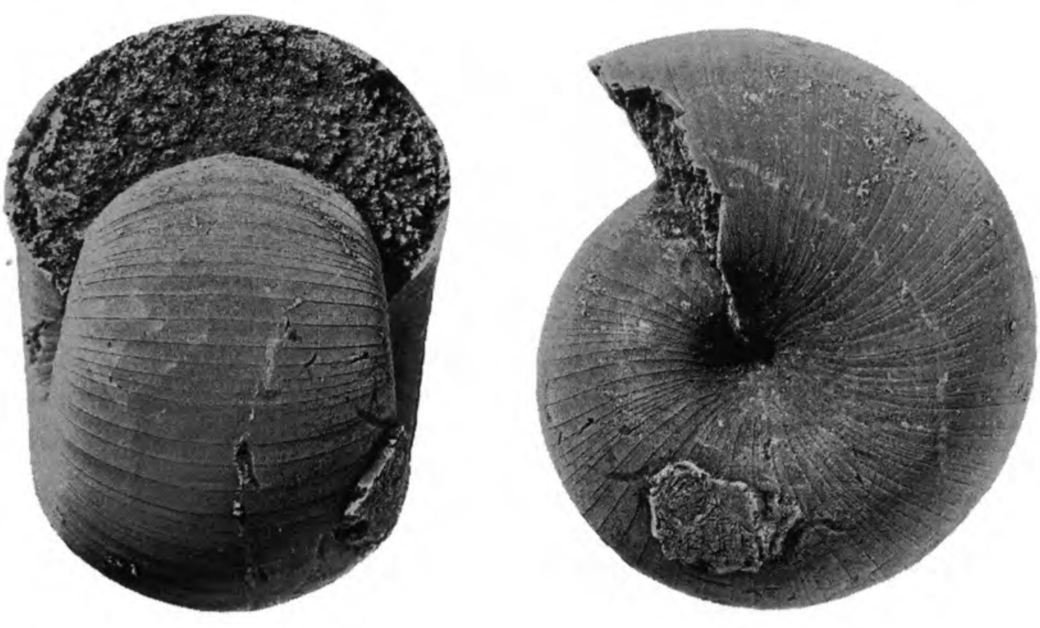
NEWSLETTER ON CARBONIFEROUS STRATIGRAPHY

Volume 19 July 2001



山

SCCS

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

Table of Contents

Newsletter on Carboniferous Stratigraphy

Edited by D.M. Work

IUGS SUBCOMMISION ON CARBONIFEROUS STRATIGRAPHY / VOL. 19 - 2001

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 Sevastopulo was elected Chair of the SCCS. Unfortunately, Dr. Sevastopulo 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 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 progress on defining 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 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 SCCS. Reports of the Working and Project groups show that progress is being made on the selection of a boundary close to the classic Tournaisian-Viséan boundary [see Working Group report by Sevastopulo in this Newsletter], and we look forward to presentations on this matter at the SCCS 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-Permian 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-Permian 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-Permian 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 chemostratigraphy, particularly with carbon, 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] delta^{13}C 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 Moscow 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 finer components of limestones. Ongoing work in the stable-isotope lab here at Iowa on the patterns within individual cyclothems, 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

SECRETARY / 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: 3531-6711199
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 Kullmann (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)

INCOME (Oct. 1999 - Sept. 2000)	**$AUS**	**$US**
	Definitive	Estimated
IUGS Grant 2000	1,702.07	1,000.00
Donations from Members	861.81	499.85
Bank Interest	2.26	1.31
TOTAL INCOME	**2,566.14**	**1,501.16**
EXPENDITURE		
Newsletter 18 (publication/postage)	1,229.00	712.82
Secretarial Assistance (Newsletter 18)	200.00	116.00
Bureau postage	90.50	52.49
Honorarium	150.00	87.00
Stationary	174.15	101.00
Bank Charges	1.80	1.05
TOTAL EXPENDITURE	**1,845.45**	**1,070.36**

BALANCE SHEET (1999-2000)	**$AUS**	**$US**
	Definitive	Estimated
Funds carried forward from 1998-99	801.02	464.59
PLUS Income 1999-2000	2,566.14	1,501.16
LESS Expenditure 1999-2000	-1,845.45	-1,070.36
CREDIT balance carried forward to 2000-2001	**1,521.71**	**882.59**
		[$895.39 * figured down]

*[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.

H. Kerp, W.H. Gillespie, C.A. Ross, J.R.P. Ross, A. Barnett, G.P. Wahlman, M. Zeller.

COVER ILLUSTRATION

Pennsylvanian ammonoid: *Pennoceras* new species, early Missourian, Mound City Shale Member, Hertha Limestone, Bourbon County, southeastern Kansas, USA, diameter 19 mm.
Photographs: D.M. Work.

CONTRIBUTIONS TO THE NEWSLETTER

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

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

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

*graphics suitable for black and white publication.

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

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

Please send contributions as follows,

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

[1]Department of Geology, Trinity College, Dublin 2, Ireland (gsvstpul@tcd.ie).

[2]Unité 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).

[3]Institute of Geology, C.A.G.S., 26 Baiwanzhuang road, Beijing 10037, China (hfhou@public.fhnet.cn.net).

[4]Guizhou 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 *Eoparastafella 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, Eostafella* and *Eoendothyranopsis* in the upper part and primitive archaediscids 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 praebeckmanni* transitional to *M. beckmanni* from the first beds. *Scaliognathus 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 *Eoparstaffella 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 *Scaliognathus anchoralis fairchildi, Doliognathus latus* and *Protognathodus 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.

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 palynomorphs).

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 grainstnes with mixed, very coarse clastics and sorted cross- to planar laminated ooidal grainstones. There is a progressive shallowing trend culminating in the uppermost Tournaisian 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 Tournaisian age with a fauna dominated by *Eblanaia michoti* and *Condrustella 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 conodonts samples.

The section also contains abundant corals, brachiopods and molluscs including large cyrtoconic 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 Sovet section has allowed the recognition for the first time in Belgium of *Eoparstafella 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 Tournaisian progressive shallowing. This part of the section can be correlated with the shallow water Avins Formation (oolite).

Summary:

Our recent investigations have shown that the evolution of *Eoparastaffella simplex* from morphotype 1 to morphotype 2 can be used as a tool to effect correlations between China and Ireland and that this level is close both to the base of the Viséan at its reference section in the Dinant Syncline and also to the first occurrence of the conodont *Gnathodus homopunctatus*. The Pengchong section at present is the best candidate for the GSSP. Detailed correlations with sections in western Europe should provide access to information about the distribution of fossil groups other than foraminifers and conodonts and also the opportunity to date the base of the Viséan radiometrically.

References:

Devuyst, F.X., Hance, L., Brenckle, P., Coen, M., Hou, H.F., Tian, S., Wang, Z., and Wu, X.H. 2000. The search for a new Tournaisian-Viséan boundary stratotype GSSP. Report of field work in Yunnan and Guang xi (South China), April 2000. Newsletter on Carboniferous Stratigraphy, 18, 11-12.

Hance, L. 1997. *Eoparastaffella*, its evolutionary pattern and biostratigraphical potential. *In*: Ross, C.A., Ross, J.P., and Brenckle, P.L. (eds.) Late Paleozoic foraminifera; their biostratigraphy, evolution, and paleoecology; and the Mid-Carboniferous Boundary. Cushman Foundation for Foraminiferal Research, Special Publication 36, 59-62.

Hance, L., Brenkle, P., Coen, M., Hou, H.F., Liao, Z.T., Muchez, P., Paproth, E., Peryt, T., Riley, N.J., Roberts, J., and Wu, X.H. 1997. The search for a new Tournaisian-Viséan boundary stratotype. Episodes, 20/3, 176-180.

Sevastopulo, G.D., and Hance, L. 2000. Report of the Working Group to establish a boundary close to the existing Tournaisian-Viséan boundary within the Lower Carboniferous. Newsletter on Carboniferous Stratigraphy, 18, 6.

Working Group to define a GSSP close to the Moscovian / Kasimovian boundary

Elisa Villa and Working Group

Depto de Geología, Universidad de Oviedo, Arias de Velasco s/n 33005 Oviedo, Spain.

1. General Report

The SCCS working group formally named as *'Working Group to define a GSSP close to the Moscovian/Kasimovian boundary'* is now involved additionally with studies related to other potential levels of correlation within the upper part of the Carboniferous System (Pennsylvanian Subsystem).

Our studies are focused on successions situated within the Carboniferous Paleoequatorial belt and adjacent regions. The Gondwana and Angara areas are not currently in the scope of the WG research because we consider that the difficulties involved with correlation within the Pennsylvanian Subsystem make it necessary to proceed through successive steps. The first step is to make correlations among paleotropical areas such as the Donets Basin (Ukraine), Moscow Basin (Russia), and Midcontinent region of North America, which have served for establishing the classical Carboniferous stratigraphic scales.

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 those 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 Myachkovian 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 Myachkovian Peski Formation and overlying lower Kasimovian Suvorovo Formation, Domodedovo section) and in the Cantabrian Mountains (upper part of the Picos de Europa Formation, Las Llacerias 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 age 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 Myachkovian 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 (Voskresenk Formation, middle Krevyakinian, 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 Dalniy Tyulkas section collected by Russian colleagues and studied by the Working Group at the 2000 meeting in Oviedo, Spain.

3) The first appearance of *Montiparus* species. Species belonging to the genus *Montiparus* are considered in Eurasia to first occur in the upper part of the lower Kasimovian, at the base of the Khamovnikian 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 *Montiparus* species (belonging to the *Montiparus umbonoplicatus* species group) could be stratigraphically significant for correlating upper Khamovnikian strata. Forms of this group with similar appearance have been recognized in the uppermost part of the Las Llacerias 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/Virgilian boundary. Therefore, this species could represent a good stratigraphic marker, correlating the Kasimovian/Gzhelian and Missourian/Virgilian boundaries.

6) The first appearance of more advanced *Idiognathodus simulator* *(sensu stricto)*. This is in the lower Virgilian 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 need 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 Demués 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; Rodríguez, 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 Kalinovo 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 Tyulkas section yielded the new conodont data mentioned above, which could provide important new clues for intercontinental correlation.

References

Davydov, V.I. 1999. Still contradictions: Moscovian-Kasimovian boundary problems: Newsletter on Carboniferous Stratigraphy, vol. 17, p. 18-22.

Ginkel, A.C. van, and Villa, E. 1999. Late fusulinellid and early schwagerinid foraminifera: relationships and occurrences in the Las Llacerias section (Moscovian/Kasimovian), Cantabrian Mountains, Spain: Journal of Foraminiferal Research, vol. 29, p. 263-290.

Heckel, P.H. 1999. Overview of Pennsylvanian (Upper Carboniferous) stratigraphy in Midcontinent region of North America, *In:* Guidebook for Field trip # 8 of XIV-ICCP: Kansas Geological Survey Open-File Report 99-27, p. 68-102.

Heckel, P.H., Alekseev, A.S., and Nemirovskaya, T.I. 1998. Preliminary conodont correlation of late Middle to early Upper Pennsylvanian rocks between North America and Eastern Europe: Newsletter on Carboniferous Stratigraphy, vol. 16, p. 8-12.

Kozitskaya, R.I., Kossenko, Z.A., Lipnyagov, O.M., and Nemirovskaya, T.I. 1978. Carboniferous conodonts of the Donets Basin: "Naukova Dumka", Kiev, 136 p. (in Russian)

Ritter, S.M., Barrick, J.E., Wahlmann, G.P., and Skinner, M.R. 1999. Stratal and faunal relationships across the Desmoinesian-Missourian boundary at Honaker Trail, Paradox Basin, Utah: a sequence biostratigraphic approach: *In:* Guidebook for Field Trip #8 of XIV-ICCP: Kansas Geological Survey Open-File Report 99-27, p. 199-207.

Rodríguez, R.M. 1999. Lower Stephanian miospores from the Cantabrian Mountains, NW Spain: Presentations of the XIV International Congress on the Carboniferous-Permian, Calgary, Programme with Abstracts p. 124.

Sanchez de Posada, L.C., Villa, E., Rodríguez, R.M., Martínez Chacón, M.L., Rodríguez, S., and Coquel, R. 1999. Demués section, Cantabrian Mountains, Spain: Data for a correlation of the upper part of the Carboniferous stratigraphic scales: Presentations of the XIV International Congress on the Carboniferous-Permian, Calgary, Programme with Abstracts p. 127.

Ueno, K., and Villa, E. 1998. Fusulinids from the Donets Basin. Preliminary stratigraphic correlations: Newsletter on Carboniferous Stratigraphy, vol. 16, p. 6-7.

Ueno, K. 1999. Moscovian and Kasimovian fusulinacean faunal succession of the Donets Basin, Ukraine: Presentations of the XIV International Congress on the Carboniferous-Permian, Calgary, Programme with Abstracts p. 146.

Villa, E., Alekseev, A.S., Barskov, I.S., Coquel., R., Davydov, V.I., Ginkel, A.C. van, Goreva, N.V., Isakova, T.N., Kabanov, P.B., Kononova, L.I., Lazarev, S.S., Lebedev, O.A., Makhlina, M.Kh., Mamet, B., Martínez-Chacón, M.L., Méndez, C., Rodríguez, R.M., Rodríguez, S. Sánchez de Posada, L.C., and Shkolin, A.V. 1997. Palaeontological analysis and comparison of the Moscovian/Kasimovian boundary beds in the Moscow Basin (Russia) and in the Cantabrian Mountains (Spain): Compte Rendue, XIII Congrès International de Stratigraphie et de Géologie du Carbonifère, Krakow, 1995, v. 1, p. 173-185.

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

Wilde, G.L. 1984. Systematics and the Carboniferous-Permian boundary: Compte Rendue, IX Congrès International de Stratigraphie et de Géologie du Carbonifère, Champaign-Urbana, 1979, v. 2, p. 543-558.

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 Syneclise 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 dolomitizied, 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. Chernykh. The lower part of the Tashly Fm yielded a typical Podolskian assemblage (*Gondolella levis, Idiognathodus podolskensis, I obliquus*), whereas its upper part yielded *Neognathodus inaequalis* and ribbed gondollelids, 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 *Neognathodus*, 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 Suvorovo Fm (basal Kasimovian strata). The last forms are probably ancestral to "*Streptognathodus excelsus*", which is typical of the upper Krevyakinian 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 gondollelids 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 Krasnousolsk (Bashkiria, South Urals). Krasnousolsk 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 Usolka 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. Pazukhin, 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 Viséan 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, *Bilinguites superbilinguis* (Bisat), *Stenoglaphyrites* sp. nov., *Schartymites 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 Tournaisian, 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-ICCP, 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 Tournaisian to the 5 from the British Visean]. 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 Tournaisian, 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. Tournaisian 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 Virgilian in the Pennsylvanian. Because this region was more marine, there was more biostratigraphic definition for these series, particularly with fusulines 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 Virgilian

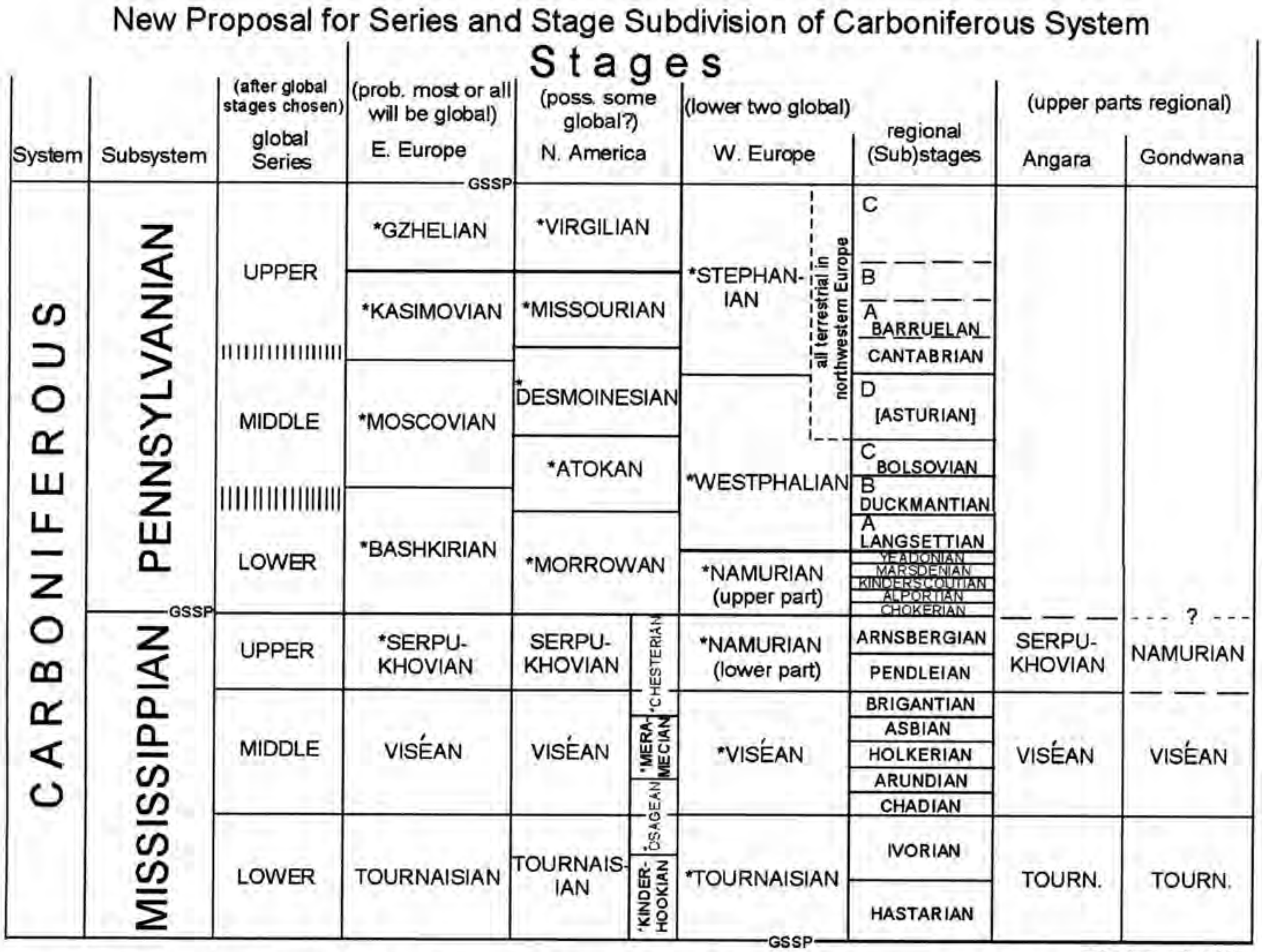


Figure 1. – Graphic chart summarizing new proposal for series and stage subdivision of Carboniferous System. Asterisks [*] show region from which geographic names are derived. Vertical lines between Pennsylvanian series names reflect uncertainty on choice of global stage names. Horizontal dashed lines 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 endemism 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 (Groves 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 Pennsylvanian 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 Tournaisian 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 subdivisions above the upper part of the Mississippian for the present time. Correlation with the Pennsylvanian pantropical realm may ultimately be achieved only when radiometric and stable-isotope chemostratigraphic methods become more refined and accurate.

Stage subdivision of the Carboniferous System

A.S. Alekseev

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

The Carboniferous System has no globally accepted stage subdivision. After ratification of splitting the system into two subsystems (Mississippian and Pennsylvanian), it is necessary to accelerate its formal subdivision into series and stages. Recently, Heckel and Villa (1999) proposed an important compromise model for constructing the Carboniferous scale, in which series would be global and stages would be regional and retain their regional names.

In my opinion, the primary objective must be subdivision of the Carboniferous into global stages, as series are only groupings of stages. To accelerate the process of stage acceptance, we should adhere to the following principles:

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 then 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 Kagarmanov (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 (Tournaisian, 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 substages (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 Ruzhencev (1978) and Ruzhencev and Bogoslovskaya (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

<table>
<tr><th colspan="2">Russia Kagarmanov 1997</th><th colspan="3">Global Bouroz et al. 1978</th><th colspan="3">Global Ruzencev, Bogoslovskaya 1978</th><th colspan="2">USA Midcontinent Dunbar 1960</th><th colspan="2">Western Europe</th><th colspan="3">Global Alekseev 2000</th></tr>
<tr><th>Series</th><th>Stage</th><th>Subsystem</th><th>Series</th><th>Stage</th><th>Subsystem</th><th>Series</th><th>Stage</th><th>System</th><th>Series</th><th>Subsystem</th><th>Series</th><th>Subsystem</th><th>Series</th><th>Stage</th></tr>
<tr><td rowspan="4">Upper</td><td rowspan="2">Gzhelian</td><td rowspan="8">Pennsylvanian</td><td rowspan="4">Stephanian</td><td rowspan="2">Gzhelian</td><td rowspan="7">Upper (or Pennsylvanian)</td><td rowspan="4">Gzhelian</td><td>Orenburgian</td><td rowspan="8">Pennsylvanian</td><td rowspan="2">Virgilian</td><td rowspan="9">Silesian</td><td rowspan="4">Stephanian</td><td rowspan="8">Pennsylvanian (or Upper)</td><td rowspan="4">Stephanian</td><td rowspan="2">Gzhelian</td></tr>
<tr><td rowspan="3">Zhigulian</td></tr>
<tr><td rowspan="2">Kasimovian</td><td rowspan="2">Kasimovian</td><td>Missourian</td><td rowspan="2">Kas imovian</td></tr>
<tr><td rowspan="2">Desmoinesian</td></tr>
<tr><td rowspan="4">Middle</td><td rowspan="2">Moscovian</td><td rowspan="4">Unnamed</td><td rowspan="2">Moscovian</td><td rowspan="3">Westphalian</td><td>Moscovian</td><td rowspan="3">Westphalian</td><td rowspan="4">Westphalian</td><td rowspan="2">Moscovian</td></tr>
<tr><td rowspan="2">Kayalian</td><td rowspan="2">Atokan</td></tr>
<tr><td rowspan="2">Bashkirian</td><td rowspan="2">Bashkirian</td><td rowspan="2">Bashkirian</td></tr>
<tr><td rowspan="8">Lower (or Mississippian)</td><td rowspan="3">Namurian</td><td>Andennian</td><td>Morrowan</td><td rowspan="2">Namurian</td></tr>
<tr><td rowspan="7">Lower</td><td>Serpukhovian</td><td rowspan="7">Mississippian</td><td rowspan="7">Mississippian</td><td>Serpukhovian</td><td rowspan="2">Dombarian</td><td rowspan="7">Mississippian</td><td rowspan="3">Chesterian</td><td rowspan="7">Mississippian (or Lower)</td><td rowspan="5">Visean</td><td>Serpukhovian</td></tr>
<tr><td rowspan="4">Visean</td><td rowspan="4">Visean</td><td rowspan="6">Dinantian</td><td rowspan="4">Visean</td><td rowspan="2">Warnantian</td></tr>
<tr><td rowspan="5">Dinantian</td><td rowspan="2">Visean</td></tr>
<tr><td rowspan="2">Meramecian</td><td>Livian</td></tr>
<tr><td>Saourian</td><td>Moliniacian</td></tr>
<tr><td rowspan="2">Tournaisian</td><td rowspan="2">Tournaisian</td><td>Tournaisian</td><td>Osagean</td><td rowspan="2">Tournaisian</td><td rowspan="2">Tournaisian</td><td>Ivorian</td></tr>
<tr><td>Gattendorfian</td><td>Kinderhookian</td><td>Hastarian</td></tr>
</table>

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 chronostratigraphic scale were supported by RFBR grants 97-05-65756 and 00-05-64288.

References:

Alekseev, A.S. 2000. Stage scale of Carboniferous System. In V.N. Puchkov (ed.). Zonalnye podrazdeleniya karbona obstshei stratigraficheskoy shkaly Rossii. Materialy Vserossiiskogo sovestshaniya, 29-31 Maya 2000. Ufa, p. 5-6 (In Russian).

Alekseev, A.S., Kononova, L.I., and Nikishin, A.M. 1996. Devonian and Carboniferous of Moscow Syneclise: stratigraphy and sea-level changes. Tectonophysics. V. 268. p. 149-168.

Cowie, J.W., and Bassett, M.G. 1989. Global; stratigraphic chart. International Union of Geological Sciences. Supplement to Episodes, V. 12 (2).

Dunbar, C.O. 1960. Historical geology. New York, 2nd ed. 500 pp.

Gradstein F.M., and Ogg, J. 1996. A Phanerozoic time scale. Episodes, V. 19 (1-2). p.3-5.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G. 1990. A geologic time scale 1989. Cambridge University Press, 263 pp.

Heckel, P.H., and Villa, E. 1999. Proposals toward a consensus on a scientifically reasonable and internationally acceptable classification and nomenclature for the Carboniferous System. Newsletter on Carboniferous Stratigraphy, V. 17, p. 8-11.

Kagarmanov, A.Kh. 1998a. On the rank of general (global) Phanerozoic scale and on the Carboniferous scale of Russia. *In:* A.S. Alekseev and N.V. Goreva (eds.). Granitsy yarusov i bioticheskie sobytiya srednego i pozdnego karbona. Vserossiiskoe sovestshanie, 7-13 avgusta 1998. Moskva. Tezisy dokladov. p.31-32.

Kagarmanov, A.Kh. 1998b. Problems of general Carboniferous scale. *In:* Postanovleniya Mezhvedomstvennogo Stratigraphicheskogo Komiteta i ego Postoyannykh Komissii. Sankt-Petersbourg. N. 30. p.21-28.

Menning, M., Belka, Z., Kullmann, J., Stoppel D., and Weyer D. 2000. On the number of Carboniferous series and stages. Newsletter on Carboniferous Stratigraphy. V. 18. p.8-10.

Odin, G.S. 1994. Geological time scale (1994). Compte Rendu Academie Scientifique du Paris. Serie II. T. 318, p.59-71.

Remane, J., Cita, M.B., and Dercourt J. et al. 2000. International stratigraphic chart. IUGS.

Ruzhencev, V.E. 1978. Written communication. *In:* A. Bouroz, O.L. Einor, M. Gordon, S.V. Meyen, and R.H. Wagner. Proposals for an international chronostratigraphic classification of the Carboniferous. Discussion. Huitieme Congres International de Stratigraphie et Geologie Carbonifère. Compte Rendu. V. 1. p.59-62.

Ruzhencev, V.E., and Bogoslovskaya, M.F. 1978. Namurian stage in evolution of ammonoids. Late Namurian ammonoids. Trudy Paleontologicheskogo Instituta. Tom 167. 338 pp. (In Russian).

Wang, X.-D. 1998. A regional chronostratigraphic chart for China and its biozones. Newsletter on Carboniferous Stratigraphy. V. 16. p. 21-23.

More radiometric ages for the Carboniferous time scale

Manfred Menning[1], Dieter Weyer[2], Günter Drozdzewski[3] and Immo Wendt[4]

[1]GeoForschungsZentrum Potsdam, Telegrafenberg C128, D-14473 Potsdam, Germany (menne@gfz-potsdam.de).

[2]Löwestrasse 15, D-10249 Berlin, Germany (dieter.weyer@t-online.de).

[3]Geologischer Dienst Nordrhein-Westfalen, De-Greiff-Str. 195, D-47803 Krefeld, Germany (drozdzewski@gd.nrw.de).

[4]Kronenweg 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 (Heiligenwald 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, Claoué-Long et al., 1995).

c) Pb-Pb zircon evaporation ages of 330 ±4 Ma (Hainichen Formation, Saxonia) and 352 ±8 Ma (Rußschiefer, Thuringian Slate Mountains, both Gehmlich 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 that of the Rußschiefer of 352 ±8 Ma. The former tuff belongs to the *Gnathodus texanus* Zone, which has an extremly long duration of about 8 Ma (Jones, 1995). The Rußschiefer is of Lower and Upper Tournaisian age (*Siphonodella crenulata* Zone up to *Scaliognathus 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.

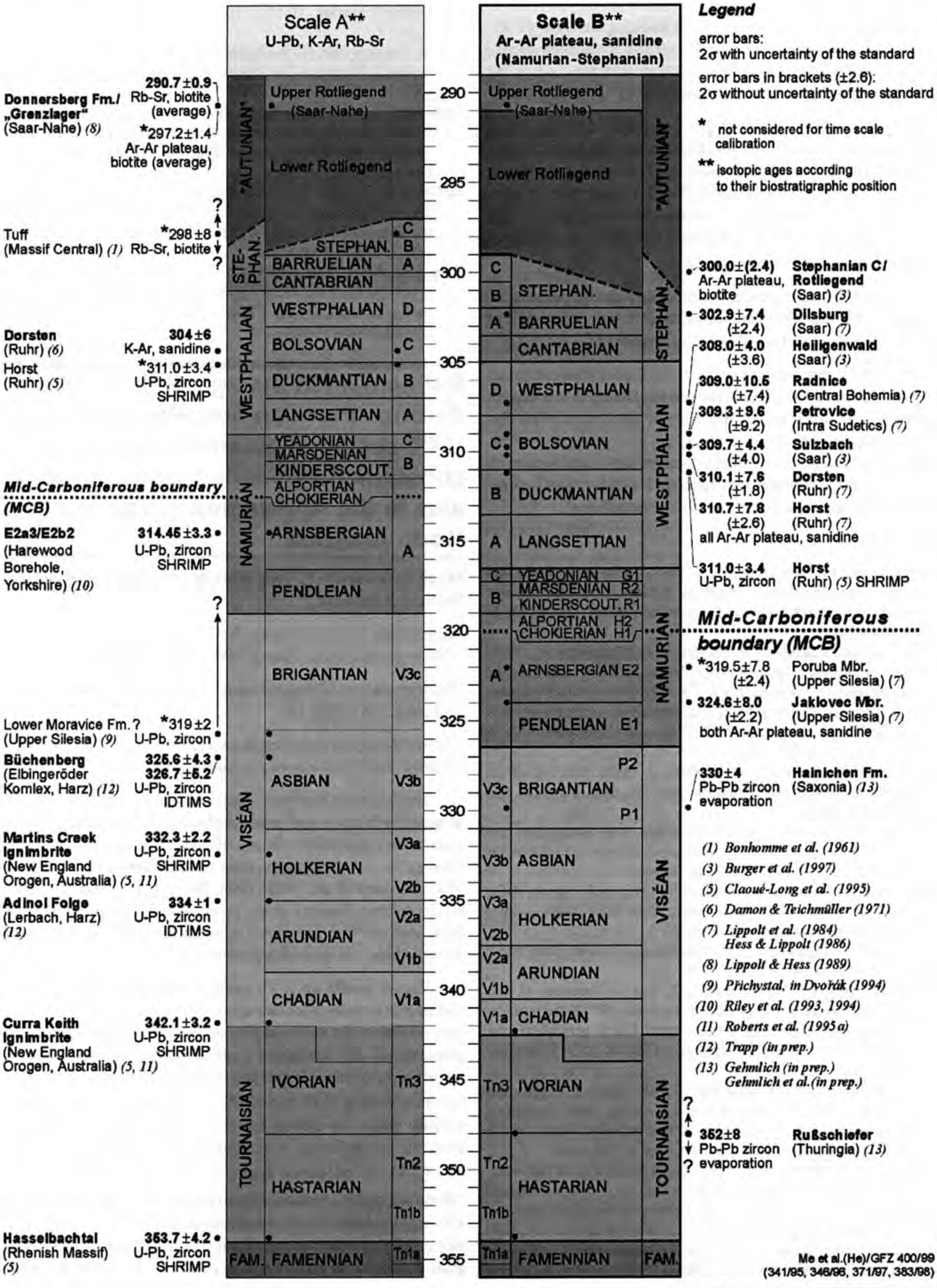
Reinvestigations of radiometric data near the Devonian-Carboniferous boundary have been started in order to verify the widely scattered ages of 354 Ma (Claoué-Long et al., 1993), 361 Ma (Yang et al., 1988), or 362 Ma (Tucker et al., 1998), and to check the consistency of radiometric ages derived from tuffs that are very close to each other. Zircons of now five tuffs from the Hasselbachtal 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 biostratigraphic dating by ammonoids and conodonts:

—*Pseudarietites westfalicus* Zone (Upper *Siphonodella duplicata* Zone)

—*Paprothites dorsoplanus* Zone (Lower *Siphonodella duplicata* Zone)

—*Acutimitoceras acutum* Zone (*Siphonodella sulcata* Zone)

—Lower *Parawocklumeria paradoxa* Zone (Lower/Middle


Scale A**
U-Pb, K-Ar, Rb-Sr
Scale B**
Ar-Ar plateau, sanidine
(Namurian-Stephanian)
Legend
error bars:
2σ with uncertainty of the standard
error bars in brackets (±2.6):
2σ without uncertainty of the standard
* not considered for time scale calibration
** isotopic ages according to their biostratigraphic position
Donnersberg Fm./ „Grenzlager" (Saar-Nahe) (8)
290.7±0.9 Rb-Sr, biotite (average)
*297.2±1.4 Ar-Ar plateau, biotite (average)
Tuff (Massif Central) (1)
*298±8 Rb-Sr, biotite
Dorsten (Ruhr) (6)
304±6 K-Ar, sanidine
Horst (Ruhr) (5)
*311.0±3.4 U-Pb, zircon SHRIMP
Mid-Carboniferous boundary (MCB)
E2a3/E2b2 (Harewood Borehole, Yorkshire) (10)
314.45±3.3 U-Pb, zircon SHRIMP
Lower Moravice Fm.? (Upper Silesia) (9)
*319±2 U-Pb, zircon
Büchenberg (Elbingeröder Komlex, Harz) (12)
325.6±4.3
326.7±5.2 U-Pb, zircon IDTIMS
Martins Creek Ignimbrite (New England Orogen, Australia) (5, 11)
332.3±2.2 U-Pb, zircon SHRIMP
Adinol Folge (Lerbach, Harz) (12)
334±1 U-Pb, zircon IDTIMS
Curra Keith Ignimbrite (New England Orogen, Australia) (5, 11)
342.1±3.2 U-Pb, zircon SHRIMP
Hasselbachtal (Rhenish Massif) (5)
353.7±4.2 U-Pb, zircon SHRIMP
"AUTUNIAN"
Upper Rotliegend
(Saar-Nahe)
Lower Rotliegend
STE-PHAN.
STEPHAN.
C
B
A
BARRUELIAN
CANTABRIAN
WESTPHALIAN
D
BOLSOVIAN
DUCKMANTIAN
LANGSETTIAN
NAMURIAN
YEADONIAN
MARSDENIAN
KINDERSCOUT.
ALPORTIAN
CHOKIERIAN
ARNSBERGIAN
PENDLEIAN
VISÉAN
BRIGANTIAN
V3c
ASBIAN
V3b
HOLKERIAN
V3a
V2b
ARUNDIAN
V2a
V1b
CHADIAN
V1a
TOURNAISIAN
IVORIAN
Tn3
HASTARIAN
Tn2
Tn1b
FAM.
FAMENNIAN
Tn1a
290
295
300
305
310
315
320
325
330
335
340
345
350
355
YEADONIAN G1
MARSDENIAN R2
KINDERSCOUT. R1
ALPORTIAN H2
CHOKIERIAN H1
ARNSBERGIAN E2
PENDLEIAN E1
P2
P1
300.0±(2.4) Ar-Ar plateau, biotite
Stephanian C/ Rotliegend (Saar) (3)
302.9±7.4 (±2.4)
Dilsburg (Saar) (7)
308.0±4.0 (±3.6)
Heiligenwald (Saar) (3)
309.0±10.5 (±7.4)
Radnice (Central Bohemia) (7)
309.3±9.6 (±9.2)
Petrovice (Intra Sudetics) (7)
309.7±4.4 (±4.0)
Sulzbach (Saar) (3)
310.1±7.6 (±1.8)
Dorsten (Ruhr) (7)
310.7±7.8 (±2.6)
Horst (Ruhr) (7)
all Ar-Ar plateau, sanidine
311.0±3.4 U-Pb, zircon
Horst (Ruhr) (5) SHRIMP
Mid-Carboniferous boundary (MCB)
*319.5±7.8 (±2.4)
Poruba Mbr. (Upper Silesia) (7)
324.6±8.0 (±2.2)
Jaklovec Mbr. (Upper Silesia) (7)
both Ar-Ar plateau, sanidine
330±4 Pb-Pb zircon evaporation
Hainichen Fm. (Saxonia) (13)
(1) Bonhomme et al. (1961)
(3) Burger et al. (1997)
(5) Claoué-Long et al. (1995)
(6) Damon & Teichmüller (1971)
(7) Lippolt et al. (1984) Hess & Lippolt (1986)
(8) Lippolt & Hess (1989)
(9) Přichystal, in Dvořák (1994)
(10) Riley et al. (1993, 1994)
(11) Roberts et al. (1995 a)
(12) Trapp (in prep.)
(13) Gehmlich (in prep.) Gehmlich et al. (in prep.)
352±8 Pb-Pb zircon evaporation
Rußschiefer (Thuringia) (13)
Me et al.(He)/GFZ 400/99
(341/95, 346/96, 371/97, 383/98)

Siphonodella praesulcata Zone)

An additional ash record for the intervening interval of the *Acutimitoceras 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 Prychistal from Upper Silesia (cited in Dvorak 1994 with a questionable stratigraphic allocation to the upper Asbian) as discussed some years ago by A. Prychistal (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:

Burger, K., Hess, J.C., and Lippolt, H.J. 1997. Tephrochronologie von Kaolin-Kohlentonsteinen: Mittel zur Korrelation paralischer und limnischer Ablagerungen des Oberkarbons.- Geol. Jb., A 147: 3-39; Hannover.

Claoué-Long, J.C., Compston, W., Roberts, J., and Fanning, C.M. 1995. Two Carboniferous ages: a comparison of SHRIMP zircon dating with conventional zircon ages and $^{40}Ar/^{39}Ar$ analysis.- *In:* Berggren, W.A., Kent, D.V., Aubry, M.P., and Hardenbol, J. (eds.): Geochronology, Time Scales and Global Stratigraphic Correlation.- SEPM Spec. Publ., 54: 1-27; Tulsa.

Claoué-Long, J.C., Jones, P.J., and Roberts, J. 1993. The age of the Devonian-Carboniferous boundary.- Ann. Soc. Géol. Belgique, 115, 2: 531-549; Liège.

Gehmlich, M. (in prep.): Die Cadomiden und Varisziden des saxothuringischen Terranes – Geochronologie magmatischer Ereignisse.- PhD thesis; Jena (Univ. Jena).

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G. 1990. A Geologic Time Scale 1989.- 1-263; Cambridge (Cambridge Univ. Press).

Jones, P.J. 1995. Timescales. 5. Carboniferous.- Austral. Geol. Surv. Org., Rec. 1995/34: 1-45; Canberra.

Menning, M., Weyer, D., Drozdzewski, G., and van Amerom, H.W.J. 1997. Carboniferous Time Scales Revised 1997. Time Scale A (min. ages) and Time Scale B (max. ages). Use of geological time indicators.- Newsl. Carbonif. Stratigr., 15: 26-28; IUGS Subcomm. Carboniferous Stratigraphy.

Menning, M., Weyer, D., Drozdzewski, G., van Amerom, H.W.J., and Wendt, J. 2000. A Carboniferous Time Scale 2000: discussion and use of geological parameters as time indicators from Central and Western Europe.- Geol. Jb. Hannover A 156: 3-44.

Prichystal, A. cited in Dvorák, J. 1994. On the correlation of radiometric and biostratigraphic data in the Namurian.- Newsl. Carbonif. Stratigr., 12: 10; IUGS Subcomm. Carboniferous Stratigraphy.

Riley, N.J., Claoué-Long, J., Higgins, A.C., Owens, B., Spears, A., Taylor, L., and Varker, W.J. 1993. Geochronometry and Geochemistry of the European Mid-Carboniferous Boundary Stratotype Proposal, Stonehead Beck, North Yorkshire, England.- Newsl. Carbonif. Stratigr., 11: 13; IUGS Subcomm. Carboniferous Stratigraphy.

Süss, P., Drozdzewski, G., and Schäfer, A. 2000. Sequenzstratigraphie des kohleführenden Oberkarbon im RuhrbeckenGeol. Jb., A 156: 45-106; Hannover.

Trapp, E. 2001. U-Pb-Geochronologie an unterkarbonischen Pyroklastiten des Harzes: Der Schlüssel zu einer verbesserten Zeitskala des Unterkarbons.- PhD thesis; Braunschweig (TU Braunschweig), 106 pp.

Tucker, R.D., Bradley, D.C., Ver Straeten, C.A., Harris, A.G., Ebert, J.R., and McCutcheon, S.R. 1998. New U-Pb zircon ages and the duration and division of Devonian time. -Earth Planet. Sci. Lett., 158: 175-186; Amsterdam.

Yang, J.-D., Wang, Y.-X., and Wang, Z.-Z. 1988. Rb-Sr dating of clay minerals.- *In:* Yu, C.-M. (ed.), Devonian-Carboniferous Boundary in Nanbiancun, Guilin, China - Aspects and Records.- 59-67; Beijing (Science Press).

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

Mona L. Becker[1,2], E. Troy Rasbury[1,3], Gilbert N. Hanson[1], William J. Meyers[1]

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

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

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

[3] E-mail: troy@pbisotopes.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

Ames Limestone (co-occurrence of *Idiognathodus simulator* and *Streptognathodus pawhuskaensis)*, the Carboniferous – Permian boundary is younger than 294 $\pm$ 6 Ma (2σ), but the 275 $\pm$ 6 Ma (2σ) age for what has been considered the Pennsylvanian-Permian boundary with no biostratigraphic control is dramatically younger than is reasonable for this boundary (which is the same as the Carboniferous-Permian 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:

AGE	Reference
290 ±20 Ma (2σ)	Harland et al., 1990
300 ± 7 Ma (2σ)	Hess and Lippolt, 1986
295 ± 5 Ma	Ross et al., 1995
301 ± 2 Ma (2σ)	Rasbury et al., 1998
292 Ma	Menning et al., 2000

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 (Chuvashov et al., 1996) and various biostratigraphic schemes. However, the age of 275 $\pm$ 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 Rasbury et al. (1998) of 301 $\pm$ 2 Ma (2σ) from marine sections in southwest Texas[1] and southern New Mexico[2]. 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 fusulinids in the Sacramento Mountains of New Mexico (Rasbury et al., in review). These cements give an age of 304 $\pm$ 2 Ma, indistinguishable from the 301 $\pm$ 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 Missourian age on the curve of Denison et al. (1994). A Missourian age is further supported by unpublished conodont results from the underlying Holder Formation that suggest at least part of the Holder Formation is Missourian (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 carbonate 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 Unocal-JNOC core 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:

Becker, M.L., Rasbury E.T., Meyers, W.M, and Hanson, G.N., U-Pb calcite age of the Late Permian Castile Formation, Delaware Basin: Potential for correlation of Late Permian events, in review, Earth and Planetary Science Letters.

Becker, M.L., Rasbury ET., Hanson, G.N., Gierlowski-Kordesch, E., and Nadon, G. U-Pb ages of lacustrine calcite from the northern Appalachian Basin: evidence for correlation problems in the Upper Paleozoic, in preparation.

Chuvashov, B.I., Foster, C.B., Mizens, G.A., Roberts, J., and Claoue-Long, J.C. 1996. Radiometric (SHRIMP) dates for some biostratigraphic horizons and event levels from the Russian and Eastern Australian Upper Carboniferous and Permian: Permophiles, v. 28, p. 29-36.

Denison, R.E., Koepnick, R.B., Burke, W.H., Hetherington E.A., and Fletcher, A. 1994. Construction of the Mississippian, Pennsylvanian and Permian seawater $^{87}Sr/^{86}Sr$ curve: Chemical Geology, v. 112, 145-167.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G. 1990. A Geological Time Scale: 1989:Cambridge, Cambridge University Press, 263 p.

Hess, J.C., and Lippolt, H.J. 1986. $^{40}Ar/^{39}Ar$ ages of tonstein and tuff sanidines - new calibration points for the improvement of the Upper Carboniferous time scale:
Chemical Geology, v. 59, p. 143-154.

Hoff, J.A., Jameson, J., and Hanson, G.N. 1995. Application of Pb isotopes to the absolute timing of regional exposure events in carbonate rocks, An example from U-rich dolostones from the Wahoo Formation (Pennsylvanian), prudhoe Bay, Alaska: Journal of Sedimentary Petrology, v. A65, p. 225-233.

Menning, M., Weyer, D., Drozdzewski, G., Amerom, H.W.J.V., and Wendt, I. 2000. A Carboniferous Time Scale 2000: Discussion and use of geologic parameters as Time Indicators from Central and Western Europe: Geologische Jahrbuch, Reihe A, v. Heft 156, p. 3-44.

Rasbury, E.T., Hanson, G.N., Meyers, W.J., and Saller, A.H. 1997. Dating of the time of sedimentation using U-Pb ages for paleosol calcite: Geochimica Et Cosmochimica Acta, v. 61, no. 7, p. 1525-1529.

Rasbury, E.T., Hanson, G.N., Meyers, W.J., Holt, W.E., Goldstein, R.H., and Saller, A.H. 1998. U-Pb dates of paleosols: Constraints on late Paleozoic cycle durations and boundary ages: Geology, v. 26, no. 5, p. 403-406.

Rasbury, E.T., Ward, W.B., and Hemming, N.G., A U-Pb age of relict marine cements from the early Permian Laborcita Formation, Sacramento Mountains, New Mexico: in review, Earth and Planetary Science Letters.

Ross, C.A., Baud, A., and Menning, M. 1995. A time scale for project Pangea: Canadian Society of Petroleum Geologists Memoir 17, p. 81-83.

Wang, Z.S., Rasbury, E.T., Hanson, G.N., and Meyers, W.J. 1998. Using the U-Pb system of calcretes to date the time of sedimentation of elastic sedimentary rocks: Geochimica et Cosmochimica Acta, v. 62, no. 16, p. 2823-2835.

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 Viséan 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

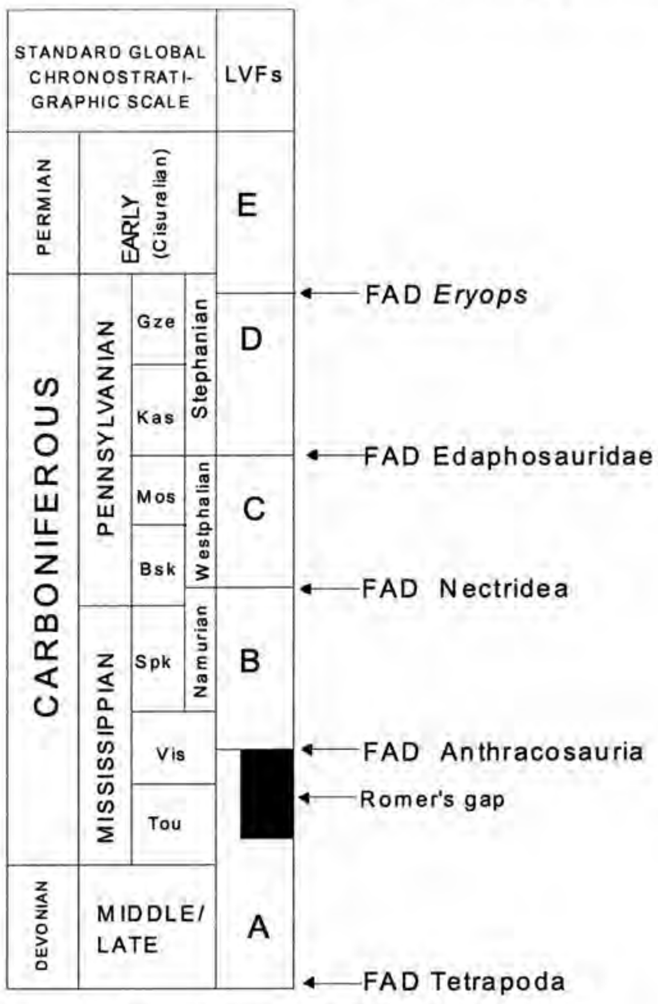


Figure 1. Informal tetrapod biochronology of the Carboniferous.

"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 of 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 tetrapod fossils 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 Anthracosauria 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 aïstopod *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 chronofauna consisting of about 30 tetrapod families. Characteristic elements of this chronofauna are loxommatoids, colosteids, aïstopods, nectrideans, anthracosaurs, temnospondyls, microsaurs 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 *Megalocephalus*, a colosteoid, nectrideans, anthracosaurs, several temnospondyls, microsaurs 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 Eryopidae, Cochleosauridae, Dissorophidae, Discosauriscidae?, Trimerorhachidae, Diadectidae, Petrolacosauridae, Varanopseidae, Sphenacodontidae and others (Benton, 1993; Milner, 1993a; Berman et al., 1997). The edaphosaur *Ianthasaurus*, 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 aïstopod, microsaurs, the diadectomorphs *Desmatodon* and *Limnoscelis*, a protorothyridid and ophiacodontid, sphenacodontid, haptodontid and edaphosaurid pelycosaurs, including *Ianthasaurus* (Vaughn, 1969, 1972; Berman and Sumida, 1990; Sumida and Berman, 1993).

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 faunachrons are global chronofaunas. 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

Ahlberg, P.E., and Milner, A.R. 1994. The origin and early diversification of tetrapods. Nature 368:507-514.

Benton, M.J. 1993. Reptilia; pp. 681-715 *In:* M.J. Benton (ed.), The Fossil Record 2. Chapman and Hall, London.

Berman, D.S., and Sumida, S.S. 1990. A new species of *Limnoscelis* (Amphibia, Diadectomorpha) from the Late Pennsylvanian Sangre de Cristo Formation of central Colorado. Annals of Carnegie Museum 59:303-341.

Berman, D.S., Sumida, S.S., and Lombard, R.E. 1997. Biogeography of primitive amniotes; pp. 85-139 *In:* S.S. Sumida and K.L.M. Martin (eds.), Amniote Origins. Academic Press, San Diego.

Bolt, J.R., McKay, R.M., Witzke, B.J., and McAdams, M.P. 1988. A new Lower Carboniferous tetrapod locality in Iowa. Nature 333:768-770.

Carroll, R.L. 1979. Problems in the use of terrestrial vertebrates for zoning of the Carboniferous; pp. 135-147 *In:* P.K. Sutherland and W.L. Manger (eds.), Neuvième Congrès International de Stratigraphie et de Géologie du Carbonifère. Southern Illinois University Press, Carbondale and Edwardsville.

Carroll, R.L., Belt, E.S., Dineley, D.L., Baird, D., and McGregor, D.C. 1972. Vertebrate paleontology of eastern Canada. XXIV International Geological Congress, Montreal, Quebec, Excursion A59:1-113.

Clack, J.A. 1997. Devonian tetrapod trackways and trackmakers: A review of the fossils and footprints. Palaeogeography, Palaeoclimatology, Palaeoecology 130:227-250.

Clarkson, E.N.K., Milner, A.R., and Coates, M.I. 1994. Palaeoecology of the Viséan of East Kirkton, West Lothian, Scotland. Transactions Royal Society of Edinburgh: Earth Sciences 84:417-425.

Coates, M.I., and Clack, J.A. 1995. Romer's gap: Tetrapod origins and terrestriality. Bulletin Museum National d'Histoire Naturelle 17:373-388.

Godfrey, S.J. 1988. Isolated tetrapod remains from the Carboniferous of West Virginia. Kirtlandia 43:27-36.

Harland, W.B., Armstrong, R.L., Cox, A.V., Craig, L.E., Smith, A.G., and Smith, D.G. 1990. A Geologic Time Scale 1989. Cambridge University Press, Cambridge, 263 pp.

Hook, R.W., and Baird, D. 1986. The Diamond Coal Mine of Linton, Ohio, and its Pennsylvanian-age vertebrates. Journal of Vertebrate Paleontology 6:174-190.

Jarvik, E. 1996. The Devonian tetrapod *Ichthyostega*. Fossils and Strata 40:1-213.

Lesquereux, L. 1879-1884. Description of the coal flora of the Pennsylvanian and of the Carboniferous formation in Pennsylvania and throughout the United States. Second Geological Survey of Pennsylvania 2:1-997.

Lucas, S.G. 1998. Global Triassic tetrapod biostratigraphy and biochronology. Palaeogeography, Palaeoclimatology, Palaeoecology 143:347-384.

Lucas, S.G. 2000. Global Carboniferous tetrapod biostratigraphy and biochronology. Geological Society of America Abstracts with Programs, v. 32, no. 7, p. A-497.

Marsh, O.C. 1891. Geological horizons as determined by vertebrate fossils. American Journal of Science 42:336-338.

Marsh, O.C. 1898. The comparative value of different kinds of fossils in determining geological age. American Journal of Science (4) 6:483-486.

Menning, M., Belka, Z., Kullmann, J., Stoppel, D., and Weyer, D. 2000. On the number of Carboniferous series and stages. Newsletter on Carboniferous Stratigraphy 18:8-9.

Milner, A.R. 1987. The Westphalian tetrapod fauna; some aspects of its geography and ecology. Journal of the Geological Society of London 144:495-506.

Milner, A.R. 1993a. Amphibian-grade Tetrapoda; pp. 665-679 *In:* M.J. Benton (ed.), The Fossil Record 2. Chapman and Hall, London.

Milner, A.R. 1993b. Biogeography of Palaeozoic tetrapods; pp. 324-353 *in* J.A. Long (ed.), Palaeozoic Vertebrate Biostratigraphy and Biogeography. Belhaven Press, London.

Milner, A.R. and Sequeira, S.E.K. 1994. The temnospondyl amphibians from the Viséan of East Kirkton, West Lothian, Scotland. Transactions of the Royal Society of Edinburgh: Earth Sciences 84:331-361.

Milner, A.R., Smithson, T.R., Milner, A.C., Coates, M.I., and Rolfe, W.D.I. 1986. The search for early tetrapods. Modern Geology 10:1-28.

Modesto, S.P., and Reisz, R.R. 1990. Taxonomic status of *Edaphosaurus raymondi* Case. Journal of Paleontology 64:1049-1051.

Panchen, A.L. 1973. Carboniferous tetrapods; pp. 117-125 *In:* A. Hallam (ed.), Atlas of Palaeobiogeography. Elsevier, Amsterdam.

Paton, R.L., Smithson, T.R., and Clack, J.A. 1999. An amniote-like skeleton from the Early Carboniferous of Scotland. Nature 398:508-513.

Rayner, D.H. 1971. Data on the environment and preservation of late Paleozoic tetrapods. Proceedings of the Yorkshire Geological Society 38:437-495.

Reisz, R.R., and Berman, D.S. 1986. *Ianthasaurus hardestii* n. sp., a primitive edaphosaur (Reptilia, Pelycosauria) from the Upper Pennsylvanian Rock Lake Shale near Garnett, Kansas. Canadian Journal of Earth Sciences 23:77-91.

Romer, A.S. 1966. Vertebrate paleontology. Third edition. University of Chicago Press, Chicago, 468 pp.

Rotai, A.P. 1979. Carboniferous stratigraphy of the USSR: Proposal for an international classification. Yorkshire Geological Society Occasional Publication 4:225-247.

Smithson, T.R. 1985. Scottish Carboniferous amphibian localities. Scottish Journal of Geology 21:123-142.

Sumida, S.S., and Berman, D.S. 1993. The pelycosaurian (Amniota: Synapsida) assemblage from the Late Pennsylvanian Sangre de Cristo Formation of central Colorado. Annals of Carnegie Museum 62:293-310.

Thulborn, T., Warren, A., Turner, S., and Hamley, T. 1996. Early Carboniferous tetrapods in Australia. Nature 381:777-780.

Vaughn, P.P. 1969. Upper Pennsylvanian vertebrates from the Sangre de Cristo Formation of central Colorado. Contributions in Science, Los Angeles County Museum of Natural History 164:1-28.

Vaughn, P.P. 1972. More vertebrates, including a new microsaur, from the Upper Pennsylvanian of central Colorado. Contributions in Science, Los Angeles County Museum of Natural History 223:1-30.

Ward, L.F. 1892. Principles and methods of geologic correlation by means of fossil plants. American Geologist 9:34-37.

Wellstead, C.F. 1982. A Lower Carboniferous aïstopod amphibian from Scotland. Palaeontology 25:193-208.

Wood, S.P., Panchen, A.L., and Smithson, T.R. 1985. A terrestrial fauna from the Scottish Lower Carboniferous. Nature 314:355-356.

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@mailer.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, Tournaisian, Viséan, Namurian, Westfalian and Stefanian, are regarded as **regional stages.**

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

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

Within the series of monographs on the stratigraphy of Germany (three of which already published in Courier Forschungsinstitut 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 Rheinisches 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 Subcommission on Carboniferous Stratigraphy.

References:

Menning, M., Belka, Z., Kullmann, J., Stoppel, D. and Weyer, D. 2000. On the number of Carboniferous series and stages. Newsletter on Carboniferous Stratigraphy, 18: 8-9.

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

Charles A. Sandberg[1], Charles E. Mason[2], and David M. Work[3]

[1]United States Geological Survey, Box 25046, Federal Center, MS 940, Denver, CO 80225, USA.

[2]Department of Physical Sciences, Morehead State University, Morehead, KY 40351, USA.

[3]Cincinnati 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 dolomicrite that is equivalent to the Rockford Limestone. The Rockford interval is dated as being close to the boundary between the youngest Kinderhookian *isosticha*-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.

Tournaisian-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 posses biostratigraphic value as *Ninella* (especially the group *Ninella donica*) occurs earlier in the uppermost Tournaisian. Subgenus *Skippella* and *Eoendothyranopsis* have been found only in the Viséan (Mamet's Zone 10 and higher), mostly in the North American and Siberian Realm.

Eoparastaffella and *Eoendothyranopsis* were studied in two profiles of the Tournaisian-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 Tournaisian age (*Scaliognathus anchoralis* Zone). The shales contain locally abundant trilobites. In the lower part biodetrital, often sandy limestones predominate, the representation of shales and biomocritic 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 (Solenoporaceae), moravamminids, 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* Brazhnikova et Rostovtseva, 1964, *Eoendothyranopsis (Ninella) lebedevae* Solovieva, 1967, *Eoendothyranopsis (Ninella) moravica* n.sp., *Eoendothyranopsis (Ninella) aksarsaica* Michno, 1975, and *Eoendothyranopsis (Ninella) transita* Lipina, 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, Tournaisian and Viséan limestones is exposed. The contact between Middle and Upper Tournaisian limestones is tectonic. The Upper Tournaisian and Lower Viséan sequence is composed of an alternation of biodetrital and biomicritic limestones and thin shale intercalations. The representation of biomicritic limestones increases to the top. A gradation with biodetrital limestone at the base and biomicritic 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 facial change can be distinguished at the Tournaisian-Viséan boundary. Matrix of grainstones is composed of microsparite and pseudosparite, however, originally it was composed of micrite. Syntaxial 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 (Solenoporaceae), moravamminids, brachiopods, trilobites, rugose corals, bryozoans, rugose corals, blue-green algae, bivalves, intraclasts and conodonts are present as well. Among conodonts gnathodids predominate (gnathodid biofacies). In the uppermost Tournaisian part of the profile *Eoendothyranopsis* is frequent while *Eoparastaffella* predominates in the Viséan. Among eoendothyranopsids the species *Eoendothyranopsis (Ninella) moravica* n. sp. is most abundant; *Eoendothyranopsis (Ninella) donica* Brazhnikova et Rostovtseva, 1964, *Eoendothyranopsis (Ninella) lebedevae* Solovieva, 1967, *Eoendothyranopsis (Ninella) aksarsaica* 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 iljtchiensis* 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 *Mestognathus 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 gnathodids, *Scaliognathus*, 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 Tournaisian-Viséan boundary. However, the tectonic disruption precludes proposing the profiles as potential candidates for a Tournaisian-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 E*oendothyranopsis*.

References

Kalvoda J. 1994. Comments on possible levels for Lower Carboniferous subdivision and results from Moravia. - Geobios, 27,5,: 615-619.

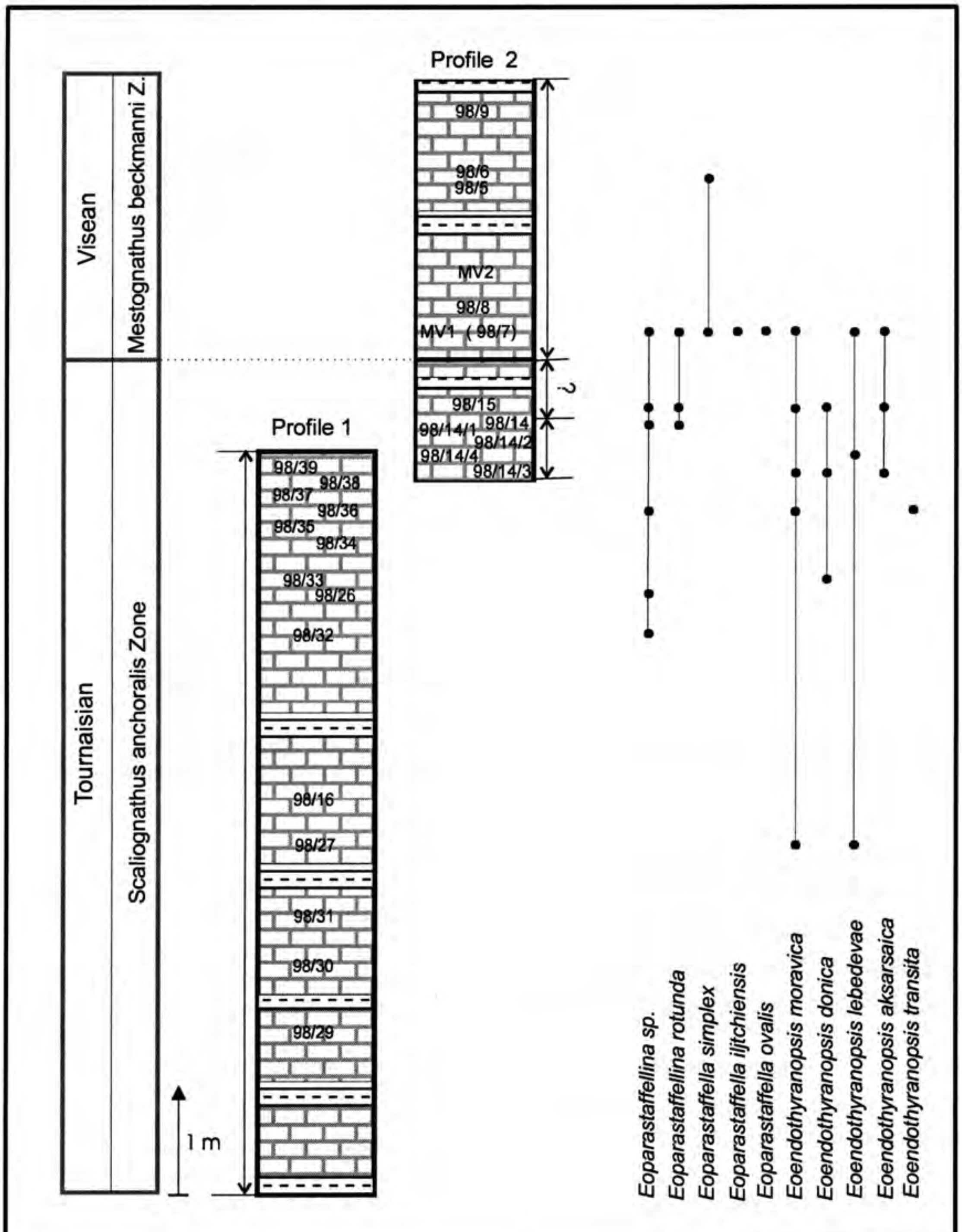


Fig. 1 Distribution of *Eoparastaffella* and *Eoendothyranopsis* in profile 1 and profile 2 in Mokra (Moravia, Czech Republic)

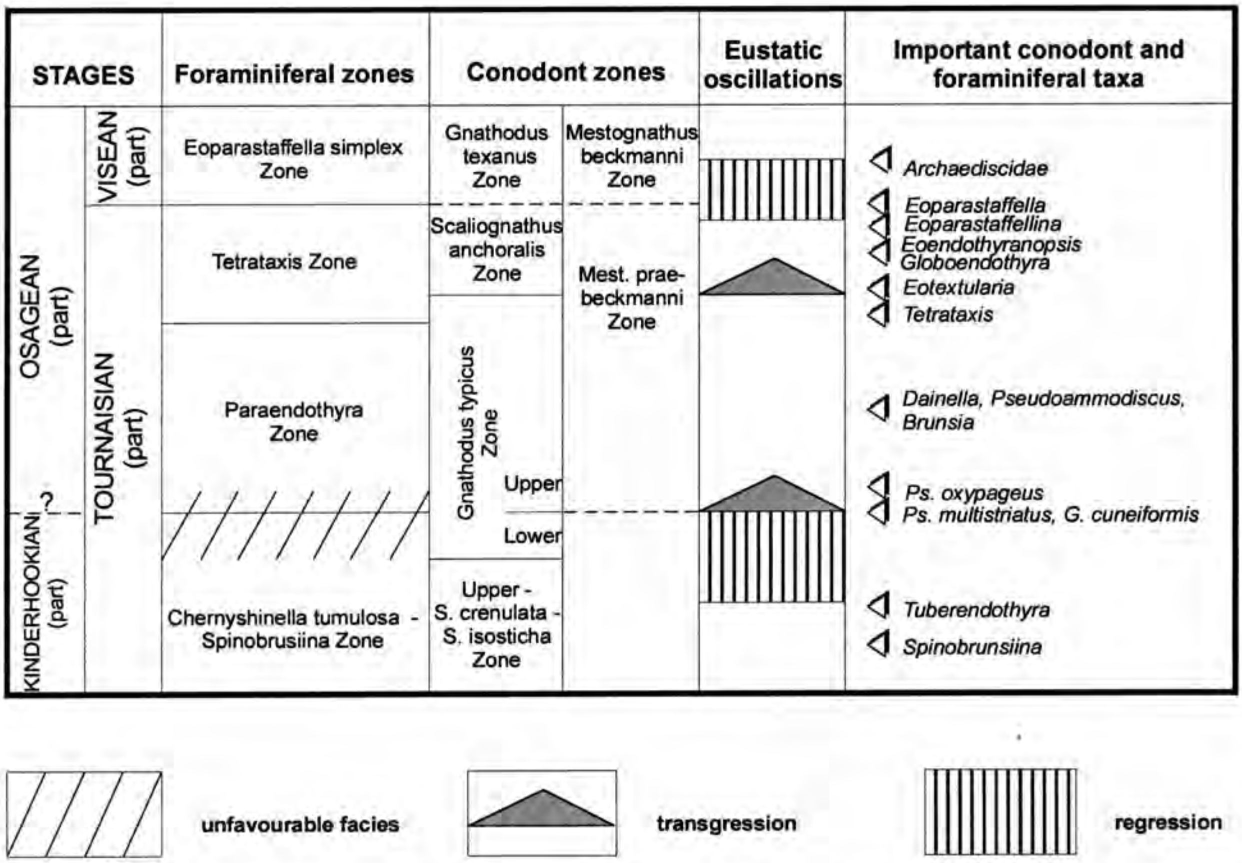


Fig. 2 Upper Tournaisian-Lower Visean foraminiferal zones in Moravia (Czech Republic) and correlation with conodont zonation and major eustatic oscillations. Modified according to Kalvoda (1994).

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 Zapadny 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 Zapadny 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.

Bed 1. Thin-, medium-laminated clastic limestones (calcarenites), oolitic limestones with interbeds of black thin-platy flints and dark-red–brown siliceous shales. The limestones contain conodonts: *Protognathodus praedelicatus* Lane, Sand. et Zieg., *Polygnathus inornatus* Br. et M., *Pseudopolygnathus* sp. (№ 26), *Neopolygnathus communis* (Br. et M.) (№ 28), *Scaliognathus anchoralis* Br. et M., *Gnathodus semiglaber*

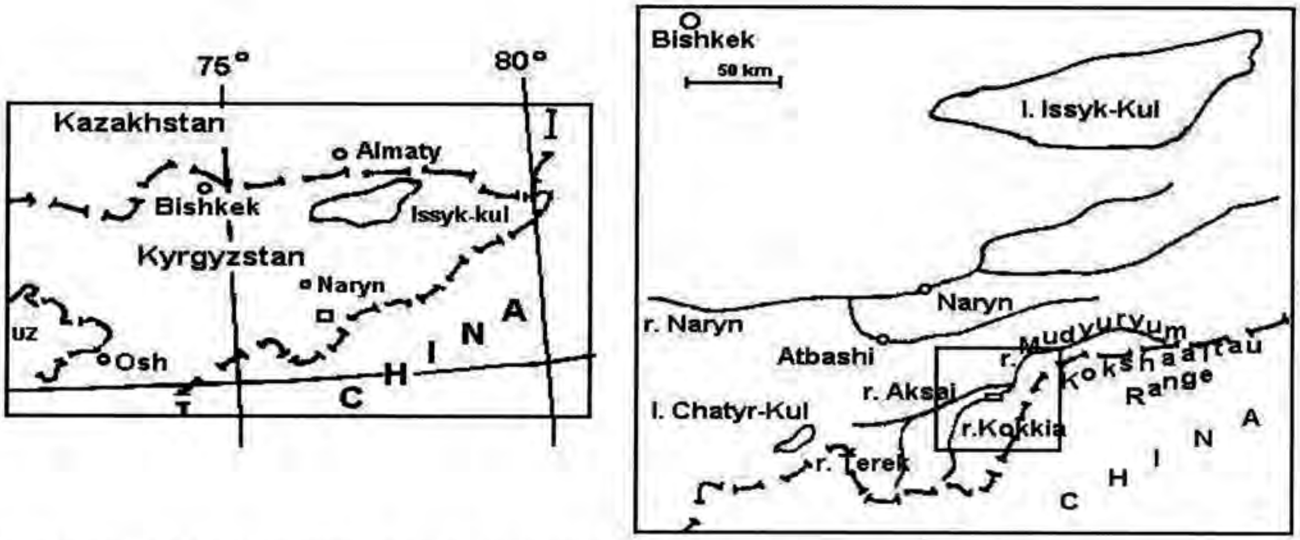


Fig. 1 Location of the Aksai section, the Kokshaaltau Range, South Tien-Shan

(Bish.), *G. typicus* Cooper (№ 34) and foraminifers: *Tournayella discoidea* Dain f. *maxima*, *Pseudoglomospira gordialis* (Jones et Parker) (№ 28, 29), *Pseudoplanoendothyra rotayi* (Dain), *Granuliferella granulosa* E. Zeller, *Endothyra kosvensis* (Lip), *E. tuberculata* Lip. (№ 31), *E. spinosa* N. Tchern. (№ 33), *E. tuberculata* Lip., *E. latispiralis* Lip. (№ 34).

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 clastic 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.) (№ 35), *Paraarchaediscus krestovnikovi* (Raus.) (№ 38) and the flints contain conodonts: *Gnathodus texanus* Roundy (№ 36).

Thickness is 54.0 m.

Bed 3. Massive large-oolitic limestones, fine-clastic limestones with rare lenses of grey flints. The limestones contain foraminifers: *Paraarchaediscus krestovnikovi* (Raus.) (№ 42).

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 Tournaisian-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 Tournaisian-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

1. Biske, Yu.S. 1996. Paleozoic structure and history of South Tien-Shan. St. Petersburg.

2. Biske, Yu.S., Guschin, S.B., and Chernyshuk, V.P. 1992. The Kokshaal passive margin of the Tarim continent in the Middle Paleozoic. Bulletin of St. Petersburg University, Geology and Geography, series 7, issue 4 (1 28).

3. Neevin, A.V., and Biske, Yu.S. 2000. Discovery of Lower Carboniferous conodonts in pelagic facies of a margin of Tarim (the Kokshaaltau Range, South Tien-Shan). Bulletin of St. Petersburg University, Geology and Geography. series 7, issue 2 (1 19).

4. Poyarkov, B.V. 1996. A position of the Devonian-Carboniferous boundary in Tien-Shan. Materials on Paleogeography and Tectonics of Tien-Shan.

5. Purkin, M.M., Poyarkov, B.V., and Rozhanetz, V.M. 1961. Stratigraphy and new foraminifera species of Tournaisian sediments in the Borkoldoi Range (Tien-Shan). ASKSSR Publishing House, volume III, issue 4.

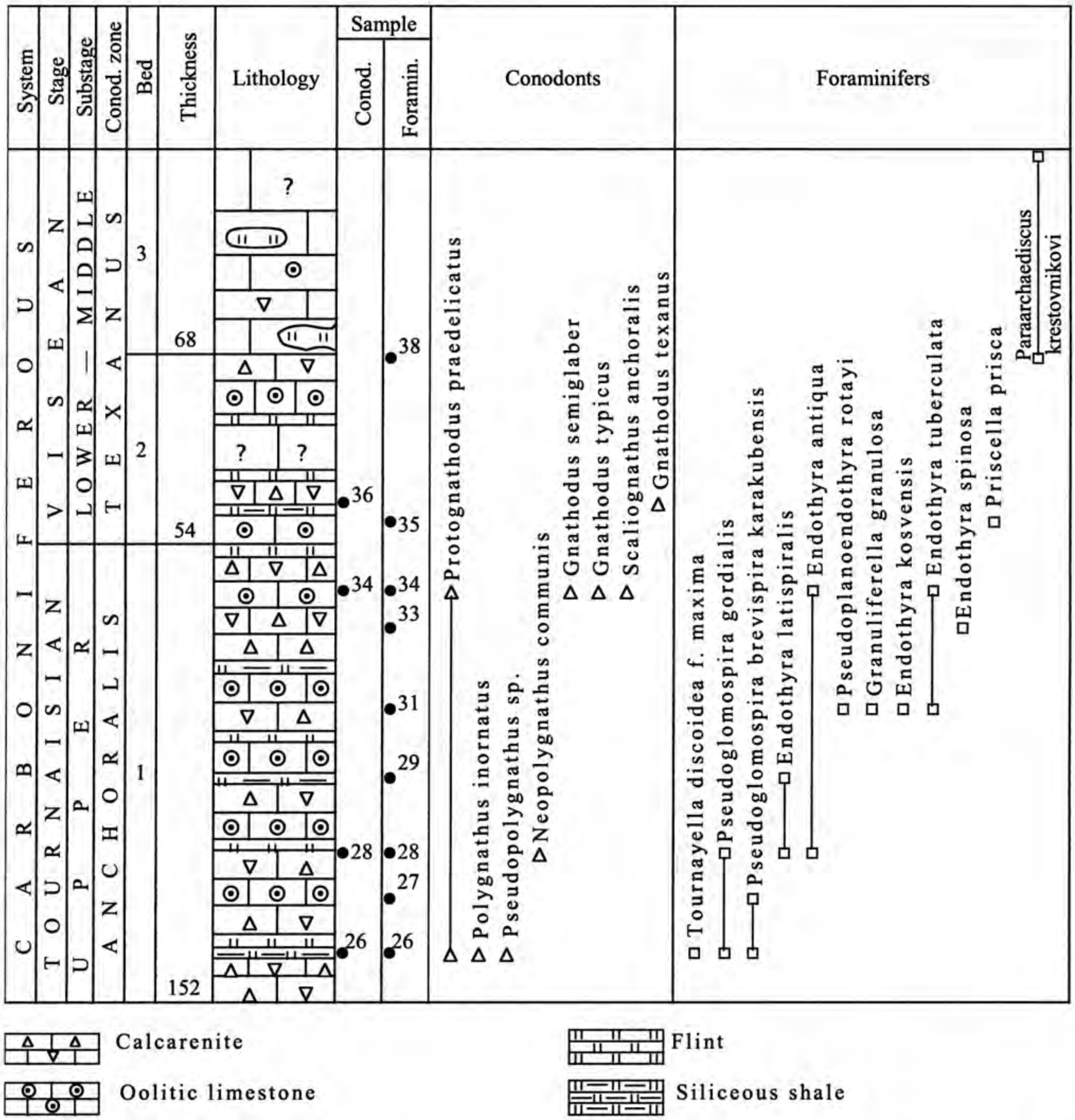


Fig. 2 Tournaisian-Visean boundary interval, conodonts and foraminifera distribution. The Aksai section (scale 1:2000)

Fauna and sedimentation near the Viséan/Serpukhovian boundary (Izyayu River section, Tchernyshev Swell, Subpolar Urals)

Olga L. Kossovaya[1], Yadviga A. Vevel[2], Andrey V. Zhuravlev[1]

[1]VSEGEI, St. Petersburg, Russia

[2]VNIGRI, 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* - *Neoarchaediscus parvus* or Cf7 foraminifer Zone (Conil et al., 1990), and the *Uralopronorites* - *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 composition 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 Isyayu 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-foraminiferal, algae-bryozoan, and crinoid-algal grain-packstones. Conodont associations are dominated by the *Gnathodus bilineatus* 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

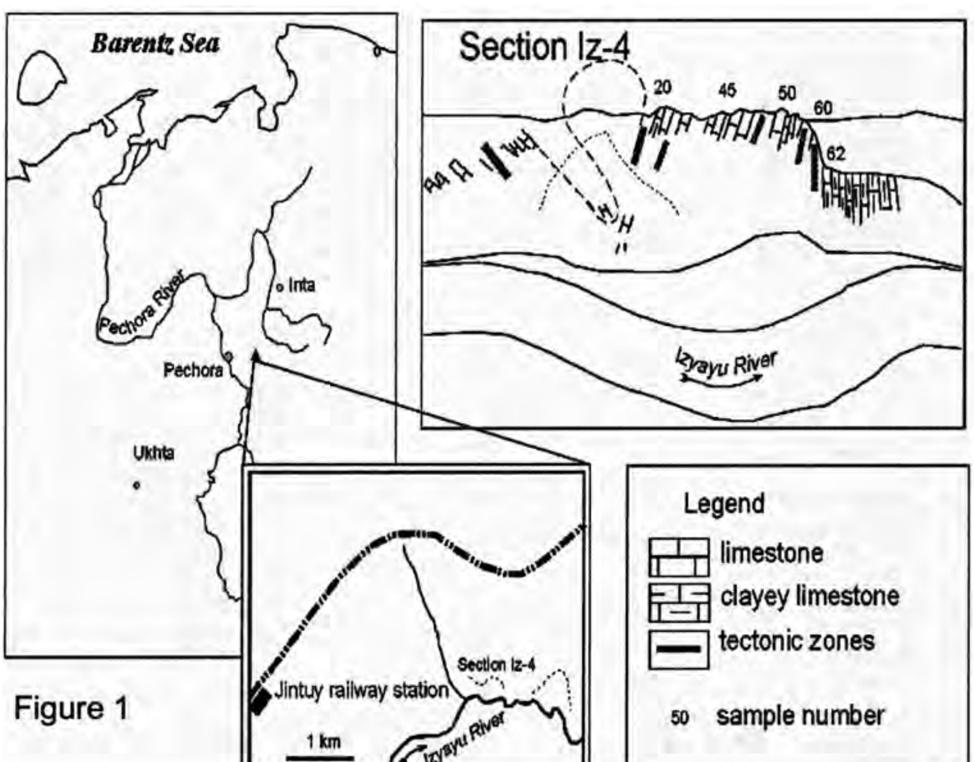


Figure 1

archaeodiscids and howchinids are numerous, but other genera (*Globoendothyra, Endothyranopsis, Climacammina, 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 *Koninckophyllum*, 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 *Fasciella*) and the rugose coral *Dibunophyllum*. Foraminiferal-crinoidal-algal pack- and wackestones containing brachiopod shells, crinoids, and ostracodes are most typical for the transgressive system tract. Foraminifers are represented by *Tetrataxis*, *Howchinia*, and numerous *Endostaffella*. In places packstones are replaced by secondary dolomite. The upper part of the transgressive system tract (maximum flooding) yielded conodonts, dominated by *Lochriea*. In this part of the section rare rugose corals *(Bradyphyllum)* occur. The foraminifer association is dominated by small *Archaediscus*, but rare *Endothyra* occur as well.

The high stand system tract (unit 6) is characterized by a gradual increase of bioclast abundance and an upward transition from ostracode-crinoidal wackestone to algal packstone. *Lochriea* and *Hindeodus* 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 increases 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 gitryi* group dominates the conodont association. Foraminifers are represented by small *Archaediscus krestovnikovi* group and *Neoarchaediscus* characteristic of a more cool, deep-water and soft-bottom environment. Rugose corals *(Asserculinia)* 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 *Lochriea 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.

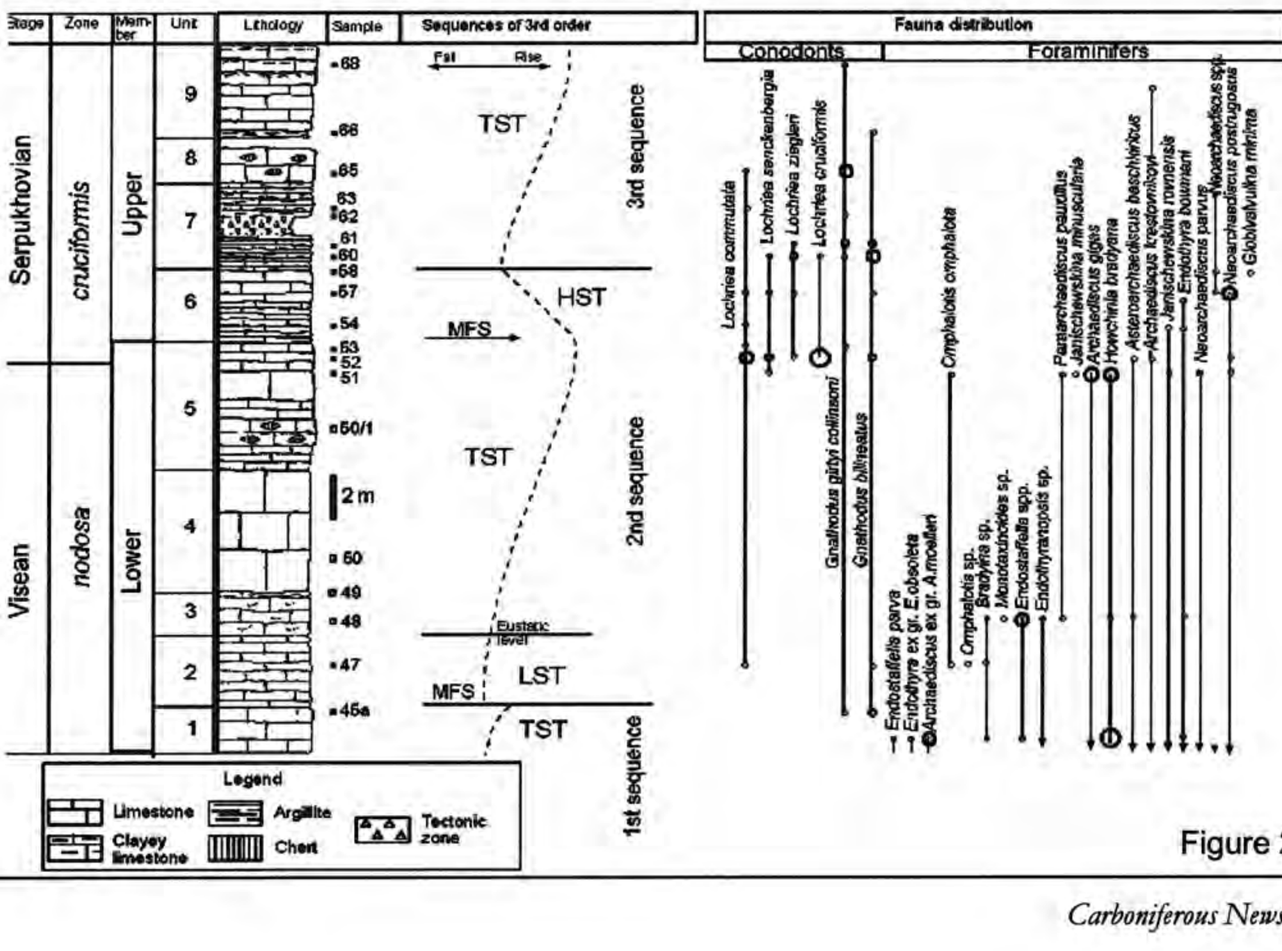


Figure 2

References

Brand, U. 1989. Global climatic changes during the Devonian-Mississippian: stable isotope biogeochemestry of brachiopods.- Palaeogeography, Palaeoclimatology, Palaeoecology 75. 311-329.

Conil R., Groessens, E., Laloux, M., Poty, E., and Tourneur, F. 1990. Carboniferous guide foraminifers, corals and conodonts in the Franco-Belgian and Campine basins. Cour. Forsch.-Inst. Senckenberg, 130. 15-30.

Guidebook. Type and reference sections of Serpukhovian, Moscovian, Kasimovian and Gzhelian stages in Moscow basin. 1998. Moscow.

Skompski, S., Alekseev, A., Meischner, D., Nemirovskaya T., Perret, M.F., and Varker, W.J. 1995. Conodont distribution across the Viséan/Namurian boundary. Cour. Forsch.-Inst. Senckenberg, 188. 177-209.

Zhuravlev, A.V., and Sobolev, D.B. 2000. Conodonts of the Viséan-Serpukhovian boundary beds of the southern part of the Tchernyshev Ridge (Izyayu River). Syktyvkarskiy paleontologicheskiy sbornik, 4. 84-89 (in Russian).

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^{o} 54' N - 37^{o} 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 Venevian, 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 (Rauser-Chernousova, 1948), and those studied recently from the Tarusian to the Protvian. Vdovenko (Makhlina et al., 1993) was the first to recognize the foraminiferal zones in this section. They are the *Pseudoendothyra globosa-Neoarchaediscus 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, *Planoendothyra* sp., and *Eostaffellina* sp., as well as long-lived, incepted from the Viséan forms *Endothyranopsis sphaericus*, *Archaediscus krestovnikovi*, *Neoarchaediscus parvus*, and *N. rugosus*, information was incomplete for precise interregional correlation on the basis of foraminifera.

The new study of foraminifera from the Venevian 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 *Neoarchaediscus 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 Venevian markers *Janischewskina* cf. *typica*, *Howchinia bradyana*, *Loeblichia paraammonoides*, and *"Endostaffella" asymmetrica*. This zone is equivalent to the foraminiferal Cf 6 δ Zone of the uppermost Warnantian stratotype or V_{3C} (Laloux, 1987) on the basis of foraminifera.

Beds with *Neoarchaediscus postrugosus*. The lower boundary of these beds corresponds to the abrupt disappearance of V_{3C} 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 Venevian 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-

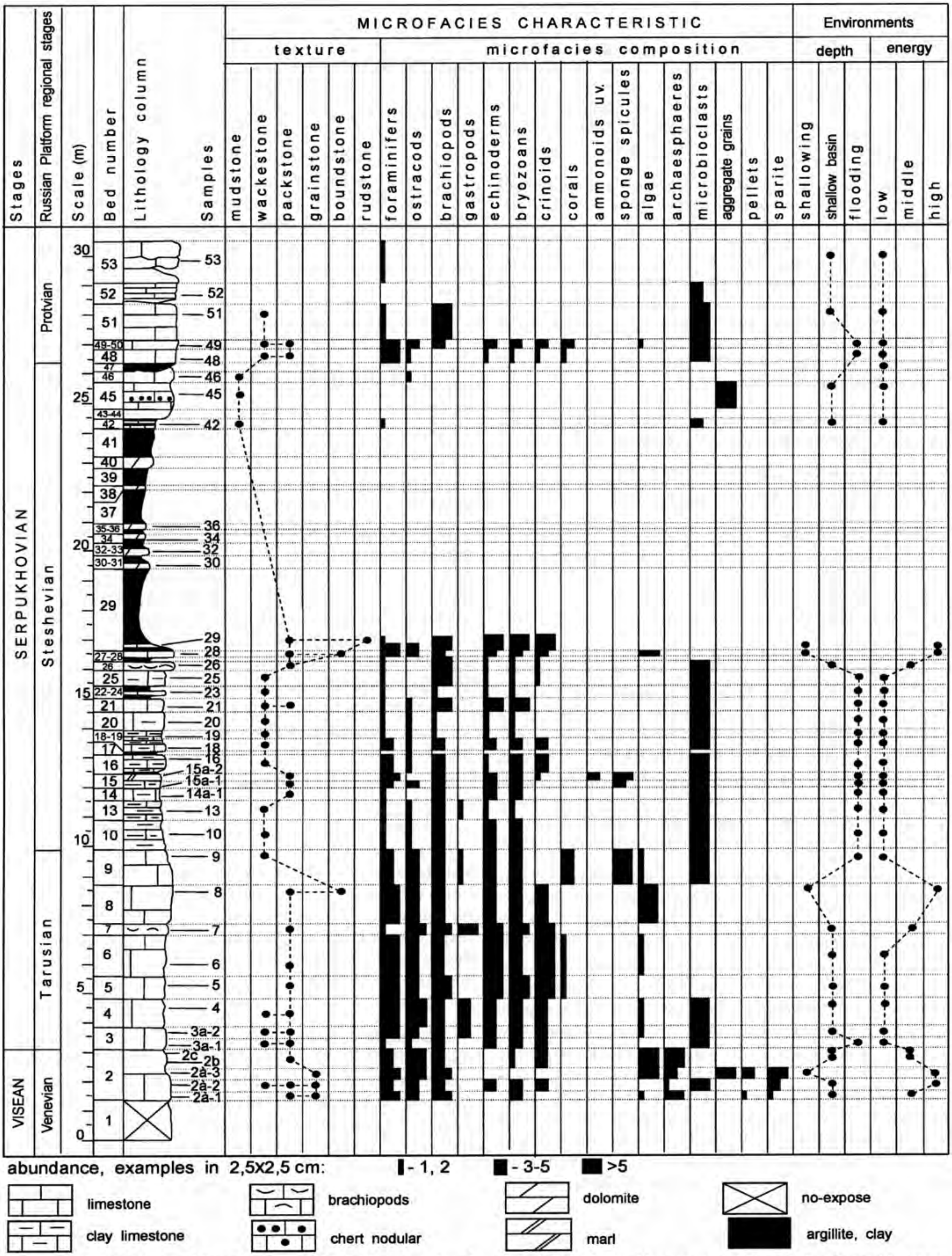


Figure 1. Lithology, Microfacies and Environments characteristics from Uppermost Visean to Serpukhovian of the Zaborie stratotype

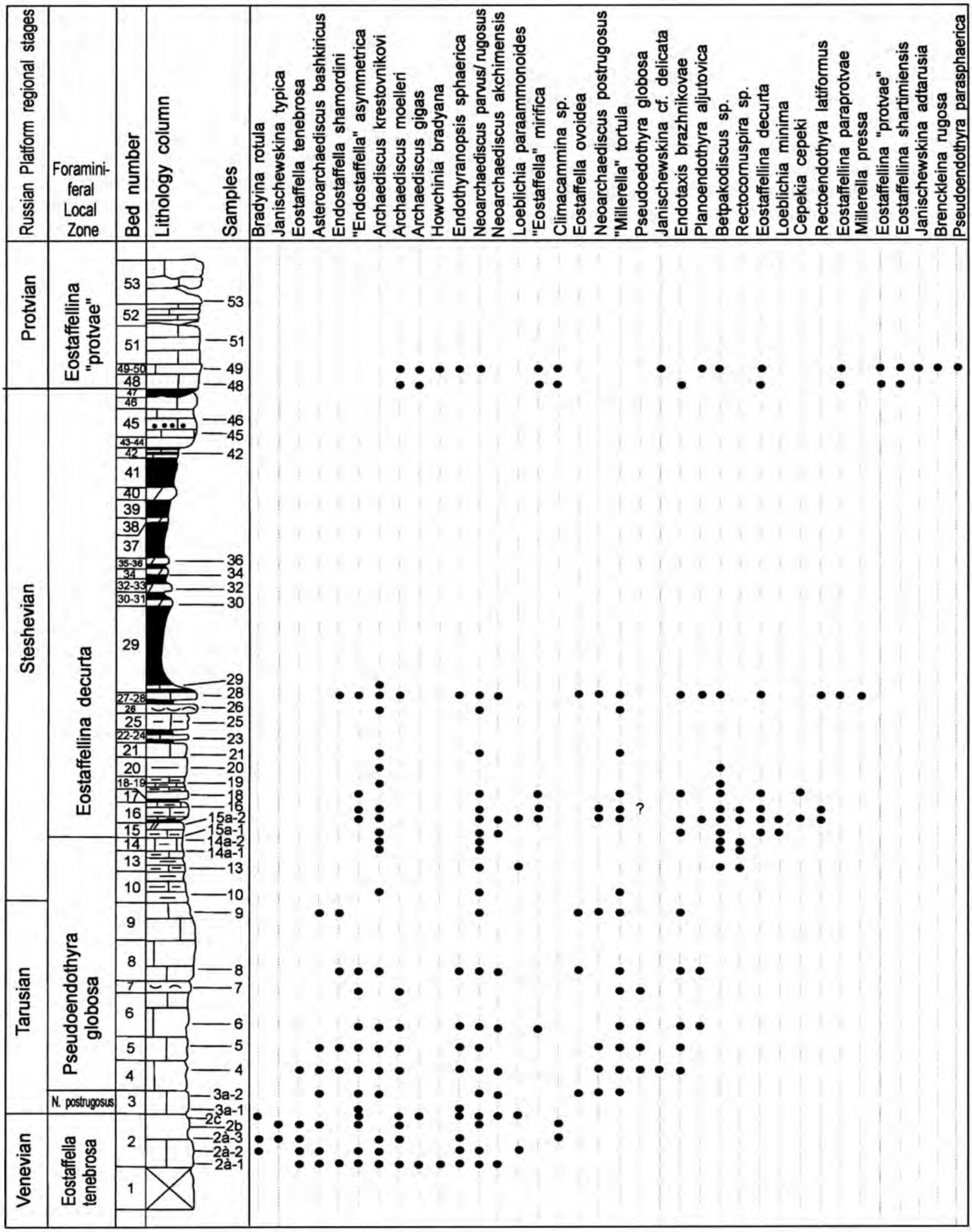


Figure 2. Ranges of the important foraminifers observed in the measured section: basis for biozonaton and intercorrelation are using short-lived forms and *Eostaffellina*, Asteroarchaediscidae, *Janischewskina* and "*Millerella*" lineages

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* (Rauser) is frequent, as well as *Janischewskina adtarusia* sp. nov,. and *Brenckleina rugosa* occurred for the first time. These two species indicate a new stage in the evolution of *Janischewskina* and the Asteroarchaediscidae. 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 Asteroarchaediscidae (*Asteroarchaediscus - Neoarchaediscus - Brenckleina*) lineages are commonly used. The *Janischewskina* lineage is most likely connected with V_3 *Cribrospira* rather than with *Bradyina* (Spravochnik..., 1996). In the Venevian this genus gives rise to *J. typica* forming complicate interseptal "chambers" and mouths but retaining a thick microgranular test wall (55 - 35 μ) and a terminal cribrate mouth. *Janischewskina delicata* 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 Nizhegubakhian Horizon. This unit is most likely equivalent to the Lower Serpukhovian (Stratigraphija...,1973) rather than the Late Viséan, because *Biseriella parva* present together with the holotype in the same thin section never reported previously (Malakhova, 1956)]. *Janischewskina adtarusia,* 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 Venevian *"Endostaffella" asymmetrica* (Rosovskaja, 1963; pl. XII, fig. 10 only) with three-layered test wall: thectum, inner- outer thectorium. 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 Asteroarchaediscidae 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, V_{3C}); 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 RFBR, project № 99 - 05 - 65476.

References

Brenckle, P.L. 1990a. Lower Carboniferous (Mississippian) boundaries working group: organization, results and future directions.- Intercontinental correlation and division of the Carboniferous System. Courier Forsch.-Inst. Senckenberg. 130:5-10.

Brenckle, P.L. 1990b. Foraminiferal division of the Lower Carboniferous / Mississippian in North America.- Intercontinental correlation and division of the Carboniferous System. Courier Forsch.-Inst. Senckenberg. 130:65-78.

Gibshman, N.B. 2000. Foraminifera characteristics of the Serpukhovian Stage stratotype in Zaborie quarry (Moscow Basin, Russian Platform).- Stratigraphy and Geological Correlation. 34., 3 figs., 3 tabs., I-III pls. (in press).

Laloux, M. 1987. Foraminifers du Viséan superieur et du Namurien du bassin Franco-belge.- Geologie. Bull. de la Societe belge de Geologie. 96. 3: 205-221 (Livret-Guide Stratotypes Carboniferes et Devoniens en Belgique).

Lipina, O.A., and Reitlinger, E.A. 1970. Stratigraphie zonale et paleozoogeographie du Carbonifere inferieur d'apres les Foraminiferes.- Compte Rendu VI Congres. Intern. Strat. Geol. Carbonif., V. III : 1101-1112. Sheffield (1967).

Makhlina, M.H., Vdovenko, M.V., Alekseev, A.S. et al. 1993. Nizhnii karbon Moskovskoy sineclisy i Voronezhskoy anteclizy. Nauka. 217. Moscow.

Malakhova, N.P. 1956. Foraminifera izbectnjakov reki Shartym na Uzhnom Urale. Trudy Gorno-Geol. In-ta, UF AN SSSR. 24: 26-71, AN SSSR, Moscow.

Rauser-Chernoysova, D.M. 1948. Stratigraphia viseiskogo jarusa uzhnogo kryla Podmoskovnogo basseina po faune foraminifer.- Tr. in-ta geol. nayk. 62. (19): 3-40.

Rich, M. 1980. Carboniferous calcareous foraminifera from NE Alabama, SC Tennessee, and NW Georgia.- Cushm. Found. Foram. Res. Spec. Publ.18. 62.

Rosovskaja, S.E. 1963. Drevneishie predstaviteli Fusulinida i ich predki. - Tr. Paleont. in-t AN SSSR. 97. 112. Moscow.

Spravochnik po sistematike foraminifer paleozoja (Endothyroida, Fusulinida). Editor: Rauser-Chernoysova D.M. 1996. Nauka. 207. Moscow.

Stratigraphija i fauna kamennougolnych otlozhenii reki Shartym (Uzhny Ural). Editor: Einor, E.L. 1973.- Kiev University. 184. Vyshaja shkola, Ukraina.

Zeller, D.E.N. 1953. Endothyroid foraminifers and ancestral fusulinids from the type Chesterian (Upper Mississippian).- Jour. Paleontol. V. 27. 2: 183-199.

Problems in Lower Serpukhovian ammonoid biostratigraphy

S.V. Nikolaeva[1] and J. Kullmann[2]

[1]Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya 123, Moscow, 117868, Russia.

[2]Institute 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 *Lochriea 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 sequences 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 *Tumulites pseudobilinguis* (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* Genozone, which they thought to correspond approximately with the base of the P_2 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 genozone in the South Urals. The correlation of the lower boundary of this genozone with the P_2 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* Genozone 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 to 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 biostratigraphical 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 falcatoid ornamentation, thus assigning the beds with falcatoid-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

(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 Aurakhmat Formation based on the appearance of *Dombarites paratectus* without falcatoid ornamentation as opposed to *Dombarites parafalcatoides,* 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 Nigmadganov 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 *Sulcogirtyoceras 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 *Sulcogirtyoceras ornatissumum, Lusitanoceras cloudi,* and *Pachylyroceras hyatti* that allow a correlation with the *Hypergoniatites-Ferganoceras* Genozone 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 plummeri, Tumulites varians* and other species. This level is most probably equivalent to the uppermost Pendleian or the basal Arnsbergian. 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-falcatoid 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* (=*Emstites*) and *Dombarites* (=*Lusitanoceras*) 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

Horn, M. 1960. Die Zone des *Eumorphoceras pseudobilingue* im Sauerland. Fortschritte in der Geologie von Rheinland und Westfalen, 3,1:303-34.

Korn, D. 1988. Die Goniatiten des Kulmplattenkalkes (Cephalopoda, Ammonoidea; Unterkarbon; Rheinisches Schiefergebirge). Geologie und Paläontologie in Westfalen, 11:1-293.

Korn, D. 1996. Revision of the Rhenish Late Viséan goniatite stratigraphy. Annales de la Societe Biologique de Belgique, 117:129-136.

Korn, D. and Horn, M. 1997. Subdivision of the basal Early Namurian (Early Carboniferous) in the Rhenish Massif (Germany). Newsletters on Stratigraphy, 35:115-126.

Nikolaeva, S.V. 1995. Ammonoids of the late Lower and early Upper Carboniferous of Central Asia. Cour. Forsch.-Inst. Senckenberg, 179, 106 pp.

Ruzhencev, V.E., and Bogoslovskaya, M.F. 1971. Namyurskiy etap v evolyutsii ammonodey. Rannenamyurskiye ammonoidei. Trudy Paleontologicheskogo Instituta, Akademiya Nauk SSSR, 133:1-382.

Skompski, S., Alekseev, A., Meischner, D., Nemirovskaya, T., Perret, M.F., and Varker, W.J. 1995. Conodont distribution across the Viséan-Namurian boundary. Cour. Forsch.-Inst. Senckenberg, 188:177-209.

Titus, A. 1999. Ammonoid biostratigraphy of the Barnett Shale (Late Mississippian), Texas, USA, p. 155-168. *In:* Fossil Cephalopods. Recent Advances in Their Study, Paleontological Institute, Russian Academy of Science, Moscow.

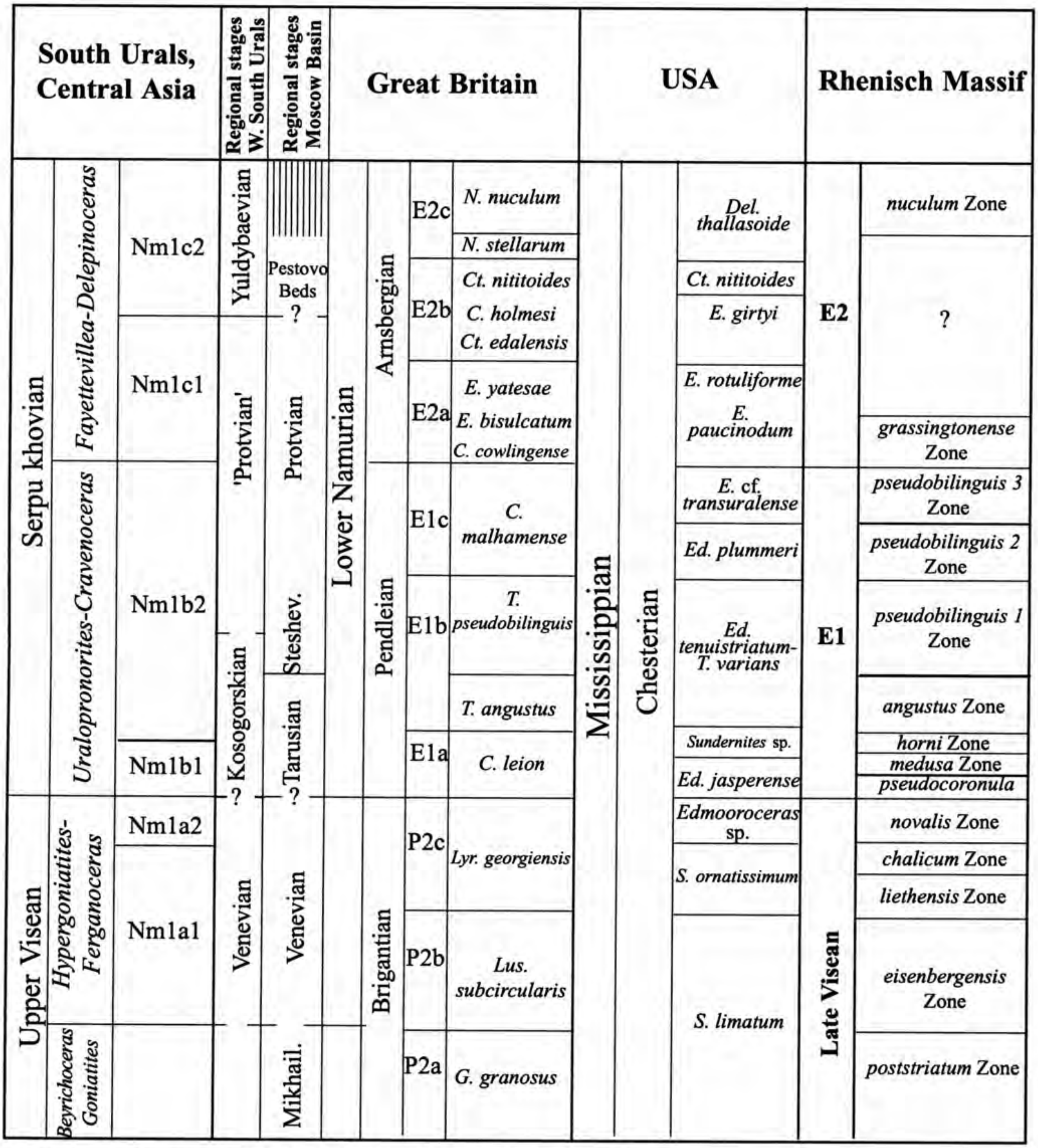


Figure 1. Correlation chart of the Serpukhovian. No vertical scale intended.

Integrated Serpukhovian biostratigraphy in the South Urals

S.V. Nikolaeva[1], E.I. Kulagina[2], V.N. Pazukhin[2] and N.N. Kochetova[2]

[1]Paleontological Institute, Russian Academy of Sciences, Profsoyuznaya 123, Moscow, 117868, Russia.

[2]Institute 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 foraminifers.

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 Kosogorskian, Protvian, and Staroutkinskian (=Yuldybaevian) Horizons and their equivalents in the Eastern Urals (Stratigraficheskie schemy, 1993). The underlying Upper Viséan deposits are represented by the Venevian Horizon. These horizons have been extensively studied and provided a basis for the zonal subdivision of the Serpukhovian. Of these, the Staroutkinskian Horizon remains problematic because in its type area it is represented by specific foraminiferal-brachiopod successions that lack ammonoids and conodonts. To replace the Staroutkinskian Horizon, we are using the Yuldybaevian Horizon, which contains ammonoids and conodonts.

Ammonoids occur in the Western and Eastern slopes of the Urals where the two successive assemblages of the *Uralopronorites-Cravenoceras* (Nm1b) and *Fayettevillea-Delepinoceras* (Nm1c) Genozones are recognized (Ruzhencev and Bogoslovskaya, 1971). The lower genozone is dominated by *Dombarites, Cravenoceras* and *Uralopronorites*. Of these, the latter two genera first appearing at this level were chosen as zonal markers. The lower part of this genozone (Nm1b1) shows the presence of the genera continuing from the Viséan (*Lusitanites, Prolecanites, Alaoceras, Neogoniatites, Lyrogoniatites)* alongside *Dombarites liratus, D. carinatus, first Cravenoceras leionoides, C. crassum, Platygoniatites molaris*, first appearing at this level. Ammonoids of this age are found in the Aktyubinsk Region (Zhaksy-Kargaly River, Dombar Hills, Kzyl-Shin Gully), in the Orenburg Region (Kiya River) in the Kosogorskian Horizon. However, in most of these sections, the lower Serpukhovian boundary is not controlled by Viséan 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, foraminifers and conodonts. The lowermost 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

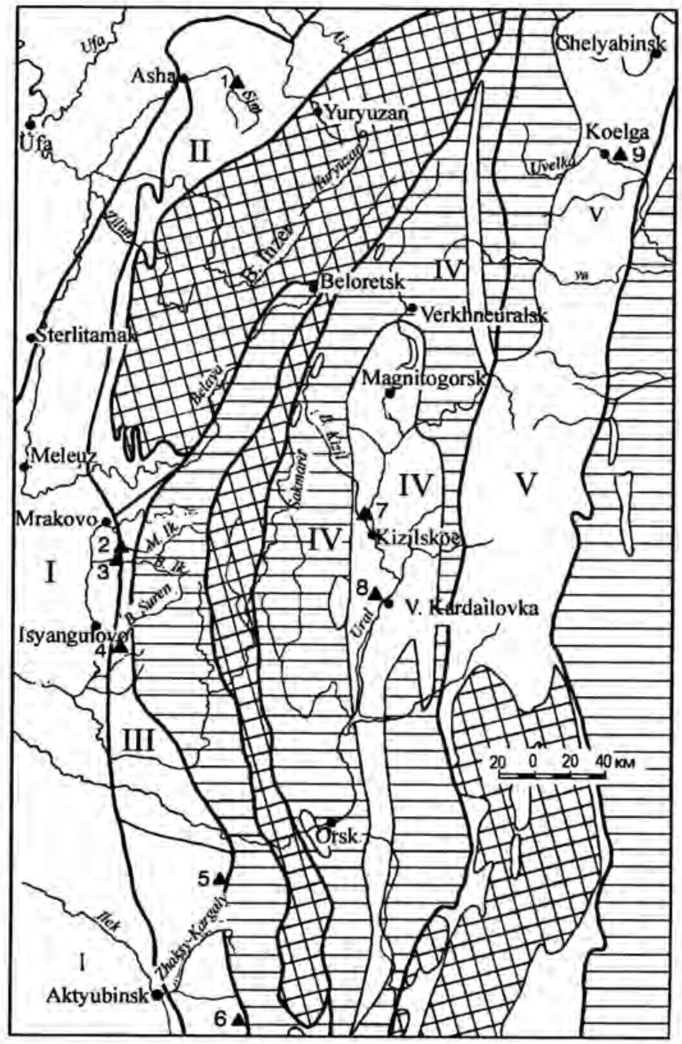


Figure 1. Location of the Serpukhovian standard sections in the South Urals. (1) Pre-Paleozoic and metamorphic rock complexes. (2) pre-Carboniferous Paleozoic rocks, (3) Carboniferous and younger rocks. I-V- Structural Zones: (I) Fore-Uralian, (II) Western-Uralian, (III) Central Uralian, (IV) Magnitogorsk, (V) Eastern Uralian, Triangles show sections: (1) Sim, (2) Muradymovo, (3) Injak, (4) Kugarchi, (5) Kiya, (6) Sholak-Sai, (7) Verkhnyaya Kardailovka, (8) Uvelka.

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. pseudocoronula-S. horni* Zones in Germany and with the *C. leion* Zone in Britain. The Nm1b2 Zone is recognized in the Dombar Hills, Zhaksy-Kargaly, Kiya, Verkhnyaya Kardailovka, Uvelka, etc. in the lower part of the Protvian Horizons. This easily identifiable assemblage contains *Cravenoceras lineolatum, C. beleutense, Dombarites tectus, D. paratectus, Verancoceras admirabile, Mirilentia uberta, Quasicravenoceras 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. varians* zones) in Europe and the USA.

The lower boundary of the *Fayettevillea-Delepinoceras*

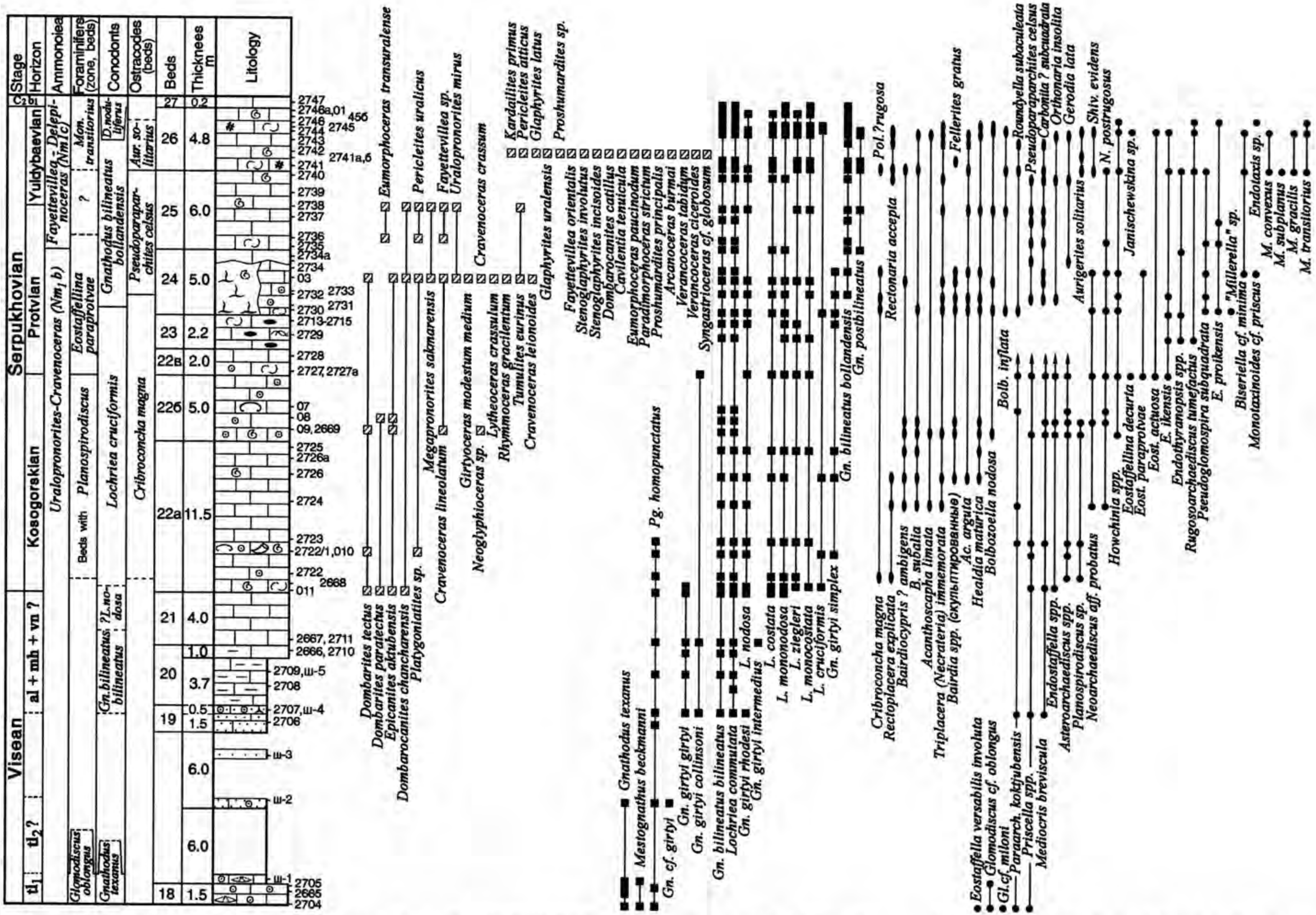


Figure 2. Correlation of the standard Sepukhovian sections in the South Urals. (1-8) limestones, (1) bedded mudstones and wackestones, (2) indistinctly bedded; (3) unbedded, bioherms; (4) bioclastic packstones and grainstones; (5) litho-bioclastic grainstones; (6) clayey limestones, (7) with chert nodules (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, Eumorphoceras tumulosum* and *E. transuralense*. The transition from the Nm1b to the Nm1c beds is observed in the Verkhnyaya Kardailovka section and the Kiya River. In both sections the assemblage containing *Cravenoceras, Dombarites* and *Lytheoceras* is replaced by that containing *Pericleites, Eumorphoceras, Glaphyrites* and *Syngastrioceras*. The important feature of this zone is that *Verancoceras, Uralopronorites mirus, Platygoniatites* and *Megapronorites* continue from the Nm1b2 Zone. The Nm1c1 Zone is established in a few localities including the Kiya River and Verkhnyaya Kardailovka sections. In stratigraphic practice the lower boundary of the zone is drawn at the beds with *Glaphyrites, Proshumardites* and *Pericleites*, and *Eumorphoceras transuralense*. The succeeding zone (Nm1c2) almost entirely corresponds with the Yuldybaevian Horizon. The most characteristic species are *Eumorphoceras transuralense, Proshumardites delepinei, Fayettevillea occidentalis,* and *Delepinoceras bressoni*. Assemblages of this age are also recorded in the sections Verkhnyaya Kardailovka, Kzyl-Shin, Sholak-Sai, Sakmara 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 *Eostaffellina 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 dependant Serpukhovian taxa. In the West-Uralian structural Zone in most sections the boundary is placed at the base of the bare dolomitic 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 *Endostaffella-Mediocris* foraminiferal biofacies. In the more favorable facies, the Viséan assemblage continues into the Serpukhovian but it is impoverished. In the sections of the coral-brachiopod facies of the West-Uralian Zone, this assemblage also contains newly appearing *Biseriella parve* (Sim River), in the Central-Uralian Zone (Muradymovo, Kugarchi, Injak) – *Archaediscus timanicus*, sometimes *Eolasiodiscus*. In the algal facies of the Magnitogorsk Zone (Bolshoi Kizil) *Monotaxinoides* and *Eolasiodiscus donbassicus* appear from the base of the Serpukhovian. Beds with *Planospirodiscus* are recognized in the cephalopod facies. Foraminifers are rare being represented by small euryfacial species of the genera *Priscella, Endostaffella, Mediocris, Asteroarchaediscus,* and *Planospirodiscus*. In this section and also in the Muradymovo, Kugarchi, and Inyak 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 *Eostaffellina 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 actuosa, 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 Yuldybaevian Horizon and with the radiation of the Howchiniidae. The assemblage also includes *Monotaxinoides gracilis, Janichevskina sp., Rectoendothyra sp.*, the first primitive *Plectostaffella*, etc., present in the Muradymovo section (type section of the Yuldybaevian 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 genera *Gnathodus, Lochriea, and Mestognathus*. In the Central-Uralian Zone (Muradymovo, Kugarchi, Kiya, and Sholak-Sai sections), Magnitogorsk Zone (Verkhnyaya Kardailovka, Bolshoi Kizil), and the East-Uralian Zone (Uvelka), the Serpukhovian contains successive conodont assemblages dominated by *Gnathodus* and *Lochriea*. Conodonts are most abundant in the sections of the cephalopod biofacies (Kiya, Sholak-Sai, Verkhnyaya Kardailovka, Muradymovo, Uvelka). Unfortunately the boundary Viséan-Serpukhovian beds in most sections are poorly exposed and provide little data. The Kiya and Verkhnyaya 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 (Venevian) and Serpukhovian beds in the South Urals contain the following conodont zones:

The *Lochriea nodosa* Zone is established in the Kiya section (beds 1-lowermost 2) in the upper part of the Venevian Horizon. The lower boundary of the zone is defined by the appearance of the index species, the upper is determined by the appearance of *Lochriea cruciformis*. The zonal assemblage contains *Lochriea mononodosa, L. monocostata, 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 girtyi, Lochriea commutata, Pseudognathodus homopunctatus*

The *Lochriea cruciformis* Zone is established in the Muradymovo, Kugarchi, Kiya, Sholak-Sai, Verkhnyaya 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 bollandensis. Lochriea multinodosa* and *Gnathodus girtyi simplex* appear from the base of the zone. The assemblage is dominated by species continued

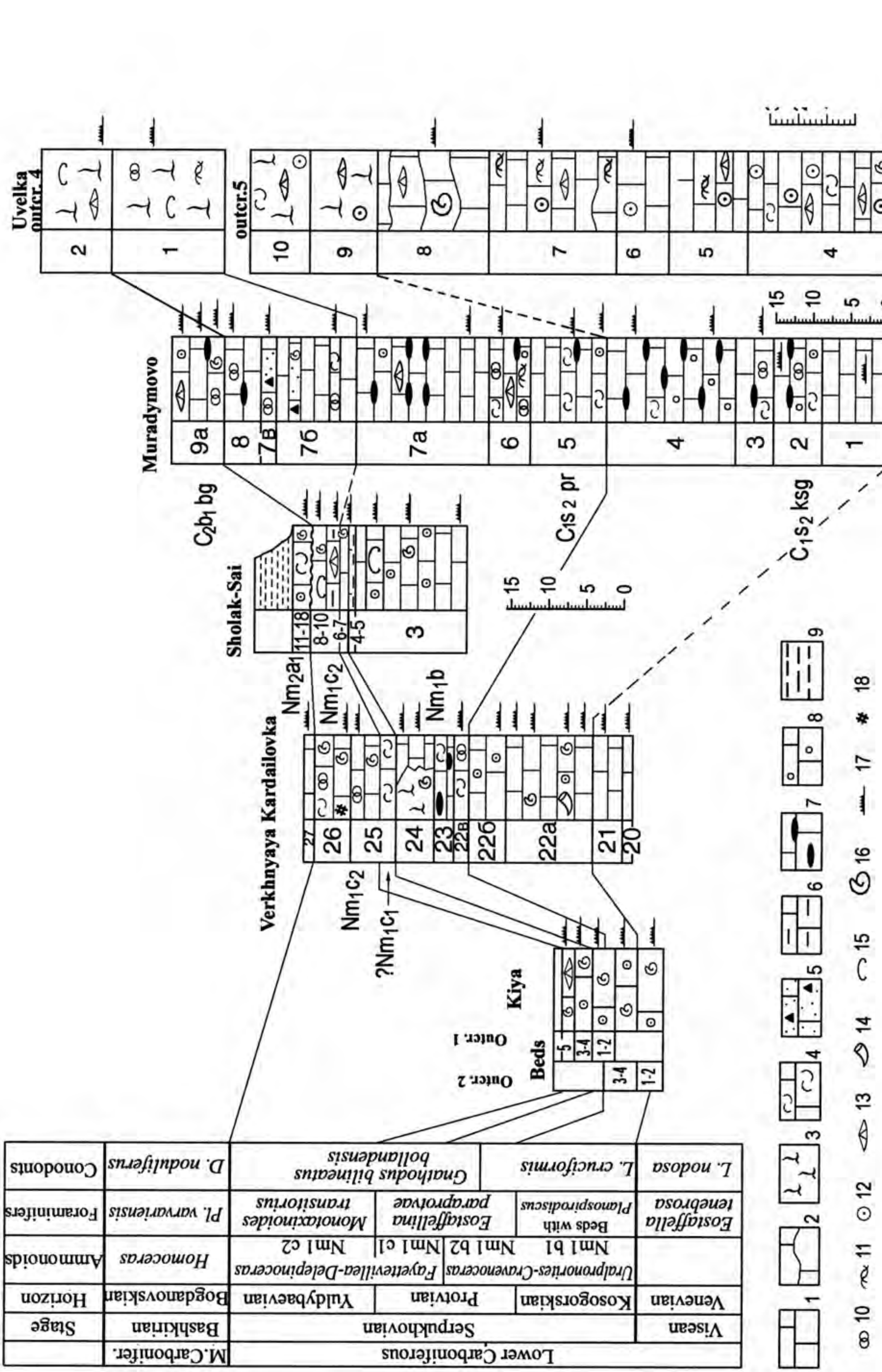


Figure 3. Verkhnyaya Kardailovka Section.

from the Viséan. In the Kiya, Sholak-Sai, and Verkhnyaya 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. commutata - L. mononodosa - 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 basinal sequences of Germany is appears earlier, in the ammonoid *Emstites schaelkensis* Zone (Skompski et al., 1995).

The *Gnathodus bilineatus bollandensis* Zone is established in the Muradymovo Kugarchi, Kiya, Sholak-Sai, Bolshoi Kizil, Verkhnyaya 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 tythys* in the Yuldybaevian Horizon in the Sim section is noteworthy. The assemblage also contains species continuing from the underlying beds.

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

The Beds with *Cribroconcha magna* correspond to the upper part of the Venevian and Kosogorskian horizons in the Kiya and Sholak-Sai sections, and apparently to the lower part of the Protvian Horizon in the Verkhnyaya Kardailovka section. The appearance of *Cribroconcha magna* sp. nov. in association with the ornamented *Bairdia* is noteworthy. The assemblage contains various species of *Rectoplacera, Rectonaria, Triplacera, Bairdia, Bardiocyprus, Acratia, Acanthoscapha*, etc. appearing at the base of the Beds. The species *Healdia maturica*, and *Bolbozoella nodosa* appear in the middle of this unit. The assemblage also contains *Polycope perminute* and *Roundyella simplicissima* recognized from the Pennsylvanian. 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 ? subquadrata*. Many species continue from the underlying beds. The assemblage also contains species of the genera *Bolbozoella, Acanthoscapha, Gerodia* and *Aurigerites,* and rectonarids become more diverse. Ostracodes of this assemblage occur together with ammonoids of the Nm1b2-Nm1c1 Zones. In the Muradymovo section, the assemblage includes *Editia*, 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 Verkhnyaya Kardailovka sections. The assemblage contains transitive species and those appearing at this level: *Shishaella circinata, Shivaella evidens, Microcoeloenella orbiculata, Dorsoobliquella ovalis, Bairdia chudolasensis, Polycope? rugosa*, etc., which become the most diverse the Lower Bashkirian. The lower part of the Verkhnyaya 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 Urals corresponds with two ammonoid genozones each containing two zones, three foraminiferal units, two conodont zones and three beds with ostracodes. The Nm1b1 ammonoid zone approximately corresponds with the foraminiferal beds with *Planospirodiscus* and their equivalents, with the upper part of the *Cribroconcha 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 foraminiferal *Eostaffellina paraprotvae* 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 Protvian Horizon. The ammonoid Nm1c1 Zone probably corresponds with the upper part of the foraminiferal *Eostaffellina paraprotva* Zone, the middle part of the *Gnathodus bilineatus bollandensis* Zone, and the upper part of the Protvian Horizon. The Nm1c2 Zone correlates with the foraminiferal *M. transitorius* Zone, the *Aurigerites solitarius* ostracode beds, the upper part of the *Gnathodus bilineatus* Zone, and the Yuldybaevian Horizon.

The most complete Serpukhovian sections are those at Muradymovo, Kugarchi, Verkhnyaya Kardailovka, Kiya, and Sholak-Sai. The Viséan-Serpukhovian transition is recognized in Kiya (conodonts, ammonoids, ostracodes). Verkhnyaya 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

Ruzhencev, V.E., and Bogoslovskaya, M.F. 1971. Namurskii etap v evolytutsii ammonoidei. Rannenamyurskie ammonoidei (Namurian time in ammonoid evolution. Early Namurian ammonoids), Trudy Paleontol. Inst. Akad. Nauk. AN SSSR, vol. 133, 382 pp.

Skompski S., Alekseev A., Meischner T., et al. 1995. Conodont distribution across the Viséan/Namurian boundary. Cour. Forsch.-Inst. Senckenberg., 188, pp. 177-209.

Stratigraficheskie skhemy Urala (dokembrii, paleozoi) (Stratigraphic schemes of the Urals [Precambrian, Paleozoic]), Ekaterinburg, 1993, 151 pp.

The Carboniferous - Early Permian marine domain in western Argentina

Arturo César Taboada

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

Carboniferous sedimentation in western Argentina was preceded by the late Devonian Precordilleranic orogeny (Furque, 1972) that produced a paleogeographic framework characterized by longitudinal ranges and basins. One of them was a narrow backarch area of deposition named the Uspallata-Iglesia Basin (González, 1985), located between two emergent meridional dorsals, the Protoprecordillera (Amos and Rolleri, 1965) to the east (currently Sierras of Uspallata, Tontal, Invernada, Volcán and Punilla) and the Protocordillera Frontal (González, 1985) to the west (at the moment Mountain ranges of Olivares and Tigre). The Protocordillera Frontal allowed the access of "Pacific" ingressions to the Uspallata-Iglesia basin through depressed areas by unstable behaviour of the dorsal. On the other hand, the Protoprecordillera was a dam (Amos and Rolleri, 1965) that impeded the entrance of the sea toward the more eastern Paganzo basin. In this scenario, various marine ingressions occurred to the west of the Protoprecordillera. 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. Epeirogenic movements (San Eduárdica 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 overlying sediments with the late Westphalian *Balakhonia-Geniculifera* 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 Precordillera. Above these faunistic associations follows a large transgression that was able to surpass the highlands of the Protoprecordillera through a few inlets and yield the Stephanian *Tivertonia-Streptorhynchus* fauna to the east, establishing the most extensive neopaleozoic marine ingression that covered western Argentina. The marine domain was posteriorly reduced to an enbayment at the southern border of de Uspallata-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 glaciomarine 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; Woppfner, 1999). This circum-pacific faunal association would have been developed almost parallel to the subpolar *Eurydesma*'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

Amos, A.J., and Rolleri, E.O. 1965. El Carbónico marino en el Valle Calingasta-Uspallata (San Juan y Mendoza). Boletín de Informaciones Petroleras, Buenos Aires, 368: 1-23.

Dickins, J.M. 1985. Late Paleozoic glaciation. *Bureau of Mineral Resources, Journal of Australian Geology and Geophysics*, 9: 163-169.

Furque, G. 1972. Precordillera de La Rioja, San Juan, and Mendoza. *In:* A.F. Leanza (ed.), Geología Regional Argentina. Academia Nacional de Ciencias, Córdoba, pp. 237-282.

Furque, G., and Cuerda, A. 1984. Estilos tectónicos de la Precordillera. 9º Congreso Geológico Argentino (S.C. de Bariloche), Actas 2: 368-370.

González, C.R. 1981. El Paleozoico superior marino de la República Argentina. Bioestratigrafía y Paleoclimatología. Ameghiniana 18 (1-2): 51-65.

González, C.R. 1985. Esquema bioestratigráfico del Paleozoico superior marino de la cuenca Uspallata-Iglesia. República Argentina. Acta Geológica Lilloana, 16 (2): 231-244.

González, C.R. 1990. Development of the Late Paleozoic glaciations of the South American Gondwana in western Argentina. Palaeogeography, Palaeoclimatology, Palaeoecology 79: 275-287.

López Gamundi, O., Limarino, C.O., and Césari, S.N. 1992. Late Paleozoic paleoclimatology of central west Argentina. Paleogeography, Paleoclimatology and Palaeoecology, 91: 305-329.

Taboada, A.C. 1999. The interval between the *Levipustula* and *Costatumulus* biozones in Patagonia. Newsletter on Carboniferous Stratigraphy, 17: 11.

Taboada, A.C. 2001. Bioestratigrafía del Neopaleozoico del Valle de Tres Lagunas, Sierra de Tepuel, provincia de Chubut. Acta Geológica Lilloana 18(2): 291-304.

Wopfner, H. 1999. The Early Permian deglaciation event between East Africa and northwestern Australia. Journal of African Earth Sciences, 29(1): 77-90.

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 Permo-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 (Suero, 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 occur 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 Malvinas (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 palaeolatitudinal position 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

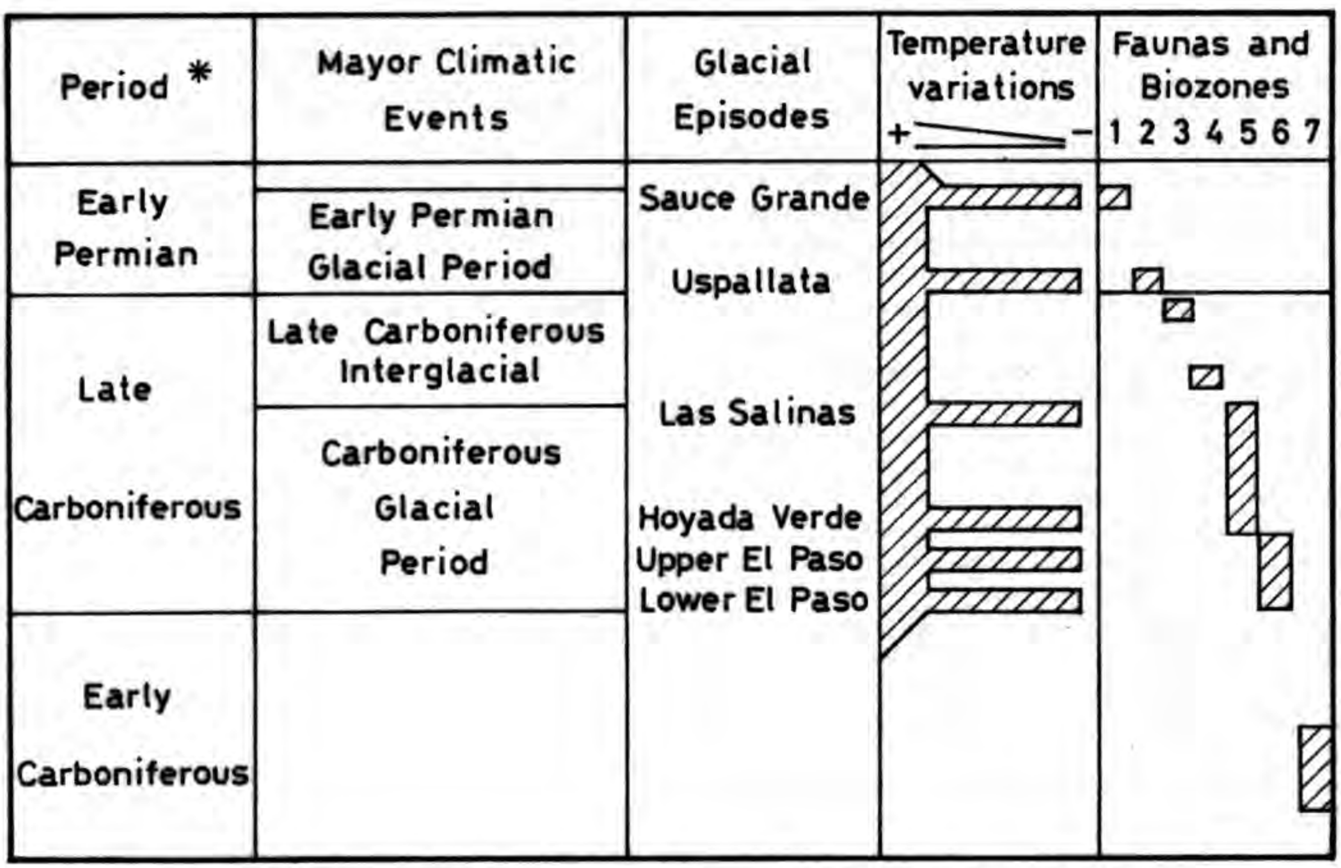


FIGURE 1: Relationships between major faunal groups and glaciations during the Late Paleozoic in Argentina.* Not to scale. 1: *Eurydesma* fauna , 2: *Costatumulus* Zone, 3: *Buxtonia-Heteralosia* assemblage, 4: *Balakhonia-Geniculifera* Zone (3+4 = "intermediate fauna"), 5: *Levipustula levis* Zone, 6: *Rugosochonetes-Bulahdelia* Zone, 7: *Protocanites* Zone.

beds of the Mojón de Hierro Formation would be the circumpolar ("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-Permian transition. The sequence in central Patagonia offers the ideal field to develop these studies.

References

Golonka, J., Ross, M.I., and Scotese, C.R. 1994. Phanerozoic palaeogeographic and palaeoclimatic modeling maps.- In: Embry, A.F., Beauchamp, B., Glass, D.J. (Eds.), Pangea: Global Environments and Resources. Canadian Society of Petroleum Geologists, Memoir 17: 1-47, 87 figs.; Calgary.

González Bonorino, G., Rafine, G., Vega, V., and Guerin, D. 1988. Ambientes de la plataforma nerítica dominada por tormentas en la sección glacigénica del Grupo Tepuel, Chubut. - Asociación Geológica Argentina, Revista 43 (2): 239-252, 11 text-figs.; Buenos Aires.

González, C.R. 1981. El Paleozoico superior marino de la República Argentina. Bioestratigrafía y Paleoclimatología.- Ameghiniana 18 (1-2): 51-65, 2 tabs.; Bs Aires

González, C.R. 1990. Development of the Late Paleozoic glaciations of the South American Gondwana in western Argentina.- Palaeogeography, Palaeoclimatology, Palaeoecology 79: 275-287, Amsterdam.

González, C.R. 1999. Permo-Carboniferous faunas and provincialism in the South American Gondwana region.- Newsletter on Carboniferous Stratigraphy 17: 12-14. Armidale.

Suero, T. 1948. Descubrimiento del Paleozoico superior en la zona extraandina de Chubut.- Informaciones Petroleras, Boletín 287: 31-48, Bs. Aires.

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

B. Evans[1], C.J. Cleal[1] and B.A. Thomas[2]

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

[2]Welsh 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 Bolsovian. The section lies 1km east of Glyn Neath, and consists of 3 km of stream bed, bank side and old 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. 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 Cwmgwrach valleys, which will help fill in some other missing parts of the succession. Temporary sections in the adjacent Selar opencast site have also been documented, where it is possible to identify large-scale structural trends.

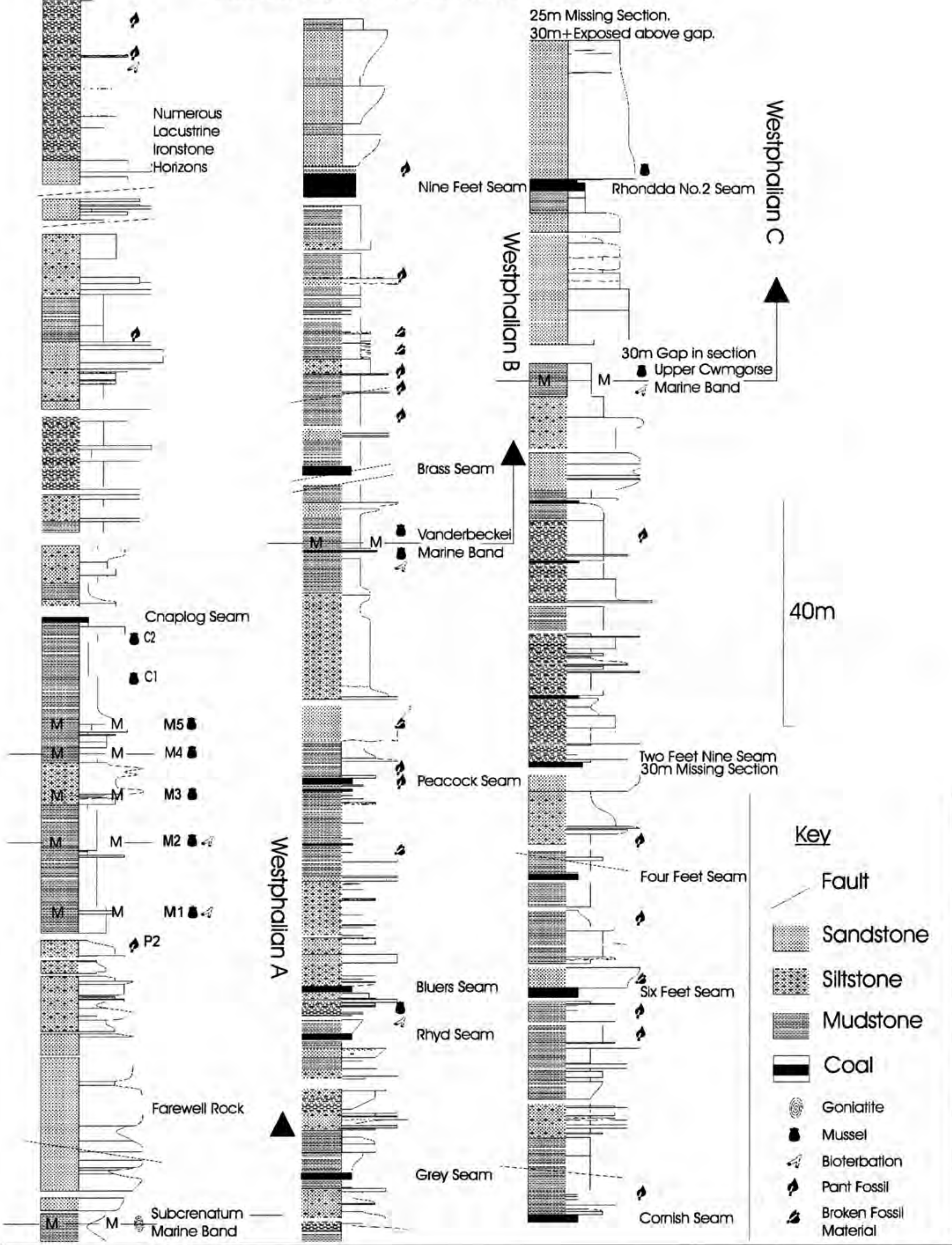
The Subcrenatum Marine Band marking the base of the Westphalian is exposed at Pont Walby. Although normally well developed in this area, only its transgressive basal shales and mudstones are exposed here, and typical faunas are rare. The contact with the overlying Farewell Rock is erosive and is seen 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 seat earths and coals, commonly known as the Bluers Group (including the Grey, Rhyd, L. Bluers, Upper. Bluers, and Lower Peacock Coals). This is particularly well exposed in the main riverbed and adjoining tributaries. There then follows several meters of cross-bedded sandstone, forming a prominent waterfall, and then 18-20 m of dark marine muds and siltstones, the Vanderbeckei Marine Band, marking the Langsettian-Bolsovian 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-

Figure 1. Basic Log of Cwm Gwrelych - Nant Llyn Fach Streams, Glyn Neath, South Wales, UK.



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 is providing 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 Gorllwyn 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 Aegiranum 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 successions exposed 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

C.J. Cleal[1], Y.G. Tenchov[2], T.K. Dimitrova[2], E.L. Zodrow[3] and B.A. Thomas[4]

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

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

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

[4]Institute 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 CO_2, 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 Bulgarian 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 in 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

Besly, B.M., and Cleal, C.J. 1997. Upper Carboniferous stratigraphy of the West Midlands (UK) revised in the light of borehole geophysical logs and detrital compositional suites. Geological Journal, 32: 85-118.

Cleal, C.J. 1984. The Westphalian D floral biostratigraphy of Saarland (Fed. Rep. Germany) and a comparison with that of South Wales. Geological Journal, 19: 327-351.

Cleal, C.J (ed.) 1991. Plant fossils in geological investigation: the Palaeozoic. Ellis Horwood, Chichester, 233 pp.

Cleal, C.J., and Thomas, B.A. 1994. Plant fossils of the British Coal Measures. Field Guide to Fossils, 222 pp.

Cleal, C.J., and Thomas, B.A. 1999. Tectonics, tropical forest destruction and global warming in the Late Palaeozoic Acta Palaeobotanica, Supplement, 2: 17-19.

DiMichele, W.A., Phillips, T.L., and Peppers, R.A. 1985. The influence of climate and depositional environment on the distribution and evolution of Pennsylvanian coal swamp plants. *In:* Tiffney, B (ed.) Geological Factors in the Evolution of Plants, pp. 223-256.

Fissunenko, O.P., and Laveine, J.P. 1984. Comparaison entre la distribution des principales espèces-guides végétales du Carbonifère moyen dans le bassin du Donetz (URSS) et les bassins du Nord-Pas-de-Calais et de Lorraine (France). Compte rendu Neuvième Congrès de Stratigraphie et de Géologie du Carbonifère (Washington and Urbana, 1979), 1: 95-100.

Menning, M., Weyer, D., Drozdzewski, G., Amerom, H.W.J. van, and Wendt, I. 2000. A Carboniferous Time Scale 2000: discussion and use of geological parameters as time indicators from Central and Western Europe. Geologisches Jahrbuch, A 156: 3-44.

Phillips, T.L., and Cecil, C.B. 1985. Paleoclimatic controls on coal resources of the Pennsylvanian System of North America - introduction and overview of contributions. International Journal of Coal Geology, 5: 1-6.

Wagner, R.H. 1984. Megafloral zones of the Carboniferous. Compte rendu 9e Congrès International de Stratigraphie et de Géologie du Carbonifère (Washington, 1979), 2: 109-134.

Zodrow, E.L., and Cleal, C.J. 1985. Phyto- and chronostratigraphical correlations between the late Pennsylvanian Morien Group (Sydney, Nova Scotia) and the Silesian Pennant Measures (south Wales). Canadian Journal of Earth Sciences, 22: 1465-1473.

Microspores or pollen?

Erwin L. Zodrow[1], Josef Pšenicka[2], Jirí Bek[3], Alan R. Hemsley[4], and Christopher Cleal[5]

[1]University College of Cape Breton, Sydney, Nova Scotia, Canada B1P 6L2 (ezodrow@uccb.ns.ca).

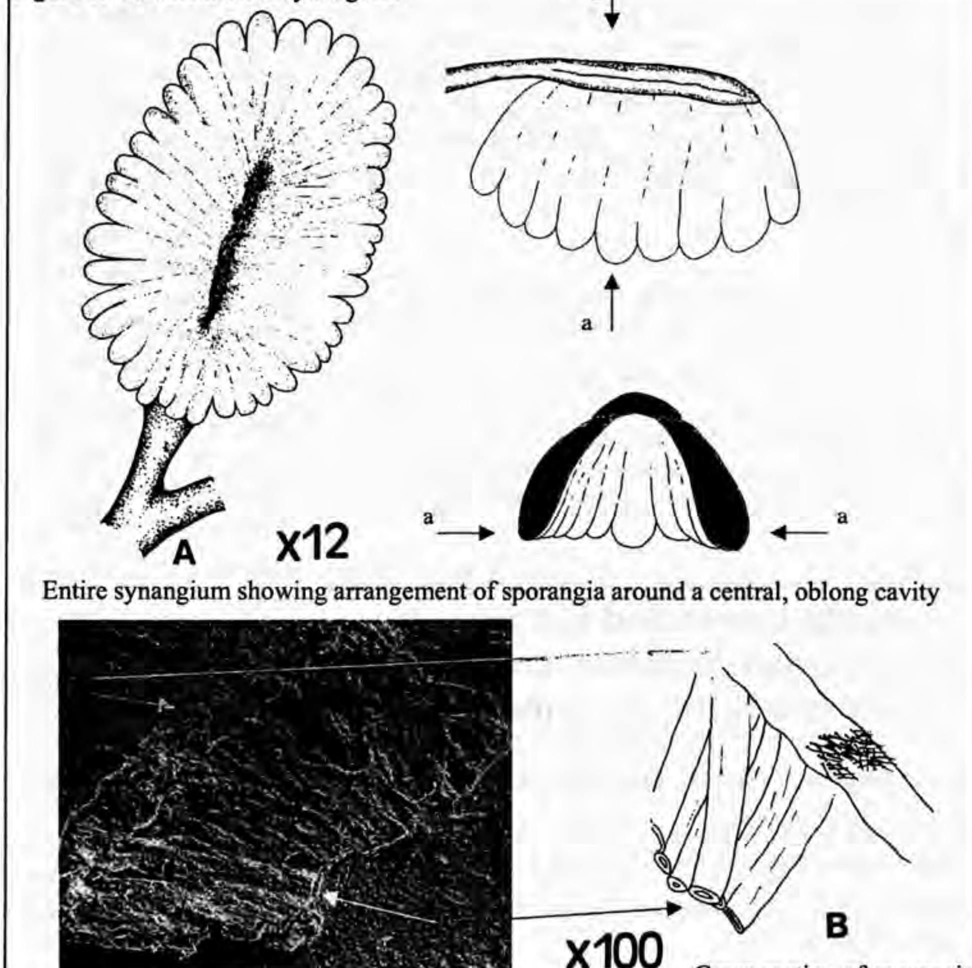
[2]Department of Paleontology, West-Bohemian Museum, Kopeckého sady 2, 301 3 Pilsen, Czech Republic (psenda.paleobot@iol.cz).

[3]Institute of Geology, Academy of Sciences, Rozvojová 135, 165 00 Prague 6, Czech Republic (mrbean@gli.cas.cz).

[4]Laboratory for Experimental Palynology, Department of Earth Sciences, Cardiff University, Cardiff CF1 3YE, UK (HemsleyAR@Cardiff.ac.uk).

[5]National Museums & Galleries of Wales, Department of Biodiversity, Cathays Park, Cardiff CF1 3NP, UK (ChrisCleal@cs.com).

Figure 1. Reconstructed synangium



Entire synangium showing arrangement of sporangia around a central, oblong cavity

Cross section of sporangia.

In the 2000 Carboniferous Newsletter (vol. 18, pp. 33-35) a pilot study of *in situ* pecopterid microspores from the Late Westphalian D in the Sydney Coalfield, Nova Scotia, Canada, was reported by Zodrow, Bek and Pšenicka. In the process of that study, an unusual synangium was noticed. The synangia 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 monolete laevigate microspores corresponding to dispersed species *Latosporites minutus* (smallest, circular form: 27.3 µm on average), *Laevigatosporites minimus* (oval, intermediate size range 20 to 34 µm), and monolete to triletoid microverrucate "microspores" corresponding to dispersed species *Punctatosporites oculus* (oval to circular, largest: 29.6 µm average). Our first impression was that the synangia resembled the marattialean 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 *Whittlesya* synangia as reconstructed by Halle (1933). The most notable difference between the two is that *Whittlesya* 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) monolete laevigate to scabrate palynomorphs isolated from sporangia of marattialean (genera like *Pecopteris, Asterotheca, Acitheca* and others, i.e., spore-producing plants) from pteridosperm plants (genera like *Whittleseya* or *Potonieia*). 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

Brousmiche, C. 1983. Les forgères sphénoptéridiennes du Bassin Houiller Sarro-Lorain. Société Géologique du Nord, Publication n. 10., 480 pp. plus atlas.

Halle, T.G. 1933. The structure of certain spore-bearing organs believed to belong to pteridosperms. Kungliga Svenska Vetenskapsakademiens Handlingar, Ser. 3, 12-6, 1-103, pls. 1-15.

Taylor, T.N. 1967. On the structure and phylogenetic relationships of the fern Radstockia Kidston. Palaeontology, 10: 42-46.

Provisional Lower and Middle Pennsylvanian conodont zonation in Midcontinent North America

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

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

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

[3]Department 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. Sweet (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 Weibel, 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 noduliferous* (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 noduliferous* – *Rhachistognathus primus* Zone of Baesemann and Lane (1985) is defined by the first occurrence of either *D. noduliferous* 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. noduliferous*, and some have argued that the former species may appear during latest Mississippian (see Morrow and Webster, 1992). However, *D. noduliferous* appears just below the first occurrence of *R. primus* in Arrow Canyon (Lane et al, 1999). The *noduliferous-primus* Zone is subdivided into a lower subzone where *Gnathodus girtyi simplex* Dunn 1966 and *G.* cf. *G. bollandensis* Higgins and Bouckaert 1968 overlap with the nominate species, and an upper subzone above the overlap (Brenckle et al., 1977; Baesemann and Lane 1985). The Midcontinent lacks *R. primus*, so this zone is called the *noduliferous* 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. noduliferous* 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-minutus* Zone. Although the *sinuatus-minutus* 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 (Baesemann 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., Baesemann and Lane, 1985), the next zone is the *Idiognathodus sinuosus* Zone, defined by the range overlap of *N. bassleri* and *I. sinuosus* Ellison and Graves 1941 (Lane and Straka, 1974).

The next overlying *Idiognathodus klapperi* Zone of Lane and Straka (1974) was defined by the presence of *I. klapperi* Lane and Straka 1974. Typical *I. klapperi* occurs only in the caprock of the Baldwin coal (Dye Formation) in southern Oklahoma (Lane and Straka, 1974), and Pa elements identical to the type material of *I. klapperi* have not been recovered elsewhere. Grayson et al. (1989; 1990) expanded the concept of *I. klapperi* 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. klapperi* to a series of distinctive late Morrowan Pa elements that had been called *I. delicatus* previously. The first appearance of *I. klapperi* was retained in Grayson's (1990) biostratigraphic model to mark a datum above the *sinuosus* 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. sinuosus,* whether or not *I. klapperi* is present below.

One solution to the inconsistencies and other problems above would be to expand the *bassleri* Zone to include the *sinuosus* and *klapperi* zones. The upper boundary would be the first occurrence of *N.* n. sp. of Lane 1977, as discussed below. Because the appearance of *I. klapperi* (in the expanded sense of Grayson) is a distinctive event in *Idiognathodus, I. klapperi* 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 *Idiognathodus* 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. medadultimus* Merrill 1972 and *N. medexultimus* Merrill 1972 (as in the upper Marble Falls Limestone of Texas: Manger and Sutherland, 1984).

Within the *atokaensis* Zone, a stratigraphically limited acme of gondolellids occurs in the southern Midcontinent and western North America. Mesogondolellids typically assigned to *Mesogondolella clarki* (Koike 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-*bothrops*', '*bothrops*', and *bothrops* 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 southern 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 (Beedeina)* Zone (see Lane and West, 1984; Lambert 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 Lester 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. medadultimus* and *N. medexultimus* based on a hypothetical terminal paedomorphocline (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. laevis*, followed by forms assigned to *G. pohli* 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. pohli* von Bitter and Merrill 1998, and the first occurrence of *N. roundyi* Gunnell 1931 *[sensu lato]*. 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 definite 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 Excello 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. fustiformis* 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 troughed 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 ornately crenulated *G. magna* Stauffer and Plummer 1932, along with non-platformed *G.* cf. *G. denuda* Ellison 1941, in the Lost Branch Formation.

References

Barrick, J. E., and Boardman, D.R. 1989. Stratigraphic distribution of morphotypes of *Idiognathodus* and *Streptognathodus* in Missourian-lower Virgilian strata, north-central Texas. *In:* Late Pennsylvanian chronostratigraphic boundaries in north-central Texas - glacial-eustatic events, biostratigraphy, and paleoecology, a guidebook with contributed papers, pt. II, Contributed papers. D.R. Boardman, J.E. Barrick, J.M. Cocke, and M. Nestell, (eds.), Texas Tech University Studies in Geology 2:167-188.

Barrick, J.E., and Lambert, L.L. 1999. Conodont taxa proposed by Jones (1941) are valid. *In:* P. H. Heckel (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian. Kansas Geological Survey Open File Report 99-27:162-169.

Barrick, J.E., and Walsh, T.R. 1999. Some older North American types of *Idiognathodus* and *Streptognathodus*. *In:* P.H. Heckel (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian. Kansas Geological Survey Open File Report 99-27:147-161.

Barrick, J.E., Boardman, D.R., and Heckel, P.H. 1996. Biostratigraphy across the Desmoinesian-Missourian boundary in North America Midcontinent, USA: Implications for defining the Middle-Upper Pennsylvanian Series boundary. Newsletters in Stratigraphy, 34:161-175.

Barrick, J.E., Heckel, P.H., and Boardman, D.R. 1999. Evolutionary patterns in Late Pennsylvanian *Idiognathodus* and *Streptognathodus* and implications for chronostratigraphic boundary characterization and recognition. *In:* P.H. Heckel (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian. Kansas Geological Survey Open File Report 99-27:178-185.

Baesemann, J.F., and Lane, H.R. 1985. Taxonomy and evolution of the genus *Rhachistognathus* Dunn (Conodonta; Late Mississippian to Early Pennsylvanian). Courier Forschungsinstitut Senckenberg, 74:93-136.

Bender, K.P. 1980. Lower and Middle Pennsylvanian conodonts from the Canadian Arctic Archipelago. Geological Survey of Canada Paper, 79-15:1-29.

Boardman, D.R. 1999. Virgilian and lowermost Permian sea-level curve and cyclothems. *In:* P.H. Heckel (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian, Kansas Geological Survey Open File Report 99-27:103-118.

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

Boardman, D.R., Nestell, M.K., and Wardlaw, B.R. 1998. Uppermost Carboniferous and lowermost Permian deposition and conodont biostratigraphy of Kansas, U.S.A. Paleoworld, 9:19-32.

Brenckle, P., Lane, H.R., Manger, W.L., and Saunders, W.B. 1977. The Mississippian-Pennsylvanian boundary as an intercontinental biostratigraphic datum. Newsletters on Stratigraphy, 6:106-116.

Dunn, D.L. 1970. Middle Carboniferous conodonts from western United States and phylogeny of the platform genera. Journal of Paleontology, 44:312-342.

Dunn, D.L. 1976. Biostratigraphic problems of Morrowan and Derryan (Atokan) strata in the Pennsylvanian System of western United States. Geological Society of America Bulletin, 87:641-645.

Ellison, S.P., Jr., and Graves, R.W. 1941. Lower Pennsylvanian (Dimple Limestone) conodonts of the Marathon region, Texas: University of Missouri School of Mines and Metallurgy, Technical Series Bulletin, v. 14, no. 3, 21 p.

Grayson, R.C., Jr. 1979. Stop Descriptions – Fifth Day. . *In:* P.K. Sutherland, and W.L. Manger, (eds.), Mississippian-Pennsylvanian shelf-to basin transition Ozark and Ouachita regions, Oklahoma and Arkansas. Oklahoma Geological Survey, Guidebook 19:67-81.

Grayson, R.C., Jr. 1984. Morrowan and Atokan (Pennsylvanian) conodonts from the eastern margin of the Arbuckle Mountains, southern Oklahoma. *In:* P.K. Sutherland, and W.L. Manger, (eds.), The Atokan Series (Pennsylvanian) and its boundaries – a symposium. Oklahoma Geological Survey Bulletin, 136:41-61.

Grayson, R.C., Jr. 1990. Canyon Creek: a significant exposure of a predominantly mudrock succession recording essentially continuous deposition from the late Devonian through the Middle Pennsylvanian. Oklahoma Geological Survey Guidebook, 27:85-114.

Grayson, R.C., Jr., Davidson, W.T., Westergaard, E.H., Atchley, S.C., Hightower, J.H., Monoghan, P.T., and Pollard, C. 1985. Mississippian-"Pennsylvanian" (Mid-Carboniferous) boundary conodonts from the Rhoda Creek Formation. *Homoceras* interval in North America. Courier Forschungsinstitut Senckenberg, 74:149-180.

Grayson, R.C., Jr., Merrill, G.K., and Lambert, L.L. 1990. Carboniferous gnathodontid conodont apparatuses: Evidence of a dual origin for Pennsylvanian taxa. *In:* W. Ziegler (ed.), 1st International Senckenberg Conference and 5th European Conodont Symposium (ECOS V), Contributions IV, Papers on conodonts and Ordovician to Triassic conodont Stratigraphy. Courier Forschungsinstitut Senckenberg, 118:353-396.

Grayson, R.C., Jr., Merrill, G.K., Lambert, L.L., Trice, E.L., Vitani, N.M., and Westergaard, E.H. 1987. Middle Pennsylvanian strata of central Texas: Stratigraphic and conodont biostratigraphic relationships. *In:* R.C. Grayson, G.K. Merrill, and J.F. Miller (eds.), Early and Late Paleozoic conodont faunas of the Llano Uplift region, central Texas. Guidebook for Field Trip 1, South-Central Section Geological Society of America. Pp.73-82.

Grayson, R.C., Jr., Merrill, G.K., Lambert, L.L., and Turner, J., Jr. 1989. Phylogenetic basis for species recognition within conodont genus *Idiognathodus* applicability to correlation and boundary placement. *In:* D.R. Boardman, J.E. Barrick, J.M. Cocke, and M. Nestell, (eds.), Missourian-lower Virgilian strata, north-central Texas: Late Pennsylvanian chronostratigraphic boundaries in north-central Texas - glacial-eustatic events, biostratigraphy, and paleoecology, a guidebook with contributed papers, pt. II, Contributed papers. Texas Tech University Studies in Geology, 2:75-94.

Groves, J.R. 1986. Foraminiferal characterization of the Morrowan-Atokan (lower Middle Pennsylvanian) boundary. Geological Society of America Bulletin, 97:346-353.

Heckel, P.H. 1989. Updated Middle-Upper Pennsylvanian eustatic sea-level curve for Midcontinent North America and preliminary biostratigraphic characterization. XI International Carboniferous Congress, 1987, *Compte Rendu*. Academica Sinica, Beijing, China, 4:160-185.

Heckel, P.H. 1994. Evaluation of evidence for glacial-eustatic control over marine Pennsylvanian cyclothems in North America and consideration of possible tectonic effects. *In:* Dennison, J.M., and F.R. Ettensohn, (eds.), Tectonic and Eustatic Controls on Sedimentary Cycles, SEPM Concepts in Sedimentology and Paleontology, No. 4:65-78.

Heckel, P.H. 1999. Overview of Pennsylvanian (Upper Carboniferous) stratigraphy in Midcontinent region of North America. *In:* P.H. Heckel, (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian, Kansas Geological Survey Open File Report, 99-27:68-102.

Heckel, P.H., and Weibel, C.P. 1991. Current status of conodont-based biostratigraphic correlation of Upper Pennsylvanian succession between Illinois and Midcontinent. *In:* C.P. Weibel, (ed.), Sequence Stratigraphy in Mixed Clastic-Carbonate Strata, Upper Pennsylvanian, East-central Illinois. Great Lakes Section, SEPM, 21st Annual Field Conference, Illinois State Geological Survey:60-69.

Heckel, P.H., Alekseev, A.S., and Nemyrovska, T.I. 1998. Preliminary conodont correlation of late Middle to early Upper Pennsylvanian rocks between North America and eastern Europe. Newsletter on Carboniferous Stratigraphy, 16:8-12.

Jones, D.J. 1941. The conodont fauna of the Seminole Formation of Oklahoma. Private Edition, University of Chicago Libraries, Chicago, Illinois:1-55.

Lambert, L.L. 1992. Atokan and basal Desmoinesian conodonts from central Iowa, reference area for the Desmoinesian Stage. *In:* P.K. Sutherland, and W.L. Manger, (eds.), Recent advances in Middle Carboniferous biostratigraphy. Oklahoma Geological Survey Circular, 94:111-123.

Lambert, L.L., and Grayson, R.C., Jr. 1993. Complexity in *Neognathodus*. (Pennsylvanian Conodonta) - Heterochrony, polymorphism, and recurrent morphotypes. Geological Society of America, Abstracts with Programs, 25:33.

Lambert, L.L., and Heckel, P.H. 1990. The Atokan/Desmoinesian boundary in North America: Preliminary considerations for selecting a boundary horizon. Courier Forschungsinstitut Senckenberg, 130:307-318.

Lambert, L.L., and Heckel, P.H. 1999. A distinct clade of troughed idiognathodid conodonts that precedes the appearance of *Streptognathodus*. *In:* P.H. Heckel, (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian, Kansas Geological Survey Open File Report, 99-27:174-177.

Lane, H.R. 1967. Uppermost Mississippian and lower Pennsylvanian conodonts from the type Morrowan region, Arkansas. Journal of Paleontology, 41:920-942.

Lane, H.R. 1977. Morrowan (Early Pennsylvanian) conodonts of northwestern Arkansas and northeastern Oklahoma. *In:* P. K. Sutherland, and W. L. Manger, (eds.,), Upper Chesterian-Morrowan Stratigraphy and the Mississippian-Pennsylvanian boundary in northeastern Oklahoma and northwestern Arkansas. Oklahoma Geological Survey Guidebook, 18:177-180

Lane, H.R., and Baesemann, J.F. 1982. A Mid-Carboniferous boundary based on conodonts and revised intercontinental correlations. *In:* W.H.C. Ramsbottom, W.B. Saunders, and B. Owens, (eds.), Biostratigraphic data for a Mid-Carboniferous boundary. Subcommission on Carboniferous Stratigraphy, Leeds: 6-12.

Lane, H.R., Brenckle, P.L., Baesemann, J.F., and Richards, B. 1999. The IUGS boundary in the middle of the Carboniferous: Arrow Canyon, Nevada, USA. Episodes, 22:272-283.

Lane, H.R., and Straka, J.J. 1974. Late Mississippian and Early Pennsylvanian conodonts, Arkansas and Oklahoma. Geological Society of America Special Paper 152:1-144.

Lane, H.R., and West, R.R. 1984. The inadequacies of Carboniferous serial nomenclature: North American examples. *In:* P.K. Sutherland and W.L. Manger, (eds.), The Atokan Series (Pennsylvanian) and its boundaries – a symposium. Oklahoma Geological Survey Bulletin, 136:91-100.

Lane, H.R., Merrill, G.K., Straka, J.J., and Webster, G.D. 1971. North American Pennsylvanian conodont biostratigraphy. Geological Society of America Memoir, 127: 395-414.

Manger, W.L., and Sutherland, P.K. 1984. Preliminary conodont biostratigraphy of the Morrowan-Atokan boundary (Pennsylvanian), eastern Llano uplift, central Texas. *In:* P.K., Sutherland and W.L. Manger, (eds.), The Atokan Series (Pennsylvanian) and its boundaries – a symposium. Oklahoma Geological Survey Bulletin 136, 115-121.

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

Merrill, G.K. 1975a. Pennsylvanian conodont biostratigraphy and paleontology of northwestern Illinois. Geological Society of America Microform Publication, 3: 1-130.

Merrill, G.K. 1975b. Pennsylvanian conodonts of northwestern Illinois – Summary and new systematics. Geology, 3: 721-722.

Merrill, G.K. 1999. *Neognathodus* and the species concept in conodont paleontology. Bollettino della Societá Paleontologica Italiana, 37: 465-473.

Morrow, J., and Webster, G.D. 1992. New stratigraphic, petrographic, and biostratigraphic data on the proposed Mississippian-Pennsylvanian boundary stratotype, Granite Mountain, west-central Utah. Oklahoma Geological Survey Circular, 94:55-67.

Rice, C.L., Kosanke, R.M., and Henry, T.W. 1994. Revision of nomenclature and correlations of some Middle Pennsylvanian units in the northwestern part of the Appalachian basin, Kentucky, Ohio, and West Virginia. Geological Society of America Special Paper, 294:7-26.

Ritter, S.M. 1994. New species and subspecies of *Streptognathodus* (Conodonta) from the Virgilian (Late Carboniferous) of Kansas. Journal of Paleontology, 68:870-877.

Ritter, S.M. 1995. Upper Missourian - Lower Wolfcampian (upper Kasimovian - Lower Asselian) conodont biostratigraphy of the Midcontinent, U.S.A.. Journal of Paleontology, 69:1139-1154.

Ritter, S.M., and Barrick, J.E. in press, Conodont biostratigraphy of the Hermosa Group (Upper Carboniferous at Honaker Trail, Paradox Basin, Utah. Journal of Paleontology.

Ritter, S.M., Barrick, J.E., Wahlman, G.P., and Skinner, M.R. 1999. Stratal and faunal relationships across the Desmoinesian-Missourian boundary at Honaker Trail, Paradox basin, Utah: a sequence biostratigraphic approach. *In:* P.H. Heckel, (ed.), Guidebook, Fieldtrip #8, XIV International Congress on the Carboniferous-Permian. Kansas Geological Survey Open File Report 99-27:199-207.

Sutherland, P.K., and Manger, W.L. 1984. The Atokan Series: an interval in search of a name. *In:* P.K. Sutherland, and W.L. Manger, (eds.), The Atokan Series (Pennsylvanian) and its boundaries – a symposium. Oklahoma Geological Survey Bulletin, 136:1-8.

Swade, J.W. 1985. Conodont distribution, paleoecology, and preliminary biostratigraphy of the upper Cherokee and Marmaton Groups (upper Desmoinesian, Middle Pennsylvanian) from two cores in south-central Iowa. Iowa Geological Survey Technical Information Series, 14:1-71.

Sweet, W.C. 1988. The Conodonta: Morphology, Taxonomy, Paleoecology, and Evolutionary History of a Long-Extinct Animal Phylum. Oxford Monographs on Geology and Geophysics, Oxford University Press, No. 10: 1-212.

Von Bitter, P.H., and Merrill, G.K. 1977. Neogondolelliform conodonts of Early and Middle Pennsylvanian age. Royal Ontario Museum, Life Sciences Occasional Paper, 29:1-10.

Von Bitter, P.H., and Merrill, G.K. 1990. Effects of variation on the speciation and phylogeny of *Diplognathodus*. Courier Forschungsinstitut Senckenberg, 118:105-129.

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

Series	Stage	*Neognathodus* ZONE	Additional *Neognathodus*	Idiognathodids	Other taxa
MIDDLE PENNSYLVANIAN	DESMOINESIAN	*roundyi*	*dilatus* "terminal taxa" *websteri*	New Genus S *I.* sp. 3 Swade	G. magna ? rare crenulated gondolellids
		asymmetricus	*inequalis* ? (several Eurasian species)	*amplificus* descendants	*G. pohli* non-crenulated gondolellids ?
		caudatus		*amplificus*	
	ATOKAN	*colombiensis*	*bothrops/* *"bothrops"/* *"pre-bothrops"*	*incurvus* descendants	* Extinction of *Declinognathodus Idiognathoides*
		atokaensis	*uralicus/* *kashiriensis*	*incurvus*	* mesogondolellids common * * 'naked' gondolellids common
		Neog. n. sp.	spp. A & B (Grayson, 1990)	after Baesemann & Lane (1985) *convexus*	
LOWER PENN.	MORROWAN	*bassleri*	(several Eurasian species)	*klapperi* *sinuosus* *bassleri*	
		symmetricus		*symmetricus*	
		higginsi		*sinuatus* U / L *noduliferus*	
MISS.		*girtyi*		*muricatus*	

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, Oboronnaja 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 Kayalian 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.

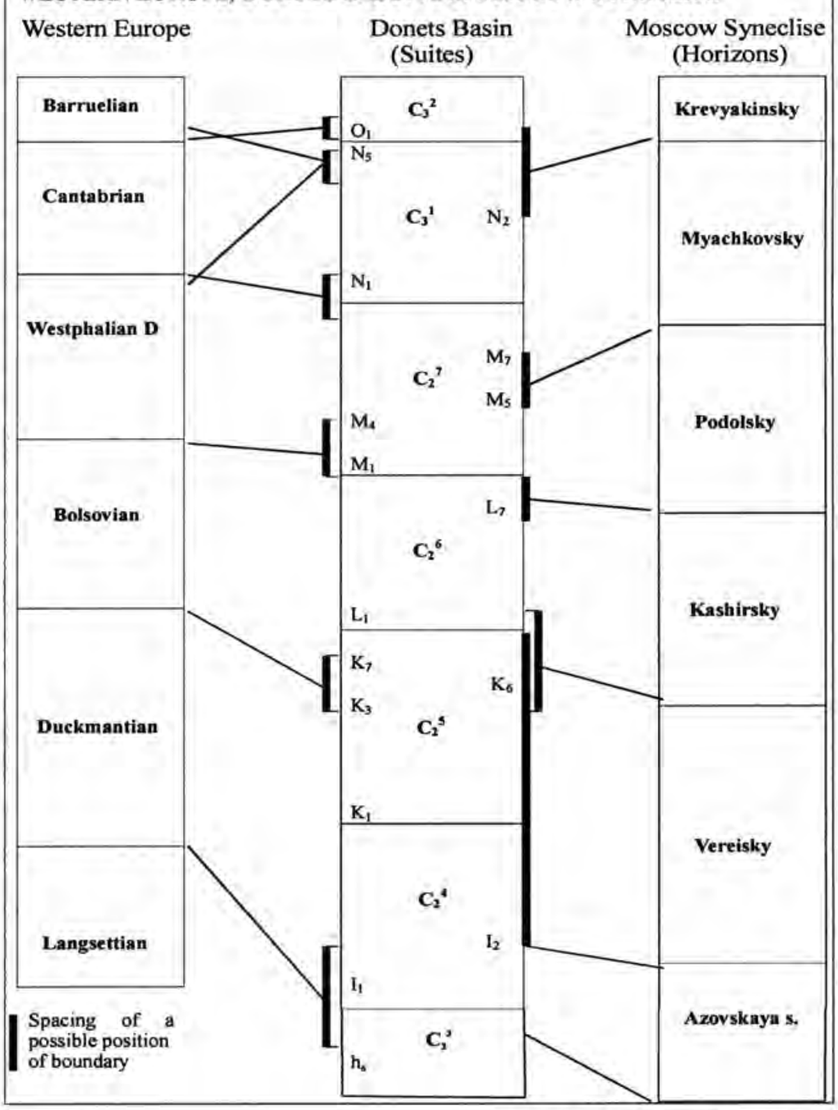
Sections in the Donets Basin are closely spaced, in which the Carboniferous succession has a number of unrivaled qualities, including: it is continuous, it is polyfacial, it is well characterized by all groups of fauna and flora, it is accessible to observation, and is well exposed. For a solution to the problems of the boundaries of the Moscovian Stage in this region, the Suites C_2^3 – C_2^5 (lower boundary of stage), and the Suites C_2^7 – C_3^2 (upper boundary of stage) should be investigated.

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 Shterovka, 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 Syneclise, 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



Fusulinid and conodont zonation of the type Moscovian Stage

T.N. Isakova, N.V. Goreva, A.S. Alekseev [1], M.Kh. Makhlina

[1]Department 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 overlay 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 paleo-valleys are filled with late Bashkirian alluvial sands and aestuarine 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 (Makhlina et al., in press).

Twelve foraminiferal 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 *Idiognathoides ouachitensis* in the Vereian).

Several fusulinid levels are important:

1. The *Aljutovella aljutovica* Zone of the basal Verian Aljutovo Formation, which contains representatives of more an-

SUBDIVISION OF THE MIDDLE CARBONIFEROUS IN SOUTHWESTERN MOSCOW SYNECLISE

Series	Stage	Substage	Formation	Member	Fusulinid zonation	Conodont zonation
UPPER	KASIMOVIAN	KREVYAKINIAN	Voskresensk		Protriticites subschwagerinoides, Obsoletes obsoletus (14)	Streptognathodus makhlinae (Sm)
			Suvorovo	Upper	Obsoletes sp., Fusiella lancetiformis (13)	Streptognathodus subexcelsus (Ss)
				Lower		
MIDDLE	MOSCOVIAN	MYACHKOVIAN	Peski	Volodarsky	Protriticites ovatus (12)	Neognathodus roundyi (Nr)
				Titovo		
				Kamenno-Tyazhino	Fusulina cylindrica (11)	
			Domodedovo	Gubastovo		
				Panshino		
			Korobcheevo	Rozhaya	Fusulinella bocki (10)	Neognathodus inaequalis (Ni)
				Nikitskoe		
				Stary Yam		
		PODOLSKIAN	Stshurovo	Pirochi	Fusulina chernovi (9)	
				Prioksky		
				Desna		
			Ulitino	Staraya Rusa	Fusulinella colaniae, Beedeina ulitinensis (8)	
				Aleksandrovka		
				Pakhra		Idiognathodus podolskensis-Neognathodus medexultimus (Ip-Nm)
			Vaskino	Korenevo	Putrella brazhnikovae (7)	
				Obraztsovo		
		KASHIRIAN	Smedva	Shugorovo	Hemifusulina vozhgalica (6)	Streptognathodus concinnus-Idiognathodus robustus (Sc-Ir)
				Zavarykino		
				Mikhnevo		
			Lopasnya	Kubasovo	Moellerites praecolaniae Fusulinella subpulchra (5)	Neognathodus medadultimus (Nm)
				Zalugi		
				Khatun		Neognathodus bothrops (Nb)
			Nara	Zabelino	Hemifusulina moelleri, Beedeina pseudoelegans (4)	
				Murzino		
				Kiyasovo		
			Tsna	Sloboda	Priscoidella priscoidea (3)	
				Inino		
				Yambirno		
		VEREIAN	Ordynka		Ovatella arta (2)	Streptognathodus transitivus (St)
						Idiognathoides ouachitensis (Io)
			Skniga		Aljutovella aljutovica (1)	Declinognathodus donetzianus (Dd)
			Aljutovo			
	BASHKIRIAN	MELEKESSIAN	Novoe Selo	Cherevo		
				Porechie		
			Sukhodrev	Chausovo		
				Ryblovo		

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, Hemifusulina* and *Taitzehoella*.

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-Kamaina kamensis* Zone contains rare *Wedekindellina* and *Parawedekindellina*.

5. The lower Myachkovian foraminiferal assemblage is dominated by the *Fusulinella 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 K_2-K_5) and in the Aegiranum Marine Band of the basal Westphalian C (Bolsovian) of Western Europe.

2. The Lower Podolskian *Idiognathodus podolskensis–Neognathodus medexultimus* 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

Barskov, I.S., and Alekseev, A.S. 1975. Middle and Upper Carboniferous conodonts of the Moscow Basin. Izvestiya Akedemii Nauk SSSR. Seriya geologicheskaya. 5. P. 84-99 (in Russian).

Makhlina, M.Kh., Alekseev, A.S., Goreva, N.V., Isakova, T.N., Goryunova, R.V., Kossovaya, O.L., Lazarev, S.S., Lebedev, O.A., and Shkolin, A.A. In press. Middle Carboniferous of Moscow Syneclise (southern part). Moscow, Paleontological Institute. 248 p. (In Russian).

Nikitin, S.N. 1890. Carboniferous of the Moscow area and artesian waters under Moscow. Trudy Geologicheskogo Komiteta. 5(1). 182 p. (in Russian).

Rauser-Chernousova, D.M., and Reitlinger, E.A. 1954. Biostratigraphic distribution of foraminifera in the Middle Carboniferous of the southern flank of the Moscow Basin. Regionalnaya Stratigrafiya SSSR. 2. P. 7-120 (in Russian).

The terminal stage of the Carboniferous: Orenburgian versus Bursumian

Vladimir L. Davydov

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

Introduction

Ross and Ross (1987; 1994; 1998) recently proposed the new Bursumian Stage to fill a gap between the newly defined base of the Permian (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 Bursumian Stage to the Pennsylvanian Subsystem above the Virgilian and below the new [in North America - *V.D.*] Permian boundary…does not confuse the existing nomenclature" (Ross and Ross, 1998, p.42). Although the Bursumian 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 terminal stage of the Pennsylvanian Subsystem and therefore logically can be considered as a new Bursumian Stage in the International Stratigraphic Scale.

Several problems exist with understanding and usage of the uppermost Carboniferous Bursumian Stage and the lowermost Permian 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/Permian transition is believed to be most complete, the stratigraphic content of the Bursumian has been changed several times in the past decade. The top of the Bursumian 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 Bursumian Stage several times.

No stratotype for either the Bursumian 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 "...Bursum 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 Bursum Formation in order to provide adequate stratigraphic and biostratigraphic characteristic of the Bursumian 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 Bursum Formation in its type section in the sense of chronostratigraphy: "the base of Bursumian 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 Bursum Formation is overlain by terrestrial rocks of the Abo Formation and therefore the top of the Bursumian in its type section cannot be defined either biostratigraphically or chronostratigraphically. The upper third of the Bursum 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-Permian boundary should most probably be placed somewhere within the Bursumian Stage (Fig. 1) in North America. In the Glass Mountains in west Texas, the Carboniferous-Permian boundary appears to be within the Grey Limestone of the Gaptank Formation and in the Bursumian type section in south-central New Mexico, within the Bursum Formation (Wardlaw and Davydov, 2000).

Conodont correlations (Wardlaw and Davydov, 2000) suggest that the Bursumian most probably corresponds to a single fusulinid zone *(Ultradaixina bosbytauensis-Schwagerina robusta* Zone) in the southern Urals succession. The duration of the Bursumian Stage in chronostratigraphic terms could be estimated approximately as 1.0-1.5 Ma (Davydov et al., 1999) depending on which definition of the Bursumian is used and its corresponding volume in the Kansas succession. Therefore, if the Bursumian was included in the Pennsylvanian succession it would be one of the smallest stages in the Late Paleozoic geochronological scale.

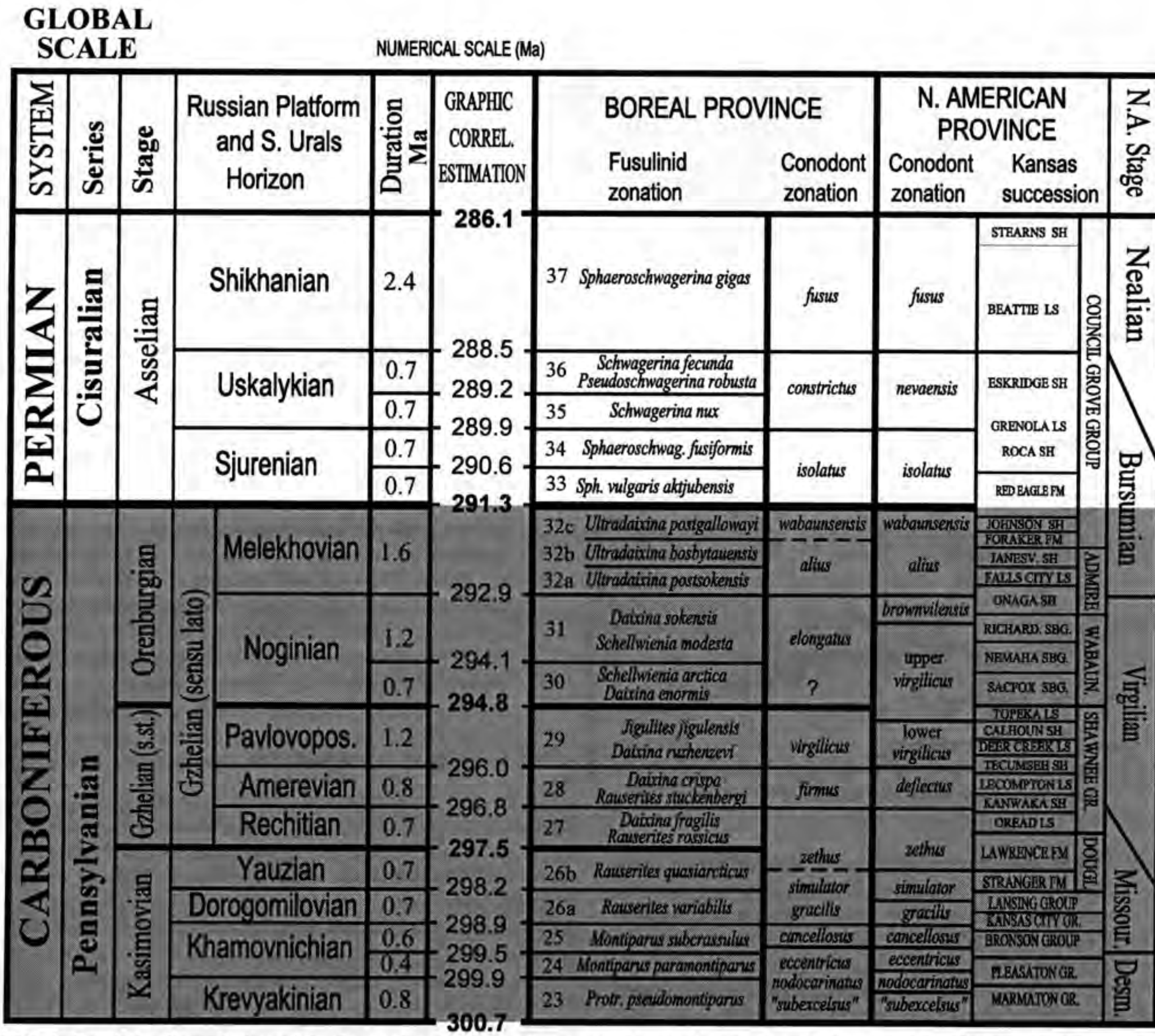


FIG. 1 Provisional correlation of the Pennsylvanian-Cisuralian succession in the Russian Platform-southern Urals and Kansas. The Pennsylvanian-Cisuralian fusulinacean zonal succession of the Boreal Province is adopted from Davydov (1996) and Krainer and Davydov (1998) and is scaled in terms of chronological units established with graphic correlation. Durations of fusulinacean zones shown in millions years were constituted using graphic correlation. Conodont zonation in the Russian Platform-southern Urals is based on Barskov and Alekseev (1979); Barsokov (1984); Chernykh (1989); Chernykh and Ritter (1996). Conodont zonation in Kansas is based on Ritter (1995); Heckel et al. (1998); and Boardman et al. (1998).

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 conodont phylogenetic succession *Streptognathodus wabaunsensis-St.isolatus* (Chernykh and Ritter, 1997). This boundary closely coincides with the traditional boundary proposed by Ruzhenzev (1951, 1954) and with the base of the *Sphaeroschwagerina 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 Gzhel' and Rusavkino and a series of exposures of dolomite along the Klyaz'ma River from Naberezhnaya village to Pavlov-Posad city. Therefore, the Gzhelian as based on the proposed series of type-sections originally included the Rechitsian (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 Oksko-Tsinsky Swell as limited by the beds with "*Schwagerina*" (= *Sphaeroschwagerina* 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

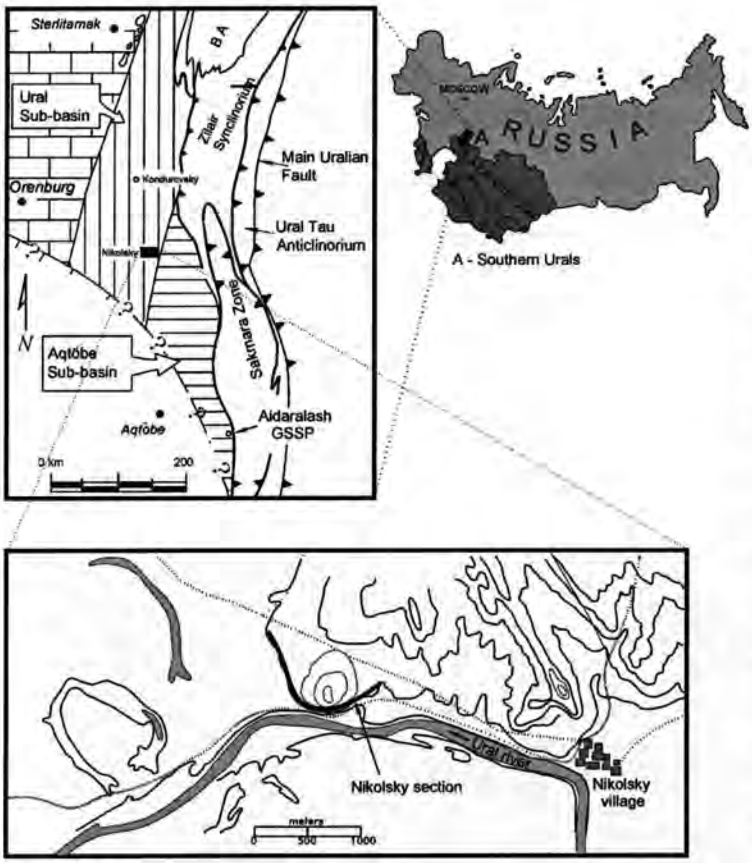


FIG. 2 Location map of the Nikol'sky section in the southern Urals region.

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 *Daixina sokensis* fusulinid Zone) defined as the Noginian Horizon (Makhlina et al., 1975). The stratigraphic position of the upper portion of this interval equal to the *Ultradaixina bosbytauensis-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 Melekhovian Horizon for this questionable stratigraphic interval.

The Orenburgian Stage was established by Ruzhenzev (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. Ruzhenzev 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 (Kireeva et al., 1971; Pnev et al., 1975). However, recently this miscorrelation has been recognized and a new *Ultradaixina bosbytauensis-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 Ruzhenzev (1954) and with the base of *Sphaeroschwagerina 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 chronostratigraphy. 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 (Alekseev 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-Uralian foredeep (Fig. 2). The type section of the Orenburgian - the Nikol'sky section - is located on the north (right) side of the Ural 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 prodeltaic shales, calcareous sandstones, conglomerates and limestones (Fig. 3) (Ruzhenzev, 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-slump) horizon, 260 mab in Nikol'sky section (Ruzhenzev, 1952). However, based on the appearance of significant assemblages of progressive fusulinaceans such as *Ditkevitchia, Schellwienia* and *Zigarella*, and on the presence of a very significant *Daixina sokensis* 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). Ruzhenzev 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 Ruzhenzev 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 Ruzhenzev from Nikol'sky section allowed him to establish a distinctive Orenburgian ammonoid assemblage (Orenburgian biochronotype of Ruzhenzev) and to recognize the stage globally (Ruzhenzev, 1950; Ruzhenzev and Bogoslovskaya, 1976). However, several typical Orenburgian ammonoids, including *Artinskia, Aristoceras, Vidrioceras* and *Emilites*, were recently found as low as the lower Gzhelian (Zakharov, 1971; Bogoslavskaya and Popov, 1986; Popov, 1992). Therefore, redefinition of the criteria for recognition of

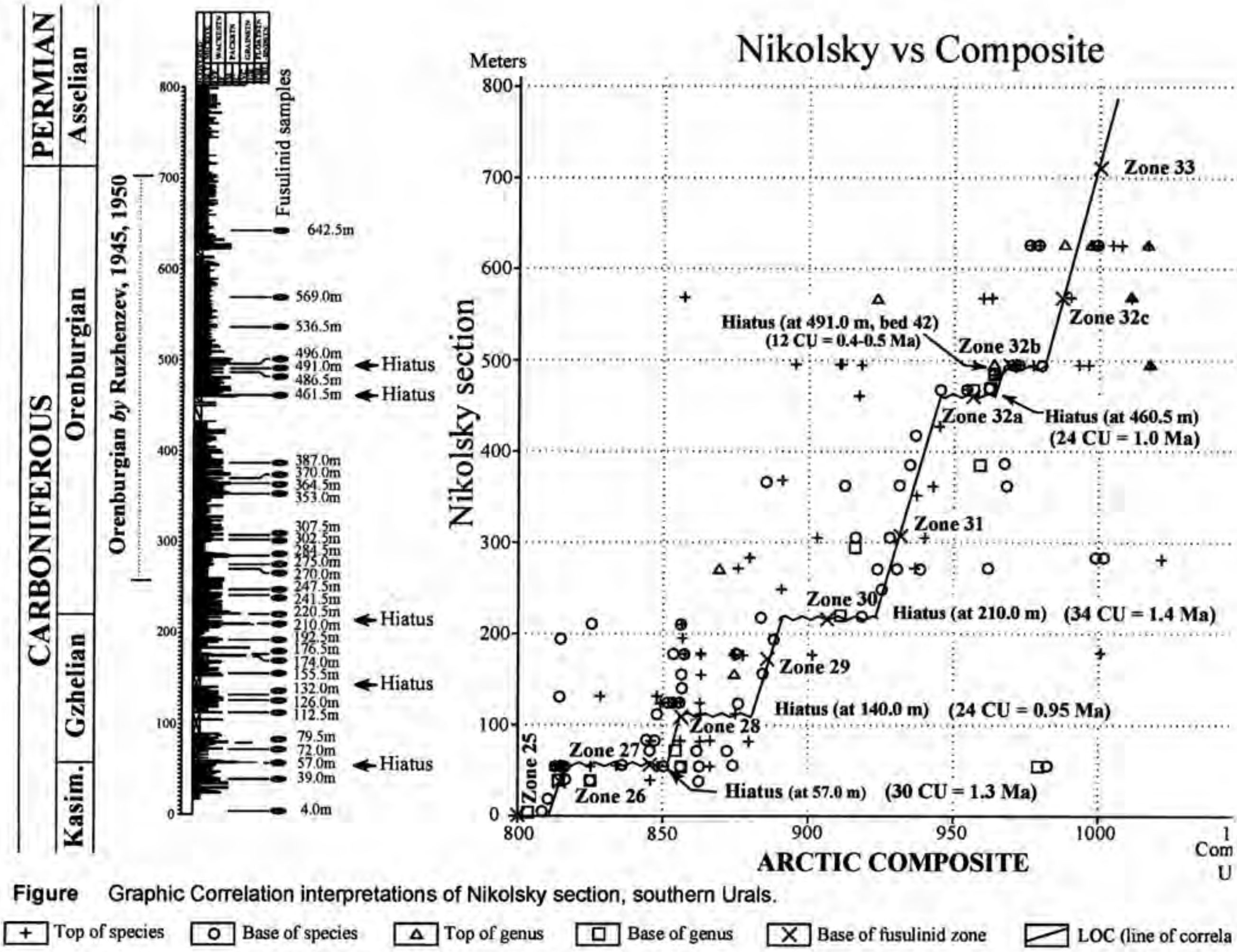


FIG. 3 Stratigraphic succession in the Nikol'sky section. On the left is the late Pennsylvanian stratigraphic succession in the Nikol'sky section. On the right is Graphic Correlation of the Nikol'sky section. Vertical axis on the graph represents the exact (linear) measurement of the section. Horizontal axis represents a chronostratigraphic 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 Orenburgian fusulinid fauna in both the Boreal and Tethyan provinces is quite prominent and different from the fusulinid faunas of the underlying Gzhelian (*sensu stricto*) and overlying Asselian Stages. At least four fusulinid genera *Ditkevitchia, Ruzhenzevites, Schellwienia* and *Zigarella* first appeared at the beginning of the Orenburgian. Several other fusulinid genera such as *Licharevites, Ultradaixina, Occidentoschwagerina, Schwagerina*, and *Rugosochusenella* appeared slightly higher at the base or near the base of *Ultradaixina bosbytauensis-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 sokensis-Schellwienia modesta* and *Ultradaixina bosbytauensis-Schwagerina robusta*. The latter is divided into three subzones in the southern Urals, Donets Basin, Central Asia and Carnic 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. wabaunsensis* 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. wabaunsensis* Zones of the Russian Platform and Urals with the *St. virgilicus, St. brownvillensis* and *St. wabaunsensis* 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 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. holtensis*. In the southern Urals the latter species was found in the Nikol'sky section in the middle Gzhelian (FAD125-LAD200 mab; Chernykh and Ritter, 1996).

The Gzhelian-Orenburgian-Asselian succession in the Nikol'sky 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'sky 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'sky 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'sky 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 *Streptognathodus 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 (Alekseev et al., 1996; Davydov et al., 1999; Leven and Davydov, 2001; see also figure 3 in this paper). *Streptognathodus zethus* was originally described from the very base of bed 4 in the Usolka section (Chernykh and Reshetkova, 1988) which on the basis of fusulinid distributions belongs in the upper Kasimovian (Chuvashov et al., 1990). In the Nikol'sky 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 Rusavkian (or Rechitsian) Horizon of the Russian Platform requires additional consideration.

Conclusions:

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

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

2. The Bursumian 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 Bursumian 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 Bursumian 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 chronostratigraphy. 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'sky 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 targeted to be close to the boundary originally proposed by Ruzhenzev.

References

Akhmetshina, L.Z. 1990. Conodonts from the Carboniferous-Permian boundary beds in the eastern margin of the PriCaspian depression. Bulletin of Moscow Society of Natural Study, geological series, vol. 65, no 1, p. 80-89. (In Russian)

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

Baars, D.L., Ross, C.A., Ritter, S.M., and Maples, C.G. 1994. Proposed repositioning of the Pennsylvanian-Permian boundary in Kansas, *In:* Baars, D.L., ed., Revision of stratigraphic nomenclature in Kansas. Kansas Geological Survey Bulletin, v. 230, p. 5-10.

Barrick, J.E., and Heckel, P.H. 2000. A provisional Conodont Zonation for Late Pennsylvanian (late Late Carboniferous) strata in Midcontinent region of North America. Newsletter on Carboniferous stratigraphy, vol. 18, p. 15-22.

Barskov, I.S. 1984. Zonal conodont scale of the upper Carboniferous and Asselian stage of the lower Permian and problems of its improvement. *In:* V.V. Menner and A.D. Grigorieva (eds.). Upper Carboniferous of the U.S.S.R... Transactions of Stratigraphical Committee of U.S.S.R., vol. 13. Nauka Publishing House, Moscow, p. 102-107. (In Russian)

Barskov, I.S., and Alekseev, A.S. 1979. Conodonts of the middle and upper Carboniferous of the Moscow Basin. News of the Academy of Sciences of the USSR, series geological, no 6, p. 84-99. (In Russian)

Barskov, I.S., Isakova, T.N., and Schastlivtseva, N.P. 1981. Conodonts from the Gzhelian-Asselian boundary beds (southern Urals). News of the Academy of Sciences of the USSR, series geological, no 5, p. 78-87. (In Russian)

Boardman, D.R., Nestell, M.K., and Wardlaw, B.R. 1998. Uppermost Carboniferous and lowermost Permian deposition and conodont biostratigraphy of Kansas, USA, *In:* Yugan, Jin, Wardlaw, B.R., Yue, and Wang, eds., Permian stratigraphy, environments and resources, v. 2, Stratigraphy and Environments, Palaeoworld 9, p. 19-32.

Bogoslovskaya, M.F., and Popov A.V. 1986. New species of ammonoids from the Carboniferous/Permian Boundary beds of the southern Urals. *In*: Carboniferous/Permian Boundary beds of the Urals, Pre-Urals area and Central Asia. B.I. Chuvashov, E.Ya. Leven, and V.I. Davydov (eds.). Nauka Publishing House, Moscow, p. 125-129. (In Russian)

Chernykh, V.V., and Ritter, S.M. 1996. Conodont biostratigraphy of the Nikolsky section (southern Urals): a progress report. Permophiles, no 29, p. 37-40.

Chernykh, V.V., and Ritter, S.M. 1997. *Streptognathodus* (Conodonta) succession at the proposed Carboniferous-Permian boundary stratotype section, Aidaralash Creek, Northern Kazakhstan. Journal of Paleontology, v. 71, no 3, p. 459-474.

Chernykh, V.V., Ritter, S.M., and Wardlaw, B.R. 1997. *Streptognathodus isolatus* new species (Conodonta): proposed index for the Carboniferous-Permian boundary. Journal of Paleontology, v. 71, p.162-164.

Chuvashov, B.I., and Chernykh, V.V. 1991. Conodont zonation in the Lower Permian. Program with abstracts, First International Congress of the Permian System, Sverdlovsk, p. A21.

Davydov, V.I. 1984. Zonal fusulinid subdivisions of the Upper Carboniferous of the southwestern Darvas. Bulletin of Moscow Society of Natural Studies, Geological Series, vol. 59, no 3, p. 41-57. (In Russian)

Davydov, V.I. 1986. Upper Carboniferous and Asselian fusulinids of the Southern Urals., *in:* Chuvashov, B.I., Leven, E.Ya., and Davydov, V.I., eds., Carboniferous—Permian Boundary beds of the Urals, Pre-Urals and Central Asia, Moscow, Nauka Publishing House, p. 77-103. (In Russian)

Davydov, V.I. 1990. Zonal fusulinid subdivisions of Gzhelian in Donets Basin and Pre-Donets Trough. Problems of Modern Micropaleontology. Transactions of Paleontological Society Session, Leningrad, v. 34, p. 52-69. (In Russian)

Davydov, V.I. 1993. The Carboniferous/Permian boundary in Russia and its position in the Aidaralash type section of the Urals. Permophiles, Newsletter of SCPS, 23, p. 5-8.

Davydov, V.I. 1996. Fusulinid biostratigraphy and correlation of Moscovian-Guadalupian North American, Tethyan and Boreal (Russian Platform/ Uralian) standards. Permophiles, 29, p. 47-52.

Davydov, V.I., Anisimov, R.M., and Nilsson, I. 1999. Upper Paleozoic Sequence stratigraphy of the Arctic Region implied from Graphic Correlation: Spitsbergen and the Barents Sea shelf; *In:* Yin, Hongfu and Tong, Jinnan, eds., Pangea and the Paleozoic-Mesozoic transition. Hubei, China University Geosciences Press, p. 94-97.

Davydov, V.I., Barskov, I.S., Bogoslovskaya, M.F., Leven, E.Ya., Popov, A.V., Akhmetshina, L.Z., and Kozitskaya, R.I. 1992. The Carboniferous/Permian boundary in the former U.S.S.R. and its correlation. International Geology Review, v. 34, no. 90, p. 889-906.

Davydov, V.I., Barskov, I.S., Bogoslovskaya, M.F., and Leven, E.Ya. 1994. Carboniferous- Permian boundary in the stratotype sections of the southern Urals and its correlation. Stratigraphy and Geological Correlation, v. 2, no. 3, p. 32-45. (In Russian and English)

Davydov, V.I., Glenister, B.F., Spinosa, C., Ritter, S.M., Chernykh, V.V., Wardlaw, B.R., and Snyder, W.S. 1998. Proposal of Aidaralash as Global Stratotype Section and Pointy (GSSP) for base of the Permian System Episodes v.21, no 1, p.11-18.

Davydov, V.I., and Kozur, H. 1997. Position of the Carboniferous/Permian Boundary in the Carnic Alps compared with the stratotype region. Proceeding of XIII International Congress on the Carboniferous and Permian, Warszawa, p. 123-130.

Davydov, V.I., and Popov A.V. 1986. Upper Carboniferous and Lower Permian sections of the southern Urals, in: Chuvashov, B.I.,. Leven, E.Ya ., and Davydov, V.I., eds., Carboniferous-Permian Boundary beds of the Urals, Pre-Urals area and Central Asia. Moscow, Nauka Publishing House, p. 29-33. (In Russian)

Davydov, V.I., and Popov A.V. 1993. Nikolsky section. Permian System: Guidebook to geological excursions in the Uralian type localities. Occasional Publication ESRI, New Series, no. 10, p. 120-130.

Heckel, P.H. 1989. Updated Middle-Upper Pennsylvanian eustatic sea-level curve for the Midcontinent North America and preliminary biostratigraphic characterization: Onieme Comgres International de Stratigraphie et de Geologie du Carbonifere, Beijing, 1987, Compte Rendu, vol. 4, p. 160-185.

Heckel, P.H., Alekseev, A.S., and Nemyrovska, T.I. 1998. Preliminary conodont correlations of late Middle to early Upper Pennsylvanian rocks between North America and eastern Europe. Newsletters on Carboniferous Stratigraphy, 16, p. 8-12.

Ivanova, E.A., and Khvorova, I.V. 1967. Biostratigraphy of the Upper Carboniferous of the Russian Platform in the light of the type sections study. Moscow Society of Natural Studies Bulletin, Geological series, vol. 42, no 5, p. 89-99. (In Russian)

Kireeva, G.D., Scherbovich, S.F., Dobrokhotova, S.V., Ketat, O.B., Malkovsky, F.S., Sjomina, S.A., Chernova, I.A., and Yagofarova, F.Z. 1971. *Schwagerina vulgaris* and *Schwagerina fusiformis* zone of the Asselian Stage of the Russian Platform and the western slope of the southern Urals. Questions of micropaleontology, no 14, p. 70-102. (In Russian)

Kotlyar, G.V., (Ed.). 1977. Stratigraphic lexicon of the USSR. Carboniferous and Permian. Leningrad, Nedra Publishing House, p. 1-535. (in Russian)

Leven, E.Ya., and Davydov, V.I. 1979. The sequence of Carboniferous-Permian boundary beds in Darvas and its implication for solving the Carboniferous/ Permian boundary problem. Abstract and program of 9th ICC., Urbana. Illinois, USA., p.116-117.

Lukas, S.G., Wilde, G.L., Robbins, S., and Estep, J.W. 2000. Lithostratigraphy and fusulinaceans of the type section of the Bursum Formation, Upper Carboniferous of south-central New Mexico. New Mexico Museum of Natural History and Science Bulletin, vol. 16, p. 1-13.

Makhlina, M.Kh, Rosovskaya, S.E., Kulikova, A.M., and Nikitina, T.A. 1975. About Noginsky Horizon of Gzhelian stage and about upper boundary of Carboniferous in the western part of Moscow Syneclise. News of High Education Organozations, Geology and Mining, no 5, p. 32-39. (In Russian)

Makhlina, M.Kh, Isakova, T.N., and Zhulitova, V.E. 1984. Upper Carboniferous in the Moscow Basin. Transactions of Stratigraphical Commity of U.S.S.R., vol.13.Upper Carboniferous of the U.S.S.R. (eds.). V.V. Menner, and A.D. Grigorieva. Nauka Publishing House, Moscow, p. 5-14. (In Russian)

Makhlina, M.Kh, Isakova, T.N. 1997. Melekhovsky Horizon - new straton of Gzhelian stage of Upper Carboniferous (Eastern-European Platform). Startigraphy and geological correlation, vol. 5, no. 5, p. 44-53. (In Russian)

Moore, R.C. 1934. Relation of cyclic depositional units to the classification of the Pennsylvanian and Permian of the northern midcontinent area. Tulsa Geological Society Digest, p. 18-20.

Moore, R.C. 1949. Divisions of the Pennsylvanian system in Kansas. Kansas Geological Survey Bulletin, vol. 83.

Nikitin, S.N. 1890. The Carboniferous of the Moscow Basin and artesianian water in the region of the Moscow Basin. - Transactions of Geological Committee., 5, (5), p.1-138 (In Russian), p.139-182. (In French)

Pnev, V.P., Polozova, A.N., Pavlov, A.M., and Faddeyeva, I.Z. 1975. Stratotype section of the Orenburgian Stage, southern Urals (Nikol'skoe village). News of Academy of Sciences of USSR. geological series, no 6, p. 100-109. (In Russian)

Popov, A.V. 1992. Gzhelian ammonoids of the Central Asia (Karachatyr Ridge). Problems of paleontology, vol. 10, p. 52-62. (in Russian)

Rauser-Chernousova, D. M. 1938. Upper Paleozoic foraminifera of Samarskaya Luka and Povolzhie region. Academy of Sciences of the U.S.S.R. Geological Institute. Transactions, v. 7, p. 69-167. (In Russian)

Rauser-Chernousova, D.M. 1949. Stratigraphy of Upper Carboniferous and Artinskian deposits of Bashkirian Preurals, *In:* Rauser-Chernousova, D.M., ed., Foraminifers of Upper Carboniferous and Artinskian deposits of Bashkirian Pre-Urals. Transactions of Geological Institute of Academy of Sciences of U.S.S.R., Issue 105, Series geology, No 35, p. 3-21., (In Russian)

Rauser-Chernousova, D.M., and Scherbovich, S.F. 1958. The schwagerins Horizon of Central part of Russian Platform, *In:* V.V. Menner, ed., Schwagerins Horizon of Russian Platfrom and underlying its deposits. Transactions of Geological Institute of Academy of Sciences of USSR. issue 13, p. 3-56, (In Russian)

Remane, J., Bassett, M.G., Cowie, J.W., Gohrbandt, K.H., Lane, H.R., Michelsen, O., and Wang, Naiwen. 1996. Revised guidelines for the establishing of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS). Episodes, v. 19, p. 77-81.

Ritter, S.M. 1995. Upper Missourian-lower Wolfcampian (upper Kasimovian-lower Asselian) conodont biostratigraphy of the midcontinent, USA. Journal of Paleontology, 69:1139-1154.

Rosovskaya, S.E. 1952. Fusulinids of Upper Carboniferous and Lower Permian of Southern Urals. Transactions of Paleontological Institute of Academy of Science of the U.S.S.R., v. 40, p. 5-50. (In Russian)

Ross, C.A., and Ross, J.R.P. 1985. Late Paleozoic depositional sequences are synchronous and worldwide, Geology, v. 13, p. 194-197.

Ross, C.A. and Ross, J.R.P. 1987. Late Paleozoic sea levels and depositional sequences, Cushman Foundation for Foraminiferal Research, Special Publication # 24, p. 137-149.

Ross, C.A. and Ross, J.R.P. 1988. Late Paleozoic transgressive-regressive deposition, *In:* Wilgus, C.K., Hastings, B.S., Kendall, C.G. St. C., Posamentier, H., and Ross, C.A., eds., Sea Level Changes: An Integrated Approach, SEPM Special Publication # 42, p. 227-247.

Ross, C.A., and Ross, J.R.P. 1994. Permian sequence stratigraphy and fossil zonation, *In:* Embry, A.F., Beauchamp, B., and Glass, D.J., eds., Pangea: Global environments and resources, p. 219-231.

Ross, Ch.A., and Ross, J.R.P. 1998. Bursumian Stage, Uppermost Carboniferous of Midcontinent and Southwestern North America. Newsletter on Carboniferous Stratigraphy, v. 16, July 1998, p. 40-42.

Ruzhenzev, V.E. 1945. Suggestions for subdividing Upper Carboniferous into Stages. Reports of the Academy of Sciences of the U.S.S.R., vol. 46, no 7, p. 314-317. (In Russian)

Ruzhenzev, V.E. 1950. Upper Carboniferous ammonoids of the Urals. Transactions of Paleontological Institute Academy of Sciences of U.S.S.R., v.29, 223 p. (In Russian)

Ruzhenzev, V.E. 1951. Lower Permian ammonoids of the southern Urals. 1. Ammonoids Sakmarian stage. Transactions of Paleontological Institute Academy of Sciences of U.S.S.R., v. 33, 188 p. (In Russian)

Ruzhenzev, V.E. 1954. Asselian stage of the Permian system. Reports of the Academy of Sciences of the U.S.S.R., v. 99, no 6, p. 1079-1082. (In Russian)

Ruzhencev, V.E., and Bogoslovskaya, M.F. 1976. Namurian Stage in ammonoid evolution. Late Namurian ammonoids. Transactions of Paleontological Institute Academy of Sciences of U.S.S.R., v. 167, 339 p. (In Russian).

Sjomina, S.A. 1961. Stratigraphy and foraminifers (fusulinids) of Schwagerina Horizon of the Oksko-Tsna Swell. Transactions of Geological Institute of Academy of Science of the U.S.S.R., v. 57, 72 p. (In Russian)

Thompson, M.I. 1954. American Wolfcampian fusulinids. University of Kansas Paleontological Contributions, Protozoa, Article 5, 226 p.

Wardlaw, B.R., and Davydov, V.I. 2000. Preliminary Placement of the International Lower Permian Working Standard to the Glass Mountains, Texas. Permophiles, no 36, p.10-13.

Zakharov, E.V. 1971. New Carboniferous ammonoids from the Karachatyr Ridge (southern Fergana). Uzbekistan Geological Journal, no 3, p. 91-96.

Report on the Carboniferous-Permian boundary in the Bohemian Massif

Zbynek Simunek

Czech Geological Survey, Klárov 3/131, 118 21 Praha I, Czech Republic.

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-GEO/PrF concerning of the Carboniferous and Permian flora and its stratigraphy.

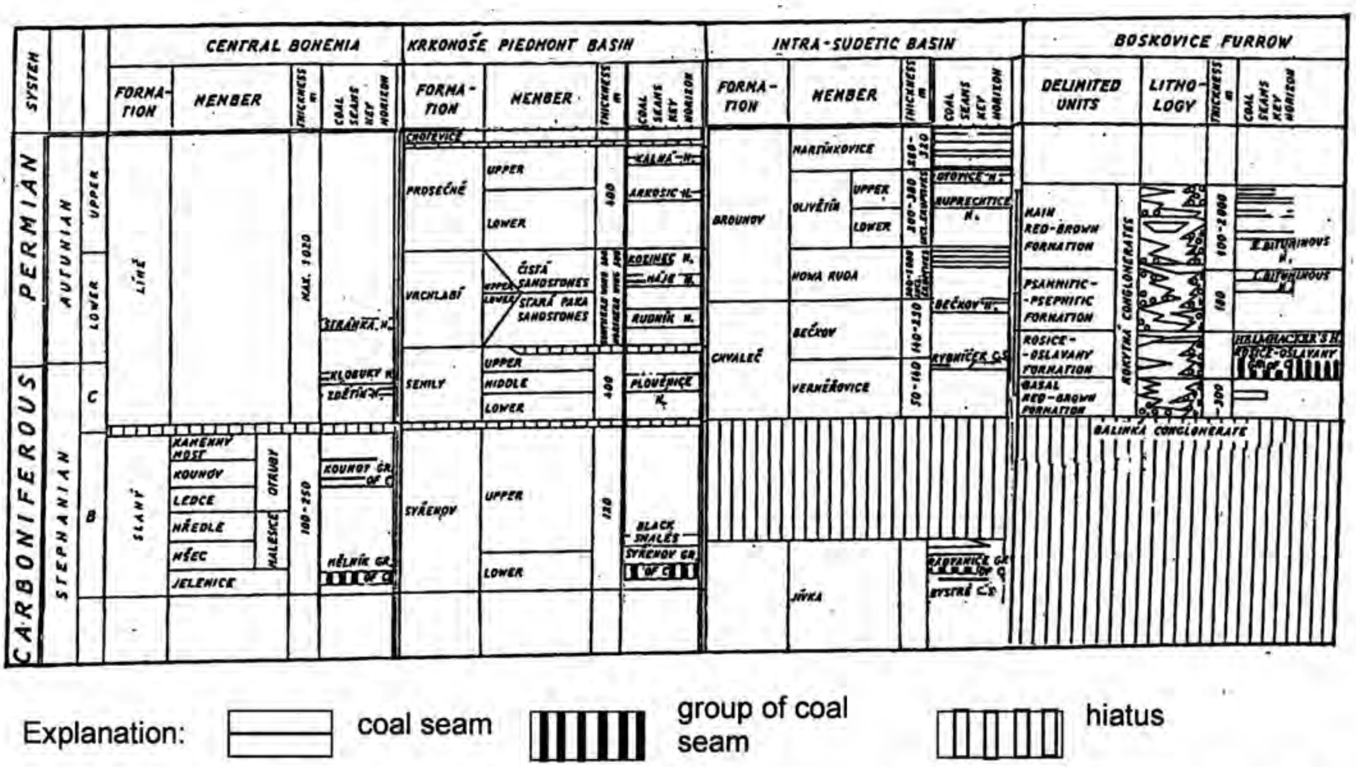
There are small gaps in sections around the Carboniferous-Permian boundary. Plant fossils are concentrated into fossiliferous horizons separated by thick layers of unfossiliferous sediments. As concerns the floral record, the most complete section through the Carboniferous-Permian boundary is in the 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 autochtonous (parautochtonous) seamforming (roof-shale) flora deriving from the seamforming flora of the Westphalian; second, the allochtonous non-seamforming flora consisting of new plant groups, or plant groups very rare in the Westphalian (e.g. conifers). The autochtonous, relatively hygrophyllous assemblage usually consists of rare lycopods, rare sphenopsids, common to

Fig. 1 Distribution of Permo-Carboniferous sediments in the Czech Republic

very common ferns (pecopterids), rare pteridosperms and cordaites. The lycopods, sphenopsids, pteridosperms and cordaites could be locally relatively common. The allochtonous, 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 Melník and Kounov 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 Intra-Sudetic 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) Líne Formation in the Kladno-Rakovník Basin. The flora is concentrated in grey fossiliferous horizons (Zdetín and Klobuky) that are compared with Plouznice and Štepanice-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 Klobuky and Štepanice-Cikvásky horizons contain very thin coal seams with autochtonous 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 pecopterids, more numerous pteridosperms, and more diversified conifers (4 species). "Callipterids" are also not known here.

Sedimentation in two other regions (Intra-Sudetic 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



1st Bituminous Horizon = Zbýšov Horizon, H - Horizon, GR OF C - Group of coal seams, C.S. - Coal seam

Fig. 2 Stephanian and Autunian in selected basins of the Czech Republic (According to Prouza 1994)

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 (walchias). "Callipterids" were probably very rare, but documented by many authors (Katzer 1895, Augusta 1937, Nemejc 1951, Šetlik 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 osmundaeformis* (Schloth.) Wagner (Rieger 1965). Practically the same flora is known also in Helmhacker's Horizon (Rieger mscr.) 12-22 m above the 1st (uppermost) coal seam, where *Mixoneura osmundaeformis* has its last occurrence in the Boskovice Furrow (graben). Rieger (1965) and Purkynová (1985) assume that the Carboniferous-Permian boundary is in the roof of the Helmhacker's Horizon. The Zbýšov 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 Intrasudetic Basin is poorly documented. The Vernérovice Member of the Chvalec Formation, contains the Rybnícek 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 osmundaeformis* have been determined here. This horizon is very similar to the roof of the 1st coal seam or to the Helmhacker'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-Doubinger 1977) (Fig. 3). Several hundreds of sterile sediments and eruptives follow after the Vernérovice Member. Plant remains have been found in the Olivetín 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 Rudník Horizon of the Vrchlabí Formation which is mostly of lacustrine origin is without doubt of Lower Autunian age. Six species of the genus "*Callipteris*" were found in the Rudník Horizon.

The age of the Líne Formation in the Central Bohemian Region is uncertain. The plant fossil record is known only from the lower part of the Líne Formation (Zdetín 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 Líne Formation is younger (probably up to the Upper Autunian). Havlena and Pešek (1980) are convinced that all sediments of the Líne Formation are of Stephanian C age.

The exact position of the Carboniferous-Permian boundary in the Blanice Furrow is not clear. The Permo-Carboniferous sediments occur in four erosional relicts. Flora with "callipterids"

Age	Time equivalent strata	Stratigraphical units	Other pteridosperms											"Callipterids"								
			Alethopteris bohemica	*Alethopteris zeilleri*	*Odontopteris brardii*	*Odontopteris intermedia*	*Odontopteris minor*	*Mixoneura osmundaeformis*	*Neurocallipteris neuropteroides*	*Neurodontopteris auriculata*	*Barthelopteris germarii*	*Callipteridium pteridium*	*Callipteridium trigonum*	*Autunia conferta*	*Autunia neumannii*	*Arnhardtia scheibei*	*Dichophyllum flabellifera*	*Rhachiphyllum lyratifolia*	*Rhachiphyllum cf. schenkii*	*Lodevia nicklesii*	*? Gracilopteris cf. bergeronii*	*"Callipteris" zbejsoviensis*
Autunian Lower	1	Zbýšov H.* (BF)								x				x	x	x	x	x		x		x
		Rudník H. (KPB)								x	x			x	x	x	x		x		x	
Probably Stephanian C	2	Helmhacker's H. (BF)						x						x	x		x					
		Rybnièek H. (IB)		x	x			cf.							x		x					
		Rosice-Oslavany F., 1st C.S. (BF)		x	x		x	x		x	x			x	x		x			x		x
Stephanian C	3	Líní F. (CBB)		x	x			x				x										
		Rosice-Oslavany F., 2nd and 3rd C.S. (BF)		x	x		x	x	x	x	x											
		Semily F. (KPB)		x			x	x	x	x	x	x										
Stephanian B	4	Slaný F. (CBB)	x	x		x			x	x	x		x									
		Radvanice Gr. of C. (IB)		x		x			x	x	x	cf.	x									
		Syænov F. (KPB)	x	x		x				x		x	x									

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 - Boskovice Furrow (graben), KPB - Krkonoše Piedmont Basin, IB - Intra-Sudetic Basin, CBB - Central Bohemian basins.
Remark: Unit 2 was considered by Nimejc (1953) to the Stephanian, by Havlena & Remy (1960, 1962) to the Autunian. I consider this unit for the Stephanian.

Fig. 3 Distribution of stratigraphically important pteridosperms and "callipterids" in individual horizons of the Bohemian Massif.

is usually considered to be Autunian, flora without "callipterids" 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); "callipterids" are also a common element in this strata, but locally can be rare or absent. Other pteridosperms are rare, as are the ferns (pecopterids) and sphenopsids (calamites). Only one very thin coal seam (Háje Coal Seam) is known from the Autunian Vrchlabí Formation in the Krkonoše Piedmont Basin. Its flora differs from other Permian floras of the Bohemian Massif by a greater proportion of pecopterids. Relatively xerophyllous elements such as "callipterids" and conifers have also been found near this coal seam. The hygrophyllous seamforming plant association disappeared in the beginning of Autunian. The table in Fig. 4 shows that the lower Autunian assemblage is low in species. The proceeding aridization in the Autunian caused reduction in fern and pteridosperm 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 Autunian depends on where the boundary between the Stephanian C and the Lower Autunian 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

Augusta, J. 1937. Über die Arten der Gattung *Callipteris* Brgt. aus dem Oberkarbon des Steinkohlenbeckens von Rosice und Oslavany in Mähren. Zbl. Mineral., Geol., Paläont., Abt. B, 5, 223-229.

Bouroz, A., and Doubinger, J. 1977. Report on the Stephanian-Autunian boundary and on the contents of upper Stephanian and Autunian in their stratotypes. Symposium on Carboniferous Stratigraphy (V. M. Holub - R. H. Wagner ed.), Ústr. úst. geol., 147-169. Praha.

Havlena, V. 1964. Geologie uhelných lozisek 2. nakl. Cs. Akad. Ved. Praha.

Havlena, V., and Pešek, J. 1980. Stratigrafie, paleogeografie a základní strukturní clenení limnického permokarbonu Cech a Moravy. Sbor. Západoces. Mus. (Plzen), Prír., 34, 1-144.

Katzer, F. 1895. Vorbereich über eine Monographie der fossiler Flora von Rossitz in Mähren. Vest. Král. Ces. Spolec. Nauk, Tr. mat.-prírodoved., 24.

Nemejc, F. 1951. K výskytu Callipteridu v obzoru slojí rosicko-oslavanských a k otázce stárí tohoto slojového pásma. Sbor. Ústr. Úst. geol., 18, 425-436.

Nemejc, F. 1953. Úvod do floristické stratigrafie kamenouhelných oblastí v CSR. - Nakl. Ces. Aakd. Ved. Praha.

Obrhel, J. 1960. Über die paläofloristischen Fazies und Assoziationen in den oberen grauen Schichten (oberes Stefanien) im Kladnoer Steinkohlenbecken (Mittelböhmen). Sbor Ústr. Úst. geol., odd. paleont., 25, 73-83.

Prouza, V. 1994. Permo-Carboniferous (Limnic Basins of the Bohemian Massif). Klomínský, J. (ed.) Geological Atlas of

Groups/Genera	Number of species in the Stephanian C	Number of species in the lowermost Autunian	Number of common species in both units
Lycopods	(2)	(2)	(2)
Sigillaria	1	1	1
Asolanus	1	1	1
Sphenopsids	(18)	(13)	(10)
Calalmites	6	4	3
Annularia	5	4	3
Asterophyllites	2	3	2
Sphenophyllum	5	2	2
Ferns	(13)	(9)	(8)
Nemejcopteris	1	1	1
Pecopteris	12	8	7
Pteridosperms	(29)	(20)	(14)
Sphenopterids	(7)	(2)	(2)
Sphenopteris	5	1	1
Dicksonites	1	1	1
Pseudomariopteris	1		
Alethopterids	(4)	(2)	(1)
Alethopteris	4	2	1
Neuropterids	(11)	(7)	(6)
Mixoneura	3	2	1
Odontopteris	2		
Neurodontopteris	1	1	1
Neurocallipteris	1	1	1
Neuropteris	3	2	2
Barthelopteris	1	1	1
Callipterides	(6)	(8)	(5)
Callipteridium	1		
"Callipteris"	1	1	1
Autunia	2	2	2
Arnhardtia		1	
Dichophyllum	1	1	1
Rhachiphyllum		2	
Lodevia	1	1	1
Taeniopterids	(1)	(1)	
Taeniopteris	1	1	
Cordaitopsida	(4)	(4)	(4)
Cordaites	3	3	3
Dicranophyllum	1	1	1
Conifers	(5)	(12)	(5)
Culmitzschia	2	5	2
Ernestiodendron	1	1	1
Otovicia		1	
Walchia	2	2	2
Hermitia		2	
Carpentieria		1	
Together:	71	60	42

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

the Czech Republic Stratigraphy. Ces. Geol. úst. Praha.

Purkynová, H. 1985. Nové poznatky o flóre rosicko-oslavanského permokarbonu. mscr. Thesis, Dept. of Geol. and Paleont., Fac. of Natural Sci., Masaryk's Univ. Brno.

Remy, W., and Havlena, V. 1960. Prinzipien der stratigraphischen Gliederung im terrestrisch-limnisch entwickelten Raum des euramerischen Florenbereiches im Jungpaläozoikum Europas. Mber. Dtsch. Akad. Wiss. Berlin, 2, 3/4, 230-235.

Remy, W., and Havlena, V. 1962. Zur Paläontologie ses Steinkohlengebirges. II. Zur floristischen Abgrenzung von Devon, Karbon und Perm im terrestrisch-limnisch entwickelten Raum des euramerischen Florenbereichs in Europa. Fortschr. Geol. Rheinld. u. Westf., 3, 2, 735-752.

Rieger, Z. 1965. Nové fytopaleontologické nálezy v rosicko-oslavanské oblsti. Cas. Mineral. Geol., 10, 1, 89-91.

Šetlík, J. 1951. Paleontologicko-stratigrafické výzkumy ve stefanienu stredních Cech a Moravy. Sbor. Ústr. Úst. geol., 18, 437-448.

Wagner, R. H. 1984. Megafloral Zones of the Carboniferous. 9e Congr. Int. Stratigr. Géol. Carbonifére Compte Rendu (Washington and Champain-Urbana 1979) 2, 109-134.

Short report to SCCS, May 2001

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 Ducabrook Formation, which contains a tetrapod-bearing fauna. Early amphibian bones are found alongside gyracanth acanthodian remains (Warren et al. 2000, Turner et al. in prep.), a large rhizodont *Strepsodus* (Johanson et al., 2000), the lungfish *Ctenodus* (Turner et al., 1999), palaeoniscoid fishes, and numerous sharks represented by teeth, scales and spines. ST has visited the Royal Scottish Museum, Edinburgh, the Hancock Museum, Newcastle-upon-Tyne and the Academy of Natural Sciences, Philadelphia to study Late Devonian to Early Carboniferous material from the Fife coast of Scotland, from Northumberland, 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 Blieck & Turner eds., 2000). A new Ph.D. student, Kate Parker (La Trobe Univ.) will investigate geology and taphonomy of Drummond Basin 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 Calcarenite vertebrate fauna.

Blieck, A., and Turner, S. (eds.) 2000. Palaeozoic Vertebrate Biochronology and Global Marine/Non-Marine Correlation. Final Report of IGCP 328 (1991-1996). Courier Forschungsinstitut Senckenberg, 223, 575 pp.

Turner, S., and Burrow, C.J. 1999. Micropaleontology, vertebrate, Pp. 740-749. In R. Singer (ed.), Encyclopedia of Paleontology. Fitzroy Dearborn Publishers. 2 volumes; 1700 pp., Chicago.

Turner, S., Kemp, A., and Warren, A.A. 1999. First Early Carboniferous lungfish (Dipnoi, Ctenodontidae) from central Queensland. Alcheringa 23, 177-182.

Johanson, Z., Turner, S., Warren, A.A. 2000. First East Gondwana record of *Strepsodus* (Sarcopterygii, Rhizodontia), from the Lower Carboniferous Ducabrook Formation, central Queensland, Australia. Geodiversitas 22(2): 161-169.

Jones, P.J., Metcalfe, I., Engel, B.A., Playford, G., Rigby, J., Roberts, J., Turner, S., and Webb, G.E. 2001. Chapter 5: Carboniferous biogeography of Australasia. In Wright, A., Talent, J.A., Young, C.C., and Laurie, J. (eds.), Palaeobiogeography of the Australasian Fauna and Flora. Memoirs AAP 23, 53 pp.

Warren, A.A.W., Currie, B.P., Durrow, C.J., and Turner, S. 2000. A redescription of *Gyracanthides murrayi* Woodward 1908 (Acanthodii, Gyracanthodii) from the Lower Carboniferous of the Mansfield Basin, Victoria, Australia. Journal of Vertebrate Paleontology, 20(2), 225-242.

PUBLICATIONS BY SCCS MEMBERS

Coquel, R., and Abdesselam-Rouighi, F. 1999. Carbonifere inferieur du Sahara occidental algerien : la Formation de Timimoun. Annales de la Societe Geologique du Nord (Lille) 2-7, 129-134.

Coquel, R., and Abdesselam-Rouighi, F. 2000. Revision palynostratigraphique du Devonien terminal-Carbonifere inferieur dans le Grand Erg Occidental (bassin de Bechar) Sahara Algerien. Revue de Micropaleontologie, 43-3, 353-364.

Fissunenko, O.P. 2000. On the problem of Moscovian Stage. Lugansk, LDPU, 66 p. (In Russian).

Fissunenko, O.P. 2001. The basic problems of theoretical stratigraphy. Lugansk, LDPU, 116 p.

Kerp, H., Krings, M., and Taylor, T.N. 2000. Morphological and biomechanical diversity among late Palaeozoic seed ferns - scrambling and climbing growth habits. *In:* Spatz, H.C., and Speck, T. (eds.), Plant Biomechanics 2000. Proc. 3rd Plant Biomech. Conf. Freiburg-Badenweiler, August 27 to September 2, 2000, 117-122. Thieme Verlag, Stuttgart.

Kerp, H., and Krings, M. In press. Kutikularanalytische Befunde zur Abgrenzung der *Odontopteris minor* f. *zeilleri* Potonié von *Odontopteris reichiana* Gutbier, Courier Forschungsinstitut Senckenberg.

Krings, M. 2000. Remains of secretory cavities in pinnules of Stephanian pteridosperms from Blanzy-Montceau (Central France): a comparative study. Botanical Journal of the Linnean Society 132: 369-383.

Krings, M. 2000. The use of biological stains in the analysis of late Palaeozoic pteridosperm cuticles. Review of Palaeobotany and Palynology 108: 143-150.

Krings, M. 2000. Zur Morphologie der Spaltöffnungsapparate von *Neuropteris cordata* (Pteridospermopsida, ?Medullosales) aus dem französischen Oberkarbon. Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 122:551-566.

Krings, M., and Kerp, H. 2000. A contribution to the knowledge of the pteridosperm genera *Pseudomariopteris* Danzé-Corsin nov. emend. and *Helenopteris* nov. gen.. Review of Palaeobotany and Palynology 111:145-195.

Krings, M., Kerp, H., and Uhl, D. 2000. Epidermale Anatomie von *Odontopteris subcrenulata* (Rost) Zeiller aus dem Stefan (Oberkarbon) von Blanzy-Montceau (Zentralfrankreich). Feddes Repertorium 111:385-398.

Krings, M., Kerp, H., Taylor, E.L., and Taylor, T.N. In press. Reconstruction of *Pseudomariopteris busquetii*, a vine-like Late Carboniferous - Early Permian pteridosperm. American Journal of Botany.

Krings, M., Kerp, H., Taylor, T.N., and Taylor, E.L. In press. How Paleozoic vines and lianas got off the ground: on scrambling and climbing Late Carboniferous - Early Permian pteridosperms. Botanical Review (special issue: Fossil history, morphology, and phylogeny of seed plants).

Krings, M., and Schultka, S. 2000. Ein besonderes Abdruckfossil von *Lyginopteris* aus dem Oberkarbon Westfalens, Deutschland. Feddes Repertorium 111:375-383.

Krings, M., and Sommer, G. 2000. Eine morphologische Aberration von *Calamostachys tuberculata* (Sternberg) Weiss aus dem Oberkarbon des Piesberges bei Osnabrück. Osnabrücker Naturwissenschaftliche Mitteilungen 26:47-52.

Krings, M., Taylor, T.N., Taylor, E.L., Axsmith, B.J., and Kerp, H. 2001. Cuticles of *Mariopteris occidentalis* White nov. emend. from the Middle Pennsylvanian of Oklahoma (USA), and a new type of climber hook for mariopteroid pteridosperms. Review of Palaeobotany and Palynology 114:209-222.

Krtichyan, G.A., and Peterson, L.N. 2000. About the volcanogenic material in the Lower Permian of the Enbolak area. Geology and mineralfossils of Krasnoyarsk area and Chakassia Republic. Krasnoyarsk, p. 104-107. (in Russian)

Legrand-Blain, M., and Perret-Mirouse, M.F. 2000. Brachiopodes et Conodontes carboniferes du Bassin de Taoudeni (Mali, Afrique de ll Ouest) : Biostratigraphie, Paleobiogeographie. Travaux de ll Institut Scientifique Serie Géologie and Geographie Physique, Rabat, 20, 92-107.

Loboziak, S., Melo, J.H., and Streel, M. 2000. Latest Devonian and early Carboniferous palynostratigraphy of Northern Brazil and North Africa a proposed integration of Western European and Gondwanan miospore biozonations. Bulletin du Centre de Recherches ELF Exploration Production, 22-2, 241-259.

Peterson, L.N. 1999. Atlas of Carboniferous spores and pollen of the Tychan diamondiferous region. Krasnoyarsk. 80 p. (in Russian)

Peterson, L.N. 2000. Characterization of the Carboniferous miospore assemblages of Middle Siberia (Tunguska and Minusa basins). Abstracts, 10th International Palynological Congress, Nanjing, China, p. 132.

Peterson, L.N. 2000. Palynological characteristics of the Kochay suite (Nord-Minusa trough). Geology and mineralfossils of the Krasnoyarsk area and Chakassia Republic. Krasnoyarsk, p. 142-147. (in Russian)

Sebbar, A. 1998. Foraminiferes et Algues calcaires du Carbonifere, bassin de Reggane, Sahara central, Algerie. Bulletin du Service Geologique de llAlgerie, 9, 2, 123-147.

Sebbar, A., Preat, A., and Mamet, B. 2000. Microfacies et biozonation de la rampe mixte carbonifere du bassin de Tindouf, Algerie. Bulletin du Centre de Recherches ELF Exploration Production, 22-2, 203-239.

Sebbar, A., Preat, A., Nedjari, A. and Mamet, B. 1999. Microfacies et modele sedimentaire du Carbonifere marin (Serpukhovien-Moscovien inferieur) du bassin de Bechar (Sahara septentrional, Algerie). Bulletin du Service Geologique de l'Algerie, 10, 2, 159-211.

Sebbar, A., Preat, A., Nedjari, A. and Mamet, B. 2000. Microfacies and sedimentary model, marine Carboniferous, Reggane Basin (Central Sahara, Algeria). Bulletin du Service Geologique de l'Algerie, 11, 1, 61-105.

Speck, T., Krings, M., and Kerp, H. 2000. A climbing late Palaeozoic seed fern with adhesive tendrils - an early finding of shock-absorbing anchoring structures in fossil climbing plants. *In:* Spatz, H.C., and Speck, T. (eds.), Plant Biomechanics 2000. Proc. 3rd Plant Biomech. Conf. Freiburg-Badenweiler, August 27 to September 2, 2000, 141-147. Thieme Verlag, Stuttgart.

Zodrow, E.L., Mastalerz, M., Orem, W.H., Simunek, Z., and Bashforth, A.R. 2000. Functional groups and elemental analyses of cuticular morphotypes of *Cordaites principalis* (Germar). Geinitz, Carboniferous Maritimes Basin, Canada. Internat. J Coal Geol. 45:1-19.

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 *"Biostratigraphic 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 Urals 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

CO-CHAIRMANS: Drs. A.Kh. Kagarmanov (Saint-Petersburg), B.I. Chuvashov (Ekaterinburg). SCIENTIFIC SECRETARIES: Drs. E.O. Amon (Ekaterinburg), O.L. Kossovaja (Saint-Petersburg).

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.

Dispatch of the Second circular – January 15, 2002.

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

SCCS VOTING & CORRESPONDING MEMBERSHIP 2001

Please check your entry and report any changes to the Secretary

ALGERIA

Mrs Fatma Abdesselam-Rouighi
Centre de Recherche et Developpement
Ave du 1er Novembre
35000 Bounerdes
ALGERIA

A. Sebbar
Universite de Boumerdes
Faculte des Hydrocarbures et de la Chimie
Dept. Gisements Miniers et Petroliers.
Ave du l' Independance
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:
sarcang@overnet.com.ar

Dr Carlos Azcuy
Depto. de Ciencias Geológicas
Pabellón 2, Ciudad Universitaria
1428 Núñez, Buenos Aires
Rep. ARGENTINA
Fax: 54-1-638-1822
Email:
azcuy@aspapa.org.ar

Dr Silvia Césari
Div. 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. González
Instituto de Paleontologia
Fundación Miguel Lillo
Miguel Lillo 251
4000 S.M. deTucumán
Rep. ARGENTINA
Fax: 081-330868
Email:
fmlgeo@uumail.unt.edu.ar

Mercedes di Pasquo
Facultad de Ciencias Exactas y Naturales.
Depto. Geologia. Ciudad Universitaria. Pabellon II. Nuñez.
Capital Federal. C.P. 1428.
Rep. ARGENTINA
Email: medipa@aspapa.org.ar
medipa@tango.gl.fcen.uba.ar

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

Dr M.S. Japas
Depto. de Ciencias Geológicas
Pabellón 2, Ciudad Universitaria
1428 Núñez, Buenos Aires
Rep. ARGENTINA

Dr Nora Sabattini
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: narchi@deakin.edu.au

Dr J.C. Claoué-Long
Aust. Geol. Survey Organisation
P.O. Box 378
Canberra City, A.C.T. 2601
AUSTRALIA
Fax: 06-249-9983
Email: jclong@agso.gov.au

Dr J.M. Dickins
Innovative Geology
14 Bent Street
Turner 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:
bengel@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:
peter.jones@geology.anu.edu.au

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

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

Prof. J. Roberts
School of Applied Geology
The University of New South Wales
Sydney, NSW 2052
AUSTRALIA
Fax: 61-2-9385-5935
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: grshi@deakin.edu.au

S. Stojanovic
71 Barracks Road
Hope Valley
Adelaide, SA 5090
AUSTRALIA
Fax: 373-4098

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

AUSTRIA

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

Dr K. Krainer
Inst. für Geol. und Paläontologie
Universität Innsbruck
Innrain 52
A-6020 Innsbruck
AUSTRIA
Fax: 0043-512-507-5585
Email:
Karl.Krainer@uibk.qc.at

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

BELGIUM

Dr A. Delmer
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
Universite de Bruxelles
50 avenue F.D. Roosevelt
Bruxelles BI000
BELGIUM

Prof. E. Poty
Service de Paléontologie animale
Universitè de Liège
Bât. B18, Sart Tilman
B-4000 Liège
BELGIUM
Fax: 32-43-665338

Hon. Prof. Maurice Streel
University of Liège
Paleontology,
Sart Tilman Bat. B18
B-4000 LIEGE 1
BELGIUM
Fax: 32-4-366 5338
Email:
Maurice.Streel@ulg.ac.be

Dr Rudy Swennen
Fysico-chemische geologie
Katholieke Universiteit Leuven
Celestijnenlaan 200C
B-3001 Heverlee
BELGIUM

BRAZIL

Mr L.E. Anelli
Instituto de Geociências
Universidade de São Paulo
CP 11348 CEP 05422-970
São Paulo
BRAZIL
Fax: 55-011-818-4129
Email: anelli@usp.br

Dr U.G. Cordani
Instituto de Geociências
Universidade de São Paulo
CP 11348 CEP 05422-970
São Paulo
BRAZIL

Dr Marleni Marques Toigo
Rua Domingos
José de Almeida 185
90420 Porto Alegre
BRAZIL

Dr A.C. Rocha-Campos
Instituto de Geociências
Universidade de São Paulo
CP 11348 CEP 05422-970
São Paulo
BRAZIL
Fax: 11-818-4129
Email: acrcampo@usp.br

Paulo Alves de Souza
Instituto de Geociencias-
Universidade de São Paulo
Instituto Geologico-SMA
BRAZIL
Email:
psouza@swan.uspnet.usp.br

BULGARIA

Dr Y.G. Tenchov
Geol.Inst. ul. Acad.
Bonchev bloc. 24
Sofia 1113
BULGARIA
Email: geoins@bgearn.acad.bg

CANADA

Dr Wayne Bamber
Geol.Surv.Canada, Calgary
3303-33rd St. N.W.
Calgary AB, T2L 2A7
CANADA
Fax: 403-292-6014
Email:
bamber@gsc.nrcan.gc.ca

Dr B. Beauchamp
Geol.Surv.Canada, Calgary
3303-33rd St. N.W.
Calgary AB, T2L 2A7
CANADA

Dr A.R. Berger
Geological Survey of Canada
Room 177, 601 Booth Street
Ottawa ON, K1A 0E8
CANADA

Dr P.H. von Bitter
Royal Ontario Museum
100 Queen Park
Toronto ON, M5S 2C6
CANADA

Dr W.R. Danner
University of British Columbia
Dept Earth & Ocean.Sciences
6339 Stores Rd.
Vancouver B.C., V6T 1Z4
CANADA

Dr Martin Gibling
Department of Geology
Dalhousie University
Halifax N.S., B3H 3J5
CANADA

Prof. Charles Henderson
Department of Geology
& Geophysics
The University of Calgary
2500 University Drive, N.W.
Calgary AB, T2N 1N4
CANADA
Fax: 1 403 284 0074
Email:
henderson@geo.ucalgary.ca

Dr W. Nassichuk
Geological Survey of Canada
3303-33rd St. N.W.
Calgary AB, T2L 2A7
CANADA

Dr M.J. Orchard
Geological Survey of Canada
101-605 Robson Street,
Vancouver, B.C., V6B 5J3
CANADA
Ph: 604-666-0409
Fax: 604-666-1124
Email:
morchard@gsc.nrcan.gc.ca

Dr Sylvie Pinard
7146 - 119 Street N.W.
Edmonton, Alberta T6G 1V6
CANADA
Fax: 403-436-7136

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.emr.ca

Dr J. Utting
Geol.Surv.Canada, Calgary
3303-33rd St. N.W.
Calgary AB, T2L 2A7
CANADA
Fax: 403-292-6014
Email:
utting@gsc.emr.ca

Dr Erwin L. Zodrow
Univ. College of Cape Breton
Dept Geology, Glace Bay H'way
Sydney N.S., B1P 6L2
CANADA
Fax: 902-562-0119
Email:
ezodrow@sparc.uccb.ns.ca

CZECH REPUBLIC

Dr Jirí Kalvoda
Dept. Geol. Paleont.
Kotlárská 2
61137 Brno
CZECH REPUBLIC
Email:
dino@sci.muni.cz

Dr Jirí Král
Dept Genetics & Microbiology
Fac. Science, Charles
University
Vinicná 5
128 44 Praha 2
CZECH REPUBLIC

RNDr Stanislav Oplustil
Charles University
Institute of Geology &
Palaeontology
Albertov 6
CZ-128 43 Prague
CZECH REPUBLIC
Email:
oplustil@prfdec.natur.cuni.cz

Dr Jirí Pesek
Dept. Geol. Paleontol.,
Fac.Science
Charles University
128 43 Praha 2, Albertov 6
CZECH REPUBLIC
Fax: +02-296-084 or +02-297-
425

RNDr Zbynek Simunek
Czech Geological Survey
Klárov 3/131
CZ-118 21 Prague
CZECH REPUBLIC
Email:
simunek@cgu.cz

EGYPT

Dr Mahmoud M. Kholief
Egyptian Petroleum
Research Inst
Nasr City, 7th Region
Cairo
EGYPT
Fax: 202-284-9997

FRANCE

Dr J-F. Becq-Giraudon
BRGM-BP 6009
F-45060 Orleans, Cédex
FRANCE
Fax: 33-38-64-36-52

Dr Robert Coquel
Lab. Paléobotanique (SN5)
Univ. des Sciences et Techn. de
Lille
F-59655 Villeneuve d'Ascq
FRANCE

Henri Fontaine
8 Allee de la Chapelle
92140 Clamart
FRANCE
Fax: 33-1-40940892

Dr Alain Izart
Université de Nancy I
Département des Sciences de
la Terre
BP 239, 54506 Vandoeuvre les
Nancy
FRANCE
Fax: (33) 83 91 25 89
Email:
Alain.Izart@g2r.u-nancy.fr

Dr G. Lachkar
Labor.Micropal., Univ.Paris VI
4 Place Jussieu
F-75252 Paris CJdex 05
FRANCE

Dr J.P. Laveine
Lab.Paléobot.,UFR Sci.de la
Terre
Univ. des Sci. et Techn. de Lille
F-59655 Villeneuve d'Ascq
CJdex
FRANCE
Fax: 33-2043-6900
Email:
Jean-Pierre.Laveine@univ-
lille1.fr

Dr Marie Legrand-Blain
Institut de Géodynamique
Université Bordeaux 3
Av. Des Facultés
F-33405 Talence
FRANCE
Fax: 56-848-073
Fax: 05-56-89-33-24
Email:
legrandblain@wanadoo.fr

Dr S. Loboziak
U.S.T.L.
Sciences de la terre
F-59655 Villeneuve d'Ascq
Cedex
FRANCE
Fax: 00 333 20 43 6900
Email:
Stanislas.Loboziak@univ-
lille1.fr

Dr M. Lys
36, rue de Buzenval
F-92210 Saint-Cloud
FRANCE

Dr D. Mercier
Ecole des Mines de Paris
35, Rue Saint-Honoré
F-77305 Fontainebleau
FRANCE

Dr G.S. Odin
Lab.Géochron.et
Sedim.Oceanique
Univ. P.& M.Curie, 4 Place
Jussieu
F-75252 Paris Cédex 05
FRANCE
Fax: 33-1-4427-4965

Dr M.F. Perret
Université Paul-Sabatier
Lab.Géol.Structurale
38 rue des 36 Ponts
F-31400 Toulouse
FRANCE
Fax: 61-55-82-50
Email:
perret@cict.fr

Dr P. Semenoff Tian-Chansky
Institut de Paléontologie
8 Rue de Buffon
F-75005 Paris
FRANCE

Dr D. Vachard
Univ.des Sciences et Tech-
niques
Science de la Terre
F-59655 Villeneuve d'Ascq
Cédex
FRANCE
Fax: 00-33-20-43-69-00
Email:
Daniel.Vachard@univ-lille1.fr

Dr M. Weyant
Dept.Géologie
Université de Caen
Esplanade de la Paix
F-14032 Caen
FRANCE

GERMANY

Dr H.W.J. van Amerom
Geol.Landesamt Nordrh.-
Westfalen
De Greiff Str.195
D-47803 Krefeld
GERMANY
Fax: 2151-897-505

Prof. Dr Michael R. W. Amler
Institut für Geologie und
Palaeontologie
der Philipps-Universitaet
Marburg
Hans-Meerwein-Strasse
D-35032 Marburg
GERMANY
Tel: +49 (0)6421 282-2113
oder 0172-6725998
Fax: +49 (0)6421 282-8919
Email:
amler@mailer.uni-marburg.de

Dr Z. Belka
Inst.und Mus.für Geol.und
Paläont.
Universität Tübingen
Sigwartstr. 10
D-72076 Tübingen
GERMANY
Fax: +49-7071-610259
Email:
belka@ub.uni-tuebingen.de

Prof. Dr Carsten Brauckmann
Technische Universität
Clausthal
Institut für Geologie und
Paläontologie
Leibnizstrasse 10
D-38678 Clausthal-Zellerfeld
GERMANY
Fax: 05323-722903
Email:
Carsten.Brauckmann@tu-
clausthal.de

Dr Peter Bruckschen
Ruhr-Universität Bochum
Geologisches Institut
Universitätsstr. 150
D-44801 Bochum
GERMANY

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

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

Mr Chr. Hartkopf-Fröder
Geol.Landesamt
Nordrh.-Westfalen
De Greiff Str.195
D-47803 Krefeld
GERMANY
Fax: +49-2151-897505
Email:
hartkopf-
froeder@mail.gla.nrw.de

Prof. Dr Hans-Georg 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
Geowissenschaften und Rohstoffe
AS Berlin
Wilhelmstr. 25-30
D-13539 Berlin
GERMANY
Fax ++49-30-36 99 31 00
Email:
peer.hoth@bgr.de

Prof. Dr Hans Kerp
Westfälische Wilhelms-
Universität
Abt.Paläobot.am Geol-Pal.Inst.
u Mus.
Hindenburgplatz 57-59
D-48143 Münster
GERMANY
Fax: 49-251-834-831
Email:
Kerp@uni-muenster.de

Dr Dieter Korn
Universität Tübingen
Geologisch-Paläontologisches
Institut
Sigwartstr. 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
Sigwartstr. 10
D-72076 Tübingen
GERMANY
Fax: +49-7473-26768
Email:
Juergen.Kullman@uni-
tuebingen.de

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

Dr Klaus-Jürgen Müller
Institut für Paläontologie
Nussallee 8,
D-53115 Bonn
GERMANY

Dr E. Paproth
Schwanenburgstr. 14
D-47804 Krefeld
GERMANY
Fax: +49-2151-710774

Dr Elias Samankassou
Institute of Paleontology
University of Erlangen-
Nuernberg
GERMANY
Fax: +49-9131-85 22690
Email:
samelias@pal.uni-erlangen.de

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:
schneidj@geo.tu-freiberg.de

Dr D. Stoppel
Bundesanst.für Geowissen. u.
Rohstoffe
Postfach 51 0153
D-30631 Hannover
GERMANY
Fax: 511-643-2304

Dr E. Thomas
Rhsbergstr. 22
D-58456 Witten-Herbede
GERMANY

Dr Dieter Weyer
Löwestr. 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@gla.nrw.de

Dr Volker Wrede
Geologisches Landesamt NRW
P.O.Box 10 07 63
D-47707 Krefeld
GERMANY

Dr Matthias Zeller
Geol.Landesamt
Nordrh.-Westfalen
De Greiff Str.195
D-47803 Krefeld
GERMANY
Fax: +49-2151-897-505

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

HUNGARY

Dr Sc. Heinz Kozur
Rézsü u. 83
H-1029 Budapest
HUNGARY
Fax: +36-1-204-4167
Email:
h12547koz@ella.hu

IRELAND

Dr Geoff Clayton
Department of Geology
Trinity College
Dublin 2
IRELAND
Fax: 3531-6711199
Email:
gclayton@tcd.ie

Dr Ken Higgins
Department of Geology
University College
Cork
IRELAND

Dr G.D. Sevastopulo
Department of Geology
Trinity College
Dublin 2
IRELAND
Email:
gsvstpul@tcd.ie

ITALY

Prof. Mario Pasini
Universitarà delle Studi di Siena
Dipartimento di Sienza della terra
I-53100 Siena
ITALY

JAPAN

Dr Shuko Adachi
Institute of Geosciences
University of Tsukuba
Tsukuba, Ibaraki 305-8571
JAPAN

Dr Masayuki Ehiro
Institute of Geology and Paleontology
Tohoku University
Aoba, Aobaku
Sendai 980-8578
JAPAN
Fax: +81-22-263-9279

Dr Yoichi Ezaki
Dept Geosciences, Fac. Science
Osaka City University
Sumiyoshi-ku
Osaka 558-0022
JAPAN

Mr T. Haikawa
Akiyoshi-dai Sci.Museum Nat.Hist.
Shuhou-chou, Mine-gun
Yamaguchi 754-0511
JAPAN

Dr Y. Hasagawa
Dept Earth Sciences, Fac.Science
Niigata University
Niigata 950-2181
JAPAN

Dr Hisaharu Igo
Dept Earth Sciences
Tokyo Gakugei University
Koganei, Tokyo 184-8501
JAPAN

Dr Hisayoshi Igo
Sakae-chou 1-31-7
Tachikawa City
Tokyo 190-0003
JAPAN

Dr K. Ishida
Dept. Material Science
Fac. Integrat. Arts & Science
Tokushima University
Tokushima 770-8502
JAPAN

Dr Kunihiro Ishizaki
Inst. Geology & Paleontology
Faculty of Science
Tohoku University, Aobaku
Sendai
JAPAN 980

Mr Atsushi Kaneko
Fukae-honchou 1-15-7
Higashi-nada-ku
Kobe 658-0021
JAPAN

Dr K. Kanmera
Maimatsubara 3-20-24
Higashi-ku
Fukuoka 813-0042
JAPAN

Dr Naruhiko Kashima
Department of Forest Resources
College of Agriculture
Ehime University
Matsuyama, Ehime 790-8566
JAPAN

Dr M. Kato
Miyanomori 1-jou 18-chome 1-15
Chuou-ku
Sapporo 064-0951
JAPAN
Fax: 81-11-644-1426

Dr T. Kawamura
Dept Earth Sci., Fac.Education
Miyagi Univ. Education, Aoba-ku
Sendai 980-0845
JAPAN
Fax: +81-22-211-5794
Email:
t-kawa@ipc.miyakyo-u.ac.jp

Dr T. Kimura
Inst. Natural History
Takada 3-14-24
Toshima-ku
Tokyo 171-0033
JAPAN
Fax: 81-3-5992-9154

Dr T. Koike
Dept Geology, Fac. Education
Yokohama National University
Hodogaya-ku
Yokohama 240-8501
JAPAN
Fax: 045-333-1536

Ms Yuko Kyuma
Tomachi 2-295-14-303
Nagasaki 850-0952
JAPAN

Dr Yoshihiro Mizuno
Department of Earth Sciences
Chiba University
Yayoi-chou, Inage-ku
Chiba 263-8522
JAPAN

Dr K. Mori
The Tohoku University Museum
Institute of Geology and Palaeontology
Tohoku University
Aoba-ku, Sendai 980-8578
JAPAN
Email:
mori@dges.tohoku.ac.jp

Dr M. Musashino
Dept Earth Sciences
Kyoto Univ. Education
Hushimi-ku
Kyoto 612-0863
JAPAN

Dr K. Nagai
Department of Physics and Earth Sciences
Faculty of Science
University of the Ryukyus
Nishihara, Okinawa 903-0213
JAPAN
Email:
k.nagai@sci.u-ryukyu.ac.jp

Dr Koji Nakamura
Inst. Geology,
Fac.Gen.Education
Hokkaido University, Kita-ku
Sapporo, Hokkaido
JAPAN 060

Dr T. Nishida
Dept Earth Sci., Fac. Education
Saga University
Saga 840-8502
JAPAN

Dr Yuji Okimura
Ohtada 236-1, Kurose-machi
Kamo-gun
Hiroshima 724-0611
JAPAN

Dr M. Ota
Kitakyushu Museum of Natural History
Nishihon-machi, Yahatahigashi-ku
Kitakyushu 805-0061
JAPAN
Fax: 093-661-7503
Email:
ota@city.kitakyushu.jp

Dr Yasuhiro Ota
Kitakyushu Museum and Institute of Natural History
3-6-1, Nishihonmachi
Yahata-Higashi-Ku 805-0061
JAPAN
Fax: 093-661-7503
Email:
yasuota@city.kitakyushu.jp

Dr Tomowo Ozawa
Dept Earth & Planetary Sci.
Faculty of Science
Nagoya Univ., Chigusa-ku
Nagoya 464-8602
JAPAN

Dr Kimiyoshi Sada
Faculty of Social Information Science
Kure University
Kure, Hiroshima 737-0182
JAPAN
Email:
ksada@ondo.kure-u.ac.jp

Dr Sumio Sakagami
(Prof. Emeritus of Chiba Univ.)
Konakano 48, Akiruno-shi
Tokyo 190-0165
JAPAN
Fax: 0425-96-0459

Dr K. Sashida
Institute of Geosciences
University Tsukuba
Tsukuba, Ibaraki 305-8571
JAPAN

Mr A. Sugimura
Akiyoshi-dai Sci.Museum Nat.Hist.
Shuhou-chou, Mine-gun
Yamaguchi 754-0511
JAPAN

Dr Tetsuo Sugiyama
Dept. Earth System Science
Faculty of Science
Fukuoka University,
Jonan-ku, Fukuoka 814-0180
JAPAN
Fax: 81-92-865-6030
Email:
sugiyama@ssat.fukuoka-u.ac.jp

Dr Jun-ichi Tazawa
Dept of Geology, Fac. of Science
Niigata University
Niigata 950-2181
JAPAN
Fax: 025-262-7278

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 Kozo Watanabe
Shinjuku 1-26-12-108
Shinjuku-ku
Tokyo 160-0022
JAPAN

Dr Wang 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@Ssat.fukuoka-u.ac.jp

Dr N. Yamagiwa
Shinkanaoka-cho 3-1,14-102
Sakai, Osaka 591-8021
JAPAN

Dr Juichi Yanagida
Izumi 3-60
Kasuga
Fukuoka 816-0853
JAPAN

Mr Y. Yoshida
GEOGYRO Corporation
Onmaeda-chou 6-4, Nishi-nana-jo
Shimogyo-ku,
Kyoto 600-8897
JAPAN

KAZAKHSTAN

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

Dr M.M. Marfenkova
Inst. Geol. Nauk
ul. Kananbai batyra 69A
480100 Alma Ata
REP. KAZAKHSTAN

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

KYRGYZSTAN

Dr Alexandra V. Djenchuraeva
Agency on Geology and Mineral
Resources of Kyrgyz Republic
prospekt Ekindik 2
720300 Bishkek
KYRGYZSTAN
Email:
mail@geoagency.bishkek.gov.kg

Alexandr V. Neevin
Agency on Geology and Mineral
Resources of Kyrgyz Republic
prospekt Ekindik 2
720300 Bishkek
KYRGYZSTAN
Email:
mail@geoagency.bishkek.gov.kg

Timur Yu. Vorobyov
Agency on Geology and Mineral
Resources of Kyrgyz Republic
prospekt Ekindik 2
720300 Bishkek
KYRGYZSTAN
Email:
mail@geoagency.bishkek.gov.kg

Olga Getman
Agency on Geology and Mineral
Resources of Kyrgyz Republic
prospekt Ekindik 2
720300 Bishkek
KYRGYZSTAN
Email:
mail@geoagency.bishkek.gov.kg

MALAYSIA

Ibrahim bin Amnan
Geological Survey of Malaysia
Tiger Lane
Ipoh
MALAYSIA
Email:
binamnan@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
Baiwanzhuang Road
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:
lixx@njnet.ihep.ac.cn

Dr Ouyang Shu
Nanjing Inst. of Geol. & Palaeont.
Academia Sinica, Chi-Ming-Ssu
Nanjing 210008
PEOPLES REPUBLIC OF CHINA
Fax: 86-25-335-7026
Email:
lixx@njnet.nj.ac.cn

Dr Ruan Yiping
Nanjing Inst. Geol. Paleont.
Academia Sinica, Chi-Ming-Ssu
Nanjing 210008
PEOPLES REPUBLIC OF CHINA

Dr Yang Shipu
China University of Geo-sciences
Chengfu Lu
Beijing 100083
PEOPLES REPUBLIC OF CHINA

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

POLAND

Prof. Jerzy Fedorowski
Institute of Geology
Adam Mickiewicz University
Maków Polnych 16
PL-61601 Poznan
POLAND
Fax: 48-61-536-536
Email:
jerzy@vm.amu.edu.pl

Dr Tadeusz Peryt
Dept of Chemical Resources
Panstwowy Instytut Geologiczny
Rakowiecka 4
PL-00975 Warszawa
POLAND

Dr S. Skompski
Institute of Geology, Warsaw Univ.
Al Zwirki i Wigury 93
PL-02089 Warszawa
POLAND
Fax: 0-048-22-220-248
Email:
skompski@sungeo.biogeo.uw.edu.pl

Dr Elzbieta Turnau
Institute of Geological Sciences PAS
Senacka 1
PL-31002 Krakow
POLAND
Email:
ndturnau@cyf-kr.edu.pl

Dr H. Zakowa
Panstwowy Inst. Geol.,
Oddzial-Swietokrzyski,
Slir Poczt. 59
PL-25953 Kielce
POLAND

PORTUGAL

Prof. M.J.Lemos de Sousa
Dept. de Geologia,
Fac.Ciências
Universidade do Porto
Praça 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 Palaeont., Geol. Faculty
Moscow State University
119899 Moscow GSP V-234
RUSSIA
Fax: 70953391266
Email:
aaleks@geol.msu.ru

Dr I.S. Barskov
Dept. of Paleontology,
Geology Faculty
Moscow State University
119899 Moscow GSP V-234
RUSSIA
Fax: 7095-9392190

Dr I.V. Budnikov
Siberian Inst. Geol., Geophys.& Min. Res.
Siberian Geological Survey
Krasny prospekt 67
630104 Novosibirsk
RUSSIA
Fax: 383-2-20-35-17, 22-57-40

Dr T.V. Byvsheva
ul. Bolshaia Academycheskaja
77 kor.1 kv. 154
125183 Moscow
RUSSIA

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

Dr Marina V. Durante
Geological Institute
Russian Academy of Sciences
Pyzhevsky per. 7
109017 Moscow
RUSSIA
Fax: +7-95-231-0443
Email:
durante@ginran.msk.su

Dr A.V. Durkina
Timan-Pechora Research Center
ul. Pushkina 2
169400 Ukhta
Komi Republic
RUSSIA
Fax: 6-13-04

Dr V.G. Ganelin
Geological Institute
Russian Academy of Sciences
Pyzhevsky per. 7
109017 Moscow
RUSSIA

Dr Nilyufer B. Gibshman
Moscow Oil and Gas Academy
Leninsky Prospect 65
117917 Moscow GSP-1
RUSSIA
Email:
nilyufer@mtu-net.ru

Dr N. Goreva
Geological Institute
Russian Academy of Sciences
Pyzhevsky per. 7
109017 Moscow
RUSSIA
Fax: +7-095-231-04-43
Email:
goreva@geo.fv-sign.ru

Dr T.N. Isakova
Geological Institute
Russian Academy of Sciences
Pyzhevsky per. 7
109017 Moscow
RUSSIA
Fax: +7-095-231-04-43
Email:
isakova@geo.fv-sign.ru

Dr R.M. Ivanova
Institute of Geology & Geochemistry
Uralian Branch, Russian Academy of Sciences
Pochtovyi per. 7
620151 Ekaterinburg
RUSSIA
Fax: +7-3432-5152-52
Email:
root@igg.e-burg.su

Dr Pavel B. Kabanov
Paleontological Institute
Russian Academy of Sciences
Profsoyuznaya 123
117868 Moscow GSP
RUSSIA
Email:
kabanov@paleo.ru

Dr A.H. Kagarmanov
Leningradsky Gorny Inst.
Vasilievsky ostr.
21 Linia, 2
199106 St Petersburg
RUSSIA

Dr N.V. Kalashnikov
Inst.Geol.,Komi Scientific Cent.
Uralian Branch, Russian Academy of Science
ul. Pervomayskaya 57
167000 Syktyvkar
RUSSIA

Dr L.I. Kononova
Dept. of Paleontology,
Geology Faculty
Moscow State University
119899 Moscow GSP V-234
RUSSIA

Dr M.V. Konovalova
Timan-Pechora Research Center
ul. Pushkina 2
169400 Ukhta
Komi Republic
RUSSIA
Fax: 6-13-04

Dr O. Kossovaya
Secretary, Russian Comm.
Carb. Stratigraphy
V.S.E.G.E.I.
Sredni pr. 74
199106 St Petersburg
RUSSIA
Email:
koss@mail.wplus.ru

Dr Elena I Kulagina
Inst. Geology
Uralian Res. Center
Russian Academy of Sciences
Ufa RUSSIA
Email:
kulagina@anrb.ru

Dr S.S. Lazarev
Paleontological Institute
Russian Academy of Sciences
Profsoyuznaya 123
117868 Moscow GSP
RUSSIA

Dr M.K. Makhlina
T.T.P. "Centrgeologia"
Varshavskoje Shosse 39a
113105 Moscow
RUSSIA
Fax: 7-095-954-38-15

Dr E. V. Movshovich
P.O. Box 1204
344091 Rostov-na-Donu-91
RUSSIA

Dr Svetlana Nikolaeva
Paleontological Institute
Russian Academy of Sciences
Profsoyuznaya 123
117868 Moscow GSP
RUSSIA
Email:
44svnikol@mtu-net.ru

Mrs M.V. Oshurkova
V.S.E.G.E.I.
Sredni pr. 74
199106 St Petersburg
RUSSIA

Dr Vladimir N. Pazukhin
Inst. Geology
Uralian Res. Center
Russian Academy of Sciences
Ufa RUSSIA

Dr L.N. Peterson
Krasnoyarskgeolsyomka
ul. Beresina, 3
660020 Krasnoyarsk
RUSSIA

Dr A.V. Popov
Leningrad University
16 Linia, 29
199178 St Petersburg
RUSSIA

Dr B.V. Poyarkov
Moskovsky prospekt 163 kv. 639
150057 Yaroslavl
RUSSIA

Dr E.A. Reitlinger
Geological Institute
Russian Academy of Sciences
Pyzhevsky per. 7
109017 Moscow
RUSSIA
Fax: +7-095-231-04-43

Dr S.T. Remizova
Inst.Geol., Komi Scientific Centre
ul. Pervomajskayja 54
167000 Syktyvkar
Komi Republic
RUSSIA
Fax: 821-2-42-53-46
Email:
strat@geol.dereza.komi.su

Dr R.A. Schekoldin
Dept of Historical Geology
Mining Institute, 21st line V.O. 2
199106 St Petersburg
RUSSIA
Fax: 812-213-26-13
Email:
benin@sovam.com

Dr O.A. Shcherbakov
Polytechnical Institute
Komsomolskiy Avenue 29a
614600 Perm
RUSSIA
Email:
geology@pstu.ac.ru

Dr M.V. Shcherbakova
Polytechnical Institute
Komsomolskiy Avenue 29a
614600 Perm
RUSSIA

Dr K.V. Simakov
N.E.Inter.Sci.Res.Inst.,Far East
Russian Academy of Sciences
Portovajy 16
685005 Madagan
RUSSIA

Dr V. Tchizhova
V.N.I.I.neft
I Dmitrovsky proezd 10
125422 Moscow
RUSSIA

Dr Alexander P. Vilesov
Geological Faculty
Perm State University
u1. Bukireva 15
614600 Perm
RUSSIA
Email:
geology@pstu.ac.ru

Dr Vladimir T. Zorin
Research & Production Firm
AZeNS@
Prospekt Marksa, 62
660049 Krasnoyarsk
RUSSIA

SLOVENIA

Dr A. Ramovs
Katedra za geologijo in paleontologijo
Askerceva 2
SLO-1000 Ljubljana
SLOVENIA
Fax: 386-61-1259-337

SOUTH AFRICA

Dr Colin MacRae
Palaeont.Sect.,Geological Survey
Private Mail Bag X112
Pretoria 0001
SOUTH AFRICA

Mr Barry Millsteed
Palaeont.Sect.,Geological Survey
Private Mail Bag X112
Pretoria 0001
SOUTH AFRICA
Fax: 012-841-1278
Email:
bmillstd@geoscience.org.za

Dr J.N. Theron
Geological Survey
P.O. Box 572
Bellville 7535
SOUTH AFRICA

SPAIN

Dr A. García-Loygorri
Cátedra de Geología
Escuela Sup. Ing. Minas
Ríos Rosas 21
28003 Madrid
SPAIN

L.F. Granados
Avda Juan Andrés 10bis
28035 Madrid
SPAIN

Dr M.L. Martinez Chacón
Depto de Geología
Universidad de Oviedo
Arias de Velasco s/n
33005 Oviedo
SPAIN
Fax: 34-8-510-3103
Email:
mmchacon@asturias.geol.uniovi.es

Dr Sergio Rodríguez
Depto de Paleontología
Facultad de Ciencias
Geológicas
Ciudad Universitaria
28040 Madrid
SPAIN
Fax: 1-394-4854
Email:
sergrodr@eumax.sim.ucm.es

Dr L.C. Sánchez de Posada
Depto de GeologRa
Universidad de Oviedo
Arias de Velasco s/n
33005 Oviedo
SPAIN
Fax: 34-8-510-3103
Email:
lposada@asturias.geol.uniovi.es

Dr Elisa Villa
Depto de Geología
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:
jardinbotcord@servicom.es

TARTARSTAN

Dr V.S. Gubareva
ul. Kosmonavtov 7 kv. 7
420061 Kazan
TARTARSTAN

THE NETHERLANDS

Dr O.A. Abbink
Department of Geo-Environment
Section Paleo-Environmental Research
NITG TNO: National Geological Survey
P.O. Box 80015
3508 TA Utrecht
THE NETHERLANDS

Bibliotheek Palaeobotanie
Lab. Palaeobotany and Palynology
Rijksuniversit., Heidelberglaan
2 NL-3584 CS Utrecht
THE NETHERLANDS
Fax: 31-30-253-096
Email:
Z.Smeenk@ beov.biol.ruu.nl

Dr A.C. van Ginkel
Nationaal Natuurhistorisch
Museum
Postbus 9517
NL-2300 RA Leiden
THE NETHERLANDS

Dr W. Khrschner
Lab. Palaeobotany & Palynology
Budapestlaan 4
NL-3584 CD Utrecht
THE NETHERLANDS

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

Dr C.F. Winkler Prins
Nationaal Natuurhistorisch
Museum
Postbus 9517
NL-2300 RA Leiden
THE NETHERLANDS
Fax: 31-71-5687666
Email:
winkler@naturalis.nnm.nl

TURKEY

Prof. Dr Demir Altiner
Department of Geological Engineering
Middle East Technical University
06531 Ankara
TURKEY
Phone:+90-312-2102680
+90-312-4275195
Fax: +90-312-2101263
Email:
altiner@tubitak.gov.tr
demir@metu.edu.tr

UNITED KINGDOM

Acquisitions
Department of Library Service
The Natural History Museum
Cromwell Road
London SW7 5BD
UNITED KINGDOM

Dr R.L. Austin
21 Bellevue Road
West Cross, Swansea
South Wales SA3 5QB
UNITED KINGDOM

Andrew Barnett
Department of Earth Sciences
University of Cardiff
CARDIFF
Wales CF1 3YE
UNITED KINGDOM
Fax: 01222 874326
Email:
BarnettAJ@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. Cleal
Department of Botany
National Museum & Gallery of Wales
Cathays Park
Cardiff CF1 3NP
UNITED KINGDOM
Fax: 01222-239-829
Email:
100015.567@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)
01782 294438 (SU office)
Email:
P.J.Cossey@staffs.ac.uk

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

Dr A.C. Higgins
Meadowview Cottage,
2 Rectory Row,
Cliddesden,
Basingstoke,
Hants, RG25 2JD
UNITED KINGDOM
Email:
alan@s-data.u-net.com

Dr M.R. House
Department of Geology
University of Southampton
Harts SO9 5NH
UNITED KINGDOM

Dr G.A.L. Johnson
Department of Geology
University of Durham
Durham DH1 3LE
UNITED KINGDOM

Mr M. Mitchell
11 Ryder Gardens
Leeds, W. Yorks. LS8 1JS
UNITED KINGDOM

Dr B. Owens
British Geological Survey
Keyworth
Nottingham NG12 5GG
UNITED KINGDOM

Dr W.H.C. Ramsbottom
Brow Cottage
Kirkby Malzeard
Ripon, N.Yorks HG4 3RY
UNITED KINGDOM

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

Dr A.R.E. Strank
British Petroleum Res.Centre
Chertsey Rd, Sunbury-on-Thames
Middlesex TW16 7LN
UNITED KINGDOM

Dr N. Turner
British Geological Survey
Keyworth
Nottingham NG12 5GG
UNITED KINGDOM

Dr W.J. Varker
Department of Earth Sciences
The University of Leeds
Leeds LS2 9JT
UNITED KINGDOM

Prof. V.P. Wright
Department of Earth Sciences
University of Cardiff
Cardiff CF1 3YE
UNITED KINGDOM
Tel: 01222 874943
Fax: 01222 874326
Email:
wrightvp@cardiff.ac.uk

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:
ghjeb@pop.ttu.edu

Mitch Blake
West Virginia Geological Survey
PO Box 879
Morgantown, WV 26507-0879
U.S.A.
Email:
blake@geosrv.wvnet.edu

Dr Darwin R. Boardman
School of Geology
Oklahoma State University
105 Noble Research Ctr.
Stillwater, OK 74078
U.S.A
Email:
amm0001@okway.okstate.edu

Dr Paul Brenckle
1 Whistler Point Road,
Westport, MA 02790
U.S.A.
Fax: 1-713-366-7416
Email:
saltwaterfarm@compuserve.com

Dr D.K. Brezinski
Maryland Geological Survey
2300 St Paul Street
Baltimore, MD 21218
U.S.A.

Dr Lewis M. Brown
Department of Geology
Lake Superior State University
Sault Sainte Marie,
MI 49783-1699
U.S.A.
Fax: 906-635-2111
Email:
lbrown@lakers.lssu.edu

Dr J.L. Carter
Carnegie Museum of Natural History
4400 Forbes Ave.
Pittsburgh, PA 15213
U.S.A.
Fax: 412-622-8837
Email:
jcl4@vsm.cis.pitt.edu

Dr D.R. Chesnut
Kentucky Geological Survey
228 Min.Res.Bldg,
University of Kentucky
Lexington, KY 40506-0107
U.S.A.
Fax: 859-257-5500
Email:
chesnut@ukcc.uky.edu

Dr H.H. Damberger
Illinois State Geological Survey
200 Nat.Res.Bldg, 615
E.Peabody Dr.
Champaign, IL 61820-6964
U.S.A.

Dr William C. Darrah
2235 Baltimore Pike
Gettysburg, PA 17325
U.S.A.

Dr Vladimir I. Davydov
Dept. Geosciences
Boise State University
1910 University Drive
Boise, ID 83725
U.S.A.
Tel: (208) 426-1119
Fax: (208) 426-4061
Email:
vdavydov@boisestate.edu

Dr J.T. Dutro Jr
5173 Fulton St. NW
Washington, DC 20016
U.S.A.
Fax: 1-202-343-8620
Email:
dutro.tom@simnh.si.edu

Dr Cortland Eble
Kentucky Geological Survey
228 Min.Res.Bldg, Univ. Kentucky
Lexington, KY 40506-0107
U.S.A.

Dr Kenneth J. Englund
40236 New Road
Aldie, VA 20105,
U.S.A.

Dr F.R. Ettensohn
Department of Geological Sciences
University of Kentucky
Lexington, KY 40506-0053
U.S.A.
Fax: 606-323-1938
Email:
geofre@ukcc.uky.edu

Dr Robert Gastaldo
Dept. of Geology
Colby College
Waterville, ME 04901
U.S.A.

Geology Library
The University of Iowa
136 Trowbridge Hall
Iowa City, IA 53342-1379
U.S.A.

William H. Gillespie
U.S. Geological Survey
916 Churchill Circle
Charleston, WV 25314-1747
U.S.A.

Dr Brian F. Glenister
Department of Geology
University of Iowa
Iowa City, IA 52242-1379
U.S.A.
Fax: 319-335-1821
Email:
geology@uiowa.edu

Dr John Groves
Dept. of Earth Sciences
University of Northern Iowa
Cedar Falls, IA 50614
U.S.A.
Email:
John.Groves@uni.edu

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

Dr Thomas W. Henry
U.S. Geological Survey
Denver Federal Center, MS 919
Denver, CO 80225
U.S.A.

Dr Thomas W. Kammer
Dept. of Geology and Geography
West Virginia University
P.O. Box 6300
Morgantown, WV 26506-6300
U.S.A.
Fax: 304-293-6522
Email:
tkammer@wvu.edu

Claren M Kidd
100 E Boyd R220
University of Oklahoma
Norman, OK 73019-0628
U.S.A.
Fax: 405 325-6451 or
405 325-3180
Email: ckidd@uoknor.edu

Dr Norman R. King
Dept. of Geosciences
University of Southern Indiana
Evansville, IN 47712
U.S.A.
Email: nking@usi.edu

Albert Kollar
Carnegie Museum of Natural History
Invertebrate Paleontology
4400 Forbes Ave
Pittsburgh, PA 15213
U.S.A.
Email:
KollarA@CarnegieMuseums.Org

Ms Andrea Krumhardt
Dept of Geology & Geophysics
University of Alaska
P.O. Box 755780
Fairbanks, AK 99775
U.S.A.
Fax: 907-474-5163
Email:
fnapk@aurura.alaska.edu

Dr Lance Lambert
Department of Physics
Southwest Texas State University
601 University Drive
San Marcos, TX 78666
U.S.A.
Email: CW12@swt.edu

Dr N. Gary Lane
Dept. of Geological Sciences
Indiana University
Bloomington, IN 47408.
U.S.A.
Fax 812-855-7899.
Email: lane@indiana.edu

Dr H. Richard Lane
National Science Foundation
4201 Wilson Blvd., Room 785
Arlington, VA 22230
U.S.A.
Tel: +1- 703-306-1551
Fax: +1-713-432-0139
Email: hlane@nsf.gov

Dr Ralph L. Langenheim
Dept Geol.,Univ. of Illinois
254 N.B.H.,1301 W. Green St.
Urbana, IL 61801
U.S.A.

Dr R.L. Leary
Illinois State Museum
Research & Collections Center
1011 East Ash Street
Springfield, IL 62703
U.S.A.
Fax: 217-785-2857
Email:
Leary@museum.state.il.us

Dr Spencer G. Lucas
Curator of Paleontology & Geology
New Mexico Museum of Natural History
1801 Mountain Road N.W.
Albuquerque, NM 87104
U.S.A.
Fax: 505-841-2866
Email:
SLucas@nmmnh.state.nm.us

Dr Richard Lund
Department of Biology
Adelphi University
Garden City, NY 11530
U.S.A.

Dr W.L. Manger
Department of Geology
Univ. of Arkansas
Fayetteville, AR 72701
U.S.A.
Email:
wmanger@comp.uark.edu

Dr Gene Mapes
Dept of Envir. & Plant Biology
Ohio University
Athens, OH 45701
U.S.A.

Dr R.H. Mapes
Department of Geology
Ohio University
Athens, OH 45701
U.S.A.

Dr C. G. Maples
Dept. of Geological Sciences
Indiana University
Bloomington, IN 47405
U.S.A.

Charles E. Mason
Dept. of Physical Sciences
Morehead State University
Morehead, KY 40351
U.S.A.
Fax: 606-783-2166
Email:
c.mason@morehead-st.edu

Dr Hermann W. Pfefferkorn
Department of Geology
University of Pennsylvania
240 S 33rd St.
Philadelphia, PA 19104-6316
U.S.A.
Fax: 215-898-0964
Email: hpfeffer@sas.upenn.edu

John P. Pope
Dept of Geoscience
University of Iowa
Iowa City, IA 52242
U.S.A.

Dr E. Troy Rasbury
Department of Geosciences
SUNY Stony Brook
Stony Brook, NY 11794-2100
U.S.A.
Fax: 631-632-8240
Email:
troy@pbisotopes.ess.sunysb.edu

Dr Carl B. Rexroad
Indiana Geological Survey
611 N. Walnut Grove
Bloomington, IN 47405
U.S.A.
Fax: 812-855-2862
Email:
Rexroad@gismo.geology.indiana.edu

Dr C.A. Ross
GeoBioStrat Consultants
600 Highland Drive
Bellingham, WA 98225-6410
U.S.A.
Fax: 360-650-3148
Email:
rossjpr@henson.cc.wwu.edu

Dr June R.P Ross
600 Highland Drive
Bellingham, WA 98225-6410
U.S.A.
Fax: 360-650-3148
Email:
rossjpr@henson.cc.wwu.edu

Dr C.A. Sandberg
U.S. Geological Survey
Box 25046, Federal Center,
MS 940
Denver, CO 80225
U.S.A.

Dr Matthew Saltzman
Dept. of Geological Sciences
275 Mendenhall Laboratory
Ohio State University
Columbus, OH 43210-1398
U.S.A.
Fax: 614-292-7688
Email: saltzman.11@osu.edu

A. Sartwell, Chief Info. Services
Geological Survey of Alabama
P.O.Drawer 0, University
Station
Tuscaloosa, AL 35486-9780
U.S.A.

Dr W. Bruce Saunders
Geology Department
Bryn Mawr College
Bryn Mawr, PA 19010
U.S.A.
Email:
wsaunder@brynmawr.edu

Dr Steve Schutter
2400 Julian Street, #1
Houston, TX 77009
U.S.A.

Serials Department
Univ. of Illinois Library
1408 West Gregory Drive
Urbana, IL 61801
U.S.A.

Dr Gerilyn S. Soreghan
Geology & Geophysics
University of Oklahoma
100 E. Boyd St.
Norman, OK 73019
U.S.A.
Email: lsoreg@uoknor.edu

Dr C.H. Stevens
Department of Geology,
School of Science
San Jose State University
San Jose, CA 95192-0102
U.S.A.
Fax: 408-924-5053
Email:
stevens@geosun1.sjsu.edu

Ms Mathilda Stucke
30 Oakland Avenue
West Hempstead, NY 11552-
1923
U.S.A.
Fax: 516-877-4711
Email:
stucke@adlibv.adelphi.edu

Dr T.N. Taylor
Department of Botany,
Haworth Hall
University of Kansas
Lawrence, KS 66045
U.S.A.
Email:
ttaylor@falcon.cc.ukans.edu

Dr T.L. Thompson
Missouri Geological Survey
Box 250
Rolla, MO 65401
U.S.A.

Dr Alan L. Titus
Grand Staircase-Escalante
National Monument
180 W 300 N
Kanab, UT 84741
U.S.A.
Fax: 435-644-4350
Email: Alan_Titus@ut.blm.gov

Dr Peter R. Vail
Dept Geol., Rice University
P.O. Box 1892
Houston, TX 77251
U.S.A.

Dr G.P. Wahlman
BP Amoco
P.O. Box 3092
Houston, TX 77253
U.S.A.
Fax: 1-281-366-7567
Email: wahlmagp@bp.com

Dr Bruce Wardlaw
U.S. Geological Survey
970 National Center
Reston, VA 22092
U.S.A.

Dr J.A. Waters
Department of Geology
West Georgia College
Carrollton, GA 30118
U.S.A.
Fax: 770-836-4373
Email: jwaters@westga.edu

Dr W. Lynn Watney
Kansas Geological Survey
1930 Constant Avenue -
Campus West
Lawrence, KS 66047
U.S.A.
Fax: 785-864-5317
Email: lwatney@kgs.ukans.edu

Dr Keith Watts
P.O. Box
Wilson, WY
U.S.A.

Dr Gary Webster
Department of Geology
Washington State University
Physical Science 1228
Pullman, WA 99164
U.S.A.
Fax: 509-335-7816

Dr R.R. West
Dept Geol., Thompson Hall
Kansas State University
Manhattan, KS 66506-3201
U.S.A.
Fax: 913-532-5159
Email: rrwest@ksuum.ksu.edu

Dr Garner L. Wilde
5 Auburn Court
Midland, Texas 79705
U.S.A.

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

UKRAINE

Dr N.I. Bojarina
Institute of Geology
Ukrainian Academy of Science
ul. Chkalova 55b
252054 Kiev
UKRAINE

Dr O.P. Fissunenko
Pedagog. Inst.
Oboronnaja 2
348011 Voroshilovgrad
UKRAINE

Dr R.I. Kozitskaya
Institute of Geology
Ukrainian Academy of Science
ul. Chkalova 55b
252054 Kiev
UKRAINE

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

Dr V.I. Poletaev
Institute of Geology
Ukrainian Academy of Science
ul. Chkalova 55b
252054 Kiev
UKRAINE

Dr Z.S. Rumyantseva
ul. Vasilovskaja 42, Kv.33
252022 Kiev
UKRAINE

Dr A.K. Shchegolev
Institute of Geology
Ukrainian Academy of Science
ul. Chkalova 55b
252054 Kiev
UKRAINE

Dr N.P. Vassiljuk
Donetskij Politekhn. Inst.
ul. Artema 58
Donetsk
UKRAINE

Mrs M.V. Vdovenko
Institute of Geology
Ukrainian Academy of Science
ul. Chkalova 55b
252054 Kiev
UKRAINE

UZBEKISTAN

Dr F.R. Bensh
Inst. Geol. & Geophys.
ul. Sulejmanovoj 33
700017 Tashkent
UZBEKISTAN

Dr Iskander M. Nigmadjanov
ul. G. Lopatina 80, kv. 35
700003 Tashkent
UZBEKISTAN

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: amm0001@okway.okstate.edu

Dr Paul Brenckle
1 Whistler Point Road,
Westport, MA 02790
U.S.A.
Email: saltwaterfarm@compuserve.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
Pyzhevsky per. 7
109017 Moskva
RUSSIA
FAX: +7 95 231 0443
Email: durante@ginran.msk.su

Dr Carlos R. González
Instituto de Paleontologia
Fundación Miguel Lillo
Miguel Lillo 251
4000 S.M. deTucumán
ARGENTINA
FAX: +54 81 330 868
Email: fmlgeo@uumail.unt.edu.ar

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

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

Dr T.I. Nemyrovska
Institute of Geological Sciences
Ukrainian Academy of Sciences
Gonchar Str., 55b
252054 Kiev
UKRAINE
Email: tnemyrov@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.emr.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. Sevastopulo
Department of Geology
Trinity College
Dublin 2
IRELAND
FAX: +353-1-671 1199
Email: gsvstpul@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 Geología
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: crl wagro@uco.es

Prof. Wang Zhi-hao
Nanjing Institute of Geology and Palaeontology
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.nnm