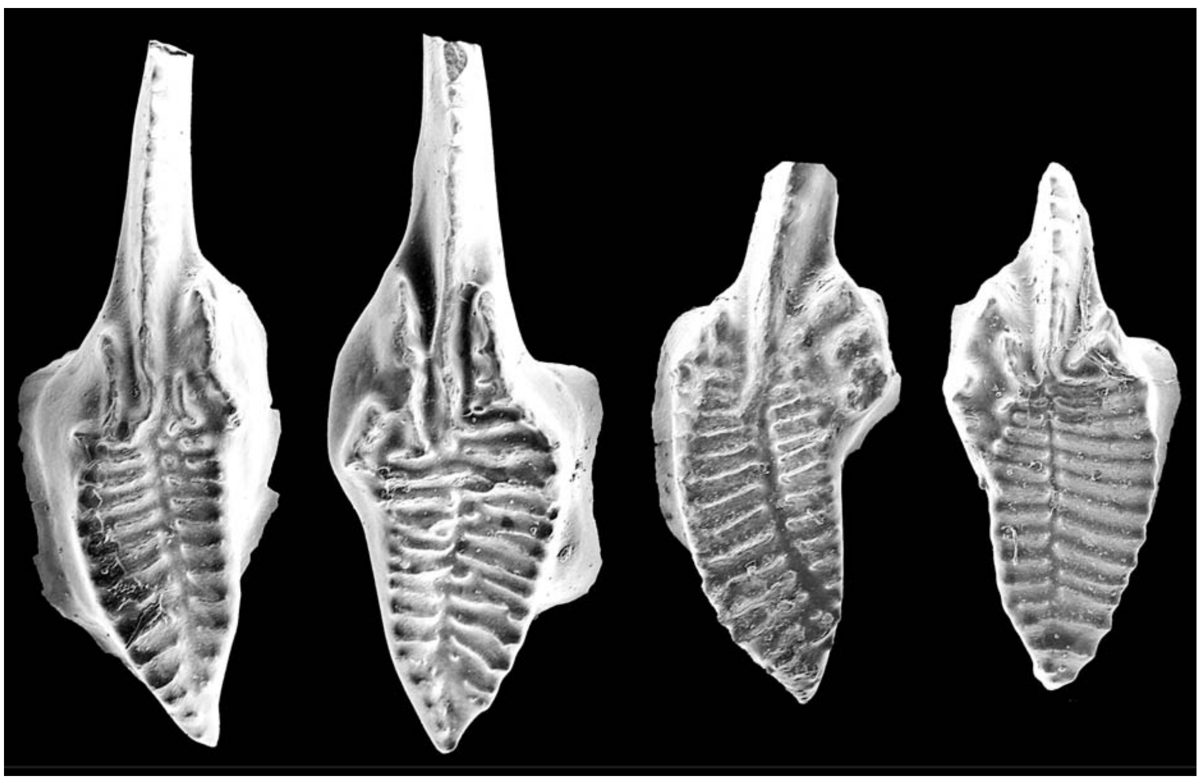
NEWSLETTER ON CARBONIFEROUS STRATIGRAPHY

Volume 23 July 2005



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. 23 - 2005

CHAIRMAN'S COLUMN

This past year has seen slow but steady progress in the selection of stage boundaries, as detailed in the individual reports that follow. The GSSP proposal for the Tournaisian-Viséan boundary is being prepared for the Subcommission vote. The Viséan-Serpukhovian Boundary Task Group is focusing on a fairly widely distributed conodont lineage that has recently been recognized also in China, and at the SCCS meeting in Liege, a potential section for the GSSP was reported by Russian workers from the eastern slope of the southern Urals. The Bashkirian-Moscovian Boundary Task Group is investigating in greater detail one of the possible conodont lineages under consideration after two other lineages were deemphasized, and work on a new potential lineage is underway. The combined Moscovian-Kasimovian and Kasimovian-Gzhelian Boundary Task Group is examining more closely the taxonomy involved in the conodont lineages that appear useful for boundary recognition. I have compiled correlation charts across both boundaries based on scales of glacial-eustatic cyclothems plus biostratigraphy (see article later in this volume). These discrete depositional units provide good potential for correlation, but unfortunately at the same time inhibit the selection of GSSPs because lowstand exposure breaks the continuity of deposition in most regions. The Boreal Stratigraphy Project Group is establishing zones of biostratigraphic correlation across the vast region of northeastern Russia. The Magnetostratigraphy Project Group reports on the status of processing samples from the complete succession across the Pennsylvanian-Permian boundary in the Big Hatchet Mountains of New Mexico, in a search for the short normal polarity zone known from the GSSP in Kazakhstan.

In regard to radiometric dating, an abstract by Schmitz, Davydov, Snyder, Ramezani, and Bowring for the 2005 Goldschmidt Conference on High-Precision Geochronology [p. A326] reports new ID-TIMS U-Pb zircon ages with precisions of $\pm$0.2-0.4 Ma from Pennsylvanian-Permian tuff beds in fossiliferous successions in the southern Urals of Russia. This shows that progress is being made in resolving the "murky state of affairs in Carboniferous radiometric dating."

2005 Liege Meeting

The 2005 SCCS Midterm meeting and field conference was held in Liege, Belgium, May 24-28, ably organized by Edouard Poty, and hosted by the Department of Paleontology at the University of Liege. An informative meeting was followed by a four-day field trip that visited many sections in the type Dinantian [Tournaisian-Viséan] region of the Meuse River valley. There, the sequence-stratigraphic architecture of this classic succession was demonstrated, and the classic Belgian substages were presented within this framework, some with redefined boundaries. The excellent guidebook for this field trip soon can be obtained by downloading from the following website address: http://www.ulg.ac.be/paleont/

Updated Guidebook for 2001 St. Louis Meeting

The guidebook for the 2001 SCCS Midterm meeting in St. Louis, USA, and field conference in the type Mississippian region of the Mississippi Valley, has been updated and published by the Illinois State Geological Survey as Guidebook 34. For information on obtaining CD or print copies of this updated guidebook, please contact:

LeAnn Benner, Information Office, Illinois State Geological Survey, 615 East Peabody Drive, Champaign, IL 61820, USA. Telephone: 217-244-2414; Email: benner@isgs.uiuc.edu

Early Planning for 2007 XVI International Carboniferous Congress in Nanjing

Planning is underway for the 2007 XVI International Carboniferous-Permian Congress in Nanjing, China. Although plans will not be finalized until late 2005, the usual intense summer heat of central China makes a June timing likely. A website soon will be set up, and until then all inquiries should be directed to Xiangdong Wang of the Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences, at: xdwang@nigpas.ac.cn

Problem of SCCS Newsletter Funding

A serious problem has arisen regarding the funding for printing and distributing this Newsletter, which I must bring to your attention. After steady small reductions in the amount of support, a recent cascade of funding cuts from UNESCO through the IUGS has caused the ICS to reduce this year's budget for all subcommissions to 75% of the previous year's level. This ICS funding has provided most of the funds that allow the SCCS Newsletter to be printed and distributed free to all voting and corresponding members, and it was significantly augmented by ~$1200 through special non-recurring circumstances in 2001 and 2002. The only other source of funds over the years has been donations from a few generous members, which unfortunately is relatively small in total, and too variable from year to year for adequate planning. The recent ICS budget cut has put the continued publication of this Newsletter in jeopardy, even in the near-term. Therefore, I strongly urge those of you who are able, to make as generous a donation as you can afford, if you wish to see the continuing publication of the Newsletter. We will have to cease publication if lack of funds makes it necessary to charge for individual issues, because we know that a number of you could not afford the cost. Please use the form that is inserted into the Newsletter, for making your donation. Thank you very much.

Philip H. Heckel

SECRETARY / EDITOR'S REPORT 2004-2005

I want to thank all who provided articles for inclusion in Volume 23 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.

Problem of SCCS Newsletter Funding

A significant reduction in funding from ICS has put continued publication of the Newsletter in jeopardy (see Philip Heckel's message in the Chairman's Column for details). Please refer to the instructions for donations on the last page of this issue.

Future Issues of Newsletter on Carboniferous Stratigraphy

The increasing number of late submissions is becoming a problem. Next year's Volume 24 will be finalized by July 2006, and I request that all manuscripts be sent before May 31—but preferably earlier. Please read the section below (page 5) regarding submission format, especially manuscript length (no more than 5 double-spaced manuscript pages without prior approval). Finally, I would be most grateful if all voting and corresponding members of the SCCS would let me know of any changes to their mailing and e-mail addresses so that we can update our records.

David M. Work

SCCS ANNUAL REPORT 2004

Membership

The Subcommission had 21 voting members in 2004 [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 the Tournaisian-Viséan boundary [which is also 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 is also 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 is also 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 is also 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 Paleozoic boreal biota, stratigraphy and biogeography, chaired by Marina Durante (Russia).

Project Group on Carboniferous magnetostratigraphy, chaired by Mark Hounslow (United Kingdom).

Chief Accomplishments in 2004

As a result of the task group meetings held at the 2003 International Carboniferous Congress in Utrecht, work on the Viséan-Serpukhovian, Bashkirian-Moscovian, Moscovian-Kasimovian, and Kasimovian-Gzhelian boundaries has reached the point where several informal proposals on event markers for those boundaries have been submitted to the task groups. These proposals are now under intensive discussion and have engendered much further research. Because these activities at the Utrecht Congress had not yet produced formal proposals, the SCCS had no formal function at the IGC in Florence in August 2004.

The Newsletter on Carboniferous Stratigraphy, Volume 22, published in July 2004, contains reports of the task groups for 2003 and 9 articles on various topics of interest, including: Updated chart of 400-ky cyclothem groupings in Midcontinent North America; Stratigraphic distribution of critical ammonoids around a potential level for the Kasimovian-Gzhelian Stage boundary; Report of the 2004 meeting of the German Subcommission on Carboniferous Stratigraphy; Carboniferous biostratigraphy of the Moscow Syneclise; Review and future prospects of Carboniferous magnetostratigraphy; Lower Desmoinesian (mid-Moscovian) conodont succession in lower and middle Cherokee Group in Midcontinent North America; Paleophytogeography and stratigraphy of Mississippian plant-bearing deposits of Angaraland; Stratigraphic potential of stigmarian limestones of the Moscow coal basin; North American regional stage nomenclature across the Carboniferous-Permian boundary, for a total of 70 pages.

Work Plan for 2005 and Following Years

The SCCS held a one-day meeting on May 24, 2005, at the University of Liege, Belgium, followed by a four-day field trip to the type Dinantian [Tournaisian-Viséan] region in the Meuse River valley of southern Belgium.

<u>Tournaisian-Viséan boundary</u>. This task group internally approved the proposal to select the GSSP at the Pengchong section in southern China, and is now preparing a formal proposal for the SCCS ballot on the GSSP.

<u>Viséan-Serpukhovian boundary</u>. This task group is now focusing work on a conodont lineage in the genus *Lochriea* as a potential boundary-defining event, and information on a potential GSSP section in the eastern slope of the southern Urals was presented at the May 2005 Liege meeting.

Bashkirian-Moscovian boundary. This task group is now focusing on taxonomic work needed to evaluate the proposals it received in 2004 for boundary-defining events in several conodont lineages, particularly that involving *Idiognathoides postsulcatus*.

Moscovian-Kasimovian boundary. This task group will meet in St. Petersburg, Russia, in August 2005, to discuss the cyclothem-based correlation chart of strata across this boundary interval as a basis for evaluating the conodont and foram lineages proposed as boundary-defining events, as well as the taxonomic issues involved.

Kasimovian-Gzhelian boundary. The same task group will discuss the cyclothem-based correlation chart of strata across this boundary interval as a basis for evaluating the conodont lineage involving *Idiognathodus simulator* (which is proposed as a boundary-defining event), and taxonomic work on this lineage will be presented, at the St. Petersburg meeting in August 2005.

Progress appears to have been sufficient in all task groups, that the selection of at least all the boundary-defining events for the stage boundaries currently envisioned in the Carboniferous is realistic by the ICS deadline of 2008. However, the strong glacial-eustatic control over sedimentation that resulted in widespread exposure surfaces across entire shelves during the time of at least the upper two boundaries is hampering the identification of potentially acceptable GSSPs. The Project Group on Carboniferous Magnetostratigraphy is focusing on supplementing the pan-tropical biostratigraphic framework, and eventually will hopefully help to integrate the tropical plant-rich terrestrial succession and the more polar fossil assemblages into the marine pan-tropical Carboniferous scale. Increasingly precise ID-TIMS measurements of U-Pb zircon ages of volcanic tuff beds in the southern Urals indicate progress in dating biostratigraphically constrained successions across important boundaries.

STATEMENT OF OPERATING ACCOUNTS FOR 2003/2004

Prepared by David Work, Secretary

(Definitive accounts maintained in US currency)

INCOME (Oct. 31, 2003 – Oct. 31, 2004)	
IUGS-ICS Grant 2004	$900.00
Donations from Members	628.72
Interest	4.17
TOTAL INCOME	**$1532.89**
EXPENDITURE	
Newsletter 22 (printing)	$665.60
Postage for bulk mailings	683.00
Mailing/Office Supplies	146.04
Bank Charges	148.00
TOTAL EXPENDITURE	**$1642.64**
BALANCE SHEET (2003 – 2004)	
Funds carried forward from 2002 – 2003	$1864.49
PLUS Income 2003 – 2004	1532.89
LESS Expenditure 2003 – 2004	-1642.64
CREDIT balance carried forward to 2005	**$1754.74**

Donations in 2004/2005:

Publication of the Newsletter on Carboniferous Stratigraphy is made possible with generous donations received from members/institutes during 2004-2005 and anonymous donations, combined with an IUGS subsidy of US $750 in 2005, and additional support from a small group of members who provide internal postal charges for the Newsletter within their respective geographic regions.

D. R. Chesnut, W. H. Gillespie, B. F. Glenister, P. H. Heckel, T. W. Kammer, Xiangdong Wang, T. Yancey

COVER ILLUSTRATION

Late Pennsylvanian conodonts.

Left: *Idiognathodus* sp. aff. *simulator* (Ellison) [left and right Pa elements], X60, Eudora Shale, Missourian/ Kasimovian, near Dewey, Washington County, Oklahoma, U.S.A.

Right: *Idiognathodus simulator* (Ellison) [left and right Pa elements], X60, Heebner Shale, Virgilian/Gzhelian, quarry at Weeping Water, Cass County, Nebraska, U.S.A. Candidate for event level that defines base of global Gzhelian Stage.

Illustrations: courtesy of J.E. Barrick.

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. Manuscripts may also be sent to the address below on CD prepared with **Microsoft Word (preferred)** or WordPerfect but any common word processing software or plain ASCII text file can usually be acommodated. Word processing files should have no personalized fonts or other code. Maps and other illustrations are acceptable in tif, jpeg, eps, or bitmap format. If only hard copies are sent, these must be camera-ready, i.e., clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time.

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

Please send contributions as follows,

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

F.X. Devuyst and George Sevastopulo

Department of Geology, Trinity College, Dublin 2, Ireland.

Progress on the T/V boundary since the 2004 Newsletter

Stable Isotopes

A detailed δ13C and δ18O curve (unpublished) was produced for the Pengchong section (late Tournaisian [top of *S. anchoralis* Zone] to early Livian [post-entry of *Pojarkovella nibelis*]) with 101 levels analyzed. 120 samples (multiple samples were taken to evaluate homogeneity and some late stage veins were sampled as well) were drilled on polished surfaces with a hand drill and analyzed at the Geology Department, Trinity College by F.X. Devuyst and R. Goodhue. Multiple analyses were performed on about 20% of the samples; mean variation was 0.07‰ for carbon and 0.14‰ for oxygen, although maximum variations observed were 0.3‰ and 0.42‰, respectively. The geological context of the Pengchong section is not ideal for isotope study, but a significant peak in the δ13C, if it existed, would not be missed. Such a peak, however, was not found in the stratigraphic range covered, with δ13C values varying between ~ +2‰ and +4.4‰. The δ18O curve oscillates more, as can be expected, between ~ -8‰ and -3‰. These values do not concern vein and pure dolomite samples. Sections of approximately the same age (late Tournaisian to early Viséan) in southern Belgium, western Ireland, and western Canada have been sampled and are ready for analysis.

In late June, F.X. Devuyst and H. Hongfei collected stable isotope samples from around the base of the *S. anchoralis* Zone in the Longdianshan section. The goal is to test for the presence of a peak in 13C identified by M. Saltzman (unpublished data) in southern Belgium which would be of great significance for correlation.

Conodonts

Task group members M. Coen, S. Tian, G Sevastopulo, and E. Groessens recently published two papers on the conodont faunas of the Longdianshan (Guangxi), Pengchong (Guangxi), and Yudong (Yunnan) sections. In late June, F.X. Devuyst and H. Hongfei collected additional control samples from the upper part of the Longdianshan section which are currently being processed and studied by G. Sevastopulo. This data should considerably improve regional and long-distance correlations.

Trilobites

The study and description of trilobites collected in 2002 at Yajiao (early Viséan, *Liobole*) and Longdianshan (late Tournaisian, *Brachymetopus*) will be published by G. Hahn and R. Hahn in two separate papers in *Paläontologische Zeitschrift* and *Geologica et Palaeontologica*, respectively. Both genera are well known in western Europe and the environmental settings and stratigraphic positions correspond.

Foraminifers

A new improved foraminifer and coral zonation of the type Dinantian (Lower Carboniferous of the Franco-Belgian Basin) by L. Hance, E. Poty, and F.X. Devuyst is in press. The latest Tournaisian foraminifer biozone is based on the appearance of *Eoparastaffella* sp. and the earliest Viséan biozone is based on the appearance of *E. simplex*.

A study by F.X. Devuyst and J. Kalvoda which describes new latest Tournaisian to earliest Viséan species of *Eoparastaffella* from throughout Eurasia and discusses the early evolution of the group will be submitted shortly. This study demonstrates an unexpected diversity of *Eoparastaffella* species early in the history of the genus and confirms its value for high-resolution biostratigraphy at the Tournaisian/Viséan transition.

In late June, F.X. Devuyst and H. Hongfei collected new samples from the latest Tournaisian to earliest Viséan part of the Pengchong section in order to obtain more material of the primitive *E. simplex* fauna. These samples are currently being processed.

Stratigraphic Nomenclature

A series of papers revising the stages and substages of the type Dinantian in southern Belgium will be published in a special volume of Geologica Belgica on "Belgian and Bordering Countries Stages." This volume will include papers on the Tournaisian, Viséan, and Moliniacian by L. Hance, E. Poty, and F.X. Devuyst. Biostratigraphic data from the Franco-Belgian Basin are reviewed and the correspondence between the base of the Viséan and the base of the Moliniacian is re-established.

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Hahn, G., and R. Hahn. In press. *Brachymetopus* (Trilobita; Carboniferous) in China. Geologica et Palaeontologica.
Devuyst, F.X., and J. Kalvoda. [in preparation] Early evolution of the genus *Eoparastaffella* (Foraminifera) in Eurasia: the '*interiecta* group' and related forms, late Tournaisian to early Viséan, Mississippian. Journal of Foraminiferal Research.
Hance, L., E. Poty, E., and F.X. Devuyst. In press. Upper Devonian and Mississippian foraminiferal and rugose coral zonations of Belgium and Northern France: a tool for Eurasian correlations. Geological Magazine.
Hance, L., E. Poty, and F.X. Devuyst. [submitted] The Viséan Stage. *In* L. Dejonghe (ed.), Belgian and Bordering Countries Stages. Geologica Belgica, special volume.
Hance, L., E. Poty, and F.X. Devuyst. [submitted] The Tournaisian Stage. *In* L. Dejonghe (ed.), Belgian and Bordering Countries Stages. Geologica Belgica, special volume.
Devuyst, F.X., L. Hance, and E. Poty. [submitted] The Moliniacian Substage. *In* L. Dejonghe (ed.), Belgian and Bordering Countries Stages. Geologica Belgica, special volume.

The Viséan-Serpukhovian boundary: a summary of progress made on research goals established at the XV-ICCP Carboniferous Workshop in Utrecht

Barry C. Richards and Task Group

Geological Survey of Canada - Calgary, 3303- 33rd St. NW, Calgary, Alberta, Canada T2L 2A7.

The first official meeting of the Viséan-Serpukhovian boundary task group was held at the Carboniferous Workshop on August 13, 2003 during the XV International Congress on Carboniferous and Permian Stratigraphy in Utrecht, The Netherlands. Several short-term research goals were established at the congress and initial progress has been made on some of them.

At the onset of the Utrecht 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. 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 (Skompski et al., 1995). Since the Utrecht meeting, Kabanov (2004), an associate member of the task group, carefully restudied the type section, confirming the unconformable nature of the lower contact.

The task group has concluded that the first evolutionary appearance of the conodont *Lochriea ziegleri* in the lineage *Lochriea nodosa – Lochriea ziegleri* currently presents the best potential for boundary definition. *Lochriea ziegleri* appears near the middle of the Brigantian Substage, which is slightly below the current base of the Serpukhovian. The lineage, best documented from relatively deep-water sections, 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). In the Zaborie quarry section, *Lochriea ziegleri* appears with *Lochriea senckenbergica* in the basal bed (about 65 cm thick) of the type Serpukhovian (Nikolaeva et al., 2002), but this is not a first evolutionary appearance.

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 at the Utrecht meeting suggested that North American conodont collections be re-examined for key taxa within the group. The latter work has not been undertaken, but the recent work of team member Alan Titus on conodont assemblages in several sections of basinal facies in the Chainman Formation of western Utah and eastern Nevada suggests the recognition of the *L. nodosa – L. ziegleri* lineage in North America is unlikely. If we use the first evolutionary appearance of *L. ziegleri* for boundary definition, it will be necessary to use either geochemical data or other species (conodont, foraminifer, or ammonoid) that appear concomitantly with the Eurasian *L. ziegleri* to achieve a precise correlation with North America. With this in mind, Alan Titus indicated that ammonoids could be used to facilitate a precise correlation between Eurasia and North America. 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.

At the Utrecht meeting, it was proposed that 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. In the Zaborie section, "*Millerella*" *tortula* appears about 50 cm above the base of the Serpukhovian (Gibshman, 2001; Nikolaeva et al., 2002). Brenckle and Groves (1981) and Brenckle (1990) proposed that *"M." tortula* Zeller 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. Since the Utrecht meeting, task group member Paul Brenckle studied the two groups of specimens and concluded that the Russian *"M." tortula* is not the same species as the one from North America. Even if the Russian and North American *"M." tortula* were the same species, there is no evidence of the Russian ancestral (pre-*tortula*) forms occurring in North America. The first appearance of *"M." tortula* is, therefore, not desirable as a global boundary marker.

In October 2004, team members Titus and Richards examined several sections of the Chainman Formation in western Utah in search of ammonoid- and conodont-bearing sections that might permit an exact correlation with Eurasian sections preserving first appearances of *Lochriea ziegleri*. A well exposed upper Viséan to lower Serpukhovian (Asbian to Pendleian) section at Jensen Wash, Utah was considered to be the best in the region and plans have been made to study and sample that section in detail for ammonoids, conodonts, and samples for stable isotope (carbon and oxygen) geochemistry. Carbonate ramp lithofacies of the upper Viséan and Serpukhovian Etherington Formation are being measured at five localities in the Canadian Rocky Mountains and sampled for conodonts, foraminifers, and geochemistry. From the study of the Etherington sections, the working group hopes to better understand the carbon stable-isotope signature of the Brigantian and Pendleian succession; in addition the work will provide another opportunity to look for the *L. nodosa – L. ziegleri* lineage.

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

John Groves and Task Group

Department of Earth Science, University of Northern Iowa, Cedar Falls, IA 50614, USA.

Summary of Activities

As of this time last year, conodont specialists in this task group had submitted three proposals for potential lower Moscovian boundary markers: 1) the appearance of *Idiognathoides postsulcatus* from *Id. sulcatus*; 2) the appearance of *Declinognathodus donetzianus* from *D. marginodosus*; and 3) the transition from early to late morphotypes of *Neognathodus nataliae*. Members of the task group reviewed the proposals and commented on the relative merits of the potential marker taxa. The following is a brief summary of comments received.

Appearance of *Idiognathoides postsulcatus*

This potential marker is attractive in that it is nearly cosmopolitan in its distribution, being known from most important areas except the Moscow Basin and South America. The appearance of *Id. postsulcatus* in some areas is closer to the traditional base of the Moscovian than are the other two potential markers. Identification by non-specialists could be difficult because of subtle morphologic differences between this species and its ancestor.

Known occurrences of potential marker taxa	Donets Basin	Moscow Basin	Urals	Great Britain	Northern Spain	Central Japan	South China	Alaska (terranes)	Arctic Canada	South America	cratonic North America
Id. postsulcatus	+		+	+	+	+	+	+	+		+
D. donetzianus	+	+	+	+				+		+	
N. nataliae	+	+			+						+

Appearance of *Declinognathodus donetzianus*

This potential marker possesses a very distinctive morphology that allows easy identification. It is known from eastern and western Europe (including the Moscow Basin), Alaska (terranes), and South America, but not from China or cratonic North America. The geographic distribution and stratigraphic level of appearance of this potential marker closely track the *Profusulinella–Aljutovella* fusulinid transition.

Appearance of Late Morphotype of *Neognathodus nataliae*

This form is known from eastern and western Europe, but not from the Arctic, Asia or South America. North American representatives are known but not yet documented. Although described in the proposal as a distinctive morphotype that is easily identified, some conodont specialists expressed uncertainty with the taxonomic concepts involved in the transition from early to late morphotypes.

An informal and non-binding poll of task group members revealed strong support for continued evaluation of *Id. postsulcatus* and moderate support for continued evaluation of *D. donetzianus*. Most task group members who responded to the poll viewed the late morphotype of *N. nataliae* as an unsuitable candidate for marking the base of the Moscovian.

Next Steps

Virtually all members of the task group have expressed interest in meeting together for discussions and side-by-side comparisons of collections from various areas. Although clearly desirable, there are no current plans for such a meeting because of funding constraints. It is hoped that the subset of members who will attend the Moscovian–Kasimovian boundary Task Group meeting in St. Petersburg, Russia, later this summer will be able to devote some time to Bashkirian–Moscovian issues and possibly examine relevant specimens.

Preliminary investigations into reported occurrences of *Id. postsulcatus* suggest that the appearance of the species may be well within the Bashkirian in central Japan (Omi and Akiyoshi Limestones) and well within the Moscovian in cratonic North America (type Atokan area). These instances of potential diachroniety must be further investigated by examining actual specimens and independently assessing (by means of multiple fossil groups) the ages of host strata.

As no clearly superior marker has yet emerged, members of the task group are encouraged to propose other events (biostratigraphic or otherwise) that may be used for defining the base of the Moscovian Stage. Lance Lambert is working on a proposal involving the conodont *Neognathodus atokaensis*.

Report of the Task Group to establish GSSPs at the Moscovian-Kasimovian and Kasimovian-Gzhelian boundaries

Elisa Villa and Task Group

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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. In August 2004, this group held a general meeting at the University of Oviedo (Spain) that was attended by members A. Alekseev, V. Davydov, N. Goreva, P. Heckel, M. L. Martínez Chacón, C. Méndez, T. Nemyrovska, L. C. Posada, S. Remizova, R. M. Rodríguez, K. Ueno, and E. Villa. Discussions and workshops during this meeting have led to substantial progress in correlation that is summarized as follows:

Moscovian-Kasimovian Boundary

The task group has established many paleontological and sedimentological links at different levels through sections and areas that are distributed worldwide. The paleontological links are mainly based on conodonts, but fusulines play an important subsidiary role. These paleontological links allow correlation of specific stratigraphic sequences (cyclothems), as is shown in the article by P.H. Heckel and 13 coauthors later in this volume. Two levels offer potential for correlation relatively near the current boundary.

1). A level of correlation very close to the present lower Kasimovian boundary in Eurasia and within the late Desmoinesian in North America could be traced by combining the occurrence of two troughed conodont species, *"Streptognathodus" subexcelsus* and *Swadelina neoshoensis*. However, the suitability of this level is diminished by the fact that in both the Midcontinent and the Moscow Basin, both taxa appear abruptly above a disconformity with no obvious antecedent in the flat morphotypes in the underlying strata. Moreover, neither of the two conodont species occur in all relevant areas.

The appearance of typical species of the fusuline genus *Protriticites* (forms exhibiting distinct wall porosity) takes place around this boundary. These forms are known from all Eurasian regions, and more primitive forms have been recorded in western USA [Wahlmann et al., 1997, Cushman Foundation for Foraminiferal Research Special Publication, 36, p. 163-168], but the appearance of the various forms may be diachronous when compared to the conodont distribution [as shown by Heckel et al., and by Isakova et al. in articles later in this volume]. In addition, the recognition of this structural feature in the wall can depend greatly on facies and preservation.

2). A potential marker at the first appearance of the conodont *Idiognathodus sagittalis* (which would raise the base of the Kasimovian to a level somewhat higher than the current one) seems to be promising, especially if considered in conjunction with the fusuline *Montiparus*. *Idiognathodus sagittalis* has been identified in most areas, specifically the Donets Basin (limestone O1) from which it was named, Moscow Basin (Mid-Neverovo Formation), Southern Urals (Dalniy Tyulkas-2 section, beds 34-35), Cantabrian Mountains (Las Llacerias section, bed 9035), and American Midcontinent (Checkerboard-South Mound, Exline, Hertha, and Swope cyclothems).

Problems to be resolved mainly concern the somewhat diachronous appearance of *I. sagittalis*, as it appears later in the Moscow and Donets Basins than in North America, probably due to facies constraints. It is also necessary to clarify the status of older tentatively identified specimens in several sections.

The fusuline *Montiparus* can play a relevant role in reinforcing correlation at levels around the first appearance of *I. sagittalis*, since species belonging to this widely distributed and more easily identified Eurasian genus have been reported also from the western USA [most recently by Davydov et al. in the abstracts for the 1999 International Carboniferous-Permian Congress in Calgary, and later confirmed by others]. *Montiparus* is also present in the Arctic province, where fusuline assemblages show transitional features that can provide clues for linking Eurasian and North American provinces.

Kasimovian-Gzhelian Boundary

The characterization of the lower Gzhelian boundary seems to be best based on the occurrence of the conodont *Idiognathodus simulator* [sensu stricto] at a number of relevant sections in areas representing both the American and Eurasian paleobiogeographic provinces. This level is situated in the Oread cyclothem (Midcontinent), Finis cyclothem (Texas), Shumway cyclothem (Illinois Basin), Upper Rusavkino Formation (Moscow Basin), Bed 4/2 of the Usolka section (South Urals), and O7 limestone (Donets Basin). Problems remaining involve taxonomic work being carried out by J.E. Barrick, D.R. Boardman, and P.H. Heckel, aimed toward distinguishing *I. simulator* [s.s.] from its ancestor termed *I.* aff. *simulator*, which occurs below it in most areas.

Correlation may be reinforced in Eurasia by the appearance of advanced forms of the fusuline *Rauserites rossicus* at a level very close to the appearance of *I. simulator* [s.s.]. This fusuline has been so far reported from the Moscow Basin, Samarskaya Luka and Trans-Volga region, northern Timan, Timan-Petchora, and Urals region of Russia, northern Fergana, Darvas, northern Greenland, Carnic Alps, Cantabrian Mountains, and the Donets Basin (where more primitive forms are reported from older beds). Therefore, the advanced form of *Rauserites rossicus* may be a tool of prime importance for correlation to be used in Eurasia in conjunction with *Idiognathodus simulator*.

Coming Steps

During the Oviedo meeting, members of the task group agreed to further study lineages involved in the proposed markers and to sample some critical intervals in more detail. P.H. Heckel began to compile a more refined correlation across both boundary intervals based on scale of glacial-eustatic cyclothems and their biostratigraphy, aimed toward resolving the existing problems, which appears later in this volume.

To continue discussions and laboratory workshops the group will meet again at the VSEGEI in St. Petersburg, Russia from August 8th to August 13th, 2005, at a meeting organized by SCCS member Olga Kossovaya of VSEGEI.

Report of the Project Group "Upper Paleozoic boreal biota, stratigraphy and biogeography"

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Last year's investigations mainly concern Upper Paleozoic biostratigraphy of the Boreal area in central northeast Russia, where the efforts of most participants in the project (V.G. Ganelin, M.V. Durante, S.S. Lazarev, A.S. Bjakov) were concentrated.

Northeast Russia is a large region containing the Verkhoyan mountain system and the Omolon and Okhota massifs, together with adjacent troughs. During 2003-2004, new versions of correlation charts were presented for all of these areas, based on marine faunas (brachiopods, pelecypods, partly forams) and fossil plant assemblages. Unfortunately, only some zones can be traced throughout all of northeast Russia. Other zones require additional study.

1. Last year very significant progress was achieved in the study of brachiopod morphology and systematics.

V.G. Ganelin extended the reinvestigation of the Linoproductidae, which dominates Permian northeast Asian communities. The new genus *Omolona*, which was derived from the genus *Terrakea,* was described, and new species of the latter genus were recognized. Some are strongly reminiscent of Australian species of the same genus, and provide a possible basis for correlation between the Boreal and Gondwana regions.

S.S. Lazarev revised the morphology and systematics of two groups of boreal brachiopods. One of these belongs to the family Schrenkiellidae (Linoproductoidea). Morphological analysis of this family permits the recognition of two new genera and the reconstruction of a phyletic lineage that consists of the genera *Krekarpia–Balakhonia–Elalia–Schrenkiella*. The second group (Horridoniini) is widely distributed throughout the Boreal region. Two phyletic lineages were reconstructed into the subgroups Sowerbina and Horrioniina, and three new genera (*Kornellia, Vigdalia, Sowerbina*) were described. These systematic and phylogenetic findings are important for stratigraphy and correlation within the Boreal region.

2. Bivalve studies by A.S. Bjakov also contributed to the Upper Paleozoic zonal succession of northeast Asia. Last year's investigations enabled Bjakov to subdivide the Early Permian *Paleoneilo parenica* Zone into four new zones. Bjakov also determined that the youngest Permian bivalve zone in northeast Russia is Changhsingian (uppermost Permian of the Tethyan scale) in age. It should be noted, however, that paleobotanical data from the same level suggests an uppermost Kazanian–lower Tatarian age.

N.I. Karavaeva and G.R. Nestell (University of Texas at Arlington, USA) have prepared for publication a description of 48 new species of Permian forams (Lagenidae) from reference sections in the Omolon massif.

M.V. Durante revised collections of fossil plants from different levels in the thick Upper Paleozoic terrigenous Verkhoyan complex from the Verkhoyan mountain system. A succession of plant assemblages with Angara affinities has been recognized there. The Verkhoyansk assemblages are very important for determining the age of Angara Late Paleozoic plant assemblages because of their association with marine faunas. Recently Durante extended the revision of Verkhoyan plant collections, and later descriptions of Upper Paleozoic Verkhoyan fossil plants will be prepared.

These paleontological investigations will neccessitate the preparation of a new version of the Boreal Upper Paleozoic zonal succession, which will form the basis for overall Boreal correlation.

Y.V. Mosseichik's paper "Paleophytogeography and stratigraphy of Mississippian [Lower Carboniferous] plant-bearing deposits of Angaraland" (Newsletter on Carboniferous Stratigraphy, 22:47-56) is based on a review of several monographs and contains a review of Upper Paleozoic fossil plants and stratigraphy in the different regions of Angaraland. New approaches to Angaran phytogeography are also demonstrated in this paper.

Report of the Carboniferous Magnetostratigraphy Project Group

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The number of members of the project group is small and we would welcome any interested persons or parties who are interested in utilizing or evaluating Carboniferous magnetostratigraphy. We would particularly welcome information from those stratigraphers working on specific sections where magnetostratigraphy could be attempted to improve international correlations and help the objectives of the SCCS. We would also welcome any news of possibly unpublished information on specific sections where magnetostratigraphy has been attempted, so as to disseminate as widely as possible both positive and negative magnetostratigraphic results to the project group.

Two projects are active at this time. The first of these being undertaken by Kate E. Zeigler[1], Spencer G. Lucas[2], Roberto S. Molina-Garza[3], and John W. Geissman[1] ([1]*Dept. of Earth and Planetary Sciences, University of New Mexico, Albuquerque, NM 87131;* [2]*New Mexico Museum of Natural History and Science, 1801 Mountain Rd NE, Albuquerque, NM 87104;* [3]*Centro de Geosciencias, Campus Juriquilla UNAM, Queretaro, Mexico, 76230*) on the magnetostratigraphy of the Pennsylvanian-Permian transition at New Well Peak, southwestern New Mexico.

The Big Hatchet Mountains in southwestern New Mexico contain excellent outcrop exposures of the

Pennsylvanian to Permian (Morrowan to Wolfcampian) Horquilla Formation. At New Well Peak in the Big Hatchets, the Horquilla section is approximately 1000 m thick and consists of intercalated limestones and marine shales, all of which dip to the southeast. This section is of great importance as it is one of the few stratigraphic sections in the western USA where sedimentation was apparently continuous across the Pennsylvanian-Permian boundary (Wilde, 2002). A variety of studies are currently being undertaken on these strata, including lithostratigraphy, fusulinid and conodont biostratigraphy, macroinvertebrate biostratigraphy, isotopic analyses, and magnetostratigraphic work. The magnetostratgraphic work is to identify in the section the short duration normal polarity magnetozone(s) which appear to characterize the Pennsylvanian- Permian transition in the Permian GSSP Aidaralash section, and other sections (see Hounslow et al., Newsletter on Carboniferous Stratigraphy, 22:35-41).

For magnetostratigraphic analyses, we drilled each limestone bed in the ~ 180-m-thick Horquilla section, resulting in 42 sites. To date, we have subjected a small subset of the samples (approximately 30 specimens) to progressive thermal demagnetization to 290º C and a second subset of six specimens has been treated with alternating field demagnetization to 100 mT. Initial results on both subsets of specimens show well-defined magnetizations, but the vectors are north-directed and steeply inclined, indicating a much younger magnetic overprint is present in these strata. We will continue thermal demagnetization treatment on one subset of specimens in order to determine whether or not an original magnetic signal can be detected in these strata. Hopefully there should be more positive results by the end of the year.

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The second item of news is that Alexei Khramov (VNIGRI, St Petersburg, Russia) has set about seeing if it is possible to refine, using modern laboratory techniques, the Bashkirian-Moscovian magnetostratigraphy which he and his group produced in the early years of palaeomagnetic research from the Donets Basin. Other recent workers' initial attempts at validating some of these results have proven unsuccessful, and there is an urgent requirement to express these apparently good magnetostratigraphic results in a modern stratigraphic framework, with up-to-date experimental techniques.

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.

Correlation of the base of the Viséan Stage in the type Mississippian region of North America

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The process of selection of a GSSP for the base of the Viséan Stage is at an advanced stage: the proposal that the base should be defined in the Pengchong stream section, Guanxi, China will be submitted to the Subcommission on Carboniferous Stratigraphy before the appearance of the next issue of the Newsletter. The proposed level in the Pengchong section has been chosen to coincide with the first appearance of the foraminifer *Eoparastaffella simplex* in the evolutionary lineage of *Eoparastaffella*, a biostratigraphical datum that allows accurate correlation with other sections in Eurasia, notably elsewhere in southern China, northern Iran, the former USSR, the Czech Republic, Belgium, and Ireland.

However, the *Eoparastaffella* lineage, and, in particular, *E. simplex*, does not occur in the type Mississippian region (or elsewhere) in North America. Other useful biostratigraphical tools for locating strata that span the base of the Viséan in Eurasia – the transition from *Mestognathus prebeckmanni* to *M. beckmanni* in the youngest Tournaisian and the first (cryptic) appearance of the conodont *Gnathodus homopunctatus* just above the base – also cannot be applied in the type Mississippian region.

Previous picks of the base of the Viséan in the Mississipppi Valley range from the base of the Osagean (Collinson et al., 1962, p. 14; 1971, Table 1) to the base of the Warsaw (Mamet and Skipp, 1970). However, the common occurrences in Europe and the Mississippi Valley of taxa such as the conodont *Scaliogathus dockali* (Lane and Ziegler, 1983; Lane and Brenckle, 2005) and the foraminifer *Viseidiscus* (Brenckle et al., 1982) makes it possible to bracket the stratigraphical interval in the type Mississippian region in which the base of the Viséan should be sought. The target strata should be the Burlington

Limestone Formation (and its lateral equivalent, the Fern Glen Formation) and the lower part of the Keokuk Limestone Formation.

In the recently published guidebook for the SCCS 2001 field conference in the type Mississippian region (Heckel, 2005), two horizons are suggested for the base of the Viséan. The first, which was in favour at the time of the field trip in 2001, is discussed in the context of the section at Dennis Hollow, Illinois (Brenckle et al., 2005, p. 35), where the base of the Viséan is placed within the Fern Glen Formation at a level within Lane and Brenckle's (2005) Conodont Faunal Unit 4L (*anchoralis–latus* Zone; *latus* Subzone), just below the lowest record of *Scaliognathus anchoralis anchoralis*. The reasoning behind this correlation was that Lane and Ziegler (1983) believed that *Scaliognathus anchoralis anchoralis*, the subspecies of *Sc. anchoralis* prevalent in the Midcontinent region of North America, evolved from *Sc. anchoralis europensis*, typical of the late Tournaisian of Eurasia, and had replaced it by the Viséan. There are two lines of argument to suggest that the latter hypothesis is incorrect.

First, both Lane and Ziegler (1983, Table 1) and Carman, (1987, fig. 4) showed that in two adjacent sections in New Mexico, the upper limit of the two subspecies is the same, and Carman showed that the range of *Sc. a. europensis* overlaps that of *Bactrognathus lanei* the eponymous species of Faunal Unit 4U, the *lanei* Subzone. In Europe, *Sc. a. anchoralis* and *Sc. a. europensis* occur together in the Carnic Alps and both have their highest recorded occurrence at the same horizon with the first occurrence of *Gnathodus texanus* (Schonlaub and Kreutzer, 1993) and just below *Gnathodus symmutatus* (Perri and Spalletta, 1998). Geraghty (1996) has shown that the latter is a junior synonym of *Gn. homopuctatus*. Belka (1985) recorded both *Sc. a. europensis* and *Sc. a. anchoralis* in Poland and showed (fig. 3) the last occurrence of each at the same horizon.

Second, several of the other conodonts of Faunal Units 4U and 5 of Lane and Brenckle (2005) have their highest occurrence in the Tournaisian of Eurasia. The range of selected taxa in the Mississippi Valley are shown in Figure 1; their ranges in Eurasia are discussed below.

Polygnathus communis communis is not known from the Viséan in Eurasia. Generally the top of its range is well below the top of the Tournaisian (see, for example, Conil et al., 1989, fig.1 for a synthesis of information from Belgium).

Doliognathus latus enters with *Sc. anchoralis europensis*, occurs sporadically within the *anchoralis* Zone, and has its last occurrence just below that of *Sc. a. europensis* in Belgium (Conil et al., 1989, fig.1).

Pseudopolygnathus pinnatus occurs sporadically from below the *anchoralis* Zone to below the highest occurrence of *Sc. a. europensis* in Europe (see, for example, Belka, 1985, fig. 3). In condensed pelagic sequences (see, for example, Perri and Spalletta, 1998, Table 2) *Ps. pinnatus* and *Sc. anchoralis* have their last occurrences at the same horizon.

Eotaphrus burlingtonensis is numerically not very abundant in Europe but has been recorded from many regions within the middle to upper part of the *anchoralis* Zone (Belka, 1985; Butler, 1973; Conil et al., 1989; Perri and Spalletta, 1998).

Polygnathus mehli first occurs just below the *anchoralis* Zone in Ireland and Britain and ranges substantially above the base of the Viséan (Sevastopulo and Nudds, 1987; and our unpublished records).

Gnathodus pseudosemiglaber has been recorded widely in Europe but there may be some inconsistency of identification of this and other species of *Gnathodus*. First occurrences have been recorded from as low as the lower boundary of the *anchoralis* Zone (for examples, see Belka, 1985; Perri and Spalletta, 1998) but in some cases are higher within the *anchoralis* Zone (for example, see Belka and Groessens, 1986; Butler, 1973). The species ranges well above the base of the Viséan. In Belgium and Ireland, faunas from above the last occurrence of *Sc. anchoralis* but below *Gn. homopunctatus* commonly are dominated by *Gn. pseudosemiglaber* (Belka and Groessens, 1986; and our unpublished records).

Gnathodus texanus may also have been interpreted differently in different regions. Its lowest occurrence in Belgium has been recorded by Belka and Groessens (1986) from just below the *anchoralis* Zone, but in Poland (Belka, 1985) its earliest occurrence defines the base of the *Gnathodus texanus* Zone, immediately above the *anchoralis* Zone.

There clearly is not an exact equivalence of the ranges of the taxa listed above in the Mississippi Valley and Eurasia (to what extent this reflects taxonomic practices remains to be established). On balance, however, it seems unlikely that the boundary can be any lower than the base of Lane and Brenckle's (2005) Faunal Unit 6, the *Gn. bulbosus* Subzone. However, as a working hypothesis, the base of Faunal Unit 7, the *Gnathodus texanus* Zone, is preferred, as suggested by Lane and Brenckle (2005, p. 78, fig. 48).

Recent work on ammonoids by Work and co-workers is relevant to the correlation of the base of the Viséan in the Mississippi Valley since faunas from the Midcontinent region are accompanied by conodonts assigned to the *bulbosus* Subzone and the *texanus* Zone (Work and Mason,

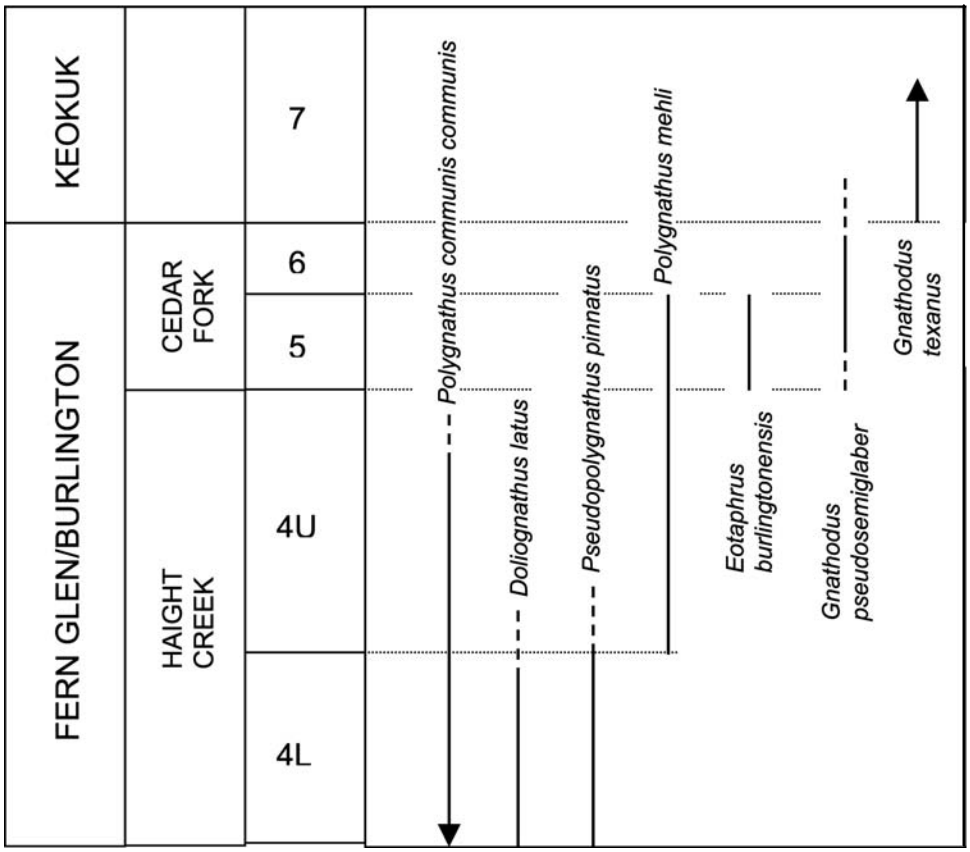

Figure 1. Range of selected conodonts in the Mississippi Valley adapted from Lane and Brenckle (2005, fig. 51). First column - Formations; second column - Members of the Burlington Formation (excluding the lower Dolby Creek Member); third column - Faunal Units.

2003, 2004). However, the rich fauna from the lower Mount Head Formation, British Columbia (Work et al., 2000) that was assigned an early Viséan age on the basis of associated foraminiferal faunas, is more probably of late Tournaisian age. The rich foraminiferal faunas were reported to contain Viséan species of *Eoparastaffella* (Mamet *in* Work et al., 2000). One of us (F.X.D.) has reviewed all the thin sections on which Mamet's determinations of *Eoparastaffella* were based and has found that the foraminifers concerned are species of *Eoendothyranopsis*. Conodonts recorded by Higgins in Work et al. (2000) are more likely to be of late Tournaisian age.

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Report on the First Meeting on Upper Paleozoic Chronostratigraphy of South America

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The First Meeting on Upper Paleozoic Chronostratigraphy of South America was held in Gramado, Brazil, November 10, 2004, as part of the XI Reuniôn de Paleobotânicos e Palinologos. The following researchers were present: from Argentina, Marilín Vergel, Pedro Gutierrez, Hugo Carrizo, Mercedes di Pasquo, Cecilia Rodriguez Amenábar, and Carlos Azcuy; from Uruguay, Angeles Beri; and from Brazil, Paulo Alves de Souza. Carlos Azcuy served as coordinator.

At this meeting the suitability of applying chronostratigraphic units established in western Europe, Russia, and the United States to the Upper Paleozoic of South America was considered. The proposal is based on the knowledge that these units have been defined on the basis of fossil associations that do not occur in this part of Gondwana. All the participants considered the proposal as a good opportunity to begin working together in a coordinated plan of activities conducive to establishing a regional chronostratigraphy. In order to obtain that objective, MDP proposed that all existing paleontological and radiometric data on Upper Paleozoic basins be assembled. The suggested methodology will include compiling on a map of South American basins data on all known localities with fossils and absolute ages, accompanied by corresponding bibliographical references.

In this first meeting, it was decided to subdivide this task in order to allow other specialists who had not participated in the meeting the opportunity to coordinate their own research with the various basin working groups. The first results of this project will be presented at the XIII Simposio Argentino de Paleobotánica y Palinología which will be held in Bahía Blanca, Argentina (May 22-26, 2006). This is a contribution to the IGCP 471.

South American Upper Paleozoic Basins

Parnaiba: Roberto Iannuzzi and Henrique Melo

Amazonas: Henrique Melo

Madre de Dios: Mercedes di Pasquo (MDP), Roberto Iannuzzi, Carlos Azcuy, Marilín Vergel, Suárez Soruco, and Jaime Oller

Paraná: Paulo Alves de Souza, Roberto Iannuzzi, Rosemary Rhon, and Angeles Beri

Chacoparaná: Marilín Vergel and Pedro Gutierrez

Tarija: Mercedes di Pasquo and Jaime Oller

Arizaro: Carlos Azcuy, Mercedes di Pasquo, and Florencio Aceñolaza

Paganzo: Carlos Azcuy, Hugo Carrizo, and Nora Sabattini

Uspallata-Iglesia: Hugo Carrizo, Cecilia Rodríguez Amenábar, Carlos González, Arturo Taboada, Gabriela Cisterna, and Nora Sabattini

San Rafael: Silvia Césari and Pablo Pazos

Tepuel-Genoa: Hugo Carrizo, Arturo Taboada, Carlos González, and Nora Sabattini.

Are regional stages necessary?

Carlos R. González

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The bipartition of the Carboniferous System adopted by the International Commission of Stratigraphy for the world stratigraphic chart is impractical in Gondwana. Correlation with the Paleoequatorial realm, from the Late Viséan to the Early Permian inclusive, is not possible by paleontologic means because of endemism of the biota. As Heckel (2001) noted, Angara and Gondwana "will need to retain regional subdivisions above the upper part of the Mississippian." This is especially the case in Argentina, where absolute ages are insufficient and somewhat imprecise, and do not give the certainty of paleontologic methods. Moreover, dating sequences of this interval frequently initiates endless discussions about their position within the world stratigraphic scale, especially of those units that are suspected to contain the Mid-Carboniferous and Carboniferous-Permian boundaries. For practical reasons, it would be more desirable, and reliable, to refer these sequences to regional stages, rather than attempting debatable correlations with the paleoequatorial standards.

The Gondwana glaciations are the most outstanding events of the Late Paleozoic. During this "ice age" climatic changes and sea-level fluctuations were the most important factors that induced the origin, evolution, and extinction of endemic taxa (Roberts, 1981; González, 1997), and marine faunas reflect variations of sea-water temperature. The best known of these are closely associated with glaciations, such as the Middle Carboniferous *Levipustula* fauna and the Early Permian *Eurydesma* fauna. However, other less well known assemblages are also indicators of temperature.

Marine sequences show a changing succession of lithofacies and biofacies that were clearly linked to paleoclimatic events. They suggest that major climatic changes occurred rapidly in terms of geologic time. The most significant of these occurred at the beginning and end of the "ice age," and at the beginning and end of the Upper Pennsylvanian interglacial. Minor variations in temperature caused discrete glaciations, but these were not so significant as to greatly affect faunal composition. After each major climatic change, a distinct faunal assemblage flourished during lapses of more or less stable, glacial or non-glacial, climatic conditions, until a new climatic change occurred. In the Carboniferous-Permian sequences of Argentina, five Major Faunal Groups can be distinguished which are closely associated with each climatic stasis. These have proved to be effective biostratigraphic units at a regional scale. Based on these Major Faunal Groups, I proposed (González, 1993) a preliminary sequence of regional stages for the Carboniferous and Early Permian. These can be matched with Australian faunas, which are, in turn, constrained by absolute age dates (Roberts et al., 1995; Claoué-Long et al., 1995) and allow a reliable correlation with the paleoequatorial standards. In this regard, the Mid-Carboniferous boundary occurs somewhere within the Serpukhovian-Bashkirian *Levipustula* Zone.

Both paleoclimatic events and their associated faunas are adequate for the subdivision of the lapse between the Late Mississippian and the Early Permian in the South American Gondwana area.

A significant advance was achieved during the First Meeting on Upper Paleozoic Chronostratigraphy of South America, held in Gramado, Brazil, in 2004. On this occasion, a concrete position was finally adopted following a proposal by Carlos Azcuy (this issue), which led to the formation of working groups that will address problems of South American Gondwana biostratigraphy. The faunal subdivision proposed in 1993 may serve as a starting point for future discussions on regional stages.

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Carboniferous Correlation Table (CCT) Karbon-Korrelationstabelle (KKT)

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Since the early attempts at a stratigraphic subdivision of Carboniferous rocks, many correlation charts of questionable merit have been proposed for the different biostratigraphic zonations and lithologic successions of the Carboniferous. For this purpose, the results of the Congresses on Carboniferous Stratigraphy since 1927 proved to be quite helpful, but difficulties are still obvious (e.g., Paproth, 1969). In western Europe (i.e., the realm of the Carboniferous Limestone Shelf Facies), small-scale differences in litho- and biofacies complicate the task. In central Europe (i.e., the realm of the Kulm Facies), these attempts are hampered by extreme variations in thickness, sedimentary unconformities, magmatic extrusions, and tectonic influences. Additionally, gaps in knowledge and lack of paleontological revision of many fossil groups largely prevented the publication of reliable correlation charts. Consequently, many workers had to manage their own attempts or, for the Dinantian (i.e., the European Lower Carboniferous), use the table published by the Arbeitsgemeinschaft für Dinant-Stratigraphie (1971).

With support from the German Subcommission on Carboniferous Stratigraphy, the authors published a Carboniferous Correlation Table (CCT; Amler and Gereke [eds.], 2002, 2003) based on the same system and principles as the highly successful Devonian Correlation Table (Weddige, 1996). Unlike the Devonian, however, the Carboniferous disadvantageously lacks the framework of a high-resolution conodont zonation. Actually, a precise multi-stratigraphy is necessary to enable reliable and accurate correlation. Furthermore, the current international subdivision of the Carboniferous lacks ratified GSSPs, and the upper boundary of the system/period remains largely unknown.

In the first two issue of the Carboniferous Correlation Table published in *Senckenbergiana lethaea* (Frankfurt/ Main) Vol. 82 (2002) and 83 (2003) we presented the biostratigraphic subdivision of the Mississippian in basinal (Kulm) facies with regional stratigraphic correlation columns for the Rhenish Basin (Amler and Gereke [eds.], 2002, 2003). Regarding the incomplete sedimentary sequence, no complete biozonation has yet been established for the Mississippian of central Europe, either because of fragmentary faunal or floral content or even general lack of biota. Local and regional biostratigraphic zonations of the Kulm sequence are based on goniatite successions, trilobites, and radiolarians (Korn, 1996; Hahn and Hahn, 1974; Braun and Gursky, 1991; Braun and Schmidt-Effing, 1993; and earlier references therein), but seem to be virtually unknown outside Germany. A lithologic and biostratigraphic correlation of Carboniferous limestone shelf and Kulm sequences is restricted to interfingering areas or large scale carbonate turbidites derived from the shelf edge that spread across the basin or, at least, parts of it (Paproth, 1969; Bender et al., 1993 and earlier references therein). However, serious correlation difficulties and uncertainties are still present due to the scarcity of common index fossils, contrasting with the fine-scaled conodont zonation of the Upper Devonian, where correlation problems occur only in pure red shale sequences.

The following parts, which are currently under preparation for a 2005 issue, will include the subdivisions of the shelf facies as well as those of the Pennsylvanian. We would like to encourage all our colleagues working in bio- and lithostratigraphy or worldwide correlation to create and provide us with their own columns for publication in forthcoming issues.

The rules and instructions largely follow those compiled by Weddige (1996, p. 268; 2000, p. 685) for the Devonian Correlation Table. We would like to stress that each column represents an individual element, is registered individually under the name of the compiler, and must be cited as such. Consequently, the compiler, who does not necessarily need to be the author of the zonation, is responsible for the respective column (see Weddige, 2000, p. 686). In each subsequent issue of the CCT previously published columns may appear in a revised version. Commentaries to individual columns may be published as separate "Annotations" in *Senckenbergiana lethaea*.

M.G had the idea of applying the concept of the successful Devonian Correlation Table to the Carboniferous. First drafts of columns were compiled by M.A. and M.G in cooperation with the authors. The final arrangement and layout of the columns was carried out by M.G after extensive coordination with the contributing authors. As the representative of the German Subcommission on Carboniferous Stratigraphy, M.A. is responsible for the contined publication of future issues of the CCT. Special thanks for information and critical comments are due to Dieter Korn (Berlin), Dieter

Meischner (Göttingen), Karl-Heinz Ribbert (Krefeld), Dieter Stoppel (Hannover), and Dieter Weyer (Berlin). M. Hellwig (Marburg) generously helped with hard- and software.

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Bivalve biostratigraphy of the Kulm Facies (Mississippian, Early Carboniferous) in central Europe

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Within the framework of the research project "Bivalve biostratigraphy of the Kulm Facies (Mississippian) of central Europe," supported by the Deutsche Forschungsgemeinschaft (German Research Foundation), a first biostratigraphic subdivision based on bivalve associations and index species has been proposed for the marine late Famennian to Serpukhovian/Bashkirian (Namurian) sequence in the Rhenohercynian Basin ("Cypridina Shale" and Kulm Facies) of western and central Europe (Amler, 2002, in press 2004). This zonation of the open marine realm is intended to assist and complement traditional and revised regional zonations based on conodonts, goniatites, radiolarians, and trilobites (compiled in Amler and Gereke, 2002).

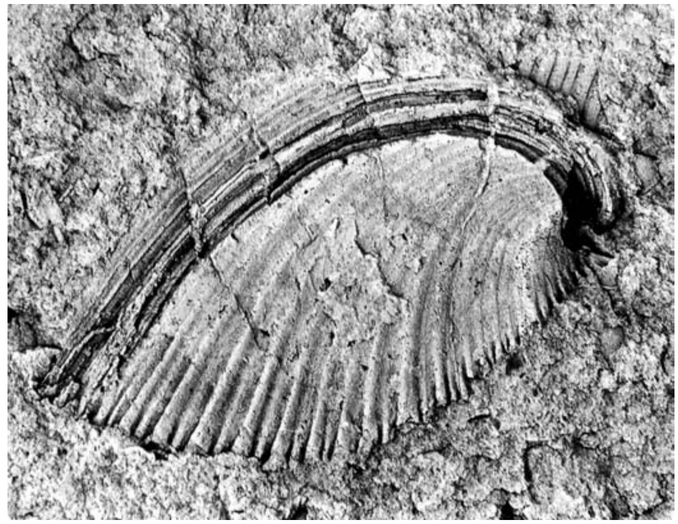

Fig. 1. *Chaenocardiola haliotoidea* (Roemer), right valve, internal mold; Kulm Shales from Aprath (Wuppertal), Germany; index species of the *Chaenocardiola haliotoidea* Zone.

The analysis of the vertical and horizontal distribution of Kulm bivalves is based on a systematic and taxonomic revision of late Paleozoic bivalves carried out over the last decade. An overview was published in Amler (1998). In contrast to bivalves of the Carboniferous Limestone Shelf Facies, the Kulm taxa predominantly occurred basin-wide

Fig. 2. *Ptychopteria* (*Actinopteria*) *sulcata* (M'Coy), left valve, internal mold; Kulm Shales from Aprath (Wuppertal), Germany; index species of the *Posidonia corrugata–Actinopteria sulcata* Zone.

driven by their planktic larval stages and their mostly pseudoplanktic life habits (Amler, 1992). In addition, they serve particularly well for biostratigraphic analyses because their phylogenetic development was not markedly interrupted at the Devonian-Carboniferous boundary (Amler, 1989, 1995, 1996a, 1999).

In the latest Famennian and earliest Mississippian basinal facies, members of the *Guerichia venusta* group (*Guerichia venusta* s. str., *Guerichia ratingensis* [= *G. venustiformis*], and *Guerichia mariannae*) are biostratigraphically important and characterize the *Guerichia venusta* (s. str.) Zone, the *Guerichia ratingensis* Zone, and the *Guerichia mariannae* Zone.

In the Mississippian Kulm Facies, members of the Eupteriomorphia (Pterioidea, Aviculopectinoidea, Buchioidea) dominate above all other groups; biostratigraphically important taxa are *Ptychopteria* (*Actinopteria*) *lepida*, *Ptychopteria* (*Actinopteria*) *sulcata*, *Streblochondria praetenuis*, *Dunbarella mosensis*, *Dunbarella yatesae*, *Posidonia becheri*, *Posidonia kochi*, *Posidonia corrugata*, *Posidonia trapezoedra,* and *Posidonia membranacea*.

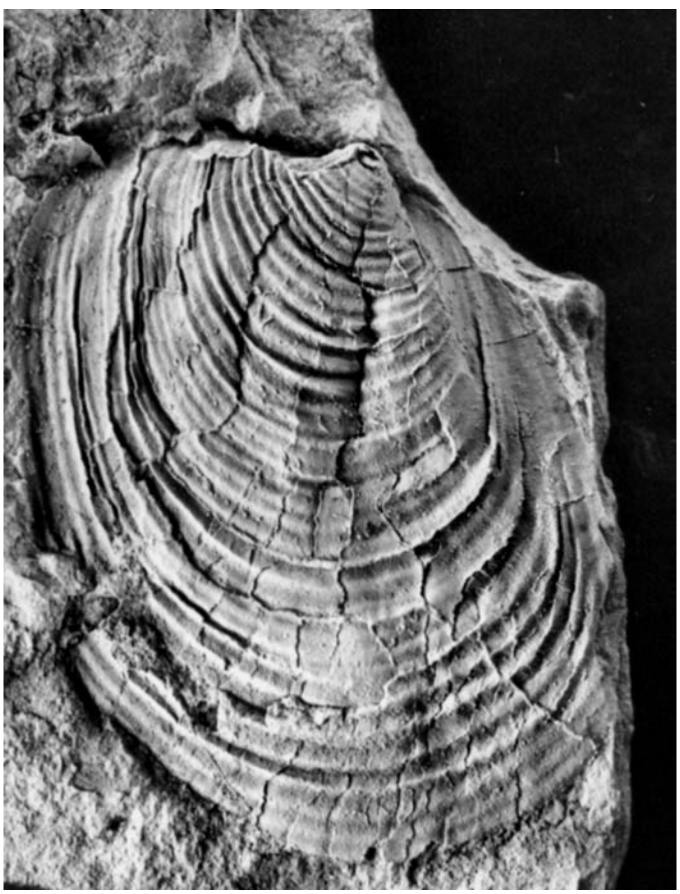

Fig. 3. *Posidonia becheri* BRONN, left valve, internal mold; Kulm Shales from Herborn, Germany; index species of the *Posidonia becheri–Dunbarella mosensis and Posidonia becheri–Posidonia kochi* Zones.

The Late Tournaisian to Serpukhovian sequence can be subdivided into six zones, mostly characterized by the joint occurrence of at least two species: *Chaenocardiola haliotoidea* Zone, *Posidonia becheri–Dunbarella mosensis* Zone, *Posidonia becheri–Posidonia kochi* Zone, *Posidonia corrugata–Actinopteria sulcata* Zone, *Posidonia trapezoedra–Actinopteria lepida* Zone, and *Dunbarella yatesae* Zone. Due to the incomplete sedimentary sequence of Middle Tournaisian to Middle Viséan age, general information gaps exist for faunal or floral content and a precise biozonation.

A correlation of the bivalve zones with the revised goniatite zonation of Korn (2002) is quite reliable. Correlation with the current radiolarian zonation (Braun 2002) is also possible, but remains quite imprecise because that zonation, too, is not dense. However, no satisfactory correlation is yet possible with the current standard zonation by foraminifers of the Carboniferous Limestone Shelf Facies.

In the future, the data base will be completed, supplemented, and verified by intensive sampling of reference sections, by multi-stratigraphical correlation, and by analysis of further material from other outcrops and sections. Other bivalve taxa may prove to be biostratigraphically important in the near future after completion of the systematic and taxonomic revision of Upper Devonian and Carboniferous bivalves.

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Fauna and sedimentation near the Tournaisian-Viséan boundary in deep-water sediments of the Jangjir Range (Southern Tien-Shan), Kyrgyzstan

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The position of the Tournaisian-Viséan boundary was agreed at the VI International Carboniferous Congress (ICC) in Sheffield, in 1967, to coincide with the first appearance of the foraminifer genus *Eoparastaffella*.

South China has been chosen as the most promising region for documenting the appearance of the *Eoparastaffella simplex* morphotype 1 – morphotype 2 transition, and consequently, the establishment of the GSSP for the base of the Viséan Stage (Hance et al., 1997; Devuyst et al., 2003).

Study of sections in shallow-water facies in the Urals, western Europe, China, and North America has demonstrated the significance of pelagic fossils (such as conodonts, ammonoids, etc.) as the key groups for establishment of the boundary and for the resolution of problems in correlation of heterofacial sections from different regions of the world (Kulagina et al., 2003). Areas having sections of deep-water facies are more appropriate for establishment of the chronological boundaries, because these sections have small thickness and contain assemblages of key faunas.

The new data presented here on Tournaisian-Viséan boundary conodonts and foraminifers were received by the authors in 2004. These investigations were part of the program on compiling the working legend for the large-scale geologic map of the Jangjir Range and adjoining territory (Fig.1). This territory contains deep-water sediments of the ancient Turkestan paleoocean. Earlier authors (Djenchuraeva, Neyevin, and Vorobyev, 2001) had attempted to establish this boundary in shallow-water sections of the Ulan carbonate platform in the Kokshaaltau Range, but there were not enough substantiated data there.

The Mississippian deep-water sediments of the Kokshaal sector of the Southern Tien-Shan are represented by several facies types exposed in a number of nappes thrusted toward the south (China). From north to south, the following types are established: Kensu cherty-carbonate, Ulan-Bozoi carbonate, Aksai cherty-carbonate-terrigenous, Sarybeless carbonate, and West-Kokshaal cherty-terrigenous (Biske et al., 2003). During the Mississippian, this vast area of the Turkestan paleoocean was a deep-water pelagic region (Kensu, Aksai, and West-Kokshaal types) with local development of carbonate platforms (Ulan-Bozoi type) and shoals (Sarybeless type).

The studied sections belong to the Kensu type, in the most deep-water area of the Turkestan paleoocean. For the first time, conodonts have been discovered in this region in the Mississippian cherty-carbonate sediments (Arashan Formation), and for the first time, the Tournaisian-Viséan boundary has been identified based on conodonts. Data on foraminifers were also received.

In order to reconstruct the history of paleobasin development, a detailed approach to studying sedimentologic and biologic changes is necessary as a basis for identifying event-stratigraphic levels. The development of sedimentary basins has an intermittent nature, and their history represents periods of relatively stable conditions interrupted by episodes of quick abiotic reconstructions (Koren' et al., 2000). These events are displayed on global and regional scales, and their succession is being identified through detailed studies of sedimentary paleobasins. On the regional scale, abiotic reconstructions, which always are accompanied by lithologic indicators, led to the regional biologic events. They are manifest by a sharp decrease or increase in biomass, taxonomic diversity, etc. Global climate changes and sea-level variation in the world ocean are the main causes of abiotic events. The last factor leads to transgressions and regressions, and to the the formation of sedimentologic datums.

Reduction of the Turkestan paleoocean area which began during the Mississippian, led to its closure in the middle of the Pennsylvanian. This process was interrupted at times by short-term transgressive cycles. One such cycle includes the base of the Viséan.

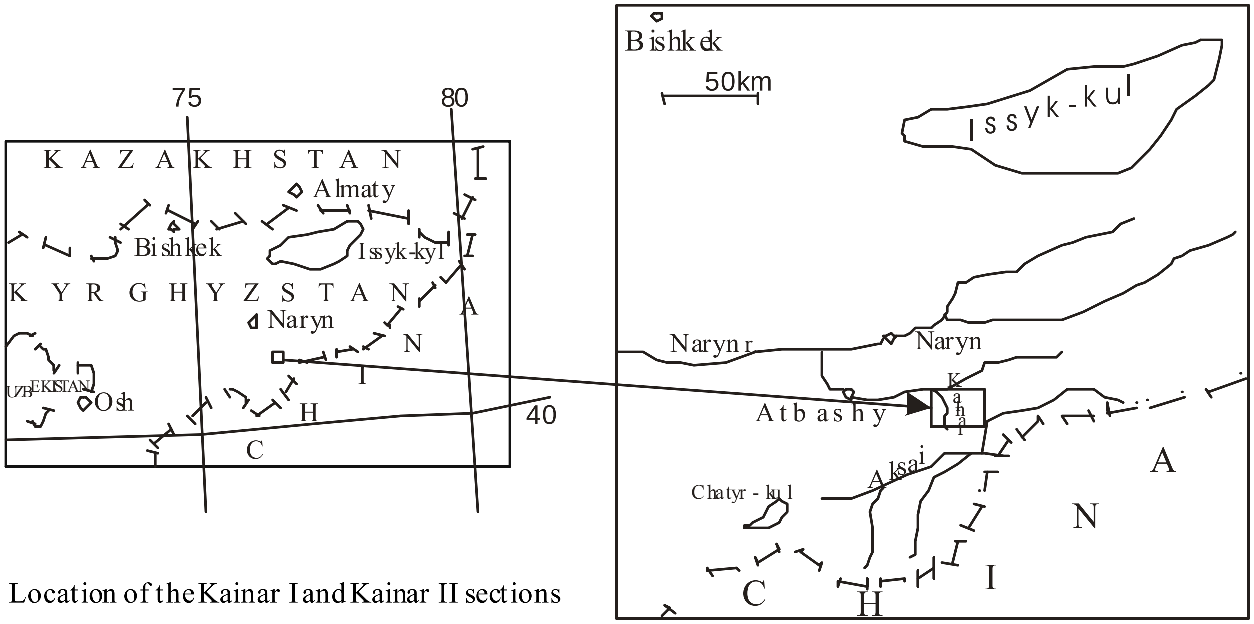

Fig. 1 Location of the Kainar I and Kainar II sections

About 10 sections were measured in the studied area, where the change from Upper Tournaisian cherty-carbonate and cherty sediments to Lower Viséan massive litho- and bioclastic carbonate rocks was observed.

Two sections (Kainar I and Kainar II) are presented in this paper. These sections were measured along the Kainar River (left tributary of the Atbashi River). Study of the conodonts allows recognition of the Mississippian conodont zonation. Additional data are included on foraminifers (see Figs. 1, 2).

The lower part of the Kainar I section (Fig. 2) consists of platy multicolored cherts with beds of greenish-gray cherty shales and gray thinly-laminated mudstones of Late Tournaisian age (*Gnathodus typicus* and *Scaliognathus anchoralis* Zones). These sediments are conformably overlain by black massive litho- and bioclastic grainstones of Early Viséan age (*Gn. texanus* Zone).

The Kainar II section (Fig. 3) contains the higher part of the stratigraphic sequence, including all conodont zones of the Viséan and Serpukhovian. In this paper, only the Viséan part is presented (*Gn. texanus*, *Gn. bilineatus bilineatus,* and *Lochriea nodosa* Zones). The base of the section (*Gn. texanus* Zone) also consists of black massive litho- and bioclastic grainstones which contain rich and varied conodont and foraminiferal assemblages. These sediments are conformably overlain by greenish-gray, gray, and black cherty siltstones, and rarely, cherts. Thinly-laminated gray mudstones and lithoclastic grainstones are developed among them.

Conclusions

1. In deep-water sediments of the studied area in the Jangjir Range of the Southern Tien-Shan, the base of the Viséan coincides with the beginning of a short-term transgression which is characterized by crinoid-foraminiferal and clastic-detrital carbonate rocks. This event is regional in nature, is clearly reflected by changes in lithology, and has been been confirmed by biostratigraphic means. This event can serve as the principal datum for identification of the Tournaisian-Viséan boundary as well as for interregional correlations.

2. The Kainar I and Kainar II sections contain a rich conodont succession near this boundary. Nine Upper Tournaisian to Serpukhovian conodont zones are recognized, in ascending order: *Siphonodella isosticha*, *Gnathodus typicus*, *Scaliognathus anchoralis*, *Gn. texanus*, *Gn. bilineatus bilineatus*, *Lochriea nodosa*, *L. ziegleri*, *Gn. bil. bollandensis,* and *Gn. postbilineatus*. Foraminifers are also identified.

3. Deep-water, sub-Tournaisian-Viséan boundary sediments of the Jangjir Range need additional detailed study including complete description of the foraminifer faunas. These data will allow more exact biostratigraphic characterization of the boundary and ultimately will lead to correlation of the conodont and foraminiferal zones of the deep-water sediments of the Southern Tien-Shan with heterofacial sections in other regions of the world.

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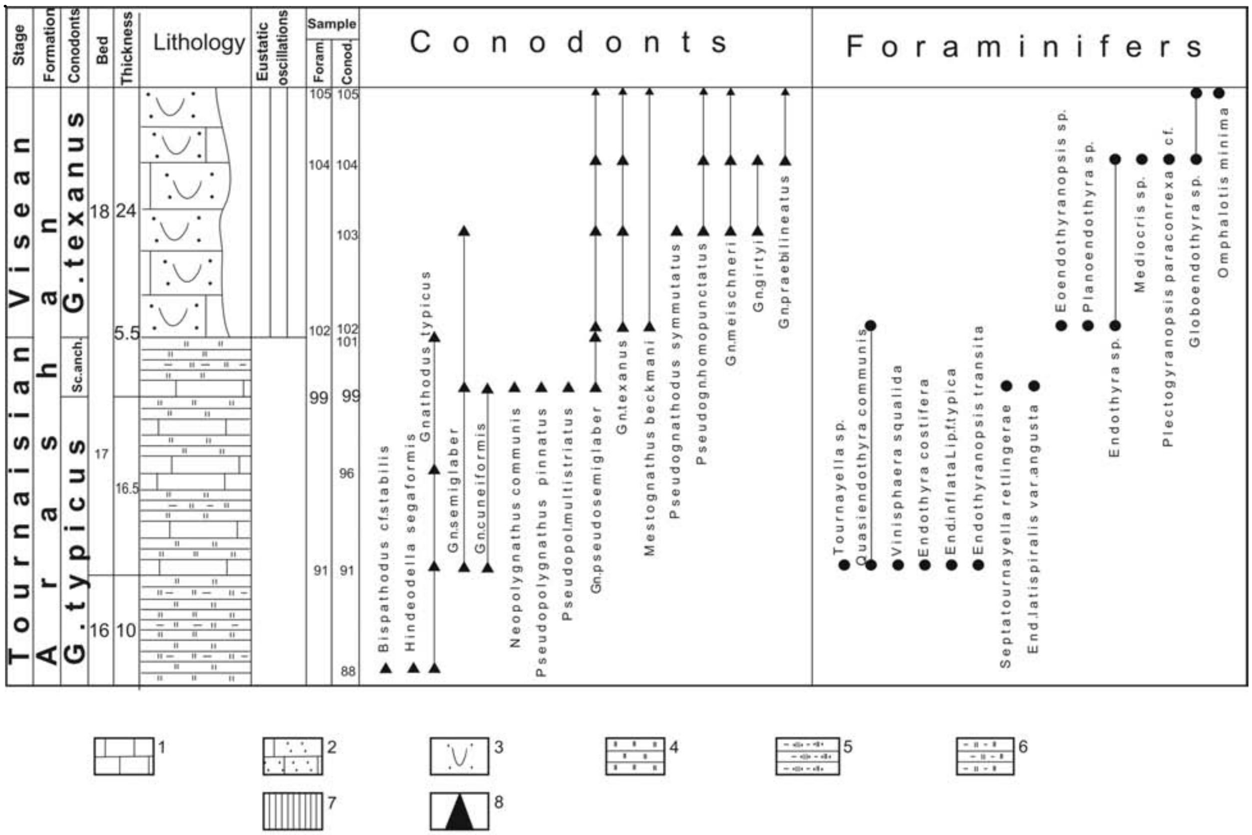

Fig.2 The Tournaisian - Visean boundary interval with conodont and foraminiferal distribution in the Kainar I Section. Scale 1:5000
(1-3) limestones: (1) mudstones, (2) lithoclastic grainstones, (3) litho-bioclastic grainstones, (4) cherts, (5) cherty siltstones, (6) cherty shales, (7) transgression, (8) regression

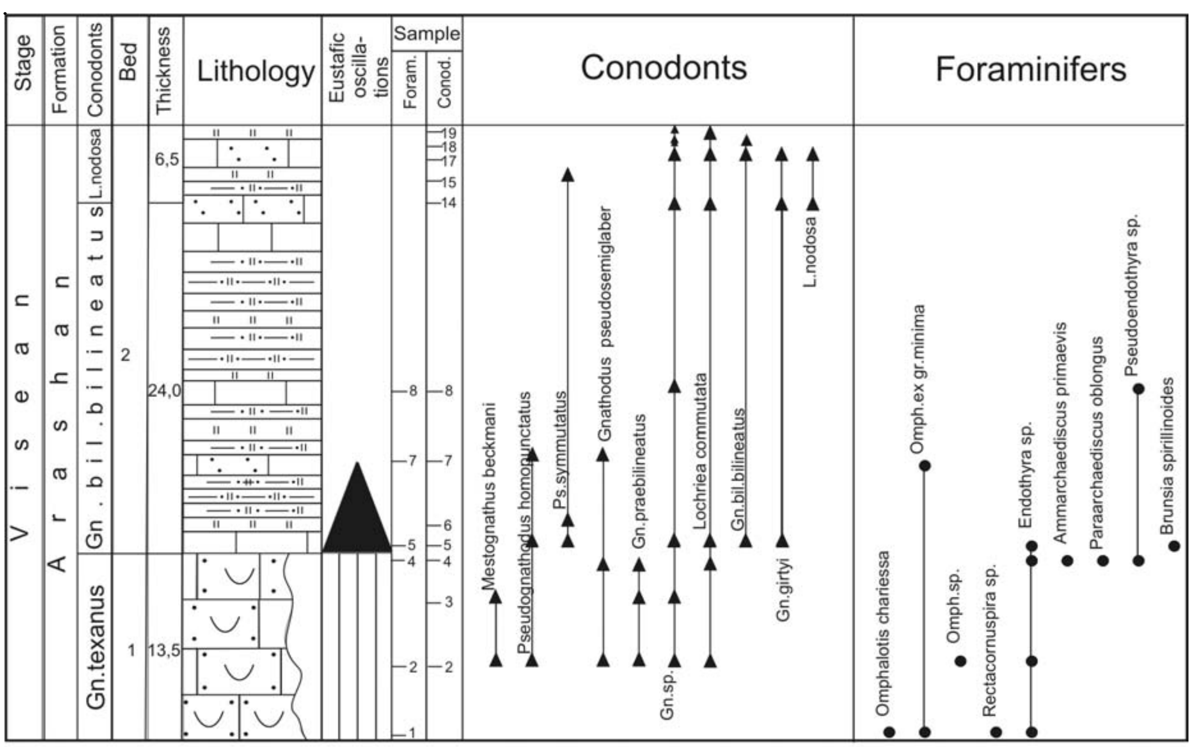

Fig.3: The Kainar II section (legend as in Fig.2)

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Viséan-Serpukhovian transition in the Middle Tien-Shan

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Introduction

Viséan and Serpukhovian deposits are widely developed in the Middle Tien-Shan. The strata are represented by a more than 800-m-thick, continuous marine carbonate sequence with rich fossil assemblages in the Chatkal-Talass Mountains, Middle Tien-Shan (Uzbekistan and adjacent countries). These deposits were formed in a marine sedimentary basin within an inner carbonate shelf platform, an outer carbonate platform, and a basinal setting. The Viséan-Serpukhovian boundary for this regional stratigraphic scheme (Table 1) is discussed below.

In this report we analyze two continuous sections containing the Viséan-Serpukhovian boundary: 1) the Mashat section (Talass Alatau Range) which was deposited on the inner platform and is rich in brachiopods, foraminifers, algae, and corals; and 2) the Paltau section (Chatkal Range) which was deposited in a basinal setting and contains a rich fossil assemblage consisting of conodonts, foraminifers, and ammonoids.

Locality and Lithologic Composition

The Mashat section (Talass Alatau Range) shows a continuous sequence of deposits from the Upper Viséan to the lower part of the Bashkirian. The Viséan-Serpukhovian boundary strata (Aksu and Mashat Formations) consist of grey, thick- and massive-bedded, organic limestone. Ooid, algal-foraminiferal, algal-crinoidal, and crinoidal-detrital limestone beds occur in between, and yield foraminifers, corals, algae, and brachiopod coquinas (Fig. 1).

The Paltau section (Chatkal Range) includes strata from the upper part of the Upper Viséan to the top of the Serpukhovian (Paltau and Aurakhmat Formations). The Upper Viséan sequence consists of carbonate conglomerates (in the lower part) and bedded organic-detrital and crinoidal-detrital limestone with interbedded thin-bedded limestone. Overlying uppermost Viséan to lower Serpukhovian deposits consist of alternating thin-bedded limestone with gradational lamination and organic limestone with interbedded turbidites (Fig. 2).

Foraminiferal Assemblages

The late Viséan foraminiferal assemblages (*Endothyranopsis crassa* Zone) include many species (62 percent) common to both sections: *Earlandia elegans*, *Pseudoammodiscus volgensis*, *Forshia mikhailovi*, *Janishewskina* sp., *Endothyra similis*, *Spinothyra pauciseptata*, *Omphalotis omphalota*, *Endothyranopsis crassa*, *Archaediscus moelleri*, and *Nodosarcaediscus saleei*. The species *Neoarchaediscus parvus* and *Parastaffella* cf. *illustria* appear in the upper part of the *Endothyranopsis crassa* Zone. *Archaediscus moelleri gigas*, *Bradyina rotula*, *Globoendothyra corbensis*, and *Omphalotis infrequentis* occur only in the Mashat section; while *Earlandia*? *orientalis*, *Archaediscus grandiculus*, *A. convexus*, *Paraarchaediscus syzranicus*, *Pseudoendothyra conciina,* and *Eostaffella constricta* are restricted to the Paltau section.

The base of the Serpukhovian is determined by the first appearance of the following foraminifers: *Biseriella parva*, *Pseudoglomospira elegans*, *Bradyina cribrostomata*, *Neoarchaediscus regularis, Asteroarchaediscus rugosus, A. baschkiricus*, *Rugosoarchaediscus agopovensis*, *R. rhombiformis,* and *Tetrataxis minuta*. The Viséan species *Planoendothyra spirillinoides, Globoendothyra globules,* and *Parastaffella illustria* also occur in both sections. The early Serpukhovian foraminiferal assemblages of the two sections are differentiated by *Howchinia gibba longa* and *Pseudoendothyra sublinis*, which occur only in the Mashat section; and *by Monotaxinoides priscus*,

Euroasiatic Scheme in Urals and Russian Platform (Kagarmanov & Donakova 1990)

System	Stage	Ammonoid	Foraminiferal Zones
CARBONIFEROUS	SERPUKHOVIAN	*Fayettevillea–Delepinoceras*	*Eostaffellina protvae-Eosigmoilina explicata-Monotaxinoides subplana*
		Uralopronarites–Cravenoceras	
			Ps.globosa-N. parvus
	VISEAN	*Hyperg.-Fergan.*	*End.crassa-Archaediscus gigas*
		Beyrichoc.-Goniatites	*End.compressa-A.krestovnikovi*

Stratigraphical Scheme in the Middle Tien-Shan (Sergunkova, Bensh et Rumyantseva, 1979; Bensh, Rumyantseva et Sergunkova, 1996)

Stage	Horizon	Brachiopods	Foraminifers	Ammonoids
SERPUKHOVIAN	Koikebiltauian	*Striatifera magna*	*Eosigmoilina rugosa – Eosigmoilina explicata*	*Fayettevillea–Delepinoceras*
	Keltemashat.	*Striatifera globulus*	*Eostaffellina protvae*	*Uralopronarites – Cravenoceras*
			Neoarchaediscus parvus	
	Mashat.	*Gigantoproductus giganteus*		
VISEAN	Aksuian		*End. crassa*	*Hypergoniatites–Ferganoceras*
		Pugilus dikarevae	*Archaediscus gigas*	
	Itelguinian	*Connectoproductus sarsimbaii*	*Endothyranopsis compressa*	*Beyrichoceras-Goniatites*

Stratigraphical Scheme in the Middle Tien-Shan (Orlova, 1994, Orlov-Labkovsky, Bensh et Mikhno, 2003)

Stage	Local substage	Brachiopods Sergunkova (1989)	Foraminifers Orlova (1994), Orlov-Labkovsky (2002)	Conodonts Nemirovskaya & Nigmadganov (1991)	Ammonoids Nikolaeva & Nigmadganov (1991)
SERPUKHOVIAN	Koikebiltauian	*Beleutella magna*	*Plectostaffella karsaklensis*	*G. postbilineatus*	*Fayettevillea–Delepinoceras*
			Plectostaffella mira obtusa – Eostaffella turkestanica	*Gnathodus bilineatus bollandensis*	
	Keltemashatian	*Striatifera angusta*	*Eosigmoilina explicata – Loeblichia minima - Plectostaffella primitiva*		
		Beleutella kirgisica	*Eostaffellina protvae – Biseriella minima*	*Lochriea cruciformis*	*Uralopronarites – Cravenoceras*
	Mashatian	*Latiproductus rectestrius*	*Neoarchaediscus regularis – Biseriella parva*		
VISEAN	Aksuian	*Gigantoproductus inflatus - Pugilus dikarevae*	*Endothyranopsis crassa*	*Lochriea nodosus*	*Hypergoniatites–Ferganoceras*
			Nodosarcaediscus saleei - Archaediscus gigas		
	Itelguinian	*Moderatoproductus sarsimbaii*	*Endothyranopsis compressa*	*Gnathodus bilineatus bilineatus*	*Beyrichoceras-Goniatites*

Table 1. Stratigraphic scheme of the Viséan-Serpukhovian transition in the MiddleTien-Shan.

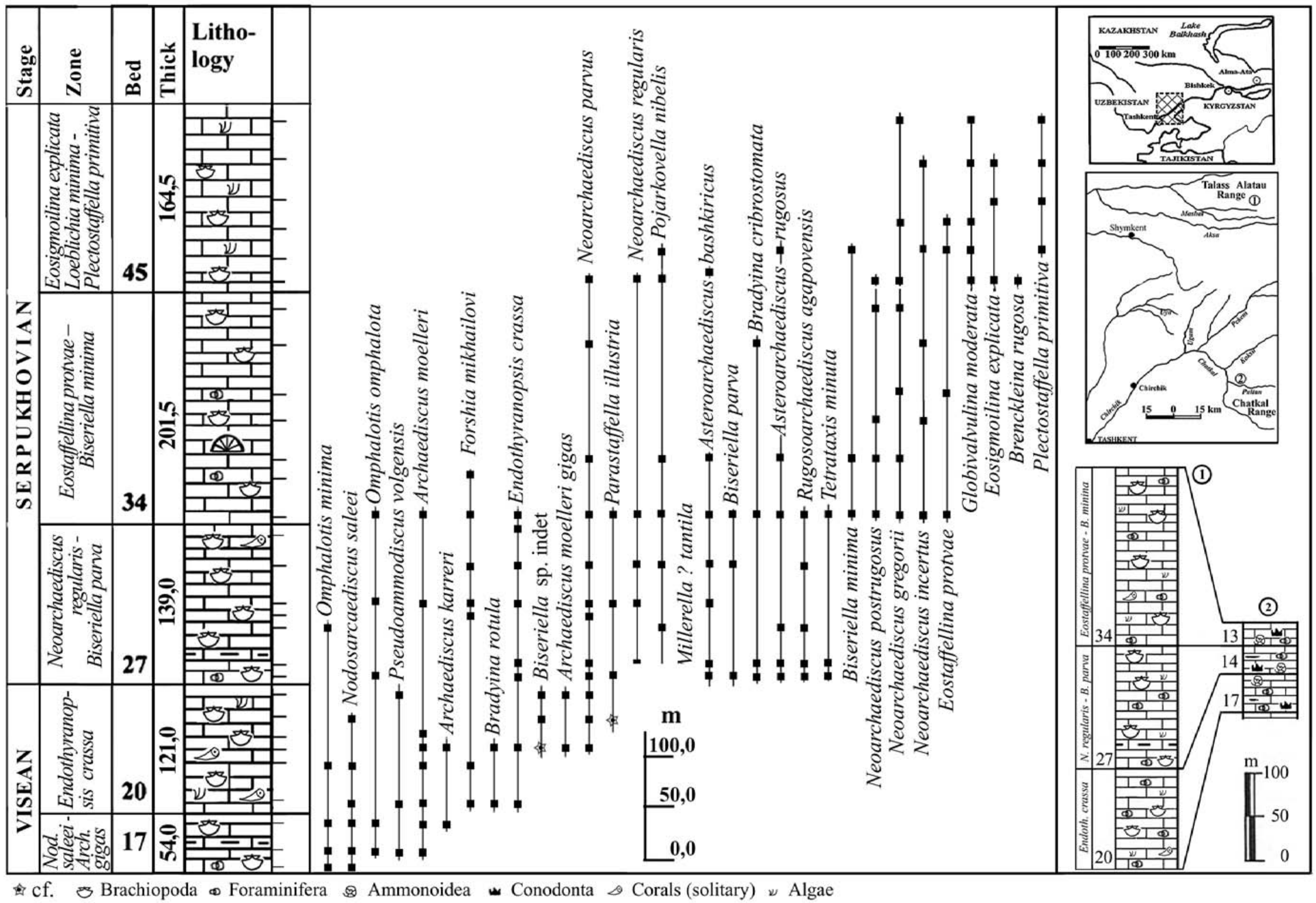

Figure 1. Distribution of the main foraminifers in the Mashat section (Tallasky Alatay Range) of the Visean – Serpukhovian transition and location of the Mashat (1) and Paltau (2) sections in the Middle Tien-Shan.

Asteroarchaediscus paraovoides, and *Eostaffella parastruvei*, which are restricted to the Paltau section. Early Serpukhovian assemblages of the *Neoarchaediscus regularis–Biseriella parva* Zone are represented by abundant and diverse foraminifers with numerous species (about 85 percent) common to both sections.

Viséan-Serpukhovian Boundary

The boundary is observed in lithologically relatively monotonous strata in both the Mashat and Paltau sections. The boundary is determined on the basis of foraminifers in the Mashat section (see "Foraminiferal Assemblages") and on ammonoids, conodonts, and foraminifers in the Paltau section (Fig. 2). Two ammonoid assemblages are

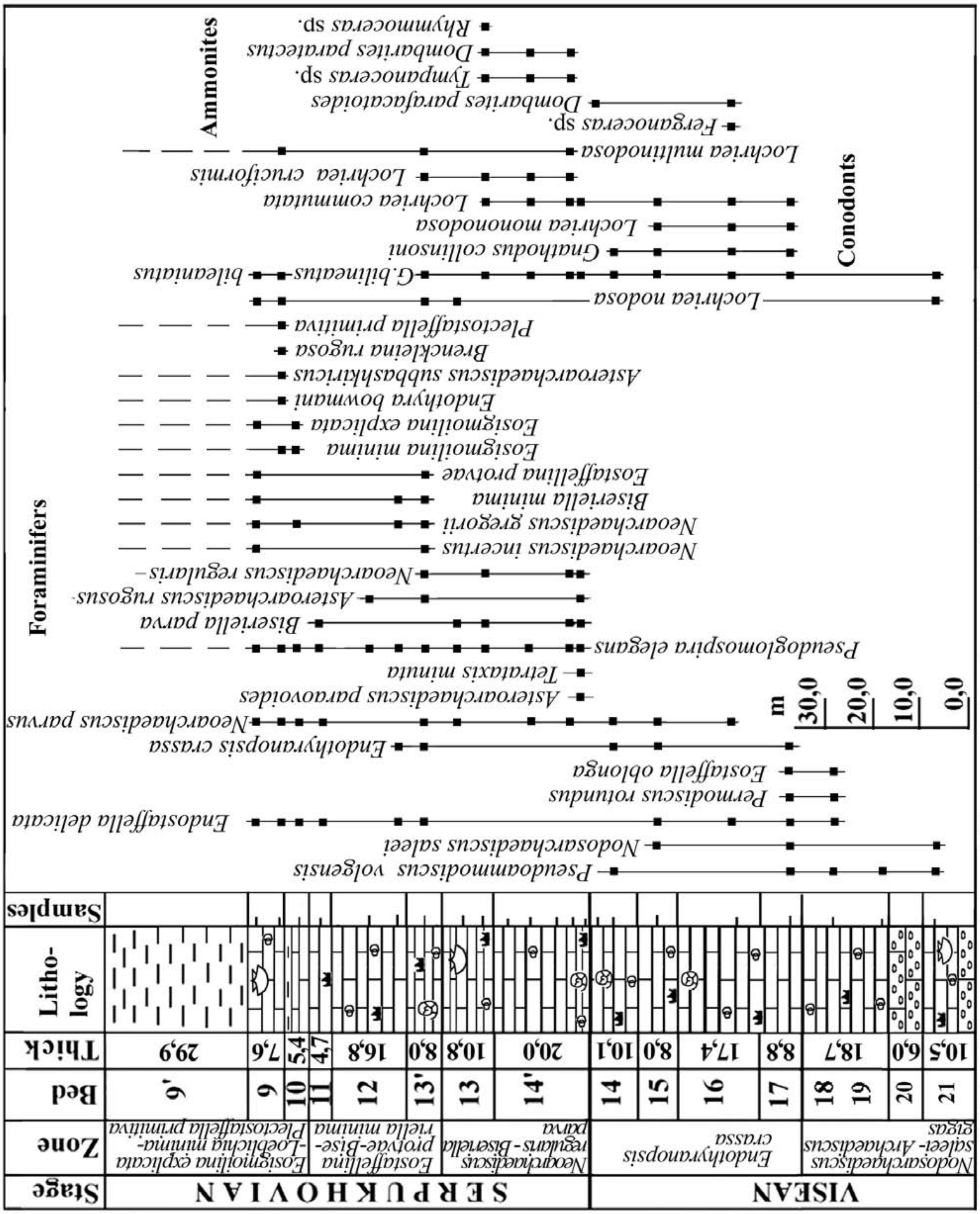

Figure 2. Distribution of the main foraminifers, conodonts and ammonoids in the Paltau section (Chatkal Range) of the Visean - Serpukhovian transition in the Middle Tien-Shan

found in bed 14 in the Paltau section (14 and 14'). The bed 14 assemblage contains *Dombarites parafalcatoides* and *Megapronorites* sp. These species indicate correlation with the late Viséan *Hypergoniatites–Ferganoceras* Zone (or P_2 of western Europe). Ammonoids of bed 14' include *Dombarocanites* sp., *Tympanoceras* sp., and *Dombarites paratectus*, which indicate correlation with the early Serpukhovian *Uralopronorites–Cravenoceras* Zone (or E_1 of western Europe). Early Serpukhovian conodonts of the *Lochriea cruciformis* Zone, including *Lochriea cruciformis*, *Paragnathodus commutatus,* and *P.* cf. *honopunotatus*, are found 25 cm lower than the ammonoids of the *Uralopronorites–Cravenoceras* Zone (E_1). The base of the Serpukhovian *Neoarchaediscus regularis–Biseriella parva* foraminifer Zone occurs above the Viséan *Hypergoniatites–Ferganoceras* ammonoid Zone (P_2), but below the Serpukhovian *Uralopronorites–Cravenoceras* ammonoid Zone (E_1). The base of the Serpukhovian *Neoarchaediscus regularis–Biseriella parva* foraminifer Zone is situated 20 cm below the Serpukhovian *Lochriea cruciformis* conodont Zone.

Conclusions

1) Ammonoids, conodonts, and foraminifers show a similar, but not coincident Viséan-Serpukhovian boundary in the Middle Tien-Shan.

2) Foraminifer assemblages are similar in different part of the same marine basin, which increases their value as indicators of the Viséan-Serpukhovian transition.

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Advances in understanding of the Viséan-Serpukhovian boundary in the South Urals and its correlation

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The Serpukhovian Stage is presently the focus of stratigraphic research because the definition of its lower boundary is one of the high priority tasks of the Carboniferous Subcommission. A new three-year project of the Russian Academy of Sciences aims to achieve a better understanding of major correlation levels within the Serpukhovian (particularly its lower boundary).

The type Serpukhovian section at Zaborie in the Moscow Basin is composed of shallow-water carbonates and clay and is incomplete (Gibshman, 2001). The lower Serpukhovian boundary in Zaborie is poorly exposed, while the uppermost Serpukhovian is completely absent. The Verkhnyaya Kardailovka section on the eastern slope of the South Urals is a very strong potential candidate for a GSSP for the base of the Serpukhovian Stage (Nikolaeva et al., 2001, 2002). Here, deep-shelf micritic limestones with cephalopods and thin-shelled ostracodes contain all the orthostratigraphic groups in a continuous succession of zones spanning the Viséan-Serpukhovian boundary interval.

In this section the Upper Viséan and Serpukhovian consist of relatively deep-water condensed carbonates rich in ammonoids, conodonts, and ostracodes, but containing only rare foraminifers. The section has been studied in great detail, all beds are described, and zones based on four biostratigraphically critical fossil groups are established.

The section has been known for decades, but only last year our research team uncovered the Viséan-Serpukhovian boundary interval in a series of four overlapping trenches (Figs. 1, 2). We identified a complete succession of conodont, foraminiferal, ammonoid, and ostracode zones in a single outcrop and were able to correlate them. Altogether, the section exposes a complete sequence from the Lower Viséan to the Moscovian. The Lower Viséan and lowermost Tulian limestones are mainly bioclastic and are underlain by Upper Tournaisian–Lower Viséan volcanic-clastic rocks. Then, following a 6-m unexposed interval, a condensed Upper Viséan-Serpukhovian carbonate sequence is exposed.

It is possible to identify three regional stages (so-called horizons) in the Serpukhovian in the Kardailovka section (Kosogorskian, Khudolazovian, and Yuldybaevian).

The Venevian Horizon includes microbioclastic structures with ammonoids and conodonts, thin-shelled ostracodes, and small euryfacial foraminifers. The beginning of the Serpukhovian was marked by deeper-water sedimentation (wackestones and microbioclastic packstones). Beds occasionally contain large bioclasts transported from zones of high energy. Fossils include ammonoids, conodonts, and thin-shelled ostracodes, but few benthic forms. In Khudolazovian time shallower-water sedimentation resumed. Fossils include algae, foraminifers, bryozoans, and brachiopods. At this time small crinoid-bryozoan bioherms (beds 22-24) were formed. The sedimentary setting indicates a relatively high energy environment at the carbonate shelf margin. By the end of Khudolazovian time the basin deepened and shows indications of low energy. Once again micritic limestone with abundant thin-shelled ostracodes, ammonoids, and conodonts was deposited.

At the end of the Late Serpukhovian the basin shallowed, while energy increased. The Yuldubaevian contains beds of bryozoan-crinoid grainstones/packstones with algae, foraminifers, and brachiopods. Microfacies indicate a sedimentary setting at the margin of a bryozoan-algal bioherm on the upper part of the carbonate platform.

The Upper Viséan–Serpukhovian part of the section contains the following zones:

Foraminifers

Beds with *Endostaffella asymmetrica*.

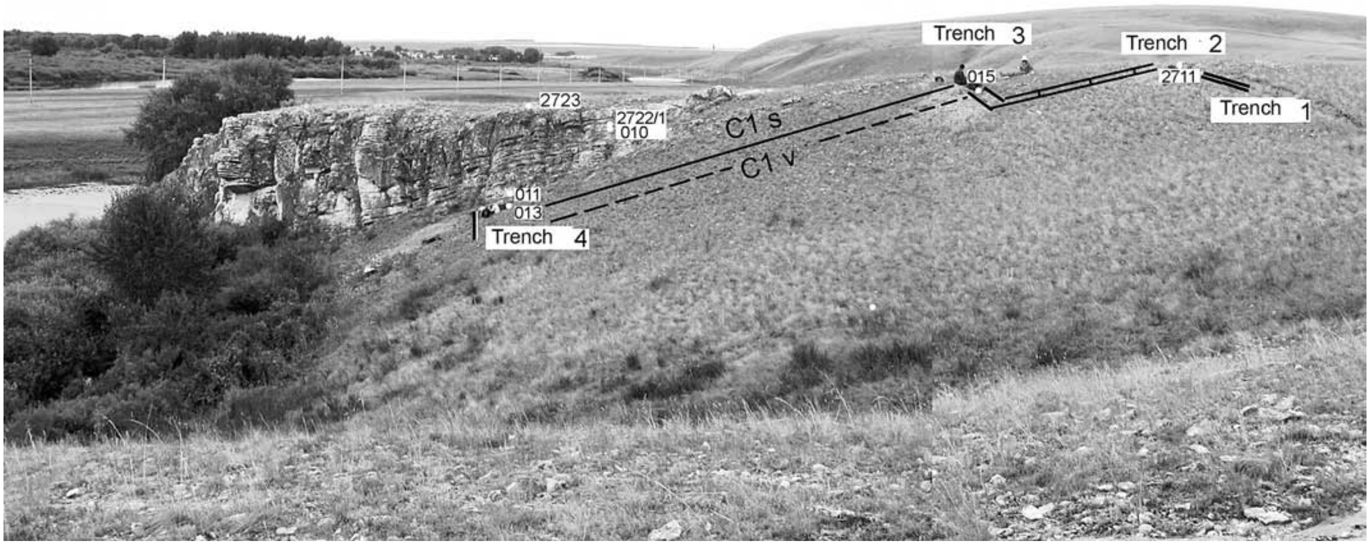
(1) *Eolasiodiscus donbassicus* Zone.
(2) *Eostaffellina paraprotvae* Zone.
(3) *Monotaxinoides transitorius* Zone.

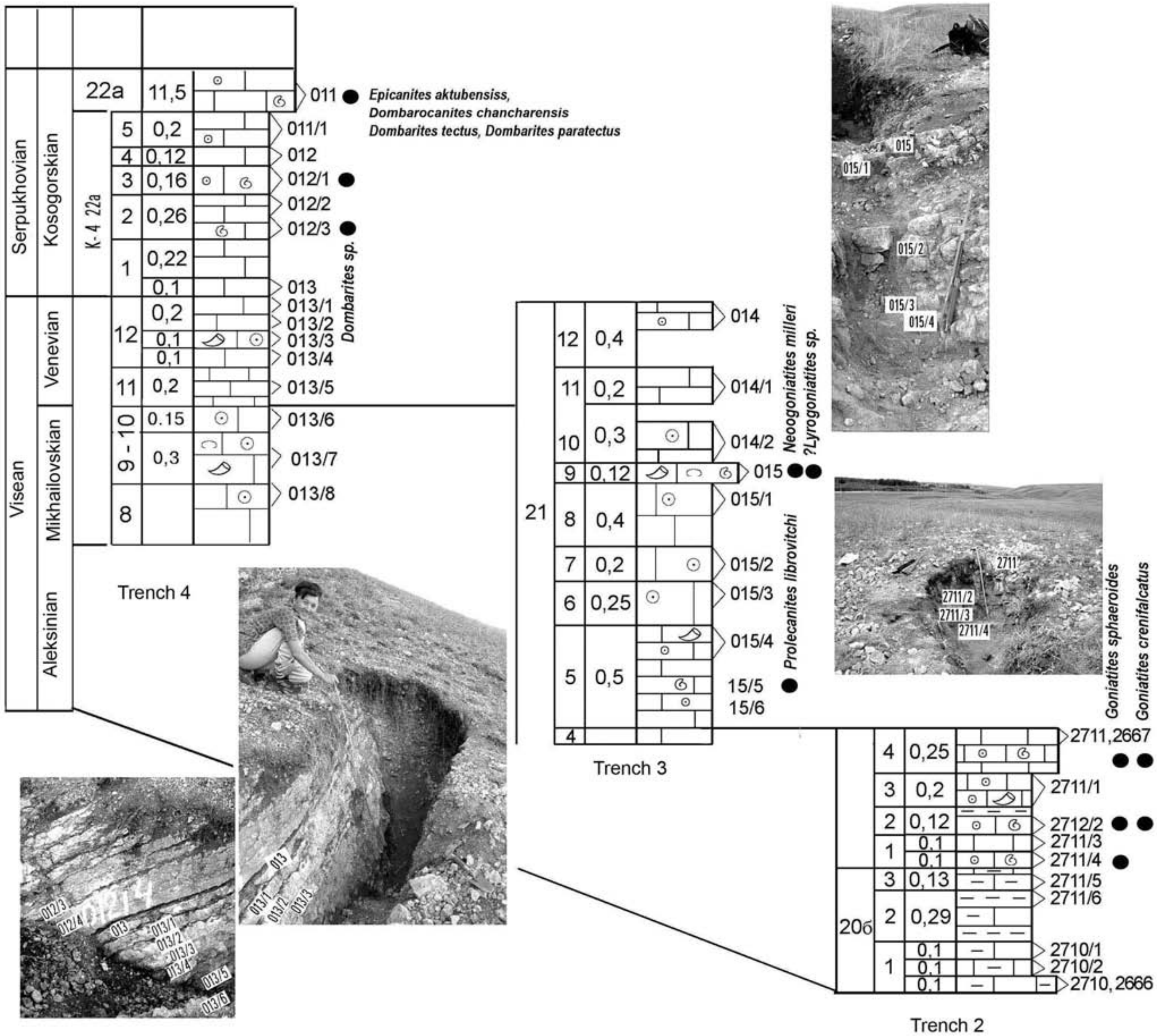
Ostracodes

(1) Beds with *Cribroconcha magna*
(2) Beds with *Pseudoparaparchites celsus*
(3) Beds with *Aurigerites solitarius*

Ammonoids

(1) *Beyrichoceras–Goniatites* Genozone. *Goniatites sphaeroides* and *Goniatites crenifalcatus* are found in trench 2 at two levels about 20 cm apart. We suggest





correlation with the Upper Asbian-basal Brigantian of western Europe.

(2) *Hypergoniatites–Ferganoceras* Genozone. Found at three levels 1 m above sample with *Goniatites* in trench 3. These are *Neogoniatites milleri, Prolecanites librovitchi* Ruzhencev, and ?*Lyrogoniatites* sp. The base of this genozone approximates a level within the uppermost Brigantian.

(3) *Uralopronorites–Cravenoceras* Genozone. Ammonoids of this genozone first occur about 1 m above the previous ammonoid level. This genozone includes over 25 m of section and spans the entire Kosogorskian and lower Khudolazovian. The most typical species is *Dombarites tectus*. This assemblage indicates the upper part of the *Uralopronorites-Cravenoceras* Genozone and corresponds to the Pendleian.

(4) Lower *Fayettevillea–Delepinoceras* Genozone. Ammonoids of this genozone are found at two levels in bed 25 (interval of 6 m), the lower being 1 m above the highest ammonoids of the *Uralopronorites-Cravenoceras* Genozone. This genozone includes the upper Khudolazovian. The distance between assemblages 3 and 4 is about 1 m. This assemblage corresponds to the lower part of the Arnsbergian.

(5) Upper *Fayettevillea–Delepinoceras* Genozone. Ammonoids of this genozone occur about 2 m above assemblage 4. This assemblage includes the Yuldybaevian and correlates with the upper E2 Zone in Europe and the *Eumorphoceras girtyi, Cravenoceratoides nititoides,* and *Delepinoceras thallasiode* Zones in America.

Conodonts

Over 90 samples were taken (average weight 2 kg); 85 contained conodonts. The collection contains over 6200 specimens, mostly *Gnathodus* and *Lochriea*. The zonal coverage ranges from the upper *Gnathodus texanus* Zone to the lower *Declinognathodus noduliferus* Zone.

1. *Gnathodus texanus* Zone (2 m)
2. *Gnathodus austini* Zone (30 cm)
3. *Gnathodus bilineatus bilineatus* Zone (6 m)
4. *Lochriea mononodosa* Zone (1.5 m)
5. *Lochriea nodosa* Zone (63 cm)
6. *Lochriea ziegleri* Zone (23.5 m). This zone includes the Kosogorskian and Khudolazovian.
7. *Gnathodus bilineatus bollandensis* (14 m). This zone includes the upper part of the Khudolazovian and the Yuldybaevian.
8. *Declinognathodus noduliferus* Zone (20 cm). The zonal subdivision of the boundary interval is based on the evolutionary lineage of the genus *Lochriea* (from *L. nodosa* to *L. ziegleri*).

Conclusions

(1) Based on this study the correlation of the regional stages (horizons) previously established in the Russian Platform and the Urals is updated.

(2) The Venevian in the South Urals is dated by the conodonts *Lochriea nodosa* and *L. mononodosa* and ammonoids of the *Hypergoniatites–Ferganoceras* Genozone. These ammonoids are similar to those from the Viséan C in Germany and the lower P2 in the UK (uppermost Brigantian). Correlation with the *ornatissimum* Zone in Texas is also possible.

(3) The base of the Serpukhovian equates to the base of the Kosogorskian and corresponds to the base of the *Lochriea ziegleri* Zone. This level in the type Serpukhovian section in Zaborie is close to the appearance of the foraminifers *"Millerella" tortula* and *Neoarchaediscus postrugosus*, which may be useful for correlation with the Chesterian.

(4) The base of the *Uralopronorites–Cravenoceras* Genozone at Verkhnyaya Kardailovka is about 75 cm above the first appearance of *Lochriea ziegleri*. However, it is evidently not the oldest *Uralopronorites–Cravenoceras* ammonoid fauna, because the mixed assemblage containing uppermost Viséan and lowermost Serpukhovian ammonoid taxa reported by Ruzhencev and Bogoslovskaya from Dombar and Kzyl-Shin has not yet been found at Verkhnyaya Kardailovka.

(5) The interval of beds 22-24 (all of the Kosogorskian and the lower part of the Khudolazovian) (=*Uralopronorites–Cravenoceras* Genozone) correlates to the $Å_1$ Zone and probably the *Tumulites varians* Zone in America. Species *Cravenoceras* of similar age are found in the Tarusian and Steshevian in the Moscow Basin.

(6) The base of the Khudolazovian coincides with the appearance of the foraminifer *Eostaffellina paraprotvae*. It is reliably correlated to the upper Steshevian in the Moscow Basin. The upper Khudolazovian contains ammonoids of the lower part of the *Fayettevillea–Delepinoceras* Genozone (= *E. paucinodum – E. rotuliforme* in America and the Lower Arnsbergian in Europe).

(7) The Yuldubaevian is dated by ammonoids characteristic of the upper part of the *Fayettevillea–Delepinoceras* Genozone. *Eumorphoceras transuralense,* which is similar to *Eumorphoceras* species from the E2 in Europe, suggests correlation with the Upper Arnsbergian and the *Eumorphoceras girtyi, Cravenoceratoides nititoides,* and *Delepinoceras thallasiode* Zones in America. The foraminifer *Monotaxinoides transitorius* suggests correlation with the Zapaltyubinian of the Donets Basin and the upper part of the Upper Arnsbergian Cf 7 Zone in the Dinant Basin.

The Serpukhovian Stage is a distinct biochronological unit characterized by specific stages in the evolution of several orthostratigraphic groups, including ammonoids, conodonts, and foraminifers. Although the type section of the Serpukhovian is in shallow-water facies, it can now be reliably correlated with deep-water sequences in the South Urals. The zonal subdivision of the Serpukhovian is well understood both in its type area and in the Urals. The lower boundary of the Serpukhovian in the Urals is based on the first appearance of *Lochriea ziegleri*, which in this case is constrained by both ammonoids and foraminifers.

Acknowledgments

The study is supported by the Russian Foundation for Basic Research, project no. 04-05-65022.

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Correlation of Viséan plant-bearing deposits of the Russian Platform

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Research on the development of Mississippian floras in the Euramerican palaeofloristic realm recognizes two main phases with their boundary in the middle of the Viséan Stage. Several authors (e.g., Novik, 1974; Lemoigne, 1988) have noted that during this interval in the tropical belt the impoverished flora of Devonian–Early Viséan time changed into the more diverse flora of Namurian-Stephanian aspect.

Analysis of the floristic sequences of Europe (Mosseichik, in press) shows that Late Tournaisian–Early Viséan time is marked by the predominance of the small-cushion lepidophytes *Archaeosigillaria, Lepidodendropsis, Sublepidodendron, Lepidodendron spetsbergense,* and *L. losseni*, etc., primitive sphenopsids (e.g., *Archaeocalamites radiatus*), and plants with fern-like foliage of the *Adiantites, Triphyllopteris,* and *Fryopsis* type.

Beginning in the Late Viséan and ranging into the Serpukhovian (Namurian A), lepidophytes with large leaf cushions (e.g., *Lepidodendron obovatum, L. volkmannianum, Sublepidophloios, Sigillaria,* etc.) became dominant. Simultaneously, the first sphenopsid *Mesocalamites* appeared, and the early gymnosperms became widespread. The fronds of progymnosperms, ferns, and pteridosperms became more diverse, and such forms as *Lyginopteris, Neuropteris,* and *Pecopteris* appeared.

This trend in the development of various plant groups and the corresponding dominance-pattern changes (the Pan-Euramerican floristic change) can be observed in practically all European Mississippian floras. It is probably connected with their growth in similar landscape conditions on coastal lowlands and plains. Therefore it could have led to similar evolutionary changes, even in geographically isolated floras.

During the middle Viséan, the epicontinental seas on the Russian Platform were reduced, and the strait between this land mass and the west–middle European islands was closed. The resulting formation of new sites and migration paths stimulated widespread plant dispersal, particularly among the early gymnosperms.

The stages of floral development mentioned above are reflected in the *Triphyllopteris* (Late Tournaisian–Early Viséan) and *Lyginopteris bermudensiformis–Neuropteris antecedens* megafloral Zones (Late Viséan–Early Serpukhovian) which were established by Wagner (1984) in the continental plant-bearing deposits of Europe and North America. The boundary between them corresponds to the III_a/III_b goniatite zonal boundary.

The recognition of these stages in Euramerican floral development allows correlation of the Viséan plant-bearing deposits of the Russian Platform coal basins as well as recognition of analogs of Wagner's (1984) megafloral zones.

Moscow Coal Basin

Two regional megafloral zones can be recognized in the Viséan of the Moscow coal basin: the *Gryzlovia meyenii*

Stage	Suites	Megafloral zones	Foraminifera zones (Alekseev et al., 2004)	Conodont zones (Alekseev et al., 2004)
Viséan	Venevsskaya	*Sublepidodendron shvetzovii*	*Eostaffella tenebrosa– Endothyranopsis sphaerica*	*Lochriea ziegleri*
				Lochriea nodosa
	Mikhailovskaya		*Eostaffella ikensis*	
	Aleksinskaya		*Eostaffella proikensis– Archaediscus gigas*	*Gnathodus bilineatus*
	Tulskaya		*Endothyranopsis compressa*	
	Bobrikovskaya	*Gryzlovia meyenii*	*No fauna*	
	Radaevskaya			

Fig. 1. Correlation of Viséan megafloral zones of the Moscow coal basin with conodont and foraminifer zones (Alekseev et al., 2004).

Stage	Europe and North America (Wagner, 1984): Goniatite zones	Europe and North America (Wagner, 1984): Megafloral zones	Pripiat' depression (Radzivill, 1989): Series	Pripiat' depression (Radzivill, 1989): Floristic assemblages		Lvov-Volyn' coal basin (Novik, 1974): Suites	Donets coal basin (Novik, 1974; Fissunenko, 1989): Suite	Donets coal basin (Novik, 1974; Fissunenko, 1989): Megafloral zones	Moscow coal basin (South flank): Suites	Moscow coal basin (South flank): Megafloral zones
Serpu-khovian	E_1	*Lyginopteris bermudensiformis – Neuropteris antecedens*	No plant remains			Ivanichskaya	C_1^2(B)	*Fryopsis polymorpha – Diplothmema patentissimum* (zone 1B)	No plant remains	
	IIγ	*Lyginopteris bermudensiformis – Neuropteris antecedens*	Uglenosnaya paralicheskaya	Assemblage 3	strata with *Neuropteris antecedens*	Poritskaya	C_1^2(B)	*Presigillaria jongmansii– Lygynopteris fragilis* (zone 1A)	Venevskaya Mikhailovskaya	*Sublepidodendron shvetzovii*
Viséan	IIβ	*Lyginopteris bermudensiformis – Neuropteris antecedens*	Uglenosnaya paralicheskaya	Assemblage 3	strata with *Lyginopteris bermudensiformis*	Ustiluzhskaya Vladimirskaya	No plant remains		Aleksinskaya Tulskaya	*Sublepidodendron shvetzovii*
	IIα	*Triphyllopteris*	Kaolini-tovaya	Assemblage 2	strata with *Rhodea moravica*	No plant remains	No plant remains		Bobrikovskaya	*Gryzlovia meyenii*
	IIδ	*Triphyllopteris*	Kaolini-tovaya	Assemblage 2	strata with *Meyenia prypiatii*	No plant remains	No plant remains		No plant remains	
Tournai-sian	IIβ -γ	*Triphyllopteris*	Zhelezis-taya	Assemblage 2	strata with *Lepidodendropsis*	No plant remains	No plant remains		No plant remains	

Fig. 2. Correlation among Viséan plant-bearing units of the Russian Platform coal basins and the megafloral zonal scale of Wagner (1984).

Zone and the *Sublepidodendron shvetzovii* Zone (Figs. 1, 2; Mosseichik, 2004).

The *Gryzlovia meyenii* Zone can be correlated with the upper (Viséan) part of the *Triphyllopteris* Zone, and the *Sublepidodendron shvetzovii* Zone can be correlated with the basal (Viséan) part of Wagner's *Lyginopteris bermudensiformis–Neuropteris antecedens* Zone. The grounds for these correlations are given in Mosseichik (2003).

Pripiat' Depression

In the Pripiat' depression the Pan-Euramerian floristic change can be observed in the change between Assemblages 2 and 3, established by Radzivill (1989) at the boundary between the Kaolinovaya and Uglenosnaya Series (Fig. 2).

It is confirmed by the predominance in the Uglenosnaya Series of diverse *Lyginopteris* and *Neuropteris,* including *L. bermudensiformis* and *N. antecedens*, as well as *Mesocalamites* and the large-cushion lepidophyte *Lepidodendron obovatum*. These plants replace *Lepidodendron spetsbergense, Adiantites antiquus, A. machanekii, Rhodea moravica,* and *Meyenia prypiatii* which characterize the underlying Kaolinovaya Series.

The basal part of the Assemblage 2 range interval corresponds to the Zhelezistaya Series, and should not be correlated with the Viséan because of the predominance of *Lepidodendropsis* remains which are characteristic of the Tournaisian part of the *Triphyllopteris* Zone.

The absence in Assemblage 3 of several elements that are characteristic of the Namurian and appear in the upper part of the *Lyginopteris bermudensiformis–Neuropteris antecedens* Zone of Wagner is clear evidence of the Viséan age of Assemblage 3.

Lvov-Volyn' Coal Basin

A zonal subdivision based upon plant remains has not been established for the Lvov-Volyn' coal basin. Novik (1974), however, reported the floristic content of the Vladimirskaya, Ustiluzhskaya, Poritskaya, Ivanichskaya and other suites.

In the Vladimirskaya and Ustiluzhskaya Suites the large-cushion lepidophyte *Lepidodendron obovatum* occurs and in the Vladimirskaya Suite *Mesocalamites roemeri* appears. In the Poritskaya Suite, an abundance of various *Lyginopteris* (including *L. bermudensiformis*), *Mesocalamites,* and *Diplothmema* occurs, as does the Pan-Euramerian zonal species *Neuropteris antecedens*. All of these reflect the gradual occupation of territory in the depression by western European plants, and all three suites can be correlated with the *Lyginopteris bermudensiformis–Neuropteris antecedens* Zone (Fig. 2).

The floristic characteristics of the overlying Ivanichskaya Suite are close to those of the Poritskaya Suite. However, *Cordaites principalis*, a form which in southern Europe is known only from Namurian A upward, appears in the Ivanichskaya Suite. This is evidence for the Serpukhovian age of the Ivanichskaya Suite.

Donets Coal Basin

Mississippian plant remains are known from the $Ñ_1^2$ (Â) Suite in the Donetz coal basin. Novik (1974) recognized two plant assemblages in this interval, 1 A and I B, which were later transformed by Fissunenko (1991) into the

Presigillaria jongmansii–Lyginopteris fragilis and *Fryopsis polymorpha–Diplothmema patentissimum* megafloral Zones, respectively.

The *Presigillaria jongmansii–Lyginopteris fragilis* Zone contains abundant remains of the large-cushion lepidophytes *Lepidodendron obovatum*, *L. veltheimii,* and *L. volkmannianum*, diverse *Mesocalamites,* and numerous species of *Lyginopteris* (among them, *L. bermudensiformis*) and *Neuropteris*. This is evidence for the existence of a rich and diverse flora, which apparently was formed by migrants from western Europe. On the basis of plant assemblage similarity, the *Presigillaria jongmansii–Lyginopteris fragilis* Zone can be correlated with the Poritskaya Suite of the Lvov-Volyn' coal basin (Fig. 2).

The assemblage of the *Fryopsis polymorpha–Diplothmema patentissimum* Zone is similar to that of the previous zone, but includes species such as *Alloiopteris quercifolia, Lyginopteris stangeri,* and *L. larischii* which are characteristic of the Early Namurian. It allows correlation with the upper part of Wagner's *Lyginopteris bermudensiformis–Neuropteris antecedens* Zone, or even with the following *Lyginopteris bermudensiformis–Lyginopteris stangeri* Zone, which together correspond to the basal part of the Serpukhovian (Fig. 2).

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Geography and succession of European floras during the Viséan

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The peculiarities of the land paleophytogeography of Viséan time were first determined by the level of evolutionary development of plants. The Mississippian forms had much less effective adaptations for reproduction and dispersal than higher gymnosperms and angiosperms, which conditioned the phytochorion [provincial] structure in the Mesozoic–Cenozoic. The reproduction process of the earlier, mainly spore-bearing forms was strongly connected to water supply. Accordingly, they were restricted in their distribution to wet lowland sites. The early gymnosperms (calamopiteans, lagenostoms, etc.) were adapted to drier conditions due to the presence of a seed. They appeared only at the end of the Devonian, apparently evolved from lowland communities, and had begun to colonize the slopes of river valleys and accumulative depressions. Therefore, solid plant cover comparable with that of recent time probably did not exist.

Recent plant dispersal factors such as zoochory were rare or of little importance. The placors, mountain ridges, and marine basins were apparently insuperable obstacles for plant migration and dispersal. Probably the plant migration paths extended along seashores and through connected intermountain depressions.

The low morphologic diversity of Mississippian plants is reflected in their rather low taxonomic differentiation at the supra-generic level. Therefore, distinctions in generic and species composition of the local floras should be used for phytochorion characterization.

Paleofloristic realms and regions of the Mississippian can be recognized on the basis of mutual floral development within the limits of large-scale geographically isolated territories of continental and subcontinental scale. These phytochoria should be characterized by high species endemism as well as by the presence of endemic genera and higher taxa, but supra-generic endemism may not be observed.

In this report the boundaries of paleofloristic provinces and districts are not only interpolated between fossil plant localities, but are also subject to a more complex reconstruction that considers the corresponding paleogeographical background.

The modified Zuerich-Montpellier school technique for comparison of taxonomic lists from various localities was applied.

Evolutionary Trends and General Scheme of Paleofloristic Zonation

It is expedient to construct two schemes of paleofloristic zonation for the territory of Europe in the Viséan: for the Early Viséan, the upper part of *Triphyllopteris* Zone of Wagner (1984); and for the Late Viséan, the lower part of Wagner's *Lyginopteris bermudensiformis–Neuropteris antecedens* Zone. Significant floristic changes took place at the boundary between these two zones (Novik, 1974; Lemoigne, 1988) which were connected with the restructuring of the general paleogeography of the Euramerican paleocontinent as well as with large-scale evolutionary innovations.

Lepidophytes with small leaf cushions (e.g., *Lepidodendropsis*, *Sublepidodendron*, *Lepidodendron spetsbergense,* etc.) were replaced in the middle Viséan by forms with larger leaf cushions, such as *Lepidodendron veltheimii, L. obovatum,* and *Sublepidophloios*. The rapid development of early gymnosperms took place, and the first cordaiteans appeared. The fronds of progymnosperms, ferns, and gymnosperms greatly diversified. Instead of the simple leaves of the *Triphyllopteris* type, the various genera *Lyginopteris, Neuropteris, Pecopteris,* etc., developed. The first mesocalamites also appeared at this boundary.

In the Viséan, the territory of the Euramerican paleocontinent and adjacent islands apparently belonged to the tropical Euramerican paleofloristic realm which is characterized by high endemism at the species and higher taxonomic levels.

Two paleofloristic areas are recognized within the Euramerican realm: North-American and European, which since the Devonian had been separated by the Caledonian mountain ranges. These areas have almost no common species, as first noted by Novik and Fissunenko (1979).

Early Viséan

During the Early Viséan, differences in floristic composition are manifest between the northern and southern regions of Europe, as first noted by Radczenko (1957).

Rather rich fossil plant localities of this age are known from southern Europe, where during the Early Viséan a large island or archipelago was situated (Fig. 1). Several common elements allow these local floras to be combined into the South-European paleofloristic province. Among these, lepidophytes such as *Lepidodendron lossenii* and plants with fern-like foliage of the *Sphenopteridium dissectum*, *Triphyllopteris,* and *Fryopsis* type dominated.

There are few known localities with Early Viséan floras in northern Europe (Fig. 1). These are scattered along the periphery of the European part of the Euramerican paleocontinent in several accumulative lowlands. These fossil floras include numerous local endemic species. Their differences probably resulted from geographical isolation, caused by barriers such as the Baltic shield placors and Caledonian mountain structure.

A distinct paleofloristic district probably existed in the territory of every such lowland. At the same time, they share several common elements including *Lepidodendron spetsbergense* and various *Adiantites*. However, there are none of the characteristic South-European forms cited above. All of these factors allow the floras of the North-European land masses to be combined into the North-European palaeofloristic province.

Late Viséan

The South-European province still existed during the Late Viséan (Fig. 1). At that time the flora of Scotland acquired a number of common elements from the South-European province, which apparently became connected with the beginning of the closing of the marine basin that divided the South- and North-European land masses. The main participants in this floristic change were pteridosperms such as *Adiantites*, *Sphenopteridium* (*S. dissectum, S. pachyrrachis, S. crassum, S. speciosum*), and *Rhodea* (*R. machaneckii, R. gigantea*), etc. The presence of these common species allows Scotland to be included in the South-European province.

At the same time, in comparison with the Early Viséan, every local flora of the South-European province experienced an increase in endemism at the generic and species levels.

On the newly exposed territory of the Lvov-Volyn' and Donets coal basins (Fig. 1) a rich flora developed, which characterizes the Donets paleofloristic province. Apparently the pteridosperms *Lyginopteris, Neuropteris,* and *Diplothmema*, and, possibly, lycopsids of the *Lepidophloios* type, migrated from the South-European province and radiated here.

The Donets province also embraces the flora of the Pripiat' depression, which was much impoverished in comparison with the floras of Donets and Lvov-Volyn' coal basins. The Donets province for Viséan–Namurian time was first established by G.P. Radczenko (Einor et al., 1964).

Late Viséan floras are known from northern Wales and Gloucestershire which include endemic lepidophytes with a small leaf-cushion including *Eskdalia variabile, E. fimbriophylla, Lepidodendron* (?) *perforatum,* and *Lepidodendropsis* (?) *jonesi,* and plants with monotonous fronds of the *Rhacopteris* type. These floras drastically differ from other coeval floras of Europe and even from the adjacent flora of Scotland. They confirm the

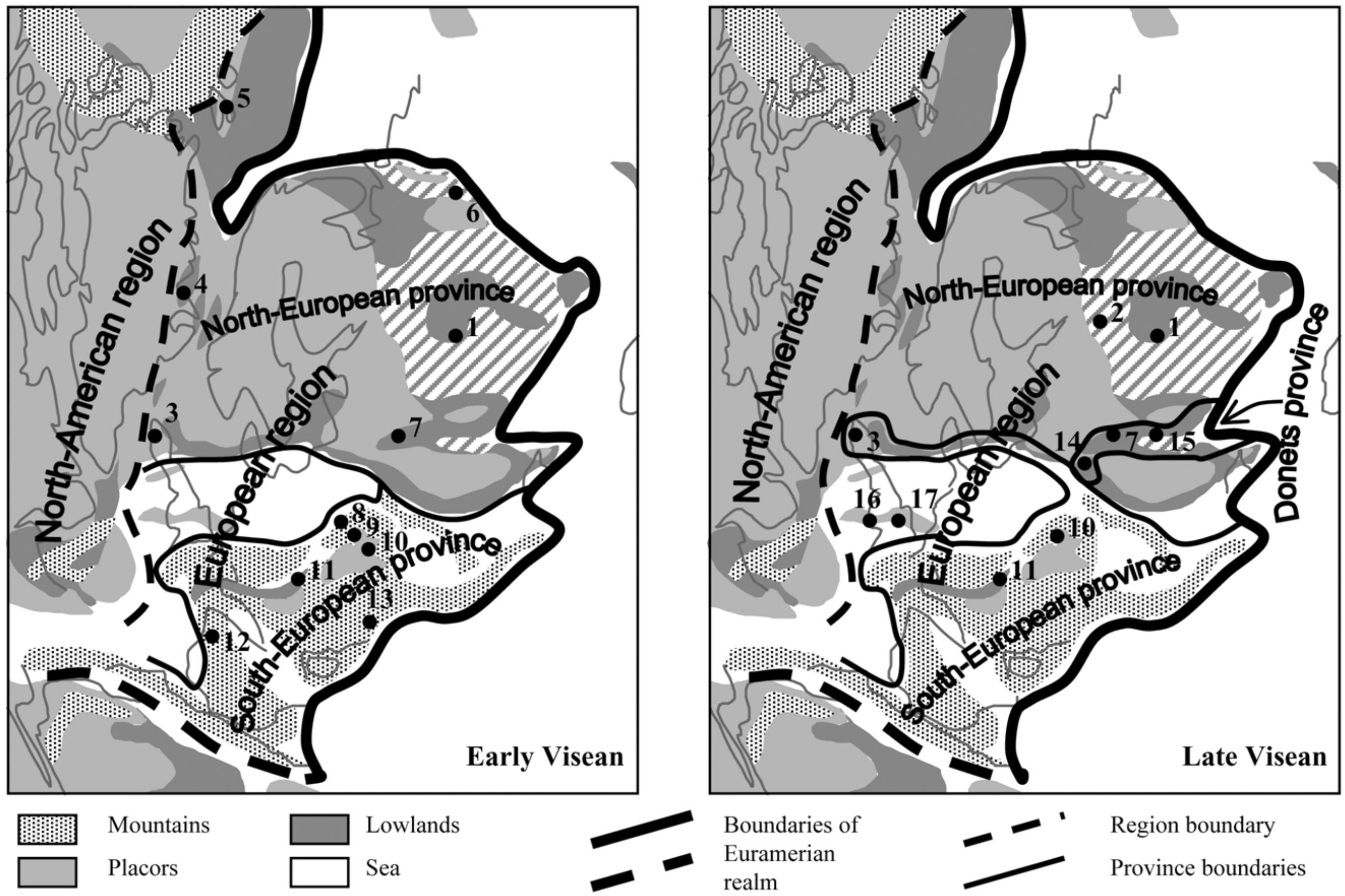

Fig. 1. Schemes of phytogeographical zonation of Europe in the Viséan [Palaeogeographical background from: "Palaeogeography Atlas…" (2000) and "Atlas…" (1961)]
Local floras: 1 – South flank of Moscow coal basin; 2 – Northwest flank of Moscow coal basin; 3 – Scotland; 4 – East Greenland; 5 – Spitzbergen; 6 – Kiselovsky coal basin; 7 – Pripiat' depression; 8 – Germany (Doberlug-Kirchhain, Delitzsch); 9 – Saxony (Kossberg bei Plauen); 10 – Lower Silesia and Moravia; 11 – Middle Vosges; 12 – Northwest Spain; 13 – Carnic Alps; 14 –Lvov-Volyn' coal basin; 15 –Donets coal basin; 16 – North Wales; 17 – Gloucestershire

paleogeographic reconstructions of an island here. The territory of this island probably belonged to a separate paleofloristic district.

The territory of the North-European province diminished owing to the enlargement of the South-European province and the formation of the Donets province. It is impossible to trace its boundaries precisely because the Late Viséan floras in this region are known only from the Moscow coal basin. Among the widespread forms there are representatives of *Adiantites, Sphenopteris,* and *Archaeocalamites radiatus*. It should be noted that the floras of the Moscow coal basin did not experience the widespread radiation of plants with fern-like foliage of the *Adiantites, Lyginopteris, Neuropteris,* and *Diplothmema* type that characterizes the South-European and Donets provinces.

Concluding Remarks

Viséan phytogeography is characterized by several marked features. Among these are:

1) Autochtonous development of small, local phytochoria (paleofloristic districts), accompanied by an increase in endemism at the generic and species levels;

2) Origination of new local phytochoria due to plant migration processes;

3) Formation of larger phytogeographical units of subregional scale (provinces) as a result of the expansion of early gymnosperms (calamopiteans, lyginopterids, etc.).

The changes in paleogeographical patterns are particularly connected with marine transgressions and regressions. The closing of straits and the formation of "land bridges" were of great importance.

The analysis of Viséan Euramerican realm floras brings more precision to our concept of the early stages of global florogenetic process. Until now it had been characterized as a "differentiation," that is, the formation of phytochoria of lower and lower rank within the limits of the plant realms that existed at that time. Now it becomes clearer that regardless of this concept, the process of formation of the Paleozoic phytochoria at their early stages apparently proceeded "from below," that is, originating from the small floristic unities that had developed autochthonously in various parts of the large geographically isolated territories of continental and regional scale.

The Mississippian radiation of gymnosperms led to gradual formation of the larger phytochoria (provinces) owing to the migration and ecogenetic expansion of these plants.

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Cyclothem [sequence-stratigraphic] correlation and biostratigraphy across the Moscovian-Kasimovian and Kasimovian-Gzhelian Stage boundaries (Upper Pennsylvanian Series) in North America and Eurasia

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Introduction

In the revised guidelines for establishing global chronostratigraphic boundaries by the International Commission on Stratigraphy (ICS), Remane et al. (1996) emphasized both the importance of selecting a marker event of optimal correlation potential for establishing the Global Boundary Stratotype Section and Point (GSSP) that defines a stage boundary, and also the principle that correlation of the strata encompassing the boundary must precede definition of the boundary. Many authors have noted that global correlation of Pennsylvanian rocks is difficult because of development of biotically distinct regions, not only the climatically distinct Gondwana and Angara poleward realms, but also the fragmentation of the pantropical realm by Appalachian-Variscan orogenic closing of tropical waterways. This led to establishment of three different regional systems of chronostratigraphic names: in western Europe where the Pennsylvanian is largely to totally terrestrial, on the Russian Platform where it is entirely marine carbonate and shale, and in Midcontinent North America where it is an alternation of marine carbonate and shale with terrestrial clastics and coal, the strata that compose the stratigraphic sequences termed cyclothems, which are recognized as products of glacial eustasy (Heckel, 1994).

The Middle to Late Pennsylvanian Midcontinent succession of widespread cyclothems (which are typically separated from one another by exposure surfaces) has been correlated across large parts of the central, eastern, and southern United States and now into part of the western United States, using the distinctive succession of conodont faunas within the successive cyclothems in what Ritter et al. (2002) termed "sequence biostratigraphy." Recognizing global control of glacial eustasy, modern Russian stratigraphers have now identified the exposure surfaces separating cyclothems in the Moscow region and have begun to correlate the cyclothems across the Russian Platform (Kabanov, 2003; Kabanov and Baranova, in press). Cyclothems can also be recognized in the Donets Basin of Ukraine and adjacent Russia, where marine carbonate and shale alternate with terrestrial clastics and coal. The stage names originating in Russia are now used for the global stages because their fusuline faunas are similar enough to be readily recognized across much of Eurasia at least at the generic level, whereas the North American fusuline faunas are mostly provincial. Recent progress in working out the conodont successions in North America, and eastern and southern Europe has shown that while a fair amount of provincialism exists, there are levels where distinctive taxa are found across most of the region. Therefore it is appropriate to establish a correlation of the glacial-eustatic cyclothems among the regions where they are recognized, specifically midcontinent North America, the Russian Platform, and the Donets Basin, and extend it to other regions where the fossil succession has been described even though cyclothems are either not yet recognized or not well-defined. This includes the western slope of the southern Urals where the succession is marine carbonate and shale, and the Cantabrian area of northern Spain and the Carnic Alps of the Austrian-Italian-Slovenian border area, which are the only parts of western Europe that have marine facies into the late Middle to Late Pennsylvanian, and where the succession is mainly marine carbonate and shale with some coarser siliciclastics in the latter area.

To establish the most reasonable correlation, the following assumptions are made: [1] Because they are glacial-eustatic, the scale of each cyclothem, that is, its relative lateral extent and water depth attained, should be roughly the same globally compared to that of the adjacent cyclothems. This assumes that local differential tectonism acts too slowly (1-2 m.y.) to mask the pattern in the more frequent fluctuations in sea level (100-400 k.y.) that resulted in the particular succession of major, intermediate, and minor cyclothems, which is well documented in Midcontinent North America and correlated into Texas (Boardman and Heckel, 1989) and the Illinois and Appalachian Basins (Heckel, 1994, 2002). This should be true for the cratonic Midcontinent and Russian Platform, but may be less so in the Donets Basin where compressional forces may have affected the strata during deposition in the aulacogen. [2] Major cyclothems with the greatest lateral extent of marine facies and the deepest-water facies on the shelves should be the most readily correlated, both because they contain deeper-water as well as shallow-water fossils, and because they would have allowed the greatest interchange of conspecific organisms across the inundated shelves of the pantropical realm. [3] Conodonts and ammonoids are the primary fossils used to correlate the cyclothems because they were likely largely pelagic, whereas the benthic and more provincial fusulines are used as secondary aids in correlation. [4] Major cyclothems are recognized in the Midcontinent by means of their conodont-rich dark phosphatic shale facies that resulted from water deep enough and far enough from shoreline to significantly reduce detrital dilution and lead essentially to sediment starvation. Major cyclothems are recognized in the Moscow Basin of the Russian Platform and in the Donets Basin also by means of greatest conodont abundance, which similarly reflects decreased sediment dilution in the deepest-water facies. In the Moscow Basin these facies are often shaly limestones (sometimes with tempestite beds) in contrast to the adjacent purer, shallower-water limestones. In the Donets Basin, these facies are usually in the non-algal limestone beds.

Moscovian-Kasimovian Boundary

Using these assumptions as guidelines, the following correlations of major cyclothems are made across the Moscovian-Kasimovian boundary (Fig. 1): The Midcontinent Lost Branch cyclothem is correlated with the Russian Voskresensk Formation and Donets Limestone N_3^3, based on the youngest abundant occurrence of the short-ranging troughed conodont genus *Swadelina* Lambert et al. 2003. Although different species of this distinctive genus dominate in the different places, *Sw. nodocarinata* (Jones 1941), which dominates the Lost Branch, may occur in both the other regions. *Idiognathodus expansus* Stauffer and Plummer 1932 occurs in both the Lost Branch and N_3^3. This correlation lines up the next older Midcontinent major Altamont cyclothem with the Suvorovo Formation in Russia, and with Donets Limestone N_3^1. *Swadelina neoshoensis* Lambert, Heckel, and Barrick 2003 occurs in both the Altamont and the next older intermediate Farlington cyclothem, and in Donets Limestone N_3 (which is at the Farlington level) and possibly in N_3^1. *Streptognathodus subexcelsus* Alekseev and Goreva 2001, which may or may not belong in *Swadelina*, occurs in the Suvorovo Formation and Donets Limestones N_3 and N_3^1. Below all these units, the conodont faunas comprise entirely flat forms that include *I. delicatus* Gunnell 1931 in the Midcontinent (Lower Pawnee, Coal City) and forms resembling *I. delicatus* in Russia (Peski formation) and in Donets Limestone N_2. The abrupt change in conodont faunas between these two levels coincides with the current base of the Kasimovian Stage in Russia.

Among fusulines, protriticitids [genera *Protriticites* and *Obsoletes*] that are considered "typical" dominate the Suvorovo and Voskresensk Formations in Russia, but are so far found only in Limestone N_3^3 in the Donets Basin. However, those found so far in Donets Limestone N_3 are considered "primitive" like those found in Russia below the Suvorovo in the middle and upper Peski cycles, which line up via conodonts with the Midcontinent Lower Pawnee and Coal City cyclothems. The latter are dominated by the provincial North American *Beedeina* faunas, but correlate via conodonts (Ritter et al., 2002) with the western U.S. units that contain primitive protriticitids reported by Wahlman et al. (1997). Donets Limestone N_2 could be as young as the Lower Pawnee major cyclothem or older, based on conodonts alone, but it is shown as older based on its fusuline content, which would mean that a significant gap exists below the *Swadelina*-bearing beds in the Donets Basin.

Above the highest *Swadelina*-bearing major cyclothem in the Midcontinent are two minor cyclothems (Glenpool,

MOSCOVIAN-KASIMOVIAN BOUNDARY BEDS CYCLOTHEM CORRELATION CHART

N. AM. MIDCONTINENT cyclothems **[MAJOR (core shale)**, Intermediate, Minor]	**MOSCOW BASIN Afanasievo Qy+Moscow cores** **[MAJOR CYCLE**, Lesser cycle]	**DONETS BASIN, Kalinovo section** **[MAJOR CYCLE**, Lesser cycle]	**SOUTH URALS,** **Dalniy Tyulkas-2, etc.**	**CANTABRIANS,** **Las Llacerias**
DENNIS (Stark): many forms, including type *S. confragus*; others fus. *Triticites* [not most primitive]	**UPPER NEVEROVO**: abundant fauna, including *I. sagittalis, S.* cf. *cancellosus, S. neverovensis* fus. *Montiparus subcrassulus*	$\mathbf{O_2}$: mostly flat forms, incl. *I. sagittalis;* *S.* cf. *confragus; Gondolella* adv. *Montiparus;* prim. triticit. (aff. *leciae*)	Nikolsky bed 2: *S.zethus?* *Montiparus subcrassulus*	9046-9047 advanc. *Montiparus* prim. *Trit.? leciae*
Mound Valley: first *S. confragus*	[not identified] **[top of Afanasievo Quarry exposure]**	O_1^2: *S. neverovensis, S.* cf. *confragus* primitive *Triticites; Montiparus* [VID]	**[upper Kasimovian cut out at Dalniy Tyulkas-2]**	9041-9044:*Triticit.?* advanc. *Montiparus*
SWOPE (Hushpuckney): many forms, including type *I. sulciferus, S. cancellosus; I. sagittalis* fus. *Eowaeringella ultimata*	**MID-NEVEROVO**: several flat & troughed forms *I. sagittalis, S.* cf. *cancellosus, I.* cf. type *sulciferus* fus. typical *Montiparus* \ advanced *Montiparus*	$\mathbf{O_1}$: flat & troughed forms: *S. 'oppletus'* type *I. sagittalis; I.* cf. type *sulciferus* dom. advanc.protriticitids; prim. *Triticites?*	Dalniy Tyulkas-2 beds 33-35: *I. sagittalis* [no fusulines]	9038-9040: advanc. *Montiparus*
HERTHA (Mound City) various flat but nodose idiognathodids, some *I. sagittalis* [no fusulines]	Lower Neverovo: type *S. neverovensis* [previously *'oppletus'*]; *Gondolella* [no fusulines]	$\mathbf{N_5^1}$ upper level: flat + troughed forms, incl. adol. *I. sagittalis; S. 'cancellosus',* *S. 'oppletus'* [no fusulines]		9035: *I. sagittalis?* *S. neverovensis* 9034: prim. *Montip.*
Critzer: same taxa as in Exline below	[not identified]	N_5^1 middle level: same as in lower level		9030: *I. eccentricus*
Exline: *Idiognathodus* morphotypes, including first *I. eccentricus; I. sagittalis.* [no fusulines] **[base of regional Missourian Stage]**	Basal Neverovo: *Idiognathodus* morphotypes plus troughed nodose forms; *I. eccentricus?* fus. rare primitive *Montiparus*	N_5^1 lower level: sparse *Idiognathodus* forms [no fusulines: TIN, KU]		
Checkerboard-S. Mound: flat forms, including *I. sagittalis.* [no fusulines]	[not identified]	N_5: [poorly known, could correlate higher if N_5^1 is a single cycle]	DT-2 bed 32: 'transitional' forms [no fusulines]	[no fusulines]
Glenpool [upr Lost Branch]: last *Neognathodus;* *I.* n. sp. B. & R. [transitional], *Sw. nodocarinata*	Ratmirovo: several forms in base, incl. *I.* cf. *trigonolobatus, Swadelina makhlinae*	N_4: [poorly known] [last *Neognathodus* reported]		9027: rare fusulines *Quasifusulinoides*
LOST BRANCH (Nuyaka Creek) type *Swadelina nodocarinata; I. expansus,* *I.* n. sp. of B. & R. [transitional to higher forms] fus. *Beedeina eximia*	**VOSKRESENSK**: type *Swadelina makhlinae; Sw. nodocarinata?,* *I. trigonolobatus* fus. typical protriticitids	$\mathbf{N_3^3}$: several forms, including *I. expansus; Sw. neoshoensis,* *Sw. nodocarinata?* fus. typical protriticitids	DT-2 beds 25-29: *Sw. makhlinae,* *S. subexcelsus* bed 19: *Sw.* *nodocarinata?* [no fusulines]	9017-9026: typical protriticitids
Norfleet: mostly *Neognathodus* some *Swadelina nodocarinata,* *I.* n. sp. of Barrick & Rosscoe [transitional]	[probably missing]	N_3^2: several forms, including *Sw. neoshoensis* [no fusulines known]		
ALTAMONT (Lake Neosho) type *Sw. neoshoensis*; broad *I.* in upper part fus. *Beedeina megista, B. acme,* etc.	**SUVOROVO**: mostly flat morphotypes; type *S. subexcelsus; I. fischeri* fus. typical protriticitids	$\mathbf{N_3^1}$: several forms, including *S. subexcelsus, I. trigonolobatus; Sw.?* [no fusulines known]	DT-2 beds 15-18: *S. subexcelsus* [no fusulines]	
Farlington: all troughed idiognathodids, including *Swadelina neoshoensis*; *Adetognathus* fus. present but unidentified	Lower Suvorovo [Lower Garnasha]: *S. subexcelsus* fus. rare typical protriticitids **[current base of Kasimovian Stage]**	N_3: several forms, including *S. subexcelsus, Sw. neoshoensis,* *Sw. nodocarinata?* fus. primitive protriticitids, as in Peski		9010-9012: primitive protriticitids
Coal City (Joe Shale): all flat morphotypes, incl. type *Idiognathodus delicatus, I. claviformis* fus. *Beedeina* [prim. protriticitid level in W. US]	Upper Peski [Volodarsky]: all flat morphotypes; some cf. *I. delicatus* fus. primitive protriticitids; *Fusulina, Fusiella*	[missing? or N_2^1 here?]	Dalniy Tyulkas-2 beds 11-14? [conodonts not yet found]	
LOWER PAWNEE (Anna): all flat forms, incl. *I. delicatus*, type *I. fustiformis,* others fus. *Beedeina* [prim. protriticitid level in W. US]	Middle Peski [L.+ U. Titovo]: sparse conodonts; some cf. *I. delicatus* fus. primitive protriticitids; *Fusulina, Fusiella*	N_2^1: [conodonts not studied] [or $\mathbf{N_2}$ here?]		
Wimer School, Higginsville: flat forms	[missing?]	[missing?]	[no fusulines]	
UPPER FORT SCOTT [Little Osage]: *I. delicatus* and other flat forms fus. *Beedeina haworthi, B. girtyi,* etc.	Lower Peski [Kamen. Tyazhina]: sparse conodonts; some cf. *I. delicatus* fus. *Fusulina, Fusiella, Fusulinella*	$\mathbf{N_2}$: all flat morphotypes; some cf. *I. delicatus* fus. *Fusulina, Taitzehoella*		9009? *Fusulinella*
LOWER FORT SCOTT [Excello]: *I. delicatus* and other flat forms; advanced *Gondolella* sp. 2 of Swade 1985 [with ridged platform] fus. *Beedeina haworthi,* etc.	Upper Domodedovo [Gubastovo]: sparse conodonts fus. *Fusulina cylindrica*	[upper of poorly exposed unnumbered units between $\mathbf{N_2}$ and $\mathbf{N_1}$ illustrated by Aizenverg et al. (1975)?] [biotas poorly known]	[younger than DT-2 bed 5 containing *G. laevis* with primitive smooth platform]	[younger than S-232 containing *G. pohli* with typical smooth platform, formerly Swade 1985 sp. 1]

P. H. Heckel, July 28, 2005

Checkerboard), followed upward by the intermediate Exline, minor Critzer, and the major Hertha and Swope cyclothems (Fig. 1). These cyclothems display a radiation of *Idiognathodus* species that tend to have coarser transverse ribs and longer adcarinal ridges than similar flat forms in the older units with *Swadelina* (Barrick et al., 1996). Recently, a new, transitional and possibly ancestral form from the Altamont-Glenpool interval from Oklahoma is under study by Barrick and S.J. Rosscoe. Above the Glenpool, first appearances involve *I. eccentricus* (Ellison 1941) in the Exline, several more nodose forms in the Hertha and an even greater variety in the Swope, including type *I. sulciferus* Gunnell 1933, type *I. eccentricus*, and type *Streptognathodus cancellosus* (Gunnell 1933). The "basic morphotype" of the earlier forms was included in *I. sulciferus* by Barrick et al. (1996), but most specimens tend to have a less prominent inner lobe than the holotype from the Swope, and so these "basic" forms may be recognized as an earlier species. Some of the forms appear to be *I. sagittalis* Kozitskaya 1978, which was named from Limestone O_1 in the Donets Basin. Above the Swope is the minor Mound Valley cycle in which *S. confragus* (Gunnell 1933) first appears, overlain by the major Dennis cyclothem, which contains a number of distinct forms including the holotype of *S. confragus*.

Above the *Swadelina*-bearing Voskresensk Formation and faunally related Ratmirovo Formation in the Moscow region, several cycles have been recognized in the complex Neverovo Formation (Basal, Lower, Middle, Upper), of which the upper two have conodonts abundant enough to be considered major (Fig. 1). Above *Swadelina*-bearing Limestone N_3^3 in the Donets Basin, several minor poorly known cycles are overlain by two major cycles (upper N_5^1, O_1) and followed by minor cycle O_1^2 and major cycle O_2. In terms of scale, the major cycles can be lined up with those in the Midcontinent, and the minor-major sequence at the top (O_1^2-O_2) both contain forms that closely resemble *S. confragus*, which occurs in the similar minor-major sequence (Mound Valley-Dennis) at the top of this part of the Midcontinent succession. Fitting the Russian succession into this framework places the major Upper Neverovo cycle equivalent to the Dennis and Limestone O_2, the major Middle Neverovo cycle equivalent to the Swope and Limestone O_1, and the two lower recognized cycles (though minor) equivalent to the more major of the several cycles in the other two regions. Thus the Lower Neverovo cycle is correlated with the Hertha and Limestone N_5^1-upper, and the Basal Neverovo cycle is correlated with the Exline and Limestone N_5^1-lower. (Some authors do not think that the thin shales separating the three limestones in Donets unit N_5^1 represent cycle boundaries; thus, if N_5^1 is a single major cycle, then the upper of the two lower poorly known beds, N_5, would be equivalent to the Exline cyclothem, because Limestone N_4 reportedly contains the highest occurrence of the conodont *Neognathodus* in the Donets Basin, and lines up well with the Glenpool cycle of the Midcontinent, which carries the highest definite occurrence of this genus in the Midcontinent.) Although most of the conodonts that dominate these cyclothems are not similar to those that dominate their scale-positional equivalents in the other regions, particularly the Midcontinent, some distinctive forms are found at the same levels. The Basal Neverovo contains a grooved form that closely resembles *I. eccentricus*, which first appears in the Exline. The Middle and Upper Neverovo contain forms that closely resemble *S. cancellosus*, which first appears in the Swope. A large-lobed form that closely resembles type *I. sulciferus* in the Swope occurs in the Middle Neverovo and Limestone O_1. *I. sagittalis*, however, occurs only in the younger, major cycles in Russia and the Donets Basin, whereas it first appears in older lesser cycles in the Midcontinent, probably because the southern Midcontinent where these cycles are best developed was more basinward, hence deeper-water than the equivalent cycles in Russia and the Donets Basin.

Larger fusulines are absent for several cycles below the Swope—Mid-Neverovo—O_1 cycle, except for rare primitive *Montiparus* [an early triticitid] in the Basal Neverovo cycle. Those that appear in the Swope—Mid-Neverovo—O_1 cycle are provincial, with *Eowaeringella* in the Swope, typical *Montiparus* in the Mid-Neverovo, and advanced protriticitids in O_1 (Fig. 1). This fusuline provinciality within eastern Europe had confounded the compatible conodont faunas there until recent discovery of a primitive triticitid [*Triticites*?] among the dominant protriticitids in Limestone O_1, suggesting that the protriticitids persisted longer in the Donets Basin than on the Russian Platform. Only in the Dennis—Upper-Neverovo—O_2 cycle do the fusuline faunas become less provincial, with advanced *Montiparus* in both east European regions and "post-primitive" *Triticites* in the Midcontinent, which helps to strengthen this correlation. The diachronous nature of the protriticitids in this part of the succession and their earlier apparent diachroneity in stage of evolution at the level of the current base of the Kasimovian argues against using these benthic fossils as boundary marker events to define global stages.

Successions in which cyclothems are not well recognized were correlated into the cyclothem framework using appearances of conodont species supplemented by fusulines (Fig. 1). In the Dalniy Tyulkas-2 section in the southern Urals, the succession of interbedded cherty limestone, siliceous marl and shale contains no obvious terrestrial deposits, exposure surfaces, or recognizable lithic cycles. However, the conodont succession of first appearances of *S. subexcelsus* in bed 15, *Sw. nodocarinata*? in bed 19, *Sw. makhlinae* (Alekseev and Goreva 2001) in bed 25, and *I. sagittalis* in bed 34 indicate correlation of this ~3 m part of the section, respectively, with the ascending major Altamont—Suvorovo—N_3^1 cyclothem, Lost-Branch—Voskresensk—N_3^3 cyclothem, and the set of cycles culminating with the Swope—Mid-Neverovo—O_1 cyclothem succession.

In the Las Llacerias section in the Cantabrian zone of northern Spain, the thick succession of fusuline-bearing, locally shaly limestone contains no obvious terrestrial deposits or lithic cycles, but modern exposure is not good enough to rule out exposure surfaces. Conodonts are sparse, but the appearance of *I. eccentricus* in sample 9030 followed by possible *I. sagittalis* and *S. neverovensis* Goreva and Alekseev 2005 in sample 9035, about 14 m higher, suggest correlation of this part of the section with the Exline—Basal-Neverovo—Lower N_5^1 cyclothem and the Hertha—Lower Neverovo—Upper N_5^1 cyclothem, respectively (Fig. 1). This is supported by the appearance of primitive *Montiparus* in sample 9034 and advanced *Montiparus* in samples 9038-9047. The latter indicates correlation with the Mid-Neverovo cyclothem in Russia, considering the higher appearance ofprimitive *Triticites*? *leciae* van Ginkel and Villa 1999 in samples 9046-9047 and in Donets Limestone O_2, which is considered correlative with the Upper Neverovo in Russia. The older ascending succession of primitive protriticitids in samples 9010-9012 and typical protriticitids in samples 9017-9026 suggest correlation, respectively, with the Middle and Upper Peski cycles plus Donets Limestone N_3, and the Suvorovo and Voskresensk cyclothems in Russia.

In the tectonically complex Carnic Alps, where siliciclastic/carbonate cyclothems are recognized locally (Massari et al., 1991), Forke and Samankassou (2000; updated by Forke and Luppold herein) reported from the lower Auernig Group an ascending faunal succession of: [1] conodonts resembling *I. expansus* and *Sw. makhlinae* plus protriticitids, [2] forms resembling *S. cancellosus* and *S. neverovensis* plus advanced protriticitids and primitive *Montiparus*, and [3] forms resembling *S. confragus* plus *Montiparus subcrassulus* Rozovskaya 1950. This succession correlates, respectively, with [1] the Lost Branch—Voskresensk—N_3^3 cyclothem, [2] the Hertha—Lower Neverovo—N_5^1 cyclothem and/or the Swope—Mid-Neverovo—O_1 cyclothem, and [3] the Dennis—Upper Neverovo—O_2 cyclothem.

Kasimovian-Gzhelian Boundary

Using the same assumptions as guidelines, adding the north-central Texas succession for its ammonoid information, and eliminating the Spanish Cantabrian succession where the sparse conodonts are not yet known to be helpful, the following correlations are made across the Kasimovian-Gzhelian boundary (Fig. 2): The major North American Midcontinent Oread cyclothem and Texas Finis cyclothem are correlated with the major Upper Rusavkino cyclothem of Russia and Donets Basin Limestone O_7, based on the first (and last) appearance of the distinctive conodont *Idiognathodus simulator* (Ellison 1941) [sensu stricto] in all regions. Correlation of the Oread with the Finis cyclothem is strongly supported by the first appearance of the ammonoid *Vidrioceras uddeni* Bose 1919 in both (Boardman and Work, 2004). Two major cyclothems below this correlated cyclothem, the Midcontinent Stanton and Texas Merriman-Upper Winchell cyclothems are correlated with the Russian Troshkovo cyclothem, based on the first appearance of the probable ancestor of *I. simulator* [s.s.], which is termed *I.* aff. *simulator*, and is currently under study by Barrick, Boardman, and Heckel. The major cyclothem between these two correlated cyclothems, the Midcontinent Cass cyclothem is correlated with the Lower Colony Creek cyclothem of Texas by the appearance of the ammonoids *Eovidrioceras conlini* (Miller and Downs 1950) and *Pseudaktubites stainbrooki* (Plummer and Scott 1937) in both, and with the Lower Rusavkino cyclothem of Russia by the first occurrence of the conodont *Streptognathodus zethus* Chernykh 1987 in both. The next major cyclothem above the Oread—Upper-Rusavkino—O_7 cyclothem, the Midcontinent Lecompton and Texas Necessity cyclothems are correlated by the presence of *I. tersus* Ellison 1941, *S. ruzhencevi* Kozur 1977 and *S. vitali* Chernykh 2002, and these are correlated with the Amerevo cyclothem of Russia by the appearance of *S. ruzhencevi* and *S. vitali*. Donets Limestone P_1 is correlated with the Amerevo of Russia by the first appearance of the fusuline *Rauserites stuckenbergi* (Rauser-Chernousova 1938), but the conodonts are not yet studied.

The succession of cyclothems below the Stanton—Troshkovo cyclothem (Fig. 2) and above the Dennis—Upper Neverovo—O_2 cyclothem (top of Fig. 1) is well correlated between the North American regions in terms of both conodonts and scale of the major cyclothems. The Midcontinent succession of five intermediate and major cyclothems lines up well by position with the five cyclothems in Russia, with only the third cyclothem upward (the minor Presnya) not at the same relative scale as its positional equivalent (Iola) in North America. The conodont succession in the Donets Basin above and below the appearance of *I. simulator* in Limestone O_7 is not as well known as it is across the Moscovian-Kasimovian boundary, so the Donets units are correlated mainly by a combination of position and scale, along with preliminary data on the conodonts. Correlating Limestone O_5 with the Stanton—Troshkovo cyclothem because O_5 contains the first definite *I.* aff. *simulator*, which first appears in this cyclothem in North America, provides a reasonable distribution of the remaining Donets cycles. We correlate Limestone O_6 with the South Bend cyclothem and O_6^1 with the Cass—Lower Rusavkino cyclothem, because we believe that the South Bend cyclothem is more widespread than the Toronto cyclothem, with which O_6^1 would be correlated if O_6 were correlated with the Cass—Lower Rusavkino cyclothem. Below O_5, eight Donets limestones line up fairly well with the nine cyclothems of all scales in Midcontinent North America, and with major cycle O_4^1 equivalent to the lower of the two major Midcontinent cyclothems (Dewey), with which the single major Russian cyclothem (Mestsherino) correlates.

Among fusulines, correlation of the Donets succession with that in the Moscow area of Russia is not clear. *Rauserites rossicus* (Schellwein 1908) first appears in the Gzhel section near Moscow with *I. simulator* in the Upper Rusavkino, but it first appears in Donets Limestone O_5, the likely Troshkovo equivalent, where it is noted as primitive, and Davydov believes that the *R. rossicus* at Gzhel are most closely related to those in O_7 (hence noted as advanced in Fig. 2). Other fusulines, such as *Jigulites makbalensis* Davydov 1986, which is considered Gzhelian, is reported to appear in Donets Limestone O_5, and with *I. simulator* in bed 7 at the Nikolsky section in the southern Urals (see below), and thus would suggest that the Donets cycles should all be raised higher. Assuming that O_7 with *I. simulator* is properly positioned and matching major with intermediate or major cycles in scale, this would bring O_6^1 up to the level of the Toronto and Mid-Rusavkino, O_6 up to the level of the Cass and Lower Rusavkino, O_5 up to the level of the Iatan, and one of the higher O_4 limestones up to the level of the Stanton and Troshkovo, but *J. makbalensis* in O_5 would still be well below the base of the Gzhelian as recognized elsewhere. We rely on the conodonts along with cycle scale as the primary basis for the correlation shown in Figure 2, but we cannot rule out the possibility that syndepositional tectonic activity distorted the scale of the cycles in the Donets Basin.

Correlation of the successions in which cyclothems are not identified is based mainly on the succession of conodonts, again using fusulines where they appear helpful. In the Dalniy Tyulkas-2 section of the southern Urals, the upward appearances of *S.*

KASIMOVIAN-GZHELIAN BOUNDARY BEDS CYCLOTHEM CORRELATION CHART

N. AM. MIDCONTINENT Cyclothems **[MAJOR (core shale)**, Intermediate, Minor]	**NORTH-CENTRAL TEXAS** [same scaling as midcontinent]	**MOSCOW BASIN** **[MAJOR**, lesser cycle]	**DONETS BASIN, Kalinovo** **[MAJOR**, lesser cycle]	**SOUTHERN URALS** **D. Tyulkas-2; Usolka**	**SOUTH URALS** **Nikolsky**
LECOMPTON (Queen Hill): *I. tersus, S. pawhuskaensis, S. ruzhencevi, S. vitali* ---------- nondiagnostic ammonoids	**NECESSITY**: *I. tersus; S. vitali, S. pawhuskaensis, S. ruzhencevi* ---------- amm. *Shumardites simondsi*	**AMEREVO**: *S. ruzhencevi, S. vitali* ---------- fus. *Raus. stuckenbergi*	P_1: [conodonts not studied] ---------- fus. *Rauserites stuckenbergi*	DT-2 bed 47: fus. *Rauserites stuckenbergi*	Bed 12: *S. vitali* [or younger?] Bed 10: fus. *R. stuckenbergi*
Spring Branch: *I. tersus, S. pawhuskaensis*	Bunger: *S. pawhuskaensis*	[not identified]	[not identified]		
Clay Creek: *I. tersus, S. pawhuskaensis*	North Leon: [not known]	[not identified]	[not identified]		
OREAD (Heebner): **type *I. simulator***, *I. tersus, S. firmus, S. pawhuskaensis* ---------- amm. *Vidrioceras uddeni*	**FINIS**: ***I. simulator***, *I. tersus, S. firmus, S. pawhuskaensis* ---------- *V. uddeni, S. cuyleri, E. conlini*	**UPPER RUSAVKINO**: ***I. simulator***, *I. tersus, S. firmus, S. pawhuskaensis* ---------- fus. *Rauserites rossicus*	O_7: dominantly flat forms; ***I. simulator***, *S. firmus* ---------- fus. advanced *R. rossicus*	DT-2 bed 46; Us. bed 4-2: ***I. simulator*** **[traditional base of**	Bed 7: ***I. simulator*** ---------- fus. *Jigulites makbalensis* **Gzhelian in Urals]**
PROPOSED	**BASE OF**	**GZHELIAN**	**STAGE**		
Toronto: *S. pawhuskaensis*	Home Creek: *S. pawhuskaensis*	Middle Rusavkino: *S. firmus, S. zethus*	[not identified]		
Amazonia: *S. pawhuskaensis*	Upr. Colony Ck: [no conodonts]	[not identified]	[not identified]		
CASS (Little Pawnee): *S. pawhuskaensis, S. zethus, S. firmus;* rare *I.* aff. *simulator* transitional to *I. simulator* ---------- ammonoids *Pseudaktubites stainbrooki, Eovidrioceras conlini*	**LOWER COLONY CREEK**: *S. pawhuskaensis, S. zethus?* ---------- amm.*Pseudaktubites stainbrooki, Eovidrioceras conlini*	**LOWER RUSAVKINO**: *S. zethus, S. firmus, S. pawhuskaensis* ---------- fus. rare, poorly known	O_6^1: dominantly flat forms *I.* aff. *simulator; S. firmus* ---------- fus. primitive *R. rossicus; Jigulites makbalensis*	Us. bed 4-1: type *S. zethus* [possibly reworked] DT-2 bed 42: *S. zethus, I.* aff. *simulator*	Bed 6: fus. *Raus. variabilis, R. quasiarcticus*
[base of regional	**Virgilian Stage]**	**[tradit. base of Gzhelian]**			
Westphalia: *S. pawhuskaensis*	Uppermost Ranger: *S. pawhusk.*	[not identified]	[not identified]		
Iatan: *S. pawhuskaensis, S. firmus*	Upper Ranger: *S. pawhuskaensis, S. firmus*	[not identified]	[not identified]		
South Bend (Gretna): *S. firmus;* first *S. pawhuskaensis;* rare *I.* aff. *simulator*	Lower Ranger: *S. firmus, S. pawhuskaensis*	[not identified]	O_6: dominantly flat forms; *S. firmus?*		Bed 5: *S. firmus, S. pawhuskaensis*
STANTON (Eudora): *S. firmus* in top; type *I.* aff. *simulator; S. gracilis* group in base ---------- amm. *Pseudaktubites newelli*	**MERRIMAN-U. WINCHELL**: *I.* aff. *simulator; S. firmus* ---------- juvenile ammonoids only	**TROSHKOVO**: *I.* aff.*simulator; Gondolella* ---------- fus. rare *R. quasiarcticus*	O_5: *S. firmus* [including type], rare *I.* aff. *simulator* ---------- fus. primitive *R. rossicus; Jigulites makbalensis* **[inferred base of Gzhelian]**		
Plattsburg (Hickory Creek): *S. gracilis* group	Mid-Winchell: *S. gracilis* group	Myasnitskaya: *Idiog. + Str.*	O_4^6: *I. toretzianus, S. firmus*		
Farley: rare *S. gracilis* group	[not identified]	[not identified]	O_4^5: [poorly known]		
Wyandotte (Quindaro): *S. gracilis* group	Lower Winchell: rare conodonts	Sadovaya: rare *Idio. + Str.*	O_4^4: [poorly known]		
IOLA (Muncie Creek): *S. gracilis* group; *I.* 'postmagnificus', other flat forms	**LWR WOLF MOUNTAIN**: type *S. elegantulus, S. gracilis*	Presnya: *S. isakovae, I. toretzianus*	O_4^3: dom. troughed forms [type *S. kalitvensis*]		
Mid-Chanute: [no conodonts]	[not identified]	[not identified]	O_4^2: no conodonts		
DEWEY (Quivira): *S. gracilis* group; *I. magnificus,* other flat forms, *Gondolella*	**MID-POSIDEON**: *S. gracilis* gp.; type *I. magnificus; Gondolella*	**MESTSHERINO**: *I. mestsherensis, S. isakovae; Gondolella*	O_4^1: trough. fms; [1st *S. firmus*], [type *I. bachmuticus*], [type *I. toretzianus*]		
Drum-Westerville: *S. gracilis* group	[not identified]	[not identified]	[not identified]		
Cherryvale (Wea): *S. gracilis* group	Lower Posideon: *S. gracilis* gp.	Perkhurovo: flat forms; *S. neverovensis*	O_4: dom. troughed forms fus. *R. aff. rossicus,* etc.		
Hogshooter: some flat forms; some transitional to *S. gracilis* group	Lowermost Posideon: [poorly known]	[not identified]	O_3: flat + troughed forms fus. *Quasifusulina, Quas'oides*		

P. H. Heckel, July 28, 2005

zethus and *I.* aff. *simulator* in bed 42, of *I. simulator* in bed 46, and of the fusuline *Rauserites stuckenbergi* in bed 47, indicate correlation of this part of the succession, respectively, with the Cass—Lower Rusavkino cyclothem, the Oread—Upper Rusavkino—O_7 cyclothem, and the Lecompton—Amerevo cyclothem (Fig. 2). In the nearby Usolka section of shaly carbonates, the presence of type *S. zethus* in bed 4-1, and the appearance of *I. simulator* in bed 4-2 suggest correlation of this part of the section with the Cass—Lower Rusavkino and Oread—Upper Rusavkino—O_7 cyclothems, respectively. In the detrital siliciclastic Nikolsky section not far away, the presence of both *S. firmus* Kozitskaya 1978 and *S. pawhuskaensis* (Harris and Hollingsworth 1933) in bed 5, the appearance of *I. simulator* in bed 7, the appearance of *R. stuckenbergi* in bed 10 and the appearance of *S. vitali* in bed 12, suggest correlation of this part of the succession, respectively, with the South Bend cyclothem of the Midcontinent (and possibly Donets Limestone O_6), the Oread—Upper Rusavkino—O_7 cyclothem, and the Lecompton—Amerevo cyclothem, although bed 12 could be younger.

In the Carnic Alps, the presence of *S. elegantulus* Stauffer and Plummer 1932, *I. magnificus* Stauffer and Plummer 1932, and *I. bachmuticus* Kozitskaya 1978, plus *Rauserites* including aff. *rossicus* and *Quasifusulina eleganta* Schlykova 1948 in the lower "Rosskofel Limestone" indicate correlation somewhere within the group of cyclothems below the Stanton—Troshkovo cyclothem. Disconformably above this, a bed with *S. zethus* and *S. pawhuskaensis* plus *Rauserites* aff. *rossicus* and *Quasifusulina* sp. may correlate with the Cass—Lower Rusavkino cyclothem. In the Cantabrian zone of Spain, fusuline faunas of the upper Puentelles Formation that include *Rauserites rossicus* and *R.* cf. *stuckenbergi* may correlate with the Oread—Upper Rusavkino—O_7 or younger cyclothems.

Potential Global Boundary Levels

The relative ease of correlation of the Oread—Upper Rusavkino—O_7 cyclothem by means of the first appearance of *I. simulator* [s.s] in all regions above strata that contain the first appearance of *S. zethus* and *I.* aff. *simulator* (including a specimen that appears transitional to *I. simulator* [s.s.] in the Midcontinent Little Pawnee Shale) indicates that this appearance would provide a good marker event for defining the base of the Gzhelian Stage. The appearance with *I. simulator* in this cyclothem in Texas and the Midcontinent of the ammonoids *Vidrioceras uddeni* and *Shumardites cuyleri* Miller and Downs 1950, the earliest species of these genera that have often been used to mark the base of the Gzhelian, serve to keep the base of the Gzhelian at its traditional position in terms of the classic ammonoid zonation. So far, the occurrences of some fusulines are not consistent with this correlation, but the appearance of *Rauserites rossicus* with *I. simulator* in the Moscow region and of the most closely related, more advanced form of *R. rossicus* with *I. simulator* in the Donets Basin, provide hope that certain fusulines may aid in identifying this boundary in Eurasia.

Although the traditional Moscovian-Kasimovian boundary was originally placed at the first appearance of protriticitid fusulines, it was later stabilized in the type region around Moscow at the base of the Suvorovo Formation (Makhlina et al., 2001), where "typical" protriticitids appear, above primitive protriticitids in the underlying Peski Formation. While some workers wish to keep the base of the Kasimovian at or near this level, the difficulty of distinguishing species among the protriticitids along with their possibly diachronous appearance relative to the conodont correlation between the Russian Platform and the Donets Basin (recently shown also for the Donskaya Luka section between these two areas by Isakova et al. in this volume) have led the conodont workers and many fusuline workers to prefer a higher boundary, above the last occurrence of the conodont *Swadelina* and below the first appearance of *I. sagittalis* and the easily identified fusuline *Montiparus*.

Ironically, the widespread exposure surfaces that help to expedite correlation will make the selection of GSSPs (which require continuous sedimentation) difficult in the shelf regions where the cyclothems are well defined. However, the correlation of sections in which cyclothems are not recognized into this cyclothem framework may allow the possibility of selecting a GSSP in a section of continuous sedimentation that can be correlated globally (at least in the pantropical belt), if several conditions are met: Cyclothems are not recognized because the section was deposited at greater water depth below lowstand, the section contains a complete succession of fossils that occur also in the more shelfward regions where the correlation framework is recognized, and the section is on a slope gentle enough that the continuity is not interrupted by debris flows that may have mixed biotas of different ages.

Acknowledgments

Among the authors, Heckel coordinated and compiled information from all authors and established the correlations; Barrick and Boardman provided conodont information for the Midcontinent; Boardman and Work provided ammonoid information for the Midcontinent and perspective on ammonoids reported elsewhere; Alekseev and Goreva provided information for correlations in the Moscow region and Dalniy Tyulkas in the Urals; Nemyrovska provided conodont and cycle scale information for correlations in the Donets Basin; Ueno provided fusuline information for the Donets Basin; Davydov provided fusuline information for the Usolka and Nikolsky sections in the Urals, and for the Donets Basin; Chernykh provided conodont data for the Usolka and Nikolsky sections in the Urals; Villa and Mendez provided information on fusulines and conodonts, respectively, for the succession in Spain. Forke and Luppold provided information on fusulines and conodonts, respectively, for the succession in the Carnic Alps. Not all authors agree with all correlations or opinions expressed herein.

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Lower Kasimovian (Pennsylvanian) of Donskaya Luka (southern Russia)

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Introduction

Donskaya Luka is the bend of the Don River where it crosses the southern part of the Don-Medveditsa Swell in the region southwest of Volgograd. In the axial part of this swell, Middle and Upper Carboniferous (Pennsylvanian) strata crop out surrounded by Jurassic and Cretaceous rocks. The largest and most famous exposure of the Carboniferous is on the right bank of the Don River close to Kremenskaya village (Fig. 1), approximately 49°28' N and 43°32' E.

The Carboniferous succession of this area was studied extensively in the early and mid-twentieth century (e.g., S. Semikhatova, 1929, 1931, 1953; E. Semikhatova, 1939, 1946; Yarikov, 1955). It is transitional from the marginal shallow-water Moscow Basin on the north, to the paralic coal-bearing Donets Basin succession on the south. The thickness of most Carboniferous subdivisions is much greater than in the Moscow Basin, and faunal assemblages of brachiopods, bryozoans, corals, and fusulinids contain some elements typical of the Donets Basin and Volga River area as well as relatively abundant endemic species.

The Moscovian to Kasimovian transition at Donskaya Luka was described previously as more complete than in the Moscow Basin. Donskaya Luka is the type area for the "sub-*Triticites* Beds" of S. Semikhatova (1947). The faunal assemblage of these beds was used as an argument to lower the boundary of the Kasimovian Stage (and the Russian Upper Carboniferous Series) from the level of the first appearance of *Triticites* (=*Montiparus*) to the first appearance of *Obsoletes*.

Lithostratigraphy

We visited some Donskaya Luka outcrops in 2003 and 2004 to study the important Moscovian-Kasimovian boundary interval in the vicinity of Kremenskaya village, at Selezneva Ravine and just downstream on the right bank of the Don River (Fig. 1). Here we present some results. It is important to stress that previously only brachiopods and fusulinids were studied in these localities, but conodonts were not.

Carboniferous strata are cyclic at Donskaya Luka. Each cycle consists of relatively thin (0.5 to 3-4 m) transgressive bioclastic limestones with relatively abundant brachiopods, corals, and fusulinids, and thick (up to 20-30 m) very shallow-water white mudstones, often brecciated, dolomitized, and with small stromatolitic buildups at some levels. These mudstones typically contain only the brachiopod *Linoproductus*. The tops of the mudstones are erosional and represent exposure surfaces. The strata are subhorizontal, or with some dip (up to 15-20° to the south along Selezneva Ravine), but normal faults with some displacement are common. This structure, together with the monotonous succession of the similar Sukhov and Selezneva Formations, has resulted in problems with correlation of individual sections.

Biostratigraphy

The lowermost part of the succession was studied in the Don 1 section (Fig. 1). The grainstone interbeds in dolomitized mudstones of the Sukhov Formation have abundant solitary Rugosa, Tabulata, and brachiopods, and also contain the fusulinids *Fusulina intermedia* Rauser and Gryzlova, *F. pulchella* Gryzlova, *F. pakhrensis* Rauser, *F. quasifusulinoides* Rauser, *F. quasicylindrica* Lee, *Pulchrella eopulchra* (Rauser and Belyaev), *Obsoletes confusus* Kireeva, *O. callosus* Kireeva, *O.* ex gr. *dagmarae* Kireeva, *O.* aff. *rosovskaae* Kireeva, *Protriticites umbonoreticulatus* Kireeva, *Fusiella* ex gr. *typica* Lee and Chen, and *F.* ex gr. *lancetiformis* Putrja. This assemblage is transitional from late Moscovian to early Kasimovian and is close to the fusulinid assemblage from the Voskresensk Formation (upper Krevyakinian Substage, the current lower part of the Kasimovian Stage) in the Moscow Basin. Conodonts are scarce at this level, and only a few elements were identifiable as *Streptognathodus* cf. *subexcelsus* Alekseev and Goreva and *Idiognathodus* sp.

The younger Selezneva Formation (about 50 m) consists mainly of white brecciated mudstones often with

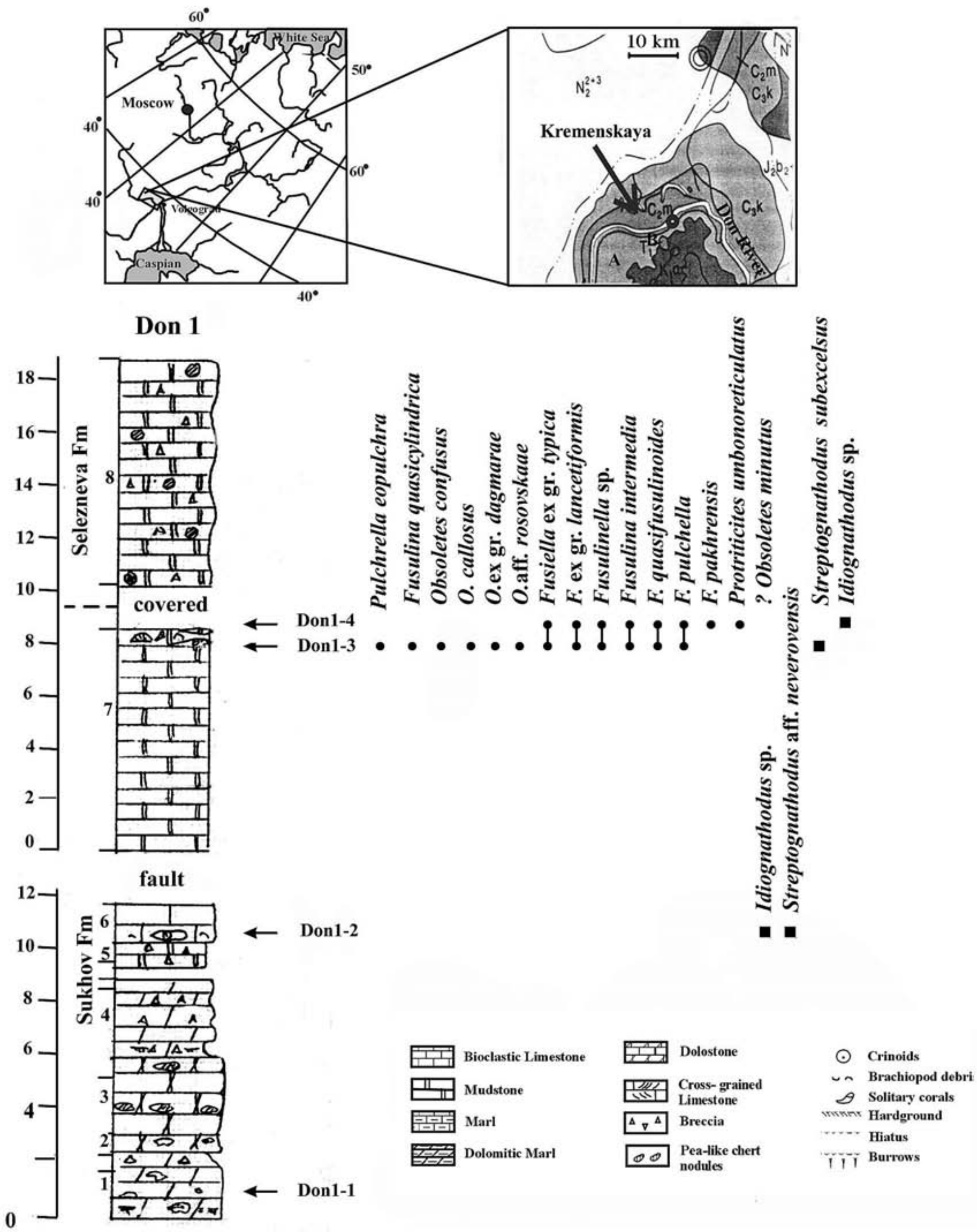

Fig. 1. Don 1 section at Donskaya Luka, on right bank of Don River near Kremenskaya village. Map shows: A — Selezneva Ravine section; B — Don 1 section.

pea-like chert nodules (Fig. 2). According to previous descriptions, thin shale horizons (1-2 m) are typical of the Selezneva, but we did not find them in the type section. The basal part of the Selezneva Formation was studied in section SZ4, where an erosional surface at the top of the white mudstones of the Sukhov (?) Formation is overlapped by a thin (up to 10 cm) green and yellow clay with limestone pebbles. This clay does not contain conodonts. The bioclastic grainstones (1.5 m) in the base of the Selezneva Formation have abundant corals and are characterized by the fusulinids *Obsoletes elongatus* Kireeva, *O. minutus* Kireeva, *O.* aff. *biconicus* Kireeva, *Protriticites plicatus* Kireeva, and *P. subschwagerinoides* Rozovskaya. Among sparse conodonts, *Streptognathodus neverovensis* Goreva and Alekseev is present. The latter species is typical of the lower Neverovo Formation (upper Khamovnikian Substage, the current middle of the Kasimovian) in the Moscow Basin.

The next transgressive level with fusulinids and conodonts is in the middle of the Selezneva Formation

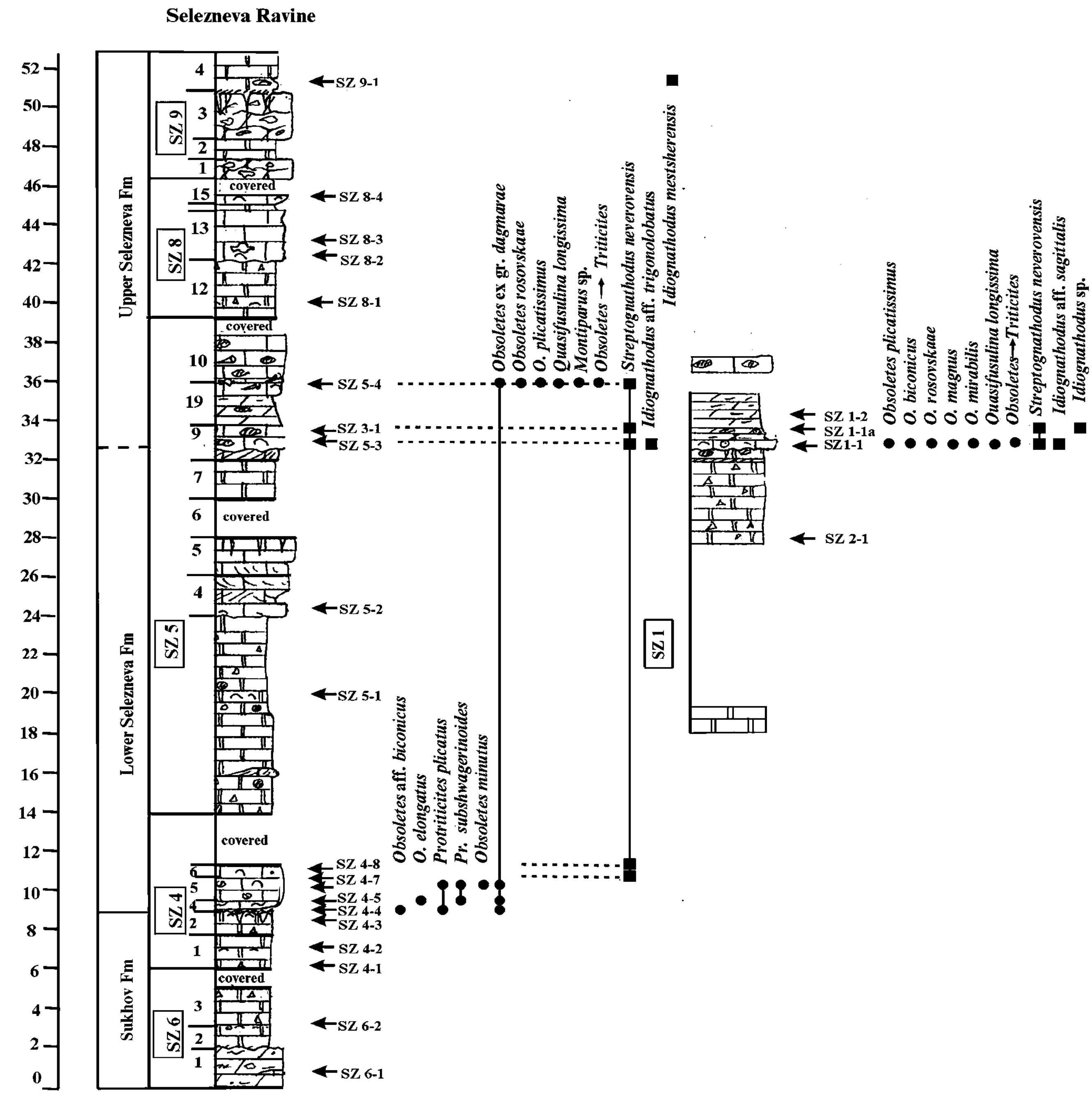

Fig. 2. Selezneva Ravine section at Donskaya Luka, on right bank of Don River near Kremenskaya village. Figure 1 shows location.

(sections SZ1, SZ3, and SZ5). Among fusulinids, species of the genus *Obsoletes* are dominant at this level: *O. biconicus* Kireeva, *O. rosovskaae* Kireeva, *O. magnus* Kireeva, *O. mirabilis* Kireeva, *O. plicatissimus* Kireeva, and *O.* ex gr. *dagmarae* Kireeva. Other fusulinids are *Quasifusulina longissima* Moeller, transitional forms from *Obsoletes* to *Triticites*, and what is most important, the first *Montiparus* sp. The same species of *Obsoletes* are present in Limestone O_1 of the Donets Basin. The conodont assemblage contains *S. neverovensis* Goreva and Alekseev, *Idiognathodus* aff. *sagittalis* Kozitskaya, and *I.* aff. *trigonolobatus* Barskov and Alekseev. Both groups, fusulinids and conodonts, confirm the correlation of this interval with the Neverovo Formation of the Moscow Basin. Rugosa in section SZ3 (not shown on Fig. 2) belong to *Bothrophyllum conicum* subsp. 1, *B. robustum* Dobrolyubova, and *Caninophyllum kokscharowi* Stuckenberg. All these taxa also are typical of the Khamovnikian. In section SZ5, a level with large solitary Rugosa, just above the fusulinid and conodont interval, contains *Siedleckia longisepta* (Greek) and "*Pseudozaphrentoides*" sp. nov.

The upper Selezneva Formation is very poor in fusulinids and conodonts. Only in the uppermost part of the formation (section SZ9), above a karstified interval (SZ9, bed 1) and just above an exposure surface in the top of bed 3, the conodont *Idiognathodus mestsherensis* Goreva and Alekseev was found (Fig. 2). This species is typical of the lower Dorogomilovian (upper Kasimovian) in the Moscow Basin (Alekseev et al., 2004).

The results of these biostratigraphic studies show that most of the "sub-*Triticites*" Beds in their stratotype are not Krevyakinian as has been widely accepted, but Khamovnikian. This fact supports the proposal to shift the lower boundary of the Kasimovian from the base of the Krevyakinian (or the *Obsoletes obsoletus–Protriticites pseudomontiparus* Zone) to some level in the Khamovnikian at the first appearance of the conodont *I. sagittalis* Kozitskaya and the fusulinid *Montiparus*.

Acknowledgments

These studies were supported by RFBR grant 03-05-64415.

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Reminiscences of W.H.C. Ramsbottom (1926–2004)

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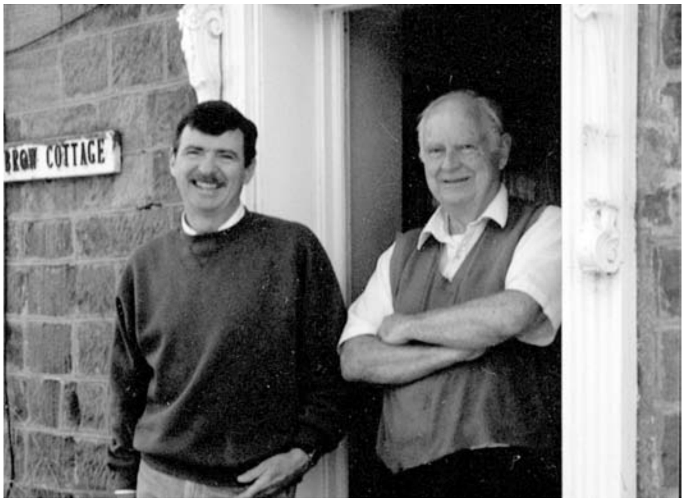
In 1971, fresh from graduate school and having completed my dissertation on Upper Mississippian ammonoids, I attended my first Carboniferous Congress in Krefeld, Germany. An afternoon Congress-cruise on the Rhine provided my first opportunity to meet many individuals otherwise familiar only as reference citations. It was also my first chance to get to know Bill Ramsbottom. In his unique, quiet, yet insistent way, he convinced me to visit him in Leeds after the Congress. This began an association with Bill as mentor, collaborator, and close friend that lasted more than three decades.

Bill grew up in Yorkshire, an area that he loved. He graduated from Clare College, Cambridge, joined the Institute of Geological Sciences, and completed his doctoral dissertation, on Ordovician crinoids. He moved to the Leeds IGS office in 1958 and purchased a Victorian red-brick house, barn, and garden, known as The Croft, in the village of Collingham, near Weatherby, about 20 minutes from Leeds. This was just down the street from W.S. Bisat, F.R.S., who was an inspiration and mentor to Bill, and whom we visited during my first visit.

Bill moved early from echinoderms to Carboniferous stratigraphy and biostratigraphy, mapping extensively in the Yorkshire region. He was promoted to a "Special Merit" position in the Survey that permitted him to conduct research full time. This was about the time that I met him, and he took it upon himself to introduce me to the ammonoid biostratigraphy of northern England. This shelf-to-basin sequence reflected largely uninterrupted deposition through the Carboniferous, contrasted to the condensed and incomplete (albeit richly fossiliferous) cratonic sections of the U.S. Midcontinent that I was familiar with.

I spent a series of summers based at The Croft in the late 1970's and 80's, often accompanied by Walter Manger, University of Arkansas. Together, we studied the historic IGS ammonoid collections, often for 12-hour daily stretches, before returning to The Croft to share evening meals with Bill and family. He loved the kitchen, and would create from apparent chaos such delightful combinations as lamb with fresh mint sauce, peas and roasted potatoes, all from his garden, followed by gooseberries and cream, then sherry and coffee served in the living room. We felt like members of the family, and saw George, Victoria, and James grow from children to adults, and even getting to know the grandchildren.



W.H.C. Ramsbottom (right) and W.B. Saunders (left) at Brow Cottage, Kirkby Malzeard, Yorkshire ca. 2000.

Bill's mind was always running at high rpm's. He had a unique way of looking at a given set of facts or a concept, sometimes discarding his ideas, at other times arriving at a whole new perspective. Thus, his view of a cyclic succession of Namurian and Dinantian stratigraphic events known as "mesothems," which were thick complete basinal successions that corresponded to condensed shelf sequences rife with unconformities, came to provide a framework for the British Carboniferous that was subsequently applied internationally.

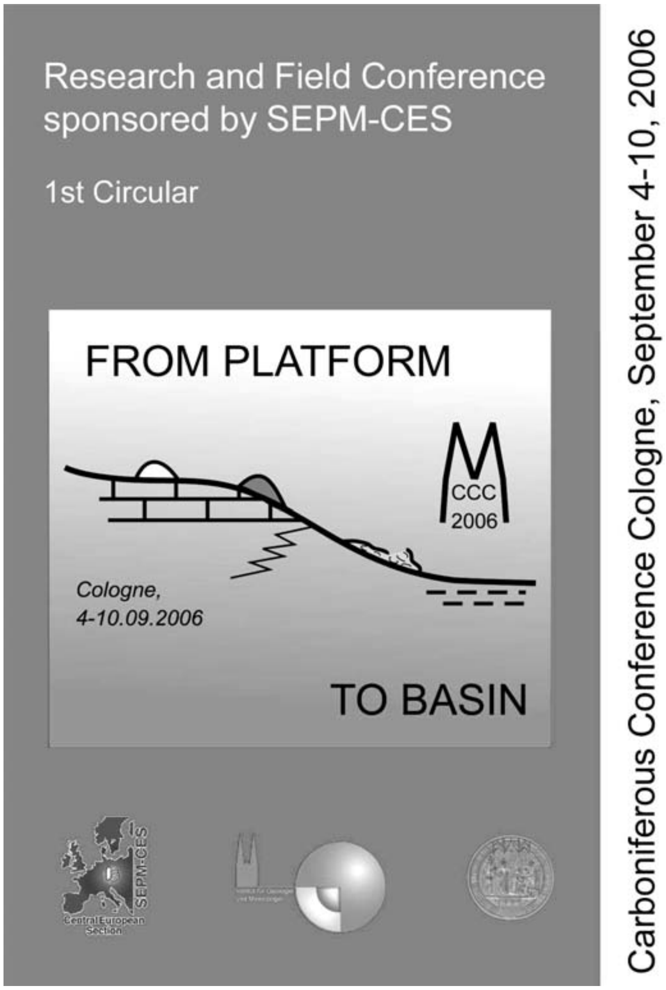
Bill insisted that Walt and I learn the British Namurian from field exposures as well as from the IGS collections. One of our first field visits was to the Irish Namurian, accompanied by Frank Hodson, Southampton University. Mindful of our tight budget, Bill joined us in sleeping on ferry deck chairs and in economy class "group lodgings," even though his IGS grade entitled him to first class accommodations. Our field work was always punctuated by history lessons and visits to historic and architectural sites. We also "re-discovered" classic ammonoid localities in Yorkshire that had not been visited since the times of such collectors as W.S. Bisat and E.W.J. Moore.

Beginning in 1976, I served as Secretary for the SCCS for almost a decade. Bill was Chair during the latter part of this tenure, and it was delightful to work with him. A major objective at that time was to try to bring some sort of consensus to then-boiling deliberations over Carboniferous subdivisions and boundary selection. What began as Working Group "discussions" often ended as shouting matches. Never once in the 35 years I knew him, did I hear Bill raise his voice; but he had a remarkable ability to restore calm, reason and direction to these meetings and the Subcommision made much headway during his Chairmanship. In 1981, together with Bernard Owens of the IGS, we organized a symposium and field meeting based in Leeds, to permit respective specialists to synthesize all available biostratigraphic data for the Mid-Carboniferous, in an effort to try to agree on a choice for the Mid-Carboniferous boundary. This led to the publication of "Biostratigraphic Data for a Mid-Carboniferous Boundary" (Ramsbottom, Saunders, and Owens, 1982) and to the formation of a committee, chaired by H. Richard Lane, to present a formal proposal for a boundary choice to be presented and voted on in Madrid in 1983. (In spite of our good intentions, it took nearly 20 years before this vote was ratified.)

Typical of Bill's creative approach, was his suggestion, one evening after dinner, that we attempt to determine the age of the youngest Mississippian and oldest Pennsylvanian in as many localities as possible (where the two are superimposed), in order to establish whether this might serve as an international datum. A week later, with the living room littered with publications, maps, and stratigraphic sections, we completed the draft of a manuscript that proposed the Mid-Carboniferous Eustatic Event, published in *Geology* in 1986. (Bill was much pleased that P.R. Vail and L. L. Sloss, father and grandfather of Sequence Stratigraphy, gave supportive reviews of the ms.)

In 1984, the Leeds office of IGS moved south to Keyworth, near Nottingham, and became the British Geological Survey. It was no surprise to me that Bill elected to take early retirement rather than move from Yorkshire. The Croft was surrendered to village sprawl and Bill moved to eighteenth century "Brow Cottage" located at the brow of a hill passing through the village of Kirkby Malzeard, near Ripon. Brow Cottage had a large attached greenhouse where he began to experiment with nasturtiums. He undertook a number of crossing experiments with different lines of this plant, including variants from South America, obtained during four visits there, including one to Venezuela with his son James. (I believe there was a paper published on the genetic results of this work, although I have not seen a copy.) At the same time, the stone barn at the rear of Brow Cottage served as a workshop where Bill both designed and manufactured grandfather-sized weight-driven clocks with wooden gears that he also designed and machined himself from exotic hardwoods. His mind was tireless. During his retirement he also undertook to make a computer-catalogue of Carboniferous foraminifers, and taught part time in the graduate programs at the universities of Sheffield and Hull.

I last visited with Bill at Brow Cottage several years ago. Though his health was beginning to fail, he was the consummate host, gentleman, and good friend… and he was still an excellent cook. I have yet to meet anyone who so loved thinking about science in new ways. His scientific accomplishments will continue to speak for themselves and his background will be detailed elsewhere. Here, I wanted to pass on some reminiscences of this quiet, friendly, persuasive, and creative individual, who did so much to influence me during the long course of our friendship.



We cordially invite you to attend the **"Carboniferous Conference Cologne 2006 (CCC-2006) – From Platform to Basin"**, a research and field conference sponsored by SEPM-CES and organised by the Institute of Geology and Mineralogy, University of Cologne**, September 4 – 10, 2006**.

CCC-2006 succeeds the meetings in Manchester (European Dinantian Environments 1984), Dublin (European Dinantian Environments 2, 1994), and El Paso (SEPM & IAS: Permo-Carboniferous Carbonate Platforms and Reefs, 2000), which strongly promoted research on a wide range of topics in Carboniferous geology. We venture to take up these roots and motivate young scientists and established colleagues to present and discuss their research results in Cologne. We offer the opportunity to experience state-of-the art results on platform and basinal facies on field trips to the classical central European Mississippian in the Belgian Ardennes and the Rhenish Slate Mountains.

See you in Cologne in September 2006!
Hans-Georg Herbig and Markus Aretz

Venue

Cologne is an ideal meeting place situated in the heart of Europe. It is easily reached by plane, train, and car from derivations worldwide.

The city, one of the largest in Germany, has more than 1 million inhabitants. Since its foundation by the Romans, 50 BC, it has been an important traffic junction and trading place. Famous for its cathedral, Cologne offers a wealth of innumerable cultural and historical treasures, world-famous museums and an active art scene.

From venerable breweries offering unique Kölsch beer and typical Cologne delicacies to first-class restaurants the city is one of Germany's leading gastronomic lights. Life in Cologne is uncomplicated and vivacious - the tolerance and cosmopolitanism of its inhabitants are proverbial. More than 49,000 students at Cologne University contribute to the young flair of the city and make the university one of the largest in Germany. Scenic landscapes including the Middle Rhine valley, a UNESCO world heritage since 2002, offer splendid touristic highlights near-by.

Host and Conference Language

The CCC-2006 will be held at the Institute of Geology and Mineralogy, Cologne University from September 6-8, 2006. The official conference language will be English - no translation facilities will be available.

Program

Main focus of the conference will be the topic "**From Platform to Basin**". Platform-basin transitions are critical interfaces displaying gradual to abrupt changes in sedimentary facies, biota, geochemical gradients, etc. Many phenomena and processes are restricted to platform-basin transitions which, moreover, might change their profile in time due to sedimentary and tectonic processes and sea-level variations. Processes acting on adjacent platforms and basins under different climatic regimes are often intimately connected across the slope and are crucial for correlation and better understanding of the complexly controlled and reacting system. Though it is intended to concentrate on the Carboniferous due to its peculiar characters in climate and advancing orogenies, contributions from adjacent time slices are welcome.

Scientific answers to the open questions should be presented in the suggested scientific sessions.

S-1: Facies patterns: Platforms, basins and their interfaces

S-2: Bioconstructions and bioconstructors across platform-basin-transects

S-3: Reconstruction of sedimentary environments, climates and palaeo-oceanography, I: geochemical proxies

S-4: Reconstruction of sedimentary environments, climates and palaeo-oceanography, II: marine faunas in greenhouse and icehouse climates

S-5: Multistratigraphic correlation of platform and basin

S-6: Sequence stratigraphy and eustacy

S-7: Basin evolution in front of prograding orogenic belts

S-8: Diagenesis and reservoirs

S-9: Open themes

S-X: If you are interested in convening a further session, please contact the organizers and reservoirs

Field Excursions

Pre-Conference Field Trip (Sept. 4-5, 2006): From palaeokarst to calci-turbidites - a carbonate platform-slope–transect from the Mississippian Limestone in eastern Belgium to the Culm Basin in western Germany.

Leaders: E. Poty (Liège), M. Aretz and H.-G. Herbig (Cologne)

Post-Conference Field Trip (Sept. 9-10, 2006): The mixed carbonate-siliciclastic facies of the Mississippian Culm Basin, Rhenish Slate Mountains – complex interplay of platform, starved basin and prograding orogeny.

Leaders: H.-G. Herbig (Cologne), M. Amler (Marburg) and D. Korn (Berlin)

Presentation

Oral presentations are scheduled for 20 minutes including five minutes for discussion. Overhead and slide projection will be available, but PowerPoint presentations are preferred. Participants are encouraged to display posters. We will provide sufficiently time for presentation and discussion. Two boards, each A0 format, are available for your presentation.

Abstracts, Field Guides and Congress Proceedings

Abstracts and Field-Guides will be published as volumes in the ISSN-coded series of the institute, "Kölner Forum für Geologie und Paläontologie".

We seek arrangements to publish selected papers from the conference proceedings in a first-class international journal.

Congress Fees

All efforts will be made to keep costs affordable. Reduced fees will be available for SEPM-CES members. For membership application please refer to: http://sepm-ces.uni-frankfurt.de

Since the conference will be held with our staff in the buildings of the institute, most costs have to be calculated for the field trips. We will give detailed information in the second circular based on approximate numbers of participants.

Social Program

Besides ice-breaker party and conference dinner we will organize guided city tours in Cologne and a River Rhine cruise.

Accommodation

Conference participants are responsible for making their own accommodation arrangements. Cologne offers a wide selection from reasonable hotels starting at 40 €/night up to first class hotels. We will give a list of hotels with special arrangements in the second circular. The well-organized public transport will guarantee easy access to the conference location.

Important Dates (deadlines)

Reply to the 1st Circular	01.07.2005
2nd Circular	Sept. 2005
Registration	01.03.2006
All Fees (Registration, Field trips)	15.04.2006
Abstracts	01.06.2006

Contact

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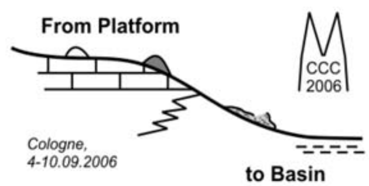

Pre-Registration

Carboniferous
Conference Cologne
sponsored by SEPM-CES

September 4 – 10, 2006

Name, Title: ....

First name: ....

Affiliation: ....

....

Address: ....

....

City ....

Postal Code ....

Country ....

Phone / Fax .... / ....

email ....

I intend to submit an abstract for a talk ☐ and/or a poster ☐

in the session .... (please indicate code) with the provisional title

....

....

....

I intend to take part in the

Pre-conference field trip (eastern Belgium to Culm Basin)	yes	no
Post-conference field trip (Culm Basin, Rhenish Slate Mountains)	yes	no

Please send back the reply form by fax or e-mail before July, 01 2005: The Second Circular will only be sent to those who have indicated their interest.

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