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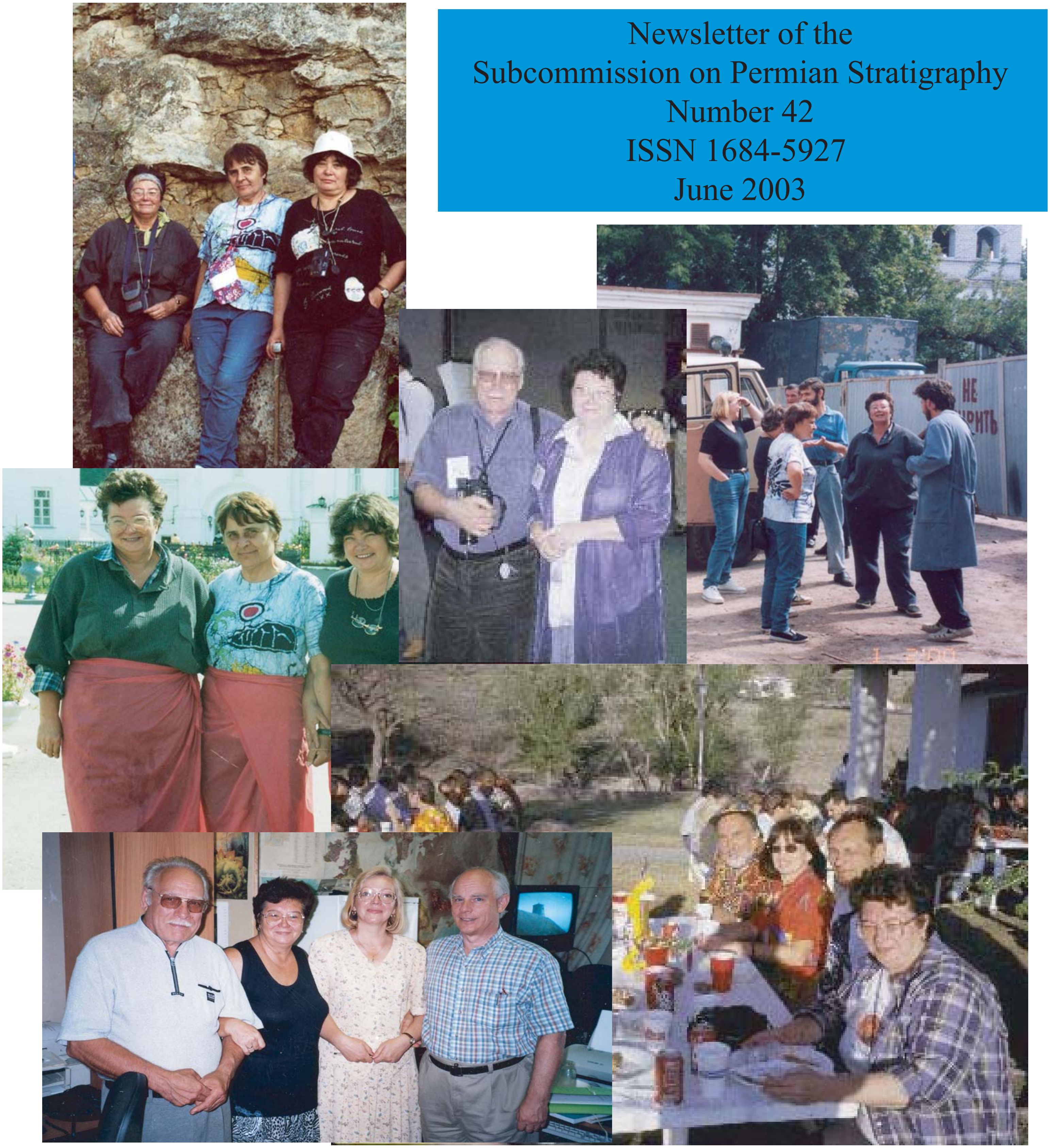

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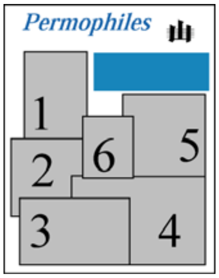

1: Field trip to Nemda River bioherms, Summer 2001. Dr. N. Esaulova with Drs. Galina Kotlyar and Olga Kossovaya. **2:** "Field" trip to the Raif Monastery near Kazan, Summer 2001. N. Esaulova with G. Kotlyar, and O. Kossovaya. Red skirts provided by monks for women not properly dressed to enter Monastery. **3:** N. K. Esaulova at her office, Kazan State University, Summer 2001, with her husband Dr. Boris Burov and Drs. Galina and Merlynd Nestell. **4:** South-central GSA meeting in Alpine, TX, Spring 2002. E. Gilmour, V. Gilmour, V. Davydov and N. Esaulova. **5:** At the back of the Geology Department of Kazan State University before field trip to the Nemda River bioherms, Summer 2001. Galina Nestell, Galina Kotlyar and Natalia Esaulova, and others. **6:** Boris Burov and Natalia Esaulova at the GSA meeting in Alpine, TX, Spring 2002.

EXECUTIVE NOTES

Notes from the SPS Secretary
Charles M. Henderson

Introduction and thanks

I want to thank those individuals who contributed articles for inclusion in the 42nd issue of Permophiles and those who assisted in its preparation. Bruce Wardlaw and I did all of the editorial work for this issue during 4.5 days at the University of Calgary. We thank Nicora Alda, Lucia Angiolini, Brian Glenister, Thomas Martens, Guang Shi, Eberhard Sittig, Ausonio Ronchi, Walter Snyder, Phan Cu Tien, Daniel Vachard, Tom Yancey and BP Canada (fieldwork consulting fees for myself were donated to Permophiles) for financial contributions to the Permophiles publication fund in support of this issue. We also thank Laurie Vaughan (Department of Geology and Geophysics, University of Calgary) for handling the donations. Continuing publication and mailing of Permophiles requires additional contributions; readers are referred to the last page of this issue. Permophiles is currently distributed to over 285 individuals and institutions and donations have not covered the expenses of the past two issues. Please remember to specify Canadian or USA dollars ($25US = $40Can.). Permophiles is recognized by the ICS as an exceptional newsletter and the support of our readers is necessary to maintain that quality.

Previous SPS Meetings and Minutes

The subcommission met during the XV International Congress on the Carboniferous and Permian at Utrecht, The Netherlands. The annual business meeting was held on Tuesday, August 12 in Room A of the Educatorium Building. There were no changes to the composition of the subcommission executive. The SPS executive includes SPS Chair (Bruce R. Wardlaw), First Vice-Chair (Ernst Ya. Leven), Second Vice-Chair (Clinton B. Foster), and the Secretary (Charles M. Henderson). The individuals in attendance at this meeting included Bruce Wardlaw, Charles Henderson, Keith Knabe, Sylvain Richoz Aymon Baud, Manfred Menning, Joerg Schneider, Driss Hmich, Ernest Gilmour, Holger Forke, Mateuz Novak, Wei Wang, Yuping Qi, Rainer Kaufmann, Clinton Foster, Elizabeth Weldon, Guang Shi, Tamra Schiappa, Krysztof Kwolek, Aleksander Protas, Walter Synder, Ausonio Ronchi, Carmine Virgili and Yugan Jin. The meeting was chaired by Bruce Wardlaw who provided a summary of the progress of SPS over the past year; this progress was summarized in three posters showing the GSSP's and potential GSSP's for the Cisuralian, Guadalupian, and Lopingian. Bruce also announced the untimely death of Natalia Esaulova. A tribute to her appears in this issue.

Yugan Jin then gave a powerpoint presentation of new work on the Wuchiapingian-Changhsingian boundary. He referred to some of the work headed up by Yue Wang on Section C, which shows a greater exposure of the Longtan Formation underlying the Changxing Limestone. This work demonstrated that there is not a major hiatus at the Longtan-Changxing contact. Section D at Meishan, however, remains the primary candidate for the W-C boundary (see Wardlaw *et al*., this issue).

Guang Shi then gave a summary of some of the progress by the Transitional Biotas as Gateways for Correlation working group. He referred to the article in Permophiles 40 and to the production of the Journal of Asian Earth Sciences, Special Issue (2002, vol. 20, #6) on the Permian of SE Asia. One of the abstracts that he presented at XV ICCP is reproduced in this issue.

Bruce Wardlaw indicated that a nominating committee was required to determine a slate of candidates for a new SPS executive to be installed at the IGC in Florence, Italy in August, 2004. His second term will come to an end at that time. He also indicated that regular changes in the voting membership are mandated by ICS. At that time, Manfred Menning indicated that he would be resigning his position as did Makoto Kato. They nominated Joerg Schneider and Yoichi Ezaki as respective replacements (see Chairs report, this issue).

Joerg Schneider reported of the poor health of Vladen Lozovsky who had suffered a stroke and indicated that some reorganization of the Continental Permian working group may be necessary in the future.

The Secretary reminded individuals that the deadline for contributions for Permophiles 42 was September 12 and that the next scheduled business meetings of the SPS will be at the GSA Rocky Mountain/Cordilleran meeting in Boise in early May 2004 and at the IGC in Florence in August 2004. He also reported the SPS vote on the Guadalupian-Lopingian boundary, which was passed by a vote of 14-1-1 (see Permophiles 41). He also indicated that order forms for the proceedings volume for the XIV ICCP (CSPG Memoir 19) were available with a special rate for XV ICCP delegates.

Business Arising from the Minutes

The nominating committee for a new slate of candidates for SPS executive has been named. The Committee will be chaired by Yugan Jin; other members include Guang Shi, Tamra Schiappa, and Bruce Wardlaw.

A slightly revised version of the SPS endorsed Guadalupian-Lopingian proposal has recently been mailed to the ICS for voting.

Please contact the secretary if you would like a PDF of the order form for Memoir 19 at the special rate of $100 Canadian.

Future SPS Meetings

The next scheduled business meetings of the SPS will be at the GSA Rocky Mountain/Cordilleran meeting in Boise in early May 2004 and at the IGC in Florence in August 2004.

Future Issues of Permophiles

Issue 43 will be finalized in February 2004 and we request that all manuscripts be sent such that Charles Henderson receives them no later than Friday February 13, 2004. Issue 43 will be compiled at the USGS in Reston, Virginia. Please see the note elsewhere in this issue regarding the preferred method of manuscript submission and format. Please follow the format as closely as possible and make our job of preparing Permophiles easier. Bruce and I ask you to *please follow the format (especially for references)*!

Despite the fact that Permophiles now has an ISSN it should be remembered that the newsletter is an informal line of communication between our various members. It is not a refereed publication. Individuals considering the naming of new taxa should really consider a refereed journal such that the taxa are properly scrutinized. Permophiles is increasingly referred to in many papers, which means that our reports should be professional and address scientific rather than personal issues. Our database is missing a number of e-mail addresses so if you haven't written to me recently or if any information has changed I would appreciate receiving a very short e-mail after receiving Permophiles. Send to charles.henderson@ucalgary.ca.

Notes from the SPS Chair

Bruce R. Wardlaw

We are nearing the end of my second term as SPS Chair, and now is a time for a little reflection and a little look to the future. First, I would like to review the brief history of the SPS's Chairs and Secretaries since its inception. I said this reflection would be brief, so here is a list:

Term	**Chair**	**Secretary**
1975-1980	Stepanov	Meyen
1980-1984	Glenister	Nassichuk
1984-1989	Sheng	Jin
1989-1996	Jin	Utting
1996-2000	Wardlaw	Spinosa
2000-2004	Wardlaw	Henderson

We owe a special thanks to the Canadians for serving as secretaries for 15 years of the Subcommission's 29 years. We know that it really is the secretary that carries the burden of work for the Subcommission and produces the newsletter (until my terms, where it became a shared responsibility of Chair and Secretary).

At the ICCP (International Congress on the Carboniferous and Permian) we had two resignations from the titular (voting) membership of the SPS with nomination for replacements.

Manfred Menning stepped down and nominated Joerg Schneider to replace him.

Makoto Kato stepped down and nominated Yoichi Ezaki. This nomination has received concurrence from ex-titular members to the Carboniferous and Triassic Subcommissions representing Japan and approval from the Stratigraphic Commission of Japan. Both nominations were accepted by the Executive of the SPS and approved to fulfill the remainder of the terms. They will be nominated to the slate of new members to be voted on before the next annual meeting at the IGC in Florence, Italy. We would like to thank Manfred and Makoto for their work on the Subcommission; Makoto especially for his tremendous efforts in the 30th IGC and Manfred on his never-ending coordination of a Carboniferous-Permian standard time scale.

It is time for further changes in the make-up of the titular membership. We stand at 16 voting members right now and I need at least two more to complete their terms and step down at the IGC. Remember, the SPS maintains a delicate balance of international membership which we need to respect, but as we approach 2004, so many of our issues have been resolved that this balance is no longer the major driving factor of the Subcommission. I will be sending requests to various individuals to step down to corresponding membership. Certainly, any member whose term exceeds 25 years will be asked.

The slate of new members will be sent out for approval with the vote for new Chair and Vice Chair early in 2004. As noted in the Secretary's report, a nominating committee is busily putting together our next slate of officers. I look forward to future correspondence with the membership and, most of all, seeing many of you at the IGC next summer.

Has your address changed since you last received Permophiles?

Please email or send any address changes to:

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SUBMISSION GUIDELINES FOR ISSUE 43

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to my E-mail address; hard copies by regular mail do not need to be sent unless requested. Please only send a single version by E-mail or in the mail; if you discover corrections before the deadline, then you may resubmit, but indicate the file name of the previous version that should be deleted. Manuscripts may also be sent to the address below on diskettes (3.5”, zip disks, or CD) prepared with a recent version of WordPerfect or Microsoft Word; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code and should be prepared in single column format. Specific and generic names should be *italicized*. Please refer to recent issues of Permophiles (*e.g*. Glenister *et al.*, Permophiles #34, p. 3) for reference style, format, *etc*. Maps and other illustrations are acceptable in tiff, jpeg, eps, bitmap format or as CorelDraw or Adobe Illustrator files. The preferred formats for Adobe Pagemaker are Microsoft Word documents and bitmap images. We use Times Roman 12 pt. bold for title and author and 10 pt. for addresses and text. Indents for paragraphs are .25”; do not use your spacebar. Word processing documents may include figures embedded at the end of the text, but these figures should also be attached as separate attachments as bitmaps or as CorelDraw or Adobe Illustrator files. Do not include figure captions as part of the image; include the captions as a separate section within the text portion of the document. If only hard copies are sent, these must be camera-ready, *i.e*., clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time. Any versions that require translation must also be submitted well ahead of the deadline. All paper versions of articles for Permophiles will be destroyed after the deadline of the subsequent issue, unless a request is made for return.

Please note that we prefer not to publish articles with names of new taxa in Permophiles. Readers are asked to refer to the rules of the ICZN. All manuscripts will be edited for consistent use of English only.

I currently use a Windows 2000 PC with Corel Word Perfect 10, Corel Draw 11, Adobe Page Maker 6.5, Adobe Illustrator 10, Adobe Photoshop 7 and Microsoft Office 2000 programs; documents compatible with these specifications will be easiest to work with.

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SUBMISSION DEADLINE FOR ISSUE 43 is Friday February 13, 2004

REPORTS

The following section reproduces selected abstracts from the XV ICCP meeting in Utrecht; in some cases minor changes or edits have been made.

The Permian of Gondwana and correlation with the global stratigraphic scale

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The stages of the marine Permian of the global stratigraphic scale were initially, primarily defined and recognised on the basis of ammonoid species and phylogenies. More recently the importance of fusulinid foraminiferans was recognised. Data from fusulinids were added to the stage definitions, and these tended to supercede the ammonoids. Over the last 15 years the occurrence of conodonts has become the primary basis for defining the boundaries of Permian stages with the base of each stage being defined by a Global Stratotype Section and Point (this has now been achieved for a majority of Permian stages). The base of each Permian stage has been or will be defined by the incoming of a single species of conodont (see Chuvashov *et al*., 2002, Chuvashov *et al*., 2003). However, application of this global scale outside of the type regions is hampered by the limited number of criteria used in defining the series and stage boundaries, as demonstrated for the Tethyan region (Leven, 2003).

Alas, the majority of the marine Permian sections of the classic supercontinent of Gondwana (Antarctica, Southern Africa, southern South America, Peninsular India and Australia) lack conodonts and fusulinid foraminiferans and have yielded sparse ammonoid faunas. These regions are large, often with extensive sequences of strata, and it has been widely demonstrated that the absence of these key faunal groups is climate related, particularly in terms of the effect on marine water temperatures. For any advance in the correlation of Gondwanan faunas with those of the Permian tropical faunas to be achieved, proxy groups must be used and correlations are enhanced by the use of ‘transitional biotas’ along ‘correlation highways’ and through ‘correlation gateways’ (Waterhouse, 2002).

Terranes accreted to the margin of cooler temperature Gondwanan (such as the fusulinid limestone and conodont bearing terranes of New Zealand and the fusulinid bearing terranes of Patagonia) do not assist in the correlation of the major Gondwanan sequences. Conversely, it is the regions of the Andean basins (northern Argentina, Bolivia and Chile) and the widespread peri-Gondwanan terranes from Iran to southeast Asia and Irian Jaya that provide regions of correlation highways.

Western Australia offers a key gateway to the southeast Asian regions on the basis of modest but scattered ammonoid faunas and a few conodont occurrences (Archbold, 1999). Unfortunately, several key conodont species are not well located or matched against the macrofossil and palynological zones of Western Australia (Foster and Archbold, 2001). Within the Western Australian

	SERIES	STAGE	Substage/Horizon	WESTERN AUSTRALIA	NEW ZEALAND	KOLYMA - OMOLON RUSSIA	YUKON CANADA
PERMIAN	LOPINGIAN	CHANGHSINGIAN		▨	*Wairakiella rostrata* *Marginalosia planata* *Spinomartinia spinosa* *Paucispinauria verecunda*	▨ ? *Stepanoviella paracurvata*	▨
		WUCHIAPINGIAN		*W. (W.) imperfecta* ▨ *Liveringia magnifica*	*Martiniopsis woodii*		
	GUADALUPIAN	CAPITANIAN		▨	*Pseudostrophalosia clarkei*	*Cancrinelloides curvatus* *Cancrinelloides obrutshewi*	*Cancrinelloides*
		WORDIAN		▨ *Sulciplica occidentalis* ▨	*Echinalosia ovalis*	*Magadania bajkurica* *Terrakea korkodonensis* *Terrakea borealis*	*Lissochonetes*
		ROADIAN		*F. coolkilyaensis* *Neochonetes (S.) afanasyevae*	*Pseudostrophalosia blakei* *Echinalosia maxwelli*	*Omolonia snjatkovi* *Mongolosia russiensis*	*Neochonetes*
	CISURALIAN	KUNGURIAN	Solikamsk	*Svalbardia thomasi* *Neochonetes (S.) nalbiaensis*	*Echinalosia discinia*	*Kolymaella ogonerensis*	*Sowerbina*
			Iren	*Fusispirifer wandageensis*	*Wyndhamia typica*	*Megousia kuliki*	
			Filippov	*Fusispirifer cundlegoensis* *Tornquistia magna*	Anidanthid fauna		
			Saranin	*Fusispirifer byroensis*	*Attenuatella altilis*	*Anidanthus aagardi*	*Antiquatonia*
		ARTINSKIAN	Sargin	*W. colemani* *E. prideri* *M. anomala* ▨	*Echinalosia conata* *Spinomartinia adentata*		
			Irgin	*N.(S.) magnus* ▨	*Terrakea dickinsi*	*Jakutoproductus burgaliensis*	*Jakutoproductus*
			Burtsev	*Coronalosia jimbaensis*	*Taeniothaerus* *Paucispinauria geniculata*	*Jakutoproductus rugosus*	
		SAKMARIAN	Sterlitamakian	*Coronalosia irwinensis*		*Jakutoproductus terechovi*	*Tornquistia*
			Tastubian	*Trigonotreta occidentalis* ?		*Jakutoproductus verchoyanicus* *Jakutoproductus expositus*	*Ogilviecoelia* *Yakovlevia* *Attenuatella Tomiopsis*
		ASSELIAN	Shikhan	*Lyonia lyoni* ?			*Orthotichia*
			Kholodnolozh	▨	*Neoplatyteichum?*	*Jakutoproductus mirandus*	*Kochiproductus*
CARBONIFEROUS				▨			*Septospirifer*

Table 1.
Trans global Gondwanan and Arctic correlations of Permian brachiopod zones for Western Australia, New Zealand, Kolyma-Omolon, Russia and Yukon, Canada. Data from Archbold (2002a, 2002b), Byakov (2000) and Waterhouse (2002).

stratigraphical sequences, it is the units with key ammonoid and/or conodont species that assist in providing the best ‘tie points’ to the global scale but perhaps, strangely, there occurrences may complicate rather than simplify the correlations proposed. For example, reliance on one or two conodont species (essentially the provincial species of *Vjalovagnathus*) has resulted in the well understood Callytharra Formation of Western Australia (Late Sakmarian – Sterlitamakian) being assigned to the Artinskian (Mei and Henderson, 2000, p. 472). The rather more complete sequence of brachiopod zones, with evolutionary lineages and migration events may be more reliable. Key faunal sequences in Western Australian and other Gondwanan regions raise concerns as to the reliability of reliance on just a few rare species of conodonts for global correlation. Not only does the limited conodont data contradict reliable ammonoid data but also extensive work over many decades that uses many fossil groups. Rather it is the use of a multiplicity of data through correlation highways that enables more reliable global correlations such as the examples provided in Table 1. The major Permian regions of the Gondwanan and Boreal realms are not just minor inconveniences for global correlations but rather are essential for understanding the global change scenarios of a significant time interval if the Earth’s history.

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Global Correlations of the Kungurian Stage and its Paleogeographic Implications for the Assembly of Pangea

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The Kungurian Stage represents a very interesting and dynamic interval of Permian Earth history. The Kungurian is a very tectonically active period as indicated by volcanism, uplift, and high subsidence rates in various areas. This suggests that major reorganization and interaction of plates during this interval affected the assembly of Pangea. In many areas the stage is represented by a significant lowstand of relative sea-level and diverse and changing climatic conditions that strongly affect the distribution of biota and thus our ability to correlate these rocks.

The Permian systemic boundaries were not well defined originally and Kungurian strata, including primarily siliciclastics and evaporites, clearly encompass beds of Murchison’s original Lower Permian. Chinese paleontologists also had a much higher boundary for the base of the Permian at the base of Chihsia Formation; the local Chihsian Stage comprises the Artinskian and Kungurian. Most Kungurian rocks in the type area for the stage along the Ural Mountains in Russia are poorly fossiliferous gypsum and red shale, but carbonate mudstone and dolomitized limestone with restricted marine faunas also occur. A potential GSSP for the Artinskian-Kungurian boundary deposits has recently been identified near the Mechetlino settlement at the Yuryuzan River. Units exposed here are the upper part of the Gabdrashitovo Formation, the overlying Sarana layers, and carbonate mudstone of the Ismagilovo Member, which is referred to the Filippovskoe Horizon. A precise point cannot yet be defined except that the definition will be the FAD of *Neostreptognathodus pnevi* within a chronomorphocline from advanced *N. pequopensis*. Bed 17 yields *N. kamajensis* and *N. pequopensis* and bed 19 includes *N. kamajensis*, *N. pequopensis*, *N. clinei*, and *N. pnevi*. Bed 18 is a sandy lithofacies that has not yielded conodonts. A laterally equivalent section includes limestone and additional samples from this section are required before a precise point can be defined. Bed 15 (Upper Artinskian) is an olistostrome with a matrix comprising the highest fusulinaceans (*Pseudofusulina* spp. and *Parafusulina solidissima*) in the section, solitary rugose corals, brachiopods, bryozoa, crinoids, and calcareous algae. Overlying beds 21-22 are the Filippovskoe Horizon (Mysovoi Formation, Ismagilovo Member); bed 21 is a steel-grey carbonate mudstone with rare interbeds of microclastic limestone that yield ostracods and the conodonts *Neostreptognathodus pequopensis*, *N. pnevi*, *N.* aff. *ruzhencevi*, and *N. tschuvashovi* (Chuvashov *et al*., 2002).

The Kungurian in the northern Urals and Novaya Zemyla includes siliciclastics and coal interbeds. The Kungurian of Western Europe is either absent or represented by terrestrial siliciclastics with pelecysaurs and other tetrapod footprints, volcanics, and minor coal. In the southern hemisphere there is evidence for renewed onset of cold conditions and local glaciation as indicated by the replacement of east Australia coal measures by marine beds with dropstones (Waterhouse, 2002).

The potential conodont chronomorphocline for the base of the Kungurian can also be recognized in the upper Great Bear Cape and upper Trappers Cove formations on southwestern Ellesmere Island, Sverdrup Basin, in the Canadian Arctic (Henderson, 1988; Beauchamp and Henderson, 1994, Mei *et al*., 2002). Kungurian strata in the Sverdrup Basin are characterized by a lowstand succession of mature siliciclastics grading basinward into shale, chert and minor carbonate. Quartz arenites of the Sabine Bay Formation contain a macroflora that indicates warm temperate conditions (LePage *et al*., 2003) and coal and coaly shale in fluvial overbank deposits indicates a humid setting, in contrast to caliche deposits in the underlying Artinskian. These terrestrial climatic conditions contrast with the shallow marine, cool-water bryonoderm carbonate; fusulinaceans and colonial rugose corals last occur in the Artinskian of the Sverdrup Basin (Beauchamp, 1994). This discrepancy has been explained by thermohaline circulation generated by seasonal melting of northern sea ice that affected much of northern Pangea, especially northwestern Pangea, from the Artinskian onward (Beauchamp and Baud, 2002). Significant tectonism in the region is demonstrated by Lower Kungurian basaltic volcanics of the Esayoo Formation in the northern Sverdrup and elsewhere by uplifts associated with compressional tectonics (Melvillian Disturbance) and the inversion of older rift-related structures (Beauchamp, 1995).

In Western Canada, the Kungurian is missing from much of the region as a result of significant tectonism. Structural inversion events near the beginning and near the end of the Kungurian result in localized non-depositional and erosional events. A mostly isolated basin, the Peace River Basin, saw the deposition of braided alluvial to deltaic deposits that grade into shallow marine siliciclastics. Aridity and isolation from cold thermohaline circulation is indicated by the development of caliche, but connections to the south allowed for a low diversity biota including conodonts for correlation.

Bryonoderm-extended to bryonoderm carbonate rocks of the Trapper Creek Formation in southeastern Idaho contain the potential basal-Kungurian conodont chronomorphocline and indicate warm to cool temperate conditions. Cold, nutrient-rich water associated with upwelling affected deposition of the Meade Peak Member of the Phosphoria, which spans the Kungurian-Roadian boundary. In contrast, warm-water tropical conditions prevailed thoughout the Kungurian in the Delaware Basin of West Texas in the Cathedral Mountain and Lower Road Canyon formations. This climatic gradient strongly affected biotic distribution. Geographic clines in conodonts have been interpreted to account for morphologic differences in *Mesogondolella* and *Jinogondolella* during the Late Kungurian and Early Roadian (Henderson and Mei, 2000) and may provide a link for correlation between cool and warm water provinces.

These geographic clines are also recognized in South China along the eastern margin of the Permian Tethys. Correlation of the Kungurian Stage at the Luodian section in Guizhou province is however controversial (Henderson and Mei, 2003). *Neostreptognathodus* spp. is very rare in South China and therefore the base of the Kungurian will have to be identified using other taxa; the first appearances of *Mesogondolella siciliensis* or *Sweetognathus guizhouensis* may be close to the proposed GSSP. Fusulinacean distribution forms the basis for Tethyan stage definitions, but the strong provincialism and biofacies controls exhibited by this organism results in a totally different fusulinacean succession in West Texas and the complete lack of fusulinaceans from many other areas including the type region of the Kungurian. The presence of both conodonts and fusulinaceans at Luodian would seemingly provide a link for correlation of global and tethyan stages, but comparison between the two groups suggests that the Kungurian is coeval with the Upper Bolorian to Murgabian (Henderson and Mei, 2003). However, traditional correlation of the Kungurian is with only the Bolorian tethyan stage (Leven, 2001). The dominantly slope carbonate succession at Luodian suggests that the Kungurian is thick (about 300 m) indicating high subsidence rates in direct contrast to the underlying Asselian-Artinskian, which are only about 125 metres in total. The above contrasting age interpretations affect the correlation of volcanics and sedimentary rocks in Oman and Sicily in the tectonically active western Tethys. It is paramount that this correlation problem is resolved so that Kungurian and later Permian tectonic and biotic events and paleogeographic reconstructions can be properly compared and assessed.

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Permian-Triassic Boundary and Extinction: Global Correlations and their Paleogeographic Implications for the Assembly of Pangaea

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If there is one undeniable characteristic for the P-T boundary, it is that the signature varies around the world, and in that sense this interval and extinction is most like today, sometimes referred to as the 6th great extinction. A second major characteristic is that the defining conodont species for the P-T GSSP, *Hindeodus parvus* is found in most sections (Yin *et al*., 2001). Strong provincialism during the Late Permian significantly contributes to these different patterns around the globe and the South China block in the Permian-Tethys and northwestern Pangea serve as good end-member examples.

Scientists have been trying unsuccessfully to attribute the P-T extinction to a major bolide impact; in contrast to the K-T, global correlation of the P-T boundary by bolide characteristics is very unlikely. Recently, the bolide theory has been brought to the forefront again, using Helium isotopes in bucky-ball fullerines (Becker *et al*., 2001) and the presence of nickel-rich metallic grains (Kaiho *et al*., 2001) as evidence for an extraterrestrial event. Other authors have disputed some of these claims based on non-duplication (Farley and Mukhopadhyay, 2001) and biostratigraphic limitations (Isozaki, 2001). Both of these studies found their “bolide-indicators” from a volcanic ash bed in South China (bed 25 at Meishan section) that is almost certainly associated with the Siberian traps, an extensive deposit of volcanic flows and explosive volcanic debris. This volcanism may have contributed to the extinction by subjecting the earth to various greenhouse (CO_2) and greenhouse inhibiting (sulphates) gases. Jin *et al*. (2000) indicated that despite the lack of compelling evidence, the rapidity of the extinction in South China, estimated at a period of less than 500,000 years, is “consistent with the involvement of a bolide impact”. The approximately 500,000-year interval is represented by a condensed succession (Jin *et al*., 2000) at Meishan that includes a sequence boundary (top of bed 24e), a volcanic ash (bed 25), an anoxic transgression (bed 26), and a hardground (top bed 27b) that point to multiple causes including anoxia, volcanic associated gases, and sea-level fluctuations. An initial phase of this extinction occurred earlier at the Guadalupian-Lopingian (G-L) boundary. Geologically these extinctions in South China are rapid, but is this the signature for the rest of the world?

In Western and Arctic Canada, a region geographically synonymous with northwestern Pangaea during the Permian, the biostratigraphic P-T boundary is recognized by the first occurrence of *Hindeodus parvus* within basal pyritic black shale of the Sulphur Mountain (in the Banff region of Western Canada; Henderson, 1997) and Blind Fiord formations (Sverdrup Basin, Arctic Canada; Henderson and Baud, 1997). These latest Permian black shale deposits indicate a major transgression of anoxic waters that may have affected a number of extinctions. However, by the end of the Permian throughout northwestern Pangaea there were only one or two species of conodonts, a few soft-bodied worms leaving traces, and hyalosponges remaining to be subjected to the oblivion of extinction. In the Sverdrup Basin, organisms like colonial rugose corals, fusulinaceans, and calcareous algae became extinct during the Late Artinskian (about 277 million years ago); numerous other fossils including bryozoans, brachiopods, and echinoderms gradually became extinct throughout the rest of the Permian. All of these organisms made it to near the end of the Permian, about 252 million years ago, in South China. All evidence points to major cooling throughout this interval (Beauchamp, 1994) followed by significant increases in temperature as indicated by the presence of redbeds and caliche in the Bjorne Formation, which is the near-shore/continental equivalent of the Blind Fiord Formation (Beauchamp and Baud, 2002). Rapid warming during the Late Permian would have ended the thermohaline circulation in northwest Pangea that coupled with the warmer water would have led to reduced circulation and anoxia and an end to the Permian chert event (Beauchamp and Baud, 2002). If viewed from northwestern Pangea, the P-T extinction occurred over a protracted interval, perhaps the last 25 million years of the Permian. The 100,000 to 500,000 year extinctions of South China were the last stages of a chaotic ecologic collapse in which the initial conditions occurred millions of years earlier in northwestern Pangea. Retallack (1999) also documented a major greenhouse warming in the Sydney Basin of Australia. Siliceous biota like radiolarians and sponges did not recover until the Lower Triassic Smithian stage about 8-10 million years later, and more than half of these were Permian Lazarus-taxa (Kozur, 1998). This extended the extinction effect’s temporal duration, at least in northwest Pangea, to as much as 35 million years. The runaway greenhouse effect was accompanied by a major negative shift in del^{13}C that may have resulted from the release of methane hydrates; this gas-on-ice resource is a major topic of economic and environmental importance today.

There is some dispute about the absolute age of the boundary interval, but such geochronologic techniques do offer a valuable tool for correlation in those areas with suitable materials. Bowring *et al*. (1998) indicated an age of 251.4 +/- 0.3 Ma for Bed 25 at Meishan and an age of 250.7 +/- 0.3 Ma for bed 28 making the boundary at bed 27c approximately 251 Ma. Metcalfe and Mundil (2001) suggest that 253 Ma is a better estimate of the age. This problem must be resolved.

Ammonoids and conodonts remain the primary tools for correlation of the boundary interval. The GSSP defined by conodonts is very closely approximated by the first occurrences of *Otoceras woodwardi* or *Otoceras boreale*. Three conodont intervals are distinguished across the boundary interval (Mei and Henderson, 2001). The Changhsingian interval is dominated by neogondolellids including the *changxingensis* lineage in the Equatorial Warm Water Province (EWWP) and the *sheni* lineage in both North Cool Water Province (NCWP) and peri-Gondwana Cool Water Province (GCWP). The latest Changhsingian and Early Grisbachian interval is marked by dominance of the *Hindeodus -Isarcicella* lineage and rarity of the *changxingensis* lineage in EWWP, abundance of both an early *carinata* lineage and the *Hindeodus -Isarcicella* lineage and in GCWP, and dominance of the *sheni* lineage and rarity of *Hindeodus -Isarcicella* lineage in NCWP. *Clarkina carinata* marks the Late Griesbachian and is abundant in GCWP and NCWP and is rare in EWWP. The Permian-Triassic boundary is not represented by extinction of conodont lineages, but only by phyletic evolution and pseudoextinction of conodont taxa. The major extinction of conodont lineages both precedes and postdates the boundary. The *Sweetognathus* lineage became confined to the EWWP during the Artinskian and finally became extinct at the G-L boundary (Mei and Henderson, 2001). The *Iranognathus* lineage, which was derived from *Diplognathodus* at the G-L boundary in EWWP and the *Vjalovognathus* lineage in GCWP became extinct in mid-Changhsingian and the *Hindeodus -Isarcicella* lineage became extinct in the Late Griesbachian. The *C. carinata* interval represents a survival interval and the appearance of *Neospathodus* near the base of Dienerian marks the beginning of the recovery phase. This pattern is comparable to conodont events during the Sakmarian and Artinskian, which are usually interpreted as a response to gradual climate change. It appears that the Permian-Triassic extinction resulted from a similar gradual process, eventually leading to an abrupt ecologic collapse, but not a sudden impact.

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Correlation of the Upper Permian and Its Paleogeographic Implications for the Evolution of Pangaea

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The Lopingian Series spans around 8 m.y. and represents a third-order depositional sequence that is bracketed by sequence boundary of the latest Capitanian below and a worldwide unconformity of the latest Changhsingian above. With the Lopingian Series in South China as the global standard for the Upper Permian, an integrated scheme of biostratigraphic zonation, magnetostratigraphic and major sequence boundaries of this series may provide a framework to link the contemporaneous sequences of all regions both inside and beyond the Palaeoequatorial realms.

Lopingian biota in the type area is characterized by the development of ceratid ammonoids, conodonts *Clarkina* and *Iranognathus*, fusulinids of the genus *Palaeofusulina* and the *Gigantopteris* flora. In addition to the biostratigraphic marks, the Wichiapingian Stage is characterized by a dominance of reversed polarity whereas the Changhsingian stage is characterized by a dominance of normal polarity. Correlations presented here indicate that Lopingian rocks exist in Northern Gondwana and Arctic regions. However, whether Lopingian rocks are present in the Great Basin of the USA requires further study. The *Cyclolobus* ammonoid fauna, and the conodont *Mesogondolella rosenkrantzi* and *M. britanica* are diagnostic of the lower Lopingian in deposits of cool water epi-Pangaea shelves. The conodont *M. sheni* is diagnostic of late Changhsingian of cool water faunas. The tetrapods of the

Cistecephalus and *Dicynodon* faunas indicate a Lopingian age for continental deposits. Accordingly, the upper part of the Sverdovinskian and Vyaskian intervals of the Tatarian, the Barfour Formation and its equivalents in Western Gondwana, and the Illawara Coal Measures and its equivalents in Eastern Gondwana are equivalent to the Lopingian.

Distribution of sedimentary régimes and biogeographic realms of the Permian is unique because most of the world's continents had, by the Middle Permian, collided to form the supercontinent of Pangaea. It was not only well controlled by climate zones but also by the relative position of the land mass. From the interior of Pangaea outward, Late Permian terrestrial deposits in continental basins, such as those in the Urals of Russia, Tianshan of China, and Karoo Basin of South Africa, are characterized by fluvial lacustrine facies. The Late Permian evaporate successions such as the Ochoan in the southwestern USA and the Zechstein in North Europe, for which biostratigraphic information is rather poor, occurred in western Pangaean embayments. Late Permian carbonate deposits on Pangaean epi-continental shelves of the northern Gondwanan margin, Cordillera and Arctic contain "cool water" faunas that cannot be readily correlated with Tethyan faunas. Between the Pangaea shelves and continental interior, Late Permian coastline deposits contain rich coal measures that are widespread in E. Australia, Indian Peninsula and North China, but faunas and floras were climatically controlled.

Late Permian Pangaea was characterized by the shift from tectonic stress, which was built up progressively from the Pennsylvanian to the Middle Permian, into the pulses of rapid stress release. Around Guadalupian- Lopingian boundary interval, basalt eruption occurred in South China (the Omei-shan Basalts) and Tarim, Pangaea rifting led to occurrence of the Zechstein basins and the intra-continent basins in South Africa, NW China and N. Urals, and the subduction along the Panthalassan margin of Asia. However, the first stress release event did not change the course of Pangaea consolidation, which was associated with widely crustal uplift. Consequently, Late Permian marine deposition slowed down or ceased in the pre-Pangaea shelves. The following pulse was expressed as the immense outpourings of Siberian traps, opening of Neotethys, and rapid collapse of regional crusts that resulted in a global transgression towards the very end of the Permian.

Depositional Architecture of Basins of the Upper Paleozoic Antler Foreland, Northern Pangaea: Examples from Nevada, USA

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The Carboniferous and Cisuralian strata exposed in Nevada reflect deposition within a series of tectonically formed basins of the Antler Foreland system positioned along the Late Paleozoic western margin of North America. A series of cyclic carbonate to mixed siliciclastic-carbonate successions separated by unconformities characterize the depositional patterns of the region and record the interaction between eustasy and tectonism. Several key sections including successions studied at the Nevada Test Site, Buck Mountain and Central Pequop Mountains contain distinct lithostratigraphic relationships that represent a combination of eustatic and tectonic influences. These successions correspond to discrete phases in sedimentary basin development capped by unconformable surfaces that have been related to tectonic and/or tectono-eustatic events.

The Nevada Test Site was the principal testing area for nuclear explosions in the United States from 1951 through 1969. The Test Site encompasses a large area within the southern Basin and Range with several areas that contain exposed Carboniferous to earliest Cisuralian strata. The Early Pennsylvanian to earliest Permian Tippipah Limestone, the main formation exposed in this region, records a tide-dominated mixed siliciclastic-carbonate ramp and reflects a unique interrelationship between eustasy, tectonics and the carbonate factory. The eustatic signal is recorded by autocyclic deposition of debris-flow and hemipelagic sedimentation and by the progradation of tidal-delta systems and buildups. The tectonic signature is also recorded by continued subsidence as indicated by sustained carbonate productivity below fair-weather wave base and by rejuvenation of the Antler highlands as indicated by the abrupt appearance of coarse recycled Antler Highland clastic material. The sudden appearance of buildups near the top of the succession in the late Pennsylvanian-earliest Permian is not the result of simple progradation but probably reflects the interrelationships of eustasy and tectonics.

Similarly in central and northeastern Nevada, Early Pennsylvanian to earliest Cisuralian stratigraphic successions indicate a similar relationship between eustasy and tectonics. The Pennsylvanian Ely Limestone is dominated by marine deposition of coarsening upward cycles of silty/sandy wackestone, packstone and subordinate micrite and grainstone and is widespread. Unconformably overlying the Ely Limestone at Buck Mountain is a thinly bedded silty micrite and wackestone unit with patchy occurrences of concretions that have yielded several poorly preserved ammonoid *Glaphyrites* sp. suggesting deeper marine deposition in a subsiding basinal environment. At least two foraminifera zones are missing across this boundary that distinctively displays erosional relief of up to 5 meters at a minimum. In the Central Pequop Mountains, a nearly identical lithologic unit unconformably overlies the Ely Limestone however no ammonoids have been recovered. The lithostratigraphic relationship recognized at both locations supports the notion that strata exposed at

Buck Mountain and in the Central Pequops represent the earliest phases of deposition and rapid subsidence of a successor basin within the Antler Foreland system.

The nature and facies relationships interpreted from stratigraphic successions studied throughout Nevada support the idea of continued tectonism throughout the Upper Paleozoic resulting in a series of successor basins within the Antler Foreland. Data collected from several stratigraphic successions throughout Nevada and mentioned above were deposited in an active tectonic setting where sedimentary environments were geographically restricted and of short duration.

Insect biochronozones - a powerful tool in the biostratigraphy of the Pennsylvanian and the Permian

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Any convincing correlation between the entirely continental Pennsylvanian to Middle Permian profiles of Western Europe and the marine standard scale has been lacking up to now (comp. Schneider *et al*., 1995). This problem stems from a remarkable situation in the Phanerozoic Eon of Earth history - a long lasting sea level lowstand and therefore exceptional vast areas of non-marine environments during the Carboniferous and the Permian. Possibly only the last five to ten million years (Pliocene - Holocene) are comparable in some respects. Additionally, the evolution of the terrestrial environments and biota is marked by the Pangaea situation, the Variscan orogenic processes, and the climatic development towards the Mesozoic green house climate. Under these specific conditions, the palaeogeographical as well as the stratigraphical distribution of the different groups of terrestrial organisms is controlled by:

- the highly differentiated potential for active and passive dispersal of the different groups, e.g. passive flying sporomorphs, active and passive flying insects, terrestrial reptiles, semiaquatic to aquatic amphibians, exclusively aquatic fishes *etc.*,
- the ecological prerequisites for active and passive dispersal and their spatial and temporal shift,
- the palaeogeographical development of evolutionary centres, distribution areas, migration routes/barriers through time on different scales - intercontinental, regional, local (realm, region, province),
- the history of each single basin, which acts as a vertical “stratigraphic filter“ as well as a horizontal palaeogeographical filter for migration and dispersal of faunas and floras,
- the large scale development of the climate, small scale climatic fluctuations and the regional to local climatic situation (meso- and microclimate) influenced by geomorphology, the rate and annual variation of precipitation/evaporation and the kind of vegetation cover as well.

Under these circumstances, only some groups meet the demands for interbasinal to interregional biostratigraphic correlations in non-marine environments: such as sporomorphs and arthropods. Sporomorphs as well as active flying insects and the minute eggs of conchostracans could easily be transported by air currents over hundreds to thousands of kilometres. Unfortunately, sporomorph biostratigraphy is hampered by the lack of evolutionary lineages and instead indicates climate zones and climatic changes rather than isochronous time levels. Well recognizable lineages in the evolution of species are known from some families of blattid insects (cockroaches) - Schneider (1982), Schneider and Werneburg (1993), Schneider *et al.* (2003, in press). Archimylacridae zones cover the time from Westphalian A to D (top Bashkirian to top Moscovian), Spiloblattinidae zones the time from the Westphalian/Cantabrian transition up to the Lower/Upper Rotliegend transition (Earliest Kasimovian to Asselian/Sakmarian transition). The Spiloblattinidae provide an interesting perspective link between Euramerica and Gondwana. They were recently reported from the Souss basin in the High Atlas Mountains of Morocco (Hmich *et al*., 2002). The insect bearing levels belong to the *Syscioblatta intermedia*- to *Sysciophlebia grata*-zone, which is Lower Stephanian (Uupper Kasimovian/Lower Gzhelian).

Starting in the Late Lower Rotliegend (Asselian), increasingly extensive red beds appear in Euramerica. Vegetation and insect faunas change to mesophil/xerophil associations. The Spiloblattinidae are replaced by typical xeromorph blattids, the Opsiomylacridae, and small Phyloblattidae with modern, Mesozoic features. Simultaneously, the entomofaunas change from blattid-dominated associations to very diverse ones (*e.g.* Elmo insect beds, Wellington Formation, Leonardian, Kansas; Obora locality, ?Artinskian, Czechia; Tambach locality, Tambach Formation, Sakmarian/Artinskian, Germany *etc*.). The most important and diverse European insect fauna was discovered in the red beds of the Salagou Formation of the Lodève basin in Southern France. Species of at least ten orders of insects have been found (*e.g.* Gand *et al*., 1997b, Nel *et al*., 1999a), among them *Phyloblatta* and *Opsiomylacris* species. Both the latter are similar to those observed at the Obora locality, in the Tambach Formation and the Wellington Formation (Schneider, 1980, 1984; Schneider in Gand *et al*., 1997). Fragments of blattid forewings show the first indications of a v-shaped cross-venation pattern. This pattern is characteristic of the genus *Aisoblatta*, which occurs first in the uppermost Kungurian and is typical of the German Zechstein and the Upper Permian of China (see Schneider, 1996). In summary, blattid insects of the Salagou Formation could indicate a Late Cisuralian

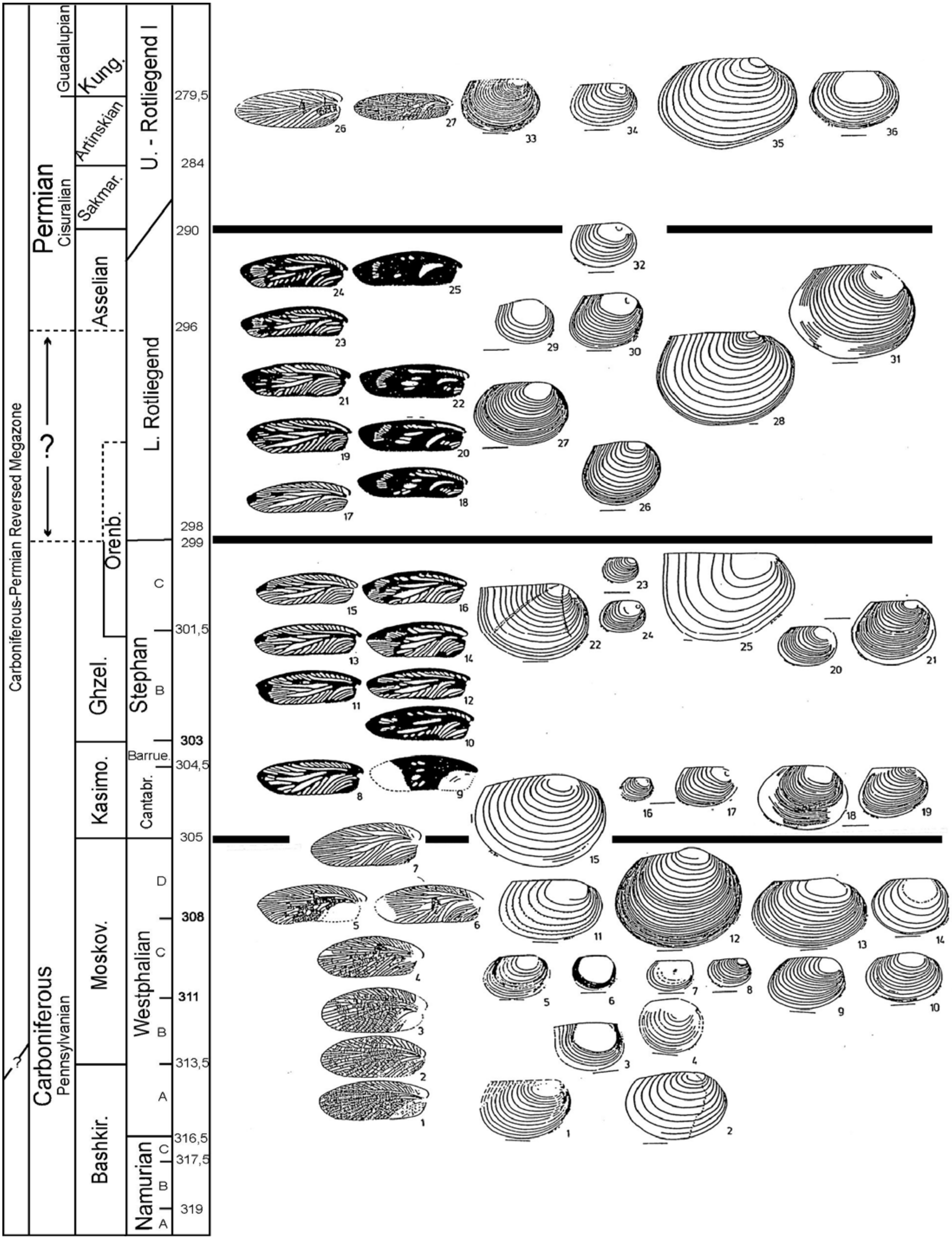

Fig. 1: Combined insect and conchostracan zonation of the Euramerian Pennsylvanian and the Permian after Schneider *et al*. (2003, in press), time scale adopted from Menning and German Stratigraphic Commission (2002).

to Early Lopingian age. According to Nel *et al*. (1999b) and Béthoux *et al*. (2001), Odonatoptera and Glosselytroptera point to a Kazanian (Wordian) age for parts of the Salagou Formation. The discovery of the oedischiid Orthoptera *Iasvia*, up to now only known from the type locality Chekarda in Russia, Ufimian, supports a Kungurian/Kazanian age for large parts of the Salagou Formation (Béthoux *et al*., 2002). The Lodève profile will be a key section for insect biostratigraphy of the Middle and Upper Permian on an intercontinental scale.

Up to now, very promising links between the non-marine profiles and the global marine scale are provided by three levels. First, *Spiloblattina variegata*, documented from shales in the top of the Ames limestone, Virgilian, Ohio, is the succeeding zone species of *S. intermedia*, late Stephanian A, Lower Ottweiler Subgroup, Saar basin, Germany. The conodonts *Streptognathodus simulator* and *Streptognathodus elegantulus* within the Ames limestone (Ritter, 1995) date this level as lower Gzhelian in age. Second, the composition of the Carrizo Arroyo entomofauna in New Mexico (Rowland, 1997) is comparable to the blattid faunas of the European Lower Rotliegend (Schneider, Lucas and Rowland, in prep). Unfortunately, guide forms of the Euramerican Spiloblattinidae-insect-zonation are missing up to now. In any case, the insects are from non-marine strata intercalated with marine limestones that yield age-diagnostic, late Virgilian conodonts, including species of *Streptognathodus*, *Adetognathus*, and *Hindeodus* (Lucas and Krainer, 2002). They will give a precise direct correlation to marine scales in the near future. Last but not least, the genus *Aissoblatta* is known from the Kungurian of Russia and the Upper Permian Xuanwei formation of China as well as from the German Copper slate, lowermost Zechstein. Besides the well-known but not very indicative *Merrillina divergens* of the Zechstein limestone, *Neogondolella* species were recently discovered in equivalents of the Copper slate (Schneider *et al*., in prep.).

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Permian-Triassic sequences in southern Tibet and end-Permian mass extinction at high southern palaeolatitude

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The Permian-Triassic sequences and faunal successions of three sections in southern Tibet have been investigated. The P-T boundary in all three investigated sections is well defined by the FAD of the conodont *Hindeodus parvus* and the species of *Otoceras*. Numerous gondolellid conodonts characterized by the cold-water types such as *Mesogondolella sheni*, *Clarkina tulongensis*, *C. taylorae* began to occur in the topmost part of the Selong Group and the basal part of the Kangshare Formation.

The Lopingian (Late Permian) deposits at the Selong Xishan section were formed in a high-energy inner shelf shoal setting and contain rich brachiopod fossils, solitary corals and bryozoans and a characteristic conodont *Mesogondonella sheni* of latest Changhsingian to earliest Triassic age in the topmost part. Brachiopod assemblages are largely comparable with those known from the Kalabagh Member of the uppermost Wargal Formation and the Chhidru Formation of the Salt Range, Pakistan, the Zewan Formation of Kashmir, the upper part of the Kuling Group in Spiti of India and the Hardmen Formation of Western Australia. These brachiopods do not comprise any warm-water elements until in the latest Permian some small and thin-shelled elements invaded into this area.

The Lopingian deposits of the Qubu and Tulong sections were formed under coastal and proximal barrier-lagoon settings and also contain brachiopods, solitary corals, bryozoans as well as some probably Late Wuchiapingian ammonoids in the lower and middle parts of the Qubuerga Formation. They are similar to those found in the Selong Group in the Selong Xishan section. However, the equivalents of the Caliche Bed at the Selong Xishan section is represented by some 20 m micaceous siltstones containing abundant terrestrial materials, palynomorphs and acritarches of regressive origin in the Qubu and Tulong sections.

Stratigraphical range data of brachiopods, corals and bryozoans at the Selong Xishan section reveal a virtually identical pattern of the end-Permian mass extinction with that known in the Tethyan and Arctic sections. Brachiopods, corals and bryozoans disappeared at the P-T boundary at the Selong Xishan section and are replaced by numerous ammonoids in the early Griesbachian. Among the 49 brachiopod species from the Selong Group and the overlying *Waagenites* Bed of the basal Kangshare Formation, 12 species disappeared at the Permian-Triassic boundary (data after Wang *et al*., 1989; Shen and Jin, 1999) and six species disappeared at the top of the Selong Group (Shen *et al*., 2000). A few foraminifers extended into the early Triassic, therefore a delayed late Griesbachian mass extinction is favored according to Wignall and Newton (2003). However, we consider that the fact a few Permian-type foraminifers extend into the early Triassic Griesbachian may not necessarily change the major extinction interval slightly below the P-T boundary if the ranges of all fossils are considered. The major extinction interval is well constrained by the sharp drop of the organic and inorganic carbon isotopic excursions in the lower and the P-T boundary defined by the conodont *Hindeodus parvus* Zone in the upper in southern Tibet and largely correlatable to that at the Meishan section in South China (Jin *et al*., 2000).

Range data of the benthic communities at the Qubu and Tulong sections are truncated by the micaceous siltstone and mudstone, therefore display an earlier disappearance pattern than at the Selong Xishan section, which is apparently facies dependent. Accompanied with the extinction event, $\delta^{13}C_{arb}$ and $\delta^{18}O$ values at the Selong Xishan section and $\delta^{13}C_{org}$ values at the Qubu section all show a sharp negative drop slightly below the P-T boundary. The topmost Permian and basal Triassic rocks are thin-bedded, fining upwards, pyritic but weakly bioturbated packstones or dolomites, and therefore represent a rapid transgression beneath the P-T boundary. The above mentioned faunal and lithological changes in southern Tibet probably indicate the presence of a warmer climate and/or a rapid deepening at the end of Permian in the northern peri-Gondwanan margin compared with the underlying section of the Lopingian deposits.

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The Permian of South Primorye, Far East Russia: a gateway for Permian global correlations

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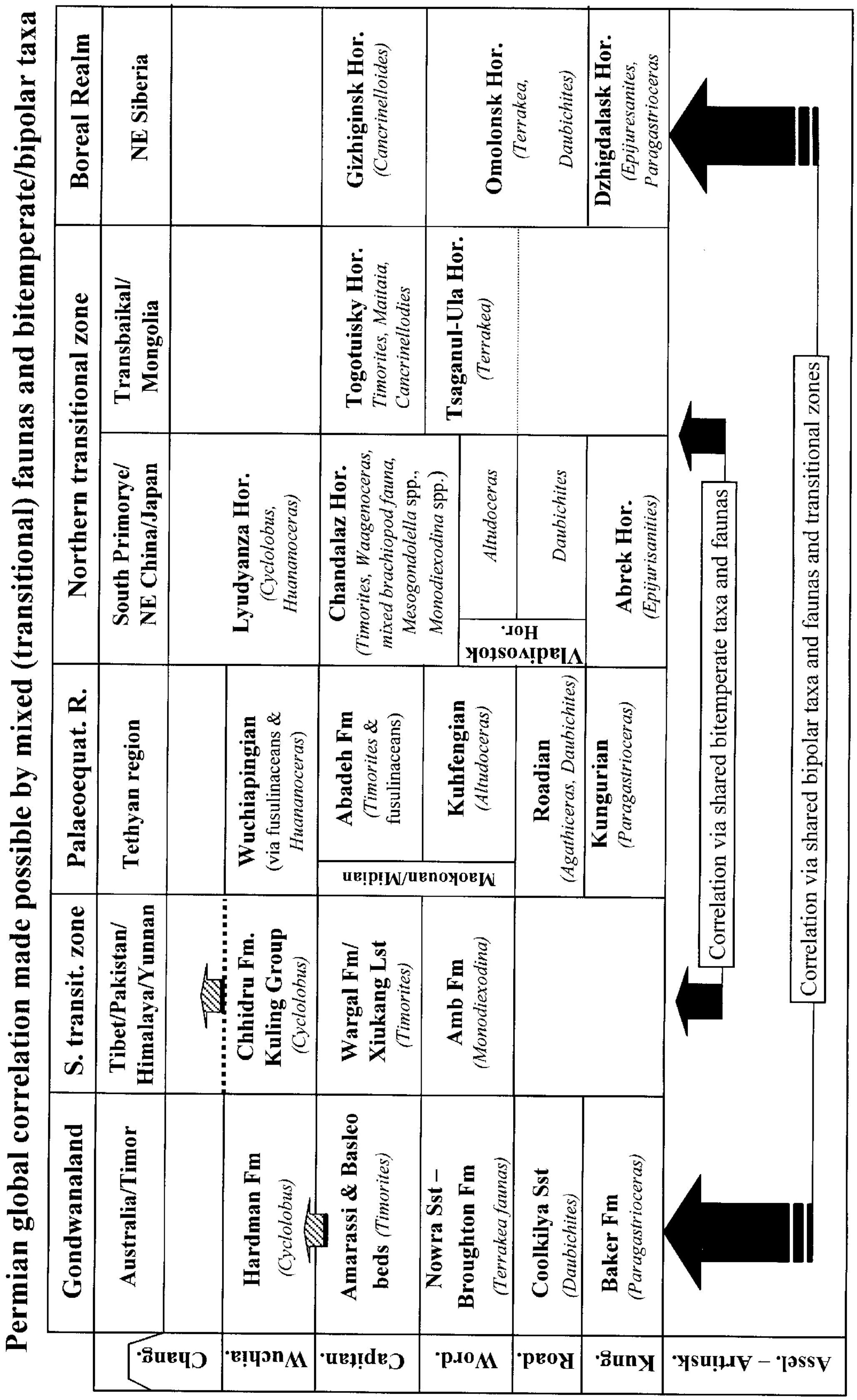

Permian global correlation made possible by mixed (transitional) faunas and bitemperate/bipolar taxa

	Gondwanaland	S. transit. zone	Palaeoequat. R.	Northern transitional zone		Boreal Realm
	Australia/Timor	Tibet/Pakistan/Himalaya/Yunnan	Tethyan region	South Primorye/ NE China/Japan	Transbaikal/ Mongolia	NE Siberia
Chang.						
Wuchia.	**Hardman Fm** *(Cyclolobus)*	**Chhidru Fm. Kuling Group** *(Cyclolobus)*	**Wuchiapingian** (via fusulinaceans & *Huananoceras)*	**Lyudyanza Hor.** *(Cyclolobus, Huananoceras)*		
Capitan.	**Amarassi & Basleo beds** *(Timorites)*	**Wargal Fm/ Xiukang Lst** *(Timorites)*	Maokouan/Midian **Abadeh Fm** *(Timorites &* fusulinaceans)	**Chandalaz Hor.** *(Timorites, Waagenoceras, mixed brachiopod fauna, Mesogondolella* spp., *Monodiexodina* spp.)	**Togotuisky Hor.** *Timorites, Maitaia, Cancrinellodies*	**Gizhiginsk Hor.** *(Cancrinelloides)*
Word.	**Nowra Sst – Broughton Fm** *(Terrakea faunas)*	**Amb Fm** *(Monodiexodina)*	**Kuhfengian** *(Altudoceras)*	Vladivostok Hor. *Altudoceras*	**Tsaganul-Ula Hor.** *(Terrakea)*	**Omolonsk Hor.** *(Terrakea,*
Road.	**Coolkilya Sst** *(Daubichites)*		**Roadian** *(Agathiceras, Daubichites)*	*Daubichites*		*Daubichites)*
Kung.	**Baker Fm** *(Paragastrioceras)*		**Kungurian** *(Paragastrioceras)*	**Abrek Hor.** *(Epijurisanities)*		**Dzhigdalask Hor.** *(Epijuresanites, Paragastrioceras*
Assel. – Artinsk.						

Correlation via shared bitemperate taxa and faunas

Correlation via shared bipolar taxa and faunas and transitional zones

The ‘biostratigraphical gateway’ concept was first proposed in 1998 at the International Symposium on the Upper Permian Stratotypes of the Volga Region held at the Kazan State University, Russia, as a new, alternative approach to enhancing Permian chronostratigraphy and global correlations. In the past few years, considerable progress has been made at several key areas of the world where mixed Permian temperate/cold-water and warm-water biotas are known to exist (see a recent report by Shi and colleagues in *Permophiles*, no. 40, p. 17-22). These include the Cimmerian micro-continental strip or terranes (such as the Karakorum, central and southern Tibet, western Yunnan, the Shan-Thai in SE Asia), the vast Russian Platform and the Pechora-Timan region in NW

Russia, and East Asia (North China, parts of Japan, Russian Far East). This report is primarily concerned with the Permian of the Barabash area in South Primorye area, Far East Russia, and discusses its potential as an important biostratigraphical gateway area for global correlations of Permian high-latitude faunas and rock sequences. Data presented here is based on the authors' joint fieldwork in the area in 2000.

The Permian lithostratigraphy in the Barabash area is defined by a succession of three formations (horizons). They are in ascending order: the Abrek Horizon (Reshetnikov Formation), the Vladivostok Horizon, and the Chandalaz Horizon. The Lyudyanza Horizon, the topmost unit of the Permian succession in South Primorye, was not seen in the Barabash section and therefore will not be discussed further. The lowermost unit, the Abrek Horizon, is largely a succession of non-marine clastics and volcaniclastic sediments, but is intercalated with at least one level of marine incursion as evidenced by the finding of a *Tomiopsis-Primorewia* brachiopod fauna from a shale-siltstone unit in the middle to upper part of the formation. In addition to the two mentioned genera, the brachiopod fauna also has a species each of *Rhynchopora* and *Spirelytha*.

The Vladivostok Horizon, directly and conformably overlying the Abrek Horizon, is dominated by volcanic rocks (mostly andesite) and volcaniclastic sediments, with rare crinoid fragments and other fossils. The Chandalaz Horizon in the Barabash section is defined at its base by an approximately 10 m interval of volcanic breccia and bioclastic limestone. There are abundant brachiopods in both the breccia and limestone, but our preliminary examination of the brachiopods show little difference in species composition between the two brachiopod assemblages. We therefore treat the brachiopods as one fauna. Two particular features of the brachiopod fauna are notable. First, the brachiopod fauna is characterized by the presence of elements characteristic of both the temperate to cold-water Boreal Realm and the warm-water palaeoequatorial Cathaysian Province. The former category of faunal elements includes such genera as *Anemonaria, Kochiproductus, Yakovlevia, Blasispirifer,* and *Kaninospirifer*. The presence of the Cathaysian faunal elements in the fauna is comparatively weaker (*i.e.*, fewer genera), but is significant, as it contains genera that are usually considered typical of the warm-water Eastern Tethyan Cathaysian Province, such as *Leptodus*, *Compressoproductus*, and *Tyloplecta*. In addition to these two categories of genera, the Barabash mixed brachiopod fauna also has several genera of bitemperate and bipolar aspects: *Rhynchopora*, *Spiriferella*, and *Neospirifer*.

Secondly, the Barabash mixed brachiopod is associated with a distinct *Monodiexodina* fusulinacean fauna. Apart from species of *Monodiexodina*, the fusulinacean fauna also contains representatives of *Metadoliolina* and *Pseudofusulina* (Katsumi Ueno, personal communication, 2002).

Although ammonoids have not been found at the Barabash section, similar brachiopod assemblages from two other localities in Far East Russia are known to have yielded ammonoid species of great biostratigraphical significance. *Timorites* has been documented from Cape Grozny in the vicinity of Vladivostok, and *Waagenoceras* and *Timorites* are known from the Bolshie Churki Range in the Amur region in Khabarovsk. At both localities, the ammonites co-exist or are closely associated with a brachiopod fauna, which is remarkably similar to the mixed brachiopod fauna from the base of the Chandalaz Horizon in the Barabash section in terms of their mixed nature and species composition.

It is therefore clear that the age of the mixed brachiopod fauna from the basal Chandalaz Horizon of the Barabash section is constrained by the associated fusulinaceans and ammonoids. According to Dr. Katsumi Ueno (personal communication, 2002) who has examined the fusulinacean fauna associated with the brachiopods, the age is likely to be '?early Midian or Capitanian'. This age determination is in agreement with the *Timorites-Waagenoceras* ammonite fauna, but somewhat different from the age suggested by conodonts from the Fanjiatun Formation of Jilin, NE China (Wang *et al*., 2000, *Acta Micropalaeontologica Sinica*, 17, 430-442.), where the *Mesogondolella*-dominated conodont fauna is found immediately underling a horizon that contains *Waagenoceras* sp. and a rich brachiopod fauna with mixed Boreal and Cathaysian affinities reminiscent of the mixed Barabash brachiopod fauna. Wang and colleagues suggest that the conodont fauna is most likely Wordian, although they have not ruled out the likelihood of its extending into early Capitanian.

Therefore, in balance of the conodont, ammonite and fusulinacean evidence, we consider the mixed brachiopod fauna at the base of the Chandalaz Horizon of the Barabash section, and for that matter all comparably mixed brachiopod faunas of East Asia (*i.e*., NE China, Japan and elsewhere in Far East Russia), to be late Wordian in age, although some may locally extend into early Capitanian.

The global significance of the Permian of South Primorye is demonstrated by the nature of its mixed Cathaysian, Boreal and antitropical brachiopod fauna and its close spatial and stratigraphical association with conodonts, ammonoids and fusulinaceans. Based on these associated and biostratigraphically more sensitive faunas and the presence of bipolar and bitemperate brachiopod genera, it is possible to establish global correlations of Permian sequences at some levels. Table 1 (next page) is an attempt in this regard and shows how some Permian rock units of Eurasia, Gondwanaland and the Palaeo-Tethys may be correlated using the concept of mixed (or transitional) faunas/areas as 'gateways' and bipolar/bitemperate taxa as key 'north-south' inter-hemispheric correlatives (note that only units that contain the same or comparable taxa are shown).

Permian-Carboniferous Tectonostratigraphic Framework for Western North America: Implications for Global Correlation

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The global correlation of Permo-Carboniferous events is critical for better understanding the events and processes that lead to the formation of Pangaea and also for how the formation of this supercontinent influenced global processes such as climatic and sea level changes, extinction and speciation. For Pangaean stratigraphic successions, this global correlation is typically discussed within a framework of: 1) biostratigraphic relationships, 2) sequence stratigraphy (that presumably reflects global sea level fluctuations), and 3) scattered radiometric dates. One critical tool we are missing is: 4) a well-calibrated time scale of sufficient detail for precise and accurate global correlation. In addition, as emphasized in this paper, we may be able to: 5) utilize subtle, tectonically produced unconformities for at least regional (continental-scale) or even global correlation. It is certainly speculative if such tectonic unconformities have value beyond regional correlation. However, it is equally clear within world-wide Pangaean stratigraphic successions that these unconformities complicate classic approaches to correlation as well as efforts to develop a calibrated time scale. The purpose of this paper then, is to outline the nature of these subtle tectonic unconformities utilizing the Carboniferous and Permian of the western U.S. as an example. They have also been documented in western Canada (*e.g.*, Henderson, 2003) and the Pre-Uralian Foredeep.

Although this tectonostratigraphic framework applies to all of the Western U.S., and via preliminary assessment, to western Canada, the primary focus of this paper is on the upper Paleozoic of eastern and southern Nevada - the “Antler foreland”. In general, the late Paleozoic continental margin of western North America is characterized by a succession of tectonically-controlled sedimentary basins. Unconformities that separate genetically related stratigraphic successions provide the key for understanding this upper Paleozoic lithotectonic history (Fig. 1). These packages of rock represent regional depositional successions created by a combination of eustatic and tectonic influences. The result is regional, and relatively long-lived, depositional systems composed of widely varied lithofacies. These depositional systems are conceptually similar to systems tracts, but much larger in scale. Evidence for the tectonic origin of these unconformities varies widely - even for the same unconformity. Where subjacent strata are deformed by folds and thrust faults, the tectonic origin is obvious. Other unconformities are markedly, to only slightly angular, and some are disconformities that can only be detected by detailed biostratigraphic data. More subtle evidence may come from superjacent strata that reflect changes in provenance of clastic detritus or paleocurrent directions. Classic lithostratigraphy and low-resolution biostratigraphy are insufficient to identify these discrete successions.

Unconformity-based Stratigraphic Framework

In general, the upper Paleozoic stratigraphy of the western US varies highly both along the strike of the continental margin and across the margin from foreland to craton. Both spatial and temporal variation record tectonic activity that created uplifts and basins along the western continental margin. These evolved through time. Although each tectonic event was unique both in style and in area of effect, each one sent a signal that can be read regionally. In addition, important eustatic sea-level changes affected the entire region, but in different ways in different places. Most of these are unconformities are regional in scale (Fig. 1), but local tectonic subsidence may locally produce a record of continuous sedimentation across the boundaries.

We have attempted to include many of the widely used stratigraphic names, in some cases these names have never been formally defined but are nonetheless broadly used. We have not tried to make a distinction between units that have or have not met Stratigraphic Code criteria for Formation status. We also made no attempt to catalog all stratigraphic names used in the region. We do, however, propose what we believe to be the least confusing uses of the most common names. As a guiding principle, we adhere to local definitions and descriptions wherever possible. The names for the basins in Figure 1 is not the key issue because these names change depending on specific geographic location; the key is to identify the regional unconformities which bound stratigraphic successions. Thus, the basin names on Figure 1 only reflect those proposed for the western margin of North America.

The C1-C2 succession is the classic Antler Foreland Basin fill. It is comprised of the deeper-water turbidites and related sediments that were shed eastward from the young Antler highlands. This basin reflects the flexural loading from the emplacement of the Roberts Mountain allochthon during the Late Devonian-Early Mississippian. The Visean boundary should be preserved within this succession.

A distinct phase of deformation preceded the C2 boundary, which defines the base of the Antler Successor Basin. This basin, in contrast to the deeper water succession of the Antler Foreland Basin, filled with marginal and shallow marine strata. The Serpukhovian boundary occurs within this stratigraphic interval; the base of the Bashkirian is locally preserved in the uppermost portion of this succession (*e.g.*, Arrow Canyon).

The stratigraphic succession(s) of the Ely and related basins comprise the C3 to C5 interval. These are characteristically cyclic carbonates deposited in a shelf to ramp settings. The cycles reflect eustatic sea level flucuations. The C4 unconformity is not fully documented, and may reflect either a minor phase of regional deformation or be entirely local in extent.

The C5-C6 succession is problematic in that it has typically been considered as part of the Ely Basin fill. However, recent work has underscored the importance of distinguishing the Hogan Basin from that of the underlying Ely (*e.g.*, Sweet and Snyder, 2002). Basically, everywhere the Hogan Formation is recognized as a lithostratigraphic unit, it is a fine-grained mixed siliciclastic-carbonate unit. The unconformity between the

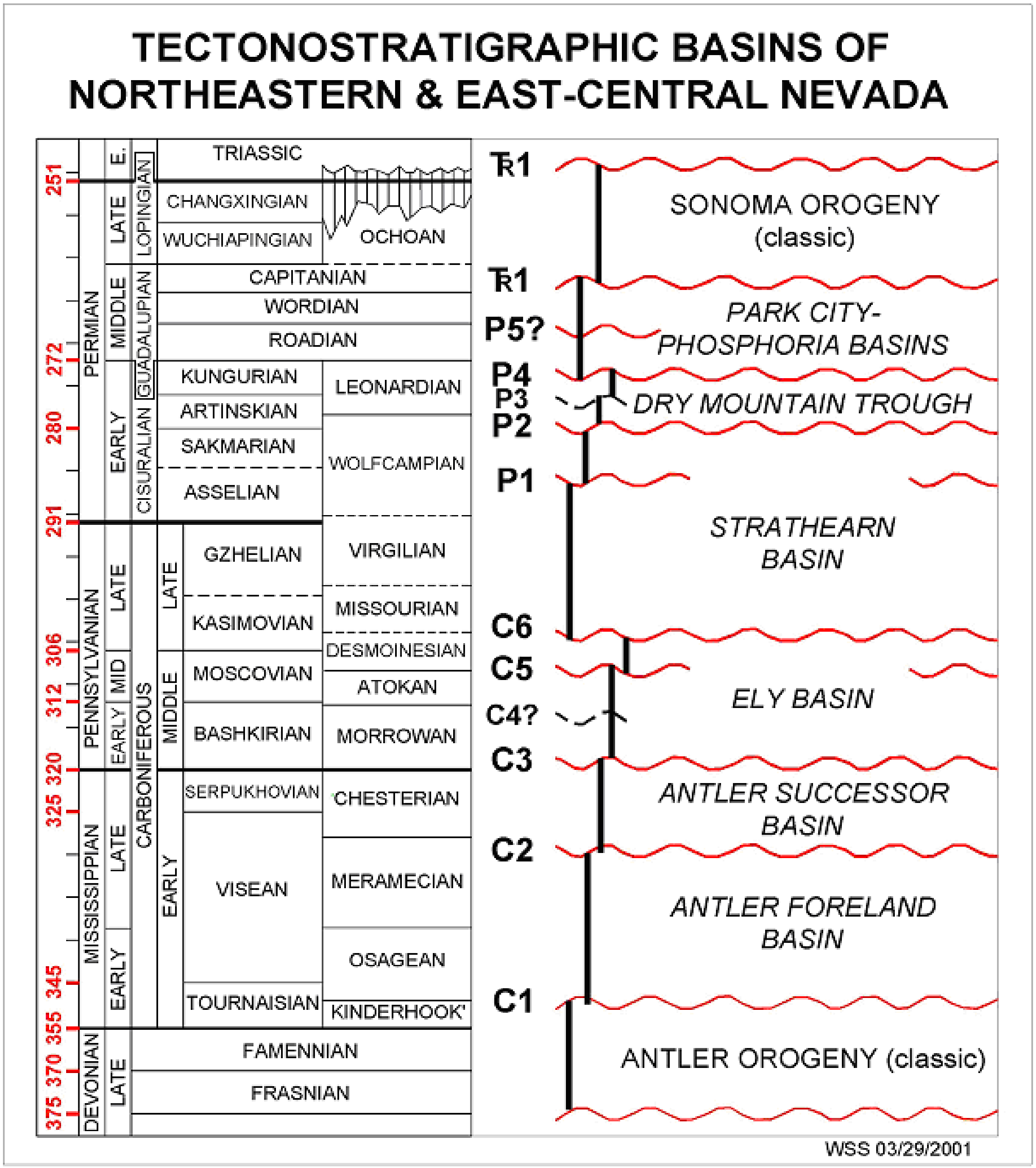

Fig. 1. Genetically related stratigraphic successions of tectonically-controlled sedimentary basins of the Upper Paleozoic of northeastern and east-central Nevada. Numerical ages marked by heavy lines are from Remane *et al*. (2000), Chuvashov *et al*. (1999), Roberts *et al*. 91995), and Cloe-long *et al.* (1995). Intervals between the numerical ages were divided into time increments of equal duration.

Hogan and subjacent Ely marks a sudden change from relatively shallow-water, open carbonate platform or ramp depositional setting to a deeper-water, basinal setting. Locally, the uppermost part of the Ely is deformed by thrust faults and folds. The base of the Kasimovian should occur within the C5-C6 interval, but it has not yet been confidently identified.

Similar to the Ely Basin, the C6-P1-P2 stratigraphic interval is comprised of two distinct successions, separated by unconformities that are locally angular. We informally refer to these as the lower and upper Strathearn successions. At some localities, the Missourian lower Strathearn rests on highly deformed Ely strata as young as Atokan. At other localities, the upper Strathearn or even the P2-P4 succession rests on remnants of the C3-C5 succession. Thus the C6 to P2 was an interval of complex tectonostratigraphic events along the continental margin.

During P2 to P4 interval, a series of deeper water basins and associated highs developed along the continental margin from Idaho to the Mojave Desert region (*e.g.*, Wood River, Cassia, Ferguson, Dry Mountain, and basins in Death Valley). A shallow-marine carbonate shelf occupied the region between or east of these basins, although some areas were locally emergent (*i.e*., the Deep Creek-Tintic uplift). Only locally are Asselian rocks preserved beneath the P1 unconformity, and to date, at only one locality have we documented basal Asselian rocks.

The Phosphoria and related basins of the P4-TR1 interval developed in Kungurian (late Leonardian) time and persisted through the Wordian or even early Capitanian. The Phosphoria basin was comprised of several depocenters, and at least two marine transgressions are recorded in the Phosphoria stratigraphic succession. Although the specific origin of the Phosphoria basin is still debated, it is clearly a tectonic basin.

Chemostratigraphy of the Permian-Triassic Boundary in the Middle Zagros Area, Iran

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The Zagros mountains form a major geological boundary in southern Iran. These mountains are the result of the collision of the Arabian and Iran plates. A well-developed Permo-Triassic boundary section named as Darreh Duzdan near Aliguodars in middle Zagros area has been researched by means of carbon isotopic chemostratigraphy. It consists of a nearly 250 m thick interval of dolomites, which are devoid of fossils for dating. This section comprises (from bottom to top): the Dalan Formation characterized by the presence of Late Permian corals, brachiopoda and encrinites which is dated as Wuchiapingian, a 2 m thick stromatolitic bed and the Kheneh Kat Formation which contains no fossils. Earlier researches suggested that this 2 m stromatolite interval should be the base of Kheneh Kat Formation of Early Triassic age, but our chemostratigraphic results show this stromatolite unit can be divided into two parts. The upper part (top 1/3 of the all stromatolite bed) should be included in the Early Triassic because of its lower to negative data of carbon isotope values as low as –0.5‰ (PDB). The lower part with higher values ranging from 3-5‰ should be placed in the Late Permian. Hence, the Permo-Triassic boundary is situated within the stromatolite beds, and the gradual depletion of carbon isotope may indicate that this boundary is conformable. The section is no deposition of most part of Changhsingian since the topmost Changhsingian, which is marked as higher carbon isotope value and gradually depleting, covers Wuchiapingian deposition. Arabian plate developed the interval of stromatolite unit from the latest Permian through to the early Triassic.

Latest Permian fusulinoideans and smaller foraminifers in the Meili Section, Guangxi, South China

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The Lopingian Series in South China has been accepted as a global standard for the youngest series of Permian chronostratigraphic unit (Remane, 2000). Two sections, the Penglaitan Section and the Tieqiao Section in Laibin of Guangxi province, have been formally proposed as the Global Stratotype Section and Point (GSSP) for the basal boundary of the Lopingian Series and the secondary reference section separately (Jin et al., 2001). However, the uppermost part of the Permian in the Tieqiao Section is poorly exposed. The Meili section, on the opposite bank of the river, offers a better exposure of this part of the succession. This section, about 70m in thickness, is composed mainly of clastic rocks intercalated with limestones. It contains the youngest Permian fossils, which could be correlated with the conodont *Clarkina yini* Zone in the Meishan Section of Zhejiang province, the GSSP of the Permian-Triassic boundary. Fusulinoidean fossils are abundant in most limestone beds, but the species diversity is rather low and monotonous. Amongst them, *Palaeofusulina sinensis* is the most dominant species, associated with *Reichelina* sp., *Parareichelina* sp., *Nankinella* sp., and *Staffella* sp.. The section as a whole, therefore, can be assigned to the *Palaeofusulina sinensis* Zone of the standard fusulinoidean zonation in the eastern Tethys and is late Changhsingian.

The *Palaeofusulina sinensis* populations from the Meili Section, from the oldest to the youngest representatives, exhibit a progressive increase in the shell size. For the first time, a microspheric generation in these specimens is recognized. The genus *Palaeofusulina* has a larger shell and more complicated shell structures than other co-existing fusulinoidean genera, and, therefore, is considered to be the leading member for the Changhsingian fusulinoidean fauna. By the end of the Permian, it became extinct together with all the other fusulinoideans.

Compared with fusulinoideans, the diversity of smaller forams in the Meili Section is higher. They are particularly abundant in limestone beds in the lower and middle part of the section. Of the smaller foraminifers, *Climacammina*, *Colaniella*, *Geinitzina*, *Pachyphloia*, *Nodosaria*, and *Glomospira* are the dominant genera, and *Robuloides*, *Agathammina*, *Paraglobivalvlinoides*, and *Abadehella* are associated. The diversity and the number of both fusulinoideans and smaller foraminifers drop towards the end of the Permian with few fossil traces extending into the early Triassic.

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	Sample level												
Species	4-1	4-2	4-3	4-4	4-5	4-6	4-7	4-8	16	18-1	18-2	20-1	23
Palaeofusulina sinensis	**A**	**A**	**A**	**A**	**A**	**C**	**A**	**A**	**A**	**A**	**C**	**C**	
Palaeofusulina sinensis (microspharic)							**R**			**R**		**R**	
Parareichelina sp.	**R**												
Reichelina sp.		**R**		**C**					**R**				
Staffella sp.		**R**			**R**		**R**						
Nankinella sp.											**R**		
Abadehella sp.	**R**	**R**							**R**				
Agathammina		**R**									**R**		
Climacammina sp.	**A**	**A**	**A**	**A**			**R**		**C**	**R**	**C**		
Colaniella parva				**R**			**R**		**A**		**R**		
Colaniella sp.	**C**	**R**	**R**		**R**		**R**		**A**		**R**		
Cryptoseptida?sp.	**R**				**R**								
Geinitzina sp. A	**C**		**R**	**C**		**R**			**A**				
Geinitzina sp. B	**C**	**C**	**C**	**C**	**C**		**C**		**R**				**C**
Geinitzina spp.	**R**							**R**	**C**				
Glomospira sp.	**A**	**C**	**R**	**A**	**C**	**R**	**C**	**R**	**A**	**C**	**R**		
Pachyphloia sp. A	**A**	**R**	**R**	**R**	**R**	**C**			**C**		**C**		**R**
Pachyphloia sp. B	**A**	**A**	**A**	**C**	**R**	**R**	**R**		**C**	**R**	**C**		**R**
Paraglobivalvulinoides sp.	**C**	**C**	**R**		**R**				**A**				
Robuloides lens	**R**			**R**				**R**					
Robuloides acutus				**C**					**R**				
Robustopachyphloia sp.				**R**									
Spireitlina sp.											**R**		
Tuberitina sp.							**R**	**R**			**R**		

Table 1. The relative abundance of the species in Meili section. The section is from bed 1 to bed 23, with the PT boundary near bed 22. **A** – abundant in the layer, **C** – common in the layer, **R** – rare in the layer

Jin, Yugan, Henderson, Charles, M., Wardlaw, Bruce, R., Glenister, Brian, F., Mei, Shilong, Shen, Shuzhong, Wang, Xiangdong, 2001. Proposal for the Global Stratotype Section and Point (GSSP) for the Guadalupian- Lopingian Boundary: Permophiles, no. 39, p. 32-42.

Global Guadalupian (Middle Permian) conodont correlation and distribution

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The Guadalupian was first proposed by Girty at the turn of the last century for the spectacular fossils found in the Guadalupe and Glass Mountains of West Texas. These faunas have been well documented and represent an unprecedented display in an exhumed, well-preserved backreef, reef, and basin. The West Texas depositional basins represent a tropical North American faunal suite, well removed from the more typical tropical Tethyan faunas of Asia and Europe. The Middle Permian was a time of strong provincialism and presents some complexities for correlation. The formal establishment of the Guadalupian and its constituent stages is based on the evolution of a single genus of conodont, *Jinogondolella*. The genus has a limited distribution though it is common to West Texas and South China.

The abundant and well-preserved conodont faunas of West Texas show that the genus of *Jinogondolella* and its species evolved through short-lived transitional morphotypes, generally through a mosaic of paedomorphogensis (retention of juvenile characters in later and later growth stages). The first species of the genus, *J. nankingensis*, is also the marker for the Guadalupian and its basal stage, the Roadian. The species is abundant in West Texas and South China but occurs rarely in several other sites (i.e., Canadian Arctic, Pamirs); however, its distribution along the western coast of Pangea represents a geographical cline from the tropical Delaware basin (West Texas) to the upwelling-influenced Phosphoria basin (Idaho) to temperate Canadian Arctic and exhibits its overlap with several genera, especially within the Phosphoria basin where it is abundant, that provide excellent correlation globally. The cline is confirmed to be geographic (nearly synchronous) by the co-occurrence and coincident range with *Neostreptognathodus newelli* in the Delaware and Phosphoria basins.

The first occurrence of *Jinogonolella aserrata* defines the base of the Wordian. It occurs outside of West Texas and South China in Oman, Mexico, and the Great Basin and northern Rocky Mountains of the U.S. In Oman it co-occurs with *Mesogonodolella siciliensis* directly tying it into the range of that common Tethyan form. In the U.S., exclusive of West Texas, it occurs rarely with *M. phosphoriensis* in the upper part of the Meade Peak Phosphatic Shale Member of the Phosphoria Formation and with *M. rosenkrantzi* in the Retort Phosphatic Shale Member of the Phosphoria Formation. *Merrillina divergens* occurs abundantly within the Retort. In Nevada, *J. aserrata* occurs in a lag deposit incorporated in the basal Triassic above Gerster Limestone-equivalent strata. *Me. divergens* occurs in the uppermost part of the Gerster, where it is preserved beneath the pre-Triassic unconformity. *Merrillina praedivergens* was separated from *Me. divergens* based on the perception that it contained an additional rudimentary denticle and had a different (lower) range. Large populations show that the morphotypes 'typical' of both species co-occur and they should be synonomized. *Merrillina divergens* is a common form to the temperate waters of the world, occurring in the Salt Range, Oman, the Volga region, the Arctic, and in the basal unit of the Zechstein. Its range, occurring below and above a major sequence boundary within the Wordian is very similar to that of *J. aserrata* in West Texas and the Phosphoria basin, and suggests that its lower range is a good marker for the upper Wordian. In the Salt Range, Pakistan, *Me. divergens* is followed in stratigraphic succession and implied evolutionary succession by a couple of undescribed species of *Merrillina* that are Lopingian (Upper Permian) co-occurring with species of *Clarkina*. This indicates that the range of *Merrillina divergens* is restricted to the Guadalupian (upper Wordian and Capitanian). Species of *Vjalvognathus*, which appears to be an important biostratigraphic form in PeriGondwana deposits, especially in Australia, also occurs in the Salt Range section, though only in mixed clastic/carbonate strata which appear to represent cooler water (cool temperate) environments as compared with the environments that produced the massive carbonates of the Wargal (temperate).

The Illawarra Reversal occurs very close to the top of the range of *J. aserrata* in West Texas, above the occurrence of *M. divergens* in the Volga region and within its range in the Salt Range. In the Guadalupe Mountains, a tuff at or about the projected position of the Illawarra, within the very top of the range of *J. aserrata*, just below the first occurrence of *J. postserrata*, the indicator for the Capitanian, yields a date of 265 Ma. It appears that the Illawarra can be used as an accessory marker for the base of the Capitanian as can the age of 265 Ma. The relationship of the occurrences of *Me. divergens* to that of the Illawarra Reversal also strengthens the supposition that its range is upper Wordian and Capitanian.

The ammonoid genus, *Waagenoceras*, has long been associated with the Guadalupian, and in particular, the Wordian. In West Texas, forms originally identified as *Waagenoceras*, now recognized as *Demarezites*, occur through the lower range of *Jinogondolella nankingensis*. Transitional forms from *Demarezites* to *Waagenoceras* and the probable first occurrence of *Waagenoceras* occur within the Pipeline Shale in the Guadalupe Mountains and the China Tank Member of the Word Formation and its equivalents in the Glass Mountains. A local hemera of *Waagenoceras* occurs in the upper (second limestone unit) of the Willis Ranch Member, just below the first occurrence of *J. aserrata*. The distribution of ammonoids and conodonts is very similar at Las Delicias, Mexico. There, the lower "*Waagenoceras*" shale contains the first occurrence of *Jinogondolella nankingensis* and *Demarezites*. The upper "*Waagenoceras*" shale contains abundant *Waagenoceras* with *J. nankingensis*. Immediately above the upper "*Waagenoceras*" shale is the first occurrence of *J. aserrata*. In West Texas, *Waagenoceras* continues to occur throughout the Word Formation and into the equivalents of the lower part of the Capitan Limestone. In fact, the last verified occurrence of *Waagenoceras* is within the Pinery Limestone Member of the Bell Canyon Formation, co-occurring with the last appearance of *Jinogonodolella aserrata*. *Waagenoceras*, therefore, is late Roadian and Wordian in age.

The distribution of *Jinogondolella*, which characterizes the Guadalupian, is somewhat limited to common occurrences in the tropical zone in South China and West Texas and the upwelling area of the Phosphoria basin. Its rarer appearances around the margin of the Tethys tropical zone and temperate zones bordering the Tethys and the northern margin of Pangea "bridge" to other faunas and other provinces making the Guadalupian an appropriate standard for the Middle Permian.

OTHER CONTRIBUTED ARTICLES

On the new finding of presumably Angaran type Early Permian flora in the Canadian Arctic

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Introduction

Recently LePage *et al*. (2003) have reported about the finding of a diverse plant assemblage on northern Axel Heiberg Island (Canadian Arctic Archipelago) in the Lower Permian (presumably, Kungurian) deposits. To their opinion, this assemblage appears to demonstrate "a strong phytogeographic connection with the Angaran floral realm". In particular, the authors identified such characteristic Angaran forms as sphenopsids *Paracalamites* sp., the peltasperms *Compsopteris* sp., the *incertae sedis* gymnosperms *Zamiopteris* sp., dispersal seeds *Angarocarpus* sp., as well as the cordaitean plants *Rufloria* spp., *Bardocarpus* sp., *Vojnovskya* sp., *Nephropsis* sp., *Pechorostrobus* sp., *Samaropsis* sp. and *Sylvella* sp. Other forms, identified as a "new *Asterotheca*-like genus", the "fern-like foliage – incertae sedis", *Trigonocarpus* spp., *Dolerotheca* sp., *Sphenobaiera* spp., *Walchia* sp. *etc*., belong to local endemics of Euramerian appearance.

The discovery of an Angaran connected Early Permian flora in the Canadian Arctic is certainly of great interest. It may force to revise some traditional schemes of phytogeographical zonation and the basic conceptions of the northwest Pangea Permian floras origin. Suddenly, the analysis of identifications of Angaran plants by LePage *et al*. (2003) shows, that all of them are at least doubtful.

Canadian plants from Angaran paleobotanist viewpoint

The photo of *Paracalamites* sp. (LePage *et al*., 2003, fig. 6 A–C) doesn't show ribs which pass through the nodes without alternation, as it is noted in the description (l.c., p. 351), and which are characteristic for the genus. In this character true *Paracalamites* pith casts are similar to those of Euramerian *Archaeoclamites*, but differ from them by more prominent ribs and more marked transverse grooves in nodes, that are not observed in Canadian forms. Besides that, the real Angaran *Paracalamites* belong to the family Tchernoviaceae (Meyen, 1982a); the presence in the Axel Heiberg flora is not confirmed by the findings of corresponding fructifications.

The poorly preserved remains, assigned to *Compsopteris* sp. (LePage *et al*., 2003, p. 353; fig. 6I), are rather similar to this genus by their outlines and the midvein extending, but lateral venation of the pinnules is not visible. At the same time, the true Angaran *Compsopteris* has a cuticle of peltasperm type and is often found in close association and apparently in organic connection with the racemose peltoid aggregations, usually referred to genera *Peltaspermum* and *Lopadiangium* (Meyen, 1982a, text-fig. 18). The last fructifications are not known in Axel Heiberg flora. The fronds, similar in outlines and general morphological organization to *Compsopteris* belong also to different plants, for example to the Cathaysian *Protoblechnum wongii* Halle from the Lower Shichtose Series of China (Halle, 1927, pls. 35–36, pl. 64, fig. 12). It should be also noted, that the fronds, similar to *Callipteris* and *Compsopteris* were found in the southwestern USA in presumably Artinskian–Kungurian age deposits (Meyen, 1987).

A dispersal seed, identified as *Angarocarpus* sp. (LePage *et al*., 2003, p. 355; fig. 7G; more adopted in the Angaran palaeobotany name – *Tungussocarpus*), does not evidently belong to this genus, which includes, in particular, the forms of *T. tychtensis* (Zal.) Sukh. type, especially those, described by N.A.Shvedov (1961) from the Permian of Enisei-Lena Region of Siberia, to which the Canadian forms are supposedly similar.

A fragment of dispersal leaf or a scale, assigned to *Zamiopteris* sp. (LePage *et al*., 2003, p. 357; fig. 7J), belongs probably to cordaitean plants. Unlike Canadian forms, in the true Angaran *Zamiopteris* lateral veins curved outwards and the axial ones are clustered in a bundle, sometimes imitating a midvein. Angaran forms have gymnosperm type cuticle with compact stomatal bands, resembling the cuticle of cordaites, dicranophylls or both (see: Meyen, 1987).

The leaves of cordaitean appearance, assigned to *Rufloria* spp. (LePage *et al*., 2003, p. 357; fig. 8A, B, Ea), couldn't be reliably identified with this genus first of all because of the poor preservation of microstructures, interpreted by LePage and his co-authors as dorsal furrows. In any case, the depicted by them leaf microstructure fragment (l.c., fig. 8B) does not allow such an assignment. The "dorsal furrows", recognized by LePage *et al*. (l.c., p. 357), could quite be formed as a result of the filling by sediment of the narrow spaces between veins and hypodermal strands. They do not show any microstructures, connected with the real dorsal furrows (e.g. strengthening bands, hairs, papillae *etc*.). The noted by the authors (l.c.) "longitudinal lenticular structures … in various parts of leaf that range from 5 to 10 mm in length and 0,5 mm in width" are not known in the true Angaran *Rufloria*.

The presumable seed remains, assigned to *Bardocarpus* sp. (LePage *et al*., 2003, p. 357; fig. 8C, D), evidently could not belong to this genus. The true Angaran *Bardocarpus* Zalessky posesses a large semicircular notch at the base of a seed that corresponds with the place of its attachment (the seeds were sessile and spirally disposed at an unbranched axis; see: Meyen, 1982a, text-fig. 33) as well as an attenuated "two-horned" apex (Meyen, 1982a, text-fig. 32; 1988, fig. 8.18).

The unclear fructifications, assigned to *Voynovskya* sp. (LePage *et al*., 2003, p. 357; fig. 8I), have evidently little in common with true Angaran *Voynovskya* Neuburg. The last female strobili have an obconical axis up to 15 mm in width, grading basally into a wrinkled peduncle and in the upper part covered by helically arranged short seed stalks. The flattened strobilus axis bore a dense "cap" of elongated sterile scales or seed stalks. The strobili were arranged in the axils of scale-like leaves of *Nephropsis* type on the specialized fertile shoots (see: Meyen, 1988, fig. 8.13). Unlike this, the fructification described by LePage *et al*. (l.c.) consists of a thin (3 mm in diameter) cylindrical axis with helically arranged scales, erroneously identified as *Nephropsis* (see below). The Angaran *Vojnovskya* was probably in lifetime connection with *Cordaites* type leaves (Meyen, 1982a, b; 1987, 1988). No one case of organic connection or close association with the *Rufloria* type leaves is known up to now.

Among the plant remains, referred to *Nephropsis* sp. (LePage *et al*., 2003, p. 357; fig. 8Fb, H), one (fig. 8H) evidently does not belong and the other (fig. 8Fb) demonstrates only superficial similarity to this genus. The true Angaran *Nephropsis* is characterized by thick, fan-like curved, several times dichotomizing veins, passing into the upper and partly into the lateral margins of the lamina.

The male fructifications, assigned to *Pechorostrobus* sp. (LePage *et al*., 2003, p. 359; fig. 8Fa), do not show a lot of diagnostic features of the genus (*e.g*. an involucre of the *Lepeophyllum* type sterile scales at the strobilus base, longitudinally oriented thickened spots in the sporangium wall, potomonosaccate pollen sometimes with the monolet or bilet proximal slit; see: Meyen, 1982b). Hence, this identification should be regarded as very strained.

A dispersal seed with asymmetrical wing, assigned to *Sylvella* sp. (LePage *et al*., 2003, p. 359; fig. 8K), apparently does not belong to this genus. The true Angaran *Sylvella* has an asymmetrical wing developed at the seed apex at the both sides of the strongly elongated micropilar projection (see: Meyen, 1982a, text-fig. 27; 1988, fig. 8.14). Instead of this, Canadian forms show 7 dichotomizing prominent longitudinal ridges on the seed wing, which bent toward one side (LePage *et al*., 2003, p. 359).

The dispersal seeds, assigned to *Samaropsis* spp. (LePage *et al*., 2003, p. 359; fig. 8J, L, M), have a little in common with *S. irregularis* Neuburg and *S. stricta* Neuburg from the Permial of Angaraland, depicted by S.V.Meyen (1982a, text-fig. 25, 28), which are cited by LePage and his co-authors.

Some general remarks

Thus, some reservation is necessary regarding the conclusion about a "strong phytogeographic connection" of Axel Heiberg flora with the Angaran floral realm, particularly, with the Vorcutskaya and younger Pechorskaya floras of the Pechora Basin (Russia). According to LePage *et al*. (2003, p. 365), the community composition of these floras is also rather similar and is dominated by

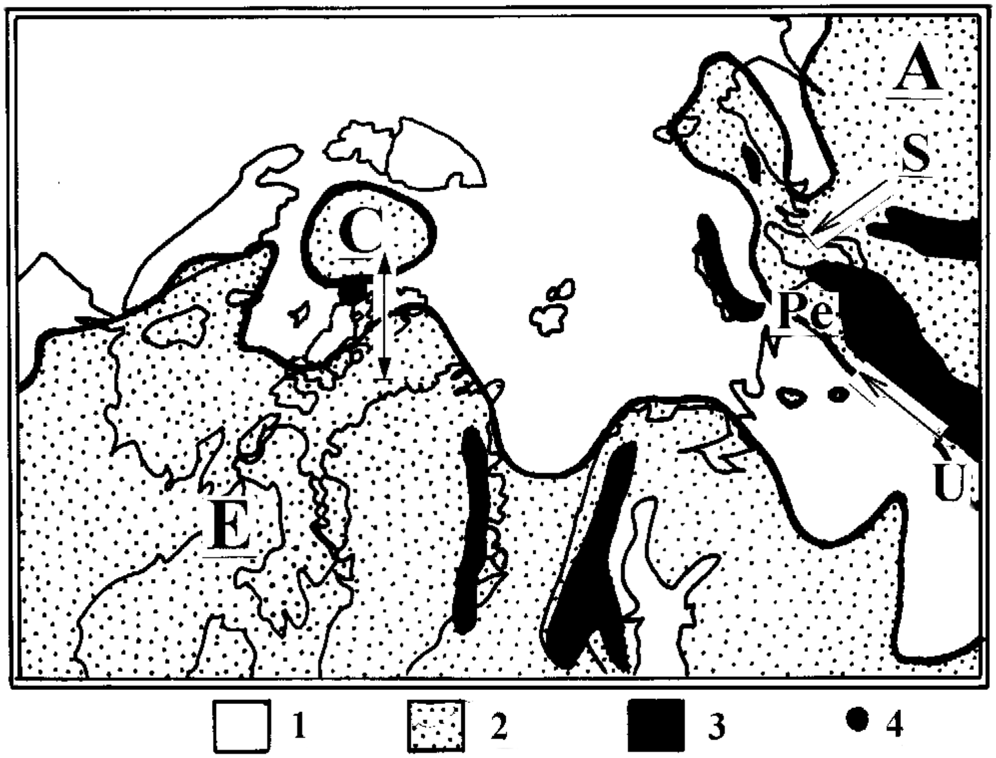

Fig 1. Phytochoria of northern Laurussia and west Angaraland at the late Early Permian: 1 – marine; 2 – lower continental; 3 – mountains; 4 – Axel Heiberg flora locality; A – Angaran floral kingdom; E – Euramerian floral kingdom; Pe – Pechora floral province of Angaran kingdom; U – Uralian floral province of Angaran kingdom; S – Siberian floral area of Angaran kingdom; C – Crockerland floral province of Euramerian kingdom; arrows show probable floristic connections. The paleogeographical map modified from: LePage *et al*., 2003.

Rufloria, *Vojnovskya* and *Zamiopteris*. In spite of these conceptions, the Pechora Basin Lower Permian (Vorcutskaya) flora was dominated by arborescent and shrubby cordaitean plants (ruflorians and vojnovskyans *sensu* Meyen, 1987). The Late Permian (Pechorskaya) flora was dominated by two plant groups, including cordaitean plants and cardiolepidians (peltasperms with *Phylladoderma* type leaves). The last shrubby forms were the main coal-forming plants. The callipterids (*Callipteris*, *Comia*, *Compsopteris*) formed apparently local mono- or oligospecies stands at river banks. They disappear simultaneously with the ruflorians in the upper part of Pechorskaya series (presumably, in the Early Tatarian time).

The conifers with *Walchia* type vegetative shoots, dominated in the Axel Heiberg flora, and occur in the Pechora Basin very rarely, and only in the Vorcutskaya series (Lower Permian).

The assumption of several authors (Olsen, 1962; A.M.Ziegler, pers. comm. to LePage *et al*., 1997), that the “fluctuating sea levels during times of major regressions could have periodically exposed parts of the shallow marine shelf between North America and Russia during the late Early Permian and would have provided a conduit for floral and, apparently, faunal exchange” has no sufficient factual basis. No traces of such floral migrations in the sections are known. Furthermore, such migrations concern not floras as a whole, but only their separate elements, which usually are represented by ruderals and not by community dominants (Tolmachov, 1986). The existence of closely related contemporaneous floras in the Canadian Arctic and in the Pechora Basin implies the same or similar succession of initial floras at both sides of a big and long-time existing marine basin, which evidently does not make phytogeographical sense.

The conclusion about the presence of Angaran plants in the Permian floras of Greenland, first made by S.V.Meyen (1982a, text-fig. 39) on the materials of R.H.Wagner (Wagner *et al*., 1982; see also: Wagner *et al*., 2002), which was subsequently spread to several Permian floras of Canada (Ziegler *et al*., 2002), had been evidenced by not always reliable identifications of vegetative parts, which had not been confirmed by the findings of fructifications of the corresponding Angaran plants.

From the phytogeographical viewpoint, taking into consideration the evidently high level of endemism and probable belonging of the Axel Heiberg plant remains to the fossil flora of large, topographically low island landmass, which was designated by A.Embry (1993) as Crockerland, it seems convenient to establish a new Crockerland paleofloristic province. Its boundaries could be conditionally interpolated as the boundaries of Crockerland landmass. On the basis of plant remains appearance the province may be preliminary assigned to the Euramerian floral kingdom. The degree of peculiarity and, consequently, the rank of this phytochorion should be defined more exactly in course of the subsequent study. Figure 1 provides a corresponding scheme of floristic zonation, modified from LePage *et al*. (2003) and taking into account the zonation schemes of S.V.Meyen (1982a, 1987; Vakhrameev *et al*., 1978).

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Editorial Note: The editors of *Permophiles* do not condone personal attacks or statements of interpretation or misinterpretation by excessive extrapolation or innuendo as is the case in the following article. However, the editors felt that a thorough edit of this paper would substantially change the author's meaning and as such have only edited misspellings, the most obvious grammatically awkward statements, and consistency of citations in the text, and the standard stages in the figures to conform to that recognized by the ICS (Remane, 2000).

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Integrated Permian ammonoid, conodont, fusulinid, marine ostracod and radiolarian biostratigraphy

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Ammonoid, conodont, fusulinid, ostracod and radiolarian biozonations and their assumed mutual correlations are presented in five figures. The Standard, Tethyan and Russian (Cis-Urals, Russian Platform) stages and their mutual correlation are shown. The numerical age of most of the stage boundaries in the Permian must be interpolated from the few reliable radiometric dates (interpolated numerical ages are shown in italics) using such data as the thickness of Panthalassa radiolarites with assumed uniform depositional rate in the different stages, number of comparable biozones of different biozonations within one stage, evaluation of Milankovitch cyclicity. Few radiometric data are known from the Permian (indicated in normal numbers).

Zonations throughout the Permian exist for ammonoids, conodonts, fusulinids and radiolarians, but the uppermost Permian *Pleuronodoceras occidentale* and *Hypophiceras changxingense* ammonoid zones just below the boundary clay up to the Permian-Triassic boundary have not yielded any fusulinids and radiolarians. An ostracod zonation on the base of phylomorphogenetic lineages is only known for the Tethyan Upper Permian (Kozur, 1985). Ostracod zonations for the Cis-Uralian Lower Permian, especially for the Kungurian, are mainly based on facies-related faunistic changes of smooth bairdiids and other predominantly smooth facies dependent forms, and have therefore only a restricted regional importance in the Cis-Uralian area. It is not clear whether the zones are synchronous throughout the Cis-Urals without independent stratigraphic control. Therefore, these zones are not shown.

Permian provincialism

Ammonoid provincialism

Throughout the Permian, a strong ammonoid provincialism is known, indicated by very different low latitude and high latitude faunas. However, Guadalupian and Lopingian high latitude ammonoid faunas are not well known except the Boreal faunas of the *Otoceras concavum* and *O. boreale* Zones, marginal Boreal and marginal Gondwanid Dzhulfian faunas with *Cyclolobus*, and marginal Boreal Roadian faunas with *Daubichites* and *Sverdrupites*. Only the Roadian faunas show a somewhat lower degree of provincialism because *Daubichites* is also present in low latitudes.

Among the low latitude ammonoid faunas of the intraplatform basin have partly similar faunas to the open sea associations (*e.g.* type Wordian ammonoid fauna of the Delaware Basin and the very similar, easily correlatable Tethyan Wordian ammonoid faunas of Rupe del Passo di Burgio or Oman, *e.g.* Rustaq, Wadi Wasit). However, partly, there are also distinct differences (*e.g.* Wordian ammonoid faunas of the South Chinese intraplatform basins). During the Lopingian, the provincialism within the low latitude ammonoid faunas becomes distinctly higher. The Dorashamian ammonoid faunas from the open sea Tethys, *e.g.* the upper Dorashamian *Paratirolites* fauna has a very wide distribution throughout the Tethys (*e.g.* Central Iran, NW Iran, Transcaucasia, Southern Alps) and in Madagascar. The Changhsingian ammonoid fauna of the South Chinese intraplatform basins is totally different from the Dorashamian faunas and cannot be correlated with ammonoids from the Dorashamian faunas. Wuchiapingian ammonoid faunas of the South Chinese intraplatform basins are likewise rather different from Tethyan and the few known North American (Coahuila, Mexico) Dzhulfian ammonoid faunas.

Conodont provincialism

In the conodont faunas, the provincialism is not strong during the Asselian to Artinskian interval (Kozur, 1995, Mei and Henderson, 2001). Only in the Boreal conodont province few forms occur, such as *Gondolelloides canadensis* Henderson and Orchard, which are not present in other provinces. The conodont provincialism becomes distinct during the Kungurian, and therefore Kozur (1995) established an independent Kungurian conodont zonation for the Eastern Gondwana province. In the Guadalupian and Lopingian the conodont provincialism is very strong (Kozur, 1995, Mei and Henderson, 2001).

The extreme Kungurian provincialism between the Tethyan and Boreal provinces established by Mei and Henderson in numerous papers, *e.g.* Mei and Henderson (2001) and Henderson and Mei (2003) is partly constructed by miscorrelation of upper Wordian Tethyan conodont faunas with the lower, middle or upper Kungurian. By this correlation of these authors the advanced *Waagenoceras* of the stratum typicum of the *Waagenoceras* type species in Rupe del Passo di Burgio is regarded as a Kungurian genus and the upper Roadian to Capitanian genus *Waagenoceras* would get a Kungurian type species (!) what would be a biological miracle because *Demarezites*, the forerunner of *Waagenoceras*, has its first appearance datum (FAD) in the Roadian and the successor genus cannot begin before the ancestor genus.

The correlation by Mei and Henderson also causes problems for the fusulinid zonation because Rupe del Passo di Burgio has a rich lower Midian fusulinid association (Kozur and Davydov, 1996), and, consequently, Mei and Henderson (2001) assigned also this lower Midian fauna into the Kungurian. Leven (2001) pointed out, if the conodont correlation of the largest part of Tethyan Guadalupian fusulinid zones with the Kungurian is correct, the Roadian, Wordian and Capitanian cannot be used for the Tethys. This is, of course, also not in the interest of Henderson (who voted in favour of the Guadalupian stages) and Mei, and we all wanted also to apply the Guadalupian stages to the Tethys and the margin of Panthalassa. Therefore, this correlation problem must be solved very soon before the Tethyan workers decide that the Guadalupian standard zonation is not acceptable.

Finally, the correlation by Mei and Henderson (2001) brings also problems with the correlation of the palaeomagnetic Illawarra Reversal, one of the most important stratigraphic marker levels in the Permian. In the Tethys, it lies close to the base of the Midian (Zakharov and Sokarev, 1991). According to the correlation by Mei and Henderson (2001), the Illawarra Reversal would be situated within the Tethyan Kungurian. According to investigations of Menning in Glenister *et al.* (1999) within the upper type Wordian of the Delaware Basin and on the Russian platform it lies at the base of the upper Tatarian (Zakharov and Sokarev, 1991), far above the type Kungurian. It is impossible that the Illawarra Reversal lies in the Tethys in an other level (Kungurian) as in the Guadalupian type area (upper Wordian) and in the Kungurian type area (within the Tatarian, in a level which corresponds to the upper Wordian). The position of the Illawarra reversal shows that the lower Midian above the Illawarra reversal, belongs not only to the Wordian, but to the upper Wordian, exactly the same correlation which is indicated by complex evaluation of all faunal elements for Rupe del Passo di Burgio in the Sosio valley of western Sicily and in the Rustaq and Wadi Wasit sections of Oman (Kozur *et al.*, 2001, Kozur and Wardlaw, 2002).

Moreover, a Wordian conodont age of the Oman fauna with *M. siciliensis* and *M. omanensis* is even directly indicated by the presence of *M. aserrata* Clark and Behnken, the index species of the Wordian. This is also indicated by ammonoids. The Wadi Wasit section contains not only the upper Wordian ammonoid fauna with *Waagenoceras*, but also the upper Wordian to Dzhulfian ammonoid genus *Timorites* (L. Krystyn, pers. comm.) and Midian fusulinids and small foraminifers.

Foraminifer provincialism

Among the benthic fusulinids the Permian provincialism is very strong. During the Asselian, when a wide Cis-Uralian connection was present between the Arctic (and North America) and the Tethys, the provincialism was distinct, but fusulinid correlation was possible from the Tethys to the Cis-Urals, Boreal realm and western North America. With the successive restriction of the Tethyan¯Cis-Uralian¯Boreal connection, the fusulinid provincialism between the Tethys, Cis-Urals, the Boreal realm and western North America became stronger and stronger. With the interruption of the Cis-Uralian connection during the Kungurian and younger time and the disappearance of the fusulinids in the Boreal realm at the base of the Roadian, the provincialism between the low latitude Tethyan and North American fusulinid fauna was so strong that almost no direct correlation with fusulinids is possible during the Guadalupian. Only during the Capitanian, one Tethyan fusulinid genus, *Yabeina*, migrated to western North America including the Guadalupian type area. Differences are also present between the Tethyan and the Perigondwana fusulinid faunas.

During the Lopingian, the fusulinids were restricted to the Tethys and marginal intraplatform basins. But even within this area, the Lopingian fusulinid fauna was not uniform. For instance, the *Palaeofusulina* fauna is not present everywhere in the fusulinid faunas of the Tethys and their marginal seas.

Radiolarian provincialism

Little is known about provincialism in radiolarian faunas. Within the low latitude areas, the Cisuralian radiolarian faunas are uniform within the Tethys, the Circum-Pacific realm and in western North America. This is also the case during the Guadalupian with its strong provincialism among many faunal groups within the low latitude faunas. Thus, in any case, the radiolarian provincialism is less pronounced than in conodont faunas. However, high latitude radiolarian faunas are not well known in the Permian. The Cis-Uralian radiolarian fauna may represent a Boreal fauna or may be influenced by the Boreal fauna. The Asselian fusulinid fauna of the Cis-Urals is identical with the Tethyan fauna and the Tastubian radiolarian faunas of the Tethys and the Cis-Urals have some identical species, but also some differences. The Sterlitamakian and Artinskian radiolarian faunas of the Cis-Urals show distinct differences to the uniform Tethyan, Panthalassan and North American low latitude faunas, but these differences may be partly caused by facies differences because the limestones with radiolarians of the Cis-Urals were deposited in distinctly less water depth than the radiolarites of the Tethys and, above all, of Panthalassa.

A distinct radiolarian provincialism is present within the Lopingian low latitude Tethyan fauna. In the western Tethys, there are two Lopingian radiolarian faunas in deep-sea sediments, one with *Neoalbaillella* and dominating *Imotoella* in the Palaeotethys and its back arc basins in Turkey, and a totally different fauna with *Ishigaconus*, *Lacisus* and *Cariver* in the Neotethys (Kozur, 1999). Both are low latitude faunas, but it seems that the *Imotoella* fauna does not occur in the equatorial tropical belt, but in subtropical regions. These differences are also recognisable between different terranes in Japan and China, but there some species are identical between the two faunas. This indicates that in the western Tethys the Palaeotethys and Neotethys are separated during the Lopingian by a total ecologic barrier for radiolarians (*e.g.* a subaerial area on the Cimmerian microcontinent which existed through large parts of the Triassic may be present already in the Lopingian). Further in the east the two radiolarian faunas had some exchange through deep-water areas but because of provincialism no full faunal exchange was possible within the two mentioned Tethyan-Panthalassan low latitude faunas. Partly the *Imotoella* fauna may be also related to cold-water upwelling.

On the other hand, in low latitude terranes in New Zealand the Lopingian *Ishigaconus-Lacisus-Cariver* fauna is present, which is also present in post-Lamar beds immediately below the Ochoan with primitive *Clarkina postbitteri* Mei and Wardlaw in the Delaware Basin. In high or median latitude terranes in New Zealand the *Imotoella* fauna is present with no distinct differences to the low latitude, but not equatorial radiolarian fauna (Takemura *et al.*, 2003).

Ostracod provincialism

The ostracod faunas as benthic faunas should be expected to have a strong provincialism during the Permian. However, as far as data are known, the provincialism was not so strong as for the ammonoid and conodont faunas. Several Tethyan Guadalupian species occur also in western North America. Even in the lower Dzhulfian of the Bükk Mts. (Hungary) in the western Tethys and in the contemporaneous Germanic Zechstein are some identical species present despite the fact that a rather broad continental barrier was present between the Zechstein Basin and the Tethys, and the faunal exchange must go from the Germanic Basin across the Boreal Sea north of Europe and Asia, along the western Panthalassa margin in eastern Asia and across the entire Tethys from its easternmost end to its western end across different ammonoid and conodont faunal provinces.

Remarks to the conodont zonation

Kozur (*e.g.* 1995, 1998) used the FAD of *S. invaginatus* Chernykh and Reshetkova for definition of the base of the Permian before *S. isolatus* was established by Chernykh *et al.* (1997), and therefore *S. invaginatus* was used together with other conodonts in the conodont Zone of the basal Asselian. As *S. invaginatus* and *S. isolatus* have exactly the same FAD and range, the *S. invaginatus-S. isolatus* Zone is here used for the basal conodont zone of the Permian. The base of the Sakmarian was placed by Kozur (1995) at the FAD of *Sweetognathus merrilli* Kozur and this definition is now seemingly widely accepted (Chuvashov *et al.*, 2003a).

The base of the Artinskian is not yet well defined by conodonts. Often the FAD of *Sweetognathus whitei* (Rhodes) is used to define the base of the Artinskian (Chuvashov *et al.*, 2003). The FAD of *S. whitei* in a phylomorphogenetic cline is perhaps a good boundary marker, and Kozur (1978, 1995, 1998) also uses *S. whitei* for the lowermost Artinskian conodont zone, but before the FAD of *S. whitei* is used for definition of the base of the Artinskian, the stratum typicum of *S. whitei* should be re-studied in detail. The holotype of *S. whitei* comes apparently from pre-Artinskian beds because it has been derived from beds dominated by *Streptognathodus* (Rhodes, 1963). This latter genus is nowhere common in the lower Artinskian, where it always rare and has its last occurrence, represented by other (Artinskian) species then in the association with *S. whitei*. Thus, may be that *S. whitei* from the Artinskian is another species, or *S. whitei* begins already within the Sakmarian.

A good agreement is with the base of the Kungurian at the FAD of *Neostreptognathodus pnevi* Kozur and Movshovich (Kozur, 1993, 1995, 1998, Jin Yugan *et al.*, 1997, Chuvashov *et al.*, 2003).

There is a full agreement to define the base of the Roadian, Wordian and Capitanian with the FAD of *Mesogondolella nankingengsis* (Jin/King), *M. aserrata* (Clark and Behnken) and *M. postserrata* (Behnken) respectively. The problem is with the correlation of the Delaware Basin and South Chinese intraplatform basins with the open sea Tethyan fauna. According to the unproven hypothesis of Mei and Henderson (2001) regarding the conodont provincialism that all Guadalupian *Mesogondolella* of the low latitudes are serrated forms (their *Jinogondolella*), Mei and Henderson assigned in many papers typical upper Wordian (lower Midian) ammonoid, conodont, radiolarian and fusulinid Tethyan faunas into the lower, middle or upper Kungurian. However, the total replacement of smooth by serrated *Mesogondolella* is only the case with the *Mesogondolella* of low latitude intraplatform basins of the Ouachita-Cathaysia conodont province (Kozur *et al.*, 2001), which have according their ostracod faunas also in great water depth warm water conditions, but not in the low latitude Tethyan open sea faunas with cold bottom water and palaeopsychrosphaeric ostracods, which have smooth *Mesogondolella* of the *M. siciliensis* group. In the western Tethys, even shallow pelagic deposits with warm bottom water (*e.g.*, Rupe del Passo di Burgio) have smooth *Mesogondolella* of the *M. siciliensis* group.

The oldest conodont of the *M. siciliensis* group is *M. saraciniensis* Gullo and Kozur which defines the lower Roadian. In the middle Roadian *M. siciliensis* begins which is in the middle Roadian accompanied by *Mesogondolella* n. sp. of the *M. phosphoriensis* group which is also known from the western USA. There, as well as in Sicily, it was so far assigned to *M. phosphoriensis*, but have not the platform outline of the holotype of this species. *M. siciliensis* is from the upper Roadian to large parts of the Wordian the only gondolellid species of the Tethys. Only in the uppermost Wordian, investigated from Oman (Rustaq

My		Standard Stage	Tethyan Stage	Fusulinid Zone (Tethys)	Ammonoid Zone		Conodont Zone	Radiolarian Zone	
					Cis-Urals/Arctic	low latitudes		low latitudes	Cis-Urals
269	CISURALIAN	Kungurian	Bolorian	Misellina parvicostata		Perrinites hilli	Mesogondolella lamberti-N. sulcoplicatus	Pseudoalbaillella rhombothoracata	
				Brevaxina dyhrenfurthi			M. zsuzsannae – Sichuanognathus ? prayi	Parafollicucullus ornatus	Pseudolithelius permicus-Ruzhencevisp. uralicus
							Mesogondolella glenisteri – N. exsculptus		
275			Yakhtashian	Chalaroschwagerina vulgaris, Pamirina (P.) darvasica			M. intermedia-N. exsculptus- N. pnevi		
		Artinskian			Neoc. fredericksi	Perrinites tardus	M. bisselli – N. pequopensis	Parafollicucullus lomentarius	Polyedroent. lautitia
					Aktub. notabilis		M. bisselli – N. ruzhencevi		
280.3				Pamirina (Levenella) leveni Chaleroschwagerina infrata	Neoshumardites triceps	Metaperrin. cumminsi	Mesogondolella bisselli – Sweetognathus whitei		Pa. cataphracta
		Sakmarian	Sakmarian		Andrianovia sakmarae	Properrinites boesei	Mesogondolella bisselli – M. visibilis – Sweetognathus primus		C. monopt.-P. plumata F. circumfusa
287				Robustoschwagerina schellwieni– Parasch. mira	Syn. principalis Svetlanoveras strigosum	Prop. bakeri	Mesogondolella uralensis – Sweetognathus merrilli	Pseudoalbaillella (Kitoconus) elegans	Holdsworthella perforata
		Asselian	Asselian	S. glomerosa-S. sphaerica			Streptognathodus barskovi	Curvalbaillella uforma	Curvalbaillella uforma
				Pseudoschwagerina uddeni	Svetlanoceras serpentinum		Streptognathodus constrictus		
290.6				Pseudoschwagerina saibulakensis			Streptognathodus cristellaris		
292				Sphaeroschwagerina fusiformis – Sphaeroschwagerina vulgaris	Svetlanoceras primore		Streptognathodus invaginatus – Streptognathodus isolatus		

Figure 1. Lower Permian (Cisuralian) Stages, Tethyan Stages, ammonoid-, conodont-, fusulinid-, and radiolarian zonations, measured and estimated (italics) numeric ages.

and Wadi Wasit sections), it is accompanied by of *M. omanensis* Kozur and Wardlaw n. sp. which was by Henderson and Mei Shilong (2003) assigned to *M. lamberti*, an uppermost Kungurian form. Within the uppermost Wordian, *M. omanensis* replaces more and more *M. siciliensis* toward the top of the Wordian.

In the atoll sequence of Rustaq, this *M. siciliensis-M. omanensis* fauna is accompanied by *M. aserrata*, when the atoll sequence is in greater water depth cut from the open sea. The occurrence of *M.aserrata* in this section is the first evidence of the index species of the Wordian in the Tethyan faunal province.

The ammonoid fauna of this level is similar to the upper Wordian ammonoid fauna of Rupe del Passo di Burgio, which is the richest Wordian ammonoid fauna in the world and is since 70 years the anchor point for the correlation of the Tethyan Wordian fauna with the type Wordian fauna in the Delaware Basin. Almost all Tethyan Wordian ammonoid faunas belong to this level and belong to the lower Midian in the fusulinid scale. This level is characterised by a sea-level highstand. The Wadi Wasit fauna belongs to the latest Wordian and contains already *Timorites* (L. Krystyn, pers. comm.) which begins in the upper Wordian and is specially characteristic for the Capitanian and still present in the Dzhulfian.

Henderson and Mei (2003) assigned the Rupe del Passo di Burgio, Rustaq and Wadi Wasit fauna into the Kungurian leaving for the entire Guadalupian only the upper Midian fauna.

The Wadi Wasit section, which begins in the upper Wordian, has a continuous upper Wordian to lower Dzhulfian sequence and ranges after a thick and widespread breccia horizon until the Early Triassic. Wardlaw (2003) stated that he has not seen any *M. stampflii* and C. *postbitteri* in the material from Wadi Wasit which I have given him. This is quite clear because I have given him only upper Wordian material what was first dissolved, and the topic of our joint conodont studies. Subsequently also the Capitanian and Dzhulfian material was dissolved which yields the most complete Tethyan uppermost Wordian to lowermost Dzhulfian pelagic conodont-dated succession of the Tethys, which is rich in conodonts, partly also in ostracods and yields also some radiolarians. Shorter parts of this sequence (*e.g.* the interval from the *M. stampflii* to the *C. postbitteri* Zones) with the same conodont succession are also known from Batain (Oman). There, they are partly accompanied by rich radiolarian faunas.

As well recognisable in Wadi Wasit, *M. siciliensis* is above the ammonoid-proven uppermost Wordian fauna with *Waagenoceras* and *Timorites* gradually and finally totally replaced by *M. omanensis*. In the same time, the upper Wordian *Parafollicucullus fusiformis* and *P. globosus* radiolarian fauna continued, which occur also in the upper *Wordian* and lower Capitanian of the Delaware basin and in Japan. The lower Capitanian conodont fauna is gradually replaced by the *Mesogondolella stampflii* fauna. *M. stampflii* is the youngest smooth *Mesogondolella* of the low latitude Tethyan conodont province. It is in Wadi Wasit immediately followed by the Lopingian *C. postbitteri* fauna. According to the assumption of Mei and Henderson (2002) that in the Tethys the Guadalupian is characterised by serrated *Mesogondolella*, and all post-Artinksian—pre-Lopingian faunas with smooth *Mesogondolella* must be Kungurian, in pelagic deposits of the entire Tethys the Kungurian is followed concordantly by Lopingian. However, the accompanying faunas in the Tethyan upper Wordian and

My		Standard Stage	Tethyan Stage	Tethyan Fusulinid Zone		Tethyan Ammonoid Zone	Conodont Zone			Radiolarian Zone	
252.7	LOPINGIAN	Changhsingian	Dorashamian			Hypophiceras changxingense	Clarkina meishanensis-Hind. praeparvus				
				Palaeofusulina sinensis		Pleuronodoceras occidentale	C. praemeishanensis				
						Paratirolites waageni	Clarkina iranica			Lacisus siphunculus – Cariver dorsoconvexus	Imotoella excelsa – Neoalbaillella grypa
							C. yini horizon				
							Clarkina changxingensis-Clarkina deflecta				
						Shevyrevites shevyrevi	Clarkina subcarinata			Neoalbaillella ornithoformis	
						Dzhulfites spinosus					
						Iranites transcaucasicus					
						Phisonites triangulus					
257.2		Wuchiapingian	Dzhulfian	Palaeofusulina fusiformis – Nanlingella		Vedioceras ventroplanum	Clarkina mediconstricta			Neoalbaillella optima s.s.	
							Clarkina orientalis				
							Clarkina transcaucasica				
						Araxoceras latum	Clarkina leveni				
				Codonofusiella kweichowensis		Roadoceras-Doulingoceras	Clarkina niuzhuangensis				
							Clarkina dukouensis				
							Clarkina postbitteri			Cariver orthogonus-Ishigaconus hamatus	
262	GUADALUPIAN	Capitanian	Midian	Afghanella robbinsae	Yabeina globosa	Timorites – Waagenoceras	M. altudaensis-C. crofti	Mesogon. stampflii	M. stampflii – I. erwini	Follicucullus ventricosus – Ishigaconus scholasticus	
							M. shannoni		M. s.-R. f.	P. convexus-F. porrectus	
					Yabeina archaica		M. postserrata		M.o.-M.s.	Parafollicucullus monacanthus	
265								M. omanensis		P. fusiformis – P. globosus	
265.3		Wordian					M. aserrata	M. sicil.-M. omanensis			
				Kahlerina – Dunbarula							
			Murgabian	Afgh. schencki	N. haydeni	Waagenoceras		M. siciliensis		Parafollicucullus globosus-Parafollicucullus longtanensis	
266.5				A. tereshkovae	N. cratulifera						
		Roadian		P. schellwieni-P. neoschwager.	N. simplex		Mesogondol. nankingensis				
			Kubergandinian		Cancellina cutalensis	Demarezites - Perrinites vidriensis		M. siciliensis-Mesogondolella n. sp.		Parafollicucullus corniculatus	
269				Armenina, Misellina ovalis				Mesogondolella saraciniensis		Spinodeflandrella foremanae – Parafollicucullus cornelli	

Figure 2. Middle and Upper Permian (Guadalupian and Lopingian) Stages, ammonoid-, conodont-, fusulinid-, and radiolarian zonations. Numeric ages in italics are estimations. M.s. – R.f. = *Mesogondolella stampflii – Rabeignathus fengshanensis* Subzone. M.e. –M.s. – *Mesogondolella omanensis – M. stampflii* Subzone.

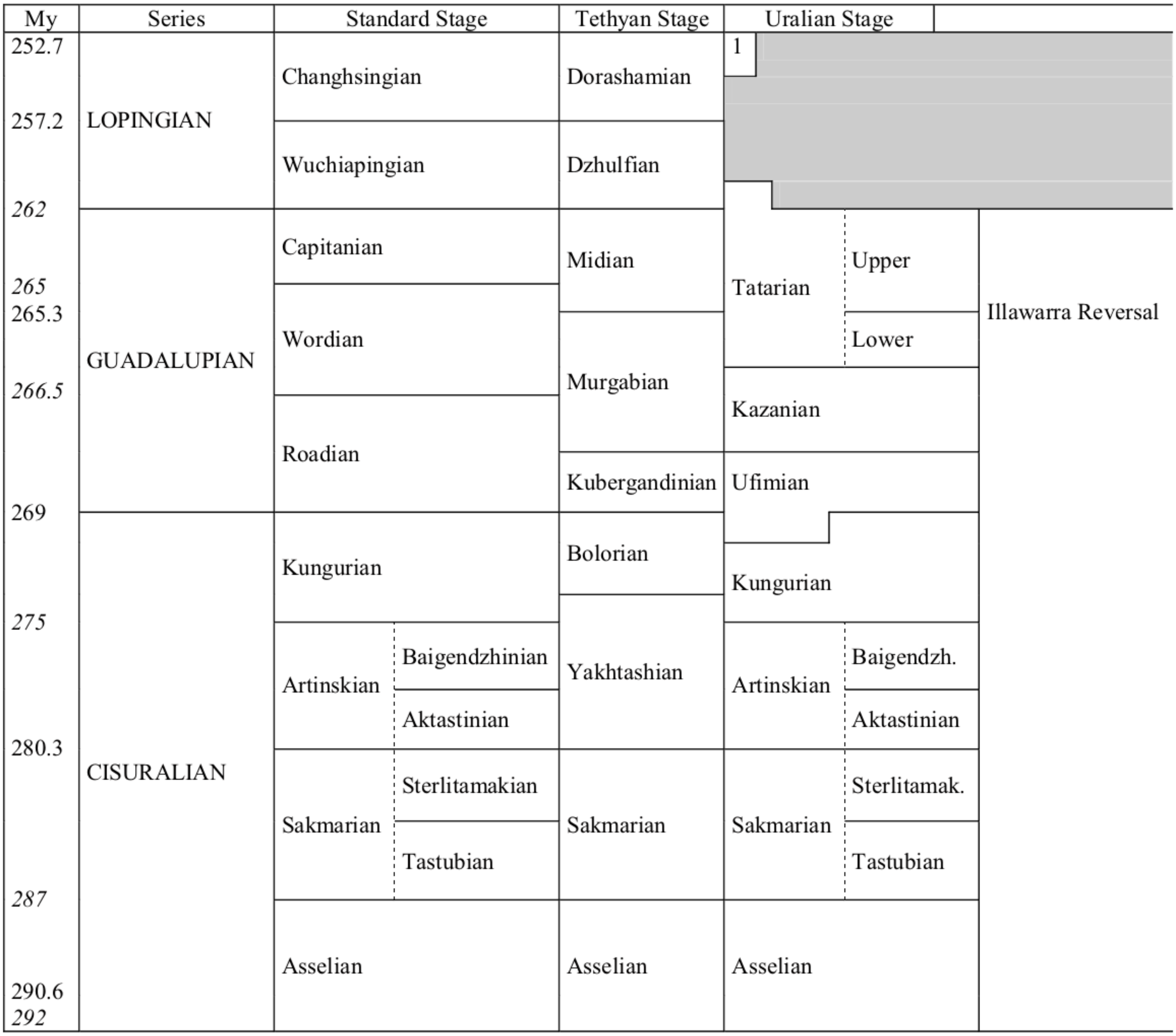

Figure 3. Permian Standard, Tethyan and Uralian Stages, position of Illawarra Reversal, measured and estimated (italics) numerical age. Filled area: Gap 1: lowermost Vetlugian (Nedubrovo).

Capitanian show a totally different picture, the presence of smooth *Mesogondolella* of the *M. siciliensis* group throughout the entire Guadalupian.

In the stratum typicum of *M. stampflii* in Sicily, an isolated block, it is the only conodont species. The late Capitanian age is in this block well established by the radiolarian fauna with *Follicucullus dactylinus* Rudenko and Panasenko, *F. porrectus* Rudenko and *Parafolliculluus convexus* (Rudenko and Panasenko). This radiolarian fauna is known from the second highest radiolarian zone of the type Capitanian in the Delaware Basin and is widespread in the upper Capitanian from Panthalassa to the westernmost Tethys. In the deeper, but more marginal environment (with transported fossils from adjacent shallower deposition areas) of the Wadi Wasit section, *M. stampflii* is accompanied (except ostracods and some radiolarians) in ascending order by *M. omanensis*, *Rabeignathus fengshanensis* and *Iranognathus erwini*, which allows the subdivision of the *M. stampflii* Zone into 3 subzones, which can be also recognized in Batain.

The *M. stampflii* fauna is gradually followed by the *C. postbitteri* fauna of the Lopingian. With the FAD of *C. postbitteri* a strong faunal change can be observed in radiolarians and other faunal groups. There begin the typical Lopingian fauna. The base of the Lopingian defined by a taxon which occurs only in very few sections of South China and nowhere else in the world is unsuitable for any correlation outside these few sections in South China, and can therefore not be applied. For this reason, the boundary outside this small area in South China, where the two subspecies created by Henderson *et al.* (2002) must be placed at another stratigraphic level, the FAD of *C. postbitteri*, where also the Lopingian radiolarian fauna begins.

The Lopingian boundary accepted by the Permian Subcommission is the only boundary in the Phanerozoic, from which the index species for the base of a stratigraphic unit (Lopingian Series, Dzhulfian = Wuchiapingian Stage) is known only from few sections in a very restricted area in South China, but not present in North America, in the Tethys or any other section outside this restricted area with this endemic taxon. Moreover, there are severe taxonomic problems with the definer taxon, despite taking into consideration the view of Mei (written comm.) that I am too old to understand his excellent taxonomy (a view that was rejected by Henderson, written comm.) which is, therefore not representative for the Chinese-American group. The differences are simply caused by the horizontal taxonomy [as conceived by the author, *this is a new term to the editors*] used by Mei, and partly, also, by Henderson and Wardlaw. This horizontal taxonomy works only, if the age of the fauna is precisely known. Then minor intraspecific differences are used to separate taxa from a well dated succession that cannot be found, if no well known succession is known and needs to be established. Characteristic for the horizontal taxonomy is that not the differential diagnosis, based on the holotypes and the intraspecific and ontogenetic variations within the compared taxa is used, but features are listed to separate two taxa which are not present, if the two holotypes and paratypes are compared. Kozur (2003) has re-figured the two holotypes of the subspecies discriminated within *C. postbitteri* and some paratypes, all re-figured from the papers of the authors of the two taxa to avoid discussions that these figured forms come not from the beds from where these authors have reported them and do not belong to the taxa which were established by these authors. Wardlaw (2003) wrote that *C. postbitteri postbitteri* has wider separated denticles, but the comparision of the two holotypes shows that in these specimens the distances between the denticles of the carina is the same. *C. postbitteri postbitteri* should have a distinct gap between the cusp and the first denticle before it, whereas in *C. postbitteri hongshuensis* this gap is missing. Both holotypes show the same distance between the cusp and the denticle in front, and one of the two paratypes of *C. postbitteri hongshuensis* which should not have this gap shows a very distinct gap between the cusp and the denticle in front, and the distance between these two denticles is much wider than in the holotype of *C. postbitteri postbitteri* which should have this feature. It is not necessary to continue this discussion because so far nobody has found the definer subspecies outside the very few sections in China, where it occurs and my studies in the Tethys have shown that it is not present.

In the worst case, the horizontal taxonomy leads to a situation that authors using this kind of taxonomy cannot recognise their own species and misidentify them, if they think, that the beds have an other age, where these forms should not occur, or they determine unrelated species as their species, if they think that in beds of an incorrectly assumed age these forms should occur. This leads to miscorrelations, if the assumed age is wrong or not known. Best examples are the determinations of Kungurian conodonts in the late Wordian ammonoid-rich red pelagic limestones of the Rustaq and Wadi Wasit sections of Oman in Henderson and Mei (2003). They determined the uppermost Wordian to lower Capitanian *M. omanensis* as their their Kungurian species (subspecies) *M. lamberti* Henderson *and* Mei despite the fact that the sections contain advanced *Waagenoceras* and many other Wordian ammonoids and partly even *Timorites,* which begins only in the upper Wordian (also in the Guadalupian type area) because they believe on the base of an erroneous assumption to the palaeobiogeography (see above) that these beds are Kungurian. This is the more strange as the Rustaq section contains *M. aserrata,* the conodont index species for the Wordian. Smooth forms of this species they described as a new Kungurian species despite the fact that also in the Wordian type section a large part of *M. aserrata* has no well recognisable serrations (name !). The slightly serrated typical *M.* aserrata they determined as Kungurian transition forms from Kungurian smooth *Mesogondolella* to Roadian *M. nankingensis* because they believe that the beds are Kungurian and according the horizontal taxonomy they cannot have *M. aserrata*. This determination are not understandable because both forms can be easily distinguished at the lower side. In *M. aserrata*, a distinct true keel is present in the anterior part of the attachment surface ("keel" of gondolellids) which is especially long in advanced *M. aserrata*. The forms of Rustaq have all a long true keel as the advanced upper Wordian *M. aserrata*. The transitional forms between Kungurian smooth *Mesogondolella* and serrated *M. nankingensis* have no true keel, a feature which begins only in advanced *M. nankingensis* in the anteriormost part of the attachment surface.

The most impressive example for the danger of the horizontal taxonomy is presented by Mei in Sweet and Mei (1999a,b). Mei restudied the collections of Sweet from the Kuh-e-Ali Bashi sections in Iran as I did several years ago. Whereas I confirmed the determinations of Sweet (Dorashamian conodonts in the Alibashi Formation of localities 1 and 4), Mei confirmed this only for locality 1, whereas he found the entire Dzhulfian conodont succession in locality 4 without any Dorashamian (Changxingian) conodonts. Teichert *et al.* (1973) established the Dorashamian Alibashi Fm. for a sequence of red pelagic limestones and shales which are underlain by upper Dzhulfian red pelagic limestones of the upper Jolfa Fm. and overlain by the Elikah Formation, which starts with the uppermost Dorashamian Boundary Clay containing *C. meishanensis* and *H. praeparvus*, but belongs to its largest part to the Lower Triassic. Locality 1 and 4 are situated at the same slope of a small Wadi which is nearly parallel to the broad main Wadi of the Kuh-e-Ali Bashi area near Jolfa in northwestern Iran. Both localities are well documented by photographs in Teichert *et al.* (1973) and as the slope has no forest or other dense vegetation, all prominent beds can be followed in the distance of some 100 m between the two localities as already pointed out by Teichert *et al.* (1973). Both are overlain by the mainly lower Triassic Elikah Fm. and underlain by the red upper Jolfa Fm. with *C. orientalis* and other upper Dzhulfian conodonts. The macrofauna of locality 4 is well shown in Teichert *et al.* (1973) and contains among other Dorashamian forms in the upper two third of the section the upper Dorashamian ammonoid genus *Paratirolites* and throughout the Alibashi Fm. the small brachiopod *Araxathyris araxensis minor*. I have sampled in two excursions about 1000 kg limestones and clays from the Alibashi Fm. of Kuh-e-Ali Bashi and I could fully confirm both the data about the macrofauna distribution in locality 4 (Kummel andTeichert in Teichert *et al.*, 1973) and the conodont data (Sweet in Teichert *et al.*, 1973). Of course, in 1973, as Sweet established *C. subcarinata*, he included all the species, which were later separated, in this species, but also he did not found any Dzhulfian form in the Alibashi Fm. of locality 4, but only Dorashamian species.

In the collection of Sweet, the uppermost *Paratirolites* Limestone of locality 4 contains *C. sosioensis* Gullo and Kozur, which is a characteristic species of the uppermost Dorashamian, in a level, which is not present in Meishan and other South Chinese sections (see below). Mei determined obviously this species as the morphologically similar, but unrelated *C. orientalis* and in his horizontal taxonomy he was successful to find all the Dzhulfian conodont zones below the *C. orientalis* Zone except the *C. leveni* Zone despite the fact that none of these zones are present in the Alibashi Formation and it would be also very strange that in the same beds which can be followed from locality 1 to locality 4 in a distance of few hundred metres, the fauna changes from a 100 % Dorashamian fauna (locality 1) into a 100 % Dzhulfian fauna. Moreover, just the *C. leveni* Zone comprises about 90 % of the Dzhulfian in Kuh-e-Ali Bashi and *C. leveni* is very common in this zone. The reason why Mei did not recognise this species in locality 4 even in his horizontal taxonomy is that it is so different from all Dorashamian species that he could not misidentify a Dorashamian conodont species as *C. leveni*.

To prove the Dzhulfian age of locality 4, Mei reported also Dzhulfian macrofauna and fusulinids in locality 4, starting with *Codonofusiella* at the base, and *Araxilevis*, *Araxoceras* and *Vedioceras* in ascending order. As he was never in the Kuh-e-Ali Bashi sections, these new data about the macrofauna in the Ali Bashi Formation of locality 4 must be obtained by re-examination of its fusulinid, ammonoid and brachiopod fauna from the material of Teichert *et al.* (1973). However, it is not to understand, how he could re-determine *Paratirolites* from locality 4 as *Vedioceras* or *Araxceras* as they belong to different superfamilies and the tiny brachiopod *Araxathyris araxensis minor* as the big brachiopods *Araxilevis* which are very different. *Codonofusiella* cannot occur in the pelagic red limestones without input of shallow water material of the Alibashi Formation for facies reasons because fusulinid cannot live in such facies and transport from shallow water areas is not present in the Alibashi Formation. Moreover, *Codonofusilella* is only present in the shallow water black to dark-grey limestones below the Jolfa Fm. and was never reported from red pelagic limestones of the Alibashi Formation. *Araxilevis* is restricted to the lower part of the Jolfa Formation, likewise from dark grey or black limestones and marls. *Araxoceras* occurs in the Iranian section exclusively in grey to light grey beds and not in red limestones and shales. Only *Vedioceras* occurs in red pelagic limestones, but in the red upper Jolfa Formation and not in *Paratirolites* Limestone of the upper Alibashi Formation and never together with *Paratirolites*.

In all Iranian sections there are two additional conodont zones, the *C. iranica* Zone and the *C. praemeishanensis* Zone between the *C. yini* fauna of the uppermost *C. changxingensis*-C.*deflecta* Zone and the *C. meishanensis*-*H. praeparvus* Zone, which are not present in South China. As they contain a very different conodont fauna from the under – and overlying zones, they are obviously missing in Meishan at a gap which is seemingly also indicated by the ä ^{13}C curve in Meishan with a distinct negative excusion just at the base of the Boundary Beds which is not present in continuous shallow water or deep water section outside China (Korte and Kozur, in press).

Remarks to the Cis-Uralian radiolarian zonation

Amon and Chuvashov (2003) presented a radiolarian zonation for the Lower Permian of the Cis-Uralian region, which is in some respect different from that presented here. The reasons for the differences are mostly to recognise, except for the *Haplodiacanthus anfractus* Zone in the upper Asselian, as the holotype of this species has been derived from the Artinskian.

In a discussion with Dr. Amon in Lausanne he promised me to check whether my or his data to the age of the holotype of *Parafollicucullus anfractus* are wrong. In the moment, the causes for this discrepancy cannot be discussed.

Other differences are caused by taxonomic problems or the use of facies-controlled fossils as zonal index species. *Hapolodiacanthus* is a junior synonym of *Parafollicucullus* (see Kozur and Mostler, 1989). If we do not accept this synonmy and regard instead *Haplodiacanthus* and *Holdsworthella* as synonymous genera, *Haplodiacanthus* is a junior synonym of *Holdsworthella*. Both genera were described in the same year, but *Holdsworthella* was established in February 1981, *Haplodiacanthus* in December 1981. Therefore *Haplodiacanthus* cannot be regarded as the senior synonym but is the junior synonym of *Holdsworthella*.

Copicyntridae are not suitable as zonal index forms as they are typical facies fossils which occur especially in shallower environments and have otherwise a very long range, and may disappear and re-appear with facies changes (shallowing or input of shallow water material).

Independent from the mentioned discrepancies between the two Lower Permian radiolarian zonations, the Sterlitamakian to Artinskian radiolarian zonation of the Cis-Urals is not well worked out and often based on long-ranging facies-controlled Entactinaria species, the occurrence of which may be facies-controlled. The stratigraphically important Follicucullidae are missing or very rare in the Sterlitamakian and Artinskian radiolarian faunas of the Cis-Urals.

The Kungurian *Ruzhencevispongus uralicus* Zone must be regarded as a regional Cis-Uralian zone for a low diversity fauna of long-ranging forms. *R. uralicus* ranges up in Panthalassa and in the Tethys in much younger levels what is not possible in the Cis-Urals because there the level of this zone is the youngest Permian horizon in which for facies reason radiolarians may occur. However, the species seems to begin in the Kungurian. For this reason it has in the Cis-Urals a short range but it cannot be used for correlation beyond the Cis-Urals.

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My		Standard Stage	Tethyan Stage	Fusulinid Zone (Cis-Urals)	Fusulinid Zone (Tethys)
269	CISURALIAN	Kungurian	Bolorian		Misellina parvicostata
				Parafusulina aff. solidissima	Brevaxina dyhrenfurthi
275		Artinskian	Yakhtashian	Parafusulina solidissima	Chalaroschwagerina vulgaris, Pamirina (P.) darvasica
				Eoparafusulina lutugini	Pamirina (Levenella) leveni
280.3				Pseudofusulina concavutas	Chalaroschwagerina infrata
		Sakmarian	Sakmarian	Parafusulina urdalensis	
				Pseudosusulina verneuili	Robustoschwagerina schellwieni – Paraschwagerina mira
287				Pseudofusulina moelleri	
		Asselian	Asselian	Gl. firma- Sph. sphaerica	Sph. glomerosa- S. sphaerica
				Pseudoschwagerina uddeni	Pseudoschwagerina uddeni
290.6				Globifusulina nux	Pseudoschwagerina saibulakensis
292				Sphaeroschwagerina fusiformis – Sphaeroschwagerina vulgaris	Sphaeroschwagerina fusiformis – Sphaeroschwagerina vulgaris

Figure 4. Correlation of the Cisuralian and Permian fusulinid zonations.

Figure 5. Late Permian Tethyan ostracod zonation.

My		Standard Stage	Tethyan Stage	Tethyan ostracod zone
252.7	LOPINGIAN	Changhsingian	Dorashamian	Indivisia buekkensis
				Petasobairdia bidentata
				Parvikirkbya fueloepi
257.2		Wuchiapingian	Dzhulfian	Parvikirkbya transita
				Carinaknightina baloghi
262	GUADALUPIAN	Capitanian	Midian	Hollinella schreteri
265				
265.3		Wordian		
			Murgabian	
266.5		Roadian		
			Kubergandinian	
269				

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Progress on the conodont taxonomy and zonation for the lower part of the Changhsingian.

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In 1981, Zhao *et al*., formally recommended Section D of the Changxing Limestone in Meishan, Changxing County, Zheijiang Province of China as the stratotype of the Changhsingian Stage, with the base of the stage located at the base of bed 2, the horizon between the *Clarkina orientalis* Zone and *Clarkina subcarinata* Zone.

Conodont taxonomy in general, and *Clarkina* taxonomy in particular, have gone through a lot of changes since 1981. The apparatus of Changhsingian *Clarkina* species is very similar in all elements with the Pa element showing the most differentiation for defining species. Species concepts based on the subtle changes in the Pa element have varied, most relying on the outline of the element, which has proved to be very unreliable in the Changhsingian.

Mei *et al*. (1998) tried to consolidate the disparate morphologic form taxa that had been identified as species into several assemblage zones within the Changxing Limestone based on the evolving change in denticulation and noting four "shape classes" in each zone. The shapes were round, square, narrow, and transitional (between square and round), typically referring to the shape of the posterior termination of the Pa element. These shapes correspond to the generalized shape outline form species concepts used by many workers of *changxingensis* (round), *deflecta* (square), *wangi* (narrow), and *subcarinata* (transitional) and yield very little stratigraphic differentiation or precision. However, Wardlaw and Mei (2000) introduced that there is a clear evolutionary progression of denticulation in the Pa elements regardless of posterior termination shape that provides a powerful zonation. Subsequently, Mei *et al.* (2001a, 2001b, 2003) have further refined the phyletic morphocline and the position of zones based on it.

The evolution of the denticulation in the lower part of the Changxing Limestone is characterized in adult specimens of the Pa element. Lambert (1994) discussed a methodology for using size as a proxy of relative maturity by using carina length (proximal to distal denticle apex) in gondolellid platform elements. Small, juvenile forms generally show more discrete denticles than large, adult forms, and then again, very large, gerontic forms display excessive fusion and commonly pathologic, bizarre characters, which is why adult characters are desired to define a species. The evolution in adult Pa elements of *Clarkina* in the lower part of the Changxing Limestone shows progressive change from a very high, discrete, reclined cusp, low partially fused posterior carina rising anteriorly (*C. longicuspidata*, fig. 1) that becomes a highly fused, high carina over its whole length, with a slightly reclined cusp that is not clearly separated from the carina and, in lateral view, looks like a high "wall" (*C. wangi*) Then, the carina reduces in height posteriorly, with denticles becoming partially discrete, and the posterior denticles clearly are separated from the cusp which is erect, showing a posteriorly declining carina and separated cusp in lateral view (*C. subcarinata*). Then, the carina further reduces in height so that the posterior-most denticles are completely discrete and depressed and there is a shallow depression in the platform, the cusp is completely separated and the depression is quite noticeable in lateral view (*C. changxingensis*). These changes in the denticulation occur over short stratigraphic intervals through brief transitional morphoclines and zonations can be based on the first occurrence of an adult Pa element displaying the different, progressive denticulation patterns or in sample-populations in which the characteristic denticulation pattern first dominates.

The change from *Clarkina longicuspidata* to *C. wangi* is expressed in transitional denticulation patterns occurring in Bed 3 of Meishan section D. The first occurrence of typical adult *Clarkina wangi* occurs near the base of Bed 4 (Bed 4a-2, 88 cm above base of section, 6 cm above base of Bed 4, measurement of Mei *et al*., 2003; apparently equivalent to 1.16 m in the section of Yin *et al*., 1996).

The change from *Clarkina wangi* to *C. subcarinata* occurs in Bed 8 (of Sheng *et al*., 1984) and the first occurrence of adult Pa elements with the denticulation pattern of *C. subcarinata* is at 13.71 m above base (section of Sheng *et al*., 1984), which appears to be within Bed 11 of Yin *et al*. (1996).

The change over to *Clarkina changxingensis* is expressed in transitional morphotypes from *C. subcarinata* in Bed 10 (Sheng *et al*., 1984) with the continuing occurrence of adult morphotypes retaining the denticulation pattern of *C. subcarinata*, overlapping the range of adult morphotypes with the denticulation pattern of *C. changxingensis* for several metres. The first adult *C. changxingensis* occurs at 16.38 m (0.54 m above base of Bed 12 of Yin *et al*., 1996).

The FAD of *Clarkina wangi* in the Meishan section D occurs just above the last occurrence of *Clarkina longicuspidata* (transitional morphotypes) and overlaps the last occurrences of *Clarkina orientalis* (through Bed 4). It is well constrained at 6 cm above the base of Bed 4 which overlies a thin mudstone that is identified in all the different bed schemes utilized to describe the section. The same mudstone contained zircons used by Mundil *et al*. (2001) for dating the base of the Changhsingian. This significant conodont evolutionary event occurs a mere 0.88 m (or 1.16 m, depending on whose measured section) above the original base proposed by Zhao *et al*. (1981) in the same section and appears to be the most compelling conodont definition for the base of the Changhsingian.

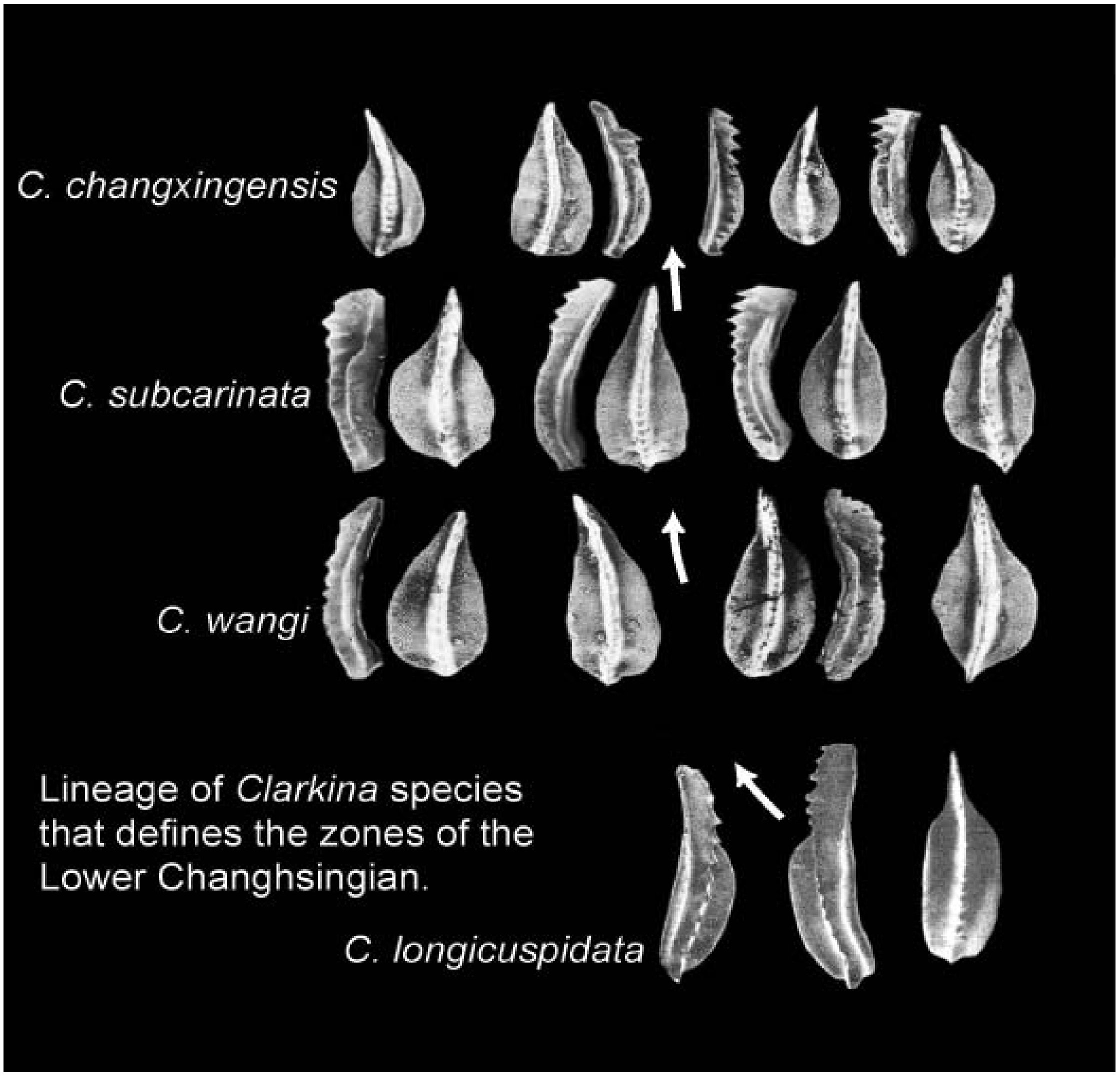

Figure 1. Lineage of *Clarkina* species that define the zones of the Lower Changhsingian.

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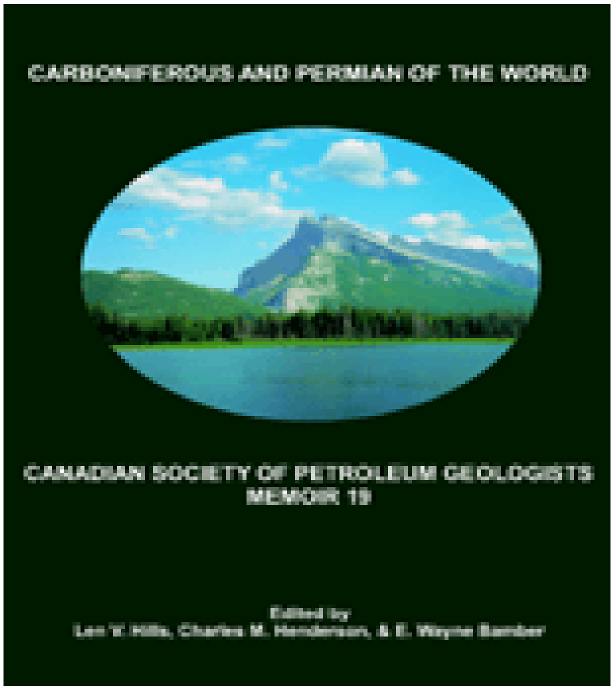

CARBONIFEROUS AND PERMIAN OF THE WORLD

CANADIAN SOCIETY OF PETROLEUM GEOLOGISTS
MEMOIR 19

Edited by
Len V. Hills, Charles M. Henderson, & E. Wayne Bamber

This memoir highlights a 100 million year interval during which the supercontinent Pangea was assembled, addressing issues of sedimentology, stratigraphy, resources, and paleontology. Memoir 19 contains 57 refereed papers representing the selected proceedings of the XIV International Congress on the Carboniferous and Permian held at the University of Calgary in August 1999.This publication will be valuable to geoscientists interested in Carboniferous and Permian geology, not only in Western Canada, but also around the world. The International Congress on the Carboniferous and Permian (ICCP) was first held in June 1927 in Heerlen, The Netherlands. The meetings have been held mostly in Europe (Heerlen, Paris, Sheffield, Krefeld, Moscow, Madrid, Krakow, Utrecht), but also in South America (Buenos Aires), Asia (Beijing), and North America (Urbana, Illinois and for the first time in Canada at Calgary, Alberta in August 1999). The meeting began by looking only at the Carboniferous from the perspective of understanding the geology of this resource-rich, coal-bearing system. At Beijing in 1987 the Permian System was added to the congress, which was a natural extension to many Carboniferous geological problems. The ICCP is one of the oldest and most prestigious of the stratigraphic congresses associated with the International Commission on Stratigraphy and the International Union of Geological Sciences. Almost three hundred people attended the Calgary meeting and presented over 300 talks, posters, and core displays. The meeting was in part sponsored by the Canadian Society of Petroleum Geologists.

Edited by Len V. Hills, Charles M. Henderson, and E.Wayne Bamber, 2002, hard cover, 947 pages, ISBN 0-920230-008

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IN MEMORIAL

IN MEMORY OF NATALIA ESAULOVA
(1948 – 2003)

Professor Natalia K. Esaulova, D. Sc., the Chair of the Department of General Geology of Kazan State University, died tragically by a lightning strike on July 16, 2003 while doing field work on the type Kazanian.

She was born on November 20, 1948 in Kazan, Russia. She graduated in 1971 from Kazan State University with the speciality “Geological mapping and exploration”. She immediately started to study Late Permian flora from the stratotype sections and to apply modern methods of research to the study of plants on the cellular level under the direction of Dr. S. V. Meyen. Her Ph.D. was successfully defended in 1984 and published as the book: “Kazanian Flora”. Her research has enhanced the study of the floral characteristics of Upper Permian deposits of the stratotype area. It also revealed regularities of the distribution of Late Permian flora along strike and changes of the nature of the biocoenoses within the limits of different facies zones. She used paleobotanical methods for detailed subdivision and correlation of Permian marine and continental deposits. The composition of the Kazanian flora of the stratotype area and its position on the boundary of four paleoregions (Atlantic, Katasian, Angarian and Gondwanian) permitted her to make wide correlations including the Canadian Arctic, Far East and China. Dr. Esaulova was also a specialist on charophyte algae.

In 1998, Dr. Esaulova successfully defended a Doctor of Sciences dissertation. She was not only a leading force in doing scientific research work on various geological and paleontological areas, but also was a well respected and talented teacher and organizer of geological education.

Natalia Esaulova was a very strong defender of the Volga-Kama stratotypes of the Middle and Upper Permian and successfully involved many international specialists in the study of the rocks and various fossil faunas of this region. By her direction and strong efforts much new data on the Upper Permian stratotypes were systematized and published. She was a driving force in the organization and very successful International Symposium on the Upper Permian stratotypes of the Volga region held in 1998. In the following years, and by her own initiative, more work was completed and also under progress on the Upper Permian stratotypes. New data included the discovery of Roadian ammonoids and conodonts.

Dr. Natalia Esaulova was a member of the Bureau of the Stratigraphic Subcommission on the Permian System of Russia (St. Petersburg), a member of the Upper Permian – Triassic section of the Regional Stratigraphic Committee on the Centre and South of the Russian Platform (Saratov), a Corresponding Member of the International Subcommission on Permian Stratigraphy, and a member of the International Subcommission on Paleozoic Flora.

With the tragic death of Natalia Esaulova, Kazan State University, the Permian System, and the entire geological community have lost an outstanding teacher, scientist, organizer of education, expert on the Permian System, and a dynamic and progressive representative of the Kazanian Geological School.

From: G. V. Kotlyar, B. I. Chuvashov, G. P. Nestell and M. K. Nestell

ANNOUNCEMENTS

ITALIA 2004

32nd International Geological Congress

Florence, Italy

August 20-28, 2004

Sessions of interest to SPS member include:

General Symposium G20.02: Permo-Carboniferous to Early Jurassic, Karoo Supergroup.

General Symposium G22.04: Global Correlation of the Cisuralian (Lower Permian) stages. Sponsored by SPS. Boris Chuvashov and Charles Henderson are co-chairs. Please contact Charles Henderson if you are interested in presenting at this session.

General Symposium G22.05: Global Permian continental biostratigraphy and biochronology. G. Cassinis and S. Lucas are co-chairs.

Topical Symposium T04.02: Late Permian-Early Triassic events. Bruce Wardlaw and Hongfu Yin are co-chairs.

And many others....

Information and PDF of second circular available at: http://www.32igc.org.

THE GEOLOGICAL SOCIETY OF AMERICA

The Subcommission on Permian Stratigraphy will meet with the GSA Rocky Mountain/Cordilleran meeting at Boise, Idaho, USA during May 3-5, 2004. See the following website for details: **http://www.geosociety.org/sectdiv/rockymtn/04rmcdmtg.htm**

Tamra Schiappa is organizing a session entitled “Upper Paleozoic Biostratigraphy of North America”. Bruce Wardlaw is organizing a session on the Permian-Triassic boundary.

Chronos will sponsor a workshop on the Permian-Triassic catastrophic extinction event just prior to the GSA meeting in Boise. For information see the following website:
http://www.chronos.org/meetings/workshops.html

One last note from the secretary.

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ANNOUNCEMENTS

The Proceedings of the Siena Scientific Meeting (Permophiles, #37, p. 36), on "Late Palaeozoic to Early Mesozoic events of Mediterranean Europe, and additional regional reports", were recently published in a special volume, no. 2 (2003) , of the Italian Geological Society Bulletin. This book of 244 pages includes 19 papers by 65 authors. The contents are:

Introduction

STAMPFLI G.M., VAVASSIS I., DE BONO A., ROSSELET F., MATTI B. & BELLINI M. – Remnants of the Paleotethys oceanic suture-zone in the western Tethyan area.

Europe

- ITALY

Tuscany

LAZZAROTTO A., ALDINUCCI M., CIRILLI S., COSTANTINI A., DECANDIA F.A., PANDELI E., SANDRELLI F. & SPINA A. – Stratigraphic correlation of the Upper Palaeozoic-Triassic successions in southern Tuscany, Italy.

ALDINUCCI M., SANDRELLI F. & PANDELI E. – Sedimentological features, depositional setting and stratigraphic significance of the Civitella Marittima formation (Verrucano Group, southern Tuscany – Italy).

Lombardy

SCIUNNACH D. – Fault-controlled stratigraphic architecture and magmatism in the western Orobic Basin (Lower Permian, Lombardy Southern Alps).

SANTI G. – Early Permian tetrapod footprints from the Orobic Basin (Southern Alps – Northern Italy). Data, problems, hypotheses.

ARMIENTI P., CORAZZATO C., GROPPELLI G., NATOLI E. & PASQUARÈ G. – Geological and petrographical study of Montecampione Triassic subvolcanic bodies (Southern Alps, Italy): preliminary geodynamic results.

Calabria

FESTA V., DI BATTISTA P., CAGGIANELLI A. & LIOTTA D. – Exhumation and tilting of the late Hercynian continental crust in the Serre Massif (southern Calabria, Italy)

Sardinia

BARCA S. & COSTAMAGNA L.G. – The Upper Carboniferous S. Giorgio succession (Iglesiente, SW Sardinia): stratigraphy, depositional setting and evolution of a late to post-Variscan molassic basin

CASSINIS G., CORTESOGNO L., GAGGERO L., RONCHI A., SARRIA E., SERRI R. & CALZIA P. – Reconstruction of igneous, tectonic and sedimentary events in the latest Carboniferous-Early Permian Seui Basin (Sardinia, Italy), and evolutionary model.

CASSINIS G., DURAND M. & RONCHI A. – Permian-Triassic continental sequences of Northwest Sardinia and South Provence: stratigraphic correlations and palaeogeographical implications.

TRAVERSA G., RONCA S., DEL MORO A., PASQUALI C., BURAGLINI N. & BARABINO G. – Late to post.Hertcynian dyke activity in the Sardinia-Corsica Domain: A transition from orogenic calc-alkaline to anarogenic alkaline magmatism.

General Topic

CASSINIS G. – Towards a stratigraphic reference table for the continental Permian of Italy.

- OTHER REGIONS

DEROIN J.P. & BONIN B. – Late Variscan tectonomagmatic activity in Western Europe and surrounding areas: the Mid-Permian Episode.

KÖRNER F., SCHNEIDER J.W., HOERNES S., GAND G. & KLEEBERG R. – Climate and continental sedimentation in the Permian of the Lodève Basin (Southern France)

YANEV S.N. – Stratigraphy, environment and palaeogeography of the Carboniferous in Bulgaria.

Non-European territories and further global contributions

GÖNCÜOGLU M.C., TURHAN N. & TEKIN U.K. – Evidence for the Triassic rifting and opening of the Neotethyan Izmir-Ankara Ocean and discussion on the presence of Cimmerian events at the northern edge of the Tauride-Anatolide Platform, Turkey.

ADAMIA SH., LEBANIDZE Z., SVANIDZE TS. & SHAVISHVILI I. – Late Paleozoic-Triassic geodynamic development of Georgia (Caucasus).

PASCUCCI V. & GIBLING M.R. – Late Palaeozoic evolution of the Eastern Maritimes Basin, Atlantic Canada.

LOZOVSKY V.R. – Correlation of the continental Permian of northern Pangea: a review.

Those who wish to acquire a copy of the above-mentioned volume should contact the General Secretary of S.G.I.: Achille Zuccari, Dipartimento di Scienze della Terra – Università degli Studi "La Sapienza", Piazzale Aldo Moro, 5 – 00185 Roma, Italy (Phone: **+ 39 06 49 59 394;** Fax : **+ 39 06 49 91 41 54;** E-mail: **zuccari@uniroma1.it).**

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