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ALBERTIANA

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

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Cover: Lepidopteris stormbergensis *from the Molteno Formation, South Africa (from J.M. Anderson and H.M. Anderson - Palaeoflora of Southern Africa, Vol. 2, 1989)*

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REPORT ON THE STS BUSINESS MEETING IN ALBRECHTSBERG (AUSTRIA)

September 10, 1994

A. Baud and M. Gaetani

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Agenda

1) Report of the Chairman
2) Subcommission activities
3) New memberships
4) Summary of the activities of the Permian/Triassic Working Group
5) Activities of the Stage Working Group
6) Information about the Triassic/Jurassic Working Group
7) Information about the Continental Triassic Working Group
8) Future plans and activities
9) Varia

1. Report of the Chairman

After welcoming the participants, the chairman gave a short report on the main proposals and decisions of the International Commission on Stratigraphy (ICS):

- revised status of the ICS (copies are available from the ICS Secretary), with new rules for elections of ICS officers,
- establishment of a Committee on Genetic Stratigraphy (CGS), with several WGs,
- reorganisation of the International Subcommission on Stratigraphic Classification; the new Guide to Stratigraphical Nomenclature has been issued, edited by A. Salvador: it is sold by The Geological Society of America, Boulder,
- dissolution of the Subcommission on Gondwana Stratigraphy,
- during the 1996 International Congress to be held in Beijing a special symposium on Triassic Stratigraphy will be organised.

Concerning the financial support of the IUGS, our Subcommission got US $ 650.- last year for the Newsletter and general expenses. Our Secretary H. Visscher was informed by a letter about this support, but he "forgot" to ask for the money. The result was that this grant was lost for our Subcommission.[1]

2. Report on the Subcommission activities and achievements

The Chairman reported on the last two meetings in Lausanne (1991) and in Kyoto (1992) respectively (cf. Albertiana 10, 1992). The main achievements were:

- approval of the subdivision of the Lower Triassic into two stages, Induan and Olenekian,
- approval of the state of the Rhaetian as a stage,
- approval of a new membership list,
- reelection of the Chairman and of the Officers of the STS,
- election of a new Chairman and a new Vice-Chairman of the Permian-Triassic Boundary Working Group (PTBWG).

The other activities of the Subcommission took place within the working groups.

3. Membership of the Subcommission: new proposals

During the meeting, the following lists have been proposed:
New voting members:

1. ORCHARD, Mike: Geological Survey of Canada, 100 West Pender street, Vancouver, V6B 1R8, B.C. (Canada)
2. STANLEY, George: University of Montana, 59812 Missoula MT (USA)

New corresponding members:

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BÜCHER, Hugo: Dept. des Sciences de la Terre de l'Université, 6 boulevard Gabriel, 21000 Dijon (France)

LOZOVSKY, Vladen R.: Moscow Geological Prospecting Institute, Moscow State Geological

[1] Don't worry! External subsidy has been sufficient to compensate for the IUGS support - H. Visscher

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YANG Jiduan, Academy of Geological Sciences, Beijing (China)

Their names are accepted by the assembly with no abstentions or votes against.

4. Report of the Stage Boundary Working Group

Prof. Gaetani, chairman of the WG reported on the activities concerning the base of the Anisian, Ladinian and Carnian. For details see the included report.

Leo Krystyn stressed the fact that it will be difficult to establish the base of the Norian in the classical area within the Hallstatt facies, because of severe condensation. There will be difficulties of correlations when moving to the thicker pelagic successions with conodonts and magnetostratigraphy. As for the Olenekian basal boundary, Y. Zakahorov lectured the following day on the Olenek stratotype along the Olenek river (see report in this volume).

5. Report of the Permian-Triassic Boundary Working Group (PTBWG)

Prof. Yin Hongfu, chairman of the working group, reported on this topic. During the last 13 months, three working group meetings have been held, in Calgary, Guiyang and Abrechtsberg. Four sections have been selected as GSSP candidates for the boundary, i.e. Meishan and Shangsi in the SE China Block, Guryul Ravine and Selung in the Himalayas, i.e. on the deformed margin of the Indian Plate.

The Chinese teams mostly worked out the Meishan section, where several kinds of stratigraphic tools have been used. The magnetostratigraphy does not seem to be successful. The Shangsi section in Setchuan has also been studied with Hallam's team for event stratigraphy. However, being in deeper water no *Hindeodus parvus* was found.

The Selung section, restudied during a joint Chinese-Canadian expedition, has serious condensations below the boundary, having only 7.5 cm of "reworked" Changxingian. M. Orchard illustrated in a previous lecture the details of this section. See also the announcement by H.H.J. Geldsetzer in Albertiana, 13, p. 24.

The Indian IGCP Committee was asked to organise a common survey to the Guryul Ravine section, but there is no answer yet. In Guiyang a tentative ballot was done amongst the people (not only of the working group) attending the meeting. Twenty-nine votes were for Meishan and one for Guryul Ravine. Amongst people present in Albrechtsberg, the ballot gave three votes for Guryul Ravine and four for Meishan. As for the criteria, three were in favour of using *Otoceras woodwardi* and four for *H. parvus*. Possibly the two choices are not perfectly isochronous, because *Otoceras* seems to appear slightly earlier than *H. parvus*.

Y. Zakharov, Vladivostok, remarked that late Dorashamian ammonoids from Primorye are very similar to the Chinese species. The systematics of these studies will be published in Calgary (Proceedings of the Pangea Symposium) or in a book published by Cambridge University Press. The accompanying conodonts are studied by H. Kozur (Budapest).

Officers of the ICS push the working group and our Subcommission to make a decision. The chairman of the Subcommission, A. Baud, announced that a first ballot will soon be sent out. The proposal of other sections as candidate is welcomed.

6. Report of the Triassic-Jurassic Boundary Working Group (TJBWG)

G. Warrington reported on the subject. At present six sections have been proposed as candidates and are being selected to proceed to establish the GSSP for the base of the Jurassic, which is automatically the top of the Triassic. Warrington has previously lectured on the details of a section along the Bristol Channel, England.

7. Report of the Continental Triassic Working Group

J. Lepper shortly discussed the report by S.G. Lucas published in Albertiana 13 concerning the Albuquerque symposium. The 500 pages volume which includes the field-guide is issued and has extensively been reviewed in Albertiana 13.

8. Future work of the Subcommission

The chairman A. Baud reminded that the duty terms of all officers will end with the Beijing Congress. However, ICS wants to have proposals for the new chairman twelve months in advance. The vice-chairman M. Gaetani is a candidate and is supported unanimously by the participating members. A vote will be organised and postal ballots will be sent to the voting members. Other suggestions and proposals are welcome until January 31, 1995. Please write to the chairman.

9. Next meeting and varia

The next plenary meeting of the STS will be held in Beijing, August 1996 during the 30th IGC.

ALBERTIANA

Comments, reactions or contributions to ALBERTIANA?
Send it to the editor!
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PERMIAN-TRIASSIC BOUNDARY WORKING GROUP

NEWSLETTER NO. 3 OCTOBER 1994

Advances

The Permian-Triassic Boundary Working Group proposed four candidates for the stratotype of this boundary during the 1993 meeting. In the past year vigorous work has been carried out in three of the candidate sections (Yin et al. in cooperation with Hallam et al. and Hansen, Li et al., Wang, Geldsetzer and Shen, Orchard). Work on the fourth one (Guryul Ravine) was blocked by the unstable condition in Kashmir. Two workshop meetings have been held, respectively in Guiyang, China (August 30; 31 attendants) and in Albrechtsberg, Austria (September 10; 23 attendants). Fifteen non-Chinese, including Remane (Chairman of the ISC), Gohrbandt (General secretary of the ISC) and five PTBWG members, participated in the field excursions to Meishan and Shangsi in South China (August 21-27). In addition, members also worked in important areas such as Arctic Canada (Henderson, Baud et al.), Iran (Golshani et al.) and South China (Yang et al., 1994). Results have been published in Albertiana 12, 13 and Permophiles 24, and also reported in about ten presentations at the two 1994 meetings (Intern. Permian Symposium, Guiyang; Shallow Tethys 4, Albrechtsberg). Census (including members and non-members) were made during the PTBWG workshops held at the two meetings. The results of votes on the favoured sections are Meishan (22), Guryul (1) and Meishan (4), Guryul (3) respectively; the sections of Shangsi and Selong received no support. There is a distinct tendency to apply the conodont *Hindeodus parvus* instead of the ammonite *Otoceras* as the index fossil of the Permian-Triassic boundary. A workshop on the definition and lineage of *H. parvus*, chaired by Yin, was held at the Guiyang meeting. The majority seems to agree on the nomenclature and definition (sixmembrante apparatus) of this species, and a lineage was suggested (*latidentatus-parvus-isacica*) by Kozur and Wardlaw. During the Permian meeting (28-31, Guiyang), Professor Remane, Chairman of the International Commission of Stratigraphy, gave a very positive evaluation on the progress of the P/T boundary research.

Meishan section. Yin et al. (1994) made a comprehensive review and recommended the D section of Meishan and the first appearance of *Hindeodus parvus* at the base of Bed 27c as the GSSP of the P/T boundary. Wang (1994) suggested the Zhongxin Dadui section of Meishan and the first appearance of *H. parvus* morphotype 1 as the GSSP. The Meishan sections are so far the only sections of the PTB candidates where integrative stratigraphy has been investigated. Chrono-, chemo- and event stratigraphic results have been extensively reported. The research on eco- and sequence stratigraphy will soon be published. This is the only PTB candidate where relatively accurate isotopic data have been obtained (Claoué-Long et al., 1991; Zhang et al., 1992). However, the find of *Otoceras* is not confirmed.

Guryul Ravine section. This is the only PTB candidate where *H. parvus* and *Otoceras* are both represented. Unlike Selong this section is not condensed. The boundary lies within Khunamuh

E1 and E2 which is considered lithologically continuous by some authors. However, the political uncertainty in Kashmir obstructs further investigation of that section. Contacts with Indian organizations for further cooperation have been unsuccessful so far. Here we call attention to the shortcomings noticed by Wang (1990, Palaeontologia Cathayana, 5), some of which were reiterated by Baud in the workshop meeting, i.e., the turbiditic nature of the Khunamuh Formation, metamorphism (>300 °C) judged by the black colour of conodonts; the lack of chrono-, chemo- and magnetostratigraphic data, and the lack of ammonoids in E1. Moreover, the Changxingian (Dorashamian) age of Zewan and/or Khunamuh E1 is not confirmed. The discontinuity between Zewan and Khunamuh, at 2.6 m below the suggested PTB between Khunamuh E1 and E2, poses another problem, because during the workshop meeting in Guiyang, Drs. Remane and Gohrbandt emphasized that the PTB should not be placed in a section where discontinuity has already been recognized within such short distance from the PTB, and that a considerable thickness of a continuous sequence above and below the PTB is needed for security.

Shangsi section. It displays a continuous and well-exposed Wujiapingian-Dienerian sequence, and it can be correlated in detail with the Meishan section. Work has been continued in 1993 and 1994, partly with Hallam and Wignall. The main problem is the absence of both *H. parvus* and *Otoceras* at the basal beds. Preparation of samples collected in the last two years appears fruitless in this respect.

Selong section. Geldsetzer et al. reported at the Guiyang workshop that the 'clay bed' between the 'Changxingian' and the 'Prechangxingian' is a fracture fill of fibrous calcite. The 7 cm thick 'Changxingian' is a reworked band with a matrix derived from the underlying 'Prechangxingian' crinoidal grainstones. Jin and Shen reported that 80% of the brachiopods are fragmented, but that the species composition is the same as that in the 'Prechangxingian'. No typical Changxingian conodonts or ammonoids have been reported yet. The negative excursion of carbon (and oxygen) isotopes occurs at 1.5 cm from the base of the 'Changxingian'. The contact with the overlying *Otoceras* level is an uneven surface. The coexistence of *H. parvus* and *Otoceras* at this level is reconfirmed by Orchard (1994), although he reported that *Isarcicella isarcica* occurred slightly higher in the same bed, not on the same specimen with *Otoceras* as was reported by Rao and Zhang (1985). Previous workers reported *N.* (or *Clarkina*) *changxingensis* and *deflecta* from the same level, but this was not confirmed by Orchard.

It is now clear that there is no confirmed Changxingian in this section. The 'Changxingian' may consist of reworked sediments deposited in the earliest Triassic, judging from the position of the carbon excursion. The *Otoceras* level may also be reworked or condensed and discontinuities exist close to or even right below it.

Other sections. Henderson, Baud et al. carried out important research in the Sverdrup Basin of Arctic Canada. Italian and Hungarian colleagues are working on the PTB of the Southern Alps and the Bueck Mountains. A Sino-Iranian team (Golshani, Jin et al.) will work in Central and NW Iran next year. Kotlyar, Kozur and Zakharov have published a paper suggesting the Dorashamian section 2 and the Sovetashen section as parastratotypes of the PTB (Albertiana, 12). Yang et al. (1994) reported the coexistence of *Hypophiceras*, *H. changxingensis* and *H. deflecta* at the lower transitional bed of Lower Yangtze.

Work plan

Work on Meishan and Shangsi will be continued by the Chinese group and partly in cooperation with Hallam, Erwin and Hansen. Special emphasis is given to a search for conodonts near the PTB, especially in the boundary clay and shale, as well as to the *Hindeodus parvus* lineage. Jin, Geldsetzer and others will do laboratory work on the Selong section from 40 m below the PTB to 50 m above it. Contacts have been made with Kapoor to continue work on the Guryul Ravine. Results will be published in a book before the 30th IGC (1996).

Many members asked for speeding up of the solution of PTB and stressed that otherwise even more of them will have retired before they will see the result. This newsletter asks all members to express their opinion on this subject in Albertiana or Permophiles and calls for additional candidates if any. We will have to take some procedure before and during the 30th IGC.

Membership

Besides the 21 members mentioned in Newsletter No. 1, the chairmen suggested four members and four corresponding members in Newsletter 2. Following Kozur's proposal, the chairman suggests Dr. Wang Chenyuan (Nanjing Institute of Palaeontology), who is now actively working on the PTB, as member of the PTBWG. This nomination has to be verified pending comments from the present members and the acceptance by the recommended person himself.

ANNUAL REPORT OF THE TETHYAN CIRCUM-PACIFIC AND MARGINAL GONDWANA LATE PALEOZOIC AND EARLY MESOZOIC CORRELATION (BIOTA, FACIES, FORMATIONS, GEOCHEMISTRY AND EVENTS)

IGCP PROJECT 359 (1993-1997) NEWSLETTER No. 5 - October 1994

1. Summary of the major past achievements of the project

The project involves 180 members from 25 countries and established cooperations with IGCP Projects 306, 321, 335, and GSGP Project (Pangea). In 1993, two meetings were held in which 42 members from 15 countries participated, and four books, 20 papers, 30 abstracts and four maps were published. In 1993 considerable progress was achieved on the Permian-Triassic boundary, event and sequence stratigraphy of the Permian and Triassic, as well as Tethyan Permian-Triassic palaeogeographic maps. The project obtained an 'excellent' evaluation and 'high' funding from the assessments of the IGCP Scientific Board for 1993.

2. Achievements of the project in 1994

2.1. General Scientific Achievements

In the view of the main objectives proposed by this project, our recent efforts are concentrated on two tasks: (1) researches on boundaries and zonations of Permian and Triassic systems, series and stages which are the premises of regional stratigraphy, and, (2) integrative regional stratigraphic charts which are the basis for interregional correlation.

1. Progress conducted by project members on boundaries and zonations of the Permian and Triassic systems, series and stages

The Permian-Triassic Boundary Working Group (chaired by H.F. Yin and Y. Zakharov) proposed four candidates for stratotype of this boundary during the 1993 meeting. In the past year vigorous work has been carried out in three of the candidate sections (Yin et al. in cooperation with Hallam et al. and Hansen, Li et al., Wang, Geldsetzer and Shen, Orchard). Work on the fourth one (Guryul Ravine) was blocked by the unstable condition in Kashmir. In addition, members also worked in important areas such as Arctic Canada (Henderson, Baud et al.) and Iran (Golshani et al.). Results have been reported in about ten presentations in the two 1994 meetings of this project (see 2.2). Census were made in the workshops of the two meetings. The results of sections being favoured are Meishan (22), Guryul (1) and Meishan (4), Guryul (3) respectively; the sections of Shangsi and Selong received no support. There is a distinct tendency to apply the conodont *Hindeodus parvus* instead of the ammonite *Otoceras* as the index fossil of the Permian-Triassic boundary. During the Guiyang meeting a workshop was held on the definition and lineage of *H. parvus*. This workshop was chaired by Yin. The majority seems agreeable on the nomenclature and definition (sixmembrante apparatus) of this species, and a lineage was suggested (*latidentatus-parvus-isacica*). During the Permian meeting (28-31, Guiyang), Professor Remane, Chairman of the International Commission of Stratigraphy, gave a very positive evaluation on the progress of P/T boundary research.

In previous years the P/C boundary and Asselian-Sakmarian-Artinskian boundaries were nearly fixed, and Chihsian or Cathedralian has been proposed for post-Artinskian, pre-Guadalupian. This year B. Glenister reiterated his proposal on the Guadalupian as a series. Finding of a relatively complete Maokouan-Wujianpingian conodont sequence enables a connection between the Guadalupian and Lopingian. On this basis Y.G. Jin (Chairman of the Subcommission of Permian Stratigraphy) et al. proposed a four-fold subdivision of the Permian system and its stage scheme which received considerable attention. However, the idea of a three-fold subdivision still persists (Yang, Ueno on the Shallow Tethys meeting, 1994).

M. Gaetani (Chairman of the Anisian-Ladinian Boundary Working Group) reported about the fruitful results of the Anisian-Ladinian boundary field workshop (1993). He and his colleagues (Black, Rieber, Muttoni, Vorös et al.) set forth suggestions for the candidates of the Olenekian-Anisian boundary (Chios, Dobrudgea?) and the Anisian-Ladinian boundary (Bagolino, Felsőörs). Somerset in the UK was proposed as Triassic-Jurassic boundary candidate by G. Warrington (Chairman of the Jurassic-Triassic Boundary Working Group). Y. Zakharov presented a contribution the Induan-Olenekian boundary in the Tethys and Boreal realms.

In summary, 1993-1994 was a productive year with considerable progress on research of the Permian and Triassic boundaries.

2. Progress of project members on regional stratigraphical charts of the Permian and Triassic

After the 1993 workshop meeting (Calgary) a panel was formed to establish an integrated stratigraphic chart of the Permian and Triassic in different regions within the Tethys, Circum-Pacific and marginal Gondwana. G. Kotlyar and V. A. Gavlirova played a major role in compiling the parts on the marine Permian and Triassic of the book 'Zonal subdivision and interregional correlation of Palaeozoic and Mesozoic of Russia and adjacent territories' (1994). G. Stanley and G. Kotlyar presented preliminary regional stratigraphic correlation charts for the Permian-Triassic of North American terranes and the Permian of Russia respectively. Y. Ezaki (leader of the Japanese group) showed the preparatory scheme of a deep sea radiolarian zonation of the Permian-Triassic and its correlation with the shallow sea biozonation based on Japanese data, which has the potential of development in a very important domain. Australian, Turkish, Iranian, Indian, Vietnamese and New Zealand colleagues have been organized to establish the charts of the marginal regions of Gondwana. In order to coordinate the format of the charts, H.F. Yin presented the regional stratigraphic charts of the Triassic of South China, which consists of five charts (chrono-, magneto-, bio-, event and sequence stratigraphy) and an explanatory text with an interregional correlation at the workshop meetings. These charts will be distributed to all panel members.

Important contributions dealing with specific disciplines of the Permian and Triassic have been provided: Jin et al. (1994) on Permian palaeontology and stratigraphy, S.G. Lucas et al. (1993) on the nonmarine Triassic, D. Erwin (1993) on the Permian-Triassic extinction and Feng, Jiang and Mi (1993-1994) on Permian-Triassic paleogeography and an extensive discussions on Middle-Upper Triassic biostratigraphy and buildups. These have greatly enlarged our knowledge of the respective areas.

With the compilation of data it becomes gradually clear that the Permian-Triassic was a geologic interval of intensive global change. The changes on the surface of the earth were related to the forming and breakup of Pangea which caused semi-synchronous, worldwide regression and transgression, transformation of geophysical regimes, continental volcanism, glaciation and deglaciation, oceanographic anomalies and mass extinction, possibly also strengthened by an extraterrestrial impact. This global change represented an episodic phase of the earth's evolution, and it should have deeply rooted causes in the earth's mantle and core and cosmic evolution. We will pursue this subject after the completion of the Permian and Triassic stratigraphic subdivisions and correlation.

2.2. List of meetings with approximate attendance and number of countries

1 International Symposium on Permian Stratigraphy, Environments and Resources (Guiyang, China, 28-31, August), co-sponsored by IGCP Projects 359 (our project) and 306, Pangea Project of GSGP. Pre-excursion: Permian-Triassic Boundary of Meishan, Hushan (21-24, August) and Shangsi (25-27, August); post-excursion: Permian sequences in Guizhou, Guangxi and northern Tianshan. Eighty participants from 12 countries attended this meeting and 84 papers were presented, either orally or at the poster sessions. A workshop meeting of our project (33 attendants) and another affiliated workshop meeting on the index conodont *Hindeodus parvus* of the Permian-Triassic boundary (11 attendants) were held.

2 Fourth International Symposium on Shallow Tethys in association with our project, P/T Boundary Working Group and Subcommission on Triassic Stratigraphy (Albrechtsberg,

Austria, 8-11, Sept.). Pre-excursions 1. Salzburg-Tirol and 2. Southern Alps; post-excursion, Northern Calcareous Alps; emphasizing the Upper Permian, Triassic and Cretaceous. Seventy-seven participants from 15 countries attended this meeting and 61 papers presented, of which 33 dealt with the Permian and Triassic. A workshop meeting (27 attendants) and a special plenary session of our project took place.

3 A workshop meeting was convened during the 9th International Gondwana Symposium (January, 1994, Hyderabad, India). Nine members participated this meeting that was chaired by Dr. Dickins. This workshop emphasized the Late Paleozoic-Early Mesozoic correlation of the northern margin of Gondwana with other parts of the world. More effective participation of India and Argentina was discussed. A Triassic Symposium in Australia (1996) was proposed (see 3.2.).

4 A workshop meeting of the Chinese Group was held in April, Beijing. Eleven persons participated. The meeting listened to new contributions by members, celebrated the productivity of the group (see 2.3.) and discussed preparations for the Permian meeting (1994), during a special session of the 30th IGC (1996), field excursions and the possibility of an international meeting in 1997.

5 Newsletters nos. 1-5 have been distributed among members and nos. 1-3, 5 published (in condensed format) in Albertiana and Permophiles.

2.3 Number of publications (including maps): list of major or most important publications

Books: 9, papers: about 50, abstracts: about 120.

Formal publications

ERWIN, D.H., 1993. The great Paleozoic crisis: life and death in the Permian. Columbia Univ. Press, New York, 327 pp.

FENG, Z.Z., JIN, Z.K., YANG Y.Q., BAO, Z.D. and XIN, W.J., 1994. Lithofacies and paleogeography of Permian of Yunnan-Guizhou-Guangxi region. Geol. Pub. House, Beijing. 146 pp., 18 pls. (in Chinese).

GUEX, J. and BAUD, A. (eds.), 1994. Recent developments on Triassic stratigraphy: Proceedings of the Triassic Symposium, Lausanne (1991). Memoires de Geologie (Lausanne), no. 22, 182 pp., 10 pls.

JIANG, N.Y. et al., 1994. Permian palaeogeography and geochemical environment in Lower Yangtze region, China. Petroleum Industry Press, Beijing. 206 pp., 8 pls. (both in Chinese and English).

JIN Y.G., UTTING, J. and WARDLAW, R. (eds.), 1994. Permian Stratigraphy, Environments and Resources, vol. 1, Palaeontology & Stratigraphy. Palaeoworld, no. 4 (spec. issue), 262 pp., 9 pls.

LUCAS, S.G. and MORALES, M. (eds.), 1993. The nonmarine Triassic. New Mexico Mus. Nat. Hist. Sci, Bull., 3 (spec. issue), 478 pp.

MI, J.R., ZHANG C.B., SUN, C.L. et al., 1993. Late Triassic stratigraphy, paleontology and paleogeography of the northern part of the Circum-Pacific belt, China. Science Press, Beijing, 219 pp., 66 pls. (in Chinese).

OLEINIKOV, A.N. (ed.), 1994. Zonal subdivision and interregional correlation of the Palaeozoic and Mesozoic of Russia and adjacent territories. Izdatelstvo VSEGEI, St. Petersburg, Pt. 1 (Palaeozoic), 158 pp., Pt. 2 (Mesozoic), 184 pp. (in Russian).

YIN Hongfu, YANG Fengqing, HUANG Qisheng, YANG Hengshu and LAI Xulong, 1993. The Triassic of Qinling Mountains and neighbouring areas. China Univ. Geosciences Press, Wuhan, 211 pp., 20 pls. (in Chinese with English summary).

Informal publications

KRISTAN-TOLLMANN, E. (ed.), 1994. Abstract volume of the Fourth International Symposium on Shallow Tethys. 64 pp.

JIN, Y.G. (ed.), 1994. Abstract volume of the International Symposium on Permian Stratigraphy, Environments and Resources. 53 pp.

2.5. Activities involving other IGCP projects, IUGC or major participation of scientists from developing countries

Cooperation exists between this project and the Permian and Triassic Subcommissions of the IUGS, IGCP Projects 306 (Stratigraphic Correlation in S.E. Asia, leader: Vu Khuc), 321 (Gondwana Dispersion and Asian Accretion, leader: Ren Jishun), 335 (Biotic Recovery from Mass Extinctions, leader: D. Erwin), GSGP Project (Pangea, Carboniferous to Jurassic, leader B. Beauchamp) and Shallow Tethys International (leaders: G. Piccoli et al.) . Meetings of 1993, 1994 and forthcoming years have been and will be largely realized through joint sponsorship with them (see 2.2. and 3.2.)

Six developing countries (China, India, Iran, Jordan, Turkey and Vietnam) have participated in this project, involving 39 scientists. India hosted a workshop meeting (1994) and is now discussing the possibility of holding a project meeting in 1996. A Sino-Iranian team led by Jin and Golshani will begin Permian research in Iran next year. In 1995 Vietnam (Trau et al.) will host a project meeting and Turkey (Guvenc et al.) will conduct a Carboniferous-Triassic field excursion. A US-China cooperation led by Erwin (leader of Project 335) on P-T extinction-recovery and snail evolution is underway. Besides, the project enjoys vigorous participation of Russia and Eastern European countries; Russia and Hungary are vibrant this year.

3. Proposed activities of the project for the coming year

3.1. General goals

As stated in 2.1., our efforts will concentrate on the boundaries of the Permian and Triassic systems, series and stages and the integrative regional stratigraphical charts. Most leaders of the boundary working groups are members of this project and they have been conducting stimulating research within the scope of the project. The groups working on the boundaries of the Triassic-Permian, Lopingian-Guadalupian and Ladinian-Anisian-Olenekian are very active and approaching a consensus in the near future (expectably during the 30th IGC, 1996). Distinctive from the stratigraphic subcommissions, our boundary research will emphasize the integrative stratigraphy in the view of global or interregional geological episodes, not only dealing with biostratigraphy.

Contributions by the panel of regional stratigraphical charts are underway and a few results have appeared. The project has announced its policy to give support to those who will report their achievements on international meetings, and to organize its final volume based on these achievements. More results are expected to be shown during the 1995 meetings.

On the basis of these two aspects, the project will try to organize researches on global change during the Permian-Triassic with the prospect that they have deeply rooted common causes, semi-synchronous interactions but different threshold values and timings of execution. This research will greatly add up to our understanding of this important period of the geological

history and may shed lights to the present and future of global changes that mankind is facing now.

3.2. Specific Meetings and Field Trips

The following meetings, either independent or in association with other projects and meetings, have been scheduled for 1995 and 1996:

1 **International Symposium on Geology of Southeast Asia and adjacent areas - a joint meeting of IGCP Projects 306, 321 and 359**

Date: November 1-3, 1995
Venue: Hanoi, Vietnam
Organizing Committee: Trau Van Tri (chairman), Phan Cu Tien (vice chairman, Res. Inst. of Geology and Mineral Resources, Thanh Xuan, Dong Da, Ha Noi, Vietnam), Dang Vu Khuc (vice chairman), J. Charvet, J.M. Dickins, H. Fontaine, S. Hada, I. Metcalfe, Ren Jishun, Tongdzuy Thanh, Yin Hongfu, Trinh Dzanh (secretary general)
Scientific topics:
- Stratigraphic correlation of South and East Asia
- Paleobiogeography of South and East Asia in the Permo-Triassic
- All aspects of Gondwana dispersion and Asian accretion
- Economic geology in South and East Asia

Field excursion (post-symposium)
- Song La section of the P-T boundary, 3 days
- Song Ma suture zone, 4 days
- Quang Ninh coal basin, 3 days

2 **Field excursion on outcrops of the Permian-Triassic and Carboniferous-Permian sequences at the Anatolian Platform (Hadim Nappe) in the Western Taurus Mountain Belt. This is in affiliation with the 6th International Symposium on Fossil Algae and Carbonate Platforms (Sept. 18-22, 1995)**

Date: Sept. 24-27, 1995
Venue: Ankara, Turkey
Organizing committee: T. Guvenc (H.U. Faculty of Engineering, Dept. of Geology, Beytepe, 06532, Ankara, Turkey), V. Toker, V.S. Ediger, G. Eseller, I.H. Demirel, M. Dogan, K. Erdogan

3 **The International Congress on Triassic Biostratigraphy, co-sponsored by Queensland University of Technology, IGCP 359 and the Gondwana Subcommission**

Date: April 9-12, 1996
Venue: Brisbane, Australia
Organizers: J.M. Dickins (chairman, co-leader of IGCP 359), John Rigby, S.C. Shah, Yin Hongfu
Scientific topics:
- Triassic-Jurassic boundary
- Triassic stratigraphy
- Triassic climate
- Permian-Triassic boundary sequence

4 **Symposium on the Permian-Triassic Boundary and Global Triassic Correlations in Marine and Non-marine Environments - 30th IGC, 1. Stratigraphy, Symposium 1.7. - together with an excursion to Permian-Triassic sections in Changxing and Hushan**

Date: August 4-14, 1996
Venue: Beijing, China
Convenors: Yin Hongfu, S. Lucas

Three of the four meetings will be hosted by developing countries. The possibility of a fifth meeting hosted by the Indian group in now under discussion.

3.3. Proposed major publications:

At least seven monographs and special issues in connection with this project have been scheduled with names of both books and their authors tentative.

BAUD, A., ZAKHAROV, Y. and DICKINS, J.M. (eds.), Late Paleozoic and Early Mesozoic Circum-Pacific bio-, geological events, a symposium of the International Field Conference on Permian-Triassic Biostratigraphy and Tectonics in Vladivostok. Papers have been collected and are now being edited.

DICKINS, J.M., YANG, Z.Y. and YIN, H.F., Late Palaeozoic and Early Mesozoic Circum-Pacific Events and their Global Correlation. Manuscripts of 25 papers have been submitted to Cambridge Univ. Press for publication.

BEAUCHAMP, B. and EMBRY, A., Symposium of Pangea, Carboniferous to Jurassic. It includes a number of presentations by IGCP 359 members.

JIN, Y.G. et al., Publication of the International Permian Symposium. Papers being collected.

KRISTAN-TOLLMANN, E., Shallow Tethys 4. Papers being collected.

YIN, H.F. et al., Upper Permian to Middle Triassic ecostratigraphy and sequence stratigraphy of Yangtze Platform and it margins (in Chinese with English summary) has been submitted to the Science Press, Beijing and will be published in 1995.

YIN, H.F., Triassic of East Asia (in Chinese). First proof of this book is now being read by the author. It will be published in 1995.

4. Summary

This project got an excellent evaluation from the assessments of the IGCP Scientific Board for 1993. Major progress has been achieved in the research on the boundaries of the Triassic-Permian, Lopingian-Guadalupian and Anisian-Ladinian. Preliminary results of regional charts of South China, Russia and other regions have been issued. Nine books and a number of papers have been published and several are now being edited. Three meetings were held and four are being prepared. Cooperation exists with IGCP Projects 306, 321, 335, GSGP Project Pangea, Shallow Tethys and other projects. Vigorous participation of the developing countries in all these activities is a distinctive character. The project is getting more impetus to approach its goal: a comprehensive correlation of the Permo-Triassic events and compilation of global changes during this important geological interval for a better understanding of the past, present and future of mankind.

IUGS UNESCO 359

THE MEISHAN SECTION

CANDIDATE OF THE GLOBAL STRATOTYPE SECTION AND POINT (GSSP) OF THE PERMIAN-TRIASSIC BOUNDARY (PTB)

Yin Hongfu, Wu Shunbao, Din Meihua, Zhang Kexing,
Tong Jinnan and Yang Fengqing

Abstract

This paper recommends the Meishan section, Changxing County, Zhejiang Province and the base of Bed 27c as the GSSP of the PTB. This section is easily accessible, well exposed and displays continuous marine sedimentation from the Changxingian to the Lower Triassic. The first appearance of *Hindeodus parvus* is suggested as the marker of the boundary stratotype point. Auxiliary markers are the $\delta^{13}C$ excursion, the Ir-spike and occurrence of *Otoceras*? stratigraphically close by. Associated contemporaneous events include volcanism, rapid transgression, anoxia and mass extinction. The suggested PTB is thus a good example of very close position and relation between chronostratigraphic and event-stratigraphic boundaries. A brief discussion on the sequence stratigraphy, ecostratigraphy and radiometric dating is also given.

Introduction

During the Permian-Triassic Boundary Working Group (PTBWG) meeting held during the Pangea conference (15-19 August, Calgary, Canada), four candidates for the GSSP of the PTB have been proposed, namely: (1) the Meishan section of Changxing, Zhejiang, (2) the Shangsi section of Guanyuan, Sichuan, (3) the Western Hill section of Selong, Tibet, and, (4) the Guryul Ravine section of Kashmir. Comparison of these four sections leads us to the conclusion that the Meishan section is the most suitable one for the GSSP. Detailed discussions on the biostratigraphic criteria such as merits and shortcomings of *Hindeodus parvus* and *Otoceras* have been published (PTBWG, 1993; Yin, 1994). This paper recommends the Meishan section in Changxing County, Zhejiang Province of South China and the base of its Bed 27c, in which *H. parvus* first occurrs, as the GSSP of the PTB.

Settings

The section is located in NW Zhejiang Province (Fig. 1), connected by highway and railway with Hangzhou, the capital of Zhejiang, and with Shanghai and Nanjing. The strata include marine Silurian to Lower Triassic, terrestrial Jurassic and Quaternary. The regional framework comprises of a series of NE trending folds initially formed during the Indosinian (Triassic) Orogeny but superimposed by the Yanshanian (Jurassic and Cretaceous) structures, constituting the Shizishan Synclinoria. The type section is located on the south eastern wing of this structure. In the Meishan area quarries are being exploited for the limestone of Changxing (or

Changhsing) Formation that is used for construction. The area thus provide six PTB sections. Zhao et al. (1981) selected Section D, located between Meishan and Xinghui, near Baoqing Village, as the stratotype of the Changxing Formation which represents the highest Permian-Changxingian of the world. Sheng et al. (1984) and Wang (1994) chose the Zhongxin Dadui quarry section, a few hundred meters east of Section D, as the stratotype of the PTB in South China. It has been described by the Chinese PTBWG (1993). Yang et al. (1987) chose Section D, which they call the Baoqing section, as the GSSP candidate of the PTB. *A stela has been established there to record the conservation regulation of the provincial administration.* Because the first appearance of *Hindeodus parvus* (Zhang, 1987) is in the D section and so far no further discoveries of *H. parvus* have been reported below this level, this paper recommends Section D as the GSSP of the PTB. The Zhongxin Dadui section is also suitable as a candidate, although its Changxingian part is not so complete as in the D section. The D section is about 150 m long, beginning at the Dzhulfian Longtan Formation in the south to the Induan Yinkeng Formation in the north. In the S Jiangsu-N Zhejiang area there are several sections in different sedimentary facies for correlation (Fig. 1).

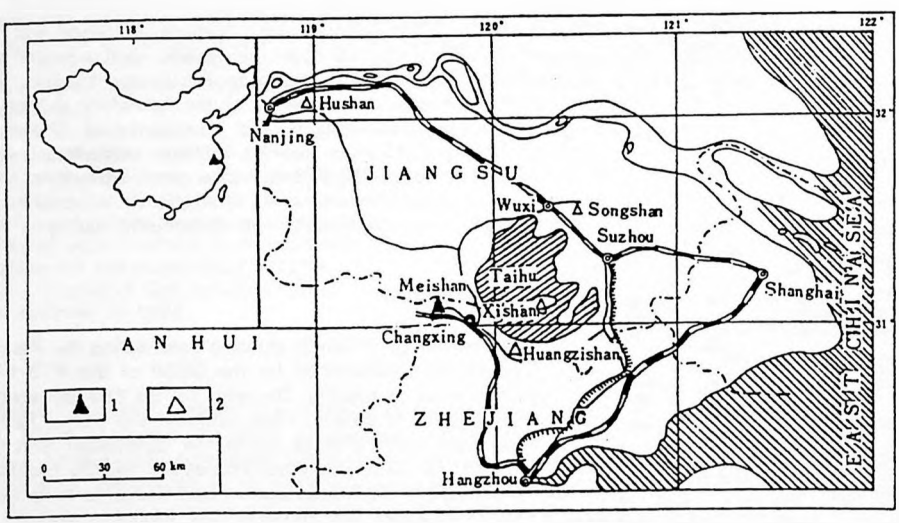


Fig. 1 The geographical setting of the Meishan section. 1 = location of the Meishan section; 2 = sections of different sedimentary facies for correlation

Litho- and biostratigraphy

In order to avoid confusion we have used the bed numbers actually marked at the section. Beds 24e-28 of the following description correspond to Beds 1-6 of the Zhongxing Dadui section published by the Chinese PTBWG (1993).

The Lower Triassic - lower Qinglong (Chinglung) Formation or Yinkeng Formation

Upper Griesbachian, or *Pseudoclaraia wangi* Zone (Yin, 1985)
corresponding with the *Isarcicella-Ophiceras-Claraia* Acme Zone

37	Interbeds of bluish-grey calcareous mudstone, black shale and grey medium- to thin-bedded calcimicrite. Limestone increasing upward, containing the bivalves *Claraia fukienensis* Chen and *C. lungyenensis* Chen, the ammonoids *Lytophiceras* sp. and ophiceratids	not ended
36	Bluish-grey calcareous mudstone and black shale intercalated with thin-bedded grey argillaceous stone, yielding the bivalves *Claraia lungyenensis* Chen and *C.* sp.	0.96 m
35	Interbeds of grey medium- to thin-bedded argillaceous limestone, bluish-grey calcareous mudstone and black shale yielding the bivalves *Claraia lungyenensis* Chen, *C.* sp.	1.00 m
34	Rhythmic interbeds of bluish-grey calcareous mudstone, black shale and bluish-grey thin-bedded marl, containing the bivalves *Claraia dieneri* Nakazawa, *Claraia lungyenensis* Chen, *C.* sp. and *Pseudoclaraia wangi* (Patte)	6.06 m
33	Yellow illite-montmorillonite clay	0.05 m
32	Interbeds of thin-medium bedded dark grey calcareous mudstone and black shale. Previously described as 'greyish yellow mudstone yielding *Pseudoclaraia wangi* (Patte), *Claraia dieneri* Nakazawa [Sheng et al., 1984]', or as 'dark grey fine siltstone yielding ammonoids: *Ophiceras* sp.; bivalves: *Claraia griesbachi* (Bittner), *C.* sp., *Pseudoclaraia wangi* (Patte) [Yang et al., 1987]'	0.76 m
31	Greyish yellow illite-montmorillonite clay	0.09 m
30	Bluish-grey marl containing ophieratids [Sheng et al., 1984], *Pseudoclaraia wangi* (Patte), *Claraia griesbachi* (Bittner) [Yang et al., 1987]'	0.55 m
29	Grey medium-bedded dolomitic calcimicrite with argillaceous and silty contents. It yields *Pseudoclaraia wangi* and ophiceratids [Sheng et al., 1984], brachiopods: *Paryphella orbicularis* (Liao), conodonts: *Anchignathodus* sp., *Gondolella* sp. and *Xaniognathodus elongatus* Sweet [Yang et al., 1987]	0.26 m

Lower Griesbachian, or *Hindeodus parvus* zone

28	Greyish-yellow illite-montmorillonite clay. Conodonts: *Hindeodus parvus* (Kozur et Pjatakova), *Hindeodus* sp., *Ellisonia teicherti* Sweet. The previous description was: 'Bed 6. Greyish yellow mudstone (0.02m) and Bed 5. Greyish yellow clay (0.02 m)' [Chinese PTBWG, 1993]	0.04 m

Beds 28-34 correspond to Mixed Bed 3 (Sheng et al., 1984)

---------- conformity *2 ----------

27	Light grey medium-bedded silty limestone, previously described as 'grey dolomitic marl [Sheng et al., 1984]', containing brachiopods: *Acosarina* cf. *minuta* (Abich), *Crurithyris flabelliformis* (Liao), *Fusichonetes pigmaea* (Liao), *Neochonetes* sp.(?), *Paryphella orbicularis* (Liao), *P. triquetra* Liao, *Waagenites* sp., *W. barusiensis* (Davidson); conodonts: *Hindeodus parvus* (Kozur et Pjatakova), *H. minutus* (Ellison), *Prioniodella ctenoides* (Tatge) and *Lonchodina muelleri* Tatge [Yang et al., 1987]. In conodont sampling by Zhang this 0.16 m thick bed was subdivided into four equally thick partitions in ascending	

order: a, b, c and d. Two specimens of *H. parvus* were discovered and illustrated by Zhang (1987) at 8 cm above the base of Bed 27, that is, at the base of Bed 27c. Wang (1994) also discovered *H. parvus* specimens in the upper half of this bed in the neighboring Zhongxin Dadui section 0.16 m
(varying between 0.14-0.17 m due to weathering)

Bed 27 corresponds to Mixed bed 2 (Sheng et al., 1984), or
the upper Transitional Bed (Yin, 1985)

---------- conformity *2 ----------

The Upper Permian Changxing Stage

Mixed bed 1 or lower Transitional Bed

26 'Black Clay'. Dark grey montmorillonite-illite claystone, partly calcareous and silty. Previously described as: 'greyish-yellow mudstone with small crystals of pyrite' [Sheng et al., 1984], or as 'dark brown, calcareous mudstone' [Yang et al., 1987]. Brachiopods: *Cathaysia chonetoides* (Chao), *Crurithyris flabelliformis* Liao, *Neochonetes convexa* Liao, *Paryphella orbicularis* (Liao), *P. triquetra* Liao, *Uncinunellina* sp., *Waagenites* cf. *soochowensis* (Chao) and *W. wongiana* (Chao); conodonts: *Neogondolella subcarinata changxingensis* (Wang et Wang), *N. deflecta* (Wang et Wang) and *N. carinata* (Clark) [Yang et al., 1987; Zhang, 1987]; also *Waagenites pseudoutah* (Sheng et al., 1984). At the Zhongxing Dadui section it yields ammonoids: *Otoceras*? sp., *Hypophiceras* cf. *martini* (Truempy), *H. changxingense* Wang, *Tompophiceras* sp., *Metophiceras* sp. and *Pseudogastrioceras* sp.; bivalves: *Peribositra baoqingensis* Chen; brachiopods: *Paracrurithyris pigmaea* (Liao), *Waagenites barusiensis* (Davidson), *Paryphella sulcatifera* Liao, *Neowellerella pseudoutah* (Huang) and *Araxathyris minuta* Grunt [Sheng et al., 1984]. 0.06 m

25 'White Clay'. Light blueish-grey illite-montmorillonite claystone, light yellowish-white when weathered, yielding conodonts: *Neogondolella changxingensis* (Wang et Wang), *N. deflecta* (Wang et Wang), *N. orientalis* Barskov et Koroleva, *N. subcarinata* (Sweet) and *Hindeodus minutus* (Ellison); non-fusulinid foraminifera: *Bradyina* sp., *Glomospira* sp., *Globivalvulina* sp., *Nodosaria* sp., *Textularia* sp. and *Hemigordius* sp. [Yang et al., 1987; Zhang, 1987] 0.04 m

The Upper Changxing Formation

Pseudotirolites-Palaeofusulina Zone

24e Grey medium-bedded micrite yielding fusulinids: *Palaeofusulina* sp.; ammonoids: *Rotodiscoceras* sp. conodonts: *Neoondolella changxingensis* (Wang et Wang), *N. deflecta* (Wang et Wang) and *N. carinata* Clark; brachiopods: *Crurithyris flabelliformis* Liao, *Neowellerella pseudoutah* (Huang) and *Wellerella delicatula* Dunbar et Condra [Yang et al., 1987; Sheng et al., 1983] 0.20 m

24d Dark grey medium-bedded wackestone with very thin bioclast-bearing calcareous mudstone interbeds. Conodonts: *Enantiognathus ziegleri* (Diebel), *Neogondolella carinata* Clark, *N. deflecta* (Wang et Wang), *N. changxingensis* (Wang et Wang), *Hibbardelloides* sp. and *Xaniognathus elongatus* Sweet;

non-fusulinid foraminifers: *Geinitzina caucasica* K. M-Maclay, *Nodosaria netchajevi* Lipina and *Pachyphyloia lanceolata* K. M-Maclay; fusulinids: *Palaeofusulina* cf. *sinensis* Sheng; ammonoids: *Pleuronodoceras mirificus* Zhao, Liang et Zheng, *Pseudogastrioceras* sp. [Yang et al., 1987; Sheng et al., 1983] 0.23 m

24c Dark grey medium-bedded dolomitic packstone, with normal graded beddings and parallel beddings. Conodonts: *Enantiognathus zeigleri* (Diebel), *Hibbardella* sp., *Hindeodella* sp., *Lonchodina muelleri* Tatge and *Xaniognathus elongatus* Sweet [Yang et al., 1987] 0.17 m

24b Dark grey medium-bedded dolomitic packstone, topped by a very thin clay bed. Conodonts: *Enantiognathus ziegleri* (Diebel), *Neogondolella changxingensis* (Wang et Wang) and *N. deflecta* (Wang et Wang) [Yang et al., 1987] 0.11 m

24a Dark grey medium-bedded wackstone, topped by a very thin clay bed. Conodonts: *Neogondolella carinata* Clark, *N. changxingensis* (Wang et Wang) and *Xaniognathus elongatus* Sweet [Yang et al., 1987] 0.10 m

(Due to space restrictions, the descriptions of Beds 1-23 are omitted here. Details of Beds 1-23 are given in the Excursion Guide of the Meishan Section prepared for the International Meeting on the Permian, Guiyang, 1994)

*1: Ouyang and Utting (1990) described three microfloral assemblages for the Permian-Triassic sections in Meishan. In ascending order these are: (1) the *Leiosphaeridia changxingensis-Mycrhistridium stellatum* Assemblage from the upper Changxing Formation, (2) the *Vittatina-Protohaploxypinus* Assemblage from the mixed beds 1, 2 and the lower part of 3, and (3) the *Lunatisporites-Ephedripites* Assemblage from the middle and upper parts of mixed bed 3.

*2: Tozer (1986, 1988) regarded the Permian-Triassic contact of the Meishan section as discontinuous and the brachiopods in the Transitional Bed as being reworked. Nakazawa and others (in Sheng et al., 1984), Wignall and Hallam (1993) and all Chinese authors, however, consider the contact to be conformable and the brachiopods to be autochthonous. The 'Boundary Clayrock' or Bed 25 was formerly placed in the Triassic. Tozer's 'discontinuous contact' is actually between Beds 24e and 25, which are now both within the Changxingian. Even there, to us the contact is clearly conformable. The 'Boundary Clayrock' was later shifted into the Permian because of the discovery of Permian conodonts in it. In the paper by the Chinese PTBWG (1993), the PTB was delineated between Beds 25 and 26 because of the occurrence of *Otoceras*? and *Hypophiceras* in Bed 26. Now we shift it upward to the base of Bed 27c, based on the first appearance of *H. parvus*. See the description of Bed 27.

Biostratigraphic correlation

The Global Stratotype Point is suggested to be located at the base of Bed 27c. This bed represents the first appearance of *Hindeodus parvus*, the index fossil of the basal Triassic, for reasons of which please refer to our previous papers (Chinese PTBWG, 1993; Yin, 1994).

It is more desirable to choose a PTB stratotype in the Tethys region where the uppermost Permian (Changxingian or Dorashamian) and lowermost Triassic (Griesbachian) stratotypes are located, and where the biota were most diversified and correlatable intercontinentally. The present correlation is thus mainly with the uppermost Changxingian-lower Griesbachian fossil beds of major Eurasian Tethys and Gondwanan Tethys sections. For correlation of still lower

beds please refer to Yin (1994).

Bed 25 or the 'White Clay', formerly 'Boundary Claystone' of volcanic origin

This claybed is widespread in South China (Yin, 1985). In Iran, a clay bed (Bed 0 of Unit a) has been reported at the supposed Permian-Triassic boundary at the Hambast C (Abadeh) section (Iran.-Jap. Res. Group, 1981), and similar beds occur in the Gheshlagh section of the eastern Elburz (Altiner et al., 1979). In the Southern Alps, a clay bed has been discovered between the Bellerophon and Werfen formations in the Casera Federata section and also in the lower part of the Tesero Member. In the Gartnerkofel the sample at the Bellerophon-Tesero boundary (sample 205; Boeckelmann, 1991) is remarkably missing, implying something lithologically softer than carbonates. The boundary rocks of Dorasham, Armenia and Kuh-e-Ali Bashi, Iran are shales. Yang and Li (1987) noticed an unstable claybed between the Chhidru Formation and the Lower Unit of the Kathwai Member at the Nammal section of the Salt Range. In the Dorasham 2-3 section this interval may be represented by reddish-brown shales. These clay and shale beds are here regarded as correlative because they occupy the same biostratigraphic level in the Permian-Triassic sequence, although some of them, e.g., the Bed 0 of Abadeh, may possibly be corresponding to the 'Black Clay'. We do not know its equivalents in the Guryul Ravine, Selong and Kuh-e- Ali Bashi. This subdivision seems to be restricted in certain regions.

So far fossils have only been reported from the 'White Clay' of the Meishan section. They are all typical Changxingian conodonts. In the Chinese literature this white 'boundary clay' was first suggested as the basal Triassic (Zhao et al., 1981; Sheng et al., 1984). Yang et al. (1987) recorded the discovery of Changxingian conodonts by Zhang Kexin in this clay but still set it in the basal Triassic. Now Chinese workers all agree that it belongs to the Permian.

Bed 26 or the 'Black Clay'

This horizon is also found in Shangsi and a few other PTB sections in South China. Its equivalent in the Gondwanan Tethys may be the *O. latilobatum* Zone or Lower *Otoceras woodwardi* Zone. (Guryul, Chhidru and Selong). It is characterized by *H. minutus, G. subcarinata changxingensis, G. deflecta,* Permian brachiopods and foraminifera, plus rare claraiids including *'Peribositra'*. The 'black clay' at Meishan yields *Otoceras?, Hypophiceras* etc, and the 'black clay' (Bed 5) plus Bed 6 at Shangsi, Guangyuan County of Sichuan, yields *Hypophiceras* etc. In Greenland, *Hypophiceras* is regarded as a time equivalent of *Otoceras*. Its equivalents in Abadeh, Kuh-e-Ali Bashi and Dorasham are actually unknown and it is possible that they are either missing (disconformity) or represented by a claybed (Abadeh) or by an unfossiliferous argillite between the *H. parvus* bed and the *Pleuronodoceras* bed (Kuh-e-Ali Bashi and Dorasham).

The Permian nature of the lower *Otoceras* zone has been suggested by a number of authors, recently by Yin (1994). The fauna of Bed 26 is predominantly Permian and the discovery of *Pseudotirolites?* in the 'black clay' of Shangsi poses a remarkable problem because this implies the partly overlapping of the *Otoceras* bed with the *Pseudotirolites* bed, if the specimen was correctly identified. Here we only mention a new discovery. From SW Ellesmere Island, Arctic Canada, Henderson (1993) reported the discovery of the late Changxingian conodonts *Gondolella subcarinata* and *G. deflecta* from lowermost Blind Fjord Formation, 1 m above the erosional surface of the underlying Van Hauen Formation, or the traditional 'Permian-Triassic boundary'. This horizon belongs to the '*Otoceras* Bed' although at the type Griesbachian section of Griesbach Creek in northern Ellesmere Island, real *Otoceras* first occurs at 22 m above the

erosional surface. Because no Changxingian strata have been reported from the Arctic, the possibility that these conodonts are reworked from Changxingian strata is minimal. If they are not reworked, this discovery implies that in the Arctic the lower part of the *Otoceras* bed could be Permian.

After the shift of the 'White Clay' into the Permian, we used to regard this 'black clay' as the basal Triassic (Yang et al., 1993; Yin et al., 1986). Now, from the above statements we deem it appropriate to place the 'black clay' or Mixed bed 1 of Meishan in the topmost Permian rather than basal Triassic.

Beds 27c-d and 28, or the *Hindeodus parvus* Zone

The base of the *Hindeodus parvus* Zone is here recommended as the Global Stratotype Point of the Permian-Triassic Boundary because this species is now publicly used as the marker for the basal Triassic. It symbolizes the appearance of Triassic newcomers, and has a much wider distribution than *Otoceras* throughout the Tethys and it may be even found in Greenland. For detailed discussions please refer to the Chinese PTBWG (1993). One more advancement needs to be mentioned. In the Sosio Valley of Sicily the Upper Permian is a slope sequence with red deep-water claystones, allodapical limestones and calcareous sandstones that contain pelagic and shallow-water fossils. The Changxingian is overlain without a break by 2 m thick laminated brownish weathered clays (anoxic event), which contain only *Hindeodus parvus*. In the lowermost Induan slope limestones *Isacicella isarcica* has been found (Kozur, 1993). This report shows that *H. parvus* can be found also in deep-water facies.

Because the upper limit of *Hindeodus parvus* ranged into the *Ophiceras* Zone or the *I. isarcica* Zone (Matsuda, 1981; Kozur et al., 1978; Iran.-Jan. Res. Group, 1981; Pak.-Jap. Res. Group, 1985; Sweet, 1992), the present concept of the *H. parvus* Zone has to be a successive appearance zone beginning with the first appearrance of *H. parvus* and topped by the first appearance of *I. isarcica*. This zone corresponds to the upper *Otoceras* Zone. In Meishan it is represented by beds 27c-d and 28. However, fragments reminiscent of this species have been found in beds 27a-b (Wang and Zhang, pers. comm.) This zone can be correlated throughout the Tethys, except in Shangsi, where the conodont *H. decrescens* replaced *H. parvus* probably because of a facies change, judging from the different sediments in Shangsi and Meishan.

This zone differs from Bed 26 in the fact that both Triassic newcomers (*I. isarcica, Claraia, Ophiceras, Unionites*) and Permian brachiopods can be found in this horizon. On the other hand the newcomers never flourished as they did in Subdivision 6, and the late Changxingian conodonts *H. changxingensis* and *H. deflecta* seldom survive to this zone.

Beds 29-37 - The *I. isarcica-Claraia-Ophiceras (IOC)* Acme Zone

Both *Ophiceras* and *Claraia* have sparse occurrences in the lower Griesbachian and even in the Upper Permian (*O. connectens* in the Salt Range, Late Permian claraiids see Yin, 1983), but it is in the early late Griesbachian that they simultaneously became flourishing, speciated and reached a high abundance. Hence it is reasonable to place *I. isarcica-Ophiceras-Claraia* in one acme zone characterising the lower Upper Griesbachian. In Meishan this is represented by Bed 29-37. Although *I. isarcica* has not been found, the occurrence of *P. wangi, C. griesbachi* and *Ophiceras* is sufficient to represent this acme zone.

This assemblage has been recommended by many authors as index fossils for the basal Triassic

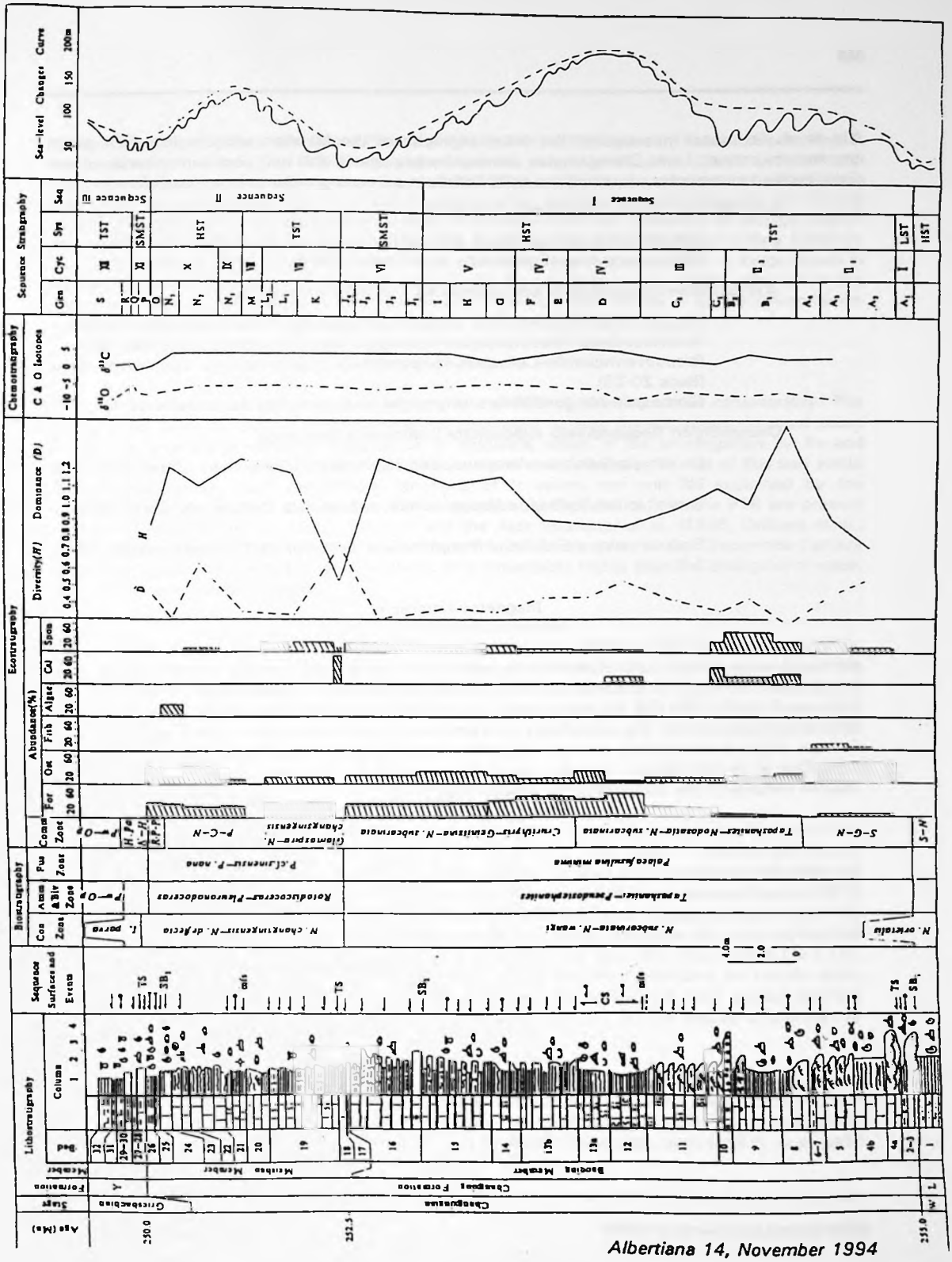
(Yao and Li, 1987; Sweet, 1992). The suggested boundary is between the lower and the upper Griesbachian (Gangetian and Ellesmerian) Substages. The merits of *I.isarcica-Ophiceras-Claraia* as index fossils of basal Triassic are: (1) the *IOC* assemblage is the first real Triassic fauna without or with little Permian relicts, (2) the IOC assemblage has been found throughout Tethys from the Alps to South China and along both the Gondwanan and Eurasian sides of it. Although *I. isarcica* has not yet been formally reported from the Arctic regions, the abundant *Ophiceras-Claraia* assemblages there allow confident interregional correlations; the *IOC* Acme Zone is a multispecies fossil zone to be prefered for biostratigraphic signatures for the GSSP, as advocated in the Guidelines and Statutes of the ICS. Moreover, continuity of sedimentation in the lower-upper Griesbachian interval is confirmed in most localities including Meishan. However, the main problem of the *IOC* assemblage is that they form an acme zone together and not a range zone. Both *Ophiceras* and *Claraia* made their first appearance before the late Griesbachian, mixed with *Otoceras* and *H. parvus*, or it occur in the Transitional Beds of South China. Even *I. isarcica* appears in the *H. parvus* Zone (Chhidru Nara), or vice versa (Hambast C section, Iran). This will induce correlation uncertainties if we cannot differentiate their first appearances from their acme zone. Moreover, traditional usage would make people preferring lower Griesbachian to upper Griesbachian as basal Triassic. For these reasons we have not chosen this assemblage as the marker of basal Triassic.

Sequence stratigraphy and ecostratigraphy

During the Changxingian the Meishan section was located between the carbonate platform to the southeast and the basin, dominated by the siliceous Dalong Formation, to its northwest. A northeast trending ridge, usually subaqueous but sometimes exposed over sealevel as in Niutoushan (15 km west of Meishan), separated the basin and the platform and Meishan was then at the platform side. The 37 m thick Changxingian sediment sequence of Meishan consists of, besides normal shallow water limestones, carbonate tempestites at upper and lower parts and carbonate turbidites at middle part, showing a subtidal slope environment, deepening at first and shallowing in a later stage. The deposits represents, in Chinese usage, an intrashelf slope and basin restricted by the southeast shelf and the northeast trending ridge. Two third-rank sequences have been subdivided, the earlier one consisting of the shelf margin, transgressive and highstand system tracks whereas the later one lacks the shelf margin system track. The topmost half meter of the Changxingian (Beds 24e, 25 and 26) becomes more argillaceous and the Permian benthos became extinct chiefly at this interval. This part is regarded as a shelf margin system tract, and together with Grieschian strata it constitutes another third-rank sequence. Bed 27 represents a transgressive system tract and Bed 26 according to Wignall and Hallam (1993) represents the transgressive surface. The maximum flooding surface is the base of Bed 28 which brought about the widespread *IOC* fossil assemblage. The rest of the Griesbachian belongs to a highstand system tract (Fig. 2).

Fig. 2 The integrative PTB stratigraphyic column of the Meishan section, Changxing, Zhejiang.

Amm = ammonoids; Biv = bivalves; Cal = calcareous sphaerules; Comm = community; Con = conodonts; CS = condensed section; Cyc = cycles; For = non--fusulinid foraminifers; Fus = fusulinids; Gen = genetic unit; L = Longtang Formation; Ost = ostracods; Seq = sequence; Spo = sponge spicules; Sys = systems tract; W = Wujiapingian; Y = Yinkeng Formation; = physical event; = chemical event; = biological event; = mixed event.


Sea-level Changes Curve
Sequence Stratigraphy
Chemostratigraphy
Ecostratigraphy
Biostratigraphy
Sequence Surfaces and Events
Lithostratigraphy
Age (Ma)
Stage
Formation
Member
Bed
Column
Diversity (H)
Dominance (D)
Abundance (%)
Coma Zone
Atma & Bir Zone
Cor Zone
Fw Zone
Syn
Cyc
Gra
Seq
Sequence III
Sequence II
Sequence I
TST
HST
SMST
LST
HST
Chaugouan
Griesbachian
Bocaina Member
Metabo Member
Charqueadas Formation
250.0
252.5
255.0
N. orcrtolu
N. rubcorvaata–N. wapi
Tapajhanites–Pseudostephanites
Paleoscyllina minima
P. clinarius–P. nana
Rotodiscocras–Pleuronodocras
N. chonkrinkrenzis–N. drifecia
I. porro
S–G–N
Tapajhanites–Nodosaria–N. subcoronata
Curvilyrtis–Geniculina–N. subcoronata
Glomospira–N. chonkrinkrenzis
P–C–N
H. Fa
A–N
R.P.F.
S–N
Spon
Cal
Algae
Fib
Ost
For
Sea-level Changes Curve

Yin et al. (in press) investigated the ecostratigraphy of the Meishan section, in which seven community zones of two Changxingian community sequences and two community zones of one Griesbachian community sequence are established. In ascending order they are as follows:

- **Griesbachian *Claraia* Community Sequence**
  - *Pseudoclaraia wangi-Claraia griesbachi* Community Zone (Beds 29-37)
  - *Hindeodus parvus* Community Zone (Beds 27-28)
- **Changxingian *Neogondolella changxingensis* Community Sequence**
  - *Hypophiceras-Neogondolella changxingensis* Community Zone (Beds 25-26)
  - *Rotodiscoceras-Palaeofusulina-Pleuronodoceras* Community Zone (Bed 24)
  - *Pseudovermiporella-Colaniella-Neogondolella changxingensis* Community Zone (Beds 20-23)
  - *Glomospira-Neogondolella changxingensis* Community Zone (Beds 17-19)
- **Changxingian *Neogondolella subcarinata* Community Sequence**
  - *Crurithyris-Geinitzina-Neogondolella subcarinata* Community Zone (Beds 13-16)
  - *Tapashanites-Nodosaria-Neogondolella subcarinata* Community Zone (Beds 8-12)
  - *Sinoplatysomus-Geinitzina-Neogondolella subcarinata* Community Zone (Beds 2-7)

Magnetostratigraphy

According to Li and Wang (1989), the Changxingian to Lowermost Triassic strata of 60 meters thickness are subdivided into 6 chrons, namely in ascending order: normal I, reversal II, normal III, reversal IV, normal V and reversal VI, of which I-IV belongs to Changxingian whereas V and VI Lower Triassic. The PTB lies at 1.2 (or 2.7) +0.14 m above the base of normal V (the 1.5 m difference in and out of the parenthesis refers to an interval of indistinct magnetic polarity; the 0.14 m refers to the interval between our PTB and the formerly recognized 'PTB' --base of Bed 25). This is in accordance with the general scheme of P-T magnetostratigraphy. The whole interval belongs to the Illawarra or P-T Mixed Superchron.

Radiometric dating

The first formal report on a radiometric age of the PTB was published by Claoué-Long et al. (1991) and Zhang et al. (1992) in the 'White Clay' or Bed 25 of the Meishan section, which is of volcanic ash origin (Yin et al., 1992). Of 35 zircons analyzed (37 analysis) in the montmorillonite-illite clay, 34 analyses, using SHRIMP-ion microprobe dating, gave a $^{206}Pb/^{238}U$ age of 251.2 ± 3.4 Ma (2σ). Although the age difference for the deposition of the black and white clays should be deducted from the above age, the formation of these claybeds was a rapid process judging from the low Mn/Ti ratio (Chai et al., 1992, Fig. 14-8). So the time difference can be neglected and we can contend ourselves with 251 Ma as the age of the PTB.

Chemostratigraphy

Stable carbon isotopes

Chen et al. (1984) have shown the minimum excursion ($\delta^{13}C$, -1.9; $\delta^{18}O$, -8.3) in the lower part

of Bed 27, dropping from the latest Permian high (+2.5-3.5‰) Recently, based on sampling at centimetre level, Xu & Yan (1993) again detected the excursion based on three samples with intervals of ca. 2 cm from the lowest 6 cm of Bed 27 (i.e. 27a-b), the minimum of which being less than -6‰. The latest Permian high is about +2‰ and the value of Beds 25 and 26 are around 0, with a short-lived excursion in Bed 26 (sample CG672c). Likewise, an abrupt drop of the carbon isotope composition across the PTB has been discovered in South China (Chen et al., 1991) and throughout the Tethys (Baud et al. 1989, Holser et al., 1991). It even occurs in Greenland (Oberhansli et al., 1989) and Spitzbergen (Gruszcznski et al., 1989), although in the latter the drop began earlier (in the Tartarian). Thus it seems to be a global phenomenon suitable for intercontinental correlation.

Iridium anomaly

The iridium data obtained by various authors at the PTB of Meishan varies considerably. The high values given by Sun et al.(1984) are not confirmed by later investigations. In most cases an iridium anomaly is either undetected or of moderate value. In the investigation by Xu and Yan only the top one centimetre of Bed 26 show the Ir spike whereas the rest of this bed yields background values. Such remarkable variations of Ir values can only be explained by the unevenness of the iridium distribution. Similar uneven distributions of Ir at the PTB are present in South China (Yin et al., 1992, Table 1) and the Alps (Brandner et al., 1986, Oddone et al., 1986, Holser et al., 1991). This is quite different from the situation at the Cretaceous-Tertiary boundary where the Ir content is consistently and remarkably higher than the background value, thus inferring a different origin.

Other chemical anomalies

Chai et al. (1992) recorded an enrichment of chalcophile elements (As, Se, Sb and Mo) in the 'White Clay' and an enrichment of siderophile elements (Ir, Au, Co and Ni) in the 'Black Clay'. Abundances of almost all lithophile elements rise considerably at the PTB. They also noted differences in REE patterns between these two boundary clays and the non-boundary clays distributed below and above the boundary in the section.

Significance of geochemical markers

The $\delta^{13}C$ excursion is so ubiquitous that Newell (1994) recommended the association of the $\delta^{13}C$ excursion with the P-T mass extinction as the natural PTB. Table 1 shows that the *H. parvus* appearance and the $\delta^{13}C$ excursion concur very closely, and that the Ir spike seems slightly antedating the $\delta^{13}C$ excursion. Owing to the priority of biostratigraphic criteria, the $\delta^{13}C$ excursion together with the unevenly distributed Ir spike are here suggested as an auxiliary markers of the boundary. Significance of the chemical anomalies will be further discussed in the paragraph on event stratigraphy.

Event stratigraphy

Volcanic event

The 'White Clay' or Bed 25 is composed of interbeds of illite and mixed montmorillonite-illite layers with subordinate kaolinite. The 'Black Clay' or Bed 26 is of mixed montmorillonite-illite with subordinate kaolinite. Both, especially Bed 25, have been claimed to be of volcanic origin based on following evidences.

Volcanic textures and characteristic minerals. Investigations of PTB minerals was carried out at the PTB of Sections B (370 m west of D) and E (400 m west of D) (Bi et al., 1993). ß quartz paramorphs have been discovered, rarely in Bed 25, but with a maximum of up to 25% of total quartz content in Bed 26 (ZCE-3 of Bi et al., 1993), much higher than those in the PTB of other South China sections, implying that the centre of acidic volcanic activity was probably near Meishan. These hexagonal dipyramid quartz are usually euhedral (few grains rounded), with resorptions on the surface, grain size ca. 0.02-0.05 mm. Crystalline temperature of ß quartz is between 573 °C and 870 °C. Below 573 °C it changes into α quartz. The α quartz found now as the paramorph of ß quartz is a typical form of phenocrysts in acidic volcanic rocks or in hypabyssal rocks. Some of the thin layers show vague blastotuffaceous textures (Fu, 1989).

Meishan	
- first appearance of *H. parvus*	= PTB
- $\delta^{13}C$ excursion	ca. 5 cm below PTB
- first appearance of *Otoceras sp.*	Bed 26(3)(6cm), 14 cm below the PTB
- Ir spike	top 1 cm of Bed 26(3), 9 cm below the PTB
Shansi (Li et al., 1989)	
- $\delta^{13}C$ excursion	Bed 28a, within 17 cm below the PTB
- Ir spike (AG253)	Bed 27c, within 21 cm below PTB
Gartnerkofel Core	
- $\delta^{13}C$ excursion	base of Mazzin (depth 220.20m)
- Ir spike (0.196 ppb)	top of Tesero (depth 224.52m)
- first appearance of *H. parvus*	top of Tesero (depth 224.74-224.97m)*
Kuh-e-Ali Bashi	
- first appearance of *H. parvus*	base of the overlying *Claraia* limestone
- $\delta^{13}C$ excursion	sample 33 in the boundary red marl (1.1m)
Nammal Nala, Salt Range	
- $\delta^{13}C$ excursion	base of the Mittiwali Member, about 4m from the base of Middle Kathwai Member (Baud et al., 1989)
- first appearance of *H. parvus*	lower part of 1.4 m thick Middle Kathwai Member, also in Zaluch section (Pak.-Jap. Res. Gr., 1985)

* Kozur (pers. comm.) argued that this is the horizon of H. Latidentatus whereas H. Parvus appears higher in Mazzin.

Table 1. Succession of the PTB markers

Other minerals

The automorphic zircon, apatite and magnetite constitute an accessory mineral assemblage typical of medium-acidic volcanic rocks. All mineral grains including the friable plagioclase have un-itched crystal faces denoting quick deposition without long distance transportation.

Microspherules

Hundreds of microsphaerules have been discovered in Beds 25 and 26 of Meishan. Most of them are lithic, ferrugenous or a mix of the two, possessing forms or structures such as impact pits, fused aggregates, tapering droplets, jet holes, vesicles, contractive wrinkles, spiral filaments and sometimes polygonal surface structure reminiscent those on the quenched metal surface. These are interpreted as melted spherules rapidly falling down, rotating and being abraded or even cracking against each other in atmosphere and then quickly cooling down in water. These process es can be carried out either by volcanic eruption or by extraterrestrial impact. The siliceous microspherules are similar to those found in the plume of Etna Volcano. There are a few diopside and spinel microsphaerules.

Autochtonous marine fossils have been found in Beds 25 and 26. Gypsum has been found in Bed 26, rare, platy, transparent and automorphic (thus preferring marine origin to supergenetic origin), some dissolved on the surface. The boron contents of Beds 17 (a clayrock 12 m below PTB), 25 and 26 are 340, 190 and 330-390 ppm respectively, all above 100 and thus suggestive of marine deposition (Bi et al., 1993). Clayrocks of Beds 25 and 26 are postulated as hydrolyzed tuff. Intermediate to acidic tuffaceous materials in marine environment are readily altered into montmorillonite, and further into mixed montmorillonite-illite.

Transgressive event

Traditional view holds that Late Permian experienced a worldwide regression and the transgression did not commence until the beginning of Triassic. However, Wu Shunbao (in Yang et al., 1993, p. 15-20) demonstrated that in South China, the transgression initiated not at earliest Triassic but instead at latest Permian. In a correlation chart of 13 Permian-Triassic sections of South China including Meishan, he showed that a horizon of remarkable lithological and faunal changes occurring score of centimetres or a few meters (in Meishan it is 0.32 m) below the PTB. The top Permian less than half meter carbonates in Meishan contain more clayey and silty terrigenous clasts denoting a shelf margin system tract (SMST) deposit. This horizon coincides with the first delineation of biotic extinction. A second horizon, Bed 26, marks the beginning of transgression carrying new pelagic ammonoids such as *Otoceras?* and *Hypophiceras*. It is accompanied by an anoxia event and its top marks the second or main delineation of extinction. The third extinction horizon is at the top of Bed 28 demarcating the disappearance of Permian relict brachiopods, followed immediately by maximum flooding surface at the base of 29 together with widespread *IOC* assemblage. Wignall & Hallam (1993), taking Meishan section for example, also emphasized the three-phased deepening and extinction events beginning in the latest Permian in South China, although they denoted the second horizon as the maximum flooding surface. The transgression in latest Permian explains why there is extensive continuous deposition between the two systems in South China.

Anoxic event

In Meishan Chai et al. (1992) recorded enrichment of chalcophile elements (As, Se, Sb and Mo)

in the 'White Clay' and enrichment of siderophile elements (Ir, Au, Co and Ni) in the 'Black Clay'. The latter denotes absorption by organic matter in reducing environment. The former is related to the presence of a large amount of pyrite at the base the 'White Clay'. Mossbauer spectrometry of samples from that base indicate that more than 99% of the iron is present in the Fe form, which implies an anoxic condition.

Wignall and Hallam (1993) developed a theory of the widespread establishment of deep-water anoxic and dysoxic conditions during the early Griesbachian, and claimed that this is the cause of the Permian-Triassic extinction. They cited that the rare earth element distribution pattern has no negative Ce anomaly (Chai et al., 1992), a condition suggestive of anoxic deposition. Values of $\delta^{13}C$ reach their lowest value at this horizon, and the value of organic carbon fraction is -27.885 (Yin et al., 1992). On the other hand, a number of dwarfed thin-shell brachiopods and ammonoids have been found in this bed suggesting dysaerobic conditions. Thus this bed may represent an alternation of anoxic and dysoxic conditions.

Mass extinction event

Most shallow benthic organisms (foraminifers, corals, brachiopods, bivalves) and cephalopods experienced a species extinction rate of 95-100% across the PTB. Detailed statistics of the mass extinction at the PTB in South China, including Meishan, have been given in Yin et al. (1984), Yang et al. (1987) and most recently in Yang et al. (1993), thus it will not be reiterated here. Yang et al. (1993, Figs. 1-13, 14, 15 and Tab. 1-1) stated a 3-phases mass extinction at the PTB in South China. The three delineations are, in ascending order:

1 Line of important biotic extinction occurring at a few decimeters to less than 4 meters below the boundary, where most Permian shallow water benthos became extinct. In Meishan this line is 0.32 m below the boundary, between Beds 24d and 24e.
2 Line between upper and lower Transitional Beds (note here that the line was shifted upward from the line in Tab. 1-1 of Yang et al., 1993, which was base of the lower Transitional Bed). This line symbolizes the appearance of Triassic newcomers and the extinction of Permian conodonts. This is approximately the line we now use as the PTB.
3 Line between *H. parvus* zone and *I. isarcica-Claraia-Ophiceras* zone, which symbolizes the extinction of most Permian relicts including brachiopods and *Otoceras* as well as the flourishing of Triassic biota. In Meishan it is between Beds 28 and 29. The relationship with the transgressive events has been discussed above.

Possible impact event

Whether there was an impact event at the PTB in Meishan as well as in South China is controversial. The evidence is concentrated in Beds 25 and 26, both being latest Permian. The possibility of an impact event in these two beds can be summarized as follows:

1 Enrichment of siderophile elements, including a moderate but inconsistent Ir anomaly, at the boundary.
2 Occurrence of a small amount of metamorphosed upper-crust debris and quartz; and microspherules consisting of diopside and chrome-bearing spinel, all likely related to impact.
3 The REE pattern suggests a result from a mixture of acidic-intermediate volcanic ash and upper crust matter spattered by an impact event.

As stated above item 1 can be interpreted as due to absorption of organic matter, and item 2 partly by volcanic explosion, thus the situation at PTB is different from that at Cretaceous-Tertiary boundary. An impact event near PTB is possible but not finally confirmed.

Conclusions

1 Recommendation of the Meishan section D, Changxing County, Zhejiang Province and its base of Bed 27c as GSSP of PTB.
2 This section provides easy accessibility, good exposure and continuity of marine sedimentation through Changxingian and Griesbachian.
3 Marker of the boundary stratotype point is the appearance of *Hindeodus parvus*; Auxiliary markers are $\delta^{13}C$ excursion, Ir spike and occurrence of *Otoceras*? and *Hypophiceras* stratigraphically close by.
4 Combined semi-contemporaneous events include volcanism, rapid transgression, anoxia and mass extinction. The suggested PTB thus is a good example of very close position and relation between chronostratigraphic and eventostratigraphic or natural boundaries.

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AGE AND CORRELATION OF THE *OTOCERAS* BEDS AT THE PERMIAN-TRIASSIC BOUNDARY

E.T. Tozer

Introduction

Most of the biochronology for the Permian-Triassic (P-T) boundary beds depends on data from ammonoid, bivalve, brachiopod and conodont faunas. This paper reviews the data provided by the otoceratacean ammonoids (Araxoceratidae and Otoceratidae) and the conodonts. The main focus is on the *Otoceras* beds, which characterize the Lower Griesbachian (Gangetian) Substage

(Tozer, 1988a, p. 295). There are two questions. First: should the base of the Lower Griesbachian be taken to define the base of the Triassic, and thus the Permian-Triassic boundary? Second, and more important, what beds are correlative with the *Otoceras* beds.

The first question has been discussed previously (Tozer, 1979, 1988a, 1988b) and will not be discussed in detail here. I continue to support the traditional view, advocated by Diener (1912), that *Otoceras* characterizes the earliest Triassic fauna. According to this view the *Otoceras woodwardi* Zone and its correlatives define the base of the Triassic System. Type locality for the Woodwardi Zone is Shalshal Cliff, in the Himalayas. Some authors advocate treating the *Otoceras* beds as Permian on the grounds that the fauna is intrinsically Paleozoic. This view has been discussed previously (Tozer, 1988a, p. 298). It is not really relevant to the main issue being considered, namely the search for correlatives of the *Otoceras* beds, not an assessment of their intrinsic characters. For the present it will not be considered further.

The second question - identification of correlatives of the *Otoceras* beds, is the main subject of current controversy. *Otoceras,* first found in the Himalayas, is now also known throughout the Arctic, (Alaska, the Canadian Arctic Islands, Spitzbergen and Siberia) and possibly in China. In both the Himalayas and the Arctic *Otoceras* is not always confined to one bed. In the Arctic two or three zones have been locally discriminated within the *Otoceras* beds. The exact correlation between these zones and the Woodwardi Zone is uncertain but there is general agreement that the *Otoceras* beds at all these localities form an entity correlatable at the level of a substage (Lower Griesbachian, Gangetian). The controversy arises when attempts are made to recognize correlatives of the *Otoceras* zones in China and Transcaucasia. Transcaucasia is used here in a broad sense, including sections in Russia (Dorasham etc.) and Iran (Dzhulfa, Shahriza, Abadeh). In both places there are concordant sections of marine Permian and Triassic strata. Some believe that the sections record continuous sedimentation but I consider that this cannot be proved. In Transcaucasia there are no occurrences of *Otoceras*. In China, poorly preserved specimens have been identified as *Otoceras* sp. (Sheng et al. 1984, p. 166) but more conservatively as "? *Otoceras*" (Wang, 1984). In China the youngest Permian rocks are called Changxingian; in Transcaucasia, Dorashamian. The Changxingian underlies the bed with "? *Otoceras*". What is the explanation for the absence of *Otoceras* in the Dorashamian and Changxingian? The writer's interpretation is that the Dorashamian and Changxingian beds are older than those with *Otoceras*. In this interpretation the *Otoceras* beds should follow the Dorashamian and Changxingian. Possibly there are breaks in the sedimentary record with Lower Griesbachian absent in Transcaucasia and possibly also China. Teichert (1990, p. 203) is of the same opinion. Nakazawa (1992, p. 25) also considers that the Griesbachian is younger than Changxingian and Dorashamian. These correlations have been contested, particularly by H. Kozur (1989) and W.C. Sweet (1992) who consider that the *Otoceras* beds are partly or wholly correlative with the Dorashamian and Changxingian. Sweet continues to maintain this position (Sweet, 1993). Erwin (1993, p. 79) considers that this correlation "seems to be correct". It is therefore necessary to review the evidence again.

Evidence that the *Otoceras* beds are younger than Dorashamian and Changxingian

Dorashamian and Changxingian have distinctive ammonoid faunas. *Paratirolites* is the most diagnostic Dorashamian form. Although the faunas do not have much in common, Changxingian and Dorashamian are generally regarded as more or less correlative. The most recent study of the Changxingian brachiopod fauna draws a similar conclusion (Xu and Grant, 1994).

The *Otoceras* fauna is not particularly varied but it is certain that the genus is not present in the

Changxingian and Dorashamian. *Otoceras* is placed in the family Otoceratidae. A closely related family - Araxoceratidae - has representatives in the Dorashamian (Bando, 1973, 1979, 1980, 1981). Preservation of Griesbachian *Otoceras* is commonly excellent, much better than that of Dorashamian Araxoceratidae. Nevertheless it is clear that Dorashamian Araxoceratidae have simpler suture lines, with fewer elements, compared with Griesbachian *Otoceras.* In spite of the differences, on morphological grounds Araxoceratidae appear to include good candidates for the ancestors of *Otoceras.* I can find no evidence to support the alternative possibility suggested by Glenister (1993) ".... that *Otoceras* is congeneric with advanced Upper Permian araxoceratins ...". In contrast I interpret the morphological differences between *Otoceras* and Araxoceratidae to suggest that *Otoceras* is younger than Dorashamian.

As already mentioned, the poorly preserved ammonoids from China identified as "? *Otoceras*" by Wang (1984) occur above the Changxing Formation (Yin, 1993, p. 22). Erwin's (1993, p. 54) record of *Otoceras woodwardi* from China seems to be based on this occurrence. I prefer the judgement of Wang, that the specimens from China cannot be positively identified as *Otoceras.* Nevertheless, if they are *Otoceras,* they support the interpretation, advocated here, that the *Otoceras* beds are younger than Changxingian.

Contributory data are provided by *Claraia.* Species of *Claraia* which indicate a Griesbachian age occur in beds which overlie both Dorashamian and Changxingian formations (Rostovstev and Azaryan, 1974, p. 92; Sheng et al., 1984, p. 143). These occurrences indicate that at least part of the Griesbachian is younger than Dorashamian and Changxingian. Recent records from Spitsbergen indicate that *Claraia stachei* Bittner, may occur both in association with and below *Otoceras boreale* (Korchinskaya and Vavilov, 1987, p. 65; Nakazawa et al., 1987; Nakazawa et al., 1990).

During the last 25 years important data bearing on the correlation of P/T boundary beds has been provided by the discovery of conodont faunas in Changxingian, Dorashamian and Griesbachian strata. Some workers, notably Kozur (1989, p. 1247) assert that "according to the conodont faunas the *Otoceras* beds were time-equivalents of the late Changxingian". Kozur's interpretation clearly influenced Erwin (1994, p. 232) who wrote that "correlations based on conodonts have resolved these problems .. [and] dramatically altered the relationships among boundary sections ..". This whole problem has now been reviewed in detail by Orchard et al. (1994). This study, based on conodonts associated with *Otoceras* in Tibet, and on comparison with specimens from the Changxingian and Dorashamian, reach conclusions different from those of Kozur. Orchard et al. find that the Griesbachian conodonts from Tibet constitute a fauna unlike that of the Changxingian and Dorashamian. Orchard (1994, p. 10) also concludes, from study of typical Dorashamian and Changxingian material, and from reviewing all the literature, that "reports of uppermost Permian conodonts in the Griesbachian, and of Griesbachian conodonts in the uppermost Permian, are refuted or remain unverified". The biochronological message provided by the conodonts appears to be wholly compatible with that of the ammonoids, namely that Griesbachian faunas are distinctively different from those of the Dorashamian and Changxingian.

Alternative interpretations

Kozur (1989) and Sweet (1992) accept correlation of the *Otoceras* beds between the Himalayas, Kashmir and the Arctic, but they go further, by proposing correlation with Dorashamian beds in Trancaucasia and Changxingian beds in China that do not contain *Otoceras.* These correlations are questioned.

Kozur (1989, p. 1252) correlates the Griesbachian (Gangetian) *Otoceras* beds with the Changxingian, despite the absence of *Otoceras,* or indeed any certain otocerataceans, in the Changxingian. For this he has a zoogeographic explanation. Kozur believes that the *Otoceras* faunas, which are found only in the boreal realm and on the Gondwana side of the Tethys, characterize deposits formed in cool waters. Restriction of *Otoceras* to cool water deposits is taken to account for its absence from the Changxingian, interpreted as having formed in the relatively warm waters of the Tethyan realm. In Kozur's interpretation the cool water Griesbachian *Otoceras* fauna is absent in contemporary Changxingian faunas of relatively warm waters. In making this interpretation of the palaeoclimatic significance of otocerataceans Kozur seems to overlook the fact that otocerataceans occur in the Dorashamian, i.e. in the Tethyan Province. As already mentioned, there are also possible occurrences of *Otoceras* in China, above the Changxingian. Thus otocerataceans cannot be regarded as an exclusively cool water group. Erwin (1994, p. 232) adopts Kozur's interpretation for *Otoceras* suggesting that "*O. woodwardi* first appeared during the latest Permian boreal, cold water faunas.."

In Kozur's scheme (1989, p. 1252) Changxingian is the terminal Permian Stage. Dorashamian (op. cit. p. 1251) is treated as the lower substage of the Changxingian. Five zones recognized in the Dorashamian (*Phisonites triangulus, Iranites transcaucasicus, Dzhulfites spinosus, Shevyrevites shevyrevi, Paratirolites waageni)* are placed below four zones (*Tapashanites chaotianensis, Pleuronodoceras mapingense, Rotodiscoceras asiaticum, Hypophiceras changxingense)* which he places in the Upper Changxingian. The *Otoceras concavum* and *O. woodwardi* zones (Lower Griesbachian) are correlated with the four zones classed as Upper Changxingian. The sequence adopted by Kozur for the Dorashamian is essentially derived from that of Ruzhencev et al. (1965). Kozur's Table (op. cit. p. 1252) does not accommodate the *Pleuronodoceras occidentale* zone, placed at the top of the Dorashamian by Zacharov and Rybalka (1987, p. 26). Kozur evidently considers that this zone should not be included in the Dorashamian. Kozur (op. cit. p. 1249) introduced his four Upper Changxingian zones, which are based on data in Zhao et al. (1978) and Sheng et al. (1984).

Kozur's youngest Permian zone (*Hypophiceras changxingense)* is based on a species, dated as Triassic by Wang (1984), from the "Lower Transitional bed", also known as "Mixed bed 1". This bed, 6-7 cm thick, overlies the 4 cm "Boundary clayrock", which in turn overlies the Changxing Formation proper (Sheng et al., 1984, p. 176; Yin, 1993, p. 22). Mixed bed 1 is also the source of the specimens identified as ? *Otoceras* sp. by Wang (1984, pl. II, figs. 15, 17-19) already mentioned. Yin (1993, p. 16) also seems to doubt the value of *H. changxingense* as an index fossil. The ammonoids from Mixed bed 1 are not adequately preserved to permit a certain age determination. *Hypophiceras changxingense* is based on specimens that are barely determinable (Wang, 1983, pl. 2, figs. 1-6, 10-12; Sheng et al. pl. I, fig. 7). They, and the associated ammonoids, do not form a firm foundation for a zone, as indicated by Kozur (1989). They may be of earliest Triassic age, as suggested by Wang (1984). The bed is dated as "Permian?" by Yin (1993, p. 2).

Kozur's scheme, with nine successive ammonoid zones in what he treats as Changxingian cannot be accepted as a standard for Upper Permian correlations for two reasons. First, the succession of upper Changxingian zones (*T.chaotianensis* through *H. changxingense)* above Dorashamian zones (*P. triangulus* through *P. waageni)* is nowhere demonstrable. Second, several of the ammonoids are based on poorly preserved specimens known only from one locality. Like *Hypophiceras changxingense,* they do not provide a good basis for a zonal scheme. *Pleuronodoceras occidentale* Zacharov (in Zacharov and Rybalka, p. 34, pl. I, fig. 11) is also based on a poorly preserved specimen, the generic affinity of which, in my opinion, is far

from certain. *Shevyrevites* is a xenodiscid ammonoid without distinctive features. *Iranites* is probably a synonym of *Shevyrevites; Dzhulfites* a synonym of *Paratirolites.* It is clear that any meaningful ammonoid zonation for the Upper Permian strata requires much more data on both the stratigraphy and morphology of the fossils. There are some distinctive ammonoids, notably the Dzhulfitidae (= Paratirolitidae) and the Pseudotirolitidae but at present most Xenodiscidae (e.g. *Shevyrevites, "Iranites", Hypophiceras)* contribute little or nothing to the chronology. Thus the ammonoids of the Dorashamian and Changxingian give absolutely no grounds for a correlation with the Lower Griesbachian.

Graphic Correlation applied to the *Otoceras* beds

Sweet's correlation of the *Otoceras* beds using graphic correlation will now be considered. He claims to have demonstrated "that the Dorasham Beds of Soviet Dzhulfa and the coeval Ali Bashi Formation of Northwest Iran represent the same interval of time as the *Otoceras woodwardi* Zone (Unit E2 of the Khunamuh Formation)..." (Sweet, 1992, p. 128). The Khunamuh section is at Guryul Ravine, Kashmir. The Dorasham and Ali Bashi formations are the source of *Paratirolites,* so this statement implies that *Paratirolites* and *Otoceras woodwardi* are essentially the same age. *Otoceras woodwardi* is not known in sections where *Paratirolites* is present and vice versa. On what grounds, then, does Sweet assert that the ranges of the two genera overlap?

Sweet's conclusion is not based on observed stratigraphy but on graphic correlation. Graphic correlation amalgamates sequential and range data for taxa from different sections. The technique results in the development of a composite standard (CS) (e.g. Sweet, 1992, Table 11.3, p. 125) which expresses the range and relative age of fossils that have not necessarily been found in sequence. Being composite, some ranges are divorced from the reality of sequences established in a stratigraphic section. The sections employed by Sweet to carry out this exercise for *Paratirolites* and *Otoceras* are Guryul Ravine (GRK), Kashmir (for *Otoceras),* and Kuh-e-Ali Bashi (KAB) and Kuh-e-Hambast (HAM), in Transcaucasia (for *Paratirolites).* In Sweet's Tables and graphs (op. cit, pp. 125, 128, 129) *Paratirolites* is not recorded but its position is evident from references to the Ali Bashi and Hambast formations. Referring to the KAB assessment it appears that the *Otoceras woodwardi* CS range does indeed indicate a correlation with the Ali Bashi Formation. However it should be noted that this correlation is in conflict with the direct evidence provided by the conodont *"Hindeodus" parvus* (Yin, 1993, p. 7). This conodont is in the *Otoceras woodwardi* Zone at GRK, and above *Paratirolites* at KAB. The correlation suggested by these occurrences thus conflicts with the graphic correlation.

The section at Kuh-e-Hambast (HAM), Abadeh, Iran, is also a locality for *Paratirolites,* in Unit 7 of the Hambast Formation (Bando, 1979, p. 134). Sweet (1992, fig. 11.3, p. 128) has given a graphic correlation of this section indicating the position of the Hambast. As at KAB *Paratirolites* is not plotted, but its position, being in the Hambast, is evident. A plot of the range of *Otoceras woodwardi* on this graph, using the data given by Sweet (op. cit, p. 125) leads to an interpretation with *O. woodwardi* appearing at the *Paratirolites* level (Dorashamian) and ranging up to overlying beds regarded as Lower Triassic.

An exercise in graphic correlation has been made by Yin et al. (1988) to show the age of *Rotodiscoceras* and *Pseudotirolites,* from the latest Permian (Changxingian) of China in relation to the *Otoceras* occurrences of Guryul Ravine (GRK). They interpret the data to show that there is a small time overlap between *Otoceras* and the Permian forms but that *Otoceras* ranges into appreciably younger beds than the Changxingian ammonoids. This interpretation is comparable

with that given above for the Kuh-e-Hambast (HAM) section.

My earlier assessment and rejection of Sweet's conclusions (Tozer, 1989) included a graphic demonstration of what would be expected if there was a paraconformity above the *Paratirolites* beds at KAB and another, below the *Otoceras* beds at GRK. The presence of these paraconformities was the interpretation of Teichert (1990, p. 203) and remains the interpretation of the writer (Tozer, 1988b).

Faunal sequences derived from graphic correlation are interpretations, not demonstrations. Even if the technique is appropriate, the data from GRK, KAB and HAM seem inadequate to confirm Sweet's correlation of the *Otoceras woodwardi* Zone with the Dorashamian *Paratirolites* beds (Sweet, 1992, p. 128).

None of the results from graphic correlation described above seem to justify a correlation of the Lower Griesbachian with the Changxingian and Dorashamian.

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CORRELATION OF THE LOWERMOST TRIASSIC

A. Dagys

Introduction

In several previous issues of *Albertiana* biostratigraphic problems concerning the Permian/Triassic boundary have been discussed. It is particularly clear that some basic problems concerning zonation and correlation of the oldest Triassic rocks still must be resolved before a global stratotype and a point (GSSP) representing the Permian/Triassic boundary in the stratotype section are selected. Accordingly, the purpose of this report is not to propose a global stratotype for the boundary, but to accent specific biostratigraphic problems concerning the Permian/Triassic boundary which have been either omitted from or incorrectly stated in previous publications.

Zonation of the lowermost Triassic based on ammonoid data

A majority of stratigraphers adhere to the view that all *Otoceras* beds from different parts of the world are more or less synchronous. Tozer (1975) was the first to demonstrate a two-fold division of *Otoceras* beds in Boreal regions (*Concavum* and *Boreale* zones) and the following extract from Tozer (1986, p. 293) is widely accepted: "The most suitable level for defining the base of the Triassic system is the base of the *Otoceras woodwardi* Zone of the Himalayas, with which the base of the *Otoceras concavum* Zone of Arctic Canada and Siberia is correlative".

Bando (1971, 1973) demonstrated that according to shell morphology during ontogeny *Otoceras concavum* is slightly less developed than *O. woodwardi* in the same phylogenetic lineage. *Otoceras concavum* retains some features inherited from the Araxoceratidae, including a flattened ventral side. During early ontogeny, shells of *O. woodwardi* from different regions of the peri-Gondwana Tethys display distinctly flattened ventral sides with three keels, but the venter of adult shells is sharp with only a single keel (Kummel, 1972, Pl. 2, figs. 5-10; Bando, 1981, Pl. 14, figs. 2, 3). *Otoceras boreale* also has a sharp venter at maturity and ontogenetic development of the venter is similar to *O. woodwardi* (Zakharov, 1971). In summary, both *Otoceras woodwardi* and *O. boreale* show an *O. concavum*-type of flattened venter during early ontogeny but both have acute (sharp) venters as adults. *Otoceras concavum* is considered to be the ancestor of the more or less synchronous *O. woodwardi* and *O. boreale*.

Only the index-species has been recorded from the *Concavum* Zone but several other ammonoid genera occur in the *Woodwardi* (*Boreale*) Zone. On this basis, the *Woodwardi* (*Boreale*) Zone can be divided into two parts (or subzones): the lower with survivors from the Permian Xenodiscidae and Episageceratidae and the upper, in which the first appearance of typical Triassic ammonoids with hexalobate sutures occur; that is, Ophiceratidae (*Ophiceras*, *Vishnuites*).

In boreal regions a two-fold division of the *Boreale* Zone can be distinguished in Greenland where *Otoceras* ex gr. *boreale* is known from the *Triviale*, *Martini* and *Subdemissum* zones

(Spath, 1930, 1935; Trumpy, 1961), the first true Ophiceratidae have been recorded only from the uppermost of these zones. Accordingly, the local *Triviale* and *Martini* zones are correlative with the lower *Boreale* Subzone and the *Subdemissum* Zone - with the upper *Boreale* Subzone. Subdivision of the *Boreale* Zone is also possible in Svalbard. According to Korchinskaya and Vavilov (1987) the lower part of the *Boreale* Zone in Svalbard contains only rare *Otoceras boreale* and *Otoceras* sp., but in the upper part of the zone (6 m above the Permian/Triassic boundary) *Otoceras boreale* is associated with numerous ophiceratids (*Ophiceras spathi, O. kochi, Vishnuites oxynotus*, etc.). According to Tozer (1967) *Ophiceras* species have been recorded from loose blocks within the *Boreale* Zone, but their exact position in the zone is unknown. According to Dagys and Ermakova (1993) the first hexalobate ammonoids appeared in the supraotoceras beds (*Morpheos* Zone) in Siberia.

In the peri-Gondwanan Tethys region the two-fold division of the *Woodwardi* Zone is less distinctive than the two-fold subdivision of the *Boreale* Zone in the Arctic. In classic sections of the Himalayas (Diener, 1912; Kummel, 1972) true ophiceratids are known from the basal *Otoceras* beds, which most probably are correlatives of the upper Subzone in the Arctic. The possibility of a two-fold division of the *Otoceras* beds in the Himalayas exists in the Selong region of southern Tibet (Wang et al., 1989). There, diverse species of *Ophiceras* occur in the upper part of the *Otoceras* beds with *O. woodwardi* (Rao and Zhang, 1985) but *Ophiceras* is absent from the lower *Otoceras latilobatum* bed. According to Nakazawa et al. (1980), and Matsuda (1981) the first true ophiceratids (*Ophiceras sakuntala*) are known only from the top of bed 52 in unit E_2 in Kashmir and this bed, which contains *Otoceras woodwardi* and xenodiscids which may be correlated with the lower *Woodwardi* Zone.

Correlation of the lowermost Triassic ammonoid zones

The *Concavum* Zone has been recognized for certain only in Arctic Canada and Siberia. Tozer (1967) assumed, on the basis of stratigraphic position that the *Concavum* Zone of Canada correlates with the "*Glyptophiceras* beds" (*Triviale* and *Martini* zones) of Greenland. This interpretation was accepted in correlation schemes presented by Yan (1988), Nakazawa (1992), Yin (1993) and others. Spath (1935) figured a whorl section of one large specimen of *Otoceras* from the "*Glyptophiceras* beds" showing a distinctly acute venter. This feature is enough to identify the specimen as *Otoceras* ex gr. *woodwardi; Otoceras concavum* retains a distinctly flattened ventral side during all stages of ontogeny.

In peri-Gondwana Tethys *O. concavum* was recorded from the Panjang Formation in Nepal in association with numerous Permian productids (Waterhouse, 1987). This fauna has not been published but identification of *O. concavum* is probably incorrect.

Nakazawa (1992) and Yin (1993) correlated the *Concavum* Zone in boreal regions with the *Latilobatum* Zone in Selong. *Otoceras latilobatum* is based on a poorly preserved specimen but it is clear that the species does not belong to the *O. concavum* group because it lacks flattened ventral flanks. The holotype of *O. latilobatum* is laterally compressed without a raised umbilical rim (*Metotoceras* of Spath) and must really be identified as *Otoceras* ex gr. *woodwardi*. The same authors suggested that the *Concavum* Zone can be correlated with Mixed Bed 1 of Meishan (Changxing). From this bed Permian brachiopods and very poorly preserved ammonoids have been collected. Wang (1984) described the ammonoids *Pseudogastrioceras, Pseudosageceras, Otoceras, Hypophiceras, Metophiceras, Tompophiceras, Ophiceras* and the nautiloid *Grypoceras* (previously identified by Zhao et al., 1981 as belonging to Otoceratidae). This assemblage, including Permian, Griesbachian and possibly even Dienerian (*Pseudosageceras*)

genera is obviously unnatural. It is most likely that such identifications are the result of poor preservation of the ammonoid fauna and a number of forms in the fauna that are identified as Triassic may equally be Permian. Specimens described by Wang (1984) as *Tompophiceras* (p. 261, Pl. II, figs. 21, 22) may in fact be *Paratirolites*, but final resolution of the problem requires that the suture line be studied. *Metophiceras* sp. (p. 261, Pl. II, figs. 23-25) is similar to the Dorashamian *Shevyrevites* and species of *Hypophiceras* (cf. *martini* and *changxingense*) to the Permian *Xenaspis*. *Hypophiceras* of Wang (1984) is a xenodiscid devoid of distinctive morphological features, and the form is absent from all recent reviews of Triassic ammonoids (Zakharov, 1978; Tozer, 1980; Shevyrev, 1986). Introduction of the *Hypophiceras* Zone as an alternative of the *Concavum* Zone (Nakazawa, 1992) appears to be most inappropriate.

<table>
<tr><th colspan="4">Boreal</th><th colspan="3">Peri-Gondwana Tethys</th><th colspan="2">Northern Tethys</th></tr>
<tr><td colspan="2">Greenland</td><td>Arctic Canada</td><td>Svalbard</td><td>Siberia</td><td>Kashmir</td><td>Central Himalayas</td><td>Tibet</td><td>Trans-caucasus</td><td>S. China</td></tr>
<tr><td colspan="2">Commune</td><td>Commune</td><td>Cl. stachei</td><td>Morpheos</td><td>Ophiceras spp.</td><td>Sakuntala</td><td>Sakuntala</td><td rowspan="4">Ophiceras spp.</td><td rowspan="4">Ophiceras spp.</td></tr>
<tr><td>U. Boreale</td><td>Subdo-missum</td><td rowspan="2">Boreale</td><td>U. Boreale</td><td>Pascoi</td><td>U. Woodwardi</td><td>Woodwardi</td><td>Woodwardi</td></tr>
<tr><td>L. Boreale</td><td>Martini Triviale</td><td>L. Boreale</td><td>Boreale</td><td>L. Woodwardi</td><td></td><td>Latilobatum</td></tr>
<tr><td colspan="2"></td><td>Concavum</td><td></td><td>Concavum</td><td colspan="3"></td></tr>
<tr><td colspan="4"></td><td colspan="3"></td><td>Pleuronodo-ceras occidentale</td><td>Pleuronodo-ceras/Roto-discoceras</td></tr>
</table>

Table 1 Correlation of the lowermost Triassic ammonoid zoal scheme

Also doubtful is the correlation of the *Woodwardi* Zone in the Himalayas (Spiti, Shalshal) with the *Concavum* Zone as suggested by Yin (1993). The oldest Triassic beds in this region, containing *Otoceras* and *Ophiceras* clearly belong to the Upper *Woodwardi* Subzone. The *Woodwardi* and *Boreale* zones are synchronous as indicated in the earlier discussion.

Correlation of lowermost Triassic ammonoid and conodont zones

In recent years conodonts that are characteristic of late Changxingian strata have been reported from *Otoceras* beds in different parts of the world. In peri-Gondwana Tethys the *Gondolella changxingensis-G. deflecta* assemblage may occur in the *Woodwardi* Zone in Kashmir and the Central Himalayas; that is, Kumuan, Spiti and Zanskar (Bhatt et al., 1981; Bhatt and Arora, 1984). Matsuda (1984) however, was unable to confirm the presence of Changxingian conodonts in the *Otoceras* beds of Kashmir and Spiti and recently Orchard (1994) expressed doubts about the presence of Changxingian conodonts in the *Otoceras* beds.

Data on conodont assemblages from the *Otoceras* beds of Tibet (Selong) are not clearly understood but have recently been reviewed by Orchard, Nassichuk and Rui (in press). In previous publications (Rao and Zhang, 1985; Yao Li, 1987; Wang et al., 1989) the *Gondolella*

changxingensis-G. deflecta assemblage was recognized in the lower part of the *Otoceras* beds (*Latilobatum* Zone). Orchard (in *Albertiana* 12, 1994) rejected the presence of typical Changxingian assemblages in the *Latilobatum* Zone.

In Boreal regions of the world information about conodonts from the *Boreale* and *Concavum* zones is very limited, Dagys and Korchinskaya (1987) described only *Gondolella carinata* from the upper *Boreale* Subzone of Svalbard. Henderson (1993) tentatively identified *Gondolella subcarinda* and *G. deflecta* from basal shales in the Blind Fiord Formation (beneath *Otoceras* beds) in Ellesmere Island, Arctic Canada. Hopefully these species from Ellesmere Island will be described and their relationships to ammonoid zones (*Concavum* and *Boreale*) explained.

Kozur (1993) revised conodonts from the oldest Triassic beds in the Kap Stosch area of Greenland, that were previously described by Sweet (*in* Teichert and Kummel, 1976). He reported *Gondolella subcarinata* and *G. orientalis* from the lower *Hypophiceras* beds (=?*Triviale* and *Martini* zones), *Hindeodus latidentatus* from the *Otoceras boreale* beds (=?*Subdemissum* Zone) and *Hindeodus parvus* from the *Ophiceras* beds (=*Commune* Zone). Conodont faunas from the lowermost Triassic of Arctic Canada and Greenland have not been described in the literature.

There is no generally accepted conodont zonation for the lower Griesbachian, but various authors have reported the presence of Changxingian conodonts in oldest Triassic strata. Assuming proper identification of Changxingian conodonts this can be interpreted in two different ways:

1. Changxingian conodonts are Permian relicts within Lower Triassic *Otoceras* faunas (Budurov et al., 1988; Nakazawa, 1992; Yin, 1993, etc.).
2. Changxingian conodonts imply at least partial synchroneity between the terminal Permian and earliest Triassic (Kozur, 1977, 1989, etc.).

Orchard (1994) suggested that identifications of Changxingian species of conodonts in *Otoceras* beds in the peri-Gondwanan Tethys region are suspect. Moreover, he indicated that *Hindeodus parvus* occurs in the *Latilobatum* Zone and that *Isarcicella isarcica* occurs in the upper part of this zone. This means that the conodont *Parvus* Zone can be correlated with the lower *Woodwardi* Zone (sensu Yin, 1993) and the *Isarcica* Zone is also partly synchronous with the *Otoceras* beds (upper *Woodwardi* Zone).

Kozur (1993) on the other hand, reported Changxingian conodonts from all *Otoceras* beds in Greenland and the lowest occurrence of *Hindeodus parvus* in upper Griesbachian strata. Accordingly, conodont information from Orchard (1994) and Kozur (1993) are incompatible with each other.

Conclusions

The main biostratigraphic problems requiring attention in lowermost Triassic strata include: 1) ammonoid zonation of the *Otoceras* beds, 2) relationships between *Otoceras* and *Pleuronodoceras-Rotodiscoceras* ammonoid faunas, 3) conodont zonation, 4) correlation of ammonoid and conodont zones. These problems have controversial, sometimes mutually exclusive interpretations and proposing a working model for the Permian/Triassic boundary on the basis of conodont and ammonoid data without resolution of those problems will be difficult.

Taking into account that conodonts have a global distribution and, contrary to ammonoids, do not show significant provincialism, this group has considerable potential to assist in defining the Permian/Triassic boundary. However, before proposing recommendations for the global stratotype section and point of the Permian/Triassic boundary within that section some problems concerning conodont taxonomy and stratigraphy must be resolved. Priority should be given to revision of the platform-type conodonts from the lowermost Triassic as initiated by Orchard (1994) and correlation of conodont and ammonoid successions in peri-Gondwana Tethys and the Arctic.

As a basis for further progress in this field the correlation scheme involving 6 biostratigraphic subdivisions in the Permian/Triassic boundary interval that was proposed by the Chinese working group (Yin, 1993) can be employed given the following provisions:

1. Subdivision 3 in the Yin (1993) scheme is unacceptable because it is based on lithologic and not paleontological data.

2. Subdivision 4 in the Yin (1993) scheme is based mainly on the so-called mixed faunas and is disputable. This unit (Subdivision 4) includes strata with typical Permian faunas (excluding suspect identifications of poorly preserved ammonoids) from China (Meishan, Shangsi) and Italy (Tesero) from Tibet and Kashmir. Subdivision 4 then is a kind of biostratigraphic conglomerate that could obscure rather than clarify correlation.

Addendum

As indicated in the introduction, the purpose of this report is to present data on ammonoids and conodonts from lowermost Triassic strata in Boreal and Tethyan regions of the world that are particularly relevant to definition of the Permian/Triassic Boundary. It should be borne in mind that a fundamental objective for Subcommissions within the IUGS Commission on Stratigraphy is to promote scientific discussion on a global scale. Accordingly, recommendations for definition of systemic boundaries that are presented to the Commission and ultimately to the IUGS Council for ratification should be based on data that has been thoroughly scrutinized and discussed. In the case of the Permian/Triassic boundary more hard data is required on faunal, particularly ammonoid and conodont biostratigraphic relationships before a final global stratotype section and point (GSSP) is selected. Final selection of such an important standard must be done with care and the process should never by accelerated simply to meet political or bureaucratic objectives.

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PROPOSALS ON REVISION OF THE SIBERIAN STANDARD FOR THE LOWER TRIASSIC AND CANDIDATE STRATOTYPE SECTION AND POINT FOR THE INDUAN-OLENEKIAN BOUNDARY

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The scheme of the substage and zonal division of the Lower Triassic recently proposed by A.S. Dagys and S.P. Ermakova (1993; Dagys, 1994) for Siberia and adjacent territory, needs in my opinion some correction (Zakharov, 1994). First of all it concerns some Induan zones and the Lower Olenekian - Upper Olenekian boundary.

1. ***Otoceras concavum*** Zone. The analysis of the data that I have on the stratotype section (Setorym River) in Siberia (Zakharov, 1978) permits to conclude that the typical representatives of the *Otoceras boreale* Spath are restricted here to the interval from 0.7 to 18-20 m above the base of the Nekuchan Suite, the lower part of which (Lower Mudstone Member) is now considered to be lowermost Triassic. The latter overlies the Upper Sandstone Member of the Permian Imtachan Suite. The stratigraphical interval for the ammonoids identified by Y.V. Arkhipov as *Otoceras concavum* Tozer seems to be significantly more limited (0.7-7.0 m) in this section, but coincides with the lower part of the interval mentioned above. The abundance of both forms falls on the same level - 5 m above the base of the Nekuchan Suite. Therefore the Zone of *Otoceras concavum* proposed for the lowermost part of the Nekuchan Suite seems to be invalid for the Siberian section.

2. ***Tompophiceras morpheous*** and ***Wordioceras decipiens*** Zones. The representatives of *Wordioceras* associate with *Tompophiceras* (*T. morpheous* Popov and *T. pascoei* Spath group) in the Setorym section. Only a single division *(Tompophiceras pascoei* Zone) seems to be proposed now for the interval between the *Otoceras boreale* and *Vavilovites sverdrupi* zones in the Verkhoyansk region.

3. ***Kingites? korostelevi*** Zone. In the Burgagandzha section, the *Kingites korostelevi* Zakharov type locality, the index species is distributed in sequences more than 100 m thick (Zakharov, 1978) which correspond at least to the three zones: *Tompophiceras pascoei, Vavilovites sverdrupi* and *Tompoproptychites turgidus*. The *Kingites korostelevi* Zone proposed for the uppermost Induan seems to be invalid.

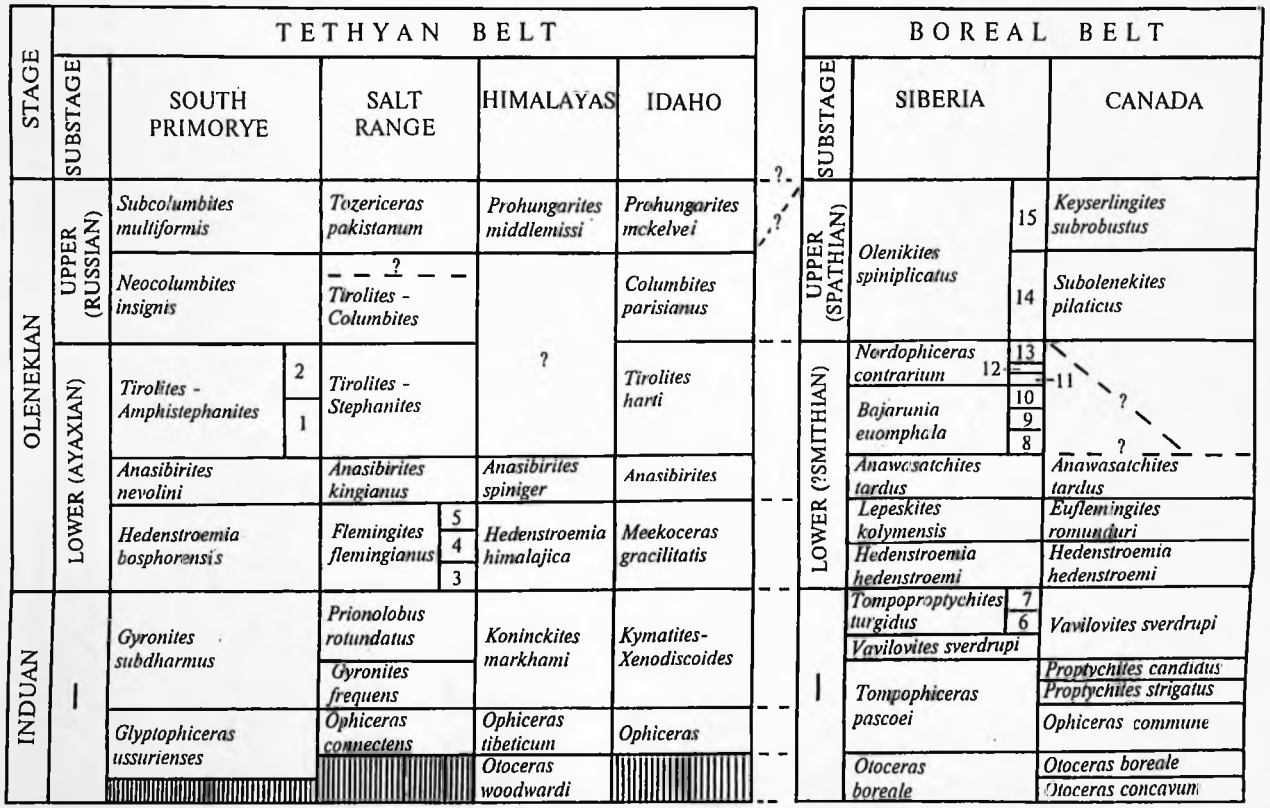
4. ***Boreoceras apostolicum*** Subzone. In my opinion, the Siberian ammonoid form described by Y.N. Popov (1961) and some other authors (Dagys and Ermakova, 1988; Ermakova, 1981) as *Dieneroceras apostolicum* (Smith) (= *Boreoceras*) is clearly distinct from American specimens (Smith, 1932): in contradistinction to typical *"Dieneroceras" apostolicum,* it is characterized by the higher external whorls of the shell, the somewhat different form of the cross-section of the whorls and the practically smooth surface of the shell. American and Siberian forms seem to be different species. The latter was recognized by me as a younger synonym of another Siberian species - *"Dieneroceras" ogonerense* Ermakova (1974) (= *Boreoceras*). Therefore, the upper subdivision of the *Bajarunia euomphala* Zone must be named the Subzone of *Boreoceras ogonerense.*

5. ***Parasibirites grambergi*** Zone. There is evidence for the *Parasibirites grambergi* unit to be in rank of the ammonoid beds within the *Olenikites spiniplicatus* Zone. In the Mengilyakh (Zakharov, 1978) and Taimir (Egorov and Kulikova, 1989) sections in Arctic Siberia *Parasibirites grambergi* Popov was met together with *Sibirites pretiosus* Mojsisovics. In the Burgagandzha sequence in the Verkhoyansk region (Zakharov, 1978), it associates with both *Sibirites pretiosus* Mojsisovics and a typical representative of the *Olenikites spiniplicatus* Zone like *Olenekoceras middendorffi* (Keyserling).

According to L.D. Kiparisova and Y.N. Popov (Kiparisova and Popov, 1956, 1964), the body stratotype for the Olenekian is situated at the lower reaches of the Olenek River in Arctic Siberia (a more exact survey is not available), but new data show that it is impossible to chose the type of the Olenekian as a single section within the stratotype region. At the same time we have some possibilities to establish the Lower and Upper Olenekian stratotypes which can together be a composite lectostratotype of the Olenekian stage (Zakharov, 1994).

First, the substages of the Olenekian were introduced by M.N. Vavilov (1967) on the basis of the ammonoid complexes of both the Verkhoyansk and Lower Olenek regions. In ammonoid terms, the base of the Upper Olenekian was drawn at the base of the *Olenikites spiniplicatus* Zone. A.S. Dagys and A.M. Kazakov (1984) later moved the *Dieneroceras* and *Nordophiceras* zones (= *Bajarunia euomphala* and *Nordophiceras contrarium* zones) from the Lower Olenekian to the Upper Olenekian. I agree with M.N. Vavilov's original proposal, taking the greatest

Fig. 1. Correlation of the ammonoid zones at the Tethys and Boreal realm. Designation of the beds (Subzones): 1 - Bajarunia dagysi *beds, 2* - Tirolites ussuriensis *beds, 3* - Pseudoceltites normalis *beds (Lower Sandstone member), 4* - Flemingites glaber *beds (=* Stachella *beds), 5* - Flemingites flemingianus *beds, 6* - Vavilovites subtriangularis *beds, 7* - Tompoproptychites umbonatus *beds, 8* - Bajarunia eikitensis *beds, 9* - Boreoceras planorbis *beds, 10* - Boreoceras ogonerense *beds, 12* - Praesibirites tuberculatus *beds, 13* - Praesibirites egorovi *beds, 14* - Parasibirites grambergi *beds, 15* - Keyserlingites subrobustus beds (Dagys and Ermakova, 1993; Dagys and Tozer, 1989; Diener, 1897; Guex, 1979; Schindewolf, 1954; Shevyrev, 1990; Waagen, 1895; Zakharov, 1978; Zakharov and Rybalka, 1987).


TETHYAN BELT
BOREAL BELT
STAGE
SUBSTAGE
SOUTH PRIMORYE
SALT RANGE
HIMALAYAS
IDAHO
SIBERIA
CANADA
OLENEKIAN
INDUAN
UPPER (RUSSIAN)
LOWER (AYAXIAN)
UPPER (SPATHIAN)
LOWER (?SMITHIAN)
Subcolumbites multiformis
Neocolumbites insignis
Tirolites - Amphistephanites
Anasibirites nevolini
Hedenstroemia bosphorensis
Gyronites subdharmus
Glyptophiceras ussurienses
Tozericeras pakistanum
Tirolites - Columbites
Tirolites - Stephanites
Anasibirites kingianus
Flemingites flemingianus
Prionolobus rotundatus
Gyronites frequens
Ophiceras connectens
Prohungarites middlemissi
Anasibirites spiniger
Hedenstroemia himalajica
Koninckites markhami
Ophiceras tibeticum
Otoceras woodwardi
Prohungarites mckelvei
Columbites parisianus
Tirolites harti
Anasibirites
Meekoceras gracilitatis
Kymatites-Xenodiscoides
Ophiceras
Olenikites spiniplicatus
Nordophiceras contrarium
Bajarunia euomphala
Anawasatchites tardus
Lepeskites kolymensis
Hedenstroemia hedenstroemi
Tompoproptychites turgidus
Vavilovites sverdrupi
Tompophiceras pascoei
Otoceras boreale
Keyserlingites subrobustus
Subolenekites pilaticus
Anawasatchites tardus
Euflemingites romunduri
Hedenstroemia hedenstroemi
Vavilovites sverdrupi
Proptychites candidus
Proptychites strigatus
Ophiceras commune
Otoceras boreale
Otoceras concavum

change in ammonoid succession at the base of the *Olenikites spiniplicatus* Zone into account (Keyserling, 1845; Mojsisovics, 1886; Lazurkin and Korchinskaya, 1963; Zakharov, 1978).

The analysis of data of the Lower Triassic sections of the stratotype regions for the Induan (Hindustan) (Waagen, 1895; Schindewolf, 1954; Kummel, 1966; Pakistani-Japanese Research Group, 1985; Kapoor, 1992) and Olenekian (Olenek River basin) (Kiparisova and Popov, 1956, 1964; Popov, 1958; Dagys, 1984; Dagys and Ermakova, 1988, 1993; Dagys and Kazakov, 1984; Dagys and Kurushin, 1985) shows that they cannot be used as boundary stratotypes for the base of the Olenekian for the following reasons:

(1) In the Olenek River basin, the Induan Stage consists of lagoonal and littoral, tuffaceous, poorly fossiliferous strata that are difficult to date.

(2) In most of the Salt Range (including Chhidru) and Central Himalayan sections, ammonoids are rare or absent in the Ceratite marls - Ceratite sandstone boundary beds (Waagen, 1895; Kummel and Teichert, 1966; Kummel, 1972). There thus is a major problem of international correlation, centered on the Induan-Olenekian boundary sequence.

At the same time we have a representative Induan-Olenekian section in the Ussuri province, which is presumed to be characterized by its intermediate position between the Boreal realm and the Himalayan province, having some common characters with both of them, and which was often mentioned in the discussion on the problem of the Induan-Olenekian boundary by L.D. Kiparisova and Y.N. Popov, the authors of the Induan and Olenekian.

A most representative section for the Induan in Far East, which yields abundant ammonoid and bivalve specimens, is the sequence located on the western coast of the Ussuri Gulf between the Seryi and Tree Kamnya Capes in the Muravev-Amursky Peninsula. It is a type for the Lazurnaya Bay Suite (Induan) in the Primorye region. Some fossils of the Ussuri Gulf were first identified by K. Diener (1895). Age determination based on a more representative ammonoid succession was reported later by L.D. Kiparisova (1938, 1954) and some other workers (Burij, 1959; Zakharov, 1968, 1978, 1992, Zakharov and Rybalka, 1987; Buryi, 1979). According to the ammonoids the Induan of South Primorye is divided into two units: *(1) the Glyptophiceras ussuriense* beds and *(2) the Gyronites subdharmus* Zone, which together correspond to the Himalayan Induan, maybe with the exception of the *Otoceras woodwardi* Zone or its lower part.

Olenekian sediments of the west coast of the Ussuri Gulf (formerly known as *Flemingites* beds) (Kiparisova, 1954, 1961) outcrop near the Tree Kamnya Cape. These beds have been a part of classic ammonoid and bivalvian studies by L.D. Kiparisova (1938, 1961) and A. Bittner (1899).

As candidate stratotype section and point for the Induan-Olenekian boundary I propose the section which lies in the Tree Kamnya Cape Ravine, about 1.6 km NE of the Tree Kamnya Cape in South Primorye (Zakharov, 1968, Zakharov et al., 1992). In this section, the base of the Olenekian Stage is marked by the first appearance of *Hedenstroemia bosphorensis* Zakharov, and disappearance of *Gyronites subdharmus* Kiparisova. This level corresponds to the base of the *Hedenstroemia himalajica* Zone of the Himalayas (Diener, 1897) and the *Hedenstroemia hedenstroemi* Zone of the Boreal realm (Dagys, Arkhipov and Bytchkov, 1979; Dagys and Tozer, 1989; Zakharov, 1978). Within the Induan-Olenekian boundary beds of the Primorye region *Hedenstroemia* associates with numerous representatives of *Gyronites (G. separatus* Kiparisova and *G.* aff. *planissimus* Spath). Somewhat higher the zonal index is known in association with abundant early Olenekian ammonoids (*Dieneroceras, Anaxenaspis, Meekoceras, Arctoceras, Pseudoprosphingites, Owenites,* etc.) bivalves, *Lingula* and Merostomoidea. This confirms the

assumption of Zakharov (1978), according to which the *Hedenstroemia* beds are coeval with the *Meekoceras gracilitatis* Zone of Idaho and Nevada (Kummel and Steele, 1962), the *Owenites* beds of Japan and South China and the *Arctoceras blomstrandi* Zone of Spitsbergen.

The problem of the stratigraphical position of the *Flemingites* beds within the Lower Triassic is animatedly discussed in recent literature. In the Primorye region, *Flemingites* was met within the candidate stratotype for the Induan-Olenekian boundary. It was recognized here somewhat above the base of the *Hedenstroemia bosphorensis* Zone, in association with other representatives of the Flemingitidae (*Euflemingites*). This very important evidence permits the correlation of the *Hedenstroemia bosphorensis* Zone of South Primorye with the *Flemingites flemingianus* Zone of the Salt Range and Madagascar and the *Euflemingites* beds of Mongolia and Trans-Baikal; the upper part of the *Hedenstroemia bosphorensis* of South Primorye corresponds, apparently, to the *Eueflemingites romundary* Zone of Arctic Canada (Tozer, 1965), (Fig. 1). In the light of the data just summarized, one may conclude that the stratigraphic schemes by some authors (Guex, 1978; Lozovsky et al., 1988; Shevyrev, 1986, 1990), showing the position of the *Flemingites* Beds below the *Hedenstroemia himalajica* Zone in the Himalayas and the *Meekoceras gracilitatis* Zone in North America, seems to be incorrect.

In South Primorye, the mentioned Induan-Olenekian bivalve succession takes place (Bittner, 1899; Kiparisova, 1938). At the same time *Promyalina shamarae* (Bittner) is restricted to the Induan *Gyronites subdharmus* Zone. It must be mentioned that much of the Lower Triassic bivalve taxonomy and stratigraphy remains in need of revision.

The Induan-Olenekian boundary beds correspond to the conodont *Neospathodus pakistanensis* Zone (Lozovsky et al., 1989). It is known that in the Salt Range, where the conodont distribution was well investigated, the *Neospathodus pakistanensis* Zone is represented by a significant part of the Olenekian Ceratite sandstone *(Flemingites flemingianus* Zone) and only the upper part of the Ceratite marls (the upper part of the *Prionolobus rotundatus* Zone) (Matsuda, 1981; Pakistani-Japanese Research Group, 1985; Sweet, 1970; Sweet et al., 1971). In North America (Utah, Canada), *Neospathodus pakistanensis* Sweet was recognized only in the Lower Olenekian (Mosher, 1973; Solien, 1975). There are some problems with the study of the *Neospathodus pakistanensis* Zone in China (Hubei) (Ding, 1992), however, its location is suspected here to be the same as in the Salt Range. In South Primorye, the occurrences of *Neospathodus pakistanensis* Sweet are associated with the two localities of the Lower Triassic at Russian Island (Buryi, 1979; Zakharov, in press). There is only a single record of *N. pakistanensis* Sweet within the top part of the Induan *Gyronites subdharmus* Zone at Ayax Bay, three other specimens were collected by G.I. Buryi (1979) in coquinoid calcareous sandstone of the Tobizin Cape characterized by the Early Olenekian *Meekoceras subcristatum* Kiparisova and *Juvenites* sp. *(Hedenstroemia bosphorensis* Zone). Thus in both South Primorye and the Salt Range the zonal index of the *Neospathodus pakistanensis* Zone is ranging near the top of the Induan and basal part of the Olenekian.

The foregoing review of mollusc and conodont data from Primorye and other regions has revealed the scarcity of known age-diagnostic Late Induan and Early Olenekian bivalves and conodonts. The Induan-Olenekian boundary may be determined now mainly on the basis of ammonoids. In ammonoid terms, the lower part of the Olenekian is marked by the appearance of a diverse assemblage: *Hedenstroemia, Meekoceras, Juvenites, Pseudoprospingites, Arctoceras, Flemingites* and *Euflemingites*. The Induan-Olenekian representatives of *Gyronites* in the Tethys differ on species level.

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WORKING GROUP ON THE ANISIAN, LADINIAN AND CARNIAN STAGE BOUNDARIES

ANNUAL REPORT

Maurizio Gaetani

The activities since the field-workshop of July 1993 have been summarised during the Albrechtsberg meeting, 10 September 1994.

Anisian

GSSP candidates. Four areas are under consideration for the GSSP: Chios, Dobrugea, Kçira and Nevada.

- Chios (Greece) has been formally proposed as candidate in the last issue of Albertiana (Muttoni et al., 1994). The extended paper on paleomagnetism has been submitted to 'Physics of the Earth and Planetary Interior'.
- Dobrugea (Rumania) is presently under study as far as paleomagnetism is concerned by Y. Gallet (IPG, Paris). Preliminary results seem to be in agreement with the Chios data (pers. comm., Y. Gallet). A new sampling has been undertaken for conodonts and ostracods in May 1994 by a Rumanian-French-Swiss team, within the framework of the Peritethys Project (both IGCP and Consortium). Preliminary results on ostracods have been presented by S. Crasquin-Soleau (UPMC, Paris) in Cracow, August 1994, during the meeting of IGCP 343. The isotopic analysis of conodonts will be the subject of a Ph.D. thesis in Lausanne, Switzerland. E. Gradinary (Bucharest) told me last August that the paper on the ammonoids should be ready around the turn of this year. We are heartily waiting for it.

- **Kçira (Albania).** The locality discovered at the beginning of this century by Nopcsa (1929), whose Spathian ammonoids were described in a monograph by Arthaber (1911), was worked out by an Albanian-Italian team in July 1994. The succession spans through the Spathian-Anisian boundary, but basal Anisian ammonoid assemblages are not preserved. Consequently, this section does not seem suitable as GSSP candidate.
- **Nevada (U.S.A.).** Work is in progress by H. Bucher (Dijon), as far as the latest Spathian ammonoids are concerned and M. Orchard (Vancouver) recently (1994) published a paper on conodonts around the boundary. Paleomagnetic studies have not been attempted, but CAI of conodonts is not promising.

Criteria to define the boundary

The appearance of a number of new ammonoid genera like *Egeiceras*, *Japonites*, *Paracrochordiceras* and *Paradanubites* may be used to define the base of the Anisian. This datum plane is slightly preceded by *Chiosella timorensis* FA and by a magnetic reversal. Consequently, we have criteria that I consider suitable, but we still need a complete description of several possible GSSP candidates to start the final selection.

Ladinian

Since the field workshop, a special number of Acta Geologica Hungarica (v. 36, no. 3, 1993) was published, dealing with the Anisian-Ladinian boundary in the Balaton area. Moreover, a taxonomic paper on conodonts has been published (Kovács, 1994). An informal meeting with several ammonoid workers was organised by W. Weitschat (Hamburg) in Epidauros (Greece) last April, where a paleomagnetic sampling was done by Y. Gallet (Paris).

Brack and Rieber (1994) proposed the Bagolino section as GSSP candidate for the boundary, which in their opinion should be drawn at the base of the *Eoprotrachyceras curionii* zone. The Milano team did additional conodont samplings in Bagolino and at the Froetchbach section, where also paleomagnetic samples were taken.

During the Albrechtsberg meeting, Hungarian colleagues distributed a first draft of a position paper to be submitted to Albertiana. Their ultimate goal is to propose the Balaton section of Felsőörs as GSSP candidate. They consider the base of the Ladinian drawn at the base of the *Reitzites reitzi* Zone as most suitable. The Felsőörs section is suitable only if the lowest position of the boundary will be selected, being the undocumented part of the highest critical interval.

During the meeting, M. Orchard explained that according to a preliminary analysis of new samplings done together with H. Bucher, several conodont taxa recently recognised by Kovács (1994) may be found in Nevada. However, *N. trammeri* is absent, indicating that this species is not suitable for intercontinental correlations. However, he is not considering the Nevada sections as GSSP candidates.

Bagolino or related sections in the Brescia area or Giudicarie seem thus to be more complete for the whole time interval. When also the conodont revision will be performed, participants of the working group will be asked to decide on the criteria to define the boundary, and where.

Carnian

Italian people interested in the problem met in June and performed a preliminary common field work in Carnia in September. Three areas will be described (S. Cassiano, W. Carnia, Raibl). Members of the working group interested in proposing other areas and sections as GSSP are encouraged.

L. Krystyn (Vienna) briefly illustrated an improved ammonoid zonal scheme for the early Carnian, with several subdivisions of subzonal or horizon rank.

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THE ANISIAN/LADINIAN BOUNDARY IN THE BALATON HIGHLAND, HUNGARY

- A COMPLEX MICROBIOSTRATIGRAPHIC APPROACH -

S. Kovács, L. Dosztály, F. Góczán, A. Oravecz-Scheffer and T. Budai

Introduction

The present article intends to give a summary of microbiostratigraphic work published in Acta Geologica Hungarica, 1993, Vol., 36 (1), for the Workshop on the Anisian/Ladinian Boundary, organized in northern Italy and western Hungary between June 27 - July 4, 1993 (but appeared, unfortunately, only with a half year's delay). Details of the problem and the activity of STS in connection with it can be found in Gaetani (Ed.), 1993; Gaetani, 1993; Brack and Rieber, 1993, 1994 and in Vörös, 1993 (for details about the ammonoid biostratigraphy in the Balaton Highland see the last work). It is emphasized that a (hopefully) well recognizable (and less disputed than at present) boundary can be established only if all the most important fossil groups having great potential to establish the stage boundary in different paleoenvironments (see Fig. 1), are taken into consideration.

Significance of a complex biostratigraphic approach to the definition of chronostratigraphic boundaries

Both modern (e.g. sequence stratigraphic) and traditional (e.g. geological mapping) geological procedures require precisely established chronostratigraphic schemes of great practical usefulness. The need of establishing the "age" of lithological sequences or even only of single units implies that they should be placed somewhere on the chronostratigraphic scale. In other words, the chronostratigraphic units or at least their boundaries defined by their stratotypes lying somewhere on the globe should be recognized in surface outcrops or in drilling cores. Thus, also the Triassic chronostratigraphic units or their boundaries, defined usually in Tethyan pelagic sequences occurring mostly in highly compressed orogenic zones (or, in some cases, in the boreal Triassic) have to be recognized in shelf carbonates or in the continental deposits of Pangea having much larger areal extension. This practical need can be fulfilled only if the different fossil groups having great biostratigraphic potential in different ancient depositional environments are taken into account for the definition of chronostratigraphic boundaries (see also Brack and Rieber, 1993 p. 455); like palynomorphs in continental (but also in marine) deposits or dasycladaceans in platform carbonates (see Fig. 1), that is, if the boundaries are defined at the most important biological events, allowing long-distance (if not global) correlations.

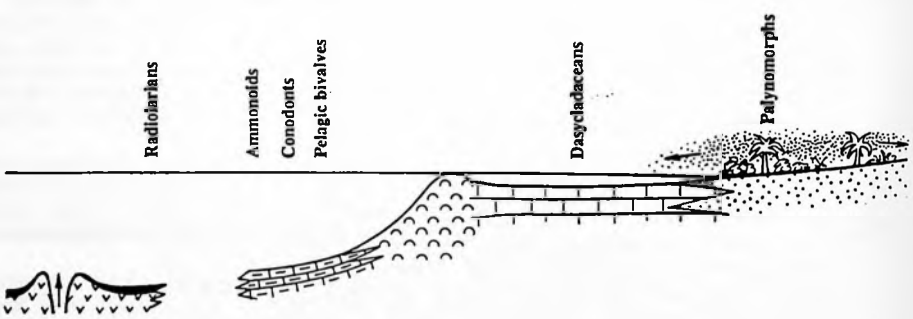
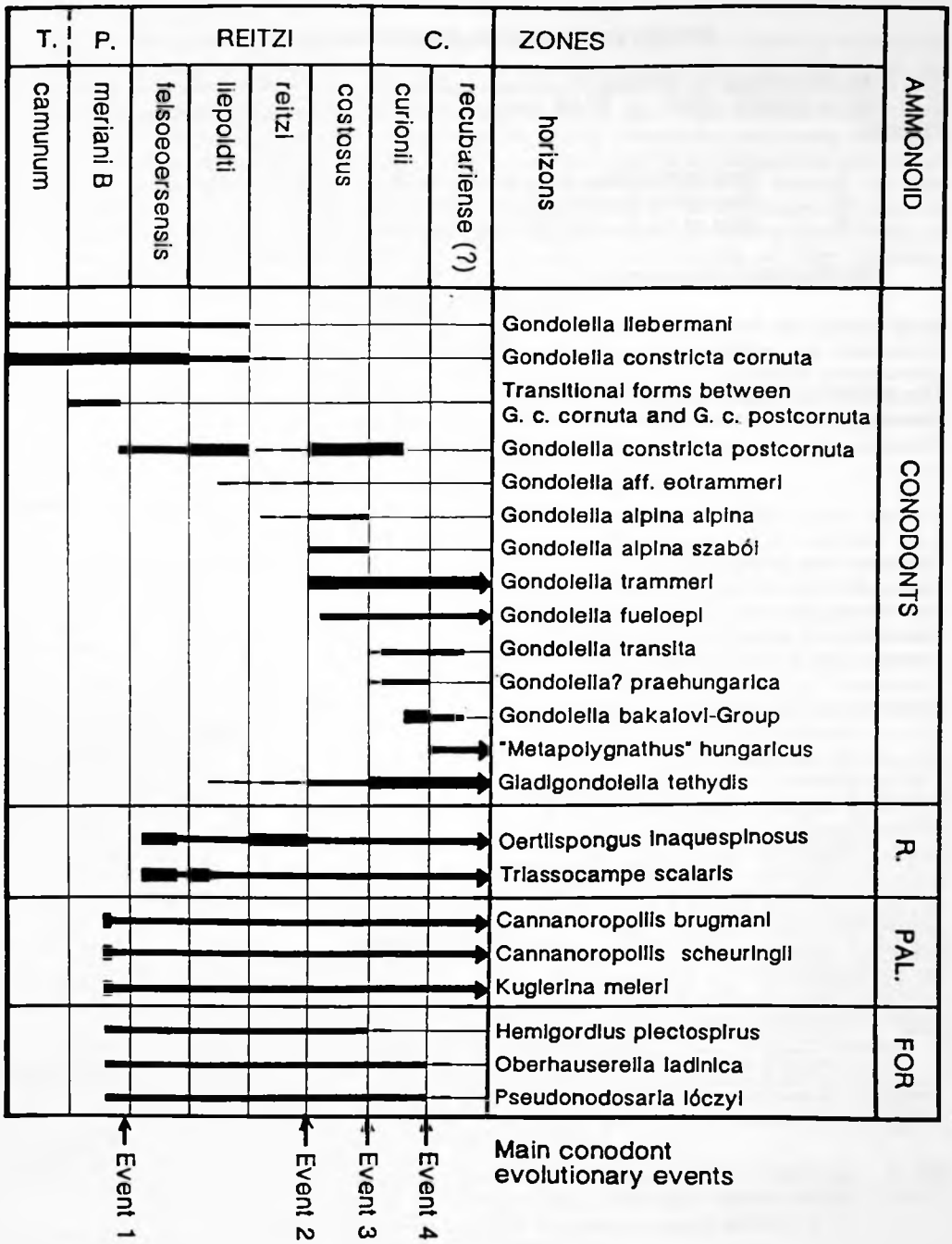


Fig. 1 The most important Triassic fossil groups having the greatest biostratigraphic potential in different depositional environments

The Balaton Highland Triassic offered a good opportunity to study the Anisian/Ladinian boundary interval by "parachronological" (if "orthochronology" is understood exclusively for ammonoids) methods: conodonts, palynomorphs, foraminifers and radiolarians. Only the dasycladacean aspect could not be studied due to the lack of coeval platform carbonates.

Fig. 2 Ranges of the stratigraphically most important conodonts, radiolarians (R), palynomorphs (PAL) and foraminifers (FOR), as determined in the investigated Balaton Highland sections. On the right the most important conodont evolutionary events (after Kovács, 1993) are shown. Ammonoid zonation after Vörös, 1993.


T.
P.
REITZI
C.
ZONES
AMMONOID
camunum
meriani B
felsoeoersensis
liepoldti
reitzi
costosus
curionii
recubariense (?)
horizons
CONODONTS
Gondolella liebermani
Gondolella constricta cornuta
Transitional forms between
G. c. cornuta and G. c. postcornuta
Gondolella constricta postcornuta
Gondolella aff. eotrammeri
Gondolella alpina alpina
Gondolella alpina szabói
Gondolella trammeri
Gondolella fueloepi
Gondolella transita
Gondolella? praehungarica
Gondolella bakalovi-Group
"Metapolygnathus" hungaricus
Gladigondolella tethydis
R.
Oertlispongus inaquespinosus
Triassocampe scalaris
PAL.
Cannanoropollis brugmani
Cannanoropollis scheuringii
Kuglerina meleri
FOR
Hemigordius plectospirus
Oberhauserella ladinica
Pseudonodosaria lóczyi
Event 1
Event 2
Event 3
Event 4
Main conodont
evolutionary events

Possible positions of the Anisian/Ladinian boundary

The three alternatives for defining the Anisian/Ladinian boundary, as reviewed in Gaetani, 1993, p. 9 and in Kovács, 1993, p. 52-55 (mostly from conodont biostratigraphic aspect), are as follows:

1. Base of the Reitzi Zone (in the redefined sense of Vörös, 1993);
2. Base of the Nevadites Zone (cf. Krystyn, 1983);
3. Base of the Curionii Zone (for the latest review see Brack and Rieber, 1993).

Significance of microfossil groups in the definition of the Anisian/Ladinian boundary in the Balaton Highland

Conodonts

The evolution of gondolelloids during the late Anisian and early Ladinian took place on three lineages, all having rose up from *Gondolella bulgarica* during a late Pelsonian radiation (see Fig. 4):

- *G. constricta* lineage
- *G. excelsa* lineage
- *G. szaboi* - *G. trammeri* lineage

The *constricta* lineage showed a fairly slow evolutionary rate with three morphological changes leading from *G. constricta cornuta* to *G. constricta postcornuta* (cf. Kovács, 1994, p. 484-485):
- slendering and slight lengthening of the unit,
- anteriorward shifting of the basal pit,
- disappearance of the larger denticle of carina next to the last one fused with the platform end.

These morphological changes, however, occur rather alternatively below the *liepoldti* horizon.

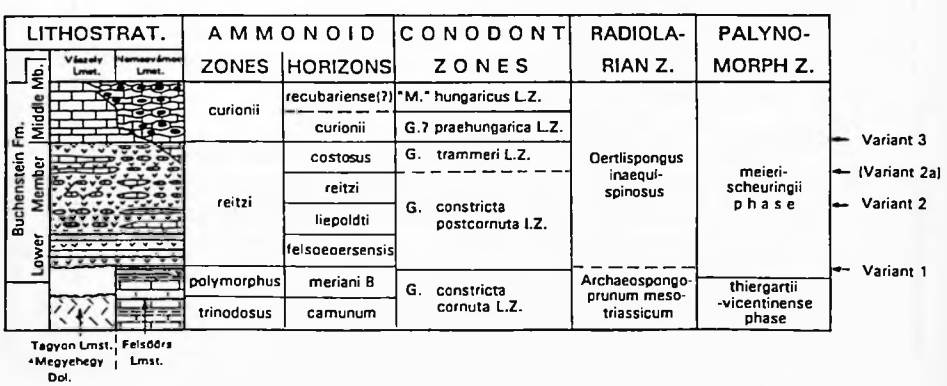


Fig. 3 Conodont, radiolarian and palynomorph zones recognized in the A/L boundary interval of the Balaton Highland. (Abbreviations at the conodont zones: L.Z. = lineage zone; I.Z. = interval zone.) Ammonoid zonation after Vörös, 1993.

The first two features can already be observed on specimens from the *meriani* B ammonoid horizon (= ? *Lardaroceras* beds; thus supporting its possible inclusion into the Reitzi Zone; cf. Gaetani, 1993, p. 8; Brack and Rieber, p. 30). However, such a form was still found in the Trinodosus Zone of the Felsőörs section (see Kovács, 1993, p. 42). These forms are designated as "transitional forms" between *G. constricta cornuta* and *G. constricta postcornuta* (although one could introduce a further subspecies for them, this could not be unambiguously separated from the already existing ones). The third feature, considered as most decisive for the separation of *G. constricta postcornuta*, can first be recognized just one bed below the base of felsőörsensis horizon in the Vászoly P-11/a section (cf. Kovács, 1993, p. 46 and Vörös, 1993, p. 20). Typical forms of *G. constricta postcornuta* showing characteristically all three features, identical with those from the lower Curionii Zone, occur only from the *liepoldti* horizon on.

Gondolella transita developed from *G. constricta postcornuta* at the base(?) of the Curionii Zone as a side-branch. However, it is very rarely represented in the studied sections. As opposed to the low evolutionary rate of the lineage below the *liepoldti* horizon, *G. constricta postcornuta* gave rise very rapidly to elongated forms in the lower Curionii Zone, which are tentatively compared with the Balkanide *G. bakalovi* Group. However, this event has no meaning for the definition of the A/L boundary. Thus, the *constricta* lineage does not provide a strong evidence for any of the three variants as the base of the Ladinian.

The appearance of the *G. szaboi* - *G. trammeri* lineage is facies controlled in the Balaton Highland, thus it has no bearing on Variant 1. However, the appearance of *G. trammeri* s.s., evolved from *G.* aff. *eotrammeri* apparently at the base of the *costosus* horizon*, has the greatest potential among all the conodont evolutionary events to establish a stage boundary. This characteristic form is represented by a fairly great number of specimens "throughout" the Ladinian (depending on the definition of its disputed lower and upper boundaries) in the Balaton Highland. At the base(?) of the Curionii Zone *G.? praehungarica* developed from *G. trammeri* s.s. (or from *G. szaboi?*), representing a transitional form between gondolelloids and "metapolygnathoids". It was found, however, only in the deep-water Felsőörs section and appears only very rarely in the lower Curionii Zone. The most important conodont evolutionary event, comparable in significance with the appearance of true trachyceratids (ammonoid Variant 3), occurred in the upper Curionii Zone with the appearance of true "metapolygnathoids" (*"M". hungaricus*). However, being much higher above any discussed ammonoid variant, it has no meaning for the definition of the A/L boundary. In the Epidauros section, characterized by numerous hardgrounds, where it was found to occur at the "base" of the Curionii Zone (Krystyn, 1983), a considerable part of this zone should be missing.

On the *excelsa* lineage, the appearance of *G. fueloepi* evolved from *G. excelsa* (or from *G. liebermani?*) at the base(?) of the *costosus* horizon might have a similar potential as *G. trammeri* does. In the Balaton Highland it is underrepresented against *G. trammeri*, whereas in NE Hungary it is much more frequent. Uncertainties exist, however, concerning its true first occurrence, and a correlation with the (still not published) North Hungarian sections is not yet carried out.

Summing up the conodont evolutionary events, the most significant ones (FO of *G. trammeri* s.s. and of *G. fueloepi* at the base(?) of the *costosus* horizon) seem to be in favour of a middle

* However, there are uncertainties concerning its FO, as the underlying reitzi horizon is not suitable for detailed conodont studies in the Balaton Highland; see "Appendix" A.

variant as the base of the Ladinian. Open problems exist, however, concerning the real FO of these two species (as the underlying *reitzi* horizon is not suitable for detailed conodont studies in the Balaton Highland) and the LO of the taxa becoming extinct at the top(?) of the *costosus* horizon (see Fig. 2) (as the zone of *Nevadites* s.s. cannot be proved up to now in the BH, see Appendix B).

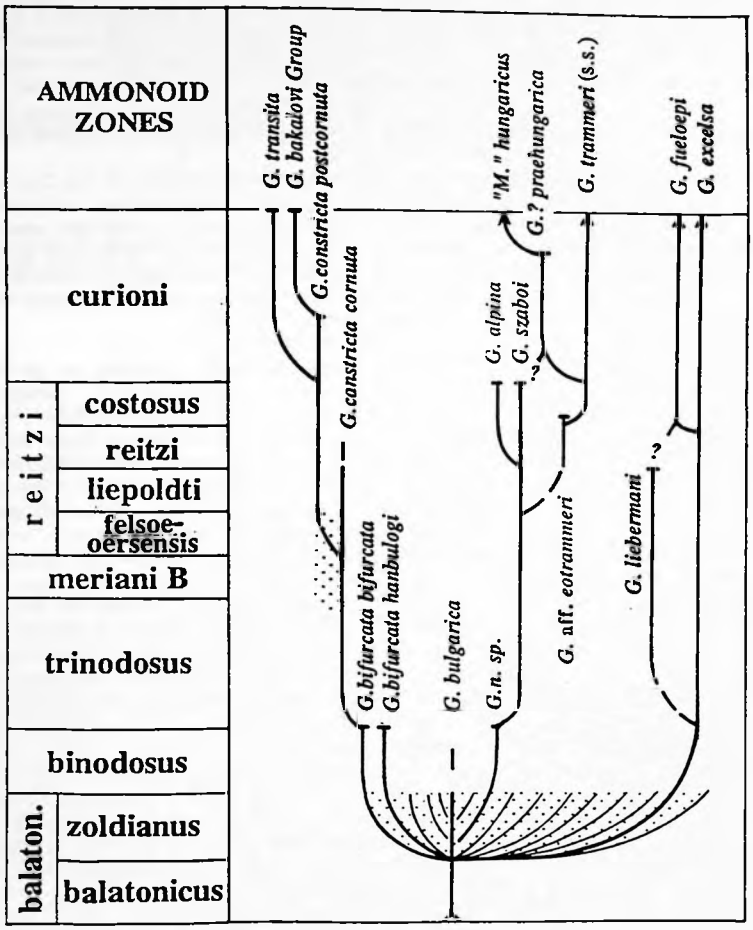


Fig. 4 *Tethyan gondolelloid conodont evolutionary lineages during the late Anisian and early Ladinian. A few stratigraphically less important or problematic forms are omitted. Ammonoid zonation after Vörös, 1987 and 1993. Because of its disputed status, the Binodosus Zone is shown independently. (G. = genus* Gondolella*; dotted line indicates rare or uncertain occurrences).*

Radiolarians

The most important event in the evolution of radiolarians during the discussed Late Anisian to Early Ladinian time interval was recognized at the FO of representatives of genus *Oertlispongus*. Although due to mostly bad preservation the record of radiolarians is patchy, this event could be correlated with the boundary of Felsőörs Limestone Formation and the "Reitzi Tuff" of Buchenstein Formation in the Felsőörs section, and thus apparently coincides with the base of the Reitzi Zone (in sense of Vörös, 1993).

CARNIAN	Paleosaturnalis triassicus
LADINIAN	Muelleritortis cochleata — — — — — — — — — — — — — — — — Oertlispongus inaequispinosus
ANISIAN	Archaeospongoprunum mesotriassicum

Fig. 5 Triassic radiolarian zones recognized in the Balaton Highland.

It is emphasized here that radiolarians have the greatest biostratigraphic potential to date ophiolitic rock assemblages, e.g. to establish a biostratigraphic zonation in ancient oceanic environments.

Palynomorphs

A very radical change in the palynomorph associations can be recognized in all the investigated sections slightly below the top of the Felsőörs Limestone Formation. This event is marked by the FO of genera *Cannanoropollis* and *Kuglerina* and by a significant change in the species of the genus *Triadispora*. The intrabasinal correlation (e.g. within the Middle Triassic Felsőörs Basin; c.f. Budai and Vörös, 1992, 1993) of this event was greatly promoted by foraminifer biostratigraphy, as the foraminifer associations showed a significant change coinciding exactly with that of the palynomorphs. It was found in bed No. 98 in the Felsőörs reference section (where the base of the Reitzi Zone is recognized at the top of bed No. 99/C; see in Vörös, 1993).

Above this event, as shown by the conodont-controlled section of the borehole Bakonyszücs—3 (Bsz—3; see Fig.6), no change could be detected in the palynomorph associations until the basal part of the Longobardian.

Foraminifers

Although foraminifers are good facies indicators and, consequently, have less stratigraphic value, they have some importance for the intraregional correlation within the Middle Triassic Felsőörs Basin (c.f. Budai and Vörös, 1992, 1993). The FO of *Hemigordius plectospirus*, *Oberhauserella ladinica*, *Pseudonodosaria loczyi* and *"Pilaminella" gemerica* were found in the same bed in all the investigated sections where the FO of the palynomorph genera *Cannanoropollis* and *Kuglerina* was recognized (cf. Góczán and Oravecz-Scheffer, 1993).

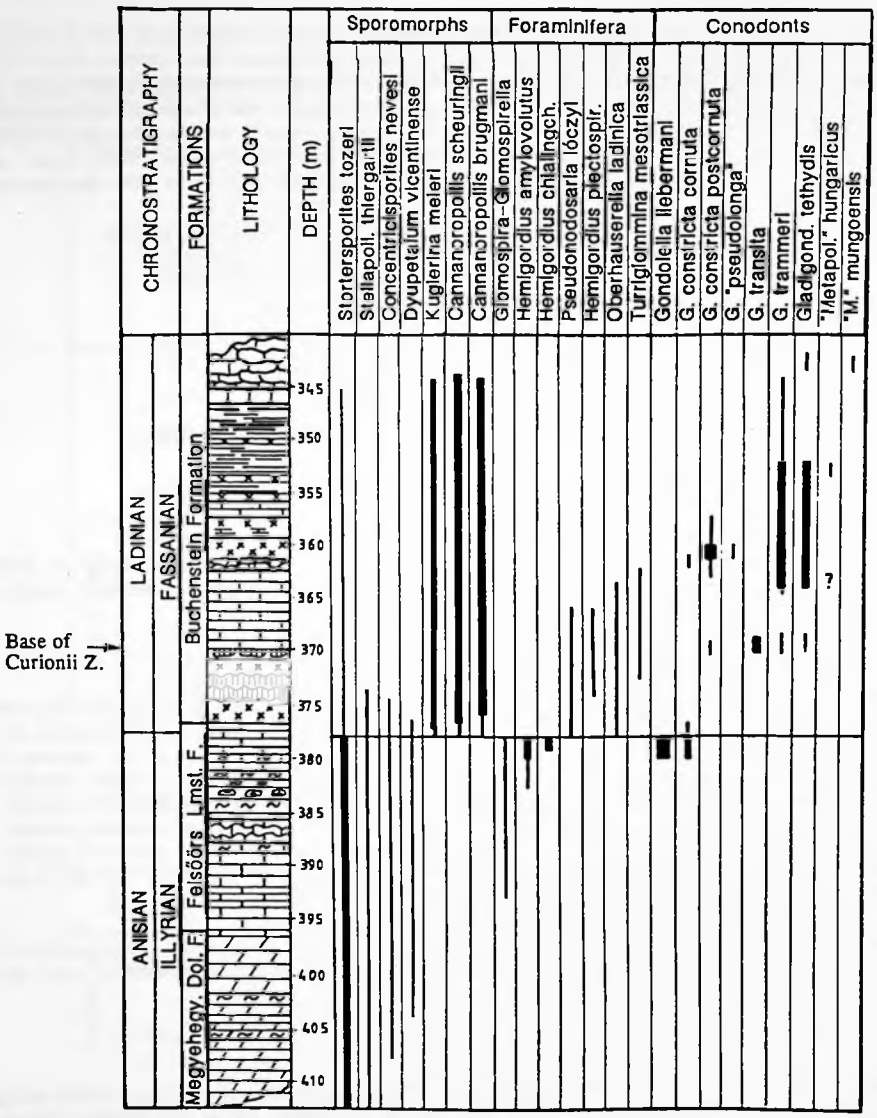


Fig. 6 *Occurrences of characteristic sporomorph, foraminifer and conodont taxa in the borehole Bakonyszücs, Bsz-3. The base of the Curionii Zone is indicated on the basis of lithological correlation and (partly) of conodonts.*

Conclusions

The A/L boundary sections in the Balaton Highland were investigated in details for ammonoids, conodonts, palynomorphs, radiolarians and foraminifers. The most important change in the evolution of palynomorphs, radiolarians and (although they have only local importance) foraminifers nearly coincides with Variant 1, thus giving a strong support to define the A/L boundary at the base of the Reitzi Zone (in the redefined sense of Vörös, 1993). No significant change was detected in the evolution of these microfossil groups at Variants 2 and 3 (and probably not until the base of the Longobardian). Conodonts could be used in favour of all three variants; however, the most easily recognizable event was found near to Variant 2 (which needs a clarification; see "Appendix" B).

Perspectives of the discussion about the A/L boundary

To arrive at a widely accepted consensus on the A/L boundary, it is unavoidable to take into consideration the different facies representing different depositional environments and to find a stage boundary (if priority is longer considered; cf. Brack and Rieber, 1994), which will hopefully be more or less recognizable both in Tethyan and outer-Tethyan Triassic sequences. This is possible only with a complex ***biostratigraphic approach***, which requires still a lot of work: to investigate the possible other candidates for the boundary stratotype with comparable methods, possibly bed-by-bed, as it was done in the case of the sections in the Balaton Highland (as far as it was possible).

It seems, that it is not the high resolutional potential (which may be often recognized to a restricted extent, e.g. in a few fossiliferous sections) but the long-distance correlational potential of certain fossil groups, which makes them suitable to define chronostratigraphic boundaries, at least at stage level. Because in the Alpine Triassic platform carbonates (the biostratigraphic zonation of which can be made first of all with dasycladaceans) have much more (at least with a magnitude of order) areal distribution than pelagic ones, it is strongly recommended to take into consideration the boundary of *Diplopora annulatissima* and *Diplopora annulata* zones, as with the range of the latter (e.g. without *D. annulatissima*) the Ladinian is usually defined (cf. Ott, 1972; Bystricky, 1986). (The same holds true for *Poikiloporella duplicata* concerning the Carnian.) Also, for correlation with Peri-Tethyan and Pangean continental Triassic, palynomorphs should play an important role in the definition of the stage boundary, which is recommended to be defined at that level, where (or close to that) the most important biological events can be recognized (as it generally should be at major chronostratigraphic boundaries).

Appendix A:

Additional informations to the FO of *Gondolella trammeri* s.s.

S. Kovács

Vászoly, P11a ditch (see Vörös, 1993, Fig. 4; Kovács, 1993, Fig. 5)

The bed 16/A yielding ammonoids of the *costosus* horizon had not been investigated for conodonts before 1993; see Kovács, 1993, p. 45-46. Subsequently, in the presence of T. Budai, I. Szabó and A. Vörös I sampled it, and also resampled beds N. 16 and 17. All of them

yielded *G. trammeri* (bed N. 16/A only a single specimen), therefore its range shown in Kovács, 1993, Fig. 6 should be extended down to the lower boundary of the *costosus* horizon in the Balaton Highland. On the other hand, these "beds" were reconstructed from loose blocks on top of the ditch, (casting doubts on samplings carried out at different times), so it is suggested to omit them from stratigraphic considerations.

Mencshely section (see Vörös, 1993, Fig. 3; Kovács, 1993, Fig. 4)

A. Vörös and T. Budai provided for me badly preserved ammonoids from the *reitzi* horizon of the section (for which I express hereby my sincere thanks). Numerous representatives of the *G. constricta* lineage have been found in their insoluble residue, but neither *G.* aff. *eotrammeri*, nor *G. trammeri* s.s. were present. Therefore, the real FO of *G. trammeri* s.s. (and also of *G. fueloepi*) remained an open question in the Balaton Highland.

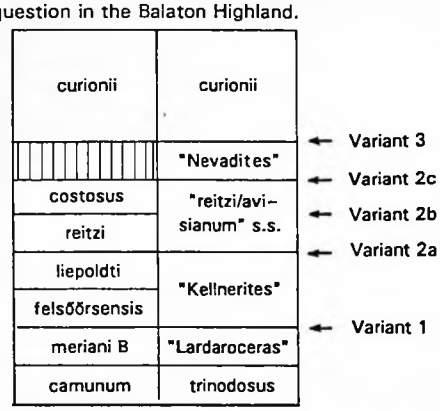


Fig. 7 Positions of the different variants proposed for the base of the Ladinian (based on Gaetani, 1993, modified). For problems of Variant 2, see Appendix B.

Appendix B:

Comments on Variant 2 (see Fig. 7)

S. Kovács

Apart from the above mentioned uncertainty concerning the real FO of *G. trammeri* s.s., also the ammonoid zonation around this variant is different, as proposed on the range charts by Brack and Rieber, 1993, Fig. 13 and Vörös, 1993, Fig. 11, respectively. It seems that the upper part of the Reitzi Zone in the latter sense (e.g. the *Halilucites costosus* horizon) is included in the Nevadites Zone in the former sense (in the SA the FO of *Halilucites* and *Nevadites* are shown to coincide and part of the range of *Aplococeras* is also included into the Nevadites Zone). Thus, would the FO of *G. trammeri* s.s. found at the base of the *costosus* horizon in the BH coincide with the base of the Nevadites Zone in the SA?

Also, if priority is not longer considered, the further maintenance of the Reitzi Zone in Mojsisovics's (1882) original sense becomes disputable. In fact, to a biostratigrapher who is not a specialist on ammonoids the ranges of ammonoids within the "Reitzi Zone" of the BH (see in Vörös, 1993, Fig. 11) suggest rather two biozones than a single one: a lower one with "*Kellnerites*" fauna and an upper one with "*reitzi/avisianum*" fauna. And, if the FO of *G. trammeri* s.s. will really be found in the *reitzi* horizon, it would give a strong evidence to define the A/L boundary (if Variant 2 would be accepted finally) with the FO of *Reitziites*, as suggested previously by Vörös and Pálfy, 1989 and Kovács, in Vörös et al., 1991.

Certainly it still needs much work to clarify, which of the three subvariants (in descending order) it would be :

Variant 2c: FO of true *Nevadites*
Variant 2b: FO of *G. trammeri* s.s.
Variant 2a: FO of *Reitziites*

The problem is further complicated, as true *Nevadites* was not found in the BH (till the publication of Vörös, 1993), whereas in Epidauros *Reitziites* is missing (cf. Krystyn, 1983; Tselepidis, pers. comm.). It should be mentioned that during the latest collecting in 1994 a specimen of *Chieseiceras* was found in the Felsőörs section (Vörös pers. comm.). It means that the gap in the section of the BH (made probable by Gaetani 1993) is rather an appearance and could be assigned to incomplete previous collections. However, this need for clarification should not mean a reason to "eliminate" Variant 2!

Abbreviations:			
	A/L	=	Anisian/Ladinian
	BH	=	Balaton Highland
	SA	=	Southern Alps
	FO	=	first occurrence
	LO	=	last occurrence

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ANISIAN - LADINIAN BOUNDARY VOLUME

Acta Geologica Hungarica, 36(1)

Volume 36/1 (1993) of Acta Geologica Hungarica was devoted to the Anisian Ladinian boundary in the Balaton Highland. The volume contains the following papers:

BUDAI, T. and VÖRÖS, A., 1993. The Middle Triassic events of the Transdanubian Central Range in the frame of the Alpine evolution. Acta Geol. Hung. 36(1): 3-14.

VÖRÖS, A., 1993. Redefinition of the Reitzi Zone at its type region (Balaton area, Hungary) as the basal zone of the Ladinian. Acta Geol. Hung. 36(1): 15-38.

KOVÁCS, S., 1993. Conodont biostratigraphy of the Anisian/Ladinian boundary interval in the Balaton Highland, and its significance in definition of the boundary (Preliminary report). Acta Geol. Hung. 36(1): 39-58.

DOSZTÁLY, L. 1993. The Anisian/Ladinian and Ladinian/Carnian boundaries in the Balaton Highland based on Radiolarians. Acta Geol. Hung. 36(1): 59-72.

GÓCZÁN, F. and ORAVECZ-SCHEFFER, A., 1993. The Anisian/Ladinian boundary in the Transdanubian Central Range based on palynomorphs and foraminifers. Acta Geol. Hung., 36(1): 73-144.

BUDAI, T., LELKES, GY. and PIROS, O., 1993. Evolutions of Middle Triassic shallow marine carbonates in the Balaton Highland (Hungary). Acata Geol. Hung., 36(1): 145-165.

These papers have been referenced in the
'Annotated Triassic Literature', ALBERTIANA, 13: 57-102.

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RECENTLY PUBLISHED NUMERICAL AGES FROM THE NONMARINE UPPER TRIASSIC

Spencer G. Lucas

One of the great problems of the Triassic timescale is its relatively poor numerical calibration. Few reliable numerical ages can be precisely correlated to Triassic biochronology (e.g., Forster & Warrington, 1985). Calibration of stage boundaries, particularly of the Late Triassic stages, has varied widely (Fig. 1). Two recently published numerical ages from nonmarine Upper Triassic rocks thus are of some interest, and their correlation to the Triassic biochronological scale merits discussion.

Ischigualasto Formation, Argentina

Rogers et al. (1992) reported 40Ar/39Ar ages of the Herr Toba bentonite bed near the base of the Ischigualasto Formation in the Ischigualasto-Villa Union basin of northwestern Argentina. Two well-defined spectra from incremental heating analyses of sanidine yielded plateau ages of 228.06 ± 0.78 Ma and 227.78 ± 0.30 Ma. (Rogers et al. considered the latter age to be the best estimate.) The Ischigualasto Formation tetrapod assemblage, type assemblage of the Ischigualastian land-vertebrate "age" of Bonaparte (1966), overlaps, but mostly overlies the Herr Toba bentonite. This assemblage is dominated by the rhynchosaur *Scaphonyx,* the traversodontid *Exaeretodon* and the giant dicynodont *Ischigualastia.* It also includes an aetosaur and the earliest Argentinian dinosaurs.

All workers identify the Ischigualastian as Late Triassic (Carnian), but there is some disagreement about its precise correlation within the stage-age. Hunt and Lucas (1991a, b), Hunt (1991), Lucas et al. (1992) and Lucas and Hunt (1993a) assigned it a late Carnian (early Tuvalian) age because: (1) the youngest rhynchosaurs are early Tuvalian, and *Scaphonyx* has been reported from the early Tuvalian Wolfville Formation of Nova Scotia; (2) a cf. *Ischigualastia* is known from the early Tuvalian Santa Rosa Formation of the Chinle Group in New Mexico; (3) all aetosaurs outside of Argentina (North America, Europe, North Africa, India) are no older d= early Tuvalian; and (4) outside of Argentina (and Brazil), no dinosaur occurrences older than early Tuvalian are known. Critical to this correlation is the occurrence of the primitive phytosaur *Paleorhinus* in early Tuvalian marine strata (Opponitzer Schichten) in Austria. This establishes a cross-correlation between marine early Tuvalian strata and nonmarine strata in North America, Europe and India that yield fossils of *Paleorhinus* (Hunt and Lucas, 1991a).

Despite this, Rogers et al. (1992) claimed the Herr Toba bentonite numerical age indicates a "middle" Carnian age for the Ischigualasto tetrapods. They arrive at this by plugging the number 227.8 into published numerical timescales; in some of these scales, 227.8 is somewhere in the middle of the Carnian. I prefer not to correlate the Ischigualasto tetrapod assemblage this way, and believe the best correlation that can be offered now is an early Tuvalian age. This means the Herr Toba bentonite data is very close to the Julian-Tuvalian boundary.

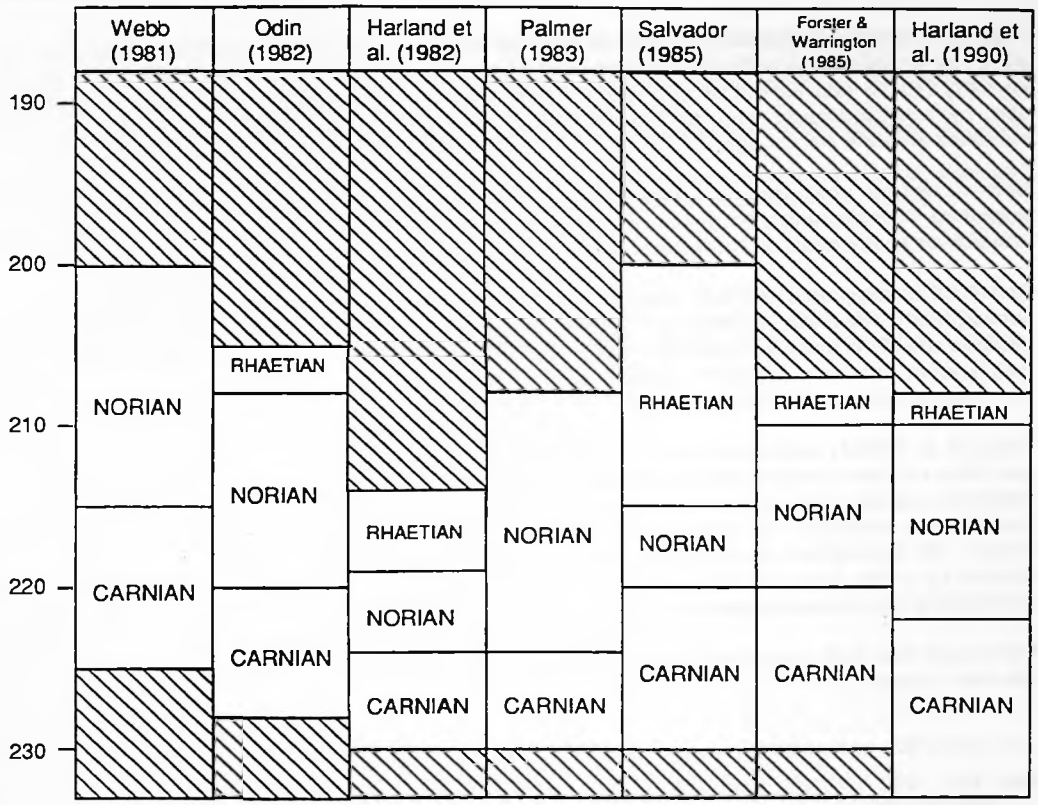

Fig. 1. Comparison of some recently published numerical calibrations of the Late Triassic timescale.

The analytical error of the Herr Toba Ar/Ar age is very small, and the analytical procedures seem beyond reproach. I therefore conclude that 228 is a reliable age for the Julian-Tuvalian boundary.

Chinle Group, U.S.A.

Riggs et al. (1994) reported a U-Pb age on zircons from the Black Forest Bed of the Painted Desert Member, Petrified Forest Formation, Chinle Group at Petrified Forest National Park, Arizona, U.S.A. They plotted analysis of an acicular zircon fraction on a standard concordia diagram using Ludwig regression to produce a discordia line with a lower intercept (crystallization age) of 207 ± 2 Ma. The Black Forest Bed is a fluvially reworked siliceous tuff for which Ash (1992) previously reported a K-Ar age on biotite of 239 ± 9 Ma.

The Black Forest Bed is in the lower part of the Painted Desert Member, strata that produce a fossil tetrapod assemblage of the Revueltian land-vertebrate faunachron of Lucas and Hunt

(1993b). Revueltian tetrapods include phytosaurs also found in the German Stubensandstein of early Norian age. Palynomorphs from the lower part of the Painted Desert Member also indicate an early Norian age (Litwin et al., 1991). Thus, the numerical ages from the Black Forest Bed can be unambiguously tied to biochronology based on tetrapods and palynomorphs that indicates an early Norian age.

Both numerical ages from the Black Forest Bed, however, are not early Norian on recently published Triassic numerical timescales. The K-Ar age is Middle Triassic, and the U-Pb age is late Norian or Rhaetian on these timescales (Fig. 1).

Ash (1992) suggested the K-Ar age of 239 Ma is the age of a Middle Triassic tuff that was subsequently reworked during Late Triassic time to form the Black Forest Bed. If so, this negates the K-Ar age as a calibration point for the early Norian. The large analytical error and well known systemic problems associated with K-Ar ages (e.g., secondary enrichment of K) also negate the value of the age to timescale calibration.

Riggs et al. (1994) suggested the U-Pb age is the syndepositional age of the Black Forest Bed, and thus an early Norian calibration point. This strikes me as very unlikely, unless all previous calibration of the Late Triassic timescale is incorrect. The U-Pb age of 207 Ma is anomalously young. One possibility is some resetting of the age by regional Late Cenozoic volcanism. Indeed, the escarpment above all Black Forest Bed outcrops at Petrified Forest National Park is capped by a late Cenozoic maar and associated basalts. Why this volcanism did not reset the zircons to a late Cenozoic age, nevertheless, is difficult to explain.

I conclude that both published numerical ages of the Black Forest Bed do not reliably calibrate the early Norian.

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Recently published literature

J. GUEX and A. BAUD, 1994. Recent developments on Triassic stratigraphy. Mémoires de Géologie (Lausanne), Vol. 22, 182 pp. ISSN 1015-3578. Sfr. 30.- or US $ 20.-

This volume contains the proceedings of the International Symposium on Triassic Stratigraphy held in Lausanne, 20-25 October 1991, under the auspices of the Subcommission on Triassic Stratigraphy. This meeting was attended by some 60 scientists and the symposium volume comprises fourteen contributions on a wide ranges of topics. Problems of correlation are discussed on the basis of various fossil groups, such as ammonoids, conodonts, brachiopods, palynomorphs and tetrapods. Subdivisions and zonations for the Triassic of various regions North America, Europe and Asia are proposed. Palaeobiography, cyclicities and extinction events are extensively discussed.

The book volume is well edited and richly illustrated with numerous schemes and tables and a series of excellent photo plates. This reasonably priced and attractively bound volume can be strongly recommended to all Triassic stratigraphers.

The book contains the following contributions:

BAUD, A. and GUEX, J., Foreword
BUCHER, H., New Ammonoids from the Taylori zone (middle Anisian, Middle Triassic) from Northwestern Nevada (USA), pp. 1-8.

BUDUROW, K. and TRIFONOVA, E., Progress in concepts about conodont and foraminifera zonal standards of the Triassic in Bulgaria, pp. 9-14.
DAGYS, A.S., Lower Triassic stage, substage and zonal scheme of north-eastern Asia, pp. 15-24.
DAGYS, A.S. and DAGYS, A.A., Global correlation of the terminal Triassic, pp. 25-34.
HIRSCH, F., Triassic multielement conodonts versus eustatic cycles, pp. 35-52.
KOLAR-JURKOVSEK T., Microfauna from the Upper Triassic of Karavanke Mts (Slovenia), pp. 53-62.
KOTLYAR, G.V. and SADOVNIKOV, G.N., Events related to the Permian/Triassic boundary, pp. 63-68.
MOERK, A., Triassic transgressive-regressive cycles of Svalbard and other Arctic areas a mirror of stage subdivision, pp. 69-82.
NAKAZAWA, K., ISHIBASHI, T., KIMURA, T., KOIKE, T., SHIMIZU, D. and YAO, A., Triassic biostratigraphy of Japan based on various taxa, pp. 83-104.
ORCHARD, M.J., Conodont biochronology around the Early-Middle Triassic boundary new data from North America, Oman and Timor, pp. 105-114.
PÁLFY, J., Paleoecological, biostratigraphic and paleobiogeographic fingerprints of brachiopod faunas case studies from the Anisian of Hungary, pp. 115-120.
SHISHKIN, M.A., Problems of global correlation of the continental Triassic on the basis of tetrapods, pp. 121-126.
SOBOLEV, E.S., Stratigraphic range of Triassic boreal Nautiloidea, pp. 127-138.
TIWARI, R.S. and VIJAYA, Synchroneity of palynological events and patterns of extinction at Permo-Triassic boundary in terrestrial sequence of India, pp. 139-154.
TOZER, E.T., Significance of Triassic stage boundaries defined in North America, pp. 155-170.
ZAKHAROV, Y.D. and SHKOLNIK, E.L., Permian-Triassic cephalopod facies and global phosphatogenesis, pp. 171-182.

The individual contributions are briefly summarized in the 'Annotated Triassic Literature', elsewhere in this issue of ALBERTIANA.

BRITISH TRIASSIC PALAEONTOLOGY: SUPPLEMENT 18

G. Warrington

Since the completion of the writer's previous supplement (No.17; ALBERTIANA, 13: 53-54) on British Triassic palaeontology, the following works relating to aspects of that subject have been published or have come to his notice:

BENTON, U.J. 1993. Late Triassic terrestrial vertebrate extinctions: stratigraphic aspects and the record of the Germanic Basin. Paleontologia Lombarda, nuova serie 2: 19-38.

BUTLER, P.M. and **MACINTYRE, G.T.** 1994. Review of the British Haramiyidae (? Mammalia, Allotheria), their molar occlusion and relationships. Philosophical Transactions of the Royal Society of London, B 345: 433-458.

CAMERON, T.D.J. 1993. 4.Triassic, Permian and pre-Permian of the Central and Northern North Sea. In KNOX, R.W.O'B. and CORDEY, W.G. (eds), Lithostratigraphic nomenclature of the UK North Sea. British Geological Survey, Nottingham.

DUFFIN, C.J. 1994. Myriacanthid holocephalans (Chondrichthyes) from the British Late Triassic. Neues Jahrbuch für Geologie und Paläontologie Abhandlungen, 192: 1-16.

JOHNSON, H., RICHARDS, P.C., LONG, D. and **GRAHAM, C.C.** 1993. United Kingdom offshore regional report: the geology of the northern North Sea. (London: HMSO for the British Geological Survey)

PAGE, K.N. 1994. Appendix to account of field excursion. Preliminary observations on the ammonite faunas of the basal Jurassic in Somerset and their global context. Proceedings of the Ussher Society, 8: 341-344.

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PARTINGTON, M.A., COPESTAKE, P., MITCHENER, B.C. and **UNDERHILL, J.R.** 1993. Biostratigraphic calibration of genetic stratigraphic sequences in the Jurassic-lowermost Cretaceous (Hettangian to Ryazanian) of the North Sea and adjacent areas. Pp. 371-386 in PARKER, J.R. (ed.), Petroleum Geology of Northwest Europe: Proceedings of the 4th Conference, London 1992, Volume 1. Geological Society, London.

STORRS, G.W. 1993. Terrestrial components of the Rhaetian (uppermost Triassic) Westbury Formation of southwestern Britain. Pp. 447-451 in LUCAS, S.G. and MORALES, M. (eds), The Nonmarine Triassic. New Mexico Museum of Natural History and Science, Bulletin 3.

STORRS, G.W. 1994. Stratigraphic distribution of plesiosaur taxa from the Lias (Rhaetian - Toarcian) of England (Abstract). Journal of Vertebrate Paleontology, 14 (supplement to No.3): 47A-48A.

STORRS, G.W. and **TAYLOR, M.A.** 1994. A new Triassic plesiosaur based upon historical material from the lowermost Lias (Rhaetian) of Street, Somerset, England (Abstract). Journal of Vertebrate Paleontology, 14 (supplement to No.3): 48A.

TALBOT, M.R., HOLM, K. and **WILLIAMS, M.A.J.** 1993. Sedimentation in low-gradient desert margin systems: A comparison of the Late Triassic of northwest Somerset (England) and the late Quaternary of east-central Australia. Pp. 97-117 in ROSEN, M.R. (ed.), Paleoclimate and Basin Evolution of Playa Systems. Geological Society of America Special Paper 289.

TUWENI, A.O. and **TYSON, R.V.** 1994. Organic facies variations in the Westbury Formation (Rhaetic, Bristol Channel, SW England). Organic Geochemistry, 21: 1001-1014.

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

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TRIASSIC-JURASSIC BOUNDARY

G. Warrington

The IUGS/ICS Triassic-Jurassic Boundary Working Group (TJBWG) is associated with the IUGS Subcommission on Jurassic Stratigraphy (SJS). The TJBWG Secretary is also a member of the Subcommission on Triassic Stratigraphy (STS) and provides a link between the subcommissions on matters regarding the system boundary. The Secretary is grateful to STS members who responded to the request, published in Albertiana 13, for information from those studying Triassic-Jurassic boundary sequences.

Presentations on TJBWG work were made in September 1994 by the Chairman and Secretary of the group at, respectively, the First French Congress on Stratigraphy, Toulouse, France, and the STS business meeting held during the "Shallow Tethys 4" symposium, Albrechtsberg, Austria, and a report on the TJBWG appears in SJS Newsletter 22 (Lyon, France, September 1994). The Secretary conducted a TJBWG business meeting on 23 October 1994, during the 4th International Congress on Jurassic Stratigraphy and Geology, Mendoza, Argentina, and made a presentation on TJBWG Work to the SJS business meeting held during that congress. An account of the TJBWG meeting in Mendoza will be prepared for future issues of the newsletters of the relevant subcommissions.

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LATE TRIASSIC CORALS AND SPHINCTOZOA OF THE NORTHWESTERN CAUCASUS

Galina V. Belyaeva and Tatyana A. Punina

In the northwestern Caucasus, upper Triassic deposits occur in the Belaya and Laba River basins, within the Peredovoi Ridge. The stratigraphy was largely unravelled in the 1930s by Robinson (1936, 1937) and supplemented and improved by Dagys (1974), Dagys and Robinson (1973), Danilevich (1951), Rostovtsev (1973) and others. Late Triassic fauna in this region was first found in 1906 by V.N. Vorobyev. The fauna includes brachiopods and bivalves, recognized by respectively F.N. Chernyshev and A.A. Borisyak. In the 1930s and 1940s palaeontological investigations of brachiopods, corals and sponges were carried out by Moisseev (1939, 1940) and ammonoids and bivalves were investigated by Robinson (1936). In the 1970s more detailed studies were carried out on brachiopods (Dagys, 1974) and ammonoids (Shevyrev (1986, 1990). These latter authors proposed appropriate schemes with biostratigraphic subdivisions.

Deposits of all three stages of the Upper Triassic are known from the northwestern Caucasus. The facies is often not persistent. The thickness varies significantly because of sedimentation breaks. The whole Upper Triassic section of the northwest Caucasus is not known in detail yet. At present, only the upper Norian-Rhaetian section has been studied layer-by-layer. Robinson and Dagys investigated this section on the western slope of Yatyrgwart Mountain (Fig. 1). Here upper Norian deposits begin with conglomerates, gritstones and sandstones, overlying massive light-coloured Anisian limestones (Shevyrev, 119, p. 93). Above, up to the top of the Rhaetian, carbonaceous deposits occur, represented by organogenous, bioclastic and clayey limestones. According to Dagys (1973, 1974), organogenous limestones compose reefs restricted to the highest mountain tops. However, we did not observe typical fossil reefs in the region. We believe (in: Boiko et al., 1991) that small bioherms and biostromes occur here; sometimes they are contiguous and combined into small bioherm massifs. The frame-builders include algae, Corallinaceae and *Lithotamnidium*, corals, sphinctozoans, inozoans, hydrozoans and bryozoans. In organic buildups sometimes brachiopods and bivalves are found, which are normally more common in interbioherm facies. Vertically, organic buildups alternate with laminated limestones and their clayey and sandy varieties. Laterally, organic limestones change into terrigenous rock varieties in which brachiopod and bivalve banks are rather common. Ammonoids are only found in sandy limestones of the uppermost Rhaetian.

According to Dagys (1974) and Shevyrev (1990), the *Rhabdoceras suessi* and *Choristoceras marshi* zones of the Tethys Triassic scheme are present in the Yatyrgvart Mountain section (respectively layers 1-6, Fig. 1), and layers 7-10). Taking the proposed international standard subdivision of the Tethys Triassic into account (Yin, 1992), one should draw the Norian-Rhaetian boundary at the base of layer 7 of this section in the northwestern Caucasus (Fig. 1).

Sphinctozoa and scleractinia have been known from Late Triassic deposits of the northwestern Caucasus since the 1940s (Moisseev, 1944). However, nobody addressed their importance for the subdivision and correlation of these deposits.

The authors, together with I.T. Zhuravleva[1] and E.V. Boiko[2], participated in 1988 in paleontological investigations in the Sakhrai River basin and the upper stream of the Khodz River. This resulted in significant collections of sphinctozoa and scleractinia. Sphinctozoa were described by G.V.Belyaeva and E.V. Boiko and published in monograph on sphinctozoa from all deposits known in the former USSR (Boiko et al., 1991).

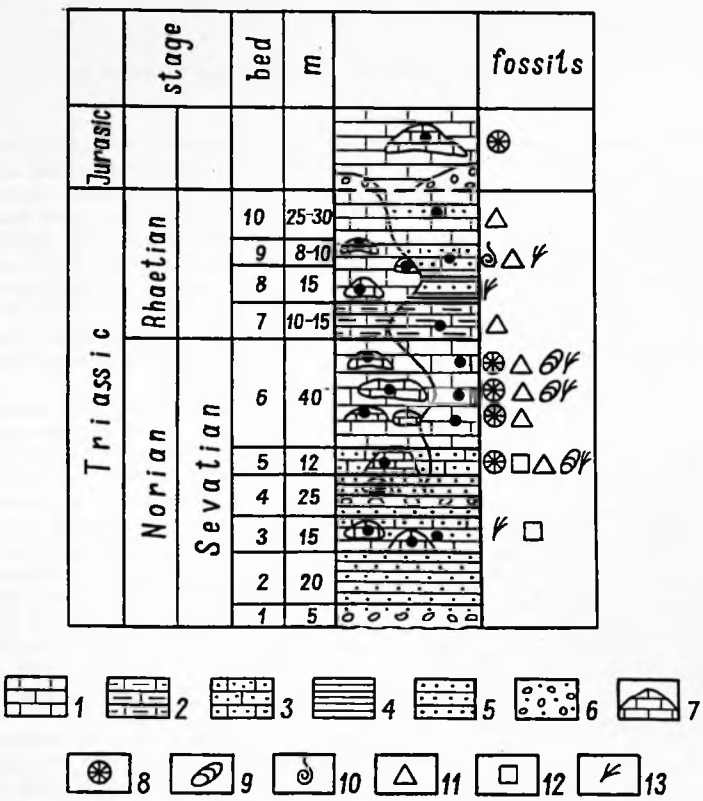

Fig. 1. Stratigraphic column of Upper Triassic deposits of the northwestern Caucasus. Legend: 1 - limestones, 2 - clay limestones, 3 - sandy limestones, 4 - siltstones and clay rocks, 5 - sandstones, 6 - conglomerates and gritstones, 7 - organic buildups (bioherms, biostromes, bioherm massifs), 8 - corals, 9 - sphinctozoa, 10 - ammonoids, 11 - brachiopods, 12 - pelecypods, 13 - algae.

[1] Institute of Geology and Geophysics of the Siberian Branch of the Russian Academy of Sciences, Novosibirsk

[2] Geological Institute of the Academy of Sciences, Dushanbe

Sphinctozoa were found in bioherm and interbioherm facies at the level of layers 5 and 6 of the Yatyrgvart Mountain section (Fig. 1), representing the uppermost part of the Norian. In our collection they are represented by: *Solassia* sp., *Girtycoelia* sp., *Amblysiphonella sahrajensis* Belyaeva, *Amblysiphonella* sp., *Cystauletes bzhebsi* Belyaeva, *Ascosymplegma caucasica* Boiko, *A. expansum* Seilacher, *Polytholosia* cf. *astoma* Seilacher, *Polytholosia* sp., *Sahraja triassica* Moisseev, *Cryptocoelia* sp., *Neoguadolupia incrustatus* Boiko and *Verticillites* sp. Predominant are representatives of families Polytholosiidae (*Sahraja triassica*, *Polytholosia* cf. *ascoma*, *Polytholosia* sp.), Ascosymplegmatidae (*Ascosymplegma caucasica*, *A. expansum*), and Sebargasiidae (*Amblysiphonella sahrajensis*, *Amblysiphonella* sp.). An analysis of the distribution of the above Sphinctozoa shows that the representatives of the genus *Ascosymplegma* are, within the Tethys, restricted to the Upper Triassic (Table 1); they occur predominantly in the upper Norian of North America (Yukon, Nevada), South America (Peru) and India. The genus *Polytholosia* was found in the Upper Triassic of North America and *P. ramosa* Sennowbari-Daryan et Reid occurs in south Yukon in the zone of *Rhabdoceras suessi* (Sennowbari-Daryan and Reid, 1986). *Polytholosia polystoma* Seilacher was found in the upper Norian-Rhaetian in the Pamirs (Boiko et al., 1990).

In the northwestern Caucasus, representatives of the genus *Sahraja* are the most abundant Sphinctozoa. These are also known from the upper Sevatian in the Pamirs and from Norian deposits of Sicily (Sennowbari-Daryan, 1982). In Greece (Sennowbari-Daryan and Schäfer, 1983), Italy, Austria, North America and Tibet, the genus *Cryptocoelia* is restricted to the Norian-Rhaetian boundary beds. In some regions representatives of *Verticillites* appeared in the late Norian and persisted up to the end of Cretaceous. Other sphinctozoa, found in the Caucasus, have a long stratigraphic range and are therefore of little importance for correlation. These are for example *Amblysiphonella*, known from Cambrian to the top of the Triassic, and *Cystauletes*, known from the Carboniferous to the Triassic.

The Sphinctozoa of the northwestern Caucasus have most common forms with late Norian complex (*Rhabdoceras suessi*) of south Yukon, (Sennowbari-Daryan and Reid, 1986) and Pamirs (Boiko et al., 1991).

Triassic corals in the northern Caucasus were first reported by A.S. Moisseev (1944), who described five species: *Retiophyllia (Thecosmilia) labaensis* (Moisseev), *Volzeia (Thecosmilia) subdichotoma* (Münster), *Margarosmillia (Thecosmilia) charlyana* (Frech), *Pamiroseris (Thamnastraea) meriani* var. *robinsoni* (Stoppani) and *Astraeomorpha* ex gr. *confusa* Winkler.

The study of the scleractinia collection we sampled in 1988 allowed us to improve ideas about the composition and stratigraphic distribution of coral complexes. The remains occur both in the form of fragments and as safe colonies. Coral microstructure is often not preserved due to strong recrystallization, so generic assignments are based only on morphological features. In the northwestern Caucasus corals were found together sphinctozoans in the Sakhral and Khodz river valleys at the level of upper Norian layers 5 and 6 and in the transitional Norian-Rhaetian beds. These include *Astraeamorpha crassisepta* (Reuss), *A. confusa* (Winkler), *Distichophyllia norica* (Frech), *Margarosmilia charlyana* (Frech), *Margarosmilia zieteni* (Klipstein), *Oedalmia* sp., *Pamiroseris meriani* (Stoppani), *Retiophyllia buonamici* (Stoppani), *R. caespitosa* (Reuss), *R. fenestrata* (Reuss), *R. gracilis* Roniewicz, *R. langobardica* (Stoppani), *R. labaensis* (Moisseev), *R. minima* (Melnikova), *R. weberi* (Vinassa de Regny) and *R. norica* (Frech).

In this complex, representatives of *Retiophyllia* predominate. Among them there is a single endemic species for the northern Caucasus - *Retiophyllia labaensis* (Moisseev). The genus

Retiophyllia is widespread in upper Norian-Rhaetian deposits of many regions. For example, *R. norica* (Frech), *R. gracilis* Roniewicz, *R. caespitosa* (Reuss), *R. fenestrata* (Reuss), *R. langobardica* (Stoppani) are common in the Kössen and Zlambach beds of Northern Alps and in the Zu limestones in Southern Alps. In the southeastern Pamirs, in deposits of the Bortepinskaya and Dzhigakochusuiskaya suites, *Retiophyllia minima* (Melnikova) and *R. weberi* (Vinassa de Regny) were found in addition to species listed above. The northern Caucasus species *Retiophyllia caespitosa* (Reuss) and *R. fenestrata* (Reuss) are known from North America (Idaho), from the upper part of the Martin Bridge Formation. The same species were found in Primorye. In addition to these, *Retiophyllia minima* (Melnikova) and *R. buonamici* (Stoppani) are known there. Apart from species of *Retiophyllia*, *Astraemorpha crassisepta* (Reuss), *A. confusa* (Winkler), *Distichophyllia norica* (Frech), and *Pamiroseris meriani* (Stoppani) are abundant in the northern Caucasus. These species have a wide geographical distribution in the Norian-Rhaetian. In the northern Caucasus, *Margarosmilia charlyana* (Frech) and *M. zieteni* (Klipstein) are found rarely in small numbers, and in areas far apart from each other. These latter species are known from the Norian of the Northern and Southern Alps, southeastern Pamirs, Primorye, and North America. *Cyatocoenia schafhautli* (Winkler) and *Oedalmia* are found in the Alps, Pamirs, North America and Primorye have the most limited geographical distribution in the northern Caucasus. As a whole, the coral complex bears the greatest similarities to the upper Norian-Rhaetian corals from Southern Alps (Zu Limestones) and southeastern Pamirs.

Common genera and species of corals and sphinctozoa from Sevatian-Rhaetian deposits of the northwestern Caucasus and other regions are given in Table 1.

The two characteristic groups of Late Triassic frame-builders show that: (1) within the Tethys, corals can excellently be correlated at species level (of the northern Caucasus seventeen species, of which only one is endemic, the others have a wide distribution), (2) at the same time, sphinctozoa can only be correlated at generic level (of the total number of eleven species, known from the southwestern Caucasus, only *Ascosymplegma expansum* Seilacher is found in North America).

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Common genera and species of Sevatian-Rhaetian sphinctozoa and corals of the northwestern Caucasus and other regions

	North Caucasus	Pamir	South-East Asia (India, China)	North America (Yukon, Oregon, Nevada)	Alps	Greece	Italy Sicily
Sphinctozoa							
Amblysiphonella	+	+	+			+	
Ascosymplegma	+	+	+	+			
A. expansum Seilacher	+			+			
Polytholosia	+	+	+				
Cryptocoelia	+	+	+	+	+	+	+
Sahraja	+	+	+				+
Verticillites	+	+		+	+	+	
Scleractinia							
Astraeomorha confusa (Winkler)	+		+	+	+		+
A. crassispeta (Reuss)	+	+	+	+			+
Cyathocoenia schafhautli (Winkler)	+	+	+	+			+
Distichophyllia norica (Frech)	+	+	+	+	+		+
Margarosmilia charlyana (Frech)	+	+	+		+		
M. zietteni (Klipstein)	+	+	+	+			
Oedalmia	+	+					
Pamiroseris meriani (Stoppani)	+	+	+	+	+		+
Reticophyllia buonamici (Stoppani)	+	+			+		+
R. gracilis Roniewicz	+				+		
R. lanobardica (Stoppani)	+	+					
R. minima (Melnikova)	+	+					
R. caespitosa (Reuss)	+			+			
R. fenestrata (Reuss)	+	+		+			
R. norica (Frech)	+	+	+	+	+		+
R. labaensis (Moisseev)	+						
R. webery (Vinassa de Regny)	+	+	+		+		

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FROM THE EDITOR

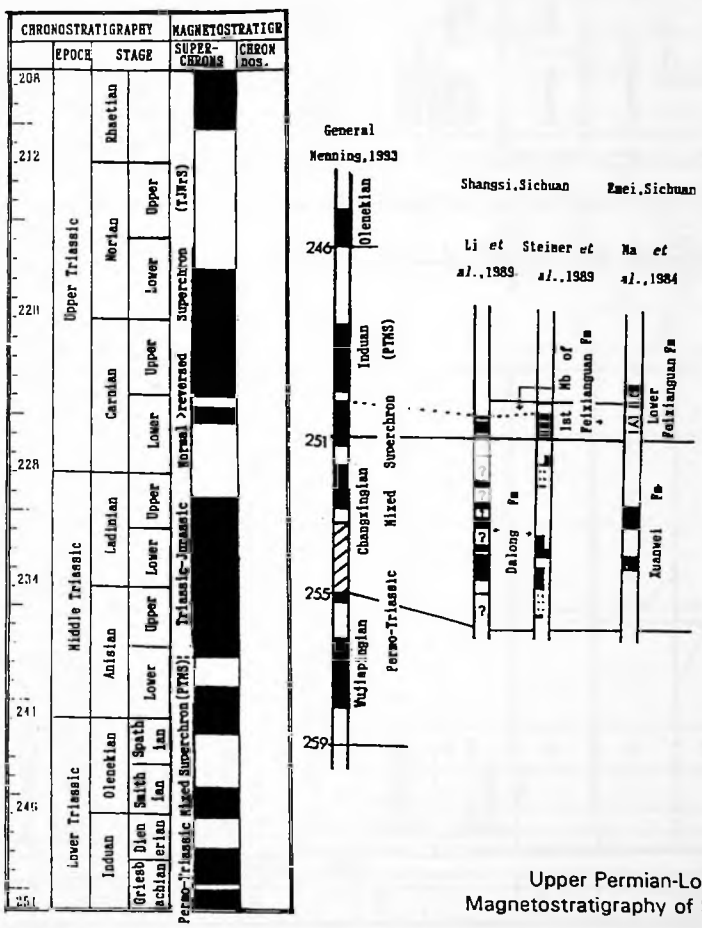
ALBERTIANA has developed into a very flourishing newsletter. Since it it published twice a year, the number of pages has doubled. This means of course that the production of ALBERTIANA has become much more time-consuming. Therefore, authors are urged to submit the contributions on a floppy disc. Only discs in MS-DOS format can be accepted, preferably in WordPerfect 5.1 or any other kind of word-processing program that can be converted into WordPerfect 5.1 (e.g. Word, WordStar or as a plain ASCII file) together with a printed hard copy. This will considerably facilitate and the production of *Albertiana*. Moreover, this will reduce the risk of typing errors. Authors are kindly requested submit text that are ready for printing; special attention should be paid to grammar and syntax. References should be in the format used in the 'Annotated Triassic Literature'. Those who do not have the possiblity to submit a manuscript in electronic format, are kindly requested to send smooth and clearly typed manuscripts in a 12-point typeface with single line spacing. Tables and schemes should be in camera-ready format, clearly drawn or printed; only originals can be accepted, xerox copies cannot longer be accepted. Due to time restrictions it is not longer possible to redraw tables and schemes as has been done previously. For the same reason it is impossible to send proofs. Although the editor can now also be reached by e-mail, discs are preferred. Triassic workers are kindly requested to send reprints or xerox copies of the titles and abstracts (including journal, volume and page numbers) of their recently publsihed papers to the editor for the 'Annotated Triassic Literature'

Hans Kerp (editor of ALBERTIANA)

SYNTHETIC REGIONAL STRATIGRAPHIC CHARTS OF SOUTH CHINA

Yin Hongfu

The following pages contain stratigraphic charts compiled by Prof. Yin Hongfu (June, 1994).



Upper Permian-Lower Triassic Magnetostratigraphy of South China

Table 2

208			AMMONOID	CONODONT
212		R		
		U N		
220		N A L N		
		U C	Thisbites-- Discotropites	
228		L C	Trachyceras-- Protrachyceras	
		U L	Protrachyceras deprati	
231		L L		Paragondolella excelsa-- Neog. nombergensis
		U A	Paraceratites trinodosus Paraceratites binodosus	Neog.constricta-- Neos.germanicus
241		L A	Nicomedites yohi Parapopanoceras nanus	Neogondolella regale
		U O	Procarnites oxynotus Tirolites cassianus, Columbites costatus	Neos. timorensis Neos. homeri Neos. triangularis
246		L O	Pseudovenites oxynotus Owenites costatus	Neos. wangeni Neos. pakistanensis
		U I	Koninkites lingyunensis Proptychites kwangsiensis	Neos. cristagalli Neos. dieneri Neos. kummeli
251		L I	V.marginalis,O.sinensis	Neog.carinata,I.isarcica 'Hindeodus' parvus

Table 2 (contd.)

208			BIVALVE	PLANT	
212		R		Dictyophyllum -- Clathropteris	Ptilozamites -- Lepidopteris
		U N	Yunnanophorus boulei		
220		N A L N	Burmesia lirata		Rireticopteris-- Pteropyllum longifolium
		U C	Halobia comata Halobia superba Costatoria kweichooweni Tosapecten		
228		L C			
		U L	Daonella lommeli Daonella indica	Annalepis zeilleri-- Neocalamites meriani	
231		L L			
		U A	Costatoria goldfussi mansuyi		
241		L A	Leptochondria illyrica		
		U O	Eumorphotis inaequicostata	Voltzia-- Neuropteridium	
246		L O	Pteria murchisoni		
		U I	E. multiformis Claraia aurita		
251		L I	Ps.wangi, C.stachei Tovapteria scythica		

Table 3

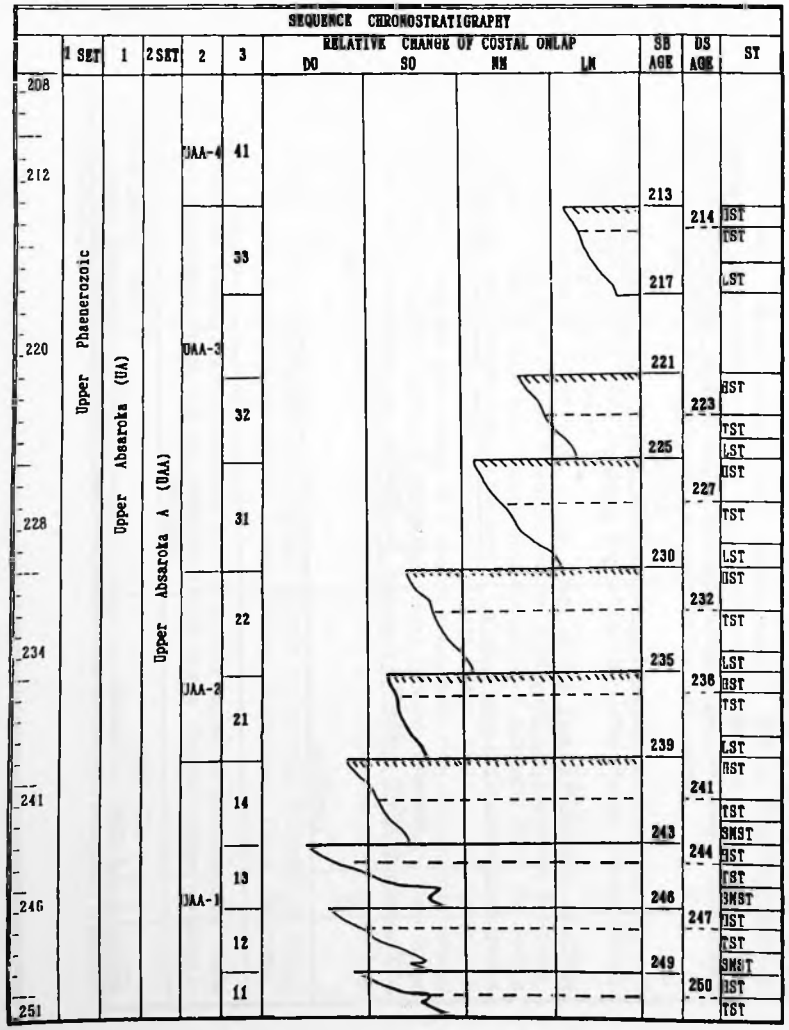


Table 3 (contd.)

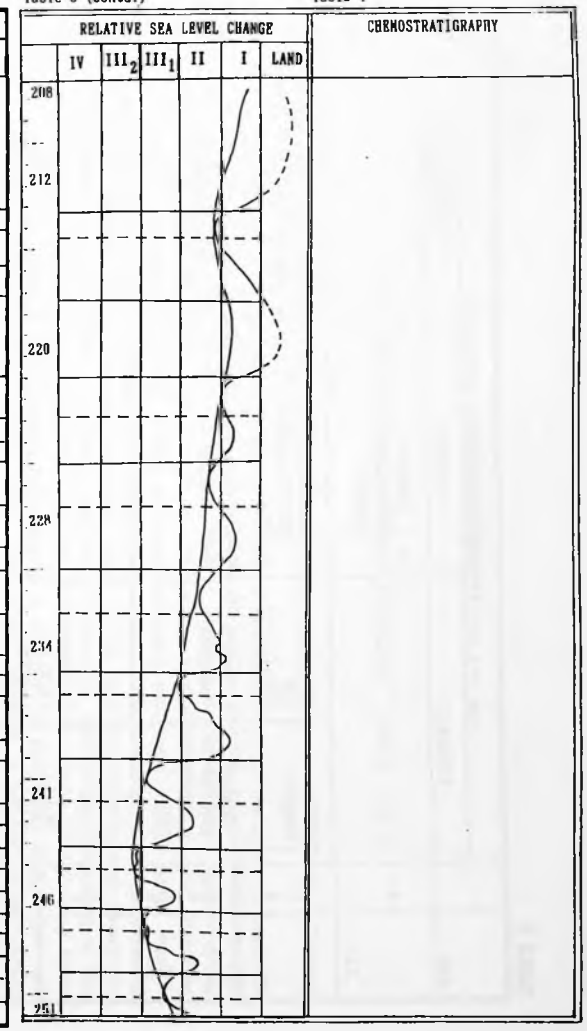


Table 4

CHEMOSTRATIGRAPHY

TABLE 5

208		EVENTOSTRATIGRAPHY			
		BIOLOGIC		OROGENIC	SEDIMENTARY
212	R	<*D.C.* Flora		Ω L Yangtze (Xiangshan Orogeny)	■
	U N	Tethys (Yangtze)	Boreal (SE China)	Ω Sanjiang, Shiwandashan Ω Bayan Har	■ –Yue-Xiang-Gan
220	M & L N	< *Yunnan opholus --Burmesia*	< *Waagen oconcha*	Ω S Qinling	→ Longmengshan E Yunnan
	U C	< *Halobia*	< *Jiangsiella, Guangella*		
228	L C			Ω Yujiang, Sanjiang	→ Yue-Xiang-Gan (Boreal)
	U L	Tethys		↑Ω Yue-Jiang-Gan ↓ S Qinling, Bayan Har	→ Youjiang → M & U Yangtze
234	L L	+ *Halobia*		Ω N Qinling	→ S Qinling S Qilian
	U A	< *Progonoceratites* U. Yangtze			→ L Yangtze
241	L A	+ *Daonella* + Mesoz. bioherm		↓ Youjiang v U. Yangtze	evaporites
	U O	< *Tirolites*			
246	L O				
	U I			v Yujiang, Sanjiang	→ maximum
251	L I	+ *IOC* Biota* x mass extinction			lack biogen.carbo. → rapid, anoxic

ANNOTATED TRIASSIC LITERATURE

Hans Kerp and Henk Visscher[1]

AIGNER, T. and BACHMANN, G.H., 1992. Sequence-stratigraphic framework of the German Triassic. Sediment. Geol., 80: 115-135.

The sequence stratigraphic methodology can be readily applied to the cratonic basin-fill of the classic German Triassic, consisting of shallow-marine to terrestrial mixed carbonate/siliclastic rocks. The whole Triassic succession represents a second-order transgression/regression cycle, built by third-order depositional sequences, systems tracts, and parasequences. Many bounding surfaces represent widely used marker beds, long used in classical lithostratigraphy. Using a synthesis of outcrop, well-log and literature data on stratal geometry, facies, cycle stacking patterns and paleogeography, a regional chart of coastal onlap was constructed. Within the limitations of the presently available biostratigraphic data, the observed cycles appear to correlate fairly well with those in other areas, but include a number of additional sequences not included in the Haq et al. (1988) chart. Comparative analysis of regional onlap curves from different, globally spread Triassic basins, together with an improved biostratigraphy will be necessary to relate the accommodation changes to eustatic versus tectonic and climatic controls and to produce a refined eustatic chart. The German Basin could provide a favourable reference point for such an analysis.

ASELMEYER, G.U. and KULKE, H., 1994. Sedimentologie und Petrologie obertriassischer und jurassischer Sandsteine und das Ölfeld Yanchang im südöstlichen Ordos-Becken (Zentral-China). Zbl. Geol. Paläont., Teil 1(7/8): 973-984.

The intracontinental Ordos Basin in the heart of the People's Republic of China contains, above an incomplete Paleozoic section, continental clastics of the Mesozoic. An approx. 1300 m thick Late Triassic-Jurassic sequence crops out along the valleys of the Yanhe and Xichuan rivers in the area of Yan'an. These siliciclastics grade from a meander plain with some thin coal seams through braided alluvium and suprajacent sandstones, siltstones plus shales of a second meandering river system to a several metres thick lacustrine carbonate of the uppermost Jurassic. The oldest oilfield in the P.R. of China is situated next to Yanchang, eastward of Yan'an. The oil is trapped in a domal or monoclinal structure within Late Triassic reservoir sandstones at shallow depth.

BERNASCONI, S.M., 1994. Geochemical and microbial controls on Dolomite Formation in anoxic environments: A case study from the Middle Triassic (Ticino, Switzerland). Contr. Sediment., 19: 2-95.

The Middle Triassic Grenzbitumenzone is a 16 m thick sequence of interbedded, finely laminated organic matter-rich dolomites and black shales. Organic carbon contents in

[1] The help of Heike Hagemann, Gaby Schwenzien and Sabine Gibas (Münster), Dr. Zwier Smeenk (Utrecht) and Dr. Sandor Kovács (Budapest) in tracing relavant literature and compiling this bibliography is gratefully acknowledged.

the dolomites reach 10wt%, whereas black shales have organic carbon contents of up to 40 wt%. Geochemical calculations based on trace metal concentrations in the black shales together with paleontological and sedimentological data indicate that the sediments of the GBZ were deposited at extremely low sedimentation rates (2 to 5m/my) in a silled shallow marine basin (30-100 m deep) under permanently anoxic conditions. Sedimentary structures indicate that the dolomites are the product of periodic turbiditic transport of calcium carbonate mud into the basin diluting a more or less constant organic matter-siliciclastic background sedimentation. Carbon isotope compositions of the dolomites range from -1.4 to -5.6‰ (PDB) indicating that dolomite was formed in the sulphate reduction zone of organic matter diagenesis. No organic or inorganic geochemical evidence for methanogenetic activity is found in the sediments, suggesting that dolomite may have formed before sulphate was completely depleted from the pore waters. Sedimentary structures and the small variations in carbon isotopic compositions suggest that dolomite is mostly of replacement origin. Commonly, depth and temperature of dolomite formation are determined solely on the basis of oxygen isotope thermometry. However, because oxygen isotope compositions of dolomite can be modified by late diagenetic exchange with warmer fluids during burial, the determination of the depth of dolomite formation is always rather speculative. Synsedimentary slump structures in the Grenzbitumenzone, however, allow the depth of dolomite formation to be constrained and to evaluate the effect of burial diagenesis on its oxygen isotopic composition. The deformation behaviour of various dolomite layers attest to early lithification, with extensive dolomitization occurring only a few centimetres to decimeters below the sediment-water interface. The oxygen isotope compositions of dolomites, however, show a relatively wide scatter and range from -0.4 to -6.5‰ (PDB). The $\delta^{18}O$-values become more negative with increasing grain-size and percentage of late diagenetic dolomite cements. Fluid inclusion data from these cements indicate a maximum precipitation temperature of approximately 70°C from fluids with salinities close to that of seawater. The range in oxygen isotopic compositions of the dolomites is therefore interpreted as the result of partial reequilibration of early formed dolomite during late diagenesis. This study shows that the combination of slow sedimentation rates and high supply of organic matter are the main factors that favoured extensive early diagenetic dolomization in the GBZ. The slow sedimentation rate allowed enough time for magnesium and sulphate to diffuse into the pore waters. The high alkalinity produced by organic matter decomposition through sulphate reducing bacteria, combined with the availability of magnesium, led to high dolomite supersaturation in the pore-waters and to the replacement of the abundant precursor calcium carbonate. Organic geochemical data indicate that the organic matter is immature and primarily of marine origin with high bacterial contribution and can be classified as type II. A high contribution of bacterial lipids to the kerogen is indicated by high hopane concentrations. A model is presented in which sedimentation and organic matter accumulation and preservation is dominated by two major factors: the periodic deposition of carbonate mud turbidites and the presence of a permanently stratified water column in which cyanobacteria and chemoautotrophic bacteria formed a bacterial plate at the anoxic-oxic interface.

Bindig, M., 1994. Die Architektur der fluviatilen Environments der Solling-Formation (Buntsandstein). Zbl. Geol. Paläont. Teil I, 1992 (11/12): 1167-1187.

The facies analysis of the Solling Formation (Buntsandstein) in an area between Alsace/Palatinate and southern Lower Saxony is presented. Sedimentation is reconstructed using analyses of vertical sections, architectural elements and palaeocurrents.

Considering the regional and stratigraphic positions, the vertical and lateral facies associations are summarized in ten mostly fluvial facies models.

BREDE, R. , HOTTENROTT, M. and SCHUSTER, C., 1993. Zur Keuper-Stratigraphie im Netraer Graben (Bl. 4926 Herleshausen; Nordhessen/Thüringen). Geol. Jb. Hessen, 121: 61-81.

The ESE-striking Netra-Graben is part of the northern Hessian-Thuringian graben system. In the eastern part of the geologic map 4926 "Herleshausen" around the mountains Eichenberg, Weinberg and Galgenrain east of Netra village, the graben along its centre contains rocks of the Middle and Upper Keuper. Another small occurrence is situated in a presumed subrosion depression near Wolfmannsgehau hamlet. There only exist isolated outcrops of the Lower Keuper and lowermost Middle Keuper but, in the uppermost Middle Keuper (Steinmergelkeuper) longer sections up into the basinal beds of the Rhaetian could be measured. Certain beds can be used as regional marker horizons. Following the palynological investigations the Rhaetian strata reach up till to the Upper Rhaetian. The microflora is compared with other occurrences in different regions. The total thickness of the Keuper lies around 360 m.

BROGLIO LORIGA, C., IETTO, A. and POSENATO, R., 1993. Banchi a *Cornucardia* nell'Unità di San Donato (Triassico superiore, Calabria settentrionale). Atti Tic. Sc. Terra, 36 (1993): 121-129.

Cornucardia banks have been identified in the upper part of the Formazione delle Dolomie, belonging to the Unità di San Donato (?Lower to Upper Triassic). They outcrop on the SE side of Timpone Scifarello, to the west of Castrovillari village (Cosenza, southern Italy). The 400-500 m thick Formazione delle Dolomie is the most fossil-rich in the entire Unità di San Donato and lies on the Formazione dei Calcari, a strongly recrystallized carbonatic unit ascribed to the Ladinian. The Unità di San Donato has been affected, to varying degrees, by strong recrystallization. The biochronological data are, therefore, very poor, particularly those inferred from macrofossils. The fossiliferous banks consist of dark saccharoidal dolomitic limestone. The fossils are mostly represented by internal molds, sometimes with recrystallized fragments of the thickest portions of the shell (umbonal and hinge regions). The fossil assemblage of the *Cornucardia* banks are dominated by *Cornucardia hornigi* (Bittner), associated with very rare specimens of *Parallelodon* sp., *Arcavicula* cf. *aspera* (Pichler) and *?Myophoriopis* sp. *C. hornigi* was first established in the Vesprém Marls (Tuvalian) of the Bakony (Hungary) and then in the uppermost San Cassiano Formation (Julian) from the Dolomites (Southern Alps). Based on these fossils a middle to late Carnian age is assigned to the Formazione delle Dolomie.

BRUGMAN, W.A., VAN BERGEN, P.F. and KERP, J.H.F., 1994. A quantitative approach to Triassic Palynology: the Lettenkeuper of the Germanic Basin as an example. *in:* A. TRAVERSE (ed.), Sedimentation of organic particles, pp. 409-429. Cambridge University Press.

This study is based on a cored section of the Obernsees well in Franken, Bavaria, Germany. A 40 m thick, densely sampled interval, covering the uppermost Muschelkalk, the Lettenkeuper and the lowermost Gipskeuper (lower Myorphorienschichten) was studied palynologically. Quantitative analysis enable the differentiation of locally controlled environmental from large scale regional changes. As a sequel to the stratigraphic interpretation of palynological samples, attention was given to palynofacies analysis, a method that focuses on the total acid-resistant organic matter content. The recognition of (eco)phases and palynofacies units may provide a distinct link between the depositional environment and the source area of the organic material. A succession of eleven different depositional environments has been recognised in the

Fassanian to upper Langobardian. The combination of quantitative palynostratigraphy and palynofacies analysis shows that such an approach contributes to a more accurate and detailed stratigraphical, depositional and environmental interpretation.

BUCHER, H., 1994. New ammonoids from the Taylori zone (middle Anisian, Middle Triassic) from Northwestern Nevada (USA). *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 1-8.

The biostratigraphic distribution of the Taylori Zone ammonoids is updated and four new species are described. A new subzone is introduced in the uppermost part of the Taylori Zone.

BUDAI, T., 1992. Middle Triassic formations of the Balaton Highland and of the Southern Alps: Stratigraphic correlation. Acta Geol. Hung., 35(3): 217-236.

This paper aims at the demonstration of the well-known relationship between the Middle Triassic sequences of the Balaton Highland and the Southern Alps, by means of geological sections. On the basis of field experience gained in the Southern Alps, and of published data, the following general statements can be made: The greatest similarity among the different regions is manifested in the Anisian sequence of the Balaton Highland and that of Lombardy. The most important common features are: (1) the continuity of sedimentary sequences, the absence of gaps and of the coarse detrital formations, (2) the lack of lateral facies variation within the Lower Anisian shallow marine carbonates, (3) the development of the sediments of the basins as a result of the Middle to Upper Anisian facies differentiation, and their relation to the platforms, (4) the very similar history of evolution of the two basins, within which at least temporal displacements can be recognized. The sedimentary hiatus and the formation of coarse detritus, as well as the dynamic evolution and strongly discordant basement of the syncline, are unknown in the Anisian sequence of the Balaton Highland, but are characteristic of the Dolomites. Between the Ladinian sequence of the Balaton Highland and that of the Southern Alps, generally the degree of similarity is less. Among the differences, the following can be emphasized: (1) volcanism proved to be more intense in the Southern Alps, (2) in the Balaton Highland, the sediments, probably deposited in a condensed manner in a pelagic basin, extend throughout the entire Ladinian, while the formations of the South Alpine basins are more variegated and thicker (possibly the occurrence of red limestone in the Balaton Highland relates to a transition towards the Schreyeralm eupelagic facies region), (3) in the Balaton Highland the broken relief developed during the Anisian, became essentially smooth in the Ladinian, while the syncline of the Southern Alps continued its dynamic evolution.

BUDAI, T., LELKES, G. and PIROS, O., 1993. Evolution of Middle Triassic shallow marine carbonates in the Balaton Highland (Hungary). Acta Geol. Hung., 36(1): 145-165.

In the Transdanubian Central Range the shallow marine carbonates show a characteristic evolution in the Triassic. The first shallow subtidal carbonates of great areal extension appeared in the Middle Triassic. Well developed "true" platforms with elevated build-ups and steep slopes towards the basins were formed only in the Carnian, and they were separated from one another by intrashelf basins filled with clastic sediments. These were the precursors of the huge shallow marine platforms grown during the Norian-Rhaetian (Hauptdolomite, Dachstein Formation).

BUDAI, T. and VÖRÖS, A., 1992. Middle Triassic history of the Balaton Highland: extensional tectonics and basin evolution. Acta Geol. Hung., 35(3): 237-250.

In the Balaton Highland, sharp lateral facies differentiation can be observed on the shelf which had been uniformly developing from the Upper Permian to the middle Anisian. The carbonate platform which developed up to the Pelsonian (Megyehegy Dolomite), disintegrated along NW-SE trending lines. Subsequently, basin sediments were deposited (Felsőörs Formation) in the subsided areas of the platform, while on those remaining in an uplifted position, shallow marine carbonate sedimentation continued (Megyehegy Dolomite, Tagyon Limestone). Based on analogies to the Middle Triassic of the Southern Alps and to the Jurassic of the Bakony Mountains, the facies differentiation occurring during the Pelsonian could have been generated by synsedimentary block tectonics; this is proven by characteristic sediments and sedimentary structures, and by submarine expansion fissures, in addition to the sudden and large-scale lateral and vertical facies changes (see Galácz and Vörös, 1972, Bechstädt et al. 1978).

BUDAI, T. and VÖRÖS, A., 1993. The Middle Triassic events of the Transdanubian Central Range in the frame of the Alpine evolution. Acta Geol. Hung., 36(1): 3-13.

The first, Pelsonian facies differentiation in the Transdanubian Central Range coincided with a global sea level rise but the effects of the local extensional tectonism were decisive. The late Illyrian event (drowning of all carbonate platforms) can be due to sudden tectonic subsidence and to the simultaneous effect of volcanic ash falls. The late Illyrian-early Ladinian rhyolitic-trachytic tuffs are widespread whereas the late Ladinian, intermediate-mafic volcanoclastics seem to be restricted to the eastern part of the TCR. Further evidences, such as distribution of diagnostic facies and paleobiogeography of brachiopods and ammonites strongly suggest that in the Middle Triassic the Transdanubian Central Range belonged to the southern shelf of the Meliata ocean in close vicinity of the Southern Alps.

BUDUROW, K. and TRIFONOVA, E., 1994. Progress in concepts about conodont and foraminifera zonal standards of the Triassic in Bulgaria. *in*: GUEX, J. and BAUD, A. (eds), Recent developments on Triassic stratigraphy. Mém. de Géologie (Lausanne), 22: 9-14.

Conodont and foraminifera zonations have been successfully applied to many stratigraphical problems in Bulgaria, including the correlation of the two different types of Triassic successions in this country.

CHONGLAKMANI, C. and GRANT-MACKIE, J.A., 1994. Biostratigraphy and facies variation of the marine Triassic sequences in Thailand. Int. Symp. on Biostrat. of Mainland Southeast Asia: Facies & Paleontology, 31 January - 5 Febmary 1993, Chiang Mai, Thailand, 1, 1993.

The marine Triassic sediments in Thailand, more than 3,000 m thick, are rather complete from Lower to Upper Triassic. The proposed biostratigraphic division, based on stratigraphic sequences in the Lampang-Phrae Basin, comprise twelve faunal assemblages. These are the *Claraia-Ophiceras* zone (Late Griesbachian); *Hollandites-Leiophyllites*, *Hollandites-Balatonites*, and *Costatoria* zones (Anisian); *Daonella indica* zone (Ladinian); *Parathrachyceras* zone (Early Carnian); *Halobia styriaca*, *H. charlyana*, *H. parallela*, and *Trigonodus* zones (Middle-Late Carnian); and the *Halobia distincta* and *Indopecten* zone (Early Norian). The marine Triassic sediments can be classified into four distinct facies, viz. the near-shore neritic, off-shore neritic, slope and basin, and deep marine facies. The first three are sediments deposited extensively from Late Griesbachian to Early Norian in the intracontinental basins, and the last represents the true oceanic sediments of Carnian age deposited in the northwest region.

Dagys, A.S., 1994. Lower Triassic stage, substage and zonal scheme of north-eastern Asia. *in*: Guex, J. and Baud, A. (eds), Recent developments on Triassic stratigraphy. Mém. de Géologie (Lausanne), 22: 15-24.

A disccussion of the biochronological scheme for the Lower Triassic of Siberia and a correlation with the Canadian scheme.

Dagys, A.S. and **Dagys, A.A.**, 1994. Global correlation of the terminal Triassic. *in*: Guex, J. and Baud, A. (eds), Recent developments on Triassic stratigraphy. Mém. de Géologie (Lausanne), 22: 25-34.

This paper summarizes the problem of the states of the Rhaetian. The authors conclude that the Rhaetian with its lower boundary at the base of the Reticulatus Zone is in full agreement with the principle of priority, has enough sharp distinctions of main groups of the marine invertebrates at the lower boundary and equivalents of such Rhaetian may be recognized throughout the world. Moreover, this interpretation allows the preservation of the traditional schame of stages and substages in the terminal Triassic.

Dagys, A. and **Weitschat, W.**, 1993. Correlation of the Boreal Triassic. Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 75: 249-256.

Based on new data the zonal scheme of the Boreal Triassic (Siberia, Svalbard, Greenland, Arctic Canada, and British Columbia) is revised. The principal correlation problems are shown. A new zonal standard is proposed for the Lower and Middle Triassic of the Boreal regions.

Dagys, A., **Weitschat, W.**, **Konstantinov, A.** and **Sobolev, E.**, 1993. Evolution of the boreal marine biota and biostratigraphy at the Middle/Upper Triassic boundary. Mitt. Geol.-Paläont. Inst. Univ. Hamburg, 75: 193-209.

New data from different revised sequences in Arctic Siberia (Okhotsk region, Omolon Basin, East Taimyr) and from Svalbard Archipelago have lead to a better understanding of the biostratigraphy of the Ladinian/Carnian transition of the boreal province. For the latest Ladinian a new zone, that of *Nathoristites lindstroemi* is proposed which does not correlate exactly with the *Frankites sutherlandi* zone of NE-British Columbia. It cannot be excluded that the Middle/Upper Triassic transition is not continuous in North Canada as previously supposed. The *Stolleyites tenuis* zone of the lowermost boreal Carnian can be divided into two subzones, at least in sections of the Okhotsk Sea (Yana River) and Eastern Spitsbergen. Precise correlation of the *tenius* zone with the *Trachyceras desatoyense* zone of British Columbia is still not possible until now.

Dosztály, L. and **Józsa, S.**, 1992. Geochronological evaluation of Mesozoic formations of Darnó Hill at Recsk on the basis of radiolarians and K-Ar age data. Acta Geol. Hung., 35(4): 371-393.

The radiolarian fauna and K-Ar ages of Mesozoic oceanic fragments of Northern Hungary have been determined. In the Tóalmás-2 borehole assemblages of Middle and Upper Jurassic age, on Darnó Hill and near Bátor and in the Szarvaskő area, Middle-Upper Triassic and Middle-Upper Jurassic ones, in borehole Tornakápolna-3 only Middle Triassic radiolarian assemblages were found. In the outcrops of Darnó Hill, normal layering of Triassic formations was encountered, while in the boreholes of the same area, normal Triassic and Jurassic sequences could be established. The similarities of K-Ar age distribution within those parts of the Darnó and Szarvaskő sequences which contain Jurassic radiolarians point to the similar geological evolution of these

two areas. The radiolarian fauna of the Triassic of these terranes is similar to that of Melléte (Meliata) Series in Southern Slovakia and that of Tornakápolna unit, which is also thought to belong to the Melléte (Meliata) series. We concluded that the Jurassic portions of the studied sequences (Vardar ocean) may have originated in the back arc system of the Triassic ocean (Melléte [Meliata] ocean), and that they came together by later nappe movements.

DUFFIN, C.J., 1994. Myriacanthid holocephalans from the British Late Triassic. N. Jb. Geol. Paläont., Abh., 192: 1-16.

New material of *Agkistracanthus mitgelensis* is described from Cotham Member of the Lilstock Formation (Penarth Group, "Rhaetic") of Saint Audries Bay, and the Late Triassic fissure filling at Holwell. This is the first record of species outside Switzerland. A tooth plate of *Myriacanthus paradoxus* is described from the Westbury Formation (Penarth Group) of Aust Cliff, extending the known range of the species into the Late Triassic.

FEJDIOVÁ, O. and SALAJ, J. 1994. Lithostratigrafická a biostratigrafická charakteristika spodného Triasu silicika na profile v Rakovnici. Zemný plyn a nafta, 39(1): 3-17.

Lower Triassic sediments of the Silicicum, biostratigraphically documented as Campilian - Lower Anisian, differ both from the Lower Triassic Lúžna Formation of the Tatricum and Veporicum and from the Benkov Formation of the Hronicum. Their characteristic feature is the minicyclic repetition of the sandstone and carbonate facies, the latter having a pseudo-nodular character. The sandstone bodies with frequent ripple marks, slump structures, rain drops traces and glauconite content sedimented in a nearshore, shallow environment. Sedimentary structures, distribution and character of fossils indicate an intensive sea level oscillation. Deposition started in an open sea of the archipelagic zone and shows the trend to the restriction of the communication with an open sea. Higher plagioclase and volcanic detritus contents in sandstones document the affinity of the source area to the volcanic arc.

FIJALKOWSKA, A., 1994. Palynostratigraphy of the Lower and Middle Buntsandstein in northwestern part of the Holy Cross Mts. Geological Quarterly, 38(1): 59-96.

Three spore-pollen assemblages, representing *Lundbladispora obsoleta-Protohaploxypinus pantii* and *Densoisporites nejburgii* Zones, were distinguished within the Lower and Middle Buntsandstein deposits in the NW part of the Holy Cross Mts. Palynofacies analysis provided for more detail data about the changes of depositional environment during the Early Triassic in the studied area. The palaeoenvironmental model used here indicates two climatic cycles in the Lower and Middle Buntsandstein.

FLÜGEL, E., RAMOVŠ, A. and BUCUR, I.I., 1993. Middle Triassic (Anisian) Limestones from Bled, Northwestern Slovenia: Microfacies and Microfossils. Geologija, 36: 157-181.

Microfacies types (predominantly intrabioclastic grainstones) and microfossils (predominantly dasycladacean algae and diverse foraminifera) characterize the Anisian carbonates near Bled (Castle Hill) and in the area WNW of Bled as subtidal to intertidal shelf sediments deposited in the inner part of the Julian carbonate platform. The age of the carbonates is Middle Anisian (Pelsonian) according to the biozonation based on foraminifera and dasycladaceans.

FOLLO, M.F.. 1994. Sedimentology and stratigraphy of the Martin Bridge Limestone and Hurwal Formation (Upper Triassic to Lower Jurassic) from the Wallowa terrane, Oregon. U.S. Geol. Surv. Prof. Paper, 1439: 1-27.

Stratigraphic and sedimentological analysis of sedimentary sequences from the Wallowa terrane of northeastern Oregon has provided a unique insight into the paleogeography and depositional history of the terrane, as well as establishing important constraints on its tectonic evolution and accretionary history. Its Late Triassic history is considered here by examining the two most important sedimentary units in the Wallowa terrane - the Martin Bridge Limestone and the Hurwal Formation. Conformably overlying epiclastic volcanic rocks of the Seven Devils Group, the Martin Bridge Limestone comprises shallow-water platform carbonate rocks and deeper water, off-platform slope and basin facies. Regional stratigraphic and tectonic relations suggest that the Martin Bridge was deposited in a narrow, carbonate-dominated (forearc?) basin during a lull in volcanic activity. The northern Wallowa platform was a narrow, rimmed shelf delineated by carbonate sand shoals. Interior parts of the shelf were characterized by supratidal to shallow subtidal carbonates and evaporites, which were deposited in a restricted basin. In the southern Wallowa Mountains, lithofacies of the Martin Bridge are primarily carbonate turbidites and debris flow deposits, which accumulated on a carbonate slope apron adjacent to the northern Wallowa rimmed shelf from which they were derived. Drowning of the platform in the latest Triassic, coupled with a renewed influx of volcanically derived sediments, resulted in the progradation of fine-grained turbidites of the Hurwal Formation over the carbonate platform. Within the Hurwal, Norian conglomerates of the Excelsior Gulch unit contain exotic clasts of radiolarian chert, which were probably derived from the Baker terrane. Such a provenance provides evidence of a tectonic link between the Baker and Wallowa terranes as early as the Late Liassic, and offers support for the theory that both terranes were part of a more extensive and complex Blue Mountains island-arc terrane.

FOSTER, C.B., BALME, B.E. and HELBY, R., 1994. First record of Tethyan palynomorphs from the Late Triassic of East Antarctica. AGSO Journal of Australian Geology & Geophysics, 15(2): 239-246.

A well-preserved Late Triassic palynoflora from the upper Flagstone Bench Formation, Prince Charles Mountains, East Antarctica, contains taxa that are also widely distributed in coeval Tethyan Laurasian assemblages. The most common and distinctive of these elements in the present assemblage are: *Enzonalasporites vigens*, *E. densus*, cf. *Ellipsovelatisporites sp.*, *Minutosaccus crenulatus*, cf. *Rimaesporites aquilonalis*, *Ovalipollis ovalis*, *Samaropollenites speciosus*, and *Duplicisporites scurrilis*. The assemblage is assigned to the Australian *Minutosaccus crenulatus* Zone, and considered to be of Norian age. Gondwanan palynofloras containing these Laurasian elements are assigned to the Onslow Microflora, which is represented by Middle and Late Triassic palynomorph assemblages from Madagascar, western and northern Australia, East Africa, and Peninsular India. Occurrences of the Onslow Microflora appear to be confined to sediments deposited in palaeolatitudes between about 40°-30°S. As well as climatic controls, we suggest that other factors influenced the distribution of the parent floral communities. In particular, availability of migration pathways along Tethyan coastal plains, that were exposed during periods of sealevel regression, was an important factor controlling the rapid dispersal of certain Triassic plants. Marine influence on the present assemblage is evident by the rare Spinose acritarchs, and one specimen of a dinocyst of the *Shublikodinium-Rhaetogonyaulax* plexus; this is the first record of a Triassic dinocyst from Antarctica.

GALLET, Y., BESSE, J., KRYSTYN, L., THÉVENIAUT, H. and MARCOUX, J., 1994. Magnetostratigraphy of the Mayerling section (Austria) and Erenkolu Mezarlik (Turkey) section: Improvement of the Carnian (Late Triassic) magnetic polarity time scale. Earth Planet. Sci. Letters, 125: 173-191.

We present a magnetostratigraphic study of two Carnian (Late Triassic) pelagic limestone sections from the Northern Calcareous Alps (Mayerling section) and southwestern Turkey (Erenkolu Mezarlik section). Biostratigraphic control is based on conodont zonation for the Mayerling section, and both on conodonts and ammonoids for the Erenkolu Mezarlik section. In both sections, the characteristic magnetization is essentially carried by a mineral of the magnetite family. Eight magnetic intervals are obtained from the Mayerling section and fourteen from Erenkolu Mezarlik. When these results are compared to the Carnian magnetostratigraphic sequence obtained from the Bolücektasi Tepe section, satisfactory correlations are observed and a composite Carnian magnetic polarity time scale containing 24 intervals can be proposed by combining all these results. The lower part of the upper Carnian is however missing (Tuvalian 1 zone and lower part of the Tuvalian 2 zone). No clear correlation is observed between our composite sequence and the other published magnetostratigraphic data of Carnian age. The satisfactory correlation observed between the Mayerling and the Bolücektasi Tepe sections indicates that both sections were deposited in the northern hemisphere, thus providing constraints on the origin of the Antalya nappes.

GOLDSTRAND, P.M.. 1994. The Mesozoic geologic evolution of the northern Wallowa terrane, northeastern Oregon and western Idaho. U.S. Geol. Surv. Prof. Paper, 1439: 55-73.

Mesozoic rocks along the Snake River in the northern Wallowa terrane represent a volcanic island and its associated sedimentary basins within the Blue Mountains island arc of Washington, Oregon, and Idaho. In the northern part of the Wallowa terrane, rock units include the Wild Sheep Creek, Doyle Creek, and Coon Hollow Formations, the (informal) Imnaha intrusion, and the (informal) Dry Creek stock. The volcanic rocks of the Ladinian to Karnian Wild Sheep Creek Formation show two stages of evolution - an early dacitic phase (lower volcanic facies) and a late mafic phase (upper volcanic facies). The two volanic facies; are separated by eruption-generated turbidites of siliceous argillites and arkosic arenites (argillite-sandstone facies). The two magmatic phases of the Wild Sheep Creek Formation may be recorded by compositional zoning from older quartz diorite and diorite to younger gabbro in the Imnaha intrusion. Although the Late Triassic Imnaha intrusion is in fault contact with the Wild Sheep Creek Formation, it may be a subduction-related pluton and was the likely magna source for the Wild Sheep Creek Formation. Interbedded with the upper volcanic facies are eruption-generated turbidite and debris flow deposits (sandstone-breccia facies) and thick carbonate units (limestone facies). The limestone facies consists of two marker units, which may represent carbonate platform environments. Clast imbrication, fossil orientation, and cross-stratification in the Wild Sheep Creek Formation indicate a shoaling to subaerial volcanic island to the south and southeast; sediment was transported to the north and northwest. The Karnian Doyle Creek Formation consists largely of epiclastic conglomerate, sandstone, and shale that were deposited in well-oxygenated basins. Vitric tuffs interbedded with these sediments suggest shallow or subaerial pyroclastic eruptions. Quartz diorite lasts in this formation may indicate uplift and erosion of part of the Imnaha intrusion related to the later emplacement of the gabbroic part of the intrusion. The Norian Martin Bridge Limestone and Upper Triassic-Lower Jurassic Hurwal Formation, exposed elsewhere in the region, were either not deposited in the study area or subsequently eroded.

GRADZINSKI, R. and UCHMAN, A., 1994. Sedimentology and ichnology of interdune deposits in the Tumlin Sandstone (Buntsandstein) in Central Poland. Zbl. Geol. Paläont., Teil 1, (7/8): 1003-1010.

The Tumlin Sandstone is dominated by very large-scale crossbedded dune sandstones which are intercalated between horizontally bedded interdune sandstones. The latter overlie horizontal erosional bounding surfaces and pass gradually upwards into the dune-apron deposits. Their inorganic fabrics indicate deposition in dry environment, on a damp surface, and in water. They contain the following trace fossils: *?Arenicolites* isp., *Cruziana problematica*, *Diplocraterion* isp., *Gordia morina*, *Planolites montanus*, *Planolites* isp., *Polaeophycus ?tubularis*, reptile footprints, radial structures, double furrows, and oval depressions. The ichnoassemblage is comparable to the mixed *Arenicolites-Cruziana* ichnofacies and shows an r-selected strategy in colonization of sediment.

GRANT-MACKIE, J.A., 1994. Mesozoic Bivalvia from Clerke and Mermaid Canyons, northwest Australian continental slope. AGSO Journal of Australien Geology & Geophysics, 15(1): 119-125.

Four sets of rock samples from two sites off the northwest Australian shelf in 3625-4480 m of water contain macrofaunas, mainly bivalves, of warm shallow-water origin. Mermaid Canyon (16°19'S, 118°23'E) provided many samples of oolitic calcarenite containing *Pseudopecten* (*Pseudopecten*) *dugong* n.sp., indicating an Early Jurassic age and Tethyan relationship. Three hand-specimens from the ridge forming the western edge of Clerke Canyon (16°29'S, 118°30'E) yielded a Norian coral-?*Lima*-oyster assemblage and the Norian-Rhaetian bivalve *Palaeocardita* aff. *globiformis* (Boettger). The latter shows relationship with southeast Asian (Indonesia-Vietnam-south China) forms.

GYALOG, L., DETRE, C. and CSILLAG, G., 1993. Upper Triassic brachiopodal dolomite in the Gánt region. Ann. Rep. Hungarian Geol. Survey, 1991, pp. 175-191.

The study describes a new Brachiopoda fauna collected in the area of Gánt (Vértes Mountains). The most typical forms of the Brachiopoda fauna found in Upper Triassic dolomite is composed of several species of the genus *Cruratula* so far unknown in Hungary. These at the same time are index fossils of the lower Carnian Cordevolian and Julian substages. The *Cruratula* facies can be observed at several localities of the Tethys region. The Gánt faunal site is one of the richest in brachiopods of the Triassic province.

HAAS, J., 1993. Formation and evolution of the "Kössen Basin" in the Transdanubian Range. Földtani Közlöny, 123(1): 9-54.

Based on studies in the Transdanubian Range an analysis of evolution of the "Kössen basin" is presented. The multi-phase basin evolution was initiated by the formation of restricted lagoon in the rezi Dolomite area. Later on, as a consequence of the fine terrigenous input the carbonate platform was drowned in the western part of the Transdanubian Range, and a restricted, oxygen-depleted basin came into being - the sedimentary environment of the Kössen Formation. On the other hand in the eastern part of the Transdanubian range the evolution of the "Dachstein Platform" continued without interruption. On the low-angle slope between the deepening basin and the platform a broad transitional belt came into being, which was occupied by the pelitic basin facies during transgressions, and then it was reoccupied by the prograding platforms as a rule. the transdanubian segment of the "Kössen basin" can fit in between the

basin formations of very similar features of the Southern Alps, and of the eastern Alps without any contradiction.

HAAS, J., 1994. Lofer cycles of the Upper Triassic Dachstein platform in the Transdanubian Mid-Mountains, Hungary. Spec. Publ. Int. Ass. Sediment., 19: 303-322.

Lofer cycles are lagoonal-peritidal cycles that are characteristic of extremely thick and broad carbonate platforms along the margin of the Upper Triassic Tethys. In the Transdanubian Mid-Mountains borehole sections expose continuous sequences of the cyclic platform carbonates several hundred metres thick. Sedimentological investigations and statistical analyses have revealed that the cycles consist of symmetric and asymmetric sequences 2-5 m thick. The ideal cycle is fairly symmetric but many cycles are condensed or incomplete and truncated. The cycles are related to relatively small-scale sea-level variations, which has resulted in considerable lateral facies migrations on a wide, marginal carbonate platform. Periodicities are estimated to range between 20 and 40 ka, and are suggestive of orbital control.

HAAS, J., 1994. Carnian basin evolution in the Transdanubian Central Range, Hungary. Zbl. Geol. Paläont. Teil I, 1992 (11/12): 1233-1252.

Carnian paleogeography of the Transdanubian Central Range (Hungary) is discussed. In the Mid-Triassic due to rifting and volcanic activity the topography became dissected, basins and carbonate platforms were formed. In the Carnian due to climatic change, a large amount of terrigenous material was transported into the basins. The fine terrigenous influx could reach the shallow platforms only in the subsequent highstand period resulting in drowning. In the next lowstand period the drowned platforms returned into the euphotic zone and began to rebuild. After a second lowstand period the basins filled up completely by the end of the Carnian creating an extremely balanced topography - a prerequisite of the Dachstein platform evolution in the Norian-Rhaetian.

HAHN, G., HAHN, R. and GODEFROIT, P., 1994. Zur Stellung der Dromatheriidae (Ober-Trias) zwischen den Cynodontia und den Mammalia. Geologica et Palaeontologica, 28: 141-159.

The Dromatheriidae Gill, 1872 are redefined and revised. This family is placed between the Trithelodontidae (Cynodontia) and the Sinoconodontidae (Mammalia). Its phylogeny and that of the attached six genera - *Dromatherium* Emmons, 1857, *Microconodon* Osborn, 1886, *Tricuspes* E. v. Huene, 1933, *Therioherpeton* Bonaparte & Barbarena, 1975, *Pseudotriconodon* Hahn, Lepage & Wouters, 1984 and *Meurthon* Sigogneau-Russel & Hahn, 1994 - is discussed. Also the genus *Tricuspes* is revised. Additional to the type species, *T. tuebingensis* E. v. Huene, 1933, a second species from the Lower Rhaetic of Lorraine is erected, *T. sigogneauae* n.sp. Three additional teeth, also from Lorraine, are described as "*Tricuspes* sp. indet.", and one tooth is grouped as "Dromatheriidae gen. et. sp. indet".

HARRIS, M.T., 1994. The foreslope and toe-of-slope facies of the Middle Triassic Latemar buildup (Dolomites, Northern Italy). J. Sed. Res., 64(2): 132-145.

The Latemar buildup was a circular carbonate buildup (4 km wide) with a central platform core (flat-bedded interior platform and massive reef margin) flanked on all sides by slope facies. Steeply dipping (30-35°) foreslope breccias are present adjacent to the margin and flat-lying graded grainstones at the toe of slope. Slope facies relate directly to depositional profile and slope angle. The steeply dipping foreslopes consist of lobate breccia beds that are 2-5 m thick and a few tens of meters across, and

extend tens to hundreds of meters downslope. Some beds are conformably overlain by thinner (< 1 m thick) beds of finer-grained carbonate sediment. The basal surfaces of the breccias are erosional and are anastomosing in both strike and dip views. The breccia talus was derived principally from margin boundstones and deposited by rockfalls and avalanches. Planar clinoforms extend the entire height of the foreslope (hundreds of meters) and bracket depositional units (clinothems) tens of meters thick. Clinoforms appear to be shear surfaces formed during large slope failures (avalanches?). Graded grainstone beds less than 1 m thick are present at the nearly flat-lying toe of slope. These consist of redeposited shallow-water (platform-interior and reef margin) carbonate sands, some with nodular limestone caps, that are interpreted as proximal carbonate turbidites. Toe-of-slope breccias are the downdip extensions of foreslope breccias and pinch out abruptly basinward. Some slope depositional processes are related to high-frequency (fourth-order and fifth-order) sea-level changes: toe-of-slope graded grainstones correspond to times of platform submergence. In contrast, foreslope breccia was deposited during both platform submergence and exposure. The slope deposits do not record the high-frequency cyclic rhythms identified in shallow-water platform sections. This is attributed to the nature of slope deposition. Downslope talus transport was episodic and localized; graded grainstone beds reflect storm redeposition.

HAY, W., THOMPSON, S., POLLARD, D., WILSON, K.M. and WOLD, C.N., 1994. Results of a climate model for Triassic Pangaea. Zbl. Geol. Paläont. Teil I, 1992 (11/12): 1253-1265.

We have used a new General Circulation Model, GENESIS version 1.02, derived from the U.S. National Centre for Atmospheric Research Community Climate Model I (NCAR-CCM I) to simulate the climate of an Earth with realistic Pangaean geography. The climate model was run assuming that the ocean heat flux was similar to that of today, atmospheric CO_2 content was four times that of today, the solar constant was 2% less than today, and the Earth's orbit was circular, with mean obliquity 23.4°. Models were run for paleogeographies at 245 Ma (Scythian) and 225 Ma (Carnian). The results indicate that no ice cap would develop over the land, and there is no permanent sea ice. The seasonal temperature variation in the interior of the continent is in the order of 50 °C. The continental areas are very dry except for a few coastal areas and along uplifts. The models both suggest an extreme seasonal monsoonal circulation, with strong westerly winds parallel to the entire coast of Gondwana and the east coast of Laurasia during the northern hemisphere summer. In both hemispheres, the effect is to the cause coastal upwelling. The model also predicts permafrost in the deeper soil layers poleward of 50° N and S. The effects of topographic uplifts on the atmospheric circulation are pervasive. Topography strongly affects the monsoonal circulation causing major deviations of the wind systems suggested in model runs with idealized geographies. Topography also plays a crucial role in concentrating rainfall in a few small areas. It is evident that in order to have a realistic simulation of paleoclimate, an accurate representation of the paleotopography is essential. It is also evident that the paleoclimate models may be useful in suggesting geological criteria that can confirm or reject the predicted paleoclimatic conditions.

HEDTSTÜCK, W., 1994. Sammeln im Unteren Muschelkalk Unterfrankens. Fossilien, 11(5): 281-286.

HEGGEMANN, H., HELMCKE, D. and TIETZE, K.-W., 1994. Sedimentary evolution of the Mesozoic Khorat Basin in Thailand. Zbl. Geol. Paläont. Teil I, 1992 (11/12): 1267-1285.

The geological record of northeastern Thailand is dominated by the Khorat group (Upper Triassic to Lower Tertiary), which is part of the extended sedimentary Khorat basin (> 600 km x 1000 km), also covering parts of northern Thailand, Cambodia, Vietnam and Laos, and can probably even be traced into SW-China (Yunnan). The evolution of the basin in Thailand can be outlined as follows: After a period of compression and deformation along the Nan-Uttaradit suture zone (Phetchabun-fold and thrust belt), comprising the Middle Permian, extensional tectonics during the Triassic led to the formation of half-grabens. In northern Thailand these basins were first filled with shallow marine deposits, but during the Late Triassic the depositional environments gradually changed to a continental "red bed" facies, whereas a great variety of fanglomerates, volcanoclastics, lacustrine and deltaic sediments were deposited in northeastern Thailand. The initial stage of the basin formation was followed by a large-scale general subsidence of the area, which formed the huge sedimentary basin of the Khorat. During the time span from the latest Triassic to the Early Cretaceous the basin filled up with more than 4.000 m of mainly fluvial and floodplain-dominated continental red beds, which also include lacustrine and brackish deposits.

HIRSCH, F., 1994. Triassic multielement conodonts versus eustatic cycles. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol., 22: 35-52.

Most Triassic multielement conodont types crossed the Permian/Triassic boundary. Anchignathodontidae range throughout the Griesbachian and Ellisoniidae until the end of the Early Triassic. Neogondolellidae offshoots include Dienerian-Spathian *Neospathodus*, Late Spathian-Early Carnian Gladigondolellinae, Anisian-Rhaetian *Paragondolella*, Ladinian *Pseudofurnishius* and *Sephardiella*, Late Carnian-Rhaetian *Epigondolella* and Rhaetian *"Misikella"*. Palaeobiogeography of conodonts is monitored by latitude, water depth and geographic isolation. The Early Triassic Panthalassic (mostly Boreal) Province of cosmopolite Neogondolellidae and Anchignathidontidae was bordered by the shallow to facially restricted (Smithian) Amerasian (Cratonic Cordilleran Sibero-Himalayan) Province of *Furnishius*, *Parachirognathus* and (Spathian) Western Tethys (Werfen) Province of *Hadrodontina-Pachycladina*. In the Late Spathian a low latitude pelagic Tethys Province of Gladigondolellinae appeared. Anisian through Early Carnian taxa into the low latitude pelagic Tethyan Province of *Gladi-* and *Paragondolella*, the mostly Boreal Panthalassic Province of the cosmopolite *Neogondolella and Sephardiella*, the Sephardic Province of *Pseudofurnishius* and the restricted Germanic Province. The Late Carnian-Rhaetian *Epigondolella* and the Rhaetian *Misikella* are Panthalassic Tethyan to Boreal. Norian *Paragondolella* species alone, define a Notal (Maori) Province (Jenkins and Jenkins, 1971; Marden et al., 1987). At the specific level of taxa further neritic/pelagic differentiation occurs as e.g. the Siberian Smithian *N. siberiensis* and Spathian *N. shevyrevi*, the North American cratonic Late Anisian *N. shoshonensis*, Late Carnian *Psamueli* lineage, and Middle Norian *E. multidentata* and in the Germanic Realm the Ladinian lineage of *N. haslachensis-watznaueri*. Relationship between Triassic "third order" eustatic sea level cycles, conodont palaeobiogeography and conodont phylogeny is analyzed. It is tentatively suggested that eustatic sea level changes (mostly rises) may coincide with phylogenetic events: Griesbachian (Anisarcicus), Dienerian (*Neospathodus*), Smithian (*Neogondolella*), Spathian (*Platyvillosus*), Late Spathian *(Gladigondolella)*, Anisian (*Paragondolella*), Ladinian (*Pseudofurnishius*, *Sephardiella*), Tuvalian (*Epigondolella*) and Rhaetian *(Misikella)*. As the result of a

significant sea level drop and related "Saharan" salinity crisis in the western Tethys, faunal extinctions, including most conodont genera occurred during the Julian (Early Carnian) and Late Carnian-Rhaetian conodont taxa derived from Paragondolella. Diversified marine environments became widely restored during the Rhaetian cycle, ending with global regression and extinction of multielement conodonts. Eustatic and phylogenetic conodont support a Triassic stage subdivision that includes the Rhaetian as a stage.

Jiarong, M., Chuanbo, Z., Chunlin, S. et al., 1993. Late Triassic stratigraphy, paleontology and paleogeography of the northern part of the Circum-Pacific Belt, China. Science Press, Beijing, China.

This book is an achievement of scientific research on the stratigraphy, paleontology and paleogeography in the eastern part of the northern China. The book deals with the continental Upper Triassic strata of nine sectors in this area, that have been discovered over the last decade and more and reported here with an analysis of their characteristics and the proposal of some new ideas. It describes many fossil groups, such as plants (188 species of 54 genera), spore and pollen (40 species of 29 genera), bivalves (26 species of 5 genera), conchostracans (7 species of 2 genera), and insects (7 species of 6 genera), and makes a number of new taxonomic proposals. Based on the systematic study of the fossils, the characteristics and their geologic ages of fossil assemblages are given for different sectors. The authors further discuss the Late Triassic floristic paleogeography, the paleoclimatic zonation, the pattern of tectonosedimentary paleogeography, the stratigraphic division and the time limit and character of the Indosinian Movement in this area. Many new ideas are offered. There are 66 fossil plates in this book.

Jurkovšek, B., 1993. Karnijske plasti s školjkami južno od Rovt. Geologija, 36: 195-205.

The author reports in short on the rich locality of fossil pelecypod valves south of Rovte. The most frequent species in the Carnian beds is *Pachycardia rugosa* Hauer, followed by *Myophoria kefersteini* (Münster). The remains of solenomorphs appear individually, and the *Trigonodus* fauna is absent.

Kamphausen, D., 1994. Eine Schädelasymmetrie bei *Cyclotosaurus* Fraas (Amphibia, Stegocephalia) aus dem Stubensandstein (Trias) von Württemberg (SW-Deutschland). Stuttgarter Beitr. Naturk., Ser. B, 212:

A skull of *Cyclotosaurus* sp. from Magstadt near Stuttgart shows a striking, asymmetry, between the right and the left side (frontals excluded from, respectively included into the orbits). According to the family diagnoses within the Capitosauroidea the left part of the skull would belong to the family Capitosauridae, the right part to the Benthosuchidae. The anomaly of the right side can be understood as an atavistic character.

Kolar-Jurkovšek, T., 1993. Karnijski mikrofosili iz Bevškega. Geologija, 36: 61-67.

In the section west of Bevško with prevailing platy limestone the fossil microfauna was studied. The association consists of foraminifers, ostracods, conodonts and fish remains. Determined microfauna is characterized by the conodont element *Neogondolella polygnathiformis* indicating the Carnian stage.

KOLAR-JURKOVSEK, T., 1994. Microfauna from the Upper Triassic of Karavanke Mts (Slovenia). *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol., 22: 53-62.

The stratigraphical sequence at Sija in Karavanke Mts is composed of Upper Triassic platy limestone. A rich fossil fauna has been recovered. Zonal subdivision is based on conodonts. Two conodont zones, lower (Epigondolella bidentata-R.Z.) and upper (Misikella hernsteini-A.Z.) have been distinguished. The lower part of the bidentata-R.Z. is characterized by the cooccurrence of the *E. bidentata* and *E. cf. humboldtensis,* while the upper part of this zone is marked by the sole occurrence of index conodont taxa. Hernsteini-A.Z. is recognized by the presence of *M. hernsteini* in association with *E. andrusovi* in its lower portion. The collections of the higher part of the sequence also include ostracod species of *Dicerobairdia bicornuta.*

KOTLYAR, G.V. and SADOVNIKOV, G.N., 1994. Events related to the Permian/Triassic boundary in the Tethys and Biarmia. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 63-68.

A presumed gap in the top beds of the Permian section in the Tethys Realm has not been confirmed by a new data. Therefore, the Lyudyanza horizon in south Primorye, which is subdivided into two zones, *Iranites* sp. (lower) and *Linchengoceras melnikovi - Colaniella parva* (upper), apparently represents the full range of the Dorasham stage. In addition to index species, abundant *Colaniella* occur: *C. leei, C. pulchra, C. xikouensis, C. cylindrica, Pseudocolaniella xufulingensis* and fusulinids - *Rechelina* spp., *Shindella* sp. A, *Stafella zisongzhengensis, St.* ex gr. *orientalis, Eonankinella* cf. *hunanensis* (Vuks and Chediya, 1986). Most species are characteristic of the Dorashamian and Changxingian in southern China, the southeast Pamirs, the Upper Toyoma Series of Japan, Greece, and Thailand.

KOVÁCS, S., 1992. Tethys "western ends" during the Late Paleozoic and Triassic and their possible genetic relationships. Acta Geol. Hung., 35(4): 329-369.

During the Late Paleozoic and Triassic four western endings of the Tethys Ocean existed: "Paleotethys" (in the sense of Sengör 1984): South Crimean-North Dobrogean branch and Pontide-Strandzadide branch; "Neotethys" (in the above sense): Dinaric-Alpine branch (Vardar/Axios Ocean and related zones) and Aegean-Sicilian branch (transformed from a kind of Paleotethyan domain into a Neotethyan). There were no connections between the extra-Carpathian "Paleotethys" western ends and the intra-Carpathian "Neotethys" northwestern end (Transylvanide-Meliatic-Euhallstatt oceanic basins); the latter formed the northwestern end of the Dinaric-Alpine branch. A "Polish-East Carpathian Gate" of the Germanic Basin via the East Carpathian zones did not exist during the early Middle Triassic; this connection was outside of the Carpathian domain, through the Predobrogean Zone. The Aegean-Sicilian branch may have been a subduction regime closing (or becoming dormant?) by Ladinian-Carnian times. This subduction resulted in the intense Triassic orogenic-type magmatism of the Southern Alps-Dinarides-Hellenides, and in the simultaneous opening of the (or an) ocean in the Dinaric-Alpine branch during the Middle Triassic as a back-arc basin. The Transylvanide-Meliatic-Euhallstatt oceanic domain was connected to the Tethys through the Dinaric-Alpine branch; comparable formations can be found in the Maliak Zone of the Hellenides. An early Late Triassic Paleotethyan suture should not be sought in the Carpathians, but within the Aegean-Sicilian branch. In this domain the Alpine sedimentary cycle began only in the Late Triassic, and in an assumed major strike-slip regime between Gondwana and Laurasia (Baud et al. 1991; Stampfli et a).

1991) it was transformed into a Neotethyan domain. Probably related to these oblique-slip movements, the seaways of the Pindos-Budva, Lagonegro and Sicani-Imerese zones formed, in which pelagic sediments were deposited throughout the rest of the Mesozoic, overlying pre-Norian olistostromal-flysch and/or volcanic complexes. The Apulian microplate was not part of Africa during the Late Paleozoic and Triassic, an "Adriatic promontory" did not exist during this time.

Kovács, S., 1994. Conodonts of stratigraphical importance from the Anisian/Ladinian boundary interval of the Balaton Highland, Hungary. Riv. It. Paleont. Strat., 99(4): 1-10.

Stratigraphically important conodonts occurring in the Anisian/Ladinian boundary interval are preliminarily described and their evolutionary lineages discussed. Among them some new taxa are proposed. *Gondolella constricta postcornuta* ssp. n., *G. fueloepi* sp. n. with two new subspecies, *G. liebermani* Kovács & Krystyn sp. n. and *G.? praehungarica* sp. n. Two of the new ones, *G. constricta postcornuta* and *G.? praehungarica* are recognized as zonal index forms in the Balaton Highland Middle Triassic.

Kozur, H., 1993. First evidence of *Pseudofurnishius* (Conodonta) in the Triassic of Hungary. Jb. Geol. B.-A., 136(4): 783-793.

The conodont genus *Pseudofurnishius* is very characteristic for the Southern Tethys and its margins and marginal seas. The reproduction area of *Pseudofurnishius* was the pelagic open sea of the Southern Tethys, where it is common especially in red nodular cherty limestones and intercalated reddish and greenish claystones and marls. From there it invaded especially the southern margin of the southern Tethys, where it can be found even near the ecologic tolerance boundaries of conodonts in shallow water carbonates and restricted basins, often without any other conodonts. On the northern margin of the southern Tethys, *Pseudofurnishius* occurs in the West (Balaton Highland) very rarely and sporadically only in beds, most suitable for conodonts (pelagic micritic limestones). In the East (southernmost Turkey) *Pseudofurnishius* is also frequent on the northern margin of Southern Tethys. In the intermediate area (southern margin of Tisza) *Pseudofurnishius* is common, but not dominant (3-15% of the platform conodonts) on the northern margin of the Southern Tethys. In the northern Tethys and their marginal seas, *Pseudofurnishius* is missing in all facies from Primorye (near Vladivostok, Russia) in the East until the Northern Calcareous Alps in the West. The paleobiogeographic importance of the conodont faunas with *Pseudofurnishius* and the *Theelia tubercula* holothurian sclerite association is discussed. Both faunas characterize the Southern Tethys and its margin/marginal seas from Spain in the West to at least Malaysia in the East. The limiting ecologic factors for the northern boundary of distribution of *Pseudofurnishius* and *Theelia tubercula* is discussed.

Kozur, H., 1993. The problem of the Lower Triassic Subdivision and some remarks to the position of the Permian-Triassic boundary. Jb. Geol. B.-A., 136(4): 795-797.

The Lower Triassic faunas and faunal successions are insufficiently known. Therefore the final decision, whether the Lower Triassic should be regarded as one stage or subdivided into two, three or four stages, is premature. Votings about the Scythian subdivision on conferences, where the majority of the voting participants has never worked on the Scythian stratigraphy and do not know even the scope of the stratigraphic units about the use of which has been voted, are "contraproductive". The range of *Otoceras* overlaps the range of *Ophiceras* in the Tethys. The conodont species *Hindeodus parvus* s. str. begins contemporaneously with the appearance of *Ophiceras*. It appears in the middle part of the *O. woodwardi* Zone on the Gondwanide

southern margin of the Tethys, but above the *O. boreale* Zone of the Boreal realm. Therefore *Otoceras* begins not only later in the Tethys than in the Boreal realm, but it ranges there also into the younger *Ophiceras* faunas. The first primitive *Isarcicella* (*I. turgida*) begins a little later than *H. parvus*. Both the first appearance of *H. parvus* and the a little younger first appearance of *Isarcicella* are world-wide recognizable events that allow the correlation of the Tethyan and Boreal scales which are not correlatable by ammonoids. Both events are suitable for the definition of the Permian-Triassic boundary. Both events are considerably younger than the diachronous first appearance of the Boreal ammonoid genus *Otoceras*.

LAKEW, T., 1994. Diagenesis of Rhaetian patch reef (Lombardian Basin, Southern Alps). Riv. It. Paleont. Strat., 100(1): 9-32.

Alternations of marine and meteoric diagenetic conditions, most probably caused by relative sea level fluctuations, are recorded in an Upper Triassic (Rhaetian) patch reef in the Calcare di Zu Formation, Lombardian Basin. Three main types of cements have been distinguished: 1) isopachous fibrous calcite cement, partially to completely filling mostly secondary solution cavities; 2) radial-fibrous calcite cement in which strongly turbid relics of precursor fibrous cements suggesting a neomorphic origin can be observed, and 3) equant spar calcite found both as a last cement occluding the remaining void space after cementation by the fibrous cements and as a neomorphic product in corals. Both marine and non-marine internal sediments are present in the patch reef. The marine internal sediments are composed of faecal pellets, peloids, micrite and bioclasts. They could be precedent, successive or contemporaneous to the isopachous marine cement and could have a geopetal disposition or may completely fill cavities. The observations made indicate that a "peloidal texture" (a nucleus of anhedral HMC crystals from which fibrous crystals radiate) could result from the introduction of peloids/fine-grained micritic intraclasts into fibrous marine cements during their growth. This texture has not been observed in geopetal infill peloids. Non marine internal sediments are composed of crystal silts and their deposition was preceded by the partial dissolution of the isopachous fibrous cements.

LI YUN, 1994. A late Triassic *Burmesia mojiangensis* sp. nov. of Mojiang, Yunnan. Acta Pal. Sinica, 33(2): 261 (Chinese with English abstract)

A new form of the genus *Burmesia, B. mojiangensis* sp. nov. from the Luma Formation of Mojiang, Yunnan, is described.

MANDL, G.W. and ONDREJIČKOVÁ, A., 1993. Radiolarien und Conodonten aus dem Meliatikum im Ostabschnitt der Nördlichen Kalkalpen (Österreich). Jb. Geol. B.-A., 136(4): 841-871.

Radiolarians and Conodonts are presented which give proof of the Triassic and Jurassic age of deepwater sediments in the eastern part of Northern Calcareous Alps (NCA) in Austria. The sedimentary sequence consists of olistolithic cherty shales at the base and black shales and sandstones on the top. The matrix of the olistolithic part is dated as late Callovian, the olistolithes (dimension from cm-size up to about 100 meters) contain Middle Triassic red radiolarites, Anisian shallow water limestones and (lower) Anisian to Norian pelagic limestones. This deepwater sequence - comparable to the 'Meliaticum' of the Western Carpathian Mountains - is incorporated within the NCA-Nappe pile as 'exotic' tectonic blocks at the localities 'Florianikogel' and 'Ödenhof'. The relation between these exotic blocks and their surroundings is discussed by means of a geological map of Florianikogel. Additional questions concerning tectonical problems of the southeastern part of NCA are discussed too.

MANGERUD, G., 1994. Palynostratigraphy of the Permian and lowermost Triassic succession, Finmark Platform, Barents Sea. Rev. Palaeobot. Palynol., 82(3/4): 317-149.

A palynostratigraphic study of the Permian and lowermost Triassic succession on the Finnmark Platform in the southwestern parts of the Barents Shelf, off-shore Norway, resulted in the identification of the following palynozones: the *Dyupetalum* sp. - *Hamiapollenites bullaeformis* Assemblage Zone of ?Kungurian-Ufimian age, the *Scutasporites* sp. cf. *S. unicus-Lunatisporites* sp. Concurrent Range Zone of Kazanian-?Tatarian age, and the *Lundbladispora obsoleta-Tympanicysta stoschiana* Assemblage Zone of Griesbachian age. The ages of the zones are based on palynological correlation with similar assemblages recorded elsewhere in the present Arctic region, in particular areas where marine faunas allow dating in terms of standard marine stages.

MARCINKIEWICZ, T. and ORLOWSKA-ZWOLIŃSKA, T., 1994. Miospores, megaspores and *Lepidopteris ottonis* (Goeppert) Schimper in the uppermost Triassic deposits from Poland. Geological Quarterly, 38(1): 97-116.

This article presents stratigraphic position of the deposits, containing the remains of the leaf of the seed fern *Lepidopteris ottonis* (Goeppert) Schimper. The opinion is that the range of this species comprises two miospore zones: *Corollina meyeriana* and *Ricciisporites tuberculatus* and one megaspore assemblage *Trileites pinguis*. In the profiles from Poland these zones document the epicontinental "Rhaetic" deposits, which - according to the chronostratigraphic scheme - belong to the Alpine stages: the Norian and Rhaetian.

MARTÍN-ALGARRA, A., MÁRQUEZ-ALIAGA, A., SOLÉ DE PORTA, N. and VALENZUELA, J.M., 1993. La serie Triasica de Los Pastores (Algeciras). Estudios Geol., 49: 21-39.

Seven superimposed lithostratigraphic units have been distinguished in the Upper Trias of Los Pastores (Algeciras). The four lower units (1 to 4) show clayey-sandy-evaporitic Keuper facies. Pollen associations obtained from dark pelitic levels, and bivalves sampled from carbonate intercalations within these four lower units allow to date them as Carnian. These lower units can be correlated with the KI to K3 units of the Keuper of the Subbetic and of other regions of the Iberian Peninsula. Concerning the three higher units, the unit 6 is pelitic-carbonatic and evaporitic and it also bears Carnian pollen associations. The units 5 and 7, however, are carbonatic and show clearly marine facies and organisms (Involutinidae and dasycladacean algae) of the same type than those shown by the Upper Triassic of Alpine Facies of the Internal Zones of the Chain (Alpujarrides and Rondaides). The Trias of Los Pastores belongs to an arid equatorial phytogeographical province, whose the vegetation was dominated by xerophytic elements. It was deposited in a wide coastal flat with marginal terrigenous influence and close to a carbonate platform, in peritidal and shallow marine depositional environments, very sensitive to sea-level fluctuations. The marine carbonate intercalations bear low-diversity, dwarf and opportunistic marine faunal associations, typical of shallow, restricted, unstable and ecologically immature environments, as it has been confirmed independently by facies analysis.

MCROBERTS, C.A., 1994. The Triassic-Jurassic ecostratigraphic transition in the Lombardian Alps, Italy. Palaeogeogr. Palaeoclimatol. Palaeoecol., 110: 145-166.

Three paleoenvironmental phases and two declines in diversity characterize the Late Triassic to Early Jurassic history of the Lombardian Platforms. The first phase, of Late Triassic time *(?Choristoceras* Zone), consists of 1-5 m thick shallowing-upward subtidal cycles of molluscan, coralline, and echinoderm wackestone and packstone of

the Zu Limestone. Biotic and ecostratigraphic characteristics such as typical *Rhaetavicula contorta* fauna and facies allow correlation to the Kössen Formation of the Northern Calcareous Alps. The second phase, of latest Triassic time (?upper *Choristoceras* Zone), consists of shallow restricted marine or peritidal carbonates of the Conchodon Formation dominated by barren lime mudstone and dolostone, algal laminites, and oolitic grainstone. The Zu-Conchodon transition predates the Triassic-Jurassic boundary and represents the first, and most severe, diversity decline for the Lombardian fauna corresponding to a fall in sea-level. Where observed, the upper and lower contacts of the Conchodon Formation are conformable and do not constitute sequence boundaries as suggested by some workers. The Lower Jurassic *(?Psiloceras* Zone) Sedrina Limestone marks the beginning of the third phase with the onset of transgression and return of normal marine conditions. Typical microfacies include molluscan, echinoderm, and sponge wackestone and packstone with abundant anomuran microcoprolites. The second diversity decline occurred at, or just above, the Triassic-Jurassic boundary at the Conchodon-Sedrina transition, where the remaining restricted Marine forms disappeared with the transgression. Anoxia was not a factor in this decline in diversity, although other mechanisms in addition to sea-level change cannot be discounted.

MLAKAR, I., 1993. O problematiki Litijskega rudnega polja. Geologija, 36: 249-338.

All available information on the now inaccessible Pb-Zb-Ba deposits Litija, Zavrstnik, Zagorica, Maljek, Hrastarija and Štriglovec was critically evaluated. Data were completed and numerous earlier unsolved questions were answered. In the studied area existence of a Middle Triassic tectonic-erosional phase was proved, the Old Tertiary overthrust structure analyzed and the relative ages of various neotectonic fault systems established.

MOERK, A., 1994. Triassic transgressive-regressive cycles of Svalbard and other arctic areas: a mirror of stage subdivision. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 69-81.

Transgressive-regressive (T-R) cycles have been recognized and compared throughout the Arctic (Sverdrup Basin, Embry 1988; Sverdrup Basin and the Barents Sea area, Moerk et al. 1989; Svalbard and East Siberia, Moerk and Egorov in prep.). "Simultaneous transgressions" (as defined by Moerk et al. 1989) are transgressions which fall within the same one or two ammonoid zones in various basins; i.e. within a time span of two million years or less. Four "simultaneous transgressions" are recognized throughout the Arctic and were initiated in the earliest Griesbachian, earliest Smithian, earliest Anisian and earliest Carnian. These transgressions which are recognized in the Sverdrup Basin, Svalbard and East Siberia, all areas which were located on the AmEurAsian Plate during the Triassic, suggest a common mechanism for the transgressions; i.e. eustasy. The other transgressions recognized are less precisely dated, or are confirmed as NOT being contemporaneous within either one basin or between several basins. These transgressions may be controlled by tectonism (c.f. Cloetingh 1986, 1988, Embry 1990).

MUTTI, M., 1994. Association of tepees and palaeokarst in the Landinian Calcare Rosso (Southern Alps, Italy). Sedimentology, 41: 621-641.

The Landinian Calcare Rosso of the Southern Alps provides a rare opportunity to examine the temporal relationships between tepees and palaeokarst. This unit comprises peritidal strata pervasively deformed into tepees, repeatedly capped by

palaeokarst surfaces mantled by terra rossa. Palaeokarsts, characterized by a regional distribution across the Southern Alps, occur at the base and at the top of the unit. Local palaeokarsts, confined to this part of the platform, occur within the Calcare Rosso and strongly affected depositional facies. Tepee deformation ranges from simple antiformal structures (peritidal tepees) to composite breccias floating in synsedimentary cements and internal sediments (senile tepees). Peritidal tepees commonly occur at the top of one peritidal cycle, in association with subaerial exposure at the cycle top, while senile tepees affect several peritidal cycles, and are always capped by a palaeokarst surface. Cements and internal sediments form up to 80% of the total rock volume of senile tepees. The paragenesis of senile tepees is extremely complex and records several, superimposed episodes of dissolution, cement precipitation (fibrous cements, laminated crusts, mega-rays) and deposition of internal sediments (marine sediment and terra rossa). Petrographical observations and stable isotope geochemistry indicate that cements associated with senile tepees precipitated in a coastal karstic environment under frequently changing conditions, ranging from marine to meteoric, and were altered soon after precipitation in the presence of either meteoric or mixed marine/meteoric waters. Stable isotope data for cements and the host rock show the influence of meteoric water (average $\delta^{18}O = 5.8‰$), while strontium isotopes (average $^{87}Sr/^{86}Sr = 0.707891$) indicate that cements were precipitated and altered in the presence of marine Triassic waters. Field relationships, sedimentological associations and paragenetic sequences document that formation of senile tepees was coeval with karsting. Senile tepees formed in a karst-dominated environment in the presence of extensive meteoric water circulation, in contrast to previous interpretations that tepees formed in arid environments, under the influence of vadose diagenesis. Tepees initiated in a peritidal setting when subaerial exposure led to the formation of sheet cracks and up-buckling of strata. This porosity acted as a later conduit for either meteoric or mixed marine/meteoric fluids, when a karst system developed in association with prolonged subaerial exposure. Relative sea level variations, inducing changes in the water table, played a key role in exposing the peritidal cycles to marine, mixed marine/meteoric and meteoric digenetic environments leading to the formation of senile tepees. The formation and preservation in the stratigraphic record of vertically stacked senile tepees implies that they formed during an overall period of transgression, punctuated by different orders of sea level variations, which allowed formation and later freezing of the cave infills.

Muttoni, G. and **Rettori, R.**, 1994. New biostratigraphic data on the Triassic of the Marathovouno Hillock area (Chios Island, Greece). Riv. It. Paleont. Strat., 99(4): 461-472.

The Island of Chios (northern Aegean Sea, Greece) is known for a well-preserved Paleozoic to Mesozoic sedimentary sequence. This paper is focused on the micropaleontology and biostratigraphy of the Marmarotrapeza Formation (Lower/Middle Triassic) and of the overlying Bunte Serie Unit (Middle Triassic), outcropping near the Marathovouno hillock section proposed by Assereto (1974) as type section for the Aegean substage (Lower Anisian). The results obtained allow to better define the age of the Bunte Serie basin and of the coeval carbonate platform, which ranges from the Anisian (?Pelsonian) to the Norian-?Rhaetian.

Nádor, A., 1994. Palaeokarstic features in Triassic-Eocene carbonates: Multiple unconformities of a 2000 million year karst evolution, Buda Mountain, Hungary. Zbl. Geol. Paläont. Teil I, 1992 (11/12): 1317-1329.

Four stages of karstification were identified in Triassic and Eocene carbonates over a

period of 200 million years, which overprinted each other. Pre-Neogene non-thermal palaeokarsts developed in meteoric and in marine mixing zones.

NAKAZAWA, K., ISHIBASHI, T., KIMURA, T., KOIKE, T., SHIMIZU, D. and YAO, A., 1994. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 83-103.

Two different faunas belonging to two different lithofacies are distinguished in the Triassic of Japan. The one belongs to the shelf facies composed of terrigenous clastic rocks, and is characterized by ammonites, bivalves, and less amount of brachiopods and gastropods. The zonation of the lower half of the Triassic is mainly based on ammonoids, while the upper half is founded on bivalve fossils. The other one belonging to the oceanic facies consists of chert, limestone, pelagic shale, and greenstone, and yields abundant conodonts and radiolarians. Molluscan fossils are also common in pelagic limestones. The zonation of the oceanic sequence is made by mainly conodonts and radiolarians The comparison of the two different zones is difficult, because the two faunas do not occur in association. Reviewing the various zonation, it becomes clear that the lower Eo-Triassic Induan strata are missing both in the shelf and oceanic facies. The latest Triassic "Rhaetian" is probably lacking in the shelf facies, but developed in the oceanic facies. The shelf facies faunas are related to those of Primorye and Siberia. On the contrary, those of the oceanic facies have typical Tethyan aspects. It is worthy of note that the land plants belong to the *Dictyophyllum-Clathroptetis* floristic province of warm climate. The present distribution of the two quite different assemblages is well explained by the plate tectonics theory.

NICOLL, R.S. and FOSTER, C.B., 1994. Late Triassic conodont and palynomorph biostratigraphy and conodont thermal maturation, North West Shelf, Australia. AGSO Journal of Australian Geology & Geophysics, 15(1): 101-118.

Late Triassic (Norian-Rhaetian) conodonts recovered from borecores and sea-bottom dredge samples on the North West Shelf off Western Australia are assigned to the *Metapolygnathus primitius*, *Epigondolella triangularis*, *E. spiculata*, *E. postera*, *E. bidentata*, *Misikella hernsteini*, and *M. posthernsteini* Zones. Based on previous studies, particularly from North America, these conodont zones can be used to tie with the standard Triassic ammonite zonation. The present record therefore provides the first set of chronologic anchor points for dating the co-occurring dinocyst assemblages and spore-pollen floras from the North West Shelf. Our conodont data show that the *Hebecysta* (al. *Heibergella*) *balmei*, *Rhaetogonyaulax* (al. *Shublikodinium*) *wigginsii*, and *Wanneria* (al. *Suessia*) *listeri* dinocyst zones are younger than suggested previously, and that some zonal ranges overlap. We conclude that further detailed palynological and conodont studies are urgently needed to resolve these problems and extend conodont age control into the early Late Triassic (Carnian) and the Middle Triassic. Key wells investigated include Ashmore Reef 1, Mt. Ashmore IB, and Sahul Shoals 1. Conodont thermal maturation data indicate a very low thermal gradient on the Ashmore Platform near the shelf margin, but a more normal thermal gradient on the Sahul Platform and a high heat flow in the onshore Bonaparte Basin.

ORCHARD, J., 1994. Conodont biochronology around the Early-Middle Triassic boundary: New data from North America, Oman and Timor. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 105-115.

Spathian and Lower Anisian conodonts are reported from Canada, the USA, Oman, and Timor. Most of these are calibrated with ammonoid faunas. Several new conodont

species are recognized informally, and the taxonomic scope of several key taxa is reviewed and found to be in need of revision. Several *Neogondolella* species occur within the Spathian of North America, although most are presently submerged in *N. jubata*; *Neospathodus homeri* and *N. triangulatis* have also been broadly interpreted in the past. The Spathian fauna from Oman contains common *Gladiogondolella* but no *Neogondolella*. Key *Neospathodus* species and some ramiform elements are common to Spathian faunas from Oman and North America. Conodonts from the Subrobustus Zone in Canada are similar to those from the Haugi Zone of Nevada, but contain many more neogondolellids, including *Neogondolella* ex gr. *regale*. *Chiosella timorensis* appears in the basal Anisian *Japonites welteri* beds in Nevada, with many *Neogondolella* ex gr. *mombergensis* and fewer *N.* ex gr. *regale*. The latter species is far more common throughout the remainder of the Lower Anisian in North America, and is accompanied first with *Nicoraella?* n. sp. A in the *Pseudokeyserlingites guexi* beds, and then with *Nicoraella germanica* in the *Silberlingites mulleri* Zone. Lower Anisian samples from both Oman and Timor contain *Chiosella timorensis* and *Gladiogondolella tethydis*.

PÁLFY, J., 1994. Paleoecological, biostratigraphic and paleobiogeographic fingerprints of brachiopod faunas: case studies from the Anisian of Hungary. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 115-125.

Temporal and spatial distribution of Anisian brachiopods in three regions of Hungary is assessed. Even though there is commonly an interaction of paleoenvironment, evolution, bioprovincialism and paleogeography, selected cases demonstrate the independent effect of primarily paleoecological, biostratigraphic or paleobiogeographic control.

PÁLFY, J. and TÖRÖK, A., 1992. Comparison of Alpine and Germano-type Middle Triassic brachiopod faunas from Hungary, with remarks on *Coenothyris vulgaris* (Schlotheim 1820). Ann. Univ. Scient. Budapestinensi de Rolando Eötvös Nom., Sect. Geol., 29: 303-319.

Two well-known Middle Triassic areas, Balaton Highland (Alpine) and Mecsek Mts (Germano-type) were investigated. The attention was concentrated on the faunistical and sedimentological characters of the fossiliferous Pelsonian (Upper Anisian) limestone. The intense collections yielded a very rich, high diversity brachiopod fauna (35 species) from the Balaton Highland and an impoverished one (7 species) from the Mecsek. Based on internal morphology the so-called *Coenothyris vulgaris* from those territories seems to be not conspecific. Sedimentological data give evidence of a shallow marine normal sedimentation which was interrupted by storms (storm-generated coquinas) in Mecsek. Various paleoenvironments of a disrupted bottom relief provided advantageous conditions for brachiopods in Balaton Highland. By the comparative faunistical analysis paleobiogeographic considerations were deducted, as the present geographic position of Balaton Highland and Mecsek is inverse to that of Triassic period.

PANDE, P.K. and KALIA, P., 1994. Upper Permian and Lower Triassic nodosariid foraminifera from the Kashmir Himalaya, India. N. Jb. Geol. Paläont., Abh., 191: 313-329.

The present paper records the benthic foraminiferal assemblages from the Permian-Triassic sections in the Guryul ravine and close to Barus (Srinagar, Jammu & Kashmir). During the transition from the Permian to the Triassic, calcareous foraminifera belonging to the superfamily Nodosariacea become more abundant and diversified. They dominate the foraminiferal assemblages of the Lower Triassic Khunamuh

Formation. Some morphological characters previously recorded only from Jurassic assemblages are observed already in the Upper Permian Zewan and the Lower Triassic Khunamuh Formations.

PAPIER, F., GRAUVOGEL-STAMM, L. and NEL, A., 1994. *Subioblatta undulata* n. sp., une nouvelle blatte (Subioblattidae Schneider) du Buntsandstein supérieur (Anisien) des Vosges (France). Morphologie, systématique et affinités. N. Jb. Geol. Paläont. Mh., 5: 277-290.

A new cockroach forewing, *Subioblatta undulata* n. sp., from the Grès à Voltzia (Upper Buntsandstein) of the northern Vosges (France) is characterized by a strong sigmoidal curve radial vein and a long, narrow anal area. Its affinities with *Subioblatta tongchuanensis* Lin, *Anusoblatta recta* Lin from the Upper Triassic of China and *Samaroblattella revelata* Riek from the Upper Triassic of South Africa are discussed, as well as its classification within the family Subioblattidae Schneider. It is necessary to reconsider the diagnosis of this family and of the genus *Subioblatta* Lin.

PAUL, J., 1993. Anatomie und Entwicklung eines permo-triassischen Hochgebietes: die Eichsfeld-Altmark-Schwelle. Geol. Jb., A 131: 197-218.

The Eichsfeld-Altmark rise, which lies between Hessian and Thuringian depressions, has been a structural high since Late Carboniferous times. The Permo-Carboniferous plutonic rocks of the Harz Mountains and the zone of the thickest volcanics in the Altmark coincide with the crest of the rise. The rise was an area of erosion during the Rotliegend. The detritus was transported into the large, rapidly subsiding North German Basin and into the smaller basins to the east of the rise at Meisdorf, Ilfeld, Muhlhausen and Richelsdorf. The relief is estimated to have been about 200 m. During the Early Zechstein (z1-z2) large areas of the rise were at sea level. Thick, biogenic carbonates and shallow-water sulphates resulted in inversion of the sedimentation conditions. More than 300 m of sediment accumulated on the rise, particulary on the slopes of the rise, and less than 50 m in the North German Basin. The rise was transformed into a sulphate-covered shelf as a consequence of shallow-water precipitation of gypsum. The facies of the Stassfurt carbonate follow the contours of the shelf. The Main Dolomite facies, which is important for exploration of hydrocarbons, is restricted to the shelf.

PAULL, R.K. and PAULL, R.A., 1994. Lower Triassic transgressive-regressive sequences in the Rocky Mountains, Eastern Great Basin, and Colorado Plateau, USA. *In:* M.V. Caputo, J.A. Peterson and K.J. Franczyk (eds.), Mesozoic Systems of the Rocky Mountains Region, USA, SEPM (Soc. Sed. Geol.), Denver, Colorado, USA.

Lower Triassic marine strata in many parts of the world are transgressive deposits, produced by a global rise in sea level after the Permian lowstand. The relative change was greater than 200 m during the Early Triassic (Scythian) interval. Superimposed upon this general trend was a series of transgressive-regressive (T-R) cycles. Three Lower Triassic transgressive sequences are well-documented in the Canadian Arctic and the Cordilleran miogeocline of the western U.S.A. In both of these regions, transgressions were rapid and of relatively short duration. In the miogeocline of the western U.S.A., three Lower Triassic transgressions spread across the site of the former Permian Sublett basin centered in southeastern Idaho during the Griesbachian, early Smithian, and early to middle Spathian stages. Three corresponding T-R cycles are recorded from Arctic Canada during the Griesbachian-Dienerian, earliest Smithian, and late Smithian-Spathian. Nearly synchronous transgressive events are recorded in marine strata of other regions, although they are not always identical in relative

magnitude. Biostratigraphic control for the T-R cycles in the Sverdrup Basin of Canada is provided by ammonoid, bivalve, and palynological data. In the western U.S.A., diagnostic macrofauna are scarce, and transgressive conodont faunas and their associated lithofacies provide information on the timing and extent of transgressive sequences. Periods of faunal expansion were linked to relative increases in sea level. Radiation of cosmopolitan Lower Triassic conodont species also reflects these eustatic changes.

Pin, H., 1994. Triassic sporopollen assemblages from northwestern margin of Junggar Basin, Xinjiang. Acta Micropalaeont. Sinica, 10(4): 384-395.

A study of of pollen and spores from two wells at the northwestern margin of the Junggar Basin. Seventy-seven genera, including one new one, and 170 species, including 21 new ones are described.

Rakús, M., 1993. Late Triassic and Early Jurassic Phylloceratids from the Salzkammergut (Northern Calcareous Alps). Jb. Geol. B.-A., 136(4): 933-963.

This article deals with the reassessment of the Late Triassic and Early Jurassic Phylloceratid cephalopods which was carried out on the original specimens of F. Hauer (1846), E. Mojsisovics 1873 and 1902), M. Neumayr (1879) and F. Wähner (1882-1898). The subject specimens are deposited in the collections of GBA and NHM in Vienna (Austria) as well as in BSM in Munich (Germany). Included are the descriptions of a new genus *Togaticeras* gen.n. and a new species *Fergusonites neumayri* sp.n. Discussed, further, are the problems of phyllogenesis of the Upper Triassic and Liassic Phylloceratid biota and their possible relationship with the Jurassic Ammonites.

Ramovš, A., 1993. *Epigondolella abneptis* and *E. spatulata* in the Lower Norian in the central Kamnik Alps, Slovenia. Geologija, 36: 69-74.

Epigondolella abneptis (Huckriede, 1958) and *E. spatulata* (Hayashi, 1968) are described from Lower Norian (Upper Triassic) deeper marine micritic limestones with chert nodules and lenses in the locality Sleme, central Kamnik Alps.

Richter, D.K., 1994. Internbreccien in der permisch-jurassischen Karbonatsequenz von Hydra (Griechenland): "Strike slip"- versus Flexurmodell. Zbl. Geol. Paläont., Teil 1(7/8): 863-873.

A revising investigation of the formation of internal and massflow breccias in the Lower Permian/Upper Jurassic sedimentary column of Hydra indicates that those breccias are not associated with major flexures but with a combination of irregularly orientated strike-slip faults and downthrow. Sinistral movements in the realm of a major E-W directed fault are particularly indicated by the problematic correlation of the sedimentary columns on the northern and southern thrust sheets of Hydra as well as by the orientation of submarine fissures which are interpreted as auxiliary shear fractures. The strike-slip movements took place in several phases in the course of rifting of the Hellenides between the Permo-Triassic boundary and the Upper Jurassic.

Rieppel, O., 1994. *Nothosaurus edingerae* Schultze, 1970: Diagnosis of the species and comments on its stratigraphical occurrence. Stuttgarter Beitr. Naturk., Ser. B., 204: 13 pp.

A new specimen of *Nothosaurus edingerae* Schultze,1970, allows the diagnosis of the species on the basis of homology (synapomorphy) within the genus *Nothosaurus,* and therewith a first step in the taxonomic revision of this group of marine Triassic reptiles. The new specimen comes from the upper Gipskeuper and therewith represents the most completely preserved skull in the geologically youngest specimens of its genus.

ROBERTSON, A.H.F. and KARAMATA, S., 1994. The role of subduction - accretion processes in the tectonic evolution of the Mesozoic Tethys in Serbia. Tectonophysics, 234: 73-94.

Ophiolitic rocks and melange occur in two belts in Serbia; to the northeast (the Vardar zone) and to the southwest (the Dinaride ophiolite belt) of the Drina-Ivanjica belt, which is interpreted as being a microcontinent rifted from Apulia. The Tethys in the Vadar zone has a long and complex Palaeozoic-early Tertiary history that is still poorly understood. Ophiolitic rocks are known to have formed at least in the early Late Jurassic. Some of the extrusives apparently formed in a supra-subduction zone setting, based on immobile element geochemical evidence. The Mesozoic Tethys in the Vadar zone closed, at least partly, by the latest Jurassic. Evidence from the Apulian margin in the southwest, and from the Drina-Ivanjica belt further to the northeast shows that a small Red-Sea-type oceanic basin rifted in the Late Permian-Early Triassic, followed by spreading in the mid-Late Triassic to Early Jurassic. Evidence from immobile trace elements shows that these extrusives are of mid-ocean ridge and within-plate type.

RUTTNER, A.W., 1993. Southern borderland of Triassic Laurasia in north-east Iran. Geol. Rundsch., 82: 110-120.

Results obtained by Iranian and European geoscientists in the critical area to the north-east of the North Iran Suture east of Mashhad are described and discussed. A slightly metamorphosed ophiolite belt, outcropping as the south-easterly continuation of the previously known ophiolites of Mashhad along the northeastern perimeter of the Fariman - Torbat-e-Jam depression, proved to be either the remnant of a Permian ocean floor or more likely the remnant of a narrow ocean trough. There is as yet no proof of a Triassic age for this ophiolitic belt. To the north of this ophiolitic belt an epicontinental Triassic sequence is exposed at the southern edge of Laurasia in the erosional Window of Aghdarband. This is the result of intermittent sedimentation in a pull-apart basin along sinistral strike-slip faults. The Triassic of Aghdarband has much in common with other deposits of the Triassic Tethys; however, it shows a few unique features, e.g. the Early Anisian *Nicomedites* fauna of a palaeobiogeographic North Tethyan Subprovince, or volcanogenic sedimentation during the late Anisian and the entire Ladinian. Permian ophiolites outcropping at the south-west corner of the Aghdarband erosional Window are transgressively overlain by basal conglomerates of this Triassic sequence. Hence the existence of a Triassic ocean south of Laurasia is very unlikely. This is in agreement with paleomagnetic data which suggest that the Central Iranian microcontinent was in direct contact with Laurasia during Triassic times. These palaeomagnetic data also suggest a clockwise rotation of the Central East Iran microplate during Triassic times (contrary to the anticlockwise rotation of this microplate in post-Triassic times). The sinistral strike-slip faulting and compression from the south-west which controls the structure of the Triassic may be derivative sequels to this clockwise rotation. All Eo-Cimmerian deformations of the Triassic rocks (e.g. folding, thrust faulting, strike-slip faulting) had stopped by Rhaetian times.

RYLEY, C. and FÅHRAEUS, L.E., 1994. Two new genera *Comperniodontella* n. gen. and *Galeodontella* n. gen., and new multielement species of *Chirodella* Hirschmann, 1959 and *Cypridodella* Mosher, 1968 (Conodonta) from the Mamonia Complex (Upper Triassic), Cyprus. N. Jb. Geol. Paläont. Abh., 193: 21-54.

Late Triassic conodonts have been recovered from the Marona, Petra Tou Romiou and Vlambouros formations of the Mamonia Complex of south-western Cyprus. The following new multielement taxa are proposed: *Chirodella falcata* n.sp., *Chirodella itama* n.sp., *Comperniodontella concinna* n.gen. et sp., *Cypridodella trabica* n.sp., and

Galeodontella phasliensis n.gen. et sp. Multielement apparatus reconstructions are also described and discussed for *Cornudina tortilis, Neogondolella hallstattensis, N. steinbergensis,* and *N.* sp. cf. *N. navicula.* A total of 24 taxa from this interval are illustrated, indicating a much higher diversity for Upper Triassic conodonts than previously documented. The identified conodont taxa are indicative of the following Late Triassic conodont zones: the *Epigondolella abneptis, Epigondolella spatulata, Epigondolella bidentata, Axiothea hernsteini* and *Axiothea posthernsteini* assemblage zones, which are indicative of a late Karnian and Norian age.

Sander, M.P., Rieppel, O.C. and Bucher, H., 1994. New marine vertebrate fauna from the Middle Triassic of Nevada. J. Paleont., 68(3): 676-680.

A description of a new and diverse fish and reptile fauna from the Middle Triassic Favret Formation of Nevada. The fauna includes the ichtyosaurs *Cymbodospondylus piscosus* and *C. nevadanus*.

Schäfer, P. and Grant-Mackie, J., 1994. Triassic Bryozoa from the Murihiku and Torlese Supergroups, New Zealand. Mem. Ass. Australas. Paleontols, 16, 52 pp.

Nineteen taxa, including two new genera and four new species of stenolaemate Bryozoa are described from the Middle and Upper Triassic Murihiku and Torlesse supergroups in New Zealand. Most taxa either belong or are closely related to late Palaeozoic trepstome families or genera. In addition, one cryptostome and two taxa of unclear bryozoan affinity occur at several localities. The Triassic, New Zealand bryozoan fauna contains endemic and Tethyan elements.

Senowbari-Daryan, B. and Ingavat-Helmcke, R., 1993. Sponge assemblage of some Upper Permian reef limestones from Phrae province (Northern Thailand). Geologija, 36:

The sponge fauna of uppermost Permian reef or reefal limestones of the Phrae province in northern Thailand include representatives of hexactinellida, sclerospongea, "spinctozoans" and "inozoans". The "sphinctozoans" and "inozoans" are described in detail. Following taxa are new: "Sphinctozoans": *Phraethalamia tubulara* n. gen., n. sp., *Ambithalamia permica* n. gen., n. sp. "Inozoans": *Bissiphonella tubulara* n. sp., *Solutossaspongia crassimuralis* n. gen. n. sp. The genus name *Belyaevaspongia* nom. nov. is proposed for *Polysiphonella* Belyaeva, 1991 (in Boiko et al., 1991), non *Polysiphonella* Russo, 1981.

Shishkin, M.A., 1994. Problems of global correlation of the continental Triassic on the basis of tetrapods. *In*: Guex, J. and Baud, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 121-126.

The evolution of land vertebrates provides a good basis for the correlation of Triassic continental deposits (Romer, 1970; Cox, 1973; Anderson and Cruickshank, 1978; Benton, 1983; Ochev and Shishkin, 1989, etc.). In spite of the regional peculiarities of this evolution, some principal faunal changes are traceable over most of the continents and reveal the most important biostratigraphic boundaries. The latter in turn may be used as a framework for a more detailed comparison of the regional faunal sequences. According to the scheme put forward by Ochev and Shishkin (1989) the global history of the Triassic tetrapods includes three principal successive phases, which roughly correspond to three main divisions of the Triassic and are named by their dominant reptilian groups as the proterosuchian, kannemeyeroid and dinosaur epochs. This scheme is typified by the faunal sequence from the Triassic of eastern and central Europe dominated by amphibians. The proterosuchian and kannemeyeroid epochs are

most fully documented here by the faunal assemblages from the Cis-Uralian Triassic. The record of the proterosuchian epoch known from this region is particularly important for several reasons: 1) in the northern hemisphere, the Early Triassic was a time of explosive tetrapod radiation, which gave rise to a number of short lived groups or genera with a limited vertical range, thus providing opportunity for a detailed stratigraphy of the fossil-bearing sections, and 2) the tetrapod zonation established for the Scythian of the Cis-Urals may be directly correlated with the marine scale, due to expansion of some of the Early Triassic labyrinthodont amphibians into the nearshore marine basins.

SMITH, A.G., SMITH, D.G. and FUNNELL, B.M., 1994. Atlas of Mesozoic and Cenozoic coastlines. Cambridge University Press.

A series of 31 paleocoastline maps for the Mesozoic and the Cenozoic, including three for the Triassic (Scythian or Spathian-Nammalian-Griesbachian, Ladinian-Anisisan and Rhaetian-Norian-Carnian) with five short introductory chapters on global reconstructions, biostratigraphic time and magnetic polarity scales, plotting paleogeographic data, and changes in land area through time.

SOBOLEV, E.S., 1994. Stratigraphic range of Triassic boreal Nautiloidea. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 127-138.

Nautiloids were not applied until recently to the subdivision and correlation of the Boreal Triassic. Detailed examination of a number of stratigraphic sections in Taimyr, Verkhoyansk Ridge, in basins of the Olenek, Indigirka, and Kolyma rivers and at the Okhotsk coast have shown that although nautiloid deposits are relatively scarce, they occur almost throughout the Triassic (Fig. 1). Siberian material revised by the author revealed the rather high taxonomic diversity of nautiloid evolution (Sobolev, 1989). It became evident that nautiloids can be successfully used in zonal stratigraphy.

SRIVASTAVA, S.C. and MANIK, S.R., 1993. Indian Seed - Compressions from Triassic of Nidpur in evolutionary perspective. Coloquios de Paleontologia, 45: 209-219.

STANLEY, G.D. JR., GONZÁLEZ-LEÓN, C., SANDY, M.R., SENOWBARI-DARYAN, B., DOYLE, P., TAMURA, M. and ERWIN, D.H., 1994. Upper Triassic invertebrates from the Antimonio Formation, Sonora, Mexico. J. Paleontol., 68(4): 33 pp.

A diverse Upper Triassic tropical marine fauna from northwestern Sonora, Mexico, includes 31 taxa of tropical invertebrates including scleractinian corals, spongiomorphs, disjectoporoids, "hydrozoans," thalamid and nonthalamid sponges, spiriferid and terebratulid brachiopods, gastropods, bivalves, coleoids, and anomuran microcoprolites. They occur within the late Karnian to Norian part of the Antimonio Formation (Antimonio terrane), which is juxtaposed against a fragmented portion of the North American craton. Most of the fauna is also known from the Tethys region. Sixteen Sonoran taxa co-occur in the western Tethys and five have never been known outside this region. Four additional taxa (one identified only at genus level) are geographically widespread. Some taxa occur in displaced terranes of North America, especially in west-central Nevada (Luning Formation). A weak link exists with the California Eastern Klamath terrane but stronger ties exist with Peru. Among Sonoran sponges, *Nevadathalamia polystoma* was previously recognized only from the Luning Formation, western Nevada. Sponges *Cinnabaria expansa, Nevadathalamia cylindrica*, and a coral, *Astraeomorpha sonorensis* n.sp., are also known from Nevada. The corals

Distichomeandra austriaca, Chondrocoenia waltheri, Pamiroseris rectilamellosa, and *Alpinophyllia flexuosa* co-occur in central Europe. Two new taxa, a spongiomorph hydrozoan, *Stromatoporidium lamellatum* n.sp., and a disjectoporoid, *Pamiropora sonorensis* n.sp., have distinct affinities with the Tethys. The geographically widespread North American brachiopod, *Spondylospira lewesensis*, and *Pseudorhaetina antimoniensis* n.gen. and sp. are among the Sonoran fauna. The Sonoran coleoid (aulacoccrid) *Dictyoconites (Dictyoconites)* cf. *D. reticulatum* occurs in the Tethys realm and *Calliconites* cf. *C. drakei* is comparable with a species from the Eastern Klamath terrane. *Calliconites milleri* n.sp. is the first occurrence of the genus outside Sicily. The bivalves *Myophorigonia jaworskii, M. salasi,* and *Palaeocardita peruviana* are known from Sonora and Peru. Eight gastropod taxa include *Guidonia* cf. *G. intermedia* and *G.* cf. *G. parvula,* both previously known from Peru, and *Eucycloscala subbisertus* from the western Tethys. The gastropods are unlike those already known from other North American terranes.

Strauss, R., 1994. Geotechnische Untersuchungen an sulfatkarstgeschädigten Tonsteinen des Röts (Oberer Buntsandstein) in Nordhessen. Zbl. Geol. Paläont., Teil 1(7/8): 1027-1038.

During extensive investigations for traffic projects in northern Hessen (Germany) Roethian clays (Upper Bunter) have been found in diverse appearances. Gypsum horizons with variable stages of leaching can be found throughout the whole sequence. For the first time deeper foundation-test-borings have been carried out down to the gypsum-bearing Roethian layers that gave interesting insights into the different stages of gypsum leaching and allowed the manifestation of characteristic rock types. By the building of a prospecting and exploration shaft it was possible to assess conventional exploration drillings in pelitic rocks.

Tiwari, R.S. and **Vijaya**, 1994. Synchroneity of palynological events and patterns of extinction at Permo-Triassic boundary in terrestrial sequence of India. *In*: Guex, J. and Baud, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 139-154.

There is no marine control for Permo-Triassic boundary on the Indian peninsula; therefore, palynology remains the only parameter for delineation of this systemic boundary. Other fossil groups have limitations because of taphonomic factors. The palynocladogram reveals that the end Permian extinction is preceded by arrays of diversification, particularly in striate disaccate pollen. Across the boundary several lineages have suffered set-back; nevertheless, some of them continue to survive with attenuating trends in taxonomic abundance and diversity. The origination of several non-striate disaccate as well as taeniate pollen, along with cavate spores, is recorded just before this boundary. Nine palynoevents have taken place along the transit from uppermost Permian to lowermost Triassic in the type area. The correlation of events amongst the basins of peninsula provides a comprehensive model depicting uniform sequential trends in the spectrum of palynological transformations. The climatic change that accompanied the boundary event was not catastrophic and abrupt but, at the same time, it was deciding and definitive; and so was the change in vegetation. These happenings could be linked with great regression of sea and resetting of tectonic movements on peninsula which were the causal factors for change in geomorphology, ecology, and the climate. The higher degree of background extinction followed by enhanced evolution in flora in the stratigraphic vicinity of systemic boundary does not qualify for mass extinction in morphos. It is a case of high turnover. The situation in marine domain was different where definite mass extinction has occurred. Such a differential response, of land and sea life, to the causal factors

supports the view that environmental stress triggered by geological readjustment, rather than the impact of bolide, was the cause of high turnover. It did not bring catastrophy to the terrestrial life at the Permo-Triassic boundary.

TÖRÖK, A., 1993. *Podichnus centrifugalis* Bromley and Surlyk: attachment trace on *Coenothyris vulgaris* (Schlotheim). *In:* J. Pálfy and A. Vörös (eds.), Mesozoic Brachiopods of Alpine Europe, Hung. Geol. Soc., Budapest, pp. 173-177.

Podichnus centrifugalis was described as the attachment (etching) trace of Recent and Cretaceous brachiopod pedicles (rootlet termination) on firm substrate. In the Triassic of Mecsek this trace occurs on the shells of *Coenothyris vulgaris*. *Podichnus* is composed of two series of pits (20-60 μm each), which are nearly perpendicular to the surface and becoming progressively larger and deeper toward the outer zones of the trace. The brachiopod which is responsible for the trace is *Coenothyris vulgaris* itself as it is suggested by the abundance of this species, the matching size of the pedicle foramen and the trace, and by the difference between pedicle foramen of terebratulids and other brachiopods. The occurrence of *Podichnus* suggests soft carbonate-mud covered bottom where brachiopod shells were the available firm places for attachment of brachiopod pedicles.

TÖRÖK, A., 1993. Brachiopod beds as indicators of storm events: an example from the Muschelkalk of Southern Hungary. *In:* J. Pálfy and A. Vörös (eds.), Mesozoic Brachiopods of Alpine Europe, Hung. Geol. Soc., Budapest, pp. 161-172.

Brachiopods are common in the Anisian *Coenothyris* beds of Mecsek Mts. (southern Hungary). The depositional environment was a carbonate mud dominated homoclinal ramp. Major sediment reworking processes involved storm-induced wave action and slumping. The occurrence of brachiopods was mainly controlled by this high-stress depositional environment resulting in the formation of a low-diversity brachiopod fauna with the predominance of *Coenothyris vulgaris*. Brachiopods and bivalves are found in three lithofacies reflecting the differences in the depositional style and the proximity of events: nodular limestones of deeper ramp with articulated brachiopod shells; limestone layers with calcareous marl intercalations of a shallower ramp; and brachiopod-bivalve shell beds. The latter one comprises parautochthonous beds of articulated *Coenothyris* shells, which is considered a brachiopod community of the deeper ramp buried by a storm-induced mud cover, and allochthonous storm-generated coquinas with disarticulated shells in a mid-ramp setting. *Coenothyris vulgaris* from the Muschelkalk of Mecsek Mts. is variable in its external shell morphology. The internal morphology is less variable and characterized by a well-developed median septum, the presence of pedicle collar and possible absence of dental plates (although it could be related to the ontogeny or to the environmental control).

TOZER, E.T., 1994. Significance of Triassic stage boundaries defined in North America. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 155-170.

New data on ammonoid faunas at and near the Permian-Triassic, Spathian-Anisian, and Anisian-Ladinian boundaries are reviewed. The question of the status of the Rhaetian is discussed. Justification is given for continued application of the boundary positions defined in North America. Use of Rhaetian as the ultimate Triassic stage is not recommended. Proposed new taxa of Triassic Ammonoidea are: *Inyoceras* n.gen., *Subhungarites* n.gen., *Pseudacrochordiceras* n.gen., and *Paracrochordiceras welteri* n.sp.

Tozer, E.T., 1994. Canadian Triassic ammonoid faunas. Geol. Bull. Canada, Bull., 147, 348 pp., 148 pl.

Data are given on the morphology and distribution of all known Canadian Triassic Ammonoidea, except the Arcestaceae. Material is described from about 850 localities in the Arctic Islands, Yukon, British Columbia and Alberta. Localities in the Arctic Islands are in the Sverdrup Basin. Except for one collection from a well in northwest Alberta, all specimens from Western Canada are from exposures in the Cordillera. A biochronology is proposed covering the whole of the Triassic, from the earliest (Early Griesbachian) to latest (Late Norian). Fifty-six divisions (zones, subzones, horizons) are recognized, grouped within stages and substages as follows: Lower Griesbachian (2), Upper Griesbachian (2), Dienerian (4), Smithian (3), Spathian (2), Lower Anisian (3), Middle Anisian (3), Upper Anisian (2), Ladinian (10), Lower Carnian (3), Upper Carnian (4), Lower Norian (7), Middle Norian (7), Upper Norian (4). The ammonoids are classified as 522 species (243 new) in 256 genera (46 new).

Trewin, N. and Hurst, A. (eds.), 1993. Excursion Guide to the Geology of East Sutherland and Caithness. Scottish Academic Press, 184 pp.

Three excursions cover the Triassic and Jurassic strata exposed along the coast from Golspie to the Ord of Caithness. Apart from a detailed description of what exposures are available on-shore to examine these economically important rocks, greatest interest attaches to the spectacular boulder-beds and rock-fall breccias of Upper Jurassic age exposed along the coast from Kintradwell to beyond Helmsdale. The guide provides a detailed description of the various localities where it can reasonably be demonstrated that these boulder-beds and rock-fall breccias originated by slumping or falling off a submarine fault-scarp, when Helmsdale Fault itself was active, downthrowing to the SE.

Urlichs, M., 1994. *Trachyceras* Laube 1869 (Ammonoidea) aus dem Unterkarn (Obertrias) der Dolomiten (Italien). Stuttgarter Beitr. Naturk., Ser. B, 217: 55 pp.

The species of *Trachyceras* from the Lower Karnian of St. Cassian and Cortina d'Ampezzo (Dolomites, Italy) are revised. Lectotypes of the following species are designated: *Trachyceras (Trachyceras) aon, Tr. (Tr.) bipunctatum, Tr. (Tr.) muensteri, Tr. (Tr.) pescolense, Tr. (Tr.) saulus, Tr. (Tr.) veltheimi, Tr. (Brotheotrachyceras)* n. subg. *brotheus and Tr. (Br.) difforme*. The new subgenus *Trachyceras (Brotheotrachyceras)* with the type species *Tr. brotheus* is introduced. In the Cassian Formation near St. Cassian mainly the Aon Zone, in its upper part also the lower Aonoides Zone have been identified. Near Cortina d'Ampezzo the lower and upper part of the Aonoides Zone is present. Since the Aon and the Aonoides Zones have been proved at the type localities of the Cordevolian near St. Cassian and of the Julian near Raibl, both substages have the same stratigraphic range. Therefore it is proposed to abandon the Julian which is based on an unsuitable type locality and to maintain the Cordevolian consisting of the Aon and the Aonoides Zones.

Utting, J., 1994. Palynostratigraphy of Permian and Lower Triassic rocks, Sverdrup Basin, Canadian Arctic Archipelago. Geol. Surv. Canada Bull, 478: 1-107.

Nine outcrop sections of Permian and Lower Triassic rocks were studied in the basin-margin and basin-centre facies of the Sverdrup Basin. Abundant, well preserved palynomorphs occur in samples from many basin-margin facies. Palynomorph assemblages in samples from deeper marine basin-centre sediments generally lack diversity of taxa and are poorly preserved. Two palynomorph zones have been

established in the Permian (Roadian and Wordian) and one in the Lower Triassic (Griesbachian). Comparison of taxa in the zones shows some zones have many genera in common, although some genera are restricted. There is almost a complete change of species between the Permian and Triassic. This, and major quantitative differences, suggest a significant hiatus between the Permian and Triassic, and probable climatic differences. Permian and Lower Triassic palynological assemblages of the Sverdrup Basin may be assigned to the Subangaran floral province. However, comparison of the Wordian assemblages of the Sverdrup Basin with those from the Kazanian stratotype west of the Urals indicates marked differences. This may be due to different paleoclimates and environments of deposition, incorrect stratigraphic correlations, or a combination of several factors. Thirty-nine miospore species are newly described: *Ahrensisporites multifloridus*, *A. thorsteinssonii*, *Apiculatisporis melvillensis*, *Cladaitina kolodae*, *Convolutispora arctica*, *C. perplexe*, *Corisaccites stradivarii*, *Crinalites sabinensis*, *Cyclogranisporites franklinii*, *Diatomozonotriletes hypenetes*, *D. igluanus*, *Dictyotriletes bamberi*, *Dyupetalum vesicatum*, *Gondisporites nassichukii*, *Gordonispora obstaculifera*, *Grandispora jansonii*, *Granulatisporites munitus*, *Hamiapollenites erebi*, *Jugasporites compactus*, *Kraeuselisporites sverdrupensis*, *Leiotriletes ulutus*, *Lophotriletes parryensis*, *Lunatisporites arluki*, *L. beauchampii*, *Neoraistrickia caudicea*, *N. delicata*, *Pallidosporites multiradiatus*, *Piceapollenites nookapii*, *Protohaploxypinus kayaki*, *P. panaki*, *Raistrickia enervata*, *Scutasporites nanuki*, *Striatoableites borealis*, *Striatopodocarpites circulus*, *Sverdrupollenites agluatus*, *S. connudatus*, *Verrucosisporites christiei*, *Vittatina heclae*, and *Weylandites segmentatus*. Two new genera, *Crinalites* and *Sverdrupollenites*, are described. Descriptions are given of all Permian pollen and spore taxa found. Seven new combinations are made for Permian and Triassic taxa (*Cordaltina vulgaris*, *Pakhapites rotundus*, *Weylandites cincinnatus*, *W. striatus*, *Lunatisporites albertae*, *Simeonospora minut*a and *Uvaesporites imperialis*).

VELEV, V., POPOV, S., BENDEREVA, K. and GEORGIEVA, N., 1993. Triassic-Jurassic intracraton tectonics and petroleum bearing of Moesian Platform (north Bulgaria). Ann. Univ. Mining Geol., Sofia, 39(1): 89-92.

Dramatic changes in the sedimentation character are observed at the Triassic-Jurassic stage of development of the Moesian Platform (microcontinent, microplate) as a passive continental margin. The vast, of comparatively inexpressive topography bottom, Middle Triassic sea begins to shallow - and disintegrate as a result of combined activity of eustative subsidence of the level and the local-zonal falling along a system of normal-slip faults part of which of listric nature. These processes determine the contours and the depocentres of areals of mostly clastic and terrigenous sedimentation, where the carbonate conglomerates and evaporites are polar elements. Coals, terrigenous-detrital and carbonate sediments are deposited during Early-Middle Jurassic stage in several sub-basins of graben, halfgraben and trough character in predominantly marine environment (thickness to 2km). The spatial discrepancy in positioning the Late Triassic and Early-Middle Jurassic basins is characteristic. At least two hypotheses concerning the explanation of this phenomenon could be examined at this stage as equally possible. Nevertheless which of them would occur reliable, the spatial relationships of the variably aged sedimentary complexes have an impact on the time and scale of oil and gas generating processes manifestation. These processes might have started quite early due to the generally increased geothermal gradient (flow), an echo of the wide-range but not particularly intensive riftogenic process.

VICZIÁN, I., 1992. Diagenetic neoformations in Middle Triassic evaporitic and carbonate rocks, Mecsek Mts. (S. Hungary). Acta Min.-Petrogr., Szeged, 33: 13-24.

In the Middle Triassic (Anisian) evaporitic and carbonate rocks of the Mecsek Mts. diagenetic neoformation of corrensite, Mg-rich chlorite, magnesite, albite and quartz has been observed by microscopic and X-ray diffraction methods. Fine-grained magnesite is found in clay mineral aggregates of siltstones of detrital origin. Magnesites of very similar lithologic character have been found in the Drauzug area of the Eastern Alps and in Hesse, Germany, in a comparable stratigraphic position. Authigenic albites in limestones occur as euhedral crystals oriented according to (010). The formation of euhedral quartz of prismatic shape is accompanied by the formation of corrensite in carbonate rocks. The stability relations of these minerals are discussed in terms of thermodynamic considerations of Lippmann. The possible effects of Mg-enrichment in the solution and of transformation reactions of detrital expandable clay minerals are discussed.

VISSCHER, H., VAN HOUTE, M., BRUGMAN, W.A. and POORT, R.J., 1994. Rejection of a Carnian (Late Triassic) "pluvial event" in Europe. Rev. Palaeobot. Palynol., 83(1/3): 217-226.

By identifying and separating the regional and local components of successive palynological assemblages from the Estherienschichten, Schilfsandstein and Lehrbergschichten in southern Germany, it is demonstrated that during Late Triassic (Carnian) times the regional vegetation remained consistently dominated by xerophytic conifers, indicative of arid climatic conditions. In the Schilfsandstein, the predominant bennettitalean and pteridophytic elements represent a much more locally derived component, corresponding to a variety of vegetation types growing on permanently moist, wet or water-saturated substrates. Widespread but local humid environmental conditions should be ascribed to high groundwater tables in a fluvial depositionary setting, rather than to a climatically induced "pluvial event".

VOGT, M., 1994. Trias-Ammoniten aus Griechenland. Fossilien, 11(5): 293-296.

VÖRÖS, A., 1993. Redefinition of the Reitzi Zone at its type region (Balaton area, Hungary) as the basal zone of the Ladinian. Acta Geol. Hung., 36(1): 15-38.

The basal part of the Buchenstein Formation corresponding to the Reitzi Zone as introduced by Böckh (1873) has been studied in details in several sections in the type region in the Balaton area. The Reitzi Zone as the basal Ladinian (Norische Stufe at that time) was defined by Mojsisovics (1882) on the basis of an assemblage of characteristic ammonoid species. The new bed-by-bed collections in several sections in the Balaton area have revealed that these characteristic taxa appear in definite faunal horizons. The application of Mojsisovics' original definition means that in the type region the Reitzi Zone is built up by the felsoeoersensis, liepoldti, reitzi and costosus horizons. Since the Reitzi Zone is regarded as the basal zone of the Ladinian, the base of this stage should be drawn at the lowermost, felsoeoersensis horizon.

WANG, K., GELDSETZER, H.H.J. and KROUSE, H.R., 1994. Permian-Triassic extinction: Organic $\delta^{13}C$ evidence from British Columbia, Canada. Geology, 22: 580-584.

The Permian-Triassic (P-T) extinction is documented geochemically in a marine sequence deposited in a basinal setting at Williston Lake, northeastern British Columbia, by using elemental and isotopic organic geochemical data from well-preserved sedimentary rocks. The $\delta^{13}C$ values of kerogens in the rocks exhibit a sudden shift at the P-T boundary from latest Permian values of -29‰ ± 1‰ (PDB) to a minimum of -

32.6‰ 2 m above the P-T boundary and then back to the Permian value 4 m above P-T boundary. After considering various factors, we conclude that reduced surface-water primary productivity following the P-T mass extinction is largely responsible for the observed $\delta^{13}C$ shift. The abruptness of the $\delta^{13}C$ shift in a sequence of continuous deposition argues that the strong pulse of extinction at the P-T boundary was sudden rather than gradual. Marine primary productivity did not recover until at least 50 to 100 ka after the time of the P-T boundary, so a higher atmospheric pCO_2 in the earliest Triassic may have resulted from buildup of dissolved CO_2 owing to reduced photosynthetic carbon demand in the surface water.

WARRINGTON, G., COPE, J.C.W. and IVIMEY-COOK, H.C., 1994. St Audrie's Bay, Somerset, England: a candidate Global Stratotype Section and Point for the base of the Jurassic System. Geol. Mag., 131(2): 191-200.

In 1967 the Somerset coastline near Watchet was proposed as the type area of the basal (Planorbis) chronozone of the Hettangian Stage and thus of the Jurassic System. Neither at that time nor subsequently, however, has a type locality and section been nominated from those available in the area. There is urgent need to select a Global Stratotype Section and Point (GSSP) for the base of the Hettangian, and of the Jurassic System. The cliff forming the headland at the west side of St Audrie's Bay, three kilometres east of Watchet, Somerset, is here proposed as the type locality and section, with the base of the Hettangian Stage, at the base of the Planorbis Chronozone, being placed at the horizon currently recognized as that at which ammonites of the genus *Psiloceras* appear. In this section the base of the Planorbis Chronozone corresponds with the base of the *Psiloceras planorbis* Biozone. The proposal of this section is conditioned by the availability of comprehensive litho- and biostratigraphic information, and the ability of the section to fulfil International Commission on Stratigraphy (ICS) requirements for a candidate GSSP.

WARTH, M., 1994. Vorkommen von *"Perna" keuperina* Blanckenhorn (Lamellibranchiata) in der Rottweiler Bank (Stubensandstein, Nor, Trias) von Baden-Württemberg. Stuttgarter Beitr. Naturk., Ser. B, 212:

"Perna" keuperina, a probably nonmarine bivalve, is mainly known from Norian deposits of Eastern France, Luxembourg and the Eifel (NW-Germany). This species has been newly discovered in numerous samples of the Rottweiler Bank (Stubensandstein, Norian) near Rottweil (SW-Germany). It seems that *"Perna" keuperina* is a characteristic fossil of the continental Norian. *"P." keuperina* is associated near Rottweil with the bivalve species *"Anodonta" dubia* O. Fraas, *Pseudocorbula keuperina* (Quenstedt) and the gastropods *Zygopleura gansingensis* (Alberti) and *"Natica"* sp. Fauna and sedimentary characters indicate an ephemeral lacustrine environment.

WEBER, K., 1994. Paläoböden im Buntsandstein am Beispiel der Forschungsbohrung Obernsees (NE-Bayern). Zbl. Geol. Paläont., Teil 1(7/8): 985-1001.

Triassic sediments of the well "Obernsees" contain numerous geologic phenomena known from literature as the so-called "purple beds". Multiple investigations with modern sedimentologic, petrographic and pedologic methods helped to "piece another part of the puzzle together" and to create a new model concerning the paleoenvironment and the soil and sediment-forming processes during the German Lower Triassic.

WHITE, D.L. and VALLIER, T.L., 1994. Geologic evolution of the Pittsburg Landing area, Snake River Canyon, Oregon and Idaho. U.S. Geol. Surv. Prof. Paper, 1439, pp. 55-73.

The Pittsburg Landing area in Idaho and Oregon consists of rocks of Pennsylvanian, Permian, Triassic, Jurassic, and Miocene age. Plutonic and metamorphic basement rocks of Pennsylvanian and Permian age are faulted over Triassic and Jurassic strata. Miocene basalt flows unconformably overlie the older rock units. The basal stratigraphic unit in the Pittsburg Landing area is the Middle Triassic Big Canyon Creek unit of the Wild Sheep Creek Formation. It consists mostly of basalt and basaltic andesite lava flows, many of them pillowed, volcanic breccia, tuff, conglomerate, sandstone, mudstone, and rare limestone. The Big Canyon Creek unit formed on the flanks of a submarine volcano. Unconformably(?) overlying the Big Canyon Creek unit is the Upper Triassic Kurry unit of the Doyle Creek Formation. It consists of volcanogenic sandstone, mudstone, tuff, and limestone that were deposited in a shallow water, low-oxygen marine environment near a volcanic landmass. In places, submarine channels are filled with coarse breccia.

WHITE, J.D.L., 1994. Intra-arc basin deposits within the Wallowa terrane, Pittsburg Landing area, Oregon and Idaho. U.S. Geol. Surv. Prof. Paper, 1439: 75-89.

Triassic and Jurassic rocks exposed at Pittsburg Landing, Idaho, lie within the Wallowa terrane. Fluvial and marine sedimentary rocks of the Jurassic Coon Hollow Formation overlie a thick sequence of Triassic marine volcaniclastic rocks. Hydroclastic mass-flow breccia and pillow lava of the Triassic Big Canyon Creek unit of the Wild Sheep Creek Formation represent metamorphosed arc lava. Breccia highest in the sequence interfingers with thinbedded, locally fossiliferous marine tuff (deposited by turbidity currents) and limey mudstone of the Kurry unit of the Doyle Creek Formation. Uplift, subaerial exposure, and erosion followed. Tuffaceous sandstone and conglomerate, shale, and silicic tuff of the Coon Hollow Formation were deposited above the resulting unconformity. The lower fluvial sedimentary rocks unit of the Coon Hollow Formation contains framework conglomerate with poorly developed imbrication and planar bedding. Tuffaceous sandstone is commonly crossbedded and pebbly. Nonreworked ash-flow tuff is locally present. The conglomerate-sandstone couplets are laterally discontinuous and form multilateral, shallow channel-fill sequences. Deposition is attributed to braided fluvial processes. The upper fluvial sedimentary rocks unit of the Coon Hollow Formation consists of a stacked sandstone and mudstone sequence formed by more distal braided to meandering fluvial to deltaic-distributary streams. Lignite bands, fossil rootlets, and abundant plant fossils are present; these features suggest a locally swampy paleoenvironment. Strata of the uppermost part of this sequence indicate a return to low energy, mud-rich marine conditions that probably represent a gradual transgression over a muddy delta. The depositional sequence records initial sedimentation on a shoaling volcano (Big Canyon Creek unit) during the Late Triassic. Nonmarine deposits represent a retrogradational fluvial sequence, and renewed marine deposition is recorded near the top of the exposed Pittsburg Landing section. The entire sequence represents a complex history of intra-arc sedimentation.

WILLIS, A.J. and MOSLOW, T.F., 1994. Stratigraphic setting of transgressive barrier-island reservoirs with an example from the Triassic Halfway Formation, Wembley Field, Alberta, Canada. AAPG Bulletin, 78(5): 775-791.

Established models for landward barrier-island migration focus primarily on the preservation pattern of transgressive facies in the shoreface, which are typically thin and buried beneath finer grained marine lower shoreface-to-offshore sediments. In

contrast, transgressive barrier-island sandstones in the Triassic Halfway Formation of Wembley field in Alberta are preserved interbedded with, and overlain by, backbarrier and nonmarine sediments. These transgressive barrier sandstones formed from coalescing washover fans during shoreface retreat and were subsequently "abandoned" as the shore-line stabilized and resumed progradation. These abandoned transgressive barrier sandstones were subsequently blanketed by backbarrier and nonmarine sediments as the coastline continued to prograde. Abandoned transgressive barrier island sandstones in the Halfway Formation are 2-6 m thick, up to 2 km wide, and form paleocoastline-parallel trends tens of kilometres in length. The trends define the paleolandward limit of transgressive events. The updip pinch-out of these sandstones in backbarrier mudstones forms a stratigraphic trap for hydrocarbons in Wembley field. Top seal is provided by nonmarine mudstones and evaporites which buried the abandoned transgressive barrier island. The sandstone has porosities and permeabilities averaging 11% and 63 md, respectively. By using well logs and cores to correlate individual parasequences in the Halfway Formation to their updip termination, it is possible to define the extent of associated marine flooding events and therefore identify exploration targets for abandoned transgressive barrier-island sandstones.

WRIGHT, J.E. and WYLD, S.J., 1994. The Rattlesnake Creek terrane, Klamath Mountains, California: An early Mesozoic volcanic arc and its basement of tectonically disrupted oceanic crust. Geol. Soc. America, 106: 1033-1056.

The Rattlesnake Creek terrane in the southwestern Klamath Mountains consists of a serpentinite matrix mélange basement unconformably overlain by a coherent cover sequence of Upper Triassic and Lower Jurassic volcanic, hemipelagic, and clastic sedimentary rocks. Both the mélange and cover sequence are intruded by a suite of ca. 193-207 Ma (U-Pb zircon) gabbroic to quartz dioritic plutons. These rocks collectively record a complex, multistage evolution through several distinct tectonic environments. Blocks in the mélange basement include peridotite, greenstone, amphibolite, pillow basalt, various generally mafic plutonic rocks, metachert, and limestone, all suspended in a matrix of sheared serpentinite. Trace element chemistry indicates that basalt, amphibolite, and greenstone blocks were derived from normal to enriched mid-oceanic-ridge basalt (N-MORB to E-MORB) and within-plate basalt (WPB) protoliths. There is no geochemical evidence that any blocks were derived from a magmatic arc, nor do any of the sedimentary rocks contained within the mélange reflect deposition near a terrigenous sediment source. Collectively these relations indicate that the basement mélange was derived by disruption of oceanic crust and upper mantle in a setting far removed from either an arc or a terrigenous landmass and are most consistent with an interpretation that mélange formation occurred in an oceanic fracture zone. The overlying cover sequence is divisible into a stratigraphically lower Salt Creek assemblage and a stratigraphically higher Dubakella Mountain assemblage, both deposited in a marine setting. Volcanic rocks in the lower assemblage are basaltic pillow lava and pillow breccia with the trace element characteristics of a primitive island arc tholeite suite, whereas those in the upper assemblage are predominantly clinopyroxene-phyric basalt to basaltic andesite and compositionally similar volcaniclastic rocks, with the geochemical characteristics of a more evolved (calc-alkaline to shoshonitic) volcanic arc suite. The geochemical character of these volcanic rocks is indistinguishable from that of the coeval early Mesozoic plutons, leading to the conclusion that these plutons represent the intrusive roots of the volcanic succession. Collectively, these rocks reflect construction of a Late Triassic to Early Jurassic island arc and indicate that subduction had initiated within or near the underlying fracture

zone assemblage by at least the Late Triassic. The latest stages of crustal disruption in the basement thus probably occurred in a subduction zone environment. Both cover sequence units also contain interlayered chert and argillite, as well as coarse epiclastic rocks with an abundance of quartzose, sedimentary, and metasedimentary grains. These clastic rocks provide the first evidence for terrigenous input into the Rattlesnake Creek terrane and indicate that the early Mesozoic arc developed in proximity to a terrigenous sediment source, probably Paleozoic rocks of the western North American Cordillera. Several lines of evidence suggest that early Mesozoic arc magmatism was accompanied by an episode of extensional tectonism. These include structure evidence for an early Mesozoic phase of high-angle faulting that appears to have localized cover sequence deposition in fault-bounded grabens, sedimentologic evidence indicating that both the basement and terrigenous sediment sources experienced episodic pulses of uplift and erosion during cover sequence deposition, and widespread intrusion of arc plutons into the upper crustal levels of the arc carapace. Both the basement complex and the early Mesozoic arc assemblage of the Rattlesnake Creek terrane were then deformed by thrust faulting, folding, and penetrative foliation development during overthrusting from the east by the western Hayfork terrane in the Middle Jurassic. Regional deformation was in response to northeast-southwest-directed shortening and was accompanied by metamorphism to subgreenschist grade. Insofar as the western Hayfork terrane represents pail of a Middle Jurassic arc whose plutonic roots intrude most Klamath Mountain terranes east of and including the Rattlesnake Creek terrane, it is clear that the Rattlesnake Creek terrane formed part of the Klamath Mountain province by Middle Jurassic time. The paleogeographic and tectonic relation of the Rattlesnake Creek terrane to the West of the Klamath Mountains prior to the Middle Jurassic, however, is unclear.

Xu, G. and GRANT, R.E., 1994. Brachiopods near the Permian-Triassic boundary in South China. Smithsonian Contributions to Paleobiology, 76: 2-68.

Sixty-eight genera and 164 species in the Changxingian Stage and 12 genera and 20 species in the lower Griesbachian Stage are recorded on the basis of brachiopod fossils collected from 32 sections in South China and from review of the Chinese literature. Of these, 24 genera and 34 species are described here, including three new genera (*Fanichonetes, Prelissorhynchia* and *Rectambitus*) and 24 new species (*Acosarina strophiria, Enteletes asymmatrosis, Peltichia schizoloides, Derbyia pannuciella, Perigeyerella altilosina, Chonetinella cursothonia, C. volitanliopsis, Fanichonetes campigia, Cathaysia spiriferoides, Uncinunellina multicostifera, Prelissorhynchia triplicatioid, Cyrolexis antearcus, Cyrolexis beccojectus, Cartorhium xikouensis, C. twifurcifer, Callispirina rotundella, Araxathyris subpentagulata, A. beipeiensis, Spirigerella discsella, S. ovaloides, Squamularia formilla, Hustedia orbicostata, Rostranteris ptychiventria,* and *Notothyris bifoldes*). The *Cathaysia chonetoides-Chonetinella substrophomenoides* assemblage zone and the *Cathaysia sinuata-Waagenites barusiensis* assemblage zone represent respectively faunas of the lower Changxingian and the upper Changxingian in clastic lithofacies; whereas the *Peltichia zigzag-Prelissorhynchia triplicatioid* assemblage zone and the *Spirigerella discusella-Acosarina minuta* assemblage zone represent faunas in limestone lithofacies. The *Crurithyris pusilla-Lingula subcircularis* assemblage zone and Permian-type brachiopods are present in the lower Griesbachian. The Changxingian brachiopod fauna can be correlated with Dorashamian fauna of Armenia; the brachiopod faunas of the Ali Bashi Formation, North-West Iran; unit 7 of the Hambast Formation, Central Iran; and the upper part of *Bellerophon* Formation of the Southern Alps. The genera *Cathaysia, Peltichia,* and *Prelissorhynchia*

are especially characteristic of the Cathaysia Tethyan Subprovince. In contrast, the West Tethyan Subprovince is characterised by the genera *Costiferina, Ombonia, Comelicania*, and many other species. Four brachiopod ecofacies are recognized in the Changxingian of South China: (1) antibiohermal dwellers; (2) calcareous substratum dwellers; (3) biohermal dwellers; and (4) ubiquitous substrate dwellers. In the lower Griesbachian, the brachiopod fauna of *Lingula* and *Crurithyris* spreads across the entire Tethys and is called the Circum-Pangaea brachiopod fauna. Massive extinction of brachiopod faunas occurred at the close of the Changxingian, with only a few Permian-types surviving into the early Griesbachian, and they completely vanished after the early Griesbachian except for harbingers of Mesozoic brachiopods.

ZAKHAROV, Y.D. and SHKOLNIK, E.L., 1994. Permian-Triassic cephalopod facies and global phosphatogenesis. *In*: GUEX, J. and BAUD, A. (eds.), Recent developments on Triassic stratigraphy. Mém. de Géol. (Lausanne), 22: 171-180.

Ammonoid ecology, the formation of phosphatic concretions and the peculiarities Of P205 distribution in the main cephalopod facies during the Late Paleozoic and Mesozoic are discussed. Nodules with a high P205 content, which reflect the terminal stage in phosphate diagenesis, are preferentially formed while ammonoids with tissue remains are sporadically localized within the sediments saturated in organic matter. The phosphatogenesis peaks within the Late Paleozoic and Mesozoic occur during periods of humid climate partially connected with transgressions. Therefore, the data on phosphatogenesis (with ammonoid participation) can be used in paleogeographic reconstructions. The Cephalopoda is one of the most widely distributed group of marine invertebrates in the Late Paleozoic and Mesozoic. Their remains are often found in phosphorites, especially in nodules, therefore the analysis of cephalopod facies is of interest to problems of phosphatogenesis. The present work is an attempt to analyze the role of ammonoids in this process by examining original material from the Permian-Triassic of the Far East, Siberia, Pamirs, Urals, Mangyshlak, Transcaucasia, the Upper Cretaceous of Sakhalin (Yu. D. Zakharov's collection), the Lower Triassic of North America (B. Kummel's collection), and the Jurassic of western Europe (U. Lehmann and W. Weitschat's collections).

ZAMPARELLI, V., 1993. Sulla presenza di alcune demospongie e coralli nel Trias mediosuperiore dell'Irpinia (Campania). Paleopelagos, 3: 241-155.

In the Irpinia region (Southern Italy) an interesting faunal assemblage has been encountered in the Middle-Upper Triassic carbonate/marly lithotypes with mud-mound affinity. Besides the already described biota association (Torre & Zampareili, 1991; Zamparelli 1990, 1991), of great interest are the demosponges and corals present both as fragments and as whole organisms in the biolithids. Among these the colonies belonging to the species *Cassianastraea reussi* (Laube), *Gumbelastraea guembeli* (Laube), etc., and the Chetetids (*Blastochetes* and *? Atrochetetes*) are particulary important, all of them pointing to a Carnian age. These associations are similar to the faunas described by Ramovs & Turnsek (1984), Turnsek *et al.* (Turnsek *et al.*, 1982, 1984, 1987), Turnsek & Buser (1989) in the Carnian of Slovenia, by Cuif & Fischer (1974), Cuif (1976) etc. in the Carnian of Turkey and especially to the faunas known in the S. Cassiano Formation in the Dolomites (Volz 1896; Cuif 1973, 1976; Dieci et al., 1970, 1977; Fursich & Wendt 1977). From this comparison a further evidence of strict similarities between the Triassic carbonate deposits in Southern Italy and in South-Eastern European domains can be deduced.

Zaninetti, L., Rettori, R. and Martini, R., 1994. *Aulotortus ? eotriasicus,* n.sp., un nuovo foraminifero del Trias medio (Anisico) delle Dinaridi ed Ellenidi. Boll. Soc. Paleont. Ital., 33(1): 43-49.

Aulotortus ? eotriasicus, n.sp., is a new name for an involutinid Middle Triassic (Anisian) foraminifer of the Dinarids previously described from the same locality of Bosnia-Herzegovina (material J.-P. Cadet, sample KDD8) by Brönnimann et al. (1973a) and assigned to *Involutina sinuosa pragsoides* (Oberhauser, 1964). The analysed material is from the Middle Anisian (Pelsonian) carbonate reefal facies of the Dinarids (Prekarstic Subzone). The new species is common in a grey organogenous limestone, sometimes dolomitic, which is overlain by the Ammonitico rosso limestone of the Han Bulog facies (Trinodosus Zone). *Aulotortus ? eotriasicus*, n. sp., is associated with some index microfossils of the Anisian, among which the typical pelsonian foraminiferal assemblage of *Meandrospira dinarica, Pilammina densa, Pilamminella grandis*. From a taxonomic point of view, the morphological characters of the unpillared involutinid *Aulotorius ? eotriasicus*, n. sp., do not allow to assign the species to the pillared Upper Triassic to Jurassic (Cretaceous?) genus *Involutina* Terquem. The here proposed attribution to *Aulotortus* Weynschenk remains doubtful, as the recrystallized test does not exhibit any lamellar structure, which, according to Piller (1978), remains the only adequate feature to distinguish the unpillared Triassic involutinid genera *Aulotortus* Weynschenk and *Triadodiscus* Piller. For the larger dimensions, the new species has been tentatively attributed to *Aulotortus*. *Aulotortus ? eotriasicus* n.sp., has also to be distinguished from the Middle (Ladinian) to Upper Triassic lenticular species *pragsoides*, to which it was assigned by Brönnimann et al., 1973. The new species essentially differs from "*Involutina sinusa pragsoides*" (= *Aulototortus pragsoides*) in having a narrower tubular second chamber, a larger number of whorls, and in having a lenticula test subangular in outline. As far as the distribution of the new species is concerned, *Aulotortus ? eotriasicus*, n.sp., has also been recorded from the Middle Anisian (Pelsonian) of the hellenid locality of Hydra (Rettori et al., in press), where the Pelsonian age of the foraminiferal assemblage (*Aulotortus ? eotriasicus*, n.sp., *Meandrospira dinarica, Pilammina densa, Pilamminella grandis* etc.) has been established on the basis of Conodonts (Angiolini et al., 1992).

Zavattieri, A.M., Volkheimer, W. and Rosenfeld, U., 1994. Palynology and facies of the Late Triassic of Comallo (Northern Patagonia, Argentina). Zbl. Geol. Paläont. Teil I, 1/2: 133-154.

In the region of Comallo, Rio Negro Province, Argentina, continental Late Triassic clastic sediments have been deposited unconformably on the metamorphic basement of the North Patagonian Massif. These sediments generally form characteristic fining upward sequences indicating a braided river system in the lower and hanging parts of the succession, a meandering river system in the middle part. In the latter the top layers of the sequences partly bear thin (cm-dm) autochthonous lignite seams. From ten stratigraphic levels three types of microfloristic assemblages were distinguished which characterize different sedimentary environments. Prevailing Polypodiacean ferns of Osmundaceans resp. characterize two different swamp environments, bisaccate grains and Araucarian type pollen higher topographic levels. A Late Triassic age of the microflora is indicated by the simultaneous occurrence of typical Triassic taxa like *Guthoerlisporites cancellous* and first representatives of the genus *Classopollis*, which does not appear before the Norian in the Gondwanide floral province. The investigated flora represents an Ipswich type and indicates temperate climatic conditions. The great amount of trilete spores in nearly all assemblages locally points to a moist environment.

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