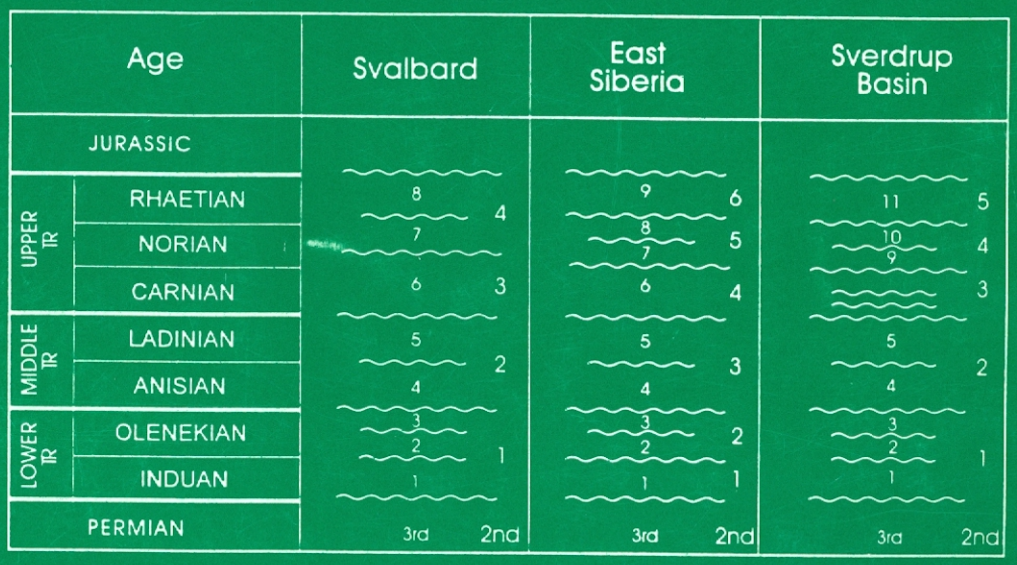
ALBERTIANA



MAY 1997

19

ISSN 0619-4324

ALBERTIANA

Editor ALBERTIANA: Hans Kerp
WWU, Abt. Paläobotanik
Hindenburgplatz 57-59
D-48143 Münster, Germany
Tel.: +49-251-832 3966
Fax: +49-251-832 4831
E-mail: kerp@uni-muenster.de

The primary aim of ALBERTIANA is to promote the interdisciplinary collaboration and understanding among the members of the I.U.G.S. Subcommission 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.

CONTENTS ALBERTIANA 19

Cover: Sequence boundary correlations throughout the Arctic showing 2nd and 3rd order sequences.
See: Atle Mørk: Triassic sequences, stages and high order sequence boundaries, p. 9-11 of this issue.

SEE PAGE 51 FOR METHODS OF PAYMENT OF ALBERTIANA 18

DALONGKOU

Statement by the Subcommission on Triassic Stratigraphy

The following statement on this matter was agreed by the officers of the Subcommission on Triassic Stratigraphy (STS) and issued to J. Remane, Chairman of the ICS, and to Voting Members of the STS and of the Permian/Triassic Boundary Working group of the STS.

1. A document has been issued by an STS Voting Member, Spencer G. Lucas, concerning a geological investigation of a non-marine Permian-Triassic boundary succession at Dalongkou, north-west China.

   The STS Executive expresses its deep concern at the tone of parts of this document which was issued to STS Voting Members and members of the STS Permian-Triassic Boundary Working Group without reference to, or the authority of, the Executive.

2. The Dalongkou matter is also the subject of a contribution by Lucas, Kozur, Molina-Garza and Geissman which appeared in Albertiana 18 and which questions whether any section in the People's Republic of China should be considered as a candidate GSSP.

   The STS Executive was not aware of the submission of this article to Albertiana, or of its acceptance by the newsletter editor.

3. The document issued by Lucas, dated 17 October 1996, and the note by Lucas et al., published in Albertiana 18, do not represent either the views or the policy of the STS.

4. The objective of the STS is to bring forward, for ratification by the ICS, candidate GSSPs for the base of the Triassic and for its component stages; all candidate GSSPs must fulfil criteria which are applicable worldwide.

5. At the STS General Assembly, held in Beijing during the 30th International Geological Congress, the Chairman of the Permian-Triassic Boundary Working Group, Yin Hongfu, reported on his group's selection of a section at Meishan, People's Republic of China, as the preferred GSSP for the base of the Triassic. The STS Chairman directed Yin Hongfu to prepare a formal proposal which would be the subject of a vote by the STS.

The STS Executive expects this formal proposal to be made as directed and, by fully addressing all qualifying criteria, that it will form an adequate basis for STS Voting Members to reach an objective decision on the section concerned.

M. Gaetani
Chairman, Subcommission on Triassic Stratigraphy
18 February 1997

The STS Chairman and Secretary have received, from Professor Cheng Zhengwu, of the Institute of Geology, Chinese Academy of Sciences, Beijing, an 8-page report in which he expresses his view of the events connected with the field investigation at Dalongkou and which were the subject of Lucas' letter and the published note by Lucas et al.

G. Warrington
Secretary, Subcommission on Triassic Stratigraphy

IUGS/ICS SUBCOMMISSION ON TRIASSIC STRATIGRAPHY (STS)

Abbreviated Minutes of General Assembly held on 6th August 1996, China World Trade Centre, Beijing, People's Republic of China

Meeting convened as part of the 30th International Geological Congress Beijing; 4-14th August 1996

Present:
G. Bachmann, A. Baud, M. Dickins, I. Dobruskina, M. Gaetani, B.F. Glenister, J. Haas, J. Hancox, C. Henderson, W.T. Holser, H. Kozur, Lai Xulong, V. Lozovsky, S.G. Lucas, G. Melnikova, J. Remane, Mei Shilong, C. Spinosa, Pan Yun tang, G. Retallack, B. Rubidge, Tong Jinnan, C. Virgili, B.R. Wardlaw, G. Warrington, Yin Hongfu

A. Baud (Lausanne), STS Chairman, opened the meeting at 19.05.

1. Apologies for absence

None received; the Assembly was advertised in Albertiana 17.

2. New Officers of STS

The following were elected, by ballot conducted through Albertiana, to serve for the next four years:

Chairman - M. Gaetani; Vice-Chairmen - M. Orchard, H. Rieber, Yu. Zakharov; Secretary-General - G. Warrington.

Baud thanked the retiring officers (Vice-Chairmen and Secretary-General) for their contributions to the work of STS.

3. News of STS members

Professor C. Virgili, the Past-Chairman of STS, was congratulated on her election as Senator for Barcelona.

The deaths of K. Balogh (6 April 1995), E. Kristan-Tollmann (25 September 1995) and H. Zapfe (July 1996) were noted with deep regret. [The work of K. Balogh was reviewed in Albertiana 17, and that of Kristan-Tollman and Zapfe in ALBERTIANA 18: ed.]

4. STS activities: 1992-1996

Baud reviewed the work of STS during his chairmanship.

Albertiana, the STS newsletter has been a major forum for presentation and discussion of Triassic stratigraphic matters. It is distributed to STS members and is available to non-members by subscription (see ALBERTIANA 17), the publication rate was increased to two issues each year in 1993.

The proceedings of the 1992 Lausanne meeting were published in 1994 as Mémoire de Géologie

(Lausanne) 22; (see ALBERTIANA 14 for details of how to obtain this volume). An Italian/Hungarian group held a field-based meeting on Anisian/Ladinian boundary sections at Bagolino and Lake Balaton and produced five publications on biostratigraphic and other factors relevant to the definition of this boundary. No information had been received on a meeting on Triassic biostratigraphy held in Australia in 1996.

Baud then asked the incoming Chairman, M. Gaetani (Milan) to conduct the remainder of the meeting.

5. New Chairman's remarks

Gaetani thanked Baud for his work as STS Chairman and expressed the hope that he would fulfil the expectations of STS members. The main STS activity concerns GSSPs; much work is in progress but, though the search for more and better information is desirable and will continue, decisions cannot be postponed indefinitely. Work on some stage boundaries is more advanced than on others but, during the next four years the STS should aim to deal with most of the boundaries which are its responsibility.

Bachmann (Halle) mentioned the 'Epicontinental Triassic' meeting planned for 1998, and invited the STS to hold a business meeting in Halle during that meeting. Gaetani said he was pleased to accept this invitation as a meeting in 1998 would form a good deadline for decisions on some GSSPs. A review and discussion of boundaries followed:

a. Permian-Triassic Boundary Working Group (PTBWG): Gaetani asked Yin Hongfu (Wuhan) to make a short report.

   Yin Hongfu gave a summary of candidate P/T boundary stratotype sections at Meishan (Zhejiang Province, South China), Guryul Ravine (Kashmir), Shangsi (Sichuan Province, South China), and Selong (Xizang (Tibet) Autonomous Region); new developments in Canada and Spiti were noted. The candidate sections had been described in greater detail on 5 August, during a joint business meeting of IGCP 359 and the PTBWG, and are documented in a special volume (Yin Hongfu (ed.) 1996. The Palaeozoic-Mesozoic Boundary: Candidates of the Global Stratotype Section and Point of the Permian-Triassic Boundary. China University of Geosciences Press, Wuhan, 137pp. ISBN 7-5625-1082-2). Yin Hongfu outlined the results of a questionnaire (PTBWG Newsletter 4: Albertiana 16). The same questions had been put informally to delegates attending the PTBWG business meeting on 5 August and a similar result obtained. With STS agreement, he would take a formal vote on the preferred candidate GSSP (Meishan).

   Remane outlined the voting procedure:

   i) Documents to be sent to all STS Voting Members, with six to eight weeks allowed for a response.
   ii) Voting papers to allow for YES and NO votes and ABSTENTIONS; 'no responses' count as 'YES'. At least 60% of the votes cast must be in favour of a proposal for it to be accepted.
   iii) If the proposal is accepted the STS will make a proposal to the ICS Secretary who will distribute documents within ICS and organise a vote which will follow the same procedure as that conducted within the STS.

   Gaetani requested Yin Hongfu to prepare the necessary documents with ballot papers for inclusion in Albertiana. Yin Hongfu was asked to send a current PTBWG membership list to the incoming Secretary-General (G. Warrington).

b. Induan-Olenekian Boundary Working Group: Gaetani said, in Zakharov's absence, that some notes had appeared in Albertiana but that work is in its early stages.

c. Olenekian-Anisian Boundary Working Group: Gaetani stated that work on this boundary is stagnant. Work on the magnetostratigraphy and the ammonoid/conodont biostratigraphy of the Kçira section, north Albania, is in press. No information has been published on the Dobrugea section and that section is not included in a paper by Gallet et al. (in press). Work on the conodont biostratigraphy of the Lower Anisian in Nevada is needed. Krystyn may have new information on ammonites from Spiti.

d. Anisian-Ladinian Boundary Working Group: Gaetani referred to articles published in recent issues of Albertiana and hoped that progress towards the definition of this boundary will be made before the Halle meeting in 1998. Hungarian workers had provided magnetostratigraphic results from the Felsöörs section which were calibrated against ammonites and other fossil groups but were too sparse. Haas (Budapest) explained that over 150 levels had been analysed but, because of overprinting and other technical problems, acceptable results had been obtained from only a few of these levels. Gaetani thanked him for this clarification and noted that the Bagolino section is remagnetized. Information is required from the Boreal region. The boundary must be correlatable to that region if possible, because of its industrial relevance. Conodonts are poor in the Boreal region but ammonite data exists; palynologists working in the region have not responded. Kozur (Budapest) commented that radiolarians may be useful in the Boreal region.

e. Ladinian-Carnian Boundary Working Group: an Italian publication on this boundary (Verso una definizione del Limite Ladinico-Carnico nel Sudalpino; Ferrara, 111 pp; 1995) is available (contact C. Broglio-Loriga, Dipartimento di Scienze Geologiche, Corso Ercole i d'Este 32, Ferrara, Italy). The use of *Daxatina* as a marker for the base of the Carnian has been suggested. Boundaries in conodont and ammonite zonation schemes do not correspond. Gaetani asked for suggestions for candidate sections in other areas.

f. Carnian-Norian Boundary Working Group: no activity has been reported.

g. Norian-Rhaetian Boundary Working Group: no activity has been reported. Gaetani remarked that, despite the lack of work or progress on some boundaries, there was clearly much activity which is yielding results. A vote on the P/T boundary appears imminent and one on the base of the Ladinian may follow soon. For the first time, there appears to be an almost complete magnetostratigraphic record from marine Triassic successions.

6. Non-marine Triassic Working Group

Gaetani asked Lucas to report on this group. Lucas (Albuquerque) stated that it has 12 members, including a magnetostratigrapher. After the Congress four members would sample the Dalongkou section in Xinjiang Province, north-west China, for isotope studies, magnetostratigraphy and palaeontology. A monograph on the floras of Arizona, by I. Dobruskina, had been published. The group is working towards correlation with marine sequences.

7. STS Newsletter: Albertiana

Gaetani commented that this publication is comprehensive and is produced and distributed satisfactorily. The cost is a problem, however, and he referred to the request made in Albertiana by Z. Smeenk (Utrecht) for financial support for the publication and said that some of the funds STS receives from ICS could be used to support the newsletter. Remane said that the subcommissions now receive their allocation from him and that part of the STS allocation could, if requested by the Subcommission, go directly to fund Albertiana.

8. STS membership

Gaetani said that the present voting membership must be revised; ICS requires a 30% change to be made every four years. He asked for suggestions for new corresponding members; the following, who collaborate with the Non-marine Triassic Working Group, were proposed by Lucas: Li Jinling (Beijing, People's Republic of China), Arcucci (La Rioja, Argentina), Rubidge (Johannesburg, South Africa), Hancox (Johannesburg, South Africa). Delegates were asked to vote on these names. All present voted 'YES'; there were no abstentions. The proposal was adopted.

9. New Secretary-General

Gaetani introduced G. Warrington, the new Secretary-General, and acknowledged the services of the retiring Secretary-General, H. Visscher. Warrington (Nottingham) outlined his activity, as a palynologist at the British Geological Survey, working on Permian, Triassic and Lower Jurassic sequences. He has been involved with the formulation and revision of the lithostratigraphic nomenclature of the Triassic in British offshore areas, served on the Stratigraphy Committee of the Geological Society of London and contributed to works on British Triassic stratigraphy, palaeogeography and the geochronology of the Triassic published by that Society. He has been an STS member since 1973; in 1991 he succeeded J. Guex (Lausanne) as Secretary of the Triassic-Jurassic Boundary Working Group (TJBWG) of the International Subcommission on Jurassic Stratigraphy; this involvement is complementary to that of STS Secretary-General and will aid communication between the two subcommissions on the matter of the mutual boundary. The TJBWG is working towards the selection of a candidate GSSP for the base of the Hettangian; potential candidates are in Austria, British Columbia, England, Nevada and South America.

10. Any other business

Yin Hongfu suggested that Yu. Zakharov should be asked to organise an international working group on the Induan-Olenekian boundary as activity on that boundary appears to be lagging behind. There should also be an Indian/Pakistani group involved with the Induan-Olenekian question and a working group on the Dienerian-Smithian boundary in Canada.

No further matters were raised.

Gaetani thanked the retiring STS Chairman and the new Secretary-General for their contributions, and the delegates for attending. He declared the meeting closed at 20.20.

G. Warrington

Secretary-General, Subcommission on Triassic Stratigraphy
20 November 1996

(Abbreviated, by the Secretary, from full minutes forwarded by him to the Chairman).

REVISED GUIDELINES FROM THE INTERNATIONAL COMMISSION ON STRATIGRAPHY (ICS)

G. Warrington: STS Secretary

Revised ICS guidelines regulating the procedure to be followed in the definition of chronostratigraphic boundaries have been published (Remane, et al., 1996). The main activity of the STS is governed by the principles expressed in these guidelines and all STS members involved with working on Triassic stage boundaries should read them; the sections on the choice of the best boundary level, on the requirements for a GSSP, and on the procedure for the submission of a GSSP are particularly important in this context. In addition to appearing in Episodes, the revised guidelines have been published in Permophiles, the newsletter of the Subcommission on Permian Stratigraphy (December 1996, No.29: 25-30). Any member who is unable to access either of these sources should contact the STS Secretary.

REMANE, J., BASSETT, M.G., COWIE, J.W., GOHRBANDT, K.H., LANE, H.R., MICHELSEN, O. and WANG NAIWEN. 1996. Revised guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). Episodes, 19(3): 77-81.

KNOW YOUR NEIGHBOURS

G. Warrington: STS Secretary

For STS members concerned with the upper or lower boundary of the Triassic the following may be useful.

The Secretary of the Triassic-Jurassic Boundary Working Group of the International Subcommission on Jurassic Stratigraphy (ISJS), the body concerned with the definition of the base of the Jurassic and, therefore, the top of the Triassic is also the Secretary of the STS (see STS officers list for contact details). The ISJS publishes a newsletter; the Secretary of the ISJS is:

Dr. F. Cecca
Università degli Studi di Urbino, Instituto di Geologia, Polo Scientifico Loc.
Crocicchia, I - 61029 URBINO, Italia
Phone: + 39 722 30426
FAX: + 39 722 304220
E-mail: F.Cecca@agora.stm.it

The Permian-Triassic Boundary Working Group of the STS is responsible for the definition of the base of the Triassic and, therefore, the top of the Permian and a matter of mutual interest to members of the Subcommission on Permian Stratigraphy (SPS). The SPS publishes the newsletter Permophiles; the Secretary of the SPS is:

Professor C. Spinosa
Department of Geosciences, Boise State University, Boise, Idaho 83725,
United States of America
Phone: + 208 385 1581
FAX: +208 385 4061
E-mail: cspinosa@trex.idbsu.edu

MEMBERSHIP RECORDS

A request for confirmation of contact details and current activity in Triassic stratigraphy was mailed to all Voting Members of the STS and the Permian-Triassic Boundary Working Group in February. At the end of April the Secretary had received 25 responses. To assist in maintaining accurate membership records and contact details ALL Voting and Corresponding members of STS are asked to send the following information to the Secretary as soon as possible, and to advise him promptly of any changes which occur, particularly to telephone or FAX numbers. *PLEASE PRINT OR TYPE INFORMATION CLEARLY*; accurate records will ensure that STS notices and the newsletter continue to reach members satisfactorily and will help keep postage and related costs to the minimum.

NAME:
ADDRESS:
TELEPHONE NUMBER:
FAX NUMBER:
E-MAIL ADDRESS:
ACTIVE IN TRIASSIC STRATIGRAPHIC STUDIES YES / NO*
WISH / DO NOT WISH* TO REMAIN IN THE STS MEMBERSHIP

(* delete as appropriate)

Please post, FAX or e-mail your response to:

Dr. G. Warrington
Secretary: Subcommission on Triassic Stratigraphy
British Geological Survey,
Keyworth, Nottingham NG12 5GG, United Kingdom

Telephone: +44 (0)115 9363407
FAX: +44 (0)115 9363437
E-mail: gwar@wpo.nerc.ac.uk

IUGS SUBCOMMISSION ON TRIASSIC STRATIGRAPHY

International Field Conference on Himalayan Permo-Triassic

For various reasons the field conference has to be postponed to July 1988. Requests concerning the conference should be directed to:

Dr. Leopold Krystyn
Paläontologisches Institut, Universität Wien,
Althanstrasse 14, A-1090 Wien, Austria.
E-mail:YBJ@pal.univie.ac.at

COMMENT - THE PERMIAN-TRIASSIC BOUNDARY: RECENT DEVELOPMENTS, DISCUSSION AND PROPOSALS by Aymon Baud - ALBERTIANA 18, p. 6-8.

J.M. Dickins

I commend the contribution from Aymon Baud for careful consideration. As a member of the P-T Boundary Working Group I have found myself with an ambivalent approach to the proposals made for recognizing the lowermost occurrence of *parvus* as the base of the Triassic System. The base of this system has, of course, special significance as the base of the Mesozoic Era.

On one hand, I would like to see the end of the almost endless discussion about the boundary position and stratotype so that we can get on with the what seems to me important questions of the geological character and explanation of what happens at this so interesting time in the earth's history.

On the other hand, I feel quite cynical about the value of using the first appearance of *parvus* and the philosophy or inadequacy of philosophy lying behind such a choice. Such a choice seems to be quite out of keeping with the history of how the eras, systems, and related units were set up and the relationships between these units and the geological time scale. It is the stratigraphical units in the field that are primary with all their geological features, not just their biological character, and the establishment of these units and their superpositional relationship which gives us the time scale. Somehow we just seem to have lost the plot. If we set up biostratigrapical units which have little practical value for the field understanding, all geological science will suffer.

Nowhere is this better illustrated than by the discovery of *parvus* in one section in the Canadian Arctic where it occurs some distance above the base of the Griesbachian Formation, the base of which, I have little doubt, represents an unconformity or disconformity above a distinctive hiatus. If *parvus* is used as the boundary, how can any sensible field map be produced ?

There are also other important difficulties about *parvus*, in addition to the argument on the inadequacy of using a single species for defining and recognizing the base of a system on a world scale. It appears at different levels as the marine transgression develops after the very major regression which is a special feature of the Permian-Triassic boundary sequence. Its value as a time marker is, therefore, limited and can lead to problems of cross correlation.

I do not have the same misgivings as Aymon Baud about the Meishan sequence as being the type for the boundary. I do not believe in an ideal boundary - does such a thing ever exist ? It does have merit in the good relationships with the underlying Permian not shown by other sections which have been considered. It is clearly a condensed sequence and as such, no doubt will probably have more than one hiatus and in this I agree with Aymon. I would place the boundary at the "boundary clay" either at the base or top - I do not have any strong feeling for one or the other. At this clay the major part of the Permian type fauna disappears after which elements of what have been regarded as of Triassic type are seen. It thus conforms to the historical concepts on what distinguished the Palaeozoic and the Mesozoic Eras and, I consider, represents, at least for the time being, the most practical boundary not just for palaeontology but for other fields of geology.

TRIASSIC SEQUENCES, STAGES AND HIGH ORDER SEQUENCE BOUNDARIES

Atle Mørk

One of the aims of 'The International Subcommission on Triassic Stratigraphy' as specified in the November 1996 volume of Albertiana is *'to promote research in order to clarify whether there are four or five 2nd -order sequences recognisable in the Triassic'* (Gaetani 1996). This statement imply that the second order sequences are eustatic in nature, i.e. the sequence boundaries have the same order throughout the earth.

First, the sequence boundaries have to be defined as objectively as possible. Furthermore, a hierarchical organisation of these sequence boundaries and their delineated sequences is clearly needed to be able to perform intra-basinal correlations and also inter-basinal correlations. Our sequences are delineated by mapping the sequence boundaries and classifying them according to their basinwide development following Embry (1995); 1st order sequence boundaries are due to major tectonic disturbances (orogenesis), 2nd and 3rd order boundaries are both developed and can be followed throughout a basin, but differs in there being a major shift in sedimentary regime for the 2nd order boundaries whereas the same sedimentary pattern continues across the 3rd order sequence boundary.

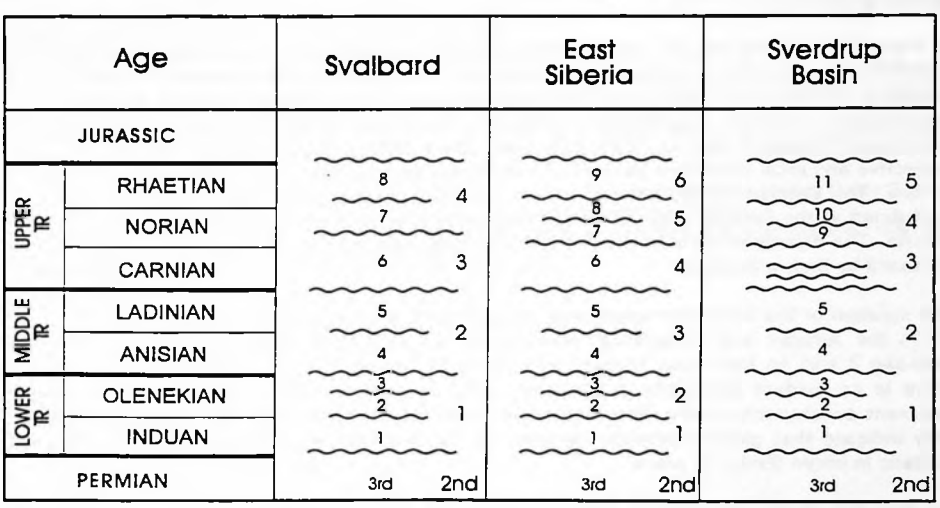


Figure 1. Sequence boundary correlations throughout the Arctic showing our 2nd and 3rd order sequences (Embry 1988, Mørk et al. 1989, Embry in press, Mørk and Egorov in prep.).

For our purposes we have classified and correlated sequence boundaries rather than sequences. The boundaries are dated on the basis of the oldest fossil which occurs above the boundary and the youngest one below it. Fossils tend to be most common in the transgressive system tract with the richest fossil beds in the deposits developed during maximum flooding. In our studies we have used the ammonoid zonation by Weitschat and Dagys (1989) and Dagys and Weitschat (1993), to correlate recognised sequence boundaries between the arctic basins.

The boreal zonation scheme by Dagys and Weitschat (1993) is quite detailed with as many as 56 zones developed in Siberia, but only four of the zones are characterised by the same ammonoid species in all the three arctic areas; and no zones (W. Weitschat pers. communication 1997) show identical fauna as seen in the Tethys. We thus lack an objective criteria to test whether the sequence boundaries (i.e. the transgressive bed) are synchronous or not. Mørk (1994) indicated that the fact that major transgressive-regressive sequences (both second and third order) or their bases are contemporaneous with the classical stage subdivision is an evidence for correlation between the type areas and the Arctic. Embry (in press) further correlated all the sequence boundaries as defined by him in the Sverdrup Basin (see Figure 1) with boundaries of the Arctic as well as in Germany, Italy, the Himalayas and North America and concluded that the correlations show that their development are global and most probably tectono-eustatic in origin.

The hierarchical system from the Exxon school uses time as an indicator for sequence order. This imply that there must be a cyclic control on the formation of sequences. Although this may be correct for some astronomic phenomena like Milankovitch cycles, this can only explain low order sequences. From the cycle chart of Haq et al. (1988) it seems that available sequence boundaries have been subjectively selected to suit their sequence duration definition and not with clear, well defined parameters.

In Figure 1, showing our 2nd and 3rd order boundaries in the Arctic, we have first defined and classified the boundaries within each basin separately. Some of the boundaries, like the early Olenekian (Mørk et al. 1994) and the basal Rhaetian, change order between the basins. Other boundaries do not have counterparts in the other basins, although the palaeontological control in the Upper Triassic is not as good as below. The assignment of order for a boundary is partly subjective and local conditions (tectonics, subsidence and sedimentation rate) may modify the order by one. The Carnian and Norian succession are also poorly preserved on Svalbard (and as yet not well dated in the Barents Sea), and more sequence stratigraphical work is also needed in Eastern Siberia. The discrepancies between these arctic areas may thus be less than shown on Figure 1 as indicated by Embry (in press).

The duration of the third order sequences varies from 1 to 10 Ma in the Triassic, however from 2 to 23 in the Jurassic and Cretaceous, whereas the duration of the second order sequences varies between 3 and 14 Ma in the Triassic, and 3 and 51 in the Jurassic and Cretaceous. In our data there is no evident periodicity or cyclicity in the occurrences of the sequence boundaries. The apparent synchroneity of the Triassic sequences as compared with the later Mesozoic sequences, may indicate that global tectonics has affected the sea level and the sequences are thus clearly eustatic in origin (Embry in press).

To map the global occurrences of the Triassic high order sequences some common criteria are recommended:

1. Sequence boundaries rather than sequences should be defined, well dated and correlated. Such boundaries can then be correlated even when they are not the same order.
2. Improved dating of the transgressive beds above the boundaries is needed for inter-regional correlations.

3. The hierarchical system for sequence boundary classification should be followed within the individual basin. This system should not be based on duration of sequences.

The framework build by answering these criteria may indicate whether the control on high order sequences in the Triassic is mainly of eustatic nature (although tectonic in origin). Our present day data from the Arctic indicate such eustatic control in the Triassic contrasting the later development in the Mesozoic (Mørk et al. 1993, 1997).

References

DAGYS, A.S. and WEITSCHAT, W., 1993. Correlation of the Boreal Triassic. Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 75: 249-256.

EMBRY, A.F., 1988. Triassic sea-level changes: Evidence from the Canadian Arctic Archipelago. In: Sea-Level Changes - An integrated approach, SEPM Spec. Publ., 42: 249-259. Soc. Econ. Paleont. Mineral.

EMBRY, A.F., 1995. Sequence boundaries and sequence hierarchies: problems and proposals. In: Steel et al. Sequence Stratigraphy on the Northwest European Margin, NPF Special Publication 5, pp 1-11, Elsevier, Amsterdam.

EMBRY, A.F. in press. Global sequence boundaries of the Triassic. Bull. Can. Petrol. Geol.

GAETANI, M., 1996. The International Subcommission on Triasssic Stratigraphy, purposes and objectives. Albertiana, 18: 3-4.

HAQ, B.U., HARDENBOL, J. and VAIL, P.R., 1988. Mesozoic and Cenozoic chronostratigraphy and cycles of sea level change. In: WILGUS, C.K., HASTINGS, B.S., ROSS, C.A., POSAMENTIER, H., VAN WAGONER, H. and KENDALL, C.G.S.C. (eds.), Sea level changes: an integrated approach, SEPM Spec. publ. 42: 71-108.

MØRK, A., 1994. Triassic transgressive-regressive cycles of Svalbard and other Arctic areas: a mirror of stage subdivision. In: Guex, G. and Baud, A. (eds.), Recent developments on Triassic Stratigraphy (Proc. Triassic Symp., Lausanne, 20-25 Oct. 1991). Mém. Géol. (Lausanne), 22: 69-82.

MØRK, A., EGOROV, A.Y. and EMBRY, A.F., 1994. Base Olenekian and base Anisian sequence boundaries produced by Triassic circumpolar 'synchronous' transgressions. In: THURSTON, D.K. and FUJITA, K. (eds.), Int. Conf. Arctic Margins 1992 Proc. OCS Study MMS 94-0040 U.S. Dept. Interior, Mineral Management Service, Alaska OCR Region. pp. 9-14.

MØRK, A. and EGOROV, A.Y., in prep. Svalbard and East Siberia Triassic sequences.

MØRK, A., EMBRY, A.F. and WEITSCHAT, W., 1989. Triassic transgressive-regressive cycles in the Sverdrup Basin, Svalbard and the Barents Shelf. In: COLLINSON, J.D. (ed.), Correlation in Hydrocarbon Exploration, Norwegian Petroleum Society, Graham & Trotman, pp. 113-130.

MØRK, A., SMELROR, M., EMBRY, A.F. and Egorov A.Y., 1993. Second and Third order T-R sequence boundaries in the Mesozoic succession of the Circum Arctic. Abstr. Pangea Conf., Can. Soc. Petrol. Geol., Calgary.

MØRK, A., SMELROR, M. and WORSLEY, D., 1997. Correlation and Non-correlation of Higher Order Circum-Arctic Mesozoic Sequences, Abstr. CSPG-SEPM 1997 joint convention Calgary.

WEITSCHAT, W. and DAGYS, A.S., 1989. Triassic biostratigraphy of Svalbard and a comparison with NE-Siberia. Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 68: 179-213.

OUTLINE OF THE TRIASSIC PALAEOGEOGRAPHY OF BULGARIA

Ivan Zagorchev and Kiril Budurov

Introduction

The Triassic System in Bulgaria is well studied in almost all aspects of palaeontology, stratigraphy and sedimentology. Previous generalizations on facies distribution and evolution of sedimentation in Bulgaria during the Triassic Period (Vaptsarova, Chemberski and Chatalov, 1984; Tronkov in Tchoumatchenco et al., 1990) were based on the information available in that time but did not account for the intricate Alpine thrust tectonics of this country (Boyanov et al., 1989). In the present paper, new ideas are summarized on the basis of own experience and newly published evidence.

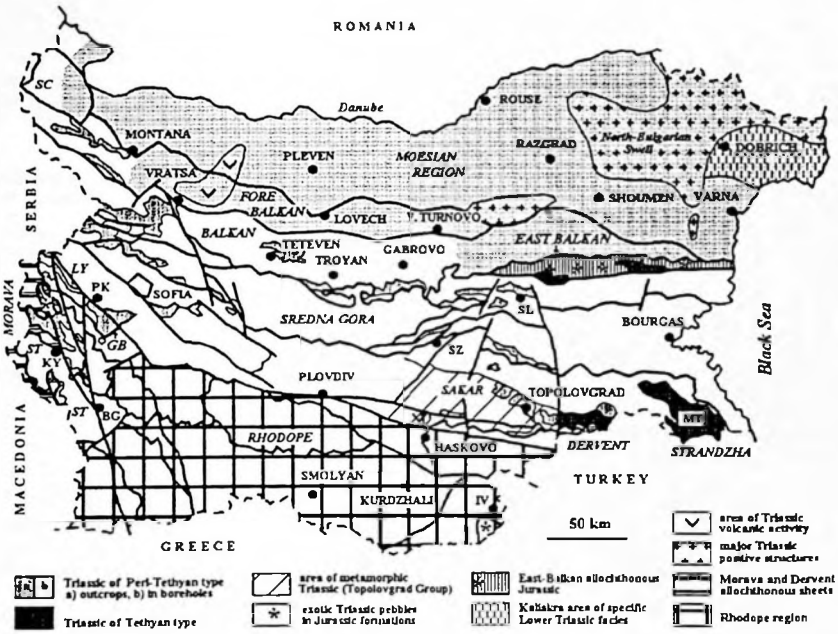


Fig. 1. Tectonic sketch of Bulgaria with principal Triassic occurrences in outcrops and boreholes

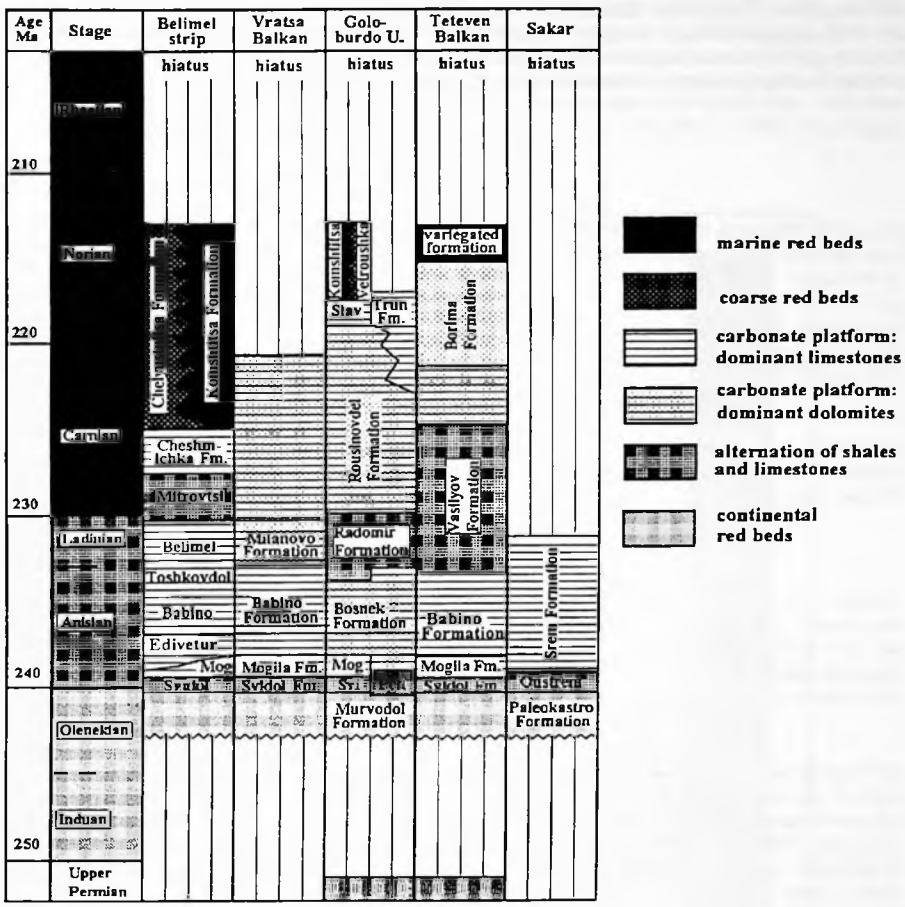


Fig 2. *Stratigraphic charts for some important Peri-Tethyan Triassic occurrences (age chart as accepted by the Peri-Tethys Programme, according to IUGS 1989 chart with modifications by Odin 1994)*

Triassic stratigraphy: Tethyan and Peri-Tethyan Triassic

The present Alpine (Alpidic) structure of Bulgaria (Fig. 1) and the Balkan Peninsula is a result of superposition of several Alpine orogenic edifices (Boyanov et al., 1989) that resulted from folding and thrusting of previous basins. The most important events of Mid-Cretaceous, Late Cretaceous and Palaeogene/earliest Neogene times veiled and almost obliterated older structures of Late Triassic age. However, relics of this older structure are discernible, and may be found even in areas of most intense younger movements (e.g., Dinkova et al., 1987).

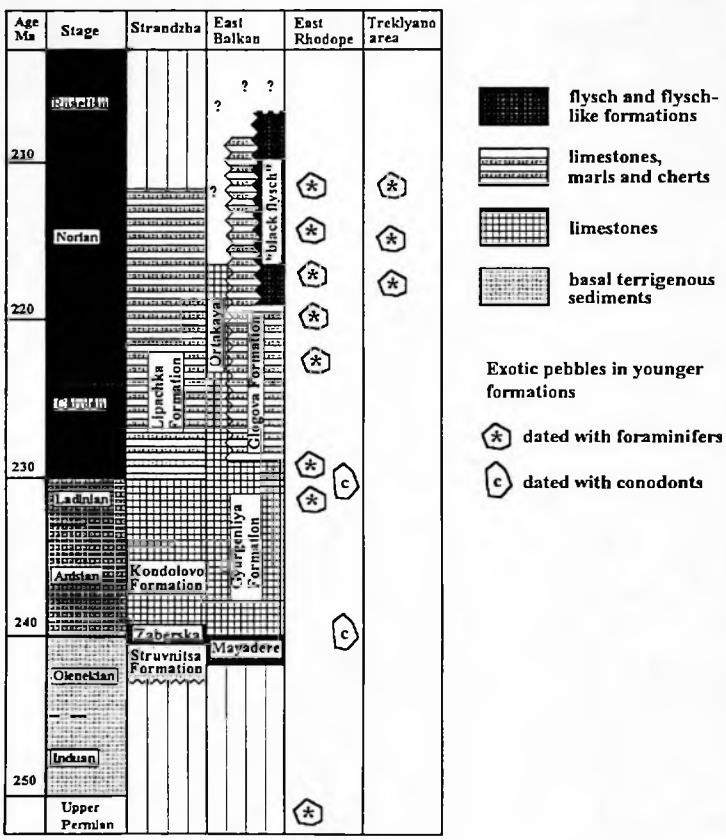


Fig. 3. Stratigraphic charts for some important Tethyan Triassic occurrences

The sedimentological features of the Triassic sections in Bulgaria exhibit a considerable variety. However, the study and comparison of the sections in the Moesian region (Chemberski, Vaptsarova, 1979), the Balkan fold belt (Chatalov, 1984a,b; Tronkov, 1973), the East-Balkan zone (Budurov et al., 1995b, 1996; Kanchev, Encheva, 1967), the Srednogorie fold belt (Chatalov, 1980, 1985a,b, 1990; Tronkov, 1975, 1981, 1983) and the Strouma Superunit in SW-Bulgaria (Budurov et al., 1995a; Zagorchev et al., 1995) show that Triassic facies changes possess definite regularities due to different Triassic palaeogeographic and palaeogeodynamic environments. Faunistic differences between Tethyan and Peri-Tethyan Triassic environments have been also described (Budurov and Trifonova, 1994). The following Triassic types (e.g., Chatalov, 1980) have been recognized:

Peri-Tethyan environments:

The **Balkanide type** (Fig. 2) is the most widespread autochthonous Triassic in Bulgaria. It occurs within the Moesian region (platform), the Fore-Balkan, the Stara-planina (Balkan), the western and central Srednogorie as well as in parts of the eastern Srednogorie, and in the Strouma Superunit in SW Bulgaria. It is classically subdivided into three groups, and namely: Petrohan Terrigenous Group (red beds of Early Triassic age); Iskur Carbonate Group (limestones and dolomites, with some marls and shales; Spathian to Norian); Moesian Group (red beds with some marls and limestones; Upper Triassic). A Subbalkanide and a Kraishtid-Srednogorie subtype have been recognized by Ganev and Stefanov (1977) but the differences between them are of minor importance.

The Triassic of **Sakar type** (Fig. 2) (Chatalov, 1995b) (Topolovgrad Group) shows Balkanide affinities but differs considerably by the high grade (amphibolite facies) of metamorphism. Transitions towards the typical Balkanide type is sought in the lower parts of the Triassic section (Toundzha Group) of the Sveti Iliya Hills.

Tethyan environments:

The **East Balkan type** (Fig. 3) consists (Kanchev, Encheva, 1967; Budurov et al., 1995a) of flysch-like formations (Olenekian Mayadere Formation; Upper Triassic black flysch) and limestones (Gyurgenliya Formation) intercalating with marls and cherts (Glogova Formations) that can be grouped into an East-Balkan Group. The stratigraphy is elaborated within huge olistoliths embedded within formations mostly of Jurassic age (Tchoumatchenco, Chernyavska, 1989) situated in an allochthonous position (East-Balkan, or Louda Kamchiya Unit).

The **Strandzha type** (Fig. 3) consists of a number of formal lithostratigraphic units recognized by Chatalov (1980, 1985a, 1990), and grouped into a Veleka Group with Grahilovo Subgroup (Lower Triassic - Anisian) and Bosna Subgroup (Anisian - Norian). A partial stratigraphic revision is made by Savov et al. (1995), stratigraphic studies and further correlations continuing by the same authors. Similarly to the East Balkan type, a lower flysch-like part (Zaberska Formation; Late Olenekian) follows closely the basal terrigenous deposits (Struvnitsa Formation). Predominant neritic limestones (Kondolovo Formation; Anisian - Ladinian) are followed by the Upper Triassic limestone - marl interbedding of the Lipachka Formation. The Triassic of Strandzha type is a part of huge allochthonous masses of the Strandzha thrust sheets thrusted over the autochthonous Triassic of Balkanide type.

Jurassic marine formations of a peculiar (alien for the southern margin of the Jurassic Moesian continent) deeper facies occur not only in the East Balkan Unit (Matorides - Tchoumatchenco et al., 1989) but also in a very restricted part of the Strouma Superunit in SW Bulgaria beneath the thrust sheets of the Morava Superunit (Zagorchev, Tikhomirova, 1986; Zagorchev, 1986), and in thrust

sheets within the East Rhodope Superunit of the Rhodope massif (Zagorchev et al., 1989). These Jurassic formations contain numerous Triassic pebbles and olistolites (Boyanov, Trifonova, 1978; Boyanov, Budurov, 1989; Trifonova, Boyanov, 1986) of exotic character, of microfacies that are not found in any autochthonous root outcrops on Bulgarian territory. The exotic Triassic pebbles (Fig. 3) are subject of special attention due to the opportunities to throw light on important palaeogeodynamic problems.

We are not able to enter here into details of the Triassic stratigraphy of Bulgaria with its great number of formal (cf. Tronkov in Tenchov, ed., 1993) and informal lithostratigraphic units. However, even a superficial glance over the stratigraphic units and their sedimentological features allows for the recognition of two principal types of sequences, and namely, Tethyan (East-Balkan; Strandzha; some exotic pebbles), and Peri-Tethyan. Chatalov (1980) used five criteria for recognition of the different Triassic types, and namely: (i) facies composition; (ii) thickness; (iii) content of fossil fauna and flora; (iv) presence or absence of magmatic rocks; and (v) grade of regional metamorphism. Only the first criterion is of paramount importance because the thickness is highly variable in function of different factors; the fossil content depends on ecological factors - the differences in the conodont and foraminifer assemblages of the Tethyan and Peri-Tethyan Triassic are, however, distinguishable but not of decisive importance; basic, intermediate and acid volcanics are known both in Tethyan and Peri-Tethyan environments; and the presence and grade of regional metamorphism is an element superimposed in the course of later, Jurassic and Cretaceous evolution.

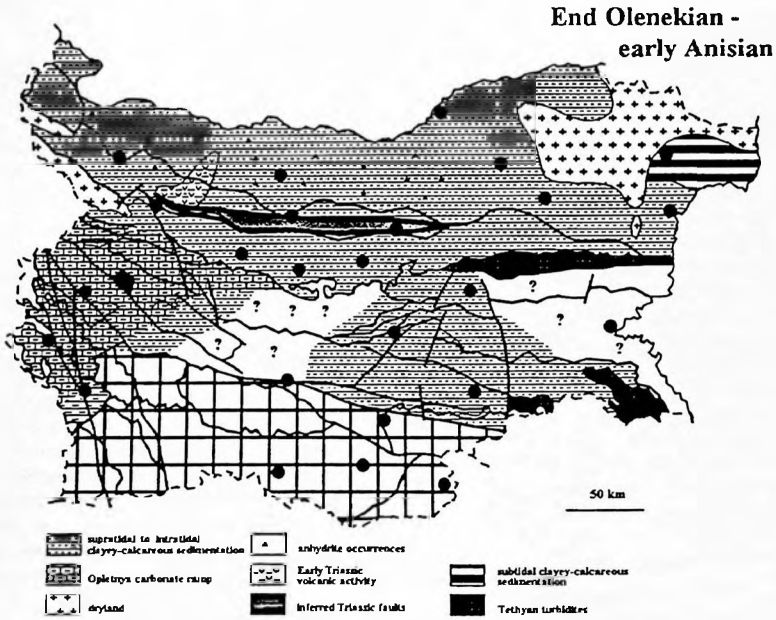


Fig. 4. Palaeogeographic map (without palispastics) for latest Olenekian - early Anisian times

The typical features of the Tethyan sequences are the presence of the following lithological varieties or facies: rhythmic turbiditic sequences (flysch? or flysch-like); pelagic limestones and marls; radiolarites; 'ammonitico rosso'.

The typical features of the Peri-Tethyan sequences are as follows: transitions from continental to littoral facies; dolomites; evaporites (anhydrite, halite); oolithic, intraclastic, and/or biodetrital limestones with abundant debris of shelf-bound fauna; bioturbations; terrigenous (sandy) interlayers; continental or marine red beds.

Triassic palaeogeography

The Triassic palaeogeography shows specific features for the different Tethyan and Peri-Tethyan environments. The Tethyan formations being in allochthonous position, the real interrelations between the Tethyan and Peri-Tethyan environments cannot be reconstructed with certainty. Therefore, former palaeogeographic studies (Vaptsarova et al., 1984; Tronkov in Tchoumatchenco et al., 1990; Tronkov, 1993) considered only the Peri-Tethyan evolution.

The Triassic evolution of the Peri-Tethyan realm followed the Hercynian folding and thrusting with formation and denudation of the Hercynian orogen. Local basins in the arid Late Permian environment either inherited earlier Late Carboniferous and/or Early Permian basins or were formed directly over denudated structures of the Hercynian orogen. The depth of denudation varied considerably: the Upper Permian formations cover in different structural units rock units of Early Permian, Late Carboniferous, Late Devonian - Early Carboniferous, Ordovician, Vendian-Cambrian or Precambrian age (e.g., Dinkova et al., 1987). The long peneplanation in Late Permian and earliest Triassic times formed the Early Triassic peneplain characterized by a low relief, relict sabkha-type Permian basins, and relics of the Hercynian orogen - island mountains and hills ('Inselberge').

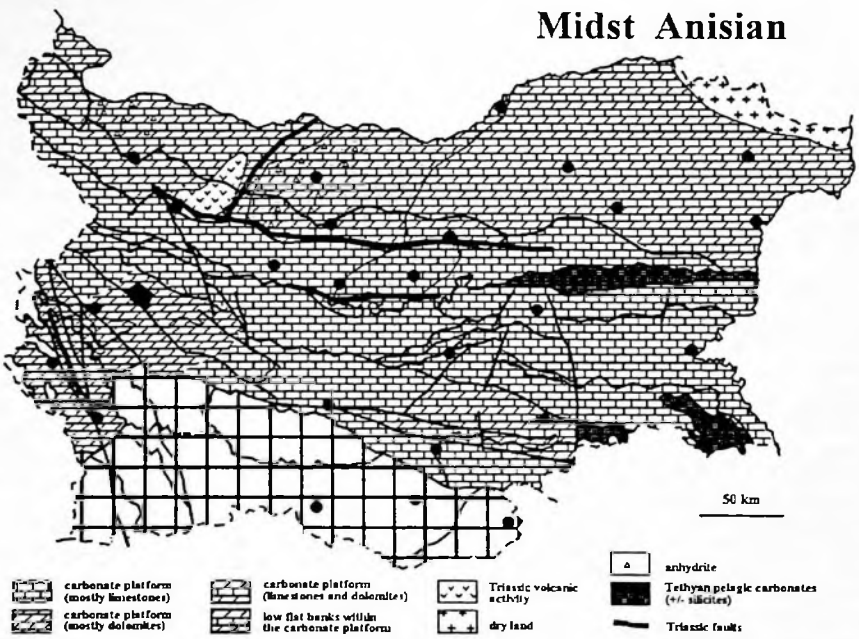
The Early Triassic began with the development of a fluvial system that consisted of alluvial and proluvial fans, fluvial braidplain, fluvial floodplain, aeolian environments, pedogenic environments, and a coastal floodplain (Mader and Chatalov, 1992). The marine transgression began (Fig. 4) near the end of Olenekian (Spathian) time, and sea waters flooded diachronously most of the Bulgarian territory in latest Olenekian and earliest Anisian times (Vaptsarova et al., 1984). The gradual transgression is especially well documented by the drilling in Northeast Bulgaria (Chemberski et al., 1996), although the postulated beginning of that process as early as in Induan (Griesbachian) time seems improbable. Several positive morphostructures remained as island drylands within the Moesian Region and the Forebalkan up to Anisian time, and namely, the South-Dobroudzha dryland and several smaller islands in Northeast Bulgaria (Chemberski et al., 1996), the Belogradchik dryland (Tronkov, 1973), and several smaller islands in the Vratsa Balkan (Tronkov, 1966). The gradual flooding of the peneplain by the sea waters occurred in variable sedimentation regimes (Chatalov, 1975) depending on interchange between fluvial and coastal floodplains and the adjacent littoral zone (transitional mud plain, supratidal evaporitic plain, peritidal and subtidal plain, lagoons, etc. with changes of low-energy

to high-energy medium). Therefore, variable transitional formations of small thickness (from 2 - 3 to 150 m) have been distinguished (e.g., Tronkov, 1983; Budurov et al., 1995b). In this variable environments, the Opletnya carbonate ramp (Tronkov, 1993) is characterized by peritidal cycles and hemicycles, being insulated from the abundant fine-grained terrigenous influx that characterized the area in latest Olenekian (Spathian) and earliest Anisian time.

The first (lower) carbonate platform (Vaptsarova et al., 1984; called by Tronkov, 1993, Bosnek

carbonate platform) was formed in Anisian time (Fig. 5) within the littoral and sublittoral zones with the deposition of limestones (Mogila and Babino Formation), dolomites (Bosnek Formation), and limestones and dolomites (Doyrentsi Formation), most of the dolomites being a result of early (and partly, late) diagenetic dolomitization.

Partially in early Anisian time, and mostly in latest Anisian or earliest Ladinian time, the carbonate platform was replaced by a shallow shelf with clayey-terrigenous and biogenic (biodetrital limestones) sedimentation (Radomir and Vasilyov Formations). It was characterized by abundant and various fauna that developed in conditions of normal salinity, relatively warm waters, abundant influx of nutrients, and subtidal shallow-water environment. This type of sedimentation continued locally also in early Carnian time, and in the Teteven area and a part of Northeast Bulgaria



(Tyulenovo Formation), up to the end of Early Carnian - beginning of Late Carnian time.

Fig. 5. Palaeogeographic map (without palinspastics) for mid-Anisian time

The second (upper; Trun) carbonate platform (Fig. 6) was set up in latest Ladinian time, and developed in Carnian and Norian times (Vaptsarova et al., 1984; Tronkov, 1993). Chemogenic sedimentation proceeded in conditions of a shallow shelf with variable salinity, and precipitation of chemogenic limestones (Trun Formation) or synsedimentary or slightly postsedimentary dolomites (Rousinovdel and Troyan Formation). The dolomites are similar to the 'Hauptdolomit' of the Austrian Alps (Stefanov, 1932). They either fill in the whole volume of the Upper Triassic carbonate

sediments or pass upwards (fossiliferous limestones at the transition to the red beds) or/and laterally into limestones (Trun Formation - massive whitish limestones with *Tubiphytes* and other algae). Various lithofacies are similar to that described in the Alps, and indicate various supratidal, intertidal or subtidal environments. Dolomites and limestones in the Teteven Balkan area formed in conditions of beginning influx of terrigenous components due to beginning differential uplift and regression (Chatalov, 1984; Vaptsarova et al., 1984). Local sedimentation breaks are also possible thus pointing at a significant event at the end of Ladinian or beginning of Carnian time. Lagoonal environment in the eastern part of the Moesian region produced thick dolomites and evaporites (anhydrite, halite) of the Preslav Formation.

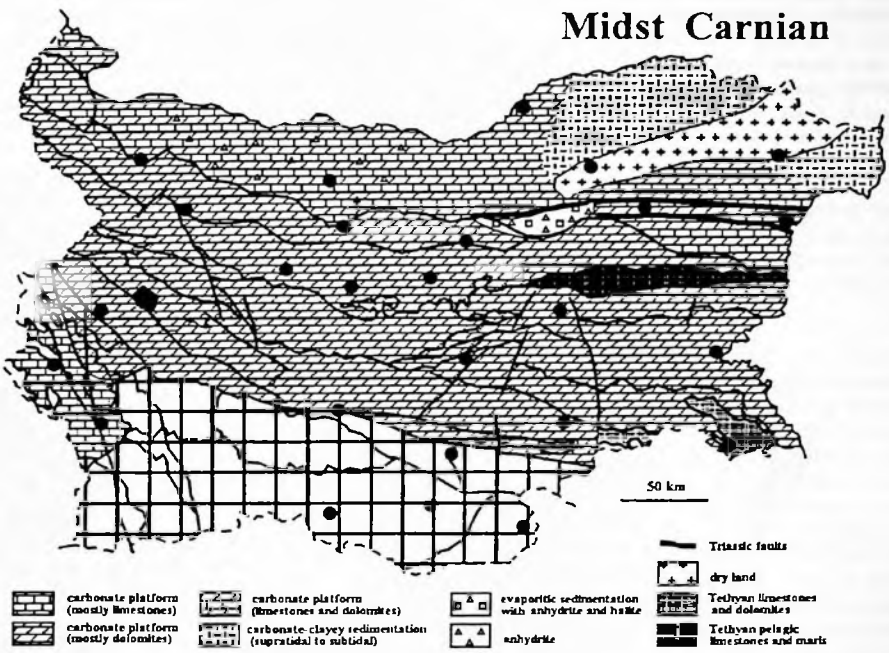


Fig. 6. Palaeogeographic map (without palinspastics) for Early/Late Carnian time

The process of disintegration of the upper carbonate platform began locally even in Carnian times, with local influx of terrigenous material from uplifted structural units. The conditions changed drastically during late Carnian to Norian times when the dolomitic sedimentation in lagoonal conditions and periodical influx of fresh waters was diachronously changed to chemogenic formation of thin limestone beds, and then, by fine-grained (red muds transformed in shales and siltstones) terrigenous sedimentation with occasional pure chemogenic sedimentation (limestones with occasional foraminifers). Horsts were formed within some of the tectonic zones (e.g., the Lyubash unit), and huge amounts of Triassic rocks (mostly of the upper carbonate platform but also coming down even to the base of the lower carbonate platform) have been eroded and deposited as

breccia and conglomerate in the adjacent fast subsiding basins (Budurov et al., 1993), as in the Golo-burdo unit (Vetroushka Formation), the West Forebalkan (Chelyustnitsa Formation; new Formation, with stratotype along the river Chelyustnichka bara), the Teteven Balkan (Borima Formation), the Troyan Balkan (Ambaritsa Formation). The disintegration of the marine basin in regression conditions was particularly intense in the Moesian region where several formations of marine red beds were deposited in small relict restricted basins with (i) terrigenous sedimentation in freshened or low-mineralized waters, (ii) clayey-carbonate sedimentation in waters of relatively increased salinity, (iii) sulphate-carbonate-clayey sedimentation in waters with strong salinity increase (Vaptsarova et al., 1984). At the end of Norian times (Fig. 7), the whole territory of Peri-Tethyan Triassic in Bulgaria was uplifted above sea level. The Jurassic transgression lasted from Hettangian to Bajocian times. The sea waters of an epicontinental sea covered consequently lowlands of the Early Cimmerian (Late Triassic) relief, and afterwards, the remaining island dry lands (brachyanticlines), as the cores of the Radova anticline, the Lyutskan anticlinorium (both in the northern parts of the Strouma Superunit - Dinkova et al., 1987), etc.

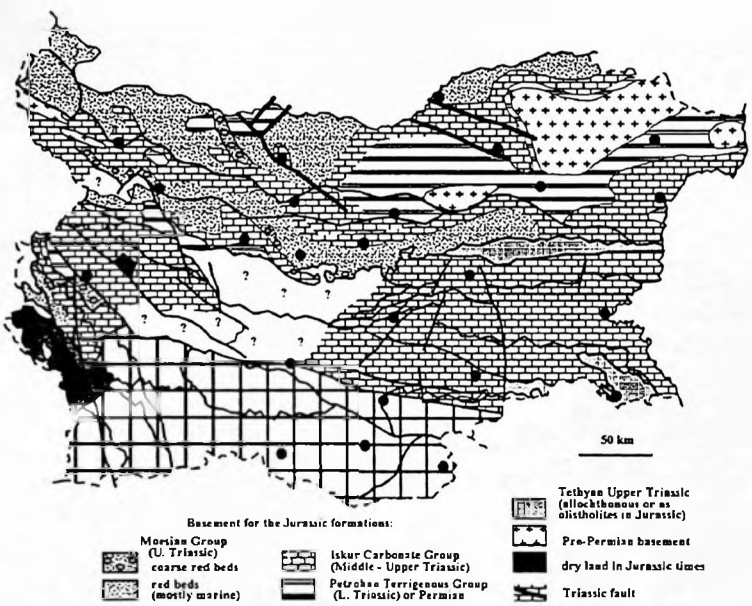


Fig. 7. Palaeogeographic map for the pre-Jurassic basement covered by the Jurassic transgression

Our knowledge on the Triassic evolution of the Tethyan realm is based upon restricted information mostly from olistolites (East Balkan) and exotic pebbles in Jurassic formations (Treklyano area in SW Bulgaria; East Rhodope). On the palaeogeographic maps (Figs. 4 to 6) the locations with Tethyan Triassic are shown in their present allochthonous position, and they give no hints about their primary position and possible later displacements (ongoing studies shall produce palinspastic reconstructions). The only root exposures of Tethyan Triassic are located in the allochthonous masses of the Strandzha unit, and bear some signature of transition to Peri-Tethyan facies.

Although variable, these composite sections allow for the reconstruction of the general trends in the Tethyan development.

The Early Triassic Tethyan environments were similar to that existing in the Peri-Tethyan realm, i.e., the existence of a low relief that developed through the peneplanation of the Hercynian orogen. The Struvnitsa Formation (metamorphic psammites, silty pelites and shales) in the Strandzha unit is the only proof for that environment. The fast subsidence at the end of Early Triassic times resulted in formation of a trough with oscillating bottom and turbiditic flysch-like sedimentation due to intense but impulsive terrigenous supply and basic to intermediate volcanic activity (in Strandzha Mountain - Chatalov, 1988; Kaziyski-dol Member of the Zaberska Formation - Savov et al., 1995) and rhythmic sedimentation of shales and limestones (distal flysch-like sediments of the Mayadere Formation in the East Balkan - Budurov et al., 1995).

The deeper-sea sedimentation continued in Anisian to early Ladinian times (and to early Carnian, and even, early Norian times in the East Balkan) with sedimentation of limestones (Kondolovo Formation in Strandzha Mountain - Chatalov, 1988; Savov et al., 1995) and limestones (partly of "ammonitico rosso" type, with thin chert interbeds - Gyurgenliya Formation, - Budurov et al., 1995) and shaly interlayers. This type of sedimentation makes the probable environment similar to the extensional environment of the continental slope with transition to the shelf areas in other Tethyan basins as North Dobroudzha (Dobrogea), the Pindos-Olonos zone, etc. Some of the huge olistolites (Ortakaya) in the East Balkan region point at a possible continuation of this formation even in Carnian to early Norian times, with the evolution of reef edifices within the newly-formed environment of deeper basin with oscillating bottom.

The Carnian to Norian (and in the East Balkan, even Rhaetian?, according to Sachariewa-Kovachewa, 1967) Tethyan evolution was marked by sedimentation in a basin with considerably varying parameters. Alternating bluish limestones, slates and sandstones of the Lipachka Formation (Longobardian - Middle Norian) in the Strandzha unit (Chatalov, 1988; Savov et al., 1995) point at a flysch-like sedimentation. A similar unit (Glogova Formation in the East Balkan - Budurov et al., 1995b) consists of flysch-like thinly-interbedding bluish limestones with abundant fauna (including well-preserved fine and fragile shells of *Monotis* and *Halobia*) with shaly marls that pass upwards into bluish marls with rich fauna, including corals. An open deeper-sea basin with persisting coral edifices is deduced. In case the Norian age of the "black flysch" (Kanchev and Encheva, 1967) was confirmed, the parallel existence of a continental slope with turbiditic sedimentation is evident. There is no indication for the end of the Tethyan Triassic sedimentation, and the possible relations to the post-dating Lower to Middle Jurassic formations, both of Tethyan and Peri-Tethyan type. No regressive Triassic facies have been found. The Lower to Middle Jurassic formations (Tchoumatchenco, Chernyavska, 1989; Tchoumatchenco et al., 1990) of the East Balkan unit are rich in olistolites of Tethyan Triassic rocks that vary in age from Olenekian (Spathian) to Norian (Budurov et al., 1995b). The Upper Triassic formations themselves (Glogova Formations) contain fragments of older Triassic rocks. Therefore, there is no definite proof about the real interrelations between the Tethyan Jurassic and Triassic: presence of continuous olistostrome formations of Late Triassic and Early - Middle Jurassic age, or sedimentation break with a hiatus.

The diverse character of the bottom of the Tethyan marine basins is proven also by the composition of Triassic pebbles within deep marine Jurassic formations in SW Bulgaria (Treklyano Group - Zagorchev, 1986) and East Rhodope (Dolno Loukovo Formation - Boyanov and Budurov, 1979; Boyanov and Trifonova, 1978; Trifonova and Boyanov, 1986; Zagorchev et al., 1989; Boyanov et al., 1990). At least three different Triassic microfacies are found in the pebbles from the lower parts of the Treklyano Group (Zagorchev, Tikhomirova, 1986), and namely: (i) *Lamelliconus* -rich oolithic limestones, indicative of a shallow shelf environment; (ii) *Nodosaria*-rich micritic limestones

indicative of a deeper shelf environment; (iii) thin radiolarites interbedded with shales, indicative of an extensional deeper-sea (continental slope?) environment. As far as no such rocks have been found in natural outcrops in the territories of SW-Bulgaria and the eastern parts of the neighbour republics of Serbia and Macedonia, it was suggested (Zagorchev, 1986) that the now entirely allochthonous Morava Superunit had been a part of the continental slope towards the Vardar ocean, and had been covered by a thin veneer of neritic Triassic sediments entirely eroded later, in Jurassic and Cretaceous times. In the thrust sheets of the East Rhodope Mountains, pebbles of silicites yielded Late Permian foraminifers, and limestone pebbles, Early Anisian (conodonts), Late Ladinian - Early Carnian (foraminifers, conodonts) and Norian (foraminifers) microfossils.

The relations between the Tethyan and Peri-Tethyan environments are also not elucidated. The information about the Tethyan environments comes entirely from allochthonous formations: thrust sheets (Strandzha) and fragments of different size (from centimetric pebbles to kilometric olistolites).

A possible indication about a transition from the typical shallow Peri-Tethyan environments to the deeper ones transitional to the Tethys may be sought in the Dobroudzha Formation (Spathian) in the easternmost parts of North Bulgaria (near Kaliakra Cape). The formation is referred (Vaptsarova et al., 1984) to the transition of the littoral to the sublittoral zone. The abundant fauna (Olferyev, 1976; Chemberski and Vaptsarova, 1979) is typical of the Alpine type of the Lower Triassic, very different from the Peri-Tethyan type. Chemberski and Vaptsarova (1979, Fig. 1) give also some hints for a possible allochthoneity of the Dobroudzha Formation over the pre-Alpine basement, and in respect of the covering Doyrentsi Formation. Therefore, two options may be considered for these rocks (Dobroudzha Formation), and namely: (i) allochthonous position as a thrust sheet over the basement and beneath the Doyrentsi Formation; (ii) autochthonous position, and gradual lateral transitions between the Tethyan and Peri-Tethyan Triassic. For the time being, no conclusive evidence about viability of any of these options can be considered.

Conclusions

As previously mentioned, Triassic palaeogeodynamic signatures are largely obliterated by later tectonics. A palinspastic reconstruction of Triassic environments and palaeogeodynamic settings should account for a number of operations removing the effects of at least Mid Cretaceous, Late Cretaceous and Palaeogene/earliest Neogene deformations. Therefore, we can rely, for the time being, only on general interpretations for earliest Jurassic times based on general ideas and scarce palaeomagnetic data (e.g., Dercourt et al., 1986) or on sounder interpretations of more restricted regional stratigraphic and palaeogeographic information (e.g., Tchoumatchenco and Sapunov, 1994). The evidence points at the existence, at least at the end of Hercynian times, of a microplate situated in the southern margin of the Eurasian continent, and consisting of the continental blocks of Thracia (Rhodope + Sredna gora ± Serbo-Macedonian), the Western Pontides and Moesia (Dercourt et al., 1986). Rifting North of it produced the basin of North Dobrogea - Crimea - Great Caucasus. It was apparently a Tethyan branch that was set up in earliest Triassic times, and developed during the whole Triassic and a considerable part of Jurassic times (at least Early and most of the Middle Jurassic). Striking similarities between East Balkan Triassic and Jurassic, and the North Dobrogea formations of the same age make possible the existence of a link between this basin and the main part of the Tethys. The detailed analysis of this possibility will be subject of another paper.

The overall extension (rifting and opening of the Tethys Ocean) that dominated the Tethyan development in Triassic times, gave a considerable impact also within Peri-Tethyan seas inside the

Balkan (or Central-Balkan) microplate. Continental rifting (or aborted rifting) may be sought in several important directions, and namely, (i) volcanic activity of basic to intermediate composition in Strandzha, the Maritsa lineament, and the western part of the southern margin of the Moesian region (of northeastern and west-northwestern strike); (ii) the outlines of some of the huge antiforms (dry lands); (iii) the abrupt facies changes; (iv) sudden considerable thickness increase in narrow rectilinear zones (see Vaptsarova et al., 1984), and/or rectilinear boundaries of contrasting facies areas; (v) presence of intraclastic carbonates, breccias, and occasional beds of sandstones and even conglomerates inside the carbonate sequences.

The fault disintegration was particularly important in Late Triassic times when it coincided with gradual uplift and marine regression. The outlines of uplifted blocks (and correspondingly, the bounding faults) strike usually almost W-E or NW-SE (Vaptsarova et al., 1984; Dinkova et al., 1986; Tchoumatchenco, Sapunov, 1994) but later rotations probably are the cause of their present outlines. More detailed comparisons would contribute substantially to the more profound understanding of the geodynamic processes within the Triassic Tethys and the Peri-Tethyan realm.

Acknowledgements

The first studies on the topic were performed by the authors in the frame of IGCP Project 4 'Triassic in the Tethys Realm'. The collaboration of E. Trifonova during long years of common studies, and discussions with G. Chatalov, Ch. Chemberski, Ch. Dabovski, D. Gheorgian, E. Mirauta, D. Papanikolaou, M. Sandulescu, A.M.C. Şengör, M. Sudar, A. Vaptsarova, and many other colleagues contributed substantially to the evolution of our knowledge and ideas. The present paper is a contribution to IGCP Project 343 'Stratigraphic analysis of the Peri-Tethyan basins' and to the international Peri-Tethys Programme. Financial support from project 603/96 'Stratigraphic and tectonic correlations of SW Bulgaria and the adjacent regions' of the National Fund "Scientific Research" of Bulgaria is gratefully acknowledged.

References

Berndt, H. 1934., Trias und Jura des Ostbalkans. Verhandl. Sächs. Akad. Wiss., Math.-Phys. Kl., Leipzig, 86: 3-102.

Boyanov, I. and Budurov, K., 1979. Triassic conodonts from carbonate breccia within the low-grade metamorphic rocks of the East Rhodopes. Geol. Balcanica, 9(1): 97-104.

Boyanov, I. and Trifonova, E., 1978. New data of the age of the phyllitoid complex from the eastern Rhodopes. Geol. Balcanica, 8(1): 3-22.

Boyanov, I., Dabovski, C.,. Gochev, P., Harkovska, A., Kostadinov, V., Tzankov, Tz. and Zagorchev, I., 1989. A new view of the Alpine tectonic evolution of Bulgaria. Geol. Rhodopica, 1: 107-121.

Boyanov, I., Rouseva, M., Toprakcieva, V. and Dimitrova, E., 1990. Lithostratigraphy of the Mesozoic rocks from the Eastern Rhodopes. Geol. Balcanica, 20(5): 3-28 (in Russian, with English abstr.).

Budurov, K. 1976. Die triassischen Conodonten des Ostbalkans. Geol. Balcanica, 6(2): 95-104.

Budurov, K. 1980. Conodont Stratigraphy of the Balkanide Triassic. Riv. Ital. Paleont., 85: 767-780.

Budurov, K. and Chatalov, G., 1978. Conodontenchronologie und Korrelation der triassischen Niveaus im Strandzha-Gebirges (Sudost-Bulgarien). C.R. Acad. bulg. Sci., 31: 1035-1038.

Budurov, K., and Trifonova, E., 1984. Correlation of Triassic conodont and foraminiferal zonal standards in Bulgaria. C.R. Acad. bulg. Sci., 37: 625-627.

Budurov, K., and Trifonova, E., 1991. Stratigraphy of the Triassic in the Strandzha-Sakar region (South-East Bulgaria): conodont and foraminifer evidence. Rev. Bulg. Geol. Soc., 52(3): 3-18.

Budurov, K., and Trifonova, E., 1994. Progress in concepts about conodont and foraminifer zonal standards of the Triassic in Bulgaria. Mém. Geol. (Lausanne), 22: 9-13.

Budurov, K., Zagorchev, I. and Trifonova, E., 1993. The Triassic in Southwest Bulgaria. Upper Triassic red beds (Moesian Group) in the Golo-bardo Unit. Geol. Balcanica, 23(5): 35-45.

Budurov, K., Trifonova, E. and Zagorchev, I., 1995a. The Triassic in Southwest Bulgaria. Stratigraphic correlation of key sections in the Iskar Carbonate Group. Geol. Balcanica, 25(1): 27-59.

Budurov, K., Trifonova, E., Petrunova, L. and Zagorchev, I., 1995b. New data on the Lower and Middle Triassic of East Balkan (Tethyan) type, East Stara-Planina Mountains. Proc. 15 Congr. CBGA, Geol. Soc. Greece, Spec. Publ. 4/1: 170-174.

Chatalov, G., 1975. Facies analysis of the Svidol Formation (Lower Triassic) of the Teteven Anticlinorium (Central Fore-Balkan). Geol. Balcanica, 5(2): 67-86.

Chatalov, G., 1984a. Contribution to the stratigraphy and lithology of the Triassic System in the Teteven Anticlinorium. Palaeont. Stratigr. Lithol., 19: 51-64 (in Bulgarian, with English summ.).

CHATALOV, G., 1984b. Contribution to the stratigraphy and lithology of the Triassic System in the Troyan Balkan. Palaeont. Stratigr. Lithol., 20: 57-70 (in Bulgarian, with English summ.).
CHATALOV, G., 1988. Recent developments in the geology of the Strandzha zone in Bulgaria. Bull. Techn. Univ. Istanbul, 41: 433-465.
CHATALOV, G., 1990. Geology of the Strandzha zone in Bulgaria. Publ. House Bulg. Acad. Sci., Sofia; 271 pp. (in Bulgarian, with English summ.).
CHATALOV, G. and TRIFONOVA, E., 1985. Contribution to the stratigraphy of the Balkanide-type Triassic in Sveti Ilija Ridge and Strandzha Mountain (SE Bulgaria). Rev. Bulg. Geol. Soc., 46: 312-324 (in Bulgarian, with English abstr.).
CHEMBERSKI, H. and VAPTSAROVA, A., 1979. The Triassic System in North Bulgaria. I. Stratigraphic principles. Geol. Balcanica, 9(1): 67-108 (in Russian, with English abstr.).
CHEMBERSKI, H., DOSKOVA, R., and TOSHEVA, E. 1996. Aspects of the Triassic transgression in Northeast Bulgaria. 6th Congr. Bulg. Geol. Soc., Summaries,pp. 100-101 (in Bulgarian).
DERCOURT, J., ZONENSHAIN, L., RICOU, L.-E., KAZMIN, V., LE PICHON, X., KNIPPER. A. et al., 1986. Geological evolution of the Tethys belt from the Atlantic to the Pamirs since the Lias. Tectonophysics, 123: 241-315.
DINKOVA, Y., ZAGORCHEV, I. and TZANKOV, Tz., 1987. Relationships between the old Alpine deformations in the Trun Anticlinorium. Geotecton. Tectonophys. Geodyn., Sofia, 20: 33-48 (in Bulgarian, with English summ.).
GANEV, M. and STEFANOV, S., 1977. Stratigraphy and correlation of the Triassic in a part of the Central Balkanides. Paleont. Stratigr. Lithol., 6: 27-46 (in Bulgarian, with German summary).
GOCHEV, P., 1991. Triassic paleogeography and Cimmerian orogeny in SE Bulgaria and on the adjacent territories. Acta Geol. Hung., 34(1-2): 3-14.
KANCHEV, I. and ENCHEVA, M., 1967. On the age of the "Black flysch" from the Luda Kamchiya part of the Eastern Balkan Range. Rev. Bulg. Geol. Soc., 28: 363-367 (in Bulgarian, witth English summ.)
MADER, D. and CHATALOV, G. 1992. Comparative palaeoenvironment modelling of Buntsandstein braided river evolution in Bulgaria and Middle Europe. Geol. Balcanica, 22(6): 21-61.
OLFERYEV, A. G., 1976. Stratigraphy of the Triassic deposits in North-East Bulgaria. Bull. Acad. Sci. USSR, Geol. Ser., 6: 88-100 (in Russian).
SACHARIEWA-KOVACHEWA, K., 1967. Norian ammonites from the Triassic at Kotel. Ann. Univ. Sofia, Fac. Geol. Geogr., 60: 75-106 (in Bulgarian, with German summ.)
SAVOV, S., DABOVSKI, CH. and BUDUROV, K., 1995. New data on the stratigraphy of the Tethyan Triassic in the Strandzha Mts., SE Bulgaria. Geol. Balcanica, 25(5-6): 33-42.
STEFANOV, A., 1932. On the stratigraphy of the Triassic System in Bulgaria in view of the Triassic from the Golo-bardo Mt. Bull. Bulg. Nat. Res. Soc., 15-16: 227-246 (in Bulgarian).
TCHOUMATCHENCO, P. and CHERNYAVSKA, S., 1989. The Jurassic System in the East Stara-planina Mountains. I. Stratigraphy. Geol. Balcanica, 19(4): 33-65 (in Russian, with English abstract).
TCHOUMATCHENCO, P. and SAPUNOV, I., 1994. Intraplate tectonics in the Bulgarian part of the Moesian platform during the Jurassic. Geol. Balcanica, 24(3): 3-12.
TCHOUMATCHENCO, P., CHERNYAVSKA, S., GORANOV, A., KOJUMDGIEVA, E., NACHEV, I., NIKOLOV, T., RUSKOVA, N., SAPUNOV, I. and TRONKOV, D., 1990. Principal paleogeographic features of Bulgaria. *In:* Evolution of the northern margin of Tethys. Mém. Soc. géol. France, 154, III: 101-121.
TENCHOV, YA. (ed.) 1993. Glossary. Bulgarian formal lithostratigraphic units (1882-1992). Publ. House Bulg. Acad. Sci., Sofia, 397 pp (in Bulgarian)
TRIFONOVA, E. AND BOYANOV, I., 1986. Late Permian foraminifers from rock fragments in the Mesozoic phyllitoid formation of the East Rhodopes, Bulgaria. Geol. Balcanica, 16(1): 25-30.
TRONKOV, D., 1966. A case of well-expressed pre-Triassic palaeorelief in Bulgaria. Bull. Geol. Inst., 15: 159-168 (in Bulgarian, with German summary).
TRONKOV, D., 1968. Über die Palaeogeographie der Trias in Bulgarien (Untertriadisches Festland von Belogradchik). C.R. Acad. bulg. Sci., 21: 363-366.
TRONKOV, D., 1973. Grundlagen der Stratigraphie der Trias im Belogradchik-Antiklinorium (Nordwest Bulgarien). Bull. Geol. Inst., Ser. Stratigr. Lithol., 22: 73-98 (in Bulgarian, with German summ.).
TRONKOV, D., 1983. Stratigraphic problems of the Iskar Carbonate Group (Triassic), Southwestern Bulgaria. Geol. Balcanica, 13(5): 91-100 (in Russian, with English abstr.).
TRONKOV, D., 1993. Triassic carbonate buildups in West Bulgaria. C.R. Acad. bulg. Sci., 46(11): 77-80.
VAPTSAROVA, A., CHEMBERSKI, H. and CHATALOV, G., 1984. Facies and evolution of sedimentary environments during the Triassic Period in Bulgaria. Geol. Balcanica, 14(2): 57-76 (in Russian, with English abstr.).
ZAGORCHEV, I., 1986. Jurassic paleogeography of a part of South-West Bulgaria in the light of new stratigraphic data. Geol. Balcanica, 16(5): 3-20.
ZAGORCHEV, I., BUDUROV, K. and TRIFONOVA, E., 1995. The Triassic in Southwest Bulgaria: Stratigraphy and Palaeogeography. Geol. Soc. Greece, Spec. Publ. 4(1): 298-303.
ZAGORCHEV, I. and TIKHOMIROVA, L., 1986. Stratigraphy of the Jurassic Treklyano Group (Southwest Bulgaria). Geol. Balcanica, 16(3): 23-44 (in Russian, with English abstr.)

RECENT VIEW ON THE INDUAN, OLENEKIAN AND ANISIAN AMMONOID TAXA AND ZONAL ASSEMBLAGES OF SOUTH PRIMORYE

Yuri D. Zakharov

At the very outset of investigations of the Triassic, C. Diener (1895) attached great importance to a study of the Early and Middle Triassic ammonoid fauna of the Ussuri region (South Primorye), which in his opinion, closely resembles the fauna of the Himalayas. Significant contributions to studies on ammonoid systematics and biostratigraphy of the Lower and Middle Triassic in the South Primorye (Russian Island, western and eastern Ussuri Gulf, western Amur Gulf, was made by L.D. Kiparisova (1961). who described about 58 ammonoid species.

There are also more recent publications (Burij and Zharnikova, 1962, 1972, 1981,1985; Vavilov and Zakharov, 1976; Zakharov, 1967a,b,1968, 1978 (in press); Zakharov and Pavlov, 1986; Zakharov and Rybalka, 1987; Zhamikova, 1981, 1985) on this topic, containing the diagnoses of some taxa, that were unknown before.

Tables Ia-i are attempt to show the recent view on the Early-Middle Triassic ammonoid taxa and zonal assemblages of South Primorye on the basis of some revision. Investigated collections are deposited at the Central Geological Museum, St. Peterburg (Diener's collection - No. 6399, Kiparisova's collection - No. 5504, Burij and Zharnikova's collections - No.'s 8239, 8701, 9653, 10195, 12010) and museum of the Far Eastern Geological Institute of FEB RAS, Vladivostok (Zakharov's collections No.'s 801, 814). About 182 species distributed 108 genera have been recorded in the Induan, Olenekian and Anisian of South Primorye. They are attributed to the 41 families - Sageceratidae, Hedenstroemiidae, Aspenitidae, Ussuriidae (order Sageceratida Zakharov) (Zakharov, 1983, 1988), Xenodiscidae, Proptychitidae, Dagnoceratidae, Paranoritidae, Nannitidae, Owenitidae, Meekoceratidae, Dieneroceratidae, Inyoitidae, Noritidae, Prionitidae, Hellenitidae, Columbitidae, fam.n. (Columbitaceae), Chioceratidae, Kashmiritidae, Xenoceltidae, Sibiritidae, Keyserlingitidae, Tirolitidae, Dinaritidae, Ceratitidae, Flemingitidae, Palaeophyllitidae, Ussuritidae, ?Danubitidae, Parapopanoceratidae, Ptychitidae, Acrochordiceratidae, Beyrichitidae, Balatonitidae, Hungaritidae, ?Longobarditidae, Sturiidae, Japonitidae, Gymnitidae, Megaphyllitidae and Cladiscidae (order Ceratitida Hyatt). *Pseudoprosphingites* and *Zhitkovites* (Prosphingitidae) (Zakharov, in press) are published in Mémoires de Géologie (Lausanne).

Thanks are due to Mrs. N.K. Zharnikova, of Vladivostok, for her kind collaboration in trying to determine and describe some new Anisian ammonoids and Mrs. L.I. Sokur for her technical help.

References

BURIJ, I.V. and ZHARNIKOVA, N.K., 1962. New species of the Triassic ceratites of Far East. Trudy NIIGA, 29: 78-92 (in Russian).

BURIJ, I.V. AND ZHARNIKOVA, N.K., 1972. New Early Triassic ceratites of South Primorye. In: I.E. Zanina (ed.), New species of the plant and invertebrate fossils of the USSR. Nauka, p. 150-160, Moskva (in Russian).

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
1. *Glyptophiceras ussuriensis* Zakharov	+												
2. *Ophiceras (Lytophiceras) eusakuntala* Zakharov		+											
3. *Proptychites hiemalis* Diener		+											
4. *Koninckites varaha* Diener		+											
5. *K. timorensis* Wanner		+		+									
6. *Preflorianites?* sp.I		+		+									
7. *Gyronites subdharmus* Kiparisova		+											
8. *G.* aff. *planissimus* Spath		+	+										
9. *G. separatus* Kiparisova			+										
10. *Ambites* sp. indet.			+										
11. *Parahedenstroemia* sp.			+										
12. *Hedenstroemia bosphorensis* Zakharov			+	+									
13. *Meekoceras subcristatum* Kiparisova			+?	+	+								
14. *Juvenites simplex* (Chao)			+cf.	+									
15. *Proharpoceras carinatitabulatum* Chao			+?										
16. *Cordillerites concianus* Kiparisova			+?										
17. *Koninckites* cf. *davidsonianus* (Koninck)			+?										
18. *Pseudosageceras longilobatum* Kiparisova				+					+				

Table 1a: Lower-Middle Triassic ammonoid succession of South Primorye

Designation of the zones (beds): *G.u.* = *Glyptophiceras ussuriense*, *G.s.* = *Gyronites subdharmus*, *H.b.* = *Hedenstroemia bosphorensis* (1 = *Gyronites separatus* beds, 2 = *Euflemingites prynadai* beds), *A.n.* = *Anasibirites nevolini*, *T.-A.* = *Tirolites-Amphistephanites* (3 = *Bajarunia dagysi* beds, 4 = *Tirolites ussuriensis* beds), *N.i.* = *Neocolumbites insignis*, *"S."m.* = *"Subcolumbites" multiformis*, *U.a.* - *Ussuriphyllites amurensis*, *L.p.* = *Leiophyllites pradyumna*, *P.b.* = *Phyllocladiscites basarginensis*, *P.o.* = *Ptychites oppeli*.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
19. *Pseudosageceras shamarense* Kiparisova	+			+									
20. *P.* cf. *multilobatum* Noetling				+									
21. *Parahedenstroemia conspicienda* Zakharov				+	+								
22. *Epihedenstroemia ajaxense* Zakharov				+									
23. *Ussuria schamarae* Diener				+?									
24. *U. iwanowi* Diener				+									
25. *U. kwangsiana* Chao (= *U.* aff. *iwanowi*)				+									
26. *Parussuria semenovi* Zakharov				+									
27. *Metussuria secreta* Kiparisova				+									
28. *M. bella* Zakharov				+									
29. "*Paranorites*" *krishtophovichi* Burij				+?									
30. *Arctoceras septentrionale* (Diener) (= "*Proptychites otoceratoides*")				+	+								
31. *A.* cf. *tuberculatum* (Smith)				+									
32. *A. prynadai* (Burij)				+?									
33. *A. labogense* (Zharnikova)				+?									
34. *A.*? *magnolobatus* (Kiparisova)				+?									
35. *A.*? *similis* (Kiparisova)				+?									
36. *A. robinsoni* (Kiparisova)				+?	+								
37. *A.*? *abrekensis* (Kiparisova)				+									
38. *Dieneroceras chaoi* Kiparisova				+									
39. *D. spathi* Kummel et Steele				+									
40. *D. schtempeli* Burij				+									

Table 1b: Lower-Middle Triassic ammonoid succession of South Primorye
Designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
41. *Anaxenaspis orientalis* (Diener)				+									
42. *Ambites* cf. *discus* Waagen				+									
43. *Meekoceras boreale* Diener				+	+								
44. *Prionolobus subevolvens* Zakharov				+									
45. *Prionolobus* sp. I				+?									
46. *Prionolobus* sp. II				+									
47. *Owenites koeneni* Hyatt et Smith				+	+								
48. *O. egrediens* Welter				+									
49. *Pseudoprosphingites ovalis* (Kiparisova)				+	+								
50. *P.* aff. *ovalis* (Kiparisova)				+									
51. *P. hexagonalis* (Zakharov)				+									
52. *P.* aff. *austini* (Hyatt et Smith)				+									
53. *Anakashmirites latiplicatus* (Diener)				+									
54. *A. shamarensis* Zakharov				+									
55. *Anakashmirites* sp.				+									
56. *Juvenites dieneri* Hyatt et Smith				+									
57. *J.* cf. *septentrionalis* Smith				+									
58. *J.* aff. *sinuosus* Kiparisova				+	+								
59. *Paranannites novikensis* Zakharov				+									
60. *Inyoites spicini* Zakharov				+									
61. *Eophyllites ascoldiensis* Zakharov				+									
62. *Hemiprionites dunajensis* Zakharov				+									
63. *Gurleyites armatus* (Welter)				+									

Table 1c: Lower-Middle Triassic ammonoid succession of South Primorye
Designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
64. *Preflorianites* cf. *radians* Chao				+									
65. *Preflorianites?* sp.II				+	+								
66. *Flemingites radiatus* Waagen				+									
67. *P.* aff. *glaber* Waagen				+									
68. *F. tobisinensis* Zakharov				+									
69. *F.*? cf. *labaensis* Kiparisova				+									
70. *Euflemingites prynadai* (Kiparisova)				+									
71. *Parahedenstroemia nevolini* (Burij et Zharnikova)					+								
72. *Prionolobus subevolvens* Zakharov					+								
73. *Meekoceras gracilitatis* (White)					+?								
74. *Arctoprionites maritimus* (Burij et Zharnikova)					+								
75. *A. ovalis* (Burij et Zharnikova)					+								
76. *Mangyshlakites primoriensis* Zharnikova					+								
77. *Hemilecanites discoides* Burij et Zharnikova					+								
78. *Hemilecanites* sp. indet.					+								
79. *Hemiprionites contortus* Burij et Zharnikova					+								
80. *H. ovalis* Burij et Zharnikova					+								
81. *Palaeokazachstanites ussuriensis* (Zakharov)					+								
82. *Anasibirites nevolini* Burij et Zharnikova (=*A. popowi*)					+								
83. *Anasibirites elegans* Burij et Zharnikova (*A. ovsiannikovi*)					+								

Table 1d: Lower-Middle Triassic ammonoid succession of South Primorye
Designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S."*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4		*m.*				
84. *Anakashmirites*? sp.					+								
85. *Wasatchites sikhotealinensis* Zakharov					+								
86. *Wasatchites* sp.					+		+						
87. *W. vlasovi* Burij et Zharnikova					+								
88. *Gurleyites maichensis* Burij et Zharnikova					+								
89. *Burijites skorochodi* (Burij et Zharnikova)					+								
90. *Subalbanites mirabilis* Zakharov					+								
91. *Bajarunia dagysi* Zakharov						+							
92. *Tchernyschevites costatus* Zakharov						+	+						
93. *Bandoites elegans* Zakharov						+	+						
94. *B. tobisinensis* (Kiparisova)						+							
95. *B. pacificus* (Zharnikova)						+							
96. *Amphistephanites parisensis* (Zakharov)						+	+						
97. *Tirolites subcassianus* Zakharov						+	+cf.						
98. *T. ussuriensis* Zharnikova							+						
99. *Tchernyschevites subdalmatus* (Zharnikova)							+						
100. *Kazakhstanites sonticus* (Zakharov)							+						
101. *K. zakharovi* Zharnikova							+						
102. *K. nicolai* (Diener)							+						
103. *Pseudosageceras* sp.								+	+				
104. *Kvalinites unicus* (Kiparisova)								+					
105. *Hellenites inopinatus* Kiparisova								+					

Table 1e: Lower-Middle Triassic ammonoid succession of South Primorye
Designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
106. *Hellenites tchernyschewiensis* Zakharov								+					
107. *H. subpraematurus* Zarnikova								+					
108. *Preflorianites venustus* Zakharov								+					
109. *Tirolites* cf. *subcassianus* Zakharov								+					
110. *Columbites ussuriensis* Burij et Zharnikova (=*C. densistriatus* and *C.* cf. *parisianus*)								+					
111. *Procolumbites subquadratum* Burij et Zharnikova								+					
112. *Neocolumbites insignis* Zakharov								+					
113. *N. grammi* Zakharov								+					
114. *Olenekoceras meridianus* (Zakharov)								+					
115. *O. miroshnikovi* (Burij et Zharnikova)								+					
116. *O. tebenkovi* (Zharnikova)								+					
117. *Svalbardiceras zhitkoviense* Zakharov.								+					
118. *Subdoricranites* ? sp.								+					
119. *Pseudosageceras simplex* Kiparisova									+				
120. *Zhitkovites globosus* (Kiparisova)									+				
121. *Columbites* sp.									+				
122. *Isculitoides*? *suboviformis* (Kiparisova)									+				
123. *Arnautoceltites gracilis* (Kiparisova)									+				
124. *Dieneroceras karasini* Kummel et Teichert									+				
125. *"Subcolumbites" multiformis* Kiparisova									+				
126. *Prenkites* aff. *timorensis* Spath									+				
127. *Preflorianites maritimus* (Kiparisova)									+				

Table If: Lower-Middle Triassic ammonoid succession of South Primorye
Designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	"S."	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4		*m.*				
128. *Leiophyllites praematurus* Kiparisova									+	+			
129. *Palaeophyllites superior* Zakharov									+				
130. *Ussuriphyllites amurensis* (Kiparisova)										+			
131. Parapopanoceratidae gen. et sp. indet.										+			
132. *Megaphyllites atlasoviensis* Zakharov										+			
133. *Prohungarites popowi* Kiparisova										+			
134. *Lenotropites*? *solimani* Kiparisova										+			
135. *Arctohungarites primoriensis* (Kiparisova)										+			
136. *Paracrochordiceras*? sp.										+			
137. *Cucoceras*? sp.										+			
138. *Tropigastrites sublahontanus* Zakharov											+		
139. "*Tropigastrites*" sp. (Columbitaceae fam. et gen. nov.)*											+		
140. *Leiophyllites pradyumna* (Diener)											+		
141. *Hollandites tozeri* Zakharov											+		
142. *Sturia* n. sp.**												+	
143. *Sturia japonica* Diener											+	+	
144. *Semiornites* ex gr. *cordevolicus* (Mojsisovics)*												+	
145. *Parasageceras discoidale* Welter**												+	
146. *Proptychitoides* cf. *trigonalis* (Arthaber)**												+	
147. *Ismidites* sp.**												+	

Table 1g: Lower-Middle Triassic ammonoid succession of South Primorye

* Author's unpublished data; ** N.K. Zharnikova's unpublished data. Other designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
148. *Procladiscites* sp.**												+	
149. *Parapopanoceras* sp.**												+	
150 *Neopopanoceras* sp.**												+	
151. *Malletoptychites* n. sp.*												+	
152. *Ptychites austro-ussuriensis* Kiparisova												+	
153. *Discoptychites domatus* (Hauer)**												+	
154. *D.* cf. *pauli* (Mojsisovics)**												+	
155. *D. reductus* (Mojsisovics)**												+	
156. *Acrochordiceras kiparisovae* Zharnikova												+	
157. *A. orientale* Zharnikova												+	
158. *A.* aff. *balarama* Diener												+	
159. *Acrochordiceras* sp. (="*Durgaites* aff. *dieneri*")												+	
160. *Paracrochordiceras pacificum* Zharnikova												+	
161. *Epacrochordiceras korobkovi* Zharnikova												+	
162. *Smithoceras* n. sp.*												+	
163. *Hollandites* aff. *arjuna* Diener												+	
164. *H.* cf. *japonicus Mojsisovics*												+?	
165. Beyrichites aff. *falciformis* Smith**												+	
166. *Gangadharites* sp.*												+	
167. *Balatonites vladivostokensis* Zakharov (="*Paraceratites* ex gr. *trinodosus*")												+	+?
168. *Platycucoceras* n. sp.**												+	

Table 1h: Lower-Middle Triassic ammonoid succession of South Primorye

* Authors's unpublished data; ** N.K. Zharnikova's unpublished data. Other designation as in Table 1a.

Species	Induan		Olenekian							Anisian			
			Ayaxian					Russian					
	G.u.	*G.s.*	*H.b.*		*A.n.*	*T.-A.*		*N.i.*	*"S." m.*	*U.a.*	*L.p.*	*P.b.*	*P.o.*
			1	2		3	4						
169. *Procarnites* aff. *andrusovi* Bajarunas**												+	
170. *"Japonites" russkiensis* Zakharov (n. gen.)*												+	
171. *Japonites* cf. *planiplicatus* Mojsisovics**												+	
172. *Anagymnites* cf. *acutus* (Hauer)**												+	
173. *Gymnites* aff. *credneri* Mojsisovics**												+	
174. *Phyllocladiscites basarginensis* Zakharov												+	
175. *Ussurites sikhoticus* (Diener)												+	
176. *U.* cf. *arthaberi* (Welter)												+	
177. *Monophyllites* cf. *sphaerophyllus* (Hauer)												+	
178. *Ptychites oppeli* Mojsisovics													+

Table 1i: Lower-Middle Triassic ammonoids succession of South Primorye

* Author's unpublished data; ** N.K. Zharnikova's unpublished data. Other designation as in Table 1a.

BURIJ, I.V. and ZHARNIKOVA, N.K., 1981. Ammonoids from the *Tirolites* Zone of South Primorye. Paleont. Zhurn., 3: 61-69 (in Russian).

DIENER, C., 1897. The Cephalopoda of the Lower Trias. Paleont. Indica. Ser. 15, 2, n. 1, I- 18 1.

KIPARISOVA, L.D., 1961. Paleontological basis of Triassic stratigraphy of Primorye region. 1. Cephalopods. Trudy VSEGEI, n.s., 48: 1-278 (in Russian).

VAVILOV, M.N. and ZAKHAROV, Y.D., 1976. The revision of Early Triassic genus *Pachyproptychites*. In: M.N. Gramm (ed.), Morphology and systematics of soviet Far East fossil invertebrates. DVNC Akad. Nauk SSSR, pp. 60-67 (in Russian).

ZAKHAROV, Y.D., 1967a. Some Noritaceae (ceratites) from the Triassic of the Far East. Paleont. Zhurn., 2: 44-51 (in Russian).

ZAKHAROV, Y.D., 1967b. New Anisian ammonoid species from southern Primorye. Paleont. Zhurn., 3: 39-47 (in Russian).

ZAKHAROV, Y.D., 1968. Lower Triassic biostratigraphy and ammonoids of South Primorye. Nauka, 175 pp., Moskva (in Russian).

ZAKHAROV, Y.D., 1978. Early Triassic ammonoids of the East USSR. Nauka, 224 pp., Moskva (in Russian).

ZAKHAROV, Y.D., 1983. Growth and development of the ammonoids. *In:* Y.I. STAROBOGATOV and K.N. NESIS (eds.), Taxonomy and ecology of Cephalopoda. ZIN Akad. Nauk SSSR, p. 26-31, Leningrad (in Russian).

ZAKHAROV, Y.D., 1988. Parallelism and ontogenetic acceleration in ammonoid evolution. In: J. WIEDMANN and J. KULLMANN (eds.), Cephalopods. Present and Past. O.H. Schindewolf Symposium Tübingen. 1985. E. Schweizerbart'sche Verlagsbuchhandlung, p. 191-206. Stuttgart.

ZAKHAROV, Y.D., (in press). Ammonoid evolution and the problem of the stage and substage division of the Lower Triassic. Mém. Géol. (Lausanne).

ZAKHAROV, Y.D. and PAVLOV, A.M., 1986. The first find of araxoceratid ammonoids within Permian of the East USSR. *In:* Y.D. ZAKHAROV and Y.I. ONOPRIENKO (eds.), Permian-Triassic events during the evolution of North-East Asia biota. DVNC Akad. Nauk SSSR, p. 74-85, Vladivostok (in Russian).

ZAKHAROV, Y.D. and RYBALKA, S.V., 1991. A standard for the PermianTriassic in the Tethys. In: Y.D. Zakharov and Y.I. Onoprienko (eds.), Problems of Permian and Triassic biostratigraphy of the East USSR. DVNC Akad. Nauk SSSR, p. 6-48, Vladivostok (in Russian).

ZHARNIKOVA, N.K., 1981. New Anisian ceratites of the family Acrochordiceratidae of South Primorye. Paleont. Zhurn., 1: 29-37 (in Russian).

ZHARNIKOVA, N.K., 1985. Ammonoids of the Lower Triassic *Columbites* zone of South Primorye. Paleont, Zhurn., 2: 31-37 (in Russian).

ALBERTIANA

Comments, reactions or contributions to ALBERTIANA?
Send it to the editor!
Hans Kerp, WWU - Abt. Paläobotanik
Hindenburgplatz 57-59, D - 48143 Münster, Germany
Note the new telephone and fax numbers !!!
Tel. +49-251-832 3966; Fax: +49-251-832 4831
E-mail: kerp@uni-muenster.de
http://www.uni-muenster.de/GeoPalaentologie/Palaeo/Palbot/ebot.html

BRITISH TRIASSIC PALAEONTOLOGY: SUPPLEMENT 21

G. Warrington

Since the completion of the writer's previous supplement (No.20; ALBERTIANA, 17: 65-66) on British Triassic palaeontology, the following works relating to aspects of that subject have been published or have come to his notice:

BARCLAY, W.J., AMBROSE, K., CHADWICK, R.A. and PHARAOH, T.C. 1997. Geology of the country around Worcester. Memoir of the British Geological Survey, 1:50000 geological sheet 199 (England and Wales). The Stationery Office, London, xii + 156pp.

BENTON, M.J. and WALKER, A.D. 1996. *Rhombopholis*, a prolacertiform reptile from the Middle Triassic of England. Palaeontology, 39: 763-782.

CRUICKSHANK, A.R.I. 1996. A *Pistosaurus*-like Sauropterygian from the Rhaeto-Hettangian of England. Mercian Geologist, 14: 12-13.

GALTON, P.M. and WALKER, A.D. 1996. *Bromsgroveia* from the Middle Triassic of England, the earliest record of a poposaurid thecodontian reptile (Archosauria: Rauisuchia). Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 201: 303-325.

GALTON, P.M. and WALKER, A.D. 1996. Supposed prosauropod dinosaurs from Middle Triassic of England referred to *Parasuchia* and Dinosauriformes. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, 1996, H.12: 727-738.

HUBBARD, R.N.L.B. and BOULTER, M.C. 1997. Mid Mesozoic floras and climates. Palaeontology, 40: 43-70.

HUNT, A.P. and LUCAS, S.G. 1991. The *Paleorhinus* Biochron and the correlation of the non-marine Upper Triassic of Pangea. Palaeontology, 34: 487-501.

JACKSON, D.I. and JOHNSON, H. 1996. Lithostratigraphic nomenclature of the Triassic, Permian and Carboniferous of the UK offshore East Irish Sea Basin. British Geological Survey, Nottingham.

KING, M.J. and BENTON, M.J. 1996. Dinosaurs in the Early and Mid Triassic? - the footprint evidence from Britain. Palaeogeography, Palaeoclimatology, Palaeoecology, 122: 213-225.

SARJEANT, W.A.S. 1996. A re-appraisal of some supposed dinosaur footprints from the Triassic of the English Midlands. Mercian Geologist, 14: 22-30.

STORRS, G.W., GOWER, D.J. and LARGE, N.F. 1996. The diapsid reptile, *Pachystropheus rhaeticus*, a probable choristodere from the Rhaetian of Europe. Palaeontology, 39: 323-349.

STORRS, G.W. and TAYLOR, M.A. 1996. Cranial anatomy of a new plesiosaur genus from the lowermost Lias (Rhaetian/Hettangian) of Street, Somerset, England. Journal of Vertebrate Paleontology, 16: 403-420.

THULBORN, R.A. 1990. Dinosaur Tracks. Chapman and Hall, London, xvii + 410pp.

TRUEMAN, C.N. and BENTON, M.J. 1997. A geochemical method to trace the taphonomic history of reworked bones in sedimentary settings. Geology, 25: 262-266.

WARRINGTON, G. 1996. Appendix 1. Permo-Triassic biostratigraphic markers. P.A1 in JACKSON, D.I. and JOHNSON, H. (q.v.).

This contribution is published with the approval of the Director, British Geological Survey (N.E.R.C.).

MIDDLE TRIASSIC AMMONOIDS FROM SPITI HIMALAYAS -

A CHANCE FOR MAJOR IMPROVEMENTS IN TETHYAN ANISIAN SUBDIVISIONS?

Marco Balini and Leo Krystyn

Tethyan Anisian ammonoid biochronology is in part still poorly developed as most regions show incomplete faunal succession, especially in the basal part. The Himalayas seem to be the only place with a continuous ammonoid record through the full range of this time-interval. We present preliminary data from the study of the "Muschelkalk" member (upper Tamba Kurkur Fm.) in Spiti between the Pin, Parahio and Lingti valleys (see Krystyn and Orchard, 1996, fig. 1). Along a 40 km wide transect across basin-strike, 10 sections have been measured and sampled. Distinct lithologies have been used to establish bed-by-bed correlations between all sections indipendently from the fossil record. As with the Lower Triassic (Krystyn and Orchard, 1996) the sequence is thickest in the southwest (Muth: 6 m) and thins basinwards towards northeast (Lalung: 4.5 m).

Thirty ammonoid bearing levels can be grouped into the following biostratigraphic units (from bottom to top): *Durgaites* (= *Keyserlingites*?) *dieneri* beds (levels 10-23), *Caucasites* beds (levels 24-25), *Nicomedites* beds (levels 26-33), *Hollandites* beds (levels 35-37), *Silesiacrochordiceras* beds (levels 38-39) and *Paraceratites* bed (level 40).

The *Dieneri* beds show distinct Anisian affinity by the presence of *Durgaites dieneri* plus related species described from Qinghai (Wang, 1985), *Paracrochordiceras, Japonites, Ussurites* and *Aegeiceras ugra* (11). They can be easily correlated with the Ugra Zone or *Aegeiceras-Japonites* beds of Chios, the upper part of the *Lenotropites-Japonites* zone of Qinghai (Wang, 1985) as well as the *J. walteri* and *P. guexi* beds of Nevada (Bucher, 1989). The *Caucasites* beds include *Caucasites, Paracrochordiceras, Japonites* and beyrichitids with correlatives in the *Laboceras-Megaphyllites* level of the Caucasus (Shevyrev, 1995) as well as in the *Mulleri* zone of Nevada (Bucher, 1989). Though not known from the Aegean type sequence the latter are, together with the *Dieneri* beds provisionally included into the Aegean substage.

A fairly long time-span might be represented by the *Nicomedites* beds with a diverse fauna of *Nicomedites* spp., *"Pseudohollandites"*, beyrichitids, *Acrochordiceras* (*sensu A. hyatti* group), *Gymnites* spp., *Buddhaites* and, in the top (33) *Pseudodanubites, Alanites* and *Nevadisculites*. Counterparts are the Osmani Zone of northern Turkey (Assereto, 1974), the *Beyrichites-Hollandites* zone of Qinghai (Wang, 1985), the *Japonites magnus* zone of Nyalam (Wang and He, 1976), the Caurus Zone (at least in part?) of North America and the lower Hyatti Zone of Nevada (Bucher, 1992b). Above the presently unproductive layer 34, follow the extremely rich *Hollandites* beds with *Hollandites* spp. (Diener, 1907), *Haydenites, Semibeyrichites, Nevadisculites, Acrochordiceras hyatti, Pseudodanubites dritarashtra, Unionvillites* sp., gymnitids, *Buddhaites* and *Ussurites*. Correlatives are to be found in the Ismidicum Zone of northern Turkey, the Caucasus and Iran (Krystyn and Tatzreiter, 1991), in the *Anacrochordiceras nodosus* zone of Nyalam (Wang and He, 1976) as well as in the upper Hyatti Zone of Nevada. *Nicomedites* and *Hollandites* beds are treated as representative of the Bithynian substage.

Levels 38 and 39 contain *Silesiacrochordiceras* and *Epacrochordiceras*, robuste thick-shelled ceratitids, pinacoceratids, additionally *Platicuccoceras*, and *Ptychites impletus* in 39. These le-

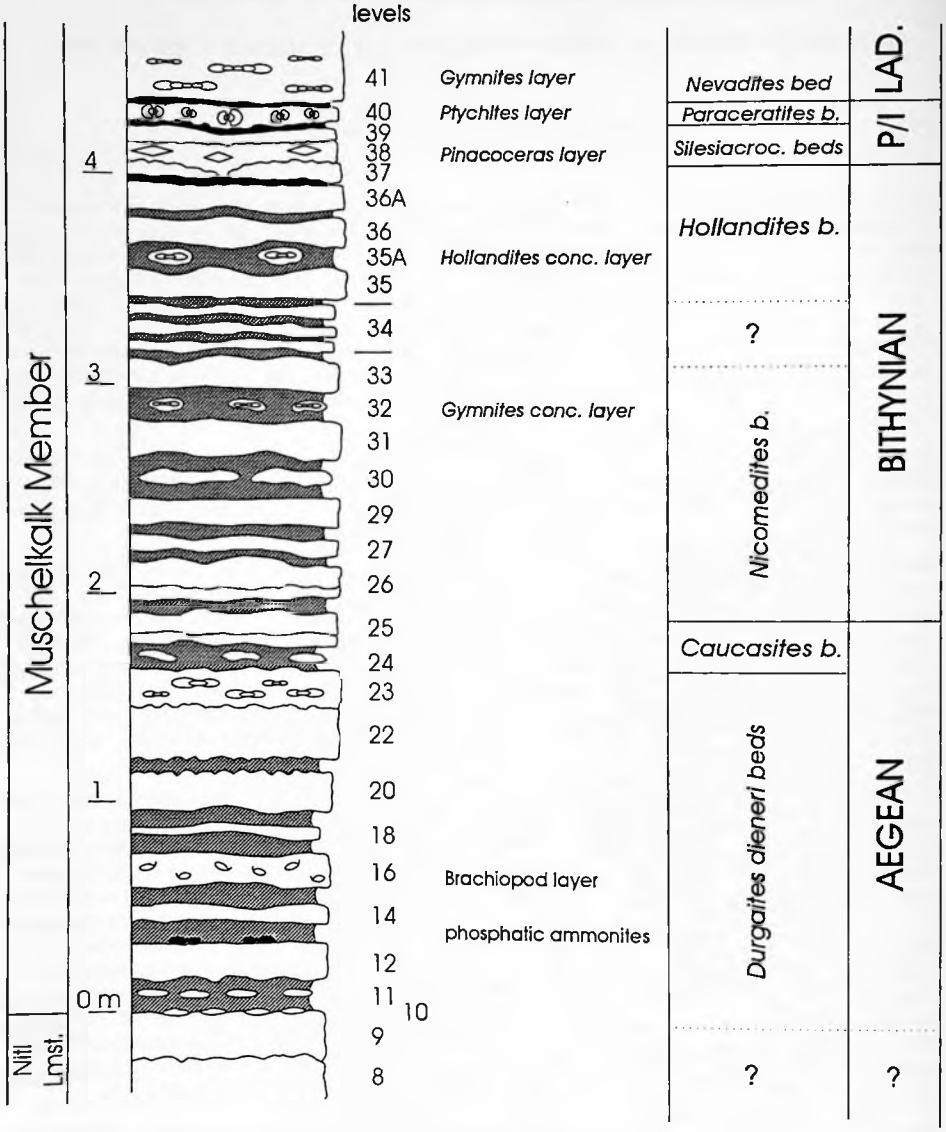


Fig. 1. *Stratigraphic section of the Muschelkalk Member of the Tamba Kurkur Formation in Spiti, based on the Guling road cut.*

vels can be assigned to the Pelsonian. From level 40 a very rich fauna is recorded. In decreasing frequency it is composed of *Ptychites* and *Discoptychites*, Gymnitidae, *Beyrichites* gr. of *B. khanikofi*, nodose Beyrichitinae, *Paraceratites* gr. of *P. trinodosus*, smooth *Japonites*, *Proarcestes*, *Flexoptychites*, *Sturia* and *Bosnites clathratus*. Especially on the basis of *Paraceratites* of the group of *P. trinodosus* this level is correlated with the Trinodosus zone of the Western Tethys (Illyrian).

Except from Muth, bed 40 is directly followed by a distinct 25-50 cm thick ammonite lumachelle bed dominated by gymnitids and therefore named as *Gymnites* layer. It contains beside various undescribed ceratitid genera *Halilucites* and true *Nevadites*. The latter indicates the Secedensis Zone which is used as base of the Ladinian. In Muth there are 2-3 lenticular ammonoid layers (altogether 15-20 cm thick) additionally developed between beds 40 and 41 that still have to be sampled in more detail. At the present the available fauna consists mainly of *Beyrichites* and *Flexoptychites*; the rare ceratitids (*Latemarites*?) and a single *Kellnerites* nevertheless indicate the Kellnerites/Retzi Zone of Brack and Rieber 1993.

The paleobiogeographic relationships seem to change considerably from bottom to the top of the sequence. Within the Aegean, *Durgaites* - closely related to the Boreal *Keyserlingites* - is unknown from the low paleolatitude Hallstatt-type fauna of Chios. The genus is otherwise quite common in the northern Tethys branch of China (with an Anisian paleolatitude >80°) and may thus reflect a mid paleolatitude affinity of this interval.

For the Bithynian, comparisons are difficult as no low paleolatitude (Hallstatt) faunas are currently knonw. With true *Nicomedites* known presently only from the northern Tethys the lower Bithynian recalls the above described Aegean trend. By the late Bithynian some increasing ties may be inferred between Spiti and Nevada by the joint occurrence of *Pseudodanubites*, *Unionvillites* and *Nevadisculites*. The beyrichitids, however, are still completely different. There is no true *Hollandites* in North America and boreal faunal elements found in Nevada (such as *Arctohungarites*, *Anagymnotoceras*, popanoceratids) are otherwise missing in Spiti. From level 33 upwards an apparent decreasing followed by an increasing of diversity is recorded. Moreover there are changes in faunal composition. In the Late Bithynian (level 37) there is the lowermost diversity, as the fauna is composed only by *Hollandites* and *Buddhaites*. This fauna is also quite different with respect to faunas of the Western Tethys and North America: *Buddhaites* is endemical and restricted to the Himalaya and also the paleogeographic distibution of *Hollandites* is restricted.

In the Pelsonian *Platicuccoceras* and acrochordiceratids are common elements in both Western Tethys and North America, while *Ptychites impletus* is similar to *P. gradinarui* from Nevada (Bucher, 1992a). With the Illyrian the fauna reaches the highest diversity and is composed by Western Tethyan elements accompanied by low paleolatitude cosmopolitan long ranging forms. In the first group *Paraceratites* gr. of *P. trinodosus*, *Beyrichites*, *Flexoptychites* and *Bosnites* are included, while the second group is composed of *Ptychites*, Gymnitidae, *Proarcestes*, *Sturia*. The smooth *Japonites* seems to be the only element which is present also in North America (Tozer, 1994), but it is not yet reported from the Western Tethys. Faunal comparison between Spiti and Western Tethys leads to point out the (apparent?) different weight of *Beyrichites s.s.* In Spiti the fauna is dominated by leiostraca ammonoids, but *Beyrichites* is very common. On the contrary in the Western Tethys the faunas with a similar high dominance of leiostraca (Han-Bulog and Schreyer Alm faunas) lack of true *Beyrichites*, which can be found in interplatform *s.l.*-like basins (i.e., Prezzo Limestone) where the faunas are in general dominated by trachyostraca ammonoids.

Conclusions

Due to the continuous ammonoid record Spiti may become extremely important for the definition and further subdivision of the Tethyan Lower Anisian (Aegean and Bithynian Substages).

The upper (Pelsonian and Illyrian) part otherwise may not contribute substantially to Anisian biochronology due to the pronounced condensation. The Spiti fauna further shows pronounced faunistic differences to that one from Nevada though both represent a comparable LPL position. This may underline the need for an independant Tethyan zonal standard despite the existing North American high quality zonation of Bucher (1988;1989;1992 - see also Tozer 1994). Finally the distinct Anisian age of the *Durgaites dieneri* beds has to be mentioned, taking into account the longlasting discussion on its Lower respectively Middle Triassic position (cf. Bucher 1989,959).

Acknowledgements

Field work has been supported by EV-K2 CNR (MB) and by "Austrian National Comitee for IGCP" - IGCP 359 (LK).

References

ASSERETO, R., 1974. Aegean and Bithynian: Proposal for two new Anisian substages. *In:* ZAPFE, H. (ed.), Die Stratigraphie der alpin-mediterranen Trias. Schr. Erdwiss. Komm. Osterr. Akad. Wiss., 2: 23-39.

BUCHER, H., 1988. A new Middle Anisian (Middle Triassic) Ammonoid Zone from Northwestern Nevada (USA). Eclog. geol. Helv., 81: 723-762.

BUCHER, H., 1989. Lower Anisian Ammonoids from the northern Humboldt Range (northwestern Nevada, USA) and their bearing upon the Lower-Middle Triassic boundary. Ecl. geol. Helv., 82: 945-1002.

BUCHER, H., 1992a. Ammonoids of the Shoshonensis Zone (Middle Anisian, Middle Triassic) from Northwestern Nevada (USA). Jb. Geol. Bundesanstalt.-A., 135: 425-465.

BUCHER, H., 1992b. Ammonoids of the Hyatti Zone and the Anisian transgression in the Triassic Star Peak Group, Northwestern Nevada, USA. Palaeontographica, 223: 137-166.

DIENER, C. 1907., The fauna of the Himalayan Muschelkalk. Mem. Geol. Surv, India, Palaeontol. Indica, Ser. 15, 5, pp. 1-140.

KRYSTYN, L. and ORCHARD, M., 1996. Lowermost Triassic ammonoids and conodont biostratigraphy of Spiti, India. Albertiana, 17: 10-21.

KRYSTYN, L. and TATZREITER, F., 1991. Middle Triassic Ammonoids from Aghdarband (NE-Iran) and their paleobiogeographical significance. *In:* RUTTNER, A. (ed.), The Triassic of Aghdarband (AqDarband), NE-Iran, and its Pre-Triassic Frame. Abh. Geol. B.-A., 38: 139-163.

SHEVYREV, A.A., 1995. Triassic ammonites of northwestern Caucasus. Nauka, v. of 174 pp.

WANG, Y. 1985. Remarks on the Scythian-Anisian boundary. Riv. It. Paleont. Strat., 90: 515-544.

WANG, Y. and HE, G., 1976. Triassic Ammonoids from the Mount Jolmo Lungma Region. A report of scientific expedition in the Mount Jolmo Lungma region (1966-1968). In: A Report of Scientific Expedition in the Mount Jolmo Lungma Region (1966-1968). Paleontology, 3: 223-438.

TOZER, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Surv. Canada, Bull. 467, pp. 663.

THE *AETOSAURUS* BIOCHRON, EARLY-MIDDLE NORIAN OF PANGEA

Spencer G. Lucas, Andrew B. Heckert and Phillip Huber

Abstract

Four specimens of the aetosaur *Stegomus* are known from Upper Triassic strata of the Newark Supergroup of the eastern United States. These specimens characterize a small aetosaur with a long narrow carapace that is distinctly waisted in front of the hindlimbs, has paramedian scutes much wider than long and lateral scutes that lack spikes. *Stegomus* thus is remarkably similar to *Aetosaurus* Fraas but has weaker sculpturing on its scutes. This is the principal difference between the two, so we regard *Stegomus* as a junior subjective synonym of *Aetosaurus* and recognize a distinct Newark species, *Aetosaurus arcuatus* (Marsh).

Aetosaurus in the Newark Supergroup is of biochronological significance because the genus has a broad distribution and one of its occurrences can be directly cross correlated to Triassic marine biochronology. *Aetosaurus* is of early-middle Norian age in the German Lower and Middle Stubensandstein. *Aetosaurus* has been found in middle Norian marine limestones in Italy correlative to the *Himavatites columbianus* ammonite zone, which directly cross correlates the genus to the standard global chronostratigraphic scale. *Aetosaurus* is present in the Bull Canyon Formation (Chinle Group) of eastern New Mexico, USA and in the Ørsted Dal Member of the Fleming Fjord Formation in Greenland, units of early Norian age. *Aetosaurus* localities in the Newark are of early-middle Norian age, a conclusion consistent with Newark palynostratigraphy and magnetostratigraphy. *Aetosaurus* thus is an index fossil of the early-middle Norian.

Introduction

Aetosaurs were herbivorous archosaurs of the Late Triassic. Their heads are extremely small relative to their bodies, their snouts lack teeth, and they have small, leaf-shaped maxillary and dentary teeth. The heavily armored body has quadrangular plates that run from the back of the skull to the tip of the tail and encase much of the abdomen as well as the entire tail. The tarsus is crocodile normal, and the ichnogenus *Brachychirotherium* probably represents aetosaur footprints.

Aetosaur fossils have a broad geographic distribution and are among the most common tetrapod fossils in many Upper Triassic, nonmarine strata. Distribution, abundance, and ease of identification make aetosaurs useful Late Triassic nonmarine index fossils (Lucas and Heckert, 1996; Heckert et al., 1996).

We have re-evaluated the taxonomy of one of the first aetosaurs described from North America, *Stegomus arcuatus* Marsh, 1896 to conclude that *Stegomus* is a junior subjective synonym of the European aetosaur genus *Aetosaurus* (Lucas et al., 1996, 1997). This enables a robust correlation of *Aetosaurus* localities in the United States, Greenland, Germany and Italy, and thus further develops the biochronological utility of aetosaurs.

Stegomus = *Aetosaurus*

The four specimens of *Stegomus* from the Newark Supergroup characterize an aetosaur with the following distinctive features: (1) relatively small overall size; (2) paramedian scutes much wider than long, with anterior bars overlapped by the preceding scute in the series; (3) lateral scutes small, trapezoidal and lacking any bone spikes; (4) paramedian scute surfaces With faint "sunburst" pattern of pits and grooves; and (5) carapace "waisted" (narrows, with a corresponding decrease in width:length ratios of dorsal scutes) immediately anterior to the pelvis.

Among the known aetosaurs, all these features are known in *Aetosaurus* Fraas, 1877. Particularly significant is the pattern of pitting on the scutes and the lack of spikes or bosses. Indeed, we are unable to distinguish specimens of *Stegomus from Aetosaurus* except by minor differences, so we consider the two genera synonymous. We retain, however, a distinct North American species of the genus, *Aetosaurus arcuatus* (Marsh, 1896), based on the following features that distinguish it from *A. ferratus* Fraas 1877 and *A. crassicauda* Fraas 1907: relatively high width:length ratio (3.5:1) of dorsal paramedian scutes in adult specimens, pitting very faint on scutes, and tail narrows rapidly posteriorly.

The *Aetosaurus* biochron

Recognition that *Stegomus* = *Aetosaurus* extends the record of this biostratigraphically significant taxon into the eastern United States. Here, we review the temporal distribution of *Aetosaurus* to establish its status as a nonmarine index to early-middle Norian time (Fig.1).

Western United States

Hunt (1994) documented aetosaur scutes from the Bull Canyon Formation of the Chinle Group in east-central New Mexico. The holotype of a new genus he proposed but did not publish is a left dorsal paramedian scute. This scute measures 75 mm wide and 31 mm long, so it has a low width:length ratio of 2.4. The scute is slightly arched transversely, indicating that it is likely a caudal dorsal paramedian. The ornamentation consists of a very faint, radial pattern of elongate pits. It thus closely resembles the Newark specimens of *Aetosaurus arcuatus,* and we assign it to that taxon. Another referred specimen from eastcentral New Mexico is a dorsal paramedian scute, which measures 76 mm wide and 27 mm long, yielding a width:length ratio of 2.8. Associated scutes and possible material from the axial and the appendicular skeleton of these specimens will be described separately. The Bull Canyon Formation is considered to be of early-middle Norian age based largely on the occurrence of a the phytosaur *Pseudopalatus* and the aetosaur *Typothorax,* both of which are index taxa of the Revueltian land vertebrate faunachron (lvf) of Lucas and Hunt (1993).

Eastern United States

Four specimens from the Newark Supergroup are referred to *Aetosaurus arcuatus: (1)* the holotype of *S. arcuatus* Marsh from the New Haven Formation in Fair Haven, Connecticut, the natural mold of the ventral surface of the dorsal thoracic armor; (2) the holotype of *S. arcuatus jerseyensis* Jepsen, an incomplete tail from the lower Passaic Formation at Neshanic Station, New Jersey; (3) the natural mold of the skull and dorsal armor of a juvenile from the Passaic Formation, Nishisakawick Creek, New Jersey; and (4) a partial tail from the "Sanford Formation" at Triangle Brick Quarry, North Carolina.

The holotype of *Aetosaurus arcuatus* (Marsh, 1896) was collected by Freeman P. Clark in his brownstone quarry at Fair Haven, located within the city limits of New Haven, Connecticut. This quarry is developed in the New Haven Formation, a red-bed unit that consists mostly of arkosic sandstone and conglomeratic sandstone. The lower part of the New Haven Formation has produced a Carnian-Norian palynoflora (Cornet, 1977), and the upper part has produced the procolophonid *Hypsognathus* and a sphenodontid (cf. *Sigmala)* indicative of a latest Triassic (probably Rhaetian) age (Huber et al., 1993b; Lucas and Huber, 1993). The *Aetosaurus arcuatus* holotype is from the middle part of the New Haven Formation, and has been assigned a middle Norian age based on correlation to other, better dated Newark Supergroup strata (Lucas and Huber, 1993).

The New Jersey specimens of *Aetosaurus* were both obtained from the Passaic Formation. The specimen described by Jepsen (1 948) was recovered from a cellar excavation in strata that pertain to the Neshanic Member of the Passaic Formation at Neshanic Station, New Jersey. The specimen described by Baird (1 986) was obtained as a loose boulder from the bed of Nishisakawick Creek in nearby Frenchtown, New Jersey, from the stratigraphically lower Warford Member of the Passaic Formation. In the Newark basin, the thickness of the stratigraphic interval from the Warford to the Neshanic Members of the Passaic Formation is about 600 m (Olsen et al., 1996, fig. 8). Based on palynostratigraphy, magnetostratigraphy, and cyclostratigraphy, Kent et al. (1995) assigned this interval to the early-middle Norian with an estimated numerical age range of 215-218 Ma. The Newark basin occurrences of *Aetosaurus* in New Jersey thus establish the entire temporal range of *Aetosaurus* in the Newark Supergroup, and were used by Huber et al. (1993b) and Lucas and Huber (1993) to help define the Neshanician lvf, of early-middle Norian age.

The North Carolina specimen was briefly described in an abstract by Parker (1 966). Its provenance is the Triangle Brick Quarry, near Glenlee, North Carolina, which exposes a 20 m stratigraphic section of fine- to medium-grained arkosic and quartzose sandstone, siltstone and shale mapped and informally named by Hoffman and Gallagher (1 989) as "Lithofacies Association 11" of the Durham sub-basin of the Deep River basin, a unit that is the stratigraphic equivalent of the lower Sanford Formation in the adjacent Sanford sub-basin (Huber et al., 1993a). Other fossils from the Triangle Brick Quarry include megafossil plants (equisetatalian stem fragments), darwinulid ostracodes, abundant conchostracans, unionid bivalves, articulated crayfish, insects, bony fishes (*Synomichthys-Cionichthys, Turseodus, Semionotus, Osteplurus*), hybodontid elasmobranchs, several morphologies of vertebrate coprolites, indeterminate labyrinthodont and phytosaur teeth and bone scrap, sphenosuchian and proterosuchian crocodilomorphs, and several, recently collected, partial skeletons of a new rauisuchian currently under study by P.E. Olsen (pers. comm., 1995). Based on lithostratigraphic correlation of the Durham and Sanford sub-basin successions (Olsen et al., 1990), Lithofacies Association 11 is stratigraphically higher than the Cumnock Formation, which produced a tetrapod fauna of latest Carnian (late Tuvalian) age (Sanfordian lvf of the Newark Supergroup) (Huber et al., 1993a,b). Hence, the Triangle Brick Quarry *Aetosaurus* comes from strata of early Norian age that belong to the early part of the Neshanician lvf, as defined by Huber et al. (1993b) and Lucas and Huber (1993).

Greenland

In Greenland, *A. ferratus* occurs in the Ørsted Dal Member of the Fleming Fjord Formation (Jenkins et al., 1994). The Ørsted Dal Member produces a diverse assemblage of vertebrates: the plagiosaurid *Gerrothorax* cf. *G. pulcherrimus* Fraas, the cyclotosaur *Cyclotosaurus* cf. *C.*

posthumus Fraas, the turtle cf. *Proganochelys,* the aetosaurs *Aetosaurus ferratus* Fraas and *Paratypothorax andressi* Long and Ballew, the prosauropod dinosaur *Plateosaurus engelhardti* Meyer, a theropod dinosaur, the mammals *Kuehneotherium* sp. and cf. ?*Brachyzostrodon,* a pterosaur, coelacanth fishes, *Saurichthys*?, a lungfish, unidentified sphenodonts and lepidosaurs? and theropod dinosaur footprints (*Grallator* sp.).

As Jenkins et al. (1994) concluded, this assemblage shares many taxa with the German Stubensandstein and clearly is of Norian age. The closest similarity of the Ørsted Dal assemblage is to the vertebrate assemblage of the Lower Stubensandstein, especially the co-occurrence in both units of *Aetosaurus ferratus* and *Paratypothorax andressi,* as well as *Cyclotosaurus, Gerrothorax,* and *Proganochelys*. We thus regard the Ørsted Dal Member vertebrates as of early Norian age (Fig. 1). However, note: (1) Jenkins et al. (1 994) presented no precise stratigraphic ordering of vertebrate fossil localities in the 150-200-m thick Ørsted Dal Member; and (2) some taxa from the Ørsted Dal Member *(Gerrothorax, Plateosaurus)* do not occur in the Lower Stubensandstein but first appear in the Middle Stubensandstein (Benton, 1993, table 1). Therefore, the possibility exists that the Ørsted Dal vertebrate assemblage includes temporal equivalents of both the Lower and Middle Stubensandstein.

Germany

In Germany, *Aetosaurus* is well-documented from the Lower Stubensandstein *(A. ferratus)* and the Middle Stubensandstein *(A. crassicauda)* of the German Keuper (Fraas, 1877; Fraas, 1907; Wild, 1989). Palynostratigraphy, vertebrate biostratigraphy, and sequence stratigraphy suggest the Stubensandstein is of early to middle Norian age (see references cited by Lucas and Huber, 1994). The most precise correlation available suggests the Lower Stubensandstein is early Norian, whereas the Middle Stubensandstein is middle Norian. This suggests *Aetosaurus* in Germany has an early-middle Norian temporal range comparable to its temporal range in the Newark Supergroup (Fig. 1).

Italy

Wild (1989) documented *A. ferratus* from the Marine Calcare di Zorzino Formation (= Zorzino Limestone) at Cene near Bergamo in the Lombardian Alps of northern Italy. The Calcare di Zorzino Formation is a carbonate and turbidite facies that immediately overlies and is, in part, laterally equivalent to the Norian Dolomia Principale (= Hauptdolomit). After the regional progradation of platform carbonates (Dolomia Principale) during the early-middle Norian, extensional tectonism produced intraplatform depressions in which the Zorzino Limestone (Aralalta Group: Jadoul, 1985) was deposited by patch reefs, turbiditic debris flows and lagoonal to freshwater facies (Jadoul et al., 1994). Palynostratigraphy and conodont biostratigraphy indicate the fossil vertebrate locality in the Zorzino Limestone near Bergamo is very close to the Alaunian (middle Norian)-Sevatian (late Norian) boundary (Jadoul et al., 1994; Roghi et al., 1995; Tintori and Lombardo, 1996). This indicates the *Aetosaurus* occurrence there documented by Wild (1989) is of late middle Norian age, correlative to the younger part of the *Himavatites columbianus* zone of the global Triassic ammonite biochronology (Tozer, 1994). This provides a direct cross-correlation of an *Aetosaurus* occurrence to marine Triassic biochronology (Fig. 1).

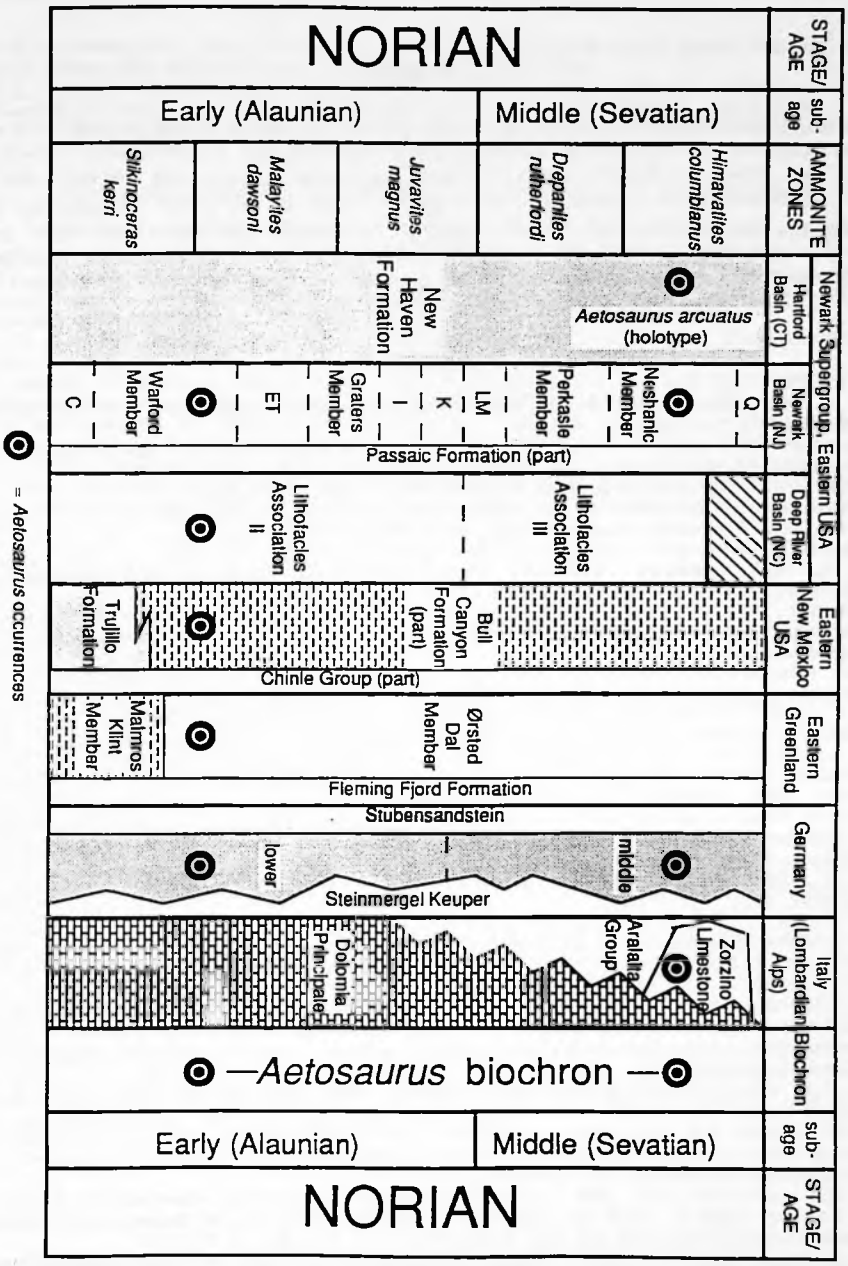


Fig. 1. Correlation of Aetosaurus*-producing strata. See text for discussion.*

Conclusion

The direct cross-correlation of *Aetosaurus* from Italy to the middle Norian accords well with the inferred age of some *Aetosaurus* records in Germany and the United States. However, the German and American records suggest *Aetosaurus* existed during both the early and middle Norian. Although this is consistent with cross-correlation to the Italian marine occurrence of *Aetosaurus,* the German and Newark Supergroup records obviously encompass a longer temporal range (Fig. 1) than the single Italian occurrence. *Aetosaurus thus* emerges as a tetrapod taxon capable of providing a robust correlation across much of Late Triassic Pangea. *Aetosaurus* is an index fossil of early-middle Norian time.

References

BAIRD, D., 1986. Some Upper Triassic reptiles, footprints and an amphibian from New Jersey: The Mosasaur, 3: 125-135.

BENTON, M.J., 1993. Late Triassic terrestrial vertebrate extinctions: stratigraphic aspects and the record of the Germanic basin. Paleont. Lombardia N.S., 2: 19-38.

CORNET, B., 1977. The palynostratigraphy and age of the Newark Supergroup. Unpublished Ph.D. dissertation, Pennsylvania State University, Pennsylvania.

FRAAS, E., 1907. *Aëtosaurus crassicauda* n.sp., nebst Beobachtungen über das Becken der Aëtosaurier. Jahresh. Ver. vaterl. Naturk. Württ., 63: 101-109.

FRAAS, O., 1877. *Aetosaurus ferratus* Fr. Die gepanzerte Vogel-Echse aus dem Stubensandstein bei Stuttgart. Württ. Naturwiss. Jb., 33(3): 1-22.

HECKERT, A.B., HUNT, A.P. and LUCAS, S.G., 1996. Redescription of *Redondasuchus reseri,* a late Triassic aetosaur (Reptilia:Archosauria) from New Mexico (U.S.A) and the biochronology and phylogeny of aetosaurs. Geobios, 29: 619-632.

HOFFMAN, C.W. and GALLAGHER, P.E., 1989. Geology of the Southeast and Southwest Durham 7.5-minute quadrangles, North Carolina. Bull. North Carolina Geol. Surv., 92: 1-34.

HUBER, P., LUCAS, S.G. and HUNT, A.P., 1993a. Revised age and correlation of the Upper Triassic Chatham Group (Deep River Basin, Newark Supergroup), North Carolina. Southeastern Geol., 33: 171-193.

HUBER, P., LUCAS, S.G. and HUNT, A.P., 1993b. Vertebrate biochronology of the Newark Supergroup Triassic, eastern North America. New Mexico Mus. Nat. Hist. Sci. Bull., 3: 179-186.

HUNT, A.P., 1994. Vertebrate paleontology and biostratigraphy of the Bull Canyon Formation (Chinle Group, Upper Triassic), east-central New Mexico with revisions of the families Metoposauridae (Amphibia: Temnospondyli) and Parasuchidae (Reptilia: Archosauria). Unpubl. Ph.D. Diss. University New Mexico, Albuquerque.

JADOUL, F., 1985. Stratigrafia e paleogeografia del Norico nelle Prealpi Bergamasche occidentali. Riv. Ital. Paleont. Strat., 91: 479-512.

JADOUL, F., MASETTI, D., CIRILLI, S., BERRA, S., CLAPS, M. and FRISIA, S., 1994. Norian-Rhaetian stratigraphy and paleogeographic evolution of the Lombardy basin (Bergamasc Alps). 15th Int. Assoc. Sedimentol., Reg. Meeting, April 1994, Ischia, Italy, Field Excursion B1, Salerno, Italy, 5-38.

JENKINS, F.A. JR., SHUBIN, N.H., AMARAL, W.W., GATESY, S.M., SCHAFF, C.R., CLEMMENSEN, L.B., DOWNS, W.R., DAVIDSON, A.R., BONDE, N. and OSBIECK, F., 1994. Late Triassic continental vertebrates and depositional environments of the Fleming Fjord Formation, Jameson Land, East Greenland. Meddel. Grønl., Geosci. 32: 1-25.

JEPSEN, G.L., 1948. A Triassic armored reptile from New Jersey. State of New Jersey Dept. Conservation Miscel. Geol. Pap., p. 120.

KENT, D.V., OLSEN, P.E. and WITTE, W.K., 1995. Late Triassic-earliest Jurassic geomagnetic polarity sequence and paleolatitudes from drill cores in the Newark rift basin, eastern North America. Journal of Geophysical Research, 100, 14965-14998.

LUCAS, S.G. and HECKERT, A.B., 1996. Late Triassic aetosaur biochronology. Albertiana, 17: 57-64.

LUCAS, S.G. and HUBER, P., 1993. Revised internal correlation of the Newark Supergroup Triassic, eastern United States and Canada. Bull. New Mexico Mus. Nat. Hist. Sci., 3: 311-319.

LUCAS, S.G. and HUBER, P., 1994. Sequence stratigraphic correlation of Upper Triassic marine and nonmarine strata, western United States and Europe. Can. Soc. Petrol. Geol. Mem., 17: 241-254.

LUCAS, S.G. and HUNT, A.P., 1993. Tetrapod biochronology of the Chinle Group (Upper Triassic), western United States. New Mexico Mus. Nat. Hist. Sci. Bull., 3: 327-329.
LUCAS, S.G., HECKERT, A.B., HUBER, P. and HUNT, A.P., 1996, The Triassic aetosaur *"Stegomus"* from the Newark Supergroup and its biochronological significance. J. Vertebr. Paleont., 16(3): 49A.
LUCAS, S.G., HECKERT, A.B. and HUBER, P., 1997, *Aetosaurus* (Archosauromorpha) from the Upper Triassic of the Newark Supergroup, eastern United States, and its biochronological significance. Palaeontology, in press.
MARSH, O.C., 1896. A new belodont reptile *(Stegomus)* from the Connecticut River Sandstone. Amer. J. Sci., 2: 59-62.
OLSEN, P.E., KENT, D.V., CORNET, B., WITTE, W.K. and SCHLISE, R.W., 1996. High-resolution stratigraphy of the Newark rift basin (early Mesozoic, eastern North America). Bull. Geol. Soc. America, 108: 40-77.
OLSEN, P.E., FROELICH, A.J., DANIELS, D.L., SMOOT, J.P. and GORE, P.J.W., 1990. Rift basins of early Mesozoic age. 142-170. *In:* HORTON, J.W. and ZULLO, V.A., (eds). The geology of the Carolinas, University of Tennessee Press, Knoxville, 180 pp.
PARKER, J.M. III., 1966. Triassic reptilian fossil from Wake County, North Carolina. J. Elisha Mitchell Soc., 82:92.
ROGHI, G., MIETTO, P. and DALLA VECCHIA, F.M., 1995. Contribution to the conodont biostratigraphy of the Dolomia di Forni (Upper Triassic, Carnian, NE Italy). Mem. Sci. Geol., 47: 125-133.
TINTORI, A. and LOMBARDO, C., 1996. *Gabonella agilis,* gen.n. sp.n., (Actinopterygii, Perleidiformes) from the Calcare di Zorzino of Lombardy (North Italy). Riv. Ital. Paleont. Strat., 102: 227-236.
TOZER, E.T., 1994. Canadian Triassic ammonoid faunas. Bull. Geol. Surv. Canada, 467, 663 pp.
WILD, R., 1989. *Aëtosaurus* (Reptilia: Thecodontia) from the Upper Triassic (Norian) of Cene near Bergamo, Italy, with a revision of the genus. Rev. Mus. Civ. Sci. Nat. "Enrico Caffi", 14:1-24.

THE PERMIAN/TRIASSIC BOUNDARY IN THE CENTRAL HIMALAYA

Alda Nicora and Eduardo Garzanti

The Manang region of the Annapurna Range (Central Nepal) is a key area to understand the environmental processes leading to drastic faunal turnover at the Permian/Triassic boundary. In this region, a thin distinct unit consisting of orange-weathering, bedded biocalcarenites to biocalcirudites with dolomitized micritic groundmass caps the Permian succession and underlies the Tamba-Kurkur Formation of Early Triassic age (Bassoullet and Colchen, 1977). This stratigraphic unit has been either formally named "Panjang Formation" and ascribed to the basal Triassic (Waterhouse, 1977; 1994; Hatleberg and Clark, 1984; Baud et al., 1996) or informally called "topmost biocalcarenites" and included at the top of the Puchenpra Formation of Permian age (Garzanti et al., 1994 a,b). Even though we are far from enthusiastic about several aspects of the stratigraphic schemes proposed by Waterhouse in the last 20 years (e.g., Gaetani et al., 1995), the paucity of toponyms in the Himalayas is such that the term Panjang may deserve unanimous acceptance. Because some fundamental points still need clarification, we will still use here the informal term "topmost biocalcarenites" (TBC).

The facts

Braga section

1. The TBC consist of three carbonate beds and two mudrock interbeds (4.3 m-thick overall).

Section	Unit	Sample-distance from TBC base (m)	Samples	*Vjalovognathus shindyensis*	*Gullodus* cf. *sicilianus*	*Gondolella* cf. *phosphoriensis*	*Hindeodus julfensis* trans. to *typicalis*	*Dicerogondolella* sp.	*Hindeodus parvus erectus*	*Hindeodus typicalis*	*Hindeodus latidentatus* emend	*Gondolella taylorae*	*Gondolella* aff. *changxingensis*	*Gondolella tulongensis*	*Gondolella carinata*	*Gondolella* aff. *carinata*	Ramiforms
TILICHO	TKK	1,47	AD 145									10	5		82		
	TKK	1,17	AD 144									17			23		1
	TKK	1,07	AD 143							1		14	6	3	15		5
	TBC	0,57	AD 142							7	68	33	44	12	77		18
	TBC	0,50	AD 141			3				2cf		7		13	25		4
	TBC	0,00	AD140		barren												
COL NOIR	TKK	2,27	AD 119												29		1
	TBC	1,27	AD 118	1			1			17	28	44	25	23	8	13	10
	TBC	0,98	AD 117		barren												
	TBC	0,30	AD 116		barren												
	TBC	0,00	AD 115		barren												
MANANG	TBC	1,20	AD 179					2				3		7	22		1
	TBC	0,00	AD 178	2	1	1			1	9	13	44	11	13	75	33	6
BRAGA	TKK	5,47	AD 189									9	3		83	5	
	TBC	4,10	AD 188							4		10	5	35	37	10	10
	TBC	3,11	AD 187		barren												
	TBC	1,20	AD 186		barren												
	TBC	0,00	AD 185	17		9											

Fig. 1. Conodont distribution across the Permian/Triassic boundary in Manang

2. The TBC overlies a mudrock interval containing a brachiopod assemblage of Bolorian/Early Kubergandian age.
3. The first carbonate bed of the TBC contains a conodont fauna (*Gondolella* cf. *phosphoriensis*, *Vjalovognathus shindyensis*) of Kubergandian-Murgabian (i.e., Roadian-Wordian) age.
4. Conodonts were not found in the second carbonate bed of the TBC.
5. The third carbonate bed of the TBC yielded the same brachiopod, coral and conodont assemblage as the other three sections described below, with the exception of Kubergandian-Murgabian conodonts.

Manang, Col Noir and Tilicho sections

1. The TBC consist of a single carbonate horizon, decreasing progressively in thickness from E to W (1.7 m at Manang; 1 m at Col Noir; 0.7 m at Tilicho).
2. The TBC at Col Noir overlie bioclastic arenites and mudrocks containing bivalve and brachiopod assemblages of Murgabian-Midian age;
3. The TBC contain abundant macrofossils (e.g., the brachiopod *Tintoriella rajah*, the coral *Plerophyllum schindewolfi*, large crinoids, fenestellid bryozoans) of Late Permian age.
4. The TBC contain a rich conodont fauna including a few badly preserved mid-Permian forms (*G.* cf. *phosphoriensis*, *V. shindyensis*, *Gullodus* cf. *sicilianus*) along with much more abundant forms held as latest Permian (e.g., *Hindeodus latidentatus* emend.), as straddling the Permian/Triassic boundary (*G. carinata, H. typicalis, G.* aff. *changxingiensis)* and as earliest Triassic *(G. taylorae, G. tulongensis*).

These important new data (Fig. 1) result both from observations on additional processed material and from revision of preliminary data (Garzanti et al., 1994 a,b), after the publication of several relevant recent papers on Himalayan stratigraphy and conodont taxonomy at the P/T boundary (e.g., Orchard et al., 1994; Kozur,1995; 1996; Baud et al., 1996; Krystyn and Orchard, 1996; Orchard, 1996; Wang, 1996).

Conodont evolution

1. Criteria to define paleontologically the Permian/Triassic boundary are still debated. The FAD of *H.parvus* is not a good choice, because the *H. latidentatus - H. parvus - I. turgida - I. isarcica* lineage represents a serious problem even for the hyperspecialist (Baud, 1996).
2. Permian characters still characterize conodont forms found in the "Otoceras beds" and partly even those found in the overlying "Ophiceras beds", the major change in conodont faunas being represented by the FAD of the genus *Neospathodus* at the base of the Dienerian "Meekoceras beds".
3. The sequence of biostratigraphic events across the P/T boundary has not been firmly established yet in the Himalayas, because paleontological evidence from uppermost Permian strata is either largely lacking (e.g., Zanskar, Spiti, Dolpo), disputed (e.g., Manang) or poor (e.g., the undeterminable Neogondolellid fauna reported from strata ascribed to the Changxingian at Selong by Orchard e al., 1994).

In short

1. The Upper Permian succession is strongly reduced in thickness in the Manang area (from a maximum of about 25 m at Col Noir to just a few metres at Tilicho and Braga; Garzanti et al., 1994b, figs. 5, 9,10), whereas it ranges from 127 to 151 m to the west in central Dolpo (Sciunnach and Garzanti, 1996) and reaches 470 m to the east in South Tibet (Garzanti et al., 1997).
2. The first bed of the TBC at Braga is Kubergandian-Murgabian in age, and thus at least the base of the TBC in this locality is definitely older than Triassic.

3. Mixing of macrofossils and conodonts of Permian and Triassic age occurs at the top of the TBC in Manang. This horizon is both condensed and reworked, and might be ascribed either to the uppermost Permian or to the basal Triassic depending on the adopted conventions (i.e., H.*latidentatus* Zone of Wignall et al., 1996).
4. Permian fossils disappear only at the base of the Tamba-Kurkur Fm., which is Griesbachian in age (i.e., *I. isarcica*/*G. carinata* Zones).

To conclude

The Permian/Triassic boundary is widely recognized as the greatest catastrophe in the history of life on Earth. In the Tethys Himalaya stratigraphic record as elsewhere (e.g., Tozer, 1986; Wignall and Hallam, 1993), however, it does not appear as one single catastrophic event, and its definition - both paleontologically and stratigraphically - is a still debated problem (e.g., Wignall et al., 1996). Mixed faunal assemblages containing macrofossils and conodonts of Permian age in calcarenites marking the P/T boundary in Manang is a closely-related sedimentological problem. Condensation, reworking and ravinement processes are explained as due to starvation and subacqueous redeposition or even erosion of underlying beds during a major stepwise transgression associated with rapid thermal subsidence at the end of the Permian "proto-oceanic" stage (Garzanti et al., 1996), rather than with subaerial exposure during a first-order eustatic sea-level drop (Bhatt et al., 1980; Baud et al., 1996).

References

BASSOULLET, J.P. and COLCHEN, M., 1977. La limite Permien-Trias dans le domaine tibétain de l' Himalaya du Nepal (Annapurnas-Ganesh Himal). Coll. Int. C.N.R.S., 268: 41-52.

BAUD, A., 1996. The Permian-Triassic boundary : recent developments, discussion and proposals. Albertiana, 18: 6-9.

BAUD, A., ATUDOREI, V. and SHARP, Z., 1996. Late Permian and Early Triassic evolution of the Northern Indian margin: carbon isotope and sequence stratigraphy. Geodin. Acta, 9: 7-77.

BHATT, D.K., FUCHS, G., PRASHARA, K.C., KRYSTYN, L., ARORA, R.K. and GOLEBIOWSKI, R., 1980. Additional ammonoid layers in the Upper Permian sequence of Spiti. Bull. Ind. Geol. Ass., 13: 57-61.

GAETANI, M., BALINI, M., GARZANTI, E., NICORA, A., TINTORI, A., ANGIOLINI, L., SCIUNNACH, D., 1995. "The Early and Middle Triassic ammonoid succession of the Himalayas in western and central Nepal. Part 1" by Waterhouse (1994): a discussion. Albertiana, 15: 1-6.

GARZANTI, E., NICORA, A. and TINTORI, A., 1994a. Triassic stratigraphy and sedimentary evolution of the Annapurna Tethys Himalaya (Manang area, Central Nepal). Riv. It. Paleont. Strat., 100: 195-226.

GARZANTI, E., NICORA, A., TINTORI, T., SCIUNNACH, D. and ANGIOLINI, L., 1994b. Late Paleozoic stratigraphy and petrography of the Thini Chu Group (Manang, Central Nepal): sedimentary record of Gondwana glaciation and rifting of Neotethys. Riv. It. Paleont. Strat., 100: 155-194.

GARZANTI, E., ANGIOLINI, L. and SCIUNNACH, D., 1996. The Permian Kuling Group (Spiti, Lahaul and Zanskar; NW Himalaya): sedimentary evolution during rift/drift transition and initial opening of Neo-Tethys. Riv. It. Paleont Strat.,102: 175-200.

GARZANTI, E., LE FORT, P. and SCIUNNACH, D., 1997. The Himalayan volcanic rifted margin: Lower Permian tholeiitic basalts in South Tibet. Tectonophysics, submitted.

HATLEBERG, E.W. and CLARK, D.L., 1984. Lower Triassic conodonts and biofacies interpretations: Nepal and Svalbard. Geol. Paleont., 18: 101-112.

KOZUR, H., 1995a. Permian conodont zonation and its importance for the Permian stratigraphic standard scale. Geol. Paläont. Mitt. Innsbruck, 20: 165-205.

KOZUR, H., 1995b. Some remarks to the conodonts *Hindeodus* and *Isarcicella* in the Latest Permian and Earliest Triassic. Palaeoworld, 6: 64-77.

KRYSTYN, L. and ORCHARD, M.J., 1996. Lowermost Triassic ammonoid and conodont biostratigraphy of Spiti, India. Albertiana, 17: 10-21.

ORCHARD, M.J., 1996. Conodont fauna from the Permian-Triassic boundary: observations and reservations. Permophiles, 28, 36-39.

ORCHARD, M.J., NASSICHUK, W.W. and RUI, L., 1994. Conodonts from the Lower Griesbachian *Otoceras latilobatum* bed of Selong, Tibet, and the position of the Permian-Triassic boundary. In Pangea: global environments and resources. Canad. Soc. Petr. Geol. Mem. 17: 823-843.

SCIUNNACH, D. and GARZANTI, E., 1996. Sedimentary record of Late Paleozoic rift and break-up in Northern Gondwana (Thini Chu Group and Tamba-Kurkur Fm.; Dolpo Tethys Himalaya, Nepal). Geodin. Acta, 9: 41-56.

TOZER, E.T., 1986. Definition of the Permian-Triassic (P-T) boundary: the question of the age of the *Otoceras* Beds. Mem. Soc. Geol. It., 34: 291-301.

WANG, C.-Y., 1996. Conodont evolutionary lineage and zonation for the latest Permian and earliest Triassic. Permophiles, 29: 30-37.

WATERHOUSE, J.B., 1977. The Permian rocks and fauna from Dolpo, North-west Nepal. Coll. Int. C.N.R.S., 268: 479-496.

WATERHOUSE, J.B., 1994. The Early and Middle Triassic ammonoid succession of the Himalayas in western and central Nepal. Part 1 - Stratigraphy, classification and early Scythian ammonoid systematics - Palaeontographica, Abt. A, 232: 1-83.

WIGNALL, P.B. and HALLAM, A., 1993. Griesbachian (Earliest Triassic) palaeoenvironmental changes in the Salt Range, Pakistan and southeast China and their bearing on the Perm-Triassic mass extinction. Palaeogeogr. Palaeoclim. Palaeoecol., 102: 215-237.

WIGNALL, P.B., KOZUR, H. and HALLAM, A., 1996. On the timing of palaeoenvironmental changes at the Permo-Triassic (P/Tr) boundary using conodont biostratigraphy. Historical Biology, 12: 39-62.

ALBERTIANA

ALBERTIANA is published twice a year by the Subcommission on Triassic Stratigraphy. Individuals can obtain ALBERTIANA for the sum of US $ 20.-or Dfl. 30.- per year.

Readers are kindly requested to pay their annual contribution timely.

European readers can send a EUROCHEQUE made payable in Dutch Guilders (Dfl. 30.-) to the LPP Foundation to: ALBERTIANA, Dr. Zwier Smeenk, Laboratory of Palaeobotany and Palynology, University Utrecht, Budapestlaan 4, NL-3584 CD Utrecht, The Netherlands. All others are kindly requested to send cash (Dfl. or US $) in a closed non-transparant envelope to the above Utrecht address. Because of the high provision c.q. transferring costs of other cheques/currencies, other methods of payment cannot be accepted. Institutions can receive ALBERTIANA on exchange basis.

All correspondence regarding the distribution of ALBERTIANA should be sent to Dr. Zwier Smeenk (Utrecht) and not to the editor!

ANNOTATED TRIASSIC LITERATURE

Hans Kerp and Henk Visscher[1]

Anderson, J., Anderson, H., Fatti, P. and Sichel, H., 1996. The Triassic explosion (?): a statistical model for extrapolating biodiversity based on the terrestrial Molteno Formation. Paleobiology, 22: 318-328.

Fitting the generalized inverse Gaussian-Poisson distribution (GIGP) to observed frequency distributions of taxa from the Late Triassic Molteno Formation of South Africa has yielded estimates of the corresponding preserved biodiversities. Three extrapolations have been made on the basis of the uniquely rich megaflora/insect coassemblages from 100 tapho-coenoses: insect species - 335 observed, 7740 preserved; vegetative species - 206 observed, 667 preserved; gymnosperm ovulate orders - 16 observed, 84 preserved. The reliability of the results varies according to the abundance and observed diversity of the taxa. These results, with further estimations in a companion paper of existed diversity (regional, continental and global), hint at Late Triassic floral and faunal richness akin to today. This conflicts with the traditionally held model of an increasing cone of biodiversity through time and suggests a phase of explosive evolution in the Triassic hitherto un-suspected. Application of the GIGP to other well documented collections from other periods might reveal a pattern of diversity trends offering fundamentally new insights into the evolving terrestrial biosphere.

Arche, A. and Lopez-Gomez, J., 1996. Origin of the Permian-Triassic Iberian Basin, central-eastern Spain. Tectonophysics, 266: 443-464.

The Iberian Basin was an intracratonic rift basin in central-eastern Spain developed since Early Permian times. The basin boundary faults were normal, listric faults controlling an asymmetric extension propagating northeast with time. Hercynian or older lineaments controlled the orientation of the Iberian Basin and extension was accommodated basically in the hanging-wall block by the formation of secondary grabens and a central high. The basin was related with the coeval Ebro, Catalan and Cuenca-Mancha Basins and their connections are discussed. Subsidence curves show that the Early Permian-Early Jurassic period of extension can be subdivided into three rifting episodes and a flexural one. Extension factor increases from 1.17 in the northwest to 1.29 near the Mediterranean coast. The increasing extension rate was accommodated by transfer faults trending NNE-SSW, more important in the Levante area. The rift evolution is intermittent and seems to reflect distinct stress fields. The collapse of the late Hercynian orogen and related increased heat flux, extension and rifting is the most probable origin of the Iberian Basin and related basins. The origin of the Catalan and the Valencia Prebetic Basins is related to the southwards migration of the Hesse-Burgundy rift along the eastern margin of the Iberian microplate.

---

[1] The help of Gaby Schwenzien (Münster) and Dr. Zwier Smeenk (Utrecht) in tracing relevant literature is gratefully acknowledged. Thanks are due to all authors who sent information on their recent publications. Of some papers which do not have an English abstract only the title is given. Some references have been obtained from secondary sources. Therefore, diacritical signs may sometimes be missing.

Ash, S., 1996. Evidence of arthropod-plant interactions in the Upper Triassic of the southwestern United States. Lethaia, 29: 237-248.

Leaves from the Upper Triassic Chinle Formation in the southwestern United States show evidence of having provided nourishment and shelter for several different types of arthropods. This evidence consists of three or four morphotypes of Feeding traces and a well defined type of gall. The feeding traces occur on the pinnules of the filicalean fern *Cynepteris lasiophora* (Daugherty) Ash and the pinnae of the bennettitalean leaf *Zamites* sp. and *Marcouia neuropteroides* Ash, a gymnosperm leaf of uncertain relationships. Typically, the feeding traces are only a few mm in length and have smooth, continuous margins which are often bordered by a narrow dark band that represents reaction tissue formed in response to feeding. Presence of this tissue indicates that the leaves continued to function after the damage occurred and while they were still attached to the parent plant. The relatively small size and shape of the feeding traces shows that they were most likely produced by grazing insects. Gall-like swellings are found on the leaves of *Dechellyia gormanii* Ash, another gymnosperm fossil of uncertain relationships. The swellings are well defined, round to deltoid in outline, and bulbous. Typically, only one such swelling occurs on a leaf. Leaves that have these swellings are often distorted or terminate abruptly al the disturbance, particularly if the structure extends over the edge of the leaf. The swellings resemble galls induced on leaves of certain modern plants by eriophyid mites and apparently are either prosoplasmatic histioid pit galls or pouch galls.

Axsmith, B.J. and Taylor, T.N., 1997. The Triassic conifer seed cone *Glyptolepis*. Rev. Palaeobot. Palynol., 96: 71-79.

A new species of the voltzialean seed cone *Glyptolepis* is described from the Late Triassic of Germany. Specimens of *Glyptolepis richteri* sp.nov. are large (up to 14.0 cm long, 3.5 cm wide) and contain numerous small, helically arranged bract scale complexes. Each cone scale is composed of eight uniform lobes, each with an obtuse apex. The bract is fused to the long cone scale stalk and expands distally into a somewhat diamond-shaped laminar unit that completely covered the underlying cone scale. A reconsideration of other fossils assigned to *Glyptolepis* suggests that all except the type material of *Glyptolepis keuperiana* Schimper, are erroneously assigned to the genus. Although *Glyptolepis* is considered a key taxon in some concepts of conifer phylogeny, evidence is presented to suggest that most reconstructions of this genus are based on inaccurate interpretations of unrelated cones.

Bachmann, G.H. and Beutler, G., 1996. Fluviatile Zyklen im Schilfsandstein (Obere Trias) von Neinstedt am Harz. Hallesches Jb. Geowiss., B 18: 131-140.

An almost complete section is described of the approx. 50 m thick Schilfsandstein (Keuper, Upper Triassic) from outcrops near the village of Neinstedt north of the Harz Mountains. The Schilfsandstein (Stuttgart Formation) consists of three fluvial fining-upward cycles, each of which has channel sandstones at its base and silty floodplain deposits with strong pedogenic overprint at its top. The Schilfsandstein is interpreted as the early Transgressive System-Tract of Keuper-sequence 3 in the sense of Aigner and Bachmann (1992), and overlies one of the most pronounced sequence boundaries of the Germanic Triassic.

Bandel, K., 1996. Some heterostrophic gastropods from Triassic St. Cassian Formation with a discussion on the classification of the Allogastropoda. Paläont. Z., 70: 325-365.

Fifteen species of Heterostropha are described, 12 of them for the first time. All are newly interpreted with regard to their taxonomic relation to fossil and living gastropods. The Streptacidoidea with long Paleozoic history are represented in the Late Triassic an St. Cassian Formation by several *Ebala*, with smooth protoconch. Cassianebalidae by *Cassiane-*

bala and *Loxebala* with laterally ornamented protoconch. The Donaldinidae of St. Cassian are represented by one species of *Donaldina* and two of *Neodonaldina* that stand in the continuation of Paleozoic species of *Donaldina*. Architectonicoidae with shells coiled in a plane and Valvatoidea appear in the St. Cassian fauna without known Paleozoic relation. In the former superfamily the Architectonicoidae can be recognized in the genus *Rinaldoconchus* with two species. Cassianaxidae with *Cassianaxis,* Amphitomariidae with *Amphitomaria*, Stuoraxidae with *Stuoraxis* and *Ampezzogyra* have a sinistral protoconch and planispirally coiled dextral teleconchs. They all resemble different modern species that have similarly small shells. Modern Hyalogyrinidae have with *Alexogyra* a new representative from the Triassic. The Valvatoidea are represented with she genera *Carboninia* and *Bandellina* of the Cornirostridae in the Triassic representatives. The relation of described species in the system of the Heterostropha is discussed.

Barattolo, F. and Bigozzi, A., 1996. Dasycladaleans and depositional environments of the Upper Triassic-Liassic carbonate platform of the Gran Sasso (Central Apennines, Italy). Facies, 35: 163-208.

Sedimentological and paleontological studies carried out on the Upper Triassic Dolomia Principale and on the Lower Liassic Calcare Massiccio carbonate platform successions of the Gran Sasso area (Central Apennine, Italy) allowed to recognize several microfacies types arranged in three different types of high frequency cycles, subtidal, peritidal and diagenetic. The cycles can be attributed to high frequency sea level oscillations on a fifth and fourth order scale. Five algal assemblages have been identified: 1. *Gyroporella vesiculifera*, 2. *Griphoporella curvata*, 3. *Palaeodasycladus* spp., 4. *Palaeodasycladus* and *Thaumatoporella*, and 5. *Tersella genoti* and *Fanesella sokaci* assemblage. In this latter assemblage two new species (*Tersella genoti* n.sp. and *Fanesella sokaci* n.sp.) are described, both from Liassic beds. In the Dolomia Principale Formation two main depositional environments have been recognized: (a) a shelf lagoon facies characterized by subtidal and peritidal cycles dominated by the *Gyroporella vesiculifera* algal assemblage, and, (b) a backmargin facies marked by peritidal and diagenetic cycles in which the *Griphoporella curvata* algal assemblage is widespread. In the Late Triassic a shallow-water carbonate facies (from lagoonal to backmargin) extended in the western and southern parts of the Gran Sasso area.

Berra, F. and Jadoul, F., 1996. Norian serpulid and microbial bioconstructions: implications for the platform evolution in the Lombardy Basin (Southern Alps, Italy). Facies, 35: 143-162.

The development of peculiar margin facies and abundant talus breccias within the Dolomia Principale inner platform is commonly observed in the Lombardy Basin during the Norian. The organisms building these margins are mainly serpulids, benthic microbes, subordinate porostromata and other encrusting forms; typical margin organisms, as sponges or corals, are extremely rare or absent. The build ups form narrow rims along the borders of tectonic controlled intraplatform basins. Regional back stepping and progradation of the margin facies on the talus breccias produced by the erosion of the reef is commonly observed in the uppermost Dolomia Principale depositional system. Widespread occurrence of serpulids and microbial margins in middle late Norian times is indicative of stressed environmental conditions - fluctuation of salinity and temperature on the inner platform and in the intraplatform basins - controlled by palaeogeographic setting. Physical characteristics allowed the bloom of forms able to develop in a wide range of environmental conditions, such as serpulids. In the late Norian, major input of fine grained clastics is recorded; close to the Norian-Rhaetian boundary, carbonate ramps were regionally restored. Locally, small serpulid and microbial bioconstructions still persist in the lowermost part of the shaly

succession, even if they are less abundant with respect to the Dolomia Principale. Patch reefs generally do not build a platform margin, but represent isolated mounds within shaly deposits. These build ups occur on the edge of former structural highs; the communities survived the environmental change responsible for the siliciclastic input and locally managed to produce mounds during the deposition of the lower part of the upper depositional system (Riva di Solto Shale).

Bi, D., Guo P. and Qian M., 1996. Trace fossils from Triassic Qinglong Formation of Lower Yangzi Valley. Acta Palaeont. Sinica, 35: 714-728.

The Lower Triassic Qinglong Formation in the Lower Yangzi Valley consists mainly of thin-bedded and medium to thick-bedded limestone, with calcareous shale, marlite, etc. in the lower part, yielding abundant trace fossils, which at least include 37 ichnogenera, i.e., *Agrichnium, Arenicolites, Asteriacites, Asterichnus, Chondrites, Cochlichnus, Dendrotichnium, Didymoulichnus, Diplocraterion, Florichnus* (ichnogen. nov.), *Gordia, Gyrolithes, Helminthopsis, Hormosiroidea, Keckia, Kouphichnium, Laevicyclus, Lockeia, Megagrapton, Micatuba, Monocraterion, Monomorphichnus, Nodituba* (ichnogen. nov.), *Ophiomorpha, Palaeophycus, Pelecypodichnus, Phycodes, Planolites, Pteridichnites, Rhizocorallium, Rugicirichnus* (ichnogen. nov.), *Salebrichnus* (ichogen. nov.), *Scalarituba, Teichichnus, Thalassinoides, Treptichnus* and *Zoophycus* together with coprolites; among them, *Arenicolites, Chondrites, Monocraterion, Monomorphichnus, Palaeophycus, Pelecypodichnus, Phycodes, Planolites, Ophiamorpha* and *Thalassinoides* are common elements. This trace fossil assemblage is composed of horizontal and vertical burrows, and some crawling traces (including trails and tracks) as well as resting traces. Both abundance and diversity of the trace fossil assemblage are in a higher condition, with horizontal burrows being dominant and vertical burrows slightly increasing upwards. Based on analysis in combination with lithologic character and ethology of occurring body fossils it is believed that they should be formed and located in a shallow-water carbonate shelf depositional environment with lower to moderate energy, above storm wave base to lower part of intertidal zone mainly on soft to firm ground, under a normal condition of salinity and oxygen in the seawater, and also belong to the range of the *Cruziana* ichnofacies.

Bourquin, S. and Guillocheau, F., 1996. Keuper stratigraphic cycles in the Paris Basin and comparison with cycles in other Peritethyan basins (German Basin and Bresse-Jura Basin). Sediment. Geol., 105: 159-182.

High resolution sequence stratigraphy of the Keuper, Paris Basin, is used to establish correlations between the basin centre evaporite series and the basin margin clastics series. The high resolution correlations show stratigraphic cycle geometries. The Keuper consists of five minor base level cycles which occur in the upper portion of the Scythian-Carnian major base level cycle and the lower part of the Carnian-Liassic major base level cycle. The maximum relative rate of subsidence for the base level fall phase of the Scythian-Carnian major cycle occurs in the eastern part of the Paris Basin. During the base level rise phase of the Carnian-Liassic major cycle, the area of highest rate of subsidence shifted westwards and northwards. This shift records the first occurrence of an independent Paris Basin which was no longer merely the western margin of the German Basin. Two phases of tectonic movement influenced the distribution of the depocentres. The first is recorded in the 'Marnes irisées inférieures' deposits. Faulting controlled evaporite sedimentation and sequence geometries by creating areas of subsidence where halite could accumulate. The second, within the 'Marnes irisées supérieures', induced a general westward and northward tilt of the basin. Concurrent migration of depocentres to the west and north produced an intra-'Marnes irisées supérieures' truncation. Comparison of the stratigraphic records of the

Paris Basin and of other Triassic Peritethyan basins (German Basin, Bresse-Jura Basin and South-East Basin) reveals numerous similarities. The coastal onlap curve of the German Keuper exhibits many similarities with the sequence evolution of the Paris Basin. But the Triassic succession is more complete in the German Basin and more cycles are observed. The major difference between these two basins during the Keuper is that the 'Marnes irisées inférieures' minor base level cycle does not occur in the German Basin. In the Bresse-Jura Basin, the major difference concerns the Lettenkohle. One minor base level cycle is recorded in the Paris Basin while no cycle is observed in the Bresse-Jura Basin.

Brinkmann, W., 1996. A mixosaur (Reptilia, Ichthyosauria) with embryos from the Grenzbitumenzone (Middle Triassic) of Monte San Giorgio (Switzerland, Canton Ticino). Eclog. Geol. Helv., 89: 1321-1344.

In 1957, during the excavation at the site "Punkt 902", a partly articulated skeleton of an adult *Mixosaurus* slightly more than one meter long was discovered, along with numerous small bones of the same genus, which are laying inside and outside of the large individual, on the upper surface of a dolomitic slab from the upper part of the middle Grenzbitumenzone (late Anisian) of Monte San Giorgio (Canton Ticino). This find represents a pregnant female and at least three, approximately 40 cm long embryos. The young, whose skeletons are now mostly disarticulated, were arranged in the uteri in head presentation, that is, were birth to have taken place, they would have been born head first. A comparison of the size of the mother with that of the juveniles, and the high degree of postcranial ossification of the latter indicate a very advanced developmental stage for the embryos. Thus, the young were surely ready for birth or even already past term. Therefore it is proposed, that complications during birth led to the deaths of the embryos and their mother.

Bucur, I.I., Strutinski, C. and Paica, M., 1997. A new occurrence of Triassic deposits NE of Oravita (southern Carpathians, Rumania) and its paleotectonic significance. Geol. Carpathica, 48: 39-48.

Until recently, in the western part of the Southern Carpathians Triassic deposits were only known south of the Nera River between Sasca Montana and Moldova Noua, belonging to the Sasca Gornjak structural unit. Core analysis of a borehole drilled NE of Oravita (Bradisorul de Jos) led to the identification of a Triassic formation of the same type and age (Early-Middle Triassic) about 20 km further northerly than previously known. As in the Sasca Montana Moldova Noua area, the Triassic deposits are overlain by a Middle Jurassic sedimentary sequence, some tens of metres thick. The paper presents a biostratigraphical analysis of the foraminiferal assemblages that have been identified in the drill core, gives a brief description of the microfacies of the carbonate deposits encountered, and comments on the paleotectonic significance of the newly found Triassic occurrence.

Cairncross, B., Anderson, J.M. and Anderson, H.M., 1995. Palaeoecology of the Triassic Molteno Formation, Karoo Basin, South Africa; sedimentological and palaeontological evidence. South Afr. J. Geol., 98: 452-478.

A collaborative sedimentological/palaeontological investigation of the Late Triassic Molteno Formation reveals a close relationship between the palaeoecological interpretations based on the two disciplines. A series of 12 vertical profiles intersecting 16 taphocoenoses in the southern Molteno outcrop belt provided the basis for the study. Eleven lithofacies, from boulder conglomerates through a variety of sandstones to siltstones, mudstones, and coals, are described. Bedload (braided) fluvial systems deposited the bulk of the sediment, and three primary depositional environments are described: upward-fining coarse-grained channel-fill deposits; upward-coarsening crevasse-splay and sheetflood sequences, and

rhythmically laminated lacustrine and marsh shales deposited in the floodplain. These each include typical floral and faunal elements. The rich Molteno flora (204 vegetative species) and fauna (predominantly insects, with 333 species) can be classified into 7 primary co-associations occupying distinct habitats: *Dicroidium* riparian forest (types 1 and 2), *Dicroidium* woodland, *Sphenobaiera* woodland, *Heidiphyllum* thicket, *Equisetum* marsh, and fern/*Ginkgo-phytopsis* meadow. For the first time these are collectively described and illustrated in a series of block diagrams. Three regional palaeoenvironmental reconstructions of the Molteno depositional basin - (a) braidplain, (b) mixed-load meander channels, and (c) distal channels - depict the habitats and plant communities identified and show the envisaged sites of the described taphocoenoses. The braidplain environment accounted for the greater part of the Molteno deposits and fossil assemblages.

CATALANO, R., DISTEFANO, P., SULLI, A., and VITALE, F.P., 1996. Paleogeography and structure of the central Mediterranean: Sicily and its offshore area. Tectonophysics, 260: 291-323.

The geology of the mainland and offshore of Sicily is illustrated by a few geologic sections and seismic profiles across the late Cenozoic orogenic belt of central and western Sicily and across the Sardinia Channel and Sicily Straits. This bell is the result of several tectonic events. Deformation involved mainly the sedimentary cover of the old African continental margin characterized by a broad basinal domain, flanked along its external (southern) margin by a shallow water carbonate platform attached to Africa in the Triassic. Compressional deformation started in the more internal basinal rock assemblages overlying a thinned crust. The most important structural characteristic of the early phase of thrusting is the duplex pile forming the bulk of the chain in Central western Sicily. The structure consists of a basal allochthon, made up of Permian to Middle Triassic layers, an intermediate duplex wedge, composed of competent Mesozoic carbonates, and a roof complex, including Upper Mesozoic-Lower Tertiary less competent rocks. Large scale clockwise rotation of the thrusts accompanied transpressional movements in the hinterland during the Pliocene. Right oblique reverse faults modified the previous tectonic contacts between the allochthons in the hinterland zones. Contemporaneous south directed imbrications affected the southern external areas, progressively incorporating foreland and piggyback basins. Development of the Gela Thrust System appears to be linked to the transpressional event; its accretion is also related to contemporaneous underthrusting at deeper levels of Mesozoic carbonate substratum. The older buried thrust sheets were pushed up to the surface breaching the deformed Tertiary cover of the Gela Thrust System. Northwards in the belt post Messinian normal growth faults opened half graben whose sedimentary fill underwent structural inversion. Alternation of extension and compression tectonics characterizes the Sicilian continental margin in the last million years.

CHANNELL, J.E.T. and KOZUR, H.W., 1997. How many oceans: Meliata, Vardar, and Pindos oceans in Mesozoic Alpine paleogeography. Geology, 25: 183-186.

The timing of rifting and subduction in the Meliata, Vardar, and Pindos zones of the Hellenic Dinaric Carpathian region indicates that they cannot be considered remnants of a single ocean basin, in contrast to several recently published Mesozoic paleogeographies, Sea floor spreading in the Meliata zone culminated in Middle Triassic (Ladinian) time and ceased in the Late Triassic, and subduction occurred from this time until Late Jurassic closure, In contrast, sea floor spreading in the Vardar zone began in Early Jurassic time and culminated in the Middle Jurassic, and subduction occurred from latest Jurassic time, In the Pindos zone, sea floor spreading was initiated in the Early Triassic, with Late Jurassic and early Tertiary subduction.

Checa, A., Company, M., Sandoval, J. and Weitschat, W., 1996. Covariation of morphological characters in the Triassic ammonoid *Czekanowskites rieberi*. Lethaia, 29: 225-235.

The Triassic ammonoid *Czekanowskites rieberi* displays a covariation of morphological characters, which is rather common in ammonoids. Its morphological spectrum ranges from laterally compressed, involute, weakly ribbed forms to depressed, semiinvolute, strongly ribbed forms. In order to study this covariation, fifteen axially cut specimens have been analyzed by means of image analysis, which allows us to obtain the ontogenetic record of radii, area and perimeter of the individual whorl cross sections. A logarithmic model of growth has been applied. Our data indicate that, owing to the covariation, the radii from the origin to the venter and to the umbilical seam of a given whorl section vary inversely in order to maintain the relative position of the center of gravity of the whorl cross section both throughout the ontogeny of single specimens and within the population. This influences hydrostatic parameters, such as the position of the center of mass and the orientation and stability of the shell. Since the ontogenetic record of the angular length of the body chamber is not known, we have calculated those hydrostatic variables using two mutually exclusive assumptions: (1) the angular length of the body chamber was constant throughout ontogeny and (2) the volume of the body chamber grew monotonically with the revolution angle. Fluctuations of the three hydrostatic variables were always less important in the first assumption. In any case, the spectrum of, for example, theoretical orientations is comparable to those observed in the species of present day *Nautilus*. The range of adult body chamber length observed in *C. rieberi* is much narrower than the theoretical adult body chamber length calculated under the second assumption which indicates that a certain control over this parameter existed in the natural population, probably in order to maintain a narrow range in orientation and stability. The excess or deficit in soft body weight was probably compensated by inverse variations in shell wall weight. The main conclusion is that, despite the extreme morphological variability, hydrostatic and, possibly, hydrodynamic properties of the population remained within narrow limits.

Chun, H.Y., 1996. Paleofloristic assemblages through geological time in Korea. Chemosphere, 33: 1705-1735.

Paleofloristic assemblages show various different characteristic features through geological time in Korea. In Korea, paleofloristic assemblages can be separated into the Carbo-Permian Pyeongan flora, Triassic-Jurassic Daedong flora, Upper Jurassic Myogok flora, Cretaceous Gyeongsang flora and Tertiary geoflora. The Triassic-Early Jurassic Daedong flora is characterized by various gymnospermous plants. These assemblages indicate low/middle latitude with a swamp/lake lacustrine paleoenvironment according to composition. The Filicinae are the most characteristic elements in number of species and diversity. The ginkgoales and coniferales are the sub-dominant elements. These plants are accompanied by non-marine Crustacea (Estheictes) and this aspect also indicate a shallow lake environment.

Climaco, A. Boni, M., Iannace, A. and Zamparelli, V., 1997. Platform Margins, Microbial/Serpulids Bioconstructions and Slope-to-basin Sediments in the Upper Triassic of the 'Verbicaro Unit' (Lucania and Calabria, Southern Italy). Facies, 36: 37-56.

The Upper Triassic carbonates of the area comprised between Maratea (Lucania) and Praia a Mare (Calabria) have been studied. They have been grouped into six facies assemblages which, in turn, define two depositional systems: *(1)* a platform margin depositional system, comprising algae- bivalves- bearing dolomites (A 1), Megalodontid-bearing limestones and dolomites (A 2), dololutites and stromatolitic/bioclastic dolomites. (A 3); *(2)* a slope to basin depositional system comprising: buildup-facies, talus breccia and coarse to fine doloarenites

(B 1), coarse to fine doloarenites and dark laminated dololutites (B 2), dark laminated dololutites (B 3). The algal and bivalve dolomites represent typical peritidal platform sediments arranged in cyclical patterns formed as shoal barrier and back-reef deposits periodically emerged and deformed in tepee structures. The outer margin of the platform was colonised by peculiar bioconstructions dominated by microbialites and serpulids; little sponges occur less frequently, whereas rare corals have been found only in some turbiditic beds. Along the slope, in a distance that can be estimated in 5 or 6 km, the coarse breccias give way to coarse turbidites, then finer turbidites and finally to dark, organic-rich micrites. Most of the floatstone and associated turbidites imply a fault-controlled slope. The laminated texture and the high organic matter content of the latter facies quite obviously point to a basin with poorly oxygenated bottom waters. In the uppermost Triassic there is an indication of a regressive trend, evidenced by the progradation of the platform facies. At that time a back-reef area was characterised by Megalodontid prairies alternated to areas of sandy bioclastic transport. However, due to the poor biostratigraphic record and intense cataclasis, no definite evidence of a well-structured Rhaetian platform margin with buildups and related basinal sediments exists. These sedimentary and paleoecological features match well with those found in the intraplatform basins of the Dolomia Principale, as well as with other coeval facies in Southern Apennines, Central Apennines, Southern Alps and in Southern Spain. Altogether, this evidence suggests that in the Norian time both Southern Alps and Apennines experienced a very similar tectonic evolution and comparable paleoceanographic conditions, characterised by the formation of numerous intraplatform throughs with restricted circulation, the latter influencing the bottom conditions as well as the marginal communities. The margins of these restricted basins, differently from the typical Dachstein reefs of the Upper Triassic Tethys, were dominated by microbial-serpulid communities.

Crane, P.R., 1996. The fossil history of the Gnetales. Int. J. Plant Sci., 157: Suppl., S50-S57.

The fossil record of dispersed pollen documents that the extant genera *Ephedra*, *Welwitschia*, and *Gnetum* are the relictual extant remnants of a group of plants that was once more widespread and much more diverse. Unfortunately, macrofossils corresponding to these dispersed palynomorphs remain sparse, and only scattered information on other organs of fossil Gnetales are available. Late Triassic and Early Jurassic fossils provide the most radical additions to knowledge of morphological diversity among probable extinct Gnetales, but more detailed information is needed to reliably and accurately establish their systematic affinities. In the long term, detailed morphological data from such fossils will be crucial for understanding morphological homologies between the reproductive structures of Gnetales and those of other plants. However, in the short term, studies of well preserved material from Cretaceous mesofloras may be more informative. Among the recent results of such studies has been the identification of small dispersed seeds with ephedroid pollen in the micropyle, and increased knowledge of the plants that produced the widespread and distinctive Mesozoic pollen grains assigned to the genus *Eucommiidites*. These data indicate that *Eucommiidites*-producers (Erdtmanithecaceae) comprise an extinct clade with probable close affinities to the Gnetales.

Damiani, R.J. and Warren, A., 1996. A new look at members of the superfamily Brachyopoidea (Amphibia, Temnospondyli) from the Early Triassic of Queensland and a preliminary analysis of brachyopoid relationships. Alcheringa, 20: 277-300.

Two further finds of *Keratobrachyops australis* Warren (Amphibia, Temnospondyli, Chigutisauridae) from the Early Triassic Arcadia Formation of Queensland provide new information concerning skull characters not noted in the holotype. The holotype of

Xenobrachyops allos Howie (Amphibia, Temnospondyli, Brachyopidae) from the same locality is redescribed following the discovery of several features not previously noted. In addition, new but fragmentary brachyopoid material from the Arcadia and overlying Glenidal Formations provides information on derived character states within the superfamily. Controversy surrounds the correct familial composition of the superfamily Brachyopoidea, with the family Brachyopidae being allied by various authors with a diversity of other Triassic and Permian families. A cladistic analysis of a number of these families has been performed in an attempt to determine interfamilial relationships. Our results support a brachyopid chigutisaurid dichotomy within the Brachyopoidea, but also suggest the families Tupilakosauridae, Dvinosauridae and Saurerpetontidae are plesiomorphous members of the clade. Further analysis of genera within the superfamily shows that several brachyopid genera cannot be distinguished by cladistic means, indicating a need for revision of its members. Future analysis may support the erection of a new brachyopoid family for species of *Sinobrachyops* and *Xenobrachyops*.

Droser, M.L., Bottjer, D.J. and Sheehan, P.M., 1997. Evaluating the ecological architecture of major events in the Phanerozoic history of marine invertebrate life. Geology, 25: 167-170.

Paleoecological changes associated with Phanerozoic mass extinctions and radiations can be categorized into four non-hierarchical, non-additive levels. First level changes include colonization of a new ecosystem. Structural changes within an established ecosystem represent the second level, changes within an already established ecological structure are the third level, and taxonomic changes within a community represent the fourth level. Applying these levels to the Ordovician radiation, end Ordovician extinction and Silurian recovery, as well as the end Permian extinction and Triassic recovery, demonstrate that paleoecological changes associated with these major events can be evaluated and compared in a more rigorous manner than previously done. Results of this analysis demonstrate that use of these levels indicates that the relative magnitude of an event as measured by taxonomic criteria may be decoupled from its paleoecological significance.

Edel, J.B. and Duringer, P., 1997. The apparent polar wander path of the European plate in Upper Triassic-Lower Jurassic times and the Liassic intraplate fracturing of Pangaea: new palaeomagnetic constraints from NW-France and SW-Germany. Geophys. J. Int., 128: 331-344.

In order to constrain the European plate motions during Triassic Lower Jurassic times, new palaeomagnetic data were acquired from various Triassic Liassic sediments of northeastern France and southwestern Germany. A Carnian palaeopole 49° N/131° E, K = 193, α_{95} = 7°, N = 4 was obtained for Keuper marls with consistent directions of normal and reversed polarities. Rhaetian sandstones, also with both polarities, and Carnian dolomites with a magnetization of probable secondary origin, provide a mean pole 51° N/112° E, K = 109, A(95) = 6°, N = 6, more westerly than that given above. The Lower Hettangian, sampled in limestones of the Xeuilley quarry near Nancy shows a N-R-N polarity sequence with well defined anti-parallel directions. The mean Hettangian pole is 55° N/100° E, K = 123, α_{95} = 11°, N = 3. Induan sandstones from the northern Vosges show two distinct overprints, one consistent with the Ladinian Carnian magnetizations already observed in the same region, the second consistent with the recalculated mean Lower Jurassic pole of Europe. Five other sites with different rock types also exhibit late overprints with Lower Jurassic directions. The mean pole calculated from these overprints is 74° N/124° E, K = 125, α_{95} = 6°, N = 6. The revised apparent polar wander path (APWP) presented here shows that for the mid Permian to the earliest Jurassic the palaeopoles of Europe stayed around 50 degrees latitude, while the longitudes drifted from 185° E to 100° E. The previously established Upper Triassic-Lower Jurassic loop of the APWP is shifted westwards by about

25°. The revised APWP involves the following plate motions. After the late Alleghanian tectonic phase, which marked the end of the Variscan orogeny, central western Europe rotated counterclockwise during about 70 Myr, up to the earliest Jurassic. The south north drift in latitude by 35° (nearly 4000 km) remained regular from 320 to 205 Ma, with a constant rate of 3.4 cm/yr. Around 205 Ma, this motion ceased, probably because of a collision somewhere in the north of Eurasia. Then, in the Lower Liassic, the plate underwent a rapid counterclockwise rotation with a Eulerian pole located in northeastern Asia, synchronous with fracturing in the Atlantic and the Neotethys areas. It is proposed that the intraplate fracturing of Pangaea was initiated by the rapid change of the megacontinent motion at the end of the Trias.

D'Engelbronner, E.R., 1996. New palynological data from Karoo sediments, Mana Pools Basin, Northern Zimbabwe. J. Afr. Earth Sci., 23: 17-30.

The palynological associations of 16 Karoo samples, collected in the Mana Pools basin, Northern Zimbabwe, were studied, and four zonal assemblages can be recognized. Assemblage I (Kondo Pools Formation) is dominated by monosaccate pollen grains and diverse alete bisaccate pollen grains occur frequently. Important but rare marker genera include *Limitisporites*, *Vittatina* and *Weylandites*. These indicate a middle to late Early Permian age (e.g. late Sakmarian to early Artinskian). The palynological assemblage, derived from the Massive Sandstone Member, Angwa Sandstone Formation, is characterized by a small number of smooth and apiculate spores, but is lacking any age significant marker taxa. Assemblages II and III, both from the Alternations Member (Angwa Sandstone Formation), and Assemblage IV (Pebbly Arkose Formation) are dominated by alete bisaccate and multitaeniate pollen grains. The rare occurrence of *Vittatina*, *Weylandites lucifer* and *Guttulapollenites hannonicus* indicates a Late Permian to Early Triassic age for Assemblage II. Based on sedimentological data and literature, a preliminary age of Early Triassic (Induan) can be given. A range from latest Fassanian (Ladinian) to Lacian (Norian) for Assemblage III is indicated by the occurrence of *Asseretospora gyrata*, *Cadargasporites senectus*, *Eucommiidites*, *Infernopollenites*, *Minutosaccus crenulatus*, *Retisulcites perforatus* and *Samarapollenites speciosus*. Small amounts of *Asseretospora gyrata*, *Cadargasporites senectus*, *Cycadopites*, *Microcachryidites* and *Minutosaccus crenulatus* indicate a slightly larger age range for Assemblage IV (e.g., Carnian to Rhaetian).

Fauconnier, D., Courtinat, B., Gardin, S., Lachkar, G. and Rauscher, R., 1996. Biostratigraphy of Jurassic and Triassic successions in the Balazuc 1 borehole (GPF Programme): stratigraphic setting inferred from dinoflagellate cysts, pollen, spores and calcareous nannofossils. Mar. Petrol. Geol., 13: 707-724.

Biostratigraphic studies palynology (dinoflagellate cysts, spores, pollen) and calcareous nannofossils of core from the borehole Balazuc 1 (BA1) allowed the various formations intersected from the Lower Kimmeridgian Upper Oxfordian to the Toarcian to be dated. Within the studied interval in Balazuc 1 borehole, 34-1652 m, only ditch cuttings samples were available through the Upper and Middle Jurassic section (34-554 m), whereas conventional cores were studied from the Lower Jurassic and Triassic sections (556-1652 m). The beds were dated on dinoflagellate cysts and calcareous nannofossils for the Lower Kimmeridgian (34 m) to Lower Bajocian Aalenian (554 m). A hiatus was identified between the Lower Oxfordian and the Upper Callovian. The upper levels of the Liassic contain only a poor microflora, providing a Toarcian-Aalenian dating. The Rhaetian Hettangian boundary is characterized at 1347.50 m and the Triassic was identified in the 'Gres du Roubreau' (Anisian-Ladinian) and in the 'Argilites sulfatées supérieures anhydritiques' (Carnian).

Fensome, R.A., MacRae, R.A., Moldowan, J.M., Taylor, F.J.R. and Williams, G.L., 1996. The early Mesozoic radiation of dinoflagellates. Paleobiology, 22: 329-338.

Dinoflagellates are a major component of the marine microplankton and, from fossil evidence, appear to have been so for the past 200 million years. In contrast, the pre-Triassic record contains only equivocal occurrences of dinoflagellates, despite the fact that comparative ultrastructural and molecular phylogenetic evidence indicates a Precambrian origin for the lineage. Thus, it has often been assumed that the dearth of Paleozoic fossil dinoflagellates was due to a lack of preservation or recognition and that the relatively sudden appearance of dinoflagellates in the Mesozoic is an artifact of the record. However, new evidence from a detailed analysis of the fossil record and from the biogeochemical record indicates that dinoflagellates did indeed undergo a major evolutionary radiation in the early Mesozoic.

Filatova, N.I. and Vishnevskaya, V.S., 1997. Radiolarian stratigraphy and origin of the Mesozoic terranes of the continental framework of the Northwestern Pacific (Russia). Tectonophysics, 269: 131-150.

Tectonostratigraphic investigation shows that the Mesozoic (Triassic-Neocomian) allochthonous terranes of the Anadyr-Koryak accretionary region, from the northwestern continental framing of the Pacific Ocean, form isolated tectonic nappes and slices dispersed all over the region, rather than fragments undeformed paleostructures. Nappes and slices of different stratigraphic horizons, derived from various geodynamic and paleolatitudinal environments, have been tectonically amalgamated into the Anadyr-Koryak region. Furthermore, these tectonostratigraphic units are accompanied by slabs of Paleozoic sequences which were also accumulated in various different paleoenvironments. Correlations of the tectonically separated Mesozoic formations are based on the radiolarians, and geochemical and lithologic methods. The tectonostratigraphic units range from Middle Triassic to Hauterivian, and are tectonically arranged in various spatial patterns. Formations of several different geodynamic environments are recognized: oceanic (abyssal plain and MOR), island arcs and marginal basins. The radiolarian assemblages suggest that the Early Mesozoic formations were deposited at different paleolatitudes: Tethyan (Anisian-Sinemurian), North Tethyan and Boreal (Pliensbachian-early Bajocian), and in a vast zone from the Equator to South Boreal (late Bajocian Hauterivian). Early to late Mesozoic tectonic paleoenvironments spanned a width greater than 3000 km. This zone was later shortened to a width of 300 km. The development of nappes and slices of the Anadyr Koryak region, and the Koryak West Kamchatka orogenic belt on the whole, was due to several collisions near the Asian continental margin. The main collision event occurred in the interval 125-105 Ma.

Foote, M., 1996. Ecological controls on the evolutionary recovery of post-Paleozoic crinoids. Science, 274: 1492-1495.

Analysis of morphological characters of a global sample of post-Paleozoic crinoid echinoderms shows that this group underwent a rapid diversification after the extinction at the end of the Permian to reach maximal morphological disparity by the Late Triassic, which is essentially the same evolutionary pattern seen during the group's early Paleozoic radiation. The accelerated morphological diversification of a single class implies that, even if clades surviving from the Paleozoic represented ecological incumbents that hindered the origin of new higher taxa, species within individual higher taxa rapidly exploited available ecological opportunities in the Mesozoic.

Gaetani, M. and Balini, M., 1996. Palaeomagnetism of a Permian-Triassic sequence in Mangislak (Kazakhstan, Cis): Comment. C.R. Acad. Sci. Paris, Sér. II, 323: 1085-1086.

Gaetani, M., Lefort, P., Tanoli, S., Angiolini, L., Nicora, A., Sciunnach, D. and Khan, A., 1996. Reconnaissance geology in Upper Chitral, Baroghil and Karambar districts (northern Karakorum, Pakistan). Geol. Rundsch., 85: 683-704.

During the summer of 1992 a geological expedition crossed the northern Karakorum range in northern Pakistan, from the Chitral to Karambar valleys, from the villages of Mastuj to Imit. Some of the areas visited were geologically unknown. A number of structural units were crossed, belonging to the Karakorum block or to other crustal blocks north of it. They are: (a) the axial batholith, in which three plutonic bodies have been identified, and (b) the northern sedimentary belt (NSB), in which three major tectonostratigraphic units form thrust stacks dipping to the north. Their internal stratigraphy and structural style are partly different. The most complete contains a crystalline basement, transgressed by a marine succession during the Early Ordovician. The youngest strata are represented by the Reshun conglomerate, of inferred Cretaceous age. The northernmost unit of the NSB is tightly folded, whereas the central one forms a monocline. Vertical faults, mainly strike slip, dissect the thrusted slabs. Metamorphic deformation is absent or reaches only the anchizone in the studied sector of the Karakorum NSB. To the north of the Karakorum proper there are several other tectonic units, separated by vertical faults. They are, from south to north: (a) the Tas Kupruk zone, with metavolcanics of basaltic to latibasaltic composition; (b) the Atark unit, mostly consisting of massive carbonate rocks of Mesozoic age; and (c) the Wakhan slates which consist of a thick widespread succession of dark slates, metasiltites and sandstones. The fine grained elastic rocks are supposed to be Palaeozoic to Early Triassic in age. The Wakhan slates are intruded by plutons belonging to the East Hindu Kush batholith, from which a single K/Ar age on muscovite gave a Jurassic age.

Galton, P.M. and Walker, A.D., 1996. *Bromsgroveia* from the Middle Triassic of England, the earliest record of a poposaurid thecodontian reptile (Archosauria: Rauisuchia). N. Jb. Geol. Paläont. Abh., 201: 303-325.

The material of the earliest poposaurid rauisuchian, *Bromsgroveia walkeri*, is described from the Bromsgrove Sandstone Formation (Middle Triassic) of the central Midlands of England. The structure of the ilium is less derived than it is in *Lythrosuchus* and much less so than in *Poposaurus* (both Upper Triassic, southwestern USA). *Teratosaurus suevicus* is a rauisuchid on the basis of a referred ilium from the Middle Stubensandstein (Upper Triassic) of Stuttgart, Germany.

Gullo, M., 1996. Conodont biostratigraphy of uppermost Triassic deep-water calcilutites from Pizzo Mondello (Sicani Mountains): evidence for Rhaetian pelagites in Sicily. Palaeogeogr. Palaeoclimatol. Palaeoecol., 126: 309-323.

Rhaetian pelagites are described for the first time from Western Sicily in the Pizzo Mondello area (Sosio Valley, Sicani Mountains) where a thick pile of Upper Triassic cherty calcilutites outcrops. The Upper Triassic pelagic calcilutites of Pizzo Mondello are divided into three lithostratigraphic units. The lower unit consists of a few meters of dark grey marls and clay marlstones (equivalent to the Mufara Fm.) of Carnian age followed by Halobia bearing cherty limestones (about 300 m thick) of late Carnian-late Norian age. The upper unit consists of white calcilutites and grey greenish marls containing the conodonts *Misikella posthernsteini* and *Zieglericonus rhaeticus* of Rhaetian age. These Rhaetian deposits are here informally named as Portella Gebbia Limestone. In the Pizzo Mondello succession the Norian/Rhaetian boundary, sensu Kozur and Mock (1991), can be approximated along the

lowermost calcilutite bed of Portella Gebbia Limestone containing the first occurrence of *M. posthernsteini*.

Gower, D.J. and **Sennikov, A.G., 1996.** Morphology and phylogenetic informativeness of early archosaur braincases. Palaeontology, 39: 883-906.

The braincases of the Triassic early archosaurs *Vjushkovia triplicostata*, *Fugusuchus hejiapensis*, *Xilousuchus sapingensis*, and *Shansisuchus shansisuchus* are described in detail for the first time. A preliminary analysis investigating the phylogenetic informativeness of braincase morphology in the earliest archosaurs incorporates 11 archosauromorph taxa and 17 informative characters. A further seven uninformative and eight problematical braincase characters are discussed.

Grauvogel-Stamm, L. and **Kelber, K.-P., 1996.** Plant-insect interactions and coevolution during the Triassic in western Europe. Paleont. Lombarda, N.S., 5: 5-23.

A review of the Triassic plant-insect interactions of western Europe is presented with some new interpretations. Several new interactions are described and discussed. This study is based on the analysis and comparison of three Triassic ecosystems which are rich in both plant and insect remains: the Grès à Voltzia (Upper Buntsandstein) of the Vosges (France) which is early Anisian, the Lower Keuper of Franconia (Germany) and the Lettenkohle of Alsace (France) which are both Upper Ladinian. Four kinds of interactions could be identified: feeding traces on plants, relations between the laying of insect eggs and host plants, parasitic relationships of galls and other growth abnormalities as well as a new fossil example of mimicry. A comprehensive account of plant-aided insect reproductive processes is given for the first time, which greatly extends the variety of fossil plant-insect interactions previously reported. Among the numerous results, the oviposition habits of the Protodonata are demonstrated, showing that they inserted their eggs in the plant tissues like the present-day endophytic Odonata. The numerous traces of their eggs in the Ladinian horsetails of Franconia (Germany) suggest moreover that this group, which was particularly flourishing in Permo-Carboniferous times, was still well established in the Triassic. The discovery of mimetic Tettigoniidae (Orthoptera) wings having an angiosperm-like venation and a leopard-like colouring led us to inquire into their significance for the process of plant-insect co-evolution. On the other hand, the floristic change in the Ladinian, with the emergence of the Cycadopsida, and the simultaneous appearance of numerous feeding traces on these new plants are evidence in favour of such a process. All these observations illustrate the dynamics of the Triassic ecosystems.

Groecke, D.R., Faure, K., De Wit, M.J. and **Willis, J.P., 1996.** Late Permian global coal hiatus linked to ^{13}C-depleted CO_2 flux into the atmosphere during the final consolidation of Pangea; discussion and reply. Geology, 24: 473-474.

Hallam, A., 1996. Recovery of the marine fauna in Europe after the end-Triassic and early Toarcian mass extinctions. In: Hart, M.B. (ed.), Biotic recovery from mass extinction events. Geol. Soc. Spec. Publ., 102: 231-236.

Hancox, P.J. and **Rubidge, B.S., 1996.** The first specimen of the Mid-Triassic dicynodont *Angonisaurus* from the Karoo of South Africa: implications for the dating and biostratigraphy of the Cynognathus Assemblage Zone, Upper Beaufort Group. S. Afr. J. Earth Sci., 92: 391-392.

The rocks of the Karoo Supergroup of South Africa are world renowned for their wealth of fossils, particularly mammal like reptiles. A newly discovered specimen of a dicynodont mammal like reptile from the uppermost part of the *Cynognathus* Assemblage Zone is

assigned to the East African genus *Angonisaurus*. The discovery of this form in the *Cynognathus* Assemblage Zone has important implications for the biostratigraphy of the zone as well as for relative age determinations based on biostratigraphic correlations.

Hauschke, N. and Wilde, V., 1996. Fazies und Fossilführung im Unterrhät des Fuchsberges bei Seinstedt (nördliches Harzvorland, Niedersachsen). Hallesches Jb. Geowiss., B 18: 141-152.

A taphocoenosis from the Lower Rhaetian of the Fuchsberg near Seinstedt (Lower Saxony, Germany) is composed of xiphosurids, small arthropods (conchostracans, malacostracans, insects), fish remains and different parts of a conifer, *Hirmerella* cf. *muensteri*. The fossiliferous strata are described in detail and discussed with regard to facies interpretation. These strata represent the deposits of a permanent stagnant water-body with episodic input of clastic material. Marine influence is indicated by scales of coelacanthid crossopterygians. Life was impossible for most of the time at the bottom of the water-body, and sometimes also higher up in the water column. Details of the depositional environment are still unclear, but there are striking similarities to some of the fossiliferous horizons within the Alsatian Lower Triassic fluvial-deltaic Voltzia Sandstone.

Heckert, A.B., Hunt, A.P. and Lucas, S.G., 1996. Redescription of *Redondasuchus reseri*, a Late Triassic aetosaur (Reptilia, Archosauria) from New Mexico (USA), and the biochronology and phylogeny of aetosaurs. Geobios., 29: 619-632.

The Late Triassic (Rhaetian) aetosaur *Redondasuchus reseri* from the Redonda Formation of eastern New Mexico, U.S.A. is distinguished from all other aetosaurs except *Typothorax* by its paramedian scutes with ventral keels, and from *Typothorax*: by its paramedian scutes with discontinuous ventral keels. *Redondasuchus* can be further distinguished from other aetosaurs by its paramedian scutes in which the lateral third is flexed downward approximately 45°. It is the only Rhaetian aetosaur currently known from the United States and is an index taxon for the Apachean land vertebrate faunachron. A cladistic analysis of the aetosaurs, utilizing both characters derived from armor and other skeletal information, indicates that two distinct grades of aetosaurs exist. There is a basal grade consisting of the paraphyletic assemblage of Aetosaurus and (*Stagonolepis* + Aetosauroides), and an advanced grade consisting of the clade Neoaetosauroides + *Redondasuchus* + [(*Longosuchus* + *Desmatosuchus*) + (*Paratypothorax* + *Typothorax*)]. Integration of the existing aetosaur biochronology with operating cladistic definitions of aetosaur taxa produces a useful biostratigraphy of Upper Triassic strata in the western United States.

Herbert, C., 1997. Sequence stratigraphic analysis of Early and Middle Triassic alluvial and estuarine facies in the Sydney Basin, Australia. Austr. J. Earth Sci., 44: 125-143.

Early to Middle Triassic sediments of the Sydney Basin (up to 1350 m thick) have hitherto been regarded as an alluvial and lacustrine succession unaffected by sea-level induced base-level changes. Here it is proposed that the dominantly alluvial sediments were deposited on an alluvial plain which graded seawards to an estuarine coastal plain. Hence, the succession had hydrological connection with the sea and, therefore, deposition may have been controlled by changes in relative sea-level. A sequence stratigraphic framework, established in the downstream alluvial plain/coastal plain transition, can be carried landward to varying degrees, even to the basin margins. The intercalation of lowstand, coarse-grained alluvial-plain sediments with transgressive and highstand fine-grained, coastal-plain sediments was influenced by high-frequency, 4th-order changes in relative sea-level which were responsible for the overall depositional character of the succession. These cycles constitute seven 3rd-order sequences. During a low-frequency, 2nd-order highstand in the Early Triassic, dominantly fine-grained coastal plain sediments were deposited, whereas during a lowstand

in the Middle Triassic, dominantly coarse-grained alluvial-plain sediments were deposited. Interbedded alluvial and estuarine sediments were deposited in the more rapidly subsiding northeastern and central parts of the basin. Landwards, in the direction of slower subsidence towards the western basin margin, shaly coastal plain intervals thinned to zero and coarse-grained alluvial-plain sediments amalgamated vertically to form thick sandstone successions. Alluvial-plain sediments are characterised by upward-fining fluvial sandstones which intercalate seawards with grey, green, and red floodplain/estuarine shales. Further seawards these sediments grade to finer grained sandstones and multicoloured shales in upwardcoarsening estuarine bayhead deltas and central bay facies. Extensive redbed deposition, considered to indicate oligotrophy, commenced during the second 3rd-order sequence above the Permian/Triassic boundary, continued during the deposition of three sequences, and finished at the end of the Early Triassic.

Herbst, R., 1996. New species of *Gleichenites* (Gleicheniaceae, Filicales) from the Upper Triassic of Argentina and Chile. Palaeobotanist, 43: 67-72.

Two new and one undetermined species of *Gleichenites* are described from the Upper Triassic Canadon Largo Formation (El Tranquilo Group) from Santa Cruz Province, Argentina, the Upper Triassic La Ternera Formation, Copiapo Province, northern Chile, and the Upper Triassic Gomero-Talcamávida Member of the Concepcion area in southern Chile. These findings together with former ones of Argentina, Australia and eventually Antarctica, reinforce the idea of a possible austral origin of the family Gleicheniaceae, or at least part of it. All the Triassic and part of the Jurassic hitherto known species from the Gondwana realm are multisorate and thus belong to the primitive members of the family included in the subgenus *Diplopterygium* in Holttum's sense.

Huang, K.N. and Opdyke, N.D., 1996. Severe remagnetization revealed from Triassic platform carbonates near Guiyang, southwest China. Earth. Planet. Sci. Lett., 143: 49-61.

An intensive paleomagnetic investigation has been conducted on the Middle and Lower Triassic platform carbonates near Guiyang, Southwest China in the hope of refining a Middle Triassic paleomagnetic pole previously reported from the region. Instead, severe late Cretaceous to Recent remagnetizations have been revealed from all the three rock formations studied, In all cases, the in situ characteristic remanent magnetization (ChRM) directions resemble or fall close to the local present day Earth's magnetic field direction and fail the fold test, despite the presence of dual polarity in two formations, The major magnetic carriers of the remagnetizations are hematite and magnetite. The cause(s) for the remagnetization events cannot be ascertained at present, but weathering in recent time and migrating fluid in the past might be responsible. It is suggested that caution should be exercised when investigating platform carbonate rocks which are prone to late remagnetization.

Huang, K.N. and Opdyke, N.D., 1996. Paleomagnetism of Middle Triassic redbeds from Hubei and northwestern Hunan Provinces, South China. Earth. Planet. Sci. Lett., 143: 63-79.

Paleomagnetic investigations have been conducted on redbeds from the Middle Triassic Badong Formation at Badong, Hubei and Sangzhi, Hunan as well as from the coeval Puxi Formation from Puxi, southeastern Hubei province, South China. The characteristic remanent magnetization (ChRM) determined from Badong and Sangzhi passes the fold test with dual polarity. The tilt corrected ChRM direction from Puxi is congruent with those from Badong and Sangzhi but is based on a smaller number of samples collected from a monocline. These ChRM directions are believed to be primary. The data indicates that Badong has been rotated clockwise by 13.5 ± 8.5° relative to Sangzhi, which, in turn, has

possibly been rotated in the same sense with respect to other parts of the Yangtze Block except eastern Sichuan based on the bend of the sampled fold axis and the Lower Triassic paleomagnetic data published for the Yangtze Block. The Lower and Middle Triassic paleomagnetic data together appear to indicate that eastern Sichuan and the border area between Sichuan, Guizhou, Hubei and Hunan provinces have been affected by differential rotations, probably due to oroclinal bending. The paleomagnetic data obtained from this study further constrain the timing of the final suturing of the YB with the North China Block to be post-Middle Triassic.

Isaksen, G.H., 1996. Organic geochemistry and geohistory of the Triassic succession of Bjornøya, Barents Sea. Org. Geochemistry, 24: 333-349.

Jenkins, F.A., Gatesy, S.M., Shubin, N.H. and Amaral, W.W., 1997. Haramiyids and Triassic mammalian evolution. Nature, 385: 715-718.

Isolated teeth referred to the family Haramiyidae are among the earliest known fossil evidence of mammals. First discovered in European Late Triassic deposits a century and a half ago, haramiyids have been interpreted as related to multituberculates, a diverse and widespread lineage that occupied a rodent like niche from the Late Jurassic to the early Tertiary. Nonetheless, haramiyid relationships have remained enigmatic because the orientation and position of the teeth in the upper or lower jaw could not be determined with certainty; even their mammalian status has been questioned. The discovery of haramiyid dentaries, a maxilla and other skeletal remains in the Upper Triassic of East Greenland reveals haramiyids as highly specialized mammals with a novel pattern of puncture crushing occlusion that differs dramatically from the grinding or shearing mechanisms of other Early Mesozoic mammals.

Johns, M.J., 1996. Diagnostic pedicle features of Middle and Late Triassic elasmobranch scales from northeastern British Columbia, Canada. Micropaleontology, 42: 335-350.

Description and illustration of diagnostic pedicle features play an important role in the identification of elasmobranch scales from the Triassic of northeastern British Columbia. Two main types of scale pedicle are recognized, truncate and tetrahedroid. Morphological changes in the scales including pedicle type, pedicle base and margins, and subcrown ornamentation are observed across the Carnian-Norian boundary. The most useful features of Middle and Late Triassic elasmobranch scales from northeastern British Columbia are described, illustrated, and organized into a hierarchy with divisions of part, supergroup, group, and subgroup. A key which can be used to determine scale subgroup is provided.

Jordan, R.W. and Chamberlain, A.H.L., 1997. Biodiversity among haptophyte algae. Biodiversity and Conservation, 6: 131-152.

The division Haptophyta is represented only by about 300 extant species showing wide diversity in morphology, biochemistry and ecology. They have a world wide distribution and are numerically important in phytoplankton populations in nearly all marine environments. Evidence from the geological record shows that they have been the major constituent of calcareous deposits since the Late Triassic and, as they have evolved quickly through time, their coccoliths have always shown wide morphological diversity. In today's oceans they occasionally produce extensive blooms, visible by satellite imagery, which have ecological impact. As a consequence of these blooms the haptophyte algae are now receiving greater attention, as their role in the global sulphur and carbon cycles may influence the world's climate, and their potential as nuisance bloom algae have implications for commercial fishing and the marine ecosystem. As it is likely that these organisms have always

produced such blooms, these effects may have been in operation for the last 200 million years.

Kamo, S.L., Czamanske, G.K. and Krogh, T.E., 1996. A minimum U-Pb age for Siberian flood basalt volcanism. Geochim. Cosmochim. Acta, 60: 3505-3511.

Establishing an accurate and precise age for Siberian flood basalt volcanism is of great importance in evaluating causes for the unequaled mass extinction of flora and fauna at the Permian-Triassic boundary. We report a new, minimum U-Pb age obtained from zircon and baddeleyite from the mineralized Noril'sk I intrusion that cuts the lower third of this rapidly deposited, 3500 m thick volcanic sequence near Noril'sk. This 251.2 ± 0.3 (2σ) Ma age is within analytical error of the SHRIMP U-Pb age for zircon from the Permian Triassic boundary at Meishan, South China [251.1 ± 3.6 Ma (2σ)], and confirms Siberian basaltic volcanism as a possible contributor to the mass extinction.

Kent, D.V. and Clemmensen, L.B., 1996. Paleomagnetism and cycle stratigraphy of the Triassic Fleming Fjord and Gipsdalen formations of East Greenland. Bull. Geol. Soc. Denmark, 42: 121-136.

A 210 m section of Late Triassic Fleming Fjord Formation (the Malmros Klint Member and the lowermost 80 m of the overlying Carlsberg Fjord beds of the Ørsted Dal Member) in the Tait Bjerg area of the Jameson Land Basin, East Greenland, was sampled for paleomagnetic study and measured for cycle stratigraphic analysis. Paleomagnetic samples were also taken from the underlying Gipsdalen Formation in the Gipsdalen area. A high stability characteristic magnetization carried by hematite was successfully isolated in 63 sampling levels in the Fleming Fjord Formation and nine sampling sites in the Gipsdalen Formation using progressive thermal demagnetization. The mean characteristic directions for the Fleming Fjord and the Gipsdalen Formations may be biased by sedimentary inclination error but are consistent with a northward drift of East Greenland of about 10° from the arid (ca. 25° N) to semihumid (ca. 35° N) paleoclimatic belts in the Middle to Late Triassic. Seven normal and reversed polarity intervals are clearly delineated in the Fleming Fjord Formation section. A preferred correlation of the magnetostratigraphy to a cyclostratigraphically calibrated reference polarity sequence recently derived from drill cores in the Newark Basin of eastern North America suggests that the sampled interval represents about a 3.5 m.y. interval of the late Norian. The Malmros Klint Member and the overlying Carlsberg Fjord beds have composite sedimentary cycles that vary in thickness from 25 m to about I m and seem to match Milankovitch orbital climatic cyclicity with periods of ~400 ky, ~100 ky, ~40 ky, and ~20 ky. The composition and thickness ratio of the cycles suggest that the measured section of the Malmros Klint Member and the Carlsberg Fjord beds represents lacustrine accumulation over about 4 m.y., a duration consistent with the magnetostratigraphic correlations.

Kent, D.V. and Olsen, P.E., 1997. Paleomagnetism of Upper Triassic continental sedimentary rocks from the Dan River-Danville Rift Basin (eastern North America). Geol. Soc. Amer. Bull., 109: 366-377.

A magnetic polarity stratigraphy and a corresponding paleomagnetic pole position are reported from 113 sampling sites representing 3000 m of Upper Triassic continental sedimentary rocks that crop out in the Dan River Danville basin of North Carolina and Virginia. Characteristic magnetizations isolated by thermal demagnetization for either the hematite bearing red siltstones or the interbedded magnetite bearing gray to black mudstones of the Leakesville Formation are indistinguishable in mean direction and pass reversal tests. The magnetic polarity sequence consists of 11 magnetozones that vary from

approximate to 100 m to 800 m in thickness and can be uniquely correlated within biostratigraphic constraints to magnetochrons E9n to E14n of the Newark geomagnetic polarity time scale. According to this correlation, the sampled section is the age equivalent of the uppermost Stockton, the entire Lockatong, and the lowermost Passaic formations of the Newark basin, and represents approximate to 7.5 my of deposition. The late Carnian Dan River Danville paleopole is located at 55.4° N 100.1° E (α_{95} = 1.9°), which is not significantly different from paleopoles reported from essentially coeval rocks in the Newark basin. Considering that the Dan River Danville and Newark basins are approximate to 600 km apart, the close agreement of the coeval paleopoles argues strongly for the overall tectonic coherence of these rift basins with respect to each other and, most probably, with respect to cratonic North America. Discordant latest Triassic paleopoles from the southwestern United States, which have tended to be attributed to fast apparent polar wander for North America in the Late Triassic and predict anomalously high paleolatitudes for eastern North America, are best accounted for by a large net clockwise rotation of the Colorado Plateau.

Kerr, R.A., 1996. Extinctions: a shocking view of the Permo-Triassic. Science, 274: 1080.

Khalifa, M.A., 1995. Stratigraphy and facies history of Upper Permian-Lower Triassic rocks in Northeast Africa, East Africa and Arabia. In: Dardir, A.A. (Ed.), Thirty years of international cooperation on the geology of Egypt and related sciences; an International conference on The studies and achievements on geosciences in Egypt. Spec. Publ. Geol. Surv. Egypt. 69: 55-82.

Klets, T.V., 1996. First discovery of conodonts from Upper Triassic deposits of Kotelnyi Island. Strat. Geol. Corr., 4: 613-615.

Koike, T., 1994. Skeletal apparatus and its evolutionary trends in a Triassic conodont *Ellisonia dinodoides* (Tatge) from the Taho Limestone, southwest Japan. Trans. Proc. Palaeont. Soc. Japan, N.S., No. 173: 366-383.

A Triassic conodont *Ellisonia dinodoides* (Tatge) from pelagic carbonate rocks of the Taho Limestone in Ehime Prefecture, Southwest Japan is reconstructed as a quadrimembrate apparatus with the M, Sa, Sb and Sc elements. The elements represent well marked evolutionary trends in the length of the processes during the Smithian to Norian. The anterior or anterolateral and posterior processes of the elements decrease in total length from the Smithian to Anisian but seem to keep the size distribution constantly until the Norian. The inferred ratio of the M, Sa, Sb, and Sc elements is 2:1:2:6 in the Smithian to Anisian. The Sa element, however, is very rare or absent in the Norian. The correlation coefficient between the number of the denticles on the processes and the size of the processes varies from 0.09 to 0.75 and does not represent any evolutionary trends during the Triassic. The decrease in size of the processses during the Triassic seems a common phenomenon in long-ranged ramiform conodonts.

Koike, T., 1996. The first occurrence of Griesbachian conodonts in Japan. Trans. Proc. Palaeont. Soc. Japan, N.S., 181: 337-346.

The Lower Triassic Griesbachian conodonts, *Hindeodus parvus* (Kozur and Pjatakova) and *Isarcicella isarcica* (Huckriede), occur in partly dolomitized dark grey carbonaceous pelagic limestones in Southwest Japan, i.e. the Taho Formation in Tahokamigumi, Shirokawa-cho, Higashiuwa-gun, Ehime Prefecture and the Kamura Formation in Kamura, Takachiho-cho, Nishiusuki-gun, Miyazaki Prefecture. The Griesbachian carbonate rock of the Taho Formation is underlain conformably by light grey dolomitic limestone including the Permian

fusullinid *Staffella* sp. The carbonate rock of the Kamura Formation is also underlain conformably by dolostone of the Upper Permian Mitai Formation. This is the first confirmation of the Griesbachian in Japan.

Koike, T., 1996. Skeletal apparatuses of Triassic conodonts of *Cornudina*. Prof. H. Igo Commem. Vol., pp. 113-120.

Small-sized Triassic conodonts referred to the form genus *Cornudina* from pelagic limestone of the Taho Formation in Ehime Prefecture, Southwest Japan are reconstructed as a unimembrate or bimembrate apparatus. *Cornudina breviramulis* (Tatge) is a bimebrate apparatus with the Pa and Pb elements. *Cornudina igoi* sp.nov. is a unimembrate apparatus with the Pa element. The Pa and Pb elements of *Cornudine breviramulis* represent evolutionary trends of decrease in total length of the antero-posterior processes and decrease in number of the denticies during the Spathian to Norian.

Kolar-Jurkovšek, T. and Juryovšek, B., 1996. Contribution to the knowledge of the Lower Triassic conodont fauna in Slovenia. Razprave IV. Razreda SAZU, 37: 3-21.

From the Lower Triassic beds in the Iška and Draga valleys, central Slovenia following conodonts are mentioned and illustrated. *Ellisonia* sp., *Foliella gardenae* (Staesche) (two morphotypes), *Hadrodontina* sp., *Pachycladina obliqua* Staesche and *Parachirognathus ethingtoni* Clark. This conodont fauna is Smithian in age.

Kozur, H.W., 1996. The systematic position of *Pseudoertlispongus* Lahm (Radiolaria) and description of some new Middle Triassic and Liassic radiolarian taxa. Geol. Paläont. Mitt. Innsbruck, Sonderband 4, pp. 287-299.

Pseudortlispongus Lahm is a transitional form between *Paroertlispongus* Kozur & Mostler and *Oertlispongus* Dumitricā, Kozur & Mostler. *Paroertlispongus*, *Pseudoertlispongus* and *Oertlispongus* appeared in successive order at the base of the lower Anisian *Paroertlispongus diacanthus* Zone, at the base of the upper Subzone *Yeharaia annulata* Subzone) of the uppermost Anisian *Spongosilicarmiger transitus* Zone and at the base of the lower Ladinian *Spongosilicarmiger italicus* Zone (= base of *Reitziites reitzi* Zone s.str.). One new genus, seven new species and one new subspecies of Middle Triassic radiolarians and the Liassic genus *Liassobetracchium* n.gen. are described.

Kozur, H. and Mostler, H., 1996. Longobardian (late Ladinian) Muelleritortiidae (Radiolaria) from the Republic of Bosnia-Hercegowina. Geol.-Paläont. Mitt. Innsbruck, Sonderband 4, pp. 83-103.

Muelleritortiidae are common in radiolarian faunas of the Longobardian *Budurovignathus mungoensis* conodont zone from the locality Varoški Creek near Fojnica south of Sarajevo. *Muelleritortis,* among them the Longobardian index species *M. cochleata* (Nakaseko & Nishimura), clearly dominate over *Pentatortis* and primitive *Tritortis species*. 10 new species and subspecies are described.

Kozur, H. and Mostler, H., 1996. Longobardian (late Ladinian) Oertlispongidae (Radiolaria) from the Republic of Bosnia-Hercegovina and the stratigraphic value of advanced Oertlispongidae. Geol. Paläont. Mitt. Innsbruck, Sonderband 4, pp. 105-193.

A very rich radiolarian fauna was found in a limestone with the conodont *Budurovignathus mungoensis* (Diebel) at the locality Varoški Creek, 2 km W of Fojnica(south of Sarajevo, Republic of Bosnia-Hercegovina). This radiolarian fauna is characteristic of the lower part of the upper subzone *(Spongoserrula fluegeli* Subzone) of the *Muelleritortis cochleata* Zone and indicates an early late Longobardian age. The stratigraphically important Oertlispongidae of

this fauna are described in the present paper. For comparison, some Oertlispongidae are described from the lower and middle Subzone of the *M. cochleata* Zone of the Southern Alps and from the Cordevolian of Sicily. 84 oertlispongid species and subspecies, 69 of which are new, have been found in the *Muelleritortis cochleata-* and *Tritortis kretaensis* zones (middle Longobardian to Cordevolian) of the Tethys.

Kozur, H.W., Kaya, O. and Mostler, H., 1996. First evidence of lower to middle Scythian (Dienerian-lower Olenekian) radiolarians from the Karakaya Zone of northwestern Turkey. Geol. Paläont. Mitt. Innsbruck, Sonderband 4, pp. 271-285.

Stigmosphaerostylus turkensis n.sp., a new entactinarian radiolarian species, is described from Dienerian to lower Smithian (lower to lower middle Scythian) limestones from the Karakaya Zone of northwestern Turkey. It is the oldest known Triassic radiolarian species. The nearly complete disappearance of radiolaria at the Permian-Triassic boundary and the development of the Lower Triassic radiolarian faunas is discussed. Nassellaria have obviously evolved during the Spathian (upper Scythian) from spicular Entactinaria without shell, but also many shell-bearing Triassic Entactinaria evolved during that time from spicular Entactinaria. The radiolarians and conodonts are accompanied by the oldest siliceous sponge spicule fauna of the Triassic. As the radiolarian fauna, only a very monotonous fauna with pentactine and very rare hexactine spicules (Hexactinellida, Lyssakida) is present that can be regarded as a pioneer fauna belonging probably only to one species.

Kumar, P., 1996. Permo-Triassic palynofossils and depositional environment in Satpura basin. Geophytology 25: 47-54.

Permo-Triassic deposits known as Bijori and Pachmarhi Formations in Satpura basin are well exposed in the Tamia scarp at Tamia in Chhindwara district, M.P. The argillaceous facies of Bijoris are unconformably overlain by the arenaceous Pachmarhi Sandstones. The carbonaceous shales of Bijoris contain rich striated - disaccates e.g., *Striatopodocarpites, Faunipollenites* with *Densipollenites* and *Crescentipollenites* and a few taeniate forms *Corisaccites, Guttulapollenites, Lunatisporites,* etc. (Palynoassemblage-A), whereas the khaki-olive (buff-coloured) day bands of Pachmarhis possess rich non-striated disaccates: *Falcisporites, Satsangisaccites* with *Nidipollenites, Alisporites, Klausipollenites, Chordasporites*, etc., as well as polysaccate *Goubinispora, Trochosporites* and appearance of cingulate forms *Playfordiaspora, Lundbladispora* (Palynoassemblage-B). The presence of *Staurosaccites* and *Brachysaccus* is a noteworthy feature of the assemblage. Palynoassemblage-A of Bijoris at TamiaGhat Road is comparable with the Late Permian palynoassemblages of Damodar (Raniganj Fm),Son (Nidpur beds), Godavari (Kamthis), Satpura (Sukh-Tawa section) and Nagpur (Kamthis - Palynozones - 1 & 2). Palynoassemblage - B of Pachmarhis in the same section of Tanmia closely compares with the Early Triassic (Scythian) palynoassemblages of Son (Nidpur beds), Rajmahal (Palynoassemblage-A of Dubrajpur Fm), Damodar (Panchet Fm), Kamthi coalfield (Palynozone-3). Sediments (argillaceous) of Bijori Formation exposed at Tamia indicate a Permo-Triassic influence having a warm humid climate, deposited under swampy conditions with gradual drying up of the basin. The arenaceous Pachmarhi Formation was deposited as a huge sand bank having warm, semi-arid climate and prolonged seasonal droughts.

Li, S.G., Sun, W.D., Zhang, G.W., Chen, J.Y. and Yang, Y.C., 1996. Chronology and geochemistry of metavolcanic rocks from Heigouxia Valley in the Mian Lue tectonic zone, South Qinling: evidence for a Paleozoic oceanic basin and its close time. Science in China, Ser. D, Earth Sci., 39: 300-310.

The metavolcanic rocks of greenschist facies developed at Heigouxia Valley in the Mian Lue tectonic zone, South Qinling orogenic belt is a bimodal volcanic series. It is composed of K-poor, Na-rich tholeiite and dacite-rhyolite. The trace elements characteristics with flat REE pattern of these tholeiites are similar to those of MORB. The Sm-Nd whole rock isochron age of (242 ± 21) Ma and Rb-Sr whole rock isochron age of (221 ± 13) Ma of this metavolcanic series consistently indicate their metamorphic time. Their relatively high initial epsilon(Nd) value of +6.1 at the metamorphic age (242 Ma) suggest that the volcanic rocks were derived from a depleted MORB type mantle source. Their trace elements and Nd isotope compositions suggest an oceanic basin developed from a rift on the continental margin of the Yangtze Block during the late Paleozoic and closed in the Triassic. This is the first case clearly showing the existence of relict of late Paleozoic oceanic crust in East Qinling belt, which provides important evidence for the Mian Lue tectonic zone as a structure zone.

Lucas, S.G. and Harris, S.K., 1996. Taxonomic and biochronological significance of specimens of the Triassic dicynodont *Dinodontosaurus* Romer 1943 in the Tübingen collection. Paläont. Z., 70: 603-622.

Two species of the dicynodont *Dinodontosaurus* from the Middle Triassic interval of the Santa Maria Formation in Rio Grande do Sul, southern Brazil, *D. teller* (Von Huene 1935) and *D. turpior* (Von Huene 1935), are based on undiagnostic lectotypes and thus are *nomina dubia.* The oldest valid, available name for a species of *Dinodontosaurus* is *D. oliveirai* Romer 1943, the type species of the genus. (The unused senior subjective synonym *Dinodontosaurus pedroanum* Caldas, 1936 has been suppressed by the ICZN. *Chanaria platyceps* Cox 1968 and *Dinodontosaurus brevirostris* Cox 1968 are junior subjective synonyms of *D. oliveirai* Romer 1943. *Dinodontosaurus* thus is a monospecific genus known from the Santa Maria Formation and the Ischichuca (= Chañares) Formation of northwestern Argentina. This dicynodont and associated tetrapods characterize the Chanarian land-vertebrate faunachron, which is of Middle Triassic age, probably Ladinian.

Lucas, S.G. and Heckert, A.B., 1996. Stratigraphy and correlation of Triassic strata around the Nacimiento and Jemez uplifts, northern New Mexico. New Mexico Geol. Soc. Guidebook, 47th Field Conf., Jemez Mountains Region, 1996, pp. 199-204.

Triassic strata exposed along the flanks of the Nacimiento and Jemez uplifts (Sandoval County, northern New Mexico) belong to the Middle Triassic Moenkopi Formation (Anton Chico Member) and the Upper Triassic Chinle Group (Agua Zarca, Salitral, Poleo, and Petrified Forest Formations). The Moenkopi Formation (strata previously assigned by most workers to the Permian Bernal Formation) is as much as 39 m thick and mostly greyish red sandstone, siltstone, mudstone, and intraformational conglomerate. It disconformably overlies the Permian Glorieta Sandstone and is disconformably overlain by the Agua Zarca Formation. The Agua Zarea is as much as 61 m thick and mostly white to brown, trough-crossbedded, quartzose sandstone and siliceous conglomerate. The overlying Salitral Formation is as much as 102 m thick and mostly purplish, smectitic mudstone. The Poleo Formation disconformably overlies the Salitral and is as much as 41 m thick and mostly greyish yellow, trough-crossbedded litharenite, subarkose and intrabasinal and siliceous conglomerate. Above the Poleo, the Petrified Forest Formation is as much as 340 m thick and dominated by reddish brown, smectitic mudstone. South of San Miguel Canyon (T19, RIW), the Poleo Formation essentially pinches out, though thin (< 20 m), lenticular equivalents of the Poleo are locally present as far southeast as Vallecito Creek (T16N, R2E). Furthermore, throughout Sandoval County, the lower portion of the mudstone-dominated interval above the Agua Zarca Formation, even where the Poleo Formation is absent, is

dominated by purplish mudstone characteristic of the Salitral Formation. Therefore, to the south of San Miguel Canyon the Salitral and Poleo Formations can be recognized locally, but the thick, mudstone-dominated section above the Agua Zarea is assigned to the Petrified Forest Formation. The Correo Sandstone Bed crops out as a bench-forming sandstone up to 15 m thick at the top of the Petrified Forest Formation along the southern flank of the Nacimiento uplift. Fossil vertebrates indicate the Petrified Forest Formation ranges in age from Adamanian to Revueltian (latest Carnian-Norian) and support lithostratigraphic correlation of the Triassic strata exposed in Sandoval County to nearby Triassic outcrops in the Chama basin, Lucero uplift, and Hagan basin.

Lucas, S.G. and Heckert, A.B., 1996. Vertebrate biochronology of the Late Triassic of Arizona. Fossils of Arizona - 4: Proc. 1996, SW Paleont. Soc. and Mesa SW Museum, Mesa, pp. 63-81.

Upper Triassic stratigraphic units of the Chinle Group in northern Arizona produce four temporally distinct vertebrate fossil assemblages. The Chinle Group stratigraphic succession includes the basal "mottled strata" and Shinarump Formation, which are overlain by the highly fossiliferous Bluewater Creek Formation and its lateral equivalents, the Mesa Redondo and Cameron Formations, which are in turn conformably overlain by the Blue Mesa Member of the Petrified Forest Formation. The Sonsela Member rests disconformably on the Blue Mesa Member throughout Arizona, and is conformably overlain by the Painted Desert Member of the Petrified Forest Formation. The Owl Rock Formation conformably overlies the Painted Desert Member in Arizona and is disconformably overlain by the Rock Point Formation. The Chinle Group is capped by a variety of younger deposits, principally Jurassic eolianites or the Pliocene Bidahochi Formation. The oldest Late Triassic tetrapod from Arizona is a single fossil of an amphibian from the Shinarump Formation, which is considered Otischalkian (early late Carnian: Tuvalian) elsewhere in the American Southwest. An early Adamanian (latest Carnian) vertebrate fossil assemblage is known from the Bluewater Creek Formation near St. Johns, and the type Adamanian vertebrate fossil assemblage is found in the younger Blue Mesa Member in the Petrified Forest National Park. An early Revueltian (early-mid Norian) vertebrate fossil assemblage is known from the Painted Desert Member in the Petrified Forest National Park. A later Revueltian vertebrate fossil assemblage has been collected from the Owl Rock Formation. The Late Triassic vertebrate record of Arizona provides data fundamental to biochronological organization of the Late Triassic vertebrate record and therefore to understanding vertebrate evolution during the Late Triassic.

Lucas, S.G., Heckert, A.B. and Hunt, A.P., 1997. Stratigraphy and biochronological significance of the Late Triassic *Placerias* quarry, eastern Arizona (U.S.A.). N. Jb. Geol. Paläont., Abh., 203: 23-46.

The combined faunas of the *Placerias* and Downs' quarries, near St. Johns in Apache County represent one of the richest Late Triassic nonmarine fossil localities in the world. The authors document their stratigraphic position, placing both near the base of the Bluewater Creek Formation in the lowermost portion of the Chinle Group. Only a skull fragment of the phytosaur *Paleorhinus* sp., suggests that the base of the Bluewater Creek Formation is of Otischalkian (late Carnian: Tuvalian) age, whereas most of the remainder of the fauna, particularly the aetosaur *Stagonolepis* and the phytosaur Rutiodon, suggest an Adamanian (latest Carnian: Tuvalian) age. We compare the type fauna of the Otischalkian and Adamanian land-vertebrate faunachrons, including the fauna of the *Placerias* and Downs' quarries, and thereby revise and expand earlier definitions of both faunachrons.

Mariotti, N. and **Pignatti, J.S., 1995.** *Claviatractites*, a new xiphoteuthinid cephalopod from the Upper Triassic of Timor. Palaeopelagos, 5: 45-52.

After a revision of the type material, *Atractites claviger* Billow, 1915, a Late Triassic xiphoteuthidid coleoid from Timor, is removed from *Atractites*. In *Atractites* there is no ventral furrow, the waist is narrower, and the phragmocone does not penetrate below the waist. Because of its unique combination of characters, A. *claviger* is designated as type species of *Claviatractites* gen. nov.; the new genus is as yet monotypic. *Claviatractites* differs from *Delphinoteuthis Mariotti* & Pignatti, 1993 in possessing a well-developed ventral furrow and an almost symmetrical profile.

Marsicano, C.A., 1996. *Otuminisaurus limensis* Rusconi, 1948: a problematic teminospondyl amphibian from the Triassic of Argentina. J. Vertebr. Paleont., 16: 785-786.

The validity of several nominal taxa referred to the Temnospondyli, and based on materials from the Triassic of Argentina, was examined by the author in a review of the Chigutisauridae (Marsicano, 1993). One of these taxa is *Otuminisaurus limensis*, originally proposed by Rusconi (1948, 1951) for a skull fragment, including the mandible. The holotype also included several "flat bones" considered to belong to the pectoral girdle by Rusconi (1948), although they were neither described nor figured. The specimen was collected in the Triassic Cacheuta Formation (Carnian-Norian) in the NW of Cerro Bayo, W of Mendoza City, West Central Argentina. It was originally housed in the Museo de Ciencias Naturales y Antropologicas (MCNA), Mendoza City, as MCNA 2500. The new taxon was at first tentatively included in the family Archegosauridae by Rusconi (1948), without justification. However, in a subsequent discussion, Rusconi (1951) recognized it as a lydekkerinid due to the shape of the skull and the number of teeth. These characters were also used by Rusconi to place *O. limensis* in a different family; a family into which he placed most of the temnospondyl taxa he described from the same area (Rusconi, 1951, 1955). Subsequently, some authors have discussed the validity of all the taxa proposed by Rusconi (Reig, 1962; Bonaparte, 1973, 1975, 1978) and they have considered *O. limensis* to be a junior synonym of the previously described brachyopoid *Pelorocephalus mendozensis* (Cabrera, 1944; Marsicano, 1993). As the holotype of *O. limensis* has been lost, a description of the material based on the works by Rusconi (1948, 1951) is provided. Moreover, the taxonomic status of the species and the characters used to justify its familiar assignation are discussed.

Martinez, R.N. and **Forster, C.A., 1996.** The skull of *Probelsodon sanjuanensis*, sp.nov, from the Late Triassic Ischigualasto Formation of Argentina. J. Vertebr. Paleont., 16: 285-291.

A new species of *Probelesodon*, *P. sanjuanensis*, from the Late Triassic (middle Carnian) Ischigualasto Formation of Argentina is described Diagnostic characters include: six postcanine teeth, highly arched zygomatic arch, well developed squamosal subangular articulation, very deep dentary with a strong posteroventral angle, and widely separated postorbitals. *Probelesodon* is also united as a monophyletic taxon. The presence of *Probelesodon* in the Ischigualasto Formation significantly extends the range of this genus From the Ladinian (Chanares Formation) into the middle Carnian.

Martinez, R.N., May, C.L. and **Forster, C.A., 1996.** A new carnivorous cynodont from the Ischigualasto Formation (Late Triassic, Argentina), with comments on eucynodont phylogeny. J. Vertebr. Paleont., 16: 271-284.

The nearly complete skull of a recently discovered carnivorous eucynodont, *Ecteninion lunensis*, gen. et sp. nov., is described. This is the first new genus of carnivorous cynodont reported from the Late Triassic (middle Carnian) Ischigualasto Formation of northwestern

Argentina, and is unique to the formation. Diagnostic features include partially differentiated cheek teeth that overlap in an imbricate pattern, elongate braincase and parietal crest, pronounced lateral expansion of the braincase, sagittal crest that overhangs the occipital plate in dorsal view, gracile postorbital bars, short osseous secondary palate, maxilla excluded from the border of the subtemporal fenestra, palatine and orbitosphenoid that contribute to the medial orbital wall, post temporal foramen enclosed within the tabular, squamosals that nearly meet at the posterior end of the sagittal crest, narrow and deep groove for the external auditory meatus, jaw articulation located at the anterior base of the zygomatic arches, and cavum epiptericum extensively floored by the prootic. A phylogenetic analysis of the Eucynodontia, using craniodental characters, places *Ecteninion lunensis* in a trichotomy with *Probainoganthus* and a monophyletic clade consisting of Tritylodontidae, Tritheledontidae, and *Morganucodon*.

Martini, R., Peybernes, B., Zaninetti, L. and Frechengues, M., 1996. Discovery of foraminifera within the transgressive systems tracts of two Anisian depositional sequences from Weser Basin (Hesse, Northern Germany). Geobios, 29: 505-511.

Three levels including Anisian (probably Pelsonian) benthonic Foraminifera [*Hoyenella* gr. *sinensis* (Ho), *Pilamminella grandis* (Salaj), *Pilammina* aff. *densa* Pantic, etc.] have been identified in the transgressive systems tracts of two depositional sequences (Muschelkalk) of the Weser Basin (Diemel Valley section). The correlation between microfaunal distribution and sequence stratigraphy is discussed. Our study shows that levels containing abundant microfaunas are only located within the transgressive systems tracts (TST) of the sequences, independently of the stratigraphic interval. Thus, the major foraminiferal diversity appears to be related to a sea level rise with results, for the Weser Basin during the Muschelkalk, in the development of a carbonate platform facies.

Medina, F. and Errami, A., 1996. L'inversion tectonique dans le bassin triasique de Tine Mellil (Haut Atlas occidental, Maroc). Implications sur le fonctionnement de la Faille du Tizi n'Test. Gaia, 12: 9-18.

The Tine Mellil basin is an isolated outcrop of Triassic formations located along the Tizi n'Test Fault Zone. Deposition is mainly of fluvial type at the base of the series, and lagoonal at the top. In spite of their reduced thickness, the six formations observed are similar to those defined in Argana and Ourika areas. The structural evolution of the basin consists of two stages: (1) a Triassic-early Liassic extension oriented N-S to NNW-SSE, with local permutations of $\sigma 3$ and $\sigma 2$, which produced ENE-WSW trending faults, and (2) a post-Eocene inversion due to a NNW-SSE trending compression. The absence of strike-slip motion along the ENE- to E-W striking fault planes, and in particular along the Tizi n'Test and Tine Mellil faults, questions the nature of the motion along the Tizi n'Test Fault Zone, classically admitted to be a strike-slip fault. The structural pattern is that of a pop-up related to the reactivation of a northward-dipping detachment plane.

Metcalfe, I., 1996. Gondwanaland dispersion, Asian accretion and evolution of Eastern Tethys. Austr. J. Earth Sci., 43: 605-623.

Most east and southeast Asian continental blocks, comprising North and South China, Indochina (including the Qamdo-Simao Block), Tarim (including the Kunlun and Ala Shan Terranes), Qaidam, Sibumasu, Qiangtang, Lhasa, Kurosegawa, Northwest and Southeast Hainan, West Burma and Woyla Terranes, had their origins on the northern margin of Gondwanaland. Phanerozoic evolution of ea:stern Gondwanaland and Tethys involved the successive rifting and separation of three continental slivers (now recognised as collages of terranes) from northern Gondwanaland, their northwards drift, and amalgamation/ accretion

to form east and southeast Asia, These continental slivers separated from the margin of Gondwanaland in the Late Devonian (North China, South China, Indochina, Qaidam, Tarim and Hainan Island Terranes), early Mid-Permian (the Cimmerian continent including the Sibumasu and Qiangtang Terranes), and Late Triassic-Late Jurassic (Lhasa, West Burma and Woyla Terranes). The northwards drift of these terranes was accompanied by the opening and closing of three successive oceans, the Palaeo-Tethys, Meso-Tethys and Ceno-Tethys. Assembly of Gondwanaland derived Asian terranes began with the amalgamation of South China and Indochina during the Early Carboniferous along the Song Ma Suture to form 'Cathaysialand'. Cathaysialand and North China formed large continental regions at low northern/equatorial latitudes within the Palaeo Tethys during the Late Carboniferous and Permian. The Tarim, Kunlun, Qaidam and Ala Shan Terranes accreted to Kazakstan/Siberia in the Permian. Separation and northward drifting of the Cimmerian continent from northeast Gondwanaland in the late Early Permian was accompanied by the opening of the Meso-Tethys. This was followed by the suturing of Sibumasu and Qiangtang to Cathaysialand in the Late Permian-Early Triassic, largely closing the Palaeo Tethys. North and South China amalgamated in the Permian Triassic and accreted to Laurasia in the Late Triassic-Early Jurassic. The Lhasa, West Burma and Woyla Terranes separated from northwest Australian Gondwanaland during the Late Triassic to Early Cretaceous as the Ceno-Tethys opened and the Meso-Tethys was destroyed by subduction beneath Eurasia. These terranes accreted to proto-southeast Asia in the Early to Late Cretaceous.

Molina-Garza, R.S. and Geissman, J.W., 1996. Timing of deformation and accretion of the Antimonio Terrane, Sonora, from paleomagnetic data. Geology, 12 24: 1131-1134.

At present, few paleomagnetic data exist to test tectonic models that link northern Mexico with the evolution of the southern Cordillera of North America. We present new paleomagnetic data for the Antimonio terrane in northwest Mexico. A moderateinclination, dual-polarity yet secondary magnetization in Triassic-Jurassic strata of the Antimonio Formation and a primary remanence in Cretaceous igneous rocks (combined result: D = 338.9°, I = 57.4°; α_{95} = 5.6°, k = 34.8; N = 20 sites) are interpreted to indicate stability of the Antimonio terrane with respect to the craton since the Late Cretaceous. A more important result, however, is a shallow-inclination, dual-polarity magnetization in Antimonio Formation strata that fails a fold test (D = 186.7°, , I = -28.4°; ; α_{95} = 7.6°, k = 28.2; N = 14 sites). We interpret the shallow-inclination magnetization as a secondary remanence acquired during accretion of the Antimonio terrane to the North American margin in the Middle or Late Jurassic, or during deformation within an essentially autochthonous Jurassic continental arc. Paleogeography and structure of the central Mediterranean; Sicily and its offshore area.

Mortimer, N. and Smale, D., 1996. Petrology of the Topfer Formation: first Triassic Gondwana sequence from New Zealand. Austr. J. Earth Sci., 43: 467-477.

The 2 km^2 outcrop of Topfer Formation is the only known sedimentary formation of Triassic age in New Zealand's Western Province. It consists mainly of uniform medium grained massive, well sorted felsic volcaniclastic sandstone with minor mudstone, conglomerate and coal. Two distinct petrofacies are distinguishable on both detrital and diagenetic composition. On the basis of common framework modes, heavy mineral assemblages, depositional environment, intrusion by Jurassic dolerite and association with Palaeozoic quartzose sandstone, we relate the Topfer Formation to the Middle to Late Triassic Gondwana sequences of the Sydney Basin, Tasmania and Antarctica. Some similarities in composition of sandstones and igneous conglomerate clasts of the Topfer Formation and those of the coeval Murihiku Terrane of New Zealand's Eastern Province suggest a common

continental magmatic are source area (possibly the intervening Median Tectonic Zone). The tiny area of Topfer Formation thus provides a key stratigraphic and palaeogeographic link between Gondwana and the Eastern Province terranes of New Zealand.

Morton, A.C., Claoué-Long, J.C. and Berge, C., 1996. Shrimp constraints on sediment provenance and transport history in the Mesozoic Statfjord Formation, North Sea. J. Geol. Soc., 153: 915-929.

Detrital zircons in sandstones of the Statfjord Formation (late Triassic early Jurassic) in the northern North Sea have been dated with the sensitive high resolution ion microprobe (SHRIMP). These sandstones lack detailed biostratigraphic control, but display distinct variations in heavy mineral assemblages which facilitate a three fold subdivision of the sequence. The lower and middle zones (heavy mineral Zones A and B) have similar characteristics, both displaying a marked upward decline in garnet abundance which has proved difficult to attribute unambiguously to change in either provenance or sedimentation history. The base of the highest zone (heavy mineral Zone C) is marked by changes in several heavy mineral indicators attributable to a shift in ultimate provenance compared with the underlying zones. The detrital zircon ages are a direct fingerprint of the sediment source terrains, and so resolve ambiguities in interpreting provenance from heavy mineral abundances alone. The age spectra indicate that both low garnet and high garnet parts of Zone A have the same ultimate provenance. This strongly suggests that garnet removal was not a function of changing provenance, but took place during the sedimentation process, probably by weathering during periods of prolonged alluvial storage. The source of Zone A is not represented in any presently exposed landmass: the required combination of Caledonian granitoids intruding or in immediate proximity to high grade Archaean-sourced metasediments is likely to have been either to the west, in the northern part of the Shetland Platform, or to the north, in what is now the Norwegian Sea. Zircons in Zone C have a distinctly different age spectrum consistent with a source in the Western Gneiss Region of southern Scandinavia, where there is the required combination of Proterozoic protoliths and Caledonian reworking.

Motani, R., 1996. Redescription of the dental features of an Early Triassic ichthyosaur, *Utatsusaurus hataii*. J. Vertebr. Paleont., 16: 396-402.

Utatsusaurus hataii is represented by exceptionally well preserved material for an Early Triassic ichthyosaur, but the preparation was incomplete at the time of the original description. Preparation of the holotype reveals new information concerning dental features. A principal diagnostic character of *U. hataii* is its isodont dentition, originally described as comprising very slender, needle sharp teeth set in distinct alveoli. That description was based largely on an equivocal radiograph of a poorly prepared referred specimen, whose specific assignation to *U. hataii* is not well established. The teeth of the holotype are shown to be robust, with blunt points, and are set in a dental groove, not as previously described.

Muttoni, G., Kent, D.V., Brack, P., Nicora, A. and Balini, M., 1997. Middle Triassic magnetostratigraphy and biostratigraphy from the Dolomites and Greece. Earth Planet. Sci. Lett., 146: 107-120.

Magnetostratigraphic and biostratigraphic data across the Anisian/Ladinian (Middle Triassic) boundary were obtained from the Frötschbach/Seceda section from the Dolomites region of northern Italy, and the Vlichos section from the Greek island of Hydra, where the Aghia Triada published section was also resampled. The Frötschbach/ Seceda section includes two radiometrically dated (U-Pb) tuff levels and covers two of the three chief candidates for the position of the base of the Ladinian, namely at the base of the *Secedensis* Zone or the

subsequent *Curionii* Zone. The Aghia Triada section yields biochronological evidence for the base of the *Secedensis* Zone, whose significance is, however, critically discussed in the light of the magnetostratigraphic correlation with Frötschbach/Seceda. The Vlichos section can be correlated with Aghia Triada and Frötschbach/Seceda by means of magnetic polarity stratigraphy and sparse fossil occurrences. The satisfactory correlation of the magnetozones allows us to construct a composite geomagnetic polarity sequence tied to Tethyan ammonoid and conodont biostratigraphy for about a 2.4 Myr interval across the Anisian/Ladinian boundary.

Muttoni, G., Kent, K.V., Meço, S., Nicora, A., Gaetani, M, Balini, M., Germani, D. and Rettori, R., 1996. Magnetobiostratigraphy of the Spathian to Anisian (Lower to Middle Triassic) Kcira Section, Albania. Geophys. J. Int., 127: 503-514.

Magnetobiostratigraphic data are presented from three Early/Middle Triassic Han Bulog Limestone successions from Kcira, northern Albania. A total of 206 standard palaeomagnetic samples were obtained for thermal demagnetization and statistical analysis from the 42, 10 and 5 m thick sections. The reversal bearing characteristic component, carried by haematite and magnetite, defines a composite sequence of six main polarity intervals (Kc1n to Kc3r) in which are embedded four short polarity intervals, one at the base of Kc1n and three towards the top of Kc1r. The early acquisition of the characteristic remanence is supported by the lateral correlation of magnetozones between sections. The Early/Middle Triassic boundary, approximated by the first occurrence of the conodont *Chiosella timorensis*, falls close to the Kc1r/Kc2n polarity transition. This is in good agreement with recently published magnetobiostratigraphic data from the coeval Chios (Greece) sections. The palaeomagnetic pole calculated from the Kcira characteristic directions lies close to the Triassic portion of the apparent polar wander path for Laurussia (in European coordinates). However, a 40-45° clockwise rotation of the external zone of the Albano Hellenic Belt to the south of the Scutari Pec Line is thought to have occurred since the Early-Middle Miocene. The Kcira pole acquires a West Gondwana affinity when restored for the Neogene clockwise rotation. If the clockwise rotation was entirely related to Neogene tectonics, the Kcira area was evidently associated with West Gondwana and located at 12-16° N of the western Tethys margin.

Nel, A., Papier, F., Grauvogel-Stamm, L. and Gall, J.-C., 1996. *Voltzialestes triasicus* gen.nov., sp.nov., le premier Odonata Protozygoptera du Trias inférieur des Vosges (France). Paleont. Lombarda, N.S., 5: 25-36.

Voltzialestes triasicus gen.nov., sp.nov. is the first true Odonata Protozygoptera from the Grès à Voltzia (Upper Buntsandstein) of the Vosges (France). Its systematic and phylogenetic position is discussed after a redefinition of the Protozygopteran venation structures. The nearest genus is *Triassolestodes* Pritykina, 1981, another Triassic genus with uncertain affinities. The phylogenetic relationships of the Protozygoptera are poorly understood, in spite of a tentative cladistic analysis.

Ochev, V.G., 1996. On the peculiarities of the Early Triassic ecosystems of South Africa and the Fore-Urals. Paleont. Zhurn., 30: 730-732.

Differences between the contemporaneous tetrapod faunas of the Fore-Urals and South Africa are discussed. They are related to climatic factors governing the evolution of respective terrestrial ecosystems.

Papier, F., Nel, A. and Grauvogel-Stamm, L., 1996. Deux nouveaux insectes Mecopteroidea du Buntsandstein supérieur (Trias) des Vosges (France). Paleont. Lombarda, N.S., 5: 37-45.

Two new representatives of the Mecopteroidea have been identified in the Grès à Voltzia (Upper Buntsandstein) of the Vosges (France): *Pseudopolycentropus triasicus* n.sp. (Pseudopolycentropidae Handlirsch, 1925) and *Prochoristella pilosa* n.sp. (Mesopanorpodidae Tillyard, 1918b). *P. triasicus* n.sp. is the only species of the genus known from the Triassic and, according to Willmann (1989), it could be a representative of the stem-group of the Antliophora. *Pro. pilosa* n.sp. is the only species known from the northern hemisphere and, according to Willmann (1989), it should be classified among the Mecoptera. Two other representatives of the Mecopteroidea have already been described from the Grès à Voltzia of the Vosges *(France): Grauvogelia arzvilleriana* (Krzeminski et al., 1994), which is the oldest known true Diptera, and *Laurentiptera gallica* (Laurentiaux & Grauvogel, 1953) which probably belongs to the stem-group of the Diptera. The Mecopteroidea of the Grès à Voltzia represent a co-occurrence of archaic representatives and more advanced ones.

Papier, F., Nel, A. and Grauvogel-Stamm, L., 1996. Nouveaux Blattodea du Buntsandstein supérieur (Trias) des Vosges, France. Paleont. Lombarda, N.S., 5: 47-60.

Two new genera *Blattodea* fore wings, *Transitoblatta reticulata* n.gen., n.sp. and *Scleroblatta densa* n.gen. n.sp., are described from the Grès à Voltzia (Upper Buntsandstein) of the Northern Vosges (France). *Transitoblatta* n.gen., which is characterized by Palaeozoic and Mesozoic features, can be considered as a transition form. *Scleroblatta* n.gen. differs from the others species of Blattodea by a strong, dark, and probably sclerous costal vein and vena dividens. The study of the hind wings shows that they probably belong to the genus *Voltziablatta* (Papier & Grauvogel-Stamm 1995). However their interest is limited as they are incomplete and do not show their folding. Associated with the numerous and diverse isolated wings, some entire cockroaches, larve, moults and diverse disjointed body remains (thorax, abdomens, legs) have also been found. Their description and some palaeoecological comments close our study of the Blattodea from the Grès à Voltzia of the Vosges (France).

Pares, J.M., Van der Voo, R. and Stamatakos, J., 1996. Palaeomagnetism of Permian and Triassic red beds of NW-Spain and implications for the tectonic evolution of the Asturian-Cantabrian Arc. Geophys. J. Int., 126: 893-901.

A palaeomagnetic study of Permo-Triassic cover rocks in the Asturian Cantabrian Arc has revealed characteristic magnetizations in 136 samples from 14 sites, yielding a mean palaeopole for each of the three regions studied (Cabo de Penas, Villaviciosa, and Tudanca). Previous work on remagnetized Palaeozoic formations in the area revealed Permian (or younger) tightening of the Arc on the basis of palaeomagnetic declinations that show relative rotations of more than 100°. According to the new palaeopoles obtained in this study, these rotations are not present to any comparable extent in the Permo-Triassic deposits, allowing us to conclude that the bulk of the rotations in the Arc is Permian in age.

Paull, R.K., Campbell, J.D. and Coombs, D.A., 1996. New information on the age and thermal history of a probable Early Triassic siltstone near Kaka Point, South Island, New Zealand. New Zealand J. Geol. Geophys., 39: 581-584.

The conodont *Neospathodus homeri* s.l. supports a late Early Triassic, Malakovian, age for an ammonoid rich horizon in the Potiki Siltstone, 0.9 km south of Kaka Point, southeast Otago, rather than an alternative designation of Early to Middle Anisian. The conodont colour alteration index suggests a thermal history with temperature not exceeding c. 80°C. The Kaka Point structural belt appears to have had a tectonic and thermal history different from that of the adjacent Murihiku Terrane.

Phipps, C.J. and Taylor, T.N., 1996. Mixed arbuscular mycorrhizae from the Triassic of Antarctica. Mycologia, 88: 707-714.

Arbuscular mycorrhizae are the most ubiquitous of mycorrhizal fungi, that have formed mutualistic relationships with virtually almost all major groups of vascular plants. Five genera of arbuscular endomycorrhizal fungi are currently delineated, but fossil arbuscular mycorrhizae have been allied with only two, *Glomus* and *Sclerocystis*. A Triassic arbuscular mycorrhiza described inhabiting the roots of *Antarcticycas* was originally allied with *Glomus*. It is now known to be a mixed colony comprised of fungi attributable to the suborders Glomineae and Gigasporineae of the Glomales, described as two new species. The fossil Gigasporinean mycorrhiza is characterized by irregularly swollen intercellular and intracellular hyphae that are coiled extensively within the cells. Arbuscules have thick trunks and narrow branches. In the Glominean form, hyphal diameter is more uniform, with coiling rarely present. Arbuscules have thin trunks and fine branches. Vesicles may be lateral or terminal. Spores are not present; therefore, the probability of more than one species of each suborder being represented cannot be conclusively demonstrated. This provides the first fossil representative of the Gigasporineae and supports current rDNA estimates of the age of the lineage. Moreover, it is the first reported instance of a mixed colony of arbuscular endomycorrhizae in the fossil record.

Racey, A., Love, M.A., Canham, A.C., Goodall, J.G.S., Polachan, S. and Jones, P.D., 1996. Stratigraphy and reservoir potential of the Mesozoic Khorat Group, NE Thailand; Part 1, Stratigraphy and sedimentary evolution. J. Petrol. Geol., 19: 5-39.

Ramovš, A., 1996. Oberfassanische (mitteltriassische) Conodonten aus Kalken südlich von Slugovo, Südslowenien. Geologija, 37, 38: 141-151.

Rather blackish platy limestones from an abondoned quarry south of Slugovo along the road from Cajnarke to Lovranovo, southern Slovenia contain an interesting conodont fauna of the *Budurovignathus truempyi* Assemblage Zone. *Budorovignathus lipoldi* n.sp., *Neogondolella slugovensis* n.sp. and *Paragondolella ?trammeri* (Kozur 1972) are described. Similar conodont-bearing limestones were thus far unknown from this area.

Repin, Y.S., 1996. New Late Triassic Bivalves from Iran and a Taxonomy of the Superfamily Spondylacea. Paleont. Zhurn., 30: 363-369.

The Superfamily Spondylacea is revised. Two new genera *Persia* and *Primahinnites*, one subgenus *Inoperna (Triasoperna)* and four new species *Persia monstrosa*, *Prospondylus? stocklini*, *Primahinnites iranica* and *Inoperna (Triasoperna) prima* are described from the Upper Triassic of Central Iran.

Retallack, G.J., 1996. Early Triassic therapsid footprints from the Sydney Basin, Australia. Alcheringa, 20: 301-314.

A large rock slab collected in 1913 from the roof of the Bellambi Colliery in the southern Sydney Basin bears fossil tracks that are now known from recent radiometric and chemostratigraphic dating to be earliest Triassic, rather than latest Permian, in age. The tracks show two distinctive features of reptiles: scale impressions and claw marks. Both manus and pes are pentadactyl, ectaxonic, semidigitigrade and have an outer interdigital angle (digits IV-V) greater than inner interdigital angles. Digit proportions are consistent with a phalangeal formula of 2-3-3-3-3. The fossil tracks are referred to the ichnospecies *Dicynodontipus bellambiensis* sp. nov. They are similar to the kinds of tracks thought to be produced by *Lystrosaurus* species. Given the abundance of these species in Early Triassic faunas of low diversity and the occurrence of members of the *Lystrosaurus* fauna in

Queensland and Antarctica, chances are good that this is indeed a trackway of *Lystrosaurus*. If considered to be made by an animal of that type, the trackway was produced using the primitive alternate gait, rather than the mammalian amble, by an animal about 84 cm long and some 22 cm high. Preservation of bones of these creatures would not be expected given the non calcareous nature of associated fossil soils in the Sydney Basin Triassic. Herbaceous lycopods, locally common in these and other Early Triassic strata worldwide, are among the most likely foods of these tusked, low browsing herbivores.

Rey, D., Turner, P. and Ramos, A., 1996. Palaeomagnetism and magnetostratigraphy of the Middle Triassic in the Iberian Ranges (central Spain). In: Morris, A. and Tarling, D.H. (eds.), Palaeomagnetism and tectonics of the Mediterranean region. Geol. Soc. Spec. Publ., 105: 59-82.

Rich, T.H. and Young, G.C., 1996. Vertebrate biogeographic evidence for connections of the East and Southeast Asian Blocks with Gondwana. Austr. J. Earth Sci., 43: 625-634.

A review of the fossil vertebrate literature indicates fluctuating affinities between aquatic faunas of China and Australia during the Devonian Period. Within the South China Block, the close similarity of the highly endemic freshwater fish faunas located on the Yangtze and Huanan terranes demonstrate that these must have been juxtaposed in the mid Palaeozoic. Analysis of the Triassic tetrapods suggests the faunas of Australia were quite distinct from those of China and Thailand. Although this evidence points to the Permo-Carboniferous as the time of separation between Australia and the various plates of southeastern Asia, unfortunately the vertebrate fossil record in these regions during those periods is so poor as to shed no direct light on the matter. One of the problems of plate motion where fossil vertebrate evidence has contributed the most is the Mesozoic position of India. Because the relevant data are of a positive nature rather than dependent on the absence of taxa, the inference from them that there was substantial faunal interchange between the subcontinent and more northern regions of Asia by the Late Cretaceous is well established.

Rieppel, O., 1996. The status of the sauropterygian reptile *Partanosaurus zitteli* Skuphos from the Middle Triassic of the Austrian Alps, with comments on *Microleptosaurus schlosseri* Skuphos. Paläont. Z., 70: 567-577.

Partanosaurus zitteli Skuphos 1893 from the Ladinian (Partnachschichten) of the northern Alps (Vorarlberg, Austria) is identified as a junior synonym of *Simosaurus gaillardoti* Meyer 1832. Its occurrence in the Germanic Basin (Upper Muschelkalk) predates its appearance in the Alpine Triassic, and suggests faunal interchange between these two faunal provinces during middle and upper Ladinian times. *Macroleptasaurus schlosseri* Skuphos 1893 is represented by very incomplete material only and must be treated as a nomen dubium.

Rieppel, O., 1997. An unusual sauropterygian from the Triassic of the Savinja Alps of northern Slovenia. N. Jb. Geol. Paläont. Mh., 1997(4): 244-254.

An incomplete tetrapod (reptile) fossil from the Savinja Alps of northern Slovenia is identified as a pachypleurosaur sauropterygian of the *Serpianosaurus-Neusticosaurus* clade. It shows a unique tarsal structure supporting the hypothesis that Sauropterygia share the lepidosauromorph synapomorphy of the pedal perforating artery passing proximal to the astragalus through the spatium interosseum between the distal articular heads of tibia and fibula. Suggestive of a separate taxon, the specimen further supports the hypothesis that speciation rate among sauropterygian reptiles in the Middle Triassic Alpine intraplatform basin facies was accelerated compared to speciation within the contiguous Germanic basin.

Robison, V.D., Liro, L.M., Robison, C.R., Dawson, W.C. and Russo, J.W., 1996. Integrated geochemistry, organic petrology, and sequence stratigraphy of the Triassic Shublik Formation, Tenneco Phoenix well, North Slope, Alaska, U.S.A. Org. Geochemistry, 24: 257-272.

Rublev, A.G., 1996. State of the art of the Phanerozoic isotopic geochronologic scale. Strat. Geol. Corr., 4: 525-534.

The modern substantiation of the boundaries in the Phanerozoic scale of geologic time is discussed with reference to absolute geochronology. The critical analysis of the isotopic geochronologic data that form the basis of modern scales shows that only a few of them are suitable for calibration of an adequate scale. At present, reliable dating is available for the following boundaries: the Cambrian lower boundary (535 Ma); the Ordovician-Silurian (440 Ma); the Jurassic-Cretaceous (more than 137 Ma); the Cretaceous-Paleogene (65 Ma); and the Paleogene Neogene (23 Ma). Moreover, the available data allow determination of many age boundaries in the Ordovician, Late Cretaceous, Paleogene, and Neogene and evaluation of boundary ages between several epochs: the early Late Silurian (421 Ma); the middle Late Devonian (367 Ma); the early Middle Triassic (238 Ma); and the early Middle Jurassic (less than 185 Ma). The principles of calibrating the modern scale, in particular the priority of the "geochronologic" approach, are discussed, as also the prospects of future work on the scale and the necessity to elaborate the geologic time scale in this country.

Rüffer, T., 1996. Seismite im Unteren Muschelkalk westlich von Halle (Saale). Hallesches Jb. Geowiss., B 18: 119-130.

Lower Muschelkalk (Anisian, Middle Triassic) crops out in the Nietleben-Bennstedt Syncline west of Halle (Germany) underlain by sedimentary rocks of Permian and Early Triassic age. Excellent outcrops are especially to be found within the so-called "Oolithbank-Zone". Different synsedimentary deformation structures and sediments are described and interpreted as the result of short term shock waves induced by seismic events. Examples exist mainly in the "Wellenkalke" within the "Oolithbank-Zone" and in the overlying basal "Mittleren Wellenkalk". Subaqueous slumping and mass flow of semiconsolidated sediments resulted in sigmoidal slab joints, irregular slump structures, and debris flow conglomerates. Seismic events are also involved in the formation of pillow-like structures and lumachelles with random orientation of shell debris. Microfacies, the large lateral extension of the seismic beds, and juxtaposition of different deformation structures and sediments support their origin as seismites. The direction of inclination of the flat slopes of the Germanic Muschelkalk Basin can be determined using the sigmoidal slab joints. They show the direction of transport within the semiconsolidated sediments and, therefore, they are suitable for palaeogeographic reconstructions. Seismic events are short time and regional active controls. Therefore they can serve for basin wide stratigraphic correlations.

Sadovnikov, G.N. and **Orlova, E.F., 1997.** Permian-Triassic boundary deposits in framing structures of the East Siberian Platform. Strat. Geol. Correl., 5: 12-18.

The first description of the stratotype of the Ust' Kel'ter Horizon with its specific characteristics is given. A new stratigraphic unit, the Marininskii Horizon, is distinguished and substantiated, and its stratotype is described. The Marininskii and Ust' Kel'ter horizons continue upward the succession of continental Permian-Triassic stratigraphic units of Siberia. Their recognition allows us to address the problem of age and correlation of the Permian-Triassic boundary deposits in the northern Siberian platform and its framing structures.

SANCHEZ-MOYA, Y., SOPEÑA, A. and RAMOS, A., 1996. Infill architecture of a non-marine half graben Triassic basin (Central Spain). J. Sed. Res., 66, 1122-1136.

Upper Permian to Middle Triassic continental red beds were studied using architectural element analysis in a selected area in Central Spain where the outstanding quality of outcrops allows a three dimensional study, These red beds were deposited in a tectonically active half graben basin with episodically changing rates of basin subsidence. Seventeen architectural elements (channel belt and overbank elements) were recognized, described in detail, and interpreted, Twelve channel belt elements and five overbank elements are present in the Buntsandstein. They combine in nine different alluvial systems with diverse bed load channel type and discharge regime (gravel bed load braided, mixed load braided, three different sandy braided, intermediate sinuosity, high sinuosity, ephemeral, and alluvial fan), Not only the sizes of the different elements but also the scale of the complete alluvial systems were emphasized in this study, The differential tectonic, vertical and lateral evolution in the area was the main control on basin asymmetry, channel interconnection, paleocurrent pattern, and consequently the fluvial architecture. The asymmetry of the basin, together with the presence of antithetic and synthetic fault systems, caused the fluvial system to migrate away from the footwall scarp, to a more eastern position, where the lowest area was located. As the effect of the initial increase in subsidence was compensated by the sedimentation, the axial southeastern trend then became reestablished.

SANO, H. and NAKASHIMA, K., 1997. Lowermost Triassic (Griesbachian) microbial bindstone-cementstone facies, southwest Japan. Facies, 36: 1-24.

On the basis of the lithostratigraphy and microscopic characters, the paper describes the facies interpretation of the upper Upper Permian (Changhsingian) and Lower Triassic (Griesbachian to Spathian) carbonates of southwest Japan, with a focus upon the lowermost Triassic (Griesbachian) microbial bindstone-cementstone. We emphasize the significant sediment-binding and stabilizing agencies of microbes chiefly of cyanobacteria along with the syndepositional cementation for the carbonate deposition on a Panthalassan buildup in a period of the Scythian reef gap. Cyanobacteria flourished as post-mass extinction disaster forms in the beginning of the Triassic. The Griesbachian microbial bindstone-cementstone we describe comprises the oldest known Triassic microbial facies. Examined were the Changhsingian Mitai Formation and the Triassic Kamura Formation (Griesbachian to Norian) in southwest Japan. These units consist entirely of carbonates and are reconstructed as relict of a shallow marine buildup upon a seamount in the Panthalassa. The Kamura Formation (ca. 38 m thick) disconformably rests upon the Mitai Formation with a drastic lithologic change. The Lower Triassic rocks we focused reach 15.5 m thick and comprise the Griesbachian and Dienerian to Spathian sections. The lower part (ca. 5.5 m) of the Griesbachian section consists of dark grey carbonaceous limestone composed of thinly layered triplets of a gastropod-bearing peloidal grainstone layer, a spar-cemented frame of clotted peloids, and a thin-laminated and occasionally stromatolitic cover of cryptomicrobial micrite in ascending order. The upper two members of a triplet often form a bindstone-cementstone layer characterized by a low-relief domed structure, or a broad hump. The upper part (ca. 2 m thick) of the Griesbachian section is composed of oncolitic limestone that contains laminae packed with gastropods. The Dienerian to Spathian section (ca. 8 m thick) consists of coquinites comprising an explosive flourish and accumulation of pectinacean bivalves. We interpret the Griesbachian rocks to have accumulated in a stagnant, ecologically rigorous tidal flat, where microbes, of possible cyanobacteria, flourished. The flourish of gastropods reflects an intermittent inundation by spring tide into the peritidal environment. The deposition of gastropods was followed by a dominant cyanobacterial activity that formed a microbial bindstone-cementstone layer along with the syndepositional

cementation in an intertidal zone. The cyanobacterial activity contributed to the formation of gently undulated, sediment-binding and stabilizing mats. The oncolitic limestone in the upper part of the Griesbachian section also suggests the cyanobacterial, or algal activity. The Griesbachian microbial-controlled sedimentation was followed by the mass accumulation of bivalves that most possibly reflects a rapid transgression in Dienerian time. All the results permit us to conclude that possible cyanobacteria were the significant rock-forming organisms as post-mass extinction disaster forms on a Panthalassan buildup in the beginning of the Scythian reef gap.

Schoch, R.R., 1997. A new capitosaur amphibian from the Upper Lettenkeuper (Triassic: Ladinian) of Kupferzell (Southern Germany). N. Jb. Geol. Paläont. Abh., 203: 239-272.

Kupferzellia wildi, a new genus and species of capitosaurs, is described on the basis of excellently preserved material from the Fossil-Lagerstätte Kupferzell (Hohenlohe, Baden-Württemberg). This small-growing capitosaur is characterized by a broad skull table, almost closed squamosal embayments, posteriorly broad interpterygoid vacuities, broad choanae, a short but deep-reaching processus retroarticularis, and an expressed processus hamatus of the prearticular. The skull is threedimensionally reconstructed on the basis of morphological data and phylogenetic hypotheses, a method which is briefly discussed.

Senowbari-Daryan, B., 1997. *Barbafera camica* Senowbari-Daryan, 1980: a Triassic worm-tube. Facies, 36: 57-68.

Barbafera carnica Senowbari-Daryan (1980), a Carnian reef fossil of uncertain systematic position, is redescribed based on extraordinarily preserved material from Carnian reef boulders of the Cassian Formation of the Southern Alps (Dolomites/Italy). *Barbafera* is interpreted as a worm tube characterized by a complicated wall structure. *Barbafera* may belong to the family Serpulidae Rafinesque.

Sha, J. and Grant-Mackie, J.A., 1996. Late Permian to Miocene bivalve assemblages from Hohxil, Qinghai-Xizang Plateau, China. J. Roy. Soc. New Zealand, 26: 429-455.

Nine fossil bivalve assemblages have been recognized in the Hohxil desert area of western Qinghai, China: Wuchiapingian *Netschajewia jiangsuensis* assemblage, Smithian-Spathian *Bakevellia costata-Leptochondria virgalensis-Entolium microtis* assemblage, Carnian *Halobia austriaca-Halobia yunnanensis- Halobia convexa* assemblage, Norian *Halobia yandongensis-Halobia* aff. *dilatata* assemblage, Carnian-Norian *Trigonodus carniolicus-Unionites? rhomboidalis* assemblage, Bathonian-Kimmeridgian *Radulopecten pamirensis-Protocardia stricklandi* assemblage, Late Jurassic *Pseudolimea*-Opis assemblage, Early Cretaceous *Eokoreanaia qinghaiensis* assemblage, and Miocene *Sphaerium nitidum* assemblage. The marine bivalves, except for the cosmopolitan *Halobia,* are Tethyan and characterised mainly the northern margin of the Tethys. Non-marine taxa are restricted Asian forms. These assemblages are very significant in studying the biostratigraphy, paleobiogeography and tectonic history of the Qinghai-Xizang Plateau. In the Early Cretaceous marine connections were broken and the area has experienced since then only terrestrial conditions.

Shields, O., 1996. Geologic significance of land organisms that crossed over the Eastern Tethys 'Barrier' during the Permo-Triassic. Palaeobotanist, 43: 85-95.

During the Permo-Triassic (P-T), some terrestrial organisms had distributions that spanned the eastern Tethys Sea between Gondwanaland and Asia while avoiding a Northwest African-Southwest European connection. These data strongly suggest that a broad paleotethys ocean-barrier did not exist, while transport across it on displaced terranes leads to further difficulties. Earth expansion overcomes these problems by joining eastern

Gondwanaland and southern Asia throughout P-T times. The apparent failure of various plate tectonic models in this region stems from their requirement that the earth's diameter has remained constant through time, thus creating an unnecessarily wide Tethys ocean. Instead, if Paleotethys were a shallow epicontinental seabarrier, it would allow some terrestrial organisms to cross at narrow passage ways during regressions. The data also require India to be connected with Asia in P-T times, whereas plate tectonic models have them separated by a wide ocean baffler then and not rejoined until Eocene times.

Shinaq, R., 1996. Subsurface Triassic sediments in Jordan; stratigraphic and depositional characteristics, and hydrocarbon potential. J. Petrol. Geol., 19: 57-76.

Shishkin, M.A., Rubidge, B.S. and Kitching, J.W., 1996. A new lydekkerinid (Amphibia, Temnospondyli) from the Lower Triassic of South Africa: implications for evolution of the early capitosauroid cranial pattern. Phil. Trans. Roy. Soc. London, B 351: 1635-1659.

A new genus and species of lydekkerinid amphibian, *Eolydekkerina magna*, is described from the lower part of the *Lystrosaurus* Assemblage Zone of South Africa. Most distinctions between *Eolydekkerina* and *Lydekkerina* (other than those related to width of interorbital area and structure of choana and squamosal occipital flange) are linked to late growth stages and particularly preorbital elongation of the skull in the former genus. The developmental trends in Lydekkerina and the Lydekkerinidae in general are analysed by comparison with the cranial pattern of juvenile rhinesuchids. The evidence suggests that the Lydekkerinidae evolved from more fully developed capitosauroid (rhinesuchid like) ancestors by gradual truncation of ontogeny in parallel with the acquisition of many advanced features, unknown in tile Permian capitosauroids. The composition of the Lydekkerinidae is reviewed, and it is suggested that the family includes six to seven valid genera known from Antarctica, Greenland, India, Russia, South Africa and Tasmania. The smaller, and obviously most paedomorphic forms come from the reptile dominated assemblages in which *Lystrosaurus* is abundant, whereas the larger ones belong to amphibian dominated assemblages.

Silberling, N.J., Grant-Mackie, J.A. and Nichols, K.M., 1997. The Late Triassic bivalve *Monotis* in accreted terranes of Alaska. U.S. Geol. Surv. Bull., 2152.

Late Triassic bivalves of the genus *Monotis* occur in at least 16 of the lithotectonic terranes and subterranes that together comprise nearly all of Alaska, and they also occur in the Upper Yukon region of Alaska where Triassic strata are regarded as representing non-accretionary North America. On the basis of collections made thus far, 14 kinds of *Monotis* that differ at the species or subspecies level can be recognized from Alaska. These are grouped into the subgenera *Monotis (Monotis), M. (Paciminotis), M. (Entomonotis)*, and *M. (Eomonotis)*. In places, *Monotis* shells of one kind or another occur in rock-forming abundance. On the basis of superpositional data from Alaska, as well as from elsewhere in North America and Far Eastern Russia, at least four distinct biostratigraphic levels can be discriminated utilizing *Monotis* species. Different species of *M. (Eomonotis)* characterize two middle Norian levels, both probably within the upper middle Norian *Columbianus* Ammonite Zone. Two additional levels are recognized in the lower upper Norian *Cordilleranus* Ammonite Zone utilizing species of *M. (Monotis)* or *M. (Entomonotis)*, both of which subgenera are restricted to the late Norian. An attached floating mode of life is commonly attributed to *Monotis*; thus, these bivalves would have been pseudoplanktonic surface dwellers that were sensitive to surface-water temperature and paleolatitude. Distinctly different kinds of *Monotis* occur at different paleolatitudes along the Pacific and Arctic margins of the North American craton inboard of the accreted terranes. Comparison between these craton-bound *Monotis* faunas and those of the Alaskan terranes indicates

that all of the *Monotis*-bearing terranes in southern Alaska south of the Denali fault were paleoequatorial in latitude during Late Triassic time. Among these terranes, the Alexander terrane was possibly in the southern hemisphere at that time. Terranes of northern Alaska, on the other hand, represented middle, possibly high-middle, northern paleolatitudes.

Srivastava, S.C. and Bhattacharyya, A.P., 1996. Permian-Triassic palynofloral succession in subsurface from Bazargaon, Nagpur District, Maharashtra. Palaeobotanist 43: 10-15.

The palynofloras in Bore-core DGW-6 from the Bazargaon area near Nagpur belong to three palynozones. Palynozones 1 and 2 are characterised by *Densipollenites magnicorpus* and *Crescentipollenites fuscus* respectively, and are equivalent to the Raniganj palynoflora, while Palynozone - 3 marked by *Falcisporites stabilis,* compares with the Panchet palynoflora. The sedimentary sequence between 236.15 to 526.30 m is equivalent to Raniganj Formation (Late Permian) and includes the coal-bearing horizon. The strata between 236.15 to 108.4 in (Lower Member) and sediments up to 108.40 m from top (Upper Member) belonging to the Kamthi Formation are considered to represent the Early Triassic (Scythian).

Stolarski, J., 1996. *Gardineria*: a scleractinian living fossil. Acta Paleont. Polonica, 41: 339-367.

The basic architecture and microstructure of the skeleton of the Recent *Gardineria* are noticeably different from those of most other modern scleractinians. The wall of the *Gardineria* skeleton is entirely epithecate (non trabecular). while in the majority of modern Scleractinia the epitheca is either absent or added to the main wall which usually is of trabecular nature. These different patterns of theca formation reflect significant anatomical differences in the peripheral parts of the polyp. The Bauplan of *Gardineria* pattern, exceptional in the modern scleractinian fauna, was widespread among early Mesozoic corals, particularly among the Triassic protoheterastraeids. Similar skeletons also occur in some late Palaeozoic rugosans (e.g., polycoeliids). *Zardinophyllum zardini*, an aberrant Triassic scleractinian coral, with a supposed rugosan septal insertion, supports the hypothesis of the rugosan origin of the Scleractinia.

Suess, H.D., 1996. A reptilian tooth with apparent venom canals from the Chinle Group (Upper Triassic) of Arizona. J. Vertebr. Paleont., 16: 571-572.

Tan, X.D., Liu, C., Fang, D.J. and Xu, T.C., 1996. A paleomagnetic study of Triassic sedimentary rocks from Qinshui Basin, Shanxi Province, North China. Sci. in China, Ser. D, Earth Sci., 39: 101-112.

The results of a combined paleomagnetic, rock magnetic and petrographic study of Middle and Lower Triassic from Qinshui Basin, North China Block are reported. The characteristic remanent magnetization from the Ermaying Formation (Middle Triassic) is carried by both magnetite and hematite. In stratigraphic coordinates, the direction (Dec. = 28°, Inc. = 44°, N = 10, α_{95} = 4°) passes the (incremental) fold test and fabric test. The corresponding paleopole is 64° N, 6° E. The remanent magnetization of samples from the bottom of the Liujiagou Formation (Lower Triassic) is carried mainly by magnetite, which shows an inverse magnetic fabric and an abnormal magnetization direction. This is probably caused by a bedding parallel compression. A comparison of Triassic paleopoles from this locality with others in North China reveals a significant tectonic rotation of the eastern North China Block and Korean Peninsula with respect to the western North China Block. The rotation probably occurred during the Indosinian Movement.

Tiwari, R.S., Vijaya, Mamgain, V.D. and **Misra, R.S., 1996.** Palynological studies on a Late Palaeozoic-Mesozoic Tethyan sequence in the Niti area of the Central Himalaya, Uttar Pradesh, India. Rev. Palaeobot. Palynol., 94: 169-196.

The results of a palynological study in eight sections from the Tethyan sequence in the Niti area are reported. The output of plant microfossils is generally poor because of adverse preservational factors. Still qualitative determinations could be made for the Late Permian, the Early Triassic and the Late Jurassic sequences. The palynological compositions, thus identified, have been correlated with well established fauna in this sequence. The palynoflora bears similarity with that of peninsular India, as described from the Damodar, Rajmahal and Kutch basins, with other regions in eastern Gondwana, and to a limited extent with the Middle East. On the basis of comparisons with the Tethyan sequence in the Niti area, the age of the non marine Permian Triassic sequence on the Indian Peninsula has been evaluated; thus the Raniganj Formation is ascertained to be of Late Permian age and the Lower Panchet Formation of Induan (earliest Triassic) age.

Tomezzoli, R.N., 1996. Estratigrafia del Grupo Cuevo (Permico-Triasico inferior) y del Grupo Tacuru (Jurasico) en las margenes del Rio Bermejo (Oran, Salta y Tarija, Bolivia). Rev. Asoc. Geol. Argentina. 51: 37-50.

Trueman, C.N. and **Benton, M.J., 1997.** A geochemical method to trace the taphonomic history of reworked bones in sedimentary settings. Geology, 25: 263-266.

Rare earth element (REE) signatures can be used to identify the original mode of deposition of fossil bones and teeth that have been reworked. This new technique may resolve the notoriously difficult problem of assessing the amount of transporter reworking undergone by fossil bones and teeth on the basis of physical parameters, such as degree of abrasion. Different REE signals characterize different pore water environments. Bones and teeth, composed of apatite, incorporate REEs rapidly during early diagenesis, and the REE signature in the bone is controlled by that of the surrounding pore waters. Reworked bones and teeth may show REE traces suggesting early diagenetic pore water conditions different from those indicated by in situ sedimentary or geochemical evidence. This situation is demonstrated in a case study from the Rhaetian (latest Triassic) of southwest England, where different bone beds are compared. In one case, the original environmental setting of reworked bone is traced by matching REE traces with contemporaneous unreworked bone assemblages in neighboring areas.

Vachard, D. and **Roche, M., 1996.** Lyssakid oxyhexactines (Hexactinellida, Spongia) in palynological preparations of the Rhaetian (uppermost Triassic) from eastern France. Geobios, 29: 171-176.

A taphocenosis with pyritized microscleres spicules of hexactinellid sponges, associated with acritarchs and dinoflagellate cysts, allows precise determination of biosedimentological conditions prevaling during deposition of a facies of the Rhaetian Sandstones from the Paris Basin.

Van de Kamp, P.C. and **Leake, B.E., 1996.** Petrology, geochemistry, and Na-metasomatism of Triassic-Jurassic non-marine clastic sediments in the Newark, Hartford, and Deerfield rift basins, Northeastern USA. Chem. Geol., 133: 89-124.

Many sandstones and associated siltstones and shales of the Triassic-Jurassic Newark Supergroup in the Newark, Hartford, and Deerfield rift basins are immature feldspathic alluvial and lacustrine closed basin deposits. They were derived from felsic igneous and metamorphic continental blocks on the flanks of their depositional basins. The provenance

was dominantly calc-alkaline basement rocks similar to the Sierra Nevada of California. The physical and chemical environments of erosion and deposition were probably similar to those in moist Pleistocene-Holocene alluvial basins and playas in the Great Basin of California and Nevada. New petrographic and geochemical data for 113 samples indicate that albite rich sandstones and shales of the Stockton, Lockatong, and Passaic Formations in the Newark Basin and in the Portland and East Berlin Formations of the Hartford Basin and analcine-rich shales (up to 52% normative analcime) of the Lockatong Formation have unusually high Na_2O contents (4-7%). Textural evidence indicates both sodium replacement in feldspars and formation of authigenic albite and analcime in these rocks. By comparison with modern sediments derived from similar provenance, using mixing models, it is estimated that up to 4% Na_2O was diagenetically added to the detrital clastics. Trace metals (Co, Cr, Cu, Ni, Zn) abundances were apparently enhanced by deposition from brines in the Lockatong Formation. Analcime deposition occurred in shales with $(Al_2O_3 + Na_2O)/SiO_2 > 0.46$; this ratio is found only in sediments to which Na has been added from salts/brines. Source rocks and the weathering products derived from them may be considered as a closed system in which sodium was retained partly in solids, as feldspar, and part went into solution during weathering. The dilute solution migrated into the depositional basin where evaporation yielded concentrated brine during semi arid to arid climate in the drier parts of similar to 21,000 yr Milankovitch cycles. Reaction of brine during diagenesis at near surface and /or shallow depths (< 2 km) with Ca-plagioclase, K-feldspar, and layer silicates at estimated temperatures < 50° C to similar to 100° C and pH 7-9 + yielded thermodynamically stable authigenic albite and analcine in the sodium metasomatised clastic sediments, Low activity of K^+ precluded development of authigenic K-feldspar. However, K^+ from solution incorporated into muds and slits as smectites were transformed to illite. Some Lockatong beds contain anomalously high P_2O_5, Ce. La, Y, Th, and U in authigenic apatite or monazite, suggestive of mobilization of these elements in diagenesis.

Vermeij, G.J. and Dorritie, D., 1996. Late Permian extinctions. Science, 274: 1550.

Vishnevskaya, V., 1997. Development of Palaeozoic-Mesozoic radiolaria in the Northwestern Pacific Rim. Mar. Micropaleont. 30: 79-95.

Investigations of Radiolaria allow us to trace the evolutionary trends and rates of these siliceous microorganisms within the Northwestern Pacific. There are several phases or 'megacycles' in the development of radiolarian fauna in Northeastern and Eastern Russia. In ascending order these are: Ordovician-Silurian, Devonian-Carboniferous, Early Permian, Late Permian, Triassic-Middle Jurassic, middle Callovian-Barremian, Aptian-early Campanian, late Campanian-early Paleocene, and late Paleocene to Recent. No evidence has been found for mass extinction at higher taxonomic levels, or for 'instantaneous' catastrophic extinction. Several of the cycles are characterised by increased diversity and morphological specialization immediately prior to extinction. Recognition of megacycles permits us to hypothesize a close relationship between radiolarian events and palaeoceanographic, palaeoclimatic and tectonic changes which took place in the Pacific. Probably a sharp change of palaeohydrography and the opening of the new submarine seaways led to the appearance and radiation of new higher taxa, including the order Nassellaria in the early Mesozoic.

Visser, J.N.J. and Praekelt, H.E., 1996. Subduction, mega-shear systems and Late Palaeozoic basin development in the African segment of Gondwana. Geol. Rundsch., 85: 632-646.

Basins within the African sector of Gondwana contain a Late Palaeozoic to Early Mesozoic Gondwana sequence unconformably overlying Precambrian basement in the interior and mid Palaeozoic strata along the palaeo-Pacific margin. Small sea board Pacific basins form an

exception in having a Carboniferous to Early Permian fill overlying Devonian metasediments and intrusives. The Late Palaeozoic geographic and tectonic changes in the region followed four well defined consecutive events which can also be traced outside the study area. During the Late Devonian to Early Carboniferous period (up to 330 Ma) accretion of microplates along the Patagonian margin of Gondwana resulted in the evolution of the Pacific basins. Thermal uplift of the Gondwana crust and extensive erosion causing a break in the stratigraphic record characterised the period between 300 and 330 Ma. At the end of this period the Gondwana Ice Sheet was well established over the uplands. The period 260-300 Ma evidenced the release of the Gondwana heat and thermal subsidence caused widespread basin formation. Late Carboniferous transpressive strike slip basins (e.g. Sierra Australes/Colorado, Karoo-Falklands, Ellsworth-Central Transantarctic Mountains) in which thick glacial deposits accumulated, formed inboard of the palaeo-Pacific margin. In the continental interior the formation of Zambesi type rift and extensional strike slip basins were controlled by large mega shear systems, whereas rare intracratonic thermal subsidence basins formed locally. In the Late Permian the tectonic regime changed to compressional largely due to northwest directed subduction along the palaeo-Pacific margin. The orogenic cycle between 240 and 260 Ma resulted in the formation of the Gondwana fold belt and overall north south crustal shortening with strike slip motions and regional uplift within the interior. The Gondwana fold belt developed along a probable weak crustal zone wedged in between the cratons and an overthickened marginal crustal belt subject to dextral transpressive motions. Associated with the orogenic cycle was the formation of mega shear systems one of which (Falklands-East Africa-Tethys shear) split the supercontinent in the Permo-Triassic into a West and an East Gondwana. By a slight: clockwise rotation of East Gondwana a supradetachment basin formed along the Tethyan margin and northward displacement of Madagascar, West Falkland and the Gondwana fold belt occurred relative to a southward motion of Africa.

Vozenin-Serra, C. and Grant-Mackie, J.A., 1996. Les bois noriens des terrains - Murihiku - Nouvelle Zélande - Intérêt Paléophytogeographique. Palaeontographica B 241: 99-125.

This paper reports the identification of Norian silicified woods from the Murihiku Terrane (New Zealand). Six structures are described: *Podocarpoxylon paralatifolium* sp.nov., *Podocarpoxylon* sp., *Planoxylon hectori* Stopes, *Tordoxylon warepanense* sp.nov., *Sahnioxylon novaezelandiae* sp.nov., and *Sahnioxylon (Homoxylon) australe* Boureau. These woods are all characterized by distinct growth rings, confirming that at the time seasonal climatic changes prevailed. This xyloflora of Gondwana affinity leads us to the conclusion that biogeographically the Murihiku Terrane was closely related to eastern Gondwana at least in Late Triassic time.

Wade, J.A., Brown, D.E., Traverse, A. and Fensome, R.A., 1996. The Triassic-Jurassic Fundy Basin, eastern Canada: regional setting, stratigraphy and hydrocarbon potential. Atlantic Geol., 32: 189-231.

Fundy Basin, one of a series of half graben that formed along the eastern margin of North America during the Triassic/Jurassic rifting of Pangaea, lies mainly to the south of the Cobequid Chedabucto Fault System in Nova Scotia and beneath the Bay of Fundy. Continental red elastic rocks and basalt flows of the Triassic and Early Jurassic Newark Supergroup crop out continuously along the Bay of Fundy and Mines Basin coast of Nova Scotia and at several sites in southern New Brunswick. These units thicken beneath the waters of the bay to a present day maximum of nearly 10 km. Proximal facies preserved along the faulted New Brunswick margin of the basin consist of upper alluvial fan and fluvial clastics which grade laterally into sheet flood deposits. Along the gently north

dipping Nova Scotia margin, facies consist of distal alluvial fan, sheet flood and plays mud flat deposits. Facies projections suggest the probability that petroleum generating lacustrine sequences are widespread along the basin axis. In the Wolfville Formation and lower part of the Blomidon Formation these may be overmature but the upper part of the Blomidon Formation and the Scots Bay Formation have the potential for appreciable quantities of hydrocarbons.

Wang, C., Kozur, H. Ihiga, H., Kotlyar, G.V., Ramovš, A., Wang, Z. and Zacharov, Y., 1996. Permian-Triassic boundary at Meishan of Changxing county, Zhejing province, China - a proposal on the global stratotype section and point (GSSP) for the base of the Triassic. Acta Micropalaeont. Sinica, 13: 109-124.

Laterally continuous sections at Meishan contain a continuous pelagic sedimentary record across the P/T boundary without stratigraphic gaps. Conodonts are present in every bed of the uppermost Permian Changxingian (Changhsingian) Stage which has its stratotype at Meishan, in every layer of the Boundary Beds and in every bed of the lowermost Triassic. The section is thermally nearly unaltered (CAI = 1-1.5) and its fossil content (ammonoids, conodonts, bivalves, brachiopods) and event succession are well studied. Absolute age and paleomagnetism have been subjected to intensive studies. The presence of sporomorphs and well recognizable events allow correlation with continental beds. The section is well accessible and under protection of the government. *Hindeodus parvus* made its earliest appearance in the middle part of Boundary Bed 2. It evolved from *Hindeodus latidentatus* in a phylomorphogenetic continuum in a continuous and monofacies stratum. Both morphotypes of the species are present. Morphotype 1 is especially well recognizable and easily distinguishable from the forerunner species *H. latidentatus*. The biostratigraphic P/T boundary is defined at the first appearance of *H. parvus*. This boundary lies at Meishan very close to the event boundary (15 cm above the event boundary and a few centimetres above the minimum in $\delta^{13}C$ in the lower Boundary Bed 2). *Hindeodus Parvus* is the first worldwide present species, which evolved after the absolute minimum in the faunal diversity indicated by the minimum in $\delta^{13}C$. For the above reasons, Meishan is regarded as the best GSSP for the Permian-Triassic boundary. No other section in the world shows comparably good conditions for defining the P/T boundary in a GSSP.

Warrington, G., 1996. Mesozoic-Tertiary spores and pollen - Triassic spores and pollen. In: Jansonius, J. and McGregor, D.C. (eds.), Palynology: principles and applications. Vol. 2: 755-766. Amer. Ass. Strat. Palynol.

Weems, R.E. and Olsen, P.E., 1997. Synthesis and revision of groups within the Newark Supergroup, eastern North America. Geol. Soc. Amer. Bull., 109: 195-209.

The Newark Supergroup currently includes nine stratigraphic groups, each of which applies to part or all of the rock column of only one or a few basins, Because the group nomenclature within the Newark Supergroup is neither inclusive nor parallel in its concepts, nearly half of the strata within the Newark Supergroup lacks any group placement. A new system is proposed herein that (1) establishes unambiguous group boundaries, (2) places all Newark Supergroup strata into groups, (3) reduces the number of group names from nine to three, (4) creates parallelism between groups and three major successive tectonic events that created the rift basins containing the Newark Supergroup, and (5) coincidentally provides isochronous or nearly isochronous group boundaries, These proposed groups are (1) the Chatham Group (Middle Triassic to basal Lower Jurassic sedimentary rocks), (2) the Meriden Group (Lower Jurassic extrusive volcanic and sedimentary rocks), and (3) the Agawam Group (new name) (Lower Jurassic sedimentary rocks above all early Mesozoic

igneous intrusive and extrusive rocks). This new rock classification system makes use of the fact that a discrete interval of synchronous or nearly synchronous volcanism and plutonism occurred throughout the early Mesozoic rift system of eastern North America, The presence or absence of volcanic rocks provides a powerful stratigraphic tool for establishing regional groups and group boundaries, The presence of sedimentary rocks injected by diabase dikes and sills, in the absence of extrusive volcanic rocks, places Newark Supergroup rocks in the Chatham Group, The presence of extrusive volcanic rocks, interbedded with sedimentary rocks injected by diabase dikes and sills, places Newark Supergroup rocks in the Meriden Group, The presence of sedimentary rocks lacking both extrusive volcanic rocks and diabase dikes and sills, places Newark Supergroup rocks in the Agawam Group, Application of this new regional group stratigraphy to the early Mesozoic rift basins requires revision of the stratigraphy of several basins to make formation boundaries match group boundaries.

WIGNALL, P.B. and HALLAM, A., 1996. Facies change and the end-Permian mass extinction in SE-Sichuan, China. Palaios, 11: 587-596.

A detailed facies investigation has been undertaken of two hey sections across the Permian-Triassic boundary in SE-Sichuan, China, with a view to learning more about the timing and cause of the end-Permian mass extinction. Both high diversity reef and level bottom faunas survived in carbonate platform environments until almost the end of the last, Changxingian, stage of the Permian. The onset of biotic decline is abrupt at the Laolongdong locality and very rapid in, the inter-reef setting at Beifengjing. The extinction at both localities is associated with the development of dysaerobic facies characterised by abundant pyrite, a decline in burrow depth and size and an, associated increase in the preservation of fine laminae. Benthic oxygen levels declined further in the Early Triassic and both anaerobic and lowest dysaerobic facies are developed. Comparable facies transitions occur in other Chinese boundary sections, which record deeper water basinal and slope settings. The SE-Sichuan sections are particularly important because they record the effects of bottom water dysoxia in, much shallower water, although the oxygen deficiency was apparently less intense The disappearance of reefs at the end of the Permian was bound up with this oxygen deficiency associated with water deepening and not, as previously claimed, with an episode of emergence and karstification.

WIGNALL, P.B. and TWITCHETT, R.J., 1996. Oceanic anoxia and the end-Permian mass extinction. Science. 272: 1155-1158.

WIGNALL, P.B. and TWITCHETT, R.J., 1996. Late Permian extinctions: reply. Science, 274: 1552.

YAO, X.L., TAYLOR, T.N. and TAYLOR, E.L., 1997. A taxodiaceous seed cone from the Triassic of Antarctica. Amer. J. Bot., 84: 343-354.

A silicified seed cone is described from the lower Middle Triassic of Antarctica. The cone measures up to 3.4 cm long and 1.4 cm wide, and consists of helically arranged cone scales attached to a eustelic axis. Bract and ovuliferous scale are approximately of equal length and fused at the base. The bract is entire and vascularized by a single trace. The ovuliferous scale contains five distal lobes, each vascularized by a terete strand that divides to form a smaller trace to each of the five inverted ovules. Ovules are small and flattened with the three parted integument attenuated into oppositely positioned lateral wings. The Triassic specimens are compared with both extant and fossil conifer seed cones and believed to have their closest affinities within the Taxodiaceae.

Yapp, C.J. and Poths, H., 1996. Carbon isotopes in continental weathering environments and variations in ancient atmospheric CO_2 pressure. Earth Planet. Sci. Lett., 137: 71-82.

Abundance and carbon isotope data from an $Fe(CO_3)OH$ component in apparent solid solution in oolitic goethites have been used to infer ancient atmospheric CO_2 pressures. A test of the validity of these estimates might be comparisons of the carbon isotope compositions of $Fe(CO_3)OH$ in oolitic goethites with time-equivalent pedogenic calcites. Temporal trends of the oolitic goethite and pedogenic calcite $\delta^{13}C$ values are generally similar, but time-equivalent samples from each of these two groups are not common in the existing data. To facilitate discussion of the concept, comparisons were made of available goethite and calcite samples even though ages of the compared samples in each pair were not identical. In four out of the five comparisons, $Fe(CO_3)OH$ abundance and $\delta^{13}C$ data were combined with pedogenic calcite $\delta^{13}C$ data to calculate physically reasonable soil CO_2 concentrations for the ancient calcitic soils. This suggests that the compared oolitic goethite and pedogenic calcite systems were responding to the same global scale phenomenon (i.e., atmospheric CO_2). Atmospheric P_{CO2} as determined from the goethites in these four "well-behaved" cases ranged from values indistinguishable from modern (within analytical uncertainty) to values up to approximately 16 times modern (modern atmospheric P_{CO2} was taken to be $10^{-3.5}$ atm). One interpretation of the fifth, "anomalous", comparison is that atmospheric CO_2 levels increased from about 3 times modern to about 18 times modern from the Triassic into the Early Jurassic. This inferred value for the P_{CO2} of the Early Jurassic atmosphere is not uniquely constrained by the existing data and needs to be substantiated. However, even considerably lower Early Jurassic atmospheric P_{CO2} values of 6 to 9 times modern (i.e., 1/3 to 1/2 of the estimated value of 18 times modern) would still indicate significant differences between the global carbon cycles then and now. These results highlight the need for more research on the behavior of the atmosphere during and after the Triassic-Jurassic transition.

Yin, H., Sweet, W.C., Glenister, B.F., Kotlyar, G., Kozur, H., Newell, N.D., Sheng, J., Yang, Z. and Zakharov, Y.D., 1996. Recommendation of the Meishan section as Global Stratotype Section and Point for basal boundary of Triassic System. Newsl. Stratigr., 34: 81-108.

The base of bed 27c in the Meishan section Changxing County, Zhejiang Province, China, is recommended as GSSP for the basal boundary of the Triassic System. The Meishan section is easily accessible, well exposed, and records continuous marine sedimentation from the Changxingian (latest Permian) into the Early Triassic. The global boundary stratotype point is placed at the first occurrence of the conodont species *Hindeodusparvus* in the evolutionary lineage *latidentatus-parvus-turgida-isarcica,* which is transitional between *Hindeodus* and *Isarcicella*. Integrated stratigraphic study of the Meishan section includes radiometric dating, and chemo-, sequence, eco-, and event-stratigraphy. The latter involves the records of possible impact events as well as volcanic, anoxic, and transgressive events. The latter three studies have identified events that appear to be recorded on a pan-Tethyan or even a global scale.

Zavattieri, A.M. and Batten, D.J., 1996. Mesozoic-Tertiary spores and pollen - Miospores from Argentinian Triassic deposits and their potential for intercontinental correlation. In: Jansonius, J. and McGregor, D.C. (eds.), Palynology: principles and applications. Vol. 2: 767-778. Amer. Ass. Strat. Palynol.

Zhao, Y., Xu, X. and Liu, B., 1996. High-frequency sequences and sea-level oscillations in the Emei area on the western margin of the upper Yangtze Platform. Sediment. Facies Palaeogeogr., 16: 1-18.

ZHU, H.C., 1996. Discovery of the earliest Triassic spores and pollen from southwest Tarim and Permian-Triassic (PT) Boundary. Chin. Sci. Bull., 41: 2066-2069.

Triassic workers are kindly requested to send reprints or xerox copies of the titles and abstracts (including a full reference) of their recently published papers to the editor of ALBERTIANA for the 'Annotated Triassic Literature'.

As we are running out of illustrations for the cover page, good quality illustrations for making an attractive cover are most welcome. So, dig in your archives and send in some nice black-and-white illustrations you would like to have on the cover of one of the forthcoming issues.

ADRESSES OF CONTRIBUTORS TO ALBERTIANA 19

Marco Balini	Dipartimento di Scienze della Terra, Università di Milano, Via Mangiagalli 34, 20133 Milano, Italy. E-mail: marco@e35.gp.terra.unimi.it
Kiril Budurov	Geological Institute, ul Akad. G. Bončev, 1113 Sofia, Bulgaria
J.M. Dickins	Australian Geological Survey Organization, P.O.Box 378, Canberra A.C.T. 2601, Australia
Eduardo Garzanti	Ev-K2-CNR, Via Ampère 56, I-20133 Milano, Italy
Andrew B. Heckert	Department of Earth and Planetary Sciences, University of New Mexico, Albuquerque, New Mexico 87131, U.S.A.
Phillip Huber	Department of Education, University of Bridgeport, Bridgeport, Connecticut 06601, U.S.A.
Hans Kerp	Abt. Paläobotanik, Westfälische Wilhelms-Universität Münster, Hindenburgplatz 57-59, D-48143 Münster, Germany. E-mail: kerp@uni-muenster.de
Leo Krystyn	Paläontologisches Institut, Universität Wien, Althanstrasse 14, A-1090 Wien, Austria. E-mail: YBJ@pal.univie.ac.at
Spencer G. Lucas	New Mexico Museum of Natural History and Science, 1801 Mountain Road NW, Albuquerque, New Mexico 87104-1375, U.S.A.
Atle Mørk	IKU Petroleum Research, N-7034 Trondheim, Norway. E-mail: atle.mork@iku.sintef.no
Alda Nicora	Dipartimento di Scienze della Terra, Università degli Studi di Milano, I-20133 Milano, Italy
Henk Visscher	Laboratory of Palaeobotany and Palynology, Budapestlaan 4, NL-3584 CD Utrecht, The Netherlands. E-mail: hvisscher@boev.biol.ruu.nl
G. Warrington	British Geological Survey, Keyworth, Nottingham NG12 5GG, United Kingdom. E-mail: gwar@wpo.nerc.ac.uk
Ivan Zagorchev	Geological Institute, ul Akad. G. Bončev, 1113 Sofia, Bulgaria. E-mail: zagor@geology.acad.bg
Yuri D. Zakharov	Far Eastern Geological Institute, Far Eastern Branch, Russian Academy of Sciences, Vladivostok 22, 690022 Russia. E-mail: fegi@visenet.iasnet.com

SUBMISSION OF MANUSCRIPTS FOR ALBERTIANA

From 1993 onwards ALBERTIANA is published twice a year. Contributions should be sent to the editor. In order to facilitate the production of this newsletter and reduce typing errors, authors are kindly requested to submit their contributions on 3½ inch **MS-DOS formatted floppy discs** together with a **printed hard copy**.

Text files should preferably be in WordPerfect 5.1, 6.1 or any other kind of word-processing program that can be converted into WordPerfect 6.1 (e.g. Word 6.0 or as a plain ASCII file); no higher versions! The normal type face is univers 10-point. The layout of contributions should be in accordance with that of those in the present issue. Titles and author's names are set in univers 14-point bold; paragraph headings are set in univers 11-point bold. References should be cited following the examples in this issue. Reference lists are set in univers 9-point with line spacing 0.9. Do not capitalise authors' names (ecept for the first letter and the initials) but either use 'small capitals' or normal typeface. Do not use 'tabs' in reference lists but 'indent + margin release'.

Illustrations can be submitted on disc, preferably in CorelDraw 5.0 or any other format that can be directly implemented in WordPerfect 6.1 (e.g., BMP, TIF). Please also provide a good clean printed copies of your illustrations. Because the mailing costs of floppy discs are twice as high as the costs of the discs themselves (at least in Germany), floppies cannot be returned. Files can also be submitted as attachments with e-mails. E-mails can be sent to the editor: *kerp@uni-muenster.de*. Sorry, but BinHex-encoded files (MacIntosh) can not be read!

Those who do not have the possibility to submit a manuscript in electronic format, are kindly requested to send smooth and clearly typed manuscripts in a 12-point typeface (sans serif) with single line spacing. Tables and schemes should be in **camera-ready** format, clearly drawn or printed; only originals can be accepted, poor xerox copies cannot be accepted. Tables and schemes should be drawn to fit on a page (remind the header and footer!). Large tables should be printed on white paper, centred on the page with left and right margins of at least 2.54 cm and upper and lower margins of at least 4 cm. Due to time constraints it is **not** possible to redraw or retype tables and schemes; tables made on non-electronic typewriters cannot longer be accepted.

Special attention should be paid to grammar and syntax. Because the editor's administrative assistance has been reduced to virtually zero, linguistic corrections will be minimal. In case of doubt, send your manuscript to a colleague for proof reading. References should be in the format used in the 'Annotated Triassic Literature'. The use of names of biostratigraphic units should be in accordance with the International Stratigraphic Guide:

- "The formal name of a biostratigraphic unit should be formed from the names of one, or preferably no more than two, appropriate fossils combined with the appropriate term for the kind of unit in question."
- "The writing and printing of fossil names for stratigraphic units should be guided by the rules laid down in the *International Code of Zoological Nomenclature* and in the *International Code of Botanical Nomenclature*. The initial letter of generic names should be capitalized; the initial letter of the specific epithets should be in lowercase; taxonomic names of genera and species should be in italics. The initial letter of the unit-term (Biozone, Zone, Assemblage Zone) should be capitalized; for example, *Exus albus* Assemblage Zone."
- "The name of the fossil or fossils chosen to designate a biozone should include the genus name plus the specific epithet and also the subspecies name, if there is one. Thus *Exus albus* Assemblage Zone is correct. After the first mention, the genus name may be abbreviated to its initial letter if there is no danger of confusion with some other genus beginning with the same letter; for example, *Exus albus* may be shortened to *E. albus*. On the other hand, the use of the specific epithet alone, in lowercase or capitalized, in italics or not (*albus* Assemblage zone, *Albus* Assemblage zone, albus Assemblage zone, or Albus Assemblage zone), is inadvisable because it can lead to confusion in the case of frequently used species names. However, once the complete name has been cited, and if the use of the specific epithet alone does not cause ambiguous communication, it may be used, in italics and lowercase, in the designation of a biozone; for example, *uniformis* Zone."

From: SALVADOR, A. *(ed.), 1994. International Stratigraphic Guide. Second Edition. International Commission on Stratigraphic Classification of IUGS International Commission on Stratigraphy. IUGS/GSA, Boulder, Co, p. 66.*

The deadline for the submission of contributions for ALBERTIANA 20 is October 30th, 1997

The production and distribution of ALBERTIANA is sponsored by the LPP Foundation
Laboratory of Palaeobotany and Palynology, Utrecht

ALBERTIANA is published by the Laboratory of Palaeobotany and Palynology Utrecht for the Subcommission on Triassic Stratigraphy. It provides a forum for short, relevant articles such as:

- reports on work in progress and new publications
- reports on conferences
- news items
- letters
- reviews
- notices
- comments

THE SUBCOMMISSION ON TRIASSIC STRATIGRAPHY