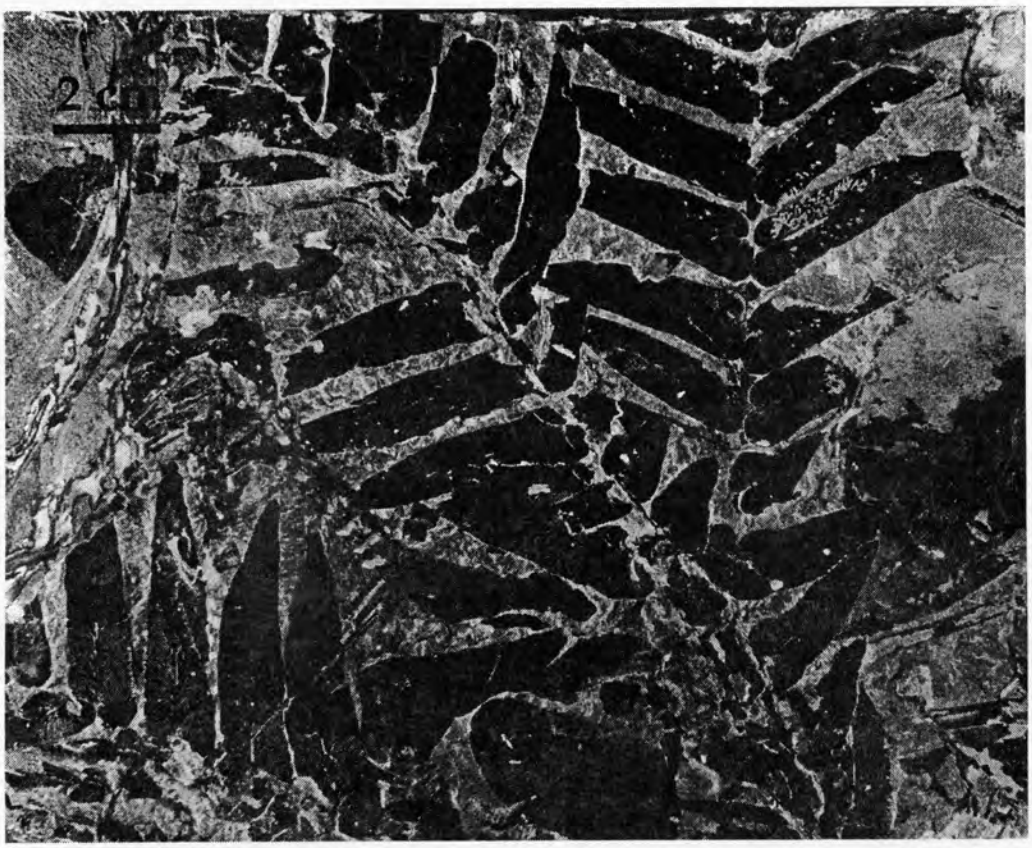
NEWSLETTER ON CARBONIFEROUS STRATIGRAPHY

Volume 16 July 1998



SCCS

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

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Newsletter on Carboniferous Stratigraphy

Edited by I. Metcalfe

IUGS SUBCOMMISION ON CARBONIFEROUS STRATIGRAPHY / VOL. 16 - 1998

Chairman's Column

The past year has brought progress towards the task of establishing a formally approved set of stratigraphic subdivisions for the Carboniferous System. The Working Group on the Moscovian-Kasimovian, which meets annually for a field and laboratory meeting, has new evidence based on conodonts and foraminifera that should lead to the definition of a GSSP for that boundary, though much stratigraphic and palaeontological work is still required for the final resolution of this task. Excellent new data are also emerging from North America and Russia that should enable a GSSP to be established at the Kasimovian/Gzhelian-Missourian/Virgillian boundary. I am delighted that the Working Group's activities have been expanded to include definition of that boundary. I would also like to think that co-operation between members of the working group and Project Group 4, currently working on subdivisions of the Bashkirian in the type area at Ufa, could lead to definition of the base of the Moscovian.

These positive results are tempered by an apparent lack of activity in other areas in vital need of attention. Despite persuasion and cajoling from the Chairman, there have been no new developments in the search for a replacement for the Tournaisian-Visean boundary at Dinant. Although Southern China contains the necessary evolutionary succession of species for definition of the boundary, thanks to the intensive work carried out by our Belgian and Chinese colleagues, a satisfactory stratotype section remains elusive. Suggestions that potential sections in the Craven Basin, UK, or in Ireland may provide a stratotype have yet to be investigated. So far nobody has volunteered to work on either section. Can any of our readers shed some light on the potential of the foraminiferid and/or conodont faunas in either of these sections to provide the information needed to redefine the Tournaisian-Visean boundary? Are there any volunteers who are prepared to take up the challenge and work on these areas?

Two other boundaries also require formal definition, the Visean-Serpukhovian/Namurian and the Bashkirian-Moscovian boundaries (referred to above). No formal SCCS work is being carried out on the Visean-Serpukhovian/Namurian boundary. Initially I suggest the establishment of a Project Group, with personnel drawn from regions with continuous marine deposition between these two Stages (eg, Russian, Europe, China and North America). Again, are there any volunteers?

Voting members were recently asked to comment upon the final draft of the Global Chart. Given our submissions, outlined in the previous issue of the Newsletter, we were somewhat startled to find that the compiler had left the subdivisions of the Carboniferous blank! There was, however, an appendix summarising the problems involved in establishing a truly global set of subdivisions for the Carboniferous. The chart made no provision for sub-systems, a matter of recent concern for SCCS, and few systems were subdivided into named series. Professor Jurgen Remane, Chairman of ICS pointed out that the classification of the stratigraphic system was far from uniform and sought advice on a number of problem areas. For example, are sub-systems needed (the Carboniferous was the only system to have sub-systems), and should series/epochs have proper names or not? There was also debate whether series could be as the smallest chronostratigraphic units that can be correlated worldwide, and stages, which normally qualify as units of global significance, should be used for regional units. Advice received from the majority of the voting members that replied to the executive led us to omit sub-systems from the Carboniferous section of the chart, and to relegate the previously named series names to stages. The latter decision was also aided by recent correspondence from Professor A. Kagarmanov, Chairman of the Russian Commission on Carboniferous Stratigraphy, informing us that his commission had not changed the status of the Russian stages to series (contrary to reports in the previous issue of the Newsletter).

As only a single set of stages was allowed on the Global Chart, we have used Tournaisian and Visean, because they are globally recognisable, and then reverted to the use of the Russian stages Serpukhovian, Bashkirian, Moscovian, Kasimovian and Gzhelian, because they are, arguably, applicable and/or identifiable across a large part of

the palaeotropical Carboniferous. Relationships between these stages and the alternative Western European and North American stages are given in a separate figure, and details of the difficulty of correlation with Gondwanan successions outlined in a set of notes.

The Global Chart is a continuously evolving document. Given the variety of views on stratigraphic classification within the Carboniferous community, we have organised an SCCS Symposium in August 1999 at the Calgary Meeting of the International Congress on the Carboniferous and Permian to continue discussion on how the Carboniferous can be best subdivided. As well as continuing the debate on the classification of the Carboniferous I hope that the discussion will stimulate research leading to the establishment of GSSPs for all of the Carboniferous stages.

A major disappointment to the Executive during 1997 was the forced cancellation of the Field and General Meeting which was to be held at the University of New England in Armidale, NSW, with fieldwork in the Southern New England Orogen of eastern Australia. Only four participants elected to indicate they wished to participate by the due date, a number far short of economic viability. The meeting was designed to show Carboniferous workers from elsewhere in the world the nature of Gondwanan successions, subduction complex and forearc basin sequences, and particularly glacial sediments. We recognise that the eastern Australian Carboniferous is different to the largely marine shelfal to basinal regions in which most Carboniferous biostratigaphic work is carried out, but are disappointed that workers from other countries chose to ignore a region that over recent years has produced successful biostratigraphic, isosotopic and magnetostratigraphic Carboniferous timescales.

Two Voting Members with many years service, Dr Walt Manger from USA and Professor A.C. Rocha-Campos from Brazil, resigned as Titular Members of the SCCS during 1997. I thank them for all they have contributed to the subcommission. The Voting Membership is now 20, the limit set under that statutes of the ICS. A number of the present Voting Members will be retiring from the SCCS in 1999 because they have reached the time limit set down in ICS statutes. The aim of the executive is to recruit active researchers from throughout the world in order that advances continue to be made to Carboniferous stratigraphy and to maintain a balanced representation on the SCCS.

I urge all Carboniferous workers to attend the Calgary Meeting of the International Congress on the Carboniferous and Permian in August 1999, so that meaningful discussion can take place on global subdivisions of the Carboniferous System.

John Roberts

SCCS ANNUAL REPORT 1997

Membership:

The Subcommission has 20 Voting members including the Executive Officers. In addition to this, corresponding membership at the date of publication stands at 257 and 7 libraries also receive the Newsletter.

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Activities in 1997/98:
Establishment of an SCCS Home Page on the internet at:

"http://www.une.edu.au/sciences/schoolphyseng/SCCS/SCCS.html".

In addition to general information and address/fax/e-mail details of members, the Newsletter is also available in the SCCS Home Page.

Revision of the Carboniferous part of the IUGS/ICS Global Stratigraphic Chart (this request from ICS generated intense disscussions/communications within the SCCS and had a generally very positive impact in rejuvenating and re-focussing the SCCS membership on the

tasks for the Subcommission in the future).

Formal ballot of Voting Members regarding the naming of the two Sub-Systems for the Carboniferous (see Secretary/ Editor's Report).

Apart from results obtained by formal SCCS Working Groups and Projects (see seperate item in Newsletter), the Newsletter on Carboniferous Stratigraphy (Vol. 15, 1997) has also reported results of a number of investigations including eustatic flooding events in the late Visean of Utah and Britain, Carboniferous macrofloras of western Newfoundland, Visean polyplacophorans from Moravia, Carboniferous Timescales, macro and micro-floras of the Westphalian D-Cantabrian boundary, the Carboniferous-Permian boundary in Argentina, atmospheric CO_2 levels at the Westphalian-Stephanian boundary, Carboniferous of western Verchoyanie, Carboniferous of Brazil, Carboniferous spores from the Tarim basin, China, Late Carboniferous facies and biostratigraphy in the Carnic Alps, and evolutionary pattern and biostrtigraphy of *Eoparastaffella*.

SCCS Work Plans for 1997-1998:
1997: Complete postal ballot for naming of the Two Carboniferous Sub-Systems.

1998: Ensure that the existing research program is continued into the succeeding years and that the formal SCCS Working Groups and Projects (see above) proceed efficiently towards their goals, preferably within a reasonable timeframe.

Organisation of general Meeting and SCCS sessions/business meeting at the Carboniferous-Permian Congress to be held in Calgary, 1999.

STATEMENT OF INCOME and EXPENDITURE FOR 1997:
(Definitive accounts are maintained in Australian currency).

INCOME (Oct. '96 - Sept. '97)	**$AUS**	**$US**
	Definitive	Estimated
IUGS Grant 1997 (CHF 1,075)	1,287.99	1015.00
Donations from Members	183.00	137.25
Bank Interest	2.52	1.89
TOTAL INCOME	**1,473.51**	**1,154.14**
EXPENDITURE		
Newsletter 15 publication/ postage)	1,241.00	930.75
Secretarial Assistance (Newsletter 15)	150.00	112.50
Bureau postage and stationery	72.70	54.53
Bank Charges	7.00	5.25
TOTAL EXPENDITURE	**1,470.70**	**1,103.03**

BALANCE SHEET (1996-97)	**$AUS**	**$US**
	Definitive	Estimated
Funds carried forward from 1996	18.08	
PLUS Income 1996-97	1,473.51	1,154.14
LESS Expenditure 1996-97	(1,470.70)	(1,103.03)
CREDIT balance carried forward to 1996-97	**20.89**	**15.67**

BUDGET REQUEST FOR 1998		**$US**
Newsletter 15 (preparation/ printing/postage		800
(Net requirement assuming receipt of US$200 donations)		
Other Bureau expenses		400
PROJECTED EXPENDITURE		**1,200**

The Subcommission has been advised by ICS that it has been allocated US$870 in IUGS funding for 1998.

Secretary/Editor's Report 1997-98

The last year brought renewed discussion and activity within the SCCS, particularly following on from the debate that ensued regarding proposed revisions to the IUGS Global Stratigraphic Chart. New information relating to the Mid-Carboniferous boundary stratotype at Arrow Canyon has led to some heated debate during the year (see contribution by Riley this issue). The Working Group to define a GSSP at or near to the Moscovian/Kasimovian boundary has been particularly active, as has Project Group 4, working on Late Namurian successions. Two Voting Members of the Subcommission, Dr Walt Manger and Professor A.C. Rocha -Campos resigned as Titular Members of the Subcommission during the year. Both Dr Manger and Prof. Rocha-Campos have many years of valuable service to the SCCS and our heartfelt thanks for all their efforts and time put into the Subcommission over the years goes out to them. These resignations brought our Titular Membership down to the maximum level of 20 allowable by the ICS. Following much discussion, a formal vote was undertaken during the year on the naming of the two divisions of the Carboniferous defined by the Mid-Carboniferous GSSP and the GSSPs at the Devonian-Carboniferous and Carboniferous-Permian boundaries. Two proposals were voted upon:

PROPOSAL 1: "That the two Sub-Systems of the Carboniferous be named "Lower Carboniferous" and "Upper Carboniferous"

PROPOSAL 2: "That the two Sub-Systems of the Carboniferous be named "Mississippian" and "Pennsylvanian"

Neither proposal received the necessary 60% majority to be carried. Please see the detailed results of voting below. A planned further vote on Proposal 2, which did receive sufficient support to warrant such, has been placed on hold pending a decision regarding the status of the two sub-divisions of the Carboniferous as Sub-Systems or as Series. It seems that the ICS prefers to abandon the use of Sub-Systems. A recent informal request to Voting members of the SCCS resulted in the majority of those responding preferring to abandon the use of Sub-Systems. This issue is clearly an important one that should be discussed, along with other important matters at our next SCCS international meeting in Calgary at the ICCP in 1999. We have arranged for a full half-day SCCS session at the Calgary meeting and also a formal SCCS business meeting. All members of the SCCS and particularly Voting Members are urged to attend. Please see the separate item for details of the ICCP to be held in Calgary, next year and I would be grateful if those SCCS members who intend to participate would let me know in good time.

I would remind members that the SCCS home page is located at: "http://www.une.edu.au/sciences/schoolphyseng/SCCS/SCCS.html".

This Newsletter will shortly be available on the home page together with Newsletter 15 and other SCCS general information and address/fax/e-mail details of members already available.

A major disappointment during 1997 was the forced cancellation of the SCCS Field and General Meeting which was to be held at the University of New England in Armidale, NSW, with fieldwork in the Southern New England Orogen of eastern Australia. We very much hope that SCCS activities at the ICCP in Calgary will make up for this!

I would be most grateful if all Voting and Corresponding Members of the SCCS would let me know of any changes to their contact details so that we may update our records. Please also keep articles for the Newsletter coming in and let me know of any other items that may be suitable for posting in our WWW Home Page.

Ian Metcalfe
July, 1998

Donations in 1996/1997:

Publication of this *Newsletter* is made possible with generous donations received from the following members/institutes during 1997-98 and anonymous donations, combined with an IUGS subsidy of US$1015 in 1997, and additional support from a small group of members who provide internal postal charges for the *Newsletter* within their respective geographic regions.

G. Playford
N. Sabattini
Eva Paproth
J. Kullman
H.H. Damberger
K.J. Müller
S. Stojanovic
M. Zeller
P.J. Jones
Timon-Pechora Research Centre

SUBCOMMISSION ON CARBONIFEROUS STRATIGRAPHY

BALLOT OF TITULAR MEMBERS

Naming of the Two Sub-Systems of the Carboniferous

RESULTS OF VOTING

	PROPOSAL 1:			PROPOSAL 2:		
	"That the two Sub-Systems of the Carboniferous be named "Lower Carboniferous"and "Upper Carboniferous"			"That the two Sub-Systems of the Carboniferous be named "Mississippian" and "Pennsylvanian"		
Name	In Favour	Against	Abstain	In Favour	Against	Abstain
J. Roberts	X				X	
J.T. Dutro Jr			X	X		
Ian Metcalfe		X		X		
Alexander S. Alekseev		X			X	
Paul Brenckle		X		X		
Boris Chuvashov	X				X	
Geoff Clayton		X		X		
Marina V. Durante	X				X	
B.A. Engel	X				X	
Carlos R. González	X					
Philip H. Heckel		X		X		
H. Richard Lane		X		X		
J.P. Laveine	X					X
Bernard L. Mamet	X				X	
Ouyang Shu			X	X		
N.J. Riley	X				X	
G.D. Sevastopulo		X		X		
Elisa Villa		X		X		
R.H. Wagner		X		X		
C.F. Winkler Prins		X		X		
TOTAL	8	10	2	11	7	1

NOTE:

Gonzalez did not register a vote for proposal 2.

SCCS ON THE INTERNET

http://www.une.edu.au/sciences/schoolphyseng/SCCS/SCCS.html

COVER ILLUSTRATION

Macroneuropteris macrophylla (Brongniart) Cleal, Shute & Zodrow; from the lower Cantabrian, Sydney Coalfield, Nova Scotia, Canada. Photograph supplied by Professor Erwin L. Zodrow.

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

1. GENERAL REPORT

By Elisa Villa

MEETING AND FIELD-TRIP IN THE CANTABRIAN MOUNTAINS (SPAIN)

During 1997, the Working Group to establish a GSSP close to the Moscovian/ Kasimovian boundary has continued its rearch program, analyzing fossil faunas and potential events that could be used for the correlation of the upper part of the Carboniferous System.

The activities of the working group include regular meetings held every year in different parts of the world. In 1997 this meeting was held in Spain and 22 members from eight different countries have participated. They met in Oviedo on September 26 and started a four-day field-trip through the eastern part of Asturias, where beatiful outcrops of Carboniferous rocks exist. Several sections showing marine Carboniferous successions (from Tournaisian to Kasimovian) were visited, but attention was mainly devoted to the strata of interest for this working group, that is, beds from the uppermost Moscovian upwards. As we did in our last meeting and field-trip in Ukraine, all participants collected samples from some relevant levels. These samples will be studied jointly by several specialists and will be a matter for discussion at subsequent meetings.

After the field-trip in the eastern part of Asturias, the working group returned to Oviedo, where we devoted four additional days to laboratory sessions and discussions. These sessions were arranged in the Departament of Geology of the University of Oviedo.

During the first three days, the group was divided into two different workshops, one dealing with conodonts and the other devoted to fusulinaceans. On the last day, all the participants got together in a special session in which several members presented their recent achivements. Dr. Phil Heckel, as a representative of the conodont group, explained the significant progress in correlation based on the study and comparison of conodonts from the American Mid-Continent, Moscow Basin, Donets Basin and Cantabrian Mountains. A particular part of the session was devoted to discussion of the preliminary studies on the fusulinds collected by Dr. Katsumi Ueno during the 1996 field-trip in the Donets Basin, and their comparison with faunas from the Cantabrian Mountains.

Finally, the whole group discussed future plans. It was agreed that Dr. Aleksander S. Alekseev will organize the next meeting in Moscow, in August 1998. Then Dr. Alekseev presented a tentative plan for this meeting, as well as for a field-trip visiting Moscovian, Kasimovian and Gzhelian outcrops in the Moscow Basin.

FUTURE PLANS

1998 Meeting in Moscow

In August 1998 the Working Group to establish a GSSP close to the Moscovian/ Kasimovian boundary will meet in Moscow from August 9th to August 17th. As in previous occassions, this meeting will consist of two parts: field-trip and laboratory sessions. The field-trip (August 10th-13th) will allow participants to visit several outcrops in the vicinity of Moscow, including the stratotypes of the Serpukhovian, Moscovian, Kasimovian and Gzhelian Stages.

In the morning of August 14th, a half-day visit to the Paleontological Institute of the Russian Academy of Sciences has been arranged, in which Working Group members will be able to examine Kasimovian and basal Gzhelian material from bore-holes in the Moscow City.

Laboratory sessions and discussions will be held in the Department of Paleontology of the Moscow State University from August 14th (afternoon) to August 16th.

A new project

Recent studies by the working group members have shown the necessity to extend our investigations to levels higher than the Moscovian/Kasimovian boundary. This research program has been substantially carried out during the last two years. Members of the conodont group have already pointed out that a clear faunal change, that could offer some potential for correlation, occurs in strata close to the Kasimovian/Gzhelian and Missourian/Virgilian boundaries. For these reasons, the working group has accepted a formal proposal from the SCCS Chairman for dealing not only with the Moscovian/Kasimovian boundary but also with the Kasimovian/Gzhelian and Missourian/Virgilian boundaries.

2. FUSULINIDS FROM THE DONETS BASIN PRELIMINARY STRATIGRAPHIC OBSERVATIONS

By Katsumi Ueno & Elisa Villa

During the field-trip in the Donets Basin, the working group members examined the Kalinovo section, where the

upper C2-7 (M Limestones), C3-1 (N Limestones), and C3-2 (O Limestones) Suites are well exposed. We collected samples from most beds of the M, N, and O Limestone series in search of fusulinid faunas. The results of this sampling have been variable: some limestones provided abundant fusulinids, but others that were supposed to contain a rich fossil fauna, are totally devoid of foraminifers.To precisely identify the specimens encountered in comparison with those described in the Donets literature, a more detailed study of these faunas will be necessary. However, some preliminary observations can be made, which provide new information for the correlation of the Upper Carboniferous successions. These remarks are summarized as follows:

1) The fusulinid fauna from the Donets Basin includes many endemic species together with a few cosmopolitan ones. This makes it difficult to compare the Donets fusulinid fauna with those reported from other areas, such as the Russian Platform and Central Asia. However, some species display evolutionary features that allow biostratigraphic comparison with forms from other parts of Eurasia that show similar features.

2) Limestones M9 and M10 have been traditionally correlated with the Myachkovsky Horizon of the Russian Platform. However, based on the occurrence of a *Putrella* species and large *Fusulina* resembling *F. kamensis*, a correlation with slightly older levels (probably Podolsky Horizon), seems to be most probable.

3) Limestones N1 and N2 have been considered in some papers to be equivalent to the uppermost Moscovian or to the lowermost Kasimovian. In our opinion, the latter possibility can be excluded, since these beds still contain clear Moscovian assemblages. The species encountered belong to *Taitzehoella*, large *Pseudostaffella*, *Fusiella*, and *Ozawainella* genera. Advanced *Fusulina*, showing transitional characters between *Fusulina* and *Quasifusulinoides*, are also present.

4) The first undoubted *Protriticites* occurs in Limestone N3 together with *Quasifusulinoides*, *Schubertella*, and *Eostaffella* species. Therefore, Limestone N3 seems to be most probably correlated with the upper Peski Formation (upper Myachkovsky Horizon) of the Moscow Basin. The occurrence in Limestone N3-3 of forms such as *Ozawainella* ex gr. *angulata*, *Fusiella* ex gr. *typica*, and *Eostaffella* sp., also supports this correlation (see remarks on the fusulinids of the Peski Formation in Villa *et al.*, 1997).

5) Due to soil cover, we could not examine the Limestones N4 and N5 at the Kalinovo section. Moreover, Limestone N5-1 is totally barren of fusulinids. All these facts are especially unfortunate since in most Russian papers, Limestone N5 has been considered to be equivalent to the basal Kasimovian of the Russian Platform, and N4 and N5 series represent a critical interval.

6) The Limestone O1 yields abundant*Obsoletes* specimens together with a few *Protriticites*. They are associated with *Fusiella*, *Ozawainella*, *Schubertella*, and *Eostaffella* species. Among them, *Fusiella* species has intermediate shell characters between *Fusiella lancetiformis* and *F. rawi*. Similar *Fusiella* species has been reported from the *Protriticites* Zone of the Cantabrian Mountains (see comment in Villa & van Ginkel, 1997, p. 157). *Ozawainella* species from O1 Limestone are quite similar to those reported by Villa & van Ginkel (1997) from the upper part of the *Protriticites* Zone of the Cantabrian Mountains The *Eostaffella* species is characterised by having a large proloculus. Based on these observations, Limestone O1 of the Donets Basin can be correlated with the upper part of the *Protriticites* Zone of the Cantabrian Mountains.

7) The Limestone O2 is characterized by the abundant occurrence of a *Montiparus* species belonging to the *M. umbonoplicatus* group. This species quite resembles a form reported from the upper part of the Las Llacerias section of the Cantabrian Mountains (Villa & van Ginkel, 1997). *Quasifusulinoides*, rhombic *Ozawainella* (which also occurs in the uppermost part of the LasLlacerias section), large *Fusiella* (similar to that from the underlying Limestone O1), and *Eostaffella* having a large proloculus, are also associated.

8) The Limestone O3 yields abundant *Quasifusulina* together with *Schubertella*, *Fusiella*, and *Eostaffella* with a large proloculus. On the contrary, primitive schwagerinid species are very rare in this limestone.

References

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3. PRELIMINARY CONODONT CORRELATIONS OF LATE MIDDLE TO EARLY UPPER PENNSYLVANIAN ROCKS BETWEEN NORTH AMERICA AND EASTERN EUROPE

By Philip H. Heckel
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At the Oviedo meeting of the SCCS Working Group on Boundary Close to Moscovian-Kasimovian (formerly W.G. No. 5), conodont morphotypes from late Desmoinesian, Missourian, and early Virgilian rocks in central and eastern North America were compared with those from late Moscovian, Kasimovian, and early Gzhelian rocks of the Moscow region of Russia and the Donets Basin (Donbass) of Ukraine. Their characteristics and preliminary correlations between the two major regions are briefly discussed in ascending order (see Figure 1). It is possible, of course, that further study of more complete faunas may lead to modifications of these preliminary results.

Late Desmoinesian faunas from the Verdigris through Pawnee Formations (illustrated in Swade, 1985) are dominated by flat-platformed *Idiognathodus delicatus* (named from the Pawnee) and related forms. Similar morphotypes are found in the late Moscovian (upper Myachkovian) in the Moscow region and in Limestone N2 in the Donbass. Earlier Desmoinesian faunas from the type Desmoinesian region in Iowa illustrated by Lambert and Heckel (1990) contain an *Idiognathodus* that resembles *I. obliquus* (which was named from Limestone M10\1 in the Donbass, and extends upward from Limestone M3, of mid-Moscovian age). These older North American faunas were not available at the meeting, and they lie below the succession shown in Figure 1.

Latest Desmoinesian faunas from the Altamont and Lost Branch Formations (illustrated in Swade, 1985) contain flat-platformed but slightly medially grooved and larger-lobed morphotypes of *Idiognathodus* that probably descended from *I. delicatus*. One of these that extends upward from the Altamont resembles a morphotype found in Limestone N3\2 in the Donbass. The Altamont and Lost Branch Formations [plus two less widespread, more basinward units (south of Iowa) not studied by Swade (1985): the Farlington Limestone bed (in the Bandera Shale between the Altamont and Pawnee Formations) and the Norfleet Limestone Member (in the Lenapah Formation, between the Altamont and Lost Branch Formations)] contain also a lineage of troughed morphotypes that have been referred by many workers to Streptognathodus. These morphotypes were illustrated by Swade (1985) as *I.* sp. 5 and I. sp. 6 rather than *Streptognathodus* because this lineage apparently became extinct at the end of the Desmoinesian, long before the appearance of the lineage of type *Streptognathodus*, which was named from the middle Missourian of Texas. The North Americans are in the process of naming this earlier troughed lineage in honor of Swade, who recognized it as distinct from type *Streptognathodus*, but died before his 1985 paper was published. His sp. 5, which dominates the Farlington Limestone bed and the lower Altamont Formation, is a deeply troughed morphotype that is not known from high Moscovian or lower Kasimovian rocks in eastern Europe, but his sp. 6, which was named *S. nodocarinatus* by Jones (1941) from a bed now included in the Lost Branch Formation, is very close to a morphotype (but one that has more divergent rostral ridges) recognized in the lower Voskresensk Formation (middle Krevyakinian, lower Kasimovian) of the Moscow region under the name *S. excelsus* (a North American name for a somewhat similar middle Missourian form). More significantly, the underlying Norfleet Limestone has recently yielded a troughed morphotype intermediate between Swade's sp. 5 and 6 that appears to be the same as *S. subexcelsus*, which was recently named in the Moscow region from what is now the lowest Krevyakinian (hence lowest Kasimovian) Suvorovo Formation, below the level of *S. excelsus* (=*nodocarinatus*). Thus the currently recognized Moscovian-Kasimovian boundary appears to be within the uppermost Desmoinesian (two major/intermediate eustatic cycles below the top). It is worth noting that this interval of the Suvorovo Formation was originally included in the Moscovian in its type area. [Another point worth noting is that Swade's sp. 5, which appears abruptly in Midcontinent North America at the base of the Farlington Limestone, resembles to some extent deeply troughed '*Streptognathodus*' *dissectus*, which was named from Limestone M5 and ranges from Limestone M1 to Limestone M9 in the Donbass and through much of the upper Lower Moscovian (upper Kashirian) in the Moscow region; its large-lobed probable descendent '*S.*' *concinnus* ranges from Limestone M9 to Limestone M10\1 in the Donbass and first appears in the upper Kashirianin the Moscow region. Although troughed morphotypes are absent from eastern Europe and Midcontinent North America until the abrupt appearance of *I.* Sp. 5 in the Farlington Limestone bed (estimated to lie somewhere between N2 and N3 in the Donbass), the '*S*'. *dissectus-concinnus* lineage may be the

ancestor of the Swade-recognized lineage ('Swad..') if it were found in M10 to N2 equivalents elsewhere in the world].

The end of the Desmoinesian was a time of widespread extinction among several faunal and floral groups in North America, including the conodont lineages 'Swad..' and *Neognathodus*, the fusulinid *Beedeina*, the brachiopod *Mesolobus*, certain goniatites, the chaetetids, and the arborescent lycopods (see Boardman et al., 1990). Heckel (1991) attributed this extinction to a eustatic regression of greater than usual magnitude. Whatever the cause, *Neognathodus* and the chaetetids disappeared earlier (at the top of the Moscovian) in the Moscow region, and fusulinids did not return to Midcontinent North America until the third major/intermediate cycle (Swope) upward in the Missourian. However, a small flat-platformed descendent of *I. delicatus* persisted in North America into a minor eustatic marine cycle above the Lost Branch Formation, represented by the South Mound Shale of southern Kansas and the equivalent Checkerboard Limestone of Oklahoma. Here it is overshadowed by a probably descendent larger morphotype, currently placed in *I. sulciferus* by Barrick et al. (1996), which persists into several higher units in the lower Missourian. *I. sulciferus* is joined in the next marine unit above the South Mound Shale, the Exline Limestone (and equivalent basinward shale) by a descendent morphotype that has a shallow, laterally displaced groove, and which is currently referred to *I. eccentricus*. Both morphotypes are joined in the next major marine unit upward, the Mound City Shale Member of the Hertha Formation, by a morphotype that has two laterally displaced grooves extending posteriorly from either side of the carina, breaking the platform ribbing into nodes; this latter morphotype is referred to as *I.* new species A by Barrick et al. (1996), but it closely resembles *Idiognathodus sagittalis*, which was named from Limestone O1 in the Donbass (but first appears there in Limestone N5\1). What the North Americans are calling *I. eccentricus* also has affinities to what is called *I. sagittalis* in the upper Voskresensk Formation (upper Krevyakinian, lower Kasimovian) of the Moscow region. The North Americans are considering redefining the Desmoinesian-Missourian boundary at the base of the Exline Limestone, which contains the first appearance of what they are calling *I. eccentricus*. Thus the position of the Desmoinesian-Missourian boundary apparently is in the upper Krevyakinian, the lowest subdivision of the Kasimovian, and between Limestones N4 and N5\1 in the Donbass, conclusions similar to those reached by Barrick et al. (1996, p. 170).

Nearly all of the major/intermediate eustatic cycles (generally represented by formations) in the type Missourian of Midcontinent North America are characterized successively by first appearances of new species in the evolving lineages of *Idiognathodus* and *Streptognathodus*. Above the Exline and Hertha, these include *S. cancellosus* in the Hushpuckney Shale Member of the Swope Formation, and *S. confragus* in the Stark Shale Member of the overlying Dennis Formation (Barrick et al.,1996), although the latter first appears in the minor Mound Valley cycle just below. Both of these morphotypes may be included in *S. appletus* (a North American taxon) by eastern European workers because of problems with illustrations and rediagnoses in the earlier North American literature (see Barrick et al., 1996, p. 169), and the European concept of *S. cancellosus* appears to range lower than the current North American concept of this North American taxon. The overlying Cherryvale Formation contains the first appearance of the deeply troughed species of 'classic' *Streptognathodus*, *S. elegantulus* (the genotype, named from the higher Iola Formation equivalent in Texas) with no lateral nodes or lobes, *S. gracilis* with a lateral node or series of nodes on one side only, and *S. excelsus* with lateral nodes or lobes on both sides. These three morphotypes extend upward into the upper Missourian, with related (but as yet less well studied) morphotypes appearing in higher cycles. Morphotypes with shape similarities but lacking the deep troughs of these three mid-Missourian species appear in Dorogomilovian (later middle to upper Kasimovian) samples from the Moscow region, and also in Limestone O3 in the Donbass. Morphotypes resembling *S. elegantulus* and *S. excelsus* are found from Limestone O4 upward to Limestones P2 and P4, respectively, in the Donbass. *Idiognathodus* morphotypes in the Swope, Dennis and Cherryvale Formations are not yet well differentiated, but some have affinities to *I. trigonolobatus* named from the upper Krevyakinian and illustrated from the lower Khamovnikian (Ratmirovo Formation) in the Moscow region. Above the Cherryvale Formation in North America, *I. magnificus* (s.s.) with an extremely prominant finely nodose inner lobe distinctly separated from the finely transversely ribbed platform, appears in the Quivira Shale (Dewey Formation), and is followed upward in the Muncie Creek Shale (Iola Formation) by a descendent form with a lessprominant inner lobe currently called (informally) *I. 'postmagnificus.'* This lineage is not known in the next two cycles upward (Wyandotte and Plattsburg), both intermediate in scale. The Dewey and Iola cycles also contain a triangular-platformed *Idiognathodus* with more coarsely nodose lobes less distinctly separated from a more

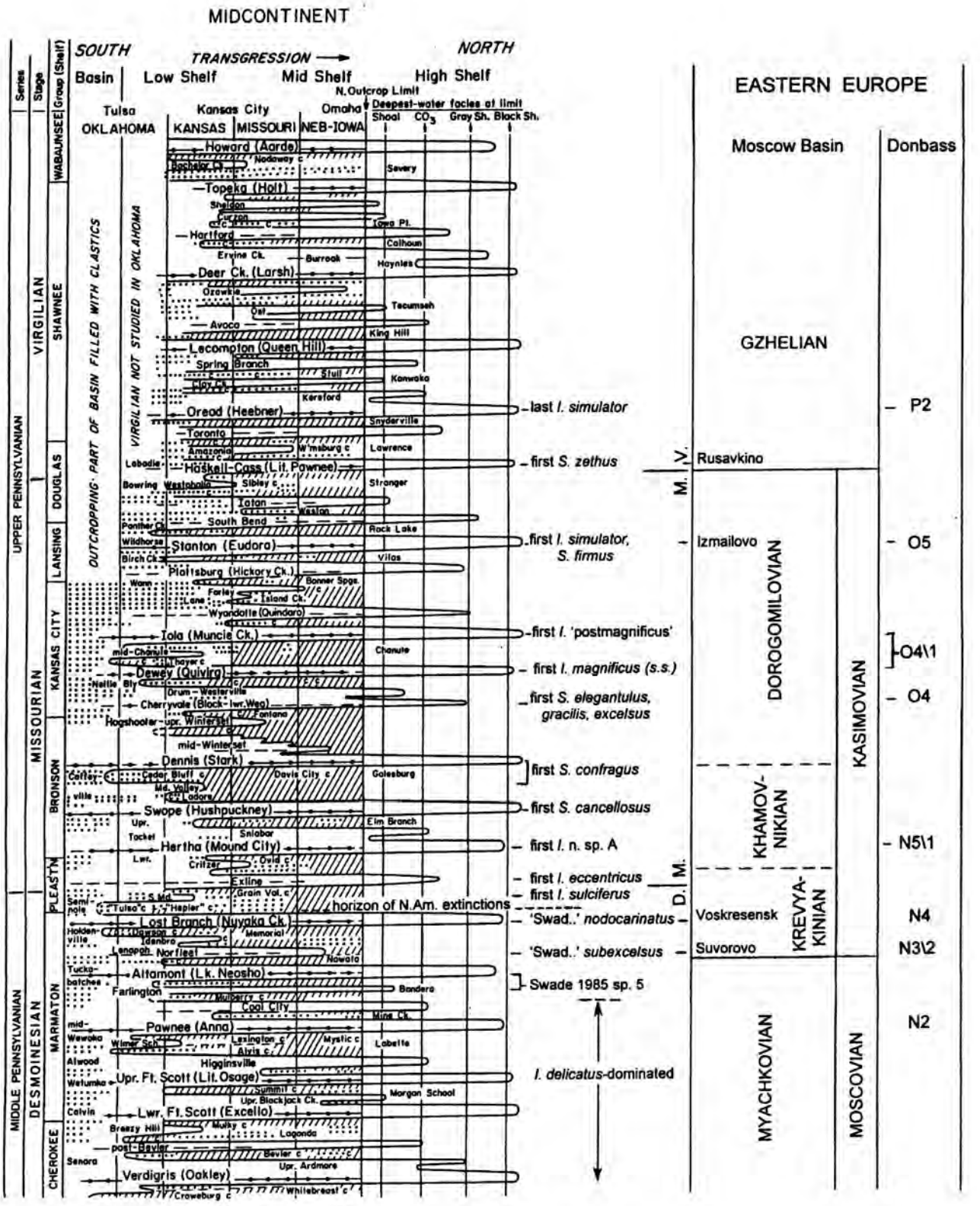

Figure 1. - Preliminary correlation of late Middle through early Upper Pennsylvanian succession of midcontinent North America with successions in Moscow Basin and Donets Basin of eastern Europe, based on observations of certain conodont morphotypes. Midcontinent succession with sea-level curve shows names of marine-dominated formations followed by name of conodont-rich shale in parentheses on left side of curve (updated from Heckel, 1989). Moscow Basin succession is based on Alekseev et al. (1996), but only names and Donbass bed numbers mentioned in text are shown on European successions.

coarsely ribbed platform. This morphotype has some affinities to *I. toretzianus*, named from Limestone O4\1 in the Donbass and reported from the Dorogomilovian of the Moscow region. Although there are some similarities between mid-Missourian and mid-Kasimovian faunas, there also appears to be a certain amount of endemism.

Upper Missourian faunas are characterized by the first appearance of distinctive *I. simulator* (a North American name) and *S. firmus* in the Eudora Shale Member of the Stanton Formation, both of which continue upward into the lower Virgilian (Heebner Shale Member of the Oread Formation). *S. firmus* was named from Limestone O5 in the Donbass; *I. simulator* first appears in the Izmailovo Formation (upper Dorogomilovian) in the Moscow region and extends upward into the lower Gzhelian, where *S. firmus* is also reported. *I. simulator* occurs from Limestones O7 to P2 in the Donbass. The North Americans are considering redefining the Missourian-Virgilian boundary at the first appearance (in the Haskell Limestone and Little Pawnee Shale Members of the Cass Formation, between the Stanton and Oread Formations) of a troughed morphotype of the non-lobed *S. elegantulus-pawhuskensis/alekseevi* lineage (that dominates upper Missourian faunas), in which small lateral lobes appear on one or both sides of the platform. This morphotype is currently called *S. zethus*, a name first applied in the southern Urals, but it is a morphotype that is recognized in the lowest Gzhelian formation (Rusavkino) in the Moscow region under the name *S. eccentricus* (because of poor illustration in the earlier North American literature), and it appears to be within the range of what is called *S. excelsus* from Limestones O4\3 to P2 in the Donbass. Because *I. simulator* also extends higher in the lower Gzhelian than the first appearance of the morphotype that is probably *S. zethus* in the Moscow region, the Missourian-Virgilian boundary appears to be nearly coincident with the Kasimovian-Gzhelian boundary in the Moscow region.

The conodonts from the Cantabrian Mountains of northern Spain shown to us by Carlos Mendez of Oviedo University are sparse in number of specimens per sample in this area of extremely thick successions of rapidly deposited sediment. There is a general impression among some who have worked in Europe (Mendez, Alekseev, and Holger Forke of Erlangen) that most Spanish forms are more similar to those forms reported from the Carnic Alps in Hungary, Slovenia and Austria than to those from Moscow. T. Nemyrovska believes that they are somewhat similar to those from the Donbass. Also there seems to be greater similarity between the Moscow Basin and Midcontinent North American conodonts than between them and the Spanish and Carnic Alps forms. Nevertheless, some Spanish morphotypes seem to have counterparts in the North American and eastern European sections. The Spanish successions have been correlated with the eastern European sections by means of fusulinids, and therefore already use the eastern European stage terminology. An upper Moscovian (Myachkovian) sample contains a morphotype that is probably *Idiognathodus delicatus*, named from the upper Desmoinesian of North America. A lower Kasimovian sample from Las Llacerias contains a morphotype that may be *I. trigonolobatus*, named from the lower Kasimovian of the Moscow region. These data support the recent correlation of the Domodedovo section near Moscow with the Las Llacerias section in northern Spain (Villa et al., 1997). A sample of the Puentelles Formation (from a section not visited on the trip), which has been considered to be higher Kasimovian in age, contains probable *Streptognathodus elegantulus* and a morphotype that is very close to the informal *I. 'postmagnificus,'* both named from the middle Missourian of North America. Thus the few recognizable morphotypes seen so far from Spain are compatible with both the fusulinid correlation of the Spanish section with eastern Europe and the conodont correlation of the eastern Europe succession with that in Midcontinent North America.

One point that we would like to make strongly is that sets of good photographs of holotypes of named taxa, with exact stratigraphic positions indicated, need to be exchanged among all active conodont workers so that taxonomic problems resulting from poor illustration of much of the early taxonomic work, which has bedeviled communication among workers and correlation among different regions of the world for so long, can be overcome and resolved. Then it will be easier to select a lineage of changing morphotypes that can be recognized on a worldwide scale. This can be done by mailing photographs of holotypes and other critical morphotypes to interested active workers, but if SEM photographs of these specimens are available, it can be done electronically via the internet, and made more readily available to more workers. Darwin Boardman at the School of Geology, 105 Noble Research Center, Oklahoma State University, Stillwater, OK 74078-3031, USA, (email: amm0001@okway.okstate.edu) has offered to provide a central facility for that purpose.

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PROJECT GROUP 4:

Zonation in Late Namurian successions: The Bashkirian Stage as a geochronological standard.

THE BASHKIRIAN SERIES IN BASHKIRIA (RUSSIA)

I. S. Barskov (Moscow), E. I. Kulagina (Ufa, Bashkiria), J. Kullmann (Tuebingen, Germany, Project Leader), S. V. Nikolaeva (Moscow) and V. N. Pazukhin (Ufa, Bashkiria)

The Bashkirian Series is the first stratigraphic unit of the Upper Carboniferous after the Mid-Carboniferous Boundary (MCB). To provide a general framework for the early Upper Carboniferous stratigraphy the working group is constantly engaged in additional studies focusing on well identifiable faunas of the early Upper Carboniferous zones in Bashkiria and their global distribution. The geochronogical unit "Bashkirian" as the epoch between the Mid-Carboniferous boundary and the base of the Moscovian Stage has been used in international stratigraphic schemes and geochronological scales in standard publications, but has been under review in respect to its boundaries.

In recent years the study of the Bashkirian made great progress in the vicinity of the original type region of the "Bashkirian Stage" south-east of Ufa. In co-operation with the Ufa research group (V.N. Pazhukhin, E.I. Kulagina and N.M. Kochetkova, Ufa Research Center RAS), with O.L. Kossovaya (All-Union Research Geol. Inst. St. Petersburg), I.S. Barskov (Moscow State University) and S. V. Nikolaeva (Paleont. Inst. Academy of Sciences in Moscow) a new attempt to define and subdivide the Bashkirian Series has been started. The major aim is to provide a basis for the choice of type sections in the Bashkirian type area (western slope of Southern Urals). Additional studies will focus on stable isotope analyses at the boundaries, especially on measurements and calculation of $0^{18}/0^{16}$ and C^{13}/C^{12} ratios from the calcitic brachiopod shells, thereby providing precise biostratigraphic dating and data on the environmental and climatic variations around the boundaries.

The Mid-Carboniferous Boundary marks the most significant incision in the ecological development of marine habitats during Carboniferous times. In its type area the Bashkirian Series is represented by shallow water carbonates up to 250 m thick yielding a variety of marine invertebrates including ammonoids, corals, conodonts, foraminifers, brachiopods and ostracods. The following subdivisions of the Bashkirian Series are recognizable :

(1) Syuranian Stage. New collections of ammonoids have resulted in a revision of the former distinction of the "Bogdanovsky" and "Syuransky horizons". Goniatite species of the genera *Homoceras* and *Isohomoceras* (compared with Western Europe: Chokierian age) have shown that both sequences belong to the lowermost stage after the MCB, because the associated foraminifera include *Semistafella* known from the former Syuransky horizon. The first stage of the Bashkirian series has to be assigned to the Syuranian Stage which has priority over the name

"Bogdanovsky horizon". The extent of this stage is in agreement with the original definition of the "Syuransky horizon" by Librovich (1947). The boundary between the West European units Alportian - Kinderscoutian, however, can be defined only by means of goniatites (entry of Reticuloceratids, see Nikolaeva & Kullmann, 1998).

(2) The second stage of the Bashkirian will be based on the "Akavassky horizon". The lower boundary of the Akavasian Stage is defined by the base of the *Neognathodus askynensis* conodont zone as well as the *Pseudostafella antiqua* foraminiferal zone. New investigations at several sections must prove the coincidence of this horizon with the base of the goniatite *Bilinguites-Cancelloceras* zone (Kullmann & Nikolaeva, 1995) and its relationship to the Yeadonian in Western Europe. The major aim of the working group is to provide new data for the choice of a type section around the boundary between Marsdenian and Yeadonian in West European terms.

(3) The third stage of the Bashkirian Series is the time interval of the "Tashastinsky horizon". The boundary between the Akavasian and the Tashastinian stages may be close to or coincident with the West European Namurian-Westphalian (or Yeadonian-Langsettian) boundary. As in many other sections this boundary is poorly documented by means of goniatites, and the best information is based on conodonts and foraminifers mainly from the Askyn section. The upper boundary of this stage is to be worked out within the investigations on the Moscovian Series, maybe in additional studies of the Askyn section.

Recent publications:

KULLMANN, J. & NIKOLAEVA, S. 1995. A Review of the Upper Namurian ammonoid biostratigraphy. *Newsletters on Stratigraphy* 32, 117-136, 10 figs., Berlin, Stuttgart.

NIKOLAEVA, S. & KULLMANN, J. 1998. A Review of Middle Namurian ammonoid biostratigraphy. *Newsletters on Stratigraphy* 28, p., 15 figs., Berlin, Stuttgart.

CONTRIBUTIONS TO THE NEWSLETTER

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

* graphics suitable for black and white publication.

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Palynological events and the mid-Carboniferous boundary

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Precise global correlation of Carboniferous strata by means of palynology is fraught with difficulties, especially where marine faunal control is lacking . A number of local and regional palynological zonation schemes have been proposed but they have only limited significance in this regard. Nevertheless, due to the common presence of some short-range elements and the synchroneity of certain palynological events, long distance correlation is still possible, particularly for the Lower Carboniferous. For example, the first appearance of large *Potonieisporites*, viz. *P. elegans* and/or *P. grandis* (Luber), occurs almost simultaneously around the base of the Serpukhovian of the northern hemisphere, as seen in the Euramerica Province (Western Europe, Clayton,1996; E. Canada, Utting in Lenz *et al.*, 1993), Angara Province (Siberian platform) and Kazakhstan (Oshurkova *et al.*, 1990) and Subangara Area (N. Xinjiang, Ouyang *et al.*, 1994; W. & N. Canada, Utting, 1993). In the Cathaysia Province (Jingyuan in Gansu Province) and the Donetsk Basin of the Euramerica Province, it appears a little later (in the upper Serpukhovian=E_2 goniatite zone, Zhu, 1989, 1995; Gao, 1987; Oshurkova *et al.*, 1990). The first and sporadic occurrence of large *Potonieisporites* or *Florinites* and *Crassispora kosankei* combined with other palynological characteristics enable us readily to correlate the base of Serpukhovian in the northern hemisphere. From the Bashkirian to the end of the Permian, global phytoprovincial differentiation, both in rank and number, becomes gradually more pronounced. This makes international palynological correlation more difficult. We here briefly discuss the mid-Carboniferous boundary in the northern hemisphere from a palynological viewpoint.

1. The Angara Province:

A drastic floral change between the Serpukhovian and Bashkirian has been recognized by Meyen (1982) who named the "Lepidophyte flora" for the Lower Carboniferous and the "Pteridospermalean assemblage" for the Bashkirian (Kaezovsky Fm.), and "this event is easily traceable throughout the Angaraland" and roughly correlatable with the floral break at the Namurian A/B boundary in W. Europe. Palynologically, a similar change is sometimes traceable too. For instance, in the Tunguska Basin (Gutova and Ryabei, 1974), the Tushamsky (Visean-Serpukhovian) assemblage dominated by *Lycospora* (and *Calamospora*) is replaced by the *Noeggerathiopsidozonotriletes psilopterus-Cyclobaculisporites trichacanthus* assemblage at the base of Upper Carboniferous (Katsky Fm.). *Cordaitina* first appears near the top of the Tushamsky; we noticed that in Meyen's (1982) Table 1, beneath the Katsky Fm. there is another formation - Yangotoisky Fm. as the basal portion of the Serpukhovian. Thus, it is quite possible that the first appearance of *Cordaitina* can be taken as indicating the beginning of the Bashikirian. Oshurkova *et al.* (1990) also mentioned the first appearance of *Cordaitina uralensis* in association with *Potonieisporites* and *Florinites* in the Bashkirian Kaezovsky Formation.

Noeggerathiopsidozonotriletes Luber 1955 (a valid name=*Psilohymena* Hart et Harrison 1973 and "*Remysporites*" of some Russian authors), as represented by *N. psilopterus* and *N. mirabilis*, is a typical Angara genus. It first appears in the late Visean (e.g. Ashlyarisky Fm. of Kazakhstan) but did not become abundant until the base of the Bashkirian (the lower portion of the Balahonsky Group in Kuznetsk or the lowest Katsky Fm. in the Tungusk Basin). The enrichment of this genus, large *Potonieisporites* or *Florinites* and *C. trichacanthus* as well as the first occurrence of *Cordaitina* together with other palynological clues may be taken as the markers of the base of the Bashkirian.

2. The Subangara Area (N. Xinjiang)

Similar drastic floral change between the Serpukhovian and Bashkirian has also been reported from N. Xinjiang, NW China, i.e. the Lepidophyte flora was suddenly replaced by

the *Angaropteridium* (a pteridosperm) flora. The Batamayineishan Formation is dated as early Bashikirian by an underlying formation yielding the *Angaridium-Mesocalamites-Noeggerathia* plant assemblage in association with cephalopods of late Visean-early Namurian A (*Eumorphoceras* goniatite zone) and by overlying strata containing the *Profusulinella-Pseudostaffella* fauna of presumed middle-late Bashikirian to early Moscovian age. Essentially different from the preceding palyno-assemblages of late Visean-Serpukhovian, the assemblage of the Batamayineishan Fm. is dominated by *Noeggerathiopsidozonotriletes* (60 % on average)--- just as in the Angara, which first appears in the late Visean to early Namurian A (E goniatite zone) deposits---in association with the earliest monosaccate *Striatolebachiites* and primitive *Protohaploxypinus* as well as other monosaccate (including large *Potonieisporites*) and bisaccate pollen, etc.(Ouyang *et al.*, 1994). The impoverishment of the mega- and palynoflora in the early Bashikirian , also seen in W. and N. Canada, is also comparable to that seen in the Angara. Thus the enrichment of *Noeggerathiopsidozonotriletes* and large *Potonieisporites* as well as the first appearance of striate pollen are provisionally taken as the markers of the Bashkirian. Considering the latter event is much earlier than elsewhere in the world, whether it represents the beginning of Bashkirian or not remains a problem to be solved. Upwards to the mid-late Bashikirian-early Moscovian Chepaizi Formation, the assemblage is already dominated by striate pollen which is much different from the Angara Province but correlatable to those known from other sites in the Subangara Area. Consequently, N. Xinjiang should belong to the Subangara Area.

3. The Cathaysian Province

The best palynological succession of Serpukhovian-Bashkirian deposits is known from Jingyuan, Gansu Province, NW China. The base of the Bashikirian or Chokerian is drawn a little below the *Declinognathodus noduliferous*-bearing horizon (equivalent to H goniatite zone) for the H_1-equivalent deposits is possibly of terrestrial origin and the miospores therein display an aspect younger than E_2 goniatite zone. The first appearance of *Densosporites reticuloides* and *Dictyotriletes bireticulatus*, the relatively abundance of *Crassispora kosankei* and *Limitisporites* as well as the extinction of *Schulzospora campyloptera*, *Raistrickia nigra* and some Visean elements may be taken as the markers of the base of the Bashkirian (i.e. the base of the Hongtuwa Formation) or the top of the Arnsbergian (Zhu, 1993, 1995; Gao, 1987). The abundance and diversity of the miospore assemblages (equivalent to H goniatite zone) are "much lower than older assemblages" (Zhu, 1993)---to some extent, this phenomenon seems to coincide with those known from Angara and Subangara although another explanation (e.g. lithology unfavourable to the preservation of miospores) is possible.

Some miospore populations characteristic of the Visean, and similar to those seen in Europe and N. America, disappeared near the top of Arnsbergian (the upper part of Tsingyuan Fm.), namely, *Raistrickia nigra*, *Rotaspora knoxiae* and *Schulzospora* spp. etc. But unlike their extinction within the Arnsbergian, some components of characteristic late Visean/upper Mississippian (cf. Owens, 1996), such as *Tripartites trilinguis*, *Rugospora corporata*, *Bellispores nitidus*, *Grandispora spinosa*, *Crassispora maculosa*, *Rotaspora fracta* and *Remysporites magnificus*, extend upward beyond the Arnsbergian (Gao, 1987; Zhu, 1993) to H, R or even to G goniatite zones. On the other hand, some elements with an aspect of late Namurian-Westphalian appear earlier (within E_2 goniatite zone) in the Cathaysia, for instance, *Limitisporites*, *Laevigatosporites* and *Vestispora fenestrata*,etc.

4. The Euramerican Province

Because the palynological SO zone as defined by Owens et al. (1977) and Clayton et al. (1977) covers the interval from the uppermost E_2 zone to the top of H_2 zone, there is some difficulty to recognize the base of H_1 zone. Owens (1996) however, recently pointed out that "detailed examination of the principal European candidate for the boundary stratotype section (Riley *et al.*, 1987) revealed few palynomorphs across the Arnsbergian-Chokierian boundary" and the last records of *Schulzospora campyloptera* in the highest Arnsbergian both in England and China has considerable significance in defining this major stratigraphic boundary. In addition, the extinction of some distinctive upper Visean components within the Arnsbergian and the appearance of some elements characteristic of the upper Namurian above this boundary may be important events for defining this boundary. Compared with the E-zone palynofloras, the H-zone assemblages seem to be also poverished in composition, but whether this represents an important event in floral evolution or not remains uncertain (note: Gothan's "Florensprung" or floral break occurs at the Namurian A/B boundary but his Namurian A includes the H-zone).

Detailed palynological studies in transitional phytogeographical areas (e.g. Kazakhstan and the Subangara

Area) and alternative continental and marine (with conodont, goniatite or fusulinid control) strata of Serpukhovian and Bashkirian age are desirable to discover some characteristic and common miospores shared by the boreal Angaran Province and the equatorial Euramerican-Cathaysian Province. This will make international recognization of mid-Carboniferous boundary easier.

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Carboniferous Biogeography of Australasian Faunas and Floras

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The current database of the major Carboniferous faunas and floras is currently being reviewed from a biogeographic perspective as part of a larger project entitled *Palaeobiogeography of Australasian Faunas and Floras* (Jones et al., 1997). The selected fossil groups (and their respective reviewers) include brachiopods (J. Roberts$_1$), corals (G.E. Webb$_2$), trilobites, bryozoans (B.A. Engel$_3$), ammonoids, foraminiferids, algae, ostracods (P.J. Jones$_4$), and conodonts (I. Metcalfe$_5$), within the marine environment, and conchostracans (P.J. Jones$_4$), vertebrates (S. Turner$_6$), plants (J. Rigby$_7$), spores and pollen (G. Playford$_2$), which spanned both continental and marine realms. Our preliminary results, interpreted without the use of quantitive analytical methods, generally confirm the broad changes in Australian climate and biogeography for the Carboniferous Period, as deduced by earlier authors (e.g., Campbell & McKellar, 1969; Runnegar & Campbell, 1976; Talent, 1984). The two principal conclusions are related to palaeolatitude.

(1) During the Early Carboniferous the high diversity of the brachiopod, coral, conodont, foraminiferid, and ostracod faunas, on the Australian craton and on the Sibumasu terrane located outboard of NW Australia, broadly reflects the environmental conditions of marine carbonate sediments (viz., warm shallow seas), and suggests a low latitudinal position of Australasia at that time. This is consistent with palaeomagnetic data that places Australasia between 0° and 40° south in the early Visean. Beyond Australasia, both tetrapod and marine benthic ostracod evidence support the notion of a land connection between the western part of Gondwana and Laurentia-Baltica at that time (e.g., Scotese & McKerrow, 1990; Metcalfe, 1996); a connection that may be as old as Late Devonian (see below).

(2) The sharply diminishing faunal and floral diversity in the latest Visean/earliest Namurian of Australia reflects the most dominant global climatic change throughout the Carboniferous Period, the advent of an Ice Age in the Namurian, and rapid movement of Australasia (and other elements of eastern Gondwana) from low southern

latitudes to high (40° to 75° south) latitudes when Gondwana was thought to have rotated clockwise.

Faunal groups with dominantly cosmopolitan genera (and often species), viz., ammonoids, brachiopods, conodonts, foraminiferids, ostracods and marine fish, provide information on the ocean and shelf currents. Of these, those without pelagic larval stages (e.g., marine, benthic ostracods) would have been unlikely to have crossed deep oceanic barriers, but would indicate juxtaposed shallow shelves of adjacent cratons.

The Early Carboniferous (Dinantian) foraminiferal faunas of the Bonaparte Basin relate to those of Eurasia, particularly Laos and Vietnam (Indochina Terrane); they belong to the Tethyan Realm, as opposed to the North American and Taimyr-Alaskan Realms (Mamet & Belford, 1968). Tournaisian conodont faunas of the near-shore (*Clydagnathus*) biofacies in the Western Australian basins have links with western Europe, Russia, and the Kuznetsk Basin, Siberia. In eastern Australia the Tournaisian basinal (*Siphonodella*) biofacies (Morey & Crane, 1982) is characteristic of the same facies in the Sibumasu and South China terranes, Europe, and the US Midcontinent. In the Visean, conodont cosmopolitanism is more marked in Western Australia than in the east, where the fauna is dominated by endemic species belonging to *Patrognathus* and the endemic genus *Montognathus* (Jenkins et al., 1993).

Other cosmopolitan groups include the brachiopods from eastern and Western Australia (Roberts, 1971, 1975) and ammonoids from eastern Australia (Campbell et al., 1983), both with Tournaisian faunas having alliances with North America, Europe, Russia and Kazakhstan. In the early Visean, global flooding introduced new faunas into Australia from the same provenances. By the late Visean, during a period of attenuated brachiopod diversity, minor links were established with northwestern Argentina.

Marine benthic ostracod faunas from the Tournaisian and Visean of Western Australia (mainly from the Bonaparte Basin; Jones, 1989, 1995) consist of cosmopolitan genera (including many species), and support the major affinities indicated by the brachiopods and ammonoids. The ostracods, which lack a pelagic larval stage, probably indicate that the shallow shelves of the western part of Gondwana and Laurentia-Baltica were sufficiently close to permit exchange of genetic material. A few provincial ostracod species also indicate the proximity of northwestern Australia to South China and parts of northern Gondwana. Early Carboniferous marine fish scales and teeth remains from Western Australia, north Queensland, and the New England Orogen relate to faunas from the US Midcontinent, Europe, and Russia (Turner, 1991, 1993).

The eastern Australian Early Carboniferous trilobite faunas share common elements with coeval faunas of Southeast Asia, China, Japan, and parts of Central Asia; this is not an exclusive relationship because the faunas of Japan, China, Central Asia and Europe also contain many common elements absent from Australia (Engel & Morris, 1997). In Australia, the lack of trilobites of earliest Carboniferous age, combined with their virtual disappearance at the end of the Early Carboniferous, renders both comparisons and the definition of provinces conjectural.

Other Early Carboniferous biota demonstrate distinctive provincialism. The coral fauna of the Bonaparte Basin has Chinese affinities (*Kueichouphyllum*-fauna), and that of eastern Australia is highly endemic (Webb, 1990). The endemic taxa are mostly confined to shallow reefal settings, whereas the cosmopolitan taxa, which are longer ranging, are part of a deeper-water fauna. The eastern Australian fauna became isolated after it had arrived from an oceanic centre of dispersal to the north and east during the Famennian or earliest Tournaisian. This oceanic centre of dispersal could well have been the Panthallassan oceanic terranes now distributed in western North America. The existence of these terranes in the Panthallassan ocean during the Carboniferous may well explain the observed biogeographic affinities with North America. Corals became virtually extinct in the eastern Australian province by the end of the late Visean, but in the Japanese province, they flourished and continued to maintain their North American character during Namurian, and Westphalian time.

The paucity of Carboniferous bryozoan faunas in Western Australia precludes any meaningful comparisons with those of eastern Australia (Engel, 1985). Despite this limitation, a marked difference in the character of the Permian faunas of both eastern and Western Australia (Engel & Ross, 1993) suggests regional differences that may have originated during the Carboniferous.

The spore-pollen flora of the Australian Early Carboniferous (*Granulatisporites frustulentus* Palynoflora) has an unambiguous regional character, but contains sufficient cosmopolitan taxa to enable correlation with Europe (Playford, 1985, 1991). The lower vascular plants (Lycopod Florule) are distinctly Gondwanan, and independent of the Eurasian floras (Rigby, 1985). Tournaisian non-marine fish scales and teeth remains from Victoria and Queensland (Drummond Basin) have similar

biotopes in North America and Europe (Long, 1988). The presence of mid-Visean tetrapods (colosteids, anthracosauroids) in the Drummond Basin, predate the North American and Scottish tetrapod occurrences, and indicate that the Mississippian Tetrapod Province may have extended through a tropical belt across the whole of Pangaea, at least across the northern Gondwanan landmass. Interchange of tetrapod faunas during the early Visean (ca. 340 Ma) supports the notion of the existence of a land connection between Laurentia and Gondwana at this time (Thulborn et al., 1996). This connection may date back to the Late Devonian, because there is good faunal evidence from freshwater fishes of initial terrestrial connections occuring at or near the Frasnian-Famennian boundary (e.g., Young, 1981, 1990).

A rapid diminution of faunal and floral diversity took place in Australia in the latest Visean and earliest Namurian, heralding a major global cooling change and the onset of glaciation. It is marked by a major turnover of biota in the earliest Namurian. The ammonoids, most brachiopod species (94%) in the latest Visean of NSW (Roberts et al., 1976), the conodont and fish faunas, and virtually all the corals became extinct, and were replaced by new brachiopod, molluscan, bryozoan and trilobite faunas (*Levipustula levis* Zone). A Gondwanan circumlittoral connection between the *L. levis* faunas of eastern Australia and Argentina (Rocha Campos & Archangelsky, 1985) is supported by the recent discovery of the same fauna on Alexander Island, Antarctica (Dickins 1995). Presumably currents on a shallow water platform permitted a free genetic exchange between the *L. levis* faunas along the "southern margin" of Gondwana. The palynofloras support Australia-Argentina faunal and floral links, with some similarities evident from Libya on the northern Gondwana fringe (Clayton & Loboziak, 1985). More difficult to explain is the occurrence in the Baikal region, Siberia, of the northern hemisphere of six brachiopod species comparable with those from the *Levipustula levis* Zone (Roberts et al., 1976). Whether this indicates a possibility of a bipolar faunal distribution, similar to that suggested by Ustritskiy (1974) for the pattern of Late Permian faunas of Australia and Siberia, is uncertain.

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Palynological Considerations on the Carboniferous of the Paraná Basin, Brazil

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Carboniferous strata of the Paraná Basin in Brazil were previously considered restricted to Sakmarian C (G interval) in age, according to the palynological subdivision proposed by Daemon and Quadros (1970), that is corresponding to the lower part of the Itararé Subgroup. This lithostratigraphic unit exhibits very heterogeneous facies associations involving glacial, periglacial, postglacial and marine deposits.

Some fauna and flora found in this unit in São Paulo and Paraná States (e.g. Foraminifera, Brachiopoda, Pelecypoda and pré-*Glossopteris* flora elements) have shown evidence of Late Carboniferous age. A summary of the biostratigraphical framework of this unit is available in Petri and Souza (1993). According to many authors, Palynology seems to be the most efficient tool in providing biostratigraphic data in the Permo-Carboniferous strata of the Brazilian Paraná Basin. Other fossil groups are not abundant and do not give sufficient resolution to allow biostratigraphical zonation.

Recent research has revealed similar Carboniferous miospore assemblages to other regions. The ones recorded in Araçoiaba da Serra (Lima *et al.*, 1983; Souza, 1996a); Buri (Souza *et al.*, 1993a; Dino and Playford, 1997) and Monte Mor (Souza *et al.*, 1993b, 1997) have been regarded as Westphalian in age, on the basis of comparisons to similar assemblages from Gondwana and extra-Gondwana areas, mainly those ones from neighbouring basins, whose Carboniferous succession is more complete.

The most important species in a biostratigraphical context and their occurrences in Paraná Basin are shown in the Table 1. These data are discussed and the taxa are illustrated in Souza (1997).

In these localities the assemblages are, in general, characterised by diverse and abundant trilete spores, followed by monosaccate pollen grains

	AS	BU	MM
-*Anapiculatisporites argentinensis* Azcuy, 1975		x	
-*Granulatisporites varigranifer* Menéndez and Azcuy, 1969	x		x
-*Raistrickia rotunda* Azcuy, 1975	x	x	x
-*Dictyotriletes muricatus* (Kosanke) Smith and Butterworth, 1967	x		
-*Foveosporites hortonensis* (Playford) Azcuy, 1975		x	
-*Ahrensisporites cristatus* Playford and Powis, 1979	x	x	
-*Cristatisporites menendezii* (Menéndez and Azcuy) Playford emend Césari, 1986			x
-*Cristatisporites inordinatus* (Menéndez and Azcuy) Playford, 1978	x	x	
-*Ancistrospora inordinata* (=*Ancistropora* sp. A in Azcuy, 1975)	x		
-*Spelaeotriletes triangulus* Neves and Owens, 1966	x		
-*Florinites occultus* Habib, 1966	x		

Table 1 - Occurrence of the most important species from new papers on Itararé Subgroup, Paraná Basin, Brazil. (AS: Araçoiaba da Serra; BU: Buri; MM: Monte Mor).

(*Potonieisporites*, *Plicatipollenites*, *Cannanoropollis* and *Caheniasaccites*). Taeniate pollen grains (*Protohaploxypinus*) are present, but rare (1 to 5%), as commonly occur in Late Carboniferous assemblages from Australia, Africa and Argentina.

There are some previous proposals on biostratigraphical zonation including these new localities in São Paulo State; among them, the informal "Pre-G" interval (Lima *et al.*, 1983). However, details are lacking. In this context, Souza (1996a; 1996b) gives new information about potential areas and materials in order to obtain a better biozonation of this interval in the Paraná Basin. According to this author, Northern Paraná and South-southeastern São Paulo States show the best possibilities, where the G interval is thicker and better represented in the area.

The Carboniferous/ Permian boundary, placed between G and H1 intervals in the Paraná Basin (Daemon and Quadros, 1970), has been discussed. Nevertheless, modifications have been introduced in this palynological subdivision and its chronological correspondence, though any can fully be applied in the Paraná Basin. It is expected that future studies, based on global scale correlation that takes into account composition differences, migration effects and paleoecological variations, can provide a better establishment of the Carboniferous / Permian boundary in the Paraná Basin.

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A regional chronostratigraphic chart for China and its biozones

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During the last decade, Chinese Carboniferous studies emphasized the search for sections suitable as stratotypes for systemic and inter-systemic boundaries, which resulted in the establishment of detailed biostratigraphic successions throughout the Carboniferous. On the other hand, the geological survey of remote areas has led to some important biostratigraphic discoveries for the determination of regional correlation. Recently, Jin et al. (in press) redefined the regional stages for the regional chronostratigraphic scheme of China as the basic units of the time scale in the Carboniferous volume of the Stratigraphic Lexicon of China. The scale comprises the Fengningian and Hutianian subsystems, each of which contains two series and their constituent stages as shown in table 1.

The Fengningian Subsystem was suggested by Liu (1955) to represent the Lower Carboniferous in China. Traditionally, it is subdivided into two stages, but Jin et al. (in press) and Wang X.D.& Jin (in press) elevated them to series: the Aikuanian Series and the Tatangian Series. The former has not been further split into stages, and contains only the Tangbagouan Stage. The latter includes the Jiusian, Shangsian and Dewuan stages, in ascending order.

The Tangbagouan Stage was first proposed by Jin et al. (in press) for the lowermost stage of the Carboniferous in China as the time equivalent of the Tangbagou Formation, which is widely recognizable by the presence of *Pseudouralinia* and its associated *Martiniella-Eochoristites* and *Finospirifer shaoyangensis* brachiopod assemblages. In geological practice, it has served for decades as a chronostratigraphic standard for correlation of its equivalents in China. The conodont succession of this stage was found in pelagic facies with eight zones, from *Siphonodella sulcata* to *Scaliognathus anchoralis*. This stage can be correlated by conodonts with the Tournaisian Series of Europe.

The Jiusian Stage was established by Jin et al.(in press) to include the stratigraphic sequences comprising the Xiangbai and Jiusi formations, from which Wu et al. (1974) reported the *Thysanophylloides* coral Zone and the *Schuchertella magna, Delepinea subcarinata-Megachonetes zimmermmani* and *Vitiliproductus groeberi* brachiopod assemblages. The Jiusian conodonts are grouped into the *Gnathodus taxanus - G. homopunctatus* Zone and the *Paragnathodus commutatus* Zone in Wangmu and Luodian, Guizhou (Wang Z. H., 1990).

The Shangsian Stage was suggested by Zhang (1988) as a chronostratigraphic extension of the Shangsi Formation or the Shangsi Limestone in Baijin, Huishui in Guizhou Province. The following zones are included: corals - *Yuanophyllum* Zone (lower), *Aulina carinata* Zone (middle), and *Palastraea* Zone (upper); brachiopods - *Balakhoia yunnanensis* Zone and *Delepinea comoides-Datangia weiningensis* Assemblage; conodonts - *Gnathodus bilineatus bilineatus* Zone to *Paragnathodus nodosus* Zone.

The Dewuan Stage was named by Yang (1980) and is well represented by the type section of the Baizuo Formation in Baizuo, Guizhou (Hou et al., 1982). It yields the brachiopods *Gondolina weiningensis, Latiproductus latissimus, Gigantoproductus edelbulgensis, Striatifera angulata,* and the corals *Palaeosmilia regia* and *Aulina rotiformis*. In the corresponding beds of pelagic facies in Nandan, Guangxi, Ruan (1981) found abundant ammonoids belonging to the *Eumorphoceras* Zone. Dewuan conodonts from Luodian in Guizhou Province and Nandan in Guangxi Region were referred to as the *Gnathodus bilineatus bollandensis-Adetognathus unicormis* Zone (Wang Z.H. & Higgins, 1989).

The Hutianian Subsystem was introduced to denote the Upper Carboniferous in China (Jin et al., in press) following the common usage of Hutian Series. This subsystem is essentially equivalent to the Pennsylvanian System of North America, and includes two series, the Weiningian Series and the Mapingian Series. These were formerly assigned to the Middle and Upper Carboniferous respectively, in most literatures published before 1990. The Weiningian Series includes three stages: the Luosuan, Huashibanian and Dalaun in ascending order, whereas the Mapingian consists of only the Xiaodushanian Stage.

The Luosuan Stage was established by Rui et al. (1987) with its type section situated at Luosu, Luodian in Guizhou Province. The first occurrence of *Declinognathodus noduliferous* and *Millerella marblensis* marks its basal boundary, which coincides with the Mid-Carboniferous boundary formally ratified by the IUGS. Four conodont zones (Table 1) and one fusulinid zone have been recognized in the stage. A brachiopod assemblage with characteristic elements such as *Alexania* and *Nantanella* was dominant in the Lusuan sequences of shelf facies.

The Huashibanian Stage was first introduced by Yang et

al. (1980) to include the time span corresponding to the Huashiban Formation, named for Huashiban, Panxian in Guizhou Province. The lower boundary of the Huashibanian Stage is marked by the appearance of *Pseudostaffella* and *Reticuloceras*. Huashiban fusulinids do not show high diversity but are characterized by a dominance of *Pseudostaffella antiqua posterior*. Ammonoids from the type section belong to the *Reticuloceras, Cancelloceras and Gastrioceras- Branneroceras* zones. The brachiopod fauna, which is abundant and highly diverse, is characterized by *Choristites, Weiningia* and *Plicatifera*.

The Dalaun Stage, first named by Yang et al. (1980), is an extension of the Dala Formation outcropping at Dala, Panxian in Guizhou Province. This stage is characterized by the appearance of *Profusulinella* in its lower part and *Fusulinella* or *Fusulina* in its upper part. Yang F.Q. (1978) documented a rich Dalaun ammonoid fauna from Faqing, Shuicheng in Guizhou Province, belonging to the *Winslowoceras decoratum* and the *Owenoceras bellilineatum shuichengense* zones. Three conodont zones were established in the basinal sequences in Luodian, Guizhou by Wang Z.H. & Higgins(1989).

The Xiaodushanian Stage was designed by Zhou et al. (1987) to denote the stratigraphic interval corresponding with a fusulinid succession consisting of five zones. The first appearance of *Protriticites* marks its basal boundary, and the top is delineated by the first occurrence of members of the Pseudoschwagerininae, a level roughly coincident with the officially defined base of the Permian System. The type section is situated near Xiaodushan, Guangnan in Yunnan Province. In most areas of South China, the fusulinids of this stage are usually grouped into two genozones, the *Montiparus* and *Triticites* zones. Wang Z.H. & Higgins (1989) grouped the Xiaodushanian conodonts of southern Guizhou into the *Streptognathodus elegantulus* and *S. elongatus* zones.

In summary, although the establishment of stages in China is relatively recent and each stage covers a long time interval, approximately equal to the present European Epoch, the wide spectrum of depositional types and the abundant faunas, as well as the continuous stratigraphic sequences, have the potential to provide GSSP(s) for the Carboniferous. The auxiliary D/C GSSP at Nanbiacun and a possible Tournaisian/Visean GSSP in South China (Hance et al., 1997) provide good examples.

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SYSTEM	SUB SYSTEM	SERIES	BIO-ZONES / STAGES	AMMONOIDA	FORAMINIFERA	CONODONTA	BRACHIOPODA	RUGOSA	POLYNOFLORA
P			Zisongian	*Properrinites plummeri*	*Pseudoschwagerina* (s. s.)	*Streptognathodus barskovi*	*Choristites jigulensis-Protanidanthus*	*Kepingophyllum, Parawentzellophyllum*	*Striatosporites major-Spinosporites spinosus*
CARBONIFEROUS	HUTIANIAN	MAPINGIAN	Xiaodushanian	*Prouddenites*	*Triticites*	*S. wabausensis*		*Nephelophyllum--*	*Florimites junior-Laevigatosporites vulgaris*
						S. nodulineatus			
					Montiparus	*S. elongatus*		*Pseudotimania--*	
					Protriticites	*S. elegantulus*		*Pseudocarniaphyllum*	*Torispora securis-Endosporites globiformis*
		WEININGIAN	Dalan	*Owenoceras*	*Fusulina cylindrica-F. quasicylindrica*	*S. oppletus*	*Buxtonia grandis*	*Arachnastraea--*	*Triquitrites tribullatus-Ahrensisporites querickel*
						S. excelsus			
					Fusulinella praebocki-Beedeina schellwieni	*Neogondolella clarki*		*Kionophyllum*	
				Winslowoceras	*Profusulinella*				*Apiculatisporis abditus-Radizonates striatus*
			Huashibanian	*Branneroceras Gastrioceras*	*Pseudostaffella antiqua*	*Idiognathoides sulcatus parvus*	*Choristites mansuyi-Semicostella panxianensis*	*Lithostrotionella stylaxis--*	*Triqurtrites bransonii-Lycospora pellucida*
				Bilinguites Cancelloceras				*Carinthiaphyllum exquisitum--*	*Crassispora kosankei-Rugospora minuta*
				Reticuloceras				*Acrocyathus*	*Densosporites sphaerotriangularis--Dictyotriletes bireticulatus*
			Luosuan	*Homoceras*	*Millerella marbiensis Eostaffella postmosquensis*	*Idiognathodus primulus* / *Neognathodus symmetricus* / *Idiognathoides sinuatus-I. sulcatus* / *Declinognathodus noduliferous*			
	FENGNINGIAN	TATANGIAN	Dewuan	*Eumorphoceras-Dombarites*	*Eostaffella mosquensis* or *E. hohsienica*	*G. bilineatus bollandensis*	*Gondolina weiningensis Gigantoproductus edelburgensis, Gulzhouella*	*Koninckophyllum--*	*Simozonotriletes verrucus-Stenozonotriletes rotundus*
						Adetognathus unicornis		*Dibunophyllum bipartitum*	*Tripartites trilinguis-Simozonotriletes arcuatus*
			Shangsian	*Goniatites*	*Lituotubella glomospiroides-Quasidiscus quangdongensis*	*Paragnathodus nodosus*	*Moderatoproductus*	*Yuanophyllum,*	*Rotaspora knoxi*
						G. bilineatus bilineatus	*Vitiliproductus groeberi-Balakhonia yunnanensis-Pugilis hunanensis,*		
			Jiusian	*Beyrichoceras*	*Dainella gumbeica-Plectogyra posneri*	*Paragnathodus commutatus*	*Delepinae subcarinata-Megachonetes zimmermanni, Schuchertella magna*	*Thysanophylloides, Siphonophyllia oppressa*	
				Ammonellipsites		*G. homopunctatus Gnathodus taxanus*		*Cyathoclisia arachnolasmoidea*	*Lycospora pusilla*
		AIKUANIAN	Tangbagouan	*Pericyclus*	*Plectogyra komi-Granuliferella complanata*	*Scallognathus anchoralis*	*Finospirifer shaoyangensis*	*Pseudouralinia,*	*Umbonatisporites (Dibolisporites) distinctus*
						G. semiglaber- G. typicus			
						Siphonodella isosticha--U. S. crenulata			
						L. S. crenulata			
						S. sandbergi	*Eochoristites-Martinlella*	*Zaphrentites parallelus*	
				Gottendorfia		*U. S. duplicata*			
						L. S. duplicata			
						S. sulcata			
D			Gelaohean	*Wocklumeria*	*Quasiendothyra kobeilusana--*	*S. praesulcata*	*Schuchertella gelaohoensis,*	*Cystophrentis*	*Retispora lepidophyta*

Table 1. Chronostratigraphic subdivisions and zonation of selected fossil groups in the Carboniferous of China (after Wang X.D. & Jin, in press).

Factors of peat taphonomy: plant preservations in coal balls

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Recently two detailed mineralogical and chemical studies on Euromerican coal balls were completed; one deals with the calcite coal balls from the Donets Basin (Zodrow, Snigirevskaya & Palmer, 1998) and the other with their "chemical cousins" siderite coal balls from Canada (Zodrow & Cleal, 1998). The quite different genetic histories are most clearly expressed from the data on stable carbon and oxygen isotopic compositions, sedimentary mineral associations, replacement and metasomatism on the different carbonate mineralogies, and on chondrite-normalized rare earth elements. A general conclusion is that calcite permineralization is much more complex than existing coal-ball literature leads to believe. However, the most striking difference is that the calcite coal balls show superior plant tissue preservation, but not consistently so, as compared with the siderite coal balls that consistently show poor preservation. For the siderite coal balls it means that macroscopically mostly 'hard parts' (xylem, vascular bundles, periderm, cortex and the like) of lycophytes are preserved in a fragmented state. By microscopic means [scanning electron methods and x-ray imaging on primary and replacement carbonate minerals], it is shown that generally the poor preservation is related to part or partial destruction of intercellular spaces, or ex cell walls? (see Fahn, 1990). This is particularly emphasized in the siderite coal balls that have pyrite content, but it is also true for the studied Donets-Basin coal balls with pyrite content. The generality of the different preservation qualities is confirmed by the very numerous studies on calcite coal-ball, and very few (three or so!) on siderite coal balls.

The different preservation potentials (calcite vs siderite calcite coal balls, presence of pyrite vs absence) can also be viewed as bias difference. It is clear that the siderite and pyrite-content coal balls show the greatest partiality, and it follows that the palaeobotanic interpretations are biased! Explanatory factors include (1.) timing of coal-ball formation in relation to peat formation, and (2.) changing palaeoenvironmental oxidation (Eh) condition. Realistically, these two are probably co-effective in the sense that the longer peat is exposed before permineralization, the more oxidation has a chance to be active to convert increasing amounts of peat into CO_2, H_2O and other oxidation products (gradual destruction of intercellular spaces or lamella of plant tissue before permineralization takes place). The assumption for the latter is an environment for changing oxic/anoxic conditions, such as changing water levels in a peat mire. However, metabolic function of heteromorphs (Ehrlich, 1996) are also involved.

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The origin of some endemic bivalves of Gondwana

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Endemic bivalve genera of Gondwana: *Eurydesma*/ *Merismopteria* and *Deltopecten* are associated with glacigenic sediments in Australial India, South Africa and Argentina. These genera that are closely linked to cold climates are generally assumed to be exclusive of the Early Permian. However, the Late Palaeozoic "ice age" started much earlier, in the Visean-Namurian. If glaciations began in the Carboniferous, it is not surprising that these genera, or their forerunners appeared during this Period in spite of the occurrence of a long lasting interglacial in the Late Westphalian-Stephanian (González, 1981, 1990).

Glacimarine sediments of Carboniferous age crop out along the peri-Gondwanic belt that extends from the Precordilleran ranges of western Argentina and continues along Antarctica to eastern Australia. These deposits, which often bear intercalated richly fossiliferous horizons, constitute an excellent field to investigate the origin and evolution of the "cold faunas" that lived during the Late Paleozoic glaciation.

When dealing with the systematic position of "*Eurydesma*" *harringtoni* González, Dr. Newell at the American Museum of Natural History revealed to me his belief of the origin of the genus *Eurydesma* in the Carboniferous. The unique specimen known of "*Eurydesma*" *harringtoni* was found in the lower portion of the *Levipustula* Zone in central Patagonia. In that issue

(González, 1972) I was not definitely persuaded it was a true *Eurydesma*, but a direct ancestor of the Early Permian stock. The material consists of the mold of a right valve, which lacks the ventral margin and posterior end of the dorsal margin. Its hinge structure shows Eurydesmatid characteristics: a transitional type ligament area with parallel grooves, and two blunt teeth in front of the area. The shell structure of *Eurydesma* is lamellar, and this is conclusive to determine its classification within the Eurydesmidae. Unfortunately, the shell is not preserved in the unique specimen of *"E." harringtoni*; in spite of this, careful revision, and delicate casts made with polyvinylsiloxan, reveal traces of what apparently was thick prismatic shell. If this characteristic is confirmed, we can no longer sustain this fossil is related to the Eurydesmidae. Whatever the case, this specimen probably belong to a new genus, as pointed out elsewhere (González, 1990), but it does not afford sufficient information, and no more material was found after repeated collections in the same and other localities.

Species of the genus *Merismopteria* were reported in latest Carboniferous-earliest Permian deposits of western Argentina (Manceñido *et al.*, 1976), and in earliest Permian sediments of Patagonia (González, 1985). In both cases the material available is insufficient for specific assignation, but reveal the occurrence of the genus *Merismopteria* around the Permo-Carboniferous boundary, earlier than Early Permian species of the genus known from Australia.

It is probably in the Deltopectinidae that we have the most outstanding case of evolution of Late Paleozoic endemic bivalves of Gondwana. Species of the genus *Deltopecten* Etheridge Jr. occur in Early Permian sediments of Australia and India, and perhaps also in eastern Argentina (Rocha Campos and Carvalho, 1975). The genus *Orbiculopecten* Gonzalez (1978) was erected to include pectinids that have the characteristic transitional ligament area, but are smaller and have more elaborate external ornament than *Deltopecten*. This genus is not acknowledged by Newell and Boyd (1995). These authors regard *Orbiculopecten* as a junior synonym of *Streblopteria*, which they place, together with *Crittendenia* and *Eocamptonetes*, in the Deltopectinidae. The genus *Orbiculopecten* was based on a single species from the lower segment of the *Levipustula* Zone of Patagonia. However, I was able to recognize similar forms in collections of Late Carboniferous fossils of eastern Australia. Moreover, latest explorations in the Carboniferous glacial rocks of Argentina, furnished abundant and well preserved remains of these pectinids. The finding of new fossiliferous localities in the Precordilleran ranges and central Patagonia, allowed recovery of one (perhaps two) new species. The material shows details of the ligament area and ornamentation, and additional information on other internal and external characteristics. These findings confirm the validity of the genus *Orbiculopecten*, and its phylogenetic link with the Early Permian genus *Deltopecten*.

During the Late Paleozoic "ice age", endemic bivalve genera evolved in Gondwana, induced primarily by low temperatures of the periglacial seas. They vanished at the end of the Early Permian, after glaciations finished and global warming started. Although first described from Early Permian sediments, latest findings show that antecessors of these genera appeared during the Late Carboniferous, or very early in the Permian. In this regard, the genus *Orbiculopecten* can be confirmed as a direct forerunner of the Early Permian *Deltopecten*. *Orbiculopecten* proves that this lineage of the Deltopectinidae arose during the early Late Carboniferous, almost immediately after the beginning of the Late Paleozoic "ice age". The genus *Merismopteria* which appeared nearly at the end of the Carboniferous had a shorter range. *Eurydesma*, we may suppose, was a short-living experiment; no true *Eurydesma* nor a certain precursor of this genus, was found so far before the Early Permian glaciation.

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Comment on global nomenclature of the Carboniferous Subsystems and the Mid-Carboniferous Boundary GSSP.

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In the recent SCCS vote about global names for the two Carboniferous subsystems I did not support the adoption of Mississippian/Pennsylvanian primarily because of problems with definition of the Mid-Carboniferous Boundary GSSP and considerations about the appropriate scope of regional chronostratigraphic names and their application in a global scheme.

The current definition of the mid-Carboniferous GSSP confuses biostratigraphy with chronostratigraphy. To define the GSSP in a rock section at the appearance of a single biostratigraphic taxon does not ensure that this appearance is an event which can be correlated isochronously into chronostratigraphically complete sections. Indeed at Arrow Canyon there is ample evidence that the first appearance of *Declinognathodus noduliferus* is more likely to result from a combination of facies control and sample point selection rather than the absolute, in a global temporal sense, first appearance of the taxon.

Even if one accepts that a GSSP can be taken at the position of a single taxon entry (which I do not), *Declinognathodus noduliferus* is unsuitable. It is an ill defined taxon which shows plasticity (Brenckle et al. 1997a, Titus et al. 1997) with a supposed ancestor, *Gnathodus girtyi simplex*. The actual distinction between *G. girtyi simplex* trans *D. noduliferus* and *D. noduliferus* ss. has not been rigorously defined. Furthermore, there are two apparently plausible phylogenies for the ancestry of *D. noduliferus* (the other, described by Nemirovskaya & Nigmadganov, 1994, being from *G. postbilineatus* through an intermediate *D. praenoduliferus*). Either one phylogeny is wrong, or the taxon is polyphyletic. This casts serious doubt on the reliability of the phylogeny used as a global correlation tool and demonstrates the pitfalls of using phylogenitic models for GSSP definition.

During my first visit to Arrow Canyon (accompanied by Alan Titus) in May 1997, we observed that the boundary interval is riddled with diastems caused by subaerial exposure. Some of these can be interpreted from information sent to Voting Members of the SCCS in 1994, but we also found evidence for an exposure surface, unrecognised before, at the base of the marine cycle in which *D. noduliferus* enters. These exposure surfaces are summarised along with a sequence stratigraphic interpretation in Fig. 1. The International Stratigraphic Guide (Salvador, 1994) states that *"The boundary stratotypes must be selected in sections representing essentially continuous deposition. The worst possible choice for a boundary stratotype of a chronc-stratigraphic unit is at an unconformity; it not only does not represent a sharp point in time, but tends to change in age laterally"*. We may not have had the luxury of this wisdom with regard to historical chronostratigraphy, but we must apply it to our GSSP's

It should be of no surprise that a carbonate platform being laid down in the glacioeustatic regime of the Mid-Carboniferous has numerous exposure surfaces (Wright et al., 1997). The choice of facies location for the present GSSP is therefore fundamentally flawed.

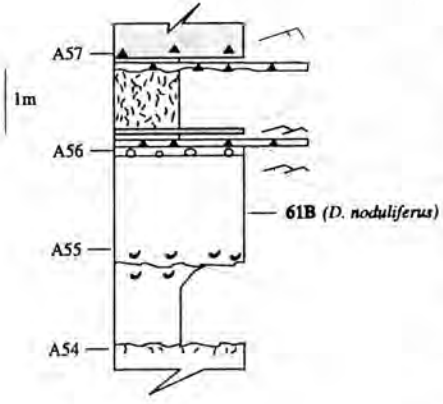
Of these exposure surfaces it is the one at "the clastic bench" (Fig. 1) which has traditionally been recognised as the base Pennsylvanian and is considered by the USGS (B. Cecil pers com. 1997) to be the base Pennsylvanian weathering surface (seen in many parts of the USA, eg. Caudill et al., 1996). This lies above the entry of *D. noduliferus* at Arrow Canyon. Moving the base Pennsylvanian down section to this biostratigraphic event departs from the traditional synthem concept of the Pennsylvanian. There is also the problem of considering the basal boundary stratotype for the Morrowan Stage; would that have to be defined at the the same point as the conodont proposal for defining the base Pennsylvanian at Arrow Canyon?

We do not know the extent of time breaks at these exposure surfaces. Time lost due to non-sequence/erosion is not measurable at Arrow Canyon because of the relatively poor resolution of the conodont biostratigraphy there (unlike dating techniques available in deeper water sections). The exposure surfaces could occupy intervals in excess of the duration of a western European stage without the conodonts (alone or in combination with any other shallow marine biostratigraphic markers at this site) being able to resolve this.

Historic and regional chronostratigraphic subdivisions are useful in the regions to which they have been traditionally applied and erected. That is where they are best understood in terms of historic use, limitations and strengths. It is inappropriate to promote regional subdivisions into global ones. Global chronostratigraphic nomenclature should be kept separate by the erection of new names (preferably not of geographic derivation) and the chronostratigraphic scope of existing regional chronostratigraphic classification should not be compromised to fit in with GSSP's.

ARROW CANYON, NEVADA USA

SECTION



LITHOLOGY

Impersistant claystone, overlain by massive X bedded calcareous fine to medium-grained sandstone
Scattered clasts as in underlying conglomerate (toward base).
Thalassinoides burrows in base of X bedded unit

Conglomerate, pebble/gravel, containing claystone clasts from underlying bed, together with calcrete nodules and ferrocretions (both reworked)

Claystone/siltstone, pale green, with iron stained ped slicks in places, otherwise blocky. No primary internal bedding apparent.

Claystone, silty, overlain by fine-grained iron stained sandstone. Ripple cross laminated, with ripple relief on upper surface.

Conglomerate, gravel/pebble size clasts of reworked calcrete nodules and chert pebbles.

Calcrete nodules become commoner toward top. Nodules are in situ and disrupt surrounding grainstone

Grainstone, fine to coarse grained with brachiopod coquina in basal part and ripples with clay drapes in upper part.

Claystone, brachiopods become commoner toward top where there is a gradational change to rudstone. Clay refuges preserved under some valves.

Grainstone, fine grained, dolomitised toward top, pyritic.
Upper surface is sharp, undulating and ironstained.
Small limonitised rhizoliths occur.

INTERPRETATION

Flooding surface at base, abundant fine clastic supply, reworked material from underlying sequence still being supplied.

Flooding surface at base. Transgressive lag of ferrocretions, claystones and calcrete nodules from erosion of underlying exposure profile.

EMERGENCE & BREAK

Deposition of fine silts and sandstones in shallow subaqueous environment. Bulk of interval then deeply weathered, leached and peded, before erosion and then deposition of overlying conglomerate.

Flooding surface at base
Subaqueous (possibly marine) reworking of exposure surface and calcrete profile.

EMERGENCE & BREAK

High stand fill to lowstand. Winnowed carbonate, high energy regime.
Late highstand shows more clay input, or lower energy. Later emergence (lowstand) shown by overprinting of calcrete nodules (seasonally arid)

(Mid-Carb. Boundary, 61B)

Maximum flooding to early highstand, reaching wavebase toward top as early high stand fill takes over.
Flooding surface at base of unit. Transgression has eroded upper part of underlying sequence.
Trangressive deposits not preserved.

EMERGENCE & BREAK

Exposure of highstand fill shoal grainstone during regression, or still stand. Plant colonisation and formation of soil profile.
Upper part of soil profile scoured by overlying transgression.

Fig 1. Diagram illustrating the position of exposure surfaces (causing chronostratigraphic breaks) closely associated with the Mid-Carboniferous Boundary GSSP, Arrow Canyon, Nevada, USA. Reference points A57 etc. are 1.5m spaced markers painted on the outcrop (Brenckle et al., 1997); 61B is the the sample which denotes the GSSP (first appearance of the conodont Declinognathodus noduliferus). Correlation of a Mid-Carboniferous boundary based on flooding surfaces would place the boundary at the flooding surface overlying reference point A54, which here rests on an exposure surface. The "clastic bench " lies between reference points A56 and A57. It is this palaeosol profile which is the top Mississippian weathering zone, the "lithostratigraphic" Pennsylvanian/Mississippian boundary lies at the top of this profile.

It is remarkable that with regard to the Mid-Carboniferous interval, so dominated by glacioeustasy, that the selection of a GSSP has not taken this fundamental characteristic into account as a means of global correlation. The GSSP could then be drawn at the base of the flooding surface which interjects between the *Eumorphoceras* and *Homoceras* Ammonoid biozonal assemblages. This would preserve the original concept of the Mid-Carboniferous Boundary and uncouple the biostratigraphy (used to bracket the event with assemblages rather define at an entry of a single taxon) from chronostratigraphy. It also gives the boundary a lithological expression.

Those who would argue that such flooding surfaces are just as diachronous as a biozonal boundary should refer to recent work on the Holocene transgression. The bulk of this glacioeustatic transgression was achieved within 8,000 years (Blanchon & Shaw, 1995). That is, in the geological context of Carboniferous time...an instant.

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Amazonas Basin palynostratigraphy

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The vast, petroleum-prospective Amazonas Basin, occupying some 500,000 km2 of northern Brazil, is the focus of a detailed palynostratigraphic study being conducted jointly by Geoffrey Playford (University of Queensland) and Rodolfo Dino (Petrobras/Cenpes, Rio de Janeiro). The study is based on over 500 samples from the mid Carboniferous to Permian Tapajos Group, which has been penetrated and extensively cored in numerous Petrobras wells in the basin's deep central portion and in the flanking north and south platforms. The palynofloras vary considerably both quantitatively and in quality of preservation. A palynostratigraphic reference section covering all four constituent units of the Tapajos Group - viz., Monte Alegre, Itaituba, Nova Olinda, and Andrira Pormations - constitutes the basis of a spore-pollen zonal sequence, in which diverse monosaccate and non-taeniate bisaccate pollen grains are prominent and taeniate bisaccates are progressively introduced. This parallels palynological successions recorded from elsewhere in Gondwana and also exhibits significant links with the United States midcontinent region. Much of the work has been completed during Geoffrey Playford's recent study leave (July 1997-January 1998) at the Petrobras Research Center. A substantial manuscript is currently being prepared and is planned for submission later this year. Preliminary results on the lower part of the Tapajos sequence were presented recently at the *IXReuni~o de Paleobotanicos e Palinologos (IX RPP)* held at Guarulhos University, SP, Brazil, during 9-12 December 1997).

Carboniferous paleofloristic successions in the South American basins (report of the coordination group)

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Introduction

This report summarizes the results of the workshop on Carboniferous Paleofloristic Succession in the South American Basins which gathered experts from Brasil, Argentina and France to present updated short reviews and to discuss common problems related to this subject. The abstracts of the invited contributions are published in "Revista Universidade de Guarulhos, Série Geociências, Ano II - Número Especial - 1997 - 280p. (e-mail: geo@server.ung.br; http://www.ung.br). This special number contains also other contributions to the "9th Meeting of Paleobotanists and Palynologists" (which included at its first day the mentioned workshop) held in Guarulhos City, State of São Paulo, Brasil, From 9th to 12th December, 1997.

Reports

The Carboniferous

Archangelsky (1997) presented a review on the evolution of the Carboniferous System subdivisions, on the SCCS structure, recommendations, concerns on age limits and on numenclatural problems. He also explained the recent SCCS proposal on the Carboniferous subdivision, reported by Metcalfe (1997). S. Archangelsky enumerated the present difficulties for age assignments and correlation in our continent. According to him, a more accurate taxonomy and better stratigraphic control are required for more reliable correlations involving the fossiliferous (megaplants and palynomorphs) beds of the South American Carboniferous.

Basin development during the Carboniferous in the South American Platform.

The great number of sedimentary basins involving Carboniferous history and the variety of evolutionary development with differences in tectonics, sedimentation and fossiliferous content makes the comparative analysis very complex and difficult, but richly informative.

A. C. Rocha-Campos dealt with the general distribution of such basins, their general features, paleogeography and paleoclimate, including the role of the glaciation in this part of Gondwana.

Though it is possible to recognize strata of the lower and upper part of the Carboniferous System in South America, according to Rocha-Campos (1997) the available biostratigraphic information is frequently too meager for clear delimitation between late Carboniferous and lower Permian. The use of international chronostratigraphic units for most of the Carboniferous of South America is still unconsistent. An exception to this is the northern part of the continent where paleoequatorial invertebrate fauna and flora occur.

The paleoequatorial transition zone

J. Broutin presented paleobotanical data and conclusions from recent research projects in the two areas of southern part of the Peritethian Plataform: 1- continental basins (Permian) of Central Marocco and, 2 - Huqf (Oman) with its Late - Early Westphalian/Early Stephanian to Late Permian marine/continental succession. According to Broutin (1997) the Oman succession represents a key-section for the intercalibration of marine and continental biostratigraphical scales. A newly named "Gharif paleoflora" was erected as standard for the Arabian Peninsula. Gondwanan, Cathaysian and Laurasian warm humid floral elements are found to be associated in this flora (Broutin, 1997). The paleogeographic significance of the Permian period was also discussed.

The Carboniferous paleobotanical and palynological elements in the South American basins: floristics and biochronostratigraphic analysis.

This topic was presented by invited experts who have published and are active on floristics and/or biochronostratigraphic analyses on Andean and cratonic basins mainly in Argentina, Brasil and Bolivia.

Azcuy (1997) presented an updated review on 5 basins in Argentina (1. Madre de Diós, 2. Tarija, 3. Paganzo, 4. Uspallata - Iglesia and, 5. Chacoparanaense basins). This author discussed the criteria for attributing the gondwanic character to these basins, their evolutive history considering also the latitudinal positions of the continent during the Carboniferous and Permian. C. Azcuy also discussed about the recognizable palynological and paleobotanical assemblages and about those palynomorphs also occurring in other basins nearby,

including the Paraná basin in Brasil.

Césari & Guttierrez (1997) also presented palynological data of four Argentinean basins: 1. San Rafael, 2. Callingasta Uspallata, 3. Chacoparana and, 4. Paganzo. They recognize four biozones in the Carboniferous - Permian sequence: 1. Association-zone *Cordylosporites - Verrucosisporites* (Early Carboniferous), 2. Association-zone *Foveosporites hortonensis - Apiculiretusispora hortonensis* (Late Carboniferous), 3. Internal-biozone *Fusacolpites fusus - Vittatina subsaccata* (early Early Permian) and, 4. Association-bizone *Lueckisporites - Weilandites* (late Early Permian). This, compared with fossil megaplant evidence allowed the authors to analyse climatic changes, paleogeography and paleoecology of that part of Argentina.

Marques - Toigo (1997) presented results of age determination based on palinomorphs, fusilinids and conodonts from the thick stratigraphic sequence of the Amazonas and Solimões basins (northern Brasil) involving the Namurian - Stephanian interval.

Iannuzzi (1997) presented the paleobotanical and some palynological data from the Poti and Piaui Formations of the Parnaiba basin (NE Brasil).

Poti Formation contains Pteridosperms (*Adiantites, Nothorhacopteris, Diplothnema gothanica* and *Triphyllopteris adiantoi*) rare *Sphenpphytes*, and rare but important fructifications attributed to the Pteridosperms.

The Piaui Formation contains only rare fossil megaplants (ferns and sphenophytes).

The Poti Formation and the underlying Longá Formation are palynologically characterized by high percentage of spores, including Devonian reworked ones. Those palynomorphs of Poti Formation represent more endemic elements.

Rösler (1997) presented and discussed the Carboniferous megaplants of the Paraná basin (South and Southeast Brasil) where the Carboniferous System is represented by the basal, and possibly also by the middle, part of the Itararé Subgroup (Tubarão Group). Paleobotanically the Carboniferous is represented by the Taphoflora A (Rösler, 1978) with arborescent lycophytes (*Brasilodendron pedroanum*), sphenophytes (*Paracalamites*), pteridosperms (*Nothorhacopteris, Botrychiopsis, Adiantites*, etc.) and conifers (*Paranocladus* and *Buriadia*) with a remarkable absence of *Glossopteris*, a very common genus in the Permian overlying sequence. Most of the Carboniferous fossil megaplants mentioned above occur in a single locality (Monte Mor). *Nothorhacopteris* occurs also in Buri locality. The rest of the possible Carboniferous part of the Itararé Subgroup is very poor in megaplant fossils, which makes correlation impracticable on this basis at the present. According to O. Rösler, the appearence of the first well-defined species of *Glossopteris* provisionally may be used as an indication that we are above the Carboniferous/ Permian boundary. But the possibility of diachronism in the appearence of *Glossopteris* at different Gondwana regions must be investigated. Obviously, as pollen, spores and megaplant fossils are botanically related, new postures in joint paleobotanical and palynological analyses certainly will promote progress in this area.

From the palynological point of view (Souza, 1997) the clear recognition of the Carboniferous in the Paraná Basin is possible only in three palynological associations occurring at Araçoiaba da Serra, Buri and Monte Mor localities, all in São Paulo state, Brasil. All the three localities present a variety of elements which permit a sure recognition of the Carboniferous in parts of the Itararé Subgroup. Several of these elements are also found in the palynological associations of the Carboniferous of Argentina and Australia, like *Cristatisporites* spp. (ex - *Ancistrospora*) *Ahrensisporites cristatus, Foveosporites hortensis, Anapiculatisporites hortensis* and *Spelaeotriletes triangulus*. According to Souza (1997), these palynological associations are characterized by the dominance of trilete spores and monossaccade pollen grains (with radial and bilateral symmetry) and by the rare participation of striated pollens.

A brief discussion and recommendations

1 As a result of the discussion it is possible to point out:

In the majority of the South American basins there are no clear reference-levels with chronologically significant elements which could permit wide correlation and a more precise age calibration among the available biostratigraphic schemes. For the same reason it is still difficult to correlate these schemes with those established in the paleoequatorial region. The phytofossils (macro and micro) were recognized as very useful and of great potential: They permitted the proposition of biostratigraphic zonations which, however, require revisions and/or improvements. Paleobotanical and mainly palynological similarities were found among some associations of Paganzo, Chacoparaná and Paraná basins with good potential for correlation. Due to the remarkable translatitudinal displacements, responsible for plant community displacements, the correlation between Gondwana Carboniferous strata and those of the paleoequatorial

region is still more difficult than among the Gondwana ones.

2 Recommendations:

The first step for improving the available correlation schemes is a better taxonomic definition of the potential key elements, particularly phytofossils (macro and micro). In view of the progress verified in the process of integration among paleobotanists and palynologist of Argentina and Brasil it is recommended that experts of both countries work together in the better taxonomic definition of the key elements and in the proposition of correlations involving Paraná, Chacoparana and Paganzo basins.

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Correlation of Middle Carboniferous – Early Permian brachiopod faunas and macroflora in Kazakhstan

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Central Kazakhstan was an intermediate (transient) province in Carboniferous times between Boreal (Angaran) and Tetetical (Euroamerican) biostratigraphic areas. Between Visean and Early Permian times, the land area expanded and complicated space and time connections of marine and surface biocenosis. Tectonic movements caused land emergence and formation of volcanic belts which were island-arcs in the Early Carboniferous and then continental. Arisen barriers blocked or changed migration of marine biocenosis, but less affected the surface floral development. When defining biogeographical zones, vast horizontal movements of lithospheric blocks for hundreds and even thousands of kilometres in Permian and Mesozoic times should be taken into account.

We present three paleotectonic non-palinspastic paleogeographic schemes, for the geodynamic and paleogeographic elements of the Ural – Tienshan and the Kazakhstani part of the Central Asian folded belt (Ural and Tienshan were included just to make up a common picture). In this publication, mainly the East part of Kazakhstan with marine regimes of Middle and Late Carboniferous is described.

The main purpose of this publication is correlation of marine and land sediments in accordance with brachiopod fauna and flora and correlation of these with the international stratigraphical scale.

Materials used include fauna from the marine inter-arc Sayak depression located in the Northern part of the Jungaro-Balkhash paleo-oceanic basin of the Kazakhstani geosynclinal system as well as in the Zaisan-Irtysh Middle Carboniferous marine depression of the same type, and in the lake-lagoon depression of the Irtysh-Altaisk geosynklinal system. Fossil floras are known both in shallow marine and in non-marine deposits.

The Lower - Middle Carboniferous boundary does not have distinct paleontological characteristics and is located within lithologically uniform graywacke sandstones. This boundary, reflecting the beginning of the new Late Paleozoic, occurs at the beginning

of the Upper Serpukhovian substage, conforming (correlating) to the *Homoceras* zone. Folding of the volcanic belt and tonalite – plagiogranite intrusions preceded this boundary. There is a clearly defined change of flora manifested as a mass occurrence of European calamites in the Central Kazakhstani Sayak zone. The *Lepidophytes* complex was replaced by the Angaran pteridosperms in the Zaisan-Irtysh region. *Antiguatonia insculpta* M.-W, *Fluctuaria corrugata* M'Coy, *Echinoconchus (Karavankina) fasciatus* (Kut.) were found in marine sediments of the Sayk basin. The Goniatites *Cravenoceras cowlungense* Bisat.,*Dombarites tectus* Libr. occurred in the boreal Zaisan-Irtysh zone. The age-range for these sediments varies from the upper part of the Serpukhovian stage to the lower part of the Bashkirian stage (zone of *Reticuloceras)*.

The most important aspects concerning the age of marine biota and floral complexes and their correlation with South Tetic region and boreal Angaran one relate to embedded Middle and Late Carboniferous sediments passing into Lower Permian. In accepted regional sections they are represented by the Tastykuduksky ($C_2 b_2 - m_1$) and Koldarsky ($C_2 m_2 - C_3 - P_1$?) horizons. Problems with the definition of their age and with correlation with other regions is a matter of current discussion. One main discrepancy is an extreme disagreement in identification of age by fauna and flora. Brachiopods as the most important group of fauna was considered to be within the Middle Carboniferous for both horizons. The floral complex of the Tastykuduksky horizon occurs throughout the Middle Carboniferous. The floral complex of the Koldarsky horizon characterizes the Upper Carboniferous and part of the Lower Permian.

In 1992 – 1994 L. Sergeeva inspected brachiopods of Tastykuduksky horizon and studied the brachiopod succession of the Koldarsky horizon located in the sediments of the Sayak marine basin. She distinguished 7 brachiopod zones within the age range Lower Bashkirian substage up to the end of the Late Carboniferous.

Summary paleontological characteristics are as follows:

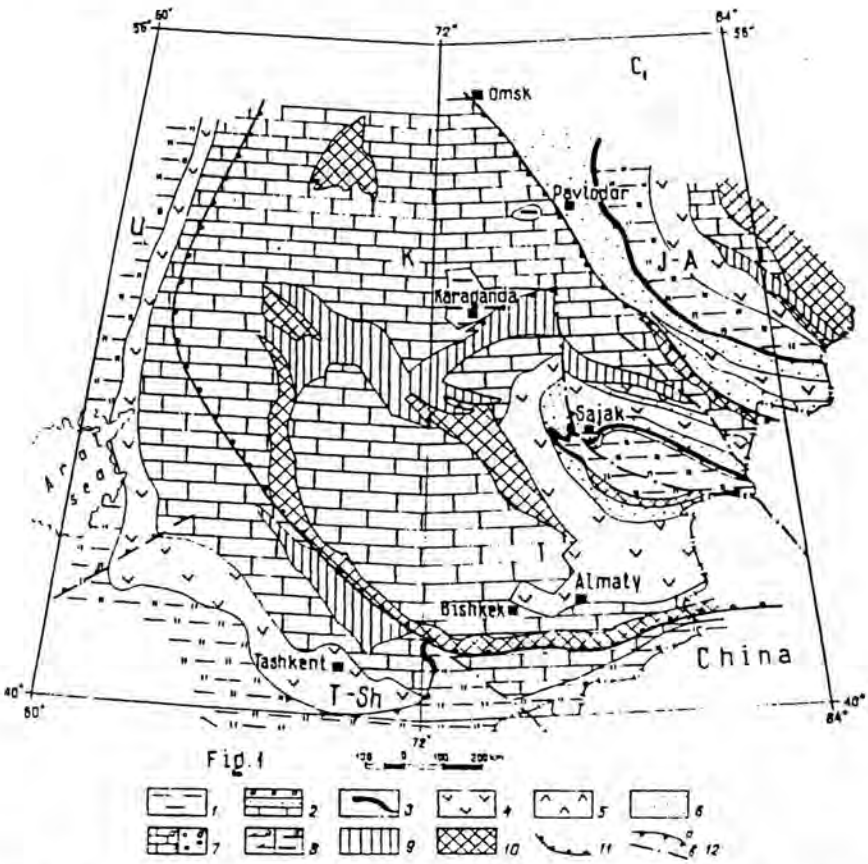

Fig. 1 Lower Carboniferous paleotectonic scheme of Kazakhstani territory

1. – oceanic siliceous-schist formations; **2.** – shallow marine, lagoonal and molasse formations of inland (locked) oceanic and interarc depressions (deeps); **3.** – ophiolite overthrusts of island arcs; **4.** – volcanic island arcs; **5** – continental volcanic belts; **6.** – interarc flysch depressions; **7.** – rear marine (a) and molasse (b) basins; **8.** – evaporites (a) and coals (b); **9.** – rear deep-sea rifts; **10.** – reclamation – land; **11.** – boundaries of geosynclinal – folded systems: U – Ural, T-Sh – Tian-Shansky, K – Kazakhstani, I-A – Irtysh-Altaysky; **12.** – thrusts (a), Mesozoic faults (b).

Tastykuduksky horizon: I^1 flora, 500 m up from base: *Calamites undulatus* Sternb., *Cal. Schutzeiformis* Kids., *Phyllotheca deliquescens* (Gopp); *Cordaites* sp., *Angaropteridium, Pecopteris angaridensis* Zal., euroamerican plants are dominant: fern, Angaran mainly. I^2 brachiopod zone: *Balkhasheconcha sarytchevae – Orulgania olgae* correlates zone of *Pseudostaffella antiqua – Ozawainella parahomboidalis*. II zone of *Neospirifer cameratus – Brachythyrina strangwaysi* correlates zone of *Aljutovella aljutovica*; goniatite *Diaboloceras aff. neumeiri*. III zone of *Reticulatia tekesensis – Choristites priscus*; foraminifera zone of *Aljutovella priskoidea*. IV zone: *Choristites loczyi. Buxtonia kalitvaensis* Lich., *Dictyoclostus donetzianus* (Lich.), *Chonetinella flemingi* (Norw. et Prat) appear along with transit and relict types such as *Neochonetes granulifer* (Owen.) and *Neospirifer condor* (d'Orb.). The age interval ranges from the end of the Early Bashkirian up to the beginning of the Late Moscovian.

Fossil flora forms Keregetasky complex in the surrounding land sediments of the same age. The floral complex is represented by a combination of Euroamerican (numerous calamite, some part of fern and cordaite), Angaran (*Rufloria, Angaropteridium, Paragondwanidium*) and cosmopolitan (*Dicranophyllum*) plants. Correlation with Euroamerican flora indicated Middle Carboniferous and with Angaran it is an indication of Middle Carboniferous Mazurovsky complex.

Association of brachiopods as well as biozones are distinct from the Sayak biota in the Zaisan-Irtysh province. The brachiopods are mainly boreal types: *Neochonetes dukhovae* Sok, *Lissochonetes taubensis* Sok., *Zakutoproduktus cheraskovi* Kasch., *Cancrinella cancriniformis* (Tscher.), *Neospirifer cameratus* (Mort) *Zaissania zaissanica Sok.* Typical complex of fossil flora: *Phyllotheca sp., Neuropteris izylensis* (Tschirk.) Neub., *Angaropteridium cardiopteroides* (Schm.) Zal., *A. potaninii* (Schm.), *Rufloria theodori* Tschirc. et Zal., *Ginkgophyllum vsevolodi* Zal. This complex completely corresponds to the Mazurovsky one in Kuzbass and correlates with the Keregetassky complex of the Tastykuduksky horizon by Angaran plants.

The new transgressive formation – the Koldarsky horizon, occurs with erosion onto this Tastykuduksky horizon and is represented by the Kungisayak suite in the marine Sayak basin. In the interval between the Tastykuduksky and Koldarsky horizons, the V complex of brachiopods yields

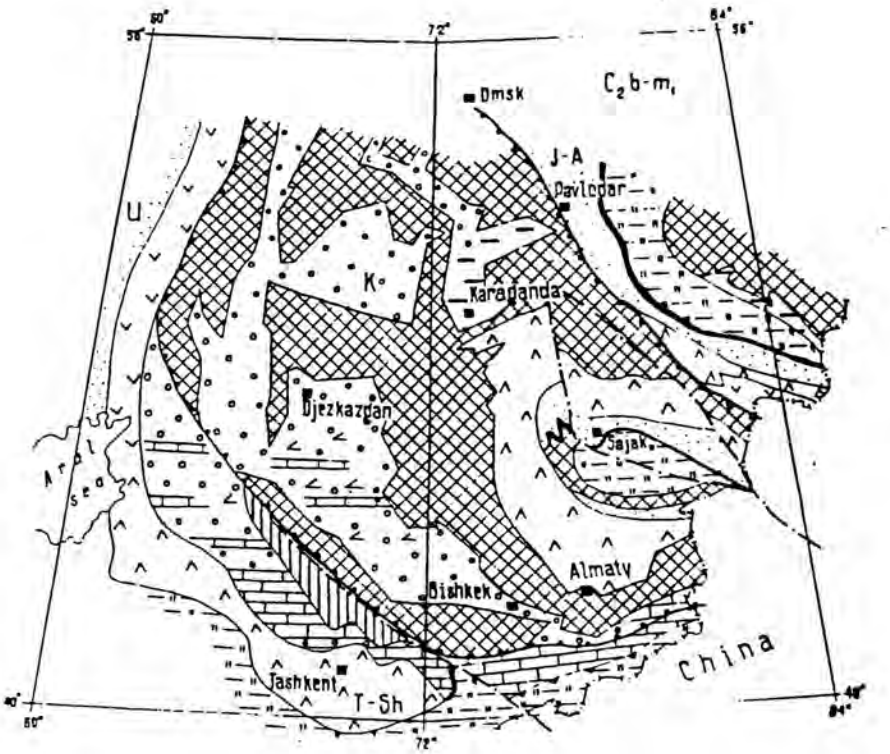

Fig. 2 Middle Carboniferous Bashkirian-Middle Moscovian

Key same as for Fig. 1.

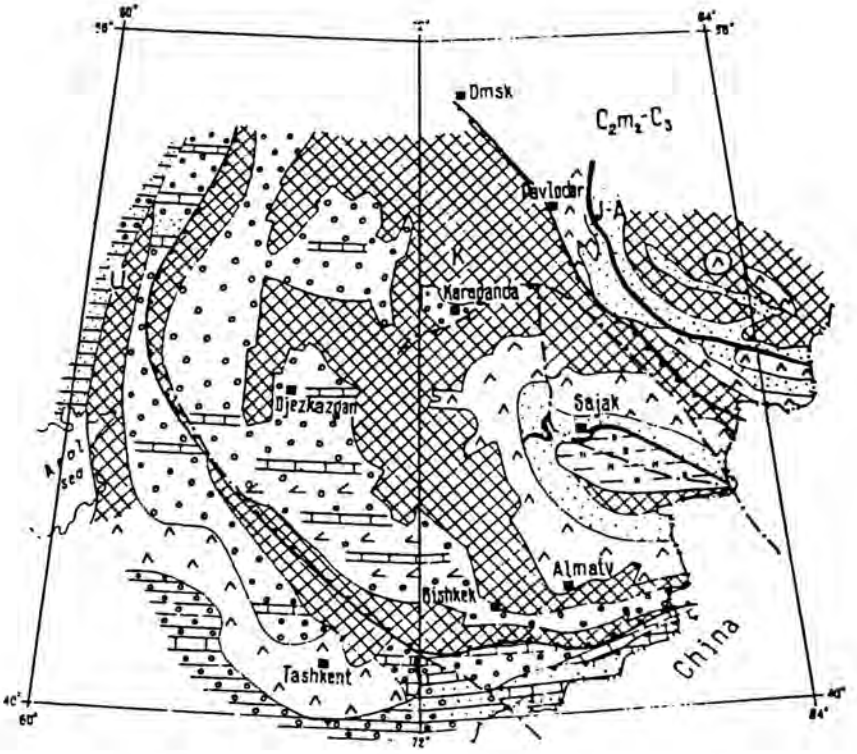

Fig. 3 Middle Carboniferous – Lower Permian

Key same as for Fig. 1.

Reticulatia pracuralensis – *Trautscholdia jigulensis* – *Linoproductus cora*. This complex of brachiopods occurs in southern Jungarya and correlates with the Myachkovsky horizon of the Russian platform (zone of *Fusulinella bocki*).

In the Sayk depresssion middle part of Kungisayaksky suite the VI complex of *Reticulatia huescuensis* zone is observed and it correlates with Gzhelian stage of Upper Carboniferous of the Russian platform, Ural and South Fergana. Species of Middle Carboniferous "survived" in the lower part of the zone. *Meekella exima* (Vern.), *Neochonetes variolata* (d'Orb.), *Linoproductus cora* (d'Orb.), *Trautscholdia jigulensis* (Stuck.) are observed with sub-zones: VI^1 - *Reticulatia huescuensis* – *Trautscholdia donetziana* and VI^2 *R. huescuensis* – *Trautscholdia pavlovi* – *Brachythyrina grandis* which are upper part of Upper Carboniferous and typical for Lower Permian. VII complex is zone of *Cancrinella cancriniformis Stepanoconchus postpunctatus* dated by Lower Permian, Asselian. Fossil flora *Rufloria theodorii* (Tschirk. et Zal.) S. Meyen., *Cordaites singularis* (Neub.) *S.* Meyen, *C. principalis* (Germ.) Gein. have been determined on level of VI^1 zone and compared with Late Carboniferous Alykaevsky flora of Angarida. In the upper part of Kungisayaksky suite fossil flora is represented by Angaran *Paracalamites similis* Zal., *Pursongia asiatica* Zal., *Zamiopteris* cf. *tajluganensis* Gorel., *Rufloria theodorii* (Tschirk. et Zal.), *Cordaites principalis* (Germ.) Gein. Euroamerican (Westphalian) plants are not numerous and represented by calamites. In continental deposits of volcanic belts the Koldarsky floral complex is distinguished from the Tastykudukskу (Keregetassky) one. This is pure gymnospermous mainly Angaran flora with predominant coraites. The complex includes: *Paracalamites frigidus* Neub., *Tschernovia ungensis* Gorel., *Pursongia asiatica* Zal., *Evenkiella* sp., *Zamiopteris glossopteroides* Schmal., *Rufloria thedorii* (Tschirk. et Zal.), *R. derzavinii* (Neub.) S. Meyen, *Cordaites singularis* Neub., *Crassinervia kuznetskiana* (Chach.) Neub. *Calamites gigas, Paracalamites decoratus, Sphenopteris germanica, Cordaites principalis* relate to Euroamerican flora.

The floral complex of the upper part of the Koldarsky horizon correlates with the Promezhutochny (intermediate) horizon of the Lower Permian of Angarida.

The latest study of brachiopod faunas of the Sayak marine basin determined its

upper age as Early Permian. Thus, the discrepancy between the age of marine faunal deposits and land flora has been removed.

In the Zhaisan-Irtysh zone the marine sedimentation discontinued at the end of the Middle Carboniferous. The Koldarsky horizon is represented by lake facies with fresh-water fauna and by phytofragments belonging to Late Carboniferous and Early Permian Alykaevsky and Upper Balakhonsky complex.

Palynostratigraphy of the Devonian-Carboniferous succession in southwest Portugal (South Portuguese Zone)

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In Southwest Portugal the Palaeozoic geology is dominated by the Aljezur and Bordeira Antiforms. The lithostratigraphic succession of Southwest Portugal was established by Oliveira *et al.*, (1985), comprising from base to top: the Tercenas Formation, of Late Famennian age; the Carrapateira Group that includes three units: the Bordalete Formation of Middle to Late Tournaisian age, the Murração Formation of Visean age and the Quebradas Formation of Namurian age; and finally the Brejeira Formation of Early Westphalian age. All the age determinations were based mainly on ammonoids, trilobites, rare corals and bivalves. However, some biostratigraphic problems remained to be solved, namely the absence of several ammonoid biozones in the Carrapateira Group and the poor age control of the Tercenas and Brejeira Formations. The aim of the present work was to precisely define the age of the succession by means of palynomorphs and test the accuracy of the results versus the local amonoid zonation (recently refined by D. Korn, 1996). What follows is a synthesis of the main results taking into account also recent ammonoid zonation.

The **Tercenas Formation** (base unknown) comprises dark marine shales with interbedded thin tempestites which grade upward to a 10m thick tidal sandstone body. Rare clymenids, brachiopods and corals suggest a Late Fammenian to Early Tournaisian age for this unit. The palynological studies indicates from base to top the *Retispora lepidophyta - Verrucosisporites nitidus* Biozone (LN) and the *Vallatisporites verrucosus - Retusotriletes incohatus* Biozone(VI). Reworked Givetian to Frasnian, and rarely Emsian miospores are present in the LN assemblages. Acritarchs are very common. The base of the sandstone member corresponds to the boundary between LN and VI Biozones, and is approximately coincident with the Devonian-Carboniferous Boundary. So, the age of Tercenas Formation is **Late Strunnian** to **Early Tournaisian**, based on palynomorphs (Pereira *et al.*, 1995).

The **Bordalete Formation** is dominated by dark pyritic shales with characteristic interbedded calcisiltitic nodules and lenticules. Rare goniatites and trilobites in the nodules indicate a Middle to Upper Tournaisian age. New palynological data show the occurrence of *Vallatisporites verrucosus - Retusotriletes incohatus* (VI), *Kraeuselisporites hibernicus-Umbonatisporites distinctus* (HD) and *Spelaeotriletes pretiosus - Raistrickia clavata* (PC) Biozones. *Maranhites* spp. are common. At the top of this unit the CM Biozone (*Auroraspora macra-Schopfites clavinger*) is missing, probably due to the presence of an hiatus. The age of Bordalete Formation is **Tournaisian**, based on palynomorphs.

The **Murração Formation** is made up of marly shales and dolomitic limestones which pass transitionally upwards into limestones interbedded with dark pyritic shales. The fossiliferous content of corals, crinoids, goniatites and trilobites gave an age that spans from the Early Visean to the Early Namurian?. The miospores study indicates the presence of assemblages assigned to the *Lycospora pusilla* (PU), *Knoxisporites triradiatus - K. stephanephorus*.(TS), *Raistrickia nigra - Propisporites laevigatus* (NL), *Savitrisporites nux* (SN), and *Bellispores nitus - Reticulatisporites carnosus* (NC) Biozones.

Two local biozones were created: *Raistrickia nigra - Propisporites laevigatus* (NL) and *Savitrisporites nux* (SN). These biozones are based in the absence of the stratigraphically useful taxa such as *Rotaspora* spp., *Tripartites* spp.and *Triquitrites* spp., and in the presence of very common species in SW Portugal, such as *Propisporites laevigatus* and *Savitrisporites nux*. The absence of the stratigraphical guides is probably due to destruction caused by the high pyritization of the spores and eventually to the diagenesis and dolomitization processses. Goniatites recovered from the upper part of Murração Formation confirms a Late Visean age (Korn, 1996). The age of the Murração Formation is **Visean**, based on palynomorphs and goniatites.

The **Quebradas Formation** is composed of pyritic black shales with intercalations of detrital limestones. The goniatite content indicates a Namurian age. Miospore assemblages recovered from this unit are assigned to the Namurian biozones, *Crassispora kosankei-Grumosisporites varioreticulatus* Biozone (KV) and *Raistrickia fulva - Reticulatisporites reticulatus* Biozone(FR), well known in Western Europe. Recent goniatite data (Korn, 1996) recognize the presence of the R1, R2, G1 and G2 Biozones. This information confirms and completes the age based in spores. No information was obtained from the base of the unit. The lack of biostratigraphic indicators suggests the possible existence of a stratigraphic hiatus, corresponding to the Lower Namurian. The age of Quebradas Formation, based on spores and goniatites is **Middle Namurian to Early Westphalian.**

The **Brejeira Formation** comprises essentially turbidites (shales and greywackes) rich in plant debris. The palynological research prove the presence of the following Miospores Biozones: *Raistrickia fulva - Reticulatisporites reticulatus* (FR), *Triquitrites sinani - Cirratriradites saturni* (SS), *Radizonates aligerens* (Ra), *Microreticulatisporites nobilis - Florinites junior* (NJ), *Torispora securis - T. laevigata* (ST) and *Thymospora obscura - T. thiessenii* (OT).

Data from goniatites and miospores indicates a **Middle Namurian** to **Westephalian D** age for the Brejeira Formation. Reworked Cambrian to Silurian acritarchs and Devonian and Lower Carboniferous miospore and acritarch taxa occur within this biozones.

These results prove the existence of close palynological affinities between Southwest Portugal and Western Europe, during the Carboniferous (Table 1).

Cronostratigraphy		Biostratigraphy: GONIATITES: Western Europe	GONIATITES: Southwest Portugal (Korn, 1997)	MIOSPORE BIOZONES: Western Europe	MIOSPORE BIOZONES: Southwest Portugal		Litostratigraphy
CARBONIFEROUS	Westphalian			OT	OT	*T. obscura*	Brejeira Formation
						T. thiessenii	
				SL	SL	*C. magna*	
						T. securis	
				NJ	NJ	*F. junior*	
				RA	RA	*S. concavus*	
						R. aligerens	
		G2	G2	SS	SS	*C. saturni*	
	Namurian	G1	G1b	FR	FR	*R. fulva*	Quebradas Formation
			G1a			*R. reticulatus*	
		R	R2	KV	KV	*C. kosankei*	
			R1				
		H		SO			Hiatus ?
		E2		TK			
		E1		NC	NC	*B. nitidus*	Murração Formation
	Visean	GO	C	VF	SN	*S. nux*	
			B				
			A	NM	NL	*R. nigra*	
						P. laevigatus	
		PE	PE	TC	?		
				TS	TS	*K. triradiatus*	
				PU	PU	*K.stephanephorus*	
						L. pusilla	
	Tournaisian			CM			Hiatus
		Ga	Ga	PC	PC	*S. pretiosus*	Bordalete Formation
				BP	?	*R. clavata*	
				HD	HD	*N. cymosa*	
				VI	VI	*U. distinctus*	
						C. cristifera	
DEVONIAN	Strunnian	Wo	Wo	LN	LN	*R. lepidophyta*	Tercenas Formation
						V. nitidus	
				LE	LE	*V. verrucosus*	

Table 1. Correlation between Southwest Portugal and Western Europe, based in goniatites and miospores.

New data on the Carboniferous paleogeography of western Turkey

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Turkey is subdivided by the Izmir-Ankara Belt (Tethyan suture zone in continuation of the Vardar Zone) into the Pontides in the north and the Taurides in the south. The Border Fold Belt in SE Turkey belongs to the margin of the Arabian Platform. The Istanbul Terrane in the northernmost Pontides is the only area in Turkey, where a Hercynian history with Lower Carboniferous deep-sea turbidites and radiolarites (Hercynian flysch) was previously recognized. The other areas were assigned to the Paleotethys (Küre Complex in the central Pontides close to the Black Sea coast, and Karakaya Complex in the southern Pontides), to the Neotethys (Pontide branch of the Neotethys, main Neotethyan Izmir-Ankara Belt and related nappes, e.g. Lycian nappes on the Taurides, as well as Antalya and Alanya nappes of the southern branch of the Neotethys), and to the Gondwana shelf (Taurides).

New stratigraphic results, especially in the Carboniferous, have strongly changed this picture. The Istanbul Terrane s.l. consists of two terranes, the Istanbul Terrane s.s. in the west and the Zonguldak Terrane in the east. Both terranes have a totally different Paleozoic and Mesozoic history. In the Istanbul Terrane shallow-water Ordovician to lower Devonian deposits are overlain by deep-water Middle Devonian to Lower Carboniferous rocks with Viséan-Serpukhovian flysch. This Hercynian sequence is followed, after a long gap, by a Triassic sequence with upper Olenekian to Cordevolian deep-water sediments and middle Carnian and younger flyschoid turbidites. In the Zonguldak Terrane, Silurian to earliest Devonian deep-water sediments are Caledonian thermally altered (Conodont Colour Ateration Index; CAI = 5). They are overlain by Devonian to Lower Carboniferous shallow water deposits without thermal alteration (CAI = 1.5). This shallow marine development did not end at the top of the Viséan as assumed previously, but ranges up to the Serpukhovian (lower Namurian) as shown by conodonts (Göncüoglu & Kozur, in prep.). The Pennsylvanian contains thick continental beds and after a long gap, the uppermost Permian and the Triassic consists of continental beds as well.

The epimetamorphic oceanic Bekirli Group of the classical "Paleotethyan" Küre Complex is a Hercynian unit. It is disconformably overlain by deformed, but unmetamorphosed Lower Triassic conglomerates, Alpine Buntsandstein, Werfen Beds, Gutenstein Limestone and Steinalm Dolomite of a typical North Alpine shallow water Triassic sequence. However, a Hercynian remnant basin existed north of the Küre Complex, indicated by pelagic Upper Carboniferous to Middle Permian faunas (conodonts, pelagic ostracods, ammonoids) from pebbles in the Lower Cretaceous Beykoz Group and, north of the Black Sea, in the Tauridian flysch of the Crimea. Oceanic rocks were not found in association with these Late Paleozoic pelagic rocks and, therefore, rather a foredeep on continental crust than a remnant ocean was present in the area. Only for this basin the term "Paleotethys" can be used.

Pelagic Carboniferous rocks of a Hercynian sequence are also present in the Karakaya Complex of the southern Pontides. The view of Okay & Mostler (1994) that there is a continuous Carboniferous-Permian-Triassic Paleotethyan sequence in the Karakaya Complex could not be confirmed. The youngest pre-Tethyan (Hercynian) pelagic rocks are Bashkirian red cherty limestones with *Idiognathoides sinuatus* Harris & Hollingsworth. The post-Bashkirian Carboniferous, Lower and Middle Permian consist of shallow water platform sediments, with several stratigraphic gaps in pre-Middle Permian time. The Middle Permian shallow water carbonate platform continued into the Upper Permian Dzhulfian Stage. Only in the uppermost Dzhulfian the first pelagic limestones began (Kozur & Kaya, 1994). Pelagic limestones are common Dorashamian (uppermost Permian) and in the uppermost Dorashamian red radiolarites and perhaps also pillow lavas are present (Kozur, 1997), indicating a latest Permian oceanic opening of the Tethyan Karakaya Ocean. The erroneous dating of the uppermost Dorashamian radiolarites as Sakmarian-Artinskian by Okay & Mostler (1994) lead to the assumption of a continuous Bashkirian-Permian Paleotethyan deep-sea sequence. Undated epimetamorphic basic volcanics, tuffs and crystalline limestones without radiolarites are lithologically very similar to the Bekirli metamorphic rocks of the Küre Complex and probably also Hercynian metamorphic rocks.

In contrast to the previous view, Lower Carboniferous deep-water deposits (flysch) indicate also a Hercynian history for the Neotethyan Izmir-Ankara Belt. In the Tavas Nappe of the Lycian nappes that were derived from the Izmir-Ankara Belt, a Lower Carboniferous deep-sea flysch (turbidites, distal turbiditic radiolarites, olistostromes) was dated by conodonts, e.g., *Gnathodus bilineatus* (Roundy) as upper Viséan (Kozur et al., in press). The southernmost occurrence of thick Lower Carboniferous

(Hercynian) flysch (deep-sea turbidites, olistostromes) were found in the Karaburun Peninsula south of the Izmir-Ankara Belt. Upper Devonian and Lower Carboniferous conodonts and radiolarians were found in radiolarites that are mostly distal turbidites. Previously, these rocks were assigned to the "Scythian-Anisian Karaeis Formation", which contains also Silurian deep-sea sediments and an Upper Silurian-lowermost Devonian Caledonian deep-sea flysch. The Hercynian flysch is overlain by a pelagic sequence that is transitional to the Serpukhovian-Bashkirian shallow water Alandere Formation. This transitional series (Dösemealti Formation, Kozur, in press) is very fossil-rich (ammonoids, brachiopods, conodonts, crinoids, ostracods, radiolarians). Conodonts allow a dating as late Viséan. The main part of the Taurides south of the Karaburun Zone has Lower and Upper Carboniferous shallow water deposits that are often incomplete by stratigraphic gaps. These Carboniferous shallow water deposits (mainly limestones) contain foraminifers, conodonts, crinoids, brachiopods and ostracods. Assumed Hercynian deep water deposits in the Bolkardag Unit (Özcan et al., 1988) could not be confirmed. They are Caledonian (Upper Silurian to lowermost Devonian) deep-sea turbidites and olistostromes. The Carboniferous is represented by shallow water sediments, mainly limestones that contain Lower Carboniferous foraminifers and Upper Carboniferous conodonts (Kozur & Ekmeçi, in prep.).

Contemporaneous with the closure of the Hercynian Ocean in the north, in the upper Viséan or Serpukhovian an ocean opened in the south. Carboniferous-Permian deep-sea sediments of this ocean were found southwest of western Turkey, in the Phyllite Group of Crete (Kozur & Krahl, 1987). The westernmost occurrence of this late Paleozoic to Cenozoic Ocean are known from western Sicily. Its eastern continuation is north of the Border Fold Belt, in NE Iraq and in Oman.

Until the Lower Carboniferous, the Taurides (except its oceanic northern margin) were the shelf of Gondwana. With the closure of the Hercynian Ocean at the end of the Lower Carboniferous and in the Bashkirian, and the contemporaneous opening of the southern Tethys, the largest part of Turkey (except the Border Fold Belt) was connected from the Pennsylvanian to the Dzhulfian with Eurasia and detached from Gondwana. With the uppermost Permian opening of the northern (Cimmerian) Tethys, the area between the southern and northern Tethys became part of the Cimmerian microcontinent that was furthermore dissected by the opening of the main Neotethys in the Izmir-Ankara Belt.

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New data on distribution of conodonts in the Lower Carboniferous of the Kuznezk basin (Siberia)

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Regional stratigraphic units of the Lower Carboniferous of the Kuznezk basin are established and traced in the area mainly by means of brachiopods, foraminiferas, ostracods and corals. Thanks to the support of the Russian Fund of fundamental investigation, grant N97-05-65209, work on "Biological and nonbiological event levels in The Late Paleozoic of Angarida" are continuing. The systematic composition and geographic distribution of the main groups of fauna (brachiopods, ostracods, foraminiferas, and conodonts) for the biostratigraphy of the region have been analysed. The history of the study of conodonts of the Kuznezk basin is limited to two works (Buckaert and Bunen, 1978; and Bushmina and Kononova, 1981). Results of our work during 1991 - 1997 provide new data on the distribution of conodonts in the Lower Carboniferous deposits (Table 1). Further investigations will allow more precise regional stratigraphic scales for the Kuznezk basin and correlations with stratotypes of West Europe.

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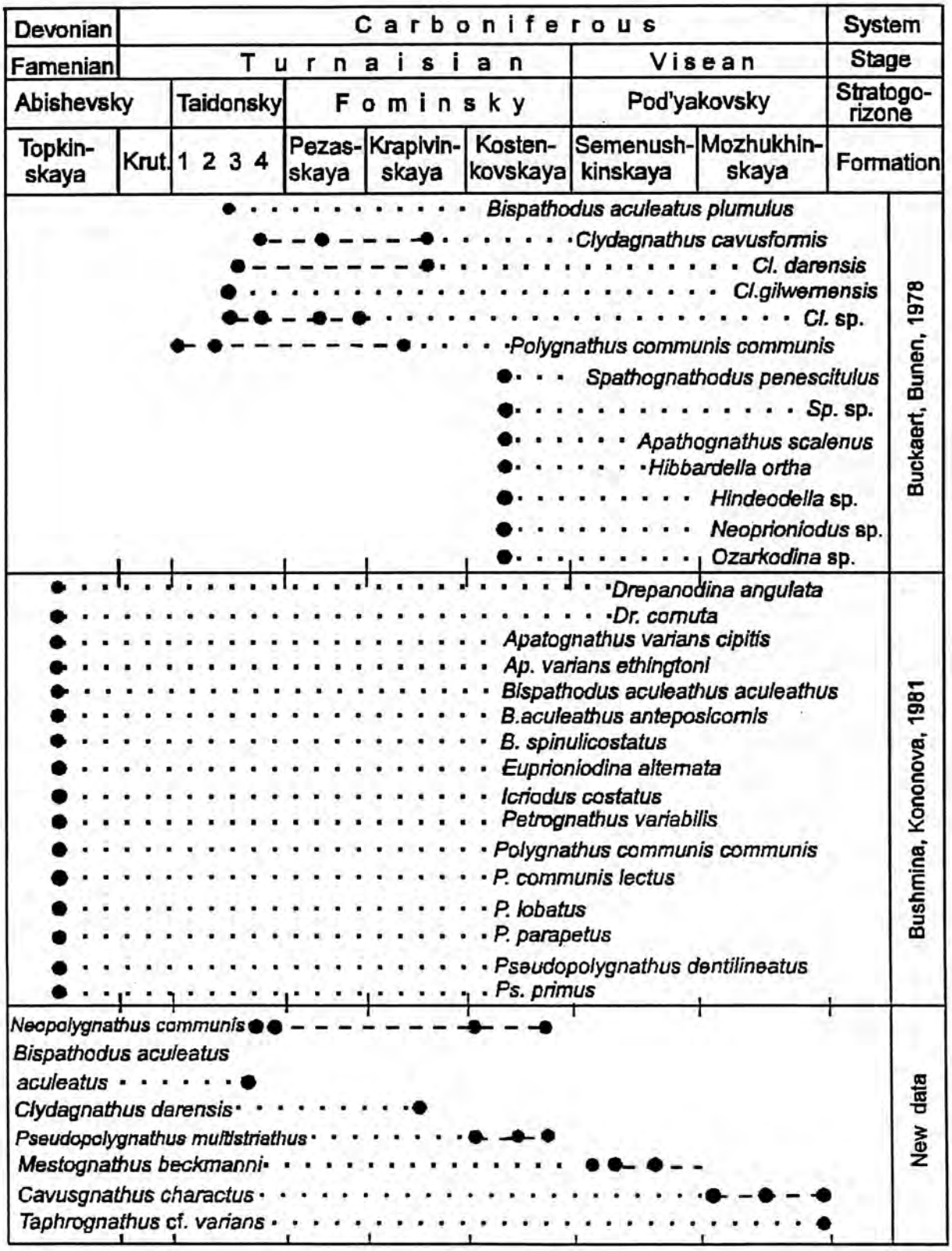

Table 1. Klets et al: Distribution of conodonts in the Upper Devonian - Lower Carboniferous of the Kuznetsk basin.

Bursumian Stage, Uppermost Carboniferous of Midcontinent and Southwestern North America

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Placement of the base of the Permian System by the Permian Subcommission (Davydov, V. I. et al., 1995) at the first appearance of the conodont *Streptognathodus isolatus* Chernykh and Ritter (1997), 27m above the base of bed 19 in the Aidaralash Section in northern Kazakhstan requires reevaluation of the Carboniferous/ Permian boundary in North American stratigraphic reference sections (Baars et al., 1992; Ross, 1963; Ross and Ross, 1994) particularly in the midcontinent and southwestern region where marine references sections for the Pennsylvanian and Permian Systems have been established.

Ross and Ross (1987a, b) used the name Bursum for the interval between the top of the Virgilian and the base of the Nealian (lower Wolfcampian) because the Bursum Formation, as redefined and used by Thompson (1954) in southcentral New Mexico and western Texas is a readily available succession of rocks to fill this time-stratigraphic gap. The Bursum Formation and its identifying faunas were used in the sense of a stage or substage in Ross and Ross (1987a fig. 3 and b). Later, Ross and Ross (1994) discussed and proposed the name Bursumian Stage for this timestratigraphic interval between the top of the traditional Virgilian Series and the newly defined base of the Permian System. This newly defined base lies within the lower part of the Council Grove Group of Kansas near the base of the Red Eagle Limestone at the base of the Bennett Shale Member or in burrows in the top of the Glenrock Limestone Member that are filled with Bennett Shale sediments (Boardman and Mazzullo, 1998).

Bursumian faunas are readily identifiable and widely correlated in North America (Thompson, 1954) in the midcontinent and southwestern states. Thompson in his 1942 study of southcentral New Mexico Pennyslvanian and Permian outcrops had initially included strata with these faunas at the top of the Pennsylvanian succession, i.e., he used the unconformity at the base of the Abo red beds and base of the Hueco Limestone as the base of the Permian. Later, after moving to the Kansas Geological Survey, and perhaps because Moore (1934, 1936, 1949) and Moore et al. (1951) by that time had established the top of the Brownville as the top of the Virgilian, Thompson (1954) recognized that fusulinaceans from the Bursum Formation were post-Virgilian (i.e., post-Brownville). They were, therefore, Permian, as defined by Moore, and were equivalent in age to fusulinaceans from the Admire Group and the lower part of the Council Grove Group of Kansas.

The Bursum Formation, as redefined by Thompson (1954), is a cyclical succession of ten or more thin depositional sequences and parasequences of sandstones, shales, limestones, and red shales, siltstones, and sandstones that were deposited on the southern flank of the North American craton. In outcrop, the succession includes both nonmarine and marine deposits including eolian siltstones, fluvial sandstones and conglomerates, siltstone- and claystone-redbeds, thin greenish-gray to dark gray marine shales, and thin shallow-water marine limestones having algae, gastropods, echinoderms, and fusulinids. Soil profiles are well-developed in parts of the succession. These beds (Thompson, 1954) form a generally gradational and transitional succession above the predominantly marine deposits of upper Virgilian strata of the Fresnal Group and below the overlying non marine red shale, siltstone, and channel and cross-bedded sandstone beds of the Abo Formation.

Although Thompson's 1942 paper sometimes has been criticized for redefining the New Mexico Pennsylanian strata as a series of fossil zones rather than as lithostratigraphic units, this study has come to be recognized as a clear, precise, and detailed stratigraphic discussion that illustrates lateral lithologic facies changes and stratigraphic relations. Thompson (1942, 1954) clearly recognized that the lithologies of his formational units gradually changed laterally and that they did have lateral continuity and consistent ages.

The Bursum Formation in it northern exposures contains more nonmarine beds and is thinner because of more extensive erosion at intraformational unconformities than to the south where the formation contains more

marine beds and is more complete. A few darker gray, cherty 'deeper-water' limestones sometimes are present in the southern part of this succession, but they are not common. In subsurface along the flanks of the Delaware and Midland basins, the limestones thicken and form a distinctive set of shelf margins that prograde basinward and locally are good petroleum reservoirs. Shelf slope equivalents include upper slope debris beds that pass basinward into dark gray to black siltstones and shales.

In mountain ranges in central and southcentral New Mexico, the Bursum intelval has been given different formational names which Thompson (1954) brought together under the name Bursum. In central New Mexico, Kelly and Wood (1946) called this interval the Red Tank Member of the Madera Formation; in the Los Pinos Mountains, Stark and Dapples (1946) referred this interval to the Aqua Torres Formation, and in the region of the Oscura Mountains, Wilpot et al. (1946) used the name Bursum Formation. The term Bursum was more widely and generally adopted and used in the Sacramento Mountains (Lloyd, 1949; Pray, 1959). However, in the northern Sacramento Mountains, the name Laborcita Formation was introduced by Otte (1959) for the Bursum intelval for the excellent exposures in Laborcita Canyon where the succession is about 660 feet (220m) thick and includes well developed parasequence cycles of thin sandstone and thin limestone beds in a predominantly shaly succession.

Several stratigraphic sections are possible candidates for a reference section for the Bursum Stage. The thickest and probably most complete is the Laborcita Canyon section. Another section described by Thompson (1954) from the Robledo Mountains also appears to be fairly complete, particularly in its upper part where Thompson's illustrations suggest that 30 to 35 m of Nealian (Lower Wolfcampian) beds may be preserved between the Bursum Formation and Hueco Limestone.

Steiner and Williams (1968), in a preliminary study of common Bursum fusulinaceans in the Laborcita Canyon area, described *Triticites ventricosus* Meek and Hayden, T. *creekensis* Thompson, *Leptotriticites americanus* (Thompson), and *Schwagerina campensis* Thompson, and also a species that they identified as *Schwagerina emaciata* (Beede) (but which is probably an undescribed earlier species). Although generally quite fossiliferous, the reported Bursum faunal diversity is relatively low.

Thompson (1954) pointed out that fusulinids of the Bursum interval are distinctive and include large, thicked-wall species of *Triticites*, such as T. *meeki*, T. *ventricosus*, T. *creekensis* and T. *cellamagnus*, which have well-developed keriotheca, high and nearly tabular chomata, and thickly fusiform shapes. Also present are early species of *Leptotriticites*, such as *L. fivensis*, *L. americana*, *L. eoextenta*, *L. hughensis* and *L. glenensis*, that have low chambers and strongly folded septa. (The earliest *Leptotriticites*, *L. sp.* aff. *L. eoextenta* (Thompson) reported by Douglass (in Mudge and Yochelson, 1962) is known from only two microspheric specimens in the Brownville Limestone from one locality in Chautauqua County, southern Kansas).

Within the Bursum interval at least two fusulinid assemblage zones are present. The lower zone has *Triticites confertus*, *Leptotriticites fivensis*, and *Oketella waldripensis*. *Schubertella kingi* is common in this lower zone although it first appears in lower strata. The upper zone is marked by the first appearance of early species of *Pseudofusulina*, such as P. *robleda*, by primitive species of *Schwagerina*, such as S. aff. *grandensis* Thompson, S. *longissimoidea* (Beede), *S. campensis* (Thompson) and S. *pinosensis* Thompson, by advanced*Triticites*, such as *T. meeki* (Moller), *T. ventricosus* (Meek and Hayden), *T. directus* Thompson, and *T. creekensis* Thompson. Also present are several *Leptotriticites* species, including *L. eoxetenta* (Thompson), *L. hughensis* (Thompson), *L. extenta* (Thompson), *L. directus* (Thompson), *L. wetherensis* (Thompson). At its top, in the Glen Rock Limestone Member at the base of the Red Eagle Limestone in Kansas, *Schwagerina campa* Thompson, *Triticites rockensis* Thompson, and *Leptotriticites glenensis* (Thompson) first appear.

Conclusions

Instead of changing the boundaries of the Virgilian Series again, particularly after its boundaries had finally become stabilized in the North American literature, Ross and Ross (1994) proposed the Bursumian Stage, named for the Bursum Formation as identified by M. L. Thompson (1954), for the post Virgilian-latest Carboniferous Stage. The Bursumian fills the gap between the top of the Virgilian and the newly defined base of the Permian in

the midcontinent and southwestern parts of North America.

The advantage in adding the Bursum Stage to the Pennsylvanian Subsystem above the Virgilian and below the new Permian boundary is that it does not confuse the existing nomenclature. The top of the North American Pennsylvanian will coincide with the base of the Permian and the named Bursumian Stage will clearly identify that this is the stratigraphic interval that has been added above the Virgilian in order to include post-Virgilian strata beneath the redefined base of the Permian. Because strata of the Bursumian Stage commonly have been placed in the lower Permian, particularly by petroleum companies in subsurface studies, giving this interval a name clearly identifies that these strata are now placed in the underlying Carboniferous and removes them from the lower part of the Lower Permian Wolfcampian Series.

The Bursumian Stage is widely recognizable in southwestern and Midcontinent North America because of its distinctive fossil fauna and lithologic relationships. It serves to redefine the top of the Pennsylvanian System to correspond to the top of the Carboniferous as defined in the western Urals region of the Russia.

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Carboniferous and Early Permian palynostratigraphy of China

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The Carboniferous and Early Permian of Liaoning, China are widespread in their distribution, are richly fossiliferous, and posses their own characteristics. The Carboniferous rocks of Liaoning, China have attracted economic interst for many years as a possible source of mineral and coal deposits. Most important paralic coal-bearing strata in East Asia are well developed, and can be divided into the Penchi (Benxi) and Taiyuan Formations.

Penchi Formation

The Penchi Formation, originally named Penchi System, was established by J.S Lee (Li Siguang) and Y.T.Chao (Zhao Yazeng) in 1926. The type locality is between Xindinggou and Mayi, about 6km West of Benxi in Liaoning, China. Wang Yu et al. (1954) remeasured the section of the Penchi Formation at Niumaoling to the Northwest of Benxi, China. The Penchi Formation can be subdivided into three parts as follows: lower part (Beds 1-3), 15m of purple shale with bauxite intercalations; middle part (Beds 4-12), 74.6m of yellow sandstone and siltly shale, alternating with shale and coal seams; upper part (Beds 13-21), about 60m of yellow shale and fine sandstone with alum shale and four intercalations of limestone, i.e Mayi, Hsiaoyu, Penchi and Niumaoling Limestones in ascending order. Based on the distribution of abundant fusulinid fossils in the limestones, five fusulinid fossil zones were established in the Penchi Formation.

In the North China Platform, the Penchi Formation was formerly correlated with the Westphalian of Europe and the Moscovian of the USSR based on *Fusulina* and *Pusulinello* and abundant *Chiristites*, *Neospirifer*, *Brachythyrinw* etc.

1. The lower (Beds 1-3) 15m of purple shale with bauxite intercalations of the Penchi Formation at Niumaoling and Tianshifu to the Northwest of Benxi, Mumengzi of Hengren, Baimashi of Lingyuan, Liaoning contain typical late Early Carboniferous spores. 38 genera and 71 species of miospores are recorded from the lower part of the Penchi Formation. These assemblages are characteristically dominated by *Lycospora* which often constitutes up to 60-70 percent or more of the assemblages. The palynological characteristics of this assemblages can be summarised as follows:

(1) Abundance of *Lycospora rotunda* (Bharadwaj) Somers, *L. subtriquetra* (Luber) Potonie and Kremp, *L noctuina* Butterworth and Williams, *L pusilla* (Ibrahim) Somers.

(2) Presence in more or less constant but sometimes slightly increased frequency of *Waltzispora polita* (Love) Sullivan, *Raistrickia nigra* Love, *Anapiculatisporites manor* (Butt. and Wil.) Smith and Butt., *Moorisporites fustis*Neves, *Convolutispora tessellata* H.S. and M., *C venuta* H.S.and M., *C florida* H.S.and M., *Ibrahimisporites magnificus* Neves, *Reticulatisporites rudis* Staplin, *Foveosporites inscupteris* Playford, *Corbulispora cancellata* (Waltz) Bharadwaj and Venkatachala, *C subalveolaris* (Luber) Sulhvan, *Grumosisporites reticulatus* Gao, *Vestispora fenostrata* (Kosanke and Brokaw) Spode in Smith and Butt., *Tripartites vetustus* Schemel, *Ahrensisporites duplicata* Neville, *Simozonotriletes brevispinosus* Gao, *Trinidulus diamphidios* Felix and Paden, *Tantillus triquetra* Felix and Burbridge, *Gansusispora tetraverrucosa* Gao, *Murosporu* sp. cf. *Zonotriletes intortus* Waltz, *Crassispora maculosa* (Knox) Sullivan, *Knoxisporites seniradiatus* Neves, *Densosporites anulatus* (Loose) Smith and Butt., *Schulzospora ocellata* (Horst) Potonie and Kremp, and *Discernisporites micromanifestus* (Hacquebard) Sabry and Neves.

(3) Very rare occurrence of *Lavigatosporites* spp., *Florinites antuquus* Schopf, *?Guthorl isporites* sp., *Vestigisporites* sp.

This miospore assemblages may be correlated with the upper part of the Chouniugou and Yushuliang Formations of late Early Carboniferous in Jingyuan, Gansu Province, China (Gao Lianda, 1987, 1988, 1989); it is therefore consided to be of Late Visean and Early Namurian (E) of Western Europe (Clayton et al. 1977).

2. The upper part of the Penchi Formation from the Kazuo and Lingyuan County, West Liaoning, China yielded rich, well-preserved spores and pollens. 70 species of spore and pollen are recognized and distributed among 32 genera. The miospore assemblage is characterized by the presence of *Lycospora* and *Crassispora* with a concentration of 20-30%. The main species in this assemblage are *Lycospora pusilla, L rotunda, L pusilla, L subtriquetra, Crassispora kosankei* (Potonie and Kremp) Bharadwaj, *Densosporites anulatus, Radiizonates aligerans* (Knox) Staplin and Jansonius, *Murospora sp., Ratospora sp., Kraeuselisporites echinatus* Owens, Michell and Marshall,

Pechetisporites kaipingiensis Gao, *Hadrochercos ningwuensis* Gao, *H. streon* Gao, *Reinschospora triangularis* Kosanke, *Alatisporites pustulatus* Ibrahim, *Ahrensisporites guerickei* (Horst) Potonie anf Kremp, *Dictyotriletes bireticulatus* (Ibrahim) Smith and Butt., *Laevigatosporites vulgaris* (Ibrahim)Alpern and Doubinger, *Columinisporites ovalis* Peppers, *Florinites ovalis* Bharadwaj.

This assemblage may be approximately correlated with the *Torispora securis-Hadrochercos stereon* (SS) zone and *Dictytriletes bireticulatus* (B) zone proposed by Gao Lianda (1984, 1985) and may be equivalent to the Westphalian of Western Europe (Clayton et al., 1977).

3. The Taiyuan Formation in Benxi of East Liaoning, Kazuo and Lingyuan of West Liaoning, China are composed of greyish dark shale and sandstone, intercalated limestone and coal beds, with a total thickness of 81-140m, yielding animal and rich plant fossils.

The Taiyuan Formation yielded abundant and well-preserved spores and pollens, 64 species of spore and pollen assigned to 36 genera were recognized. The assemblages from this zone are characterised by the following features:

(1) Abundance of *Lycosporapusilla, L rotunda, Crassispora kosankei.*

(2) Appearance of the first *Gulsporites cochlearis* (Imgrund) Imgrund, *G. laevogatus* Gao, *Spinosporites spinosus* Peppers, *Rorispora securis* (Balme) Alpern, Doubinger and Horst, *Thymospora thiessenii* (Kosanke) Alpern and Doubinger.

(3). More or less constant occurrence of *Anapiculatisporites minor, Reinschospora triangularis, Triniduluadian phiidios, Ahrensisporites guerickei, Alatisporitespustulatus.*

(4) This assemblage is characterized by an increase of the Pteridosperms and Gymnosperms making up 20-30% in some samples, which mainly include tbe following species *Potoniasporites vonicus* Bharadwaj, *Florinites ovalis, F. mediapudens* (Loose) Potonie and Kremp, *Wilsonites ornatus* Wilson and Coe.

This miospore assemblage may be correlated with the the Late Carboniferous of North China (Gao Lianda, 1984,1985) belonging to the Stephanian of West Europe (Clayton et al, 1977).

4. The Shansi Formation is mainly composed of dark or dark gray shale intercalated with sandstone and thin coal beds, totalling 7-40m thick.

This assemblage is defined by the disappearance of the typical Carboniferous elements, the Shansi Formation contains a great number of genera and species dominated by typical Permian elements, suggesting a new stage of spore evolution.

The miospore assemblages assigned to this zone are characteristically dominated by the Pteridosperms and Gynmosperms which often constitutes up to 30 percent or more of the assemblages, these include *Florinites ovalis, F. minutus, F. mediapudens, Crusisoccites* sp., *Valiasaccites* sp., *Wilsonites ornatus, Alisporites* sp., *Limitisporites* sp., *Cycadopites cymbafus* Balme and Hennlly, *Sulcatisporites* spp.

The lower limit of this zone is marked by the first appearance of *Sinulatisporites sinensis* Gao, *S. shanxiensis* Gao, *Punctatosporites* and *Laevigatosporites* are abundant in the Shansi Formation, but *Gulisporites* Imgrund is the most abundant genus, averaging 10-15 percent of the total spore population, *Gulisporites chchlearis* is the most abundant species(10%).

Judging from characteristic components of the spore assemblage the Shansi Formation is correlated with those of North China (Gao Lianda, 1984, 1985) and may be roughly correlated with the lower part of the Autunian of Western Europe (Clayton et al., 1977).

NOTE: No references were provided with this contribution - Ed.

Erratum

A.C. Rocha-Campos and L.E. Anelli have informed the editor that their report (as Brazilian corresponding members) "Palynology of the Itararé Subgroup (late Paleozoic) in northern Paraná Basin" in SCCS Newsletter, V. 14, pp. 9-10, was based on the following thesis by P.A. Souza and that they had no intention of claiming authorship of the said article:

Souza, P.A. 1996. Palinologia e estratigrafia do Subgrupo Itararé em Araçoiaba da Serra (Westphaliano, Bacia do Paraná), Estado de São Paulo, Brasil. São Paulo. Masters Dissertation, Instituto de Geociências, USP, 192 pp, unpublished.

ABSTRACTS

Palynological Correlation of Major Pennsylvanian (Middle and Upper Carboniferous) Chronostratigraphic Boundaries in the Illinois and other Coal Basins

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Geological Society of America, Memoir 188, 111 p., 6 figs., 17 tables, 3 pl., 2 appendixes

Pennsylvanian (Middle and Upper Carboniferous) strata of the Illinois Basin are correlated palynologically with other coal basins in the United States, western Europe, and the Donets Basin. Published reports and recent palynological analyses of coal samples from the Illinois Basin, western part of the Midcontinent, and the Appalachian Coal Region were used in making the correlations. Correlations are made on the basis of first and last appearances and major changes in relative abundance of spore taxa. Studies of plant megafossils and faunas are briefly discussed in relation to some of the palynological correlations.

The chronostratigraphic classification of the Pennsylvanian System in the western part of the Midcontinent Region was adopted by the Illinois State Geological Survey for the Illinois Basin largely on the basis of studies of marine fossils. The precise position of the Morrowan–Atokan Stage boundary in Illinois is still not satisfactorily known. It generally has been correlated with the base of the Tradewater Formation but is herein correlated with the top of the Reynoldsburg Coal Bed, which is at the base of the formation. The top of the Morrowan occurs just above the base of the Tradewater Formation in western Kentucky and in the upper part of the Mansfield Formation in Indiana. The Atokan–Desmoinesian Stage boundary in Illinois is correlated with the top of the Seville Limestone Member and equivalent limestone beds in Indiana and western Kentucky.

The Desmoinesian–Missourian (Middle–Upper Pennsylvanian) boundary is correlated with the base of the Lake Creek Coal Member or, if that is not present, at the top of the Lonsdale Limestone Member in western Illinois and the top of the middle bench of the West Franklin Limestone Member in eastern Illinois and western Indiana. The Missourian–Virgilian Stage boundary has been correlated, in the absence of adequate palynological data, with strata a little below the Shumway Limestone Member as determined by fusulinid evidence.

The Lower–Middle Pennsylvanian boundary in the Pennsylvanian stratotype in West Virginia proposed by the U.S. Geological Survey (USGS) is older than the Lower–Middle Pennsylvanian boundary of the Midcontinent. The latter correlates with the base of the Pounds Sandstone Member in Illinois and the Bee Spring Sandstone Member in western Kentucky. Although the Middle–Upper Pennsylvanian Series boundary has been correlated with the boundary between the Allegheny and Conemaugh Formations, the series boundary at the proposed stratotype is at the top of the Charleston Sandstone, which is difficult to correlate outside of its stratotype area. If the Middle–Upper Pennsylvanian boundary of USGS usage is raised slightly to correlate with the Middle–Upper Pennsylvanian boundary in the Midcontinent and the Westphalian–Stephanian boundary in Europe, it would be more easily recognized outside the Appalachian Coal Region because of the major changes in composition of faunas and coal-swamp floras that occurred at that time.

The Namurian–Westphalian boundary of western Europe is tentatively correlated with the base of the Battery Rock Sandstone Member in Illinois. The Westphalian A–B boundary is correlated with the top of the Morrowan, the Westphalian B (Duckmantian) – C (Bolsovian) boundary with the lower part of the Tradewater Formation in Illinois, the Westphalian C–D boundary with the Atokan–Desmoinesian boundary, and the Westphalian–Stephanian boundary with the Desmoinesian–Missourian boundary. The lowest stage of the Stephanian (Cantabrian) has not been adequately identified in North America. Correlation of the Westphalian–Stephanian boundary with strata in northern China is possible because of the major palynological changes that occur at the boundary.

The boundary between the Bashkirian and Moscovian Series in the Donets Basin is correlated approximately with the top of the lower one-fourth of the Tradewater Formation in Illinois and Kentucky and with the upper one-fourth of the Mansfield Formation in Indiana. The Bashkirian–Moscovian boundary is correlated with the upper part of the Westphalian B. The boundary between the Moscovian and Kasimovian Series is just below the Desmoinesian–Missourian boundary and is approximately equivalent to the Middle–Upper Pennsylvanian boundary as presently designated in the Appalachian Coal Region.

Plate 1 is a correlation chart of Pennsylvanian (Namurian B to Stephanian C) strata of coal basins from Oklahoma and Iowa in the west to the Donets basin in the east. Plate 2 shows the ranges of spores used in the correlations. Plate 3 shows the relative abundance of the most abundant spores. Plate 4 shows distribution of spores below and above the Middle-Upper Pennsylvanian (Westphalian-Stephanian) boundary.

Distribution of Boghead Algae in Illinois Basin Coal Beds

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Illinois State Geological Survey, Circular 558, 20 p., 6 figs., 3 tables, 1 color plate

The alga, *Botryococcus*, has been observed in coal macerations of eleven coal beds inthe Tradewater Formation (Lower and lower Middle Pennsylvanian) in the Illinois Basin: the Reynoldsburg, Breckinridge, Mariah Hill, Tarter, Hermon, Lewisport, Delwood, New Burnside, Brush, Murphysboro, and Bancroft(?) coals. Although *Botryococcus* is rare at most of the 43 sample sites where it was observed, it is abundant at two sites of the Lewisport coal and one site each of the Reynoldsburg, Breckinridge, New Burnside and Brush Coals. It is common at two sites of the Delwood Coal and one site of the Tarter and Mariah Hill Coals. *Botryococcus* has been found more commonly (eleven sites) in the Delwood Coal than in any other coal. Although it is extant, *Botryococcus* has not been observed in the Illinois Basin above the lower Middle Pennsylvanian even though hundreds of samples of the most extensive coal seams in the basin, which occur in the upper Middle Pennsylvanian, have been examined. In addition, palynological identifications of some of the coal beds, especially in the subsurface, are presented for the first time. A pattern of distribution in abundance of *Botryococcus* is not apparent due to the small number of sites of each of the coals containing the alga.

The Lewisport coal and overlying and underlying strata at one sample site were macerated to compare the abundance of *Botryococcus* with the lithology and composition of the spore assemblages. The alga is most abundant in the coal and overlying coaly shale in which *Lycospora*, produced by large lycopod trees, is most abundant. *Botryococcus* is least abundant in the underclay and the gray shale that overlies the coaly shale in which fern spores are most abundant; *Granasporites medius*, representing the arborescent lycopods, *Diaphorodendron*, and *Synchysidendron* is most abundant in the gray shale. Sphenopsid spores are abundant in the coal, underclay, and some intervals of gray shale overlying the coal. Coal beds other than the Lewisport, in which *Botryococcus* is abundant, also contain an abundance of *Lycospora*.

Petrographic analyses of selected samples indicate an average of 0.5 to 3.2 volume percent of *Botryococcus* in coals bearing this type of alginite (liptinite group of macerals). The *Botryococcus* occurs in irregularly shaped masses or colonies. These colonies are embedded in a matrix of desmocollinite vitrinite along with small sporinite (*Lycospora*) and to a lesser extent other macerals that are common in coals of bituminous rank. The colonies comprise up to 60 or more percent of certain ultra-thin layers of the coals. Such layers or bands are properly termed torbanite. Microscopical (optical and SEM) studies suggest that the colonies of *Botryococcus* have not been permanently compressed from their original morphology during subsequent coalification.

Because *Botryococcus* lived in fresh to brackish water environments, the association of abundant algae and *Lycospora* reinforces evidence from earlier paleobotanical studies that coal swamp lycopod trees grew in the wettest parts of the swamps that were flooded, at least part of the time.

FORTHCOMING CONFERENCE

XIV INTERNATIONAL CONGRESS ON THE CARBONIFEROUS AND PERMIAN
Calgary, Alberta, Canada
August 17-21
1999

ORGANIZING COMMITTEE

Honourary Chairman
Bernard Mamet

Chairman
Charles Henderson

INVITATION

Geologists from around the world interested in Carboniferous and Permian rocks are invited to meet at Calgary Alberta Canada between August 17-21, 1999. The theme for the meeting is

A WORLD IN TRANSITION: UNDERSTANDING RESOURCES AND ENVIRONMENT FOR TOMORROW.

The theme is intended to reflect a temporal duality. The world today is in a state of transition from the industrial revolution to the communication -information revolution. Technological changes are occurring at an amazing pace, affecting the way we do our science. The world of the Carboniferous and Permian was also in transition as continental fragments amalgamated into Pangea and changes occurred at a pace too great for many organisms. The deposition, burial, and alteration of communities of these organisms provided the resources for today. The integrative and multidisciplinary efforts of current geoscientists to better understand the evolution of the earth during the Carboniferous and Permian will help us find more resources for tomorrow and provide insight into important environmental questions about how we affect our world.

TECHNICAL PROGRAM

The congress will focus on the many global aspects of Carboniferous and Permian environments and resources as well as the various system boundaries (Devonian/Carboniferous, mid-Carboniferous, Carboniferous/Permian, Permian/Triassic). The following are the major theme sessions planned:

1. Carb.-Permian conodonts; Pander
2. Other conodonts; Pander
3. Upper Paleozoic Palynology
4. Other Paleontology (Forams, Corals, Brachs, Ammonoids)
5. Mississippian Tectonics and Stratigraphy
6. Pennsylvanian Tectonics and Stratigraphy
7. Permian Tectonics and Stratigraphy
8. Reefs
9. Evaporites
10. Phosphates
11. Coal
12. World Petroleum
13. Boundaries/Chronostrat
14. Extinctions/Recovery
15. Western Canada Carb. and Permian Geology; Petroleum for Local crowd
16. Canadian Paleontology; CPC
17. General Sedimentology
18. Global Synthesis; Climate, Cycles, Geochemistry, Pangea

We have arranged for a full half-day session for the SCCS at this meeting plus a formal evening Subcommission business meeting. For further information and copies of the first circular please contact the organisers at:

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PUBLICATIONS BY SCCS MEMBERS

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NEW PUBLICATION

In the summer of 1998 the Czech Geological Survey in Prague will release a new publication:

J. Pesek *et al.*: Paleogeographic Atlas (Late Paleozoic and Triassic Formations, Czech Republic).

The Atlas contains 41 contour and paleogeographic maps depicting 16 levels of the Carboniferous, Permian and Triassic on territory of the Czech Republic (Central Europe). Approximate price is 49 US dollars.

The publication can be ordered from the following address:

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Klarov 3
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SCCS VOTING & CORRESPONDING MEMBERSHIP 1998

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