised on the basis of conodont assemblages with supporting evidence from ammonoid zones.

MUSCHELKALK - STRATIGRAPHY, SEDIMENTOLOGY, PALAEOECOLOGY

International Symposium With Field Trips

August 12 - 20, 1991

Bildungshaus Kloster Schöntal, Baden-Württemberg, Germany

Muschelkalk research has been stimulated in the last years in different ways. The Dynamic Stratigraphy model of the Southwest German Upper Muschelkalk allowed an integrated interpretation of lithostratigraphy and facies, including isolated former observations on palaeoecology and sediment structures. For the Upper Muschelkalk of the northern and eastern part of the Germanic Basin a comparable synopsis has not been accomplished yet. For the Lower and Middle Muschelkalk available overview models have to be revised and new models have to be developed. However, though there is a large data base, an overall analysis of the Muschelkalk covering the entire Germanic Basin with its complicated facies patterns and its different fossil communities is still missing. Finally the sequential stratigraphy of the Muschelkalk has to be correlated with the sedimentary cycles outside the Germanic Basin.

The 1991 Muschelkalk Symposium in Schöntal aims to fill the gaps of knowledge, to present new models, to integrate the data and to set up objects of research. The field trips covering classical areas of Muschelkalk research in Baden-Württemberg, Franconia, Hesse, Thuringia and Silesia will give much opportunity for discussion and contrastive field studies and will thus help to overcome the traditional regionalism in previous research work.

Kloster Schöntal, situated in the heart of Muschelkalk in the beautiful and pleasant valley of the River Jagst, once a Cistercian monastery, now a communication centre for arts and sciences, recommends itself with its restored baroque rooms and cloister gardens as an ideal meeting place. A cultural by-program will accompany the workshop.

The program includes two days of contributed papers and lectures by Prof. Dr. A. Seilacher (Tübingen) on "Fossilagerstätten des Muschelkalks" and Dr. G. Taddey (Stuttgart) on "Die Hohenlohe und Schlesien". There are two field trips. A one-day trip to the Muschelkalk of the Hohenlohe area and a five-days trip to Muschelkalk deposits in North Baden-Württemberg, Lower Franconia, East Hesse, Thuringia, Silesia and the Chrzanow Basin.

Interested colleagues are invited to present posters and/or papers (20 minutes + 5 minutes discussion) no later than September 1, 1990. Abstracts in English or German should not exceed one page. Subjects are lithostratigraphy, biostratigraphy, facies models, cyclicity, basin analysis, palaeoecology. Contributions will be published. Symposium languages are German and English. The second circular will be mailed in spring 1991 to those who have already registered. Registration deadline is May 31, 1991.

Symposium fees are:

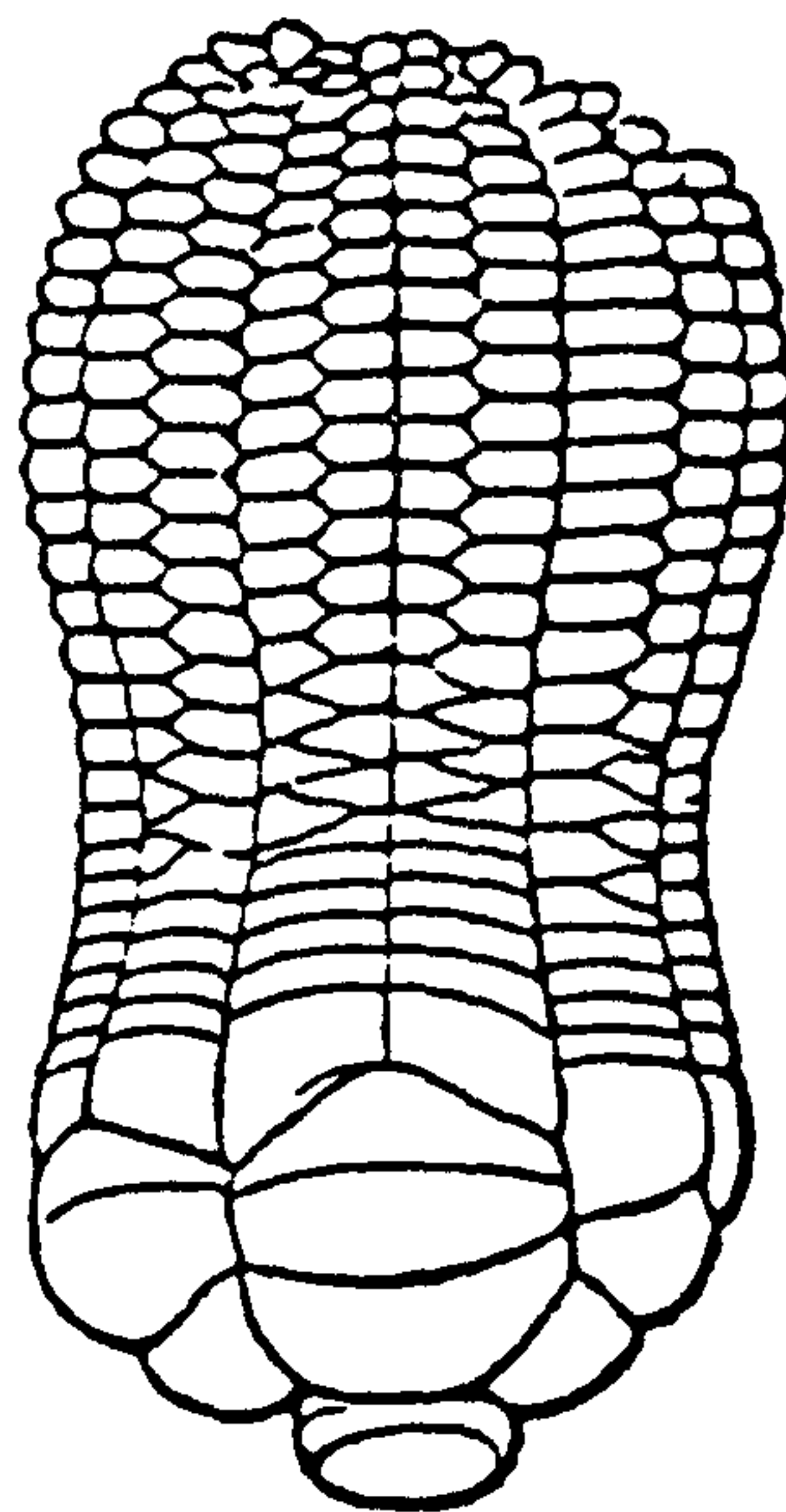
Accommodation in double rooms, full board, by-program and the one-day field trip: DM 280.00

The extended package with the five-day field trip is approx. DM 980.00. The extra charge for single rooms is DM 8.00 per night.

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ANNOTATED TRIASSIC LITERATURE**Hans Kerp**

AINSWORTH, N.R., 1989. Rhaetian, Hettangian and Sinemurian ostracoda from the Fastnet Basin, offshore Southwest Ireland. *Geol. Surv. Ireland Bull.*, 4(2): 107-150.

Rhaetian, Hettangian and Sinemurian ostracoda from 247 productive samples from the Fastnet Basin are described. Biostratigraphy and palaeoecology are discussed with reference to other selected areas.

AINSWORTH, N.R., O'NEILL, M. AND RUTHERFORD, M.M., 1989. Jurassic and Upper Triassic biostratigraphy of the North Celtic Sea and Fastnet Basins. in: **BATTEN, D.J.** (ed.), *Northwest European Micropalaeontology and Palynology*, British Micropal. Soc. Ser., Ellis Horwood, Chichester, pp. 1-44.

A detailed biostratigraphy for the Jurassic and Upper Triassic of the North Celtic Sea and Fastnet Basins is proposed. Within this interval, 25 associations can be recognized, among one in the Upper Triassic. The Triassic-Jurassic boundary is difficult to locate, owing to long-ranging and relatively sparse microfossil assemblages transgressing the boundary.

BENFIELD, A.C. and WARRINGTON, G., New records of the Westbury Formation (Penarth Group, Rhaetian) in North Yorkshire, England. *Proc. Yorkshire Geol. Soc.*, 47(1): 29-32.

The subdrift outcrop of the late Triassic Penarth Group has recently been continuously traced along the Vale of York, principally from borehole data. The sediments have yielded palynomorphs and sporadic macrofossils which indicate deposition in a marine environment during latest Triassic (Rhaetian) times. These beds are correlated with the Westbury Formation of the Penarth Group.

CATALOV, G. and VISSCHER, H., 1990. Palynomorphs from Stoilovo Formation, Veleka Group (Triassic), Strandza Mountain, Southeast Bulgaria. *Geologica Balcanica*, 20(2): 53-57.

Low-grade metamorphic rocks of the Stoilovo Formation are dated as Early Triassic on the basis of palynomorphs.

DEMATHIEU, G.R. and OOSTERINK, H.W., 1988. New discoveries of ichnofossils from the Middle Triassic of Winterswijk (the Netherlands). *Geologie en Mijnbouw*, 67: 3-17.

Some recently discovered new vertebrate tracks from the Middle Triassic of Winterswijk are described. Some remarks are made on previously reported material.

DOSZTALY, L., 1989. Triassic radiolarians from Dallapuszta (Mount Darnó, N Hungary). *Annula Rep. Hung. Geol. Inst. of 1988, Part II*, pp. 193-201.

A more precise age assessment (Middle-Upper Langobardian) of the red radiolarite bed of Mt. Darnó is presented.

ESHET, Y., DRUCKMAN, Y., COUSMINER, H.L., HABIB, D. and DRUGG, W.S., 1988. Reworked palynomorphs and their use in the determination of sedimentary cycles. *Geology*, 16: 662-665.

Three major sedimentary cycles are identified in the Permian-Triassic subsurface sequence of Israel on the basis of palynomorphs. Stratigraphic variation in the abundance of reworked detritus may be useful for the recognition of sedimentary cycles which are otherwise not evident in the rock record.

GOODARZI, F., BROOKS, P.W. and EMBRY, A.F., 1989. Regional maturity as determined by organic petrography and geochemistry of the Schei Point Group (Triassic) in the western Sverdrup Basin, Canadian Arctic Archipelago. *Marine and Petroleum Geology*, 6(4): 290-302.

Maturity and source rock potential of organic rich beds in the Triassic Schei Point Group, Sverdrup Basin, have been investigated using reflected light. Results are compared with geochemical maturity parameters (Rock-Eval, biomarkers).

HAAS, J., TOTH-MAKK, A., ORAVECZNE-SCHEFFER, A., GOCZAN, F., ORAVECZ, J. and SZABO, I., 1988. Lower Triassic key sections in the Transdanubian Mid-Mountains. *Ann. Inst. Geol. Publ. Hung.*, 65(2), 356 pp.

Descriptions of a number of Lower Triassic key sections from five key boreholes and some additional boreholes and outcrops are presented. Regional stratigraphic correlations and facies changes were studied. The geohistory is analysed and organic matter maturity studies allowed the understanding of postdepositional processes. Biostratigraphic results and chronostratigraphy are discussed in a separate chapter with special regard to the Permian-Triassic and Lower-Middle Triassic boundaries.

HAGDORN, H., 1986. *Isocrinus? dubius* (Goldfuss, 1831) aus dem Unteren Muschelkalk (Trias, Anis). *Z. geol. Wiss. Berlin*, 14: 705-727.

A description of an Anisian crinoid, so far only known as isolated columnals, with comments on its taxonomy, palaeobiogeography and evolution.

HAGDORN, H., 1988. *Aignimacrinus calyconodalis* n.g. n.sp., eine ungewöhnliche Seelilie aus der Obertrias der Dolomiten. *N. Jb. Geol. Paläont. Mh.*, 1988, H. 2: 71-96.

Description of a new crinoid with highly specialized stalk elements and the description of the new family Aignimacrinidae.

HEUNISCH, C., 1986. Gliederung und Milieuinterpretation des fränkischen Unteren Keupers aus palynologischer Sicht. *Geologica Bavarica*, 89: 151-159.

A palynological study of the Lower Keuper in Lower and Middle Franconia (Germany). Four different facies zones could be recognised.

HEUNISCH, C., 1990. Palynologie der Bohrung "Natzungen 1979", Blatt 4321 Borgholz (Trias; Oberer Muschelkalk 2, 3, Unterer Keuper). *N. Jb. Geol. Paläont. Mh.*, 1990, H. 1: 17-42.

The 53 m thick sequence of Upper Muschelkalk 2 (partly) and 3 and Lower Keuper yielded 85 positive palynological samples. Emphasis is laid on palynostratigraphy and palynofacies. The age of the beds is (Upper Ladinian, Langobardian). Variations within different phytoplankton groups indicate transgressive and regressive phases.

HUNT, A.P. and LUCAS, S.G., 1988. Late Triassic fauna from the Los Esteros Member of the Santa Rosa Formation, Santa Fe County, New Mexico, and its biochronological implications. *New Mexico J. Sci.*, 28(2): 107-116.

The first fauna from the Upper Triassic Santa Rosa Formation is described and indicates a correlation with the lower Petrified Forest Member of the Chinle Formation in northeastern Arizona.

JAROSHENKO, O.P., 1988. Microspores from the sporangia of the lycopsid *Tomioostrobus radiatus* Neuburg (Lower Triassic, Kuzbass). in: CHLONOVA, A.F. (ed.), *Papers of USSR palynologists for the 7th International Palynological Congress, Brisbane, Australia, 1988*, pp. 77-80.

Microspores of *Tomioostrobus* show a close affinity with the disperse spore genus *Aratrisporites*. (in Russian).

JAROSHENKO, O.P. and GOLUBEVA, L.P., 1989. New species of spores from the Lower Triassic of Pechorskaja Sinekliza. *Paleont. Dzhurn.*, 1989, 4: 101-108.

A description of new species of *Aratrisporites* and *Pechorosporites* from the Lower Triassic. (in Russian).

KELBER, K.-P., 1990. Die versunkene Pflanzenwelt aus den Deltasümpfen Mainfrankens vor 230 Millionen Jahren. *Beringeria, Sonderheft 1*: 1-67.

A very well illustrated report on the macrofloras of the Franconian Lower Keuper with a brief historical account and systematic characterizations of the most important groups. Special attention is given to taphonomy and palaeoecology.

KIETZKE, K.K., 1989. Calcareous microfossils from the Moenkopi Formation (Triassic, Scythian or Anisian) of Central New Mexico. *New Mexico Geol. Soc. Guidebook, 40th Field Conf., Southeastern Colorado Plateau*, pp. 181-190.

Charophytes, spirorbid worms and ostracods have been recovered from lacustrine and fluvial sediments of the Moenkopi Formation in the Lucero Mesa area of Cibola County. The fauna suggests an Early to Middle Triassic age for these beds. Remarks on the depositional environment are made.

KIM, J.H., 1989. *Sphenophyllum* sp. (Sphenopsida) newly found from the Upper Triassic Boengunsa Formation, Nampo Group, Korea. *Bull. Nat. Sci. Mus. Tokyo, C* 19(3): 93-96.

The latest occurrence of *Sphenophyllum*, an essentially Late Palaeozoic plant, from the Triassic of Korea.

KRISTAN-TOLLMANN, E., 1988. Unexpected microfaunal communities within the Triassic Tethys. in AUDLEY-CHARLES, M.G. and HALLAM, A. (eds.), *Gondwana and Tethys. Geol. Soc. Publ.*, 37: 213-223.

Planktonic, pelagic, vagile and sessile benthic elements of show a surprising uniformity in the Triassic of the Tethys region. Potentially important groups that have been little utilized previously for biogeographical research are discussed.

KRISTAN-TOLLMANN, E., 1988. Unexpected communities among the crinoids within the Triassic Tethys and Panthalassa. in: BURKE, R.D. et al. (eds), Echinoderm Biology, Proc. 6th Int. Echinoderm Conf., pp. 133-142.

Macro- and microcrinoids from different kinds of environments in the Triassic of the Tethys realm and the Pacific area are discussed with special reference to their distribution.

KRISTAN-TOLLMANN, E., 1988. A comparison of Late Triassic agglutinated foraminifera of Western and Eastern Tethys. Abh. Geol. B.-A. Wien, 41: 245-253.

Examples of common species of arenaceous and calcareous agglutinated foraminifera and their distribution in the Tethys-Panthalassa.

LOT, G.K. and WARRINGTON, G., 1988. A review of the latest Triassic succession in the U.K. sector of the Southern North Sea Basin. Proc. Yorkshire Geol. Soc., 47(2): 139-147.

Well-log data are used to redefine the base of the Late Triassic "Winterton Formation" in the U.K. Southern North Sea Basin. In a cored offshore succession the redefined formation is lithostratigraphically and biostratigraphically correlatable with the Penarth Group of onshore U.K. sequences. It is proposed that the use of the term Penarth Group is extended to the offshore area and that the "Winterton Formation" is abandoned.

LUCAS, S.G. and HAYDEN, S.N., 1989. Triassic stratigraphy of West-Central New Mexico. New Mexico Geol. Soc. Guidebook, 40th Field Conf., Southeastern Colorado Plateau, pp. 191-212.

Triassic strata in New Mexico are exposed over four, disjunct terranes. The oldest Triassic strata in these terranes pertain to the Moenkopi Formation which has an Early or Middle Triassic age. These beds are disconformably overlain by the Chinle Formation. Remaining Triassic strata are all assignable to the Chinle Formation. The paper provides lithological, sedimentological characterizations and comments on the fossil content.

LUCAS, S.G. and HUNT, A.P. (eds.), 1989. Dawn of the age of dinosaurs in the American Southwest. New Mexico Museum Nat. Hist., Albuquerque, 414 pp.

A thick volume on the Upper Triassic of the American Southwest (Arizona, Texas, New Mexico). Although the title of this book might suggest that this book is entirely devoted to dinosaurs, it contains contributions on sedimentology, invertebrate paleontology, palaeobotany and palaeoclimatology. Twenty two individual contributions are grouped under four headings, viz. "Localities", "Stratigraphy and Sedimentology", "Paleontology", and "Faunal Analysis and Biochronology". The list of contributors includes: S. Ash, K.L. Ballew, B. Davidow-Henry, R.F. Dubiel, S.C. Good, A.P. Hunt, K. Kietzke, R.E. Kirby, R.A. Long, S. Lucas, M.T. McCrea, P.A. Murry, K. Padian, J.M. Parrish and B. Small.

OSBORN, J.M., TAYLOR, T.N. and WHITE, J.F., 1989. *Palaeofibulus* gen. nov., a clamp-bearing fungus from the Triassic of Antarctica. Mycologia, 81(4): 622-626.

Systematic description and discussion of a new species of clamp-bearing fungus from the Early to Middle Triassic of Antarctica.

PETRUNOVA-OLOVA, L., 1988. Palynomorphs from the type-section of Mitrovici Formation (Middle-Upper Triassic) at Mitrovici Village, Mihajlovgrad District, Northwest Bulgaria. Rev. Bulg. Geol. Soc., 49(1): 98-103. (in Bulgarian with English abstract).

Palynological characterization of the type-section of the Mitrovci Formation which is probably Upper Ladinian (Langobardian).

PETRUNOVA-OLOVA, L., 1988. Palynomorphs from Mitrovci Formation (Middle-Upper Triassic) from borehole sections in Northwest Bulgaria. *Rev. Bulg. Geol. Soc.*, 49(3): 108-112. (in Bulgarian with English abstract).

Palynological correlation of five borehole sections. The associations probably have an Upper Ladinian (Langobardian) age.

RAUNSGAARD-PEDERSEN, K., CRANE, P.R. and FRISS, E.M., 1989. The morphology and phylogenetic significance of *Vardekloeftia* Harris (Bennettitales). *Rev. Palaeobot. Palynol.*, 60: 7-24.

A revision of the bennettitalean reproductive structure *Vardekloeftia* Harris on the basis of original and newly collected material from the Upper Triassic of East Greenland. The organization of the ovules, pollination and dispersal are discussed. Comparisons with other Bennettitaleans reveal that *Vardekloeftia* is a rather unspecialized early member of this group.

RUFFELL, A. and WARRINGTON, G., 1988. An arenaceous member in the Mercia Mudstone Group (Triassic) west of Taunton, Somerset. *Proc. Ussher Soc.*, 7(1): 102-103.

A description of an arenaceous member in the Mercia Mudstone Group. On the basis of palynological data this member is considered to be analogous to the Late Triassic Schilfsandstein of Germany.

SALAJ, J., TRIFONOVA, E., GHEORGHIAN, D. and CORONEOU, V., 1988. The Triassic foraminifera microbiostratigraphy of the Carpathian - Balkan and Hellenic realm. *Mineralia Slov.*, 20(5): 387-415.

Triassic foraminiferal assemblages and a zonation from the Carpathian-Balkan and Hellenic zones in Czechoslovakia, Romania, Bulgaria and Greece with references to Hungarian and Polish material.

SIMMS, M.J. and RUFFELL, A., 1990. Climatic and biotic change in the Late Triassic. *J. Geol. Soc.*, 147(2): 321-327.

Evidences for climatic changes from arid to wet monsoonal are documented on the basis of lithological developments and biotic turnovers for the Middle and Late Carnian. This change has been documented for over more than 90° of longitude between 5° and 50° north of the Triassic equator. This change may have been caused by rising atmospheric CO₂ levels due to volcanism associated with the incipient dispersal of Pangea.

SOPENA, A., LÓPEZ, J., ARCHE, A., PÉREZ-ARLUCEA, M., RAMOS, A., VIRGILI, C. and HERNANDO, S., 1988. Permian and Triassic rift basins of the Iberian Peninsula. in: MANSPEIZER, W. (ed.), *Triassic-Jurassic Rifting - Continental breakup and the origin of the Atlantic Ocean and passive margins*.

A review of the geologic development of Permian and Triassic basins, i.e. Cantabrian Mountains, Pyrenees, Catalanian Ranges, Central System Margins, Iberian, Ranges and the southern margin of the Iberian Massif. Evolution and tectonic activity are clearly related. The model for the evolution of the Iberian ranges recognises three distinct periods. The third period (Late Permian to at least Early Jurassic) comprises rift-basin development and Buntsandstein sedimentation followed by marine sediments as the Tethys sea encroached on the margins of the Iberian Massif.

SUNEBY, L.B. and HILLS, L.V., 1988. Palynological zonation of the Heiberg Formation (Triassic-Jurassic) Eastern Sverdrup Basin, Arctic Canada. *Bulletin of Canadian Petroleum Geology*, 36(4): 347-361.

Three complete sections of the sandstone-dominant deltaic Heiberg Formation of the Sverdrup Basin, Canadian Arctic Archipelago were studied for palynology. Four biozones and two subzones were recognized, covering the Norian to (?)Toarcian.

SWEET, W.C., 1988. A quantitative conodont biostratigraphy for the Lower Triassic. *Senckenbergiana Lethaea*, 69: 253-273.

Data on the measured ranges of conodont species in stratigraphic sections in Kashmir, Pakistan, Japan, western United States, northern Italy, and far-eastern USSR have been assembled graphically into a biostratigraphic framework for the Lower Triassic (Scythian) that may be divided at 95% confidence level into 21 chronozones. Traditional biozones have only half the resolution of the graphically assembled scale. Only nine of the 14 or more zones previously proposed are regarded as recognizable.

TATE, M.P. and DOBSON, M.R., 1989. Late Permian to early Mesozoic rifting and sedimentation offshore NW Ireland. *Marine and Petroleum Geology*, 6(1): 49-59.

A Late Permian, Triassic and Early Lias rift succession up to 1 km thick is revealed from offshore NW Ireland. Sediments are preserved in long narrow grabens. This line of basins, superimposed on a Caledonoid fractured basement, underwent a complex structural evolution. Since the Late Permian they primarily developed as a wrench-modified rift system.

VEEVERS, J.J., 1989. Middle/Late Triassic (230 ± 5 Ma) singularity in the stratigraphic and magmatic history of the Pangean heat anomaly. *Geology*, 17(9): 784-787.

The Phanerozoic history of dispersal and coalescence contain an epoch of a radical change at about the Middle/Late Triassic boundary (230 ± 5 Ma) marked by: (1) the final coalescence of Pangea, and (2) the incipient dispersal of Pangea by the onset of rifting in eastern North America and northwest Africa, Argentina, East Africa and Western Australia. This correlates with a change from: (1) an icehouse state to a greenhouse state, and (2) changes, from a fall to a rise, in the sea-level curve.

VÖRÖS, A. and PÁLFY, J., 1989. The Anisian/Ladinian boundary in the Vászoly section (Balaton Highland, Hungary). *Fragmenta Mineralogica et Palaeontologica*, 14: 17-27.

The Anisian-Ladinian boundary in a Balaton Highland section is drawn by ammonoid biostratigraphy. Two ammonoid biozones are recognized. Remarks are made on brachiopod biostratigraphy.

WHITE, J.F., 1989. A Trichomycete-like fossil from the Triassic of Antarctica. *Mycologia*, 81(4): 643-646.

A description of a Triassic fungus from Antarctica.

WITTE, W.K. and KENT, D.V., 1989. A middle Carnian to early Norian (225 Ma) paleopole from sediments of the Newark Basin, Pennsylvania. *Geol. Soc. Amer. Bull.*, 101(9): 1118-1126.

Although extensive thermal demagnetization is necessary, two components of magnetization can be isolated from the middle to late Carnian and early Norian sediments of the Newark Basin. In these, the lowermost strata of the Newark Basin, a high unblocking temperature magnetization of normal and reversed polarity, aquired at about the time of deposition of the sediments, produces a palaeopole (53.5°N/101.6°E) consistent with the age of the sediments and a correlatable magnetic polarity stratigraphy.

YANG ZUNYI and YIN HONGFU, 1987. Achievements in the study of Permo-Triassic events in South China. *Advances in Science of China, Earth Sciences*, 2: 23-43.

Based on 31 sections, seven formations of the uppermost Permian Changxingian Stage are established, among which four are new. The Permo-Triassic transitional beds are defined, its age being suggested to be lower Griesbachian. The authors have proposed *Anchignathodus parvus* (= *Hindeodus parvus*) Zone as the beginning of the Triassic System.

YIN HONGFU, YANG FENGQING, LAI XULONG and YANG HENGSHU, 1988. Triassic belts and Indosinian development of the Qinling Mountains. *Geoscience*, 1988(3): 355-365. (in Chinese with English abstract).

A review of the geotectonics of the Early-Middle Triassic of the Qinlin Mountains.

YIN HONG-FU, HUANG SIJI, ZHANG KEXING, YANG FENGQING, DING MEIHUA, BI XIANMEI and ZHANG SHUXING, 1989. Volcanism at the Permian-Triassic boundary in South China and its effects on mass extinction. *Acta Geol. Sinica*, 1989(2): 169-181. (in Chinese with English abstract).

Most of the Permian-Triassic boundary clayrocks in South China are of volcanic origin. Many minerals and structures typifying volcanic activities have been found. Thousands of microsphaerules have been collected in twelve sections. The Permian-Triassic boundary is characterized by a prevalent sudden $\delta^{13}\text{C}$ drop. The mass extinction at the end of the Permian is, according to the authors, caused by volcanic activity, including degassing and subsequent forest fire.

YIN HONG-FU and LING QUI-XIAN, 1986. Triassic palaeobiogeographic provincialialization of China. Selected papers of the 13th and 14th Academic Sessions Paleont. Soc. China, Anhui Publ. House Sci. and Techn., pp. 189-203. (in Chinese with English abstract).

The Lower-Middle Triassic of China is divided into four palaeobiogeographic regions pertaining to three realms and further subdivided into ten provinces. Brief remarks on the diversity, ecology and biogeographic aspects of each province are made. Divisions of realms and regions are mainly controlled by factors reflecting climate, latitude and palaeogeographic (plate-tectonic) isolation.

ZHOU ZHIYAN, 1989. Late Triassic plants from Shaqiao, Henyan, Hunan Province. *Palaeont. Cathayana*, 4: 131-197.

Description of several new taxa of Late Triassic plants with remarks on their ecology.

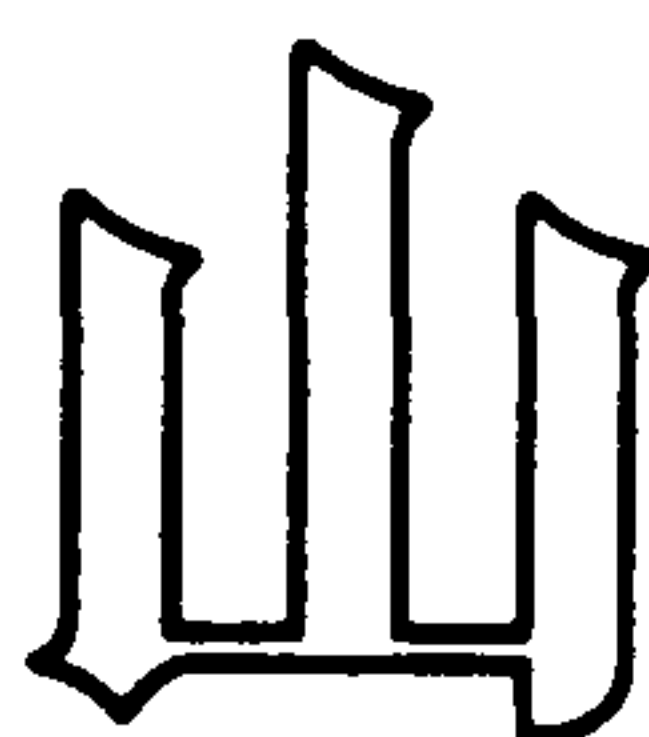
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