

# *Permophiles*

International Commission on Stratigraphy  
International Union of Geological Sciences



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This issue of *Permophiles* is dedicated to  
the immeasurable and continuing  
contributions of  
**Professor Brian Glenister**



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**1:** Brian Glenister carrying the weight of the Permian on his shoulders in China. **2:** A young Brian Glenister in an informal pose reminiscent of the cover of *Permophiles* #35 (December 1999) featuring Vasily Ruzhencev. **3:** Brian Glenister in Russia with a much younger future SPS Chair in the background. This issue is dedicated to the immeasurable and continuing contributions to Brian Glenister (see article p. 33-35).



# EXECUTIVE NOTES

## Notes from the new SPS Secretary

### Introduction and thanks

This note represents the first communication from me as the new secretary of the Subcommittee on Permian Stratigraphy and an editor of *Permophiles*. My term as Secretary of the SPS began in conjunction with the 32<sup>nd</sup> International Geological Congress August 2004 in Florence, Italy.

On behalf of the Permian community, I wish to express my appreciation to Prof. Charles Henderson and Dr. Bruce Wardlaw for their exceptional efforts in compiling the *Permophiles* newsletters in the previous four years. My objective is to achieve the same level of excellence.

I would like to take this opportunity to thank all contributors to this issue of *Permophiles* and those who assisted in its preparation. We are indebted to Charles Henderson, Bruce Wardlaw, Brian Glenister, Claude Spinosa and Vladimir Davydov for editing this issue.

We thank the following individuals for contributing toward the *Permophiles* publication fund: Brian Glenister, Tamra Schiappa, Bruce Waterhouse, Giuseppe Cassinis, Gary Johnson, and Norman Newell. We also thank Laurie Vaughan (Department of Geology and Geophysics, University of Calgary) for handling the donations. Future donations will continue to be handled at the University of Calgary so please mail your donation to Charles Henderson.

### Future Issues of Permophiles

The next issue of *Permophiles* (#45) will be compiled during late May 2005, and will be prepared by Charles Henderson and me in Nanjing, China. Everyone is encouraged to submit manuscripts, announcements or communications before May 21, 2005. Manuscripts and figures can be submitted as attachments via my email address ([szshen@nigpas.ac.cn](mailto:szshen@nigpas.ac.cn); or [shen\\_shuzhong@yahoo.com](mailto:shen_shuzhong@yahoo.com)). Hard copies by regular mail do not need to be sent unless requested. However, large electronic files such as plates in Photoshop or tif format may be sent to me on discs or hard copies of good quality under my mailing address below. Please follow the format on Page 5 of issue 43 of *Permophiles*.

I currently use a Windows XP PC with CorelDraw 11, Adobe Page Maker 7.0, Adobe Photoshop 7 and Microsoft Office XP programs. Documents compatible with these specifications will be easier to work with.

*Permophiles* is expensive to prepare and mail; donations do not meet our current costs. We would like to reduce this cost by sending some copies via email as a PDF document and individuals could print the issue themselves. If you are willing and able (receive a 3-5 MB file and have access to a printer) to do this then please send an email to me. Send to [szshen@nigpas.ac.cn](mailto:szshen@nigpas.ac.cn) and indicate your willingness. We will continue to supply printed copies to those who desire as well as to libraries. This should reduce costs and allow for more timely distribution.

### Previous SPS meeting and Minutes

An official business meeting of the SPS was held at Florence, Italy on the 23<sup>rd</sup> of August, 2004 in conjunction with the 32<sup>nd</sup> International Geological Congress. The individuals in attendance at this meeting included Alfredo Arche, Aymon Baud, Boris I. Chuvashov, Vladimir Davydov, Mercedes di Pasquo, Douglas Erwin, Cassinis Giuseppe, Phil Heckel, Charles M. Henderson, Yugan Jin, Heinz Kozur, Atsushi Matsuoka, Manfred Menning, Ausonio Ronchi, Tamra Schiappa, Joerg Schneider, Shuzhong Shen, Guang R. Shi, Walter Snyder, Claude Spinosa, John Utting, Carmina Virgili and Bruce R. Wardlaw.

The meeting was initially chaired by Bruce R. Wardlaw (former SPS Chairman). He introduced the new SPS Chairman Charles Henderson and all in attendance applauded to thank Bruce for his excellent work as the SPS Chairman and for his great contributions to the SPS. Then the meeting was conducted by Charles Henderson (new Chairman). He announced me as the new Secretary, Dr. Vladimir Davydov as the new Vice-chairman, and the new voting members for the Subcommittee on Permian Stratigraphy. Drs. Yoichi Ezaki, Tamra A. Schiappa, Vladimir Davydov, Prof. Joerg W. Schneider, Drs. Shuzhong Shen, Xiangdong Wang and Guang R. Shi respectively replace Profs. Makoto Kato (resigned) and Claude Spinosa (retiring), Prof. Brian F. Glenister (retiring), Dr. Manfred Manning (resigned), Prof. Sheng Jinzhang (retiring), Prof. Liao Zhuoting (retiring) and Dr. Heinz Kozur (retiring). The chair asked the assembled corresponding and voting members whether they objected to the present SPS membership and heard no objection.

Reports from various working groups were discussed. Dr. Boris I. Chuvashov gave a report on the progress on the GSSPs for the base of the Artinskian and base of the Kungurian by the Cisuralian Working Group. Dr. Guang Shi reported the progress on "Using transitional biota as gateways for Global Correlation" and the "Permian Research Group of SE Asia" by the SPS Working Group. A report by Guang R. Shi will be found in this issue. Prof. Joerg Schneider reported on the progress of the continental Permian/non-marine to marine correlation working group.

### Future SPS Meetings

The next scheduled SPS meeting will be held in conjunction with the "Triassic Chronostratigraphy and Biotic Recovery" meeting at Chaohu during May 23-25, 2005. The next official business meeting of SPS will be held in conjunction with "The Nonmarine Permian" meeting to be held at Albuquerque, New Mexico, USA, October 21-29, 2005. Dr. Spencer Lucas is the convener. Announcements for both meetings are found in this issue.

### Report on the SPS vote for the Wuchiapingian-Changhsingian boundary

A proposal for the GSSP for the Wuchiapingian-Changhsingian boundary and ballot were sent in April 2004 to SPS voting members. A successful and conclusive vote requires 60% of the group to vote at least a 60% majority. The SPS voting

members have voted 15-1 in favour (93.3%) and it is here declared that the Wuchiapingian-Changhsingian boundary as defined by the FAD of *Clarkina wangi* at the base of bed 4a-2 at the Meishan Section D has been passed by the Subcommittee on Permian Stratigraphy.

The results are as follows:

Prof. Giuseppe Cassinis	Yes
Dr.. Boris I. Chuvashov	Yes
Dr. Clinton Foster	Yes
Prof. Brian Glenister	Yes
Prof. Charles Henderson	Yes
Prof. Sheng Jinzhang	Yes
Dr. Makoto Kato	Yes
Dr. Galina Kotljar	Yes
Dr. Heinz Kozur	No
Prof. Ernst Ya Leven	Yes
Dr. Manfred Menning	Yes
Dr. Claude Spinosa	Yes
Dr. John Utting	Yes
Dr. Bruce R. Wardlaw	Yes
Prof. Jin Yugan	Yes
Prof. Liao Zhuoting	Yes

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### Notes from the past SPS Secretary

#### Charles M. Henderson

This note represents my last communication as secretary of the Subcommittee on Permian Stratigraphy. I have enjoyed working with Bruce over the past four years and look forward to editing future issues of *Permophiles* in my new role as SPS Chair. I will continue to collect donations for publication costs of *Permophiles* at the University of Calgary.

This issue of *Permophiles* was compiled during 2.5 days in late October 2004 at Claude Spinosa's luxurious cabin in northern Idaho. As I type these words I am looking out at a storm brewing over Pend Oreille from a cold Canadian wind making me feel at home with my American colleagues Bruce Wardlaw, Brian Glenister, Claude Spinosa and Vladimir Davydov who have helped edit this issue. Technical problems and other delays have resulted in the late publishing of this issue.

This special issue of *Permophiles* (#44) will be the only issue of 2004 in order to facilitate the transition of the new executive and to get back on track in terms of publication timing. Readers of *Permophiles* can be rest assured that two issues (#45 and #46) will be produced in 2005 (with deadlines of May 21 and October 1, 2005).

### Notes from the SPS Chair

#### Charles M. Henderson

I would like to begin by acknowledging the valuable contributions made by the previous executive and especially by the past-Chair, Bruce R. Wardlaw. Under Bruce's guidance the SPS has made considerable progress and all of the Middle and Upper Permian GSSP's as well as the base of the Permian have been ratified by SPS; all but the base of the Changhsingian have also been ratified by ICS and IUGS. SPS members should applaud the contributions by Bruce and his Vice-Chairs Ernst Leven and Clinton Foster; indeed their contributions as active SPS members will continue for a long time yet.

It is now time to introduce a new executive. Shuzhong Shen from the Nanjing Institute of Geology and Paleontology will be the Secretary and Vladimir Davydov from Boise State University will serve as Vice-Chair. I welcome them to the executive and look forward to working with them over the next several years.

The SPS should have three priorities for the next few years. **1.** The completion of the GSSP process by ratifying detailed proposals for the base-Sakmarian, base-Artinskian, and base-Kungurian. This must be done before 2008 as mandated by ICS. Preliminary proposals in Permophiles 41 (December 2002) indicated that certain details were still required and much of that work has been completed (see abstracts related to IGC32 Cisuralian session in this issue) so there do not appear to be any problems fulfilling that goal. **2.** The investigation of interprovincial correlation problems that have especially plagued the Middle and Upper Permian. Guang Shi leads a group looking at Gateways between the various provinces (see report in this issue) and a new working group is proposed in this issue to address W-E correlation problems in the Tethys and S. China carbonate platforms. **3.** Once the marine GSSP's are completed it is paramount that these positions be correlated into continental successions. Continental workers have made many significant contributions and have published a wealth of papers, but very few of these have been documented in Permophiles. I would like to see that change. Facies transitional between marine and continental are well displayed in several regions and these need to be studied in considerable detail by multi-disciplinary teams. I invite these researchers to make contributions to future Permophiles issues. Some of this progress will be discussed at the Nonmarine Permian meeting at Albuquerque, New Mexico in October 2005 (see announcement of second circular in this issue); the SPS will hold its annual official business meeting at this event.

There have been significant changes to the voting membership of the SPS over the past year. This was essential to bring some very active younger researchers onto the voting team; such renewal is mandated by ICS, in fact. Some of the active retiring members would have liked to retain their voting status, but it is important to not increase the number of voting members. In trying to address these concerns I have designated a new type of member, herein referred to as Honourary Members (see page 4). Honourary Members will receive all GSSP proposals and will be invited to comment on them; their comments will be recorded in subsequent revisions, but they will not actually vote on the proposal. This is intended to honour our retiring members who continue to make significant contributions to the Permian.

In conclusion, I invite SPS contributing, voting and honorary members to make suggestions to me regarding SPS changes in priority, procedure, and communication that they would like to see instituted. In fact, early issues of Permophiles had many letters and informal communications as well as research articles (see contribution by Brian Glenister and Walter Nassichuk in this issue). I would be happy to see more of these in future issues.

### Notes from the Past Chair

**Bruce R. Wardlaw**

It was with great pleasure that I turned over the reins of the Chair to Charles Henderson this August at the IGC. I am sure the SPS will be well served by his leadership. Shuzhong Shen as Secretary and Vladimir Davydov as Vice-Chair make for a well rounded executive and I look forward to working for them. I will continue to participate on many of the working groups, particularly to improve correlation. I plan to concentrate most of my energies to the Permian-Triassic Time Slice Project and the development of improved taxonomic dictionaries, database sharing and manipulation. I continue to encourage you all to participate. Current information is available from <http://www.paleostrat.org>. Thank you all for your support over the last eight years.

**Has your address changed since you last received Permophiles?**

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## SUBMISSION GUIDELINES FOR ISSUE 45

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 (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.* Wang and Henderson, Permophiles #43, p. 5) 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 (you should too!). Indents for paragraphs are .20"; 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 Draw 12, Adobe Page Maker 7.0, Adobe Photoshop 7 and Microsoft Office programs; documents compatible with these specifications will be easiest to work with.

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**Submission Deadline for Issue 45  
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# REPORTS

## **Global correlation of Lower Permian (Cisuralian) stages: contents and problems as presented at the Symposium g-22.04 (32<sup>nd</sup> International Geological Congress): some tasks for the future**

**Boris I. Chuvashov**

The objective of this report (and Symposium G –22.04 of the 32<sup>nd</sup> IGC) is to provide full information concerning the biostratigraphic potential of the Lower Permian Stages, all of whose stratotypes are located on the western slope of the Urals and have been either formalized (like the Asselian Stage) or proposed as candidates (like the Sakmarian, Artinskian, and Kungurian stages) for the General International Stratigraphic Scale.

Stage stratotypes are located in the Pre-Uralian foredeep, which during the Early Permian formed the eastern margin of an extensive East-European marine basin (EEB). In the southern part, this basin was connected with waters of the Tethys Basin, and in the northern part, with the western seas of the Arctic biogeographical belt. The specific regional biota of the East-European Basin developed under the influence of Tethyan and Arctic biotas. Such a unique position of the EEB has strengthened considerably the correlation potential of the Uralian sections.

Additional research efforts of biostratigraphic substantiation of Early Permian stage boundaries have been initiated by the Subcommission on Permian Stratigraphy - SPS (Soviet Union, Perm, August, 1991) and realized by the creation of the *Cisuralian Stage Working Group* (Chair, Prof. B. I. Chuvashov).

The biostratigraphic substantiation of Lower Permian stages during this period of work, in accordance with GSSP program has been realized, basically, by the following specialists: fusulinids and “small” forams were studied by Drs. B. I. Chuvashov and V. I. Davydov; radiolarians by Drs. E. O. Amon and H. Kozur; ammonioidea by Dr. M. F. Bogoslovskaya; and conodonts by Dr. V. V. Chernykh. The geological documentation and choice of reference sections were carried out by B. I. Chuvashov.

Most of the research has been conducted by investigators from the Laboratory of Stratigraphy and Paleontology, Institute of Geology and Geochemistry, Uralian Branch, Russian Academy of Science in Ekaterinburg, Russia. During the initial phase of the research, involving substantiation of Carboniferous - Permian boundary (and also the lower boundary of Asselian Stage) active participation was undertaken by the following foreign colleagues: Chief Paleontologist U.S. Geological Survey, Dr. B. R. Wardlaw; researchers of Permian Research Institute, Boise State University, Dr. W. S. Snyder, and Prof. C. Spinosa; researcher of The University of Iowa, ammonioidea specialist Prof. B. F. Glenister; and researcher from Brigham Young University, conodont specialist Dr. S. Ritter.

The state of knowledge of the Lower Permian stages was reported and discussed more than once at various sessions of the Subcommission on Permian Stratigraphy; simultaneously special colloquia were conducted on taxonomy and biostratigraphy of fusulinids and conodonts. Reports on the same subjects occurred at session the International Carboniferous-Permian Congress (Canada, Calgary, 1999) and at the special symposium “*Stages of*

*Permian System*” of the 31<sup>st</sup> International Geological Congress in Rio-de-Janeiro, Brazil, 2000.

The Symposium held within the framework of the 32<sup>nd</sup> IGC, in 2004, aimed to demonstrate the correlation potential of Lower Permian stages. Presently the possibility exists for the recognition of the lower boundaries of all Cisuralian stages in China, Arctic Canada, and USA. Background data were presented in a series of oral and poster presentations in Section 132, Symposium G22.04 – *Global Correlation of the Cisuralian (Lower Permian) stages*, Chairpersons: Boris Chuvashov and Charles Henderson at the 32<sup>nd</sup> IGC, in Florence; edited abstracts for these sessions are included in this volume following this article.

In addition to the special biostratigraphic research efforts indicated above, a systematic investigation is being initiated on isotope dating of the main biostratigraphic (stages and horizons) boundaries utilizing U/Pb dates obtained from zircons occurring in numerous horizons of ash tuffs. This work is carried out cooperatively with the Permian Research Institute, Boise State University and with the Massachusetts Institute of Technology. The objective is to develop precise and consistent dates of the widespread Permian strata and volcanogenic successions, and to strengthen the correlation of sections in Tethyan and Arctic zones and extensive Permian successions in Gondwana.

Studies of stable isotopes O and C in brachiopod shells can provide significant data for the reconstruction of the physical and geographical Early Permian environments and for correlation of Lower Permian sections of the Urals and adjacent territories. This work is being carried out in cooperation with the Laboratory of Geochemistry of Texas (A&M) University.

Some investigations for near future include:

1. Biostratigraphic documentation for definition of lower boundaries of the Sakmarian, Artinskian (see page 6) and Kungurian (see page 7) stages are nearly finished. However, we need time during 2005 and 2006 to develop more precise locations of the lower and the upper boundaries of the Kungurian Stage. A definition of the upper boundary of the Kungurian in Russia, in other words, the lower boundary of the Middle Permian, will be very important in global correlation of the Permian stages. The base of the Middle Permian (Guadalupian) or Roadian Stage has already been ratified by IUGS.

2. Isotopic dating of the main biostratigraphic boundaries should be considered critically important for construction of the Permian and General Stratigraphic Scale and necessary for GSSP proposals to ICS.

3. It could be predicted that careful studies of stable isotopes of O and C occurring within Permian carbonate sequences in the different areas could be very important for global correlation and for paleogeographic reconstruction.

4. The results of the activities of the Working Groups indicated above should be discussed in late 2005 or during 2006 in special meetings of the Subcommission on Permian Stratigraphy. The last of the above meetings could be organized in the Urals and could include field trips to demonstrate the proposed stratotypes of Sakmarian, Artinskian and Kungurian stage boundaries.

Figures. Illustrations of potential base-Artinskian and base-Kungurian GSSP sections are depicted on pages 6 and 7.

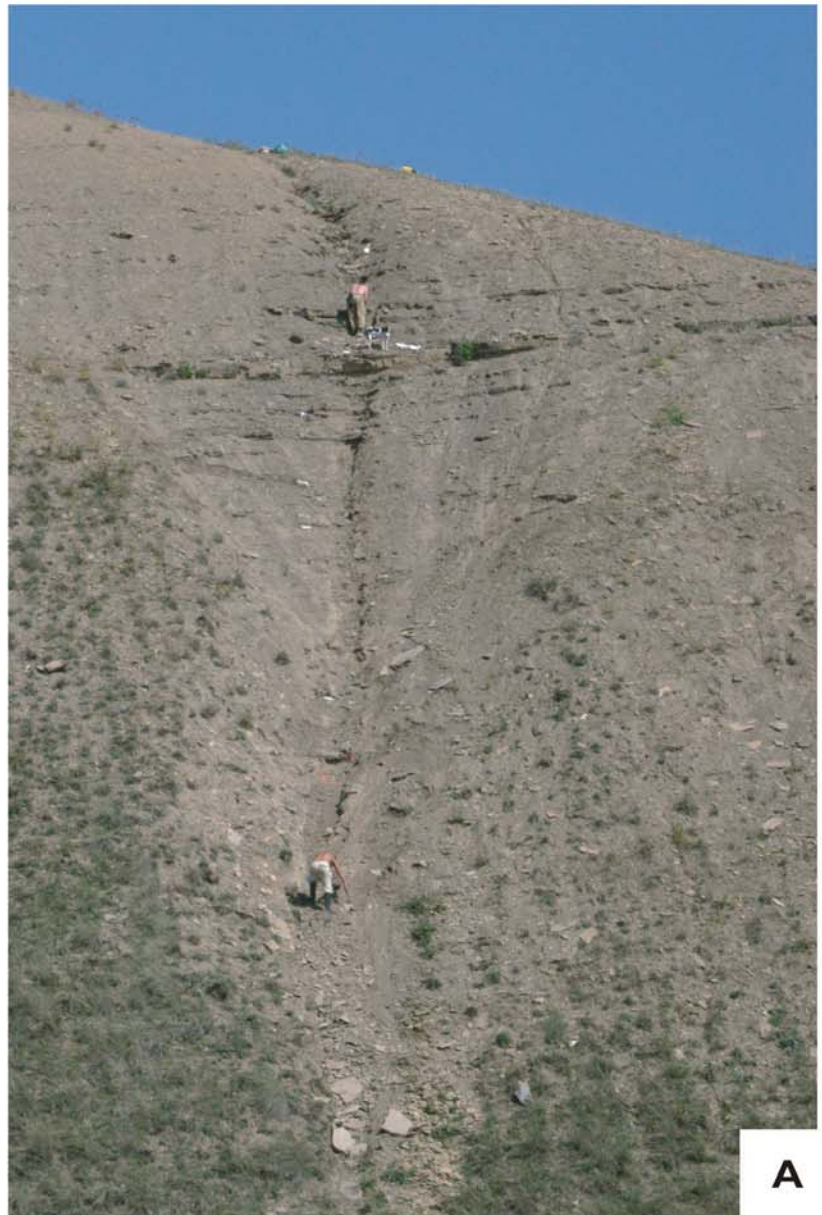
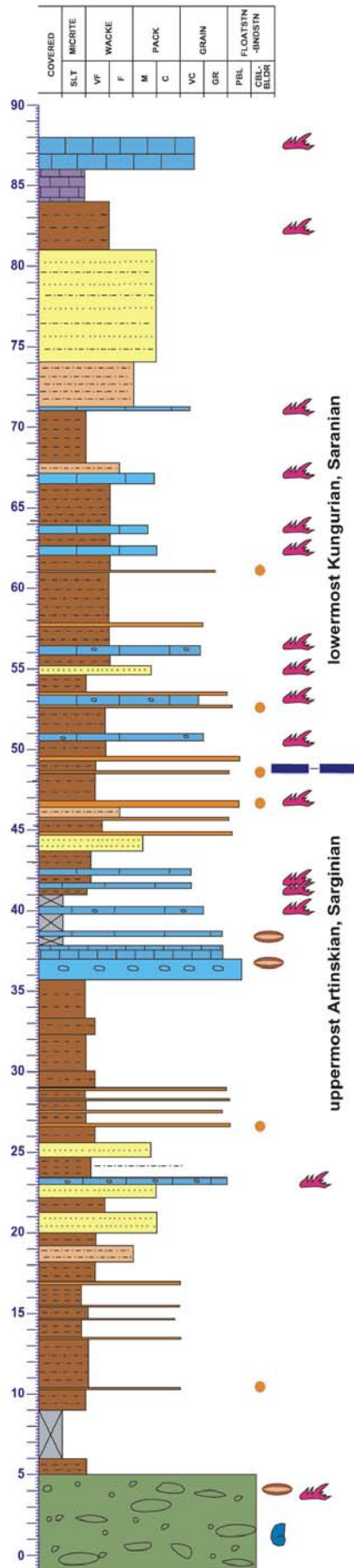


Sakmarian-Artinskian succession at Dal'ny Tulkas Section, S. Urals.  
**A** - general view of lower Artinskian portion of the section, from 0 mab (meters above the base of the section) up to approximately 30 mab;  
**B** - the Sakmarian-Artinskian boundary beds, yellow line represents approximate position of the proposed boundary at 3.8 mab; **C** - uppermost beds of Sakmarian from 3.0 to 10.0 mab.





## Mechetlino Section



Artinskian-Kungurian succession at Mechetlino Section, Juresan' River, S. Urals. **A** - boundary n, from 0 mab beds in Mechetlino section; for scale see people cleaning the slope; the lower one standing at approximately 23 mab, the upper one - at 40.2 mab. The proposed boundary is located at approximately 50.7 mab; **B** - volcanic ash bed at 53.3 mab. For more explanations see Dal'ny Tulkas section.

The following represent edited abstracts presented at session 132 (G22.04) of the 32<sup>nd</sup> International Geological Congress at Florence during Monday, August 23, 2004. The session entitled "Global Correlation of the Cisuralian (Lower Permian) stages" was co-chaired by Boris I. Chuvashov and Charles M. Henderson.

## ZONAL SCALE OF THE LOWER PERMIAN OF URALS ON CONODONTS

**CHERNYKH Valery<sup>1</sup>, CHUVASHOV Boris<sup>1</sup>**

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Keywords: Lower Permian; conodonts; zonal scale; Urals.

Asselian consists of the following zones (bottom-up): *Streptognathodus isolatus*, *S. glenisteri*, *S. cristellaris*, *S. sigmoidalis*, *S. constrictus*, and *Sweetognathus expansus*. Sakmarian consists of the following zones (bottom-up): *Sweetognathus merrilli*, and *S. binodosus*. Artinskian consists of the following zones (bottom-up): *Sweetognathus whitei*, *Sw. obliquidentatus*, *Sw. clarki*, and *Neostreptognathodus pequopensis*. Kungurian consists of the following zones (bottom-up): *Neostreptognathodus pnevi*, and *N. parapecuopensis*. Kazanian consists of the following zones (bottom-up): *Kamagnathus chalimbadzhai*, and *K. volgensis*. As an example of the correlative potentialities of the scale we quote the comparison of the Ural Stages boundaries with some synchronous USA formations. The proposed scale permits: 1) to identify Asselian as an interval from Red Eagle Limestone Formation to Stearns Shale Formation inclusive (Kansas); 2) to indicate lower boundary of Sakmarian in the upper part of Eiss limestone in Bader Limestone Formation (Kansas); 3) to determine lower boundary of Artinskian in the base of Florence Limestone of Chase Group (Kansas), in base of Riepetown Formation (Utah, Nevada), in uppermost Tensleep Sandstone (Wyoming); 4) to find lower boundary Kungurian in Glass Mountains in Skinner Ranch Formation 48 metres above the base of the section (West Texas); 5) to compare Kazanian stage with Roadian strata of Northern Utah.

## GLOBAL PENNSYLVANIAN-PERMIAN FUSULINACEAN CORRELATIONS: HOW RELIABLE IS IT?

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Keywords: Late Paleozoic; fusulinacean; provincialism; homeomorphism; correlation.

Historically global correlation for the Upper Paleozoic was based on the concept of fusulinid genozone association. Fusulinid workers considered Late Paleozoic fusulinids to be cosmopolitan and that the same genera occupied a variety of regions and had similar chronologic ranges. Two important reasons limit the use of fusulinids in global biostratigraphic correlation: provincialism in geographic distribution and homeomorphy in evolution. Fusulinids are warm-water benthic organisms that exhibit provincialism in distribution and that are influenced by paleoclimatic, paleotectonic and paleoenvironmental factors that control the degree of this provincialism. Several major factors such as the assembly of

Pangaea, combined with global sea-level falls associated with climate cooling, created the appearance of barriers (either physical or thermal) between eastern and western hemispheres resulting in an increase in provincialism. Paleoclimatic warming events, associated with transgressions during the Pennsylvanian - Permian provided better connections regionally within provinces and between eastern and western hemispheres, decreasing the degree of provincialism. Therefore warming/transgression events are important periods that allow for improved development of a framework for intercontinental correlation. Recently, much progress has been made in the studies of fusulinid successions and it is recognized that FADs of some taxa (either genera or species) could vary significantly. It could be due to a possible independent origin of similar morphotypes in different provinces or due to variations in dispersal patterns. Further study is needed to determine whether we are dealing with the independent appearance of taxa or with migrational occurrences of the same taxa between provinces. Combining the efforts of specialists of different fossil groups such as conodonts, foraminifera, radiolaria and ammonoids along with radiometric, magnetostratigraphic and stable isotopes studies the development of global fusulinid correlation will improve. This study is supported by the NSF grants EAR 0106796, EAR-ITR 0218799 and EAR-ITR/AP 0312392.

## PERMIAN OF THE VERKHOYANYE (KEY REGION OF SIBERIA)

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Keywords: Permian; brachiopods; ammonoids.

The best marine Permian sections of Siberia occur in Verkhoyanye. The entire thickness of Permian terrigenous rocks is about 4-6 thousand metres (sandstone, siltstone and argillite). The biostratigraphy and stratigraphic correlations are based mainly on brachiopod studies, but the location of the stage boundaries in the particular sections were defined mainly by ammonoids. Six regional horizons and 19 biozones have been established for the Permian of this area. Khorokytian horizon is Asselian-Early Sakmarian age and includes the brachiopod zone *Jakutoproductus verchoyanicus-Spirelytha kislakovi* and the ammonoid zone *Bulunites mezhvilki*. The Echian horizon is Late Sakmarian-Artinskian age and includes 2 brachiopod zones: *Jakutoproductus rugosus-Alispiriferella gydanensis* and *Jakutoproductus burgaliensis-Spirelytha kislakovi* and 3 ammonoid zones: *Uraloceras simense*, *Eotumaroceras endybalense*, *Eotumaroceras subyakutorum*. Tumarian horizon is Kungurian-Ufimian age and includes 3 brachiopod zones: *Anidanthus aagardi*, *Megousia kuliki*, *Kolymaella ogonerensis* and 2 ammonoid zones: *Tumaroceras yakutorum*, *Epijuresanites musalitini*. The Delenzhian horizon is Kazanian age and includes 3 brachiopod zones: *Mongolusia russiensis*, *Terrakea*, *Tumarinia zavodowskyi* and 2 ammonoid zones: *Sverdrupites harkeri*, *Sverdrupites baraiensis*. The Dulgalakhian horizon is Early Tatarian age and includes the brachiopod zone *Canocrinelloides obrutschevi*.



Ammonoidea are not known. The Khalpirki horizon is Late Tatarian age and includes the brachiopod zone *Crassispirifer monumental*. Ammonoidea are not known.

## CISURALIAN BIOSTRATIGRAPHY OF THE GREAT BASIN, WESTERN UNITED STATES

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Keywords: Cisuralian; biostratigraphy; western United States; ammonoids; fusulinaceans.

The tectonically active nature of the western margin of the U.S. coupled with eustasy during the Late Paleozoic has provided challenges for researchers seeking a detailed biostratigraphic framework for the region. During the Cisuralian, a series of basins developed along the continental margin. Defined by regional unconformities and recognized as tectonostratigraphic units, Cisuralian strata are laterally discontinuous or completely missing in areas making regional correlation difficult. Despite the inherent problems of working out the stratigraphy in a tectonically active regime, a Cisuralian biostratigraphic framework has been formulated based on the occurrences of conodonts, ammonoids and fusulinaceans. In continuous sections, the C-P boundary (base of Asselian Stage) is recognized within the conodont phylogeny *Streptognathodus wabaunsensis* - *S. isolatus*. This horizon is coincident in the southern Urals with *Sphaeroschwagerina fusiformis*- *S. vulgaris* fusulinacean zone and FAD of *Svetlanoceras* and *Juresanites* ammonoid genera. Due to provincialism, neither *Sphaeroschwagerina fusiformis*- *S. vulgaris* indexes are present in North America. Local species of *Triticites*, *Leptotriticites* and *Pseudofusulina* (=Schellwienia?) have been recognized, allowing for provisional correlation studies. The traditional basal Asselian *Svetlanoceras*-*Juresanites* genozone is also missing with only Artinskian ammonoid localities known. The Sakmarian is recognized by the appearance of *Sweetognathus merrilli* and the FAD of *Eoparafusulina*. The Artinskian was a time of great ammonoid diversity in the Great Basin. Species of *Uraloceras*, *Medlicottia*, *Metalegoceras*, *Properrinites*, *Neocrinites*, and others co-occur with elements of *Sweetognathus whitei* and *Mesogondolella bisselli* supporting an Artinskian age. FAD of *Chalaroschwagerina* and a diverse assemblage of *Schwagerina*, *Pseudoschwagerina*, *Stewartina*, and advanced *Eoparafusulina* characterized this time. The Kungurian is recognized by the co-occurrences of *Neostreptognathodus pnevi* and *Neostreptognathodus "exsculptus"* in shallow water facies disconformably overlying Artinskian strata. The Kungurian fusulinid assemblage is closely related to the Artinskian fauna, but differs in the absence of *Pseudoschwagerina* and *Stewartina* and FADs of advanced and diverse *Chalaroschwagerina*, *Schwagerina* and *Praeskinerella guembeli* and *P. crassitectoria*.

## CISURALIAN TECTONOSTRATIGRAPHY OF THE WESTERN UNITED STATES

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Keywords: stratigraphy; tectonics; global; correlation.

The Cisuralian was a time of tectonic unrest in the western United States, when a succession of basins and uplifts developed along the continental margin. In some places, the resulting stratigraphy is marked by important unconformities that developed during the transition from one phase of basin development to the next. At other locations, in contrast, continued or increased subsidence lead to more complete stratigraphic records during the same tectonic event. Thus, we refer to this as a "tectonostratigraphy" to reflect the important role that tectonism played in development of the stratigraphic architecture. Regionally, unconformities separate genetically related tectonostratigraphic successions. Evidence for the tectonic origin of these unconformities varies widely - even for the same unconformity. Where subjacent strata are deformed by folds and thrust faults, the tectonic origin is obvious. Other unconformities are markedly, to only slightly angular, and some are disconformities that can only be detected by detailed biostratigraphic data. More subtle evidence may come from superjacent strata that reflect changes in provenance of clastic detritus or paleocurrent directions. The nomenclature for succession-bounding unconformities, (C1, C2, etc., and P1, P2, etc.) reflect the first, second, etc., one developed during the Carboniferous and Permian respectively. The lowermost strata of the middle Kasimovian-late Asselian C6-P1-P2 stratigraphic interval, at some localities, rests on highly deformed strata as young as Moscovian. At other localities, P1-P2 succession is superjacent to remnants of Mississippian or older successions. Thus the C6 to P2 was an interval of complex tectonostratigraphic events along the continental margin. Nevertheless, a few important transition successions are preserved across the C-P boundary that can serve as potential global correlation points. The Asselian-Sakmarian boundary is only locally preserved, being cut out by the P2 unconformity. The P2-P3-P4 succession arguably includes the Sakmarian-Artinskian boundary, but clearly encompasses the base of the Kungurian. The mid- to late Kungurian P4 boundary marks the initiation of the dominantly Guadalupian Park City-Phosphoria basins which persisted through the Wordian or even early Capitanian.

## CORRELATION OF CISURALIAN (LOWER PERMIAN) GSSP'S INTO THE SVERDRUP BASIN, CANADIAN ARCTIC ARCHIPELAGO

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Keywords: Permian; Cisuralian; GSSP; conodonts; Sverdrup Basin.

Global Stratotype Sections and Points (GSSP) provide definitions for the geologic time scale that most take for granted. Ideally, GSSP definitions should be globally correlatable. However, provincialism during the Permian has made truly global definitions almost impossible. Ratified definitions for the base of the Wordian and Capitanian (Middle Permian Guadalupian Series) and nearly ratified definitions for the base of the Wuchiapingian and Changhsingian (Upper Permian Lopingian Series) cannot be recognized in the Sverdrup Basin. However, other techniques and other fossils can be used to correlate this succession. Ironically, the interval with the least provincialism (Lower Permian Cisuralian Series) has proven the most elusive. The base-Asselian GSSP (base Permian) has been ratified for the Aidaralash section, Kazakhstan at the first appearance datum (FAD) of *Streptognathodus isolatus*. In the Sverdrup Basin, a form similar to *S. isolatus* has been recovered from lowstand facies of the Hare Fiord Formation; this species is absent in carbonate platform successions where an unconformity separates Gzhelian from mid-late Asselian faunas. Recent proposals indicate that *Sweetognathus* and *Neostreptognathodus* species will define the base of the other Cisuralian stages. The initial chronomorphocline within this plexus from *S. expansus* to *S. merrilli* has not been recognized in the Sverdrup Basin. The FAD of *S. merrilli* defined within the Kondurovsky section, Russia cannot be precisely correlated. However, *Streptognathodus* species suggest that the base Sakmarian is within another Hare Fiord lowstand. The chronomorphocline from *S. merrilli* through a new species to *S. whitei* is well developed in the Sverdrup Basin. The point defined at the Artinskian FAD of *S. whitei* in the Dal'ny Tulkas section, Russia can be precisely correlated within the early highstand of the Great Bear Cape Formation. Early stages in the evolution of *Neostreptognathodus* species are well displayed in the Sverdrup Basin, as is the chronomorphocline from *N. pequopenensis* to *N. pnevi*. The point defined at the FAD of *N. pnevi* in the Metchetlino section, Russia can be precisely correlated into a lowstand succession of the Trappers Cove Formation. These latter correlations are important because the Kungurian marks the beginning of Permian provincialism, which becomes very strong during the early Roadian; the GSSP for that Guadalupian stage can be correlated into the Sverdrup Basin using geographic clines.

## STAGE BOUNDARIES AND RADIOLARIAN ZONAL SCALE FOR LOWER PERMIAN DEPOSITS IN REGION OF CIS-URALIAN STRATOTYPE

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Keywords: Lower Permian; Cisuralian; radiolarians.

In upper Paleozoic sediments in territory of Urals the radiolarians are distributed mainly in areas of southern and middle Cis-Urals. Here radiolarians are found in various rocks of Late Carboniferous and Early Permian age within the limits of Kasimovian to Kungurian stages, but there are no well-documented data on the presence of radiolarians in Middle and

Early Carboniferous sediments, in Lower Permian rocks in northern and subpolar Urals, and also in Late Permian rocks. In Lower Permian deposits of the territory of southern and middle Cis-Urals, which is the territory for location of historical Lower Permian stage stratotypes, eleven radiolarian biostratons in a rank of local zones have been recognized. From them, the zone *Latentifistula crux* occupies a transitive position between Gzhelian and Asselian stages; the zone *Tetragegnon vimineum* - *Copiellintra diploacantha* marks the lower boundary of Sakmarian stage; the zone *Rectotortementum fornicatum* marks the upper boundary of Sakmarian stage; the zone *Entactinosphaera crassicalthrata* - *Quinqueremis arundinea* marks the lower boundary of Artinskian stage; the zone *Polyentactinia lautitia* marks the upper boundary of Artinskian stage; the zone *Ruzhencevispongus uralicus* is distinguished at the upper part of Kungurian stage. In Cis-Uralian region all radiolarian zones are well correlated with zones based on forams and conodonts. Presently, the most exact inter-regional and subglobal correlations are possible using conodont zonal scale that allows: (a) to precisely determine the real age of boundaries of radiolarian biostratons; and, (b) to precisely determine the correspondence between Uralian regional radiolarian stratons and stages of international stratigraphic scale. Minuteness of radiolarian scale is almost comparable to minuteness of conodont scale.

## ASSELIAN STAGE OF CIS-URALIAN DIVISION OF PERMIAN SYSTEM: BIOSTRATIGRAPHY AND CORRELATIVE POTENTIAL

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Keywords: Lower Permian; Asselian Stage; biostratigraphy; correlation; Cis-Uralian.

The lower Asselian stage boundary is the lower boundary for the entire Permian System. According to fusulinid data it is determined by the first appearance of *Sphaeroschwagerina*, between the ammonoid genozone *Shumardites* - *Vidrioceras* - *Svetlanoceras*; according to conodont data it is located in the evolutionary sequence *Streptognathodus wabaunsensis* - *S. isolatus* - *S. glenisteri* at the *S. isolatus* point. In Gondwana, the Asselian Stage is singled out according to brachiopods (Australia) or according to stratigraphic position under layers with presumably Sakmarian ammonoidea. In the northern part of South America the most probable Asselian sediments are available in Venezuela, Columbia, Bolivia. Comparison with stage stratotype is possible on associations of small forams and fusulinids, but stage boundaries are not hard to substantiate. In Tethyan Paleozoic zone the Asselian sediments are known in Sumatra, Thailand, Malaysia, Vietnam, China, and Japan. The best results are achieved (with use of fusulinids) in territory of Central Asia where correlation with stratotype is realized at the level of zones. In the western part of the Tethyan realm the best section is one of Carnic Alps where fusulinid data are confirmed by conodonts. The Asselian Stage is here related to the biggest part of Grenzland Formation. For whole eastern and south-eastern territory of Tethyan area exists an indistinctness with upper boundary of Asselian Stage. Usually, it



can be identified according to occurrence of *Monodiexodina*. A similar situation takes place in the Russian Far East. In southern Mongolia (Peritethyan area) is known the full reference section of Asselian Stage where fusulinid zones identical to stratotype are recognized. An upper fusulinid association is changed by deposits with *Monodiexodina* assemblage. In Canadian Arctic Archipelago all stages of Cis-Uralian stratotype sections can be recognized, based on fusulinids (in part) and on conodonts. In extensive territory of USA some sections are known that border Carboniferous - Permian sediments. In part of them according to fusulinid and conodont data Asselian deposits can be distinguished. Lower stage boundary (based on *S. isolatus*) is determined in middle member of limestones of Red Eagle Formation (Kansas). Upper member of Grenola Formation (Burr limestone) is compared to *S. constrictus* Zone, i.e. to middle part of Asselian Stage. The Neva Limestone is correlated with the upper part of Asselian Stage according to presence of *Sweetognathus expansa*.

## SAKMARIAN STAGE OF CIS-URALIAN DIVISION OF PERMIAN SYSTEM: BIOSTRATIGRAPHY AND CORRELATIVE POTENTIAL

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Keywords: Lower Permian; Sakmarian Stage; biostratigraphy; correlation; Cis-Uralian.

The Sakmarian Stage in the stratotype basin is distinguished in the volume of two horizons: a lower Tastubskian and an upper Sterlitamakskian. Stage subdivision and correlations are based, inside the uniform sedimentary basin, on fusulinids (three fusulinid zones), ammonioidea (two biostratigraphic zones), conodonts, radiolarians, and corals. In southwest part of Australia (Perth Basin) in upper part of Holmwood Formation there are ammonioidea *Juresanites jacksoni*, which can be related to lower part of Sakmarian Stage. Above the bryozoan-crinoid limestones of Fossil Cliff Formation, the ammonoid *Svetlanoceras* is found in common with local species; limestones of this formation are compared to upper part of the Sakmarian Stage. In the Paleozoic Tethyan zone the mostly carbonate rocks of Sakmarian age (fusulinids, conodonts) are known in Sumatra, Thailand, Malaysia, Vietnam, China, and Japan. The Sakmarian Stage in territory of Central Asia (Karachaty, Darvaz, Tien Shan) includes two fusulinid zones *Robustoschwagerina schellwieni* and *Pseudofusulina vulgaris* - *Cuniculinella narynica*. It is remarkable, that *Pseudofusulina moelleri*, *P. aff. tschernyschewi*, *Monodiexodina ferganica* enter into composition of lower zone. The upper zone includes characteristic *Pseudofusulina callosa*, *P. urdalensis*, and also *Monodiexodina ferganica*. In the western part of the Tethyan zone, the best studied section is in the Carnic Alps where fusulinid data are confirmed by conodonts. Here the lower part of the Sakmarian stage is related to the upper part of Grenzand Formation, and "Upper *Pseudoschwagerina* limestone" forms the top part of Sakmarian Stage. On the western slope of northern and subpolar Urals, in the upper part of Tastubskian horizon is distinguished the equivalent of south uralian *verneuli* zones – the *Globifusulina uralica* Zone. Zonal species are accompanied here with numerous

*Pseudofusulina* (?) *tschernyschewi*, which is morphologically similar to *Monodiexodina*. In the Canadian Arctic Archipelago and Alaska in several sections sequences of fusulinid zones have been observed that correlate with the stratotype sections on the basis of direct comparison of fusulinids and conodonts. In the Lower Permian section of Alaska, the Sakmarian Stage, apparently, is represented completely. On territories of USA are found sections where analogues of Sakmarian Stage are available or could be assumed to be present. In a Kansas section, *Sweetognathus merrilli* conodonts are found in the upper part of Eiss Limestone.

## ARTINSKIAN STAGE OF THE CIS-URALIAN (LOWER PERMIAN) DIVISION: BIOSTRATIGRAPHY AND CORRELATIVE POTENTIAL

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Keywords: Cisuralian; Lower Permian; Artinskian Stage; biostratigraphy; global correlation.

Biostratigraphy of Artinskian Stage in stratotypical basin is based on fusulinids, brachiopods, ammonioidea, conodonts and radiolarians, these groups are used for interbasin correlation excluding brachiopods. Lower Stage boundary is determined on occurrence of the conodont *Sweetognathus whitei*. Within the limits of Gondwana, the most proved substantiation of Artinskian Stage was realized for Western and Eastern Australia, where it is based on brachiopods, rare finds of ammonioidea and conodonts (which assemblage composition noticeably differs from conodont assemblages in other regions). In the Tethyan realm, the Artinskian Stage is proved by the presence of conodonts. In Southern China, in a Guizhou Province section is found the following sequence of conodont zones: *Mesogondolella bisselli* - *Sweetognathus whitei* - *Neostreptognathodus pequopensis* (Artinskian) - *Mesogondolella intermedia* - *M. giujioensis* (Kungurian). In Japan the Artinskian includes the conodont zones *Neogondolella bisselli* - *Sweetognathus whitei* and *Diplognathodus oertlii* - *Neostreptognathodus pequopensis* (Sarginskian horizon and Kungurian?). In Tien Shan, Pamir, and Darvaz the Artinskian Stage is traditionally compared to the local Yakhtashian Stage, made on the basis of the evolutionary phase of fusulinids and also on ratio between underlying and covering rocks. In western Tethyan (Southern Alps), the Artinskian is related to the upper part of the "Upper *Pseudoschwagerina* Limestone" (*Sweetognathus whitei*) and Troglkofel Formation with *Neostreptognathodus* aff. *pequopensis*. In Western Canada the lower boundary of Artinskian Stage is fixed by the conodont zone *Neogondolella bisselli* - *Sweetognathus whitei*. In Arctic Canada, Artinskian sediments are recognized according to similarity with Uralian ammonoid and conodont assemblages, including the sequence *Neogondolella bisselli* - *Sweetognathus whitei*, *Neostreptognathodus pequopensis*, and *N. clarki*. In Alaska, Artinskian sediments (Burtzevskian and Irginskian horizons) refer the layers of limestones with various assemblages of fusulinids and brachiopods. In USA, the Artinskian Stage is traditionally compared with sediments of the Leonard Formation though the fusulinids and ammonioidea

are obviously different there, but a full similarity of conodont assemblages exists between the Urals and the regarded region. The conodont sequence as recognized in Uralian Stage stratotype (*S. whitei*-*Neostreptognathodus clarki* - *N. pequopensis*) is well traced in the USA.

## KUNGURIAN STAGE OF THE CIS-URALIAN DIVISION: BIOSTRATIGRAPHY AND CORRELATIVE POTENTIAL

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Keywords: Lower Permian; Kungurian Stage; biostratigraphy; global correlation.

The Kungurian Stage in stratotypical basin is subdivided into four horizons: Saraninskian, Filippovskian, Irenskian and Solikamskian. Historical Stage stratotype located near Kungur Town on Sylva River; stratotype of lower stage boundary was offered in section near Mechetlino Village on Yuryuzan' River (the western slope of Southern Urals). Stage correlations inside the sedimentary basin are based on small forams, brachiopods, ostracods, and miospores. There are some levels with ammonoidea and conodonts; the last ones are more widely distributed. The base of Kungurian Stage in Eastern Australia is possible to relate with Brenxton Formation, *i.e.* marine series of terrigenous sediments and volcanic tuffs. The ammonoidea *Aricoceras meridionalis* found there are more advanced in comparison with Artinskian representatives of genus *Neocrinites*, which descendants they are. In China (Guizhou Province) the regional Chihnsian Stage begins with the conodont zone *Neostreptognathodus pequopensis*, and the following zone is *Mesogondolella intermedia* - *M. guijioensis*. In the Kungurian here it is possible to relate the upper part of *N. pequopensis* Zone and the subsequent zone *M. intermedia* - *M. guijioensis*. Next above *Mesogondolella idahoensis* Zone begins the Roadian Stage. In the southern Pamirs the Kungurian Stage can be related to the Kochusaysk Suite (local Bolorian Stage), which contains the conodonts *Mesogondolella intermedia*, *Neostreptognathodus sulcificatus*, *N. leonovae*, and *Sweetognathus guizhouensis*, etc. This assemblage can be correlated with the top of the Irenskian horizon or to the Solikamskian horizon of Kungurian Stage; the last seems as most probable. This position is supported also by that circumstance; the Kochusaysk Suite in all investigated sections lies with an obvious gap on underlying rocks. The Kungurian Stage in western Arctic and Spitsbergen archipelago, including the Solikamskian horizon, is a part of the Starostinsk Suite. In central and eastern areas of northern Greenland it is a part of the Kim Field Formation. In Arctic Canada, the Kungurian can be compared to the upper part of Trappers Cove and Sabine Bay formations; this interval is determined by the conodont zone *Neostreptognathodus prayi* - *N. ruzhenzevi*. In other sections of the Sabine Bay Formation, the conodonts *Neostreptognathodus pnevi* or morphotypes, transitional from *N. ruzhenzevi* to *N. pnevi*, are found, and overlying parts of the section contain *N. prayi*.

## PRECISE RADIOMETRIC CALIBRATION OF THE LATE PALEOZOIC TIME SCALE - NEW

## OPPORTUNITY IN DEVELOPMENT: SOUTHERN URALS, RUSSIA

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Keywords: Late Paleozoic; chronostratigraphy; ash beds; radiometric calibration; southern Urals.

The Late Paleozoic was an important interval in Earth history that is associated with the final assembly and early evolution of Pangaea, major eustatic changes in sea level, and global climate change from the Pennsylvanian "ice house" to the Permian "hot house". The detailed, high-resolution conodont-foraminiferal-ammonoid zonation for the Pennsylvanian-Cisuralian, with over 30-35 zones contrasts sharply with the handful of useful radiometric dates employed in Pennsylvanian-Cisuralian time scale building. With a duration of the Pennsylvanian-Cisuralian Epochs close to 50 m.y. the zones on average give a resolution better than 1.5-1.0 my, whereas on average there is less than one radiometric date per 10 my. Worse, there are no dates for the Bashkirian, Sakmarian, Artinskian and Kungurian and single dates only in the Moscovian, Kasimovian, Gzhelian and Asselian. The biostratigraphic calibration is also compromised in that the dates for the Upper Pennsylvanian and the rest of Cisuralian come from continental sequences of Western Europe that only poorly correlate with marine sequences in the type regions. Dates assigned to biostratigraphically well-constrained western European regional stages within the Namurian and Westphalian are needed to correlate with the well-calibrated standard biozonal scales and international stages. Similar issues compromise the few available radiometric constraints on the Lower Permian from Australia. Although Permian biostratigraphy of Australia is reasonably established, it is based on provincial foraminifers, palynomorphs, and brachiopods and cannot provide reliable global correlation. Numerous interstratified volcanic ash layers within biostratigraphically constrained sequences were currently found in the Upper Paleozoic sections of the southern Urals. In the majority of samples conodonts and radiolaria were recovered along with excellent zircons. The ability to obtain detailed paleontologic data and precise radiometric ages from the same stratigraphic horizon provides a potentially powerful tool for precise calibration of this interval of the time scale with quantitative techniques. Radiometrically calibrated scale will improve global correlation of marine and continental sequences as well as expand our understanding on process rates in paleobiology, paleoecology,



paleoclimatology, paleotectonics and sedimentology. This project is supported by the NSF grants EAR 0106796 and EAR-ITR 0218799 and by RNSF grant 03-05-64766.

## THE CONODONT BIOCHRONOTYPES OF THE LOWER BOUNDARIES OF THE STAGES OF WEST-URALIAN DIVISION OF THE URAL PERMIAN

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Keywords: Lower Permian; conodonts; biochronotype; lower boundary; Urals.

The study of conodont evolutionary development, executed for last 10 years on the stratotypical territory of the Lower Permian deposits within the limits of Ural region, has allowed to establish the biochronotypes of the lower boundaries of the stages of the West-Uralian division of the Permian System. The biochronotype of the lower boundary of Asselian (being also the boundary between Carboniferous and Permian systems) is established in the evolutionary sequence *Streptognathodus wabaunsensis* - *S. isolatus* - *S. glenisteri* on the first occurrence of *S. isolatus* morphotype. The biochronotype of the lower boundary of Sakmarian is established in an evolutionary sequence *Sweetognathus expansus* - *S. merrilli* - *S. binodosus* n. sp. - *S. whitei* on the first occurrence of *S. merrilli*. The biochronotype of the lower boundary of Artinskian is established in an evolutionary sequence *Sweetognathus binodosus* - *S. whitei* - *S. obliquidentatus* on the first occurrence *S. whitei*. The biochronotype of the lower boundary of Kungurian is established in an evolutionary sequence *Neostreptognathodus pequopensis* - *N. pnevi* on the first occurrence *N. pnevi*. The offered biochronotypes allow identification of the lower boundaries of stages of the West-Uralian Division of the Permian System in territory of USA, Canada and China. The find of the representatives of *Kamagnathus* (Chernykh *et al.*, 2001) in the Kazanian deposits of Povolzhia that is also present in the basal Road Canyon Formation (USA), allow identification of the lower boundary of the Guadalupian in the European part of Russia as the basis of Kazanian.

## CORRELATION OF THE CISURALIAN STAGES TO THE NORTH AMERICAN REGIONAL STANDARD

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Keywords: Cisuralian; correlation; Permian; North American Standard; West Texas

Working Groups of the Subcommittee on Permian Stratigraphy have stabilized definitions for the base of all the Cisuralian stages and have nearly completed selection of appropriate GSSPs. These definitions can be correlated directly in most cases to the section in the Glass Mountains, West Texas, the North American Regional Standard for the Permian. The Grey Limestone Member, Gaptank Formation, is a shallow-water

carbonate at the top of the formation. Conodont faunas are sparse, but the faunas at the base and top of the member correlate to those just below and above the first appearance of *Streptognathodus isolatus* in the stratotype for the base of the Permian and Asselian Stage and indicate the base of the Asselian to occur within the middle of this 10 m unit. The overlying Neal Ranch Formation, base of the American Wolfcampian, is dominated by prodelta siltstone with common plant debris with limestone and limestone conglomerate interbeds. At 52 m above the base, *Streptognathodus barskovi*, *S. isolatus* and *Sweetognathus merrilli* occur. The overlapping ranges of these species indicate the base of the range of *Sw. merrilli*, and the base of the Sakmarian. The overlying Lenox Hills Formation is largely deltaic conglomerate and does not yield conodonts or many other fossils. However, in the Dugout Mountain area, it contains common limestone in its upper part that yields a sparse fauna of *Sweetognathus whitei* and *Neostreptognathodus transitus*, correlating to the Upper Artinskian, and suggests that the Sakmarian/Artinskian boundary is somewhere in the conglomerates of the lower part of the Lenox Hills Formation. The Skinner Ranch Formation (the base of the type Leonardian) is largely limestone and limestone conglomerate with abundant conodont faunas. In its type section, it contains *Neostreptognathodus pequopensis* at its base (uppermost Artinskian). At 17 m, a plethora of species of *Mesogondolella* and *Neostreptognathodus* occur, including *Neostreptognathodus "exsculptus"*. *N. exsculptus* and *N. pnevi* co-occur in sections in Nevada and suggest that this occurrence in West Texas correlates to the base of the Kungurian. Essentially, the American Leonardian and the Kungurian are the same.

## DEVONIAN - CARBONIFEROUS - PERMIAN CORRELATION CHART 2003 (DCP 2003)

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Keywords: Devonian; Carboniferous; Permian; stratigraphy; geochronology.

The above authors plus Tamara I. Nemyrovska (Geological Institute Academy of Sciences of Ukraine, Kiev), Joerg W. Schneider (Geologisches Institut der Bergakademie Freiberg), Karsten Weddige (Forschungsinstitut Senckenberg Frankfurt

a.M.) and Dieter Weyer (Berlin) have created the Devonian - Carboniferous - Permian Correlation Chart 2003 (DCP 2003) for the Priority Program 1054 of the Deutsche Forschungsgemeinschaft "The Late Paleozoic in the light of sedimentary geochemistry" to compare trends of isotopes of carbon, sulphur, nitrogen, and oxygen on an improved stratigraphic base. More than 40 regional marine and continental sections from six continents and more than 40 zonations of ammonoids, brachiopods, bryozoans, corals, foraminifers, ostracods, radiolarians, and several continental fossil groups have been correlated with the global reference scale of the ICS (2002) using numerous stratigraphic methods. Significant differences between synonymous global and regional chronostratigraphic units as well as lithostratigraphic (mapping) units are elucidated. The DCP 2003 is based on the Stratigraphic Table of Germany 2002 (STD 2002) of the German Stratigraphic Commission (2002) in which the global reference stages were integrated, and calibrated using isotopic ages and geological time indicators. An important aim in its construction was made to avoid stretched and compressed time spans as far as possible. The full continental facies of several sections is the main reason for the tremendous correlation problems. Therefore, isotopic ages became increasingly more important, not only for numerical calibration, but within their margins of error, for correlation. The only magnetostratigraphic marker in the Late Paleozoic that appears to be reliable for correlation is the Illawarra Reversal (265 Ma). To elucidate inaccurate ages and correlations as well as gaps of unknown duration, numerous arrows are shown. Lithofacies of the sections are differentiated by colours. Glacial sediments and coals, the position of index fossils, and historical vs established (as GSSP) boundaries are shown. German Stratigraphic Commission (ed.) (2002): Stratigraphic Table of Germany 2002, Potsdam (GeoForschungsZentrum). International Commission on Stratigraphy (2002): [www.micropress.org/stratigraphy/Paleo.htm](http://www.micropress.org/stratigraphy/Paleo.htm), [www.micropress.org/stratigraphy/gssp.htm](http://www.micropress.org/stratigraphy/gssp.htm).

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## **Report of SPS Working Group on "Using Transitional Biotas as Gateways for Global Correlation"**

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### **Membership of the working group**

The formal membership of the working group is listed below at the request of the new SPS Chair Professor Charles Henderson, along with brief reports of some of the members. The members comprise those who have expressed interest in formerly joining this working group. However, we acknowledge the fact that there is actually a much greater number of colleagues than what is listed here, who have been actively involved in research activities that have directly or indirectly enhanced our efforts in achieving the objectives of this working group.

Lucia Angiolini (Italy),  
Neil W. Archbold (Australia)  
Tatyana Grunt (Russia)  
Galina Kotlyar (Russia)  
Heinz W. Kozur (Hungary)  
Ian Metcalfe (Australia)  
Shuzhong Shen (China)  
Guang R. Shi (Australia)  
A. K. Srivastava (India)  
Jun-ichi Tazawa (Japan)  
Katsumi Ueno (Japan)  
Xiang-dong Wang (China)  
Bruce Wardlaw (USA)  
Yuri D. Zakharov (Russia)

### **Reports of individual working members:**

**Report from Dr. L. Angiolini:** During the last two years Dr. L. Angiolini has actively continued her research directly related to the aims of this working group in collaboration with A. Nicora and M. Gaetani of the same Department and S. Crasquin of CNRS, Univ. Pierre et Marie Curie, Paris. Several field trips have been devoted to sample Middle-Upper Permian brachiopods, ostracods, conodonts and foraminifers from the Permian successions of the Antalya Nappe near Kemer, in Turkey and in the allochthonous nappes of Chios Island, in Greece. During 2003-2004 three expeditions were organized in the Alborz Mountains of North Iran to sample the Lower Permian-Early Triassic succession in the frame of the MEBE Programme (Middle East Basin Evolution. BP- CNRS INSU- ENI- PETRONAS- SHELL- TOTAL- UPMC). A very rich and interesting biota has been collected bed-by-bed from the Early Permian to the Permo-Triassic boundary, comprising brachiopods (under study by L. Angiolini), conodonts (under study by A. Nicora), fusulinids (under study by K. Ueno), small foraminifers (under study by R. Rettori), cephalopods (under study by M. Balini), ostracods (under study by S. Crasquin) and palynomorphs (under study by M. Stephenson). The Permian succession of the Alborz Mountains seems to be much more articulated than previously thought, with sharp lateral variations of facies and thickness, and the biota itself shows very interesting affinities with both the Gondwanan Realm and also the Tethyan and Boreal Realms. The integrated study of the whole biota is raising significant problems that, albeit difficult to understand and resolve at the moment (!), will be really interesting for future global Permian correlations. The strong transitional character of the North Iranian biota will be of great help as it represents a very useful gateway for Permian global correlations.

Very recently Dr. Angiolini has started to collaborate with Dr. M. Stephenson of the British Geological Survey on detailed correlations of the Oman surface-subsurface Permian succession. This research, which seems to be very promising for the study of Permian transitional biota, is based on the analyses of brachiopods and palynomorphs from well cores kindly provided by A. Heward of PDO, Muscat. Results from this work are still in progress, but they promise to be really interesting as the well cores record a very rich biota which is currently under analyses (brachiopods by L. Angiolini, conodonts by A. Nicora, palynomorphs by M. Stephenson, fusulinids by E. Leven). In the near future O, C and Sr analyses on brachiopod shells from Oman and Saudi Arabia



will be performed in collaboration with PDO, BGS, NIGL, both for palaeoclimatic purposes and for dating (Sr). The research conducted by Dr. L. Angiolini and co-workers has resulted in many recent publications, details of which are provided at the end of this report.

**Report from Dr. Galina Kotlyar:** Over the past 2 years, Dr. G. Kotlyar and co-workers have continued their effort in aligning the Permian sequences of North, Southeast and Northeast Russia with those of the lower latitudes. As a result, they have been able to establish 1) some preliminary but significant correlations between the Permian deposits of Siberia, Russian Far East and Mongolia (Kotlyar *et al.* 2004a); 2) the main events and dynamics in the development of biota (especially brachiopods, Rugosa, bivalves, conodonts and foraminifera) at the Middle Artinskian, Middle Kungurian, Kazanian (=Roadian), Middle Tatarian (=Wordian/Capitanian boundary) and Midian/Dzhulfian (=Guadalupian/Lopingian) intervals (Kotlyar *et al.* 2004b); and 3) the global significance of the mixed Permian Tethyan-Boreal-Gandwanan invertebrate faunas (brachiopods, fusulinids, bryozoans and some conodonts) and Angara-Euromerican-Cathaysian floras in the Primorye and Transbaikalian regions of East Russia as gateways for correlation of Permian sequences among different palaeobiogeographical realms (Kotlyar *et al.*, 2003; in press)

**Report from Heinz W. Kozur:** In a recent paper by Kozur (2004), numerous new species from the Dorashamian (Changhsingian) of Central and NW Iran were described, among them not only Tethyan warm water faunas, but also cold water faunas which occur also in high latitudes. Especially important is *Clarkina hauschkei borealis* Kozur, which occurs in the *C. hauschkei* Zone of Iran and Transcaucasia (uppermost 10 cm below the Boundary Clay), in the lower *O. boreale* Zone (*H. triviale* Zone) of Greenland (Kozur, 2004) and in the lower *O. boreale* Zone of Arctic Canada, formerly described as *C. cf. subcarinata* s.l. by Henderson and Baud (1997).

The Iranian sections were situated around the tropic of Capricorn (Abadeh) to more than 1000 km north of it in direction to the equator during the Lopingian. The Lopingian fauna is generally a warm water fauna widely distributed throughout the entire open Tethys Sea. However, in several horizons cold water forms from high latitudes are also present. In the lower Dzhulfian (Wuchiapingian) *C. niuzhuangensis* Zone and *C. leveni* Zone besides dominating warm water forms (*C. niuzhuangensis*, *C. leveni*) cool water forms, *Hindeodus typicalis* (Sweet) and *Merrillina postdivergens* Kozur, are widely distributed. During the Dorashamian three distinct horizons with cold-water faunas occur which totally replace the warm water faunas. Most pronounced is the cold-water horizon in the lower *C. yini-C. zhangii* Zone. The lowermost 1-3 cm of this zone have the typical warm-water fauna with *C. zhangii*, which is suddenly replaced by a cool water fauna without any warm-water *Clarkina*, but with common small specimens of *Hindeodus typicalis* and *Merrillina* sp. Only a few *Clarkina* are present, totally different from the warm water faunas. They belong to the *C. planata* group. In the upper *C. yini-C. zhangii* Zone suddenly the warm-water fauna with *C. zhangii* comes back. The highest horizon with cool-water faunas start in the *C. hauschkei* Zone. There, last warm-water elements, such as *C. changxingensis*, are gradually replaced by cool- water forms from the higher latitudes, such as *C. hauschkei borealis* (see

above), *C. tulongensis* (Tian), *C. praetaylorae* Kozur, *C. nassichuki* (Orchard), *C. kazi* (Orchard), *Clarkina meishanensis* Zhang, Lai, Ding and Liu, *Hindeodus typicalis* (Sweet). In the southernmost section at Abadeh, the entire *C. hauschkei* Zone does not contain any warm-water fauna, but only *Hindeodus typicalis* and *Merrillina* sp. At the base of the *C. meishanensis-H. praeparvus* Zone all warm water elements disappear and only *C. meishanensis*, *Hindeodus typicalis*, *H. praeparvus* and *Merrillina ultima* Kozur are present.

**Report from Dr. Guang Shi and colleagues:** Dr. Guang Shi and collaborators (Shuzhong Shen, Liz Weldon, Monica Campi, Xiang-dong Wang) have continued to focus their attention on the Southern Transitional Zone (Tibet, SW China, SE Asia) and eastern Australia, although Guang has at the same time also diverted some attention to the Northern Transitional Zone in collaboration with Russian, Chinese and Japanese colleagues. Monica Campi has successfully completed her PhD thesis on the Permian brachiopod faunas of Sichuan in SW China and the Central Belt of Peninsular Malaysia, while Liz is close to submitting her PhD thesis on the Permian marine faunas of the Broughton Formation in the southern Sydney Basin, eastern Australia. Professor Shen has been leading a very active research team in Nanjing with a central focus on the Permian of southern Tibet, while Professor Wang continues his active research on the Permian transitional faunas of Western Yunnan. Key Permian horizons of mixed marine faunas are being identified from both Tibet and West Yunnan with a view to establishing them as effective gateways for Permian correlations across biogeographical boundaries.

**Report from Professor Jun-ichi Tazawa:** Professor Tazawa is continuing his work on the Northern Transitional Zone with a central focus on the Upper Palaeozoic stratigraphy, palaeontology and biogeography of Japan and adjacent areas in East Asia. His contributions are reflected in many of his and co-workers' recent publications: Tazawa (2002, 2003a,b; 2004a-c); Tazawa and Miyake (2002), Chen and Tazawa (2003), Shi *et al.* (2002), Tazawa *et al.* (2004); Ueno and Tazawa (2003, 2004).

**In conclusion** to this report, I should also mention a recent development of the SPS International Working Group. In late 2003, a proposal was made to the Editorial Board of the *Journal of Asian Earth Sciences* to organize and publish a special issue in the Journal on the Permian of East Asia with particular reference to the Northern Transitional Zone (i.e., Japan, North and NE China, Korean Peninsular, Mongolia and East Russia). I am pleased to inform the readers of "Permophiles" that this proposal has been accepted and we are now in the process of collating, reviewing and editing manuscripts submitted to this special issue. It is anticipated that the special issue will be published in 2005.

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- regarding non-marine - marine correlations was presented by Lützner *et al.* (2003) on isotopic ages of the uppermost Pennsylvanian and Lower Permian in the European continental Permian reference section of the Thuringian Mts. Basin (comp. Schneider *et al.* 1995, *Permophiles* #26). It was shown that cross checking of biostratigraphic data with isotopic ages allowed increasingly improved correlations between the continental Pennsylvanian/Permian basins and the marine standard scale as well as allowing the isotopic and biostratigraphic determination of the P/C boundary in non-marine profiles for the first time.
- During the 32<sup>nd</sup> International Geological Congress, Florence, Italy in 2004, a special session on "Global Permian continental biostratigraphy and biochronology" was organized by Cassinis, Lozovsky and Lucas. The progress on this field during the last two years was summarized in a joint contribution of Schneider (Germany), Bethoux (France), Cassinis (Italy), Gand (France), Kerp (Germany), Lozovsky (Russia), Lucas (U.S.A.), Menning (Germany), Ronchi (Italy) and Werneburg (Germany).
- Manfred Menning has spent a lot of time and effort in the joint project Menning and Schneider, DFG Me 1134/5, funded by the Deutsche Forschungsgemeinschaft (German Science Foundation, DFG), to bring together more than sixty stratigraphers to construct a very sophisticated global "Devonian-Carboniferous-Permian Correlation Chart" (DCP 2003). This correlation chart has been presented in various stages of development at several national and international meetings for critical discussions – most importantly during the international "Cotta workshop, Freiberg 2004 – Environmental reconstruction and biostratigraphy in the Palaeozoic" (organizers: Schneider/Elicki/Cleal/Oplustil). This workshop was held jointly with the Central European meeting of IGCP 469 "Late Westphalian terrestrial biotas and palaeoenvironments of the Variscan foreland and adjacent intramontane basins", on October 9-11, 2004, in Freiberg, Germany. The newest correlation charts of basins dominated by non-marine deposits with the marine stages, compiled by Schneider and Roscher (2004) from various data in the literature and based on our own investigations, could be seen and downloaded from <http://www.geo.tu-freiberg.de/palaeo/> - Korrelationstabellen Karbon/Perm. This compilation will continue to be improved in the near future by further use of literature citations and new data for each basin.

## Short report on activities of the non-marine – marine correlation working group of the SPS

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This report focuses on the main activities of 2003 and 2004. Detailed information about the most significant research results on interregional and global non-marine - marine correlations will be given in the next issue of *Permophiles*. The highlight in 2003 was the International Congress on C/P stratigraphy, held in Utrecht, the Netherlands. Members of the working group organized special sessions dedicated to Carboniferous/Permian stratigraphy and basin development, as Session 3A, "Permian basin development and climate: Rotliegend" (co-ordinators Bachmann/Gaupp/Schneider), Session 4, "Carboniferous and Permian time scales" (co-ordinators Menning/Schneider/Kerp), Session 5 D "Late Paleozoic Paleontology: Paleobotany" (co-ordinator Kerp). More than 10 contributions of working group members were given at the congress. Beyond that, a very interesting research report

Very fruitful fieldwork has been done by a Moroccan/German team (Saber/Hmich/Schneider) in the spring 2004 in Permian red beds of the Atlas Mts. – new tetrapod sites (containing bone fragments) were discovered in the Permian Khenifra Basin and Permian/Triassic transitional deposits of the Argana Basin. A joint French/German excavation on a newly discovered Late Permian tetrapod bone site was arranged in summer 2004 by G. Gand, J. Schneider and R. Werneburg, supported by the French Association des Geologues du Permian (AGCP) and the universities of Montpellier (France) and Freiberg (Germany).

As discussed last year at Utrecht and again in Florence this year, the various activities of the working group need more efficient organization. The cooperation, focussing up to now on Euramerica, must be extended to the other Pangea regions. Increasing success has been reached for the correlation of Lower Permian deposits between the continental basins, but not for the Middle and Upper Permian part of the profiles nor in the correlation between them and the marine scale. We have to look for promising fossiliferous

sequences, as in the Lodève Basin in Southern France. Future plays could be the continental Permian red beds in Texas and mixed marine-continental sequences as in Argentina (Pganzo Basin) as well as the Volga-Kama river region west of the Urals. During the next several weeks we will be brainstorming on future research via e-mail and your ideas are requested!

The next important meeting will be held in Albuquerque, New Mexico, 21-29 October 2005 – “The non-marine Permian”, organized by Spencer G. Lucas, [slucas@nmmnh.state.nm.us](mailto:slucas@nmmnh.state.nm.us) and sponsored by the SPS (see second circular in this issue).

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## Guadalupian News

**Bruce R. Wardlaw**

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The formal paper establishing the Guadalupian and component Roadian, Wordian, and Capitanian Stages as International Standards for the Middle Permian has finally been submitted to the journal *Episodes*! It includes an additional figure to the proposal published in a previous issue of *Permophiles*, shown here as Figure 1. Figure 2 shows the participants of the Guadalupian (1) Symposium on the outcrop of the GSSP for the Guadalupian, Middle Permian.

Figure 1 (below). Correlation of formations and members of the Guadalupe Mountains, Delaware Basin, and Glass Mountains, ranges of important fossils and International Standard for the Guadalupian

Figure 2 (next page). Brian Glenister, among many, posing on the Guadalupian boundary, Stratotype Canyon, Guadalupe Mountains National Park, Texas.

Guadalupe Mountains	Delaware Basin	Glass Mountains	Ranges of Important Fossils	International Standard
Traditional Capitanian	Reef Trail Lamar McCoombs Rader Pinery Hegler	Altuda Capitan	<i>Jinogondolella aserrata</i> <i>Jinogondolella postserrata</i>	Capitanian
Goat Seep	Manzanita South Wells Getaway	Vidrio Appel Ranch	<i>Timorites</i> <i>Strigoniatis</i> <i>Polydiexodina</i> <i>Yabeina</i>	Wordian
Cherry Canyon Brushy Canyon Pipeline Williams Ranch El Centro		Willis Ranch China Tank	<i>Paracelites</i> <i>Waagenoceras</i> <i>Parafusulina</i>	Roadian
Shumard		Road Canyon Cathedral Mountain (part)	<i>Demareizites</i> <i>Jinogondolella nankingensis</i>	Kungurian





**New Working Group: Neotethys, Palaeotethys, and South China intraplateau basin correlations**

**Purpose as directed by the Chair, Charles Henderson:** To investigate the various correlation problems associated with conodonts, fusulinaceans and ammonoids in Permian strata over the broad region regarded as the “Tethys” Sea and including the South China carbonate platform successions. Numerous interpretations and claims, including those by Heinz Kozur below, have been made regarding correlation problems associated with provincialism, endemism, and taxonomic philosophy. This working group is charged to investigate these problems in detail and provide well-documented evidence supporting or refuting the many claims and to provide testable models for these interpretations.

**Composition of Working Group:** This working group will be co-chaired by Heinz Kozur and Vladimir Davydov. Some suggested members include Charles Henderson, Bruce Wardlaw, Wang Chengyuan, Guang Shi, Shuzhong Shen, Yue Wang, Ernst Leven, Merlynd and Galina Nestell and possibly others. These individuals should contact the Secretary of the Permian Subcommittee as to their willingness or not to be on this working group and to suggest other potential members. Anyone not listed, but interested in this problem, should contact the Secretary (Shuzhong Shen) regarding their interest.

**Opening Statement:** The following represents an initial position by Heinz Kozur that indicates some of these problems as he interprets them.

**Correlation of low latitude open sea and intraplateau basin conodont faunas**

**Heinz W. Kozur**

During the Middle Permian to Triassic interval conodont faunas of open sea and intraplateau basin may be very different and difficult to correlate. Examples include the correlation of the Muschelkalk of the Germanic Basin, the Middle Permian intraplateau Basins (Delaware Basin, South Chinese basins) and the Upper Permian South Chinese intraplateau basins to the Tethys. The conodont endemism of the intraplateau basins always develops in the same manner. When the intraplateau basin is invaded by a conodont fauna from the open sea, the same conodonts occur both in the open sea and in the intraplateau basins, but sometimes not all conodont taxa can invade an intraplateau basin. For instance, the Spathian (Upper Olenekian) to Julian (Middle Carnian) *Gladigondolella* never invaded intraplateau basins. This difference does not harm the correlation between the open sea and intraplateau conodont faunas because most forms can invade an intraplateau basin from the open sea so long as it is not settled by species which had evolved in this basin. However, the reverse is not true. New taxa that have evolved within an intraplateau basin cannot invade the open sea because they are adapted to intraplateau basin ecological conditions (e.g., thermospheric conditions with warm bottom water in the intraplateau basins against psychrospheric conditions with cold bottom water below 200-500 m in the open sea). During the Middle Permian, these intraplateau endemic forms partly could invade

the open sea, but not survive in the predominant areas with psychrosphaeric conditions where the open sea conodonts are better adapted. However, they could reach areas with thermosphaeric conditions within the open sea (e.g., atoll seas or backreef seas) and there co-exist with or even dominate over open sea taxa, and they can also reach other intraplatform basins by travelling along the margin of the open sea. In this way intraplatform basins separated by wide oceanic areas contain the same intraplatform basin conodont fauna (e.g., serrated Middle Permian *Mesogondolella* in the Delaware and South Chinese intraplatform basins). During the Upper Permian and Triassic; however, this possibility was lost and species which evolved in intraplatform basins could not invade even ecologically similar areas within the open sea or adjacent intraplatform basins which were connected to the same ocean. Thus, the South Chinese intraplatform species *Clarkina wangi* was not only missing in the open sea Tethys, but also in other Tethyan marginal seas, and *Neogondolella haslachensis* or *Celsigondolella watznaueri* of the Germanic Basin could not invade the nearby intraplatform basins at the southern and western margin of Tethys.

In the Upper Permian and Triassic, the ammonoid taxa of the intraplatform basins also became endemic. During the Middle Permian the most important ammonoid taxa of the intraplatform basins and the open sea were identical (e.g., *Waagenoceras* or *Timorites*), whereas during the Upper Permian and Triassic the ammonoid faunas of the intraplatform basins and the open sea became very different and all stratigraphically important taxa of the open sea were missing in intraplatform basins (e.g., the Upper Permian *Paratirolites* and other open sea guide forms known from the eastern to westernmost Tethys and even from Madagascar versus the *Pseudotirolites* fauna of the South Chinese intraplatform basins and all open sea Middle Triassic guide forms known from the entire Tethys versus the intraplatform Germanic Basin *Ceratites* fauna). Only close to the gates between the intraplatform basins and the open sea were shells of dead ammonoids rarely washed in from the open sea into the intraplatform basins (not vice versa), probably during big storms (hurricane-like). An example is a single discovery of *Nevadites* in the ammonoid-rich *Ceratites* fauna of the middle *C. spinosus* Zone in Southern Germany (Ulrichs and Kurzweil, 1997). The conodont and ammonoid endemism makes the correlation of the open sea and intraplatform basins in the Middle Permian impossible, if only conodonts are considered, and in the Upper Permian and the Triassic for many parts impossible, if ammonoids and conodonts are utilized. For this reason, Mojsisovics *et al.* (1895) refused to define the Triassic stages in the intraplatform Germanic Basin despite the fact that it represents the type area of the Triassic System. In the Permian, the Guadalupian and Lopingian stages were defined within intraplatform basins, even the Upper Permian stages with endemism in the conodont and ammonoid faunas. The conodont successions of intraplatform basins have the advantage of very clear phylomorphogenetic lineages, which may allow even a finer subdivision than the conodont succession of open sea deposits. Thus, in the Germanic Upper Muschelkalk, 7 well separable conodont zones are present in the interval from the upper Illyrian to the lower Longobardian. In the same time interval Kozur (2003) discriminated 6 conodont zones from which the lower 3 show only slight differences and therefore they are often united into one zone. The disadvantage of the GSSP in intraplatform

basin is that the conodont zones of these intraplatform basins cannot be correlated in detail (level of conodont zone) with the conodont zonation of the open sea. Thus, even today it is not possible to correlate directly one of the 7 conodont zones of the Upper Muschelkalk in the Germanic Basin with the conodont zonation of the open sea and it is likewise not possible to correlate the numerous *Ceratites* zones of this interval.

Similar problems exist with the correlation of Guadalupian and Lopingian stages. This can be best demonstrated at the famous fossil localities of Rupe del Passo di Burgio in Sicily, Rustaq and Wadi Wasit in Oman and Kuh-e-Ali Bashi at Jolfa (NW Iran). Before the definition of the Guadalupian stages by conodonts in the Delaware Basin, Rupe del Passo di Burgio was assigned by all workers into the Wordian based mainly on ammonoid faunas (Heritsch, 1933, Miller, 1933, and Kahler, 1939) or into the lower Midian based on fusulinid faunas (Kozur and Davydov, 1996). This included also the conodont workers (e.g., Bender and Stoppel, 1965, Kozur, 1975, 1978) despite the fact that the smooth *Mesogondolella siciliensis* (Kozur) is more similar to Kungurian smooth *Mesogondolella lamberti* Henderson and Mei, then to the Wordian *M. aserrata* (Clark and Behnken). This Wordian age was based on the ammonoid fauna with advanced *Waagenoceras*, advanced *Paraceltites* and many other ammonoids which are characteristic for Wordian sediments, and on the typical Middle Permian fusulinid fauna.

After the definition of the Guadalupian stages with serrated *Mesogondolella* in the Delaware intraplatform basin, which are mostly not present in the open sea Tethys, the opinion of the conodont workers concerning the age of the Rupe del Passo di Burgio fauna was split. Mei and Henderson (2001) and Henderson and Mei (2003) assigned the *M. siciliensis* fauna of Rupe del Passo di Burgio into the Kungurian. The differences between Boreal Kungurian *Mesogondolella* and Kungurian *M. siciliensis* was regarded as an important evidence for Kungurian conodont provincialism. Kozur *et al.* (2001a,b) and Kozur and Wardlaw (2002) continued to regard the Rupe del Passo di Burgio conodont fauna as Wordian.

The situation is similar with the Oman sections of Rustaq and Wadi Wasit. The Rustaq sections contain an atoll sequence which contains *M. siciliensis* and *M. aserrata* according to Kozur *et al.* (2001a,b) and Kozur and Wardlaw (2002). However, these forms were put into *M. rustaqensis* Mei and Henderson (aserrate forms) and into transitional forms between *M. lamberti* and *M. nankingensis* (Ching) for slightly serrated forms by Henderson and Mei (2003). The ammonoids of the Oman localities are similar to those of Rupe del Passo di Burgio, but Krystyn (pers. comm.) found a *Timorites* in the *Waagenoceras* faunas of the Wadi Wasit section. Thus, this fauna is younger than the Rupe del Passo di Burgio fauna. This is also indicated by the development of *M. omanensis* Kozur and Wardlaw n. sp., which evolved from *M. siciliensis* and replaces that species displayed in a continuous transitional morphocline in their material. However, *M. omanensis* is very similar to the upper Kungurian *M. lamberti* and has a morphologic overlap with this species. Thus, again Henderson and Mei (2003) assigned Rustaq and Wadi Wasit into the Kungurian. This shows that with conodonts alone the question cannot be solved, whether the Rupe del Passo di Burgio, Rustaq and Wadi Wasit faunas are (upper) Wordian or Kungurian.

The same problems exist with the Changhsingian conodont and ammonoid faunas from the South Chinese intraplatform basins.



The ammonoid faunas are endemic throughout the entire Changhsingian of South China, except the uppermost part that contains *Hypophiceras* which is widely distributed in South China, the Tethys and the Boreal realm. The lower Changhsingian gondolellid conodont faunas are very different from the Dorashamian Tethyan open sea faunas which are also present in low latitude Panthalassa. This is best demonstrated by Mei in Sweet and Mei (1999), who revised all Changhsingian conodonts from the Changhsingian GSSP at Meishan and knows this fauna best. Mei revised the conodont material of Sweet (in Kummel *et al.*, 1973) from the stratotype of the Dorashamian Alibashi Formation at Kuh-e-Ali Bashi, west of Jolfa. This stratotype is composed by the sections 1 and 4 of Teichert *et al.* (1973). Both sections are only a few 100 m apart on the same vegetation-free slope and can be easily correlated bed by bed. More than 50 % of the thickness of both sections yielded the upper Dorashamian ammonoid genus *Paratirolites* and both sections have a typical Dorashamian conodont open sea conodont fauna. In both sections the Boundary Clay above the *Paratirolites* Limestone and the continuous transition to the Triassic is exposed. Despite this fact, Mei assigned the rich Dorashamian conodont fauna of section 4 to the Wuchiapingian (Dzhulfian) and recognized almost all Dzhulfian (Wuchiapingian) conodont zones from the *C. dukouensis* up to the *C. orientalis* Zone, except the *C. leveni* Zone, which comprises, however, the largest part of the real Dzhulfian at Kuh-e-Ali Bashi. In this case the miscorrelation is easy to recognize because of the published and illustrated (Teichert *et al.*, 1973) macrofauna with *Paratirolites* and Dorashamian brachiopods which are very different from the Dzhulfian brachiopods, and because of the stratigraphic position between Upper Dzhulfian beds below and lowermost Triassic beds above. This example demonstrates well that the intraplatform basin conodonts of the Changhsingian are nearly uncorrelatable with the open sea Tethyan conodonts of the same age.

The problems with the correlation of the conodont faunas from low latitude intraplatform basins and the open sea can be solved by joint work of specialists for different faunal groups. For instance, from South China Guadalupian Tethyan fusulinids were reported in sections with serrated *Mesogondolella* (e.g., *M. nankingensis* in the Nanjing area). A Working Group should at first investigate all South Chinese intraplatform sections with Tethyan fusulinids and conodonts. If these sections contain serrated *Mesogondolella*, a precise correlation of the Kubergandinian, Murgabian and Midian fusulinid faunas with the Guadalupian stages should be possible. The same cross correlations are possible with radiolarians because the Delaware Basin contains the same radiolarian species as Panthalassa and the Tethys, but radiolarians are not yet well studied in the Middle Permian interval, especially in the Delaware Basin. For the Guadalupian, also an ammonoid correlation should be possible. The Guadalupian ammonoids of the Delaware Basin have at least the same succession of genera as in the open sea Tethys.

Beside consideration of data on the correlation between the Middle-Upper Permian low latitude intraplatform basins with the open sea, the Working Group should examine data on the Guadalupian and Lopingian conodont provincialism and to the causes for the conodont and ammonoid endemism in low latitude intraplatform basins, despite the fact that both are among the most mobile nektonic and nekto-benthic fossil groups.

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## International Workshop on the Meishan-Cores Project (October 8-10, 2004, Nanjing)

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The Permian-Triassic boundary succession exposed in quarries at Meishan, South China has been extensively studied during the past twenty years. Critical results on paleontological and geochemical evidence for the Permian-Triassic mass extinction have been reported; nevertheless, many ambiguous or conflicting data remain to be clarified. Blind tests using a complete and fresh core are urgently needed because much of the disagreements about the boundary succession could be the result of outcrop alteration of samples and/or missing very thin beds that contain anomalous geochemical signals. In order to obtain a complete succession of rock samples free from outcrop contamination and weathering, we have launched a drilling project aimed at resolving the timing and geochemistry of Permian-Triassic Events (PTEs) at Meishan.

An international workshop on the Meishan-cores Project was held October 9 and 10, 2004 in the Nanjing Institute of Geology and Palaeontology (NIGPAS). Participants include Luann Becker (UC Santa Barbara), Samuel A. Bowring (MIT), Douglas Erwin (NMNH, Smithsonian Institution), Charles Henderson (University of Calgary, Calgary), Frank Kyte (UCLA), Richard Lane (NSF, USA), Roger Summons (MIT), Yao Yupeng (NSF China), Shang Qinghua (IVPP, CAS), Wu Yasheng (IGG, CAS), Cao Changqun, Jin Yugan, Liu Lujun, Shen Shuzhong, Wang Jun, Wang Xiandong, Wang Wei, Wang Yue, Yang Qun, and Zhu Huichen from NIGP, CAS. A morning session of eight talks was held on October 9<sup>th</sup>.

Topics comprised "Characteristics of the PTB interval in NW Pangea and global correlation problems using conodont biostratigraphy" (Charles Henderson), "Evidence for an Impact Event at the Permian-Triassic boundary" (L. Becker), "Primary Mineralogical and Chemical Characteristics of the Major K/T and Late Eocene Impact" (F. Kyte), "Molecular evidence for widespread photic zone anoxia in the Tethys sea during P-T times" (R. Summons), "A preliminary report on the continental Permian-Triassic boundary sections in southwestern China" (Shen Shuzhong), "Isotope carbon profile of the PTB continental section in N. Tianshan" (Cao Changqun), and "The EARTHTIME Initiative, Problems and progress in High-precision U-Pb geochronology, with examples from P/Tr and Ediacaran/Cm transition" (S. Bowring).

The afternoon session focused on the working plan, which consisted of introducing reports on the cores, the microstratigraphy of Permian-Triassic boundary succession, and a summary of proposals received to date. Later a discussion meeting was conducted in the core chambers housing the cores from Meishan. The following is a brief summary on the drilling program and the proposed research programs.

### The Drilling Program

In Meishan, the Lower Triassic Yinkeng Formation comprises two members. The lower member, dominated by thin-bedded micritic limestone with intercalations of shale, can be subdivided

into five parts. The basal part (bed 25 to bed 34-lower), 5.2 m thick, consists of medium-bedded marl with more than 5 thin beds of ash clay. The 2<sup>nd</sup> part, 7.4 m thick, is composed of depositional cycles of thin-bedded micritic limestone, grey calcareous shale and black shale. The 3<sup>rd</sup> part, 7.3 m thick, is composed of cyclic deposits from thin to medium- and thin-bedded micritic limestone with argillaceous laminae and calcareous shale. The 4<sup>th</sup> part, 49.0 m thick, consists of alternating beds of medium- and thin-bedded micritic limestone, of which some beds are marked by argillaceous laminae. The upper member, 170 m thick, consists of medium- to thick-bedded micritic limestone with three beds of debris flow deposits. Late Permian formations include the 46m thick Changxing Limestone in the upper and the coal-bearing Longtan Formation in the lower. Changhsingian beds at Meishan are dominated by slope facies. Contemporaneous deposits of the shallow shelf carbonate facies and the basinal radiolarian chert facies, cropping out in the areas respectively east and west of Meishan. In comparison to the Garnerkofel-1 Core (Carnic Alps), Austria, the Permian-Triassic boundary beds of Meishan are more fossiliferous, better constrained by radiometric ages, and well complemented by sections in neighbouring regions.

Two wells were drilled at the western part of the Meishan outcrop, 550 m and 150 m from Section D. Meishan-1 begins close to the boundary between the lower and upper members of the Yinkeng Formation, near the base of the lowest debris flow bed, which is about 70 m above the Permian-Triassic boundary. Recovery of the first 80 m of this core is less than 90% since the thin- to medium-bedded limestone beds are rather fragile and strongly deformed. Recovery of the remaining portion of the core, including the 1<sup>st</sup> and 2<sup>nd</sup> parts of the lower member of the Yinkeng Formation (20 m), the Changxing Formation (67 m), and the top part of the Longtan Formation (40 m) reaches 96%. Meishan-2 started from the same level as Meishan-1, and stopped at Bed 22 of the Changxing Formation, 9.6m below P-T boundary. The depth of Meishan-2 is 134 m. Though recovery of this core reaches 96%, the core for the 3<sup>rd</sup> and 4<sup>th</sup> parts of the Lower Member of the Yinkeng Formation appears somewhat fragmental.

Ash clay beds in the core are often incomplete because the bentonite was softened by circulating water used to flush drill cuttings. Supplemental samples for fresh clay beds around the Permian-Triassic boundary will be collected at Section C through a blasting operation. The other reason for collecting supplemental samples at Section C is that previous geochemistry studies are based on samples from this section or the nearby Section D.

The drilling was undertaken from January 1<sup>st</sup> to March 2<sup>nd</sup>, 2004 by the Prospecting Team 119, State Bureau of Coal Geology. Drill cuttings were flushed out by circulating water. The drill was equipped with two cases and 112 mm diamond bite; the core diameter was 86 mm. The core was logged, as it came from the barrel, by the site geologists with assistance of Shen Shuzhong, Cao Changqun or Zhang Hua from Nanjing Institute of Geology and Palaeontology, CAS. It was protected by plastic core bag before being put in core boxes. Logging of acoustic, apparent resistivity, natural gamma-ray and natural potential was conducted on both wells with a TYSC-3Q digit logger. Core and log data are housed in NIGPAS.

## Proposed Research Programs

Discussions over the last months, suggest the following studies. Nevertheless, proposals of other investigations on core materials and data are most welcome, particularly the investigations which have not been included in the following programs.

**A. An integrated succession for the Changhsingian Stage.** 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 has also been proposed to serve as the GSSP for the Wuchiapingian-Changhsingian boundary (Jin *et al.*, in press). Establishment of the GSSPs for the top and bottom boundaries of the Changhsingian Stage provides a unique opportunity to establish a unit stratotype for a stage. The core provides a precise and uniform stratigraphic succession to integrate the results from parallel investigations of paleontology, geochemistry and sedimentology, and thus might lead to better understanding of the relationship between various lines of evidence.

**B. Timing of the P-T events.** The Meishan Permian-Triassic sections contain volcanic ash and carbonized tuff at about 35 different levels. U-Pb zircon geochronology of the ash-beds from Meishan and other sections has resulted in a number of published dates, including a  $251.2 \pm 3.4$  Ma SHRIMP age from bed 25 at Meishan (Claoue-Long *et al.*, 1991; Zhang *et al.*, 1992),  $250.0 \pm 0.2$  Ma of  $40\text{Ar}/39\text{Ar}$  age (Renne *et al.*, 1995),  $251.4 \pm 0.2$  Ma of TIMS age (Bowring *et al.*, 1998), an inferred date of  $>254$  ? Ma (Mundel *et al.*, 2001), and  $252.4 \pm 0.3$  Ma (Mundel *et al.*, 2004). At face value the two newest data sets disagree by as much as 3 Ma for the age of the boundary. Fresh samples of ash beds around the P-T boundary (beds 25, 28 and 33) are now needed for further investigation in different labs. Meanwhile, time series analysis will be conducted based on radiometric ages, drill logs, magnetic susceptibility and geochemistry data.

**C. A blind test for the suggested extraterrestrial event.** Evidence cited for and against an impact cause of the extinction have included the analysis of iridium and other siderophile elements (Sun *et al.*, 1984; Chai *et al.*, 1986; Clark *et al.*, 1986; Orth, 1989), the presence of fullerenes (Becker *et al.*, 2001; Farley *et al.*, 2001), the interpretation of anomalous sulfur isotope signatures (Kaiho *et al.*, 2001; Basu *et al.*, 2003) and the presence of micro-spherules (He, 1985; Yin *et al.*, 1989) from the boundary clay. Evidence for an extraterrestrial impact at the P/T boundary is controversial. In order to determine whether there is credible geochemical evidence to support arguments of an asteroid impact or another extraterrestrial event, studies on iridium, fullerenes and  $\text{He}^3$ , platinum group elements, microspherules and other micro-objects, and sulphur isotope will be undertaken.

**D. The organic geochemistry evidence.** Analyses of carbon isotopes (carbonate and/or organic) have been done by Zhou and Kyte (1988), Xu *et al.* (1993), Li (1998), Hensen *et al.* (1998), Cao *et al.* (2002) and Nan and Liu (2004). A dramatic depletion of 6 ppm within bed 27 was reported by Xu *et al.* (1993), but has not been confirmed subsequently. Further studies on the nature of organic molecules are being undertaken, but at present these studies are limited in value by the highly weathered nature of surface outcrops.

New samples obtained from drill cores will provide an unparalleled opportunity for fresh material.

## Sampling and Sample Distribution

Multiple sets of samples will be collected for the research programs. Sampling will be accomplished using a saw with a 30 cm cutting disc reinforced with diamonds. The sample sets for measuring magnetic susceptibility and studies of microfacies, paleontology and diagenesis will be cut through the whole length of core Meishan-1. The sample sets representing a complete succession from bed 24 to bed 29 across the boundary will be collected for geochemical analyses from both cores, and will be supplemented by samples from blasted outcrop. We will send rock block samples directly to each collaborating investigator together with relevant stratigraphic data.

## Schedule

An international symposium for a timely exchange of the results of various research programs could be very interesting to all collaborators. We are planning to prepare a general summary on the main results and organize a symposium on P-T events in 2005. The final reports and conclusions will be compiled into a special volume of PALEOWORLD, a new journal on integrated paleontology of China and neighbouring regions, published by Elsevier.

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## The Permian-Triassic Time Slice Project

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The Permian-Triassic Time Slice Project is a major test case for CHRONOS—Integrated chronostratigraphic database and tool development, a NSF-funded project. Bruce Wardlaw and Vladimir Davydov are the principal investigators. Charles Henderson will join the project as an additional principal investigator in the next funding cycle. The project held its organizational meeting May 1-2 at Boise State University and developed an aggressive timeline and set ambitious milestones (figure 1). We are currently compiling as many sections as we can for inclusion in a test run of new correlation tools (including a modified CONOP, constrained optimization correlation program from Pete Sadler) in December. I have included a lot of my own unpublished data and conodont images. Specifically, thousands of digital images from Meishan, China and the Salt Range, Pakistan have been provided. Data are available at <http://www.paleostrat.org>. The simplest way to share data is simple spreadsheets with common fields. An example is shown in Figure 2. If you would like to learn more about the project please go to the website or contact Bruce or Vladimir.

Figure 1. Timeline and Milestones:

- 1—*CHRONOS Permian-Triassic Time Slice Project* Workshop #1
- 2—Mini-Workshop to examine implications and problems of database system and tool applications
- 3—*CHRONOS Permian-Triassic Time Slice Project* Snapshot Report—Synthesis of *CONOP* and *StrataPlot* tools analysis of data entered by Dec. 3, 2004.
- 4—*CHRONOS Permian-Triassic Time Slice Project* Workshop #2, in association with the International Symposium on Triassic Chronostratigraphy and Biotic Recovery.
- 5—*CHRONOS Permian-Triassic Time Slice Project* Workshop #3 (mini-workshop); and preparation of formal publication.
- 6—Permian *Permian-Triassic Time Slice Project* Report—Group set of publications on the Synthesis of data entered by October, 2005; with an on-line “exploration” outreach version.

Permian-Triassic Time Slice Project Time Line and Milestones	1 May 2004	June	July	August	September	October	November	December	January 2005	February	March	April	May	June	July	August	September	October	November	December	January 2006
First Workshop (BSU)--Organization	1																				
Assimilation of Data																					
Mini-Workshop (AGU)--Snapshot								2													
2nd Set of CONOP & StrataPlot Runs									3												
Second Workshop (Chaohu, China)												4									
3rd Workshop (NMNH)--Results & Plans																		5			
Further Work, IGCP, other support																			6		

Sample	mab	Latitude	Longitude	Formation	Member	Bed	Lithology	Collector	Date
D/C-34	-0.66	31.08194N	119.70637E	Luguan	None	0	Siltstone	Nickol and Meitalk	
MB-31	-0.58	31.08194N	119.70637E	Luguan	None	0	Siltstone	Mei	3/15/1999
MB-30	-0.48	31.08194N	119.70637E	Luguan	None	0	Siltstone	Mei	3/15/1999
1-1	-0.4	31.08194N	119.70637E	Luguan	None	0	Siltstone	Meland Henderson	10/12/2000
MB-29	-0.38	31.08194N	119.70637E	Luguan	None	0	Siltstone	Mei	3/15/1999
MB-28	-0.28	31.08194N	119.70637E	Luguan	None	1	Siltstone	Mei	3/15/1999
MB-27	-0.15	31.08194N	119.70636E	Luguan	None	1	Carbonate Midstone	Mei	3/15/1999
1-2	-0.12	31.08194N	119.70636E	Luguan	None	1	Carbonate Midstone	Meland Henderson	10/12/2000
MB-1	0	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Mei	3/15/1999
2-1	0	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
D/C-23	0	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Nickol and Meitalk	
MB-2	0.16	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Mei	3/15/1999
2-2	0.2	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
2-3	0.32	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
D/C-24	0.36	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
2-4	0.47	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
D/C-25	0.5	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
3-1	0.56	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
3-2	0.7	31.08194N	119.70636E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
Bed 3 tuff	0.75	31.08194N	119.70634E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
D/C-26	0.8	31.08194N	119.70634E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4a-1	0.82	31.08194N	119.70634E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4a-2	0.88	31.08194N	119.70634E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4a-3	1.07	31.08194N	119.70634E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4a-4	1.41	31.08235N	119.70633E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
MB-3	1.56	31.08238N	119.70633E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4b-1	1.6	31.08239N	119.70633E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4b-2	1.74	31.08241N	119.70632E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
4b-3	1.85	31.08194N	119.70632E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
5-1	2.15	31.08250N	119.70631E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
MC-1	1.9	31.08157N	119.70615E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
MC-1	1.9	31.08157N	119.70615E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
REG-1	1.96	31.08157N	119.70615E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000
MB-4	3.56	31.08158N	119.70611E	Changxiang	Baoqing	2	Carbonate Midstone	Meland Henderson	10/12/2000

Figure 2. Examples of sample data and species distribution spreadsheets for Meishan section D, China, incorporating unpublished images of Wardlaw with published images of Mei and others.

Sample	mab (base)	mab (top)	1 mab 12.8	log scale data	ork scale	taoz	wang
D/C-34	-0.66	-0.44	X				
MB-31	-0.58	-0.48					
MB-30	-0.48	-0.38					
1-1	-0.4	-0.3		X			
MB-29	-0.38	-0.28					
MB-28	-0.28	-0.15					
MB-27	-0.15	0					
1-2	-0.12	-0.04		X			
MB-1	0	0.16					
2-1	0	0.2		X	X		
D/C-23	0	0.36	X				
MB-2	0.16	0.26					
2-2	0.2	0.3		X			
2-3	0.32	0.47		X	X		
D/C-24	0.36	0.5					
2-4	0.47	0.56		X			
D/C-25	0.5	0.82					
3-1	0.56	0.7		X			
3-2	0.7	0.8		X			
Bed 3 tuff	0.75	0.81					
D/C-26	0.8	1.02					
4a-1	0.82	0.87		X			
4a-2	0.88	1.07		X			X
4a-3	1.07	1.3		X			X
4a-4	1.41	1.57		X			X



## Carboniferous-Permian Stratigraphy of the Midcontinent

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The Admire, Council Grove and lower Chase Groups of Kansas, Oklahoma and Nebraska are placed into three third-order depositional sequences, a Gzhelian late highstand sequence set, a Council Grove transgressive and highstand sequence set, and a Chase transgressive sequence set. Sequences are defined by bounding maximum exposure surfaces and placed within the zone of exposure surfaces (typically, stacked paleosols). Conodonts are abundant in open marine deposits and most marine units have a differing and characteristic faunal make-up. Several of the maximum flooding surfaces have the introduction of new conodont species, including the index species that define the base of the Asselian, Sakmarian, and Artinskian (Fig. 1). *Streptognathodus isolatus* occurs at the base of the Bennett Shale Member of the Red Eagle Limestone, shown in an outcrop in Figure 2. *Sweetognathus merrilli* occurs in the Eiss Limestone Member of the Bader Limestone and *Sweetognathus whitei* occurs in the Florence Limestone Member of the Barnston Limestone.

Generally, cyclothem-scale depositional sequences from the Admire, Council Grove, and Chase groups are comprised of a two-component (hemicycle) system, one being carbonate-dominated and the other siliciclastic-dominated. The carbonate-dominated hemicycle of the depositional sequences generally is thick (1-25 metres) and generally represents more dominantly marine conditions. The thick carbonates are overlain by a relatively thick (5-15 metres) red and green caliche-bearing blocky silty mudstones and siltstones hemicycle that commonly contains well-defined pedogenic features (Miller and West, 1993, Miller and others, 1996). These red and green deposits are generally thought to have formed during late stages of sealevel fall, lowstand, and perhaps earliest transgression. Close examination of both the dominantly marine carbonate hemicycle as well as the dominantly nonmarine siliciclastic hemicycle reveals a much more complicated scenario for their origin.

Within the carbonate hemicycle fossiliferous wackestones and packstones are the dominant facies. The carbonate hemicycle is typically capped by either foraminiferal grainstones or peritidal thin-bedded ostracode-bearing mudstones. Within the carbonate dominated hemicycle three basic types of siliciclastic facies are also present including: (1) grey to black, fissile to blocky, commonly silty, poorly fossiliferous shales and mudstones (Facies 1), (2) grey to black fissile to blocky, commonly silty, highly fossiliferous shales and mudstones with abundant *Streptognathodus* conodonts, *Ammodiscus* foraminifers, orbiculoid brachiopods,

abundant fish debris, and ammonoids (Facies 2), (3) light grey, green, or tan, blocky to fissile, poorly fossiliferous silty mudstones and shales (Facies 3).

Facies 1 occurs immediately above maximum marine flooding levels in a number of Council Grove depositional sequences including above the lower Americus Limestone, upper Johnson Shale, basal Legion Shale, above the Sallyards Limestone, above the lower Burr Limestone, above a limestone in the Salem Point Shale, above an unnamed limestone in the middle Stearns Shale, above the lower Middleburg Limestone, above the lower Crouse Limestone, above the lower Funston Limestone, and in the upper Fort Riley Limestone. These shales contain a limited ostracode and bivalve fauna with no conodonts. Additionally, evaporite minerals including gypsum and anhydrite (largely replaced by silica) are locally present in this lithofacies. This facies typically grades laterally into poorly fossiliferous silty carbonates with shallow water indicators such as low diversity ostracode and bivalve assemblages. We view this facies as representing a marginal marine perhaps lagoonal environment created by extremely rapid sea-level fall coupled with an dramatic increase in the influx of siliciclastic sediments immediately following maximum marine flooding. This sea-level fall created localized low oxygen and perhaps variable salinity conditions on the proximal or high shelf.

Facies 2 is restricted to the lower Council Grove Group including the upper Americus, middle Hughes Creek Shale, upper Hughes Creek Shale, Bennett Shale, and in a shale parting within the lower Neva Limestone. These black shales are best developed in northern Kansas, and Nebraska, but have been documented in the Hugoton Embayment (Puckette and others, 1995). This facies contains the conodont *Streptognathodus*-biofacies, *Ammodiscus* foraminifer biofacies, along with locally abundant ammonoids and inarticulate brachiopods. Furthermore, this facies shows evidence of condensed sedimentation with high conodont abundance (100-1,000 platform conodont elements/kilogram). Laterally, in southern Kansas and northern Oklahoma, this facies changes into highly fossiliferous shaly glauconitic wackestone with the same conodont biofacies with evidence of condensed sedimentation along with phosphatized molluscs. We interpret the Facies 2 along with the equivalent shaly glauconitic carbonate facies to represent offshore maximum marine flooding condensed sections.

Facies 3 occurs in numerous carbonate-dominated hemicycles within the Admire to Chase interval. This lithofacies commonly overlies the Facies 1 or may directly overlie and separate carbonates within the hemicycle. This lithofacies is poorly fossiliferous, usually containing a low diversity ostracode and foraminifer assemblage, may contain silica-replaced evaporite nodules, and grades laterally into poorly fossiliferous shallow to restricted marine carbonates. This facies is interpreted to represent a marginal marine condition created by rapid forced regression accompanied by an increase in siliciclastic sedimentation on the shelf. The facies commonly separates high frequency 5th order cycles within the overall thicker carbonate hemicycle. It is similar to Facies 1 but lacks the inferred low oxygen component. Commonly Facies 1 grades laterally into the Facies 3.

The thick (5-15 metres) red and green mudstone hemicycles are also highly complex. Within these intervals, extensive evidence of pedogenesis is present including columnar peds, blocky peds, pseudanticlines, root traces, boxwork carbonates,

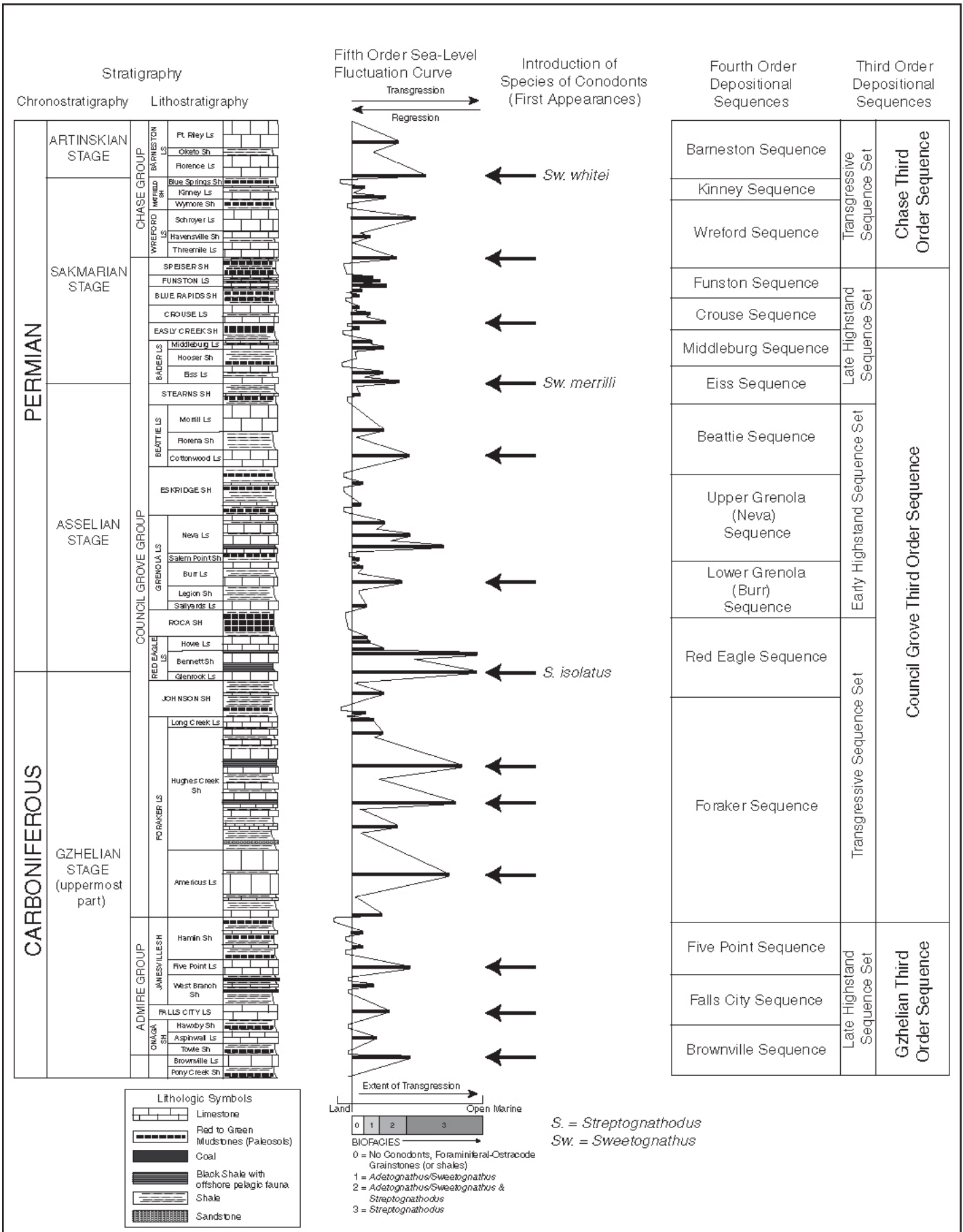


Figure 1. Stratigraphy, sea-level curve, levels of conodont species introduction and depositional sequences for the interval from the Pony Creek Shale Member of the Wood Siding Formation to the Fort Riley Limestone Member of the Barnston Limestone.

desiccation cracks, carbonate nodules, and rhizocretions (Joeckel 1991, Miller and West 1993, Miller, 1994, Miller and others, 1996). In stark contrast to Virgilian depositional sequences that have well developed incised valleys fills (Archer and Feldman, 1995), incised valley fills are rare to absent in the Council Grove outcrop belt from northernmost Oklahoma to Nebraska. These thick siliciclastic intervals are commonly punctuated by thin (<1metre) carbonates and mudstones that indicate marineinfluenced deposition (Miller and West, 1993). The thin marine or marginal marine deposits commonly contain a low diversity foraminifer and ostracode microfaunal assemblage along with a low diversity mollusc-dominated or rarely brachiopod macrofossil assemblage. Typically, these siliciclastic intervals contain up to two of these minor marine bands. Each of these marine bands is separated by red to green blocky to crumbly mudstones that demonstrate clear evidence of pedogenic features.

Marginal marine deposits are characterized by a very low diversity microfaunal assemblage consisting of *Geisina* ostracodes, *Thurammina* foraminifers, and no conodonts. These deposits usually occur in green, grey to black, clayey to silty mudstones. Nearshore shallow normal marine deposits contain a low diversity microfaunal assemblage consisting of the *Cavellina* ostracode biofacies, encrusting foraminifers with agglutinated foraminifers including *Ammodiscus* cf. *A. semiconstrictus* var. *regularis*, and the *Adetognathus*/*Sweetognathus* conodont biofacies. This biofacies occurs in carbonates as well as siliciclastic dominated facies. The moderate depth open shelf microfaunal assemblage consists of a high diversity ostracode *Amphissites* biofacies, a high diversity benthic foraminifer biofacies including *Tetrataxis*, *Globivalvulina*, *Climacammina*, *Deckerella*, *Endothyra*, *Endothyranella*, *Ammobaculites*, as well as fusulinaceans, along with the *Streptognathodus* conodont

biofacies. This facies is usually found in wackestones, but also occurs in shales that are in close stratigraphic proximity to the fossiliferous wackestones. Deepershelf marine deposits occur in the Facies 2 and equivalent shaly, glauconitic, and fossiliferous wackestones. These deposits contain a reduced diversity benthic assemblage including inarticulate brachiopods (e.g., *Orbiculoidea*) and the *Ammodiscus* foraminifer biofacies, along with a pelagic component consisting of rare ammonoids, fish debris and the *Streptognathodus* conodont biofacies. This deep shelf assemblage is well represented in maximum marine flooding marine condensed sections of the Facies 2 but is restricted to the lower Council Grove Group.

Depositional sequences from the upper Wabaunsee and Admire groups comprise the late highstand sequence sets in a third order composite depositional sequence that includes most of the Gzhelian strata. The Council Grove Group comprises one-third order sequence (Council Grove Third Order Sequence) with the base of the Americus Limestone representing the transgressive surface. The Bennett Shale Member of the Red Eagle Limestone contains the most widespread maximum marine flooding condensed section of the Council Grove Group, and thus corresponds also to maximum transgression of the composite third order sequence. Additionally, the Red Eagle Limestone extends further paleo-landward into Oklahoma than any other unit of the Council Grove Group (Branson, 1964, p. 61). The Foraker and Red Eagle sequences form a retrogradational stacking pattern of sequences that comprises the transgressive systems tract of the third order sequence. The highstand systems tract includes sequences that stack into aggradational (Lower and Upper Grenola Sequences) and progradational stacking patterns (Beattie through Funston Sequences) with a very major Type 1 unconformity developed in the Speiser Shale at the top of the



Figure 2. Photograph of Glenrock Limestone and thin skin of overlying Bennett Shale (the Carboniferous/Permian boundary) featuring the backside of Brian Glenister in middle of the photo. Tuttle Creek Spillway Section, Manhattan, Kansas.



Council Grove Group. The Wreford and Barneston Sequences of the overlying Chase Group belong to the retrogradational transgressive systems tract to the Chase Third Order Sequence. The Barneston Limestone also has been demonstrated to extend further paleo-landward into Oklahoma (Branson, 1964, p. 61).

More detailed information on the sequence stratigraphy and conodont taxonomy and stratigraphy will be published in a Kansas Geological Survey Bulletin by Boardman, Wardlaw, and Nestell titled "Stratigraphy of the uppermost Carboniferous and Lower Permian from the North American Midcontinent" which is currently in review.

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been deposited in very shallow carbonate platform and mid-ramp settings, respectively. Preliminary identification of faunal contents of strata shows that the duration of the coverage the Permian sea in the Shotori and Shirgesht basins was longer than that of the Kalmard basin because Permian strata in the Kalmard area are probably not younger than Sakmarian, whereas within the other two areas strata yield foraminiferal faunas assignable to Bolorian-Dorashamian. Three major transgressive cycles can be recognized within the Upper Paleozoic succession in central-eastern Iran. The Sardar Formation represents the first transgression that started in Serpukhovian-early Bashkirian and ended in early late Moscovian (Leven, Davydov and Taheri, in press). Next, the Zaladu-Khan transgression spans part or the entire Kasimovian through Asselian and possibly the Sakmarian. The third Jamal transgression (Shirgesht) started locally from Bolorian, but in most sections from Kubergandian and extended to the end of the Permian.

## Introduction

The Permian in central and eastern Iran for many years has been referred to the Jamal Formation (Stöcklin *et al.*, 1965; Ruttner *et al.*, 1968). The age of the Formation based on irregular sampling of brachiopods, conodonts, ammonoids and fusulinids has been proposed to be Artinskian-through the top of the Permian (Stöcklin *et al.*, 1965; Ruttner *et al.*, 1968; Kahler 1974, 1977). Aghanabati (1977) was the first to distinguish Permian sequences of the Kalmard area as a separate unit and named it the Khan Formation. He divided this formation into three members regarded as Lower, Middle and Upper Permian respectively. Each member of the Khan Formation represents a sedimentary cycle that can be correlated to the Dorud, Ruteh and Nesen Formations in the Alborz region of Northern Iran. In recent years, more detailed examinations of the Jamal Formation in the Shotori and Shirgesht areas have been conducted by Partoazar (1992) and Taheri (2002). Mixed carbonate-siliciclastic sequences of the lowermost portion of Jamal Formation in Shirgesht area have been designated as the new Bag-e-Vang Member (Formation). The age of this member, thought to be Asselian and Sakmarian, is based on data from the Ozbak-Kuh region (Partoazar, 1992). However, it has been shown that the Bag-e-Vang Member in Shirgesht, its type section, is Bolorian in age (Leven and Vaziri, 2004) and that mixed carbonate-siliciclastic sequences in the Ozbak-Kuh region are older (Late Pennsylvanian-Asselian) than the Bag-e-Vang Member and represent a separate formation – the Zaladu Formation (Leven and Taheri, 2003). Despite the fact that numerous exposures of Permian deposits are widely distributed in central-eastern Iran, only a few have received detailed investigation by stratigraphers and paleontologists. On the other hand, the existence of conspicuous differences between the Kalmard area and its surrounding regions during Permian time prompted us to study 9 stratigraphic sections in three separate areas to help resolve some ambiguities. The purposes of this paper are (1) to summarize stratigraphy of Permian successions in the Kalmard area, (2) to recognize difference between the Kalmard area and the Shotori-Shirgesht regions during Permian in regard to lithology, faunal content and tectonics.

## Permian in Kalmard, Shotori and Shirgesht areas, central-eastern Iran

Sakineh Arefifard and Vladimir I. Davydov

### Abstract

To clarify more precisely details of Permian strata in eastern-central Iran, 9 stratigraphic sections located in Kalmard, Shotori and Shirgesht areas were measured and sampled. Characteristics of Permian successions in the Kalmard area and tectonic evidence indicate that during Permian time this area was thoroughly distinct from two other areas (Shotori and Shirgesht) confirming a former hypothesis. The Permian strata in the Kalmard area have lithic characteristics diagnostic of shore line deposition, in striking contrast to those of the Shotori and Shirgesht areas that have

## Geological setting

Iran can be divided into different tectonic domains, each with its own discrete characteristics and structural and tectonic evolution. Eight geological provinces can be recognized there, but from Precambrian to Carboniferous the same deposits have persisted in most provinces, including siliciclastic-carbonate strata and even volcanic deposits, strengthening the important interpretations that they formed a united block placed on the eastern margin of Gondwana (Stöcklin, 1968). This block had been located close to the Arabian platform. During Middle-Late Permian and Early Triassic time, the Iran block rifted northward to form the Neo-Tethys basins and later collided with Eurasia during Middle-Late Triassic time. The first classification of tectonic elements of Iran was provided by Stöcklin (1968). Alavi (1991) recently modified this classification. The area under study comprises the part of a central Iran province considered to be a microcontinent. On the basis of long west-trending faults this microcontinent was divided (by Nayband, Kalshaneh and Kuhbanan) into sub-blocks that are known as Lut, Tabas and Yazd (Sengor, 1990). Alavi (1991) in recognition of long strike-slip dextral faults (Nayband, Kalmard, Kuhbanan and Posht-e-Badam), divided the central Iran Province into four sub-blocks Lut (LB), Tabas (TB), Posht-e-Badam (PBB) and Yazd (YB) (Figure 2). The Shotori and Shirgesht areas are placed within the Tabas block and are separated from Yazd block by the Kalmard and Kuhbanan faults. These north-south trending faults have played an important role in separating agents of sedimentary facies after late Precambrian and have been active in many ways throughout Phanerozoic: some of them focused earthquake activities (Berberian, 1981). Berberian and King (1981) cited one of the features of the Tabas block as a deep depression that possessed this quality throughout Paleozoic and Mesozoic.

The Kalmard area is situated within the Yazd block at West Shotori ranges and Southwest Shirgesht. Location of the Kalmard area between two very active faults named Kalmard and Naeni formed a mobile zone throughout Paleozoic. Therefore its lithostratigraphic units demonstrate remarkable facies changes compared with other central Iran areas. As a result of tectonic activity of these faults, the Kalmard area sporadically emerged as land areas and at other times as a subsiding graben dominated by subsidence and marine environments.

General characteristics of the Permian successions in Kalmard, Shotori and Shirgesht Areas (eastern-central Iran)

The best outcrops of Permian deposits in the Shotori area are located in Shotori Range, where the Jamal Formation was designated. In the Shirgesht area this formation is best exposed in the Bagh-e-Vang Mountain region. Permian strata in the Kalmard area are well exposed in many sections. In order to scrutinize Permian successions and document lithologic features and fossil contents of these strata in areas under consideration, 9 stratigraphic sections were studied, four sections in the Shotori and Shirgesht areas and five in the Kalmard area. All studied sections are well exposed, although some are slightly disturbed tectonically. The comparatively good exposures of sections permit accurate study of Permian strata and the stratigraphy is summarized below.

## Jamal Formation in Shotori area

The Formation was established by Stocklin *et al.* (1965) with type section located in the south-wall of Kuh-e-Mehdi, southern promontory of Kuh-e-Jamal, approximately 52 Km southeast of the town of Tabas, Iran. Our selected sections in Shotori area are located 5 and 8 km east of the type section of the Jamal Formation. In this area the Jamal Formation is underlain by the Sardar Formation without visible angular unconformity, but there is a significant hiatus between these two formations.

The uppermost unit of the Sardar Formation includes white medium- to thick-bedded sandstone interbedded with shale. The basal beds of Jamal are shell fragment-bearing sandy limestone. The major part of Jamal Formation is composed of gray to dark gray medium- to thick-bedded grainstone-packstone interbedded with wackestone, micritic limestone and oolitic limestone; the upper units of this formation include re-crystallized limestone. The fossil content of the Jamal Formation is dominated by small foraminifers and algae and fragments of bryozoans, brachiopods, crinoids and gastropods. Fusulinid and coral horizons are rare throughout the succession. Corals occur in the middle part of the Jamal Formation. Samples yielding fusulinid and corals are currently under study. Previous data (Jenny-Deshusses, 1983) and our preliminary analysis of samples suggest Kubergandian – Dorashmian age for the formation. Lithologic characteristics of the Jamal Formation indicate deposition within shallow to very shallow water. The Jamal Formation is overlain by Lower Triassic yellow platy micritic limestone of the Sorkh Shale Formation with fault contact. In the second section chosen for our study section in the Shotori area, the boundary between the Sorkh Shale and the Jamal formations is partly covered.

## Jamal Formation in the Shirgesht area

In this area, the best stratigraphic section of the Jamal Formation is exposed in Bagh-e-Vang Mountain, nearly 50 km north of the town of Tabas. The section was studied by Ruttner *et al.* (1968), Partoazar (1992), Taheri (2002) and Leven and Taheri (2004). We have singled out the Bagh-e-Vang and Shesh Angosht stratigraphic sections in Shirgesht area. In both sections the Jamal Formation is unconformably underlain by red to brown thin-bedded fine sandstone of Sardar Formation. Partoazar introduced the basal parts of Jamal Formation as the Bagh-e-Vang Member comprising very coarse fusulinid-bearing grainstone including additional pebbles of silty limestone and micritic limestone. The upper two-thirds of Bagh-e-Vang Member contain black medium-bedded fusulinid grainstone with interbedded black shale. The Jamal Formation (*sensu stricto*) starts with black massive coarse grainstone with fusulinids and a conglomerate bed with matrix of very coarse grainstone and sharp clasts. The main part of Jamal Fm consists of dark to gray thick- to medium-bedded cherty micritic limestone with thin wackestone-packstone at the base of some beds containing smaller foraminifera and radiolarians. The thickness of wackestone-packstone horizons increases upwards and finally is replaced by reefoidal limestone in the upper portion of the middle Jamal Formation and terminates with oolitic limestone and dolomites; it is overlain by platy micrites of the Sorkh Shale Formation. The lithologic features in the Bagh-e-Vang section suggest transgressive sedimentation in a mid-ramp setting for deposition of the major part of Jamal Formation and a significant regression for its upper part.

In the Shesh Angosht section, the Jamal Formation has similar lithologies, but is thinner than the Bagh-e-Vang section. The Formation there is composed of dark-gray, thick- to medium-bedded micritic limestone interbedded with wackstone to packstone and rare grainstone horizons. Supposedly, the setting in the Shesh Angosht section was slightly deeper.

The age of Jamal Formation in these two sections proposed by Ruttner *et al.* (1968) and Partoazar (1992) has been recently revised by Leven and Vaziri (2004). Well documented and thoroughly studied fusulinid and small foraminifers in the Bagh-e-Vang section indicate a Bolorian age for the Bagh-e-Vang Member and a Midian-Doroshmian age for the upper (postreefoidal) portion of Jamal Formation. The age of the lower and major portion of Jamal Formation is still not well constrained.

### Khan Formation in Kalmard area

Permian strata in this area were named the Khan Formation (Figure 3) by Aghanabati (1977). The type section is located in southwest Kalmard Karavanseray, nearly 120 km west of the town of Tabas, central Iran. We have measured and sampled 5 stratigraphic sections in this area. The Khan Formation rests unconformably on Lower Carboniferous limestone of the Gachal Formation and is overlain by Lower Triassic yellow vermiculate limestone of the Sorkh Shale Formation. There is a disconformity between the Khan and the Sorkh Shale Formations indicated by a bauxite horizon. Although the total thickness of the Khan Formation varies slightly from section to section, its lithological content is generally the same throughout. Therefore we intend to describe the stratigraphic characteristics of Khan Formation in general. This formation is represented mainly by red to brown cyclic sequences that start with gravel to cobble conglomerate or with very coarse to coarse sandstone. The size of the clasts decreases upwards and the topmost portion of each cycle represent shallow water thick- to medium-bedded packstone to grainstone. The distinguishing feature of this formation is the siliclastic material that encompasses the chief deposits. The lithological content of the Khan Formation suggests its deposition near shore. The paleontologic content of the Khan Formation includes abundant fusulinids, smaller foraminifers, brachiopods, crinoids, bryozoans and rare horizons of solitary corals. Fusulinid and coral samples of the Khan Formation are currently under study. Our preliminary identification of fusulinids suggests Asselian and possibly Sakmarian age for the middle-upper Khan Formation. Kahar (1977) earlier reported *Ferganites isfarensis* (Bensh) and advanced *Daixina* (or *Shagonella*) in the area, unfortunately, with no precise location of the samples. Nevertheless, these faunas indicate the presence at least upper Kasimovian-Gzhelian marine strata in the area. All the data mentioned above suggest a Late Pennsylvanian-Asselian, or possibly Sakmarian age for the Khan Formation. Therefore, the Khan Formation in many respects is similar to the newly established Zaladu Formation in Ozabk-Kuh region (Leven and Taheri, 2003). Whether or not these two formations are synonyms should be considered further; however, it is obvious now that there is a thick Late Pennsylvanian-early Cisuralian transgressive succession within the Late Paleozoic that has not been previously recognized.

### Conclusions

The Jamal Formation in the type area formed in open shallow carbonate platform environments. The Permian is represented there by thick shallow marine limestone (including oolites), with numerous benthic fossils – predominantly algae, foraminifers, brachiopods, crinoids, bryozoans, corals and rare fusulinids. The age of Jamal Formation in the type section is Kubergandian-Dorashmian.

The Jamal Formation in the Shirgesht area formed in a mid to outer ramp setting. The Bag-e-Vang Member represents an older, transgressive part of the Jamal Formation, absent in the Shotori region.

Permian strata in the Kalmard area were deposited in a completely different sedimentological setting in contrast to that of Jamal Formation in Shotori and Shirgesht areas as indicated by its lithologic characteristics, fossil content and tectonic evidence. As function of important Precambrian faults, the Kalmard area has been tectonically active and this has influenced its geologic history.

Three major transgressive cycles can be recognized within the Upper Paleozoic succession in central-eastern Iran. The Sardar Formation represents the first transgression that started in Serpukhovian-early Bashkirian and ended in early late Moscovian (Leven, Davydov and Taheri, in press). Next, the Zaladu-Khan transgression spans part or the entire Kasimovian through Asselian and possibly Sakmarian. The third Jamal transgression (locally Shirgesht) starts from Bolorian, but in most sections from Kubergandian and extends into the end of the Permian.

### Acknowledgements

To Brian Glenister for editing the English and content. The support for this study has been received from NSF grants.

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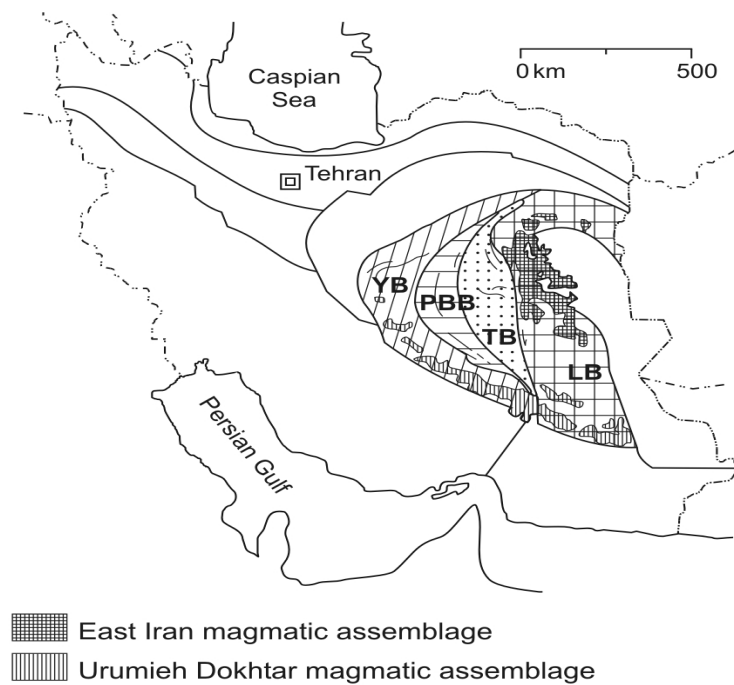


Figure 1. Generalized tectonic map of Iran (after Alavi, 1991)  
In this classification Central Iran micro-continent divided into four blocks:  
LB(Lut Block), T.B.(Tabas Block), PBB (Pash-e-Badam Block),  
YB (Yazd Block). Kalmard area located within PBB Block.

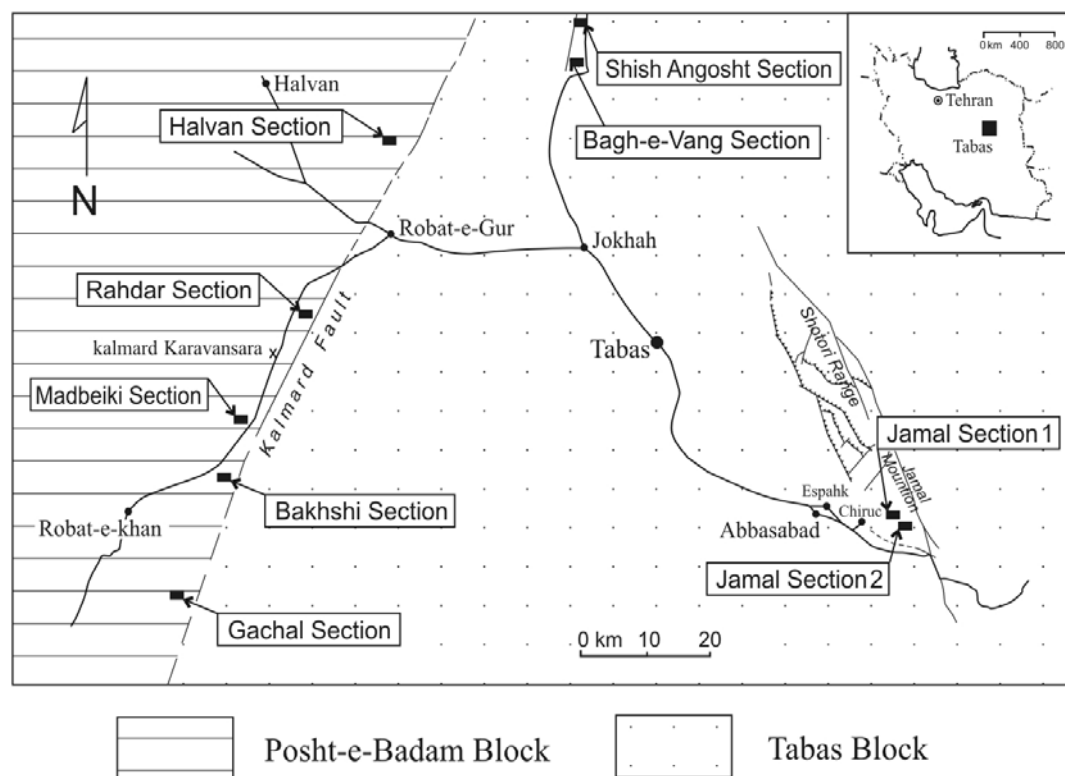
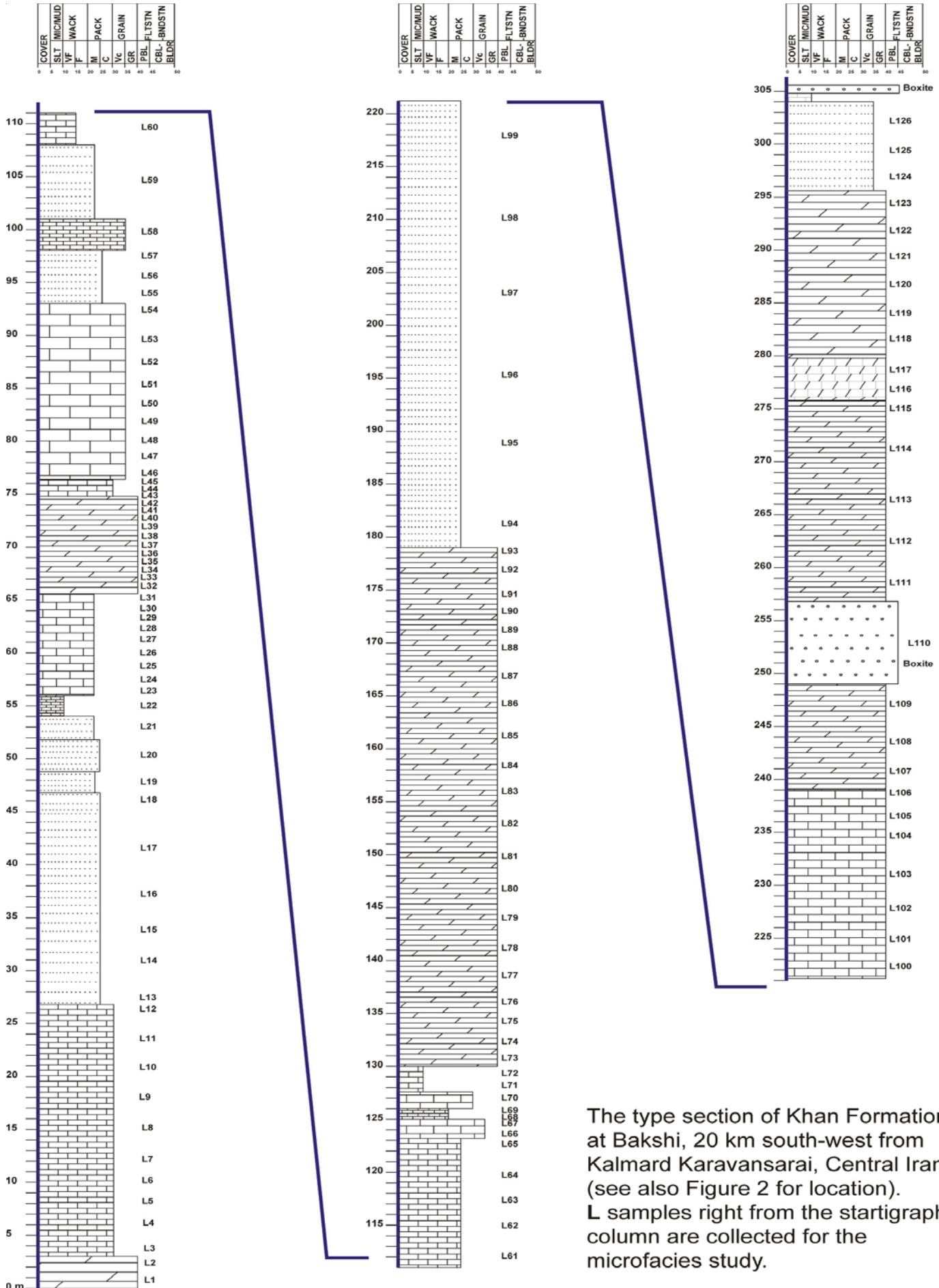


Figure 2 - Index map with location of the studied sections.



The type section of Khan Formation at Bakshi, 20 km south-west from Kalmard Karavansarai, Central Iran (see also Figure 2 for location). L samples right from the stratigraphic column are collected for the microfacies study.

## **Founding Years of the Subcommittee on Permian Stratigraphy**

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#### **Introduction**

Authorization for organization of a Subcommittee on Permian Stratigraphy (originally SCPS, now SPS) was provided by the International Commission on Stratigraphy (ICS) at its 1972 Montreal meeting. The inaugural meeting was held in Moscow, three years later, but by 1978 some Permian workers were dissatisfied with formulation of objectives and progress toward their achievement. Correspondence between ICS Chairman Anders Martinsson and SPS Vice-Chairman S. V. Meyen (also Secretary) and W. W. Nassichuk produced the consensus that the problem arose from "...a simple matter of (inadequate) communication." As a consequence, in July 1978 Secretary Meyen distributed a two page "IUGS Subcommittee on Permian Stratigraphy – Current Information" statement offering to "...organize a regular issue of an informal SCPS Newsletter", and requested submission of current information on a full range of topics of interest to Permian workers. He noted that with limited resources he could provide only 20 originals, and invited others to duplicate and distribute copies regionally. SCPS Newsletter 1, a 10-page compilation with broad geographic and subject coverage appeared in February 1979, edited and typed by Dr. Meyen. Other issues have followed on a more or less regular schedule.

Success of the SPS Newsletter in improving communication between Permophiles was essentially immediate, with the first issue precipitating a spirited exchange between R. E. Grant and J. B. Waterhouse. Scientific content and insight of the early numbers was consequential. For example, in SCPS Newsletter 1 Dick Grant anticipated much of the current consensus on subdivision of Permian time, favouring and justifying acceptance of the Southern Urals as reference for the Lower Permian Series, and the Guadalupian for the Middle Permian. Knowledge of the South China sections had not reached the present level at that time, and Grant favoured the "Arax River" sections for the Upper Permian, although noting the potential of the "Changxing Limestone" as a future reference.

Much of the recent success of the SPS is attributable directly to improvement of communication through the Newsletter (renamed Permophiles, #11, May 1986). This venue encourages workers to report new findings and to evaluate the growing database, rather than depending on exchanges at infrequent international meetings. Consequently the succession of Newsletters represents a useful summary of the progressive growth of insight into the complexities of a vital interval of geologic time.

#### **History Prior to Newsletter 1 (1979)**

The International Commission on Stratigraphy (ICS), parent to the Subcommittee on Permian Stratigraphy (SPS) has roots that go back to various permanent working groups of the

International Geologic Congress (IGC) that discussed stratigraphic classification and terminology at the earliest Congress meetings (Paris 1878 and Buologne 1881). One of those IGC groups was named the Commission on the International Lexicon on Stratigraphy at the IGC meeting of 1910 in Stockholm. It was reorganized as the Commission on Stratigraphy at the 1952 IGC meeting in Algiers, and was given a mandate to promote international standards and cooperation in stratigraphy.

The International Union of Geological Sciences (IUGS) was founded in 1961 and a number of permanent groups of IGC were transferred to IUGS, including the ICS in 1965. However, even to this day the ICS has continued to convene every four years in conjunction with meetings of the IGC. During the IGC meeting in Montreal in 1972, the newly elected executive of the ICS, Canadians D. J. McLaren (Chairman) and W. W. Nassichuk (Secretary-General) invited the renowned Permian specialist D. L. Stepanov (Russia) to organize a Subcommittee on Permian Stratigraphy within the ICS. The inaugural meeting of the Subcommittee was held in conjunction with the 8<sup>th</sup> International Congress on Carboniferous Stratigraphy and Geology in Moscow, 1975. Elections to the Subcommittee were held in Moscow, and elected officers and Titular Members were subsequently approved by the full Commission early in 1976. The first executive of the Subcommittee was Chairman D. L. Stepanov, first Vice-Chairman W. W. Nassichuk (Canada), and the second Vice-Chairman/Secretary S. V. Meyen (Russia). Subsequent officers and members are listed in each issue of the SPS Newsletter/Permophiles.

Before and after the 1975 Moscow Carboniferous congress, field trips were conducted to important stratotype areas in the Urals. During the course of the Moscow meeting, at least 20 formal presentations dealt with Permian biostratigraphy, most relating to the Carboniferous/Permian boundary. Many fossil groups were discussed in terms of their biostratigraphic value, but special emphasis was placed on fusulinaceans and ammonoids; V. N. Andrianov from Yakutsk displayed Permian ammonoids from eastern Siberia. There was some general agreement that the base of the Permian should be defined at the base of the Asselian Stage, but an equally strong opinion, particularly from fusulinacean and conodont workers, stressed that a particularly profound break occurs between the Asselian and Sakmarian.

Considerable discussion was devoted to the question of the Series subdivisions for the Permian, some favouring a three-fold and others a two-fold division. No vote was taken on these questions, but opinions seemed equally divided. There was a general concern that additional studies should be carried out on faunas and rocks in potential stratotype areas before international standards were selected.

During the Moscow meetings a Working Group on the Carboniferous/Permian boundary was convened under the leadership of Charles A. Ross (U.S.A.). Similarly, plans were formulated to convene a Working Group on the Permian-Triassic boundary in cooperation with the Subcommittee on Triassic Stratigraphy. At that time Chairman Stepanov was leader of the IGC project entitled "Permo-Triassic Stage of Geological Evolution", much broader in scope than boundary definition.

The late Sergei Meyen, in addition to being a brilliant paleontologist and stratigrapher was also a particularly vital proponent for action within the Subcommittee. He initiated



discussions in Moscow on the most important objectives for the Subcommission, one of which was to agree on a scheme for international correlation of both marine and nonmarine successions. To that end, he proposed that subcommission members prepare simple correlation charts for all regions of the world showing the various divergent views on correlation for each specific region. He showed, for example, that there was little agreement amongst authors on correlation of the base of the Zechstein in Europe. Some thought it correlated with the base of the Kungurian, some with the base of the Kazanian, and still others with the base of the Tatarian. All of these views could be shown on a chart and would form the basis for discussion at future Subcommission meetings. The following Working Groups were established at the Moscow meeting to cover a range of other important activities related to Subcommission objectives.

Working Group on Permian Stratigraphy of North America (Grant, Meyen, Glenister),

Working Group on the Continental Permian of Europe (Falke),

Working Group on Gondwana/Laurasia Correlation (Utrinsky, Meyen, Dickens),

Working Group on Boreal Stratigraphy (Utrinsky, Nassichuk),

Working Group on Tethys Stratigraphy (Leven, Minato),

Working Group on Fusulinid-Ammonoid Zonation (Ross, Pavlov),

Working Group on Conodonts and other non-fusulinacean microfossils (Kozur),

Working Group on Paleoclimatology (Utrinsky, Stehli, Dickens).

In 1976, members of the Subcommission met at the IGC in Sydney (Australia) for continuation of various initiatives taken in Moscow. It was agreed that the Correlation Chart Program should be kept simple in the beginning to show various ideas for correlation based on different fossil groups for each region. This allayed the fears of members who mistakenly thought that the purpose of the Correlation Program was to prepare a detailed global correlation chart much like that presented for North America by Dunbar and others (1960). J. B. Waterhouse pressed for Soviet and American workers to clarify and summarize the lithological and faunal content of Permian stages proposed for the Soviet Union and the United States. Finally, J. M. Dickens convened a meeting of the Working Group on Paleoclimatology, which recommended that a symposium on Permian climate be organized, a bibliography on world climate be prepared, and that attention should be paid to oxygen isotopes for paleotemperature studies.

During 1978, the Subcommission was particularly active. Some members participated in the Warsaw Symposium on the Permian of Central Europe, others traveled to Nanjing (China) to participate in broad-ranging discussions of the Permian and the Permian-Triassic boundary, and to encourage Chinese scientists to participate in Subcommission activities. Subcommission members were also invited to participate in activities of the Working Group on the Unified Stratigraphic Time-Scale, led by P. P. Timofeev. The first Newsletter appeared early in 1979, and a memorial on the first page paid tribute to the distinguished Russian paleontologists V. E. Ruzhencev and T. G. Sarycheva, both of whom died in 1978.

Richard E. Grant and W. W. Nassichuk led a meeting of the Subcommission in Washington (D.C.), in May 1979, just prior to

meetings of the 9<sup>th</sup> International Congress on Carboniferous Stratigraphy and Geology that was held in Urbana, Illinois. Physical and chemical nature of the Permian-Triassic boundary and the distribution of rocks and fossils in China formed the primary bases for discussion.

Subsequent activities of the Subcommission are covered in the 43 issues of SPS Newsletters/Permophiles published 1979-2003 (many available at <http://pri.boisestate.edu/permophiles/index.html>). This 44<sup>th</sup> special issue is the first and only issue in 2004.

## **FRONT PAGE**

**The photo on the front page symbolically shows Brian F. Glenister carrying on his shoulders the burden of Permian in China**

## **VOLUME DEDICATION**

**This volume of Permophiles is dedicated to Professor Brian F. Glenister in recognition of his immeasurable contributions towards the establishment of the modern Permian Time Scale and the nearly fifty years of leadership in the study of Permian biostratigraphy.**

Of particular note is the leadership role assumed by Brian during and following the 1991 Permian meeting in Perm, Russia. Brian recognized the catalytic significance of the International Congress Permian System of the World hosted in Perm by Russian colleagues. He saw that watershed event as perhaps the last opportunity to provide the geologic community with a widely accepted and scientifically valid Permian Time Scale. During the 13 years following the Perm meeting, he seized the opportunity to lead the Permian community around the endless bickering over "housekeeping details" that mired previous Permian Subcommissions; he envisioned three definable subdivision of Permian System – Lower Permian in Russia, Middle Permian in the American Southwest and Upper Permian in China. The merit and validity of that scheme is now nearly universally accepted by the Permian community and the formalization is well underway.

**To recognize Professor Brian F. Glenister's contributions in this endeavour we provide a collage of field photos taken in Russia, China and the American Southwest.**

**On behalf of the entire Permian community, the outgoing executive Board of the Permian Subcommission takes this opportunity to extend Professor Brian F. Glenister warmest regards and heartfelt thanks.**





# ANNOUNCEMENTS

Second Circular and Registration

for

The International Symposium

on

## Triassic Chronostratigraphy and Biotic Recovery

23-25 May 2005 (Monday-Wednesday)

to be held in

Chaohu City, Anhui Province, The People's Republic of China

For further information of the symposium, excursions, accommodation, travel details and payments, please contact:

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Task Group on Induan-Olenekian Boundary 1

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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 format. Italics, bold, font size are as are tabs assuming you follow the submission rules on page 2). An 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 (not the jpeg or other image type).



# ANNOUNCEMENTS

## **Second Circular THE NONMARINE PERMIAN Albuquerque, New Mexico USA 21-29 October 2005**

Hosted by the New Mexico Museum of Natural History and Science (NMMNH) 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 Subcommission 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 NMMNH 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 Premeeting fieldtrip 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 NMMNH, Albuquerque
- 23-25 October Platform presentations and posters, NMMNH
- 25 October (evening) Banquet
- 26-28 October Postmeeting fieldtrip to northern NM to examine nonmarine red beds and classic 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. Consult S. Lucas for format. All submitted materials need to be in electronic format.

### **FURTHER INFORMATION**

Watch this website for further information. <http://www.nmmnh-abq.mus.nm.us/nmmnh/permianmeet.html>

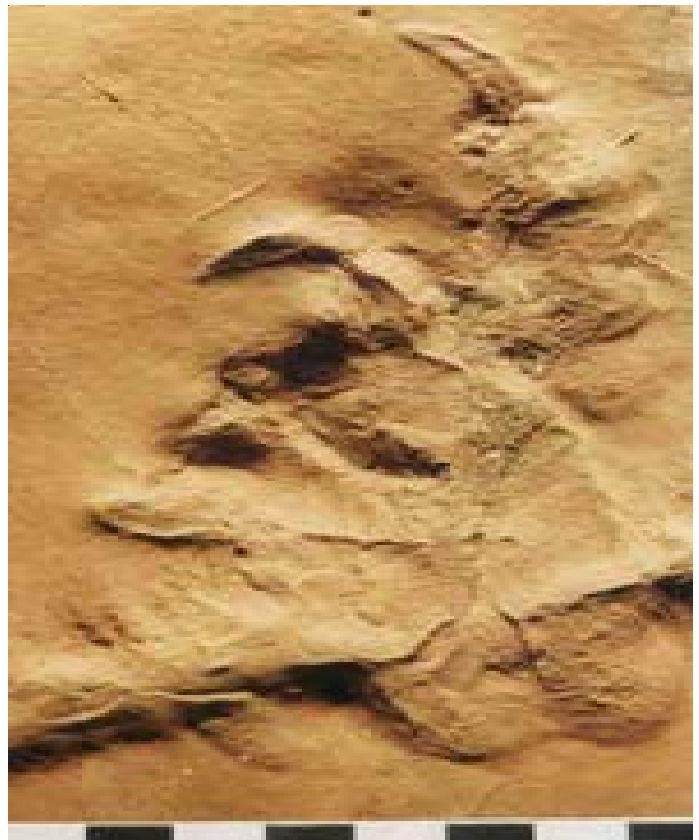
### **PRE-REGISTRATION**

Registration for the symposium will be \$50 USD before 1 May 2005, and \$100 USD after 1 May 2005. Registration for fieldtrips will be possible at the third circular

**REGISTRATION FORM** in Adobe Acrobat PDF format

If you wish to make registration payments by credit card, please consult the following link to our **Online Museum Store**

<http://www.nmmnh-abq.mus.nm.us/nmmnh/permianmeet.html>



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