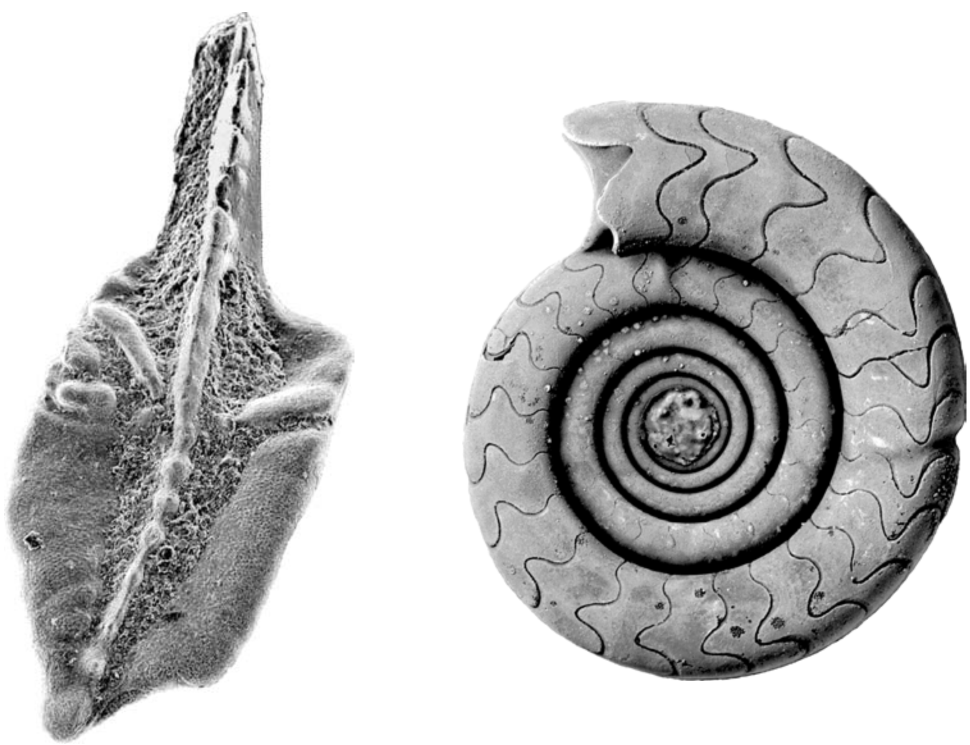
NEWSLETTER ON CARBONIFEROUS STRATIGRAPHY

Volume 20 July 2002



SCCS

I.U.G.S. SUBCOMMISSION ON CARBONIFEROUS STRATIGRAPHY

Table of Contents

Newsletter on Carboniferous Stratigraphy

Edited by D.M. Work

IUGS SUBCOMMISION ON CARBONIFEROUS STRATIGRAPHY / VOL. 20 - 2002

CHAIRMAN'S COLUMN

The last year has seen progress toward definition of boundaries between the stages of the Carboniferous System. This is in keeping with the mandate of the ICS, our parent body, that all GSSPs should be selected by 2008. This mandate was strongly reconfirmed at a mid-June ICS meeting in Urbino, Italy.

Status of Boundary Working [Task] Groups

The definition of the Tournaisian-Viséan boundary proposed by the Working [Task] Group chaired by George Sevastopulo has been approved by the membership, as indicated in the Secretary/Editor's Report. I have appointed chairs for two new Task Groups [as Working Groups are now called by IUGS mandate to ICS] dealing with two boundaries, one close to the Viséan-Serpukhovian boundary, and the other close to the Bashkirian-Moscovian boundary. The Task Group to establish a GSSP close to the existing Viséan-Serpukhovian boundary is chaired by Barry Richards of the Canadian Geological Survey and is in the process of soliciting membership. The Task Group to establish a GSSP close to the existing Bashkirian-Moscovian boundary is chaired by John Groves of the University of Northern Iowa and is also in the process of soliciting membership. There has been more progress in focusing on lineages within fossil groups that will ultimately define the boundaries close to the Moscovian-Kasimovian boundary and close to the Kasimovian-Gzhelian boundary, as shown in the report of that Working [Task] Group chaired by Elisa Villa. Thus there are now Task Groups either in progress or just getting underway with the tasks of selecting GSSPs close to the boundaries of all the stages that are currently recognized in eastern Europe, the lower two with classic western European series names and the upper five with the classic Russian stage names. I look forward to seeing the progress reports on definition and selection of stage boundaries at the Workshop on Carboniferous Stratigraphy that is planned for the Fifteenth Conference on Carboniferous and Permian Stratigraphy [XV-ICCP], which will be held in Utrecht, The Netherlands, in August 2003.

Number of Stages and Likely Names

It thus appears likely that there will be seven stages in the Carboniferous System, three in the Mississippian Subsystem and four in the Pennsylvanian Subsystem. Most workers seem to regard this as a reasonable number [see Menning et al. 2001 in Newsletters in Stratigraphy, 38: 201-207]. The names of the Mississippian stages are [or likely will be] Tournaisian, Viséan, and Serpukhovian, pending final selection of suitable GSSPs. The names of the lower two Pennsylvanian stages will very likely be Bashkirian and Moscovian, pending selection of a suitable GSSP. This is because the potentially competing North American names include the Atokan Stage, which straddles this boundary and which is difficult to define biostratigraphically because of inadequacies in its type area. The names of the upper two Pennsylvanian stages could be either Kasimovian and Gzhelian or Missourian and Virgilian because the lower boundaries of the Kasimovian and Missourian are fairly close, and the lower boundaries of the Gzhelian and Virgilian may be nearly coincident. The choice in my opinion lies in which of the two name sequences have greater recognition worldwide on the basis of their included biota, regardless of where the appropriate boundary GSSPs may ultimately be chosen. One corresponding member has found the Russian names to be useful in Canada and India. I welcome input on this matter from other workers in areas outside of the United States and Russia, particularly from those working in southern Europe, northern Africa, southern and eastern Asia, the Arctic region, and the southern continents outside of the Gondwanan facies.

Series Subdivision

This brings up the issue of series subdivision of the Carboniferous, for which I and A. S. Alekseev presented two different possibilities in separate articles in last year's Newsletter [volume 19], asking for input by e-mail or as articles for this year's Newsletter [volume 20]. I proposed that series names be Lower, Middle, and Upper Mississippian, and Lower, Middle, and Upper Pennsylvanian, with each series comprising a single stage, except for the Upper Pennsylvanian, which would comprise two stages. Alekseev proposed four series based on all of the traditional western European series names except for the Namurian, which has been split by the mid-Carboniferous boundary. To compensate for the loss of the Namurian, he proposed extending the Westphalian Series downward to include the upper Namurian as the lower part of the Bashkirian Stage, and extending the Viséan Series upward to include the lower Namurian Serpukhovian Stage as its upper part. The lower part of the Viséan Series would be subdivided into three stages, and the Tournaisian Series would be subdivided into two stages, both using the established Belgian names. I was rather surprised that I received no direct response to this issue. One article submitted to this Newsletter, by Wagner and Winkler Prins, commented favorably on several aspects of both proposals, but noted problems with extending the names Viséan and Westphalian far beyond what they traditionally have encompassed. I find that the main problem with Alekseev's proposal is that it would require three new stage boundaries to be selected for the Belgian stages above the bases of the Tournaisian and Viséan series, which would require experts in that part of the succession to form new Task Groups. I realized another problem when I composed my article on Pennsylvanian radiometric dates that appears in this Newsletter: The traditional Stephanian may include only a small part of late Pennsylvanian time [defined by the official Carboniferous-Permian boundary in the southern Urals], the remainder being represented by the Autunian. This issue will also be discussed at the Carboniferous workshop in Utrecht.

Radiometric Dating

I have not been informed of any new significant dates for the Carboniferous beyond those reported in the articles by Menning and others and Becker and others in last year's Newsletter [volume 19]. The report by Davydov and others in this year's Newsletter that they have collections of both radiometrically datable minerals and abundant conodonts from the same volcanic ash beds in critical southern Urals sections [near that where the Carboniferous-Permian GSSP was selected] is welcome news. This means that more biostratigraphically well constrained dates will become available to hopefully clarify the 'murky state of affairs in Carboniferous radiometric dating'. In the meantime, I was stimulated by questions from several colleagues to summarize my opinions on the meaning of the various, often conflicting dates that have been presented for the Pennsylvanian Subsystem. This summary appears as a separate article later in this Newsletter. The ICS meeting emphasized the importance of accurate radiometric dating throughout the stratigraphic column, and I expect that radiometric dating will be discussed further in Utrecht.

Chemostratigraphy

Saltzman [2002 GSA Bulletin 114: 96-108] reports more localities in the western U.S. that show the mid-Tournaisian delta ^{13}C spike to nearly 7, which he and coauthors reported in 2000 [Geology 28: 347-350]. The research group coordinated by Ethan Grossman at Texas A & M University [in a paper published in the volume for the August 2002 Carboniferous Biostratigraphic meeting in Ekaterinburg, Russia] illustrates a delta ^{13}C spike of somewhat lesser magnitude very close to the Serpukhovian-Bashkirian [Mid-Carboniferous] boundary in the Urals. This latter shift from relatively low values in the Serpukhovian has potential significance in chemically correlating the Mid-Carboniferous boundary into the Gondwana and Angara regions, where it is not yet accurately identified because of the loss of the typical late Mississippian pantropical marine fossils in those regions as they cooled significantly. It is hoped that some aspect of chemostratigraphy may soon be able to record the exact times of inferred cooling, one of which in the Kuznetsk Basin of Siberian Angaraland is described in the article by Ganelin and Durante in this Newsletter. Ongoing work in the stable isotope lab here at Iowa shows a pattern in a late Desmoinesian cyclothem that is different from that in the mid-Missourian cyclothem mentioned last year, indicating that each Midcontinent cyclothem needs to be analyzed in detail and its pattern interpreted in terms of diagenetic factors as well as several environmental factors of local and regional scale. An interesting new study from the University of Erlangen [Horacek et al. in 2001 Terra Nostra, 4: 20-24] shows that delta ^{18}O data extracted from the apatite of conodonts in Midcontinent Pennsylvanian cyclothems appear to reflect ice-volume changes as well as temperature changes that occurred during cyclothem deposition. The mid-June ICS meeting also emphasized the importance of integrating all the various newer chemical methods in stratigraphy with the classic biostratigraphic-based scale, and I hope that more interesting trends in chemostratigraphy will be presented in Utrecht.

'Carboniferous of the World'

Manuscripts are coming in for the remaining volumes of this very useful compendium on global Carboniferous stratigraphy, and general editors Robert Wagner and Cor Winkler Prins are making plans for publication of Volume IV focusing on North America as early as 2003. The Appalachian region is complete, and the Midcontinent region is nearly so, and an appeal is made to other regional coordinators to urge submission of remaining manuscripts as soon as possible.

St. Louis Field and General Meeting

In September 2001, the SCCS met in St. Louis, U.S.A., in the heart of the type region for the Mississippian Subsystem, the lower of the two basic Carboniferous subdivisions. Led by Paul Brenckle and Rich Lane who have compiled a large amount of biostratigraphic data on this succession, the initial two-day field trip up the Mississippi River visited type Kinderhookian and classic Osagean localities [equivalent to Tournaisian and lower Viséan] and type Meramecian [mid-Viséan] localities around St. Louis. The following day was spent in a general meeting with eight presentations covering topics of Mississippian stratigraphy and biostratigraphy, with a focus on the Tournaisian-Viséan boundary and a potential GSSP in China, and on the biostratigraphy of the Serpukhovian Stage in Russia. The list of authors and titles appears at the end of this column. The last three days were spent on a field trip down the Mississippi River visiting mainly Meramecian and type Chesterian localities [equivalent to upper Viséan and Serpukhovian]. The updated guidebook for this field trip will soon be available for purchase from the Illinois State Geological Survey in Champaign, Illinois 61820, U.S.A.

Speakers and Titles, St. Louis General Meeting, September 10, 2001

H. Richard Lane: Overview of Mississippian stratigraphy in its type region

Geoff Clayton: Mississippian palynostratigraphy

George Sevastopulo, Francois-X. Devuyst, and Luc Hance: Progress toward a better definition of the Tournaisian-Viséan boundary: Implications for long-distance correlations

Francois-X. Devuyst, H.F. Hou, M. Coen, L. Hance. G.D. Sevastopulo, F. Tian, and X.H. Wu: The Pengchong section (South China, Guangxi Autonomous Region), a GSSP candidate for the base of the Viséan

Nilyufer B. Gibshman and Elena A. Kulagina: Lower Carboniferous foraminiferal zonal standard of Russia, a basis for international correlation and definition of the approximate position of the Tournaisian-Viséan boundary

Nilyufer B. Gibshman: Foraminifera of the Serpukhovian Stage type area (Moscow Basin) as a basis for international correlation and determination of the position of the Viséan-Serpukhovian boundary

Svetlana V. Nikolaeva, Elena A. Kulagina, and V.N. Pazukin: An integrated biostratigraphy for the Serpukhovian of the Urals

Svetlana V. Nikolaeva and Juergen Kullmann: Updated Serpukhovian ammonoid biostratigraphy in the Urals and Central Asia

Philip H. Heckel

SECRETARY / EDITOR'S REPORT 2001-2002

I want to thank all who provided articles for inclusion in Volume 20 of the Newsletter on Carboniferous Stratigraphy and those who assisted in its preparation. I am indebted to P.H. Heckel for editorial contributions; and to P. Thorson Work for coordinating the compilation of this issue

Ballot on Definition of Tournaisian-Viséan Boundary

At the time that the 'Working Group to establish a boundary close to the existing Tournaisian-Viséan boundary' was established at the 1995 Krakow Carboniferous Congress, the biostratigraphic definition was not specified. In 2000, George Sevastopulo and Luc Hance [Newsletter on Carboniferous Stratigraphy, v. 18, p. 6] reported for the Working Group that a lineage within the foraminifer genus *Eoparastaffella* has the potential to provide a biostratigraphic tool of high resolution for correlation around the boundary. This lineage was illustrated by Hance in the 1997 Carboniferous Newsletter [v. 15, p. 40-41]. In the 2001 Carboniferous Newsletter [v. 19, p. 7-8], Sevastopulo, Hance and others summarized the encouraging results that have been obtained using this biostratigraphic tool from the Pengchong section in South China, which has good potential for being selected as a GSSP for this boundary (see also Sevastopulo et al., p. 6-7, this issue). At the September 2001 SCCS Meeting and Field Trip in St. Louis, the Working Group proposed to submit officially to the SCCS voting membership the biostratigraphic criterion based on the first appearance of *Eoparastaffella simplex* in the lineage *Eoparastaffella ovalis* group » *Eoparastaffella simplex* to define the base of the Viséan. This definition was informally approved without dissent by attendees at that meeting. Accordingly, a formal ballot on the Working Group's proposed definition of the Tournaisian-Viséan boundary was distributed to the Voting Members of the SCCS in early 2002, which was overwhelmingly approved by the membership (19 affirmative votes, 2 non-responses).

Future Issues of Newsletter on Carboniferous Stratigraphy

The recent decrease in funding received from ICS (down 20% in 2002) combined with the steadily increasing number of corresponding members and the high volume of manuscripts received makes the future of the Carboniferous Newsletter uncertain. The relatively small number of donations received in 2001 is insufficient to offset the increasing number of corresponding members requesting copies, and makes it critical that financial donations be received from members who can afford to donate, in order to help offset the resulting increase in publication and distribution costs. The Newsletter is expensive to publish and distribute, and it is our hope that increased donations will enable us to continue to distribute copies to all who desire them (please refer to the instructions for donations on the last page of this issue).

Next year's Volume 21 will be finalized by July 2003, and I request that all manuscripts be sent before May 31—but preferably much earlier. I ask all authors to please read the section below (page 5) regarding submission format, especially manuscript length and diagram scale. Finally, I would be most grateful if all voting and corresponding members of the SCCS would let me know of any changes to their postal and e-mail addresses so that we may update our records.

David M. Work

SCCS ANNUAL REPORT 2001

Membership

The Subcommission had 21 voting members in 2001 [see list at end of Newsletter]. In addition, corresponding membership at the time of publication stands at 312 persons and 6 libraries.

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Working and Exploratory Project Groups

Working Group to establish a boundary close to the Tournaisian-Viséan boundary, chaired by George Sevastopulo (Ireland).

Working Group to establish a boundary close to the Moscovian-Kasimovian boundary [which is also close to the Desmoinesian-Missourian boundary], chaired by Elisa Villa (Spain). This group is also looking at potential boundaries close to the Kasimovian-Gzhelian [and Missourian-Virgilian] boundary.

Project Group on a chronostratigraphic level around the Viséan V3a-V3b boundary, chaired by Nick Riley and Bernard Owens (UK).

Project Group on a boundary close to the Viséan-Namurian/Serpukhovian boundary, chaired by Nick Riley (UK).

Project Group on zonation in late Namurian successions to help establish the Bashkirian Stage as a geochronological standard, chaired by Juergen Kullmann (Germany).

Project Group on comparative Angara and Gondwana biostratigraphy, chaired by Marina Durante (Russia).

Chief Accomplishments in 2001:

Geoff Clayton [Ireland] was elected Vice-Chair of the SCCS. We produced a short document concerning the new official nomenclature of the two parts of the Carboniferous System that was officially approved by the SCCS, ICS and IUGS in

1999-2000. We are sending it out to journals of international distribution, notifying them that the two basic subdivisions of the Carboniferous System are the Mississippian Subsystem and the Pennsylvanian Subsystem, rather than Lower and Upper Carboniferous (used in many parts of the world), which are ambiguous terms from one part of the world to another.

Working and Project Group reports received are given later in this Newsletter.

In September 2001, the SCCS sponsored a general meeting at St. Louis, Missouri, USA, with an associated field trip led by Paul Brenckle and Rich Lane that visited the type region of the Mississippian Subsystem in the Mississippi River valley north and south of St. Louis. This meeting was attended by a total of 22 people, including 7 voting members of the SCCS and 1 member of the ICS executive board. A total of 8 participants, including 4 voting members, came from Europe. The SCCS meeting included 8 presentations, which focused on the promising candidate section in south China for a GSSP for the Tournaisian-Viséan boundary, and on biostratigraphy of the Tournaisian-Viséan and Viséan-Serpukhovian boundary intervals in Russia.

A 108-page guidebook entitled '*Stratigraphy and Biostratigraphy of the Mississippian Subsystem (Carboniferous System) in its Type Region, the Mississippi River Valley of Illinois, Missouri, and Iowa*' was published for the field trip associated with the September 2001 SCCS meeting in St. Louis. This guidebook summarizes the basic lithostratigraphy of the type Mississippian, and the immense amount of biostratigraphic information collected and analyzed during the 1970s by Paul Brenckle and Richard Lane while supported by Amoco Production Company, along with a summary of current knowledge on the Mississippian succession in Iowa, which contains some enigmatic units that only now are becoming better understood.

The Newsletter on Carboniferous Stratigraphy, Volume 19, published July 2001, contains reports of Working Groups for 2000, and 24 articles on various topics, including alternative possibilities for series and stage classification of the Carboniferous and the latest data on radiometric dating in the Carboniferous, as well as many articles on various aspects of Carboniferous stratigraphy from many parts of the world, for a total of 79 pages.

Work Plan for 2002 and Following Years:

In view of the IUGS mandate to have all GSSPs chosen by 2008, we believe that it is time to establish two new Working Groups, one to deal with selection of a GSSP close to the existing Viséan-Serpukhovian stage boundary, and the other to deal with selection of a GSSP close to the Bashkirian-Moscovian stage boundary.

We are encouraging further movement toward consensus on competing suggestions for series and stage names and classification of the Mississippian and Pennsylvanian Subsystems, along with the ongoing work on selecting appropriate global stage boundaries within the Carboniferous System.

We are urging more effort on reconciling the disparate radiometric dates by different methods at many levels in the Carboniferous, for more dating of biostratigraphically well-constrained strata, and also for more work on stable carbon and oxygen isotopes and other methods of chemostratigraphy within the Carboniferous, as outlined in the Chairman's Column.

We are calling for the more timely submittal of remaining manuscripts for the final two volumes of 'The Carboniferous of the World' to general editors Robert Wagner and Cor Winkler Prins.

STATEMENT OF OPERATING ACCOUNTS FOR 2000/2001, Prepared by David Work, Secretary (Definitive accounts were maintained in US currency)

INCOME (Oct. 2000--Sept. 2001)	**$US**
IUGS Grant in 2001	1,000.00
Donations from Members	225.54
TOTAL INCOME	**1225.54**
EXPENDITURE	
Newsletter 19 printing and postage	1995.31
Mailing Supplies (Newsletter 19)	63.52
Bank Charges	126.94
TOTAL EXPENDITURE	**2185.77**
BALANCE SHEET (2000- 2001)	
Funds carried forward from 1999 - 2000	2853.07
PLUS Income 2000 - 2001	1225.54
LESS Expenditure 2000 - 2001	-2185.77
CREDIT balance carried forward to 2001- 2002	**1892.84**

Donations in 2001/2002:

Publication of this *Newsletter* is made possible with generous donations received from members/institutes during 2001-2002 and anonymous donations, combined with an IUGS subsidy of US $800 in 2002, and additional support from a small group of members who provide internal postal charges for the *Newsletter* within their respective geographic regions.

COVER ILLUSTRATION

Mississippian (early Osagean) conodont and ammonoid from the Borden Formation, Milepost 135 roadcut section near Morehead, Rowan County, northeastern Kentucky, USA (see Sandberg, Mason, and Work, Carboniferous Newsletter, v. 19, p. 23).

Left: *Polygnathus communis carinus* Hass, 2.3 m above base of Borden Formation [2.3 m above base of Henley Bed]. SEM: C.A. Sandberg.

Right: *Kazakhstania colubrella* (Morton), 17 m above base of Borden Formation [1.5 m above base of Nancy Member]. Photograph: D.M. Work.

CONTRIBUTIONS TO THE NEWSLETTER

The Newletter on Carboniferous Stratigraphy is published annually (in July) by SCCS. It is composed of written contributions from its members and provides a forum for short, relevant articles such as:

*reports on work in progress and / or reports on activities in your work place

*news items, conference notices, new publications, reviews, letters, comments

*graphics suitable for black and white publication.

Contributions for each issue of the Carboniferous Newsletter should be timed to reach the Editor before 31 May in the year of publication. It is best to submit manuscripts as attachments to Email messages. Except for very short news items, please send messages and manuscripts to my Email address followed by hard copies by regular mail. Manuscripts may also be sent to the address below on diskettes prepared with **Microsoft Word (preferred)** or WordPerfect but any common word processing software or plain ASCII text file can usually be acommodated; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code. Maps and other illustrations are acceptable in tif, jpeg, eps, or bitmap format (plus a hard copy). 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.

Due to the recent increase in articles submitted by members we ask that authors limit manuscripts to 5 double-spaced pages and 1 or 2 diagrams, well planned for economic use of space.

Please send contributions as follows,

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Progress report of the Working Group to establish a boundary close to the existing Tournaisian-Viséan boundary within the Lower Carboniferous

G. Sevastopulo[1], F.X. Devuyst[2]*, L. Hance[2], H. Hou[3], M. Coen[2], G. Clayton[1], S. Tian[3] and X.H. Wu[4]**

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In September 2002, at the SCCS field meeting on the type Mississippian held in St. Louis (USA), the group proposed to submit officially to the voting members the biostratigraphic criterion based on the evolution of *Eoparastaffella* proposed by Hance (1997) to define the base of the Viséan. It is a preliminary step for choosing the most appropriate stratotype. This criterion is based on the morphological evolution of the genus from the Upper Tournaisian to the Viséan regardless of the species. Simple morphologic parameters can be used by non-foraminifer specialists to characterize this evolution and identify the base of the Viséan. Two coefficients are proposed: the e/r ratio (Hance, 1997) which characterizes the shape of the last whorl and the sphericity index (S) which is an approximation of the general shape of the test (Fig.1). Both indexes display a general progressive increasing trend from the Tournaisian to the Viséan and a shift at the boundary which correspond to the entry of *Eoparastaffella simplex*.

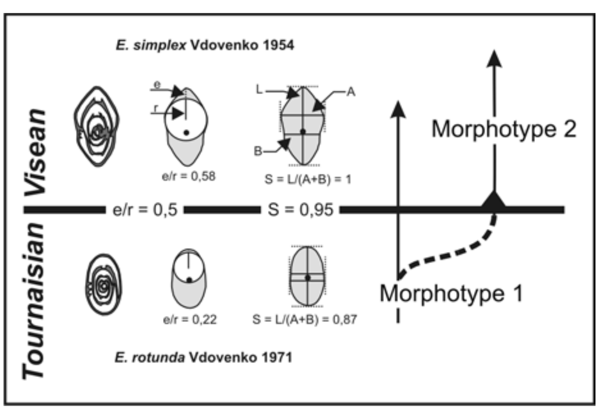

Fig. 1. *Eoparastaffella* morphotypes and morphometric coefficients across the T/V boundary.

The proposed criterion has been tested successfully in Belgium, Ireland, northern Iran and southern China. It should also be easily applied in the Czech Republic (Ondrackova, 2001). According to the Working Group, it is the best criterion proposed so far to define the base of the Viséan (Sevastopulo and Hance, 2000).

At the same meeting the group presented abundant new foraminiferal material from southern China constrained by conodonts (Fig.2) documenting for the first time the early evolution of the Ozawaineliids. This material shows that the Viséan *Eoparastaffella simplex* (morphotype 2 of Hance, 1997) evolves progressively from *E. ovalis* among the other species (*rotunda*, *fundata*) of the Tournaisian stock (all belonging to morphotype 1) (Fig. 3).

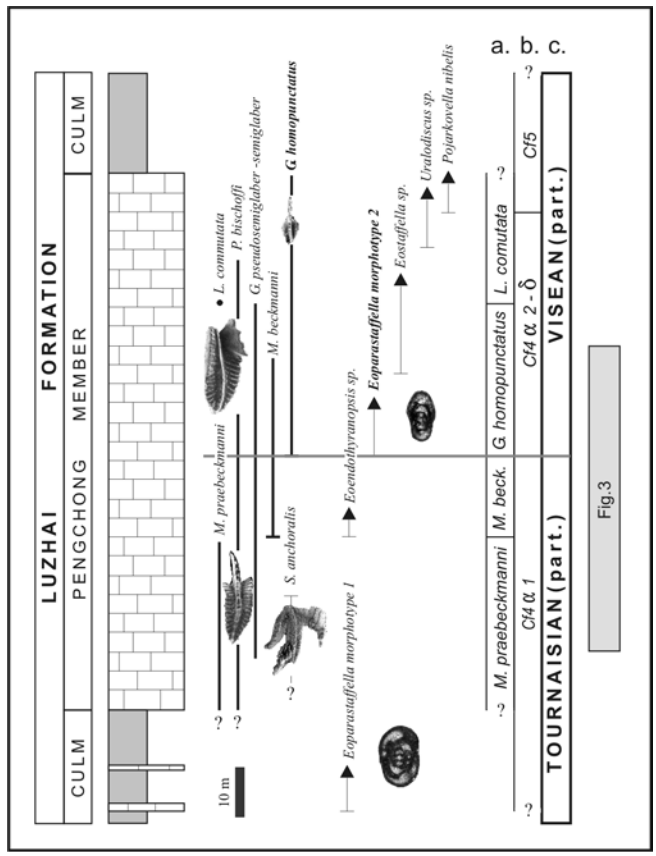

Fig. 2. Distribution of the most significant conodonts and foraminifers taxa in the Pengchong section. a. conodonts biozones; b. foraminifers biozones; c. Belgian stages.

Since then new field work has been conducted in southern China and northern Iran to precise and test the criterion.

South China (Guangxi Autonomous Region):

New sampling of the **Pengchong** section, the best candidate stratotype so far (Hance et al., 1997a; Sevastopulo et al., 2001) has been done to better document the sequence from the Tournaisian to the Viséan. The work has focused on the following points:

- re-sampling of the Tournaisian-Viséan transition for conodonts (S. Tian, M. Coen – study of the material in progress);

- test sampling of shale inter-beds for condonts (G. Sevastopulo – in progress);
- detailed sampling of dark shale interbeds for palynomorphs (G. Clayton – in progress);
- selective re-sampling of the critical interval for foraminifers (L. Hance, F.X. Devuyst, X.H. Wu - study of the enormous material well advanced);
- detailed sampling of selected limestone beds for petrography (F.X. Devuyst - study almost completed).

Contacts have been taken with M. Saltzman of the Ohio State University (USA) to study the C and O stable isotopes and with M. Hu of the Lancaster University (UK) for the magnetostratigraphy.

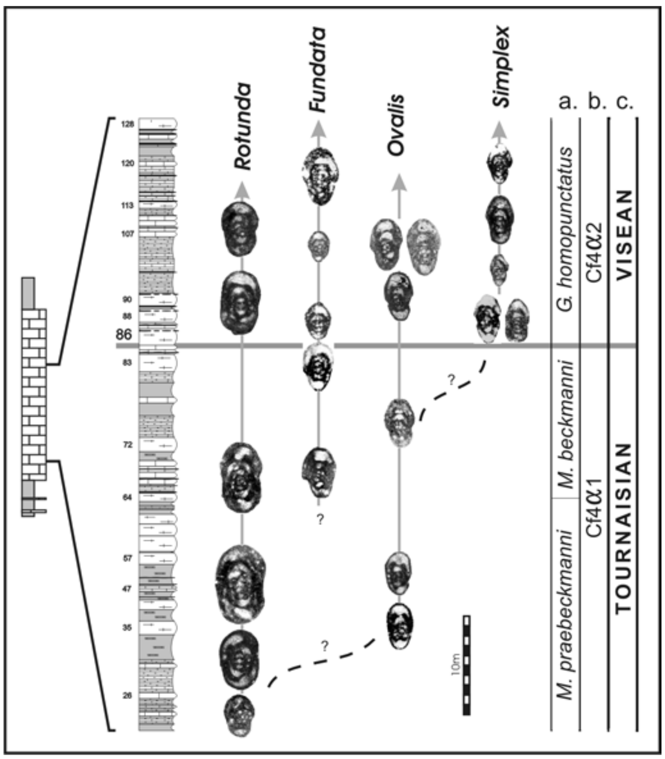

Fig. 3. Evolution of *Eoparastaffella* across the T/V boundary in the Pengchong section. a., b., c. as for Fig.2.

A southwards shallower equivalent of the Pengchong section, the **Longdianshan** section has also been investigated in more detail. A coral zonation has been established in this section by Xu and Poty (1997). This should allow a better correlation between the platform and the basin in a sequence stratigraphical framework (Hance et al., 1997b).

Northern Iran (Alborz Range):

The **Gaduk** section (Gaduk valley, north of Teheran) has been sampled for foraminifers and corals in collaboration with D. Vachard of the Université des Sciences et Technologies de Lille (France) and of B. Hamdi of the Geological Survey of Iran. Foraminiferal material is abundant and the base of the Viséan has been recognized on the basis of *Eoparastaffella*. Corals are being currently studied by E. Poty of the Université de Liège (Belgium).

A global understanding of the sedimentology of the T/V transition integrated with the biostratigraphical data is critical in the definition of a boundary stratotype. Work is in progress in this respect with the publication of a sequence stratigraphy framework for the Lower Carboniferous of the Namur-Dinant Basin (type Dinantian) and its correlation with northern France (Hance et al. 2001) and southern England (Hance et al, in press). The drastic sea level drop that lead to the emersion of platform areas in these regions has been traced to western Ireland and Southern China (Hance et al., 1997b). Current data therefore show that the T/V transition will be missing in most platform areas and that suitable stratotypes have to be searched in deeper sedimentation zones.

References:

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A report from the Working Group to define a GSSP close to the Moscovian-Kasimovian boundary

Searching for levels of correlation within the upper part of the Carboniferous System (Upper Pennsylvanian)

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During the year 2001, the SCCS working group formally named '*Working Group to define a GSSP close to the Moscovian-Kasimovian boundary*' has continued progressing with studies related to several potential levels of correlation within the upper part of the Carboniferous System (Pennsylvanian Subsystem). These levels are within an interval from the uppermost Moscovian (upper Desmoinesian) to the lower Gzhelian (lower Virgilian).

The main areas investigated are paleotropical areas such as the Donets Basin (Ukraine), Moscow Basin and South Urals (Russia), and Midcontinent region of North America, areas that have served for establishing the classical Carboniferous stratigraphic scales. During the study of successions from these areas, we have found some stratigraphic events related to conodont and fusulinoidean evolution which represent the basis for the potential levels of correlation. These events have been summarized in volume 19 of *Newsletter on Carboniferous Stratigraphy* (report by E. Villa and Working Group, 2001).

The most recent studies by members of our working group show that a strong fusulinoidean provincialism existed in Eurasia during late Kasimovian time, making it difficult to establish correlations on the basis of the fusulinoideans between the western Paleo-Tethys areas (Central Asia, Cantabrian Zone, Carnic Alps) and the Donets and Moscow Basins (Villa and others, 2001, 2002). However, some lower Gzhelian fusulinoidean faunas [e. g., *Rauserites rossicus* (Schellwien)] show wider distribution and, therefore, they seem to have a potential for correlation within Eurasia (Villa and Ueno, 2002). This wider geographic distribution could be the consequence of a major early Gzhelian trangression (Villa and others, in progress).

Conodont faunas are being intensively investigated in all concerned areas. It is worth mentioning the new data gathered from the North American Midcontinent and Paradox Basin (by Jim Barrick, Phil Heckel and Lance Lambert), the Cantabrian Zone (by Carlos Méndez) and the Moscow Basin and South Urals (by Aleksander Alekseev and Natalya Goreva):

Jim Barrick, Phil Heckel and Lance Lambert report that a revised preliminary conodont zonation for the Lower and Middle Pennsylvanian of Midcontinent North America was presented at the Pander Symposium at the North-Central Geological Society of America meeting in April, 2002 (Lambert and others, 2002). A summary of the complete revised Pennsylvanian conodont zonation for Midcontinent North America will be presented as a poster session at the ECOS VIII meeting in Toulouse in June, 2002 (Barrick and others, 2002). Earlier versions of the zonation were given previously in the *Newsletter on Carboniferous Stratigraphy* (Barrick and Heckel, 2000; Lambert and others, 2001).

The American members also reported that a paper on Middle and Late Pennsylvanian conodonts from the Honaker Trail Formation in Utah was published by Ritter and others (2002), in which several of the major cyclothems of the North American Midcontinent were correlated with Paradox Basin cycles using conodont faunas. This paper also documents that the occurrence of the fusulinoidean *Protriticites* in the Honaker Trail section corresponds approximately to the Lower Pawnee cyclothem in the Midcontinent, the third major cyclothem below the base of the Missourian Stage. This is also below the first appearance of New Genus S, which was used by Lambert and others (2001) to name the highest idiognathodontid conodont zone of the Desmoinesian.

Other relevant conodont information concerns the Las Llacerias section (Cantabrian Mountains, Spain), as reported by Carlos Méndez. A significant finding is *Gondolella pohli* von Bitter and Merrill 1998, recovered from a thin interval within the uppermost *Fusulinella* Zone (lower or middle part of the upper Myachkovian); its youngest occurrence is slightly above the last *Neognathodus* species recorded in this section (*Neognathodus* aff. *inaequalis*). *Gondolella pohli* was described from the late middle Desmoinesian of northwestern Illinois, western Indiana and south-central Iowa in the United States, in strata containing isolated *Neognathodus* assemblages. Therefore, the presence of *G. pohli* in the Las Llacerias section could suggest a correlation of part of the upper Myachkovian with the late middle Desmoinesian of North America. Also a remarkable fact higher in this section is the record of an isolated specimen of *Idiognathodus eccentricus* (Ellison) in the upper part of the *Protriticites* Zone, which could suggest the correlation of a level within the upper Kreviakinian with the lower Missourian. A communication on the upper Moscovian-middle Kasimovian conodonts from the Las Llacerias section will be presented at the Ecos VIII meeting in June of this year (Méndez, 2002, in press).

Aleksander Alekseev reported an interesting finding (*Idiognathodus fischeri* sp. nov.) in limestone N3/2 of the Kalinovo section (Donets Basin, Ukraine). This occurrence suggests correlation of limestone N3/2 with the upper part of the Suvorovo Formation (lowermost Kasimovian) of the Moscow Basin. He also informed us that two monographic volumes dealing with the stratigraphy and paleontology of the middle Carboniferous (mainly Moscovian) of the Moscow Basin have been published recently (Makhlina and others, 2001a,b). These volumes contain a discussion on the lower Kasimovian boundary.

A detailed study of the deep-water Dalniy Tyulkas succession (Bashkiria, South Urals) is being completed by Dr. Alekseev and his group, who investigated the distribution of fusulinoideans, rugose corals and conodonts at 27 levels throughout the succession and have identified the position of the Moscovian/Kasimovian boundary by means of conodonts. This correlation with the Moscovian/Kasimovian boundary of the Moscow Basin is based on: a) the presence of *Idiognathodus* *sagittalis* (typical of the Neverovo Fm in the Moscow Basin, and occurring also in Donets Basin, Spain, and American Midcontinent) in the Dalniy Tyulkas 2 section; b) the record at the top of the of Dalniy Tyulkas 1 section of *Streptognathodus makhlinae*, a taxon that is characteristic of lower Kasimovian (upper Krevyakinian) strata.

Beate Fohrer, Tamara Nemyrovska, Elias Samankassou, and Katsumi Ueno continued studying beds around the Moscovian-Kasimovian boundary in the Kalinovo section of the Donets Basin, Ukraine. The multidisciplinary studies include sedimentology, sequence stratigraphy, biostratigraphy, and paleoecology. Fossil groups involved are ostracodes (Fohrer), foraminifers (Ueno), and conodonts (Nemyrovska). Furthermore, they have measured the Moscovian strata of the Izvarino section. The studies are still in progress and their results will be published soon.

During 2001, the Working Group did not hold a general meeting. However, in August 2001, the Moscow group (led by Aleksander Alekseev) carried out a field-trip to Dalniy Tyulkas section as part of the preparation of the WG general meeting and field-trip scheduled for the summer of 2002. The study of the Dalniy Tyulkas section is of great interest since, as mentioned above, it has yielded deep-water conodont faunas bearing potential significance for correlation. The interval investigated by the Moscow group during this last trip has been extended to include the Kasimovian-Gzhelian transition as well.

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CONTRIBUTIONS BY MEMBERS

Views and interpretations expressed / presented in contributions by members are those of individual authors / co-authors and are not necessarily those of the SCCS and carry no formal SCCS endorsement.

Observations and constraints on radiometric dating of the Pennsylvanian succession in North America and its correlation with dates from Europe

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Since the publication of the excellent summary and discussion of radiometric dates obtained for the Carboniferous System by Menning and others (2000, updated 2001a), I have been asked by a number of colleagues about how the various dates obtained primarily from western Europe relate to the succession in North America, particularly to the Pennsylvanian Subsystem in the Midcontinent. At the risk of grossly oversimplifying a complex situation because I am not familiar with the technical detail of the many methods of radiometric dating, I feel nevertheless that it is appropriate to summarize my observations on the stratigraphic context of the dates that are provided from various sources and the consequent significance to the dating of the biostratigraphically constrained marine successions. These marine successions are where the global boundaries within the Carboniferous are being chosen and into which all other regional successions will eventually need to be correlated.

North American Radiometric Dates

In contrast to the multitude of dates available from central to western Europe listed in Menning et al. (2000) derived from the large number of volcanic tuffs and tonsteins [reworked ash] in that area, there are very few radiometric dates available for North America owing to the relative scarcity of these readily datable beds here. The only date I am aware of that has been obtained from a similar rock type in North America is that from the Fire Clay tonstein in the Appalachian Basin reported by Kunk and Rice (1994). This date of 310.9 $\pm$ 0.8 Ma lies halfway between the Kendrick and Magoffin marine members of the Breathitt Formation. It is correlated with the upper part of the Trace Creek Member in the lower Atoka Formation of the southern Midcontinent based on ammonoid zonation (Rice et al. 1994) and with beds near the Westphalian B-C [Duckmantian-Bolsovian] boundary in western Europe based on plant fossils. This date is derived from sanidine using the Ar/Ar plateau method and thus is considered a maximum age [Scale B] by Menning et al. (2000, figure 6), who (p. 10) suggested that this is the scale that should normally be used. This date is in close agreement with dates of ~310-311 Ma [with wider spreads] around the Westphalian B-C boundary in Germany shown by Menning et al. (2000, figure 6), also derived from sanidines using the Ar/Ar plateau method, but with one U-Pb zircon date. This not only provides a radiometric tie point for the late early Atokan Stage (Fig. 1), but also underpins the approximate correlation of the Atokan with Westphalian B and C [Duckmantian and Bolsovian] based on various groups of fossils.

Using a U-Pb method of dating certain penecontemporaneous paleosol calcites [caliche], which are common between marine units in the cyclic non-volcanic North American Pennsylvanian succession, Rasbury et al. (1998) estimated the Carboniferous-Permian boundary at 301 $\pm$ 2 Ma and the Missourian-Virgilian boundary at 307 $\pm$ 3 Ma in the southwestern U.S. However, more recent unpublished conodont data suggest that this succession is not as well biostratigraphically constrained as originally thought in this tectonically disturbed area. Using this same method in the same laboratory, Becker et al. (2001) reported dates for biostratigraphically well constrained named units in the relatively undisturbed western part of the Appalachian Basin. They dated the paleosol directly below the lower Virgilian Ames Limestone at 294 $\pm$ 6 Ma, and the late Desmoinesian lacustrine Upper Freeport Limestone at 302 $\pm$ 4 Ma. These dates are more consistent with the 310-Ma late early Atokan volcanic sanidine date lower in the Appalachian succession than are the southwestern U.S. dates. This is because they provide a span of 9 million years for the middle and upper Atokan and nearly the entire Desmoinesian stages, rather than the much shorter 4 million years for the same amount of Atokan, plus the entire Desmoinesian and Missourian stages provided by the New Mexico Missourian-Virgilian boundary date of 307 $\pm$ 3 Ma.

Cyclothem Estimates of Stage Duration

Menning et al. (2000) used stratal thickness estimates to help evaluate the many disparate radiometric dates and calibrate the dated succession in western Europe. Using stratal thickness to estimate time is fraught with uncertainty because of the greatly variable rates of tectonic subsidence that provided accommodation space. However, shelf successions of glacially induced cyclothems of a constrained range of periodicities that are also able to be biostratigraphically correlated by evolving conodont lineages provide the most likely setting for relatively more accurate estimates to be obtained by this method. Therefore, I use numbers of recognized transgressive-regressive cyclothems in Midcontinent North America, in various groupings as to scale, to estimate relative durations of stages in that region. Recognizing the lack of precision in the cyclothem data, and also in the radiometric dates with wide data spreads, I nonetheless offer the following age estimates of important boundaries in the Midcontinent Pennsylvanian based only on the dates that are biostratigraphically well constrained:

The lower Virgilian sub-Ames Limestone date of 294 $\pm$ 6 Ma and the late Desmoinesian Upper Freeport Limestone date of 302

± 4 Ma provide a span of about 8 myr for the highest Desmoinesian, lowest Virgilian and the entire intervening Missourian Stage. Considering that the Altamont cyclothem is the probable Midcontinent correlative of the Upper Freeport Limestone and the Oread Limestone is the known Midcontinent equivalent of the Ames Limestone (Heckel, 1994), this span encompasses a total of 32 cyclothems of all scales, and provides an average cycle period of 250 kyr. Because this period is halfway between the 100-kyr and 400-kyr periods of the two longer orbital parameters involved in glacial eustasy, it implies that cyclothems of larger scales [major and intermediate of Heckel (1986)] are more strongly controlled by the longest period and those of minor scale are more controlled by the shorter period[s]. Therefore, the minor cycles are grouped with those of larger scale to attempt to delineate probable 400-kyr cyclothems. Within this same Altamont to Toronto [sub-Oread] succession, there are about 17 major and intermediate-scale cyclothems, which provide an estimate of about 470 kyr for the period of this scale of cyclothem, not far above the 400 kyr expected for the longest orbital parameter. Considering the wide data spreads on these two younger Appalachian dates, I will assume an average 400-kyr length for the major to intermediate cyclothems [each grouped with any adjacent minor cyclothems] in this succession. The lowest three of these cyclothems are in the Desmoinesian, and the highest two are in the Virgilian, with 12 constituting the intervening Missourian Stage. The Missourian would thus be about 5 myr long, and would span the range from about 300 to 295 Ma. Below the Desmoinesian Altamont cyclothem, there are 7 major and intermediate cyclothems down to the well known Verdigris cyclothem, which is two fifths of the way to the base of the Desmoinesian where it is most complete in eastern Oklahoma above the type Atokan. [This computation is based on the total number of about 40 cycles of all scales obtained by adding those in Heckel (1994) to those identified below the Verdigris by Boardman, Marshall and Lambert in this Newsletter]. Adding these 7 to the top 3 and extrapolating the remaining three fifths, this would estimate 25 larger-scale [400-kyr] cyclothems and a 10-myr length for the total Desmoinesian. This would place its base at 310 Ma, which is just above the correlated Appalachian tonstein sanidine date of 311 Ma, and does not leave much time for the middle and upper Atokan. From the Oread cyclothem upward, the lower Virgilian contains 8 similar cyclothems through the Howard cyclothem, which is about two fifths of the way up to the top of the Virgilian where it is most complete and is overlain by biostratigraphically well correlated basal Permian strata. [This computation is similarly based on the total number of about 50 cyclothems of all scales shown by Boardman (1999, p. 117)]. Adding the two cyclothems below the Oread and then extrapolating the number to 25 larger-scale cyclothems total would provide 10 myr for the total Virgilian, and would push the age of the Carboniferous/Pennsylvanian-Permian boundary to 285 Ma, younger than even the relatively young approximate Harland et al. (1990) estimate of 290 ± 20 Ma.

However, Boardman (1999) showed that the upper three-fifths of the Virgilian in the Midcontinent include proportionally many more cyclothems of minor scale than are in the lower two-fifths, and he and his coauthors in this Newsletter show that more of the Desmoinesian cyclothems below the Verdigris are similarly less in scale than those above. Therefore, it is appropriate to regroup the cyclothems with respect to the 400-kyr average cycle length. Grouping two pairs of adjacent intermediate cyclothems [Wyandotte-Plattsburg, and South Bend-Iatan] in the Missourian provides ten 400-kyr cycles and a length of 4 myr for the Missourian. Retaining the 300 Ma date for the Desmoinesian-Missourian boundary then yields a date of 296 Ma for the Missourian-Virgilian boundary. Grouping more intermediate and particularly the minor cycles together in the Virgilian provides about fifteen 400-kyr cycles for a total length of 6 myr for the Virgilian. This would put the top of the Virgilian [the Carboniferous-Permian boundary] at 290 Ma, where the Harland et al. (1990) estimate had it. Similarly grouping Desmoinesian cyclothems of various scales [although lateral extent is much less well known for the sub-Verdigris cyclothems] produces about twenty 400-kyr cyclothems. This provides 8 myr for the length of the Desmoinesian, places the Atokan-Desmoinesian boundary at 308 Ma, and leaves 3 myr for the upper part of the Atokan above the correlated Appalachian tonstein sanidine date of 311 Ma. The type Atokan contains few readily recognizable cyclothems but it is immensely thick because of rapid subsidence in the Arkoma Basin during that phase of Ouachita mountain-building. Therefore, 3 myr is a reasonable time span for its middle and upper part.

It is appropriate also to use the cycle data to further evaluate the southwestern U.S. dates of Rasbury et al. (1998). Assuming equal durations, recognition of all cycles, and no systematic distribution of missing cycles, they estimated an average cycle period of 143 ± 64 kyr for all cycles in the successions they studied, significantly shorter than the 400-kyr period typically ascribed to them. However, they recognized only 29 cycles in the Virgilian, compared to the approximately 50 cycles of all scales recognized by Boardman (1999) in the Midcontinent where the succession is more complete and is overlain by basal Permian strata accurately correlated by conodonts with the Uralian succession where the basal Permian boundary was selected. This means that about two fifths of the Virgilian cycles recognized in the Midcontinent are either missing or not recognized in their southwestern succession. Nonetheless, this more complete figure of 50 cycles provides an average cycle period of 120 kyr for the 6 myr length of the Virgilian based on their dates, which is even closer to the 100-kyr orbital parameter involved in glacial eustasy. However, applying this average cycle period similarly to the total of 24 cycles of all scales in the Missourian produces a length of 2.9 myr, and the total of 40 cycles of all scales in the Desmoinesian yields 4.8 myr. This total of 7.7 myr far exceeds the 4 myr span between their Missourian-Virgilian boundary date of 307 Ma and the Appalachian late early Atokan tonstein sanidine date of 311 Ma without even including the middle and upper Atokan Stage. Even assuming an exact 100-kyr cycle period, this computation produces a 6.4-myr duration for the Desmoinesian and Missourian, which is still incompatible with the late early Atokan Appalachian date. Furthermore, their 301-Ma date for the Carboniferous-Permian boundary makes the Permian about 50 myr long compared to a maximum of only 20 myr for the Pennsylvanian. When it is considered that roughly the lower one-third of the Permian comprises cyclothems of the same type that dominates the Pennsylvanian, the early Permian would be similarly greatly shortened, and the resulting much greater length of middle and late Permian time seems excessive. Therefore, the roughly 290-Ma date for the C-P boundary and the 400-kyr periods for groupings of minor cycles around the larger-scale cyclothems appear far more compatible with the other data discussed above.

Significance of Dates for Correlation of Boundaries

At this point it is important to emphasize that the Carboniferous-Permian boundary is officially defined in the southern Urals by an event in a conodont lineage. Therefore, the only C-P boundary dates that are meaningful are either those that are obtained from that succession or those that can be biostratigraphically correlated with it. From SHRIMP U-Pb dates of zircons from tuffs in the Urals succession reported by Chuvashov et al. (1996), Menning et al. (2000, figure 7) provided an estimate of 292 Ma for the Carboniferous-Permian boundary. This was based on interpolation between dates of 300.3 ± 3.2 Ma at the Moscovian-Kasimovian boundary and 290.6 ± 3.0 Ma in the lower Asselian [=lowermost Permian]. This estimate is much more compatible with the Appalachian lower Virgilian sub-Ames paleosol date of 294 Ma of Becker et al. (2001) than with the older Rasbury et al. (1998) date of 301 Ma from southwestern U.S., or the Stephanian Ar/Ar plateau dates of 300 to 303 Ma from western Europe. In strong support, the sub-Ames paleosol date can be biostratigraphically correlated with the lower Gzhelian Stage in the southern Urals succession via the North American Midcontinent succession based on conodonts (Heckel, 1994; Heckel et al., 1998). Furthermore, the 300 Ma date for the Moscovian-Kasimovian boundary in the Urals is very close to the 302 Ma late Desmoinesian Appalachian date (Fig. 1), which can also be correlated with that boundary by means of bracketing conodont faunas, via the Midcontinent succession (ibid.).

In a similar fashion, it is important to emphasize that the estimates of any age [from ~290 to ~300 Ma] for the Carboniferous-Permian boundary that are based on dates from successions that are unconstrained as to correlation with the marine succession within which that boundary is defined are essentially meaningless for dating the boundary, no matter how precise they may be, as Menning et al. (2000, p. 33) indicated. This includes those dates from the entirely nonmarine Stephanian and Autunian shown in the upper part of their figure 6, between which the boundary has been considered by many workers to be the Carboniferous-Permian boundary in northwestern Europe. The 298 ± 8- and 300.0 ± 2.4-Ma dates near the Stephanian-Autunian boundary may date that particular boundary in that particular place, but if the ~290-Ma date for the Carboniferous-Permian boundary based on arguments above is accurate, then the precise 290.7 ± 0.9-Ma date from the base of the Upper Rotliegend at Saar-Nahe shown on the chart of Menning et al. (2000, figure 6) means that the entire Lower Rotliegend [hence the Autunian] is Missourian and Virgilian [and Kasimovian and Gzhelian]. Likewise, if accurate, the 275-Ma date of Becker et al. (2001) for the Monongahela-Dunkard contact in the Appalachian Basin, which has traditionally been considered to be the Pennsylvanian-Permian boundary in that region, means that most if not all of the Monongahela Group is lower Permian.

Estimates of Boundary Dates

Based on the discussions above, I provide below a summary of likely boundary age estimates and durations of North American stages at our current state of information:

Virgilian-Permian boundary:		290 Ma
Virgilian Stage	6 myr	
Missourian-Virgilian boundary		296 Ma
Missourian Stage	4 myr	
Desmoinesian-Missourian boundary		300 Ma
Desmoinesian Stage	8 myr	
Atokan-Desmoinesian boundary		308 Ma
Atokan Stage	5 myr	
Morrowan-Atokan boundary		313 Ma
Morrowan Stage	7 myr	
Mid-Carboniferous boundary		320 Ma

The Mid-Carboniferous boundary is taken directly from Scale B of Menning et al. (2000, figure 6), which they stated should be used normally. This is reassuring, considering that this boundary is at 312.5 Ma in their Scale A, which would essentially eliminate the Morrowan Stage from the geologic time scale in view of the late lower Atokan Appalachian tonstein date of 311 Ma.

Because the Russian stage names are used for the marine Pennsylvanian over much of the world and work is underway on correlating them with the North American stages (e. g., Heckel et al., 1998; Groves et al., 1999), I have taken the liberty of providing below a summary of likely boundary age estimates and durations of Russian stages, based on these correlations and other considerations discussed both above and below:

Gzhelian-Permian boundary		290 Ma
Gzhelian Stage	6 myr	
Kasimovian-Gzhelian boundary		296 Ma
Kasimovian Stage	5 myr	
Moscovian-Kasimovian boundary		301 Ma
Moscovian stage	11 myr	
Bashkirian-Moscovian boundary		312 Ma
Bashkirian Stage	8 myr	
Mid-Carboniferous boundary		320 Ma

The Kasimovian-Gzhelian and Missourian-Virgilian boundaries are nearly coincident (Heckel et al., 1998). I assigned the age of 301 Ma to the Moscovian-Kasimovian boundary because it currently appears to be about two cyclothems older than the Desmoinesian-Missourian boundary based on preliminary conodont correlations (Heckel et al., 1998). This is very close to the 300 ± 3.2-Ma date for this boundary reported from the southern Urals by Chuvashov et al. (1996; see also Menning et al., 2000,

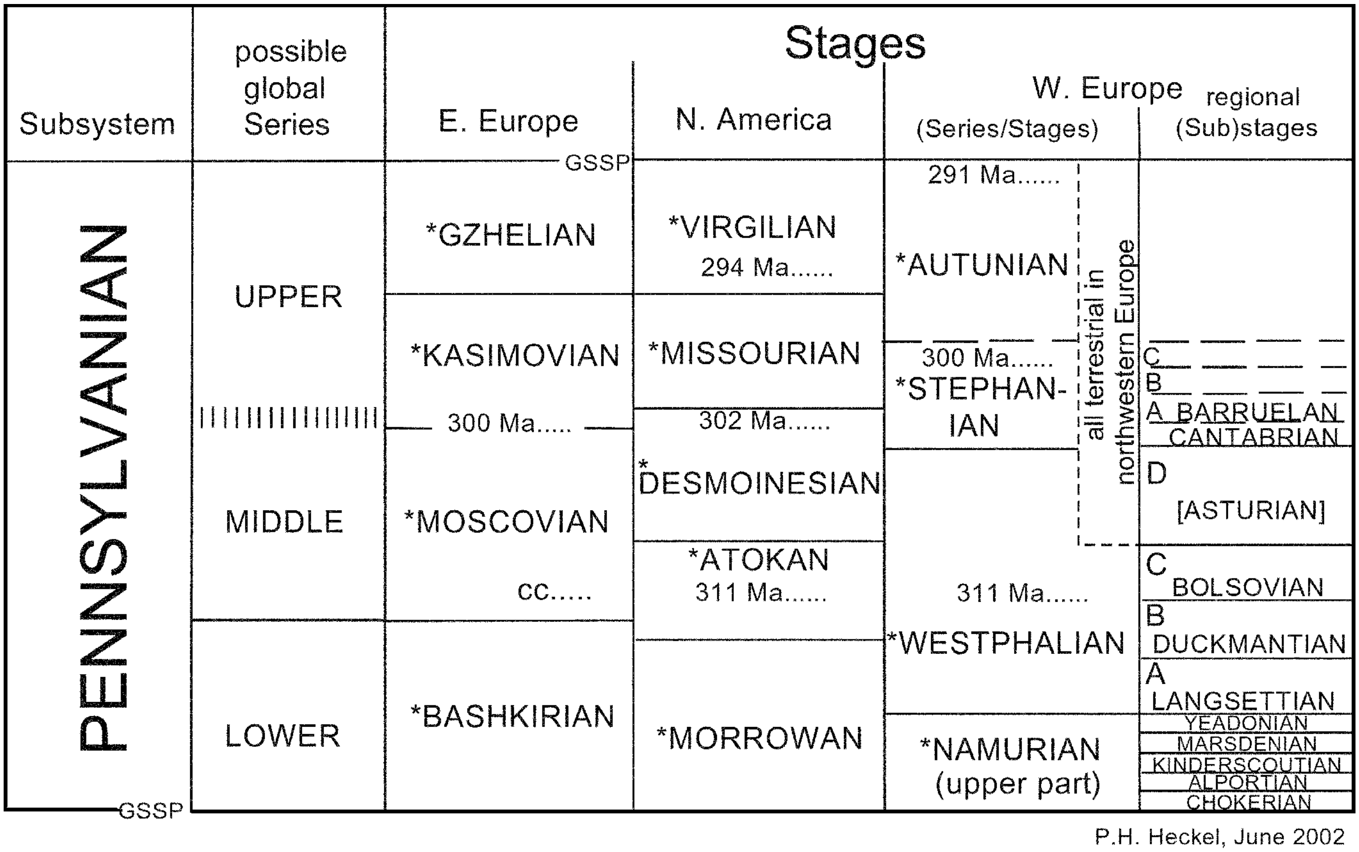

Figure 1. – Graphic chart of Pennsylvanian stages showing those radiometric dates from North America that are consistent with radiometric dates from eastern and western European marine successions. Letters cc refer to tight conodont correlation of lower Moscovian with Westphalian B-C boundary. This chart also shows recorrelation of western European named terrestrial succession with marine successions that is more consistent with radiometric dates from Stephanian and Autunian series/stages than is the traditional correlation with the Carboniferous-Permian boundary between them.

figure 7). I used the 312-Ma date for the Bashkirian-Moscovian boundary shown in Menning et al. (2001b) because it is well correlated by conodonts near the basal Moscovian with the 309-311-Ma dates they show for the Bolsovian of central Europe. The 314-Ma date that was used by Groves et al. (1999) for the Mid-Carboniferous boundary is close to that of Scale A of Menning et al. (2000, figure 6), which was specifically stated as minimum ages, whereas I am using their Scale B, which was stated as maximum ages to be used normally, and appears more reasonable as outlined in the discussion above.

Conclusions

It ultimately appears from all this material that the biostratigraphically well constrained boundary dates within the Pennsylvanian Subsystem provided above are quite closely coincident between North America and both western and eastern Europe near the mid-Westphalian B-C [Duckmantian-Bolsovian] boundary (Fig. 1). Specifically, the 311-Ma late early Atokan Fire Clay tonstein date from the Appalachian is correlated near the Westphalian B-C boundary, which is shown by Menning et al. (2001b) to be dated also at 311 Ma based on several 309-311-Ma dates within the middle and lower Bolsovian. They also show that the basal Bolsovian is correlated with a horizon just above the basal Moscovian of eastern Europe by means of identical conodont faunas. At higher levels, however, only the North American and eastern European dates are nearly coincident. Specifically, the late Desmoinesian date of 302 Ma from the Appalachians is close to the Moscovian-Kasimovian boundary date of 300 Ma from the Urals, and the 292-Ma interpolated date for the officially selected Carboniferous-Permian boundary in the marine eastern European succession is close to the estimated 290-Ma date for that boundary in the biostratigraphically well correlated North American Midcontinent succession. In contrast, a 300-Ma date in northwestern Europe is reported from the late Stephanian [traditionally regarded as highest Carboniferous], and a 291-Ma date is shown at the Lower-Upper Rotliegend boundary in the Autunian (Menning et al., 2000, figure 6). If these dates are accurate, they call for both reclassifying much of the Autunian of northwestern Europe as late Carboniferous and no longer using the Stephanian to define the latest Carboniferous, as Menning et al. (2000, p. 29) explained. Such a reclassification also would be consistent with recent comments to me by R.H. Wagner that Missourian and Virgilian floras resemble Lower Rotliegend floras more than Stephanian floras.

In summary, I want to emphasize that the dates for boundaries of marine-based Pennsylvanian stages given above are only estimates derived from the radiometric dates from marine successions that appear most consistent with one another and with the most reasonable grouping of cyclothem data from the most complete succession, the American Midcontinent. However, they seem to be the most reasonable estimates to be used until more precise and accurate radiometric age dates from biostratigraphically constrained marine successions become available.

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Stages of the Carboniferous System

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Historical

Numerous authors have pointed out the apparent discrepancy between the duration of stages as defined in the West European, East European and North American regional chronostratigraphic classifications for the Carboniferous System. The West European stages are markedly smaller than the East European and North American ones, this being the result of upgrading the Namurian, Westphalian and Stephanian stages of yore to series, which has led to the former substages being recognised as stages. This process commenced with van Leckwijck (1964), who raised the Namurian to Series rank, the Westphalian and Stephanian following suit (George and Wagner, 1969, 1972). It is noted, however, that West European stages were considered to be only of regional value and unsuitable for worldwide correlation (cf. Bouroz et al., 1977-1978).

In 1989, at the SCCS Meeting in Provo (UT) the SCCS Working Groups on the subdivision of the Lower Carboniferous (Mississippian) and Upper Carboniferous (Pennsylvanian) reported on the most suitable horizons to be used for subdividing these units into worldwide stages, as based on changes in the faunas and floras (cf. Brenckle, 1990; Winkler Prins, 1990). After discussions both for the Mississippian and for the Pennsylvanian, three horizons were suggested and eventually six SCCS working groups were created to study the respective boundary intervals in order to come to a specific limit and boundary stratotype (GSSP), thus potentially creating a total of seven stages. Unfortunately, no definite proposals have been made so far, with the exception of a recent note on the definition of the Tournaisian/Viséan boundary. It may be regarded as essential to have the working groups come together at the next SCCS meeting (e.g. during the XV ICCP at Utrecht, The Netherlands, 2003) in order to evaluate the suitability of possible boundaries and to listen to proposals of possible boundary-stratotypes. It is obviously important to assess the various proposals. Also, one should consider whether the proposed threefold subdivision of both the Mississippian and the Pennsylvanian, resulting in six series, is worthwhile, particularly if the series should be found to coincide with the stages.

Heckel (2001) and Alekseev (2001) both proposed classifications for the Carboniferous System with special reference to the palaeoequatorial belt (Table 1). The series suggested by Alekseev (2001) are in our view inappropriate, since he changed the meaning of units that have a long record and thus would create confusion. Notably his Visean consisting of the Viséan and the lower part of the Namurian (i.e. the Serpukhovian), and his Westphalian which combines the well established Westphalian with the upper part of the Namurian (i.e. a large part of the Bashkirian) at the bottom, and the lower part of the Cantabrian at the top. This also

Table 1. General subdivision of the Carboniferous showing the boundaries for which SCCS working groups 1-8 were created (cf. Brenckle, 1990; Winkler Prins, 1990) and the recent proposals by Heckel (2001) and Alekseev (2001).

Subsystems	Heckel (2001) Series	Heckel (2001) Stages	Alekseev (2001) Series	Alekseev (2001) Stages	suggested boundaries (1990)	
						C/P boundary
	U	Gzhelian		Gzhelian	8	
		Kasimovian	Stephanian	Kasimovian	....	
Pennsylvanian	M	Moscovian		Moscovian	.......7.......	
					.......6.......	
	L	Bashkirian	Westphalian	Bashkirian	5	
						mid-Carboniferous boundary
	U	Serpukhovian		Serpukhovian	4	
			Visean	Warnantian	....	
	M	Viséan		Livian	3	
Mississippian				Molinacian	....	
				Ivorian		
	L	Tournaisian	Tournaisian		........2........	
				Hastarian	1	
						D/C boundary

means that he reduced the size of the Stephanian by raising its lower boundary, excluding the lower part of the Cantabrian, so as to make it coincide with the Moscovian/Kasimovian boundary.

Analysis

The 1/2 ("mid-Tournaisian") boundary apparently poses a problem, since no suggestions have been made so far by the working group. The 2/3 ("Tournaisian/Viséan") boundary appears to be at an acceptable level, the remaining problem being the selection of a suitable boundary stratotype. The 3/4 ("late Viséan") boundary poses some problems, but so would a Viséan/ Serpukhovian boundary (cf. Nikolaeva and Kullmann, 2001). It would seem essential that at least one of these boundaries should be established. The 5/6 ("Bashkirian/Moscovian") boundary appears to pose a serious problem since the originally proposed boundary at the base of the *Branneroceras branneri* Zone proved impractical. Still, it seems useful to have a limit near that level for a balanced subdivision. The 6/7 ("mid-Moscovian") boundary project has been (temporarily?) abandoned (cf. Engel, 1992). The working group on the 7/8 ("Moscovian/Kasimovian") boundary has been the most active and it seems likely that eventually a measured judgment can be made on this boundary. The Kasimovian/Gzhelian boundary, as envisaged by both Heckel and Alekseev, is discussed by the same working group, but less progress seems to have been made so far.

It should be noted that the units defined by boundaries more or less corresponding to the proposals of 1989 (Brenckle, 1990; Winkler Prins, 1990; Engel, 1992) generally do not coincide with existing regional stages or series, and where they appear to do so (e.g. Bashkirian, Moscovian) these units pose serious problems since their boundaries are inadequately known. As a general principle, it may be advisable not to deviate too far from historical chronostratigraphic units, unless these are problematical, i.e. used in very different ways in different parts of the world.

Heckel (2001) produced a useful summary chart in which six possible subdivisions ("global series") are proposed, and which also reflects the current regional chronostratigraphic classifications for Eastern Europe, North America, and Western Europe, all part of the palaeoequatorial belt with warm water faunas and warm, humid floras. The Pennsylvanian of the high palaeolatitude Gondwana and Angara areas was left undivided, which is realistic, particularly for Gondwana. With regard to the historically important West European classification it is noted that the West European series are scaled down to stages by Heckel, and that the "Asturian", Cantabrian and Barruelian (sub)stages are marked as "terrestrial in NW Europe". The latter statement is factually correct but likely to be misunderstood since the stratotypes are in SW Europe and are predominantly marine (cf. Wagner and Winkler Prins, 1985; Wagner et al., in press).

Conclusions

The vexed question of the duration of stages has not been addressed by Heckel (2001), but it is clear that the "global series" are meant to coincide with stages, particularly with regard to the Mississippian Subsystem. Alekseev (2001) produced a three-tiered classification in which subsystems are subdivided into series and the series into stages. Unfortunately, his correlations are partly inaccurate, such as equating upper Bashkirian and Moscovian with the Westphalian, and Kasimovian and Gzhelian with Stephanian (compare the more detailed correlation chart in Wagner and Winkler Prins, 1997). Neither Heckel (2001) nor Alekseev (2001) addressed the problem of inadequate stratotypes for some of the existing (chrono)stratigraphic units whose names were invoked. There is an inherent problem in the use of stage names which have obtained biostratigraphic recognition beyond the limitation of its traditional stratotype. However, the general principles enunciated by Alekseev (2001) are impeccable, and the arguments given by Heckel (2001) also make good sense. The present writers concur to a large extent with both Heckel (2001) and Alekseev (2001), but, for practical reasons, prefer to ask first of all for the results of investigations carried out by the various working groups, which should include data on correlations.

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Correlation of the Viséan-Serpukhovian boundary in its type region (Moscow Basin) and the South Urals and a proposal of boundary markers (ammonoids, foraminifers, conodonts)

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As we reported in the last issue of the Newsletter, Viséan-Serpukhovian boundary biostratigraphy was recently the subject of much study involving index fossil groups (foraminifers, conodonts, ammonoids, ostracodes) as part of the Serpukhovian Project sponsored by the Russian Academy of Sciences. A working group on this project (based in Moscow and Ufa) studied a series of Serpukhovian sections including the Serpukhovian type section at Zaborye, an auxiliary section in the Novogurovsky Quarry (both in the Moscow Basin), and the Verkhnyaya Kardailovka and Bolshoi Kizil sections in the South Urals. In summer 2001 S.V. Nikolaeva resampled the Kiya section in the South Urals (identifications are still in progress). One major task was a search for a suitable level for definition of the Lower Serpukhovian boundary based on different fossil groups and to decide whether it is possible to choose one of any previously proposed levels or to continue the search for a new one. To approach this we sampled and studied boundary beds in several of the most important sections. It is known that in the type region in the Moscow Basin the boundary under study is located approximately at the level between the Venevian and Tarusian, while in the South Urals it is between the Venevian and Kosogorskian (see Gibshman, 2001; Nikolaeva et al., 2001).

This is a report on the progress of our work. The Venevian-Tarusian boundary in the type Serpukhovian section in Zaborye was sampled for the first time for conodonts and foraminifers. All beds and sample levels were marked in the section. Two borings were drilled in the quarry to provide more samples from the crucial level. Foraminiferal assemblages from the Novogurovsky section were studied and zones established by Gibshman (2001) were confirmed. In the South Urals the Verkhnyaya Kardailovka section was re-examined around the boundary interval using trenches, and new ammonoid and conodont levels were found. Foraminifers from the Bolshoi Kizil section were studied and a new foraminiferal zonation for the Serpukhovian was proposed.

Ammonoids

Nikolaeva and Kullmann (2001) discussed recent criticism of the use of the cravenoceratid ammonoid *Cravenoceras leion* and closely related species of the same genus for recognition of the Viséan-Serpukhovian boundary. It was shown that despite shortcomings the use of these taxa is the best solution known today for the ammonoid-based correlation of this level. One of the reported difficulties in correlation of the beds with *Cravenoceras leion* in Europe and synchronous beds in the Urals was the lack of ammonoids in the beds intermediate between the Viséan and Serpukhovian. As a result the geochronology of ammonoid faunas in the critical interval was not well supported by stratigraphic occurrences. In the summer of 2001 new ammonoid-bearing beds were exposed in a trench in the Viséan interval of the Verkhnyaya Kardailovka section. This is so far the earliest ammonoid assemblage found in this section. Ammonoids were found in Bed 21 (sample 2711). The assemblage contains *Goniatites sphaeroides* and *Goniatites crenifalcatus*. These ammonoids are characteristic of the Upper Viséan ammonoid *Beyrichoceras-Goniatites* Genozone. In the South Urals ammonoids of this age are also found in the Orenburg region (Sakmara River) and in Kazakhstan (Aktyubinsk region). Because neither of these species occurs outside the South Urals and adjacent regions of Kazakhstan the interregional correlation is based on their similarity to *Goniatites* species from Western Europe. Based on this, it is possible to assume the correlation with the boundary beds of the Goα and Goβ Zones in Germany. The succeeding assemblage found ca. 4 m above (in the Kosogorskian) (sample 011) indicates the *Uralopronorites-Cravenoceras* Genozone (most likely its upper part) (see Nikolaeva et al., 2001). Thus, the interval of 4 m in the Verkhnyaya Kardailovka section between the above two samples supposedly includes the Upper Viséan *Hypergoniatites-Ferganoceras* Genozone (probably equivalent of the P2 Zone in Europe) and the lower part of the *Uralopronorites-Cravenoceras* Zone (Nm1b1) which is previously reported from the Kiya section in the Orenburg region). This situation is extremely interesting because this is the first section in the South Urals where the transition between the Viséan and Serpukhovian ammonoid zones can be observed and their real geochronology established. The great potential of this section is supported by the fact that results from ammonoids are corroborated by those from conodonts. The new ammonoid assemblage is found with conodonts of the *Gnathodus bilineatus bilineatus* Zone, which suggests that the missing *Hypergoniatites-Ferganoceras* assemblage may be recovered within the *Lochriea nodosa* conodont Zone. The ammonoid-based correlation of the boundary beds with the Zaborye type section (Moscow Basin) is difficult because Zaborye contains just a few ammonoid occurrences of Serpukhovian age (mostly *Cravenoceras*) in the Tarusian and overlying Steshevian much above the boundary level. However, the possibility of establishing the first appearances of Serpukhovian index taxa among foraminifers, ammonoids, and conodonts in the deep-water rock sequence of Verkhnyaya Kardailovka makes it the best candidate so far known for investigation and establishment of the GSSP of the Viséan-Serpukhovian boundary.

Foraminifers

Markers for the definition of the Viséan-Serpukhovian boundary are proposed based on detailed bed-by-bed analysis of the foraminiferal distribution in three carbonate sequences representing different facial types. The section in the Zaborye Quarry (Gibshman, 2001) is represented by shallow-water epicontinental facies (limestone-clay sequence). The Verkhnyaya Kardailovka section (Nikolaeva et al., 2001) indicates a deeper water environment and is considered so far the best candidate for the global standard of the Lower Serpukhovian boundary. The Bolshoi Kizil section (Kulagina and Gibshman, in press) indicates a biohermal sedimentary environment. Three foraminiferal zones are proposed as a standard foraminiferal zonal sequence for the Serpukhovian Stage of Russia; these are (in ascending order): (1) *Neoarchaediscus postrugosus-Janishewskina delicata-Eolasiodiscus donbassicus* Zone; (2) *Eostaffellina paraprotvae* Zone; and (3) *Monotaxinoides transitorius* Zone. The study was focused on the search for the foraminiferal markers for the Viséan-Serpukhovian boundary. Although a single species marking the Viséan-Serpukhovian boundary has not yet been chosen, the following species may be used in different regions: *Neoarchaediscus postrugosus* (tracked in Zaborye and Verkhnyaya Kardailovka), *Janishewskina delicata* (best represented in Zaborye and Bolshoi Kizil), *Eolasiodiscus donbassicus* (Bolshoi Kizil) and "*Millerella*" *tortula* (Zaborye). The co-occurrence of "*Millerella*" *tortula* and *Neoarchaediscus postrugosus* in the Zaborye Quarry is a potentially good marker for the Viséan-Serpukhovian boundary and for correlation of this level with the base of the Mid-Chesterian Glen Dean Limestone in Breckenridge County, Kentucky (Zeller, 1953) and with the Mid-Chesterian Foraminiferal Zone 17 of the Black Warrior Basin, USA. Brenckle (1990), however, referred the Glen Dean Limestone to the Upper Viséan. This precludes us from using the species ''*Millerella*'' *tortula* as a boundary marker at this time.

The underlying Upper Viséan *Eostaffella tenebrosa* Zone is determined largely on the cosmopolitan species *Janischewskina typica*, which is also found at this level in Belgium, whereas the index species *E. tenebrosa* has a more restricted geographical distribution. In Verkhnyaya Kardailovka this zone tentatively corresponds to the beds with *Endostaffella asymmetrica*. The species *Howchinia bradyana*, *Loeblichia paraammonoides*, and *Climacammina simplex* can be used as additional uppermost Viséan index species.

The lower boundary of the *Neoarchaediscus postrugosus - Eolasiodiscus donbassicus - Janischewskina delicata* Zone is typified in the Zaborye section (Bed 3, sample 3a-1) (Gibshman, 2001) and is drawn close the base of the Tarusian (slightly above). The previously employed species *Pseudoendothyra globosa* has been shown to be a local zonal indicator strongly dependent on facies and consequently has been excluded from the proposed scale. The species *Planoendothyra aljutovica*, *Eostaffella mirifica*, *Monotaxinoides subplanus*, *Eostaffellina decurta*, *Rectoendothyra latiformis*, and *Loeblichia minima* also appear in this zone, although distinctly above its base. Apart from the Serpukhovian species, the assemblage contains species continuing from the Upper Viséan: *Janischewskina typica*, *Endothyranopsis sphaerica*, *Omphalotis omphalotis*, *Eostaffella ikensis*, *E. raguschensis*, *Archaediscus gigas*, etc., which sometimes dominate and may outnumber the index Serpukhovian species.

In the Verkhnyaya Kardailovka section (deeper-water facies with cephalopods) (Kulagina in Nikolaeva et al., 2001) this zone corresponds to the beds with *Planospirodiscus* – *Neoaracheodiscus postrugosus*. The latter species appears on the same level as "*Millerella*" *tortula* in the Zaborye section suggesting a correlation of the lower Kosogorskian and the lower Tarusian. In Verkhnyaya Kardailovka foraminifers are rare and represented by very small unidentifiable species of the genera *Endothyra*, *Endostaffella*, *Mediocris*, and *Asteroarchaediscus*. This zone in Verkhnyaya Kardailovka is constrained by ammonoids of the lower part of the *Uralopronorites-Cravenoceras* (Nm1b1) Zone, and by conodonts of the lower part of the *Lochriea cruciformis* Zone.

A new contribution to the foraminiferal studies is the reexamined Bolshoi Kizil section. The section is represented by a series of carbonates with algal bioherms ranging from the Upper Viséan to the Lower Bashkirian (Kulagina and Gibshman, in press).

The total taxonomic diversity in the upper part of the Viséan (Venevian) and Serpukhovian is over 50 species, 27 of which are new. The *Eolasiodiscus donbassicus* Zone is established in this section based on the first appearance of the index species, whereas the species *Janischewskina delicata* may also be used as a marker species of the Viséan-Serpukhovian boundary. We preferred using *Eolasiodiscus donbassicus* as a zonal index because of the high taxonomic diversity of Eolasiodiscidae and the presence of *Howchinia subconica*, *Monotaxinoides gracilis*, and *M. subplanus* which are characteristic of the bioherm environment. At the same time the appearance of *Janischewskina delicata* indicates an important evolutionary innovation at the Viséan-Serpukhovian boundary because this species shows almost synchronous appearance at this level in Bolshoi Kizil and Zaborye (Gibshman, 2001).

Conodonts

For the first time detailed conodont records were obtained for the type Serpukhovian section in Zaborye (Barskov et al., in press). Conodonts were recovered from 61 successive levels (Venevian - 3 levels, Tarusian -17 levels, Steshevian - 38 levels, Protvian - 3 levels. Total is ca. 7000 elements). The quantitative distribution differs in the section (per 2 kg of rock: Tarusian 1-few hundreds elements, Steshevian (limestone part)- 50-250, (clay part) - 10-500 elements, Protvian - 5-250 elements).

Among platform elements, the *Gnathodus girtyi* group is dominant (*Gn. g. girty*, *Gn. g. intermedius*, *Gn. g. simplex*). The assemblage also includes "aberrant" elements with additional ornament of the platform (*Gn. g. soniae*) which first appear in the Steshevian. The group *L. commutata-L. monodosa* is slightly less abundant (39 levels). The Serpukhovian index species *L. cruciformis*, *L. ziegleri*, and *L. senckenbergica* are recovered from 24 levels. *Lochriea nodosa* appears in the Venevian. The Tarusian is marked by the appearance of the species with auxiliary ridges on either side of the platform (*L. ziegleri*, *L. senckenbergica*, *L. cruciformis*) (Sample 3c, Bed 3). For a recent review of the occurrences of these species see Skompski et al. (1995). It is possible that these species represent a single phylogenetic lineage, although the lineage has not been not tracked in a single section. Because of the absence of phylogenetic data supporting taxonomic assignments and the geochronological sequence of the appearance of index features, the best solution for today would be a choice of one of these species similar to what was suggested for definition of some Permian boundaries. In the case of the lower Serpukhovian boundary, the best choice would be between *L. ziegleri* and *L. senckenbergica* because there are some reports in the literature that *L. cruciformis* may occur in the uppermost Viséan. In the type Serpukhovian section in Zaborye *L. ziegleri* occurs from the base of the Tarusian. Data on earlier occurrences of this species in Germany need more satisfactory support.

In the South Urals conodonts from the Viséan-Serpukhovian boundary beds have been studied in many sections. The Verkhnyaya Kardailovka and Kiya sections are particularly significant because they also contain ammonoids at many levels ranging from Upper Viséan to Upper Serpukhovian in age. In Verkhnyaya Kardailovka all exposed beds of the Upper Viséan and Serpukhovian were sampled by V.N. Pazukhin. Conodonts were recovered from 80 of 85 samples (average weight of a sample 2 kg). The most detailed sampling was performed for the uppermost Viséan (in part by means of trenching) and Upper Serpukhovian. In these parts conodonts were most abundant. In total the collection of conodonts from this section includes ca. 5500 specimens, of which *Gnathodus* and *Lochriea* are dominant. The section contains a succession of conodont zones ranging from the upper part of the *Gn. texanus* Zone to the lower part of the *D. noduliferus* Zone.

In the South Urals the *Gnathodus texanus* Zone is found in the Radaevian, Tulian and the lower part of the Bobrikovian horizons. In Verkhnyaya Kardailovka (Bed 18, thickness 2.0 m) the zonal assemblage is found in the lower part of the Tulian Horizon (Upper Viséan) and includes *Gnathodus texanus*, *Mestognathus beckmanni*, *Pseudognathodus homopunctatus*, *Psg. symmutatus*, *Hindeodus scitulus*, and others. The section above this level up to the base of the *L. cruciformis* Zone is unexposed and was studied in trenches. A geochronologically younger conodont assemblage was recovered 6 m above the *Gn. texanus* Zone.

The *Gnathodus bilineatus bilineatus* Zone (Beds 19.1-21.4, thickness 12.3 m). Bed 19.1 (trench 2) contains a transitional assemblage provisionally assigned to the lower part of the *Gnathodus bilineatus bilineatus* Zone based on *Gnathodus girtyi* in association with *Gnathodus texanus* and *Pseudognathodus homopunctatus*. The insoluble residue of this sample contains small ammonoid shells. The zonal index species is found 6.6 m above the base (bore pit 4 and trench 1), in association with *Gnathodus girtyi girtyi*, *Gnathodus girtyi collinsoni*, and *Lochriea commutata*. The upper part of zone shows the appearance of *Gnathodus girtyi intermedius*, *Gnathodus girtyi soniae*, and *Mestognathus bipluti*.

The *Lochriea mononodosa* Zone (Beds 21.5-21.10, thickness 1.85 m). The zone is defined by the appearance of the index

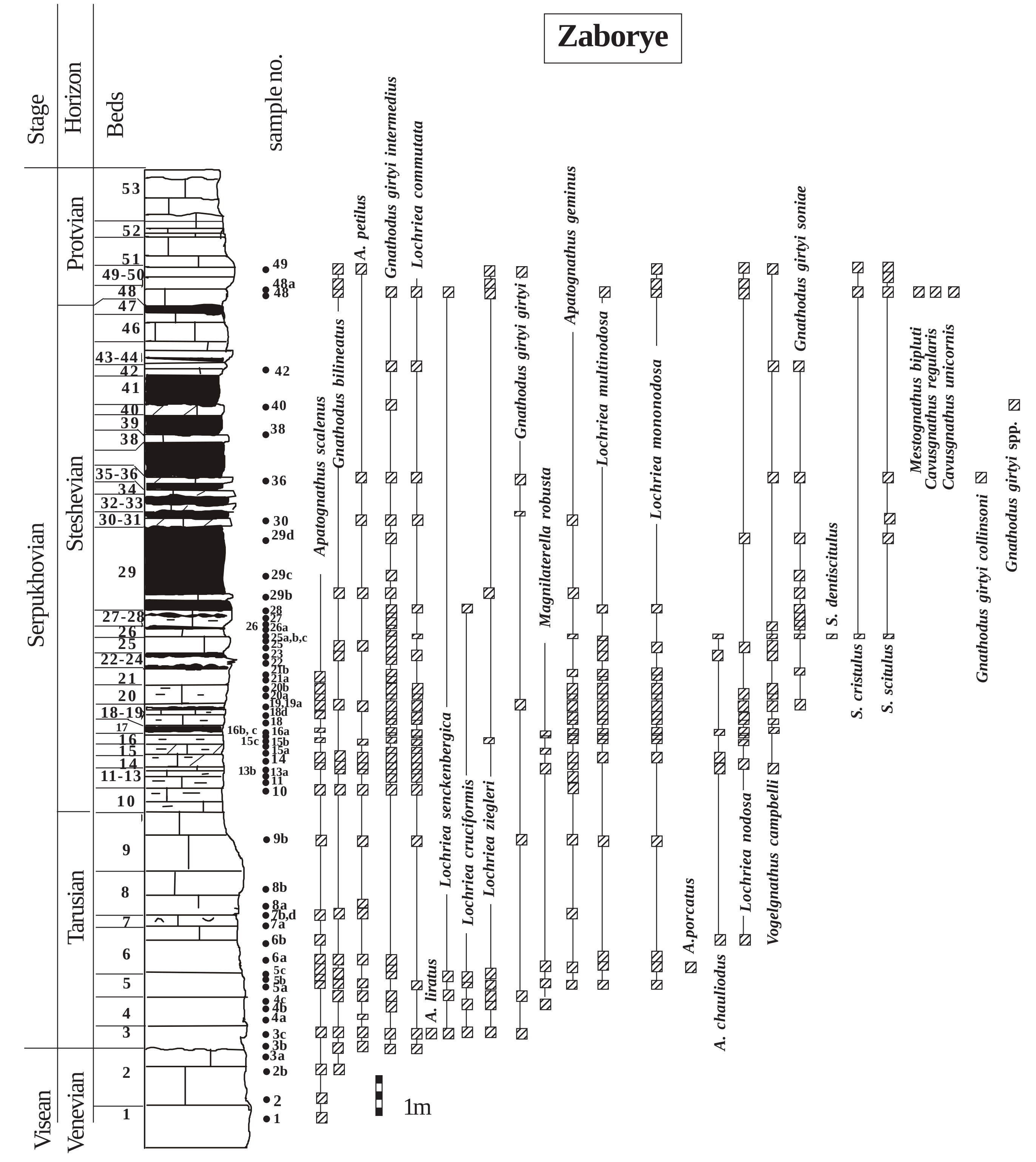

Fig. 1. Conodonts in the type Serpukhovian section in Zaborye (Barskov et al., in press).

species. *Lochriea monocostata* appears in the upper part of the Zone. The assemblage contains the long ranging species *Gnathodus bilineatus bilineatus*, *Gnathodus girtyi girtyi*, *Lochriea commutata*, and *Pseudognathodus homopunctatus*.

The *Lochriea nodosa* Zone (Beds 21.11-21.12, thickness 0.7 m). *Lochriea costata*, *Lochriea monocostata*, and *Lochriea nodosa* appear in this Zone. The assemblage is largely composed of the long ranging species *Gnathodus bilineatus bilineatus*, *Gnathodus girtyi girtyi*, *Lochriea commutata*, and *Pseudognathodus homopunctatus*.

Beds with *Lochriea ziegleri* (Beds 22a.1 and 22a.2, thickness 0.58 m). The beds are defined based on the appearance of the index species in association with the majority of species continuing from the underlying zone. *Lochriea ziegleri* appears below the base of the equivalents of the Namurian in England and Germany (Skompski et al.,1995) and supposedly appears below

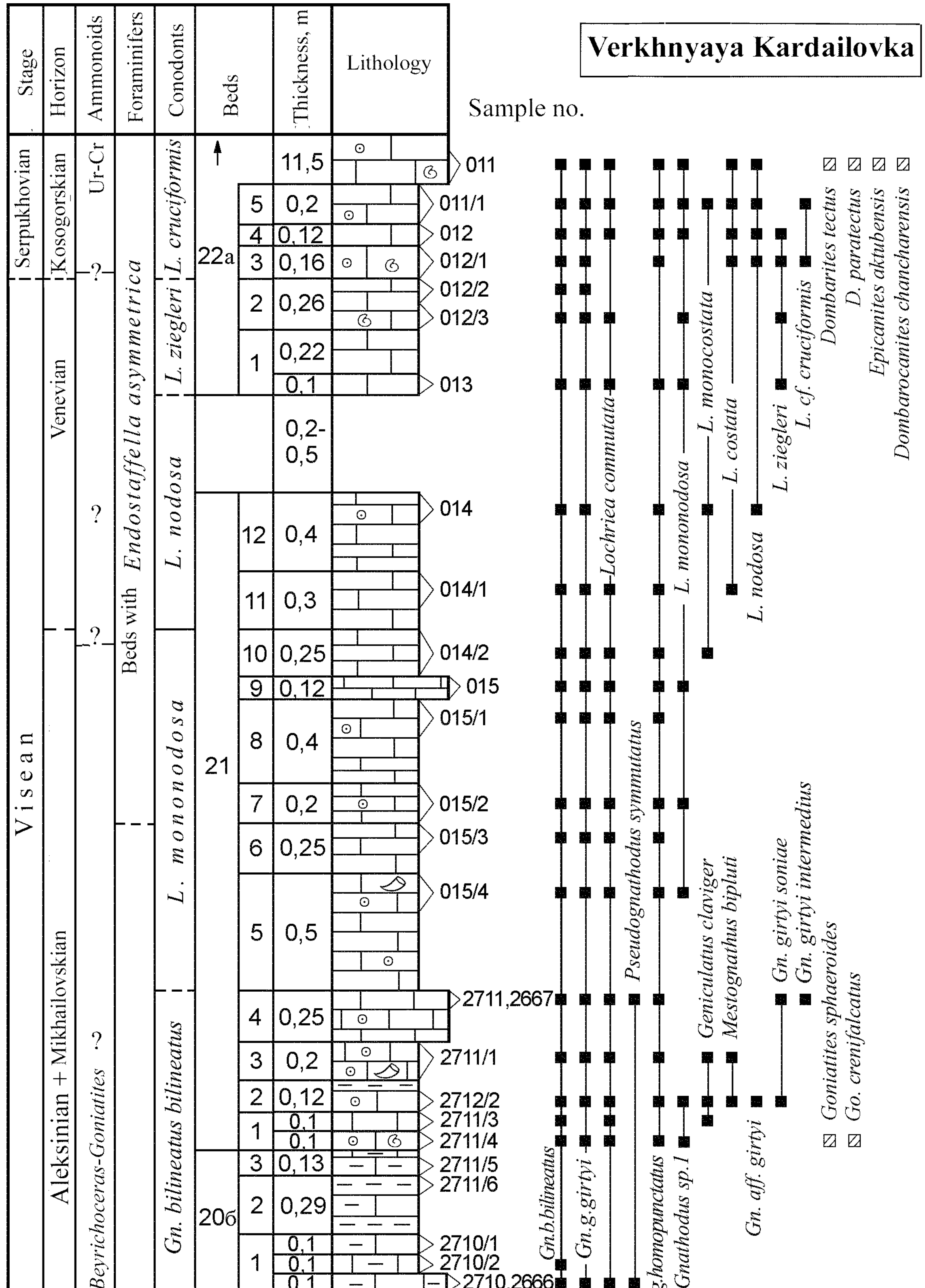

Fig. 2. New data on conodont and ammonoid distribution in the Visean-Serpukhovian boundary beds in the Verkhnyaya Kardailovka section (composed by V.N. Pazukhin).

the Serpukhovian in the Urals.

The *Lochriea cruciformis* Zone is recognized in the Kosogorskian and lower Khudolazian horizons (Beds 22a.3-lower part of 24, thickness 23 m). The lower boundary is defined by the appearance of the index species. *Gnathodus girtyi simplex* and *Gn. pseudosemiglaber* appear in this zone. The assemblage also contains *Gnathodus bilineatus bilineatus*, *Gn. girtyi girtyi*, *Lochriea costata*, *L. monocostata*, *L. mononodosa*, *L. nodosa*, *L.*

ziegleri and other species. In Verkhnyaya Kardailovka the species *Lochriea cruciformis* is represented only by transitional varieties. The conodont-based Viséan-Serpukhovian boundary approximately corresponds with the base of the *Lochriea cruciformis* Zone, which is the last member in the evolutionary lineage *L. commutata - mononodosa - L. monocostata - L. costata - L. cruciformis*. The species *L. cruciformis* is widespread in Eurasia. Its first appearance corresponds to the base of the Serpukhovian (and Namurian) in the shelf sequences of England, Poland, and Ukraine. In the more basinal sections of Germany, it is recorded below, in the *Emstites schaelkensis* ammonoid Zone (Skompski et al., 1995).

The *Gnathodus bilineatus bollandensis* Zone is recognized in the upper part of the Khudolazian and the Yuldybaevian horizons (Beds 24-26, thickness ca. 14 m). The base of the zone is defined by the appearance of the index species. The assemblage includes a number of long ranging species (e.g., *Gnathodus bilineatus bilineatus*, *Gn. girtyi simplex*, *Lochriea commutata*, *L. costata*, *L. cruciformis*, *L. monocostata*, *L. mononodosa*, *L. nodosa*, *L. ziegleri*). Several specimens intermediate between *Gn. girtyi simplex* and *D. noduliferus* are found in this zone.

The *Declinognathodus noduliferus* Zone (Bed 27, thickness 0.2 m) is defined based on the appearance of the infrequent occurrence *Declinognathodus inaequalis* against a background of the typical Serpukhovian assemblage.

Conodonts of the Viséan-Serpukhovian boundary beds show a successive change in the zonal assemblages based on the evolution of the genus *Lochriea*. The closest level to the ammonoid-based boundary is the base of the *L. cruciformis* Zone. However, this species is rare in Verkhnyaya Kardailovka and other sections in the South Urals and its representatives in this region are morphologically different from the type specimen and are somewhat similar to *L. costata* and *L. ziegleri*. The species *L. ziegleri* is more frequent. It appears slightly earlier than *L. cruciformis* and is probably a better choice as a boundary marker.

Conclusions

(1) The boundary beds in the Zaborye type section contain the marker foraminifera species *Neoarchaediscus postrugosus* and *Janishewskina delicata*. The species "*Millerella*" *tortula* which is also present in this section may prove to be a good marker after its distribution is studied in greater detail in the type Chesterian sections. Close to this level is the appearance of the conodonts *L. cruciformis*, *L. ziegleri*, and *L. senckenbergica*, which are potential boundary markers.

(2) The Verkhnyaya Kardailovka section in the South Urals is a well-studied carbonate sequence containing ammonoids, foraminifers and conodonts near the Viséan-Serpukhovian boundary. The biostratigraphic resolution here is higher than in any other section studied to date, although the entire biostratigraphic potential of this section for establishing a GSSP is yet to be fully understood. It is already clearly seen that the potential boundary choices indicated by three fossil groups are set close together in this section. The boundary interval shows the appearance of the Serpukhovian ammonoids *Dombarites* and *Cravenoceras*, the foraminifers *Planospirodiscus* and *Neoaracheodiscus postrugosus*, and the conodonts *Lochriea cruciformis* and *L. ziegleri*. Our future work will focus on better exposing the Viséan-Serpukhovian boundary interval in an attempt to recover more fossiliferous levels for better documentation of boundary relationships.

(3) The Bolshoi Kizil section provides new, promising material for correlation of the foraminiferal zones of the South Urals with those in the type Serpukhovian region in the Moscow Basin, and we expect to be able to formulate broad interregional correlations with the sections elsewhere.

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Foraminiferal and conodont subdivisions in the Bashkirian-Moscovian boundary beds in the South Urals

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The Bashkirian-Moscovian boundary beds in the South Urals are best represented in the Western-Uralian Zone where they are composed of carbonates containing many fossils. The Bashkirian-

Moscovian boundary in this region is drawn at the boundary between the Asatauian and Solontsian horizons. Foraminiferal and conodont subdivisions have been studied in the Askyn and Seryat sections (Fig. 1). In the Askyn section (stratotype section for the Bashkirian Stage), foraminiferal zones were established by Sinitsyna (see Sinitsyna et al., 1984; 1987), while conodont zones were established by Nemirovskaya and Alekseev (1995). The Seryat section is located 150 km south of the Askyn section, on the right bank of the Belaya River and was described by Khvorova (1961) and Chuvashov et al. (1990). Sedimentological analysis was conducted by Proust et al. (1996; 1998) for both of these sections. We have continued to study these sections and have established foraminiferal and conodont zonations in the Seryat section.

In the Askyn section the foraminifera-based Bashkirian-Moscovian boundary is established between beds 30 and 31 (Sinitsyna et al., 1984; 1987). Bed 30 is composed of medium- and thick-bedded mudstones interbedded with algal bafflestones and thinly-bedded, coarse-grained, and fine-grained bioclastic grainstones. The upper part is composed of medium- and thinly-bedded limestones containing small lenses and nodules of chert with bioclastic-oolitic grainstones at the top. Bed 31 is composed of thinly- and medium-bedded limestones with lenses and bands of chert. Mudstones and microbioclastic wackestones with bands of algae (*Donezella*) and foraminiferal-algal packstones are dominant. Foraminifera were found only in the two latter rock types.

The foraminiferal assemblage of the Asatauian corresponding to the *Tikhonovichiella tikhonovichi* Zone is intermediate between the Bashkirian and the Moscovian. The species *Tikh. tikhonovichi* (Raus.) and *Tikh. nibelensis* (Raus.), and the first representatives of the groups *Profusulinella prisca* (Deprat) and Pr. *rhomboides* Lee et Chen, which become widespread in the Moscovian, appeared for the first time in the Asatauian Horizon. *Eostaffella*, *Pseudostaffella*, Archaediscida, *Eoschubertella* and other taxa from the underlying beds continued their evolution. The Solontsian Horizon corresponds to the *Aljutovella aljutovica* Zone (Beds 31-37). The species *Schubertella gracilis* Raus., *Aljutovella* aff. *arrisionis* Leont., *Aljutovella aljutovica* (Raus.), and *A. subaljutovica* Saf. appear successively from the base to the top of Bed 31. Higher in the section the species diversity of *Aljutovella* and *Profusulinella* increases. Of *Profusulinella*, the species *Pr. prisca timanica* Kir., *Pr. prisca sphaeroidea* Raus. are typical.

Conodonts of the Asatauian and the lower part of the Solontsian horizons (Beds 30-32) belong to a single assemblage of the *Neognathodus atokaensis* Zone. *Neognathodus atokaensis* Grayson, *Diplognathodus coloradoensis* Murray et Chronic, and *Dip. orphanus* Merrill first appear in this zone. *Idiognathodus aljutovensis* Al., Barsk. et Kon., and *Idiognathoides ouachitensis* Harlton appear in the upper part of this zone. Conodonts of the *Neognathodus uralicus* Zone appear beginning in Bed 33. The lower boundary of this zone is defined by the appearance of *N. uralicus* Nem. et Al. and *Streptognathodus einori* Nem. et Al. Higher in the section, in Bed 35, *N. kashiriensis* Goreva and *Neognathodus* sp.1 appear. The species *Declinognathodus donetzianus* Nem., which is used as a marker for the base of the Moscovian in the Donets Basin and the Russian Platform, appears considerably above the base of the zone in the South Urals.

In the Seryat section the boundary beds are composed of thickly-bedded limestone with lenses of chert. The top of the Bashkirian is composed of a thick, non-fossiliferous series of dolomites (Beds 27-35). The upper part (Beds 36-37) is mainly composed of fine-grained bioclastic and lump packstone with interbeds of fusulinid-rich, strongly dolomitized limestone. The lower boundary is drawn provisionally. The Moscovian (Beds 38-40) is composed of wackestones, fine-grained bioclastic, algae-foraminiferal-bioclastic grainstones, and, more rarely, algal bafflestone. Rocks are often dolomitized. Because of strong dolomitization, foraminifera are often difficult to identify, although it is observed that the sequence of appearances of taxa is similar to that in the Askyn section. Conodont zones are the same as in the Askyn section and their species composition is similar. Conodonts in the boundary beds in the Seryat section are represented by a larger number of specimens (per kg), although their species diversity is reduced. This section does not contain *Diplognathodus* and *Streptognathodus*, whereas *Idiognathodus aljutovensis*, which appears only in the upper part of the *N. atokaensis* Zone in the Askyn section, appears almost from its base in the Seryat section.

The main role in foraminifera-based definition of the lower Moscovian boundary belongs to the evolutionary lineage *Profusulinella – Tikhonovichiella – Aljutovella*. The lower boundary is defined by the appearance of fusulinids with fluted septa which form arches in the flanks of the test and in the axial ends in the final two-three volutions (genus *Aljutovella* Rauser 1951). The genus *Tikhonovichiella* Solovieva *in* Rauser-Chernousova and others, 1996 includes more primitive species of Aljutovellidae Solovieva *in* Rauser-Chernousova and others, 1996, which differ from *Aljutovella* in their smaller size, semi-rhomboid test, and weakly fluted septa, rarely with arches in the last volution. Members of the family Schubertellida, which occur in facies less favorable for large fusulinids, may be used as additional markers for the lower Moscovian boundary. In such facies the lower boundary may be drawn based on the appearance of *Schubertella gracilis* Raus.

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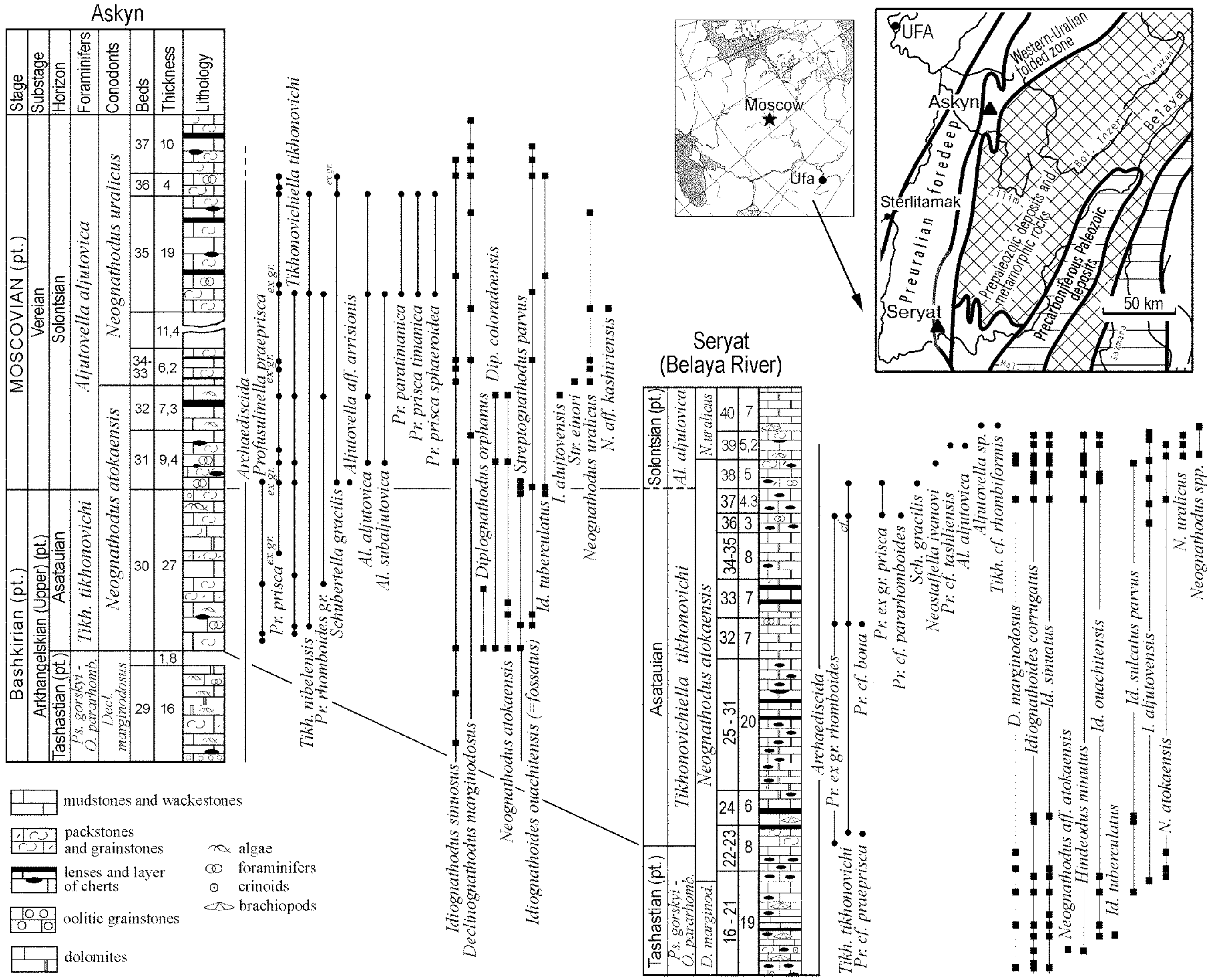

Figure 1. Distribution of selected taxa in the Askyn and Seryat sections. Stratigraphic column and foraminifers in the Askyn section are according to Sinitsyna and Sinitsyn (1987), conodont ranges are according to Nemirovskaya and Alekseev (1995) and Pazukhin.

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Biostratigraphy of the Carboniferous of Angaraland

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The characteristic feature of Carboniferous biota is the high degree of biogeographic differentiation. There were three different endemic floras: I) Early Carboniferous [mostly Mississippian] lepidophytean flora; II) very poor post-lepidophytean flora (Serpukhovian? – first half of Bashkirian); III) Late Carboniferous [mostly Pennsylvanian] – Permian Cordaitean flora, which followed one another during the Late Paleozoic within Angaraland.

The rise of endemism in the Angara flora took place near the Devonian-Carboniferous boundary. At the stratotype section of the Angaran continental Lower Carboniferous in the Minusa Basin, the uppermost Famennian cosmopolitan Cyclostigma zone was followed by the endemic lepidophytean association (Meyen, 1976; Zorin, 1998). The global palynological "lepidophytus" zone top, marking the Devonian-Carboniferous boundary (base of the *Gattendorfia* limestone) is available in the Minusa Basin, and also in the uppermost part of the Bystrjanka suite, i.e., near the same level as the Cyclostigma zone.

I. The Early Carboniferous [Mississippian] lepidophytean flora of Angaraland is represented by two different geofloras. 1) The older one (Tournaisian) consists of mainly thin-stemmed and small leaf-cushioned lepidophytes (endemic genera *Pseudolepidodendron*, *Ursodendron*, *Tomiodendron*, and cosmopolitan *Eskdalia*). Very rare fern-like plants are regarded as cosmopolitan taxa also. They are certain species of *Adiantites*, *Triphyllopteris rarinervis*, *Aneimites acadica*, and *Rhacophyton*? sp. 2) The younger (Viséan – Serpukhovian?) geoflora consists of mainly thick-stemmed unbranched lepidophytes (genera *Tomiodendron*, *Angarophloios*) with a mixture of more delicate *Lophiodendron* and *Angarodendron*. There are no cosmopolitan lepidophyte genera at this level. Fern-like plants are represented by endemic genera *Abacanidium* and *Angaropteridium* with cyclopteroid pinnules. Only very rare *Rhodeopteridium* and problematical *Cardiopteridium* may be regarded as cosmopolitan taxa.

Near the end of the Early Carboniferous most of the lepidophytes suddenly disappeared. Meyen (1968, 1987) regarded this event as a result of a strong cooling. We agree with this conclusion because analysis of the constituents of the post-lepidophytean *Abacanidium* flora determined that it consists of Viséan – Serpukhovian lepidophyte assemblage relics. Many species of *Abacanidium* and *Angaropteridium* predominate here. Rare lepidophytes are represented by *Angarodendron* and some new genera with small leaf cushions and small stems. Meyen (1968, 1987) discovered the disappearance of thick stemmed lepidophytes ("Ostrogskian episode") in the middle of the Ostrogsky series, near the boundary between the Evseevsky and Kaezovsky suites in the Kuznetsk Basin.

II. The poor Post-lepidophytean flora, characterizing the Kaezovsky suite and widely distributed all over Angaraland consists of the following plants: *Angarodendron*, *Paracalamites mrassiensis* Radcz., *Abacanidium* spp., *Angaropteridium* spp., rare *Rhodeopteridium*, and *Trigonocarpus minimus*.

Meyen (1968) compared the "Ostrogskian episode" with Gothan's "Florensprung" that took place near the Namurian A/B boundary (base of the *Reticuloceras* Zone). This level was regarded in the 1970s as the Lower/Middle Carboniferous boundary and the boundary between the Mississippian and Pennsylvanian (Bouroz et al., 1975)

The present authors do not agree with this point of view. At the end of the 1970s it became clear that Gothan's "Florensprung" was due to a stratigraphic gap rather than climatic change (Havlena, 1977). Therefore it was useless for determining the age of the "Ostrogskian episode". On the other hand, the Ostrogskian cooling event coincides with the very short marine transgression indicated by marine beds at the Evseevsky/Kaezovsky suite boundary. According to V.G. Ganelin, the age of the brachiopod assemblage in this bed is latest Viséan (P_2 ammonoid zone). Therefore, the Ostrogskian cooling episode is older than the Mississippian-Pennsylvanian boundary.

It is necessary to mention that a very similar cooling event (the disappearance of a warm-climate lepidophytean flora to and replacement by a poor *Nothorhacopteris* flora) took place in Gondwana during the late Viséan through early Namurian. Therefore it is possible to speak about a global cooling event, expressed outside the tropical region and marking the middle Carboniferous climatic change. That is why the boundary between lepidophytean and post-lepidophytean floras of Angaraland may be regarded as a global correlation level.

III. The youngest Angaran Carboniferous flora is the Pteridosperm – Cordaitean flora. It is the oldest geoflora of the long-lived Cordaitean flora. Cordaites, represented by two genera: *Cordaites* and *Rufloria* (mainly *Praerufloria*) predominated here. Pteridosperms (*Angaridium*, *Angaropteridium*, *Paragondwanidium*, some neuropterids) were widely distributed also. Ferns were rather rare. There are various Euramerican taxa (*Calamites*, *Autophyllites*, *Calamostachys*, some *Sphenophyllum* and *Annularia*) among arthropsids. Most plants of the Pteridosperm – Cordaitean flora have no ancestors in older floras and more likely appeared in Angaraland because of migration (Durante, 1995). The age of the Pteridosperm – Cordaitean flora is most of the Late Carboniferous [Pennsylvanian] after early Bashkirian.

In marine basins surrounding the Angara continent (Taimyr Peninsula, northeastern Russia, Transbaikal region, northern Mongolia, eastern Kazakhstan), endemic faunas without conodonts, fusulinids or other warm-climate groups appeared during the late Viséan (Ganelin and Tschernjak, 1996). Older (Tournaisian – early Viséan) deposits are classified here as the Prykolymsky and Neruinsky regional series. The Devonian-Carboniferous boundary was carefully studied in the Omolon massif and identified on the basis of conodont evolution (change from presulcata to sulcata standard zones). According to Gagiev (1996), three standard early Tournaisian conodont zones (*sulcata*, *duplicata*, *sandbergi*) may by recognized in the Kolyma – Omolon region. The late Tournaisian – early Viséan zones are different from the standard zones, but may be correlated with them without any problem (Gagiev, 1996). Younger zones have been established provisionally.

In the younger deposits there were two types of endemic late Viséan – Late Carboniferous [Pennsylvanian] boreal marine faunal communities here.

1) The Taimyr–Kolyma fauna (Magarsky regional series of the Russian Northeast and analogs in other boreal regions) is characterized by the disappearance of genera of European affinity among the predominant brachiopods. Some endemic genera *(Balakhonia, Orulgania, Verkhotomia, Sajakella, Flexaria–Balkashiconcha* phylogenetic line) appeared. The Magarsky foraminiferal community is represented mainly by archaediscids. Ammonoids from the lower part of the Magarsky series (*Goniatites americanus*, *G. granosus*, *Neoglyphioceras abramovii*) are of late Viséan age. The early Bashkirian age of the

EAST-EUROPIAN SCALE			STANDARD AMMONOID ZONES
SYSTEM	SERIES	STAGES	
CARBONIFEROUS	UPPER	Gzhelian	*Shumardites-Vidrioceras*
		Gzhelian / Kasimovian	*Dunbarites Parashumardites*
		Moscovian	*Pseudoparallegoceras-Wellerites*
		Moscovian	*Parallegoceras Eowellerites*
		Moscovian	*Diaboloceras Winslowoceras*
		Bashkirian	*Diaboloceras Axinolobus*
		Bashkirian	*Branneroceras Gastrioceras*
		Bashkirian	*Bilinguites – Homoceras*
	LOWER	Serpukhovian	*Fayettevillea – Cravenoceras*
		Visean	*Hypergoniatites-Ferganoceras*
		Visean	*Beyrichoceras-Goniatites*
		Visean	*Merocanites – Ammonel1ipsites*
		Tournaisian	*Pericyclus*
		Tournaisian	*Protocanites-Gattendorfia*

REGIONAL SCALE OF ANGARALAND

OMOLON MASSIF AND OTHER REGIONS OF NE ASIA

REGIONAL SERIES	COMMUNITY TYPES	BRACHIOPOD ASSEMBLAGES	AMMONOID ZONES	CONODONT ZONES
PARENSKY	VERKHOYAN	*Verkhoyania monstrosus*	*Eoshumardites*	
		Verkhoyania immemoratus		
		Verkhoyania magiveemsis		
		Verkhoyania taymyrensis		
OLCHINSKY		*Verkhoyania sp.*		
		Verkhoyania centispinus	*Diaboloceras - Kayutoceras*	
		Verkhoyania parvulus		
		Orulgania tukulaensis	*Yanshinoceras-Yakutoceras*	
MAGARSKY	TAYMYR KOLYMA	*Balkhashiconcha gigantea*		
		Balkhashiconcha sp.- Settedabania stepanovi	*Epicanites pertenuis*	
		Balkhashiconcha infima–Verkhotomia gunbiniana	*Goniatites granosus – Neoglyphioceras abramovi*	*bilineatus*
		Balkhashiconcha piassinaensis-Verkhotomia plenodes	*Goniatitus americanus*	
NERUINSKY	KUZNETSK – TAYMYR	*Latiproductus zyrjankensis – Productus productus*		*Up. texanus*
		Latiproductus tulensiformis- Neos[pirifer sinuatoplicatus		*L. texanus*
		Marginatia burlingtonensis –Setigerites altonensis		*latus-typicus*
				punctatus
PRYKOLYMSKY				*delicatus*
				crenulata
				sandbergi
				duplicata
				sulcata

KUZNETSK AND MINUSINSK COAL BASINS

Regional series	Suites	Great floras	Geofloras	Plant assemblages	
LOWER BALAKHONSKY	ALYKAEVSKY	CORDAITEAN	PTERIDOSPERM CORDAITEAN	*Praerufloria spp., Angaropteridium spp., Paragondwanidium spp., Krylovia sp.*	*Angaridium finale, Ginkgophyllum spp., Angarocarpus ungensis mongolicum, A.*
	MAZUROVSKY				*Angaridium submongolicum, A. potaninii Samaropsis siberiana*
					Angarodendron obrutschevii
OSTROGSKY	KAEZOVSKY	POSTLEPIDOPHYTEAN	DOPHYTEAN	POSTLEPIDOPHYTEAN	POSTLEPIDOPHYTEAN
	EVSEEVSKY	LEPIDOPHYTEAN	THICK STEM LEPIDOPHYTES	*Tomiodendron kemeroviense, Tomiodendron asiatica., Angarophloios alternans*	
MINUSINSKY	BAYNOVSKY				
	JAMKINSKY				
	SOLOMENSKY				
	SAMOCHVALSKY		THIN STEM LEPIDOPHYTES *Pseudolepidodendron igrischense, Tomiodendron varium, Escdalia elliptica*		
	ALTAYSKY				

upper part of the Magarsky series is determined by the presence of middle Bashkirian ammonoids in the lower part of the overlying series.

2) The Verkhoyansk type of marine faunal communities (Olchinsky and Parensky series of the Omolon massif and their analogs in other regions) is characterized by poorly diversified faunal assemblages and the predominance of endemic taxa. Forams are mainly represented by sessile and arenaceous forms. Among brachiopods some new endemic genera (*Verkhoyania, Jacutoproductus, Jakutella, Taimyrella*) together with primitive anidanthids are widely distributed. Corals and trilobites are absent. Ammonoids are known from some levels. The oldest (*Yanshinoceras – Yakutoceras*) assemblage from the lower part of the Olchinsky series is represented by endemics. The younger (*Diaboloceras – Kayutoceras*) assemblage is a correlative of the standard *Diaboloceras – Axinolobus* ammonoid Zone (latest Bashkirian). Therefore the age of the lower part of the Olchinsky series is late Bashkirian. Its upper part with a very poor marine fauna may be regarded as Moscovian.

The overlying Parensky series is characterized by new species of the same endemic genera as Olchinsky forms. In addition, some genera of East-European affinity appeared among forams (*Protodosaria*) and brachiopods (*Waagenoconcha, Muirwoodia* and others). Ammonoids are represented by late Moscovian – Kasimovian *Eoshumardites*. The presence of Asselian – Sakmarian ammonoids in the lower part of the overlying series allows the Parensky series to be determined as Kasimovian – Gzhelian in age.

Conclusions

1. As shown above, the greatest event in Angara floral history was the “Ostrogskian episode”, a sudden disappearance of warm-climate endemic lepidophytes due to global cooling. This event may also be recognized in Gondwana. Therefore this level may be regarded as a global event. Other floristic boundaries may be followed only within Angaraland.

2. Only Tournaisian – lower Viséan subdivisions in the Angara faunal succession have a good correlation potential. The great change in younger (endemic) faunas took place only near the Magarsky and Olchinsky series boundary coinciding with the base of the standard *Branneroceras – Gastrioceras* ammonoid Zone. This level may be followed within and outside of Angaraland. Other boundaries may be used for correlation only into the Boreal realm.

3. The history of the Angara Carboniferous biota shows the existence of great breaks in floral and faunal successions near the middle of the system. Nevertheless, none of these breaks coincides with the selected boundary between the Carboniferous subsystems.

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Sea-level fluctuation curve for the Cherokee Group (lower and middle Desmoinesian/upper Moscovian) in the Arkoma-Cherokee Basin area of eastern Oklahoma

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Based on surface exposures and selected near-surface core analysis, we present a sea-level curve for the Cherokee Group of Oklahoma and southeastern Kansas. This sea-level curve augments an earlier curve by Heckel (1986) that included the top of the Cherokee Group along with the upper Desmoinesian Marmaton Group of Midcontinent North America. The Cherokee Group comprises 29 cyclothemic depositional sequences (cyclothems), ten of which contain black fissile and phosphatic shales deposited at maximum transgression. Significantly, 19 of these cyclothems contain conodonts that for the first time will enable documentation of the complete Desmoinesian conodont succession from Midcontinent North American.

Introduction

The Desmoinesian stratigraphic succession in the North American Midcontinent has long been argued as one of the most fossiliferous and complete in the world, for this time interval. However, the lower two-thirds of the Desmoinesian, the Cherokee Group, has been inadequately studied both in terms of its cyclicity and also in terms of its faunal succession.

The most complete stratigraphic succession of the Cherokee Group occurs in the Arkoma Basin in east-central Oklahoma. In this region the Cherokee Group is exceedingly thick (in excess of 1000 meters), due to rapid basin subsidence along with glacial-eustatic sea-level rises and penecontemporaneous highstand deltaic sedimentation. Northward through the Cherokee Basin of northeastern Oklahoma and southeastern Kansas toward the northern shelf area of the Midcontinent, the Cherokee Group thins tremendously to 100 meters or less and is typically missing many of the minor and some of the intermediate cyclothems seen southward, due to either nondeposition or erosion. The type Desmoinesian in Iowa on the northern shelf is significantly less complete than coeval strata in the Arkoma-Cherokee Basin area.

The sea-level curve presented herein is derived from surface exposures in the Arkoma and Cherokee Basins, based on preliminary reports of Marshall and Boardman (2002) and Boardman and Marshall (2002). Additionally, some stratigraphic intervals not seen on outcrop are based completely on near-surface cores provided by the Oklahoma Geological Survey.

Magnitude of Cyclothems

Estimating the magnitude of sea-level rises is based primarily on a combination of lithofacies and biofacies analysis.

Those sequences with black-fissile and phosphatic shales represent major cyclothems and are interpreted to have been deposited beneath a thermocline associated with upwelling (Heckel, 1977). These major sea-level fluctuations are thought to represent maximum water depths between 50 and 200 meters. The black fissile phosphatic shales are characterized by the *Idioprioniodus-Gondolella* Biofacies, which according to Heckel and Baesemann (1975) represents the most offshore conodont association. These shales locally carry from 100 to over 1000 Pa conodont elements per kilogram. Additionally, they contain locally abundant ammonoids and shark debris. Preliminary analysis shows that these major cyclothems are traced across all parts of the North American Midcontinent. Ten of these are identified within the Cherokee Group in addition to the four recorded from the Marmaton Group by Heckel (1986), yielding a total of fourteen for the Desmoinesian Stage as a whole (Figure 1).

Intermediate cyclothems are represented by either gray shales or carbonates characterized by moderately abundant conodonts (from 50 to 300 per kilogram) representing the *Idiognathodus* Biofacies. These maximum transgressive deposits are interpreted to represent deposition near the base of the euphotic zone around 50 meters of water depth. Five cyclothemic sequences of this scale are identified in the Cherokee Group in the Arkoma and Cherokee Basins.

Minor cyclothems comprise a variety of lithofacies including carbonates and shales. They are characterized by low numbers of conodonts from the *Idiognathodus* or *Adetognathus* Biofacies, or contain no conodonts at all. In this study, these minor cycles are identified almost exclusively in the Arkoma Basin, and few have been identified north of that region.

Summary of Cyclothems

The lowermost part of the Cherokee Group includes the Hartshorne and McAlester formations in ascending order (Figure 1). The lower Hartshorne sandstone complex is largely deltaic and associated with the underlying Atoka Formation. The upper Hartshorne is commonly recognized as an incised valley complex and represents the initial lowstand stage of the first Desmoinesian cyclothemic sequence. The McAlester Formation contains two major cyclothems, one in the basal McCurtain Shale and the other near the top of the McCurtain Shale. These sequences contain the conodont *Idiognathodus obliquus* Kossenko and Kozitskaya, which allows correlation of the lower Cherokee Group with the base of the upper Moscovian Stage in the Donets and Moscow Basins of eastern Europe. The upper McAlester Formation contains five minor cycles, in which only the unnamed limestone above the Tamaha coal contains conodonts. This part of the McAlester Formation is thought be missing from the northern shelf area.

The Savanna Formation (Figure 1) contains two major cyclothems, one including the Doneley Limestone, and the other above the Drywood coal. Additionally the Sam Creek is recognized as an intermediate cyclothem, whereas the two lower cycles are considered minor. The upper two major cyclothems are believed to be traceable across the Midcontinent.

The Boggy Formation (Figure 1) includes one major cyclothem, the Inola, which lies above the Bluejacket coal, and is traceable across the Midcontinent. Additionally, one intermediate cyclothem above the Wainwright coal and five minor cycles are recognized. None of the intermediate or minor cycles within the Boggy Formation has yet been traced into the northern shelf area.

The Senora Formation (Figure 1) includes five major cyclothems, one above the Weir-Pittsburg coal, one above the Tebo coal, one above the Tiawah Limestone, one above the Croweburg coal (Verdigris), and one above the Mulky coal (Excello-Lower Fort Scott). At least the upper three of these are traceable across the Midcontinent. Three intermediate cyclothems are recognized, one above the Mineral coal, one above the Fleming coal, and one above the Bevier coal. All of these contain conodonts and at least the upper one is traceable across the Midcontinent. Additionally, two minor cycles with more localized distribution are present.

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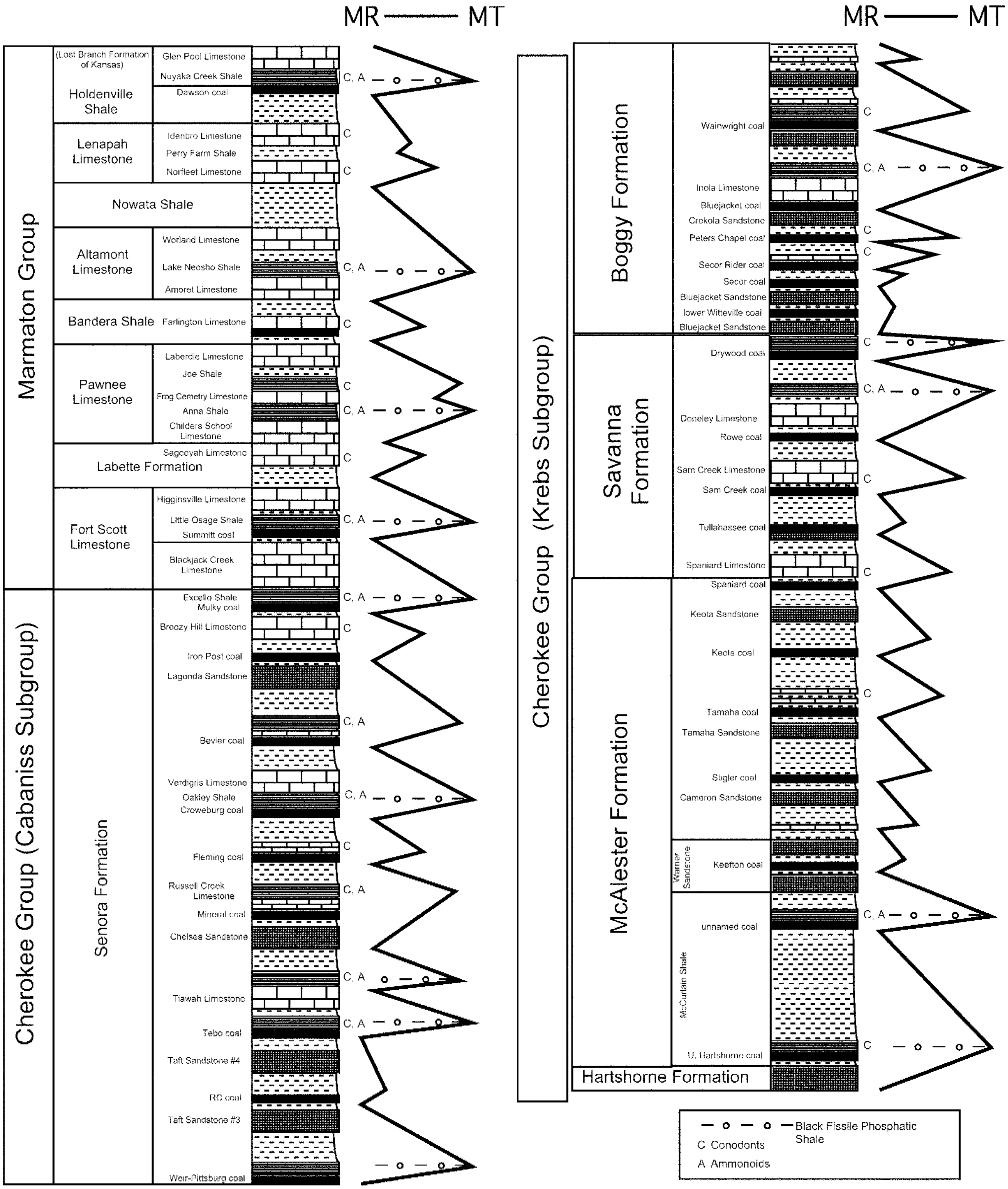

Figure 1. Sea-level fluctuation curve for Desmoinesian Stage based on outcrop and core data from northeastern Oklahoma. MR = maximum regression; MT = maximum transgression. Curve of Heckel (1986) from Verdigris cyclothem upward shows greater number of minor cycles that are distinguished only on northern shelf. That curve also classifies cyclothem that includes Excello shale (Lower Fort Scott) with Marmaton Group rather than with Cherokee Group (as in this article), but this does not alter total number of major Desmoinesian cyclothems.

Report on the Pennsylvanian conodont zonation from the Nashui section of Loudian, Guizhou, China

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Carboniferous and Permian marine sediments are widely distributed and well developed in South China, especially in Guizhou. In many places, such as at the Nashui section near Luodian, they form a continuous sequence of limestone containing conodonts, fusulinids, foraminifers, ammonoids, corals, and brachiopods, thus providing an excellent opportunity to study the Pennsylvanian biostratigraphy, mid-Carboniferous and Carboniferous-Permian boundaries, and the conodonts of this interval.

In the last two decades of the 20th Century, knowledge of mid-Carboniferous, Pennsylvanian (Upper Carboniferous), and Carboniferous-Permian conodont biostratigraphy in South China, mainly in the Nashui section, has been rapidly advanced. Many papers describing the conodont biostratigraphy of this interval in South China have been published. Based on studies by Xiong and Zhai (1985), Dong et al. (1987), Kang et al. (1987), Rui et al. (1987), Wang et al. (1987), Zhang et al. (1988), Wang and Higgins (1989), Wang (1991, 1996) and Zhang (2000), the Upper Carboniferous conodont zonation in South China can be summarized in descending order as follows: the *Streptognathodus wabaunsensis*, *S. elongatus*, *S. elegantulus*, *S. oppletus*, *S. parvus*, *Neogondolella clarki*, *Idiognathoides sulcatus parva*, *Idiognathodus primulus*, *Neognathodus symmetricus*, *Idiognathoides sinuatus*, *I. sulcatus* and *Declinognathodus noduliferus* zones. In the period from 1991 to 2001, the present authors three times collected conodont samples systematically and abundantly from uppermost Lower Carboniferous through Lower Permian strata in the Nashui section, near Luodian, Guizhou. The purpose of these studies is to investigate and describe the Pennsylvanian conodont sequence from the Nashui section in more detail, and to correlate it properly with that of Russia and North America.

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Conodont zonation at the Nashui section

The Nashui section, located on the side of the Wangmo-Luodian highway, about 44 km southwest of Luodian town, is easily accessible by car from Guiyang, the capital of Guizhou Province. The Pennsylvanian strata in the Nashui section, which have not been named up to now, are mainly composed of black, dark-grey and grey thin- to medium-bedded wackestone, packstone, grainstone, mudstone and chert, with normal graded bedding and massive bedding, representing basin-marginal, gentle-slope deposits. The biota is characterized by planktonic and benthonic faunas, which have been found in association with each other. The benthonic fauna is composed of non-fusulinacean foraminifers, fusulinids, calcareous algae and corals (very rare), while the planktonic fauna is very rich in conodont species. Firstly, Xiong and Zhai (1985) discovered the *Streptognathodus elongatus*, *S. wabaunsensis*, *S. elegantulus*, *S. suberectus*, *Idiognathodus delicatus*, *Streptognathodus oppletus*, *Gondolella qiannanensis*, *Idiognathoides corrugatus* and *Declinognathodus lateralis* zones in the Upper Carboniferous strata at this site. Later, Wang, Rui and Zhang (1987) and Wang and Higgins (1989), who studied the same sequence at this site, erected the following conodont zones, from top to bottom: the *Streptognathodus elongatus*, *S. elegantulus*, *S. oppletus*, *S. parvus*, *Neogondolella clarki*, *Idiognathoides sulcatus parva*, *Idiognathodus primulus*, *Neognathodus symmetricus*, *Idiognathoides sulcatus-I. sinuatus- I. corrugatus*, *Declinognathodus noduliferus* and *Gnathodus bilineatus bollandensis* zones. Most recently, Wang (1991) described the *Streptognathodus barskovi* and *S. wabaunsensis* zones above and below, respectively, the Carboniferous-Permian boundary. Wang (1996) also described the *Idiognathoides sinuatus*, *I. sulcatus* and *Declinognathodus noduliferus* zones at the base of the Upper Carboniferous sequence at this site. The specimens from the Nashui section described as "*Streptognathodus barskovi*" by Wang (1991) are referred to *Streptognathodus longilatus* Chernykh and Ritter (1997). With additional collections and restudy of existing collections a more detailed conodont zonation is possible. The vertical distribution of the conodonts in the Nashui section is shown in Fig. 1 and this newer zonation, from youngest to oldest rocks, is as follows:

Permian Asselian *Streptognathodus isolatus* Zone

Pennsylvanian Mapingian *S. wabaunsensis* Zone

S. tenuialveus Zone

S. firmus Zone

S. sp. nov. A Zone

Dalaan *S. simulator* Zone

S. sp. nov. B Zone

S. gracilis- S. excelsus Zone

S. cancellosus Zone

S. clavatulus Zone

S. nodocarinatus Zone

Idiognathodus podolskensis Zone

Mesogondolella clarki- Idiognathodus robustus Zone

Huashibanian *Diplognathodus ophenus- D. ellesmerensis* Zone

Idiognathoides ouachitensis Zone

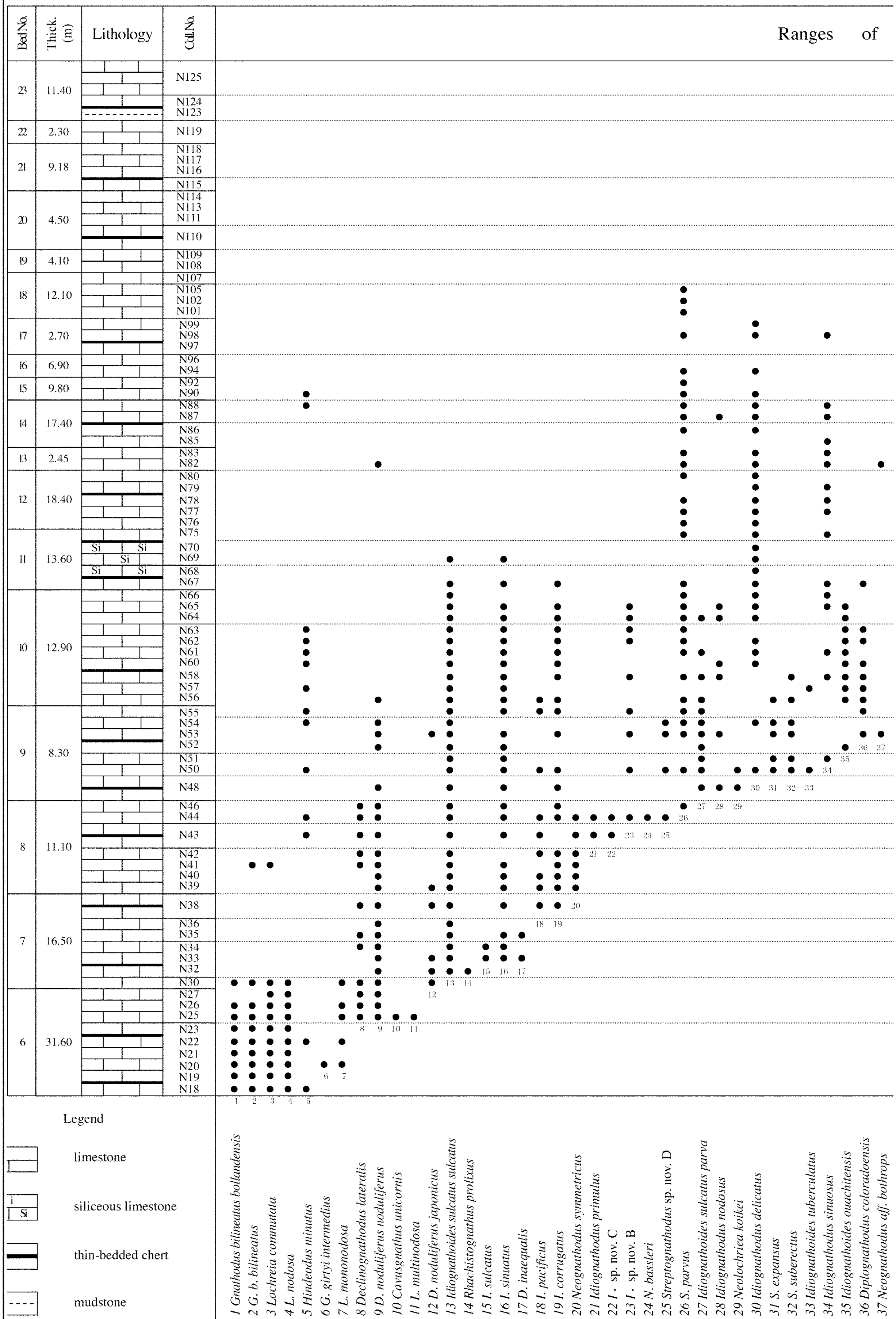
Luosuan *Streptognathodus expansus* Zone

Idiognathoides sulcatus parva Zone

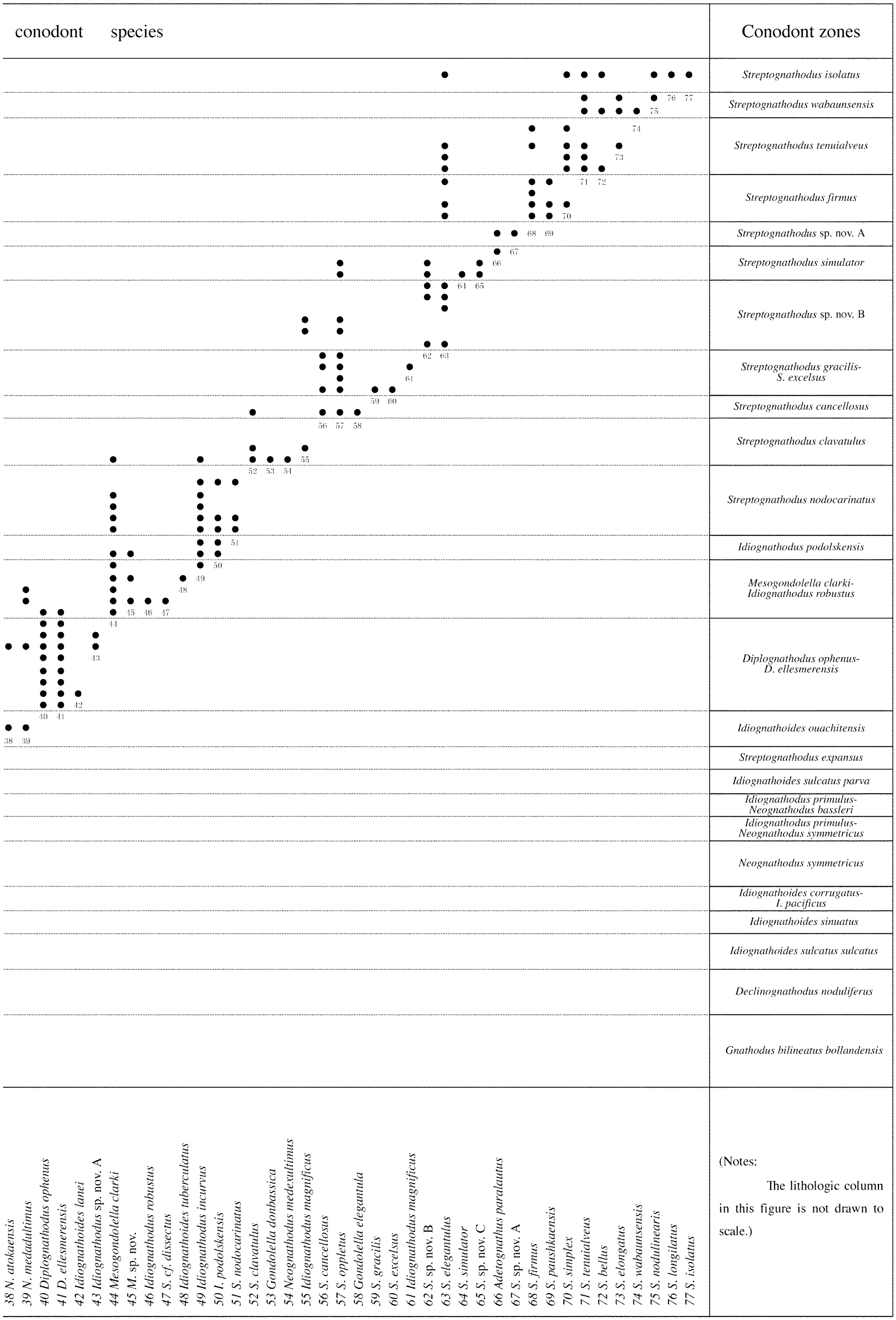
Idiognathodus primulus- Neognathodus bassleri Zone

I. primulus- N. symmetricus Zone

Fig.1 Vertical distribution of conodont species and



conodont zones in the Nashui section of Luodian, Guizhou



This paper				Xiong et Zhai, 1985		Wang, Rui et Zhang, 1987		Wang et Higgins, 1989		Wang, 1991		Wang, 1996	
P_1	Asselian	Asselian	*S. isolatus*		*S. elongatus*					Permian	*S. barskovi*	Upper Carboniferous (part)	
Pennsylvanian	Gzhelian	Mapingian	*S. wabaunsensis*	"Maping Formation"	*S. wabaunsensis*	Mapingian				U. Carboniferous (part)	*S. wabaunsensis*		
			S. tenuialveus				*S. elongatus*		*S. elongatus*		*S. elongatus*		
			S. firmus		*S. elegantulus*		*S. elegantulus*	Mapingian	*S. elegantulus*		*S. elegantulus*		
			S. sp. nov. A			Weiningian							
	Kasimovian	Dalaan	*S. simulator*		*S. suberectus*								
			S. sp. nov. B	"Dala Formation"			*S. oppletus*		*S. oppletus*				
			S. gracilis-S. excelsus										
			S. cancellosus		*I. delicatus*			Weiningian					
			S. clavatulus		*S. oppletus*		*S. parvus*		*S. parvus*				
			S. nodocarinatus										
	Moscovian		*I. podolskensis*										
			M. clarki-I. robustus	"Huashiban Formation"	*G. qiannanensis*		*N. clarki*		*N. clarki*				
		Huashibanian	*D. ophenus-D. ellesmerensis*										
	Bashkirian		*I. ouachitensis*										
		Luosuan	*S. expansus*										
			I. sulcatus parva				*I. s. parva*		*I. s. parva*				
			I. primulus-N. bassleri			Luosuan	*I. primulus*		*I. primulus*				
			I. primulus-N. symmetricus										
			N. symmetricus				*N. symmetricus*		*I. sinuatus*				*N. symmetricus*
			I. corrugatus-I. pacificus										
			I. sinuatus		*I. corrugatus*		*I. sulcatus-I. corrugatus-I. sinuatus*		*I. sulcatus-I. corrugatus*				*I. sinuatus*
			I. sulcatus sulcatus										*I. sulcatus*
			D. noduliferus		*D. lateralis*		*D. noduliferus*		*D. noduliferus*				*D. noduliferus*
Mississippian	Serpukhovian	Duwuan	*G. bilineatus bollandensis*	"Ruya Form."	*G. bilineatus bilineatus*	Tatangian	*G. bilineatus bollandensis*	Tatangian	*G. bilineatus bollandensis*			L. Carbonif.	*G. bilineatus bollandensis*

Table 1 Comparison between some conodont zonations of the Pennsylvanian in the Nashui section of Luodian, Guizhou

Neognathodus symmetricus Zone

Idiognathoides corrugatus-
I. pacificus Zone

I. sinuatus Zone

I. sulcatus sulcatus Zone

Declinognathodus noduliferus Zone

Mississippian Duwuan *Gnathodus bilineatus bollandensis* Zone

A comparison between the conodont zonations presented by previous authors and that presented in this paper from the Nashui section can be made (see Table 1).

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Volcanic ashes in the upper Paleozoic of the southern Urals: New perspectives on Pennsylvanian time scale calibration

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The Late Pennsylvanian through Early Permian was an important interval in Earth's history – significant events of this age include the final assembly and early evolution of Pangea, major eustatic changes in sea level, and global climate change from the Pennsylvanian "ice house" to the Permian "hot house". Unfortunately, the poor temporal resolution of the geologic time scale during this interval limits substantially our ability to clarify and correlate many aspects of late Paleozoic geologic history. The late Paleozoic provides an important example: commonly cited time scales differ by as much as 14 Ma in the estimated age of the Pennsylvanian-Permian boundary, and vary by as much as 500% in the inferred duration of various stages (e.g., DNAG 1983, Ross and Ross 1988, Harland et al. 1990, Gradstein and Ogg 1996, Cowie and Bassett 1989, Jones (AGSO) 1995; Rasbury et al., 1998; Menning et al., 2001, Becker et al, 2001). Without a rigorously calibrated Pennsylvanian and Permian time scale, basic questions regarding the final assembly and early evolution of Pangaea, duration of Pennsylvanian cyclothems, as well as a host of other late Paleozoic problems, will remain unresolved. Significant uncertainties in this part of the time scale arise because the numerical ages assigned to period and stage boundaries are based on linear interpolation between relatively sparse control points. Moreover, the existing control points were obtained from stratigraphic sections in different parts of the world, assigned positions in the time scale using several different taxa (marine *vs* terrestrial) and /or from the different biogeographic provinces, and moreover dated by several different radiometric techniques. Because many fundamental aspects of geologic research depend directly on the accuracy and precision of the geologic time scale, improving its age calibration is critical and requires a robust, well constrained, and internally consistent framework of biostratigraphic and geochronologic data for the Late Carboniferous through Early Permian.

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's 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 zircons, conodonts and radiolaria in upper Paleozoic volcanic ash layers of the southern Ural foreland. More details, particularly about techniques we are developing to recover zircons and microfossils from volcanic matrix, will be published soon.

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 Precambrian basement; (6) Ordovician-middle Devonian shelf succession; (7) Zilair Series (Late Devonian-Mississippian basinal succession); and (8) foredeep basin; and (9) undisturbed Russian Platform.

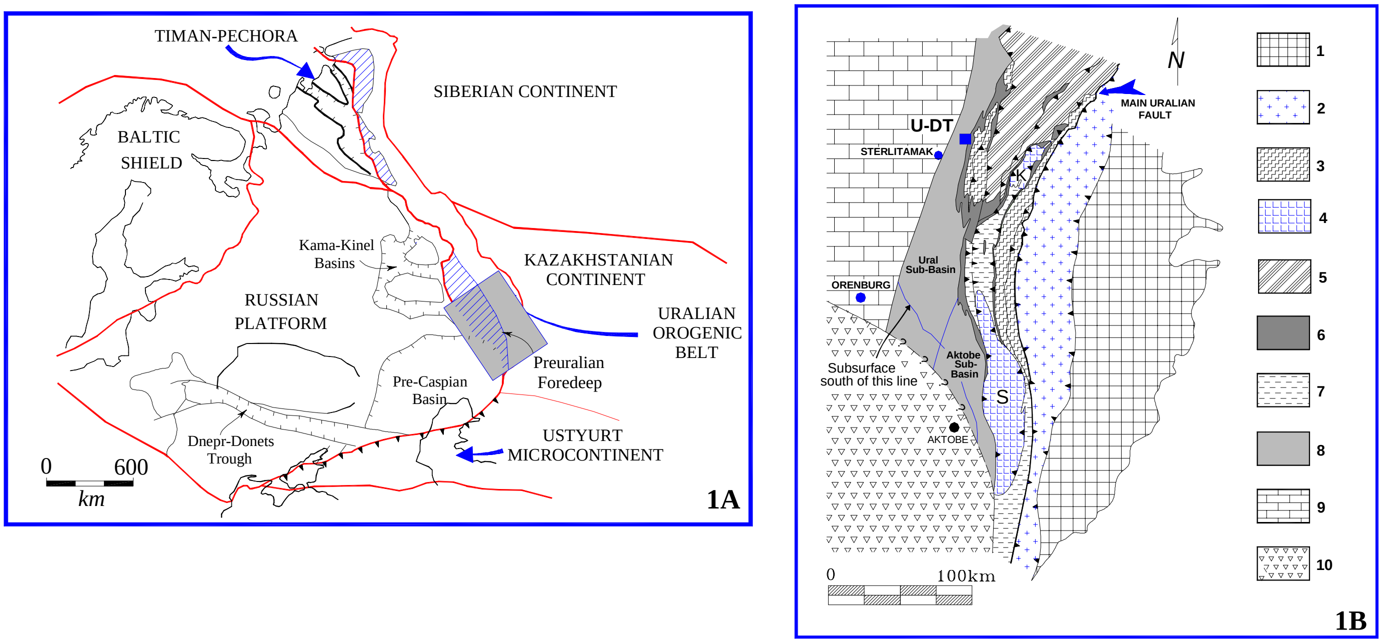
The Pre-Uralian Foredeep (Figures 1B, 2) was initiated during the Middle Carboniferous, and formed in response to a series of collisions along the eastern margin of the European continent. Collision and accretion involved a combination of arc terranes, and continental fragments (the Tagil-Magnitogorsk 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) sub-basin, and the southern Aqtöbe (or Aktyubinsk) sub-basin (e.g., Ruzhencev, 1951; Khvorova, 1961; Chuvashov et al.,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 micrites and wackestone-packstone-grainstone packages. The southern Pre-Uralian Foredeep is bounded to the north by the Karatau Fault and widens southward where the foredeep strata become covered by Mesozoic/Cenozoic strata and merges 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 some 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 the Tagil- Magnitogorsk Arc, where Permian and possibly Pennsylvanian dikes and hypabyssal silicic and alkaline intrusions cut marine Viséan 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 Foredeep 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

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.



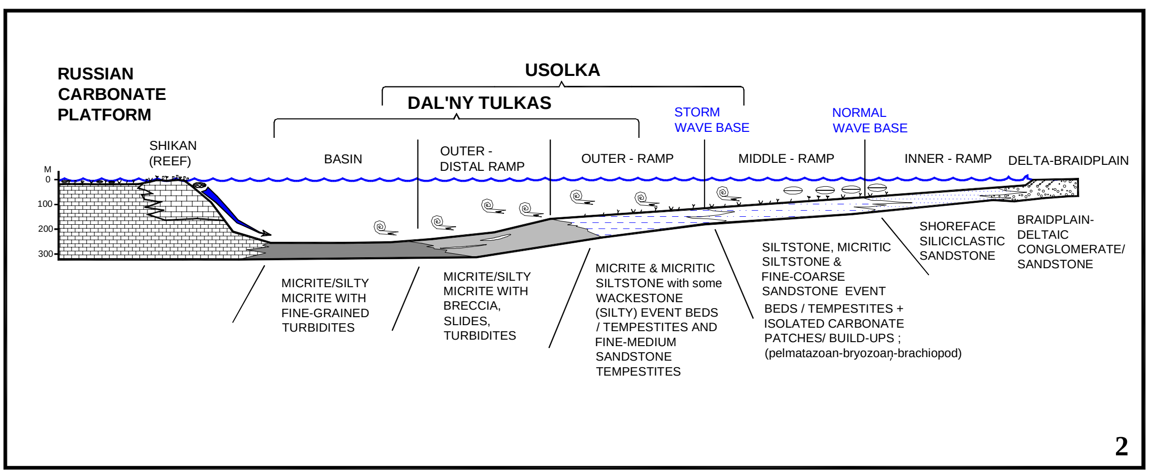


Figure 2 Southern Pre-Uralian foredeep basin model, late Pennsylvanian- Cisuralian. Mixed carbonate-siliciclastic setting.

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) Dalny Tulkas roadcut, and 3) Dalny Tulkas Quarry (Figure 1B and Figure 3).

After field and laboratory processing of 61 samples, we found well-preserved conodonts in many. In fact, conodonts in several samples were so numerous that the concentrates were essentially “conodont sands” (e.g., Figure 4B). Eighteen 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. Abundant radiolaria were found in 22 samples; however, their preservation was usually poor.

Although biostratigraphic investigation of the studied sections is not yet complete, most of the Pennsylvanian and Cisuralian stage boundaries there are well constrained (Chuvashov et al. 1993, 2000; Chernykh and 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 vol-

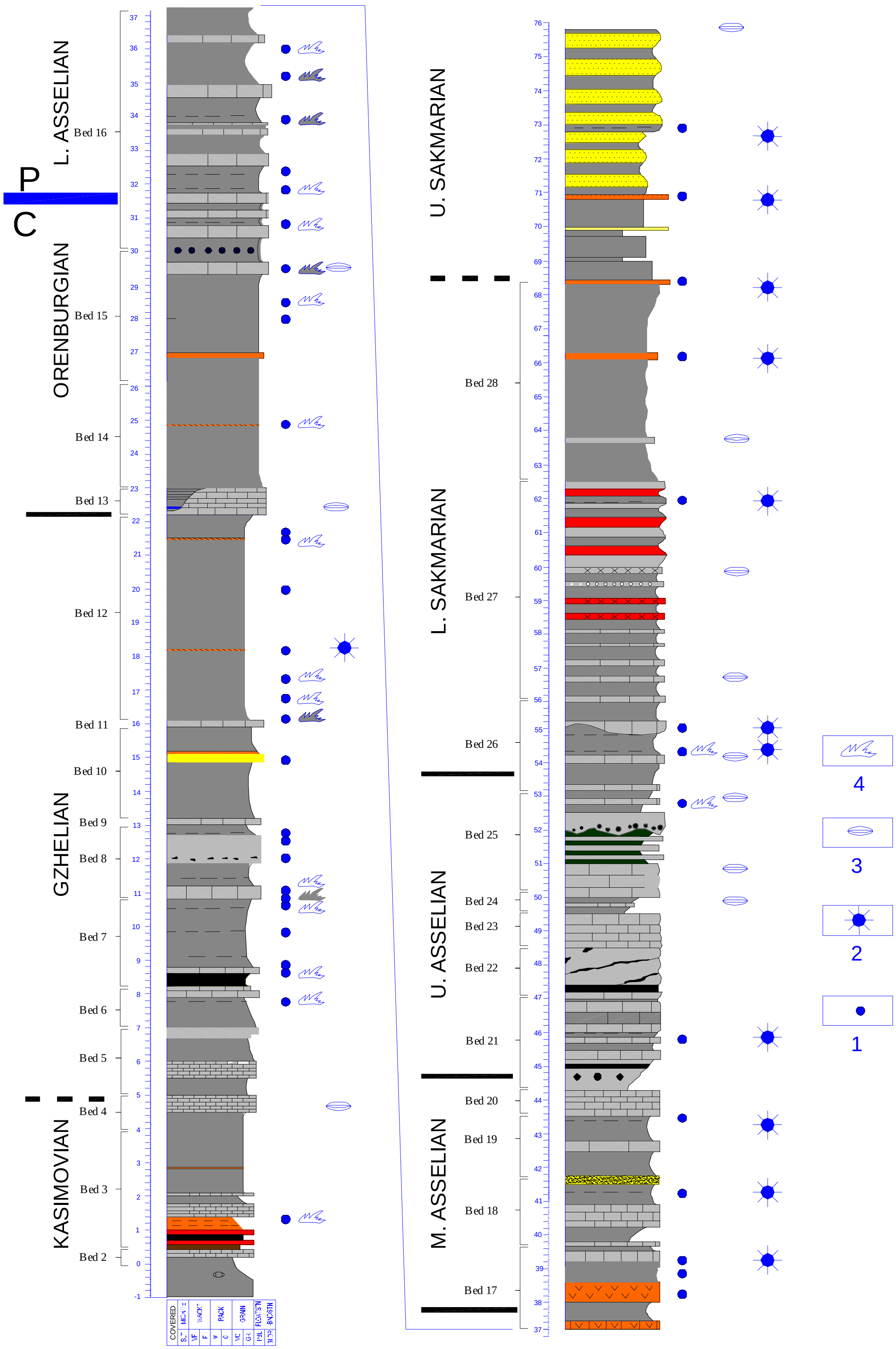


Figure 3 Distribution of fusulinids and volcanic ash beds and contained microfossils (conodonts and radiolaria) in the Usolka section. Bed numbers and biostratigraphic subdivision of the section are after Chuvashov et al., 1993 and our new data. 1 - volcanic ash; 2 - radiolaria; 3 - fusulinids; 4 - conodonts. Conodont symbols with shadow pattern represent volcanic ash beds with rare conodonts; whereas symbol with no shadow indicates abundant occurrence of conodonts in the volcanic ash beds.

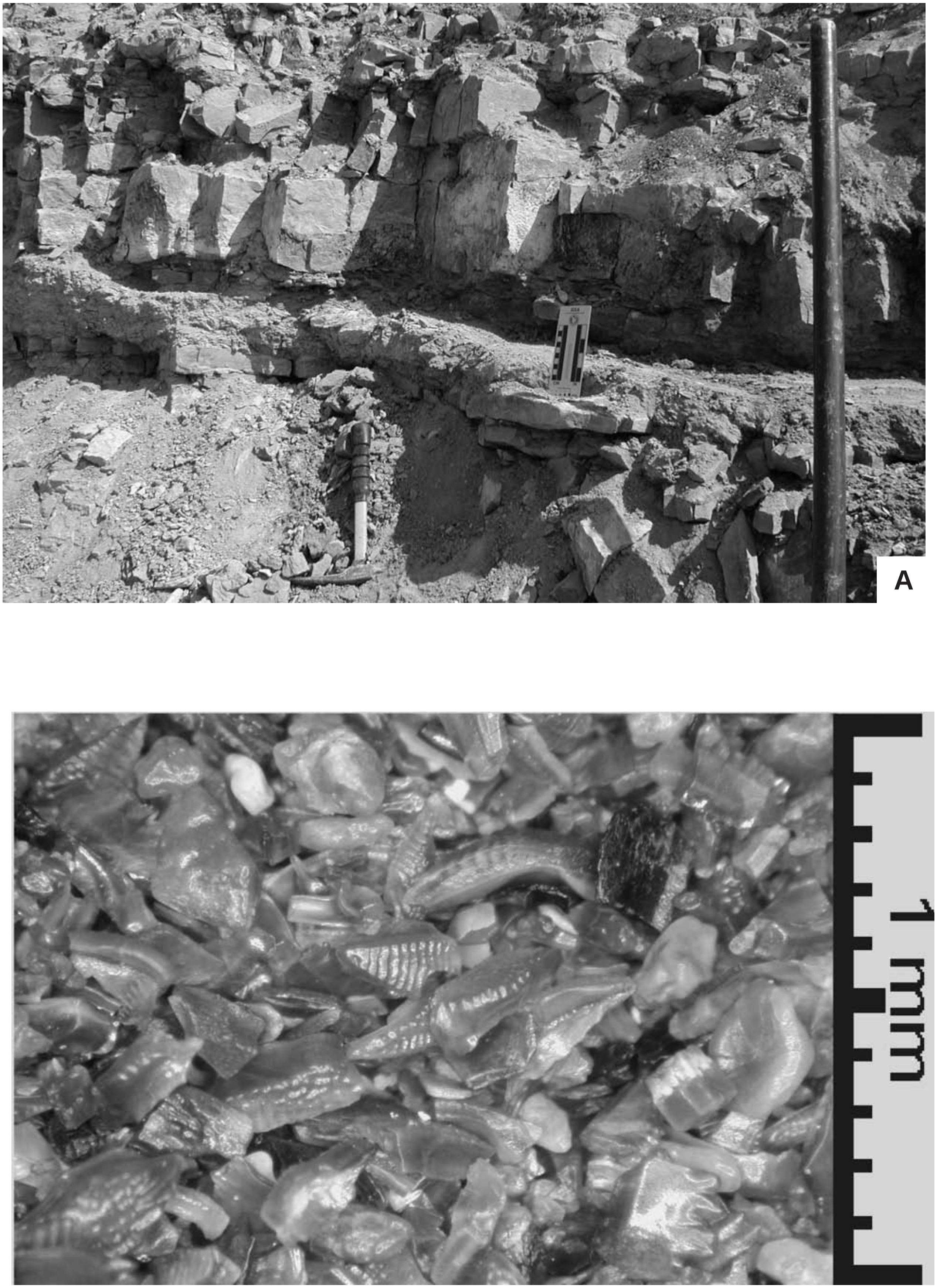


Figure 4 Volcanic ash bed at the D. Tulkas quarry section, (A) and conodont fauna recovered from this ash bed (B).

canic ashes collected this year in the Urals. The ash layer at 32.4 Mab in the Usolka section, i.e. 0.6 m above the previously suggested C/P boundary (Chernykh et al., 1997) contains numerous and well preserved zircons and the conodont *Streptognathodus isolatus* - the index species for the base of the Permian.

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 the Massachusetts Institute of Technology under the 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 systematics of the zircons and obtain the high-precision (+/- 0.25 B 0.5 Ma) age determinations needed for a robust calibration of the timescale. Volcanic ash samples from the southern Urals also provide the opportunity to analyze K/Ar and ^{40} Ar/^{39} Ar isotopic systems. Other minerals separated from the collected samples include crystals of volcanic K-feldspars (i.e., orthoclase/microcline, sanidine etc.) and possibly hornblende. Hopefully within a decade "… the murky state of affairs surrounding radiometric dating of the boundaries within and delimiting the Carboniferous System…" (Heckel, 2001, p. 2), will no longer an issue.

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Conclusions:

1. Ash layers in the southern Urals are a potentially important source of biostratigraphically significant microfossils such as conodonts and radiolaria and radiometrically datable zircons and K-feldspars. The co-occurrence 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-feldspars) in the Pennsylvanian and Cisuralian type sections in southern Urals open 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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Bursum Stage, uppermost Carboniferous of North America

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In reply to Davydov (2001), it is not a matter of Orenburgian versus Bursumian. The Orenburgian Stage in the Urals fills the top of the Carboniferous above the Gzhelian Stage and below the Permian Cisuralian Series. The Bursumian Stage in North America fills the top of the Pennsylvanian above the Virgilian Series and below the Bennett Shale Member of the Red Eagle Formation to complete the North American Pennsylvanian succession to make it equivalent to the top of the Carboniferous.

The Bursumian and Orenburgian have different stratigraphic bases; the lower Orenburgian, Noginian Horizon is apparently equivalent to the upper part of the North American Virgilian Series. We find Davydov's figure 1 (2001) in error. The Virgilian Series is overlain in continuous succession by the base of the Bursumian Admire Group of Kansas and the top of the Bursum would be placed at the top of the Glenrock Member of the Red Eagle Formation. The Bursum fauna as used by Thompson (1954) includes in Kansas only those faunas from the Admire Group and lower part of the Council Grove Group up to and including the Glenrock. This includes Wilde (1990) Bursum fauna PW-1 which, at that time, he placed in the Wolfcampian. The Grenola Limestone, about 16 m higher has, in the Neva Limestone Member, *Paraschwagerina* and is considered of Nealian age so that the top of the Bursumian has not been suggested as high as the Eskridge Shale.

The regional Late Pennsylvanian-Early Permian stratigraphy is summarized by Kottlowski (1962) for New Mexico and Ross (1973) for southeastern Arizona. The Bursum Formation was described by Wilpolt and Wanek (1951) for a stratigraphic unit that is transistional between the dominantly marine carbonates of Virgilian age below and overlying red beds of the Abo Formation in southcentral New Mexico. The type Bursum section was selected for its stratigraphic position rather than its fauna but it does contains a merger, but identifiable, fusulinid fauna of *Triticites*, *Leptotriticites*, and *Schwagerina* (Lucas and others, 2000). Prior to this study, however, the Bursum Formation has been widely traced in the region (Thompson, 1954) and was reported in detail from the Sacramento Mountains (Pray, 1961; Otte, 1959) and Robledo Mountains in southcentral New Mexico (Wahlman and King, 2002). Steiner and Williams (1968) reported on the fusulinds in the Sacramento Mountains and Wahlman and King (2002) reported on the Robledo fusulinids. The Bursum Formation is traced as far south as the Hueco Mountains in West Texas (Williams, 1963).

The Bursum fusulinid fauna also appears in northcentral Texas in the Waldrip and lower Camp Creek Members of the Pueblo Formation (Thompson, 1954). A much more diverse Bursum fauna appears in thick and expanded sections in the Chiricahua Mountains of southeastern Arizona and in the Big Hatchet Mountains in southwest New Mexico. Southeastern Arizona includes shelfal strata, included in the Earp Formation, and the shelf margins and marginal slopes sediments included in the Horquilla Limestone around the Pedregosa Basin. In southeastern Arizona, in the Whetstone Mountains, the fusulinids from the shelf part of the Bursumian interval has been described by Ross and Tyrrell (1965) from the lower part of the Earp Formation. Also, from the lower part of a much thicker Earp Formation, Sabins and Ross (1963, 1965) described Bursumiam fusulinids in the shelf margin and upper shelf slope deposits of the Chiricahua Mountains, where, in the Portal section (between117 to 398 m [385 to 1315 ft]) the stratigraphic interval containing the Bursumian fauna reaches 303 m (1000 ft) in thickness before passing into carbonate beds bearing Nealian *Pseudoschwagerina uddeni* (Sabins and Ross, 1965). At Dunn Springs Mountain, a 121 m (400 ft) thick section is not complete at its top, but does includes *Leptotriticites tumidus and S. providens* and, higher, *S. vervillei* so that it includes Nealian beds that are exposed at the top (Sabins and Ross, 1965). The Bursumian part of the Dunn Springs section, 110 m (360 ft) thick, is a more shelfal facies and contains additional Bursumiam species. The Bursumian fusulinid fauna based on a composite of all the Portal and Dunn Springs sections is *Triticites pinguis, T. creekensis*, *T. meeki*, *T. cellamagnus*, *Schwagerina dunnensis*, *S. silverensis*, *S. emaciata*, *S. compacta*, and *Rugosofusulina* sp. *Schubertella kingi* ranges slightly lower in the upper part of the Virgilian and higher into the Nealian. The Portal section is our candidate stratotype section for the type Bursumian Stage based on its fauna and supplemented by the Dunn Springs Mountain section.

In the Big Hatchet Mountains in southwest New Mexico, the Bursumian sections are carbonate facies and called a part of the Horquilla Limestone. There, they are also shelf, shelf margin, reef, and upper slope deposits (Zeller, 1965). The fusulinids listed by Zeller (1965) were identifications by Skinner and Wilde. Above the Virgilian platform carbonate, they reported from the Bugle Ridge section *Triticites ventricosus* tribe, *Schwagerina* sp., *T. uddeni*, *T. ventricosus* var. *meeki*, *S. huecoensis*, *Schwagerina* sp. (shaped like *S. thompsoni*), *Triticites* sp. (large, massive internal deposits), *S.* cf. *emaciata*, and *Schubertella* sp. From the New Well Peak section Skinner and Wilde (in Zeller, 1965) reported *Triticites* sp., *Schubertella kingi*, *Rugosofusulina*? sp., *Schwagerina* sp., *T. pinguis*, and *T. ventricosus*, and from the Borrego Section, they reported *Triticites* sp., *T. ventricosus* tribe, *T. ventricosus*, *Schwagerina* spp., and *Schubertella* sp.

With rare exception, the Bursumian fusulinid fauna shows little similarity with the Upper Orenburgian fauna which is dominated by *Ultradaixina*.

Davydov (2001) also is in error to say that the Nealian has not been proposed adequately. In the Glass Mountains, West Texas, the Wolf Camp Hills section 24 of King (1930) is the type section and the interval from King's Bed 3 up to the base of the Lenox Hills (King's Hess) conglomerates comprises the Neal Ranch Formation (Ross, 1959, 1963). The Nealian Stage and the Nealian Age are based on these outcrops. Davydov has no evidence for where the conodont-defined base of the Permian is in King's (1930) Section 24. It might be in, below, or on top of the Gray Limestone (Bed 2 of King's Wolf Camp Hills section), or it might be missing because of erosion.

Davydov (2001) calculates the Bursumian is a short stage, 1.0-1.5 Ma, but it fills a gap of at least 1.6 million years on his chart and, based on the Kansas sections, we consider the Bursumian to be at least five or six fourth-order depositional sequences at about 100 Ma each, and, therefore, to be twice as long as the Asselian, i.e., at least three fourth-order depositional sequences.

We find the Bursumian Stage critical in filling the nomenclature gap at the top of the Virgilian Series. It has a well known fauna that is widely distributed on the southern craton of North America. It is well known in sections along the cratonic margin and passes continuously upward from Virgilian strata and it, in turn, passes upward into Nealian Age rocks of Early Permian age. We do not find the stratigraphic defects that Davydov (2001) tries to see. We believe the inclusion of the Bursumian Stage at the top of the Virgilian Series is neccessary in North America for the correlation of the interval between the top of the Virgilian Series, as established by Moore (1936), and the base of the newly conodont-defined, higher stratigraphic base of the Permian in North America.

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Carboniferous-Permian transition at Carrizo Arroyo, New Mexico, USA

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Carrizo Arroyo is located on the eastern edge of the Colorado Plateau, 50 km southeast of Albuquerque in central New Mexico (~ 34°45'N, 107°07'30"W). Here, an approximately 100-m thick section of intercalated clastic rocks and limestones apparently encompasses the Carboniferous-Permian boundary and yields extensive fossil assemblages (including two Lagerstätten) of marine and nonmarine origin (Fig. 1).

The base of the section is relatively thick, ledge-forming gray limestone (composed mostly of bioclastic wackestones, and subordinate crinoidal packstone and bioclastic grainstone) and interbedded drab shales of the upper part of the Atrasado Formation of the Madera Group. Fusulinaceans of middle Virgilian age from uppermost Atrasado limestones are *Triticites arcuosoides* Ross, *T. whetstonensis* Ross & Tyrell and *T.* cf. *T. bensonensis* Ross & Tyrell (identifications by G. L. Wilde).

Most of the section at Carrizo Arroyo (Fig. 1) can be assigned to the Red Tanks Member of the Bursum Formation, a dominantly clastic (nonmarine) lithofacies of the more marine lithofacies that generally characterize the Bursum Formation to the south. Indeed, Carrizo Arroyo is the type section of the Red

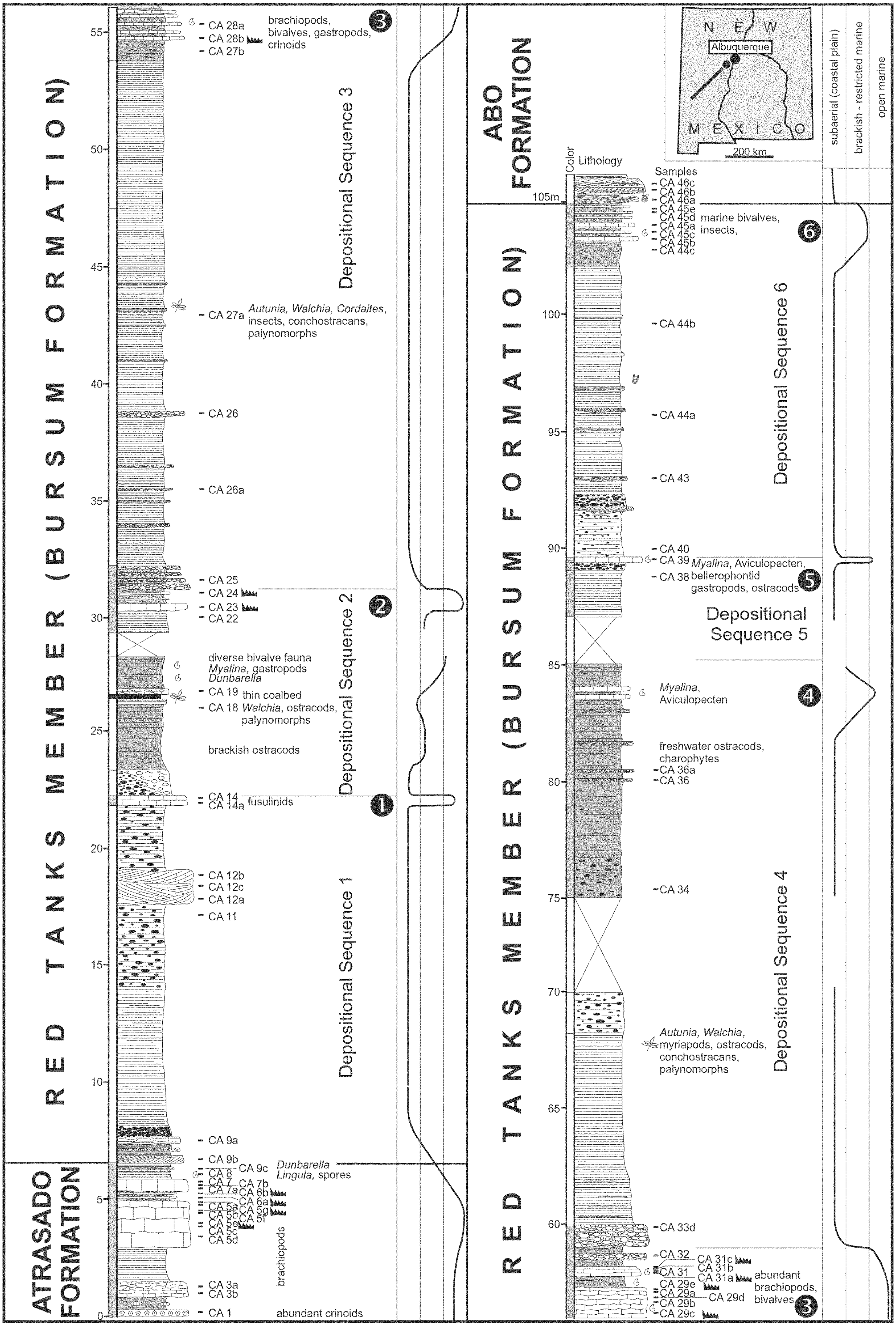

Figure 1. Measured stratigraphic section of Carboniferous-Permian transition at Carrizo Arroyo, central New Mexico.

Tanks Member (Kelley and Wood, 1946). The section is 98 m thick and is mostly green and red shale, mudstone and siltstone of nonmarine origin. Crossbed azimuths and imbricate pebbles in beds of sandstone and conglomerate in the section indicate paleoflow dominantly to the southeast. Like Kues and Kietzke (1976), we interpret Red Tanks deposition to have been on a coastal plain influenced by a fluvio-deltaic complex sourced to the northwest in the Zuni highland of the Ancestral Rocky Mountains.

The stratigraphic architecture of the Red Tanks Member at Carrizo Arroyo can be interpreted to indicate the presence of six depositional sequences (Krainer et al., 2001) (Fig. 1). Each begins with a conglomerate or sandstone sharply incised into underlying mudrocks that fines upward into mudrock-dominated floodplain or lacustrine strata. A marine limestone caps each sequence, and these limestones identify six marine flooding events. Each sequence consists mostly of mudstone/siltstone beds, some of which contain abundant calcrete nodules and other evidence of pedogenesis. A thin coal bed in the middle of depositional sequence 2 is underlain by fossiliferous siltstone (plants, ostracods) and overlain by marly mudstone containing marginal marine molluscs and plant debris. Carbonate conglomerates at the bases of depositional sequences 3 and 4 probably represent upper shoreface deposits, and as thin layers in depositional sequence 4 represent small channel fills. Sandstones are present at the base of sequence 1 (shoreface deposits), in the upper part of sequence 1 (fluvial channel fills) and in sequence 6 (thin fluvial channel-fill deposits).

Thin, fossiliferous gray limestone beds or gray mudstone/limestone interbeds are at the top of each sequence. Limestones of the lower three sequences contain abundant bioclasts indicating deposition in a shallow, open marine environment. Dominant microfacies are bioclastic wackestones containing fusulinids (*Triticites* in sequence 1), foraminiferal wackestones with abundant calcivertellids (sequence 2), and bioclastic wackestones containing abundant fragments of brachiopods, molluscs, smaller foraminifers, echinoderms, ostracods, bryozoans, rare trilobites, *Tubiphytes*, the problematic alga *Nostocites* and *Palaeonubecularia* (encrusting bioclasts and forming small oncoids). Limestones of sequences 1, 2 and 3 yield conodonts. The fossils in limestones at the tops of sequences 4, 5 and 6 indicate a restricted marine environment. Typical microfacies are ostracod wackestones (sequence 5) and bioclastic mudstones and wackestones containing gastropods and bivalves, some ostracods and rare small foraminifers (sequence 6).

The Red Tanks Member sequences indicate that the coastal plain environment represented by mudstones/siltstones was repeatedly inundated by short term transgressive events that deposited fossiliferous, shallow marine limestones during relative highstands of sea level. Eustatic fluctuations of sea level may be the source of at least some of these transgressive events, but the Carrizo section was deposited in the Ancestral Rocky Mountain foreland, and we suspect that regional tectonism was the primary force driving local sedimentation.

At Carrizo Arroyo, nonmarine red beds of the Abo Formation overlie the Red Tanks Member. These strata are regionally assigned a Wolfcampian age, largely because they interfinger with the Wolfcampian Hueco Group to the south (e.g., Cook et al., 1998). The Abo Formation is fluvial deposits derived from highlands to the north. At Carrizo Arroyo it yields a sparse fossil record of plant impressions (mostly *Walchia*) and tetrapod footprints (principally *Dromopus* and *Batrachichnus*).

The Red Tanks Member yields fossils from many beds, and at stratigraphic levels 43 m and 68 m above the base of the section (Fig. 1) are Lagerstätten of plants, insects, crustaceans, eurypterids and other fossils. Red Tanks fossils include palynomorphs (Traverse and Ash, 1999), charophytes, megafossil plants (Tidwell and Ash, 1980; Ash and Tidwell, 1982, 1986; Tidwell et al., 1999), ostracods (Kietzke, 1983), foraminiferans, bryozoans, brachiopods, gastropods (Kues, 1983), bivalves (Kues, 1984), nautiloids, eurypterids (Kues and Kietzke, 1981), crustaceans (Schram, 1984), insects (Kukalova-Peck and Peck, 1976; Durden, 1984; Rowland, 1997), echinoids, fish ichthyoliths and bones of amphibians and reptiles (Cook and Lucas, 1998; Harris and Lucas, 2001).

Placement of the Virgilian-Wolfcampian boundary in the Carrizo Arroyo section has been contentious. Various workers have considered the Red Tanks Member entirely Virgilian, entirely Wolfcampian, or have placed the Virgilian-Wolfcampian boundary at diverse points in the section (see review by Tidwell et al., 1999). Indeed, it is possible that the entire section, at least up to the base of the Abo Formation, is of Carboniferous age. Conodonts we have recently collected and now under study hopefully will resolve this issue.

Ongoing studies of the Carrizo Arroyo section encompass its geology and many aspects of its paleontology. They will be brought together in 2003 in a monograph to be published by the New Mexico Museum of Natural History.

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In search of chemotaxonomic signatures of Pennsylvanian pteridophylls

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Fragments of large dissected fronds (compound leaves) of seed ferns and true ferns preserved as foliar adpression (pteridophylls) are commonly found worldwide in the Pennsylvanian. As a result of relatively low maturity or having experienced minor tectonic disturbances and limited burial or both, coal-forming fossil plants in the Sydney Coalfield, Nova Scotia, Canada, are noted for their excellent preservation that includes cuticles, naturally macerated cuticles, and *in-situ* reproductive organs (spores and pollen). However, phylogenetic study of the adpressions is hindered by the difficulties of establishing a reliable taxonomy that is based on floral morphology, limited knowledge of frond architecture, and reproductive organs.

In our research for additional taxonomic parameters to further phylogenetic studies, we have analyzed numerous foliar specimens from the Sydney Coalfield using infrared spectroscopy (FTIR), and pyrolysis-gas chromatograph/mass spectrometry (py-Gc/Ms). The focus of the research is to identify chemical signatures for developing a chemotaxonomic basis for classification of the Pennsylvanian foliage species. The plant groups studied include seed and true ferns ("tree ferns"), and secondarily cordaites trees. The majority of species studied belong to the more systematically studied seed ferns (neuropterids, odontopterids, alethopterids, eusphenopteri ds, and reticulopterids), followed by true fern sphenopterids and pecopterids. For well-defined tree fern species belonging to *Alethopteris*, *Odontopteris*, *Pecopteris* and *Reticulopteris*, FTIR-derived CH_2/CH_3 ratios, in conjunction with contributions from carboxyl groups, demonstrated a better potential for discriminating between genera and species than molecular signatures obtained by py-Gc/Ms. However, the latter technique provided better data for generically differentiating *Alethopteris*, *Odontopteris*, and *Reticulopteris* from *Pecopteris* (as groups of Medullosales and Marattiales, respectively).

Sphenopterids represented in the Sydney Coalfield sample set include the true fern species *Oligocarpia brongniartii* and *Zeilleria delicatula* that are preserved as naturally macerated cuticles (NMC), and the seed-fern *Eusphenopteris neuropteroides* that additionally is preserved as coalified adpressions. FTIR spectra of NMC seed fern *E. neuropteroides* and the true fern sphenopterid *O. brongniartii* are very similar, except that the latter does not have aromatic bands in the 700-900 cm^{-1} out-of-plane region. Py-Gc/Ms indicates the presence of more aromatic compounds for the seed fern than for the two true fern sphenopterids. Another difference between seed and true fern sphenopterids is a lower ratio of integration areas of CH_2 and CH_3 bands in chemically treated NMC specimens for the seed fern. These observations suggest slightly higher aromaticity for the seed ferns, perhaps related to some chemotaxonomic differences. It is also noted that py-Gc/Ms is a more efficient analytical technique for obtaining potentially useful chemotaxonomic data from adpressions than is FTIR. FTIR is best suited for analysis of cuticular samples.

In all species studied, however, recognizing and extracting robust and chemotaxonomically useful information from FTIR and py-Gc/Ms data is still hindered by the difficulty of separating the effects of variable maturation and preferential preservation of certain organic carbon compounds from the true make-up of the once-living species.

Database management of a collection of Carboniferous macrofossils: Sydney Coalfield, Nova Scotia, Canada

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For the past 26 years, the senior author has been systematically collecting Carboniferous macrofossils from coastal outcrops, waste piles of coal mines, and from open-pit and underground coal mines mainly in the Sydney Coalfield (Bolsovian to early Cantabrian age) on Cape Breton Island, Nova Scotia, Canada. Represented in the collections are the main plant groups (ferns, “seed ferns”, lycophytes, cordaites, sphenopsids) known from the Late Pennsylvanian Period. In the main, the preservation is by compression/impression, but in slightly less than 2 percent of the specimens the plant cuticle is preserved through the process of natural maceration. Although siderite concretions are abundant in the roof shales of coal seams, plants are rarely preserved in them. Those that are, are acellular. The comparison is with siderite concretions from Mazon Creek in the U.S.A.

The collection consists of ca. 15,000 macrofloral specimens. All specimens are properly accessioned, stratigraphically documented, and are organized into a palaeobotanical collection that is housed at the University College of Cape Breton, Sydney, Nova Scotia and curated by Professor E.L. Zodrow.

The collections are being computerized through a grant from the Canadian Government, Human Resources Department Canada, and an in-kind donation of software (MIMS) from the Nova Scotia Museum, Halifax, in 2001. MIMS software (Management Information Museum System) has been especially developed for this purpose and is an efficient and user-friendly system. The initial phase of the computerization consists of data transcription of basic information about the specimens (accession number, initial taxonomic data, location, and stratigraphy in reference to officially recognized coal seams in the Sydney Coalfield). This will be accomplished by November, 2002. The second phase will incorporate into the database details about the type and published specimens of the collections, synonymy, description, and digitized pictures.

A website is being developed in parallel with the computerization of the macrofloral collections which eventually will contain the complete data of phases 1 and 2 to serve the international community as a research and educational base.

Report on the 9th Coal Geology Conference held in June 2001 at Prague, Czech Republic

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The 9th Coal Geology Conference was held at the Faculty of Science, Charles University. The co-conveners were the Czech Geological Survey and the Geological Institute of the Academy of Sciences, Czech Republic. Two parallel technical sessions were held on June 26-28. Two pre- and two post-conference field trips to the Blanice and Boskovice Permo-Carboniferous grabens and the Sokolov and North Bohemian Tertiary basins were held. The conference was attended by 51 Czech geologists and 35 foreign professionals from the Federal Republic of Germany, Federal Republic of Russia, Federal Republic of Yugoslavia, India, Peoples Republic of China, Poland, Rumania, Slovenia, Taiwan, Turkey, Ukraine, and USA. Altogether 55 papers and 16 posters were presented at the conference.

Selected papers presented at the conference will be published in a Special Volume of Acta Universitatis Carolinae, Geologica, 2002. The Volume of Abstracts from this conference can be ordered for USD 15 + 5 or 10 postal charges in Europe and overseas, respectively at the following address : ir@natur.cuni.cz.

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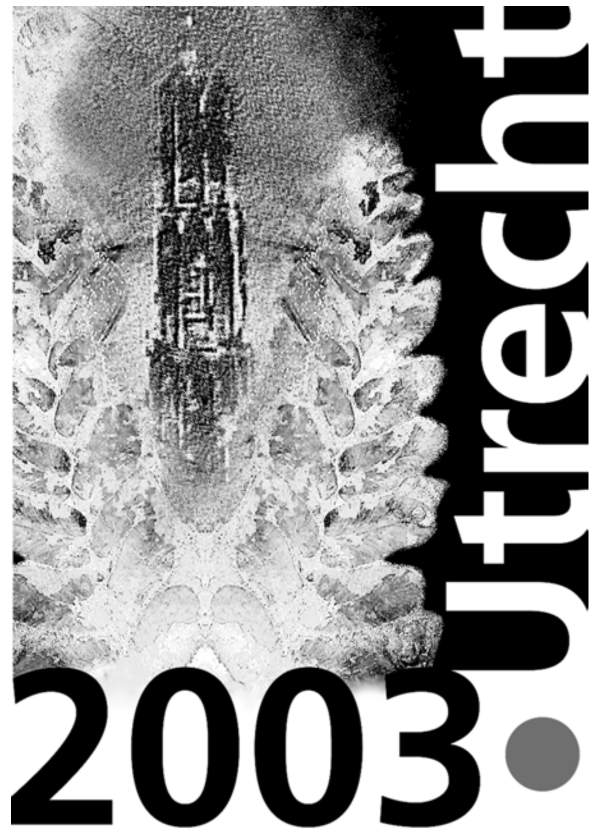
First announcement

Permo-Carboniferous around the Southern North Sea Basin



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Universiteit Utrecht

XV^th^ International Congress on Carboniferous and Permian Stratigraphy

XV^th International Congress on Carboniferous and Permian Stratigraphy

Utrecht,
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August 10-16, 2003

The XVth International Congress on Carboniferous and Permian Stratigraphy will be organised by the Netherlands Institute of Applied Geoscience TNO - National Geological Survey (TNO-NITG) and the Faculty of Earth Science of the Utrecht University, in Utrecht, the Netherlands in close co-operation with the Royal Geological and Mining Society of the Netherlands (KNGMG). The congress will take place at the campus of the Utrecht University in the period between 10 - 16 August 2003. The venue is within 5 minutes walking distance from the buildings of the Faculty of Earth Sciences of Utrecht University and TNO-NITG.

The theme of the XV ICC-P is the 'Permo-Carboniferous around the Southern North Sea Basin'. Permian and Carboniferous deposits are of great economic importance around this basin. Numerous gas fields occur in these deposits in this mature exploration area. In addition, this area has a long tradition of mining activities related to Carboniferous coal and Permian copper and salt. This led to a good understanding of the geology and stratigraphy of these deposits. Despite the fact that recent oil and gas exploration studies contributed to several new insights, few of these have been published to date. The objective is to bring these new results to the attention of the participants of this Congress.

In order to visualise the geology of the Southern North Sea Basin, various field excursions will be organised to several classical exposures in Germany, Belgium and the U.K.

We invite you to come to Utrecht to meet and discuss ideas with university, industry and consulting geoscientists working in different fields of research.

Associated meeting: 55th meeting of the International Committee for Coal and Organic Petrology

In the same period and at the same location the International Committee for Coal and Organic Petrology (ICCP) will hold its annual meeting.

For more information on this meeting see www.nitg.tno.nl/eng/55ICCP.shtml or www.iccop.org.

Scientific Programme

The programme of the International Congress on Carboniferous and Permian Stratigraphy includes a 5 day meeting with oral and poster presentations, and workshops. Pre- and post-meeting field trips will be organised.

Topics of the scientific programme:

1 Economic geology
NW Europe
Pericaspian and Caspian region
World petroleum
CO_2 storage and Coalbed methane
Salt

2 Carboniferous stratigraphy, sedimentology, and tectonics
Lower Carboniferous [Mississippian] stratigraphy
Upper Carboniferous [Pennsylvanian] stratigraphy

3 Permian stratigraphy and tectonics
Rotliegend sedimentation
Zechstein basin development
Magnetostratigraphy

4 The Permian-Triassic boundary in Europe

5 Late Paleozoic Paleontology and paleobotany
Macropaleontology
Micropaleontology
Palynology
Paleobotany

6 Variscan tectonics and basin development

7 Global correlations and Pangea

Workshops

1. Carboniferous stratigraphy
2. Permian stratigraphy
3. Core workshops

Field trips

1. Carboniferous outcrops at the eastern margin of the Southern North Sea (Germany) (3 days)
2. Carboniferous outcrops at the western margin of the Southern North Sea, UK (4 days)
3. Geology of the Rhenohercynian zone, Germany (3 days)
4. Coal mine and mine museum, Germany (1 day)
5. Stratigraphy and tectonics of the intra-Variscan Carboniferous-Rotliegend basin (Saar Trough; Rheinland-Pfalz), Germany (2 days)
6. Lower Carboniferous [Mississippian] outcrops along the Meuse river, Belgium (2-3 days)
7. Lower Carboniferous [Mississippian] carbonates, Belgium (2-3 days)
8. Lower Carboniferous [Mississippian] of the Boulonnais region, Northern France (3 days)
9. Lower Carboniferous [Mississippian] rocks in the Harz and Central Germany (2 days)
10. Rotliegend rocks in the Harz and Central Germany (3 days)
11. Permian rocks in the Harz and Central Germany (3 days)
12. Permian and Triassic of Central Germany (3-4 days)
13. Borth salt mine, Wesel, Germany (1 day)
14. Historical sites of coal mining in the Netherlands, Germany, and Belgium (2 days)
15. Visit to the Carboniferous fossil and plant collection of Naturalis, Leiden, the Netherlands (1 day)

Publications

A selection of papers will be published in a special issue of the Netherlands Journal of Geosciences accompanied by a CD-ROM covering the remaining papers. The contributions will be limited to 10 printed pages per paper. Papers have to be submitted electronically and will be reviewed. A strict time frame will be kept to ensure publication of the proceedings within 18 months after the Congress.

Participation Fees

Participants:	**EUR**	**330, -**
Students:	**EUR**	**40, -**
Early registration	**EUR**	**300, -**

(Before March 1st, 2003)

Second announcement

The Second Announcement will be published in December 2002 and will provide detailed information

Call for papers

Please submit your abstract for oral presentation or poster before December 1st, 2002. See our website for instructions to authors.

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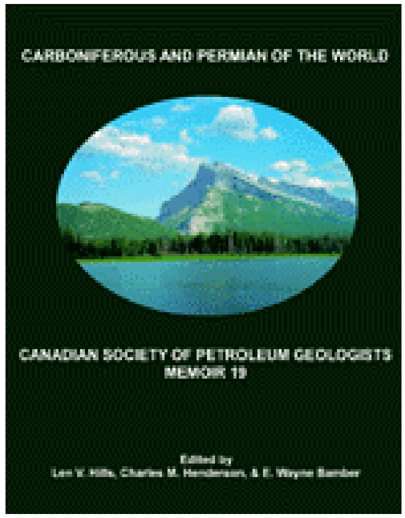

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