NEWSLETTER ON CARBONIFEROUS STRATIGRAPHY

Volume 22 July 2004

Ratified global Carboniferous subdivision

SYSTEM	SUBSYSTEM	SERIES	STAGE
CARBONIFEROUS	PENNSYLVANIAN	UPPER	Gzhelian
			Kasimovian
		MIDDLE	Moscovian
		LOWER	Bashkirian
	MISSISSIPPIAN	UPPER	Serpukhovian
		MIDDLE	Viséan
		LOWER	Tournaisian

P.H. Heckel 2004

SCCS

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

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Newsletter on Carboniferous Stratigraphy

Edited by D.M. Work

IUGS SUBCOMMISSION ON CARBONIFEROUS STRATIGRAPHY / VOL. 22 - 2004

CHAIRMAN'S COLUMN

This past year has seen significant progress in defining boundaries and establishing global classification for the Carboniferous System, much of it as a result of the 15th International Congress on the Stratigraphy and Geology of the Carboniferous and Permian Systems [XV-ICCP] held in Utrecht, The Netherlands, in August 2003. At the Carboniferous workshops on Wednesday, August 13, all boundary task groups met for several hours in adjacent rooms, where a number of presentations were made, much discussion took place, and critical microfossils were examined by interested workers. At the SCCS meeting on Friday, August 15, discussion ranged across a number of topics, but focused on the two alternatives for series subdivision of the Carboniferous that were proposed in the 2001 Newsletter. Since then, the task groups have been busy focusing on various biostratigraphic events that may be useful for defining stage boundaries, and ballots were held on the series subdivision of the Carboniferous System and on a related issue of rank of the smallest existing regional chronostratigraphic units in western Europe.

Status of Boundary Task Groups

The Tournaisian-Viséan Boundary Task Group chaired by George Sevastopulo is preparing to circulate its GSSP proposal for the base of the Viséan at the first appearance of the foraminifer *Eoparastaffella simplex* in the lineage *E. ovalis – E. simplex* in the Pengchong section near Liuzhou in Guangxi, southern China (see Devuyst et al., 2003 *Episodes*, 26: 105-115). The Viséan-Serpukhovian Boundary Task Group chaired by Barry Richards had its first official meeting with 10 members in attendance at Utrecht, where certain conodont lineages and a foram lineage were selected for further detailed study. The Bashkirian-Moscovian Boundary Task Group chaired by John Groves also had its first official meeting in Utrecht, where proposals for boundary-level events were requested by this spring, resulting in a preliminary proposal that outlines two independent conodont lineages for further focus, but no proposal for foram lineages because of strong provincialism in that group. The Moscovian-Kasimovian Boundary Task Group chaired by Elisa Villa also met in Utrecht, where three preliminary proposals for boundary events, two based on fusulines and one based on conodonts that is consistent with one of the fusuline events, were presented to focus ongoing detailed work. The nearly identical Kasimovian-Gzhelian Boundary Task Group, also chaired by Elisa Villa, received a strong boost at an unrelated November meeting on global correlation hosted by Manfred Menning in Potsdam, Germany, where several task group members agreed upon a potentially suitable conodont lineage that is consistent with the working ammonoid definition of this boundary in the Urals, for further detailed study. More detail on the activities of each boundary task group follows the introductory part of this newsletter. In addition, the project group on Upper Paleozoic Boreal Biota: Stratigraphy and Biogeography, chaired by Marina Durante, is focusing activity on biotas and cooling events and terrestrial floral differentiation in Angaraland.

Series Subdivision

As a result of ballots taken by the SCCS in late 2003 and ratified by the ICS and IUGS in early 2004, the Carboniferous System now has an official global series and stage classification and nomenclature (Figure 1). In several ballots taken between 1987 and 1999, the SCCS had voted to subdivide the Carboniferous into two subdivisions with the rank of subsystems, which were named Mississippian and Pennsylvanian. In the succeeding years, a combination of western European and Russian names have become generally accepted for the stages, but the problem remained on how to subdivide the two subsystems into series. An alternative of using four of the five classic western European names as series, but adding the lower and upper Namurian (which was split by the Mid-Carboniferous boundary) to the adjacent Viséan and Westphalian respectively, was rejected, largely for destabilizing traditional nomenclature and requiring more global stage boundaries to be selected at this time. The alternative of using the positional terms 'lower', 'middle', and 'upper' for each of the two subsystems was adopted. Therefore, the 'Lower Mississippian Series' comprises the Tournaisian Stage, the 'Middle Mississippian Series' comprises the Viséan Stage, the 'Upper Mississippian Series' comprises the Serpukhovian Stage, the 'Lower Pennsylvanian Series' comprises the Bashkirian Stage, the 'Middle Pennsylvanian Series' comprises the Moscovian Stage, and the 'Upper Pennsylvanian Series' comprises the Kasimovian and Gzhelian Stages (Figure 1). This terminology is flexible, because if any of the longer stages are later subdivided into two or more globally recognized stages, then the current stage name would be elevated in rank to series with equivalency to the positional series name. For example, if it could be subdivided, the Viséan Stage would become the Viséan Series, which would equal the Middle Mississippian Series (just as it does as a stage), and it would comprise the two new stages. Furthermore, this terminology maintains stability of nomenclature, because it does not significantly alter the traditional usage of names, since the positional series names that have been applied to the Mississippian and Pennsylvanian in North America were never stringently defined biostratigraphically. Although the regional chronostratigraphic nomenclatures for western Europe and Midcontinent North America [United States] are still appropriately used in the regions within which they were established, global equivalents should be specifically mentioned in articles dealing with those regions. It is now appropriate for all SCCS members, voting and corresponding, to set a good example by using the official global nomenclature in those publications that concern regions outside of the areas of regional nomenclature, particularly in journals of international distribution. Accordingly, editor David Work and I have initiated a policy of editing Newsletter contributions that still use the old nomenclature to a format of presenting the global nomenclature as standard, with the old traditional nomenclature in brackets in the title and at first mention in the text, in order to aid readers in the transition.

Western European Substages

Starting some years ago, the SCCS voted officially to recognize 15 stages in the Namurian, Westphalian, and Stephanian Series of the regional western European classification [Pendleian, Arnsbergian, Chokierian, Alportian, Kinderscoutian, Marsdenian, Yeadonian, Langsettian, Duckmantian, Bolsovian, Westphalian D/Asturian, Cantabrian, Barruelian, Stephanian B, and Stephanian C], with up to 7 more stages proposed for the Tournaisian and Viséan Series, for a potential total of 22 stages for the entire Carboniferous in that region. The Russian Stratigraphic Commission has consistently ranked the Tournaisian and Viséan as stages (along with the locally named younger Serpukhovian, Bashkirian, Moscovian, Kasimovian, and Gzhelian Stages), and this opinion of many fewer stages for the entire Carboniferous [7], close in number to those in the adjacent Devonian and Permian Systems [7 and 9 respectively], had strong support among the stratigraphers who expressed their opinions to me or in publications. Therefore, another SCCS ballot approved the withdrawal of official recognition of stage rank from the current subdivisions of the Namurian, Westphalian, and Stephanian regional classification in western Europe. Thus, their rank as regional chronostratigraphic units should be that of substage. This will keep the scale of units in the regional classifications as close as possible to the scale of similarly ranked units in the global classification. Because regional stages and all substages are outside the concern of the ICS and IUGS, no further ratification is needed for this decision.

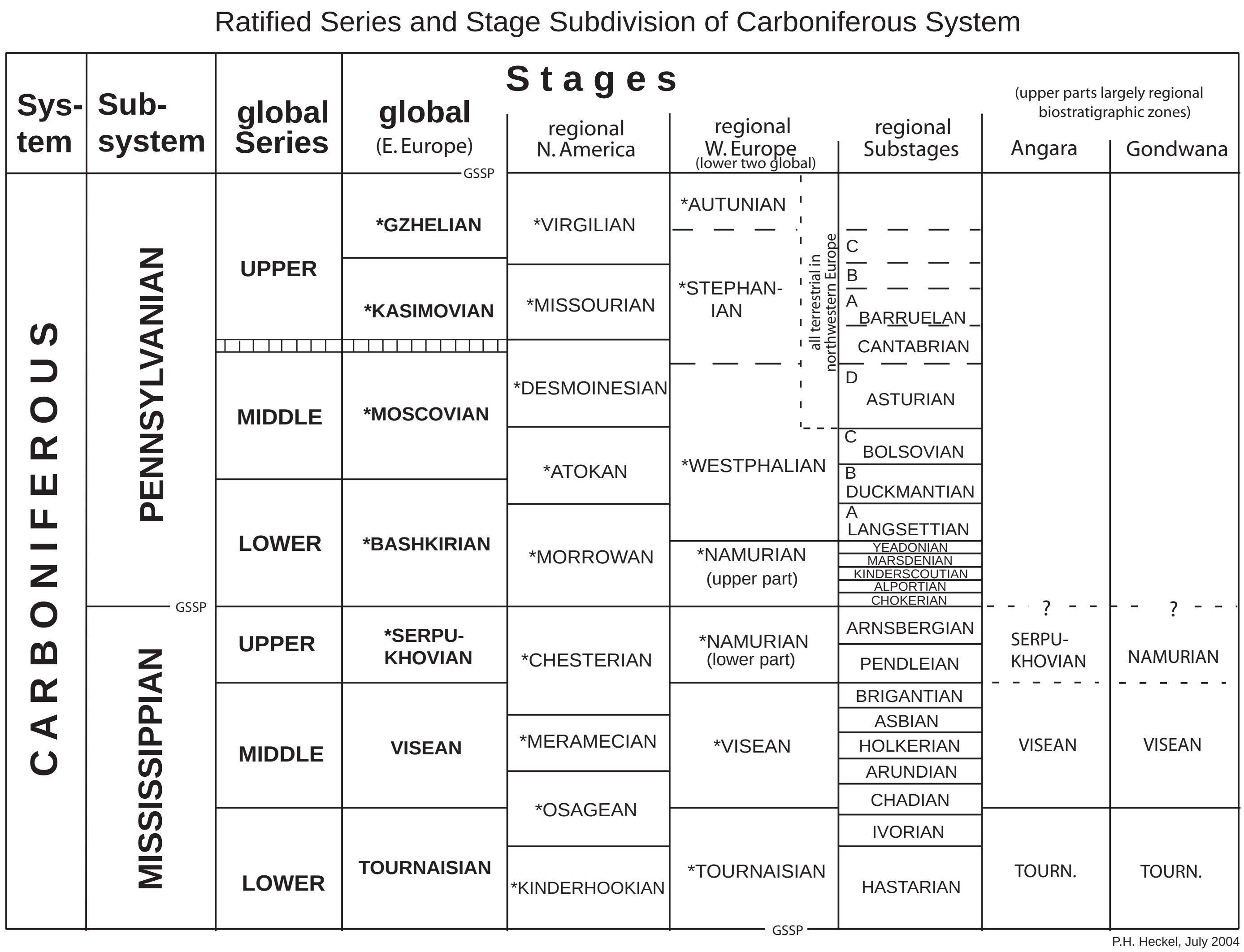

Figure 1. Graphic chart showing recently ratified global series and stage subdivision of Carboniferous System. Vertical lines separating Moscovian and Kasimovian Stages reflect uncertainty of level at which the event defining that boundary will be chosen (see task group report by E. Villa in this Newsletter); the series boundary will be the same as the selected stage boundary. Horizontal dashed lines show boundaries with various degrees of uncertainty as to correlation. Asterisks [*] show region from which geographic names were derived.

New Members for 2004-2008

The new ICS statutes require that subcommission voting members serve no more than 3 terms [12 years]. Accordingly, seven long-serving members will retire at the time of the International Geological Congress in Florence this August, and one other member will retire then for health reasons. Eight new members were selected by the executive group [consisting of the Chair, Vice-Chair, and Secretary] from a total of 12 nominations received from current members in a process that was made difficult by the excellent qualifications of all nominees. Considerations for selection included research focus on biotic groups significant in defining boundaries, geographic familiarity with important regions for boundary selection, stratigraphic familiarity with the part of the succession in which boundaries have yet to be chosen, and support among the continuing members, in addition to the ICS requirements for regional and methodological diversity. We thank the retiring members for their many contributions and long years of service to the SCCS, and we welcome the new members in anticipation of their ongoing contributions to Carboniferous stratigraphy.

Retiring members [with fields of basic expertise] are:

Paul Brenckle, USA [forams]
Boris Chuvashov, Russia [microfossils]
Marina Durante, Russia [plants]
Carlos Gonzalez, Argentina [Gondwanan biostratigraphy]
George Sevastopulo, Ireland [crinoids]
Robert Wagner, Spain [plants]
Cor Winkler Prins, Netherlands [brachiopods]
Wang Zhi-hao, China [conodonts]

New members [with fields of basic expertise] are:

John Groves, USA [forams]
Jin Xiao-chi, China [stratigraphy]
Jiri Kalvoda, Czech Republic [forams, conodonts]
Dieter Korn, Germany [ammonoids]
Olga Kossovaya, Russia [corals, Pennsylvanian stratigraphy]
Elena Kulagina, Russia [forams]
Svetlana Nikolaeva, Russia [ammonoids]
Wang Xiang-dong, China [corals, conodonts]

2005 SCCS Meeting in Dinantian Type Region of Belgium, May 24-28, 2005

At the Utrecht Congress, voting member Luc Hance and Belgian colleagues volunteered to host the 2005 field meeting in the type Dinantian region of the Tournaisian and Viséan Stages in Belgium. This meeting will start with a conference in Liege where oral and poster presentations will be given on May 24. The following 4-day field trip will visit a number of localities that illustrate both the stratotypes of the component substages of the Tournaisian and Viséan and the sequence stratigraphy of these units that has recently been worked out by Belgian stratigraphers and paleontologists, and which illustrates the complex sedimentary history of this classic region. More detailed information on the localities to be visited and a pre-registration form are provided later in this Newsletter.

2007 XVI-ICCP in Nanjing, China

Also at the Utrecht Congress, the proposal by Chinese colleagues was accepted to host the Sixteenth International Congress on Carboniferous and Permian Stratigraphy and Geology [XVI-ICCP] in Nanjing, China, in 2007. More information on this Congress will be forthcoming in future issues of the Newsletter.

Global Correlation Chart

Members will be interested that an initiative organized by Manfred Menning during 2003 and sponsored by the Deutsche Forschungsgemeinschaft [DFG] is in the process of producing a global correlation chart for the Devonian, Carboniferous, and Permian Systems [DCP 2003]. This started with two meetings in Potsdam in April and November of 2003, and now involves the work of many international scientists who are summarizing the litho- and chronostratigraphy of critical classical sections and the biostratigraphy of many fossil groups. An early version was posted at the Utrecht Congress, and a more comprehensive version will be presented at the IGC in Florence in August 2004.

Radiometric Dating

I have not been informed of any new significant radiometric dates on Carboniferous rocks, but members should be aware that there is a new initiative termed Chronos that has been established for the purpose of standardizing procedures for radiometric dating in order to enhance comparability among dates from different regions, among other things. This will hopefully start to alleviate the 'murky state of affairs in Carboniferous radiometric dating' illustrated by Menning and his colleagues in 2000. Interested persons can visit the recently established website www.chronos.org for more information.

Magnetostratigraphy

This past year, the 'Working Group on Carboniferous Magnetostratigraphy' has been formed by Mark Hounslow of Lancaster University, Britain, to focus on developing the paleomagnetic framework for the Carboniferous System. (This is technically a 'project group' under the ICS statutes.) This very welcome new group will hopefully expedite the process of integrating the tropical terrestrial scale and the Gondwanan and Angaran local biostratigraphic scales into the tropical marine global scale of the Carboniferous. An informative summary article on the current status of paleomagnetic data that are available for the Carboniferous, and an invitation to interested persons to join this group, appear later in this Newsletter.

Philip H. Heckel

SECRETARY / EDITOR'S REPORT 2003-2004

I want to thank all who provided articles for inclusion in Volume 22 of the Newsletter on Carboniferous Stratigraphy and those who assisted in its preparation. I am indebted to P. H. Heckel for editorial assistance; and to P. Thorson Work for coordinating the compilation of this issue.

New SCCS Executive

The period of the current SCCS executive expires at the IGC in Florence, August 2004. In May 2003 a ballot of the voting members was conducted to elect the SCCS nominees to the ICS for the Chair and Vice-Chair for the next four year period 2004-2008. Only single candidates were nominated for Chair, Dr. Philip H. Heckel, and Vice-Chair, Dr. Geoffrey Clayton. In a secret ballot, both candidates were elected unanimously. Voting Result: (Yes - 17, No - 0, Abstain - 0, No Response - 4). Drs. Heckel and Clayton were subsequently ratified by the ICS as the incoming Chair and Vice-Chair of the SCCS, respectively, for the term commencing at the IGC in Florence, August 2004.

3 Ballots on Standardization of Classification within the Carboniferous System

In October 2003 a ballot of the voting members was initiated to standardize classification within the Carboniferous System (for further details see the Chairman's Column). Following are the results of the 3 separate ballots which were subsequently ratified by the IUGS/ICS and are binding on the SCCS:

1. BALLOT ON SERIES SUBDIVISION, ALTERNATIVE A [Tournaisian and Viséan Series in Mississippian Subsystem, and Westphalian and Stephanian Series in Pennsylvanian Subsystem, all subdivided into two or more stages]. Voting Result: (For - 3; Against - 12; Abstain - 4; No Response - 2). The proposal was therefore not adopted.

2. BALLOT ON SERIES SUBDIVISION, ALTERNATIVE B [Lower, Middle, and Upper Series in Mississippian Subsystem, and Lower, Middle, and Upper Series in Pennsylvanian Subsystem, most initially comprising one stage, but subject to further stage subdivision if possible]. Voting Result: (For - 14; Against - 3; Abstain - 2; No Response - 2). The proposal was therefore adopted by 74% [out of 19 votes cast, which is 90% of 21 voting members] of the voting members.

3. BALLOT ON PROPOSAL II [Withdrawal of official recognition of stage rank from current subdivisions of Namurian, Westphalian and Stephanian regional classification in western Europe]. Voting Result: (For - 17; Against - 1; Abstain - 1; No Response - 2). The proposal was therefore adopted by 89% [out of 19 votes cast, which is 90% of the 21 voting members] of the voting members.

Details of individual votes may be found in the table below.

	Ballot 1	Ballot 2	Ballot 3
Dr. Alexander S. Alekseev	yes	abstain	yes
Dr. Demir Altiner	no	yes	yes
Dr. Darwin R. Boardman	no	yes	yes
Dr. Paul Brenckle	no	yes	yes
Dr. Boris Chuvashov	abstain	abstain	abstain
Dr. Geoffrey Clayton	no	yes	yes
Dr. Marina V. Durante	no response	no response	no response
Dr. Carlos R. González	no	yes	yes
Dr. Luc Hance	yes	no	yes
Dr. Philip H. Heckel	abstain	yes	yes
Dr. Ian Metcalfe	no	yes	yes
Dr. Tamara I. Nemyrovska	no	yes	no
Dr. Barry C. Richards	no	yes	yes
Dr. Nicholas J. Riley	no	yes	yes
Dr. George D. Sevastopulo	yes	no	yes
Dr. Katsumi Ueno	no	no	yes
Dr. Elisa Villa	abstain	yes	yes
Dr. Robert H. Wagner	no	yes	yes
Dr. Wang Zhi-hao	no response	no response	no response
Dr. Cor F. Winkler Prins	no	yes	yes
Dr. David M. Work	abstain	yes	yes

Future Issues of Newsletter on Carboniferous Stratigraphy

Next year's Volume 23 will be finalized by July 2005, 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 7) regarding submission format, especially manuscript length (no more than 5 double-spaced manuscript pages *without prior approval*) 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 2003

Membership

The Subcommission had 21 voting members in 2003 [see list at end of Newsletter]. In addition, corresponding membership at the time of publication stands at 293 persons and 7 libraries.

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Task and Exploratory Project Groups

Task Group to establish a boundary close to the Tournaisian-Viséan Boundary [which will be the base of the Middle Series of the Mississippian Subsystem] chaired by George Sevastopulo (Ireland).

Task Group to establish a boundary close to the Viséan-Serpukhovian Boundary [which will be the base of the Upper Series of the Mississippian Subsystem], chaired by Barry Richards (Canada).

Task Group to establish a boundary close to the Bashkirian-Moscovian Boundary [which will be the base of the Middle Series of the Pennsylvanian Subsystem] chaired by John Groves (USA).

Task Group to establish a boundary close to the Moscovian-Kasimovian Boundary [which will be the base of the Upper Series of the Pennsylvanian Subsystem], chaired by Elisa Villa (Spain). This group is also dealing with a boundary close to the **Kasimovian-Gzhelian Boundary** within the Upper Series of the Pennsylvanian Subsystem.

Project Group on Upper Palaeozoic Boreal Biota: Stratigraphy and Biogeography, chaired by Marina Durante (Russia).

Project Group on Carboniferous Magnetostratigraphy, chaired by Mark Hounslow (United Kingdom), newly formed in early 2004.

Chief Accomplishments in 2003

In a late 2003 ballot, the SCCS voted on two issues:

1. It voted with a 74% majority to classify each of the two subsystems into Lower, Middle and Upper Series for a total of six series in the Carboniferous System. Because there are current plans for only seven stages in the Carboniferous, each of the lower five series at the current time comprises only one stage. However, if any of these geographically named stages can be further divided into two or more globally significant stages in the future, then the current stage name can be used as a series name with equal standing to the current positional series name.

2. It voted with an 89% majority to withdraw official recognition of stage rank from the 15 named and lettered stages previously approved in the upper part of the western European regional classification. Because there are current plans to select boundaries for only seven global stages in the Carboniferous, this means that the former western European stages can be recognized only as regional substages, and the scale of regional and global ranks will be similar.

Work on the Tournaisian-Viséan boundary resulted in the publication of the description of a potential GSSP by Devuyst et al. (2003 *Episodes*, 26: 105-115). Based on fruitful meetings at the Utrecht Congress, work on the Viséan-Serpukhovian, Bashkirian-Moscovian, Moscovian-Kasimovian, and Kasimovian-Gzhelian boundaries has reached the point that task group chairs have called for proposals on the boundary events that will be used to define them.

The Newsletter on Carboniferous Stratigraphy, Volume 21, published in July 2003, contains reports of the task groups for 2002, and 8 articles on various topics, including: Updated cyclothem constraints on Pennsylvanian radiometric dating in North America; Defining boundary stratotypes – speciation, migration and extinction; Upper Viséan-Serpukhovian conodont zonation in South China; Upper Paleozoic glaciations in Argentina; Challenge to the existence of the 'Ostrogsky Episode' in Siberia; Correlation of the Moscow Basin Mississippian with the Euramerican floral zonation; Correlation of new radiometric dates from the French Massif Central with other Variscan occurrences; and Carboniferous tetrapod footprint biostratigraphy and biochronology, for a total of 54 pages.

Work Plan for 2004 and Following Years

As a result of the August 2003 Carboniferous Congress in Utrecht, the following activities are planned in the task groups:

Tournaisian-Viséan boundary. With the *Episodes* paper on the GSSP published, this task group is preparing a formal proposal for the SCCS vote on the GSSP.

Viséan-Serpukhovian boundary This task group is focusing future work on a foram lineage and a few particular conodont lineages as potential boundary-defining events.

Bashkirian-Moscovian boundary. This task group is focusing work on the proposal it received in early 2004 for a boundary-defining event based on one of two different conodont lineages.

Moscovian-Kasimovian boundary. This task group will discuss the proposals received on three possible lineages for boundary-defining events, two among forams and one among conodonts, at the task group meeting in Oviedo, Spain, prior to the August 2004 IGC in Florence, Italy.

Kasimovian-Gzhelian boundary. Attention is focused on a conodont lineage that provides good potential for a boundary-defining event. Taxonomic work on this lineage will be presented at the Oviedo meeting in August 2004.

Progress appears to have been sufficient in all task groups that the selection of all the stage boundaries currently envisioned in the Carboniferous is realistic by the ICS deadline of 2008. The newly established Project Group on Carboniferous Magnetostratigraphy will be focusing on both supplementing the pan-tropical biostratigraphic framework, and particularly on integrating the tropical plant-rich terrestrial succession and the more polar fossil assemblages into the marine pan-tropical Carboniferous scale.

STATEMENT OF OPERATING ACCOUNTS FOR 2002/2003
Prepared by David Work, Secretary
(Definitive accounts maintained in US currency)

INCOME (Oct. 31, 2002 – Oct. 31, 2003)	
IUGS-ICS Grant 2003	$900.00
Donations from Members	400.00
Interest	5.29
TOTAL INCOME	**$1325.29**
EXPENDITURE	
Newsletter 21 (printing)	$849.00
Postage for bulk mailings	514.14
Mailing/Office Supplies	127.94
Bank Charge	120.29
TOTAL EXPENDITURE	**$1611.37**
BALANCE SHEET (2002 – 2003)	
Funds carried forward from 2001 – 2002	$2150.57
PLUS Income 2002 – 2003	1325.29
LESS Expenditure 2002 – 2003	-1611.37
CREDIT balance carried forward to 2004	**$1864.49**

Donations in 2003/2004:

Publication of the Newsletter on Carboniferous Stratigraphy is made possible with generous donations received from members/institutes during 2003-2004 and anonymous donations, combined with an IUGS subsidy of US $900 in 2004, and additional support from a small group of members who provide internal postal charges for the Newsletter within their respective geographic regions.

A. Blieck, L. S. Dean, W. H. Gillespie, E. Grossman, P. H. Heckel, N. R. King, J. Kullmann, R. L. Langenheim, S. G. Lucas, M. Menning, G. Nadon, H. W. Pfefferkorn, C. A. Ross, J. R. P. Ross, C. A. Sandberg, C. H. Stevens, P. R. Vail, E. Villa and the Spanish Research Group, G. P. Wahlman, Xiang-dong Wang, G. Webster, R. R. West, T. Yancey

COVER ILLUSTRATION

Ratified global Carboniferous subdivision.

Illustration: courtesy of P.H. Heckel.

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,

AIR MAIL to: David M. Work
Maine State Museum
83 State House Station,
Augusta, ME 04333, USA

EMAIL to: **david.work@maine.gov**

Progress report of the Task Group to establish a boundary close to the existing Tournaisian-Viséan boundary

F.X. Devuyst[1], G. Sevastopulo[1], L. Hance[2], H. Hou[3], J. Kalvoda[4], and X.H. Wu[5]

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[5]Guizhou Bureau of Geology, Beijing Road, Guiyang, China.

The Task Group to establish a boundary close to the existing Tournaisian-Viséan boundary is now in the final stage of submitting an official proposal to the IUGS. The biostratigraphic criterion proposed by the group was formally approved by the voting members of the SCCS in 2002 (Work, 2002). A summary publication was published in *Episodes* in June 2003 for the International Congress on the Carboniferous and Permian in Utrecht (the Netherlands) where the group presented its last results and conclusions (Sevastopulo et al., 2003; Hance and Devuyst, 2003; Devuyst and Hance, 2003). The Chairman of the SCCS, P.H. Heckel, requested additional information on the correlation of the GSSP with regions where the guide *E. simplex* was absent, essentially North America. Although this is a long standing problem that cannot be solved without extensive research, we are preparing a summary of the available data and research focusing on alternative methods of correlation is underway. In the following report we present new results and research directions.

Macrofauna

The Pengchong section contains an exceptionally rich and diversified fauna of foraminifers, and notably of *Eoparastaffella,* and a relatively good fauna of conodonts, but very few macrofossils (a few brachiopods and corals, see Devuyst et al., 2003). This is due to the nature of the deposits, which mainly consist of size-sorted allochthonous grains transported in a very narrow starved basin from the nearby shallow platform. The mechanism of transport (modified grain flows or high-density turbidity currents) of the majority of the beds exposed in Pengchong was apparently characterized by very little down-slope mixing. This would explain why the conodont fauna is dominated by relatively shallow water taxa and the poor state of preservation (mechanical breakage) of the few deeper-water taxa recovered. This also explains the delayed first occurrence of the deeper-water archaediscid foraminifers. These important biostratigraphic guides (Cf4b, Arundian) occur only in the upper part of the section, at the same level as the Cf5 (Livian, Holkerian) guide *Pojarkovella nibelis* and much above the Arundian conodonts *Lochriea commutata* and *Gnathodus austinii*. At this level the contribution of reworked upper-slope sediments and suspension deposits becomes larger (Figure 1).

The situation is different in the Yajiao section which was located in another narrow basin nearby, in a probably more distal setting, or at least further away from an active platform sediments source than Pengchong (contrary to what was proposed in Hance et al., 1997). Indeed the Yajiao section is characterized by a higher ratio of background/allochthonous deposits and the reworked sediments were deposited in generally thinner beds with sedimentary structures typical of normal turbidity currents (Hance et al., 1997). The section contains a rich and very well-preserved basinal conodont fauna and a good succession of archaediscids consistent with the conodonts and other foraminiferal guides. Conversely, the foraminifers and notably the *Eoparastaffella* fauna is poorer than in Pengchong for the uppermost Tournaisian to lowermost Viséan (pre-Arundian) interval. However the section contains trilobite- and ammonoid-rich levels around the Tn-V boundary in an interval dominated by organic-rich shales, argillaceous dolomites, and siliceous mudstones (Figure 1). Specimens were collected in one of these levels (bed 71, Figure 2) and sent to specialists for identification. In view of the first results a more detailed bed-by-bed sampling will be undertaken.

Ammonoids

Relatively compressed negative casts of ammonoids are very abundant around bed 71 in the Yajiao section. Four specimens collected in January 2002 were sent to D.M. Work who provided us with the following information: the four specimens belong to *Merocanites* sp. Incomplete preservation of the sutures (the diagnostic V-shaped ventral lobe is not visible on any of the specimens) and flattening prevent more detailed identification (whorl cross section shape is a critical species-level character in *Merocanites*).

Trilobites

The same level (Yajiao, bed 71) yields relatively abundant fragments of trilobites. Four samples collected at the same time as the ammonoids were sent to G. Hahn for study. The samples contain negative casts of 2 cranidia and of 3 pygidia belonging to *Liobole* (*Sulcubole*) n. sp. and *Liobole* (*Liobole*) n. sp. (Hahn, in preparation). The species are not known in Europe and it is the first time that these genera have been recorded from China. *Liobole* is the index for the Erdbachian (*Pericyclus* Stage) and is typical of the Kulm facies of Central Europe and SW England.

Palaeomagnetism

About 100 samples have been collected in the Pengchong section (with higher sampling density around the Tn-V boundary) for palaeomagnetism but, unfortunately, no original signal is preserved.

Taxonomy and Phylogeny of *Eoparastaffella*

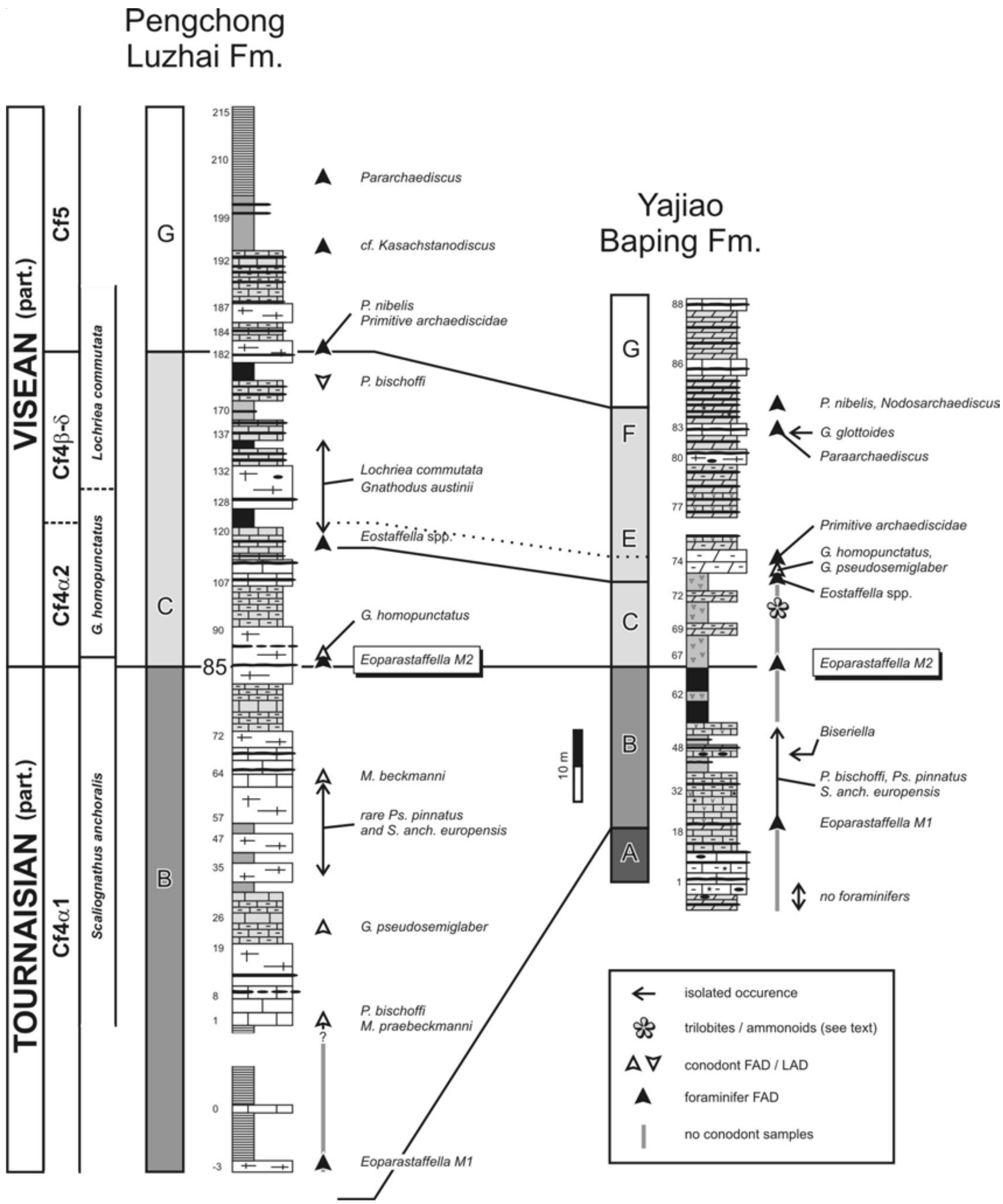

Figure 1. Correlation between the proposed new GSSP, Pengchong section, and the nearby Yajiao section which contains trilobites and ammonoids. Letters A to F refer to the local foraminifer association of Hance et al. (1996). Association G is introduced here and defined by the entry of the Cf5 guide *Pojarkovella nibelis*. The dashed line indicates the approximate position of the base of the Arundian.

On the basis of the literature (which concerns mainly the former USSR) and of abundant material collected in various parts of Eurasia during the search for a new Tn-V boundary GSSP, F.X. Devuyst and J. Kalvoda are currently reviewing the taxonomy of the genus *Eoparastaffella*. There remains important work to be done outside the former USSR where most of the research on *Eoparastaffella* was concentrated (in the 1950s to 1970s). Species that were originally described in the former USSR and previously known only in their type-area have now been found in distant locations (e.g., *Eoparastaffella fundata*, *E. interiecta*, *E. restricta*, *E. florigena*, *E. fabacea*, etc.). Unfortunately, the biostratigraphic resolution of data from the former USSR is commonly poor, *Eoparastaffella* spp. being reported from broad horizons and assemblage zones. At present, the regions investigated include South China, northern Iran, the Czech Republic, Belgium, and Ireland. Conodonts are being used as an independent control on correlation. Especially rich and diversified faunas of *Eoparastaffella*, which allow phylogenetic studies, have been recovered from the following sections: Pengchong (Guangxi, S. China), Daizhaimen (Yunnan, S. China), Mokra (Czech Republic), Rush-Lane (eastern Ireland), and Oughterard (western Ireland). One of the main conclusions of our ongoing study is that the genus is extremely diversified and that there is a great potential to use it for very fine biostratigraphy in the Tournaisian-Viséan

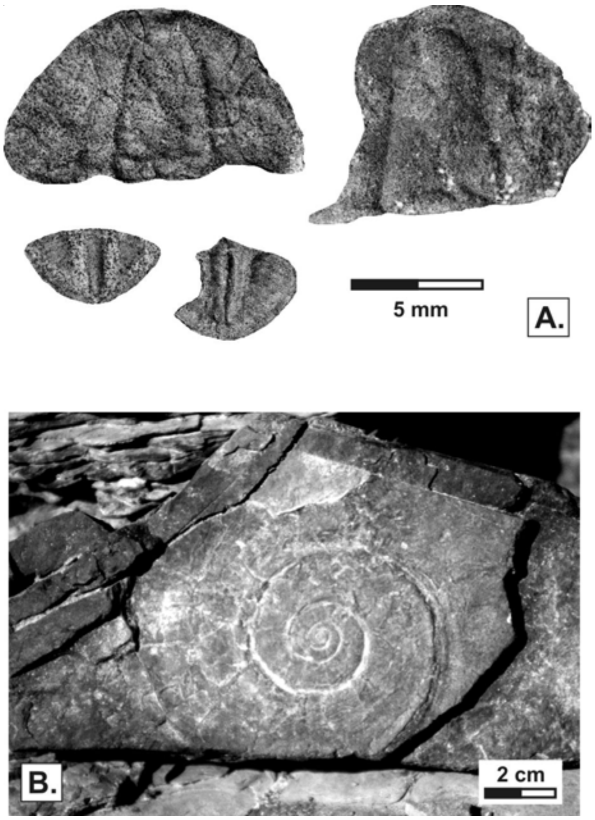

Figure 2. Example of the macrofauna of bed 71 in the Yajiao section. A. *Liobole* n. sp.; B. *Merocanites* sp. (identifications by G. Hahn, D. Work, and G. Sevastopulo).

boundary interval. The abundant material collected from the above mentioned localities shows a considerable variability of the genus with progressive morphological transitions between species (e.g., *E. ovalis sensu* Vdovenko, 1964 – *E. simplex*, *E. rotunda* – *E. interiecta*, *E. interiecta* – *E. tummida*, *etc*.). A species which appears to be of particular biostratigraphic interest and which was poorly known until recently is *E. interiecta*. It has now been found to be well represented in the Czech Republic and Ireland (east and west coasts) and present in northern Iran and South China. It appears in the latest Tournaisian (upper *anchoralis* Zone) among the first *Eoparastaffella* and is therefore a useful marker (Kalvoda and Devuyst, in preparation). The taxonomy of the stratigraphically important species *E. ovalis* is also under revision.

Biometry

A new biometric coefficient to characterize the shape of an *Eoparastaffella* specimen in axial section and therefore the morphological evolution of the genus at the Tn-V transition has been developed (see Devuyst et al., 2003) and has been tested extensively with good results (Devuyst and Hance, 2003). It is based on a few simple measurements that can be taken from published plates. It combines a measure of the angularity of the last whorl (diagnostic criterion in *Eoparastaffella*), of the sphericity of the test, and of the depth of the umbilicus. It has proved useful not only to locate the entry of Viséan subangular forms in a progressive morphological evolutionary lineage (Hance and Muchez, 1995; Hance, 1997; Devuyst et al., 2003), but also in taxonomic studies.

Foraminifer Biozonation

The Lower Carboniferous foraminifer zonation of the type-Dinantian (Lower Carboniferous of the Franco-Belgian Basin) is being reviewed and updated by L. Hance and F.X. Devuyst.

In the two main published zonations (Mamet, 1974; Conil et al., 1991) the Viséan pattern is more satisfactory than the Tournaisian, due to the worldwide development of shelf settings during the Lower Viséan, which created conditions more suitable for foraminifers over wide areas. The main problems in correlating the Belgian Tournaisian zones reflect discontinuous foraminiferal records, due to unfavourable environmental conditions in the lower ramp and basin (Dinant Sedimentation area) and to pervasive dolomitization of the inner ramp (Condroz and Namur sedimentation areas).

Recent progress in understanding the Belgian Dinantian sequence stratigraphy (Hance et al., 2001, 2002) and the new data from South China require modification of former interpretations with strong implications on biostratigraphy. Improvements concern mainly the Upper Tournaisian and the Lower Viséan. The new scheme allows better correlations between the classical Eurasian areas. It has been presented at the ICCP in Utrecht (Hance and Devuyst, 2003) and will be published in the coming months.

Correlation with Laurentia

Correlating precisely the base of the Viséan between Eurasia and the type Mississippian region and indeed most of North America has always proved extremely difficult because of endemism in most fossil groups. *Eoparastaffella* seems to be virtually absent from North America. *Eoparastaffella ovalis* and *E. simplex* have been reported from the Canadian Cordillera (Mamet, 1976; Mamet et al., 1986), but after examination of the original material we could not confirm the attribution even to the genus. These specimens most likely belong to *Eoendothyranopsis* which is a very abundant and widespread genus in North America and much rarer in most of Eurasia. *Gnathodus homopunctatus* which is a very useful conodont guide for the base of the Viséan in Eurasia is virtually unknown from North America at that level except the eastern coast of Canada (Eurasian affinities). Other useful uppermost Tournaisian genera in Eurasia such as *Mestognathus praebeckmanni* and *M. beckmanni* are very rare. Conversely, *Gnathodus texanus,* which is the index species of the biozone of the same name, is rarely recorded in Eurasia and poses problems of identification. According to most authors, the Tn-V boundary occurs in the upper part of the Burlington Fm. of the Mississippi Valley (Austin et al., 1973; Lane and Ziegler, 1983; Brenckle, 1991; Work et al., 2000) based on conodonts. However, this results in positioning the Tn-V boundary within the range of *Scaliognathus anchoralis* and of other taxa that are only known in the Tournaisian in Eurasia such as *Polygnathus communis communis* and *Eotaphrus burlingtonensis*. Indeed the conodont fauna typical of the upper part of the Burlington Fm. looks very similar to the well known Upper Tournaisian assemblage of Eurasia. To try to resolve this apparent contradiction a research project has been set up and funded (by the Irish Research Council for Science, Engineering and Technology) at Trinity College, Dublin. It will investigate the C stable isotope record of a broad interval encompassing the suspected position of the Tn-V boundary in

North America and compare it with the traditional boundary in Western Europe and the newly proposed GSSP in South China. Hopefully this approach, in combination with sequence stratigraphy, will lead to increased resolution of the correlation. This work is being undertaken in collaboration with M. Saltzman and fieldwork started this summer in the Canadian Cordillera in collaboration with B. Richards.

References

Austin, R.L., R. Conil, and F.H.T. Rhodes. 1973. Recognition of the Tournaisian-Viséan boundary in North America and Britain. Annales de la Société Géologique de Belgique, 96:165-188.

Brenckle, P.L. 1991. Foraminiferal division of the Lower Carboniferous/Mississippian in North America, p.65-78. *In* P.L. Brenckle and W.L. Manger (eds.), Intercontinental Correlation and Division of the Carboniferous System. Courier Forschungsinstitut Senckenberg, 130.

Conil, R., E. Groessens, M. Laloux, E. Poty, and F. Tourneur. 1991. Carboniferous guide foraminifers, corals and conodonts in the Franco-Belgian and Campine Basins, p. 5-30. *In* P.L. Brenckle and W.L. Manger (eds.), Intercontinental Correlation and Division of the Carboniferous System. Courier Forschungsinstitut Senckenberg, 130.

Devuyst, F.X., L. Hance, H. Hou, X. Wu, S. Tian, M. Coen, and G. Sevastopulo. 2003. A proposed Global Stratotype Section and Point for the base of the Viséan Stage (Carboniferous): the Pengchong section, Guangxi, South China. Episodes, 26(2):105-115.

Devuyst, F.X., and L. Hance. 2003. Early evolution of the genus *Eoparastaffella* (foraminifer): a high-resolution biostratigraphical tool for the Tournaisian-Viséan boundary. Abstracts, XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 123-124

Hance, L. 1997. *Eoparastaffella*, its evolutionary pattern and biostratigraphic potential. Cushman Foundation for Foraminiferal Research Special Publication, 36:59-62.

Hance, L., and F.X. Devuyst. 2003. The Eurasian Mississippian (Lower Carboniferous) foraminiferal succession. Abstracts, XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 196.

Hance, L., and P. Muchez. 1995. Study of the Tournaisian-Viséan transitional strata in South China (Guangxi). Abstracts, XIII International Congress on Carboniferous-Permian, Krakow, Poland, 1995, p. 51.

Hance, L., P. Muchez, H.F. Hou, and X. Wu. 1997. Biostratigraphy, sedimentology and sequence stratigraphy of the Tournaisian-Viséan transitional strata in South China (Guangxi). Geological Journal, 32:337-357.

Hance, L., E. Poty, and F.X. Devuyst. 2001. Stratigraphie séquencielle du Dinantien type (Belgique) et corrélation avec le Nord de la France (Boulonnais, Avesnois). Bull. Soc. Géol. France, 172(4):411-426.

Hance, L., E. Poty, and F.X. Devuyst. 2002. Sequence stratigraphy of the Belgian Lower Carboniferous – tentative correlation with the British Isles. *In* L.V. Hills, C.M. Henderson and W. Bamber (eds.), Carboniferous and Permian of the World. Canadian Society of Petroleum Geologists Memoirs, 19.

Lane, H.R., and W. Ziegler. 1983. Taxonomy and phylogeny of *Scaliognathus* Branson and Mehl 1941 (Conodonta, Lower Carboniferous). Senckenbergiana lethaea, 64:199-225.

Mamet, B. 1974. Une zonation par Foraminifères du Carbonifère Inférieur de la Théthys Occidentale. Septième Congrès International de Stratigraphie et de Géologie du Carbonifère, Krefeld, Germany, 1971, Compte Rendu, 3: 391-407.

Mamet, B. 1976. An atlas of microfacies in Carboniferous carbonates of the Canadian Cordillera. Geolgical Survey of Canada Bulletin, 255, 131 p.

Mamet, B., E.W. Bamber, and R.W. Macqueen. 1986. Microfacies of the Lower Carboniferous Banff Formation and Rundle Group, Monkman Pass map-area, northeastern British Columbia, Geological Survey of Canada Bulletin, 353, 93 p.

Sevastopulo, G.D., L. Hance, F.X. Devuyst, H. Hou, X.H. Wu, and M. Coen. 2003. A new GSSP for the base of the Viséan (Mississippian, Carboniferous): a candidate from southwest China. Abstracts, XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 491-493.

Work, D.M., W.W. Nassichuk, and B.C. Richards. 2000. Lower Viséan ammonoids from the lower Mount Head Formation, east-central British Columbia, Geological Survey of Canada Bulletin, 541, 71 p.

Work, D.M. 2002. Secretary / Editor's Report 2001-2002. Newsletter on Carboniferous Stratigraphy, 20:3.

The Viséan-Serpukhovian boundary: a summary based on the XV-ICCP Carboniferous Workshop in Utrecht

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Introduction

The first official meeting of the Viséan-Serpukhovian boundary Task Group was held at the Carboniferous Workshop on August 13th 2003 at the XV International Congress on Carboniferous and Permian Stratigraphy in Utrecht, The Netherlands. Several issues were clarified and some research goals established. The voting members in attendance were Markus Aretz, Paul Brenckle, Geoff Clayton, Nilyufer Gibshman, Dieter Korn, Richard Lane, Tamara Nemyrovska, Yu-ping Qi, Barry Richards, and John Utting. In addition, Phil Heckel and several members of the Tournaisian-Viséan boundary task group attended and provided valuable input. The summary provided below is based on notes taken immediately after the Utrecht meeting and on subsequent discussions with task group members.

Summary

At the onset of the workshop, we discussed the Serpukhovian type section in the Zaborie quarry in the Moscow Basin, focusing on the major depositional and biostratigraphic events recorded by the lower part of the section. The lower boundary of the type Serpukhovian is an unconformity that is traceable throughout much of the Moscow Basin and resulted from a transgression subsequent to latest Viséan regression and subaerial exposure (Skompski et al., 1995). In the southern part of the Moscow Basin, including the Zaborie quarry, the Serpukhovian disconformably overlies an uppermost Viséan (Venevian regional horizon) limestone interval containing paleosols and karstified limestone (Kabanov, 2003). In the Zaborie section, the foraminifers *Neoarchaediscus postrugosus* and *Janishewskina delicata* first appear immediately above the base of the Serpukhovian. "*Millerella*" *tortula* appears about 50 cm above the base of the Serpukhovian (Gibshman, 2001; Nikolaeva et al., 2002). The conodonts *Lochriea cruciformis*, *Lochriea ziegleri,* and *Lochriea senckenbergica* also appear in the basal bed (about 65 cm thick) of the type Serpukhovian (Nikolaeva et al., 2002). The Viséan-Serpukhovian boundary in the Zaborie quarry is approximately correlative with the unconformable Viséan-Namurian boundary in the Namur-Dinant Basin of Western Europe (Skompski et al., 1995; Nikolaeva and Kullmann, 2001).

Later in the meeting, two potential stratigraphic levels were considered for the Viséan-Serpukhovian GSSP: 1) a level near the middle of the Brigantian Substage and slightly below the existing Viséan-Serpukhovian boundary and 2) a position near the middle of the Asbian Substage (near the base of the Chesterian), which is well below the boundary. Most participants thought that the stratigraphic level of the Viséan-Serpukhovian GSSP should be as close to the base of the type Serpukhovian as possible and that a position as low as the middle Asbian would be radical enough to cause confusion in the literature. Some participants favored the position within the Asbian for the base of the Serpukhovian Stage because the potential for finding a taxon suitable for defining the GSSP may be greater there. The lower to middle Asbian also records the onset of the moderate- to high-amplitude glacial-eustatic sea level changes characteristic of the late Mississippian and Pennsylvanian (Smith and Read, 2000; Barnett et al., 2002).

Regarding potentially definitive biotic lineages, ammonoid expert Dieter Korn indicated that late Viséan and early Serpukhovian ammonoids were not common in most marine facies and the possibility of finding a suitable ammonoid species near the present Viséan-Serpukhovian boundary was remote. Ammonoid specialist Alan Titus (written commun., 2004) was in general agreement with that conclusion but indicated ammonoids could be used to facilitate precise global correlations near the boundary whatever taxon is used to define the GSSP. Ammonoid-based geochronology is well developed near the level of the Viséan-Serpukhovian boundary because beds near the boundary contain numerous very distinct ammonoid morphotypes (Svetlana Nikolaeva; written commun., 2004).

Conodont specialist Rich Lane suggested that a late Viséan lineage containing the first evolutionary appearance of the widely distributed (Asia, eastern and western Europe, and North America) conodont *Gnathodus bilineatus* had good potential for defining a GSSP. The European and Chinese conodont experts thought the first evolutionary appearance of *G. bilineatus* near the mid-Asbian (middle V3b) was too low and that a conodont lineage within the *Lochriea* group of species would be more suitable. Revision of the *Lochriea* species classification by Nemyrovska, Perret, and Meischner (1994) and verification of their stratigraphic ranges in the most important European localities by Skompski et al. (1995) resulted in the conclusion that a group of the *Lochriea* species ornamented by numerous nodes or ridges appears either at or a short distance below the Viséan-Serpukhovian boundary. Among these species*, L. ziegleri* and *L. cruciformis* occur most commonly and nearest to the boundary (Skompski et al., 1995).

Within the *Lochriea* group of species the most important lineage, in terms of defining the Viséan-Serpukhovian boundary, is probably *Lochriea nodosa* – *Lochriea ziegleri*, with *L. ziegleri* appearing near the middle of the Brigantian Substage, which is slightly below the current base of the Serpukhovian. The lineage is best documented from relatively deep-water sections where the abundance of conodonts is higher than in shallow-water sections that are often separated by terrestrial lithofacies. The lineage has been identified in several European sections (Nemirovskaya et al., 1994; Skompski et al., 1995). In addition, one of the task group, Qi Yu-ping, recently recognized the lineage *L. nodosa* – *L. ziegleri* and other lineages within the *Lochriea* group of species in the Nashui section near the town of Luodian, Guizhou, southern Peoples Republic of China (Wang and Qi, 2003). An important marine flooding event, recognized in the Chainman Shale of western Utah (SW USA) and in the Bowland Shale of the Craven Basin in northern England, occurred near the middle Brigantian (Titus and Riley, 1997) and could facilitate global correlations at this stratigraphic level (Andrew Barnett; written commun., 2004).

Because the *L nodosa* – *L. ziegleri* lineage and other biostratigraphically important lineages within the *Lochriea* group have not been observed in the Americas, the conodont experts decided to re-examine North American conodont collections for key taxa within the group. It was also recommended that the phylogeny of *G. bilineatus* be carefully restudied because it is relatively poorly known. According to Belka (1991), its evolutionary appearance within the sequence from *Gnathodus praebilineatus* has been demonstrated only in Poland and possibly in Belgium.

The foram experts mainly discussed the phylogeny of "*Millerella" tortula* because its first evolutionary appearance might be used for boundary definition, if the controversy about its phylogeny can be favorably resolved. Brenckle and Groves (1981) and Brenckle (1991) proposed that *"M." tortula* evolved from *Endostaffella discoidea* and gave rise to "*M." designata* and "*M." advena/cooperi* later in the Chesterian. Gibshman (2001, 2003), however, proposed the lineage *"Endostaffella" asymmetrica – "Millerella" tortula – Millerella pressa*, based largely on specimens from the Zaborie quarry in Russia. In the Zaborie quarry section, *"Endostaffella" asymmetrica* occurs in the late Viséan Venevian horizon, whereas *"Millerella" tortula* appears slightly above the Viséan-Serpukhovian boundary (Gibshman and Baranova, 2003). The North American and Russian specimens assigned to "*M." tortula* may represent different taxa because the two groups of specimens show subtle morphological differences. For example, the Russian species appears to have a more angular periphery than those from North America. Task group members Paul Brenckle and Nilyufer Gibshman have agreed to study the problem of the phylogeny of "*M.*" *tortula*.

The palynologists attending the meeting indicated that palynomorphs would not be suitable for defining the GSSP, although four palynological events that could be potentially useful for global correlation occurred in the late Viséan to early Serpukhovian. The palynological events are: 1) appearance of *Tripartites vetustus* at the Asbian-Brigantian boundary, 2) appearance of *Schopfipollenites* near the Asbian-Brigantian boundary, 3) appearance of *Ibrahimispores* and *Schulzospora* in the early Pendleian, and 4) the appearance of *Potonieisporites* at the Pendleian-Arnsbergian boundary.

Several task group members expressed the opinion that it probably will not be possible to use the first evolutionary appearance of a single taxon for global correlations near the present Viséan-Serpukhovian boundary. Instead, it may be necessary to use a number of evolutionary first occurrences in addition to the principal taxon used to define the GSSP.

Conclusions

1. The evolutionary appearance of a taxon in a lineage within the *Lochriea* group of species could be suitable for definition of a GSSP near the current Viséan-Serpukhovian boundary, particularly if that lineage can be found in North America. If the species of *Lochriea* selected for boundary definition can not be found in the Americas, we may be able to achieve a precise correlation with North America by using other species (conodont, foraminifer or ammonoid) that appear near the same biostratigraphic level as that taxon.

2. In the event that a taxon within the *Lochriea* group of species cannot be used for definition of a GSSP near the current base of the Serpukhovian, we will search for a suitable lineage and taxon at a either a slightly higher or lower stratigraphic level. The majority of the task group members are strongly opposed to selecting a position as low as the first evolutionary occurrence of *Gnathodus bilineatus* near the middle Asbian.

3. The first evolutionary appearance of the foraminifer "*Millerella" tortula* might be used for either defining a GSSP near the current Viséan-Serpukhovian boundary or for assisting with global correlations near the boundary, if the controversy about the phylogeny of the species is favorably resolved.

4. Whatever taxon is used for boundary definition, we will retain the name Serpukhovian for the upper stage of the Mississippian unless a clear majority of our task-group members think the use of Serpukhovian is no longer appropriate.

5. As soon as a suitable taxon has been found for GSSP definition, we will advance rapidly with the Viséan-Serpukhovian boundary project.

Immediate Work Plans

1) Examine North American conodont collections for key taxa within the *Lochriea* group of species.

2) Measure selected sections in relatively deep-water successions that cross the Viséan-Serpukhovian boundary in the southern Rockies of western Canada and in western Utah to search for the *Lochriea nodosa – Lochriea ziegleri* lineage and other suitable lineages within the *Lochriea* group of species.

3) Reevaluate the phylogeny of "*Millerella" tortula*.

4) Look for other taxa that could either be used to define the Viséan-Serpukhovian GSSP or assist with global correlations at that level.

References

Barnett, A.J., P.M. Burgess, and V.P. Wright. 2002. Icehouse world sea-level behavior and resulting stratal patterns in late Viséan (Mississippian) carbonate platforms: integration of numerical forward modeling and outcrop studies. Basin Research, 14:417-438.

Belka, Z. 1991. Potential conodont levels for intercontinental division of the Lower Carboniferous. Courier Forschungsinstitut Senckenberg, 130:11-14.

Brenckle, P.L. 1991. Foraminiferal division of the Lower Carboniferous/Mississippian in North America. Courier Forschungsinstitut Senckenberg, 130:65-78.

Brenckle, P.L., and J.R. Groves. 1981. Evolution of eostaffellid foraminifers in late Chesterian (Late Mississippian) strata of the North American Midcontinent. Geological Society of America Abstracts with Programs, p. 416.

Gibshman, N.B. 2001. Foraminiferal biostratigraphy of the Serpukhovian Stage stratotype (Zaborie quarry, Moscow Basin). Newsletter on Carboniferous Stratigraphy, 19:31-34.

Gibshman, N.B. 2003. Foraminifera characteristic of the Serpukhovian Stage Sratotype in Zaborie quarry (Moscow area). Stratigraphy and Geological Correlation, 11:39-63. (In Russian, English)

Gibshman, N.B., and D.V. Baranova. 2003. Foraminifera *Janischewskina* and *Millerella*; their evolutionary pattern and biostratigraphic potential. Abstracts, XVth International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 175-177.

Kabanov, P.B. 2003. Serpukhovian Stage Stratotype in the Zabor'e quarry, Part 1: lithofacies characterization. Stratigrafiya Geologicheskaya Korrelyatsiya, 11:20-38.

Nemirovskaya, T., M-F. Perret, and D. Meischner. 1994. *Lochriea ziegleri* and *Lochriea senckenbergica* – new conodont species from the latest Viséan and Serpukhovian in Europe. Courier Forschungsinstitut Senckenberg, 168:311-317.

Nikokaeva, S.V., and J. Kullmann. 2001. Problems in lower Serpukhovian ammonoid biostratigraphy. Newsletter on Carboniferous Stratigraphy, 19:35-37.

Nikolaeva, S.V., N.B. Gibshman, E.I. Kulagina, I.S. Barskov, and V.N. Pazukhin. 2002. 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). Newsletter on Carboniferous Stratigraphy, 20:16-21.

Skompski, S., A. Alekseev, D. Meischner, T. Nemirovskaya, M-F. Perret, and W.J. Varker. 1995. Conodont distribution across the Viséan/Namurian boundary. Courier Forschungsinstitut

Senckenberg, 188:177-209.
Smith, L.B., and J.F. Read. 2000. Rapid onset of late Paleozoic glaciation on Gondwana: evidence from Upper Mississippian strata of the Midcontinent, United States. Geology, 28:279-282.
Titus, A., and N. Riley. 1997. Recognition and correlation of eustatic flooding events in the late Viséan of Utah (SW USA) and Britain (NW Europe). Newsletter on Carboniferous Stratigraphy, 15:19-22.
Wang, Zhi-hao, and Yu-ping Qi. 2003. Report on the upper Viséan-Serpukhovian conodont zonation in south China. Newsletter on Carboniferous Stratigraphy, 21: 22-24.

Report from the Task Group to establish a GSSP close to the existing Bashkirian-Moscovian boundary

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New Members

It is a pleasure to report that Drs. Luis C. Sanchez de Posada, Maria-Luisa Martinez, Carlos A. Mendez, and Rosa-Maria Rodriguez have joined the previously announced 17 members of our Task Group as collaborators with Elisa Villa. This team of Spanish researchers has received government funding to work on the Bashkirian-Moscovian transition in the Cantabrian Mountains.

Progress toward Identifying a Basal Moscovian Marker

Our Task Group held its first meeting in Utrecht in connection with the XV ICCP (August 2003). Seven members of our group along with SCCS Chairman Philip Heckel and several members of the Moscovian-Kasimovian boundary group attended the meeting. Discussion centered on developing a strategy for selecting a lower Moscovian GSSP by 2008. As an outgrowth of the Utrecht meeting, Task Group members were asked to submit formal proposals for boundary-defining datums by Spring, 2004. Tamara Nemyrovska and other conodont specialists within the Task Group jointly prepared a detailed proposal that was submitted in early April and is presently being edited. Once finalized, the proposal will be circulated throughout the entire Task Group for internal review and commentary.

Briefly, the document prepared by Nemyrovska et al. identifies two independent conodont events as potential boundary-defining datums: 1) the evolutionary origin of *Declinoghathodus donetzianus* from *D. marginodosus*; and 2) the evolutionary origin of *Idiognathoides postsulcatus* from *I. sulcatus*. The proposal includes unambiguous taxonomic characterizations of both potential marker taxa, along with documentation of their known stratigraphic and geographic occurrences and occurrences of important auxiliary taxa from other biotic groups.

It appears likely that the eventual boundary-defining marker will be a conodont, as no other proposals were submitted. Earlier, in response to a survey that was circulated immediately after the formation of the Task Group, several events within fusulinoidean lineages were identified as occurring near the Bashkirian-Moscovian transition: 1) evolutionary changes within the *Profusulinella* phylogeny; 2) the evolutionary appearance of *Aljutovella* (from *Profusulinella*); 3) the evolutionary appearance of *Neostaffella* (from *Pseudostaffella*); and 4) the evolutionary appearance of *Eofusulina* (from *Verella*). It is clear, however, that none of these events possesses optimal global correlation potential. The genera *Aljutovella*, *Neostaffella,* and *Eofusulina* are limited in their geographic distributions to Eurasia, with no known occurrences in subarctic North America or South America. The genus *Profusulinella* is more widespread, but its level of appearance in North and South America is demonstrably much younger than in Eurasia.

Related Activities

Task Group members Elena Kulagina, Elisa Villa, and John Groves received a two-year (2003-04) “Collaborative Linkage Grant” from NATO’s Scientific Affairs Division to work on the evolutionary origin of the fusulinoidean *Profusulinella* and its relation to the Bashkirian-Moscovian boundary.

Task Group member Uwe Brand received a five-year Discovery Grant from NSERC (Natural Sciences and Engineering Research Council of Canada) to conduct biochemostratigraphic work on Carboniferous and Devonian carbonates. Some of the funds will support work on the Bashkirian-Moscovian boundary.

Progress on the search for a fossil event marker close to the Moscovian-Kasimovian boundary

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The Task Group to establish the Moscovian-Kasimovian and Kasimovian-Gzhelian boundaries has continued studies on potential levels of correlation and fossil lineages within the interval from the uppermost Moscovian to lower Gzhelian. Conodonts, although exhibiting some provincialism, show the greatest potential for intercontinental correlation at both boundaries. Fusuline faunas exhibit stronger provincialism, but the discovery of the Eurasian genus *Protriticites* in the western USA in mid-upper Desmoinesian strata (Wahlman et al., 1997) has kept that option open, since typical or advanced representatives of *Protriticites* have been used to define the traditional base of the Kasimovian in various Eurasian regions (Davydov, 2003).

Main Conodont Lineages around the Moscovian-Kasimovian Boundary

Regarding the Moscovian-Kasimovian boundary, conodont faunas are being intensively investigated in several relevant areas, with new data from the Midcontinent and Paradox Basins in North

America (Ritter et al., 2002), the Cantabrian zone of Spain, and the Moscow and Donets Basins, and southern Urals of eastern Europe. Two major conodont faunas characterize lower Kasimovian strata in eastern Europe and the Desmoinesian-Missourian boundary strata in North America:

A) The lower fauna, in the lower Kasimovian Kreviakinian Substage and in the upper Desmoinesian Stage, is characterized by the occurrence of a troughed clade (recently named *Swadelina* Lambert, Heckel, and Barrick, 2003 to distinguish it from the younger troughed true *Streptognathodus*), along with species of *Idiognathodus*, the genus that dominates upper Moscovian and middle Desmoinesian strata. *Swadelina* includes two closely related species *Sw. neoshoensis* and *Sw. nodocarinata* in North America, and apparently also *"Sw." makhlinae* in eastern Europe.

B) The upper fauna in the lower middle Kasimovian Khamovnikian Substage and lower Missourian Stage is dominated by a group of *Idiognathodus* morphotypes that include *I. sagittalis* in eastern Europe and *I. sulciferus* and its descendant *I. eccentricus* in North America. As a result of a meeting of conodont workers A. Alekseev, J. Barrick, N. Goreva, and T. Nemyrovska in Moscow in May-June 2003, *I. sagittalis* is now recognized to occur with *I. sulciferus* and *I. eccentricus* in the two lowest Missourian cyclothems in the North American Midcontinent.

Preliminary Proposals on Moscovian-Kasimovian Boundary Markers

At the 2002 task group meeting in Ufa, Russia, task group members commenced to discuss the potential of some particular taxa for being boundary markers. A. S. Alekseev indicated that the conodont lineage that includes *I. sagittalis* now appears to hold more promise for providing a correlatable evolutionary event upon which to base a GSSP than do previously considered older lineages in the upper Moscovian. An event in the *I. sagittalis* lineage would be slightly younger than the traditional base of the Kasimovian around Moscow, and would be closer to the Desmoinesian-Missourian regional boundary established in North America (Heckel et al., 2002), which is based on the first appearance of *I. eccentricus*, a taxon that is related to the *I. sagittalis* lineage. The idea of raising the lower Kasimovian boundary is opposed by V. Davydov, who believes that this boundary should remain at its traditional level and be defined on an evolutionary event within a lineage from primitive to advanced *Protriticites*. S. Remizova supported a younger boundary (closer to the appearance of *I. sagittalis*) at the first appearance of *Montiparus* because it is more easily recognized than fusuline taxa around the traditional base of the Kasimovian (Remizova, 2003).

In May 2003, four conodont specialists, A. Alekseev, J. Barrick, N. Goreva, and T. Nemyrovska, met in Moscow to work on the taxonomy of the group of morphotypes that includes *I. sagittallis, I. eccentricus, I. sulciferus*, and their relatives, and to delineate an event that can be identified in Russia, the Ukraine, the U.S., and other parts of the world where marine rocks exist across this boundary. Some progress was made, including recognition of *I. sagittalis* in the U.S. (as mentioned above), but further taxonomic work is not yet completed. Two North American species, including *I. eccentricus*, have been reported by C. Mendez from Spain (Méndez, 2002) in their expected positions with respect to the fusuline correlation with the Moscow region. Alekseev and his Moscow colleagues have intensified their search for potential GSSPs by recollecting a more complete Afanasievo section in the Moscow region and the Dalniy Tyukas 2 section in the southern Urals that was visited during the 2002 meeting (Alekseev et al., 2002).

Discussions continued during the 2003 Task Group meeting that was held at the XV- ICCP (Utrecht, August 2003). This meeting was attended by members V. Davydov, H. Forke, N. Goreva, P. Heckel, M. L. Martinez Chacon, T. Nemyrovska, C. Okuyucu, L. C. Posada, S. Remizova, R. Rodriguez, K. Ueno, and E. Villa. Task group leader E. Villa summarized the advantages and disadvantages of the three biostratigraphic candidates proposed at the Ufa meeting as markers for a Moscovian-Kasimovian boundary:

Proposal A: First Appearance of Advanced *Protriticites*

Advantages: It would be placed close to the present Moscovian-Kasimovian boundary, so that the traditional position of this boundary would be preserved. *Protriticites* is present in the most important Carboniferous areas from Eurasia and in the western part of North America.

Problems: The fossil marker proposed is a genus, whose identification is usually more subjective than the recognition of a species. The recognition of the main diagnostic feature (a wall pierced by distinct pores) depends greatly on preservation. This type of wall might appear diachronously in different species groups leading from *Fusulinella* to *Protriticites*. *Protriticites* has not been found so far in the North American Midcontinent.

Proposal B: First Appearance of *Montiparus*

Advantages: Present in most important Carboniferous areas of Eurasia and probably occurring also in western North America. Close to (usually slightly higher than) a level bearing potential for conodont correlation, which would allow a combined usage of both fossil groups in long distance correlations.

Problems: The taxon proposed is a genus. Its type of wall might appear diachronously in different species groups leading from *Protriticites* to *Montiparus* (the same problem as with *Protriticites*). *Montiparus* has not been found so far in the Midcontinent. It is uncertain if the North American forms, if present, are directly linked to the Eurasian forms

Proposal C: First Appearance of *Idiognathodus sagittalis*

Advantages: Present in most important Carboniferous areas from Eurasia and North America. It always appears above *Swadelina* and close to the fusuline *Montiparus* where the latter two are present. Most conodont-bearing organisms were probably pelagic and thus should have wider species distribution than benthic organisms.

Problems: The isochronous appearance of *I. sagittalis* [and of its other associates such as *Montiparus*] throughout its geographic range need to be evaluated with independent evidence.

Distinction of *I. sagittalis* from closer forms may be difficult.

After debating these proposals, attendants agreed that during the following months group members will work on completing the relevant phylogenies and on correlating the areas involving as many taxa as possible. The next meeting is planned for Oviedo, Spain, in August 2004.

Advances on the Correlation of the Kasimovian-Gzhelian Boundary

Regarding the Kasimovian-Gzhelian boundary, discussions between J. Barrick and A. Alekseev at the 2003 meeting in Moscow focused attention on using the first appearance of *Idiognathodus simulator* in its strict sense to define the base of the Gzhelian, because that taxon, which was named from North America, is found near the base of the Gzhelian in both the Moscow and southern Urals region of Russia. This taxon would be more appropriate than *Streptognathodus zethus*, which has been used informally in some recent reports, because *S. zethus* was named from upper Kasimovian strata in the southern Urals. In further discussions with P. Heckel, ammonoid workers D. Work and D. Boardman expressed strong support for using *I. simulator s.s*. because it is more consistent with the classic ammonoid boundary used in the Urals when correlated with the ammonoid succession in the southern Midcontinent of North America. This idea was further supported by Russian colleague B. Chuvashov and other European colleagues at an October 2003 meeting attended by P. Heckel and A. Alekseev in Potsdam Germany. J. Barrick is working on the taxonomy of its descent from its ancestor *I.* aff. *simulator* in the upper Missourian of North America.

References

Alekseev, A.S., N.V. Goreva, E.I. Kulagina, O.L. Kossovaya, T.N. Isakova, and A.N. Reimers. 2002. Upper Carboniferous of South Urals (Bashkiria, Russia). Guidebook of the Field Trip of the Working Group to establish a GSSP in the upper part of the Carboniferous System (SCCS Project 5), August 2002, Moscow and Ufa, 56 p.

Davydov, V.I. 2003. Evolution of *Protriticites* and its utilization in the Moscovian/Kasimovian boundary definition. Abstracts, XV International Congress on Carboniferous and Permian Stratigraphy, Utrecht 2003, p. 111-113.

Heckel, P.H., D.R. Boardman, and J.E. Barrick. 2002. Desmoinesian-Missourian regional stage boundary reference position for North America, p. 710-724. *In* L.V. Hills, C.M. Henderson, and E.W. Bamber (eds.), Carboniferous and Permian of the World. Canadian Society of Petroleum Geologists Memoir, 19.

Lambert, L.L., P.H. Heckel, and J.E. Barrick. 2003. *Swadelina* new genus (Pennsylvanian Conodonta), a taxon with potential chronostratigraphic significance. Micropaleontology, 49:151-158.

Méndez, C.A. 2002. Upper Carboniferous conodonts (upper Moscovian-middle Kasimovian) from the Las Llacerias section (Cantabrian Mountains, North Spain). Abstracts, ECOS-VI (European Conodont Symposium VII), Toulouse, France.

Remizova, S.T. 2003. Fusulinoida of the Kasimovian/Gzhelian strata from Northern Timan. Abstracts, XV International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 435-437.

Ritter, S.M., J.E. Barrick, and M.R. Skinner. 2002. Conodont sequence biostratigraphy of the Hermosa Group (Pennsylvanian) at Honaker Trail, Paradox Basin, Utah. Journal of Paleontology, 76:495-517.

Wahlman, G.P., G.J. Verville, and G.A. Sanderson. 1997. Biostratigraphic significance of the fusulinacean *Protriticites* in the Desmoinesian (Pennsylvanian) of the Rocky Mountains, western U.S.A., p. 163-168. *In* C.A. Ross, J.R.P. Ross, and P.L. Brenckle (eds.), Late Paleozoic Foraminifera; Their Biostratigraphy, Evolution, and Paleoecology, and the Mid-Carboniferous Boundary. Cushman Foundation for Foraminiferal Research Special Publication, 36.

Activities of the Project Group "Upper Paleozoic boreal biota: stratigraphy and biogeography"

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This project is investigating the biogeographic patterns and trends in connection with the problems of Carboniferous and Permian stratigraphy. This past year the studies were concentrated on zonation of the Mississippian [Lower Carboniferous] plant cover of Euramerica and Angaraland. Yu.V.Mosseichik (Moscow) composed schemes of paleofloristic zonation for the territory of Angaraland during the Tournaisian, Viséan, and Serpukhovian, and outlined some basic mechanisms of phytochorion formation (see her report "Paleophytogeography and stratigraphy of Mississippian [Lower Carboniferous] plant-bearing deposits of Angaraland" in this issue of Newsletter on Carboniferous Stratigraphy). Recent investigations in the field of Late Paleozoic phytogeography show the necessity of subsequent development of zonation schemes in the following directions (Durante et al., 2004, in litt.):

1. Reconstruction of landscape-geographic and climatic characteristics of phytochoria.

2. Recognition of the main types of paleophytogeographic boundaries and the reconstruction on this basis of the characteristics of Carboniferous phytochorion boundaries and their changes in space and time.

3. Elaboration of criteria for comparison of ancient floras.

4. Precision of the rank of phytochoria according to their endemism patterns.

5. Reconstruction of main plant migration paths in the process of ancient phytochorion development.

6. Investigation of influence of the macroevolutionary, geologic, climatic and other events on ancient phytochorion formation.

The strategic direction of investigations in Carboniferous paleophytogeography seems to be in a transition from static schemes of palaeofloristic zonation (panoramas) to dynamic phytogeographical models (scenarios), in order to develop a general theory (model) of evolution of plant cover (Meyen, 2002).

* * *

In the next 4 years the activities of this project group will concentrate particularly on the realization of two subprojects concerning the problems of Carboniferous biogeography and stratigraphy.

Subproject 1. Biotas and Cooling Events in the Middle of the Carboniferous

This subproject provides investigation of the influence of supposed cooling events in the middle of the Carboniferous ("Ostrogsky" episode in Angaraland, the beginning of Gondwanan glaciation, etc.) on the continental and marine biotas, in order to recognize the coincidence and causal relations of these events, as well as to estimate their stratigraphic potential.

The investigations will focus particularly on the interdisciplinary regional study of the Mississippian [Lower Carboniferous] of the Kuznetsk and Minussinsk Basins (Angaraland), of the Moscow coal Basin (eastern periphery of Euramerica), as well as of the other boreal and mentioned regions. The aim is to document biotic changes in the late Viséan–early Serpukhovian, which are supposed to be connected with the global cooling at that time (Durante, 1995, 2000; Ganelin and Durante, 2002; Meyen, 1968; etc.), as well as to analyze other possible causes of these changes (Mosseichik and Ignatiev, 2003).

The subproject envelops the following main fields of investigation:

1. *Paleobotany.* The macro- and palynofloral data will be examined to determine chronologic and geographic changes of the main types of ancient vegetation.

2. *Paleozoology.* The changes of terrestrial invertebrates and (if available) vertebrates will be investigated in connection with the floral restructurings.

3. *Sedimentology.* The climatically sensitive characters (coals, red-beds, etc.) of flora- and fauna-bearing deposits will be studied to determine the possible influence of cooling events and other abiotic factors.

4. *Stratigraphy.* The time and causal relations of biotic changes with climatic, tectonic and other abiotic events will be examined to determine the stratigraphic potential of these changes for interregional and global correlations.

The regional coordinator of the subproject in Russia and in the countries of the former USSR is Yulia V. Mosseichik (e-mail: mosseichik@ginras.ru). The overall subproject leader is Marina V. Durante (durantemv@ginras.ru).

Subproject 2. Terrestrial Floral Differentiation in the Mississippian [Early Carboniferous]

This subproject provides the composition of zonation schemes for Touranaisian, early and late Viséan, and Serpukhovian vegetation, as well as the investigation of regularities of phytochorion formation at that time. The aim is to examine an initial stage of the Earth's plant-cover differentiation, particularly connected with evolutionary radiation and spreading of the early gymnosperms.

The investigations will focus on zonation of the terrestrial vegetation of Angaraland, Gondwanaland, Euramerica, the Kazakhstan microcontinent, and other Mississippian landmasses.

The subproject particularly implies:

1. Elaboration of principles of paleofloristic zonation, taking into consideration the peculiarities of plant-cover composition and structure.

2. Interpretation of climatic, landscape and florogenetic connections of the main phytochorions.

3. Investigation of parallel (convergent) plant evolution in the North and South extratropical latitudes to determine its bearing on the Earth's phytogeographic structure.

4. Examination of common traits in the geographic distribution of Mississippian land flora and fauna, conditioned by latitudinal climatic zonality and the most important biogeographical barriers to dispersal; the segregation of biochoria.

The regional coordinator of the subproject in Russia and in the countries of the former USSSR is Yulia V. Mosseichik (mosseichik@ginras.ru). The overall subproject leader is Igor A. Ignatiev (ignatievia@ginras.ru).

* * *

Anyone who is interested in participating in the subprojects should contact the relevant regional coordinator or the overall subproject leader.

References

Durante, M.V. 1995. Reconstruction of Late Paleozoic climatic changes in Angaraland according to phytogeographic data. Stratigraphy and Geological Correlation, 3(2):123-133.

Durante, M.V. 2000. Global cooling in the Middle Carboniferous. Newsletter on Carboniferous Stratigraphy, 18:31-32.

Durante, M.V., I.A. Ignatiev, and Yu.V. Mosseichik. 2004. Perspective investigation themes in the field of Late Palaeozoic palaeophytogeography. Unpublished manuscript. Moscow. 5 p. (In Russian)

Ganelin, V.G., and M.V. Durante. 2002. Biostratigraphy of the Carboniferous of Angaraland. Newsletter on Carboniferous Stratigraphy, 20:23-26.

Meyen, S.V. 1968. On the age of Ostrogskaya Suite of the Kuznetsk basin and on the analogous of the Namurian in the continental deposits of Northern Asia. USSR Acad. of Sci. Reports, 180(4): 944-947. (In Russian)

Meyen, S.V. 2002. Main problems of palaeofloristics, p. 119-121. *In* Sbornik pamiati chlena-korrespondenta AN SSSR, professora Vsevoloda Andreevicha Vakhrameeva. GEOS, Moscow. (In Russian)

Mosseichik, Yu.V., and I.A. Ignatiev. 2003. Did the "Ostrogsky episode" really exist? Newsletter on Carboniferous Stratigraphy, 21:26-29.

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.

Updated cyclothem grouping chart and observations on the grouping of Pennsylvanian cyclothems in Midcontinent North America

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Since my previous article on this subject, more information has come to my attention, mainly about the scale and grouping of cyclothems, such that it seems appropriate to update the cyclothem grouping chart that appeared in Heckel (2003). In addition, I have been urged to add to the grouping chart the first appearances of conodont species, many of which define the lower boundaries of the conodont zones that recently have been established by my colleagues and I (Barrick et al., in press 2004), supplemented by later information from Boardman et al. (this volume), in order to facilitate the global correlation of these units. Because I am not aware of any new germane North American radiometric dates, I have not recomputed the cyclothem calibration charts at this time. However, the cyclothem regrouping plus the clarification of the exact stratigraphic position of one of the previous Appalachian dates require further comments on the cyclothem calibration of the existing dates.

Cyclothem Groupings

A combination of recent field and lab work by D. R. Boardman and my formal review of an extensive manuscript on the Pennsylvanian stratigraphy of Missouri, has led to changes in the cyclothem groupings that appeared on Figure 1B in Heckel (2003). The most extensive of these changes involve the lower Desmoinesian (mid-Moscovian) Cherokee Group [McCurtain through Breezy Hill on Figure 1, right side], for which the first sea-level curve was presented by Boardman et al. (2002). Boardman et al. (this volume) reevaluated some of the cyclothem exposures in the slope to basin-margin region of northeastern Oklahoma where they were first defined, and eliminated or reduced the scale of some of them. Considering that this succession was apparently deposited on a greater slope than in the shelf area of Kansas, Missouri and northward, the criterion of black fissile phosphatic shales as characterizing only major cyclothems (of the same scale as the younger Desmoinesian, Missourian, and Virgilian major cyclothems that contain dark phosphatic shales across the entire shelf into Iowa and Nebraska) appears not to be diagnostic in some cases. Upon examining the Cherokee cycles in Missouri, both via the literature and outcrop visits, I have reduced the scale of several of the same cyclothems and regrouped many of the lesser cycles into fewer groupings of inferred 400-k.y. scale (Figure 1, right side). I realize that part of the reason for the lack of many well developed black fissile shales across the shelf at this time was due to the generally lower sea-level stand during early Cherokee deposition. However, it appears that several cycles of lesser scale (determined as such by the lack of much, if any, marine sediment above their equivalent coal in Missouri) did develop dark phosphatic shale facies on the greater slope in Oklahoma. This is not surprising considering that upwelling would be more likely facilitated on a slope during a smaller inundation than on a shelf. The generally lower sea level at highstands is nonetheless reflected in most of the remaining major Cherokee cyclothems that do extend across Missouri into Iowa, as they appear to display a greater amount of lateral facies changes among black and dark gray shales and lime packstones and wackestones, along with less predictable vertical differentiation of lithic types than are seen in the younger major cyclothems across the shelf (e.g., Heckel, 2002). Therefore, I now recognize only 5 major cyclothems and associated groupings [McCurtain, Doneley, Inola, Tiawah, and Verdigris] in the Cherokee Group instead of the 9 major cyclothems and 8 groupings shown in 2003. In the upper Cherokee, I added two additional minor cyclothems [Post-Robinson Branch, Post-Wheeler] to the Verdigris grouping. These are traced across a large part of Missouri (Gentile and Thompson, in review), but are not yet detected in Oklahoma where the otherwise more complete succession of older Cherokee units was summarized by Boardman et al. (2002; this volume).

There are fewer changes to the chart in the previously better known part of the succession above the Cherokee Group. Most of these involve the recognition of minor cycles within previously named cyclothems by means of previously undetected conodont-rich shales in limestone units by D. R. Boardman and his students throughout the Virgilian (Gzhelian), and by J. P. Pope and his students in the Missourian and lower Virgilian (Kasimovian-Gzhelian). Those that occur within transgressive or regressive limestone members not previously named on the chart are added with the prefixes 'Mid-' or 'Upper' before the member name. Those that occur within units already named on the charts are denoted by the + symbol after the unit name to save space. Because nearly all of these additions appear to represent reversals of sea-level trend within an intermediate or minor cycle, or within the transgressive or regressive member of a major cyclothem (and are thus at the parasequence scale), they increase the number of minor cycles recognized, but do not change the cycle groupings at the 400-k.y. scale.

Evolving Methods for Delineating 400-k.y. Cyclothems

At this stage of our knowledge, it is reasonable to accept the concept that the sea-level fluctuations responsible for the Pennsylvanian cyclothems are controlled by changes in ice sequestration on polar continents driven by climatic changes that are related to changes in solar insolation caused by variation in the Earth's orbital parameters, even though the exact linkages between the orbital variations and the changes in ice volume are not yet worked out. Therefore, from a strictly hypothetical point of view, a ~400-k.y. cyclothem [controlled by the long eccentricity parameter] should comprise approximately 20 identifiable fluctuations of sea level, considering that the shortest orbital parameter [precession] is close to ~20 k.y. in duration. The intermediate orbital parameters of ~40 k.y. [obliquity] and ~100 k.y. [short eccentricity] (along with the fact that the actual parameter periods are not exact multiples of one another), would generate a fair amount of irregularity in their modulation of the magnitude of ice volume changes, hence sea-level fluctuations, and thus give rise to both the intermediate cyclothems and the various different sequences of minor, intermediate, and major cyclothems that occur within the particular 400-k.y. groupings.

In making the 400-k.y. groupings, I have assumed that a grouping would contain no more than one major cyclothem, but it hypothetically could contain up to ~20 changes in sea level, which could be manifest in cycles of any smaller scale. It is tempting to relate the intermediate cyclothems to the 100-k.y. parameter, but while some of them are distributed evenly throughout the grouping, others are concentrated unevenly in the upper or lower part (Figure 1). Moreover, two or three 100-k.y. parameter cycles could be integrated into one major cyclothem, depending on the poorly understood linkages between the different orbital parameters and changes in ice volume. It is obvious from the chart that the current greatest number of readily detected cyclothems in any grouping is 8, somewhat short of the 20 that might be expected. In addition to the fact that more minor cycles are very likely to be found as work continues, there are other reasons why more cycles may not be found at the scale of most current field and lab work. Obvious reasons relate to relative elevation and slope of the shelf with respect to the range of sea-level change. If the shelf is high enough, only the greatest inundations will reach it and deposit marine sediment, as in the Appalachian region during later Pennsylvanian time (Heckel, 1994, Fig. 8). If the shelf is low enough, it will receive all of the minor and intermediate as well as the major inundations, but many of the minor cycles that are contained within the greater transgressions and regressions may not be detectable in depositional settings of water depth great enough to encompass the same facies throughout a depth range greater than that of the sea-level fluctuation (the concept of 'missed beats').

As mentioned in Heckel (2003), the work of Nadon and Kelly (2004) in the high-shelf Appalachian region has uncovered several minor T-R cycles of marine deposition within a general marine unit [Ames] recognized as equivalent to a single major cyclothem [Oread] in the Midcontinent, which has a widespread conodont-rich dark phosphatic shale that represents a long period of sediment starvation and condensed deposition. The several minor cycles involving thin marine units above paleosols that are seen in the several meters of this interval in the Appalachian region are presumably hidden in the typically few decimeters to centimeters of deep-water Heebner Shale in the Midcontinent. Very recently, however, Algeo et al. (2004) illustrate a detailed geochemical transect of the unburrowed black phosphatic facies of the offshore Hushpuckney Shale [Swope cyclothem, the sixth major cyclothem below the Oread] from a Kansas core, which shows about 12 cycles of variation in trace metals and organic carbon that appear to represent minor fluctuations in climate (and perhaps in sea level) that would be otherwise undetectable in this deep-water facies. These thus could be the minor cycles that are manifest on outcrop as observable sea level changes only on the Appalachian high shelf [but for the Hushpuckney, these would be in the equivalent Brush Creek marine unit, well below the Ames]. If this type of minor cyclicity becomes identified in the condensed black phosphatic shales of the other major cyclothems, and if it can be shown to be related to sea-level change, then we are approaching the possibility that most of the 20 smallest cycles are incorporated within the condensed part of the major cyclothems on the low shelf region of Kansas. This would appear to justify my original assumption of including no more than one major cyclothem in a 400-k.y. grouping.

The boundaries between the major cyclothems (hence between the 400-k.y. groupings) are obvious in the well-developed paleosols and incised surfaces between the marine units in the high-shelf Appalachian region (Heckel et al., 1998), where the sea was some distance away for long periods of time between the major marine inundations. However, the boundaries between the inferred 400-k.y. groupings become more difficult to determine lower on the shelf, where the marine deposits of lesser inundations intervene between the major cyclothems, and the paleosols become less distinctive. The problem thus becomes where to place the grouping boundaries low on the shelf, that is, between which of the many lesser cyclothems that intervene between the major cyclothems. The general working consensus is to place them at the exposure surfaces that extend the farthest basinward, or at the horizons of greatest incision (as Boardman et al., this volume, show for much of the Cherokee), but either of these is often not evenly spaced between what would be considered reasonable 400-k.y. groupings. For example, the 2003 mid-Missourian Dewey cycle grouping contained only the Dewey major cyclothem because the paleosols and exposure surfaces both above and below it extend far southward into Oklahoma, with significant incision on the overlying surface removing the Dewey in much of the Kansas-Oklahoma border area. To achieve better consistency, I now have combined the Dewey with the underlying Cherryvale grouping to form the new Cherryvale-Dewey grouping that is closer in scale [one major, one intermediate, and three minor cycles] to the other Missourian groupings (Figure 1). In some cases distinctive changes in conodont faunas are used to delineate grouping boundaries, but the fact that a major change of *Streptognathodus* species appears to take place within the offshore Eudora shale of the major Stanton cyclothem suggests that this procedure is not entirely dependable either. At this point, cycle grouping still remains at least partly an art.

Changes in Calibration of Radiometric Dates

The recognition of additional minor cycles by any of these methods obviously shortens the average cycle length of all cycles, but it may be some time before very many of the shortest cycles can be identified and the average computed cycle length approaches 20 or even 40 k.y. Taking the currently recognized twenty-six 400-k.y. cycle groupings as representing 10.4 m.y., the

2004 CHART OF MIDCONTINENT PENNSYLVANIAN CYCLOTHEMS, GROUPINGS, AGE DATES, AND CONODONT ZONES

N. Am. Stage	Cyclothems of all scales	Cyclothem Grouping [~400 k.y.]	Date [Ma]	First appearance of significant conodonts, with bold face indicating base of zones
Virgil	Mid-Johnson Long Creek **UPPER HUGHES CREEK** **Middle Hughes Creek** Lower Hughes Ck + **Americus** Basal Americus	**FORAKER** [formation name] **[III of O&P 2003,** **with 12 cycles]**	301±2 [R]	***Streptognathodus wabaunsensis***
	Upper Hamlin Lower Hamlin **Five Point +** West Branch **Falls City +**	**Admire** [group name] **[=Falls City-Five Point,** **II of O&P 2003,** **with 9 cycles]**		*Streptognathodus flexuosus* *Streptognathodus alius*
	Aspinwall **Brownville** Grayhorse Nebraska City French Creek Jim Creek **Grandhaven** **Dover-Dry**	**Richardson** [subgroup name] **[I of O&P 2003,** **with 8 cycles]**		***Streptognathodus brownvillensis****; S. bellus*
	Maple Hill Wamego Tarkio **Elmont** **Reading** **Wakarusa +** **Burlingame**	**Nemaha** [subgroup name]		[position of holotype of *S. virgilicus*]
	Silver Lake **Rulo** Happy Hollow White Cloud **Winzeler** **HOWARD [Shng Ck/Aarde]**	**HOWARD**		
	Bachelor Creek **TOPEKA [Holt]** Mid-Dubois Sheldon	**TOPEKA**		[holotype of *S. holtensis*]
	Curzon **Hartford +** **DEER CK [Larsh-Burroak] +** Ozawkie	**DEER CREEK**		*S. holtensis*
	Ost **Avoca** Mid-Beil **LECOMPTON [Queen Hill]** **Spring Branch**	**LECOMPTON**		***Streptogn. virgilicus [s.l.]****; S. ruzhencevi*
	Clay Creek Kereford/Elgin Mid-Plattsmouth **OREAD [Heebner]** **Toronto**	**OREAD**		*I. lobulatus* ***Idiognathodus simulator [s.s.]****; I. tersus*
Virgil **M'sou**	Amazonia **CASS [Little Pawnee]** Westphalia	**CASS**		***Streptognathodus zethus***
	Iatan **South Bend [Gretna]** **STANTON [Eudora]** Birch Creek **Plattsburg [Hickory Creek]**	**STANTON**	307±3 [R]	*S. pawhuskaensis* ***Idiognathodus* aff. *simulator****; S. firmus* [*S.* sp. with bent trough axis dominant]
	Upper Farley Lower Farley **Wyandotte [Quindaro]** **IOLA [Muncie Creek]** Mid-Chanute	**IOLA**	**[B]** **294±6**	*Streptognathodus* sp. with bent trough axis *Idiognathodus* "postmagnificus" **[*S. gracilis* zone, upper part]**

	Upper Cement City **DEWEY [Quivira]** Drum-Westerville **Cherryvale [Block-Wea]** Hogshooter-upper Winterset	**Cherryvale-DEWEY**		*Idiognathodus magnificus [s.s.]* ***Streptog. gracilis****; S. elegantulus; S. excelsus*
	mid-Winterset + **DENNIS [Stark]**	**DENNIS**		[holotype of *Streptognathodus confragus*]
	Mound Valley Mid-Bethany Falls **SWOPE [Hushpuckney]**	**SWOPE**		***Streptognathodus confragus*** ***Streptognathodus cancellosus***
M'sou Desm	Sniabar **HERTHA [Mound City]** Critzer **Exline** Checkerboard-South Mound	**Exline-HERTHA**		*Idiognathodus clavatulus; I.* n. sp. A ***Idiognathodus eccentricus****; I. sagittalis* *I. sulciferus*
	Glenpool **LOST BRANCH [Nuyaka Ck]**	**LOST BRANCH**		[holotype of *Swadelina nodocarinatus*]
	Idenbro **Norfleet** **ALTAMONT [Lake Neosho]** Amoret **Farlington**	**ALTAMONT**	**302±4 [B]**	***Swadelina nodocarinatus*** [holotype of *Swadelina neoshoensis*] ***Swadelina neoshoensis***
	Coal City [Joe] **LOWER PAWNEE [Anna]** Wimer School/Sageeyah	**PAWNEE**		[holotype of *Idiognathodus delicatus*]
	Higginsville **UPR FT SCOTT [Little Osage]**	**UPPER FORT SCOTT**		
	Upper Blackjack Creek **LOWER FT SCOTT [Excello]** Breezy Hill	**LOWER FORT SCOTT**		***Idiognathodus delicatus***
	Post-Bevier Post-Wheeler Upper Ardmore **VERDIGRIS [Oakley]** **Post-Fleming** Post-Robinson Branch **Post-Mineral/Russell Creek**	**VERDIGRIS**		***N. roundyi****;* [holotypes of *I. iowaensis, I. rectus, I. mundulus,* and *G. pohli*] ***Idiognathodus iowaensis***
	Upper Tiawah/Post-Scammon? **POST-TEBO/LOWER TIAWAH** Post-RC Coal Post-Weir-Pittsburg Uppermost Boggy Post-Wainwright	**TIAWAH**		*I. robustus; I. crassadens; N.* cf. *roundyi;* *Gondolella pohli*
	INOLA Post-Peters Chapel Post-Secor Rider Post-Secor Post-Lower Witteville	**INOLA**		***Neognath. asymmetricus****; I. podolskensis*
	Post-Drywood **POST-ROWE/DONELEY** **Sam Creek** Post-Tullahassee Spaniard	**DONELEY**		***Idiognath. obliquus****; N.* cf. *asymmetricus*
Desm	Post-Keota Post-Tamaha Post-Stigler Post-Warner Post-Keefeton **McCURTAIN**	**McCURTAIN**		*Idiognathodus praeobliquus; Neogn. bothrops*
Atoka	Mid-Upper [cycles not identified]			
Atoka	Lower [" " "]		**311±1 [K&R]**	

Figure 1. Chart showing updated estimated 400-k.y. cyclothem groupings, utilizing fewer groupings than in 2003 because of newer information from lower Desmoinesian Cherokee Group and reevaluation of mid-Missourian grouping, both explained in text. Additional minor cycles prefaced by 'Mid-' or 'Upper' are from work of D. R. Boardman and J. P. Pope and their students. Plus sign [+] means that one more minor cycle is now recognized in that named unit. O&P refers to groupings of Olszewski and Patzkowski (2003) in upper Virgilian. Conodont information is from Barrick et al. (in press 2004), modified by Boardman et al. (this volume). **Conodont name in bold face denotes first appearance that also defines base of zone bearing that name.** Scale of cyclothems is shown as follows: **MAJOR CYCLOTHEM [core shale]; Intermediate cyclothem;** Minor cyclothem. **Sources of Appalachian dates: [B] = Becker et al. (2001), [KR] = Kunk and Rice (1994);** Southwestern U.S. dates: [R] = Rasbury et al. (1998).

130 cycles of all scales now recognized in the Desmoinesian through Virgilian interval on Figure 1 have an average computed period of 80 k.y. The reduction in number of presumed 400-k.y. cyclothem groupings from Desmoinesian through Virgilian time from 30 to 26, however, reduces the total length of this time interval from the 2003 grouping by 1.6 m.y., and therefore brings the cyclothem calibration into greater compatibility with an older Carboniferous-Permian boundary closer the ~300 Ma date favored by some workers (e.g., Rasbury et al., 1998). Specifically, if the assumptions of Heckel (2003) are retained that the late early Atokan Appalachian date of 311 Ma (Kunk and Rice, 1994) is accurate and that the middle-late Atokan interval was 3 m.y. long, then the Desmoinesian through Virgilian interval would be 10.4 m.y. long, and the Carboniferous-Permian boundary would be at ~297.6 Ma. Furthermore, reduction of the assumption of the middle-late Atokan duration to 2 m.y. would bring the C-P boundary to 298.6 Ma, even closer to where Rasbury et al. (1998) placed it.

A further comment on the Pennsylvanian radiometric dates currently available from North America is appropriate here because of more recent information I received on the exact stratigraphic position of one of the dated horizons used in the previous calibration (Heckel, 2003). G. C. Nadon of Ohio University showed me where the authors collected the ‘sub-Ames’ paleosol that provided the date of 294$\pm$6 Ma reported by Becker et al. (2001). It was some distance below the Ames Limestone [equivalent to the Midcontinent Oread cyclothem], just above the Portersville marine unit [equivalent to the Iola cyclothem, three 400-k.y. cyclothem groupings below the Oread] near Athens, Ohio, where there are no marine units between the Portersville and the Ames. Therefore, the material providing this date is late Missourian, probably equivalent to the paleosol beneath the Plattsburg cyclothem in the base of the Stanton grouping (Figure 1, left side). This correction moves this radiometric date outside of its 2-sigma error range to nearly 301 Ma on the Heckel (2003, Figure 3, 4B) calibration charts, and even to 302 Ma if the four fewer older cycle groupings in the Desmoinesian and Missourian mentioned above are factored in (making the Desmoinesian through late middle Missourian only fifteen 400-k.y. cycles or 6 m.y. long, which added to the 3-m.y. length of the middle-late Atokan interval makes the paleosol only 9 m.y. younger than the 311 Ma Appalachian date). This correction also places the 294$\pm$6 Ma Appalachian date stratigraphically below the less well biostratigraphically constrained 307$\pm$3 Ma southwestern U.S. date of Rasbury et al. (1998) for the Missourian-Virgilian boundary, making it even less compatible than in previous calibrations. Clearly, more biostratigraphically constrained and systematically collected radiometric dates are needed from central and eastern North America.

References

Algeo, T.J., L. Schwark, and J.C. Hower. 2004. High-resolution geochemistry and sequence stratigraphy of the Hushpuckney Shale (Swope Formation, eastern Kansas). Implications for climato-environmental dynamics of the Late Pennsylvanian Midcontinent Seaway: Chemical Geology, 206:259-288.

Barrick, J.E., L.L. Lambert, P.H. Heckel, and D.R. Boardman. In press 2004. Pennsylvanian conodont zonation for Midcontinent North America. Revista Espanola de Micropaleontologia, 36(2): 231-250.

Becker, M. L., E.T. Rasbury, G.N. Hanson, and W.J. Meyers. 2001. Refinement in the age of the Carboniferous-Permian boundary based on U-Pb dating of biostratigraphically constrained syn-sedimentary carbonates in the Appalachian region of North America. Newsletter on Carboniferous Stratigraphy, 19:18-20.

Boardman, D.R., T.R. Marshall, and L.L. Lambert, 2002. Sea-level fluctuation curve for the Cherokee Group (lower and middle Desmoinesian/upper Moscovian) in the Arkoma-Cherokee Basin area of eastern Oklahoma. Newsletter on Carboniferous Stratigraphy, 20:26-28.

Boardman, D.R., P.H. Heckel, and T.R. Marshall. 2004. Preliminary report on lower Desmoinesian (mid-Moscovian) conodonts from lower and middle Cherokee Group of southern Midcontinent North America: Newsletter on Carboniferous Stratigraphy, 22:41-47.

Gentile, R.J., and T.L. Thompson. In review. Paleozoic succession in Missouri, Part 5, Pennsylvanian Subsystem of Carboniferous System. Missouri Geological Survey Report of Investigation.

Heckel, P. H. 1994. Evaluation of evidence for glacial-eustatic control over marine Pennsylvanian cyclothems in North America and consideration of possible tectonic effects, p. 65-87. *In* J.M. Dennison and F.R. Ettensohn (eds.), Tectonic and Eustatic Controls on Sedimentary Cycles. SEPM Concepts in Sedimentology and Paleontology, 4.

Heckel, P.H. 2002. Genetic stratigraphy and conodont biostratigraphy of upper Desmoinesian-Missourian (Pennsylvanian) cyclothem succession in Midcontinent North America. Canadian Society of Petroleum Geologists Memoir, 19: 99-119.

Heckel, P.H. 2003. Updated cyclothem constraints on radiometric dating of the Pennsylvanian succession in North America and its correlation with dates from Europe. Newsletter on Carboniferous Stratigraphy, 21:12-20.

Heckel, P.H., M.R. Gibling, and N.R. King. 1998. Stratigraphic model for glacial-eustatic Pennsylvanian cyclothems in highstand nearshore detrital regimes. Journal of Geology, 106:373-383.

Kunk, M.J., and C.L. Rice. 1994. High precision $^{40}Ar/^{39}Ar$ age spectrum dating of sanidine from the Middle Pennsylvanian Fire Clay tonstein of the Appalachian Basin. Geological Society of America Special Paper, 294:105-113.

Nadon, G.C., and R.R. Kelly. 2004. The constraints of glacial eustasy and low accommodation on sequence stratigraphic interpretations of Pennsylvanian strata, Conemaugh Group, Appalachian basin, U.S.A., p. 29-44. *In* J.C. Pashin and R.A. Gastaldo (eds.), Sequence Stratigraphy, Paleoclimate, and Tectonics of Coal-Bearing Strata. AAPG Studies in Geology, 51.

Olszewski, T.D., and M.E. Patzkowski. 2003. From cyclothems to sequences: the record of eustasy and climate on an icehouse epeiric platform (Pennsylvanian-Permian, North American Midcontinent). Journal of Sedimentary Research, 73:15-30.

Rasbury, E.T., G.N. Hanson, W.J. Meyers, W.E. Holt, R.H. Goldstein, and A.H. Saller. 1998. U-Pb dates of paleosols: Constraints on late Paleozoic cycle durations and boundary ages. Geology, 26:403-406.

Stratigraphic distribution of the ammonoids *Shumardites* and *Vidrioceras* and implications for the definition and correlation of the global Gzhelian Stage, Upper Pennsylvanian Series

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Traditionally, the Gzhelian Stage of the Moscow Basin and Russian Platform and the regional Virgilian Stage of North America have been considered equivalent and characterized by the *Shumardites–Vidrioceras* ammonoid Genozone (Bogoslovskaya, 1984; Boardman et al., 1994a, b). Ruzhencev (1950) reported ammonoids from the C3JZ horizon of the Zhigulian Stage, which is now included in the lower Gzhelian based upon the fusulinaceans [*Rauserites rossicus, R. paraarcticus,* and *R. stuckenbergi*] that occur with the ammonoids. However, no representatives of *Vidrioceras* Böse, 1919 or *Shumardites* Smith, 1903 occur that low in the stratigraphic sections of the southern Urals. The absence of biostratigraphically significant ammonoids in the Kasimovian-Gzhelian boundary interval in the southern Urals and Moscow Basin necessitates reference to other sections.

Strata on the Eastern Shelf of the Midland Basin (north-central Texas) contain the highest diversity of middle Upper Pennsylvanian ammonoids in the world, including the ancestral taxa of both *Vidrioceras* and *Shumardites* as well as a succession of species of both genera (Boardman et al., 1994a, b). The evolution of *Vidrioceras* and *Shumardites* is of particular significance in defining the Kasimovian-Gzhelian boundary.

Boardman et al. (1994b) demonstrated the polyphyletic nature of the family Shumarditidae based on detailed sutural analysis. They erected the family Parashumarditidae to include a clade of shumarditid-like taxa that shared an asymmetry of the dorsal subdivision of the internal lateral lobe (*Parashumardites* Ruzhencev, 1939; *Aktubites* Ruzhencev, 1955; *Eoshumardites* Popov, 1960; and *Eovidrioceras* Boardman, Work, and Mapes, 1994b).

Eovidrioceras, the proximate ancestor to *Vidrioceras*, is the root stock for the family Vidrioceratidae (Boardman et al., 1994b). *Eovidrioceras* differs from *Vidrioceras* by its lack of tripartation of the umbilical lobe. Boardman et al. (1994b) included *E. inexpectans* Boardman, Work, and Mapes, 1994b and *E. bulakensis* (Popov, 1992) within the genus, to which we now add the morphologically more advanced species *Vidrioceras conlini* Miller and Downs, 1950. Its lateral lobe is similar to *Vidrioceras*, but the umbilical lobe is undivided, making it morphologically intermediate between *Eovidrioceras* and *Vidrioceras sensu stricto*. *Eovidrioceras conlini* is present in both the basal Virgilian Colony Creek Shale in north-central Texas (Figure 1) and the basal Virgilian Little Pawnee Shale Member of the Cass Formation in the North American Midcontinent (Boardman et al., 1989, 1994a, b). The earliest and morphologically most primitive species of *Vidrioceras*, *V. uddeni,* first appears in the middle Virgilian Finis Shale Member of the Graham Formation in north-central Texas (Miller and Downs, 1950; Boardman et al., 1994a, b) and the equivalent Heebner Shale Member of the Oread Formation in the Midcontinent (Boardman et al., 1994a, b).

Boardman et al. (1994b) restricted the family Shumarditidae to include *Preshumardites* Plummer and Scott, 1937, *Pseudaktubites* Boardman, Work, and Mapes, 1994b, and *Shumardites*. The Shumarditidae includes taxa that share an asymmetry of the ventrad subdivision of the internal lateral lobe that is opposite from that of the Parashumarditidae. Boardman et al. (1994a, b) proposed an Upper Pennsylvanian zonation based on a detailed phylogeny of the shumarditid lineage (*Preshumardites* > *Pseudaktubites* > *Shumardites*). The basal Virgilian Colony Creek Shale in north-central Texas contains the morphologically most advanced species of *Pseudaktubites, P. stainbrooki* (Plummer and Scott, 1937). *Pseudaktubites stainbrooki* also occurs in the equivalent Little Pawnee Shale Member of the Cass Formation in southern Kansas (Boardman et al., 1994a, b). The earliest and morphologically most primitive species of *Shumardites, S. cuyleri* Plummer and Scott, 1937, first appears in the middle Virgilian Finis Shale Member of the Graham Formation in north-central Texas (Miller and Downs, 1950; Boardman et al., 1994b). The Necessity Shale Member of the Graham Formation (Figure 1) contains *Shumardites cuyleri* and the more advanced species *Shumardites simondsi* Smith, 1903. The Wayland Shale Member of the Graham Formation (not on Figure 1) contains only *Shumardites simondsi*. Thus far, *Shumardites* has not been recovered from the North American Midcontinent.

In summary, the base of the regional Virgilian Stage (Heckel, 1999) does not coincide with the base of the *Shumardites–Vidrioceras* Genozone, but falls within the *Pseudaktubites* Genozone, based on data from both the North American Midcontinent and north-central Texas (Boardman et al., 1994a). If the base of the *Shumardites–Vidrioceras* Genozone is to be retained to define the base of the Gzhelian, this level will have to be recorrelated to the level of the middle Virgilian Finis Shale and equivalent Heebner Shale in North America (Figure 1). Conodonts, because of their abundance and apparent cosmopolitan distribution, will ultimately be the best fossil to define this boundary globally.

Arguably the best taxon to define the base of the global Gzhelian Stage is *Idiognathodus simulator* (Ellison, 1941) which has recently been used to mark the base of the Gzhelian in the Moscow region (Alekseev et al., this volume, p. 33; Villa and Working Group, this volume, p. 16). The holotype of *Idiognathodus simulator* is from the middle Virgilian Heebner Shale Member of the Oread Limestone in the Midcontinent, but Ellison (1941) also illustrated *I. simulator* from the upper Missourian Eudora Shale Member of the Stanton Limestone in that region. Barrick and Boardman (1989) illustrated

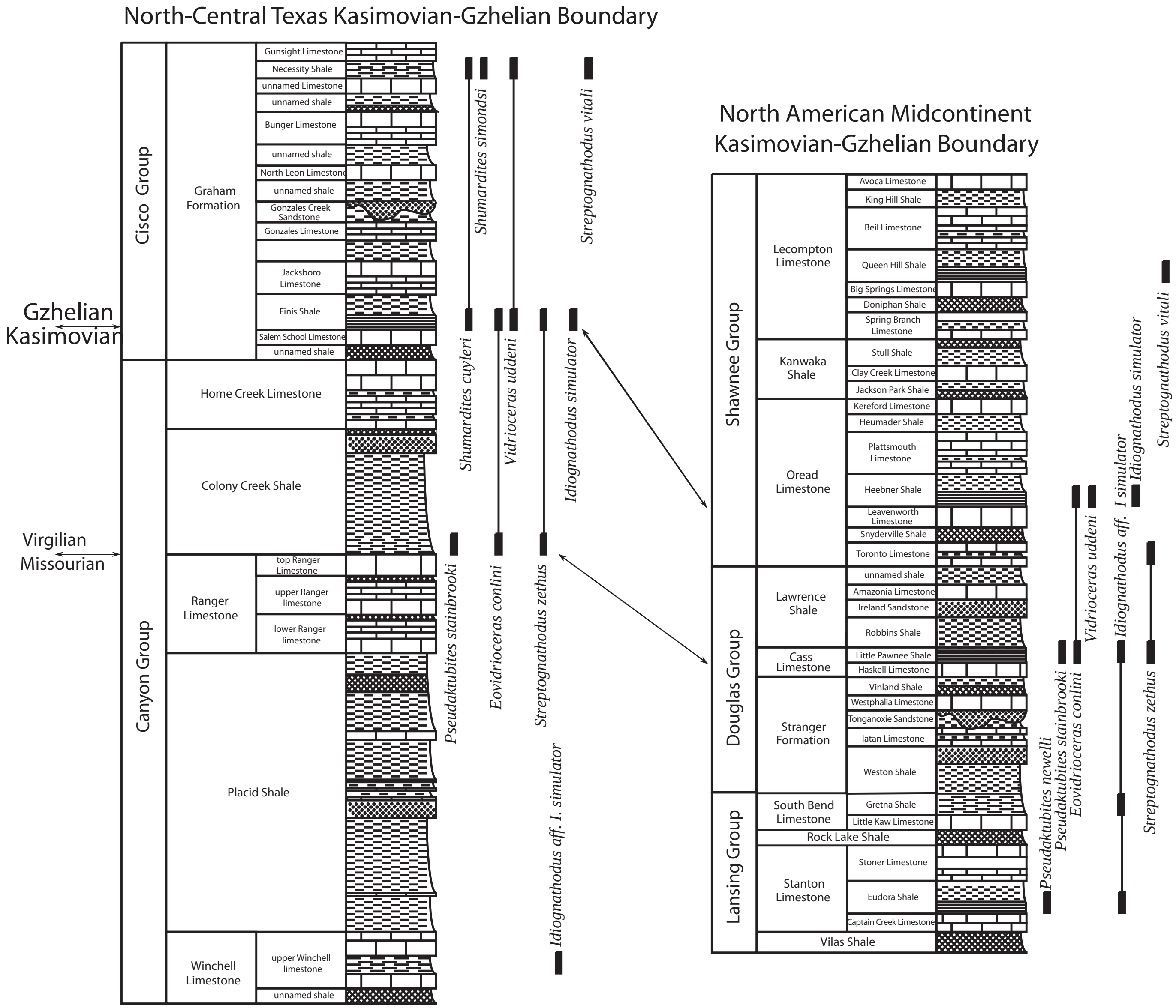

Figure 1. Comparison of regional Missourian-Virgilian boundary and proposed global Kasimovian-Gzhelian boundary in north-central Texas and Midcontinent North America. Midcontinent classification of Lansing and Douglas Groups are from Heckel and Watney (2002). Ammonoid data for Colony Creek Shale based on Scott and Armstrong (1932); Plummer and Scott (1937); Miller and Furnish (1940a); Mapes and Boardman (1988); Boardman et al. (1989, 1994a, b); and Work and Boardman (1995). Ammonoid data for Finis Shale based on Plummer and Scott (1937); Miller and Furnish (1940a, b, c); Miller and Downs (1950); Miller and Furnish (1954); Boardman et al. (1994a, b). Ammonoid data for Necessity Shale based on Plummer and Scott (1937); Miller and Furnish (1940a, c); Boardman et al. (1994a, b). Conodont data for Winchell Limestone, Colony Creek Shale, Finis Shale, and Necessity Shale based on Barrick and Boardman (1989); Barrick et al. (in press 2004); and photographs of *Streptognathodus vitali* Chernykh, 2002 provided by A.S. Alekseev. Ammonoid data for Eudora Shale based on Unklesbay (1962); and Boardman et al. (1994a, b). Ammonoid data for Gretna Shale based on Boardman et al. (1994a, b). Ammonoid data for Little Pawnee Shale based on Miller and Swineford (1957); Boardman et al. (1994a, b); and Work and Boardman (1995, 2003). Ammonoid data for Heebner Shale based on Unklesbay (1962); and Boardman et al. (1994a, b). Conodont data for Midcontinent based on Ellison (1941); Barrick et al. (in press 2004); and photographs of *Streptognathodus vitali* Chernykh, 2002 provided by A.S. Alekseev.

Idiognathodus simulator from the middle Virgilian Finis Shale Member of the Graham Formation, as well as from the upper Missourian upper Winchell Limestone in north-central Texas. Consequently, *Idiognathodus simulator* has been viewed as spanning the Missourian-Virgilian boundary in North America. However, Barrick and Boardman (1989) described differences between the Missourian and Virgilian representatives of *I. simulator*, noting that the Virgilian forms are more highly asymmetrical and have deeper grooves. Recently, Barrick et al. (in press 2004) suggested that the two morphotypes can be separated at the species level and that *I. simulator sensu stricto* first appears at the Finis-Heebner level. The older, ancestral species was designated *I.* aff. *simulator*. Formal description of the new species is underway by J. E. Barrick.

We strongly support using the first appearance of *Idiognathodus simulator s.s*. to define the base of the global Gzhelian Stage. Significantly, this level corresponds to the level of first appearance of both *Shumardites* and *Vidrioceras* (base of the *Shumardites–Vidrioceras* ammonoid Genozone) which has traditionally been used to define the base of the Gzhelian among ammonoid-bearing successions. In addition to occurrences in the North American Midcontinent and north-central Texas, *I. simulator* has been reported from the southern Urals (Chernykh and Reshetkova, 1988; Chernykh, 2000, 2002), the Moscow Basin (Alekseev et al., 2004), the Donets Basin (Kozitskaya et al., 1978), the Nashui Section near Luodian in Guizhou, China (Wang and Qi, 2002), the "H" Limestone Member of the Gaptank Formation of west Texas (D.R. Boardman, unpublished conodont collections), the Illinois Basin (Heckel and Weibel, 1991), and the Appalachian Basin (Heckel, 1999, p. 85). Correlation of the proposed Gzhelian boundary in North America is shown in Figure 2.

References

Alekseev, A.S., N.V. Goreva, T.N. Isakova, and M.Kh. Makhlina. 2004. Biostratigraphy of the Carboniferous in the Moscow Syneclise, Russia. Newsletter on Carboniferous Stratigraphy, 22:28-35.

Barrick, J.E., and D.R. Boardman. 1989. Stratigraphic distribution of morphotypes of *Idiognathodus* and *Streptognathodus* in Missourian-lower Virgilian strata, north-central Texas, p. 167-188. *In* D.R. Boardman, J.E. Barrick, J.M. Cocke, and M. Nestell M. (eds.), Middle and Late Pennsylvanian Chronostratigraphic Boundaries in North-Central Texas: Glacial-Eustatic Events, Biostratigraphy, and Paleoecology. Texas Tech University Studies in Geology, 2.

Barrick, J.E., L.L. Lambert, P.H. Heckel, and D.R. Boardman. In press 2004. Pennsylvanian conodont zonation for Midcontinent North America. Revista Española de Micropaleontologia, 36(2):231-250.

Boardman, D.R. 1999. Virgilian and lowermost Permian sea-level curve and cyclothems, p. 103-118. *In* P.H. Heckel (ed.), Middle and Upper Pennsylvanian (Upper Carboniferous) Cyclothem Succession in Midcontinent Basin, USA. XIV International Congress on the Carboniferous-Permian, Calgary, Canada, Guidebook for XIV-ICCP Field Trip #8, Kansas Geological Survey Open-File Report 99-27.

Boardman, D.R., and P.H. Heckel. 1989. Glacial-eustatic sea-level curve for Pennsylvanian of north-central Texas and biostratigraphic correlation with curve for Midcontinent. Geology, 17:802-805.

Boardman, D.R., and R.H. Mapes. 1984. Revision of the Missourian-Virgilian boundary in north-central Texas. Geological Society of America Abstracts with Programs, 16:78.

Boardman, D.R., R.H. Mapes, and D.M. Work. 1989. Ammonoids from the Colony Creek Shale (Caddo Creek Formation, Canyon Group) with implications for correlation of the position of the Missourian-Virgilian boundary in north-central Texas, p. 201-220. *In* D.R. Boardman, J.E. Barrick, J.M. Cocke, and M. Nestell M. (eds.), Middle and Late Pennsylvanian Chronostratigraphic Boundaries in North-Central Texas: Glacial-Eustatic Events, Biostratigraphy, and Paleoecology. Texas Tech University Studies in Geology, 2.

Boardman, D.R., D.M. Work, R.H. Mapes, and J.E. Barrick. 1994a. Biostratigraphy of Middle and Late Pennsylvanian (Desmoinesian-Virgilian) ammonoids. Kansas Geological Survey Bulletin, 232, 121 p.

Boardman, D.R., D.M. Work, and R.H. Mapes. 1994b. Revision of the family Shumarditidae Plummer & Scott, 1937, p. 48-56. *In* D.R. Boardman, D.M. Work, R.H. Mapes, and J.E. Barrick, Biostratigraphy of Middle and Late Pennsylvanian (Desmoinesian-Virgilian) Ammonoids. Kansas Geological Survey Bulletin, 232.

Bogoslovskaya, M.F. 1984. Main stages of the ammonoid evolution in the Late Carboniferous, p. 88-91. *In* V.V. Menner and A.D. Grigorjeva (eds.), Upper Carboniferous of the U.S.S.R. Mezhvedomstrennyi stratigraficheskii komitet, Trudy, 11.

Chernykh,V.V. 2000. Upper Carboniferous conodont zonation of the South Urals, p. 100-101. *In* V.N. Puchkov (ed.), Zonalnye podrazdeleniya karbona obschei stratigraphicheskoi shkaly karbona Rossii. Materialy vserossiiskogo soveschanya, May 2000, Ufa. Gilem Publisher, Ufa. (In Russian)

Chernykh V.V. 2002. Zonal conodont scale of Kasomovian and Gzhelian Stages on conodonts of the genus *Streptognathodus*, p. 302-306. *In* B.I. Chuvahov B.I. and E.O. Amon. (eds.), Stratigrafiya i paleogeografiya karbona Evrazii., Sbornik nauchnykh statei., Institut geologii i geokhimii Uralskogo otdeleniya RAN., Ekaterinburg. (in Russian)

Chernykh, V.V., and N.P. Reshetkova. 1988. Zonal segregation of boundary deposits of the Carboniferous and Permian of the western slope of the central and southern Urals according to conodonts, p. 62-78. *In* B.I. Chuvashov (ed.), Biostratigraphy and lithology of the Upper Palaeozoic of the Urals. Uralian Branch, USSR Academy of Sciences, Sverdlovsk.

Ellison, S. 1941. Revision of the Pennsylvanian conodonts. Journal of Paleontology, 15:107-143.

Heckel, P.H. 1986. Sea-level curve for Pennsylvanian eustatic marine transgressive-regressive depositional cycles along Midcontinent belt, North America. Geology, 14:330-335.

Heckel, P.H. 1999. Overview of Pennsylvanian (Upper Carboniferous) stratigraphy in Midcontinent region of North America, p. 68-102. *In* P.H. Heckel (ed.), Middle and Upper Pennsylvanian (Upper Carboniferous) Cyclothem Succession in

Correlation of Kasimovian-Gzhelian Boundary Strata in North America

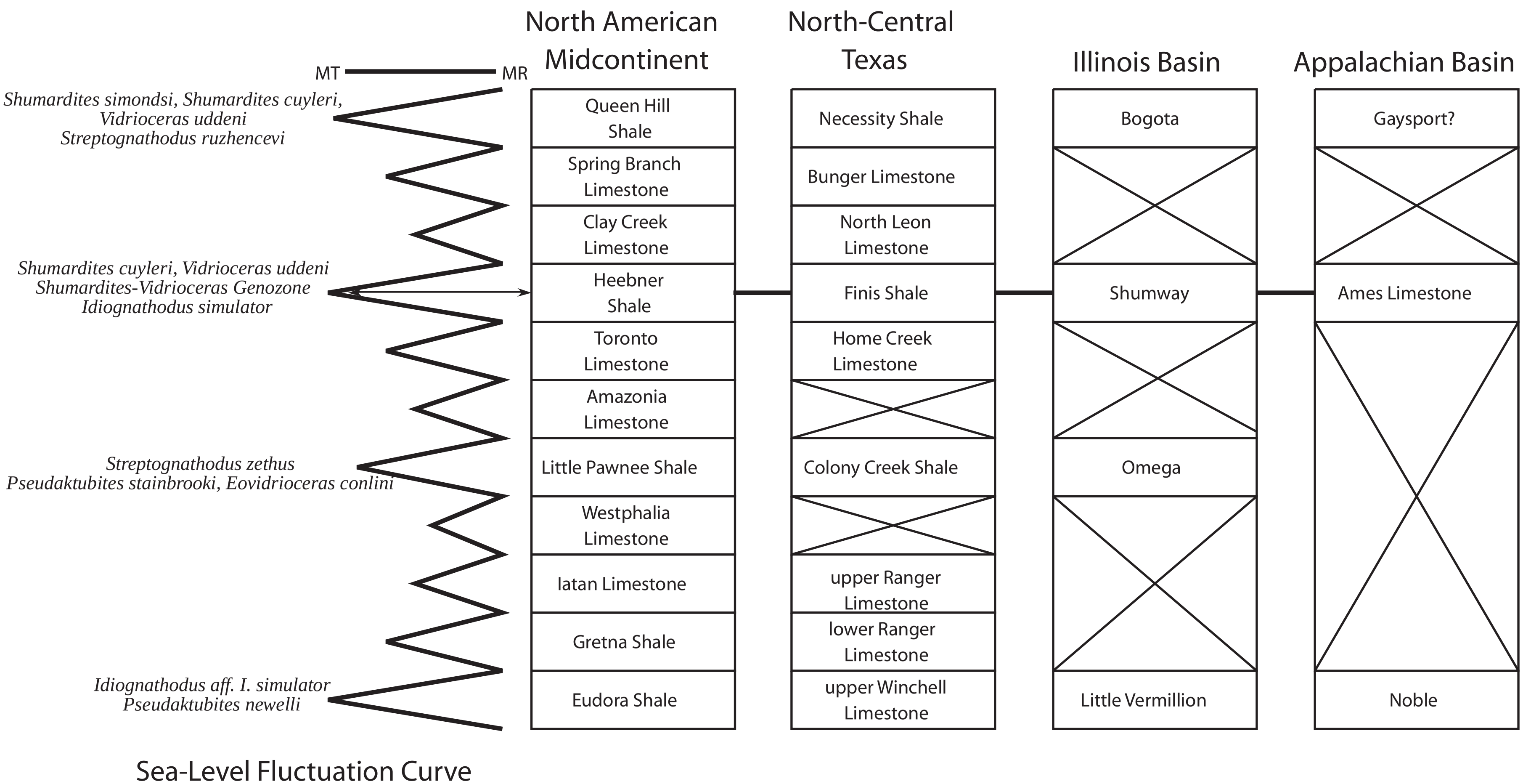

Figure 2. Sea-level curve for central and eastern North America showing correlation of proposed base of global Gzhelian Stage (arrows and horizontal line between columns); modified from Heckel (1986), Boardman and Heckel (1989), and Boardman (1999). Correlations based on Barrick and Boardman (1989), Boardman and Heckel (1989), Heckel and Weibel (1991), and Heckel (1999).

Midcontinent Basin, USA. XIV International Congress on the Carboniferous-Permian, Calgary, Canada. Guidebook for XIV-ICCP Field Trip #8, Kansas Geological Survey Open-File Report 99-27.
Heckel, P.H. 2004. Chairman's column. Newsletter on Carboniferous Stratigraphy, 22:1-3.
Heckel, P.H., A.S. Alekseev, and T.I. Nemyrovska. 1998. Preliminary conodont correlations of late middle to early upper Pennsylvanian rocks between North America and Eastern Europe. Newsletter on Carboniferous Stratigraphy, 16:8-12.
Heckel, P.H., and W.L. Watney. 2002. Revision of stratigraphic nomenclature and classification of the Pleasanton, Kansas City, Lansing, and lower part of the Douglas Groups (lower Upper Pennsylvanian, Missourian) in Kansas. Kansas Geological Survey Bulletin, 246, 69 p.
Heckel, P.H., and C.P. Weibel. 1991. Current status of conodont-based biostratigraphic correlation of Upper Pennsylvanian succession between Illinois and Midcontinent, p. 60-69. *In* C.P. Weibel (ed.), Sequence Stratigraphy in Mixed Clastic-Carbonate Strata, Upper Pennsylvanian, East-Central Illinois. Great Lakes Section, Society of Economic Paleontologists and Mineralogists, 21st Annual Field Conference, Illinois State Geological Survey.
Kozitskaya, R.I., Z.A. Kossenko, O.N. Lipnyagov, and T.I. Nemirovskaya. 1978. Conodonts from the Carboniferous of the Donets Basin. Izd. Nauka Dumka, Kiev, 136 p.
Mapes, R.H., and D.R. Boardman. 1988. The upper Paleozoic (Pennsylvanian-Permian) ammonoid *Emilites*. Journal of Paleontology, 62:69-75.
Miller, A.K., and R.H. Downs. 1950. Ammonoids of the Pennsylvanian Finis Shale of Texas. Journal of Paleontology, 24:185-218.
Miller, A.K., and W.M. Furnish. 1940a. Permian ammonoids of the Guadalupe Mountain region and adjacent areas. Geological Society of America Special Paper, 26, 242 p.
Miller, A.K., and W.M. Furnish. 1940b. Studies of Carboniferous ammonoids, pts. 1-4. Journal of Paleontology, 14:356-377.
Miller, A.K., and W.M. Furnish. 1940c. Studies of Carboniferous ammonoids, pts. 5-7. Journal of Paleontology, 14:521-543.
Miller, A.K., and W.M. Furnish. 1954. The classification of Paleozoic ammonoids. Journal of Paleontology, 28:685-692.
Miller, H., and A. Swineford. 1957. Paleoecology of nodulose zone at top of Haskell Limestone (Upper Pennsylvanian) in Kansas. American Association of Petroleum Geologists Bulletin, 41:2012-2036.
Plummer, F.B., and G. Scott. 1937. Upper Paleozoic ammonites in Texas. University of Texas Bulletin, 3701, 516 p.
Ruzhencev, V.E. 1950. Upper Carboniferous ammonoids of the Urals. Akademiya Nauk SSSR, Paleontologicheskogo Instituta, Trudy, 33, 188 p. (In Russian)
Scott, G., and J.M. Armstrong. 1932. Geology of Wise County, Texas. University of Texas Bureau of Economic Geology Bulletin, 3224, 77 p.
Unklesbay, A.G. 1962. Pennsylvanian cephalopods of Oklahoma. Oklahoma Geological Survey Bulletin, 96, 150 p.
Wang, Zhi-hao, and Yu-ping Qi. 2002. Report on the Pennsylvanian conodont zonation from the Nashui section of Luodian, Guizhou, China. Newsletter on Carboniferous Stratigraphy, 20:29-33.
Work, D.M., and D.R. Boardman. 1995. Ammonoids from the Robbins Shale Member, Lawrence Formation, Douglas Group of Kansas with implications for placement and correlation of the Missourian-Virgilian boundary. Geological Society of America Abstracts with Programs, 27:97.
Work, D.M., and D.R. Boardman. 2003. *Mapesites*, a new Upper Pennsylvanian (lower Virgilian) ammonoid from Kansas. Journal of Paleontology, 77:1195-1197.

Report on the 2004 Annual Meeting of the German Subcommission on Carboniferous Stratigraphy

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The annual meeting of the German Subcommission on Carboniferous Stratigraphy was held in Battenberg (Hesse) from April 16-18, 2004. As in past years the meeting was supplemented by field trips related to Carboniferous stratigraphy, facies development, and sea-level changes in the southern shelf of Laurussia.

During the first part of the meeting the participants visited outcrops of Mississippian (Tournaisian to Viséan) strata in the Waldeck, Wittgenstein, and Dill synclines at the eastern margin of the Rheinisches Schiefergebirge (central Germany). In this region, the Lower Carboniferous succession is mostly composed of black and dark gray shales, siliceous shales, cherts, and interfingering turbiditic limestones (Gursky 1997). This area was of historical importance for the study of Carboniferous biostratigraphy (Kulick 1960; Nicolaus 1963) and is currently under re-investigation for a refinement of Mississippian litho- and biostratigraphy of the central European Kulm "Basin" (Korn 2002, 2003a, b). Of special importance are the well-known Bromberg quarries near Medebach which serve as a key section for a correlation of biostratigraphic scales, tephrostratigraphy, and lithostratigraphy as well as eustasy (Korn 2003a, b). The field trip guide will be published in one of the next volumes of "Kölner Forum für Geologie und Paläontologie" (Cologne).

During the official part of the meeting the assembly was informed about the elections in 2003 of voting members of the subcommission. Michael Amler (University of Marburg) and Volker Wrede (Geologischer Dienst NRW, Krefeld) were reelected as chairman and secretary for the period 2004-2007. Current activities of the subcommission include:

1) A redefinition of the Namurian B/C boundary in the Ruhr area (western Germany) was recently published.

2) The first volume of a series of monographs on the stratigraphy of Germany, "Das Oberkarbon (Pennsylvanium) in Deutschland," is currently in press (Courier Forschungsinstitut Senckenberg, Frankfurt/M.). The second volume, "Das

Unterkarbon (Mississippium) in Deutschland," will be published in 2005 as one of the series of the Deutsche Geologische Gesellschaft, Hannover.

3) A "Carboniferous Correlation Table" comparable to the well-known "Devonian Correlation Table" is in preparation. The correlation of the Mississippian Kulm Facies in Central Europe was recently published (Amler and Gereke 2002, 2003); the Carboniferous Shelf Facies and the Pennsylvanian will be published soon.

4) A loose-leaf compendium of German lithostratigraphic units, comparable to the "Lexique Stratigraphique" published forty years ago, is in preparation. The assembly nominated a group of lithostratigraphers who will review proposals for redefined and newly defined Carboniferous lithostratigraphic units from Central Europe.

5) Finally, a biostratigraphic zonation of the Mississippian Kulm Facies was proposed by Amler (2002, in press).

The next meeting of the German Subcommission on Carboniferous Stratigraphy will be held in late April 2005 at Greitz, with field trips to Carboniferous outcrops of Thuringia. Guests from other countries are encouraged to attend the meeting; more information will be available in autumn/winter 2004 from the chairman (M.R.W. Amler) or the secretary (V. Wrede).

References

Amler, M.R.W. In press. Bivalve biostratigraphy of the Kulm Facies (Early Carboniferous, Mississippian) in central Europe. Newsletters in Stratigraphy.

Amler, M.R.W. 2002. Column B 016 cm 02. Bivalven-Zonen, p. 697. *In* M.R.W. Amler and M. Gereke (eds.), Karbon-Korrelationstabelle (KKT) – Carboniferous Correlation Table (CCT). Senckenbergiana lethaea, 82.

Amler, M.R.W., and M. Gerek (eds). 2002. Karbon-Korrelationstabelle (KKT) – Carboniferous Correlation Table (CCT). Senckenbergiana lethaea, 82:691-709.

Amler, M.R.W., and M. Gereke (eds). 2003. Karbon-Korrelationstabelle (KKT) – Carboniferous Correlation Table (CCT). Senckenbergiana lethaea, 83:235-247.

Gursky, H.-J. 1997. Die Kieselgesteine des Unter-Karbons im Rhenohercynikum. Sedimentologie, Petrographie, Geochemie und Paläoozeanographie. Geologische Abhandlungen Hessen, 100:1-117.

Korn, D. 2002. Column B 011 cm 02. Ammonoideen-Zonen und Geno-Zonen, p. 695. *In* M.R.W. Amler and M. Gereke (eds.), Karbon-Korrelationstabelle (KKT) – Carboniferous Correlation Table (CCT). Senckenbergiana lethaea, 82.

Korn, D. 2003a. Medebach-Bromberg, Late Viséan standard reference section of the Rhenohercynian. Geologica et Palaeontologica, 37:77-88.

Korn, D. 2003b. Die Formationen der Kulm-Fazies im Rheinischen Schiefergebirge, p. 236-242. *In* M.R.W. Amler and M. Gereke (eds.), Karbon-Korrelationstabelle (KKT) – Carboniferous Correlation Table (CCT). Senckenbergiana lethaea, 83.

Kulick, J. 1960. Zur Stratigraphie und Palaeogeographie der Kulm-Sedimente im Eder-Gebiet des nordöstlichen Rheinischen Schiefergebirges. Fortschritte in der Geologie von Rheinland und Westfalen, 3:243-288.

Nicolaus, H.-J. 1963. Zur Stratigraphie und Fauna der *crenistria*-Zone im Kulm des Rheinischen Schiefergebirges. Beihefte zum Geologischen Jahrbuch, 53:1-246.

Biostratigraphy of the Carboniferous in the Moscow Syneclise, Russia

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The Moscow Syneclise is a vast sedimentary basin located in the center of the Russian Platform. During the Carboniferous the Moscow Syneclise occupied a position not far from the paleoequator. The southern limb of the syneclise is the type area of the Serpukhovian, Moscovian, Kasimovian, and Gzhelian Stages. The Carboniferous sediments here consist mainly of shallow-marine carbonates, containing several minor terrigenous intervals. There are two, important gaps in the succession: late Tournaisian-early Viséan, and the entire Bashkirian. The modern stratigraphic scale includes 33 regional stages and 62 formations, which produce a good stratigraphic framework.

The study of fusulinids and conodonts from the stratotype sections and the revision of data provided by earlier researchers have resulted in a detailed zonation of 34 foraminiferal and 28 conodont zones.

This report briefly outlines the main results of stratigraphic investigations of the Carboniferous in the Moscow Syneclise over the last several years.

Stratigraphy

Carboniferous sediments in the Moscow Syneclise consist mainly of shallow-marine carbonates, with several minor terrigenous intervals and two major gaps (late Tournaisian-early Viséan, and Bashkirian). The accepted official Carboniferous regional stratigraphic scale for the Russian Platform was ratified in 1988 and published by Kagarmanov and Donakova (1990). The description of Mississippian [Lower Carboniferous] stratigraphy was published by Makhlina et al. (1993). The more detailed stratigraphic scale for the Moscovian Stage was proposed on the basis of detailed stratigraphical, paleontological and lithological studies (Makhlina et al., 2001a, b). The latest publications contain the integrated characteristics of numerous type and reference sections for substages, formations, and members. The description of facies distribution is given for every substage. Revision of the stratigraphy of the Kasimovian and Gzhelian Stages is still in progress. The modern Carboniferous stratigraphic scale includes 33 regional substages and 62 formations, which produce a firm chronostratigraphic and lithostratigraphic framework.

As a most important group in modern stratigraphy, foraminifers have been used in the subdivision of the sedimentary succession of the type region for more than 150 years. The first Carboniferous conodonts from the Moscow Syneclise were recorded by Pander (1856), and more were later reported by Barskov et al. (1971).

The foraminiferal and conodont zonations have been modified several times, and here we put forward their latest versions. The conodont zonation contains 28 zones, and the foraminiferal zonation consists of 34 zones (Figure 1).

Mississippian (Lower Carboniferous)

The Mississippian succession is represented by three main sedimentary sequences: lower Tournaisian, middle Tournaisian, and middle Viséan-Serpukhovian, each separated by unconformities.

Foraminiferal Zonation

The evolutionary succession of foraminiferal assemblages recovered in the Mississippian has resulted in the recognition of 13 successive zones, which are summarized by Vdovenko et al. (1990) and Makhlina et al. (1993). Recently the foraminiferal zonation of the Serpuhkovian was revised by Gibshman (2001) and Kulagina et al. (2003).

The Tournaisian in the Moscow Syneclise is subdivided into four zones: *Bisphaera malevkensis–Earlandia minima, Prochernyshinella disputabilis–Tournayellina beata, Chernyshinella glomiformis–C. paraglomiformis, Chernyshinella glomiformis–Spinoendothyra krainica–Paleospiroplectammina tchernyshinensis.* The base of the Carboniferous is marked by the first appearance of the index-species of the *Bisphaera malevkensis–Erlandia minima* Zone, but it coincides with short gap, as the uppermost Famennian is absent. The Viséan can be subdivided into four zones also: *Endothyranopsis compressus, Eostaffella proikensis–Archaediscus gigas, Eostaffella ikensis, Eostaffella tenebrosa–Endothyranopsis sphaerica.*

The Serpukhovian zonal scale is based on recent research on foraminiferal distribution in the stratotype Zaborie section (Gibshman, 2001). This section contains from base to top, the *Eostaffella tenebrosa* Zone in the Venevian, then the *Neoarchaediscus postrugosus* Beds, *Pseudoendothyra globosa* Zone, *Eostaffellina decurta* Zone, and *Eostaffellina "protvae"* Zone in the Serpukhovian. The Serpukhovian subdivisions are based on the evolution of the Janischewskinidae, Eostaffellidae, Archaediscidae, and Howchinidae (Kulagina et al., 2003). The main evolutionary trends within these lineages are used to define individual zones. The lower boundary of the Serpukhovian is defined by the first appearance of *Neoarchaediscus postrugosus* and "*Millerella" tortula.* In addition to these markers it is possible to identify the base of the Serpukhovian using the first appearance of *Pseudoendothyra globosa* and *Janischewskina delicata*.

Conodont Zonation

Mississippian conodont assemblages are dominated by shallow-water taxa in most of the succession. Its conodont zonation (Barskov, 1984; Barskov et al., 1984) was updated by Makhlina et al. (1993). We use the scale of Makhlina et al. (1993) with minor amendments (Alekseev et al., 1996). The succession of conodont assemblages recovered in the Mississippian has resulted in recognition of 7 conodont zones. The boundaries between conodont zones commonly are established only arbitrarily, because facies influence and transgressive-regressive cyclicity limit the ranges of taxa. The standard conodont zonation based on the succession of deep-water taxa (*Siphonodella* and *Gnathodus*) could be used only in part.

In the regional conodont zonation for the Tournaisian, the evolutionary succession of *Patrognathus* species was used. This interval (Malevkian and Upian) is subdivided into three zones: *Patrognathus crassus, P. variabilis,* and *P. anderssoni* (Barskov et al., 1984). The *Siphonodella quadruplicata* Zone corresponds to the Cherepetian Substage.

The Upper Viséan (Tulian-Venevian) contains few conodonts and can be subdivided into only two zones: *Gnathodus bilineatus* and *Lochriea nodosa*.

The Serpukhovian conodonts from the Russian Platform were recorded by Barskov et al. (1971). Recently, more detailed characteristics of this interval were obtained for the type Serpukhovian section (Nikolaeva et al., 2002). The *Gnathodus girtyi* group is dominant, and the group *Lochriea commutata – L. mononodosa* is slightly less abundant. *Lochriea ziegleri* has its first appearance in topmost Venevian, but permanently occurs from the base of the Tarusian. The conodont-based Viséan-Serpukhovian boundary approximately corresponds with the base of the *Lochriea ziegleri* Zone. The appearance of the foraminiferal species *Neoarchaediscus postrugosus* is close to this level. The terminal Serpukhovian Zone is *Adetognathus unicornis*, but this species was recorded from only one section.

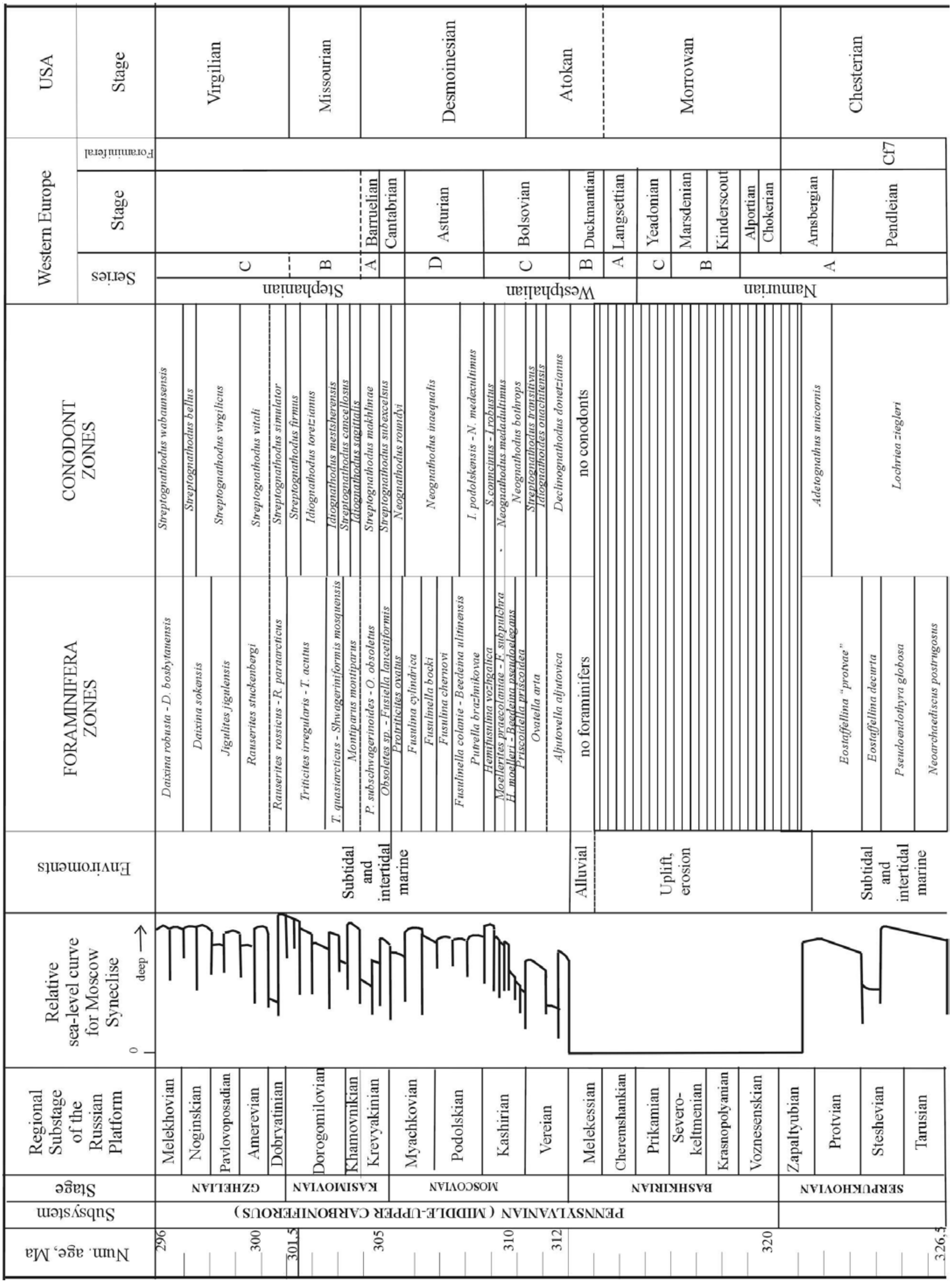
Pennsylvanian (Middle and Upper Carboniferous)

The Pennsylvanian marine sequence of the Moscow Syneclise is a famous shallow marine carbonate succession that was formed under the strong influence of glacio-eustatic sea-level fluctuations. The Mid-Carboniferous boundary is marked by gap, as Bashkirian marine sediments are absent in the Moscow Syneclise. In the southwestern part only continental sediments of Bashkirian age are known (Aza Fm.). The Pennsylvanian part of the zonation includes 21 fusulinid and 21 conodont zones.

Foraminiferal Zonation

The fusulinid zonation of the Moscovian Stage was proposed by Rauser-Chernousova and Reitlinger and modified recently (Makhlina et al., 2001a, b). Now 11 fusulinid zones have been identified in the Moscovian Stage. The Kasimovian and Gzhelian Stages can be subdivided into 10 fusulinid zones.

The subdivision of the Moscovian Stage is based on evolution of the Fusulinida. The Vereian assemblage is typically dominated by members of the families Profusulinellidae and


USA
Stage
Virgilian
Missourian
Desmoinesian
Atokan
Morrowan
Chesterian
Western Europe
Series
Stage
Foraminiferal
Stephanian
Westphalian
Namurian
Barruelian
Cantabrian
Asturian
Bolsovian
Duckmantian
Langsettian
Yeadonian
Marsdenian
Kinderscout
Alportian
Chokerian
Arnsbergian
Pendleian
Cf7
CONODONT ZONES
Streptognathodus wabaunsensis
Streptognathodus bellus
Streptognathodus virgilicus
Streptognathodus vitali
Streptognathodus simulator
Streptognathodus firmus
Idiognathodus toretzianus
Idiognathodus mestsherensis
Streptognathodus cancellosus
Idiognathodus sagittalis
Streptognathodus makhlinae
Streptognathodus subexcelsus
Neognathodus roundyi
Neognathodus inaequalis
I. podolskensis - N. medexultimus
S. concinnus - I. robustus
Neognathodus medadultimus
Neognathodus bothrops
Streptognathodus transitivus
Idiognathoides ouachitensis
Declinognathodus donetzianus
no conodonts
Adetognathus unicornis
Lochriea ziegleri
FORAMINIFERA ZONES
Daixina robusta - D. bosbytauensis
Daixina sokensis
Jigulites jigulensis
Rauserites stuckenbergi
Rauserites rossicus - R. pararcticus
Triticites irregularis - T. acutus
T. quasiarcticus - Shwagerinaformis mosquensis
Montiparus montiparus
P. subschwagerinoides - O. obsoletus
Obsoletes sp. - Fusiella lancetiformis
Protriticites ovatus
Fusulina cylindrica
Fusulinella bocki
Fusulina chernovi
Fusulinella colanie - Beedeina ulitinensis
Putrella brazhnikovae
Hemifusulina vozhgalica
Moellerites praecolaniae - F. subpulchra
H. moelleri - Beedeina pseudoelegans
Priscoidella priscoidea
Ovatella arta
Aljutovella aljutovica
no foraminifers
Eostaffellina "protvae"
Eostaffellina decurta
Pseudoendothyra globosa
Neoarchaediscus postrugosus
Environments
Subtidal and intertidal marine
Alluvial
Uplift, erosion
Relative sea-level curve for Moscow Syneclise
deep
0
Regional Substage of the Russian Platform
Melekhovian
Noginskian
Pavlovoposadian
Amerevian
Dobryatinian
Dorogomilovian
Khamovnikian
Krevyakinian
Myachkovian
Podolskian
Kashirian
Vereian
Melekessian
Cheremshankian
Prikamian
Severo-keltmenian
Krasnopolyanian
Voznesenskian
Zapaltyubian
Protvian
Steshevian
Tarusian
Stage
GZHELIAN
KASIMOVIAN
MOSCOVIAN
BASHKIRIAN
SERPUKHOVIAN
Subsystem
PENNSYLVANIAN (MIDDLE-UPPER CARBONIFEROUS)
Num. age, Ma
296
300
301.5
305
310
312
320
326.5

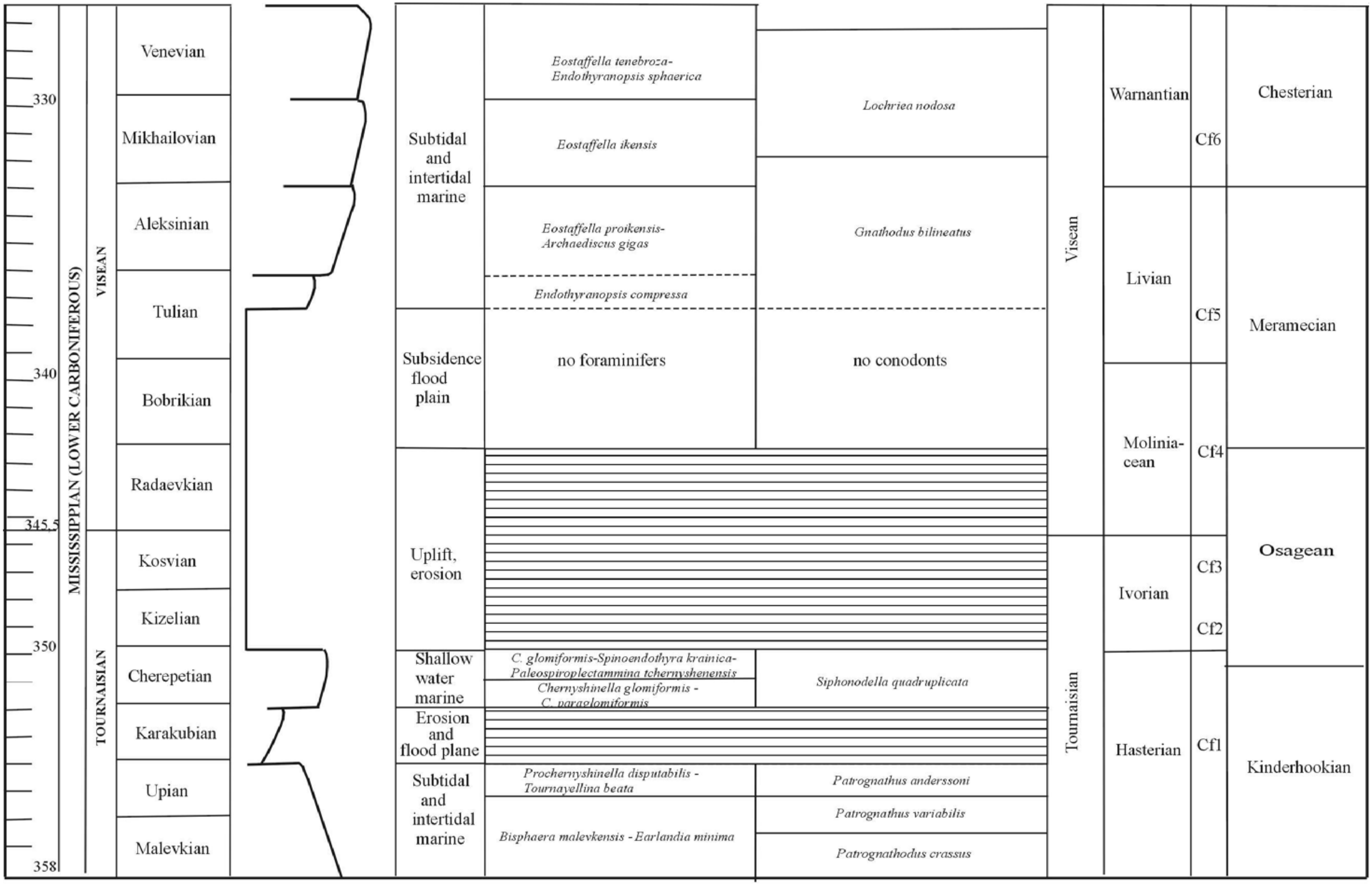


Figure 1. Stratigraphic subdivision of Carboniferous System in Moscow Syneclise. Based on more recent information in Krevyakinian Substage: *Streptognathodus makhlinae* should be *"Swadelina" makhlinae. Streptognathodus subexcelsus* should be *"Streptognathodus" subexcelsus.*

Aljutovellidae. The *Aljutovella aljutovica* Zone of the basal Vereian (Aljutovo Fm.) contains some representatives of more ancient (Bashkirian) lineages and is easily traceable in the paleoequatorial belt. The *Ovatella arta* Zone contains fusulinids mainly known from the underlying zone, and only the first appearance of *Ovatella* helps to distinguish this zone. The Kashirian assemblage becomes more diverse as the result of the appearance and evolution of the family Hemifusulinidae and the subfamily Beedeininae. The base of the Kashirian is marked by the first appearance of such genera as *Priscoidella*, *Hemifusulina,* and *Taitzehoella.* This substage contains the following succession of zones: *Priscoidella priscoidea*, *Hemifusulina moelleri–Beedeina pseudoelegans*, *Moellerites praecolaniae–Fusulinella subpulchra*, and *Hemifusulina vozhgalica*. The family Fusulinidae evolved mainly during the Podolskian and the Myachkovian. One genus gradually replaced the other. The main Podolskian genera are *Putrella*, *Fusulinella,* and *Fusulina*. The base of the Podolskian coincides with the first appearance of *Putrella*. In the Moscow Syneclise the Podolskian Substage can be subdivided into three local zones*: Putrella brazhnikovae*, *Fusulinella colaniae–Beedeina ulitinesis,* and *Fusulina chernovi*. The Myachkovian is also subdivided into three local zones: *Fusulinella bocki*, *Fusulina cylindrica,* and *Protriticites ovatus*. The *Fusulinella bocki* group is the dominant lineage within lower Myachkovian fusulinid assemblages. The upper Myachkovian *Protriticites ovatus* Zone contains rare primitive *Protriticites.*

The subdivision of the Kasimovian and Gzhelian Stages is based on the evolution of the Schwagerinida. Traditionally the lower boundary of the Kasimovian coincides with the first appearance of *Obsoletes*, which is at the base of the general *Protriticites pseudomontiparus–Obsoletes obsoletus* Zone for the Russian Platform. However, in the Moscow Syneclise the first typical species of *Obsoletes* appears above this boundary in the next higher local fusulinid zone (*Protriticites subschwagerinoides–Obsoletes obsoletus* Zone, as shown in Figure 1). The first appearance of the distinctive genus *Montiparus* and the species *M. montiparus* is a good marker for the younger *Montiparus montiparus* Zone. The *Triticites quasiarcticus–Schwageriniformis mosquensis* Zone and *T. irregularis–T. acutus* Zone occur in the Upper Kasimovian of the Russian Platform. However, their local equivalent zones in the Moscow Syneclise are *Schwageriniformis mosquensis* and *Triticites irregularis–T. quasiacticus,* respectively.

The Gzhelian Stage corresponds to the *Rauserites rossicus— R. paraarcticus*, *R. stuckenbergi*, *Jigulites jigulensis*, *Daixina sokensis*, and *Daixina robusta–D. bosbytauensis* Zones. The lower boundary of the Gzhelian is defined by the appearance *Rauserites rossicus*, but the exact level of this event is not known. The top of the Gzhelian was changed when the GSSP for the lower boundary of the Permian System was accepted (Davydov et al., 1998). The new regional Melekhovian Substage at the top of the Gzhelian on the Russian Platform was proposed to include the *Daixina robusta–D. bosbytauensis* interval, which previously belonged to the Asselian (Makhlina and Isakova, 1997).

Conodont Zonation

The difficulties in developing the standard conodont zonation for the Pennsylvanian are partly related to the paucity of regional conodont studies for this time interval and the uncertainty of phylogenetic relationships between the main lineages of platform conodonts. In addition, the most important problems derive from biogeographic provincialism and endemism as a result of high amplitude glacioeustatic sea-level fluctuations.

The first conodont zonation was proposed by Barskov and Alekseev (1975). Over the past several years, important advances have been made in understanding the stratigraphic distribution of conodonts in shallow-water sediments of the type sections of the Moscovian, Kasimovian, and Gzhelian Stages (Alekseev and Goreva, 2000, 2003). The revised and new data on conodont distribution throughout various localities on the Russian Platform significantly improve knowledge of the taxonomic diversity and constrain the stratigraphic ranges of the species, thus facilitating the correction of the conodont zonation. Now 9 conodont zones have been identified in the Moscovian Stage, 7 in the Kasimovian, and 5 in the Gzhelian. Almost all zones of the scale are interval-zones, with the lower boundaries defined by the first appearance of the index species.

The Moscovian conodont zonation has been updated by Alekseev and Goreva (Makhlina et al., 2001a, b). Three zones were distinguished within the lowermost Moscovian Vereian Substage: *Declinognathodus donetzianus*, *Idiognathodus ouachitensis* (without *D. donetzianus*), and *Streptognathodus transitivus*. The subdivision of the Kashirian, Podolskian, and Myachkovian Substages is based mainly on *Neognathodus* evolution. The Kashirian is subdivided into three zones: *Neognathodus bothrops*, *N. medadultimus,* and *Streptognathodus concinnus–Idiognathodus robustus*. The Podolskian Substage contains two conodont zones: *Idiognathodus podolskensis–Neognathodus medexultimus*, and *Neognathodus inaequalis.* The *Neognathodus inaequalis* Zone also includes the lower part of the Myachkovian Substage. The upper part of the Myachkovian Substage (Domodedovo and Peski Fms.) is equivalent to the *Neognathodus roundyi* Zone.

The Kasimovian part of the zonation includes 7 zones. The lower Kasimovian contains abundant conodonts with rapid changes in assemblages. The traditional base of the Kasimovian is marked by the first appearance of "*Streptognathodus" subexcelsus* Alekseev and Goreva. The upper part of the Krevyakinian and basal strata of the Khamovnikian (lower Ratmirovo Fm.) belong to the "*Swadelina*" *makhlinae* Zone, and most of the Khamovnikian belongs to the *Idiognathodus sagittalis* Zone. However, most of the Ratmirovo Fm. and the lowermost Neverovo Fm. (1-1.5 m) do not contain *Idiognathodus sagittalis*. *"Swadelina" makhlinae* Alekseev and Goreva could be a member of the lineage separated recently by Lambert et al. (2003) as the new genus *Swadelina*, but Pb elements (Ozarkodinida) typical for it are not yet known in the Moscow Basin. The top of the Khamovnikian and basal strata of the Dorogomilovian belong to the *Streptognathodus cancellosus* Zone. The upper Kasimovian (Dorogomilovian) conodont zonation should be revised with additional data. The *Idiognathodus mestsherensis* Zone corresponds to the lower part, the *Idiognathodus toretzianus* Zone to the middle part of the Dorogomilovian, and the *Streptognatodus firmus* Zone to the top of the Kasimovian Stage.

Only the lower part (Dobryatinian Substage) of the Gzhelian is well exposed and characterized by conodonts in the Moscow Basin. Therefore the zonation of the rest of the Gzhelian was developed on the basis of conodont distribution in the South Urals sections (Chernykh, 2000, 2002), which are the deep-water, predominantly hemipelagic Usolka section in Bashkiria and the Nikolskiy flysch section in the Orenburg region. The Gzhelian zonation is based on the evolution of the *Streptognathodus* lineage and contains 5 zones: *S. simulator*, *S. vitali*, *S. virgilicus, S. bellus,* and *S. wabaunsensis*. The lower boundary of the Gzhelian is established at the base of the *S. simulator* Zone and is defined by the first occurrence of the typical forms of the index species. This zone is exposed in the old quarries at Gzhel and Rusavkino, east of Moscow, where its diverse fauna includes *S. simulator* and a thin interval with *Gondolella* in the upper Rusavkino Formation. The base of the next higher *S. vitali* Zone also contains *S. ruzhencevi* in the lowermost Amerovo Formation nearby.

Correlation

Several of the conodont and fusulinid species groups could represent important biostratigraphic markers because they have been found in the Moscow Syneclise, in the North American Midcontinent, and in other regions.

Foraminiferal Correlation

1. The co-occurrence of "*Millerella*" *tortula* and *Neoarchidiscus postrugosus* in the stratotype of the Serpukhovian (Zaborie quarry) is a potentially good marker for the Viséan-Serpukhovian boundary. The presence of "*Millerella*" *tortula* makes it possible to correlate the base of the Serpukhovian with the mid-Chesterian in Midcontinent USA (Kulagina et al., 2003).

2. The *Aljutovella aljutovica* Zone of the basal Vereian (Aljutovo Fm.) contains mainly representatives of Bashkirian lineages, but it is easily traceable in the paleoequatorial belt.

3. The base of the Kashirian is marked by the first appearance of *Priscoidea, Hemifusulina,* and *Taitzehoella*.

4. The first *Fusulinella* occurs in the mid-Kashirian interval.

5. The base of the Podolskian coincides with the entrance of *Putrella.*

6. The lower Myachkovian foraminiferal assemblages are dominated by the *Fusulinella bocki* group.

Conodont Correlation

1. *Lochriea ziegleri* occurs close to the base of the Tarusian and this event has good potential for the Viséan-Serpukhovian boundary.

2. The Lower Vereian *Declinognathodus donetzianus* Zone is recognized in the Donets Basin (limestones K_2–K_5) and the Aegiranum Marine Band of the basal Westphalian C (Bolsovian) of Western Europe.

3. The level with *Gondolella laevis* (lower Podolskian *Idiognathodus podolskensis*–*Neognathodus medexultimus* Zone) is traceable almost world-wide (Moscow Basin and South Urals, Donets Basin, Cantabrian Mountains, and in several states of the USA).

4. The top of the *Neognathodus roundyi* Zone coincides with the last occurrence of *Neognathodus*, but this event is probably diachronous.

5. The *"Swadelina" makhlinae* Zone probably correlates with the *Swadelina nodocarinata* Zone (Barrick et al., in press 2004) at the top of the Desmoinesian in North America.

6. *Idiognathodus sagittalis* is widespread. In addition to the Donets Basin (where it was first described) and the central Russian Platform, it was found in the Volga region (Sungatulina, 2001, 2002), South Urals (Alekseev and Goreva, 2002), North Timan (Goreva et al, 1997), North America (Barrick et al., in press 2004), and north Spain (Mendez, 2002). In the Moscow Basin, the *I. sagittalis* Zone corresponds to the middle part of the Khamovnikian (Neverovo Fm.). The earliest *Montiparus* first appears close to this level.

7. The lower boundaries of the *simulator, virgilicus,* and *wabaunsesis* Zones are the most significant levels for correlation in the Gzhelian. These zones are present in the USA Midcontinent (Barrick et al., in press 2004) and probably in South China.

Relative Sea-Level Curve for Moscow Syneclise

The Carboniferous sea-level curve for the Moscow Syneclise presented here (Figure 1) is almost the same as that published by Alekseev et al. (1996). However, it differs in some important details since the data for early Gzhelian time are now more accurate.

The Famennian-Tournaisian boundary interval is marked by sea-level fall during the latest Famennian, giving rise to the development of a sharp hiatus. An early Tournaisian transgression covered almost the entire area with normal marine water. A prominent early and middle Viséan regression induced prolonged erosion and then accumulation of coal-bearing floodplain sediments in the southern and western parts of the Moscow Syneclise. During the late Viséan, a new transgression began and reached a maximum in early Serpukhovian time.

The Mid-Carboniferous boundary is marked by the sharp Bashkirian sea-level drop in response to Gondwanan glaciation. During latest Bashkirian, a transgression encroached on the Moscow Syneclise via deep paleovalleys in which alluvial clastics were deposited. During Moscovian, Kasimovian, and Gzhelian time, a shallow-marine basin, in which carbonates were deposited under the influence of high-amplitude glacio-eustatic sea-level oscillations, occupied the Moscow Syneclise.

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References

Alekseev, A.S., and N.V. Goreva. 2000. Conodont zonal scale of Moscovian, Kasimovian, and Gzhelian Stages, p. 7-8. *In* V.N. Puchkov (ed.), Zonalnye podrazdeleniya karbona obscheistratigraficheskoi shkaly karbona Rossii. Materialy vserossiiskogo soveschanya, May 2000, Ufa. Gilem (Ufa). (In Russian)

Alekseev A.S., and N.V. Goreva. 2002. Conodonts and the position of the Moscovian-Kasimovian boundary in the South Urals. Abstracts, VIII International Conodont Symposium. ECOS VIII. Toulouse - Albi. June 22-25, 2002. Strata. Ser. 1. Communications, 12:14.

Alekseev, A.S., and N.V. Goreva. 2003. Provisional conodont zonation for the Kasimovian and Gzhelian stages. Abstracts, XV International Congress on Carboniferous and Permian Stratigraphy, Utrecht, August 2003, p. 18-19.

Alekseev, A.S., L.I. Kononova, and A.M. Nikishin. 1996. The Devonian and Carboniferous of the Moscow Syneclise (Russian Platform): stratigraphy and sea-level changes. Tectonophysics 268:149-168.

Barrick, J.E., L.L. Lambert, P.H. Heckel, and D.R. Boardman. In press 2004. Pennsylvanian conodont zonation for Midcontinent North America. Revista Española de Micropaleontologia, 36(2):231-250.

Barskov, I.S. 1984. Conodont zonation for Upper Carboniferous and Asselian and a work for its modernization, p. 102-107. *In* V.V. Menner and A.D. Grigorieva (eds.), Verkhnii karbon SSSR. Mezhvedomstvennyi Stratigraficheskyi Komitet SSSR, Trudy, 13. (In Russian)

Barskov, I.S., and A.S. Alekseev. 1975. Conodonts of Middle and Upper Carboniferous of Moscow Basin. Izvestiya Akademii Nauk SSSR, Seriya Geologicheskaya 6:84-99. (In Russian)

Barskov, I.S., A.S. Alekseev, and N.V. Goreva. 1971. On the conodonts of the Lower Carboniferous Steshevo Beds near Serpukhov. Doklady Akademii Nauk SSSR, 201(6):1422-1425. (In Russian)

Barskov, I.S., A.S. Alekseev, N.V. Goreva, L.I. Kononova, and A.V. Migdisova. 1984. Carboniferous zonation of the East-European Platform by conodonts, p. 143-151. *In* V.V. Menner (ed.), Paleontologicheskaya kharacteristika stratotipicheskikh i opornykh razrezov karbona Moskovskoi sineklizy. Moskovskii Universitet Press, Moskva. (In Russian)

Chernykh, V.V. 2000. Upper Carboniferous conodont zonation of the South Urals, p. 100-101. *In* V.N. Puchkov (ed.), Zonalnye podrazdeleniya karbona obschei stratigraphicheskoi shkaly karbona Rossii. Materialy vserossiiskogo soveschanya, May 2000, Ufa. Gilem Publisher, Ufa. (In Russian)

Chernykh, V.V. 2002. Kasimovian and Gzhelian zonal scale on conodonts of genus *Streptognathodus,* p. 302-306. *In* B.I. Chyvashov (ed.), Stratigrafiya and paleogeografiya karbona Evrasii. Institut geologii i geochimii Uralskogo otdeleniya Rossiiskoi Akademii Nauk, Ekaterinburg. (In Russian)

Goreva, N.V., D.S. Kashik, O.L. Kossovaya, N.V. Lozhkina, O.A. Miklukho-Maklai, L.M. Molchanova, and G.I. Shafranovskii. 1997. Carboniferous and Permian reference sections of the North Timan. Trudu mezhvedomstvennogo stratigtaficheskogo komiteta 24 (Sankt-Peterburg), 288 p. (In Russian)

Gibshman, N.B. 2001. Foraminiferal biostratigraphy of the stratotype Serpukhovian Stage (Zaborie quarry, Moscow Basin). Newsletter on Carboniferous Stratigraphy, 19: 31-34.

Davydov, V.I. 1997. Middle-Upper Carboniferous boundary: the problem of definition and correlation. Proceedings of the XIII International Congress on the Carboniferous and Permian, Warszawa, I:113-122.

Davydov, V.I., B.F. Glenister, C. Spinosa, S.M. Ritter, V.V. Chernykh, B.R.Wardlaw, and W.S. Snyder. 1998. Proposal of Aidaralash as Global Stratotype Section and Point (GSSP) for base of the Permian System. Episodes, 21(1):11-18.

Kagarmanov, A.Kh., and L.M. Donakova (eds.). 1990. Decision of interdepartmental regional stratigraphic conference on Middle and Upper Paleozoic Russian Platform with regional stratigraphic scales, Leningrad, 1988. Vsesoyuznyi Geologisheskii Institut, Leningrad: 41 p., 95 scale sheets. (In Russian)

Kulagina, E.I., N.B. Gibshman, and V.I. Pazukhin. 2003. Foraminiferal zonal standard for Lower Carboniferous of Russia and its correlation with conodont zonation. Rivista Italiana di Paleontologia e Stratigrafia, 109(2):167-179.

Lambert, L.L., P.H. Heckel, and J.E. Barrick, 2003. *Swadelina* new genus (Pennsylvanian Conodonta), a taxon with potential chronostratigraphic significance. Micropaleontology, 49(2): 151-158.

Makhlina, M.Kh. and T.N. Isakova. 1997. Melekhovian Horizon - new subdivision of the Gzhelian Stage of the Upper Carboniferous (East-European Platform). Stratigraphy and Geological Correlation 5(5):458-467.

Makhlina, M.Kh., M.V. Vdovenko, A.S. Alekseev, T.V. Byvsheva, L.M. Donakova, L.M. Zhulitova, L.I. Kononova, N.I. Umnova, and E.M. Shik. 1993. Lower Carboniferous of the Moscow Syneclise and Voronezh Anteclise. Nauka, Moskva, 320 p. (In Russian)

Makhlina, M.Kh., A.S. Alekseev, N.V. Goreva, T.N. Isakova, and A.N. Drutskoi. 2001a. Middle Carboniferous of the Moscow Syneclise (southern part). Vol. 1. Stratigraphy. Paleontologicheskii Institut RAN, Moskva, 237 p. (In Russian)

Makhlina, M.Kh., A.S. Alekseev, N.V. Goreva, R.V. Gorjunova, T.N. Isakova, O.L. Kossovaja, S.S. Lazarev, O.A. Lebedev, and A.A. Shkolin. 2001b. Middle Carboniferous of the Moscow Syneclise (southern part). Vol. 2. The paleontological characteristics. Naychnyi Mir, Moscow, 328 p. (In Russian)

Mendes, C.A. 2002. Upper Carboniferous conodonts (Upper Moscovian – Middle Kasimovian) from the Las Llacerias section (Cantabrian Mountains, North Spain). Abstracts, VIII International Conodont Symposium. ECOS VIII. Toulouse - Albi. June 22-25, 2002. Strata. Ser. 1. Communications 12:44.

Nikolaeva, S.V., N.B. Gibshman, E.I. Kulagina, I.S. Barskov, and V.N. Pazukhin. 2002. 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). Newsletter on Carboniferous Stratigraphy, 20:16-21.

Pander, H. 1856. Monographie der fossilen Fische des silurischen Systems der russisch-baltischen Gouvernements. K. Akad. Wiss. St. Peterburg, 91 p.

Sungatulina, G.M. 2001.Upper Carboniferous conodonts of the Middle Volga region, p. 241-244. *In* V.M. Podobina, V.M. (ed.), Evolyuciya zhizni na Zemle. Materialy 2 Mezhdunarodnogo simposiuma, Noyabr, 12-15, 2001. Publishing House NTL., Tomsk. (In Russian)

Sungatulina, G.M. 2002. Middle and Upper Carboniferous conodonts of the Middle Volga region and their stratigraphic sig-

nificance. Kazan University Press, Kazan, 22 p.
Vdovenko, M.V., D.E. Aizenverg, T.I. Nemirovskaya, and V.I. Poletaev. 1990. An overview of Lower Carboniferous biozones of the Russian Platform. Journal of Foraminiferal Research. 20(3):184-194.

Magnetostratigraphy of the Carboniferous: a review and future prospects

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Introduction

The earths magnetic field during the Phanerozoic is fixed essentially in one of two dipolar states. One of normal polarity (like at the present day), when the magnetic field in the Northern Hemisphere is directed downwards (and northwards), and in the Southern Hemisphere is directed upwards. During periods of reverse polarity, the magnetic field reverses in direction into the opposite state. These changes in direction (and polarity states) can be recorded in sediments and igneous rocks through a variety of processes, which act upon the enclosed magnetic minerals, which are often primarily various forms of Fe-Ti oxides. The time duration of these changes in polarity is short (few hundred to few thousand years) and consequently the polarity boundaries recorded in sediments and volcanic rocks provide potentially the closest analogue of truly chronostratigraphic boundaries. An interval of single polarity is called a magnetozone, and is bounded by an upper and lower polarity boundary from magnetozones of opposite polarity.

Magnetostratigraphy has the great potential for global and local correlation independent of sedimentary environments and biotic differences. However, a stable and validated magnetic polarity pattern, fixed to stage or biostratigraphic boundaries does not exist for the Carboniferous, and is an ultimate aim of much magnetostratigraphic work both in the past and hopefully into the future. The construction of a Carboniferous magnetostratigraphy linked to biostratigraphic zonations therefore has great potential in helping to aid the selection of sections proposed as a Global Stratotype Section and Point (GSSP) and their auxiliary sections, and examine their intercontinental correlation. In the longer term it also has the ability of correlating chronostratigraphic and biostratigraphic boundaries into faunal realms, different from those in which the stage boundary GSSP's will be defined.

The general pattern of the polarity changes during the Carboniferous has been known for many years (Irving and Parry, 1963; Khramov et al., 1974), and is composed of a dominantly reverse polarity state from about the Mississipian- Pennsylvanian boundary into the Late Permian. This is the Permo-Carboniferous Reverse Superchron (PCRS, or Kiaman superchron). The Mississippian appears to contain magnetozones of both reverse and normal polarity, whose extent, polarity bias, and position relative to stage boundaries and biostratigraphy is currently 'work in progress.' Over the past 40 years there have been many attempts to better constrain the polarity pattern, which have been matched with various degrees of success, and currently our best Carboniferous estimates are derived from regional-based studies, without currently any easy means to confidently link them together. This state of knowledge to a large extent, follows how the consolidation of magnetic polarity patterns for parts of the Mesozoic are being constructed- where more extensive regional-based studies have ultimately allowed the identification of inter-continental correlations and the consolidation of the magnetozone patterns linked to stage and biostratigraphic zonations. Consequently the magnetostratigraphic data will be reviewed in a regional context.

The Americas

Palaeomagnetic investigations of the Carboniferous in North America have a long history. Unfortunately much of the work on carbonate platform successions have been plagued by basin-wide problems of remagnetision (Roy and Morris, 1983; McCabe and Elmore, 1989). The most successful Carboniferous magnetostratigraphic studies in the Americas have been performed at the Minudie-Joggins sections in Nova Scotia (DiVenere and Opdyke, 1991a), Maringouin Peninsula, New Brunswick (DiVenere and Opdyke, 1990), and the Mauch Chunk Formation, Pennsylvania (DiVenere and Opdyke, 1991b; Opdyke and Channel, 1996; Opdyke et al., 2000; Figure 1). The sections in Nova Scotia and New Brunswick are predominantly red and grey coloured fluvial successions. The biostratigraphy is dominantly provided by palynological zonation, which links it to the European stages and is discussed in Buchan and Chandler (1999) and Opdyke et al. (2000). Opdyke et al. (2000) placed the uppermost normal magnetozone (N8) in the Yeadonian (latest Namurian), and the N6 magnetozone within the Marsdenian (Figure 1). Based on Australian sections they proposed the base of the PCRS should be defined at the top of the N6 normal magnetozone within the Claremont Formation (Figure 1). However, Buchan and Chandler (1999) have disputed this and suggested it should be placed higher in the Canadian sections. The New Glasgow Formation in Nova Scotia, is the lateral equivalent of the Joggins Formation. Normal polarity is dominant in the New Glasgow Formation, suggesting to Buchan and Chandler (1999) that the base of the PCRS should be placed within the Joggins/ New Glasgow Fm. However, short duration normal polarity intervals are known from the base of the PCRS, within the Russian Donets Basin (Opdyke et al., 1993), and its possible that Buchan and Chandler (1999)

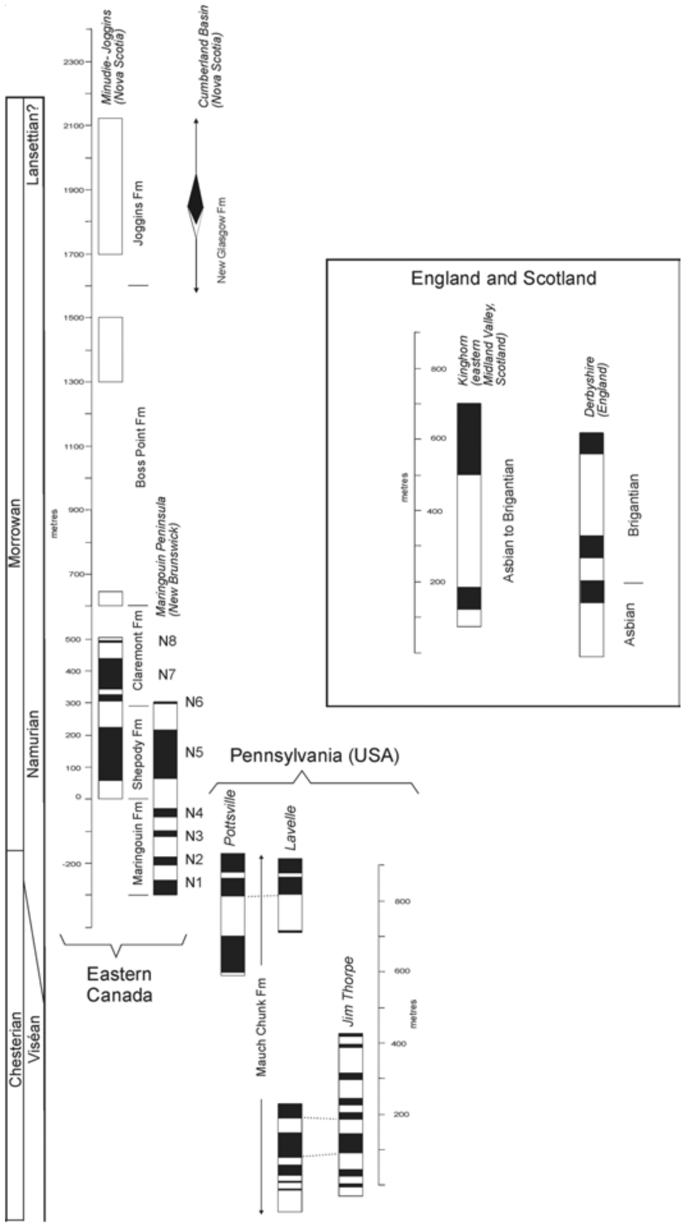

Figure 1. Summary of magnetostratigraphic data for sections from North America and western Europe (section/locations in italics). All sections are drawn to depth scales except that from Derbyshire. White= reverse polarity, black= normal polarity, gap in column= gap in sections/no data. Diamond symbol indicates polarity information, not related to a continuous stratigraphic section, with approximate age range indicated, and approximate polarity content of data.

detected one of these in the Nova Scotia sections. However, the age of these Canadian sections has been called into question, with some maintaining that the Joggins Formation is entirely pre-Westphalian in age (Utting and Giles, 1998), and that a hiatus exists at the base of the Boss Point Formation, adding greater uncertainty to the age of the base of PCRS in these sections.

DiVenere and Opdyke, (1991b) and Opdyke and DiVenere (1994) presented the magnetostratigraphy from the upper part of the Mauch Chunk Formation, which a red-bed succession without biostratigraphically significant fossils. Its placement relative to the stratigraphy shown in Figure 1 is largely based on palynology from the overlying and underlying units, and on local lithological correlations to better dated units (Opdyke et al., 2000). Based on these, the upper part of the Potsville section appears to span the Mississippian-Pennsylvanian boundary (i.e., is upper Arnsbegian), and the lower part is no older than latest Viséan. Magnetostratigraphic data presented in Opdyke and DiVenere (1994) and Opdyke and Channel (1996), from lower in the Mauch Chunk Formation extend this magnetostratigraphy to the base of the Chesterian (upper Viséan). Reverse and normal polarity intervals of Morrowan age (late Namurian to Lansettian) were confirmed by Nick et al. (1991) on reddened palaeosols. In addition, Alva-Valdivia et al. (2002), from a limited dataset, have detected both reverse and normal polarity intervals in the Mississippian of Mexico.

Studies of the younger parts of the Pennsylvanian (Atokan and younger) through to the Lower Permian in North America have only detected reverse polarity associated with the PCRS (Diehl and Shive, 1981; Miller and Opdyke, 1985; Steiner, 1988; Magnus and Opdyke, 1991). This is in contrast to results from Russia and the Ukraine, which have shown short normal magnetozones (Khramov and Rodionov, 1981; Khramov, 2000). Alva-Valdivia et al. (2002) have also detected normal polarity intervals from two sites in Missourian (Stephanian) strata

Russia and Asia

Russian workers had by the mid 1970s produced a compilation of the Carboniferous magnetostratigraphy, using sections in the Donets Basin and the southern Urals (Khramov, 1963; Khramov et al., 1974; Khramov and Rodionov, 1981). The Bolshaya Kalitva, Davyovka, and Mikhailovsk Gorge sections through the Kasimovian, Moscovian, and Bashkirian in the Donets Basin, show dominantly reverse polarity through the Moscovian and Kasimovian (Figure 2). Major intervals of normal polarity occur within the Mikhailovsk Gorge section, starting in the uppermost Bashkirian (Figure 2). The quality of the measurements which contributed to this compilation have been difficult to assess because the information was obtained prior to modern palaeomagnetic cleaning methods and was prior to the recognition of pervasive remagnetisation events, which are now known to be common in orogenic belts and some extensional basin successions. Opdyke et al. (1993) restudied the Moscovian sequences in the Donets Basin but could not confirm the proposed Moscovian polarity zones. This may be because the magnetozones were originally detected within siltstones and sandstones, which were not studied by Opdyke et al. (1993), who focused mainly on limestones (Khramov, 2000). Perhaps this mirrors similarities to the problems experienced in examining Carboniferous limestone successions of western Europe and North America?

The data presented in Khramov et al. (1974) through the Serpukhovian, Viséan, and Tournaisian from the Kalmius and Malaya Shishovka sections is dominated by reverse polarity. The lack of similarity between the frequency of normal polarity intervals in the Viséan from the Russian data and the data from the Maunch

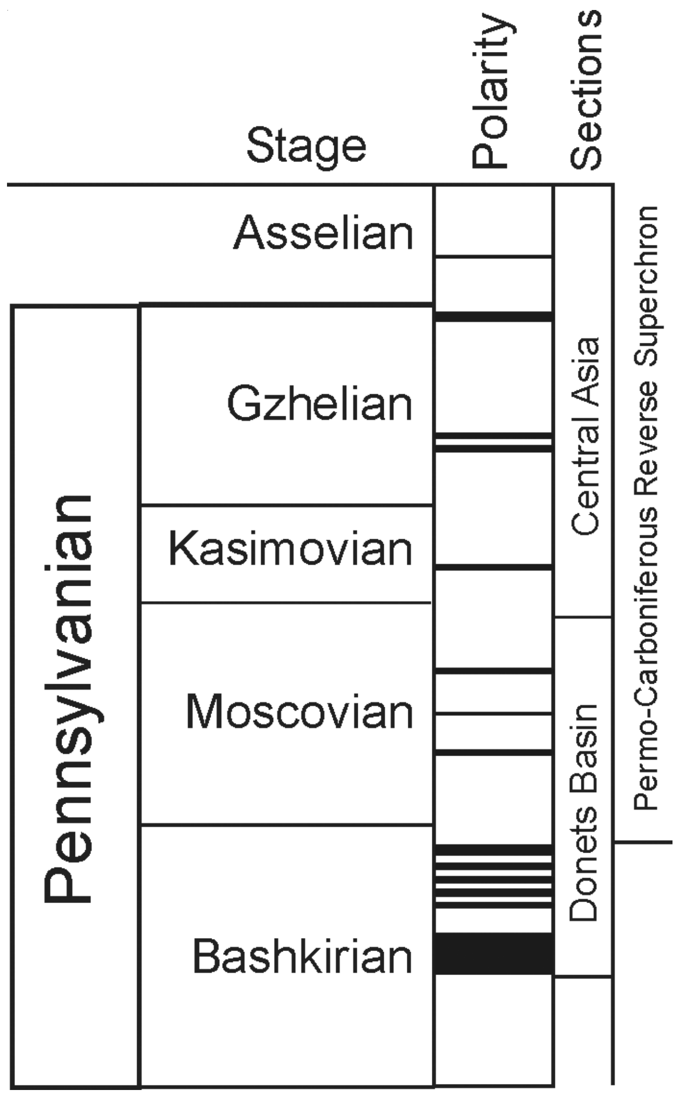

Figure 2. Composite of magnetostratigraphic data from Russsia and the Ukraine for the Pennsylvanian. Primary data mostly from Khramov et al. (1974), compilation from Khramov (2000).

Chunk Formation in North America is conspicuous, and suggests the Russian data for this interval is perhaps suspect, having possibly been affected by remagnetisations. Derder et al. (2001) in a palaeopole study sampled a Serpukhovian to Moscovian succession on the Sahara Craton, and identified reverse and normal polarity magnetisations. They suggested the PCRS had started by the end of the Serpukovian, although is clearly at odds with the Donets Basin and the North American data.

To date the only unequivocal identification of normal polarity magnetozones within the PCRS is within the uppermost Carboniferous (Figure 2). The Permian GSSP section at Aidaralash contains a normal magnetozone which is mostly restricted to the *Ultradaixiana bosbytauensis–Schwagerina robusta* fusulinid Zone, directly below the Carboniferous-Permian boundary. This normal magnetozone, which has been named the "*Kartamyshian*" by Davydov and Khramov (1991) has also been detected in the Nikolsky section of the southern Urals, the Belaya River section of the northern Caucasus, and the Ivano-Darievka section of the Donets Basin (Khramov, 1963; Khramov and Davydov, 1984; Davydov et al., 1998). This may also be correlated with a normal magnetozone in the Manebach Formation in northeastern Germany (Menning et al., 1988). It therefore appears to be an important magnetostratigraphic marker for the Carboniferous-Permian boundary.

Kolosev (1984, 2001) has presented some magnetostratigraphic data from the Tournaisian of the Russian Far East. Stone et al. (2003) have suggested that this data, from the Omulevka area, is strongly contaminated by remagnetisations, since it was not used by them for palaeopole determinations, indicating that its validity for constructing a magnetostratigraphy is in doubt. Lu et al. (1991) reported polarity reversals from the Devonian-Carboniferous boundary section at Dapsoushang (China), although the validity of these data has not been demonstrated by any later studies of important sections in the same area. Unpublished preliminary studies on sections in Guizhou province appear to indicate sections studied so far, probably do not carry a primary Carboniferous magnetisation (Hou Hongfei, pers. comm., 2004).

Western Europe

Much palaeomagnetic work has been done on the European Carboniferous, both within the Variscan fold belts, and extensional basins external to Variscan deformations. Much of this work on Viséan carbonates (e.g., Turner et al., 1979; Palmer et al., 1985; Palmer, 1987) consistently identified reverse polarity magnetisations, with shallowly dipping negative (upwards directed) inclinations. These are now know to be remagnetisations associated with events in the latest Carboniferous and early Permian, that is during the PCRS (Piper et al., 1991; Thominski et al., 1993; McCabe and Channel, 1994). This became clear when good quality palaeomagnetic data were acquired from Viséan volcanic successions, showing both reverse and normal magnetic polarity and directions consistently different from the later PCRS remagnetisation directions (Torsvik et al., 1989; Piper et al., 1991). External to the Variscan front the remagnetisations are commonly pre-folding, so the palaeomagnetic fold test is of little value in distinguishing age of magnetisation.

The studies by Torsvik et al. (1989) and Piper et al. (1991) from successions of interbedded lavas and sediments, provide the only convincing examples of a magnetostratigraphic polarity pattern extracted from the Viséan of western Europe (Figure 1). The study of Torsvik et al. (1989) from the Kinghorn Volcanic Formation, is dated by its lateral interdigitation with sediments which are Asbian to Brigantian in age (Browne et al., 1999). Hence, these magnetozones should be approximately equivalent to the Asbian to Brigantian magnetozones detected by Piper et al. (1991), and the late Viséan parts of the Maunch Chunk Formation in Pennsylvania (Figure 1).

Other European Carboniferous magnetostratigraphies reported, such as Kolesov (1984), from southern Belgium are doubtful due to the pervasive and complete remagnetisation of surrounding Devonian and Carboniferous sediments (Thominski et al., 1993; Zegers et al., 2003). Occasional vestiges of

Carboniferous-like normal polarity magnetisations in the carbonate platform and basin successions of northern England may be real (e.g., Turner et al., 1979; Addison et al., 1985), but the lateral extent of these has yet to be investigated. Based on existing data, Piper et al. (1991) suggested that primary magnetisations might be preserved better in silicified limestone units, which were somehow able to resist the remagnetisation process.

Normal polarity lavas from the Tournaisian of northern England are also known (Oppenheim et al., 1994), suggesting that probable mixed polarity intervals may extend to the base of the Carboniferous (Opdyke and Channel, 1996).

The thick Namurian and Westphalian successions in western Europe have not been investigated at large, due to problems of weak magnetisations, sometimes poor exposure and perceptions of non-ideal lithologies for palaeomagnetic study. The red-bed successions which characterize the Westphalian D, Bolsovian, and Stephanian in some parts of Europe have yielded what appear to be primary late Carboniferous reverse polarity magnetisations (Turner et al., 1985; Johnson et al., 1997), which suggest that the base of the PCRS is older than Bolsovian.

Australasia

Irving and Parry (1963) first recognized the PCRS from studies in Australia, and therefore sections in New South Wales are critical in defining and dating the base of the PCRS. However, the originally studied section in the Lower Hunter Valley near Paterson, is now known to include a 14 Ma gap, so the significance of the original work for this boundary and its global correlation is in doubt (Claoué-Long et al., 1995; Roberts et al., 1995; Idnurm et al., 1996).

However, Opdyke et al. (2000) have defined and dated the base of the PCRS in the southern Rocky Creek Block of the Tamworth Belt, New England Orogen, eastern Australia, which seems to be a more complete section across the base of the PCRS. They identified the base of the PCRS as the change from normal to reverse polarity between two ignimbrites in the lower part of the Clifden Formation, the normal polarity Wanganui Andesite Member (Roberts et al., 2003) and the Eastons Arm Rhyolite (reverse-polarity), and named it the Wanganui normal magnetozone. The two ignimbrites have been dated by SHRIMP $^{206}U/^{238}Pb$ zircon analysis (using SL13 as the zircon standard) at 319.2 ± 2.8 Ma (2F) for the Wanganui Andesite and at 317.8 ± 2.8 Ma (2F) for the succeeding Eastons Arm Rhyolite, indicating an age for the top of the Wanganui magnetozone of about 318 Ma. A single observation of normal polarity in a red ignimbrite of uncertain stratigraphic position, apparently above the Eastons Arm Rhyolite, could imply a slightly younger age for the base of the PCRS. However, an account of further mapping by Roberts et al. (2003) is not specific about the stratigraphic position of this red ignimbrite. Opdyke et al. (2000) proposed a probable correlation of the Wanganui normal magnetozone with the N6 normal magnetozone in the Claremont Formation of Nova Scotia, with the proviso that the doubtful younger normal unit in the Clifden Formation could correlate with the N8 normal zone in the Boss Point Formation of Nova Scotia (Figure 1). Accordingly, they proposed the age of the base of the PCRS to be likely between about 318 Ma and 316 Ma. These data are consistent with mixed magnetic polarity mid Carboniferous volcanic formations (~325-317 Ma) in Queensland (Anderson et al., 2003), and Carboniferous palaeopole data from the Rocky Creek and Werrie Blocks of the Tamworth Belt (Klootwijk 2002, 2003).

On the basis of further mapping and SHRIMP dating using AS3 as the zircon standard, Roberts et al. (2003) suggested 327.2 ± 2.9 Ma as the most likely age for the Wanganui normal magnetozone. The U/Pb zircon dates described by Opdyke et al. (2000) were obtained using the SHRIMP I and SHRIMP II ion microprobes, following the procedures of Claoué-Long et al. (1995), using SL13 as the zircon standard. The U/Pb zircon dates of Roberts et al. (2003) were obtained using the SHRIMP II ion microprobe and SL13 and AS3 as zircon standards. Critical appraisal of four zircon standards used for SHRIMP dating (Black et al., 2003a) have shown that the SL13 is the most heterogenous in U/Pb of the four standards and that the ages resulting from that heterogeneity are generally younger than the ages derived from the other three standards. Black et al. (2003a) conclude that the SL13-calibrated ages are on average about 1.0% younger than those based on their preferred TEMORA 1 (Black et al., 2003b) standard, but that "it is unrealistic to uniformly apply such a conversion factor because of demonstrable Pb/U heterogeneity within SL13". Black et al. (2003a) also conclude that the AS3-calibrated ages are about 1% older than those based on the TEMORA 1 standard. Pending further insights on the use of TEMORA 1 as the preferred, most reliable, zircon standard for SHRIMP U/Pb dating, it is debatable whether or not Roberts et al. (2003) AS3-based date of 327.2 ± 2.9 Ma for the top of the Wanganui normal magnetozone is an over-correction of the Opdyke et al. (2000) SL13-based dating constraint of about 318 Ma.

Conclusions and Future Prospects

The base of the PCRS is a major stratigraphic marker for the lower parts of the Pennsylvanian. From the Australian sections, this boundary appears to be radiometrically dated either at about 318 Ma or 327.2 ± 2.9 Ma. Using the Australian biostratigraphy for these sections indicates the base of the PCRS occurs within the mid to late Namurian. However, the older radiometric age would place it at the base of the Namurian (~base of Serpukhovian), using the Gradstein and Ogg (1996) timescale for the Carboniferous. These older radiometric ages contradict the American and Donets Basin data which approximately agree, placing it around the boundary of the Namurian-Westphalian and in the mid to late Bashkirian. Clearly more work needs to be done to resolve these discrepancies.

One short normal polarity interval within the PCRS appear to be validated from duplicate sections (Davydov et al., 1998), suggesting this and perhaps others may provide good stratigraphic markers in the Pennsylvanian, particularly if more can be verified and tied to biostratigraphic constraints.

Most of the Namurian/Serpukhovian and Viséan appears to be characterized by fairly rapid changes in magnetic polarity, with at least 16 normal polarity magnetozones through the Namurian and Viséan. This corresponds to a potential stratigraphic resolution better than the number of European substages. Currently there is not sufficient information to assess the overall pattern of polarity changes for the Tournaisian.

The successful palaeomagnetic work, which has helped to define the Carboniferous magnetostratigraphy is to a large extent based on successions of clastic sediments, both using sections in North America and those in Russia and the Ukraine. Studies on interbedded volcanic and clastic successions currently form the best Carboniferous magnetostratigraphic data from Australia and Western Europe. Limestone dominated successions, certainly from Europe and North America appear not to provide good recorders of the Carboniferous magnetic field, due to pervasive remagnetision problems during the PCRS. However, even within the Variscan fold belts, given suitable low burial temperatures, basinal successions do hold a little promise for extracting good palaeomagnetic and magnetostratigraphic data (Zegers et al., 2003). There is insufficient data to say if remagnetisation is a common problem with sections in China and Russia/Ukraine.

What should be the focus for the future? Any magnetostratigraphic work must be a direct collaboration between biostratigraphers and palaeomagnetists, to ensure that magnetozone boundaries are linked as close as feasible to biostratigraphic, sequence stratigraphic (or other) indicators within the sections- this produces the tightest integration of all suitable stratigraphic markers. Land-based studies of the Mesozoic, which have attempted to build linked bio-magnetostratigraphies, have relied heavily upon hemi-pelagic and pelagic carbonates, which have not been subjected to reductive diagenesis for much of their burial history. Such lithologies would clearly be a good target for further work in the Carboniferous, however, whether such successions ever existed for the Carboniferous, and/or have not been heated to unacceptably high temperatures for palaeomagnetic measurements is debatable. Hence, clastic successions, which interfinger with both terrestrial and marine successions, are likely to provide the best archive for constructing a magnetostratigraphic scale, linked to biostratigraphy for the Carboniferous.

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References

Addison, F.T., P. Turner, and D.H. Tarling. 1985. Magnetic studies of the Pendleside Limestone: evidence for re-magnetisation and late diagenetic dolomitisaton during a post Asbian normal event. Journal Geological Society London, 142:983-994.

Alva-Valdivia, L.M., A. Goguitchaichvii, M. Grajales, A.F. de Dios, J. Urrutia- Fucugaughi, and C. Roseles. 2002. Further constraints for Permo Carboniferous magnetostratigraphy: case study of the sedimentary sequence from San Salvador-Patlanoaya (Mexico). Comptes Rendu Geosci., 334:811-817.

Anderson, K.L., M.A. Lackie, D.A. Clark, and P.W. Schmidt. 2003. Paleomagnetism of the Newcastle range, northern Queensland: Eastern Gondwana in the late Paleozoic. Jour. Geophys. Res., 108, doi: 10.1029/2002JB001921.

Black L.P., S.L. Kamo, I.S. Williams, R. Mundil, D.W. Davis, R.J. Korsch, and C. Foudoulis. 2003a. The application of SHRIMP to Phanerozoic geochronology; a critical appraisal of four zircon standards. Chemical Geology, 200:171-188.

Black L.P., S.L. Kamo, C.M. Allen, J.N. Aleinikoff, D.W. Davis, R.J. Korsch, and C. Foudoulis. 2003b. TEMORA 1: a new zircon standard for Phanerozoic U-Pb geochronology. Chemical Geology, 200:155-170.

Browne, M.A.E., M.T. Dean, I.H.S. Hall, A.D. Mcadam, S.K. Monro, and J.I. Chisholm.1999. A lithostratigraphical framework for the Carboniferous rocks of the Midland Valley of Scotland. British Geological Survey Research Report, RR/99/07

Buchan, K.L., and F.W. Chandler. 1999. Paleomagnetism of the distal member of the New Glasgow Formation, Nova Scotia, Canada: new constraints on magnetic polarity stratigraphy near the base of the Kiaman superchron. Jour. Geol., 107: 271-286.

Claoué-Long J.C., W. Compston, J. Roberts, and C.M. Fanning. 1995. Two Carboniferous ages: a comparison of SHRIMP zircon dating with conventional zircon ages and 40Ar/39Ar analysis, p. 3-21. *In* W.A. Berggren, D.V. Kent, M.-P Aubrey, and J. Hardenbol (eds.), Geochronology Time Scales and Global Stratigraphic Correlation. Society for Sedimentary Geology (SEPM) Special Publication, 54.

Davydov, V.I., and A.N. Khramov. 1991. Paleomagnetism of Upper Carboniferous and Lower Permian in the Karachatyr region (southern Ferhgana) and the problems of correlation of the Kiama hyperzone, p. 45-53. *In* A.N. Khramov (ed.), Paleomagnetism and Paleogeodynamics of the Territory of the USSR. Transactions of VNIGRI. (In Russian)

Davydov, V.I., B.F. Glenister, C. Spinosa, S.M. Ritter, V.V. Chernykh, B.R. Wradlaw, and W.S. Snyder. 1998. Proposal of the Aidaralash as Global Stratotype Section and Point (GSSP) for the base of the Permian System. Episodes, 21:11-17.

Derder, M.E.M., B. Smith, B. Henry, A.K. Yelles, B. Bayou, H. Djellit, R. Ouali, and H. Gandriche. 2001. Juxtaposed and superimposed palaeomagnetic primary and secondary components from the folded Middle Carboniferous sediments in the Reggane basin (Saharan Craton, Algeria). Tectonophysics, 344:403-422.

Diehl, J.F., and P.N. Shive. 1981. Paleomagnetic results from the late Carboniferous/ Early Permian Casper Fm: implications for northern Appalachian tectonics. Earth. Planet. Sci. Lett., 54:281-291.

DiVenere, V.J., and N.D. Opdyke. 1990. Palaeomagnetism of the Maringouin and Shepody Formations, New Brunswick: a Namurian magnetic stratigraphy. Can . J. Earth Sci., 27:803-810.

DiVenere, V.J., and N.D. Opdyke. 1991a. Magnetic polarity stratigraphy and Carboniferous paleopole position from the Joggins Section, Cumberland Basin, Nova Scotia. Journal of Geophysical Research, 96:4051-4064.

DiVenere, V.J., and N.D. Opdyke. 1991b. Magnetic polarity stratigraphy in the uppermost Mississippian Mauch Chunk Formation, Pottsville, Pennsylvania. Geology, 19:127-130.

Gradstein, F. M., and J. Ogg. 1996. A Phanerozoic time scale. Episodes, 19:3-5.

Idnurm, M., C. Klootwijk, H. Théveniaut, and A. Trench. 1996. Magnetostratigraphy, p. 22-51. *In* G.C. Young, G.C. and J.R. Laurie (eds.), An Australian Phanerozoic Timescale. Oxford University Press.

Irving, E., and L.G. Parry. 1963. The magnetism of some Permian

rocks from New South Wales. J. Geophys, London, 7(4): 395-411.
Johnson, S.A., B.W. Glover, and P. Turner. 1997. Multiphase reddening and weathering events in the Upper Carboniferous red beds from the English West Midlands. Jour. Geological Society of London, 154:735-745.
Khramov, A.N. 1963. Paleomagnetism of Paleozoic. Transactions of VNIGRI, 283 p. (In Russian)
Khramov, A.N. 2000. The general magnetostratigraphic scale of the Phanerozoic, p. 24-45. *In* A.I. Zhamoida (ed.), Supplement to the Stratigraphic Code of Russia. Transactions of VSEGEI, St. Petersburg. (In Russian)
Khramov, A.N., and R. Rodionov. 1981. The geomagnetic fuield during Paleozoic time, p. 99-116. *In* M. McElhinny et al. (eds.), Global Reconstruction and the Geomagnetic Field during the Paleozoic. Advances in Earth Planetary Sciences, 10, Reidel Publishing, Dordrecht.
Khramov, A.N., and V.I. Davydov. 1984. Paleomagnetism of Upper Carboniferous and Lower Permian in the South of the U.S.S.R. and the problems of structure of the Kiama hyperzone. Transactions of VNIGRI, p. 55-73. (In Russian)
Khramov, A.N., G.I. Goncharov, R.A. Komisssarova, E.P. Osipova, I.A. Pogarskaya, V.P. Rodionov, I.P. Stautsilais, L.S. Smirnov, and N.N. Forsh. 1974. Paleozoic Paleomagnetism. Transactions of VNIGRI, 238 p. (In Russian)
Klootwijk, C.T. 2002. Carboniferous palaeomagnetism of the Rocky Creek Block, northern Tamworth Belt, and the New England pole path. Australian Journal of Earth Sciences, 50:131-135.
Klootwijk, C.T. 2003. Carboniferous palaeomagnetism of the Werrie Block, northern Tamworth Belt, and the New England pole path. Australian Journal of Earth Sciences, 50:865-902.
Kolesov, E.V. 1984. Paleomagnetic stratigraphy of the Devonian-Carboniferous boundary beds in the Soviet North-East and in the Franco-Belgian Basin. Annales Société Geoloque de Belgique, 107:135-136.
Kolesov, E.V. 2001. The Paleomagnetism of the Upper Paleozoic volcanogenic-sedimentary sequences of Prikolym uplift, p. 32-44. *In* K.K. Simakov, K.K. (ed.), Paleomagnetic studies of geological rocks in the northeast of Russia. Magadan. (In Russian)
Liu, H.F., Z.Q. Bai, H.D. Wang, and K.S. Yaskawa. 1991. Search for the geomagnetic reversal near the Devonian-Carboniferous boundary. J. Geomag. Geoelec., 43:755-764.
Magnus G., and N.D. Opdyke. 1991. A palaeomagnetic investigation of the Mintrun Formation, Colorado: a study in establishing the timing of remanence acquisition. Tectonophysics, 187:181-189.
McCabe, C., and R.D. Elmore. 1989. The occurrence and origin of late Paleozoic remagnetisation in the sedimentary rocks of North America. Rev. Geophys., 27:471-494.
McCabe, C., and J.E.T. Channel. 1994. Late Palaeozoic remagnetisation during in limestones of the Craven Basin (Northern England) and rock magnetic fingerprinting of remagnetised carbonates. J. Geophys. Res., 99:4603-4612.
Menning, M., G. Katzung, and H. Lützner. 1988. Magnetostratigraphic investigations in the Rotliegendes (300-252 Ma) of Central Europe. Zetschrift für Geologischen Wissenschaften, 16:1045-1063.
Miller, J.D., and N.D. Opdyke. 1985. The magnetostratigraphy of the Red Sandstone Creek section, Vail, Colorado. Geophys. Res. Lett., 12:133-136.
Nick, K., K.D. Xia, and R.D. Elmore. 1991. Paleomagnetic and petrographic evidence for early magnetisations in successive terra rosa palaeosols, Lower Pennsylvanian Black Prince Limestone, Arizona. J. Geophys. Res., 96:9873-9885.
Opdyke, N.D., and V.J. Di Venere. 1994. Magnetic polarity stratigraphy of the Mauch Chunk Formation, Pennsylvania, EOS., Transactions of the American Geophyical Union Spring Meeting, 75:130.
Opdyke, N.D., and J.E.T. Channell. 1996. Magnetic Stratigraphy. Academic Press, London and San Diego, 364 p.
Opdyke, N.D., A.N. Khramov, E. Gurevitch, A.G. Iosifidi, and I.A. Makarov. 1993. A paleomagnetic study of the middle Carboniferous of the Donets Basin, Ukrain. EOS Trans. Am. Geophys. Union, Spring Meeting, p.118.
Opdyke, N.D., J. Roberts, J. Claoue-Long, E. Irving, and P.J. Jones. 2000. Base of the Kiaman: its definition and global significance. Geological Society of America Bulletin, 112(9):1315-1341.
Oppenheim, M.J., J.D.A. Piper, and T.C. Rolph. 1994. A palaeointensity study of the Lower Carboniferous transitional geomagnetic field directions: the Cockermouth lavas, northern England. Phys. Earth and Planet. Inter., 82:65-74.
Palmer, J.A. 1987. Carboniferous magnetostratigraphy. Ph.D. Newcastle upon Tyne.
Palmer, J.A., S.P.G. Perry, and D.H. Tarling. 1985. Carboniferous magnetostratigraphy. Journal of the Geological Society London, 142:945-955.
Piper. J.D.A., D. Atkinson, S. Norris, and S. Thomas. 1991. Palaeomagnetic study of the Derbyshire lavas and intrusions, central England: definition of Carboniferous apparent polar wander. Phys. Earth and Planet. Int., 69:37-55.
Roberts J., X. Wang, and M. Fanning. 2003. Stratigraphy and correlation of Carboniferous ignimbrites, Rocky Creek region, Tamworth Belt, Southern New England Orogen, New South Wales. Australian Journal of Earth Sciences, 50:931-954.
Roberts, J., J.C. Claoué-Long, P.J. Jones, and C.B. Foster. 1995. SHRIMP zircon age control of Gondwanan sequences in Late Carboniferous Australia, p. 145-174. *In* R. Dunay and E. Hailwood (eds.), Non-Biostratigraphical Methods of Dating and Correlation. Geological Society of London Special Publication, 89.
Roy, J.L., and W.A. Morris. 1983. A review of palaeomagnetic results from the Carboniferous of North America; the concept of Carboniferous geomagnetic field horizon markers. Earth Planet. Sci. Letters., 65, 167-181.
Steiner, M.J. 1988. Paleomagneism of the Late Pennsylvanian and Permian: a test of the rotation of the Colorado Plateau. J. Geophys. Res., 93:2201-2215.
Stone, D.B., P. Minyuk, and E. Kolesev. 2003. New palaeomagnetic paleolatitudes for the Omulevka terrane of northeast Russia: a comparison with the Omolon terrane and the eastern Siberian platform. Tectonophysics, 377:55-82.
Thominski, H.P., J. Wohlenburg, and U. Bleil. 1993. The remagnetisation of Devonian-Carboniferous sediments from the Ardenno-Rhenish Massif. Tectonophysics, 225:411-431.
Torsvik, T.H., O. Lyse, G. Atteras, and B.J. Bluck, 1989. Palaeozoic

palaeomagnetic results from Scotland an their bearing on the British apparent polar wander path. Phys. Earth Planet. Int., 55: 93-105.
Turner, P., I. Metcalfe, and D.H. Tarling. 1979. Palaeomagnetic studies of some Dinantian limestones from the Craven Basin and a contribution to Asbian magnetostratigraphy. Proc. York Geol. Soc., 42:371-396.
Turner, P., D.J. Vaughan, and B. Besly. 1985. Remanence acquisition in red beds from the Coal Measures of central England. Journal of the Geological Society London, 142:1015-1028.
Utting, J., and P.S. Giles. 1998. Palynological zonation of Visean, Namurian and Westphalian (Carbonifeorus) rocks of Atlantic Canada; Paper presented at GAC/MAC, Quebec City.
Zegers, T.E. M.J. Dekkers, and S. Bailly. 2003. Late Carboniferous to Permian remagnetisation of Devonian limestones in the Ardennes: role of temperature, fluids and deformation. Jour. Geophys Res., doi:10.1029/2002JB002213.

Project Group on Carboniferous magnetostratigraphy: invitation to interested persons

A number of persons have expressed an interest in forming a working group with informal ties to the SCCS, to extend the use of magnetostratigraphy within the Carboniferous. This invitation is in parallel with the review of Carboniferous magnetostratigraphy within this issue. Some outline aims of the working group are:

1) To enhance the interaction and dialogue between palaeomagnetists, and other earth scientists with an interest in understanding the Carboniferous system in its global context.

2) To increase the utilization of magnetostratigraphy in achieving the goals of the stage boundary task groups.

3) The definition of a magnetostratigraphic polarity pattern for the Carboniferous linked to biostratigraphy, sequence stratigraphy and other forms of stratigraphic indicators. In the longer terms magnetostratigraphy might provide a primary means of correlation of the disparate Carboniferous biotas, independent of marine or terrestrial environmental contexts.

4) Define and locate, relative to all stratigraphic scales, the boundaries of the Permo-Carboniferous Reverse Superchron (the Kiaman).

If you would like to join this working party, and contribute to the dialogue between those whose measure and those who use magnetostratigraphy, please e-mail Mark Hounslow (m.hounslow@lancaster.ac.uk).

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Preliminary report on lower Desmoinesian (mid-Moscovian) conodonts from lower and middle Cherokee Group of southern Midcontinent North America

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Desmoinesian (late Moscovian) conodont faunas have been known for some time from Midcontinent North America (Gunnell, 1931, 1933; Stauffer and Plummer, 1932; Harris and Hollingsworth, 1933; Ellison, 1941; Youngquist and Heezen, 1948; Youngquist and Downs, 1949; Swade, 1985; Barrick and Boardman, 1989; Lambert, 1992; Lambert et al., 2003; Stamm and Wardlaw, 2003). Despite these reports no comprehensive analysis of the Desmoinesian succession has been completed, even though the North American Midcontinent may arguably have the best and most complete conodont succession of this age certainly within North America and possibly the world.

The best known Moscovian conodont successions have been described from the Moscow Basin (Barskov and Alekseev, 1975, 1976; Barskov et al., 1975, 1978; Goreva, 1984; Alekseev and Goreva 2001; Goreva and Alekseev, 2001), and the Donets Basin (Kossenko, 1975; Kozitskaya et al., 1978; Nemyrovska et al., 1999). Additionally, Moscovian conodonts have been reported from the northern Andes (Stibane, 1967), several provinces of China (Shanxi: Wang and Li, 1984; Xinjiang: Zhao et al., 1986; Guizhou: Wang and Qi, 2002), Egypt (Kora, 1989), and Turkey, (Capkinoglu, 2003). Desmoinesian conodonts from North America outside of the Midcontinent have been described from the Appalachian Basin (Sturgeon and Youngquist, 1949; Merrill, 1968, 1972), Colorado (Murray and Chronic, 1965), the Illinois Basin (Merrill, 1975; Brown et al., 1991; Rexroad et al., 2001; von Bitter and Merrill, 1998), California (Stevens et al., 2001), and the Paradox Basin in Utah (Ritter et al., 2002).

The North American Midcontinent Desmoinesian succession includes about 26 conodont-bearing cyclothems (Figure 1). This current report is the first study to document the conodont succession within the lower and middle (sub-Verdigris) part of the Cherokee Group, which represents about the lower half of Desmoinesian strata in the Arkoma-Cherokee Basin in northeastern Oklahoma and adjacent southern Kansas. This interval contains 13 conodont-bearing cyclothems, of which 8 yield significant faunas and are illustrated herein (Figures 2-3). The current preliminary report is based on some 2,000 conodont Pa elements. We recognize three faunal intervals within the sub-

Verdigris Cherokee Group, which represent informal zones following the methodology used by Barrick and Boardman (1989). This report also initiates the updating of the Pennsylvanian conodont zonation of Barrick et al. (in press 2004).

***Idiognathodus praeobliquus* Faunal Interval** (Figure 2)

The *Idiognathodus praeobliquus* faunal interval occurs in an unnamed black phosphatic shale bed in the basal McCurtain Shale Member of the McAlester Formation at the base of the Krebs Subgroup in east-central Oklahoma. This faunal interval contains *Idiognathodus praeobliquus* Nemyrovska, *I.* n. sp. A, and *Neognathodus bothrops* Merrill. The co-occurrence of *I. praeobliquus* and *N. bothrops* suggests correlation with the lower Kashirian Horizon [Substage] of the Moscow Basin and the Donets Basin, based on the work of Goreva and Alekseev (2001) and Nemyrovska et al. (1999), respectively. *Idiognathodus* n. sp. A is similar to *I. gibbus* Lambert, which occurs in what has been referred to as upper Atokan strata in Iowa (Lambert, 1992).

***Idiognathodus obliquus* Faunal Interval** (Figure 2)

The Idiognathodus obliquus faunal interval contains *Idiognathodus obliquus* Kossenko and Kozitskaya, *I.* n. sp. A, *I.* n. sp. B, *I.* n. sp. C, and *Neognathodus* cf. *asymmetricus* (Stibane). This faunal interval occurs in the Sam Creek Limestone and in the Doneley marine unit above the Rowe Coal in the Savannah Formation. *Idiognathodus obliquus* appears to represent a cosmopolitan species, as it is reported in the Moscow Basin (Goreva and Alekseev, 2001), Donets Basin (Nemyrovska et al., 1999) (from which it was named), Keeler Basin in California (Stevens et al., 2001), Paradox Basin in Utah (Ritter et al., 2002), northern Midcontinent (Lambert, 1992), and southern Midcontinent (this report). *Idiognathodus* n. sp. B is similar to *I. obliquus* except the transverse ridges are not as significantly oblique. *Idiognathodus* n. sp. C is similar to *I. ignisitus* Stamm and Wardlaw, but differs in having less well developed lobes. It is highly likely that *I.* n. sp. C is ancestral to *I. ignisitus*. It is also likely that many of the specimens illustrated by Stamm and Wardlaw (2003) as *Idiognathodus ignisitus* belong to *I. mundulus* Youngquist and Downs, 1949, based on an SEM photograph of the holotype provided by J. E. Barrick. *Idiognathodus mundulus* was named from a Cherokee shale bed in Iowa that is most likely in the Verdigris cyclothem.

***Idiognathodus podolskensis* Faunal Interval** (Figures 2, 3)

The *Idiognathodus podolskensis* faunal interval contains *Idiognathodus podolskensis* Goreva, *I. robustus* Kossenko and Kozitskaya, *I. iowaensis* Youngquist and Downs, *I. crassadens* Stamm and Wardlaw, *I.* n. sp. D, *Neognathodus asymmetricus*, *N.* aff. *asymmetricus, N. intrala* Stamm and Wardlaw, *N. roundyi* (Gunnell), *N.* cf. *roundyi*, and species of *Gondolella*, including *G. pohli* von Bitter and Merrill. *Idiognathodus podolskensis* Goreva is similar to *I. obliquus* but differs in having fewer and less oblique transverse ridges, and in having only slightly flaring adcarinal ridges. This interval includes the Inola Limestone in the Boggy Formation and extends up through the Verdigris Limestone. The lowest part of the *I. podolskensis* faunal interval in the Inola Limestone contains the last occurrences of *I.* n. sp. A, and *I.* n. sp. C in the study area, along with the first appearances of *I. podolskensis* and *Gondolella* aff. *laevis*. The Tiawah Limestone and associated black shales contain the first appearance of *I. robustus, I. crassadens,* and *Neognathodus* aff. *asymmetricus* and *N.* cf. *roundyi*. The species concept of *Idiognathodus robustus* has been recently clarified by the English translation provided by T. Nemyrovska. Stamm and Wardlaw (2003) illustrated forms that they referred to *I. robustus* from the younger Verdigris Limestone level throughout the USA. These forms do not fit with the original species concept but belong in a more advanced though closely related species. *Idiognathodus robustus s.s.* lacks adcarinal ridges, and the carina terminates in a node or node field. Somewhat more immature specimens from the Tiawah Limestone have this configuration. The forms illustrated by Stamm and Wardlaw (2003) have fused adcarinal ridges with irregular fusion of accessory denticles. We illustrate similar forms from the Russell Creek Limestone (Figure 3) and include these in *I. iowaensis* Youngquist and Heezen, 1948, which are similar to *I. rectus* Youngquist and Downs, 1949, both of which are named from the Verdigris cyclothem in Iowa and are currently undergoing restudy. The *Neognathodus* cf. *roundyi* from the black shale above the Tiawah Limestone appears to be transitional between *N. asymmetricus* and *N. roundyi*. Another characteristic of the Tiawah fauna is a *Gondolella* 'bloom' in the black shale below the Tiawah Limestone, which contains *Gondolella pohli* forming up to 50% of the fauna. The younger Russell Creek Limestone contains *Idiognathodus iowaensis, I. podolskensis,* and *I. crassadens*. The post-Fleming [caprock] limestone is a shallower-water carbonate that contains a low diversity assemblage consisting of a more slender morphotype of *I. podolskensis*. The top of the *I. podolskensis* faunal interval occurs in the Verdigris cyclothem, which was characterized by Stamm and Wardlaw (2003) and contains *Idiognathodus podolskensis*, *I. iowaensis, I. crassadens, Neognathodus roundyi, N. asymmetricus*, *N. intrala,* and *Gondolella pohli* in the southern Midcontinent as well as all the holotypes of all the species named by Youngquist and Heezen (1948) and Youngquist and Downs (1949) in the northern Midcontinent.

Acknowledgments

We thank Tamara Nemyrovska and James Barrick for information and thoughtful discussion relevant to conodont taxonomy.

References

Alekseev, A.S., and N.V. Goreva. 2001. Description of new characteristic taxa-Conodonta, p. 113. *In* A.S. Alekseev, A. S. and S.M. Shik (eds.), Middle Carboniferous of Moscow Syneclise (southern part), Volume 2, Biostratigraphy. Scientific World, Moscow.

Barrick, J.E., and D.R. Boardman. 1989. Stratigraphic distribution of morphotypes of *Idiognathodus* and *Streptognathodus* in Missourian-lower Virgilian strata, north-central Texas, p. 167-188. *In* D.R. Boardman, J.E. Barrick, J.M. Cocke, and M. Nestell M. (eds.), Middle and Late Pennsylvanian Chronostratigraphic

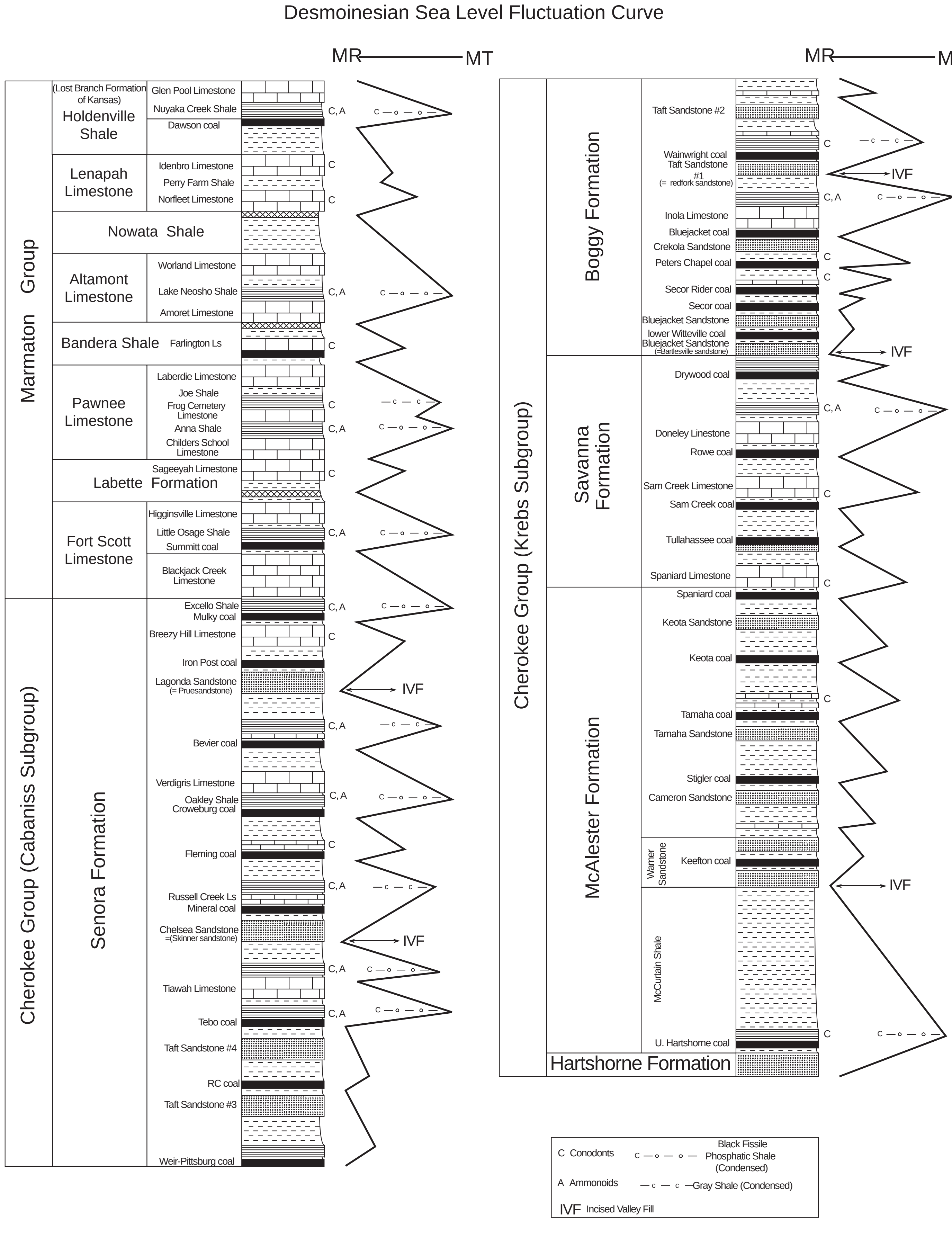
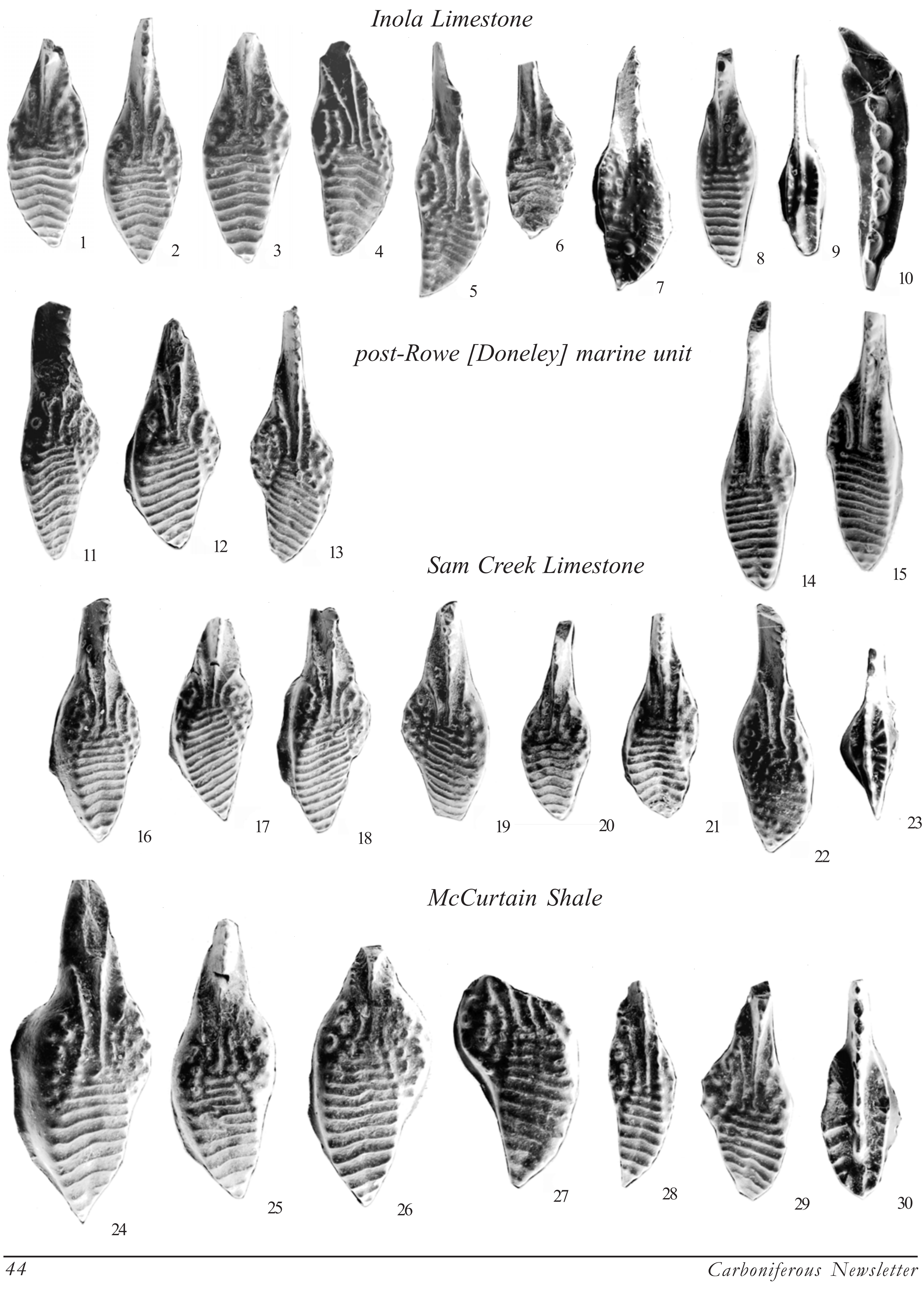


Figure 1. Lithostratigraphic classification and sea-level fluctuation curve for Desmoinesian Stage, based on outcrop and core data from northeastern Oklahoma and adjacent southeastern Kansas (updated from Boardman et al., 2002).


Inola Limestone
1
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post-Rowe [Doneley] marine unit
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Sam Creek Limestone
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McCurtain Shale
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Boundaries in North-Central Texas: Glacial-Eustatic Events, Biostratigraphy, and Paleoecology. Texas Tech University Studies in Geology, 2.

Barrick, J.E., L.L. Lambert, P.H. Heckel, and D.R. Boardman. In press 2004. Pennsylvanian conodont zonation for Midcontinent North America. Revista Española de Micropaleontologia, 36(2):231-250.

Barskov, I.S., A.S. Alekseev, and S.V. Shurygina. 1975. Conodonts of the Middle and Upper Carboniferous in the Moscow region. Byulleten Moskovskogo Obshchestva Ispytateley Prirody, Otdel Geologicheskiy, 50, 158 p.

Barskov, I.S., and A.S. Alekseev. 1975. Conodonts of the Middle and Upper Carboniferous from the vicinity of Moscow. Izvestiya Akademii Nauk SSSR, Seriya Geologicheskaya, 6:84-99.

Barskov, I.S., and A.S. Alekseev. 1976. New species of the genus *Idiognathodus* (Conodonta) from the middle Upper Carboniferous of the Moscow region. Paleontologischnii Zhurnal, 1976:119-121.

Barskov, I.S., A.S. Alekseev, L.I. Kononova, and A.V. Migdisova. 1987. Atlas of Upper Devonian and Carboniferous conodonts. Moscow University Press, 141 p.

Boardman, D.R., T.M. Marshall, and L.L. Lambert. 2002. Sea-level fluctuation curve for the Cherokee Group (lower and middle Desmoinesian/upper Moscovian) in the Arkoma-Cherokee Basin area of eastern Oklahoma. Newsletter on Carboniferous Stratigraphy, 20:26-28.

Brown, L.M., C.B. Rexroad, D.L. Eggert, and A.S. Horowitz. 1991. Conodont paleontology of the Providence Limestone Member of the Dugger Formation (Pennsylvanian, Desmoinesian) in the southern part of the Illinois Basin. Journal of Paleontology, 65: 945-957.

Capkinoglu, S. 2003. First records of conodonts from the Permo-Carboniferous of Demirozu (Bayburt), eastern Pontides, NE Turkey. Turkish Journal of Earth Sciences, 12(2):199-207.

Ellison, S. 1941. Revision of the Pennsylvanian conodonts. Journal of Paleontology, 15:107-143.

Goreva, N.V. 1984. Conodonts of the Moscow strata in the Moscow section, p. 44-122. *In* V.V. Menner (ed.), Palaeontological characteristics of stratotype and reference sections of the Moscow Basin Carboniferous: (conodonts and cephalopoda). Moscow University, Moscow. (In Russian)

Goreva, N.V., and A.S. Alekseev. 2001. Conodonta, p. 33-54. *In* A.S. Alekseev and S.M. Shik (eds.), Middle Carboniferous of Moscow Syneclise (southern part), Volume 2, Biostratigraphy, Scientific World, Moscow.

Gunnell, F.H. 1931. Conodonts from the Fort Scott limestone of Missouri. Journal of Paleontology, 5:244-252.

Gunnell, F.H. 1933. Conodonts and fish remains from the Cherokee, Kansas City, and Wabaunsee Groups of Missouri and Kansas. Journal of Paleontology, 7: 261-297.

Harris, R.W., and R.V. Hollingsworth. 1933. New Pennsylvanian conodonts from Oklahoma. American Journal of Science, 24(147):193-204.

Kora, M. 1989. Biostratigraphy of the Late Paleozoic succession in Gabal Ekma, southwestern Sinai, Egypt. Neues Jahrbuch fuer Geologie und Palaeontologie, Abhandlungen, 177(5):293-307.

Kossenko, Z.A. 1975. New species of conodonts from deposits of Moscovian Stage in southwestern part of Donets Basin. Geologichii Zhurnal, 35:126-133.

Kozitskaya, R.I., Z.A. Kossenko, O.N. Lipnyagov, and T.I. Nemyrovska. 1978. Conodonts from the Carboniferous of the Donets Basin. Izd. Nauka Dumka, Kiev, 136 p.

Lambert, L.L. 1992. Atokan and basal Desmoinesian conodonts from central Iowa, reference area for the Desmoinesian Stage. Oklahoma Geological Survey Circular, 94:111-123.

Lambert, L.L., P.H. Heckel, and J.E. Barrick. 2003. *Swadelina* new genus (Pennsylvanian Conodonta), a taxon with potential chronostratigraphic significance. Micropaleontology, 49:151-158.

Merrill, G.K. 1968. Allegheny (Pennsylvanian) conodonts. Unpublished Ph. D. Dissertation, Louisiana State University, Baton Rouge, Louisiana, 184 p.

Merrill, G.K. 1972. Taxonomy, phylogeny, and biostratigraphy of *Neognathodus* in Appalachian Pennsylvanian rocks. Journal of Paleontology, 46:817-829.

Merrill, G.K. 1975. Pennsylvanian conodont biostratigraphy and paleoecology of northwestern Illinois. Microform Publication - Geological Society of America, Issue 3, 130 p.

Murray, F.N., and J. Chronic. 1965. Pennsylvanian conodonts and other fossils from insoluble residues of the Minturn Formation (Desmoinesian), Colorado. Journal of Paleontology, 39: 594-610.

Nemyrovska, T.I., M-F. Perret-Mirouse, and A. Alekseev. 1999. On Moscovian (Late Carboniferous) conodonts of the Donets Basin, Ukraine. Neues Jahrbuch fur Geologie und Palaontologie, Abhandlungen, 214(1-2):169-194.

Rexroad, C.B., J.A. Wade, G.K. Merrill, L.M. Brown, and P. Padgett. 2001. Conodont biostratigraphy and depositional environments of the Mecca Quarry Shale Member and the Velpen Limestone

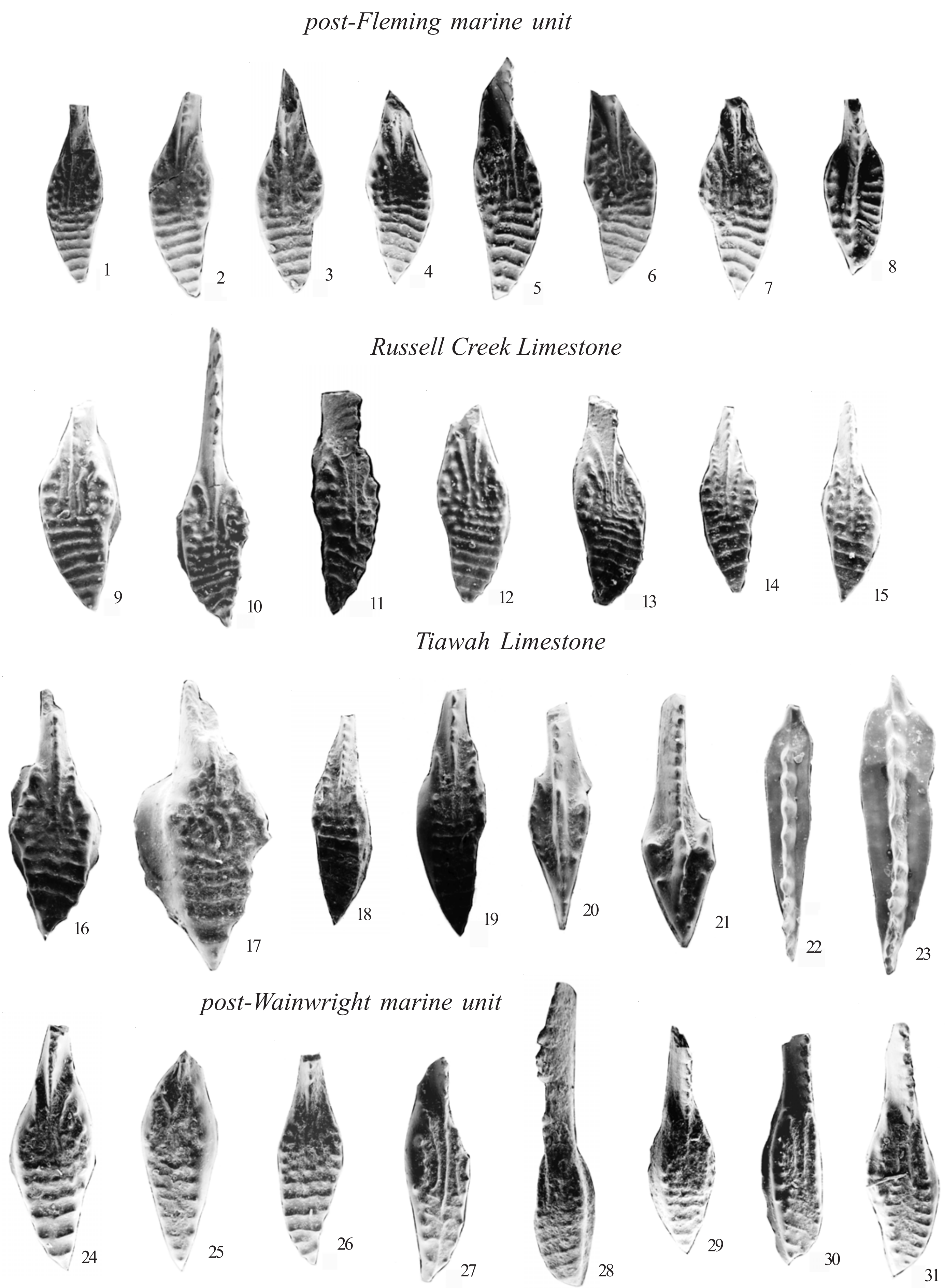
Figure 2. Conodonts from the lower Cherokee Group [Krebs Subgroup]. All magnifications X55.

Inola Limestone [middle Boggy Formation]
1, 3-5 *Idiognathodus podolskensis*
2 *Idiognathodus* n. sp. B
6-7 *Idiognathodus* n. sp. A
8 *Idiognathodus* n. sp. C
9 *Neognathodus asymmetricus*
10 *Gondolella* aff. *laevis*

Post-Rowe [Doneley] marine unit [Savanna Formation]
11-13 *Idiognathodus obliquus*
14-15 *Idiognathodus* n. sp. C

Sam Creek Limestone [Savanna Formation]
16 *Idiognathodus* n. sp. B
17-19 *Idiognathodus obliquus*
20-22 *Idiognathodus* n. sp. A
23 *Neognathodus* cf. *asymmetricus*

McCurtain Shale [McAlester Formation]
24-28 *Idiognathodus praeobliquus*
29 *Idiognathodus* n. sp. A
30 *Neognathodus bothrops*


post-Fleming marine unit
Russell Creek Limestone
Tiawah Limestone
post-Wainwright marine unit

Member of the Linton Formation (Pennsylvanian, Desmoinesian) in the eastern part of the Illinois Basin, U.S.A. Indiana Geological Survey Special Report, 63, 19 p.

Ritter, S.M., J.E. Barrick, and M.R. Skinner. 2002. Conodont sequence biostratigraphy of the Hermosa Group (Pennsylvanian) at Honaker Trail, Paradox Basin, Utah. Journal of Paleontology, 76(3):495-517.

Stamm, R.G., and B.R. Wardlaw. 2003. Conodont faunas of the late Middle Pennsylvanian (Desmoinesian) Lower Kittanning Cyclothem, USA. SEPM Special Publication, 77: 95-121.

Stauffer, C.R., and H.J. Plummer. 1932. Texas Pennsylvanian conodonts and their stratigraphic relations. University of Texas Bulletin, 3201:13-50.

Stevens, C.H., P. Stone, and S.M. Ritter. 2001. Conodont and fusulinid biostratigraphy and history of the Pennsylvanian to Lower Permian Keeler Basin, east-central California. Brigham Young University Geology Studies, 46:99-142.

Stibane, F.R. 1967. Conodonten des Karbons aus den nordlichen Anden Sudamerikas. Neues Jahrbuch fur Geologie und Palaontologie, Abhandlungen, 128(3):329-340.

Sturgeon, M.T., and W.L. Youngquist. 1949. Allegheny conodonts from eastern Ohio. Journal of Paleontology, 23:380-386.

Swade, J.W. 1985. Conodont distribution, paleoecology, and preliminary biostratigraphy of the Upper Cherokee and Marmaton Groups (Upper Desmoinesian, Middle Pennsylvanian) from two cores in south-central Iowa. Iowa Geological Survey Technical Information Series, 14, 71 p.

von Bitter, P.H., and G.K. Merrill. 1998. Apparatus composition and structure of the Pennsylvanian conodont genus *Gondolella* based on assemblages from the Desmoinesian of northwestern Illinois, U.S.A. Journal of Paleontology, 72:112-132.

Wang, Z-h., and R-l. Li. 1984. Discovery of Late Carboniferous conodonts from Shanxi Province and its significance. Acta Palaeontologica Sinica, 23(2):196-203.

Wang, Z-h., and Y-p. Qi. 2002. Report on the Pennsylvanian conodont zonation from the Nashui section of Loudian, Guizhou, China. Newsletter on Carboniferous Stratigraphy, 21:29-32.

Youngquist, W.L., and R.H. Downs. 1949. Additional conodonts from the Pennsylvanian of Iowa. Journal of Paleontology, 23:161-171.

Youngquist, W.L., and B.C. Heezen. 1948. Some Pennsylvanian conodonts from Iowa. Journal of Paleontology, 22:767-773.

Zhao, Z-x., H-x.Yang, and X-m. Zhu. 1986. Conodonts from the Shiqiantan Formation in Kelamaili Mts., Xinjiang and their geological age. Acta Micropalaeontologica Sinica, 3(2):193-204.

Paleophytogeography and stratigraphy of Mississippian [Lower Carboniferous] plant-bearing deposits of Angaraland

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The possibilities of stratigraphic correlation of Mississippian [Lower Carboniferous] deposits, based on megafloral remains, are strictly dependent on our knowledge of phytogeographical provinciality of this time.

Until the end of the 1950s, the concept of planetary homogeneity of plant cover during the Mississippian, suggested in the pioneer works of R. Zeiller, W. Gothan, and W. Jongmans, had been predominant in the literature. Radczenko (1957) published the first scheme of paleofloristic zonation of North Eurasia of this time. Later, several authors investigated the phytogeographical provinciality of this time (S. Meyen in Vakhrameev et al., 1970, 1978; Novik and Fissunenko, 1979; Raymond et al., 1985; Wnuk, 1996; etc.), and supported the floristic unity and a high degree of endemism in the Mississippian vegetation of Angaraland.

A systematic analysis of the patterns of endemism and the combination of paleobotanical data with their paleogeographic and sedimentary background allow the proposal of more detailed zonation schemes for Angaran Mississippian floras (Mosseichik and Ignatiev, 2003; Mosseichik, 2003a, b, c; Mosseichik, in press).

This zonation was made "from below," that is, from the smallest units recognized for separate epochs on the basis of plant localities of similar floristic composition, which reflect their primary space relations, with due regard for the paleogeographic distribution of corresponding landscape-sedimentary environments. To build up a hierarchy of phytochorions, the "weight" of characters (floristic and physiognomic) has been determined *a posteriori*, according to their observed geographical distribution.

Following the ideas of A. Engler's historical plant geography, paleofloristic kingdoms (realms) have been segregated on the basis of common genesis of the floras. Their boundaries were interpolated along the margins of paleocontinents or their separate regions, which were developed during prolonged geographic

Figure 3. Conodonts from the middle Cherokee Group [mostly lower Cabaniss Subgroup]. All magnifications X55.

Post-Fleming marine unit [middle Cabaniss Subgroup]
1-7 *Idiognathodus cf. podolskensis*
8 *Neognathodus asymmetricus*

Russell Creek Limestone [middle Cabaniss Subgroup]
9-11 *Idiognathodus iowaensis*
12-13 *Idiognathodus podolskensis*
14-15 *Idiognathodus crassadens*

Tiawah Limestone [lower Cabaniss Subgroup]
16-17 *Idiognathodus robustus*
18-19 *Idiognathodus crassadens*
20 *Neognathodus* aff. *asymmetricus*
21 *Neognathodus* cf. *roundyi*
22-23 *Gondolella pohli*

Post-Wainwright marine unit [upper Boggy Formation at top of Krebs Subgroup]
24-31 *Idiognathodus* n. sp. D

isolation. According to the principles of floristic plant geography, kingdoms should be characterized by endemic families, areas by endemic subfamily or tribe rank, and provinces and districts by endemic genera and species. The shortage of suprageneric taxa for phytochorion characterization, caused by the slow progress of plant macroevolution in the Mississippian, lead us to implement for this purpose patterns of endemism at the generic and species level (the *principle of taxonomical regression*).

For comparison of taxonomic lists of local paleofloras, a technique was applied that represents a modification of classical methods of the phytosociological table rearrangements of J. Braun-Blanquet's (Zuerich-Montpellier) school.

* * *

During the Devonian and Mississippian, the Angaran paleocontinent (Angaraland) lay in the high northern latitudes, isolated from other land masses by seas (Atlas… , 1966; etc.). S. Meyen (in Vakhrameev et al., 1970, 1978) pointed out that at that time the territory of Angaraland belonged to one large phytochorion with a frost-free climate, which we consider as the *Angaran paleofloristic kingdom.* The data on the age and composition of the Angaran Mississippian floras are summarized in several works (Durante, 1976; Gorelova, 1978; Mosseichik, in press; Vakhrameev et al., 1970, 1978; Zorin, 1998; etc.).

Tournaisian

The Tournaisian flora of Angaraland is characterized by archaic forms, identified as *Protolepidodendron, Lepidodendropsis, Pseudolepidodendropsis carneggianum, Cyclostigma kiltorkense, Archaeopteris, Rhacophyton, Archaeocalamites,* and *Sphenophyllum subtenerrimum.* Toward the top of the section they are gradually replaced by neoendemics, particularly by the thick-stem lycopods *Ursodendron, Angarophloios,* and *Tomiodendron*, which predominated in the plant communities of aggraded lowlands. Two palaeofloristic districts are recognized (Figure 1).

The *Minussinsk district* (Md) embraced the territory of several interconnected intermountain areas, situated within the limits of the recent Altai-Sayana mountain region. Similar lake-alluvial sedimentary environments occurred there. The characteristic elements of the flora were represented by the lycopods *Ursodendron*, *Pseudolepidodendron, Tomiodendron, Eskdalia*, as well as by plants with fern-like foliage: *Adiantites, Aneimites, Triphyllopteris, Caulopteris ogurensis*.

The *Central Mongolia district* (CMd) includes a flora that grew in a limited intermountain area. The endemic lycopods *Eskdalia varia* and *Protolepidodendron* (*P. asiaticum*, *P. orientale*, *P. brevinternodium*) predominated there. They become extinct at the end of the Tournaisian, simultaneously with the disappearance of the area itself due to orogenic processes.

Viséan

The Viséan was a flourishing time for the endemic Angaran lycopod genera *Angarophloios, Tomiodendron, Ursodendron, Angarodendron, Lophiodendron,* etc. At least three paleofloristic districts may be recognized (Figure 1).

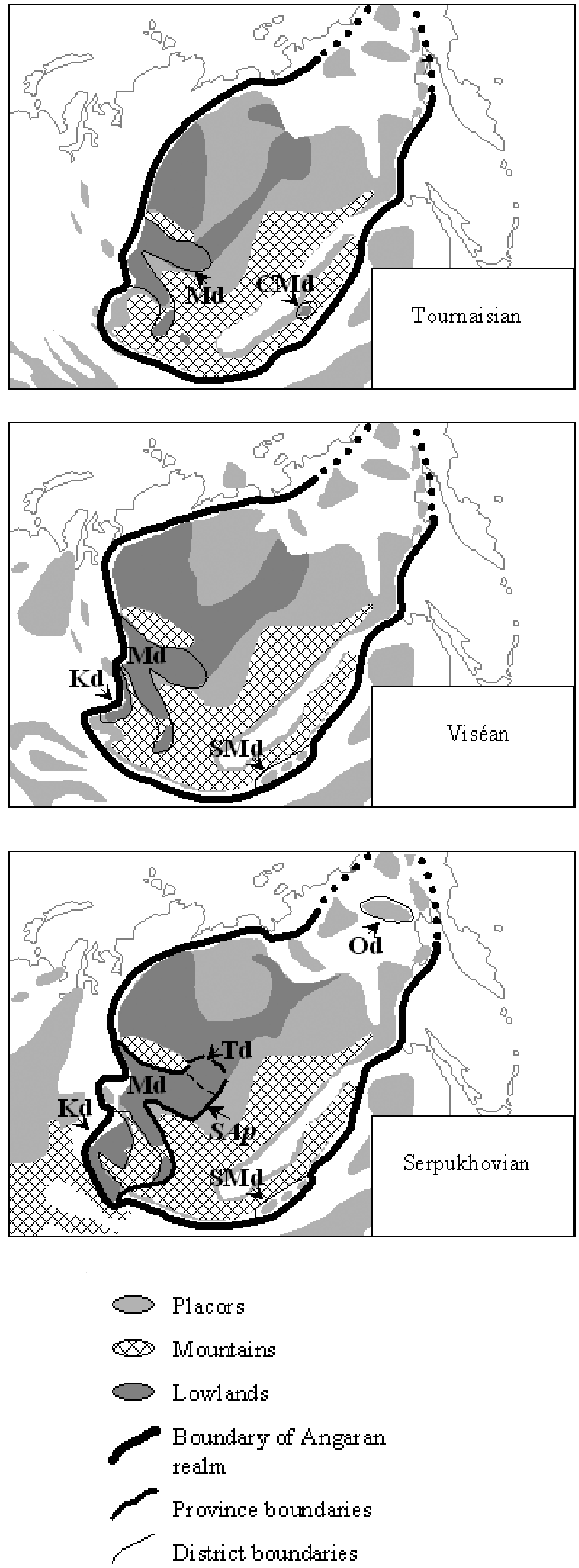

Figure 1. Scheme of paleofloristic zonation of Angaraland during Mississippian.

The *Minussinsk district* (Md) still existed with the same limits as in the Tournaisian. Its characteristic elements were the lycopods *Ursodendron distans, Demetria subasiatica, Angarophloios alternans, Eskdalia varia, Tomiodendron asiaticum, T. kemeroviense, Lophiodendron tyrganense,* as well as plants with fern-like foliage: *Caulopteris ogurensis*.

The *Kuznetsk district* (Kd) was formed in the area of the recent Kuznetsk and Gorlovka basins, which had been exposed as the sea regressed and then occupied by plants that migrated from the adjacent region of the Minussinsk basin. The common forms of the Kuznetsk and Minussinsk districts are the lycopods *Ursodendron distans, U. chacassicum, Lophiodendron tyrganense, Tomiodendron ostrogianum, T. kemeroviense.* At the same time, in the area of the Kuznetsk district flourished some early pteridosperms (*Cardiopteridium parvulum, Angaropteridium abaeanum, A. chacassicum, Angarocarpus ovoides*).

The *South-Mongolia district* (SMd) was formed on a cluster of volcanic islands, situated in present-day southern Mongolia. Side by side with elements of the Kuznetsk and Minussinsk floras (*Ursodendron chacassicum, Lophiodendron tyrganense*), the endemic lycopods *Gobiodendron tsochituinicum*, *Lophiodendron variabile*, *Mongolostrobus thomasii*, *Stigmaria* (?) *mongolica, Angarophloios* cf. *sigillarioides*, *A.* cf. *alternans* are known from there.

Serpukhovian

In the Serpukhovian the Angaran paleofloristic kingdom was characterized by the same endemic lycopod genera as in the Viséan (only *Ursodendron* disappeared). Simultaneously, the pteridosperms with foliage of the *Angaropteridium* type and the seeds of *Samaropsis, Angarocarpus,* and *Trigonocarpus* type still were flourishing. At least five paleofloristic districts existed in Serpukhovian time (Figure 1).

Due to the “collision” of the Kazakhstan microcontinent with Angaraland, the territory of the *Kuznetsk district* expanded to the west, into the region of modern eastern Kazakhstan. Several Angaran pteridosperms (*Angaropteridium ligulaeformis, Trigonocarpus minima,* etc.) and other plants migrated there.

The *Minussinsk district* embraced also the area around Tomsk, where a small island was situated. An evolutionary radiation of pteridosperms (*Angaropteridium, Cardiopteridium parvulum, Angarocarpus ovoides,* etc.) took place there.

The *Tunguska paleofloristic district* (Td) included the territory of the middle branch of the Angara River. Among its characteristic forms were the lycopods *Angarodendron obrutschevii, Angaropteridium cardiopteroides, Sublepidodendron tyrgani*, *Ursodendron distans*. The northeastern boundary of this district apparently moved to the northeast following plant migrations, and its southeastern boundary was ecotonous.

The Kuznetsk, Minussinsk, and Tunguska districts were joined into the *Sayana-Altai paleofloristic province* (SAp). This unit formed as a result of the ecogenetic expansion of endemic Angaran pteridosperms (*Angaropteridium abaeanum, A. cardiopteroides, Cardiopteridium parvulum, Angarocarpus ovoides,* etc.).

On the territory of the modern Omolon Mountains, the island flora of the *Omolon paleofloristic district* (Od) existed, composed of characteristic endemic lycopsids *Lophiodendron variabile, Tomiodendron regulare, Angarophloios leclercqianus, Angarophloios sigillarioides*, as well as of the widely distributed lycopsid *Tomiodendron kemeroviense* and the primitive fern *Chacassopteris concinna*.

The island flora of the *South-Mongolia district* (SMd) was represented mainly by local endemics, particularly by the lycopsids *Angarophloios obscurus, Tomiodendron (?) mongolicum, T.(?) subregulare* and by pteridosperms (*Abacanidium* sp., cf. *Samaropsis chachlovii*).

The solitary plant megafossils known from various horizons of the Serpukhovian on the northeastern and eastern Siberian platform, do not allow the paleophytogeographical relations of the corresponding territories to be estimated.

Some General Conclusions

The formation of the plant cover of Angaraland during the Mississippian followed a path of mainly autochthonous development of several geographically isolated floras, which occupied coastal lowlands. Many of these floras were deeply rooted in the ancestral Late Devonian floras of the same regions.

This type of plant cover development was related to the appearance and growth in number of endemics at the genus and species rank, characterizing the solitary isolated territories.

In the Tournaisian and Viséan such a geographically restricted development of forms was rather primitive and only weakly adapted for wide distribution and ecogenetic expansion of groups like lycopods and ferns. As a result, only small phytochorions (districts) arose, which results in serious difficulties for regional and intercontinental correlations.

The formation of larger phytochorions (provinces) was related to the expansion of evolutionarily advanced groups of gymnosperms. The remains of these plants, among which the dispersed leaves of Angaran cordaitean plants (*Cordaites tyrganicus*) first appear at the base of Moscovian deposits, allow establishment of wider stratigraphic correlations.

References

Atlas of lithologic-palaeogeographical maps of the USSR. Scale: 1:7500000. Vol. 2. 1966. Leningrad. (In Russian)

Durante, M.V. 1976. Palaeobotanical basis of the stratigraphy of Carboniferous and Permian of Mongolia. Nauka, Moscow, 179 p. (In Russian)

Ganelin, V.G., and M.V. Durante. 2002. Biostratigraphy of the Carboniferous of Angaraland. Newsletter on Carboniferous Stratigraphy, 20:23-26.

Gorelova, S.G. 1978. The flora and stratigraphy of the coal-bearing Carboniferous of middle Siberia. Palaeontographica B, 165: 7-77.

Mosseichik, Yu.V. 2003a. To the scheme of the palaeophytogeographical zonation of Angaraland in the Early Carboniferous. Vestnik Tomskogo Gosudarstvennogo Universiteta. Seria “Nauki o Zemle,” Prilozhenie 3(II):143-144. (In Russian)
Mosseichik, Yu.V. 2003b. Problems of Early Carboniferous phytogeography. Tezisy dokladov XLIX sessii Vserossiiskogo Paleontologicheskogo Obschestva, St. Petersburg, p. 131-133. (In Russian)
Mosseichik, Yu.V. 2003c. First stages of geographical differentiation of plant diversity in the Early Carboniferous: palaeobotanical perspective. Abstracts, 16th International Symposium “Biodiversity and Evolutionary Biology” of the German Botanical Society (DBG), 17th International Senckenberg Conference, Frankfurt am Main, p. 70.
Mosseichik, Yu.V. In press. The peculiarities of palaeofloristic zonation of the land in Early Carboniferous (on the example of Angaraland floras). (In Russian)
Mosseichik, Yu.V., and I.A. Ignatiev. 2003. On the principles of palaeofloristic zonation of Angaraland in the Early Carboniferous. Vestnik Tomskogo Gosudarstvennogo Universiteta, Seria “Nauki o Zemle,” Prilozhenie 3(II):145-147. (In Russian)
Novik, E.O., and O.P. Fissunenko. 1979. To the problem of Carboniferous phytogeography. Kiev, 54 p. (In Russian)
Radczenko, G.P. 1957. To the problem of first appearence of phytogeographical and climatic zonality in Northern Eurasia, p. 42-63. *In* Problems of Palaeobiogeography and Biostratigraphy. Gosgeoltekhizdat, Moscow. (In Russian)
Raymond, A., W.C. Parker, and J.T. Parrish. 1985. Phytogeography and paleoclimate of the Early Carboniferous, p. 169-222. *In* B.H. Tiffney (ed.), Geological Factors and the Evolution of Plants. Yale University Press, New Haven.
Vakhrameev, V.A., I.A. Dobruskina, E.I. Zaklinskaja, and S.V. Meyen. 1970. Palaeozoic and Mezozoic floras of Eurasia and Phytogeography of this Time. VEB Gustav Fischer Verlag, 424 p. (In Russian)
Vakhrameev, V.A., I.A. Dobruskina, E.I. Zaklinskaja, and S.V. Meyen. 1978. Palaeozoische und mesozoische Floren Eurasiens und die Phytogeographie dieser Zeit. VEB Gustav Fischer Verlag, 300 p.
Wnuk, Ch. 1996. The development of floristic provinciality during the Middle and Late Paleozoic. Rev. Paleobot. Palynol., 90: 5-40.
Zorin, V.T. 1998. Lower Carboniferous of the Minusinsk Trough (Stratigraphy and Plants). ZAO “Monitek,” St.-Petersburg, 143 p. (In Russian)

Footnotes

1 Ganelin and Durante (2002) correlate this interval in Angaraland with the upper Viséan.

“Stigmarian” limestones of the Moscow coal basin Mississippian [Lower Carboniferous]: their nature and stratigraphic potential

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In the Mississippian limestone series of the Moscow coal basin, there are limestone beds that contain in their tops a horizon of *in situ* rhizophores of the *Stigmaria* type, which belonged to tree lycopsids (*Lepidodendron* ex gr. *robertii, Ogneuporia seleznevae*, etc.).

Each horizon is represented by the remains of the dichotomous arms of rhizophores, covered by long radiating appendages. These appendages surround or spread upon the surface of coral remains and brachiopod shells (Shvetsov, 1922). In other cases they rest against and spread upon the surface of the underlying limestone bed, which apparently was hard at the time of rhizophore growth. These and other observations show that the rhizophores grew in soft lime silt. The upper surface of the stigmarian beds usually shows traces of exposure and erosion (Figure 1).

G.P. Helmersen first described such «stigmarian» limestones in 1841. In 1886 A.O. Struve recognized the basal “Stigmarian beds” in the “Lower stage” of the “Mountain limestone” of the Moscow coal basin. This concept was widely adopted by geologists until K.I. Lissitsyn (1911) showed the occurrence of stigmarian horizons throughout the entire limestone series.

Hecker (1980) proposed the idea of using stigmarian horizons as stratigraphic markers, which can be traced across large areas. Such a possibility depends on the nature of these plant beds, which is interpreted in different ways by various authors.

Shvetsov (1922, 1938) proposed that the stigmarian horizons formed in the coastal zone of a very shallow sea. He reasoned that “the land was so flattened, the height differences were so trifling and the sea depth was so insignificant, that the smallest lowering of sea level led to the exposure of large areas. …Several times the shallow sea was replaced by continental conditions, giving rise to stigmarian flora, which again disappeared with sea-bottom deepening” (Shvetsov, 1938, p. 98). In 1932 Shvetsov proposed that stigmarian vegetation was similar to recent mangroves, which was followed by other authors (Hecker, 1980; Meyen, 1981; Vakhrameev et al., 1970; etc.). Only in the last few years was this viewpoint called into question (Ignatiev and Mosseichik, 2002; Mosseichik et al., 2003; etc.).

Criteria for Recognition of Ancient Mangroves with Respect to Shvetsov’s Hypothesis

T.M. Harris rightly considered that the term “mangrove” is applied *sensu stricto* only to the recent tropical plant communities that are dominated by *Avicennia, Bruguera, Nipa, Rhizophora* and several other forms, as well as to their fossil remains of Cenozoic age. The extrapolation of this concept to Mesozoic and Paleozoic vegetation is only possible on the basis of a rather complex set of criteria that reflect the structural and ecological peculiarities of mangroves as a general type of plant community. The incompleteness of these criteria led to contradictions or to the advancement of an *ad hoc* hypothesis, as in the case of "mangrove" cordaitean-dominated plant communities in the Pennsylvanian of the United States (Phillips and Raymond, 1983).

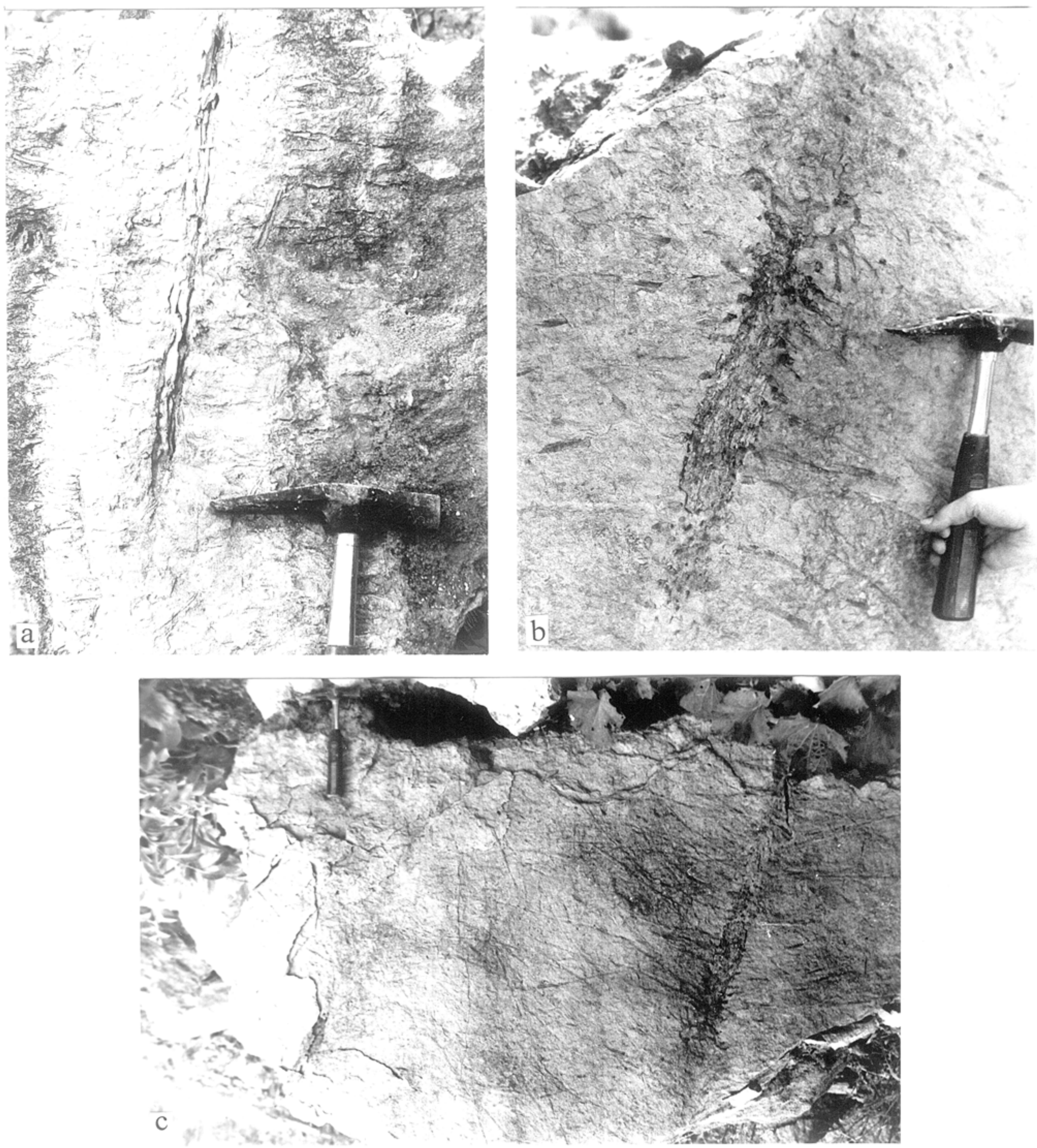

Figure 1. *Stigmaria* rhizophores in Upper Viséan limestones of Moscow coal basin; Kaluga region, Brontsy quarry, Mikhailovsky Horizon; *a* – arm of rhizophore, lying on bedding plane; *b* – another specimen, showing numerous appendages; *c* – same limestone block under lower magnification; limestone matter is entirely penetrated by rhizophore appendages.

We use the following criteria to recognize a mangrove type of ancient vegetation (Mosseichik et al., 2003):

1) growth in frost-free tropical and subtropical climates;

2) growth in stable environments protected from sea waves by banks, sandbars, coral reefs, etc.;

4) growth in the zone of tidal activity, which causes the formation of characteristic horizontal zonation with the predominance of one or several different species in each zone;

5) growth in stress environments of excess salinity and hydrogen sulphide contamination of the substrate, causing the formation of peculiar soils and peats;

6) plants with a complex of adaptive characters for salt accumulation and excretion (aerial roots, succulent leaves with well developed water-bearing tissue, viviparous reproduction, etc.);

7) low species diversity resulting from plant growth in stress biotopes.

The vegetation of “stigmarian” limestones exhibits only a few of these criteria, no one of which is specific for mangroves.

Stigmarian vegetation shows growth on a flat seacoast under conditions of seasonal damp tropical climate (Shvetsov, 1938, etc.; Hecker, 1980; Lower Carboniferous… , 1993), as well as low species diversity. However, both traits are characteristic not only of mangroves, but also of several other types of tropical coastal plant communities.

Unlike recent mangroves, the vegetation of “stigmarian” limestones was formed under unstable conditions of frequent transgressions of the sea (Lower Carboniferous… , 1993). Tidal activity within the shallow epicontinental sea, which causes the horizontal zonation of vegetation, was absent or very low. The rhizophore pattern also does not confirm the existence of such zonation.

One of the characteristic traits of recent mangroves is the formation of peculiar hydromorphic saline soils, highly disturbed by invertebrates (Thionic Fluvisols, in FAO classification). The mangrove peats or “stinking black mucks” are formed under anaerobic conditions (Snedaker, 1978). Such soils, peats and mucks, as well as the traces of invertebrate activity do not occur in the “stigmarian” limestones. The paleosoils of stigmarian horizons could be interpreted as “rendzines” (Lozet and Mathieu, 1998).

The well-developed aerenchyme with air-bearing cavities in the arms of *Stigmaria* rhizophores is characteristic not only of mangrove plants, but also of other plants growing in conditions of low oxygen in the soil (Duddington, 1974).

Unlike “stigmarian” limestone vegetation, recent mangroves are characterized by a complex succession dynamics (Richards, 1961).

Hypothesis of Pioneer Colonization

Judging by the rhizophore sizes, the stigmarian horizons belong to a single generation of trees, which grew on the lime surface, exposed during a regressive phase of eustatic fluctuation. Thus, a *pioneer colonization* of newly formed biotopes took place.

Therefore, after exposure, erosional activity and inwash of sediments from adjacent more elevated places took place, which, along with the wind, aided the dispersal of diaspores of lycopsid trees. Fresh-water pools supplied by atmospheric precipitation, as well as by fresh groundwater within the superficial layers of lime substrate, were the main conditions for germination of the plantlets.

The density of lycopsid pioneer populations, judged by the distance between adjacent rhizophores, was not high, which was probably related to unfavorable environmental conditions. From the viewpoint of age composition, these populations belonged to the *invasion* type, that is, they initially consisted of young plants. Later, they transitioned to the *regressive* phase, represented by old individuals.

The process of colonization was interrupted probably by hardening of the lime substrate. Erosion and sediment influx could also be of importance, as well as a prolonged existence of young plants in the form of plantlets, which is characteristic of the recent club-mosses (Mirkin et al., 2001).

The lime paleosoils associated with stigmarian rhizophore horizons, are characterized by the absence or poor development of a humus soil horizon (A), particularly of the surface accumulation of organic remains (“forest litter”, $\grave{A}_0$). This was apparently related to the rather low biological productivity of the community, as well as to the high mineralization rates of dead plant matter.

Some Stratigraphic Consequences

The size of stigmarian vegetation in local populations was probably determined by the size of the corresponding homogeneous biotope and could be measured in hundreds of square meters. This practically excludes the supposed possibility of tracing single stigmarian horizons for a distance of hundreds of kilometers (Hecker, 1980). At the same time, the appearance of stigmarian horizons can mark the rhythmostratigraphic units, established for various developmental stages of the marine basin, which are related to tectonic-eustatic fluctuations of the world ocean. Such units are in particular the subformations (subsuites) C_1tl_3, C_1al_{1-3}, C_1mh_{1-3}, corresponding to the rhythms of VIII order $\acute{a}_2$ and $\hat{a}_1$, $\hat{a}_2$ of the Viséan-Serpukhovian rhythm of V order (Fig. 2).

Substage	Horizons	Subsuits	Rhythms			
			VIII	VII	VI	V
Upper Viséan	Venevsky	C_1vn_2		γ	Upper Viséan	Viséan–Serpukhovian
		C_1vn_1				
	Mikhailovsky	C_1mh_3	β_2	β		
		C_1mh_2				
		C_1mh_1				
	Aleksinsky	C_1al_3	β_1			
		C_1al_2				
		C_1al_1				
	Tulsky	C_1tl_3	α_2	α		
		C_1tl_2	α_1			
		C_1tl_1				

Figure 2. Rhythmostratigraphic scheme of Mississippian of Moscow coal basin (modified from: Lower Carboniferous… , 1993).

References

Duddington, C.L. 1974. Evolution and Design in the Plant Kingdom. Thomas Y. Crowell Co., New York, 259 p.

Hecker, R.F. 1980. Traces of invertebrates and stigmarias in marine deposits of the Lower Carboniferous of the Moscow Syneclise. Nauka, Moscow, 89 p. (In Russian)

Ignatiev, D.A., and Yu. V. Mosseichik. 2002. Peculiarities of the development of Moscow Basin Viséan flora on the background of main geological events, p. 136-140. *In* Sbornik pamiati chlena-korrespondenta AN SSSR, professora Vsevoloda Andreevicha Vakhrameeva, GEOS, Moscow. (In Russian)

Lozet, J., and C. Mathieu. 1998. Dictionary of Soil Science. Mir, Moscow, 398 p. (In Russian)

Lower Carboniferous of the Moscow syneclise and Voronezhskaya anteclise. 1993. Nauka, 222 p. (In Russian)

Meyen, S.V. 1981. Vestiges of Indian Herbs. Mysl', Moscow, 160 p. (In Russian)

Mirkin, B.M., L.G. Naumova, and A.I. Solomestch. 2001. Modern vegetation science. Logos, Moscow, 264 p. (In Russian)

Raymond, A., and T.L. Phillips. 1983. Evidence for an Upper Carboniferous mangrove community, p. 19-30. *In:* H.J.Teas (ed.), Tasks for Vegetation Science, 8.

Richards, P. 1961. Tropical rain forest. Izdatel'stvo inostrannoi literatury, Moscow, 448 p. (In Russian)

Shvetsov, M.S. 1922. To the problem of stratigraphy of Lower Carboniferous deposits. Vestnik Moskovskoi gornoi akademii, 1(2):223-242. (In Russian)

Shvetsov, M.S. 1938. History of Moscow Basin in Dinantian epoch. Moskovskogo geologo-razvedochnogo instituta, Trudy, 12:3-107. (In Russian)

Snedaker, S.C. 1978. Mangroves: their value and perpetuation. Nature and Resources, 14(3):6-13.

Vakhrameev, V.A., I.A. Dobruskina, E.I. Zaklinskaja, and S.V. Meyen. 1970. Palaeozoic and Mezozoic floras of Eurasia and phytogeography of this time. VEB Gustav Fischer Verlag, 424 p. (In Russian)

Bursumian, Newwellian and North American stage nomenclature across the Carboniferous-Permian boundary

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In the late 1990s, when a GSSP for the base of the Permian (Carboniferous-Permian boundary) was ratified (Davydov et al., 1998), it was already clear that this boundary is higher than the base of the Wolfcampian (Virgilian-Wolfcampian boundary), which has long been the base of the Permian in North American usage (Figure 1). The new GSSP was thought to correspond to a level in the lower Wolfcampian that in fusulinid biostratigraphy is approximated by the base of the Nealian substage, which is approximately the lowest occurrence of *Pseudoschwagerina* (e.g., Baars et al., 1994b; Wahlman, 1998)

Most workers have wanted the North American stage boundaries to match the new GSSP (Fig. 1) and thus proposed two possible solutions: (1) move the Wolfcampian base up to the new GSSP, thereby enlarging the Virgilian Stage to include what had always been considered lower Wolfcampian (Baars et al., 1992, 1994a, b; Lucas et al., 2001); or (2) recognize a Bursumian Stage for what was formerly lower Wolfcampian, so that the new GSSP is approximated by the Bursumian-Wolfcampian boundary (Ross and Ross, 1994, 1998, 2002).

Although several workers have used the term Bursumian Stage, it has never been properly defined. In 1997, I began work in collaboration with K. Krainer, B. S. Kues, and the late G. L. Wilde to develop a comprehensive undertstanding of the lithostratigraphy, paleontology, sedimentology, and biostratigraphy of the Bursum Formation at its outcrops across much of south-central and central New Mexico, USA (e.g., Lucas et al., 2000, 2001, 2002; Lucas and Wilde, 2000; Lucas and Krainer, 2004). One conclusion of our studies is that the Bursum Formation cannot provide an adequate stage stratotype (also see Davydov, 2001; Wilde, 2002), so the term Bursumian should be abandoned. The principle reason for this is that much of the Bursum Formation is nonmarine or very shallow marine facies that lack biostratigraphically useful fossils, and the Bursum is everywhere overlain by nonmarine red beds. The type section of the Bursum Formation in the northern Oscura Mountains of Socorro County, New Mexico, is an excellent example of these drawbacks (Lucas et al., 2000, 2002). It is 85 m thick, mixed marine-nonmarine facies, the upper 35 m lack biostratigraphically useful fossils and nonmarine red beds of the Abo Formation overlie it.

The inadequacy of the Bursum Formation to provide a stratotype for a Bursum Stage is now appreciated by Ross and Ross (2002, p. 39), who proposed the Portal section in the Chiricahua Mountains of southeastern Arizona as "the candidate stratotype section for the type Bursumian Stage." However, this section is in the Horquilla Formation in the Pedregosa basin,

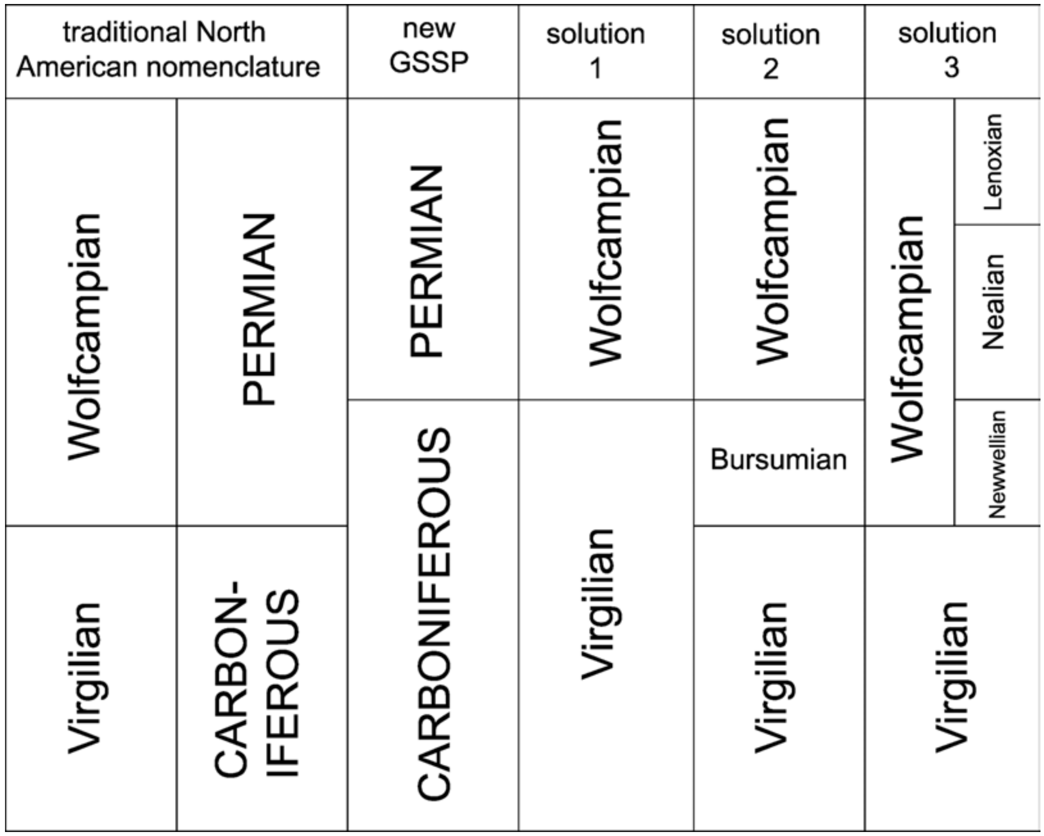


Figure 1. Different views of North American stage nomenclature across the Carboniferous-Permian boundary as a result of the establishment of the GSSP for the base of the Permian. "Solution 3" is advocated here.

where no Bursum Formation exists, so why call the stage Bursumian? Furthermore, the Portal section is structurally complex, so the published succession of fusulinids (Sabins and Ross, 1963) is questionable (Wilde, 2002).

Recognizing all of these problems with the Bursumian, Wilde (2002) recently proposed the Newwellian to take the place of Bursumian. He proposed Newwellian as a substage of the Wolfcampian. Explicitly defined by Wilde (2002), Newwellian is based on a section in the Pedregosa basin, an excellent and very fusulinid-rich section of the Horquilla Formation in the Big Hatchet Mountains of southwestern New Mexico. Those who have been using the undefined term Bursumian can now replace it with Newwellian.

In the stratigraphic utopia sometimes referred to as "Hedbergian stratigraphy," we will use only one set of stage names globally, and each of the system boundaries will correspond to a stage boundary. However, the North American Pennsylvanian-Permian stages are a valuable secondary standard of stage names (sensu Cope, 1996) that will not go away soon; too much oil and gas continues to be extracted by those who routinely use terms like Virgilian and Wolfcampian, and have no real interest in or are unable to use (mostly because of a lack of data) the terms Gzhelian, Asselian or Sakmarian.

Furthermore, why should the North American stage boundaries be changed to meet the GSSP? The GSSP was defined by criteria wholly different than those used to define the stages, and, technically speaking, only the stages of the standard global chronostratigraphic scale (Gzhelian and Asselian) need to have their boundary correspond to the GSSP (Salvador, 1994, 9.C.5.b).

So, *quo vadis* Bursumian? I propose a simple solution. Bursumian needs to die a merciful death, and the correctly defined Newwellian should be used as a substage of the Wolfcampian, as proposed by Wilde (2002). Furthermore, I suggest no redefinition of the Virgilian or the Wolfcampian to meet the new GSSP. If there is a real problem here, it lies in the choice of the base Permian GSSP. Why not move the GSSP to meet the base of the Wolfcampian, and thereby honor longstanding practice as recorded in millions of pages of scientific literature, company reports, and well logs?

References

Baars, D.L., C.G. Maples, S.M. Ritter, and C.A. Ross. 1992. Redefinition of the Pennsylvanian-Permian boundary in Kansas, mid-continental USA. International Geology Review, 34:1021-1025.

Baars, D. L., C.A. Ross, S.M. Ritter and C.G. Maples. 1994a. Proposed repositioning of the Pennsylvanian-Permian boundary in Kansas. Kansas Geological Survey Bulletin, 230:5-10.

Baars, D.L., S.M. Ritter, C.G. Maples, and C.A. Ross. 1994b. Redefinition of the Upper Pennsylvanian Virgilian Series in Kansas. Kansas Geological Survey Bulletin, 230:11-16.

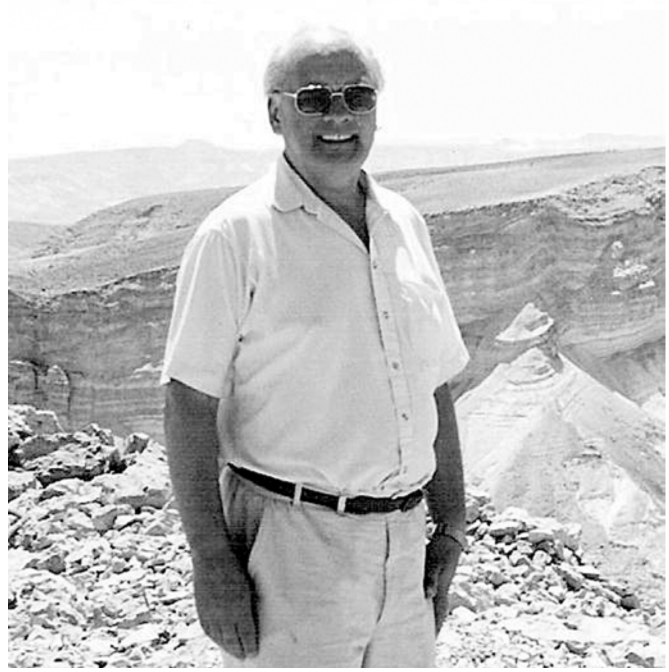
Cope, J.C.W. 1996. The role of the secondary standard in stratigraphy. Geological Magazine, 1996:107-110.

Davydov, V.L. 2001. The terminal stage of the Carboniferous:

Orenburgian versus Bursumian. Newsletter on Carboniferous Stratigraphy, 19:58-64.
Davydov, V.I., B.F. Glenister, C. Spinosa, S.M. Ritter, V.V. Chernykh, B.R. Wardlaw, and W.S. Snyder. 1998. Proposal of Aidaralash as Global Stratotype Section and Point (GSSP) for the base of the Permian System. Episodes, 21:11-18.
Lucas, S.G., and K. Krainer. 2004. The Red Tanks Member of the Bursum Formation in the Lucero uplift and regional stratigraphy of the Bursum Formation in New Mexico. New Mexico Museum of Natural History and Science Bulletin, 25:43-52.
Lucas, S.G., and G.L. Wilde. 2000. The Bursum Formation stratotype, Upper Carboniferous of New Mexico, and the Bursumian Stage. Permophiles, 36:7-10.
Lucas, S.G., K. Krainer, and B.S. Kues. 2002. Type section of the Upper Carboniferous Bursum Formation, south-central New Mexico, and the Bursumian Stage. New Mexico Geological Society Guidebook 53, p. 179-192.
Lucas, S.G., B.S. Kues, and K. Krainer. 2001. The Bursumian Stage. Permophiles, 39:23-28.
Lucas, S.G., G.L. Wilde, S. Robbins, and J.W. Estep. 2000. Lithostratigraphy and fusulinaceans of the type section of the Bursum Formation, Upper Carboniferous of south-central New Mexico. New Mexico Museum of Natural History and Science Bulletin, 16:1-13.
Ross, C.A., and J.P. Ross. 1994. The need for a Bursumian stage, uppermost Carboniferous, North America. Permophiles, 24:3-6.
Ross, C.A., and J.P. Ross. 1998. Bursumian Stage, uppermost Carboniferous of mid-continent and southwestern North America. Newsletter on Carboniferous Stratigraphy, 16:40-42.
Ross, C.A., and J.P. Ross. 2002. Bursumian Stage, uppermost Carboniferous of North America. Newsletter on Carboniferous Stratigraphy, 20:39-40.
Sabins, F.F., and C.A. Ross. 1963. Late Pennsylvanian-Early Permian fusulinids from southeast Arizona. Journal of Paleontology, 37:323-365.
Salvador, A., ed. 1994. International Stratigraphic Guide. Trondheim and Boulder, IUGS and GSA, 214 p.
Wahlman, G.P. 1998. Fusulinid biostratigraphy of the new Pennsylvanian-Permian boundary in the southwest and midcontinent U.S.A. Geological Society of America Abstracts with Programs, 30(3):34.
Wilde, G.L. 2002. The Newwellian Substage; rejection of the Bursumian Stage. Permophiles, 41:53-62.

Memorial: Alan Charles Higgins (1936–2004)

R. L. Austin, B. Owens, and E.G. Spinner



Alan Higgins was born in Hanley, Staffordshire on 16th December 1936, the youngest of three children. Throughout his childhood he was fascinated by the natural history of the nearby Peak District and it was not surprising that sciences played an important part in his education at Hanley High School. In 1955, he went to the University of Sheffield to study Geology and obtained a 2(1) degree in 1958. During those early years in Sheffield, he came under the influence of the late Prof. Leslie Moore and on graduation was encouraged by him to undertake research on Namurian conodonts. At that time, little was known of the true potential of conodonts and indeed almost nothing of their occurrence in Upper Carboniferous rocks. Alan collected samples extensively throughout the southern Pennine region, often working closely with the staff of the Geological Survey and generated the first Namurian conodont zonation for the British Isles. He exploited every opportunity to prove the value of conodont studies outside the Carboniferous Period and in 1962 published the results of an investigation on the microfaunas found in the Durness Limestone of northwest Scotland. His Ph.D. was completed in 1961.

In late 1961, he was awarded a DSIR (Government) Fellowship which allowed him to work in Brussels at the offices of the Belgian Geological Survey whilst investigating the stratigraphic distribution of conodonts in the Namurian type sections of the Namur Basin. These studies, carried out in close collaboration with Jos Bouckaert, established detailed correlations with the British sequences and highlighted the difficulties of using the Belgian sequences as the basis for global correlations. Alan returned to Sheffield in 1963 and was appointed to a lectureship in Geology. Although carrying a significant teaching commitment in stratigraphy, palaeontology, and sedimentology, he embarked on the most research productive phase of his career. In collaboration with Robert Wagner, he initiated work on the Carboniferous conodont faunas from the Cantabrian Mountains of northern Spain, providing important links with the macrofloral evidence and ammonoid associations. Alan's research ability and potential were recognised in 1964 with the award of the Daniel Pidgeon Fund of the Geological Society of London for his contributions to conodont biostratigraphy.

His involvements in broader scale geological projects is exemplified by his participation in the University of Sheffield field projects in East Greenland in 1974 to establish the age of the Tertiary basalts of the Kangerdlungssuaq area and the implications for the timing of the opening of the North Atlantic. Alan was responsible for the organisation of the biostratigraphy and documentation of the sedimentary sequences. His work on the Pennine Carboniferous successions continued with further revisions to the conodont biozonation of the Namurian rocks which he applied widely to the interpretation of successions throughout Europe. His achievements were recognised by the University of Sheffield in 1982 with the award of his D.Sc. and a Readership in Geology.

During a sabbatical visit in 1978, Alan spent some time working in the oil industry in Canada and returned in 1981 to spend a short period working at the GSC Institute of Sedimentary & Petroleum Geology in Calgary. In 1983, he resigned from his Sheffield post and returned as Chief Palaeontologist of the Geological Survey of Canada in Calgary where in addition to his administrative duties, he made important contributions to the regional studies in the Beaufort Sea area and undertook further conodont and maturation studies on the Devonian and Lower Carboniferous subsurface basins of the Rocky Mountains. He was responsible for negotiating significant commercial funding for the Survey's biostratigraphic activities.

In 1986 he returned to the UK to join BP Research in Sunbury on Thames as a Research Associate in Stratigraphy. His new research included the development (with Peter Swaby) of expert systems for the identification of microfossils, in particular, digitising the outlines of conodonts. He was also involved in various chemostratigraphy projects including in particular the development of a strontium isotope database for use in operational projects.

At the time of the review of the future of Geology as a discipline in the UK sector of higher education in the mid-1980s, Alan was influential nationally, in highlighting the importance of biostratigraphy and micropalaeontology.

With the contraction of the oil exploration business in the early 1990s, Alan together with other former Sunbury colleagues, John Athersuch and Paul Britton, established the consultancy firm Stratadata in which he played a major role as both bio- and chemostratigrapher. His achievements here included the development of new 87Sr / 86Sr isotope databases for the Phanerozoic, which were successfully applied throughout Southeast Asia and the North Sea.

Alan always remained committed to playing a significant corporate role in the development of biostratigraphy. He was a founder member of the British Micropalaeontological Society, going on to serve as it's Secretary between 1977-1980 and it's Chairperson between 1986-1989 in addition to being the first Chairman of the Conodont Group. The Society recognised his contribution to their activities with the award of Honorary Membership in 2002. Alan was also an active long-term member of the international Pander Society of conodont researchers.

Alan also had a significant role in the activities of the IUGS Subcommission on Carboniferous Stratigraphy including acting as Secretary to the Mid-Carboniferous Working Group during its critical appraisal of stratotype sections around the world, prior to the selection of a Global Stratotype. He had field visits to prospective candidate sections in Russia, China, USA, and the UK, establishing relationships with specialists in many fields. His methodical handling of the Group's business and his ability to maintain good personal relationships with all participants contributed to the successful outcome. The Geological Society of London appointed him as an Honorary Secretary in 1995.

Despite having major heart surgery in the early 1990s, Alan always remained active in geology. He was found to be suffering from cancer two years ago and appeared to have responded well to surgery. He was admitted to hospital for routine follow up treatment in late March 2004 and died suddenly on 2nd April.

Selected Bibliography

Austin, R.L., and A.C. Higgins. 1985. Introduction, p. 13-31. *In* A.C. Higgins and R.L. Austin, R.L. (eds.), A stratigraphical Index of Conodonts. Ellis Horwood Ltd. for British Micropalaeontological Society.

Bouckaert, J., and A.C. Higgins. 1970. La base du Namurien dans le Bassin de Dinant. Bull. Soc. Belge Geol Paleontol. Hydrol., 72:1-17.

Bouckaert, J., and A.C. Higgins. 1970. The position of the Mississippian-Pennsylvanian boundary in the Namurian of Belgium. Congres et Colloques de Univ. Liege, 55:197-204.

Burnett, R.D., A.C. Higgins, and R.L. Austin. 1994. Carboniferous-Devonian conodont CIA in England, Wales and Scotland. The pattern and its interpretation: a synoptic review, p. 267-280. *In* P. Konigshof and R. Werner (eds.), Willi Ziegler Festschrift I, Courier Forschunginstitut Senckenberg, 168.

Ebdon C.C., A.J. Fraser, A.C. Higgins, B.C. Mitchener, and A.R.E. Strank. 1990. The Dinantian stratigraphy of the East Midlands: a seismographic approach. Journal of the Geological Society London, 147:519-536.

Henderson, C.M., E.W. Bamber, B.C. Richards, A.C. Higgins, and A. McGugan. 1993. Permian (Chapter 4: Stratigraphy), p. 272-293. *In* D.F. Stott and J.D. Aitken (eds.), Sedimentary Cover of the Craton in Canada, Geological Survey of Canada, Geology of Canada Series, 5.

Higgins, A.C. 1961. Some Namurian conodonts from North Staffordshire. Geol. Mag., 98:210-224.

Higgins, A.C. 1962. Conodonts from the Griotte Limestone of NW Spain. Not. Comm. Inst Geol. Min. Espana, 65:5-22.

Higgins, A.C. 1962. An investigation of the distribution of conodont faunas in the Namurian of the South Pennines. Unpublished Ph.D. Thesis, University of Sheffield.

Higgins, A.C. 1965. The significance of conodonts in the Carboniferous of Europe. Proceedings of Subcommission of Carboniferous Stratigraphy, Sheffield, p. 69-75.

Higgins, A.C. 1967. The age of the Durine Member of the Durness Limestone Formation at Durness. Scottish Journ. Geol., 3: 382-388.

Higgins, A.C. 1967. The Bradfield – Ewden area, p. 89-94. *In* R. Neves and C. Downie (eds.), Geological Excursions in the Sheffield Region and the Peak District National Park.

Higgins, A.C. 1971. Conodont biostratigraphy of the late Devonian – early Carboniferous rocks of the south central Cantabrian Cordillera. Trabajos de Geologia Univ. Ovieda, 3:179-192.

Higgins, A.C. 1974. Conodont zonation of the Lower Carboniferous of Spain and Portugal. Belgian Geol. Surv., International Symposium on Belgian Micropalaeontological Limits (Namur, 1974), Publ. No. 4, p. 1-17.

Higgins, A.C. 1975. Conodont zonation of the late Viséan - early Westphalian strata of the south and central Pennines of northern England. Bulletin of the Geological Survey of Great Britain, 53, 90 p.

Higgins, A.C. 1981. The distribution of conodonts in relation to the palaeogeography of the late Viséan- Namurian time, p. 37-51. *In* J.W. Neale and M.D. Brasier (eds.), Microfossils from Recent and Shelf Seas. Ellis Harwood Ltd., Chichester.

Higgins, A.C. 1981. Coprolitic conodont assemblages from the Lower Westphalian of North Staffordshire. Palaeontology, 24: 437-441.

Higgins, A.C. 1981. The position and correlation of the boundary between the proposed Mississippian and Pennsylvanian Subsystems. Newsletters in Stratigraphy, 9:176-182.

Higgins, A.C. 1982. A Mid-Carboniferous boundary in the Western Europe conodont sequence, p. 13-14. *In* W.H.C. Ramsbottom, W.B. Saunders, B. Owens (eds.), Biostratigraphic Data for a Mid-Carboniferous Boundary. IUGS Subcommission on Carboniferous Stratigraphy, (Leeds, 1981).

Higgins, A.C. 1985. The Carboniferous System: Part 2, Conodonts of the Silesian Subsystem from Great Britain and Ireland, p. 210-227. *In* A.C. Higgins A.C. and R.L. Austin, R.L. (eds.), A Stratigraphic Index of Conodonts. Ellis Horwood Ltd. for the British Micropalaeontological Society.

Higgins, A.C., and R.L. Austin. eds. 1985. A Stratigraphical Index of Conodonts. Ellis Horwood Ltd. for the British Micropalaeontological Society, 263 p.

Higgins, A.C., and J. Bouckaert. 1968. Conodont stratigraphy and palaeontology of the Namurian of Belgium. Mem. Serv. Geol. Belgique, 10, 51 p.

Higgins, A.C., B.C. Richards, and C.M. Henderson. 1991. Conodont biostratigraphy and paleoecology of the uppermost Devonian and Carboniferous of theWestern Canada Sedimentary Basin, p. 215-251. *In* M. Orchard and A.D. McCracken (eds.), Ordovician to Triassic Conodont Paleontology of the Canadian Cordillera. Geological Survey of Canada Canada Bulletin, 417.

Higgins, A.C., and E.G. Spinner. 1969. Techniques for the extraction of selected microfossils. Geology Journal Association of Teachers of Geology, 1:12-28.

Higgins, A.C., and W.J. Varker. 1982. Lower Carboniferous conodont faunas from Ravenstonedale, Cumbria. Palaeontology, 25:145-166.

Higgins, A.C., and C.H.T. Wagner-Gentis. 1982. Conodonts, goniatites and biostratigraphy of the Early Carboniferous from the Cantabrian Mountains, Spain. Palaeontology, 25:313-350.

Higgins, A.C., C.H.T. Wagner-Gentis, and R.H. Wagner. 1964. Basal Carboniferous strata in part of northern Leon, NW Spain: stratigraphy, conodont and goniatite faunas. Bull. Soc. Belge Geol. Paleontol. Hydrol., 72:205-248.

Ramsbottom, W.H.C., A.C. Higgins, and B. Owens. 1979. Palaeontological characterisation of the Namurian of the stratotype area (A report of the Namurian Working Group). 8eme Congres International de Stratigraphie et de Geologie Carbonifere (Moscow 1975), Compte Rendu, 3:85-99.

Richards, B.C., E.W. Bamber, A.C. Higgins, and J. Utting. 1993. Carboniferous (Chapter 4, Stratigraphy), p. 202-271. *In* D.F. Stott and J.D. Aitken, J.D. (eds.), Sedimentary Cover of the Craton in Canada. Geological Survey of Canada, Geology of Canada Series, 5.

Riley, N.J., J. Claoue-Long, A.C. Higgins, B. Owens, D.A. Spears, L. Taylor, and W.J. Varker. 1993. Geochronology and geochemistry of the European Mid-Carboniferous Boundary proposal-Stonehead Beck, North Yorkshire, England. Newsletter on Carboniferous Stratigraphy, 11:13.

Soper, N.J., C. Downie, A.C. Higgins, and L. Costa. 1976. Biostratigraphic ages of the Tertiary basalts on the East Greenland continental margin and their relationship to plate separation in the North Atlantic. Earth and Planetary Sciences Letters, 32:149-157.

Soper, N.J., A.C. Higgins, C. Downie, D. Matthews, and P.E. Brown. 1976. Late Cretaceous-early Tertiary stratigraphy of the Kangerdlungssuaq area, East Greenland and the opening of the northeast Atlantic. Journal of the Geological Society London, 132:85-104.

Varker, W.J., and A.C. Higgins. 1979. Conodont evidence for the age of the Pinskey Gill Beds of Ravenstonedale, northwest England. Proceedings of the Yorkshire Geological Society, 42:357-369.

Wagner, R.H., and A.C. Higgins. 1979. The Carboniferous of the USSR: its stratigraphic significance and outstanding problems of world-wide correlation, p 5-22. *In* R.H. Wagner, A.C. Higgins, and S.V. Meyen (eds.), The Carboniferous of the USSR. Yorkshire Geological Society Occasional Publication, 4.

Wagner, R.H., A.C. Higgins, and S.V. Meyen (eds). 1979. The Carboniferous of the USSR: Reports presented to the I.U.G.S. Subcommission on Carboniferous stratigraphy 8th International Congress Congress on Carboniferous Stratigraphy and Geology, (Moscow, 1975). Yorkshire Geological Society Occasional Publication, 4, 247 p.

ANNOUNCEMENTS

CARBONIFEROUS-PERMIAN TRANSITION AT CARRIZO ARROYO, CENTRAL NEW MEXICO

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

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

http://museums.state.nm.us/nmmnh/nmmnh.html.

Table of Contents:

Mid-Congress Field Trip 2005 : The Dinantian of Belgium Revisited

May 24-28 2005 – First Circular

Organization

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Scientific Program

May 24 - Conference day (University of Liège) : Progress in long-distance correlations.

Oral presentations will be 15 minutes, followed by 5 minutes discussion. Posters are most welcome and will be displayed in the lecture hall.

Accommodations in Liège

May 25 to 28 - Field trip in the type Dinantian of Belgium.

New field data collected in the last decade by the revision of the century-old geological maps of southern Belgium and an integrated bio- and sequence-stratigraphical approach have improved the understanding of the sedimentary history and clarified the stratigraphic succession of the Belgian Tournaisian and Viséan. The field trip will be mainly devoted to :

1. Sequence-stratigraphy and biostratigraphy of the type Dinantian, from late Famennian (Strunian) until Namurian.

2. Chronostratigraphic subdivisions (stage and substage stratotypes) and widespread correlations.

3. Palaeogeographic units and sedimentology. Evolution from a ramp to a shelf during the Dinantian. Section from proximal to distal environments. Effects of the early phase of Variscan shortening on Middle Viséan sedimentation.

May 25: Starting point in Liège.

1. Ourthe Valley section (Condroz sedimentation area), from Strunian to Middle Viséan. D/C boundary. Definition of Tournaisian sequences and biostratigraphy. Lateral and vertical extension of the solution collapse Belle Roche Breccia.

2. Engis quarry (eastern Namur sedimentation area), continuous but incomplete Tournaisian and Viséan succession resting on Famennian siliciclastics. Five third-order sequence boundaries and related gaps. Evaporitic facies in the Upper Tournaisian. Unconformity between the Middle Viséan and the Namurian siliciclastics.

Accommodations in Namur.

May 26:

1. The Tournaisian of Tournai (Hainaut sedimentation area).

2. Middle and Upper Viséan deposits in Seilles, Samson (stratotype of the Warnantian Substage) and Lives (stratotype of the Livian Substage), southern Namur sedimentation area. Lateral development of Middle Viséan evaporites and their solution collapse ("Grande Brèche").

Accommodations in Namur.

May 27:

1. Tournaisian and Upper Viséan of the Hoyoux valley (Condroz sedimentation area).

2. Transition from the Condroz sedimentation area to the Dinant sedimentation area : T/V boundary in Sovet railway cutting; Tournaisian at Yvoir (Ivorian stratotype).

Accommodations in Namur.

May 28:

1. Distal carbonate facies with Waulsortian buildups in the Dinant sedimentation area. D/C boundary in Hastière (Hastarian stratotype); periwaulsortian lagoonal facies in Salet road section (Moliniacian stratotype). Tournaisian section with Waulsortian buildups at Gendron-Celles.

2. Dinant (Leffe quarry): Lower Viséan deep water facies to Middle Viséan evaporites and solution collapse breccias.

Most visited sections will provide macrofossils and will be documented by detailed lithological columns making possible sampling for micropalaeontology, sedimentology, and geochemistry.

Access to Liège

The University of Liège can be easily reached by public transportation from the Brussels airport. A registration desk will be open at the Department of Geology on May 23 and 24.

The field trip will end in Namur railway station (railroad connections with Brussels airport, Paris, and Germany).

Registration fees

450 €, including hotels, meals and car or bus transportation for the field trip. Drinks for the dinner will not be covered.

Calendar

October 31 : pre-registration

January 31 : final program sent out to participants with further logistic information

February 28 : final registration and payment of a deposit of 200 € (bank information for payment will be given in the second circular).

For practical reasons, the number of attenders will be limited to 30.

Pre-Registration Form   Deadline for Pre-Registration : 31 October

Name : ____

Position : ____
Institution : ____

Address : ____
____
____
____
____

Phone : _______________
Fax : ________________
E-mail ________________

Probability of attendance
Highly probable
Probable

____

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