Permophiles

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International Union of Geological Sciences

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Subcommission on Permian Stratigraphy
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EXECUTIVE NOTES

Notes from the SPS Secretary
Charles M. Henderson

Introduction and thanks

I want to thank those individuals who contributed articles for inclusion in the 43rd issue of Permophiles and those who assisted in its preparation. Bruce Wardlaw and I did all of the editorial work for this issue during 4 days in February 2004 at the USGS in Reston, Virginia. We thank Donald W. Boyd, Doug Erwin, John Filatoff, William F. Grauten, Gary D. Johnson, Prof. Dr. G. Kowalczyk, Norman D. Newell, Hermann W. Pfefferkorn, Dr. Charles A Ross, Dr. June R. P. Ross, and Prof. Helmut Wopfner for financial contributions to the Permophiles publication fund in support of this issue. We also thank Laurie Vaughan (Department of Geology and Geophysics, University of Calgary) for handling the donations.

The Permophiles account is currently running a deficit of 505.04, even before costs for this issue are taken into account. Several individuals are regular contributors and I thank you for that continued support. However, additional contributions are necessary if we are to continue to produce and mail Permophiles. If you would like to contribute please refer to the last page of this issue. Permophiles is currently distributed to 285 individuals and institutions and donations typically cover only 50% of the expenses. Please remember to specify Canadian or USA dollars ($25US = $35Can.). Permophiles is recognized by the ICS as an exceptional newsletter and the continuing support of our readers is necessary to maintain that quality.

Previous SPS Meetings and Minutes

An official business meeting was not held for the SPS at the Wuchiapingian-Changhsingian boundary workshop at Nanjing in October, but numerous members of the subcommission were in attendance. A report on this workshop by Yue Wang and Charles Henderson may be found in this issue.

Business Arising from the Minutes

Following the WC boundary workshop a proposal for the base-Changhsingian was produced and submitted for voting to the WC boundary working group. The results of that vote are announced below.

In Permophiles 42 it was announced that a revised version of the SPS endorsed Guadalupian-Lopingian GSSP proposal would be distributed to ICS for voting. The results of that vote are announced below.

Future SPS Meetings

The next scheduled SPS meeting will be held at the Rocky Mountain-Cordilleran Section GSA meeting in Boise Idaho during early May 2004 and the official annual business meeting will be held in association with the Cisuralian session at the 32nd International Geological Congress in Florence, Italy during late August 2004. Announcements about both meetings may be found in the back pages of this issue.

Future Issues of Permophiles

Issue 44 will be finalized in late June 2004 and we request that all manuscripts, announcements or communications be sent such that Charles Henderson receives them no later than Friday, June 18, 2004. Issue 44 will hopefully be compiled at Pend Oreille Lake in northern Idaho and at the University of Calgary. Please see the note on page 5 regarding the preferred method of manuscript submission and format. Please make our job easier by following the format instructions. Please follow the format for references; you too can add those commas and colons! Permophiles now has an ISSN number and it is increasingly referred to in many papers, which means that our reports should be professional and address scientific rather than personal issues. The primary function of Permophiles is for discussion of Permian issues so we are always interested in replies to the various contributions; these must also follow the format as outlined elsewhere.

Our database is still missing a number of e-mail addresses and phone numbers so if you haven't written to me recently I would appreciate receiving a very short e-mail after receiving Permophiles 43; put Permophiles Update as the subject for easy sorting in my email server. Send to charles.henderson@ucalgary.ca.

Report on the ICS Vote for the Guadalupian-Lopingian boundary

The following communication was received from James Ogg, Secretary ICS on February 12, 2004. "ICS voting members have all voted 100% in favour of the SPS proposal for the base-Wuchiapingian (Guadalupian-Lopingian) GSSP. I will send a copy of the proposal to IUGS for ratification at their March meeting." See Permophiles 39 for the original proposal.

Report on the Working Group Vote for the Wuchiapingian-Changhsingian boundary

The WC boundary working group consisted of Yugan Jin (Chair), Charles Henderson, Bruce Wardlaw, Sam Bowring, Robert Nicoll, Yuri Zakharov, Shuzhong Shen, Xiangdong Wang, Yue Wang, Zhihao Wang, Shilong Mei, Changqun Cao, Lide Chen, Yujing Wang, and Kexin Zhang. Everyone voted 100% in favour for the proposed GSSP. See this issue for a slightly revised version of this proposal. This proposal and a ballot will be sent to SPS voting members at the end of February 2004.

Report on Cisuralian GSSP progress

The secretary will coordinate revisions to the base-Sakmarian GSSP proposal and it is hoped that a vote can be conducted prior to the IGC meeting in Florence. The SPS Chair reports elsewhere on the base-Artinskian and base-Kungurian progress.

Notes from the SPS Chair

Bruce R. Wardlaw

This note will be short, listing the results of the nominating process, turnover in membership and participation in a Permian-Triassic Boundary Workshop.

A nominating committee was selected at the last annual meeting held during the ICCP meeting in Utrecht. Yugan Jin (Chair), Guang Shi, and Tamra Schiappa were tasked with coming up with a slate for the next Chair and Vice Chair for the Subcommission to be installed at the next IGC in Florence. Jin kindly asked the present Chair to also be part of the nominating committee. The committee unanimously nominated Charles M. Henderson for Chair and Vladimir I. Davydov for Vice Chair. A postal ballot will go out to all current voting members on March 1. Three voting members resigned last summer and recommended interim replacements to finish their terms (see annual report that follows). All three were accepted by the SPS Executive. Following ICS recommendations for turnover in its subcommission titular membership, all members that have served on the SPS for more than 21 years will be retired at the next IGC (this includes 2 current members). A separate postal ballot will go out for the approval of the recommendations for 5 full term (4 year) positions by the voting membership.

The SPS is co-sponsoring a Workshop on the Permian-Triassic extinction and recovery. Please refer to the note and announcement at the back of this issue for more information.

SUBCOMMISSION ON PERMIAN STRATIGRAPHY

ANNUAL REPORT 2003

1. TITLE OF CONSTITUENT BODY

International Subcommission on Permian Stratigraphy (SPS)

2.-3. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY

Mission Statement and Goals

The Subcommission's primary goal 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 refined regional correlation.

Fit within IUGS Science Policy

The objectives of the Subcommission relate to two main aspects of IUGS policy:

(i) The development of an internationally agreed scale of chronostratigraphic units, fully defined by GSSPs where appropriate and related to a hierarchy of units to maximize relative time resolution within the Permian period;

(ii) Establishment of frameworks and systems to encourage international collaboration in understanding the evolution of the Earth during the Permian Period.

4. ORGANIZATION

The Subcommission has an Executive consisting of a Chair, two Vice-Chairs, and Secretary, who are all Voting Members of the Subcommission. There are sixteen total Voting Members. The Subcommission proposes in its changeover of membership and officers for the upcoming IGC to go to an Executive consisting of a Chair, only one Vice-Chair and a Secretary. The Voting Members will remain at 16.

The objectives of the Subcommission are pursued by Working Groups, both Stratigraphic and Thematic, that are disbanded upon completion of their directed task. For example, the Working Groups on the Carboniferous and Permian Boundary and on the Guadalupian (Middle Permian) and its constituent stages have been disbanded on the successful establishment of their defining GSSPs. The current Working Groups are: the Cisuralian, the Lopingian, Continental Permian, and Transitional biotas as gateways for global correlation. The Subcommission also supports a special project titled "The Permian: from glaciation to global warming to mass extinction"

5. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SOURCES OTHER THAN IUGS

The SPS receives strong support from Russian, Chinese, and American governments and individuals when working on the specific Series and Stages proposed in each country. The University of Calgary (Canada) and Boise State University (USA) helped support our operations. Individual donors and the U.S. Geological Survey strongly supported the activities of SPS this year.

6. INTERFACE WITH OTHER INTERNATIONAL PROJECTS

The SPS interacts with many international projects on formal and informal levels. SPS is taking a very active role on the development of integrated chronostratigraphic databases participating on ***CHRONOS***, initially an NSF funded initiative. SPS is active with IGCP Project 359: Correlation of Tethyan, Circum-Pacific and marginal Gondwanan Permo-Triassic and the Permian Research Group of SE Asia.

7 & 9. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2003

The proposal for the GSSP of the Lopingian was sent forward for a vote by the ICS.

Planning and funding for an October, 2003, Changhsingian (Upper Lopingian)Working Group Meeting and Field Trip in Nanjing China was a major accomplishment and included Chinese, Australian, American and Canadian participants. A formal proposal for the Changhsingian has been approved by formal vote by the Working Group and is being prepared for the Subcommission.

Faunal definitions were agreed to for the remaining Cisuralian stages (Sakmarian, Artinskian, and Kungurian). Field work was conducted to resample and remeasure potential candidate sites. One in particular, for the Kungurian, proved to be spectacular in that not only did it provide continuous faunal sampling, but had several tuff horizons with good quality zircons, increasing its chronostratigraphic potential greatly.

Chief products in 2003 include:

SPS Newsletters 41 and 42 were produced in 2003 and circulated to a mailing list of 280 and placed on our internet site hosted by Boise State University. The newsletter, *Permophiles*, now has an ISSN number (ISSN 1684-5927).

Numerous abstracts and papers were presented by members of the Subcommission and in support of its workshop and symposium held at the International Congress on Carboniferous and Permian Stratigraphy held in August at Utrecht, the Netherlands. Many of these abstracts are highlighted in

Newsletter 42.

8. CHIEF PROBLEMS ENCOUNTERED IN 2003

None.

10. SUMMARY OF EXPENDITURES IN 2003:

INCOME		
Donations	$	1,000
University of Calgary support		2,000
U.S Geological Survey		10,200
ICS		800
TOTAL		14,000
EXPENDITURE		
Publication of *Permophiles*		2,000
Support for travel for international meetings and field work		10,000
Publication costs other than the newsletter		2,000
TOTAL		14,000

11-14. WORK PLAN, CRITICAL MILESTONES AND ANTICIPATED RESULTS TO BE ACHIEVED FOR NEXT YEAR:

(a) Formal vote on the Changhsingian GSSP by the Subcommission.
(b) Submittal of the formal proposal for the Sakmarian GSSP
(c) Submittal of the formal proposal for the Kungurian GSSP
(d) Continued work on the Artinskian potential stratigraphic candidates.
(e) Produce two issues of *Permophiles*
(f) Conduct Symposiums on the Permian-Triassic and Lower Permian and an Annual Business Meeting at the International Geological Congress at Florence this summer.

15-16. BUDGET AND ICS COMPONENT FOR 2004

Cisuralian Working Group (field expenses)	$	4,000
Lopingian Working Group (Proposal development and dispersal)		1,000
Symposia and annual Meeting at IGC, Florence		3,000
Publications (Newsletter, targeted articles of scientific need)		4,000
Internet upkeep		1,000
TOTAL 2004 BUDGET		13,000
TOTAL BUDGET REQUEST (ICS)		1,000

17. REVIEW CHIEF ACCOMPLISHMENTS OVER LAST FIVE YEARS (1998-2002)

The SPS has approved the general divisions of the Permian and has now made 4 successful GSSP proposals for Stages (Asselian, Roadian, Wordian, Capitanian). Support for documentation (field work, publication) of the various chronostratigraphic methods for the establishment of the GSSPs has been the most outstanding and differentiating character of this Subcommission. *Permophiles* has become an internationally respected newsletter/journal.

18. OBJECTIVES AND WORK PLAN FOR NEXT 5 YEARS (2004-2008)

Finish the establishment of all the GSSPs of the constituent stages of the Permian.
2003-2004 Formal completion of the Changhsingian GSSP.
2004 Formal ratification of the Lopingian GSSP
2004 Formal completion of the Sakmarian GSSP.
2005 Formal completion of the Kungurian GSSP
2006 Formal completion of the Artinskian GSSP

19. SUBMITTED BY:

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APPENDICES

List of Voting Members

Prof. Giuseppe Cassinis
Dr. Boris I. Chuvashov
Dr. Clinton B. Foster
Prof. Brian F. Glenister (Retiring)
Prof. Charles M. Henderson
Dr. Jinzhang Sheng (Retiring)
Dr. Makoto Kato (Resigned)
Dr. Galina Kotlyar
Dr. Heinz Kozur (Retiring)
Prof. Ernst Ya. Leven
Dr. Manfred Menning (Resigned)
Prof. Claude Spinosa (Resigned)
Dr. John Utting
Dr. Bruce R. Wardlaw
Dr. Yugan Jin
Dr. Zhouting Liao (Retiring)

Accepted replacements for resigned members

Dr. Yoichi Ezaki (for Kato)
Prof. Joerg W. Schneider (for Menning)
Dr. Tamra A. Schiappa (for Spinosa)

Slate of Nominees for office:

Prof. Charles M. Henderson, Chair
Dr. Vladimir I. Davydov, Vice-Chair

Recommended for full term positions
(2004-2008)

Dr. Yoichi Ezaki
Prof. Joerg W. Schneider
Dr. Tamra A. Schiappa
Dr. Shuzhong Shen
Dr. Xiangdong Wang
Dr. Guang Shi

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Canada

SUBMISSION GUIDELINES FOR ISSUE 44

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to my E-mail address; hard copies by regular mail do not need to be sent unless requested. Please only send a single version by E-mail or in the mail; if you discover corrections before the deadline, then you may resubmit, but indicate the file name of the previous version that should be deleted. Manuscripts may also be sent to the address below on diskettes (3.5", zip disks, or CD) prepared with a recent version of WordPerfect or Microsoft Word; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code and should be prepared in single column format. Specific and generic names should be *italicized*. Please refer to recent issues of Permophiles (*e.g.* Glenister *et al.*, Permophiles #34, p. 3) for reference style, format, *etc*. Maps and other illustrations are acceptable in tiff, jpeg, eps, bitmap format or as CorelDraw or Adobe Illustrator files. The preferred formats for Adobe Pagemaker are Microsoft Word documents and bitmap images. We use Times Roman 12 pt. bold for title and author and 10 pt. for addresses and text. Indents for paragraphs are .25"; do not use your spacebar. Word processing documents may include figures embedded at the end of the text, but these figures should also be attached as separate attachments as bitmaps or as CorelDraw or Adobe Illustrator files. Do not include figure captions as part of the image; include the captions as a separate section within the text portion of the document. If only hard copies are sent, these must be camera-ready, *i.e.*, clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time. Any versions that require translation must also be submitted well ahead of the deadline. All paper versions of articles for Permophiles will be destroyed after the deadline of the subsequent issue, unless a request is made for return.

Please note that we prefer not to publish articles with names of new taxa in Permophiles. Readers are asked to refer to the rules of the ICZN. All manuscripts will be edited for consistent use of English only.

I currently use a Windows 2000 PC with Corel Word Perfect 10, Corel Draw 11, Adobe Page Maker 6.5, Adobe Illustrator 10, Adobe Photoshop 7 and Microsoft Office 2000 programs; documents compatible with these specifications will be easiest to work with.

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SUBMISSION DEADLINE FOR ISSUE 44 is Friday June 18, 2004

REPORTS

Report of the Workshop "Lopingian Stratigraphy and Events"

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Charles Henderson
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The workshop was held during the period from October 12-22, 2003. It combined activities for two cooperative groups including one working on PT events and the other on the WC stage (Wuchiapingian-Changhsingian) boundary. Both groups visited the Meishan section from October 12-14 and the Shangsi section from October 17-23. During the two days (15th and 16th) at Nanjing Institute of Geology and Palaeontology, the PT event group gave talks to Chinese colleagues in Nanjing, and the WC boundary group examined specimens from the sections in Meishan, Jiangya, Huangyan and Shangsi. The attendees included SPS Chair Bruce Wardlaw (United States Geological Survey), SPS Secretary Charles Henderson (University of Calgary, Canada), Robert Nicoll (Australian National University), Samuel Bowring, Roger Summons, James Crowley (Massachusetts Institute of Technology, USA), Douglas Erwin (Smithsonian Institution), Jin Yugan, Wang Zhihao, Wang Chengyuan, Wang Xiangdong, Shen Shuzhong, Wang Wei, Wang Yue, Qi Yuping (Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences), Chen Lide (Yichang Institute of Geology & Mineral Resources, Chinese Academy of Geology). Three main points regarding the WC boundary and the PT event may be concluded from the meeting:

1) A consensus was reached that the WC Stage boundary GSSP be placed at the FAD of *Clarkina wangi*. Among the many complete WC boundary sections in southern China, only the Meishan and Shangsi sections have been studied in various stratigraphic aspects, and the Jiangya section has been studied systematically on conodonts. In Meishan, the relevant portion of the C-section, which was exposed recently, provides more Late Wuchiapingian conodonts. The workshop examined the specimens from these sections to test the correlation potential of the boundary levels between *Clarkina longicuspidata* and *C. wangi*, which was previously suggested for the Meishan Section by Charles Henderson, Bruce Wardlaw and Mei Shilong in 2001 and 2002. It was unanimously agreed that the transition from *Clarkina longicuspidata* to *Clarkina wangi* was clearly present at Meishan C and Jiangya sections. It was also recognized that *Clarkina wangi* was present at the Shangsi section, but that sampling was too widely separated to show the lineage. During the field trip to Shangsi, samples spaced one metre apart were collected from 68 to 90 metres (according to section measured by Ian Metcalfe

and Robert Nicoll) for further study. There were two opinions regarding the recognition of the taxon *Clarkina wangi*. The first (as discussed by Chengyuan Wang and Zhihao Wang) indicates that the taxon is recognized by a high wall-like and fused carina and a pointed posterior platform outline. The second viewpoint (as discussed by Charles Henderson and Bruce Wardlaw) is that *Clarkina wangi* is recognized by a high wall-like and fused carina in specimens that exhibit a wide variability of posterior platform outlines (including pointed or narrow, rounded, square and transitional between square, rounded or narrow). Both of these views are taxonomically valid, but it is important to note that the difference of opinion does not affect the FAD of the taxon.

2) There was general agreement, but not unanimous support, that the Meishan section D is to be proposed as the candidate for the GSSP of the WC boundary, and the Jiangya and Shangsi sections as auxiliary reference sections. The definition is at a point 82 cm above the base of the Changxing Limestone in the lower part of Bed 4 at Meishan D section, just above the flooding surface of the second parasequence in the Changxing Limestone. The FAD of *C. wangi* at Section C in Meishan is at the point 120 cm above the base of the Changxing Limestone following a 20 cm thick interval with the transitional form from *Clarkina longicuspidata* to *Clarkina wangi* (see plate 1). Chengyuan Wang pointed out that the Jiangya section offers radiolarians and other fossils that should be studied in detail before any decision is made. The radiolarians would be a useful addition, but they appear to be dominated by simple, long-ranging spherical forms that would not add much to regional and interregional correlation potential. It is recommended that this additional work at the Jiangya section be conducted, but that it is not necessary in order to define the boundary.

3) In order to obtain a complete succession of rock samples free from any outcrop contamination and weathering, a drilling project has been launched aimed at resolving the timing and geochemistry of Permian-Triassic Events (PTEs) at Meishan, South China. After detailed discussion, the PT event group decided the position for the core drilling. The Meishan core will cut 100 metres of the earliest Triassic Yinkeng Formation and 60 metres of the latest Permian Changxing Limestone and Longtan Formation. Core samples will be curated and made available on a competitive basis to all qualified specialists willing to enter into a cooperative investigation with our group. The Permian-Triassic boundary succession exposed in quarries at Meishan has been extensively studied during the past twenty years. As a consequence of intensive studies of various aspects of the stratigraphy, Section D at Meishan was ratified by IUGS as the GSSP for the Permian-Triassic boundary (Yin *et al.*, 2001), and also has been proposed to serve as the GSSP for the Wuchiapingian-Changhsingian boundary (Jin *et al.*, 2003). Establishment of the GSSPs for the top and bottom boundaries of the Changhsingian Stage gives us a rare opportunity to establish a unit stratotype for the stage. A complete core through this stage will enable us to integrate various data into a cross-disciplinary comprehensive succession.

References

Jin Yugan, Henderson, Charles, Wardlaw, Bruce, Shen Shuzhong, Wang Xiangdong, Wang Yue, Cao Changqun, Chen Lide, 2003, Proposal for the Global Stratotype Section and Point (GSSP) for the Wuchiapingian-Changhsingian Stage boundary (Upper Permian Lopingian Series): Permophiles, 43, p. 8-25.

Mei, S.L., Henderson, C.M., Wardlaw, B.R., 2001, Progress on the definition for the base of the Changhsingian: Permophiles, 38, p. 36-37.

Wardlaw B.R.and Mei, Shilong, 2000, Conodont definition for the basal boundary of the Changhsingian Stage. In; Jin, Yugan, (ed.) Conodont definition on the basal boundary of Lopingian stages; A report from the International Working Group on the Lopingian Series: Permophiles, 36, p. 39-40.

Yin Hongfu, Zhang Kexin, Tong Jinnan, Yang Zunyi, Wu Shunbao, 2001, The Global Stratotype Section and Point (GSSP) of the Permian-Triassic Boundary: Episodes, 24(2), p. 102-114.

Plate explanation for Plate 1 (next page)

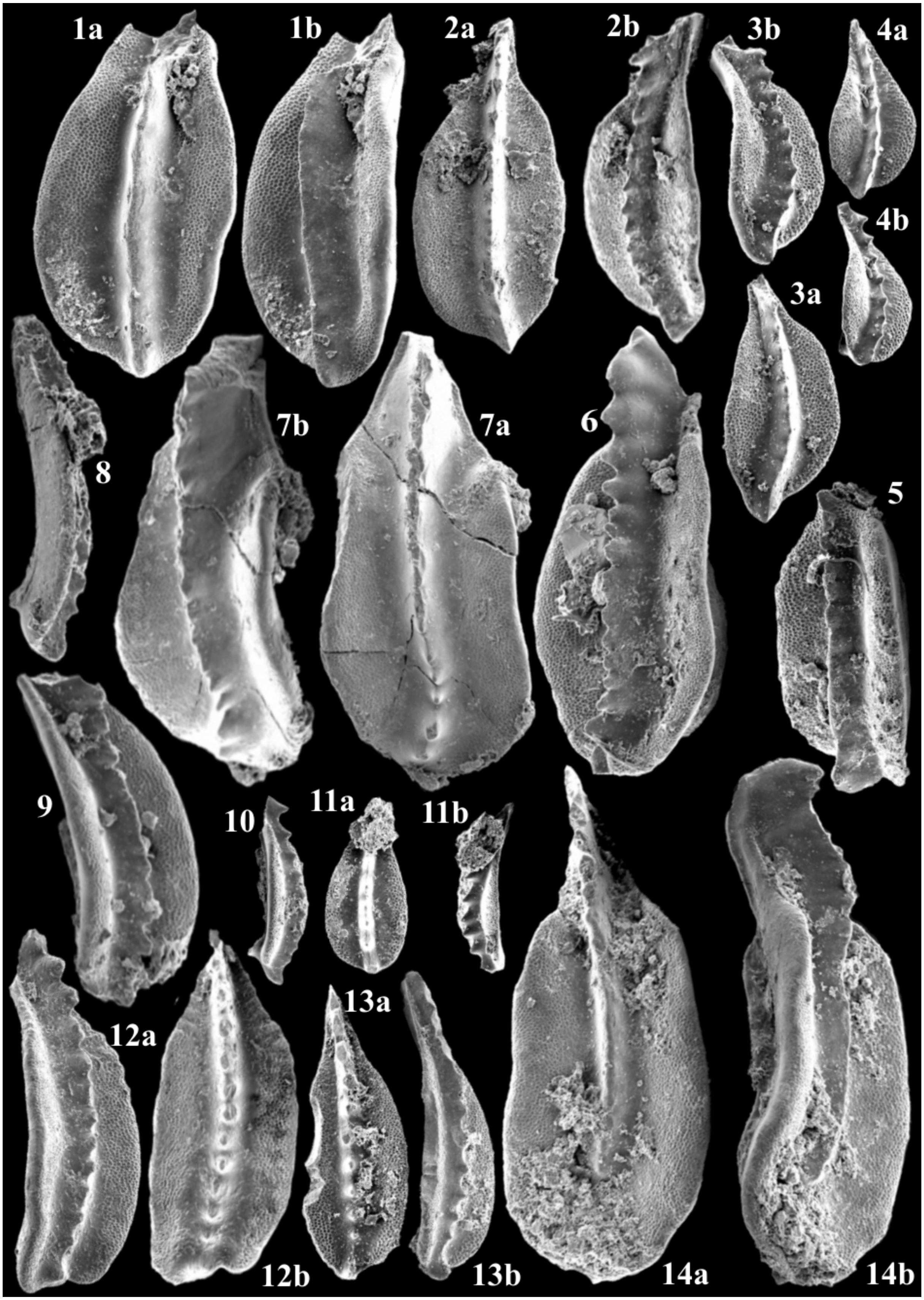
All specimens are SEM photos magnified X70. Letters a and b are used with the same number when both upper (a) and oblique lateral (b) views of the same specimen are illustrated.

1-5, 10. *Clarkina wangi* (Zhang). All are Pa elements showing intra-population and ontogenetic variation; 1, 3, 4 are from sample 6-2; 2 is from sample 5-14; 5 and 10 are from sample 5.1. Note fused carinal denticles even in juveniles (specimens 4, 10).

6-9. *Clarkina longicuspidata* transitional with *C. wangi*. All are Pa elements. 6, 8 are from sample 4 (which was 4.1-4.2); 7 is from sample 3-8 (which was 4.3b); 9 is from sample 5-1. These transitional specimens have a gap adjacent to the cusp, but high middle denticles some of which are laterally compressed or high mostly fused and compressed middle denticles, but still a minor gap between the cusp and second last denticle.

11-13. *Clarkina longicuspidata* Mei and Wardlaw. All are Pa elements. 11 is from sample 3-7 (which was 4.3a); 12 is from sample 3-3 (which was 4.7); 13 is from sample 3-5 (which was 4.5).

14. *Clarkina orientalis* (Barskov and Koroleva). Large Pa element from sample 3-5 (which was 4.5).


1a
1b
2a
2b
3b
4a
4b
3a
8
7b
7a
6
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9
10
11a
11b
12a
13a
12b
13b
14a
14b

Proposal for the Global Stratotype Section and Point (GSSP) for the Wuchiapingian-Changhsingian Stage boundary (Upper Permian Lopingian Series)

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Introduction

The Changhsingian represents the second and last stage of the Upper Permian, which is also known as the Lopingian Series. It is officially referred to as an informal chronostratigraphic unit (Remane *et al*., 2000) since formal recognition of this stage boundary has not yet been presented to the International Union of Geological Sciences for ratification.

Grabau (1923) recognized the *Oldhamina* fauna from the Changxing as the youngest one of the Permian faunal succession and first named the Changxing Limestone (note the stage is spelled according to old transliteration and the formational term using current pinyin spelling according to practice of Chinese Stratigraphic Commission) (Grabau, 1931). Huang (1932) referred the Changxing Limestone as the Latest Permian standard unit of South China. Sheng (1955, 1962), Chao (Zhao in present spelling, 1965) and Zhao *et al*. (1978) subsequently documented the correlation potential of the Changxing Limestone as a standard of the uppermost Permian on the basis of ammonoids and fusulinaceans. Furnish and Glenister (1970) and Furnish (1973) suggested the Changhsingian as a chronostratigraphic unit. Zhao *et al.* (1981) formally proposed the Changhsingian as an international standard for the last stage of the Permian with the D Section in Meishan as the stratotype. The base of the Changhsingian Stage was recommended to be defined at the horizon between the *Clarkina orientalis* Zone and the *C. subcarinata* Zone that is located at the base of bed 2 (*sensu* Zhao *et al*. 1981), which is the base of the Changxing Limestone in Section D at Meishan, Changxing County, Zhejiang Province, China (Fig. 1A). The basal part of this stage is also marked by the occurrence of advanced forms of *Palaeofusulina*, and the tapashanitid and pseudotirolitid ammonoids.

The basal-Changhsingian boundary defined by Zhao *et al.* (1981) has been widely used since it was defined, as it reflects the well-defined faunal changes in major fossil groups such as conodonts, brachiopods, ammonoids, corals and fusulinaceans (Jin *et al*. 1997). These faunal changes may, however, be accentuated by the presence of a significant unconformity a short distance below the base of the Changxing Limestone. Proximity to this unconformity has led others to look for a suitable boundary a little higher in the section. Wardlaw and Mei (2000) suggested that the First Appearance Datum (FAD) of *Clarkina subcarinata sensu stricto* would be a suitable boundary at 13.71 m above the base of the Changxing Limestone at Section D, based on a significant change in the denticulation of gondolellid conodonts. Later, Mei and Henderson (2001) and Mei *et al*. (2001) suggested that the base of the Changhsingian Stage could be defined within the *C. longicuspidata* – *C. wangi* lineage in Bed 4 based on revised taxonomic definitions. The latter definition is only about 88 cm higher than the traditional boundary suggested by Zhao *et al.* (1981); thus it is in close proximity to the historical boundary position. The proposed boundary (Fig. 2) is placed at a recognizable point within the gradual morphologic change in a conodont evolutionary lineage that is recognized by a sample-population approach; this accounts for the considerable variability exhibited by these species. The proposed boundary occurs near the flooding surface in the second parasequence of the Changxing Limestone in the lower part of Bed 4, and is therefore a more suitable position with respect to continuity of deposition. This proposal presents the detailed definition of this boundary.

Location of Type Section

The Meishan D section is located between the cities of Nanjing and Shanghai in Changxing County, Zhejiang Province, SE China (Figures 1A,B,C). The exact location of Meishan D section is 31°4’55”N and 119°42’22.9”E. This section is well protected and freely accessible to scientific researchers since it was ratified by IUGS as the GSSP for the Permian-Triassic boundary in 2001.

Geologically this section is located along the western slope of the Meishan Anticline consisting of Upper Paleozoic and Lower Triassic rocks. The stratigraphic succession is well exposed and not very structurally disturbed.

Description of the Wuchiapingian-Changhsingian boundary succession at Section D

Zhao *et al.* (1981), Sheng *et al.* (1984) and Yin *et al*. (1996) described the Meishan Section in detail. Changqun Cao collected detailed conodont samples continuously from the boundary interval between the Longtan Formation and the Changxing Limestone in Section D at Meishan, Zhejiang, China. This interval includes

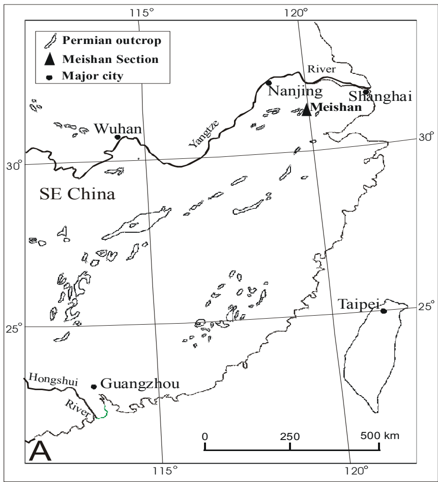
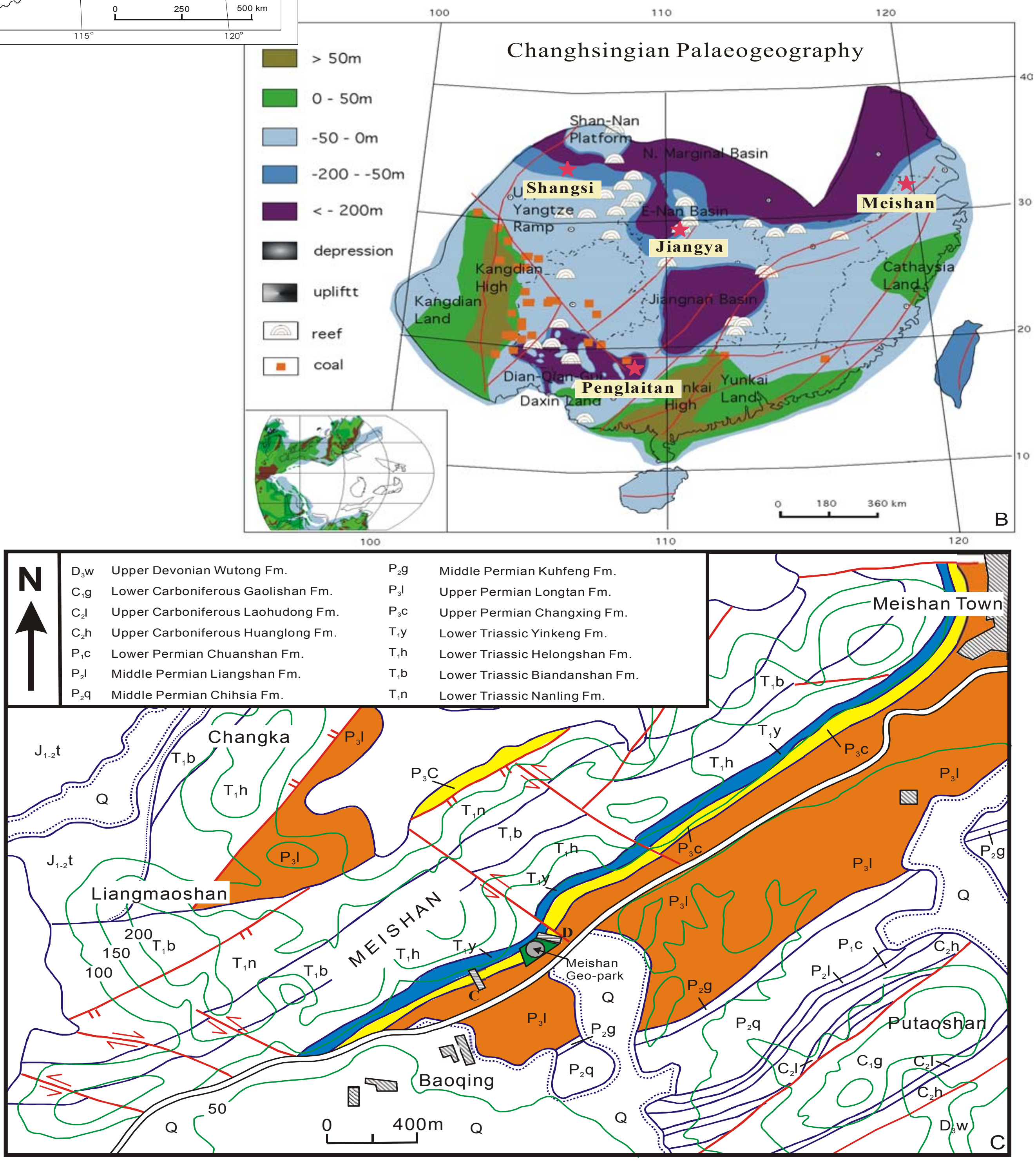


Figure 1. Maps showing the position in Meishan, Changxing County of Zhejiang Province of the proposed GSSP for the Wuchiapingian-Changhsingian Boundary at Section D and the supplemental Section C. Map A shows the proximity of the section between Shanghai and Nanjing. Map B shows the position with respect to paleogeographic setting. Map C shows the position with respect to the geology in the region of Sections C and D as well as the Geopark constructed for the Permian-Triassic boundary GSSP.



Beds 1, 2, 3, 4a, 4b and 5 of Yin *et al*. (1996). The boundary between Beds 1 and 2 is the lithologic boundary between the underlying Longtan Formation and the overlying Changxing Limestone. In addition, conodont samples from Section C have been extensively collected; section C is a new exposure about 300 metres from Section D that has been studied by Yue Wang and others in which the upper Longtan Formation was excavated. The value of Section C is that it exposes more of the upper Longtan Formation and that it clearly shows the transitional nature of deposition across the Longtan/Changxing formational boundary. This removes one objection to the proposed stratotype that not enough of the underlying beds were present even though it doesn't have any bearing on the definition, which occurs higher in the lower part of the Changxing Limestone.

The descriptions and identified fossils from each unit at Section D are summarized in Figures 2, 3, 4.

Upper Permian (Lopingian) Changxing Limestone

Bed 5 (depth, 211-370 cm). Dark grey thin- to medium-bedded bioclastic micritic limestone with siliceous bandings, with normal graded beddings and small sandy wavy beddings. Non-fusulinacean foraminifers (330-370 cm, ACT 109): *Glomospira* sp.; (290-330 cm, ACT 109): *Frondicularia ovata* K. M. Maclay, *Damgarita* sp., *Nodosaria krotovi* Tcherd; (250-290 cm, ACT 108): *Geinitzina uralica* K. M. Maclay, *Globivalvulina distensa* Wang, *Nodosaria longissima* Sue, *Damgarita* sp., *Pseudonodosarlina* sp.; (210-250 cm, ACT 107): *Damgarita* sp., *Frondicularia* sp., *Geinitzina splandli* Tcherd.; fish (210–370 cm): Palaeomiscoidei gen. et sp. indet., *Sinohelicoprion changxingensis* Liu and Chang, *Sinoplatysomus meishanensis* Wei; ostracods (210-370 cm): *Bairdiacypris fornicata* Shi, *Bairdia wrodeloformis* Chen, *Basslerella firma* Kellett, *Eumiraculum changxingensis* Chen, *Petasobairdia bicornuta* Chen, *Silenmites sockakwaformis* Shi. Conodonts (215-230 cm, 5-1): *Clarkina wangi* (Zhang).

Bed 4b (depth, 158-211 cm). Grey thin- to medium-bedded bioclastic micritic limestone, intercalating light grey thin-bedded calcareous mud rock in the upper part, with slightly wavy beddings. Non-fusulinacean foraminifers (158-211 cm, ACT 106): *Geinitzina splandli* Tcherd., *Pseudoglandulina conicula* K. M. Maclay; fusulinaceans (158-211 cm): *Palaeofusulina minima* Sheng and Chang; fish (158-211 cm): Amblypteridae? Coelacanthidae gen. et sp. indet., Palaeoniscoidei gen. et sp. indet., *Sinohelicoprion changxingensis* Liu and Chang, *Sinoptatysomus meishanensis* Wei; ostracods (158–211 cm): *Basslerella obesa* Kellett, *Petasobairdia bicornuta* Chen. Conodonts (185-205 cm, 4b-3): *Clarkina orientalis* (Barskov and Koroleva), *C. wangi* (Zhang); (174-180 cm, 4b-2): *Clarkina orientalis* (Barskov and Koroleva), *C. wangi* (Zhang); (160-167 cm, 4b-1): *Clarkina orientalis* (Barskov and Koroleva), *C. longicuspidata* transitional to *C. wangi*, *C. wangi* (Zhang).

Bed 4a (depth, 80.5-158 cm). Grey thick-bedded bioclastic micritic limestone. Fusulinaceans (85-125 cm, ACT 104): *Palaeofusulina minima* Shang et Chang, *Reichelina changhsingensis* Sheng and Chang; non-fusulinacean foraminifers (125-158 cm, ACT 105): *Frondicularia palmate* K. M. Maclay, *Geinitzina splandli* Tcherd, *Globivalvulina* sp., *Nodosaria longissma* Sue; (85-125 cm, ACT 104): *Nodosaria delicate* Wang, *Damgarita* sp.; brachiopods (85-158 cm): *Cathaysia chonetoides* (Chao), *C. parvalia* Chang. Conodonts (141-157 cm, 4a-4): *Clarkina longicuspidata* transitional to *C. wangi*, *C. wangi* (Zhang); (107-130 cm, 4a-3): *C. longicuspidata* Mei and Wardlaw, *C. longicuspidata* transitional to *C. wangi*, *C. wangi* (Zhang); (88-107 cm, 4a-2): *Clarkina longicuspidata* Mei and Wardlaw.

Bed 3 (depth, 56-80.5 cm). Greyish yellow illite-montmorillonite clay, U-Pb age: 257 Ma (Mundil *et al*. 2001). (56-82 cm) Greyish black silty and calcareous mud rock intercalating argillaceous mud rock, with horizontal bedding. Conodonts (70-80 cm, 3-2): *Clarkina longicuspidata* Mei and Wardlaw, *C. longicuspidata* transitional to *C. wangi*; (56-70 cm, 3-1): *Clarkina longicuspidata* Mei and Wardlaw.

Bed 2 (depth, 0-56 cm). Dark grey thick-bedded silt-bearing micritic limestone. Non-fusulinacean foraminifers (0-55 cm, ACT 103): *Collaniella* sp., *Eacristellaria* sp., *Geinitzina postcarbonica* Spandel, *Pseudoglandulina conica* K. M. M'Clay. Conodonts (47-56 cm, 2-4): *Clarkina longicuspidata* Mei and Wardlaw; (32-47 cm, 2-3): *Clarkina longicuspidata* Mei and Wardlaw, *C. orientalis* (Barskov and Koroleva); (20-30 cm, 2-2): *Clarkina longicuspidata* Mei and Wardlaw; (0-20 cm, 2-1): *Clarkina longicuspidata* Mei and Wardlaw, *C. orientalis* (Barskov and Koroleva).

- Conformable Contact -

Upper Permian (Lopingian) Longtan Formation

Bed 1 (depth of upper part, 0 to -30 cm). Dark dolomitized calcirudite with fragments of limestone, siltstone and phosphate. Non-fusulinacean foraminifers (0 to -30 cm, ACT 102): *Geinitzina uralica* K. M. M'Clay, *Hemigardius* sp., brachiopods (0 to -30 cm, ACT 102): *Orbiculoidea* sp., *Cathaysia chonetoides* (Chao), *Paryphella gouwaensis* Liao, *Spinomarginifera* sp. Conodonts (-4 to -12 cm, 1-2): *Clarkina longicuspidata* Mei and Wardlaw.

(depth of lower part, -30 to -70 cm). Dark medium-bedded calcareous siltstone with horizontal bedding surfaces. Conodonts (-30 to -40 cm, 1-1): *Clarkina longicuspidata* Mei and Wardlaw.

Description of the Wuchiapingian-Changhsingian boundary succession at Section C

The descriptions and identified fossils from each unit at Section C are summarized in Figures 5, 6, 7.

Upper Permian (Lopingian) Changxing Limestone

Bed 13 (depth, 1668 - 1797cm) Grey medium- to thick-bedded bioclastic micritic limestone, with abundant ostracods, small foraminifera and calcareous algae. Brachiopods: *Cathaysia chonetoides* Chao, *Orthothetina regularis* Huang(MSC8).

Bed 12 (depth, 1661 - 1668cm) Greyish yellow thin-bedded silty phosphatic rock, with shale bed of 0.5cm and 1.5cm thick respectively at its top and bottom.

Bed 11 (depth, 1615 - 1661 cm) Grey thin- to medium-bedded siliceous sponge spicule-bearing bioclastic micritic limestone with siliceous bandings, with muddy wavy beddings. Bioclasts include small foraminifers, siliceous sponge spicules, gastropods and a few echinoderms. Conodonts: *Clarkina wangi* (Zhang), *C. wangi-subcarinata* transitional form; Foraminifer: *Colaniella* sp. (MSC6-4).

Bed 10 (depth, 1594 - 1615) White medium-bedded carbonized tuff.

Bed 9 (depth, 1540 - 1594cm) Grey thin- to medium-bedded bioclastic micritic limestone with horizontal laminas, contain bioclasts of ostracods, small foraminifers, fish bones, siliceous sponge siliceous sponge spicules, other spicules, and intraclasts. Brachiopods: *Araxathyris* sp., *Meekella* sp., *Cathaysia chonetoides* Chao, *Neochonetes* sp. (MSC6-2); Conodonts: *Clarkina wangi* (Zhang) (MSC6-1,2); Foraminifer: *Colaniella* sp. (MSC6-1, 2).

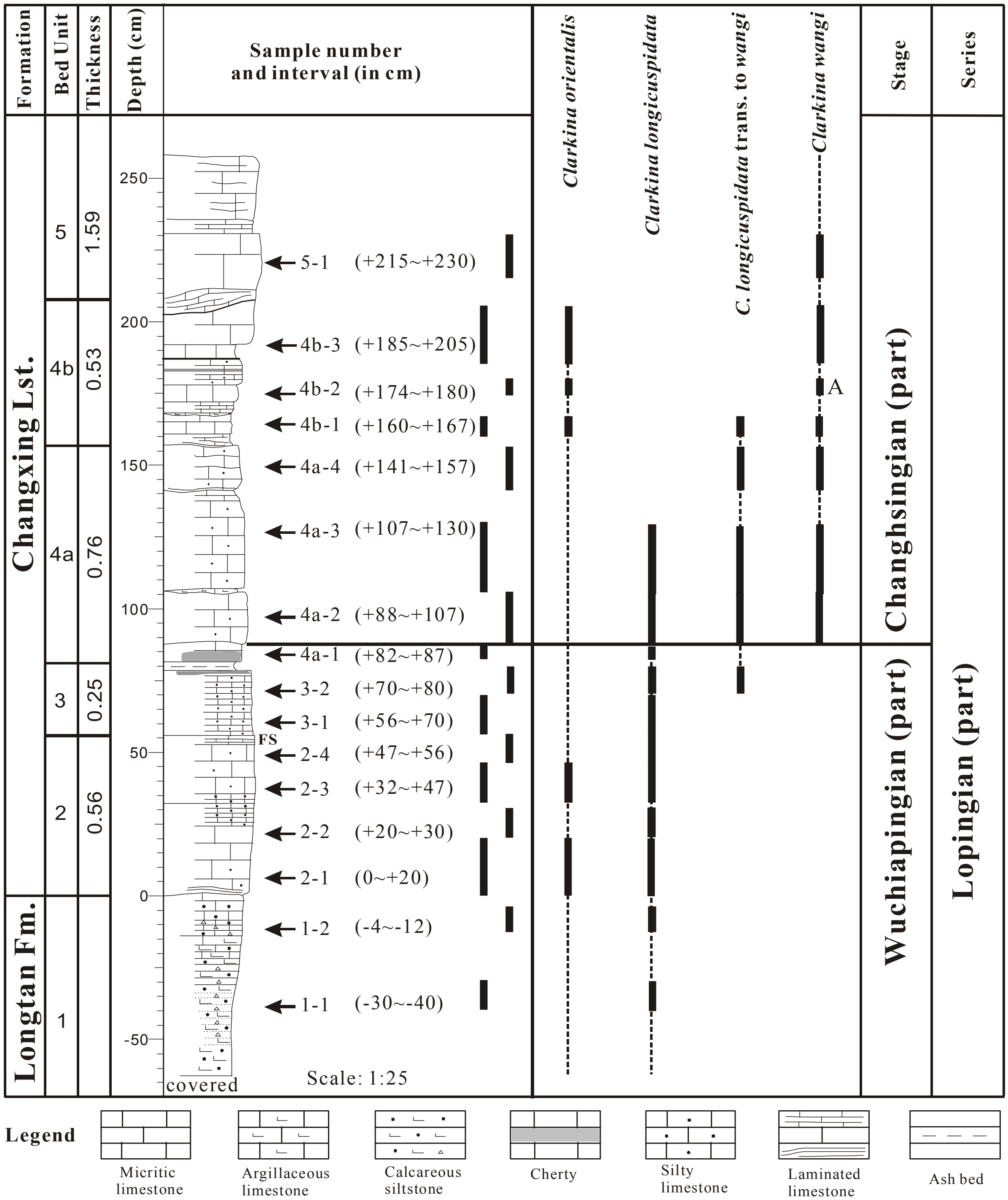


Figure 2. Ranges of key conodonts around the Wuchiapingian-Changhsingian Boundary interval at Section D, Meishan.

Bed 8 (depth, 1287 - 1540cm) Alternative beds of dark thin- to medium-bedded bioclastic micritic limestone and that with laminated chert bands, forming 5 cycles; horizontal bedding; bioclasts include fragments of foraminifers, brachiopods, ostracodes, sponge spicules, calcareous algae, fish bone, gastropods and echinoderms, oriented usually. Brachiopods: *Cathaysia chonetoides* Chao (MSC5-12,13); *C. chonetoides* Chao, *Araxathyris* sp. (MSC5-14); Conodonts: *Clarkina wangi* (Zhang) (MSC5-9,13,14).

Bed 7 (depth, 1217 - 1287cm) Dark grey medium-bedded biomicritic limestone with muddy horizontal laminae. Bioclastics are mainly composed of sponge spicules in top part and abundant ostracods, small foraminifers and sponge spicules in the rest parts. Ammonoid: *Sinoceltites* sp. (MSC5-1,4); *Pseudogastrioceras* sp. (MSC5-3); *Tapashanites* sp. (MSC5-4); Conodonts: *Clarkina longicuspidata* Mei and Wardlaw, *C. longicuspidata-wangi* transitional form, *C. wangi* (Zhang), *C. orientalis* (Barskov and Koroleva) (MSC5-1); *C. wangi* (Zhang) (MSC5-3); Fusulinaceans: *Palaeofusulina simplex* Sheng and Chang, P. aff. *sinensis* Sheng (MSC5-1); Brachiopods: *Araxathyris* sp., *Orthothetina* sp., *Cathaysia chonetoides* Chao, *Neochonetes* sp. (MSC5-1); *Cathaysia chonetoides* Chao (MSC5-2); *Spinomarginifera lopingensis* Kayser (MSC5-3); Foraminifer: *Colaniella* sp. (MSC5-1,2,4).

Bed 6 (depth, 1203 - 1217cm) Black cherty and rich organic shale, laminated, containing quartz silt, mica and chert grains, organic-

Figure 3. Picture showing the unit stratotype for the Changxing Limestone prior to construction of the Geopark.

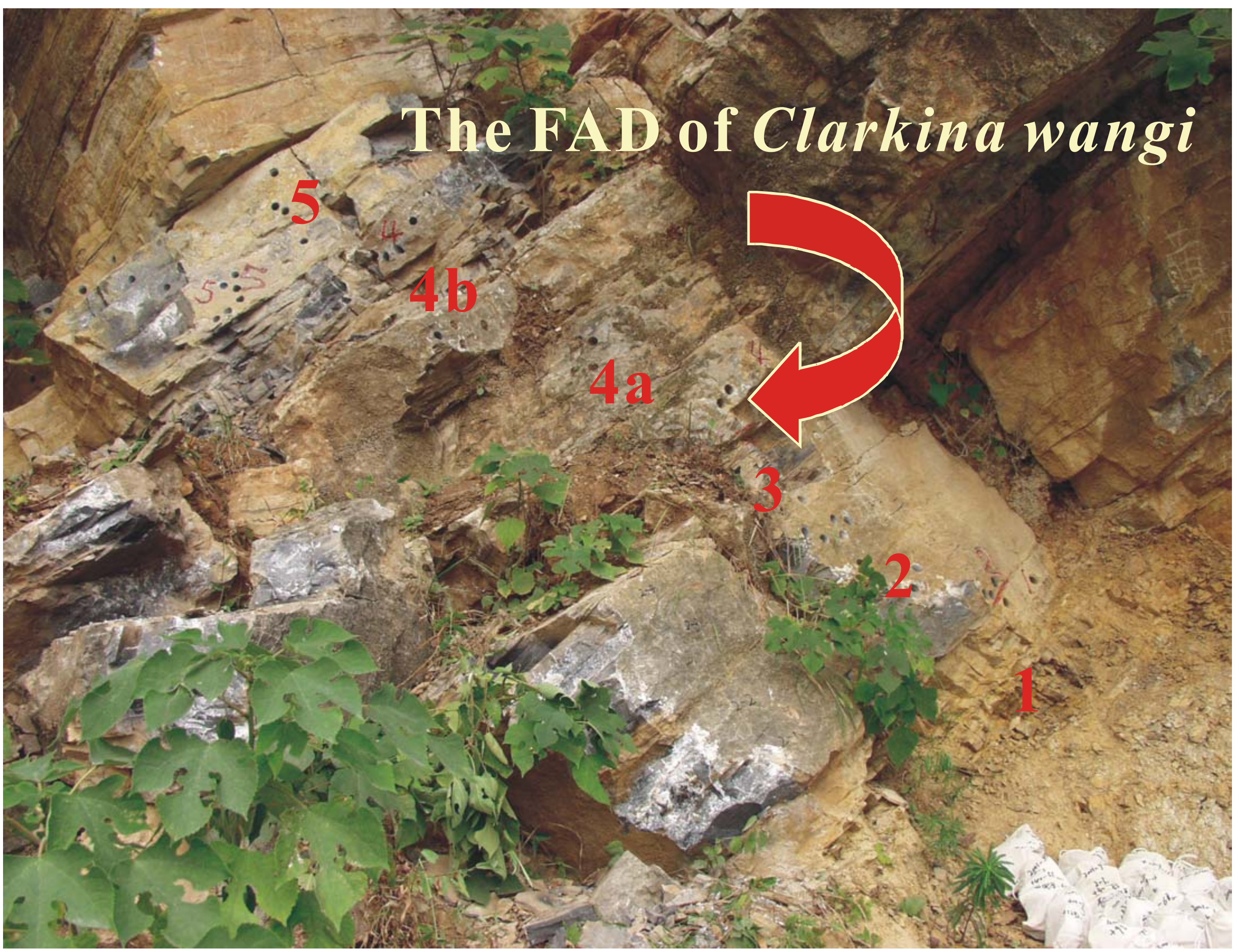


Figure 4. Picture showing the proposed Wuchiapingian-Changhsingian Boundary interval at Section D, Meishan.

rich and bioclastic, with 3 cm thick clay bed at the bottom. Conodont: *Clarkina longicuspidata-wangi* transitional form (MSC 4-1).

Bed 5 (depth, 1118 - 1203 cm) Black thin- to medium-bedded and laminated biomicritic limestone, containing organic debris of foraminifers, ostracods, calcareous spicules, brachiopods and echinoderms; partly dolomitized. Brachiopods: Fusulinaceans: *Reichilina changhsingensis* Sheng and Chang, *R. media* K.M. MaClay, *R. pulchra* K.M. MaClay (MSC4-3b); *Cathaysia chonetoides*, *Spinomarginifera lopingensis* (MSC4-6), *Cathaysia chonetoides*, *Spinomarginifera lopingensis* (MSC4-5); *Cathaysia chonetoides* (MSC4-4); *Cathaysia chonetoides*, *Neochonetes* sp. (MSC4-3a); *Orthothetina* sp. (MSC4-3b); Conodonts: *Clarkina longicuspidata* Mei and Wardlaw (MSC4-6); *C. longicuspidata* Mei and Wardlaw, *C. orientalis* (Barskov and Koroleva) (MSC4-5); *C. longicuspidata* Mei and Wardlaw (MSC4-3a); *C. longicuspidata-wangi* transitional form, *C. orientalis* (Barskov and Koroleva), *C. longicuspidata* Mei and Wardlaw (MSC4-3b); Foraminifer: *Colaniella* sp. (MSC 4-3, 5); Ammonoid: *Pseudogastrioceras* sp. (MSC 4-4).

Bed 4 (depth, 1079 - 1118) Dark marl with horizontal lamina, containing intraclasts, sand grains, and fragments of ostracods, sponge spicules, foraminifers, fish bone and other biogenic debris; thin clay bed ranging from 2 to 10 cm in thickness occurring between marl beds at the bottom of this bed. Brachiopods: *Cathaysia chonetoides* Chao, *Neochonetes* sp., *Orthothetina regularis* Huang (MSC 4-8a); Conodonts: *Clarkina longicuspidata* Mei and Wardlaw (MSC4-8b, 4-7).

- Conformable contact-

Upper Permian (Lopingian) Longtan Formation

Bed 3 (depth, 824 - 1079) Alternative beds of grey mudstone and earthy yellow, thin beds of calcareous siltstone or silty limestone, consisting of 6 cycles. From the corresponding part of Bed 0 of Section D Zhao *et al*. (1981) reported *Orbiculoidea minuta* Liao, *Orthotichia* sp., *Paryphella gouwaensis* Liao, *Spinomarginifera lopingensis* (Kayser), *Sp. kuichowensis alpha* Huang, *Streptorhynchus* sp. (ACT 32). New collections include brachiopods: *Neochonetes* sp. (MSC4-9)

Bed 2 (depth, 730 - 824) Grey mudstone intercalated with greenish grey thin dolomitic sandstone or sandy dolomite, forming 3 cycles.

Bed 1 (depth, 0 - 730 m) Greenish-grey or earthy yellow mudstone intercalated with thin beds of siltstone that contain abundant brachiopods and a few of ammonoids. Ammonoid: *Pseudogastrioceras* sp. (MSC 3-17); Foraminifer: *Colaniella* sp. (MSC3-22); Fusulinacean: *Reichilina* sp. (MSC3-22); Brachiopods: *Squamularia grandis*, *Enteletes retardate*, *Cathaysia chonetoides*, *Orthothetina regularis*, *Spinomarginifera lopingensis*, *S. kueichowensis*, *Neochonetes* sp., *Edriosteges poyangensis* (MSC3-17), *Enteletes retardate, Cathaysia chonetoides*, *Orthothetina rubber, Orthothetina regularis, Acosarina minuta, Spinomarginifera lopingensis, Neochonetes* sp. (MSC3-22), *Enteletes retardate*, *Derbyia* sp., *Haydenella kiangsiensis, Cathaysia chonetoides, Orthothetina regularis*, *O.* sp., *Acosarina minuta, Spinomarginifera lopingensis, Neochonetes* sp. (MSC3-23), *Enteletes retardate, Cathaysia chonetoides, Neochonetes* sp., *Spinomarginifera kuizhowensis* Huang (MSC3-24), *Enteletes retardate, Cathaysia chonetoides, Acosarina minuta, Spinomarginifera lopingensis, Neochonetes* sp. (MSC3-25), *Cathaysia chonetoides, Neochonetes* sp. (MSC3-28), *Squamularia grandis*, *Enteletes retardate*, *Cathaysia chonetoides, Spinomarginifera lopingensis*, *Neochonetes* sp. (MSC3-29)

Depositional Succession at the Wuchiapingian-Changhsingian boundary

Regionally, the Longtan Formation is a coal-bearing, marginal-marine unit. The generalized stratigraphic succession of this formation from core records of all wells in Meishan (Zhao *et al*., 1978) as well as core records from wells near Section D and C (CK 818 and CK658) shows that this formation, some 300m in thickness, represents a transgressive sequence with a brief regression between the middle and upper parts. The lower part is about 90 m thick, consists of coarse sandstone, siltstone and bauxitic clay beds with fossils of roots and stems, and bears mineable coal beds. Plant fossils from bauxitic clay beds include *Gigantopteris nicotianaefolia* Schenk, *Protoblechnum wangi* Halle, *Taeniopteris norinii* Halle, and *Pecopteris* sp. The middle part, 80 m in thickness, is composed of alternating beds of fine-grained sandstone and sandy siltstone. It contains three one-metre thick sandy limestone beds containing abundant brachiopods, corals and the fusulinacean *Chenella* sp. This part is capped by a 12 m thick coal-bearing unit, which comprises alternating beds of cross bedded, fine grained sandstone and silty mudstone containing fragmental plant fossils. The upper part, 60 m in thickness, comprises mudstone intercalated with fine-grained sandstone. Fossils of ammonoids Araxoceratidae gen. et sp. indet., *Pseudogastrioceras* sp.; bivalves *Palaeoneilo sunanensis* Liu, *P.* cf. *leiyangensis* Liu, *Pernopecten* sp., *Schizodous* cf. *dubiiformis* Waagen; brachiopods *Anidanthus* cf. *sinosus* (Huang), *Acosarina* sp., *Cathaysia chonetoides* (Chao), *Crurithyris* sp., *Prelissorhynchia* sp. have been reported from the uppermost 4m thick unit. Ammonoids, including *Pseudogastrioceras* sp., *Jinjiangoceras* and *Konglingites* sp. were recorded from this part. The sedimentary and fossil features are indicative of a gradually deepening trend from the coastal swamp, shallow and deeper shelf with a brief interval of swamp deposition between the middle and upper parts. The maximum regression during the Wuchiapingian Stage occurs within the middle part of the formation, which is represented by the widespread limestone beds overlying the mineable coal beds.

Transgressive deposits (fine cherty siliciclastics) of the Talung, the basal Changxing Limestone, and upper Longtan Formation overlie this maximum regression within the Longtan Formation, presumably in an unconformable contact; however, the extent of this unconformity is uncertain. Regionally, the boundary between the Longtan Formation and the Changxing Limestone is regarded as a sequence boundary (Zhang *et al*. 1997). However, in sections C and D at Meishan, this boundary is represented by a smooth transition from calcareous mudstone beds that increase in thickness upward to thick-bedded bioclastic limestone, indicating that the sequence boundary is lower within the upper Longtan Formation. It seems more appropriate to place the sequence boundary at the top of the middle part of the Longtan Formation because the 12 m thick fine-grained sandstone and sandy mudstone unit is characterized by cross bedding, coal seams and plant fossils indicating a coastal facies. The exposure at the Meishan D section contains only the uppermost part of the Longtan Formation (Figures 2, 4). These beds include earthy yellow, calcareous siltstone and

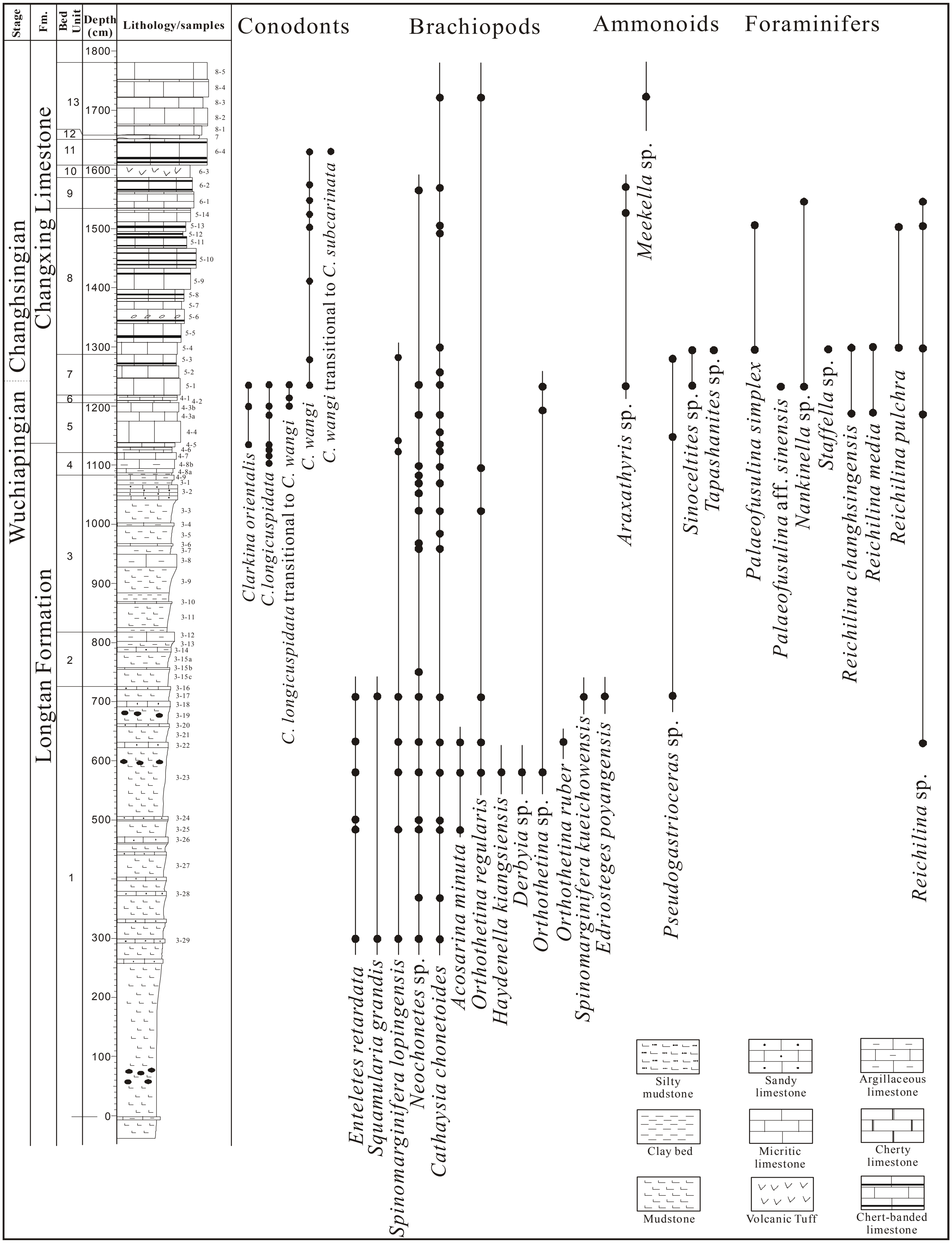


Figure 5. Stratigraphic occurrences of fossils around the Wuchiapingian-Changhsingian interval at Section C, Meishan.

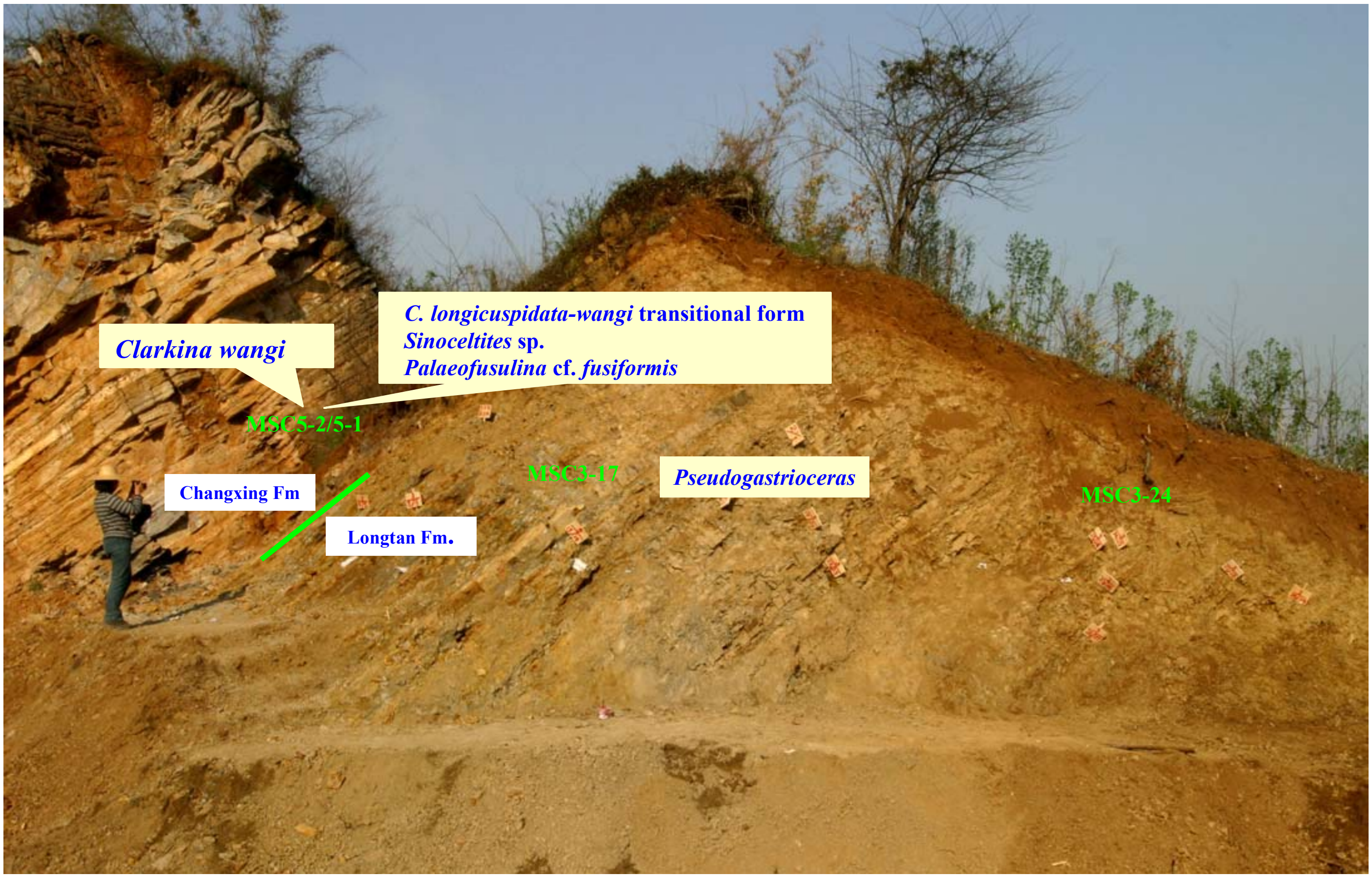


Figure 6. The Wuchiapingian-Changhsingian Boundary interval at Section C, Meishan.

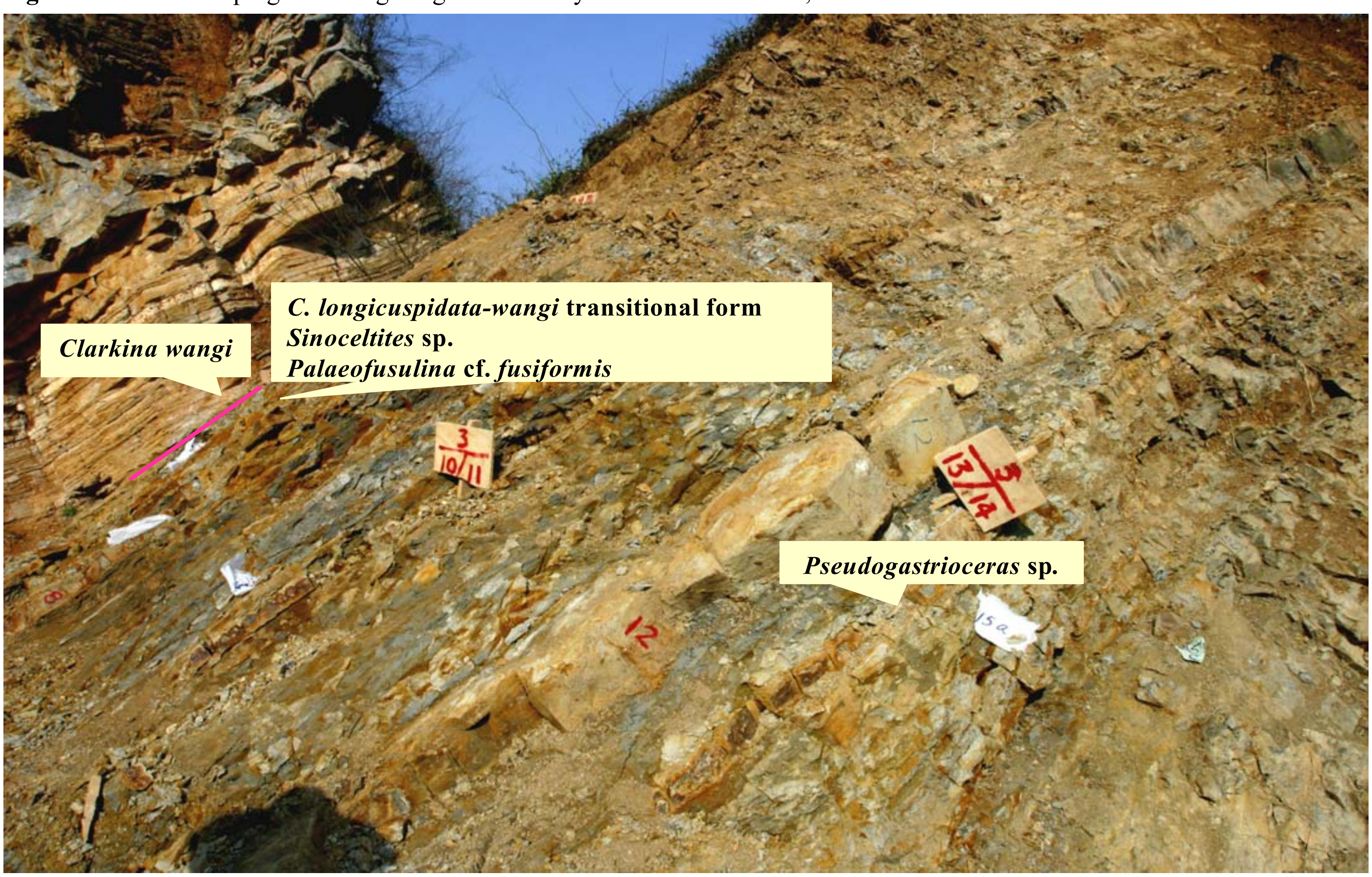


Figure 7. Details around the Wuchiapingian-Changhsingian Boundary at Section C, showing the gradual lithological change from the silt-dominated Longtan Formation to the carbonate-dominated Changxing Formation.

mudstone with horizontal beds of increasing thickness that contain ammonoids and brachiopods (Zhao *et al*. 1981). This bed appears to be conformable with the overlying Baoqing Member of the Changxing Limestone and may represent the first transgressive cycle above the unconformity in the middle to upper Longtan Formation; the bed is not assigned to the Talung Formation because of the lack of chert.

The lowest bed (Bed 2) of the Changxing Limestone at section D, which is represented by dark grey, thick-bedded silty wackestone, appears to form the upper part of a cycle or parasequence. Bed 3 contains greyish black calcareous mudstone and thin-bedded argillaceous mudstone that may represent the flooding unit of a second parasequence in the section. Beds 4 and 5 include thin to medium bedded wackestone and represent the regressive portion of this second parasequence. The speciation event from *Clarkina longicuspidata* to *C. wangi* occurs just above the flooding surface of the second parasequence. Yin *et al.* (1996) and Zhang *et al*. (1997) illustrate numerous high-frequency cycles throughout the Changxing Limestone.

Fossil Succession

Conodonts

The descriptions and identifications of gondolellid conodont taxa around this boundary have gone through a number of changes over the past several years during a search for a reliable high-resolution biostratigraphy for the Lopingian. Mei *et al*. (in press) describe a population approach for gondolellid taxa that involves analysis of the entire sample-population from juveniles to adult specimens and recognizes that for this interval, the carinal denticulation pattern is the most important morphologic feature, although all other morphologic characters are considered and described. The key to this approach is that rare morphotypes within sample-populations that resemble closely related taxa are not recognized as separate taxa unless a distinct growth series can be demonstrated. Rare specimens within a population may exhibit one or several characters that are thought to be diagnostic of other species meaning that a large number of specimens must be examined in order to make identifications. The separate identification of rare morphotypes including large gerontic pathogenic morphotypes has resulted in apparent long ranges and high apparent diversities. The evolution of *Clarkina* species during much of the Lopingian involves a series of small gradational evolutionary events within an anagenetic series of species. The speciation events are recognizable and correlatable because the changes in the proportion of new characters occur over a relatively narrow interval. During this interval there are forms that are transitional in character. The basal-Changhsingian is defined by the FAD of *Clarkina wangi* within the lineage from *C. longicuspidata* to *C. wangi* at the base of Bed 4a-2 at Meishan D. The detailed distribution of this lineage is provided for both Meishan Section C and Meishan Section D. At section C (Figure 5), *Clarkina longicuspidata* is recognized from 10.95 to 12.45 metres (samples lower in the section have not yet been processed), specimens of *C. longicuspidata* transitional to *C. wangi* occur from 11.9 to 12.45 metres, and *C. wangi* occurs from 12.2 to 16.4 metres in the section (higher samples have not been processed). At section D (Figure 2), *Clarkina longicuspidata* occurs from –0.4 to 1.3 metres, specimens of *C. longicuspidata* transitional to *C. wangi* occur from .7 to 1.67 metres, and *C. wangi* occurs from .88 to 2.3 metres in the section (it ranges higher, but these data are not included here). Thus the interval with transitional specimens ranges from 0.55 metres at Section C to 0.97 metres at section D, demonstrating the high degree of resolution. The FAD of *Clarkina wangi* occurs 1.35 metres above the base of the Changxing Limestone at Section C and .88 metres above the base at Section D, but this difference may reflect differential weathering as much as any lateral facies changes given that the exposure at section C is so fresh. Above the interval with transitional specimens the identification becomes very clear and in general the abundance seems to increase; the first abundant *Clarkina wangi* in section D occurs at 1.74 metres or .86 metres above the FAD.

The following taxonomic section is slightly modified from Mei *et al.* (in press) and details the descriptive changes necessary to recognize these taxa according to the sample-population approach. Figure 8 shows some of the morphologic characters of the key conodont taxa for defining the GSSP.

Clarkina longicuspidata Mei and Wardlaw in Mei *et al*. 1994
Figs. 8a1, a2, b1, b2

Clarkina longicuspidata Mei and Wardlaw in Mei *et al*. 1994, p. 136, pl. II, figs. 7-9.

Original Diagnosis: A species of *Clarkina* characterized by a Pa element with a square to bluntly rounded posterior termination to the platform which is widest near the middle part, a terminally located long and large proclined cusp, a marked gap between the cusp and the posteriormost denticle, denticles increasing in height anteriorly except for distal few, with the widest one near the anterior narrowing of platform, well-developed smooth furrows, upturned lateral margins and a smoothly abrupt anterior narrowing of the platform (Mei *et al*. 1994, p. 136).

Emended Diagnosis: A species of *Clarkina* with a denticulation in adult Pa elements that has a more or less erect cusp that is as high as or a little bit higher than the posteriormost denticle. The slope of the cusp is gentle, low and usually 1.5 to 2 times as long as the height of the cusp. The cusp joins the penultimate posterior denticle by a ridge that gently slopes down from the cusp and forms the lowest and narrowest part of the carina, just posterior to the penultimate posterior denticle, which is usually considerably reduced and fused; the connecting ridge forms a wide concave arc in lateral view. This wide gap becomes less prominent in larger gerontic specimens and in stratigraphically younger specimens. The platform is usually elongate, usually widest around the middle and tapering toward the anterior. The posterior platform termination ranges from narrowly pointed to rounded and squared.

Holotype: The specimen illustrated on pl. II, fig. 7 (Mei and Wardlaw in Mei *et al*., 1994) with the depository number of NIGP121717.This specimen is from Sample QT-67 in the upper Wuchiaping Formation at Nanjiang Section, Sichuan, South China.

Remarks: This species is differentiated from *Clarkina subcarinata* (Figs. 3h, i1, i2) by its prominent gap anterior to the cusp. However, this wide posterior carinal gap becomes considerably reduced in larger gerontic specimens and in stratigraphically younger speci-

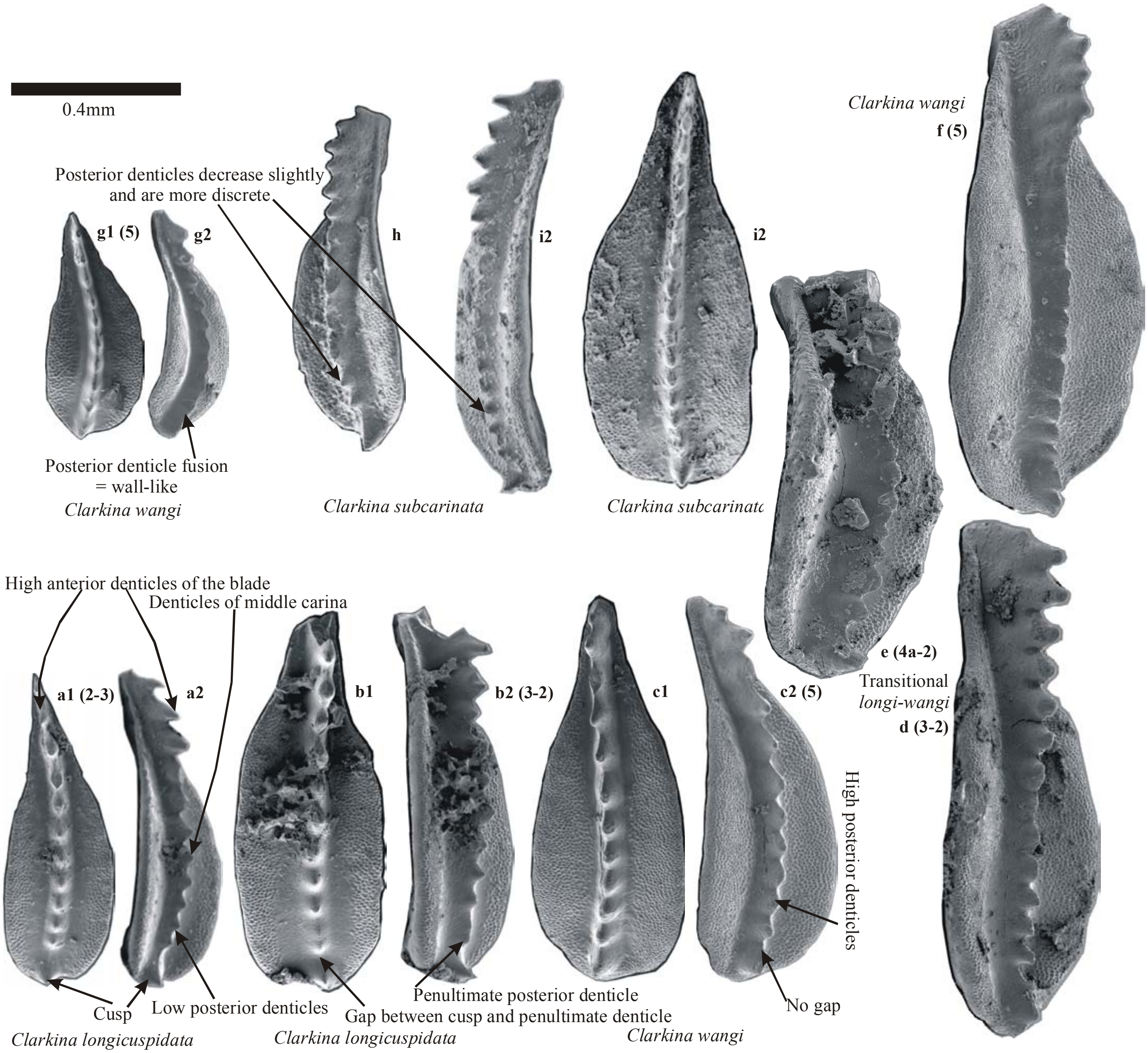


Figure 8. Plate depicting the key conodonts for defining the base Changhsingian GSSP as well as some of the key morphologic features discussed in the text.

mens. *Clarkina wangi* differs from this species by lacking a gap between the cusp and the posterior denticles. Specimens that are transitional between *C. longicuspidata* and *C. wangi* have a gap, but high middle denticles some of which are laterally compressed (Figure 8d, Sample 3-2) or high, mostly fused and compressed middle denticles, but still a minor gap (Figure 8e, Sample 4-2).

Occurrence: Upper Wuchiapingian to lowermost Changhsingian, South China.

Clarkina wangi (Zhang 1987)
Figs. 8c1, c2, g1, g2, f

Neogondolella subcarinata elongata Wang and Wang 1981a, p. 118, pl. II, figs. 1-4.
Neogondolella subcarinata elongata Wang and Wang 1981b, pl. 1, figs. 21, 25.
Neogondolella subcarinata elongata Wang and Wang in Zhao *et al.* 1981, p. 80, pl. VI, figs. 1-5.
Gondolella wangi Zhang 1987, pl. 1, fig. 4.
Non *Neogondolella wangi* Dai and Zhang 1989, p. 234, pl. 49, figs. 19-22.
Neogondolella wangi Dai, Tian and Zhang in Tian 1993, pl. 4, figs. 23a, 23b.
Clarkina wangi (Zhang). Mei *et al*. 1998, p. 225, pl. III, fig. K.
Clarkina subcarinata (auct. non Sweet in Teichert *et al.* 1973). Mei *et al*. 1998, pl. I, fig. E, pl. II, fig. I.
Clarkina prechangxingensis Mei *et al*. 1998, pl.1, fig. I.
Clarkina predeflecta Mei *et al*. 1998, pl. II, figs. E, J, pl. III, fig. C.

Original Diagnosis: Unit wide, widest around the middle of the unit, tapering considerably both anteriorly and posteriorly, usually no free blade. The posterior end of the unit extends posteriorly and sharp, with a prominent and recline cusp. The anterior blade is a little bit higher than the rest of carina, and lowers down toward the posterior. The attachment surface on the lower surface is wide. Unit is prominently arched at the middle (Translated from Chinese in Wang and Wang 1981a).

Original English Diagnosis: A subspecies of *Neogondolella subcarinata* characterized by an elongated and posteriorly inclined cusp and by a wide platform that abruptly narrows anteriorly (Wang and Wang 1981b, p.231).

Original Description: Platform wide, arched, and slightly curved laterally, its greatest width near middle or mid-posterior. Cusp commonly projects beyond posterior platform, forming a posterior separate wedge, commonly forming part of margin of platform. Denticles on carina partly fused, increasing in size and spacing anteriorly. Platform abruptly tapering at posterior end and at anterior one third to one fourth of unit. Free blade not well developed. Lower attachment surface wide and having a pit, surrounded by elevated loop posteriorly; keel gradually elevated from pit (Wang and Wang 1981b, p. 231).

Emended Diagnosis: A species of *Clarkina* with a platform of the narrow-type, widest at the midlength of the posterior and middle platform where platform tapers to both the anterior and posterior and is thus lenticular in outline, denticles and the reclined cusp are largely fused as a continuous carina that keeps nearly the same height, extends beyond the posterior platform margin and thus makes the platform end projectively pointed. In advanced forms the carina is less fused and decreases slowly in height up to the reclined cusp (Mei *et al*. 1998, p. 225).

New Emended Diagnosis: A species of *Clarkina* with a denticulation in adult Pa elements that has posterior denticles that are of near equal height and a cusp that is not clearly separated from the carina with largely fused denticles. The carina in lateral view keeps about the same height towards the end of the platform and very often looks like a high "wall". The carina extends beyond the posterior platform margin and thus makes the platform end projectively pointed. In advanced forms the carina is less fused and decreases slowly in height until the reclined cusp.

Remarks: This species was originally named by Wang and Wang (1981a, 1981b) as a subspecies of *Neogondolella subcarinata*, *N. subcarinata elongata*. Later, this subspecies was elevated to species level by both Zhang (1987) and Dai and Zhang (1989). Since the species name "*elongata*" has been used for a Lower Triassic species by Sweet (1970), both Zhang (1987) and Dai and Zhang (1989) renamed it "*wangi*". Specimens designated as *N. wangi* by Dai and Zhang are from the Shangsi section and have a different denticulation pattern – they are not *Clarkina wangi*. Mei *et al*. (1998) tentatively limited this species to specimens with a platform of the narrow-type and a wall-like carina. Specimens with this type of denticulation, but with different shapes of platform outline were tentatively named *Clarkina prechangxingensis* (round-morphotype), *C. wangi* (narrow-morphotype), *C. predeflecta* (square-morphotype) and *C. subcarinata* (transitional mophotype) by Mei *et al*. (1998) in an attempt to consolidate the disparate form taxa identified previously. Mei *et al*. (1998) stated: "The taxonomy of form species is tentatively followed here to avoid dramatic taxonomic change, although the present authors are ready to accept taxonomic adjustments to the multi-element species in the near future." Following this trend and based on the holotypes of the form species we apply the names *Clarkina wangi* to the forms with the high, wall-like carina with various platform outlines, and *Clarkina subcarinata sensu stricto* to the forms with a similar denticulation to *C. wangi*, but the posterior denticles are usually moderately reduced in height and partially discrete.

Holotype: The specimen illustrated with the depository number of 53222 by Wang and Wang (1981a; pl. II, figs. 3, 4) and by Wang and Wang (1981b; pl. 1, figs. 21, 25). This specimen is from Sample ACT-116, which is from the middle Bed 5 of Sheng *et al*. (1984, 1987). The stratigraphic position is approximately corresponding to the middle of Bed 8 of Yin *et al*. (1996).

Occurrence: Lower Changhsingian, South China.

Ammonoids

The occurrence of *Pseudogastrioceras* sp., *Jinjiangoceras* and *Konglingites* sp. in the upper part of the Longtan Formation suggests the upper part of the Longtan Formation is Latest Wuchiapingian. Based on fossil data from northern Jiangxi Province, Zhao *et al.* (1978) suggested two latest Wuchiapingian ammonoid zones, the *Konglingites* Zone in the lower and the *Sanyangites* Zone in the upper part. In the meantime, they pointed out that these two zones share all other ammonoid genera except the named genera *Sanyangites* or *Konglingites*. Occurrences of *Sanyangites* are limited and *Konglingites* could extend into higher level while *Sanyangites* is absent or occurs in the top portion of the section. Therefore, the lack of *Sanyangites* does not necessarily mean any depositional gap in Sections C and D.

The appearance of the tapashanitid and pseudotirolitid forms marks a turning point of phylogenetic development of Lopingian ammonoid faunas. The lowest occurrence of the tapashanitid genus *Sinoceltites* in Section C coincides with the FAD of *Clarkina wangi*, the indicative conodont species of the Changhsingian basal boundary. The other tapashanitid genus *Tapashanites* appears firstly 42 cm above the proposed boundary. A fully diversified Early Changhsingian ammonoid fauna occurs in a bed about 4 m above the boundary at Section D.

Brachiopods

Liao (1979) studied brachiopods around the boundary between the Changxing Formation and the Longtan Formation at Section C. Such species as *Orbiculoidea minuta* Liao, *Acosarina* sp., *Streptorhynchus* sp., *Paryphella gouwaensis* Liao, *Anidanthus* cf. *sinosus* (Huang), *Cathaysia chonetoides* (Chao), *Prelissorhynchia* sp. and *Spinomarginifera lopingensis* (Kayser) were recorded from the topmost bed of the Longtan Formation. Shuzhong Shen studied new collections, including more than 1300 brachiopod specimens from the Changhsingian/Wuchiapingian boundary beds of Section C. The collection includes 15 species in 12 genera. As shown in Figure 5, brachiopods are very abundant and diverse in the uppermost part of Longtan Formation and are dominated by many common Lopingian species. *Spinomarginifera lopingensis, Edriosteges poyangensis, Orthothetina ruber* and *Squamularia grandis* are the most common species in the late Wuchiapingian in South China (Liao, 1980; Shen and Shi, 1996). *Cathaysia chonetoides, Haydenella kiangsiensis* and *Orthothetina regularis* are very abundant in the whole Lopingian in South China. Above Bed 1 at Section C, brachiopods remain very abundant, but apparently become less diverse. Some species with relatively large shells such as *Squamularia grandis, Edriosteges poyangensis, Enteletes retardata* disappear at the top of Bed 1. Only a few small brachiopods including the tiny *Neochonetes* sp. and *Cathaysia chonetoides* continue to be present in the topmost bed (Bed 2) of the Longtan Formation and in the lowest part of the Changxing Limestone (Beds 3-8). This change in brachiopod composition may indicate a continuous transgression from the upper part of the Longtan Formation to the lower part of the Changxing Limestone.

Fusulinaceans

The Changhsingian fusulinacean fauna is characterized by the dominance of the genus *Palaeofusulina* in the Tethys. The Wuchiapingian-Changhsingian boundary in the carbonate successions of South China used to be indicated by the appearance of the Changhsingian fusulinacean genera *Palaeofusulina* and *Gallowayinella* (Rui and Sheng, 1981). The genus *Gallowayinella* may extend downward into the uppermost Wuchiapingian because it has been reported in association with *Clarkina orientalis* (Wang *et al*., 1997). In Section D, the lowest occurrence of the genus *Palaeofusulina* is right above the boundary. In addition to the primitive form such as *P. simplex* Sheng and Chang, an advanced form close to *P. sinensis* Sheng also occurs in the same level with the first tapashanitid ammonoid genus and the first *Clarkina wangi* at Section C (sample number MSC 5-1). More advanced forms, such as *Palaeofusulina sinensis,* do not appear until the Late Changhsingian (Bed 17 of Section D). Among the others, *Reichelina changhsingensis* Sheng and Chang and *R. pulchra* K.-M. Maclay, which first occur in Bed 4a, are both characteristic forms of the Changhsingian fusulinacean faunas of South China.

Palynomorphs

Changhsingian palynomorphs, identified within the *Leiosphaeridia changxingensis – Micrhystridium stellatum* Assemblage Zone, are monotonous quantitatively and mainly include acritarchs. In addition to the named species, the zone contains *Veryhachium* cf. *hyaloderlatum*, *Tympanicysta stoschiana* and *Baltisphaeridium*? sp. (Ouyang and Utting, 1990). All of these species occur first about 50 cm above the bottom of the Changxing Limestone, that is Bed 3, except of *Micrhystridium stellatum* , which does not appear until 4m above the base. From Bed 1 to Bed 11 of Section C, palynomorphs were obtained from 16 levels. Those from the base of Bed 1 to the lower part of Bed 4 are characterized by a dominance of fossil spores and pollen with scarce acritarchs. Among them, spores and pollen reach 85% and 15% respectively. Spores such as *Crassispora orientalis*, *Triquitrites sinensis*, *Calamospora* sp., *Macrotorispora gigantean* and *Anticapipollis elongate*, and pollen of *Florinites florini* occur in all 10 levels. Characteristic forms of the Wuchiapingian palynological assemblages found only from one or two levels include *Bactrosporites shaoshanensis* (MSC 3-24), *Patellisporites meishanensis* (MSC 4-8a, 4-9), and *Tumulispora triangulates* (MSC 3-2, 4-9). The acritarch *Micrhystridium stellatum* occurs in the basal part of Bed 1 and Bed 4 (MSC 4-8a). Composition of the palynological assemblages underwent a dramatic change near the boundary level. Those from Bed 6 to the lower part of Bed 11 are mostly acritarchs, which contain all component species of *Leiosphaeridia changxingensis – Mycrhystridium tellatum* Assemblage Zone.

Other fossils

No indicative forms for the base of the Changhsingian Stage can be identified from non-fusulinacean foraminifers and ostracods, although both groups are rather abundant and diverse. *Colaniella* is usually referred to as a distinct foraminifer genus of the Changhsingian in South China. Fossils of this genus are particularly rich in the Changhsingian of northern peri-Gondwana regions, but the primitive forms might appear in the Late Wuchiapingian. In Section D of Meishan, The genus *Colaniella* first appears in Bed 2. The ostracods from the lower part of Bed 2 to Bed 7 of Sheng *et al*. (1984), that is, the lower 10 metres of the Changxing Limestone, are grouped into a single ostracod assemblage. It is named as *Bairdia urodeloformis - Acratia subfusiformis - Eumiraculum changxingensis* Assemblage and is characterized by the dominance of small and smooth forms. However, it is noteworthy that all three leading species of the assemblage occur first in Bed 4 at Section D (Shi and Chen, 1987). It is equally interesting to note that various fossil fishes appear in Bed 4a and 4b at Section D, including *Sinohelicoprion changxingensis* Wei and *Sinoplatysomus meishanensis* Wei and others (Wei, 1977).

Chemostratigraphy

Chemostratigraphic investigations have been undertaken for carbon isotope and trace elements. Studies on stable isotope ratios of carbon were based on bulk sediment samples. The profile of carbon isotope values from all previous studies on the Longtan and Changxing Limestone at Section D (Figure 9) exhibits a lower value around the boundary between these two beds (Li, 1998; Nan and Liu, in press). It ranges from -3.4 to -0.2 per mil in Bed 1, 2 and 3, from -1 to 2.9 per mil in Bed 4a, 4b and 5. The average carbon isotopic value for the topmost Wuchiapingian beds is -.21 per mil while that for the Early Changhsingian beds is about 2.5 per mil. A depletion of carbon isotopic values has been detected at two localities around the Wuchiapingian-Changhsingian boundary. In the Shangsi Section, Sichuan Province, a decrease of carbon isotopic value occurs at the boundary between the Wuchiaping and Talung formations as well as at the Wuchiapingian-Changhsingian boundary (Li *et al*., 1989). The magnitude of depletion reaches -1 per mil from an average value 3 per mil at the base of the Changhsingian Stage. Recently, Shao *et al*. (2000) reported a depletion of isotope carbon ratios around the Wuchiapingian-Changhsingian boundary at the Matan Section in the Heshan area, Guangxi. The decrease of carbon isotopic values around the Wuchiapingian-Changhsingian boundary in three distant localities of South China demonstrates a substantial marine chemical shift that corresponds with biotic evolutionary changes.

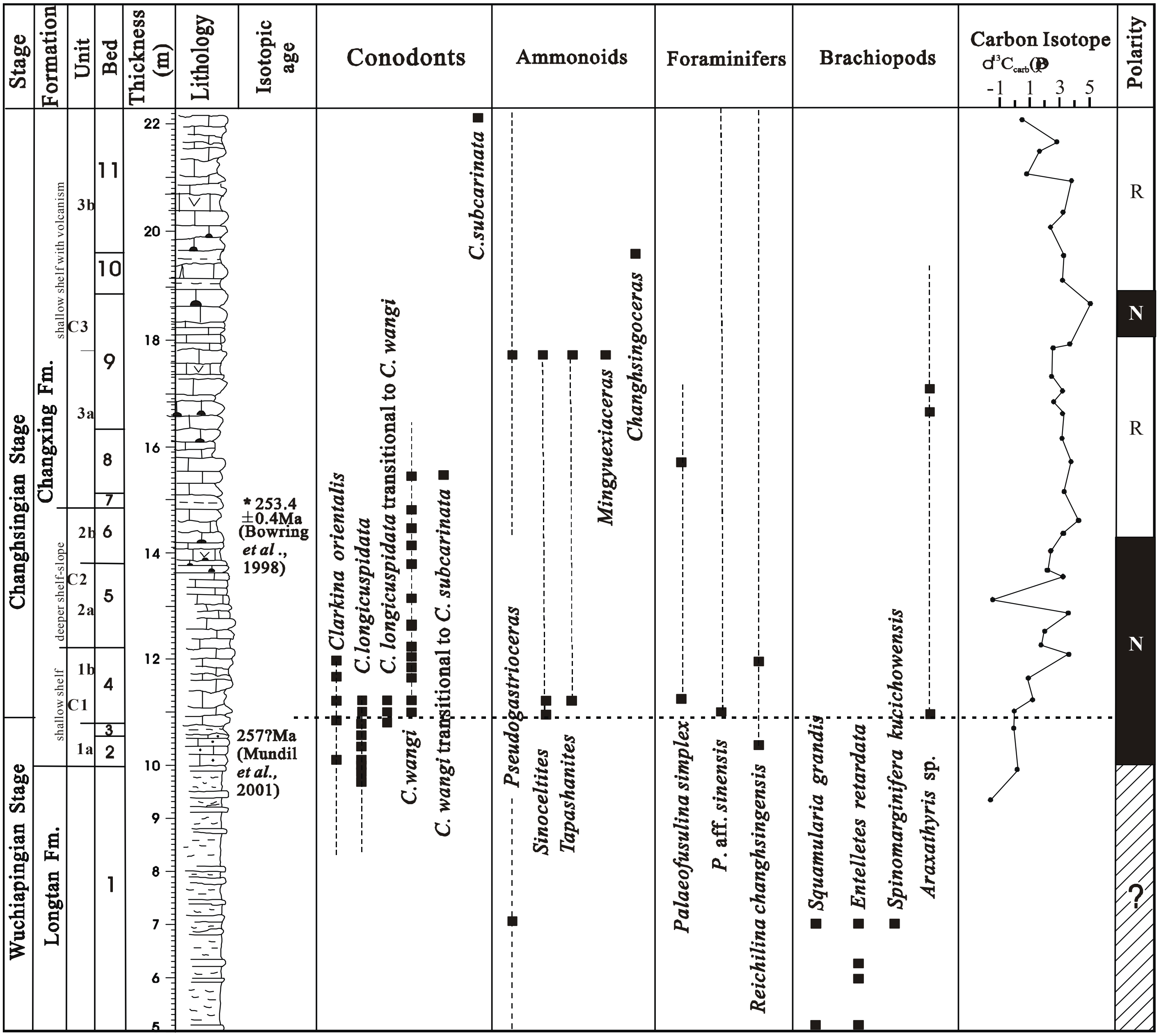


Figure 9. Integrated stratigraphic sequences around the Wuchiapingian-Changhsingian boundary in Meishan and the distribution of various fossil groups, carbon isotopes, geochronologic ages, and magnetic reversals. Note that the lithologic succession is subdivided into both beds and units. The beds are based on historical usage and are depicted to allow comparison with the literature. It is recognized that these beds are actually bedsets or parasequences except in the case of the ash beds, which represent true beds. The units are based on distinctive lithologic changes that reflect interpreted changes in depositional environment.

Magnetostratigraphy

Li *et al*. (1989) and Li and Wang (1989) divided polarity zones of the Changxing Limestone at Section D into four polarity zones. The basal part is 5 metres thick and is dominated by normal polarity and thus, is regarded as the basal normal zone, which may range from the *Clarkina orientalis* Zone to the *C. wangi* Zone. This implies that the proposed boundary is within a normal polarity zone (Figure 9) and a reversal occurs within the *C. wangi* Zone. Among these zones, the basal normal polarity zone appears at the same level as that in the upper part of the *C. liangshanensis* and the *C. orientalis* Zones of the Shangsi Section and the Lungtan Formation of the Hechuan Section. Although the nature of remnant magnetization of the Permian section in South China is often rather weak and scattered (Dobson *et al*., 1993), the Changhsingian polarity patterns in various sections are essentially consistent (Liu *et al*., 1999; Jin *et al*., 2000). This magnetostratigraphic sequence can be correlated well with that of the Meishan Section. Bed 11 of the Shangsi Section coincides with the conodont *Clarkina liangshanensis* Zone and represents the topmost level of the Wuchiapingian reversed polarity zone. Normal polarity is revealed from Bed 12 to Bed 16, which corresponds to the upper part of the *C. liangshanensis* and the *C. orientalis* Zones. Definitely, the uppermost Wuchiapingian possesses a broad normal polarity, which precedes a reversal in the Early Changhsingian.

Geochronology

Using the IDTIMs U-Pb method on zircon, two sets of isotopic ages on the ash clay beds from Section D have been calculated (Figure 9). Bowring *et al*. (1998) provided an age of 253.4 ± 0.2 Ma to Bed 7 through the analysis of multi-zircon grains from the ash beds of the Baoqing Member. Mundil *et al* (2001) preferred analyses on a single zircon grain and suggested an age of 257 ± 0.7 Ma or "257 Ma?" to an ash bed between Bed 3 and Bed 4, which is about 70 cm above the base of the formation (not 7 m above the *Clarkina orientalis* Zone as stated by the authors). On the other hand, the estimated duration of the Changhsingian based on both sets of isotopic ages tend to be around 3 million years, from +253.4 Ma to 251.2 Ma of Bowring *et al*. (1998) and from 257 Ma to 254 Ma of Mundil *et al*. (2001). Currently there is a general consensus of 251 Ma for the Permian-Triassic boundary (Remane *et al*., 2000) and we herein assign the base of the Changhsingian Stage to 254 Ma.

Potential Stratotype Points

Wardlaw and Mei (2000) suggested that the First Appearance Datum (FAD) of *Clarkina subcarinata sensu stricto* would be a suitable boundary at 13.71 m above the base of the Changxing Limestone at Section D, based on a significant change in the denticulation of gondolellid conodonts. However, others considered this boundary rather high since many other taxa considered characteristic of the Changhsingian would be regarded as Late Wuchiapingian. Later, Mei and Henderson (2001) suggested that the base of the Changhsingian Stage could be defined within the *C. longicuspidata – C. wangi* lineage in Bed 4 based on revised taxonomic definitions. The latter definition is only about 88 cm higher than the traditional boundary suggested by Zhao *et al.* (1981); thus it is in close proximity to the historical boundary position. This potential boundary occurs near the flooding surface in the second parasequence of the Changxing Limestone in the lower part of Bed 4, and is therefore a very suitable position with respect to continuity of deposition. In addition, the first occurrence of the tapashanitid ammonoid *Sinoceltites* and the fusulinacean *Palaeofusulina* aff. *sinensis* coincide with the FAD of *Clarkina wangi* and the tapashanitid ammonoid *Tapashanites* first appears only 42 cm higher (Figure 9).

Proposed Wuchiapingian-Changhsingian GSSP

The proposed GSSP for the Wuchiapingian-Changhsingian Stage boundary is at the FAD of *Clarkina wangi* (defined by the high fused wall-like carina) within the lineage from *Clarkina longicuspidata* to *Clarkina wangi* at a point 88 cm above the base of the Changxing Limestone in the lower part of Bed 4 (base of 4a-2) at Meishan D section, just above the flooding surface of the second parasequence in the Changxing Limestone (Figures 2, 4).

Correlation of the proposed Wuchiapingian-Changhsingian GSSP

The regional correlation of the suggested boundary level, the FAD of *Clarkina wangi,* was discussed in detail during the Workshop on Oct. 16, 2003 in Nanjing. The defining point is clearly indicated at Section C in Meishan by the FAD of *C. wangi* at 120 cm above the base of the Changxing Limestone following an interval of 20cm thickness with the transitional forms from *Clarkina longicuspidata* to *Clarkina wangi*.

Having studied four Guadalupian – Lopingian sections in northwestern Hubei, Tian (1993) suggested an evolutionary lineage from *Clarkina parallela* Tian to *C. wangi* Dai and Zheng. Among them, the Lopingian conodont succession from the Jiangya Section is relatively complete. Based on the samples collected extensively by Lide Chen and Changqun Cao around the Wuchiaping - Talung formation boundary, the evolutionary lineage from *Clarkina longicuspidata* to *C. wangi* also can be traced. The FAD of *Clarkina wangi* within this lineage occurs at or near bed JY70. In the Shangsi Section, the FAD of *Clarkina wangi* remains to be identified precisely. The Wuchiapingian-Changhsingian boundary interval is clearly recognizable by the depletion of isotopic carbon ratios and the normal polarity zone appearing above the Late Wuchiapingian reversed polarity zone.

In the western Tethys, the Dorashamian Stage (Rostovtsev and Azaryan, 1973) is correlatable with the Changhsingian Stage. Conodont zones of the Dorashamian Stage in Northern Iran can be correlated one for one with those of the Changhsingian in South China (Sweet and Mei, 1999). *Clarkina wangi* was combined with *Clarkina subcarinata* in the basal assemblage zone of the Ali Bashi Formation in Northern Iran. The precise level of the FAD of *Clarkina wangi* needs to be defined in the future. Zhao *et al*. (1981) indicated that the ammonoid *Paratirolites- Shevyreites* Zone from the Ali Bashi Formation might be correlated with the *Tapashanites- Pseudostephanites* Zone since index genera such as *Paratirolites* and *Shevyreites* also occur in the Lower Changhsingian beds in Guizhou Province of South China. They suspected that the Ali Bashi Formation lacked three ammonoid zones that occur in the upper part of Changhsingian strata in South China.

In the Salt Range of Pakistan, the upper part of the Wargal Formation above the Larkrik Member contains conodont zones from the *Clarkina dukouensis* to *C. longicuspidata* Zone (Wardlaw and Mei, 1998), and therefore, represents nearly the whole Wuchiapingian Stage. Instead of *Clarkina wangi*, *Vjalovognathus* sp. B follows the occurrence of *Clarkina longicuspidata* in the Kalabagh Member and the basal part of the Chhidru Formation. The diagnostic fusulinacean genus *Palaeofusulina* is scarce in shelf deposits of northern Gondwana, but instead the foraminifer genus *Colaniella* is common. Advanced forms like *Colaniella minima* and *C. nana*, which occur first in the basal Changhsingian in Section D of Meishan, first appear in the topmost Wargal Formation (Unit 5) and the basal beds of the Chhidru Formation (Unit 2). Magnetostratigraphic data indicate that the upper part of the Wargal Formation is characterized by an extensive reversed polarity zone that may be correlated with the reversed polarity zone of the Wuchiapingian in South China. The upper part of the Wargal Formation and the Chhidru Formation can be correlated with the normal polarity zone of the Changhsingian because these strata contain a broad normal polarity (Jin, Shang and Cao, 2000).

In the deep oceanic Tethys, radiolarians of the *Neoalbaillella optima* and *N. ornithoformis* zones are correlated respectively with the *Nanlingella simplex* and *Palaeofusulina sinensis* zones (Ishiga, 1990). This correlation indicates that these two zones belong to the Wuchiapingian and the Changhsingian respectively.

The proposed GSSP for the Wuchiapingian-Changhsingian boundary raises a challenge for the correlation of the boundary level outside Tethyan regions as well as for continental sequences. Major provincialism controls have resulted in the lack of a directly applicable worldwide biostratigraphic zonation for much of the Late Permian, indicating that it is necessary to resort to other means of correlation, such as major sequence boundaries and maximum flooding surfaces, significant reversals of polarity, remarkable isotopic fluctuations, and isotopic ages to establish a reliable correlation. For example, in North China, Embleton *et al*. (1996) reported the upper part of the upper Shihhotse Formation is dominated by reversed polarity and thus, can be correlated with the Wuchiapingian reversed polarity zone. Uppermost Wuchiapingian and Changhsingian marine sequences are dominated by normal polarity (Menning and Jin, 1998), as is the top of the Shihhotse Formation and the overlying Sunjiagou Formation.

Results of voting by the Wuchiapingian-Changhsingian Working Group

The Working Group consisted of the following members: Yugan Jin (Chair), Charles Henderson, Bruce Wardlaw, Sam Bowring, Robert Nicoll, Yuri Zakharov, Shuzhong Shen, Xiangdong Wang, Yue Wang, Zhihao Wang, Shilong Mei, Changqun Cao, Lide Chen, Yujing Wang and Kexing Zhang. Most members of the working group and others including Chengyuan Wang met during a workshop in Nanjing in October 2003. Having reached a general consensus regarding the GSSP definition, a proposal and ballot was produced after the workshop. All members of the working group voting unanimously in favour of the proposal (15 Yes; 0 No; 0 Abstain). This proposal, which includes only minor revisions from the original circulated to the working group, has been submitted to SPS voting members for a formal vote.

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Early Permian flora from the Canadian Arctic revisited

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An Early Permian (Kungurian) flora recently described from Axel Heiberg Island, Canadian Arctic Archipelago, by LePage *et. al*. (2003) is the only fossil macroflora of that age known to occur within the area bounded by Prince Edward Island (Atlantic Canada), Greenland, Alaska, and Eastern Siberia. Ignatiev (2003) questioned the identification of the plant macro-fossils and the paleobiogeographic conclusions reached. His detailed comments can be grouped into five main headings:

(1) Identifications are questioned because detailed anatomy or connection with fructifications is not known for the material from the Canadian Arctic.

(2) If the identifications are incorrect, then the composition of the Axel Heiberg flora is quite different from those of the Angaran floral realm.

(3) Conifers with *Walchia* type vegetative shoots are rare in Angaran floras while they are common in the Axel Heiberg flora.

(4) Migration of plants between the Angaran Realm (Pechora Basin) and the Axel Heiberg Island area is seen by Ignatiev (2003) as questionable or impossible.

(5) An alternative hypothesis is proposed by him, suggesting that the Axel Heiberg flora represents a subunit of the Euramerian floral realm that he calls the "Crockerland paleofloristic province."

These concerns expressed by Ignatiev (2003) require responses that are provided below in the order in which they are presented in Permophiles (number 42, June 2003) and listed above.

(1) The main point made by Ignatiev (2003) deals with the identification of plant macrofossils. LePage *et al*. (2003) made it clear that the material of the Permian Axel Heiberg flora is not well preserved, having had a complex taphonomic history and occurring in a marine limestone. Therefore, they restricted the identifications of the plant macrofossils to the generic level. These generic identifications were largely based on gross morphology, and this point was clearly stated. However, Ignatiev (2003) claims that many of the identifications would only be possible if either cuticular, or other anatomical details, or organic connections of plant parts were preserved. In other words, he states that fossil floras that are preserved with different degrees of detail cannot be compared to one another, and that gross morphology alone cannot be used for identification. While there are situations in paleobotany where certain specific morphological or anatomical details are needed before a reliable identification can be made, Le Page *et al.* (2003) presented an entire flora and were very careful not to overstate their case. Therefore, while the limitations of their identifications must be recognized, they are nevertheless valid. If a comparison of morphology holds true, then similarity exists. Modern methods of taxonomy are based on this premise. If we accept the approach of Ignatiev (2003), we would seriously limit the progress of paleobotany and restrict the science to the interpretation of those plant fossils that are rather completely preserved, show a large amount of detail, and have been studied for a long time. This would further place undue restrictions on the field with unfortunate consequences, because even the initial interpretations provided with the description of new floras enables one to establish hypotheses that will guide further research, and may or may not stand the test of time. Our findings based on macroflora are actually supported by palynological results (Utting, 1994) that show the similarity and thus connection of Permian floras from the Canadian Arctic Archipelago with the palynofloras of the Pechora Basin.

(2) If Ignatiev (2003) was correct, then the composition of the Axel Heiberg flora would be quite different from those described from the Angaran floral realm. However, the morphological similarity between the floras from both regions would still exist and needs explanation. An alternative explanation is that the forms identified as Angaran on Axel Heiberg Island are new taxa that experienced convergent evolution or vicariant species. For instance, we can find a comparison in the Recent. Although there are taxonomic differences at the species level between the Canadian boreal forest and the Russian taiga, the forests of these massive floristic provinces are still dominated by spruces, pines, and larches, even at their extreme eastern and western ranges. The incomplete preservation of the Axel Heiberg taxa, which was emphasized by LePage *et al.* (2003), does not lend itself to the erection of new taxa. The more prudent way is to make comparisons with already described taxa, and restrict identification to the generic level.

(3) The difference in the frequency of conifers with *Walchia* type vegetative shoots between Angaran floras and the Axel Heiberg Island flora is to be expected. This was a flora growing in an extrabasinal setting where different dominance patterns can exist. LePage *et al.* (2003) never claimed that the Axel Heiberg flora was Angaran, but rather that it had strong phytogeographic connections with the Angaran floral realm.

(4) The migration of Angaran plants to the Axel Heiberg Island area would be nothing unusual and can be expected. The two areas were at the same latitude and experienced similar climates. Therefore, similar environments can be expected to have existed. Migration of plants will occur whenever and wherever geographic barriers are removed or breached between suitable habitats by long-term tectonic or climatic, or short-term extreme events (corridors, filter bridges, and sweepstake routes of G.G. Simpson, see Lane, 1992, p. 121-122). The migration of dominant trees is well documented for the Quaternary (see for instance Delcourt and Delcourt, 1991, as a summary of the extensive literature). In the Late Paleozoic, the migrations of dominant taxa have been documented by Iannuzzi and Rösler (2000) for Gondwana and Laveine *et al.* (2000) for the tropics of the Carboniferous. How could the uniformity of the Carboniferous Euramerian flora or the Carboniferous and Permian floras of Gondwana be explained without long-distance migration? The notion that only ruderals (weeds),

and not dominant taxa, migrate may perhaps be applicable for the extremely short time-frames studied by modern ecologists, but it is certainly incorrect in deep time.

(5) LePage *et al*. (2003) interpreted the Axel Heiberg Island flora as one with Euramerian and Angaran elements. This is the simplest explanation based on the comparison of morphology as outlined above. This interpretation is supported by the fact that palynomorphs from the Permian of the Canadian Arctic show a clear similarity with palynofloras from the Pechora Basin (Utting, 1994). The alternative hypothesis presented by Ignatiev (2003) that the Axel Heiberg Island flora represents a subunit of the Euramerian floral realm, which he calls the "Crockerland paleofloristic province", requires more complex explanations, namely that all taxa that are not Euramerian are new and represent convergent evolution to Angaran taxa. In our view, this is unlikely.

In summary, LePage *et al*. (2003) recorded an important new macroflora locality in Arctic Canada, presented identifications, admittedly based on fragmentary and not too well preserved material, and the most likely explanation of the significance of the Axel Heiberg Island flora based on macrofloral data supported by findings based on microflora (Utting, 1994). These results can now serve as the starting point for further research.

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The age of the palaeomagnetic reversal around the Permian-Triassic boundary

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Biostratigraphically well constrained palaeomagnetic reversals are very important for correlations, especially across facies boundaries. They are a very important tool for detailed correlation between marine and continental sections. However, there is an unfortunate, a tendency to fit reversals to assumed or real biostratigraphic boundaries despite the fact that they do not necessarily coincide with these boundaries. This leads to correlation problems within the marine realm and to even larger problems for correlation between marine and continental beds because there is often no biostratigraphic control to prove or reject these correlations. This is especially true with the Permian-Triassic boundary (PTB), where generally data were fit by compilation into the PTB that was accepted or generally used at the time of publication. For a long time, the base of the Buntsandstein of the Germanic Basin, the base of the Boundary Clay in the Tethys and in the South Chinese intraplatform basins, the base of the Tesero Horizon of the basal Werfen Formation of the Southern Alps, and the base of the *Otoceras concavum* Zone in Arctic Canada were regarded as the PTB. None of these former PTB definitions coincide with the FAD of *H. parvus* (Kozur and Pjatakova). The boundary between the Bellerophon Limestone and the Tesero Horizon of the Werfen Group is actually a diachronous boundary (Kozur, 1994, 1998a,b. Korte and Kozur, in press). The base of the Buntsandstein is regionally assigned to different horizons. In Germany it lies at the base of the Calvörde Formation above the Fulda Formation (Bröckelschiefer) and in Poland it lies a little above the base of the upper Fulda Formation.

The beginning of the normal magnetic interval, which straddles the PTB (shortened herein as N_{PT}) was often placed in China at the base of the Boundary Clay. The Boundary Clay was generally not investigated in the Chinese sections because the soft, weathered and fissile clay bed is unsuitable for getting samples for reliable investigations, and until now, no palaeomagnetic data were known from the Boundary Clay in China. Nevertheless, only Heller *et al.* (1988, 1995) showed a short interval of unknown polarity in the Boundary Clay at the Shangsi section. In most other papers (*e.g.* Steiner *et al.*, 1989, Scholger *et al.*, 2000, Gallet *et al.*, 2000, Fig. 7, Nawrocki *et al.*, 2003) the beginning of the normal polarity close to the PTB was shown at the base of the Boundary Clay and equated with the PTB. Jin Yugan *et al.* (2000) used correctly the PTB at the FAD of *H. parvus*, confirmed by the International Stratigraphic Commission, and put therefore the *C. meishanensis* Zone in the Boundary Clay into the Permian, but shifted the beginning of the normal interval up to the beginning of the Triassic with the FAD of *H. parvus* referring to Li and Wang (1989) for Meishan. By so doing, they put the Boundary Clay, from which no data are known, into the underlying reversed interval. Only Yin *et al.* (1996) quoted correctly the data of Li and Wang (1989): "The normal interval begins 1.2 or 2.7m below the Boundary Clay of Meishan and straddles the PTB, wherever it is placed. The difference from 1.5 m is an interval of indistinct magnetic polarity." Thus, in contrast to these published data from

Figure 1: Position of the studied Iranian sections; 1: Kuh-e-Ali Bashi section, 9 km W of Jolfa village. 2: Shahreza section, 14 km NW of Shahreza village, 3.5 km SE of Shahzadeh Ali Akbar village. 3: Abadeh section, Kuh-e-Hambast, 60 km SE of the town of Abadeh.

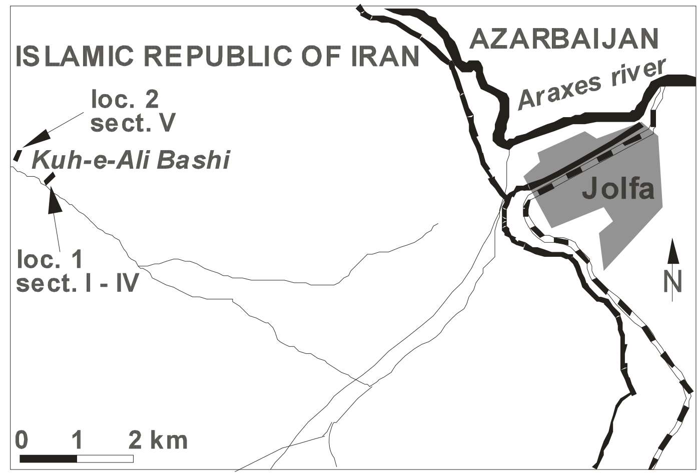

Figure 2: Investigated sections from Kuh-e-Ali Bashi, 9 km SW of Jolfa village (after Korte and Kozur, in press). Palaeomagnetic samples are from section V.

Meishan, the beginning of the normal interval was placed at the base of the Boundary Clay when the base of the Triassic was assigned to the base of the Boundary Clay, and at the higher base of the *H. parvus* Zone, when the base of the Triassic was defined by the FAD of *H. parvus*. By this procedure, the beginning of the normal interval always remained at the base of the Triassic.

Steiner *et al.* (1989) assigned the base of Bed 28 to the base of N_{PT} and the base of the Triassic in the Shangsi section. This assignment was logical because at that time the base of the Triassic was placed at the base of Bed 28. In this section Beds 22-26 belonged to a reversed zone, Bed 27 had not yielded any palaeomagnetic data, and Beds 28-31 had normal polarity (Heller *et al.*, 1988, Li *et al.*, 1988, 1989, Steiner *et al.*, 1989, Lai *et al.*, 1996). Jin *et al.* (2000) also put the beginning of the normal palaeomagnetic interval at the base of Bed 28, which they equated with the base of the *H. parvus* Zone. *H. parvus*, however, begins 4.6 m higher within Bed 30 (Nicoll *et al.*, 2002). Thus, in this section the normal polarity zone also begins clearly within the Upper Permian and not at the base of the Triassic.

A similar assignment was made in Gallet *et al.* (2000). By correlation of the *C. meishanensis* Zone with the *H. praeparvus*, *H. parvus* and lower part of *I. staeschei* (= *I. isarcica*) zones their PTB was assigned to the base of the Boundary Clay despite the fact that the definition for the base of the Triassic by the FAD of *H. parvus* was already accepted at that time. The correlation between *Clarkina* and *Hindeodus-Isarcicella* faunas is unknown for the Triassic base. In Meishan, and also in Abadeh and the other Iranian sections, *C. meishanensis* Zhang, Lai, Ding, Wu and Liu occurs only in the Boundary Clay or in the lower part of the Boundary Clay (see also Mei *et al.*, 1998) together with *H. praeparvus* Kozur. Above this level at Meishan, but still below the FAD of *H. parvus, C. zhejiangensis* Mei (Mei *et al.*, 1998) co-occurs with *H. praeparvus*. In the Iranian sections, *C. zhejiangensis* is missing, but *C. meishanensis* and *H. praeparvus* co-occur in the level, as in South China. A *C. meishanensis-H. praeparvus* Zone is thereby discriminated. In shallow water deposits, only the latter species is present. Above this level, *H. parvus* begins in Meishan at the base of Bed 27c, above the last occurrence (LAD) of *C. meishanensis*. Even higher, in Bed 28, *I. isarcica staeschei* Dai and Zhang begins. The same succession occurs in Abadeh, Shahreza, Jolfa and Zal sections (Central and NW Iran). Likewise, the assumed gap in the upper Dorashamian of the Abadeh section below the Boundary Clay (Gallet *et al.*, 2000) is not recognized herein because the *C. changxingensis-C. deflecta* Zone with the *C. yini* fauna at its top *(Editors note*: Wardlaw and Mei, 1998 in Permophiles 31, p. 3-4 refer to the *C. yini* Zone and therefore this wordy construction is unnecessary) is well represented by a very rich conodont fauna. The *C. changxingensis-C. deflecta* Zone is successively followed by the *C. iranica* Zone, the *C. praemeishanensis* fauna, and the *C. meishanensis-H. praeparvus* Zone, which begins at the base of the Boundary Clay in the Abadeh sections. Thus, there is no gap in the upper Dorashamian. In contrast, two conodont faunas are present between the *C. yini* fauna and the *C. meishanensis-H. praeparvus* fauna that are missing in Meishan. Despite the fact that Gallet *et al*. (2000, Fig. 3) have correctly indicated that there were no palaeomagnetic data from the Boundary Clay, they show in their Fig. 7 that the normal Zone in Abadeh begins exactly at the base of the Boundary Clay, which is equated with the base of the Triassic using their correlation of the *C. meishanensis* fauna with the *Hindeodus-Isarcicella* faunas including the *H. parvus* fauna. However, in Abadeh *H. parvus* begins 1.38 m above the base of the Boundary Clay (Kozur, in press).

Referring to Yin *et al.* (1996), the beginning of the normal zone in the Meishan section is correctly shown in Gallet *et al.* (2000) based on the previous palaeomagnetic data, and the PTB with the FAD of *H. parvus* is used. For Shangsi, however, the old boundary at the base of Bed 28 (base of Feixianguan Formation) is used as the PTB where N_{PT} begins, and this is a level with *Changxingoceras* sp., *Hunanoceras* spp., *Pseudogastrioceras* spp., *Pleuronodoceras* spp. and *Pseudotirolites* spp. (Lai *et al.*, 1996), which is a typical upper Changhsingian ammonoid fauna below the *C. meishanensis-H. praeparvus* Zone. As mentioned above, the PTB with the FAD of *H. parvus* is 4.6. m higher, in Bed 30 according to Nicoll *et al*., (2002). This is also well indicated by the minimum in ä ^{13}C in the same level (Baud *et al.*, 1989). In Arctic Canada, Gallet *et al.* (2000) placed the base of the Triassic at the base of the N_{PT} that lies close to the base of the *Otoceras concavum* Zone, which is well below the FAD of *H. parvus* (Henderson and Baud, 1997, Kozur, 1998a,b). In this case, an old PTB definition was used.

The attempt by Gallet *et al.* (2000) to fit previously published palaeomagnetic data into the ratified PTB definition is well seen in Zakharov and Sokarev (1991) discussing the Dorasham II-3 section. Zakharov and Sokarev (1991, p. 15) reported the beginning of N_{PT} at 0.5 m below the top of the *Paratirolites* Limestone. This is well below the Boundary Clay with the *C. meishanensis*-*H. praeparvus* Zone used by Gallet *et al.* (2000) as their PTB, which is distinctly below the FAD of *H. parvus*. Despite this fact, the beginning of the normal Zone is shown at the PTB. The same correlations are used by Besse *et al.* (1998), but in this paper it is not clear which PTB they used, and therefore the Gallet *et al*. (2000) paper was used for the discussion herein.

Scholger *et al.* (2000) regarded the facies change between the Bellerophon Limestone and the Tesero Horizon as a synchronous boundary event and wrote: "Importantly, the current event (*i.e.* boundary event) at the base of the Tesero Horizon can be regarded as a synchronous boundary in a strict sense" (Scholger *et al.*, p. 504). This is very surprising because, in the Bulla (Pufels) section, the normal event begins roughly at the boundary between the Bellerophon Limestone and the Tesero Horizon of the basal Werfen Group (last reversed sample 5 cm below the boundary, first normal sample 5 cm above the boundary). In the Siusi (Seis) section, however, the last reversed sample is in the upper Tesero Horizon, 42 cm above the Bellerophon Limestone, and the first normal sample is in the lower Mazzin Member (*sensu* Scholger *et al*., 2000), 72 cm above the Bellerophon Limestone. This clearly indicates that in the short distance between these two sections, the boundary between the Bellerophon Limestone and the Tesero Horizon is a diachronous boundary, which has nothing to do with the Tethyan event boundary (Kozur, 1994, 1998a,b). As already shown by Kozur (1994) using paleontological data, the Tesero Horizon of the western Southern Alps is replaced toward the east by the upper Bellerophon Limestone and its upper part, by the Mazzin Member. Finally, in the Carnian Alps, the Mazzin Member lies directly on the Bellerophon Limestone. Only in this area, and in the Bükk Mountains the top of the Bellerophon Limestone corresponds to the event boundary, which however, is not the PTB that lies higher, defined by the FAD of *H. parvus*. This example shows that it is dangerous to regard facies boundaries close to the PTB as a synchronous PTB event. By so doing, a diachronous PTB is produced. This is well seen in the paper by Scholger *et al.* (2000, Fig. 7) because they correlate the boundary between the Bellerophon Limestone and the Tesero Horizon with the PTB and the synchronous event boundary at which the palaeomagnetic normal zone N2 begins, despite the fact that in the Bulla and Siusi sections N2 begins different distances above the base of the Tesero Horizon (see above). Scholger *et al.* (2000) recognized the interfingering between the Tesero Horizon and Mazzin Member, but not the replacement of the lower and middle Tesero Horizon by the upper Bellerophon Limestone toward the east. The differences in the beginning of N 2 must be in this case explained by different sedimentation rates. However, if we take for the Bulla section the highest possible beginning of N2 at 4 cm above the top the Bellerophon Limestone and for the Siusi section the lowest possible position around 45 cm above the top of the Bellerophon Limestone, then in Siusi the sedimentation rate must be 9X larger than in Bulla. However, according to Scholger *et al.* (2000), the sedimentation rate at Bulla is larger than in Siusi. If we compare the carbon isotope curves for the Siusi section (Newton *et al.*, 2004) with that of the Bulla section (Korte and Kozur, in press) it can be recognized that the sedimentation rate in both sections is roughly the same for the upper Bellerophon Limestone–Mazzin Member interval (in this comparison it must be understood that the less than 1 m thick Tesero Horizon *sensu* Scholger *et al.*, 2000 corresponds only to the lower part of the about 7 m thick Tesero Horizon by Newton *et al.* 2004; thus, only the metres above the base of the Tesero Horizon can be compared). This means that the differences in the beginning of the normal Zone, which straddle the PTB are caused by the Tesero Oolite facies beginning later in the Bulla section compared with the Siusi section, confirming the paleontological data by Kozur (1994) that toward the east the Bellerophon Limestone replaces more and more the lower and middle Tesero Horizon. Unfortunately, the sampling around the boundary between the Bellerophon Limestone and the Tesero Horizon was not dense enough in the Siusi section by Newton *et al.* (2004) to recognize the amount of facies replacement (about 0.5m spacing between the highest sample of the Bellerophon Limestone and the lowest sample of the Tesero Horizon).

Korte and Kozur (in press) have also confirmed by stable isotope data that the boundary between the Bellerophon Limestone and the Tesero Horizon of the Werfen Group is a diachronous facies boundary.

Given that so many papers showed or tried to show that the marine PTB lies at the beginning of a normal palaeomagnetic interval (see above), independent from the position of this boundary (base of Boundary Clay, FAD of *H. parvus*, FAD of Boreal *Otoceras*), it is understandable that Nawrocki *et al.* (2003) correlated the base of the normal zone in the Germanic Basin with the PTB. This boundary in Poland was also equated with the base of the Buntsandstein in the Germanic Basin, the traditional Permian-Triassic Boundary.

The beginning of the lowermost palaeomagnetic normal zone (sn1) is recognized within the lowermost upper Fulda Formation (lowermost upper Bröckelschiefer) of the uppermost Zechstein (middle part of Z7) and this datum was correlated with the international scale (Bachmann and Kozur, 2002, Bachmann *et al.*, 2003, Szurlies, 2001, Szurlies *et al.*, 2000, 2003). Nawrocki *et al.* (2003) assigned the beginning of sn1 to the base of the Buntsandstein in Poland, but the Polish Buntsandstein begins a little above the base of upper Z7 in Germany, which is within the uppermost Zechstein of Germany. This level lies distinctly below the base of the Triassic, which is situated as deepest level at the base of an oolitic limestone named as the Oolite Alpha 2 (Kozur, 1998a,b, see also Kozur, this volume). This boundary (*e.g.,* boundary between the *Falsisca postera* and *F. verchojanica* conchostracan zones) was confirmed by ä$^{13}C_{org}$ and ä$^{13}C_{carb}$ minima in the lower Oolite Alpha 2 by Hansen and Korte in Bachmann and Kozur (2003) and Kozur (2003). Thus, definitely, in the Germanic Basin sn1 straddles the PTB.

There is an objective problem in addition to the above-discussed subjective problems regarding the correlation of the

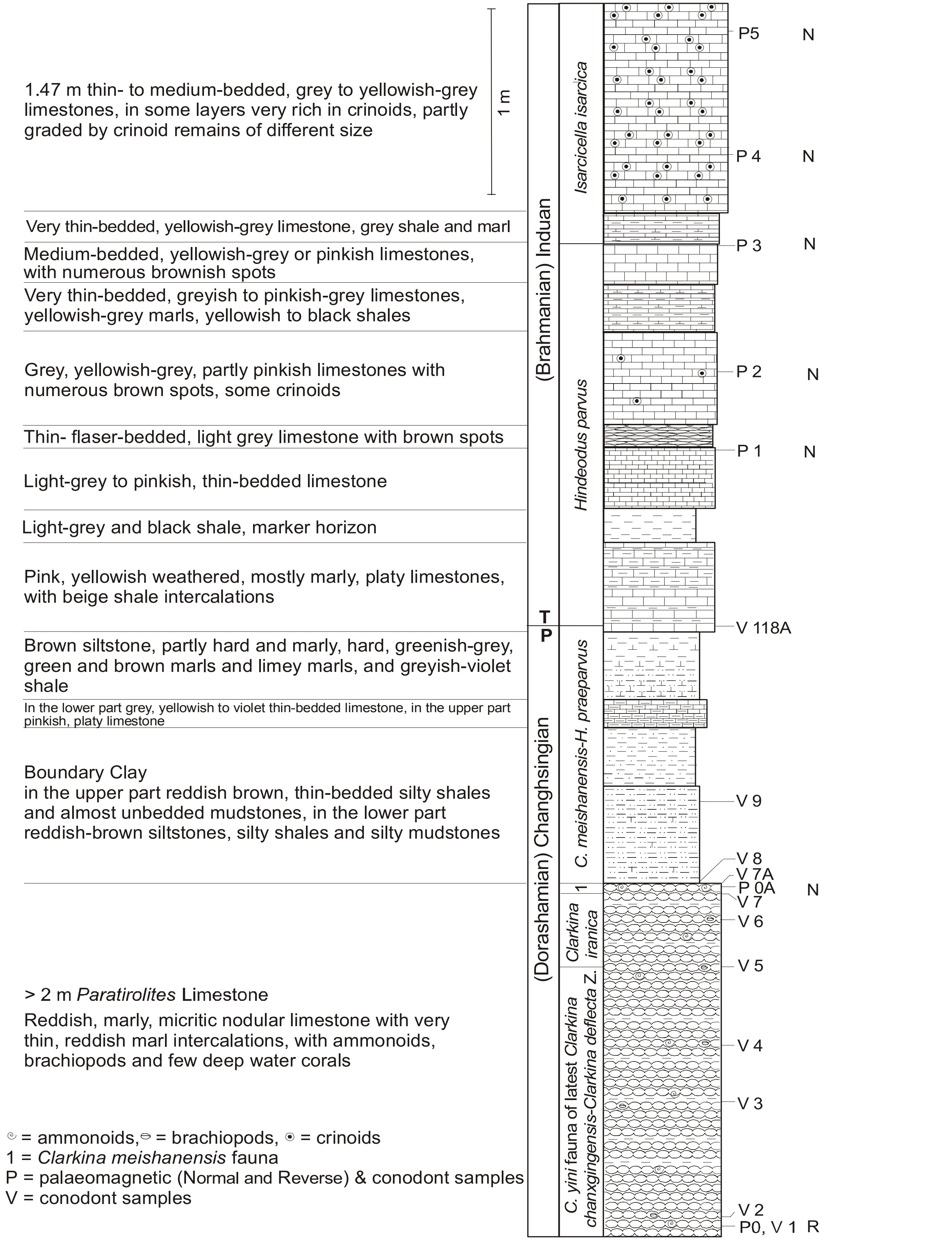

Figure 3: Position of palaeomagnetic and important conodont samples in locality 2 of Fig. 2 and area 1 of Fig. 1; section V of Kuh-e-Ali Bashi near Jolfa.

palaeomagnetic zones around the PTB. Zhu and Liu (1999) presented a new palaeomagnetic study of the Meishan section that yielded results different from previous results by Li and Wang (1989). The latter authors show a palaeomagnetic zonation, in which normal zone V begins 1.2 m (or 2.7m because 1.5 m of rock has uncertain magnetic polarity) below the Boundary Clay (1.34-1.37 m below the PTB) in a level which, according to the data by Mei *et al.* (1998), is within the *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone, and ranges up to the *I. isarcica* Zone. Zhu and Liu (1999), however, show that the normal Zone begins much earlier, 5.07 m below the PTB, which is within the upper third of the *C. changxingensis*-*C. deflecta* Zone and well below the *C. yini* fauna; this normal polarity zone ranges up to the *I. isarcica* Zone, except for a 0.06 m horizon around the PTB within Bed 27 that is reversed magnetized (confirmed by three samples in stratigraphic order). The data by Zhu and Liu (1999) were used by Yin *et al.* (2001). Peng *et al.* (2001) also used these data for high-resolution correlation with the Shangsi section. They correlated the reversed Bed 26 of Shangsi with the supposedly reversed Bed 27 of Meishan. As clearly seen by the fauna and also by the carbon isotopes, this correlation based on new palaeomagnetic data of the Meishan section cannot be confirmed. Bed 26 of Shangsi has a rich conodont fauna before the event boundary that belongs to the *C. changxingensis*-*C. deflecta* Zone. Bed 27 of Meishan has a sparse conodont fauna above the event boundary that belongs to the upper *H. praeparvus* Zone and to the entire *H. parvus* Zone.

This reversed horizon immediately around the PTB cannot be observed anywhere else in the world. The Meishan section is extremely condensed in the level of beds 26 to 28 (the sedimentation rate in this stratigraphic level is about 10X higher in the Iranian PTB sections, and about 100X higher in the Germanic Basin, Kozur, in press), meaning that the 0.06 m reversed horizon in Meishan could correspond to 0.6 m in the Iranian sections and 6 m in the Germanic Basin. Therefore, this level could not have been missed in samples from all sections outside Meishan.

All well correlated published palaeomagnetic data in the world have shown that the change from reversed to normal polarity close to the PTB occurs distinctly below the PTB; the PTB lies within the lower third of this normal Zone. In the section Dorasham II-3 in Azarbaijan, north of the Iranian border, the normal polarity begins 0.5 m below the top of the *Paratirolites* beds (Zakharov and Sokarev, 1991). The FAD of *H. parvus* is more than 1 m above the top of the *Paratirolites* Beds. Only a few kilometres away in the Jolfa section, south of the border, the level 0.5 m below the top of the *Paratirolites* Limestone corresponds to the upper *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone. In the Shangsi section, the normal polarity zone begins at the base of Bed 28; Bed 27 has unknown polarity and Bed 26 below has reversed polarity (Heller *et al.*, 1995, 1988, Li, 1988, 1989, Peng *et al.*, 2001, Steiner *et al.*, 1989). The PTB as defined by the FAD of *H. parvus* in this section is in Bed 30, about 4.6 m above the base of Bed 28 (Nicoll *et al.*, 2002), and the base of the normal polarity zone. In addition, the FAD of *H. parvus* is near the minimum in the carbon isotope curve (Baud *et al.*, 1989). Gallet *et al.* (2000) found the beginning of the normal zone immediately above the Boundary Clay of Abadeh, but also put the Boundary Clay in this normal zone. 1.38 m above the base of the Boundary Clay is the base of the *H. parvus* Zone and the negative values in the carbon isotope curve begin close to this boundary. The upper Hambast Formation is reversed according to Gallet *et al.* (2000), but because a non-existing big gap was shown in the upper Dorashamian, it is not clear, from which level the uppermost sample in the Hambast Formation was derived. In Scholger *et al.* (2000) the beginning of the normal polarity Zone is shown in the Bulla section (Southern Alps) distinctly below the FAD of *H. parvus*. The carbon isotope values from the lowermost Tesero Horizon, where the normal interval begins, corresponds to those of the *C. yini* fauna in Meishan and Jolfa (Korte and Kozur, in press). In the Siusi section the beginning of the normal zone is higher, within the uppermost Tesero Horizon or lowermost Mazzin Member *sensu* Scholger *et al.* (2000), 42-72 cm above the base of the Tesero Horizon (see above), but the base of the Triassic is much higher, around 7 m above the base of the Tesero Horizon (Newton *et al.*, 2004) as determined by the beginning minimum in the carbon isotope data (beginning of negative values). In the Griesbach Creek section of Arctic Canada, both the *O. concavum* and the *O. boreale* Zones have normal polarity (Ogg and Steiner, 1991). The FAD of *H. parvus* in the Arctic is above the *O. boreale* Zone s.s. within the *T. pascoei* Zone between the *O. boreale* Zone s.s. and the *Ophiceras commune* Zone (Kozur, 1998b), and therefore, the *O. concavum* Zone and the *O. boreale* Zone s.s. belong to the Permian. *(Editors note*: Kozur (1998b) demonstrated this correlation in Greenland; in the Canadian Arctic, Henderson and Baud (1997) demonstrated that the local first occurrence of *H. parvus*, but not necessarily its true FAD, occurred within the upper *Otoceras boreale* Zone).

In all these marine sections, there is no reversed horizon around the FAD of *H. parvus,* the position of which is also clearly shown in the carbon isotope data in the low latitudes. The interval from the *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone up to the middle *I. isarcica* Zone belongs to a normal zone that straddles the PTB throughout the world. Reverse horizons are not present in this interval.

To check the beginning of the normal interval in terms of the new high-resolution conodont zonation, and the presence or absence of a reversed interval around the FAD of *H. parvus*, several palaeomagnetic samples were taken in the Iranian PTB sections Abadeh, Shahreza and Jolfa (Fig. 1) and given to Dr. M. Szurlies, Potsdam, who carried out the palaeomagnetic investigations; these samples were also dated using conodonts. The results will be published by Szurlies and Kozur in Albertiana. I am very grateful to Dr. Szurlies for his permission to use the palaeomagnetic results in the present paper. In Abadeh the CAI is 3 from which good palaeomagnetic data cannot be expected, despite the fact that Gallet *et al.* (2000) got reliable data. In Shahreza, the CAI is 2.5 and also this value is not very good for palaeomagnetic investigations, but Besse *et al.* (1998) got reliable data with a reversed horizon in the uppermost Hambast Formation (younger beds were not investigated). The Jolfa section yielded well preserved conodonts (CAI = 1), and from this very good palaeomagnetic data were expected.

As predicted from the CAI data, the Abadeh section yielded only poor palaeomagnetic data. 2 cores were taken from the lowermost 0.16 m thick limestone bed above the 30 cm thick Boundary Clay. This limestone contains *H. praeparvus* of the uppermost Permian *H. praeparvus* Zone. In the underlying Boundary Clay, *C. meishanensis* is very rarely present. Both cores were strongly remagnetized. 3 cores were taken from the upper stromatolite layer, 1.80 m above the base of the Boundary Clay. This sample belongs to the lower *H. parvus* Zone of the lowermost Triassic. The laterally taken sample Aba 69 yielded a ä ^{13}C value of –0.07 ‰ (Korte *et al.*, in press). Despite remagnetization, a weak normal field is documented.

The Shahreza section also yielded poor palaeomagnetic data. Two cores of sample SP1 were remagnetized. This sample was taken 1.75 m above the base of the Boundary Clay, the ä ^{13}C value is –0.11 ‰ (measured by Dr. C. Korte, Bochum). It lies 0.25 m above the base of the Triassic within the lower *H. parvus* Zone. Sample SP2 was taken 7-11 cm below the boundary between the Hambast Formation and the overlying Boundary Clay. It contains conodonts from the boundary of *C. iranica* Zone to *C. praemeishanensis* fauna of late Dorashamian age. The ä ^{13}C value is + 1.69 ‰ (measured by Dr. C. Korte, Bochum). 6 cores represent mainly intermediate directions and one core is normally magnetized. Sample SP3 was taken 0.7 m below the top of the Hambast Formation from the *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone of upper Dorashamian. 2 cores show intermediate directions.

All 7 samples of the Jolfa V section (Figs. 2, 3) show good palaeomagnetic results. The oldest sample P0 was taken 1.80-1.90 m below the Boundary Clay, and belongs to the lower *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone. Sample J94 from the same horizon has a ä ^{13}C value of +2.91 ‰ (Korte and Kozur, in press). The 3 cores are reversed. All other samples belong to N_{PT}. Sample P0A (4 cores) was taken from the uppermost 4 cm of the *Paratirolites* Limestone, which correlates with the *C. praemeishanensis* fauna. ä ^{13}C varies in this level between +0.29 and +0.64 ‰ (Korte and Kozur, in press). Sample P1 (4 cores) was taken from 2.30-2.36 m above the base of the Boundary Clay. It belongs to the upper *H. parvus* Zone. Sample J 125 from the same horizon has a ä ^{13}C value of –0.72 ‰, against –1.55 ‰ from the base of the Triassic (Korte and Kozur, in press). Sample P2 (4 cores) was taken from 2.73-2.77 m above the base of the Boundary Clay and belongs also to the upper *H. parvus* Zone. Sample J 127 from the same horizon has a ä ^{13}C value of –0.49 ‰ (Korte and Kozur, in press). Sample P3 (4 cores) at 3.40-3.45 m above the base of the Boundary Clay, sample P 4 at 3.90-3.96 m above the base of the Boundary Clay, and sample P 5 at 4.58-4.63 m above the base of the Boundary Clay belong to the *I. isarcica* Zone.

These preliminary palaeomagnetic data of Dr. M. Szurlies from the PTB level has resulted in the following conclusions:

1.) As expected by the CAI values in Abadeh, Shahreza and Jolfa, the Jolfa (Kuh-e-Ali Bashi) section V has brought the best palaeomagnetic results and the Permian of Jolfa will be studied in detail in the future.

2.) The base of the Triassic does not coincide with the beginning of a normal zone, but rather the normal zone straddles the PTB. Including the beginning of the normal Zone 0.5 m below the top of the *Paratirolites* Limestone in the neighbouring Dorasham II-3 section in Azerbaijan (Zakharov and Sokarev, 1991) some kilometres toward the north of Kuh-e-Ali Bashi section V at Jolfa, the *C. iranica* Zone (proven in Dorasham II-3 by Zakharov and Sokarev, 1991), the *C. praemeishanensis* fauna (proven in section V), the *C. meishanensis*-*H. praeparvus* Zone (proven in Abadeh by Gallet *et al.*, 2000, and confirmed by our rather weak data from this locality), the *H. parvus* Zone (proven in Abadeh by Gallet *et al.*, 2000, and confirmed by our rather weak data from this locality, and proven for the upper *H. parvus* Zone by our data from Jolfa), and the lower and middle *I. isarcica* Zone (proven in our material from Jolfa) belong to the normal interval which straddles the PTB.

3.) The upper third of the *C. changxingensis*-*C. deflecta* Zone (including at least the lower part of the *C. yini* fauna) belongs to a short reversed Zone.

4.) Our data support the previous palaeomagnetic data by Li and Wang (1989) in Meishan and do not support the new data by Zhu and Liu (1999). These latter data are also not supported by previous data around the FAD of *H. parvus* (present PTB).

5.) Our data support the position of the PTB within the lower Calvörde Formation of the Lower Buntsandstein (*e.g.*, Kozur, 1968a,b, Szurlies, 2001). The reversed Zone zrz (=Zechstein reversed zone, Szurlies *et al.*, 2003) is a very short zone, which comprises only the upper third of the *C. changxingensis*-*C. deflecta* Zone, including at least the lower part of the *C. yini* fauna. In the Germanic Basin it corresponds to the lower Fulda Formation (lower Bröckelschiefer) and the basal part of the upper Fulda Fm.) as shown by Szurlies (2001) and Szurlies *et al.* (2003).

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Dating of the event succession in marine and continental beds around the Permian-Triassic boundary (PTB)

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High-resolution biostratigraphic and event-stratigraphic subdivision and correlation is possible around the Permian-Triassic Boundary (PTB) in the South Chinese intraplatform basins, *e.g.* in Meishan, the GSSP for the base of the Triassic. Conodonts are the most suitable for biostratigraphic subdivision, with additional data yielded by ammonoids, brachiopods and the sudden disappearance of fungal spore mass occurrences at the base of the Boundary Clay. The event-stratigraphic markers are, in stratigraphic order: the beginning of a normal palaeomagnetic interval, the sudden lithostratigraphic changes at the base of the Boundary Clay, the strong negative excursion in the carbon isotope curve with a minimum around the PTB, and the mass occurrences of cosmic and volcanic microspherules, with a distinct peak a little above the base of the Boundary Clay. Tuff intercalations at the base of the Boundary Clay and in Bed 28 at Meishan, immediately above the *H. parvus* Zone of lowermost Triassic, yielded radiometric data, which differ, however, in different papers, resulting in dates for the PTB ranging from 251 to 253 Ma.

There are several problems with the Meishan section, mainly regarding different events, but also one biostratigraphic problem. The latter is the absence of the *Clarkina iranica* Zone with all its characteristic species, *C. sosioensis* Gullo and Kozur, *C. iranica* n. sp. and *C. abadehensis* n. sp., and the absence of the *C. praemeishanensis* fauna, both situated between the well developed *C. yini* fauna of the uppermost *C. changxingensis-C. deflecta* Zone and the *C. meishanensis-H. praeparvus* Zone. The *C. iranica* Zone is present in the entire western Tethys. In Central and NW Iran and in Transcaucasia of Armenia and Azarbaijan it occurs in pinkish or light-grey nodular pelagic limestones of maximum 40 cm thickness (upper *Paratirolites* Limestone). These limestones were deposited below storm wave base. It is the youngest zone with a rich warm-water conodont fauna. The *C. praemeishanensis* fauna is a very poor to moderately rich, only exceptionally very rich, fauna of warm-water conodonts with the first immigration of cold-water forms (*Hindeodus*, *Merrillina*). It occurs only in a very thin (4-10 cm) interval either in the uppermost *Paratirolites* Limestone, or above the *Paratirolites* Limestone, separated from it by a greenish clay, in a grey, nodular, micritic, marly, pelagic, filamentous limestone immediately below the Boundary Clay. These limestones were deposited below storm wave base, at least in the Zal and Jolfa sections (NW Iran). In the Abadeh and Jolfa area, the rocks of the *C. praemeishanensis* fauna are often removed by a high energy event at the base of the Boundary Clay, and in one of the investigated sections (section III of locality 1 in Kuh-e-Ali Bashi, 9 km SW of Jolfa, see Kozur, this issue, Fig. 2), these sediments were redeposited in pockets containing conodonts of the *C. praemeishanensis* fauna and the upper *C. iranica* Zone. This reworking of the soft sediments reached down to about 80-100 m water depth and removed in shallower water depth (around 30m at the base of the Boundary Clay, as calculated for Abadeh) up to as much as 20 cm of sediment comprising the C. *praemeishanensis* fauna and the upper *C. iranica* Zone.

The absence of the *C. iranica* Zone and the *C. praemeishanensis* fauna between the *C. yini* fauna and the *C. meishanensis-H. praeparvus* Zone in Meishan can be explained in three different ways:

1. There is a gap or a time of non-sedimentation. According to Zhang *et al.* (1996), the base of the third-order sequence SB3 is at the base of Bed 24e, 10 cm below the base of the Boundary Clay, and therefore a gap is rather improbable. A short time of non-sedimentation is possible, as also indicated in some Iranian sections by a hardground at the top of the *Paratirolites* Limestone, above which *Hypophiceras* is common sometimes.

2. The beds were removed as soft sediment by a high energy event at the base of the Boundary Clay. No investigations of such an event have been carried out at Meishan, and would be difficult because the highly weathered yellowish brownish basal part of the Boundary Clay would probably not display such features to identify it. As it can be assumed that the high-energy event in the western and central Tethys (not investigated in the eastern Tethys) was caused by an extremely strong tsunami (see below), it may be that this tsunami was still more prominent in the intraplatform basins in South China because tsunamies generally get stronger in embayments of the open sea. Moreover, a water depth of only 10-30 m is assumed by Zhang *et al.* (1996) for the level of Bed 24e immediately below the Boundary Clay and the coast-line is assumed to be close (*e.g.* 15 km west of Meishan, Yin *et al.*, 1996).

3.) The Lopingian of the South Chinese intraplatform basins has a rather endemic fauna, in which important guide forms of the Tethys are missing. For instance, the *Paratirolites* ammonoid fauna of the upper Dorashamian occurs within the entire western Tethys, as far west as the Southern Alps (Posenato and Prinoth, 1999), and *Paratirolites* is present in the intra-Gondwanan rift Basin, which runs from Batain in Oman to Madagascar. Madagascar is the southernmost occurrence of *Paratirolites* (Furnish, 1973). The Changhsingian ammonoids of South China are all endemic, even the genera are not present in the Tethys, except *Pleuronodoceras,* which invaded the Tethys when the endemism ended shortly before the PTB event boundary. This strong endemism makes the South Chinese ammonoid successions poorly suited for Lopingian correlations. In the conodont fauna the endemism is not so strong. However, such common and very characteristic species as *Clarkina nodosa* n. sp. from the lower *C. changxingensis-C. deflecta* Zone are not present in South China. Other species, however, such as the very characteristic *C. parasubcarinata* Mei, Zhang and Wardlaw are common both in the intraplatform basins of South China and in the Tethys. Thus, theoretically, the absence of all conodonts of the *C. iranica* Zone and of the *C. praemeishanensis* fauna in Meishan could be related to endemism. However, two observations speaks clearly against this explanation. *C. iranica* and *C. abadehensis* are present in South China, but not in Meishan (Kozur, in press).

The other observation comes from the content of the *C. praemeishanensis* fauna. *C. praemeishanensis* n. sp. is a transitional form between *C. zhangi* Mei and *C. meishanensis*. *C. praemeishanensis* is a very variable form. The majority of the forms has a distinctly smaller cusp than *C. meishanensis* (as in *C. zhangi*), and no gap between the cusp and the carina as in *C. zhangi*, but the cusp is erect or nearly erect as in *C. meishanensis*. Other rather rare forms have a posteriorly inclined cusp as in *C. zhangi*, but a rather long gap between the cusp and the carina as in *C. meishanensis*. All *C. praemeishanensis* have a thin platform similar to the warm-water *Clarkina* of the Dorashamian and different from the thick platform in *C. meishanensis* and the cold-water *Clarkina* of the *C. carinata* group. Thus, *C. praemeishanensis* is clearly younger than *C. zhangi,* which occurs below the *C. iranica* Zone with *C. yini,* as in the *C. yini* fauna of Meishan. An age younger than the *C. yini* fauna is also indicated by the presence of *C.* cf. *meishanensis.* This form corresponds in detail to *C. meishanensis* (very large, erect cusp, gap between the cusp and the carina, platform outline), but the platform is thin as in all Upper Permian warm-water *Clarkina*. The thickening of the platform in typical *C. meishanensis* may depend on strong ecological stress within the Boundary Clay, or these forms are the immediate forerunners of *C. meishanensis* within the very variable *C. praemeishanensis* population.

Thus, obviously the time interval of the *C. iranica* Zone and *C. praemeishanensis* fauna is missing in Meishan, whether there is a short gap, a short time of non-sedimentation or these beds were removed by the high energy event at the base of the Boundary Clay.

The following problems exist with respect to events close to the PTB in the Meishan section:

A) Different palaeomagnetic results (see Kozur, this volume).

Only a few remarks are given here to this problem. According to Li and Wang (1989), their normal zone V begins in a level that is according to the data by Mei *et al.* (1998) within the *C. yini* fauna of the uppermost *C. changxingensis*-*C. deflecta* Zone, and ranges up to the *I. isarcica* Zone. Zhu and Liu (1999), however, show that the normal Zone begins much earlier, 5.07 m below the PTB within the upper third of the *C. changxingensis*-*C. deflecta* Zone, well below the *C. yini* fauna. It also ranges up to the *I. isarcica* Zone, but just around the PTB in Bed 27 there is an interval, which is reversed magnetized (confirmed by three samples in stratigraphic order). As shown in Kozur (this issue), the data by Li and Wang (1989) fits perfectly with data from Szurlies (in Kozur, this issue) from Abadeh, Shahreza and especially Jolfa, section V (see Kozur, this isue, Figs 1-3). Also all previous publications with biostratigraphically well dated palaeomagnetic data show that a normal zones begins below the PTB and ranges up to the *I. isarcica* Zone. No section outside Meishan has shown a reversed interval around the FAD of *H. parvus* (Kozur and Pjatakova).

B) Two rather different curves for the stable carbon isotopes were presented by Xu and Yan (1993), Yin and Zhang (1996) and Bowring *et al.* (1998) on one side and by Jin *et al.* (2000) on the other side.

The data by Xu and Yan (1993) show two distinct minima, one in the black clay (around –5 ‰) of the upper Boundary and a second in Bed 27a (around –6 ‰) immediately below the PTB. A third weak minimum between –1.5 ‰ and –1.9 ‰ lies in the *H. parvus* Zone. The data by Jin *et al.* (2000) show a distinct minimum around -1.5 ‰ close to the base of the Boundary Clay in the lower part of Bed 25, and two week minima around 0 in Beds 27a and in the lower *H. parvus* Zone. The minimum in the upper Boundary Clay and time equivalents could not be confirmed in sections outside Meishan. Values of ä $^{13}C_{carb}$ between -5 ‰ and -6 ‰ were not found in low latitudes, where the minima close to the PTB are generally between-1 ‰ and -2 ‰, sometimes only between –0.1 ‰ and –0.2 ‰, rarely down to -3 ‰ and exceptionally (Shangsi, Siusi) between -3 ‰ and -4 ‰ (Margaritz *et al.*, 1988, Baud *et al.*, 1989, Margaritz and Holser, 1991, Newton *et al.*, 2004, Korte and Kozur, in press, for different sections in the Southern Alps and Iran). The very negative values published in Xu and Yan (1993) may be caused by a mixed signal of ä $^{13}C_{carb}$ and ä $^{13}C_{org}$, if the organic material was not dissolved before the measurements. The minimum in the upper Boundary Clay may be produced in this manner. Around the PTB everywhere a distinct minimum is present, mostly between -1 ‰ and -2 ‰, but in the range between –0.1 ‰ and -4 ‰ (see above). The values by Jin *et al.* (2000) around 0 fall nearly within this scope.

More difficult is the situation with the lower minimum in Bed 25 a little above the base of the “white clay” presented by Jin *et al.* (2000), but below that shown by Baud *et al.* (1989). In all continuous low latitude sections, this first minimum is not present (Southern Alps, Shahreza of Central Iran, Zal of NW Iran, Margaritz *et al.*, 1988, Baud *et al.*, 1989, Margaritz and Holser, 1991, Newton *et al.*, 2004, Korte and Kozur, in press) and a rather gradual decrease until the negative values close to the PTB is shown. However, in the Abadeh and Jolfa sections, where the beds with the *C. praemeishanensis* fauna are removed partly by the high energy event at the base of the Boundary Clay, and in Meishan, where the *C. iranica* Zone and the *C. praemeishanensis* fauna are missing, this first minimum close to the base of the Boundary Clay is present. It is not certain that this minimum is related to this short gap or local removal of beds containing the *C. praemeishanensis* fauna. In all these sections, especially in the Meishan section, the carbonate content of the rocks is extremely low and partly represented by shells, mainly ostracod shells. This also could be a reason for this minimum because in the other sections that show a gradual decrease of the ä ^{13}C value to negative values around the PTB, the carbonate content of the Boundary Clay is higher or the Boundary Clay is not present as in the South Alpine sections. Whereas, in low latitude sections the gradual decrease of the carbon isotope data to negative values around the PTB seems to be the rule, in the Boreal realm, a distinct minimum both in ä $^{13}C_{org}$ and ä $^{13}C_{carb}$ is present above the event boundary (Oberhänsli *et al.*, 1989, Twitchett *et al.*, 2001). The minimum in ä $^{13}C_{carb}$ started about 2 m later as the minimum in ä $^{13}C_{org}$ (Twitchett *et al.*, 2001). These minima are distinctly below the FAD of *H. parvus*. The minimum in ä $^{13}C_{org}$ in low latitudes is in the upper part of Bed 26 in Meishan, also before the minimum in ä $^{13}C_{carb}$ within Bed 27. As a whole, Meishan is not a suitable standard for the low latitude ä $^{13}C_{carb,}$ but for ä $^{13}C_{org}$ it seems to yield reliable data.

The advantage of Meishan is, without any doubt, the presence of tuff layers in Bed 25 (basal part of Boundary Clay) and in Bed 28 at the base of the *I. isarcica* Zone. Two sets of radiometric data were published recently for the PTB at Meishan. Bowring *et al.* (1998) reported 251.4 Ma ± 0.3 for Bed 25 of Meishan (lower *C. meishanensis*-*H. praeparvus* Zone) and 250.7 Ma ± 0.3 for Bed 28 (basal *I. isarcica* Zone). From these data an age of the PTB of about 251 Ma can be concluded. Mundil *et al.* (2001), on the other hand, reported values slightly older than 254 Ma for Bed 25 and 252.5 Ma ± 0.3 for Bed 28, concluding 253 Ma for the PTB. There are problems with both sets. 251 Ma for the PTB seems to be inconsistent with the 247 Ma for the base of Anisian (Lehrmann *et al.*, 2002). Four million years for the entire Scythian (Induan + Olenekian stages) is too short considering the Milankovitch cycles of the Germanic Basin (Kozur, 2003, and Kozur, in prep.), as well as the number of biozones and sedimentation rates in the marine Lower Triassic. Approximately 253 Ma for the PTB (Mundil *et al.*, 2001) is a reliable value, when 247 Ma is used for the base of the Anisian. However, Mundil *et al.* (2001) mentioned that >254 Ma for Bed 25 is a very weak value. The time span from the base of Bed 25 to the base of the Triassic (PTB) cannot be >1 million years. As shown by correlation with the Germanic Basin (Bachmann and Kozur 2002), this interval has a minimum duration of about 0.12 million years. The maximum duration would be 0.25 million years (see below). A solution to this problem may be found in the basic data of Bowring and others (1998). They recorded two data clusters in Bed 25, one at 251.4 Ma ± 0.3 and one at 252.7 Ma ± 0.4. They rejected the older cluster as inherited and used the younger one, which fit in their other data. But as correctly stated by Mundil *et al.* (2001), the older data cluster inferred an equally plausible age assignment. If we use 252.7 Ma for Bed 25 and 0.12 million years for the duration of the *C. meishanensis*-*H. praeparvus* Zone (minimum duration of the interval between the event boundary and the biostratigraphic PTB), we get an age of 252.6 Ma for the PTB, close to the value of 253 Ma (Mundil *et al.*, 2001), and a duration of about 100 thousand years for the *H. parvus* Zone, as 252.5 Ma for Bed 28 (Mundil *et al.*, 2001) corresponds to the base of the overlying *I. isarcica* Zone. If we use this estimated PTB of 252.6 Ma and the 247 Ma for the base of Anisian (Lehrmann *et al.*, 2002), we get a duration of 5.6 million years for the Lower Triassic. This is nearly identical with the Scythian duration estimated by astronomic calibration of the Induan to Lower Olenekian and estimation of the Upper Olenekian (Kozur, 2003, Bachmann and Kozur, in prep.).

The event succession around the PTB in Iran and Transcaucasia is the same as in South China, but because of the 10X higher sedimentation rate around the PTB (Boundary Clay and overlying beds) in Transcaucasia and Central Iran, the faunal turnover can be much better represented in the Iranian sections. Moreover, the event boundary lies in the sections Shahreza (Central Iran), Jolfa and Zal (both NW Iran), Dorasham and Sovetashen (Azarbaijan, Armenia, both Transcaucasia) within red coloured sediments and, therefore, the benthic faunal succession is not overprinted by dysaerobic or anoxic conditions. Palaeomagnetic data are less ambiguous than that of South China, which differs for Meishan in different papers (see Kozur, this volume). The following events close the PTB can be found: (1) The normal palaeomagnetic interval which straddles the PTB begins about 50 cm below the top of the *Paratirolites* Limestone (Zakharov and Sokarev, 1991), within the upper *C. yini* fauna somewhat below the base of the *C. iranica* Zone and ranges up to the *I. isarcica* Zone. (2) A very sharp facies change occurs at the base of the Boundary Clay, which is connected to a strong high energy event recognizable in shallow water sediments and in sediments deposited down to about 80-100m water depth, well below the storm wave base. This high-energy event caused submarine reworking of the soft bottom and a thin layer of underlying limestone. (3) Within an interval from the uppermost *C. yini* fauna up to the lower *H. parvus* Zone, the number of cosmic and volcanic microspherules is distinctly higher than below and above this level. Within this interval a distinct maximum of microsphaerules can be observed in the lower, but not lowermost part of the Boundary Clay. (4) A dramatic climatic change can be observed at the base of the Boundary Clay, which started, however, with the invasion of the first cold-water elements (many *Hindeodus*, few *Merrillina*) and an abrupt decrease of warm-water *Clarkina* species within the *C. praemeishanensis* fauna. This decrease is much stronger in the southernmost outcrops (in Abadeh area, Central Iran), which was situated close to the tropic of Capricorn during the PTB interval, than in the northern outcrops (Zal, Jolfa, northwestern Iran), which were situated about 1000 km to the north of the Abadeh area during the Permian. The Boundary Clay was deposited below the storm wave base in Jolfa and Zal and perhaps also in Shahreza, and contains almost exclusively *Hindeodus* in a depauperate fauna. The disaster taxon, *C. meishanensis,* which developed from *C. praemeishanensis* of the foregoing *C. praemeishanensis* fauna, is present only in the lower part. The *Hindeodus* dominated fauna with very rare *Merrillina* and very rare *C. meishanensis* in the lower part is regarded as a cold-water fauna. A rich conodont fauna is present between the Boundary Clay and the base of the Triassic in the Zal section. It is dominated by *Merrillina* with *Hindeodus* common. It is a typical cold-water fauna. In the other sections, this interval has a poor fauna of *Merrillina* and *Hindeodus*. (5) A distinct minimum in the carbon isotope curve occurs around the PTB. (6) In the somewhat shallower sections at Abadeh and Shahreza, a pronounced stromatolite (partly thrombolite) horizon occurs around the PTB above the Boundary Clay and continues until the *H. parvus* Zone. The faunal succession is partly similar and partly different from that in the intraplatform basins of South China. A rich warm-water fauna is present at the top of the *C. iranica* Zone. In the southernmost sections (Abadeh area), immediately above the *C. iranica* Zone, 14 cm below the Boundary Clay, the warm-water conodonts suddenly disappear within pelagic pink to light grey, filamentous limestones in which, in the same facies, extremely rich in conodonts, and just below a few cold-water elements are present (*Hindeodus*, very rare *Merrillina*). In the sections that were situated around 1000 km to the north in the direction of the equator during the PTB interval, a distinct change in the conodont fauna occurs only in the uppermost 1 cm from rich faunas to the first cold-water elements. Within < 0.5 cm, the warm-water conodont fauna disappeared from these sections and was replaced by a poor cold-water fauna of the Boundary Clay dominated by *Hindeodus*, with few *C. meishanensis* in the lower Boundary Clay and very few *Merrillina*. No distinct change in the benthic foraminifer and ostracod fauna and diversity can be observed through this interval. In the southern sections (Abadeh and Shahreza), a distinct change in the foraminifer fauna occurs within the upper Boundary Clay. The Permian foraminifers became small and then disappear, but reappear in some levels immediately above the Boundary Clay before they finally disappear somewhat before the PTB. The ostracod fauna of the upper Boundary Clay changes into a low diversity fauna in the same level where the Permian foraminifers disappear. No further changes occur across the PTB.

In shallow water deposits the base of the Triassic (FAD of *H. parvus*) and the events of the pelagic realm are well recognizable, except the Boundary Clay, which is only present in somewhat deeper facies, as in the Gerennavár section of Bükk Mts. (Hungary).

Events 1-6 are also well recognizable in the continental succession of the Germanic Basin, (1) lies in the lowermost part of upper Bröckelschiefer (Fulda Fm.); (2) is the base of the Buntsandstein in Germany, characterized by (4) dramatic climate change from hot arid conditions to humid conditions; (3) lies 3 to 4.5 m above the base of the Buntsandstein (from the oolitic limestone horizon oo Alpha 1 to 1.5 m above it); (5) lies in the lower part of oo Alpha 2 which correspond, based on conchostracans, to the lowest possible level of the PTB; (5) lies in the lower part of oo Alpha 2.

In the fresh-water lake deposits of the central Germanic Basin around the PTB, the Milankovitch cycles are very well developed. The precession cycles (~ 20,000 yrs) are well recognizable and 5 of them are grouped in a short eccentricity cycle (~ 100,000 yrs). By the Milankovitch cyclicity, the time span between the events can be calculated. As the events are the same in continental and marine deposits, also the duration of the pelagic conodont zones can be calculated. The palaeomagnetic reversal to a normal interval, which straddles the PTB, occurs 90,000 to 100,000 years before the event Boundary. This is the probable duration of the interval missing in Meishan between the Changxing Limestone and the Boundary Clay. In the Iranian and Transcaucasian sections, the beginning of the normal interval lies around 50 cm below the top of the *Paratirolites* Limestone, 50-60 cm below the Boundary Clay. From this interval, up to 40 cm belongs the *C. iranica* Zone. From this, the maximum duration of the *C. iranica* Zone is 60,000 to 67,000 years. The sudden disappearance of the warm-water fauna at Abadeh, around the Permian Tropic of Capricorn, is 14 cm below the Boundary Clay (where these beds are not removed by the high energy event). This corresponds to 21,000 to 23,000 years before the event boundary and also to the duration of the *C. praemeishanensis* fauna. About 1000 km toward the Permian equator, in the sections Jolfa and Zal, this disappearance was at the base of the Boundary Clay. As in the uppermost 0.5 cm of the underlying Ali Bashi Formation, the warm-water fauna was still present and its disappearance was quite sudden, <800 years, but the frequency of the warm-water conodonts dropped over an interval of 2 cm below the Boundary Clay that would equate to about 3,000 to 3,200 years.

The disappearance of the Permian benthic foraminifers in the same sections was about 120,000 years later, at the PTB, corresponding to the duration of the *C. meishanensis-H. praeparvus* Zone. This value is much more uncertain. The base of the Triassic in the Germanic Basin is the lowest possible boundary. This is true both for the paleontological correlation and for the correlation by carbon isotope changes. The beds below the oo Alpha 2 in the lower part of eccentricity cycle 2 of the Calvörde Fm. of the Lower Buntsandstein contain *Falsisca postera* from the youngest Permian conchostracan zone. *F. verchojanica* (Molin), the guideform of the lowermost Triassic, begins only in eccentricity cycle 3, about 100,000 years later. The lower part of oo Alpha 2 corresponds to a minimum in ä $^{13}C_{org}$ and in this level ä $^{13}C_{carb}$ is also much lower than in oo Alpha 1 of the lower eccentricity cycle 1 of the Calvörde Fm. (measured by Dr. C. Korte, Bochum). The higher limestone levels of eccentricity cycle 2 and of the basal eccentricity cycle 3 have not been investigated yet. The lower oo Alpha 2 of the Nelben section near Könnern, Germany, yielded a ä $^{13}C_{carb}$ value of -4.21 ‰, which increases up to the top of the oo Alpha 2 to a value of -3.04 ‰ (data measured by Dr. Korte, Bochum). Nevertheless, the -4.21 ‰ is not the absolute minimum because ä $^{13}C_{carb}$ values from fresh-water limestone is much lower than from marine limestone and it seems that the minimum in ä $^{13}C_{carb}$ lies above the minimum of ä $^{13}C_{org}$. In Meishan, the minimum of ä $^{13}C_{org}$ lies in the uppermost part of Bed 26 (Hansen *et al.*, 2000, see above), in between the base of the Boundary Clay and the base of the Triassic. If it lies in continental beds at the same level, it would yield a duration of around 0.2 million years for the interval between the base of the Boundary Clay and the base of the Triassic.

One of the most interesting events is the high-energy event at the base of the Boundary Clay. It may be found in all Iranian sections, and in the 3000 km distant Bükk Mountains of Hungary. In the relatively shallow water deposits of the Bükk Mountains (calculated Boundary Clay water depths around 10-20 m), this high-energy event is very strong and reworked the sediment (including limestone below the soft sediment, and transported intertidal limestone from coastal areas from at least 50 km away). In the Abadeh sections of Central Iran (calculated base of the Boundary Clay water depth of about 30 m), up to 20 cm of sediments were removed over very short distances. In the deepest investigated section Zal of NW Iran (calculated Boundary Clay water depth was below storm wave base at about 80-100 m), only soft sediment reworking on the scale of few millimetres occurred. The cause for this high-energy event was probably a mega-tsunamis. The big distance in which this high-energy event is observed is not unusual for tsunamis. In the 20^{th} century tsunamis in Japan and Hawaii were recorded which had their origin in earthquakes with submarine epicentres as far as the Aleutian islands (Alaska) and offshore Chile. Very surprisingly, weak water movements related to such a mega-tsunami are registered in water depths of 80-100 m. The origin of such a mega-tsunami may be the huge volcanic eruption at the boundary between Tethys and Panthalassa, which occurred just at the base of the Boundary Clay and yielded fallout of felsic to intermediate tuffs over an area of 2 million km^2 in South China (Kozur, 1998a,b). This huge eruption was probably caused by the explosion of an insular volcano, which could trigger directly or by a strong related earthquake, a huge tsunami. Another possibility would be an extraterrestrial impact in the sea.

According to Kozur (1998a,b) the biotic crisis at the PTB and several of the above mentioned events were mainly caused by the interaction of the long-lasting huge, to a large part explosive Siberian Trap volcanism during the Dorashamian and lowermost Triassic in Permian high latitudes and the huge explosive felsic to intermediate volcanism at the Tethyan event boundary which caused a volcanic winter. This latter volcanic centre was at the Tethys-Panthalassa boundary north of the equator. Further evidence for this model has been found recently.

Within the warm-water Dorashamian conodont fauna of the pelagic Iranian sections three levels were found in which all warm-water conodonts disappeared abruptly and were replaced by cool-water conodonts (*Hindeodus*, *Merrillina*). These horizons were not related to any change in water depth. The mode of change in the conodont faunas is the same as at the base of the Boundary Clay. But whereas at the base of the Boundary Clay these changes were also present in equatorial regions (*e.g.* South China), these earlier cold-water immigrations did not reach the equatorial area. Therefore, the warm-water fauna recovers very fast, when the water temperature rose again. These cooling phases were obviously related to very strong explosive phases of the Siberian Trap volcanism. This can be shown well for the upper of these cooling phases. It is in Iran, situated in the upper, but not uppermost part of a very short reversed horizon (according to Gallet *et al.*, 2000, 1.8 m below the base of the Boundary Clay at Abadeh) below the long normal zone, which straddles the PTB. The cooling horizon lies in between 78 and 96 cm below the Boundary Clay within the *C. yini* fauna and ends 22 cm below the *C. iranica* Zone in Abadeh. In the Germanic Basin, that reversed horizon, in which lies the cooling event in the lower part and the base of the upper Fulda Formation comprising a little more then one short eccentricity cycle (about 0.1 million years). On the Russian Platform, NE of Moscow, the Nedubrovo Formation of the lowermost Vetluga Group corresponds to the upper part of this reversed horizon (Lozovsky *et al.*, 2001a,b). Lozovsky *et al.* (2001a) found altered volcaniclastic material geochemically related to the Siberian trap in the middle part of the Nedubrovo Fm. In pelagic marine low latitude sections in this level a strong extinction in the plankton (radiolarians) can be observed and the radiolarites disappear in low latitudes and high northern latitudes (beginning of a low latitude and northern high-latitude radiolarian gap, which continued to the top of the Lower Olenekian (top of the Smithian).

Both volcanic centres are on the northern hemisphere (northern high latitude for the Siberian Trap and northern low-latitude for the explosive volcanism at the base of the Boundary Beds, see above). Under such circumstances the Permian-Triassic biotic crisis would be much less severe in high southern latitudes, if the long-lasting Siberian Trap and the huge explosive volcanism north of the equator were the main reasons for the biotic crisis. This has been proven by Kamata *et al.* (2003), Takemura *et al.* (2003) and Yamakita *et al.* (2003). They found a continuous radiolarian sequence across the PTB at Arrow Rocks Island, Waipapa Terrane, New Zealand that is well dated by conodonts and that exhibits no strong changes in the radiolarian faunas at the PTB and shows no radiolarian gap from the uppermost Permian to the top of the Smithian.

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ANNOUNCEMENTS

32nd International Geological Congress

Florence, Italy

August 20-28, 2004

Sessions of interest to SPS member include:

General Symposium G20.02: Permo-Carboniferous to Early Jurassic, Karoo Supergroup.

General Symposium G22.04: Global Correlation of the Cisuralian (Lower Permian) stages. Sponsored by SPS. Boris Chuvashov and Charles Henderson are co-chairs.

General Symposium G22.05: Global Permian continental biostratigraphy and biochronology. G. Cassinis and S. Lucas are co-chairs.

Topical Symposium T04.02: Late Permian-Early Triassic events. Bruce Wardlaw and Hongfu Yin are co-chairs.

And many others....

Information and PDF of second circular available at: http://www.32igc.org.

Invited Oral Presentations for the Permian-Triassic (T04.02) session include:

Douglas Erwin: "Testing causes of the end-Permian mass extinction"

Yugan Jin: "A review on the first phase of end-Permian mass extinction"

Paul Randall Renne: "The Time Scale of extinctions and paleoenvironmental crisis from 40Ar/39Ar dating of Permo-Triassic bentonites at Shangsi"

Jinnan Tong: "Events during the recovery time at the beginning of the Triassic"

Bruce R. Wardlaw: "A new chronostratigraphic framework for the Permian-Triassic extinctions and recovery: A CHRONOS Time Scale project"

Hongfu Yin: "Permian-Triassic events in South China – Recent Advances"

There are also several additional volunteered oral presentations and posters.

Oral Presentations for the Lower Permian Cisuralian (G22.04) Session include:

Valery Chernykh and **Boris Chuvashov**: "Zonal Scale of the Lower Permian of Urals on Conodonts"

Vladimir Davydov: "Global Pennsylvanian-Permian fusulinacean correlations: How reliable is it?"

Aleksandr Klets, **Ruslan Kutygin**, and **Igor Budnikov**: "Permian of the Verkhoyanye (Key region of Siberia)"

Tamra Schiappa, **Claude Spinosa**, **Vladimir Davydov**, and **Bruce R. Wardlaw**: "Cisuralian biostratigraphy of the Great Basin, western United States"

Walter Snyder, **Vladimir Davydov**, **Tamra Schiappa**, and **Bruce R. Wardlaw**: "Cisuralian tectonostratigraphy of the Western United States"

Charles M. Henderson: "Correlation of Cisuralian (Lower Permian) GSSP's into the Sverdrup Basin, Canadian Arctic Archipelago"

There are numerous additional posters associated with this session.

The annual business meeting of the Subcommission on Permian Stratigraphy will follow this session.

ANNOUNCEMENTS

FIRST CIRCULAR

THE NONMARINE PERMIAN

Albuquerque, New Mexico USA
21-29 October 2005

Hosted by the New Mexico Museum of Natural History and Science (NMMNHS)

Organizing Committee:
S. Lucas, A. Heckert and A. Hunt (Albuquerque);
W. DiMichele (Washington, D.C.); V. Lozovsky (Moscow);
K. Krainer (Innsbruck); C. Sidor (Old Westbury);
M. Steiner (Laramie); G. Cassinis (Pavia),
L. Buatois (San Miguel de Tucumán)

GENERAL

An international symposium on the nonmarine Permian will cover all aspects of the subject, including tectonics, paleogeography and sedimentation, paleoclimatology, biostratigraphy and biochronology, ichnology, paleobotany, invertebrate paleontology and vertebrate paleontology. A special session devoted to the current status of the Permian timescale will be held in conjunction with the Subcommision on Permian Stratigraphy of the IUGS. Two field trips will be held, one before and one after the meeting. Attendance on the trips is optional for those who can only participate in the symposium.

TIME AND LOCATION

The meeting will follow the Annual Meeting of the Geological Society of America, which will be in Salt Lake City, Utah, 16-19 October 2005 , so attendance at both meetings is possible.

Albuquerque is a city of about half a million people on the Rio Grande in central New Mexico. It is easily reached via its international airport or by train, bus or auto. The NMMNHS houses the world's largest Permian footprint collection in addition to large regional collections of fossil plants, insects, invertebrates and vertebrates of Late carboniferous-Permian age.

SCHEDULE

21-22 October: Pre-meeting field trip to southern NM to examine Lower Permian tracksites interbedded with marine strata in the Robledo Mountains, and to examine the mixed marine-nonmarine Carboniferous-Permian boundary interval of the Bursum Formation.
22 October (evening): Opening night party at NMMNHS
23-25 October: Platform presentations and posters, NMMNHS
25 October (evening): Banquet
26-28 October: Post-meeting field trip to northernNM to examine nonmarine red beds andclassic fossil localities of the Cutler depositional system.

PUBLICATIONS

The proceedings of the symposium will be published as a *Bulletin of the New Mexico Museum of Natural History and Science* at the time of the symposium. Participants are encouraged to submit abstracts, extended abstracts or articles (up to 20 pages, double-spaced typescript) for the volume. Deadline for submission is 1 April 2005. Contact S. Lucas for format information if you will submit an article. All submitted materials need to be in electronic format.

ADDITIONAL INFORMATION

Watch this website for additional information. Please contact a member of the organizing committee for additional information or contact:

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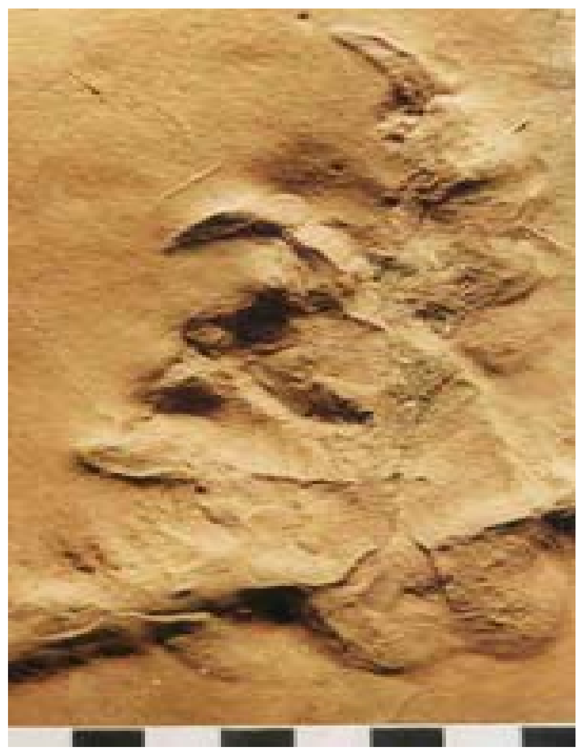

One last note from the secretary.

Permophiles is created by pasting text into Adobe Pagemaker. Hidden codes within Word documents make a time consuming job even more difficult.

Please do not enter any hidden codes like ctrl-1.... Please follow the format. Italics, bold, font size are fine as are tabs (if you follow the submission rules on page 2). **And NO SMALL CAPS please for authors!**

Finally, the figure captions should be separate from the figures; the captions should be part of the word document.

ANNOUNCEMENTS

The Subcommission on Permian Stratigraphy will meet with the GSA Rocky Mountain/Cordilleran meeting at Boise, Idaho, USA during May 3-5, 2004. See the following website for details:
http://www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm
Tamra Schiappa is organizing a session entitled "Upper Paleozoic Biostratigraphy of North America".

Chronos will sponsor a workshop on the Permian-Triassic catastrophic extinction event just prior to the GSA meeting in Boise. For information see the following website:
http://www.chronos.org/meetings/workshops.html

Dear Permian-Triassic Researchers,

CHRONOS is a recently NSF funded project for the development of integrated chronostratigraphic databases and toolkits. The Permian-Triassic extinction and recovery has been a popular subject lately and a lot of new data has been collected on the subject. The age control and basic detailed chronostratigraphic correlation of the data does not allow significant resolution of the sequencing of many events that could prove or disprove (or weight) its effect on the extinction and recovery. To this end *CHRONOS* has targeted a time slice project of the Permian-Triassic extinction interval as a testbed for development and design of integrated internet chronostratigraphic databases and toolkits with the anticipation that "better time" will yield "better answers". We invite you to participate!

In order to achieve the main objective of the time slice project to create a solid and reliable chronostratigraphic framework for the Permian-Triassic transition we need to have the data from the most important sections all over the world available through WEB- accessible database(s). We plan to thoroughly collect most of the published/available data from these sections and place them into PALEOSTRAT, a sample-based data entry and tracking system, also NSF funded and part of the CHRONOS system (www.paleostrat.com).

Many of you have worked on the P/T extinction and recovery problem for years and own a significant amount of published/unpublished data that you have collected or compiled. We are requesting you to help us by becoming active in this endeavor and participate in data sharing or, at least, data correction in the PALEOSTRAT database. If you participate by entering your own data, it will be under your own control (through the MyData option) until you'll decide to release it and have it available to the community. We have already entered much of the reference citations and created a conodont taxonomic dictionary that should be available soon.

Once the initial framework in the PALEOSTRAT database is setup we plan to have a workshop on May 1-2, 2004 at Boise State University (before the regional Rocky Mountain / Cordilleran Geological Society of America that will be held at Boise on May 3-5). At this workshop we plan to discuss the P/T extinction and recovery problem from different prospectives and identify where, how and what should be done in the chronostratigraphic realm in order to solve the problem(s). Unfortunately, we are doing everything at once as we get this started and the PALEOSTRAT database is not yet fully functionable; however, the following can be placed in the database immediately:

1. Basic sample/section information, *i.e.* precise [up to +/- 3-5 m] location in DD or degr/min/sec or UTM; position within the succession; when, who collected sample; who and when studied it; storage location etc.
2. Physical stratigraphy information – lithology, petrography, paleo-environmental info etc.
3. Biostratigraphy and taxonomy - any taxa, their description, images, ranges (ages), environmental/facies info *etc.*

This is to be a truly interactive project, so that you can influence it at any level at any time. Please do. Whether you can attend the workshop or not, we are encouraging all of you to deliver as much information as you willing to and be actively involved in this project. With the new technology that is available these days and with databases and tools that we are developing right now, we anticipate being able to push science forward for the benefit of you and of the entire scientific and public communities.

Thank you,

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U.S. Geological Survey

P.S.: It is interesting that this issue of *Permophiles* has two articles on the P-T Boundary and refined chronostratigraphy. We would like to point out that a more refined conodont zonation (Wardlaw and Mei, 1998, *Permophiles* no. 31, p. 3-4) has been proposed but ignored in this issue and that the conodont faunas from the upper part of Bed 24 from the Meishan Section are, as of yet, not fully described. In Wardlaw's notes and photographed specimens dating back to 1993, there is a least one undescribed species in his material. Henderson, on a recent sabbatical to China, recognized a new bed, "Bed 24f", a thin (about 1cm), capping

ANNOUNCEMENTS

limestone separated by a consistent thin shale parting from 24e. Since the species utilized by Kozur (this issue) are undescribed and have been for over a year of their use, who is to say that Wardlaw's new species or Henderson's new bed do not represent the "missing" fauna or interval at Meishan? Certainly, the efforts of the upcoming CHRONOS workshop will make all this information available for some stimulating discussions.

Fieldtrip Announcement

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

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

The highlights are: From post-rift shallow shelf transgressive carbonate to correlated carbonate slope turbidites and avalanches, platy lime-mudstone and condensed deep-water red ammonoid lime-mudstone, shale and chert deposits.

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

For this 4 day fieldtrip, a short summary is given below:

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

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

On more distal parts, the basinal and oceanic sedimentation resulted in various types of carbonate, of chert and siliciclastic deposits, presently found in the Hawasina Nappe. Middle Permian radiolarites (Buday'ah) and red ammonoid limestone (Rustaq) deposited on lava are cropping out as blocks of various dimensions, the Oman Olistoliths, north or west of the «autochthonous» tectonic window.

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

All information including cost and applications are to be found at :
http://www.squ.edu.om/sci/Centers/VR/IAS/home.htm

Aymon Baud

NEW BOOKS

Kolar-Jurkovsek, T. & Jurkovsek, B. 2002: *Karbonski gozd: Karbonske plasti z rastlinskimi fosili pri Ljubljanani / Carboniferous Forest: Carboniferous Strata with Plant Fossils near Ljubljana.* Geološki zavod Slovenije / Geological Survey of Slovenia, 191pp., including figures (black and white, colour), 28 black and white plates. Language Slovene/English. Format 16 x 24 cm. ISBN 961-90403-5-X.

This book documents a Westphalian megaflora that was collected along the motorway construction in central Slovenia.

Price EUR 20, plus handling charges. For orders contact Mrs. Irena Trebušak (phone: ++386 1 2809 733, fax: ++386 1 2809 753, e-mail: irena.trebusak@geo-zs.si).

Tea Kolar-Jurkovsek

CARBONIFEROUS-PERMIAN TRANSITION AT CARRIZO ARROYO, CENTRAL NEW MEXICO

NEW MEXICO MUSEUM OF NATURAL HISTORY AND SCIENCE BULLETIN 25 (2004)

The New Mexico Museum of Natural History is pleased to announce the publication of the latest volume in our bulletin series: Carboniferous-Permian Transition at Carrizo Arroyo, Central New Mexico (Bulletin 25), edited by Spencer G. Lucas and Kate E. Zeigler. The table of contents is listed below. **The volume is available for $30 and can be ordered through the museum's website: http://museums.state.nm.us/nmmnh/nmmnh.html.**

Spencer Lucas

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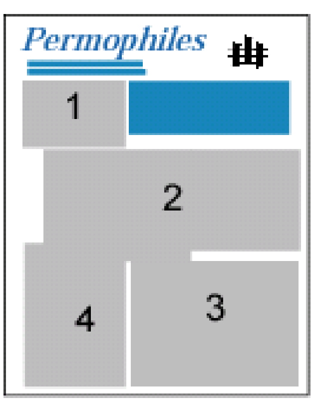
Contents



1: Well-groomed Geopark at Meishan for the P-T boundary GSSP making this an excellent location for a second GSSP; photo by C. Henderson November 2003. **2:** The "body stratotype" for the Changhsingian is seen in these two photos spliced together; photo was taken by C. Henderson during a sunset in November 2003 and shows stairs on left to the P-T GSSP and stairs on right to the proposed base-Changhsingian GSSP location. **3:** Close-up of the proposed GSSP for the base-Changhsingian; the point is indicated as GSSP in red lettering (see proposal beginning on p. 8); photo taken in November 2003 by C. Henderson. **4:** The SPS Chair and Secretary dressed in Permophiles Blue at Guangyuan, Sichuan, China in front of some of their samples collected at the Shangsi section; photo by Xiangdong Wang in October 2003; this trip was part of the Lopingian stratigraphy and events workshop held at Nanjing China and reported in this issue (see p. 5).