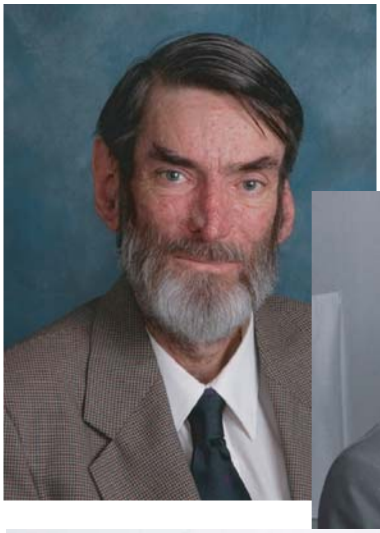
Permophiles

International Commission on Stratigraphy
International Union of Geological Sciences

Newsletter of the
Subcommission on Permian Stratigraphy
Number 47
ISSN 1684-5927
June 2006



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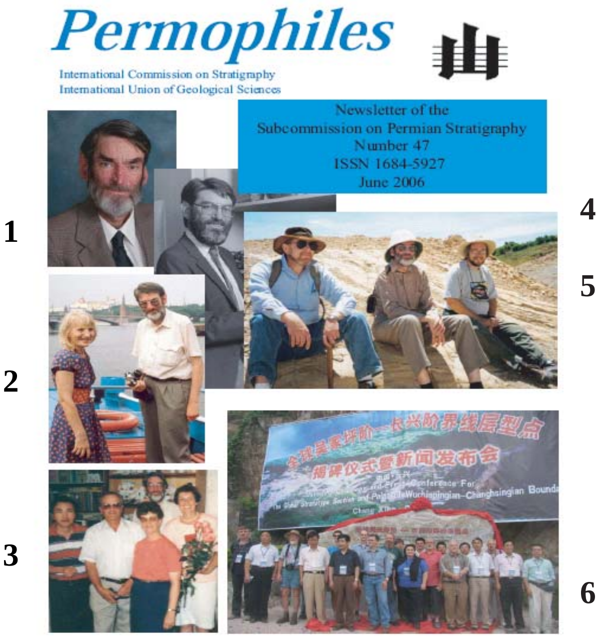

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Explanation of Cover: **1.** This issue is dedicated to the memory of Neil Archbold (1950-2005) and to his lasting contributions to Permian paleontology and stratigraphy. Photo taken in 2003. **2.** With T. Grunt in Moscow 1998. **3.** With Guang Shi, Claude Spinosa (former SPS Secretary), his wife Jean, and T. Leonova. **4.** Neil Archbold in 1995. **5.** At Bold Hill, Bacchus Marsh, Victoria 1998 including Clinton Foster (former SPS Vice-Chair). **6**. Unveiling Ceremony of the base-Changhsingian GSSP on June 14, 2006 including participants of the IPC pre-conference fieldtrip A3 to Meishan and Chaohu. Meishan, Changxing County, Zhejiang Province, China.

EXECUTIVE NOTES

Notes from the SPS Secretary

Introduction and thanks

I want to thank Profs. John A. Talent, Guang R. Shi, Giuseppe Cassinis, and Bruce Waterhouse, as well as Dr. Monica Campi who contributed articles, reports or notes for inclusion in this 47th issue of Permophiles. I also thank Charles Henderson for coming to Nanjing; we did all of the editorial work for this issue during 7 days from June 8th to 14th. We thank individuals for financial contributions to the Permophiles publication fund in support of this issue and remind our readers that despite the fact that we have gone mostly electronic there are still costs involved in printing and mailing a limited number of copies. Permophiles is recognized by the ICS as an exceptional newsletter and the continuing support of our readers is necessary to maintain that quality. All of the previous issues of Permophiles can be freely downloaded at http://www.nigpas.ac.cn/permian/web/index.asp. All members are welcome to visit our website, download Permophiles and join in the PermoForum to discuss Permian issues.

Previous SPS Meeting and Minutes

A ceremony to celebrate the formal ratification of the Lopingian-base and the Changhsingian-base GSSP by IUGS in conjunction with the field excursion A3 of the International Palaeontological Congress 2006 (IPC2006) was held at the Meishan Geopark on the 14th of June. The Lopingian-base GSSP has been ratified at the Penglaitan section in Laibin County, Guangxi Province and the Changhsingian-base GSSP has been ratified at the Meishan Section D in Changxing County, Zhejiang Province, China. Local government officers from Changxing County and media attended the ceremony. I chaired the ceremony and Professor Sha Jingeng, Director of Nanjing Institute of Geology and Palaeontology gave a brief introduction for the working process for those two GSSPs. SPS Chairman Charles Henderson, Doug Erwin, the officers from Changxing government all gave short speeches to congratulate the establishment of GSSPs in South China. After the ratification of the Changhsingian-base GSSP, the Meishan Section D has become a unique section with two GSSPs at the same section thereby establishing the body stratotype of the Changhsingian. Unfortunately, Prof. Jin Yugan, the chair of both the Lopingian-base and Changhsingian-base Working Groups could not attend the ceremony. After the short ceremony, the participants of the pre-conference field excursion of IPC 2006, Cao Changqun, Charles M. Henderson, John A. Talent, Roger Summons, Doug Erwin, Matthew E. Clapham, Zhong-Qiang Chen, Yasuo Kondo, Enzo Farabegoli, M. Cristina Perri, Shanan Peters, Aleksander Klets, Roger Pierson and I, visited all Permian-Triassic sections in the Meishan Geopark.

Future SPS Meeting and IPC2006

1) An SPS meeting will be held on June 20, 2006 during the second International Palaeontological Conference at Beijing China. IPC2006 will be held just after editing this issue. More than 850 participants from 50 different countries will join in the conference. There are a few sessions related to Permian, including integrated stratigraphy (G11 convened by Charles Henderson and Shen Shuzhong), Late Paleozoic: the end-Permian extinction following a 100 m.y. long stability (T8 convened by Doug Erwin and Wang Xiangdong), Past and present global changes and biotic saltations (S6 convened by Yin Hongfu), Palaeoecology, palaeobiogeography, palaeogeography and palaeoclimate (G7 convened by John Talent and Guang R. Shi) and Geo-biodiversity: taxa, morphology and ecology (S2 convened by Arnie Miller) etc. Selected abstracts related to the Permian are provided in this issue.

2) An SPS meeting will be held in Siena, Italy, in conjunction with the Field Conference on the Stratigraphy and Palaeogeography of late- and post-Hercynian basins in the Southern Alps, Tuscany and Sardinia, and comparisons with other Western Mediterranean areas and geodynamic hypotheses, between September 18-23, 2006. This field excursion is sponsored by the Italian Geological Society. The Field Conference will consist of an initial excursion (September 18-21) followed by two day meeting (September 22-23) in Siena. The field excursion will focus on the Permian and Triassic continental sequences in the southern Provence, western Liguria and northwestern Tuscany. Oral or poster contributions are welcome; abstract deadline is July 30, 2006. Additional information is available from Prof. G. Cassinis, Dipartimento di Scienze della Terra, Università degli Studi, Via Ferrata No. 1, 27100 Pavia, Italy. Tel: 39 0382 985834. Fax: 39 0382 985890. E-mail: cassinis@unipv.it. The first circular has been sent out and is available at http://manhattan.unipv.it/sem_conf_new.htm (this information is provided by Prof. Giuseppe Cassinis).

3) Another SPS business meeting will be held in conjunction with the XVI International Congress on Carboniferous and Permian that will be held at Nanjing between June 21- 24, 2007 (see detailed first circular in this issue). This conference is sponsored by Chinese Academy of Sciences, National Natural Science Foundation of China, Ministry of Science and Technology, China, Chinese Academy of Geological Sciences, The International Subcommission on Carboniferous Stratigraphy and The International Subcommission on Permian Stratigraphy. Prof. Wang Xiangdong and I will co-chair the Organizing Committee of the conference. We warmly welcome our colleagues all over the world to Nanjing to participate in this conference.

This issue of Permophiles

This issue of ***Permophiles*** is dedicated to the memory of Prof. Neil Archbold. We are deeply saddened by the news of Neil's departure. He was my teacher, colleague and friend. It was Neil Archbold who established the detailed Permian biostratigraphical framework in Western Australia which is very useful for the correlation of the Permian System in the peri-Gondwanan region. Neil was particularly popular with brachiopod researchers. We will remember a special scientist and colleague who was passionate about brachiopods and brought his infectious sense of fun to all who worked with him. We will all miss him.

Future issues of Permophiles

The next issue of ***Permophiles*** (Issue 48) is scheduled for late October 2006 after GSA, which will be prepared by Charles Henderson and me in Calgary. Everyone is encouraged to submit manuscripts, announcements or communications by Monday October 16. Manuscripts and figures in the appropriate format can be submitted via my email address (szshen@nigpas.ac.cn; or shen_shuzhong@yahoo.com) as attachments or by our SPS website (http://www.nigpas.ac.cn/permian/web/index.asp). Hard copies by regular mail do not need to be sent unless requested. However, large electronic files such as plates in Photoshop or TIF format may be sent to me on discs or hard copies of good quality under my mailing address below. Alternatively, large files can also be transferred via the submitting system on our SPS website. Please follow the format on Page 3 of issue 44 of ***Permophiles***.

Cancellation of the Cisuralian Workshop

A field workshop on the Cisuralian GSSPs was planned last year in order to complete the GSSP proposals in a timely fashion for voting during 2007. This workshop was tentatively set for July 24 – August 4, 2006 in the southern Urals. It's greatly regretful that Boris Chuvashov could not undertake the workshop because of some significant budget cuts and changes in the Russian Academy of Sciences at the last stage. A new plan for the Cisuralian GSSPs will be discussed shortly among the SPS.

SPS Website is online

Our SPS website has been available for one year now and it provides information on activities of the SPS, events and meetings, the organization of SPS, the progress of GSSPs related to the Permian stages and various working groups as well as all issues of Permophiles. It also provides links to useful partner organizations such as IUGS, ICS, the Permian Research Institute at Boise State University, and the Late Palaeozoic Research Group at Nanjing Institute of Geology and Palaeontology. We have also designed a PermoForum on the website, with the goal to stimulate on-line discussions by members of the Permian community to share ideas and thoughts. The username and password to enter this PermoForum are respectively ***SPS (username)*** and ***wangi (password)***. In addition, you can download all of the previously published Permophiles issues. All members or people who are interested in the Permian issues are encouraged to visit our website, download Permophiles, and submit your comments.

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Notes from the SPS Chair

Charles M. Henderson

Shuzhong Shen and I completed this issue during seven warm days at the Nanjing Institute of Geology and Palaeontology where I enjoyed some fantastic Chinese hospitality. This 47th issue of ***Permophiles*** went online on June 15th and now our readers can download not only this issue, but every previous issue from the same website (http://www.nigpas.ac.cn/permian/web/index.asp). The content of these issues has centred on providing timely information on the Permian and increasing communication between researchers on the Permian. As a result ***Permophiles*** is widely cited in the scientific literature and this testifies to the value of the efforts of previous executives to continue to produce and help evolve this volume.

In the last issue of Permophiles I indicated that there would be a Cisuralian field excursion to the southern Urals to visit the three potential GSSPs for the base-Sakmarian, base-Artinskian, and base-Kungurian. A considerable amount of work has been completed and we have informal definitions for each as discussed in ***Permophiles*** #41. However, there is still work needed, in particular on geochemistry, geochronology, access and reproducibility; Mark Schmitz and Vladimir Davydov are working on the completion of the geochronology of the many ash layers found near the selected Cisuralian GSSP sections. It is important that full and free access to these locations be demonstrated by the Russian geologic community such that geochemical and paleontologic samples can be collected and shipped in a timely fashion for analysis. Unfortunately and sadly, this field excursion was cancelled at a very late date. This is a significant blow to our attempts to complete the Permian timescale by 2008 as mandated by IUGS. It also calls into question one of the most fundamental requirements for a GSSP – namely ACCESS. The field excursion has been delayed to the summer of 2007 – any delay beyond this point may necessitate SPS to consider other potential GSSPs for the Cisuralian stages.

In contrast, I had the welcome opportunity to represent the SPS at the ceremony to honour the Upper Permian or Lopingian Series GSSPs on June 14th. We were there to celebrate two decisions – decisions between geologists and paleontologists from several countries – an international collaboration that was not easily struck, but wholly satisfying once completed as now we have a means to calibrate and correlate the Upper Permian. The ceremony was held at Meishan, the site of the base-Changhsingian GSSP in Changxing County, Zhejiang Province. Government representatives were present from Changxing County, Zhejiang Province, which is the site for the base-Wuchiapingian GSSP. I thank those representatives for their interest and support to make these sites freely available for future geoscientists as well as maintain the sites for the general public, especially the Geopark at Meishan (see cover, p. 5 and p.24 for more). My only regret is that Prof. Jin Yugan was unable to attend. Professor Jin was the Chair of the working groups for both boundaries. Lao Jin's inspiration has been an important element of my career development and I sincerely hope that he feels better soon.

There have been no business meetings since the last issue of Permophiles, but a meeting is scheduled for June 20 in association with the second International Palaeontological Conference in

Beijing. A second meeting in 2006 is scheduled for September 22 in Siena, Italy in association with a European continental Permian meeting organized by Prof. Cassinis (see announcement in this issue). This meeting follows a very successful non-marine meeting in Albuquerque last October. It is great to see so much work being done on these successions as this is an important task for SPS following establishment of the marine GSSPs – that is to correlate marine rocks into continental successions. I hope that we can see more reports in future issues of ***Permophiles*** from those groups working on continental successions. These workers as well as all those working on marine rocks of Carboniferous and Permian age should be seriously considering their attendance at the XVI International Congress on the Carboniferous and Permian (**ICCP**) to be held June 21-24, 2007 in Nanjing China (see announcement in this issue).

This issue honours a few individuals that have made significant contributions to Permian geology and paleontology during their careers. The geological community and especially the Permian community is saddened by their deaths. I want to thank John Talent for his excellent words on Neil Archbold. I only met Neil Archbold once, but after reading John's obituary I regret this and wished I had known Neil better. It is an inspirational story. Bruce Waterhouse was inspired to also write about Neil and included in his obituary accounts of the lives of Norman Newell and Mac Dickens. Mac was honoured in Permophiles 46. I have talked briefly in the past with Norman Newell at a number of major geological meetings and knew him to be a fine gentleman and avid reader and supporter of Permophiles. We can learn a lot from the lives of these individuals and I thank Bruce for sharing his experiences with these fine geological gentlemen. These accounts remind us of the short time we have to make our contributions and point to a passing of the torch so to speak, but they also remind of the importance of renewal. Those of us working in geology and paleontology must continue to encourage today's youth to take up the challenge of the profession. Judging from the lives of Archbold, Dickens, and Newell as told to us by Talent and Waterhouse, there is excitement, travel and discovery ahead for those that do.

Finally, I submitted the SPS annual report to ICS in December and this report is appended below. This report can also be downloaded from our website (http://www.nigpas.ca.cn/permian/web/index.asp) and from the ICS website (http://www.stratigraphy.org/). I wish to encourage Permophiles readers and those interested in stratigraphy to take a look at these websites as they contain considerable valuable information.

International Commission on Stratigraphy Subcommission on Permian Stratigraphy

ANNUAL REPORT 2005

1. TITLE OF CONSTITUENT BODY

International Subcommission on Permian Stratigraphy (SPS)

Submitted by:

Charles M. Henderson, Chairman SPS
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Website: www.geo.ucalgary.ca/asrg

2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

The Subcommission's primary objective is to define the series and stages of the Permian, by means of internationally agreed GSSPs, and to provide the international forum for scientific discussion and interchange on all aspects of the Permian, but specifically on refined regional correlations.

Fit within IUGS Science Policy: The objectives of the Subcommission involve two main aspects of IUGS policy:

1. The development of an internationally agreed chronostratigraphic scale with units defined by GSSPs where appropriate and related to a hierarchy of units to maximize relative time resolution within the Permian System; *and*
2. Establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth during the Permian Period.

3. ORGANIZATION

The Subcommission has an Executive consisting of a Chairman, a Vice-Chairman, and a

Secretary; all three are Voting Members of the Subcommission. These three executive positions are new as of the IGC meeting in Florence in August 2004. There are sixteen total Voting Members representing most regions of the world where Permian rocks are exposed. The objectives of the Subcommission are pursued by both stratigraphic and thematic Working Groups that are disbanded upon completion of their directed task. For example, the Working Groups on the Carboniferous-Permian Boundary, on the Guadalupian stages (Middle Permian), on the base-Lopingian boundary (base-Wuchiapingian Stage), and on base-Changhsingian have been disbanded on the successful establishment of their defining GSSP's and ratification by IUGS. The current working groups include:

1. Cisuralian stages
2. Continental Permian
3. Transitional biotas as gateways for global correlation
4. Neotethys, Palaeotethys, and S. China intraplatform basin correlation

The Subcommission also supports a special project titled "*The Permian: from glaciation to global warming and mass extinction*".

Officers for 2004-2008:

Chair: Professor Charles M. Henderson, University of Calgary
Vice-Chair: Dr. Vladimir Davydov, Boise State University
Secretary: Dr. Shuzhong Shen, Nanjing Institute of Geology and Palaeontology

Website: *http://www.nigpas.ac.cn/permian/web/index.asp*. This site includes all back issues of *Permophiles* in downloadable PDF format (#1 in 1978 to #46 Dec. 2005). Links to *Permophiles*/Permian research have also been established at http://pri.boisestate.edu/ and http://www.geo.ucalgary.ca/asrg.

4. INTERFACES WITH OTHER INTERNATIONAL PROJECTS

SPS interacts with many international projects on formal and informal levels. SPS is taking an active role on the development of integrated chronostratigraphic databases by participating with CHRONOS and PALEOSTRAT, which are NSF funded initiatives. Bruce Wardlaw and Vladimir Davydov are concentrating on the

Permian-Triassic Time Slice Project and the development of improved taxonomic dictionaries, database sharing and manipulation with PALEOSTRAT. SPS is also involved in core study from a drilling project of the Permian-Triassic boundary at Meishan, China; this project is an international collaboration investigating the signature and causes of the P-T extinction.

SPS co-sponsored meetings on *Triassic Chronostratigraphy and Biotic Recovery* in Chaohu, China in May 2005 and on the *Nonmarine Permian* in Albuquerque, New Mexico in October 2005 and will meet at the *2nd International Palaeontology Congress* in Beijing, China in June 2006.

5. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2005

GSSP's: The proposal for the base-Changhsingian was voted and ratified by ICS/IUGS in 2005.

Publications: The June 2005 issue of *Permophiles* (#45) was produced at Nanjing China during June 2005 and distributed to a mailing list of 280. The December 2005 issue of *Permophiles* (#46) was produced at the University of Calgary during November 2005 and distributed as a pdf on our website. In addition the remaining back issues of *Permophiles* were scanned and added to our website providing a complete series of communications by Permophiles since 1978.

Meetings: The SPS conducted two business meetings in 2005 including at the Triassic Chronostratigraphy and Biotic Recovery meeting in Chaohu, China on May 23, 2005 with 27 in attendance and at the Non-marine Permian Conference at Albuquerque New Mexico on Oct. 23, 2005 with 28 in attendance. This latter conference was organized by Spencer Lucas and was very successful with 68 people in attendance from 12 countries.

Membership: Significant changes were made to our voting membership in 2004, but only one change in voting membership occurred in 2005. Professor Giuseppe Cassinis of Italy retired as a voting member and Dr. Marc Durand of Universite de Nancy, France was voted by the executive as a replacement. The SPS executive created a new membership category in 2004, Honourary Members, to reflect the significant past and continuing contributions of some retiring voting members. Professor Cassinis was added to that list in 2005. Honourary Members will receive GSSP proposals and be invited to comment on the merits of the proposal, but they will not vote on the proposal. The revisions suggested by Honourary Members will be included in subsequent versions of the proposal.

6. CHIEF PROBLEMS ENCOUNTERED IN 2005

There were no major problems in 2005.

7. SUMMARY OF EXPENDITURES IN 2005 (ANTICIPATED THROUGH MARCH 2006):

INCOME
Donations: $ 600
University of Calgary support (1): $4,500
NIGPAS (2): $1,000
ICS (3): $ 900
TOTAL: $7,000 *(quoted in US$ using 0.84 as the conversion from Canadian$)*

(1) University of Calgary support from NSERC grant to Charles Henderson.
(2) NIGPAS (Nanjing Institute of Geology and Palaeontology) support from NSF-C grant to Shuzhong Shen.
(3) University account includes revenue from ICS and donations minus printing and postage. Current balance is a deficit of $245.49 CAN ($207US).

EXPENDITURES:
Printing and Mailing of *Permophiles* (1): $1,707.00
Travel support for *Permophiles* Production (2): $1,000.00
Support for travel for SPS sponsored international meetings and fieldwork (3): $4,500.00
TOTAL: $7,207.00 (quoted in US$ using .84 as the conversion from Canadian$)
BALANCE: -$207.00

(1) paid by donations and ICS support
(2) Shen to Calgary
(3) Henderson to Chaohu and Nanjing China and Albuquerque NM

8. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2006):

1. Cisuralian Working Group Workshop to be conducted in July 24-August 4, 2006.
2. Analysis of samples collected by working group in #1.
3. Preparation of proposal by Cisuralian Working Group on base-Sakmarian GSSP.
4. Production of *Permophiles* #47 in Nanjing during June 2006.
5. Business meeting to be held during IPC in Beijing June 2006.
6. Production of *Permophiles* #48 in Calgary during November 2006.

9. BUDGET AND ICS COMPONENT FOR 2006

Cisuralian Working Group Field Excursion (1) $34,000
Annual Business Meeting, Beijing, IPC (2) $ 2,500
Permophiles and GSSP printing and postage $ 1,900
Permophiles travel (3) $ 1,000

TOTAL 2006 BUDGET $40,000
Support from University of Calgary (Henderson; NSERC) $ 5,000
Support from NIGPAS (Shen; NSF-C) $ 3,000
Fieldtrip Participants to form Cisuralian Working Group $30,000
Anticipated donations for *Permophiles* $ 600

TOTAL BUDGET REQUEST (ICS) $ 1,400
(1) Based on $800.00/participant internal costs in Russia for 20 participants (includes Russians) and average airfare of $1,200 times 15 international participants.
(2) Cost of travel to IPC meeting for Executive
(3) Cost of Shen travel to Calgary in November

10. REVIEW CHIEF ACCOMPLISHMENTS OVER PAST 5 YEARS (2001-2005)

The SPS has approved the general divisions of the Permian and has now had 6 GSSP's ratified by ICS and IUGS (Asselian, Roadian, Wordian, Capitanian, Wuchiapingian, Changhsingian). Support for documentation (fieldwork and publications) of the various chronostratigraphic methods for the establishment of the GSSP's has been the most outstanding and differentiating character of this Subcommission. *Permophiles* has become an internationally respected newsletter and bears an ISSN designation (1684-5927) and is deposited in the National Library of Canada; nine issues were published during the five-year period. *See Accomplishments in 2005 (above) for additional details.*

11. OBJECTIVES AND WORK PLAN FOR NEXT 4 YEARS (2005-2008)

The primary objective is to complete the GSSP process by 2008. We currently anticipate that the last three GSSP's (Sakmarian, Artinskian, and Kungurian) should be ratified by 2007. In order to achieve this, the SPS executive is preparing an International Workshop for July 24-August 4, 2006 at the probable Cisuralian GSSP sites along the west flank of the Urals. This field workshop will be limited to twenty researchers and they will be charged with completing analysis of new samples and producing first drafts of GSSP proposals by early to mid-2007. New samples will document geochemical signatures and augment extensive geochronologic work, and conodont samples will highlight the accessibility of the sections and reproducibility of the chosen potential points. The trip will end at Aidaralash, Kazakhstan to celebrate the production of a permanent display for the base-Permian GSSP. We anticipate the following schedule:

1. A vote by SPS on the **Sakmarian** proposal may be conducted during early 2007.
2. A vote by SPS on the **Artinskian** is anticipated during late 2007.
3. A vote by SPS on the **Kungurian** is anticipated during late 2007.

Once this process is completed SPS will shift focus toward three directions:

1. Correlations into **Continental deposits**,
2. Correlations **across provincial boundaries** and within the Tethys region,
3. Detailed documentation of the **geologic evolution** of the Earth during the Permian with respect to the established chronostratigraphic framework.

List of Working Groups and their officers

1. Cisuralian stages; Chairman is **Boris Chuvashov**
2. base-Changhsingian Stage; Chairman is **Yugan Jin**
3. Continental Permian Correlations; Chairman is **Joerg Schneider**
4. Transitional biotas as gateways for global correlation; Chairman is **Guang Shi**
5. Neotethys, Palaeotethys, and S. China intraplatform basin correlation; Co-Chairmen are **Vladimir Davydov** and **Heinz Kozur**.

COMMUNICATION

On the following page, the Permian time scale is repeated in this issue from *Permophiles* #46 for the information of SPS members. I have noticed that many workers seem to prefer their local scales in publications; this practice is acceptable if these scales are calibrated with the International Scale.

Recent references to the development and correlation of the time scale were provided by Manfred Menning and copied below:

Käding, K.-C., 2005. Der Zechstein in der Stratigraphischen Tabelle von Deutschland 2002. - Newsl. Stratigr., 41, 1/3: p. 123-127.

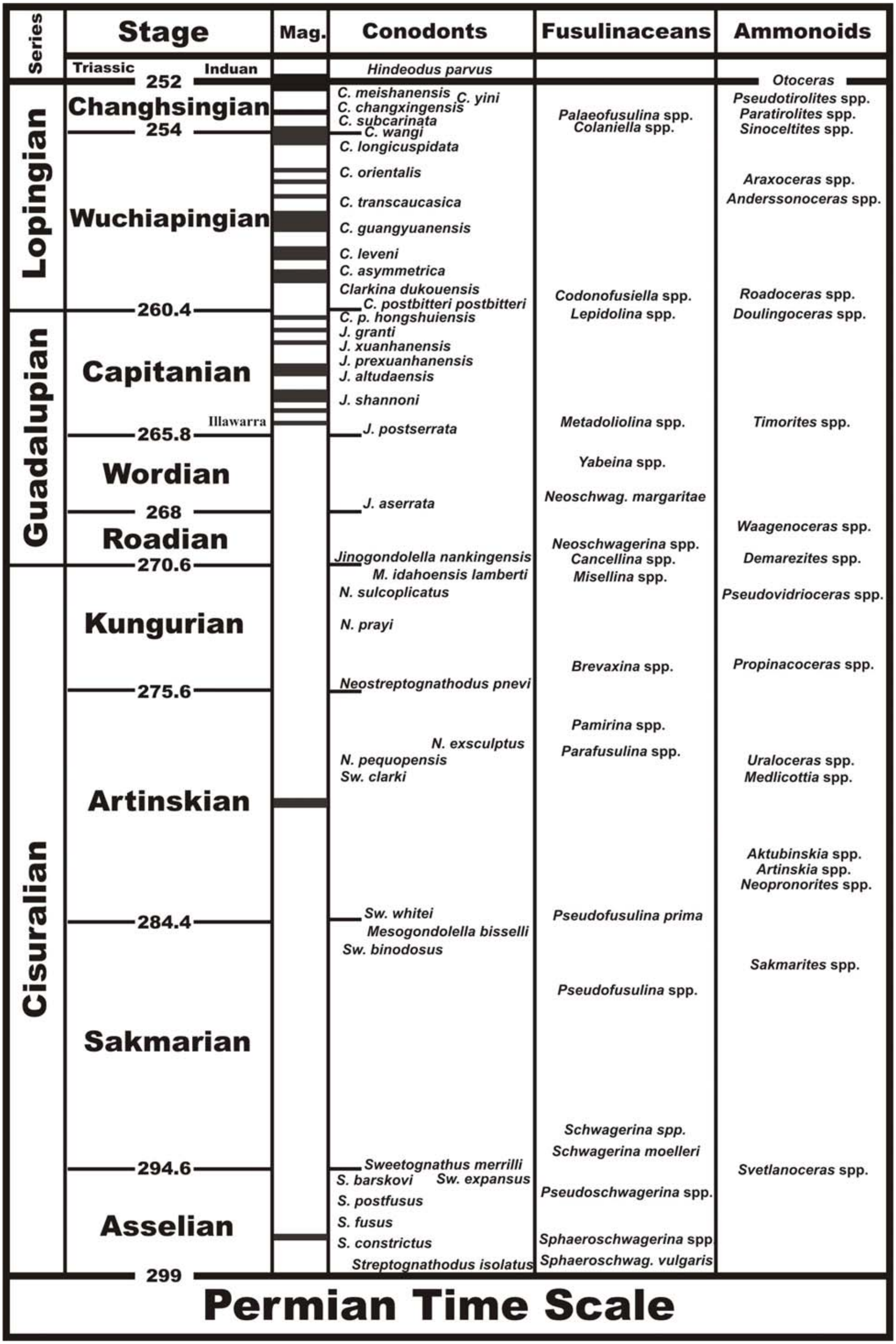
Lutz, M., Etzold, A., Käding, K.-Ch., Lepper, J., Hagdorn, H., Nitsch, E. and Menning, M., 2005. Lithofazies und Leitflächen: Grundlagen einer dualen lithostratigraphischen Gliederung. - Newsl. Stratigr., 41, 1/3: p. 211-223.

Menning, M., Alekseev, A.S., Chuvashov, B.I., Davydov, V.I., Devuyst, F.-X. Forke, H.-C., Grunt, T.A., Hance, L., Heckel, P.H., Izokh, N.G., Jin, Y.-G., Jones, P.J., Kotlyar, G.V., Kozur, H.W., Nemyrovska, T.I, Schneider, J.W., Wang, X.-D., Weddige, K., Weyer, D., Work, D.M., 2006 (ca. August). Global time scale and regional stratigraphic reference scales of Central and West Europe, East Europe, Tethys, South China, and North America as used in the Devonian-Carboniferous-Permian Correlation Chart 2003 (DCP 2003). - Palaeogeogr. Palaeoclimat. Palaeoecol.; Amsterdam, 56 pp.

Menning, M., Benek, R., Boy, J., Ehling, B.-C., Fischer, F., Gast, R., Kowalczyk, G., Lützner, H., Reichel, W. and Schneider, J.W., 2005. Das Rotliegend in der Stratigraphischen Tabelle von Deutschland 2002 - Paternoster-Stratigraphie auf dem Rückzug. -Newsl. Stratigr., 41, 1/3: p. 91-122.

Menning, M., Gast, R., Hagdorn, H., Käding, K.-Ch., Simon, T., Szurlies, M. and Nitsch, E., 2005. Zeitskala für Perm und Trias in der Stratigraphischen Tabelle von Deutschland 2002, zyklostratigraphische Kalibrierung von höherer Dyas und Germanischer Trias und das Alter der Stufen Roadium bis Rhaetium 2005. - Newsl. Stratigr., 41,1/3: p. 173-210.

Menning, M., Weyer, D., Wendt, I. and Drozdzewski, G., 2005. Eine numerische Zeitskala für das Pennsylvanium in Mitteleuropa. - In: Deutsche Stratigraphische Kommission (Koordination: V. Wrede): Stratigraphie von Deutschland V - Das Oberkarbon (Pennsylvanium) in Deutschland. - Cour. Forsch.-Inst. Senckenberg, 254: p. 181-198.



International Permian Time Scale

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REPORTS

Beware of your FO and be aware of the FAD

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Someone reading this title and understanding the subtleties of the English language might think that I was talking about Heinz Kozur, but actually Heinz and I do communicate on a regular basis. In the fashion world fads come and go with time, but in the geological world, GSSP (Global Stratotype Section and Point) FADS are generally unchanging.

One of the tasks that many of us perform on a regular basis is to review manuscripts for publication. In some recent manuscripts that I have reviewed there seemed to be a lack of appreciation for the correlation of GSSP definitions and in the interest of communication and generating comment I provide this brief note.

Quoting from the abridged version of the Stratigraphic Code on the ICS website (1) “Chronostratigraphic units are bodies of rocks, layered or unlayered, that were formed during a specified interval of geologic time. The stage has been called the basic working unit of chronostratigraphy…and it is defined by its boundary stratotype, sections that contain a designated point in a stratigraphic sequence of essentially continuous deposition, preferably marine, chosen for its correlation potential. The boundaries of chronostratigraphic units are synchronous horizons by definition. In practice, the boundaries are synchronous only so far as the resolving power of existing methods of time correlation can prove them to be so.”

For example, the GSSP for the base of the Triassic (the PTB or Permian-Triassic Boundary or actually the base of the Induan Stage) is defined by the FAD (First Appearance Datum) of *Hindeodus parvus* at the base of bed 27c at Meishan Section D in south China. *This is the only location where this definition is directly applicable.* In many Paleozoic GSSPs the evolutionary event of a conodont species has been chosen to define the stage boundary because the widespread nature of these species indicates high correlation potential. If chosen carefully, the FAD of a species at the GSSP should be the earliest occurrence of that species anywhere in the world and thus represent the true evolutionary appearance. This is impossible to prove, but by using various other means of chrono-correlation a reasonable level of confidence can be achieved. The first occurrence of this species at any other section is theoretically either correlative or younger than that at the GSSP. To recognize the lowermost Triassic elsewhere we must correlate that point by using all physical means possible. As a result, the local FO (First Occurrence) of *Hindeodus parvus* in any other section, whether it is in Shangsi China (Nicol et al., 2002) or Opal Creek in Western Canada (Henderson, 1997) does not necessarily define the base of the Triassic in that section. It merely indicates that you are within the range or biozone of *Hindeodus parvus* and thus within the Lower Triassic; the FO may indeed coincide with the FAD at Meishan, but it does not follow that it must. To correlate the PTB as defined at Meishan is to be aware of the FAD as well as involving the use of all physical means of correlation including other fossils (brachiopods, ammonoids, or other species of conodonts, for example, *H. eurypyge*, *H. changxingensis*, and *Clarkina taylorae* may be useful), major extinction events (like that occurring at the top of bed 24e at Meishan just below the FAD of *H. parvus*), marker beds like ashes (beds 25 and 28 at Meishan have yielded geochronologic ages of about 252 million years), geochemical means (carbon isotopes; for example at Meishan, a major negative shift in carbon isotopic values occurs just below the FAD of *H. parvus* in bed 26), sequence stratigraphy (a Sequence Boundary is defined at the top of bed 24d at Meishan), magnetostratigraphy (the PTB occurs within a normal polarity zone), and any other available technique. Many of these occurrences or values can be cross-calibrated using graphic correlation techniques including Pete Sadler's CONOP program. By employing such techniques it becomes apparent that the FO of *Hindeodus parvus* at Shangsi (Nicol et al., 2002) does not correlate with the PTB, but rather occurs about 4.5 metres above the PTB. Beware of that FO; its higher occurrence may result from any number of reasons (biostratigraphic pitfalls) including biofacies restriction.

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Nicoll, Robert S., Metcalfe, I., and Wang Cheng-Yuan, 2002. New species of the conodont genus Hindeodus and the conodont biostratigraphy of the Permian-Triassic Boundary interval. Journal of Asian Earth Sciences: 20, p. 609-631.

The following section contains selected abstracts presented at the Second International Palaeontological Congress held June 17-21, 2006 at Beijing, China. These abstracts are published in an abstract volume of IPC 2006 and are repeated here for the convenience of the SPS members. All the references and figures in the abstracts have been deleted to save space for this issue.

Lower Permian brachiopods and palynomorphs of the Alborz Mountains (North Iran) and their palaeobiogeographic affinity

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North Iran has always been considered of Gondwanan affinity for several reasons: its pre-Palaeozoic basement is thought to be related to the Baikalian orogenetic cycle, its Cambrian sedimentary rocks are similar to those occurring south of the Zagros suture. Similarly the region lacks Variscan deformation and is located south of the supposed position of the Palaeotethys suture. Paleontological evidence has also been used to suggest Gondwanan affinity because north and central Iranian Devonian stromatoporoids, rugose corals and brachiopods were considered to be similar to those of Armenia, Afghanistan and Karakorum. But in fact the Devonian fauna has a cosmopolitan character and shares affinities with northern regions also (Western Europe and Russian platform).

This study of the Lower Permian Dorud Formation of the Alborz Mountains (north Iran) illustrates how fossil groups can be used to infer the palaeobiogeographic affinities of continental blocks. Brachiopods of the Durud Formation comprise a Derbyiidae gen. et sp. ind., *Neochonetes* (*N.*) sp. ind., *Costispinifera* sp. ind., *R. uralica*, *Calliprotonia* sp. ind., *J. dorudensis*, *L. dorotheevi*, *Cancrinella cancriniformis*, Linoproductidae gen. et sp. ind., *A.* aff. *juresanensis* and *Larispirifer* sp. They show strong affinities with the Asselian-lower Sakmarian faunas of the Urals and of the Russian Platform to the north, and to a lesser extent to the Trogkofel Limestone (Carnic Alps) in the west. The palynomorph assemblage, which is dominated by monosaccate pollen, with very few spores, is most unlike those recorded from the Asselian- Sakmarian *Granulatisporites confluens* Biozone which is ubiquitous in the Gondwana region.

The assemblages of Asselian-early Sakmarian brachiopods and palynomorphs from Dorud are have a south boreal or north palaeoequatorial affinity, consistent with the southern provinces of the Boreal Realm and of the W Tethys province, and are dramatically different from coeval faunas and microflora of the Gondwanan peripheral regions from Western Australia, India, Karakorum, Central Afghanistan and Oman. It is difficult to explain the boreal affinity of the Dorud brachiopods and palynomorphs if north Iran is considered part of the Peri-Gondwanan fringe during the Asselian-early Sakmarian. A more northerly position for this block at this time is thus more likely.

Abnormalities of organic carbon isotope in non-marine Permian-Triassic boundary sequences of Dalongkou and Taoshuyuan, Xinjiang, China

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To investigate the organic carbon isotope excursions in the non-marine Permian-Triassic boundary sequences and correlate this with that in the marine sequences, 126 samples were determined for the carbon ratios $\delta^{13}C_{org}$) of kerogen samples spanning 102 metres from the Guodikeng Formation to the Lower Triassic Jiucaiyuan Formation in the southern limb of Dalongkou Anticline (SDA) and Taoshuyuan sections of Xinjiang, China. Associated fossil assemblages suggested the P-T boundary is in the middle part of Guodikeng formation (proposed P-T boundary at A, B or C in figure below), and provided significantly biostratigraphic overlaps during the Permian-Triassic transition.

Two negative $\delta^{13}C_{org}$ spikes were detected in the middle part of Guodikeng Formation. The later Permian $\delta^{13}C_{org}$ values oscillate between -26‰ and -21‰ in the lower part of Guodikeng Formation. First negative $\delta^{13}C_{org}$ spike occurred rapidly with minimum values less than -29‰ at the base of bed 55. Followed temporary recovery with values up to -24‰, the $\delta^{13}C_{org}$ values drop rapidly to around -30‰ and coincide with the occurrence of Lower Triassic fossil of vertebrate *Lystrosaurus* at the base of bed 64. In the uppermost interval of Guodikeng Formation, it recovers to averaging value of -24‰, and then oscillates largely with maximum excursions up to 14‰ in the Lower Triassic Jiucaiyuan Formation. Similar $\delta^{13}C_{org}$ excursion pattern occurred also apparently within 116 samples in the Guodikeng Formation of Taoshuyuan section, and could be identified in that of marine P-T boundary sequence of Meishan, southern China. The negative abnormality zones near the P-T boundary both in marine and terrestrial sequences characterised significantly by the underlying stability stage in Later Permian and the overlying larger oscillation stage in the Lower Triassic stratigraphic intervals. Therefore, the first negative $\delta^{13}C_{org}$ in non-marine sequences could be correlated to that occurred from bed 23 to bed 24d in the marine section of Meishan. In turn, the second negative spike might be corresponded to that occurred in the "Black shale" of bed 26 in Meishan, and may suggested as a marker for the non-marine P-T boundary definition.

Recently most studies suggested a complex feedback mechanism on the global ecosystem collapse rather than a single and sudden catastrophic event such as the rapid outpouring of Siberian flood basalts and meteorite impact during the end-Permian extinction. Multiple negative δ13C spikes both in marine and terrestrial P-T sequences recorded in the uppermost Permian or in the lowermost Triassic stratigraphic intervals. Moreover, relatively rapid $\delta^{13}C$ excursions are often superimposed on a gradual Upper Permian decline. Sustained environmental degradation associated with the atmospheric hypoxia plus climate warming has been proposed recently for the end-Permian catastrophic event. Both in marine and terrestrial P-T sequences, the first occurrences of negative $\delta^{13}C$ excursions should reflect environmental stress which might be the result of a later Permian sea-level drop. However, because the occurrence of a temporary recovery in $\delta^{13}C$ with values similar with that in the Late Permian period, the occurrence of second negative spike could not be discarded the effect on the global carbon cycle from some sudden and sharp events such as the meteorite impact.

The rise of the modern evolutionary fauna: decoupled taxonomic and ecological response during the end-Guadalupian extinction

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The replacement of Palaeozoic rhynchonelliform brachiopod-dominated marine benthic communities by post-Palaeozoic assemblages dominated by the molluscan Modern evolutionary fauna was one of the most significant ecological transitions in the Phanerozoic, completely restructuring the ecosystem and paving the way for modern marine communities. The timing of the abrupt diversity switch has been tightly constrained, occurring during the catastrophic mass extinction at the Permian-Triassic boundary. In contrast, the shift in ecological dominance, as measured by relative abundance in marine communities, has only been assumed to be synchronous with the taxonomic change. However, this assumption ignores potential effects of the earlier end-Guadalupian extinction, at the end of the Middle Permian. In order to test whether the ecological transition was contemporaneous with the end-Permian taxonomic shift, we quantified Permian community change in fossil assemblages from offshore tropical carbonate environments collected from the western United States, Greece, and China. Early and Middle Permian fossil communities were overwhelmingly dominated by brachiopods, which comprised an average of 98.9% of an assemblage. Bivalves only accounted for 0.7% and were strongly dominated by epifaunal forms (>90% of the bivalve population). Although bivalves were rare, it appears that they were smaller than co-existing brachiopods. In contrast, Late Permian assemblages contained a mixture of brachiopods and molluscs: brachiopods only comprised 34.6%, with bivalves accounting for 17.9% and gastropods the most abundant group at 47.5%. Bivalve life habits were also more evenly distributed, with 52% epifaunal suspension feeders and 42% infaunal suspension feeders. In addition, bivalves were more comparable in size to co-existing brachiopods; their median size was approximately 80% that of brachiopods from the same sample. These results demonstrate that a substantial portion of the ecological transition from brachiopods to bivalves, in terms of relative abundance, ecological dominance of infaunal forms, and size distributions, had occurred prior to the end-Permian biotic crisis and was apparently synchronous with the end-Guadalupian extinction. However, a new compilation of Middle and Late Permian global diversity reveals that the end-Guadalupian crisis was only a minor event, with slightly elevated extinction intensity of 33.9% at the genus level, relative to 27.7% extinction in the preceding Wordian and 32.1% in the succeeding Wuchiapingian. Only 34.3% of rhynchonelliform brachiopod genera and 31% of bivalve genera were eliminated during the Capitanian stage. This low overall intensity and weak selectivity contrasts markedly with the end-Permian mass extinction (77.9% overall; 96.1% for brachiopods and 62.9% for bivalves) and implies extreme decoupling of taxonomic and ecological responses during the end-Guadalupian extinction. The cause of the decoupled behaviour is unknown, but may have been influenced by environmental changes during the Guadalupian-Lopingian transition or the end-Guadalupian extinction mechanism itself. It therefore appears that mass extinctions and catastrophic taxonomic change are not necessarily required to trigger major ecosystem restructuring such as the rise of the Modern evolutionary fauna.

Patterns of faunal change through the Permian: a section based study of brachiopod originations and extinctions from Sichuan, China

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The study of extinction and origination patterns in the Permian is of interest as the largest mass extinction in Earth's history occurred at the end of this period, with a second major mass extinction approximately 8 Ma earlier, at the Guadalupian-Lopingian boundary (Jin et al., 1994; Shen and Shi, 2002). This study examined brachiopod diversities and patterns of faunal change at the relatively complete Chuanmu section, Sichuan. This section extends from the Late Artinskian (Cisuralian) to the Triassic, allowing us to develop a clear picture of Permian brachiopod diversity in this area. A total of 131 brachiopod species from 70 genera and 33 families were identified from this section. The patterns of brachiopod diversity through the Permian at this section were analyzed using proportionate origination and extinction rates, which indicated five origination and two extinction events at this section. The origination events were: 1) the top of Liangshan Formation; 2) during the Chihsia Formation; 3) at the beginning of the Maokou Formation; 4) the end of the Longtan and beginning of the Changhsing Formations, and 5) the middle of the Changhsing Formation. The first extinction event, in the lower part of the Changhsing Formation, was relatively minor, while the second extinction event (at the end of the Permian) corresponds to the global end-Permian mass extinction, resulted in the disappearance of Permian-type brachiopods from this section. The end-Guadalupian mass extinction is not clearly recognized at the Chuanmu section due to a depositional hiatus during the late Maokouan and very early Lopingian at this section.

Permian fusulinids fauna of the Daguanshan Formation, Xiahe and Tongren County, western Qinling, China

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The Permian Daguanshan Formation outcrops in Xiahe County, Gansu Province and Tongren County, Qinhai Province. The Daguanshan Formation is composed of reef limestone. Based on a study of the fusulinid fauna, we assigned the Daguanshan reef limestone to the Middle to Late Permian. There are abundant reef-building organisms in the Daguanshan reef limestone, such as fibrous sponges, calcisponges, bryozoans, calcareous algae and colonial corals. The attached-reef organisms include the fusulinids, the non-fusulinid foraminifers, brachiopods, bivalves, gastropods, echinoderms and corals.

In this study 16 species belonging to 12 genera were recognized from the Daguanshan Formation. Three fusulinid zones – based on genera - can be identified in ascending order as follows: *Parafusulina* zone, *Neoschwagerina* zone, and *Codonofusiella* zone. (1)*Parafusulina* zone: This zone represents the lower parts of Maokouian Stage. The base of zone is undefined, and the top of the zone is defined by the LAD of the genus *Parafusulina*. Associated taxa include; *Parafusulina shaksgamensis*, *Pseudofusulina postkraffti*, *Parafusulina* cf. *gigantea*, *Pseudofusulina* sp., *Pseudofusulina fusiformis*, *Neoschwagerina* sp., *Scubertella* sp., *Schwagerina bicornis*, *Codonofusiella* sp., and *Schubertella* sp. This zone is present in many sections of the Maokouian in the Middle Permian of south China, including Fujian, Zhejiang, Jiangsu, Guizhou, and Hubei Provinces. (2) *Neoschwagerina* zone: This zone, of late Maokouian age, begins with the LAD of the genus *Parafusulina* and ends with the the LAD of the genus *Neoschwagerina*. Common species are *Neoschwagrina* sp., *Verbeekina* sp., *Kahlerina* sp., and *Toriyamaia* sp. The genera *Yabeina* and *Staffella* are absent from the study area, however they commonly occur in other areas of south China where the *Neoschwagerina* zone is present. This zone is widely distributed across south China. (3) *Codonofusiella* zone: The zone represents the Wuchiapingian Stage. The lower limit is defined by the LAD of *Neoschwagerina*, and the upper limit is not clear. Common elements are *Codonofusiella* sp., *Schwagerina* sp., *Pseudofusulina* sp., *Afghanella* sp., and *Sphaerulina* sp. The Zone is extensively developed in the Wuchiapingian strata in the provinces of Sichuan, Guizhou, Anhui, Hubei, and Guangdong across south China. The three fusulinid zones indicate that the age of Daguanshan Formation in the study area is Maokouian, Middle Permian, to Wuchiapingian, Late Permian in age.

Late palaeozoic biogeography and palaeogeography of central Asian terranes in NW China: an integration of faunal and tectonostratigraphic constraints

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New and previous fossil data from Central Asian terranes (Afghanistan, Uzbekistan, Karakorum-Kunlun Mts, Tarim Basin, Qaidam Basin, Tienshan Mts, Junggar Basin, Altaids, Kazakstan, and Mongolia) indicate a significant degree of latitudinal variation in biogeographic patterns during the Late Palaeozoic through the marginal seas along northern Gondwana, the Palaeo-Tethys Ocean and the seas along the southern margin of the Siberian continent. Semi-quantitative and quantitative analysis of the distribution patterns of brachiopods, corals and fusulinids across this region, together with critical analysis of their tectonostratigraphic settings combined with current palaeogeographical data, provide more accurate, more sophisticated models of the dynamics of the Late Palaeozoic–Central Asian marine systems. This study focuses on the Late Devonian to Permian intervals with primary emphasis on the terranes of NW China. These blocks were juxtaposed against major collisional orogenic belts; their depositional histories have been controlled by the assembly and displacement of these tectonic units. The biogeographic affinity and tectonostratigraphic information derived from the NW China blocks indicate significant amounts of palaeolatitudinal variation triggered by displacement of the terranes during the Late Palaeozoic. The palaeogeographic positions of the NW Chinese blocks relative to other tectonic blocks during the Late Palaeozoic are elucidated by using the evolving provincialism of marine faunas and non-marine floras. The Tarim Basin was a mobile plate in the Palaeo-Tethys. It belonged to the same biogeographic province as South China; they were located in close proximity to each other during the latest Devonian to Early Carboniferous. During the Late Carboniferous the faunas of the Tarim Block developed clear links with Europe and the Urals, but decreasingly with South China; this is consistent with westwards movement of the block. Throughout the Permian the Tarim Basin underwent continuous movement towards the Europe-Asian continent, but did not become united with the supercontinent until the end of the Permian. Other NW Chinese blocks such as central and northern Tienshan Mts, Junggar Basin, and Qaidam Basin were parts of/or accreted to the Kazakhstan palaeoplate during the Devonian–Carboniferous. The Chinese Altai region was part of the Siberian plate during Devonian–Carboniferous. Subsequently both the accreted Kazakhstan and Siberian plates docked with the Europe–Asian supercontinent during the Late Carboniferous to Permian.

Environmental and biotic changes across the Permian–Triassic boundary in western Tethys: the Bulla parastratotype, Italy

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The sedimentary and biotic evolution of a 190m interval of shallow marine and lagoonal facies in the Bellerophon and Werfen formations in the Southern Alps has allowed comparison of western with eastern Tethys: Meishan D section (southern China), Salt Range (Pakistan) and Abadeh (Iran). The results are as follows:

1) The upper part of the Bellerophon Fm. (Changhsingian *changxingensis-deflecta* Zone) shows only modest biotic variation connected with tectonically-driven local variation and perhaps to more general climatic variation. The $\delta^{13}C$ decrease starting in the uppermost 30m of the Bellerophon Fm. is correlated with decrease in global organic productivity starting about 1m below the PTB in Chinese sequences and 20m below in the Abadeh section. This interval culminated in a regression truncated by an unconformity–paraconformity (Unconformity 1).

2) The uppermost Bellerophon Fm. is a ca 1m transgressive-regressive sedimentary cycle, the informally named Bulla mbr (Changhsingian: Early *praeparvus* Zone). The maximum flooding interval of this unit possibly had a slight increase in biodiversity, mainly in foraminifers, algae and brachiopods. The high increase in biodiversity previously reported may, in part, reflect abundance of biota and organic matter reworked into transgressive and regressive intervals. We suggest partial correlation of the basal unconformity of the Bulla mbr (Unconformity 1) with the regressive uppermost Bed 24e of the Meishan D section marking the disappearance of foraminifers and algae in the eastern Tethys. We also suggest diachronous disappearance of benthic taxa in the Tethys, with the Southern Alps acting like a refugium.

3) The main extinction (first extinction phase, mainly regarding foraminifers) in the Southern Alps occurred in a thin ca 25cm interval including the uppermost regressive Bulla mbr, Unconformity 2, and possibly, the basal transgressive bed of the Tesero Mbr of the Werfen Fm. This interval is correlated in part with regressive Bed 26 of Meishan D section. The main decrease in abundance and biodiversity in the Southern Alps coincides with appearance of small oolites with crystalline outer cortex near the basal transgressive tract of the lower Tesero Mbr, a ca 220cm sedimentary cycle, which is followed by extension of microbialitic layers alternating with veritable biostromes with brachiopods and byssate bivalves as salient components among the algae. Vacated niches favoured evolution of conodonts. Hindeodid conodont biodiversity increased with species developing characteristics of Isarcicella. This interval has been referred to the Changhsingian Late *praeparvus* Zone and correlated with Bed 27a–b of Meishan D section. The PTB has been identified in the Bulla section at 1.30m from the base of the Werfen Fm.—with the first appearance of *Hindeodus parvus* defining the base of the *parvus* Zone—in a microbialitic layer correlated with Bed 27c of Meishan D section. Around the PTB the major part of the remaining Permian biota disappeared. Gymnocodiacean algae were the last group to undergo extinction within the Triassic layers.

4) Biodiversity dropped severely in the succeeding bioturbated microbialitic interval from which conodonts are absent. More humid climate is reflected in a more sandy marine substrate inhabited by *Lingula*, *Unionites* and *Claraia*. Conodonts recurred in the schizohaline upper part. The succeeding entry of the biozonal markers Isarcicella lobata, I. staeschei and I. isarcica allow discrimination of three conodont biozones. The layer with entry of I. staeschei has been aligned with Bed 28 of Meishan D section. The main extinction phase in the western Tethys seems to correspond to a gradual but swift transition from acid-bath to alkaline-bath. The Bulla section with abundant data on biotic and depositional variation is here considered as the PTB parastratotype for the shallow marine western Tethys.

Cyclic morphology and population approaches toward high-resolution biostratigraphy of Late Permian and earliest Triassic gondolellid taxa

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Late Permian and Early Triassic gondolellid taxa are largely discriminated by changes in the configuration of carinal denticles. The presence of discrete denticles typical of only juvenile *Jinogondolella granti*, in adults of the descendant *Clarkina postbitteri* suggests a paedomorphic evolutionary process. This evolutionary event is associated with a major sequence boundary and extinction (Middle-Upper Permian boundary) and involved the evolution of a new gondolellid genus, *Clarkina*, defined by the lack of serration, high anterior blade-like denticles, and major change in platform outline. The discrete denticulation may be related to a deepening event during the Early Wuchiapingian. Depositional shallowing is subsequently associated with younger

Wuchiapingian taxa that typically show increasingly closely spaced denticles, culminating in the wall-like carina of *C. wangi* at the Wuchiapingian-Changhsingian boundary. While it is true that the smallest juveniles of *Clarkina* species appear to be very similar, some hint of the evolutionary process is revealed by comparing juveniles of *C. longicuspidata* and *C. wangi*. Juvenile *C. longicuspidata* have relatively discrete denticles compared to the increasingly fused denticles of intermediate and larger mature forms. In contrast, denticles of juvenile *C. wangi* are already partially fused, and in adults closing the anterior gap adjacent to the cusp, forming the high wall-like carina, completes this fusion. This implies a heterochronic process involving acceleration of development or peramorphosis. This small-scale evolutionary event within an anagenetic series of *Clarkina* species is associated with a series of relatively minor flooding surfaces. Younger Changhsingian taxa show a breakup of the wall-like carinal development, but they remain typically characterized by closely spaced denticles that decrease in height posteriorly. Discrete carinal denticles within *Clarkina* species are however again associated with the major flooding and extinction event near the Permian-Triassic boundary. Detailed geochronologic work for Upper Permian and lowermost Triassic rocks in South China may allow some quantification of these evolutionary rates. The high anterior (or ventral) blade in *Clarkina* may have served a similar function to the long anterior blade of other ozarkodinid conodonts like *Streptognathodus* that constrains element motion to the transverse plane and apparently maximised food-processing efficiency. This may provide a palaeobiologic basis for relating the morphologic variation used in Upper Permian and Lower Triassic biostratigraphy. The importance of the carinal shape in these taxa may be related to the parallel evolution or extinction of taxa representing potential food sources or to the availability of food sources along some environmental gradient. The cyclic nature of the carinal morphology and the ontogenetic changes that occur within species indicates that a sample population approach is needed. The sample population approach typically views the entire collection within a given sample collected over a thin interval in the rock record as a population and recognizes the most consistent and stable characters within that sample population for identification. Rare morphotypes within sample-populations that resemble related taxa are not recognized as separate taxa unless a distinct growth series can be demonstrated. This approach will allow the discrimination of the closely similar taxa necessary to define a precise high-resolution biostratigraphic zonation.

Middle Permian fusulinids from the Xainza area of the Lhasa block, Tibet

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Fusulinids hitherto reported from the Xiala Formation in the Xainza area of the Lhasa Block consist of 69 (15 genera). Of these, 26 species (4 genera) are identified from the authors' collections and the remainder from previous studies (Chu, 1982; Wang *et al*., 1986). The presence of *Neoschwagerina* sp., *Verbeekina verbeei* and absence of *Yabeina* indicate a probable Maokouan age, approximately late Roadian to Wordian (Jin, 2002). Our fauna differs markedly from contemporaneous fusulinid faunas from Cathaysian South China, especially in regards to dominant taxa. At generic level, the Maokouan fusulinids from South China are characterised by a flourishing of Neoschwagerinidae and Verbeekinidae—26% and 37% of the total genera respectively—but in the Xiala Formation, Neoschwagerinidae is relatively impoverished, restricted to only one genus: *Neoschwagerina*. Moreover, the Xiala Formation fusulinids lack 60% of the genera occurring commonly in coeval fusulinid faunas from South China (*e.g. Praesumatrina*, *Sumatrina*, *Metadoliolin*, and *Yangchienia*.). At species-level, Neoschwagerinidae, Verbeekinidae and Schwagerinidae were most diverse in South China during the Maokouan with a dominance of *Neoschwagerina*, *Parafusulina*, *Schwagerina* (each with 16 species) and *Verbeekina* (with 9 species). In the Xainza area, however, species of Neoschwagerinidae and Verbeekinidae account merely for 1% and 3% of the total species respectively, and the Schwagerinidae have the highest species diversity (54%) in the Xiala Formation. The dominant genera are *Chusenella* (25 species) and *Nankinella* (17 species) with only one species in each of *Neoschwagerina*, *Parafusulina* and *Verbeekina*. The fusulinids from the Xiala Formation of the Xainza area, with 32% endemics, are thus regionally distinctive.

Late middle Permian Kamura event and the Guadalupian-Lopingian boundary mass extinction: a high productivity-cooling event in mid-panthalassa

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A secular change in stable carbon isotope ratio of carbonate carbon (ä^{13}Ccarb) was analyzed in the Middle to Upper Permian shallow marine carbonates in Kamura, Japan, in order to document the oceanographic change in the superocean Panthalassa with respect to the mass extinction across the Guadalupian-Lopingian boundary (G-LB). The Permian carbonates were derived from a palaeo-atoll complex developed on an ancient seamount in mid-Panthalassa. The Capitanian (Upper Guadalupian) Iwato Formation (19 m-thick dark grey limestone) and the conformably overlying Wuchiapingian (Lower Lopingian) Mitai Formation (17 m-thick light grey dolomitic limestone) are composed of bioclastic limestone of subtidal facies, yielding abundant fusulines. The Iwato Formation is characterized mostly by unusually high positive δ^{13}Ccarb values of +4.9 to +6.2‰, whereas the Mitai Formation is characterized by low positive values from +1.9 to +3.5‰. The negative excursion occurred in three steps around the G-LB and the total amount of the negative shifts reached over 4‰. A remarkably sharp drop in δ^{13}Ccarb values, for 2.4‰ from 5.3 down to 2.9‰, occurs in a 2 m-thick interval of the topmost Iwato Formation, after which all the large-shelled fusulines and bivalves disappeared abruptly. Such a prominent high positive δ^{13}Ccarb plateau interval in the end-Guadalupian followed by a large negative shift across the G-LB was detected for the first time, and this trend in the mid-superoceanic sequence is correlated chemostratigraphically in part with the GSSP (Global Stratotype Section and Point) candidate for the G-LB in South China. The present results prove that the end-Guadalupian event occurred doubtlessly on a global scale, affecting the circum-Pangean basins, Tethys and Panthalassa oceans. The end-Guadalupian interval of a high positive plateau inδ^{13}Ccarb values over +5‰ is particularly noteworthy because it recorded an unusually high bio-productivity period that has not been known in the Permian. This end-Guadalupian high productivity event, newly named the Kamura event, suggests burial of a huge amount of organic carbon, draw-down of atmospheric CO_2 and resultant global cooling at the end of Guadalupian, considerably after the Gondwana glaciation. The low temperatures during the Kamura event may have caused the end-Guadalupian extinction of large-shelled Tethyan fusulines and bivalves adapted to warm climate. On the other hand, the following event of ca. 4‰ negative shift in δ^{13}Ccarb values across the G-LB indicates a global warming in the early Lopingian. This may have allowed radiation of the new Wuchiapingian fauna, and this trend appears to have continued into the Mesozoic. These observations are in good agreement with the global sea-level curve in the Middle-Late Permian. The smooth and gradual pattern of the negative shift suggests that the causal mechanism was not of a catastrophic nature (*e.g.* bolide impact, sudden melting of methane hydrate) but was long and continuous.

Records of marine reptiles from the Panxian and Guanling faunas, Guizhou Province, southwestern China: markers of the Triassic biotic recovery after the end-Permian mass extinction

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After the end-Permian extinction, the biosphere started to recover slowly during the Early Triassic while the environment was unstable. During the late Early Triassic, the earliest records of the marine reptiles (*e.g.* ichthyosaur and sauropterygian) appeared in south China, Japan, Spitsbergen, and British Columbia, Canada, but they were rare and fragmentary. The marine ecosystem began to stabilise and the organisms radiated rapidly in the Middle Triassic, during which time the Panxian fauna occurred in the ancient Guizhou sea. The Panxian fauna was discovered in the Upper Member of the Guanling Formation (conodont *Nicoraella kockeli* Zone, Pelsonian of Middle Anisian), Xinmin, Panxian County, Guizhou Province, southwestern China. Marine reptiles of the Panxian Fauna known so far include: three ichthyosaurs (a new species of *Mixosaurus*, *Phalarodon* cf. *P. fraasi*, and a new taxon of basal ichthyopterygian); one protorosaur (*Dinocephalosaurus orientalis* Li, 2003); two nothosaurid sauropterygians (a new species of *Nothosaurus*, and a new species of *Lariosaurus*); and possible placodont and pachypleurosaurid sauropterygians. The new species of *Nothosaurus* is the second representative of this genus from southwestern China and outside the western Tethyan faunal province; the new species of *Lariosaurus* is the oldest definite record of this genus known so far. The nothosaurids from the Panxian fauna further strengthen the palaeobiogeographic affinities between Middle Triassic marine reptiles from South China and the western Tethyan, and are of important significance to study the early history of this family. In the early Late Triassic, the global diversity reached its highest of the Triassic. The Guanling fauna from the Wayao Member (conodont *Paragondolella polygnathiformis* Zone, Carnian), Falang Formation, Xinpu, Guanling County, Guizhou Province corresponds to this peak phase, that marks a full recovery of marine organism diversity from the end-Permian extinction. Reptiles became the top predators in the marine realm just as dinosaurs emerged on land. The fossil marine reptiles from the Guanling Fauna provide an important link between the Triassic Pacific and Tethyan, and between Triassic basal forms and the Jurassic-Cretaceous marine top predators. The most remarkable fossils are the large completely articulated ichthyosaur skeletons up to and more than 10 m, and the first recorded thalattosaurs and placodonts in China. Following our review, of the 17 named reptilian taxa, eight are considered to be valid: three ichthyosaurs (*Qianichthyosaurus zhoui* Li, 1999; *Guizhouichthyosaurus tangae* Cao and Luo in Yin *et al*., 2000; *Guanlingsaurus liangae* Yin in Yin et al., 2000); three thalattosaurs (*Anshunsaurus huangguoshuensis* Liu, 1999; *Xinpusaurus suni* Yin in Yin *et al*., 2000; *Xinpusaurus kohi* Jiang *et al*., 2004); and two placodonts (*Sinocyamodus xinpuensis* Li, 2000; *Psephochelys polyosteoderma* Li and Rieppel, 2002). The Panxian and Guanling Faunas are of high diversity, containing well preserved and completely articulated skeletons of marine reptiles associated with fish and invertebrates, and are two of the best examples of marine reptile records in life history, and markers in the process of Triassic biotic recovery.

Upper Paleozoic brachiopods of marginal seas of the Angarida: events and stages in development

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During the Late Paleozoic, Angarida was surrounded by marginal seas extending over a continental shelf. The Late Tournaisian Stage is the time of maximum Early Carboniferous transgression, and a time directly before the collision of the Angarida continent and the Kazakhstan continent. The Scheglovian event is the beginning of the closing of the Palaeoasian Ocean. It is expressed in a drastic decrease in taxonomic diversity of different faunal groups as well as in the change of lithology. The best sections of the marine Carboniferous and Permian deposits around the Angarida continent are known from the Verkhoyanye-Okhotian region. This area is characterized by a coastal zonation from continental facies – on the west, to basin facies – on the east. Sequences of Carboniferous and Permian of Verchoyanye-Okhotian region are characterized by cyclical successions. Regional units correspond to transgressive-regressive cycles of the highest order. Their biostratigraphy and stratigraphic correlations are based mainly on brachiopod studies. Twelve regional horizons and twenty-three biozones have been established for this area in the Carboniferous and Permian. The main events influencing the history of continental development and recorded in the sediments of the marginal seas are located at the base of the Bazovian and Solonchanian horizons, the Carboniferous-Permian boundary and the base of the Tumarian, Delenzhian and Dulgalakhian horizons. Six bioevents were recognized: 1 – Scheglovian event, 2 – Tylakhian event, 3 – Setlandian event, 4 – Tumarian, 5 – Delenzhian event and 6 – Dulgalakhian event. The Angarida continent determined the synchronisation of geological processes occurring not only on the land, but also along its periphery – within shelf sedimentary basins. Alignments of the Carboniferous and Permian stratigraphic charts of the different regions along the periphery of the Angarida Continent were made on the basis of: (1) detailed biostratigraphic chart for the Verkhoyanye-Okhotian area; (2) established global events boundaries within the studied region; (3) reference correlative intervals. The latter corresponds to the maximum transgression. The assemblages of brachiopods that characterize the local stratigraphic units have been of prime importance for interregional correlation. The names of these units are used for referencing interregional correlative intervals that include Krapivian, Magarian, Natalian, Early-Solonchanian, Late-Kygyltassian, Khorokytian, Early-Tumarian, Early-Delenzhian and Early-Dulgalakhian intervals.

Statistical correlation between fusulinacean fauna and sea-level changes through the Early and Middle Permian in southern Guizhou, China

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Sea-level changes from the end of the Loudianian to the Lengwuan in the study area include seven 3rd-order cycles, each with two stages, *i. e.* an early rise, and a late rise to fall. The first three cycles belong to the first phase, the last four cycles to the second phase. The second phase is characterized by faster early-rise rates in cycles compared with the first phase. Statistical results on numbers of species, first appearance of species (FAS), and last appearance of species (LAS) of fusulinacean faunas during sea-level changes have the following features for correlation between faunas and simultaneous sea-level changes.

1) Percentages of number of FAS in a stage to total number of FAS, three maximum values of about 36% of all FAS occurred wholly in the first phase with percentages obviously higher than the average value of FAS per stage. Moreover, the total number of FAS and the evenness number of FAS per assigned thickness-interval of strata in the first phase were 1.5 and 2.2 times as much as in the second phase.

2) However, the percentages of the number of LAS in a stage to total number of LAS, four maximal values including about 43% of all LAS occurred in the second phase with total number of LAS about 1.8 times as much as in the first phase. The total number of LAS in the first phase, in which the number of LAS in any stage was not higher than the evenness number of LAS per stage, was more or less evenly distributed in six stages, but about 69% of LAS in the second phase was concentrated on four early-rise stages.

3) The number of species in each stage persistently increased within the first phase, reached a climax at the end of the first phase, and then definitively decreased during the second phase except for a brief increase in one stage.

The features above demonstrate that sea-level changes with slower early-rise rates favoured increase in species diversity in the fusulinacean fauna due to the higher rate of speciation and the lower rate of disappearance. Conversely, the sea-level changes with faster early-rise rate could have been seriously detrimental to the fauna because the very high rate of disappearance and the lower rate of speciation led to a great decrease in species diversity. Therefore, it could be deduced that the 3rd-order changes of sea level were an important environmental background, and the early-rise rate of sea-level changes might be one of the key factors related to the evolutionary pattern of “Maokouan” fusulinaceans discriminated from fossil data from the same area.

The correlations of biomarker data of Late Permian in Meishan section

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With the data of four biomarker parameters, C31 2α-methylhopane index (2α-MHI), C31 3β-methylhopane index (3β-MHI), regular steranes/17α-hopanes and C35 homohopane index (C35-HHI), which were attained from Meishan Core-1, some probable interpretations of the end-Permian anoxia event are given. By analyzing these data it was noticed that there are many obvious correlations between them, and additional comparisons with the data of sea-level changes and inorganic carbon isotope shift can be made. According to the biomarker parameters, the end-Permian anoxia might have already begun at the early Changhsingian Stage, and it progressed with a quick transgression. Such a long period of extensive anoxia affected the organisms in the shallow water. In the early Triassic, the marine environment was almost oxic and the reconstruction of the ecosystem was led by prokaryotic organisms.

The Permian/Triassic transition was divided into five stages, A-E (see the figure). In stage E, the high 3β-MHI indicates a high activity of methanotrophic bacteria in a sulfate depleted environment (Brocks *et al*. 2005), and the low C35 homohopane index shows an oxic sedimentary environment (Peters and Moldowan 1991). In stage D, with a very high C35-HHI, both 3β-MHI and 2α-MHI dropped dramatically. These reveal an anoxic shallow sea with low cyanobacteria and methanotrophic bacteria activity. And, low ratio of regular steranes/17α-hopanes means prominent prokaryotic input to buried organic matter (Moldowan *et al*. 1985). In stages B and C the C35-HHI is still high, but decreased a little. Together with relatively high 3β-MHI and 2α-MHI it could be presumed that the shallow water column was possibly dysoxic. And, the high ratio of regular steranes/17α-hopanes indicates the organic matter input mainly came from algae and higher plants. So an enhanced terrestrial weathering during this long term regression might have brought a large amount of nutrition and organic matter to the ocean and then been buried, thus resulting in the slight positive excursion of δ^{13}C in a short time. When the sea-level reduced to its lowest point, most biomarker parameters fluctuated dramatically. Right after the mass extinction the 2α-MHI rose quickly and got a very high value, almost 4-7 times higher than before. That was because of much more expanded shallow marine environment (resulted from the remarkable transgression in stage A), and the decrease of competing and grazing pressure after the mass extinction.

Biodiversity dynamics of the superorder fusulinoida (foraminifera) during its evolutionary path

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Superorder Fusulinoida Fursenko, 1958 is one of the main groups among marine invertebrate organisms, used for dating and correlation of the Late Palaeozoic deposits. In superorder Fusulinoida 6 orders, 29 families and 187 genera are distinguished. Fusulinoida have appeared in Early Carboniferous (Visean age) and have existed for almost 95 million years up to the end of Permian epoch. In order to assess the Fusulinoida's biodiversity dynamics over time, a graph illustrating the change in the number of genera in each order of the superorder Fusulinoida was constructed (Fig.1). Similar charts have been published by E.Ya. Leven (2003). However, our interpretation differs from the last a little. The schedule for superorder Fusulinoida as a whole is represented by a curved line with three precise peaks, approximately equal, but varied in qualitative content. The first peak, which is caused by burst of genera formation in order Fusulinida, falls at the Moscovian age. The second peak of generic diversity in superoder Fusulinoida is marked from Asselian up to Artian ages and is defined by primary prevalence of genera number in order Schwagerinida. The character of a variety curve of Schwagerinida is qualitatively similar to the schedule on Fusulinida. In both orders we notice a fast increase in their generic variety at the initial stage and, after rather a short period of the maximal values of genera number, there is a fast reduction, and then the stage of their gradual decline and extinction is fixed. In the case of Schwagerinida significant reduction of a variety occurs in Artian and Kungurian ages. At a final stage of existence Schwagerinida, a few of its genera live up to the end of Middle Permian. The third peak on the schedule of a generic variety in superorder Fusulinoida falls at Middle Permian (Roadian, Wordian and Capitanian ages). In this time interval, the general values of number for the Fusulinoida genera are little bit lower than in the two first intervals, giving peaks of a variety on the schedule. But the main difference is that the third peak qualitatively differs from first two since there is no domination by any one order. Neoschwagerinida determined the aspect of middle Permian Fusulinoida fauna, but they never achieved such generic variety, as Fusulinida in Middle Carboniferous or Schwagerinida in Early Permian. In relation to their rather low level of a generic variety, Neoschwagerinida have been comparable to other orders existing at that time, Schubertellida and Staffellida. At the end of Middle Permian, set against a background of proceeding reduction of the shallow shelf seas and an increasingly arid climatic, the Schwagerinida and Neoschwagerinida became extinct. In Late Permian the generic variety of Fusulinoida sharply reduced, they are replaced by a few genera of Staffellida, Ozawainellida and a little more variation in the Schubertellida genera. By the end of the Permian epoch the final phase of Fusulinoida has come to an end.

The greatest end-Permian catastrophic events: progress and perspectives from China

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The end-Permian mass extinction has been unanimously ranked as the greatest mass extinction during the Phanerozoic, eliminating about 95% of all the species in the world's ocean and also heavily affected terrestrial ecosystems (*e.g.* Erwin, 2006). Although it has been extensively studied, its causes remain a mystery. In China, intensive investigations have taken place in high-resolution biostratigraphy (Zhao *et al*., 1981; Sheng *et al*., 1984; Yin *et al*., 1996; Shen *et al*., 2006), analytic palaeobiology and computer modeling (Jin *et al*., 2000), microstratigraphy and sedimentology (Cao and Shang, 1998), geochemistry (Cao *et al*., 2002) and geochronology (Bowring *et al*., 1998; Mundil *et al*., 2004). These investigations have occurred in different facies and different palaeogeographical settings including southeast China, southwest China, Tibet and northwest China.

Careful analyses show that the widely perceived end-Permian mass extinction (in the sense of Sepkoski, 1981) actually consisted of two phases, one at the end-Guadalupian which is either called the pre-Lopingian crisis or the end-Guadalupian mass extinction (Jin, 1993; Jin *et al*., 1994; Stanley and Yang, 1994; Shen and Shi, 1996, 2002; Shi *et al*., 1999; Wang and Sugiyama, 2000; Yang *et al*., 2004) and another at the close of the Changhsingian (Jin *et al*., 2000). Relatively little is known about the first phase in comparison to the second. What has been recognized however, is that the pre-Lopingian crisis is much less pronounced than the second extinction event (Shen and Shi, 2002), and it is taxonomically selective and possibly palaeobiogeographically different in severity (Wang and Sugiyama, 2000; Shen and Shi, 2002; Yang *et al.*, 2004). Corals and fusulinids experienced significant decline, brachiopods, foraminifera, bivalves and gastropods, however, did not show distinctive changes (Jin *et al*., 1994; Shen and Shi, 2002). The crisis was associated with ^{13}Ccarb depletion was recognized at the major global regression. A dramatic Guadalupian-Lopingian boundary (Wang *et al.*, 2004; Kaiho *et al*., 2005). Although the pre-Lopingian crisis may be consistent in timing with the Emeishan igneous province in South China (Zhou *et al*., 2002), the cause-effect links between them remain unclear.

Detailed statistical analyses based on high-resolution biostratigraphy and geochronology suggest that the effects of the end-Changhsingian mass extinction were rather rapid or even catastrophic, and probably lasted less than a couple of hundred thousand years or possibly even less than tens of thousands of years (Bowring *et al*., 1998; Jin *et al*., 2000; Kaiho *et al*., 2001; Shen and Shi, 2002; Xie *et al*., 2005). The sudden disappearance of fossil groups happened in various depositional environments from terrestrial to marine, from littoral, carbonate platform, reef, slope to basinal facies. It is also comparable in timing and pattern to the extinction event in the peri-Gondwanan region of southern high palaeolatitudes (Shen *et al*., 2006). A rapid climatic warming event is indicated by the southward invasion of various warm-water faunas in the peri-Gondwanan region. Rugose corals, brachiopods, fusulinids, ammonoids, *etc*. all turned out to be the victims of this bioevent. Recent investigations into the terrestrial alluvial, marine/nonmarine transitional and littoral Permian-Triassic boundary (PTB) sequences in southwest China also reveal a rapid climatic drought and deforestation of the tropical *Gigantopteris* megaflora which is synchronous with the mass extinction of marine organisms. The end-Changhsingian event was associated with a sharp negative drop of both ^{13}Corg, which occurs slightly below the PTB in both marine and ^{13}Ccarb and terrestrial sequences. A rapid transgression also began in the latest Changhsingian, frequent volcanic activities indicated by multiple ash beds occur near the Permian-Triassic boundary, and widespread anoxic conditions prevailed during the extinction and its aftermath intervals (Wignall and Twitchett, 1996; Grice *et al*., 2005; Xie *et al*., 2005).

The temporal coincidence between the extinction event and the flood basalt in Siberia (Renne et al., 1995), and evidence of climatic warming (greenhouse effect) possibly derived from carbon dioxide released from frequent volcanic eruptions suggest that volcanism is probably the most plausible causal links between the eruptions and the mass extinction. This scenario is also supported by widespread multiple ash beds or tuffs near the PTB in South China. However, the China ash beds are from pyroclastic volcanism, probably from northern Vietnam or southern China, rather than from the Siberian flood basalts based on the presence of bi-pyramidal quartz, which is associated with subduction-related volcanism. Therefore, to establish a close cause-effect link between volcanism and mass extinction remains a task for future multidisciplinary research (Erwin *et al*., 2002). The geochronogical and statistical evidence of a catastrophic extinction at the close of the Changhsingian continues to activate the scenario of an extraterrestrial impact as the cause of the extinction. The most suggestive evidence of this scenario is the presence of helium and argon trapped in a variety of fullerences (Becker *et al.*, 2001; Li et al., 2005). However, experimental results of Becker *et al.* (2001) were not validated by the subsequent study (Farley and Mukhopadhyay, 2001). Microspherules possibly related to volcanism or impact have been widely reported from the PTB sections in south China (He, 1985; Gao, 1987; Yang et al., 1991). However, sources of the PTB microspherules remain unclear in terms of their chemical composition and abundance. Sedimentological evidence of anoxia advanced by Wignall and Hallam (1992, 1993) and Isozaki (1997) has been widely recognized in South China based on the lithologic and community shift, frequent occurrences of framboidal pyrite and a biomarker of Chlorobiaceae across the PTB (Wignall and Hallam, 1993; Cao and Shang, 1998; Grice *et al*., 2005; Xie *et al*., 2005). However, the evidence for anoxia could reflect extinction rather than anoxia (Erwin *et al.*, 2002).

In order to unravel the cause(s) of the end-Permian mass extinction, a detailed working plan was made recently. Two wells were drilled in 2004 at a quarry near the PTB GSSP section in Changxing, Zhejiang Province, SE China. A total thickness about 340 m of the cores was collected. In addition, large quantities of very fresh samples from the quarry at Meishan have been accomplished by blasting quarry faces. Research programs including an integrated succession for the Lopingian Series, timing of the end-Permian event, a blind test for the suggested extraterrestrial event, organic geochemical evidences and co-evolution in the Permian-Triassic terrestrial and marine ecosystems are suggested.

The marine Permian of east and northeast Asia: an overview of biostratigraphy, palaeobiogeography and palaeogeographical implications

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The marine Permian is extensively distributed in east and northeast Asia, but their mutual correlations and alignments with the international Permian chronostratigraphic timescale remains a major challenge due to profound marine provincialism during the Permian. In this paper, an attempt is made to synthesise the Permian biostratigraphy, faunal successions and mutual correlations (where possible) throughout east and northeast Asia, region by region, based on both published literature and the author's field observations in specific parts of this vast region. Correlation of the Permian marine successions of NE Asia with the Permian international timescale and, in particular, with the Gondwanan Permian marine sequences, is aided by employing biogeographically mixed faunas from east Asia (SE Mongolia, NE China, South Primorye of Far East Russia and the South Kitakami Terrane of Japan) as "biostratigraphic gateways", coupled with some bipolarly and bi-temperately shared Permian marine taxa and faunas. With this new "biostratigraphic gateway method", it has been possible to correlate, with reasonable confidence, some of the high-palaeolatitude Permian marine rock units and faunas of NE Asia with those of the Tethyan region and Gondwana. Palaeobiogeographically, the Permian marine faunas of E and NE

Asia are assigned to four major provinces: Verkolyman, Sino-Mongolian-Japanese, Cathaysian, and Panthalassan provinces, on the basis of their palaeogeographic distribution patterns and characteristics of faunal assemblages. Of these, the Sino-Mongolian-Japanese Province has considerable significance for regional palaeogeographic, plate tectonic and palaeoceanographic reconstructions during the Middle Permian because of its conspicuously mixed cool- and warm-water marine biota. The origin of this biogeographically mixed marine biota is interpreted to have resulted from a combination of factors including the increased tectonic convergence between the Bureya-Jiamusi Terrane and the Sino-Korean Platform during the Permian and intermingling of both warm- and cold-water ocean currents off the eastern coastal areas of the Bureya-Jiamusi Terrane and the Sino-Korean Platform during the Middle Permian.

Permian fusulinaceans from the Tengchong block, western Yunnan, China

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The Tengchong Block, a tectonostratigraphic unit of western Yunnan, southwest China, has Permo-Carboniferous sequences with biota of strong Gondwana-affinity. Many authors have therefore suggested the block is of Gondwanan provenance (e.g. Wang, 1983; Jin, 1994, 2002; Wopfner, 1996), but the arduous terrain has long restricted field work and accumulating data necessary for analysing the palaeogeographic development of this block. Fusulinacean fossils reported here came from two horizons in the Permian Dadongchang Formation north of Tengchong township, specifically near Kongshuhe and Shanmutang villages. The fauna from the lower part of the Dadongchang Formation in the Kongshuhe section consists of *Eoparafusulina tschernyschewi tschernyschewi* (Schellwien, 1909), *E. malayensis* Igo, Rajah and Kobayashi, 1979, *Parafusulina* sp., *Monodiexodina wanneri* (Schubert, 1915), and may be Artinskian in age. The fauna from the middle part of the Dadongchang Formation in the Shanmutang section consists of *Chusenella mingguangensis* sp. nov. *C.* sp. indet., *Parafusulina* sp., *Pseudofusulina* sp., *Monodiexodina gigas* sp. nov., and is probably of Wordian to Capitanian age.

The low generic and specific diversities and absence of Cathaysia-indicating pseudoschwagerinids, verbeekinids, and neoschwagerinids are remarkable features of the fusulinacean faunas of the Tengchong, Baoshan and Sibumasu blocks. However, the species-composition of the fauna from the Tengchong Block is also different from those of the other two blocks, emphasizing a regional character of the fauna of the Tengchong Block.

Distribution of small foraminifers in the Permian-Triassic boundary strata at Meishan section, Zhejiang, China

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Sixty-three species in 21 genera of non-fusulind small foraminifers are identified from the middle and upper Changhsingian Stage and the Permian-Triassic boundary strata at the Meishan Section in Changxing County, Zhejiang Province, where the named Changxing Limestone and the GSSPs (Global Stratotype Section and Point) for both base and top of the Changhsingian Stage are located, based upon a high-resolution samples at the section. The uppermost Changhsingian and the Permian-Triassic boundary strata are sampled and thin-sectioned at intervals of 2-4 cm. The overall distribution of the small foraminifers at the section shows an apparent sharp drop at the near top of the Changxing Formation with only nine species of five genera extending over the main event bed, Bed 25, among which *Nodosaria netschajewi* and *N.* sp. are observed in Bed 29 as well. However, a closer view on the distribution of the small forams in the topmost part of the Changhsingian indicates a significant gradual decrease towards the end of the Changhsingian. The real distribution is a smooth decline though a statistical analysis might show a stepwise extinction. These data would be of importance for a better understanding of the extinction pattern at the end of the Permian as well as the nature of the events.

Relating the fossil record to deglaciation in the Early Permian of Gondwana: development of a Gondwana-wide biotic deglaciation model

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Deglaciation sequences of Early Permian age in Gondwana have until now been distinguished mainly on lithological criteria by reference to climate-sensitive lithologies such as diamictite, limestone, glacial shales (with dropstones and varves) and associated geochemistry, whereas identification on biotic criteria such as vegetational or faunal change has not been employed. Data shows that the maximum rate of deglaciation probably occurred around the *Granulatisporites confluens* palynological Biozone, at least in Australia, Antarctica, East Africa, India and Arabia, in late Asselian – early Sakmarian times.

Present paleontological data, which are admittedly widely-scattered geographically, and of different stratigraphic scales and resolutions clearly show diversity increase from glacial conditions to post glacial conditions. Amongst the marine fauna, a cold water fauna consisting of bivalves such as Eurydesma and Deltopecten, and brachiopods such as *Lyonia* and *Trigonotreta*, were established in the earliest post glacial marine transgressions that did not affect all of Gondwana. Above this is a more diverse, increasingly warmer, temperate fauna, including brachiopods, bryozoans, bivalves, cephalopods, gastropods, conularids, fusulinids, small foraminifers, asterozoans, blastoids and crinoids like that of the Saiwan Formation/Haushi limestone of Oman.

The palynomorph succession shows some consistency across Gondwana in Asselian-Sakmarian rocks. Very broadly a change from monosaccate pollen assemblages, associated with fern spores to more diverse assemblages with common non-taeniate bisaccate pollen occurs through the deglaciation period. In Oman, where this has been studied in greatest detail, the upland saw changes from a glacial monosaccate pollen-producing flora to a warmer climate bisaccate pollen-producing flora; while in the terrestrial lowlands, a parallel change occurred from a glacial fern flora to a warmer climate colpate pollen-producing and lycopsid lowland flora. The sedimentary organic matter of the clastic rocks of the Oman sequence records a corresponding $\delta^{13}C$ trend (from approximately -21 to -24‰) believed to reflect palaeoatmospheric change due to postglacial global warming.

The advantages of developing a deglaciation model would be in understanding in detail the response of life to increasing temperatures and other climate change, and might be useful in the study of modern biotic change during global warming. However to achieve such a model more detailed bed by bed interdisciplinary palaeontological studies of measured sections demonstrably related to climate-forced deglaciation must be carried out. For these studies to be comparable across Gondwana, sections must be precisely correlateable so that like can be compared with like. Therefore a Gondwana-wide palynostratigraphy, uniting the four or five schemes presently in existence for the former continents of Gondwana, needs to be established.

Molecular evidence for radical changes in ocean chemistry, globally, across the Permian Triassic boundary

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The Late Permian mass extinction was most extensive in Earth's history, resulting in around 90% of marine animal species, and many terrestrial taxa, becoming extinct. Shallow and deep water anoxia, euxinia, global warming, Siberian Trap volcanism, collapse and oxidation of methane hydrates, sea level change and bolide impact are among the proposed causes of the extinction event.

Samples from outcrop, and from a new core drilled through the Permian-Triassic (P-Tr) Boundary at the type marine section at Meishan, have been examined for biomarker and isotopic evidence of environmental and associated biotic change. Late Permian sediments from Meishan Beds 22-30 are characterized by indicators of anoxia including low Pr/Ph ratios and abundant aryl iosprenoids and isorenieratane derived from the precursor carotenoid isorenieratene. These latter biomarkers, derived from brown species of green sulfur bacteria (Chlorobiaceae), are considered reliable indicators of euxinic water columns where hydrogen sulfide extends into the photic zone. Highest abundances of Chlorobiaceae biomarkers occur through Beds 24 to 27 and so bracket the major extinction horizon evident in ash Bed 25. Additional sub-maxima of Chlorobiaceae biomarker abundances, at Beds 30, 35 and 37 in the Early Triassic and coincident with monotonous bivalve debris suggestive of mass extinction, indicate that pulses of photic zone euxinia occurred well after the Permian and may have caused the biodiversity recovery to be protracted.

The prevalence of aryl isoprenoids and isorenieratane is also recorded in a recently cored borehole, Hovea-3, of the Perth Basin, Western Australia (Grice et al., 2005). Other, well-established, boundary sections in Tibet and at the Great Bank of Guizhou, had similar biomarker patterns as did two sections outside the Tethys realm, in Western Canada and at Kap Stosch in East Greenland. In fact, the presence of biomarkers for Chlorobiaceae at six separate locations, worldwide, indicates that water column euxinia was pervasive during and after the extinction event and suggest that sulfide may have been a key toxic agent, as is supported by the photochemical modeling studies of Kump *et al*. (2005). Widespread outcropping of anoxic sulfidic waters onto continental shelves compromised aerobic habitats and might ultimately have allowed a hydrogen sulfide plume to influence continental regions and compromise terrestrial organisms (Kump *et al*., 2005). Further evidence for widespread euxinia comes from $\delta^{34}S$ isotope studies on sulfate and sulfide minerals at P-Tr sections from numerous locations worldwide (*e.g*. Nielsen and Shen, 2004).

At Meishan, a pronounced negative C-isotopic excursion of around 4 per mil for kerogen is evident reaching a maximum near the top of bed 26 (black shale layer). This, and roughly parallel shifts in carbonate $\delta^{13}C$, have been observed in other P-Tr sections worldwide. The carbon isotopic excursions, and accompanying anomalies in nitrogen and sulfur isotopes, indicate there was a major reorganization of the global carbon cycle over the P-Tr Boundary. Biomarker and isotopic anomalies found for Meishan have much in common with those observed in black shales deposited during the early Aptian, late Cenomanian and late Frasnian oceanic anoxic events. This suggests globally pervasive euxinia is not a rare phenomenon and may explain many of Earth's major mass extinctions.

Paleoecology of the Permian alatoconchid bivalves from north-central Thailand

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Alatoconchid bivalves are found extensively in Permian limestones along the mountain belt west of the Khorat Plateau in north-central Thailand. More than 30 localities with alatoconchid beds have been studied stratigraphically and sedimentologically. The bivalves were observed mainly in bedded, dark to light grey wackstones and packstones. Limestones with alatoconchids occur in beds are few centimetres thick to very thick-bedded of the Saraburi Group. They range in age from Murghabian to Midian based on fusulinid biostratigraphy (Wielchosky andYoung, 1985). Dolomitic limestones occur interbedded with limestones. Collapsed limestone breccias with red matrix and fragments of alatoconchids, corals and other shelf organisms are interpreted as palaeocave deposits. The sequence stratigraphy reveals fluctuations in sea level. Alatoconchids are alate, equivalved bivalves with vertical plane of commissure and wing-like flanges with dorsal ridge. The largest adult shells are up to one meter width whereas the smallest juvenile shells are less than one centimetre. Dark grey micritic limestones with both adult and juvenile shells in living or growth position imply a soft substrate with high content of organic matter. Burrows with micritic infillings in alatoconchid shells were probably caused by cyanobacteria and indicate depositional environments below the photic zone. Associated fossils consist of fusulinids, brachiopods, massive corals, solitary corals, bellerophontid gastropods, algae, sponges and crinoids; these suggest relatively shallow, clear water. Storm events, discriminated from tempestites, occurred occasionally. These are mainly composed of calcirudite and calcarenite shell beds. Dislocated massive corals, upside-down coral heads and fusuline storm sheets indicate occasional turbulent water as well.

Ca.-100-m.y.-long foraminiferal faunal record before the end-Permian extinction in a mid-ocean setting: perspective from Paleo-Tethyan oceanic carbonate buildups in the Changning-Menglian belt, sw china

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The Changning-Menglian Belt in West Yunnan, SW China, is regarded as a displaced ophiolite belt between the Cathaysian Lincang Massif (Permian-Triassic volcanic arc developed along the continental margin of “Cathaysialand”) and the Cimmerian Baoshan Block (Gondwana-derived continental sliver), representing one of closed remnants of the Paleo-Tethys Ocean in East Asia. The belt contains huge, Carboniferous-Permian carbonate bodies of mid-ocean origin, formed by the carbonate factory upon OIB edifices (oceanic islands and/or plateaus) in the Paleo-Tethys Ocean. These oceanic carbonates involve continuous records of approximately 100-m.y.-long, biotic and environmental changes in an open-ocean setting within the Paleo-Tethys before the end-Permian mass extinction. In this paper, we review the foraminiferal faunal succession from two sections of these oceanic carbonates in the Changning-Menglian Belt; they are the Yutangzhai section and the Shifodong section. These two sections cover almost the whole of the Changning-Menglian oceanic carbonate succession, and thus are optimal for understanding the general overview of stratigraphy and biotic succession in a Paleo-Tethyan open-ocean condition. The Yutangzhai section, about 1100 m thick, starts from weathered basalt, followed by thick piles of pure carbonates that are free from the influx of terrestrial siliciclastic materials. They are composed essentially of shallow-marine limestone, and are dominated by wackestone, packstone, and fine grainstone with a minor amount of peritidal dolo-mudstone, except markedly observed cementstone in the lowermost part. Large-scale, reef-related sediments consisting of skeletal metazoan frameworks are absent. These facies associations suggest that the carbonates in the Yutangzhai section are mostly of back-reef sediments in a seamount depositional system. We recognized seventeen, essentially continuous fusuline faunas ranging from the Serpukhovian (late Mississippian/late Early Carboniferous) to the Midian/Capitanian (late Guadalupian/late Middle Permian) in this section. No significant faunal break can be recognized in this section. Because some of corals from the basal part of the carbonate succession presumably indicate a Visean age, the pedestal basalt is of Visean or slightly older. The generic and some specific compositions of the Yutangzhai fusuline assemblages indicate that the faunal succession is essentially similar to what we can see in the Tethyan and Panthalassan areas and is of typical tropical Tethyan type although their generic diversity is definitely lower than those of Paleo-Tethyan shelves (such as South China, Indochina, and Central Asia).

The Shifodong section, about 100 m thick, represents the topmost part of the Changning-Menglian, Paleo-Tethyan oceanic carbonate succession. This section is rich in foraminiferal remains and has been assigned to the Changhsingian (late Lopingian/late Late Permian) in previous studies by the occurrence of *Palaeofusulina sinensis*. Our biostratigraphic study demonstrated that it is subdivided into the *Codonofusiella* cf. *kwangsiana* Zone (Wuchiapingian), *Palaeofusulina minima* Zone (early Changhsingian), and *Palaeofusulina sinensis* Zone (late Changhsingian) in ascending order. The fusuline and smaller foraminiferal associations in the Shifodong section show a high taxonomic diversity and have a close affinity with coeval faunas found in South China. Moreover, our recent, preliminary isotopic analysis detected a level with a strong negative shift of $\delta^{13}C$ value (from 4.1‰ to -0.6‰; comparable with carbon isotopic data from the P-T boundary section in Meishan, South China) within a microbe-dominated interval just overlying the very latest Permian *Palaeofusulina sinensis* Zone in the upper part of the section.

This may suggest a possibility that the section is across the P-T boundary. If this interpretation is available, the Shifodong section is also unique to comprehend an end-Permian, oceanic environment and shallow-marine biotic demise in a far distal area from the “Shallow Tethys” (Pangean shelves) as well as the nature of P-T boundary event in a mid-ocean setting in the Paleo-Tethys.

An abrupt shift in S-isotopic composition: evidence for H_2S input as a trigger of the end-Permian marine biotic crisis and environmental mutagenesis

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Many mechanisms have been proposed to explain the end-Permian extinctions, one of them being the massive release of hydrogen sulfide to the ocean and atmosphere (Nielsen and Shen, 2004; Kump *et al*., 2005). However, more evidence needs to be investigated. In this paper, we will focus on an interpretation of the S-isotopic excursion pattern around the main extinction interval in Meishan section, China, the Global Stratotype Section and Point (GSSP) for the Permian-Triassic boundary.

The abrupt and strong negative shifts in $\delta^{34}S_{rock}$, $\delta^{34}S_{suphate}$ and $\delta^{34}S_{pyrite}$ synchronously occur with the negative shift in $\delta^{13}C_{carb}$ from Bed 24e to Bed 26 (Fig. 1), strongly indicating a common trigger for the change of CO_2 and H_2S source in the ocean. The 34S-depletion character for the intervals above Bed 24 is similar to that in the East Greenland Basin (Nielsen and Shen, 2004). What is more important is that a strong positive shift in δ^{34}Spyrite (δ^{34}Srock) occurs in Bed 24e (the last-appearance interval of a wide variety of Late Permian faunal species, according to Jin *et al*., 2000). This S-isotope shift pattern is very similar to that of δ^{34}Spyrite in the Tenjinmaru and Sasayama sections from Japan (Kajiwara, 1994).

The possible mechanism for such a S-isotope shift pattern is suggested as follows: massive H_2S was abruptly input (released) into the bottom water, accompanying the deposition of Bed 25 (illite-montmorillonite claystone of volcanic origin), it then diffused downwards into Bed 24e and scavenger Fe2+ formed semi-euhedral or euhedral pyrite, thus leading to ^{34}Spyrite enrichment in Bed 24e and probably iron depletion in the sea. While above Bed 25, the very low sedimentary rate, and decreased Fe supply, caused extensive sulphide reoxidation and sulphate reduction, leading to strong $^{34}S_{pyrite}$ depletion. Thus, the strong positive shift in $\delta^{34}S_{pyrite}$ in Bed 24e is considered to be important evidence for the massive H_2S input into the ocean. The source or genesis of H_2S is discussed in detail.

Radiation of the fusulinoideans between the two phases of the end-Permian mass extinction, South China

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The end-Permian mass extinction is one of the largest bioevents in geological history. The benthic groups such as fusulinids, corals and bryozoans, nevertheless, suffered most severely at the end of the Guadalupian, which was regarded as the first phase of the event. As a consequence of the pre-Lopingian global regression, the large-scale carbonate platforms that used to be the habitats for the endemic benthos fauna disappeared in the peri-Pangean region, and the relic shelves in the Palaeotethys also disappeared. The changes in the ecosystem turned out to be a disaster for the benthos living in the carbonate environments. Among them, the fusulinoideans suffered a generic extinction rate of 76% globally, and 87% in South China. Those capable of living in the sandy or wider environments other than carbonate platform survived and became the dominant figures of the Wuchiapingian. For example, the genera *Codonofusiella* and *Reichelina* were so abundant in Wuchiapingian that they formed the *Codonofusiella* fossil zone in South China. The explosion of new genera in the Late Permian did not start until the Changhsingian Stage when *Palaeofusulina minima* first appeared as a pioneer in the lower Changhsingian and *P. sinensis* appeared as an advanced form in the upper Changhsingian. Thus, the genus *Palaeofusulina* was regarded as an index fossil for the Changhsingian Stage.

However, recent studies on the Capitanian-Wuchiapingian boundary led to the discovery of the Wuchiapingian *Palaeofusulina* fauna in Penglaitan, Laibin County, Guangxi Province. The fauna is composed mainly of large-sized and long-fusiform forms as well as a few small fusiform figures. The increasing data of the genus made it necessary to re-evaluate its evolution pattern because there exists an evolutionary vacuum between the supposed ancestor *Dunbarula* and the Changhsingian *Palaeofusulina*. In this cladistic analysis, ten species were selected, including the six subgroups of *Palaeofusulina*, the type species of *Nanlingella* and *Parananlingella*, and the newly discovered species of *Palaeofusulina* and *Gallowayinella* in Penglaitan, with *Dunbarula mathieui* as an outgroup. The result shows that the two morphologic types of *Palaeofusulina* in the early Wuchiapingian stand for two evolutionary lineages. One is the long-fusiform form, including *Gallowayiella* sp *A*. and *Palaeofusulina* sp *A*., which diversified in the early Wuchiapingian, but became less diverse during the Changhsingian. The other is represented by the small and fusiform species, which formed the dominant lineage of *P. minima -P. sinensis - P. ellipsoidalis* and *P. prisca* in Changhsingian.

Of the fusulinoidean genera that appeared in the Upper Permian, nearly 70% of the genera developed in a short period of time soon after the Pre-Lopingian crisis. A comparison between the evolutionary change of Late Permian fusulinids and the palaeogeographic shift indicates that rebound and final extinction of fusulinids during their survival phase coincided closely with the appearance and elimination of small-scaled isolated carbonate platforms in southwest China.

Global and provincial correlations of the Guadalupian (Middle Permian) Broughton Formation, southern Sydney Basin, eastern Australia

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The first detailed taxonomic study of the brachiopod and mollusc faunas from the Broughton Formation, in the southern Sydney Basin, eastern Australia has recently been conducted. The results of the study assisted in determining a Wordian (Guadalupian or Middle Permian) age for the formation and have been utilized with additional paleomagnetic and small foraminifera data to aid in regional and global correlation. The correlation of Guadalupian faunas and sedimentary successions between basins in eastern Australia, and other basins and provinces around the world, is an ongoing problem. Many of the faunas found in the Sydney Basin at that time are endemic at a species level to the basin or at a generic level to the Austrazean Province. A few taxonomic elements illustrate antitropical distribution and provide some correlation to the Boreal Realm, and some other elements represent faunas of Gondwana affinities in East Asia. These faunas are significant tools for correlation because they provide useful links to the international time scale at other localities. This is particularly important because the subdivision of the time scale is primarily based on conodont faunas, which are absent from the Permian of eastern Australia. In the Austrazean Province there is a close correlation between the fauna studied in the Broughton Formation with fauna from: the Muree Sandstone and Mulbring Siltstone in the northern Sydney Basin; the Malbina Formation, Member E in Tasmania; the Moonlight Sandstone Member (Gebbie Formation) and the Blenheim Formation in the Bowen Basin; and the Mangarewa Formation in New Zealand. Foster and Archbold (2001) correlated the *Sulciplica occidentalis* Zone, in the Westralian Province, with the Broughton Formation, in the Austrazean Province based on brachiopod data. Further correlations can be made between the fauna in the Broughton Formation and the Omolonsk Horizon, in the Kolyma-Omolon area of Siberia.

Radiolarian and conodont biozonation in the pelagic Guadalupian–Lopingian boundary interval at Dachongling, Guangxi, South China, and Mid-Upper Permian global correlation

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The first appearance of the conodont *Clarkina postbitteri* Mei and Wardlaw was defined as the indicator for the Guadalupian-Lopingian (G–L) boundary in the Global Stratotype Section and Point (GSSP) at Penglaitan of Laibin city, Guangxi, South China (Jin *et al*. 1994; Mei *et al*. 1994a, 1994b, 1998; Mei and Shi 1999; Jin *et al*. 1997; Jin *et al.* 2001a; Jin *et al.* 2001b; Henderson *et al.* 2002). Although the GSSP is in a section of limestones and cherts, no radiolarian guide species have been recovered there, and identification of the G–L boundary in terms of radiolarian zonation has been debatable (Ishiga 1990; Blome and Reed 1992; Kozur 1993; Wang *et al*. 1994; De Wever *et al*. 2002). The establishment of an adequate reference section for the G–L boundary in a section of radiolarian-bearing pelagic cherts would be useful for biostratigraphic correlation in the G–P boundary interval between continent marginal and oceanic basins. High–resolution microbiostratigraphic work from the Guadalupian–Lopingian transitional interval of a Middle–Upper Permian section of pelagic ribbon cherts at Dachongling, near Qinzhou city in Guangxi, South China, has identified six conodont zones, including a *granti-crofti* Zone, a *hongshuiensis* Zone, a *postbitteri* Zone, a *dukouensis* Zone, an *asymmetrica* Zone and a *guangyuanensis* Zone in ascending stratigraphic order. Additionally, four coeval radiolarian zones were identified, consisting of a *Follicucullus falx–Foremanhelena triangula* Zone, an *Albaillalla yamakitai* Zone, an *A. levis* Zone and a *Neoalbaillella ornithoformis* Zone (also in ascending order). The basal Lopingian GSSP at Penglaitan, South China, is correlated with the base of bed Dch 45-21 at Dachongling on the basis of the first occurrence of the conodont *C. postbitteri postbitteri* Mei and Wardlaw. The first appearances of the radiolarians *Albaillella yamakitai* Kuwahara and *A. cavitata* Kuwahara at the same level indicate that both FADs can be used for identifying the G–L boundary in radiolarian-bearing pelagic cherty facies. The appearance of both radiolarian species in the sections at Sasayama, Gujo-Hachima in Southwest Japan, and in the Quinn River Formation of north-central Nevada, indicates that both boundary-index radiolarian fossils can be traced worldwide. Many works have revealed that both the conodont and radiolarian biozones exhibited prominent provincialism during this time, so it is therefore important to establish a translational section containing both well-developed conodont and radiolarian biozones.

The protracted Permo-Triassic crisis and the multi-act mass extinction around the Permian-Triassic boundary

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The Permo-Triassic crisis constituted a great turning period in the geological history. The Paleozoic biota remarkably declined since the end-Guadalupian phase of extinction and experienced a long-term decline during Late Permian, which eventually led to their final decimation at the PTB. This general trend coincided with the greatest Phanerozoic regression. Thus the two phases of mass extinction, the end-Guadalupian and the PTB are related, and the recovery lasted for the entire Early Triassic. ä^{13}Ccarb perturbations also ranged from Late Wuchiapingian to the end of Early Triassic and were multi-phase. Therefore, the Permo-Triassic crisis was a protracted one spanning Late Permian-Early Triassic. The PTB mass extinction took place in three episodes, the prelude, the main act and the epilogue. This paper provides evidences to show that the prelude commenced prior to the event beds (beds 25-26) at Meishan and coincided with the ebb of end-Permian regression. The epilogue happened at late Greisbachian and coincided with the second volcanogenic layer at Meishan. The temporal distribution of the multi-act extinction constrains interpretation of mechanisms of this greatest mass extinction, especially the role of a postulated bolide impact happened about 50,000 after the prelude. The prolonged and multi-phase pattern of the Permo-Triassic crisis favours mechanisms of Earth's intrinsic evolution. The integration of Pangea may have linked with the greatest Phaenerozoic regression, the PTMS paleomagnetic disturbance, the widespread extensive volcanism and other mechanisms through common geosphere interactions in the earth's depth. These remote causes put together could be responsible for the profound changes in marine, terrestrial and atmospheric environments that evoked the P/T mass extinction. A bolide impact is possible, but not necessary and adequate to explain these changes.

Micro and macroflora assemblages and their evolutional patterns near PTB, western Guizhou and eastern Yunnan, South China

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Both marine and non-marine continuous PTB strata are well developed in western Guizhou and eastern Yunnan, South China, making it an ideal place to undertake research considering the terrestrial - ecological system evolution across the Permian - Triassic Boundary (PTB).

These boundary sections can be used as one of the high-resolution methods for the subdivision and correlation of the PTB from marine to land. Three clear palynological assemblages are recognised across the PTBST at some terrestrial PTB sections in western Guizhou and eastern Yunnan, South China. Assemblage 1 (Xuanwei Formation) is dominated by a Late Permian palynological assemblage of ferns and pteridosperms, with a few gymnosperms. Most of them are Palaeozoic types with the appearance of some typical Late Permian pollen such as *Lueckisporites*. Assemblage 2 (PTBST) is marked by an abrupt drop of palynomorphs and the appearance of fungal spores, though it is still dominated by a palynological assemblage of ferns and pteridosperms, with a few gymnosperms. A mixed flora containing both Late Permian and Early Triassic elements occur in this assemblage. Most palynomorphs are still typical of the Late Permian types as found in Assemblage 1; however, some palynomorphs of Early Triassic age (such as *Lundbladispora* and *Taeniaesporites*) appear. In Assemblage 3 (the top Xuanwei Formation and Kayitou Formation), the proportion of gymnosperm pollen increases rapidly and exceeds ferns and pteridosperms for the first time in western Guizhou and eastern Yunnan, although the content of palynomorphs was still very sparse. Some special palynomorphs of Early Triassic age (such as *Lundbladispora*, *Aratrisporites* and *Taeniaesporites*) were present in greater abundance in this assemblage.

Plant fossils are abundant mainly in the Xuanwei Formation, with very few species found in the Kayitou Formation. The PTB in nonmarine strata marks a decrease of plants and the compositional change of plants from the dominance of Palaeozoic ferns and pteridosperms to the dominance of Mesozoic gymnosperms. Three plant assemblages have been recognized from this area, which can be regionally correlated in South China. The first assemblage (Late Permian, upper part of the Xuanwei Formation) is named *Gigantopteris nicotinnaefolia-Lobatannularia multifolium-Schizonteura manchuriens*is flora. The second (in the PTB clayrocks of the uppermost Xuanwei Formation) is named *Gigantonoclea guizhouensis-Ullmannia* cf. *bronnia-Annularia pingloensis* flora. The third (Early Triassic Indian Stage, Kayitou Formation) is named *Annalepis-Ullmannia* flora.

The extinction pattern within the flora derived from macroplant and palynomorph data declined suddenly at the PTB after a long-term, gradual evolution, followed by a lesser extinction during the earliest Triassic. The first extinction happened in the sediments when the Cathaysian flora decreased sharply and the so-called fungi appeared abundantly. In the meantime, there are abundant woody root fossils (*e.g. Stigmaria*) in this suite of sediments, indicating the deterioration of environments during that time. The transitional flora in the PTB strata disappeared gradually and isochronously throughout the whole area. The second extinction in the earliest Triassic totally exterminated the Cathaysian *Gigantopteris* flora.

The study of plant and palynomorph fossils, combining clay minerals, inorganic geochemistry and sedimentary facies in this area enable us to interpret the events occurring at that time. Our conclusions are that the mass extinction across the PTB in western Guizhou and eastern Yunnan was probably caused by the Siberian basaltic eruption episode and the siliceous volcanism in South China. These lithospheric events represented by volcanisms heralded a series of climatic and environmental events, giving rise to a catastrophe for the biosphere.

Permian palaeogeographic implications of the Lhasa block based on new lithologic and faunal data from the Mujiuco area, Xainza, Tibet

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The Lhasa Block is currently bracketed by the Bangong-Nujiang Suture to the north and the Yarlung-Zangbo Suture to the south. Over the past two decades, its palaeogeographic and tectonic evolution during the Paleozoic-Mesozoic transition has been much discussed. Some considered it to be a part of the Cimmerian Continent (*e.g*. Sengor, 1979; Metcalfe, 1999; Wang e*t al*., 2003); others suggested it separated from Gondwana during the Early Permian (*e.g*., Allègre *et al*., 1984; Ueno, 2003), and still others believed it was rifted from Gondwana in the Late Triassic (*e.g*. Metcalfe, 2002; Li *et al.*, 2004). New lithologic and faunal data from the Permian of the Mujiuco area of Xainza County, Tibet, suggest the Lhasa Block contains differing lithologic sequences and faunas which imply it probably rifted from Gondwana during the Early Permian and then became an isolated block. This conclusion is implied by the following data: (1) The Late Permian (Lopingian) sequence in the Mujioco area is completely different from the Lopingian Selong Group of the Himalaya Tethys Zone in southern Tibet (Shen *et al.*, 2002). The latter represents a continuous transgressive sequence from continental (Qubu Formation) to marine (Qubuerga Formation). On the other hand, the Lopingian Mujiuco Formation (Cheng *et al*., 2002) in the Mujiuco area of Xainza County, conformably overlies the Middle Permian (Guadalupian) Xiala Formation—a regressive sequence. Moreover, Late Permian marine deposits are rare in most areas of the Lhasa Block, areas, such as the Nyixung-Ombu area and the Cuoqen Basin having flora-bearing continental deposits (Li *et al*., 2002; Zhou *et al*., 2002) (2) During the Guadalupian (Middle Permian), the Lhasa Block became characterized by the presence of fusulinids, compound corals and rather warm-water brachiopods as well as the *Shanita-Hemigordius* foraminiferal fauna. The latter is mostly confined to Gondwana-derived blocks (Jin *et al*., 2004). By contrast, faunas of the Selong Group of southern Tibet are dominated by solitary corals and cold-water brachiopods of strong Gondwanan affinities, but fusulinids are absent. (3) The presence of the Early Permian basalts (Garzanti *et al*., 1999) in Gyirong County, Tibet, probably indicates incipient opening of Neotethys. Therefore, we consider that the Lhasa Block probably rifted and drifted from northern Gondwana as early as Early Permian. Its rifting probably formed a new seaway and resulted in formation of seamount-type carbonate deposits during the Middle and Late Permian along the Yarlung-Zangbo Suture (Li *et al.*, 2005). This conclusion conflicts with previous palaeomaganetic data (Dong *et al*., 1991) and has not been confirmed by discovery of any pre-Triassic oceanic deposits within the Yarlung-Zangbo Suture Zone.

Ceremony for the base-Changhsingian and base-Wuchiapingian GSSPs: June 14, 2006 at Meishan, Changxing County, Zhejiang Province. Below is the speech given by SPS Chair Charles Henderson.

We are celebrating two different kinds of decisions. The first is by geologists and paleontologists involved in a truly international effort. It took a long time to get to this agreement as is typical in the geological profession, but it is very satisfying to reach the point where we can now officially register the base of the Changhsingian Stage on the International Time Scale. We now have a common language and method for calibrating and correlating an interval of time representing the last 2 million years of the Permian, culminating in the Permian-Triassic Boundary that was also officially honoured at this same location 5 years ago.

We are also celebrating a geological decision for the base of the Wuchiapingian Stage. This Global Stratotype Section and Point is located near Laibin along the Hongshui River of Guangxi Province. All of this work was conducted over the past two decades with a very concentrated effort during the past five years – an effort that was led by the strong leadership of Academician Professor Jin Yugan of the Nanjing Institute of Geology and Palaeontology and I especially wish to thank him. Others that were instrumental in this work included Shen Shuzhong, Wang Yue, Wang Xiangdong, Cao Changqun, Mei Shilong, Chen Lide, Brian Glenister and Bruce Wardlaw.

Finally, we are celebrating a second type of decision. This decision was made by the government officials of Changxing County in this beautiful Zhejiang Province to honour these international geological decisions with this extremely impressive GeoPark. I know that the county has spent a great deal of money to prepare these fantastic grounds and the panels that display the history of life. I sincerely thank them for their efforts in preserving these natural sites and believing in the value of science. I am especially gratified when I see the general public and travelers come to this site as they can learn something of what earth scientists do. As SPS Chair I extend my thanks for this ceremony and hospitality – Xie Xie.

IN MEMORIAL

Passing of a Polymath: Neil Wilfred Archbold (1950–2005)
Professor of Palaeontology, Deakin University

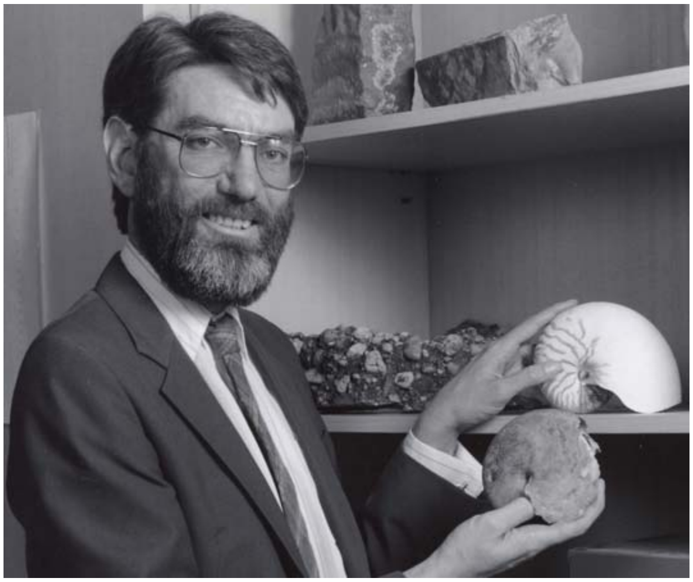
Wisdom begins in wonder.
– Socrates (469–399 BC).
My country is the world, and my religion is to do good.
– Thomas Paine (1737–1809)

Neil Wilfred Archbold, born 14 August 1950 in Ringwood, Victoria, was the younger son of Dorothy Alice Archbold (née Fletcher) and the late Stuart James Archbold. The Archbold family was closely associated with the gold-mining town of Chewton in central Victoria where Archbold's Gold Treatment Works had been operated by the Archbold family for over 100 years, commencing with Jeremiah Archbold (1846-1917) and ending with Harry Archbold (1929-1988), a cousin of Neil's father, Stuart. For Neil, sensitive to history, Chewton was an ever-surprising place, breathing with the collective toil of his ancestors. Archbold's was purchased in 1997 by Heritage Council Victoria, renovated by them, and launched on 17 May 2003 as a major heritage feature and tourist attraction, coinciding with an Archbold family reunion. Neil and wife Linda were there for the unveiling. Much as Archbold's was renowned for being able to extract gold from rocks that appeared utterly non-auriferous, Neil proved to be capable of extracting valuable scientific information from the most intractable materials.

Neil and brother Jim were brought up in Mitcham, one of Melbourne's eastern suburbs. As a child Neil was seriously ill, but numerous major operations from when he was eight until he was twelve, undertaken by the renowned surgeon Sir Albert Ernest Coates (1895–1977), saved his life. Sir Albert had put Neil's chances of survival at 2%. In the three years 1958–1961 there had, in fact, been 14 major bouts of surgery. He had been chubby before the operations, but, after that multitude of operations, he resembled a broom-stick and remained that way for the rest of his life.

Neil survived several subsequent operations and was always quick to give credit to his mother's unrelenting attention to him—without her, he insisted, he would never have survived. His mother has commented that every month, every day that Neil lived beyond age 12 was a bonus. And Neil, revelling in being alive, was grateful each morning he awoke, having survived another night. For him—perhaps more conscious of his being as a consequence of the traumas he had been through—every moment seemed imbued with heightened significance. It seemed there was never a moment that he felt life owed him anything.

Neil early displayed a passion for all aspects of natural history, but he had a special love of Lepidoptera and arachnids. As a boy he and brother Jim delighted in rearing Emperor Gum Moths (*Opodiphthera eucalypti*) from their enormous green caterpillars found in eucalypt and peppercorn trees. His passion for natural history and especially Lepidoptera was maintained throughout his life. The Archbold garden in Doncaster in eastern suburban Melbourne featured plants with a long history through time ("living fossils") including *Ginkgo biloba*, *Nothofagus cunninghamii* (myrtle beech), and araucarias. Among Neil's prized living fossils was a King Billy Pine (*Athrotaxis selaginoides*) that he had carried as a seedling from Tasmania.



In order to attract butterflies, the Archbolds, as Neil and brother Jim had done as children, grew an array of stinging nettles, milkweed and other plants that dedicated gardeners would have swiftly uprooted from their gardens. They monitored the swift spread of the introduced European Wasp (*Vespula germanica*) and the corresponding rapid decline to near extinction by the late 1970s of the Emperor Gum Moth in the vicinity of Melbourne.

Because leaf-chewing was viewed as a symptom of a healthy garden, the Archbolds avoided use of garden chemicals. There were no great swathes of butterfly-attracting plants in the Archbold garden: a small clump here, one or two there, mostly like weeds. On one occasion when I visited their home, easily overlooked inhabitants of the Archbold garden included Lesser Wanderers around the milkweed (*Asclepias fruticosa*), Australian Admirals lurking among the stinging nettles (*Urtica* spp.), Painted Ladies checking out everlastings (*Helichrysum* spp.), a Swallowtail or two lured by lemon trees, Imperial Blues and Fiery Jewels attracted by *Acacia* spp. and, inevitably, Cabbage White butterflies looking for cabbages… They exemplified the elemental and meaningful simplicity of the Archbolds' life-style. Neil, as Liz Weldon tells me, even had a special penchant for cream-filled butterfly cakes…

Neil had a passion for collecting stamps and coins. As an ailing boy he developed an unusual pastime of making vast numbers of 30-centimetre-diameter cardboard replicas of coins in his collection. These he would spin into treetops until they lodged among the branches, and would subsequently collect them when dislodged by wind, and again spin them aloft.

Neil relished the music of Stravinsky and the grand classics of Wagner and Mahler, but also had a soft spot for Prokofiev, Shostakovich and Khatchaturian, all of whom had lived under the menacing shadow of Stalin's murderous megalomania. His love of music broadened as he grew older, but never extended to jazz, country and western, heavy metal, rock, reggae, rap or techno.

Neil had little time for contemporary art, but had a deep love of paintings and etchings by the great naturalist artists who had painstakingly and with extreme accuracy depicted flowers, birds, insects, and especially his beloved butterflies. He also had a passion for sailing ships. So much so that in the late 1970s he commissioned notable watercolourist Dorca Charles Sewell to paint, from all available data, the Swedish barque 'La Bella' (also referred to as 'Labella'), which ran aground on a reef about 250 m offshore near the mouth of the Hopkins River at Warrnambool in southwest Victoria on 10 November 1905. There was a family connection with Warrnambool. It is therefore understandable that among Neil's favourite spots where he seemed to draw stimulation were the often-windswept Warrnambool–Port Campbell coast. Other inspirational sites included Canadian Bay at Mount Eliza on the Mornington Peninsula southeast of Melbourne.

During World War II, Neil's father, Stuart, had been an ace fighter pilot. He was one of the first pilots to use rockets, and at one stage ran a dive-bombing school at Mildura. Subsequently, as a commercial pilot, he flew Douglas DC3s, DC4s and DC6s for Australian National Airways and then was one of Air Ceylon's (now Sri Lankan Airlines) initial pilots. He then joined Qantas, flying Super Constellations (which he loved), Electras and Boeing 707s until his retirement in 1975. Stuart was killed at Bacchus Marsh on 12 May 1980 when a glider in which he was the passenger and the towing plane, still linked, suddenly plummeted to earth from an altitude of about 500 ft (about 160 m). Neil and brother Jim coped well with the despair resulting from loss of their legendary father—so tragically, in such a public way.

Australia has almost half the endangered mammal species of the globe. Earth Sanctuaries Ltd, founded by Dr John Wamsley in South Australia in 1985, set about purchasing substantial blocks of land, particularly with remnant native vegetation, fencing them to keep out feral animals and plants, and introducing rare and endangered Australian plants and animals. It is not surprising that such an initiative, focused on restoration ecology, had immediate appeal for Neil and wife Linda. They were early supporters, enthusiastically buying shares in the organization to help purchase additional blocks of land in various habitats—scattered across Australia—to be used as refuges for native Australian flora and fauna. For Neil, causing the death of birds or other animals, large or small, especially for sport, was beyond comprehension.

Neil's secondary school education at Camberwell Grammar School in Canterbury, Melbourne, completed in 1969, included several years of studying Chinese; this was of enormous help when he embarked subsequently on studies of palaeobiogeography of the Asia–Australia region. He maintained contact with his old school, making regular visits, sometimes as an invited speaker. At Melbourne University he undertook degrees of BA, funded by a Commonwealth University Scholarship, MSc and then a PhD, completed in 1983. In 1973 he was awarded the C. M. Tattam Scholarship in Geology and was awarded a University of Melbourne Postgraduate Scholarship (1976–1979) enabling him to undertake a PhD on Permian brachiopods. He was fortunate to have had as postgraduate supervisor the late George Thomas, a genial, fatherly soul of exceptionally broad interests who also had a passion for Carboniferous and Permian brachiopods, especially of Western Australia. Not surprisingly, because of this, Neil's research focused on the spectacular Permian faunas of Western Australia, especially the brachiopods, the most prominent element in most of those faunas. The pleasure he derived from working with these faunas and the associated stratigraphies continued throughout his life, and it was from them that his interests spread so fruitfully into questions of Late Palaeozoic biogeography and intercontinental stratigraphic alignments.

While doing his postgraduate degrees, Neil was employed as a part-time tutor (1973–1980) and then full-time tutor (1980–1982) in the Geology Department of the University of Melbourne. He also tutored for the Council of Adult Education in Melbourne for 17 years (1973–1989) until full-time employment as Lecturer in Earth Sciences at the Rusden campus of Victoria College (incorporated into Deakin University, 1992) finally necessitated relinquishing some of the stimulus he derived from teaching mature-age students. He nevertheless continued to give talks, laced with gentle wit, to amateur groups such as the Field Naturalists Club of Victoria, of which he was a member. For many years (1983–1988) he continued his association with Melbourne University as a Research Associate in its School of Earth Sciences but his new roles at Deakin made continued association with and frequent travel to his *alma mater* increasingly difficult. He had taught Higher School Certificate evening classes at University High School for three years (1977–1980), had temporary employment as a Scientific Services Officer in the Division of Geomechanics with the Commonwealth Scientific and Industrial Research Organization in Melbourne (1983–1986), and had stints as a contract lecturer in the Department of Earth Sciences at Monash University (1984–1988), in the Department of Geology at Melbourne University (1986) and with the Department of Geography and Earth Sciences at the Melbourne College of Advanced Education (1988-1989). Neil was a charismatic tutor and lecturer, loved by all for his kindness and the gentle *joie de vivre* that was characteristic of his lectures; they were never obscure or unintelligible. Nevertheless, a truly permanent academic position somehow seemed to elude him.

The patchwork of short-term teaching commitments came to an end when he was appointed Senior Tutor in Earth Sciences at Victoria College (1989). It was the start of a new and even more dynamic era in which his diverse talents were given free range; a meteoric rise to academic prominence ensued. Within a year he was promoted to Lecturer (1990–1992), then Senior Lecturer (1993–1995) and finally Professor (personal chair) in Earth Sciences (1995–). During that period, Victoria College metamorphosed into a campus of the rapidly expanding Deakin University (1992). Neil became head of the Earth Sciences sector at Deakin (1993–2000).

Neil could never refuse appointment to committees where he felt he might be able to facilitate laudable results. At Melbourne University he was a member of the University Council (1978–1979) and a member of its Committees on Research and Graduate Studies (1978–79), the Library (1978), and the Faculties of Arts and Science (both in 1979). At Victoria College he was a member of Faculty of Applied Science Higher Degrees Committee (1991–1992) and the Faculty of Applied Science Research Committee (1991–1992). At Deakin University, Neil served on a dozen or more committees. This notwithstanding, he continued to pour out research papers at an incredible rate. He was a member of Deakin's Research Committee (1993–1997), its Research Committee's Higher Degree Regulations Working Group (1993), its Faculty of Science and Technology Promotions Committee (1993–1994), its School of Aquatic Science and Natural Resources

Management (AS&NRM) Research and Graduate Studies Committee (1993–1999), and the AS&NRM Board (1994–1999). The list seems endless. At various times he was Acting Chair of the School of AS&NRM, and Acting Head of the Graduate School, Faculty of Science and Technology. Among numerous other committees, he was the Director of Deakin's Research Priority Area "Global Change and Palaeoenvironments" (2000-2003), and for many years (until 2001) Chair of the Faculty Research and Development Committee. He was a member of Deakin's Academic Board and Chair of Deakin's Higher Degree by Research Committee (both 2004 until his death).

When Neil joined Deakin University, its Earth Science discipline was a minor entity focused on undergraduate teaching. He soon developed it into a widely recognized teaching and research group with numerous linkages to national and overseas institutions. Neil tried to be everything at Deakin: researcher, administrator, fund-raiser (principally through the Australian Research Council) and proselytiser—especially for palaeontology, evolution and biostratigraphy.

He enjoyed challenging students to think critically. To first-year students he showed films such as *Armageddon* and *Deep Impact*, requiring them to succinctly critique Hollywood's versions of science. His excursions were always congenial, punctuated by counter lunches at interesting hotels, interludes of sampling products of favourite bakeries, and intense, freewheeling, intellectually bracing—one might say symbiotic—discussions, occasionally punctuated by dry humour. He had the capacity to fill even emptiness with penetrating explanations. There was never a hint of supercilious professorial detachment. The students tended to flock around him like seagulls around a tuna boat. He found such interludes to be a tonic. As he said to me on numerous occasions: "I enjoy nothing more than interacting with my students!"

Neil received several awards for teaching excellence. He supervised numerous Honours and postgraduate students at Deakin as well as at Melbourne University. There were no half measures with his supervision of his research students. Zhong Qiang Chen, one of his former PhD students, has stressed the enormous amount of time Neil would devote to polishing their English, and then, face to face, go through their text, sentence by sentence, to make sure the clearest possible interpretations were being presented. For them he was not only a mentor, but a role model of scientific and personal integrity—amusing, discerning, always optimistic, always supportive (he was never one to throw rotten tomatoes from the sideline). Neil was a reservoir of vast knowledge, a master of the sage perspective.

Neil was disappointed that the keystone of traditional teaching, the benign guru–disciple relationship, of which he was a natural exponent, seemed to be waning rapidly in proportion to the increase—pervading all levels of academia—of a managerial class characterized by few if any scholarly credentials, and not having a clue about nation building. For him, ambitious martinets-cum-philistines seemed to be gaining the upper hand, far and wide, to the potential long-term detriment of Australia. He was glad that Deakin University seemed to be lagging well behind in that regard. Neil felt that what might best be called punitive teaching was also on the increase, with essential content, comprehension and scholarly pleasure being forced to give way to an assortment of academic hurdles including increasingly exhaustive formal progress reports. He deplored the way the Canberra commissars had forced universities to give priority to clever ways of generating money in preference to augmentation of intellectual achievement. He also deplored the way the same largely faceless and anonymous bureaucracy had generated a crescendo of demands for "accountability"—liberally peppered with what Don Watson has aptly defined as weasel words—focusing increasingly on trivia. Neil noted that, partly as a spinoff from this crescendo of administrative onerousness, compassion seemed to have become passé, outmoded. The time for effective lecture preparation, teaching and for deep-rooted research had been seriously diminished.

Neil served as a member of various advisory committees concerned with the School of Mining, Geology and Metallurgy of the Ballarat University College/University (1989–1998) and of the Royal Melbourne Institute of Technology (1991–1998). Among numerous honours was one that gave him great pleasure: his appointment (1994 until his death) as Guest Professor at the China University of Mining and Technology.

Neil was prominent in activities of the International Union of Geological Sciences (IUGS), having been a titular member of its Subcommissions on Gondwana Stratigraphy (1986 until his death) and History of Geology (1992 until his death), as well as corresponding member of the Permian and Carboniferous subcommissions (from 1986 and 1992 respectively). He was co-convenor of the Australian Working Group on "Using Permian mixed biotas as gateways for Permian global correlations", had been a member of the International Geological Correlation Program project 203 on "Permo–Triassic events of the eastern Tethys region and their intercontinental correlation" (1985-1988), and had been a member of the Working Group on the Carboniferous–Permian boundary (1987-1993).

Neil was a member of many scholarly societies, most importantly the Royal Society of Victoria (from 1973), the Geological Society of Australia (from 1973), the Coal Geology Group of the GSA, the Earth Science History Group of the GSA, the Association of Australasian Palaeontologists (AAP), the Paleontological Society (U.S.A) and the Palaeontological Associations of Argentina and Spain. He had been a committee member (1982) and, subsequently treasurer (1983–1985) of the Victorian Division of the Geological Society of Australia (GSA), chairman of the D. E. Thomas Memorial Medal Committee (1985 until his death), a committee member of AAP (1982–83), secretary of AAP (1994–1996), and chairman of the Earth Sciences History Group of the GSA (from 2003). For many years he had been a member of the International Commission on the History of Earth Sciences (INHIGEO). Arguably his most important contribution however was his input to the Royal Society of Victoria as honorary librarian for many years, as a member of Council (1992–2005), as Vice-President (1999–2000) and President (2001–2004). During this time Neil became ringleader in defence of the Society against a concerted effort to deflect it from its traditional scientific focus towards becoming an elite club with minimal scientific involvement. That the society's traditional broad-scale scientific focus was maintained and expanded and that its pre-eminence among the Royal Societies in Australia was enhanced owes much to Neil's efforts.

Neil believed that time spent in anger or bitterness was intolerable but, nevertheless, was profoundly disappointed when his research associateship of the School of Earth Sciences at Melbourne University was terminated at the end of 1998 by the then head of geology, doubtless responding to a dictate from senior management to reduce the large number of research associates having a formal connection with the school. This was particularly disappointing for one who had given so much to his *alma mater*. Neil was also profoundly disappointed when a proposal that he spear-headed from Australian brachiopod workers for running the 5th International Brachiopod Congress in Australia was rejected at the 4th IBC in London (in 2000), mainly by European colleagues reluctant to travel to the Antipodes. Though no alternative venue was tabled, Neil did not take it personally. A similar bid, again spearheaded by Neil, to run the 6th IBC in Australia met with approval from delegates at the 5th IBC meeting in Copenhagen.

From 1985 until his death, Neil had received 15 research grants from the Australian Research Council, and for many years was a diligent assessor of ARC research grant submissions. Initially his ARC grants were concerned with plate tectonic relationships within Australia and between it and its neighbours during Permian times, and with time control on the Permian of the Bowen and Sydney Basins, but soon spread to probing patterns of provinciality and their implications worldwide with principal foci being on India, South-east Asia, the Tibet–Yunnan region of China and, eventually, the Late Palaeozoic of South America. Some of the grants were solo, some, especially on palaeobiogeography, being in association with Guang R. Shi, also of Deakin University. Neil's research association with Guang proved especially fruitful

At the time of his death Neil had produced 205 scientific papers (31 of these as abstracts; 94 as sole author), but with others still coming through "the mill". Evidence of the ease with which he established fruitful communication with colleagues globally is indicated by the 40 or more significant co-authors from at least 20 institutions, scattered globally, involved in 87 of his publications. From his initial core area of research on the taxonomy of Permian brachiopods from Western Australia, he spread into considerations of other taxonomic groups (especially bivalves and trilobites), palaeogeography and palaeobiogeography, palaeoclimatology and palaeoecology, oceanic circulation patterns, and global stratigraphic alignments for the Permian and, later, Carboniferous systems. His numerous publications in these areas, especially on palaeobiogeography, contained many commendable exercises in quantitative palaeobiogeography with Guang R. Shi. These were based on a monumental, six-part critical listing of all Permian brachiopod taxa from the Western Pacific Region, compiled mostly by Guang and himself—though with collaboration from Shuzhong Shen for the last two parts—and published by the School of Applied Science and Natural Resources Management, Deakin University (1993–1997). These compilations were major items within a constant stream of taxonomic papers on Late Palaeozoic brachiopods from around the world: the Northern Territory, Timor, Irian Jaya, Thailand, China (Xinjiang, South China, Tibet and West Yunnan), Argentina, India, Russia and Serbia that included a series of papers (numbered 1 to 14, 1980–1997) on the taxonomy of Permian brachiopods from Western Australia, published in the Proceedings of the Royal Society of Victoria. Neil's taxonomic output included documentation of more than 150 new species, nearly 40 new genera and subgenera, five new subfamilies and one new family of brachiopods as well a new species of trilobite and one of bivalves. The brachiopod world has included several workaholics whose published output was gargantuan: James Hall, G. Arthur Cooper, Vladímir Havlíèek and a great contemporary, Art Boucot. Neil was very much one of the same ilk, producing six, seven or more significant publications a year.

During the 1980s, when concerned with Permian faunas from various localities in Timor, Irian Jaya and Papua New Guinea, Neil came across the work of Richard Archbold (1907–1976), an heir to early fortunes of the Standard Oil Company. Richard, an American who had led and provided most of the funding for four major biological-cum-anthropological expeditions (1929–1939)—the first to Madagascar and the subsequent three to inland New Guinea—became one of Neil's heroes. The question of whether or not Richard was a far distant relative of the Australian Archbolds was never resolved.

Neil derived much pleasure from documenting the palaeontology of the marine incursion into the Permian glacially-derived sequences of the Bacchus Marsh district in Victoria; this incursion had escaped more than 150 years of intermittent investigations by many workers. Neil was knowledgeable on the Cenozoic stratigraphy of southeastern Australia, publishing a modicum of work on Cenozoic brachiopods, echinoids and marsupials. One of his major achievements was a pivotal role in publication (1995) during the height of the Yugoslav wars of a comprehensive volume in Serbian and English on the Carboniferous of northwest Serbia by six authors, with himself and Smiljana Stojanoviæ-Kuzenko contributing the large and copiously illustrated chapter on brachiopods.

Neil, the idealist, was amazed by the long and hideous history of colonialism, its savagery, megalomania, and terrible sagas of rule by coercion. He was appalled by the forces of chaos and brutality that continue to overtake the lives of individuals and nations, as had occurred in India during partition and in recent years in Rwanda, Afghanistan, Chechnya and the former Yugoslavia. He was dumbfounded by the ideological extremism, rampant greed and perilous shortsightedness of the contemporary western world. He was astonished by political extremism born out of foreign occupation, and the more recent saga of the absurd: warrior intellectuals hunting desperately beneath Iraqi prayer rugs for *post hoc* justification of a frivolous war. Neil took heart, however, that in Moorish Spain, Norman Sicily and in Sarajevo (before the Bosnian War, 1992–1995) it had been possible for profoundly differing cultures and religions to live together for a long time in comparative harmony.

Neil believed there was no need for religion and science to be in conflict, to be invariable antagonists. He was convinced that the loud, irrational, fundamentalist voices, with their potential for engendering violence—and presently demanding a choice be made—are not representative of the mainstream Judaeo–Christian–Muslim religious communities, nor for that matter of any other sizeable religious group. Neil was tolerant of the entire spectrum of religious persuasions. He had come from a liberal Presbyterian background, but this connection had waned with time. He was a scientist to the core, the immensity of time and the vast panorama of organic evolution, from primitive prokaryote to modern man, ecosystems, and ultimately to the biosphere itself, never ceasing to fascinate him; the swift revival of doctrinaire creationism and its latest expression, intelligent-design theory—untestable, based on discredited science—to dismay him. Neil viewed the creationist *risorgimento* as largely the same old stuff: William Paley dressed up with a more sophisticated set of feathers.

Neil had a passion for history, global as well as Australian, and could discourse profoundly on seemingly unrelated topics ranging from the history of the Austro-Hungarian Empire, the Soviet Union, and the Australian gold-rush era—and the architectural artefacts of the last of these. With such interests it was inevitable that he would become a Life Member of the National Trust of Australia (Victoria). He had a passion for old books and antique maps, especially ancient scientific monographs, not just tomes connected with his research, but icons of publishing elegance. Neil had an aversion to the published word being turned back into pulp—apart from newspapers, dumbed-down journalism, and breathless discoveries of the obvious. His immense professional library, including a vast number of reprints and photocopies, has been gifted to the Royal Society of Victoria. The Society has agreed to it being housed under lock-and-key as a special collection in the Deakin University library.

Throughout his career Neil had probed the early history of the earth sciences in Australia, publishing papers on the debate over the age of the black coals, the history of vertebrate palaeontology in Australia, the 1874 and 2004 transits of Venus, and on Sir Frederick M'Coy, J. E. Tennison Woods, Joseph Jukes and the remarkable brachiopod worker, Georgiy Nikolaevich Frederiks, a gentle apolitical palaeontologist-stratigrapher-tectonicist executed during the Great Terror in Stalinist Russia early in 1939. Neil's research in the history of the earth sciences became enriched during his later years from association with Doug McCann. Neil had planned, with Doug, to generate an account of the emergence of the theory of continental drift and its transmutation into plate tectonic theory. As Doug has reminded me, Neil particularly revelled in his investigations into the "coal debate", discovering that the history, as presented until now, had, curiously, been completely biased—skewed well away from what was the true story. Neil sought better understanding of why various events in the history of the earth sciences in Australia had been pitched in particular ways, and how their depiction had been coloured by underlying human motivations.

Neil was thoroughly steeped in the history of the geological surveys of Australia during the 1800s, especially those of Western Australia and Victoria and, early in his career, had published on the history of the former. The geologists of Alfred Selwyn's Geological Survey of Victorian (1852–1868) and subsequent Victorian geological survey groups during the later 1800s were Neil's heroes. Of particular interest was James Stirling (1852–1909), a notably benign person, a self-taught geologist, botanist, and elegant draftsman who, *inter alia*, published significant accounts of the alpine flora of Victoria. He had been, briefly, a monumental mason, an architectural draftsman and, subsequently, the Lands Department surveyor at Omeo. James was loved by the mining communities of northeastern Victoria, so much so that the gold miners of the Haunted Stream goldfield (which he had done much to develop) insisted their principal village be named Stirling in his honour. James had remarkably modern views on education and equality of the sexes, had enthusiastically accepted the then new theory of organic evolution, and relished giving "adult education" lectures on science and technology. His was a family fascinated by the natural world—birds, insects, flowers and geology—as well as anthropology. Neil believed that Stirling, who became Government Geologist (1897-1900) under Alfred W. Howitt, Secretary for Mines, had been undervalued, especially for his vigorous and pivotal role in the quest for black coals in the south Gippsland Early Cretaceous rock sequences (at that time believed to be Jurassic), and for pioneer investigations of the Latrobe Valley brown coals.

Howitt (1830–1908), earnest, elitist, was an efficient administrator, explorer and remarkable pioneer anthropologist and, like Stirling, was also an amateur geologist and botanist of note. This may have been the root of what seems to have been Howitt's distaste for Stirling, but he may have been irked by Stirling's remarkably liberal views for the late 1800s. Howitt, at least in old age, was not good in personal relationships, was given to sourly dismissive comment (perhaps heightened from long and bitter denigration by armchair anthropologist Andrew Lang), and was reluctant to accept new data calling for modification of his earlier geological opinions. He seems to have been detested by his geologist underlings, among them William Baragwanath Jr. (pers. comm., 1964) and Ernest Lidgey. Neil, more a kindred spirit of the genial James than the crusty Alfred, had hoped that he and Doug McCann might produce something substantial—liberally illustrated by examples of Stirling's elegant drafting—to help "set the record straight". Doug has informed me that Neil would have loved also to have helped rehabilitate other neglected, maligned and misunderstood Victorian geologists and palaeontologists, among them J. W. Gregory and Sir Frederick McCoy. He wanted to devote more time to bringing them back to life, to reclaiming the truth.

Neil inherited and greatly enjoyed driving a 1962 Humber Vogue car that had been his grandmother's. Reluctantly he had to part with it when upkeep and difficulties in obtaining spare parts became too great. He was a member of the Olive Club, a light-hearted intellectual group of scientists, judges, architects, librarians and engineers which has three-monthly meetings over dinner to discuss matters of general interest, some of moment, some inconsequential. He was also a member of the Skeptics, the Field Naturalists Club of Victoria, a literary coterie known as the Boobooks Club, and the venerable Wallaby Club (founded 1894), an organization conducting day walks and, like the Olive Club, focused on serious, but lively discussion.

Neil's marriage to Linda Botham in 1984 was pivotal for his career. She made their home in Doncaster not only a base, but a haven. Her unflagging support enabled him to focus to great effect on his increasingly vast spectrum of interests. Despite frail health, he travelled overseas to participate in conferences in Argentina, Australia, Canada, Denmark, England, New Zealand, the Netherlands, Oman, South Africa and the former USSR (Tartaria) where he was delighted to find our joint paper (with Viktor Z. Machlin) on the ill-fated G. N. Frederiks, executed with other noteworthy earth scientists by order of Stalin, displayed prominently in an exhibition mounted at Frederiks's *alma mater*, the University of Kazan'—in czarist times one of the elite Imperial Universities.

The University of Kazan' mounted a memorable meeting of the Subcommission on Permian Stratigraphy in 1998. The entire meeting took place by boat. The participants, committed to geniality, presented papers and gourmandized their way—sturgeon, caviar and marvellous fruit that was not only delicious, but eminently photogenic—down the Volga from Kazan' to historic Permian localities including ones at the centre of Frederiks's earlier works. Among them was Simbirsk (later Ul'yanovsk; now Simbirsk again), former home of the Ul'yanovs, a polite middle-class family with a high sense of social responsibility whose six children included Aleksandr, a brilliant zoology student, and Vladimir (later to become V. I. Lenin). Aleksandr, among 15 confederates, nearly all students, arrested and accused of plotting to assassinate Czar Aleksandr III, refused to recant his reformist beliefs and was callously hung at age 21 with four other conspirators by a government committed to meeting terrorism and savagery with even greater barbarism. His execution on 5 May 1887 transformed the surviving children and especially Vladimir into committed revolutionaries. Neil was disappointed that presentation of the Ul'yanov home in 1998, though interesting, had yet to rise above Soviet-era politics and mythology.

In late 1997 (30 November–3 December) Neil was joint-organiser of the Strzelecki International Symposium on "The Permian of Eastern Tethys" in Melbourne, and was one of the three editors of the large volume derived from that meeting and published a year later by his beloved Royal Society of Victoria.

Neil still had a large palette of interesting and ambitious research to be done, but he was looking forward to early retirement at the end of 2005, to a life with fewer deadlines, fewer life-and-death appointments, less forward-planning, and with more peace of mind, but his frailty was increasing. Colleagues on the Gotland excursion of the Fifth International Brachiopod Congress (4–8 July 2005) had noted how Neil, cheerful as ever, but perhaps more wraithlike in appearance, was unable to walk far without stopping to regain breath.

In later years Neil travelled to Argentina three times and established very warm research and personal linkages with colleagues in Argentina, four of whom visited Australia and became firm family friends: Tristan Simanauskas, Gabriela Cisterna, Arturo Taboada and Alejandra Pagani. Neil was much attracted by Argentina, a land of religion, culture and strong family ties with a tumultuous history, chameleon-like politics, and a determination to make a new future after the military dictatorship of the 1970s. Neil fell ill following participation in Gondwana 12, the Twelfth International Gondwana Congress (6–11 November 2005), in Mendoza, Argentina, at which he made a conference presentation. Argentinian colleagues rushed to Mendoza to help in every possible way but, after two weeks in hospital, on 28 November at the Clinica de Cuyo in Mendoza, with wife Linda at his bedside, he passed away. A large community of friends—about 300 of them—participated in a memorial service at Wantirna, an outer suburb of Melbourne, on 14 December 2005.

The connecting thread through Neil's odyssey had been pragmatism, a journey that nevertheless found beauty in virtually every corner. He nevertheless was saddened by the consumer culture gone wild—rich in goods, but poor in everything that gives breadth and depth to a community—and our increasingly free-floating and more and more dangerous world. Neil was inspirational because he was a people-person, always concerned with the people-side of things. He would discourse equally kindly with anyone: shy or confrontational, couth or uncouth, brilliant or belligerently dumb, as well as the genial slacker, the ambitious twit, and that fortunately rare breed, the insolent impostor. The last of these—he had met a few—amazed him. Neil had a genuine social conscience, a humanism that looked kindly on even the hardest face.

Neil, one of the most talented and admired earth scientists in Australia, was tenacious and meticulous, a tireless and profound figure who never lost sight of the magic of the world around him, and courageously evaluated and took on board new data and new theories. His curiosity drove him to diversify. He loved innovation but, in this age of over-amplification, he was wary of fashion. His devotion to his science and his willingness to share his knowledge and expertise—and tirelessness in doing so—set him apart. Though unflaggingly self-critical and self-effacing, he had a consuming desire to produce and produce. As a scientist there was a momentum to him; he seemed unstoppable. He drove himself unsparingly. He revelled in being alive; he revelled in the musicality of words. Neil's physical frailty and bouts of illness had made him more tolerant than most of us and more compassionate. In this he paralleled another great brachiopod worker, a long-time friend of mine, the late J. G. ('Jess') Johnson of the State University of Oregon, Corvallis. Jess produced voluminously and perceptively throughout most of a professional career attached to artificial diaphragms. Such people are role models for all of us, even the physically able-bodied.

Neil's all-too-brief career is thus a lesson on the capacity of an individual to quietly bring about change. Those who knew Neil were always amazed by his buoyancy, despite his manifest frailty. His ingrained empathy for the human condition and his profound sense of social responsibility seemed to become more resilient as time went on. There were surely moments of despair but, if so, he kept these to himself. Neil was unique—inimitable, irreplaceable.

It was appropriate that Neil's ashes should be scattered in Chewton, *locus* of so much Archbold history. Among the numerous historic features in and near Chewton is the immense Garfield waterwheel about a kilometre north of the town, reputedly the largest waterwheel in the Southern Hemisphere. It was there that Neil's ashes were scattered by his brother Jim.

Compilation of this obituary has been facilitated by information supplied by Neil's wife Linda, his brother and sister-in-law Jim and Sue, Monica Campi, Doug McCann and Guang Shi, supplemented by illuminating reminiscences from Zhong Qiang Chen, Bernie Joyce, Fons VandenBerg and Liz Weldon. All helped balance my perspective.

John A. Talent
Macquarie University

Obituaries for N. D. Newell, J. M. Dickins, and N. W. Archbold

Bruce Waterhouse

25 Avon Street, Oamaru, New Zealand

The year 2005 saw the death of three international paleontologists who amongst other fields of research, concerned themselves with Permian stratigraphy, fossils and correlations on a world scale.

Norman Newell spent most of his career at the American Museum of Natural History, New York, where he taught paleontology to generations, of whom many became distinguished paleontologists and geologists. Nils Eldredge, who succeeded Norman at the museum, recorded in a New York Times obituary how Norman, contrary to at least some expectations, hammered the theme of extinctions rather than evolution: eventually Nils and Stephen Gould realized the significance of Norman's message, in proposing their theory of punctuated equilibria for explaining the spasmodic changes in life, separated by often long still-stands. Norman naturally helped organize the Permian/Triassic conference in Calgary in 1971 (Canadian Society of Petroleum Geologists, Memoir 2, 1973) that marked a significant step towards full recognition of the extinction shock at the end of the Permian Period. And he undertook the defence of evolution against creationist muddlements. But most of his career, apart from an innovative time studying Permian reefs, was absorbed in describing bivalve fossils, mostly Permian, many Carboniferous or Triassic, especially from the United States, and also from Japan, Brazil, Australia, with attention to European and even New Zealand fossils (Fossils of the then-Soviet Union figured little!). He co-operated in several outstanding studies, such as with Keiji Nakazawa and Bruce Runnegar, and since the 1970's, worked closely with Donald Boyd of Wyoming, scrutinizing generally new material, patiently and luminously unravelling the course of evolution amongst bivalves. What is most extraordinary about Norman's contributions is the sheer number of years devoted to research. After early days interpreting aerial photographs, he launched into two still highly regarded and seminal studies on "Pectinacea" and "Mytilacea" mostly from US Carboniferous, the first published in 1937. In 1995 he published with Donald Boyd a study on chiefly Permian Pectinida, daring in its innovations in classification, when in his mid-eighties. The last paper sent to me is dated 2002. So there have been more than 65 years of new and intriguing discoveries. There have been few who can match such a record, and we can salute the mental alertness, the drive, the discipline in going on, instead of turning to an easier and less demanding life style.

Norman and I first met in 1964, in Calcutta, India, where we were examining the great collections of Permian fossils kept at the Geological Survey of India. There we joined by Mac Dickins from the Bureau of Mineral Resources, Geology and Geophysics, Canberra. Mac and I had known each other since the mid-fifties. We three then teamed up to go to the Salt Range in Pakistan, and the adventures we shared are relayed in an early N. Z. Geological Society newsletter, published about 1965. We had to pass through a village hostile to foreigners – or geologists, and we escaped on our way to Chhidru in a shower of stones. On our way back after a successful day, we recruited the Chhidruans to act as guard: they mounted camels and brandished rifles, and through the bad guy village we stormed, dust and stones and rifle shots. The Chhidruans were notorious in the district, hadn't paid taxes for years, and no doubt they recognized fellow ruffians in us geologists. Mac was another bivalve specialist. I still recall Charles Fleming, my boss in the New Zealand Geological Survey, warning me in horrified tones that Mac was politically unsound. Whether so, I have no idea, as we seemed to find more immediate concerns to talk about. What remains memorable about Mac was his quiet manner, shrewd if perhaps iconoclastic or even idiosyncratic approach, and delightful self-deprecating smile. Mac came out with his finest study in 1963 on west Australian molluscs, a still outstanding work, and later spent considerable time using bivalves to characterize Permian stratigraphy in east Australia. He assumed an important role in Gondwana geology, serving as President of the Gondwana Symposium organization for many years. He also delighted in poring over nineteenth century collections of British Carboniferous bivalves, being convinced (like me) that they contained the forebears of Australian Permian bivalves. He further paid scrupulous attention to Soviet studies (ah ha??) and combined in an excellent study in 1992 with Noel Morris and Kira Astafieva-Urbaiitis on the evolution of anomalodesmatan bivalves worldwide.

Neil Archbold was much younger than the other two; he died during a Gondwana field-trip in Argentina, and really was not well during the conference meetings. Neil had had to struggle against ill-health all his working life, even in the early seventies when I first met him as a student of George Thomas at Melbourne University. Despite these difficulties, Neil was courteous, good-humoured, and insightful, with a wide range of interests, as displayed by his historical researches and the important role he played in the Royal Society of Victoria. In paleontology, Neil shaped an outstanding career, on mostly Permian brachiopods. First he delivered an impressive array of papers on brachiopods (especially Productida and Spiriferida) from Western Australia, and later he extended his research first into Timor and Indonesia, then into South America and into southeast Asia, mostly Thailand and Tibet. Becoming a Professor in a college of Deakin University, Melbourne, he set up a dynamic group of excellent staff, and brought in advanced and brilliant students especially from China and South America, as well as Australia. He named more than forty new genera, the agreed mark of a significant contribution in paleontology according to R. E. Grant (1980, The human face of the brachiopod, Presidential Address for the Paleontological Society, Journal of Paleontology 54: 499-507), as well as new species and family group categories. There was more to Neil in his record of service. It was he who helped fund from his resources an important publication by David Briggs on east Australian brachiopods as a memoir for the Association of Australasian Palaeontologists. He also showed considerable courage and integrity, for he was not always well treated by his peers. Shamefully, papers were rejected or severely refereed because he refused to join the witch-hunt that ludicrously sought to remove the controversial V. J. Gupta from the scientific record. With his growing knowledge of Himalayan brachiopods, Neil was aware that Gupta, whatever his faults (and they were surely many), had been involved in publishing valid taxa from the Himalayas, and such taxa, no matter who authored them, should not be ignored.

As a mark of the esteem in which he was held, he was asked at the last brachiopod conference (in 2005) to host and organize the next conference at Deakin. All at the meetings were thrilled that Neil should be so chosen. Alas, too late.

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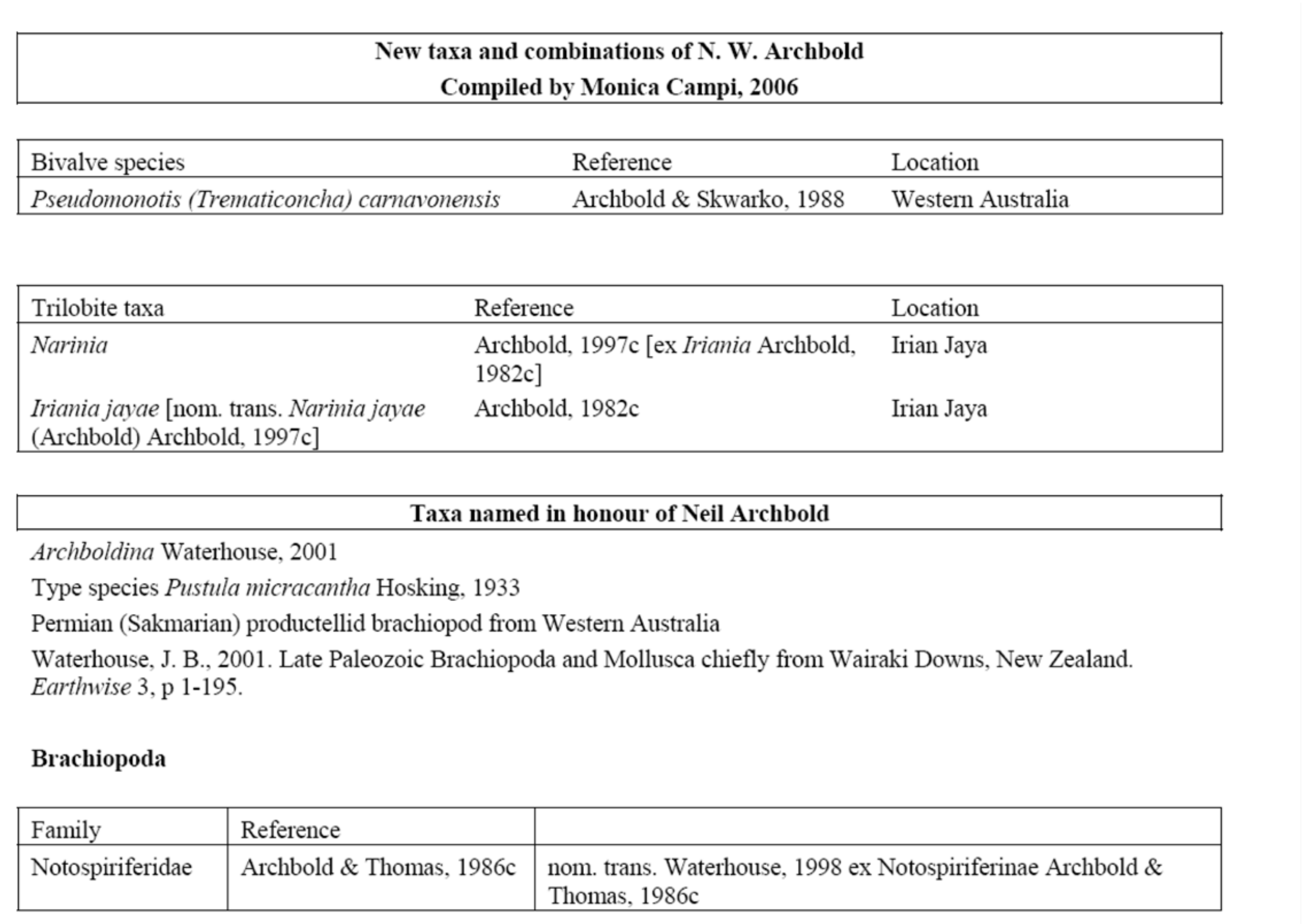

New taxa and combinations of N. W. Archbold
Compiled by Monica Campi, 2006

Bivalve species	Reference	Location
Pseudomonotis (Trematiconcha) carnavonensis	Archbold & Skwarko, 1988	Western Australia

Trilobite taxa	Reference	Location
Narinia	Archbold, 1997c [ex *Iriania* Archbold, 1982c]	Irian Jaya
Iriania jayae [nom. trans. *Narinia jayae* (Archbold) Archbold, 1997c]	Archbold, 1982c	Irian Jaya

Taxa named in honour of Neil Archbold

Archboldina Waterhouse, 2001

Type species *Pustula micracantha* Hosking, 1933

Permian (Sakmarian) productellid brachiopod from Western Australia

Waterhouse, J. B., 2001. Late Paleozoic Brachiopoda and Mollusca chiefly from Wairaki Downs, New Zealand. *Earthwise* 3, p 1-195.

Brachiopoda

Family	Reference	
Notospiriferidae	Archbold & Thomas, 1986c	nom. trans. Waterhouse, 1998 ex Notospiriferinae Archbold & Thomas, 1986c

Subfamilies (5)	Reference	Name genus
Caenanopliinae	Archbold, 1980b	*Caenanoplia* Carter, 1968
Glottidiinae	Archbold, 1981b	*Glottidia* Dall, 1870
Mingenewiinae	Archbold, 1980a	*Mingenewia* Archbold, 1980a
Notospiriferinae	Archbold & Thomas, 1986c	*Notospirifer,* Harrington, 1955
Quinquenellinae	Archbold, 1981d	*Quinquenella* Waterhouse, 1975
Svalbardiinae	Archbold, 1982a	*Svalbardia* Barkhatova, 1970

Subgenera (8)	Reference	Type species
Echinalosia (Notolosia)	Archbold, 1986c [later transferred to generic rank]	*N. dickinsi* Archbold, 1986c
Heteralosia (Etherilosia)	Archbold, 1993b [later transferred to generic rank]	*Strophalosia etheridgei* Prendergast, 1943
Neochonetes (Huangichonetes)	Shen & Archbold, 2002	*Chonetes substrophomenoides* Huang, 1932
Neochonetes (Nongtaia)	Archbold, 1999a	*Neochonetes (Nongtaia) taoni* Archbold, 1999a
Neochonetes (Sommeriella)	Archbold, 1982f [ex *Neochonetes (Sommeria)* Archbold, 1981e]	*Chonetes pratti* Davidson 1859
Neochonetes (Zechiella)	Archbold, 1999a	*Chonetes davidsoni* von Schauroth 1856
Neochonetes (Zhongyingia)	Shen & Archbold, 2002	*Neochonetes zhongyingensis* Liao, 1980
Neospirifer (Quadrospira)	Archbold, 1997e	*Neospirifer plicatus* Archbold & Thomas, 1986a

Genera (33)	Reference	Type species
Argentiella	Archbold, Cisterna & Sterren, 2006	*Argentiella stappenbecki* Archbold, Cisterna & Sterren, 2006
Aurilinoproductus	Shen, Shi & Archbold, 2003a	*Aurilinoproductus alatus* Shen, Shi & Archbold, 2003a
Balikunochonetes	Chen & Archbold, 2002	*Balikunochonetes liaoi* Chen & Archbold, 2002
Callytharrella	Archbold, 1985b	*Dictyoclostus callytharrensis* Prendergast, 1943
Carilya	Archbold, 2001h	*Taeniothaerus miniliensis* Coleman, 1957
Cimmeriella	Archbold & Hogeboom, 2000	*Productus tenuistriatus* de Verneuil var. *foordi* Etheridge, 1903
Coolkilella	Archbold, 1993b	*Cancrinella coolkilyaensis* Archbold, 1983e
Costatispirifer	Archbold & Thomas, 1985a	*Costatispirifer gracilis* Archbold & Thomas, 1985a
Crassispirifer	Archbold & Thomas, 1985a	*Spirifer rostalinus* Hosking, 1931
Cratispirifer	Archbold & Thomas, 1985a	*Cratispirifer nuraensis* Archbold & Thomas, 1985a
Cundaria	Archbold, 1996d	*Cundaria aquilaformis* Archbold, 1996d
Etherilosia	Archbold, 1993b [nom. trans. ex *Heteralosia (Etherilosia)* Archbold, 1993b]	*Strophalosia etheridgei* Prendergast, 1943
Gatia	Archbold, 1993b	*Gatia suberba* Archbold, 1993b
Gruntea	Shi, Shen & Archbold, 1999	*Posicomta grunti* Shi & Shen, 1997
Guadalupelosia	Archbold & Simanauskas, 2001	*Strophalosia inexpectans* Cooper & Grant, 1975

Imperiospiria	Archbold & Thomas, 1993	*Imperiospira fransjosefi* Archbold & Thomas, 1993
Jinomarginifera	Shen, Shi & Archbold, 2003b	*Jinomarginifera lhazeensis* Shen, Shi & Archbold, 2003b
Latespirifer	Archbold & Thomas, 1985a	*Latespirifer callytharrensis* Archbold & Thomas, 1985a
Liveringia	Archbold, 1987b	*Liveringia magnifica* Archbold, 1987b
Lyonia	Archbold, 1983e	*Linoproductus cancriniformis* var. *lyoni* Prendergast, 1943
Mingenewia	Archbold, 1980a	*Mingenewia anomala* Archbold, 1980a
Nakimusiella	Shen, Archbold, Shi & Chen, 2001b	*Nakimusiella selongensis* Shen, Archbold, Shi & Chen, 2001b
Neopsilocamara	Shen, Archbold, Shi & Chen, 2001b	*Neopsilocamara laevis* Shen, Archbold, Shi & Chen, 2001b
Notolosia	Archbold, 1986c [nom. trans. ex *Echinalosia (Notolosia)* Archbold, 1986c]	*N. dickinsi* Archbold, 1986c
Occidalia	Archbold, 1997c	*Occidalia shahi* Archbold, 1997c
Santanghuia	Chen & Archbold, 2002	*Santanghuia santanghuensis* Chen & Archbold, 2002
Syrella	Archbold, 1996d	*Syrella occidenta* Archbold, 1996d
Tethyochonetes	Chen, Shi, Shen & Archbold, 2000	*Waagenites soochowensis quadrata* Zhan, 1979
Tivertonia	Archbold, 1983c	*Lissochonetes yarrolensis* Maxwell, 1964
Tupelosia	Archbold & Simanauskas, 2001	*Tupelosia paganzoensis* Archbold & Simanauskas, 2001
Waterhousiella	Archbold, 1983e	*Waagenites speciosus* Waterhouse & Piyasin, 1970
Woolagia	Archbold, 1997e	*Woolagia playfordi* Archbold, 1997e
Wooramella	Archbold (in Hogeboom & Archbold, 1999)	*Pustula senticosta* Hosking, 1933

Species (156)	Reference	Location
Aulosteges tenuispinosus	Archbold, 1991b	Irian Jaya
Argentiella stappenbecki	Archbold, Cisterna & Sterren, 2006	Argentina
Aurilinoproductus alatus	Shen, Shi & Archbold, 2003a	Tibet
Balikunochonetes liaoi	Chen & Archbold, 2002	Xinjiang, northwest China
?Bullarina striata	Shen, Archbold, Shi & Chen, 2001b	Tibet
Callytharrella khalii	Archbold & Barkham, 1989	Timor
Cancrinella coolkilyaensis	Archbold, 1983e	Western Australia
Cancrinella irwinensis	Archbold, 1983e	Western Australia
Cartorhium imperfectum	Archbold, 1993b	Western Australia
Chonetinella aidunaensis	Archbold, 1991b	Irian Jaya
Chonetinella ainimi	Archbold, 1982d	Irian Jaya
Cleiothyridina perthensis	Archbold, 1997e	Western Australia
Comuquia australis	Archbold, 1984b	Western Australia
Coolkilella maitlandi	Archbold, 1996d	Western Australia
Coronalosia argentinensis	Archbold & Simanauskas, 2001	Argentina
Costatispirifer gracilis	Archbold & Thomas, 1985a	Western Australia
Costatumulus occidentalis	Archbold, 1993b	Western Australia

Costatumulus sahnii	Singh & Archbold, 1993	eastern Himalaya
Costatumulus shengmiensis	Shen, Archbold & Shi, 2001a	Tibet
Costatumulus tazawai	Shen, Archbold, Shi & Chen, 2001b	Tibet
Costiferina thomasi	Archbold, 1985b	Western Australia
Craniscus tasmaniensis	Archbold, 1991d	Tertiary of Tasmania
Crassispirifer condoni	Archbold & Shi, 1993	Western Australia
Crassispirifer mingenewensis	Archbold, 1996d	Western Australia
Crassispirifer pinguis	Archbold & Thomas, 1985a	Western Australia
Cratispirifer nuraensis	Archbold & Thomas, 1985a	Western Australia
Cundaria aquilaformis	Archbold, 1996d	Western Australia
Cyrtella koopi	Archbold, 1990	Western Australia
Demonedys granti	Archbold, 1980b	Western Australia
Dyschrestia colemani	Archbold, 1984b	Western Australia
Echinalosia denisoni	Archbold, 1987b	Western Australia
Echinalosia simpsoni	Archbold, 1996d	Western Australia
Eliva timorensis	Archbold & Bird, 1989	Timor
Elivina bisnaini	Archbold & Barkham, 1989	Timor
Elivina hoskingae	Archbold & Thomas, 1985b	Western Australia
Elivina yunnanensis	Shi, Fang & Archbold, 1996b	western Yunnan
Etherilosia calytrixi	Archbold, 1996c	Western Australia
Etherilosia carolynae	Archbold, 1996c	Western Australia
Etherilosia convexa	Shen Shi & Archbold, 2003a	Tibet
Fusispirifer carnavonensis	Archbold & Thomas, 1987	Western Australia
Fusispirifer coolkilyaensis	Archbold & Skwarko, 1988	Western Australia
Fusispirifer cundlegoensis	Archbold & Thomas, 1987	Western Australia
Fusispirifer kennediensis	Archbold & Thomas, 1987	Western Australia
Fusispirifer legrandblainae	Archbold & Thomas, 1987	Afghanistan
Fusispirifer quinnaniensis	Archbold & Thomas, 1987	Western Australia
Fusispirifer wandageensis	Archbold & Thomas, 1987	Western Australia
Gatia suberba	Archbold, 1993b	Western Australia
Globiella youwangensis	Shi, Fang & Archbold, 1996b [referred to *Cimmeriella foordi* (Etheridge) by Archbold & Hogeboom, 2000]	western Yunnan
Hoskingia qomolangmaensis	Shen, Shi & Archbold, 2003a	Tibet
Hoskingia skwarkoi	Archbold, 1997e	Western Australia
Imperiospira campbelli	Archbold & Thomas, 1993	Western Australia
Imperiospira dickinsi	Archbold & Thomas, 1993	Western Australia
Imperiospira fransjosefi	Archbold & Thomas, 1993	Western Australia
Jakutoproductus australis	Simanauskas & Archbold, 2002	Argentina
Jinomarginifera lhazeensis	Shen, Shi & Archbold, 2003b	Tibet
Kitakamithyris kartagensis	Chen & Archbold, 2000	Xinjiang, northwest China
Krotovia inflata	Shen, Archbold, Shi & Chen, 2001b	Tibet
Latespirifer amplissimus	Archbold & Thomas, 1985a	Western Australia
Latespirifer callytharrensis	Archbold & Thomas, 1985a	Western Australia
?Lethamia obscurus	Archbold, 1984b	Western Australia
Lingula occidentalis	Archbold, 1981b	Western Australia

Linoproductus pigrami	Archbold, 1982d	Irian Jaya
Liveringia magnifica	Archbold, 1987b	Western Australia
Magniplicatina gigantea	Shen, Shi & Archbold, 2003a	Tibet
Megasteges geniculatus	Shen, Shi & Archbold, 2003a	Tibet
Mingenewia anomala	Archbold, 1980a	Western Australia
Nakimusiella selongensis	Shen, Archbold, Shi & Chen, 2001	Tibet
Neochonetes (Nongtaia) taoni	Archbold, 1999a	Thailand
Neochonetes (Sommeriella) afanasyevae	Archbold, 1981e	Western Australia
Neochonetes (Sommeriella) cockbaini	Archbold (in Archbold & Shi, 1993)	Western Australia
Neochonetes (Sommeriella) hardmani	Archbold, 1993b	Western Australia
Neochonetes (Sommeriella) hockingi	Archbold, 1991c	Western Australia
Neochonetes (Sommeriella) irianensis	Archbold, 1991b	Irian Jaya
Neochonetes (Sommeriella) magnus	Archbold, 1997e	Western Australia
Neochonetes (Sommeriella) marpoensis	Archbold & Gaetani, 1993	Northwest Himalaya, India
Neochonetes (Sommeriella) nalbiaensis	Archbold, 1993b	Western Australia
Neochonetes (Sommeriella) obrieni	Archbold, 1996c	Western Australia
Neochonetes (Sommeriella) regularis	Shen, Archbold, Shi & Chen, 2001b	Tibet
Neochonetes (Sommeriella) robustus	Archbold, 1981e	Western Australia
Neochonetes (Sommeriella) tenuicapillatus	Archbold, 1981e	Western Australia
Neochonetes fredericksi	Archbold, 1979 [nom. nov. for *Chonetes tenuistriatus* Fredericks, 1926 non *Chonetes tenuistriata* Hall, 1860]	USSR
Neopsilocamara laevis	Shen, Archbold, Shi & Chen, 2001b	Tibet
Neospirifer (Quadrospira) woolagensis	Archbold, 1997e	Western Australia
Neospirifer amplus	Archbold & Thomas, 1986a	Western Australia
Neospirifer foordi	Archbold & Thomas, 1986a	Western Australia
Neospirifer grandis	Archbold & Thomas, 1986a	Western Australia
Neospirifer plicatus	Archbold & Thomas, 1986a	Western Australia
Neospirifer postplicatus	Archbold & Thomas, 1986a	Western Australia
Notolosia dickinsi	(Archbold, 1986c) [*Echinalosia (Notolosia) dickinsi* Archbold, 1986c]	Western Australia
Notolosia millyiti	(Archbold, 1988e) [*Echinalosia (Notolosia) millyiti* Archbold, 1988b]	Western Australia
Occidalia shahi	Archbold, 1997e	Western Australia
Phricodothyris occidentalis	Archbold & Thomas, 1984b	Western Australia
Quinquenella australis	Archbold, 1981d	Western Australia
Quinquenella magnifica	Archbold, 1982e	Irian Jaya
Quinquenella semiglobosa	Shen, Archbold & Shi, 2001a	Tibet

Retimarginifera waterhousei	Archbold, 1984c	Western Australia
Retimarginifera xizangensis	Shen, Archbold, Shi & Chen, 2001b	Tibet
Rhynchopora australasica	Archbold, 1996c	Western Australia
Santanghuia santanghuensis	Chen & Archbold, 2002	Xinjiang, northwest China
Spirelytha fredericksi	Archbold & Thomas, 1984b	Western Australia
Spirelytha kashirtsevi	Archbold, 1993b	Western Australia
Spirelytha miloradovichi	Archbold & Thomas, 1984b	Western Australia
Spirelytha stepanoviana	Archbold & Thomas, 1984b	Western Australia
Spirifer (Spirifer) gancaohuensis	Chen & Archbold, 2000	Xinjiang, northwest China
Spiriferella cundlegoensis	Archbold & Thomas, 1985b	Western Australia
Spiriferella etheridgei	Archbold & Thomas, 1985b	Western Australia
Spiriferella orientalis	Archbold & Bird, 1989	Timor
Stenoscisma ratmani	Archbold, 1982d	Irian Jaya
Stereochia irianensis	Archbold, 1982d	Irian Jaya
Strophalosia enantiensis	Archbold, 1996d	Western Australia
Strophalosia irwinensis	Archbold, 1990	Western Australia
Strophalosia jimbaensis	Archbold, 1986c	Western Australia
Sulciplica occidentalis	Archbold, 1995	Western Australia
Sulcirugaria tibetensis	Shen, Shi & Archbold, 2003a	Tibet
Sulcitaria skwarkoi	Archbold, 1991b	Irian Jaya
Svalbardia narelliensis	Archbold, 1981e	Western Australia
Svalbardia thomasi	Archbold, 1981f	Western Australia
Syrella occidenta	Archbold, 1996d	Western Australia
Syringothyris irianensis	Archbold, 1991b	Irian Jaya
Taeniothaeris aifamensis	Archbold, 1991b	Irian Jaya
Taeniothaeris densipustulatus	Shen, Archbold, Shi & Chen, 2001b	Tibet
Taeniothaeris qubuensis	Shen Shi & Archbold, 2003a	Tibet
Taeniothaerus quadratiformis	Archbold, 1997e	Western Australia
Taeniothaerus roberti	Archbold, 1996d	Western Australia
Tethyochonetes chaoi	Chen, Shi, Shen & Archbold, 2000	South China
Tethyochonetes flatus	Chen, Shi, Shen & Archbold, 2000	South China
Tethyochonetes? liaoi	Chen, Shi, Shen & Archbold, 2000	South China
Tivertonia chumikensis	Archbold & Gaetani, 1993	Northwest Himalaya, India
Tivertonia tatmariensis	Singh & Archbold, 1993	eastern Himalaya
Tomiopsis balgoensis	Archbold & Thomas, 1986c	Western Australia
Tomiopsis globosus	Archbold & Thomas, 1986c	Western Australia
Tomiopsis hardmani	Archbold & Thomas, 1986c	Western Australia
Tomiopsis harringtoni	Archbold & Thomas, 1986c	Argentina
Tomiopsis notoplicatus	Archbold & Thomas, 1986c	Western Australia
Tomiopsis pauciplicatus	Archbold & Thomas, 1986c	Western Australia
Tomiopsis rarus	Archbold & Thomas, 1986c	Western Australia
Tomiopsis siangensis	Singh & Archbold, 1993	eastern Himalaya
Tomiopsis teicherti	Archbold & Thomas, 1986c	Western Australia
Tomiopsis woodwardi	Archbold & Thomas, 1986c	Western Australia
Tornquistia gregoryi	Archbold, 1981c	Western Australia
Tornquistia magna	Archbold, 1980b	Western Australia
Tornquistia occidentalis	Archbold, 1980b	Western Australia

Tornquistia subquadratus	Archbold, 1990	Western Australia
Trigonotreta dickinsi	Archbold & Thomas, 1986a	Western Australia
Trigonotreta lightjacki	Archbold & Thomas, 1986a	Western Australia
Trigonotreta lyonsensis	Archbold & Thomas, 1986a	Western Australia
Trigonotreta neoaustralis	Archbold & Thomas, 1986a	Western Australia
Trigonotreta orientensis	Singh & Archbold, 1993	eastern Himalaya
Trigonotreta victoriae	Archbold, 1991e	Victoria
Trigontreta tangorini	Archbold, 2004b	New South Wales
Tupelosia paganzoensis	Simanauskas & Archbold, 2001	Argentina
Tyloplecta pseudorossica	Archbold, 1979 [nom. nov. for *Productus yangtzeensis* var. *rossica* Licharew, 1937 non *Productus rossicus* Keyserling, 1856]	Caucasus
Waagenites stani	Archbold, 1988e	Western Australia
Woolagia playfordi	Archbold, 1997e	Western Australia
Wyndhamia colemani	Archbold, 1987b	Western Australia
Zhejiangospirifer giganteus	Shen, Shi & Archbold, 2003b	Tibet

New combinations (44)	Reference	Original designation
Biplatyconcha grandis (Waterhouse)	Shen, Shi & Archbold, 2003a	*Platyconcha grandis* Waterhouse, 1975
Brachythyrinella occidentalis (Thomas)	Archbold, 1982b	*Trigonotreta narsarhensis* (Reed) var. *occidentalis* Thomas, 1971
Callytharrella callytharrensis (Prendergast)	Archbold, 1985b	*Dictyoclostus callytharrensis* Prendergast, 1943
Carilya coolkiliensis (Coleman)	Archbold, 2001h	*Taeniothaerus coolkiliensis* Coleman, 1957
Carilya miniliensis (Coleman)	Archbold, 2001h	*Taeniothaerus miniliensis* Coleman, 1957]
Carilya roberti (Archbold)	Archbold, 2001h	*Taeniothaerus roberti* Archbold, 1996d
Carilya teicherti (Coleman)	Archbold, 2001h	*Taeniothaerus teicherti* Coleman, 1957
Cimmeriella foordi (Etheridge)	Archbold & Hogeboom, 2000	*Productus tenuistriatus* de Verneuil? var. *foordi* Etheridge, 1903
Coolkilella bella (Etheridge)	Archbold, 1993b	*Productus bellus* Etheridge, 1918
Costatumulus capillatus (Waterhouse)	Archbold, 1996c	*Terrakea capillata* Waterhouse (in Foster & Waterhouse, 1988)
Costatumulus polliciformis (Waterhouse)	Shen, Shi & Archbold, 2003a	*Cancrinella polliciformis* Waterhouse, 1978
Costiferina wadei (Prendergast)	Archbold, 1985b	*Dictyoclostus callytharrensis* var. *wadei* Prendergast, 1943
Craniscus skeatsi (Allan)	Archbold, 1991d	*Ancistrocrania skeatsi* Allan, 1940
Crassispirifer rostralinus (Hosking)	Archbold & Thomas, 1985a	*Spirifer rostralinus* Hosking, 1933
Crassispirifer? kimberleyensis (Foord)	Archbold & Thomas, 1985a	*Spirifera kimberleyensis* Foord, 1890
Cyrolexis superstes (de Verneuil)	Shen, Shi & Archbold, 2003a	*Terebratula superstes* de Verneuil, 1845
Dyschrestia micracantha (Hosking)	Archbold, 1984b	*Pustula micracantha* Hosking, 1933
Echinalosia (Echinalosia) prideri (Coleman)	Archbold, 1986c	*Strophalosia prideri* Coleman, 1957
Etherilosia prendergastae (Coleman)	Archbold, 1993b	*Heteralosia (Etherilosia) prendergastae* in Archbold, 1993a originally *Strophalosia prendergastae* Coleman, 1957

Fusispirifer byroensis (Glauert)	Archbold & Thomas, 1987	*Spirifer byroensis* Glauert, 1912
Gjelispinifera decipiens (Hosking)	Archbold, Thomas & Skwarko, 1993	*Spiriferina cristata* var. *decipiens* Hosking, 1933
Globiella flexuosa (Waterhouse)	Archbold, 1983e	*Stepanoviella flexuosa* Waterhouse, 1970
Globiella foordi (Etheridge)	Archbold, 1983e	*Productus tenuistriatus* var. *foordi* Etheridge, 1903 [later referred to *Cimmeriella* by Archbold & Hogeboom, 2000]
Heteralosia complectens (Etheridge)	Archbold, 1986c	*Strophalosia complectens* Etheridge, 1918
Lyonia lyoni (Prendergast)	Archbold, 1983e	*Linoproductus cancriniformis* var. *lyoni* Prendergast, 1943
Megasteges fairbridgei (Coleman)	Archbold, Thomas & Skwarko, 1993	*Aulosteges fairbridgei* Coleman, 1957
Megasteges septentrionalis (Etheridge)	Archbold, 1986c	*Aulosteges baracoodensis* var. *septentrionalis* Etheridge, 1907
Myodelthyrium dickinsi (Thomas)	Archbold, 1991c	cf. *Pseudosyringothyris dickinsi* Thomas, 1971
Neospirifer hardmani (Foord)	Archbold & Thomas, 1986a	*Spirifera hardmani* Foord, 1890
Punctocyrtella australis (Thomas)	Archbold, Thomas & Skwarko, 1993	*Cyrtella nagmargensis australis* Thomas, 1971
Semilingula occidentaustralia (Archbold)	Archbold, Thomas & Skwarko, 1993	*Lingula occidentaustralis* Archbold, 1981b
Stictozoster senticosa (Hosking)	Archbold, 1984b	*Pustula senticosta* Hosking, 1933
Streptorhynchus plata (Waterhouse)	Shen, Shi & Archbold, 2003a	*Arctitreta plata* Waterhouse, 1978
Tethyochonetes longtanensis (Liao)	Chen, Shi, Shen & Archbold, 2000	*Waagenites longtanensis* Liao, 1984
Tethyochonetes quadrata (Zhan)	Chen, Shi, Shen & Archbold, 2000	*Waagenites soochowensis quadrata* Zhan, 1979
Tethyochonetes wongiana	Chen, Shi, Shen & Archbold, 2000	*Chonetes wongiana* Chao, 1928
Tivertonia jalchensis (Amos)	Cisterna et al., 2002c	*Lissochonetes jalchensis* Amos, 1961
Tivertonia yarrolensis (Maxwell)	Archbold, 1983c	*Lissochonetes yarrolensis* Maxwell, 1964
Transennatia timorensis (Hamlet)	Archbold & Bird, 1989	*Productus gratiosus* var. *timorensis* Hamlet, 1928
Trigonotreta pericoensis (Leanza)	Cisterna et al., 2002c	*Spirifer (Spirifer pericoensis* Leanza, 1945
Waagenoconcha waageni (Rothpletz)	Archbold & Bird, 1989	*Productus waageni* Rothpletz, 1892
Wooramella senticosta (Hosking)	Archbold in Hogeboom & Archbold, 1999	*Pustula senticosta* Hosking, 1933
Wyndhamia multispinifera (Prendergast)	Archbold ,1987b	*Strophalosia multispinifera* Prendergast, 1943
Wyndhamia multispinifera (Prendergast)	Archbold, Thomas & Skwarko, 1993	*Strophalosia multispinifera* Prendergast, 1943

ANNOUNCEMENTS

Future SPS meetings

Continental Permian Meeting in Italy

A SPS meeting will be held in Siena, Italy, in conjunction with the Field Conference on the “Stratigraphy and Palaeogeography of late- and post-Hercynian basins in the Southern Alps, Tuscany and Sardinia, and comparisons with other Western Mediterranean areas and geodynamic hypotheses”, September 18-23, sponsored by the Italian Geological Society. The Field Conference will consist of an initial excursion (September 18-21) followed by two day meeting (September 22-23) in Siena. The field excursion will focus on the Permian and Triassic continental sequences in the southern Provence, western Liguria and northwestern Tuscany. Oral or poster contributions are welcome; abstract deadline is July 30, 2006. Additional information is available from Prof. G. Cassinis, Dipartimento di Scienze della Terra, Università degli Studi, Via Ferrata No. 1, 27100 Pavia, Italy. Tel: 39 0382 985834. Fax: 39 0382 985890. E-mail: cassinis@unipv.it. The first circular has been sent out and is available at http://manhattan.unipv.it/sem_conf_new.htm.

Neil W. Archbold Memorial Symposium
Invitation for Expressions of Interest

The Royal Society of Victoria and the Faculty of Science and Technology at Deakin University propose to hold a NEIL W. ARCHBOLD MEMORIAL SYMPOSIUM. The symposium will be held in honour of the late Neil Archbold, Professor of Palaeontology, Deakin University, and immediate past president of the Royal Society of Victoria. Professor Archbold (14th August 1950 – 28th November 2005) was an eminent Australian palaeontologist who specialized in Permian brachiopods. He died in Mendoza, Argentina, following his participation in Gondwana 12 – the Twelfth International Gondwana Congress.

This Memorial Symposium will provide an opportunity for colleagues and friends to honour and celebrate Professor Neil Archbold’s life and work by attending the Symposium and/or contributing Symposium papers which will be published as a special issue of the *Proceedings of the Royal Society of Victoria* (a peer reviewed and internationally circulated journal). Details of the planned Symposium are included below:

NEIL W. ARCHBOLD MEMORIAL SYMPOSIUM
Friday 24th November 2006
to be held at
The Royal Society of Victoria’s Hall
9 Victoria Street, Melbourne, Victoria 3000, Australia

The organisers welcome expressions of interest from anyone who wishes to (please tick):

- ? attend the Symposium
- ? attend the Symposium and present a paper
- ? offer a paper for the Proceedings but are unable to attend the Symposium

A conference brochure with registration details is currently being prepared and will be finalized and sent out once feedback has been received.

For further information please contact:

Professor Guang Shi
School of Life and Environmental Sciences
Deakin University, Melbourne Campus
Email: grshi@deakin.edu.au

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First Circular
XVI International Congress on the Carboniferous and Permian XVI ICCP

Invitation

Geologists from around the world interested in Carboniferous and Permian rocks are invited to meet at Nanjing, People’s Republic of China, June 21- June 24, 2007. The Carboniferous and Permian in China are characterized by excellent outcrops, a wide spectrum of depositional types, characteristic fauna and flora, and above all, fully developed successions. During recent years, research on the Carboniferous and Permian in China has experienced exciting developments and has achieved great success in four areas. 1) Locating exposures for candidates as stratotypes of series and stage boundaries to establish detailed integrated stratigraphic sequences, especially in the Mississippian and Late Permian (Lopingian). 2) Exploring the Carboniferous and Permian in South China, North China and Northwest China for coal-bearing beds, and sources of oil and gas. 3) Detailed geological and palaeontological survey of the Peri-Gondwana Carboniferous and Permian in Tibet and West Yunnan, which has led to significant progress in understanding the evolution of the Paleo-Tethys, the dispersion of Gondwana, and Asian accretion. 4) Studies of Carboniferous and Permian geological events and processes using bio-diversity, isotope geochemistry, and other stratigraphic data, which have resulted in a more comprehensive understanding of the end-Permian mass extinction as well as other events.

We believe that we can offer our colleagues a vibrant academic environment for discussions on the Carboniferous and Permian world, as well as opportunities to see the amazing geological record of Carboniferous and Permian biotic and physical processes.

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Chinese Academy of Geological Sciences
The International Subcommission on Carboniferous Stratigraphy
The International Subcommission on Permian Stratigraphy

Congress Organizers

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State Key Laboratory of Palaeontology and Stratigraphy
Institute of Geology and Mineral Resources, CAGS
China University of Geosciences
Nanjing University

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Secretary General: Xiao-juan WANG

Venue and Schedule

The venue for the XVI ICCP will be in the International Conference Hotel of Nanjing (http://www.nic-hotel.com), a garden-style grand hotel very close to the Sun Yatsen Mausoleum and the Ming Emperor’s Tomb, within the Purple Mountain Scenic Area at eastern Nanjing, Jiangsu Province, East China.

Natural Setting and cultural resources: Nanjing is an economic and cultural centre in East China, having a total population of about 6 million and boasts a long history and rich cultural heritage. Archeological relics indicate that some 6,000 years ago humans lived here in primitive communities. Furthermore, ancient human and hominid fossils found in Nanjing have proven that this area was inhabited by ancient humans over 300,000 years ago. Since 220AD ten dynasties or regimes have made their respective capitals in Nanjing one after another. With its elegant natural setting and rich cultural resources, Nanjing is well known as a tourist attraction. Among hundreds of scenic spots the most outstanding historic relics for tourism are: the Sun Yatsen Mausoleum, the Ming Emperor’s Tomb, the approximately 1,400 years old Jiming Temple, the relics of the Taiping Heavenly Kingdom, the majestic ancient city walls, the stone carvings of the Southern Dynasty, and the pagoda for Buddhist relics. The top natural scenic spots are the East Suburbs Scenic zone, the Qixia Temple and hills, Xuanwu Lake, Mochou Lake, and the Qinhuai River Scenic zone. Two-thirds of the Ancient City Wall of Nanjing is intact, the longest and best-preserved city wall in China. Nanjing is one of China’s four key cities in scientific research and education. In total, Nanjing has 48 institutions of higher learning, including the following geological organizations: Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences; Department of Earth Sciences, Nanjing University; Nanjing Institute of Geology and Mineral Resources; Nanjing Institute of Geophysics in Petroleum Exploration; Nanjing Petrological and Mineralogical Test Center; Nanjing Geological Museum; and the newly established Nanjing Palaeontological Museum.

Schedule:
June 14-June 19: Pre-congress field excursions
June 20- Arrive Nanjing, Registration and welcome reception
June 21-June 24 Talk and poster sessions, workshops
June 22- Congress banquet
June 25-Depart Nanjing
June 25- June 30: Post-Congress field excursions

Travel

- By air to Nanjing transferring at Beijing, Guangzhou, Xi’an, Hong Kong, Macau or other large cities within China; or from Incheon (Seoul), Osaka, or Singapore. Delegates may take the Nanjing airport taxi to the International Conference Hotel in Eastern Suburb Scenic Park (cost approx. 15 USD). (Strongly recommended)
- By train or shuttle via Shanghai to Nanjing: Delegates who fly into Shanghai Pudong International Airport may either take the airport bus/taxi to Shanghai railway station and then the train (3 hours) to Nanjing or chose the airport shuttle directly to Nanjing (4 hours) using the express highway. (Not recommended because of inconvenient transfer at Shanghai Railway Station for non-Chinese speaking delegates)

Obtaining a visa to visit China: Please check to see if your visit to China will require a visa. Delegates with a valid passport from Japan and Korea in the visa waiver program may enter China for two weeks stay without a visa. Delegates from countries not included in the visa waiver program are required to obtain a visiting or travel visa. The process involves contacting the nearest Chinese embassy or consulate in the country where your passport will be issued. We will send an official invitation letter issued by Chinese Academy of Sciences to delegates who need to apply for a visiting visa.

Scientific Programs

Meeting Format: The meeting will consist of concurrent sessions of talks, each of 20 minutes (including questions and transition). Talks will be grouped based on broad themes. There will be one poster session, which will include afternoon refreshments. Speakers will normally be limited to one presentation (talk) at the meeting. Individuals may participate as a non-presenting coauthor on additional talks. Individuals may participate in as many posters presentations as they wish. Details will follow in the Second Circular.

Proposed sessions:

1. Carboniferous and Permian Palaeobotany and Microflora
2. Carboniferous and Permian Macro-and microfossils
3. Devonian F-F Mass Extinction and Mississippian Recovery
4. Biotic Turnovers during the mid-Carboniferous boundary and Early Permian
5. Carboniferous and Permian Reef, Biofacies, and Basin Analysis
6. Evolutionary Palaeogeography and Palaeoclimatology
7. Integrative Stratigraphy and High Resolution Biostratigraphy
8. Isotopic Geochemistry and Geobiology in the Permo-Carboniferous
9. Gondwana and Peri-Gondwana Faunas, Stratigraphy, and Geology
10. Bio-Diversity Patterns and Quantitative Analysis of Biotic Databases
11. Stratotypes, Boundaries, and Global Correlations
12. End-Permian Biotic Mass Extinction and Early-Triassic Recovery
13. Pangea formation and breakup
14. Cyclothemic Stratigraphy and Sequence Stratigraphy
15. Carboniferous and Permian Coal, Petroleum, and Economic Geology
16. Computerized Palaeontology
17. Palaeontological Education for the Public

Call for Abstracts: Abstracts for the meeting are due **April 1, 2007**. A request for abstracts will be announced in the Second Circular, which will also have instructions for electronic submission of abstracts. The Abstract volume for the meeting will be edited by Yue Wang and Ronald R. West and distributed to registered delegates at the meeting.

Proceedings Volume: A volume of congress proceedings is planned for publication in <u>*Palaeoworld*,</u> an Elsevier peer-reviewed quarterly journal dedicated to studies of palaeontology and stratigraphy centred in China and the neighbouring regions. Original works on fossils and strata, comparative studies worldwide, and interdisciplinary approaches with related disciplines are encouraged. <u>*Palaeoworld*</u> is oriented toward a broad spectrum of geoscience researchers as well as experts and students in evolutionary biology who are interested in historical geology and biotic evolution.

Manuscripts for the proceedings volume are encouraged, and should be prepared following the *Guide for Authors of Palaeoworld*. This guide can be downloaded from the Palaeoworld website of Elsevier (http://ees.elsevier.com/palwor/). Contributed papers relating to the topics of ICCP are invited from registered participants. Please note that the deadline for contributions to the proceedings volume is scheduled for December 31, 2007.

Workshops: Several free workshops will be scheduled and are mainly designed for subcommissions on the Carboniferous and Permian stratigraphy. A workshop on the Meishan drilling project that aims at resolving the timing and geochemistry of Permian-Triassic Events (PTEs), South China will also be planned.

Any colleagues or working groups wishing to hold a special symposium or workshop are advised to contact the organizers with their ideas no later than December 31, 2006.

Language: The official language for the scientific program and all business of the meeting is English.

Proposed Field excursions

A. Pre-Congress excursions:

A1. Carboniferous and Permian marine sequences in Jiangsu and Zhejiang, including the GSSPs for the Permian-Triassic boundary and the base-Changhsingian in Meishan, Zhejiang Province.

A2. Carboniferous and Permian carbonate sequences in Northwest Tarim, Xinjiang.

A3. Pennsylvanian to Lower Triassic continental sequences in Hancheng, South Sha'anxi.

A4. Pennsylvanian to Permian continental sequences in Shanxi and Hebei.

C. Post-Congress excursions:

C1. Gondwanan and Peri-Gondwanan Carboniferous and Permian sequences in Xizang (Tibet).

C2. Peri-Gondwanan Carboniferous to Permian sequences in West Yunnan.

C3. Carboniferous to Permian marine sequences in Guizhou and Guangxi, including the GSSP of the Guadalupian-Lopingian boundary and GSSP candidate for the Tournaisian-Visean boundary.

C4. Devonian to Carboniferous marine sequences in Guangxi, including the Devonian reef complexes and the para-stratotype of the Devonian-Carboniferous boundary.

C5. Devonian-Carboniferous marine sequences including the Hongguleleng F-F refuge faunas and geological records of the end-Permian mass extinction in the continental sequence, North Xinjiang.

Social Programs

Welcome Reception: After on-site registration, delegates can share a buffet style reception with beer, wine, and juice in the dining hall of the hotel. Full vegetarian fare will also be provided.

Banquet Dinner: A formal Chinese style banquet dinner will be held at the evening of June 22.

Guest Program: No formal guest program is planned at this time. However, the congress organizers can help coordinate local excursions to suit most interests. Feel free to request information, provide suggestions or just share potential interests.

Accommodations and Food

Hotel:
International Conference Hotel of Nanjing (www.nic-hotel.com): 6 km from the Nanjing Institute of Geology and Palaeontology: single room (in No.6 building, with bathroom, TV, telephone, air conditioner and refrigerator, current price: RMB 400 per night); two-bed room A (in No.6 building, with bathroom, TV, telephone, air conditioner and refrigerator, current price: RMB 400 per night); two-bed room B (in No.1 building, with bathroom, TV, telephone, air conditioner and refrigerator, current price: RMB 500 per night); suite A (in No.1, No.2, No.3 buildings, with one king-size bed, a bathroom, TV, telephone, refrigerator, current price: RMB 600; suite B (in No.1, No.2, No.3 buildings, with additional sitting room, one king-size bed, a bathroom, TV, telephone, refrigerator, current price: RMB 800 per night).

Restaurants and Daily Meals:
Daily meals are in the hotel and are in buffet style with an exception of the banquet dinner.

Type of clothing and weather conditions:
Daytime highs in Nanjing for the meeting dates historically average 35 ^{o}C with lows of 24 ^{o}C; summer clothing is appropriate. All hotel rooms and conference halls are air-conditioned. Those who participate in excursions to Tibet and Xinjiang will need a jacket.

Registration

- Registration fees*:
Before April 1, 2007:

Regular participant: 400 US$, includes meeting resources and support, abstract volume, proceedings volume, refreshments at session breaks, and all meals including breakfast, lunch, and supper from June 21 to June 24, as well as reception and banquet dinners.

Student: 200 US$, as above: individual must provide a student identification card from current institution at time of on-site registration.

Accompany: 150 US$, as above: with the exception of abstract and proceedings volumes.

After April 1, 2007:

Regular participant: 450 US$, student: 250 US$, and accompany: 200 US$

(* Registrations fees are subject to modification depending on the current rate of exchange between the Chinese Yuan RMB and USD. The rate of exchange on March 10, 2006 was 100 US$ = 804.7 RMB Yuan.)

Payment: A down payment for the meeting and field trips will be requested in the Second Circular. The balance will be due at the time of the meeting, payable in $USD.

- Registration form: A pre-registration and reply form is attached and the first circular can be downloaded from the Congress website: www.ICCP2007.cn as of April 15, 2006.

Important Dates

April 15, 2006: First Circular available on line
May 1, 2006: Distribution of the printed copy of the First Circular
December 31, 2006: Deadline for returning the Reply Form from the 1st Circular
February 1, 2007: Second Circular available online and distribution
April 1, 2007: Deadline for pre-registration and abstract submission
May 1, 2007: Third Circular available online
December 31, 2007: Deadline for manuscript submission of the proceedings volume

(This animal is Bixie (in Chinese pronounciation) that is one of the symbols of Nanjing City and means ‘ward off evil’, originally intended to provide powerful spiritual protection.)

Thank you for your *Permophiles* Subscription Donation!

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Amount of Donation:

Please specify Canadian or US dollars.