ALBERTIANA

Contents Albertiana 24

A. S. Dagys † and W. T. Holser † 02

In Memoriam - Algirdas-Zenonas Stanislovo-Dagys (1932 - 2000) 02

Ballot for the executive of the ics subcommission on triassic stratigraphy 05

From the chairman: The Permian / Triassic boundary decided 05

Report on the STS activity 06

Results of the vote on GSSP of Permian - Triassic boundary 10

From the secretary 11

From the editor 11

Original Papers

Y.D. Zakharov, Y. Shigeta, A.M. Popov, A.N. Sokarev, G.I. Buryi, V.V. Golozubov, E.S. Panasenko and E.A. Dorukhovskaya: The candidates of global stratopype of the boundary of the induan and olenekian stages of the Lower Triassic in southern Primorye. 14

S.G. Lucas and A.B. Heckert: Biochronological significance of Triassic nonmarine tetrapod records from marine strata. 30

T. Jinnan and L. Zhili: the Middle Triassic stratigraphy and sedimentary paleogeography of south China. 37

M.J. Orchard, E.S. Carter, and E.T. Tozer: fossil data and their bearing on defining a Carnian-Norian (Upper Triassic) boundary in western Canada. 48

G. Warrington: British Triassic palaeontology: supplement 24. 56

Announcements

Final circular: Oman Pangea symposium and field meeting. 57

First circular and call for papers: The International Symposium on the global stratotype of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events. 61

Literature

H. Kerp, H. Visscher and G. Warrington: new Triassic literature. 66

Guidelines for the submission of manuscripts to Albertiana. 82

Addresses of contributors. 84

A. S. Dagys † and W. T. Holser †

It is with great sadness that I record the deaths of two long-standing members, Algirdas S. Dagys, a former Vice-Chairman of the Subcommission, and William ('Bill') T. Holser, a Voting Member of the Permian-Triassic Boundary Working Group.

I am grateful to E. S. Sobolev, Yu. D. Zakharov and Yin Hongfu for their appreciation of Algirdas Dagys and his work which appears elsewhere in this issue. Mary Ann Holser kindly supplied sources from which I have compiled the following appreciation of Bill.

Bill Holser (1920-1999) was born in Bakersfield, California. He attended the California Institute of Technology, gaining his bachelor's degree in 1942 and his master's in 1946; during the war he served in the U.S. Navy in the South Pacific theater with the rank of Lieutenant Commander. His PhD was awarded from Columbia University in 1950. Bill had a distinguished career as a research geochemist, with a particular interest in the geochemistry of ancient oceans, an aspect which he pursued in relation to Permian-Triassic boundary successions, amongst others. His work yielded more than 150 published contributions. He worked for Chevron Oil Field Research from 1958 until 1970 when he became Professor in the Department of Geological Sciences in the University of Oregon, Eugene, where he was also departmental head from 1971 until 1974. On retirement in 1986 he became Emeritus Professor in the Department. Bill was an Honorary Life Fellow of the Mineralogical Society of America and a fellow of both the American Geophysical Union and the Society of Economic Geologists; in 1976 he was a Fulbright Fellow. He was editor of The American Mineralogist (1966-1972) and of the International Tables for Crystallography (1963-1965, 1971-1976). Bill married Mary Ann Harris in Grand Rapids, Michigan in 1954 and is survived by Mary Ann, their five children, four grand children and his brother Alexander.

In memory of Bill the Holser family have proposed The William T. Holser Visiting Scholar Fund. The purpose of this is to enable the Department of Geological Sciences in the University of Oregon to invite one distinguished scholar to the campus each year for one week to exchange ideas and information with students and faculty members and to give a lecture named in Bill's memory. Members who wish to support this initiative may send contributions to: Dr William T. Holser Visiting Scholar Fund, Department of Geological Sciences, 1272 University of Oregon, Eugene, OR 97403-1272, United States of America. Contributions should be payable to the UO Foundation/Department of Geological Sciences and marked 'in memory of William T. Holser'.

Geoffrey Warrington, STS Secretary

In Memoriam - Algirdas-Zenonas Stanislovo-Dagys (1932 - 2000)

Algirdas-Zenonas Stanislovo-Dagys is no longer with us. A Professor of Geology, a prominent scientist, an outstanding paleontologist and stratigrapher, he died in Vilnius on January 7, 2000, after a long and serious illness.

A.S. Dagys was born on August 30, 1932 in Kaunas, Lithuania. After graduation from the Geological Department of Moscow University in 1955 he became a post-graduate student at the Institute of Geology and Geography in Vilnius but soon moved back to Moscow University where he specialized in paleontology. As a post-graduate student, Dagys studied the stratigraphy and brachiopod faunas of the Triassic of the north-western Caucasus. After university he continued his research in Vilnius, presented a dissertation in January 1960, and received the degree of candidate in geology. In May 1960 Dagys came to Novosibirsk where the best and most fruitful period of his scientific activity was spent at the Institute of Geology and Geophysics. In 1989 he left Novosibirsk for Vilnius to stay at the Institute of Ecology of Lithuania, but until the very last days of his life he continued to work keenly on geological problems of Siberia.

His creative thinking and fervent striving for knowledge, his enthusiasm coupled with a persistent and whole-hearted nature and incredible efficiency made Dagys a brilliant expert in many theoretical and practical fields of geology. His activity encompassed an extremely wide range of problems in invertebrate paleontology and the Mesozoic stratigraphy and paleogeography of Siberia and the Far East, but brachiopods were his special interest. He investigated Triassic brachiopods from different regions of Russia, as well as Jurassic and Lower Cretaceous brachiopods from northern Middle Siberia. After revising the taxonomy and stratigraphy of world Triassic brachiopod records he distinguished over one hundred new highest-rank taxa, suggested an original interpretation of the ontogeny and phylogeny of several groups, and developed a new system of numerous brachiopod taxa, following their main evolutionary trends and investigating their stratigraphic significance. These works resulted in a doctorate thesis on Triassic brachiopods which was presented in 1970.

In the late 1970s, Dagys became involved in studies of ammonoids, another group of Triassic fossils important for the stratigraphy of Siberia, and soon arrived at notable achievements. Independently and in collaboration with other Siberian scientists, he studied Induan, Olenekian, Anisian, and Ladinian ammonoids, distinguished about fifteen new genera and over twenty new species, specified the taxonomy of Boreal ammonoids and investigated some important aspects of their evolution.

Dagys' work on Triassic and Liassic stratigraphy is of great importance. Work under his leadership, as well as his personal efforts, yielded a new scheme of zonal stratigraphy of Liassic deposits in Siberia, which is as detailed as those from the best documented regions of Western Europe. He headed research in the systematisation and correlation of Triassic zonal stratigraphy of north-eastern Asia and collaborated with Dr. E.T. Tozer of the Geological Survey of Canada on the development of a Boreal Triassic standard.

For many years Dagys was engaged in field studies of Triassic deposits in the eastern part of the Yenisei-Khatanga and Lena-Anabar basins in relation to the assessment of their petroleum potential. This work resulted in significant changes to the existing Boreal Triassic correlations and regional lithostratigraphic schemes, and pushed forward comprehensive paleontological research.

Studies of the geographic distribution of Triassic marine invertebrates and the biogeography of Triassic seas were of particular value as they validated the mobilistic hypotheses. On the basis of a thorough analytical investigation of faunal and geological data Dagys argued for the "suspect terrane" approach to Triassic formations of the Koryak Upland, South Sakhalin, and Sikhoteh-Alin. Combined lithological, geochemical, and paleontological research in cooperation with specialists from SNIIGGMS (Novosibirsk) permitted Dagys to make paleogeographic reconstructions for northern Middle Siberia and to infer the scenario of Triassic landscape history.

Dagys paid much attention to field observations and was himself an experienced field geologist. He spent almost every summer on field trips, examined tens of cross sections and made unique collections of fossils from regions of Siberia that are difficult of access.
Dagys was the author of about 200 publications, among which the most important are twelve

monographs and three paleontological atlases that made him known as an outstanding expert in Mesozoic stratigraphy and paleontology.

In addition to his scientific activity, Dagys was involved in administrative matters. He was repeatedly elected as a Vice Chairman of the Subcommission on Triassic Stratigraphy of the International Commission on Stratigraphy. He was Principal Investigator of the Russian team of the project "Upper Triassic of the Tethys" which formed part of the UNESCO Geological Correlation Program. He was a member of the Departmental Committee on Stratigraphy as he entered the Bureau of its Triassic Section, and was the head of the same section in the Siberian Division of the Committee. He contributed a lot to the work of the 24th IGC in Moscow in 1984, both as a speaker and as an organiser of the excursion to Permian-Triassic boundary terranes in the eastern Verkhoyan area.

Above all Dagys was a remarkable teacher. From 1972 to 1974 he taught at the Kabul Polytechnical Institute in Afghanistan, and for years he was a professor at the Novosibirsk University.

Dagys left behind a number of disciples who continue working on Mesozoic paleontology and stratigraphy of Siberia and the Far East. He demanded a lot from his disciples, and was no less demanding of himself.

As a person, Dagys was very nice and easy going. His colleagues and students, as well as anybody who had ever met him at workshops or on field trips, will always remember this bright person, the Scientist and the Teacher.

Evgeny S. Sobolev, Yuri D. Zakharov, Yin Hongfu

BALLOT FOR THE EXECUTIVE OF THE ICS SUBCOMMISSION ON TRIASSIC STRATIGRAPHY

In accordance with ICS requirements the Chairman of the Subcommission on Triassic Stratigraphy has asked Voting Members of the Subcommission to vote on the officers who will form the Executive of the Subcommission from the period from 2000 until 2004. The present Chairman (M. Gaetani) and one Vice-Chairman (H. Rieber) wish to retire from the Executive in 2000.

The following were proposed as officers of the Subcommission for 2000-2004:

Chairman:	M. Orchard, Geological Survey of Canada, Vancouver
Vice-Chairman:	Yu. D. Zakharov, Vladivostock, Russia
Vice-Chairman:	Yin Hongfu, China University of Geosciences, Wuhan
Secretary-General:	G. Warrington, British Geological Survey, Nottingham

The results of the ballot are as follows:

Responses:	18 (Y - For; N - Against; A - Abstention)			
Proposed Chairman	(M. Orchard)	Y (18)	N (0)	A (0)
Proposed Vice-Chairman	(Yu. D. Zakharov)	Y (16)	N (1)	A (1)
Proposed Vice-Chairman	(Yin Hongfu)	Y (16)	N (1)	A (1)
Proposed Secretary-General	(G. Warrington)	Y (16)	N (1)	A (1)

M. Gaetani
Chairman, Subcommission on Triassic Stratigraphy

G. Warrington
Secretary-General, Subcommission on Triassic Stratigraphy

October 1999

FROM THE CHAIRMAN

The Permian / Triassic boundary decided

The postal ballot within the Subcommission on Triassic Stratigraphy concerning the GSSP of the base of Triassic, defined in the section D of Meishan (China) at the base of bed 27c, gave the following results:

Voting Members: 31 - Votes received: 27 (87%)

Yes: 22 (81%)
No: 2
Abstention: 2
Yes for Meishan as GSS, but at different Point: 1.

Consequently the proposal is approved by the Subcommission on Triassic Stratigraphy. The results have been forwarded to the International Commission on Stratigraphy for final approval. After 18 years of activity of the ad hoc WG, this is a good result, being the first GSSP of Triassic to be formally accepted.

Maurizio Gaetani

REPORT ON THE STS ACTIVITY

Maurizio Gaetani

My 4-year term of service as Chairman of the Subcommission on Triassic Stratigraphy will end at the meeting in Rio de Janiero in August, 2000. I would like to review some aspects of STS activity during my period of office.

The stage nomenclature for the Triassic was decided at the meeting in Lausanne in1991. This was not a decision made through a formal postal ballot but the names of the 7 stages have been almost generally adopted and are not the subject of serious debate. The Series subdivisions have been commonly accepted for more than one century.

The task of the STS is to propose GSSPs for the stages to the ICS and to improve correlation through physical methods; a timescale for the Triassic is also of great interest.

GSSPs

As repeatedly stated by the Chairman of the ICS, the primary duty of every Subcommission is to define stages and their GSSPs, for the sake of stability of nomenclature and world-wide recognition. Not one Triassic GSSP had been defined in 1996 and in 2000 only that for the base of the Induan, marking the base of the Triassic, has reached the final stages in the approval process. I was convinced that other GSSPs could have been defined in the last few years. The situation regarding each of the Triassic stage boundaries is as follows;

Base of the Triassic (base of Induan)

The ad hoc Working Group proposed to the STS that Section D at Meishan, China, should be selected as the GSSP for this level, with the base of the Induan Stage, and of the Triassic, placed in bed 27c, at the appearance of Hindeodus parvus. This proposal has been subject of a postal ballot amongst the Voting Members of the STS and received a large majority of votes in favour, though some members considered Meishan inadequate because of low sedimentation rate. At the end of a long process, during which other candidates has been abandoned for various reasons, the proposal of Meishan as the GSSP has been now forwarded to the ICS for approval and ratification.

Base of Olenekian

Up to now, no significant sections have been described in the Tethyan realm. The best are undoubtedly in the Olenek river area and in the Taymir peninsula. However, access to sites in those areas presents considerable logistically difficulties. The Vice-Chairman of the STS, Yu. Zakharov, suggested that alternative sections should be sought near Vladivostok where access is easier. A proposal is awaited though additional research may be required.

Base of Anisian

During the Halle meeting of the STS (1998) it was decided to abandon the proposal made by Muttoni et al. (1994) of the Marathouvuno section (Chios) as a candidate GSSP. This section had also been proposed by Assereto (1974) as a reference section for the Aegean substage but it appears to be too condensed and to include some minor gaps. At Halle the STS decided to ask Romanian workers to publish their results on the Desli Caira section in order that it could be evaluated as a candidate. The boundary is fairly clearly defined by the appearance of the ammonoid genera Japonites, Paradanubites, Paracrochordiceras and of the conodont C. timorensis (evolute form) and magnetostratigraphy also allows recognition of the boundary interval, between the late Spathian largely reversed sequence and the early Anisian dominantly normal interval. The $\delta^{13}C$ also show a very useful shift just above the boundary.

A workshop, organized by Dr. E. Gradinaru (Bucharest University), was held in Tulcea, N Dobrugea, Romania, from 7 to 10 June 2000 but no definitive results have yet been published. The scientific group preparing the documentation consists of: E. Gradinaru (general setting and ammonoid biostratigraphy and taxonomy), A. Nicora (Milano) and M. Orchard (Vancouver) (conodonts, using also the previous work by E. Mirauta), J. Besse and Y. Gallet (Paris) magneto-stratigraphy. L. Krystyn (Vienna) was involved with the magnetostratigraphy at an earlier stage.

We are eagerly awaiting publication of the results that could allow definition of the boundary which does not seem to offer major correlation problems. Ammonoids are important but often rare; conodonts will be probably the most useful biostratigraphic tool.

Base of the Ladinian

The ad hoc Working Group met in the field in Italy and Hungary in 1993, and it was followed by very active research that elucidated many points. However, it became apparent that no single obvious solution presented itself and that at least three or four possible definitions of the boundary were at our disposal. It also appeared that ammonoids often have wider correlation potential than the conodonts which are also biased by a very complex taxonomy. The Anisian/Ladinian boundary interval was a time of quick evolutionary changes and the interpretation of conodont specialists differs considerably on matters of species and subspecies definition.

An informal postal ballot within the Working Group resulting in rather balanced answers. A proposal to place the boundary at the base of the Reitzi Zone was favoured mostly by Hungarian workers; suggested use of the base of the Secedensis Zone was supported mainly by Italian workers; use of the base of the Curionii Zone probably received more widely distributed support than the other proposals. Amongst ammonoids, reitzi has perhaps the least correlation potential, being mostly known around the borders of Adria; secedensis has better potential, being present both in Tethys and in Nevada and corresponding to a major change in the ammonoid evolution, but it is not particularly common in the fossil record; curionii has the best correlation potential, but provides a less obvious boundary in relation to the conodont data.

The magnetostratigraphy is fairly well known and various reversals may be recognised in the boundary interval. As far as candidate GSSPs are concerned, two have been proposed: Felsoors and Bagolino. Felsoors, in Hungary, is an artificial section which, in my opinion, should be supported only if the boundary is to be placed at the base of the Reitzi Zone; magnetostratigraphy is patchy. Bagolino is better, especially if the boundary is placed at the base of the Curionii Zone, but the section is remagnetized. However, good bed-by-bed correlation to the western Dolomites, where a detailed magnetostratigraphic scale has been established (Muttoni et al., 1998), is possible.

Thus in my opinion, the selection of the boundary is mostly matter of convention and good will is necessary to adopt a compromise solution.

Base of the Carnian

In recent years it has become clear that the conodont P. polignathiformis, often used to define the lower boundary of the Carnian, appears earlier than the ammonoid Trachyceras aon which was traditionally used to define this boundary. Recent researches have also demonstrated that other rare Trachyceras appear earlier than aon.

Loriga et al. (1998), proposed the use of the appearance of the ammonoid Daxatina to define the base of the Carnian, with a candidate GSSP at Prati di Stuores (Italy), the locality indicated as typical for the Cordevolian by Mojsisoviscs. In the Prati di Stuores section, the sedimentation rate is high and the conodont content is very diluted. Magnetostratigraphy is available. No other sections have been proposed in Europe. Balini et al. (1998) pointed out some problems with the Stuores section. Work is in progress in Spiti, Himalaya, in an attempt to elucidate some aspects that are not well expressed in the Stuores section. It is possible that, in 2001, the Stuores section will be proposed as the candidate GSSP, with an auxillary section in Spiti.

Base of the Norian

No Working Group has been established for this boundary, but activity is in progress in both North America and Europe. The future chairman of the STS, M. Orchard is aiming to establish an ad hoc WG. Possible candidate GSSPs for this boundary may be identified soon.

Base of the Rhaetian

After the Lausanne (1991) decision to keep the Rhaetian as an independent stage no work has taken place.

Physical correlations

The necessity to supplement biostratigraphy with physical stratigraphic tools to achieve improved correlations between Triassic sequences has been accepted in recent years. Considerable efforts have been made to build up a magnetostratigraphic scale based on biostratigraphically controlled successions. A first draft is now largely complete, with at least 90% of the Triassic covered by a magnetostratigraphic scale. Other techniques, such as chemostratigraphy, using $\delta^{13}C$ or $\delta^{87}Sr$, have been investigated, but are still in a pioneering stage.

Numerical ages

The definition of numerical ages for the Triassic is far from being achieved and I think a major effort should be directed to this goal. There is fairly good agreement concerning the ages of both the base (c. 251 Ma) and the top (c.199 Ma) of the Triassic but the timescale for the internal subdivisions requires considerable improvement. The biostratigraphically well calibrated dates proposed by Mundil et al. (1996), placing the base of the Ladinian at c.241 Ma, indicate the potential significance of such dates. If this age is accepted, the implication is that the Induan, Olenekian and Anisian had a combined duration of no more than 10my, with the whole Lower Triassic being probably only slightly more than 5 my long. In this case, sedimentation rates for the Lower Triassic sequences at several places in the Alps and in the Caucasus would appear to have been excessively high. Also, the present lively discussion on the interpretation of the Latemar cycles is largely dependent on the time span attributed to the Ladinian.

Cyclostratigraphy

The Newark lacustrine set of sediments have been thoroughly investigated by Olsen and Kent in recent years. These workers produced an astronomical calibration of the measured cycles that covers most of the Upper Triassic. It will be interesting to see whether the same cycles can be recognised in sections outside the paleo-equatorial belt of the Newark type of basins.

Which future for the STS?

In the last years, the IUGS Board and the ICS have begun to provide financial support for specific projects rather than for the steady activity of the Subcommissions. The small amount of money that each Subcommission may receive in future (US$ 1000-2000) should be used as seed-money for project aiming to develop into a specific topic, such as definition of a GSSP or refinement of the timescale, with scheduled dead-lines like any other scientific projects.

These are my views the challenges for the future. I was honoured to serve as Chairman of this Subcommission, and I hope to be able to continue to add my work to that of the many others who are endeavouring to improve our knowledge of the Triassic.

References

Assereto, R., 1974. Aegean and Bithynian: proposal for two Anisian substages. Schriftenr. Erdwiss. Komm. Oesterr. Akad. Wiss., 2: 23-39.

Balini, M., Krystyn, L. & Torti, V., 1998. In search of the Ladinian/Carnian boundary: Perspectives from Spiti (Tethys Himalaya). Albertiana, 21: 26-32.

Broglio Loriga, C., Cirilli, S., De Zanche, V., di Bari, D., Gianolla, P., Laghi, G.F., Manfrin, S., Mastandrea, A., Mietto, P., Muttoni, G., Neri, C., Posenato, R., Rechichi, M., Rettori, R. & Roghi, G. 1998. A GSSP candidate fro the Ladinian/Carnian boundary: the Prati di Stuores/Stuores Wiesen section (Dolomites, Italy). Albertiana, 21: 22-18.

Mundil, R., Brack, P., Meire, M., Rieber, H. & Oberli, F., 1996. High resolution U-Pb dating of Middle Triassic volcaniclastics; time-scale calibration and verification of tuning parameters for carbonate sedimentation. Earth Planet. Sci. Lett., 141: 137-141.

Muttoni, M., Kent, D.V. & Gaetani, M., 1994. - The base of Anisian. A candidate Global stratotype section and point from Chios Island (Greece). Albertiana, 13: 37-43.

Muttoni, M., Kent, D., Meço, S., Balini, M., Nicora, A., Rettori, R., Gaetani, M. & Krystyn, L., 1998. Towards a better definition of the Middle Triassic magnetostratigraphy and biostratigraphy in the Tethys Realm. Earth Planet. Sci. Lett., 164: 285-302.

RESULT OF THE VOTE ON GSSP OF PERMIAN-TRIASSIC BOUNDARY

PTB Working Group

On behalf of the Permian-Triassic Boundary Working Group (PTBWG), we report to you the result of the formal vote on the Global Stratotype Section and Point (GSSP) of Permian-Triassic Boundary. This vote by correspondence was taken during the period from October 25, 1999 to January 17, 2000. The proposal was to place the GSSP at the base of Bed 27c, Section D, Meishan, Changxing County, Zhejiang Province, China, where the conodont Hindeodus parvus first appeared. Among the 28 titular members of the PTBWG, Dr. Wang Yigang has long been unable to be contacted and no one knows where he is, and to our great sorrow Professor William T. Holser died recently. Therefore only 26 voting sheets were actually delivered. with the following result:

- Unresponsive votes: 3
- Responses: 23, responsive percentage 88.4%, exceeding the necessary 60%
- Negative responses (No): 3
- Positive responses (Yes): 20, positive percentage 87.0%, exceeding the necessary 60% quorum of support

According to the new regulation of ISC, this motion is passed by PTBWG. We now proceed to apply to STS for a formal vote on the same motion and hope it to be taken as soon as possible.

We also take this occasion to mourn the recent death of William T. Holser, professor of the University of Oregon, and Algirdas S. Dagys, professor of the Lithuanian Academy of Sciences. Along with other responsibilities, Prof. Holser was a voting member of PTBWG. His works on the geochemistry of the Permian-Triassic Boundary greatly contributed to the resolution of the boundary problem. Prof. Dagys is long known as the expert on Triassic, especially the Triassic of ex-USSR. His works on the Lower Triassic of NE Siberia remarkably advanced our knowledge of Permian-Triassic boundary. Their thoughtful ideas and always helpful attitude have been stimulating to our group. We express our profound grief to their family members and pray that they may be sustained by a Higher Power.

Yin Hongfu,
Chairman of the PTBWG

Yuri Zakharov
Vice-chairman of the PTBWG

FROM THE SECRETARY

Newsletter Editor

Hans Kerp recently became one of the five standing members of the Deutsche Forschungsgemeinschaft review committee for palaeontology.

Hans has edited Albertiana for 10 years but has decided that increasing commitments and pressures of work make it impossible for him to continue as editor after the completion of this issue. Hans' contribution to the Subcommission has been the considerable effort and dedication necessary to prepare the newsletter copy and transmit it to the University of Utrecht for production and distribution; he has edited 17 issues of the newsletter and his contribution will be sorely missed.

Members contact information

All members are requested to advise the Secretary immediately of any changes to their contact details (postal or e-mail addresses; phone or FAX numbers) to ensure that information from the Subcommission reaches them without delay. The following changes to information included in Albertiana 22 (February 1999) have been notified:

- Carter, E.S. – e-mail: carter@pdx.edu
- Grant-Mackie, J. - e-mail: jgrantmackie@glgnov2.auckland.ac.nz
- Kolar-Jurkovšek, T. – Phone: ++ 386 61 136 75 98; FAX: ++ 386 61 136 75 96; e-mail: tea.kolar@geo-zs.si
- Silberling, N. – e-mail: slbrlng@classic.msn.com
- Zakarov, Yu.D. - e-mail: yurizakh@mail.ru

Dr. Rosanna Martini should be added to the list of corresponding members. Her address is:
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http://www.unige.ch/sciences/terre/geologie/welcome.html

FROM THE EDITOR

A New Editor !

As has been announced the previous issue, I am stepping back as editor of Albertiana. The main reason is that I currently have hardly any time to edit and compile this newsletter. I have recently been elected as one of the four standing reviewers for palaeontology of the German Science Foundation (DFG). This, together with other various other commitments, like the editorship of one of the leading journals in my own research discipline, administrative duties within my university, and last but not least teaching and research, take more time than I have. Another important point is that I feel that Albertiana can use some fresh blood. I have been editor since 1990 and was responsible for 17 of the 24 issues of Albertiana that have been published to date. Having been editor for such a long time, I was of course very concerned about Albertiana's future. Therefore, I am very happy that an excellent successor has been found. I am very pleased that my good friend and colleague Dr. Wolfram Kürschner is willing to take over the editorship of Albertiana. Wolfram is a palaeobotanist/palynologist and was originally trained as a geologist/stratigrapher and also worked in stable isotope geochemistry. Wolfram holds a lectureship at Laboratory of Palaeobotany and Palynology in Utrecht, an institute with a long tradition in Triassic research and the birthplace of Albertiana. The Utrecht institute is willing to further support Albertiana. Although IUGS makes a small contribution each year and readers are requested for donations, this does not cover the actual printing and mailing costs. Therefore, I am very pleased that the future of Albertiana is secured now. I am sure that our new editor will further improve the quality of this newsletter.

Hans Kerp, (former) editor of Albertiana

Although Albertiana is scheduled to appear twice a year, this issue is published with a considerable delay. By the time the issue should have gone to press only very few contributions had been received. Therefore, it was decided to postpone publication. However, for various reasons I had very little time during the summer. Unfortunately, this led to further delay for which I apologize.

Hans Kerp

ANNOUNCEMENTS

31st International Geological Congress
Rio de Janeiro, Brazil, 6-17th August 2000

A meeting of the Triassic Subcommission was scheduled for the 10th August during the IGC in Rio de Janeiro.

Carnian-Norian Boundary Working Group.

A Carnian-Norian boundary working group is being formed under the auspices of the Triassic Subcommission. Some researchers with a known interest and active research on this boundary have been contacted and invited to participate. Others who would like to be involved are invited to write and inform me (as Chair) of their interest and potential scientific contribution. Broad representation of researchers from both the marine and continental realms is sought, and individuals from as many countries as have a stake in proposing a potential GSSP are welcome to participate.

The composition of Working Group will be announced in the next Albertiana, along with a short list of potential GSSP sites. To this end, I also invite a brief summary statement of localities that might be considered in this exercise. These should include a note of their chief attributes, published accounts, and work in progress.

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Moroccan Triassic Pollen

Dear Colleague,

We are glad to inform you that, among the activities of the Moroccan Group of Permian and Triassic, a catalog of Moroccan Triassic pollen has been prepared.
This catalog can be consulted online on the site:
http://fmedina.homepage.com/palynocatalog/palynocatalog.html
Please note that, because the catalog was prepared by stratigraphers which are not palynologists, the names of genera and species are those given by the original authors and synonymies have not been studied.

Sincerely yours, Professor F. Medina Scientific Institute, Rabat, Morocco

THE CANDIDATES OF GLOBAL STRATOPYPE OF THE BOUNDARY OF THE INDUAN AND OLENEKIAN STAGES OF THE LOWER TRIASSIC IN SOUTHERN PRIMORYE

Annual Report 2000 of IOBWG

Yuri D. Zakharov, Yasunari Shigeta, Alexander M. Popov, Anatoly N. Sokarev, Galina I. Buryi,
Vladimir V. Golozubov, Eugene S. Panasenko and Era A. Dorukhovskaya

Introduction

During the many years of investigations on the Lower Triassic several suggestions for stage and substage subdivisions have been made (e.g., Mojsisovics, 1882; Mojsisovics et al., 1895; Kiparisova & Popov, 1956, 1964a, b; Tozer, 1965, 1978; Vavilov & Lozovsky, 1970; Zakharov, 1973, 1978, 1986; Kozur, 1972, 1992; Kummel, 1973; Guex, 1978; Rostovcev & Dagys, 1984; Shevyrev, 1990). On the 29th International Geological Congress (Kyoto, 1992) Kiparisova & Popov's (1964a,b) scheme with a twofold division (Induan and Olenekian stages) has been approved at last. However, then another problem came up immediately: the choice of the Global Stratotype and Point for the boundary between these two stages. Therefore, a special working group (IOWG) was formed in 1997 with Prof. Yu.D. Zakharov (Vladivostok) as chairman and Dr. A. Baud (Lausanne) as vice-chairman.

The problem of the Induan-Olenekian boundary is complex because the Lower Triassic sections of the stratotype regions for the Induan (Hindustan, Indus River Basin) and Olenekian (Arctic Siberia, Olenek River Basin) cannot be used as boundary stratotypes for the base of the Olenekian and points for the following reasons:

1. The Induan Stage in the Olenek River basin (Boreal realm) consists of lagoonal and littoral, tuffaceous and poorly fossiliferous strata that are difficult to date.
2. In most Salt Range and Central Himalayan sections (Himalayan province) ammonoids are rare or absent, in Ceratite marls - Ceratite sandstone boundary beds, where the Induan-Olenekian boundary seems to have been recognized.

Hence, there are some problems with regard to the global correlation of the Lower Triassic, which concentrate on the Induan-Olenekian boundary sequence. However, we have representative Induan-Olenekian and Lower Olenekian sections (Burij, 1959; Korzh, 1959; Kiparisova, 1961, 1972; Zakharov, 1968, 1978, 1997) in the Ussuri province. This region is regarded as intermediate between the Boreal realm and the Himalayan province, having some common characters with both of them, and was often mentioned in discussions on problems of the Induan-Olenekian boundary by Kiparisova and Popov (1956, 1964 a,b). Most of these sections are located near Vladivostok in South Primorye.

Vladivostok was founded 1860 at Murav'ev, Amursky Peninsula as a military outpost. The construction of fortifications and a railroad necessitated geological investigations. The first geological studies there were carried out by Margaritov, a graduate from the St.- Petersburg University, who arrived in Vladivostok in 1880 as mathematics teacher. He became an active member of the Society for the

Investigation of the Amur Region, and head of several ethnographic and geological field parties, resulting in remarkable discoveries. For example, on the western coast of the Ussuri Gulf, between Tri Kamnya Cape and Shamara Bay (now Lazurnaya) he discovered, much to his surprise, some fossils, bivalves and ammonoids. Margaritov's collection fell into the hands of the President of the Russian Academy of Sciences, Karpinsky, a recognized expert in Late Paleozoic ammonoids, who distinguished Triassic bivalves («*Pseudomonotis*», «*Avicula*») and ceratitid ammonoids including *Meekoceras*; «*Ceratites*».

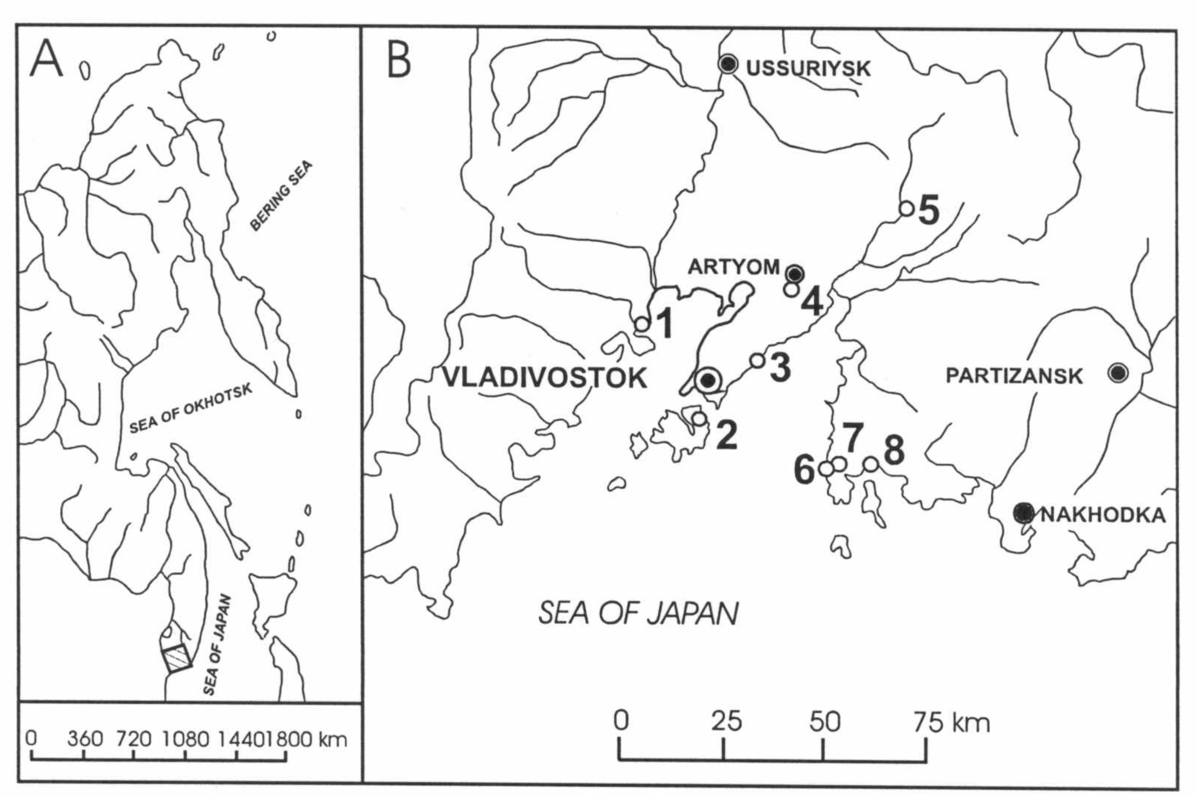

Fig. 1. Location of Induan-Olenekian transition outcrops, South Primorye. A -Location of the investigated area (shaded), B - South Primorye. Sections: 1 - Atlasov Cape, 2 - Ayax Bay, 3 - Tri Kamnya Cape and Orel clift, 4 - Artyom SMID quarry, 5 - Artyomovka River, 6 - Kom-Pikho-Sakho Cape, 7 - Yuzhnorechensk (Shimeuza) station, 8 - Abrek Bay.

Later, Triassic marine deposits in the Vladivostok region were studied by Ivanov (1891), chief of a geological team carrying out reconnaissance studies for the construction of the Trans-Siberian railroad. He also collected mollusc remains in the Shamara Bay area and he was the first who collected bivalves and ammonoids on Russian Island. He recognized the following succession of Triassic sediments in the South Primorye (Ussuri) region: (1) basal conglomerate, (2) sandstone and clay sandstone member and (3) thin-bedded sandstone member with algae and worm remains. On Karpinsky's initiative, a representative collection of Ivanov's and a part of Margaritov's collections were sent to the Austrian paleontologist Diener who studied them together with more abundant material that he had collected from the Lower Triassic of the Himalayas. From the lower part of the section, described by Ivanov, Diener (1895) identified the Early Triassic ammonoids *Proptychites* and *Lytophiceras*, and from the middle part the Early Triassic ammonoids *Pseudosageceras*, *Ussuria*, *Arctoceras* (= «*Meekoceras* (*Koninckites*)»), *Anaxenaspis* (= «*Xenaspis*»), *Kazakhstanites* (= «*Dinarites*») and *Xenoceltites* (= «*Ceratites*»). From Ivanov's upper member he identified the Anisian forms *Ussurites* (= «*Monophyllites*»), *Ptychites* and *Acrochordiceras*. Diener paid great attention to the discovery of Triassic marine deposits in the western Pacific, because at that time the Himalayas, Alps and Arctic Siberia were the only well known areas for the occurrence of Early Triassic ammonoids.

Ivanov's bivalve and brachiopod collections were later investigated and described by Bittner (1899). Stratigraphical investigations by Margaritov and Ivanov in the South Ussuri area were continued by Wittenburg (1910, 1916), who distinguished the (1) «*Pseudomonotis*» (= *Eumorphotis*) *iwanowi*, (2) «*Terebratula*» (= *Fletcherithyris*) *margaritovi* and (3) «*Xenodiscus*» (= *Kazachstanites*) *nicolai* Zones in the Lower Triassic and (4) the *Ptychites kokeni* Zone in the Anisian (Middle Triassic).

The importance of Lower and Middle Triassic rocks in the southern Primorye increased after the publication of the monographs by Kiparisova (1961, 1972) and later works. Kiparisova (1961) described more than 30 Early Triassic, and 28 Middle and Late Triassic ammonoid taxa and presented the following zonal scheme of the Lower Triassic: (1) basal conglomerate, (2) *Proptychites* Zone (or *Meekoceras* Zone), (3) *Flemingites* Zone, (4) *Prosphingites* Zone, and (5) *Subcolumbites* Zone. The Induan-Olenekian boundary was first recognized at the top of the *Flemingites* Zone (Kiparisova, Popov, 1956; Burij, 1959; Korzh, 1959), but later at its base (Kiparisova & Popov, 1964a,b; Kiparisova, 1972); moreover, instead of two zones (*Flemingites* and *Prosphingites*) the use of only a single Zone was suggested.

The fossil material collected by the major collective of Far Eastern geologists (Prynada, Nozdreev, Belyaevsky, Burij, Vasilyev, Korzh et al.) formed the basis of Kiparisova's 1961 work. The first used collection was made in 1928. It is necessary to keep in mind that Kiparisova's personal collections were restricted to the main material from the Middle Triassic and that for the Lower Triassic stratigraphical scheme she used material collected by other contributors.

Zakharov's (1968) monograph, with descriptions of 90 species of Triassic ammonoids from South Primorye, for the first time discussed the considerable facies variability of the Lower Triassic of this area. This was not taken into account in earlier correlation attempts. Consequently some ammonoid assemblages of some Lower Triassic zones were misrespresented.

The following zonation scheme for the Lower Triassic of the Far East (Zakharov, 1968, 1978. 1997); Zakharov, Rybalka, 1887; Burij et al, 1972; Burij & Zharnikova, 1981) accepted on the IVth Interdepartmental Regional Stratigraphic Conference in Khabarovsk (1990) will be discussed below:

Olenekian Stage

Upper Substage (Russian)

7. Subcolumbites multiformis Zone
6. Neocolumbite insignis Zone

Lower Substage (Ayaxian)

5. Tirolites - Amphistephanites Zone
   b. Tirolites ussuriensis beds
   a. Bajarunia dagysi beds
4. Anasibirites nevolini Zone
3. Hedenstroemia bosphorensis Zone

Induan Stage

2. Gyronites subdharmus Zone
1. Glyptophiceras ussuriense beds.

In 1976 Burij and co-authors (Burij, 1997; Burij et al., 1976, 1977, 1993) established four horizons in Induan, Olenekian and Anisian strata of South Primorye: Lazurnian, Tobizin, Chernyshev and Karazin. Recently in connection with research of facies variability of Lower and Middle Triassic sediments in limits of this interval the formations (suites) (Zakharov, 1997) were follow-up established.
Buryi (1979) was the first who studied Early Triassic conodont assemblages from South Primorye, but it must be noted that the review of conodont data from Primorye and other regions revealed the scarcity of age-diagnostic Late Induan and Early Olenekian conodonts.

Recently Zakharov (1995, 1996) proposed the Tri Kamnya Cape section as a Global stratotype for the Induan-Olenekian boundary. This contribution aims to propose the Abrek Bay section as a second candidate for the Global Stratotype of the lower boundary of the Olenekian.

The Abrek Bay section

The section is located in the Abrek Bay (north-eastern coast), about 0.8 km N of Yunshi Cape, South Primorye, at 42°55' N and 131°36' E.

Biostratigraphy

Ivanov first noted the presence of Triassic bivalve and gastropod mollusks in clay sediments of Abrek Bay in Strelok Gulf (Diener, 1895). Kiparisova (1938) later described *Claraia aurita* Hauer, *Eumorphotis multiformis* Bittner «*Pecten*» (= *Chlamys*?) *kryshtofowichi* Kiparisova, *Myoconcha* aff. *goldfussi* Dunk., and *Posidonia abrekensis* Kiparisova, collected in Abrek Bay by Wittenburg (1908-1923) and Kryshtofovich (1924). The first desciption of Triassic cephalopods of Abrek Bay area is from Kiparisova (1961). She described two Early Triassic nautiloid taxa (*Menuthionautilus* and «*Syringoceras*») and seven Early Triassic ammonoid taxa (*Hedenstroemia*, *Arctoceras* (= «*Proptychites*»), *Gyronites* and *Meekoceras*), collected by Nozdreev, Trifonov, Burij and Korzh (1938-1956). She described also one ammonoid (Kiparisova, 1961) collected by Nozdreev (1936), which she believed to be the Anisian form *Discoptychites* aff. *compressus* Yabe et Shimizu, although no suture is visible.

Kiparisova (1972) noted essential discrepancies between the Triassic stratigraphic schemes of Abrek Bay of Nozdreev (Kiparisova, 1972), Burij (1959), Korzh (1959) and Vasilyev (Kiparisova, 1972). The boundary between the Induan and Olenekian stages would on one hand be defined by the appearence of *Hedenstroemia* and *Meekoceras*; on the other the change from a sandy facies to silty one. This, however, conflicts with Nozdreev's data, who found *Hedenstroemia* in the sandy facies of the Lower Triassic.

Dagys (1974) described a new brachiopod genus (Abrekia) from Burij's collections from Lower Triassic sandstone of Abrek Bay and also regarded it as Induan in age.

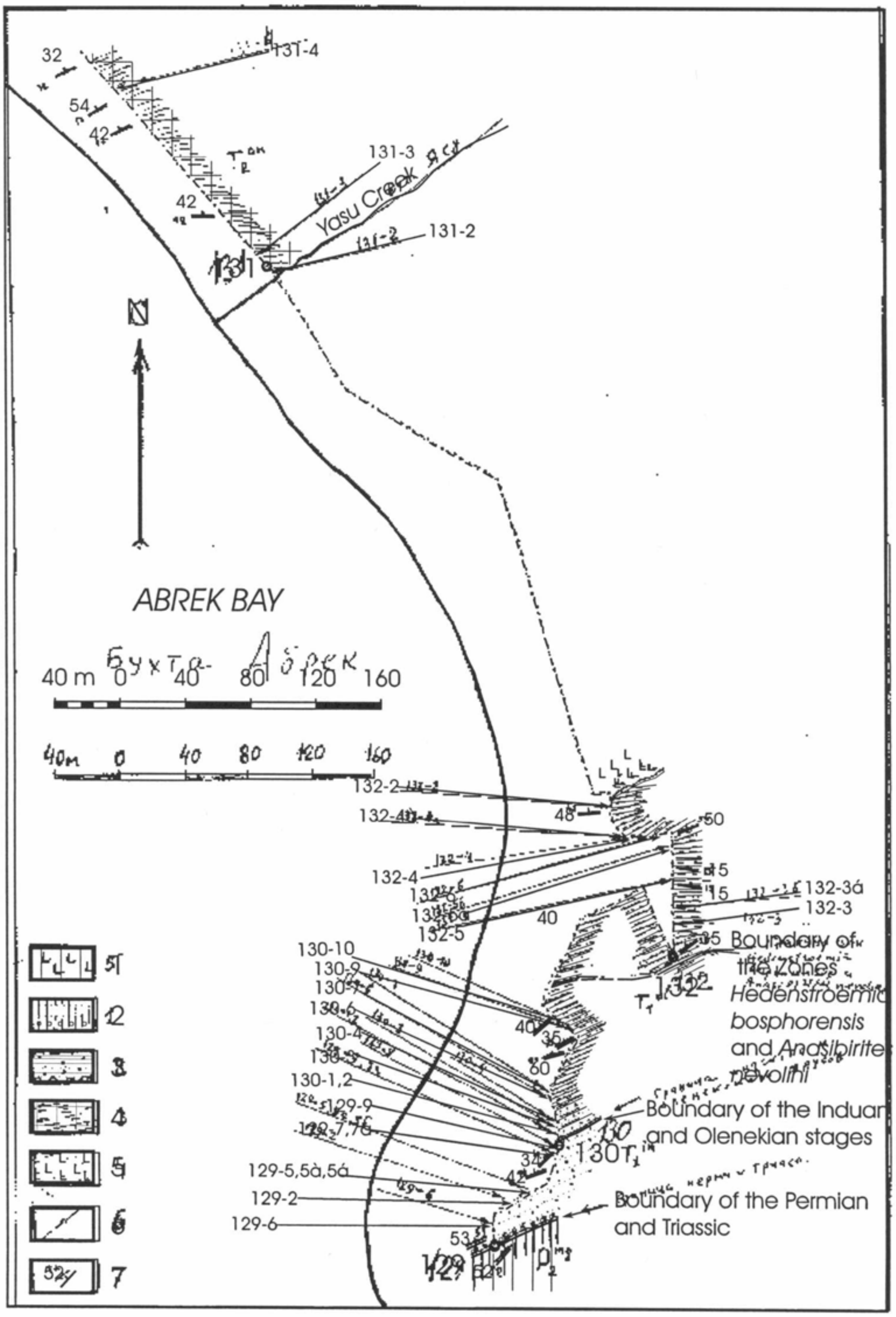

Fig. 2. Sketch map locating the Abrek Bay section. 1 - Murgabian (Abrek Formation), 2 - Induan (lower and middle Lazurnaya Formation), 3 - Lower Olenekian, Ayaxian (upper Lazurnaya and lower Zhitkov Formations), 4 - Anisian (Karazin Formation), 5 - dykes of porphyrite, 6 - geological route, 7 - bed elements.

From top to bottom, the sequence of the Anisian, Olenekian and Induan in the Abrek Bay section investigated by Zakharov, Shigeta, Popov and Panasenko in summer 1997-98 (Fig. 2 and 3) is as follows:

Anisian Stage

Phyllocladiscites basarginensis Zone (lower part)

19. Dark grey mudstone with large nodules without mollusk remains — over 10 m
    Nodules contain abundant of pure preserved radiolarians (spherical *Spumellaria*; det: Panasenko)
18. Dark grey mudstone and siltstone with interbeds of grey fine-grained striped sandstones, calcareous-marly nodules and lenses — 25.0 m
    With ammonoids (*Leiophyllites* sp.) in the lower part and small bivalves, gastropods, ammonoids (*Cuccoceras* sp. nov.) and nautiloids (*Trematoceras* sp.) in the upper part.
    Kiparisova (1961, 1972) has adduced information on a fragment of ceratitid ammonoid living chamber which was found by Nozdreev in dark-grey mudstone of Abrek Bay in association of *Posidonia abrekensis* Kiparisova. It was tentatively identified as the Anisian form *Discoptychites*. However, it rather may be *Parahedenstroemia*; representatives are known in both the Hedenstroemia bosphorensis and the Anasibirites nevolini of the Olenekian stage. Kiparisova (1938) was, apparently, right, when she firstly consider *Posidonia abrekensis* Kiparisova to be Early Triassic in age.

Unexposed interval — (over 100 m in thickness)

Olenekian Stage

Lower Olenekian (Ayaxian) Substage

Anasibirites nevolini Zone

17. Grey, striped siltstone (metamorphic near the contact with dyke of diorite porfirite) — 2-3 m
16. Dark grey mudstone with calcareous-marly nodules and lenses, intercalated with striped siltstone — 5.0 m
    Contains ammonoids (*Arctoceras labogense* Zharnikova), *Pseudoprosphingites magnumbilicatum* (Kiparisova), *Koninckites timorensis* Wanner, *Parakymatites* sp. nov., *Meekoceras varaha* Diener, *Meekoceras* sp. nov., *Hemiprionites dunajensis* Zakharov, *Preflorianites* cf. *radians* Chao.
    It is possible to speculate that *Arctoceras abrekensis* (Kiparisova) (1961) was found by Nozdreev just in the member 16.
15. Dark grey siltstone and mudstone with calcareous-marly nodules and thick lenses of coquinoid marl — 35.0 m
    With brachiopods (*Abrekia sulcata* Dagys), small bivalves (*Promyalina* sp., *Posidonia*? sp.), ammonoids (*Pseudosageceras longilobatum* Kiparisova, *Pseudosageceras* sp., *Arctoceras labogense* (Zharnikova) (dominant), *Arctoceras subhydaspis* (Kiparisova), *Arctoceras septentrionale* (Diener), *Pseudoprosphingites magnumbilicatum* (Kiparisova), *Owenites koeneni* Hyatt et Smith, *Gyronitidae* gen. et sp. nov., *Koninckites timorensis* Wanner (dominant), *Gurleyites* sp., *Anasibirites nevolini* Burij et Zharnikova, *Palaeokazakhstanites ussuriensis* (Zakharov), *Euflemingites prynadai* (Kiparisova), *Eophyllites* sp.

Hedenstroemia bosphorensis Zone

14. Dark grey siltstone and mudstone with calcareous-marly nodules and lenses and rare interbeds (up to 15 cm) of grey medium-grained sandstone — 23.0 m
    With small bivalves (*Velopecten minimus* Kiparisova), small gastropods and ammonoids (*Pseudoprosphingites magnumbilicatum* (Kiparisova), *Gyronitidae*?, *Koninckites timorensis* Wanner, *Meekoceras varaha* Diener (dominant), *Flemingites radiatus* Waagen, *Anaxenaspis cf. orientalis* (Diener) at the base of member.
13. Greyish-green, striped (because of very thin interlayers of mudstone) siltstone with rare nodules of marl — 8.6 m
    With ammonoids (*Meekoceras varaha* Diener, Meekoceras sp. nov.)
12. Greyish-green, fine-grained striped (because of presence of very thin interlayers of mudstone) sandstone with dark grey, calcareoun-marly boulders and lenses — 10.0 m
    With bivalves (*Palaeoneilo? prynadai* Kiparisova, *Pteria ussurica* (Kiparisova), *Eumorphotis iwanowi* (Bittner), *Promyalina* sp., *Anadontophora fassaensis* (Wissman), ammonoids (*Parahedenstroemia conspicienda* Zakharov, *Inyoites spicini* Zakharov, *Arctoceras septentrionale* Diener, *Pseudoprosphingites magnumbilicatum* (Kiparisova), *Ambites* sp., *Koninckites aff. timorensis* Wanner, *Meekoceras boreale* Diener, *Meekoceras varaha* Diener, *Dieneroceras chaoi* Kiparisova, *Preflorianites cf. radiatus* Chao.
11. Dark grey mudstone, intercalated with grey-green, fine grained striped sandstone (up to 20 cm thick) and grey medium-graines sandstone (5-10 cm thick) — 2.7 m

10. Light grey, striped, medium-grained sandstone, intercalated with grey green, fine-grained sandstone (5 cm thick) and with calcareous-marly boulders 8.0 m

Contains nautiloids (*Gyronautilus praevolutum* (Kiparisova)) and ammonoids (*Meekoceras boreale* Diener). *Hedenstroemia sp. indet* (Kiparisova, 1961) seems to be found by Korzh in the member 10 or just below.

9. Grey, middle-grained sandstone intercalated with grey thin-grained, striped sandstone, with small, acute-angled pieces of dark grey siltstone and thin (5 cm) layer of dark grey mudstone at the base 2.15 m

Yield ammonoids (*Melagathiceratidae gen. et sp. nov.*)

8. Light grey, medium-grained sandstone intercalated with grey, thin-grained, striped (because of presence of very thin layers of mudstone) sandstone and lenses of conquinoid calcareous sandstone (up to 50 cm thick); the surface of beds show distincted asymmetric signs of ripples 1.8 m

With brachiopods (*Lingula borealis* Bittner, *Orbiculoides* sp., *Albrekia sulcata* Dagys (dominant), bivalves (*Promyalina* sp.), ammonoids (*Arctoceras? sp. indet.*, *Melagathiceratidae gen. et sp. nov.*).

7. Grey, medium-grained sandstone with rare and very thin layers of dark grey mudstone and siderite boulders and layer (30 cm) of grey, coquinoid calcareous sandstone at the base 2.6 m

Yields bivalves (*Promyalina* sp., *Entolium microtis* (Wittenburg), *Velopecten minimus* Kiparisova, Pectinidae gen. et sp. nov.), ammonoids (*Meekoceras boreale* Diener, Ambites sp.), Nautiloids (*Phaedrysmocheilus* sp.).

Induan Stage

6. Greyish-green, medium-grained sandstone with very thin interlayers of dark grey mudstone, that appear within every 0.5-0.6 m, and a layer (30 cm) of coquinoid calcareous sandstone at the base; asymmetric ripples are recognizable at bed surfaces 5.0 m

With brachiopods (*Lingula aff. borealiis* Bittner, *Orbiculoidea* sp.), bivalves (*Eumorphotis multiformis* (Bittner), *Neoschizodus laevigatus* (Zieten), *Anodontophora fassaensis* (Wissman)), gastropods, ammonoids (*Gyronites subdharmus* Kiparisova), *Ambites* sp.

5. Greyish-green, medium-grained, micaceous sandstone with many thin layers (2-10 mm, rarely 40 mm) of dark grey mudstone and lenses (up to 30 cm) of coquinoid calcareous sandstone; asymmetric ripples are recognizable at bed surfaces - and evidence of the SE (125°) flow 6.0 m

With bivalves (*Neoschizodus laevigatus* (Zieten), plant leaves

4. Greyish-green, medium-grained sandstone with lenses (up to 15 cm thick) of coquinoidal calcareous sandstone and layer of grey, striped (because of presence of very thin (1-3 mm) layers of mudstone (sandstone, 5 m above the base) 8.0 m

With brachiopods *Lingula borealis* Bittner, *Orbiculoides* sp.), bivalves (*Claraia australasiatica* Krumb., *Promyalina putiatinensis* (Kiparisova), *Eupecten cf. ussuricus* (Bittner), *Entolium microtis* Wittenburg), ammonoids (*Gyronites subdharmus* Kiparisova), arthropodes (crabs).

3. Greyish-green, medium-grained sandstone with rare pebbles and rare lenses (up to 1-3 cm thick) of conglomerate and small, angular pieces of dark grey siltstone and rare fragments of bivalve shells 19.0-21.0 m

2. Greyish-green, medium grained sandstone with many lenses (up to 1-3 cm thick) of conglomerate 4.0-4.5 m

1. Conglomerate with small and intermediate sized pebble and greish-green, sandy matrix, which characterized by well sorted disintegrated material. Pebbles consist of mainly felsic and intermediate effusive rocks 3 m

Triassic basal conglomerate overlies with unconformity and erosion Murgabian terrestrial sediments of the Abrek Formation, represented in its upper part by light-grey, coarse-grained, tuffaceous sandstone and gravelstone.

Analysis of the faunistic assemblages

Radiolarians

Triassic radiolarians in Far East (Sikhote-Alin, Japan) are to date only known from cherts in olistostrome strata. During our investigation in 1997 abundant pure preserved radiolarians (spherical Spumellaria) were found and identified by Panasenko in terrigenous sediments of the Lower Anisian (lower part of the *Phyllocladiscites basarginensis* Zone) in Abrek Bay (Zakharov et al., in press).

Brachiopods

Five to six species of Lower and Middle Triassic brachiopods are known from Abrek Bay (Zakharov, Popov, 1999); in the Induan only inarticulates were found. Lower Olenekian sediments are characterized by the appearance and mass development of articulate brachiopods like *Abrekia sulcata* Dagys. *Lingula borealis* Bittner and *Orbiculoidea sp.* are characteristic for the sandstone facies of both the Induan and Lower Olenekian, with a prevalence *Orbiculoidea* in the top of the Induan.

Bivalves

In the lower part of the Induan bivalves and other invertebrates are very rare (single and broken valves). Similar bivalve assemblages were recognized in the sandy facies of both the upper Induan and lower Olenekian. Common species include *Entolium microtis* Wittenburg, *Neoschizodus laevigatus* (Zieten), and *Anodontophora fassaensis* (Wissman).

Among the dominant species occurring only in the Induan, only *Promyalina shamarae* Bittner and possibly also *Promyalina putiatinensis* (Kiparisova) can be mentioned here, although *Promyalina sp.*, closely resemling *Promyalina putiatinensis* occurs in the Lower Olenekian.

Nautiloids

Nautiloid remains were discovered only in the Olenekian and Anisian of Abrek Bay. Three taxa of Olenekian nautiloids occur: *Phraedrysmocheilus sp.*, *Menuthionautilus korzhi* Kiparisova and *Gyronautilus praevolutum* (Kiparisova). *Trematoceras sp.* is known from the Lower Anisian.

Ammonoids

Only two ammonoids are known from the Induan: *Gyronites subdharmus* Kiparisova (zonal species-index) and *Ambites sp.*

The base of the Olenekian *Hedenstroemia bosphorensis* Zone in the Abrek Bay section is determined by the first appearance of representatives of *Meekoceras*, which higher in the Zone associate with *Hedenstroemia* and some other typical Olenekian representatives. The ammonoid assemblage of the *Hedenstroemia bosphorensis* Zone consists of 18 species belonging to 14 genera (Fig. 3).

The base of the *Anasibirites nevolini* Zone in the section is marked by the first appearance of the zonal species-index. Further characteristic species of this zone are *Arctoceras labogense* (Zharnikova) (dominant), *Arctoceras subhydaspis* (Kiparisova), *Arctoceras abrekensis* (Kiparisova), *Gurleyites sp.*, *Palaeokazakhstanites ussuriensis* (Zakharov), *Hemiprionites dunajensis* Zakharov, *Eophyllites sp.* and *Parakymatites sp.nov.* Many ammonoid taxa first occurring in this zone (e.g., *Arctoceras septentrionale* (Diener), *Pseudoprosphingites magnumbilicatum* (Kiparisova), *Owenites koeneni* Hyatt et Smith, *Koninckites timorensis* Wanner, *Meekoceras varaha* Diener) are known also form the *Hedenstroemia bosphorensis* Zone of this section or in other sections in adjacent districts of South Primorye. Altogether the ammonoid assemblage of the *Anasibirites nevolini* Zone of Abrek Bay consists of 20 species belonging to 15 genera.

Ammonoids and other invertebrate groups are extremely rare in the Anisian part of the Abrek Bay section. They are represented by two forms only: *Leiophyllites sp.*, *Cuccoceras sp.nov.* They are representatives of the *Phyllocladiscites basarginense* Zone (or *Leiophyllites pradyumna* and *Phylloclasiscites basarginensis* Zone).

Crustaceae

A crab claw was found in the sandy facies of the Induan.

Amphibians
The presence of amphibian remains in clayey sediments of the *Anasibirites nevolini* Zone is shown by small fragments of osteal tissue.

Paleomagnetic results

According to Sokarev & Golozubov's new data (Zakharov et al., in press) the at least several of the 17 stratigraphical levels of the *Gyronites subdharmus* (Fig. 3, levels I-IV), *Hedenstroemia bosphorensis* (levels V-XIII) and *Anasibirites nevolini* (levels XIV-XVII) zones show a normal polarity. This suggests that the enitre interval represents a uniform, extended normal polarity zone.

Induan-Olenekian boundary beds in some other sections of the Primorye region

2.1 Tri Kamnya Cape
Recently, Zakharov (1994, 1996) discovered *Hedenstroemia bosphorensis* (Zakharov), *Parahedenstroemia sp.*, *Gyronites separatus* Kiparisova, *Gyronites aff. planissimus* Spath and *Ambites sp.* in the basal part of the Olenekian in the Tri Kamnya Cape section (in the sandy facies). The most representative ammonoid assemblage of the *Hedenstroemia bosphorensis* Zone (*Pseudosageceras*, *Parahedenstroemia*, *Ussuria*, *Arctoceras*, *Prosphingitoides*, *Paranannites*, *Ambites*, *Koninckites*, *Meekoceras*, *Anakashmirites*, *Flemingites* and *Euflemingites*) was found stratigraphically higher, in the clay facies, in association with the conodont *Neospathodus dieneri* Sweet (Buryi, 1979). The *Anasibirites nevolini* Zone has not been found in the section - the beds containing *Palaeokazakhstanites* and *Priolobus* (member 24) (Zakharov, 1996) could belong to this zone. Finds made during the last years in this section indicate that *Meekoceras gracilitatis* White occurs in the *Hedenstroemia bosphorensis* Zone, which is widespread in the western USA.

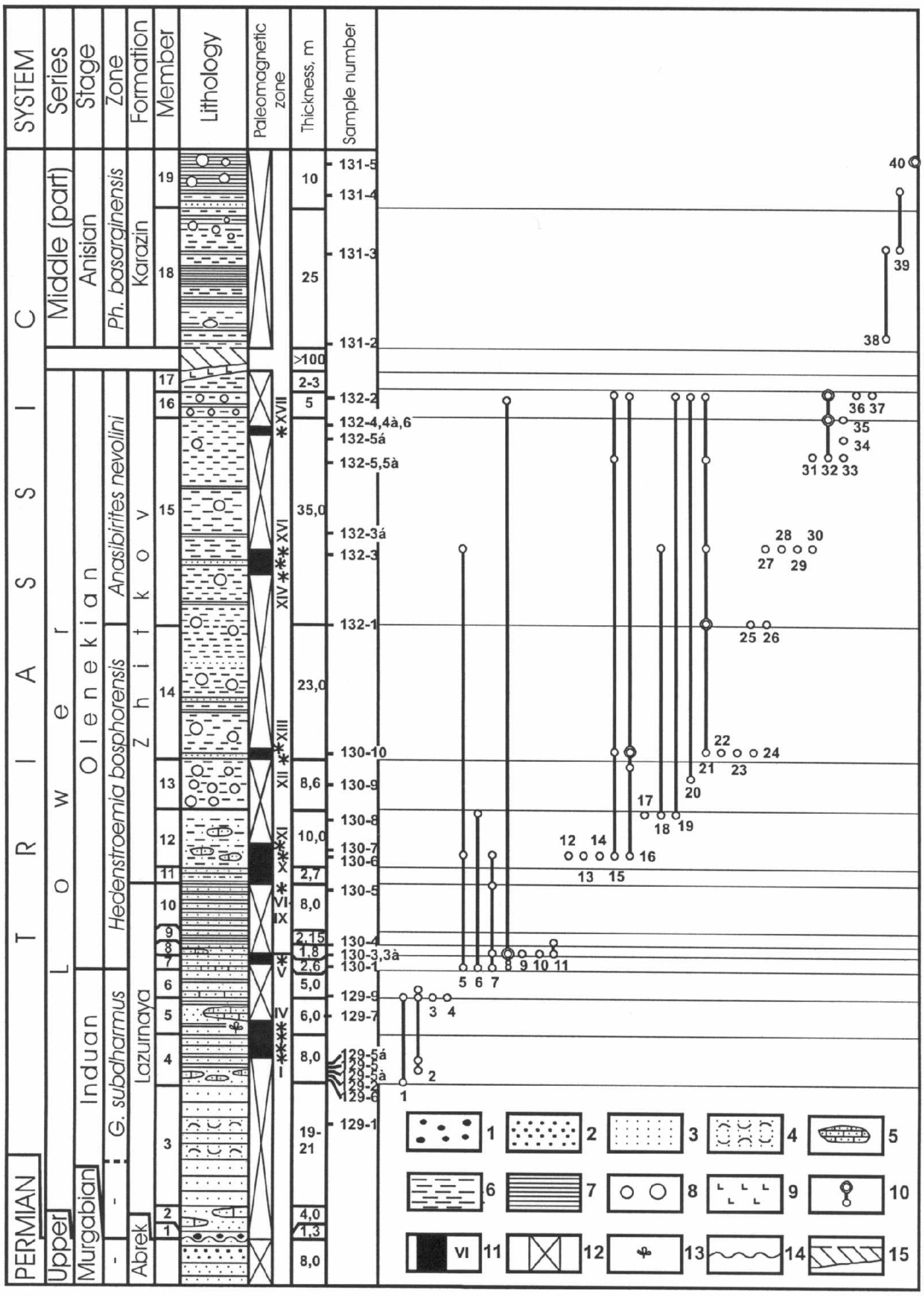

Fig. 3. Distribution ammonoids and some brachiopods and bivalves in the Induan, Olenekian and Anisian of Abrek Bay section. 1 - conglomerate, 2 - gravelstone, 3 - sandstone, 4 - sandstone with fragments of mollusk valves, 5 - coquinoid calcareous sandstone, 6 - siltstone, 7 - mudstone, 8 - nodule of marl, 9 - dike of porphyrite, 10 - interval of species distribution (domination is indicated by a double ring), 11 - paleomagnetic zone (interval of normal polarity), 12 - uninspected interval, 13 - plant remains, 14 - erosion, 15 - tuf-interval.

Species: 1 - *Gyronites subdharmus* Kiparisova, 2 - *Promyalina putiatinensis* (Kiparisova), 3 - *Promyalina* *schamarae* (Bittner), 4 - *Koninckites sp.* indet., 5 - *Promyalina sp.*, 6 - *Ambites sp.*, 7 - *Meekoceras boreale* Diener, 8 - *Abrekia sulcata* Dagys, 9 - *Hedenstroemia sp. indet.*, 10 - *Arctoceras? sp. indet.*, 11 - *Melagathiceratidae gen. et sp. nov.*, 12 – *Inyoites spicini* Zakharov, 13 - *Koninckites aff. timorensis* Wanner, 14 - *Dieneroceras chaoi* Kiparisova, 15 - *Pseudoprosphingites magnumbilicatum* (Kiparisova), 16 - *Meekoceras varaha* Diener, 17 - *Parahedenstroemia conspicienda* Zakharov, 18 - *Arctoceras septentrionale* (Diener), 19 - *Preflorianites cf. radiatus* Chao, 20 - *Meekoceras sp. nov.*, 21 - *Koninckites timorensis* Wanner, 22 – *Gyronitidae?*, 23 - *Flemingites radiatus* Waagen, 24 - *Anaxenaspis cf. orientalis* (Diener), 26 - *Anasibirites nevolini* Burij et Zharnikova, 27 - *Owenites koeneni* Hyatt et Smith, 28 - *Gyronitidae gen et sp. nov.*, 29 - *Palaeokazakhstanites ussuriensis* (Zakharov), 30 - *Eophyllites sp.*, 31 - *Pseudosageceras sp. indet.*, 32 - *Arctoceras labogense* (Zharnikova), 33 - *Euflemingites prynadai* (Kiparisova), 34 - *Arctoceras subhydaspis* (Kiparisova), 35 - *Pseudosageceras longilobatum* Kiparisova, 36 - *Parakymatites sp. nov.*, 37 - *Hemiprionites dunajensis* Zakharov, 38 - *Leiophyllites sp.*, 39 - *Cuccoceras sp. nov.*

2.2. Orel cliff

This section is located at the western coast of the Ussuri Gulf, 2 km north of Tri Kamnya Cape. Induan-Olenekian transition strata are fully developed in the sandy facies of the Lazurnaya Formation. The upper Induan is here, like in the Tri Kamnya Cape section, characterized by *Gyronites subdharmus* (Kiparisova), associated with *Promyalina schamarae* (Kiparisova) and conodonts - *Neogondolella cf. carinata juv.* (Clark), *Neospathodus? sp. indet.*, *Hindeodella sp. indet.*, *Lonchodina sp. indet.* (the latter were recently discovered by G.I. Buryi). *Meekoceras cf. subcristatum* Kiparisova and *Gyronites separatus* Kiparisova have been discovered at the base of the Olenekian, from where Buryi identified some conodonts (*Neospathodus sp. indet.*, *Diplododella sp. indet.* and *Lonchodina cf. triassica* (Müller)).

Isotopic analyses have shown, that $\delta^{13}C$ values in the upper part of the Induan reach + 1.2‰, are slightly reduced at the Induan-Olenekian boundary (up to + 0.3‰), and do not exceed + 0.8‰ in the remaining exposed part of the lower Olenekian (Zakharov et al., 1999). It should be noted that in organogenic carbonates of the middle Olenekian (*Tirolites - Amphistephanites* Zone) of South Primorye anomalously high 13C values (up to 4.9‰) were measured (Zakharov et al., 1999); this correlates well with middle Olenekian anomalies of the North Caucasus (Zakharov et al., 1999b, 2000).

2.3. Kom-Pikho-Sakho Cape

The section (Fig. 1) has much in common with the Abrek Bay section. The Induan-Olenekian boundary also is located in the sandy facies at the first appearence of *Meekoceras*. An abundant early Olenekian ammonoid assemblage (*Pseudosageceras*, *Hedenstroemia*, *Parussuria*, *Metussuria*, *Tellerites*, *Arctoceras*, *Prosphingitoides*, *Juvenites*, *Owenites*, *Prionolobus*, *Meekoceras*, *Inyoites*, *Hemiprionites*, *Gurleyites*, *Preflorianites*, *Bandoites*, *Flemingites*, *Euflemingites*) of the *Hedenstroemia bosphorensis* Zone is known from the lower part of the clay facies associated with the conodont *Furnishius triseratus* Clark (Burij, 1979). The main disadvantage of this section is the presence of a series of small faults at the Induan-Olenekian transition strata (5-10 m offset).

2.4. Yuzhnorechensk (Shimeuza)

Like in a number of other sections (Abrek, Orel, Kom-Pikho-Sakho) the sandy facies is characterized by the occurrence of species of *Meekoceras* (*Hedenstroemia bosphorensis* Zone). In the clay facies that forms the upper part of this zone, ammonoids are extremely abundant and varied (*Hedenstroemia*, *Ussuria*, *Metussuria*, *Arctoceras*, *Prosphingitoides*, *Owenites*, *Dieneroceras*, *Koninckites*, *Prionolobus*, *Parakymatites*, *Meekoceras*, *Inyoites*, *Hemiprionites*, *Flemingites*, *Eophyllites*). Conodonts from this interval include *Neospathodus discreta* (Müller), *N. zharnikovae* Buryi, *Furnishius triserratus* Clark, *Parachirognatus symmetrica* (Staeshe), *Hadrodontina subsymmetrica* (Müller), *H. nevadensis* Müller, *Chirodella dinodoides* (Tatge), *Lonchodina triassica* Müller, *L. nevadensis* Müller (Buryi, 1979). In the overlying *Anasibirites nevolini* Zone the zonal index-species occurs together with *Arctoceras, Juvenites, Gurleyites* and *Melagathiceratidae gen. et sp.nov.* An major disadvantage of this section is that Induan deposits are absent.

2.5. Artyom environs

We here present the first information on a section in the SMD quarry, 6 kms NE of the Uglovaya railway station. In northern part of the quarry the *Anasibirites nevolini* Zone is exposed. This zone is characterized by an abundance of ammonoids - e.g., *Arctoceras labogense* Zharnikova, *Prosphingitoides ovalis* (Kiparisova), *Prosphingitoides sp. nov.*, *Juvenites simplex* (Chao), *Prionolobus involutus* Zakharov, *Meekoceras sp. nov.*, *Hemiprionites dunajensis* Zakharov, *Anasibirites nevolini* Burij et Zharnikova, *Xenoceltites sp. nov.*, *Anaxenaspis sp. nov.*, *Melagathiceratidae gen. et sp. nov.* -, and bivalves - *Posidonia mimer* Oeberg, *Posidonia ussurica* Kiparisova, *Posidonia sp.*, *Nuculana elliptica* (Goldfuss), *Pteria ussurica* (Kiparisova), *Leptochondria cf. bittneri* Kiparisova, *Atomodesma? sp.* (det.: Dorukhovskaya). Underlying sediments, inluding sandstones, are not exposed here (only found in loose blocks). Judging from the occurrence of *Leiophyllites* and *Hollandites*? the southern part of the quarry consists of Anisian sediments. The relationship of this member to underlying sediments is still uncertain.

2.6. Artyomovka River

Early Olenekian ammonoids are known from the clay facies of the *Hedenstroemia bosphorensis* Zone on the left bank of the Artemovka River (*Arctoceras*, *Prosphingitoides*, *Juvenites*, *Owenites*, *Dieneroceras*, *Meekoceras*, *Hemiprionites*, *Anaxenaspis*, and *Eophyllites*). Induan sediments are not exposed there. The ammonoid assemblage of the overlying *Anasibirites nevolini* Zone includes *Parahedenstroemia*, *Arctoceras*, *Parananites*, *Owenites*, *Arctoprionites*, *Hemiprionites*, *Wasatchites*, *Gurleyites*, and *Subalbanites*. The following conodonts are known from the *Anasibirites nevolini* Zone: *Neogondolella milleri* (Müller), *Neospathodus waageni* Sweet, *N. discreta* (Müller), *Furnishius triserratus* Clark, *Hindeodella nevadensis* Müller, *H. budurovi* Buryi, *H. raridenticulata* Müller, *Hadrodontina adunca* Staesche, *H. symmetrica* (Staesche), *H. subsymmetrica* (Müller), *Parachirognathus symmetrica* (Staesche), *H. subsymmetrica* (Müller), *Parachirognathus symmetrica* (Staesche), *Lonchodina triassica* (Müller) This is the type section of the *Anasibirites nevolini* Zone in South Primorye (Burij et al., 1972; Zakharov, 1978).

2.7. Ayax Bay

Ayax Bay is the only place on Russian Island, where the Induan-Olenekian transition in a sandy facies can be studied. The top of the Induan, approximately 2 m thick, exposed on the coast, contains ammonoids (*Gyronites? sp.*) bivalves (e.g., *Eumorphotis multiformis* (Bittner), *Promyalina shamarae* (Bittner)(Zakharov, 1996), and also conodonts (*Neospathodus pakistanensis* Sweet, *Parachirognathus sp.* (Buryi, 1979). An index-species of the *Gyronites subdharmus* Zone obviously occur at the same stratigraphical level in an adjacent section of Novik Bay.

Somewhat higher in the sequence (at the roadside, and cliff in the south coast of the Ayax Bay) sandstone with small ammount of coquinoid calcareous sandstone are found. This sandstone is supposed to be of early Olenekian age because of the presence of *Proharpoceras carinatitabulatum* Chao and *Juvenites cf. simplex* (Chao). The little material from the Abrek Bay section and other Lower Triassic sections in South Primorye shows, that strata characterized by early Olenekian ammonoids are easily recognized. The major difficulty regarding the Induan-Olenekian transition in the area is its poor exposure in most of the sections.

Lithological facies of the Lower and Middle Triassic of South Primorye

There are two main lithologies in the Lower Triassic in South Primorye: (1) the polyfacies type and (2) the bifacies type. The first is characteristic for the western sections (Russian Island, western coast of the Amur Gulf between Alasov and Ugolnyi Capes), and the second for the eastern sections (Artyomovka River, Artyom environs, Kom-Pikho-Sakho Cape, Krasnorechensk (Shimeuza) station, Abrek Bay). The Tri Kamnya Cape section of western coast of the Ussuri Gulf lithologically holds an intermediate position between the series of sections but tends to the polyfacies type.

The sections of Russian Island are proposed as reference for the polyfacial type of the Lower Triassic in South Primorye. Zakharov (1997) recognized several formations there:

1. The Lazurnaya Formation, comprising the Induan and the lower part of the Olenekian *Hedenstroemia bosphorensis* Zone (it is primarily exposed in Ayax Bay area of Russian Island, but its stratotype is located at western coast of the Ussuri Gulf, between Lazurnaya (Shamara) Bay and Tri Kamnya Cape (Zakharov, 1968).
2. The Tobizin Formation, comprising the *Hedenstroemia bosphorensis* Zone (excluding its basal beds) and the *Anasibirites nevolini* Zone, with its stratotype at Tobizin Cape, Russian Island
3. The Schmidt Formation, only comprising the *Tirolites - Aphistephanites* Zone with the stratotype at Schmidt Cape, Russian Island
4. The Zhitkov Formation comprising the *Neocolumbites insignis* and *Subcolumbites multiformis* Zones, with the stratotype at Zhitkov Cape, Russian Island. The latter is overlain there by the Anisian Karazin Formation, having its stratotype in the district of Karazin Cape, Russian Island.

The first three formations are represented mainly by sandy facies, but the Lazurnaya Formation (110 m) differs by the predominance of coarse, disintegrated rocks at its base and the appearance of bivalve coquinas in its middle and upper parts. The Tobizin Formation (180 m) is characterized by the development of cephalopod coquinoids and the appearance of the thin siltstone member. The Schmidt Formation (40 m) is characterized by the abundance of rather thick (up to 1.2 m) lenses of bivalve and brachiopod coquinoid calcareous sandstone and limestone. The Zhitkov Formation (85 m) is strongly differs from the underlying formations of the Lower Triassic in the extensive development of siltstone and mudstone with abundant remains of ammonoid and bivalve shells. The Karazin Formation is characterized by a predominance of banded and spotted sandy siltstone alternating with sandstone, including unusually light, arkose, lacking benthonic mollusc remains (except the basal beds), but with radiolarian and ammonoid remains.

The Lower Triassic of the eastern sections comprise only two formations: the Lazurnaya and Zhitkov formations. The sharp boundary between these - see e.g. the Abrek Bay section (Fig. 3) - lies in the *Hedenstroemia bosphorensis* Zone. The sequential change of facies correlates with a lower subsidence of the basin in the western or southwestern parts than in the eastern part.

The deposition of the sediments of the Karazin Formation seems to have taken place on the deepest parts of a shelf as is evidenced by radiolarian accumulations in boulders at Abrek Bay; radiolarians are not known from the more shallow shelf facies of the Lower Triassic. Typical Far East Anisian facies are widespread - from Little Khingan in the northwest up to South Primorye and Kitakami in the southeast. The reduction of the number of benthonic remains in Anisian sediments could be related with to the accumulation in the deepest parts of a shelf with an oxygen deficit. For the benefit of various conditions of sedimentation in Early and Middle Triassic more expressed intensivity of phosphatogenes during Anisian can testify in comparison with Induan and Olenekian (Zakharov & Shkolnik, 1994).

Concluding remarks

Our analysis shows that in the present stage of biostratigraphic investigation only two candidates for a global stratotype of the Induan-Olenekian boundary can be proposed: (1) the Tri Kamnya Cape – Orel cliff section, and (2) Abrek Bay section. All other investigated Lower Triassic sections of the Lower Triassic, can, even when less favorable, be used for studying ammonoid assemblages of the Upper Induan and Lower Olenekian in order to get a better overall view, and thus may help to solve many problems with regard to global correlations.

The position of the Induan-Olenekian boundary in South Primorye, the Himalayas, Siberia and Canada can be defined at first appearence of the ammonoid *Hedenstroemia*. The occurrence of *Meekoceras gracilitatis* White in association with *Flemingites* and other typical representatives of the *Hedenstroemia bosphorensis* Zone in South Primorye allows a sound correlation with both the *Meekoceras gracilitatis* Zone of Idaho and the *Flemingites flemingianus* Zone of the Salt Range. It recently became clear that *Euflemingites prynadai* (Kiparisova) and representatives of the genus *Arctoceras* occur throughout the lower two zones of the Olenekian in South Primorye. Because species of *Euflemingites* and *Arctoceras* are known from the Lower Triassic of the Boreal realm, there enable a more accurate correlation of the Smithian of the Boreal realm (Tozer, 1995) with the lower zones of the Ayaxian substage of the Tethys (Zakharov, 1997).

The extended interval of normal polarity assumed for the investigated part of the Olenekian in South Primorye and data the destribution of *Arctoceras* and *Euflemingites* could correspond to a large zone of normal polarity of Spitsbergen and Canada (Mørk et al., 1999) that has recently been established in the Smithian *Euflemingites romundary* (upper part) and *Wasatchites tardus* zones.

References

Arthaber, G., 1911. Die Trias von Albanien. Beitr. Paläontol. Geol. Österr. -Ung. Anf. Orients. Wien., 24: 169-277.

Bittner, A., 1899. Trias-Ablagerungen des Süd-Ussuri-Gebietes in der Ostsibirischen Küstenprovinz. Mém. Com. Géol., 7(4): 1-35, Taf.1-4.

Burij, I.V., 1959. Triassic stratigraphy of South Primorye. Trudy Dalnevost. Politekhn. Inst., 1959(1): 3-34. (In Russian.)

Burij, I.V., 1997. Paleogeography of Triassic sedimentation in South Primorye. Mém. Géol. (Lausanne), 30: 25-34 (in Russian).

Burij, I.V. & Zharnikova, N.K., 1981. Ammonods from Tirolites Zone of South Primorye. Paleont. Zhurn., 1981(3): 61-69 (in Russian).

Burij, I.V., Zakharov, Y.D., Zharnikova, N.K. & Nevolin, L.A., 1972. On finding of Anasibirites fauna in South Primorye and its stratigraphical significance. In: Osadochnye i vulkanogennye formatsii Dalnego Vostoka (Sediment and volcanogenic formations of Far East), 1972: 79-81. Vladivostok, DVNC Akad. Nauk SSSR (in Russian).

Burij, I.V., Zharnikova, N.K., Lozovsky, V.R. & Buryi, G.I., 1977. K biostratigrafii nizhnego triasa Yuzhnogo Primorya (To Lower Triassic biostratigraphy of South Primorye). Izv. Vysshikh uchebnykh zavedenii, » Geolgiya i Razvedka» , VINITI, 1977 (243-77 Dep.): 1-34, Moskva (in Russian).

Burij, I.V., Zharnikova, N.K. & Buryi, G.I., 1976. To the problem of subdivision of the Lower Triassic of South Primorye. Geol. Geoph., 1976(7): 150-156 (in Russian).

Burij, I.V., Buryi, G.I. & Zharnikova, N.K., 1976. Stratigraphy and interrelationship of marine and continental Triassic deposits in South Primorye. In: S.G. Lucas & M. Morales (eds.), New Mexico Mus. Nat. Hist. Sci., Bull, 3: 47-49.

Buryi, G.I., 1979. Lower Triassic conodonts of South Primorye., 143 pp., pls. 1-21. Moskva, Nauka (in

Russian).
Chao King-joo, 1959. Lower Triassic ammonoids from Western Kwangsi, China. Palaeontol. Sinica, N.S.B., 9: 155-355.

Dagys, A. S., 1974. Triassic brachiopods, 387 pp., pls. 1-49. Novosibirsk, Nauka (in Russian).

Diener, C., 1895. Triadische Cephalopodenfaunen der ostsibirischen Küstenprovinz. Mém. Com. Géol., 14(3): 1-59, pls. 1-5, St.-Péterbourg.

Guex, J., 1978. Le Trias Inférieur des Salt Ranges (Pakistan): problèmes biochronique. Eclog. Geol. Helv., 71: 105-144.

Ivanov, D.L., 1891. Geological report 1888. Gornyi Zhurn., 1891(8): 248-304 (in Russian).

Karpinsky, A.P., 1888. Margaritov's investigations in Primorye area. Izv. Geol. Com., 21: 349-351 (in Russian).

Kiparisova, L.D., 1938. Lower Triassic bivalves of Ussuri region. Trudy GIN AN SSSR, 7: 197-311 (in Russian).

Kiparisova, L.D., 1961. Paleontological basis of Triassic stratigraphy of Primorye region. 1. Cephalopods. Trudy VSEGEI, n. ser., 48: 1-278, pls. 1-38 (in Russian).

Kiparisova, L.D., 1961. Paleontological basis of Triassic stratigraphy of Primorye region. 2. Late Triassic molluscs and general stratigraphy. Trudy VSEGEI, n. ser., 181: 1-246, pls. 1-17 (in Russian).

Kiparisova, L.D. & Popov, Y.N., 1956. Subdivision of the Lower series of the Triassic system into stages. Dokl. Akad. Nauk SSSR, 109(4): 842-845 (in Russian).

Kiparisova, L.D. & Popov, Y.N., 1964. The project of subdivision of the Lower Triassic into stages. XXII Int. Geol. Congress, Rep. Soviet Geologists, Problem 16a, p. 91-99 (in Russian).

Korzh, M.V., 1959. Petrographiya triasovykh otlozheniy Yuzhnogo Primorya i paleogeographiya vremeni ikh obrazovaniya (Petrography of Triassic sediments of South Primorye and paleogeography of the time of their accumulation), 83 pp.. Moskva, Izd. AN SSSR (in Russian).

Kiparisova, L.D., Popov Y.N., 1964. A scheme for the subdivision of the Lower Triassic into stages. Intern. Geol. Congress (India). Report of the Twenty-Second Session. Pt. 8. Proceedings of section 8. Palaeontology and Stratigraphy., p. 223-232. New Delhi.

Kozur, H., 1972. Vorläufige Mitteilung zur Parallelisierung der germanischen und tethyalen Trias sowie einige Bemerkungen zur Stufen- und Unterstufengliederung der Trias. Mitt. Ges. Geol. Bergbaustud., 21: 361-412.

Kozur, H., 1992. The problem of the Lower Triassic subdivision. Albertiana, 10: 21-22.

Kummel, B., 1973. Aspects of the Lower Triassic (Scythian) stage. Mem. Canad. Soc. Petrol. Geol., 1973(2): 557-571.

Mojsisovics, E., 1882. Die Cephalopoden der mediterranen Triasprovinz. Abb. Geol. Reichsanst., 10: 1-322.

Mojsisovics, E, 1886. Arktische Triasfaunen. Beitraege zur palaeontologischen Charakteristik der arktisch-pazifischen Triasprovinz. Mem. Acad. Sci. Nat., 7(33): 1-159, St. Petersbourg.

Mojsisovics, E., Waagen, W. & Diener, C., 1895. Entwurf einer Gliederung der pelagischen Sedimente des Trias-System. Sitz. Ber. Akad. Wiss. Wien, math. Naturwiss. Kl., 104: 1271-1302.

Mørk, A., Elvebakk, G., Fosberg, A.W., Hounslow, M.W., Nakrem, H.A., Vigran, J.O. & Weitschat, W., 1999. The type section of the Vikinghogda Formation: new Lower Triassic unit in central and eastern Svalbard. Polar Res., 18: 51-82.

Mojsisovics, E., 1873-1875. Das Gebirge um Hallstatt. 1. Die Mollusken Faunen der Zlambach und Hallstaetter-Schichten. Abhandl. Geol. Reichsanst. Wien, 6(1,2): 1-174.

Rostovtsev, K.O. & Dagys, A.S., 1987. A standard for the Lower Triassic. 27th Int. Geol. Congress. Stratigraphy. C.01.1, 79-86. Moskva, Nauka (in Russian).

Shevyrev, A.A., 1990. Ammonoids and Triassic chronostratigraphy. Trudy Paleont. Inst AN SSSR, 241: 1-179 (in Russian).

Shevyrev, A.A., 1995. Triassic ammonites of Northwestern Caucasus. Trudy Paleont. Inst., 264: 174 pp. (in Russian).

Tozer, E.T., 1965. Latest Lower Triassic ammonoids from Ellsmere Island and north-eastern British Columbia. Bull. Geol. Surv. Can., 123: 1-45.

Tozer, E.T., 1978. Review of the Lower Triassic ammonoids succession and its bearing on chronostratigraphic nomenclature. Schriftern. Erdwiss. Kom. Oester. Akad. Wiss., 4: 21-36.

Tozer, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Survey Canada Bull., 467: 1-663.

Vavilov, M.N. & Lozovsky, V.R., 1970. To the problem of Lower Triassic stage differentiation. Izv. Akad. Nauk SSSR, Ser. Geol., 1970 (9): 93-99 (in Russian).

Wittenburg, P.V., 1910. Geological note on Murav'ev-Amursky Peninsula and Russian Island, 44 pp., S.-Petersburg (in Russian).

Wittenburg, P.V., 1916. Geological description of Murav'ev-Amursky Peninsula and Imper. Evegene. Zapiski Obstchestva Izucheniya Amurskogo Kraya, 15: 1-480 (in Russian).

Voinova, E.V., Kiparisova, L.D. & Robinson, V.N., 1947. Class Cephalopoda. Atlas rukovodyaschikh form iskopaemykh faun SSSR (Atlas of guide fossil fauna of USSR), 7. Triassic System., p. 124-176. Moskva-Leningrad: Gosgeolizdat (in Russian).

Waagen, W., 1895. Salt Range fossils. 2. Fossils from Ceratite Formation. Paleont. Indica. Ser. 13, 2: 1-323.

Zakharov, Y.D., 1968. Biostratiraphiya i ammonoidei nizhnego triasa Yuzhnogo Primorya (Lower Triassic biostratigraphy and ammonoids of South Primorye), 175 pp., pls. 1-31. Moskva, Nauka (In Russian).

Zakharov, Y.D., 1973. New stage zone subdivision of the Lower Triassic. Geologiya i geophizika, 1973(7): 51-58 (in Russian).

Zakharov, Y.D., 1978. Rannetriasovye ammonoidei Vostoka SSSR (Early Triassic ammonoids of the East USSR), 224 pp., pls. 1-19. Moskva, Nauka (in Russian).

Zakharov, Y.D., 1986. The problem of stage-subdivision of the Lower Triassic. Albertiana., 6: 14-21.

Zakharov, Y.D., 1994. Stratotype of the Induan-Olenekian boundary of the Lower Triassic. Tikhookeanskaya Geologiya, 1994(4): 33-44 (in Russian).

Zakharov, Y.D., 1996. The Induan-Olenekian boundary in the Tethys and Boreal realm. Ann. Mus. Civ. Rovereto. Sec.: Arch., St., Sc. Nat., Suppl., 11: 133-156.

Zakharov, Y.D., 1997. Ammonoid evolution and the problem of the stage and substage division of the Lower Triassic. Mém. Géologie (Lausanne), 30: 121-136.

Zakharov, Y.D. & Popov, A.M., 1999. New data on Induan/Olenekian boundary in South Primorye. Annual report 1999 of IOBWG. Albertiana, 22: 19.

Zakharov, Y.D. & Shkolnik, E.L., 1994. Permian-Triassic cephalopod facies and global phosphatogenesis. Mém. Géologie (Lausanne), 22: 171-182.

Zakharov, & Rybalka, S.V., 1987. A standard for the Permian-Triassic in the Tethys. In:Y.D. Zakharov & Y.I. Onoprienko (eds.), Problems of Permian and Triassic biostratigraphy of the East USSR, p. 6-48, pls. 1-5. Vladivostok, DVNC AN SSSR (in Russian).

Zakharov, Y.D. & Sokarev, A.N., 1991. Biostratigraphiya i paleomagnetizm permi i triasa Evrazii (Permian and Triassic biostratigraphy and paleomagnetism of Eurasia), 135 pp. Moskva, Nauka (in Russian).

Zakharov, Y.D., Ukhaneva, N.G., Ignatyev, A.V., Afanasyeva, T.B., Buryi, G.I., Panasenko, E.S., Popov, A.M., Punina, T.A. & Cherbadzhi, A.K., 2000. Latest Permian and Triassic carbonates of Russia: new palaeontological findings, stable isotopes, Ca-Mg ratio, and correlation. In: H.Yin, J.M. Dickins, G.R.Shi & J.Tong (Editors), Permian-Triassic evolution of Tethys and Western circum-Pacific. Developments in palaeontology and stratigraphy, 18: 141-171.

Zakharov, Y.D., Ukhaneva, N.G., Ignatyev, A.V., Popov, A.M. & Punina, T.A., 1999. Prelimenery data on carbon and oxygen isotopic composition of Triassic organgenic carbonates of the Tethyan belt and biological productivity of Triassic seas. Tikhookeanskaya Geologiya, 18 (3):47-53 (in Russian).

Zakharov, Y.D., Ukhaneva, N.G., Ignatijev, A.V., Afanasyeva, T.B., Buryi, G.I., Kotlyar, G.V., Panasenko, E.S., Popov, A.M., Punina, T.A., Cherbadzhi, A.K. & Vuks, V.Y., 1999. Dorashamian, Induan, Olenekian, Anisian, Ladinian, Carnian, Norian and Rhaetian carbonates of Russia: stable isotopes, Ca-Mg ratio, and correlation. Albertiana, 22. 27-30.

Zakharov, Y.D., Shigeta, Y., Popov, A.M., Sokarev, A.N., Buryi, G.I., Golozubov, V.V., & Panasenko, E.S., in press. Candidates in global stratotype of the Induan-Olenekian boundary (Lower Triassic) in Primorye region. Stratigr. Geol. Correlation (in Russian).

BIOCHRONOLOGICAL SIGNIFICANCE OF TRIASSIC NONMARINE TETRAPOD RECORDS FROM MARINE STRATA

Spencer G. Lucas and Andrew B. Heckert

We review 16 records of nonmarine Triassic tetrapod fossils from marine strata or from nonmarine strata closely intercalated with marine strata. Most of these records provide important points of cross correlation between nonmarine Triassic tetrapod biochronology and marine biochronology of the Triassic, which is based mostly on conodonts and ammonoids. Particularly important among these are records of tetrapod index taxa of the nonmarine timescale, which facilitates its cross-correlation to the standard global chronostratigraphic scale for Triassic time. These records thus allow cross-correlation of: Lootsbergian = middle-late Induan; Nonesian = Olenekian; Perovkan = early Anisian; Berdyankian = midlate Ladinian; Otischalkian = Carnian; and Revueltian = mid Norian.

Introduction

The standard global chronostratigraphic scale for Triassic time is based on marine invertebrate biostratigraphy, especially of conodonts and ammonoids. In nonmarine Triassic strata, tetrapods (amphibians and reptiles) provide a robust global biochronology with which to subdivide Triassic time (Lucas, 1998). Records of nonmarine tetrapods in Triassic marine strata thus can provide a direct cross-correlation of marine and nonmarine Triassic biochronology. Here, we review these records (Fig. 1) and establish their significance to such cross-correlation (Fig. 2). Note that we only review marine records of nonmarine tetrapods, not those of the marine tetrapod groups found in Triassic strata (Hupehsuchia, Nothosauria, Placodontia, Sauropterygia, Ichthyosauria, Plesiosauria and some Prolacertilia). Also, we have confined our review to records in true marine strata or to those records in nonmarine strata that are closely interbedded with well-correlated marine strata. We do not include records in nonmarine strata that can only be correlated to marine strata indirectly. Finally, although we hope ours is a complete list (given here in numerical order, from oldest to youngest), we seek comments/additions from interested parties.

Early Triassic

1. Wordy Creek Formation, eastern Greenland

Marine strata yield the temnospondyls *Luzocephalus kochi* (Säve-Söderbergh), *L. johanssoni* (Säve-Söderbergh), *Wetlugasaurus groenlandicus* (Säve-Söderbergh), *Stoschiosaurus nielseni* (Säve-Söderbergh) and *Tupilakosaurus heilmani* Nielsen (Säve-Söderbergh, 1935; Nielsen, 1954). The lowest occurrence (LO) of *Luzocephalus* is in the *Ophiceras commune* Ammonite Zone, and the genus extends up through the "*Proptychites rosenkrantzi* Zone." Most of the Wordy Creek amphibians are from the younger "*Anodontophora fassarensis* beds," which are the youngest Lower Triassic strata in this section (Nielsen, 1935; Säve-Söderbergh, 1935). This establishes a late Griesbachian-early Dienerian (middle Induan) range of *Luzocephalus*, but the other temnospondyl taxa are middle or late Dienerian (late Induan) in age (Trümpy, 1961, Silberling & Tozer, 1968; Tozer, 1994).

Luzocephalus, *Tupilakosaurus*, and *Wetlugasaurus* occur in the Vokhmian Horizon of the Vetlugian Series of the Russian Urals (Shishkin et al., 1995). This fauna includes *Lystrosaurus*, an index taxon of the Lootsbergian land-vertebrate faunachron, so the amphibians establish a middle-late Induan age for at least part of Lootsbergian time.

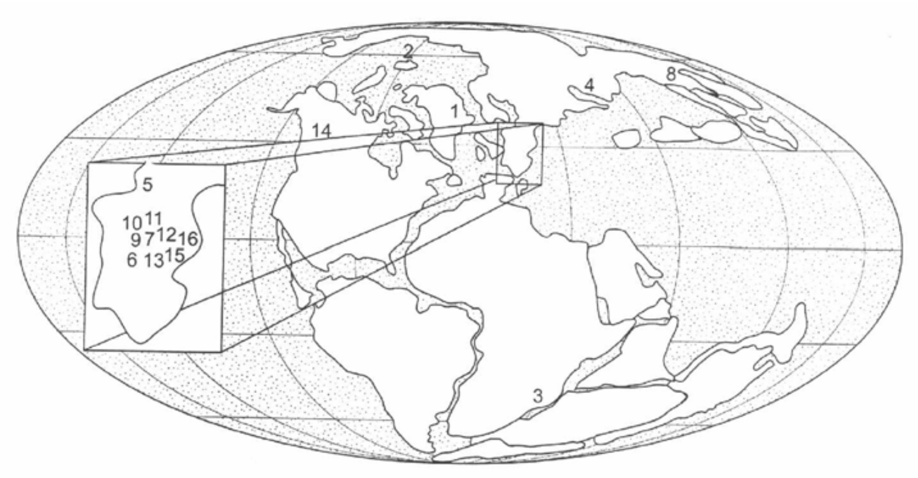

Fig. 1 Distribution of the 16 marine occurrences of Triassic nonmarine tetrapods in Pangea. Numbers are those used in the text

2. Sticky Keep Formation, Svalbard

Temnospondyls that co-occur here with early Olenekian (Smithian) ammonites (Buchanen et al., 1965; Tozer, 1967) are: *Sasenisaurus spitsbergensis* Wiman, *Peltostega erici* Wiman, *P. wimani* Nilsson, *Aphaneramma rostratum* Woodward, *Lyrocephaliscus euri* (Wiman), *Teretrema acuta* Wiman and *Boreaosaurus thorslundi* Nilsson (Wiman, 1910, 1915; Nilsson, 1942, 1943; Cox & Smith, 1973). These trematosaurs are believed to have been *euryhaline* amphibians that may have actually lived in marine environments. They also reflect a high diversity and abundance of trematosaurs characteristic of the Nonesian. However, the Svalbard trematosaur taxa are mostly endemic and thus only provide stage-of-evolution evidence for an Olenekian-Nonesian cross-correlation.

3. Andavakoera Formation, northwestern Madagascar

The upper part of the marine Andavakoera Formation (lower Dienerian) yields a diverse assemblage of temnospondyls: ?*Benthosuchus madagascanensis* Lehman, ?*Wetlugasaurus* sp., *Mahavisaurus dentatus* Lehman, *M. australis* (Lehman), *Aphaneramma sp.*, *Alfasaurus elongatus* Lehman, *Tertrema sp.*, *Tertremoides ambilobensis* Lehman, *Trematosaurus madagascariensis* Lehman, *Wantzosaurus elongatus* Lehman and *Deltacephalus whitei* Swinton (Swinton, 1956; Lehman, 1961, 1966, 1979). The *Benthosuchus* and *Wetlugasaurus* identifications have been debated (Cosgriff, 1984), but if correctly determined, the record of these Lootsbergian index taxa in the Andavakoera Formation provides a Lootsbergian-Dienerian (late Induan) cross-correlation. The diverse *trematosaurs* in the Andavakoera Formation also parallel the Sticky Keep Formation record. Indeed, some of the same taxa occur in both the Sticky Keep and the Andavakoera, which reinforces the cross correlation of the Lootsbergian and Dienerian.

4. Mangyshlak Peninsula, western Kazakstan

Lozovsky and Shishkin (1974) documented *Parotosuchus sequester* Shishkin from marine upper Olenekian strata that yield *Tirolites* and other ammonites. *Parotosuchus* (sensu stricto) is an index taxon of Nonesian time, with numerous nonmarine records. This provides a direct Nonesian-late Olenekian cross-correlation.

Middle Triassic

5. Gogolin Formation (lowermost Muschelkalk), Polish Silesia - fragmentary temnospondyl and archosaur fossils include the types of *Mentosaurus waltheri* Röpke, *Eurycervix posthumus* Huene, and "*Xestorrhytias perrini*" Meyer, all of which are indeterminate mastodonsaurids, and therauisuchian *Zanclodon silesiacus* Jaekel, based on a single tooth. Ammonite biostratigraphy places the Gogolin Formation in the lower Anisian (e.g., Kaim & Niedwiedzki, 1999). The tetrapod material, however, is too fragmentary to be of much biochronological significance. Nevertheless, it closely resembles some of the tetrapods from the Upper Buntsandstein of southwestern Germany-eastern France, and thus supports a Perovkan-early Anisian correlation.

6. Röt Formation (upper Buntsandstein), southwestern Germany-eastern France - these strata are lower Anisian marginal marine to interbedded nonmarine/marine facies of well-established age because of their close physical relationship to the lower Muschelkalk. The common amphibian from the Röt Formation, *Eocyclotosaurus*, is an index taxon of the Perovkan found in both Europe and the western United States (e.g., Ortlam, 1970; Morales, 1987). The Röt records of *Eocyclotosaurus* thus provide a Perovkan-early Anisian cross-correlation.

7. Partnach Formation, Austria - The early Ladinian Partnach Formation of western Austria yielded a temnospondyl jaw fragment that Sander & Meyer (1991) identified as cf. *Cyclotosaurus sp.* However, this specimen could just as well belong to *Mastodonsaurus* (cf. Schoch, 1999), so it is of limited biochronological significance.

8. Badong Formation, Hunan, China - Zhang (1975) described the unusual archosaur *Lotosaurus adentus* from the Badong Formation of Hunan, which yields primitive species of the ammonite *Proganoceratites* and the marine bivalve *Leptochondria subillyrica* and is of Anisian age (H. Yin, written comm., 2000). *Lotosaurus* is endemic to this record, so it is of no current biochronological significance.

9. Upper Muschelkalk (Meissner Formation and equivalents), southwestern Germany - the uppermost Muschelkalk contains several bonebeds (Hagdorn & Reif, 1988). These include records of *Mastodonsaurus* (Schoch, 1999), a *Dinodontosaurus-like* dicynodont (Broili, 1921) and *rauisuchians* ("*Zanclodon scheutzi*" Fraas), among other terrestrial tetrapods. These records, which are early Ladinian in age, provide an important cross-correlation of the Berdyankian (index taxon = *Mastodonsaurus*) to part of Ladinian time.

10. Lettenkeuper, southwestern Germany - parts of the lower Keuper include marine, marginal marine and evaporitic strata and yield a prolific vertebrate record dominated by *Mastodonsaurus* (Schoch, 1999). This provides cross-correlation of part of the Berdyankian to the late Ladinian (Longobardian).

Late Triassic

11. Raibler Schichten, Austria - Koken (1913) described *Metoposaurus santaecrucis* from a conglomeratic sandstone in the upper part of the Raibler Schichten. This is a Julian record, and thus

cross-correlates part of the Otischalkian (index taxon = *Metoposaurus*) to the early Carnian.

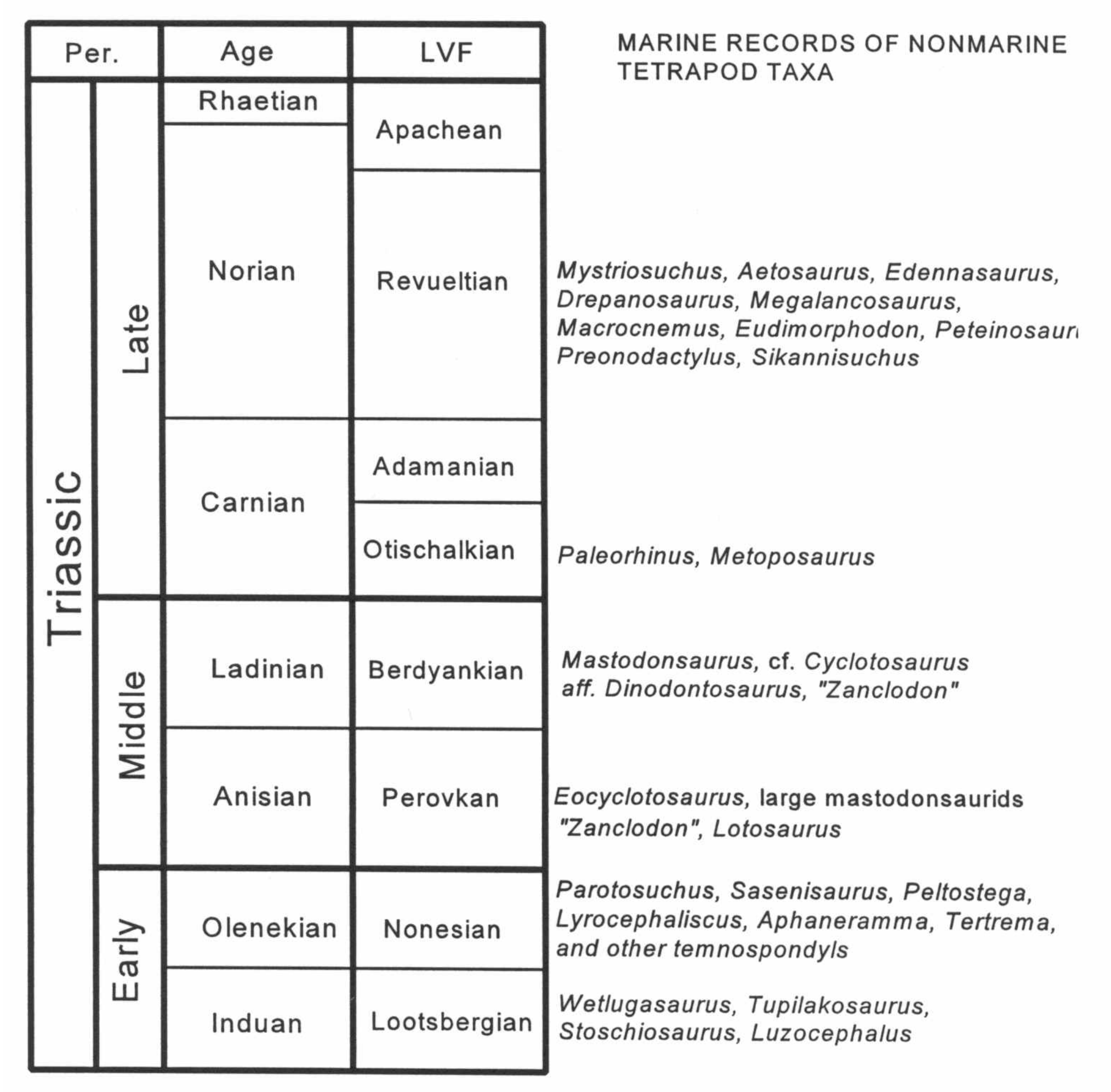

Fig. 2 Triassic nonmarine tetrapods showing cross-correlations with the marine chronostratigraphic scale. Index taxa of land-vertebrate faunachrons indicated in bold type.

12. Opponitzer Schichten, Austria - Huene (1939) described a skull fragment of the phytosaur *Paleorhinus* (= *Francosuchus*) from the lower part of the Opponitzer Schichten (Kalk) near Lunz, Austria. The occurrence is of late Carnian (Tuvalian) age (Janoscheck & Matura, 1980), but it cannot be tied precisely to a particular ammonite zone. *Paleorhinus* is an index taxon of the Otischalkian and has a broad distribution across Pangea (Hunt & Lucas, 1991; Lucas, 1998). The Opponitzer Schichten record of *Paleorhinus* thus cross-correlates part of the Otischalkian to the Tuvalian.

13. Lunz Schichten (Sandstone), Austria - Stur (1873) reported *Mastodonsaurus giganteus* Jaeger? from the Lunz Sandstone in the Austrian Alps. This is an early Carnian (Julian) record, broadly correlative

to the German Schilfsandstein. However, we have examined the material Stur described, and it is not diagnostic of *M. giganteus*, and could just as well belong to *Cyclotosaurus*. Therefore, this record is of limited biochronologic significance.

14. Pardonet Formation, British Colombia - Nicholls et al. (1998) described *Sikannisuchus huskyi*, an archosaur of uncertain affinities, from the Pardonet Formation of northeastern British Columbia, Canada. Associated conodonts indicate the record is early Norian (*triangularis* Conodont Zone). Nevertheless, *Sikannisuchus* is endemic to this location, so the record is of no current significance to cross-correlation.

15. Zorzino Limestone, Lombardian Alps, Italy - The Zorzino Limestone (Calcare de Zorzino) has been correlated to the mid-Norian *Himavatites columbianus* Ammonite Zone (Jadoul et al., 1994; Roghi et al., 1995). Nonmarine tetrapods from this unit at the Cêne and Endenna quarries in Lombardy are the diapsid *Endennasaurus acutirostris* Renesto; a sphenodontian, *Diphydontosaurus*; the drepanosaurids *Drepanosaurus unguicaudatus* Pinna and *Megalancosaurus preonensis* Calzavara, Muscio & Wild; the phytosaur *Mystriosuchus planirostris* Meyer, the aetosaur *Aetosaurus ferratus* Fraas; a new species of *Macrocnemus*; and the pterosaurs *Eudimorphodon ranzii* Wild and *Peteinosaurus zambelli* Wild. *Mystriosuchus* and *Aetosaurus* are Revueltian index taxa, and this provides an important Revueltian-mid Norian cross-correlation (Lucas et al., 1998).

16. Forni Dolomite, Veneto Prealps, Italy - the Forni Dolomite (Dolomia di Forni) in northeastern Italy is the same age as the Zorzino Limestone (Roghi et al., 1995). Its nonmarine tetrapods are the drepanosaurids *Drepanosaurus unguicaudatus* Pinna and *Megalancosaurus preonensis* Calzavara, Muscio & Wild; and the pterosaurs *Eudimorphodon rosenfeldi* Dalla Vecchia, *Eudimorphodon* sp. and *Preonodactylus buffarinii* Wild (Dalla Vecchia, 1995). These tetrapods are endemic to northern Italy, so they are of little significance to biochronology beyond reinforcing the cross-correlation provided by the Zorzino Limestone.

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References

Broili, F., 1921. Ein Fund von cf. Placerias Lucas in der kontinentalen Trias von Europa. Zbl. Mineral. Geol. Paläont., 1921:339-343.

Buchanan, S.H., Challinor, A., Harland, B.W. & Parker, J.R., 1965. The Triassic stratigraphy of Svalbard. Norsk Polarinst. Skrifter, 135: 1-94.

Cosgriff, J.W., 1984. The temnospondyl labyrinthodonts of the earliest Triassic. J. Vertebr. Paleont., 4: 30-46.

Cox, C.B. & Smith, D.G., 1973. A review of the Triassic vertebrate faunas of Svalbard. Geol. Mag., 110: 405-418.

Dalla Vecchia, F.M., 1995. A new pterosaur (Reptilia, Pterosauria) from the Norian (Late Triassic) of Friuli (northeastern Italy). Preliminary Note. Gortania, 16: 59-66.

Hagdorn, H. & Reif, W.-E., 1988. Die "Knochenbreccie von Crailsheim" und weitere Mitteltrias-Bonebeds in Nordöst-Württemberg - alte und neue Deutungen; in Hagdorn, H., (ed.), Neue Forschungen zur Erdgeschichte von Crailsheim. Sonderb. Ges. Naturk. Württemberg, 1: 116-143.

Huene, F.v., 1939. Ein primitiver Phytosaurier in der jungeren nordostalpin. Z. Mineral. Geol. Paläont., 1939: 139-144.

Hunt, A.P. & Lucas, S.G., 1991. The Paleorhinus biochron and the correlation of the nonmarine Upper Triassic of Pangaea. Palaeontology, 34: 191-198.

Jadoul, F., Masetti, D., Cirilli, S., Berra, S., Claps & Frisia, S., 1994. Norian-Rhaetian stratigraphy and paleogeographic evolution of the Lombardy basin (Bergamasc Alps). 15th International Association Sedimentologists Regional Meeting, April 1994, Ischia, ltaly, Field Excursion Bl, Salermo, Italy, p. 5-38.

Janoscheck, W.R. & Matura, A., 1980. Austria; in Anonymous, ed., Geology of the European countries: Dunod, Paris, p. 1-88.

Kaim, A. & Niedwiedzki, R., 1999, Middle Triassic ammonoids from Silesia, Poland: Acta Palaeont. Polonica, 44: 93-115.

Koken, E., 1913. Beiträge zur Kenntnis der Schichten von Heiligenkreuz (Abteitel, Sudtirol). Abh. K.K. Geol. Reichsanst., 15: 1-43.

Lehman, J.P., 1961. Les stégocéphales du Trias de Madagascar. Ann. Paléont. (Vertébrés), 47: 109-154.

Lehman, J. P., 1966. Nouveaux stégocéphales du Trias de Madagascar. Ann. Paléontologie (Vertébrés), 52: 117-139.

Lehman, J.P., 1979. Nouveaux trématosaures de Madagascar: Les stégocéphales du Trias de Madagascar et leur paléoécologie. Ann. Paléont. (Vertébrés), 65:35-53.

Lozovsky, V.R. & Shishkin, M.A., 1974. Pervaya nakhodkha labirintodontov v nizhnem Triase Mangyshlaka [First discovery of a labyrinthodont in the Lower Triassic of Mangyshlak]. Dokl. Akad. Nauk SSSR, 214: 169-172.

Lucas, S.G., 1998, Vertebrate biostratigraphy and biochronology of the nonmarine Triassic: Palaeogeogr. Palaeoclimatol. Palaeoecol., 143: 347-384.

Lucas, S.G., Heckert, A.B. & Huber, P., 1998. Aetosaurus (Archosauromorpha) from the Upper Triassic of the Newark Supergroup, eastern United States, and its biochronological significance. Palaeontology, 41:1215-1230.

Morales, M., 1987. Terrestrial fauna and flora from the Triassic Moenkopi Formation of the southwestern United States. J. Arizona-Nevada Acad. Sci., 22: 1-20.

Nicholls, E.L., Brinkman, D.B. & Wu, X., 1998, A new archosaur from the Upper Triassic Pardonet Formation of British Columbia: Can. J. Earth Sci., 35: 1134-1142.

Nielsen, E., 1935. The Permian and Eotriassic vertebrate-bearing beds of Godthaab Gulf (east Greenland). Meddel. Grønland, 98(1): 1 -111.

Nielsen, E. ,1954. Tupliakosaurus heilmani n.g. et. n.sp., an interesting batrachomorph from the Triassic of east Greenland. Meddel. Grønland, 72(8): 1-33.

Nilsson, T., 1942. Sasenisaurus, a new genus of Eotriassic stegocephalians from Spitsbergen. Bull. Geol. Inst. Univ. Upsala, 30: 91-102.

Nilsson, T., 1943. On the morphology of the lower jaw of Stegocephalia with special reference to Eotriassic stegocephalians from Spitsbergen. 1. Descriptive part. Kungl. Svenska Vetenkapasakad. Handl., (3) 20(9): 1-46.

Ortlam, D., 1970. Eocyclotosaurus wolschmidti n.g. n.sp. - ein neuer Capitosauride aus dem Oberen Buntsandstein des nördlichen Schwarzwaldes. N. Jb. Geol. Paläont., Mh., 1970: 568-580.

Roghi, G. Mietto, P. & Dalla Vecchia, F.M., 1995. Contribution to the conodont biostratigraphy of the Dolomia di Forni (Upper Triassic, Carnia, NE Italy). Mem. Sci. Geol., 47: 125-133.

Sander, P.M. & Meyer, C., 1991, A labyrinthodont jaw fragment from the marine Triassic of the Alps. N. Jb. Geol. Paläont. Mh., 1999: 222-232.

Säve-Söderbergh, G. ,1935. On the dermal bones of the head in labyrinthodont stegocephalians and primitive Reptilia. Meddel. Grønland, 98(3): 1-211.

Schoch, R.R., 1999, Comparative osteology of Mastodonsaurus giganteus (Jaeger, 1828) from the Middle Triassic (Lettenkeuper:Longobardian) of Germany (Baden-Württemberg, Bayern, Thüringen). Stuttgarter Beitr. Naturk., B, 278:1-175.

Shishkin, M.A., Ochev, V.G. & Tverdokhlebov, V.P. (eds.), 1995. Biostratigrafiya kontinentalnovo Triasa yuzhovo Priuralya [Biostratigraphy of the Triassic of the southern pre-Urals]. Nauka, Moscow, 203 pp.

Silberling, N.J. & Tozer, E.T., 1968. Biostratigraphic classification of the marine Triassic in North America. Geol. Soc. Amer., Spec. Paper, 110: 1-63,

Stur, D., 1873. Mastodonsaurus giganteus Jaeger im Lunzersandstein der Grube Pielach bei Kirchberg an der Pielach, in den nordöstlichen Kalkalpen. Verh. K.-K. Geol. Reichsanst., 1873: 18-19.

Swinton, W. E., 1956. A neorhachltomous amphibian from Madagascar. Ann. Mag. Nat. Hist., (12)9: 60-64.
Tozer, E.T., 1967. A standard for Triassic time. Geol. Surv. Canada Bull., 156: 1-103.
Tozer, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Surv. Canada Bull. 467: 1-663.
Trümpy, R., 1961. Triassic of east Greenland; in Raasch, G.O. (ed.), Geology of the Arctic: University of Toronto Press, Toronto, p. 248-254.
Wiman, C., 1910. Ein paar Labyrinthodonten Reste aus der Trias Spitzbergens. Bull. Geol. Inst. Univ. Uppsala, 9: 34-40.
Wiman, C., 1915. Über die Stegocephalens aus der Trias Spitzbergens. Bull. Geol. Inst. Univ. Uppsala 13: 1-34.
Zhang, F., 1975. A new thecodont Lotosaurus, from Middle Triassic of Hunan. Vertebrata PalAsiatica, 13: 144-147.

THE MIDDLE TRIASSIC STRATIGRAPHY AND SEDIMENTARY PALEOGEOGRAPHY OF SOUTH CHINA

Tong Jinnan and Liu Zhili

The Middle Triassic was the great turning period of South China from marine sedimentary basins to continental deposits or erosion. This paper summarizes the distribution and variation of the stratigraphic sequences, lithofacies and biotas in the various Middle Triassic depositional basins of South China. The close relationship between the biotic paleoecology and the lithofacies as well as the sedimentary facies, thus the paleogeography, is demonstrated. The process of the transition from the depositional paleogeography and its relation to the tectonic settings is concluded therefore.

During the Middle Triassic a great turn took place in the development of sedimentary basin of South China. Following the final suture of Cathaysia Block with Yangtze Block (including the Lower Yangtze region), Yangtze Block matched completely with North China Block (Yin et al., 1999), while the extensive Indosinian Movement wreaked havoc in the eastern Tethys. Then the sediments in the main part of South China transformed gradually from marine to terrestrial. As a result the most remarkable changeover of stratigraphic structure and sedimentary paleogeography in South China occurred in the Middle Triassic. It would be of great importance to clarify the stratigraphic structure of this region and its sedimentary paleogeographic pattern for fully understanding this great geologic turning process.

1. The Middle Triassic sedimentary sequences and lithofacies in South China

The South China mainly mentioned in this paper includes Yangtze Block, including the Lower Yangtze region, to the east of Kangdian Oldland and Cathaysia Block as well as the depression region between the blocks. Considering no Middle Triassic records have been reported from southern Guangdong and Hainan, the Indochina-South China Sea Block will not be discussed here. The northern border of South China is based upon the boundary of the Stratigraphic Realm used in the Multiple Classification and Correlation of the Stratigraphy of China (e.g. Zhao and Ding, 1996).

South China is subdivided into four sedimentary provinces, according to the sedimentary sequences, the regional tectonic difference and the development of sedimentary basin in the Middle Triassic. Each sedimentary province has similar stratigraphic sequence and unique lithofacies, but the difference between the Anisian and Ladinian is apparent (Fig. 1 and Table 1).

1.1 Cathaysia Sedimentary Province

The Middle Triassic in this province occupied the Cathaysia Block and its neighboring areas of Yangtze Block such as Guangdong, southern Jiangxi and southeastern Hunan. Its boundary to the Lower Yangtze sedimentary province shifted from Jiangshan-Shaoyang fault northward to Jiande-Changsha deep fault in the Middle Triassic (Wu et al., 1994). The Middle Triassic of this province consists mainly of terrestrial and littoral clastic rocks. The marine sediments increased from southeast to northwest and decreased to disappear from the Anisian to Ladinian. In the southwestern Fujian the Middle Triassic is the Anren Formation composed mostly of red clastic rocks. Huangben Formation in northern Guangdong and Yangjia Formation in central Jiangxi are also dominated by clastic sediments but they contain some eurytropic fossils (Nan and Zhou, 1996). The Middle Triassic of southeastern Hunan consists mainly of carbonates and its lower part, Sanbao'ao Formation, has some interbeds of siltstone and mudstone while the upper part, Shijing Formation, is dominated by evaporate carbonate rocks with more purplish red clastic interbeds.

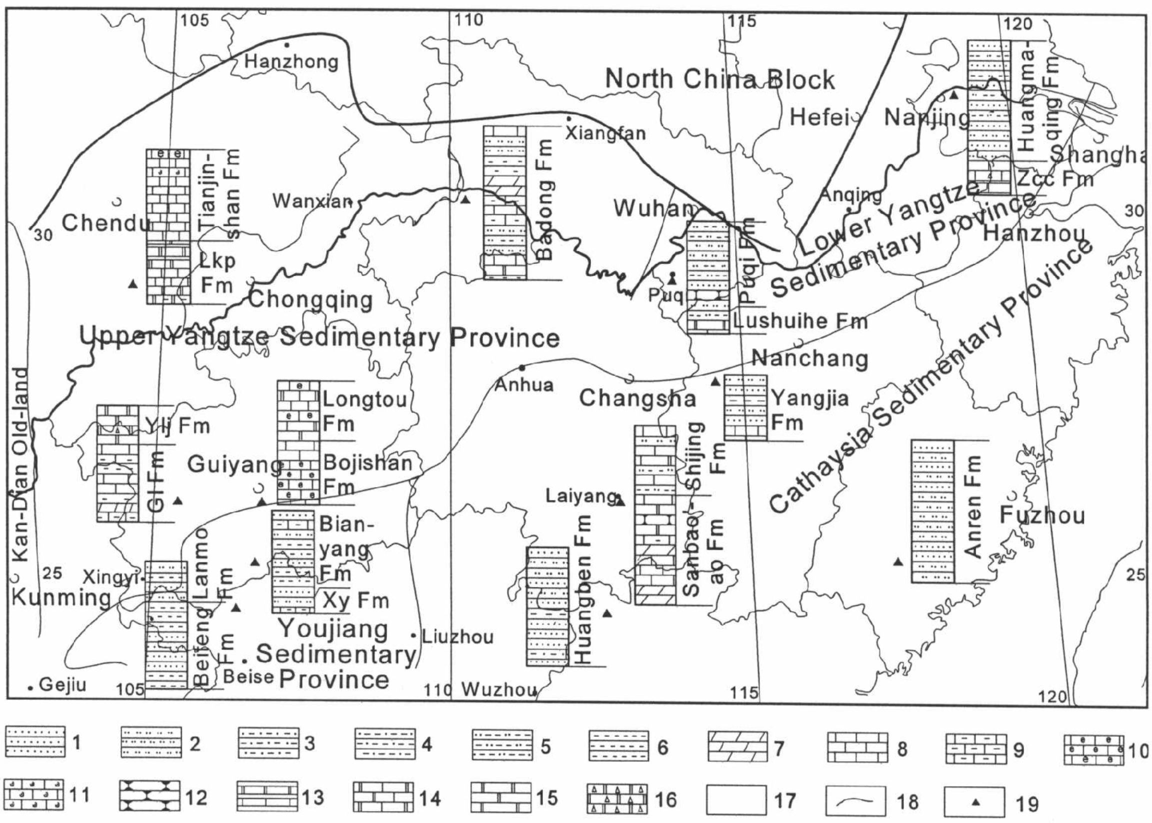

Fig.1 The Middle Triassic sedimentary basins and typical stratigraphic sequences in South China: 1. sandstone; 2. siltstone; 3. argillaceous sandstone; 4. arenaceous mudstone; 5. silty mudstone; 6. mudstone; 7. marl; 8. limestone; 9. argillaceous limestone; 10. bio-clastic limestone; 11. oolitic limestone; 12. nodular limestone; 13. dolomite intercalating gypsum beds; 14. dolomitic limestone; 15. dolomite; 16. dolomitic solution-breccia; 17. old land; 18. boundary between sedimentary provinces; 19. typical section and point

1.2 Lower Yangtze Sedimentary Province

This province includes the Middle and Lower Yangtze to the east of Wuhan in Yangtze River drainage area, and the Middle Triassic sequences are basically accordant in the whole province. The Anisian Zhouchongcun Formation is composed mainly of evaporate carbonate rocks intercalated with gypsum beds, though Lushuihe Formation in the Middle Yangtze area contains more clastic rocks (Zhang et al., 1986). In the Ladinian, the entire province was covered by coastal-fluviolacustrine clastic sediments, i.e. Huangmaqing Formation and Puqi Formation.

1.3 Upper Yangtze Sedimentary Province

This province covered the Upper Yangtze platform of Yangtze Block occupied by the Middle Triassic carbonate rocks, including western Hubei, Chengdu-Chongqing basin, northern and western Guizhou and eastern Yunnan. The Middle Triassic is made mostly of carbonate rocks and dolomite is commonly a notable component of it. The Anisian is widely distributed in the province, called Leikoupo Formation in the Chengdu-Chongqing basin and Guanling Formation (s.s.) in Guizhou and eastern Yunnan (Dong, 1987). However, many red clastic beds are intercalated in Hubei, northern Hunan, Chongqing, eastern Sichuan and northeastern Guizhou so that Badong Formation is named here. In the mean time, a narrow carbonate belt of "reefoid formation", whose core is called Bojishan Formation (Tong, 1997) or Poduan Formation (Dong, 1987), developed in the front of the carbonate platform. The breccia limestone in the south of the "reefoid" belt is Qingyan Formation. During the Ladinian, many caliche sediments of "agate-like" structure (Fang and Wen, 1992) overlie this "reefoid" formation, and Longtou Formation is named. Neither bindstone and framestone are recorded, nor well-developed breccia limestone in its south is observed though Songzikan Formation is used here in the Ladinian (Tong, 1997). The Ladinian carbonate rocks of platform facies are widespread in Sichuan and Guizhou, though the Yangliujing Formation contains much evaporate dolomite in eastern Yunnan to central Guizhou. Tianjingshan Formation is composed of normal carbonate rocks in Chengdu-Chongqing basin, which might be greatly influenced by the western Tethys.

1.4 Youjiang Sedimentary Province

It was a pull-apart chasmic trough behind Yangtze Block when it moved northward (Yin et al., 1999) and locates at the juncture of (south) Guizhou, (northwest) Guangxi and (southeast) Yunnan. The Middle Triassic consists of terrigenous clastic rocks of big thickness, and carbonate sequences occur in some isolated carbonate buildups within the basin. In the depressed clastic basin, the Anisian is named separately as Xinyuan Formation, Banna Formation, Baifeng Formation and Xuman Formation due to the different composition in various areas, while the Ladinian is called Bianyang Formation and Lanmu Formation. The Anisian carbonate rocks on the buildup platform in Guangxi is Guohua Formation, which is overlapped by the Ladinian terrigenous clastic rocks of Lanmu Formation.

In addition, the Middle Triassic acid volcanic and pyroclastic rocks, Banba Formation, are in Pingxiang-Dongxing, southern Guangxi.

As a whole, the Anisian carbonate rocks are mainly on Yangtze Block and dominated by dolomite and dolomitic limestone, including Zhouchongcun Formation of Lower Yangtze, Leikoupo Formation and Guanling Formation of Upper Yangtze, and Bojishan Formation and Qingyan Formation at the southern edge of Upper Yangtze. The Anisian clastic sediments are mostly distributed in Cathaysia sedimentary province, Anren Formation, Huangfen Formation and Yangjia Formation, and the depressed Youjiang sedimentary province, Xinyuan Formation, Banna Formation, Baifeng Formation and Xuman Formation. However, there exist carbonate sediments, Guohua Formation, on the buildup platforms in Youjiang province, and terrigenous clastic rocks interbedded in Yangtze carbonate platforms (Badong Formation). However, the mixed sequences of carbonate and clastic rocks mainly occur at the transitional areas between the sedimentary provinces, such as Sanbao'ao Formation in southeastern Hunan and Lushuihe Formation in southeastern Hubei.

Table 1 The Middle Triassic lithostratigraphic units, basic lithology and major fossils in South China

Stage	Lower Yangtze sedimentary province		Upper Yangtze sedimentary province			
Ladinian	**Huangmaqing Formation** Sediments dominated by arenaceous clastics. Grey fine sandstone and siltstone in the lower part and purplish psepholite and mudstone in the upper. Yielding bivalves: *Asoella illyrica*, *Danaeopsis-Bernoullia* Flora and charophytes and ostracods	**Puqi Formation** Argillaceous and arenaceous clastic sediments. Purplish red mudstone, siltstone and fine sandstone. Yielding some plant fossils	**Badong Formation** Mixed carbonate and clastic sediments. Grey marl and dolomitic limestone interbedded with purplish red and celadon mudstone and siltstone Yielding bivalves: *Asoella subillyrica*, *A. illyrica*, *Costatoria goldfussi*, *C. goldfussi mansuyi*, *C. submultistriata*, *Pleuromya elongata*, *Entolium discites*, *Unionites spectus*, and ammonoids: *Progonoceratites* sp.	**Tianjingshan Formation** Carbonate sediments. Grey thick-bedded limestone. Yielding bivalves: *Gervillia modiola*, *Elegantina elegans*, *Rhaetina angustaeformis*	**Yangliujing Formation** Evaporate carbonate sediments. Grey massive dolomite and limestone. Yielding bivalves: *Asoella illyrica*, *Unionites* spp., and crinoids *Traumatocrinus hsui*, and brachiopods: *Mentzellia* sp., *Nudispririferina* sp.	**Longtou Formation** Carbonate sediments Grey limestone, "agate-like" limestone and bioclastic limestone Yielding bivalves: *Entolium* sp., *Pteria* sp.
Anisian	**Zhouchongcun Formation** Sediments of evaporate carbonates and clastics with gypsum. Yellowish grey limestone, dolomite and gypsum-solution slither rocks in the lower part, and mudstone intercalated with marl and sandstone in the upper. Yielding bivalves: *Costatoria radiata*, *C. submultistriata*, *Asoella illyrica*, *A. subillyrica*, *Entolium discites*, and ammonoids: *Lenotropites* sp., *Ussurites* sp.	**Lushuihe Formation** Carbonate and clastic sediments. Grey limestone and dolomite in the lower part, and grey mudstone and siltstone in the upper. Yielding bivalves: *Asoella illyrica crassistriata*, *Neoschizodus laevigata*, *Mytilus* sp., *Pleuromya* sp., *Pteria* sp., *Bakevellia* sp.		**Guanling Formation** (**Leikoupo Formation**) Evaporate carbonate sediments. Grey limestone, argillaceous dolomite intercalating mudstone, gypsum and halite. Yielding bivalves: *Costatoria goldfussi*, *C. goldfussi mansuyi*, *Asoella illyrica*, *A. paradoxica*, *Pleuromya elongaata*, and ammonoids: *Progonoceratites pulcher*		**Bojishan Formation** Carbonate sediments Grey bioclastic limestone, calcirudite and bindstone Yielding bivalves: *Neomorphotis* spp., *Asoella illyrica*, and ammonoids: *Japonites* sp., and brachiopods: *Nudispiriferina minima*

Table 1 (*continued*)

<table>
<tr><th rowspan="2">Stage</th><th colspan="3">Cathaysia sedimentary province</th><th colspan="4">Youjiang sedimentary province</th></tr>
<tr><th></th><th></th><th></th><th></th><th></th><th></th><th></th></tr>
<tr><td>Ladinian</td><td rowspan="2">Anren Formation
Fine clastic sediments.
Purplish siltstone intercalated with arkosic quartzous sandstone in the upper part, and grey calcareous sandstone and calcareous siltstone in the lower.
Yielding only palnts: Neocalamites? sp. and sporopollen</td><td rowspan="2">Huangben Formation (Yangjia Formation)
Arenaceous and argillaceous clastic sediments.
Purplish red mudstone, siltstone and fine sandstone.
Yielding bivalves: Asoella illyrica, A. paradoxica, Neoschizodus spp, Gervillia sp., Costatoria sp., Entolium sp., Pteria sp., and plants</td><td>Shijing Formation
Carbonate mixed with fine clastic sediments
Greyish and lilac limestone and dolomitic limestone, purplish calcareous siltstone and mudstone interbeded in the upper part</td><td colspan="3">Bianyang Formation
Terrigenous clastic turbidite sediments.
Grey sandstone intercalating calcareous mudstone.
Yielding bivalves: Daonella spp., Posidonia spp., Halobia spp., and ammonoids: Protrachyceras sp.</td><td rowspan="2">Banba Formation
Volcanics and volcanic clastic sediments
Rhyolite porphyry, lava, ash tuff interbedded with some mudstone beds.
Yielding few bivalves: Posidonia sp.</td></tr>
<tr><td>Anisian</td><td>Sanbao'ao Formation
Carbonate mixed with clastic sediments.
Grey thin-bedded limestone and marl intercalating siltstone and mudstone beds.
Yielding bivavles: Asoella illyrica, A. subillyrica, A. albertii, A. paradoxica, Posidonia spp., Entolium discites</td><td>Xinyuan Formation (BannaFormation)
Argillaceous fine clastic sediments.
Greyish green mudstone and siltstone intercalating some limestone
Yielding bivalves: Daonella spp., Posidonia spp., and ammonoids: Balatonites spp., Leiophyllites sp., Acrochodiceras sp.</td><td>Baifeng Formation (Xuman Formation)
Fine clastic turbidite sediments.
Celadon sandstone intercalating mudstone
Yielding bivalves: Daonella spp., Posidonia spp., and ammonoids: Balatonites spp., Cuccoceras sp., Leiophyllites sp., Acrochordiceras sp.</td><td>Guohua Formation
Carbonate sediments.
Grey limestone and oolitic limestone intercalating mudstone and dolomite.
Yielding bivalves: Unionites sp., Entolium sp., Chlamys spp., Posidonia sp., and gastropods: Worthenia sp.</td></tr>
</table>

In the Ladinian, carbonate sediments were obviously limited, mainly in Upper Yangtze sedimentary province, Yangliujing Formation, Tianjingshan Formation and Longtou Formation. Cathaysia province and Lower Yangtze province were deposited of terrigenous clastics, and mainly terrestrial red sediments. In the depressed Youjiang province, terrigenous clastic rocks, Lanmu Formation and Bianyang Formation, extended even over the Anisian carbonate buildup platforms.

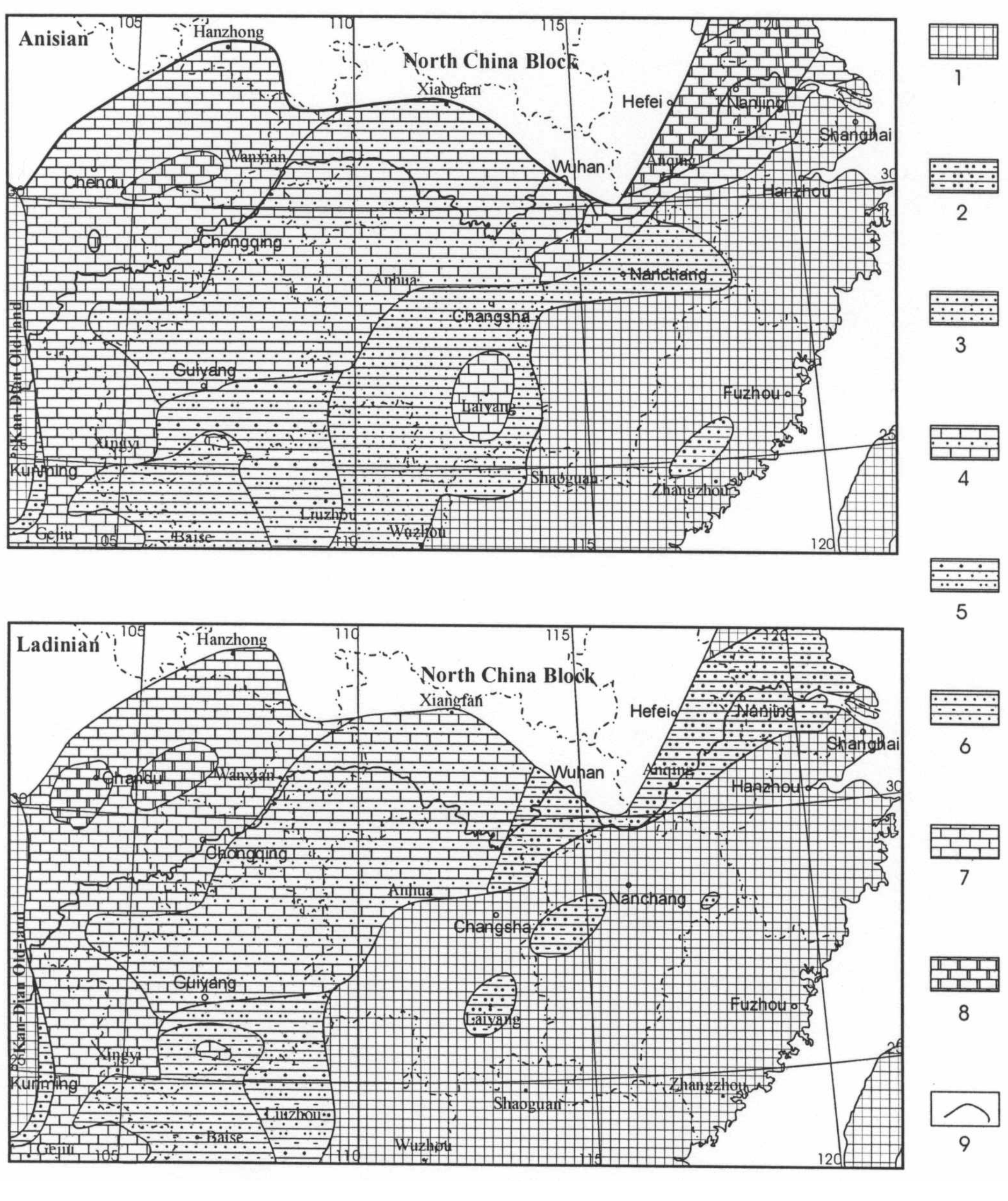

Fig. 2 The Middle Triassic lithofacies and paleogeography in South China: 1. nondepositional area, 2. terrestrial lacustrine clastic deposit, 3. littoral clastic deposit, 4. littoral mixed clastic and carbonate deposit, 5. shallow shelf argillaceous deposit, 6. deep shelf clastic turbidite deposit, 7. open platform carbonate deposit, 8. restricted platform salty carbonate deposit, 9. boundary between lithofacies and paleogeographic units.

2. The Middle Triassic biotas in South China

The Middle Triassic contains rich fossils in South China and the biotic ecological differentiation is clear. Bivalves were especially diversified and widespread, and they were of distinctive assemblages and associated biotic groups in various lithofacies. They are clearly similar and related to lithofacies differentiation.

According to the ecological features of dominant biotas, the Middle Triassic biotas of South China can be subdivided into two ecological groups, which are particularly characteristic of bivalve groups. One is shallow ecological group, which occupied Cathaysia, Lower Yangtze, Upper Yangtze sedimentary provinces as well as the carbonate buildups in Youjiang sedimentary province. It is the predominant biologic group in both carbonate and clastic facies of these provinces. The other ecological group is characterized by deep-water nektonic and nektobenthic organisms and distributed mainly in the deep-water facies of terrigenous clastic sediments in Youjiang sedimentary province.

In shallow ecological group, *Costatoria* and *Asoella* are the most characteristic forms, among which the typical species are *C. goldfussi*, *C. goldfussi mansuyi*, *C. submultistriata*, *A. illyrica*, *A. subillyrica*, and *A. paradoxica*, and they have the widest distribution. Other common forms include some species of such genera as *Unionites*, *Neoschizodus*, *Entolium*, *Pleuromya*, *Mytilus* and *Pteria*. According to the ecological features and body structures of these forms, two ecological subgroups can be distinguished. One is composed of endobenthic and movable epibenthic forms, which are characteristic of relatively thick, weighty and considerable convexity of shells such as *Costatoria*, *Neoschizodus*, *Unionites*, and *Pleuromya*. The other subgroup is byssus-fixing or freely lying forms of thin and compressed shell such as *Entolium*, *Asoella*, *Pteria*, and *Mytilus*, and some have also certain swimming ability by means of the clapping of their shells. The former ecological subgroup usually dominated littoral and neritic carbonate facies, while the latter was common in the littoral detrital area. They had also associated with different biotic taxa in different areas and lithofacies. In region the former, associated sometimes with *Progonoceratites*, gastropods and few brachiopods, was predominant in Upper Yangtze, and the latter mainly in Lower Yangtze and Cathaysia sedimentary provinces, occasionally in the strata of terrestrial flora. On the whole, the ecological subgroup of *Costatoria* was extensive in South China during the Anisian, and the subgroup of *Asoella* was predominant during the Ladinian. The *Costatoria* subgroup was, however, mostly in semi-closed shallow sea, while the *Asoella* subgroup was rich in open littoral facies.

Daonella was the most characteristic of the deep-water ecological group. It was motive epibenthic group against high pressure and less oxidizing conditions (Kobayashi, 1967) and lived only in the Middle Triassic deep-water facies (Tong, 1992). The typical bivalves in this ecological group include *Daonella* as well as most species of *Posidonia* and *Halobia*, and they are commonly associated with nektonic ammonoids. *Posidonia* and ammonoids are the most important markers of this group in the early Anisian when *Daonella* did not develop to some degree. *Halobia* joined them in the late Ladinian. The bivalves in this ecological group are characteristic of thin and flat shells, and low biotic diversity but high abundance (Tong, 1997). They lived in the deeper water of the depressed Youjiang sedimentary province, predominant in the terrigenous clastic facies and especially rich in the strata of turbidite.

However, there is a band of mixed ecological groups at the southern edge of the carbonate Upper Yangtze sedimentary province contiguous to the clastic Youjiang basin. The "reefoid formation" in this belt is characterized by the fossils of shallow bank facies, including algae forming the Anisian bindstones, some hexacorals and bryozoans, as well as rich bivalves, gastropods, brachiopods, and even ammonoid shell-beds (Fang and Wen, 1992; Tong and Huang, 1992; Lehrmann et al., 1998).

Concerning as the spatial and temporal distribution of the ecological groups and subgroups, Cathaysia sedimentary province was occupied by *Asoella* subgroup but a few members of *Costatoria* subgroup in the northwest during the Anisian and more terrestrial plants in the late Middle Triassic. Lower Yangtze sedimentary province had a certain elements of *Costatoria* subgroup in the early Anisian but *Asoella* subgroup was predominant in the Anisian. Terrestrial plants, charophytes and ostracods developed well in most parts of the province during the Ladinian. Upper Yangtze sedimentary province is characteristic of widespread Costatoria subgroup though a certain elements of Asoella subgroup existed at the juncture of Sichuan, Hubei and Guizhou as well as Chongqing City. In Youjiang sedimentary province, *Daonella* group and ammonoids are the most distinctive biota, but *Costatoria* subgroup occupied the carbonate buildups as well in western Guangxi and southern Guizhou during the Anisian.

In a word, the Anisian marine ecological groups were widespread in South China, especially the members of the abnormal marine *Costatoria* subgroup nearly everywhere throughout the region. The marine ecospace reduced remarkably in the Ladinian when the epibenthic ecotypes replaced the predominant endobenthos, while the terrestrial ecospace extended considerably. Meanwhile, the ecospace of the deep-water *Daonella* ecological group enlarged to the areas of the early isolated carbonate buildups.

3. The Middle Triassic sedimentary facies and paleogeography in South China

During the Pangea time of the Paleozoic-Mesozoic transition, South China was composed of several northward-drifting blocks in Tethys, which constantly adjoined and coupled to the northern Laurasian blocks (Yin et al., 1999). Cathaysia Block was uplifted prior to Yangtze Block so that it received terrestrial sediments earlier in the Middle Triassic. The main body of Yangtze Block was also uplifted gradually from marine to continental facies, from restricted salty marine sediments to terrestrial fluviolacustrine deposits (Fig. 2). But at the edges of Yangtze Block, marine sedimentation sustained much longer. In Youjiang depression at the south of Upper Yangtze the normal marine sequences extend up even into the Upper Triassic.
As matter of the fact, the Cathaysia Block and Lower Yangtze sedimentary province belonged a single sedimentary paleogeographic unit while the Upper Yangtze and Youjiang sedimentary provinces were another affiliated unit in the Middle Triassic according to the differentiation of the sedimentary sequences, lithofacies and biotas.

In Cathaysia and Lower Yangtze sedimentary provinces, the essential pattern of the Middle Triassic paleogeography and the differentiation of sedimentary facies are in SE-NW direction.

The southeastern part, including most Zhejiang, Fujian and Guangdong, which is the major part of Cathaysia sedimentary province, was uplifted to be denuded except for a relict lacustrine clastic facies in southern Fujian. The denudation was continuously expanding northwestward during the Middle Triassic. In the northwestern part, including western Zhejiang, central Jiangxi, southeastern Hunan and northwestern Guangdong, extensive littoral clastic deposition happened in the Anisian, but most parts of the area became denuded in the Ladinian and only few littoral clastic lakes remained in central Jiangxi and southeastern Hunan. At the marginal area of Yangtze Block, where Lower Yangtze sedimentary province and Cathaysia Block adjoin, semi-restricted to restricted lagoonal carbonate facies and evaporate sediments developed well in the Anisian. With the continuous compression and elevation between Yangtze Block and North China Block, this area became littoral clastic facies in the late Anisian and final terrestrial fluviolacustrine facies in the Ladinian.

Accordingly, in the Middle Triassic, the total paleogeographic pattern of the Cathaysia and Lower Yangtze provinces was a continent-marginal sedimentary basin declining northwestward. Denudation was expanding steadily from the Anisian to Ladinian while the sedimentary facies zones migrated northwestward rapidly. The whole region finished the transformation from sea to land in the latest Anisian.

In the Upper Yangtze and Youjiang sedimentary provinces, the Middle Triassic paleogeography was a typical pattern of continental margin deepening from north to south, accompanied by an accordant differentiation of sedimentary facies. The main body of Upper Yangtze was an enormous shallow carbonate platform, from the Chengdu-Chongqing basin, eastwards to western Hubei and northwestern Hunan, southwards to northern and southwestern Guizhou and southeastern Yunnan, even including some parts of northwestern Vietnam (Vu Khuc, 1994). However, the lithofacies difference inside the platform is notable. There mixed lots of littoral clastic sediments in the eastern part, while a narrow zone of detrital facies occurred in front of Kangdian Oldland. Evaporites with gypsum scatter in central Sichuan and Nanchong. A narrow reefoid carbonate formation located on the southern edge of the platform, facing the depressed Youjiang basin. This kind of reefoid carbonate sediments appeared as well on some isolated buildup platforms in Youjiang sedimentary province. Some organisms capable of reef-building and related sedimentary structures came to pass in this belt during the Anisian (Tong and Huang, 1992; Lehrmann et al., 1998), but it evolved only a passive shallow bank finally in the Ladinian (Liu et al., 1987; Tong and Huang, 1992; Fang and Wen, 1992; Enos et al., 1997). In front of carbonate platform was a narrow slope, which yielded gravitative sediments rich of carbonate breccia.

In southern Guizhou and northern Guangxi of Youjiang province subsisted the biotas and clastic sediments of deep-water facies. Except for the isolated carbonate buildup of Bangen, Guizhou, and platform of Tiandong-Baise, Guangxi, clastic turbidites scattered in the basin, especially at the juncture of Guizhou, Yunnan and Guangxi, where turbidites were in both Anisian and Ladinian. Nevertheless, the silty and argillaceous sediments of shallow shelf were the main components in the most areas of southern Guizhou and central Guangxi during the Middle Triassic. Meanwhile, a vast amount of intermediate-acid volcanic rock of island-arc type appeared at Qinzhou, southern Guangxi (Zhao and Ding, 1996), and intense depression happened at Baise-Qiubei of northwestern Guangxi and southeastern Yunnan during the Ladinian (Feng et al., 1997).

On the whole, sedimentary paleogeography of Upper Yangtze and Youjiang sedimentary provinces became further diversified during the Ladinian. On the Upper Yangtze platform, clastic sediments decreased and carbonate facies became more shallow and salty. In the Youjiang clastic basin turbidity sedimentation was very active and formed a big thickness of rocks, even expanding over the carbonate platforms (Enos et al., 1998). The extensive geographic differentiation and speedy basin-filling indicate the forthcoming of the great turn in the development of basin. The end of the Ladinian was therefore the great turning point of the basin (Yin, 1982; Tong, 1997). From the Late Triassic on, the entire sedimentary basin was uplifted so that the paleogeographic pattern of platform-basin did not exist any more. The Kangdian Oldland upraised for a very long time began to receive sediment but Guizhou and Guangxi were gradually elevated, thus a new pattern of lithofacies and paleogeography in east-west direction was formed.

4. Conclusion

1. The Middle Triassic was a special period in the sedimentary paleogeographic history of South China. It has completely recorded the course of all sedimentary provinces from sea to land and their interrelationship, which is of great importance to study the regional tectonics and geological history of South China.

2. The spatial difference and temporal change of the lithofacies, biotas and sedimentary paleogeography in Middle Triassic of South China was clearly related. The variation of ecological types and the alteration of biotic composition give exact expression to the history of the regional paleogeographic change and the development of sedimentary basin in this region.

3. Cathaysia-Lower Yangtze and Upper Yangtze-Youjiang were two separate distinct sedimentary basins, in which the sedimentary and paleontological records were interrelated. But the two basins had quite different evolutionary histories, which indicates that they had different dynamics in the transition from sea to land.

References

Enos, P., Wei Jiayong & Lehrmann, D.J., 1998, Death in Guizhou —Late Triassic drowning of Yangtze carbonate platform. Sediment. Geol., 118:55-76

Fan Jiasong & Wen Chuanfen, 1992, Re-examination of the Middle Triassic "reefs" in Central Guizhou, South China —The discovery of Triassic caliche deposits. Chinese Sci. Bull., 37: 438-440.

Feng Zengzhao, Bao Zhidong, Li Shangwu et al., 1997, Lithofacies palaeogeography of the Early and Middle Triassic of South China. Petroleum Industry Press, Beijing.

Dong Weiping, 1987, Regional Geology of Guizhou Province —Triassic. Geol. Mem. Ministry Geol. Mineral Res. China, Ser.1, No.7, 277-321. Geol. Publ. House, Beijing.

Kobayashi, T., 1967, The Daonella and Halobia facies of the Thai-Malay Peninsula compared with those of Japan. Geol. Paleont. Southeast Asia, 3:93-122

Lehrmann, D.J., Wei Jiayong & Enos, P., 1998, Controls on facies architecture of a large Triassic carbonate platform: the Great Bank of Guizhou, Nanpangjiang basin, South China. J. Sediment. Res., 68: 311-326.

Liu Baojun, Zhang Jinquan & Ye Hongzhuan, 1987, Shelf-slope sedimentary environment of Middle Triassic in Southwest Guizhou. Acta Sediment. Sinica. 5: 1-13.

Enos, P., Wei Jiayong & Yan Yangji, 1997, Facies distribution and retreat of Middle Triassic platform margin, Guizhou Province, South China. Sedimentology, 44:563-584

Nan Yi & Zhou Guoqiang (eds), 1996, Stratigraphy (Lithostratigraphic) of Guangdong Province. Multiple Classification and Correlation of the Stratigraphy of China, No.44. China University of Geosciences Press, Wuhan

Tong Jinnan, 1992, A study of the paleoecology of the Middle Triassic bivalve aonelland sidonia from South Guizhou. Exploration of Geosciences, (7):115-119.

Tong Jinnan, 1997, The Middle Triassic environstratigraphy of Central-South Guizhou, SW China. China University of Geosciences Press, Wuhan.

Tong Jinnan & Huang Siji, 1992, The development of the Middle Triassic buildup in Guizhou and its geochemical facies. Earth Science, 13:218-237

Vu Khuc, D., 1994, Triassic bivalves in Vietnam. Proc. Int. Symp. Stratigr. Correlation of Southeast Asia, 15-20 November, 1994, Bangkok, Thailand. 185-194

Wu Yinglin, Zhu Hongfa, Zhu Zhongfa, Yan Yangji, Qin Jianhua et al., 1994, Triassic lithofacies paleogeography and mineralization in South China. Geological Publishing House, Beijing.

Yin Hongfu, 1982, Discussion on the Ladinian stage in China. Geological Review, 28(3):235-239.

Yin Hongfu, Wu Shunbao, Du Yuansheng & Peng Yuanqiao, 1999, South China defined as part of Tethyan archipelagic ocean system. Earth Science, 24(1):1-12

Zhang Renjie, Meng Fansong & Zhang Zhenlai, 1982, The Triassic of the Southeastern Hubei. Bulletin of Yichang Institute of Geology and Mineral Resource, (5):42-51

Zhao Ziqiang & Ding Qixiu (eds.), 1996, Regional Stratigraphy of Central-South China. Multiple Classification and Correlation of the Stratigraphy of China, No.40. China University of Geosciences Press, Wuhan.

FOSSIL DATA AND THEIR BEARING ON DEFINING A CARNIAN-NORIAN (UPPER TRIASSIC) BOUNDARY IN WESTERN CANADA

M.J. Orchard, E. S. Carter, and E. T. Tozer

The newly-described successions of nasellarian radiolarians around the Carnian-Norian (Upper Triassic) boundary in Queen Charlotte Islands indicates their potential as tools for global correlation. The boundary interval reflects a time of gradual radiolarian change, with new taxa appearing synchronously with both *Communisti* and *Primitius* conodont zone faunas. The base of the *Communisti* Zone and the *Macrolobatus* ammonoid Zone are broadly coincident and hence this datum can be recognized with all three fossil groups. The base of the *Primitius* Zone falls within the *Macrolobatus* Zone and does not correspond to a clear ammonoid datum in North America, whereas the base of the succeeding *Kerri* ammonoid Zone does not correspond to a unequivocal microfossil signal. *Norigondolella navicula*, a conodont formerly used to subdivide the *Primitius* Zone and identify the Norian, appears facies controlled and caution is suggested in its use as an index to the base of the Norian. A case is therefore made for drawing the Carnian-Norian boundary at the datum common to the base of the *Macrolobatus* ammonoid Zone and Communisti conodont Zone.

Introduction

Western Canada has provided a wealth of Upper Triassic biochronological data. This was demonstrated initially by the synthesis of a standard zonation based on ammonoid and some bivalve faunas (Tozer, 1967, 1994). Later, conodonts were shown to have great utility (Mosher, 1973; Orchard, 1983, 1991a, b), all the more because they were fully intercalibrated with the ammonoid successions (Orchard and Tozer, 1997). More recently, radiolarians were added to this scheme through the richly fossiliferous oceanic successions preserved in the Wrangell terrane (Carter et al., 1989, Carter 1993), whilst ichthyoliths isolated from the conodont samples promise to provide a further stratigraphic tool (Johns et al., 1997).

Carnian-Norian Boundary (CNB)

The Carnian and Norian stages were named in the 19th Century from fossil occurrences in Austria, representative of Tethys. Most of the fossils concerned were ammonoids obtained from isolated localities. Little was known about the faunal sequence. In the 20th Century many new data on Triassic ammonoid successions were found in North America, Europe and Asia. From the data in Nevada and British Columbia, Silberling and Tozer (1968, p. 16) proposed that a Carnian-Norian boundary be recognized between the *Macrolobatus* and *Kerri* ammonoid Zones. Type locality for the former (index species *Klamathites macrolobatus*) is in Nevada, for the latter (index species *Stikinoceras kerri*) in northeastern British Columbia. Their sequence is demonstrable in both Nevada and British Columbia. More recently, new data from Tethys localities have been acquired and interpreted by Krystyn (1980, p. 72), who draws the Carnian-Norian boundary between the "*Anatropites*-Bereich" and the *Guembelites jandianus* Zone. *Anatropites* occurs in the *Macrolobatus* Zone, *Guembelites* in the *Kerri*

Zone. It thus seems that the Carnian-Norian boundary drawn by Silberling and Tozer in North America is at least approximately coeval with the boundary recognised by Krystyn in Tethys.

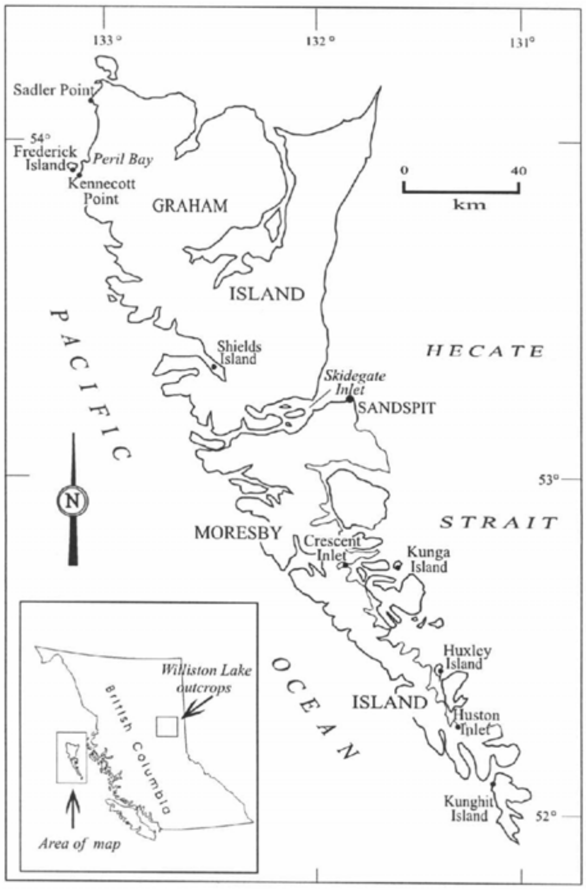

Fig. 1. Map of Queen Charlotte Islands showing important conodont/radiolarian localities relevant to this study Inset shows the location of northeast British Columbia sections.

At present, the only definition of the Carnian-Norian Boundary (CNB) is in terms of the ammonoid faunas. In cratonal areas of western Canada, the boundary interval also approximates a time of significant change in sedimentary regime: shallow water carbonates of the Baldonnel Formation are succeeded by deeper water facies of the Pardonet Formation. On the west coast, on Queen Charlotte Islands, the boundary lies entirely within the ‘oceanic' slope deposits of the Peril Formation, part of the allochthonous Wrangell Terrane.

The purpose of this review is to discuss microfaunal changes (conodonts and radiolarians) within the marine realm of western Canada that may potentially be used in global correlation and definition of the CNB, and thus contribute towards the resolution of historical events that date from that time. Detailed correlations with Tethys and with the continental realm are not attempted here.

Northeast British Columbia: ammonoid-conodont intercalibration

The ammonoid succession about the CNB comprises the zones of *Tropites welleri* (2 subzones), *Klamathites macrolobatus* (undifferentiated), and *Stikinoceras kerri* (2 subzones) (Tozer, 1994, p. 37-40). Relational superposition of the *Kerri* Zone above the *Macrolobatus* Zone at Pardonet Hill on Williston Lake is discussed by Tozer (op. cit.). In British Columbia, representative faunas of the *Macrolobatus* Zone are variable and their differentiation is not possible at this time, although associated conodonts suggest a range of ages.

The conodont zonation employed here was established largely in northeastern British Columbia. The taxonomy and nomenclature of the conodont species about the CNB are still in a state of flux but criteria presented previously (Orchard, 1991a, b) serve to adequately define successive zones that embrace potential levels for definition of the CNB, namely the *Nodosus*, *Communisti*, and *Primitius* zones. Upper Carnian radiation of metapolygnathid conodonts through the *Macrolobatus* ammonoid Zone produced at least two separate lineages that are useful in subdividing the interval. The older lineage comprises *Metapolygnathus lindae-M. zoae-M. samueli-M. pseudoechinatus* (encompassing the *Welleri-Macrolobatus* zones), whereas the younger lineage led from M. nodosus directly to *M. primitius* (*Macrolobatus-Kerri* zones). *Metapolygnathus communisti* variants are related to the latter stock and range largely within the *Macrolobatus* Zone.

Metapolygnathus primitius appears in the *Macrolobatus* Zone and ranges upward through most of the *Kerri* Zone, where the species invariably dominates the conodont faunas, except where ‘floods' of *Norigondolella* occur. The common appearance of *Norigondolella navicula* within the range of *M. primitius* has formerly been taken to mark the base of the Upper *primitius* Zone and of the Norian Stage (Orchard, 1983, 1991b; also cf. Krystyn, 1980). This datum has been used as a working base for the Norian because its diagnostic conodonts are known in association with many occurrences of ammonoids of the *Kerri* Zone. However, *Norigondolella* is sometimes absent from *Primitius* Zone faunas of *Kerri* Zone age, which cautions against reliance on the taxon as an indicator of basal Norian strata.

Queen Charlotte Islands: conodont-radiolarian intercalibration

One remarkable feature of the Upper Triassic sections outcropping on Queen Charlotte Islands (QCI) is the outstanding successions of conodont and radiolarian microfossils contained within the Peril Formation of the Kunga Group (Carter et al., 1989; Orchard, 1991a; Desrochers and Orchard, 1991; Carter, 1991, 1993). The Late Triassic biostratigraphic succession (Upper Carnian to Rhaetian) is extraordinarily complete and contains significant occurrences of conodonts and radiolarians, but ammonoids and bivalves are less common than in northeast B.C. and calibration with the ammonoid zonation is therefore often indirect and via associated conodonts (Orchard et al., 1995).

Carnian-Norian boundary microfaunas occur in fine-grained micrite concretions in the Peril Formation. The most complete sequences are present at Sadler Point and Frederick Island on northern Graham Island (Fig. 1). At these localities, macrofauna is limited to poorly preserved ammonoids and/or occurrences of the bivalve *Perihalobia alaskana*. The latter has been regarded as an indicator of the Lower Norian *Stikinoceras kerri* Zone (Tozer, 1967, p. 36). Additional radiolarian collections from Shields Island, Kunga Island, Crescent Inlet, Huxley Island, Huston Inlet, and Kunghit Island (Fig. 1) provide supplementary information on the Carnian-Norian boundary microfaunas. Ammonoids of the uppermost Carnian *Klamathites macrolobatus* Zone are known at both Huxley Island and Kunghit Island, which thus provides direct tie-in with the ammonoid zonation (Orchard, 1991a, fig. 5).

Representatives of each of the CNB conodont zones are present on QCI (Orchard, 1991a). Good examples of the both the *Communisti* and *Primitius* Zones are associated with *Macrolobatus* Zone ammonoids, leading to an effective differentiation of those ammonoid faunas. *Primitius* Zone conodonts are associated with *Perihalobia*. However, *Norigondolella navicula* unexpectedly occurs prior to the *Primitius* Zone. It is suggested that the earlier appearance of *Norigondolella* in the deeper water facies of the Wrangellian Peril Formation compared with the epicratonic seas of western Pangaea is a result of environmental factors. Hence, modification of the zonal scheme established in northeast B.C. may be necessary.

The radiolarian successions of QCI have been documented in a preliminary fashion (Carter, 1991; Orchard et al., 1990) and only the diverse Rhaetian succession has been documented in detail (Carter, 1990, 1993; Carter and Guex, 1999; Dumitrica and Carter, 1999). The CNB succession at several key localities has been summarized in a recent web-based publication (Carter and Orchard, 2000); this contribution repeats the essential features of the succession.

The radiolarian faunas are well preserved, diverse and contain many well known forms along with a variety of new species. Spumellarians overwhelmingly dominate the fauna, comprising upwards of 80% of individuals with genera such as *Capnodoce* De Wever, *Capnuchosphaera* De Wever, and *Sarla* Pessagno being the most common. The vast numbers and diversity of spumellarians, some possibly endemic, suggests they were well adapted to the region. Only the abundant nassellarian fauna have been studied thus far: these display greater variety of shape and form and may prove more useful for global correlation. Over 90 species are recognized in the 33 samples studied; the distribution and abundance of 54 of the most common nassellarians (plus one spumellarian) from Sadler Point and Frederick Island is shown in Carter and Orchard (2000, tables 1 and 2).

Radiolarians from QCI are associated with conodonts of the *Communisti* and *Primitius* zones of Orchard (1991a), those from the latter zone being the more common. A single collection from the underlying *Nodosus* Zone has been partly documented to provide a lower datum. Radiolarians are common in strata equivalent to the *Nodosus* and *Primitius* zones. Coverage is much more limited in the *Communisti* Zone, an interval of rapid evolution in the conodont faunas. The radiolarian assemblages are also dated by comparison with existing zonations of Blome (1984) and Sugiyama (1997), although both schemes are imprecise in terms of independent dating.

The most abundant nassellarian genera in the Queen Charlotte assemblages are *Canesium* Blome, *Canoptum* Pessagno, *Corum* Blome, *Multimonilis* Yeh, *Poulpus* De Wever, *Syringocapsa* Neviani, *Triassocampe* Dumitrica, Kozur and Mostler, and *Trilatus* Yeh. Numerous species described from Oregon (see Blome, 1984; Yeh, 1989) are present in varying abundance, including *Bulbocyrtium tubum* Yeh, *Canesium lentum* Blome, *Canoptum farawayense* Blome, *C. macoyense* Blome, *Castrum perornatum* Blome, *Corum speciousum*

Blome, *Latium paucum* Blome, *Multimonilis pulcher* Yeh, *Pachus longinquus* Blome, *Pseudosaturniforma minuta* Blome, and *Triassocampe immaturum* Blome. The dominance of these species in both Oregon and Queen Charlotte Islands implies that the two areas were in close proximity in the Late Triassic Panthalassan Ocean. It is also noteworthy that some of these species have been found in Japan (Sugiyama, 1997) and in the accreted terranes of southern British Columbia (Cordey, 1998).

The rare occurrence of some demonstrably global indicators described from southern Europe, Japan, and the Russian Far East is judged to be more important for correlation. These include: *Bulbocyrtium reticulatum*, *Hozmadia spinosa*, *Pentactinocarpus acanthicus*, *Pseudosaturniforma carnica*, *Pseudotriassocampe hungarica*, *Triassocampe sulovensis*, and *Xiphotheca longa*, described by Kozur and Mostler (1979, 1981, 1994) and Dumitrica et al. (1980) from areas in Austria, Hungary and Italy; *Poulpus pansus*, *P. phasmatodes*, *P. piabyx*, *Syringocapsa batodes*, and *Xiphotheca karpensionensis*, described by De Wever (in De Wever et al., 1979) from Greece; *Triassocampe coronata* from the Russian Far East (Bragin, 1991); and, from Japan, *Haeckelicyrtium sp. A* , *Poulpus carcharus*, *Veles vulgaris*, *Xipha nodosa*, and *Nassellarian indet. A* , described by Sugiyama (1997), and *Trilatus robustus*, described by Nakaseko and Nishimura (1979). Distribution data for these species are presented in Carter and Orchard (2000, tables 1, 2). The balance of the Queen Charlotte fauna is new and consists mostly of species of *Annulopoulpus* Kozur and Mostler, *Bulbocyrtium* Kozur and Mostler, *Canesium* Blome, *Corum* Blome, *Haeckelicyrtium* Kozur and Mostler, *Poulpus* De Wever, *Sanfilippoella* Kozur and Mostler, *Trilatus* Yeh, *Veghia* Kozur and Mostler, and several indeterminate nassellarians.

Distributional data from all localities sampled indicates that over two-thirds of nassellarian species studied range through the *Communisti* and *Primitius* conodont zones, suggesting that the Carnian-Norian boundary interval was a time of gradual, rather than dramatic radiolarian change. This change is apparent more in the increasing abundance of certain genera and species than in abrupt extinctions and the appearance of successor taxa. For example, some genera arising in strata equivalent to the *Communisti* Zone, e.g. *Pachus* Blome and *Syringocapsa* Neviani, are rare and represented by a single species whereas in the younger *Primitius* Zone they are more abundant and diverse. This phenomenon is true also for *Corum* Blome, which occurs sporadically in the lower part of *Primitius* Zone strata but a little higher becomes very abundant and diverse.

The succession of conodont and radiolarian faunas is best demonstrated in the stratigraphic sequence at Sadler Point, which is the most complete anywhere in QCI. The range of 20 of the most abundant nassellarian species with respect to the conodont zones is shown in Figure 2, which also incorporates overall ranges suggested by supplementary data from Burnaby Island, Shields Island and Kunghit Island. Against the background of fairly gradual radiolarian evolution across the boundary four new appearances are recorded in the *Communisti* Zone and seven in the lower part of the *Primitius* Zone. The last appearance of *Bulbocyrtium aff. reticulatum* (which ranges down to the *Nodosus* Zone) occurs in the *Communisti* Zone, whereas *Multimonilis pulcher*, *Veles vulgaris*, *Triassocampe coronata*, and *Poulpus carcharus* go extinct in the *Primitius* Zone. *Xipha nodosa* appears to be restricted to *Primitius* Zone in QCI; its range in Japan is similarly short, although somewhat older (see Sugiyama, 1997).

Summary

Preliminary observations on the radiolarian succession in QCI indicate that the potential for global correlation around the CNB using Late Triassic nassellarians is quite good. Broadly, over two-thirds of total radiolarian species studied range through the *Communisti* and *Primitius* conodont zones indicating the CNB interval was a time of gradual, rather than dramatic radiolarian change. Nevertheless, new taxa are recognized at the base of both the *Communisti* and *Primitius* zones, either of which could serve as a datum for boundary definition.

The *Communisti* Zone corresponds to a position coincident with, or approximating the base of the *Macrolobatus* ammonoid Zone, based on occurrences on QCI (GSC loc. C-157382, Kunghit Island) and northeast British Columbia (GSC loc. 68202, Mt. McLearn) (Orchard, 1991a, fig. 5; Orchard and Tozer, 1997, p. 684).

Data from both the Queen Charlottes (GSC locs. C-157119, C-157123, Huxley Island) and northeastern British Columbia (GSC locs. 64616, 64628, Pardonet Hill; 94738, Mt. Laurier) demonstrate that the base of the *Primitius* Zone falls within the *Macrolobatus* Zone (Orchard, 1991a, fig. 8; Orchard and Tozer, 1997, p. 685). Hence, although the use of the *Primitius* Zone as the datum for the CNB has clear microfossil characteristics, it has the effect of including some *Macrolobatus* Zone ammonoid faunas within the Norian. Differentiation within that ammonoid zone in British Columbia is not currently possible based on the ammonoid fauna alone. This lack of a well defined ammonoid signature corresponding to the base of the *Primitius* Zone therefore constitutes a problem for recognizing such a boundary based on ammonoids.

Use of the base of the succeeding *Kerri* ammonoid Zone as the boundary datum, as has been customary in North America, apparently does not correspond to a clear or reliable conodont or radiolarian signal. Samples from the *Kerri* Zone invariably yield a *Primitius* Zone conodont fauna, but it may or may not include *Norigondolella navicula*, a taxon used formerly to differentiate Lower and Upper parts of the *Primitius* Zone (Orchard, 1983, 1991a, b). Apparent facies control of this species cautions against its indiscriminate use as an index to the CNB.

Use of the base of the *Communisti* Zone as the datum for the Carnian-Norian boundary has the advantage of providing contemporaneous ammonoid, conodont and radiolarian indices for its recognition.

References

Blome, C.D., 1984. Upper Triassic Radiolaria and radiolarian zonation from western North America. Bull. Amer. Paleont., 85(318), 88 p.

Bragin, N. Ju, 1991. Radiolaria and Lower Mesozoic units of the USSR east regions; Academy of Sciences of the USSR, M. Nauka, Trans., 469: 1-125 (in Russian, with English summary).

Carter, E.S., 1990. New biostratigraphic elements for dating Upper Norian strata from the Sandilands Formation, Queen Charlotte Islands, British Columbia, Canada. Mar. Micropaleont., 5: 313-328.

Carter, E.S., 1991. Late Triassic radiolarian biostratigraphy of the Kunga Group, Queen Charlotte Islands, British Columbia. in: Woodsworth, G.J. (ed.) Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. Geological Survey of Canada, Paper 90-10, p. 195-201.

Carter, E.S., 1993. Biochronology and paleontology of uppermost Triassic (Rhaetian) radiolarians, Queen Charlotte Islands, British Columbia, Canada; Mém. Géologie (Lausanne), 11, 175 p.

Carter, E.S. & Guex, J, 1999. Phyletic trends in uppermost Triassic (Rhaetian) Radiolaria: two examples from Queen Charlotte Islands, British Columbia, Canada; Micropaleontology, 45: 183-200.

Carter, E. S. & Orchard, M.J, 2000. Intercalibrated conodont-radiolarian biostratigraphy and potential datums for the Carnian/Norian boundary within the Upper Triassic Peril Formation, Queen Charlotte Islands. in: Current Research 2000-A; Geological Survey of Canada.

Carter, E.S., Orchard, M.J, & Tozer, E.T., 1989. Integrated ammonoid - conodont - radiolarian biostratigraphy, Late Triassic Kunga Group, Queen Charlotte Islands, British Columbia. in: Current Research, Part H; Geological Survey of Canada, Paper 89-1H, p. 23-30.

Cordey, F., 1998. Radiolaires des complexes d'accrétion de la Cordillère Canadienne (Colombie-Britannique). Geol. Surv. Canada Bull., 509, 209 p.

Desrochers, A. & Orchard, M.J, 1991. Stratigraphic revisions and carbonate sedimentology of the Kunga Group (Upper Triassic-Lower Jurassic), Queen Charlotte Islands, British Columbia. in: Woodsworth, G.J. (ed.), Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. Geol. Surv. Canada, Paper 90-10, p. 163-172.

De Wever, P., Sanfilippo, A., Riedel, W.R., & Gruber, B., 1979. Triassic radiolarians from Greece, Sicily and Turkey. Micropaleontology, 25: 75-110.

Dumitrica P. & Carter, E.S., 1999. Family Kungalariidae, n. fam., new Mesozoic entactinarian Radiolaria with a nassellarian-type initial spicule. Micropaleontology, 45: 418-428.

Dumitrica, P., Kozur, H. & Mostler, H., 1980. Contribution to the radiolarian fauna of the Middle Triassic of the Southern Alps. Geol.- Paläont. Mitt. Innsbruck, 10: 1-46.

Johns, M.J., Barnes, C.R. & Orchard, M.J, 1997. Taxonomy and biostratigraphy of Middle and Upper Triassic elasmobranch ichthyoliths from northeastern British Columbia. Geol. Surv. Canada Bull. 502, 235 pp.

Kozur, H. & Mostler, H., 1979. Beiträge zur Erforschung der Mesozoischen Radiolarien. Teil III: Die Oberfamilien Actinommacea Haeckel 1862 emend., Artiscacea Haeckel 1882, Multiarcusellacea nov. der Spumellaria und triassische Nassellaria. Geol.-Paläont. Mitt. Innsbruck, 9(½): 1-132.

Kozur, H. & Mostler, H., 1981. Beiträge zur Erforschung der Mesozoischen Radiolarien. Teil IV : Thalassosphaeracea Haeckel, 1862, Hexastylacea Haeckel, 1882, emend. Petrushevskaja, 1979, Sponguracea Haeckel, 1862 emend. und weitere triassische Lithocycliacea, Trematodiscacea, Actinommacea und Nassellaria. Geol.-Paläont. Mitt. Innsbruck, Sonderbd. 1, 208 p.

Kozur, H. & Mostler, H., 1994. Anisian to Middle Carnian radiolarian zonation and description of some stratigraphically important radiolarians. Geol.-Paläont. Mitt. Innsbruck, Sonderbd., 3: 39-255.

Krystyn, L., 1980. Triassic conodont localities of the Salzkammergut region (northern Calcareous Alps). in: Schonlaub, H.P. (ed.), Second European Conodont Symposium, Guidebook and Abstracts. Abh. Geol. Bundesanst., p. 61-98.

Mosher, L.C., 1973. Triassic conodonts from British Columbia and the northern Arctic Islands. Geol. Surv. Canada Bull., 222: 141 193.

Nakaseko, K. & Nishimura, A., 1979. Upper Triassic Radiolaria from southwest Japan. Sci. Rep. College of General Education, Osaka University, 28: 61-109.

Orchard, M.J., 1983. Epigondolella populations and their phylogeny and zonation in the Norian (Upper Triassic); Fossils and Strata, 15: 177-192.

Orchard, M.J., 1991a. Late Triassic conodont biostratigraphy of the Kunga Group, Queen Charlotte Islands, British Columbia. in: Woodsworth, G.J. (ed.), Evolution and Hydrocarbon Potential of the Queen Charlotte Basin, British Columbia. Geol. Surv. Canada, Paper 90-10, p. 173-194.

Orchard, M.J., 1991b. Upper Triassic conodont biochronology and new index species from the Canadian Cordillera. in: Orchard, M.J & McCracken, A.D. (ed.) Ordovician to Triassic Conodont Paleontology of the Canadian Cordillera. Geol. Surv. Canada Bull., 417: 299-335.

Orchard, M.J., Carter, E.S., Desrochers, A. & Tozer, E.T., 1995. Triassic Stratigraphy. in: Haggart, J.W., Jakobs, G.K. & Orchard, M.J, Mesozoic Stratigraphy and Paleontology of Haida Gwaii (Queen Charlotte Islands) basis for Tectonic Interpretations; Geological Association of Canada, Field Trip Guidebook, B4, p. 1-123.

Orchard, M.J., Carter, E.S., Tozer, E.T., Lesack, K., McKay, K., Weston, M.L., Woodsworth, G.J. & Johns, M.J., 1990. Electronic database of Triassic Kunga Group biostratigraphic data; Geological Survey of Canada, Open File 2284.

Orchard, M.J. & Tozer, E.T., 1997. Triassic conodont biochronology, its calibration with the ammonoid standard, and a biostratigraphic summary for the Western Canada Sedimentary Basin. Bull. Canadian Petrol. Geol., 45: 675-692.

Silberling, N.J. & Tozer, E.T., 1968. Biostratigraphic Classification of the Marine Triassic in North America. Geol. Soc. Amer. Spec. Paper 10: 1-63.

Sugiyama, K., 1997. Triassic and Lower Jurassic radiolarian biostratigraphy in the siliceous claystone and bedded chert units of the southeastern Mino Terrane, Central Japan. Bull. Mizunami Fossil Mus., 24: 79-193.

Tozer, E.T., 1967. A Standard for Triassic time. Geol. Surv. Canada Bull., 156, 103 pp.

Tozer, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Surv. Canada Bull., 461, 663 p.

Yeh, Kuei-Yu, 1989. Studies of Radiolaria from the Fields Creek Formation, east-central Oregon, U.S.A. Bull. Nation. Mus. Nat. Sci. Taiwan, 1: 43-110.

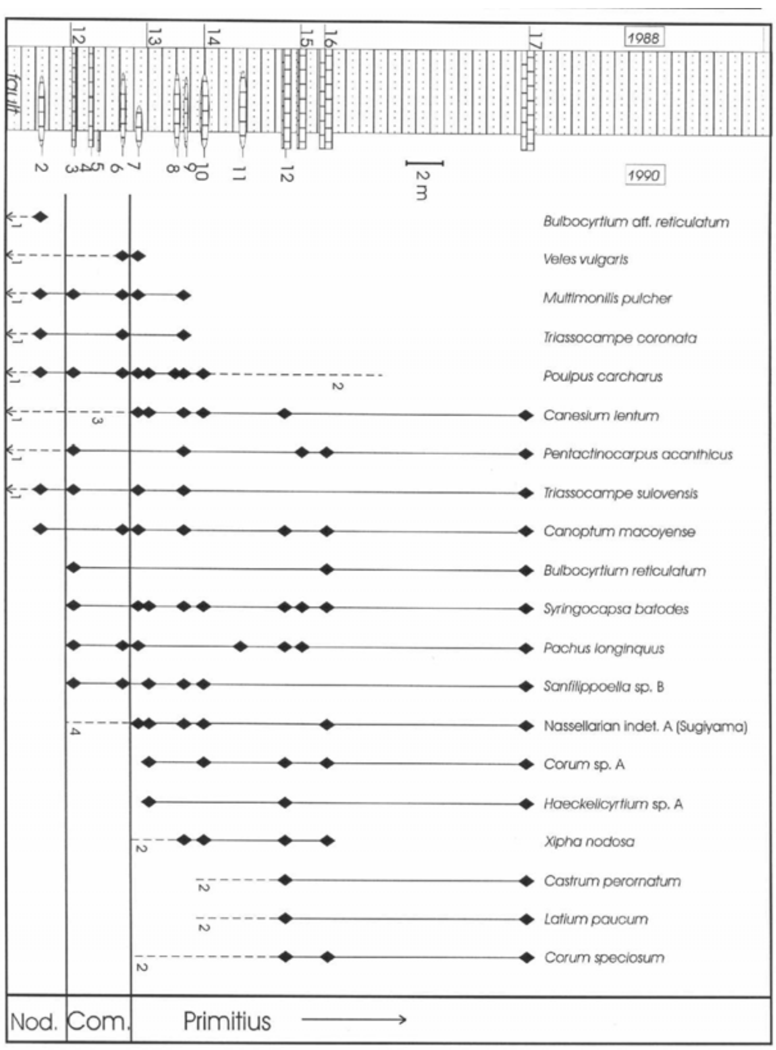

Fig. 2 Range chart for selected Late Triassic radiolarians in strata of the Nodosus (Nod.), Communisti (Com.) and Primitius conodont zones on Sadler Point. Notations: 1= range lowered to Nodosus Zone as suggested by data from Burnaby Island; 2= range extended higher and lower in the Primitius Zone as suggested by data from Frederick Island; 3= range lowered to Communisti Zone as suggested by data from Shields Island; 4= range lowered to Communisti Zone as suggested by data from Kunghit Island.

BRITISH TRIASSIC PALAEONTOLOGY: SUPPLEMENT 24

G. Warrington

Since the completion of the writer's previous supplement (No.23; Albertiana, 23: 43) on British Triassic palaeontology, the following works relating to aspects of that subject have been published or have come to his notice:

BLOOS, G. & PAGE, K.N. 1999. The basal Jurassic ammonite succession in the north-west European province - review and new results. GeoResearch Forum, 6: 27-39.

BUCKMAN, J.O., DOUGHTY, P.S., BENTON, M.J. & JERAM, A.J. 1999. Palaeoenvironmental interpretation of the Triassic sandstones of Scrabo, County Down, Northern Ireland: ichnological and sedimentological studies indicating a mixed fluviatile-aeolian succession. Irish Journal of Earth Sciences, 16 (1997/8): 85-102.

CLARK, N.D.L. 1999. The Elgin Marvel. Open University Geological Society Journal, 20 (2) Symposium Edition 1999: 16-18.

COPP, C.J.T., TAYLOR, M.A. & THACKRAY, J.C. 1997. Charles Moore (1814-1881), Somerset geologist. Somerset Archaeology and Natural History, 140: 1-36.

DINELEY, D.L. & METCALF, S.J. 1999. British Triassic fossil fishes sites. Pp.325-351 in Dineley, D.L. & Metcalf, S.J. Fossil Fishes of Great Britain, Geological Conservation Review Series, 16. Joint Nature Conservation Committee, Peterborough, xxi+ 675pp.

EDWARDS, R.A. 1999. The Minehead district - a concise account of the geology. Memoir of the British Geological Survey, 1:50000 geological sheet 278 and part of 294 (England & Wales). London: The Stationery Office, xii+ 128pp.

HOPKINS, C. 1999. New finds in the Hopeman Sandstone. Open University Geological Society Journal, 20 (2) Symposium Edition 1999: 10-15.

LUCAS, S.G., HECKERT, A.B, FRASER, N.C. & HUBER, P. 1999. Aetosaurus from the Upper Triassic of Great Britain and its biochronological significance. Neues Jahrbuch für Geologie und Paläontologie Monatshefte, Jg 1999, Heft 9: 568-576.

SWIFT, A. & MARTILL, D.M. (eds). 1999. Fossils of the Rhaetian Penarth Group. Field Guide to Fossils No.9. The Palaeontological Association, 312pp.

WARRINGTON, G., WILSON, A.A., JONES, N.S., YOUNG, S.R. & HASLAM, H.W. 1999. Stratigraphy and sedimentology. Pp.10-40 in PLANT, J. A., JONES, D. G. & HASLAM, H. W. (editors), The Cheshire Basin: Basin evolution, fluid movement and mineral resources in a Permo-Triassic rift setting. Keyworth, Nottingham; the British Geological Survey, xvii+ 263pp.

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

FINAL CIRCULAR

OMAN PANGEA SYMPOSIUM AND FIELD MEETING

Information and Inscription directly on web site:
http://www.geoconfoman.unibe.ch

On the occasion of the International Conference on the Geology of Oman
organised at Sultan Qaboos University, Seeb/Muscat,
January 12 to January 16, 2001,
an Oman Pangea Symposium and field meeting is scheduled

This Oman Pangea Symposium and field meeting wil be co-sponsored by the Global Sedimentary Geology Program (chairman Dr. Benoit Beauchamp), by the International Subcommission on Permian Stratigraphy (chairman Dr. Bruce R. Wardlaw) and by the International Subcommission on Triassic Stratigraphy (chairman Prof. Maurizio Gaetani). The symposium will take place within the Southern Tethys and Arabian Continental Margin topic of the Conference (Prof. Alastair Robertson).

SCIENTIFIC ORGANISERS OF THE SYMPOSIUM AND FIELD MEETING
Dr. Aymon Baud and Prof. Jean Marcoux, with the help of the BRGM and other experts.

OBJECTIVE
With the presentation of new and recent results on Permian and Triassic sediments of Oman, the aim of the Symposium and the three fieldtrips are to provide a forum to geologists who are interested in the time interval of Pangea for discussing global changes related to Pangea integration, North Gondwana and Central Tethys evolution; It will be an unique opportunity for sedimentologists, statigraphs and paleontologists who are working within Permian and Triassic time interval, biotic crisis, extinction, recovery and evolution at the Paleozoic-Mesozoic transition to discuss, to look and to sample at the spectacular Permian and Triassic outcrops belonging to the Oman former continental margin, from shallow shelf to deep marine sediments and seamounts. For the petrograph-geochimists, Oman is a key area for the study of the magmatism linked with the **Permian Neotethys opening** and with the Triassic intra-oceanic seamounts.

GENERAL THEME
Pangea and Tethys, moving Plates and environmental Changes.

SECONDARY THEMES
- Progress in the **Permo-Triassic Stratigraphy** and Palaeontology of the Central Tethys and its Gondwana margin.
- Comparison between the **Permo-Triassic continental margins** of Oman, Arabia, Iran, N India (Himalayas) and N Australia.

Further Informations by Aymon Baud, Geological Museum, UNIL-BFSH2, CH-1015 Lausanne, Switzerland, tel.: xx41 21 692 44 71, fax xx41 21 692 44 75, e-mail:
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Pre-Conference Excursion No. A01

Permo-Triassic Deposits: from the Platform to the Basin and Seamounts

Leaders: A. Baud, F. Bechennec, F. Cordey , L. Krystyn, J. le Métour, J. Marcoux & R. Maury
Dates: January 8 - 11, 2001
Cost: US$500

The mountainous belt located in the eastern part of the Arabian Peninsula, the Oman Mountains, expose a segment of the Gondwanian margin interpreted as a flexural upper plate. During the end of the Cretaceous, this segment was sliced and brought on the Arabian continent with the obduction of the ophiolite, part of the Tethyan ocean. Following a lower Permian rifting phase and middle Permian break-up (birth of the Neotethys), a wide carbonate platform developed during late Permian and Triassic times on the inner part of the margin. This Permian-Triassic sequence is exceptionally well exposed in the Jebel Akhdar Mountains, as part of the "autochthonous" which crops out in a large tectonic window. The Permian and Triassic shallow water carbonate rocks occurring in this area belong to the Akhdar Group, with two main lithologic units: the Saiq and Mahil Formations. The Saiq Formation, about 700 m thick and made up of three transgressive - regressive cycles unconformably overlies Precambrian strata, documenting the upper Permian marine transgression. The following 800 m thick Triassic dolomitic Mahil Formation confirms the cyclic and restricted shallow marine environment upward. Carbonates derived from the platform represented the major source for the thick sequence of slope carbonates deposited near the platform margin. On more distal parts, the basinal and oceanic sedimentation resulted in various types of carbonate, cherts and siliciclastic deposits, presently found in the Hawasina Nappe. Middle Permian radiolarites and red ammonoides limestones as Middle Triassic black marls and limestones deposited on lavas are croping out as blocks of various dimensions, the Oman Olistolits, both sides of the "autochthonous" tectonic window. Also new results on Permian and Triassic magmatism will be presented.

Spectacular and recently studied outcrops in Wadi Wasit, Ba'id, Aq Quil, Jebel Misfah, Jebel Misht and Jebel Akhdar areas allowed to reconstruct the former geometry of the margin during Late Permian and Triassic times.

Pre-Conference Excursion No. A02

Lower to Middle Permian Sedimentation on the Arabian Platform: the Huqf Area (S. Central Oman) and the Jebel Akhdar (Oman Mountains)

Leaders: L. Angiolini, J. Broutin, S. Crasquin & J.-P. Platel
Dates: January 7 - 11, 2001
Cost: US$625

This excursion will provide a unique opportunity to see and sample the Peri-Gondwanan Permian successions of the Sultanate of Oman. In the spectacular scenarios of the mountains and the desert, different faunal and floral associations and depositional environments from platform to shallow basin will be visited.

Starting in the desert of the Interior Oman, the excursion will visit the Huqf area, a region marked by gentle deformed and uplifted Palaeozoic formations. Here, the Early to Middle Permian is represented by two mega-sequences separated by a regional unconformity, recording two major transgressive events respectively controlled by the last phase of the Gondwanan deglaciation and by the opening of the Neotethys. The first sequence consists of Lower Permian glacio-lacustrine deposits of the Al Khlata Formation succeeded by the transgressive marine deposits of the Saiwan Formation, marking the complete deglaciation of the region. The latter unit, of late Sakmarian age, yelds a rich and well preserved brachiopod (L. Angiolini), bivalve, gastropod, crinoid and bryozoan fauna.

Resting unconformably, the upper sequence is composed at the base of a thick fluvial terrigenous unit, the Gharif Formation. This sequence terminates with the highly fossiliferous [brachiopods, ostracodes, conodonts, bivalves, gastropods, cephalopods, trilobites (L. Angiolini & S. Crasquin)] transgressive marls and bioclastic limestones of the Khuff Formation, of which only the Wordian part is exposed below the angular unconformity of the Triassic continental Minjur Formation.

The Huqf succession represents a key-section for the intercalibration of Early to Middle Permian marine and continental biostratigraphical scales. In fact, if on one hand the fauna shows a marked transitional character, being represented by cosmopolitan, Gondwanan, Tethyan and endemic taxa, on the other the newly named "Gharif Paleoflora" (J. Broutin) is erected as a standard for the Arabian Peninsula. This warm humid assemblage is of outstanding palaeogeographic significance, because it comprises associated Gondwanan, Cathaysian and Laurasian floral elements.

Moving to the the Oman Mountains, this excursion will examine together with the excursion A01 the Permian succession cropping out in the north-western part of the Jebel Akhdar window, along the Wadi Sahtan. Here, the Permian is represented by the Wordian marine Saiq Formation, lying with a spectacular angular unconformity on the Proterozoic-Lower Paleozoic autochthone series. The Saiq Formation consists of conglomerates at the base overlain by bioclastic limestones and reef limestones which capped by dolomites. This unit marks the transgression on the newly formed Neotethyan margin.

Post-Conference Excursion No. B01

Permo-Triassic Deposits: from Shallow Water to Base of Slope and Basin

Leaders: A. Baud, F. Bechennec, F. Cordey, J. Marcoux, R. Maury & J. le Metour
Dates: January 17 - 20, 2001
Cost: US$500

The mountainous belt located in the eastern part of the Arabian Peninsula, the Oman Mountains, expose a segment of the Gondwanian margin, interpreted as a flexural upper plate. The Permian-Triassic sequence deposited on the inner part of this margin is exceptionally well exposed in the Saih Hatat Mountains, as part of the "autochthonous" which crops out in a large tectonic window. The Permian and Triassic shallow water carbonate rocks occurring in this area belong to the Saiq and Mahil Formations. The Saiq Formation, about 400 m thick, consists of transgressive - regressive cycles of shallow carbonate and lava flows unconformably overlying Precambrian strata and documenting the upper Permian marine transgression and rift opening. The following Triassic dolomitic Mahil Formation confirms the cyclic and restricted shallow marine environment upward.

Carbonates derived from the platform represented the major source for the thick sequence of slope carbonates (the Sumeini Group) deposited near the platform margin, cropping out in the Sumeini area near the border between Oman and the United Arab Emirates. The lower part of this group (about 1700 m thick) is included in the Maqam Formation, late Permian to late Triassic in age. Key section of the Oman margin architecture, the Wadi Maqam has been re-investigated in terms of biochronology, sequence and isotope stratigraphy. On more distal parts, the basinal and oceanic sedimentation resulted in various types of carbonate, cherts and siliciclastic deposits, presently found in the Hawasina Nappe. Middle Permian radiolarites and red ammonoides limestones as Middle Triassic black marls and limestones deposited on lavas are croping out as blocks of various dimensions, the Oman Olistolits, both sides of the "autochthonous" tectonic window. Also new results on Permian and Triassic magmatism will be presented.

Spectacular and well studied outcrops in Saih Hatat, Rustaq, Buday'ah, Wadi Maqam and Jebel Sumeini areas allowed to reconstruct the former geometry of the margin during Late Permian and Triassic times.

Excursion Information and Inscription directly on web site:
http://www.geoconfoman.unibe.ch

FIRST CIRCULAR AND CALL FOR PAPERS

The International Symposium on The Global Stratotype of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events

10-13 August 2001
to be held in
Changxing, Zhejiang Province, The People's Republic of China

For updates consult: http://www.cug.edu.cn/cugnew/overview/dept/dxy/ptb/index.htm

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OBJECTIVES:

This symposium is designed to provide a forum to all kinds of scientists who are interested in the Permian-Triassic boundary and its related great events for examining the key section of the Permian and Triassic boundary at Meishan, Zhejiang Province and discussing the great transition between the Paleozoic and Mesozoic and its associated events.

The field excursions provide you opportunity to visit some typical sequences from the Carboniferous to Lower Triassic and/or some paralic and continental Permian-Triassic boundary sections in South China.

DATE, VENUE AND LANGUAGE:

Pre-symposium Field Excursion:	8-9 August 2001
Symposium:	10-13 August 2001
During-symposium Field Excursion:	11 August 2001
Post-symposium Field Excursion 1:	14-15 August 2001
Post-symposium Field Excursion 2:	14-18 August 2001
Place:	Changxing, Zhejiang Province
Language:	English will be the official language for all presentations

IMPORTANT DATES:

1 February 2001: Deadline for submission of response to first circular
1 May 2001: Deadline for submission of abstracts for the proceedings
1 July 2001: Deadline for submission of pre-registration
13 August 2001: Deadline for submission of papers for the special symposium volume

THEMES:

The symposium will be structured into four main themes:
- The global stratotype of the Permian-Triassic boundary and its geological setting;
- Stratigraphy of the Permian and Triassic boundary and its global correlation over various facies;
- Tectonics, paleogeography, paleoclimatology and paleoecology during the Paleozoic and Mesozoic transition;
- Biotic crisis, mass extinction and recovery, and connected events across the Permian and Triassic boundary.

FIELD EXCURSIONS:

Pre-Symposium Field Excursion: Guangde, Anhui Province and Changxing, Zhejiang Province (8-9 August 2001)

This two-day field excursion will provide you an overview of the geological setting in Meishan area, Changxing County. You will visit some typical sections from the Devonian to Triassic, which well recorded the evolution of the eastern Tethys during the Pangea from late Paleozoic to Triassic. The differentiation of the Changhsingian facies and some key boundaries will be observed as well.

During-Symposium Field Excursion: Meishan Section, Changxing, Zhejiang Province (11 August 2001)

During the symposium we will spend one day at the well-known Meishan Section of the Changxing Limestone and Permian-Triassic boundary to examine the sequence and discuss its related aspects.

Post-Symposium Field Excursion 1: Chaohu, Anhui Province (14-15 August 2001)
The Permian and Triassic stratigraphical and paleontological sequence at Chaohu, Anhui Province is one of the best and well-studied sections in the Lower Yangtze region. The Changhsingian and Lower Triassic here were formed on deep shelf (or slope) while Meishan was on shallow shelf. Here you will visit an excellent Permian and Triassic sequence, and especially the Lower Triassic as well as the Middle Permian is quite exemplary. In addition, we might have a stop in Nanjing, Jiangsu Province, where you could observe a section situated in the transitional facies from Meishan to Chaohu.

Post-Symposium Field Excursion 2: Liuzhi-Weining, Guizhou Province (14-18 August 2001)
This excursion supposes to provide you for a unique chance to trace the Permian-Triassic boundary from marine to continental via paralic facies. Many excellent marine Permian-Triassic boundary sequences have been studied in the central and southern Guizhou while the continental sections are in the western Guizhou and northeastern Yunnan. The paralic Permian-Triassic boundary sections are located in the central-western Guizhou Province. During the excursion you will visit a series Permian and Triassic boundary sections from marine to continental via paralic facies in the central-western Guizhou Province so that you might figure out a correlation between the marine and continental boundaries.

PUBLICATIONS:

We anticipate that refereed and accepted papers will be published either as a book or as a special issue of an international journal. The paper must be presented (either orally or in poster) before being considered for publication. But all abstracts will be collected into the Proceedings of the Symposium, which will be delivered to every participant at the Symposium. All the papers and abstracts must be in English and submitted to the secretariat before the deadlines. Refer to the second circular for the details of the submission of the papers and abstracts.

REGISTRATION:

Registration should be made to the registration form attached on the second circular, which will be sent to all who respond to the first circular. Registration fee for the symposium (including the Proceedings, morning and afternoon teas, and the during-symposium field excursion and during-symposium sightseeing in Changxing County) will be $200 US Dollars. Pre-Symposium field excursion fee (including field guidebook, transportation and meals) will be $100 US Dollars. The post-symposium field excursion 1 to Chaohu costs $150 US Dollars (including field guidebook, transportation, and accommodation). The post-symposium field excursion 2 to Guizhou will be $450 US Dollar (including field guidebook, accommodation, transportation during the field excursion in Guizhou, and a single flight from Nanjing to Guiyang). Refer to the second circular for the details.

HOTEL ACCOMMODATION:

Several hotels in the downtown of Changxing County are arranged for participants. Room rate ranges from $20 to $50 US Dollars per night for standard double rooms and $15 to $30 US Dollars per night for standard single rooms. Details and reservation forms for hotels will be distributed in the second circular.

TRANSPORTATION:

Changxing is located in the northern Zhejiang Province, to the west of Taihu Lake, bordering on Jiangsu and Anhui provinces. It is in the mid-way of the Nanjing-Hanzhou freeway, 110 km to Hanzhou and 200 km to Nanjing. A highway also connects it to Shanghai in about 150 km. The Hanzhou-Chaohu railway goes through Changxing City with a few trains daily from Hanzhou.

Pre-Registration Form for:

The GSSP of the Permian-Triassic Boundary and the Paleozoic-Mesozoic Events

Forename:
Initial(s):
Surname:
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Title:
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I plan to attend the Symposium (Please tick)

❑ very probably ❑ probably ❑ unlikely

I plan to contribute with an

❑ oral paper ❑ poster

Tentative title:

I plan to attend the pre-Symposium field excursion

❑ very probably ❒ probably ❒ unlikely

I plan to attend the post-Symposium field excursion 1 to Chaohu

❒ very probably ❒ probably ❒ unlikely

I plan to attend the post-Symposium field excursion 2 to Guizhou

❒ very probably ❒ probably ❒ unlikely

Comments/Suggestions:

Date:

Signature:

NEW TRIASSIC LITERATURE

Hans Kerp, Henk Visscher and Geoffrey Warrington

Aigner, T., Hornung, J., Junghans, W.-D. & Pöppelreiter, M.,1999. Baselevel cycles in the Triassic of the South-German Basin: a short progress report. Zbl. Geol. Paläont. Teil. I., 1998: 537-544.

Aita, Y. & Bragin, N.Yu., 1999. Non-Tethyan Triassic radiolaria from New Zealand and northeastern Siberia. Geodiversitas, 21: 503-526.

Alcober, O., 2000. Redescription of the skull of Saurosuchus galilei (Archosauria, Rauisuchidae). J. Vertrebr. Paleont., 20: 302-316.

Al'mukhamedov, A., Medvedev, A.Y. & Kirda, N.P., 1999. Comparative analysis of geodynamic settings of the Permo-Triassic magmatism in East and West Siberia. Geol. Geofiz., 40: 1575-1587.

Al'mukhamedov, A.I., Medvedev, A.Y. & Kirda, N.P., 2000. Rhyolites is the component of the Triassic volcanic-sedimentary sequence of West-Siberian plate. Dokl. Akad. Nauk, 371: 200-203.

Amodeo, F., 1999. The uppermost Triassic-Jurassic of the Lagonegro Basin. Stratigraphic studies on the Scisti Silicei Formation in Basilicata (southern Italy). Mém. Géol. (Lausanne), 33: viii+ 121pp.

Antonellini, M. & Mollema, P.N., 2000. A natural analog for a fractured and faulted reservoir in dolomite: Triassic Sella Group, northern Italy. AAPG Bull., 84: 314-344.

Arche, A. & López-Gómez, J., 1999. Tectonic and geomorphic controls on the fluvial styles of the Eslida Formation, Middle Triassic, Eastern Spain. Tectonophysics, 315: 187-207.

Ash, S.R. & Creber, G.T., 2000. The Late Triassic Araucarioxylon arizonicum trees of the Petrified Forest National Park, Arizona, USA. Palaeontology, 43: 15-28.

Atudorei, V., 1999. Constraints on the Upper Permian to Upper Triassic marine isotope curve. Case studies from the Tethys. Ph.D. Thesis, 160 pp. + plates and tables. Géol. Mus. Lausanne / Dept. Earth Sci. Univ. Lausanne.

Atudorei, V., Baud, A., Crasquin-Soleau, S., Galbrun, B., Gradinaru, E., Mirauta, E., Renard, M. & Zerrari, S., 1997. Extended scientific report of the Project 95-32 "The Triassic of North-Dobrogea". Geol. Mus. Lausanne, 60 pp.

Axsmith, B.J., Taylor, E.L., Taylor, T.N. & Cúneo, N.R., 2000. New perspectives on the Mesozoic seed fern order Corystospermales based on attached organs from the Triassic of Antarctica. Amer. J. Bot., 87: 757-768.

Bachman, G., Beutler, G. & Hagdorn, H., 1999. Muschelkalk und Keuper am Autobahndreieck Bayreuth/Kulmbach, Nordost Bayern. Hallesches Jahrb. Geowiss., B21: 1-34.

Balini, M., Gavrilova, V.A. & Nicora, A., 1999. Biostratigraphical revision of the classic Lower Triassic Dolnapa section (Mangyshlak, West Kazakhstan). Zbl. Geol. Paläont. Teil. I., 1998: 1441-1462.

Balini, M., Germani, D., Nicora, A. & Rizzi, E., 2000. Ladinian/Carnian ammonoids and conodonts from the classic Schilpario-Pizzo Camino area (Lombardy): Revaluation of the biostratigraphic support to chronostratigraphy and paleogeography. Riv. Ital. Paleont. Strat., 106: 19-58.

Bandyopadhyay, S. & Sengupta, D.P., 1999. Middle Triassic vertebrates of India. J. Afr. Earth Sci., 29: 233-241.

Basu Mallik, S., Piper, J.D.A., Das, A.K., Bandyopadhyay, G. & Sherwood, G.J., 1999. Palaeomagnetic and rock magnetic studies in the Gondwana Supergroup (Carboniferous-Cretaceous), northeast India. Mem. Geol. Soc. India, 44: 87-116.

Bayer, U., Scheck, M., Rabbel, W., Krawczyk, C.M., Gotze, H.J., Stiller, M., Beilecke, T., Marotta, A.M., Barrio-Alvers, L. & Kuder, J., 1999. An integrated study of the NE German Basin. Tectonophysics, 314: 285-307.

Bavec, M., 1999. Ladinian carbonate and pyroclastic rocks between Jagrsce and Zelin (Slovenia). Geologija, 41: 41-69.

Becker, G., 2000. Contributions to Palaeozoic Ostracod Classification [POC], No. 14 - The Superfamily Bairdiocypridacea Shaver, 1961 - 2. Family Pachydomellidae Berdan & Sohn, 1961, cont. Upper Palaeozoic spinose forms. N. Jb. Geol. Paläont., Abh., 215: 275-296.

Belivanova, K., 1997. Diagenesis of the Triassic carbonate rocks from the Golo Bardo Mountain, southwestern Bulgaria. Geol. Balcanica, 27: 27-35.

Belivanova, V., 1999. Triassic in the Golo Bardo Mountain - one example for t.he Balkanide facial type of Triassic in Bulgaria. Zbl. Geol. Paläont. Teil. I., 1998: 1105-1122.

Benatov, S., 1997. Costirhynchopsis vidlicis (Urosevic, 1981) - a new brachiopod species for the Bulgarian Middle Triassic. Geol. Balcanica, 27: 37-43.

Benatov, S., 1999. Macrofauna from Peri-Tethyan Middle Triassic in the southem slopes of Westem Stara Planina Mountain (Western Bulgaria). Zbl. Geol. Paläont. Teil. I., 1998: 1137-1144.

Beutler, G., Farrenschon, J., Hauschke, N., Oppermann, K. & Seeling, M., 1999. Das Typusprofil der Weser-Formation (Oberer Gipskeuper, Mittlerer Keuper) nördlich Polle/Weser (südliches Niedersachsen). Hallesches Jahrb. Geowiss., B21: 55-66.

Beyer, C., 2000. Magnetic investigation of well cores from the North Sea basin; An important contribution to the global polarity scale for the Triassic. Geol. Carpathica, 51: 193-193.

Bhatt, D.K., Joshi, V.K. & Arora, R.K., 1999. Conodont biostratigraphy of the Lower Triassic in Spiti Himalaya, India. J. Geol. Soc. India, 54: 153-167.

Bhatt, D.K., Joshi, V.K. & Arora, R.K., 2000. Conodont biostratigraphy of the Lower Triassic in Spiti Himalaya. J Geol. Soc. India, 55: 688-688.

Bjerring, H.C., 1999. A new amphibious tetrapod from the Greenlandic Eotriassic. Meddel. Grønland, Geosci., 38: 42pp.

Blake, D.B., Tintori, A. & Hagdorn, H., 2000. A new, early crown-group asteroid (Echinodermata) from the Norian (Triassic) of Northern Italy. Riv. Ital. Paleontol. Strat., 106: 141-155.

Blanke, H. & Patzschke, M., 1999. Ein temporärer Aufschluss von Rhät-Kohle (Obere Trias) bei Morsleben (nördkiches Sachsen-Anhalt). Hallesches Jahrb. Geowiss., B21: 67-78.

Bolt, J.R. & Chatterjee, S., 2000. A new temnospondyl amphibian from the Late Triassic of Texas. J. Paleont., 74: 670-683.

Boyd, D.W. & Newell, N.D., 1999. Lyriomyophoria Kobayashi, 1954, a junior synonym of Elegantinia Waagen, 1907. J. Paleont., 73: 547-548.

Boyd, D.W., Nice, D.E. & Newell, N.D., 1999. Silt injection as a mode of fossilization: A Triassic example. Palaios, 14: 545-554.

Bragin, N.Y., 2000. The Permian-Triassic crisis in the biosphere as manifested in the Paleo-Pacific deep-water sequences. Strat. Geol. Correl., 8: 232-242.

Brack, P., Rieber, H. & Urlichs, M., 1999. Pelagic successions in the Southem Alps and their correlation with the Germanic Middle Triassic. Zbl. Geol. Paläont. Teil. I., 1998: 853-876.

Bragin, N.Yu. & Krylov, K.A., 1999. Early Norian radiolaria from Cyprus. Geodiversitas, 21: 539-569.

Brea, M. & Artabe, A.E., 1999. Triassic Apocalamitaceae (Sphenophyta) of the Paramillo Formation, Agua de la Zorra, Mendoza province, Argentina. Ameghiniana, 36: 389-400.

Broecker, W.S. & Peacock, S., 1999. An ecologic explanation for the Permo-Triassic carbon and sulfur isotope shifts. Global Biogeochem Cy., 13: 1167-1172.

Bromley, R.G. & Mørk, A., 2000. The trace fossil Phoebichnus trochoides in the condensed Triassic-Jurassic-boundary strata of Svalbard. Zbl. Geol. Paläont. Teil I., 1998(11-12): 1431-1439.

Brückner-Röhling, S.,1999. Chemocyclicity in the Middle Muschelkalk of Northern Germany. Zbl. Geol. Paläont. Teil. I., 1998: 941-952.

Bucur, I.I., 1997. Signification stratigraphique des Dasycladales Mesozoiques. Stud. Univ. Babes-Bolyai, Geologia, 42(2): 2-24.

Budai, T., Császár, G., Csillag, G., Dudko, A., Koloszár, L. & Majoros, G., 1999. A Balaton-Felvidék Földtana. Magyarázó a Balaton-fevidék földtani térképéhez, 1 : 50.000 (Geology of the Balaton Highland. Explanation of the geological map of the Balaton Highland, 1: 50 000). Occ. Pap. Geol. Inst. Hungary, 197: 257pp.

Budurov, K. & Petrunova, L., 1999. Muschelkalk conodonts as components of the Peri-Tethyan fauna. Zbl. Geol. Paläont. Teil. I., 1998: 989-996.

Budurov, K., Zagorchev, I., Trifanova, E. & Petrounova, L., 1997. The Triassic in southwest Bulgaria. Contribution to the stratigraphy of the Iskur Carbonate Group in the Vlahina Mountain.

Geol. Balcanica, 27: 19-26.

Caron, C., Jamal, M., Zeinab, H. & Cerda, F., 2000. Basin development and tectonic history of the Euphrates graben (Eastern Syria): a stratigraphical and seismic approach. In: S. Crasquin-Soleau & É Barrier (eds), Peri-Tethys Memoir 5: new data on Peri-Tethyan sedimentary basins. Mém. Mus. Nation. Hist. Nat., 182: 169-202.

Carrilat, A., Martini, R., Zaninetti, L., Cirilli, S., Gandin, A. & Vrielinck, B., 1999. The Muschelkalk (Middle to Upper Triassic) of the Monte di Santa Giusta (NW Sardinia): sedimentology and biostratigraphy. Eclog. Geol. Helv., 92: 81-97.

Cirilli, S., Iannace, A., Jadoul, F. & Zamparelli, V., 1999. Microbial-serpulid build-ups in the Norian-Rhaetian of the Western Mediterranean area: ecological response of shelf margin communities to stressed environments. Terra Nova, 11: 195-202.

Chatalov, A.G., 1999. Calcitization of dolomite in the Spathian and Anisian carbonate rocks from the western Balkanides, Bulgaria. N. Jb. Geol. Paläont., Mh., 1999(10): 614-640.

Chatalov, A.G., 1999. The Mogila Formation (Spathian - Anisian) in the Western Balkanides of Bulgaria - ancient counterpart of an arid peritidal complex. Zbl. Geol. Paläont. Teil. I., 1998: 1123-1136.

Chotin, P., Ait Brahim, L. & Tabyaoui., 2000. The southern Tethyan margin in northeastern Morocco; sedimentary characteristics and tectonic control. In: S. Crasquin-Soleau & E. Barrier (eds), Peri-Tethys Memoir 5: new data on Peri-Tethyan sedimentary basins. Mém. Mus. Nation. Hist. Nat., 182: 107-128.

Clausen, O.R. & Pedersen, P.K., 1999. Late Triassic structural evolution of the southern margin of the Ringkøbing-Fyn High, Denmark. Mar. Petrol. Geol., 16: 653-665.

Clement, G., 1999. The actinistian (Sarcopterygii) Piveteauia madagascariensis Lehman from the Lower Triassic of northwestern Madagascar; a redescription on the basis of new material. J. Vertebr. Paleont., 19: 234-242.

Courel, L. & Demathieu, G. R., 2000. Une nouvelle ichnoespèce Coelurosaurichnus grancieri du Trias supérieur de l'Ardèche, France. Geodiversitas, 22: 35-46.

Courel, L., Salem, H.A., Ismael, H.B., El Mostaine, M., Fekirine, B., Kamoun, F., Mami, L., Oujidi, M. & Soussi, M., 1999. An overview of the epicontinental Triassic series of Maghmb (N-W Aftica). Zbl. Geol. Paläont. Teil. I., 1998: 1145-1166.

Crasquin-Soleau, S., Berra, F. & Rettori, R., 2000. A Late Triassic ostracod assemblage from the Quattervals Nappe (austroalpine, Northern Italy). Riv. Ital. Paleont. Strat., 106: 181-189.

Cuny, G., Hunt, A., Mazin, J.-M. & Rauscher, R., 2000. Teeth of enigmatic neoselachian sharks and an ornithischian dinosaur from the uppermost Triassic of Lons-le-Saunier (Jura, France). Paläont. Z., 74: 171-185.

Curtis, K. & Padian, K. 1999. An Early Jurassic microvertebrate fauna from the Kayenta Formation of northeastern Arizona: microfaunal change across the Triassic-Jurassic boundary. Paleobios, 19: 19-37.

Dagys, A., Bucher, H. & Weitschat, W., 1999. Infraspecific variation of Parasiberites kolymensis Bychkov (Ammonoidea) from the Lower Triassic (Spathian) of Arctic Asia. Mitt. Geol.- Paläont. Inst. Univ. Hamburg, 83: 163-178.

Dalla Vecchia, F.M., 2000. Tanystropheus (Archosauromorpha, Prolacertiformes) remains from the Triassic of the Northern Friuli (NE Italy). Riv. Ital. Paleont. Strat., 106: 135-140.

Damiani, R.J., 1999. Parotosuchus (Amphibia, temnospondyli) in Gondwana: biostratigraphic and palaeobiogeographic implications. S. Afr. J. Sci., 95: 458-460.

Danelian, T., Lekkas, S. & Alexopoulos, A., 2000. Discovery of Triassic radiolarites in an ophiolitic complex of the southernmost Peloponnese (Agelona, Lakonia, Greece). C.R. Acad. Sci., IIa, 330: 639-644.

Das, A.K., Piper, J.D.A., Bandyopadhyay, G., Basu Mallik, S., Sherwood, G.J. & Mondal, S., 1999. Magnetopetrologic study of sediments from the Gondwana Supergroup, northeast India. Mem. Geol. Soc. India, 44: 117-127.

Detre, C., 1999. Biostratigraphic evidences of the Triassic-Jurassic boundary in the Mesozoic horst near Csövár. Ann. Rep. Geol. Inst, Hungary, 1992-1993/II: 21-25.

Diedrich, C., 1999. Vertebrate track ichnofacies types of the Oolith member (Lower Muschelkalk, Middle Triassic) in the central Teutoburger Wald (NW Germany) and their stratigraphical, facial and palaeogeographical significance. Zbl. Geol. Paläont. Teil. I., 1998: 925-940.

Di Giulio, A., Tribuzio, R., Ceriani, A. & Riccardi, M.P., 1999. Integrated analyses constraining the provenance of sandstones, a case study; the Section Peak Formation (Beacon Supergroup, Antarctica). Sed. Geol., 124: 169-183.

Dill, H.G., Wehner, H., Botz, R. & Dultz, S., 2000. Chemical logging of continental-marine depositional systems. A tool to unravel the palaeogeography and diagenetic alteration of fine-grained clastic rocks in a transitional environment of deposition (Triassic-Liassic, Southeastern Germany). Chemie der Erde - Geochemistry 60: 129-171.

Dixon, J., 2000. Regional lithostratigraphic units in the Triassic Montney Formation of western Canada. Bull. Can. Petrol. Geol., 48: 80-83.

Dolenec, T., Buser, S. & Dolenec, M., 1999. The Permian-Triassic boundary in the Karavanke Mountains (Slovenia): stable isotope variations in the boundary carbonate rocks of the Košutnik Creek and Brsnina Section. Geologija, 41: 17-27.

Dolenec, T., Lojen, S. & Dolenec, M., 2000. The Permian-Triassic boundary in the Inrija Valley (western Slovenia): isotopic fractionation between carbonate and organic carbon at the P/Tr transition. Geologija, 42: 165-170.

Dostal, J. Gale, V. & Church, B.N., 1999. Upper Triassic Takla Group volcanic rocks, Stikine Terrane, north-central British Columbia: geochemistry petrogenesis, and tectonic implications. Can. J. Earth Sci., 36: 1483-1494.

Dronov, V.I., 2000. Triassic deposits of the Buguchi backbone in the Rushan-Pshart Pamirs. Dokl. Akad. Nauk., 371: 344-346. MAR 2000

Dronov, V.I., 1999. The first find of Triassic fauna in volcanic rocks of the Rushan-Pshart Pamirs. Dokl. Akad. Nauk., 369: 225-227.

Dumitrica, P. & Carter, E.S., 1999. Family Kungalariidae, n. fam., new Mesozoic entactinarian Radiolaria with a nassellarian-type initial spicule. Micropaleontology, 45: 418-428.

Egenhoff, S.O., Peterhänsel, A., Bechstädt, T., Zühlke, R. & Grötsch, J., 1999. Facies architecture of an isolated carbonate platform: tracing the cycles of the Latemàr (Middle Triassic, northern Italy). Sedimentology, 46: 893-912.

Egerov, A.Y. & Mørk, A., 2000. The East Siberian and Svalbard Triassic successions and their sequence stratigraphical relationships. Zbl. Geol. Paläont. Teil I, 1998(11-12): 1377-1430.

Ekart, D.D., Cerling, T.E., Montanez, I.P. & Tabor, N.J., 1999. A 400 million year carbon isotope record of pedogenic carbonate: Implications for paleoatmospheric carbon dioxide. Amer. J. Sci., 299: 805-827.

Erlstrom, M. & Guy-Ohlson, D., 1999. An Upper Triassic, Norian-Rhaetian, outlier in Skane, southern Sweden. Medd. Dansk Geol. Forening, 44: 89-97.

Ermakova, S.P. & Kutygin, R.V., 2000. The Induan Stage in the eastern upper-Yana region. Geol. Geofiz., 41: 671-678.

Et-Touhami, M., 1999. Lithostratigraphy and depositional environments of Lower Mesozoic evaporites and associated red beds, Khemisset Basin, northwestem Morocco. Zbl. Geol. Paläont. Teil. I., 1998: 1217-1242.

Farris, M.A., Oates, M.J. & Torrens, H.S., 1999. New evidence on the origin and Jurassic age of palaeokarst and limestone breccias, Loch Slapin, Isle of Skye, Scottish J. Geol., 35: 25-29.

Fijalkowska-Mader, A., 1999. Palynostratigraphy, Palaeoecology and Palaeoclimatology of the Triassic of South-Eastern Poland. Zbl. Geol. Paläont. Teil. I., 1998: 601-628.

Flynn, J.J., Parrish, J.M., Rakotosamimanana, B., Simpson, W.F., Whatley, R.L. & Wyss, A.R., 1999. A Triassic fauna from Madagascar, including early dinosaurs. Science. 286: 763-765.

Freudenberger, W., Fritzer, Th. & Geiger, A., 1998. Der Mittlere und Obere Buntsandstein in Kernbohrungen bei Coburg. Geol. Bavarica, 103: 295-320.

Frisch, U. & Kockel, F., 1999. Quantification of Early Cimmerian movements in NW-Germany. Zbl. Geol. Paläont. Teil. I., 1998: 571-600.

Gabrielsen, R.H., Odinsen, T. & Grunnaleite, I., 1999. Structuring of the Northern Viking Graben and the More Basin; the influence of basement structural grain, and the particular role of the More-Trondelag Fault Complex. Mar. Petrol. Geol., 16: 443-465.

Gallego, O.F. & Melchor, R.N., 2000. La familia family Ulugkemiidae Novozhilov, 1958 (Conchostraca) en el Triásico de Argentina: implancias paleobiogeográficas. Ameghiniana, 37: 47-58.

Gallet, Y., Besse, J., Krystyn, L., Marcoux, J., Guex, J. & Theveniaut, H., 2000. Magnetostratigraphy of the Kavaalani section (southwestern Turkey): Consequence for the origin of the Antalya Calcareous Nappes (Turkey) and for the Norian (Late Triassic) magnetic polarity timescale. Geophys. Res. Lett., 27: 2033-2036.

Gallet, Y., Krystyn, L., Besse, J., Saidi, A. & Ricou L.E., 2000. New constraints on the Upper Permian and Lower Triassic geomagnetic polarity timescale from the Abadeh section (central Iran). J. Geophys. Res., Solid Earth, 105(B2): 2805-2815.

Galton, P.M., 2000. The prosauropod dinosaur Plateosaurus Meyer, 1837 (Saurischia: Sauropodomorpha). I. The syntypes of P. engelhardti Meyer, 1837 (Upper Triassic, Germany), with notes on other European prosauropods with "distally straight" femora. N. Jb. Geol. Paläont. Abh., 216: 233-275.

Garza, R.S.M., Geissman, J.W. & Lucas, S.G., 2000. Palaeomagnetism and magnetostratigraphy of uppermost Permian strata, southeast New Mexico, USA: Correlation of the Permian-Triassic boundary in non-marine environments. Geophys. J. Int., 141: 778-786.

Garzanti, E., 1999. Stratigraphy and sedimentary history of the Nepal Tethys Himalaya passive margin. J. Asian Earth Sci., 17: 805-827.

Gawlick, H.-J., 2000. Sedimentologie, Fazies und Stratigraphie der obertriassischen Hallstätter Kalke des Holzwehralm-Schollenkomplexes (Nördliche Kalkalpen, Salzburger Land). Jn. Geol. B.-A., 142: 11-31.

Gawlick, H.-J. & Bohm, F., 2000. Sequence and isotope stratigraphy of Late Triassic distal periplatform limestones from the Northern Calcareous Alps (Kalberstein Quarry, Berchtesgaden Hallstatt Zone). Int. J. Earth Sci., 89: 108-129.

Gawlick, H.-J. & Hopfer, N., 1999. Stratigraphie, Fazies und Hochdruck-Mitteltemperatur-Metamorphose der Hallstatter Kalke der Pfeilwand (Nordliche Kalkalpen, Osterreich). Z. dtsch. geol. Ges., 150: 641-671.

Geluk, M.C., 1999. Palaeogeography and structural development of the Triassic in the Netherlands - new insights. Zbl. Geol. Paläont. Teil. I., 1998: 545-570.

Geluk, M.C. & Röhling, H.-G., 1999. High-resolution sequence stratigraphy of the Lower Triassic Buntsandstein: A new tool for basin analysis. Zbl. Geol. Paläont. Teil. I., 1998: 727-747.

Genise, J.F., Mangano, M.G., Buatois, L.A., Laza, J.H. & Verde, M., 2000. Insect trace fossil associations in paleosols: The Coprinisphaera ichnofacies. Palaios, 15: 49-64.

Gibbs, M.T., Bluth, G.J.S., Fawcett, .P.J. & Kump, L.R., 1999. Global chemical erosion over the last 250 my: variations due to changes in paleogeography, paleoclimate and paleogeography. Amer. J. Sci., 299: 611-651.

Glikson, A.Y., 1999. Oceanic mega-impacts and crustal evolution. Geology, 27: 387-390.

Gnaedinger, S. & Herbst, R., 1999. Triassic flora from the El Tranquilo Group, Santa Cruz province, Patagonia. Part VI: Ginkgoales. Ameghiniana 36: 281-296.

Godefroit, P., 1999. New traversodontid (Therapsida: Cynodontia) teeth from the Upper Triassic of Habay-la-Vieille (southern Belgium). Paläont. Z., 73: 385-394.

Götz, A.E. & Feist-Burkhardt, S., 1999. Palynofacies and sequence analysis of the Lower Muschelkalk (Middle Triassic, German basin). Zbl. Geol. Paläont. Teil. I., 1998: 877-892.

Gower, D.J., 1999. The cranial and mandibular osteology of a new rauisuchian archosaur from the Middle Triassic of southern Germany. Stuttgarter Beitr. Naturk., Ser. B, 280: 1-49.

Grigelis, A. & Norling, E., 1999. Jurassic geology anad foraminiferal faunas in the NW part of the East European Platform. A Lithuanian-Swedish geotraverse study. SGU Research Papers, series Ca 89 Uppsala, 101pp.

Guerra-Sommer, M., Cazzulo-Klepzig, M. & Iannuzzi, R., 1999. The Triassic taphoflora of the Parana Basin, southern Brazil: a biostratigraphical approach. J. Afr. Earth Sci., 29: 243-255.

Haas, J. & Budai, T., 1999. Triassic sequence stratigraphy of the Transdanubian Range (Hungary). Geol. Carpathica, 50: 459-475.

Haas, J., Hámor, G. & Korpás, l., 1999. Geological setting and tectonic evolution of Hungary. Geol. Hungarica Ser. Geol., 24: 179-196.

Hafid, M., 2000. Triassic-early Liassic extensional systems and their Tertiary inversion, Essaouira Basin (Morocco). Mar. Petrol. Geol-, 17: 409-429.

Hagdorn, H., 1999. The Triassic - Crucial period of post-Paleozoic echinoderm phylogeny and its treasure trove in the Germanic Muschelkalk. Zbl. Geol. Paläont. Teil. I., 1998: 983-988.

Hagdorn, H. & Rieppel, 0., 1999. Stratigraphy of marine reptiles in the Triassic of Central Europe. Zbl. Geol. Paläont. Teil. I., 1998: 651-678.

Haggart, J.W. & Orchard, M.J., 1999. Upper Triassic (Rhaetian) debris-flow deposits in the Sandilands Formation, Queen Charlotte Islands, British Columbia. Geol. Surv. Canada, Current Research 1999-A: 185-191.

Halami , J., Slovenec, D. & Kolar-Jurkovšek, T., 1998. Triassic pelagic limestones in pillow lavas in the Orešje Quarry near Gornja Bistra, Medvednica Mt. (northwest Croatia). Geol. Croat., 51: 33-45.

Halasz, D., Marton, E., Haas, J. & Pálfy, J., 2000. Palaeomagnetism of a Triassic-Jurassic boundary section: Csovar, Hungary. Geol. Carpathica, 51: 171-172.

Hallam, A. & Wignall, P.B., 1999. Mass extinctions and sea-level changes. Earth Sci. Rev., 48: 217-250.

Hallam, A. & Wignall, P.B., 2000. Facies changes across the Triassic-Jurassic boundary in Nevada, USA. J. Geol. Soc. London, 157: 49-54.

Hancox, P.J., 1999. The Continental Triassic of South Africa. Zbl. Geol. Paläont. Teil. I., 1998: 1285-1324.

Hancox, P.J., Damiani, R.J. & Rubidge, B.S., 2000. First occurrence of Paracyclotosaurus (Temnospondyli, Capitosauridae) in the Karoo basin of South Africa and its biostratigraphic significance. S. Afr. J. Earth Sci., 96: 135-137.

Hassan, S., Ishiga, H., Roser, B.P., Dozen, K. & Naka, T., 1999. Geochemistry of Permian-Triassic shales in the Salt Range, Pakistan: implications for provenance and tectonism at the Gondwana margin. Chem. Geol., 158: 293-3414.

Haubold, H., 1999. Tracks of the Dinosauromorpha from the Lower Triassic. Zbl. Geol. Paläont. Teil. I., 1998: 783-796.

Haunold, Y., Dobrozemsky, G., Krystyn, L., Kiesl, W. & Bichler, M., 1999. REE distributions in Triassic conodonts. Boll. Soc. Paleont. Ital., 37: 515-525.

Heckert, A.B. & Lucas, S.G., 1999. Taxonomy, phylogeny, biostratigraphy, biochronology, paleobiogeography, and evolution of the Late Triassic Aetosauria (Archosauria:Crurotarsi). Zbl. Geol. Paläont. Teil. I., 1998: 1539-1588.

Heckert, A.B., Lucas, S.G. & Harris, J.D., 1999. An aetosaur (Reptilia: Archosauria) from the Upper Triassic Chinle Group, Canyonlands National Park, Utah; in Santucci, V. L. and McClelland, L.. (eds.), National Park Service paleontological research volume 4: Lakewood, Colorado, National Park Service [NPS/GDR/GRDTR-99/03], p. 23-26.

Holz, M. & Scherer, C.M.S., 1999. Sedimentological and paleontological evidence of paleoclimatic change during the Triassic in South Brazil: evidence of a global trend towards a humid paleoclimate. Zbl. Geol. Paläont. Teil. I., 1998: 1589- .

Holzforster, F., Stollhofen, H. & Stanistreet, I.G., 1999. Lithostratigraphy and depositional environments in the Waterberg-Erongo area, central Namibia, and correlation with the main Karoo Basin, South Africa. J. Afr. Earth Sci., 29: 105-123.

Huang, K.N. & Opdyke, N.D., 2000. Magnetostratigraphic investigations of the Middle Triassic Badong Formation in South China. Geophys. J. Int., 142: 74-82.

Hubbard, R.N.L.B. & Boulter, M.C., 2000. Phytogeography and paleoecology in western Europe and eastern Greenland near the Triassic-Jurassic boundary. Palaios, 15: 120-131.

Irmen, A.P. & Vondra, C.F., 2000. Aeolian sediments in lower to middle (?) Triassic rocks of central Wyoming. Sediment. Geol., 132: 69-88.

Isbell, J.l. & Askin, R.A., 1999. Search for evidence of impact at the Permian-Triassic boundary in Antarctica and Australia: Comment. Geology, 27: 859.

Isozaki, Y., 1999. Plume Winter: Mass extinction and environment catastrophe across the Permo-Triassic boundary. Fossils (Palaeontological Society of Japan), 66: 45-46. (In Japanese).

Jabour, H., Morabet, A.M. & Bouchta, R., 2000. Hydrocarbon systems of Morocco. In: S. Crasquin-Soleau & E. Barrier (eds), Peri-Tethys Memoir 5: New data on Peri-Tethyan sedimentary basins. Mém. Mus. Nation. Hist. Nat., 182: 143-158.

Jalil, N.E., 1999. Continental Permian and Triassic vertebrate localities from Algeria and Morocco and their stratigraphical correlations. J. Afr. Earth Sci., 29: 219-226.

Jenny-Deshuses, C., Martini, R. & Zaninetti, L., 2000. Découverte du foraminifère Colaniella Likharev dans le Permien supérieur de la vallée du Sosia (Sicile). C.R. Acad. Sci. Paris, Sciences de la Terre et des planètes, 330: 799-804.

Jiarun, Y., Enay, R. & Xiaoqiao, W., 1999. The first report of the Late Triassic-Early Jurassic passage beds in the Eastern Tethyan Himalaya. C.R. Acad. Sci., Sér. II, 329 a: 125-133.

Jiang De-xin & Yang Hui-qiu., 2000. Petroleum sporo-pollen assemblages in Tarim Basin. Acta Sediment. Sinica, 18: 80-88.

Jiang, W., Luo, Y.Q. & Lu, T.Q., 2000. The Lower Triassic conodonts and its significance to oil and gas exploration in Sichuan Basin. Acta Micropalaeont. Sinica, 17: 99-107.

Jin, Y.G., Shang, Q.H. & Cao, C.Q., 2000. Late Permian magnetostratigraphy and its global correlation. Chinese Sci. Bull., 45: 698-705.

Jin, Y.G., Wang, Y., Wang, W., Shang, Q.H., Cao, C.Q. & Erwin, D.H., 2000. Pattern of marine mass extinction near the Permian-Triassic boundary in South China. Science, 289: 432-436.

Johns, M.J., Barnes, C.R. & Orchard, M.J., 1999. Progress on Triassic ichthyolith biostratigraphy and regional thermal-maturation studies, Trutch and Halfway maps areas, northeastern British Columbia. Current Research - Geol. Surv. Canada, pp. 51-59.

Jones, T.D., Ruben, J.A., Martin, L.D., Kurochkin, E.N., Feduccia, A., Maderson, P.F.A., Hillenius, W.J., Geist, N.R. & Alifanov, V., 2000. Nonavian feathers in a Late Triassic archosaur. Science, 288: 2202-2205.

Jorgensen, P.J. & Fielding, C.R., 1999. Debris-flow deposits in an alluvial-plain succession: the Upper Triassic Callide Coal Measures of Queensland, Australia. J. Sed. Res., 69: 1027-1040.

Jovanovi , R., 1998. Basic characteristics of Lower Triassic continental beds of western Serbia and their analysis and interpretation. Ann. Géol. Penins. Balk., 62: 305-324.

Jurkovšek, B., Ogorelec, B. & Kolar-Jurkovšek, T., 1999. Lower Triassic beds from Tehovec(Polhov Gradec Hills, Solvenia). Geologija, 41: 29-40.

Kamata, Y., 1999. Lower Triassic (Spathian) radiolarians from the Kuzu area (Tochigi Prefecture, central Japan). Geodiversitas, 21: 657-673.

Kamei, A., Owada, M., Hamamoto, T., Osanai, Y., Yuhara, M. & Kagami. H., 2000. Isotopic equilibration ages for the Miyanohara tonalite from the Higo metamorphic belt in central Kyushu, Southwest Japan: Implications for the tectonic setting during the Triassic. Island Arc, 9: 97-112.

Kammerer, Th., 1999. Über ein Vorkommen von Unterem Keuper (Erfurt-Formation, Trias) bei Mellingen (TK 25 5034 Weimar Ost). Geowiss. Mitt. Thüringen, 7: 71-76.

Kazakov, A.M., Mogucheva, N.K., Devyatov, V.P. & Smirnov, L.V., 2000. The Triassic system in the section of the Tyumenskaya superdeep borehole SD-6 (West Siberia). Geol. Geofyz., 41: 318-326.

Kazanskii, A.Y., Kazanskii, Y.P., Saraev, S.V. & Moskvin, V.I., 2000. The Permo-Triassic boundary in volcanosedimentary section of the West-Siberian Plate according to paleomagnetic data (from studies of the core from the Tyumenskaya superdeep borehole SD-6). Geol. Geofyz., 41: 327-339.

Keim, L. & Schlager, W, 1999. Automicrite facies on steep slopes (Triassic, Dolomites, Italy). Facies, 41: 15-26.

Kent, D.V. & Olsen, P.E., 1999. Implications of astronomical climate cycles to the chronology of the Triassic. Zbl. Geol. Paläont. Teil. I., 1998: 1463-1474.

Kent, D.V. & Olsen, P.E., 2000. Magnetic polarity stratigraphy and paleolatitude of the Triassic-Jurassic Blomidon Formation in the Fundy basin (Canada): implications for early Mesozoic tropical climate gradients. Earth Sci. Planet. Lett., 179: 311-324.

Khmelevska, O., Kovalevych, V. & Peryt, T.M., 2000. Changes of seawater composition in the Triassic-Jurassic time as recorded by fluid inclusions in halite. J. Geochem. Explor., 69: 83-86.

Kimura, T. & Ohana, T., A unique Cycadocarpidium from the Upper Triassic Nariwa Group, West Japan. Bull. Kitakyushu Mus. Nat. Hist., 19: 111-116.

King, M.J. & Thompson, D.B., 2000. Triassic vertebrate footprints from the Sherwood Sandstone Group, Hilbre, Wirral, northwest England. Proc. Geol. Assoc., 111: 111-132.

Knaust, D., 1999. Signatures of tectonically controlled sedimentation in Lower Muschelkalk carbonates (Middle Triassic) of the Germanic Basin. Zbl. Geol. Paläont. Teil. I., 1998: 893-924.

Koike, T., 1999. Apparatus of a Triassic conodont species Cratognathodus multihamatus (Huckriede). Palaeont. Res., 3: 234-248.

Korpás, L., 1998. Palaeokarst studies in Hungary. Occ. Pap. Geol. Inst. Hungary, 195: 139 pp.

Korpás, L., Hofstra, A.H., Ódor, L., Horváth, L., Haas, J. & Zelenka, T., 1999. Evaluation of the prospected areas and formations. Geol. Hungarica Ser. Geol., 24: 197-293.

Koša, E. & Jano ko, J., 1999. Storm-dominated mixed siliclastic-carbonate "Szin" ramp (GI'ac Unit of the Silicicum Superunit. Inner Western Carpathians): implication for Lower Triassic eustasy. Slovak Geol. Mag., 5: 201-212.

Kozur, H.W., 1999. Remarks on the position of the Norian-Rhaetian boundary. Zbl. Geol. Paläont. Teil. I., 1998: 523-536.

Kozur, H.W., 1999. The correlation of the Germanic Buntsandstein and Muschelkalk with the Tethyan scale. Zbl. Geol. Paläont. Teil. I., 1998: 701-726.

Krassilov, V.A., Afonin, S.A. & Lozovsky, V.R., 1999. Floristic evidence of transitional Permian-Triassic deposits of the Volga-Dvina region. Permophiles, 34: 12-14.

Krugovykh, V.V. & Mogucheva, N.K., 2000. Palyno- and phytostratigraphy of the Triassic reference section of Cape Tsvetkov (Eastern Taimyr, Siberia). Geol. Geofiz., 41: 535-550.

Krull, E.S., Retallack, G.J., Campbell, H.J. & Lyon, G.L., 2000. 13Corg chemostratigraphy of the Permian-Triassic boundary in the Maitai Group, New Zealand: evidence for high-latitudinal methane release. New Zeal. J Geol. Geophys., 43: 21-32.

Labbassi, K., Medina, F., Rimi, A., Mustaphi, H. & Bouatmani, R., 2000. Subsidence history of the Essaouira basin (Morocco). In: S. Crasquin-Soleau & E. Barrier (eds), Peri-Tethys Memoir 5: new data on Peri-Tethyan sedimentary basins. Mém. Mus. Nation. Hist. Nat., 182: 129-142.

Langer, M.C., Abdala, F., Richter, M. & Benton, M.J., 1999. A sauropodomorph dinosaur from the Upper Triassic (Carnian) of southern Brazil. C.R. Acad. Sci., Sér. IIa, 329: 511-517.

Lein, R. & Gawlick, H.-J., 1999. Die tektonische Stellung der Hallstätter Schichtfolge des Naßwald-Halbfensters - Neuergebnisse auf der Grundlage von stratigraphischen, faziellen und Conodont Colour Alteration Index (CAI) Untersuchungen (Ober-Trias, Nördliche Kalkalpen). Mitt. Ges. Geol. Bergbaustud. Österr., 42: 181-186.

Liu, S. & Yang, S., 2000. Upper Triassic-Jurassic sequence stratigraphy and its structural controls in the western Ordos Basin, China. Basin Res., 12: 1-18.

Liu, Z.S., 1999. Triassic palynological assemblages from the northern margin in Tarim Basin of Xinjiang, NW China. Acta Palaeont. Sinica, 38: 497-504.

Lombardo, C., 1999. Sexual dimorphism in a new species of the actinopterygian Peltopleurus from the Triassic of northern Italy. Palaeontology, 42: 741-760.

Looy, C.V., Brugman, W.A., Dilcher, D.L. & Visscher, H., 1999. The delayed resurgence of equatorial forests after the Permian-Triassic ecologic crisis. Proc. Nat. Acad. Sci. U.S., 96: 13857-13862.

López-Gómez, J., Arche, A., Calvet, F. & Goy, A., 1999. Epicontinental marine carbonate sediments of die Middle and Upper Triassic in the westemmost part of the Tethys Sea, Iberian Peninsula. Zbl. Geol. Paläont. Teil. I., 1998: 1033-1084.

Lucas, S.G., 1999. The epicontinental Triassic, an overview. Zbl. Geol. Paläont. Teil. I., 1998: 475-496

Lucas, S.G., 1999. Tetrapod-based correlation of the nonmarine Triassic. Zbl. Geol. Paläont. Teil. I., 1998: 497-522.

Lucas, S.G. & Estep, J.W., 1999. Permian, Triassic, and Jurassic stratigraphy, biostratigraphy, and sequence stratigraphy in the Sierra del Alamo Muerto, Sonora, Mexico. in Bartolini, C., Wilson, J.L. & Lawton, T.F. (eds.), Mesozoic sedimentary history of north-central Mexico. Geol. Soc. America, Spec. Pap., 340: 271-286.

Lucas, S.G., Heckert, A.B. & Estep, J.W., 1999. Correlation of Triassic strata across the Rio Grande rift, north-central New Mexico. in Pazzaglia, F.J., Lucas, S.G. & Austin, G.S. (eds.), Albuquerque geology [New Mexico Geological Society Guidebook, 50th Field Conference]: Socorro, New Mexico Geol. Soc., p. 305-310.

Lucas, S.G., Heckert, A.B. & Hunt, A.P., 2000. Probable turtle from the Upper Triassic of east-central New Mexico. N. Jb. Geol. Paläont. Mh., 2000(5): 287-300.

Lucas, S.G., Heckert, A.B., Fraser, N.C. & Huber, P., 1999. Aetosaurus from the Upper Triassic of Great Britain and its biochronological significance. N. Jb. Geol. Paläont. Mh., 1999: 568-576.

Lugardon, B., Grauvogel-Stamm, L. & Dobruskina, I., 1999. The microspores of Pleuromeia rossica Neuburg (Lycopsida; Triassic): comparative ultrastructure and phylogenetic implications. C.R. Acad. Sci. II A 329: 435-442.

MacLeod, K.G., Smith, R.M.H., Koch, P.L. & Ward, P.D., 2000. Timing of mammal-like reptile extinctions across the Permian-Triassic boundary in South Africa. Geology, 28: 227-230.

Mahadevan, T.M., 2000. Numerical classification of coal-bearing cycles-cluster analysis - Channel sandstone bodies in fluvial Permian-Triassic Gondwana succession of peninsular India - Discussion. J. Geol. Soc. India, 55: 450-451.

Maisch, M.W., 2000. Observations on Triassic ichthyosaurs. Part VI. On the cranial osteology of Shastasaurus alexandra Merriam, 1902 from the Hosselkus limestone (Carnian, Late Triassic) of Northern California with a revision of the genus. N. Jb. Geol. Paläont. Abh., 217: 1-25.

Makhlouf, I.M., 2000. Early Triassic intertidal/subtidal patterns of sedimentation along the southern margins of the Tethyan seaway, Jordan. J. Asian Earth Sci., 18: 513-518.

Marcano, M.C., Van der Voo, R. & MacNiocaill, C., 1999. True polar wander during the Permo-Triassic. J. Geodyn., 28: 75-95.

Márquez-Aliaga, A., Emig, C.C. & Brito, J.M., 1999. Triassic lingulide brachiopods from the Iberian Range (Spain). Géobios, 32: 815-821.

Marsicano, C., 1999. Chigutisaurid amphibians from the Upper Triassic of Argentina and their phylogenetic relationships. Palaeontology, 42: 545-565.

Marsicano, C.A., Perea, D. & Ubilla, M., 2000. A new temnospondyl amphibian from the Lower Triassic of South America. Alcheringa, 24: 119-123.

Martini, R., Zaninetti, L., Villeneuve, M., Cornée, J-J, Krystyn, L., Cirilli, S., De Wever, P., Dumitrica, P. & Harsolumakso, A., 2000. Triassic pelagic deposits of Timor: palaeogeographic and sea-level implications. Palaeogeogr. Palaeoclimatol. Palaeoecol., 160: 123-151.

Marzolf, J.E., 1999. Triassic paleogeography of the Panthalassan margin of southwestern North America: a regional synthesis based on sequence stratigraphy. Zbl. Geol. Paläont. Teil. I., 1998: 1497-1538.

Marzoli, A., Renne, P.R., Piccirillo, E.M, Ernesteo, M., Bellieni, G. & De Min, A., 1999. Extensive 200-million-year-old continental flood basalts of the Central Atlantic Magmatic Province. Science, 284: 616-618.

Mastandrea, A., Neri, C., Ietto, F. & Russo, F., 1999. Misikella ultima Kozur & Mock, 1991: first evidence of Late Rhaetian conodonts in Calabria (Southern Italy). Boll. Soc. Paleont. Ital., 37: 497-506.

Maurer, F., 2000. Wachstumsanalyse einer mitteltriadische Karbonatplattform in den wwwestlichen Dolomiten (Südalpen). Eclog. Geol. Helv., 92: (3) 361-378.

McElwain, J.C., Beerling, D.J. & Woodward, F.I., 1999. Fossil plants and global warming at the Triassic-Jurassic boundary. Science, 285: 1386-1390.

McGowan, C. & Motani, R., 1999. A reinterpretation of the Upper Triassic ichthyosaur Shonisaurus. J. Vertebr. Paleont., 19: 42-49.

McRoberts, C.A., 2000. A primitive Halobia (Bivalvia: Halobioidea) from the Triassic of northeast British Columbia. J. Paleont., 74: 599-603.

Medina, F., 1999. Structural styles of the Moroccan Triassic basins. Zbl. Geol. Paläont. Teil. I., 1998: 1167-1192.

Meng, F., 1999. Studies on Pleuromeia from Middle Triassic along the Yangtze River valley and systematics of Isoëtales. Acta Geosci. Sinica, 20: 215-221.

Milroy, P.G. & Wright, V.P., 2000. A highstand oolitic sequence and associated facies from a Late Triassic lake basin, south-west England. Sedimentology, 47: 187-209.

Minikh, M.-G., 1999. Ichthyofauna in the Triassic from European Russia and its stratigraphic importance. Zbl. Geol. Paläont. Teil. I., 1998: 1337-1352.

Misík, M. & Jablonský, J., 1999. Lower Triassic quartzites of the western Carpathians: sources of clastics, and transport directions. Geol. Carpathica, 50: 58-59.

Morad, S., Ketzer, J.M. & De Ros, L.F., 2000. Spatial and temporal distribution of diagenetic alterations in siliciclastic rocks: implications for mass transfer in sedimentary basins. Sedimentology, 47: 95-120.

Motani, M., 1999. On the evolution and homologies of ichthyopterygian forefins. J. Vertebr. Paleont., 19: 28-41.

Motani, R., 1999. The skull and taxonomy of Mixosaurus (Ichthyopterygia). J. Paleont., 73: 924-935.

Muttoni, G., Gaetani, M., Budurov, K., Zagorchev, I., Trifonova, E., Ivanova, D., Petrounova, L. & Lowrie, W., 2000. Middle Triassic paleomagnetic data from northern Bulgaria: constraints on Tethyan magnetostratigraphy and paleogeography. Palaeogeogr. Palaeoclimatol. Palaeoecol., 160: 223-237.

Nagy, R., 1999. Platform-basin transition and depositional models for the Upper Triassic (Carnian) Sandhorhegy Limestone, Balaton Highland, Hungary. Acta Geol. Hungarica, 42: 267-299.

Nagy. Zs. R., 1999. Platform-basin transition and depositional models for the Upper Triassic (Carnian) Sandhorhegy Limestone, Balaton Highland, Hungary. Acta Geol. Hung., 42: 267-299.

Nath, T.T., 1999. Fresh water gastropods from the Maleri Formation (Upper Triassic) of the Godavari Valey, Andhra Pradesh. J. Geol. Soc. India, 54: 399-403.

Nawrocki, J., 1999. Paleomagnetism of Permian through Early Triassic sequences in central Spitsbergen: implications for paleogeography. Earth Planet. Sci. Lett., 169: 59-70.

Neuweiler, F., Peckmann, J. & Ziems, A., 1999. Sinusoidally deformed veins ("Sigmoidal-kluftung") in the Lower Muschelkalk (Triassic, Anisian) of Central Germany: sheet injection structures deformed within the shallow subsurface. N. Jb. Geol. Paläont. Abh. 214: 129-148.

Neveling, J., Rubidge, B.S. & Hancox, P.J., 1999. A lower Cynognathus assemblage zone fossil from the Katberg Formation (Beaufort Group, South Africa). S. Afr. J. Earth Sci., 95: 555-556.

Northwood, C., 1999. Actynopterygians from the Early Triassic Arcadia Formation, Queensland, Australia. Mem. Queensland Mus., 43: 787-796.

Nützel, A. & Senowbari-Daryan, B., 1999. Gastropods from the Late Triassic (Norian-Rhaetian) Nayband Formation of central Iran. Beringeria, 23: 93-132.

Nyambe, I.A., 1999. Tectonic and climatic controls on sedimentation during deposition of the Sinakumbe Group and Karoo Supergroup, in the mid-Zambezi Valley Basin, southern Zambia. J. Afr. Earth Sci., 28: 443-463.

Ockert, W. & Rein, S., 1999. Ein vollständiges Profil des Oberen Muschelkalks bei Behringen (TK 25 5231 Stadtilm). Geowiss. Mitt. Thüringen. 7: 51-70.

Ockert, W. & Rein, S., 1999. Stratigraphy of the Upper Muschelkalk and fossil content of the atavus- and pulcher-zone (Upper Anisian) near Troisted (Thuringia). Zbl. Geol. Paläont. Teil. I., 1998: 953-962.

O'Keefe, F.R., Rieppel, O. & Sander, P.M., 1999. Shape disassociation and inferred heterochrony in a clade of pachypleurosaurs (Reptilia, Sauropterygia). Paleobiology, 25: 504-517.

O'Keefe, F.R. & Sander, P.M., 1999. Paleontological paradigms and inferences of phylogenetic pattern: a case study. Paleobiology, 25: 518-533.

Olsen, P., 1999. Giant lava flows, mass extinctions, and mantle plumes. Science, 284: 604-606.

Olsen, P.E. & Kent, D.V., 1999. Long-period Milankovitch cycles from the Late Triassic and Early Jurassic of eastern North America and their implications for the calibration of the Early Mesozoic time-scale and the long-term behaviour of the planets. Phil. Trans. Roy. Soc. London, A.357:

1761-1786.

Olson, P.E. & Kent, D.V., 1999. High-resolution early Mesozoic Pangean climate transect in lacustrine environments. Zbl. Geol. Paläont. Teil. I., 1998: 1475-1496.

Orchard, M.J., 1999. Conodont faunas and Upper Triassic stratigraphy, Trutch map area, northeastern British Columbia. Current Research - Geol. Surv. Canada, pp. 45-50.

Orchard, M.J. & Rieber, H., 1999. Multielement Neogondolella (Conodonta, upper Permian - middle Triassic). Boll. Soc. Paleont. Ital., 37: 475-488.

Orchard, M.J., Struik, L.C., Taylor, H. & Quat, M., 1999. Carboniferous-Triassic conodont biostratigraphy, Nechako NATMAP Project area, central British Columbia. Current Research - Geol. Surv. Canada, pp. 97-108.

Oujidi, M., 1999. Triassic marine onlap in the southwestern peritethyan domain, example of Oujda Mountains (Eastern Morocco). Zbl. Geol. Paläont. Teil. I., 1998: 1243-1268.

Oujidi, M. & Elmi, S., 2000. Evolution de l'architecture des monts d'Oujda (Maroc oriental) pendant le Trias et au début du Jurassique. Bull. Soc. Géol. France, 171: 169-179.

Oujidi, M., Courel, L., Benaouiss, N., El Mostaine, M., El Youssi, M., Et Touhami, M., Ouarhache, D., Sabaoui, A. & Tourani, A.-I., 2000. Triassic series of Morocco: stratigraphy, palaeogeography and structuring of the southwestern Peri-Tethyan Platform. An overview. In: S. Crasquin-Soleau & É. Barrier, (eds), Peri-Tethys Memoir 5: New data on Peri-Tethyan sedimentary basins. Mém. Mus. Nation. Hist. Nat., 182: 23-38.

O'Sullivan, P.B., Gibson, D.L., Kohn, B.P., Pillans, B. & Pain, C.F., 2000. Long-term landscape evolution of the Northparkes region of the Lachlan Fold Belt, Australia: Constraints from fission track and paleomagnetic data. J. Geol., 108: 1-16.

Pálfy, J & Dosztály, l., 1999. A new marine Triassic-Jurassic boundary section in Hungary. GeoResearch Forum, 6: 173-179.

Pálfy, J., Smith, P.L. & Mortensen, J.K., 1999. A revised numeric time scale for the Jurassic. GeoResearch Forum, 6: 181-182.

Pálfy, J., Mortensen, J.K., Carter, E.S., Smith, P.L., Friedman, R.M. & Tipper, H.W. 2000. Timing the end-Triassic mass extinction: First on land, then in the sea? Geology, 28: 39-42.

Pálfy, J., Smith, P.L., Mortensen, J.K. & Friedman, R.M., 1999. Integrated ammonite biochronology and U-Pb geochronometry from a basal Jurassic section in Alaska. GSA Bull., 111: 1537-1549.

Papin, Y.S. & Lezhin, A.J., 1999. Lithologic and paleontologic boundary between Permian and Triassic in the Kuznetsk Basin. Zbl. Geol. Paläont. Teil. I., 1998: 1325-1336.

Parente, M. & Climaco, A., 1999. Dasycladalean green algae from the Upper Triassic of Mt. Rotonda (Verbicaro Unit, Calabria-Lucania Border, southern Italy). Facies, 41: 159-182.

Pelikan, P., 1999. Triassic and Jurassic formations of the area of the borehole Felsotarkany-7 (Bukk Mts, N Hungary). Foldtani Kozlony, 129 (4): 593-609.

Peng, Y., Pan, G., Lou, J & Liu, J, 1999. Upper Triassic sequence stratigraphy and development of the Shengda Residual Back-arc Basin in Northern Three-River Area. Acta Geosci. Sinica, 20: 318-324.

Pe-Piper, G. & Piper, D.J.W., 1999. Were Jurassic tholeiitic lavas originally widespread in southeastern Canada?: a test of the broad terrane hypothesis. Canadian Journal of Earth Sciences, 36: 1509-1516.

Pe-Piper, G. & Reynolds, P.H., 2000. Early Mesozoic alkaline mafic dykes, southwestern Nova Scotia, Canada, and their bearing on Triassic-Jurassic magmatism. Can. Mineral., 38: 217-232.

Pérez-López, A., 1999. Epicontinental Triassic of the Southern Iberian Continental Margin (Betic Cordillera, Spain). Zbl. Geol. Paläont. Teil. I., 1998: 1009-1032.

Philippe, M., Torres, T., Zhang, W. & Zheng, S., 1999. Sahnioxylon, bois mesozoique a aire disjointe; Chine, Inde et Antarctique occidental. Bull. Soc. Géol. France. 170: 513-519.

Phipps, C.J., Axsmith, B.J., Taylor, T.N. & Taylor, E.L., 2000. Gleichenipteris antarcticus gen. et sp. nov. from the Triassic of Antarctica. Rev. Palaeobot. Palynol., 108: 75-83.

Pique, A., Charroud, M., Laville, E., Ait Brahim, L. & Amrhar, M., 2000. The Tethys southern margin in Morocco; Mesozoic and Cainozoic evolution of the Atlas domain. In: S. Crasquin-Soleau & E. Barrier (eds), Peri-Tethys Memoir 5: new data on Peri-Tethyan sedimentary basins. Mém.

Mus. Nation. Hist. Nat., 182: 93-106.

Plant, J.A., Jones, D. G. & Haslam, H.W. (eds.). 1999. The Cheshire Basin: Basin evolution, fluid movement and mineral resources in a Permo-Triassic rift setting. Keyworth, Nottingham; the British Geological Survey, xvii+ 263 pp.

Podobina, V.M., Kabanova, V.M., Kothesha, S.N., Makarenko, S.N., Savina, N.I. & Tatianin, G.M., 1999. Permian-Liassic deposits and palynological assemblages from boreholes of the West Siberian Plain. Zbl. Geol. Paläont. Teil. I., 1998: 1367-1376.

Pöppelreiter, M., 1999. Controls on the epeiric successions exemplified with the mixed siliciclastic - carbonate lower Keuper (Ladinian, Germanic Basin). Tübinger Geowiss. Arb., A 51: 1-126.

Prinz-Grimm, P. & Mojica, J., 1999. Obertriassische Ammoniten der unteren Saldaña-Formation (Chicalá-Schichten) bei Payandé, Provinz Tolima, Kolumbien. Profil, 16: 21-33.

Ptaszynski, T., 2000. Lower Triassic vertebrate footprints from Wiory Holy Cross Mountains, Poland. Acta Palaeont. Polonica, 45: 151-194.

Putis, M., Kotov, A.B., Uher, P., Salnikova, E.B. & Korikovsky, S.P., 2000. Triassic age of the Hroncok pre-orogenic A-type granite related to Continental rifting: A new result of U-Pb isotope dating (Western Carpathians). Geol. Carpathica, 51: 59-66.

Qin, J.H., Yan, Y.J., Wu, Y.L. & Tan, Q.Y., 1999. The sedimentary characteristic and evolution of the Early-Middle Triassic deep water carbonate slope in Guiyang and Zhengfeng area, Guizhou Province and its tectonic controls. Acta Sedim. Sinica, 17: 547-552.

Racki, G., 1999. Silica-secreting biota and mass extinctions: survival patterns and processes. Palaeogeogr. Palaeoclimatol. Palaeoecol., 154: 107-132.

Radzinski, K.-H., 1999. Zur lithostratigraphischen Gliederung der Bernburg-Formation (Unterer Buntsandstein) im mittleren und nördlichen Teil von Sachsen-Anhalt. Mitt. Geol. Sachsen-Anhalt, 5: 73-93.

Rakotosolofo, N.A., Torsvik, T.H., Ashwal, L.D., Eide, E.A. & De Wit, M.J., 1999. The Karoo Supergroup revisited and Madagascar-Africa fits. J. Afr. Earth Sci., 29: 135-151.

Rampino, M.R., Prokoph, A. & Adler, A., 2000. Tempo of the end-Permian event: High-resolution cyclostratigraphy at the Permian-Triassic boundary. Geology, 28: 643-646.

Rein, S., 1999. Die Cephalopoden des Oberen Muschelkalks (Mittlere Trias) und das Archimedische Prinzip. Veröff. Naturkundmus. Erfurt, 18: 57-63.

Rein, S., 1999. Ophiuren als Aasfresser in Ceratitengehausen? Veröff. Naturkundmus. Erfurt, 18: 57-63.

Renesto, S., 2000. Bird-like head on a chameleon body: New specimens of the enigmatic diapsid reptile Megalancosaurus from the Late Triassic of Northern Italy. Riv. Ital Paleont. Strat., 106: 157-179.

Retallack, G.J., 1999. Search for evidence of impact at the Permian-Triassic boundary in Antarctica and Australia: Reply. Geology, 27: 860.

Rieppel, O., 1999., The sauropterygian genera Chinchenia, Kwangsisaurus, and Sanchiaosaurus from the Lower and Middle Triassic of China. J. Vertebr. Paleont., 19: 321-337.

Rieppel, O., 1999. The origin and early evolution of turtles. Ann. Rev. Ecol. Syst., 30: 1-22.

Rieppel, O., 1999. Phylogeny and paleobiogeography of Triassic Sauropterygia: problems solved and unresolved. Palaeogeogr. Palaeoclimatol. Palaeoecol., 153: 1-15.

Rieppel, O., 1999. Variation of cranial characters in Cymatosaurus 'gracilis' Schrammen 1899 (Reptilia, Sauropterygia), and its implications for systematics. Paläont. Z., 73: 369-375.

Rieppel, 0., 1999. Middle Triassic marine vertebrates from the northern Gondwanan shelf. Zbl. Geol. Paläont. Teil. I., 1998: 1269-1284.

Rieppel, O. & Hagdorn, H., 1999. A skull of Cyamodus kuhnschnyderi Nosotti & Pinna 1993, from the Muschelkalk of Wasselonne (Alsace, France). Paläont. Z., 73: 377-383.

Rieppel, O., Mazin, J.M. & Tchernov, E., 1999. Sauropterygia from the Middle Triassic of Makhtesh Ramon, Negev, Israel. Fieldiana: Geology (N.S.), 40.

Röhling, H.-G., 1999. The Quickborn Sandstone - a new lithostratigraphic unit in the lowermost Middle Buntsandstein (Scythian). Zbl. Geol. Paläont. Teil. I., 1998: 797-812.

Rössle, S., Himmerkus, J. & Dittrich, d., 1999. Stratigraphie und sedimentologie des Oberen Muschelkalk der nördlichen Trier-Luxemburger Bucht (Forschungsbohrung Docendorf und ergänzende Kernbohrungen südlich Bitburg). Mainzer Geowiss. Mitt., 28: 143-186.

Rothwell, G.W., Grauvogel-Stamm, L. & Mapes, G., 2000. An herbaceous fossil conifer: Gymnospermous ruderals in the evolution of Mesozoic vegetation. Palaeogeogr. Palaeoclimatol. Palaeoecol. 156: 139-145.

Ruben, J., Jones, T., Hillenius, W, Martin, L. & Korochkin, E., 1999. Non-avian feathers in a Triassic basal archosaur. Amer. Zool., 39: 51 Sp. Iss.

Russo, F., Mastandrea, A., Stefani, M. & Neri, C., 2000. Carbonate facies dominated by syndepositional cements: a key component of Middle Triassic platforms. The Marmolada case history (Dolomites, Italy). Facies, 42: 211-226.

Sansom, I.J., 2000. Late Triassic (Rhaetian) conodonts and ichthyoliths from Chile. Geol. Mag., 137: 129-135.

Sashida, K., Kamata, Y., Adachi S. & Munasri, 1999. Middle Triassic radiolarians from West Timor, Indonesia. J. Paleont., 73: 765-786.

Sashida, K., Nakornsri, N, Ueno, K. & Sardsud, A., 2000. Carboniferous and Triassic radiolarian faunas from the Saba Yoi area, southernmost part of peninsular Thailand and their paleogeographic significance. Sci. Rep. Inst. Geosci. Univ. Tsukuba, Ser. B., 21: 71-99.

Scheck, M. & Bayer, U., 1999. Evolution of the Northeast German Basin - inferences from a 3D structural model and subsidence analysis. Tectonophysics, 313: 145-169.

Schlüter, T., 2000. Moltenia rieki n.gen., n.sp. (Hymenoptera: Xyelidae?), a tentative sawfly from the Molteno Formation (Upper Triassic), South Africa. Paläont. Z., 74: 75-78.

Schoch, R.R., 1999. Comparative osteology of Mastodonsaurus giganteus (Jaeger, 1828) from the Middle Triassic (Lettenkeuper: Longobardian) of Germany (Baden-Württemberg, Bayern, Thüringen). Stuttgarter Beitr. Naturk., Ser. B, 278: 1-175.

Schoch, R.R., 2000. The stapes of Mastodonsaurus giganteus (Jaeger 1828) - structure, articulation, ontogeny, and functional implications. N. Jb. Geol. Paläont. Abh., 215: 177-200.

Schoch, R.R., 2000. Biogeography of stereospondyl amphibians. N. Jb. Geol. Paläont. Abh., 215: 201-231.

Schoch, R.R., 2000. The status and osteology of two new cyclotosaurid amphibians from the Upper Moenkopi Formation of Arizona (Amphibia : Temnospondyli; Middle Triassic). N. Jb. Geol. Paläont. Abh., 216: 387-411.

Schoch, R.R. & Werneburg, R., 1999. The Triassic labyrinthodonts from Germany. Zbl. Geol. Paläont. Teil. I., 1998: 629-650.

Scholger, R., Mauritsch, H.J. & Brandner, R., 2000. Permian-Triassic boundary magnetostratigraphy from the Southern Alps (Italy). Earth Planet. Sci. Lett., 176: 495-508.

Schönborn, G., 1999. Balancing cross sections with kinematic constraints; the Dolomites (northern Italy). Tectonics, 18: 527-545.

Schweickert, R.A. & Lahren, M.M., 1999. Triassic caldera at Tioga Pass, Yosemite National Park, California: structural relationships and significance. Bull. Geol. Soc. Amer., 111: 1714-1722.

Senowbari-Daryan, B. & Hamadani, A., 1999. Girvanella coated udoteacean oncoids from the Upper Triassic (Norian-Rhaetian) Nayband Formation, south of Abadeh (central Iran). Revue de Paleobiologie, 18:597-606.

Senowbari-Daryan, B., Bernecker, M., Krystyn, L. & Siblik, M., 1999. Carnian reef biota from a megabreccia of the Hawasina complex (Al Aqil, Oman). Riv. Ital. Paleont. Strat., 105: 327-342.

Shen, S.Z. & Yugan, J., 1999. Brachiopods from the Permian-Triassic boundary beds at the Selong Xishan section, Xizang (Tibet), China. J Asian Earth Sci., 17: 547-559.

Shen, Z., Fang, F., Wang, P., Tan, X. & Wang, Z., 1999. Paleomagnetism of Early Triassic Daye Formation and its tectonic implications. Chinese Sci. Bull., 44: 412-418.

Shevyrev, A.A., 2000. The lower boundary of the Triassic and its correlation in marine sediments: Article 2. Boreal sections of the basal Triassic and their correlation with the Permian-Triassic boundary deposits of the Tethys. Strat. Geol. Correl., 8: 49-59.

Shu, O.Y., Deng, X.G., Shen, Y.B., Zheng, X.S. & Liu, X.H., 2000. Late Triassic plant microfossils from Miers Bluff Formation of Livingston Island, South Shetland Islands, Antarctica. Antarctic Sci., 12: 217-228.

Siblík, M., 1999. Upper Triassic brachiopod fauna of Steinplatte near Waidring, Austria. Geol. Carpathica, 50: 67-68.

Simon, T., 1999. Geochemical investigations at the Buntsandstein/Muschelkalk boundary in Southwest Germany. Zbl. Geol. Paläont. Teil. I., 1998: 769-782.

Smith, A.G., 1999. Gondwana: its shape, size and position from Cambrian to Triassic times. J. Afr. Earth Sci., 28: 71-97.

Sommer, M.G., Klepzig, M.C., Ianuzzi, R. & Alves, L.S.R., 1999. A Flora Dicroidium no Rio Grande do Sul: implicações bioestratigráficas. Pesquisas, 26: 3-9

Spalletti, L., Artabe, A., Morel, E. & Brea, M., 1999. Paleofloristic biozonation and chronostratigraphy of the Argentine Triassic. Ameghiniana, 36: 419-451.

Stanley, G.D. & Senowbari-Daryan, B., 1999. Upper Triassic reef fauna from the Quesnel terrane, central British Columbia, Canada. J. Paleont., 73: 787-802.

Steen, O. & Andresen, A., 1999. Effects of lithology on geometry and scaling of small faults in Triassic sandstones, East Greenland. J. Struct. Geol., 21: 1351-1368.

Stiller, F., 1999. Phenotypic variability, deformations and post-traumatic reactions of the stem of Encrinus cf. liliiformis Lamarck (Crinoidea) from the Middle Triassic of Qingyan, south-western China. Paläont. Z., 73: 303-318.

Stiller, F., 2000, Two early millericrinids and an unusual crinoid of uncertain systematic position from the lower Upper Anisian (Middle Triassic) of Qingyan, southwestern China. J Paleont., 74: 32-51.

Storey, B.C., Curtis, M.L., Ferris, J.K., Hunter, M.A. & Livermore, R.A., 1999. Reconstruction and break-out model for the Falkland Islands within Gondwana. J Afr. Earth Sci., 29: 153-163.

Strunck, P., Gaupp, R. & Steffan, M., 1999. Early Triassic movement of Upper Permian (Zechstein) salt in Northwest Germany. Zbl. Geol. Paläont. Teil. I., 1998: 679-700.

Sues, H.D., Olsen, P.E. & Carter, J.G., 1999. A Late Triassic traversodont cynodont from the Newark Supergroup of North Carolina. J. Vertebr. Paleont., 19: 351-354.

Sues, H.D., Olsen, P.E., Scott, D.M. & Spencer, P.S., 2000. Cranial osteology of Hypsognathus fenneri, a latest Triassic procolophonid reptile from the Newark Supergroup of eastern North America. J. Vertebr. Paleont., 20: 275-284.

Sullivan, R.M. & Lucas, S.G., 1999. Eucoelophysis baldwini, a new theropod dinosaur from the Upper Triassic of New Mexico, and the status of the original types of Coelophysis. J. Vertebr. Paleont., 19: 81-90.

Sullivan, R.M. & Lucas, S.G., 1999. Pennsylvania's dinosaurs and other Triassic reptiles: Natural History Notes of the State Museum of Pennsylvania

Suo, S., Zhong, Z. & You, Z., 1999. Location of Triassic tectonic suture between collided Sino-Korean and Yangtze cratons in Dabie-Sulu region, China. J. China Univ. Geosci., 10: 281-286.

Surkov, M.V., 1999. A new middle Triassic Kannemeyeriid from the Pechora District. Palaeont. J., 33: 420-421.

Surkov, M.V., 2000. On the historical biogeography of Middle Triassic anomodonts. Paleont. Zhurn., 2000(1): 79-83.

Szulc, J., 1999. Anisian-Camian evolution of the Germanic basin and its eustatic, tectonic and climatic controls. Zbl. Geol. Paläont. Teil. I., 1998: 813-852.

Szurlies, M., 1999. Zyklenstratigraphie und Gamma-Ray-LOg-Korrelation im unteren Buntsandstein (Untere Trias) des nördlichen Harzvorlandes. Hallesches Jahrb. Geowiss., B21: 35-53.

Tan, X.D., Kodama, K.P., Wang, P.Y. & Fang, D.J., 2000. Palaeomagnetism of Early Triassic limestones from the Huanan Block, South China: no evidence for separation between the Huanan and Yangtze blocks during the Early Mesozoic. Geophys. J Int., 142: 241-256.

Tang Liangjie, Jin Zhijun, Zhang Mingli, Zhang Binshan, You Fubao & Luo Jing, 1999. Tectonic evolution of Qaidam Basin in Sinian - Triassic. Sci. Geol. Sinica, 34: 289-300.

Tanner, L.H. & Brown, D.E., 1999. The upper Triassic Chedabucto Formation, Guysborough County, Nova Scotia: depositional and tectonic context. Atlantic Geol., 35: 129-138.

Taylor, D.G., Boelling, K. & Guex, J, 1999. The Triassic/Jurassic boundary in the Gabbs Formation, Nevada. GeoResearch Forum, 6: 225-235.

Tiwari, R.S., 1999. Towards a Gondwana palynochronology. J. Palaeont. Soc. India, 44: 1-14.

Tiwari, R.S., 1999. Paradigm of FAD, LAD and DOD of some miospore taxa in Late Permian and Early Triassic successions on the Indian peninsula. J. Palaeont. Soc. India, 44: 69-89.

Tiwari, R.S., 1999. The palynological succession and spatial relationship of the Indian Gondwana sequence. PINSA, 65 A: 329-375.

Tewari, R.C., 2000. Numerical classification of coal-bearing cycles-cluster analysis - Channel sandstone bodies in fluvial Permian-Triassic Godwana succession of peninsular India - Reply. J. Geol. Soc. India, 55: 451.

Therrien, F. & Fastovsky, D.E., 2000. Paleoenvironments of early theropods, Chinle Formation (Late Triassic), Petrified Forest National Park, Arizona. Palaios, 15: 194-211.

Török, Á., 1999. Muschelkalk carbonates in soudiem Hungary: an overview and comparison to German Muschelkalk. Zbl. Geol. Paläont. Teil. I., 1998: 1085-1104.

Török, Á., 2000. Formation of dolomite mottling in Middle Triassic ramp carbonates (Southern Hungary). Sediment. Geol., 131: 131-145.

Tourani, A., Lund, Benaouiss, & Gaupp, R., 1999. Stratigraphy of Triassic syn-rift-deposition in Western Morocco. Zbl. Geol. Paläont. Teil. I., 1998: 1193-1216.

Troncoso, A. & Herbst, R., 1999. Triassic Ginkgoales from northern Chile. Rev. Geol. Chile, 26: 255-273.

Troncoso, A., Gnaedinger, S. & Herbst, R., 2000. Heidiphyllum, Rissikia y Desmiophyllum (Pinophyta, Coniferales) en el Triásico del norte chico de Chile y sur de Argentina. 37: 119-126.

Turner, B.R., 1999. Tectonostratigraphical development of the Upper Karoo foreland basin: orogenic unloading versus thermally-induced Gondwana rifting. J. Afr. Earth Sci., 28: 215-238.

Turner, P., Shelton, R., Ruffell, A. & Pugh, J., 2000. Palaeomagnetic constraints on the age of the Red Arch Formation and associated sandstone dykes (Northern Ireland). J. Geol. Soc. London, 157: 317-325. 2000

Twitchett, R.J.,1999. Palaeoenvironments and faunal recovery after the end-Permian mass extinction. Palaeogeogr. Palaeoclimatol. Palaeoecol., 154: 27-37.

Uher, P., 1999. Clasts of tourmaline-rich rocks in Lower Triassic quartzites, the Tatric Unit, central western Carpathians: tourmaline composition and problem of source areas. Geol. Carpathica, 50: 140-141.

Uno, K., 1999. Early Triassic palaeomagnetic results from the Ryeongnam Block, Korean Peninsula: the eastern extension of the North China Block. Geophys. J. Int., 139: 841-851.

Unterschutz, J., Erdmer, P., Thompson, R.I. & Daughtry, K.L., 1999. Transition from Neoproterozoic to Triassic stratigraphy, Silver Star Mountain, Vernon map area, British Columbia. Current Research - Geol. Surv. Canada, pp. 199-204.

Urlichs, M. & Tichy, G., 1999. Correlation of the Bleiglanzbank (Gipskeuper, Grabfeld Formation) of Germany with Upper Ladinian beds of the Dolomites (Italy). Zbl. Geol. Paläont. Teil. I., 1998: 997-1008.

Vasilev, E., 1998. Kushliovo Formation, a new formation in the Grahilovo Subgroup (Veleka Group, Strandjian type Triassic), Central Strandja Mountain. Rev. Bulgarian Geol. Soc., 59: 92-94,

Vasilev, Y.R., 1999. Quantitative estimation of macrovolume displays of Permian-Triassic trap magmatism on the Siberian platform. Dokl. Akad. Nauk, 367: 380-384.

Vecsei, A., Goldbeck, A., Heunisch, C. & Luppold, F.W., 1999. Coastal bar dynamics in the Upper Muschelkalk of the southwestem Germanic Basin. Zbl. Geol. Paläont. Teil. I., 1998: 963-982.

Velledits, F., 1999. Anisian terrestrial deposits in the sequences of the Northern Bukk Mts (Anisian-Ladinian layers of the Also-Sebes-viz key-section and Miskolc-10 borehole = Zsofiatorony). Foldtani Kozlony, 129 (3): 327-361.

Velledits, F., Berczine Makk, A. & Piros, O., 1999. Facies and age of the Kisfennik Limestone (Bukk Mts). Foldtani Kozlony, 129 (4): 573-592.

Vet, I., Triassic sourced oil shows near Budapest. Ann. Rep. Geol. Inst. Hungary, 1992-1993/II: 111-115.

Vet, I., Hetényi, M., Hámor-Vidó, M., Hufnagel, H. & Haas, J., 2000. Anaerobic degradation of organic matter controlled by productivity variation in a restricted Late Triassic basin. Org.

Geochem., 31: 439-452.
Vuks, V.I., 1999. Triassic foraminifers of the Crimea, Caucasus, Mangyshlak and Pamirs (biostratigraphy and correlation). Zbl. Geol. Paläont. Teil. I., 1998: 1353-1367.
Wang, C.Y., 1999. Conodont mass extinction and recovery from Permian-Triassic boundary beds in the Meishan sections, Zhejiang, China. Boll. Soc. Ital. Paleont., 37: 489-495.
Wang, Y.D., 1999. Fertile organs and in situ spores of Marattia asiatica (Kawasaki) Harris (Marattiales) from the Lower Jurassic Hsiangchi Formation in Hubei, China. Rev. Palaeobot. Palynol., 107: 125-144.
Wang, X.F., Metcalfe, I., Jian, P., He, L.Q. & Wang, C.S., 2000. The Jinshajiang suture zone: tectono-stratigraphic subdivision and revision of age. Sci. China Ser D - Earth Sci., 43: 10-22.
Warren, A., 1999. Karoo tupilakosaurid; a relict from Gondwana. Trans. Roy. Soc. Edinburgh, Earth Sci., 89: 145-160.
Waterhouse, J.B., 1999. The early and middle Triassic ammonoid succession of the Himalayas in western and central Nepal. Part 4. Late Scythian. Palaeontographica, A254: 101-190.
Waterhouse, J.B., 1999. The early and middle Triassic ammonoid succession of the Himalayas in western and central Nepal. Part 5. Systematic studies of the early Anisian. Palaeontographica, A255: 1-84.
Weedon, G.P., Jenkyns, H.C., Coe, A.L. & Hesselbo, S.P., 1999. Astronomical calibration of the Jurassic time-scale from cyclostratigraphy in British mudrock formations. Phil. Trans. Roy. Soc. London, A.357: 1787-1813.
Weber, J. & Ricken, W., 1999. Fluvial architecture and silica diagenetic pattern of the Solling Folge (Reinhardswald trough, Solling area, NW Germany). Zbl. Geol. Paläont. Teil. I., 1998: 747-768.
Weibel, R., 1999. Effects of burial on the clay assemblages in the Triassic Skagerrak Formation, Denmark. Clay Minerals, 34: 619-635.
Weibel, R. & Grobety, B., 1999. Pseudomorphous transformation of geothite needles into hematite in sediments of the Triassic Skagerrak Formation, Denmark. Clay Minerals, 34: 657-660.
Wignall, P.B. & Benton, M.J., 1999. Lazarus taxa and fossil abundance at times of biotic crisis. J. Geol. Soc. London, 156: 453-456.
Wilson, J.A., 1999. A nomenclature for vertebral laminae in sauropods and other saurischian dinosaurs. J. Vertebr. Paleont., 19: 639-653.
Xia, W.C. & Zhang, N., 2000. Middle Triassic Radiolaria from turbidites in Ziyun, Guizhou, South China. Micropaleontology, 46: 73-87.
Yang Feng-qing & Xiong Wei. 2000. Late Triassic deep water trace fossils and their sedimentary environment in the Jinmuda, Rangtang, Sichuan. Acta Sediment. Sinica, 18: 73-79.
Yatabe, Y., Nishida, H. & Murakami, N., 1999. Phylogeny of Osmundaceae inferred from rbcL nucleotide sequences and comparison to the fossil evidences. J. Plant Res., 112: 397-404.
Yates, A.M., 1999. The Lapillopsidae; a new family of small temnospondyls from the Early Triassic of Australia. J. Vertebr. Paleont., 19: 302-320.
Yates, A.M. & Warren, A.A., 2000. The phylogeny of the 'higher' temnospondyls (Vertebrata : Choanata) and its implications for the monophyly and origins of the Stereospondyli. Zool. J Linn. Soc. London, 128: 77-121.
Yin, J.R., Yao, H.Z. & Pei, S.W., 1999. Comparative study in ichnology, an example of deep-water flysch Phycosiphon assemblage from the Late Triassic strata of western Sichuan. Acta Palaeont. Sinica, 38: 228-236.
Yue, W., Ye, Z. & Bi, Z., 1999. Sedimentary environments and facies architecture of Middle-Upper Triassic Huangmaqing Formation: a palaeofluvio-deltaic depositional system. Acta Geosci. Sinica, 20: 309-317.
Zagorchev, I., Trifonova, E., Budurov, K. & Stoykova, K. 1998. Newly recognized Upper Triassic and Jurassic formations in southwest Bulgaria: palaeogeographic and palaeodynamic implications. Geol. Balcanica, 28: 35-43.
Zhang, L.J & Wang, X.F., 1999. Important Triassic palynomorphs from the Tarim Basin of Xinjiang. Acta Micropalaeont. Sinica, 16: 393-404.

Triassic workers are kindly requested to send reprints or xerox copies of the titles and abstracts (including journal name, volume and page numbers) of their recently published paper to the editor for the "Annotated Triassic Literature". E-mails with all relevant information are also most welcome.

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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.

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