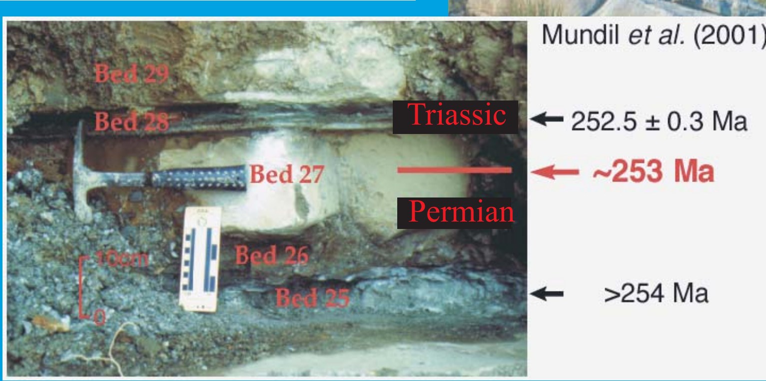
Permophiles

International Commission on Stratigraphy
International Union of Geological Sciences

Newsletter of the
Subcommission on Permian Stratigraphy
Number 39
December 2001



Contents

Cover Photos

Top; Close-up view of the Guadalupian-Lopingian boundary interval at Penglaitan, Guangxi Province, China. Two potential boundary positions at the base of bed upper 6i and base of 6k are indicated by arrows. **Middle**; Blue star is situated within the Laibin Limestone which was deposited as a shallow water lowstand succession with underlying deeper water Maokou to the left. **Lower**; Close-up of Meishan section D and new dates for the P-T boundary (see Metcalfe and Mundil in this issue).

EXECUTIVE NOTES

Notes from the SPS Secretary
Charles M. Henderson

Introduction and thanks

I want to thank those individuals who contributed articles for inclusion in the 39th issue of Permophiles and those who assisted in its preparation. Bruce Wardlaw and I did all of the editorial work for this issue during a hectic 3 days at the USGS in Reston, Virginia. We thank Edward Wilson, Garner Wilde, Gary Johnson, Yasuhito Oto, Gregory Wahlman, and Norman Newell for financial contributions to the Permophiles publication fund in support of this issue. We also thank Sharron Kaser (Department of Geology and Geophysics, University of Calgary) for handling the donations. Continuing publication and mailing of Permophiles requires additional contributions; readers are referred to the last page of this issue. Permophiles is currently distributed to 285 individuals and institutions and donations have not covered the expenses of the past two issues. Please remember to specify Canadian or USA dollars ($25US = $40Can.). Permophiles is recognized by the ICS as an exceptional newsletter and the support of our readers is necessary to maintain that quality.

Previous SPS Meetings and Minutes

The subcommission met during the International Symposium on the Global Stratotype of the Permian-Triassic Boundary meeting at Changxing, China from 7:30 to 9:00pm on August 12, 2001 (Room 511, Jinling Hotel). There were no changes to the composition of the subcommission. The SPS executive includes SPS Chair (Bruce R. Wardlaw), First Vice-Chair (Ernst Ya. Leven), Second Vice-Chair (Clinton B. Foster), and the Secretary (Charles M. Henderson). The individuals in attendance at this meeting included Charles Henderson, Clinton Foster, Jin Yugan, Aymon Baud, Mike Orchard, Tadeusz Peryt, Bob Nicoll, Yuri Zakharov, Shilong Mei, Qi Yuping, Shuzhong Shen, Ian Metcalfe, Wang Zhi-hao, and Wang Cheng-yuan.

The meeting was chaired by Clinton B. Foster (2nd Vice-Chair) and the minutes were taken by Charles Henderson (Secretary). Reports from the various working groups were discussed. Charles Henderson and others discussed the degree of progress regarding the Cisuralian Working Group. This group appears to be lagging behind the progress on the other two series, but some plans are being formulated (see Chair's Report). The base and the top of the Permian have both been ratified. The Middle Permian Guadalupian stages have been ratified. Yugan Jin provided a slide presentation regarding the Guadalupian-Lopingian boundary that was followed by considerable discussion. It was indicated that a vote on the boundary should follow in the near future. Jin *et al.* provide the status of this proposal within a report elsewhere in this issue. Shilong Mei indicated that consensus for the base of the Changhsingian is fast approaching. A brief update by Mei *et al*. can be found in this issue, which outlines a possible position for that boundary. Alternative positions are also provided in this issue by Wang *et al.* Other discussions surrounded the new statutes for the International Commission on Stratigraphy and the push to have all Phanerozoic GSSP's completed by 2008. It was also suggested that the executive consider providing ISSN numbers to Permophiles to provide a better vehicle for citation and to provide an official publication for annual reports and taxon names. There was also a request for the names of all voting members to appear in the next issue. This is provided in the Chair's report. The secretary was directed to take these issues to the Chairman, Bruce Wardlaw. The meeting was adjourned and in a time-honoured tradition the Chair of the meeting, Clinton Foster, provided refreshments. Cheers to Clinton for the much appreciated "cool" refreshments.

Business Arising from the Minutes

During our February meeting Bruce and I decided that I would make an application for ISSN numbers such that our next issue, Permophiles #40 would have such a designation. However, we also decided that we do not wish to see the tone of the newsletter change. The newsletter is an informal line of communication between our various members. It is not a refereed publication. Currently it does not constitute a formal publication for taxon names and we will continue to discourage its use as such a vehicle. Individuals considering the naming of new taxa should really consider a refereed journal such that the taxa are properly scrutinized.

Future SPS Meetings

The next scheduled SPS meetings will be held at the GSA south-central section meeting in Alpine Texas (April 11-12, 2002) and in conjunction with the European Conodont Symposium (ECOS VIII) to be held June 22 to June 25, 2002 at Toulouse and Albi, France. The SPS will conduct a business meeting at the ECOS meeting. Please visit the ECOS site for details: http://www.le.ac.uk/geology/map2/con-nexus/ECOS/ECOS_VIII.html

Future Issues of Permophiles

Issue 40 will be finalized in August 2002 and we request that all manuscripts be sent such that Charles Henderson receives them no later than August 1, 2002. Issue 40 will be compiled at the University of Calgary. Please see the attached note regarding the preferred method of manuscript submission and format. Following the format as closely as possible makes our job of preparing Permophiles easier. Bruce and I ask you to *please follow the format (especially for references)*! Although Permophiles is not an official publication, it is increasingly referred to in many papers, which means that our reports should be professional and address scientific rather than personal issues. The primary function of Permophiles is for discussion of Permian issues so we are always interested in replies to the various contributions. These must also follow the format as outlined elsewhere. A report and list of names of the Cis-Uralian Working Group is requested for the next issue.

Permophiles #38 had a long discussion regarding Kungurian/ Wordian correlations by Kozur *et al*., (p. 15-21) and a short reply by myself in which I indicated a longer reply for the next Permophiles. Instead, both authors have submitted papers to a special issue of PPP related to the Oman conference, which will allow readers to better assess the opposing positions.

Our database is missing a number of e-mail addresses so if you haven't written to me recently I would appreciate receiving a very short e-mail after receiving Permophiles 39 (if you didn't do so after #38 or if any data has changed) so that I can check my records for addresses, phone numbers, and e-mail addresses. Send to henderson@geo.ucalgary.ca.

Notes from the SPS Chair
Bruce Wardlaw

Progress

1. Cisuralian.—New material is being distributed to many of the members of the working group and a formal workshop will be held in November this year to finalize the definitions of those stages that we have proposals for (Sakmarian and Artinskian) and to develop/finalize whatever is necessary to establish the Kungurian. Though the progress of this working group is not apparent to most *Permophiles* readers, it is significant and a full report stemming from the formal workshop will appear in next Winter's issue.
2. Guadalupian.—The formal article for *Episodes* will be distributed to the authors in March for submittal to *Episodes* in April.
3. Lopingian.—Jin, Henderson, and Wardlaw held a very fruitful planning meeting and appear to have settled all issues involving the bases of the Lopingian and Changhsingian. Proposals for both will be distributed shortly.
4. *Permophiles* should be back on track for more regular Winter/ Summer distribution.

Stratigraphic Databases

The Chair of SPS has gotten very involved in stratigraphic databases and has participated in a couple of workshops, taking a prominent roll in developing *Chronos*—interactive chronostratigraphy and stratigraphic databases to produce a dynamic, global timescale to frame Earth history events and processes for societal benefit. The principal goals of *Chronos* system are:
1. Assembly, integration, and distribution of data relevant to geologic time.
2. Maintenance of a consensus geological timescale.
3. Public Outreach—Communicate to public the importance of understanding rates in natural processes using the geological timescale.
4. Research Outreach—Provide a fundamental research tool for geoscience community and a temporal framework for understanding the 4th dimension (rates and processes).

Please contact the Chair if you are interested in this dynamic movement to coordinate and utilize chronostratigraphic information.

SUBMISSION GUIDELINES FOR ISSUE 40

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to my E-mail address followed by hard copies by regular mail. Please only send a single version by E-mail and in the mail; if you discover corrections before the deadline, then you may resubmit, but indicate the file name of the previous version that should be deleted. Manuscripts may also be sent to the address below on diskettes (3.5" or zip disks) 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 (Glenister *et al.*, Permophiles #34, p. 3) for reference style (comma after the date and colon after the title please), format, *etc*. Maps and other illustrations are acceptable in tif, jpeg, eps, bitmap format or as CorelDraw files. The preferred formats for Adobe Pagemaker are Microsoft Word documents and tif files for images. We use Times Roman 12 pt. bold for title and author, 10 pt. for addresses and text, and 10 pt. bold for subheadings (flushright). Indents for paragraphs are .2"; do not do these using the space bar. Word processing documents may include figures embedded at the end of the text, but these figures should also be attached as separate attachments in tif format 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 articles with names of new taxa are not normally published in Permophiles. Readers are asked to refer to the rules of the ICZN. All manuscripts will be edited for consistent use of English only.

I currently use a Windows 2000 PC with Corel Word Perfect 10, Corel Draw 10, Adobe Page Maker 6.5, Adobe Illustrator 9, and Microsoft Office 2000 programs; documents compatible with these specifications will be easiest to work with.

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SUBMISSION DEADLINE FOR ISSUE 40 IS AUGUST 1, 2002

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES

INTERNATIONAL COMMISSION ON STRATIGRAPHY

Annual Report 2001
Subcommission on Permian Stratigraphy

	Series		Stage *GSSP (Tr)
Permian	Upper	Lopingian	Changhsingian
			Wuchiapingian
	Middle	**Guadalupian**	**Capitanian* GSSP**
			Wordian* GSSP
			Roadian* GSSP
	Lower	**Cisuralian**	Kungurian
			Artinskian
			Sakmarian
			Asselian* **GSSP**

1. TITLE OF CONSTITUENT BODY: Subcommission on Permian Stratigraphy, ICS
2. OVERALL OBJECTIVES: To establish a reliable chronostratigraphic timescale for and subdivisions of the Permian and to promote and refine regional correlation.
3. FIT WITHIN IUGS SCIENCE POLICY: To promote an international chronostratigraphy.
4. ORGANIZATION: The SPS has 4 officers, a Chair, a Secretary, and two Vice-Chairs. The subcommission is comprised of 16 voting members and 280 corresponding members from all regions of the world. The officers are listed below and the full list of voting members follows this report.

Chairman: Bruce R. Wardlaw
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5. EXTENT OF NATIONAL/REGIONAL/GLOBAL SUPPORT FROM SORCES OTHER THAN IUGS:
The SPS receives strong support from Russian, Chinese, and American governments and individuals when working on the specific Series and Stages proposed in each country. The marine-terrestrial correlation activity, especially for the Upper Permian receives strong support from European countries, specifically from Italy, Germany, Russia and France. The University of Calgary (Canada) and Boise State University (USA) helped support our operations. Russia and the Kazan government help support efforts for the regional Volga standards for the Middle and Upper Permian and their correlation to the international standard. Individual donors and the U.S. Geological Survey strongly supported the activities of SPS this year.
6. INTERFACE WITH OTHER INTERNATIONAL PROJECTS:

I G C P Project 359: Correlation of Tethyan, Circum-Pacific and marginal Gondwanan Permo-Triassic.
The marine-terrestrial working group of the SPS has a working relationship with the new working groups of the Subcommission on Gondwana Stratigraphy specifically, those under the umbrella of Event Stratigraphy: Floral Correlation, Faunal Correlation, and Physical Correlation with the common aim toward resolution of global correlation of late Paleozoic- early Mesozoic terrestrial and marine sequences.

7. CHIEF ACCOMPLISHMENTS IN 2001:

a. The formal acceptance for the Guadalupian and its constituent stages was achieved and the final write-up for *Episodes* was completed and is now in review.

b. Major breakthroughs were achieved in clearing the taxonomic log-jam that was holding up the formal proposal for the Lopingian (Upper Permian) and its constituent stages (Wuchiapingian and Changhsingian, see *Permophiles* no. 38), and formal proposals are anticipated within the year.

c. Work continues on the Cisuralian (Lower Permian), specifically refined conodont/fusulinid correlations and numeric age dating, and proposals for the Sakmarian, Artinskian, and Kungurian boundaries are making progress.

d. The SPS Special Project "The Permian: from glaciation to global warming to mass extinction" to use detailed biostratigraphy and numerical age dates to create an initial framework for correlating and evaluating global events during the Permian made significant progress this year. Several tuff beds in the Upper Carboniferous and Lower Permian of Russia and Kazakhstan yielded wonderful conodonts and zircons! This special project will help in the development of the Permian GSSP's by providing important stratigraphic, biostratigraphic and numerical age dates to the specific Subcommission working groups.

e. The Subcommission successfully sponsored and participated in North American Paleontological Convention (NAPC) at which it had its formal annual meeting and sponsored and participated in The International Symposium on the Global Stratotype of the Permian-Triassic boundary and the Paleozoic-Mesozoic events and held a working meeting, sponsored and participated in the International Conference on the Geology of Oman, Pangaea Symposium and Field Meeting, and finally, participated in the field conference on the Stratigraphic and Structural evolution on the Late Carboniferous to Triassic continental and marine successions in Tuscany (Italy), regional reports and general correlation.

8. CHIEF PROBLEMS ENCOUNTERED IN 2001:

The printing and publication of the SPS newsletter, *Permophiles*, was switched from Boise State University to the University of Calgary this year. As an interim measure, the USGS published issue no. 37, but issue no. 38 was delayed in setting up the printing procedure at the University of Calgary.

9. CHIEF PRODUCTS IN 2001:

Permophiles no. 37.
Permophiles no. 38.
The Guadalupian and component Roadian, Wordian, and Capitanian Stages as the international standards for the Middle Permian Series, a manuscript in review for *Episodes*.

10. SUMMARY OF EXPENDITURES IN 2001:

The SPS spent $13,000 for calendar year '01
Funding sources included: Boise State University
University of Calgary and local Consortium
Individual donations
Personal donation from the Chair
U.S. Geological Survey
International Commission on Stratigraphy

11. WORK PLAN FOR NEXT YEAR:

- Conduct annual business meeting at ECOS VIII, Eighth International Conodont Symposium held in Europe.
- Sponsor and participate in symposium on the Permian of the Southwest (USA) and lead a field trip on "Middle Permian Stratotypes of the Guadalupe Mountains National Park in conjunction with the South-Central Section, GSA (Geological Society of America).
- Participate in ICS First Conference on Future Directions in Stratigraphy
- Publication of two issues of *Permophiles* (and in a more timely fashion)

12. CRITICAL MILESTONES TO BE ACHIEVED NEXT YEAR:

- Formal Proposal for the base of the Lopingian (Upper Permian) Series and Wuchiapingian Stage.
- Formal Proposal for the base of the Changhsingian Stage.

13. ANTICIPATED RESULTS/PRODUCTS NEXT YEAR:

- Publication of the above mentioned formal proposals.
- Publication of two issues of *Permophiles*.

14. COMMUNICATION PLANS:

It is planned to continue to use *Permophiles* as our major format for open and lively communication and as many international meetings as possible. Work on making all past issues of *Permophiles* available on the internet should be nearing completion.

15. SUMMARY BUDGET FOR NEXT YEAR:

Total……………………………… 13,000

16. POTENTIAL FUNDING SOURCES OUTSIDE IUGS:
    Boise State University
    University of Calgary and local consortium
    U.S. Geological Survey
    Individual Personal Donations

17. REVIEW CHIEF ACCOMPLISHMENTS/RESULTS OVER THE LAST 5 YEARS (PERIOD 1997-2001):

- Formal ratification and publication of "Proposal of Aidaralash as Global Stratotype Section and Point (GSSP) for base of the Permian System" (*Episodes*, v. 21, no. 1).
- Formal ratification of Guadalupian (Middle Permian) Series and its component stages (Roadian, Wordian, and Capitanian) GSSPs.
- Digitization of many past issues of *Permophiles* and establishment of available website at Boise State University, Permian Research Institute (http://pri.boisestate.edu/index.html) under SPS-Newsletter.
- Publication of the bi-annual newsletter *Permophiles* and its steady improvement and circulation. Publication runs were 100 before 1997 and have increased to almost 300 today.

18. SUMMARIZE ANTICIPATED OBJECTIVE AND WORK PLAN FOR THE NEXT 5 YEARS (PERIOD 2002-2006):

- Formal proposal of the Lopingian (Upper Permian) and Wuchiapingian Stage GSSP (2002).
- Formal proposal of the Changhsingian Stage GSSP (2002).
- Formal proposal of the Sakmarian Stage GSSP (2003).
- Formal proposal of the Artinskian Stage GSSP (2003)
- Formal proposal of the Kungurian Stage GSSP (2004)
- Publication of refined biostratigraphy and numerical age dates of the international Permian standard scale and its correlation to regional standards.
- Continue improving and publishing the biannual newsletter in both paper and digital formats.
- Complete digitization of past issues of *Permophiles* (from 1978) so that all are available over the internet.

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REPORTS

Histological features of some Late Permian *Hindeodus*

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Hindeodus parvus has been selected as the index species for the base of the Triassic (Yin *et al*., 2001). However, the abundance of closely related taxa causes a number of taxonomic problems and is particularly difficult with material of poor preservation. For example, a number of subspecies and morphotypes of *Hindeodus parvus* were established (Kozur 1989, Zhu X., Lin L., Zhong Y., 1997 among others), and these taxa have only minor morphological differences. Additional “non-morphological” (*e.g*. histological) features of these taxa may partly help resolve these problems. This article is aimed to provide a histological description of some Late Permian hindeodids, and to detect additional diagnostic features.

Material

Studied conodont samples derived from the Transcaucasus reference sections (Akhura, Dorasham II, Karabaglyar II, Ogbin, and Avush) were transferred to author by Dr. G. V. Kotlyar. The sampled stratigraphic interval comprises the *postbitteri* to *parvus* conodont zones. Hindeodids were recovered from some levels only. The most abundant *Hindeodus* fauna was found in the lowermost Triassic (*parvus* conodont Zone) and in the Lower Dzhulfian (*asymmetrica* conodont Zone).

Methods and terminology

Histology of Pa elements of hindeodids has been studied with optic microscope in reflected and transmitted light under magnification 100x-400x. Images have been taken with digital camera PC Vision-300. Use of immersion liquid (glycerine) enables one to observe details of internal composition of the elements (distribution of hard tissue types) in transmitted light. Specific histological terminology used is explained in Zhuravlev, 2001.

Histological descriptions

Class Conodonta Pander 1856
Order Ozarkodinida Dzik 1976
Suborder Prioniodinina Sweet 1988
Family Anchignathodontidae Clark 1972
Genus *Hindeodus* Rexroad and Furnish 1964

Type species: *Hindeodus cristulus* (Youngquist and Miller) 1949

Pa element of type species is characterized by occurrence of white matter cores in the denticles. Deepest cores are situated in the anterior part of the element, and posterior denticles have small white matter cores (Fig. 1.1). Core of anteriormost denticle is slightly shifted toward the posterior (Figs. 1.1, 2.1). This shift is a feature at the generic level; it occurs in all Carboniferous, Permian, and Triassic species.

Hindeodus excavatus (Behnken) 1975

In the Pa element, white matter composes denticle cores and their roots areseparated by lamellar tissue. The roots are not deep and increased slightly toward the anterior. The anteriormost denticle demonstrates a characteristic shift of the white matter core (Fig. 2.2).

Regular microreticulation texture (MRT) dominates over the element blade, denticles are covered by striation (MRT classification see in Zhuravlev, 2001).

Hindeodus julfensis (Sweet) 1973

The Pa element is characterized by cores of denticles composed of white matter. The cores have rather short roots slightly increasing toward the anterior. The white matter core of the anteriormost denticle is shifted significantly toward the posterior (Fig. 2.3).

Element blade is covered by regular MRT and the anteriormost denticle bears linear MRT grading into striations.

Hindeodus minutus (Ellison) 1941

In the Pa element, white matter composes denticles and their roots in the blade. The roots are separated by lamellar tissue that becomes deeper toward the anterior (Fig. 1.3). The white matter core of the anteriormost denticle shifted toward the posterior (Figs. 1.3, 2.4), however some examples figured by H. Kozur (1978, Taf.VII, figs. 18, 20, 22) demonstrate that a wide core of white matter occupied whole whole denticle.

The blade and upper surface of the basal cup are covered by regular MRT, denticles bear linear MRT grading into striations. Average cell imprint size (for regular MRT) is about 7 um.

Hindeodus parvus parvus (Kozur and Pjatakova) 1976

In the Pa element, white matter composes denticles and their deep roots in the blade. The deepest roots are in the anterior denticles. The anteriormost denticle has the white matter core shifted toward the posterior in the lower part (Fig. 2.5). This species differs from other Late Permian hindeodids by the essential root of the anteriormost denticle core (deep and wide) and it is less different in depth from the other denticle cores. These cores are nearly fused. Average depth of the cores is higher (in relation to the blade height) than in other hindeodids (Fig.2).

The blade is covered by regular to linear MRT grading into striations on the denticles.

Hindeodus parvus erectus Kozur 1996

In the Pa element, white matter composes denticles and their deep roots in the blade. The roots are distributed very close to each other and become deeper toward the anterior (Figs. 1.2, 2.6). The relation of sizes of denticle cores and their distribution are similar to those of *Hindeodus parvus parvus*.

Element is covered mainly by regular MRT excluding the denticles bearing striations.

Hindeodus typicalis (Sweet) 1970

In the Pa element, white matter composes denticle cores and their roots in the blade. The roots are separated by lamellar tissue and decrease in depth toward the posterior. The anteriormost denticle core is shifted toward the posterior (Figs. 1.4, 2.7).

The blade is covered by regular MRT grading into linear MRT and striations on the denticles.

Conclusions

All studied species of *Hindeodus* show a similarity in hard tissue histology and microreticulation textures. However, the *Hindeodus parvus* group can be distinguished by the essential difference between depth and width of the anterior denticle core and the depth of cores of the other denticles. The depth of core roots of the denticles (excluding anterior ones) is rather uniform and the cores are nearly fused. These features can be observed in examples of incomplete preservation (upper part of anteriormost denticle is broken or all the denticles are broken). So, they can help to distinguish the *H. parvus* group from other Late Permian hindeodids, but the Early Triassic *Isarcicella* has similar histological features.

Acknowledgements

The author thanks Dr. G. V. Kotlyar for kind assistance and collection of conodont samples. This work was supported by RFBR grant.

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Zhu X., Lin L., Zhong Y. 1997, The further study of Hindeodus parvus in P\T boundary bed in Northern Jiangxi, and rediscussion of P\T boundary: Journal of Jiangxi Normal University, **21,** p. 1-5.

Zhuravlev, A.V. 2001, Variation in the outline and distribution of epithelial cell imprints on the surface of polygnathacean conodont elements: Lethaia, **34**(2), p. 136-142.

Figure 1. Digital micro-photos of Pa elements of *Hindeodus* (transmitted light, emersion): 1 – *Hindeodus cristulus* (Youngquist and Muller), Lower Carboniferous, Serpukhovian, Pikalevo Quarry, sample PQ4-1; 2 – *Hindeodus parvus erectus* Kozur, Lower Triassic, Induran (*parvus* Zone), Karabaglyar 2 section, sample 441-2; 3 – *Hindeodus minutus* (Ellison), Upper Permian, Dzhulfian, Dorasham 2 section, sample 14-3-1; 4 – *Hindeodus typicalis* (Sweet), Upper Permian, Dzhulfinian (*leveni* Zone), Akhura section, sample 35-11.

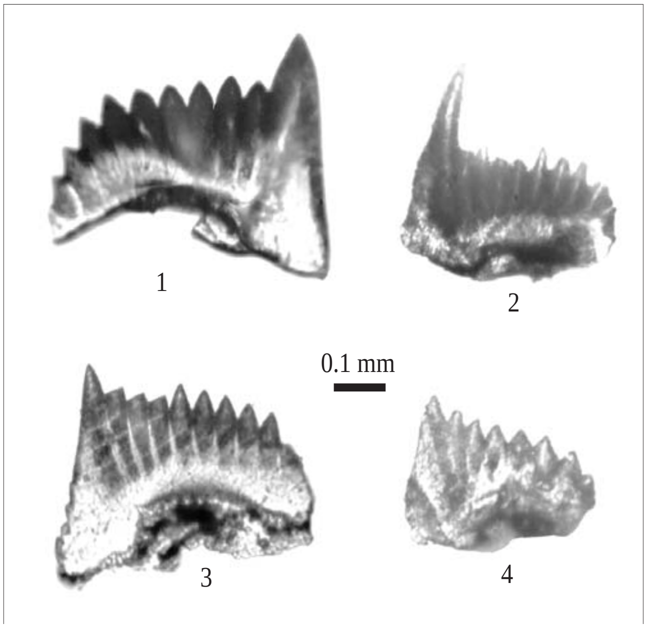
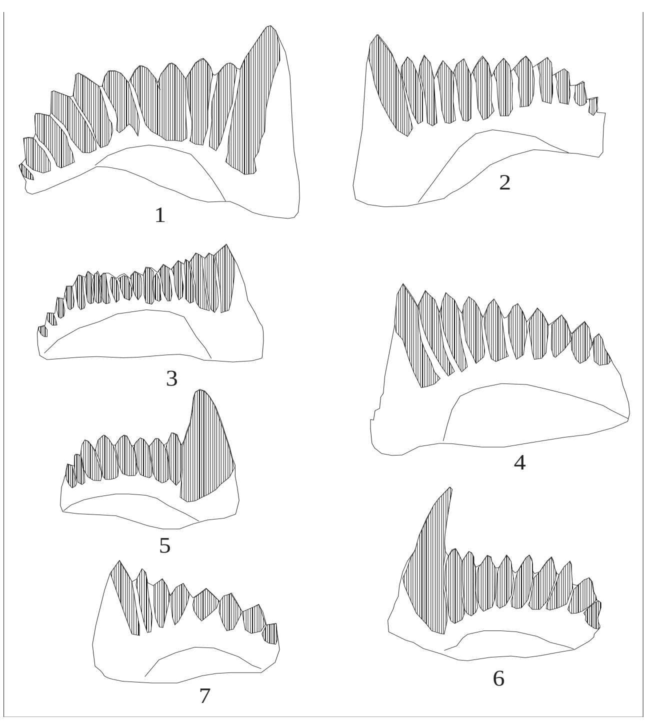


Figure 2. Schematic drawing of hard tissue distribution in the Pa elements of studied hindeodids: 1 – *Hindeodus cristulus* (Youngquist and Muller); 2 – *Hindeodus excavatus* (Behnken); 3 – *Hindeodus julfensis* (Sweet); 4 – *Hindeodus minutus* (Ellison); 5 – *Hindeodus parvus parvus* (Kozur and Pjatakova); 6 – *Hindeodus parvus erectus* Kozur; 7 – *Hindeodus typicalis* (Sweet).



Update on the definition for the base of the Changhsingian stage, Lopingian Series

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In Permophiles #38 we indicated that the base of the Changhsingian could be defined somewhere within beds 3 or 4 at the Meishan section D. Based on new material as well as the refinement of new taxonomic methods for gondolellid taxa, we now indicate that the base of bed 4 at Meishan section D would be a suitable GSSP candidate. The following paragraph is an abstract submitted for presentation at the Geological Association of Canada meeting in Saskatoon in May 2002.

The base of the Changhsingian Stage was formally recommended in 1981 to be defined as the horizon between the *Clarkina orientalis* Zone and the *Clarkina subcarinata* Zone, which is located at the base of Bed 2, the base of the Changxing Formation in Section D at Meishan, Changxing County, Zhejiang Province, China. The present paper suggests that the base of the Changhsingian Stage could be defined within the *Clarkina longicuspidata – Clarkina wangi* lineage based on a refined taxonomic approach. The denticulation in adult Pa elements of *Clarkina* from Bed 2 and below have a cusp that is largely reclined in which the length is 1.5 to 2 times as long as the height of the cusp. Posteriormost denticles are usually considerably reduced and fused with the anterior portion of the cusp to form the lowest and narrowest part of a posteriorly declining carina; they form a wide concave arc in lateral view. This denticulation cannot be substantially differentiated from that of *Clarkina longicuspidata*. *Clarkina longicuspidata* is thus used as a species defined by a population concept to include morphotypes with various platform outlines, but the same denticulation as mentioned above. The denticulation in adult Pa elements of *Clarkina* from Bed 4 to Bed 9 has posterior denticles that are not reduced and a cusp that is not clearly separated from the carina that bears largely fused denticles. The carina in lateral view keeps the same height towards the end of the platform and looks like a high wall. We redefine and apply the names *Clarkina wangi* to the forms with the high, wall-like carina, and *Clarkina subcarinata sensu strictu* to the forms with a similar denticulation to *C. wangi*, but the posterior denticles are usually moderately reduced in height and partially discrete. This gradual phylogenetic species concept completely encompasses the holotype and topotypes of *Clarkina subcarinata* (Sweet, 1973). The transitional forms from the denticulation of *Clarkina longicuspidata* to that of *C. wangi* occur within bed 3. The first occurrence of typical *Clarkina wangi* occurs near the base of Bed 4. We suggest that the base of the Changhsingian be defined by the FAD of *Clarkina wangi* at the base of Bed 4 in Section D at Meishan, Changxing County, China.

A Recommendation: A desirable area and sections for the GSSP of the Changhsingian lower boundary

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Abstract

Current Changhsingian conodont taxonomy is very unstable. Mei *et al.*(1998) named three new species and two new subspecies and recognized six conodont zones for the Changhsingian. Two years later, Wardlaw & Mei (in Jin, 2000a) abandoned these species concepts, and put all Changhsingian gondolellid species into three species based upon a new concept and proposed three conodont zones for the Changhsingian. Their new species concept introduced uncertainty to the conodont taxonomy. The origins of *Clarkina subcarinata* and *C. wangi* are still not clear and *Clarkina changxingensis* cannot be used to define the base of the Meishanian Substage. The situation of the current work on Changhsingian conodonts is too premature. Much more extensive work on Changhsingian conodonts needs to be undertaken before these boundaries are defined.

The Meishan sections are not suitable for establishment of a basal Changhsingian GSSP. The lower part of the Changhsing Limestone contains neither ammonoids nor radiolarians because it is a typical shallow water facies and there is a gap between the Longtan Formation and the Changhsing Limestone. Conodont taxonomy related to the lineage from *Clarkina orientalis* to *C. subcarinata* cannot be solved in the Meishan sections. However, in W. Hubei and W. Hunan, there are many Late Permian deep water facies deposits, yielding abundant conodonts, ammonoids and radiolarians. The boundary strata between the Wuchiaping Formation and Dalung Formation are continuous deposits. The evolutionary lineage from Late Wuchiapingian *Clarkina* to Early Changhsingian *Clarkina* is well represented in this area. Huangyan section in Hubei and Jiangya section in W. Hunan could be desirable sections for selection of the base of the Changhsingian Stage GSSP.

Current situation and problems

Jin (2000c) reported in Permophiles 37 that "The Lopingian and its stages Wuchiapingian and Changhsingian have been accepted as semi-formal units in the new international stratigraphic chart (Remane, 2000). It is important to keep this progress stable and therefore GSSPs for these two stages should be established as soon as possible". However, the current situation of conodont study is too premature to define the base of the Changhsingian

Mei *et al*. (1998) proposed a refined succession of Changhsingian and Griesbachian neogondolellid conodonts from the Meishan section; they named three new species and two new subspecies and recognized six conodont zones for the Changhsingian. More importantly, they reported that the four conodont species, *Clarkina subcarinata*, *C. wangi*, *C. prechangxingensis* and *C. predeflecta*, appeared simultaneously at the base of the Changhsingian (see Text-fig. 1 of Mei *et al.*, 1998). After two years, they abandoned all new species and new subspecies named by Mei *et al.* (1998), as well as the six conodont zones they had proposed. They have now proposed three conodont zones for the Changhsingian and provided new diagnoses for three conodont species. "We pick the point at the first appearance of adult forms with a clearly separate cusp, and partially discrete posterior carinal denticles as the first occurrence of *Clarkina subcarinata* (*sensu strictu*) which is at 13.71m above the base of the Changxing Limestone at Meishan (D)" (Wardlaw and Mei, in Yin *et al*., 2000a).

In 2001, Mei *et al*. (2001a,b) changed the definition and the point for the base of the Changhsingian Stage. In the August paper (Mei *et al*., 2001a) which appeared at the Changxing meeting they concluded that "The first occurrences of *Clarkina wangi* should be somewhere within Bed 3, probably at the base of Bed 3. We suggest that the base of the Changhsingian be defined by the FAD of *Clarkina wangi* in section D at Meishan, Changxing County, China". After a few months, they further concluded that "the first occurrence of *Clarkina wangi* should be somewhere within Bed 3 or Bed 4. We suggest that the base of the Changhsingian be defined by FAD of *Clarkina wangi* in Section D at Meishan, Changxing County, China at a point to be determined very soon."

Comparison of different definitions and points as proposed by Mei *et al.* (1998; 2000a in Yin) and Mei *et al*. (2001a.b) clearly demonstrate that basal Changhsingian conodont taxonomy is far from mature. The definition and the point have changed too often and to quickly to trust them. Their species concept changed several times and it has introduced a level of uncertainty to conodont taxonomy, which demonstrates that it is too premature to define the base of the Changhsingian.

The origins of *Clarkina subcarinata* and *wangi* are still unclear. Nobody has clearly defined the morphocline from the uppermost Wuchiapingian *Clarkina* to Changhsingian *Clarkina.* The major break in fauna parallels the big lithologic change between the Wuchiapingian and Changhsingian. There is a gap between the Wuchiapingian and Changhsingian at the Meishan section. We have to search a continuous Wuchiapingian- Changhsingian section with continuous morphoclines between the uppermost Wuchiapingian *Clarkina* to Changhsingian *Clarkina* and choose the FAD of a well recognizable species as the marker for the base of the Changhsingian. This position should be close to the traditional Wuchiapingian-Changhsingian boundary. The GSSP should rest on a solid taxonomic base.

Jin (2000b) states that the Lopingian Series "is subdivided into the Wuchiapingian and Changhsingian Stage, each of which contains two substages". The Wuchiapingian and Changhsingian basal boundaries have not yet been defined. Two members of the Changhsingian Stage of Chao (1965) were named respectively by Sheng and Jin in 1994 as two substages: the Baoqingian and the

Meishanian. They proposed that the boundary between these two substages was defined by the earliest occurrence of *Clarkina changxingensis* at the base of bed 13 of the D section at Meishan, Changxing. This boundary definition cannot be accepted, because *Clarkina changxingensis* appears very early in bed 10 according to Mei *et al.* (1998) (see Text-fig 1 from Mei *et al.*, 1998), which coincides with or is even earlier than "the first occurrence of *Clarkina subcarinata* (*sensu strictu*), which is at 13.71 m above the base of the Changxing Limestone at the Meishan (D) section", as proposed by Wardlaw and Mei (in Jin, 2000a). Therefore, this definition for the base of the Meishanian substage is of no value (Wang *et al.*,2000).

From the facts mentioned above, it is clear that the definitions for the Changhsingian and its substage, based on conodonts, is currently too premature. Current conodont taxonomy is very unstable. Much more extensive work on conodont taxonomy, especially on the morphoclines from late Wuchiapingian *Clarkina* to Changhsingian *Clarkina* needs to be undertaken prior to such boundary definitions.

Some problems on the Meishan section of Changxing County as the Changsingian basal boundary stratotype.

An obvious gap exists between the Longtan Formation and Changhsing Limestone. Some basal conglomerates are distributed randomly in the lower part of the Changhsin Limestone. Major facies changes occur between the Longtan Formation and Changhsing Limestone. The lower part of the Changhsing Limestone is a shallow water facies deposits; there are neither ammonoids nor radiolarians present. Conodont evolutionary lineages cannot be well studied because the deposits between the Longtan and Changhsing formations are not continuous. For this reason, the correlation potential is poor at present. Mei wants to put the base of the Changhsingian Stage at a horizon about 2 m above the base of the Changhsing Limestone within Bed 3 or 4, but this point has an obvious artificial factor because Mei *et al.* (2001a,b) are trying to establish a so-called golden column (two golden spikes at the same section); they change their taxonomy rapidly for establishment of the basal Changhsingian GSSP at the Meishan section. Below this point there is not enough exposed sequence, as would be necessary for a good GSSP position.

Desirable area and sections for the basal Changhsingian Stage GSSP.

Northwestern Hunan and Western Hubei are the best areas in China for the study of Late Permian conodonts. In these areas, there are typical basinal facies in the upper Dalong Formation or Changhsing Limestone of the Rencunping, Xiaofutou and Jiangya sections. The lower parts of the Dalong or Changhsing formations of these sections have typical basin-margin and slope facies. Both formations conformably overlie the Wuchiaping Formation according to the analysis of Tian (1993b).

In this area many ammonoids and radiolarians as well as foraminifers have been found in addition to conodonts (Tian 1993b, plate II; Chen, 2002 in press), especially in the lower parts of the Dalong or Changhsing formations. This is very important for international correlation and therefore these sections have a great correlation potential. Conodont evolutionary lineage between upper Wuchiapingian and lower Changhsingian can be studied in conodont-rich continuous sections.

Introduction to two sections:

a. Huangyan(Yellow Stone) section. This section is located near the border of Hubei and Sichuan, in Jianshi County of Hubei; it was first studied by Chen Li-de (2002, in press). The 56m thick Dalong Formation is mainly composed of limestone, siliceous limestone and calcareous mudstone. In the basal part of the Dalong Formation, Chen Li-de (2002, in press) has found the Wuchiapingian ammonoids *Konlingites* sp. and *Sanyannites* sp. and the conodont *Clarkina orientalis* (Barskov & Koroleva). In the middle part of the Dalong Formation, the Changhsingian ammonoids *Tapashanites* sp., *Pseudotirolites* sp., *Changhsingoceras* sp. and *Pleuronodoceras* sp. have been found. It can be clearly demonstrated that the base of the Changhsingian Stage should be within the lower part of the middle Dalong Formation in continuous deposits. Chen Li-de believes that the base of the Changhsingian should be within the 2m thick interval between Bed 20 and Bed 26. This section contains abundant radiolarians, but unfortunately they have not been studied. Conodont samples were collected in Dec. 2001 and are currently being processed. The presence of several ash beds in the Dalong Formation, which will allow radiometric age determinations, is very important.

b. Jiangya section. Tian(1993b) has pointed out that the lower part of the Dalong (Changxing) Formation is a typical basin margin and slope facies, containing extremely abundant conodonts (several thousand per kg). He estimated that water depth was 100-150 m in this area. A primary conodont sequence has been established in this area by Tian (1993a,b). The base of the Changhsingian falls within an interval about 4 m thick between beds 15 and 16.This section could provide excellent conodont faunas for the study of conodont evolutionary lineages across the Wuchiapingian-Changhsingian boundary. This section also contains abundant radiolarians and ammonoids (Tian, 1993b).

Common effort

It seems that a group of geologists wants to establish very urgently the GSSP for the base of Changhsingian at the Meishan section before studying any alternative or better sections. They have changed rapidly and frequently their opinion about the position of the base of the Changhsingian before the conodont taxonomy in the Wuchiapingian-Changhsingian boundary interval is well established, and encouraging an urgent premature vote and final decision before basic taxonomic and biostratigraphic work is done in the Wuchiapingian-Changhsingian interval. We hope that all voting members of the Permian Subcommission will consider the current situation of the study for the base of the Changhsingian, especially the deficiencies of the Meishan section for defining the base of the Changhsingian.

The Jianshi County of Hubei and Cili County of Hunan have been officially approved by Chinese state government as "Open Counties", which is legally free for foreign visitors to access and to collect. We welcome all Permian specialists to study these sections we mentioned above, especially Bruce Wardlaw, Charles Henderson, Shilong Mei, and Heinz Kozur; we could jointly study these sections as a common effort. The GSSP could be established in this area in the near future after finishing the conodont and radiolarian studies.

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Age of the Permian-Triassic Boundary and Mass Extinction

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The Global Stratotype Section and Point (GSSP) for the base of the Triassic and hence the Permian-Triassic/Paleozoic-Mesozoic boundary has been formally established and ratified by the International Union of Geological Sciences (IUGS) at Section D, Meishan, Changxing County, Zhejiang Province, China (Yin *et al*., 1996, Yin *et al*., 2001, Tong and Yin, 2001). This boundary is defined by the first appearance of the conodont species *Hindeodus parvus* (Kozur & Pjatakova) in Bed 27c at the Meishan D section and is estimated to have an age of ~253 Ma based on single zircon U/Pb analyses of the bracketing ash beds (see below).

Permian-Triassic transition sequences in South China contain numerous volcanic ash/clay layers, which contain minerals suitable for isotopic dating. In particular the Meishan sections have attracted attention from geochronologists who have attempted to constrain the age of the Permian-Triassic boundary and mass extinction by means of radioisotopic dating including estimates of the tempo of P-T extinction events. The 16 cm thick calcareous mudstone of Bed 27 at Meishan (Figure 1), which contains the biostratigraphically defined Permian-Triassic boundary, is underlain by a 6 cm thick black mudstone (Bed 26) and a 5 cm thick volcanic clay (Bed 25), and overlain by a 4 cm thick volcanic clay (Bed 28). The occurrence of these volcanic layers, closely bracketing the formally defined P-T boundary, and the occurrence of other volcanic ash/clay layers higher and lower in the sequence has made the Meishan and other similar sections in South China prime targets for isotope geochronology work. The main P-T mass extinction level has been recognized at the base of the volcanic clay of Bed 25 at Meishan (Jin *et al*., 2000). This event boundary level (Bed 25 clay) was the first to be dated at Meishan by Claoué-Long *et al.* (1991) who obtained a SHRIMP zircon ^{238}U-^{206}Pb age of 251.2 ± 3.4 Ma. Subsequently, Renne *et al.* (1995) determined an age of 249.9 ± 0.2 Ma (considering internal errors only) for the same layer using $^{40}Ar/^{39}Ar$ on feldspar grains. Bowring *et al*. (1998) published a series of IDTIMS $^{238}U-^{206}Pb$ ages for volcanic ash/clay layers at Meishan, including an age of 251.4 ± 0.3 Ma for Bed 25 and an age of 250.7 ± 0.3 Ma for Bed 28. All of these ages were averaged to determine an age for the P-T boundary of ca. 251 Ma (Yin *et al*., 2001), if the effects of lead loss, xenocrystic contamination for the zircons, and any systematic bias between U/Pb and Ar/Ar isotopic systems is discounted. However, it has been shown that the zircon populations are particularly complex which can only be recognized by the application of single zircon analyses (Mundil *et al*., 2001) whereas multi-crystal analyses tend to yield considerably younger ages. Also, it is imperative that for the averaging of ages from different isotopic systems, systematic errors such as uncertainties on standards and decays constants are considered. There is evidence that there is a systematic bias between U/Pb and $^{40}Ar/^{39}Ar$ isotopic systems with $^{40}Ar/^{39}Ar$ ages being approximately 1-2% too young (Min *et al*. 2000). Yin *et al*. (2001) also quoted new U/Pb SHRIMP ages in their recent *Episodes* overview paper on the P-T boundary GSSP and they attributed these dates to Metcalfe *et al*. (1999). These dates have never been published and were not presented in Metcalfe *et al*. (1999). Yin (2001) has corrected this misquote and we urge all those interested in our new SHRIMP isotopic data to wait for formal publication of the results and not to use the dates presented by Yin *et al*. (2001), which were *preliminary* results presented orally at a meeting in Wuhan.

Our international Australian-US American-Chinese research group has been conducting biostratigraphic, isotope geochronologic, palaeomagnetic and chemostratigraphic studies on marine and non-marine Permian-Triassic boundary sections in China since 1996 (see Metcalfe *et al*. 2001 for details). One result of our study is that isotopic ages reported by Bowring *et al*. (1998) for individual layers from Meishan, appear to be underestimated by as much as 1%. ***The age of the currently defined Permian-Triassic Boundary is estimated by our own studies and a re-assessment of previous worker's data at ca. 253 Ma,*** slightly older than our IDTIMS $^{206}Pb/^{238}U$ age of 252.5 ± 0.3 Ma for Bed 28, just 8cm above the GSSP boundary (Mundil *et al*., 2001). ***The age of the main mass extinction, at the base of Bed 25 at Meishan, is estimated at slightly older than 254 Ma*** based on an age of >254 Ma for the Bed 25 ash. Because the ages from Meishan are complex and sometimes incoherent, these results have to be confirmed by additional radioisotopic-age data from the boundary interval in other places, *e.g*. the Shangsi section (N. Sichuan). Initial U/Pb and 40Ar/39Ar ages confirm our findings and conclusions from the Meishan section. Interestingly, the P-T boundary as defined by *Hindeodus parvus* is 4.5 metres higher at Shangsi than the previously interpreted lithological/event boundary and this position for the boundary is supported by new high resolution IDTIMS $^{206}Pb/^{238}U$ data from the Shangsi section (Mundil *et al.* in prep).

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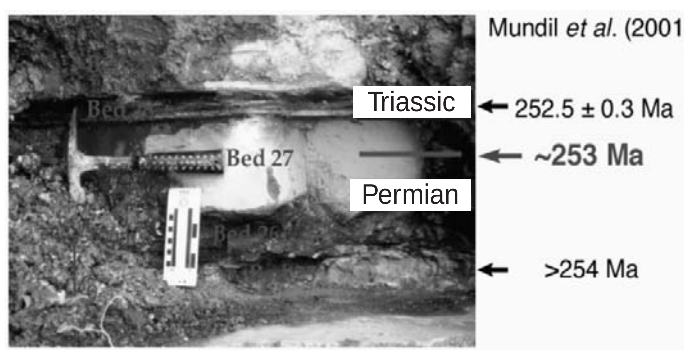
Figure 1. Permian-Triassic boundary beds at Meishan Section D and ages reported by Mundil *et al.* (2001).



Volcanic ashes in the Upper Paleozoic of the southern Urals: Their biostratigraphic contstraints and potential for radiometric dating

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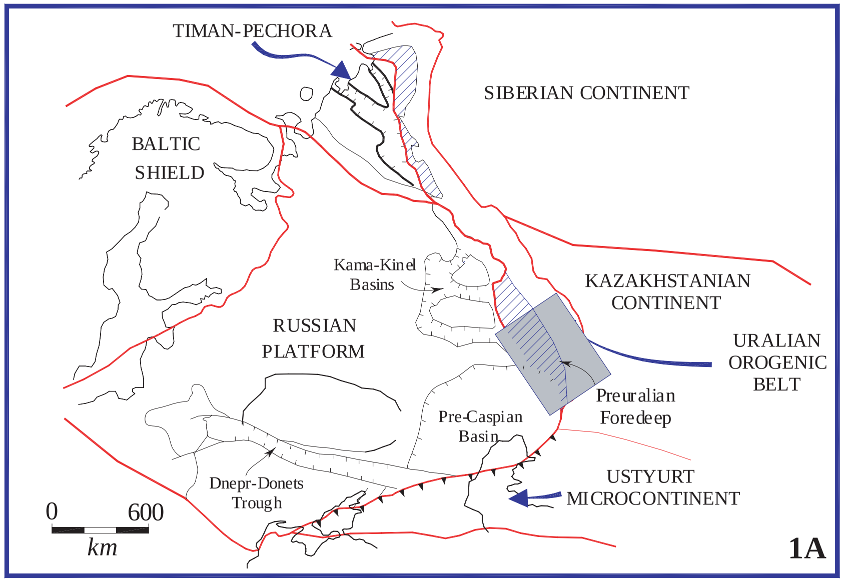
Numerous volcanic ash layers with numerous clear, multifaceted zircons of high optical quality occur within the upper Pennsylvanian and Cisuralian successions of the southern Urals, and most of these ash layers contain abundant radiolaria and well-preserved conodonts. Such ashes have been used routinely elsewhere for radiometric age control, but rarely studied from a paleontologic perspective. Paleontologic investigations have seldom focused on volcanic ashes because: 1) they are a relatively minor component in most stratigraphic sections; and 2) techniques for recovery of micropaleontologic objects from ashes are not well established. Nevertheless, the potential to obtain detailed paleontologic data and precise absolute age control ***from the same stratigraphic horizon*** can provide a powerful tool for understanding process rates in paleobiology, paleoecology, sedimentology and in the rest of geological disciplines.

The study of zircons from the Late Pennsylvanian through early Permian at the stage/substage level using the type sections and principal reference sections in the foreland of the southern Urals in Russia-Kazakhstan offers an unparalleled opportunity for accurate and precise time scale calibration for several reasons. First, the southern Urals contain the Global Stratotype Section and Point (GSSP) for the base of the Permian and this region is a candidate for the GSSP for the Cisuralian and Pennsylvanian stages as well. Regardless of the final outcome of the Pennsylvanian GSSP stage designations, the Russian sections will, at minimum, be critical reference sections for global correlation. Thus, the internationally accepted biostratigraphic *definition* of the Pennsylvanian through Cisuralian (Early Permian) time scale is linked directly to the southern Urals. Second, marine fossils are numerous and well preserved in this region, making detailed multitaxa biostratigraphic control possible. Finally, the late Paleozoic sections of the southern Urals contain numerous interstratified volcanic ash layers, making precise radiometric age control possible. Here, we document the occurrence of conodonts and radiolaria in upper Paleozoic volcanic ash layers of the southern Ural foreland and briefly describe techniques developed to recover these microfossils from volcanic matrix.

Principal tectonic elements within the region are illustrated in Figure 1A, and include: the European continent, consisting of the Baltic Shield, Russian Platform, Timan-Pechora region, Kama-Kinel and Pre-Caspian basins; Uralian Orogenic Belt (including the Pre-Uralian Foredeep); Ustyurt Microcontinent (a paleoTethyan terrane), and the Kazakhstan and Siberian continents. Historically, the Uralian system has been divided into several major fault-bounded longitudinal belts, or megazones. This longitudinal tectonic zonation has been reinterpreted recently to reflect modern terminology (Brown *et al*., 1996). From east to west, the megazones are now regarded as (Figure 1B): accreted arcs and microcontinents including (1) Eastern Uralian Microcontinents, and (2) Tagil-Magnitogorsk Arc; (3) orogenic hinterland (Ural Tau; (4) the Sakmara, and Kraka nappes; foreland fold-thrust belt, including (5) Bashkirian Precamrian basement,); (6) Ordovician-middle Devonian shelf succession; (7) Zilair Series (late Devonian-Mississippian basinal succession); and (8) foredeep basin; and (9) undisturbed Russian Platform.

The Pre-Uralian Foredeep (Figures 1B, 2) was initiated during the Middle Carboniferous, and formed in response to a series of collisions along the eastern margin of the European continent. Collision and accretion involved a combination of arc terranes, and continental fragments (the Tagil-Magnitogorsk Arc, Ural Tau, and Eastern Uralian microcontinent). Overthrusting of the East European continent margin by the tectonic elements of the Uralian Highlands is presumed to have produced a flexural load that created a classic foreland basin, the Pre-Uralian Foredeep. Uralian orogenesis concluded with the collision and suturing of the Kazakhstan and Siberian continents to the EC in Late Permian-Middle Triassic time (Zonenshain *et al*., 1990; Snyder *et al*., 1994). Overall, the Late Carboniferous-Early Permian foredeep shallowed eastward and deepened westward and was broken up into a series of sub-basins (Figure 1B; Snyder *et al*., 1994). Two sub-basins within the southern foredeep have been delineated: the northern Ural (or Uralo-Ikskaya) basin, and the southern Aqtöbe (or Aktyubinsk) basin (e.g., Ruzhencev, 1951; Khvorova, 1961; Chuvashov,1993; Snyder *et al*., 1994). Geophysic data and facies changes suggest the boundary between these two sub-basins most probably are structural (Melamud, 1981). The uppermost Carboniferous through Cisuralian strata of the Aqtöbe sub-basin are predominantly clastic, consisting of micritic siltstone, fine to coarse allochemic sandstone, and conglomerate units (Khvorova, 1961; Snyder *et al*., 1994). Correlative units in the Ural sub-basin include predominantly carbonate dominated strata, consisting of silty micrites, allochemic wackestone-packstone-grainstone packages, floatstone and rudstone. Abundant fossil faunas are present in the wackestone-packstone-grainstone packages (Figure 2). The southern Pre-Uralian Foredeep is bounded to the north by the



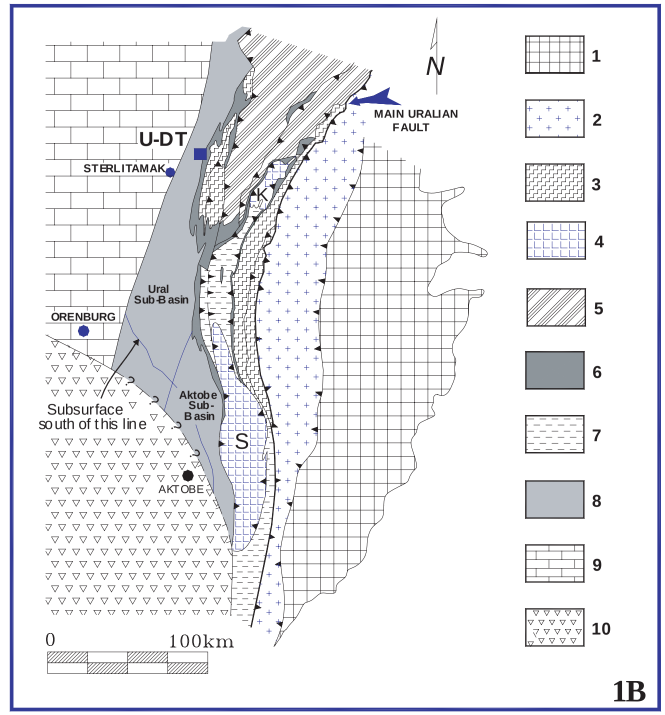


Figure 1. Structural elements of Eurasian Pangea (1A) and southern Urals (1B). Shadow box on 1A - southern Urals enlarged in figure 1B. **Accreted terranes:** 1 - Eastern arc/ microcontinent; 2 - Tagil-Magnitogorsk arc; 3 BUraltau; Foreland; 4 - Oceanic nappes (S- Sakmara, K - Krakau); **Fold-Thrust belt**: 5 - Precambrian basement (Bashkirian anticlinorium; 6 - Ordovician-middle Devonian shelf succession; 7 - Zilair Series (Late Devonian-Mississippian basinal succession); 8 - Pre-Uralian foredeep (Pennsylvanian-Triassic); 9 - Russian Platform; 10 - Pre-Caspian Basin. U-DT (black box in the upper center) B location of the studied sections.

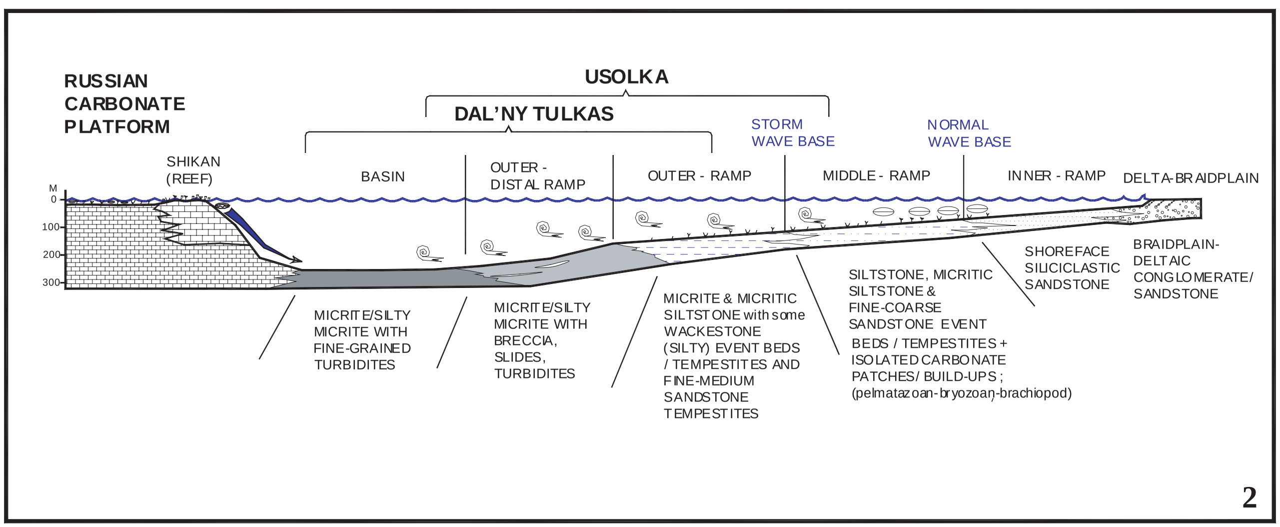


Figure 2. Southern Pre-Uralian foredeep basin model, late Pennsylvanian-Cisuralian. Mixed carbonate-siliciclastic setting.

Karatau Fault and widens southward where the foredeep strata become covered by Mesozoic/Cenozoic strata and merge in the subsurface with upper Paleozoic strata of the Pre-Caspian Basin (Figure 1B).

Volcanic ash horizons are widely distributed in the southern Ural foreland, and are present in many of the classic late Paleozoic sections of the region. Most ash layers are easily recognized in the field because of their striking colors, including yellow-brown, red-brown and various shades of green. Their thickness varies from 1 to 20 cm. Both lower and upper contacts of volcanic ash layers are sharp, generally planar, and can be clearly determined. The tuffaceous material is altered and poorly consolidated, making them weather recessively relative to the surrounding clastic and carbonate strata. Most of volcanic ash layers have a distinctive soft, soapy texture. The most probable volcanic source for the ash layers in the southern foredeep is the eastern part of Tagil- Magnitogorsk arc, where Permian dikes and hypabyssal silicic and alkaline intrusions cut marine Visean and Serpukhovian sediments (Chervyakovsky, 1978; Mizens, 1997). Thin but widespread air-fall volcanic ash layers form potentially important stratigraphic markers in the offshore facies of the Pennsylvanian- Cisuralian of the Preuralian Foredeeep Basin. Preservation of volcanic ash in the southern Pre-Urals was strongly influenced by depositional environment. Specifically, volcanic ash deposited in relatively deep environments (middle ramp, outer ramp, basin) had a high preservation potential. Ash beds deposited at inner ramp positions were highly affected by reworking and erosion.

As a part of ongoing research in the southern Urals, we have systematically sampled several key sections in the region for multitaxa paleontology. Our sampling strategy included the collection of volcanic ashes for radiometric age control. However, during the processing of relatively small (1.0-1.5 kg) preliminary ash samples for zircon recovery, we noted the presence of well-preserved conodonts in many samples. Consequently, we began to empirically derive methods that would allow simultaneous recovery of zircons and micropaleontologic materials from the ashes. We collected volcanic ash beds within mid-ramp carbonate as well as offshore mixed carbonate-siliciclastic successions in three sections: 1) Usolka, 2) Dal'ny Tulkas Road Cut, and 3) Dal'ny Tulkas Quarry (Figures 1B, 3, 4).

First, the surface of volcanic ash beds were cleaned to avoid contamination from loose surficial material (Figure 3A). Next, about 10-15 kilogram (sometimes up to 30 kg) of volcanic ash material was carefully collected with shovel and/or ice axe. We used large plastic bags to hold the collected material to prevent contamination. Field processing was conducted to reduce sample weight and volume, and create a preliminary concentrate. Most of the material in the ash horizons has weathered to various clay minerals (up to 80-90 %). Each sample was placed in a 15-gallon plastic tub with clean water. The water was carefully taken from the Usolka River to avoid any suspended contaminate material. Samples were then worked by hand to disintegrate lumps and generate a suspension of clay in the water. Clay rich water was decanted out and the tub was refilled with fresh clean water. This step was typically iterated three to four times per sample. After most of the clay was washed out, samples were wet sieved with # 4 (5 mm) and # 30 (0.6 mm) sieves. At this point, samples mass was usually reduced to 2-8 kg. Samples were then placed in labeled plastic buckets. Diluted 10-15% acetic acid was added to remove all dissolvable (perhaps primarily carbonate) material. To avoid possible loss of material due to sometimes-vigorous reaction, we added acid with great care. Samples were left in the acid bath for approximately one day and then washed with fresh water. Sample weights were commonly reduced to 1-5 kg, depending on the carbonate component in each sample. Next, an initial density separation was conducted using a 14-inch gold pan. Relatively high-density material was concentrated until samples were reduced to 0.3-0.5 kg. Samples were then air-dried and placed into labeled ziplock plastic bags for transport to the lab.

Initial processing in the lab commonly included a second 10-15% acetic acid bath for 3-5 days. After the reaction stopped completely, liberated clay was washed from the samples. After the second acid bath, sample weights ranged from 0.1 to 0.4 kg. Next, samples were placed in an ultrasonic bath to further disintegrate polygranular aggregates. Each sample was placed with clean water into a glass container and exposed to the ultrasonic agitation for one to three days. Clay and other light fractions were decanted periodically and replaced with clean water until no additional clay suspended material was generated. At this stage, sample weights were reduced to 0.01 to 0.1 kilogram. Fe-bearing minerals were then

Figure 3. Volcanic ash bed at the D. Tulkas quarry section, bed 17.9 mab (A) and heavy mineral fraction laden with conodonts recovered from this ash bed (B).

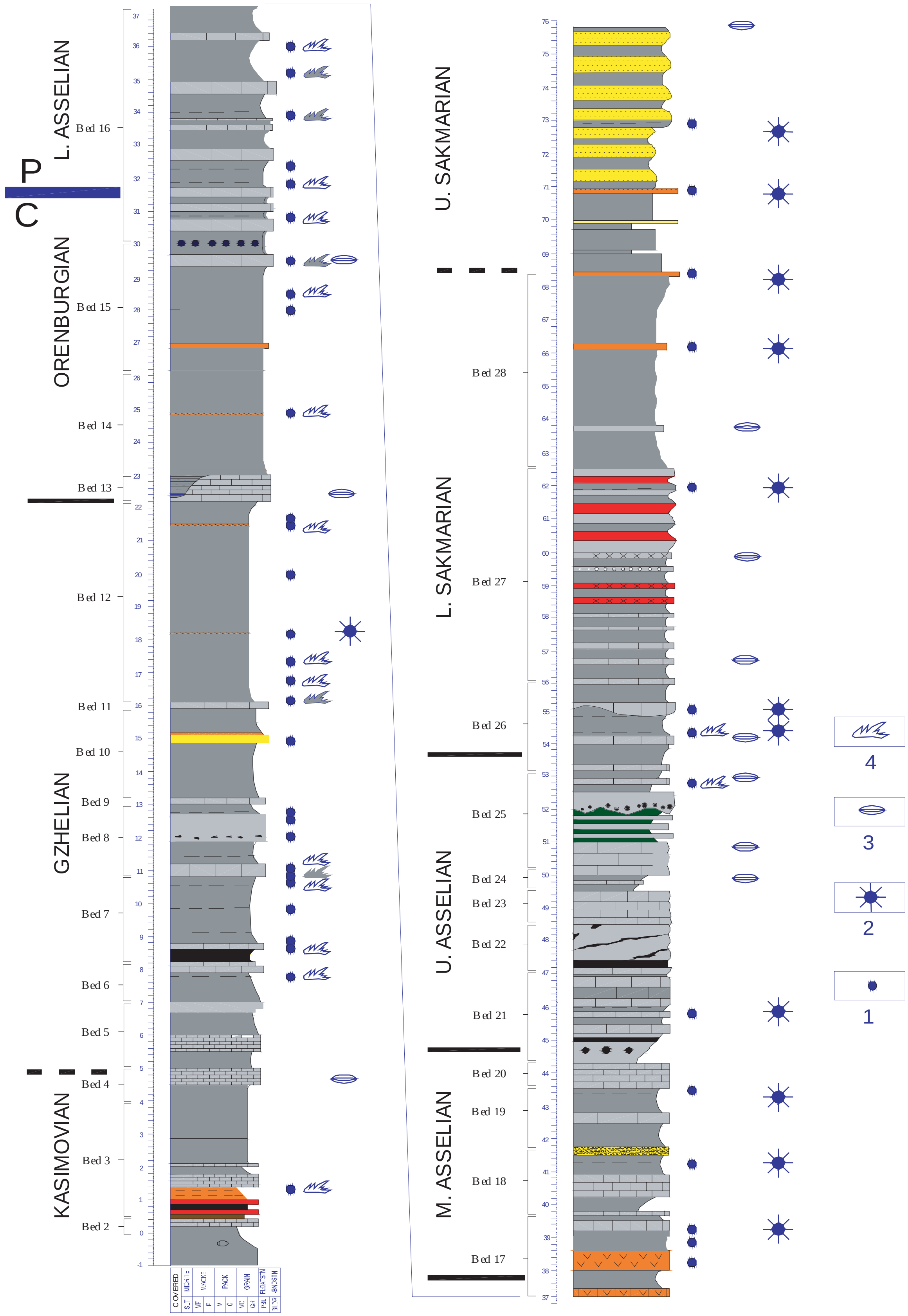


Figure 4. Distribution of fusulinids and volcanic ash beds and the ash bed's contained microfossils (conodonts and radiolaria) in the Usolka section. Bed numbers and biostratigraphic subdivision of the section are given according to Chuvashov *et al*., 1993 and our new data. 1 volcanic ash; 2 radiolaria; 3 fusulinids; 4 conodonts. Conodont symbols with shadow pattern represented volcanic ash beds with rare conodonts; whereas symbol with no shadow indicates abundant occurrence of conodonts in the volcanic ash beds. For more details see table 1.

removed from the samples using a Franz magnetic barrier separator. Because our target minerals zircon, apatite (conodonts) and silica (radiolaria) have low magnetic susceptibility, they were concentrated in the relatively non-magnetic fraction. Magnetic separation usually reduced sample weights to 5-50 g. The final step of processing was density separation using standard heavy liquid techniques. We used non-toxic lithium heteropolytungstates at a working density of 2.85 g/mL. After heavy-liquid separation, the weight of the relatively heavy fraction averaged 2-3 g.

After processing 61 samples, we found well-preserved conodonts in many (Table 1). In fact, conodonts in several samples were so numerous that the concentrates were essentially “conodont sands” (*e.g*., Figure 3B). 18 samples contain abundant conodonts, 14 samples contain enough conodonts (20 to 100 specimens) to get taxonomically reliable identification, and 7 samples contained rare to very rare conodonts. In addition, abundant radiolaria were found in 22 samples; however, their preservation was usually poor.

Although current and further biostratigraphic investigation of the studied section is underway for most of the Pennsylvanian and Cisuralian stage boundaries they are already well-constrained biostratigraphically (Chuvashov *et al*. 1993, 2001; Chernykh & Ritter, 1997). They potentially could be and, we hope, will be precisely constrained radiometrically. Numerous clear, multifaceted zircons of high optical quality were found in many samples after we processed volcanic ashes collected this year in the Urals. An ash layer in the Usolka section immediately above the C/P boundary (32.4 metres above base; MAB) contains the conodont *Streptognathodus isolatus* - the index species of the base of the Permian (Chernykh *et al*., 1997).

We plan to perform high-precision U-Pb zircon geochronology from these samples. Isotopic compositions will be determined using isotope dillution B thermal ionization mass spectrometry (ID-TIMS) in the geochronology laboratory at Massachusetts Institute of Technology under supervision of S. A. Bowring. We anticipate analyzing as many as fifteen individual zircon fractions from each sample in order to clearly resolve the isotopic systemmatics of the zircons and obtain the high-precision (+/- 0.25 B 0.5 Ma) age determinations needed for a robust calibration of the timescale.

Uralian volcanic ash samples potentially provide the opportunity to analyze K/Ar and ^{40}Ar/^{39}Ar isotopic systems. The other mineral separates from these samples, except zircon, contain crystals of volcanic K-spars (i.e. feldspar, orthoclase/microcline, sanidine etc.), and possibly hornblende.

The authors wish to express their appreciation to the BSU student Dustin Sweet who described and measured Dal’ny Tulkas and Dal’ny Tulkas Quarry sections and greatly assist in the entire field work; students of Uralian Mining Institute Katrin V. Likhacheva and Maria P. Titova thanks for their filed assistance. This project supported by National Science Foundation grant EAR 0106796.

Conclusions

1. Ash layers in the southern Urals are a potentially important source for micropaleonological objects such as conodonts and radiolaria, in addition to their value as zircon/plagioclase bearing and radiometrically datable horizons. The combination of both increases the global significance of Pennsylvanian and Cisuralian sections in the southern Urals.

2. Out of 61 ash layers collected, 18 contained abundant conodonts, 14 contained 20 to 100 conodont specimens, 8 contained rare to very rare conodont specimens. Abundant radiolaria were found in 22 samples; their preservation, however, was usually poor.

3. Discovery of ash layers with conodonts, radiolaria, and radiometrically dateable minerals (i.e. zircons and K-spars) in the Penn sylvanian and Cisuralian type sections in southern Urals provide an exceptional opportunity to develop a well-constrained numerical time scale and Graphic Correlation Composite Standard Section for the Pennsylvanian-Cisuralian geological time period and to examine rates of geological and paleobiological processes in the late Paleozoic.

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USOLKA SECTION								
Age	**Sample No.**		**MAB total**	**Ash layers**		**Zircon**	**Fossils**	
				Thickness	Color	quantity	type	quantity
Moscovian	1	01DES461	(-) 6.3 mab	10-12 cm	yellow	P	Co	M
Kasimovian	2	01DES481	1.25 mab	15-20 cm	yellow	P	Co	A
Gzhelian	3	01DES31	7.8 mab	~5 cm	brown	P	Co	A
	4	01DES32	8.6 mab	15 cm	brown	P	Co+ Rd	M
	5	01DES41	8.85 mab	5 cm	green-gray	P	Co+ Rd	N
	6	01DES42	9.85 mab	10 cm	green-gray	P	Co	N
	7	01DES43	10.65 mab	11 cm	green-gray	P	Co	A
	8	01DES51	10.8 mab	8 cm	yellow	N	Co	R
	9	01DES52	11.0 mab	2 cm	yellow	R	Co	A
	10	01DES63	12.0 mab	8 cm	orange	P	Co	R
	11	01DES71	12.6 mab	2 cm	light grayish	N	Co+ Rd	N
	12	01DES73	12.75 mab	5 + 2 cm	orange	P	Co+ Rd	N
	13	01DES81	14.9 mab	10-15 cm	orange	P	Co+ Rd	N
	14	01DES82	16.15 mab	4 cm	orange	P	Co	R
	15	01DES101	16.75 mab	5 cm	orange	P	Co+ Rd	A
	16	01DES111	17.3 mab	3 cm	light orange	R	Co	A
	17	01DES112	18.2 mab	1 + 3 cm	dark orange	P	Co+ Rd	N
	18	01DES113	20.0 mab	2.5 cm	orange	R	Co+ Rd	N
	19	01DES121	21.45 mab	4 cm	orange+white	P	Co	M
	20	01DES122	21.65 mab	5 cm	orange+white	P	Co+ Rd	N
Orenburgian	21	01DES132	24.9 mab	5 cm	light yellow	R	Co	A
	22	01DES133	28.0 mab	2.5 cm	orange+white	P	Co	N
	23	01DES141	28.5 mab	3 cm	orange	R	Co	A
	24	01DES143	29.5 mab	1 + 3 cm	orange	P	Co	R
	25	01DES144	30.8 mab	4 cm	dark orange	P	Co	A
	26	01DES151	31.8 mab	4.5 cm	orange-brown	R	Co	M
Asselian	27	01DES194	32.4 mab	1 cm	light orange	P	Co+Am	A
	28	01DES195	33.9 mab	5 cm	dark orange	P	Co	R
	29	01DES201	35.2 mab	4 cm	orange	R	Co	R
	30	01DES202	36.0 mab	2 cm	brown orange	P	Co	M
	31	01DES203	38.25 mab	4 cm	cream-beige	P	Co+ Rd	N
	32	01DES204	38.85 mab	4.5 cm	white	P	Co+ Rd	N
	33	01DES211	39.25 mab	2-3 cm	light orange	N	Co	R
	34	01DES212	41.25 mab	2 cm	white	P	Rd	A
	35	01DES213	43.45 mab	8-10 cm	gray-green	P	Rd	A
	36	01DES221	45.8 mab	6-8 cm	gray-green	N	Rd	A
	37	01DES225	52.8 mab	4 cm	gray-brown	N	Co	A
	38	01DES231	54.35 mab	3-4 cm	brown-tan	P	Co+ Rd	M+A
	39	01DES232	55.05 mab	5-7 cm	brown	P	Rd	A
Sakmarian	40	01DES241	62.0 mab	4-5 cm	l. brown-orange	P	Rd	A
	41	01DES242	66.2 mab	2 cm	orange-yellow	P	Rd	A
	42	01DES243	68.4 mab	3 cm	orange-yellow	N	Rd	A
	43	01DES251	70.9 mab	1-2 cm	light orange	P	Rd	A
	44	01DES252	72.9 mab	1 cm	light orange	N	Rd	A
	45	01DES253	92.5 mab	10-12 cm	white-greenish	N	Co+ Rd	N

Table 1. Distribution of zircons, conodonts and radiolaria in the studied sections. **Mab** - metres above the base of section; thick volcanic ash beds (>10 cm) shown in bold. Minerals and microfossils recovered from volcanic ash beds: **A** B ammonoids, **C** B conodonts, **R**-radiolaria; quantitative characteristic of microfossils and zircons: **N** B none, **P** B presence, **R** - rare (< 10 specimens), **M** - many (> 10 < 100 specimens), **A** - abundant (> 100 specimens).

D. TULKAS QUARRY SECTION								
Age	Sample No.		MAB total	Ash layers		Zircon	Fossils	
				Thickness	Color	quantity	type	quantity
Moscovian	1	01DES332	2.26 mab	3-4 cm	orange	P	Co	A
	2	01DES341	3.95 mab	4-6 cm	orange	P	Co	R
	3	01DES343	6.28 mab	5 cm	orange	P	Co+ Rd	N
	4	01DES351	12.4 mab	3-5 cm	orange	P	Co+ Rd	N
	5	01DES362	17.9 mab	3 cm	orange	P	Co	A
Kasimovian	6	01DES363	19.7 mab	5-8 cm	pramge	P	Co	A
	7	01DES371	20.25 mab	7-9 cm	orange	P	Co	A
D. TULKAS SECTION								
Artinskian	1	#905	10.5	2-3 cm	white, yellowish	P	Rd	A
	2	01DES403	12.5 mab	5-6 cm	white, yellowish	P	Rd	A
	3	#908	18.5 mab	5-6 cm	white, yellowish	P	Rd	A
	4	01DES411	24.5 mab	15-18 cm	white, yellowish	P	Rd	A
	5	01DES412	27.0 mab	7-8 cm	white, yellowish	P	Rd	A
	6	01DES413	28.7 mab	5 cm	white, yellowish	N	Rd	A
	7	01DES414	34.4 mab	12-15 cm	white, yellowish	N	Rd	A
	8	01DES421	37.5 mab	12-15 cm	white, yellowish	N	Rd	A
	9	01DES422	43.7 mab	5-7 cm	yellow-orange	N	Rd	A
	10	01DES425	98.4 mab	10 cm	tan	N	Rd	A
	11	base of G1	113.5	3-5 cm	white, yellowish	R	Rd	A
	12	01DES434	120.5 mab	15-16 cm	orange	N	Rd	A
	13	22 mab #G2	140	3-5 cm	white, yellowish	R	Rd	A
	14	5 mab #G4	147.5	10-12 cm	white, yellowish	P	Rd	A

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Paleobotany of the Upper Carboniferous/Lower Permian of the Southern Urals. Part 3. Generative organs of gymnosperms

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The present report includes preliminary notes on the oldest known generative organs of pteridosperms belonging to the Peltaspermales order. The material originates from the Upper Carboniferous (Gzhelian) and Lower Permian (Asselian and Sakmarian) of the Southern Urals (see previous notes: Naugolnykh, 1999, 2000). Some additional remarks on associated seeds are given as well.

The collection studied is kept at the Geological Institute of Russian Academy of Sciences (GIN RAS) under number 4856.

OBSERVATIONS

***Peltaspermum* sp.** (Fig. 1, A; Fig. 2, A). Seed-bearing (ovulate or =ovuliferous) discs (peltoids) with six radial sectors. Each sector bears radially elongated seed scar. Disc margin has six lobes corresponding to the radial sectors. Disc size is 5x4 mm.

There is a single almost complete disc. The disc is radially symmetrical, slightly deformed, exposed by its adaxial surface. The marginal lobes of subtriangular form, but sometimes can be rounded. Maximal width of the lobe is 1.2 mm. Four lobes are preserved completely; two lobes show only their proximal parts.

Small conic uplifting is present at the disc centre. The uplifting corresponds to the disc stalk attached to the adaxial surface of the disc, but not preserved.

Each radial sector bears round or ovoid seed scar, occupied considerable part of the sector.

Judging from the scar outlines, partly repeat outlines of the formerly attached seed, the seeds were similar, if not identical, to the seeds of *Cordaicarpus*-type without sarcotestal wings, previously described from the same locality (Naugolnykh, 1999, Fig. 1, B, D).

The ovuliferous disc described above and determined in open nomenclature as *Peltaspermum* sp. is different from other known species of *Peltaspermum* in the very small number of the radial sectors and subsequently in the smaller number of seeds. Most probably, the disc should be described as a new species of *Peltaspermum*.

Remarks. Up to the present day the most ancient find of the true peltasperms with radially symmetrical seed-bearing discs was *Peltaspermum retensorium* (Zalessky) Naugolnykh and Kerp 1986. This species is characteristic for Kungurian and, probably, Artinskian of the Middle and Southern Urals. However, sterile leaves of callipterids, very similar to the fronds of *P. retensorium* are widely spread in considerably older deposits of Northern hemisphere, e. g. Rotliegend of Europe and synchronous strata in North America, which are as old as Asselian and Sakmarian.

It is assumed that the female generative organs *Autunia milleriensis* Krasser are associated with these callipterid fronds there (Kerp, 1982, 1988). Occasionally true peltoids (radially symmetrical ovuliferous discs) are found together with typical callipterid fronds in Lower Permian (Asselian-Sakmarian) assemblages in Europe and northern part of Africa (Aassoumi, 1994), and Central Asia (Bykovskaya, 1988, and personal communication).

Our seed-bearing disc *Peltaspermum* sp. from the uppermost Carboniferous (Gzhelian) of the Cis-Urals most probably belongs to a peltaspermalean pteridosperm with callipterid foliage. Callipterids *Callipteris conferta* (Sternberg) Brongniart (*Autunia conferta* sensu Kerp, 1988) and some other related species can be found rarely in the Upper Carboniferous of N. America (Dunkard Formation) and Europe. The assignation of the sterile callipterid fronds from the Upper Carboniferous and Lower Permian of the northern hemisphere to Peltaspermales is quite realistic. Therefore, the paleontologically documented history of peltasperms, very advanced pteridosperms, or so-called "seed ferns" can be traced into the Late Carboniferous.

Locality: Aidaralash, layer 17/2, Kazakhstan; Upper Gzhelian.

***Permotheca* sp**. (Fig. 1, B; Fig. 2, B). Male generative organ of pteridosperm belonging to Peltaspermales. This remain is a synangium that consists of three preserved sporangia. Sporangia are almost free and connected by their margins only at their basal parts. Length of the sporangia is 5-6.5 mm; maximum width is 2 mm. Thus, the sporangia are relatively narrow, and they are different in this character from other known Lower Permian representatives of *Permotheca*. The sporangia are of prolonged elliptical form with slightly acute apexes. Maximal width is located near sporangial apex. Surface of the sporangia bears fine spiral ribs and furrows (axis of the spiral direction is long axis of the sporangium). The relief of the sporangial surface is due to well developed spirally arranged long epidermal cells, very typical for representatives of *Permotheca* (see, for instance, Krassilov et al., 1999) and male fructifications of some other primitive gymnosperms (*Arberiella*). Besides the relief formed by the numbers of epidermal cells, there are one or two wide and deep folds on each sporangium. These folds probably correspond to sporangial opening for depollination. One can see an ovoid scar located at the base of the synangium. The regular form of the scar supports the idea it was formed by special layer of cells adopted for pollen sacs (sporangia) separation. Scar length is 2 mm, width – 1 mm. Similar scars of the attachment of sporangial head (synangium) to the stalk of the fructification (male cone) were recorded for other peltasperms (i.e., *Peltaspermum retensorium*; Naugolnykh, Kerp, 1996, fig. 7, A).

Locality: "Sim", Sim City, Bashkortostan, Russia; Upper Sakmarian.

There is one male fructification, represented by one small fragment (Fig. 3, A). The fructification belongs to another type, and, most probably, of Trigonocarpalean affinity. Poor preservation of the fragment doesn't allow this remain be studied properly.

Additional observations on isolated seeds

Isolated seeds of the localities studied (Aidaralash section) were briefly described and discussed in the previous report (Naugolnykh, 1999). During the last two years some new material of this kind has appeared. New findings are preliminarily and characterized below as three different morphotypes, without giving any Latin names.

Morphotype 1 (Fig. 3, C). Platyspermic seeds of small size (from 4 up to 10 mm long) and rounded or elliptical outlines. Spermoderma smooth. Seed scarlet is located at the centre of basal ("ventral") part of the seed. The scarlet is small, difficultly observed. The scarlet is slightly uplifted, sometimes can be surrounded by two narrow laminas (septa) located along the main plane of the seed. Two small wings are present. They symmetrically surround the micropyle.

Remarks. Seeds of this kind were found in the Sakmarian only, *e.g.* in Kozhim-1 locality (Pechora Cis-Urals, Lower Kosjinskian Subsuite, Kosjinskian Suite) and in Kondurovka and Sim localities. It is quite possible, that this distinctive morphotype of the isolated seeds can be regarded as an index-fossil for the Sakmarian of the Cis-Urals.

Very similar seeds were described as *Diceratosperma* Andrews (1941) from the Lower Permian of the Northern America. Most probably, the American specimens of *Diceratosperma* and the seeds briefly characterized above can belong to one and the same group of gymnosperms. Andrews believed that *Diceratosperma* belonged to the plant with *Dichophyllum* Elias leaves. Very similar leaves are known from the Permian of the Cis-Urals, where they traditionally attributed to *Mauerites* Zalessky (probably, older synonym of *Dichophyllum*).

Locality: Aidaralash, layer 16/1, Gzhelian

Morphotype 2 (Fig. 3, B). Small seeds 3.5 mm long and 2 mm wide with ovoid outlines and acute prolonged micropylar part. The most completely preserved specimen is broken up along its axis, therefore some inner structures can be observed.

The outermost layer is relatively thick (up to 0.7-0.8 mm) and should be regarded as an integument. At the apical part of the seed the integument forms a tube-like structure. The next, inner structure is separated from the integument by free space ("perinucellar space"). The structure is fusiform, with long, spine-like apex. Inside the apex the sagittal channel is located. This fusiform structure can be interpreted as a nucellus.

There is one more inner structure inside the nucellus, disposed at the nucellus basal part. It has ovoid outlines and probably is a megasporal membrane with embryonic tissue inside.

A small band of conducting tissues goes into the basal part of the seed and forms the small halaza.

Locality: Aidaralash, layer 16/1, Gzhelian.

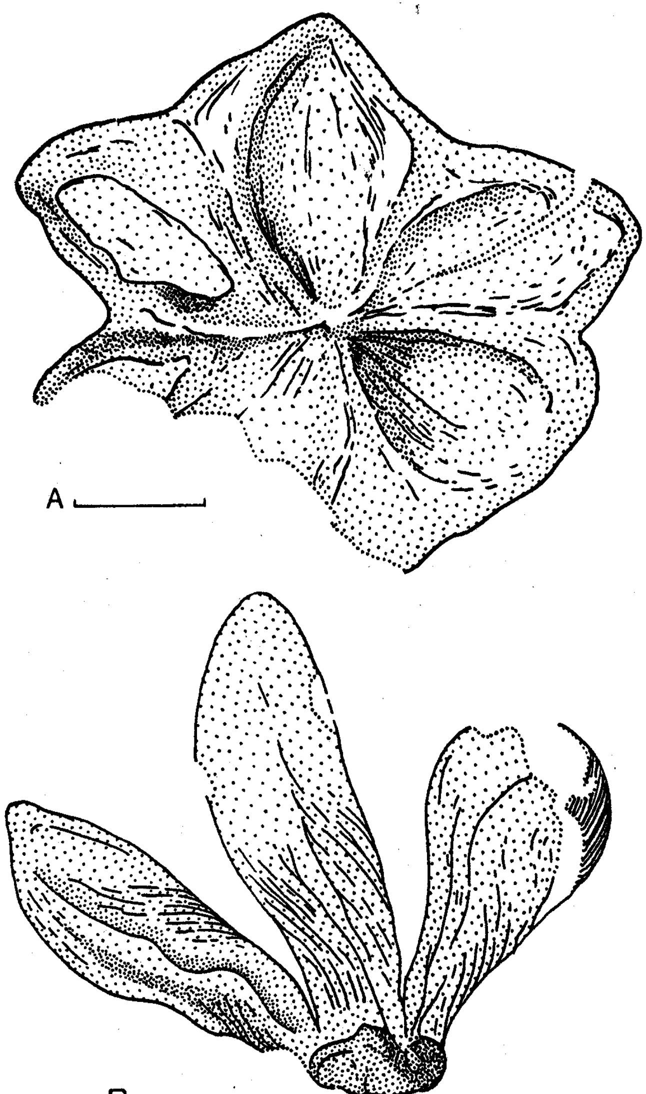

Figure 1. Generative organs of peltospermalean pteridosperms from the Upper Gzhelian (A) and Sakmarian (B) of the Southern Urals. A – *Peltaspermum* sp., spec. GIN RAS 4856/4; B – *Permotheca* sp., spec. GIN RAS 4856/14. Localities: Aidaralash, layer 17/2(A); Sim (B). Scale: 2 mm.

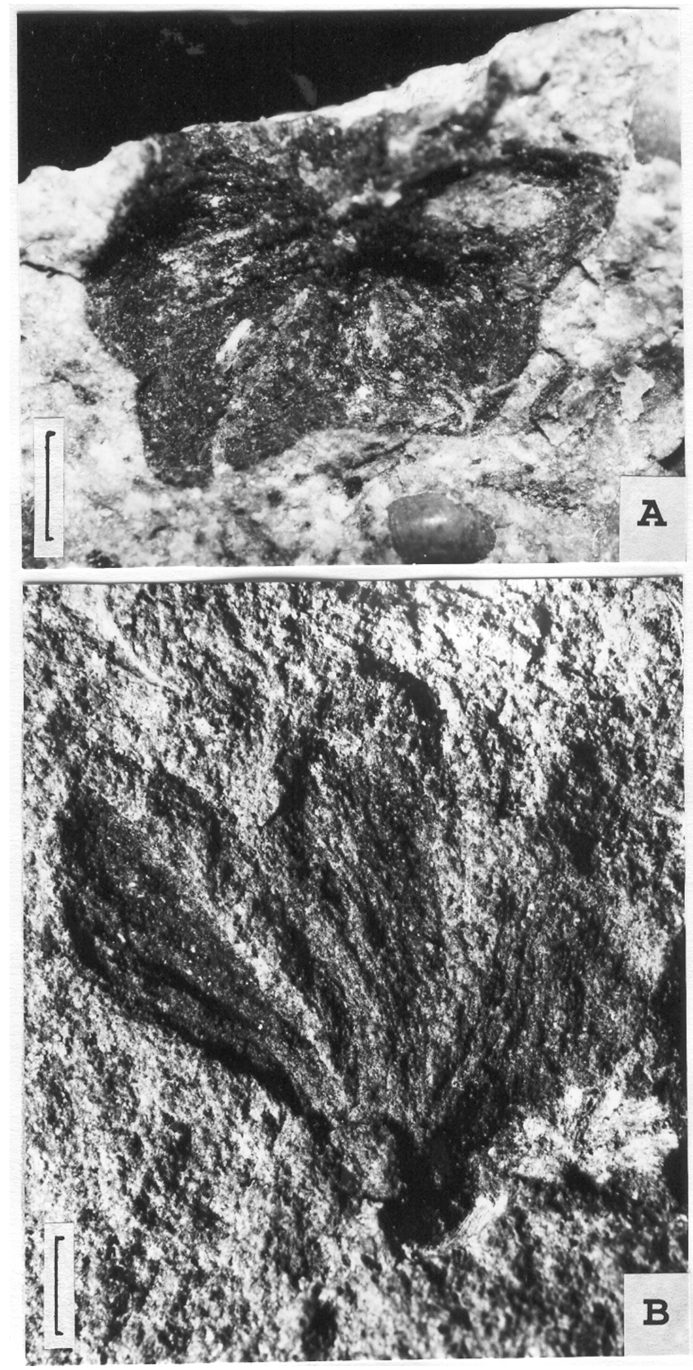

Figure 2. Generative organs of peltospermalean pteridosperms from the Upper Gzhelian (A) and Sakmarian (B) of the Southern Urals. A – *Peltaspermum* sp., spec. GIN RAS 4856/4; B – *Permotheca* sp., spec. GIN RAS 4856/14. Localities: Aidaralash, layer 17/2 (A); Sim (B). Scale: 2 mm.

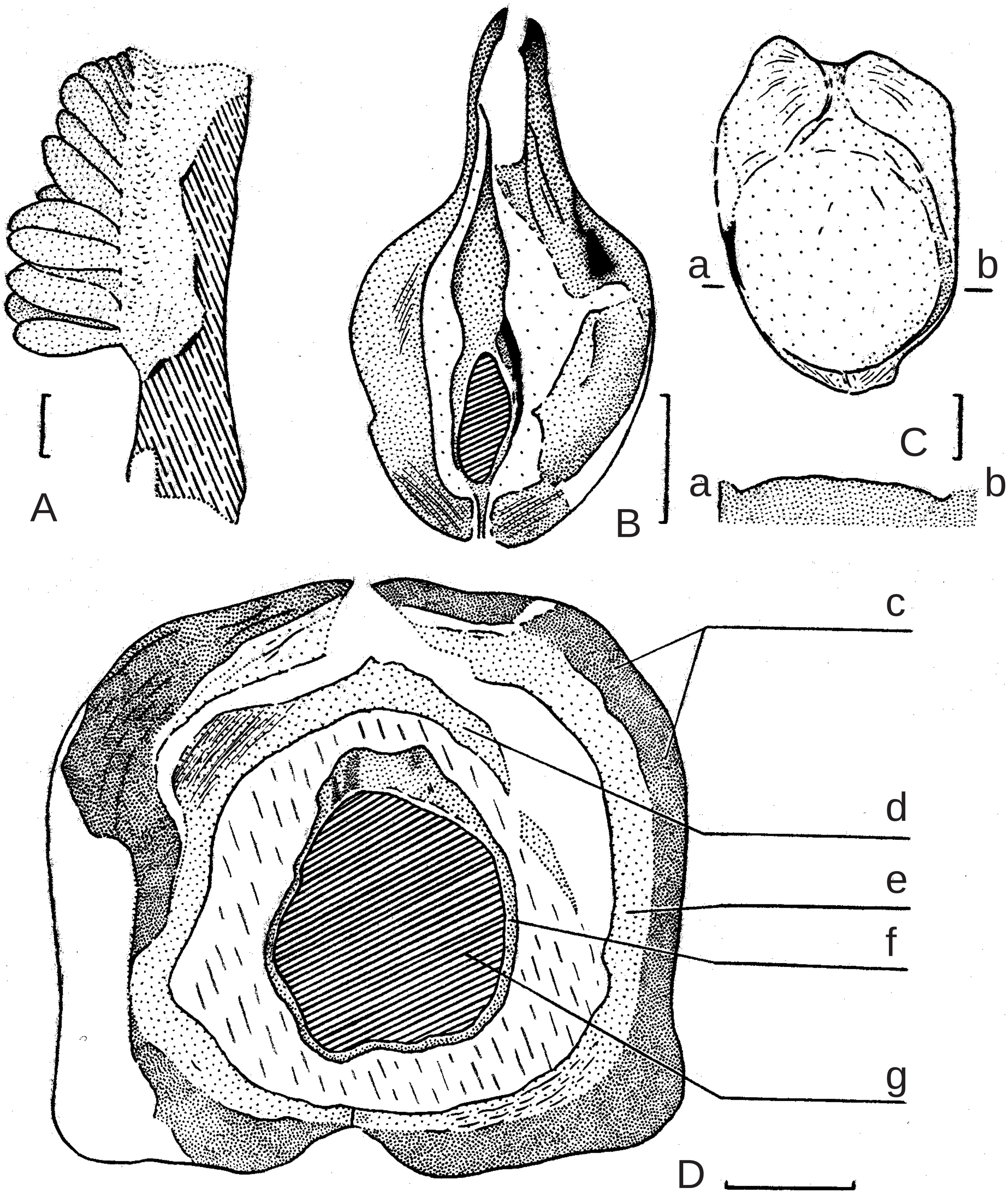

Figure 3. Generative organ of pteridosperm (A) and isolated seeds (B, D) from the Upper Gzhelian (A, B, D) and Sakmarian (C) of the Southern Urals. A – male fructification of pteridosperm, probably of trigonocarpalean affinity, spec. GIN RAS 4856/1; B – seed of Morphotype 2, spec. GIN RAS 4856/8; C – seed of Morphotype 1, spec. GIN RAS 4856/12; D – seed of Morphotype 3, spec. GIN RAS 4856/1; c – external integument; d, e – internal integument (d – deformed part, e – part, still attached to external integument; f – nucellus; g – megaspore membrane with embryonic tissues. Localities: Aidaralash, layer 16/1 (A, B), layer 17/2 (D); Kondurovka (Karakurumskaya Formation; C). Scale: 1 mm (A, B, D), 2 mm (C).

Morphotype 3 (Fig. 3, D). Small isometric platyspermic (?) seeds 5x5 mm with round outlines. Since one of the specimens is broken, some details of inner structure can be studied.

The outermost layer consists of two distinctive parts: an outer layer and an inner layer. They can be interpreted as outer and inner integuments. At the central part of the seed an ovoid structure is present. This structure most probably is a nucellus with megaspore membrane inside.

At the seed base the small scarlet occurs. The scarlet corresponds to the place of attachment of the seed to seed-bearing organ.

Locality: Aidaralash, layer 17/2, Gzhelian.

Conclusions

Generative organs of pteridosperms belonging to Peltaspermales are described (*Peltaspermum* sp., *Permotheca* sp.). Some additional observations on isolated seeds briefly characterized in open nomenclature are given. Presence of *Peltaspermum* seed-bearing discs (peltoids) in Gzhelian of the Southern Urals is the basis to suggest that the most ancient representatives of peltaspermalean pteridosperms were as old as Late Carboniferous.

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The Bursumian Stage

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In North America, the Carboniferous (Pennsylvanian)-Permian boundary long corresponded to the base of the Wolfcampian Stage (Virgilian-Wolfcampian boundary). The recent establishment in western Kazakstan of a GSSP (global stratotype section and point) for the Carboniferous-Permian boundary (Davydov *et al*., 1998) forced the position to change in the North American regional scale. Correlation of this new boundary to the North American fusulinacean zonation indicates that the base of the Permian would now be close to the LO (lowest occurrence) of *Pseudoschwagerina*, which is within the Wolfcampian Stage (*e.g*., Baars *et al*., 1994b; Wahlman, 1998). Thus, the newly defined Carboniferous-Permian boundary corresponds to the lower-middle Wolfcampian boundary of earlier usage (Fig. 1).

In the standard global chronostratigraphic scale, each system base corresponds to the base of a stage (e.g., Aubry *et al*., 1999). Therefore, the secondary standard (*sensu* Cope, 1996) provided by the North American regional stages should also have the Carboniferous (Pennsylvanian)-Permian System boundary correspond to the base of a stage, but this requires some modification or redefinition of the regional stages. Baars *et al.* (1992, 1994a, b), working in Kansas, proposed to solve this problem by redefining the Virgilian Stage to encompass strata previously included in the lower Wolfcampian (Fig. 1). A second solution, advocated by Ross and Ross (1994), is to recognize an uppermost Carboniferous Bursumian Stage equivalent to the lower Wolfcampian of earlier usage (Fig. 1).

Various workers have used the term Bursumian, but only Ross and Ross (1994) have presented a rationale for a Bursumian Stage between the Virgilian and Wolfcampian. Nevertheless, Ross and Ross provided no explicit definition of the Bursumian, but instead based it on Thompson's (1954) use of the term Bursum Formation in New Mexico and West Texas, USA (Fig. 2). Thus, Ross and Ross (1994, p. 3) stated that Thompson "clearly recognized that this unit [Bursum Formation] had lithologic continuity from north to south in both the San Andres and Sacramento Mountains of south-central New Mexico and that it extended into the northern part of the Hueco

PER	ST	RUSSIAN PLATFORM FUSULINACEANS	N. AMERICAN FUSULINACEANS	N. AMER. STAGES				PER
PERMIAN	Asselian	*Sphaeroschwagerina fusiformis*	*Pseudoschwagerina beedei* and *Paraschwagerina gigantea*	Wolfcampian	middle	Wolfcampian	Wolfcampian	PERMIAN
		Sphaeroschwagerina vulgaris (aktjubensis)						
UPPER CARBONIFEROUS	Ghzelian	*Ultradaixina* spp.	*Triticites creekensis, Schwagerina* and *Pseudofusulina*		early	Virgilian	Bursumian	PENNSYLVANIAN
			Triticites and *Dunbarinella*	Virgilian			Virgilian	

Figure 1. Position of Carboniferous-Permian boundary on the Russian platform (left) and the position with respect to the North American regional stages with three alternative stage usages: traditional (left), expanded Virgilian (middle) and use of Bursumian Stage (right).

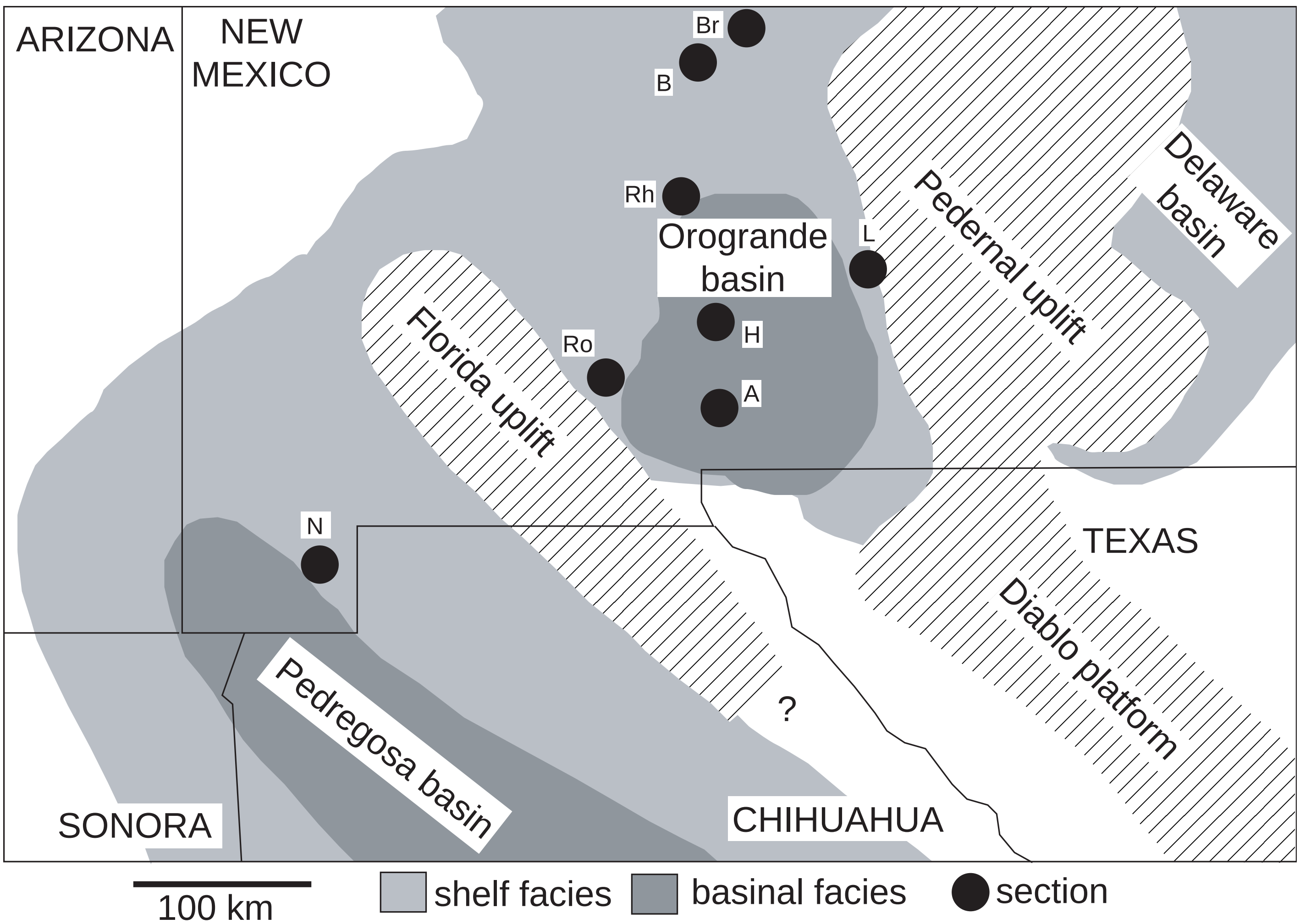

Figure 2. Simplified paleogeographic map of southern New Mexico in Virgilian-early Wolfcampian time (modified from Wilson and Jordan, 1988), showing locations of sections mentioned in the text and in Figure 3: A = Ash Canyon, B = type section of Bursum Formation, Br = type section of Bruton Formation, H = Hembrillo Pass, L = Laborcita Canyon, N = New Well Peak, Rh = Rhodes Canyon and Ro = Robledo Mountain.

Mountains of West Texas." Nevertheless, Thompson's use of Bursum over this broad region was not as a lithostratigraphic unit, but as a fusulinacean biostratigraphic unit (zone). Thus, Thompson (1954, p. 18) stated that "the term Bursum should be redefined so as to apply only to pre-Abo Wolfcampian rocks of New Mexico." This is why he broadly applied the name Bursum to strata now termed the upper part of the Panther Seep Formation (San Andres Mountains: Kottlowski *et al.*, 1956), Laborcita Formation (Sacramento Mountains: Otté, 1959), "Bursum-equivalent limestone unit" (Robledo Mountains: Wahlman and King, 2002) and Hueco Group (Hueco Mountains: Williams, 1963). These strata are not part of a single lithostratigraphic unit (formation), but instead they are an interval of diverse lithotypes with a distinctive fusulinacean assemblage of early Wolfcampian age (also see Kues, 2001). Thus, Thompson used Bursum to refer to a fusulinacean zone, not to a lithostratigraphic unit.

Bursum fusulinaceans, though distinctive, have long been recognized as typical of the early Wolfcampian (e.g., Zone PW-1 of Wilde, 1990). Thus, **"**Bursumian**"** as currently used is equivalent to a single fusulinacean zone (Lucas *et al.*, 2000; Davydov, 2001). An alternative biostratigraphy in central New Mexico, suggested by Myers (1988) and implied in the data of Lucas *et al.* (2000), could recognize two "Bursumian" fusulinacean zones, a lower one between the LO of *Triticites creekensis* and the LO of *Schwagerina*, and an overlying zone containing primitive *Schwagerina* together with *T. creekensis* and several species of *Leptotriticites*. However, the base of the fusulinacean defined Bursumian is below the base of the Bursum Formation at its type section, and indeed has not been located there (Lucas *et al*., 2000; Lucas and Wilde, 2000). Also, the upper third of the Bursum type section lacks biostratigraphically significant marine fossils, and the nonmarine Abo Formation overlies the Bursum. Clearly, the Bursum lithostratotype is not a suitable type section for a Bursumian Stage (Lucas *et al*., 2000).

Indeed, we have studied Bursum Formation sections throughout central New Mexico, and at all sections the upper Bursum lacks biostratigraphically significant fossils and is overlain by nonmarine red beds of the Abo Formation (Fig. 3). Therefore, no Bursum Formation section can serve as an ideal stratotype of a Bursumian stage. Even identifying a boundary stratotype point for the base of the Bursumian remains problematic in sections of the Bursum Formation. Furthermore, basinal sections of the Bursum interval are those where Bursum strata are equivalent to part of the upper Panther Seep Formation and lowermost Hueco Group (Figs. 2-3) (Kottlowski *et al.*, 1956; Lucas and Kues, 2001). These sections also have a sparse record of fusulinaceans (most notably *Schwagerina* at the Hueco base) and macroinvertebrates (Thompson, 1954; Kottlowski *et al.*, 1956; Soreghan and Giles, 1999; Kues, 2002b; Lucas *et al.*, 2002), and thus do not provide good potential stratotypes for the Bursumian.

Two potential "Bursumian" stratotypes outside of the Bursum outcrop belt are present in New Mexico (Fig. 2). One is at Robledo Mountain, where strata of a "Bursum-equivalent limestone unit" immediately underlying the base of the Hueco Group contain a well-studied "Bursumian" fusulinacean assemblage and are overlain by Nealian fusulinaceans at the base of the Hueco Group (Wahlman and King, 2002). The other is in the Pedregosa Basin of southwestern New Mexico at New Well Peak in the Big Hatchet Mountains. Here, strata of the Horquilla Limestone contain a remarkable record of fusulinaceans from Virgilian through middle Wolfcampian time (Zeller, 1965; Skinner and Wilde, 1975; Wilde, 1975). However, the "Bursum-equivalent limestone unit" and overlying basal Hueco Group at Robledo Mountain contain a low diversity of fusulinaceans (Wahlman and King, 2002), and the fusulinaceans of the Horquilla Limestone and their stratigraphic ranges have not yet been completely published.

In New Mexico, macroinvertebrates (mostly brachiopods, bivalves and gastropods) from the type section of the Bursum Formation and correlative strata differ little from stratigraphically lower, Virgilian macroinvertebrates (Kues, 1996, 2002a). The significant change in the macroinvertebrate fauna occurs above the Bursum Formation, in the overlying Hueco Group (Kues, 1995**,** 2002a). Therefore, on the basis of macroinvertebrates alone, the Bursum interval has closest affinities to the traditional Virgilian**,** and a "Bursumian" stage would be difficult to justify.

Finally, although numerical ages for the "Bursumian" and underlying and overlying stages are uncertain, most evidence suggests that the time represented by "Bursumian" deposition is much less than that represented by any of the North American Pennsylvanian, or Eurasian Carboniferous, stages. Harland *et al.* (1990) indicated that the shortest of the Eurasian stages, the Gzhelian, was about 6 million years (my) long. The Virgilian in North America, which began before the Gzhelian and ended about 1 my before the end of the Gzhelian, can be estimated based on the information in Harland *et al.* (1990) at about 7.5 my; the underlying Missourian Stage at 4.5 my, and the overlying Wolfcampian Stage (including what other authors would call "Bursumian") at about 18 my. Ross *et al.* (1995), on the other hand, without explaining the basis for their ages, compressed the Missourian, Virgilian and "Bursum" stages into about 10 my (Missourian, 3 my; Virgilian, 4 my; "Bursum", 3 my), and considered the duration of the Wolfcampian to be about 12 my. Such great variation in timescales obscures accurate assessment of the length of "Bursumian" time in numerical terms.

More recently, Rasbury *et al.* (1998), working in the Sacramento Mountains of south-central New Mexico, and using U-Pb dating of paleosols in well-studied cyclic sequences, obtained an age of 302.4 $\pm$ 2.4 Ma for the (traditional) Virgilian-Wolfcampian boundary, and 307 $\pm$ 3 Ma for the Missourian-Virgilian boundary, indicating a length for the Virgilian of 4.6 my. The duration of deposition of the Laborcita Formation, which is of earliest Wolfcampian (traditional boundary) age and coeval with the Bursum Formation (Steiner and Williams, 1968), was given as 2.4 my. Thus, Harland *et al.*'s (1990) and Rasbury *et al.*'s (1998) absolute ages for the Missourian and Virgilian, as well as the undoubted long duration of the Wolfcampian, all strongly suggest that these stages are much longer than the "Bursumian" Stage.

The fusulinacean record also supports the idea that "Bursumian" time is much shorter than Virgilian or Wolfcampian time. The "Bursumian" comprises one, or at the most two, plausible fusulinacean zones. In contrast, Myers (1988), working in central New Mexico not far north of the Bursum type section, recognized five successive Virgilian zones, compared to two "Bursumian" zones. And, the data on Midcontinent Virgilian fusulinacean ranges provided by Sanderson *et al.* (2001)

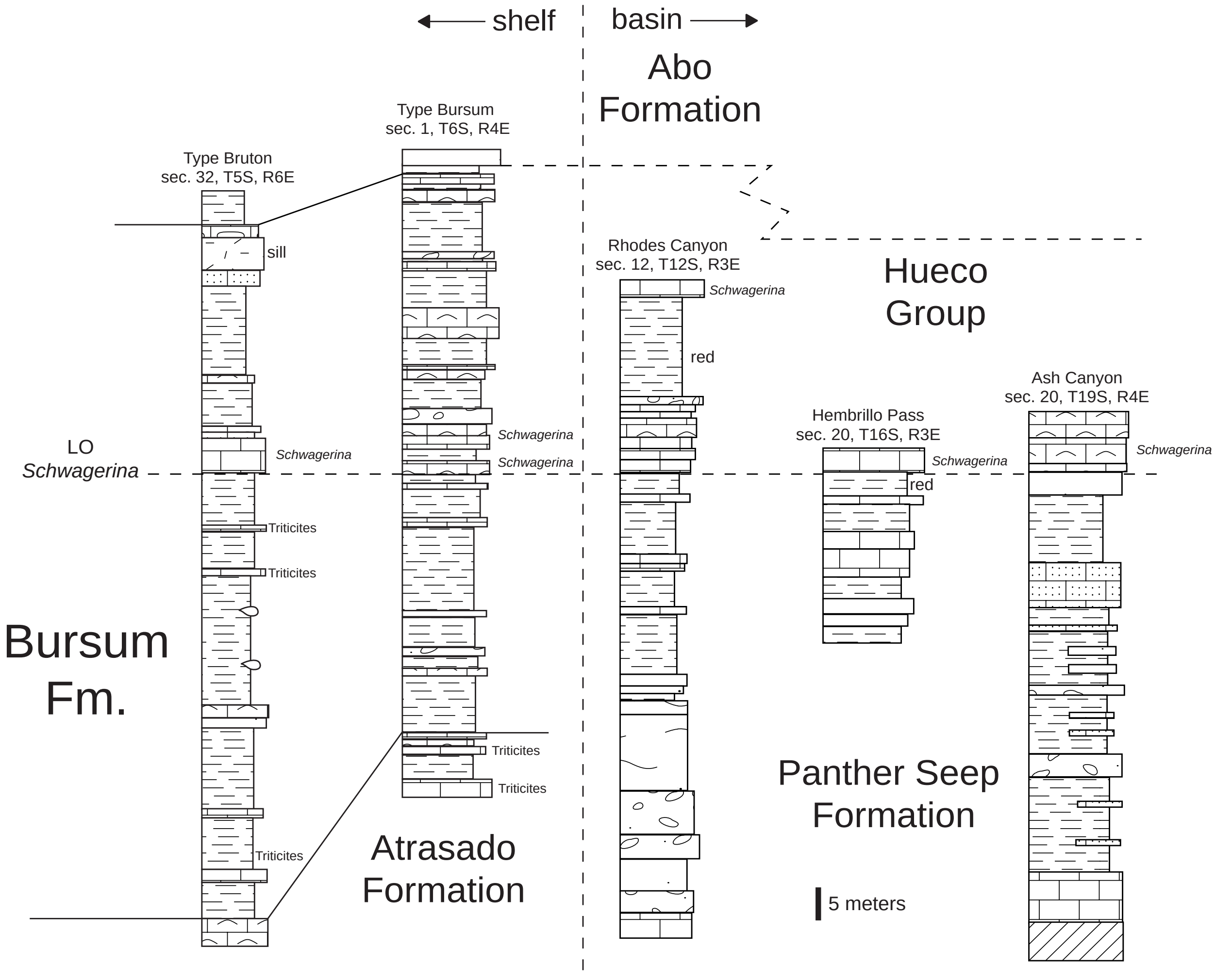

Figure 3. Selected stratigraphic sections of the Bursum Formation showing correlation of strata from the shelf (type Bruton and type Bursum) to the basinal facies (Rhodes Canyon, Hembrillo Pass and Ash Canyon) of the Orogrande basin. See Figure 2 for location of sections. Datum is basal Hueco Group limestone and local LO of *Schwagerina*

suggests that even more well-defined fusulinacean zones could be defined there, using zone concepts similar to those used for "Bursumian" zones. Thus, if the "Bursumian" were to be accepted as a stage, it would represent a much shorter time interval than any other Carboniferous or Permian stage, and would include only one or two fusulinacean zones. Indeed, such a "Bursumian Stage" would convey no information beyond that available from the fusulinacean zones.

Based on the above observations, we conclude the following:

1. A Bursumian Stage will always lack an ideal stratotype in the Bursum outcrop belt in New Mexico.
2. **"**Bursumian**"** as now used is equal to only one or at most two fusulinacean zones and represents considerably less time than other Carboniferous-Permian stages, so the concept of a "Bursumian" stage is no more than a stage name applied to one or two fusulinacean zones.
3. The Bursum Formation has a macroinvertebrate fauna of essentially Virgilian aspect, so on macroinvertebrates alone, its affinities are Virgilian. There is no distinctive "Bursumian" macrofauna.
4. The interval called **"**Bursumian**"** may work as a substage of the Wolfcampian, comparable to, but of shorter duration than the Nealian or Lenoxian, but of approximately the same magnitude as the substages of the Asselian (Harland *et al.*, 1990). However, this does not realign the North American stage boundaries to match the new Carboniferous-Permian boundary.
5. If there is value in defining a new stage or other named chronostratigraphic unit (substage) between the Virgilian and Wolfcampian, it should be defined outside the Bursum outcrop belt (also see Davydov, 2001).
6. The simplest solution has already been advocated—to extend the Virgilian upward to include the traditional lower Wolfcampian "Bursumian" interval **(**= fusulinacean zone PW-1 of Wilde, 1990). This may not satisfy the fusulinacean workers, who recognize the "Bursumian" interval as a distinctive time of transition from typical Virgilian to typical Wolfcampian fusulinacean assemblages**.** However, it accords well with the macroinvertebrate faunal changes, and would allow the **"**Bursumian**"** interval , under a different name, to become a fusulinacean-based substage of the Virgilian. If this strategy is adopted, it would be desirable to define formally and name fusulinacean substages for the remainder of the Virgilian as well.

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Two New Types of Megaspore from Permian Gondwana Sequence of India

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Abstract

The chemical analysis of carbonaceous shale samples collected from Barakar Seam (Lower Permian, Lower Gondwana) of Pench Valley Coalfield, Satpura Gondwana Basin, Madhya Pradesh, India indicates a well preserved assemblage of megaspores. Two types of megaspore with prominent oranamentations on exosporium and distinct mesoporium are described as *Penchiella* gen. nov. and *Sethiaspora* gen. nov.

Introduction

Megaspores are known from almost all the horizons of Permian Gondwana of India i.e. Talchir, Karharbari, Barakar, Barren Measures and Raniganj (Maheshwari & Tewari, 1988). However, in comparison to *sporae dispersae* their number and occurrence are limited. The variety of megaspores recovered from Gondwana sequence of India is significant in the sense that their presence suggests the existence of different types of lycopodiaceous remains, whereas megafossil record shows only one genus, *Lycopodiopsis*= *Cyclodendron* (Srivastava, 1996).

During the collection of plant fossils of Satpura Gondwana Basin of Central India, samples were collected from different collieries of Pench Valley Coalfield situated in Chhindwara District, Madhya Pradesh , India (for Map and Geology of the area see Raja Rao,1983). The carbonaceous shale samples of upper seam of Barakar Formation (Lower Permian) exposed in Sethia Colliery have yielded different varieties of megaspores. Amongst them two types of megaspores are described. The type slides and negatives of figured specimens of megaspores are preserved in the museum of Birbal Sahni Institute of Palaeobtany, Lucknow.

Description of the Megaspores

***Penchiella* gen. nov.**

Type species : *Penchiella barakarensis* gen. et sp. nov.

Generic diagnosis : Megaspores azonate,trilete, arcuate ridges faintly marked , exosporium covered with long, fleshy, stout, simple and bifurcated appendages each appendage further divided into two processes with pointed or blunt apices, mesoporium dark, without cushions.

Comparison : *Penchiella* gen. nov. is distinct from all the known megaspores in having distinct exosporium ornamentation and characteristic dark coloured mesosporium. The megaspore is comparable with *Singhisporites baculatus* (Kar) Bharadwaj and Tiwari 1970 in possessing simple, furcate processes and a dark brown well defined inner body. However, difference lies in exine sculpture and mesoporium . Ornamental processes in *S. baculatus* are filamentous, ribbose baculae observed only in macerated condition while its mesosporium (inner body) is big and occupies ¾ of spore cavity. *Penchiella*, however, shows prominent, long, stout, processes in dry condition and small dark mesosporium occupying only ¼ of spore cavity as visible in wet condition .

Derivation of name : The genus is named after Pench Valley Coalfield,

***Penchiella barakarensis* gen. et sp. nov.**

(Figures 1-3,5)

Holotype : B.S.I.P. Museum Slide No. 12675

Locality & Horizon : Sethia Colliery, Pench Valley Coalfield, Satpura Gondwana Basin,

Madhya Pradesh, India; Barakar Formation, Lower Permian, Lower Gondwana.

Specific diagnosis: Megaspores trilete, circular to semi triangular in proximo-distal orientation, azonate, triradiate ridges prominent, thin, ¾ spore radius long, ending up at thin contact ridges, exosporium covered all over with fleshy, stout, long,simple and furcate processes broad at base having pointed and blunt apices; mesosporium small, dark-brown in colour, occupying ¼ of spore cavity, without cushions.

Dimensions:

<u>Dry Condition</u>

Overall size : 450-470x350-500 µm

Size of tri-radiate ridges : 180-220 x 30-40 µm

Width of contact ridges : 20-30 µm

Length of appendages : 30-60 µm

Width of appendages at base : 20 µm

Width of appendages near apex : 5-15 µm

Wet Condition :

Overall size : 550-600 x 600-650 µm

Size of appendages : 50-60 x 10 µm
Diameter of mesosporium (Inner body): 180-200 µm
Description : Circular to semi-triangular megaspores bear uniformly disposed simple and furcate elongate appendages which are slightly broad at base and have blunt or pointed apices. Differential maceration in conc. HNO_3 and KOH dissolves the exosporium ornamentation slightly, but not completely. However, tri-radiate ridges and contact ridges, which are observed in dry condition, completely disappear after maceration. It is therefore, not possible to take their measurements. Thick dark brown, mesosporium (inner body) occupying ¼ of spore cavity is discernible which is without cushions.

***Sethiaspora* gen.nov.**

Type species – *Sethiaspora gondwanensis* gen. et sp.nov.

Generic diagnosis: Megaspores azonate, trilete, circular, arcuate ridges indistinct, exosporium verrucate, margin shows long, slender simple processes; mixed with apically divided processes, mesosporium semicircular to triangular, hyaline, with cushions.

Comparison : *Sethiaspora* gen. nov. is distinct from other megaspores in exine ornamentation which shows long, slender processes apically divided into 2 or more pointed or blunt branches. This type of ornamentation is comparable with that in the genus *Ramispinatispora* Pant and Mishra 1986. However, the ornamental processes are much shorter and stouter and mesosporium is without cushions in *Ramispinatispora* .

Derivation of name: The genus is named after the name of colliery.i.e. Sethia Colliery.

***Sethiaspora gondwanensis* gen. et sp. nov.**
(Figures 4,6-9)

Holotype: BS IP Museum Slide No.12676

Locality & Horizon: Sethia Colliery, Pench Valley Coalfield, Satpura Gondwana Basin,
Madhya Pradesh, India; Barakar Formation, Lower Permian, Lower Gondwana.

Specific diagnosis: Megaspores trilete, more or less circular in proximo-distal orientation, azonate, tri-radiate ridges straight, about ¾ spore radius, ending near faintly visible arcuate ridges, exosporium verrucate, equatorial region shows slender, simple and branched processes,apically divided into 2 or more pointed to blunt apices; mesosporium thin, transparent, smooth, semicircular to triangular, proximal side showing a number of cushions arranged trigonally along tri-radiate mark.

Dimensions :

Dry condition
Overall size : 450-600 x 450-550 µm
Length of tri-radiate Ridges : 180-200 µm
Width of tri-radiate ridges : 30 µm
Size of verrucae : 20 x 5-10
Length of simple appendages : 40 µm
Width of simple appendages at base : 10 µm
Width of simple appendages near apex : 5 µm
Length of branched appendages : 40-50 µm
Width of branched appendages at base: 20 µm
Width of pointed apices : 10 µm
Width of blunt apices : 30 µm

Wet condition
Overall size : 600-800 x 450-800 µm
Length of tri-radiate ridges : 200-300 µm
Width of tri-radiate ridges : 20-30 µm
Width of arcuate ridges : 20 µm
Length of simple appendages : 10-20 µm
Width of simple appendages at base : 20-30 µm
Width of simple appendages at apex : 5-10 µm
Length of branched appendages : 40-70 µm
Width of branched appendages at base : 20 µm
Width of pointed tips of branched appendages : 10 µm
Width of blunt tips of branched appendages : 20-30 µm
Size of mesosporium (inner body):300-400 µm
Size of cushions : 5-20 µm

Description : Megaspores are usually circular in outline but sometimes may be subcircular. Tri-radiate ridges are prominent, straight to wavy, may be uniformly wide or narrow at tri-junction and wide at ends, sometimes one of the tri-radiate ridges is wider than the other two. Arcuate ridges are faint, usually merged with the margin. Tri-radiate ridges end up at arcuate ridges The megaspore body is covered with small verrucae. However, all around the margin, long, slender branched and simple processes are present. The processes may be closely or distantly placed. Differential maceration in conc. HNO3 and KOH dissolves the exosporium completely and reveals well defined triangular to spherical, thin, transparent mesosporium (inner body) possessing a number of trigonally arranged cushions along faintly visible trilete mark.

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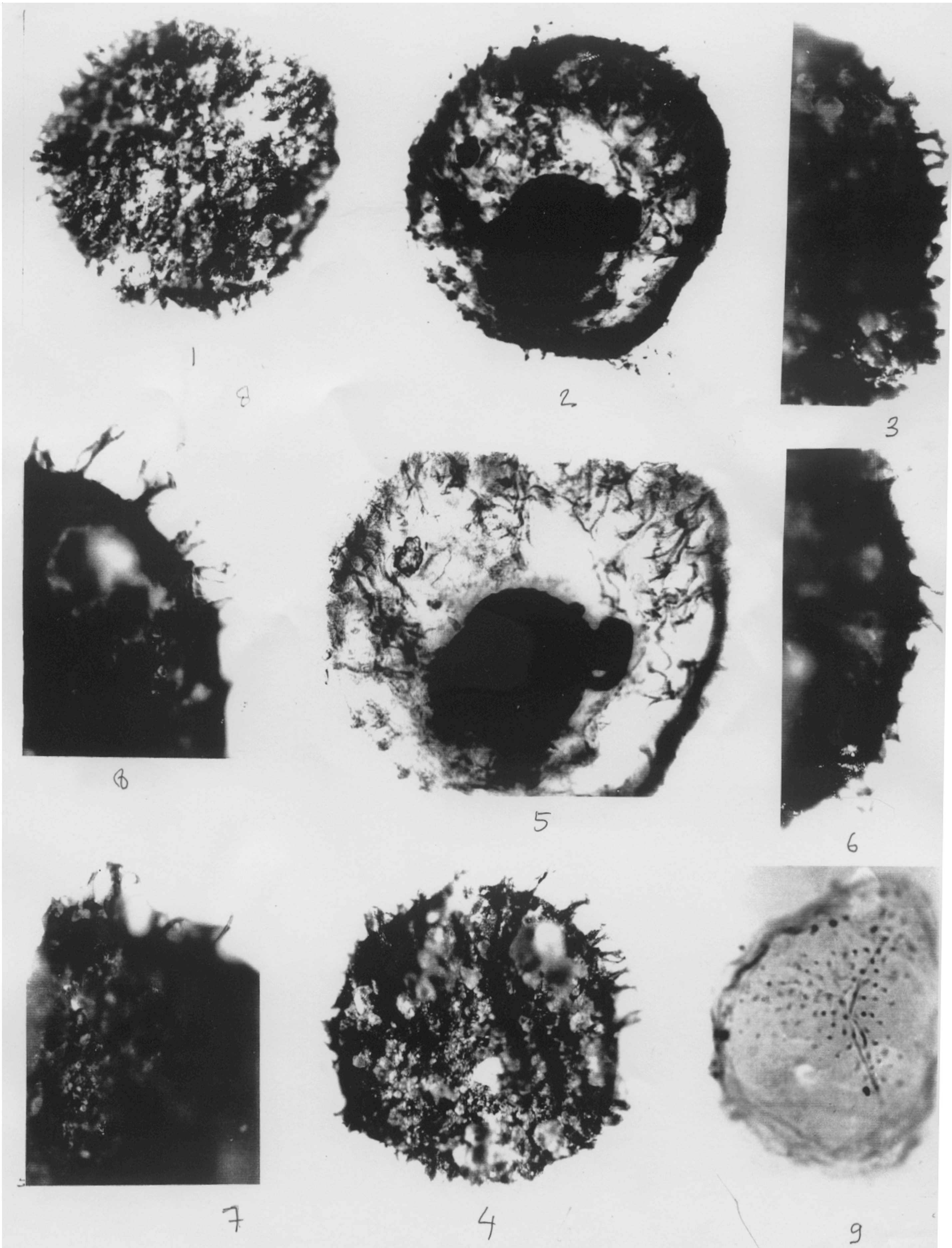

Explanation of Figures

Penchiella barakarensis gen. et sp. nov. (Figures 1-3,5; BSIP Slide No.12675)

1. Proximal surface of megaspore in dry condition, x90
2. Photograph taken in wet condition to show dark coloured mesosporium, x90
3. A portion of dry megaspore enlarged to show furcate ornamentation over exosporium, x137
5. Macerated megaspore showing exosporium disintegration and ornamentation, x137

Sethiaspora gondwanensis gen. et sp. nov. (Figures 4,6-9; BSIP Slide No.12676)

4. Proximal surface of megaspore in dry condition, x117
a. Margin of megaspore is enlarged to show simple and branched processes over exosporium, x270
9. Mesosporium in wet condition showing trigonally arranged cushions, x126

Editor's Note: Permophiles does not constitute formal publication of taxonomic names; it is an informal newsletter!

Latest Guadalupian-Earliest Lopingian Conodont Faunas from West Texas

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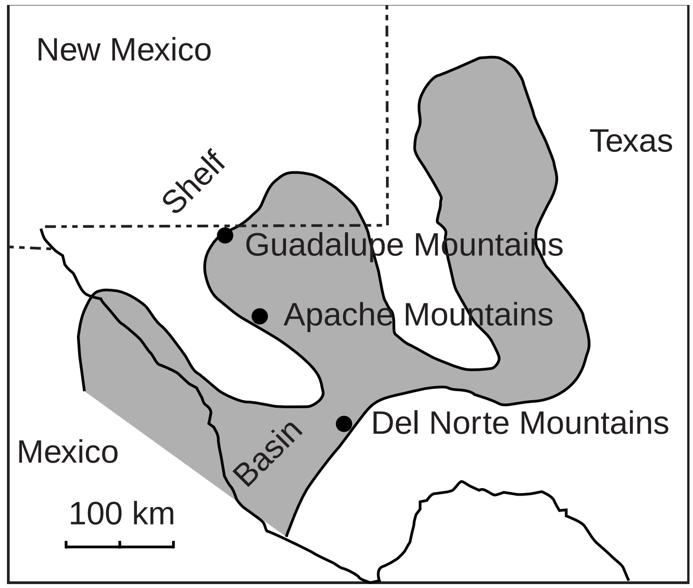
Latest Guadalupian and earliest Lopingian conodont faunas from West Texas have been reported including the appearances of *Jinogondolella granti* and *Clarkina postbitteri* (*i.e.,* the Altuda Formation from the Bird Mine section, Del Norte Mountains; Wardlaw and Mei. 1998; and the Reef Trail Member of the Bell Canyon Formation, Reef Trail section, Guadalupe Mountains; Wilde *et al.*, 1999). These reports have been ignored (Mei *et al.*, 1998) or questioned (Mei and Henderson, 2001). This note is an abbreviated abstract of an upcoming paper that documents the occurrences of both *Jinogondolella granti* and *Clarkina postbitteri* (now = *C. postbitteri hongshuiensis*) from West Texas. The location of critical sections and examples of the two species are illustrated in Figure 1.

Latest Guadalupian and potentially earliest Lopingian conodont faunas are found in the above mentioned Bird Mine and Reef Trail sections and in an additional section of the Lamar Limestone Member of the Bell Canyon Formation in the Apache Mountains. A sample from the Bird Mine section shows a complete morphological transition series from *Jinogondolella crofti* to primitive "*Clarkina*" sp. (Wardlaw and Mei, 1998). New material from the upper part of the Apache Mountains section has yielded abundant examples of *Clarkina postbitteri* in a complete growth series. From a related section also in the Apache Mountains a sample yielded abundant examples of *Jinogondolella granti* in a complete growth series. The presence of abundant material displaying a complete identifiable growth series clearly establishes the presence of these species in West Texas. That the species utilized in defining the conodont zonation for the proposed GSSP for the Guadalupian-Lopingian boundary in South China; that is, *Jinogondolella granti* and *Clarkina postbitteri* (Jin *et al.*, 2001), are present also in West Texas indicates that the Guadalupian-Lopingian boundary, or at least a position very close to it, is preserved in the uppermost sediments of the Bell Canyon and Altuda Formations.



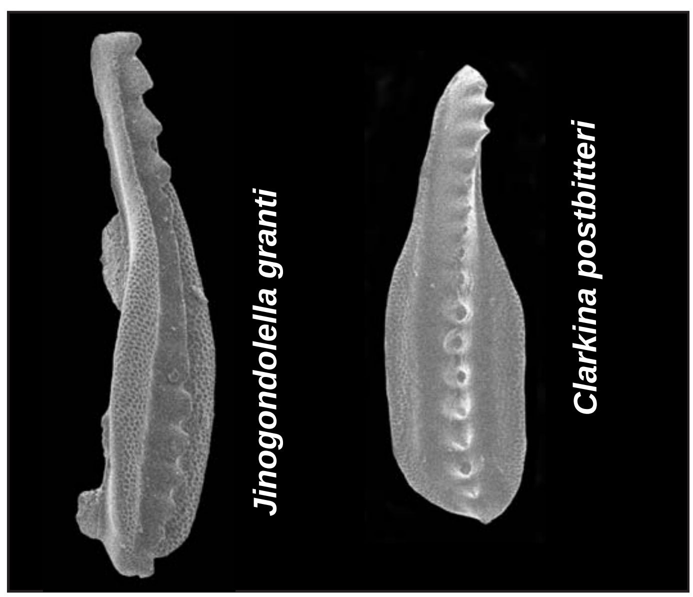


Figure 1. Location of sections and examples of *Jinogondolella granti* and *Clarkina postbitteri* from West Texas. All the sections containing the latest Guadalupian-earliest Lopingian conodonts represent slope deposition around the margin of the Delaware Basin.

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Proposal for the Global Stratotype Section and Point (GSSP) for the Guadalupian-Lopingian Boundary

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Introduction

In the new edition of the International Stratigraphic Chart recommended by the International Commission on Stratigraphy (Remane, 2000) the Lopingian Series is referred as a semiformal global standard chronostratigraphic unit for the youngest series of the Permian System. This series and its component stages, the Wuchiapingian and Changhsingian stages can be precisely defined by biostratigraphic, sequence stratigraphic, and magnetostratigraphic subdivisions as well as isotopic age. As a decision of the Subcommission, the Guadalupian - Lopingian boundary or Capitanian - Wuchiapingian boundary has been informally defined at the base of the *Clarkina postbitteri* Zone and that of the Changhsingian Stage, at the base of the *Clarkina subcarinata* Zone.

The boundary between the Guadalupian and Lopingian Series was historically designed to coincide with a global regression, that is, the boundary surface between the Middle and the Upper Absaroka Megasequences. It has been documented as a level coincident with an important mass extinction event. Consequently, this boundary should be precisely delineated within a conformable sequence and it also offers advantages for international correlation and in practical field geology.

Extensive surveys on marine sections over the past few decades prove that only a few sections can be considered to be continuous across the Guadalupian - Lopingian boundary. Those with complete succession of pelagic faunas are particularly rare. Guadalupian – Lopingian boundary successions were reported from Abadeh and Jolfa in Central Iran, S.W. USA, and the Salt Range. The section of the Laibin Syncline in Guangxi Province, China is unique among these sections in that it contains a complete and inter-regionally correlatable succession of pelagic conodont zones and other diverse, and inter-regionally correlatable Permian fossils. Here we formally propose to establish the Global Stratotype Section and Point (GSSP) for the basal boundary of the Lopingian Series at the first occurrence of *Clarkina postbitteri postbitteri* Mei and Wardlaw in Bed 6k of the Penglaitan Section, and to refer the Tieqiao (Rail-Bridge) Section on the western slope of the syncline as a secondary reference section.

Location of type section

The county town of Laibin is midway between Guilin, one of the major tourist cities in China, and Nanning, the provincial capital of Guangxi Province, and takes about two hours to reach it from these two major cities (Fig.1). The completeness of the sequence, excellent exposure, and easy accessibility of the Laibin sections have attracted many visitors from foreign countries during the last two decades.

This county has been officially approved by the state government as an “OPEN AREA”, which is legally free for foreign visitors to access. However, visitors who wish to collect samples from the proposed stratotype are required to obtain permission and assistance from this county’s government, since the GSSP would be under the permanent protection of this government as soon as it is ratified.

The Jiangnan Basin, which consistently subsided during the late Paleozoic and Early Triassic between the Yangtze and Cathaysia cratons, extended southward into the Laibin area of eastern Guangxi (Wang and Jin, 2000). Structurally, these sections are located on the eastern slope of the Laibin Syncline (Fig.2). Penglaitan is the name of a rocky islet of the Hongshui River, some 20km east of Laibin. The Penglaitan Section of the Maokouan-Lopingian strata was measured along the southern bank of the Hongshui (Red-water; pronounced Hong-sway) River nearby this rocky islet. The Tieqiao (Rail Bridge) Section on the western slope of the syncline is situated on the northern bank of the Hongshui River, 2 km south of the county town of Laibin.

Description of type section

Permian rocks are extensively exposed along the banks of the Hongshui River, and have not suffered any substantial structural disturbance. Sha *et al*. (1990) divided the Permian succession of the Tieqiao Section into the Maping, Chihsia, Maokou, Heshan and Tailung formations. The Kungurian Chihsia Formation contains black bituminous limestone with

Figure 1. Location map of southern China highlighting the locations of Tieqiao and Penglaitan sections.

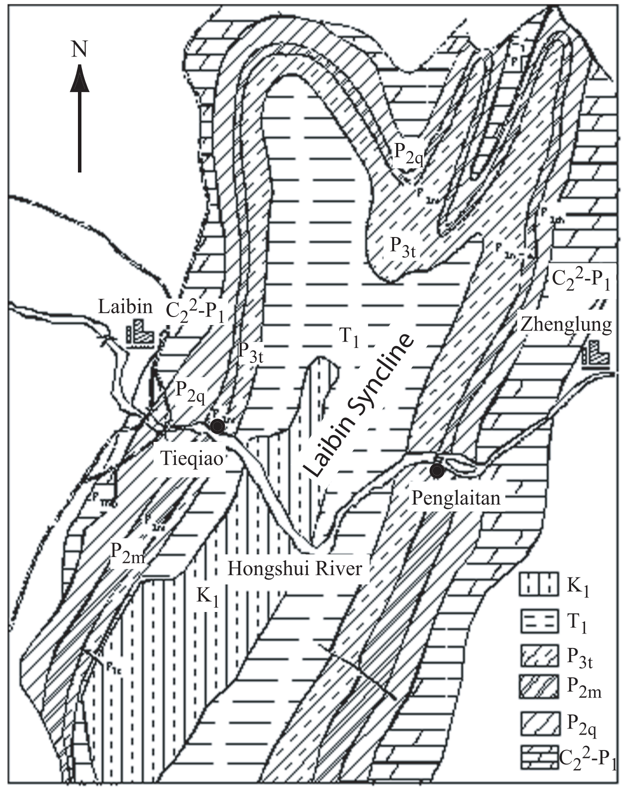

Figure 2. Geological map showing the Laibin Syncline and the positions of sections (after Jin *et al*., 1998). K_1- Lower Cretaceous; T_1- Lower Triassic; P_{3t}-Talung Formation; P_{2m}-Maokou Formation; P_{2q}-Chihsia Formation; C_2^2-P_1-Maping Formation.

chert bands deposited in relatively deep water. The Guadalupian Maokou Formation reaches 302 m in thickness. Member I is composed of carbonate siltstone and sandstone of turbidite-hemipelagic facies with allochthonous bioclasts. It is characterized by the occurrence of conodonts from the *Sweetognathus subsymmetricus* Zone. Member II, about 56 m in thickness, comprises interbedded radiolarian chert and carbonate mudstone, which are mostly basinal facies; the diagnostic conodont for the base of the Guadalupian, *Jinogondolella nankingensis*, first appears in this member. Member III consists of massive carbonate debris flow deposits with a rich radiolarian fauna and is 26 m in thickness. Member IV (Beds 115-118) contains interbedded radiolarian chert and cherty carbonate mudstone and sandstone; it is 133 m thick, and comprises more than 10 cycles of turbidite deposits. Member V (Bed119) or the Laibin Limestone, is 11m in thickness and is composed of massive limey sandstone and siltstone of distal tempestite facies. The Heshan Formation, 150 m in thickness, is composed of black cherty limestone of basinal facies in the lower part and white bioclastic carbonate of sponge reef facies in the upper part. Abundant conodont samples were made along three parallel sections (Sections A, B and C) of the Guadalupian-Lopingian boundary interval at the Tieqiao Section. These Permian lithostratigraphic units can be recognized in succession at the Penglaitan Section without much change. The Laibin Limestone at Penglaitan is about 8 m thick and contains thinner bedded carbonate in the middle part. The Heshan Formation, 270 m in thickness at Penglaitan, is mostly composed of chert and lenticular limestone of basinal facies. Reefal carbonates of the Late Wuchiapingian are reduced to 10 m in thickness.

Depositional sequence of the G/L boundary interval

"If major natural changes in the historical development of the Earth can be identified at specific points in sequences of continuous deposition, these may constitute desirable points for the boundary-stratotypes of stages." (Hedberg, 1977). The Guadalupian-Lopingian boundary coincides with the boundary surface between the Middle and the Upper Absaroka Megasequences that is caused by an important event of global sea-level change. A regional survey of Guadalupian-Lopingian boundary successions shows that the Laibin Limestone represents a lowstand systems tract deposited on the slope during the Guadalupian-Lopingian boundary interval; this interval is probably characterized by an unconformity in all other shelf sections (Fig.3).

From Member IV of the Maokou Formation to the Laibin Limestone, chert and cherty carbonate mudstone of shelf to basinal facies change into grainstones and packstones of distal tempestite facies. This marks a rapid shallowing as several transitional facies units are missing in-between. The lower part of the Laibin Limestone (Bed 2-5 in Tieqiao; Bed 2-3 in Penglaitan) is characterized by packstone of tempestite facies and wackestone with rich algal lamellae that exhibit continuous shallowing. Well-developed stylolites in Bed 5 of the Tieqiao Section may have formed at an interval indicating submarine erosion or non-deposition. Faunal changes further prove that Bed 3 - Bed 5 (except the upper part) in Tieqiao and Bed 3 (except the topmost part) in Penglaitan represent the deposits of the near-shore *Hindeodus* conodont biofacies, which is interpreted as at or near the maximum regression in the Laibin area. The Guadalupian-Lopingian succession of conodont faunas was dominated by gondolellid conodonts that inhabited deeper environments as a whole, but was interrupted briefly by the dominance of a shallow water conodont fauna, the *Hindeodus* sp. interval, in Beds 3, 4 and most of Bed 5 at the Tieqiao Section and Bed 3 (except the topmost part) at the Penglaitan Section. Brachiopods, corals and other shallow-water benthic fossils are frequently present in these beds. Accordingly, the sequence boundary or the maximum regression lies on the top of Bed 5 at Tieqiao, and the top of Bed 3 at Penglaitan.

The top of the uppermost shallowing-upward cycle of the "lowstand" unit is the transgressive surface (Van Wagoner *et al*., 1988, 1990). The late lowstand or early transgressive systems tract (Bed 5f to Bed 6j in Tieqiao, Bed 3c6 to Bed 6k in Penglaitan) contain thick-bedded crinoid grainstone and lenticular packstone that reflect the beginning of an overall deepening. These rocks consist of high frequency cycles of deposition. Each cycle is dominated by the hummocky, cross-stratified crinoid grainstone in the lower portion and lenticular packstone in the upper, often with vertical burrows or infilling structures at the top. The facies change is interpreted to range from fine-grained deposits of relatively deeper below-wave-base facies to an intertidal environment. The conodonts of the *Jinogondolella granti* and *Clarkina postbitteri sensu lato* zones are associated with deposition of the latest lowstand and earliest TST, and occur mostly in the lenticular packstone. It is obvious that there were minor depositional hiatuses between all of the cycles; however, none of them are significant in terms of the resolution of conodont chronostratigraphy because most of them occur within the same conodont zone.

The last two cycles of the Laibin Limestone in the Penglaitan Section are respectively composed of Bed 6g - 6i-lower and Bed 6i-upper to 6k. No measurable time break is evident between or within these cycles though evidence for suspected depositional gaps have been observed in both candidate boundary levels. Wavy bedding between the neighboring couplets is distinct; well-developed burrows are only seen from the upper part of Bed 6k. Bed 6h and 6i-lower are coarse crinoidal grainstone, which contain very rare conodont fragments, but fish remains and small gastropods are more common. Bed 6i-upper comprises mostly packstone with some carbonate mudstone intraclasts. Bed 6j contains abundant mudstone intraclasts and numerous small solitary corals. This bed is inconsistent in thickness and consequently Bed 6k may contact directly with Bed 6i–upper. The intraclasts were interpreted as consolidated carbonate breccia that were reworked by storms and introduced into the Penglaitan deposits during subsequent rising sea level. In the Tieqiao Section Bed C8 can be correlated with Bed 6j in the Penglaitan Section since both beds comprise abundant mudstone intraclasts, numerous small solitary corals and *Clarkina postbitteri hongshuiensis*. It is possible that the corresponding part of Bed 6h to 6i-lower from the Penglaitan Section is missing at the Tieqiao Section because there Bed 6i with abundant *C. postbitteri sensu lato* lies directly over Bed 6h that contains abundant *Jinogondolella granti* just as Bed 6g from the Penglaitan Section does (Henderson *et al.*, in press). Applying the transgressive-regressive sequence model of Embry (1988, 1990), this point could be viewed as the beginning of a new sequence within a conformable succession.

The subsequent transgressive unit (Bed 7) in Penglaitan is composed of high-frequency cycles that overall deepen upward; the cycles consist of lenticular mud limestone deposited below storm-wave-base to chert of the shelf to basinal facies, with or without clay bed at the base. This transgressive unit is a response to the very rapid sea-level rise at the time of the *C. dukouensis* Zone.

To sum up, the Laibin Limestone can be referred to as an "intersequence", resulting from the lowstand of sea level in areas that were previously in a deep-water position. It was deposited during the late parts of sea level fall and early parts of sea level rise. The supposed correlative conformable surface associated with the Guadalupian - Lopingian sequence boundary on the platform can be placed around this level. Bed 6i-upper indicates a much faster and widespread transgression starting in the top part of the Laibin Limestone. The flooding event is delineated by the occurrence of the *C. postbitteri sensu lato* conodont Zone in Beds 6i-upper to 6k at the Penglaitan Section, which might extend northward to the Chengzhou Basin of southern Hunan, far beyond the distribution of underlying conodonts from the *J. granti* Zone.

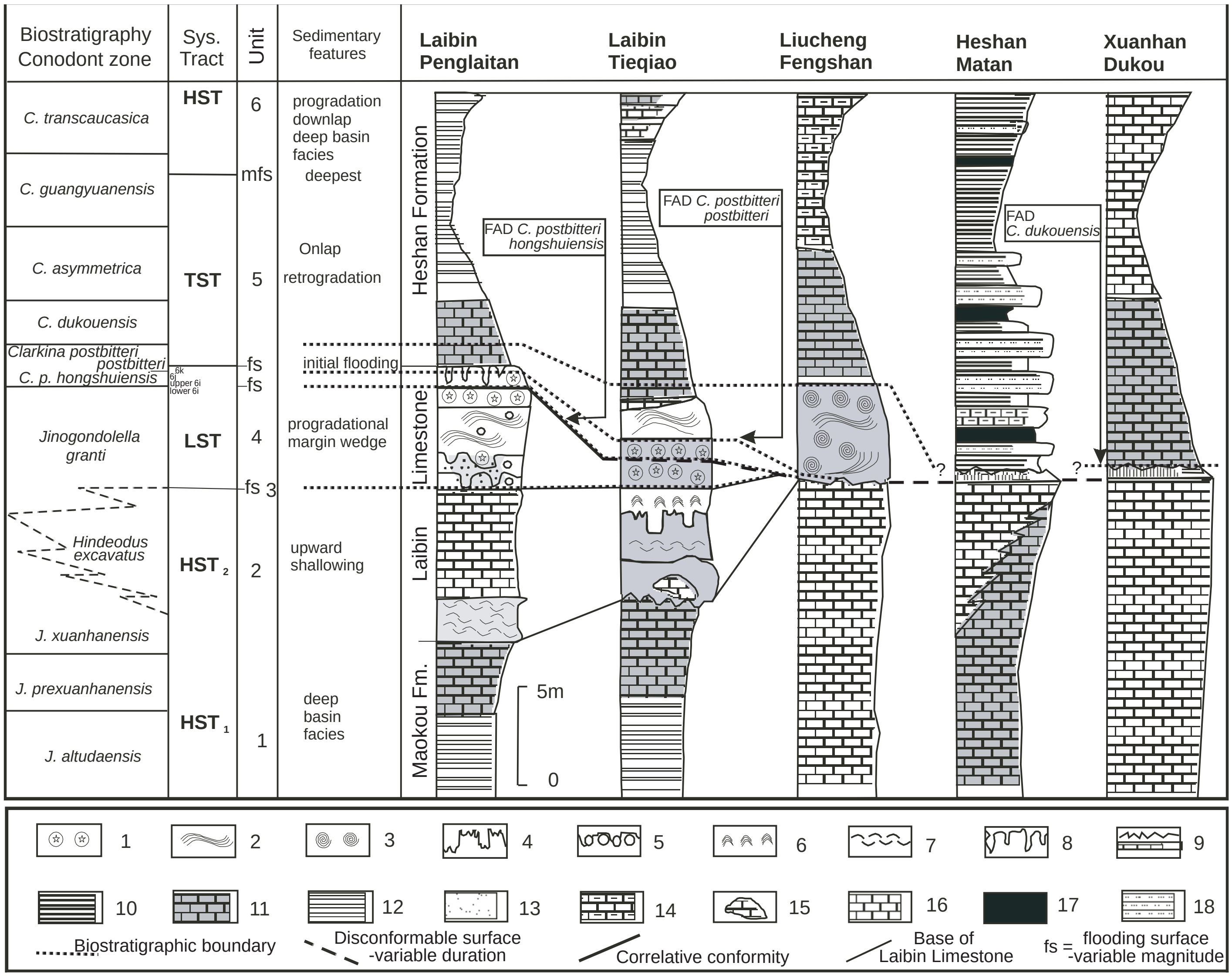

Figure 3. Sequence biostratigraphic diagram showing lithology, key sequence stratigraphic surfaces and biozonal boundaries for five key sections. The figure highlights the complete nature of the succession at Penglaitan and the hiatus at shelf sections like Matan and Dukou (provided by Chen Zhongqiang and Jin Yugan).

Fossil successions

Conodonts from the Laibin Limestone (Fig. 4) in both Tieqiao and Penglaitan sections are exclusively dominated by *Jinogondolella* species in the basal part (Bed 2 at Tieqiao and Bed 2 at Penglaitan) and by *Clarkina* species in the uppermost part (Bed 6i to Bed 8 at Tieqiao and Bed 6i-upper to 6k at Penglaitan). The lower part of the Laibin Limestone (Bed 3 to the middle of Bed 5 at Tieqiao; Bed 3 (except the uppermost part) at Penglaitan) is dominated by *Hindeodus*. Rare specimens of shallow water elements like *Sweetognathus fengshanensis* and *Iranognathus erwini* were also recovered respectively within the lower Bed 3 and 6k at Penglaitan. *Jinogondolella* and *Clarkina* species also dominate conodonts from equivalent beds at the Fengshan Section, but contain more common to abundant nearshore shallow water elements *Hindeodus*, *Sweetognathus fengshanensis*, *Iranognathus erwini*, and *Sweetina* (in order of decreasing abundance). Based on the stratigraphic range and evolution of species of *Jinogondolella* and *Clarkina*, three phylogenetic conodont zones are recognized around the Guadalupian-Wuchiapingian boundary in Tieqiao and Penglaitan sections: the *Jinogondolella granti* Zone ranges from upper part of Bed 5 through Bed 6h in the Tieqiao Section, and from the uppermost Bed 3 through 6i-lower (4.8m thick) in the Penglaitan Section; the *Clarkina postbitteri sensu lato* Zone ranges from Bed 6i through lower Bed 9 in the Tieqiao Section, and from 6i-upper through 7b (there are no conodonts from bed 7c and 7d) in the Penglaitan Section; the *Clarkina postbitteri sensu lato* Zone is overlain by the *Clarkina dukouensis* Zone that starts at Bed 7e in the Penglaitan Section. Recently, the *Clarkina postbitteri sensu lato* Zone in the Penglaitan section has been subdivided into two subzones: the lower *Clarkina postbitteri hongshuiensis* subsp. nov. Subzone ranges through beds 6i-upper and 6j, and the upper *Clarkina*

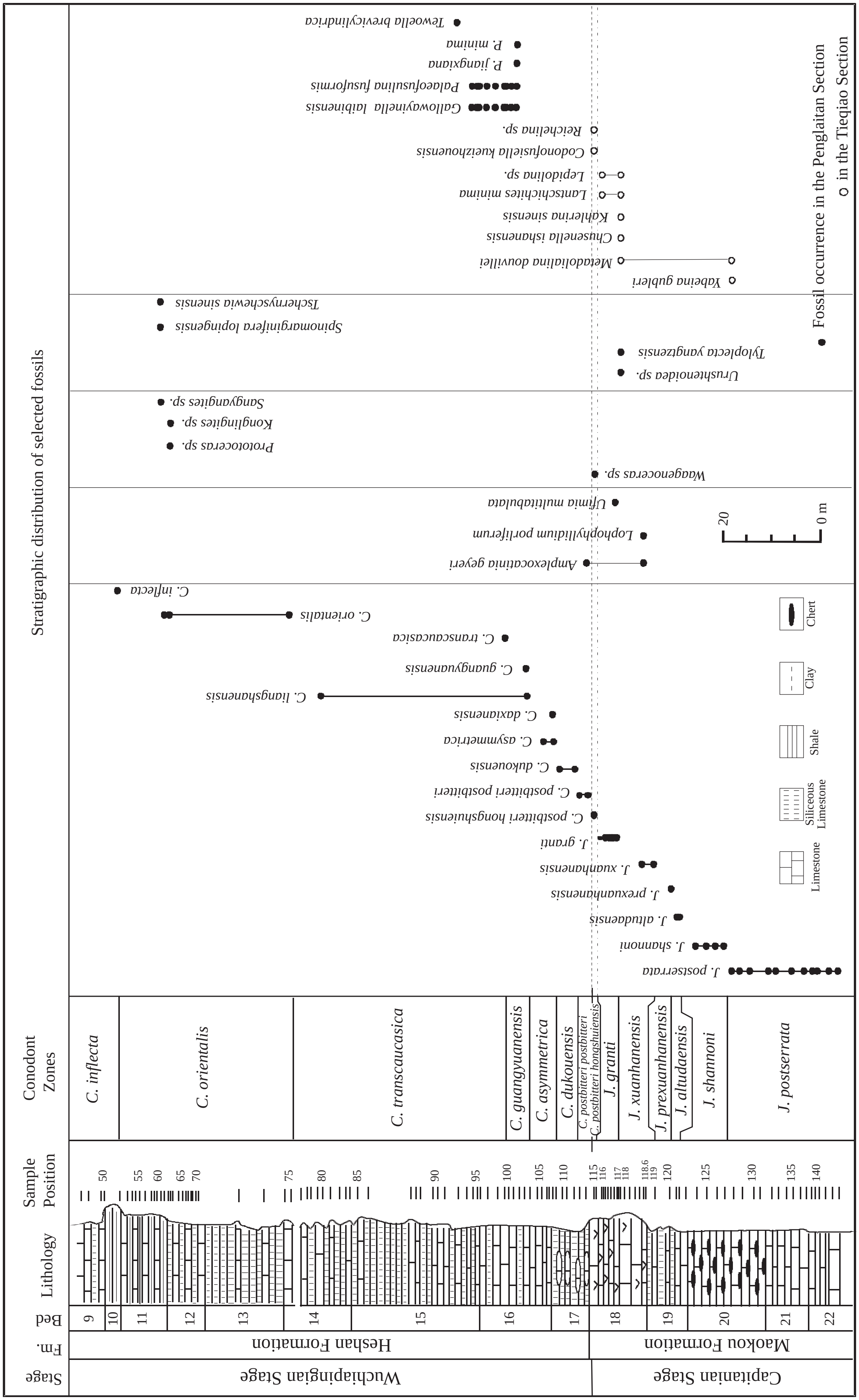

Figure 4. The Guadalupian-Lopingian boundary sequence at the Penglaitan and Tieqiao sections and the distribution of various fossil groups (modified after Jin *et al*., 1998).

postbitteri postbitteri Subzone ranging from beds 6k through 7b. *Clarkina postbitteri hongshuiensis* subsp. nov. is transitional between *Jinogondolella granti* and *Clarkina postbitteri postbitteri*. It is usually close to *Jinogondolella granti* in its denticulation with closely spaced to fused middle denticles and sometimes with a gradually narrowing anterior platform. It is close to *Clarkina postbitteri postbitteri* with a high anterior blade and sometimes with an abruptly narrowing anterior platform as well as the lack of anterior platform serration (Henderson *et al*., in press). One plate (Plate 1) highlights some of the elements of *J. granti*, *C. p. hongshuiensis*, and *C. p. postbitteri* illustrated by Henderson *et al*. (in press).

Fusulinaceans are rich in the Maokouan-Lopingian boundary succession of the Laibin section. The lower part of the Laibin Limestone comprises the fusulinaceans of the *Metadoliolina* Zone (Fig. 4). The upper part of this Member is referred to an acme zone, the *Lantschichites minima* Zone. This zone is very thin, only 2 meters in thickness. The *Codonofusiella kueichowensis* Zone is recognized in the beds with the conodont *Clarkina postbitteri postbitteri* (Beds 8a-c) in the Tieqiao Section, which contains monotonous *Codonofusiella* and *Reichelina.* The newly proposed *Palaeofusulina jiangxiana* Zone occurs in the lower part of the Heshan Formation, which also contain the *Clarkina asymmetrica* conodont Zone and range upward to the *C. guangyuanensis* conodont Zone.

Ammonoids referred to *Waagenoceras* have been found in the topmost part of the Maokou Formation (Bed 6k) at the Penglaitan Section (Fig. 4). This fact implies that Maokouan ammonoids extend upward into the *C. postbitteri sensu lato* Zone as do the ammonoids from the same zone in southern Hunan.

Magnetostratigraphic investigation and isotopic dating

For magnetostratigraphic investigation, Menning collected 640 oriented cylinders from the Chihsia, Maokou and basal part of the Heshan formations at the Tieqiao Section and the Guadalupian- Lopingian boundary sequence at the Penglaitan Section (Menning *et al.*, 1996). Partial or total remagnetization complicates the magnetostratigraphic research. Isotopic age of the tuff beds at the Penglaitan Section has been studied since 1995, and the tuff bed of the late Changhsingian was dated as 252.4 ± 0.2 Ma by Bowring *et al.* (1998). Samples from Bed 6a and 7c near the boundary in the Penglaitan Section are under analysis.

Chemostratigraphy

Values for del^{13}C drop from + 2.0 per mil in the Laibin Limestone to -0.7 per mil at the base of the Heshan Formation (Bed 8a to Bed 8c, the upper part of the *C. postbitteri sensu lato* Zone), return to an average value in Bed 9, and jump to the highest value +5 per mil del^{13}C in the reef carbonate of the Heshan Formation. Isotopic strontium values are consistent with carbon isotopic trends showing a dramatic drop in Bed 8a to Bed 8c. (Wang Wei, pers. comm.).

In summary, the Penglaitan and the Tieqiao sections are excellent sections in which to establish a finely resolved chronology and meet with the requirements for serving as GSSP. However, the Penglaitan Section is preferred as the GSSP for the Guadalupian-Lopingian boundary because of excellent outcrops of both Wuchiapingian and Changhsingian beds.

Potential stratotype points

Two levels are presented here for selection. The proposal for the FAD of *Clarkina dukouensis* at bed 6k is not regarded as an acceptable choice for selection because the basal boundary of the *C. dukouensis* Zone, after further study by conodont experts, is recognized at bed 114-7e of the Penglaitan Section, which is above a clay bed (114-7c) that may indicate considerable environmental change (Jin, 2000). A detailed study demonstrates that specimens of *Clarkina* from bed 6k belong to *Clarkina postbitteri* rather than to early forms of *Clarkina dukouensis* (Henderson *et al*., 2000; Henderson, 2001) and herein, bed 6k (Figs. 5, 6) is reported to contain the first appearance of *Clarkina postbitteri postbitteri* (Henderson *et al*., in press).

Option A:

This option is a point defined by the FAD of *Clarkina postbitteri hongshuiensis* subsp. nov. (Henderson *et al*., in press) that occurs within an evolutionary lineage from *Jinogondolella granti* to *Clarkina postbitteri postbitteri.* Henderson *et al*. (in press) provide the formal descriptions of these taxa.

The FAD of *C. postbitteri hongshuiensis* is at or close to the boundary surface between the Middle and the Upper Absaroka Megasequences. This horizon can be traced in different lithofacies by the recognition of either the major sequence boundary or a remarkable changeover from conodont faunas dominated by *Jinogondolella* below in the Maokouan to those dominated by *Clarkina* above with total absence of *Jinogondolella* in the Wuchiapingian. The conodont succession around the Guadalupian – Lopingian boundary is marked by a rapid change from *Jinogondolella* into *Clarkina*. Consequently, it would be easy to locate the Guadalupian-Lopingian boundary close to the sequence boundary by the level of lowest occurrence of *Clarkina* and other corresponding stratigraphic markers.

Two questions are raised by this option. The first is that the reported occurrences in Texas of *Clarkina postbitteri* (Wardlaw pers. comm., 2002) and of transitional morphotypes between *J. crofti* and *C. postbitteri* (Wardlaw and Mei, 1998a) is in dispute. Wardlaw *et al*. (in this issue of Permophiles 39) now refer this taxon to “*Clarkina*” sp. and indicate that this taxon in West Texas occurs with *Jinogondolella* spp. including *J. granti*. It appears that conodont evolutionary trends within the Jiangnan and Delaware basins were similar and that *Clarkina*-like taxa appear in both areas as the Delaware Basin became evaporitic and the southern part of the Jiangnan Basin was represented by the lowest stand of sea-level. Within or near the continuous marine environments of the southern Jiangnan Basin, a successful lineage probably develops from *Jinogondolella granti* to *Clarkina postbitteri hongshuiensis*.

The second question is that a depositional hiatus has been suggested below Bed 6i-upper, in part because conodonts are absent or very rare below this surface suggesting very shallow water deposition. As described in the paragraph on depositional

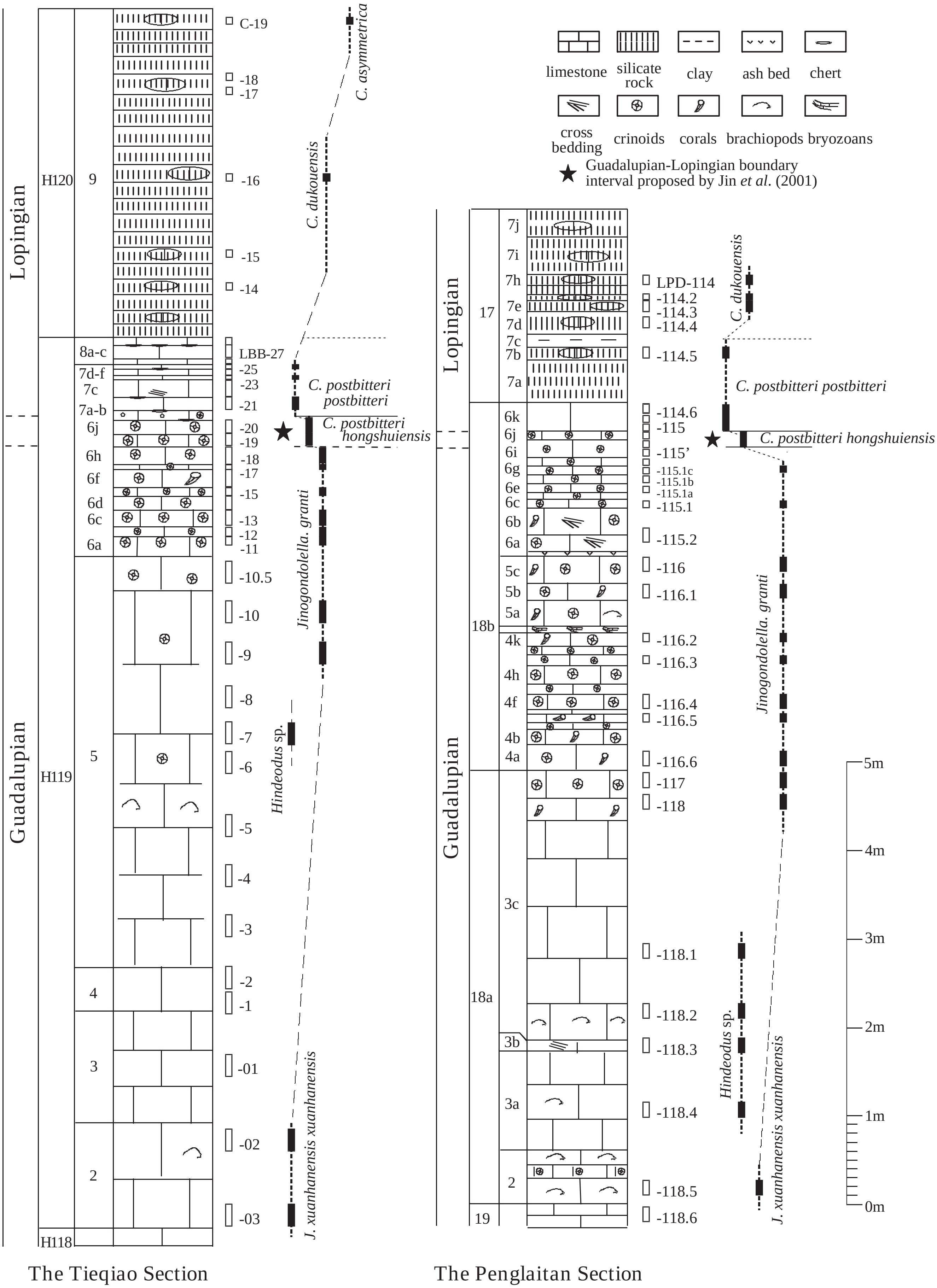

Figure 5. Key conodonts around the Guadalupian-Lopingian boundary interval in the Tieqiao and Penglaitan sections (modified after Mei *et al.*, 1998a).

succession, the upper part of the Laibin Limestone consists of high frequency cycles. Both Bed 6i-lower and Bed 6k form the upper parts of the uppermost two cycles and are fairly gradational and continuous with the lower parts of each cycle. Though depositional gaps might occur between cycles, they seem no more than those at normal bedding planes; that is, they are insignificant in terms of the resolution of conodont chronostratigraphy. A conodont zone usually comprises many cycles.

Some colleagues consider that only such rapid change of fossils and rocks permits worldwide correlation and recognition of beds of a defined age. Others indicate that the rapid faunal and sedimentological changes reflect an incomplete geological record; this view would require a boundary definition based on subtle stratigraphic changes that may not be useful for subsequent correlation.

Option B.

A point defined by the FAD at the base of Bed 6k of *Clarkina postbitteri postbitteri* within an evolutionary lineage from *C. postbitteri hongshuiensis* subsp. nov. to *C. dukouensis*. The FAD of *C. postbitteri sensu lato* could also be used to approximate this boundary, as it is only 20 cm below the defining point at the base of Bed 6i-upper at the Penglaitan Section. The reason for taking the name *Clarkina postbitteri postbitteri* is that the holotype of *C. postbitteri postbitteri* is from Bed 6k, of which the main part was originally marked as Bed 115 and the transitional part between Bed 115 and 114, as Bed 114.6.

Clarkina postbitteri postbitteri is a transitional form between *C. postbitteri hongshuiensis* and *C. dukouensis*. Therefore, the FAD of *C. postbitteri postbitteri* is defined within a gradational lineage in which deposition is continuous.

The main questions regarding this option are as follows. First, it may not be possible to consistently demonstrate the exact point at which *Clarkina postbitteri hongshuiensis* becomes *C. postbitteri postbitteri*, although it is fairly clear at Penglaitan. An arbitrary point in a morphologic transition is exactly that, arbitrary, and almost certainly inconsistent.

Second, this level does not correspond exactly to any major event in global biological or environmental change, and thus, this fossil zone alone is not sufficient for inter-regional correlation of the Guadalupian-Lopingian boundary sequences if we are to satisfy both of the requirements for depositional completeness and correlation potential. With that in mind, “priority can be given to the level with the best correlation potential” (Guideline of the ICS, 1996) and a compromise solution between these two requirements for the candidate section must be found. Our members need reliable information from various sources, including especially from the conodont workers, in order to make the right decision. In addition, a flexible mind and some concessions in selection of the GSSP are necessary in order that this arbitrary reference point can gain a majority of votes.

Decision of the International Working Group on the Lopingian Series

The Lopingian Boundary Working Group consists of Yugan Jin, Brian Glenister, Bruce Wardlaw, Charles Henderson, Cheng-yuan Wang, Claude Spinosa, Douglas Erwin, Ernst Leven, Galina Kotlyar, Guangrong Shi, Heinz Kozur, Jinzhang Sheng, Zhuoting Liao, Shilong Mei, Shuzhong Shen, Tatyana Leonova, Vladimir Davydov, Xiangdong Wang, and Yukio Isozaki. An informal survey was conducted on the following four choices: 1. Both options are acceptable, 2. Option A is preferred, 3. Option B is preferred, 4. Neither option is acceptable. Among the 18 members of the working group who have replied, eight members prefer Option A, seven prefer Option B, two remain noncommittal until the index conodont taxa at the boundary levels are officially published, and eight feel both options are acceptable but seven of them have their own preferences between the two. If we add up the numbers of members who support choices (1) and (2), Option A gets support from 12 members. Likewise, if we add up the numbers of members who support choices (1) and (3), Option B also gets support from 12 members.

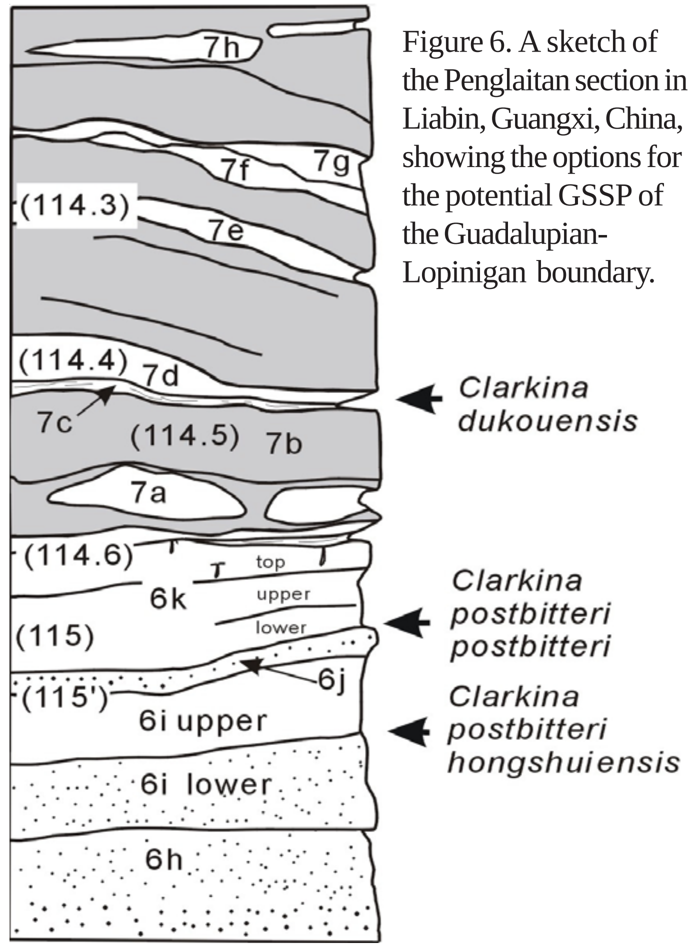

Figure 6. A sketch of the Penglaitan section in Liabin, Guangxi, China, showing the options for the potential GSSP of the Guadalupian-Lopinigan boundary.

Although the survey shows a unanimous agreement on supporting the Penglaitan Section as the stratotype section, neither of the two potential boundary levels has gained a required majority of support. As a result, the selection of the boundary level has now become a tie. In order to break the tie and to reach a timely consensus, the authors would like to ask the members to support Option B, even though it may not be ideal or necessarily better than Option A. Our rationale is that the stratotype point is arbitrary and conventional, and thus its selection ought to be practical as well as principled. In practice, correlation of this Guadalupian-Lopingian boundary will be achieved by using a set of drastic faunal and physical changes and need not rely only on the mor-

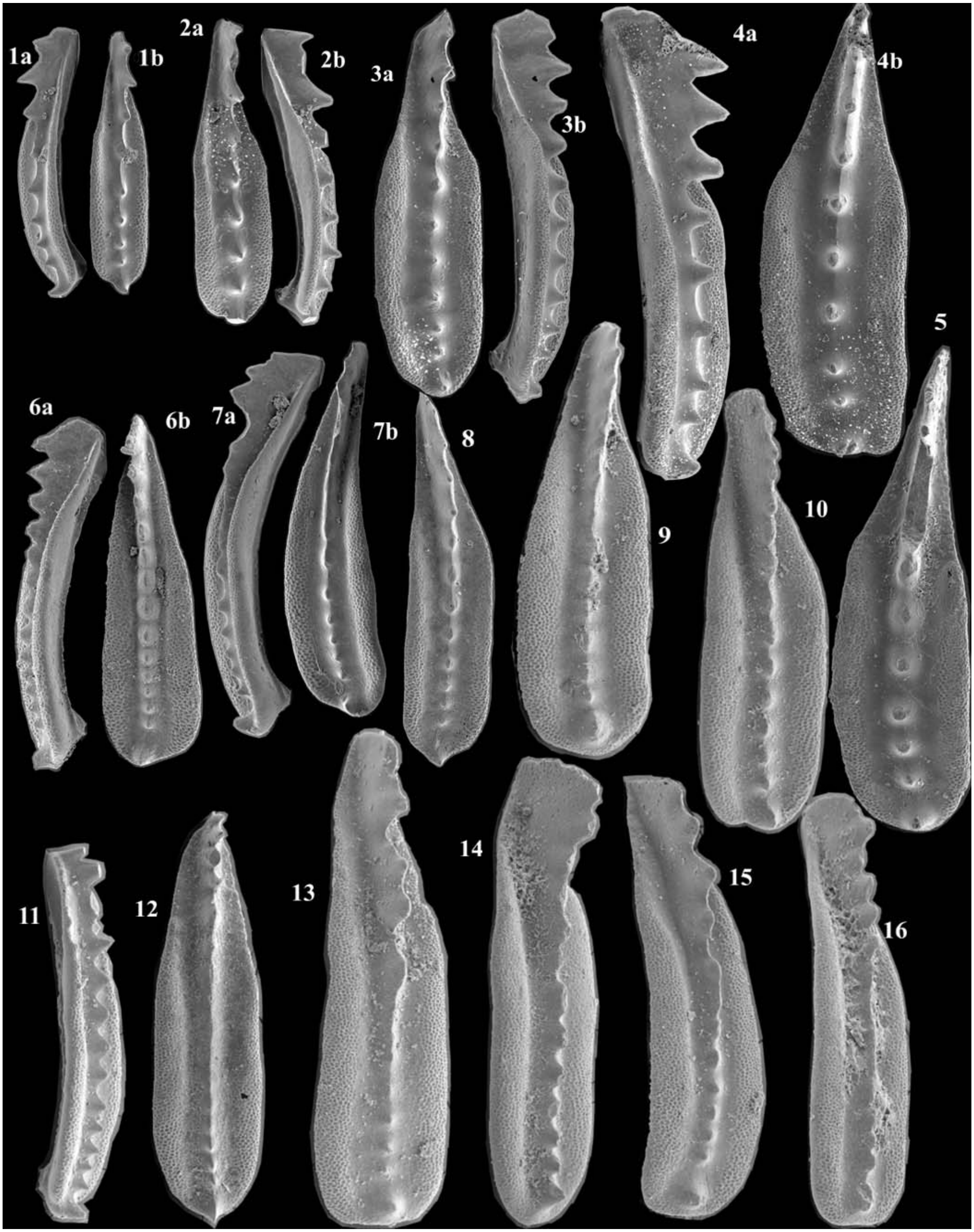

Plate 1. All specimens are SEM photos magnified the same amount (for scale specimen 9 is exactly 1 mm in length). Letter a and b designate different views of the same specimen.

Figures 1, 6-10, 13-16. *Clarkina postbitteri hongshuiensis* n. subsp. Henderson, Mei and Wardlaw (in press). Figures 1, 6, 8, 13-16 are from bed 6i-upper and figures 7, 9, 10 are from bed 6j at Penglaitan.

Figures 2-5. *Clarkina postbitteri postbitteri* Mei and Wardlaw 1994. All specimens are from bed 6k at Penglaitan.
Figures 11-12. *Jinogondolella granti* Mei and Wardlaw 1994. Both specimens are from bed 6h at Tieqiao

phological changes within the *Clarkina postbitteri* lineage.

This proposal has been sent to the voting members of the Working Group, and the decision of the Working Group will be reported in the next issue of Permophiles.

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ANNOUNCEMENTS

FIRST INTERNATIONAL PALAEONTOLOGICAL CONGRESS

6-10 July 2002 Sydney, Australia

The International Palaeontological Association, the Australasian Association of Palaeontologists, Macquarie University Centre for costratigraphy and Palaeobiology, and the Australian Museum extend a warm invitation to you to attend the First International Palaeontological Congress (IPC-2002) to take place in Sydney on 6-10 July 2002. Formal sessions of IPC-2002 will take place principally at Macquarie University.

Palaeontologists throughout the world have suggested themes for symposia at the Congress; we hope we have included most topics of current interest. We have endeavoured to cover topics that will showcase our science as a vital one, contributing to solving problems for biologists, geologists, isotope geochemists and climatologists alike. If anyone feels they have not been catered for, please contribute to Symposium 21: Aspects of other organisms.

Associated with the Congress will be two symposia: a Symposium in honour of Prof. Geoffrey Playford's sustained contribution to micropalaeontology, especially palynology, and the Jane Gray Memorial Symposium celebrating Jane's lifetime commitment to innovative research.

Coupled with the Congress will be meetings of IGCP 410 The Great Ordovician Biodiversity Event: implications for global correlation and resources, and IGCP 421 North Gondwana mid-Palaeozoic bioevent/biogeography patterns in relation to crustal dynamics, as well as meetings of the Association of Australasian Palaeontologists and the Pander Society. The Congress will be an appropriate venue for showcasing other activities of IUGS subcommissions on stratigraphy, and IGCP projects with a significant biochronologic focus. Please contact the Organising Committee in order to book a time-slot.

The Committee received excellent feedback from the First Circular; as a consequence, titles of some of the symposia have been altered slightly and excursions modified. The excursions, as well as visiting regions noted for their outstanding palaeontological interest, will provide opportunities to see some of the unique landscapes of Australia. Despite problems with airlines, both international and domestic, the Committee is determined to push forward with the program as set out herein. Any changes will be communicated directly to individuals who may be affected and as general announcements on Paleonet and on the Congress web page.

Sydney is built around one of the most scenic harbours in the world. Its comparatively mild winters, and high diversity of food, wine and coffee houses offers an ideal location to interact with colleagues and make new friends. Technical aspects of the Congress will be intercalated with a diverse spectrum of social activities including a day for local excursions to enable visitors to sample the many attractions, scientific and cultural, of Sydney and its surroundings. The venue for the Congress is Macquarie University, 17 km northwest of the Harbour Bridge and the Central Business District (CBD).

The Committee looks forward to meeting you in July 2002 at Macquarie University in what we believe will be a series of educationally stimulating and culturally enjoyable events.

John A. Talent
Chair of the Organising Committee
President of the International Palaeontological Association

Important Dates

Submission of Abstracts: March 30, 2002

Registration and deposit: March 30, 2002

Final Payments and Accommodation booking: March 30, 2002

Technical Sessions: Sat. July 6 to Wed. July 10, 2002

Pre-congress excursions: Commence from June 23; most from June 30, 2002

Post-congress excursions: Commence July 11; last one concluding on July 29, 2002

For more information go to the website at http://ipa.geo.ukans.edu/convention.html

Coming Soon! – Canadian Society of Petroleum Geologists MEMOIR 19

CARBONIFEROUS AND PERMIAN OF THE WORLD, XIV INTERNATIONAL CONGRESS ON THE CARBONIFEROUS AND PERMIAN (M19)

This memoir highlights a 100 million year interval during which the supercontinent Pangea was assembled, addressing issues of sedimentology, stratigraphy, resources, and paleontology. Memoir 19 contains 60 refereed papers representing the selected proceedings of the XIV International Congress on the Carboniferous and Permian held at the University of Calgary in August 1999.This publication will be valuable to geoscientists interested in Carboniferous and Permian geology, not only in Western Canada, but also around the world. Topics covered include:

- Belloy Formation sequences and paleogeography in the Peace River Basin
- Seven papers on Cyclothems from Western Canada, USA, and Spain
- Coal Resources and a North Sea gas play
- U-Pb geochronology, sedimentology and stratigraphy of tuff in the Exshaw Formation
- Carboniferous palynology and megaflora
- Carboniferous sedimentology and stratigraphy of eastern North America
- Paleontological correlations of the Carboniferous and Permian
- Discussions on Global Stratotype Sections and Points for Carboniferous and Permian stages.

The International Congress on the Carboniferous and Permian (ICCP) was first held in June 1927 in Heerlen, The Netherlands. The meetings have been held mostly in Europe (Heerlen, Paris, Sheffield, Krefeld, Moscow, Madrid, Krakow), but also in South America (Buenos Aires), Asia (Beijing), and North America (Urbana, Illinois and for the first time in Canada at Calgary, Alberta in August 1999). The meeting began by looking only at the Carboniferous from the perspective of understanding the geology of this resource-rich, coal-bearing system. At Beijing in 1987 the Permian System was added to the congress, which was a natural extension to many Carboniferous geological problems. The ICCP is one of the oldest and most prestigious of the stratigraphic congresses associated with the International Commission on Stratigraphy and the International Union of Geological Sciences. Almost three hundred people attended the Calgary meeting and presented over 300 talks, posters, and core displays. The meeting was in part sponsored by the Canadian Society of Petroleum Geologists.

Edited by Len V. Hills, Charles M. Henderson, and E. Wayne Bamber, 2001 (December), hard cover, approx. 800 pages, ISBN 0-920230-008

To order your copy go to: www.cspg.org/Publications/publications/.html

Available in February, 2002

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