# Table of Contents

CHAIRMAN'S COLUMN .............................................................................. 1  
SECRETARY / EDITOR'S REPORT 2000-2001 ........................................... 3  
SCCS ANNUAL REPORT 2000 ..................................................................... 4  
WORKING/PROJECT GROUP REPORTS ...................................................... 7  
  Progress report of the Working Group to establish a boundary close to the existing  
  Tournaisian-Viséan boundary within the Lower Carboniferous. ............. 7  
  Working Group to define a GSSP close to the Moscovian / Kasimovian boundary  .......................................................... 8  
  Project Group 4: Zonation in Late Namurian successions: the Bashkirian Stage as a  
  geochronological standard .................................................................. 11  
CONTRIBUTIONS BY MEMBERS ............................................................... 12  
  New proposal for series and stage subdivision of Carboniferous System (Heckel) 12  
  Stage subdivision of the Carboniferous System (Alekseev) .................... 14  
  More radiometric ages for the Carboniferous time scale (Menning et al.) .......... 16  
  Refinement in the age of the Carboniferous - Permian boundary based on U-Pb dating of  
  biostratigraphically constrained syn-sedimentary carbonates in the Appalachian  
  region of North America (Becker et al.) .............................................. 18  
  Toward a Carboniferous tetrapod biochronology (Lucas) ......................... 20  
  Report on the Annual Meeting of the German Subcommission on  
  Carboniferous Stratigraphy (Amler) .................................................. 23  
  Position of Kinderhookian-Osagean boundary in northeastern  
  Kentucky and southern Ohio (Sandberg et al.) .................................... 23  
  Tournaisian-Viséan boundary in Mokra near Brno (Czech Republic) (Ondrackova) .............................................................. 24  
  New data on conodonts and foraminifera from the Tournaisian-Viséan boundary beds  
  of the Kokshaaltau Range (South Tien-Shan, Kyrgyzstan) (Djenchuraeva et al.) .............................................................. 26  
  Fauna and sedimentation near the Viséan/Serpukhovian boundary  
  (Izyayu River section, Tchernyshev Swell, Subpolar Urals) (Kossovaya et al.) 29  
  Foraminiferal biostratigraphy of the Serpukhovian Stage stratotype  
  (Zaborie quarry, Moscow Basin) (Gibshman) ...................................... 31  
  Problems in Lower Serpukhovian ammonoid biostratigraphy (Nikolaeva and Kullmann) .......... 35  
  Integrated Serpukhovian biostratigraphy in the South Urals (Nikolaeva et al.) .............................................................. 38  
  The Carboniferous - Early Permian marine domain in western Argentina (Taboada) ...................................................... 43  
  New data on the Late Palaeozoic glaciations in Argentina (González) ........ 44  
  Exposures of the Westphalian Series in the Upper Neath Valley, South Wales (Evans et al.) ...................................................... 45  
  Climatic and vegetational changes in Late Carboniferous tropical forests -  
  a NATO-funded project (Cleal et al.) ................................................ 47  
  Microspores or pollen? (Zodrow et al.) ................................................. 49  
  Provisional Lower and Middle Pennsylvanian conodont zonation in Midcontinent  
  North America (Lambert et al.) ....................................................... 50  
  The Moscovian Stage - What is it?  
  An offer to recommend operation of a project group (Fissunenko) ............ 56  
  Fusulinid and conodont zonation of the type Moscovian Stage (Isakova et al.) .............................................................. 57  
  The terminal stage of the Carboniferous: Orenburgian versus Bursumian (Davydov) ...................................................... 58  
  Report on the Carboniferous-Permian boundary in the Bohemian Massif (Simunek) ...................................................... 64  
  Short report to SCCS, May 2001 (Turner) ............................................. 67  
PUBLICATIONS BY SCCS MEMBERS ..................................................... 68  
FORTHCOMING CONFERENCES ............................................................. 69  
SCCS VOTING & CORRESPONDING MEMBERSHIP 2001 ......................... 70  
SCCS OFFICERS AND VOTING MEMBERS 2000-2004 .......................... 79
CHAIRMAN’S COLUMN

The last couple of years have been turbulent ones within the SCCS as outlined in the Chairman’s Column and the Secretary/Editor’s Report 1999-2000, published in last year’s issue of this Newsletter [July 2000, 18: 1-3]. A brief summary of the earlier history of actions taken by the SCCS shows that the SCCS voted overwhelmingly in 1987 to recognize the Carboniferous as a single system with two basic subdivisions ranked as subsystems [1988 Carboniferous Newsletter, 6: 12-13], but with the names of the subsystems left open. In 1995 the SCCS voted and the ICS ratified the selection of the Mid-Carboniferous boundary in Arrow Canyon, Nevada, USA, at a stratigraphic position that essentially coincides with the Mississippian-Pennsylvanian boundary as consistently used for many years in the USA. In 1998, the SCCS in close votes rejected the ambiguous terms Lower and Upper Carboniferous, while voting in favor of using the names Mississippian and Pennsylvanian for the two subsystems. Because the latter vote was just short of the 60% statutory majority of votes needed for a final decision, a second vote was required by ICS statutes to finalize this decision. This second vote was not held, apparently because of perceived problems with lack of space for subsystems on the International Stratigraphic Chart, which was then in the process of being drafted. The question of rank of the two basic subdivisions of the Carboniferous was reopened at the SCCS meeting at the XIV International Congress on the Carboniferous-Permian in Calgary in 1999, with no clear consensus emerging in a chaotic informal vote by show of hands among all who were present at the general meeting. The formal ballot sent to SCCS titular members in late 1999 dealt with the rank of the two basic subdivisions [an issue previously settled by an overwhelming formal recorded SCCS vote], rather than the second vote on the names for the subdivisions that is required by ICS statutes. Therefore the ICS Bureau stepped in and replaced the ballot on rank alone with a ballot containing the second vote on the names of the subdivisions as Mississippian and Pennsylvanian, and including a reconfirmation of their previously established ranks as subsystems. Both issues carried by a large majority of the votes cast, as shown in the 2000 Secretary/Editor’s Report.

In balloting that took place in 1999 and 2000, I was elected Vice-Chair, and George Sevastopoulos was elected Chair of the SCCS. Unfortunately, Dr. Sevastopoulos had to withdraw from the Chair-elect position for health-related reasons just prior to the International Geological Congress in Brazil in August 2000, where the elected positions were to become official. Because there was not sufficient time for a new election for Chair prior to the IGC meeting, the ICS Bureau decided that as Vice-Chair-elect, I should assume the position of Chair. I accepted this position in order to maintain some sense of stability within the SCCS and because I am strongly in favor of trying to achieve as much consensus as possible on the many outstanding problems facing the SCCS. I appointed David Work of the Cincinnati Museum as Secretary of the SCCS, and in balloting that took place in 2000-2001, Geoffrey Clayton was elected Vice-Chair of the SCCS. As a result of clarification of the issue in a recent revision of the ICS Statutes mandated by the IUGS, Commission and Subcommission secretaries who are appointed from outside the regularly elected voting membership automatically have voting membership in that body. Therefore Dr. Work is the 21st voting member of the SCCS. We all look forward to serving the titular and corresponding membership of the SCCS for the next few years. We wish to thank former Chair John Roberts for his many years of service to the SCCS and for his leadership in encouraging the various working and project groups to make progressive definitions and boundaries within the Carboniferous System. We also wish to thank former Secretary Ian Metcalfe for his many services to the SCCS over the past four years, and especially his timely publication of excellent editions of the Newsletter on Carboniferous Stratigraphy.

Deadline for GSSP Placement

I have recently received word from the Executive Board of the ICS stating explicitly that “The IUGS Executive Board directed ICS to have completed the entire suite of GSSP placements by 2008, with the majority of the geological periods having fully defined stages by 2004.” Because the IUGS is the source of funding for ICS and hence the major source of funding for SCCS, we must pay close attention to this directive. The SCCS [and adjoining subcommissions] have so far selected only the lower and upper boundaries of the Carboniferous System and the Mid-Carboniferous boundary between the Mississippian and Pennsylvanian Subsystems. Therefore our Working and Project groups have a large amount of work to do in a relatively short period of time, considering the past history of Subcommission decisions. In view of this, I direct your attention to the article by Manfred Menning and others in the July 2000 Carboniferous Newsletter [18: 8-9] on the desirability of having relatively few stages in the Carboniferous, as in the adjacent Devonian and Permian Systems, rather than the large number of stages that have been established in the western European Carboniferous above the Lower Tournaisian. I must support the fewer number of stages for which GSSPs must be selected and ratified for pragmatic as well as scientific reasons.

Potential Series and Stage Subdivisions

The above situation, of course, brings up the issue of how to deal with series and stage subdivision of the Carboniferous now that the two major subdivisions have been reaffirmed as subsystems. Heckel and Villa [1999 Carboniferous Newsletter, 17: 8-11] suggested that stages remain regional [because of the difficulty of correlating boundaries of these stages globally, among other things], while series be defined with global boundaries. Because of ICS statements that boundary levels be sought to stages, along with strong consensus that stages are the basic unit.
for global correlation among members who expressed their opinions to us, this may not be a viable alternative, but we would invite comments from others on this possibility. At a 2000 Working Group meeting in Oviedo, Spain, I suggested a significant modification of this idea, which addresses both the desirability of having relatively few global stages, and series with names that do not distort the previous long-term usage of familiar geographic names [see later article in this Newsletter]. Titular member A.S. Alekseev has proposed an innovative alternative subdivision that combines the western and eastern European names, although with modified boundaries for some familiar western European names [see later article in this Newsletter]. We invite all members to comment on these proposals and, if they wish, to suggest more alternatives in what I hope will be a fruitful discussion of this important issue. Between now and next May, comments should be made via e-mail to us so that they may be circulated among as many members as possible for discussion that will help to refine the proposals or to clarify any new ideas that may be proposed, for publication in the July 2002 issue of the Newsletter.

**Progress on Selection of Stage Boundaries**

Selecting stage boundaries for even a small number of stages in the Carboniferous has presented real challenges to the SSCS. Reports of the Working and Project groups show that progress is being made on the selection of a boundary close to the classic Tourmaisian-Viséan boundary [see Working Group report by Servatopolu in this Newsletter], and we look forward to presentations on this matter at the SSCS meeting this coming September in St. Louis, USA. The field trip associated with this meeting will visit exposures that include this boundary in the type region of the Mississippian Subsystem in the Mississippi River valley. This trip will also visit several exposures of strata that are associated with the classic Viséan-Namurian/Serpukhovian boundary [on which there is no news from the Project Group since the report by Nick Riley in the 2000 Newsletter, 18: 7]. Status of work on this boundary in Russia will also be presented at the St. Louis meeting this September. The Working Group involved in defining boundaries close to the Moscovian-Kasimovian [Desmoinesian-Missourian] and Kasimovian-Gzhelian [Missourian-Virgilian] boundaries has held 5 meetings in Spain, eastern Europe, and midcontinent USA from 1996-2000. It has established several possible horizons of correlation, and will meet again in the southern Urals in 2002 [see Working Group report by Villa in this Newsletter]. A Desmoinesian-Missourian regional stage boundary reference position for North America will be published by myself, Boardman and Barrick in the Calgary XIV Carboniferous Congress reports, but it is not yet known if this boundary can be correlated globally. Certainly, the IUGS directive to the ICS mentioned above that all GSSPs are expected to be chosen by 2008 requires that we expend more immediate effort in selecting global stage boundary GSSPs within the two subsystems of the Carboniferous.

**Status of Radiometric Dating**

A significant problem facing Carboniferous stratigraphers is the murky state of affairs surrounding radiometric dating of the boundaries within and delimiting the Carboniferous System, as forcefully illustrated in the important 2000 paper by Menning and others in Geologische Jahrbuch [A 156: 3-44; see also 1997 Carboniferous Newsletter, 15: 26-28, and update later in this Newsletter]. They show a discrepancy of 7.5 Ma for the Mid-Carboniferous boundary [312.5-320 Ma], depending on the radiometric method used. They also show that there are essentially no biostratigraphic constraints on the age dates used to estimate the Carboniferous-Pennsylvanian boundary in western Europe. Uncertainty surrounding the age of this boundary here and elsewhere exists because the igneous minerals necessary for the commonly utilized dating methods are most often found in terrestrial or thick volcanic successions where marine fossils are lacking, rare, or indeterminate. This boundary has been estimated to range from ~290 [Harland group 1990] to 300 Ma [Hess and Lippolt 1986 Chemical Geology 59: 143-154] with rather large data spreads. Rasbury and others [1998 Geology 26: 403-406] have developed a method for dating certain caliches in paleosols, which are often found between biostratigraphically constrained marine horizons in the cyclic Pennsylvanian-Pennsylvanian successions in several parts of the world. Their dating of this boundary in southwestern USA as ~301 Ma with a small data spread has been found [unpublished conodont data] to be not as well biostratigraphically constrained at the top as originally believed in this tectonically disturbed area, but this method applied to lacustrine and soil carbonates in the Appalachian Basin has yielded biostratigraphically constrained ages closer to those of the Harland 1990 and Menning et al. 2000 estimates for units close to the Desmoinesian-Missourian boundary and within the lower Virgilian [see summary report by Becker et al. in this Newsletter]. I have provided several biostratigraphically well constrained caliche samples to this research group for systematic analyses of strata from mid-Desmoinesian through Missourian and Virgilian strata to the Carboniferous/Pennsylvanian-Pennsylvanian boundary in the Midcontinent North American type region of all these stages. This type of systematic radiometric work needs to be initiated elsewhere in biostratigraphically well constrained successions.

**Status of Stable Isotope Chemostratigraphy**

Another path of research that is yielding interesting and potentially useful results is stable carbon and oxygen isotope chemostратigraphy, particularly with respect to the Pennsylvanian, which appears to be less susceptible to significant diagenetic change than oxygen [see Carpenter and Lohmann, 1997 Geochimica et Cosmochimica Acta 61: 4831-4846] as it has responded to organic productivity changes in the ocean. Most of this work so far has focused on well-preserved brachiopod shells, which appear to yield the highest [most positive = heaviest] δ13C values among identifiable carbonate rock components. Matrix and cement values of the same samples are generally lower [see Mii et al., 1999 GSA Bulletin 111: 960-973], hence are considered to be more affected by diagenesis. These authors also showed on a summary diagram of 27 formations spanning the Carboniferous in central USA that moderate brachiopod values, generally ranging from +1 to +5 per mil PDB [with most between +2 and +4] during the Mississippian, spiked to +6 in the late Kinderhookian [mid-Tournaisian] and increased above the mid-Carboniferous boundary to a higher range between +3 and +6 for the entire Pennsylvanian. They related the mid-Carboniferous shift partly to increased sequestration of light organic carbon and partly to closure of the seaway
between Laurussia and Gondwana. Bruckschen et al. [1999 Chemical Geology 161: 127-163] showed that trends in European Carboniferous brachiopods have more scatter in the Mississippian [but with values concentrated between +2 and +4], and show an increase and tightening of the range of nearly all values to between +4 and +6 in the lower Pennsylvanian, increasing upward to nearly +7, but with much scattering higher in the section toward negative [lighter] values in the Moscovian region. Most recently, the European Pennsylvanian delta$^{13}$C values have been illustrated to be significantly higher than the North American values [Mii et al., 2001 Chemical Geology 175: 133-147], presumably reflecting differences that developed in the two seas after their connecting seaway was closed.

These reports provide the most recent general background trends for more detailed studies focused on smaller parts of the succession that can be useful for correlation at a finer scale. The mid-Tournaisian positive spike has been more recently recognized in fine-grained carbonate components at three places in the USA as well as in European brachiopods and can be arguably related to the timing of the Antler orogeny in western North America [Saltzman et al., 2000 Geology 28: 347-350]. Unpublished negative delta$^{13}$C excursions in the upper Moscovian of both Spain and Russia [see report Working Group by Villa in this Newsletter] also used data from more detailed studies of limestones. Ongoing work in the stable-isotope lab here at Iowa on the patterns within individual cyclothem, and using only the fine-grained carbonate mud matrix of samples, has recently uncovered a positive delta$^{13}$C excursion in the regressive limestone of a mid-Missourian cyclothem. In addition to the potential for discovering short-term shifts that may be useful in correlation, these latter more detailed studies show that carbonate mud matrix, which is always available in carbonate successions, may be able to show the same trends as pristine brachiopods. This should allow detailed C-isotope studies to break free from dependence on finding and testing for pristine brachiopods, which are rare or lacking in many carbonate successions. The resulting potential for more sample-intensive work on stable isotopes of Carboniferous successions should expedite the high temporal resolution in different basins that is necessary for recognizing changes in carbon cycling that can be useful for finer tuning of global correlation.

Status of ‘Carboniferous of the World’

Finally, I wish to make a plea on behalf of the editors of the 5-volume IUGS-sponsored reference set entitled ‘Carboniferous of the World’, of which 3 very useful volumes have already been published, in 1983 [East Asia], 1985 [Australia, India, Africa, and South America], and 1996 [Eastern Europe, Northern and Western Asia]. General editors and SCCS titular members Robert Wagner and Cor Winkler Prins are patiently awaiting manuscript submittals for volumes 4 and 5 on North America and Western Europe. To all contributors for these remaining volumes, please complete your manuscripts and submit them as soon as possible. Thank you.

Philip H. Heckel

---

**SECRETAKY / EDITOR’S REPORT 2000-2001**

Following my appointment as Secretary of SCCS in late 2000, the Secretariat was relocated to the Cincinnati Museum where it is now housed in the Museum of Natural History & Science. The transition went smoothly due in large part to the efforts of former Secretary Ian Metcalfe who went to great lengths to pass on his extensive ‘institutional memory’ on the SCCS Secretariat. On behalf of the entire SCCS I would like to thank Ian for his many contributions to the Subcommission during his tenure as Secretary. As editor of the Newsletter on Carboniferous Stratigraphy he achieved new levels of excellence, and I hope that I will be able to maintain his high standards!

I want to thank all who provided articles for inclusion in the 19th issue of Newsletter on Carboniferous Stratigraphy and those who assisted in its preparation. I am indebted to P.H. Heckel for editorial contributions; and to P. Thorson Work for coordinating the compilation of this issue. This year saw a doubling in the number of articles submitted by members, and as a result the current issue—at 79-pages—is the largest in SCCS history. This, combined with a steady increase in the number of corresponding members (up nearly 30 in the past year alone) makes it critical that financial donations from members help offset the resulting increase in publication and distribution costs. The Newsletter is expensive to produce, and it is our hope that donations will enable us to continue to distribute copies to all who desire them—regardless of whether they make a donation or not.

**Future Issues of Newsletter on Carboniferous Stratigraphy**

Issue 20 will be finalized by June 2002, and I request that all manuscripts be sent before May 31—but preferably much earlier. Late manuscripts, arriving close to the deadline, cannot be sent back to the author for proofreading. I ask all authors to please read the section below (page 6) regarding submission format and manuscript length. Finally, I would be most grateful if all voting and corresponding members of the SCCS would let me know of any changes to their postal and e-mail addresses so that we may update our records.

David M. Work
SCCS ANNUAL REPORT 2000

Membership

The Subcommission had 20 voting members in 2000 [see list at end]. In addition, corresponding membership at time of publication stands at 290 persons and 7 libraries.

Officers

Chair:
Dr. Philip H. Heckel
Department of Geology
University of Iowa
Iowa City, IA 52242
U.S.A.
Fax: +1 (319) 335-1821
Email: philip-heckel@uiowa.edu

Vice-Chair:
Dr. Geoffrey Clayton
Department of Geology
Trinity College
Dublin 2
IRELAND
Fax: 353-1-6711199
Email: gclayton@tcd.ie

Secretary/Editor:
Dr. David M. Work
Cincinnati Museum Center
Geier Collections and Research Center
1301 Western Ave.
Cincinnati, OH 45203
U.S.A.
Fax: +1 (513) 287-7095
Email dmwork@fuse.net

Working and Exploratory Project Groups

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

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

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

Project Group on a boundary close to the Viséan-Namurian/Serpukhovian boundary, chaired by Nick Riley (UK) [approved at the Calgary Congress in 1999].

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

Project Group on Comparative Angara and Gondwana Biostratigraphy, chaired by Marina Durante (Russia) [approved at the Calgary Congress in 1999].

Chief Accomplishments in 2000:

The nomination of George Sevastopulo as Chair without opposition was ratified by the ICS in early 2000. Following Sevastopulo’s withdrawal as Chair-elect for health reasons in June 2000, Vice-Chair-elect Philip Heckel was promoted to Chair by the ICS Executive Bureau. Heckel appointed David Work as Secretary of the SCCS. An election begun in 2000 resulted in election of Geoff Clayton as Vice-Chair in 2001.

The late 1999 ballot decision naming the two subdivisions of the Carboniferous System as Mississippian and Pennsylvanian, and reaffirming their rank as subsystems, was ratified by ICS in early 2000.

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

Newsletter on Carboniferous Stratigraphy, Volume 18, published July 2000, contains reports of Working Groups for 1999, results of the above-mentioned ballot, and 12 articles on various topics, for a total of 59 pages.

Work Plan for 2001 and Following Years:

The SCCS Field Conference and General Meeting in St. Louis, Missouri, USA, September 8-13, 2001, will be led by Paul Brenckle and Richard Lane, and coordinated by Philip Heckel, with aid from David Work and state geological survey personnel. It will focus on lithostratigraphy and biostratigraphy of the type Mississippian Subsystem, to provide more impetus toward selecting global boundaries within that subsystem, for which one working group and two project groups already exist, but with work so far focused on Eurasia.

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

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

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

Philip H. Heckel
### Statement of Operating Accounts for 1999/2000:
Prepared by Ian Metcalfe, past Secretary.
(Definitive accounts were maintained in Australian currency)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definitive</td>
<td>Estimated</td>
</tr>
<tr>
<td>IUGS Grant 2000</td>
<td>1,702.07</td>
<td>1,000.00</td>
</tr>
<tr>
<td>Donations from Members</td>
<td>861.81</td>
<td>499.85</td>
</tr>
<tr>
<td>Bank Interest</td>
<td>2.26</td>
<td>1.31</td>
</tr>
<tr>
<td><strong>TOTAL INCOME</strong></td>
<td><strong>2,566.14</strong></td>
<td><strong>1,501.16</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>EXPENDITURE</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Newsletter 18 (publication/postage)</td>
<td>1,229.00</td>
<td>712.82</td>
</tr>
<tr>
<td>Secretarial Assistance (Newsletter 18)</td>
<td>200.00</td>
<td>116.00</td>
</tr>
<tr>
<td>Bureau postage</td>
<td>90.50</td>
<td>52.49</td>
</tr>
<tr>
<td>Honorarium</td>
<td>150.00</td>
<td>87.00</td>
</tr>
<tr>
<td>Stationary</td>
<td>174.15</td>
<td>101.00</td>
</tr>
<tr>
<td>Bank Charges</td>
<td>1.80</td>
<td>1.05</td>
</tr>
<tr>
<td><strong>TOTAL EXPENDITURE</strong></td>
<td><strong>1,845.45</strong></td>
<td><strong>1,070.36</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BALANCE SHEET (1999-2000)</th>
<th>$AUS</th>
<th>$US</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definitive</td>
<td>Estimated</td>
</tr>
<tr>
<td>Funds carried forward from 1998-99</td>
<td>801.02</td>
<td>464.59</td>
</tr>
<tr>
<td>PLUS Income 1999-2000</td>
<td>2,566.14</td>
<td>1,501.16</td>
</tr>
<tr>
<td>LESS Expenditure 1999-2000</td>
<td>-1,845.45</td>
<td>-1,070.36</td>
</tr>
<tr>
<td><strong>CREDIT balance</strong></td>
<td><strong>1,521.71</strong></td>
<td><strong>882.59</strong></td>
</tr>
<tr>
<td>carried forward to 2000-2001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*$[The discrepancy in the U.S. dollar credit balance figures is a result of the slight decrease in the relative value of the Australian dollar from 58.5% used in figuring: total income, to 58.0% used in figuring total expenditure and credit balance. Because the Australian dollar amount is definitive, I used the U.S. dollar amount figured from the Australian dollar amount at the most recent exchange rate for determining carryover in item #11 below – P. H. Heckel]
Donations in 2000/2001:

Publication of this Newsletter is made possible with generous donations received from the following members/institutes during 2000-2001 and anonymous donations, combined with an IUGS subsidy of US $1000 in 2000, and additional support from a small group of members who provide internal postal charges for the Newsletter within their respective geographic regions.


COVER ILLUSTRATION

Pennsylvania ammonoid: Pennoceras new species, early Missourian, Mound City Shale Member, Hertha Limestone, Bourbon County, southeastern Kansas, USA, diameter 19 mm.

CONTRIBUTIONS TO THE NEWSLETTER

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

* reports on work in progress and / or reports on activities in your work place
* news items, conference notices, new publications, reviews, letters, comments
* graphics suitable for black and white publication.

Contributions for each issue of the Carboniferous Newsletter should be timed to reach the Editor before 31 May in the year of publication. It is best to submit manuscripts as attachments to Email messages. Except for very short news items, please send messages and manuscripts to my Email address followed by hard copies by regular mail. Manuscripts may also be sent to the address below on diskettes prepared with Microsoft Word (preferred) or WordPerfect but any common word processing software or plain ASCII text file can usually be accommodated; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code. Maps and other illustrations are acceptable in tif, jpeg, eps, or bitmap format (plus a hard copy). If only hard copies are sent, these must be camera-ready, i.e., clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time.

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

Please send contributions as follows,

AIR MAIL to: David M. Work
Cincinnati Museum Center
1301 Western Avenue,
Cincinnati, OH 45203, USA

EMAIL to: dmwork@fuse.net
Progress report of the Working Group to establish a boundary close to the existing Tournaisian-Viséan boundary within the Lower Carboniferous

G. Sevastopulo1, L. Hance1, F.X. Devuyst2*, M. Coen2*, H. Hou3, S. Tian4, and X.H. Wu4

1Department of Geology, Trinity College, Dublin 2, Ireland (gsvtspui@tcd.ie).
2Unité de Géologie, Université Catholique de Louvain, 3 place Louis Pasteur, 1348, Louvain-la-Neuve, Belgium (hance@geol.ucl.ac.be, devuyst@hotmail.com, coen@geol.ucl.ac.be).
3Institute of Geology, C.A.G.S., 26 Baiwanzhuang road, Beijing 10037, China (hifhou@public.filnet.cn.net).
4Guizhou Bureau of Geology, Beijing road, Guiyang, China.

*Research assistant of the Belgian National Fund for Scientific Research (FNRS).
**Research associate of the FNRS.

As concluded in the 2000 report of the group (Sevastopulo and Hance, 2000), the best criterion proposed so far to define the Tournaisian-Viséan boundary is the transition from morphotype 1 to morphotype 2 in the evolutionary lineage of the foraminifer Eoparastaffella simplex (Hance, 1997). In the historical stratotype (Bastion section, Namur-Dinant Basin, Belgium) the record of the entry of Eoparastaffella at the base of the Viséan referred to a single specimen of Eoparastaffella simplex, reducing its global stratigraphical value. Recent work has therefore focused on the search for a section displaying a continuous evolution of the genus Eoparastaffella in three main areas: South China, Ireland and Belgium.

South China: first results of field work conducted in April 2000 (report in the Newsletter: Devuyst et al., 2000).

Pengchong Section:

Previous work (Hance et al., 1997) had shown that this section was promising.

The outcrop in the bed and along the banks of a small river was cleaned and has been shown to be much more continuous than previously thought. The section is 130m thick. It has been re-logged and re-sampled (103 new samples for foraminifers, 4 spot samples for palynomorphs and 170 samples of about 2kg each for conodonts). Bed numbers have been painted on the outcrop to facilitate further work.

The section exposes the Pengchong Member (dark, medium to thin bedded limestone with common chert, interpreted as an outer ramp facies) which forms an intercalation in the basinal culm facies of the Luzhai Formation. The Pengchong Member is composed mainly of sorted packstones and grainstones with abundant shallow water allochthonous material (algae, micrite lithoclasts, mostly formed by micritization, and ooids), interbedded with subordinate packstones, rich in moravamminids, sponge spicules and radiolarians, and dark shales. There is no evidence for calciturbidites in the field and the preliminary interpretation of the limestone beds is that they are tempestites.

The samples have yielded a rich fauna of foraminifers with very abundant ozawainellids. The material has been studied both in China (Wu) and Belgium (Hance). Eoparastaffella simplex morphotype 1 is present from the base of the section upwards. Other biostratigraphically significant and cosmopolitan taxa include Mediocris, Loeblichia fragilis, Eostaffella and Eoendothyranoopsis in the upper part and primitive archaeoecids at the top of the section. Most of this fauna has already been published by Hance et al. (1997). Most of the conodont samples were productive but yielded faunas of generally low abundance and diversity, consisting mainly of gnathodids and polygnathids. The base of the section is in the upper part of the anchoralis Biozone with Mestognathus praebuckmanni transitional to M. beckmanni from the first beds. Scalognathus anchoralis europensis has been recorded from two levels approximately 25m below the first Eoparastaffella simplex morphotype 2 (T-V boundary). A few levels have yielded Gnathodus homopunctatus; the first of these coincides with the entry of Eoparastaffella simplex morphotype 2. The anchoralis-homopunctatus interval will be resampled in more detail this summer. 4 palynomorph samples have been processed by G. Clayton (Trinity College, Dublin) but were not productive. Ostracods are very abundant; they are under study.

The Pengchong section can be correlated with nearby transitional and platform sections with diverse faunas of foraminifers and conodonts and has been interpreted in terms of sequence stratigraphy by Hance et al. (1997).

Two sections from Yunnan were logged and sampled in April 2000 (Devuyst et al., 2000).

Dazhaimen:

The Dazhaimen section does not reach the T-V boundary and the uppermost beds have yielded the foraminifer Biseriella bristolensis which characterizes the top (Avins Formation) of the 2nd order sequence preceding the T-V boundary in Belgium and southwest England.

You Wang:

The You Wang section has yielded interesting conodont faunas. The lower part is of late Tournaisian age but contains reworked early Tournaisian forms. The middle part contains a typical early anchoralis Biozone fauna with Scalognathus anchoralis fairchildi, Dolloinathus latus and Prognathodus cordiformis. The diversity and abundance of conodonts decrease drastically in the upper part probably because of a shallowing and no diagnostic conodont taxa have been found. It is therefore not known if the T-V boundary occurs within the section. Foraminifers will be studied soon.

July 2001
Ireland:
The Oughterard area, western Ireland, has been investigated and a borehole drilled by the Geological Survey of Ireland has been logged and sampled in detail (221 samples for petrography and foraminifers, 13 samples for conodonts and 13 samples for polygnaths). The section is 220m thick and is composed of marginal marine sands at the base passing rapidly to mixed clastics and carbonates and shallow water limestones. The dominant microfacies are shallow, subtidal, peloidal packstones and grainstones rich in molluscs and brachiopods with common thalli of Koninckopora, thought to have been deposited below fair weather wave base, and very shallow, subtidal, unsorted coarse lithoclastic and algal grainstones with mixed, very coarse clastics and sorted cross-to-planar laminated ooidal grainstones. There is a progressive shallowing trend culminating in the uppermost Tourmaisian and an abrupt shallowing in the lower Viséan. The first shallowing correlates with Belgium and southwest England and is interpreted as being largely eustatic in nature while the second seems to be related to local tectonic activity.

The fauna of foraminifers is abundant but characterized by a relatively low diversity. The first limestone beds of the section are of late Tourmaisian age with a fauna dominated by Eblanaia michot and Condrustraella modavensis. Eoparastaffella simplex morphotype 1 and 2 are present and although the former is not abundant it is possible to place the T-V boundary with good precision.

The conodont samples yielded only one specimen of Polygnathus mehli and one specimen of Mestognathus beckmanni at the top of the section. New samples have been collected in the field and will be processed soon.

The palynological samples are currently under study. Very abundant organic material (often woody) has been observed in the residues of the conodont samples.

The section also contains abundant corals, brachiopods and molluscs including large cyrtococid nautiloids.

A thin, indurated, coarse grained tuff occurs approximately 10m below the T-V boundary and the possibility of radiometric dating is currently being investigated.

The section can be correlated with down-ramp sections (Headford/Shrule and Dunmore boreholes, for example) and several other nearby sections.

Sections in the Dublin Basin (such as that at Rush, County Dublin) also prove to have a record of the evolution of Eoparastaffella simplex.

Belgium:
Resampling of the classical mid-ramp Soviet section has allowed the recognition for the first time in Belgium of Eoparastaffella simplex morphotype 1. The taxon occurs in the pebbles of a single debris flow bed which is thought to represent the culmination of the upper Tourmaisian progressive shallowing. This part of the section can be correlated with the shallow water Avins Formation (ooid).
During the last five years we have developed a work program based on yearly field-trips followed by a general meeting and joint laboratory sessions, the latter mainly devoted to the comparison and exchange of paleontological materials. So far we have visited the Donets Basin (1996), Cantabrian Mountains of northern Spain (1997), Moscow region (1998), Midcontinent region of North America (1999), and Spain again (2000).

Earlier studies have shown that the special conditions created after the formation of the supercontinent Pangea led to a marked marine provincialism during late Carboniferous time. As a result of such biogeographic differences, all the fossil groups investigated show a high degree of endemism and, therefore, the subdivision and correlation of the Pennsylvanian Subsystem face much greater difficulties than other Paleozoic systems.

In spite of these difficulties fusulines and conodonts still seem to bear a potential for global stratigraphic correlation, and are at present the two fossil groups being most intensively investigated.

Some distinctive events and correlations among fusulines and conodonts

During the study of the successions mentioned above, we have found some potential stratigraphic events that deserve further study (described below, from older to younger events):

1) The first appearance of Protriticites species and presence of Streptognathodus subexcelsus. Species assigned to the genus Protriticites first occur in Eurasia in strata of late Myachkovichian age, at the top of the Moscovian. These earliest Protriticites usually correspond to forms belonging to Protriticites ovatus. It is remarkable that forms belonging to, or resembling, the conodont Streptognathodus subexcelsus occur in the Moscow Basin (uppermost part of the late Myachkovichian Peski Formation and overlying lower Kasimovian Suvorovsky Formation, Domodedovo section) and in the Cantabrian Mountains (upper part of the Picos de Europa Formation, Las Llacerras section) together with these first Protriticites (Villa, Alekseev, and others, 1997).

First Protriticites species occur in the Kalinovo section (Donets Basin) in the N3 limestone (Ueno and Villa, 1998). This limestone is tentatively correlated with the levels of the Moscow Basin and Cantabrian Mountains in which the first appearance of Protriticites has been recorded. However a slightly younger cannot be excluded, since the N3 limestone overlies a thick siliciclastic succession that lacks fusulines.

Protriticites species have also been reported from western North America (Idaho, Utah, Nevada), where they occur together with middle Desmoinesian fusulines (Wahlman and others, 1997). Therefore, a correlation of the upper Myachkovich with the middle Desmoinesian seems to be possible. However, we have to first demonstrate by other means (apart from fusulines) that these western North American Protriticites species are more or less the same age as the Eurasian ones. Research on the conodont fauna of the western North American successions that have yielded Protriticites species shows that at one locality "Idiognathodus" nodocarinatus [see 2] below occurs several cycles above the level of Protriticites (Ritter et al., 1999).

2) The first appearance of "Idiognathodus" nodocarinatus (Swade 1985, sp. 6). This conodont species group could represent an important biostratigraphic marker since it has been found in the Moscow Basin (Voskresenky Formation, middle Kryvakan erotic, the lower substage of the Kasimovian), the North American Midcontinent (Lost Branch Formation, upper Desmoinesian) (Heckel, Alekseev and Nemirovskaya, 1998), the Illinois Basin, and Utah (Heckel, 1999). Related morphotypes that precede it in the Midcontinent now have been identified in the Pre-Urals near the top of the Dalnii Tyulka section collected by Russian colleagues and studied by the Working Group at the 2000 meeting in Oviedo, Spain.

3) The first appearance of Montiparbus species. Species belonging to the genus Montiparbus are considered in Eurasia to first occur in the upper part of the lower Kasimovian, at the base of the Khamnovkian substage. Representatives of these Eurasian forms have also been identified in Missourian strata by Wilde and Skinner in Texas (mentioned by Wilde, 1984) and, more recently, by Davydov in Nevada (1999). Nevertheless, the use of these fusulines for intercontinental correlation still requires much additional research.

More advanced Montiparbus species (belonging to the Montiparbus umbonoplicatus species group) could be stratigraphically significant for correlating upper Khamnovkian strata. forms of this group with similar appearance have been recognized in the uppermost part of the Las Llaceras section (van Ginkel and Villa, 1999) and in the O2 limestone of the Kalinovo section (Ueno, 1999).

4) The first appearance of primitive Idiognathodus simulator and Streptognathodus firmus. These two conodont species provide useful biostratigraphic information, linking the North American Midcontinent, Moscow Basin and Donets Basin. Their first occurrences take place in North America Midcontinent in strata of late Missourian age (Eudora Shale Member of the Stanton Formation; Heckel, 1999). In the Moscow Basin Idiognathodus simulator first appears in the uppermost Dorogomilovian near the top of the Kasimovian (Heckel, Alekseev and Nemirovskaya, 1998). The oldest record of Streptognathodus firmus in the Donets Basin (Kalinovo section) has been reported from Limestone O4/1 (Kozitskaya and others, 1978).

5) The first appearance of Streptognathodus zethus. The conodont species currently named Streptognathodus zethus is recognized at the base of lowest Gzhelian strata in the Moscow Basin (lower Rusavkino Formation) and in the Little Pawnee Shale Member of the Cass Formation (Midcontinent), the level at which some North American stratigraphers have proposed to place the Missourian/Virgillian boundary. Therefore, this species could represent a good stratigraphic marker, correlating the Kasimovian/ Gzhelian and Missourian/Virgillian boundaries.

6) The first appearance of more advanced Idiognathodus simulator (sensu stricto). This is in the lower Virgillian Heebner Shale in North America and in the lower Gzhelian upper Rusavkino Formation in Moscow region and Limestone O7 in Donets Basin. This level may be useful for global correlation.

It is necessary to emphasize that all of these correlations.
nead more detailed studies and so must be considered as preliminary findings. The most important facts to point out are that some pieces of evidence indicate that the Desmoinesian/Missourian boundary correlates with a level within the lower Kasimovian, and that the lower Virgilian boundary seems to be very close to the lower Gzhelian boundary.

**Palynomorph data**

In addition to fusulines, conodonts and other marine fossils, we are also studying palynomorphs from several sections of the Cantabrian Mountains, such as the Deméules section, which contains an alternation of marine and terrestrial beds. A detailed study of this section has provided a tentative correlation of the Western and Eastern European stratigraphic scales (Sanchez de Posada and others, 1999; Rodriguez, 1999).

**Other studies**

Other studies still in progress deal with sequence stratigraphy in the several areas, and with the analysis of carbon and oxygen isotopes. The latter have been conducted in the Moscow Basin, the Cantabrian Mountains and the Donets Basin. These analyses (performed by Dr. Martin Brasier from the Oxford University), have provided data that merit additional comments. A section in the Moscow Basin (Domodedovo) shows a negative excursion in both the carbon and oxygen curves in the upper part of the upper Myachkovian Peski Formation. Similar analyses from strata of the same age in the Las Llacerias section (Cantabrian Mountains) show a negative excursion of the most positive values [in multiple analyses from the same sample] in both carbon and oxygen curves in upper Myachkovian strata of the Picos de Europa Formation. In the Kaliyov section in the Donets Basin, isotopic analyses did not provide useful information, as the curves were erratic with extremely low values for carbon isotopes, which suggest more fresh-water input or perhaps extensive diagenetic alteration.

It is remarkable that both Domodedovo and Las Llacerias sections show a minimum in the carbon curves at approximately the same stratigraphic level (correlated by means of both conodonts and fusulines). Although the covariance of oxygen with carbon suggests influence of diagenesis, the negative excursion in the most positive carbon values may reflect depositional changes. Negative carbon excursions can indicate a change in the carbon cycle toward either weathering of more organic-rich facies or decreased burial of organic carbon, possibly due either to decreased productivity or a sea-level fall, which likely reflect climate changes that occurred in latest Moscovian time. More extensive work is needed from this and additional sections in different geographic regions to adequately interpret these data. A much more detailed sampling for isotopic analyses was made recently in the Las Llacerias section by Prof. W. Buggisch (University of Erlangen) and Dr. Holger Forke (Forschungsinstitut Senckenberg, Frankfurt), which will provide more refined data from this section.

**Future steps**

At the most recent general Working Group meeting (University of Oviedo, Spain, September 2000), it was agreed to hold the next general meeting and field trip in summer of 2002 in the South Urals, where the Dalniy Tyulka section yielded the new conodont data mentioned above, which could provide important new clues for intercontinental correlation.

**References**


2. Activities of Russian members of the SCCS Working Group

Aleksander S. Alekseev

Department of Paleontology, Geological Faculty, Moscow State University, Moscow, 119899, Russia; and Paleontological Institute of Russian Academy of Sciences, Moscow, 117868, Russia.

During this past year, Russian members of the Working Group have achieved a number of results, which can be summarized as follows:

1. A monograph on the Middle Carboniferous succession of the Moscow Syncline has been completed and the first volume (Stratigraphy) is already in press. Although not so detailed, lowermost Kasimovian strata are also described in this book.

2. During the end of April and early May 2000, the Moscow group visited the Dalniy Tyulkas section (Bashkiria, South Urals), a small quarry in which some 20 m of the Tashly and Kurkin formations are exposed. The lower two thirds (Tashly Fm) consist of limestones, sometimes dolomitized, with abundant chert nodules, and containing several beds with brachiopods, fusulines and corals.

The working group made a preliminary sampling for conodonts, a fossil group that was first studied from this section by V. Cherynych. The lower part of the Tashly Fm yielded a typical Podolianskian assemblage (Gondolella levis, Idiognathodus podolskensis, I obliquus), whereas its upper part yielded Neogonathodus inaequalis and ribbed gondolellids, which indicate a Myachkovian age.

Only the lower part (about 3 m) of the Kurkin Fm is visible in this quarry. It consists of thin dolomitized and silicified limestones, with abundant intercalations of volcanic ashes (clays) and chert layers in their uppermost part. The clays in places contain abundant conodonts, an assemblage without Neogonathodus, but with shallow troughed Idiognathodus-Streptognathodus close to I. subexcelsus, and forms that were found recently in the Moscow bore-hole 1832 section, from beds belonging to the lower part of the Susurovo Fm (basal Kasimovian strata). The last forms are probably ancestral to Streptognathodus excelsus", which is typical of the upper Krevyshakian Voskresensk Fm. This conodont content supports the conclusion that the Dalniy Tyulkas section embraces the Moscovian-Kasimovian boundary interval, which is here represented in deep-water facies showing a dominance of gondolellids in the conodont assemblages.

3. As a result of this discovery, we propose to organize during the summer of 2002 a Working Group meeting and field trip in Krasnoussolsk (Bashkiria, South Urals). Krasnoussolsk is a small country town with a famous spa close to it. This spa is based on cold sulphur springs rising from Moscovian limestones. During the field trip we will be able to visit at least 4 sections in a radius of only 5-10 km: a) Dalniy Tyulkas section (Upper Moscovian to Lower Artinskian), showing deep water facies; b) The famous Usoikey section (Upper Kasimovian-Sakmarian) also showing deep water facies; c) The Tashly section (Bashkirian-Moscovian), exposing strata deposited in shallower conditions; and d) The Voskresenka section (Upper Kasimovian-Gzhelian), which exposes a reef in whose flank there are limestones containing fusulines, ammonoids, brachiopods and conodonts. During August 2001 we hope to open in the first section (Dalniy Tyulkas) a trench that will expose a good section of the Kasimovian-Gzhelian interval (total thickness about 40 m).

Project Group 4: Zonation in Late Namurian successions: the Bashkirian Stage as a geochronological standard.

J. Kullmann (Project Leader)

Institute und Museum für Geologie und Paläontologie, Universität Tübingen, Sigwartstr. 10, D-72076 Tübingen, Germany.

As reported in Newsletter 17 (1999), the Russian members of the group (I.S. Barskov, Moscow; E.I. Kulagina, Ufa, Bashkiria; S.V. Nikolaeva, Moscow; V.N. Puzikhin, Ufa, Bashkiria; and others) are constantly engaged in developing a general framework for early Upper Carboniferous stratigraphy. Because of the difficulties in recognizing well identifiable and globally comparable faunas at the base of the Bashkirian the group's investigations have been extended to include studies on the Serpukhovian Stage (see Nikolaeva and Kullmann, this issue). Studies of a variety of fossil groups in the type region of the Bashkirian Stage south-east of Ufa (western slope of the South Urals) will be continued to provide a basis for the selection of a type section in the Bashkirian type area. One of the sections currently under study is on the left bank of the Bolshoi Kizil River (tributary of the Ural River) and spans the interval from the Visian through the Bashkirian. Ammonoids were recovered from Bashkirian limestones (which also contain conodonts, foraminifers, and ostracodes). Sample 21/2 contains Cancelloceras sp. nov., Cancelloceras elegans Ruzhencev et Bogoslovskaya, Bilinguities superbilinguis (Bisat), Stenoglyphites sp. nov., Schartmyrites barbotanus (Verneuil). This assemblage is dated Nm2c2 = G1. Sample 21/3 (collected from the same level as 21/2 but slightly downhill) contains Wiedeyoceras sp. nov., Cancelloceras sp. nov., Cancelloceras elegans Ruzhencev et Bogoslovskaya and is also dated Nm2c2 = G1.
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.

New proposal for series and stage subdivision of Carboniferous System

Philip H. Heckel
Department of Geoscience, University of Iowa, Iowa City, IA 52242, USA (philip-heckel@uiowa.edu).

Largely because of the difficulty of correlating the boundaries of the different regional stage successions that have developed in Carboniferous strata in different parts of the world, Heckel and Villa (1999 Carboniferous Newsletter 17: 8-11) suggested that stages remain regional, while series be defined with global boundaries. The statement in ICS Statute 5.4 that “Boundary stratotypes are sought to the level of Stages, but not at smaller stratigraphic scales” implies that stage boundaries should be global, but in my opinion, does not mandate it. Nevertheless, the strong consensus among SCCS members who expressed their opinions to me is that stages should be the basic unit for global correlation. Therefore, I believe that the SCCS should attempt to define global stage boundaries. However, considering the difficulty of selecting boundaries within the Carboniferous as illustrated by the long time it has taken to select the mid-Carboniferous boundary and to make progress on the other intra-Carboniferous boundaries, compared to the relatively small amount of time [7 years] that the ICS is providing for the final selection of all global boundaries by 2008, it is important that we attempt to select the minimal number of stage boundaries that can adequately subdivide the Carboniferous on a worldwide scale. This smaller number of stages is consistent with the point raised by Menning et al. (2000 Carboniferous Newsletter 18: 8-9) that the Carboniferous should have a similar number of stages as those of adjacent periods [Devonian – 7, Permian – 9], that is, about 10 or less. However, a total of 22 stages are already recognized in the Carboniferous of Western Europe. Finding appropriate global boundaries for all of these would be an extremely difficult task, even without considering the 2008 deadline. At a 2000 working group meeting in Oviedo, Spain, I suggested a modification (Figure 1) of the ideas in Heckel and Villa, which satisfies the desirability of both having relatively few global stages and having series with names that do not distort the previous long-term usage of familiar geographic names.

The most commonly used names in Western Europe for subdividing the Carboniferous on a potentially globally correlatable scale are Tournaïnian, Viséan, Namurian, Westphalian and Stephanian, which have been ranked as series there since the mid-1900s and subdivided into 21 or 22 stages (see summary in Wagner and Winkler Prins, 1997 Proceedings XIII-ICCC, 1: 187-196). The upper three series were officially subdivided into a total of 15 stages [7 in the Namurian, and 4 each in the upper two]. The lower two series were subdivided [but without official SCCS sanction] into 5 regional stages in Belgium and 6 regional stages in England [with a total of 7 attained by adding the 2 from the Belgian Tournaïnian to the 5 from the British Viséan]. It is well known that the upper Westphalian and the entire Stephanian are completely terrestrial in their type regions of northwestern Europe, and are so far not able to be correlated directly with the marine realm. The Namurian now is split above the second stage from the base by the Mid-Carboniferous subsystem boundary, and the lower and upper parts are called Serpukhovian and Bashkirian, respectively, in Eastern Europe. It is clear from all the considerations outlined above that the 22 stages used in western Europe are more appropriately regarded as regional substages, for which boundary choices are outside of the official mandate of the ICS to the SCCS. This means that the former series names are available as stage names for the Carboniferous if they are globally correlatable.

The most commonly used names in Eastern Europe for subdividing the Carboniferous on a potentially globally correlatable scale are Tournaïnian, Viséan, Serpukhovian, Bashkirian, Moscovian, Kasimovian, and Gzhelian, which have been traditionally ranked as stages. All these stages are developed in the marine realm, hence they are potentially correlatable more widely. Tournaïnian and Viséan appear to be used far more widely as names than any others for subdivisions at the appropriate stage scale for the lower part of the Carboniferous. In East Asia, the Chinese series and stage names (Wu, 1991 Compte Rendu XI-ICC, 1: 84-96) have not been used outside of China.

In the USA where the Carboniferous has been traditionally recognized as two systems, Mississippian and Pennsylvanian, each system was subdivided into series, but with different names in different regions. In the Appalachian region, the positional terms Lower, Middle and Upper were used in both systems for a total of 6 series, but without rigorous biostratigraphic definition because lithostratigraphy had long been the dominant focus of American workers. In the Midcontinent region, a total of 9 geographic names were used as series: Kinderhookian, Osagean, Meramecian, and Chesterian in the Mississippian, and Morrowan, Atokan, Desmoinesian, Missourian, and Virginian in the Pennsylvanian. Because this region was more marine, there was more biostratigraphic definition for these series, particularly with fusulinids in the Pennsylvanian. In addition, certain state geological surveys have grouped the Midcontinent names as stages into the positionally named series of the two systems, following the scheme of Moore and Thompson (1949 AAPG Bulletin 33: 275-302) for the Pennsylvanian. The informal groupings that emerged are Lower Mississippian Series comprising the Kinderhookian Stage, Middle Mississippian Series comprising the Osagean and Meramecian Stages, Upper Mississippian Series comprising the Chesterian Stage, Lower Pennsylvanian Series comprising the Morrowan Stage, Middle Pennsylvanian Series comprising the Atokan and Desmoinesian Stages, and Upper Pennsylvanian Series comprising the Missourian and Virginian
New Proposal for Series and Stage Subdivision of Carboniferous System

**Stages**

<table>
<thead>
<tr>
<th>System</th>
<th>Subsystem</th>
<th>(after global stages chosen)</th>
<th>(prob. most or all will be global)</th>
<th>(poss. some global?)</th>
<th>(lower two global)</th>
<th>regional (Sub)stages</th>
<th>(upper parts regional)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>GSSP</td>
<td>E. Europe</td>
<td>N. America</td>
<td>W. Europe</td>
<td>Angara</td>
<td>Gondwana</td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td></td>
<td>*Gzhelian</td>
<td>*Virgilian</td>
<td>*Stephanian</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MIDDLE</td>
<td>*Kasimovian</td>
<td>*Missourian</td>
<td></td>
<td>*Silesian</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td>*Moscovian</td>
<td>*Desmoinesian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td>*Bashkarian</td>
<td>*Atokan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td>*Serpukhovian</td>
<td>*Serpukhovian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td>*Tournaisian</td>
<td>*Tournaisian</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MISSISSIPPIAN</td>
<td>PENNSYLVIAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td></td>
<td>*Bashkarian</td>
<td>*Morrowan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td></td>
<td>*Viséan</td>
<td>*Viséan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LOWER</td>
<td></td>
<td>*Tournaïsian</td>
<td>*Tournaïsian</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Graphic chart summarizing new proposal for series and stage subdivision of Carboniferous System. Asterisks (*) show region from which geographic names are derived. Vertical lines between Pennsylvanian series names reflect uncertainty on choice of global stage names. Horizontal dashed lines show various degrees of uncertainty as to correlation of those boundaries.

Stages. Note that three of the series contain only one stage, while the other three contain two stages each. Some of these names have been extended outside the USA, mainly to northern South America where fossil suites are somewhat similar.

Because the positional series names Lower, Middle and Upper in the two American systems were never rigorously biostratigraphically defined, they remain available for series names within the Mississippian and Pennsylvanian Subsystems of the Carboniferous System whatever stage names are used or wherever stage boundaries are defined. There appears to be an emerging consensus among Mississippian workers with whom I have been in contact that the widely used names Tournaisian and Viséan are acceptable for global stage names, and that Serpukhovian is acceptable if an appropriate basal boundary can be selected, because the traditional base of the Chesterian is well below the top of the Viséan. Therefore an appropriate subdivision of the Mississippian Subsystem would be Lower Mississippian Series comprising the Tournaisian Stage, Middle Mississippian Series comprising the Viséan Stage, and Upper Mississippian Series comprising the Serpukhovian Stage.

The Pennsylvanian Subsystem presents more of a problem because of greater endemicism among even the marine biotas, and also because boundary selection is much more difficult due to the many more widespread disconformities resulting from glacial eustasy. Nevertheless, some progress is being made on global correlation within the marine realm in both the lower part (Grove et al., 1999 Journal of Paleontology 73: 529-539) and the upper part (Heckel et al., 1998 Carboniferous Newsletter 16: 8-12), and on characterization of potential boundaries in the upper part of this subsystem (current Newsletter report of Villa and Working Group). It is quite apparent that the Eastern European stage names are in much greater use than American stage names across most of the world. If this greater usage results more from wider distribution of their characteristic fossils than simply from tradition, and if appropriate GSSPs can be selected in areas of more continuous sedimentation than the Moscow region where the upper three of them were named, then most and possibly all the Eastern European stage names will likely become the global stage names. Because that issue is not yet resolved, I have retained two alternative possibilities for series boundaries in the Pennsylvanian Subsystem on Figure 1. The Lower Pennsylva-
nian Series would comprise either the Bashkirian Stage or the Morrowan Stage. The Middle Pennsylvanian Series would comprise either the Moscovian Stage or the Atokan Stage plus the Desmoinesian Stage. The Upper Pennsylvanian Series would comprise either the Kasimovian Stage plus the Gzhelian Stage or the Missourian Stage plus the Virgilian Stage.

In this classification scheme, most of the positionally named series comprise only a single geographically named stage. While some workers may view this as a disadvantage because it provides very little of the expected hierarchy, there are two major mitigating advantages. One is that because the positional names Lower, Middle, and Upper as already applied to the names Mississippian and Pennsylvanian in the USA have never been rigorously biostratigraphically defined, they could readily be applied to units between boundaries chosen for European stage names, without radically changing their traditional usage. The other is that fewer stage boundaries will need to be chosen in the Mississippian, than in the alternative scheme proposed by A. S. Alekseev in the next article in this Newsletter. In that article, Alekseev proposes an innovative subdivision of the Carboniferous that combines the western and eastern European names, but with modified boundaries for some familiar western European names and with more stages needing boundaries to be selected within the Tourmaisian and Viséan Series.

Unfortunately, there is so far no biostratigraphic framework that will readily allow correlation of the more polar Gondwana or Angara regions with the pan-tropical realm where the global subdivision is being established. Those regions will need to retain regional sub-divisions above the upper part of the Mississippian for the present time. Correlation with the Pennsylvanian pan-tropical realm may ultimately be achieved only when radiometric and stable-isotope cheunostratigraphic methods become more refined and accurate.

1. We should first accept stage names and their succession, because searching for GSSPs for unspecified boundaries at nontraditional levels will inhibit timely progress toward the desired end of selecting final stage boundaries.

2. Every stratigraphic term that is currently a candidate for the global chronostratigraphic scale has had its boundaries or biostratigraphic definition changed at some point in its history. This means that relatively minor changes of stage content do not mandate a change in their names.

3. There are no stage names with priority in the global scale because no global scale has ever been formally ratified internationally. However, it is not useful to introduce completely new stages without the testing of their utility by usage through time. For example, in the USSR and Russia more than 40 Carboniferous stages have been proposed since 1864, but only 5 of them have attained uniform usage and the others are now abandoned.

4. The main objective of the ICS is to attain stability of stratigraphic nomenclature, that is, to include in the scale those stages that are most utilized in Carboniferous stratigraphy. The “most utilized” stages are those that have been included in most official general stratigraphic scales, such as those published by ICS (Cowie and Bassett, 1989; Remane et al., 2000) or in global time scales (Harland et al., 1990; Odin, 1994; Gradstein and Ogg, 1996).

5. How many stages do we need? The answer to this question was addressed by Kargarmanov (1998) and later by Menning et al. (2000). The number of stages should be more or less equal for several adjacent systems, in our case Devonian, Carboniferous and Permian. Also stage duration should be comparable with other Paleozoic systems. It is clear that 7 Carboniferous stages (present) are not enough, but 15 or 32 are too many. The best solution would be subdivision into 10-12 stages with mean durations of about 5-6 Ma, which is typical for the whole Phanerozoic.

Several models of Carboniferous subdivision have been proposed. In an early one that was relatively popular among SCCS members in the late 1980s and early 1990s, traditional Carboniferous stages as used in Russia (Tourmaisian, Viséan, Serpukhovian, etc.) were upgraded to series rank. Because each series should be subdivided into several stages, this proposal generated a problem of far too many stages. For example, on the Russian Platform, 32 regional marine sub-stages (horizons) have official status in the Carboniferous time scale (Alekseev et al., 1996), and all of them could be discussed as potential stage candidates together with the large number of western European stages. This proposal is counterproductive, because it would mandate selection of far too many GSSPs.

Another proposal was published by Ruzhenev (1978) and Ruzhenev and Bogošlovskaya (1978). They proposed to split each of the two subsystems into two series: Dinantian and Namurian in the Lower subsystem, and Westphalian and Gzhelian in the Upper subsystem (Figure 1). These authors distributed 10 stages among the 4 series. This proposal looks to be most appropriate in its gross construction, although the names and some
boundary positions need to be corrected. The Carboniferous scale in China has a similar structure (Wang, 1998).

Still another proposal was put forward recently by P. H. Heckel (unpublished table distributed among members of a Working Group in Oviedo, Spain, September 2000). According to it, nearly every stage would correspond to a series (except for the uppermost two stages that are united in one series). This proposal is unacceptable because it runs counter to the established stratigraphic hierarchy of each unique series composed of two or more unique stages. It will also encourage construction of numerous independent regional scales.

If we will follow the above-stated 5 principles as the basis for construction of the Carboniferous stage scale, the most acceptable could be the subdivision proposed by Alekseev (2000) (Figure 1 above).

In this proposal each subsystem is split into two series with their own geographic names. The Mississippian Subsystem could be subdivided into Tournaisian and Viséan series. The latter would incorporate the Serpukhovian as a stage, which is reasonable because its faunal assemblages are very close to Viséan assemblages.

The Pennsylvanian Subsystem would also contain two series: Westphalian and Stephanian. The negative by-product of this is the necessity to move the basal Westphalian boundary downward to include the upper part of Namurian above the Mid-Carboniferous boundary.

According to this proposal the Carboniferous would contain 10 stages, with 2 stages per series, except for 4 in the Viséan. The Tournaisian and Viséan could be subdivided into the traditional Belgian stages below the Serpukhovian. The Pennsylvanian Subsystem could be subdivided into the 4 Russian stages: Bashkirian, Moscovian, Kasimovian and Gzhelian.

The advantages of this newly proposed Carboniferous scale are:

1. It includes names from all three main regional Carboniferous scales (Eastern European, Western European and North American).
2. It consists of stages that have good potential for their GSSPs to be selected in continuous successions.
3. It consists of stages with names that are present in the most utilized regional Carboniferous scales.
4. It reflects the most important biotic and paleogeographic changes during the Carboniferous Period.

The studies that resulted in this version of the Carboniferous chronostatigraphic scale were supported by RFBR grants 97-05-65756 and 00-05-64288.

References:
More radiometric ages for the Carboniferous time scale

Manfred Menning1, Dieter Weyer2, Günter Drozdzewski3 and Immo Wendt4

1GeoForschungsZentrum Potsdam, Telegrafenberg C128, D-14473 Potsdam, Germany (menne@gfz-potsdam.de).
2Löwestrasse 15, D-10249 Berlin, Germany (dieter.weyer@t-online.de).
3Geologischer Dienst Nordrhein-Westfalen, De-Greiff-Str. 195, D-47803 Krefeld, Germany (drozdzewski@gd.nrw.de).
4Kronenweg 11, D-30900 Wedemark, Germany (immo.wendt@t-online.de).

In this newsletter the most recent Carboniferous time scale was published in volume 15 (Menning et al., 1997) as an abstract of a paper at that time announced to appear in Geologische Rundschau (Stuttgart), but later published in Geologisches Jahrbuch (Hannover) (Menning et al., 2000). Compared to the 1997 version, scale 2000 includes eight additional radiometric ages from Central Europe:

a) Ar-Ar sanidine ages of 300.0 ±2.4 Ma (Stefan C/ Rotliegend), 308.0 ±4.0 Ma (Heiligenwal Schichten), and 309.7 ±4.4 Ma (Sulzbach, all Saar region, Burger et al., 1997).

b) U-Pb zircon SHRIMP age of 311.0 ±3.4 Ma (Horst Schichten, Ruhr basin, Claué-Long et al., 1995).

c) Pb-Pb zircon evaporation ages of 330 ±4 Ma (Hainich Formation, Saxonia) and 352 ±8 Ma (Rübschäfer, Thuringian Slate Mountains, both Gehrmuth in prep.).

These above ages (a, b, c) fit with Time Scale B of 1997.

d) U-Pb zircon IDTIMS (crystallization) ages of 326.1 ±2.8 Ma (Büchenberg Schichten/Formation) and 334 ±1 Ma (Adinol Folge/Formation, both Harz Mts., Trapp, 2001).

These ages (d) fit with Time Scale A of 1997 (Fig. 1).

The stratigraphic position of the dated tuffs according to the reference scale used is precise except for that of the Adinol Folge of 334 ±1 Ma and those of the Rübschäfer of 352 ±8 Ma. The former tuff belongs to the Gnathodus texanus Zone, which has an extremely long duration of about 8 Ma (Jones, 1995). The Rübschäfer is of Lower and Upper Tourmaisonian age (Siphonodella crenulata Zone up to Scalioigathus anchoralis Zone), but the position of the dated tuff layer remains uncertain within this lithostratigraphic and conodont zonal sequence.

Time Scales A and B were developed to underline the variability in radiometric ages and to create a time scale with minimum ages (A) and maximum ages (B). Using the chronogram method (e.g., Harland et al., 1990), a time scale that lies between Scales A and B would be created.

Reinvestigations of radiometric data near the Devonian-Carboniferous boundary have been started in order to verify the widely scattered ages of 354 Ma (Claué-Long et al., 1993), 361 Ma (Yang et al., 1988), or 362 Ma (Tucker et al., 1998), and to check the consistency of radiometric ages derived from tuffs that are very close to each other. Zircons of now five tuffs from the Hasselbach auxiliary D-C boundary stratotype section (Rhenish Slate Mountains) will be studied using the IDTIMS method (Trapp et al., in preparation). These ashes within a rather condensed sequence of about 10 m thickness offer very detailed lithostratigraphic dating by ammonoids and conodonts:

—Pseudarietites westfalicus Zone (Upper Siphonodella duplicata Zone)
—Paprophytes dorsoplanus Zone (Lower Siphonodella duplicata Zone)
—Acutothoricas acutum Zone (Siphonodella sulcata Zone)
—Lower Parawockmeria paradoxa Zone (Lower/Middle
Siphonodella praesulcata Zone

An additional ash record for the intervening interval of the Acutimitioceras prorsum Zone (Upper Siphonodella praesulcata Zone) will come from the Bohlen section near Saalfeld in the Thuringian Slate Mountains (Linnemann et al., in preparation).

Using an early Namurian A position for the 319 Ma age of Parychistral from Upper Silesia (cited in Dvorsak 1994 with a questionable stratigraphic association to the upper Asbian) as discussed some years ago by A. Parychistral (J. Hladil, Prague, pers. comm. May 2000), this age would be consistent with Time Scale A and with the middle Namurian A Harewood SHRIMP-age of 314.45 ± 3.3 Ma (Riley et al., 1993) (Fig. 1).

The Westphalian might have a relatively shorter duration of little less than 8 Ma, when parasequences (5th order cycles) from the Ruhr Basin (Süss et al., 2000) are considered.

Available radiometric ages from the Upper Carboniferous (Pennsylvanian) of North America and the Donets Basin cannot contribute to a more precise calibration of the Central/West European reference scale because of: a) the greater number of radiometric ages from Central Europe that are consistent with each other, and b) the sometimes less accurate biostratigraphic correlation of those sections (mainly of terrigenous facies).

References:


Refinement in the age of the Carboniferous - Permian boundary based on U-Pb dating of biostratigraphically constrained syn-sedimentary carbonates in the Appalachian region of North America

Mona L. Becker1,2, E. Troy Rasbury1,3, Gilbert N. Hanson1, William J. Meyers1

1Department of Geosciences, State University of New York at Stony Brook, Stony Brook, NY 11794-2100, USA.

2Present address: Department of Earth Sciences, Parks Road, Oxford, OX1 3PR, UK.

E-mail: Mona.Becker@earth.ox.ac.uk

E-mail: troy@pbiotopess.ess.sunysb.edu

The isotope lab at Stony Brook has established U-Pb dating of stratigraphically and petrographically well-constrained syn-sedimentary carbonates from a variety of marine and terrestrial settings for determining the time of sedimentation (Hoff et al., 1995; Rasbury et al., 1997; 1998; Wang et al., 1998; Becker et al., in review; Rasbury et al., in review). Samples are selected from sections that have been deposited rapidly, so that an age directly dates the time of sedimentation.

Recent results on U-Pb dating of lacustrine and palustrine carbonates provide absolute age constraints for the Late Paleozoic section of the northern Appalachian Basin (Becker et al., in preparation). The lacustrine Upper Freeport Limestone near the top of the Allegheny Group (late Desmoinesian) in western Pennsylvania yields a U-Pb age of 302 ± 4 Ma (2σ). A paleosol from directly below the marine lower Virgilian Ames Limestone of the Conemaugh Group in southern Ohio yields an age of 294 ± 6 Ma (2σ). A paleosol from the Monongahela-Dunkard lithostratigraphic contact yields an age of 275 ± 6 Ma (2σ), which although unconstrained biostratigraphically, has been conventionally considered the Pennsylvanian-Permian boundary in this region. Based on the early Virgilian conodont assemblage from the

18 Carboniferous Newsletter
Ames Limestone (co-occurrence of *Idiognathodus simulator* and *Streptognathodus pawhuskaensis*), the Carboniferous–Permain boundary is younger than 294 ± 6 Ma (2σ), but the 275 ± 6 Ma (2σ) age for what has been considered the Pennsylvanian–Permain boundary with no biostratigraphic control is dramatically younger than is reasonable for this boundary (which is the same as the Carboniferous–Permain boundary now that the Pennsylvanian is officially recognized as the upper subsystem of the Carboniferous System).

Previous ages reported for the Carboniferous–Permian boundary are:

<table>
<thead>
<tr>
<th>AGE</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>290 ± 20 Ma (2σ)</td>
<td>Harland et al., 1990</td>
</tr>
<tr>
<td>300 ± 7 Ma (2σ)</td>
<td>Hess and Lippolt, 1986</td>
</tr>
<tr>
<td>295 ± 5 Ma</td>
<td>Ross et al., 1995</td>
</tr>
<tr>
<td>301 ± 2 Ma (2σ)</td>
<td>Raszbury et al., 1998</td>
</tr>
<tr>
<td>292 Ma</td>
<td>Menning et al., 2000</td>
</tr>
</tbody>
</table>

A Carboniferous-Permian boundary age younger than 294 Ma is consistent with the boundary age suggested by Menning et al. (2000) of 292 Ma for central and western Europe based on U-Pb zircon ages (Chuvashev et al., 1996) and various biostratigraphic schemes. However, the age of 275 ± 6 Ma (2σ) for the Monongahela-Dunkard contact in the Appalachian region is far younger than any proposed Carboniferous-Permian boundary date. In this case, the age of the paleosol at that contact suggests that most, if not all of the Monongahela Group in the Appalachian region is Permian rather than Pennsylvanian in age.

The boundary age based on the conodont-constrained Ames Limestone is inconsistent with the age proposed by Raszbury et al. (1998) of 301 ± 2 Ma (2σ) from marine sections in southwest Texas¹ and southern New Mexico². This discrepancy in ages for the Carboniferous – Permian boundary suggests a problem with global correlation based on current fusulinid biostratigraphical schemes in that region. This discrepancy is further supported by a precise age on altered aragonite marine cements in algal mounds of the Laborcita Formation immediately below the Carboniferous – Permian boundary based on fusulins in the Sacramento Mountains of New Mexico (Raszbury et al., in review). These cements give an age of 304 ± 2 Ma, indistinguishable from the 301 ± 2 Ma age proposed for the boundary in this section. The Sr isotopic composition of the altered cements is more radiogenic than that proposed for the Late Pennsylvanian (Virgilian), the age that is suggested by the occurrence of *Pseudoschwagerina* from right above the algal mounds. Sr concentrations in these cements are greater than 2000 ppm suggesting they should record marine values, but the Sr isotopic composition is compatible with a Mississippian age on the curve of Denison et al. (1994). A Mississippian age is further supported by unpublished conodont results from the underlying Holder Formation that suggest at least part of the Holder Formation is Mississippian (J.E. Barrick, personal communication to P.H. Heckel) although it has been generally considered to be entirely Virgilian.

The results of these studies highlight the great potential for using logically selected well-characterized syn-sedimentary carbonates samples to directly date the time of sedimentation. This allows the establishment of time relationships between marine and terrestrial sections as well as between various index fossils. Absolute age constraints on biostratigraphical horizons are the only way to evaluate global correlations and will be critical for refining the geological time scale.

Notes:

¹ Samples are from a U-Pb core collected from the Central Basin Platform with fusulinid stratigraphy by Garner Wilde.
² Samples from the Holder and Laborcita Formations of the Sacramento Mountains where Gene Rankey found *Pseudoschwagerina* above the algal mounds of the Laborcita.

Acknowledgements: This research has been funded by a DOE grant DEFG0294ER14449 to Gil Hanson and Bill Meyers. Collaborators for the studies discussed include Bob Goldstein, Art Saller, Beth Gierlowski-Kordesch, Greg Nadon, Bruce Ward and Gary Hemming. This work would not have been possible without the stratigraphic framework established by our collaborators. We also thank Phil Heckel and Jim Barrick for discussions on biostratigraphy.

References:


---

**Toward a Carboniferous tetrapod biochronology**

Spencer G. Lucas

New Mexico Museum of Natural History, 1801 Mountain Road N.W., Albuquerque, NM 87104-1375, USA.

**Introduction**

On the standard global chronostratigraphic scale, Carboniferous time is measured primarily by the evolution of fusulinids, conodonts, brachiopods and ammonoids. The relatively rapid evolutionary turnover of genera and species of these taxa provides the basis for the regional (in Eastern Europe) subdivision of the Carboniferous into as many as seven epochs that encompass 25 stages (Rotai, 1979; Harland et al., 1990), though a globally applicable timescale may discriminate only about eight stages (e.g., Menning et al., 2000). In nonmarine Carboniferous strata, biostratigraphy has largely been based on megafossil plants and palynomorphs, following a tradition that extends back to the nineteenth century (e.g., Lesquereux, 1879-1884; Ward, 1892).

The use of fossil tetrapods (amphibians and reptiles) to subdivide Carboniferous time also dates back to the 1800s, when Marsh (1891, 1898) divided the North American Carboniferous into the "Sauropus beds" and "Eosaurus beds." He indicated that the former, based on a footprint ichnotaxon, is the time of the first amphibians, whereas the latter is the time of the first reptiles. Unlike Carboniferous plant-based biostratigraphy, no tradition grew out of Marsh's work. Indeed, those who have more recently reviewed the Carboniferous tetrapod record (e.g., Romer, 1966; Panchen, 1973; Carroll, 1979; Milner et al., 1986; Milner, 1993b) have not attempted temporal subdivision based on tetrapods.

Tetrapods have not been used to subdivide Carboniferous time for reasons discussed at length by Carroll (1979; also see Rayner, 1971). Carroll concluded that no useful tetrapod biozonation of the Carboniferous is possible because: (1) many Carboniferous tetrapod records are endemic occurrences of a taxon known only from a single locality, and therefore of no real value to correlation between localities; (2) many Carboniferous tetrapod taxa have long temporal ranges, indicative of low rates of evolutionary turnover, so they do not provide a robust basis for a refined subdivision of Carboniferous time; and (3) facies control of Carboniferous tetrapod occurrences (especially red-bed versus coal measure occurrences) confound correlation. Put simply, there are few index taxa with which to construct a Carboniferous tetrapod biochronology.

A second problem for developing a Carboniferous tetrapod biochronology is that many localities (especially in North America) are widely dispersed geographically and cannot be placed in stratigraphic order by superposition. Instead, they are assigned an age based on local marine or plant biostratigraphy, and then placed into temporal order. The only exception to this is the Scottish Midlands, where a large number of Visian to Westphalian tetrapod localities can be placed in temporal order by stratigraphic superposition (Smithson, 1985). As Smithson (1985) noted, this superposition identifies two distinct tetrapod assemblages, with turnover at about the beginning of the Westphalian. The tetrapod record from the Scottish Midlands thus presents a firm basis upon which to develop tetrapod biostratigraphy and biochronology of part of Carboniferous time.

Here, I propose that four informal divisions of Carboniferous time can be recognized based on tetrapod evolution (Fig. 1). Following Lucas (1998, 2000), I term these intervals faunachrons, which are biochronological units characterized by a distinctive

---

**Figure 1. Informal tetrapod biochronology of the Carboniferous.**
“fauna,” and with boundaries defined by the first appearance datum (FAD) of a taxon.

**Faunachron A**

The tetrapod-body fossil record begins in Upper Devonian strata with occurrences of stem tetrapods in Pennsylvania, Greenland, Scotland, Latvia, Russia and Australia. Late Devonian tetrapod tracks are known from Australia and Scotland. All these records appear to be from Frasnian-Fammenian age (Clack, 1997).

Although Devonian tetrapod records have a broad geographic distribution, they lack abundance and diversity, a point noted by Rayner (1971). Particularly significant is the lack of lower-level taxa (genera and species) that are widespread and thus of value to correlation. Therefore, the Devonian tetrapod record provides a flimsy basis for biostratigraphy and biochronology.

Faunachron A can be defined as the time between the FAD of tetrapods and the beginning of faunachron B, which is defined by the FAD of anthracosaurs. Stem tetrapods (“ichthyostegalians”) dominate the tetrapod record during faunachron A. The characteristic assemblage is from the Celsius Bjerg Group in East Greenland (Jarvik, 1996). However, there are no tetrapod genera during faunachron A that can be used as index taxa, so tetrapod-based correlations within faunachron A are not possible.

**Romer’s gap**

The Late Devonian tetrapod record is followed by a substantial hiatus (at least 15 million years) in the tetrapod fossil record before tetrapods are found again in middle Viséan strata. This gap is made striking by the sudden Viséan appearance of several major tetrapod taxa, including temnospondyls, anthracosaurs and amniotes (e.g., Ahlberg and Milner, 1994). Clearly, as several workers have emphasized, the functional transition from water to land and the ensuing early diversification of terrestrial tetrapods took place during this gap.

Coates and Clack (1995) named this hiatus Romer’s gap. Recent discoveries (e.g., Paton et al., 1999) indicate that it may be possible to fill this gap with further collecting. Thus, Romer’s gap may only be an artifact of inadequate sampling, not due to an absence of potential fossil record. Recognition of Romer’s gap underscores the current incompleteness of the early fossil record of tetrapods.

**Faunachron B**

The FAD of Anthracosaurus defines the beginning of faunachron B, a time interval that saw the relatively widespread initial radiation of anthracosaurs and amniotes. Localities of faunachron B age are in Utah, West Virginia, Iowa, Illinois, Nova Scotia and Scotland (e.g., Carroll et al., 1972; Wellstead, 1982; Smithson, 1985; Godfrey, 1988; Bolt et al., 1988). The recently discovered tetrapods from the Drummond basin in eastern Australia include a colosteid, a possibly temnospondyl and an anthracosaur (Thulborn et al., 1996) and are also of faunachron B age.

The most diverse assemblage in this interval is East Kirkton in Scotland, and I consider it characteristic. East Kirkton is a lacustrine deposit near the top of the “upper oil shale group” (= Strathclyde Group) and has produced a stem tetrapod, the temnospondyl Balanerpeton, a larger unidentified temnospondyl, the aistopod Ophiderpeton, the stem amniote Eldeceeon, the anthracosaur Silvanerpeton, the stem amniote Westlothiana and larger, unidentified anthracosaurs (Clarkson et al., 1994; Milner and Sequeira, 1994; Wood et al., 1985).

I hesitate to identify index taxa for faunachron B, because all taxa from this time interval are known from one or a few localities. However, Godfrey (1988) has demonstrated that tetrapod-based correlations in this time interval are possible, for example, between Greer, West Virginia and Cowdenbeath, Scotland.

**Faunachron C**

The beginning of Faunachron C can be defined by the FAD of Nectridea, although their sudden appearance and early diversity suggests older records remain to be discovered. Faunachron C approximately correlates to Westphalian time and encompasses what Milner (1987) described as a homogenous chrono Fauna consisting of about 30 tetrapod families. Characteristic elements of this chrono Fauna are loxommatoids, colosteids, aistopods, nectrideans, anthracosaurs, temnospondyls, microsaurians and early amniotes. Faunachron C age localities are widely distributed in Euramerica and include sites in Arizona, Illinois, Ohio, Nova Scotia, the Czech Republic and Great Britain (Milner, 1987).

The best index taxa of faunachron C are the loxommatoids Baphetes and Loxomma, whereas other potential index taxa such as Anthracosaurus and Dendrerpeton have much more geographically restricted distributions. The Linton, Ohio assemblage is one of the most diverse faunachron C assemblages, and I consider it characteristic. It includes the loxommatoids Baphetes and Megalepches, a colosteoid, nectrideans, anthracosaurs, several temnospondyls, microsaurians and early amniotes (Hook and Baird, 1986).

**Faunachron D**

The FAD of Edaphosauridae defines the beginning of faunachron D. This marks a substantial change in the tetrapod fauna at about the Westphalian-Stephanian boundary, with the first appearances of Eryopidea, Cochleoidea, Dissorophidae, Discosauriscidae, Trimerorhachidae, Diadectidae, Petrolacosauridae, Varanospeidae, Sphenacodontidae and others (Benton, 1993; Milner, 1993a; Berman et al., 1997). The edaphosaur lanthasaurus, known from Colorado, Kansas and the Czech Republic (Reisz and Berman, 1986; Modesto and Reisz, 1990; Sumida and Berman, 1993), is the best possible index taxon.

Localities of faunachron D age are widely distributed and include sites in New Mexico, Colorado, Kansas, Pennsylvania and the Czech Republic. The Badger Creek assemblage from the Sangre de Cristo Formation near Howard, Colorado may be considered characteristic. It includes a labyrinthodont, an aistopod, microsaurian, the diadectomorphs Desmatodon and Limnoscelis, a protorothyrid and ophiacodontid, sphenacodontid, haplodontid and edaphosaurid polycaul, including lanthasaurus (Vaughn, 1969, 1972; Berman and Sumida,
Conclusion

The tetrapod record can be used to divide Carboniferous time into only four intervals, largely because of the limited geographic distribution, low taxonomic diversity and inadequate sampling of the Carboniferous tetrapod record. In essence, these four tetrapod-based faunichrons are global chrono- faunas. They provide poor biochronological resolution and a limited basis for tetrapod-based correlation, but accurately map current understanding of the major phases in Carboniferous tetrapod evolution.

References


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

Michael R.W. Amler,
Chairman, German Subcommission on Carboniferous Stratigraphy
Institut für Geologie und Paläontologie der Philipps-Universität Marburg, Hans-Meerwein-Strasse, D-35032 Marburg, Germany (amler@mail.uni-marburg.de).

The annual meeting of the German Subcommission on Carboniferous Stratigraphy was held in Cologne from April 27 to 29, 2001. As in past years the meeting was supplemented by field trips related to Carboniferous stratigraphy and geology. During the first day we visited outcrops of Famennian to Viséan strata in the Velbert Anticline, a region of historical importance for the study of the Devonian/Carboniferous boundary and, also, of current interest, for the transition of the Carboniferous Limestone shelf area into the central European Kulm “Basin”. The last day focussed on the stratigraphy of the Aachen region which corresponds to that of the Belgian sequence in the Late Devonian and Early Carboniferous.

During the official part of the meeting the assembly voted on several Carboniferous topics of national and regional importance and decided in accordance with the contribution by Menning et al. (2000):

1. The Lower Carboniferous (Mississippian; Hastarian to Arnsbergian) and the Upper Carboniferous (Pennsylvanian; Chokierian to Gzhelian) are regarded as series.

2. The five regional stratigraphical units of western and central Europe, Tournaissian, Viséan, Namurian, Westfalian and Stephanian, are regarded as regional stages.

3. The units Tournaissian, Viséan, Serpukhovian, Bashkirian, Moscovian, Kasimovian and Gzhelian are recommended as global stages.

4. The 21 Carboniferous units of western and central Europe, Hastarian to Stephanian C, are regarded as substages.

Within the series of monographs on the stratigraphy of Germany (three of which already published in Courier Forschungsinstilten Senckenberg, Frankfurt / M.), two volumes on the Carboniferous are almost ready for publication in late 2001. The assembly corrected an earlier decision on the titles and voted for “Das Unterkarbon (Mississippium) in Deutschland” and “Das Oberkarbon (Pennsylvanium) in Deutschland”.

The next meeting of the German Subcommission will be held in late April/early May 2002 at Arnsberg, Iserlohn or Menden with field trips to Carboniferous and Late Devonian outcrops along the northern border of the Rheinishes Schiefergebirge. Guests from other countries are invited to attend the meeting; detailed information in autumn/winter 2001 from the chairman (M.R.W. Amler) or secretary (V. Wrede) of the German Sub-

Position of Kinderhookian-Osagean boundary in northeastern Kentucky and southern Ohio

Charles A. Sandberg¹, Charles E. Mason², and David M. Work³

¹United States Geological Survey, Box 25046, Federal Center, MS 940, Denver, CO 80225, USA.
²Department of Physical Sciences, Morehead State University, Morehead, KY 40351, USA.
³Cincinnati Museum Center, Geier Collections and Research Center, 1301 Western Ave., Cincinnati, OH 45203, USA.

Preliminary results of a detailed study of conodonts and ammonoids demonstrate that the Kinderhookian-Osagean (K-O) boundary is positioned close to the base of the Henley Bed (or Member) of the Borden and Cuyahoga Formations. This K-O boundary position generally is only about 50 cm above the base of these units and is interpreted to represent a non-depositional hiatus. The current study, based on residues obtained from the processing of large (10-200 kg) clay shale and mudstone samples, has yielded large conodont faunas from conodont-poor rocks that previously were dated only by ammonoids. These large faunas have enabled recognition of the standard sequence of Lower Mississippian conodont zones and precise correlations with stratigraphic units in adjacent areas. The basal 10 cm of greenish-gray phosphatic claystone is recognized to be the Jacobs Chapel equivalent and is dated as the lower part of the Lower crenulata Zone. This interval is succeeded by a thin bed of yellowish-orange-weathering argillaceous dolomite that is equivalent to the Rockford Limestone. The Rockford interval is dated as being close to the boundary between the youngest Kinderhookian isostichia-Upper crenulata Zone and the succeeding earliest Osagean Lower typicus Zone. Studies to determine whether even this bed might be entirely earliest Osagean are in progress. The remainder of the Henley Bed and Farmers Member, and the overlying Nancy Member of the Borden Formation in Kentucky are dated as Upper typicus Zone. The lower Nancy Member contains, in association with Upper typicus Zone conodonts, the Cave Run Lake ammonoid fauna, comprising Kazakhstania colubrella, Muensteroceras oweni, and Karagandoceras “n. sp. The identical ammonoid fauna, also in association with Upper typicus Zone conodonts, has been recovered from a measured section of the Cuyahoga Formation along Ohio Highway 32 at the Pike-Adams County line.
Tournaissian-Viséan boundary in Mokra near Brno (Czech Republic)

L. Ondrackova,

Department of Geology and Paleontology, Faculty of Science, Kotlarska 2, 611 37 Brno, Czech Republic.

In the definition of Lower Carboniferous stages, attention has recently concentrated mainly on the evolutionary changes from Eoparastaffellina to Eoparastaffella (the change from Eoparastaffella Morphotype 1 to Morphotype 2 sensu Hance). The evolution of Eoparastaffella can be traced mainly in the Paleotethyan Realm, while Eoparastaffella is absent or rare in the Siberian and North American realms where Eoendothyranopsis plays an important role. As representatives of the genus are also quite common at the Tn-V boundary in the Paleotethyan Realm (the Urals, the East European Platform, Moravia, south China), it seems promising to extend the study of evolutionary lineages at the Tn-V boundary to this genus as well.

In Eoendothyranopsis, we can distinguish the more irregularly coiled subgenus Skipella and Ninella from the more regularly coiled Eoendothyranopsis. These differences may possess biostratigraphic value as Ninella (especially the group Ninella donica) occurs earlier in the uppermost Tournaissian. Subgenus Skippella and Eoendothyranopsis have been found only in the Viséan (Mamek's Zone 10 and higher), mostly in the North American and Siberian Realm.

Eoparastaffella and Eoendothyranopsis were studied in two profiles of the Tournaissian-Viséan boundary beds in the Mokra quarries (Moravia, Czech Republic). The first profile is composed of an alternation of limestones and red to green shales of the uppermost Tournaissian age (Scalognathus anchoralis Zone). The shales contain locally abundant trilobites. In the lower part biotedral, often sandy limestones predominate, the representation of shales and bioclastic limestones increases to the top of the profile. Microfacially, packstones predominate; wackestones and grainstones are less frequent. Micrite is often partly recrystallized to microsparite and pseudosparite. Crinoids are the most abundant clasts, although foraminifers, grains of quartz, calcispheres, ostracodes, red algae (Solenoporaaceae), moravamnids, brachiopods, bryozoans, blue-green algae, bivalves and trilobites occur as well. The studied foraminiferal genera in the profile are represented mostly by Eoendothyranopsis. The following species have been recognized: Eoendothyranopsis (Ninella) donica Brazhinikova et Rostovtsjeva, 1964, Eoendothyranopsis (Ninella) lebedeva Slovjeva, 1967, Eoendothyranopsis (Ninella) moravica n.sp., Eoendothyranopsis (Ninella) aksarsaitica Michno, 1975, and Eoendothyranopsis (Ninella) transita Lipta, 1955. The genus Eoparastaffella is represented only by the evolutionarily older subgenus Eoparastaffellina (see Fig. 1).

In the second profile an overturned sequence of Famennian, Tournaissian and Viséan limestones is exposed. The contact between Middle and Upper Tournaissian limestones is tectonic. The Upper Tournaissian and Lower Viséan sequence is composed of an alternation of biotedral and bioclastic limestones and thin shale intercalations. The representation of bioclastic limestones increases to the top. A gradation with biotedral limestone at the base and bioclastic limestones in the top of the beds is locally apparent. Microfacially, packstones and grainstones are present, especially in the lower part of the profile, and no facia change can be distinguished at the Tournaissian-Viséan boundary. Matrix of grainstones is composed of microsparite and pseudosparite, however, originally it was composed of micrite. Syntectial rim sparite mostly bound to crinoids is locally abundant. Crinoids again represent the most abundant clasts, although foraminifers and calcispheres are also frequent. Ostracodes, quartz grains, red algae (Solenoporaaceae), moravamnids, brachiopods, trilobites, rugose corals, bryozoans, rugose corals, blue-green algae, bivalves, intraclasts and conodonts are present as well. Among conodonts gnathidids predominate (gnathidid biofacies). In the uppermost Tournaissian part of the profile Eoendothyranopsis is frequent while Eoparastaffella predominates in the Viséan. Among eendothyranopsids the species Eoendothyranopsis (Ninella) moravica n.sp. is most abundant; Eoendothyranopsis (Ninella) donica Brazhinikova et Rostovtsjeva, 1964, Eoendothyranopsis (Ninella) lebedeva Slovjeva, 1967, Eoendothyranopsis (Ninella) aksarsaitica Michno, 1975 were found as well. No representatives of Eoendothyranopsis (Eoendothyranopsis) have been found even though some specimens show a certain similarity to the subgenus.

Among eoparastaffellins Eoparastaffella simplex Vdovenko, 1954 is the most frequent species. In addition, Eoparastaffella ovalis Vdovenko, 1954 and Eoparastaffella littenchensis Postojalko, 1975 have been found. Eoparastaffella evoluta Vdovenko, 1971 and Eoparastaffella pseudochomata Vdovenko were determined from older samples. Among evolutionary older eoparastaffellins Eoparastaffellina rotunda Vdovenko, 1971 was distinguished. The first occurrence of Eoparastaffella simplex Vdovenko, 1954 in the profile coincides with the first occurrence of the index conodont Mesognathus beckmanni Bischoff, 1957. No representatives of the subgenus Eoendothyranopsis have been found.

The joint presence of shallow water bioclasts (foraminifers, algae, calcispheres, crinoids, rugose corals etc.) and deeper water fauna (conodonts — abundant gnathidids, Scalognathus, trilobites) as well as apparent gradation suggests that most of the limestones can be regarded as calciturbidites. The joint presence of abundant index taxa of calcareous foraminifers and conodonts makes the profiles ideal for the recognition of the Tournaissian-Viséan boundary. However, the tectonic disruption precludes proposing the profiles as potential candidates for a Tournaissian-Viséan boundary stratotype, the search for which is now in progress worldwide.

The study of the abundant foraminiferal fauna of the Mokra profiles will continue to bring more detailed information on the evolution of Eoparastaffella and Eoendothyranopsis.

References
Fig. 1 Distribution of *Eoparastaffella* and *Eoendothyranopsis* in profile 1 and profile 2 in Mokra (Moravia, Czech Republic)
New data on conodonts and foraminifers from the Tournaisian-Viséan boundary beds of the Kokshaaltau Range (South Tien-Shan, Kyrgyzstan)

A.V. Djenchuraeva, A.V. Neevin, T.Yu. Vorobyov
State Agency on Geology, Bishkek, Kyrgyz Republic (mail@geoagency.bishkek.gov.kg).

Foraminifers and conodonts on which separation of Tournaisian-Viséan sediments is made were discovered by the authors in samples from siliceous-carbonate strata along a section situated on the right bank of the Zadpny Aksai River (central part of the Kokshaaltau Range, South Tien-Shan) (Fig. 1).

In this strata only foraminifers were discovered previously [4,5]. A poor assemblage of foraminifers did not allow the Tournaisian-Viséan boundary to be exactly determined. In carbonate-siliceous sediments of this region conodonts were later described [3]. However, foraminifers and conodonts were only found jointly on the right bank of the Zadpny Aksai River in the Aksai section. Based on an analysis of their time range it was possible to biostratigraphically divide a homogeneous facies of strata and reveal a boundary of spread of Tournaisian and Viséan assemblages of these two fossil groups.

The siliceous-carbonate strata is lithologically represented by calcarenites, oolitic limestones with interbeds of flints and siliceous shales. These rocks contain Upper Tournaisian foraminifers and conodonts. Lower Viséan limestones without siliceous shales overlie concordantly the Upper Tournaisian rocks and upwards there are more massive limestones classified tentatively as Middle Viséan-age. The lithologic composition of the rocks and their contained microfossils allowed Yu.S. Biske [1,2] to define this strata as slope facies of an edge of a carbonate platform of the Tarim paleocontinent.

In the studied section the following zones were defined:

The Carboniferous System, Tournaisian Stage, Upper substage, anchoralis Zone.

Fig. 1 Location of the Aksai section, the Kokshaaltau Range, South Tien-Shan


Thickness is 152.0 m.

**The Visean Stage, Lower-Middle substages, texanus Zone.**

The zone was defined by the first occurrence of the conodont index species *Gnathodus texanus* Roundy.

**Bed 2.** Thin-, medium-laminated elastic limestones (calcarenites), oolitic limestones with interbeds of thin-platy flints. The absence of greyish-brown platy siliceous shales is characteristic. The limestones contain foraminifers: *Priscella prisca* (Raus. et Reitl.) (*N*º 35), *Paraarchaeodiscus krestovnikovi* (Raus.) (*N*º 38) and the flints contain conodonts: *Gnathodus texanus* Roundy (*N*º 36).

Thickness is 54.0 m.


Thickness is 66.0 m.

The research yielded the following results:

1. Two conodont zones were defined in the Aksai section: *anchoralis* and *texanus* Zones. They make it possible to track the Touraisian-Viséan boundary on the first appearance of the zonal taxon *Gnathodus texanus* Roundy against the background of the homogeneous lithologic composition of the deposits.

2. Conodonts and foraminifers occur jointly here and supplement each other. This correlation on two dominant faunal groups raises the value of each of them, especially when they are separated from one another because of various composition of rocks containing them.

3. Replacement of the homogeneous siliceous-carbonate strata (Beds 1, 2) by the massive large-oolitic limestones without interbeds of flints and the absence of conodonts in the massive limestones can indicate that the change of the facial situation (shallowing of a sea basin) was not at the Touraisian-Viséan boundary but later – at the Lower-Middle Viséan boundary.

Since conodonts are a weakly investigated faunal group in this region, joint dating with foraminifers of age of the sediments expands the prospects of using this orthostratigraphic group of microfossils for separation of Carboniferous formations in Kyrgyzstan and their correlation with the International Scale.

**References**


<table>
<thead>
<tr>
<th>Conodont zone</th>
<th>Bed</th>
<th>Thickness</th>
<th>Lithology</th>
<th>Sample</th>
<th>Foraminifera</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>54</td>
<td>68</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Protagnathodus praedelicatus**
- **Polygnathus inornatus**
- **Pseudopolygnathus sp.**
  - **Neopolygnathus communis**
    - **Gnathodus semiglaber**
    - **Gnathodus typicus**
    - **Scaliognathus anchoralis**
    - **Gnathodus texanus**

- **Tournayella discoidea f. maxima**
- **Pseudoglobopecten gordialis**
- **Pseudoglobopecten brevispina karakubensis**
- **Endothyra latispinalis**
- **Endothyra antiqua**
  - **Pseudoplanendothrya rotayi**
  - **Granuliferella granulosa**
  - **Endothyra kosvensis**
    - **Endothyra tuberculata**
    - **Endothyra spinosa**
      - **Priscella prisca**
        - **Paraarchaeodiscus krestovnikovi**
Fauna and sedimentation near the Viséan/Serpukhovian boundary (Izayu River section, Tchernyshev Swell, Subpolar Urals)

Olga L. Kossovaya¹, Yadviga A. Vevel², Andrey V. Zhuravlev³

¹VSEGEI, St. Petersburg, Russia
²VNIGRI, St. Petersburg, Russia

The position of the Viséan/Serpukhovian boundary has not yet been settled with certainty. The boundary is considered as corresponding to the base of the *Pseudoendothyra globosa - Neoarchaedicus parvus* or C17 foraminifer Zone (Conil et al., 1990), and the *Uraloprotronites - Cravenoceras* or E1 (*Cravenoceras leion*) goniatite Zone. As a consequence of detailed biostratigraphic studies, the boundary of the Viséan and Serpukhovian is established approximately at the base of the *Lochreia cruciformis* conodont Zone in relatively shallow-water deposits (Skompski et al., 1995; Zhuravlev and Sobolev, 2000). However, this zone was not described in the type region of the Serpukhovian (Russian Platform) (Skompski et al., 1995) because revision of the huge conodont collections is not yet completed (Nikolaeva et al., in preparation). So, the exact position of the Viséan/Serpukhovian boundary within the conodont zonal sequence is not yet clear.

The shallow-water regime at the end of the Viséan in the Russian Platform is the main reason to search for other sections where the Viséan/Serpukhovian boundary is traceable and characterized by various fauna. Significant changes in lithologic com-

position and facies near the boundary necessitates using a number of detailed zonal successions based on nektic and benthic fauna. This facies change is considered as initiated by global climatic change (global cooling, according to Brand, 1989) and a short-term regression-transgression couplet.

The Izayu River section situated in the Tchernyshev Swell (Fig. 1) contains fossiliferous deposits of the Upper Viséan and lowermost Serpukhovian. This section was studied by the authors in 1998 with respect to the Viséan/Serpukhovian boundary beds. Primary attention was paid to foraminifers, conodonts, corals, and sedimentary sequences (Fig. 2). The section is composed of two lithologically different members. The contact between them approximately corresponds to the Viséan/Serpukhovian boundary. The lower member of the studied section is composed of detrital and algal limestones. The upper member is composed of micro-laminated micritic and clayey limestones intercalated with thin layers of argillite. This lithologic change probably reflects a eustatic sea-level rise following a fall in the latest Viséan (Fig. 2) and is also traceable in the stratotype region of the Serpukhovian Stage (Guidebook, 1998).

Investigation of microfacies allows recognition of three third-order sedimentary sequences (Fig. 2):

**First sequence**

A transgressive system tract is represented by crinoid-foraminifer, algae-bryozoan, and crinoid-algal grain-packstones. Conodont associations are dominated by the *Gnathodus blineatus* group (Fig. 2). Small *Siphonodenron junceum* dominates the Rugosa association. Subsequent deepening led to a change of coral associations and to the appearance of the solitary corals *Cyathaxonia* and *Ufimia*. Among foraminifers large
archaeodiscids and howchinids are numerous, but other genera (Gleboendothyra, Endothyranopsis, Climacocammin, Eostaffella, Bradyina) are rare.

Maximum flooding surface is considered at the top of unit 1.

Second sequence

A diastem marks the base of the sequence. A low stand system tract corresponds to unit 2. Microfacies are represented by algae-foraminiferal wackestone containing the shallow-water rugose coral Koninkophyllum, and the foraminifers Omphalotis and Bradyina.

Units 3, 4, and 5 are considered as transgressive system tract. The lower part of the tract is characterized by the appearance of abundant algae (mainly Calcifolium and Fasculina) and the rugose coral Dibunophyllum. Foraminiferal-crinoidal-algal packstone-wackestones containing brachiopod shells, crinoids, and ostracodes are most typical for the transgressive system tract. Foraminifers are represented by Tetraactis, Howchinia, and numerous Endostaflia. In places packstones are replaced by secondary dolomites. The upper part of the transgressive system tract (maximum flooding) yielded conodonts, dominated by Lochria. In this part of the section rare rugose corals (Bradyihyllum) occur. The foraminifer association is dominated by small Archaediscus, but rare Endothyra occur as well.

The highstand system tract (unit 6) is characterized by a gradual increase of bioclastic abundance and an upward transition from crinoidal-wackestone to algal packstone. Lochria and Hindoedus dominate poor conodont associations in this part of the section. Small Archaediscus, rare Endothyranopsis and Janischewskina compose diverse but not abundant foraminifer associations. Algae abundance decreases and foraminifer abundance decreases in the upper part of the tract.

Third sequence

Only the transgressive system tract of this sequence was studied. The sediments are represented by micro-laminated mudstones (units 7, 8, 9) containing clay minerals and cherty inclusions. The presence of thin-shelled brachiopods is characteristic. Conodont and foraminifer associations demonstrate diversity and abundance decreases upward. The ubiquitous Gnathodus gilrty group dominates the conodont association. Foraminifers are represented by small Archaediscus krestovnikovi group and Neorchaediscus characteristic of a more cool, deep-water and soft-bottom environment. Rugose corals (Asserculina) were found only in one sample (sample 65).

Data obtained permits the following stratigraphic conclusions. Based on conodonts the Viséan-Serpukhovian boundary is drawn in the upper part of unit 5 by the first appearance of Lochria cruciformis in the phylogenetic succession L. senckenbergica - L. cruciformis (Zhuravlev and Sobolev, 2000). Foraminifers allow supposing a lower position of the boundary marked by the appearance of the Serpukhovian genus Monotaxinoides in association with the Viséan-Serpukhovian Howchinia bradyana at the middle of unit 3 (Fig. 2). Thus, in the studied section the difference between lower limits of conodont and foraminifer zones determining the position of the V/S boundary is observed.

This work was supported by RFBR grant #99-05-65290.
Foraminiferal biostratigraphy of the Serpukhovian Stage stratotype (Zaborie quarry, Moscow Basin)

Nilyufer B. Gibshman

Russian University of Oil and Gas, Dept. Geology, Leninsky Prospect 65, Moscow, Russia
(nilyufer@mtu-net.ru).

The Serpukhovian Stage, proposed by S. N. Nikitin in 1890, was re-established in the Russian stratigraphic scheme in 1974 and since then it has become internationally recognized. Zaborie quarry, the Serpukhovian Stage stratotype, is located in the southern margin of the town of Serpukhov (54° 54’ N - 37° 24’ E). The limestones in the basal and upper parts and shale with marl, dolomite interbeds in the middle part of the sequence are almost completely exposed and range from the Venetian, that is uppermost Viséan, through the Tarusian, Steshevian, and Protvian of the Serpukhovian Stage.

Foraminifera studied previously come from the Tarusian to the middle part of the Steshevian (Rauscher-Chernousova, 1948), and those studied recently from the Tarusian to the Protvian. Vdovenko (Makhлина et al., 1993) was the first to recognize the foraminiferal zones in this section. They are the *Pseudoendothyra globosa-Neoarchaeidiscus parvus* and *Eostaffellina protvae* Zones, which correspond with the Tarusian-Steshevian and Protvian, respectively. Because *P. globosa* and *E. protvae* were not discovered in this section and zonal assemblages contained a few Serpukhovian species *Endothyra phrissa* Zeller, *Planendothyra* sp., and *Eostaffellina* sp., as well as long-lived, incepted from the Viséan forms *Endothyranopsis sphaericus*, *Archaediscus krostovnikovii*, *Neoarchaeidiscus parvus*, and *N. rugosus*, information was incomplete for precise interregional correlation on the basis of foraminifera.

The new study of foraminifera from the Venetian to Protvian (600 thin sections from 41 beds) discovered over 100 taxa, including the thirty stratigraphically important Serpukhovian species and forms incept in the Viséan from the Zaborie stratotype for the first time (Gibshman, 2000). Microfacies and environments evolution have been analyzed bed-by-bed (Fig. 2). Holotypes of the most important Serpukhovian species were also analysed in detail. In terms of the foraminiferal zonation of the Russian Platform proposed by Lipina and Reitlinger (1970), with some changes, the measured section (Fig. 2) contains from the base to the top the *Eostaffella tenebrosa* Zone; beds with *Neoarchaeidiscus postrugosus*; *Pseudoendothyra globosa* Zone; *Eostaffellina decurta* Zone and *Eostaffellina protvae* Zone, recognised by the first occurrence of the index species.

*Eostaffella tenebrosa* Zone (beds 1,2) in addition to the index species contains over 50 forms, including the Venetian markers *Janischewskina cf. typica*, *Howchinia bradyana*, *Loebichia para ammonoides*, and “*Endostaffella* asymetrica.” This zone is equivalent to the foraminiferal C16 8 Zone of the uppermost Warrantian stratotype or V3C (Laloux, 1987) on the basis of foraminifera.

Beds with *Neoarchaeidiscus postrugosus*. The lower boundary of these beds corresponds to the abrupt disappearance of V3C foraminifera and the appearance of indeterminable Staffellidae (sample 3a-1). The taxonomic diversity increases a quarter of a meter above (sample 3a-2) and *N. postrugosus* and “*Millerella* tortula” appear for the first time. The second species was unknown in Moscow Basin until recently (Gibshman, 2000). These two markers indicate the Viséan - Serpukhovian boundary in the Zaborie stratotype. The relative sea level curve (Fig. 1) reflects the sharp change from shallowing upwards in the Venetian to deepening in the Tarusian. Nevertheless, the evolution of foraminifers continued.

*Pseudoendothyra globosa* Zone. The lower boundary is defined by the first appearance of the index species in bed 4, the upper boundary corresponds with the first occurrence of *Eostaffellina decurta* in bed 15. Besides the index species and the two Serpukhovian lower boundary markers, six new forms occur (Fig. 2). *J. cf. delicata* indicates a new stage in the evolution of *Janischewskina*. The *P. globosa* Zone corresponds to most of the Tarusian and the lowermost Steshevian. The Tarusian-Steshevian boundary and the boundary between the *P. globosa* and *E. decurta* Zones do not coincide.

*Eostaffellina decurta* Zone. The lower boundary is defined by the first occurrence of the index species, the upper boundary coincides with the inception of *Eostaffellina “protvae”* in bed 48. In addition to the index species, the assemblage contains six new forms which occur successively (Fig. 2). Taxonomic diversity is variable in the *E. decurta* Zone. It decreases in beds 16-26, and is highest in bed 28, where *Eostaffellina paraprotvae* and *Millerella pressa* occur for the first time. These two species indicate new stages in the evolution of *Eostaffellina* and *Millerella*, respectively. The uppermost part of the *E. decurta* Zone (beds 30-47) contains no foraminifera, because of an increase in clay and do-
<table>
<thead>
<tr>
<th>Stages</th>
<th>Russian Platform regional stages</th>
<th>Scale (m)</th>
<th>Bed number</th>
<th>Lithology column</th>
<th>Samples</th>
<th>MICROFACIES CHARACTERISTIC</th>
<th>Environments</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISEAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>texture</td>
<td>depth</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>microfacies composition</td>
<td>energy</td>
</tr>
<tr>
<td>Viseanian</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serpukhovian</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 1.** Lithology, Microfacies and Environments characteristics from Uppermost Visean to Serpukhovian of the Zabone stratotype.
Figure 2: Ranges of the important foraminiferal species observed in the measured section. The basis for biozonation and intercorrelation are using short-lived forms and indices of the "Eostaffella" lineage and other genera, such as "Milliera" and "Eostaffella".
lomite sedimentation (Fig. 1). The *E. decurta* Zone corresponds to most of the Steshevian.

**Eostaffellina “protvae” Zone.** The lower boundary is defined by the first occurrence of the index species (bed 48), while the upper boundary corresponds with the erosion surface. Apart from the index species this assemblage contains six new forms; *E. paraprotvae* (Rausser) is frequent, as well as *Janischewskina adarussia* sp. nov., and *Brenckleina rugosa* occurred for the first time. These two species indicate a new stage in the evolution of *Janischewskina* and the Asteroarchaeididae. Both taxa were unknown in the Moscow Basin until the present study.

Because the index species are endemic, this zonation of the Serpukhovian could be used only in the Russian Platform. However the presence of cosmopolitan taxa opens the possibility for world-wide correlation.

Three generic lineages, in addition to the *Eostaffellina* lineages, are proposed for interregional correlation of the Zaborie stratotype. The *Janischewskina* and “Millerella” lineages are new, while the *Eostaffellina* and Asteroarchaeididae (*Asteroaarchaeidus - Neoarchaeidus - Brenckleina*) lineages are commonly used. The *Janischewskina* lineage is most likely connected with *V3 Criboospira* rather than with *Bradyna* (Spravochnik... 1996).

In the Venonian this genus gives rise to *J. typica* forming complex interseptal “chambers” and mouths but retaining a thin microgranular test wall (55 - 35 µ) and a terminal cribrate mouth. *Janischewskina delicta* which appears in the Lower Serpukhovian has a thinner test wall (28 - 21 µ), fewer coils (2 compared to 3 in *J. typica*), and more simple interseptal “chambers” and mouths [The holotype comes from the lower part of the Nizhnegubakhian Horizon. This unit is most likely equivalent to the Lower Serpukhovian (Stratigraphija... 1973) rather than the Late Venian, because *Biseriella parva* presents together with the holotype in the same thin section never reported previously (Malakhova, 1956)]. *Janischewskina adarussia*, which appears in the uppermost Serpukhovian, differs from other species in having a thinner test wall (14 µ), a higher growth rate of the last (third) coil and the terminal chamber, although retaining a complicated morphology of interseptal “chambers” and mouths. The “Millerella” lineage evolved from the Venonian “Endostaffella” asymetrica (Rosovskaja, 1963; pl. XII, fig. 10 only) with three-layered test wall: thectum, inner-outer thortocum. In the Tarusian, the test of “M.” *tortula* was formed by changing to planispiral coiling, preserving three-layered test wall, and plectogyroid juvenarium [the holotype comes from the Middle Chesterian, Midcontinent USA (Zeller, 1953, pl. 26, fig. 13, 14, 18, 17, 26 only). At the end of the Steshevian, *Millerella pressa* appears via a transition to planispiral coiling [the holotype comes from the Kearny formation, Patterson well 1, M.L. Thompson].

**Summary.** The new data obtained on the evolution of “Millerella”, *Janischewskina* and Asteroarchaeididae indicates at least four possible levels are useful for tentative world-wide correlation of the Zaborie stratotype. From the oldest to the youngest, these levels and their approximate time-stratigraphic equivalents are: I. Top *E. tenebrosa* Zone (uppermost Viséan, V3c); II. Beds with *N. postrugosus* — “M.” *tortula* inception (base of the Serpukhovian Stage, Mid-Chesterian, Midcontinent USA); III. Base *P. globosa* Zone — *J. delicata* occurrence (slightly above the base of the Serpukhovian Stage, close to the base of the Nizhnegubakhian Horizon, South Urals); IV. E. “protvae” Zone — *B. rugosa* appearance (Upper Serpukhovian, Upper Chesterian). However, have proposed correlation with Midcontinent, U.S.A. do not coincide with the previous one (Brenckle, 1990a, b) and find conformation (Rich, 1980) in NW Alabama, SC Tennessee and NW Georgia, USA.

The study was supported by RBFR, project № 99 - 05 - 65476.

**References**


Problems in Lower Serpukhovian ammonoid biostratigraphy

S.V. Nikolaeva and J. Kullmann

1Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya 123, Moscow, 117868, Russia.
2Institute und Museum für Geologie und Paläontologie, Universität Tübingen, Sigwartstr. 10, D-72076 Tübingen, Germany.

The Serpukhovian Stage is of great interest in the context of Carboniferous stratigraphy because of the enormous proliferation of new faunal elements of different fossil groups. The Serpukhovian ammonoid faunas and their late Viséan forerunners underwent extremely rapid radiation: the number of species increased from 14 per million years (m.y.) in the upper Viséan (lower Brigantian, P1 in England) to 83/m.y. during the uppermost Viséan (upper Brigantian, P2 in England), and stabilized at a level of about 40 to 50/m.y. during the Serpukhovian.

Despite the high diversity and rapid evolution of the Serpukhovian ammonoid faunas, Serpukhovian ammonoid biostratigraphy has been the subject of intense debate for over four decades. The best studied sections of this interval are in Western and Central Europe and North America, while the richest faunas are recorded in the South Urals, Central Asia, and China. Because most of the species that have been proposed as global zonal markers are restricted to the Subvariscan realm, a satisfactory correlation with sections of other realms remains problematic. No accepted definition of the Lower Serpukhovian boundary, based either on ammonoids, conodonts or foraminifers, has been yet achieved. The type Serpukhovian area in the Moscow Region is represented by carbonate-clay sequences and contains few ammonoids (three or four genera represented by a dozen specimens altogether). The Viséan-Serpukhovian boundary in its type area is thought to coincide approximately with the Viséan-Namurian boundary in Western Europe. This correlation is mainly supported by conodont data (Skompski et al., 1995). The lowermost Serpukhovian ammonoid assemblage in the type area is recovered from the middle of the Tarusian Horizon which is certainly far above the entry of the conodonts Locchria cruciformis and L. ziegleri, which are possible boundary markers.

Lower Boundary. The Viséan-Serpukhovian boundary has traditionally been drawn at the base of the unit containing Cravenoceras-Eumorphoceras faunas, which in many areas coincides with a stratigraphic unconformity. The earliest representative of the genus Cravenoceras, C. leion Bisat, 1930 (=Emstites leion in the taxonomy of Korn, 1996, 1997), was recorded from the lower Namurian of Great Britain; for a long time it was treated as the boundary marker according to the decision of the Heerlen Congress in 1958. However the usefulness of this species is mainly restricted to the British Isles (Northern England), whereas in other regions (e.g. the Rhenisch Massif) the occurrences are questionable (see Korn, 1988, 1996). In addition, the identification of this species is very difficult, because it requires perfectly preserved shells. Skompski et al. (1995), reviewing available data on the ammonoid occurrences in the basal Serpukhovian world-wide, found that a boundary definition based on Cravenoceras was in many ways insufficiently supported. Serpukhovian faunas in the Rhenisch Massif contain a range of girtyoceratids that have been successfully used in biostratigraphy (Horn, 1960, Korn, 1988, 1996, Korn and Horn, 1997, etc.). Horn (1960) suggested the placement of the lower base of the Namurian at the level of the first appearance of the girtyoceratid Tumultites pseudobolinguis (Bisat, 1922). This species apparently appears later than Cravenoceras leion but was considered a better boundary marker. However, Ruzhencev and Bogoslovskaya (1971) argued that the use of this species as a lower Namurian boundary marker would cause complications in Namurian stratigraphy elsewhere outside the Rhenisch Massif because this species appears above the first entry of Cravenoceras leion, and also above the lower boundary of their second Lower Namurian Unit (E1b) (see below). In their opinion the use of this marker would have destroyed the concept of the Lower Namurian as a unit containing Eumorphoceras and Cravenoceras, because much of these faunas would be left beyond the Lower Namurian. Considering these difficulties Ruzhencev and Bogoslovskaya (1971) proposed the boundary much lower than its first appearance, at the base of their Hypergoniatites-Ferganoceras Genzone, which they thought to correspond approximately with the base of the P2 Zone in Europe. In fact, this boundary is readily recognized in the South Urals and Central Asia. However, elsewhere in Europe this level is practically unrecognizable because of the absence of the agathiceratid genus Dombarites, the index ammonoid of the genzone in the South Urals. The correlation of the lower boundary of this genzone with the P2 zone may in fact be different from that suggested by Ruzhencev and Bogoslovskaya (Korn, 1996). Ruzhencev and Bogoslovskaya carefully studied the assemblage of the above Uralopronorites-Cravenoceras Genzone and recorded the species Cravenoceras leionoides, which they regard as close to C. leion and may come from a stratigraphically related level. However, our recent observations do not seem to confirm this opinion. A recent study showed that the earliest cravenoceratid in the section near the village of Verkhnyaya Kardailovka is C. lineolatum, that occurs in Bed 22a (sample no. 09) ca. 10 m below the earliest published record of this species (Ruzhencev and Bogoslovskaya, 1971) who found it in association with C. leionoides in Bed 3. The lowermost ammonoid occurrence in this section apparently belongs to the Nm1b2 zone, rather than the basal Nm1b1 Zone, which is thought to coincide with the basal beds of the Eumorphoceras Zone in Europe. Therefore, no ammonoid-based lower Serpukhovian boundary is fixed in the Kardailovka section. No transition from the Upper Viséan to the Lower Serpukhovian ammonoid assemblages was observed in the few sections where the Nm1b1 level was confirmed by ammonoids. In biostratigraphic practice, the basal boundary of the Nm1b1 zone in this area is usually drawn at the base of the Kosogorskian Horizon, at a level with the first Cravenoceras, Uralopronorites, Tympanoceras and Dombarites without falcatoïd ornamentation, thus assigning the beds with falcatoïd-ornamented Dombarites (many of them placed in Lusitanoceras by Korn et al., 1999) to the Viséan. In this situation the main stratigraphic potential may lie with the Kiya section, where ammonoids certainly belonging to the basal Serpukhovian were recorded in a continuous succession.

July 2001

35
(Ruzhencev and Bogoslovskaya, 1971, p. 64). However, this section needs to be re-examined since there are no records of Upper Viséan ammonoids. In the Paltau section (Tian-Shan, Central Asia) Nikolaeva (1995) placed the ammonoid-based Viséan-Serpukhovian boundary within the Aurakhat Formation based on the appearance of Dombarites pararactus without falcatoïd ornamentation as opposed to Dombarites parafalcatoïdes, the species typical of the Late Viséan. The thickness of rock separating these two ammonoid samples does not exceed 3 m. The lower Serpukhovian boundary was drawn in an apparently continuous sequence and was supported by the earliest records of L. cruciformis determined by Nigmatganov in 1989, a fact that has been generally overlooked in the literature. Korn (1996) discussed all the shortcomings of the traditional Cravenoceras leion-based level and proposed Eumorphoceras (=Edmooroceras) pseudocoronula as an alternative. However, this species is not found outside Western Europe; Korn (1996, 1997) admitted that the stratigraphic position of this species outside the Rhenisch Massif, e.g. in the British Isles, is uncertain. The basal Lower Namurian beds in Great Britain contain from one to three beds containing Cravenoceras leion and it is not yet clear from which bed the type material of Eumorphoceras pseudocoronula was recovered. Calver and Ramsbottom in 1961 stated that the bed with E. pseudocoronula occurs considerably above the beds with the type specimens of C. leion (ca. 7-8 m), whereas Korn (1996) regards these indications as insufficient evidence of the precise stratigraphic position of the occurrences. Therefore, even within the Subvariscan realm, the value of this species as a global stratigraphic marker is limited. In Arkansas (USA) the basal Fayetteville beds are apparently the equivalent of the lower Serpukhovian (probably the beds with Sulcogirycoceras jasperense). In Texas (USA) the apparent equivalents of the basal Serpukhovian beds contain no ammonoids (Titus, 1999). The lowermost datable beds of the Barnett Formation contain Sulcogirycoceras ornatissimum, Lustianoceras claudi, and Pachylyroceras hyatti that allow a correlation with the Hypergoniattites-Ferganooceras Genzone in the Urals, Central Asia and the upper part of the Brigantian of Western Europe. Considerably higher in the succession is the bed containing Eumorphoceras plumeri. Tumulites varians and other species. This level is most probably equivalent to the uppermost Pendleian or the basal Asmsbergian. The basal Serpukhovian successions in Portugal, Spain, Lvov-Volhynia Basin, Donets Basin and Poland are not well supported by ammonoids.

Summarizing the above data, it is clear that within each of the four areas (Great Britain, Germany, South Urals and Central Asia) correlation of the lower Serpukhovian boundary is generally straightforward. It is based on E. pseudocoronula in Germany, Cravenoceras leion in Britain, the first appearance of Cravenoceras and Dombarites carinatus in the South Urals, and Dombarites with non-falcatoïd ornamentation in Central Asia. However, interregional correlations remain inadequate, although all the above levels seem to be stratigraphically close. Perhaps, the problem could be solved by joint research on the phylogeny of the first Cravenoceras (=Emsites) and Dombarites (=Lustianoceras) and the latest Goniatites from all the above areas, in a search for phylogenetic transitions in the most complete sections to define the levels of the first appearances.

The work of SVN was supported by the RFBR grant no. 99-0565473.

References

Figure 1. Correlation chart of the Serpukhovian. No vertical scale intended.
Integrated Serpukhovian biostratigraphy in the South Urals

S.V. Nikolaeva¹, E.I. Kulagina¹, V.N. Paukhin¹ and N.N. Kochetova¹

¹Paleontological Institute, Russian Academy of Sciences, Profsoyuзнaya 123, Moscow, 117868, Russia.
²Institute of Geology, Ufa Research Center, Russian Academy of Sciences, ul. Karla Marksa 16/2, Ufa 450000, Russia.

The Serpukhovian Stage was re-established in the Russian Stratigraphic scheme in 1974, and since then it has become internationally recognized. In its type area in the Moscow Basin, the Serpukhovian sections are incomplete, e.g., the upper part of the Serpukhovian is missing. The biostratigraphy of the Serpukhovian in Russia is largely based on the complete Carboniferous sequences of the Urals, which usually contain ammonoids, conodonts and foraminifera.

The territory of the Urals is subdivided into four structural zones, different tectonically and sedimentarily (Fig. 1). In the Western Urals, the Serpukhovian includes the Kosogorskiian, Protvian, and Staroutkinskiian (=Yuldyaevian) Zones and their equivalents in the Eastern Urals (Stratigraphicheskie shemy, 1993). The underlying Upper Visian deposits are represented by the Zemlinskian Horizon. These horizons have been extensively studied and provided a basis for the zonal subdivision of the Serpukhovian. Of these, the Staroutkinskiian Horizon remains problematic because in its type area it is represented by specific foraminiferal-brachiopod successions that lack ammonoids and conodonts. To replace the Staroutkinskiian Horizon, we are using the Yuldyaevian Horizon, which contains ammonoids and conodonts.

Ammonoids occur in the Western and Eastern slopes of the Ural where the two successive assemblages of the Uralopronotrites-Cravenoceras (Nm1b) and Fayettevillea-Delepolioceras (Nm1c) Genozones are recognized (Ruzhelevsky and Bogoslovskaya, 1971). The lower genzone is dominated by Dombarites, Cravenoceras and Uralopronotrites. Of these, the latter two genera first appearing at this level were chosen as zonal markers. The lower part of this genzone (Nm1) shows the presence of the genera continuing from the Visian (Lusitanites, Prolocanites, Aloceras, Neognathites, Lyrogostiopites) alongside Dombarites liratus, D. carinatus, first Cravenoceras leionoidea, C. crassus, Platygnathites molaris, first appearing at this level. Ammonoids of this age are found in the Aktyubinsk Region (Zyksy-Kargaly River, Dombar Hills, Kyzyl-Shin Gully), in the Orenburg Region (Kiya River) in the Kosogorskiian Horizon. However, in most of these sections, the lower Serpukhovian boundary is not controlled by Visian ammonoid faunas. The well-studied and easily accessible section on the right bank of the Ural river opposite the Verkhnyaya Kardailovka Village is composed of limestones of the Kizil Formation containing ammonoids, foraminifera and conodonts. The lowest ammonoid-bearing beds in this section were thought to represent the Nm1b1 Zone, but the presence of the Nm1b2 Zone is more likely because no critical Nm1b1 taxa are found, while many taxa typical of the Nm1b2 Zone are present (see Fig. 2). The Kiya section probably has a larger stratigraphic potential in respect of the Lower Serpukhovian boundary, but it requires re-examination. The Nm1b1 Zone is likely to correlate with the E. pseudorhacoria-S. horn Zones in Germany and with the C. leon Zone in Britain. The Nm1b2 Zone is recognized in the Dombor Hills, Zyksy-Kargaly, Kiya, Verkhnyaya Kardailovka, Uvelka, etc. in the lower part of the Protvian Horizons. This easily identifiable assemblage contains Cravenoceras lineolatum, C. beulense, Dombarites tectus, D. paratectus, Verancoceras admirable, Miritinella iberica, Quasciconoceras costatum and Tumulites eurinus, first appearing at this level. The occurrence of T. eurinus suggests the correlation of the Nm1b2 Zone with the second half of the E1 Zone (approximately from the level of Tumulites angustus or T. varius zones) in Europe and the USA.

The lower boundary of the Fayettevillea-Delepolioceras

Figure 2. Correlation of the standard Sepukhovian sections in the South Urals. (1-8) limestones, (1) bedded mudstones and wackestones, (2) indistinctly bedded; (3) unbedded, bioherms; (4) bioclastic packstones and grainstones; (5) litho-bioclastic grainstones; (6) clayey limestones, (7) with chert nodules (8) sphaera-lump and pellet packstones-grainstone, (9) shales, (10-17) fossils: (10) foraminifers, (11) algae, (12) crinoids, (13) brachiopods (14) corals, (15) ostracodes, (16) ammonoids, (17) conodonts, (18) bryozoans
Genozone lies within the Protvian Horizon and is marked by the appearance of Pericleites, Proshumardites, Glaphyrites, Stenoglaphyrites, Eumorophocras tumulosum and E. transuralense. The transition from the Nm1b to the Nm1c beds is observed in the Verkhnya Kardailovka section and the Kiya River. In both sections the assemblage containing Cravenoceras, Dombarites and Lytheoceras is replaced by that containing Pericleites, Eumorophocras, Glaphyrites and Syngastriceras. The important feature of this zone is that Verancoceras, Uralopronotries mirus, Platyyoniates and Megaprnonotries continue from the Nm1b2 Zone. The Nm1c1 Zone is established in a few localities including the Kiya River and Verkhnya Kardailovka sections. In stratigraphic practice the lower boundary of the zone is drawn at the beds with Glaphyrites, Proshumardites and Pericleites, and Eumorophocras transuralense. The succeeding zone (Nm1c2) almost entirely corresponds with the Yuldaevian Horizon. The most characteristic species are Eumorophocras transuralense, Proshumardites delepinei, Fayettwellia occidentalis, and Delepinoceras bressoni. Assemblages of this age are also recorded in the sections Verkhnya Kardailovka, Kzyly-Shin, Sholak-Sai, Sakmarra and Pismyanka rivers, and Muradymovo.

Foraminifers. Three successive foraminiferal assemblages are recognized in the Serpukhovian sections studied. The assemblages correspond with the Beds with Planospirodiscus and the Eostaffella paraprotvae and Monotaxinoides transitorius zones.

The Lower Serpukhovian boundary corresponds with the lower boundary of the Kosogorskian Horizon and is usually defined by the impoverished foraminiferal assemblage and by the appearance of a few new facially dependent Serpukhovian taxa. In the West-Uralian structural Zone in most sections the boundary is placed at the base of the olomitic series (Sikaza and Belaya rivers). In the flyschoid facies of the Central-Uralian structural zone the lower portion of the Serpukhovian is dominated by the Eostaffella-Mediocris foraminiferal biofacies. In the more favorable facies, the Viséan assemblage continues into the Serpukhovian but it is impoverished. In the sections of the coastal facies of the West-Uralian Zone, this assemblage also contains newly appearing Biseriella parve (Sim River), in the Central-Uralian Zone (Muradymovo, Kugarchi, Injak - Archaeiscus timanicus, sometimes Eolasiodiscus. In the algal facies of the Magnitogorsky Zone (Bolshoi Kizil) Monotaxinoides and Eolasiodiscus donbassicus appear from the base of the Serpukhovian. In beds with Planospirodiscus are recognized in the cephalopod facies. Foraminifers are rare being represented by small euryfacial species of the genera Priscella, Eostaffella, Mediocris, Asteoarchaedis, and Planospirodiscus. In this section and also in the Muradymovo, Kugarchi, and Injak sections these beds and their equivalents are not controlled by Viséan faunas. The Uvelka section displays the Upper Viséan beds (the Eostaffella ikensis tenebrosa Zone), although the lower Serpukhovian beds contain no foraminifers (only ammonoids and conodonts).

The succeeding Eostaffella paraprotvae Zone is observed in many sections and the foraminiferal content is similar in both subregions. In the Kugarchi and Muradymovo sections, foraminifers occur in association with conodonts. The lower boundary of this zone is defined by the appearance of index species and also Eostaffella mirifica, Eostaffellina actuaus, Monotaxinoides subplanus, M. priscus, etc. This zonal assemblage corresponds with the foraminiferal association of the Protvian Horizon in the Russian Platform.

The Monotaxinoides transitorius Zone is established in the most sections based on the appearance of the index species. It corresponds with the Yuldaevian Horizon and with the radiation of the Lowerginiidae. The assemblage also includes Monotaxinoides gracilis, Janichewskina sp., Rectoendothyra sp., the first primitive Plectostaffella, etc., present in the Muradymovo section (type section of the Yuldaevian Horizon), Kugarchi and V. Kardailovka. The upper boundary of the zone is not very distinct, it is based on the appearance of Plectostaffella varvariensis.

Conodonts. In the South Urals conodonts are studied from the Serpukhovian and Viséan-Serpukhovian boundary beds in the four structural zones. In the West-Uralian Zone, conodonts are rare and were recovered from only a few samples from the Sim and Belaya rivers. In the first (the shallowest) section, conodonts are represented only by the genus Cavusgnatus, in the second, by the genus Gnathodus, Lochriaea, and Mestognathus. In the Central-Uralian Zone (Muradymovo, Kugarchi, Kiya, and Sholak-Sai sections), Magnitogorsky Zone (Verkhnya Kardailovka, Bolshoi Kizil), and the East-Uralian Zone (Uvelka), the Serpukhovian contains successive conodont assemblages dominated by Gnathodus and Lochriaea. Conodonts are most abundant in the sections of the cephalopod biofacies (Kiya, Sholak-Sai, Verkhnya Kardailovka, Muradymovo, Uvelka). Unfortunately the boundary Viséan-Serpukhovian beds in most sections are poorly exposed and provide little data. The Kiya and Verkhnya Kardailovka sections which contain both conodonts and ammonoids have the best potential in this respect. The entire collection of Upper Viséan and Serpukhovian conodonts contains 10,000 specimens, with pectiniform elements dominating.

The Upper Viséan (Venezian) and Serpukhovian beds in the South Urals contain the following conodont zones:

The Lochriaea nodosa Zone is established in the Kiya section (beds 1 - lowermost 2) in the upper part of the Venezian Horizon. The lower boundary of the zone is defined by the appearance of the index species, the upper is determined by the appearance of Lochriaea cruciformis. The zonal assemblage contains Lochriaea monodonosa, L. mononostata, L. costata and in the upper part L. ziegleri. The assemblage contains many transitive species continuing from the underlying zone (V. Kardailovka section, beds 19 - upper part, 20, 21 - lower part): Gnathodus bilineatus bilineatus, G. girtyi sp., Lochriaea commutata, Pseudognathodus homopunctatus.

The Lochriaea cruciformis Zone is established in the Muradymovo, Kugarchi, Kiya, Sholak-Sai, Verkhnya Kardailovka, and Uvelka sections. The lower boundary is defined by the appearance of the index species, and the upper by the appearance of Gnathodus bilineatus hollandensis. Lochriaea multinodosa and Gnathodus girtyi simplex appear from the base of the zone. The assemblage is dominated by species continued.
from the Viséan. In the Kiya, Sholak-Sai, and Verkhnaya Kardailovka sections conodonts of this zone are found in association with ammonoids of the Nm1b1-Nm1b2 Zones. The conodont-based Viséan-Serpukhovian boundary approximately corresponds with the base of the Lochriea cruciformis Zone. The zonal species L. cruciformis is the final stage in the evolutionary lineage L. communata - L. monodonosa - L. monocostata - L. costata - L. cruciformis. The species L. cruciformis is widespread in Eurasia. Its first appearance coincides with the base of the Namurian and Serpukhovian in the shelf sequences of England, Poland, and Ukraine. In more basal sequences of Germany is appears earlier, in the ammonoid Emistites schaelkensis Zone (Skompski et al., 1995).

The Gnathodus bilineatus bollandensis Zone is established in the Muradymovo Kugarchi, Kiya, Sholak-Sai, Bolshoy Kizil, Verkhnaya Kardailovka, and Uvelka sections. The lower boundary of the zone is defined by the appearance of the index species, the upper boundary by the appearance of Declinognathodus noduliferus. Gnathodus kiensis and Gn. postbilineatus also appear in this zone. The presence of Adetognathus thyrsus in the Yuldabaevian Horizon in the Sim section is noteworthy. The assemblage also contains species continuing from the underlying beds.

Ostracodes. Ostracodes occurring in the Serpukhovian cephalopod faeces of the South Urals are taxonomically diverse. Ostracode assemblages recovered from the Verkhnaya Kardailovka, Kiya, and Sholak-Sai sections are similar and always contain rectonariids. Among the other faunal zones, ostracodes are studied from the Muradymovo section. The Venetian and Serpukhovian contain three successive ostracode-based units.

The Beds with Cribrorhynchus magna correspond to the upper part of the Venetian and Kosogorskian horizons in the Kiya and Sholak-Sai sections, and apparently to the lower part of the Protovian Horizon in the Verkhnaya Kardailovka section. The appearance of Cribrorhynchus magna sp. nov. in association with the ornamented Bairdia is noteworthy. The assemblage contains various species of Rectoplacera, Rectonaria, Triplacera, Bairdia, Bardocypris, Acratia, Acanthoscaphe, etc. appearing at the base of the Beds. The species Healdia maturica, and Bolbozoella nodosa appear in the middle of this unit. This assemblage also contains Polyclope perminuta and Roundyella simplicissima recognized from the Pennsylvania. This assemblage was found in association with ammonoids of the Nm1a2-Nm1b Zones.

Beds with Pseudoparaparchites celsus are established in the V. Kardailovka and Sholak-Sai sections. The lower boundary is defined by the appearance of the index species in association with abundant Carbonita ? subquadraata. Many species continue from the underlying beds. The assemblage also contains species of the genera Bolbozoella, Acanthoscaphe, Gerodia and Aurigerites, and rectonariids become more diverse. Ostracodes of this assemblage occur together with ammonoids of the Nm1b2-Nm1c1 Zones. In the Muradymovo section, the assemblage includes Edita, diverse Healdia and species known from the Upper Mississippian (Chesterian) of North America: Ectodemites planus, Ect. tumidus.

Beds with Aurigerites solitarius are established in the Kiya and Verkhnaya Kardailovka sections. The assemblage contains transitive species and those appearing at this level: Shihaesla circinata, Shivaella evidens, Microcoeloena orbiculata, Dorsoobliquella ovalis, Bairdia chudolensis, Polyclope rugosa, etc., which become the most diverse the Lower Bashkirian. The lower part of the Verkhnaya Kardailovka section contains a few Fellerites gratus. This species typically occurs in the lower part of the Bogdanovskian Horizon in the Uvelka and Muradymovo sections.

Thus, the Serpukhovian in the Ursals corresponds with two ammonoid genozones each containing two zones, three foraminiferan units, two conodont zones and three beds with ostracodes. The Nm1b1 ammonoid zone approximately corresponds with the foraminiferan beds with Planospiriodiscus and their equivalents, with the upper part of the Cribrorhynchus magna ostracode beds, with the larger lower part of the conodont L. cruciformis zone and with the Kosogorskian Horizon. The succeeding ammonoid Nm1b2 Zone corresponds with the larger lower part of the foraminiferan Eostaffellina paraprotovae Zone, the upper part of the conodont Zone L. cruciformis, the lower part of the Gnathodus bilineatus bollandensis Zone and the lower part of the Protovian Horizon. The ammonoid Nm1c1 Zone probably corresponds with the upper part of the foraminiferan Eostaffellina paraprotovae Zone, the middle part of the Gnathodus bilineatus bollandensis Zone, and the upper part of the Protovian Horizon. The Nm1c2 Zone correlates with the foraminiferan M. transitorius Zone, the Aurigerites solitarius ostracode beds, the upper part of the Gnathodus bilineatus Zone, and the Yuldabaevian Horizon.

The most complete Serpukhovian sections are those at Muradymovo, Kugarchi, Verkhnaya Kardailovka, Kiya, and Sholak-Sai. The Viséan-Serpukhovian transition is recognized in Kiya (conodonts, ammonoids, ostracodes). Verkhnaya Kardailovka displays almost the entire Serpukhovian (ammonoids, conodonts, foraminifers, ostracodes). In Muradymovo, the Serpukhovian contains foraminifers and conodonts, and in the upper part also ammonoids and ostracodes.

The study was supported by the RFBR grant no. 99-05065473.

References
The Carboniferous - Early Permian marine domain in western Argentina

Arturo César Taboada

Instituto de Paleontología, Fundación Miguel Lillo, Miguel Lillo 251, Tucumán (4000), Argentina (fnlgeo@itucbs.com.ar).

Carboniferous sedimentation in western Argentina was preceded by the late Devonian Precordillerian orogeny (Furque, 1972) that produced a paleogeographic framework characterized by longitudinal ranges and basins. One of them was a narrow backarc area of deposition named the Usallata-Iglesia Basin (González, 1985), located between two emergent meridional dalfs, the Prototprechdilleria (Amos and Roller, 1965) to the east (currently Sierras of Usallata, Tontal, Invermada, Volcán and Punilla) and the Protocordilleria Frontal (González, 1985) to the west (at the moment Mountain ranges of Olivares and Tigre). The Protocordilleria Frontal allowed the access of "Pacific" inpressions to the Usallata-Iglesia basin through depressed areas by unstable behaviour of the dorsal. On the other hand, the Prototprechdilleria was a dam (Amos and Roller, 1965) that impeded the entrance of the sea toward the more eastern Pajanzo basin. In this scenario, various marine inpressions occurred to the west of the Prototprechdilleria. The older, in the late Tournaisian-early Viséan, brought the cool? Protocanites fauna, followed in the late Viséan-Namurian by the cold gondwanic Levipustula fauna and the Rugosochonetess-Bulahdelia association, which are closely associated with glacigenic sediments. Episodic movements (San Eduardica phase of Furque and Cuerda, 1984) affected the region in the early? Westphalian, causing the disconformity between the beds bearing the Levipustula fauna and the overlaying sediments with the late Westphalian Balakhonia-Genticulifera fauna. The latter fauna was linked to a formidable climatic change in the region that brought to the setting mild environments (interglacial of González, 1990; paleoclimatic subphase IIIb of López Gamundi et al., 1992) following the disappearance of the previous glacial conditions associated with the Levipustula fauna in the Precordilleria. Above these faunistic associations follows a large transgression that was able to surpass the highlands of the Prototprechdilleria through a few inlets and yield the Stephanian Tivertonia-Streptonychus fauna to the east, establishing the most extensive neopaleozoic marine ingestion that covered western Argentina. The marine domain was posteriorly reduced to an embayment at the southern border of de Usallata-Iglesia basin where the Costatumulus amosi fauna dwelled. During the Asselian the temperate paleoclimatic conditions which existed since the late Westphalian in the region were interrupted by a transient glaciation documented by glacimarine sediments intercalated within the Costatumulus amosi fauna. These glacial deposits reflect local fluctuations linked to Alpine type glaciation (González, 1981) or a mitigating effect by the paleolatitudinal gradient to circumpolar glaciated areas.

In Patagonia marine deposits with the Costatumulus amosi fauna, correspond to the widespread sea level rise that took place at the end of the glaciations in the whole of Gondwana (Dickins, 1985; Wopfner, 1999). This circum-pacific faunal association would have been developed almost parallel to the subpolar Eurystesna's fauna of the Sauce Grande Basin but in lower paleolatitudes and in less cold seas (Taboada, 1999, 2001) during the progressive global climatic amelioration of the Asselian-Tastubian.

References

New data on the Late Palaeozoic glaciations in Argentina

Carlos R. González

Fundación Miguel Lillo, Miguel Lillo 251, 4000 Tucumán, Argentina (fmlgeo@tucbbs.com.ar).

Latest advances confirm that the Permian-Carboniferous “ice age” in Argentina lasted from the latest Viséan or earliest Namurian (Early Serpukhovian) until the Asselian-Sakmarian. Distribution of faunas also confirms that there were two major glacial periods: one in the Carboniferous and the other in the earliest Permian, which are separated by a climatic amelioration at the latest Carboniferous (González, 1981).

Three or four discrete Carboniferous glaciations are recorded in western Argentina (González, 1990) and in central Patagonia (Sauco, 1948; González Bonorino et al., 1988). These are enrolled between the oldest glacial events of this age. The latest palaeontological findings and detailed mapping in central Patagonia have led to the recognition of a new glacial episode, which is probably the youngest of the Carboniferous glacial period. Evidence of this last event occurs at different localities of the central and northern sector of the Tepuel Basin, and are everywhere associated with the latest occurrence of *Levipustula levis* so far known in Argentina. This event is here named the Las Salinas glaciation (Fig. 1).

The greatest development of Early Permian glacial deposits in South America occurs in the Paraná Basin and in the Sauce Grande Basin (Southern Hills of Buenos Aires), which are located in the south-eastern portion of the continental area, and in the Malvínas (Falkland) Islands in the South Atlantic, close to the east of southern Patagonia. All of them are associated with the *Glossopteris* flora, but only deposits of the Sauce Grande Basin yield the *Eurydesma* fauna. Things are different to the west of these regions. Even though sedimentological and palaeontological evidence for glaciation of this age is poor in western Argentina, and inconclusive in Patagonia, the possibility that ice sheets that developed to the east also extended over these two regions is still under discussion. The uppermost strata of the Tepuel Group in central Patagonia (Mojón de Hierro Formation) yield “more or less endemic” flora and fauna with some equatorial affinities, which are in general assumed to be of Early Permian age. However, these deposits do not show clear evidence of glaciation. This is puzzling because during the Early Permian the palaeolatitude of Patagonia was not much different from that during the Carboniferous glacial period (see Golonka et al., 1994) and consequently, these deposits and faunas should reflect the Asselian glaciation. In this regard, we may ponder that a possible cause for the lack of glacial sediments in the Mojón de Hierro Formation is because the Early Permian glaciation occurred posteriorly, during the erosive or non-depositional period that followed in this Basin. In this case, the fauna of the lower

---

**FIGURE 1:** Relationships between major faunal groups and glaciations during the Late Palaeozoic in Argentina.* Not to scale.
beds of the Mojón de Hierro Formation would be the circum-polar ("cold") equivalent to the "intermediate" ("warm") fauna of western Argentina (González, 1999). The question will be answered only after a more detailed knowledge of the evolution of the Gondwanan faunas and floras during the Carboniferous-Pennant transition. The sequence in central Patagonia offers the ideal field to develop these studies.

References


Access to the site may be gained via the public footpath at Pont Walby or from the South along Forest tracks. It should be noted that numerous parts of this section are relatively inaccessible and can be studied only with great care.

The section itself is exposed in a steep-sided valley that starts at 20 m above sea level. The valley can be followed southwards, where it cuts through productive Westphalian strata, up onto the Rhigos escarpment (a sandstone ridge of the South Wales Pennant Formation) that lies 300 m above sea level. The area directly east and west of the geological section has, in the past, been the subject of much drift mining, and of late, opencast coal extraction. In places the proposed section remains as the only original tract of in situ surface geology in the area.

When the survey is complete, the total vertical thickness of strata in this section is expected to exceed 500 m. Currently there is 90% continuous natural exposure along the length of section, and it is intended later to uncover some of the remaining, non-exposed parts of the succession (funded by the Countryside Council for Wales). There are also complimentary sections to the west of the main site, in the Blaengwrach and Cwmghwrach valleys, which will help fill in some other missing parts of the succession. Temporary sections in the adjacent Salar opencast site have also been documented, where it is possible to identify large-scale structural trends.

The Subcrenalum Marine Band marking the base of the Westphalian is exposed at Pont Walby. Although normally well developed in this area, only its transgressive basal shales and mudstones are exposed here, and typical faunas are rare. The contact with the overlying Farewell Rock is erosive and is seen in the riverbed beneath the viaduct. The Farewell Rock reaches thickness of 52 m and comprises massive, trough cross-bedded, quartzitic sandstones interbedded with thinner sandstones and silts.

Across much of the South Wales Coalfield, the Astell Coal usually overlies the Farewell Rock. The seam itself cannot be seen in the section, but there is a large adit on the south-west bank of the river marking its position. However, the overlying series of plant and marine beds that are well documented for South Wales can be seen here. There then follows more than 25 m of lacustrine tabular and nodular ironstone horizons, which have been extensively worked and are well exposed in the quarry cuttings to the west of the main pathway.

Above the ironstone interval is a sequence of thick sea beds and coals, commonly known as the Bluer Group (including the Grey, Rhyd, L. Bluer, Upper, Bluer, and Lower Peacock Coals). This is particularly well exposed in the main riverbed and adjoining tributaries. There then follows several meters of cross-beded sandstone, forming a prominent waterfall, and then 18-20 m of dark marine muds and siltstones, the Vanderbeckei Marine Band, marking the Langsettian-Bolsonian boundary.

The sequence above the marine band is iron rich with numerous thin tabular iron bands forming significant riverbed cascades. Two of the most productive seams in the area, the Brass and Nine Feet Coals, are also in this part of the sequence. They are not exposed in the main section, due to faulting and commer-

---

**Exposures of the Westphalian Series in the Upper Neath Valley, South Wales**

B. Evans¹, C.J. Cleal¹ and B.A. Thomas²

¹Dept Biodiversity and Systematic Biology, National Museums & Galleries of Wales, Cathays Park, Cardiff CF10 3NP, UK.

²Welsh Institute of Rural Studies, University of Aberystwyth, Ceredigion SY23 3AL, UK.

In the last issue of this Newsletter, we reported on the early stages in a project to document the natural exposures of Westphalian strata in stream sections near Glyn Neath, South Wales (project funded by the Countryside Council for Wales and the National Museums & Galleries of Wales). We are now twelve months further into the work and this is an interim report on progress.

Work has centered on the Cwm Gwrelych - Nant Llyn Fach stream sections (OS grid reference SN891064-SN906039), which provide a near complete exposed succession through the Langsettian, Duckmantian and lower Bolsonian. The section lies 1km east of Glyn Neath, and consists of 3 km of stream bed, bank side and open cast exposure. The tenure of most of the section is held by four main bodies: Celtic Energy, Forest Enterprise, Neath and Port Talbot Council, and a private landowner.
cial exploitation, but they can be seen in adjacent temporary and local natural sections.

The rest of the Duckmantian stratigraphy is relatively well exposed in the main stream section where most of the productive coals are found. The coals are also being worked (by adjacent Celtic Energy) in the neighbouring opencast mine, which provides exceptional opportunities for collecting palaeobotanical specimens. The sequence consists of cyclic deposits, which start with prominent, erosive based sandstones that locally 'wash out' coals seams. However, such 'wash outs' do not occur in the Nant Llyn Fach section, which thus provides an exceptionally complete stratigraphy. The Cornish, Six Feet, Four Feet, Two Feet Nine and Gollwyn Seams are found interspersed by a series of large waterfalls that have developed over the resistant channel-fill sandstones.

There follows another sequence of marine bands (referred to as the Upper Marine Group) and terminates, after the significant Upper Cockshot Rock (a 7-8 m sandstone), with the Aeigianum Marine Band marking the base of the Bolsovian Stage.

The sequence above this is well exposed for 20-30 m in the main stream section, before becoming inaccessible due to coniferous forest. However, there are broken exposures here, which combine with what can be seen in adjacent alternative local sections to provide details of the stratigraphy. This indicates low energy, backswamp environments, and includes numerous thin coals and coarsening upward cycles, with sections best exposed around the occasional sandstone crags that crop out in the stream bed itself.

The top of the section is yet to be fully documented, but is known to run from the Upper Cwmgorse Marine Band to above the Rhondda No. 2 Coal. Some details have been recorded, although accessibility to the exposure is very difficult given the geographic setting. This final part of the section will be fully documented by early August.

The work has confirmed that this area provides a unique resource for geological science. There will be, after final excavations have taken place (hopefully later this year), a complete exposed succession through the Langsettian, Duckmantian and lower Bolsovian, including most of the key marine bands used for intercoalfield correlation. Nowhere else in Europe can this be seen in natural and conservable outcrop. The nearest comparison is with the exposures succeeded along the coast of Northumberland in north-east England, but this only shows a part of the succession. For some years, now, the boundary stratotypes for the lower three Westphalian stages have been identified in very small exposures in northern England. However, the exposures near Glyn Neath must be regarded as effectively 'standard' sections for body of these stages as represented in their classic non-marine development of the Variscan Foreland.

Climatic and vegetational changes in Late Carboniferous tropical forests - a NATO-funded project


1Department of Biodiversity and Systematic Biology, National Museums & Galleries of Wales, Cathays Park, Cardiff CF1 3NP, UK (ChrisCleal@cs.com).

2Institute of Geology, Bulgarian Academy of Sciences, Acad. G. Bonchev Street, Block 241113 Sofia, Bulgaria (ytENCHOV@abv.bg, tadi@geology.bas.bg).

3University College of Cape Breton, Sydney, Nova Scotia, Canada B1P 6L2 (ezodore@uccb.ns.ca).

4Institute of Rural Studies, University of Wales Aberystwyth, Llanbadarn Campus, Aberystwyth, SY23 2EX (bat@aber.ac.uk).

The Late Carboniferous is one of the best analogues for conditions today. It is the only other time in the geological past when there was both extensive polar ice and tropical rain forests. The Upper Carboniferous stratigraphical and fossil record is thus a major tool for testing ideas about the link between tropical forestation, levels of atmospheric CO₂, and global temperature. However, this requires us to understand what was controlling the extent of the Late Carboniferous tropical forests. Were the forests fluctuating in size due to climate change (as suggested by Phillips and Cecil, 1985), or were other factors at play and the changes in forestation causing climate change (see Cleal and Thomas, 1999)?

This is the topic of an international project being funded as part of the NATO Science Programme. The main aim is to identify geographical variations in the composition of the coal forests during the latter half of their existence (Bolsovian to early Cantabrian). This is to be examined over a baseline of 2500 km, between north-western Europe and the Canadian Maritimes on the one hand, and eastern Bulgaria on the other. If the changes appear to be taking place more or less synchronously between the two areas, then climate change is the most likely factor controlling forest distribution. If, on the other hand, significant differences can be identified, then tectonics may be the driving force behind the vegetational changes, which in turn caused climatic change.

Palynofloras

To understand the composition of the bulk of the forests, it is necessary to look at the coal seams. In the upper Westphalian and lowermost Stephanian of Europe, this can only be achieved through the study of the palynology of the coals. This can reveal how the proportion of the main plant-groups changed with time in the two study-areas. Tatiana Dimitrova has already made significant progress in understanding the palynofloras from the Dobrudja Coalfield, Bulgaria, and is continuing to expand the available data. Similar data is needed from the western areas,
especially from Canada, where the late Westphalian palynofloras are well preserved. The British palynofloras are generally poor from this part of the succession, which either has coals that are too high in rank (e.g., S. Wales) or are in coal-poor, mainly red-bed successions.

**Macrofloral biostratigraphy**

How can we correlate the changes in the palynofloras between the two areas? There are no tonsteins or thin marine bands in the Canadian and British coalfields that could provide a non-biotic means of correlation, such as found in Western Europe (e.g., Menning et al., 2000). Correlation must therefore depend on biostratigraphy, mainly using the floras. It is widely accepted that the macrofloral record from the clastic sediments between the coals is a useful biostratigraphical tool (e.g., Wagner, 1984; Cleal, 1991) but will it help with the correlation of the palynological record? An obvious objection is that the vegetation preserved in the clastic deposits may have been affected by the same environmental influences as the peat-forming vegetation. Hence, it would be as unreliable for biostratigraphical correlation as the palynology. On the other hand, the clastic-substrate vegetation was not as constrained by edaphic conditions as the backswamp vegetation and thus less vulnerable to extrinsic stress (DiMichele et al., 1985). For instance, it is noticeable that similar macrofloras occur in both coal-bearing and non-coal-bearing upper Westphalian sequences in southern Britain (Besly and Cleal, 1997). However, the hypothesis has not been properly tested and is to be one of the main aims of the present project.

A key part of the project will therefore be to compare the macrofloral biostratigraphies of the study areas. There is a well-established macrofloral biostratigraphy for the late Westphalian, developed mainly in western Europe (Wagner, 1984; Cleal, 1984, 1991; Cleal and Thomas, 1994), and eastern Canada (Zodrow and Cleal, 1985). No comparable biostratigraphy has been worked out for the eastern European floras. It is therefore our intention to determine how well the western European biostratigraphy can be applied to the Bulgarian Dobrudzha Coalfield macrofloras. This may help establish detailed correlations with the sequences in Britain and Canada. It may also indicate significant changes taking place in the clastic substrate vegetation in eastern Bulgaria. Although this vegetation was only a small part of the forest as a whole, the evidence may provide an insight into the climatic or other environmental changes taking place here in the late Westphalian.

**The NATO project**

NATO is funding the project for two years. The first meeting of the team members was held in September 2000 in Sydney, Nova Scotia, Canada. This gave the team an opportunity to examine together the sequence of macrofloras there and to discuss issues relating to taxonomic usage and nomenclature in the two areas. It also provided us with the opportunity to look at the palynofloras, based on an extensive suite of preparations provided by the Geological Survey of Canada (originally prepared by Dr Graham Dalby).

The next meeting was held in May 2001, at Sofia. This allowed us to look at the extensive collection of borehole samples from the Dobrudzha Coalfield held at the Geological Institute there and to discuss how these relate to what we saw in Canada. The third meeting will be in October of 2001, at Cardiff, when the British evidence will be examined. The final meeting, to be held in March 2002, will be in Cardiff, when the data will be brought together.

This is not the first time that long-distance correlations of these floras have been attempted (Fissunenko and Laveine, 1984). However, it is, we believe, the first time that variations in the macrofloras and palynofloras have been integrated. Also, the project is involving specialists from all three countries, which should overcome any problems of differing interpretations in the taxonomy of the fossils—when we use a name in the two areas being considered, we should be reasonably confident that we are referring to the same species.

**References**


Microspores or pollen?

Erwin L. Zodrow¹, Josef Pšenička², Jiří Bek³, Alan R. Hemsley⁴, and Christopher Cleal⁵

¹University College of Cape Breton, Sydney, Nova Scotia, Canada B1P 6L2 (ezzodrow@uccb.nsc.ca).
²Department of Paleontology, West-Bohemian Museum, Kopeckého sady 2, 301 3 Pilsen, Czech Republic (psenda.paleobot@iol.cz).
³Institute of Geology, Academy of Sciences, Rozvojová 135, 165 00 Prague 6, Czech Republic (mrbean@gli.cas.cz).
⁴Laboratory for Experimental Palynology, Department of Earth Sciences, Cardiff University, Cardiff CF1 3YE, UK (HemsleyAR@Cardiff.ac.uk).
⁵National Museums & Galleries of Wales, Department of Biodiversity, Cathays Park, Cardiff CF1 3NP, UK (ChrisCleal@cs.com).

In the 2000 Carboniferous Newsletter (vol. 18, pp. 33-35) a pilot study of in situ pectorid microspores from the Late Westphalian D in the Sydney Coalfield, Nova Scotia, Canada, was reported by Zodrow, Bek and Pšenička. In the process of that study, an unusual synangium was noticed. The synangium originated from a ca. 40 by 25 cm large fragmentary frond that is entirely fertile and without sterile foliage. A small laterally-elongate cup-shaped synangium is borne distally on many of the pinnule lobes, attached to the abaxial surface. The synangia are oval in transverse section and appear to consist of a ring of laterally-fused elongate sporangial tubes (Fig. 1). The well-preserved claviform synangia contain two types of palynomorphs: the monolectic laevigate microspores corresponding to dispersed species *Latosporites minutus* (smallest, circular form: 27.3 μm on average), *Laevigatosporites minusculus* (ovoid, intermediate size range 20 to 34 μm), and monolectic to trilete microverrucate "microspores" corresponding to dispersed species *Punctatosporites oculus* (ovoid to circular, largest: 29.6 μm average). Our first impression was that the synangia resembled the marattiallean fern *Radstockia*, as interpreted by Taylor (1967), but on closer inspection the arrangement of the sporangia is clearly different. The Carboniferous fern *Crossotheca* has sporangial clusters borne distally on digitate pinnules (e.g., Brousmiche, 1983), but the clusters do not have an oval transverse section, and sporangia are not fused. Additionally, the sporangia are attached to the ends of the pinnule lobes, and not to the abaxial surface. The present sporangial configuration (Fig. 1) bears some similarity to the cup-shaped *Whittlesea* synangium as reconstructed by Halle (1933). The most notable difference between the two is that *Whittlesea* synangia are usually interpreted as having a round cross section, and also it is not thought to have been attached to pinnule lobes in this way. The size of the synangia of the present specimen tends to indicate they are fern. However, the present synangia occur exclusively with sterile medullosalean foliage of the alethopteroid and linopterid form which suggests pteridosperm affinity.

It is impossible to distinguish smallest (i.e., less than 25-30 μm) monolectic laevigate to scabrate palynomorphs isolated from sporangia of marattiallean (genera like *Pecopteris*, *Asterotheca*, *Acitheca* and others, i.e., spore-producing plants) from pteridosperm plants (genera like *Whittlesea* or *Potoniella*). All of these palynomorphs are of the same morphological type and they seem to be identical when studying them in the light microscope and SEM. However, there is a paucity of TEM studies comparing palynomorphs isolated from spore-producing and pteridosperm plants.

In an attempt to resolve the issue of origin (microspores vs. pollens), TEM will be performed in the near future in the Laboratory of Experimental Palynology, Cardiff University by ARH.
Sections will be examined to study the stratification of the palynomorphs, nature of laesurae, sporangial walls and layers. Differentiation could also be dependent on whether or not medullosalean pollen grains have unusual ultrastructural wall stratification (pers. comm., Dec. 2000, T.N. Taylor). However, the problem of pollen and spores is very complicated, and nobody knows the answer because we do not know the megagametophytes of plants.

References


Provisional Lower and Middle Pennsylvanian conodont zoning in Midcontinent North America

Lance L. Lambert 1, James E. Barrick 2, and Philip H. Heckel 3

1Department of Earth and Environmental Sciences, Univ. of Texas at San Antonio, San Antonio, TX 78249, USA.

2Department of Geosciences, Texas Tech University, Lubbock, TX 79409-1053, USA.

3Department of Geoscience, University of Iowa, Iowa City, IA 52242, USA.

Introduction

Important advances have been made in understanding Pennsylvanian conodont biostratigraphy in North America since the summary of Lane et al. (1971). However, no comprehensive summary of these advances yet exists. Swift (1988, Chart) prudently showed only “No widely recognized conodont zones” for post-Morrowan conodonts because the new information resides in numerous papers that primarily address biostratigraphic and taxonomic issues on a restricted geographic and stratigraphic scale.

The pioneering efforts of Lane (1967, 1977) and colleagues (see below) led to a detailed zonation for Morrowan strata, which are restricted to a relatively small area in the southern Midcontinent. Atokan deposits are more widespread, but a combination of stratigraphic and taxonomic problems have hindered development of an Atokan conodont zonation, particularly regarding stratigraphic and biostratigraphic relations in its type area (Lane and West, 1984). Despite this, studies by Grayson (1979, 1984; Grayson et al., 1989; 1990) and Lambert (1992; Lambert and Heckel, 1990) have begun to resolve problems surrounding placement and correlation of the Morrowan/Atokan and Atokan/Desmoinesian boundaries.

By the Desmoinesian, cyclothemic sequences became well developed and widespread across the Midcontinent. Ranges of significant conodont taxa have been plotted against the cyclothem succession, and used to identify and correlate cyclothems in the northern Midcontinent with those in Texas and the Illinois and Appalachian Basins (Merrill, 1972, 1975a,b; Swade, 1985; Heckel, 1989; Barrick and Boardman, 1989; Boardman and Heckel, 1989; Heckel and Weibol, 1991; Heckel, 1994, 1999). Although taxonomic revision of the important genera Neognathodus, Idiognathodus and Streptognathodus will take considerable time, many useful species are now sufficiently well described and illustrated that they can be used for rigorous biostratigraphic correlation in upper Desmoinesian through Virgilian strata (Barrick and Boardman, 1989; Ritter, 1994, 1995; Barrick et al., 1996; 1999; Boardman et al., 1998; Barrick and Walsh, 1999; Barrick and Lambert, 1999; Boardman, 1999). Successions of several of these species are enabling more distant correlations with the western USA (Ritter et al., 1999; Ritter and Barrick, in press) and eastern Europe (Heckel et al., 1998).

Morrowan Stage (Lower Pennsylvanian)

The Mid-Carboniferous boundary (Mississippian/ Pennsylvanian Subsystem GSSP) has been placed at the first appearance of Declinognathodus noduliferus (Ellison and Graves 1941) in Arrow Canyon, Nevada (Lane et al., 1999), a horizon that also defines the concurrent base of the Lower Pennsylvanian Series and the Morrowan Stage. Morrowan conodont zones were first proposed by Lane (1967), then modified by Lane and Straka (1974) in a zonation that has been widely used in North America. That zonation has continued to be updated by Lane (1977), Lane and Baesemann (1982), and Baesemann and Lane (1985) (Fig. 1, right column).

The base of the Declinognathodus noduliferus – Rhachistognathus primus Zone of Baesemann and Lane (1985) is defined by the first occurrence of either D. noduliferus or R. primus Dunn 1966, the latter restricted to western North America. There, the first appearance of R. primus commonly precedes the first appearance of D. noduliferus, and some have argued that the former species may appear during latest Mississippian (see Morrow and Webster, 1992). However, D. noduliferus appears just below the first occurrence of R. primus in Arrow Canyon (Lane et al., 1999). The noduliferus-primus Zone is subdivided into a lower subzone where Gnathodus girtyi simplex Dunn 1966 and G. cf. G. pollandensis Higgins and Bouckaert 1968 overlap with the nominate species, and an upper subzone above the overlap (Brenkle et al., 1977; Baesemann and Lane 1985). The Midcontinent lacks R. primus, so this zone is called the noduliferus Zone, and has been reported from the Rhoda Creek Formation in southern Oklahoma (Grayson et al., 1985) and possibly from the Marble Falls Formation in Llano region of central Texas (Dunn, 1970; Grayson et al., 1987). The holotype of D. noduliferus from the Dimple Limestone in the Marathon region of west Texas (Ellison and Graves, 1941) was apparently reworked into younger Morrowan beds (Grayson, 1984).

In the Midcontinent, the first appearance of Idiognathoides sinuatus Harris and Hollingsworth 1933 defines the base of the sinuatus Zone of Lane (1977). For sections in western North America, Lane and Baesemann (1982) modified this zone by
adding *Rhachistognathus minutus* (Higgins and Bouckaert 1968) as an index, and renaming the zone the *sinuatus-miniatus* Zone. Although the *sinuatus-miniatus* Zone appears to represent an insignificant stratigraphic interval between the *noduliferous-primus* Zone and the overlying *Neognathodus symmetricus* Zone in western North America (especially Arrow Canyon), the *sinuatus* Zone occupies several meters of strata in southern Oklahoma (Lane, 1977) and northwestern Arkansas (Baeseman and Lane, 1985).

The *Neognathodus symmetricus* Zone and the subsequent *N. bassleri* Zone are both defined by the first occurrence of *N. symmetricus* (Lane 1967) and *N. bassleri* (Harris and Hollingsworth 1933) respectively, and have been applied consistently since originally proposed (Lane, 1967; Lane and Straka, 1974). These two mid-Morrowan conodont zones have been reported from a number of localities across North America. Grayson (1990) proposed the *Neognathodus higginsi* Zone, which is equivalent to the combined *noduliferous* and *sinuatus* zones, based on the appearance of *N. higginsi* (Grayson et al., 1985), the predecessor to *N. symmetricus*.

No consistent zonation has been developed for Morrowan conodonts above the *bassleri* Zone. In typical zonations (e.g., Baeseman and Lane, 1985), the next zone is the *Neognathodus sinusus* Zone, defined by the range overlap of *N. bassleri* and *I. sinusus* Elliston and Graves 1941 (Lane and Straka, 1974).

The next overlying *Idiognathoides klipperi* Zone of Lane and Straka (1974) was defined by the presence of *I. klipperi* Lane and Straka 1974. Typical *I. klipperi* occurs only in the capping of the Baldwin coal (Dye Formation) in southern Oklahoma (Lane and Straka, 1974), and *Pa* elements identical to the type material of *I. klipperi* have not been recovered elsewhere. Grayson et al. (1989, 1990) expanded the concept of *I. klipperi* to include *Pa* elements in which the anterior extensions of the adcarinal grooves are incorporated into the platform. Using this definition, they applied the name *I. klipperi* to a series of distinctive late Morrowan *Pa* elements that had been called *I. delicatus* previously. The first appearance of *I. klipperi* was retained in Grayson’s (1990) biostratigraphic model to mark a datum above the *sinuatus* Zone.

The base of the overlying *Idiognathoides convexus* Zone was tentatively defined as the range of *Id. convexus* (Ellison and Graves 1941) below the appearance of *Idiognathoides* n. sp. (Lane et al. 1972) by Lane and Straka, 1974). This zone has been applied and labeled in an inconsistent manner, but is most often indicated by the first occurrence of *Id. convexus* following the appearance of *N. bassleri*, and usually *I. sinusus*, whether or not *I. klipperi* is present below.

One solution to the inconsistencies and other problems above would be to expand the *bassleri* Zone to include the *sinuatus* and *klipperi* zones. The upper boundary would be the first occurrence of *N. n. sp.* of Lane 1977, as discussed below. Because the appearance of *I. klipperi* (in the expanded sense of Grayson) is a distinctive event in *Idiognathodus*, *I. klipperi* could be used to subdivide the expanded *bassleri* Zone into two subzones once the taxon is better characterized. The *bassleri* zone is the first to contain additional morphotypes of *Neognathodus*, most of which are poorly circumscribed in North America. They include *N. sp.* A and sp. B of Grayson (1990), which may or may not be conspecific with some of the numerous Eurasian species named from Baskirian and Moscovian strata.

The next overlying zone has never been consistently defined. Zones based on *Idiognathoides* n. sp. (Lane and Straka 1974), *Neognathodus* n. sp. (Lane 1977) and *Idiognathoides ouachitensis* (Grayson, 1979, 1984; Lane and Baesemann, 1982; Baesemann and Lane, 1985) have been used. We recommend using the *Neognathodus* n. sp. zone of Lane (1977). This form is widespread in western North America, the Midcontinent and the Appalachian Basin, but its presence is commonly obscured by misassignment to various Desmoinesian species.

**Atokan Stage (Lower Middle Pennsylvanian)**

It has been difficult to adequately define the Atokan Stage because of the lack of a good stage boundary definition and unclear litho- and biostratigraphic relationships in the original type region (Lane and West, 1984). The Morrowan/Atokan boundary has variously been assigned to lie at the base, top, and within the various incarnations of the *Neognathodus* n. sp. Zone. When the base of the Atokan is defined on the appearance of the foraminifer *Eoschubertella* (Sutherland and Manger, 1984; Groves, 1986), the boundary falls within this conodont zone (Fig. 1). Some workers had used the appearance of *Diplognathodus* to identify the Morrowan/Atokan boundary (e.g., Dunn, 1976; Lane, 1977; Bender, 1980), but that genus has since been demonstrated to range significantly lower (von Bitter and Merrill, 1990). The *Neognathodus Pa* elements that Grayson et al. (1989) and Grayson (1990) assign to *I. incurvus* Dunn 1966 appear at or near the base of the Atokan, according to them.

The *Neognathodus atokaensis* Zone of Grayson (1984) extends from the first occurrence of *N. atokaensis* Grayson 1984 to its last occurrence, and essentially represents the middle Atokan. The upper boundary of the zone can be better defined once the taxonomy of the several co-occurring and the overlying *Neognathodus* morphotypes becomes stabilized. On his plate captions, Grayson (1984) designated two different specimens as holotype when erecting *N. atokaensis*. Museum labeling and the text clearly require that specimen 1 on plate three be treated as the holotype, but the characters described in the text refer primarily to specimen 8 on plate one. At the time, both morphologies were included within Grayson’s morphological concept of *N. atokaensis*, but it has become increasingly clear that these two forms are distinct. Coeval strata also produce Asian morphotypes named *N. kashiriensis* Goreva 1982 and *N. uralicus* Nemirovskaya and Alekseev 1994. *Neognathodus uralicus* is a distinctive morphotype that is common in the southern Midcontinent, but usually has been incorrectly referred to *N. medadulitmus* Merrill 1972 and *N. medadulitmus* Merrill 1972 (as in the upper Marble Falls Limestone of Texas: Manger and Sutherland, 1984).

Within the *atokaensis* Zone, a stratigraphically limited asence of gondolellids occurs in the southern Midcontinent and western North America. Mesogondolellids typically assigned to *Mesogondolella clarki* (Kolde 1967) are common in the *N. atokaensis* zone (see von Bitter and Merrill, 1977). So-called ‘naked’ gondolellids typically assigned to *Gondolella gymna*
Merrill and King 1971 are more often limited to the lower atokaensis Zone. Gondolellids are otherwise exceedingly rare in Atokan strata in North America.

The zone of Neognathodus colombiensis (new) overlies the N. atokaensis Zone. It is characterized by numerous morphotypes with a relatively even, symmetrical upper surface. Grayson (1990) and collaborators have referred these morphotypes to (in implied sequence) N. 'pre-boothrops', 'boothrops', and boothrops Merrill 1972. Many workers have forced them into other Neognathodus species. The name Neognathodus colombiensis Stibane 1967 has priority among these symmetrical forms, and is used here to designate these relatively poorly circumscribed forms that, as a group, characterize a well circumscribed zone. During the time represented by the colombiensis zone, Declinognathodus and Idiognathoides dwindle to extinction in North America. Neither has been recovered above the latest Atokan in the northern Midcontinent, or possibly the earliest Desmoinesian in the southeastern Midcontinent and western North America.

Desmoinesian Stage (upper Middle Pennsylvanian)

The exact position of the Atokan/Desmoinesian boundary remains unresolved, but it is commonly equated with the base of the Fusulinella/Fusulina (Beedainia) Zone (see Lane and West, 1984; Lamb and Heckel, 1990). The basal Desmoinesian in its type region possesses a conodont fauna that includes the first occurrence of both Neognathodus caudatus Lambert 1992 and Idiognathodus amplificus Lambert 1992. Neognathodus caudatus was a widely distributed taxon that has been recovered from the marine interval above the Cliffland Coal in the type Des Moines area, the subsurface Hugoton Embayment of Kansas, the Lyster Limestone in Oklahoma, and various localities across Asia. Because N. caudatus can provide a reliable marker for the basal Desmoinesian, we erect the caudatus Zone, for which the base is defined by the first appearance of this species (Fig. 1). Some North American workers have used I. amplificus to correlate lower Desmoinesian strata (Rice et al., 1994; Ritter and Barrick, in press), and this species may also be used to recognize the base of the Desmoinesian.

The next Desmoinesian zone we propose is defined by the first occurrence of Neognathodus asymmetricus Stibane 1967. Most workers in North America have ignored N. asymmetricus, and instead inconsistently split these forms between N. medadulitimus and N. medadulitimus based on a hypothetical terminal paedomorphiccline (Merrill, 1975a, 1999). Placing both into N. asymmetricus (which has priority) obviates this entrenched problem. Additional Neognathodus morphotypes occur in the asymmetricus zone, but are rare and poorly circumscribed. Morphotypes assigned here to N. asymmetricus are widely distributed in most Midcontinent localities within this stratigraphic interval. Gondolella species in the asymmetricus Zone had not developed the crenellated platform edges characteristic of the genus in the late Desmoinesian, and can be loosely assigned to G. ex. gr. lavis, followed by forms assigned to G. poehli von Bitter and Merrill 1998. Idiognathodus amplificus and its descendent morphotypes offer the potential for future subdivision.

Each of the major genera (Neognathodus, Idiognathodus, Gondolella) changes near the boundary that subdivides the

Midcontinent Desmoinesian into the Cherokee Group below, and the Marmaton Group above. The first well-developed cyclothem of the Midcontinent is the Verdigris cyclothem at the top of the Cherokee. It contains the youngest non-crenulated gondolellid, G. poehli von Bitter and Merrill 1998, and the first occurrence of N. roundyi Gunnell 1931 (sensus lati). The latter appearance marks the base the roundyi Zone, which includes the entire Marmaton Group. The numerous Neognathodus morphotypes that characterize this interval have been designated by a variety of names, but most species concepts are based on juvenile holotypes that had not attained adult features. N. roundyi (Gunnell 1931), which has been applied widely to forms with a single inner node regardless of size, has priority among them. Its stratum typicum lies in the middle Marmaton. Neognathodus dilatus (Stauffer and Plummer 1932) is the next oldest name, but may only represent an ontogenetic stage in N. roundyi. Its stratum typicum is several cyclothems higher in the latest Desmoinesian Lost Branch cyclothem. The wide variation in parapet development exhibited by Neognathodus populations throughout the middle and late Desmoinesian must be analyzed before any definitive taxonomic conclusions can be drawn. Lambert (1992) and Lambert and Grayson (1993) inferred that developmental constraints on parapet morphology might have weakened with an apparent loss of ecological competition following the extinction of partially homeomorphic Declinognathodus and Idiognathoides. Note that the potential taxonomic confusion posed by the largely ignored Jones (1941) publication might be resolved by recognizing these broadly variable middle and late Desmoinesian neognathodids as a descendant clade assigned to Bicarniodus Jones 1941 (Barrick and Lambert, 1999). Otherwise the large number of species names currently applied to these late Desmoinesian morphotypes, especially Merrill's (1975a; 1975b) 'terminal neognathodids', would compete with Jones's (1941) equally numerous names should they be interpreted to constitute distinct species.

A more detailed zonation of the late Desmoinesian is accomplished by using species of Idiognathodus and a closely related unnamed genus. The nodose Idiognathodus morphotype I. sp. 3 of Swade 1985 first appears in the Excenco shale of the Lower Fort Scott cyclothem at the base of the Marmaton Group, and ranges upward through the Coal City cyclothem (Heckel, 1999). This span of strata includes the genotype as well as the early named species I. delicatus Gunnell 1931, which has been used indiscriminately around much of the world for lobed, flat Idiognathodus morphotypes throughout the Pennsylvanian. We propose the Swade 1985 I. sp. 3 Zone for the lower Marmaton pending our current studies to determine which of several previous names (e.g., I. justiformis Gunnell 1933; I. acutus Ellison 1941) is appropriate for this form.

We propose that the next overlying zone be based on the first occurrence of New Genus 'S', a trenched clade of idiognathodids that preceded the appearance of Streptognathodus (Lambert and Heckel, 1999; Lambert et al., in prep.). In the Midcontinent, the New Genus 'S' Zone can be subdivided into lower and upper subzones based on the sequential appearance of species that were first recognized by Swade (1985). The lower subzone appears just above the Coal City cyclothem with the
first appearance of Swade 1985 I. sp. 5 in the Farlington cyclothem (Heckel, 1999; Lambert and Heckel, 1999), and also includes the overlying Altamont cyclothem. The upper subzone is defined by the occurrence of Swade 1985 I. sp. 6 (to which we assign the specific name nodocarinatus Jones 1941) and includes the latest Desmoinesian Lost Branch cyclothem.

The platformed lineage of Gondolella is non-crenulated through G. pohli in the Verdigris cyclothem near the top of the Cherokee Group, but attains the characteristic upper Desmoinesian platform crenulation in the Excello Shale at the base of the Marmaton Group, coincident with the base of the Swade 1985 I. sp. 3 Zone. These forms are referred to G. bella Stauffer and Plummer 1932 by Merrill (1975a). Although exceedingly rare through most of the Marmaton, Gondolella reappears as the more ommately crenulated G. magna Stauffer and Plummer 1932, along with non-platformed G. cf. G. denuda Ellisson 1941, in the Lost Branch Formation.

References


<table>
<thead>
<tr>
<th>Series</th>
<th>Stage</th>
<th>Neognathodus</th>
<th>Additional Neognathodus</th>
<th>Idiognathodids</th>
<th>Other taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>ZONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDDLE PENNSYLVANIAN</td>
<td></td>
<td>roundyi</td>
<td>dilatus “terminal taxa”</td>
<td>New Genus S</td>
<td>G. magna ?</td>
</tr>
<tr>
<td>DESMOINESIAN</td>
<td></td>
<td>asymmetricus</td>
<td>websteri</td>
<td>l. sp. 3 Swade</td>
<td>rare crenulated gondolellids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>caudatus</td>
<td>inequalis ?</td>
<td>amplificus</td>
<td>G. pohli</td>
</tr>
<tr>
<td></td>
<td></td>
<td>colombiensis</td>
<td>(several Eurasian species)</td>
<td>descendants</td>
<td>non-crenulated gondolellids</td>
</tr>
<tr>
<td>ATOKAN</td>
<td></td>
<td>atokaensis</td>
<td>bothrops/“bothrops”/“pre-bothrops”</td>
<td>amplificus</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Neog. n. sp.</td>
<td>uralicus/</td>
<td>incurvus</td>
<td>* Extinction of</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>kashiriensis</td>
<td>descendants</td>
<td>Declinognathodus</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>spp. A &amp; B</td>
<td></td>
<td>Idiognathoides</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Grayson, 1990)</td>
<td></td>
<td>* mesogondolellids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>bassleri</td>
<td>(several Eurasian species)</td>
<td></td>
<td>‘naked’ gondolellids</td>
</tr>
<tr>
<td>LOWER PENN.</td>
<td></td>
<td>symmetricus</td>
<td></td>
<td></td>
<td>common</td>
</tr>
<tr>
<td>MORROWAN</td>
<td></td>
<td>higginsi</td>
<td></td>
<td>convexus</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>girtyi</td>
<td></td>
<td>klapperi</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sinuosus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bassleri</td>
<td></td>
</tr>
<tr>
<td>Miss.</td>
<td></td>
<td></td>
<td></td>
<td>symmetricus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>sinuatus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>noduliferus</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>muricatus</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. – Provisional conodont zonation for Lower and Middle Pennsylvanian (Morrowan, Atokan, and Desmoinesian stages) in Midcontinent North America.
The Moscovian Stage - What is it?
An offer to recommend operation of a project group

O.P. Fissunenko
Lugansk Pedagogical University, Oboronnaya 2, 91011 Lugansk, Ukraine (pplgpi@telecom.lg.ua).

The well known German philosopher G.W.F. Hegel once noted: "only in the boundaries something is that it is". The wise saying of this philosopher is reflected in practically all international and national stratigraphic codes. In them it is emphasized that any stratal subdivision should have well defined lower and upper boundaries.

Unfortunately, our forerunners have not always adhered to this rule. In the XIX century not all stratal divisions were defined with observance of the specified requirements. Such has appeared also with the Moscovian Stage.

In the early half of the XIX century within the limits of the Russian Platform the Moscovian Stage was defined. It was supposed that this division encompassed all the interval of the section located above the lower Carboniferous. At first this stage was correlated with the Westphalian and Stephanian of Western Europe, but it was later established that the Moscovian Stage corresponds only to the top of the Westphalian.

The boundaries of the Moscovian Stage in the Russian framework were repeatedly updated. In the early half of the XX century, A.P. Rotai and S.V. Semikhatova established that within the limits of the Russian Platform beneath the Moscovian Stage and above the lower Carboniferous occurs one more subdivision, which in the Donets Basin was named the Kavyalian Stage (A.P. Rotai), and east of the Russian Platform was named the Bashkirian Stage (S.V. Semikhatova).

Thus, in its stratotypical terrain the Moscovian Stage has appeared without a precisely expressed lower boundary, and its upper boundary was repeatedly updated.

While the position of the upper boundary of the Moscovian Stage can be updated by careful paleontological studies of all groups, its lower boundary in other regions actually cannot be determined, as it is not defined in its stratotype. There is a situation when the measurement standards of the lower and upper boundaries of a stage should be transferred to another region, where the applicable intervals are well defined paleontologically.

Sections in the Donets Basin are closely spaced, in which the Carboniferous succession has a number of unrivaled qualities, including: it is continuous, it is polyfacial, it is well characterized by all groups of fauna and flora, it is accessible to ob-

All this allows a recommendation to provide stratotypes for the lower and upper boundaries of the Moscovian Stage in the Donets Basin. It is possible to recommend a project group for the study of sections describing the lower boundary of the stage in the area of the village Shetrovka, and also in a number of diverse areas for the study of the upper boundary of the stage in sections close to the villages of Kalinovo, Jeleznaya, and Skilevaya.

For a solution to this problem, an international project group should be created, as a structure within which work can be conducted by the various specialists.

On the appended correlation scheme for the chronostratigraphic subdivisions in Western Europe, Donets Basin and Moscow Syncline, the thick vertical lines show the limits within which there can be boundaries of the subdivisions of the Moscovian Stage.

---

**CORRELATION SCHEME FOR CHRONOSTRATIGRAPHIC SUBDIVISION IN WESTERN EUROPE, DONETS BASIN AND MOSCOW SYNECLISE**

<table>
<thead>
<tr>
<th>Western Europe</th>
<th>Donets Basin (Suites)</th>
<th>Moscow Syncline (Horizons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barruelian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cantabrian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Westphalian D</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bolsovian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duckmantian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Langsettian</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spacing of a possible position of boundary

- C_1^4
- C_2^3
- C_3^2
- C_4^1
- C_5^0

Horizons:
- K_1
- K_2
- K_3
- K_4
- K_5

Suites:
- M_1
- M_2
- M_3

Carboniferous Newsletter
Fusulinid and conodont zonation of the type Moscovian Stage

T.N. Isakova, N.V. Goreva, A.S. Alekseev, M.Kh. Makhлина

1Department of Paleontology, Geological Faculty, Moscow State University, Moscow, 119899, Russia; and Paleontological Institute of Russian Academy of Sciences, Moscow, 117868, Russia.

The Moscovian Stage was proposed by S.N. Nikitin (1890) on the succession of the southern part of the Moscow Basin in Central Russia. The Moscovian strata are represented mainly by shallow-water cyclic limestones (up to 150 m thick) that overlie the Lower Carboniferous rocks with an unconformity that spans most of the Bashkirian (lowermost stage of the Russian middle series of the Carboniferous System). Only where buried paleovalleys are filled with late Bashkirian alluvial sands and aequataurine silts and clays, does the transition from Bashkirian to Moscovian appear more or less continuous.

The Moscovian is subdivided into 4 regional substages: Vereian, Kashirian, Podolskian and Myachkovian which were introduced by Ivanov in 1923-1926. The fusulinid zonation was proposed by Rauser-Chernousova and Reitlinger (1954) and the conodont zonation was proposed by Barskov and Alekseev (1975). Both zonations have been modified several times and here we put forward their latest versions developed during the recent revision of Moscovian stratigraphy (Makhлина et al., in press).

Twelve foraminferal and 9 conodont zones (Table 1) are recognized in the Moscovian in its type area. Most of these are established on the first appearance of the zonal index species (with the exception of beds with Idignathoides ouachitensis in the Vereian).

Several fusulinid levels are important:
1. The Aljutovella aljutovica Zone of the basal Vereian Aljutovo Formation, which contains representatives of more an-

<table>
<thead>
<tr>
<th>Series</th>
<th>Substage</th>
<th>Formation</th>
<th>Member</th>
<th>Fusulinid zonation</th>
<th>Conodont zonation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPPER</td>
<td>KREVKYAKINIAN</td>
<td>Voskresenak</td>
<td>Upper</td>
<td>Protritites subschwager/oides</td>
<td>Streptognathodus makhlinae (Sm)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower</td>
<td>Obseletes obsoleatus (14)</td>
<td>Streptognathodus subexculus (Sr)</td>
</tr>
<tr>
<td></td>
<td>Suvorovo</td>
<td>Vitovski</td>
<td>Titova</td>
<td>Protritites ovatus (12)</td>
<td>Neognathodus roundyi (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kamennoyazyhino</td>
<td>Substovovo</td>
<td>Fusulinilla cylindrica (11)</td>
<td>Neognathodus inequilis (Ni)</td>
</tr>
<tr>
<td></td>
<td>Peski</td>
<td>Rozhaya</td>
<td>Prochiki</td>
<td>Fusulinilla bocki (10)</td>
<td>Idignathodus podolskensis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stary Yan</td>
<td>Prickoy</td>
<td>Fusulina cernovi (9)</td>
<td>Idignathodus medicum</td>
</tr>
<tr>
<td></td>
<td>Domodadovno</td>
<td>Sloboda</td>
<td>Sloboda</td>
<td>Fusulinilla columbiae, Bevedina ultinens (8)</td>
<td>Idignathodus podolskensis-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Penahino</td>
<td>Penahino</td>
<td></td>
<td>Neognathodus medicum</td>
</tr>
<tr>
<td>MIDDLE</td>
<td>PODOLSKIAN</td>
<td>Estonian</td>
<td>Estonian</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Staraya Rusa</td>
<td>Aleksandrovka</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pakhra</td>
<td>Pakhra</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rutella</td>
<td>Rutella braznikovae (7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Obraztsovo</td>
<td>Obraztsovo</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MIDDLE</td>
<td>MOSCOVIAN</td>
<td>Smolov</td>
<td>Shugorovo</td>
<td>Hemifusulina vozhga (6)</td>
<td>Streptognathodus condinus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zarysko</td>
<td>Zarysko</td>
<td>Moellerites praecolaniae</td>
<td>Idignathodus robustus (Sr-In)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zalovskoe</td>
<td>Zalovskoe</td>
<td>Fusulinilla pulchra (5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Khatun</td>
<td>Khatun</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lopasnya</td>
<td>Krasnovo</td>
<td>Krasnovo</td>
<td>Hemifusulina moelleri, Bevedina pseudoelegans (4)</td>
<td>Neognathodus med autoplay (N)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Zabelino</td>
<td>Zabelino</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Murzino</td>
<td>Murzino</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Krylovsky</td>
<td>Krylovsky</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sloboda</td>
<td>Sloboda</td>
<td>Priscoidella priscoides (3)</td>
<td>Neognathodus bothrops (Nb)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inino</td>
<td>Inino</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nara</td>
<td>Ordyanov</td>
<td>Ordyanov</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Snigov</td>
<td>Snigov</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aljutovo</td>
<td>Aljutovo</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ordyanov</td>
<td>Ordyanov</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Novoselov</td>
<td>Novoselov</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cherevo</td>
<td>Cherevo</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Porechile</td>
<td>Porechile</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sukhodrev</td>
<td>Sukhodrev</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chausovo</td>
<td>Chausovo</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ryblov</td>
<td>Ryblov</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

July 2001
cient (Bashkirian) lineages, but which is easily traceable in the paleoequatorial belt.

2. The base of the Kashirian is marked by the first appearance of Priscoidella, Hemijsulina and Taizheoella.

3. The first Fusulinella occur in the mid-Kashirian interval.

4. The base of the Podolskian coincides with the entrance of Putrella. The Upper Podolskian Fusulina chernovi-Kamutina kamensis Zone contains rare Wedekindellina and Paraewedekindellina.

5. The lower Myachkovian foraminiferal assemblage is dominated by the Fusulinaella bocki group.

The most important and correlatable conodont levels are:

1. The Lower Vereian Declinognathodus donetzianus Zone which is recognized in the Donets Basin (limestones K2-K5) and in the Aegirurn Marine Band of the basal Westphalian C (Bolsovian) of Western Europe.

2. The Lower Podolskian Idiognathodus podolakensis-Neognathodus medeazulitius Zone which contains the level with Gondolella levis—a species which is traceable world-wide (Moscow Basin, Volga River, and South Urals in Russia; Donets Basin in Ukraine; Cantabrian Mountains in Spain; several states in the USA; and in Canada).

3. The top of the Neognathodus roundyi Zone coincides with the last appearance of Neognathodus.

The work was supported by RFBR grants 97-05-65756 and 00-05-64288

References

The terminal stage of the Carboniferous: Orenburgian versus Bursianian

Vladimir L. Davydov

Permian Research Institute, Boise State University, Department of Geosciences 1910 University Drive, Boise, ID 83725, USA (vldavydov@boisestate.edu).

Introduction

Ross and Ross (1987; 1994; 1998) recently proposed the new Bursianian Stage to fill a gap between the newly defined base of the Permain (Davydov et al., 1992; 1998) and the top of the Virgilian in its traditional sense at the top of Brownville Limestone in Kansas (Moore, 1934; Moore, 1949; Thompson, 1954). This proposal has been suggested because "adding the Bursianian Stage to the Pennsylvanian Subsystem above the Virgilian and below the new [in North America -K.D.] Pennsylvanian boundary...does not confuse the existing nomenclature" (Ross and Ross, 1998, p.42). Although the Bursianian has been proposed as a regional stage for the Midcontinent and southwestern North America (Ross and Ross, 1994, 1998) it is meant to be a regional stage of the Pennsylvanian Subsystem and therefore logically can be considered as a new Bursianian Stage in the International Stratigraphic Scale.

Several problems exist with understanding and usage of the uppermost Carboniferous Bursianian Stage and the lowermost Permain Nealian Stage as either regional North American units or international standards because neither stage has been properly defined or described. In the Midcontinent sections where the Carboniferous/Permain transition is believed to be most complete, the stratigraphic content of the Bursianian has been changed several times in the past decade. The top of the Bursianian has been placed at the base of the Neva Limestone (Baars et al., 1992), the top of the Red Eagle Formation (Ross and Ross, 1985, 1988, 1995), and more recently at the base of the Red Eagle Formation (Ross and Ross, 1998). It does not make sense to prevent redefinition of the top of Virgilian, while redefining the top and consequently the volume of the newly proposed Bursianian Stage several times.

No stratotype for either the Bursianian or the Nealian has ever been proposed and their bases have never been adequately established as required by the International Commission on Stratigraphy (ICS) for definition of system, series and stage boundaries (Remane et al., 1996). Because Ross and Ross used "...Bursianian Formation and its identifying faunas ...in the sense of a stage or substage" (Ross and Ross, 1998, p.40), Lucas et al. (2000) studied the type section of the Bursianian Formation in order to provide adequate stratigraphic and biostratigraphic characteristic of the Bursianian in its type area in south-central New Mexico. This important study demonstrated a significant problem with the definition of both the base and the top of the Bursianian Formation in its type section in the sense of chronostratigraphy: "the base of Bursianian Stage, if it corresponds to the base of a fusulinid zone, is stratigraphically lower, at an unidentified stratigraphic level in the Madeira Group" (Lucas et al., 2000, p.12). The Bursianian Formation is overlain by terrestrial rocks of the Abob Formation and therefore the top of the Bursianian in its type section cannot be defined either biostratigraphically or chronostratigraphically. The upper third of the Bursianian Formation in its type section does not contain fusulinids or other important fossils at all.

Davydov (1996) and Wardlaw and Davydov (2000) suggested that the recently proposed International Carboniferous-Permain boundary should most probably be placed somewhere within the Bursianian Stage (Fig. 1) in North America. In the Glass Mountains in west Texas, the Carboniferous-Permain boundary appears to be within the Grey Limestone of the Gapank Formation and in the Bursianian type section in south-central New Mexico, within the Bursianian Formation (Wardlaw and Davydov, 2000).

Conodont correlations (Wardlaw and Davydov, 2000) suggest that the Bursianian most probably corresponds to a single fusulinid zone (Ultradaixina bosbyauensis-Schwagerina robusta Zone) in the southern Urals successions. The duration of the Bursianian Stage in chronostratigraphic terms could be estimated approximately at 1.0-1.5 Ma (Davydov et al., 1999) depending on which definition of the Bursianian is used and its corresponding volume in the Kansas succession. Therefore, if the Bursianian was included in the Pennsylvanian succession it would be one of the smallest stages in the Late Paleozoic geochronological scale.
In the last decade a comprehensive restudy of a relatively complete succession of Gzhelian-Orenburgian-Asselian strata in the southern Urals has resulted in the establishment of an officially accepted GSSP for the Carboniferous-Permian boundary (Davydov et al., 1998). Following the rules of the International Commission on Stratigraphy, the Pennsylvanian-Permian boundary is defined within the condont phylogenetic succession Streptognathodus wabaunensis-Str. isozelatus (Chernykh and Ritter, 1997). This boundary closely coincides with the traditional boundary proposed by Ruszenzev (1951, 1954) and with the base of the Sphaerenschwagerina fusiformis and S. vulgaris fusulinacean Zone (Davydov et al., 1992).

The newly accepted Carboniferous-Permian boundary has produced the problem of an unbalanced chronostratigraphic scale for the Pennsylvanian, particularly for the Upper Pennsylvanian (Fig. 1). Comparison of the Kasimovian and Gzhelian (sensu lato) Stages reveals that the Gzhelian in this newly enlarged sense (sensu lato) is chronostratigraphically about two times greater than the Kasimovian (6.0-6.5 Ma versus 3.0-3.5 Ma).

The Gzhelian Stage was originally proposed by Nikitin (1890) in the Moscow Basin as the limestone and dolomite succession above the light red clay and limestone (equivalent to the modern Kasimovian Stage) exposed near Dorogomilov village, Yauza River in Moscow and Voskresensk city. As proposed by the Nikitin the Gzhelian Stage includes limestones near the villages of Gzel' and Rusavkino and a series of exposures of dolomite along the Kljaz'ma River from Rabubehnya village to Pavlov-Posad city. Therefore, the Gzhelian as based on the proposed series of type-sections originally included the Rechitian (or Rusavkian), Amerevian and Pavlovoposadian Horizons of the modern Moscow Basin stratigraphic succession. Because of the poor preservation of the upper Gzhelian in the Moscow Basin, Nikitin defined the top of the Gzhelian in the Okso-Tsinsky Swell as limited by the beds with 'Schwagerina' (= Sphaerenschwagerina in the modern sense). However, in reality the stratigraphic interval between the Pavlovoposadian Horizon and the base of the "Schwagerina" Horizon has not been properly studied and understood for many years. Ivanova and Rosovskaya (1967) suggested that this questionable interval was
FIG. 2 Location map of the Nikol’sky section in the southern Urals region.

equivalent to the “Pseudofusulina” Horizon and the Orenburgian. However, no conclusive data in support of this suggestion was reported. Only in the mid-1970’s was the lower portion of this interval (equivalent to the *Dactylioceras* sokenisi fusulinid Zone) defined as the Nogjinian Horizon (Makhlina et al., 1975). The stratigraphic position of the upper portion of this interval equal to the *Ultradauxina bosphoriana-Schwagerina robusta* fusulinid Zone has for many years been uncertain and has been included in the Upper Carboniferous (Rauser-Chernousova and Scherbovich, 1958; Sjomina, 1961) or the Lower Permian (Makhlina et al., 1984). Makhlina and Isakova (1997) recently proposed the Melekhovskiy Horizon for this questionable stratigraphic interval.

The Orenburgian Stage was established by Ruzhenev (1945, 1950) as the terminal unit in the Carboniferous succession. The type section of the Orenburgian as proposed by Pnev et al. (1975) and Kotlyar (1977) is the Nikol’sky section in the southern Urals. Ruzhenev suggested that Orenburgian is equal to the “Pseudofusulina” Horizon established in the Samarskaya Luka and southern Urals (Rauser-Chernousova, 1938, 1949; Rosovskaya, 1952). In the late 1960’s the Orenburgian was removed from the stratigraphical scale in Russia due to miscorrelation between transitional Carboniferous-Permian successions in the Russian Platform and southern Urals (Kheeva et al., 1971; Pnev et al., 1975). However, recently this miscorrelation has been recognized and a new *Ultradauxina bosphoriana-Schwagerina robusta* fusulinacean Zone proposed (Leven and Davydov, 1979; Davydov, 1984, 1986). It demonstrated that previous miscorrelation had resulted in lowering the boundary of the base of the Permian in the Russian Platform. This miscorrelation is now corrected and the actual position of the base of the Permian is defined and officially accepted (Davydov et al., 1998). This boundary very closely coincides with the traditional base of the Permian as originally proposed by Ruzhenev (1954) and with the base of *Sphaerenschwagerina fusiformis* and *S. vulgaris* fusulinacean Zone (Davydov et al., 1992).

After the base of the Permian was defined in the Global Scale it became more obvious that the Orenburgian is an independent stage which should be included in the International Stratigraphic Scale between the Gzhelian (*sensu stricto*) and Asselian Stages. Inclusion of Orenburgian into the Global Pennsylvanian scale makes it balanced as the Kasimovian, Gzhelian and Orenburgian Stages are all three approximately equal in terms of chronosтратigraphy. The Orenburgian has historical priority over any other stratigraphic unit suggested for this time interval. One important advantage of this suggestion is that the type Orenburgian is located in the same region where the base of the Asselian (and consequently the base of the Permian) is established and therefore no miscorrelation of transitional beds between these two stages is possible.

The Orenburgian is the time of several major Late Paleozoic sea-level fluctuations which most probably resulted from climatic changes. In the Russian Platform and in the Arctic these sea-level fluctuations are represented by a series of significant sequence boundaries expressed in the sedimentary record as unconformities (Aleksseev et al., 1996; Davydov et al., 1999). The scale and character of these unconformities previously was not clearly recognized because the Orenburgian - particularly in the carbonate succession of the Russian Platform - is quite incomplete. It is represented there by several highstand system tract carbonate packages bounded by unconformities with a significant (or even predominant) part of the Orenburgian missing. In the southern Urals the Orenburgian is believed to be more complete as it is located within the relatively deep portion of the eastern slope of the pre-URAL deep (Fig. 2). The type section of the Orenburgian - the Nikol’sky section - is located on the north (right) side of the Urals River, about 2.0 km west of Nikol’sky village, Orenburg Province, Russia (Fig. 2). The Nikol’sky section comprises over 1000 m of east-dipping prodeltic shales, calcareous sandstones, conglomerates and limestones (Fig. 3) (Ruzhenev, 1945; 1950; Davydov and Popov, 1993). The Orenburgian stage in this section is slightly over 500 m thick (between 220.5 mab [meters above the base] and 731 mab). The base of Orenburgian originally was defined at the “marine breccia” (sea-clump) horizon, 260 mab in Nikol’sky section (Ruzhenev, 1952). However, based on the appearance of significant assemblages of progressive fusulinaceans such as *Dikevichia*, *Schellwienia* and *Zigarella*, and on the presence of a very significant *Dactylioceras* sokenisi group (*D. enormis* etc.) at 220 mab in the Nikol’sky section, Davydov and Popov (1986, 1993) placed the base of Orenburgian 40 m below its original position (Figure 2). Ruzhenev did not specifically define the top of the Orenburgian, but it was by that time the last exposure at the section. Recently the covered interval above the Nikol’sky section was excavated and additional fusulinid and conodont samples were recovered. Conodont study suggests placement of the Carboniferous-Permian boundary (or top of the Orenburgian) at 712.0 mab in the Nikol’sky section (Chernykh and Ritter, 1996) or 5 meters above the level where Ruzhenev placed his top of the Orenburgian.

The Orenburgian is characterized by prominent assemblages of conodonts, ammonoids and fusulinids throughout (Fig. 3). Orenburgian ammonoids described by Ruzhenev from Nikol’sky section allowed him to establish a distinctive Orenburgian ammonoid assemblage (Orenburgian biochronotype of Ruzhenev) and to recognize the stage globally (Ruzhenev, 1950; Ruzhenev and Bogoslovskaya, 1976). However, several typical Orenburgian ammonoids, including *Artinskia*, *Aristoceras*, *Vadriceras* and *Emilites*, were recently found as low as the lower Gzhelian (Zakharov, 1971; Bogoslovskaya and Popov, 1986; Popov, 1992). Therefore, redefinition of the criteria for recognition of
The Orenburgian fusulinid fauna in both the Boreal and Tethyan provinces is quite prominent and different from the fusulinid faunas of the underlying Gzhelian (sensa stricto) and overlying Asselian Stages. At least four fusulinid genera Dittkevitchia, Razhenzevites, Schellwienia and Zigarella first appeared at the beginning of the Orenburgian. Several other fusulinid genera such as Licharevites, Ultradaxina, Occidentioschwagerina, Schwagerina, and Rugosochusenella appeared slightly higher at the base or near the base of Ultradaxina bostyausensis-Schwagerina robusta fusulinid Zone. The Orenburgian Stage in the western Tethys and Boreal provinces is characterized by three fusulinacean zones: Daixina enormis-Schellwienia arctica, Daixina sockensis-Schellwienia modesta and Ultradaxina bostyausensis-Schwagerina robusta. The latter is divided into three subzones in the southern Urals, Donets Basin, Central Asia and Carpathian Alps (Davydov et al., 1992; Davydov, 1993; Davydov and Kozur, 1998).

The conodont biostratigraphy of the Orenburgian in the Urals and the Russian Platform has been studied only provisionally (Barskov and Alekseev, 1979; Barskov et al., 1981; Barskov, 1984; Akhmetshina, 1990; Chernykh and Ritter, 1996) and is still poorly known. In the Russian Platform and the southern Urals the Orenburgian possibly can be divided into two conodont zones: Streptognathodus elongatus at the base and St. wabaunensis at the top (Barskov, 1984; Chuvashov and Chernykh, 1991). However, criteria for a conodont definition of the base of the Orenburgian as a global stage is not yet evident because ranges of conodont species as they are defined in the Boreal and Tethyan provinces on one side and in North America on the other are significantly different. For example, Streptognathodus elongatus which is a common element in the lower Orenburgian in the Boreal and Tethyan provinces occurs only in the very narrow stratigraphic interval of the Brownville Limestone and Greyhorse Limestone in the upper Wood Siding Formation (Boardman et al., 1998) in the North American Midcontinent. Ritter suggested correlation of the St. elongatus and St. wabaunensis Zones of the Russian Platform and Urals with the St. virgilius, St. brownvillensis and St. wabaunensis Zones in the North American Midcontinent (Ritter, 1995). However, if this correlation were accepted, the Orenburgian would be equal to most of the Virgilian in

**Figure** Graphic Correlation interpretations of Nikol’sky section, southern Urals.

![Graphic Correlation Interpretations](image)

**FIG. 3** Stratigraphic succession in the Nikol’sky section. On the left is the late Pennsylvanian stratigraphic succession in the Nikol’sky section. On the right is Graphic Correlation of the Nikol’sky section. Vertical axis on the graph represents the exact (linear) measurement of the section. Horizontal axis represents a chronostatigraphic scale of the Arctic-Urals Composite section. Composite Standard Section is calibrated in Composite Units (1 CU=40 K years) using radiometric dates of Chuvashov et al. (1996) and inferred rates of fusulinacean evolution (Menning et al., 1997). Circles and squares on the graph are FADs (First Appearance Datums) of taxa (consequently species and genera) and crosses (species) and triangles (genera) are their LADs (Last Appearance Datums). Line of correlation (LOC) splits FADs and LADs in a way allowing the least net-disruption of ranges ("economy of fit"). Horizontal segments of LOC represent hiatuses estimated in terms of composite standard time-scale. Five inclined segments of LOC on the graph represent continuous depositional packages ("sequences"). Horizontal alignments on the graph at 57.0 m, 140.0 m, 210.0 m, 460.0 m, and 491.0 m represent unconformity within the succession. Estimated duration of the hiatuses in composite units and in million years (Ma) is shown on the graph. See Fig. 1 for names of fusulinacean zones.

the Orenburgian ammonoid fauna is required.
the North American Midcontinent which is not supported by other data. By now we can suggest that in the North American Midcontinent, the base of the Orenburgian appears to be close to the base of Wabaunsee Group, and most probably should be placed somewhere below the Brownville Limestone and above the Topeka and Howard Limestones, where Ritter (1995) reported St. holensis. In the southern Urals the latter species was found in the Nikol’sk’y section in the middle Gzhelian (FAD125-LAD200 mb; Chernykh and Ritter, 1996).

The Gzhelian-Orenburgian-Asselian succession in the Nikol’sk’y section has been analyzed sedimentologically and with graphic correlation (Fig.3). Several sequence boundaries were found within the studied succession. These sequence boundaries are expressed in the section as a sharp change in sedimentological pattern and/or sometimes as gravel conglomerate horizons, as for example in bed 7 (57.0 mab). Graphic correlation allows a precise estimate of the missing sedimentary record at the sequence boundaries. Sequence boundaries with pronounced hiatuses were found at the base of the Gzhelian (sensu stricto) Stage (base of fusulinid zone 27), and at the base of Orenburgian Stage (base of fusulinid zone 30) as these stages were defined in the Nikol’sk’y section (Davydov and Popov, 1993). Other sequence boundaries coincide with the bases of fusulinid zones 28, 32, and 32a. No sequence boundaries were found at the base of fusulinid zones 29, 31, and 33. The latter (33) coincides with the currently established base of the Permian (Davydov et al., 1998; Chernykh and Ritter, 1996).

The appearance of a sequence boundary at the base of the Orenburgian in its type section with a significant hiatus of approximately 1.4 Ma duration creates several problems. First of all, the Nikol’sk’y section cannot be used as a potential type section for establishing the base of the Orenburgian because a possible hiatus is present there. Considering the Orenburgian to be a global stage, it is obvious that its base, as with the bases of the other Pennsylvanian stages, will be defined on the basis of conodonts - the only cosmopolitan pelagic fossil group at that time. Comparing conodont distribution against proposed sea-level fluctuations in the Midcontinent region as proposed by Heckel (1989), by Ritter (1995), and by Boardman et al. (1998), we can conclude that significant conodont turnovers occurred at the sea-level highstands. This means that any potential conodont definition of the base of the Orenburgian would be off of its present position in the Nikol’sk’y section in the southern Urals coincides with sequence boundary. However, we assume that any potential boundary definition should be targeted to be close to the boundary originally proposed by Ruzhenzev.

A similar situation occurs with the definition of the base of Gzhelian. Conodont workers recently proposed the FAD of Streptagnostodus zethus as a possible index for the definition of the base of the Gzhelian (Heckel et al., 1998; Barrick and Heckel, 2000). In the North American Midcontinent this species appears in the Haskell Limestone which has been interpreted to represent a high stand system tract (Heckel, 1989; Ritter, 1995). However, in the Russian Platform, the southern Urals, and in Central Asia the base of the Gzhelian coincides with a sequence boundary (Aleksseev et al., 1996; Davydov et al., 1999; Leven and Davydov, 2001; see also figure 3 in this paper). Streptagnostodus zethus was originally described from the very base of bed 4 in the Usoinka section (Chernykh and Reshetkova, 1988) which on the basis of fusulinid distributions belongs in the upper Kasimovian (Chuvashov et al., 1990). In the Nikol’sk’y section, Chernykh and Ritter (1996) reported St. zethus from bed 4, which based on fusulinids was defined as upper Kasimovian (Davydov and Popov, 1993). All of these facts suggest that the proposed correlation of the redefined base of the Virgilian (Haskell Limestone) with the base of the Gzhelian Rusavian (or Rechitsian) Horizon of the Russian Platform requires additional consideration.

Conclusions:

The proposal of the Bursumanian as a terminal stage of the Pennsylvanian cannot be considered to be appropriate for several reasons:

1. No type-section for the Bursumanian has been proposed and its base has not been adequately established as required by the International Commission on Stratigraphy (ICS);

2. The Bursumanian as defined would be one of the shortest stages in the Pennsylvanian with an estimated duration of 1.0-1.5 Ma; this is usually considered the duration of a single biostratigraphic zone.

3. The appearance of the Bursumanian in the Pennsylvanian scale does not stabilize its stratigraphic nomenclature as the top of the stage and consequently its volume has been redefined at least three times during the past decade.

4. In the type region of the Bursumanian both the base and top of the stage have significant defects in biostratigraphic characteristic.

The Orenburgian as an independent stage should be included in the International Stratigraphic Scale between the Gzhelian (sensu stricto) and Asselian Stages. Inclusion of the Orenburgian into the Global Pennsylvanian scale would make it balanced, as all three stages (Kasimovian, Gzhelian and Orenburgian) are approximately equal in terms of chronostратigraphy. The Orenburgian has historical priority over other stratigraphic units suggested for this time interval.

The Orenburgian is characterized by prominent assemblages of conodonts, ammonoids and fusulinids. However redefinition of the Orenburgian ammonoid assemblage and additional study of the Orenburgian conodont fauna is required.

Sequence boundaries with pronounced hiatuses were found at the base of Orenburgian Stage (base of fusulinid zone 30) as the stage was defined in its type in the Nikol’sk’y section. Because significant conodont turnovers in the Upper Pennsylvanian occurred at sea-level highstands, any of the potential conodont definitions of the base of the Orenburgian would be off of its present position in the Southern Urals. However, this possible boundary definition should be targeted to be close to the boundary originally proposed by Ruzhenzev.

References


Report on the Carboniferous-Permian boundary in the Bohemian Massif

Zbynek Simunek


This contribution is a summary of several years work on the projects of the Grant Agency of the Czech Republic Nos 205/94/0692 and 205/96/1231 and the Grant Agency of the Charles University No. 227/200/B-GE0/PrF concerning the Carboniferous and Permian flora and its stratigraphy.

There are small gaps in sections around the Carboniferous-Permian boundary. Plant fossils are concentrated into fossiliferous horizons separated by thick layers of unfossiliferous sediments. As concerns the floral record, the most complete section through the Carboniferous-Permian boundary is in the Boskovice Furrow (graben) (see Fig. 2).

Two types of flora occur in the Bohemian Massif from the beginning of the Stephanian (Obrhel 1960): first, the autochthonous (paraautochthonous) seamforming (roof-shale) flora deriving from the seamforming flora of the Westphalian; second, the allochthonous non-seamforming flora consisting of new plant groups, or plant groups very rare in the Westphalian (e.g. conifers). The autochthonous, relatively hygrophilous assemblage usually consists of rare lycopsids, rare sphenopsids, common to very common ferns (ppecopterids), rare pteridosperms and cordaites. The lycopsids, sphenopsids, pteridosperms and cordaites could be locally relatively common. The allochthonous, mostly mesophilous to xerophilous assemblage usually contains rare remains of sphenopsids, ferns, pteridosperms, cordaites and conifers, but pteridosperms and cordaites could be locally common. These assemblages document that climate changed from relatively humid in the end of the Westphalian to relatively arid at the end of the Stephanian and in the Permian. There was a fluctuation of humid periods in the middle of the Stephanian (B) when coal measures were formed in three areas of the Bohemian Massif - the Melnik and Koukov Group of coals in the Central Bohemian basins, the Syrenov Group of coals in the Krkonoše Piedmont Basin and the Radvanice Group of coals in the Intrasudetic Basin (see Fig. 1, 2). The Barruelian (Stephanian A) formations are usually composed of variously coloured (grey, brown, red, grey green) mudstones or claystones and conglomerates. They contain rare, poorly preserved flora (Šetlík 1977). A similar situation is the case of the Upper Stephanian (C) Line Formation in the Kladno-Rakovník Basin. The flora is concentrated in grey fossiliferous horizons (Zdeňk and Klouby) that are compared with Plouznice and Stepanice-Cikvásky horizons in the Krkonoše Piedmont Basin (Fig. 2). Other sediments include dark reddish mudstone to claystone that contain rare, very poorly preserved flora. The Klouby and Stepanice-Cikvásky horizons contain very thin coal seams with autochthonous flora in the roof-shales. “Callipterids” have not yet been found. The Plouznice horizon is of lacustrine origin. The plant assemblage differs by the lesser amount of ppecopterids, more numerous pteridosperms, and more diversified conifers (4 species). “Callipterids” are also not known here.

Sedimentation in two other regions (Intrasudetic Basin and Boskovice Furrow) starts in the Stephanian C after a large gap. The Rosice-Oslavany Group of coals in the Boskovice Furrow is situated close to the Carboniferous-Permian boundary. This group of coals is remarkable because there is a lithologic and floristic change in the roof-shales of the 1st (uppermost) coal seam. The plant assemblage of the 2nd and 3rd coal seam consists of many tree ferns (pecopterids), frequent sphenopsids (calamites) and
relatively rare pteridosperms (except few species). The floral assemblage in the roof of the 1st coal seam is quite different. Ferns are very rare, pteridosperms are more common and diversified. Cordaites are relatively abundant. This assemblage is also rich in conifers (walchas). “Callipterids” were probably very rare, but documented by many authors (Katzer 1935, August 1937, Nemecke 1951, Štětik 1951 and Rieger 1965). Together 5 species of “Callipteris” have been recorded in this layer (see Fig. 3). Remy and Havlena (1960, 1962) considered “Callipteris” as the index genus for the Permian. On the other hand, some pteridosperms found here are considered to be Stephanian (e.g. Mixoneura omsundaeformis (Schloth.) Wagner (Rieger 1965). Practically the same flora is known also in Helmacher’s Horizon (Rieger mscr.) 12-22 m above the 1st (uppermost) coal seam, where Mixoneura omsundaeformis has its last occurrence in the Boskovice Furrow (grabten). Rieger (1965) and Purkynová (1985) assume that the Carboniferous-Permian boundary is in the roof of the Helmacher’s Horizon. The Zbyšov Horizon (1st Bituminous Horizon) in the Boskovice Furrow is about 300 m above the 1st coal seam (Havlena 1964) and its flora is typically Autunian with seven species of “Callipteris” (see Fig. 3).

The equivalent flora of the Intra-Sudetic Basin is poorly documented. The Vernérovice Member of the Chvalc Formation, contains the Rybnicek Horizon with a coal seam that yielded plant remains in its roof rocks. This assemblage is relatively poor, but two species of “Callipteris” and also Mixoneura omsundaeformis have been determined here. This horizon is very similar to the roof of the 1st coal seam or to the Helmacher’s Horizon in the Boskovice Furrow in terms of flora. This is the second example of the co-existence of Stephanian pteridosperms and “callipterids” (Bouroz-Dobinger 1977) (Fig. 3). Several hundreds of sterile sediments and eruptives follow after the Vernérovice Member. Plant remains have been found in the Olivetin Member probably of Upper Autunian age.

Carboniferous and Permian strata in the Krkonoše Piedmont Basin are divided by a small hiatus. The Stephanian Semily Formation does not contain any “callipterids”. The Rudnik Horizon of the Vrchlub Formation which is mostly of lacustrine origin is without doubt of Lower Autunian age. Six species of the genus “Callipteris” were found in the Rudnik Horizon.

The age of the Line Formation in the Central Bohemian Region is uncertain. The plant fossil record is known only from the lower part of the Line Formation (Zdetin and Klobuky horizons). These horizons are undoubtedly of Stephanian C age. The age of about 600 m of sediments above the Klobuky Horizon is not known. Holub and Prouza (pers. com., Fig. 2) believe that the Line Formation is younger (probably up to the Upper Autunian). Havlena and Pešek (1980) are convinced that all sediments of the Line Formation are of Stephanian C age.

The exact position of the Carboniferous-Permian boundary in the Blanín Furrow is not clear. The Permo-Carboniferous sediments occur in four erosional relicts. Flora with “callipterids”
<table>
<thead>
<tr>
<th>Age</th>
<th>Time equivalent strata</th>
<th>Stratigraphical units</th>
<th>Other pteridopsams</th>
<th>&quot;Callipteris&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autian</td>
<td></td>
<td>Zbyškov H. * (BF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower</td>
<td></td>
<td>Rudník H. (KPB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Probably</td>
<td></td>
<td>Heimbacher’s H. (BF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stephanian</td>
<td></td>
<td>Rybníček H. (IB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>Rosice- Oslavany F., 1st C.S. (BF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lini F. (CBB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rosice- Oslavany F., 2nd and 3rd C.S. (BF)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Samil F. (KPB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>Stark F. (CBB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radovnice Gr. of C. (IB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Syman F. (KPB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explanation: * horizon called also 1st Bituminous Horizon, H - Horizon, F - Formation, M - Member, C.S. - Coal seam

Gr. of C. - Group of coal seam; BF - Bozkovice Furrow (graben), KPB - Krkonose Piedmont Basin, IB - Intra-Sudetic Basin, CBB - Central Bohemian basins.

Remark: Unit 2 was considered by Ni mejc (1853) to the Stephanian, by Havlena & Remy (1960, 1962) to the Autianian.

I consider this unit for the Stephanian.

Fig. 3 Distribution of stratigraphically important pteridopsams and "callipteris" in individual horizons of the Bohemian Massif.

is usually considered to be Autianian, flora without "callipteris" is regarded as Stephanian C.

The Permian plant assemblages are different from the Stephanian assemblages. Conifers dominate in the Permian (locally 50-90% of specimens); "callipteris" are also a common element in this strata, but locally can be rare or absent. Other pteridopsams are rare, as are the ferns (pecopteris) and spinosids (calamites). Only one very thin coal seam (Häse Coal Seam) is known from the Autianian Vrchlabi Formation in the Krkonose Piedmont Basin. Its flora differs from other Permian floras of the Bohemian Massif by a greater proportion of pecopteris. Relatively xerophyllous elements such as "callipteris" and conifers have also been found near this coal seam. The hygrophyllous seamforming plant association disappeared in the beginning of Autianian. The table in Fig. 4 shows that the lower Autianian assemblage is low in species. The proceeding aridization in the Autianian caused reduction in fern and pteridopsam species and an increase of conifers. The table in Fig. 4 contains all genera except fructifications. The change between the Carboniferous and Permian was small. Forty-two species have been found in common in these units. The exact number of species in the Stephanian C and in the lower Autianian depends on where the boundary between the Stephanian C and the Lower Autianian is placed (see Fig. 3). The changes were gradual with many fluctuations of seasonally wetter and drier climates with an inclination to dry climate. The flora of the Stephanian C belongs to the Sphenophyllum angustifolium Zone, the critical interval of the Carboniferous-Permian boundary belongs to the Autunia conferta Zone (according to Wagner, 1984).

References


Fig. 4. Stephanian C and Lower Autunian plant genera of the Bohemian Massif

the Czech Republic Stratigraphy, Ces. Geol. úst. Praha.
Purkyňová, H. 1985. Nové poznámky o flóre rosicko-
Remy, W., and Havlena, V. 1960. Prinzipien der
stratifizischen Gliederung im treseislich-linnisch-
entwickelten Raum des euamerikanischen Florenreiches im
Remy, W., and Havlena, V. 1962. Zur Paläontologie des
Steinkohlengebirges II. Zur floristischen Abgrenzung
von Devon, Karbon und Perm im treseislich-linnisch-
entwickelten Raum des euamerikanischen Florenreiches in
Rieger, Z. 1965. Nové fytopalaeontologické nálezy v rosicko-
Šetlík, J. 1951. Paleontologicko-stratigrafické výzkumy ve
stefaniu stredních Cech a Moravy. Sbor. Ústř. Úst. geol.,
18, 437-448.
Wagner, R. H. 1984. Megafossil Zones of the Carboniferous. 9th
Congr. Int. Stratig. Géol. Carbonifère Compte Rendu (Wash-
ington and Champain-Urbana 1979) 2, 109-134.

Susan Turner
Queensland Museum, P.O. Box 3300, South Brisbane,
QLD 4101, Australia.

Work continues on the Lower Carboniferous of the
Drummond Basin, central Queensland, Australia. Dr. Arne
Warren (La Trobe Univ.) and ST have a joint ARC large
grant to investigate Tournaisian and Viséan non-marine
sites to elucidate the unique mid Viséan Middle Paddock
site in the Dacrobrook Formation, which contains a tetra-
pod-bearing fauna. Early amphibian bones are found
alongside gyracanth acanthodian remains (Warren et al.
2000, Turner et al. in prep.), a large rhizodont Strepssodus
(Johanson et al., 2000), the lungfish Ctenodus (Turner et al.,
1999), palaeoniscid fishes, and numerous sharks repre-
sented by teeth, scales and spines. ST has visited the
Royal Scottish Museum, Edinburgh, the Hancock Museum,
Newcastle-upon-Tyne and the Academy of Natural Sci-
ences, Philadelphia to study Late Devonian to Early Car-
boniferous material from the Fife coast of Scotland, from
Northernumberland, and Pennsylvania. She is working in
conjunction with Dr Ted Daeschler (ANS, PA) on the
microfauna from the Catskill Formation of Red Hill site,
Pennsylvania (e.g., Elliott et al. in Biliate & Turner eds.,
2000). A new Ph.D. student, Kate Parker (La Trobe Univ.)
will investigate geology and taphonomy of Drummond Bas-
in sites in more detail this upcoming field season.

In the marine Lower Carboniferous ST is working with
M.Sc. student, Benita Chambers (JCU, Townsville) on the
Lower Carboniferous Viséan Utting Calcarenites vertebrate
fauna.

Biochronology and Global Marine/Non-Marine Correlation.
tut Senckenberg, 223, 575 pp.
Turner, S., and Burrow, C.J. 1999. Micropaleontology, vertebrate,
PP. 740-749. In R. Singer (ed.), Encyclopedia of Paleontol-
ogy. Fitzroy Dearborn Publishers. 2 volumes; 1700 pp., Chi-
icago.

Turner, S., Kemp, A., and Warren, A.A. 1999. First Early Carbon-
iferous lungfish (Dipnoi, Ctenodontoidei) from central
Queensland: Rotheringa 23, 177-182.

record of Strepssodus (Sarcopterygii, Rhizodontia), from the
Lower Carboniferous Dacrobrook Formation, central

Jones, P.J., Metcalfe, I., Engel, B.A., Playford, G., Rigby, J.,
iferous biogeography of Australasia. In Wright, A., Talent, J.A.,
Young, C.C., and Laurie, J. (eds.), Palaeobiogeography of the

A redescription of Gyracanthides murrayi Woodward 1908
(Acanthodii, Gyracanthidiidae) from the Lower Carboniferous
of the Mansfield Basin, Victoria, Australia. Journal of Verte-

July 2001
PUBLICATIONS BY SCCS MEMBERS


First circular, announcement and information request

RUSSIAN ACADEMY OF SCIENCES (RAS), URALIAN BRANCH OF RAS, INTERDEPARTMENTAL STRATIGRAPHIC COMMISSION OF RUSSIA (ISC), CARBONIFEROUS COMMITTEE OF ISC, INSTITUTE OF GEOLOGY AND GEOCHEMISTRY OF URALIAN BRANCH OF RAS

International meeting

BIOSTRATIGRAPHIC BASING FOR STAGE BOUNDARIES OF CARBONIFEROUS SYSTEM IN EASTERN EUROPE

August 1-3, 2002, Ekaterinburg, RUSSIA

RAS, ICS and Institute of Geology and Geochemistry announce that in August 1-3, 2002, in Ekaterinburg City an international symposium “Biosratigraphic basing for stage boundaries of Carboniferous system in Eastern Europe” will be held. Main aim of meeting is preparation and choice of stratotypes for Serpukhovian, Bashkirian, Moscovian, Kazimovian and Gzhelian Carboniferous stages located in Eastern Europe as the members of General Stratigraphic Scale (GSS). The meeting will be accompanied by excursions on territory of Mid and Southern Uralas with demonstration series of reference sections, which can apply for role of international stratotypes and members of GSS. Field excursions will be organized starting from two centers: 1) from Ufa City onto territory of Southern Urals, and 2) from Ekaterinburg City onto territory of Mid Urals. One series of excursions will be held before the beginning of meeting, other - after it. The publishing of meeting materials volume and guidebook of geological excursions is supposed. Working languages of meeting - Russian and English.

Organizing Committee


Organizing Committee address:
Institute of Geology and Geochemistry, Uralian Branch of RAS, Pochtovy per. 7, 620151 Ekaterinburg, RUSSIA.

E-mail (Director office): root@igg.e-burg.su, igg@uran.ru.

Dr. Chuvashov B.I. – e-mail: Chuvashov@igg.uran.ru, telephone (3432) 71-05-88. Dr. Amon E.O. – e-mail: Amon@igg.uran.ru. In all cases is welcomed the electronic communication, using e-mail address of Conference Secretary (Amon@igg.uran.ru).

CONTROL DATES:
Preliminary registration of participants and reception of application for reports - November 1, 2001.
Representation of materials for meeting – March 15, 2002.

Information request

(Please present it to Organizing Committee till November 1, 2001 using e-mail preferably)

Surname:
Name:
Electronic address:
Telephone, fax (with codes of cities):
Institution (full name, post address):
Preliminary report title:
Participation in field excursion(s): no, yes in one, yes in both

July 2001
SCCS VOTING & CORRESPONDING MEMBERSHIP 2001
Please check your entry and report any changes to the Secretary

ALGERIA
Mrs Fatma Abdesselam-Roughi
Centre de Recherche et Développement
Ave du 1er Novembre
35000 Boumerdes
ALGERIA
A. Sebbar
Universite de Boumerdes
Faculte des Hydrocarbures
et de la Chimie
Dept. Gisements Miniers et Petroleurs.
Ave du l'Indépendance
35000 Boumerdes
ALGERIA
Fax: (213) 24 81 91 72
Email: sebbar_2001@yahoo.fr

ARGENTINA
Dr S. Archangelsky
URQUIZA 1132
Vicente Lopez
1638 Buenos Aires
Rep. ARGENTINA
Fax: 54-1-982-4494
Email: sarciang@overnet.com.ar

Dr Carlos Azucy
Dep. de Ciencias Geologicas
Pabellon 2, Ciudad
Universitaria
1428 Núñez, Buenos Aires
Rep. ARGENTINA
Fax: 54-1-638-1822
Email: azucy@esapa.org.ar

Dr Silvia Cesari
Dv. Paleobotanica
Museo de Cs. Naturales
"B. Rivadavia"
Av. A. Gallardo 470
1405 Buenos Aires
Rep. ARGENTINA

Dr N. Rubén Cuneo
Palaeontological Museum "E. Feruglio"
Av. 9 de Julio 655
9100 Trelew, Chubut
Rep. ARGENTINA

Dr Carlos R. Gonzalez
Instituto de Paleontologia
Fundación Miguel Lillo
Miguel Lillo 251
4000 S.M. de Tucuman
Rep. ARGENTINA
Fax: 081-330868
Email: fmgeo@uwmmail.unr.edu.ar

Mercedes di Pasquo
Facultad de Ciencias
Exactas y Naturales,
Dep. Geologia. Ciudad
Universitaria. Pabellon II.
Núñez.
Capital Federal. C.P. 1428.
Rep. ARGENTINA
Email: medipa@esapa.org.ar
medipa@tango.gi.fcen.uba.ar

Dr Arturo C. Taboada
Instituto de Paleontologia
Fundación Miguel Lillo
Miguel Lillo 251
4000 S.M. de Tucuman
Rep. ARGENTINA

Dr M.S. Japas
Dep. de Ciencias Geologicas
Pabellon 2, Ciudad Universitaria
1428 Núñez, Buenos Aires
Rep. ARGENTINA

Dr Nora Sabatini
Universidad Nacional de la Plata Facultad de Ciencias Naturales y Museo
Paseo del Bosque
1900, La Plata
Rep. ARGENTINA

AUSTRALIA
Prof. N.W. Archbold
School of Ecology and Environment
Deakin University,
Rusden Campus
Clayton VIC 3168
AUSTRALIA
Fax: 03-9244-7480
Email: marchi@deakin.edu.au

Dr J.C. Clauod-Long
Aust. Geol. Survey Organisation
P.O. Box 378
Canberra City, A.C.T. 2601
AUSTRALIA
Fax: 06-249-9983
Email: jcllong@ags.org.au

Dr J.M. Dickens
Innovatie Geology
14 Bent Street
Tumer Canberra, ACT 2612
AUSTRALIA
Fax: 06-249-9999

Dr B.A. Engel
Department of Geology
University of Newcastle
Callaghan NSW 2308
AUSTRALIA
Fax: +61-049-216-925
Email: benga@geology.newcastle.edu.au

Dr T.B.H. Jenkins
89 Eton Road
Lindfield, NSW 2070
AUSTRALIA

Dr P.J. Jones
Department of Geology
Australian National University
Canberra ACT 0200
AUSTRALIA
Tel: 02-62493372
Fax: +61-2-62495544
Email: p.jones@geology.anu.edu.au

Dr I. Metcalfe
Asia Centre
University of New England
Armidale, NSW 2351
AUSTRALIA
Fax: 02-67733596
Email: metcalf@mae.une.edu.au

Prof. G. Playford
Department of Earth Sciences
The University of Queensland
Queensland 4072
AUSTRALIA
Fax: 07-365-1277
Email: gaof@sol.earthsciences.uq.edu.au

Prof. J. Roberts
School of Applied Geology
The University of
New South Wales
Sydney, NSW 2052
AUSTRALIA
Fax: 02-9385-5935
Email: j.roberts@unsw.edu.au

Dr Guang R. Shi
School of A.S. & N.R.M.
Deakin University,
Rusden Campus
Clayton VIC 3168
AUSTRALIA
Email: gshi@deakin.edu.au

S. Stojanovic
71 Barracks Road
Hope Valley
Adelaide, SA 5090
AUSTRALIA
Fax: 373-4096

Dr S. Tumer
Queensland Museum
P.O. Box 3300
South Brisbane, QLD 4101
AUSTRALIA
Fax: 61-7-3846-1918
Email: s.tumer@mailbox.uq.oz.au

AUSTRIA
Dr F. Ebner
Institut für Geowissenschaften
Montanuniversität Leoben
A-8700 Leoben
AUSTRIA

Dr K. Kainer
Inst. für Geol. und Paläontologie
Universität Innsbruck
Innkrain 52
A-6020 Innsbruck
AUSTRIA
Fax: 0043-512-507-5585
Email: k.kainer@uibk.ac.at

Prof. Dr H.P. Schönlaub
Geol. Bundesanstalt Wien
Postfach 127
Rasumofskygasse 23
A-1031 Wien
AUSTRIA
Fax: +431-712-5674-56
Email: hschoenlaub@cc.geolba.ac.at

BELGIUM
Dr A. Deimer
16 Av Col Daumerie
B-1160 Bruxelles
BELGIUM

F. X. Devuyst
Unité de Géologie,
Université Catholique de Louvain,
3 place Louis Pasteur,
1348, Louvain-la-Neuve,
BELGIUM
Email: devuyst@hotmail.com

Dr E. Groessens
Service Géologique de Belgique
13 rue Jenner
B-1000 Bruxelles
BELGIUM

Dr Luc Hance
Unité de Géologie,
Université Catholique de Louvain,
3 place Louis Pasteur,
1348, Louvain-la-Neuve,
BELGIUM
Fax: 322-647-7359
Email: hance@geol.ucl.ac.be

Prof. Bernard L. Mamet
Laboratoire de Geologie
Université de Bruxelles
50 avenue F.D. Roosevelt
Bruxelles B1000
BELGIUM

Prof. E. Poty
Service de Paléontologie animale
Université de Liège
Bât. B18, Sart Tilman
B-4000 Liège
BELGIUM
Fax: 32-43-665338
Dr. Z. Belka
Inst. und Mus. für Geol. und Paläont.
Universität Tübingen
Sigmistr. 10
D-72076 Tübingen
GERMANY
Fax: +49-7071-610259
Email: belka@ub.uni-tuebingen.de

Prof. Dr. Dr. Peter Bruckschen
Ruhr-Universität Bochum
Geologisches Institut
Universitätsstr. 150
D-44801 Bochum
GERMANY
Fax: 0521-722903
Email: Peter.Bruckschen@rub.de

Dr. Günter Drozdowski
Geologisches Landesamt Nordrhein-Westfalen
De-Greiff-Str. 195
D-47803 Krefeld
GERMANY
Fax: +49-2151-89 75 05
Email: drozdowski@glw.nrw.de

Dr. Holger Forke
Institut für Paläontologie
Levenichstr. 28
D-91054 Erlangen
GERMANY
Email: forke@pal.pal.uni-erlangen.de

Mr. Dr. Hartkopf-Fröder
Geologisches Landesamt Nordrhein-Westfalen
De Greiff Str. 195
D-47803 Krefeld
GERMANY
Fax: +49-2151-897505
Email: hartkopf-froeder@glw.nrw.de

Prof. Dr. Dr. Hans-Peter Herbig
Universität zu Köln,
Geologisches Institut
Zülpicher Str. 49a
D-50674 Köln
GERMANY
Fax: +49-221-470-5080
Email: herbig.paleont@uni-koeln.de

Dr. Peer Hoth
Bundesanstalt für Geochemie und Rohstoffe
AS Berlin
Wilhelmstr. 25-30
D-13359 Berlin
GERMANY
Fax: +49-30-36 99 31 00
Email: peer.hoth@bgr.de

Prof. Dr. Dr. Hans Kerp
Westfälische Wilhelms-Universität
Abt. Paläontologie
D-48143 Münster
GERMANY
Fax: +49-251-834-831
Email: Kerp@uni-muenster.de

Dr. Dieter Korn
Universität Tübingen
Geologisch-Paläontologisches Institut
Sigmistr. 10
D-72076 Tübingen
GERMANY
Fax: +49-7071-29 69 90
Email: dieter.korn@uni-tuebingen.de

Prof. Dr. J. Kullmann
Inst. und Mus. für Geol. und Paläont.
Universität Tübingen
Sigmistr. 10
D-72076 Tübingen
GERMANY
Fax: +49-7473-26768
Email: juergen.kullmann@uni-tuebingen.de

Dr. Manfred Menning
GeoForschungsZentrum Potsdam
Telegrafenberg, Haus C128
D-14473 Potsdam
GERMANY
Fax: +49-331-288-1302
Email: menning@gfz-potsdam.de

Dr. Klaus-Jürgen Müller
Institut für Paläontologie
Nussallee 8,
D-53115 Bonn
GERMANY
Fax: +49-221-470-5080
Email: herbig.paleont@uni-koeln.de

Dr. Prof. Dr. Jörg Schneider
TU Bergakademie Freiberg
Institut für Geologie
Bernhard-von-Cotta-Str. 2
D-09596 Freiberg
GERMANY
Fax: +49-3731-39 35 99
Email: schneidl@geo.tu-freiberg.de

Dr. D. Stoppel
Bundesanstalt für Geowissenschaften und Rohstoffe
Postfach 51 0153
D-30631 Hannover
GERMANY
Fax: 0511-643-2304
Email: tECHNOLOGIEnutzung

Dr. Dieter Weyer
Löwesstr. 15
D-10249 Berlin
GERMANY
Email: dieter.weyer@t-online.de

Dr. Volker Wrede
Geologisches Landesamt Nordrhein-Westfalen
De Greiff-Str. 195
D-47803 Krefeld
GERMANY
Fax: +49-2151-89 75 05
Email: wrede@glw.nrw.de

Dr. Prof. Dr. W. Ziegler
Senckenbergisches Museum
Senckenberganlage 2
D-60325 Frankfurt 1
GERMANY

Dr. Sc. Heinz Kozur
Rózsák u. 83
H-1029 Budapest
HUNGARY
Fax: +36-1-204-4167
Email: h12547koc@gmail.com
KAZAKHSTAN

Dr. V. Koshkin
KazIMS
ul. K. Marx, 105
480100 Alma Ata
REP. KAZAKHSTAN

Dr. M.M. Marfenkova
Inst. Geol. Nauk
ul. Kananbai batyr 68A
480100 Alma Ata
REP. KAZAKHSTAN

Dr. M.I. Radchenko
ul. Shagabutdinova 80 kv. 39
480059 Alma-Ata
REP. KAZAKHSTAN

KYRGYZSTAN

Dr. Alexander V. Dzhenchuraev
Agency on Geology and Mineral Resources of Kyrgyz Republic
8-19-1 Nanakuma, Jonan-ku
Fukuoka 814-0180
JAPAN
Fax: 81-92-865-6030
Email: xs083@sat.fukuoka-u.ac.jp

Dr. W. Xiang-dong
Department of Earth System Science
Faculty of Science
Fukuoka University
8-19-1 Nanakuma, Jonan-ku
Fukuoka 814-0180
JAPAN
Fax: 81-92-865-6030
Email: xs083@sat.fukuoka-u.ac.jp

Dr. N. Yamagawa
Shinkanaroka-cho 3-1, 14-2
Sakai, Osaka 591-8021
JAPAN
Fax: 81-92-865-6030
Email: xs083@sat.fukuoka-u.ac.jp

Mr. Y. Yoshida
GEOCYRO Corporation
Onmaeda-chou 8-4, Nishi-nana-jo
Shimogyo-ku,
Kyoto 600-8897
JAPAN

MALAYSIA

Ibrahim bin Amnan
Geological Survey of Malaysia
Tiger Lane
Ipoh
MALAYSIA
Email: ibn@tm.net.my

NEW ZEALAND

Dr. J.B. Waterhouse
25 Avon St.
Oamaru
NEW ZEALAND

PEOPLES REP. CHINA

Dr. Gao Lianda
Inst. Geol., Chinese Acad. Geol. Sciences
Beijing
PEOPLES REPUBLIC OF CHINA

Dr. Guo Hongjun
Changchun College of Geology
6 Ximinzhu Street
Changchun, Jilin
PEOPLES REPUBLIC OF CHINA

Dr. Li Xingxue
Nanjing Inst. Geol. Paleont.
Academia Sinica, Chi-Ming-Ssu
Nanjing 210008
PEOPLES REPUBLIC OF CHINA
Fax: 86-25-3357026
Email: lxx@njjnet.ihep.ac.cn

Dr. Ouyang Shu
Nanjing Inst. of Geol. 
Academia Sinica, Chi-Ming-Ssu
Nanjing 210008
PEOPLES REPUBLIC OF CHINA
Fax: 86-25-3357026
Email: lxx@njjnet.nj.ac.cn

PORTUGAL

Prof. M.J. Lemos de Sousa
Dept. de Geologia, Fac.Ciências
Universidade do Porto
Praca de Gomes Teixeira
4099-002 Porto
PORTUGAL
Fax: (+351) 22 3325937
Email: mlsousa@fc.up.pt

Prof. J.T. Oliveira
Instituto Geológico e Mineiro
Estrada da Portela, Bairro
Zambujal
Apartado 7586
2720 Alfragide
PORTUGAL

RUSSIA

Dr. Alexander S. Alekseev
Dept. of Paleont., Geol. Faculty
Moscows State University
119899 Moscow GSP V-234
RUSSIA
Fax: 70953391266
Email: aaleks@geol.msu.ru

Dr. I.S. Barskov
Dept. of Paleontology,
Geology Faculty
Moscows State University
119899 Moscow GSP V-234
RUSSIA
Fax: 7095-9392190
Email: d.v. bunikov
Siberian Inst. Geol., Geophysics &
Min. Res.
Siberian Geological Survey
Krasny prospekt 67
630104 Novosibirsk
RUSSIA
Fax: 303-210-15-17
Email: dbysheva@bolshal academicheskaja
77 kor. 1 kv. 154
125183 Moscow
RUSSIA

Dr. Boris Chuvashov
Inst. Geology/Geochemistry
Russian Academy of Sciences
Pochtory per. 7
620151 Ekaterinburg
RUSSIA
Email: chuvashov@igg.uran.ru

Dr. Marina V. Durant
Geological Institute
Russian Academy of Sciences
Pechorskay per. 7
109017 Moscow
RUSSIA
Fax: +7-95-231-0443
Email: durante@giran.msk.ru

CARBONIFEROUS NEWSLETTER
<table>
<thead>
<tr>
<th>Name</th>
<th>Organization/Institution</th>
<th>Address/Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr M.L. Martínez Chacón</td>
<td>Depto de Geologia</td>
<td>Universidad de Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avda de Velasco s/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33005 Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fax: 34-8-510-3103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email: <a href="mailto:mmachaon@asturias.geol.uniovi.es">mmachaon@asturias.geol.uniovi.es</a></td>
</tr>
<tr>
<td>Dr Sergio Rodríguez</td>
<td>Depto de Paleontología</td>
<td>Facultad de Ciencias Geológicas</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ciudad Universitaria</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28040 Madrid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fax: 1-394-4854</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email: <a href="mailto:srodrig@eumax.sim.ucm.es">srodrig@eumax.sim.ucm.es</a></td>
</tr>
<tr>
<td>Dr L.C. Sánchez de Posada</td>
<td>Depto de Geología</td>
<td>Universidad de Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avda de Velasco s/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33005 Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fax: 34-8-510-3103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email: <a href="mailto:lposada@asturias.geol.uniovi.es">lposada@asturias.geol.uniovi.es</a></td>
</tr>
<tr>
<td>Dr Elisa Villa</td>
<td>Depto de Geologia</td>
<td>Universidad de Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avda de Velasco s/h</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33005 Oviedo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fax: 34-8-510-3103</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email: <a href="mailto:evilla@asturias.geol.uniovi.es">evilla@asturias.geol.uniovi.es</a></td>
</tr>
<tr>
<td>Dr R.H. Wagner</td>
<td>Unidad de Paleobotánica</td>
<td>Jardín Botánico de Córdoba</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Avenida de Linneo s/n</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14004 Córdoba</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SPAIN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fax: 34-57-295-333</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Email: <a href="mailto:jardinnat@servicom.es">jardinnat@servicom.es</a></td>
</tr>
<tr>
<td>TARTARSTAN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr V.S. Gubareva</td>
<td></td>
<td>ul. Kosmonavtov 7 kv. 7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>420061 Kazan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TARTARSTAN</td>
</tr>
</tbody>
</table>

**THE NETHERLANDS**

- **Bibliothek Palaobotanie**
  - Lab. Palaobotany and Palynology
  - Rijksunivers., Heidelberglaan
  - 2 NL-3584 CS Utrecht
  - THE NETHERLANDS
  - Fax: 31-30-263-096
  - Email: z.smeenk@beov.biol.ửu.nl

- **Dr A.C. van Ginckel**
  - Nationale Natuurhistorisch Museum
  - Postbus 9517
  - NL-2300 RA Leiden
  - THE NETHERLANDS

- **Dr W. Khrshner**
  - Lab. Palaobotany & Palynology
  - Budapestiaan 4
  - NL-3584 CD Utrecht
  - THE NETHERLANDS

- **Subcommissie Stratig. Nederland**
  - Nationale Natuurhistorisch Museum
  - Postbus 9517
  - NL-2300 RA Leiden
  - THE NETHERLANDS

- **Dr C.F. Winkler Prins**
  - Nationale Natuurhistorisch Museum
  - Postbus 9517
  - NL-2300 RA Leiden
  - THE NETHERLANDS

  - Fax: 31-71-5887666
  - Email: winkler@natuurlijk.rmn.nl

**TURKEY**

- **Prof. Dr Demir Aliyin**
  - Department of Geological Engineering
  - Middle East Technical University
  - 06831 Ankara
  - TURKEY
  - Phone: +90-312-2102680
  - +90-312-4275195
  - Fax: +90-312-2101263
  - Email: aliyin@tubitak.gov.tr
  - demir@metu.edu.tr

**THE UNITED KINGDOM**

- **Acquisitions Department**
  - Cabinet Office Service
  - The Natural History Museum
  - Cromwell Road
  - London SW7 5BD
  - UNITED KINGDOM
  - Email: alan@s-data.u-net.com

- **Dr. R.C. House**
  - Department of Geology
  - University of Southampton
  - Hants SO9 5NH
  - UNITED KINGDOM

- **Andrew Barnett**
  - Department of Earth Sciences
  - University of Cardiff
  - CARDIFF
  - Wales CF1 3YE
  - UNITED KINGDOM
  - Fax: 01222 874326
  - Email: BarnettA@cardiff.ac.uk

- **Dr Karen Braithwaite**
  - Exploration & Geological Analysis
  - British Gas Research Centre
  - Ashby Road
  - Loughborough, LEICS, LE11 3QU
  - UNITED KINGDOM
  - Fax: 01509-283-137
  - Email: karen.braithwaite@bggrc.co.uk

- **Dr. C.J. Cleave**
  - Department of Botany
  - National Museum of Wales
  - Cathays Park
  - Cardiff CF1 3NP
  - UNITED KINGDOM
  - Fax: 01222-239-829
  - Email: 100015.587@compuserve.com

- **Dr. Patrick J Cossey**
  - Division of Natural Sciences (Geology)
  - School of Sciences
  - Staffordshire University
  - College Road
  - Stoke-on-Trent
  - ST4 2DE
  - UNITED KINGDOM
  - Tel/Fax 01270 872002 (base for project)
  - 01270 294498 (SU office)
  - Email: P.J.Cossey@staffs.ac.uk

- **Dr R.M.C. Edgar**
  - 23 High Bond End
  - Knaseborough, North Yorks HG5 9BT
  - UNITED KINGDOM
  - Fax: 01423-865-892
  - Email: 100305.1736@compuserve.com

- **Dr A.C. Higgins**
  - Meadowview Cottage, 2 Redacre Row, Cliddesden, Basingstoke, Hants, RG25 2JD
  - UNITED KINGDOM
  - Email: alicia@uk.dial.pipex.com

**U.S.A.**

- **Dr. James E. Barrick**
  - Department of Geosciences
  - Texas Tech University
  - Lubbock, TX 79409-1053
  - U.S.A.
  - Phone: (806) 742-3107
  - Fax: (806) 742-0100
  - Email: ghj eb@pop.ttu.edu
SUBCOMMISSION ON CARBONIFEROUS STRATIGRAPHY (SCCS)
OFFICERS AND VOTING MEMBERS 2000-2004

CHAIR:

Dr Philip H. Heckel
Department of Geology
University of Iowa
Iowa City, IA 52242
U.S.A.
FAX: +1 319 335 1821
Email: philip-heckel@uiowa.edu

VICE-CHAIR:

Dr Geoffrey Clayton
Department of Geology
Trinity College
Dublin 2
IRELAND
FAX: +353 1 671 1199
Email: gclayton@tcd.ie

SECRETARY/EDITOR:

Dr. David M. Work
Cincinnati Museum Center
Geier Collections and Research Center
1301 Western Avenue
Cincinnati, OH 45203
U.S.A.
FAX: +1 513-345-8501
Email: dmwork@fuse.net

OTHER VOTING MEMBERS:

Dr Alexander S. Alekseev
Dept of Palaeont., Geol. Faculty
Moscow State University
119899 Moscow GSP V-234
RUSSIA
FAX: 70953391266
Email:aaleks@geol.msu.ru

Dr Demir Altiner
Department of Geological Engineering
Middle East Technical University
06531 Ankara
TURKEY
FAX: +90-312-2101263
Email: demir@metu.edu.tr

Dr Darwin R. Boardman
Geology Department
Oklahoma State University
105 Noble Research Ctr.
Stillwater OK 74078
U.S.A.
Email: amm00001@okway.okstate.edu

Dr Paul Brenckle
1 Whistler Point Road,
Westport, MA 02790
U.S.A.
Email: saltwaterfarm@compuserv.com

Dr Boris Chuvashov
Inst. Geology/Geochemistry
Russian Academy of Sciences
Pochtoryi per. 7
620219 Ekaterinburg
RUSSIA
FAX: 7 3432 515252
Email: chuvashov@igg.uran.ru

Dr Marina V. Durante
Geological Institute
Russian Academy of Sciences
Puzhevskey per. 7
109017 Moskva
RUSSIA
FAX: +7 95 231 0443
Email: durante@ginran.msk.su

Dr Carlos R. González
Instituto de Paleontología
Fundación Miguel Lillo
Miguel Lillo 251
4000 S.M. de Tucumán
ARGENTINA
FAX: +54 81 330 868
Email: fmilgeo@uunmail.unt.edu.ar

Dr Luc Hance
Unité de Géologie,
Université Catholique de Louvain,
3 place Louis Pasteur,
1348, Louvain-la-Neuve,
BELGIUM
FAX: 32 647-7359
Email: hance@geol.ucl.ac.be

Dr Ian Metcalfe
Asia Centre
University of New England
Ardmialde NSW 2351
AUSTRALIA
FAX: +61-67-733596
Email: imetcalf@une.edu.au

Dr T.I. Nemirovskaya
Institute of Geological Sciences
Ukrainian Academy of Sciences
Gonchar Str., 55b
252054 Kiev
UKRAINE
Email: tmimroy@i.com.ua

Dr B.C. Richards
Geological Survey of Canada
3303-33rd St. N.W.
Calgary AB, T2L 2A7
CANADA
FAX: 403-292-5377
Email: brichards@gsc.ec.gc.ca

Dr N.J. Riley
British Geological Survey
Keyworth
Nottingham NG12 5GG
UNITED KINGDOM
FAX: +44-115-9363200
Email: N.Riley@bgs.ac.uk

Dr G.D. Sevastopolou
Department of Geology
Trinity College
Dublin 2
IRELAND
FAX: +353-1-671 1199
Email: gsvepul@tcd.ie

Dr Katsumi Ueno
Dept. Earth System Science
Faculty of Science
Fukuoka University,
Jonan-ku, Fukuoka 814-0180
JAPAN
Email: katsumi@fukuoka-u.ac.jp

Dr Elisa Villa
Depto de Geologia
Universidad de Oviedo
Arias de Velasco s/n
33005 Oviedo
SPAIN
FAX: +34 8 510 3103
Email: evilla@asturias.geol.uniovi.es

Dr R.H. Wagner
Unidad de Paleobotánica
Jardín Botánico de Córdoba
Avenida de Linneo s/n
14004 Córdoba
SPAIN
FAX: +34 57 295 333
Email: cr1wagro@uicco.es

Prof. Wang Zhi-hao
Nanjing Institute of Geology and
Palaontology
Academia Sinica
Nanjing 210008
CHINA
Email: fmxu@nigpas.ac.cn

Dr C.F. Winkler Prins
Nationaal Natuurhistorisch Museum
Postbus 9517
NL-2300 RA Leiden
THE NETHERLANDS
FAX: +31 715 133 344
Email: winkler@naturalis.nm