ALBERTIANA

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Contents

The primary aim of ALBERTIANA is to promote the interdisciplinary collaboration and understanding among members of the I.U.G.S. Subcommission on Triassic stratigraphy. Within this scope ALBERTIANA serves as the 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 anouncements, literature reviews, progress reports, preliminary notes etc. - i. e. those contributions in which information is presented relevant to current interdisciplinary Triassic research. An electronic version of ALBERTIANA is also available in PDF format @ http://www.bio.uu.nl/~palaeo/Albertiana/Albertiana01.htm.

Cover: Photograph of Induan-Olenekian boundary strata at the West Pingdingshan Section, indicating the boundaries marked by conodonts and ammonoids (see also article on pp. 13-28)

Executive Notes

From the Chair

After almost 4 years as Chair of STS, now is a good time to review what has been accomplished during this term, and what remains undone. I refer chiefly to our primary objective of formalizing the time scale by defining GSSPs for all stages. In 2000, the P-T boundary stood alone as the only formally agreed GSSP when we began accelerated efforts to establish active formal task groups for each boundary. In spite of progress in all these groups, no additional GSSP proposals have been formally presented to STS. With the time limits set by IUGS for all GSSP definitions to be completed by 2008, time is not on our side!

On a positive note, both the base Olenekian and base Anisian task groups appear set to bring forward proposals for single candidates, while crucial work on the Upper Triassic stages is underway with a view to reaching some consensus on those three GSSPs during the IGC in Florence. The base Ladinian deliberations, already advanced beyond the other GSSPs a decade ago, has now reached a critical point. As announced elsewhere in this issue, the A-L task force has recently completed a final vote on two prospective GSSP ammonoid datums. The results show an absolute majority for neither the base Reitzi nor the base Curionii zones - as represented at the well known candidate sections at Felsõörs and Bagolino respectively - although the latter datum remains the more popular. The impasse is not new, but now we have a clear and current picture. Given the present frame of reference for the task force, i.e. an agreeable ammonoid datum, this picture is unlikely to change.

Technically, the A-L ballot provides a 53% majority for Curionii datum because the 3 Abstains give a total of 17 votes cast (9/17). In reality, 6 task group members expressed no preference for either candidate, whereas an adequate 64% of those who did vote prefer the Curionii datum. These numbers do not provide an absolute majority although they do show a clear majority view. What now? One option is to start over with a new task force unencumbered by the need to find an agreeable ammonoid datum as the boundary index. A preferred option, and one for which I have received positive feedback from the International Commission on Stratigraphy, is to canvass the STS voting members for their support, or not, for the task force majority view. This I will do. If the support is there, I will then ask the task force to prepare a final dossier for the Curionii option. Beyond that, the process calls for a formal vote on the dossier within the STS, the ICS, and ultimately the IUGS.

From the Secretary

'TRIASSIC COAST CRUISES'

The Dorset and East Devon Coast World Heritage Site, on the south coast of England, is commonly referred to as the 'Jurassic' coast. However, the western end of the site, in Devon, consists almost entirely of Triassic rocks. These comprise, in ascending order, the constituent formations of the Aylesbeare Mudstone (Induan-Olenekian?), Sherwood Sandstone (Olenekian?-Anisian), Mercia Mudstone (Ladinian-Rhaetian), Penarth (Rhaetian) and basal Lias (Rhaetian) groups. These units crop out successively from Orcombe Point, near Exmouth, in the west, to Pinhay Bay, near Lyme Regis, in the east. The best way of seeing this 'Triassic' coast is from the sea and 2 to 3-hour afternoon cruises are operated, as 'Jurassic Coast Cruises', from Exmouth on Tuesdays and Thursdays from June to September, subject to weather conditions. For further information contact Stuart Line;

(01392 42771; e-mail:info@stuartlinecruises.co.uk)

Look also at:

www.stuartlinecruises.co.uk.

KARL MÄDLER (1902 – 2003)

It was with great sadness that I learnt of the death, on 22 October 2003, of the palaeobotanist and palynologist Karl Mädler. Mädler was one of the pioneers of Triassic palynology in Germany and was awarded his doctoral degree (Dr. rer nat.) by the Technischen Hochschule Hannover in 1963 for work on this subject. When I began postgraduate work on the palynology of the British Trias in 1964 this work had just been published (Mädler, 1964a); a copy is a treasured item in my literature collection.

Mädler commenced palaeobotanical work in 1931, working on Tertiary floras with Professor R. Kräusel at the University of Frankfurt am Main. He continued palaeobotanical studies, of Permian, Cretaceous and Tertiary material, throughout his life. After joining the Niedersächsisches Landesamt für Bodenforschung in Hannover he also worked on charophytes and Mesozoic megaspores and commenced palynological studies of the German Trias (Mädler, 1964a, 1964b, 1968) and Lower Jurassic.

An obituary of Karl Mädler by Volker Wilde (Frankfurt am Main), which appeared in A.A.S.P. Newsletter 37 (1) (March 2004), cites further sources of information.

G. Warrington

References:

Mädler, K. 1964a. Die geologische Verbreitung von Sporen und Pollen in der Deutschen Trias. Beihefte zum Geologischen Jahrbuch, 65: 147pp.

Mädler, K. 1964b. Bemerkenswerte Sporenformen aus dem Keuper und unteren Lias. Fortschritte in der Geologie von Rheinland und Westfalen, 12: 169-200.

Mädler, K. 1968. Sporen aus der germanotypen Trias, insbesondere Nordwestdeutschlands. Beihefte der Berichte Naturhistorischen Gesellschaft, 5 (Keller-Festschrift): 457-475.

Contact information

The Secretary retired from the British Geological Survey at the end of July, 2003, and, under ICS rules, ends his term as Secretary of the Subcommission on Triassic Stratigraphy (STS) this year. He is now an Honorary Visiting Fellow at the University of Leicester (see: New contact information. Activities at Leicester will include continuing involvement with the STS, with the Triassic/Jurassic Boundary Task Group of the International Subcommission on Jurassic Stratigraphy (as Chairman) and with IGCP projects 458 (Triassic-Jurassic Boundary Events) and 467 (Triassic Time and Correlations: as UK National Correspondent,), in addition to the completion of a number of palynological studies of the British Trias, and the revision of the report on correlation of Triassic rocks in the British Isles (Warrington et al., 1980; Geological Society, London, Special Report 13).

STS members are requested to advise the Secretary immediately of any change to their postal addresses, telephone or FAX numbers (including national and area codes) and e-mail addresses in order that they may receive STS information without delay

The following change to contact information has been notified:

Dr G. Warrington (STS Secretary)

New postal address: 3 Lamcote Gardens, Radcliffe on Trent, Nottingham NG12 2BS, UK

New phone: +44 (0)115 9334723

New e-mail: gw47@le.ac.uk

ICS Subcommission on Triassic Stratigraphy

Minutes of joint Business Meeting of the STS and IGCP Project 467, St. Christina, Italy, 13 September 2003

Chairman: M. Orchard

Secretary: M. Balini

Present:

G.H. Bachmann, M. Balini, A. Baud, T. Bechstädt, P. Brack, S. Furin, P. Gianolla, E. Gradinaru, J. Haas, M. Horacek, M. Hounslow, A. Nicora, D. Kent, H. Kozur, L. Krystyn, E. Kustatscher, M. Menning, P. Mietto, R. Mundil, G. Muttoni, C. Neri, M. Orchard, J. Palfy, N. Preto, H. Rieber, M. Rigo, A. Riva, G. Roghi, A. Vörös, J.P. Zonneveld, R. Zühlke

Agenda:

1. Report by the Chairman
2. Future Meetings
3. Review of the Triassic time scales

Item 1.

The Chairman opened the STS-IGCP467 joint meeting at 3.55 p.m., remembering that the goals of the IGCP 467, focused on the trans-panthalassan correlations, are very similar to the goals of the STS. IGCP 467 will end in 2006, while the main business of the STS must be concluded by 2007 in order for GSSP ratification to be completed by IGC2008.

The Chairman told the convenors that G. Warrington, who acted as Secretary for the STS from 1996, cloud not attend the meeting. Warrington unfortunately is no more financially supported because of his retirement from the British Survey.

The Chairman announced some changes in the 2004-2007 board of the STS. He continues as chairman and Ying Hongfu is confirmed as vice-chairman. M. Balini (Italy) is proposed as second vice-chairman, and C. McRoberts (USA) as Secretary.

Item 2.

The programme is very rich, especially for the year 2004. In the year of the 32rd Geological Congress two meetings/workshops are scheduled. Moreover some of the members of the STS are also involved in one of the Florence pre-congress field trips.

2004

- Chaohu (China): Triassic Chronostratigraphy and biotic recovery, May 2004. The symposium is mostly focused on the Lower Triassic. More information will be distributed by e-mail and included in the next issue of Albertiana. ***

- Spiti (Himachal Pradesh, India): The Triassic of Spiti, last week of June-first week of July. The preliminary circular, included in Albertina 28, is distributed to all the attenders of the meeting.

- Karakorum (Pakistan): A traverse through central Asia ranges, from the Indian plate to Karakorum, end of June-July 2004. 32rd Geological Congress, Italia 2004, pre-congress field trip PR-01. Information in the congress website (http://www.32igc.org).

2005

New Zealand, Wellington. Triassic stratigraphy and correlations in the circum-Pacific region, March, 2005. Details in the next issue of Albertiana ***

2006

Svalbard, Boreal Triassic, late August and early September. The meeting is organized with an indoor session and one day ship excursion to Festningen section. On the basis of the financial support, a field excursion to Central Spitzbergen by helicopter will be also organized. Information are included in Albertiana 28.

2007

Albuquerque, The Global Triassic, May 2007. Final meeting of the IGCP 467 and possibly the last meeting of the STS.

Item 3.

Induan/Olenekian boundary WG (chairman Y. Zacharov)

Orchard reported the activity of the WG. There is a progress in China, and the chinese specialist on conodonts has spent 3 months this year in Vancouver studying and discussing the conodont taxonomy. The new data will be probably presented during the Chaohu meeting.

Olenekian/Anisian boundary WG (chairman E. Gradinaru)

Gradinaru presented the state of the art on Desli Caira section (Roumania). Gradinaru summarized the data on conodonts, ammonoids, paleomag and foraminifers. There are still some minor problems with some ammonoids, i.e., Siberian Olenikitids. The study of conodonts is nearly over and the specialists discussed the taxonomy. Gradinaru acknowledged the suitability of the conodont *Chiosella timorensis* as the defining index for the Olenekian-Anisian boundary.

At Desli Caira there is also a rather good chemostratigraphic record, so it is possible to recognize the boundary by using several stratigraphic tools. Gradinaru was willing to be able to write a GSSP proposal soon, possibly before Florence Conference (August 2004).

Anisian/Ladinian boundary WG (chairman A. Baud)

Orchard introduced the discussion on the bounadry problem with a short review of the schedule established during Veszprem meeting (September 2002). During the meeting it was decided to fix a dead-line for the submission of GSSP proposal at the end of december 2002. Two proposals were submitted by the end of the year (Brack et al., and Vörös et al.), and one (Mietto et al.) later in 2003. A preliminary ballot on the eligibility of Mietto et al. proposal was organized at the beginning of July. Orchard asked Baud to present the result of the ballot, and Baud presented to the convenors the following data: votes received=15; 9 in favor and 6 against the eligibility. As the majority of 60% of votes has been reached, the third proposal has been accepted.

After invitation by Orchard Baud started to lead the discussion. Baud opened the discussion on the boundary proposals stating that despite of Balini's comments published on Albertiana, Brack et al. proposal fulfill the requirements to be taken into account for the selection of the GSSP because the proposed GSSP is undoubtfully and clearly illustrated in Brack et al. fig. 4. Balini replied that in Brack et al. proposal there is only the synthetic range chart of Bagolino composite section and not the range chart of the GSSP proposed site (site B). Balini also added that no one GSSP has been selected on a composite section, and quoted Meishan section (base of the Triassic) as exemple of GSSP defined in one outcrop selected within several very close sites, but with specific range chart. The discussion was closed by Baud who stated that Meishan section is composite so that Bagolino section can be also accepted. Orchard commented that problems recognized in the presentation of a proposal should not invalidate it, but rather be cause to improve the file whilst it remained within the purview of the task group. Orchard also commented that constructive comments by Balini served the entire subcommission by drawing attention to potential problems in presentation.

Rieber presented some comments to Mietto et al. proposal. In particular Rieber pointed out the separation into two different genera of *Aplococeras avisianum* and *Pseudoaplococeras vodgesi* on the basis of suture line, whorl section, ventral side, oraments and lenght of body chamber. Mietto replied that *Aplococeras avisianum* has a very wide variability and that A. vodgesi falls within the variability of *A. avisianus*. Krystyn reported some exemples of Triassic ammonoids with wide variability not only of the morphology, but also of the suture line. Orchard asked Rieber about the F.O. of *Eoprotrachyceras subasperum* and of *E. curionii*. Rieber answered that they are not exactely coeval, but they have the same suture line.

Mietto distributed the preprint of a paper in press on the next issue of Rivista Italiana di Paleontologia e Stratigrafia, with the illustration of the new data from Bagolino section. The discussion then touched several other aspects as need of a standard, possible other criteria, correlatability of other criteria, with contribution by Maurer, Muttoni, Orchard, Kent, Menning, Rieber, Krystyn, Schlager, Vörös, Kozur. Brack distributed to the convenors an errata corrige of the fig. 6 of his GSSP dossier.

At the end of the discussion Baud remembered the schedule of the WG: first ballot between three proposal, if no one of the proposals gets the 60% of vote, the proposal with less votes will be excluded from a second ballot between the two remaining proposals. The first ballot will be distributed to the WG members within few days after the St. Christina meeting. Orchard added that abstension is a vote, while no vote is no vote. The GSSP is accepted when it is voted by 60% of the people voting.

Ladinian/Carnian boundary WG (chairman Maurizio Gaetani)

Gaetani could not attend St. Christina meeting, then the state of the art on the boundary sections is presented by Balini.

Dolomites: the Padova team is investigating a new section in Dolomites, covering the interval Daxatina-Aon zones, that is not exposed at Prati di Stuores. A large conodont sampling has been done and the samples are under process.

Spiti: in July 2003 the middle part of the *Frankites* zone has been sampled for conodonts in order to test the morphological variability of *Metapolygnathus*/*Paragondolella polygnathiformis*, a possible marker for the boundary. The data will be available by June, 2004, and the best sections will be visited during the Spiti field trip.

South Canyon (Nevada): this site is of great interest for the correlations between Tethys and North America. Some preliminary results were illustrated by two posters (Hopkin & McRoberts; Balini & Krystyn) at the Vancouver meeting (May 2003).

Carnian/Norian boundary WG (chairman Mike Orchard)

Orchard informed on the recent developments on conodonts. During Vancouver meeting (May, 2003) Orchard, Krystyn and Kozur discussed at lenght the problems of conodont taxonomy and biostratigraphy for the C/N boundary interval. In particular they discussed and compared the conodont record from Black Bear Ridge (British Comubia) with that from Pizzo Mondello (Sicily), as Nicora made available her collection from Sicily. The species common in the two successions were established and the two sections are now well calibrated.

Norian/Raethian boundary WG (chairman Leo Krystyn)

Krystyn reported that the nucleus of the working group was established during the last STS meeting in Vancouver (May 2003), but all the people interested have been invited to join the group.

Chairman thanked those present for their partecipation and declared the meeting closed at 6.15 p.m.

M. Balini

*** Post scriptum The China conference is now scheduled for May 2005 and the New Zealand one is postponed to March 2006 when it will be a joint meeting with InterRadXI (see meeting announcements elsewhere in this volume).

From the editor

Please note a couple of new enhancements in the electronic (pdf) version of ALBERTIANA:

(1) Albertiana contains now hyperlinks which will connect you directly to the URL or website when you click with your mouse on the address while connected to the internet.

(2) Data files that come with articles, such as for example large excel files with original data from your quantitative analyses, (which are difficult to incorporate in the electronic journal) are available for download from the ALBERTIANA website. A hyperlink in the electronic version of ALBERTIANA will lead you directly to file on the WWW.

Please note, that contributions for the special SPITI Volume (30) are due at 1st of June,

Please note that the deadline for the next ALBERTIANA issue (31) is the 1st September 2004.

W. M. Kuerschner

Announcements

International Geological Correlation Program

Project 467: Triassic Time and Trans-Panthalassan correlations.

A web site is now available for this project. Go there to find out the latest on meetings etc.

http://paleo.cortland.edu/IGCP467/index.html

Meeting Reports

Triassic Geochronology and Cyclostratigraphy a field symposium St. Christina / Val Gardena, Dolomites, Italy, September 11 - 13, 2003
Joint meeting of the Seceda Coring project, STS and IGCP 467 in collaboration with the Geological Survey of Bozen/Bolzano.

This concluding meeting of the Seceda Coring Projct was organized by P. Brack (Zurich), W. Schlager (Amsterdam) and M. Stefani (Ferrara). Its focus centered around the issue of measuring time in (Triassic) stratigraphy through the application of independent methods including high-resolution radiometric age dating and orbital clocks. A key issue was the so called Latemar controversy which was addressed during the first symposium day as well as on the field trips to Seceda and Latemar.

58 scientists from 14 countries attended the symposium. The technical sessions comprised 21 oral and 18 poster presentations and a final meeting and discussion of STS. 43 participants were on the excursion to Seceda (one day) and 22 managed to climb the peaks of Latemar (two days).

Highlights of the first symposium day included the presentation of largely reproducible U-Pb-ages of zircons from volcaniclastic layers at similar stratigraphic levels in Upper Anisian - Ladinian sedimentary successions of the Southern Alps and Hungary and obtained by three independent research groups. New age results confirm previous ones but are not compatible with the interpretation based on spectral analysis of basic cycles in the platform interior succession at Latemar as controlled by earths precession. The experts of cycle analysis promised to thoroughly test alternatives such as a basic cycle of as yet unclear significance being modulated by orbital parameters.

The second symposium day saw another session on platform carbonate cycles, i.e. of Upper Triassic age, whose interpretation as orbitally controlled was frequently assumed but is more difficult to evaluate. Despite the absence of independent and tight age constraints, orbital control seems to be largely accepted for the long record of lacustrine cycles of the Newark cores whereas other cycles in terrestrial sediments of the UK seem not to show evidence for Milankovitch-type control. Other topics of this day included themes such as the stratal architecture of the Middle Triassic in British Columbia, the history of carbonate platforms after their growth stage in the Dolomites and Daonella biostratigraphy.

The field trips benefited from outstanding weather con ditions and allowed an impressive demonstration of Ladinian rocks of the Ladinian Dolomites.

In addition to the main scientific sessions, a conodont workshop on the Olenekian-Anisian boundary, and a business meeting also took place (see minutes).

P. Brack, Zurich

Future Meetings

1st announcement

A meeting in Wuhan, China will take place in May 2005 (see circular).

Date change

The meeting in New Zealand previously scheduled for March 2005 will now take place in March 2006 and will be a joint meeting with radiolarian workers at the INTERRAD XI. More information will be posted at the IGCP 467 website when available.

Fieldtrip

For all interested scientists and for those who have not be able to participate in January 2001 to the Permo-Triassic Fieldtrip in Oman, a new and unique opportunity is offer in January 2005, before or after the IAS international meeting January 10-13 in Muscat :

<u>Fieldtrip F13 - Birth and Early development of the Tethyan Oman Margin from Middle Permian to Middle Triassic: a geochemical and sedimentological approach.</u>

The headlines are : « From post-rift shallow shelf transgressive carbonates to correlated carbonate slope turbidites and avalanches, platty lime-mudstone and condensed deep-water red ammonoid lime-mudstone, shales and chert deposits.

This fieldtrip will be leaded by Sylvain Richoz and Aymon Baud, (Lausanne) , Leopold Krystyn (Vienna), Jean Marcoux (Paris) and Richard Twittchett (Plymouth).

<u>For this 4 days fieldtrip, a short summary is given below :</u>

The mountainous belt located in the eastern part of the Arabian Peninsula, the Oman Mountains, expose a segment of the Gondwanian margin, interpreted as a flexural upper plate. The Permian-Triassic sequence deposited on the inner part of this margin is exceptionally well exposed in the Jabal Akhdar Mountains, as part of the “autochthonous” which crops out in a large tectonic window. The Permian and Triassic shallow water carbonate rocks occurring in this area belong to the Akhdar Group, with two main lithologic units: the Saiq and Mahil Formations. The Saiq Formation, about 700 m thick and made up of three transgressive - regressive cycles unconformably overlies Precambrian strata, documenting the upper Permian marine transgression. The following 800 m thick Triassic dolomitic Mahil Formation confirms the cyclic and restricted shallow marine environment upward.

Carbonates derived from the platform represented the major source for the thick sequence of slope carbonates (the Sumeini Group) deposited near the platform margin, cropping out in the Sumeini area near the border between Oman and the United Arab Emirates. The lower part of this group (about 1700 m thick) is included in the Maqam Formation, Middle Permian to late Triassic in age. Key section of the Oman margin architecture, the Wadi Maqam has been re-investigated in terms of biochronology, sequence and isotope stratigraphy.

On more distal parts, the basinal and oceanic sedimentation resulted in various types of carbonates,, of cherts and siliciclastic deposits, presently found in the Hawasina Nappe. Middle Permian radiolarites (Buday’ah) and red ammonoides limestones (Rustaq) deposited on lavas are croping out as blocks of various dimensions, the Oman Olistolits, North or West of the “autochthonous” tectonic window.

Spectacular and well studied outcrops of the Jabal Akhdar Mountains in the Wadi Sathan, of nearby Rustaq, of Buday’ah, of Wadi Maqam and Jebel Sumeini areas allowed to reconstruct correlated facies model, sequence and isotope stratigraphy and the former geometry of the margin from Middle Permian to Middle Triassic time.

All informations costs and applications are to be found at :

http://www.squ.edu.om/sci/Centers/VR/IAS/home.htm

Aymon Baud

FIRST CIRCULAR AND CALL FOR PAPERS

The International Symposium on Triassic Chronostratigraphy and Biotic Recovery 23-25 May 2005 (Monday-Wednesday) Chaohu, Anhui, China

CO-SPONSORS:

Subcommission on Triassic Stratigraphy, ICS
International Working Group of Induan-Olenekian Boundary
IGCP-467 (Triassic Time and trans-Panthalassan Correlation)
National Natural Science Foundation of China
China National Commission of Stratigraphy
China University of Geosciences

ORGANIZERS:

China University of Geosciences

Office of Land and Resources, Anhui Province

Government of Chaohu City, Anhui Province

OBJECTIVE:

This symposium is designed to provide a forum to all kinds of scientists who are interested in the Triassic chronostratigraphy, esp. the Lower Triassic, and the ecosystem reconstruction and biotic recovery in the early Triassic, as well as the related biotic and environmental events following the mass extinction. The symposium will take place at a city where a typical Lower Triassic sequence of good geological and stratigraphical markers is well exposed and a GSSP candidate of the Induan-Olenekian boundary is located. The pre- and post-symposium field excursions will lead you to examine various Upper Permian-Lower Triassic sequences in different paleogeographic facies, including the famous Meishan Section, P-T sections from normal marine to terrestrial via paralic facies, and Lower-Middle Triassic sections with tuffaceous beds at the boundary, as well as the Guanling Fauna characterized by rich reptiles and fully-preserved crinoids.

DATE, VENUE AND LANGUAGE:

Date: Pre-symposium Field Excursion: 21-22 May 2005 (Saturday-Sunday)

Route: Changxing-Nanjing-Chaohu

Symposium: 23-25 May 2005 (Monday-Wednesday)

Mid-symposium Field Excursion: 24 May 2005 (Tuesday)

Date: Post-symposium Field Excursion: 26-30/31 May 2005 (Thursday-Monday/Tuesday)

Route: Chaohu-Guiyang-Guanling-Weining-Guiyang/—Guandao-Guiyang

Place: Chaohu, Anhui Province, China

Language: English will be the official language for all presentations

IMPORTANT DATES:

31 September 2004: Deadline for submission of response to first circular

1 February 2005: Deadline for submission of abstracts for the proceedings

1 April 2005: Deadline for submission of pre-registration

THEMES:

The symposium will be structured into four main themes:

Triassic chronostratigraphy and GSSPs;

End-Permian mass extinction and Triassic recovery as well as related events;

Triassic paleontology and paleoecology;

Correlation between marine and continental Triassic.

FIELD EXCURSIONS:

Pre-symposium Field Excursion: Changxing, Zhejiang Province and Nanjing, Jiangsu Province, 21-22 May 2005 (Saturday-Sunday)

This two-day field excursion will provide you to view the famous Meishan Section, where the GSSP of the Permian-Triassic boundary, the type section of the Changhsingian Stage and a potential GSSP of the stage are located, and a Lower Triassic sequence of different facies in Nanjing, which was a transitional facies between Meishan and Chaohu.

Mid-symposium Field Excursion: Chaohu City, Anhui Province, 23 May 2005 (Monday)

During the symposium we will spend half day to visit some Lower Triassic sections in Chaohu, which are the best-studied Lower Triassic sequences in South China. The Changhsingian and Lower Triassic here were formed on deep shelf (or slope), while Meishan was on shallow shelf. The well-dated sequence by conodonts, ammonoids, paleo-magnetic and carbon-isotopic events will be closely examined.

Post-symposium Field Excursion: Central-Western/ Southern Guizhou Province, 26-30 /31 May 2005 (Thursday-Monday/Thursday)

This excursion supposes to provide you for a unique chance to trace the Permian-Triassic boundary from marine to continental via paralic facies. Many excellent marine Permian-Triassic boundary sequences have been studied in the central and southern Guizhou while the continental sections are in the western Guizhou and northeastern Yunnan. During the trip we will have a stay at the locality (field museum) of the Guanling Fauna, which is a Ladinian-Carnian fossil assemblage typically composed of well-preserved reptiles and crinoids. The final extra day is designed for those who are willing to have a view of the Lower-Middle Triassic sequence well-defined by conodonts and some dated tuffaceous beds in South Guizhou.

REGISTRATION:

Registration should be made to the registration form attached on the second circular, which will be sent to all who respond to the first circular. Registration fee for the symposium (including the Proceedings, morning and afternoon teas, and the mid-symposium field excursion) will be $150 US Dollars. Pre-Symposium field excursion fee (including field guidebook, transportation and meals) will be $200 US Dollar. Post-Symposium field excursion fee (including field guidebook, accommodation, transportation during the field excursion in Guizhou, and a single flight from Nanjing to Guiyang) will be around $500 US Dollar. Refer to the second circular for the details.

HOTEL ACCOMMODATION:

Several hotels in the downtown of Chaohu City are arranged for participants. Room rate ranges from $20 to $50 US Dollars per night for standard double rooms and $20 to $35 US Dollars per night for standard single rooms. Details and reservation forms for hotels will be distributed in the second circular.

TRANSPORTATION:

Chaohu is a mid-size city of Anhui Province with a very good traffic, 45 km from Hefei, the capital of the province, and is severed by railway and freeway, about a half-hour on freeway or railway to Hefei City. Moreover, it is only 90 km from Chaohu to Nanjing, the capital of the Jiangsu Province. It is about 180 km to the northwest of the Meishan Section, where the GSSP of the Permian-Triassic boundary is located. Therefore, Chaohu has a good traffic with a beautiful environment as well as complete geological records, and it is a geological teaching and practicing base of many universities and colleges in China.

Pre-Registration Form for:
The International Symposium on
Triassic Chronostratigraphy and Biotic Recovery
23-25 May 2005 Chaohu, Anhui, China

Forename: Initial (S): Surname:

Title: Sex (M/F):

Institution:

Full Address:

Country:

Telephone: Fax:

E-mail:

I plan to attend the Symposium (please tick)

very probably probably unlikely

I plan to contribute with an

oral paper poster

Tentative title:

I plan to attend the pre-Symposium field excursion

very probably probably unlikely

I plan to attend the post-Symposium

very probably probably unlikely

Comments/Suggestions:

Data: Signature:

Please complete and return to (by 31 September 2004):

Drs. Tong Jinnan and Zhao Laishi

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The A/L boundary Task Force

Aymon Baud, chairman of the A/L boundary Task Force

Short final report

The final vote from the Anisian-Ladinian Boundary Task Force expired February 10 and resulted in a majority of 9 votes in favour of the the base of the *Curionii* Zone, in only 5 votes for the base of the *Reitzi* Zone s.s. and 3 abstentions.

Our STS chairman, Mike Orchard, is giving (page 3) the next step for a formal vote of the STS voting Members.

A. Baud, chairman of the A-L Boundary Task Force Feb. 27, 2004

Scientific Reports

Proposal of Chaohu Section as the GSSP Candidate of the Induan-Olenekian Boundary

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Abstract

The Olenekian Stage of the Lower Triassic is named from the Boreal Realm, but the stage has never been properly defined, nor has it been applied in the low-latitude Tethyan Realm, with exception of North Caucasus and Mangyshlak. This paper proposes a stratotype for the Induan-Olenekian boundary in the low-latitude Tethyan Realm. South China is one of the main regions in the Tethyan Realm with well-developed Lower Triassic sequences and abundant fossils. According to the basic stratigraphic records and various accumulated data, we believe that the West Pingdingshan Section in Chaohu, Anhui Province is one of the best sequences to define the Induan-Olenekian boundary. The first appearance datum (FAD) of conodont *Neospathodus waageni* is the preferred index to define the boundary. This datum lies 26 cm below the FAD of the ammonoids *Flemingites* and *Euflemingites*, and is located slightly prior to the top of the second Triassic normal magnetozone, and the peak of the first Triassic positive excursion of carbon isotope $\delta^{13}C$.

Introduction

This paper briefly summarizes the major achievements of the most recent studies on the Lower Triassic, especially the Induan-Olenekian boundary, in the Chaohu area, Anhui Province, South China. The Induan-Olenekian boundary can be well defined by the FAD of conodont *Neospathodus waageni*, which also approximates the base of ammonoid *Flemingites-Euflemingites* Zone; it is also related to the magnetostratigraphy and carbon isotopic stratigraphy. Previously, extensive studies on the lithostratigraphy, lithofacies and paleogeography, ecostratigraphy, sequence stratigraphy have been underatken, and there have been two geological surveys at a scale of 1:50000 in the area. We believe that the Chaohu section meets all the requirements for the GSSP of the Induan-Olenekian boundary.

The Olenekian Stage was proposed by Kiparisova and Popov (1956) based on the type section along the lower reaches of the Olenek River, Siberia. Later research showed that this section contains only the *Olenikites spiniplicatus* Zone of the Upper Olenekian Stage. Lazurkin and Korchinskaya (1963) proposed a section at the Mengilyakh Creek as its lectostratotype. However, there are no definite index fossils to define the base of the Olenekian at the Mengilyakh Creek section. The Interdepartmental Stratigraphic Committee of the ex-USSR adapted the section of the Lekeer River as the stratotype of Lower Olenekian in ex-USSR, with the FAD of *Hedenstroemia hedenstroemi* as the lower boundary of Olenekian. However, this section lies in East Verkhoyan, outside the type area (Rostovtsev and Zhamoida, 1984). The Buur-Nyykabyt section, 225 km upstream of the Olenek River also contains *H. hedenstroemi*, but there is a conglomerate bed overlying the lagoon-continental Induan strata, thus implying a hiatus (Zakharov, 1996). As a result, the base of the Olenekian, i.e. the Induan-Olenekian boundary, cannot be defined either in the sections from the type area or in the lectostratotype.

In fact, of the seven Triassic stages decided through ballot by the STS in 1992 (Gaetani, 1992), only the Olenekian is named from the Boreal Realm in high-latitude regions. If the boundary is defined in the Boreal Realm, its application in the vast low-latitude regions will be difficult. Therefore, Zakharov (1994) and Zakharov et al. (2000) successively proposed two sections from the Russian South Primorye, which are believed to yield a mixed Boreal and Tethyan fauna, as candidates of the Induan-Olenekian boundary (Zakharov, 1994; Zakharov et al., 2000). Ammonoid *Hedenstroemia bosphorensis* was suggested as the index fossil to define the boundary. However, *Hedenstroemia* is a genus which was prevailing in the high-latitude regions and not widespread in the low-latitude regions. Nevertheless, the co-existing *Flemingites*, *Euflemingites*, *Meekoceras* and others have been commonly used as the index fossils to identify the boundary in the low-latitude regions. Meanwhile, the conodonts have received more and more attention in the definition of the chronostratigraphic boundaries and they have been taken as the chief markers in many GSSPs. Though the conodonts in the high-latitude regions are not so common as in the low-latitude regions, most of the key forms are still recognizable. Therefore, the conodonts should be considered in the definition of the Induan-Olenekian boundary.

Stratigraphic records and biostratigraphic data are usually richer in the low-latitude regions, where the biotic evolution is more rapid and so the biostratigraphy is of higher resolution and precision. Therefore, the low-latitude regions have theoretical biostratigraphic merits to define chronostratigraphic units. Albeit the Induan below the Olenekian Stage has its type area along the Indus River of the Indian Subcontinent, the upper Induan Ceratite Marl and Ceratite Sandstone in the type area contain too few fossils to allow a definition of the top of the Induan definitely. In contrast, the Lower Triassic in South China, which was situated in the eastern part of the low-latitude Tethys, has a good fossil record. Many good Lower Triassic sections covering various facies in South China have been studied. Their stratigraphic sequences appear complete and correlative not only throughout the low-latitude regions, but also throughout the world. As such, they are suitable for the GSSPs of the Lower Triassic and the base of the Middle Triassic.

Among the numerous good Lower Triassic sections in South China, the Lower Triassic of Chaohu, Anhui Province, eastern China is the most representative as it has not only rich and relatively complete ammonoid, conodont and bivalve sequences, but also a unique geological background to perform various stratigraphical studies such as magnetostratigraphy, carbon isotope stratigraphy, and isotope dating.

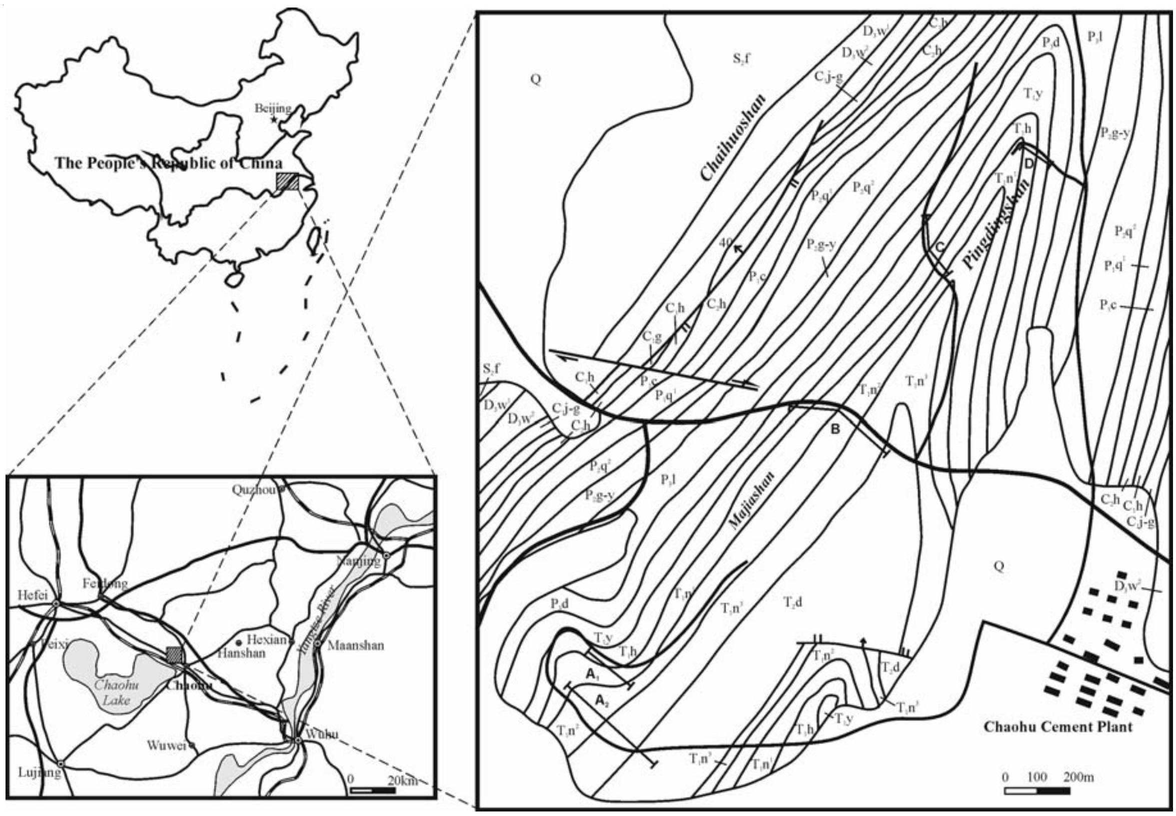

Fig. 1. Location map and geological map of the Chaohu sections in Anhui Province, East China
A1+A2, South Majiashan Section; B, North Majiashan Section; C, West Pingdingshan Section; D, North Pingdingshan Section; S_2t, Middle Silurian Fentou Formation; D_3w^1, Upper Devonian Wutong Formation (Lower Member); D_3w^2, Upper Devonian Wutong Formation (Upper Member); C_1j-g, Lower Carboniferous Jinling and Gaolishan formations; C_1h, Lower Carboniferous Hezhou Formation; C_2h, Upper Carboniferous Huanglong Formation; P_1c, Lower Permian Chuanshan Formation; P_2q^1, Middle Permian Qixia Formation (Lower Member); P_2q^2, Middle Permian Qixia Formation (Upper Member); P_2g-y, Middle Permian Gufeng and Yinping formations; P_3l, Upper Permian Longtan Formation; P_3d, Upper Permian Dalong Formation; T_1y, Lower Triassic Yinkeng Formation; T_1h, Lower Helongshan Formation; T_1n^1, Lower Triassic Nanlinghu Formation (Lower Member); T_1n^2, Lower Triassic Nanlinghu Formation (Middle Member); T_1n^3, Lower Triassic Nanlinghu Formation (Upper Member); T_2d, Middle Triassic Dongma'anshan Formation; Q, Quaternary.

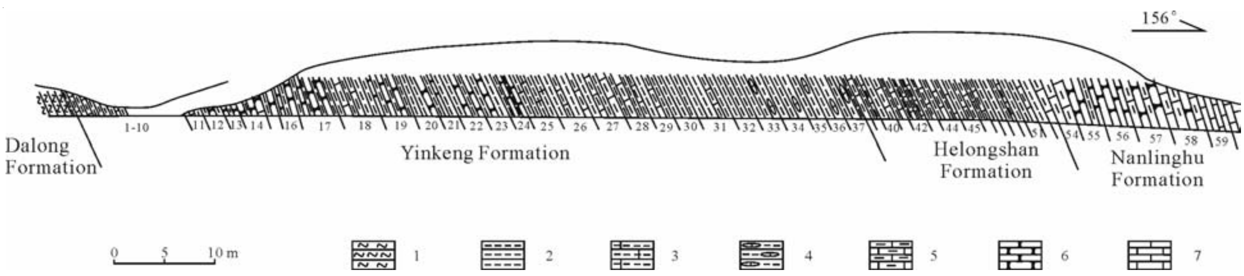

Fig. 2. Profile of the Lower Triassic section at West Pingdingshan, Chaohu, Anhui
1, Cherty mudrock; 2, mudrock; 3, calcareous mudrock; 4, mudrock with lenticular limestone; 5, marl; 6, nodular limestone; 7, limestone.

Geological background

Chaohu is a mid-size city of Anhui Province with a good traffic communication, about one half-hour by freeway or railway to Hefei City, the capital of Anhui Province (fig. 1). It is about 180 km to the northwest of the Meishan Section, where the GSSP of the Permian-Triassic boundary is located (Yin et al., 2001). During the Early Triassic they were both on the Lower Yangtze carbonate ramp with Chaohu located in a deeper water area than Meishan. The Lower Triassic at Chaohu is composed of a series of multiple cycles of mud-lime rocks, with the argillaceous content decreasing upward while limestone becomes the predominant lithology in the upper part. The section at Chaohu contains a fauna rich in conodonts, ammonoids and thin-shelled and compressed bivalves such as *Claraia*, as well as some fish and reptile fossils. Thus the Lower Triassic biostratigraphical sequence is marked by conodonts and ammonoids allowing for a well-defined stratigraphy. In addition, the close-spaced alternations of mud-lime rocks in the Lower Triassic provide favorable provision for the carbonate carbon isotope analysis as well as magnetostratigraphical study.

The Lower Triassic in Chaohu is mainly exposed in the northwestern suburb of the Chaohu City, where it constitutes the core of the Majiashan-Pingdingshan Synclinorium (fig. 1). The synclinorium plunges northward, so the Lower Triassic is entirely exposed only in the southern part, the Majiashan Mt., while the northern part, the Pingdingshan Mt., has only the outcrop of the lower part of Lower Triassic. The classic Lower Triassic sequence in Chaohu is the Majiashan Section in the South Majiashan Mt., at which most of the early work has been done, such as sedimentology, lithostratigraphy, ecostratigraphy, sequence stratigraphy, as well as bivalve, ammonoid and conodont biostratigraphy (see Tong et al., 2001a, 2001b) for review). Because the lower part of the South Majiashan Section has been heavily covered since the 1990s, the studies of recent years had to be performed at some newly-exposed Pingdingshan sections, about 2000 m to the north of the Majiashan Section. The sections are on the limbs of the Pingdingshan Syncline. The strata from the Permian-Triassic boundary to the Induan-Olenekian boundary are continuously exposed at the North Pingdingshan Section. The topmost Permian in this area is the Dalong Formation composed of siliceous rocks and chert beds, which are coeval with the Changxing Formation but in different facies. The stratigraphic sequence at the Permian-Triassic boundary is clearly similar to that at the Meishan Section. The same “boundary clay bed” and “boundary limestone” are distinctive in the Permian-Triassic boundary sequence.

At the West Pingdingshan Section the Lower Triassic is even better exposed except for about 10 m of strata at the base of the Lower Triassic, which is covered by a road leading to a quarry on the hill side. However, the Permian-Triassic boundary is still observable (fig. 2). The sequence around the Induan-Olenekian boundary, up to the lower part of upper Olenekian (Spathian), is extremely good for study. The Induan-Olenekian boundary defined by the ammonoid *Flemingites* Zone is quite close to the FAD of *Neospathodus waageni*. This section is proposed as the candidate for the Induan-Olenekian boundary stratotype.

As the upper part of Upper Olenekian in the Pingdingshan Mt. has been eroded, the upper part of the sequence can be studied in the Majiashan Mt. Although a new quarry exposes the lower part of the Olenekian here, the Upper Olenekian and the Lower Anisian at the earlier- studied Majiashan Section are much better.

Induan-Olenekian boundary sequence and fossils at the West Pingdingshan Section

The best-exposed and studied Induan-Olenekian boundary strata are at the West Pingdingshan Section. The section was exposed by a road leading to a quarry of the Dongya Cement Plant and the exposed profile is about 5 m high above the side of the road (fig. 2). Another road cut through the strata again at 3 m above the profile and the boundary strata can be surveyed comparatively.

The boundary sequence at the West Pingdingshan Section is described as follows (fig. 3):

Yinkeng Formation (from Bed 1 to Bed 37)

Flemingites-Euflemingites Zone (from Bed 24-21 to Bed 25-33)

Neospathodus waageni Zone (from Bed 24-16 to Bed 52-1)

Neospathodus waageni waageni Subzone (from Bed 25-10 to Bed 52-1)

Bed 25. Grayish brown to grayish black shale intercalated by a few thin beds of greenish gray calcareous mudrock and two thin beds of grayish black pyrite-bearing micritic limestone in the lower 172 cm, dominated by black shale and intercalated by three beds of grayish yellow bentonitic claystone 1—5 cm thick; and greenish gray to gray medium-bedded argillaceous nodular limestone and banding limestone intercalated by some thin beds of calcareous mudrock in the upper 69 cm. It is subdivided into 33 subbeds.

25-33. Greenish gray limestone with argillaceous bands, yielding *Neospathodus waageni waageni*, *N*. sp., *Platyvillosus costatus*, *P*. *hamadai*, *Parachirognathus* cf. *tricuspidatus*..5 cm

25-32. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 3, *Platyvillosus costatus*, *P*. *hamadai*, and some ramiform elements...5 cm

25-31. greenish gray limestone with argillaceous bands, yielding *Neospathodus waageni waageni*, *N*. *novahollandiae*, *N*. *conservatives*, *N*. sp., and some ramiform elements...10 cm

25-30. greenish gray mudrock intercalated by greenish gray argillaceous limestone, yielding *Neospathodus waageni waageni*, *N*. *waageni* n. subsp. A, *N*. *waageni* n. subsp. B, *N*. *novahollandiae*, *N*. sp., *Parachirognathus* sp., and some ramiform elements...12 cm

25-29. greenish gray limestone with argillaceous bands, yielding *Neospathodus dieneri* Type 2, *N*. *dieneri* Type 3, *N*. *cristagalli*, *N*. *waageni waageni*, *N*. *waageni* n. subsp. A, *N*. *novahollandiae*, *N*. n. sp. L, *N*. sp., *Platyvillosus costatus*, *P*. *hamadai*, *Parachirognathus* sp., and ramiform elements..3 cm

25-28. greenish gray argillaceous nodular limestone, yielding *Neospathodus waageni waageni*, *N*. *waageni* n. subsp. B, *N*. *novahollandiae*, *N*. sp., and some ramiform elements...12 cm

25-27. greenish gray limestone with argillaceous bands, yielding *Neospathodus waageni waageni*, *N*. *waageni* n. subsp. A, *N*. n. sp. E. and some ramiform elements; *Euflemingites*? sp. ....5 cm

25-26. greenish gray argillaceous nodular limestone, yielding *Neospathodus cristagalli*, *N*. *waageni waageni*, *N*. *waageni* n. subsp. A, and some ramiform elements...12 cm

25-25. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 3, *N*. *cristagalli*, *N*. *waageni waageni*, *N*. *waageni* n. subsp. B, *N*. aff. *discretus*, *N*. *peculiaris*, *N*. *alberti*, *N*. *novahollandiae*, *N*. n. sp. E, *N*. n. sp. H, *N*. n. sp. L, *Platyvillosus costatus*, and ramiform elements...5 cm

25-24. black shale intercalated by greenish gray limestone with argillaceous bands, yielding *Neospathodus cristagalli*, *N*. *waageni waageni*, *N*. *novahollandiae*, *N*. sp., *Platyvillosus costatus*, and some ramiform elements......8 cm

25-23. grayish yellow bentonitic claystone with rhyolitic component, yielding *Neospathodus cristagalli*, *N*. *dieneri* Type 3, *N*. *waageni waageni*, *N*. *alberti*, *N*. n. sp. G, *N*. n. sp. L, *Platyvillosus costatus*, and some ramiform elements ....5 cm

25-22. grayish black shale, yielding *Neospathodus waageni waageni* (?), *N*. sp., *Platyvillosus costatus*, and some ramiform elements; *Dieneroceras* cf. *ovale*..10 cm

25-21. grayish black shale, yielding *Neospathodus waageni waageni* (?), *N*. sp., and some ramiform elements; *Pseudosageceras* sp., *Dieneroceras* sp.; *Eumorphotis inaequicostata*..10 cm

25-20. grayish black shale, yielding *Neospathodus waageni waageni*, *N*. *cristagalli*, *N*. sp., and some ramiform elements..10 cm

25-19. grayish black shale, yielding *Neospathodus* sp., and some ramiform elements.......................................10 cm

25-18. grayish black shale, yielding *Neospathodus cristagalli*, *N*. sp., and some ramiform elements.................10 cm

25-17. grayish black shaly pyrite-bearing micritic limestone, yielding *Neospathodus cristagalli*, *N*. sp., *Parachirognathus* cf. *tricuspidatus*, and some ramiform elements..8 cm

25-16. grayish black shale, yielding *Neospathodus* sp., and some ramiform elements.......................................10 cm

25-15. grayish black shale intercalated by 2 cm grayish yellow argillaceous limestone, yielding *Neospathodus* sp., and some ramiform elements..10 cm

25-14. grayish black shale intercalated by grayish yellow claystone with rhyolitic component, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 2, *N.* sp., and some ramiform elements; *Euflemingites* sp., *Prosphingitoides*? sp.; *Eumorphotis inaequicostata*, *E.* sp...10 cm

25-13. grayish black shale, yielding *Neospathodus cristagalli*, *N.* sp., some ramiform elements; *Euflemingites*? sp., *Owenites*? sp., *Euflemingites* sp.; *Eumorphotis huancangensis*, *E. inaequicostata*, *E.* sp.................................10 cm

25-12. grayish black shale, yielding *Neospathodus* sp., some ramiform elements; *Flemingites* sp., *Pseudosageceras tsotengense*; *Eumorphotis huancangensis*, *E. inaequicostata*. *E.* sp...10 cm

25-11. grayish black shale, yielding *Neospathodus* sp., some ramiform elements; *Pseudosageceras tsotengense*, *Flemingites* sp.; *Eumorphotis inaequicostata*, *E.* sp...8 cm

25-10. grayish yellow bentonitic claystone with rhyolitic component, yielding *Neospathodus waageni waageni*, *N. dieneri* Type 1, *N. dieneri* Type 2, *N. cristagalli*, *N.* n. sp. B, *N.* n. sp. K, *N.* sp., and some ramiform elements...2 cm

Neospathodus waageni n. subsp. B Subzone (from Bed 24-20 to Bed 25-9)

25-9. grayish black shaly limestone, yielding *Neospathodus* sp., some ramiform elements; *Preflorianites* cf. *strongi* ....4.5 cm

25-8. grayish black shaly limestone, yielding *Neospathodus* sp., some ramiform elements; *Preflorianites* cf. *strongi*, *Dieneroceras* sp..4.5 cm

25-7. grayish black shaly limestone, yielding *Neospathodus* sp., some ramiform elements; *Dieneroceras* sp.; *Eumorphotis huancangensis*, *E. inaequicostata*, *E.* sp., *Posidonia* sp...4.5 cm

25-6. grayish black shaly limestone, yielding *Neospathodus* sp., some ramiform elements; *Flemingites* sp., *Euflemingites* sp., *Paranorites* sp...4.5 cm

25-5. grayish yellow bentonitic claystone with rhyolitic component, yielding *Neospathodus* sp.........................2 cm

25-4. grayish black shale, yielding *Neospathodus* sp...5 cm

25-3. grayish black shale, yielding *Neospathodus* sp.; *Paranorites* cf. *ovalis*, *Koninckites* sp., *Pseudosageceras* sp. ....5 cm

25-2. grayish black shale, yielding *Neospathodus* sp.; *Euflemingites* sp., *Paranorites* cf. *ovalis*, *P.* sp., *Koninckites* cf. *lolowensis*; *Eumorphotis huancangensis* ....5 cm

25-1. grayish black shale, yielding *Neospathodus* sp.; *Flemingites* sp., *Pseudosageceras* sp., *Euflemingites*? sp.; *Eumorphotis inaequicostata*, *E.* sp..5 cm

Bed 24. Composed of four cycles of grayish brown mudrock and argillaceous limestone or limestone with argillaceous bands, dominated totally by mudrock. It is subdivided into 22 subbeds.

24-22. greenish gray argillaceous limestone intercalated by greenish gray mudrock, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 2, *N. dieneri* Type 3, *N. waageni* n. subsp. A, *N. waageni* n. subsp. B, *N.* n. sp. C (?), *N.* n. sp. E, *N.* n. sp. K, *N.* sp., some ramiform elements; *Euflemingites*? sp., *Dieneroceras* sp...4 cm

24-21. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 2, *N. dieneri* Type 3, *N. waageni* n. subsp. A, *N. waageni* n. subsp. B, *N. cristagalli* (?), *N.* n. sp. B, *N.* n. sp. C (?), *N.* n. sp. E, *N.* n. sp. F, *N.* n. sp. K, *N.* sp., some ramiform elements; *Flemingites*? sp., *Euflemingits*? sp. ....4 cm

Gyronites-*Prionolobus* Zone (from Bed 18-9 to Bed 24-20)

24-20. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 2, *N. dieneri* Type 3, *N. waageni* n. subsp. A, *N. waageni* n. subsp. B, *N. cristagalli* (?), *N.* n. sp. B, *N.* n. sp. E, *N.* n. sp. F, *N.* sp., and some ramiform elements...3 cm

Neospathodus waageni n. subsp. A Subzone (from Bed 24-16 to Bed 24-19)

24-19. greenish gray calcareous mudrock intercalated by thin-bedded limestone, yielding *Neospathodus* sp. and some ramiform elements...4 cm

24-18. greenish gray calcareous mudrock intercalated by greenish gray argillaceous limestone, yielding *Neospathodus* *dieneri* Type 1, *N. dieneri* Type 2, *N. dieneri* Type 3, *N. cristagalli* (?), *N.* n. sp. C. and some ramiform elements...6 cm

24-17. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1 (?), *N. dieneri* Type 2, *N.* sp., and some ramiform elements..6 cm

24-16. greenish gray argillaceous limestone, yielding *Neospathodus waageni* n. subsp. A, *N. dieneri* Type 2, *N.* sp., and some ramiform elements..7 cm

Neospathodus n. sp. C-*N.* n. sp. D Zone (from Bed 23-4 to Bed 24-15)

24-15. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N.* n. sp. C, *N. cristagalli* (?), *N.* sp., and some ramiform elements..7 cm

24-14. greenish gray calcareous mudrock..5 cm

24-13. grayish black calcareous mudrock..13 cm

24-12. greenish gray calcareous mudrock intercalated by thin-bedded limestone...5 cm

24-11. greenish gray calcareous mudrock..5 cm

24-10. grayish black calcareous mudrock, yielding *Gyronites*? sp...5 cm

24-9. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N.* sp., and some ramiform elements..10 cm

24-8. greenish gray calcareous mudrock, yielding *Prionolobus* sp., *Koninckites* sp., *Eumorphotis* sp...............15 cm

24-7. grayish black calcareous mudrock, yielding *Koninckites* sp., *Eumorphotis* sp..10 cm

24-6. grayish black calcareous mudrock, yielding poor-preserved ammonoids..10 cm

24-5. grayish black calcareous mudrock, yielding poor-preserved ammonoids..5 cm

24-4. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N.* n. sp. C, *N.* sp., some ramiform elements; poor-preserved ammonoids..5 cm

24-3. greenish gray calcareous mudrock, yielding poor-preserved ammonoids..10 cm

24-2. grayish black calcareous mudrock, yielding poor-preserved ammonoids, *Eumorphotis* sp..........................5 cm

24-1. grayish black calcareous mudrock, yielding *Gyronites*? sp., *Eumorphotis* sp...15 cm

Bed 23. Composed of four cycles of mudrock and banded limestone, dominated totally by mudrock. It is subdivided into 14 subbeds.

23-14. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, and some ramiform elements..5 cm

23-13. greenish gray argillaceous nodular limestone, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 3, *N. cristagalli* (?), *N.* n. sp. C, *N.* n. sp. D, *N.* sp., some ramiform elements; *Eumorphotis* sp....................................8 cm

23-12. greenish gray argillaceous nodular limestone, yielding *Neospathodus dieneri* Type 1, *N. dieneri* Type 2, *N.* n. sp. C, *N.* n. sp. D, *N.* sp., some ramiform elements; *Prionolobus* sp.; *Eumorphotis* cf. *venetiana*, *E.* sp. ....4 cm

23-11. greenish gray argillaceous limestone, yielding *Neospathodus dieneri* Type 1, *N.* n. sp. C, *N.* n. sp. D, *N.* sp., and some ramiform elements..7 cm

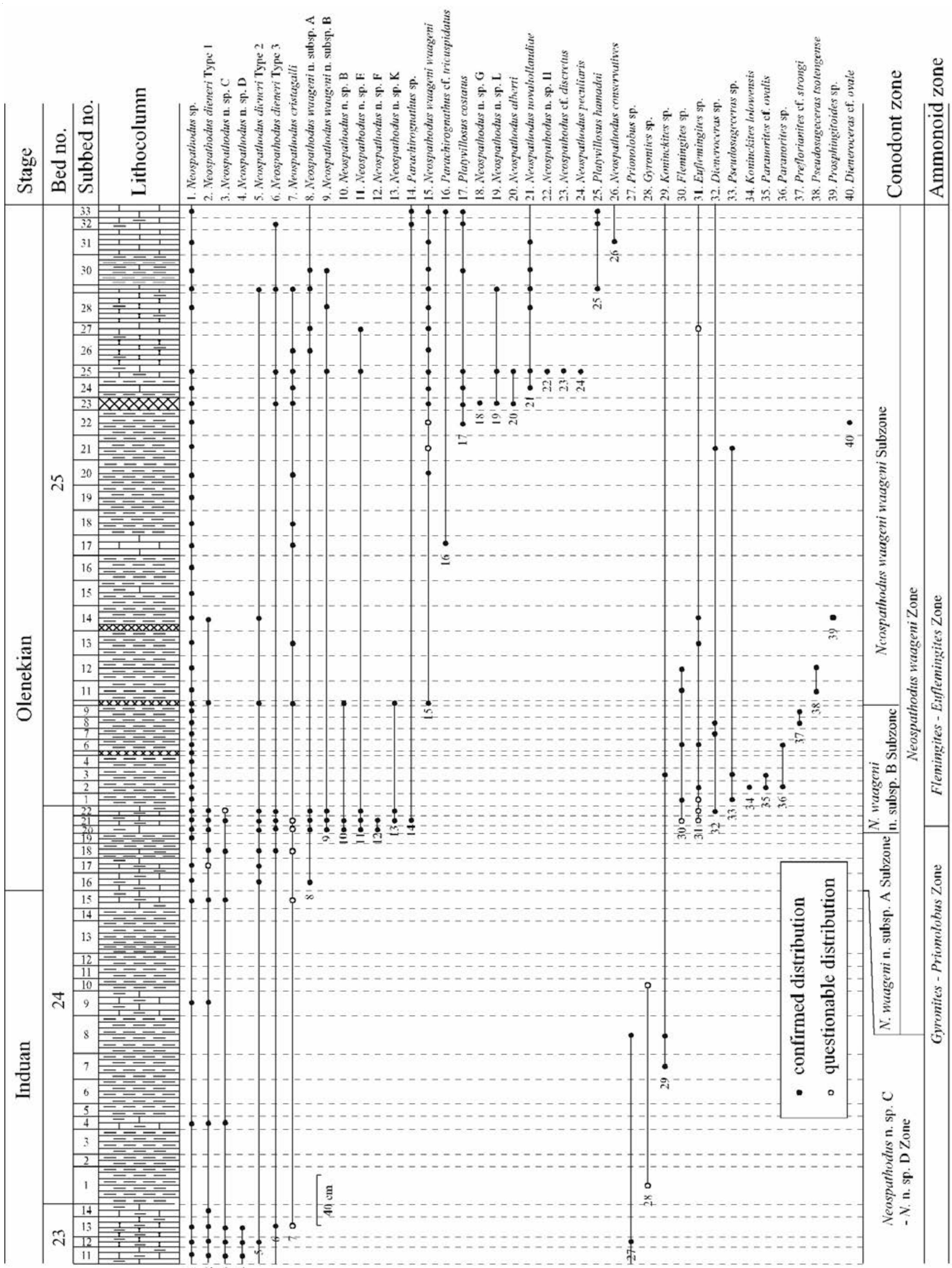

Fig. 3. Stratigraphic column and fossil distribution around the Induan-Olenekian boundary at the West Pingdingshan Section

Fossils are quite abundant in the strata around the Induan-Olenekian boundary at the West Pingdingshan Section and about 1000 specimens of conodonts, 200 specimens of ammonoids and 100 specimens of bivalves are recovered from the 5 m strata around the boundary. It seems that this interval was a relatively diversifying period of many groups, including conodonts and ammonoids, in comparison to the average distribution of the fossils through the Lower Triassic (fig. 3).

Definition of the Induan-Olenekian boundary at the Chaohu sections

The Induan and Olenekian were first proposed as the two stages of the Lower Triassic by Kiparisova and Popov (1956) based upon the Boreal Realm ammonoids though the Induan was from the Indus River in the Tethyan region. They correlated these two stages with the Lower Eo-triassic, including Otoceratan, Gyronitan and Flemingitan, and the Upper Eo-triassic, including Owenitan, Columbitan and Stephanitan, summarized in the Tethyan region by Spath (1934). However, later studies indicated that the Flemingitan fossils along the Indus River occurred in the lower part of the Olenekian in the Boreal Realm, thus Kiparisova and Popov (1964) revised the Induan-Olenekian boundary along the Indus River and placed the Flemingitan of Spath (1934) into the Olenekian. Since then, the fossils from the Flemingitan have been taken as the indices to define the Induan-Olenekian boundary in the vast low-latitude region because the typical Olenekian ammonoids defining the boundary in the Boreal Realm are scarcely found in low-latitude regions. However, this boundary is generally placed at the top of the Flemingitan in China (see Yin and Tong (2002) for discussion) while it is at the base of the Flemingitan in the other regions over the world.

As the ammonoids are more or less restricted by paleogeography and facies in general, the conodonts have advantage in the accurate definition of the chronostratigraphic units. Sweet et al. (1971) summarized the Lower Triassic conodont sequence especially based on the conodont study of good ammonoid-controlled strata in the Salt Range and Trans-Indus Ranges, West Pakistan (Sweet, 1970). Accordingly, conodonts became used more widely as the key forms to define the Induan-Olenekian boundary in the low-latitude regions. In Chaohu the conodont *Neospathodus waageni* seems the best index to define the boundary. Repeated studies confirm that the FAD of *Neospathodus waageni* is 26 cm below the base of the ammonoid *Flemingites*-*Euflemingites* Zone, the FAD of *Flemingites* and *Euflemingites* at the West Pingdingshan Section (fig. 3). According to published evidence, *N. waageni* has a worldwide distribution and it has been found at nearly all marine Lower Triassic sections in South China where conodonts were studied. This species has been reported from many sections in both low- and high-latitude regions, including Pakistan, Malaysia, Timor, Kashmir, Japan, Australia, India, Nepal, Northern Vietnam, Italy, Norway, western North America, Canada, Russia and others. This species is also distributed much wider than *Neospathodus pakistanensis*, the underlying conodont zonal fossil in the zonation of Sweet et al. (1971). Works also indicate that the *Neospathodus pakistanensis* Zone might not be a distinct and absolute biostratigraphic unit and it was sometimes used as coeval with the lower part of the *Neospathodus waageni* Zone (Sweet and Bergstroem, 1986; Orchard, 1995) Meanwhile, no assured *N. pakistanensis* has been recognized at the West Pingdingshan Section.

Lower Triassic stratigraphical sequence in Chaohu

The Yinkeng and Helongshan formations, Induan and lower Olenekian, which have been well studied are well developed at the Pingdingshan sections while the data of the Nanlinghu Formation, Upper Olenekian, are chiefly from the South Majiashan Section (fig. 4).

Lithostratigraphy

The Lower Triassic of Chaohu mainly consists of calcareous and argillaceous components. The argillaceous rocks are predominant in the lower part while the calcareous beds prevail in the upper part. According to different composition and bedding conditions of the rocks, three formations can be recognized. The lower one, the Yinkeng Formation, is mostly composed of alternations of mudrock (shale) and thin-bedded limestone, intercalated by some medium-bedded limestone in the lowest and upper parts and sometimes by some thin beds of marlstone or nodular limestone in the middle and upper parts. The mudrock and limestone usually appear in a series of multiple mudrock-limestone cycles, but the formation is relatively dominated by argillaceous component. The Yinkeng Formation is well exposed at the West Pingdingshan Section except that a few meters at the base are covered by a road leading to a hillside quarry, but the basal part is well studied at the North Pingdingshan Section (fig. 1). The formation is about 75 m thick and contains rich ammonoid, bivalve and conodont fossils (fig. 4).

The middle unit is the Helongshan Formation, which is chiefly composed of the rhythmic alternations of thin-bedded mudrock and limestone except for two thick beds of limestone at the base which mark the beginning of the formation. The formation is relatively thin, only about 20 m thick, and exposed well at all the sections in Chaohu. It is relatively dominated by an argillaceous component and the rocks are thin-bedded and the thin limestone beds sometimes become lenticular or nodular, thus forming nodular limestones. The fossils are quite rich in this formation, including ammonoids, bivalves, conodonts and bony fishes.

The upper unit of Lower Triassic is the Nanlinghu Formation. This formation consists mainly of thick- bedded limestone and nodular limestone, interbedded with medium- to thin-bedded limestone and very thin mudrocks. The cyclic bedding is formed by regular sequence of various thicknesses of the limestone beds or by the alterna-

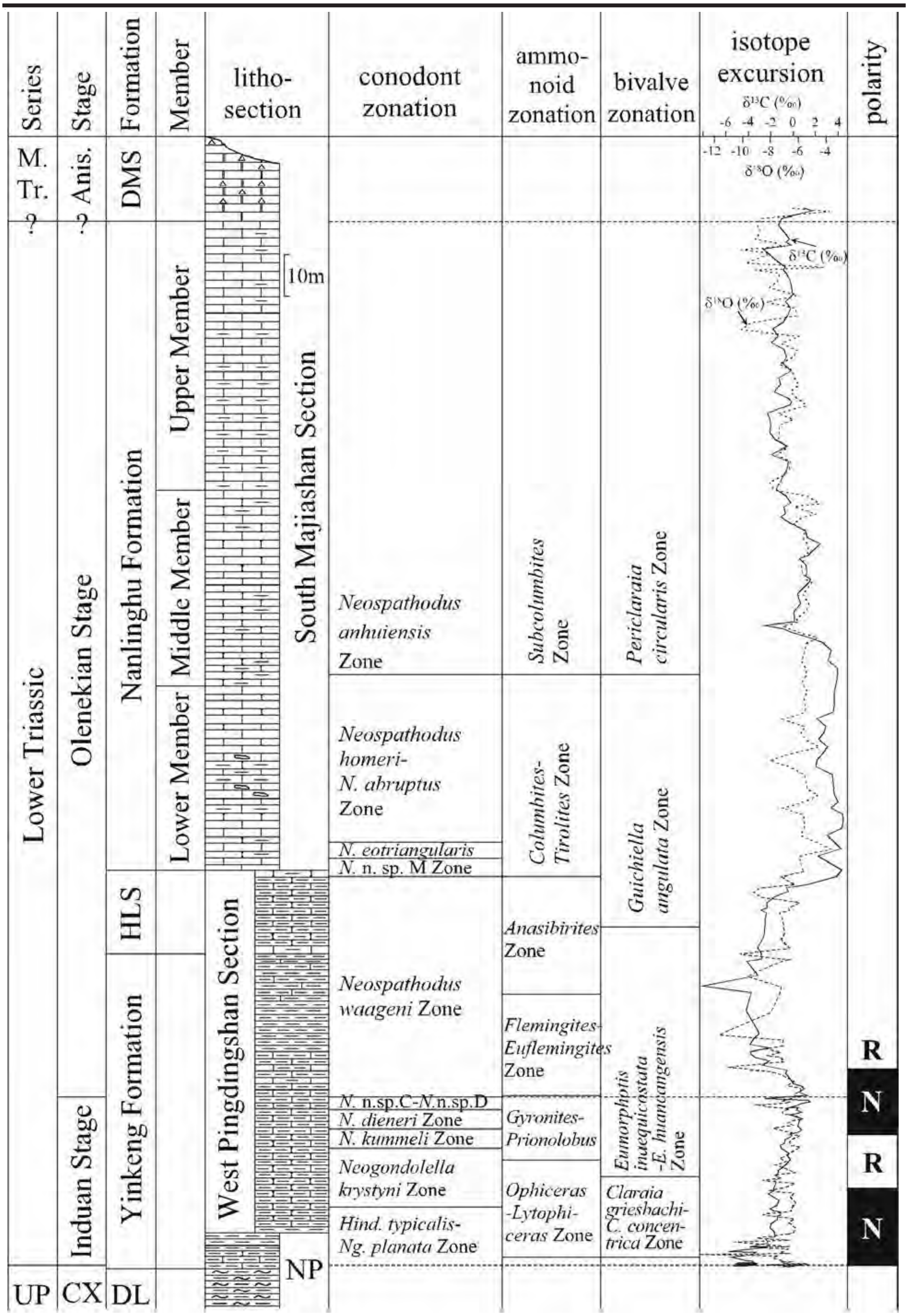

Fig. 4. Integrated Lower Triassic stratigraphical sequence in Chaohu, Anhui
Anis, Anisian Stage; CX, Changhsingian Stage; DL, Dalong Formation; DMS, Dongma'anshan Formation; HLS, Helongshan Formation; M. Tr, Middle Triassic; N, Normal Polarity Zone; NP, North Pingdingshan Section; R, Reversed polarity.

tion of the limestone and mudrock. This formation is much thicker, about 150 m, than the two lower formations and it is entirely exposed only at the South Majiashan Section (fig. 1). Three members are recognized. The Lower Member is about 44 m thick at the South Majiashan Section and composed of the cycles of medium- to thick-bedded limestone and relatively thin beds of greenish gray mudstone. The Middle Member, about 47 m thick, includes two parts where the lower part consists of interbeds of purplish brown medium- to thick-bedded nodular limestone and relatively thin beds of dark gray mudstone while the upper is of interbeds of dark gray thick-bedded limestone or limestone with argillaceous bands and black mudstone. The Upper Member consists of cyclic beds of grayish thick-bedded limestone and very thin mudrocks. The formation is clearly dominated by limestone with some intercalated beds of fine-grained breccia limestone in the lower part formed by distal storm or turbidite, and some dolomitic beds at the top partly formed due to the closure and evaporation in the basin. The Nanlinghu Formation was obviously formed at a much higher depositional rate but it still contains rich fossils, though not as many as in the two lower formations. It includes ammonoids, bivalves, conodonts, as well as some bony fishes and reptiles.

The underlying topmost Permian lithostratigraphical unit is the Dalong Formation. The boundary between the Dalong and Yinkeng Formations is well seen at the North Pingdingshan and West Pingdingshan sections where an 18-cm bed of limestone marks the base of the Yinkeng Formation, which is believed to correspond with Bed 27 at the Meishan Section (Yin, et al., 1996]. The overlying basal Middle Triassic lithostratigraphical unit, the Dongma'anshan Formation, is not fully preserved in Chaohu and its upper part has been eroded. It is composed mainly of evaporites such as dolomite, dolomitic limestone and evaporite-solution breccias; its base is observed at the North Majiashan and South Majiashan sections.

Biostratigraphy

Fossils are very rich throughout the Lower Triassic in Chaohu and the studied taxa include ammonoids, bivalves, conodonts, bony fishes and a few reptiles. The ammonoids and conodonts are of special importance in stratigraphy to define the Early Triassic geochronology. Most Early Triassic bivalves are also characteristic though they are not so accurate in geochronology as the ammonoids and conodonts. The vertebrates such as bony fishes and reptiles found in Chaohu would be distinctive in age but the locations where such vertebrates are collected are still limited.

Ammonoids

Since Guo (1982) firstly studied the Lower Triassic ammonoids at the South Majiashan Section (Guo Peixia, 1982), repeated investigations have been undertaken on the ammonoid biostratigraphy in various Lower Triassic sections of Chaohu and a continuous Lower Triassic ammonoid zonation has been established (fig. 4).

Chaohu is one of the few locations in South China yielding a complete Lower Triassic ammonoid biostratigraphic sequence. However, the ammonoids in Chaohu are mostly from argillaceous rocks, commonly from mudrocks and the fossils are preserved as molds without shells or they are strongly compressed, thus the exact identification of the fossils are difficult and only genera could be identified. Even so, many Lower Triassic ammonoid genera are of stratigraphic significance and the zonation is therefore based on the generic level. All zonal ammonoids were typical and correlative in South China, even in the Tethyan region. Six ammonoid zones are recognized from the bottom up, they are *Ophiceras-Lytophiceras* Zone, *Gyronites-Prionolobus* Zone, *Flemingites-Euflemingites* Zone, *Anasibirites* Zone, *Columbites-Tirolites* Zone and *Subcolumbites* Zone.

Conodonts.

The conodonts in the Lower Triassic of Chaohu are quite rich, especially in the lower and middle parts while relatively rare in the upper part. The only conodont study in the earlier years was that by Ding (1983) who described 6 Lower Triassic conodont zones (Ding Meihua, 1984), corresponding well with the common conodont biostratigraphical sequence proposed by Sweet et al. (1971), based upon the fossils from the South Majiashan Section. Repeated analyses on the conodonts at the various Lower Triassic sections in Chaohu have retrieved thousands of conodont specimens in recent years, which show a more assured and usable conodont sequence (fig. 3). According to the new conodont data, 9 conodont zones are found in the Lower Triassic of Chaohu: *Hindeodus typicalis-Neogondolella planata* Zone, *Neogondolella krystyni* Zone, *Neospathodus kummeli* Zone, *Neospathodus dieneri* Zone, *Neospathodus* n. sp. C-*Neospathodus* n. sp. D Zone, *Neospathodus waageni* Zone, *Neospathodus* n. sp. M Zone, *Neospathodus eotriangularis* (n. sp.) Zone and *Neospathodus abruptus-N. homeri* Zone.

The conodont fossils are usually extracted from the calcareous rocks, especially from limestones and they are found in nearly all limestone beds of the Yinkeng and Helongshan Formations. Even the calcareous mudrocks in the upper part of the Yinkeng Formation are rich in conodonts. Conodonts become less common in the overlying Nanlinghu Formation and are rare in the thick-bedded limestone of the upper part of the formation. No definite Anisian fossils, neither ammonoids nor conodonts, have been discovered in the Nanlinghu Formation and the Dongma'anshan Formation of Chaohu, thus the boundary between the Lower Triassic Olenekian and the Middle Triassic Anisian is unconstrained.

Bivalves

Bivalves are extremely abundant and commonly form shell-beds of one single species in some argillaceous rocks, especially in mudrocks. All the bivalves are compressed and thin-shelled and preserved only as molds without shells. Bivalves coexist commonly with ammonoids in the Yinkeng Formation and sometimes in the Helongshan Formation but they rarely coexist with ammonoids in the Nanlinghu Formation since they are only found in the intercalated mudrocks while the ammonoids mostly are from the limestone. Most of the Lower Triassic bivalves are of some stratigraphic value and four bivalve zones can be recognized in ascending order in the Lower Triassic of Chaohu (fig. 3), namely *Claraia griesbachi-C. concentrica* Zone, *Eumorphotis inaequicostata-E. huancangesis* Zone, *Guichiella angulata* Zone, and *Periclaraia circularis* Zone.

Claraia is the first Triassic bivalve genus found in Chaohu and it dominates the lower part of the Yinkeng Formation. *Eumorphotis* came a little later and it is characteristic in the interval from the upper part of the Yinkeng Formation to the base of the Nanlinghu Formation though some species of *Claraia* are also common in this interval. *Posidonia* is a typical opportunistic form with small and thin shells (Yin Hongfu, et al., 1995; Tong Jinnan, 1998) and it commonly assembles at some horizons to form the "shell-mudrock". The *Posidonia* shells are generally so small and crowded that their exact identification becomes difficult, and sometimes they may even be suspected to be juvenile claraiids. *Posidonia* is commonly seen from the upper Yinkeng Formation to the upper Nanlinghu Formation. *Periclaraia* and *Guichiella* are characteristic endemic forms in Chaohu and its neighboring areas and they occur only in the Olenekian. *Periclaraia* occurs only in the Nanlinghu Formation while *Guichiella* is predominant in the Helongshan Formation (Li Jinhua and Ding Baoliang, 1981).

Vertebrates.

Some skeletal vertebrate fossils were also collected from the Lower Triassic of Chaohu, including bony fishes and ichthyosaurs. The bony fishes are mainly from two horizons in the middle and upper parts of the Helongshan Formation, and include *Plesioperleidus yangtzensis*, *P. dayeensis*, *P*. n. sp., *Jurongia fusiformis*, *Qingshania cercida* and *Suius* cf. *S. brevis*. Some saurichthyids were also found in the Nanlinghu Formation, coexisting with ichthyosaurs. Two ichthyosaur genera, *Chaohusaurus* Young and Dong (Young Chongchian, 1972) and *Chensaurus* (Chen) (Chen Zulie, 1985), revised by Mazin et al. (1991), were named from the Upper Member of the Nanlinghu Formation in Chaohu, including four species, i.e. *Chaohusaurus guishanensis*, *C*. n. sp., *Chensaurus chaoxianensis* and *C. faciles*. All of these vertebrate fossils are so far found only in the Olenekian of South China. The ichthyosaur forms from Chaohu show some primitive characteristics in the history of ichthyosaurs (Motani and You, 1998).

Carbon isotope stratigraphy

376 samples from various Lower Triassic sections in Chaohu were analyzed for $\delta^{13}C_{carb}$ and $\delta^{18}O_{carb}$. The data cover the whole Lower Triassic sequence with an average interval of 50 cm in the Yinkeng and Helongshan formations and 200 cm in the Nanlinghu Formation. The analyses were performed at the Earth Surface System of Hubei Province, China University of Geosciences and selective examinations were sent to the State Laboratory of Paleobiology and Stratigraphy in Nanjing and the Isotope Analytical Center at Yichang Institute of Geology and Mineral Resources. The repeated analyses of separately collected samples at the North Pingdingshan Section and a corresponding analysis of the samples from the West Pingdingshan Section resulted in an entirely identical isotope values.

The carbon isotope curve shows two complete cycles through the Lower Triassic (fig. 4). The Dalong Formation in the topmost part of the Permian is composed of cherty mudrocks and no carbonate carbon isotope was obtained. The Permian-Triassic boundary limestone yields an evident negative $\delta^{13}C_{carb}$ value, which is clearly corresponding with the "global carbon isotopic anomaly" at the Permian-Triassic boundary (Baud, A. et al., 1989). The $\delta^{13}C_{carb}$ value remains low for the base of the Yinkeng Formation but gradually increases for the Yinkeng Formation, reaches zero and turns positive for the Induan-Olenekian boundary. However, an even greater negative excursion of $\delta^{13}C_{carb}$ occurs in the Helongshan Formation, Lower Olenekian. This anomaly is confirmed by the data from all the North Pingdingshan, West Pingdingshan and South Majiashan sections and it may be related to the sudden decline of the disaster taxa which flourished during the survival phase following the end-Permian mass extinction, while the anomaly at the Permian-Triassic boundary is believed to result from the mass extinction at the end of the Paleozoic (Tong Jinnan et al., 2002). Following this negative anomaly occurs a rapid positive shift of the $\delta^{13}C_{carb}$ around the Helongshan Formation and Nanlinghu Formation transition, which is also detected at all the sections. The $\delta^{13}C_{carb}$ is relatively high, around 4‰, for the Lower Member of the Nanlinghu Formation but gradually decreases for the Middle and Upper members according to the data from the South Majiashan Section. It turns negative firstly for the Middle Member, but the data from the Middle Member are dominated by positive values while the data from the Upper Member are mostly negative. However, the negative shift of $\delta^{13}C_{carb}$ data from the Nanlinghu Formation does not reach the lowest values in the Yinkeng and Nanlinghu formations but it does not turn back to the positive value up to the Dongma'anshan Formation (fig. 4).

Magnetostratigraphy

Thirty-two levels were sampled by drilling oriented 1-inch diameter cores scattered through the complete Induan and part of the Lower Olenekian exposed in the North Pingdingshan Section and the West Pingdingshan Section. As part of the Lower Induan sediments are covered in the West Pingdingshan Section, the missing interval was sampled in the North Pingdingshan Section. The rocks, which could be drilled, were limestones and argillaceous limestones while shaly mudrocks had to be avoided.

Four clasts from a debris-flow (brecciated limestone of the Dongma'anshan Formation in the South Majiashan Section) were sampled. The clasts showed different orientations in the debris-flow. When the rock was thermally demagnetized the resultant vector was uniform almost to 400°C, where they showed different orientations. At higher temperatures a new magnetic vector was created presumably as the result of thermal conversion of magnetite. Thus, it can be concluded that the sediments have been thermally overprinted, but the primary magnetic signal is preserved in a narrow temperature interval around 400°C. All the other samples were demagnetized after NRM measurement in steps of 360, 380 and 400°C.

The samples from the two sections belong to two different limbs of a syncline and allow evaluation of the data through the fold test. The material passes the fold test since the normal inclination deviates by around 3 degrees, which is insignificant as it is within the range of the sampling accuracy.

The magnetic polarity pattern shows the presence of an Early Triassic normal period followed by R-N-R. The proposed Induan-Olenekian boundary is located close to the top of the second normal polarity zone in the Triassic (fig. 3).

Conclusions

1. Chaohu has good accessibility.

2. Paleogeographically, Chaohu was located during the Lower Triassic on the deep shelf of the Lower Yangtze Block in the eastern Tethys. A complete depositional sequence rich in fossils is preserved and the interbedded argillaceous and calcareous rocks are most suitable for the establishment of both biostratigraphic and non-biostratigraphic sequences.

3. The Lower Triassic in Chaohu has been well studied in terms of the ammonoids, bivalves, conodonts, bony fishes, ichthyosaurs, lithostratigraphy, biostratigraphy, carbon (and oxygen) isotope stratigraphy, magnetostratigraphy, as well as ecostratigraphy (Yin Hongfu, et al., 1995), sequence stratigraphy (Tong Jinnan, 1997) and sedimentology (Li Shangwu, Wu Shenghe, 1988).

4. Conodont *Neospathodus waageni* sweet is the best index fossil to define the Induan-Olenekian boundary, which is good for global correlation. The FAD of *Neospathodus waageni* n. subsp. A (the base of the *Neospathodus waageni* Zone) is just 26 cm below the FAD of ammonoids *Flemingites* and *Euflemingites* (the base of the *Flemingites-Euflemingites* Zone) at the West Pingdingshan Section. *Neospathodus waageni* had a nearly global distribution and it has been found in most regions of the world, including the Boreal Realm.

5. Chaohu is one of the best locations in the world to study the Lower Triassic and to designate as the type area to define the Induan-Olenekian boundary.

Acknowledgements

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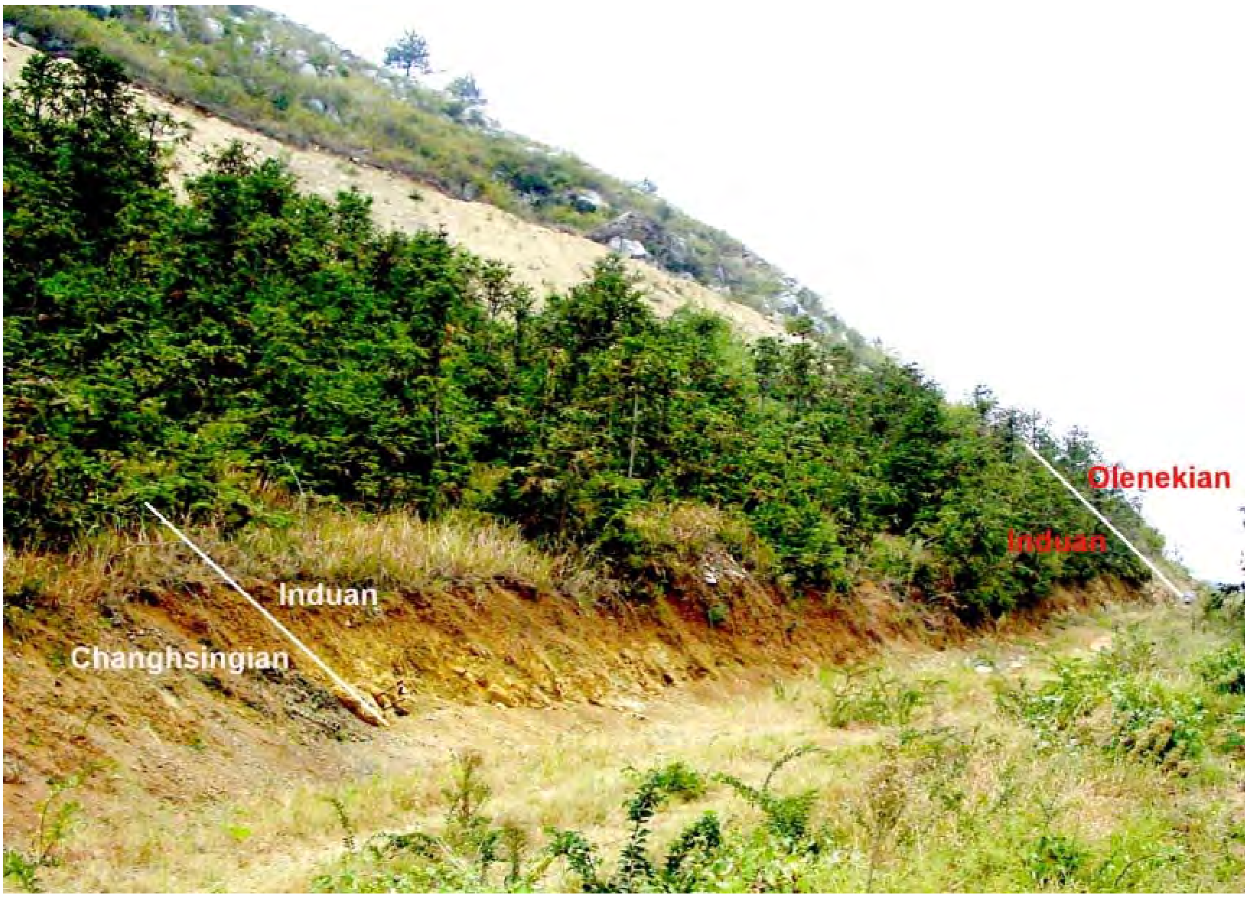
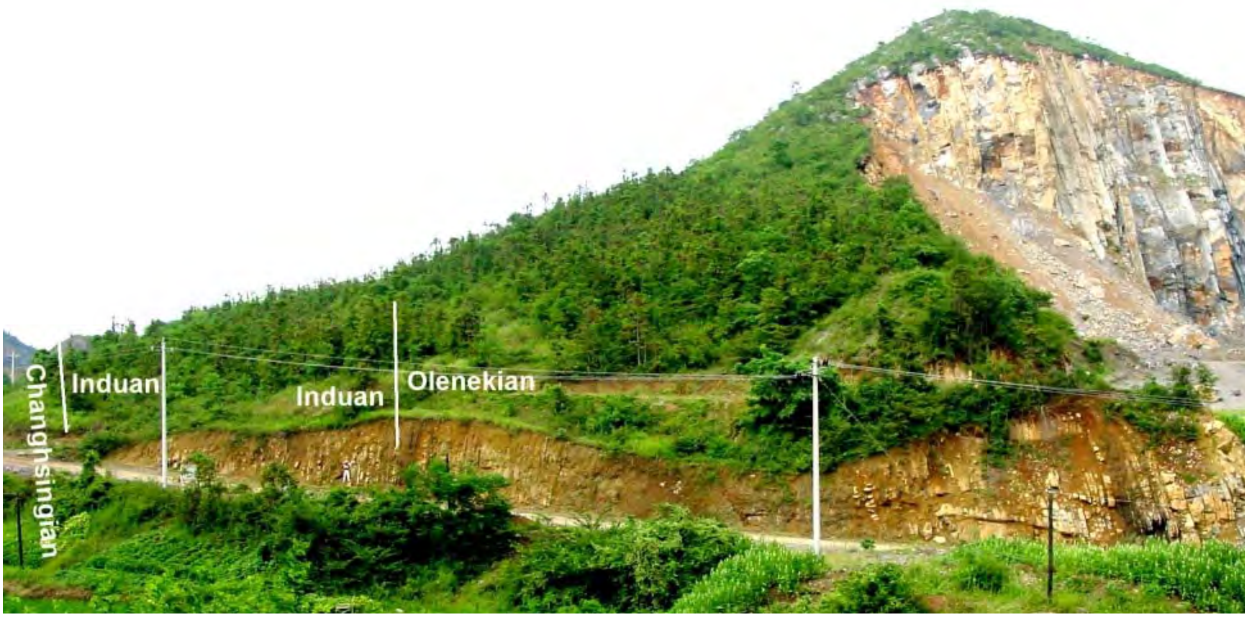
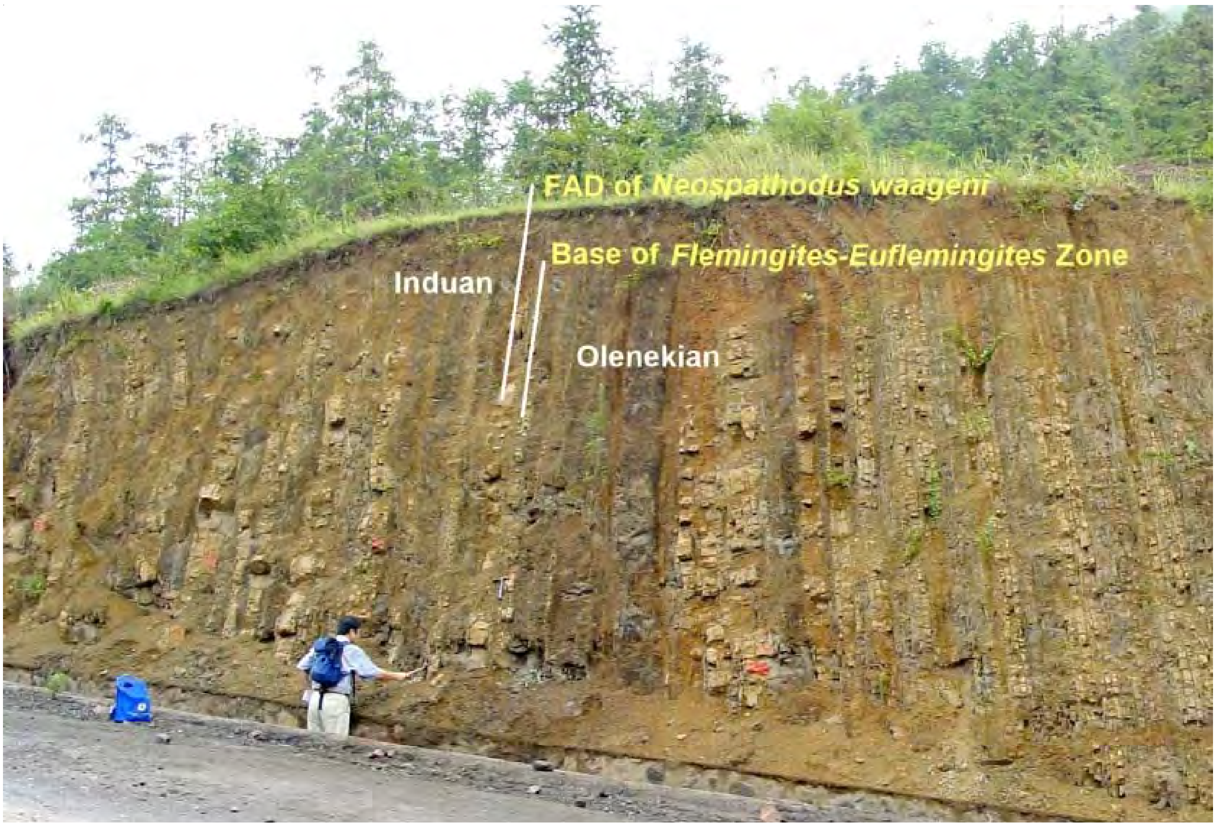


Picture 1: Profile of the Lower Triassic of the North Pingdingshan Section, Chaohu, Anhui Province

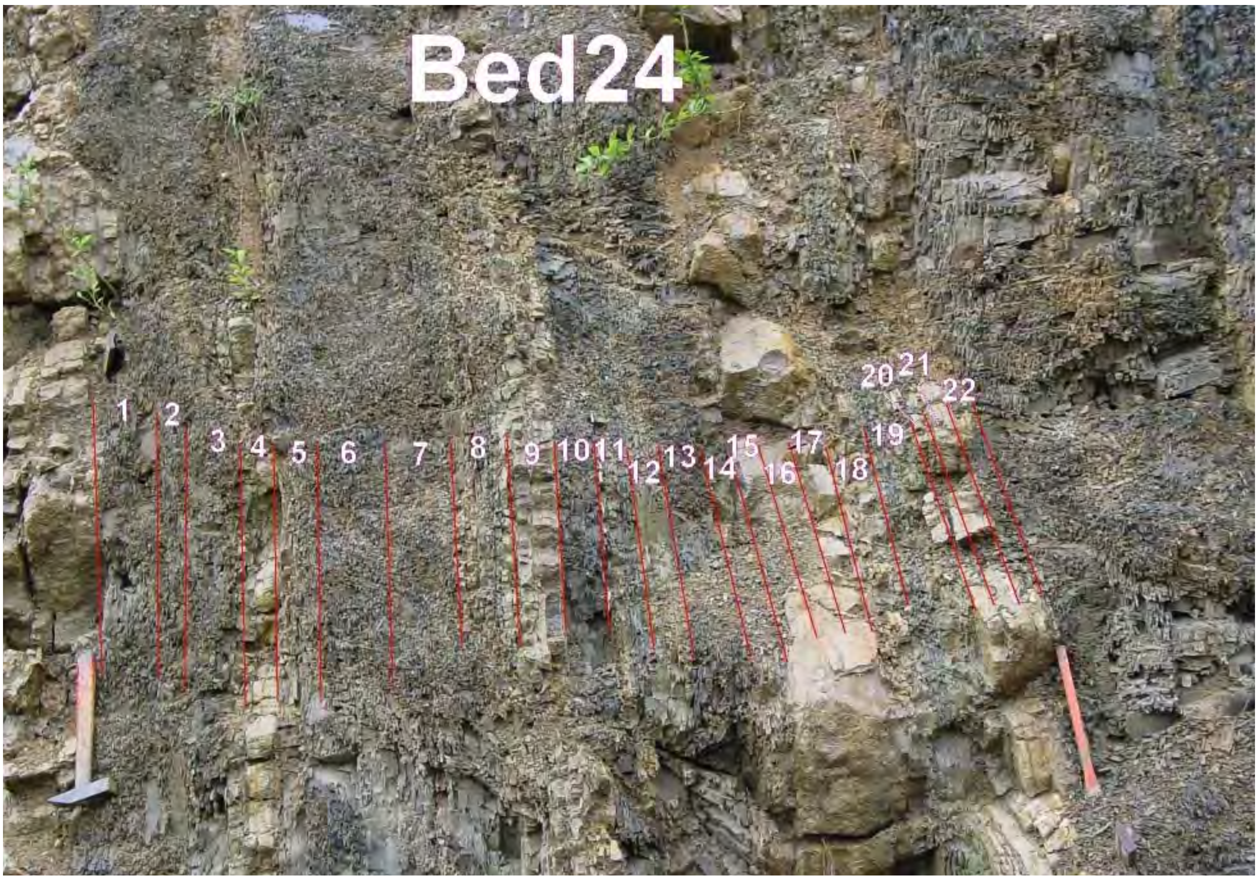


Picture 2: Profile of the Lower Triassic of the West Pingdingshan Section — the proposed Global Stratotype Section of the Induan-Olenekian boundary

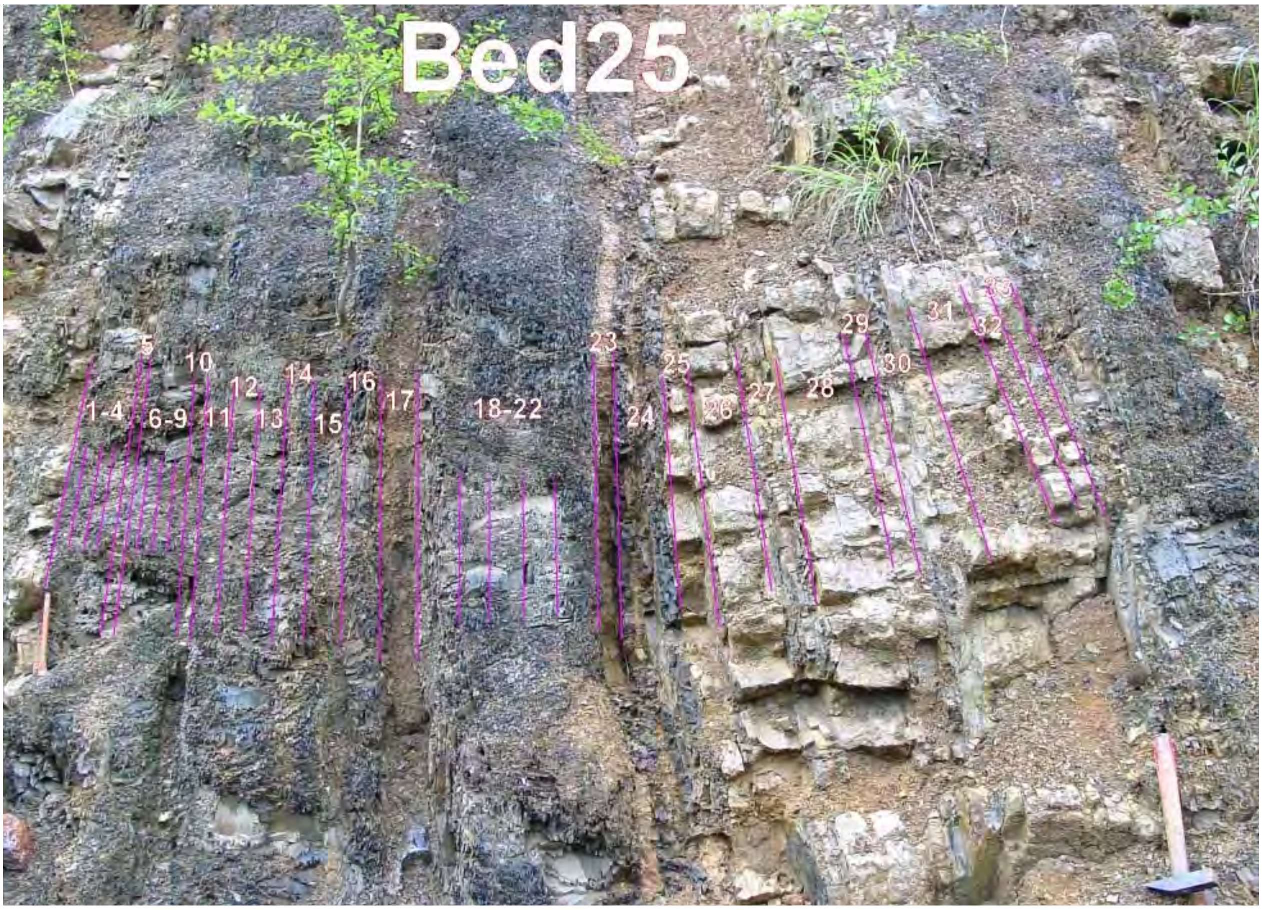


Picture 3: Induan-Olenekian boundary strata at the West Pingdingshan Section, indicating the boundaries marked by conodonts and ammonoids

Picture 4: Subdivision of Bed 23 in the West Pingdingshan Section
See the text for the detailed description of the sub-beds



Picture 5: Subdivision of Bed 24 in the West Pingdingshan Section
See the text for the detailed description of the sub-beds



Picture 6: Subdivision of Bed 25 in the West Pingdingshan Section
See the text for the detailed description of the sub-beds

Triassic Ammonoid Succession In South Primorye: 2. Middle Olenekian Tirolites – Amphistephanites Zone

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Abstract

A review of a new data on the middle Olenekian (*Tirolites – Amphistephanites* Zone) biostratigraphy of South Primorye is given on the basis of the five main sections: Balka, Zhitkov, Tobisin, Shmidt and Konechnyj. Data on ammonoid distribution show that all brachiopod species from Russian Island described by Bittner and Dagys on the basis of other workers' collections (*Fletcherithyris margaritovi*, *Piarorhynchella triassica*, *Costispiriferina mansfieldi*, *Paranorellina parisi*, *Hustedtiella planicosta* and *Spirigerinellina pygmaea*) are from the middle Olenekian *Amphistephanites-Tirolites* Zone, but not from the Induan or Upper Olenekian, as considered earlier. The *Tirolites – Amphistephanites* Zone can be correlated on the basis of both paleontological data and positive carbon-isotopic anomalies, which were discovered in South Primorye, South China, Salt Range and North Caucasus now.

Introduction

During a long time we have no information on paleontological characteristics for the middle Olenekian of South Primorye. Only in 1981 Burij and Zharnikova (1981) described five middle Olenekian ammonoid species revised later by Zakharov (Zakharov and Rybalka, 1987). The *Tirolites – Amphistephanites* Zone introduced by Zakharov (Zakharov and Rybalka, 1987; Zakharov, 1997) locates between the *Anasibirites nevolini* and *Neocolumbites insignis* Zones (Table). Middle Olenekian conodonts of Russian Island were described by Buryi (1979) and Rybalka (Zakharov and Rybalka, 1987).

According to Dagys (1974), Xu and Liu (1983) and Chen et al. (2002) brachiopods are very rare in the Lower Triassic everywhere (Idaho, Greenland, South Primorye, Japan, Central Himalaya, Salt Range, South China, North Caucasus, Mangyshlak and Balkans) and their generic diversity very low. Only about 18 genera of Lower Triassic articulate brachiopods (*Meishanorhynchia*, *Neowellerella, Crurithyris?, Abrekia, Spinomarginifera, Costispiriferina, Fletcherithyris,Hustedtiella, Sulcatinella, Piarorhynchella, Plectoconcha, Piarorhynchella, Costispiriferina, Paranorellina, Spirigerinellina, Thyratriaria, Compositella, Lissorhynchia*) are known now.

The first Triassic brachiopods ("*Terebratula" margaritovi* Bittner) of South Primorye (Schmidt and Zhitkov Capes in Russian Island) were investigated by Bittner (1899), who considered them to be early Triassic in age. Later Dagys (1965, 1972, 1974) investigated *Fletcherithyris margaritovi* (Bittner) from Russian Island in detail (he considered it to be Induan) and determined some other brachiopod species from Russian Island and Abrek Bay, but their stratigraphical affixment was given also inaccurately by him.

The aim of this contribution, sequential of our previous paper (Zakharov et al., 2002), is to show the revised data on distribution of both ammonoids and brachiopods in the middle part of the Olenekian (upper Ayaxian Substage, *Tirolites – Amphistephanites* Zone) of South Primorye, where articulate brachiopods are most abundant in that region.

Middle Olenekian ammonoid, brachiopod and conodont distribution

Balka Cape

The Balka Cape section locates at the north-western part of the Paris Bay in Russian Island. Only the lower and middle parts of the Zhitkov Formation (*Tirolites – Amphistephanites* Zone) about 32 m in thick is exposed there (Fig. 1). It is composed there, as in other sections of Russian Island, by grayish-green sandstone with relatively thick lenses of sandy limestone-coquina and white limestone. The lower part of the formation is characterized by brachiopods (*Hustedtiella planicosta* Dagys, *Paranorellina parisi* Dagys, *Spirigerellina pygmaea* Dagys and, apparently, *Piarorhynchella triassica* (Girty)) (Dagys, 1972, 1974), bivalves (*Neoschizodus laevigatus* (Zieten)) and ammonoids (*Tchernyschevites costatus* Zakharov, *Bandoites elegans* Zakharov). In the middle part of the Formation only bivalves and ammonoids *Tchernyschevites costatus* Zakharov and *Amphistephanites parisensis* (Zakharov) were discovered.

Zhitkov Cape

The Zhitkov Cape section is described at the north-eastern part of Russian Island. This is the stratotype of the Zhitkov Formation (Fig. 2). Its full thickness is 40 m. In descending order, its sequence in the stratotpe section is:

54. Greyish-green sandstone with lenses (0.2-0.3 m) of sandy limestone-coquina.....................................16.0 m

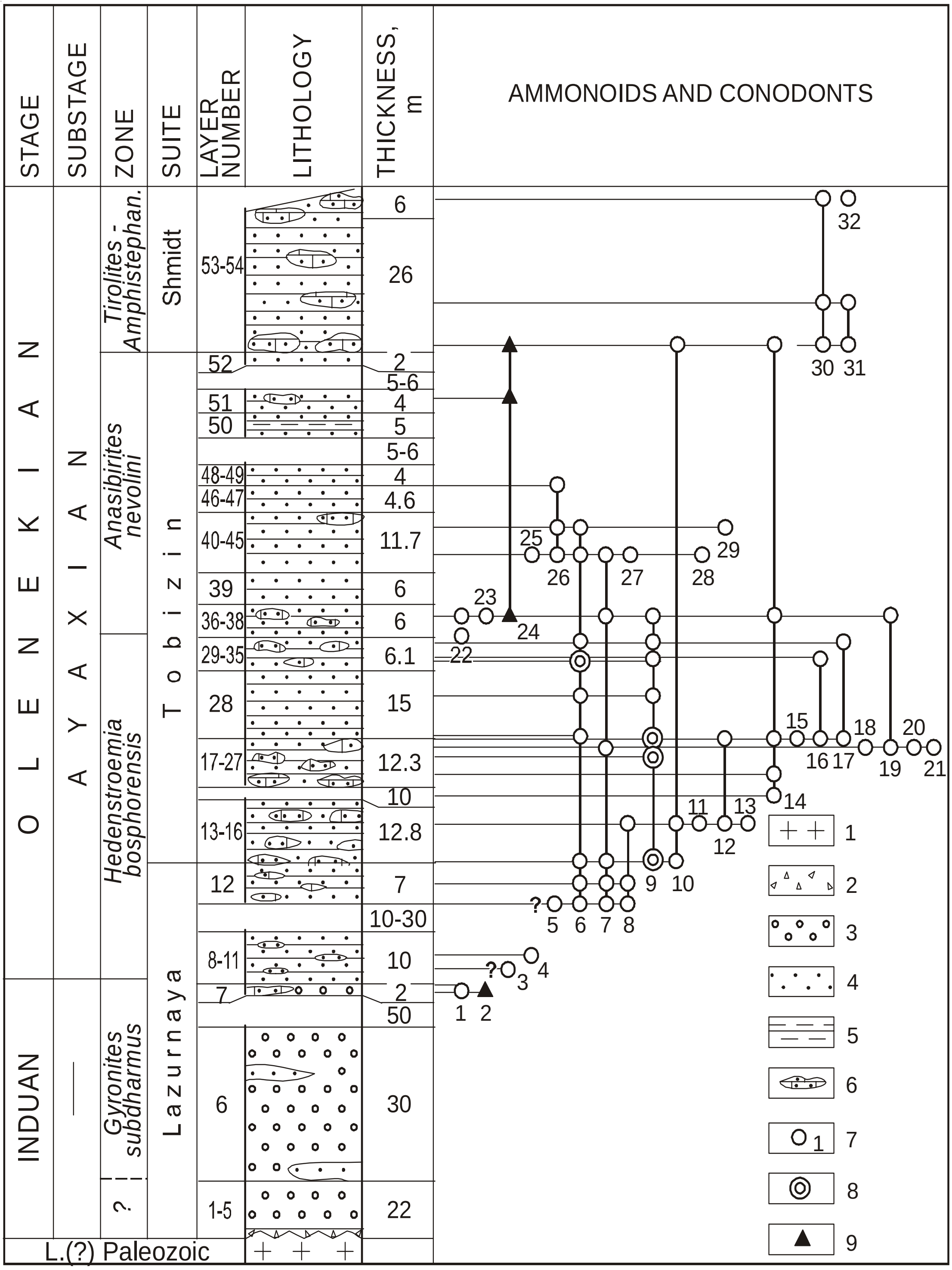

Fig. 1. Lithostratigraphical column of Triassic sediments exposed between Margaritov and Balka. Designation: 1 – granite, 2 –grusstone,3 – conglomerate, 4 – sandstone, 5 –siltstone, 6 – lenses of calcareous sandstone-coquina, 7 – mollusk species and its number, 8 - dominant mollusc species and its number, 9 – conodont species and its number). Species: 1 – *Gyronites* sp., 2 – *Neospathodus pakistanenis*, 3 – *Proharpoceras carinatitabulatum,* 4 – *Juvenites* cf. *simplex*, 5 – *Gyronites* aff. *planissimus,* 6 – *Arctoceras septentrionale,* 7 – *Juvenites* sp., 8 – *Dieneroceras chaoi,* 9 – *Meekoceras subcristatum,* 10 – *Pseudosageceras* sp., 11 – *Epihedenstroemia ajaxensis,* 12 – *Hedenstoemia bosphorensis,* 13 – *Ussuria iwanowi,* 14 – *Arctoceras* sp., 15 – *Owenites koeneni*, 16 - *Pseudosageceras longilobatum,*– 17 - *Prosphingitoides hxexagonalis*, 18 – *Preflorianites* sp., 19 – *Meekoceras boreale,* 20 – *Anaxenaspis orientalis,* 22 – *Inyoites spicini*, 23 - *Arctoceras labogense*, 24 – *Furnishius triserratus*, 25 – *Meekoceras* sp., 26 – *Preflorianites* sp. 1, 27 – *Hemiprionites* sp. indet., 28 – *Gurleyites* sp., 29 – *Ambites* cf. *discus,* 30 – *Tchernyschevites costatus*, 31 – *Bandoites elegans,* 32 – *Amphistephanites parisensis.*

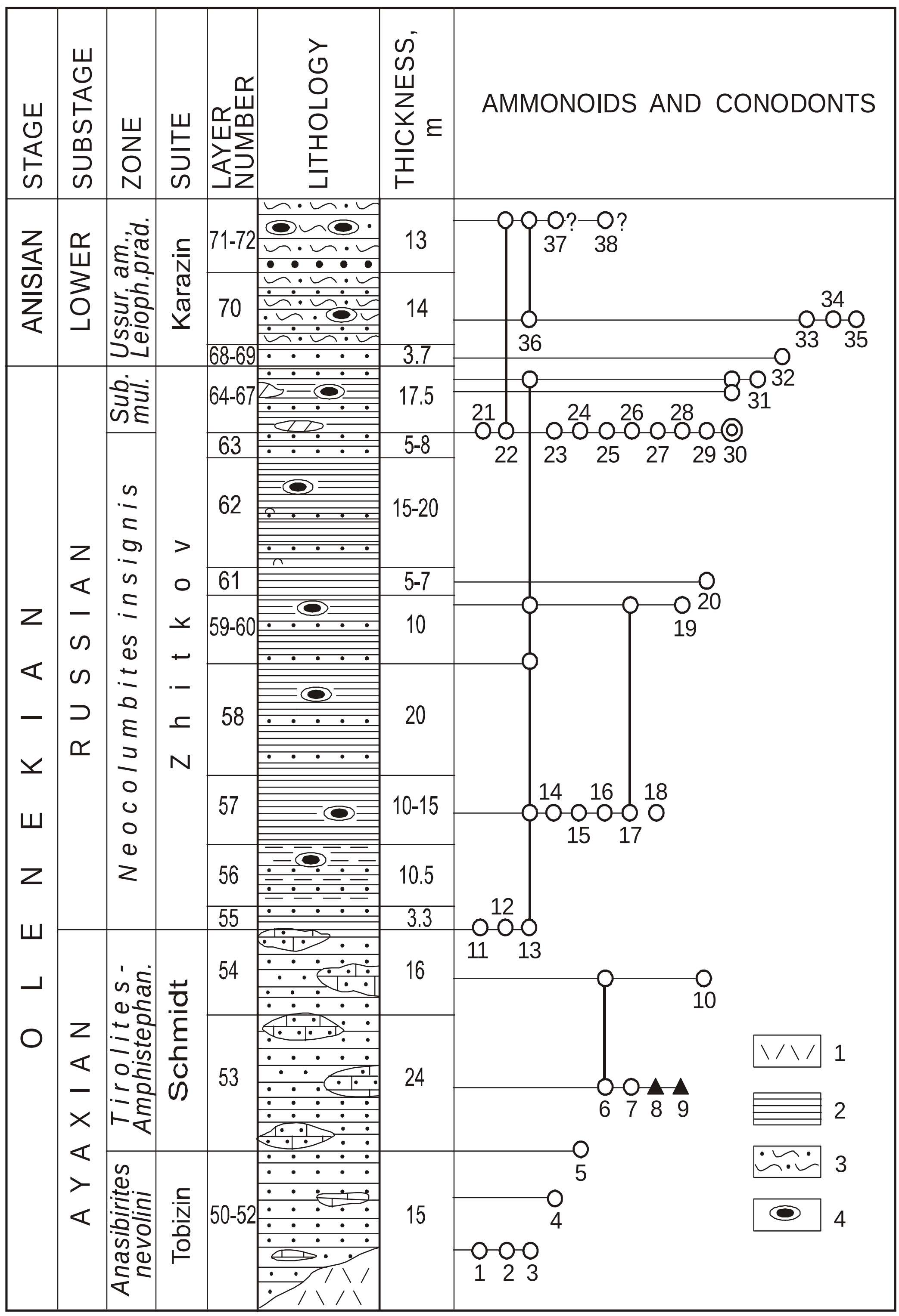

Fig. 2 Lithostratigraphical column of Triassic sediments exposed at the south-western part of the Zhitkov Cape: 1 – Cretaceous felsite porphyry, 2 – mudstone and siltstone, 3 – spotted sandy siltstone, 4 – calcareous concretion. Abbreviation: *Sub. mul.* - *Subcolumbites multiformis, Uss. am. – Ussuriphyllites amurensis, Leoph. prad. – Leiophyllites pradyumna.*

Species: 1 – *Pseudosageceras intermedium*, 2 – *Meekoceras subcristatum*, 3 – *Ambites*? sp., 4 – *Meekoceras* sp., 5 – *Tchernyschevites costatus*, 6 – *Bandoites elegans,* 7 – *Kazakhstanites* sp., 8 – *Neogondolella jubata*, 9 - *Furnishius triserratus,* 10 – Tirolites? sp., 11 – *Pseudosageceras* sp., 12 – *Nordophiceras* sp., 13 – *Columbites* sp. indet., 14 – *Svalbardiceras zhitkoviense,* 15 – *Tirolites* cf. *subcassianus*, 16 – *Khvalinites* cf. *unicus,* 17 – *Hellenites inopinatus,* 18 – *Neocolumbites grammi,* 19 – *Olenekoceras miroshnikovi,* 20 – *Procarnites* sp., 21 – *Pseudosageceras longilobatum,* 22 – *P. simplex,* 23 – *Zhitkovites insularis*, 24 – *Pseudoprosphingites globosus,* 25 – *Isculitoides suboviformis,* 26 – *Arnauticeltites gracilis,* 27 – *Prenkites* aff. *timorensis,* 28 – *Preflorianites maritimus,* 29 – *Dieneroceras karazini,* 30 – *Subcolumbites multiformis,* 31 – *Arnautoceltites* sp., 32 - *Leiophyllites* sp., 33 – *Hollandites tozeri,* 34 – *Japonites russkiensis,* 35 – *Sturia japonica,* 36 – *Leiophyllites pradyumna,* 37 – *Hollandites* cf. *japonicus,* 38 – *Ptychites austroussuriensis.*

Brachiopods – *Fletcherithyris margaritovi* (Bittner), *Costispiriferina* aff. *mansfieldi* (Girty), *Thyratryaria*? sp., *Compositella*? sp., Atriboniidae gen. nov., *Lissorhynchia*? sp., bivalves - *Eumorphotis iwanowi* Bittner, nautiloids – *Phaedrysmocheilus* sp., ammonoids - *Tirolites?* sp., *Bandoites elegans* Zakharov.

53. Greyish-green sandstone with thick (1 m) lenses of sandy limestone-coquina.......................................24.0 m

Brachiopods – *Lingula borealis* Bittner, *Costispiriferina* aff. *mansfieldi* (Girty), *Costispiriferina* sp.; bivalves - *Neoschizodus laevigatus* (Zieten), *Eumorphotis iwanowi* (Bittner), gastropods, cephalopods – *Trematoceras* sp., *Bandoites elegans* Zakharov, *Kazakhstanites sonticus* (Zakharov), conodonts – *Neogondolella jubata* Sweet, *Neospathodus triangularis* (Bender), *Enantiognathus ziegleri* (Diebel), *Hindeodella triassica* (Müller), *Hadrodontina symmetrica* (Staesche), *Furnishius triserratus* Clark.

Tobizin Cape

Only the lower part of the Zhitkov Formation (10-15 m thick) is known at the south part of Russian Island (Fig. 3). It is characterized by inarticulate brachiopods (*Lingula borealis* Bittner), bivalves (*Eumorphotis iwanowi* (Bittner)) and ammonoids (*Amphistephanites parisensis* (Zakharov), *Bandoites tobisinensis* (Kiparisova), *"Flemingites" tobisinensis* Zakharov).

Schmidt Cape

In descending order, the sequence of the Schmidt Formation (38-40 m) at the south-eastern part of Russian Island is (Fig. 4):

Tirolites –Amphistephanites Zone

Tirolites ussuriensis Beds

9. Grey sandstone with thin (1 cm) interlayers of siltstone and mudstone.......……………........................…2.5 m

Ammonoids – *Tirolites* sp., *Wasatchites* sp., *Preflorianites*? sp.

8. Greyish-green sandstone with thick (1 m) lenses of sandy limestone-coquina and limestone ..…………………………………………….......25.0 m

Brachiopods – *Fletcherithyris margaritovi* (Bittner), ä âóñòâî ð ê è - *Bakevellia exporrecta* (Lepsius),

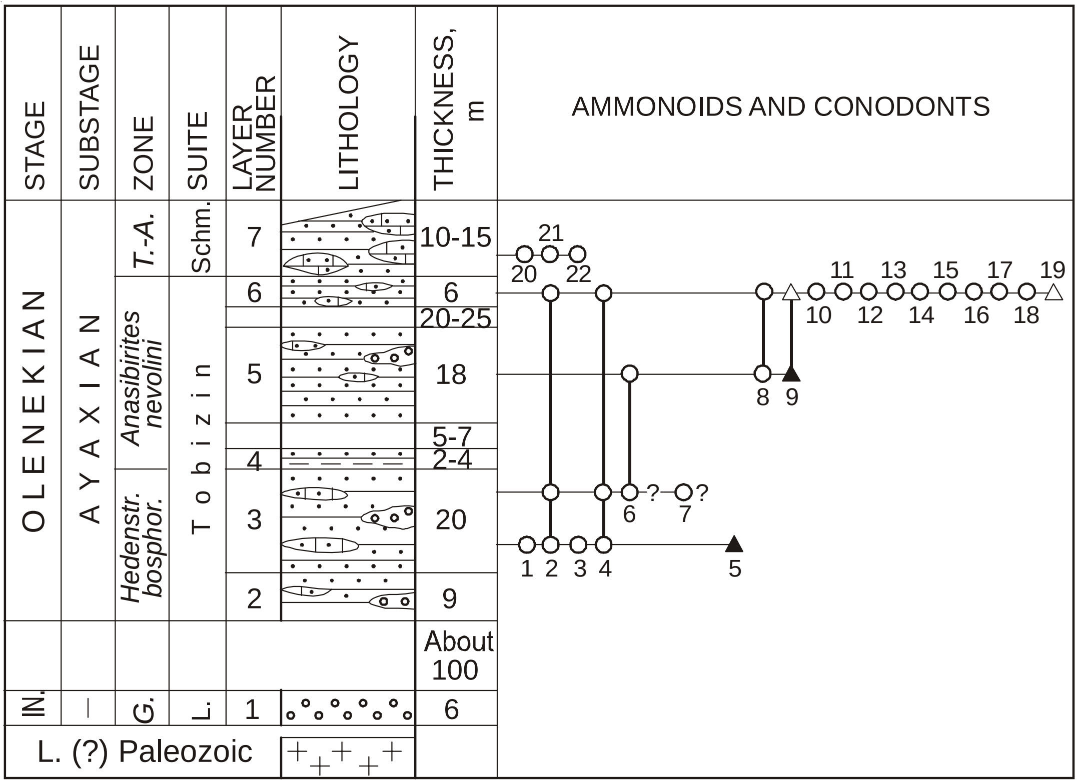

Fig. 3. Lithostratigraphical column of Triassic sediments exposed at the Tobizin Cape. Designation as in Fig. 1. Abbreviation: *G. – Gyronites subdharmus, Hedenstr. bosphor. – Hedenstroemia bosphorensis, T.-A. - Tirolites-Amphistephanites,* IN. – Induan, L. – Lazurnaya, Schm. – Schmidt.
Species: 1 - *Ussuria* aff. *iwanowi*, 2 – *Arctoceras septentrionale*, 3 – *Dieneroceras* sp., 4 – *Meekoceras subcristatum*, 5 – *Neospathosdus pakistanensis,* 6 – *Meekoceras* cf. *boreale,* 7 – *Koninckites varaha,* 8 – *Owenites koeneni,* 9 – *Furnishius triserratus,* 10 – *Parahedenstroemia conspicienda,* 11 – *Anasibirites* sp., 12 – *Hemiprionites* sp., 13 – *Wasatchites sikhotealinensis,* 14 – *Arctoceras labogense,* 15 – *Meekoceras* aff. *gracilitatis,* 16 – *Juvenites?* sp., 17 – *Koninckites timorensis*, 18 – *Prosphingitoides ovalis,* 19 – *Neospathodus* aff. *hommeri,* 20 – *Amphistephanites parisensis,* 21 – *Bandoites tobisinensis,* 22 – *"Flemingites" tobisinensis.*

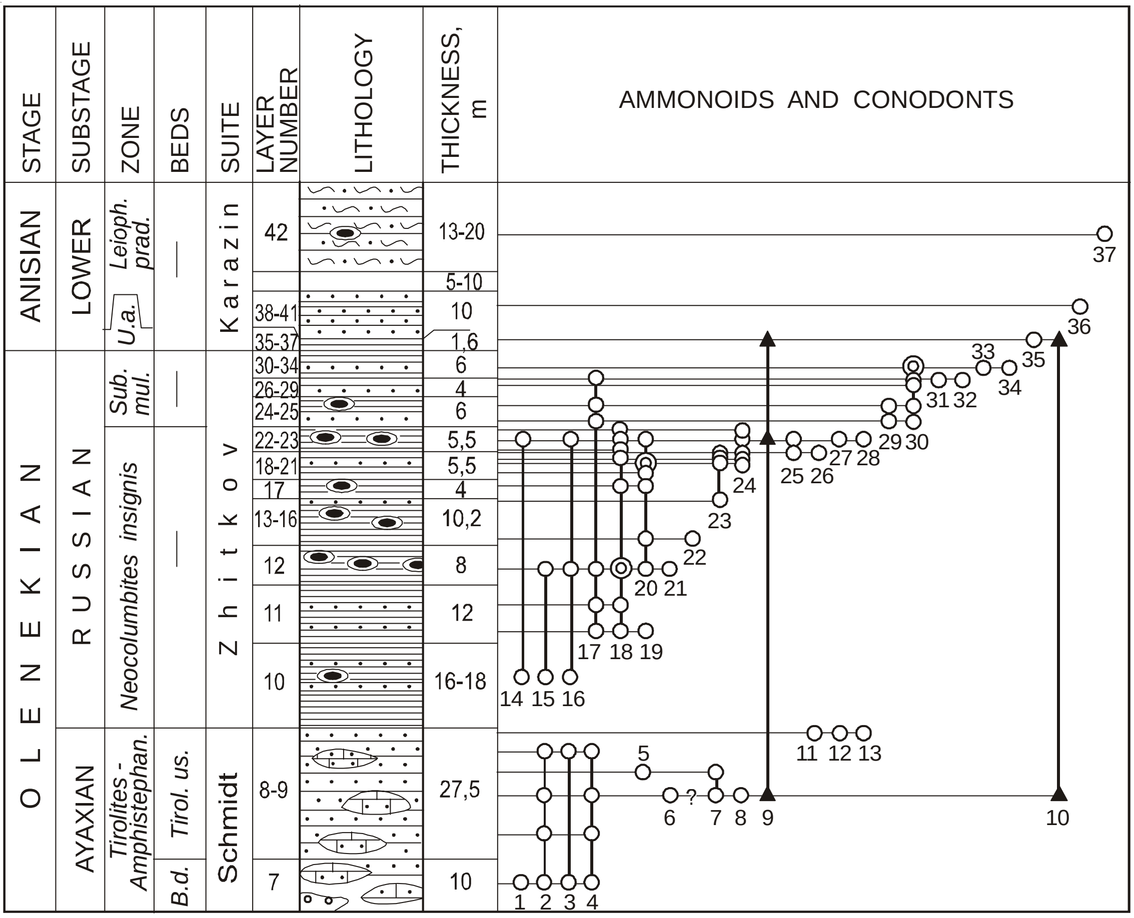

Fig. 4. Lithostratigraphical column of Triassic sediments exposed at the Schmidt Cape and Tchernyschev Bay. Designation as in Fig. 1 and 2. Abbreviation: *Tirolites-Amphistephan. – Tirolites-Amphistephanites, Sub. m. – Subcolumbites multiformis, U.a. – Ussuriphyllites amurensis, Leioph. prad. – Leiophyllites pradyumna, B.d. – Bajarunia dagysi, Tirol.us. – Tirolites ussuriensis.*

Species: 1 - *Bajarunia dagysi*, 2 – *Tchernyschevites costatus*, 3 – *T. subdalmatus*, 4 – *Bandoites elegans,* 5 – *Kazakhstanites sonticus*, 6 – *K. zakharovi*, 7 – *Tirolites subcassianus,* 8 – *T. ussuriensis*, 9 – *Neospathodus homeri*, 10 – *N. triangularis,* 11 – *Tirolites* sp., 12 – *Wasatchites* sp., 13 – *Preflorianites?* sp., 14 – *Hemilecanites discoides,* 15 – *Columbites* aff. *parisianus,* 16 – *Burijites skorochodi,* 17 – *Pseudosageceras* sp., 18 – *Khvalinites unicus,* 19 – *Hellenites tchernyscheviensis,* 20 – *Columbites ussuriensis,* 21 – *Leiophyllites praematurus*, 22 – *Neocolumbites insignis,* 23 – *Neocolumbites grammi*, 24 – *Olenekoceras miroshnikovi*, 25 – *Procolumbites subquadratus*, 26 – *Olenekoceras* sp., 27 – *Hellenites inopinatus,* 28 – *Hemilecanites* sp., 29 – *Arnautoceltites* sp., 30 – *Subcolumbites multiformis*, 31- *Arnautoceltites gracilis*, 32 – *Prenkites timorensis,* 33 – *Zhitkovites globosus,* 34 – *Palaeophyllites superior,* 35 – *Ussuriphyllites amurensis,* 36 – *Leiophyllites* aff. *pradyumna*, 37 – *Balatonites* sp. indet*.*

Eumorphotis iwanowi (Bittner), gastropods, ammonoids - *Tchernyschevites costatus* Zakharov, *T. subdalmatus* (Zharnikova), *Bandoites elegans* Zakharov, *Kazakhstanites sonticus* (Zakharov), *K. zakharovi* Zharnikova, *Tirolites subcassianus* Zakharov, *T. ussuriensis* Zharnikova, conodonts - *Neospathodus homeri* (Bender), *N. triangularis* (Bender), *N. zaksi* Buryi. Brachiopods *Fletcherithyris margaritovi* (Bittner) are most abundant there (Fig. 5).

Bajarunia dagysi Beds

7. Greyish-green sandstone with lenses (0.6 m) of sandy limestone-coquina and conglomerate.......……………………………..………..........10.0 m

Bivalves – *Eumorphotis multiformis* (Bittner), *Neschizodus* sp., *Bakevellia* sp., cephalopods – *Trematoceras* sp., *Bajarunia dagysi* Zakharov, *Amphistephanites parisensis* (Zakharov), *Thernyschevites costatus* Zakharov, *T. subdalmatus (*Zharnikova), *Bandoites elegans* Zakharov.

Konechnyj Cape

The largest accumulation of Lower Triassic articulate brachiopod shells has been discovered in the Schimdt Formation of the Konecnyi Cape (Russian Island, Novik Bay). The sequence (20-30 m) is characterized by crinoids, bryozoans, brachiopods and very rare bivalves (*Eumorphotis multiformis* (Bittner) and ammonoids (apparently, *Tchernyschevites costatus* Zakharov) (Fig. 6). Numerous brachiopods are represented by *Fletcherithyris margaritovi* (Bittner), *Costispiriferina* aff. *mansfieldi* (Girty) and some new taxa of Spiriferinida and Rhynchonellida.

Fig. 5. Brachiopod (*Fletcherihyris margaritovi*) gathering in the middle Olenekian *Amphistephanites-Tirolites* Zone of the Schmidt Cape, Russian Island.

Conclusions

1. The *Tirolites – Amphistephanites* Zone in South Primorye is characterized by marked ammonoid and brachiopod assemblages; it can be correlated on the basis of both paleontological data and the positive carbon-isotopic anomalies, which recently were discovered in South Primorye, South China (Anhui Province, Chaohu) (Tong et al., in press), North Caucasus (Rufabgo, Svinyachya and Kapustina) (Zakharov et al., 2000) and Salt Range (Atudorei, 1999) now.

2. Data on ammonoid distribution show that all brachiopod taxa from Russian Island (Far East) described by Bittner and Dagys on the basis of other workers' collections are from the single level: middle Olenekian *Amphistephanites-Tirolites* Zone, but not from Induan or Upper Olenekian, as considered earlier (Dagys, 1965, 1972, 1974). Rare brachiopod shells are also present in both the Late Olenekian *Neocolumbites insignis* and the *Subcolumbites multiformis* Zones and also in Lower Anisian Zones of Russian Island, but they do not investigated yet.

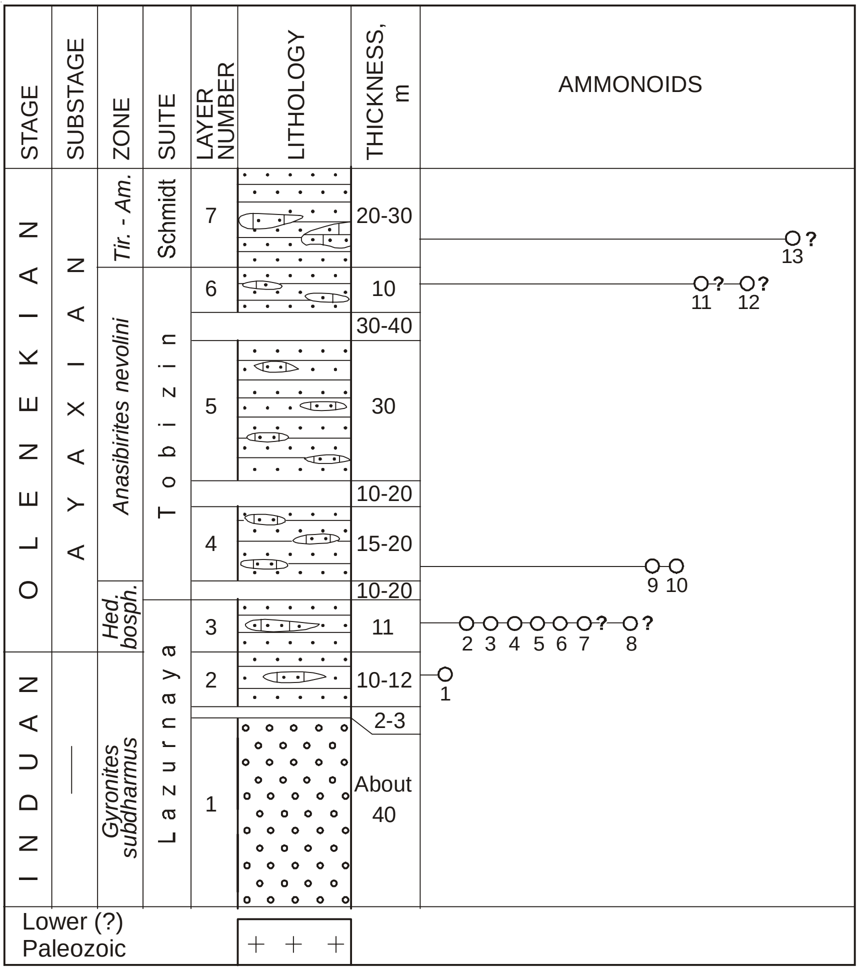

Fig. 6. Lithostratigraphical column of Triassic sediments exposed between the Melkovodnaya Bay and Konechnyj Cape. Designation as in Fig. 1. Abbreviation: *Hed. bosph. – Hedenstroemia bosphorensis, Tir.-Am. – Tirolites-Amphistephanites.*

Species: 1 - *Gyronites subdharmus,* 2 – *Dieneroceras chaoi*, 3 – *Hedenstroemia bosphorensis,* 4 – *Owenites* sp. indet., 5 – *Prosphingitoides* sp. indet., 6 – *Juvenites novikensis,* 7 – *Meekoceras boreale,* 8 – *Arctoceras* sp., 9 – *Meekoceras subcristatum,* 10 – *Arctoceras labogense,* 11 – *A. robinsoni,* 12 – *A. septentrionale,* 13 – *Tchernyschevites costatus.*

2. Within the Triassic of South Primorye more or less abundant brachiopod assemblages were discovered at the three stratigraphical levels: (1) Induan-Olenekian boundary transition (Abrek Bay), (2) middle Olenekian *Amphistephanites-Tirolites* Zone (Russian Island) and (3) the base of the Ladinian (Western Amur Gulf, Atlassov Cape area).

3. It is known that Lower Triassic articulate brachiopods at whole are characterized by very low taxonomic diversity (only about 17 genera or some more have been described). South Primorye is one of most perspective areas for studying of Lower Triassic articulate brachiopods because not less than 15 genera are present here, part of them seems to be new ones and need in detail investigation.

Acknowledgment

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Fig. 7. Brachiopod (*Costispiriferina* aff. *mansfieldi* (Girty)) and some other taxa) gathering in the middle Olenekian *Amphistephanites-Tirolites* Zone of the Konechnyj Cape, Russian Island.

Fig. 8. Brachiopod (*Abrekia costata* Dagys) gathering in the Induan-Olenekian transition of the Abrek Bay.

Fig. 9. Brachiopod gathering in the lowermost part of the Ladinian *Monophyllites-Protrachyceras* Beds of the Atlassov Cape area.

The Global Stratigraphic Section and Point2 (GSSP) of the base of the Olenekian Stage (Lower Triassic)

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IOBWG exists about seven years. The first list of the IOBWG was published in Albertiana 20 in 1997 (Zakharov, 1997c). Since then three members died (Prof. Algirdas S. Dagys from Vilnius, Dr. Nikolai I. Kurushin from Novosibirsk and Dr. Valeria S. Rudenko from Vladivostok) and some people retired on a pension. I am very sorry. In the upshot, five new members have been invited (Table).

Discussion on the Induan-Olenekian boundary after 29th IGC in Kyoto has been published in Albertiana (Baud and Gaetani, 1992; Zakharov, 1994a, 1995, 1997a,b,c, 1999a,b; Zakharov and Popov, 1999; Zakharov et al., 1999, 2000, 2002a,b,c; Zakharov et al., in press; Dagys, 1999; Tong et al., 2001, 2002; Kozur, 2003) and some other journals (Dagys, 1997; Zakharov, Y.D., 1994b, 1996, 1997d; Tong et al., 2003; Tong et al. in press; Markevich, P.V. and Zakharov, Y.D., in press).

As a result, three candidate stratotype sections for the Induan-Olenekian boundary have been offered: Tri Kamnya Cape, South Primorye (Zakharov, 1996), Abrek Bay, South Primorye (Zakharov et al., 2000, 2002c) and Chaohu, Anchui Province (Tong et al., 2003). But it must be admitted, taking into consideration some results of prolonged and comprehensive analysis of complete data on ammonoid and conodont biostratigraphy, magnetostratigraphy and carbon-isotopic stratigraphy obtained from these sections and taking into account also some political conditions that only Chaohu one seems to be a section agreeable to the global standards. Detailed information on that section partly known from publications (Tong et al., 2001, 2002, 2003; Tong et al., in press) will be given soon to all IOBWG members.

Because the main complex of field and analytic works on the Chaohu section has been realized, we are going to learn the IOBWG members' opinion on it in January-February 2004, using, apparently, their absentee ballots.

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Lower Triassic conodont biostratigraphy and speciation of *Neospathodus waageni* around the Induan-Olenekian boundary of Chaohu, Anhui Province, China.

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Introduction

In the summers of 2000-2003, we investigated the Lower Triassic sections at Chaohu, Anhui Province, China. The best-studied Lower Triassic sequence in the area was formerly that at Majiashan, which was first studied by the Anhui Geological Surveying Team during the 1: 200.000 regional geological survey in the 1970s. Fossils are very abundant and diverse throughout the Lower Triassic and led to the differentiation of three bivalve assemblages (Li and Ding, 1981), six ammonoid zones (Guo and Xu, 1980), and six conodont zones (Ding, 1983). Recent studies have focused on the Pingdingshan section, which is about 2000 m to the north of the Majiashan Section on a separate limb of the Pingdingshan Syncline. The West Pingdingshan Section in Chaohu displays an exceptional Lower Triassic sequence, particularly around the Induan-Olenekian boundary, for which it represents a GSSP candidate (Tong et al., 2003).

Biostratigraphy

The Lower Triassic strata at West Pingdingshan, Chaohu is divided into three formations, in ascending order these are the Yinkeng, Helongshan and Nanlinghu formations. The entire section is 112.8 m in thickness.

Lithologically the Yinkeng Formation is characterized by a series of multiple cycles of mud-lime rocks; its lower part is composed of grayish green, thin-bedded, calcareous mudstone intercalated by a few beds of thin-bedded limestone and grayish green thin-bedded nodular limestone. The fauna includes thin-shelled bivalves such as *Claria radilis, C. aurita, C. concentrica, C. hubeiensis, C. griesbachi, C. stachei, Eumorphotis huancangensis;* and the ammonoids *Ophiceras* sp., *Lytophiceras* sp., *Preflorianites?* sp., *Gyronites* sp., and *Prionolobus* sp. The conodonts from the lower Yinkeng Formation include *Hindeodus* sp., *H. typicalis, Isarciella*? sp., *Neospathodus kummeli, Ns. dieneri (3 morphotypes), Ns.* n. spp. B, C, and D, *Neogondolella planata, Ng. carinata, Ng. orchardi,* and *Ng. krystyni*.

The middle part of the Yinkeng Formation is composed of interbeds of grayish green, thin-bedded calcareous mudstone; gray, thin-bedded argillaceous limestone and nodular limestone; and three intercalations of rhyolitic clay in the upper part (2 to 5cm thick)> The macrofauna consists of the bivalves *Eumorphotis* sp. and *Posidonia* sp., the ammonoids *Flemingites* cf. *ellipticus*, *E.* sp., *Euflemingites* sp., *Koninckites* sp., *Koninckites lolowensis*, *Owenites* sp., and *Pseudosageceras* sp. Conodonts include *Neospathodus waageni* n. subsp. A, *Ns. waageni* n. subsp. B, *Ns. waageni sensu stricto*, *Ns. cristagalli*, *Ns. novaehollandiae*, *Ns. conservativus*, *Ns*. aff. *discretus*, *Ns.* n. sp. L, *Plativillosus costatus*, and *P. hamadai* (Zhao et al., 2003a).

The upper part of the Yinkeng Formation is gray/brown laminated calcareous mudstone, intercalated by a few beds of gray, thin-bedded-lenticular, sometimes pyritiferous, argillaceous limestone. It contains the ammonoids *O. pakungensis, Dieneroceras* sp., *Arctoceras* aff. *lolowense*, *Pseudocelites* sp., *Wasachite*s sp., *Hemiprionites* sp., *Juvenites orientalis*, together with bivalves *Eumorphotis* sp. and *Posidonia* sp. The conodonts are represented by *Neospathodus waageni* n. subsp. A, *Ns. waageni s. s.*, *Ns.* aff. *waageni*, *Ns. novaehollandiae*, and *Ns. conservativus*.

Lithologically the Helongshan Formation is composed of interbeds of grayish green thin-bedded calcareous mudstone and gray thin-bedded argillaceous limestone, intercalated with grayish brown shale. In the lower part medium-thick bedded limestone exhibit cross-bedding with 1-cm thick lenticular cross sets. The formation contains ammonoids such as *Dieneroceras* sp., *Euflemingites* sp., *Anasibirites* cf. *kwangsianus*, together with conodonts *Neospathodus* n. sp. M, *Ns. waageni s. s.*, and *Ns.* aff. *spitiensis*.

The Lower part of the Nanlinghu Formation is composed of grayish-green, medium-bedded, nodular limestone interbedded with a few beds of gray green calcareous mudstone. The upper part is composed of dark to black medium-bedded calcareous mudstone and light gray to black massive limestone intercalated with medium-bedded marl. Rich conodont faunas are characterized by *Neospathodus eotriangularis, N. homeri, N. abruptus, Aduncodina unicosta, Cornudina?* sp., and *Icriospathodus collinsoni*.

Conodont zonation

Of 286 samples collected from West Pingdingshan section for conodont analysis, 172 were productive and included 51 conodont species and subspecies, 13 of which were new (**Table 1**). Our analysis is at the scale of centimeters around the Induan-Olenekian boundary. A total of 2187 conodont elements includes 51 stratigraphically useful species referable to 11 genera: *Hindeodus, Isarcicella(?), Neogondolella, Neospathodus, Platyvillosus, Cratognathodus, Parachirognathus, Pachycladina, Ellisonia, Aduncodina* and *Cornudina?*. About 38 species distributed in 8 genera were also recorded at a nearby section at North Pingdingshan. Nine conodont zones are recognized in the Lower Triassic of West Pingdingshan and confirmed at North Pingdingshan (**Table 2**). Full description and discussion of these zones will be done later, but the following is a summary.

Olenekian Stage (from Bed 24-16 to Bed 59)

Neospathodus abruptus - *Neospathodus homeri* Zone

Neospathodus eotriangularis Zone

Neospathodus n. sp. M Zone

Neospathodus waageni Zone

Neospathodus waageni waageni Subzone

Neospathodus waageni n. subsp. B Subzone

Neospathodus waageni n. subsp. A Subzone

Induan Stage (from Bed 5-2 to Bed 24-16)

Neospathodus n. sp**.** C - *Neospathodus* n. sp. D Zone

Neospathodus dieneri Zone

Neospathodus dieneri Morphotype 3 Subzone

Neospathodus dieneri Morphotype 2 Subzone

Neospathodus dieneri Morphotype 1 Subzone

Neospathodus kummeli Zone

Neogondolella krystyni Zone

Hindeodus typicalis - *Neogondolella planata* Zone

Tong et al. (2001, 2003) and Zhao et al. (2002, 2003b) proposed the FAD of conodont *Neospathodus waageni* Sweet 1970 as the preferred index to define the Induan-Olenekian boundary: this is 26 cm below the FADs of the ammonoids *Flemingites* and *Euflemingites* at the West Pingdingshan section. During this work, stratigraphically significant new subspecies of *Neospathodus waageni* have been recognized. All occurrences of the *Ns. waageni* group are confined to the mid-upper part of Yinkeng and Helongshan formations and its greatest abundance is coincident with the *Euflemingites-Flemingites* ammonoid Zone.

Numerous specimens of *Neospathodus waageni* from Chaohu can be differentiated into at least three forms, herein referred in open nomenclature to the new subspecies A and B, and *Ns. waageni* sensu stricto. Both *Ns. waageni* n. subsp. A and *Ns. waageni s. s.* are relatively equidimensional in shape and have rounded basal cavities in contrast to *Ns. waageni* n. subsp. B which has a relatively elongate rectangular shape and elliptical basal cavity. The most consistent criteria for differentiating these subspecies, and what appears to be an evolutionary trend, is the variation in the profile of the basal margin. In *Ns. waageni* n. subsp. *A*, it is entirely straight whereas in *N. waageni* n. subsp. B it is turned up posteriorly; the basal margin of *Ns. waageni s. s.* is strongly upturned at the posterior end.

The three subspecies of *Neospathodus waageni* clearly occur in succession at the Pingdingshan sections, and as such define three subzones of the *Neospathodus waageni* Zone. The *Ns. waageni* n. subsp. A *S*ubzone is 0.28 m thick, the *Ns. waageni* n. subsp. B Subzone is 0.52 m thick, and the *Ns. waageni s. s.* subzone is 52.14 m thick. The thinness of the former two subzones might be related to the rapid evolution of the species at its inception. All three species co-occur within the highest subzone.

Apart from the name giver, the *Neospathodus waageni* n. subsp. A Subzone is characterized by three morphotypes of *Ns. dieneri* and rarer *Ns*. n. sp. C. The middle subzone is marked by the appearance of *Ns. waageni* n. subsp. B plus abundant *Ns. dieneri* morphotype 1, the peak abundance of *Ns. dieneri* morphotype 2, a few *Ns. dieneri* morphotype 3, and *Ns*. n. spp. B, E, and F. The base of the *Flemingites –Euflemingites* zone is 0.03m above the base of the middle subzone. The succeeding subzone of *Ns. waageni* is characterized by the association of each of its subspecies plus *Ns. cristagalli,* all three morphotypes of *Ns. dieneri*, *Ns. spitiensis*, *Ns.* aff. *discretus*, *Ns. conservativus*, *Ns. novaehollandiae, Ns. peculiaris*, *Ns*. n. sp. L, *Ns.* aff. *waageni*, *Platyvillosus costatus*, *P. hamadai*, *Parachirognathus* sp., *Pachycladina* sp., and *Aduncodina unicosta*. The peak abundance of both *Ns. dieneri* morphotype 3 and *Ns. cristagalli* occur in this interval. The top of the *Ns. waageni* Zone is drawn at the FAD of *Ns*. n. sp M.

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Tables 1 and 2 can be downloaded at the internet site of ALBERTIANA at

http://www.bio.uu.nl/~palaeo/Albertiana/Albertiana01.htm

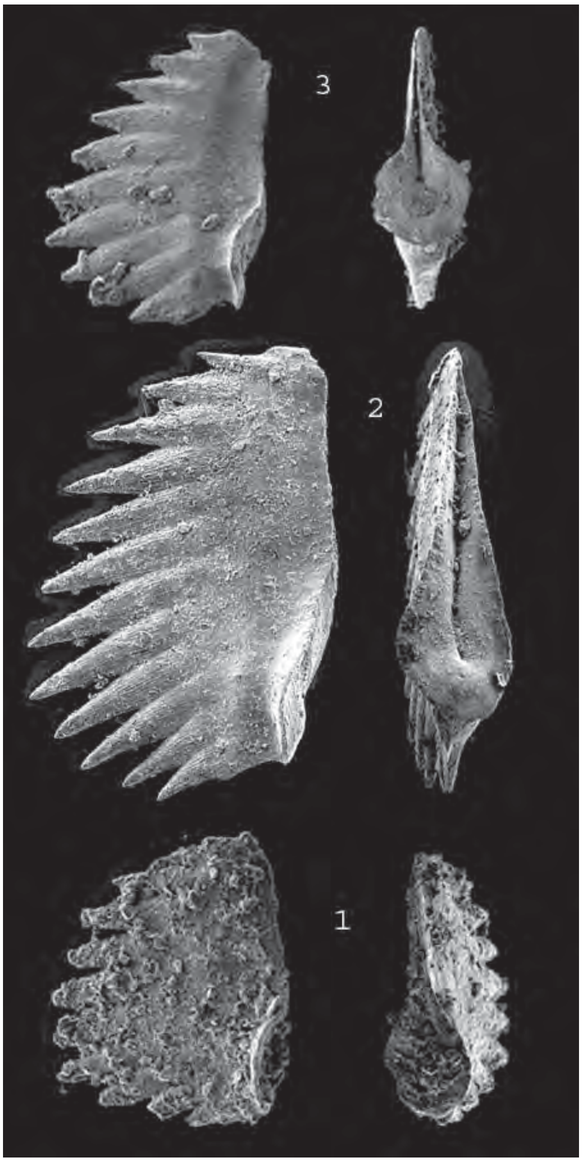

Figure - all specimens are from West Pingdingshan.
Fig. 1. *Neospathodus waageni* n. subsp. A. CUG030007, Sample (Bed): CP27-1 (27).
Fig. 2. *Neospathodus waageni* n. subsp. B. CUG030002, Sample (Bed): CP25-7 (25-25).
Fig. 3. *Neospathodus waageni waageni* Sweet, 1970. CUG030001, Sample (Bed):CP25-11 (25-29).

The ammonoid succession in the BAGOLINO section (NE Italy)

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Introduction

We wish to present here some considerations on *Comment on: "Refined ammonoid biochronostratigraphy of the Bagolino section (Lombardian Alps, Italy), GSSP candidate for the base of the Ladinian Stage" by Mietto P, Gianolla P., Manfrin S. & Preto N.* recently presented by Brack P. & Rieber H. We find necessary to reply to this comment, because we cannot agree with most of the criticisms exposed there. In our reply, we will try, once again to follow the spirit of constructive criticism suggested by the International Code of Stratigraphic Nomenclature.

General comments

On the basis of data from an interval of the Bagolino section, which was ill-checked by the Swiss Authors, the writers found some layers in which, among a diversified ammonoid fauna, *Aplococeras avisianum* occurs. This and other taxa from the investigated horizons are new for the Bagolino section, despite the several researches (cf. Brack and Rieber, 1986; 1993a; 1993b) carried out there so far.

The Swiss Authors regret for the poor preservation of the illustrated material: it is indeed a shortcoming of the Bagolino section that ammonoid faunas are poorly preserved in some key intervals. However, as long as the specimens can be determined, the poor preservation of faunas in some intervals do not imply that such intervals should be not investigated. We shown that, despite most specimens are crushed, incomplete and preserved as films, some taxa (including *A. avisianum*) can be identified.

The open nomenclature used for some specimens is a consequence of the poor preservation, rather than of "problems in identifying ammonoids with such few distinct characters as *Aplococeras*" (Brack and Rieber, 2003b). With poorly preserved material, some caution in the taxonomic identification is due. In these circumstances, we regard as particularly significant the fact that we were anyway able to identify some specimens at the species level.

The *vogdesi-avisianum* debate

Brack and Rieber (2003b) state that the occurence of *A. avisianum* in two subsequent beds at Bagolino is not sufficient for the definition of a FAD. However, as clearly explained by the writers (Mietto et al., 2003; Mietto et al., in press), the occurrence of *A. avisianum* at bed B2c 10 is interpreted as FAD basing not simply on the occurence of the marker taxon on two beds, but mainly on (1) the evaluation of the whole distribution of faunas in the critical interval at Bagolino, and (2) the similar distribution observed in other sections of the Southern Alps and Hungary. This approach seems to be the same of Brack and Rieber (2003a) in their GSSP proposal, where the occurrence of *E. curionii* at ca.63.5 m is interpreted as FAD mainly because the whole distribution of ammonoids in this critical interval can be found in several sections of the Southern Alps. From a merely formal point of view, it must be pointed out that *E. curionii* from Bagolino was never illustrated (cf. Brack and Rieber, 1986; 1993a; 1993b, 2003a).

Brack and Rieber (2003b), basically on the base of the suture line, consider *A. avisianum* and *A. vogdesi* as two distinct species belonging to two different genera: *Aplococeras* for the former, and *Pseudaplococeras* for the latter. The genera *Aplococeras* and *Pseudaplococeras* were considered by Assereto (1969) and Silberling and Nichols (1982) as synonyms. However, Hyatt and Smith (1905), Smith (1914) and Silberling and Nichols (1982) illustrate the suture line of *A. vogdesi* as goniatitic, while the suture line of *A. avisianum* is ceratitic.

As regards this question, Norman Silberling riexamined topotypes of *A. vogdesi*, stored in the USGS warehouse in Denver (Co). He states that "of the several remaining specimens from the Dunni beds only two (one each from single-bed collections M618 and M619) showed suture lines that were prepared many years ago. At diameters of ca. 20 mm the sutures are apparently goniatitic. However, the sutures were evidently prepared by grinding away the outer shell and smoothing the surface with acid, so fine denticulations just inside the shell could have been lost. None of the other remaining specimens of Aplococeras from stratigraphically higher and lower levels seem amenable to exposure of their sutures. The strata at Fossil Hill, as with most of the other exposures of Triassic rocks in Western Nevada, are in the greenschist facies of metamorphism (having CAI's of ca. 5) and are thus quite recrystallized. So, the possible identity of A. vogdesi and A. avisianus remains an open question." Together with Silberling we want to emphasize that the specimens examined are topotypes whose sutures were prepared 40 years ago, presumably in the same manner as the plesiotypes illustrated in Silberling and Nichols (1982). We thus suggest that the apparently goniatitic suture of *A. vogdesi* may be a result of either invasive old methods of preparation and/or the strong recrystallization.

We examined also a topohyle of *A. vogdesi* stored at the University of Milan, and illustrated by Assereto (1969: fig. 2.10). This specimen (Fig. 1) exhibits a fairly indented first lateral lobe at the whorl height of ca. 5 mm, corresponding to a shell diameter of ca. 23 mm. The first and second lateral saddles are slender in shape, the first lateral lobe is twice deep than the external one. The suture line of this specimen is thus comparable to that of *A. avisianum* at the same whorl height, as well as the morphological characters of the shell. We thus confirm the synonymy between *A. avisianum* and *A. vogdesi*, and reject the use of genus *Pseudaplococeras*.

The Crassus Subzone "problem"

Brack and Rieber (2003b) suggest that we consider three important genera, namely *Nevadites*, *Halilucites* and *Ticinites*, to appear together at the base of the Crassus Subzone. The statement was taken from Mietto and Manfrin (1995) and is cited correctly, but was based on still preliminary data. Presently, new data from Bagolino, Hungary, the Latemar platform and unpublished sections of the central-eastern Dolomites indicate that *Halilucites* appears below *Ticinites* of the *crassus* group. On the base of these new data, the writers were able to state that "the three key genera of the Crassus Subzone have their FO at different stratigraphic levels" (Mietto et al., in press). This discussion highlights the importance of findings as the *Halilucites rusticus* of Bagolino illustrated by Mietto et al. (in press) and, later, by Brack and Rieber (2003b), for the reconstruction of the ammonoid distribution in this critical interval. The necessity to present complete ammonoid distributions, without hiding supposedly negligible data, should be thus evident.

Furthermore, the Swiss Authors emphasize that the base of the Crassus Subzone do not correspond to the base of the Secedensis Zone of Brack and Rieber, if it is true that the base of the Crassus Subzone should be positioned at the appearance of genus *Nevadites*. Thus, according to Brack and Rieber (2003b), at Bagolino the base of the Crassus Subzone should be positioned where the first *Nevadites* occurs, ca. 2 m above the base of the Secedensis Zone (which corresponds to the "Ticinites beds").

In response to this, we point out that (1) *"Nevadites" secedensis*, *"N." avenonensis*, *"N." crassiornatus*, *"N." ambrosionii*, *"N." dealessandrii* are not true *Nevadites* (Manfrin and Mietto, 1995), and have thus probably a different (younger) stratigraphic distribution; and that (2), as we consider *Halilucites*, *Ticinites* of the *crassus* group and true *Nevadites* (represented in the Southern Alps by, e.g., *N. symmetricus* from Marmolada) as typical of the Crassus Subzone, it is reasonable to put the base of this subzone at the FO of *Halilucites* in Bagolino.

Conclusions

The most important consideration arising from the current discussion is, in our view, that the Bagolino section is probably undersampled with respect to its ammonoid fauna, despite the intensive research activity of the last > 15 years (cf. Mietto et al., in press). In fact, after the renewed interest on the Anisian / Ladinian boundary, further investigations on a minor portion of the Bagolino section yielded new taxa for the section, and the distribution of other important taxa, as genera *Halilucites* and *Kellnerites*, changed significantly. We suggest that a systematic study of the Bagolino section may yield further data on the ammonoid distribution at this key locality.

We sustain, in agreement with earlier works (Mietto and Manfrin, 1995; Manfrin and Mietto, 1995; Mietto et al., in press), that the best solution for the base of the Ladinian is the FAD of genus *Nevadites* (*sensu* Tozer, 1994). It seems indeed that the FAD of significant genera as *Nevadites*, *Celtites*, *Parasturia* and *Halilucites* are all within the Crassus Subzone; this subzone contains thus the major ammonoid turn-over of the critical interval, and this circumstance maximizes the potential of long distance correlations, at least considering the first two genera. However, a single section in which these events are all documented in stratigraphic order has not yet been found: because of this reason, the writers offered a compromise proposal for the base of the Ladinian stage, suggesting the FAD of *A. avisianum* as the criterion for the boundary. In our view, this proposal can be shared mainly because of the weakness of the alternative proposals. The choice of the FAD of *R. reitzi* to define the base of the Ladinian allows correlation only within the Tethyan domain. On the contrary, the choice of the FAD of *E. curionii* allows long distance correlation only under the assumption that different species belonging to the same genus (namely, *E. curionii* in Europe and *E. subasperum* in North America) appear at the same time; we believe that this assumption is biologically unacceptable. Furthermore, as already highlighted (Mietto et al., in press), the nomenclatural stability of carbonate platforms would be devastated by putting the base of the Ladinian as high as at the FAD of *E. curionii*.

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Figure 1: topohyle of "*Lecanites vodgesi*" Hyatt & Smith from Nevada (Assereto, 1969: fig. 2.10), with a preserved portion of the suture line.

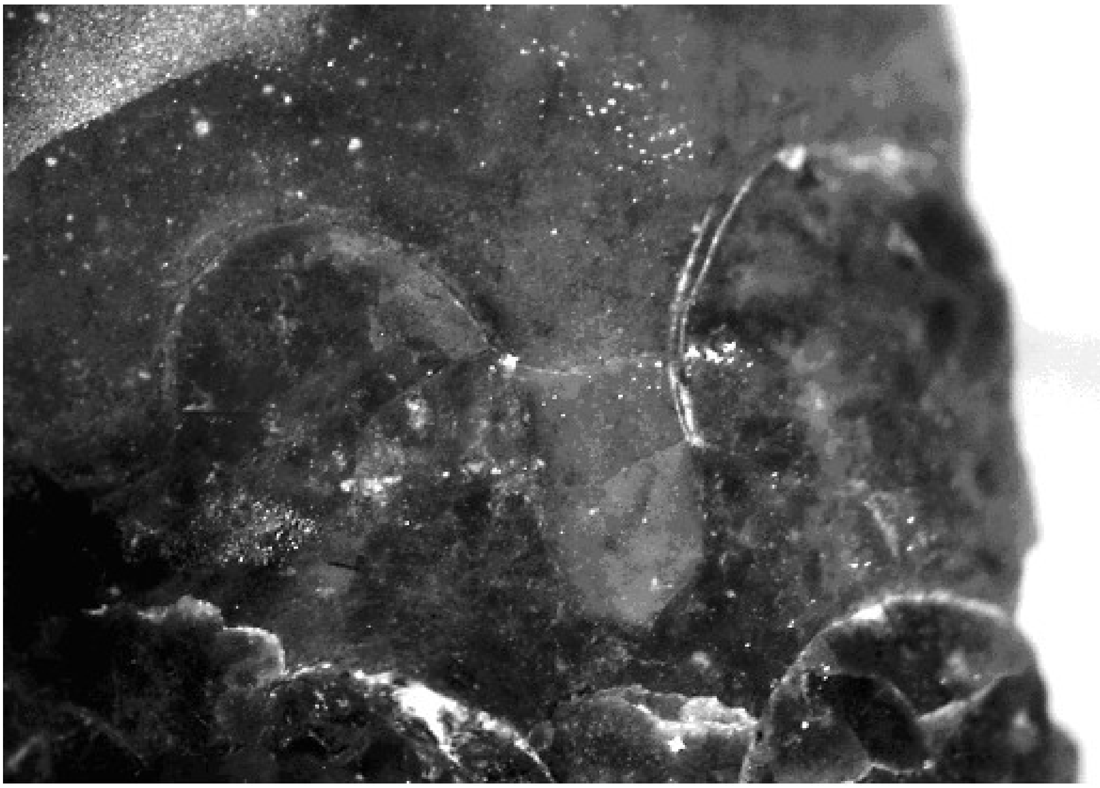

Figure 2: Magnification of the last suture of the specimen of Fig. 1. At a whorl height of ca. 5 mm (corresponding in this case to a shell diameter of ca. 23 mm), the first lateral lobe is fairly denticulated.

New Triassic Literature

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The help of Dr. Z. Smeenk (Utrecht) in tracing relevant literature is gratefully acknowledged.

British Triassic paleontology: supplement 29

G. Warrington

Since the completion of the writer's previous supplement (No.28; ALBERTIANA, 28: 109) on British Triassic palaeontology, the following works relating to aspects of that subject have been published or have come to his notice:

Collins, J. S. H. 2002. A taxonomic review of British decapod Crustacea. Bulletin of Mizunami Fossil Museum, 29: 81-92.

Dalla Vecchia, F. M. 2003. New morphological observations on Triassic pterosaurs. Geological Society, London, Special Publications, 217: 23-44.

Hawkins, T. R. W. & Saul, G. H. 2003. Complex extensional faulting of Triassic rocks north of York, North Yorkshire, UK. Proceedings of the Yorkshire Geological Society, 54 (4): 257-267.

Lyle, P. 2003. The north of Ireland. Classic Geology of Europe 5. Harpenden, Terra Publishing: x+214pp.

Mitchell, W. I. (ed.). 2004. The Geology of Northern Ireland - our Natural Foundation (2nd edition). Belfast, Geological Survey of Northern Ireland, x+318pp.

Naylor, D., Philcox, M. E. & Clayton, G. 2003. Annaghmore-1 and Ballynamullen-1 wells, Larne-Lough Neagh Basin, Northern Ireland. Irish Journal of Earth Sciences, 21: 47-69.

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GUIDELINES FOR THE SUBMISSION OF MANUSCRIPTS TO ALBERTIANA

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Text files can be submitted formatted as *.wpd, *.doc or *.rtf files and illustrations as pixel based graphics (e.g: *.bmp, *.tif, *.gif or *.jpeg) or vector based graphics (e.g: *.ai, *.cdr) that can be directly imported into Adobe PageMaker. Please provide good, clean, flat, printed copies (NOT xerox copies) of any illustrations, which MUST be designed to fit on an A4 page (centered, with at least 2.54 cm wide margins left and right, and 4 cm margins at the top and bottom).

Special attention should be paid to grammar and syntax - linguistic corrections will be minimal. In case of doubt, send your manuscript to a colleague for proof reading. References should be in the format used in the ‘New Triassic Literature’ section in issue 25 of Albertiana. Please write all Journal titles in full length. The use of names of biostratigraphic units should be in accordance with the International Stratigraphic Guide:

The formal name of a biostratigraphic unit should be formed from the names of one, or preferably no more than two, appropriate fossils combined with the appropriate term for the kind of unit in question.”

The writing and printing of fossil names for stratigraphic units should be guided by the rules laid down in the International Code of Zoological Nomenclature and in the International Code of Botanical Nomenclature. The initial letter of generic names should be capitalized; the initial letter of the specific epithets should be in lowercase; taxonomic names of genera and species should be in italics. The initial letter of the unit-term (Biozone, Zone, Assemblage Zone) should be capitalized; for example, Exus albus Assemblage Zone.”

The name of the fossil or fossils chosen to designate a biozone should include the genus name plus the specific epithet and also the subspecies name, if there is one. Thus Exus albus Assemblage Zone is correct. After the first letter; for example, Exus albus may be shortened to E. albus. On the other hand, the use of the specific epithet alone, in lowercase or capitalized, in italics or not (albus Assemblage zone, Albus Assemblage zone, albus Assemblage zone, or Albus Assemblage zone), is inadvisable because it can lead to confusion in the case of frequently used species names. However, once the complete name has been cited, and if the use of the specific epithet alone does not cause ambiguous communication, it may be used, in italics and lowercase, in the designation of a biozone; for example, uniformis Zone.”

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

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Lower Triassic Conodont distributionat West Pingdingshan Section,Chaohu

Sample	Depth from the	Depth from	Conodonts																																									
number	each base:m	the PTB:m	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
CPX5-1	0-0.07	0.25-.33	1	2	1		1				2																															
CPX5-2	0.07-0.13	0.33-.38		1		1					2																															
CPX5-3	0.13-0.27	0.38-0.42		10	6																																					
C11-3	1.13-1.18	10.68-10.73		1	1			1																																		
C11-4	1.4-1.5	10.95-11.05		1	1																																					
C13-4	1.47-1.51	14.48-14.52					1				1																															
C14-4	1.66-1.7	16-18-16.24					1				1																															
C15-2	0.27-0.3	17.1-17.4																																								
C15-4	0.69-0.74	17.47-17.52																																								
CP16	1.63-1.70	19.45-19.52					1	4	4	1	2																															
CPX16,61	1.7-1.73	19.52-19.55						1			2																															
C17,59	0.34-0.47	20.29-20.42					1	2	1																																	
C17-3	3.85-3.91	23.8-23.86						2	1		2																															
C18-9	3.61-3.65	27.51-27.55																																								
CPX19	0.4-0.5	28.11-28.21										2	2																													1
C20-2	0.47-0.53	31.24-31.3										2																														2
CP20	1.49-1.54	32.31-32.36										1																														4
C20-4	1.67-1.72	32.44-32.49											1																													
C21-2	0.3-0.38	32.49-33.02											4																													
CP21-1	0.65-0.7	32.29-33.34												2																												
C21-5	1.19-1.23	33.83-33.87											2	3																												
CP21-2,C21-6	1.26-1.36	33.9-34																																								3
44,C21	1.66-1.86	34.3-34.5												6																												1
C21-8,CP21-3	1.93-1.96	34.3-34.6											2																													
C22-2	0.55-0.67	35.15-35.27												3																												2
C22-3,CP22-1	0.8-0.85	35.4-35.45											1	11	3																											2
C22-5	1.3-1.45	35.9-36.05													1																											2
CP22-2	1.45-1.5	36.05-36.1											1	4																												
CP22-3	2.21-2.24	36.81-36.84											3	2																												4
C22-6	2.38-2.4	36.98-37											4	2																												5
C22-8	2.4-2.46	36.98-37.06											1																													
C23-2,CP23-1	0.45-0.47	37.61-37.63											4	1																												6
Cp23-2,41	0.74-0.87	37.9-38.08											4	1			1	3																								
C23-4	1.05-1.07	38.21-38.23											2																													

C23-5,40	1.25-1.33	38.41-38.49											3	2			17	1																										
C23-7,39	1.86-1.93	39.02-39.09											1				1	1																										4
C23-8,CP23-4	1.95-1.99	39.11-39.15											3	4			1	30																										15
C23-9,37	2.0-2.08	39.16-39.24											3		1		1	1				1?																						2
C23,36	2.08-2.13	39.24-39.29											2																															
CP24-1,33,C24-2	0.3-0.35	39.59-39.64											4				3																											4
CP24-2,C24-4,34	0.78-0.85	40.04-40.14											1																															2
CP24-6-1	1.13-1.2	40.42-40.49											1				1					1?																						1
CP24-6-2	1.2-1.27	40.49-40.56												2									1																					1
CP24-6-3	1.27-1.33	40.56-40.62											1?	1																														4
CP24-6-4	1.33-1.39	40.62-40.68											1	1	1		1					1?																						
6	1.44-1.48	40.73-40.77																																										7
CP24-7,7	1.48-1.51	40.77-40.8											3	1	3	3			1	1		1?	1	2																				7
CP24-8,8	1.51-1.56	40.8-40.85											11	37	7	3	1?		7	8	1	1?	1	4																				34
CP24-9,9,CP24-4,C24-2	1.56-1.6	40.85-40.89											4	24	2		1?		1		1		2	2																				16
C25,C7	0-0.05	40.89-40.94																																										1
C8	0.05-0.09	40.94-40.99																																										1
C9	0.1-0.15	40.99-41.04																																										13
C10	0.15-0.2	41.04-41.09																																										3
C11,CP25-1,13	0.2-0.22	41.09-41.11																																										2
14	0.22-0.265	41.11-41.155																																										1
15	0.265-0.31	41.155-41.2																																										1
16	0.31-0.355	41.2-41.245																																										1
17	0.355-0.4	41.245-41.29																																										3
CP25-2,C15,C25-2,18	0.4-0.42	41.29-41.31											4	3		1					1	3			2																			50
19	0.42-0.52	41.31-41.41																																										2
20	0.52-0.62	41.41-41.51																																										1
CP25-3,21	0.62-0.72	41.51-41.61																				1																						10
22	0.72-0.82	41.61-41.71											1	1																														10
23	0.82-0.82	41.71-41.81																																										12
24	0.92-10.2	41.81-41.91																																										2
CP25-4,25	1.02-1.09	41.91-41.98																				1																						4
26	1.09-1.19	41.98-42.08																				1																						5
27	1.19-1.29	42.08-42.18																																										5
28	1.29-1.39	42.18-42.28																				2			1																			5
29	1.39-1.49	42.28-42.38																							1?																			4
30	1.49-1.59	42.38-42.48																							2?																			22

CP25-6,C25-7,31	1.59-1.64	42.48-42.53													31							14			24	2		5				2												40
32	1.64-1.72	42.53-42.61																				2			4								2											10
CP25-7	1.72-1.77	42.61-42.66													35				2			33		3	90		2	74		2	1	3	2											102
CP25-8	1.77-1.89	42.66-42.78																				3	3		5																			4
CP25-9	1.89-1.94	42.78-42.83																	2				2		1																			4
CP25-10	1.94-2.06	42.83-42.95																						1	5								1											6
CP25-11	2.06-2.09	42.95-42.98												1	2							3	2		11			4					1											6
CP25-12	2.09-2.21	42.98-43.1																					2	1	3																			4
CP25-13	2.21-2.31	43.1-43.2																							3								2		1									2
CP25-14	2.31-2.36	43.2-43.25													1																													3
CP25-15	2.36-2.41	43.25-43.3																							1																			7
CP26-1	0.6-0.64	43.9-43.94													1										5										1?									2
CP26-2	1.2-1.24	44.5-44.54													1										4									1										
C26-4	1.51-1.56	44.81-44.85																																	1									1
CP26-3	1.7-1.77	45-45.07																					2		2																			5
CP26-4	2.43-2.48	45.74-45.78																							1																			2
C26-6	2.64-2.69	45.94-45.99																							1																			2
CP26-5	3.0-3.06	46.36-46.42																							4																			2
C26-7	3.29-3.33	46.59-46.63													1																													4
CP27-1	0.7-0.75	47.33-47.38																					2		1																			2
CP27-2	1.94-1.91	48.57-48.6																																										1
C27-4	2.85-2.9	49.48-49.53																							2																			4
CP28-1	0.2-0.3	50.07-50.17																																										2
CP28-2	1.32-1.34	51.19-51.21													1																													
C28-3	2.42-2.47	52.29-52.34																																										1
C29-2	0.6-0.68	52.94-53.02																							1								1											2
C29-4	2.41-2.47	54.75-54.81																																										2
C30-2	0.9-0.95	55.71-55.76																																										
C30-3	1.55-1.64	56.36-56.45																											1															1
C30-4	2.53-2.57	57.34-57.38																																										12
CPX31	0.5-0.53	57.88-57.91																																		1								1
C34-2	2.5-2.53	68.35-68.38																																										1
CPX38,79	0.2-0.3	74.61-74.71																																										
C39-2,80	0.95-1.0	75.93-75.98																																						1			
C40,81	0-0.15	76.03-76.18																																										
CPX41-CPX49																																												
C50-2	0.43-0.48	91.23-91.28																																										5

C52-2	0.48-0.58	93.43-93.53																																		3					1?		10
C54-1	0.16-0.23	94.78-94.85																																		4					1		2
C55-1,96	0-0.1	97.26-97.36																																		9	1						
C56-1	0-0.05	99.9-99.95																																				1				1	1
C56	1.75-1.80	101.65-101.7																																				1	1			1	1
C57-1	2.86-2.91	105.69-105.74																																					1				
C57,99	3.21-3.31	106.04-106.14																																									2
C58	0-0.1	106.74-106.84																																									
C58-1	2.0-2.1	108.74-108.84																																									2
C59	0-0.1	111.43-111.53																																									1

1.Hindeodus minutus Ellison
2.H.typicalis Sweet
3.H.sp.
4.Isarcicella(?) sp.
5.Neogondolella carinata Clark
6.Ng.planata Clark
7.Ng.krystyni Orchard
8.Ng.orchardi Orchard
9.Ng.sp.
10.Neospathodus kummeli Sweet
11.Ns.dieneri type 1
12.Ns.dieneri type 2
13.Ns.dieneri type 3
14.Ns.sp.B(sp.nov.)
15.Ns.sp.C(sp.nov.)
16.Ns.sp.D(sp.nov.)
17.Ns.sp.E(sp.nov.)
18.Ns.sp.F(sp.nov.)
19.Ns.sp.K(sp.nov.)
20.Ns.cristagalli Huckriede
21.Ns.waageni n. subsp. A
22.Ns.waageni n. subsp. B
23.Ns.waageni Sweet sensu stricto
24.Ns.sp.G(sp.nov)
25.Ns.sp.H(sp.nov.)
26.Ns.sp.L(sp.nov.)
27.Ns.aff. waageni Sweet

28.Ns.discretus Muller
29.Ns.peculiaris Sweet
30.Ns.alberti
31.Ns.novaehollandiae McTavish
32.Ns.spitiensis Geol
33.Ns.conservativus Muller ?
34.Ns.sp.I(nov.sp.)
35.Ns.sp.M(sp.nov.)
36.Ns.sp.N(sp.nov.)
37.Ns.eotriangularis
38.Ns.homeri Bender
39.Cratognathodus sp.
40.Ns.cf.abruptus Orchard
41.Ns.abruptus Orchard
42.Ns.sp.
43.Platyvillosus costatus Staesche
44.Pl.hamadai Koike
45.Parachirognathus cf.tricuspidatus Staesche
46.Pa.sp.
47.Pachycladina sp.
48.Cornudina breviramulis Tatge
49.Aduncodina unicosta Ding
50.Ramiform elements
51.Ns.spathi Sweet
52.Ns.aff. crassatus Ochard
A.Ophiceras.sp.
B.Lptophiceras. Sp.
C.Gyronites sp.
D.Prionolobus sp.
E.Prionolobus impressus
F.Dieneroceras dieneri
G.Dieneroceras cf.ovalis
H.Dieneroceras sp.(bed36 to 40)
I. Preflorianites cf.strongi
J.Paranorites cf.ovalis
K. Paranorites sp.
L.Flemingites sp.

M.Euflemingites sp.
N. Euflemingites cf.ellipicus
O.Koninckites lolowensis
P.Koninckites sp.
R. Clyperoceras cf.kwangsiensis
S.Clyperoceras cf.lenticulare
T. Pseudosageceras tsotengense
U.Vishnuites pralambha
W.Xenodiscoides sp.
X. Owenites pakungensis(bed 33)
Y.Owenites sp.
Z.Arctoceras aff. Lolouensis(bed 33)
AA.Pseudoceltites sp.(bed 33)
AB.Wasachites sp.
AC.Hemiprionites sp.
AD.Juvenites orientalis Chao
AF.Anasiblrites cf. kwangstana(bed 51)

										Ammonites																									
43	44	45	46	47	48	49	50	51	52	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	R	S	T	U	W	X	Y	AB	AC	AD
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							2			*																									
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							10																												
							9																												
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							6																												
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							62																												
							32																												
							36																												
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							48						*-																						
							25																												
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							65																												
							1																												
							32																												
			3				216														*	*													
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							4																												
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							22																												
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							6																												
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4																																			

58							29																												
2							5																												
26							150																												
							5																												
17	1		1				2																												
			1				8																												
							4																												
9	1						4																												
	8	2																																	
							9															*	*								*				
							20																												
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							8																												
			5	2		2	90										*																		
							80										*																		
							95																												
							40																												

							32																												
							7																												
							24																												
							20	3	1																										
							104																												
							2																												
					1		4																												
							3																												
							4																												
							5																												

Sampl	Depth from	Depth from	Conodonts																																							
number	base of ea	the PTB	*H. changxingensis*	*H.typicalis*	*H.sp.*	*Ng.planata*	*Ng.carinata*	*Ng.krystyni*	*Ng. sp.*	*Ns.kummeli*	*Ns.dieneri* Type 1	*Ns.dieneri* Type 2	*Ns.dieneri* Type 3	*Ns* sp.C	*Ns*.sp.D	*Ns*.cf.*abruptus*	*Ns*.sp.E	*Ns*.sp.F	*Ns.cristagalli*	*Ns.waageni n. subsp. A*	*Ns.waageni n. subsp. B*	*Ns.waageni sensu stricto*	*Ns* .sp.L	*Ng.elongata*	*Ng.aff. sweeti*	*Ns* sp.M	*Ns* sp.O	*Ns*. sp.P	*Ns* sp.Q	*Ns* .aff.*crassatus*	*Ns.spathi*	*Ns.eotriangularis*	*Ns.aff. waageni*	*Ns.abruptus*	*Ns.homeri*	*Aduncodina unicosta*	*Parachirognathodus sp.*	*Cratognathodus sp.*	*Ns* sp.	*Platyvillosus coststus*	*P.hamadai*	Ramiforms	*Ic. collinsoni*
A-3			2	1	3																																						
A5-1	0-0.09	0--0.09		1	3																																						
A5-2	0.09-0.18	0-0.09		1																																							
A6	0-0.1	0.09-0.19			2																																						
A7	0-0.14	0.23-0.34			4	1	1		1																																		
A8	0.39-0.52	0.37-0.46		1	3																																						
A9	0-0.05	0.46-0.51			4																																						
A11	0-0.10	0.86-0.96			1																																						
A11-1	0.3-0.4	1.16-1.26			2																																						
A11-3	0.59-0.69	1.45-1.55		4	6																																						
A12-1	0.4-0.5	2.16-2.26		1	1																																						
AP13-	0.2-0.3	2.84-2.94			5	1			1																																		
A13,1	0.5-0.6	3.14-3.24		1	6																																						
A13,1	0.9-1.0	3.54-3.64			1																																						
A13-3	1.22-1.34	3.86-3.98		2	4																																						
A14	0.4-0.5	5.14-5.24				1			1																																		
AP17	1.0-1.1	11.24-11.34			2			2																																			
AP22	0.25-0.35	15.39-15.49				6	5	2	4																																	14	
A27-2	0.66-0.76	21.53-21.63								1	2																													2			5	
AP28	0.74-0.84	22.37-22.47								1																													1			7	
AP29	0.45-0.55	22.92-23.02								1	1																												1			2	
AP39-	0.47-0.57	31.47-31.57									3																												1			5	
AP40-	0.91-1.01	32.48-32.58									2																												1			2	
AP41-	0.66-0.71	34.43-34.48									1	2																											2			8	
AP42-	0.69-0.74	35.17-35.22									2	9																											2			8	
A42-3	0.74-0.81	35.22-35.29									1	2	1																										2			6	
AP43-	0.12-0.15	35.41-35.44											2																										2			1	
AP43-	0.77-0.87	36.06-36.16									1	4	1																										2			11	
A44-1	0.5-0.6	36.66-36.76										1																											2			2	
A44-2	0.6-0.7	36.76-36.86										2																											1			10	
AP44-	0.70-0.83	36.86-36.99									1	2	2																										1			13	
A45-2	0.45-0.6	37.67-37.82										1	1																										1			2	
A45-3	0.6-0.72	37.82-37.94										1	1																										1			4	
AP45-	0.72-0.75	37.94-37.97										1	1		1																											2	
AP46-	0.6-0.70	37.57-37.67										2																														5	
A46-3	0.79-0.85	38.76-38.82									4	6	2	12	30																								16			40	
AP47-	0.59-0.66	39.51-39.58									1		1	2																									2			5	
A48-2	0.6-0.7	40.18-40.28									2			2																									5			16	
A49-2	0.36-0.4	40.84-40.88										2	1				1	1		1																			2			2	
A49-3	0.78-0.84	41.26-41.32										2	1								2																		4			2	
AP50-	0.5-0.52	41.94-41.96											5						4		1	4	2																20	10		40	
AP50-	0.52-0.59	41.96-42.03											3						4	1	1	4	10														2		7	7		20	
AP50-	0.59-0.63	42.03-42.07									1		4						1			3															2		5	2	1	20	
AP50-	1.09-1.2	42.53-42.64																			1	1															2		2	1	1	10	
AP50-	1.27-1.35	42.71-42.79																				1																	2			4	
AP52-	1.0-1.02	45.19-45.21																																					1			3	
AP54-	0.35-0.37	45.94-45.96																				1																	1			7	
AP58-	0.2-0.22	52.59-52.61																																					1			10	
AP61-	0-0.07	57.49-57.56																						1	1	7	16	1	1	1									25			27	
AP62-	0-0.1	58.09-58.19																								2	4												4				
AP63-	0-0.05	59.59-59.64																		4						4	8	16	2										20			10	
AP64-	0.3-0.4	60.42-60.52																								22	2	14			4	3	2						20			14	
AP64-	0.9-0.95	61.02-61.07														1															1				1		2		3			4	
AP65-	0.03-0.2	62.15-62.32																																	1				2			3	
AP66-	0.95-1.0	63.44-63.49																																					1			2	2
AP67-	0-0.05	64.49-64.54																																			2	1	2			4	1
AP69-	0.4-0.5	69.29-69.39					2		2																													1	2			4	
AP69-	2.5-2.6	71.39-71.49														3															6			2	2	14		1	2			50	