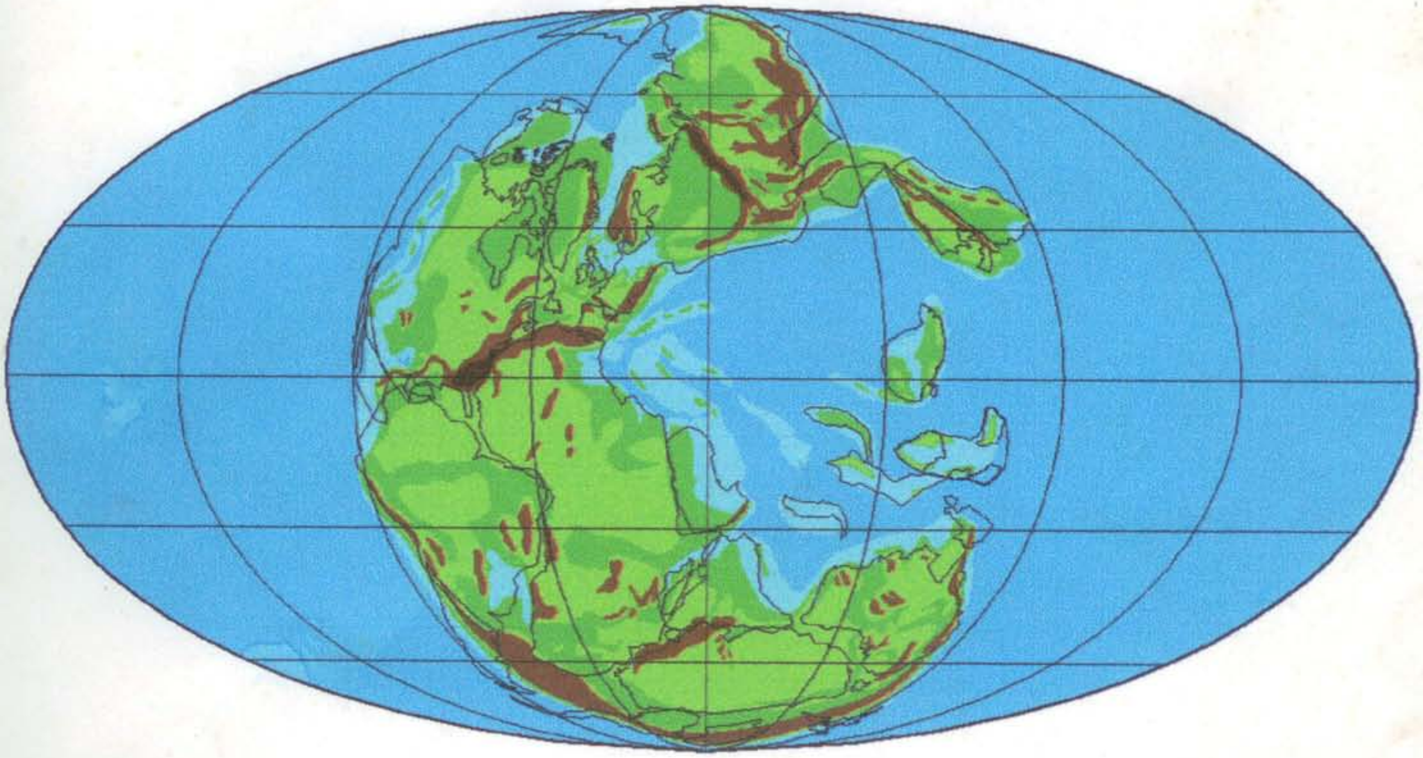
Permophiles

Number 29 December 1996
A NEWSLETTER OF THE
SUBCOMMISSION ON
PERMIAN STRATIGRAPHY



SUBCOMMISSION ON PERMIAN STRATIGRAPHY

INTERNATIONAL COMMISSION ON STRATIGRAPHY

INTERNATIONAL UNION OF GEOLOGICAL SCIENCES (IUGS)

TABLE OF CONTENTS

SECRETARY'S NOTES

By Claude Spinosa

I would like to take this opportunity to thank all the contributors to this issue of ***Permophiles*** and those who assisted in its preparation. I am particularly indebted to B. F. Glenister S. M. Ritter, B. R. Wardlaw, V. I. Davydov, W. S. Snyder and T. A. Schiappa. who reviewed manuscripts and final copy. A. M. Ziegler graciously provided the map on the cover page and the Permian Paleogeography map insert.

The next issue of ***Permophiles*** is scheduled for June 1997. Contributions must arrive in Boise by May 1. Manuscripts should be submitted on diskettes prepared on WordPerfect or MSWord; printed hard copies must accompany them. Maps and other illustrations 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. We can also receive contributions via E-mail, Fax or through FTP; however, please contact me for details.

New section: Letters, Comments and Responses

A new section, *Letters, Comments and Responses,* has been added to ***Permophiles*** and will continue in future issues. It is hoped this section will encourage a continuing dialog among readers of ***Permophiles***. This issue's section has nine letters and five responses. Brief comments and responses to articles, letters or responses that appear in this issue may be sent for publication in the June 1997 issue of ***Permophiles***.

A message from the chair

Bruce Wardlaw, as the new SPS Chair, would like to acknowledge the tremendous job Jin Yugan has done for the Subcommission in his two terms and looks forward to his continued contributions for an internationally accepted Permian System. Other SPS officers join Bruce Wardlaw in extending sincere thanks to Jin Yugan, John Utting, and Boris Chuvashov for their contributions as officers of the SPS.

Future meetings

Bruce Wardlaw announces that future meetings of the Permian Subcommission will be held in conjunction with:

1) the International Conference on Permian of Eastern Tethys: Biostratigraphy, Palaeogeography and Resources, 30 November-3 December 1997, in Melbourne, Australia;

2) a Lopingian Field Symposium in China, probably in late winter, 1998,

3) a Continental Permian of Europe Symposium,

4) the Carboniferous Congress in Calgary, Canada, 1999, and

5) the next IGC in Rio de Janeiro, Brazil.

Subcommission on Permian Stratigraphy (SPS) and International Commission on Stratigraphy (ICS)

The International Commission on Stratigraphy (ICS) is composed of the Commission Bureau and nineteen subcommissions, of which the Subcommission on Permian Stratigraphy (SPS) is one. Names and addresses follow.

International Commission on Stratigraphy bureau:

ICS Chairman Prof. Jürgen Remane Institut de Géologie Université de Neuchâtel Rue Emile-Argand.11 CH-2007 Neuchâtel, Switzerland	**ICS 1st Vice Chair** Dr. H. Rich Lane AMOCO Exploration and Production Technology P.O. Box 3092. Houston Texas 77253, USA.
ICS Secretary General Prof. Olaf Michelson Dept. of Earth Sciences University of Aarhus DK-8000 Arhus C, Denmark	

Subcommission on Permian Stratigraphy:

SPS Chairman Dr. Bruce R. Wardlaw U.S. Geological Survey 926A National Center Reston, VA 22092-0001, USA fax: 703-648-5420 voice: 703-648-5288 bwardlaw@geochange.er.usgs.gov	**SPS 1st Vice Chairman** Prof. Ernst Ya. Leven Geol. Inst. RAS 10917 Pyjevskyi per 7 Moscow, Russia voice: 095-230-8121 iloewen@uniinc.msk.ru
SPS 2nd Vice Chairman Dr. C. B. Foster Australian Geol. Surv. Org. GPO Box 378 Canberra 2601, Australia cfoster@selenite.agso.gov.au	**SPS Secretary** Prof. Claude Spinosa Dept. of Geosciences Boise State University Boise, Idaho 83725, USA fax: 208-385-4061 voice: 208-385-1581 cspinosa@trex.idbsu.edu

Minutes of the meeting of the Subcommission on Permian Stratigraphy, 30[th] International Geological Congress, Beijing, China, August 8, 1996

Call to order

Bruce R. Wardlaw, assumed the new chair of the Permian Subcommission and called the meeting to order at 4:00 P.M..

The following persons were in attendance

Titular members: G. Cassinis, Boris Chuvashov, J. M. Dickins, Brian F. Glenister, Heinz Kozur, Manfred L. Menning, Claude Spinosa, Bruce R. Wardlaw, Jin Yugan, Liao Zhuo-ting.

Corresponding members: Evgeny Axenov, Ildar Bareyev, Rasim Diyashev, Inna Dobruskina, Douglas H. Erwin, Natalia Esaulova, Tatjana Grunt, Charles Henderson, H. Richard Lane, Tatyana Leonova, Shilang Mei, Vladen Lozovsky, Jürgen Remane, Alexei Rozanov, John Rigby, Anatoly Shevelev, Carmine Virgili, Geoffrey Warrington, Zho Zuren, Yuri Zakharov.

New SPS officers and new voting members

New SPS officers were announced:

Chair: Bruce R. Wardlaw

1st Vice Chair: Ernst Ya. Leven

2nd Vice Chair: C. B. Foster

Secretary: Claude Spinosa

The election of the following new titular members was announced:
Mike Orchard, Geological Survey of Canada
Liao Zhuo-ting, Nanjing Institute of Geology and Paleontology.

Results of the written ballot mailed to voting members by Dr. Jin Yugan

The written ballot sent out by Jin Yugan read as follows:

A. I agree with the usage of the Cisuralian Series and its constituent stages, i.e. the Asselian, the Sakmarian, the Artinskian, and the Kungurian Stage for the lower part of the Permian System.
Yes No Abstain

A-a. I prefer using "the Kungurian Stage\the Cathedralian Stage" rather than "the Kungurian Stage"
Yes No Abstain

B. I agree with the usage of the Guadalupian Series and its constituent stages, i.e. the Roadian, the Wordian, and the Capitanian Stage for the middle part of the Permian.
Yes No Abstain

C. I agree with the usage of the Lopingian Series and its constituent stages, i.e. the Wuchiapingian and the Changhsingian for the upper part of the Permian.
Yes No Abstain

C-a. I prefer using "the Dzhulfian Stage" rather than "the Wuchiapingian Stage"
Yes No Abstain

JinYugan reported the following results:

A	Yes 14	No 1	Abstain 0
A-a	Yes 1	No 10	Abstain 4
B	Yes 15	No 0	Abstain 0
C	Yes 15	No 0	Abstain 0
C-a	Yes 6	No 7	Abstain 2

The vote by B. Chuvashov was received late and was not counted by Jin Yugan in this tabulation.

Working group reports

Brief reports were presented by: Jin Yugan, Chair of the Lopingian working Group; by Brian F. Glenister, Chair of the Guadalupian Working Group; and by Boris Chuvashov, Chair of the Asselian, Sakmarian and Artinskian Working Group. The secretary requested that each working group chairperson provide more detailed written reports for inclusion in this issue of ***Permophiles***; see below.

Discussion

Extensive discussions ensued regarding results of the poll submitted by Jin Yugan. Of special interest were questions A, B, and C that approve subdividing the Permian System into three Series - Cisuralian, Guadalupian, and Lopingian. Some of the comments were read from letters presented to officers of the ICS or SPS. In the interest of presenting these detailed comments to the entire SPS membership and to all readers of ***Permophiles***, the letters are reproduced in this issue. See *Letters, Comments and Responses*, page 5.

WORKING GROUP REPORTS

REPORT FROM WORKING GROUP OF THE ASSELIAN, SAKMARIAN AND ARTINSKIAN STRATOTYPES

By B. Chuvashov

This group started its activity immediately after the Congress "Permian System of the World" (Perm, August 1991) and following the study of stratotypes and parastratotypes of Asselian, Sakmarian, Artinskian and Kungurian stages till now. Our group does not try to concentrate all effort for study one stratotype section only. We are studying, at least, two parastratotypes of each stage from different facial zones with distinct diversity of organic remains. Result of this approach should be a significant increase in stratotype information and correlation potential.

Recently there is this kind of situation with studies of the stratotypes:

1. The Asselian stage has a stratotype section (Ruzhentsev, 1937) along the Assel River (basin of Sakmara River). This section has not had any recent description and urgently needs additional serious lithological and paleontological investigation. We have a rather good parastratotype section in the Middle Urals (Ekhlakov,1986; Tscherbakova,1986) which is represented by bedded carbonates of platform type with very rich and diverse faunas of fusulinid, brachiopods and bryozoans. Unfortunately, ammonoids and conodonts are absolutely absent here.

The boundary beds between Carboniferous and Permian were studied at some sections. Two of them - Aidaralash and Nikolsky - are composed by flysh type sediments and the last one - Krasnousolsky - is represented by a condensed section. All of the mentioned sections give a good basis for correlating the boundaries of fusulinids, radiolarians, ammonoids and the conodont biostratigraphic zone between them. There are plenty of publications about Aidaralash, Nikolsky and Krasnousolsk sections (Chuvashov, Leven, Davydov, 1986; Permian System. Guides to geological excursions, 1993 et al.). But these sections represent the lower part of the Asselian stage only. Recent level of the information about Asselian stage in whole will be presented by description of the sequence along Assel River.

2. The Sakmarian stage has its stratotype within the Kurmaya Ridge on the Sakmara River near the Kondurovka railway station. This section has been considered before (Karpinsky, 1874) like a "lower belt of Artinskian ammonoids". Later V. E. Ruzhentsev (1950) created the Sakmarian stage (s. str.) like a middle part of the Artinskian stage of A. P. Karpinsky. There are some publications about this section (Rauser-Chernoussova,1965; Chuvashov et al.1991,1993). This material should be supplemented by some paleontological plates with fusulinids, radiolarians, ammonoids and conodonts. We urgently need, in addition, proofs for definition of the Sakmarian- Artinskian boundary according to ammonoids and conodonts within this section.

3. Artinskian stage. This stage was named after the Arty Settlement on the Ufa River, 200 km west of Ekaterinburg. The thick flysh sequence with ammonoids, which are exposed here, has been treated by A. Karpinsky (1874) like an "Upper belt of Artinskian ammonoids". Brief descriptions of this section were presented by some authors: P. Krotow, 1885; V. Nalivkin, 1949; B. Chuvashov, G. Dupyna, 1973. Data about ammonoids of this sequence exist in some books and papers (Murchison, Verneuil, Keyserling, 1841; Karpinsky, 1891; Krotow, 1885; Bogoslovskaya, 1962).

During the years 1992 to 1996 we tried to find new data about fusulinids, ammonoids and conodonts along this section and correlate the boundaries of above biostratigraphic zones. The thick sequence of bedded carbonates has been studied on the Eastern rim of Russian platform near the town of Krasnoufimsk like a parastratotype of the Artinskian stage. The stratotypes of Burzevskian, Irginskian, Sarginskian and Saraninskian horizons are situated in this regions. We have new data about the distribution of fusulinids, ammonoids and conodonts with upper part of this section like a good base for mutual correlation between fusulinid and ammonoid-conodont zones.

4. The description of Kungurian stratotype near the town of Kungur has been given before (Permian System: Guidebook. 1993). We are going to present a parastratotype of Kungurian which is composed of marine carbonate- terrigenous sediments with ammonoids and conodonts. This section is situated along Sylva River upstream from the town of Kungur. Some levels with ammonoids and conodonts exist here.

Results of ours investigations will be presented in a series of monographs in Russian with lengthy English version which could be as extensive as 75 % of the Russian text. A special monograph will be devoted to each stage. The following general contents are expected for each monograph: Chapter 1- History of investigation; 2- Lithological and Paleontological characteristics of stratotype and parastratotypes; 3- Biostratigraphic, lithological and event boundaries; 4-Correlation of stage within sedimentary basin and local (basinal) stratigraphic chart; 5- Global correlation of stage. Supplement: 1- Description of new paleontological taxa; 2- paleontological plates.

The following schedule is expected for presentation of the stratotype descriptions: 1997 - Artinskian stage; 1998- Kungurian stage; 1999- Sakmarian stage; 2000- Asselian stage.

B. Chuvashov (Chairman)
Institute of Geology & Geochemistry of the Urals
Pochtavy per 7
Ekaterinburg 620154
Russia

REPORT OF THE GUADALUPIAN WORKING GROUP

By Brian F. Glenister

The Second International Guadalupian Symposium (Guadalupian II), sponsored by the U.S. Geological Survey, Sul Ross State University, and the Subcommission on Permian Stratigraphy (ICS-IUGS) was held in Alpine, Texas, and adjacent field areas April 10-13, 1996. Registration totaled 45, but did not include Sul Ross students and staff, whose generous logistic support contributed greatly to the successful conduct of the meeting. Canadian and American participants were joined by overseas colleagues from China, Germany, Hungary, Switzerland, and Russia. Abstracts, field guides, and summary biostratigrpahic data for the entire Permian of West Texas were published as an 80-page Symposium volume, limited quantities of which are available from Co-Convenor Bruce R. Wardlaw, USGS, 926A National Center, Reston VA 20192, U.S.A. All proposed stratotypes for the Guadalupian Series and its component Roadian, Wordian, and Capitanian stages were visited in the course of the field trips. Additionally, many participants visited the proposed body stratotype for the uppermost Cisuralian "Kungurian" Stage, which lies in Leonard Mountain (Glass Mountains, West Texas), in objective stratigraphic succession directly beneath the type Road Canyon Formation.

Nine of the 16 Titular Members of the SPS attended Guadalupian II, and were joined by other specialists in informal discussions of many aspects of the Permian System.

Full minutes of the meeting are provided in Permophiles #28. Of particular relevance is the proposal "To proceed with all appropriate speed to establish the Guadalupian as the Middle Permian Series": 25 voted in favor, 0 against, and 4 abstained. Former SPS Chair Jin Yugan subsequently submitted a formal written questionnaire to the 16 Titular Members of SPS, asking whether "I agree (to) the usage of the Guadalupian Series, and its constituent stages, i.e. the Roadian, Wordian and Capitanian Stage for the middle part of the Permian". Fifteen are recorded as responding Yes by the July 10 1996 deadline, 0 voted No, and 0 voted abstain; of the remaining Titular Members, B. I. Chuvashov (Russia) recorded a late Yes vote, and J. M. Dickins (Australia) reported that he did not receive the ballot. These data indicate that the Permian specialists most active in deliberations on international standards for the Permian strongly favor the choice of the Guadalupian Series. However, the series of statements appearing later in the present issue of Permophiles reveal that there is some current opposition to this choice.

Manfred L. Menning (Geo Forschangs Zentrum, Potsdam, Germany) took advantage of participation in Guadalupian II to make collections from the type Guadalupian for magnetostratigraphic analysis. Five hundred samples were taken from the upper Cathedralian, Roadian, Wordian, and Capitanian of the Guadalupe Mountains. It is anticipated that the low CAI (1) will permit detection of syngenetic magnetization, especially in some limestones, and permit precise location of the Illawarra Magnetic Reversal. To date, the widespread magnetic overprint by post-Permian goethite has been removed by heating. In related studies, Doug Erwin (National Museum of Natural History) and Sam Bowring (Massachusetts Institute of Technology) are dating a volcanic ash that occurs between the Hegler and Pinery limestone members of the Bell Canyon Formation section on Nipple Hill. This occurrence is within Bruce Wardlaw's proposed stratotype for the Capitanian Stage. It lies 20 meters below the base of the Jinogondolella postserrata conodont zone, in the same section collected by Manfred Menning. Zircons are relatively abundant, and a reliable geochronologic age is anticipated by early 1997.

The primary basis for definition of the base of both the Permian and the Triassic is selection of an arbitrary but readily definable point within respective continuous conodont chronoclines. A similar procedure is being employed for the base of the basal Guadalupian Roadian Stage, and it is probable that conodonts will provide the primary basis for definition of most Permian stages. Bruce R. Wardlaw (USGS, Reston) has contributed the following summary for Guadalupian stages (see Table, Permophiles, 28, p. 4).

The evolution of Mesogondolella idahoensis into Jinogondolella nankingensis transpired through a mosaic paedomorphocline. A short-ranging transitional form can be recognized both qualitatively and quantitatively. The evolution of Jinogondolella nankingensis into J. aserrata and J. aserrata into J. postserrata also appear to have occurred through a mosaic morphocline, and a short-ranging transitional form can be recognized for both. An arbitrary point within these various morphoclines provides an excellent boundary for the Guadalupian/Roadian base, the Wordian base, and the Capitanian base, respectively. First appearances of features considered diagnostic of nankingensis, aserrata, and postserrata in adult forms provide such points and are located in the El Centro Member of the Cutoff Formation (nankingensis), the upper part of the Getaway Member of the Cherry Canyon Formation (aserrata), and the upper part of the Pinery Limestone Member of the Bell Canyon Formation (postserrata.) Sections where the conodont distribution is documented for each conodont-defined boundary are located in Stratotype Canyon (El Centro), Guadalupe Pass (Getaway), and Nipple Hill (Pinery; Guadalupian II, 1996). The top of the Guadalupian will be defined by the definition of the base of the Lopingian in China. Several conodonts co-occur in the uppermost part of the marine Permian in West Texas and in China, the most promising being Clarkina postbitteri, which occurs in the very top of the Altuda Formation (post-Lamar Reef Trail Formation of Wilde and Rudine, Guadalupian II, 1996, p. 23) in West Texas and in the Heshan Formation, Guiyang, China.

Brian F. Glenister (Chairperson)
Department of Geology
The University of Iowa
Iowa City, Iowa 52242 U.S.A.

REPORT OF THE CARBONIFEROUS-PERMIAN BOUNDARY WORKING GROUP

Brian F. Glenister and Bruce R. Wardlaw

Interest in developing international consensus on formal definition of a base for the Permian System (and coincident top of the Carboniferous) was heightened by the International Congress on the Permian System of the World, Perm, Russia, August 5-10, 1991. The pre-sessional field excursion to classic sections in the Southern Urals of Russia and Kazakhstan was pivotal in refocusing attention on Aidaralash Creek, Aktyubinsk (currently Aqtöbe) region of northern Kazakhstan. This section was used by V. E. Ruzhencev, almost one-half century earlier, to designate a lower boundary for the basal Permian Asselian Stage, primarily by reference to ammonoid cephalopod distributions. Subsequent detailed field and laboratory analysis of the Aidaralash section, and comparison with contemporaneous sections in the Urals and elsewhere culminated in formal proposal of Aidaralash as GSSP for the base of the Permian (Davydov et al., 1995, Permophiles, 26, p. 1-9). The base was defined as the first occurrence of the "isolated-nodular" morphotype of the Streptognathodus "wabaunsensis" conodont morphocline, 27m above the base of Bed 19. This level is a mere 26.8m below the ammonoid boundary originally proposed by Ruzhencev, and 6.3m below the level favored by many fusulinacean workers.

Consequently, the three levels may be considered synchronous for practical purposes.

Coincident with submittal of the Aidaralash manuscript for publication, copies were distributed to voting members of the Carboniferous/Permian BWG, who approved the GSSP, with one abstention. Titular Members G. Cassinis (Italy), J. M. Dickins (Australia), B. F. Glenister (USA), C. B. Foster (Australia), Sheng Jin-zhang (China), M. Kato (Japan), G. V. Kotlyar (Russia), H. Kozur (Hungary), E. Ya. Leven (Russia), M. Menning (Germany), W. W. Nassichuk (Canada), C. A. Ross (USA), J. Utting (Canada), Jin Yugan (China), and B. R. Wardlaw (USA) voted in favor of the proposal. The remaining voting member, B. Chuvashov (Russia) abstained. Upon this approval by the P/T BWG, the proposal was approved subsequently, first by the Full Commission of the International Commission on Stratigraphy, and later by the International Union of Geological Sciences with final ratification during the 1996 Beijing meeting of the International Geological Congress. A final summary account will be published in Episodes.

Brian F. Glenister (Chairperson)
Department of Geology
The University of Iowa
Iowa City, Iowa 52242
U.S.A.

Bruce R. Wardlaw (Secretary)
MS962A, National Center
Reston, Virginia 22092-0001
U.S.A.

LETTERS, COMMENTS AND RESPONSES

The International Congress on the Permian System of the World held in Perm, in August 1991, served as stimulus for renewed discussion and study of the Permian System. A number of important issues have been discussed at SPS meetings and field excursions since 1991. Debated issues include subdivisions of the Permian System and location of stratotype sections. Should there be two subdivisions, three, four? Where should stratotypes be established?

It has been proposed and accepted that the Permian be subdivided into three series - the Cisuralian, the Guadalupian and the Lopingian as the Lower, Middle and Upper Permian Series. Results of a ballot mailed by then SPS Chairman, Jin Yugan, to SPS voting members (see page 2) indicate almost unanimous support for this scheme. The ballot and the results generated considerable discussion at the SPS meeting in Beijing. Portions of the discussion came in the form of prepared letters in opposition to the new scheme. In order to foster a logical and rational evaluation of the scientific merits of the new scheme, SPS officers decided to publish these letters. The letters, published below, were provided to SPS or ICS officers; they are included herein verbatim. Present and recent SPS officers were provided an opportunity to respond to the letters; responses also are included below. Additional responses from corresponding members may be published in the next issue of ***Permophiles***.

Because much of the discussion regarding the new subdivision scheme for the Permian focuses on the Kazanian and Tatarian versus Guadalupian and Lopingian, the cover page of this issue of ***Permophiles*** is a reconstruction of Tatarian paleogeography by A. M. Ziegler and associates. Also Dr. Ziegler has kindly provided a set of maps of Permian Paleogeography for inclusion in this issue of ***Permophiles***. Furthermore, because part of the discussion involves application of the rules of stratigraphic nomenclature, we include a copy of the latest revision of the "GUIDELINES FOR THE ESTABLISHMENT OF GLOBAL CHRONOSTRATIGRAPHIC STANDARDS BY THE INTERNATIONAL COMMISSION ON STRATIGRAPHY (ICS)". Please see page 26.

Letter from V. Ganelin, A. Gomankov, M. Durante, T. Grunt, S. Lazarev, I. Morozova, V. Gorsky, E. Guseva, and S. Pukhonto

July 12, 1996

To: Chairman of the International Stratigraphic Commission. Prof. Jurgen R. REMANE
To: Chairman of the International Permian Subcommission of ICP., Prof. Jin Yugan

At the meeting of International Permian Subcommission held in April, 1996 in the town of Alpine (USA), the draft scheme of the new standard division of the Permian System into three series: Cisuralian, Guadalupian and Lopingian ones have been discussed and preliminarily voted. The scheme had been prepared by the initiative group of American geologists.

As far as we know, the scheme is supposed to be approved by the International Stratigraphic Commission at the coming Session of the International Geological Congress in China.

Legal approval of the suggested division of the Permian System into three series with proper names automatically entails rejection of the classical stratotype of the Permian system that has been used for over 150 years. Thus the very notion of the Permian System suggested by R. Murchison is being rejected. Such radical actions, we believe, have to be handled with a great deal of caution.

Though we fully understand and sympathize with the desire of American geologists motivated by the feeling of national prestige to see the Guadalupian Series in the global scale of the Permian System, we cannot agree with the suggested scheme for the reason of excessive haste and lack of consideration.

Revision and modernization of the classical Permian scale based largely on the continental deposits is perhaps justified. However, haste in such important question may cause new, even more serious complications. Among possible problems related to the above scheme the following are already feasible:

1. The Permian scale loses its integrity, whereas correlation of boundaries of the series with the stratotypes in different continents that belong to various paleobasins requires more serious substantiation than one available now.
2. Legal recognition of the series with the proper names without stage subdivision may cause two independent aspects of division that do not correspond to one another: division into stages and division into series.
3. It is unclear - and the authors of the scheme ignore the problem absolutely - how the suggested scale of the Permian System could be used outside of the Equatorial Zone (within the Gondwana, Angaraland or Biarmia). Meanwhile these areas cover almost 3/4 of the territory of the Permian deposits. Taking into account all the above, we suggest that the official approval of the global scale of the Permian System should be postponed. A possible solution of the present complications could be approval of the above scheme as an operational (auxiliary) scale for the Equatorial Zone. Further research will show whether the above scheme could become basis of the Global Standard.

V. Ganelin, A. Gomankov, M. Durante,
Geological Institute RAS, Moscow
T. Grunt, S. Lazarev, I. Morozova,
Paleontological Institute RAS, Moscow
V. Gorsky, E. Guseva,
VSEGEI, Sankt - Petersburg
S. Pukhonto,
POLARGEO, Vorkuta

Letter from B. V. Burov, A .K. Gusev, N. K. Esaulova, V. G. Khalimbadzha and A. I. Shevelev

On the problems of International Stratigraphy of the Permian System

According to the ICP-regulations, definition of series' and stages' boundaries and the points of global boundaries' stratotypes must be done for all systems. Nowadays, western geologists formed the opinion that "stages of the general Permian system above the Artinskian do not meet international requirements since none of the boundaries can be clearly traced outside the stratotypical area, and therefore they cannot be a global standard". As a result of discussions, majority of the ICPS-members came to a conclusion that the Permian scale must be based on marine sections. Boundaries of series and stages must coincide with contrast biostratigraphic ones, and be defined using conodonts' zone boundaries for which a zone standard has been created. A scale containing Urals (Russia) stages in the Lower Permian, and regional subdivisions of North America and China in the Upper Permian is proposed as an international that. Thus, the proposed stratotype will be lacking the major sedimentation field of the single fore-Urals basin.

The global stratigraphy is to:

1 - reveal stages and other subdivisions of the general scale on the basis of trustworthy sedimentary sequences, and,
2 - globally correlate stratigraphic subdivisions of the same age, and boundaries between them. The Lower and Upper Permian sequence of stages within a single platform basin with normal conditions of sedimentation is no doubt more trustworthy than Tethys sections associated with complex tectonic processes of the ocean's closing, displacements, dislocations, rotations, and secondary changes, where it is very

difficult to reconstruct a sequence of various outcrops. The supposition that there had been substantial sedimentation breaks in sediments of the Volga-Urals region during the Late Permian contradicts to biostratigraphic and paleomagnetic data, and to the fact that they accumulated during the orogenic period when the east margin of the East-European Platform was warping for a long time. For the Upper Permian sections of the Volga- Urals region, zone scales based on foraminifers, pelecypods, ostracods, fish, terrestrial vertebrates, macroflora, miospores have been elaborated. Conodonts have also been found. and are being used in detailed correlation of the Permian deposits. Radiolarians are being studied, and brachiopods are being revised. There have been carried out precise and detailed paleomagnetic studies, and position of the Kiama-Illawarra boundary within the Tatarian Stage has been defined. Number of magnetic zones in the stratotype is not less than in all known Tethyan sections including the Transcaucasian those.

Major correlation problems are related at present to the Upper Permian subdivisions rather than lower ones which formed in the normal marine basin. This is the time of sedimentation which is associated with the final stage of Hercynian tectogenesis, and a transition from thalassocratic to geocratic conditions. Global stratigraphic correlation, i.e. definition of sequences and boundaries of the same age, must be realized irrespective of facies (marine, transitional or continental), because facies features of sections indicate relations between physical and geographical conditions, sedimentation conditions, but not space-and-time relations between stratigraphic subdivisions studying of which is the main target of stratigraphy. So, we consider drawing up an international scale on the basis of marine sections only to be a methodological mistake in stratigraphic studies. Also worth taking notice of is another circumstance associated with classic notions about universality of biostratigraphic methods. Nowadays biostratigraphic methods are generally considered to be limited (as well as all other ones). Thus, the global paleomagnetic Kiama-Illawarra boundary in the Volga-Urals stratotype no doubt coincides with a beginning of the Tatarian Stage; in the Solyanoy Range - with lower "productus limestones" series of the Amb fm; and in South China - with the Maokou and Longtan fms. ascribed to the Lower Permian.

As we regard it, changes in international standards are only accepted in two cases:

1) existing stratigraphic subdivisions are useless, 2) as a result of detailed studies, new more complete sections appear which provide trustworthy global correlation. A notion that "none of the boundaries above the Artinskian can be clearly traced outside the stratotypical area" is mistaken since the Solikamskian-Sheshminskian boundary within the Ufimian, and the Urzhumskian-Severodvinskian boundary within the Tatarian are boundaries between the global large-scale stages of development of the earth's crust, biotas and magnetic field. The scale containing stratigraphic marine sections of Tethys, North America and China is also local. The mechanism of their revealing is not quite clear. If they are based on phylogenetic principle, how can 5 to 6 zones exist within deep-water-horizon conditions which were stable?

We regard the Volga-Urals (East-European) scale as a most felicitous one for it is based on the sections of shallow-marine marginal basin containing remains of typical marine, brackish-water, and freshwater fauna, macroflora and miospores. These sections are transitional from marine to continental ones. Biostratigraphic and magnetostratigraphic boundaries are correlated. Behavior of ancient magnetic field was studied in all zones of normal and reversed polarities, as well as in most of transitional those including Kiama-Illawarra. The most detailed and trustworthy Upper Permian scale was elaborated for the Volga-Urals region only. That corresponds to the Pakistani paleomagnetic data of Friedrich Heller (1991). Reliability of paleomagnetic marine data (North Caucasus, Primorie, Pamirs, zechstein of Poland and Germany, North America and China) leaves much to be desired.

The Upper Permian stages in the west are possible to correlate via the Pechorian Urals, Novaya Zemlya, Canadian Arctic towards North America, and in the east - via Aktyuba Urals, East Kazakhstan, Kuwletsk Basin, Far East (Primorie) and China towards Japan and Australia. Dominance of marine sections in works of western geologists, and the fact that they cannot be directly correlated with continental sections will demand establishing such a standard among the stratotypes. But, nevertheless, the correlation with those will only be possible via a series of intermediate sections.

Considering the above-mentioned facts we would conclude that:

1. Facies belonging does not matter when choosing stratotypes because stratigraphy deals with space-and-time relations of stratons, but not with their paleogeographic belonging.
2. Epicontinental-marine area of the Upper Permian rocks is several times as large as the marine that. Moreover, even having substituted a stratotype, the problem of correlation of the Upper Permian marine, continental and continental deposits will still remain.
3. The Permian Volga-Urals stratotype is now located within a single area, and relations between subdivisions are clear or can be studied. There are events within the stratotype which are associated with the end of Urals tectogenesis, re-ordering of sedimentation, re-orientation of general stratigraphic relations and global (but not only local or regional) re-orientation of flora and fauna.
4. It is necessary to gain an understanding of global and regional relations between magnetostratigraphic and biostratigraphic subdivisions.

B. V. Burov, A. K. Gusev, N. K. Esaulova,
V. G. Khalimbadzha,
Kazan University,
18 Lenin St. , Kazan, 420008, Russia

A. I. Shevelev,
Tatar Republican Commission on Natural Resources

Letter from I. A. Dobruskina

September, 15, 1996

An open letter to the Chief of International Stratigraphic Commission Prof. I. Remane (to be published in "Permofiles")

Dear Prof. I. Remane!

I am very sorry to express my disappointment over the meeting of the Permian Subcommission at 08.08.1996 during the 30th International Geological Congress in Beijing.

The meeting of the Permian Subcommission showed very clearly that scientific community is not yet ready to reach a decision concerning the International standard for the Permian System. The major problem consists of different understandings of correlation between different local stratigraphical schemes. In the first case it concerns the correlation between the schemes of the Cisural and Texas.

The main reason for such disagreement is the incompleteness of research. In the Cisuralian section investigation of conodont's is still not completed. In the Texas section paleomagnetic investigations are only now starting. For an adequate understanding of the relations between the two sections it is necessary to wait till the results of these investigations will be published.

I do not see any reason to hurry to reach hasty nonscientific decision, to force people to vote. It would be only an illusion of agreement, an illusion of common language, an illusion of establishing a helpful standard. The eclectic standard is always undesirable. In our case it is possible to avoid it. Let us wait. We should always think more and more before changing the existing standard. Any change in the International Geochronological Scale leads to its instability. Instability of the International Geochronological Scale is more dangerous than the incompleteness of the Standard.

Let us wait. Let us not make hasty revolutionary decisions. We, Russians (and ex-Russians) know better where revolutionary decisions lead. We will pay too high a price for them in future.

Let us not convert scientific discussions into political games or sport. Let us respect different opinions and let us respect our opponents, not just our supporters. Let us not discriminate against people because of their "party membership" - voting members or corresponding members. Let us declare that receiving (or not receiving) the scheme as a standard does not say anything about the quality of research: "default" all schemes competing for a standard should be a result of good research. To get it as a standard (or not) depends on other criteria, doesn't it?

So, I have the following suggestions:

1. Delay at least for a year a vote on the International Standard for the Permian System.
2. Compile a special issue of "Permophiles" with short papers (short reviews - a page) of different suggestions. Ask to submit papers from at least Glenister, Chuvashov, Esaulova, Dickins, Virgili...

Publish in the same issue also letters of disagreement at least of Durante and Puchonto, which we gave to Wardlaw in Beijing.

In introduction to this issue, explain the existing situation: what is already accepted by Permian Subcommission; which standard should be used now, before the decision, i.e. which scheme is to be changed; when the Subcommission intends to discuss this problem and how.

3. Call for such papers in previous issue of "Permofiles" and publish in it a list of suggestions for the Standard for the Permian System with the list of supporters and opponents of each suggestion: full names with membership in the Permian Subcommission. Instead of a blue page with faceless numbers of voting for and against.
4. Give people time to think about this issue and about new results an paleomagnetism for the Texas section and conodonts for the Cisurals. Think how to arrange REAL SCIENTIFIC DISCUSSION before voting.

P. S. I am writing this letter alone, but many people told me about the same feelings after the meeting. Believe me that the present situation with the Standard is not clear to the majority of people after many previous meetings. We ask for your help in changing the situation. I hope that you will understand our concerns. Thank you.

With great respect,

I. A. Dobruskina
a corresponding member of the Permian Subcommission

Letter from B. V. Burov

Chairman of the International Stratigraphic Commission
Chairman of the Permian Stratigraphic Subcommission

The problems of global correlation of the Permian stage scale of the Volga-Urals region resulted in elaboration of an independent scale of stages for the marine Tethys. At present, there are some variants of a new Permian scheme based on marine formations alone.

By now, old taxa of the Volga-Urals stratotype have been reviewed, and the new those are being studied; the regional formation-genetic and facies reconstruction in favor of continuity and low rate of sedimentation were carried out along with numerous paleomagnetic investigations. There have been studied hundreds of outcrops and wells, boundaries of magnetic zones corresponding to inversions of ancient geomagnetic field. For the purpose of correlation, the Permian Illawarra was typified as four generalized subdivisions (Nl, R2, N2, R3) corresponding to orthozones (Fig. I). Paleomagnetic structure of the Illawarra superzone served as a basis of stratigraphic division and geological mapping of the Tatarian and Lower Triassic.

The Permian marine scale is based solely on paleontological data. More or less satisfactory paleomagnetic results are only available for some Permian and Triassic

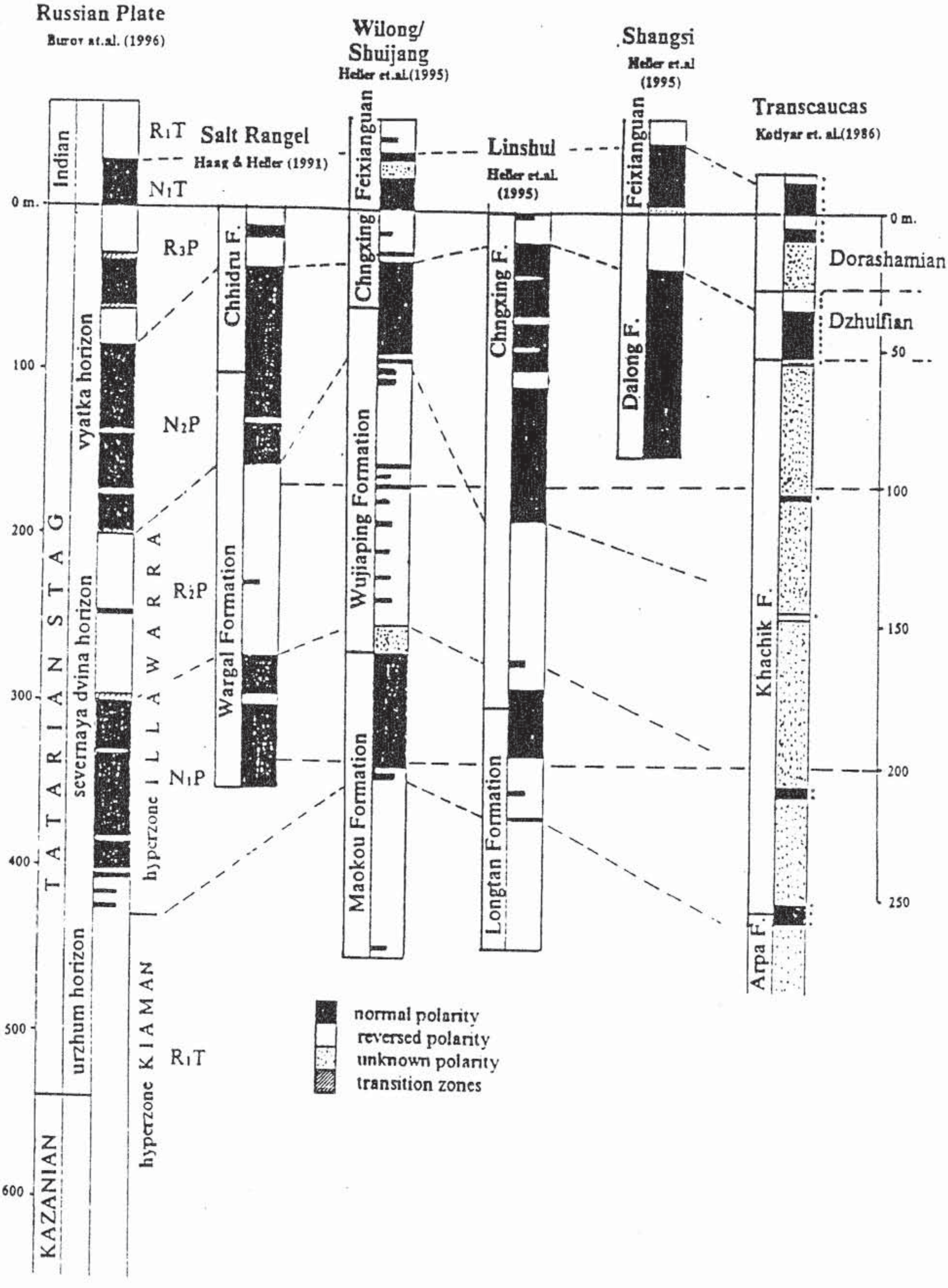


Figure 1. Scheme of paleomagnetic correlation of the Upper Permian Stratotype (the Volga and Kama regions) with Tethyan sections (Pakistan. South China. Transcaucasus). (Burov. Heller).

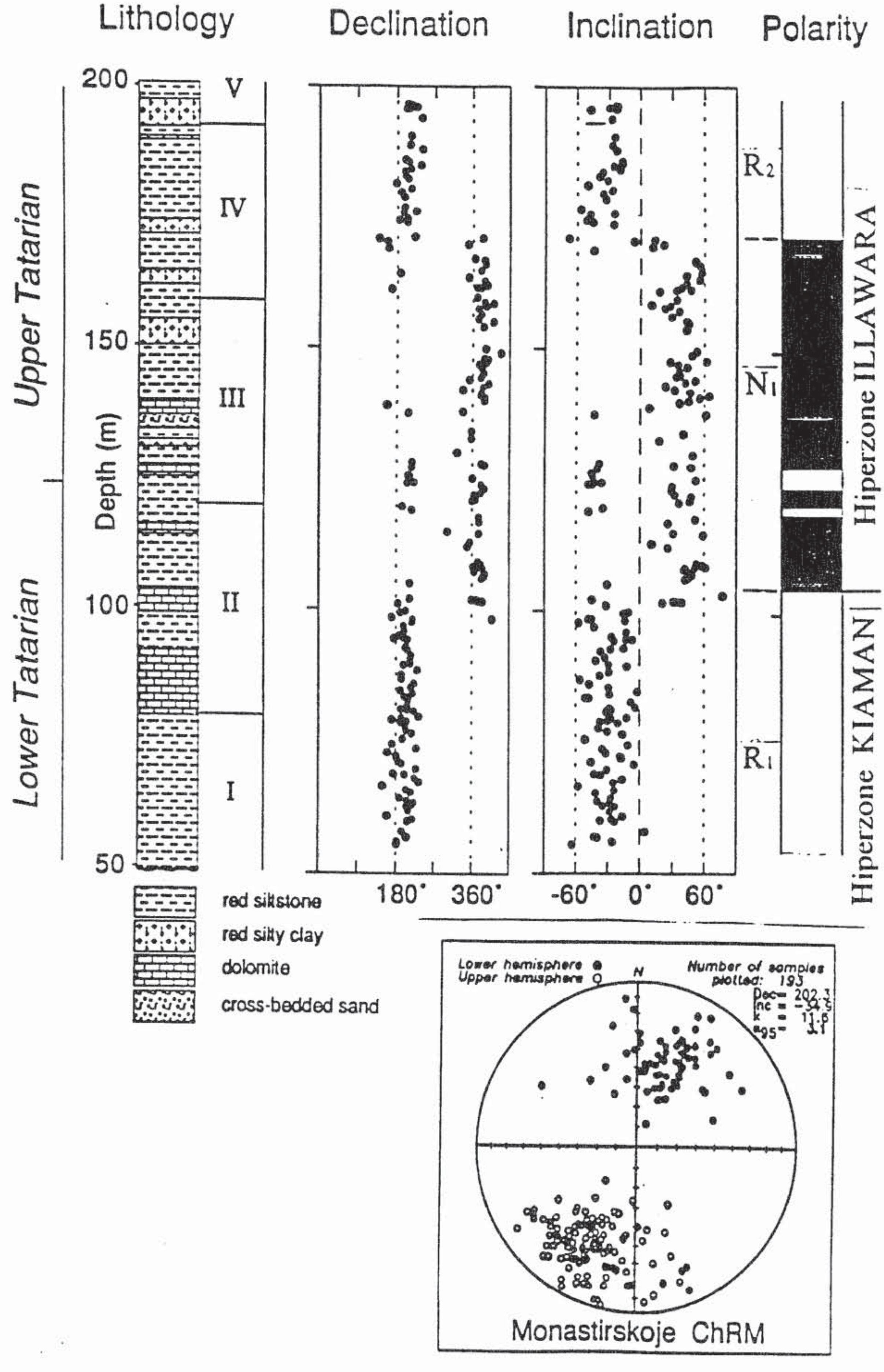


Figure 2. Paleonagnetic section "Monastyrskoye" and stereoprojection vectors J_n^o (Burov, Heller)

sections of Pakistan and South China (F. Heller at al. 1988, 1991, 1995). The Transcaucasian paleomagnetic section (Kotlyar et al. 1991) considered by many as a reference section (Fig.1), has not yet been studied in detail. There are only five samples for five magnetic zones (of 11 as a whole), other zones also have single samples only. Without any timing, the authors distorted the column (5-6 times) and correspondingly time structure of the Illawarra superzone having extended the upper relatively thin part, and narrowed the lower one. We understand the difficulties associated with paleomagnetic investigations of marine sediments which end up after complex dislocations in conditions leading to intensive weathering. After appearance of secondary ferromagnetic minerals, magnetization becomes multicomponent, primary component being partially or fully destroyed. So we need detailed magnetic-mineralogical examinations, analysis of magnetic components, tectonic corrections (rotation, inclination), along with broad experience in such kind of investigations. All these requirements demand much of the final material's quality, especially for the Transcaucasian section which is one of the key areas.

Paleomagnetic data on South China and Pakistan by F. Heller (1988, 1991, 1995) are based on hundreds of measurements of orientated samples collected at 1 m-interval which are in good accordance with the paleomagnetic scale of the Volga-Urals stratotype: the Permian part of Illawarra has a similar structure and equivalent magnetic zones (Fig. 1). After normalization of the Caucasian Permian relative to suites' thickness, and revision of the ranks of the magnetic zones defined before, the paleomagnetic section appears to be not a bit more complete than the Volga-Urals that. Considering polarity, the Dzhulfian and Dorashamian stages correspond to the Dalong and top Wujiaping fms. of the Shangsi section, Chhidru and top Wargal of the Salt Range, and the Vyatskian horizon of the Tatarian Upper Permian of the Volga-Urals stratotype (Fig. 1). The Tatarian stage is in accordance with the Maokou and Longtan fms. which are considered in China to be the equivalents of the Lower Permian.

The marine scale of the Permian is proposed instead of the Volga-Urals for the purpose of standardization. Standard scale is drawn using boundaries (points) of reference section, but the proposed scale lacks such points which exist in schemes only. And even in schemes the boundaries for some taxa are ambiguous. The new scale, as we think, does not cntribute toany standardization, but only complicates the problem. We think that, in order to standardize the Permian scale (in particular, the upper part), paleomagnetic data should be used wider in combination with paleontological.

Paleomagnetic scale represents inversions. Considering their duration (0.5 - 5 x 104 yrs) and the possibility to choose the beginning or the end of an inversion, - these are quite sharp and distinct boundaries which are simultaneously recorded in all newly-formed rocks, and unlike lithofacies and biofacies boundaries do not shift in time. The Upper Permian contains one of the most significant paleomagnetic boundaries. The inversed Kiama interval (70 ma) changes into the unsteady Illawarra (10-15 ma). The boundary is easy to recognize using the top of the thick inversed zone without its base in the known sections. This boundary has been studied in numerous sections of the Volga-Urals. That lies in the middle Tatarian, and Monastirskij ravine (8 km up the Volga river from the Tetyushi) which has been studied in detail by the paleomagnetic staff of the Kazan University as well as F. Heller in 1994 (Fig.2), can serve as its stratotype. The second reliable boundary could be the base of basal layers of the Vokhminskian which contains Triassic terrestrial vertebrates reflecting on the beginning of a new period and a new era, and carries normal magnetization peculiar to the base Lower Triassic of Tethys. Situated between these two points (base of the first normal Triassic magnetic zone and top Kiama superzone), the section can be marked in detail using paleomagnetic boundaries of lower rank. As the author thinks, the change in generation of geomagnetic field (top Kiama R-superzone) and inversions of the N-R Illawarra taking place in the Permian time can be the basis of standardization of the Permian stratigraphic scale, or at least its upper part. In this respect, the Volga-Urals stratotype can serve as an international standard.

In conclusion, I would like to propose to:

1. Standardize the Permian chronostratigraphic scheme on the basis of paleontological and paleomagnetic data taking the top Kiama as a major marking horizon;

2. Establish Monastirskij ravine on the Volga river as an international standard of top Kiama.

3. Carry out detailed paleomagnetic investigations for the purpose of global correlation for all key sections, especially for possible stratotypes;

4. Carry out the global paleomsgnetic investigations of Illawarra to further improve the Permian scale.

I would like to share my own experience and lab facilities for global correlation and detailed paleomagnetic investigations of sections.

The variants of a new Permian chronostratigraphic scale based solely on marine formations are being considered.

B. V. Burov
Professor of Kazan University,
Head of the Chair of Regional Geology

Letter from S. K. Pukhonto

Dear Chairman

International Permian Subcommission decided on its meeting in Alpine (USA, Texas) to subdivide Permian system into three series two of them being in Texas and China and one - in Cisural. I study biostratigraphy of the Permian deposits in the North-Eastern part of the Russia including Petchora coal basin for 30 years and consider that this Decision is extremely premature. Attempts to distinguish three series in Permian on different continents destroys our understanding this system as a continuity. It seems to me especially inadmissible to distinguish the Middle Permian in the southern regions of the USA because the transferring of the stratotypes into tropic area will deprive many geologists in northern areas of the Globe of the opportunity to correlate their sections with International time scale. To my opinion not all possibilities that give the Ural sections were used completely despite their prospective geographic position. Really besides well known stratotype sections of Kungurian and Ufimian on the Middle Cisural there are some more sections in Pechora region (on Kojim, Vorkuta, Khey-Jaga, Syr-Jaga rivers and some others) with intelayering marine, continental and brackish water deposits. The contain numerous and diverse flora, fauna and palynological complexes and have solid correlation with Uralian stratigraphic scheme Russian geologists continue working to improve the stratigraphic scheme of Permian on the northern part of the East-European platform. In the 1997 a meeting and a field trip will take place near Vorkuta city. Pechora coal basin where Lower and lower-most Upper Permian (Asselian - Ufimian) deposits are widespread. The goals of the meeting and field trip are to demonstrate this complex, the lower boundary of the Permian and the boundaries between Lower and Upper Permian. This meeting will held on July of 1997. We invite geologists to participate this meeting and hope that it will be very interesting for them.

S. K. Pukhonto
Leading geologist
OAO "Polyarnouralgeologya"

Letter from Tatjana Grunt

July 10, 1996

Dear Dr. Bruce R. Wardlaw,

I would like to draw your attention to the problems connected with the elaboration of the Permian Standard.

Up to now the classical type area of the Permian System, established by Sir Roderick Impey Murchison in 1841 on the base of the Cisuralian and Russian Platform sections has been preserved safely for more than 150 years.These sections were considered not only as a single unified region for the Permian System as a whole, but also for all composing subdivisions (two series and seven stages).

As it is possible to see on the figure enclosed, the Permian System according to several consecutive proposals of the group of specialists, consisting mainly of the voting members of ICS Permian Subcommission, dating back from 1992 - 1996 should be divided into three parts, each being recognized in the separate continent. According to these proposals only the Early Permian (Cisuralian) stages have their type areas on the territory of the Russian Platform. The type section of the Guadalupian - the MiddlePermian - in the case of three - fold subdivision of the Permian System - (or the Early Late Permian in the case of two - fold subdivision) is proposed to be recognized in Texas, while the Lopingian - the Late (or the Late Late) Permian - in China.

The formal reasoning for such kind of decision from the point of view of these students is insufficient faunistic characteristic of the Ufimian and Tatarian type sections as well as the aspiration to ground these subdivisions of the Permian in the normal - marine Equatorial basins.

I would consider this new concept of the Permian Operation scheme as not valid for a global standard. The main reasons for my conclusion are following:

1 . The difficulties of the Permian biostratigraphy depend not only on the features of the type sections of the Ufimian and Tatarian. They depend on true complicated palaeogeography of the Permian. This is connected directly with the highest biogeographical differentiation in the Late Permian compared to the rest of the Paleozoic. Taking into account this complicated situation, it is impossible to solve the problem of the Permian Standard by a single replacement (substitution) of one type section by another. Such kind of solution could be taken in the extreme situation only, when all the other possibilities are exhausted.

2. Legal affirmation of the new Permian Standard consisting of three series, each having its proper name, entails immediately the refusal of the classical type area of the Permian System. The unified scale of the Permian being divided into three series with the type sections located in three various continents (each series corresponding to different paleobasin) separated by vast distances, loses its integrity. Being accepted this decision would disturb the present - day stability of the stratigraphic nomenclature, as the fixing of proper designations of proposed series automatically results in the recognition of the corresponding stage - names.

3. It is absolutely clear, that only Russia and China obtain complete, representative and perspective sections, which could be used for the elaboration of Standard Permian scale. The sections of the Russian Platform are of high correlative potential. It is important, that the stages of the Permian Standard scale have been established and substantiated within the single large region. The presence of rich palynological assemblages, as well as the wide distribution of abundant continental flora and fauna can also be considered as an advantage of these sections over the sections from any other area. The position of the Kiama - Illawara hiperzones boundary within the Tatarian in the type area is also fixed precisely. This section could be proposed as an international standard of the Kiama - Illawara hyperzones boundary already now. At the same time the precise Kiama - Illawara hyperzones boundary is not yet established either in the Tethyan or in the North American sections.

The sections of the South China could be successfully used for the subdivision of the uppermost part of the Permian as well as for the definition of the Permian/Triassic boundary (but the last problem is in line of the International Triassic Subcommission and has not been solved yet).

4. On the contrary, the North American sections are not sufficient enough for the purposes of elaboration of the Permian Global standard. Only the middle (Guadalupian) part is represented by relatively satisfactory sections.

The sections of the Guadalupian series could probably meet formal requirements but in fact they do not correspond the general situation of Permian biostratigraphy and biogeography.

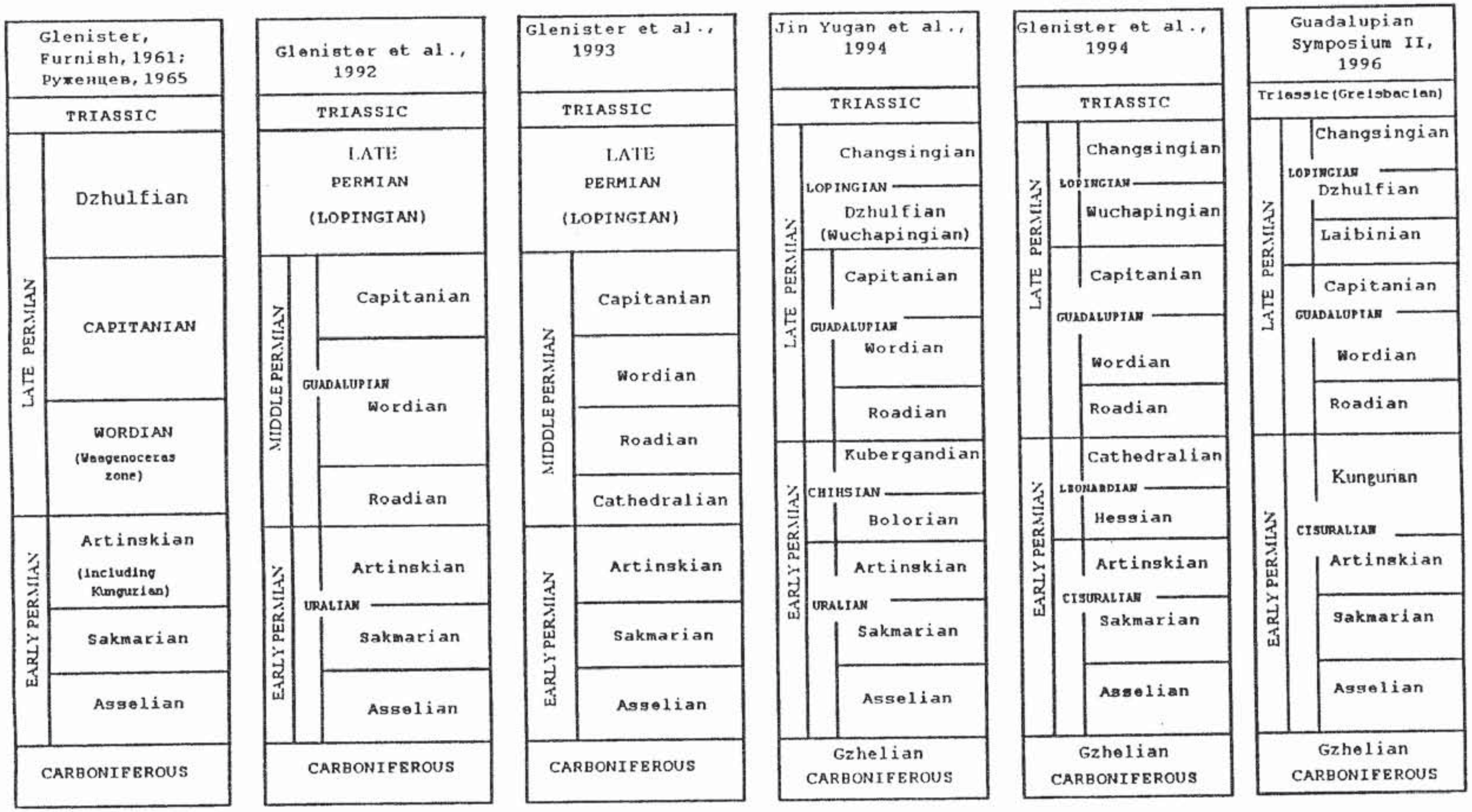


Figure 1. Different versions of the revision of the Permian scale.

the basins of the Equatorial Middle Continent being isolated biogeographically from the Euro - Asian basins; therefore the biota is characterized by high degree of endemism and very low correlative potential.

From this point of view such activity of American colleagues in their aspiration to introduce the Guadalupian into the International standard seems to be excessively hasty. Sometimes it looks rather like a protection of national prestige than like the true necessity of modernization of present - day standard scale. For example, the version of the Permian Standard which has been voted just before the present (Beijing) Congress is not accessible for specialists as it has not been published yet.

5. The proposal under discussion does not give any kind of possibility of utilization of this scale outside of the Equatorial Belt. The vast areas of the North Euro - Asiatic and Perigondwanian Late Permian basins are not taken into account, as the sections outside the Equatorial Zone do not contain characteristic tropical faunistic remains like conodonts or fusulinids (the proposed scale being based on these two faunistic groups mainly), and ammonoids are exceptionably rare. The principles of establishing and faunistic grounding of the Permian standard even have not been discussed. Therefore the impossibility of the utilization of this scale outside the Equatorial Belt deprives specialists of the common stratigraphic language. The proposed scale could be possibly used as a transitional one for the Equatorial climatic zone, but it seems that at the present time it is to early to affirm this scale as an International Standard.

6. The rank of proposed series (or subseries) is still not clear. It is obvious, that the rank of the Cisuralian/Guadalupian and the Guadalupian/Lopingian boundaries is not the same. The lower boundary of the Lopingian is poorly grounded even inside the Equatorial Belt. The problems of the correlation of the subdivisions of stage - rank are not established entirely up to now.

7. The elaboration of the Permian Standard is connected with the necessity of maximum stability of names. This could be reached only by the following of the principle of priority in this field. Unfortunately the proposals of the last five years do not follow and even ignore this principle that is generally accepted in science.

That is why it seems to me impossible to take such important decisions without detailed previous investigations and without deep analysis of all possible alternatives without open discussion and full value publications.

For the first hand the Early/Late Permian boundary must be traced in the sections of various biogeographic regions, and it is absolutely insufficient to fix it in the type section of the Guadalupian only.

One must take into account that the Early/Late Permian boundary is not only the boundary of conodont zones in the continuos marine sedimentation of a single section. In reality this boundary has been established by A. Netchaev in the sections of the Russian Platform in 1915 as the most striking boundary within the whole Permian in the aspect of the ecologo - systematical reorganization and development of Permian marine and terrestrial biota. The Roadian only recently has been recognized as the Early Late Permian. Before, this subdivision was considered as the Early Permian (Furnish. 1973; Cowie, Bassett, 1989, Wardlaw, Collinson, 1984). This specific example demonstrates once more that it is especially important to have the sequence of sedimentation within the single basin, which could serve as a stable basis for correlations with sections from various areas. Only the type area of the Permian System, at present time can really represent a solid basis for wide transcontinental correlations. And, finally, in my opinion true agreement reached by the majority of specialists working in this field but not only the agreement among the voting members of the Subcommission should be achieved as a final result of our work on Global Permian Standard.

References

J. W. Cowie, M. G. Bassett. Global Stratigraphic Chart with geochronometric and magnetostratigraphic calibration. Int. Union of Geol. Sci.. P. 1. 1989, 1 p.

Furnish W. M. Permian stage names in Permian and Triassic System and their mutual boundary. Can. Soc. Petrol., Geo., Mem. 2, 1973. PP. 522 - 548.

Glenister B. F. A call to action. Permophiles No 22. June, 1993. A Newsletter of SCPS. PP. 2 - 5.

Glenister B. F. et al. The Guadalupian: proposed International Standard for the Middle Permian Series. Internat. Geol. Rev. 1992. V. 34, No 9. PP.657 - 688.

Glenister et al. Revised Operational Scheme of Permian Chronostratigraphy. Permophiles. No 25. 1994. PP. 12 - 15.

Jin Yugan , B. F. Glenister, G. V. Kotlyar, Sheng Jinzhang. An operational scheme of Permian chronostratigraphy. "Palaeoworld 4". V. 1. Palaeontol. Stratigr. 1994. Nanjing Univ. Press. PP. I - 13.

Murchison R. I. Geologicheskie nablyudenia v Rossii (in Russian). [Geological observations in Russia]. Geol. Journ. Part 4, I 1- 12. 1841. PP. 160 - 170.

Netchaev A. V. Kazanskiy i Ufimskiy yarusy Permskoy sistemy (in Russ.) [Kazanian and Ufimian stages of the Permian System]. Geologichesiy Vestnk. V. 1, No 1. 4 - 6 PP.

Second International Guadalupian Symposium. Abstracts and Proceedings. Sul Ross State University Alpine, Texas, USA. Edited by Bruce R. Wardlaw and David M.Rohr. 80 p.

Wardlaw B. R., Collinson J. W. Conodont paleoecology of the Permian Phosphoria Formation and related rocks of Wyoming and adjacent areas. Conodont Biofacies and Provincialism. Geological Society of America. Special Paper 196. 1984. PP. 263 -281.

Tatjana Grunt
Palaeontological Institute RAS,
Moscow, Russia

Letter from Marina Durante

July 29, 1996

To: Chairman of the International Permian Subcommission of ICP Prof. Jin Yugan

Dear chairman

I and my colleagues have received an information about the proposals concerning with a changing of our traditional view on the stratotype area location and a standard subdivision of the Permian system, which have been done at the International Subcommission meeting at April of this year (USA). As I understand instead of the traditional stratotype area (Middle Cis-Ural and Russian platform eastern part) where the Permian system as a whole and it standard subdivisions (two series, six stages) have been outstanded there have been proposed to subdivide Permian to three series with type sections at different continents: the Lower one (Cis-Uralian) in Russia, the Middle one (Guadalupian) in USA, the Upper one (Lopingian) in China.

I can't be at Peking subcommission meeting and decide to express my opinion by letter. I hope you'll take it into consideration.

1) Formally the cause of the Cisuralian standard scale revision is either an insufficient faunistic characteristic of some stages (Kungurian, Ufimian) or an absence of marine fauna at all (Tatarian).

According to my opinion it can'be a cause of a full Upper Permian scale transformation because very important faunistic data have been received by the standard section correlation with marine ones located at Northern and Polar Cisural as far as at another Arctic regions.

That's why I think that the best way of the Cisuralian scale changing is not a refusing from classic Upper Permian subdivisions but a transformation of them with taking into consideration marine fauna data. This way of changing helps to keep stability of the scale and the stratigraphic language. It seems me that a keeping of this stability is one of the main tasks of the International Permian subcomission but now this problem have appeared outside of it scope.

2) According to my opinion the main difficulties of Upper Permian (post-Kungurian) biostratigraphy isn't an insufficient faunistic characteristic of classical Cisural subdivisions but a high degree of palaeogeographical and biogeographical differentiation.

In this situation it is necessary to estimate a global correlation potention of classical and proposed Permian scales. In spite of a rich faunistic content of Guadalupian and Lopingian series as far as new stages these subdivisions can't be recognized outside the Equatorial belt. Among three archistratigraphic groups of marine fauna (conodonts, fusulinida, ammonoidea) served as the biostartigraphical basis of the new Upper Permian scale only rare ammonoidea are available into Boreal (Biarmia, Angaraland) and Anti-Boreal (Gondwana) areas. Nevertheless they are represented by different genera here. Therefore proposed Upper Permian scale can't be the base of a global correlation. It is only provincial (the Equatorial belt) one.

A global correlation potential of the classical Cisural section is higher. Most part of Cisuralian subdivisions are recognizable in Gondwana. The cause of this phenomena is a similarity of Boreal and Anti-Boreal marine fauna and miospore assemblages. Besides there are two correlation levels in the Cisural standard section, what may be regarded as global ones. First of them is the base of the Sverdrupites-Daubichites ammonoid zone widely distributed all over Boreal and Anti-Boreal areas. The position of this level into the Cisural section is the Middle of Ufimian (the Sheshma horizon foot). Into the Equatorial belt it position is rather uncertain. As a rule this level is regarded here as coinciding with the base of Roadian. But this idea must be supported by new investigations because single findings of pre-Roadian conodonts at the same level as first Sverdupites (Nassichuk in Utting, 1994) suppose different age of the bases of Roadian and Sverdrupites - Daubichites ammonoid zone.

The second global level is the change of Kiama / Illavara palaeomagnetic zones, which best expression is known in Australia and Cisural (two Tatarian substages boundary). In Tethian this palaeomagnetic change position isn't exactly determined till now.

It is clear that because of mentioned similarity of Boreal and Anti-Boreal marine fauna and miospore assemblages there are more then two levels traceable from the Boreal area to Gondwana, but most of them aren't described carefully.

To the contrast of proposed Upper Permian scale whose detailed zonal subdivisions can be followed only inside Equatorial belt Cisuralian scale may be used as a basis for global correlation. It is one of the causes why the proposed scale can't be approved recently as the World Upper Permian standard.

3) As we mentioned above a changing of the Cisuralian Upper Permian scale to the new one proposed by the Permian subcommission have been followed by replacing of the single stratotype area (Cisural and Russian platform eastern part) to three ones (Ural, Texas and China) where type sections of new series have been located. Certainly in this case it is the great problem to give proof of coinciding of the elder subdivision roof to the foot of younger one. I showed above to a possible gap between the proposed roof of Lower Permian (Sverdrupites-Daubichites zone base) and Middle Permian (Guadalupian) foot. It is possible to see that tracing of Lopingian base is a very complicated problem too. That's why I think that outstanding of Guadalupian as a Middle Permian series is very dangerous, because it located into very specific basin very far from classical Tethian sections. It seems me that in this situation we never sure in a certanity of the series boundaries.

As a conclusion it is possible to say that two different Upper Permian scales are really existing: Cisuralian (Boreal) one and the proposed by the Permian subcommission the Equatorial belt scale. In spite of a rich faunal content and detailed zonal subdivision the latter can't be used as the Global standard because these subdivisions are not recognizable outside the Equatorial belt i.e. inside 3/4 of Upper Permian basins.

I think that a mechanical change of the Cisuralian (Boreal) stratotype to the Equatorial one is at least useless from the point of view of outstanding the Global Upper Permian standard. Besides this decision can provoke many new problems, some of them I try to tell above.

That's why I ask you as a chairman and all voting members of the subcommission to delay your approval of the new version of the Permian system main subdivision.

It seems me that it is necessary to organize the special working groop (ar some of them) where this problem can be regarded from different points of view including the analyze of the great volume of new stratigraphic data concerning with Boreal and Anti-Boreal Permian. As to myself only after this analyze and a wide open discussion the decision according to the Permian system subdivision can be proposed.

Please don't regard my disagreement with the Permian subcommission decision as a low estimation of the Permian subcommission great activity during last years. This activity was admirable and have returned our thoughts from the regional problems of Permian stratigraphy to Global Ones.

Marina Durante
Geological Institute RAS,
Moscow, Russia

Letter from S. Lazarev

25 June 1996

Dr. B. Wardlaw
(Bureau of International Commission on Stratigraphy)

Dear colleague,

[Preamble: We have now serious threat for stability of nomenclature in General Scale of Permian (see below). It is possible to wait the same threat for future with reference to old names of any System. That is why I send the message as short memorandum not only to Permian Subcommission].

The logic of my suggestions concerning the construction of the General Scale, in particular, that of the Permian System, is grounded only on one premise: any stratigraphic scale is a scheme of substantial classification. This is testified by all the history of the construction and development of stratigraphic scales with permanent transferences of stratigraphic boundaries: this means none other than the change of hierarchy of the boundaries of stratons (stratigraphic units).

I fully realize the fact that stratigraphic classification has its specifity. At the same time, there are common features inherent in every classification. Let us proceed from the thesis: the problem of the selection of competitive names is a technical problem in any classification, not touching upon the substantial kernel of classified objects. As such, this problem has to be solved by the same way in any classification.

Half a century ago biologists solved successfully the problem of the choice of competitive names, having adopted separate decisions concerning nomenclatorial and substantial problems. The notions "type" and "typical" were separated in biology once and for ever. I mean the work connected with the creation of International Nomenclature codes in biology. May be the success of this work can be explained by a greater acuteness of this problem in biology, where the quantity of objects (taxa) are much more numerous than objects in stratigraphy (stratons). Just the underestimation of nomenclatorial problems in the stratigraphy led O. Shindewolf and his protagonists to the erroneous opinion about the uselessness of the stratotypes at all. At the same time, these stratigraphers were absolutely right in stating that the stratotype was unnecessary as substantial standard. Exactly these stratigraphers were the first who refused from the typologic conception in stratigraphy, that is, they understood the fact any stratigraphic unit was a result of the synthesis (logic construct), and there was no and could not be an ideal section which would keep all the complex of correlative features sufficient for interregional correlations, even if only for sea facies. It is always necessary to indicate key section (or sections) in every region, which should bear no relation to the nomenclature. Neither should bear relation to the nomenclature the geographic location of so-called "boundary stratotypes" (the word "stratotype" as nomenclatorial type is appropriate here).

Up to now, the type of a straton carries an excessive burden - that of the bearer of the content. That is why in the system "type-name-content" we always should for the save of the stability of the name either not to change anything, or, when changing the content (it is inevitable process in any science), change also the name (otherwise nobody would understand what is implied by the name of a straton). Principle of priority cannot work in this system.

In order to ensure the maximum of the stability of the nomenclature in any possible perturbations of the content, we have to separate clearly nomenclatorial aspects of the classification from substantial ones, as it was done by biologists (see the Preamble of ICZN).

This would require introduction of the hierarchy into the process of the typification itself. Only then the principle of priority (the priority of the namel) could work.

I cannot discuss these difficult problems here in detail and in English, but I hope that two of my papers will be published in the magazine "Stratigraphy and Geological Correlation." The change of the procedure of typification would serve as a basis for the creation of the true jurisdiction in the stratigraphy, particularly for the creation of the International Code of the Stratigraphic Nomenclature.

Nomenclatorial problems are especially sharp for the Permian System because of the maximum of the geographic differentiation, and continental deposits, beginning from the Kungurian, more and more predominated over marine deposits. The acceptance of the names Guadalupian and Lopingian inevitably will lead to the substitution of the stage names in these series. The logic of the modernization of the scale will lead eventually to the refusal of the name "Permian," because it is suggested to withdraw all the names (and corresponding stratotypes) from that part of the scale which was used by R.Murchison of the establishment of the Permian System.

Of course, substantial modification of any scale is a necessary and inevitable procedure but the choice and fixation of any new versions of series and stage boundaries should not be connected with the replacement of the traditional nomenclature; otherwise after every new revision of the scale we should have to substitute old names.

Thus, my suggestions concerning nomenclatorial aspects of the problem come to the following:

1. We must not hurry with the intoroduction of new nomenclature for the Permian System. Otherwise in 5-10 years the new names might become as habitual as the traditional ones, and we cannot foresee the results of further substantial revision of the Permian system which would entall next replacement of names. It is not excluded, however, that stratigraphic jurisdiction (nomenclatorial codes in stratigraphy).

If so, in 10-15 years a contradiction, known in biology, can arise between the necessity of stabilization of names (the supreme aim of nomenclatorial codes) and the following to the priority principle which is providing mis stability.

2. It seems to me that there is a time to think about the creation of precisely nomenclatorial code in the stratigraphy, which would require the change in the procedure of typification. All national codes known up to now aim at the solution of not nomenclatorial but substantial problems. Such an approach to the creation of codes contradicts the spirit of the science itself. The creation of similar frameworks for the contents is unnatural even whithin the borders of seperate states and quite unreal for all the countries. Therefore the first attempt to create International Code in stratigraphy was failed. We need NOMENCLATORIAL Code in stratigraphy but not Stratigraphic Code.

Dr. S. Lazarev
Paleontological Institute RAS,
Profsoyuznaya 123,
Moscow 117647 Russia
FAX: (095)-954-38-15

Letter from A.I. Shevelev

16 July 1996

Chairman of the Permian Stratigraphic Subcommission, Chairman of the International Stratigraphic Commission

According to the ICP requirements, definition of boundaries of series and stages, points of global stratotypes' boundaries must be carried out for all systems. The lower Permian boundary and stages cause no problem at present. But the Upper Permian does. Some scholars think that none: of the Upper boundaries can be clearly defined outside the stratotypical area, and cannot therefore be a global standard. It has been suggested that the Upper Permian stages be in marine sections. This resulted during the last two years in three marine chronostratigraphic schemes which were in fact biostratigraphic (using conodonts, ammonoids, fusulinids). Actually, none of them are satisfactory. Indicative of this are numerous amendments to names of stages, zones, and their relations.

We believe that before making final decision, it is necessary to elaborate a new approach that would allow for the Permian continental sediments and preservation of the stratotypes along with creation of a marine scale. Formal use of marine scale cannot solve the problem of correlation. We believe that, to chronostratigraphic scale of the Upper Permian, ecotones should be applied that are based on event-stratigraphic approach using chronological interchangeability of stratigraphic features providing reliable correlation not only within the Biarmia but also outside. Ecotones provide wider possibilities for global correlation and are able to dovetail the Volga-Urals Upper Permian conodonts of Tatarstan Republic, goniatites Pseudogastrioceras at the base of the Kazanian of the Vim river's basin of the East-European Platform with goniatites Altudoceras of the Lower Wordian of North America. This method has been long applied by our American colleagues. Since we know that the Roadian of Glass Rocks of Texas contains no "Roadian complex" of ammonoids that originates from the Phosphoria fm. (Nevada), and shows good correlation with it.

We believe that the chronostratigraphic scheme cannot be drawn on the biostratigraphic basis only using three faunal groups of limited areas. Biostratigraphic boundaries must be controlled using magnetostratigraphic those, namely magnetic inversions within Illawarra.

We suppose the obvious advantage of the Volga-Urals Upper Permian to be their location on the sea-land boundary that enables ecotones and paleomagnetism to be used, and to correlate different paleogeographic provinces and areas.

We believe the following must be done in the framework of an international program:

1 - Determination of an approach to the Upper Permian chronostratigraphic scheme.

2 - Elaboration of zonal schemes using different fauna and flora groups (conodonts, ammonites, brachiopods, fusulinids, miospores, macroflora, terrestrial vertebrates) of the Boreal and Tethyan regions for further correlation through the series of intermediate sections.

3 - Obtaining reliable paleomagnetic data on all reference sections (especially stratotypes) for making a standard magnetostratigraphic stratotype of the Upper Permian.

On behalf of the Government of Republic of Tatarstan, we would like to propose:

1 - Works on correlation of the Upper Permian stratotypes of the Volga-Urals region (both within Russia and outside).

2 - July-August 1998 International Symposium on the Volga Upper Permian with excursions to be included in the international program.

All interested persons are invited to take part in these works.

A.I. Shevelev
The Chairman of the Commission on Natural Resources of Republic of Tatarstan

Some general considerations concerning the definition of stratigraphic Units and their boundaries

Comments to statements opposed to the new subdivision of the Permian System, as adopted by the Subcommission on Permian Stratigraphy of ICS

By Jurgen Remane

The new subdivision of the Permian System, as voted by the Permian Subcommission (SPS), has led to a number of opposing statements, some of them rather passionate. New chronostratigraphic schemes should of course be thoroughly discussed before being codified by GSSPs. But there is also the danger that essential aspects are obscured by arguments which are not related to the central point: Does the new subdivision allow to make progress in interregional correlations or not? This is strictly a matter of practical considerations, not of historical arguments.

I am not a specialist in Permian stratigraphy. I will thus only deal here with the more general aspects of boundary definition and priority in chronostratigraphy, which take an important place in all nine letters published in this issue.

1. The problem of priority

According to the opponents of the new scheme, the new type-regions cannot be correlated with the historical Cisuralian type-region and would therefore be unacceptable as a standard. This argument implies that the priority of the classical type-regions should be respected, an implication which is even explicitly stated in some of the letters. This is, however, not in agreement with the Guidelines of ICS (also published in this issue of Permophiles).

In a general way, the correlation of new standards with classical type-regions though desirable, is not a condition sine qua non for their acceptation. If necessary, it must be possible to abandon a classical type-region which does not satisfy the demand for reliable interregional correlations. The most important question is then if the new type-region offers the better support for interregional correlations outside the classical type-region. But as far as I can see, no facts relevant to this aspect were presented by the opponents of the new subdivision, with the exception, perhaps, of magnetostratigraphy.

Magnetostratigraphy has indeed become an important tool for interregional chronocorrelations. But we should not forget that the Magnetic Polarity Time Scale based on oceanic anomalies does not extend as far back as the Permian. Magnetostratigraphic correlations in pre-Late Jurassic sediments depend thus heavily on biostratigraphy.

It should also be recalled that there is no formal priority regulation in chronostratigraphy - as stated in the Guidelines of ICS. The comparison with the International Code of Zoological Nomenclature, postulating in the same time the creation of a corresponding code in stratigraphy is misleading: Chronostratigraphic units are like physical units of measure and not like animal species. The rules of Zoological Nomenclature allow to modify the contents of a species without changing its name, whereas the name of a chronostratigraphic unit is always intimately linked with its duration.

2. Should all systems of the Global Chronostratigraphic Standard be represented by one single type-region?

The classical Permian subdivision was based on a unified type-region. According to the opponents, the new scheme would be seriously hampered through the introduction of two new type-regions on different continents. In other words: the unified type-region should be preserved.

To this I would oppose the case of the Devonian, where all eight stage boundaries (including the base and the top of the system) are at present defined by GSSPs. In the course of the redefinition of Devonian stages, two venerable classical names were abandoned: the Gedinnian (Dumont 1848) and the Siegenian (Kayser 1895). Out of the seven Devonian stages only one, the Eifelian, was redefined in the classical type-region of the Ardennes/Rhenish Slate Mountains (which, by the way, does not correspond to the eponymic type-region of Murchison and Sedgwick 1835). The other Devonian stages have their basal GSSP in the Barrandean area of the Czech Republic (Lochkovian, Praguian), in Uzbekistan (Emsian), in Morocco (Givetian), and in the Montagne Noire of Southern France (Frasnian, Famennian, base of the Carboniferous System). Devonian GSSPs are thus dispersed over three continents: Asia, Africa, and different countries of Europe, but this does not seem to be a source of any problems.

3. Should any decision about the subdivision of the Permian be postponed?

The demand to wait for new results concerning the correlation of the new type-regions with the classical one is in my opinion not well motivated. The proposal of a new subdivision is being discussed for a couple of years. So why are the facts we are asked to wait for not at hand now? In this context, it may be useful to cite from the Minutes of the IUGS Executive meeting in January 1996: "Unfortunately ICS is commonly perceived as a commission that sends groups around the world to analyze sections and recommend, after very prolonged analysis (8, 10, 15 or even 18 years) the location at which a boundary-defining spike should be driven". This is not a very flattering appreciation.

So let us try to show that this appreciation is not entirely justified. In my opinion, the Subcommission on Permian Stratigraphy has made good progress towards the solution of a difficult task and should not be hindered in making further progress in this direction.

Jurgen Remane, Chairman of ICS
Institut de Géologie,
Université de Neuchâtel
Rue Emile-Argand,11,
CH-2007 Neuchâtel,
Switzerland

Response to 9 letters

by Brian F. Glenister

I am unwilling to comment specifically on the group of nine letters that protest the developing consensus on international standardization of the subdivisions of geological time, but recommend that the writers consult the Guidelines and Statutes of ICS (Cowie et al., 1986; Remane et al., this volume), as these reflect the growing experience of participants and have directed our activities. I must add that I am disappointed at the several accusations that active SPS members are motivated by nationalistic considertions. My personal support for designation of the Southern Urals of Kazakhstan and Russia as standards for the systemic boundary and the Cisuralian stages, for use of the American Southwest as standard for the Guadalupian stages, and for transfer to South China for the Lopingian stages and the Erathem boundary is based on their respective scientific merits. After two decades of active and commonly vocal participation in deliberations of the SPS, marked by achievement of personal field and literature familiarity with all three areas, I am convinced that they are the best choices.

Collective merit of the nine letters can be judged best by reading them. However, an informed and objective evaluation is provided by the accompanying letter of ICS Chairman Dr. Remane. Beyond this, I invite readers to refer to my earlier evaluation of stratigraphic principles and procedures as they pertain to Permian standards (Glenister, 1993). Additionally, please review our proposal for the base of the Permian (Davydov et al., 1995), the only boundary ratified to date, and for the base of the Triassic (Yin Hongfu et al., in press, ?1996). These will reveal the diversity and quality of the data that characterize the leading choices for international standards.

References

Cowie, J.W., Ziegler, W., Boucot, A.J., Bassett, M.G., and Remane, J., 1986. Guidelines and Statutes of the International Commission on Stratigraphy ICS). Cour. Forsch.-Inst. Senckenberg, 83, p. 1-14.

Davydov, V.I., Glenister, B.F., Spinosa, C., Ritter, S.M., Chernykh, V.V., Wardlaw, B.R., and Snyder, W.S., 1995. Proposal of Aidaralash as GSSP for he base of the Permian System. Permophiles, 26, p. 1-9.

Glenister, B.F., 1993. A call to action. Permophiles, 22, p. 2-5.

Yin, H.F., Sweet, W.C., Glenister, B.F., Yang, Z.Y., Sheng, J.Z., Kozur, H., Zakharov, Y.D., and Kotlyar, G. Recommendation of the Meishan section as Global Stratotype Section and Point (GSSP) for basal boundary of theTriassic System. Newsletters on Stratigraphy, in press, ?1996.

Brian F. Glenister
Department of Geology
The University of Iowa
Iowa City, Iowa 52242, U.S.A

Approach to a precise global chronostratigraphic scale --A reply to the comments on the proposed integrated chronostratigraphic scheme for the Permian System

By Jin Yu-gan and M. Menning

As we have predicted in our paper (Jin et al., 1994), this proposed scheme evoked diverse comments. Apart from the verbal comments at relevant meetings, 34 comments and letters touching on the scheme have been presented. Subsequent to the original version of the scheme (Jin et al., 1994a), a revised version (Jin et al., 1994b) and a voted version (Jin, 1996) were put forward. Indeed it was gratifying to find the constructional advice and criticism from the comments, involving the names and subdivisions in the scheme. We understand fully that we could not step forward in defining the various boundary stratotypes without an agreement on the names and boundary levels of chronostratigraphic units of the Permian System and without a thorough discussion to bring together all necessary information.

A. To our astonishment most of the comments do not concern the substantial contents of the scheme but argue with the general points of view expressed in "The guidelines for establishment of global chronostratigraphic standards by the International Commission on Stratigraphy" (Remane et al., 1996) and in "The International Stratigraphic Guide" (Salvador, 1994). Detail discussion on these points are really beyond the scope of this reply, but a brief explanation on the following points could not be avoided.

1. How to build up a precise global chronostratigraphic scheme for the Permian System?

With great anxiety we saw that the approval of proposed scheme would entail rejection of the upper part of the traditional standard in Urals which had been used for over 150 years (Ganelin et al., this issue). It is regrettable, but is necessary.

To Permian workers in countries other than Russia, it is an obvious fact that the traditional standard in the Urals has never served as a precise standard effectively in a global scale, and it is particularly true for the part above the Artinskian. One can not recognize the accurate equivalents of Kazanian and the Tatarian in Tethyan, American, Gondwanan and West European successions. The real status is that the traditional standard is mostly cited in correlation with other major regional standards, the Tethyan, North American, Gondwanan, and West European.

It is generally agreed that the cornerstones supporting a precise global chronostratigraphic scheme are the GSSPs for the systemic and intra-systemic boundaries. Anyone who agrees with the requirements for a GSSP will find that there is little potential of erecting the GSSPs for the chronostratigraphic subdivisions above the Artinskian in the traditional standard succession.

Success in defining the GSSP of Carboniferous-Permian boundary proves that progress in establishing a precise chronostratigraphic scheme only can be made with the help of friendly international cooperation. The C\P boundary defined originally by the founder of Permian System is not less geologically important than the present one. It is easily applied in the field and was unanimously accepted for half century in China, and also supported by experts in other countries. Thanks to colleagues who took the interest of the whole stratigraphic community into account, this longstanding problem has been solved smoothly.

2. The favorable facies and key fossil group in defining the GSSPs

It has been recognized by the Subcommission that, in general, the open marine facies forms a better basis for the biostratigraphic precision needed for international correlation, and the evolutionary clines of conodonts can provided a precise boundary of great correlation potential. This is not to imply that there are not facies rich in other groups, for example fusulinids, ammonoids, spores and pollens, which are very important for correlation, but it is normally easier to correlated into such sections secondarily from primary sections in the deeper marine facies. It is a very convincing fact that nearly all ratified GSSPs of Paleozoic are defined by the key elements of conodonts. It is also an important fact that only the succession of conodont zones can be precisely identified in all Cisuralian sequences of the Urals, Southwest USA and South China. Of the continental fossil groups, even the most conspicuous boundary level, the Permian-Triassic boundary in the same palaeogeographic region can be correlated only with large discrepancy (Esaulova. 1995; Koloda and Kanev, 1996).

3. Priority in the nomenclature of chronostratigraphic names

We agree with the statement of priority in the Stratigraphic Guide (Salvador, 1994) that Priority should be respected. However, the critical factors should always be the usefulness of the unit, the adequacy of its description, freedom from ambiguity, and suitability for widespread application.

Priority should not hamper the necessary revision in chronostratigraphic subdivisions. Clearly, nobody would like to displace the well established name of the Permian with the Dys by the priority alone. For the uppermost series of Silurian, the Pridolian Series of marine facies was widely accepted as a substitute of the Dowtonian Series of continental succession in the classic area.

In the proposed scheme, as many of the names of chronostratigraphic units of the traditional succession are adopted as we could by priority. For example, the Kungurian sequence is obviously not suitable for defining the GSSPs, but we reserved the name since the basal part can be widely recognized in terms of marine fossil groups.

4. It is the time to build up the global chronostratigraphic scheme based on the marine succession.

To this question, the answer from a majority of experts on Permian marine fossils are positive (Bogoslovskaya and Leonova, 1994; Leven, 1994; Davydov, 1994), largely because of the zonation of major marine fossil groups have been well studied.

It should not regarded the proposed scheme as having a hastily manner (Dobruskina, this issue). As we described previously(Jin et al., 1994; Jin, 1996), attempts to build an integrated scheme initiated in early 1960s, and the Permian Subcommission has worked on the scheme for two decades. A draft of proposed scheme appeared first in the early 1980s (Waterhouse, 1982), and has been basically accepted by an international geological time scale in 1989 (Harland et al., 1990). Comparing to the other systems, the progress in establishing the Permian time scale should be ranked as rather slow because the unusual difficulties in correlation.

B. With regard to the discrepancies on refining faunal successions, selection of subdivisions and suitable boundary levels in the proposed scheme. The points of the issue are on the levels of basal boundary for the series.

1. The basal boundary of the Kungurian and its equivalents

We have hesitated to change the traditional basal boundary of the Kungurian Stage, and therefore, put the basal boundary of the Chihsian\Cathedralian Series at the level corresponding to the Yakhtashian and the Borolian Stage. It is really an important result of the discussion on the scheme, that there is a mounting consensus to lower the level of the Kungurian and its equivalents to the base of the *exsculptus* zone, which corresponds to the base of the Cathedralian in USA (Jin et al.,1994b) and the Yakhtashian in Central Asia (Leven, 1994), but is just above the major regression surface within the Longlinian in South China (Zhu, 1996). The Kungurian in the voted scheme occupies the same time interval as the Leonardian Series in the revised scheme (Jin et al., 1994b).

2. The Roadian and its equivalents

The Roadian was placed above the Kubergandinian Stage in the original version of the scheme, because of the indicative species of lower boundary of the Roadian. *Jinogondolella nankingensis* has not been found from the beds below the *Neoschwagerina simplex-Praesumatrina neoschwagerinoides* Zone and its equivalents in South China. At present, it is necessary to locate accurately the basal level of the Roadian Stage in Tethyan succession in term of conodont zonation.

On the other hand, the ammonoid assemblage of Roadian aspect has been found within the *Misellina parvicostata-Armenia* Zone in southeast Pamir, and within the *Cancellina cutalensis* Zone in Afghanistan. This fact suggests the Roadian and the Kubergandinian are coeval (Bogoslovskaya and Leonova, 1994; Leven, 1994). However, the possibility should not be excluded that the ammonoids assigned to the Roadian could extend down to the beds below the Road Canyon Formation in the USA (Davydov, 1994). It is apparent that the Roadian ammonoids occur in the beds below the basal boundary of Roadian Stage (Wardlaw, 1996) in Southwest USA, and do not confine to the Kubergandinian in Tethyan successions, and may extend into the *Neoschwagerina simplex* Zone (Kotlyar and Pronina, 1995).

C. Guadalupian-Lopingian conodont zonation

The conodonts from the succession around the Guadalupinian-Lopingian boundary in Tethyan region used to be included in a single ill-defined zone, the *Clarkina bitteri-C.? wilcoxi* Zone (Kozur, 1992a), the *Neogondolella bitteri-N. liangshanensis* Zone (Wang, 1990). In 1992, Kozur dated the conodonts, including *Mesogondolella altudaensis, M. "babcocki"*, and *Clarkina subcarinata* from the Altuda Formation in Southwest USA as the Dzhulfian-Lower Changhsingian (Kozur, 1992b).

Based on the new data from South China, Mei et al. (1994a, 1994b; Jin et al., 1993) established a new succession of 6 conodont zones between the *postserrata* Zone of Capitanian and the *liangshanenesis* Zone of middle Wuchiapingian. It provides a firm basis for defining the Guadalupian-Lopingian boundary, and proves that the "Dzhulfian-Lower Changhsingian conodonts" of Kozur (1992b) should be late Capitanian and earliest Wuchiapingian in age. We are pleased to see that present zonation of Guadalupian-Lopingian conodonts have been essentially accepted. Most arguments subsequent to the papers of Mei et al. have disappeared except two points which should be clarified.

As shown in a correlation chart, when Mei et al.(1994a) published the latest Capitanian conodonts from Xunhan, Kozur (1994a) argued that Mei et al.'s *altudaensis* Zone, *xuanhanensis* Zone and *prexuanhanensis* Zone as an equivalent of the *shannoni* Zone in Southwest USA, and assigned his *altudaensis* Zone in the lower part of Wuchiapingian. It should be noted that the species of *shannoni* had not been published that time. Then, Mei et al.(1994b) published a complete Guadalupian-Lopingian conodont succession from Laibin. Kozur and Wardlaw (pers. commun., 1996) now agree that the *shannoni* and *altudaensis* Zones of West Texas are equivalent to the *shannoni* through *granti* Zones of China and represent the latest Capitanian Zones. Wang (1995) questioned the early Wuchiapingian conodont zonation based on a single sample reported by Li (1991) which Wang interpreted from the literature as having most species present. Mei and Wardlaw discussed this report in detail (1996, p. 134-135) and show that the material illustrated from sample W-2 (Li, 1991) are all species common to the *leveni* Zone (i.e., *leveni* and *"post"asymetrica = niuzhuangensis*).

D. Magnatostratigraphy and isotopic dating

It was suggested to integrate into the proposed scheme with the data of magnetostratigraphy (Burov, this issue). We fully agree with this suggestion and did mark the magnetostratigraphic zones in the proposed scheme. The magnetostratigraphic and chronological data would be a powerful tool in erecting the North-South correlation of the Permian, which is hardly possible tackled merely by biostratigraphic means. Studies on isotopic age of Permian rocks are equally important. We are glade to tell that these topics have attracted several qualified international teams. The current targets of these studies include locating the Illawarra Reversal, which occurs near the base of the Capitanian, and dating the volcanigenous beds in the succession of good biostratigraphic control in SW USA and Tethyan areas.

References

Bogoslovskaya, M.F. and Leonova, T.B., 1994. Comments on the Proposed Operational Scheme of Permian Chronostratigraphy. Permophiles, No. 25, November, p.15-17.

Bogoslovskaya, M.F., 1995. Ammonoid-Based Correlation of Marine Permian Successions. Abstract, International Symposium on Evolution of Permian Marine Biota, Moscow, p.49-51.

Burov Boris V. and Natalia K. Esaulova, 1995. On the Problems of the Study of the Upper Permian Stratotypes. Permophiles, No. 27, November, p.30-34.

Davydov, Vladimir I. 1994. On the Proposed Operational Scheme of Permian Chronostratigraphy. Permophiles, No.25, November, p.20-21.

Grunt, Tatjana, 1994. Standard Permian Biostratigraphic Scale with Respect to Permian Marine Biogeography. Permophiles, No.25, November, p.21-25.

Harland, W. B., Armstrong, R. L., Cox, A. V., Craig, L. E., Smith, A. G., and Smith, D. G., 1990. A geological time scale 1989, 1-263. Cambridge University Press.

Jin Yu-gan, Mei Shi-long and Zhu Zhi-li, 1993. The potential stratigraphic levels of Guadalupian\Lopingian boundary. Permophiles 23: 17-20.

Jin Yu-gan, B. F. Glenister, C. K. Kotlyar & Sheng Jin-zhang, 1994 : An Operational Scheme of Permian Chronostratigraphy , Palaeoworld, vol.4;1-14.

Jin Yu-gan, Sheng Jin-zhang, Glenister, B.F., Furnish, W.M., Kotlyar, G.V., Wardlaw, B.R., Heinz Kozur, Ross, C.R. and Claude Spinosa, 1994. Revised Operational Scheme of Permian Chronostratigraphy. Permophiles, No.25, November, p.12-14.

Jin Yu-gan, Mei Shi-long & Zhu Zili :1994. The Maokouan-Lopingian boundary sequences in South China. Palaeoworld, vol.4:119-132.

Jin Yu-gan.1996 A global chronostratigraphic scheme for the Permian System. Permophiles 28: 4-10.

Kozur, H. 1995. Permian conodont zonation and its importance for the Permian stratigraphic standard scale. Geol. Palant. Mitt. Innsbruck, 20: 165-205.

Leven, Ernst Ya 1994. Comments on the Proposed Operational Scheme of Permian Chronostratigraphy. Permophiles, No.25, November, p.17-20.

Kotlyar Galina V. and Galina P. Pronina, 1995. Murgabian and Middian States of the Tethyan Realm. Permophiles, No.27, November, p.23-26.

Kotlyar, Galina V. 1995. Comments on the Proposed Operational Scheme of Permian Chronostratigraphy. Permophiles, No.26, June, p.23-25.

Kotlyar, G.V., 1995. Main Boundaries in the Evolution of Permian Biota. Abstract, International Symposium on Evolution of Permian Marine Biota, Moscow, p.57-58.

Lazarev, S.S., 1995. The Problem of Stability of Stratigraphic Names in the Standard of the Permian System. Abstract, International Symposium on Evolution of Permian Marine Biota, Moscow, p.60-61.

Leonova, T.B., 1995. Main developmental Stages of Permian Ammonoids. Abstract, International Symposium on Evolution of Permian Marine Biota, Moscow, p.61-62.

Mei Shilong, Jin Yugan and Bruce R. Wardlaw, 1994a . Succession of conodont zones from the Permian "Kuhfeng Formation", Xuanhan, Sichuan and its implications in global correlation. Acta Palaeontologica Sinica, 42(1):1-21.

Mei Shilong, Jin Yugan and Bruce R. Wardlaw,1994b . Succession of conodont zones from Permian Wuchiaping Formation, Northern Sichuan. Acta Micropalaeontologica Sinica, (2): 1-24.

Mei Shi-long, Jin Yu-gan and Bruce Wardlaw: 1994c. Zonation of conodonts from the Maokouan-Lopingian boundary strata South China. Palaeoworld, vol.4: 165-178.

Mei Shi-long, Bruce R. Wardlaw, 1996, On the Permian conodont "*liangshanensis-bitteri*" Zone and related problems, *in* Wang Hongzhen and Wang Xunlian, eds., Centennial Memorial Volume of Prof. Sun Yunzhu: Paleontology and Stratigraphy. China University of Geosciences Press, ch. 17, p. 130-140.

Shevelev, A.I., Khalimbadzha, V.G., Burov, B.V., Esaulova, N.K. and Gusev, A.K., 1995. On the Problems of the International Permian Stratigraphic Scale. Permophiles, No.27, November, p.38-39.

Taraz, Hooshang 1995. On the Proposed Operational Scheme of Permian Chronostratigraphy. Permophiles, No.26, June, p.25-26.

Wardlaw, Bruce R., 1996: Range chart for the Permian of West Texas, in Guadalupian II, Alpine, Texas, 61-80.

Wang Cheng-yuan, 1995. Upper Permian Conodont Standard Zonation. Permophiles, No.26, June, p.20-23.

Waterhouse, J. B., 1982. An early Djulfian (Permian) brachiopod faunule from Upper Shyok Valley, Karakorum range, and the implications for dating of allied faunas from Iran and Pakistan. Contribution to Himalayas Geology, 2: 188-233.

Jin Yu-gan
Nanjing Institute of Geology & Palaeontology
Nanjing 210008, China

M. Menning
GeoForschungsZentrum Potsdam
Telegrafenberg A26, D-14473 Potsdam
Germany

Some remarks about the new stratigraphic scale for the Permian System

22 October 1996

By B. I. Chuvashov

During my last stay in Beijing I gave to Prof. Jurgen R. Remane (Chairman of International Stratigraphic Commission), Prof. Jin Yugan (Ex-Chairman of Permian Subcommission) and Dr. B. Wardlaw (Chairman of Permian Subcommission) several letters of my Russian colleagues containing their opinions according to new variant of Stratigraphic Scale of the Permian System, which has been approved by voting members of Permian Subcommission. There is a very splendid and generous decision of Permian Subcommission to publish above mentioned letters in this volume of Permophiles. And now I have a good possibility don't repeat all very significant proofs of Russian specialists. I share all arguments of my colleagues against of last decision of Permian Subcommission and should present some additional considerations on this incorrect step of the Permian Subcommission members.

1- Permian Subcommission made a very dangerous precedent like an example of historic memorials demolishing. We are having an open way to very simple change of stratotypes now if a new section will be a little better studied than former one.

2- Permian System has been erected by R. Murchison like a composition of Kungurian (partly), Ufimian, Kazanian and Tatarian recently known stages. Replacement of this stratigraphic interval by Guadalupian and Lopingian Series means really a change of name, sense and contents of the Permian System by new ones.

3- This replacement could be explained by a tremendous stratigraphic potential of new series and stages for Permian System in whole, but it is not in reality. NOTHING WILL BE CHANGED IN SCIENTIFIC PROGRESS. Both of series - Guadalupian and Lopingian - have a correlative potential within the restricted areas of Tethys in North America and Eurasia. No obstacles were to use both series like the reference sections to trace of stage boundaries within of very restricted areas of their possibilities.

RUSSIAN SPECIALISTS HAVE NOT ANY POSSIBILITIES TO USE A NEW UPPER PERMIAN STRATIGRAPHIC UNITS IN EVERYDAY ACTIVITY.

4- There is a serious mistake of Permian Subcommission and Stratigraphic Commission to lead down a potential of stratigraphy to conodont and ammonoid biostratigraphy. Real progress in Permian stratigraphy (like Stratigraphy in whole) will be connected with using of all complex of organic remains. For Upper Permian stages the real great progress could be expected like results of future study of tetrapods, insects, fishes and other. Don't forget, please, that marine Kazanian stage has a good correlative possibilities by help of ammonoids, conodonts. Real global correlation of Permian, like other stratigraphic systems, will be reached by radiometric and paleomagnetic methods. There is a great delusion that it could be done by biostratigraphic method.

5- The Russian voting members of Permian Subcommission (Galina Kotlyar and Ernst Leven) have violated of 2.5 point (page 70) of the Russian Stratigraphic Codex. This point sounds like this:

" Stratotypes of general stratigraphic units, which have been established before and wide used, sometimes don't correspond to recent requests. A decision about possibility of an additional study or change of a stratotype should be made by a corresponding Subcommission of the International Stratigraphic Commission. If a discussed stratotype is situated on the territory of our country (Russia B. Ch.) this problem should be discussed by Russian Stratigraphic Committee before."

6. I think there is a very simple way to avoid a blind path of next progress for a stratigraphic cooperation: both series - Guadalupian and Lopingian- should be treated like a parastratotypes of Russian Late Permian stages like I suggested by my voting.

B. I. Chuvashov
Institute of Geology & Geoch. of the Urals
Academy of Science
Pochtavy per 7
Ekaterinburg 620154, Russia
Ex- Vice- Chairman of Permian Subcommission

On the problems of the Permian Global Scale

By E. Ya. Leven

The SCPS activity during several passed years resulted of establishing of GSSP for the Permian system base, as well as establishing of Permian three series and provisional stages. All above are significant progress in Global Permian stratigraphy. However, we can not be in euphoria and are thinking that Permian Global Scale will be completed very soon at nearest time. Just one example with C/P boundary problem, which was solved only after about 20 years of hard struggle and discussions, showed how this process is going. The consensus, concerning Permian's series and their provisional boundaries was reached because of these series and boundaries corresponds with most certain and correlatable events of Permian history. Below, I would like to indicate some problems, which we can meet during a process of Permian Scale establishing in nearest future. I hope it will helpful for the strategy ways of the future SCPS investigations.

Scale Ideology. The stratigraphical geochronological scale of Phanerozoic systems and their subdivisions (series and stages) were originally established as a geo-historical scale. It means that subdivisions of this scale correspond with natural stages of Earth's geological history and with stages of biota history. Namely on the basis of this principle were established of Phanerozoic systems, series and stages, which usually characterized by complex of data and which reflect from the events of geological history. Establishing of subdivision's boundaries is secondary procedure, which should just to assist for the understanding of volumes and boundaries of stratigraphic subdivisions and their correlation. Secondary significant of boundary position also can be concluded from the fact, that no one unquestionable boundary in Phanerozoic scale are present, many boundaries still not established and discussed until now. However own Phanerozoic scale are present. The boundaries establishing is conventional procedure, which based on an agreement of selection of most convenient level (boundary) for definition and correlation. But the own boundary should be maximal close to the eventional basis of the scale.

At the present time, is growing tendency to substitute the principals of complexes characteristic of subdivisions by creating of datum marks, which are defining the volumes of subdivisions. Thus, definition of these datum marks are become paramount and definition of own subdivisions secondary. It is to way to create very formal scale, instead geo-historical ones. This tendency now are going with the Permian system, when main attention is concentrated on the establish of conodont data marks, where one species of conodont exchange to another. It resulted, that stages are become a parts of sections between conodont datum marks. Scale is transform from geo-historical to the "conodontostratigraphical" one. That approaches to establish of Permian scale is too formal and unacceptable.

The boundaries of Permian System. The ratification of proposal, made by the Permian Subcommission concerning GSSP for the base of the Permian on Aidaralash Creek location is great success. The Carboniferous/Permian boundary based on a complex characteristic and correlates through main regions of with marine Permian. I believe, that the problem of the top of the Permian also will solve successfully soon. Recent discussions concerning what group of fauna: conodonts or ammonoids-- should indicates of the Permian/Triassic boundary have a scholastic character, because both versions of the boundary are closely similar. The version with conodont definition on my point of view is preferable, because of the conodont data stability.

Series and their boundaries. Establishing of Guadalupian series into the Permian have objective basis, because the beginning and the end of Guadalupian are corresponds with great events in Permian history: transgression and regression, - which caused of essential biotic reconstructions. The top of the Guadalupian is more or less clear and unquestionable. However, there are some doubts concerning the position of the Guadalupian base. I would like to refresh the fact, that in Guyang Symposium (1994), the suggested now position of Guadalupian base, which corresponds with first appearance of *J. nankingensis*, was not accepted. It caused, that in S. China *J. nankingensis* was first reported at the mid-Murgabian (bed 46 in Loadian section; Excursion Guidebook, 1994). Thus, lower portion of Murgabian and whole Kubergandian would be pre-Roadian. However, it contradicted by Roadian ammonoid occurrences at the lower portion of Kubergandian in the Pamirs (Chediya et al., 1986). This contradict was canceled by Dr. Kozur, who identified *J. nankingensis* from collection of Dr. Wang Chengyuan, from bed 25b of Loadian section. I identified there lower Kubergandian *Parafusulina* too. In that time I thought, that the bases of Roadian and Kubergandian are coincident and I voted for establishing of Guadaluian series. However, Chinese specialists continue to infuse on the former data of first occurrences of *J. nankingensis* within the Murgabian (Jin Yugan, 1996). I believe, that solving of this problem would be possible only with close contact of Chinese conodont workers with Dr. Kozur and Dr. Wardlaw.

Main defection of recently proposed three-fold scheme of the Permian is series disproportionately. Also, this scheme does not show some of great events (exchanges transgressive and regressive tendencies during the Permian), climatic changes, and some of the reconstructions of marine biota within Cisuralian (Leven, 1994, Leven et al., 1996). The great event within the Cuisuralian was the basis for suggesting to divide Permian into four series, united into two subsystems (Leven, 1992). But during the Alpine symposium discussions of this suggestion was canceled, because of the insufficient data concerning mid-Cisuralian boundary. However, four folded Permian scheme does not lost its attraction and principal basis, and I think that the Permian Subcommission have to focus on this problem and will organize special Working Group for its resolving.

Stages and their boundaries. Recently published stages scale (Jin Yugan, 1996) have a provisional character. Until time, where each stage can be ratified it should be taken whole proves, as its peculiarity, complex characteristics of fossils, to provide identification and correlation of these stages within different biogeographical provinces. The stages boundaries are require the special proves. In each case Subcommission should first establish the criterion (better criterions), by which the stages' boundaries will be defined, and second-- established the GSSP. Also, it should be shown, how each of suggestive boundary is correlates. No one of stages from recently suggested scale does not meet such conditions. During the process of boundaries establish, we will meet the problems of stages names, as it was with Kungurian on Alpine symposium (Report of the Meeting in Alpine, Texas, Permophiles, # 28). From my point of view, we have strongly follow of priority rule: the original or former name of stage should be saved, if its volume and boundaries does not changed much. We can not renounce of stages names established in stratotype region in case that the boundaries could not defined there clear. Almost all stages of Phanerozoic would be canceled, because of characteristic of their boundaries does not meet criterions of recent days. As international stratigraphical experience shows, we can change the boundaries position on the basis of the other sections, which sometimes are located very far from the stratotype area.

On some an examples I would like to show what complicated problems we have to resolve, until time where stages scale will be finally established. So, the base of the Artinskian now suggested to defined by first appearance of *S. whitei*. This conodont species in W. Texas, Glass Mountain occurs in upper portion of Lenox Hill Fm., where Sakmarian ammonoids are reported (Furnish, 1973). In South China *S. whitei* ranged together with Sakmarian fusulinids. There are notes in literature, that in general that upper Sakmarian and lower Artinskian fusulinid and conodont assemblages are closely similar. In this case I would suggested to put Sakmarian/Artinskian boundary somewhere above its recent position. It is, by the way, will more corresponds with geohistorical data. Resolving of indicated problem is actual and close related with the problem of two-folded subseries division of the Cisuralian.

The base of the Kungurian now suggested to identified by first appearance of *N. pnevi*, and *N. exculptus*. The first conodont species is absent if Tethys. The second one is reported from the *Pamirina darvasica* fusulinid zone (Zhu Zili, 1996), which on the basis of ammonoids correlates with Artinskian (Leven et al., 1992). The ammonoids, which were found in W. Texas, Glass Mnt. above the first appearance of *N. pnevi*, and *N. exculptus*, are also Artinskian in age (Furnish, 1973).

I have discussed above about contradictions with *J. nankingensis* range in N. America and in Tethys and related with this problem of definition of Roadian base . Similarly, there are different data concerning the top of Roadian. Jin Yugan (1996) pointed out that the top of Roadian, which defined by first appearance of *J. aserrata*, in Tethys sections coincides with base of *Neoschwagerina craticulifera* fusulinid zone. At the same time Kozur (personal comm.) identified of Wordian conodonts from bed 28 of Loadian section, from where were reported of fusulinids typical for *N. simplex* zone (Excursion Guidebook, 1994). If Kozur is right, the Wordian is about an equivalent of Murgabian (*Neoschwagerina* fusulinid genozone). However, in Sicily and Western Canada typical Wordian ammonoids occur together with Midian, i.e with younger fusulinids (Kozur & Davydov, 1996; Ross, 1971). The number of similar an examples could be increased. From all above mentioned I can conclude that the recent stages scale is far as complete. Because of the stages boundaries have to be defined by conodonts, most actual is to establish correlation of conodont zonal scale with scales by another fossil groups, particularly with fusulinid and ammonoid one. Moreover it is necessary, because of the rare occurrences of conodont in Boreal and Tethyan provinces, their using is limited. We can not established any boundary stage only on the basis of exchange of one conodont species to another. We have to know, would be this boundary to correlates by other fossils. If not, the suggestive boundary is not acceptable.

The resolving of all above mentioned problems could not be realize without of close cooperation between specialists who studied different fossils and different regions. One of the most priority work for the Permian Subcommissions is to organize such kind of cooperative investigations.

References

Excursion Guidebook. Intern. Symp. Permian stratigr., environm. & resources. Guiyang, China. 1994, pp. 1-40.

Furnish W. M. (1973) - Permian Stage names. Permian and Triassic Systems and their mutual boundary, pp. 522-548.

Jin Yugan (1996) - A Global chronostratigraphic scheme for the Permian System. Permophiles, 28, pp. 4-9.

Kozur H. (1996) - Abstract and proceeding of the Second Intern. Guadalupian Symposium. p. 11-15.

Leven E. Ja. (1994) - The Mid-Early Permian transgression and regression of the Tethys. Mem. Can. Soc. Pet. Geol., 17, pp. 233-239.

Leven E. Ja., Leonova T. B. & Dmitriev V. Yu. (1992) - The Permian of the Darvaz-Transalai zone of Pamir: fusulines, ammonoids and stratigraphy. Trans. Paleontol. Institute. Russian Ac. Sci., 253. p. 1-203.

Leven E. Ja., Bogoslovskaia M. F., Ganelin V. G. et al. (1996) - Reorganization of marine biota during the Mid-Early Permian Epoch. Stratigraphy and Geol. Correlation. 4. *1*, p. 57-66.

Ross Ch. A. (1971) - New species of *Schwagerina* and *Yabeina* (*Fusulinacea*) of Wordian age (Permian) from Northwestern British Columbia. GSC Bull. 197: Contrib. To Can. Paleont. Published by Department of Energy, Mines and Resources. Ottawa, Canada, pp. 95-106.

Spinosa C. (1996) - Report of the meeting in Alpine, Texas. Permophiles, 28, pp. 1-4.

Chedija I. O., Bogoslovskaia M. F., Davydov V. I., & Dmitriev V. Yu. (1986) - Fusulinids and ammonoids in the stratitype of the Kubergandian Stage (South-East Pamir). Annual volume of Paleontol. Soc. of USSR, 29, Leningrad, Nauka, pp. 28-53.

Zhu Zili (1996) - The Chihsian Series in South China. Permophiles, 28, pp. 16-17.

E. Ya. Leven
Geol. Inst. RAS
10917 Pyjevskyi per 7
Moscow, Russia

Guidelines for the establishment of global chronostratigraphic standards by the International Commission on Stratigraphy (ICS) (Revised)

by J. Remane, M. G. Bassett, J. W. Cowie, K. H. Gohrbandt, H. R. Lane, O. Michelsen and Wang Naiwen, with the cooperation of members of ICS

1. INTRODUCTION

The Silurian-Devonian Boundary Committee was the first to put into practice (in 1960) the principle to define chronostratigraphic units by their lower boundary only, which thus becomes automatically the upper boundary of the underlying unit. The Silurian-Devonian boundary-stratotype at Klonk in the Czech Republic was ratified on the 24th International Geological Congress (IGC) at Montreal, 1972. During this process, the Committee developed the principles of chronostratigraphic boundary definition. These "lessons learned" (McLAREN, 1977:23) constituted the basis of the first Guidelines of ICS, where the concept of the Global Standard Stratotype-section and Point (GSSP) was introduced: **"This Boundary Stratotype Section and Point is the designated type of a stratigraphic boundary identified in published form and marked in the section as a specific point in a specific sequence of rock strata and constituting the standard for the definition and recognition of the stratigraphic boundary between two named global stratigraphic (chronostratigraphic) units"** (COWIE et al. 1986:5). This definition is still valid for the Phanerozoic: A GSSP voted by the Full Commission of ICS (the Bureau of ICS and Chairpersons of all ICS Subcommissions, see also BASSETT, 1990) and confirmed by the Executive of the International Union of Geological Sciences (IUGS) represents a ratified boundary definition.

The necessity of a precise Global Chronostratigraphic Scale is obvious. Research on global events means comparison of stratigraphic documents from distant regions - but how can we be sure to deal with the same event throughout, without having a precise and reliable chronostratigraphic scale? The same is true for the establishment of eustatic sea-level curves or the reconstitution of global climatic changes in the past. Progress in these and many other fields of geologic research is only possible if progress is also made in the definition of chronostratigraphic units.

2. AIMS AND PRINCIPLES

2.1. Aims of the Revision

The original Guidelines were issued by the Bureau of ICS (COWIE et al. 1986) and summarized by COWIE (1986) in Episodes, the official publication of IUGS, and by COWIE (1990, 1991). They have guided uniformity of definition for twenty chronostratigraphic boundaries during ten years of successful application. The experience gained in this process has confirmed the basic principles of the original Guidelines. Nevertheless, a cautious revision of the Guidelines appears useful for different reasons:

(1) The Precambrian Subcommission of ICS has proposed a global stratigraphic subdivision for the Proterozoic where boundaries are defined in terms of absolute ages (see sect. 2.2), with entirely new names for the nine Proterozoic systems created on this basis. The resultant new subdivision of the Proterozoic was voted by ICS and ratified by IUGS on the 28th IGC in Washington, 1989; it is thus formalized (and should therefore not have been omitted in the 2nd edition of the ISG).

(2) During the last years, great progress has been made in the field of non-biostratigraphic methods of correlation (See sect. 3.1). These should therefore be given more weight in the choice of boundary levels and type-sections.

(3) Certain problems concerning the philosophy of boundary definition came up repeatedly in recent discussions of GSSP candidates, such as the necessity to respect priority, to have natural boundaries (see sect. 2.4), the rôle of fossils in boundary definition (see sect. 3.1), and the degree to which global correlation has to be exact before defining a boundary (see sect. 2.3).

(4) Since the publication of the original Guidelines (COWIE et al., 1986) important publications on the principles of stratigraphy have appeared, especially the 2nd edition of the International Stratigraphic Guide (ISG) (SALVADOR, 1994), or HARLAND (1992). The position of the Guidelines in this new context had to be clarified.

The rôle of the Guidelines remains, however, unchanged. They regulate the procedures of boundary definition, the selection of an appropriate boundary level, and the corresponding voting procedures (also partly dealt with in art. 3 and 7.1 of the statutes of ICS). They further define the requirements to be fulfilled by the stratotype-section housing the boundary point.

2.2. The Precambrian Standard

The new boundary-type definition, first introduced for the Proterozoic in 1989, was necessitated by the lack of adequate fossils in most of the Precambrian. It is termed herein the **Global Standard Stratigraphic Age (GSSA).** Defining boundaries in terms of absolute ages means that the numerical value of the boundary age is a theoretical postulate independent from the method applied to obtain numerical ages. But, as in the case of boundaries defined by a GSSP, an explicit motivation for the choice of the proposed numerical value should be given, clarifying in the same time its relation to traditional boundary definitions. GSSAs have the same status for boundary definition in the Precambrian as GSSPs have in the Phanerozoic.

2.3. Correlation Precedes Definition

Except for the Precambrian, this principle is still valid. To define a boundary first and then evaluate its potential for long-range correlation (as has been proposed in some cases) will mostly lead to boundary definitions of limited practical value. On the other hand, it would be unrealistic to demand that a given boundary be recognizable all over the world before it can be formally defined. In each case we must find the best possible compromise, otherwise the search for the Holy Grail of the perfect GSSP will never end.

2.4. Priority and Natural Boundaries

Our main task for a number of years will be to develop precise boundary definitions for traditional chronostratigraphic units. Most of them were defined in the last century by their characteristic fossil contents, and their boundaries coincided with spectacular biostratigraphic and lithologic changes. These were "natural" boundaries, in perfect agreement with the catastrophist philosophy of that time. In reality, rapid faunal turnovers are to a certain extent artefacts due to stratigraphic gaps or condensation. Most of the classic type-localities are thus unsuitable for a precise boundary definition: we have to look for new sections where sedimentation is continuous across the boundary interval; but then boundaries will rarely correspond to a lithologic change.

The idea that chronostratigraphic boundaries should always correspond to something "visible" has also led to conflicting regional "definitions" of international chronostratigraphic boundaries, which were adapted to regional lithostratigraphic boundaries of different ages.

There is no formal priority regulation in stratigraphy. In redefining boundaries, priority can therefore be given to the level with the best correlation potential. The redefinition will give us the opportunity to use fossil groups (such as conodonts) and methods of chronocorrelation (such as magnetostratigraphy) which were unknown or poorly developed at the time of the original definition. This does not mean that priority should be totally neglected. Practice considerations will incite us to limit changes to the necessary minimum. If, however, the interregional correlation potential of a traditional boundary does not correspond to the needs of modern stratigraphy, its position has to be changed.

Chronostratigraphic boundaries are conventional boundaries. They are a matter of normative science and can be decided by a majority vote (COWIE et al., 1986). To a certain degree, this principle can be reconciled with the demand for natural boundaries. As stated above, most of the classical boundaries are not clear-cut but correspond to critical biotic and/or climatic transitions. Placing a boundary within such an interval will preserve the advantage of having successive units which are distinguished by their contents. But where exactly the boundary is to be placed, is a matter of convention and practical considerations.

Once a boundary is (re)defined by a GSSP or a GSSA, it should be used in all published figures and tables. Such an obligation will not hinder any authors from expressing their personal opinions.

2.5. Boundary-stratotypes instead of Unit-stratotypes

If chronostratigraphic units were defined by unit-stratotypes, the boundary between two adjacent units would be defined by two separate GSSPs: as upper boundary of the lower unit in one unit-stratotype and as lower boundary of the succeeding unit in the other. The Global Chronostratigraphic Scale must, however, be constituted of strictly contiguous units, without overlaps and with no gaps between them. But there is no method of correlation which would guarantee a perfect isochrony of two separate boundary points, even at a short distance apart (HARLAND, 1992).

This problem was already recognized in the 1st edition of the ISG (HEDBERG, 1976), but unit-stratotypes for chronostratigraphic units were still admitted as an alternative possibility. In the 2nd edition (SALVADOR, 1994), boundary-stratotypes are given a stronger preference, but as a whole, the position remains ambiguous: "Since the only record of geologic time...lies in the rocks themselves, the best standard for a chronostratigraphic unit is a body of rocks formed between two designated instants of geologic time." (SALVADOR 1994: 88).

The Guidelines of ICS are unambiguous: **Chronostratigraphic units of the Phanerozoic Global Standard can only be defined through boundary stratotypes.** Even should the situation arise (e. g. as in the Silurian stratotypes in Britain) that the GSSPs defining the lower and upper boundaries of one and the same unit are located in the same section, this does not imply that the stratigraphic interval and its biota between the two GSSPs represent a unit stratotype.

For several systems, upper and lower boundaries are now defined by GSSPs. Following the choice of the best type-section these are located in distant regions: the base of the Silurian in Scotland, UK; that of the Devonian in the Czech Republic; that of the Carboniferous in the Montagne Noire, France; of the Permian in Kazakhstan; and the base of the Quaternary in Italy.

The lower boundaries of chronostratigraphic units of higher rank (series, systems etc.) are automatically defined by the base of their lowermost stage. In other words: the lower boundary of a system is always also a series and a stage boundary.

A GSSP cannot be compared to the holotype of Zoological Nomenclature; it corresponds rather to a standard of measure in physics (HARLAND, 1992). The use of terms like holostratotype, parastratotype etc. should therefore be avoided (COWIE et al., 1986). If reference sections and points seem necessary in order to give a better understanding of the boundary in another facies or paleobiogeographic context, an auxiliary stratotype point may be defined. Such auxiliary points are subordinate to a GSSP.

3. THE CHOICE OF THE BEST BOUNDARY LEVEL

3.1. Some General Considerations about Chronostratigraphic Methods

Chronostratigraphy and chronocorrelation have been discussed at length in the ISG (SALVADOR, 1994). We may thus limit the following discussion to selected topics which are of particular importance for the choice of the boundary level.

Considerable progress has been made during the last years in developing and in improving methods of non-biostratigraphic chronocorrelation. Some of them are based on geochemical signals, like the famous Ir-spike used as guidance for the definition of the Cretaceous/Paleogene boundary, or on shifts of stable isotopes which should be helpful in the definition of the Permian/Triassic boundary (BAUD et al., 1989).

Reversals of the Earth's magnetic field are important, because they are a worldwide phenomenon and practically instantaneous, thus providing a precise and reliable means of chronocorrelation. Late Jurassic to Recent reversals have been calibrated to the MagneticPolarity Time Scale based on oceanic anomalies (HAILWOOD, 1989).

Geophysical and geochemical events are, however, repetitive and do not allow an unequivocal determination of the age. They need calibration through radioisotopic or biostratigraphic dating. Unfortunately, radioactive isotopes are rarely available where needed so that stratigraphic routine work depends mostly on other methods. But radioisotopic datings are very important for the quantitative calibration of relative ages. Biostratigraphic boundaries, i. e. the boundaries of the material stratigraphic occurrence of species, are diachronous (ISG). This fact has, however, been overstated. A species exists for a finite span of time and is therefore characteristic of a certain geologic interval. In rapidly evolving lineages this may be less than 1 million years, so that most biostratigraphic datings attain a higher degree of resolution than the use of radioisotopes.

The use of fossils for calibrating chronostratigraphic units does not only involve tracing of biostratigraphic boundaries. It is indeed less a matter of correlation than of determining relative ages within a biochronologic standard of reference. Biochronology is the reconstruction of the succession of species in time through the synthesis of local and regional biostratigraphic data (for a recent overview, see REMANE, 1991). The chronostratigraphic reliability of biostratigraphic boundaries can thus be tested by comparing data from different species. In this process, mathematical approaches (Quantitative Stratigraphy) play an increasingly important rôle (GRADSTEIN et al., 1985; GUEX, 1991; MANN & LANE, 1995).

Fossil species depend on the environment and are biogeographically limited. An appropriate choice of wide spread species may diminish but never totally eliminate these shortcomings. Radioactive isotopes do not suffer from these geographical restrictions; but their resolution diminishes with increasing age. Therefore, non-biostratigraphic markers like magnetic reversals and stable isotopes have gained increasing importance in long range lateral correlation.

3.2 The Best Boundary-level

With the above considerations in mind, the correlation potential of any boundary level should be tested through a detailed study of several continuous successions covering the critical interval, if possible on different continents. The most suitable of these sections can then be selected for definition of the GSSP. If two boundary levels of equal correlation potential are available, the better candidate (see chapter 4) will decide the choice of the boundary level.

This implies the integration of data from different facies and paleogeographic provinces in a global synthesis. The perfect GSSP; where all elements of such a synthesis are well represented, will often not be available. Flexibility is therefore necessary in order to make a timely decision.

The boundary definition will normally start from the identification of a level which can be characterized by a marker event of optimal correlation potential. This marker event may be a magnetic reversal, some kind of geochemical or isotopic signal, or the first appearance or last occurrence of a fossil species. However, only the boundary point in the section, the GSSP (COWIE et al., 1986) formally defines the boundary. This means that an occurrence of the primary marker does not automatically determine the boundary. Other markers should therefore be available near the critical level, in order to support chronostratigraphic correlation in sections other than the GSSP. If the primary marker is a fossil species, first appearances are generally more reliable than extinction events, especially if the gradual transition between the marker and its ancestor can be observed.

4. REQUIREMENTS FOR A GSSP

The danger of eternalizing the search for the best type-section has already been addressed in sect. 2.2. **The stratotype-section should contain the best possible record of the relevant marker events.** In this sense, the requirements listed below characterize the ideal section. Not all of them can be fulfilled in every case, but the fact that all GSSPs are voted by ICS in accordance with the present Guidelines insures that flexibility will not degenerate to arbitrariness.

4.1. Geological Requirements

4.1.1. **Exposure over an adequate thickness** of sediments is one requirement to guarantee that a sufficient time interval is represented by the section, so that the boundary can also be determined by interpolation, using auxiliary markers close to the boundary.

4.1.2. **Continuous sedimentation:** no gaps, no condensation in proximity of the boundary level.

4.1.3. The **rate of sedimentation** should be sufficient that successive events can be easily separated.

4.1.4. **Absence of synsedimentary and tectonic disturbances.**

4.1.5. **Absence of metamorphism and strong diagenetic alteration** (identification of magnetic and geochemical signals).

4.2. Biostratigraphic Requirements

4.2.1. **Abundance and diversity of well preserved fossils** throughout the critical interval. Diversified biotas will offer the best possibility of precise correlations.

4.2.2. **Absence of vertical facies changes** at or near the boundary. A change of litho or biofacies reflects a change of ecologic conditions which may have controlled the appearance of a given species at the boundary level. A sharp lithofacial change may also correspond to a hiatus. "An obvious boundary should be suspect" (COWIE et al., 1986).

4.2.3. **Favourable facies for long range biostratigraphic correlations;** this will normally correspond to an open marine environment where species with a wide geographic range will be more common than in coastal and continental settings. The latter should therefore be avoided.

4.3. Other Methods

Magnetostratigraphy, sequence stratigraphy, cyclostratigraphy, analysis of stable isotopes should be given due weight in the selection of a GSSP. If a choice has to be made between candidates having more or less the same biostratigraphic qualities, the one offering the better applications of non-biostratigraphic methods should be preferred.

4.3.1. **Radioisotopic dating.** Whenever possible, it is important to achieve direct quantitative calibration (numerical age) of a chronostratigraphic boundary at the GSSP.

4.3.2 **Magnetostratigraphy.** A reproducible magnetic reversal stratigraphy is a desirable requirement in order to know where in the magnetostratigraphic sequence the GSSP is located.

4.3.3. **Chemostratigraphy**, including the study of vertical changes of the proportions of stable isotopes, which may be indicative of global events.

4.3.4. The regional paleogeographical context and the facies relationships of the stratotype-section should be clarified. Knowledge of the sequence stratigraphy will contribute to an understanding of these relations.

4.4. Other Requirements

4.4.1. The GSSP should be indicated by a permanently fixed marker.

4.4.2. Accessibility: Candidate sections in remote regions which can only be visited by organizing costly expeditions should normally be excluded from the selection.

4.4.3. Free access for research to the type-section for all stratigraphers regardless of their nationality.

4.4.4. When making a formal submission to ICS, the concerned Subcommission should try to obtain guarantees from the respective authority concerning free access for research and permanent protection of the site.

5. PROCEDURE FOR THE SUBMISSION OF A GSSP

5.1. Editing of the Submission

Submissions must be prepared in English. In order to provide a clear picture of the qualities of the proposed GSSP candidate, the formal submission to ICS or to the concerned Subcommission should give the following information:

(1) name of the boundary;

(2) indication of the exact location (coordinates) of the stratotype-section on a detailed topographic map or aerial photograph, if possible at a scale not less than 1 : 50.000;

(3) location on a detailed geologic map;

(4) detailed description of the stratotype-section including a litholog and photos of the section, indicating the bed in which the boundary-point is defined and the key-levels for all physical and biostratigraphic markers;

(5) motivation for the choice of the boundary level and the stratotype-section, with a discussion of failed candidates and their ease of intercontinental correlation;

(6) any comparison with former usage should be discussed fully;

(7) discussion of all markers used in the determination of the boundary level;

(8) illustration of important fossils;

(9) results of radioisotopic dating, indicating clearly what method has been used;

(10) results of all votes within the Working Group and the Subcommission.

Note: Within these procedures, only items 1, 6, 7, 9, 10, and the motivation for the choice of the boundary-level are relevant to the establishment of a GSSA.

Following acceptance of the submission within these Guidelines, the Chairperson or the Secretary of ICS will arrange a vote by the Full Commission within a period of no more than 60 days.

5.2. Voting Procedure

In accordance with the ICS statutes, all formal votes must be conducted by postal ballot, giving a deadline of 60 days for the receipt of votes. Voting members (of the Working Group, Subcommission or Full Commission) may vote "YES", "NO", or "ABSTAIN". The last step in the selection of a final candidate for a boundary level and/or a GSSP should always be a vote on one single candidate (COWIE et al., 1986).

In outline, this procedure includes the following steps:

(1) Successive votes of the concerned Working Group leading to the choice of a boundary level and final vote on a single GSSP or GSSA candidate.

(2) If this obtains the statutory majority in the Working Group, vote on the GSSP or GSSA candidate in the respective Subcommission.

(3) In case of a statutory majority, formal submission of the candidate to ICS for vote.

(4) Again, in case of a statutory majority, submission of the GSSP or GSSA candidate to the IUGS Executive Committee for ratification, together with an abstract of the submission, prepared by the responsible ICS body.

ICS should attempt to finalize, within 3 years after IUGS ratification, any remaining official steps for the protection of the site with the authorities of the country where the GSSP is located.

6. REVISION OF A GSSP

A GSSP or GSSA can be changed if a strong demand arises out of research subsequent to its establishment. But in the meantime it will give a stable point of reference. Normally, this stability should be maintained and the practical value of the boundary definition tested for a minimum period of ten years. Revisions for other reasons should be made only in exceptional circumstances, such as:

(1) The permanent destruction or inaccessibility of an established GSSP,

(2) a violation of accepted stratigraphic principles discovered only after the ratification of a GSSP.

7. SELECTED REFERENCES

The 2nd edition of the ISG (SALVADOR, 1994) contains a comprehensive list of publications dealing with the principles and techniques of stratigraphy. The present list of references was therefore limited to papers providing further information on the principles underlying these Guidelines, adding some titles not mentioned in the ISG.

Bassett, M. G., 1990, International Commission on Stratigraphy, *in* : Briggs, D. E. G. & Crowther, P. C. (eds.), Paleobiology, a synthesis, Blackwell, p. 468-469.

Baud, A., Magaritz, M., and Holser, W. T., 1989, Permian-Triassic of the Tethys: Carbon isotope studies, Geol. Rdsch., v. 78, p. 649-677.

Cowie, J. W., 1986, Guidelines for Boundary Stratotypes, Episodes, v. 9, p. 78-82.

Cowie, J. W., 1990, Global Boundary Stratotypes, *in* : Briggs, D. E. G. & Crowther, P. C. (eds.), Paleobiology, a synthesis, Blackwell, p. 471-482.

Cowie, J. W., 1991, Opening speech, 11e Congr. Internat. Stratigr. GCol. Carbonifère, Beijing 1987 v. 1, p. 16-20, Nanjing, 1991.

Cowie, J. W., Ziegler, W., Boucot, A. J., Bassett, M. G., and Remane, J.,1986, Guidelines and Statutes of the International Commission on Stratigraphy (ICS): Courier Forschungsinst. Senckenberg, v. 83, p. 1-14.

Gradstein, F. M., Agterberg, F. P., Brower, J. C. and Schwarzacher, W. S. (eds.), 1985, Quantitative Stratigraphy, Unesco/Paris, Reidel, 598 p.

Guex, J., 1991, Biochronological Correlations, Springer.

Harland, W., B., 1992, Stratigraphic guidance and regulation: A critique of current tendencies in stratigraphic codes and guides, Geol. Soc. Am. Bull., v. 104, p. 1231-1235.

Hedberg, H. D. (ed.), 1976, International Stratigraphic Guide - A guide to stratigraphic classification, terminology and procedure: New York, John Wiley and Sons, 200 p.

Hailwood, E. A., 1989, Magnetostratigraphy, Geol. Soc., Spec. Report No. 19, Blackwell, 84 p.

Mann, K. O. and Lane, H. R. (eds.). 1995. Graphic

Correlation. SEPM Soc. Sedim. Geol., Spec. Publ. No. 53, 263 p.
McLaren, D. J., 1977, The Silurian-Devonian Boundary Committee - A final report. *in* : Martinsson, A. (ed.), The Silurian-Devonian Boundary: Stuttgart, IUGS Series A. no. 5, p. 1- 34.
Odin, G. S., 1992, New stratotypes for the Paleogene, the Cretaceous/Paleogene, Eocene/Oligocene and Paleogene/Neogene boundaries: Neues Jahrb. Geol. Paläont. Abh. v. 186, p. 7-20.
Remane, J., 1991, From biostratigraphy to biochronology: Time correlation by fossils, 11e Congr. Internat. Stratigr. Géol. Carbonifère v. 1, p. 187-200.
Salvador, A. (ed.), 1994, International Stratigraphic Guide - A guide to stratigraphic classification, terminology and procedure. 2nd edition, Internat. Union of Geol. Sciences and Geol. Soc. of America, 214 p.

Conclusion

by J. Remane, Chairman of ICS

The text of the Revised Guidelines as presented above, is the result of a close cooperation between the Bureau and the Subcommissions of ICS. A first provisional draft was prepared by J. Remane, Chairman of ICS, taking into account proposals made by K. H. Gohrbandt, then Secretary General of ICS. A more formal draft was established on this basis by the Bureau of ICS on its meeting at Neuchâtel (Switzerland) in March 1994. This was circulated to all Subcommissions for comments and criticism. That draft was also presented for discussion on the International Symposium on Permian Stratigraphy at Guiyang (China) in September 1994, the 4th International Symposium on Jurassic Stratigraphy at Mendoza (Argentina) in October 1994, and on the 2nd International Symposium on Cretaceous Stratigraphy at Brussels (Belgium) in September 1995. The final version, which incorporated as far as possible oral and written comments received from members of ICS bodies, was worked out on the meeting of the Bureau of ICS at Neuchâtel in April 1996, attended by J. Remane (Chairman), M. G,. Bassett (lst Vice-chairman), O, Michelsen (Secretary General), and H. R. Lane (lst Vice-chairman elect), and was then submitted for vote to the Full Commission of ICS (consisting of the 5 members of the Bureau of ICS and the 16 Chairpersons of ICS Subcommissions).

In this vote, the Revised Guidelines were approved by the Full Commission with an overwhelming majority, with only one opposing vote. The Revised Guidelines have thus become a formal and mandatory document regulating the procedure to be followed in the definition of chronostratigraphic boundaries. The particular importance of this text lies also in the fact that this is the first document on stratigraphic procedures issued by ICS which represents a voted formal agreement.

J. Remane,
Institut de Géologie,
Université de Neuchâtel
Rue Emile-Argand, 11,
CH-2007 Neuchâtel, Switzerland

M. G. Bassett,
Dept. of Geology
National Museum of Wales,
Cathays Park, Cardiff CF1 3NP, Wales, U.K.

Dr. J. W. Cowie,
Department of Geology, University of Bristol
Bristol BS8 1RJ, England U.K

K. H. Gohrbandtth,

H. R. Lane,
AMOCO Exploration and
Production Technology
P.O. Box 3092, Houston,
Texas 77253, USA

O. Michelsen
Dept. of Earth Sciences,
University of Aarhus
DK-8000 Arhus C, Denmark

Prof. Wang Naiwen
Institute of Geology, Chinese Academy of
Geological Sciences
Baiwanzhuang Road 26
Beijing 100037, P. R. China

Conodont evolutionary lineage and zonation for the Latest Permian-and the Earliest Triassic*

By Wang Cheng-yuan

Abstract

Isarcicella staescheri is a valid species that defines an independent conodont zone between *Hindeodus parvus* and *I. isarcica* Zones. The so-called *H. latidentatus--H. parvus--I. turgida--I. isarcica* lineage proposed by Zhang et al. (1995) should be revised to be the *H. latidentatus--H. parvus--I. staescheri--I. isarcica* evolutionary lineage. The conodont zones for the P/T boundary beds proposed by Zhang et al. (1995) have to be revised also. In the pelagic facies, the conodont zones in ascending order are *Clarkina changxingensis--C. deflecta* Zone- *C. carinata* Zone and *C. planata* Zone. In the shallow water facies, the conodont zones in ascending order are *H. latidentatus* Zone--*H. parvus* Zone--*I. staescheri* Zone--*I. isarcica* Zone and *H. postparvus* Zone.

Key Words: P/T boundary beds, conodont lineage, Zones, *Isarcicella staescheri* Zone

Conodonts are of utmost importance for the Permian--

* A research program supported by National Nature Science Foundation of China. No. 49272078

Triassic boundary beds, and *Hindeodus parvus* has been accepted as the marker of the base of the Triassic system. Unfortunately, certain aspects of boundary conodonts are poorly known. For example, the apparatuses of species of *Hindeodus* and *Isarcicella* are obscure. In addition, the conodont lineage and zonation are still disputed among conodont workers.

***Isarcicella staescheri* --a valid species and zonal index.** The holotype of *Isarcicella isarcica* has one denticle on each side of the carina. Sweet (1977), in agreement with Staesche (1964), included the laterally adenticulate elements in *Isarcicella isarcica* (Huckriede) as one of the three morphotypes of the species (i.e. morphotype 1). Morphotypes 2 and 3 include the laterally denticulate elements with one denticle or a denticle series respectively on either or both sides. Kozur and Pjatakova (in Kozur, 1975) ascribed these laterally adenticulate elements to the new species *Anchignathodus parvus,* which have been accepted by conodont workers as an independent species and an index fossil for the base of the Triassic because the *Hindeodus parvus* is quite different from the *Isarcicella isarcica* both in morphology and in stratigraphic position. Most conodont workers, including Staesche (1964), Sweet (1977), Paull (1982) Perri and Andraghetti (1987), Perri (1991), and Zhang et al. (1995), agree that *Isarcicella isarcica* has two morphotypes with the same stratigraphic ranges. Dai and Zhang (1989) named a new species *Isarcicella staescheri* for Morphotype 2. Kozur (1995) placed *Isarcicella staescheri* into *Isarcicella isarcica* as its subspecies. But conodont workers have not paid enough attention to the stratigraphic position of the so-called two morphotypes of the *Isarcicella isarcica.* In fact, *Isarcicella staescheri* and *Isarcicella isarcica* are also different, both in morphology and in stratigraphic position. *Isarcicella staescheri* appears much earlier than *Isarcicella isarcica.*

For example:

a. At the Changxing section, *Isarcicella staescheri* first appears at bed 28 (Zhang et al., 1995, identified this specimen as *Isarcicella isarcica.*);

b. At the Heping section, Luodian County, Guizhou Province, the present author has found 8 specimens of the *Isarcicella staescheri* but without any specimen of the *Isarcicella isarcica;*

c. At Selong Xishan section of Tibet, the so-called *Isarcicella isarcica,* which corresponds to Morphotype 2 of Sweet (Orchard et al., 1995, p. 832) and is about 10-30 cmhigher than *Hindeodus parvus* in the section, should be assigned to *Isarcicella staescheri*;

d. The conodonts from the Werfen Formation, southern Alps, Italy, show that *Isarcicella staescheri* and *Isarcicella isarcica* have different stratigraphic positions. Especially in the Tesero section, *Isarcicella isarcica* (TS26) is about 10 m higher than the first occurrence of the *Isarcicella staescheri* (TS19) (Perri, 1991, p. 27, Tab. 2). Even the three species, *H. parvus, I. staescheri* and *I. isarcica,* co-occur in the same sample (TS26, BU27); it does not mean an intraspecific variability. Those three species have different stratigraphic ranges, their first occurrence horizons are different; it is an evolutionary lineage.

e. Five specimens of *Isarcicella* were found by Matsuda (1981) in samples from two horizons (bed 61 and 63) of Guryul Ravine section in Kashmir. All of them are referred to *Isarcicella isarcica* - Morphotype 2 by Sweet which bears one or two denticles on one side of carina. Here we assign it to *Isarcicella staescheri.* The real *Isarcicella isarcica* (Morphotype 3 of Sweet) which bears one or two denticles on both side of carina has not been found in the Kashmir samples.

f. At the Xiaoba section of the Anxian County, Sichuan Province, *Isarcicella staescheri* first appears at bed 21, 4.80 m higher than the P/T boundary, *Isarcicella isarcica* first appears at bed 26, about 40 m higher than the P/T boundary, indicating again that *Isarcicella staescheri* appears earlier than *Isarcicella isarcica.* (Li et al., 1989, p. 20-22).

g. The Tongkou section in the Beichuan County and the Shangsi section in the Guangyuan City also show the sequence of the *H. parvus--I. staescheri--I. isarcica.* (Li et al., 1989, p. 10-20.).

h. At the Yangou section of the Loping City, Jiangxi Province, one very primitive specimen of *Isarcicella isarcica* and more than twenty specimens of *Isarcicella staescheri* have been found (bed 15), all specimens of *Isarcicella staescheri* have more advanced structure (long series of denticles), indicating also that the *Isarcicella staescheri* should appear earlier than *Isarcicella isarcica.*

Isarcicella staescheri should be a valid species, and also a zonal fossil for the *Isarcicella staescheri* Zone between the *H. parvus* and the *I. isarcica* Zone.

Agreement and discrepancy in the study of conodonts from the Meishan section

Conodonts of the Permian--Triassic boundary beds at the Meishan section have been intensively studied in recent years (Wang, 1994a, 1994b, 1995; Lai et al., 1995; Zhang et al., 1995). The results of the study on conodonts by different authors agree as follow:

1. *Clarkina subcarinata* disappears at the top of the Changhsing Limestone.
2. *Clarkina deflecta* and *C. xiangxiensis* disappears within the boundary bed 1 (or bed 26)
3. The range of *Clarkina meishanensis* is restricted to boundary bed 1 (or bed 25-26).
4. *Clarkina carinata* appears a little earlier than *Hindeodus parvus.*
5. The range of the *Hindeodus changxingensis* is restricted within boundary bed 1-2 (or bed 25-27).
6. *Hindeodus typicalis* has a long range through the P/T boundary beds.
7. *Hindeodus parvus* first occurs within boundary bed 2 (the base of AEL882-3) or bed 27 (the base of the bed 27c); indicating the base of the Triassic. This species evolved from *Hindeodus latidentatus.*
8. P/T biostratigraphic boundary is somewhat higher than the eventostratigraphic boundary; and abandoned the opinion that " The Permian--Triassic boundary presents an excellent case for integration of biostratigraphic and eventostratigraphic criteria. "(Yin.1994).

9. *Isarcicella staescheri* first occurs at bed 28, only 8 cm higher than the base of the *Hindeodus parvus* Zone; indicating again that the P/T boundary section at the Meishan is very condensed.

10. All Chinese conodont workers support that the Meishan section should be GSSP for the base of the Triassic.

Nevertheless there are still some discrepancies among Chinese conodont workers of the Meishan section:

1. Wang (1994, 1995) reported that *Clarkina changxingensis* extended up to the upper part of boundary bed 2 (or bed 27), passing through P/T boundary. Lai et al. (1995) and Zhang et al. (1995) reported that this species disappeared at the top of bed 26, just below the P/T boundary.

2. Zhang et al. (1995, fig. 1) documented that *Clarkina carinata* has a very long range, even in the Changhsing Limestone, but Wang (1994, 1995) and Wang et al. (1996) documented that most so-called *Clarkina carinata* specimens in the upper Changhsing Limestone should be *Clarkina cf. carinata;* the real *Clarkina carinata* first occurs at boundary bed 1, a little below the *Hindeodus parvus* Zone. This species is from the *Clarkina cf. carinata* (Wang, 1996), which was first reported from the Meishan section by Clark et al. 1986).

3. Wang (1994a, 1994b, 1995, 1996) placed the eventostratigraphic boundary at the base of boundary bed 1 (Claystone bed), 15 cm below the biostratigraphic boundary, because this is beginning of the P/T events, and great lithological changes occurred; it is also an important horizon indicating the mass extinction. Lai et al. (1995), Zhang et al. (1995) placed the eventostratigraphic boundary at the base of bed 27, 8 cm below the biostratigraphic boundary, but did not explain the reason in their papers.

4. One of the great discrepancies is about the conodont sequence across the P/T boundary beds. Lai et al. (1995), Zhang et al. (1995) formally proposed a conodont lineage based on the study of the Meishan section, i.e the *H. latidentatus--H. parvus--I. turgida--I. isarcica.* This evolutionary lineage is not reliable; it has to be revised.

First, Lai et al. (1995), Zhang et al. (1995) have no documented *I. turgida* between the *H. parvus* Zone and the *I. isarcica* Zone (= *I. staescheri* Zone) at the Meishan sections. How can we recognize this lineage? In fact, there is only an 8 cm interval for the *H. parvus* Zone at the Meishan section, itis hard to believe that there is an intermediate link between the *H. parvus* Zone and the *I. isarcica* Zone(=*I. staescheri* Zone here); in addition, the unique specimen of the *Isarcicella isarcica* (=*I. staescheri*) that Lai et al. (1995) found at bed 28 has two denticles on the one side of the basal cavity, this is a more advanced specimen of this species, indicating this is not the earliest horizon of the species. If this lineage is present, why not establish a *I. turgida* Zone?

According to the identification of Wang (1994, 1995), and Kozur et Wang (1995), *Hindeodus turgidus* first occurs in bed 29. All so-called *H. turgidus* specimens with a small cusp and very expanded basal cavity should be assigned to *H. cf. turgidus. Hindeodus turgidus* and is not part of the lineage from the *H. parvus* to the *I. staescheri*.

Second, so-called *I. isarcica* in bed 28 should belong to *I. staescheri*. This specimen has two denticles on one side of the basal cavity, it is far from the holotype of the *I. isarcica*, which has one or two denticles on both sides of the basal cavity. The present authors consider that these are two independent species, and proposed a new conodont lineage - the *H. latidentatus--H. parvus--I. staescheri--I. isarcica* lineage (Fig. 1, 2).

5. The conodont zonation for P/T boundary beds is also viewed differently by the Chinese conodont workers. In ascending order, Zhang et al. (1995) recognized: 1. The *Clarkina changxingensis--C. deflecta* Zone for the Changhsingian Stage, including Fauna 1 to Fauna 3 at the latest Changhsingian; 2. *H. parvus* Zone; 3. *I. isarcica* Zone (=*I. staescheri* Zone); 4. *Clarkina carinata--C. planata* Zone. Based on the study by the present author, the conodont zonation for the P/T boundary beds should distinguish between shallow water facies (or *Hindeodus* biofacies) and pelagic facies (or gondolellid biofacies). One advantage of the Meishan section is the co-occurrence of conodonts from the shallow water facies and the pelagic facies. It provides an excellent case for the correlation of the conodont zones in different facies.

In the shallow water facies, *H. latidentatus* Zone, *H. parvus* Zone, *I. staescheri* Zone, *I. isarcica* Zone, *H. postparvus* Zone have been established (Fig. 2, 3). In the pelagic facies, *Clarkina changxingensis--C. deflecta* Zone--*C. carinata* Zone--*C. planata* Zone has also been established (Fig. 2, 3)

6. Jin et al. (1994) and Sheng et al. (1994) said "The so-called boundary clay at the top of the Changhsingian is in fact a residual bed on the non-depositional surface"; it means, the P/T boundary beds at Meishan section do not represent continuous sedimentation. Wang (1994a, 1994b), Wang et al. (1996) pointed out that the boundary clay was deposited below the storm wave base. It is a continuous deposit.

7. Six "subdivisions" have been proposed by Yin (1994) and Yang et al. (1995) for the Permian--Triassic boundary beds, and they "suggest delineation of the P/T boundary between subdivisions 4 and 5, that is at the base of the *H. parvus* zone". But the concept of the "subdivision" is very obscure. Some "subdivisions" are different biostratigraphic units("subdivision" 1 or 5 is Zone, "Sudivision" 2 is Assemblage Zone and "subdivision" 6 is Acme Zone); whereas the "subdivision" 3 is a lithostratigraphic unit (boundary claystone). It is impossible to make a correlation based on such obscure concepts. In addition, the base of the "subdivision" 5 (= Mixed bed 2) and the base of the *H. parvus* Zone (= the base of AEL882-3 or the base bed 27c) are not at same level (Wang, 1994a, 1994b, Yin et al., 1994, Zhang et al., 1995). The conclusion of the "delineation of the P/T boundary between subdivisions 4 and 5 " can not be accepted.

Revised conodont zones for the Earliest Triassic

The earliest Triassic conodont zones should be revised. In the pelagic facies and shallow water facies the conodont sequences are quite different (Fig. 2, 3).

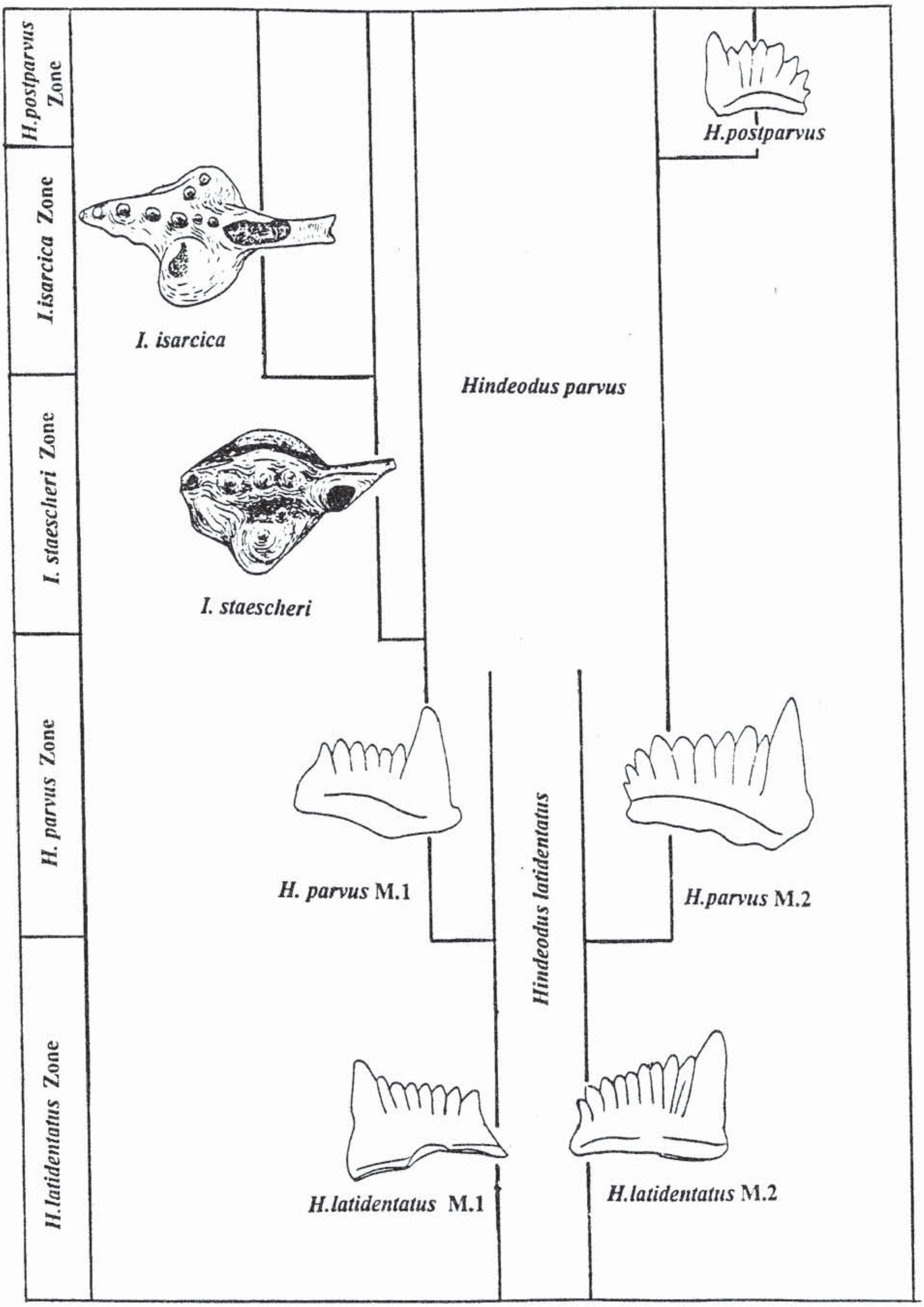


Figure 1. Conodont zonation and evolutionary lineage at the Permian-Triassic boundary beds.

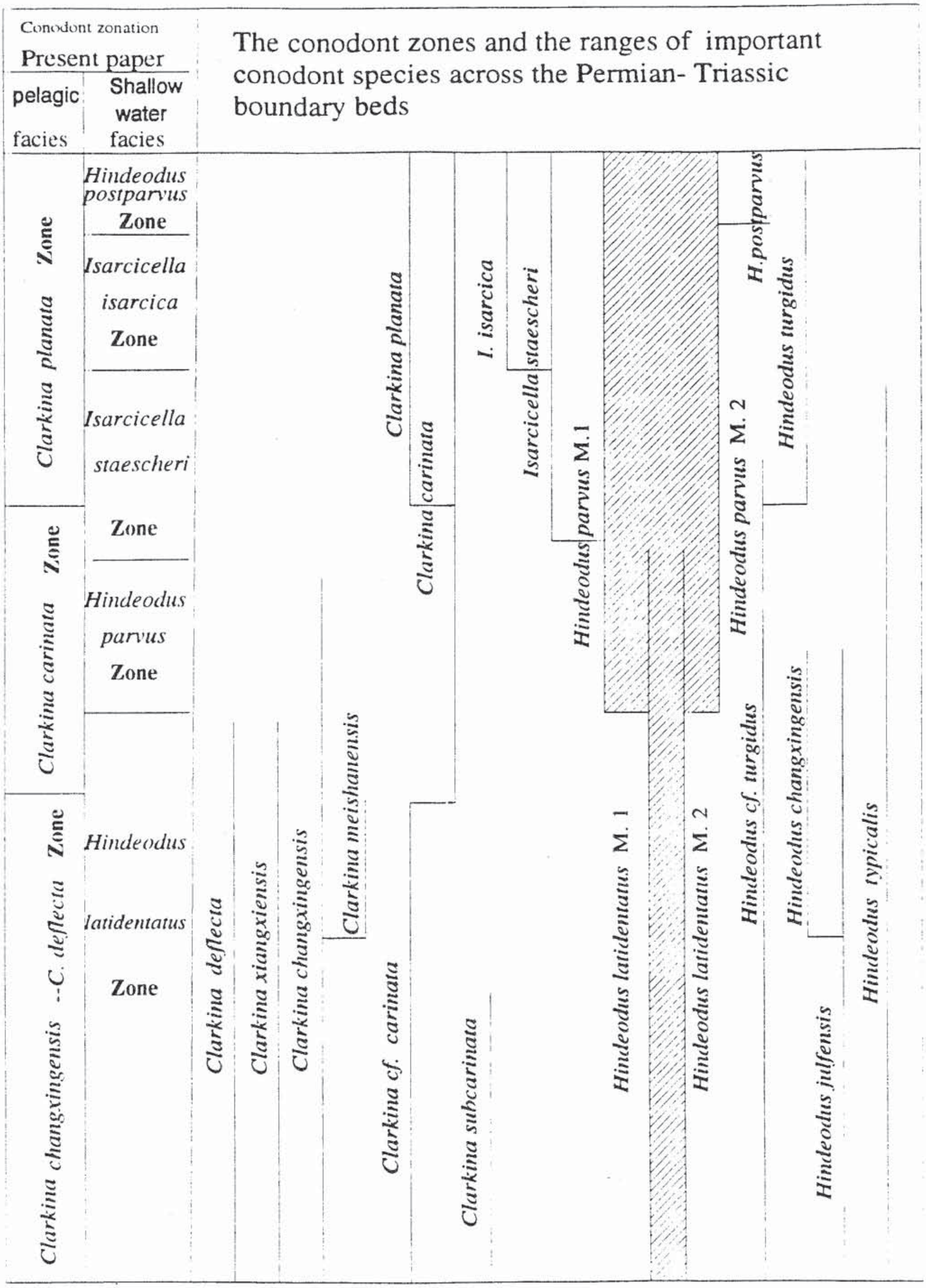


Figure 2. Range chart of selected important conodont species in the P/T boundary beds

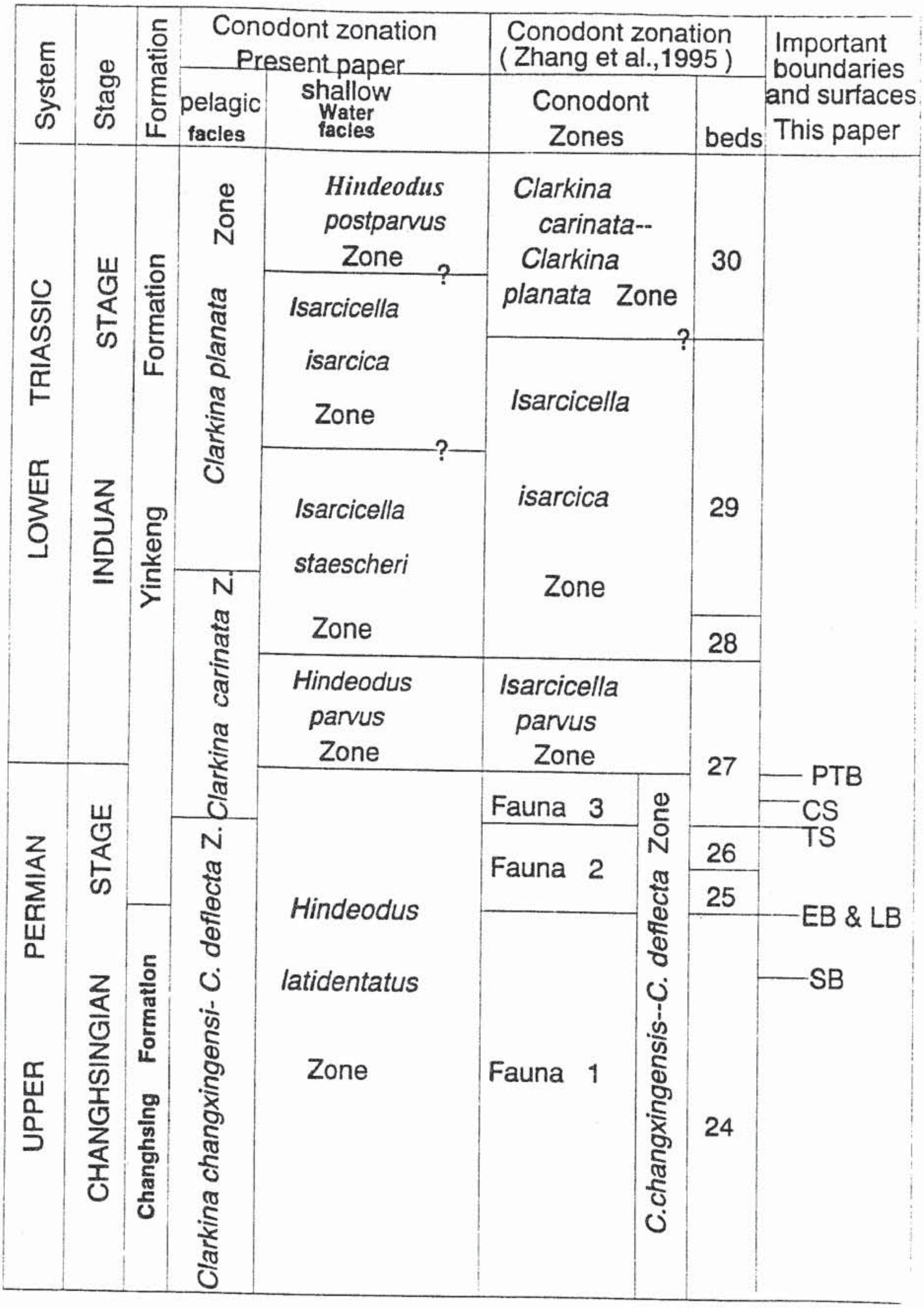


Figure 3. Conodont zones of pelagic and shallow water facies tentatively correlated with the Meishan section, Changxing County.

Shallow water facies

***H. parvus* Zone**

Lower limit: defined by the first occurrence of *Hindeodus parvus* (Kozur et Pjatakova, 1976) Morphotype 1

Upper limit: defined by the first occurrence of *Isarcicella staescheri* Dai et Zhang, 1989

Remarks: *Clarkina deflecta, C. subcarinata, C. meishanensis* disappeared just close the start of the *H. parvus* Zone, but *Clarkina changxingensis, Hindeodus changxingensis* and *H. julfensis* finally extincted within this zone, only *Clarkina carinata, Hindeodus latidentatus* M.1, *H. parvus* M.1, *H. parvus* M.2 and *Hindeodus cf. turgidus* could pass through this zone

***Isarcicella staescheri* Zone**

Lower limit: defined by the first occurrence of the *Isarcicella staescheri* Dai et Zhang, 1989

Upper limit: defined by the first occurrence of the *Isarcicella isarcica* (Huckriede, 1958)

Remarks: *Clarkina changxingensis, Hindeodus changxingensis* and *H. julfensis* extincted just close to the start of the *Isarcicella staescheri* Zone. *Clarkina carinata, Hindeodus turgidus, H. parvus* M.1, *H. parvus* M.2, and *H.typicalis* are present in this zone.

***Hindeodus postparvus* Zone**

Lower limit: defined by the first occurrence of the *H. postparvus* Kozur, 1989

Upper limit: defined by the first occurrence of the *Neospathodus kummeli* Sweet, 1970

Remarks: *Clarkina carinata, I. isarcica, Hindeodus parvus* are still present in this zone. The *H. postparvus* Zone corresponds to the *Ophiceras commune* ammonoid Zone (Kozur, 1989). In the South China, we have not found this species.

Pelagic facies

***Clarkina carinata* Zone**

Lower limit: defined by the first occurrence of the *Clarkina carinata* (Clark, 1959)

Upper limit: defined by the first occurrence of the *Clarkina planata* (Clark, 1959)

Remarks: Zhang et al. (1995) reported that the species *Clarkina carinata* has a very long range just across the P/T boundary beds (Zhang et al., 1995, p. 671, fig. 1). Wang documented that the earliest occurrence of this species was from boundary bed 2 (=bed 27). All so-called *Clarkina carinata* identified by Zhang et al. (1995) at the uppermost Changhsing Limestone were assigned to *Clarkina cf. carinata* by Wang (1995), Wang et al. (1996). Lower limit of this species is a little earlier than the lower limit of the *H. parvus*. This species evolved from the *Clarkina cf. carinata*.This Zone corresponds to the *H. parvus* Zone and the lower part of the *I. staescheri* Zone (Fig. 2,3).

***Clarkina planata* Zone**

Lower limit: defined by the first occurrence of the *Clarkina planata* (Clark, 1959)

Upper limit: defined by the first occurrence of the *Neospathodus kummeli* Sweet, 1970

Remarks: *Clarkina planata* evolved from the *Clarkina carinata*. It first occurs at the bed 29 at the Meishan section (Zhang et al. 1995, fig. 1), somewhat higher than the first occurrence of the *Isarcicella isarcica*. It is equivalent to the interval from the upper *I. staescheri* Zone to the *H. postparvus* Zone in the shallow water facies (Fig. 2,3).

PTB: P/T biostratigraphic boundary; **CS**: C^{13} minimum surface; **TS**: Transgressive surface; **EB**: Eventostratigraphic boundary; **LB**: Lithostratigraphic boundary; **SB**: Sequence stratigraphic boundary.

References

Clark, D. L., Wang, C. Y., Orth, J. and Gilmore, J.S., 1986: Conodont survival and low iridium abundances across the Permian- Triassic boundary in South China. Science, 233:984-986.

Huckriede R., 1958: Die Conodonten der mediterranen Trias und ihr stratigraphischer Wert. Palaeont. Z.,**32**(3/4):141-175.

Kozur, H., 1977: Revision der Conodontengattung *Anchignathodus* und ihrer tyusart.- Zeitschr. geol Wiss. **5**(9):1113-1127.

Kozur, H. 1978: Beitrage zur Stratigraphie des Perms. Teil II: Die Conodontenchronologie des Perms.- Freiberger Forsch.-H., **C334**:85-161.

Kozur, H., 1990: The taxonomy of the gondolellid conodonts in the Permian and Triassic. Cour. Forschunginst. Senckenberg, **117**:409-469.

Kozur, H., 1995: Permian conodont zonation and its importance for the Permian stratigraphic standard scale. Geol Palaeont. Mitt Innsbruck, **20**:165-205.

Li Zi-shun, Zhan Li-pei, Dai Jin-yie, et al., 1989: Study on the Permian--Triassic biostratigraphy and event stratigraphy of Northern Sichuan and Southern Shaanxi. Geological Memoirs, Series 2, Number 9, 1-439. Geological Publishing House, Beijing.

Lai Xu-long., Ding Mei-hua, and Zhang Ke-xin, 1995: The significance of the discovery of *Isarcicella isarcica* at the Meishan Permian--Triassic boundary stratotype section in Changxing, Zhejiang Province. Exploration of Geosciences, **11**:7-11.

Matsuda, T., 1981: Early Triassic conodonts from Kashmir, India. part 1: *Hindeodus* and *Isarcicella*. Jour. of Geosci., Osaka City Univ., **24**(3):75-108.

Orchard, M. J., Nassichuk, W.W. and Rui Lin, 1995: Conodonts from the Lower Griesbachian *Otoceras latilobatum* beds of Selong, Tibet and the position of the Permian--Triassic boundary. Pangea: Global Environments and Resources. Canada Society of Petroleum. Memoir. **17**:823-843.

Paull, R. K., 1982: Conodont biostratigraphy of Lower Triassic rocks, Terrace Mountains, northwestern Utah Geol. Assoc. Publ., **10**: 235-249.

Perri, M.C., 1986: A Spathian conodont fauna from the Cencenighe Member of the Werfen Formation (Scythian), Southeastern Dolomites, Italy: Bull. Soc. Paleont. Ital., **24**(1985)(1):23-28.

Perri, M.C., 1991: Conodont biostratigraphy of the Werfen Formation (Lower Triassic), Southern Alps, Italy. **30** (1):23-46.

Perri, M. C., and Andraghetti, M., 1987: Permian--Triassic boundary and Early Triassic conodonts from the Southern Alps, Italy: Riv. It. Paleont. Strat., **93** (3):291-328.

Sheng Jin-zhang and Jin Yugan, 1994: Correlation of Permian deposits in China. Palaeoworld, **4**:14-113.

Staesche, U., 1964: Conodonten aus dem Skyth von Sudtiral. N. Jb. Geol. Palaeont. Abh., **119** (3):247-306.

Sweet, W.C., 1970: Uppermost Permian and Lower Triassic conodonts of the Salt Range and Trans-Indus Ranges, West Pakistan. Univ. Kansas Dept. geol. Spec. Publ., **4**: 207-275.

Sweet, W.C., 1977: Genus *Hindeodus*, genus *Isarcicella*. In Ziegler, W. (ed.). Catalogue of Conodonts, **3**:203-230., *Hindeodus*- pl. 1-2. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Tian Chuan-rong, Dai Jin-ye and Tian Shu-gang, 1983: Triassic conodonts. In Edited by Chengdu Institute of Geology and Mineral resources. Paleontological Atlas of Southwest China, Volume of Microfossils: 345-411. Geological Publishing House, Beijing.

Wang Cheng-yuan, 1994a: Eventostratigraphic boundary and biostratigraphic boundary of the Permian--Triasic in South China. Jour. of Stratigraphy, **18** (2):145-121.

Wang Cheng-yuan, 1994b: A conodont-based high-resolution eventostratigraphy and biostratigraphy for the Permian--Triassic boundaries in South China. In: Jin Yugan et al. (eds). Permian Stratigraphy, Environments and Resources, V. 1:Palaeontology & Stratigraphy. Palaeoworld, **4**:234-248. Nanjing University Press.

Wang Cheng-yuan,1995: Conodonts of Permian--Triassic boundary beds and biostratigraphic boundary. Acta Palaeontologica Sinica., **34**(2):129-151.

Wang Cheng-yuan, Kozur, H., Ishiga, H., Kotlyar, G.V., Ramovs, A., Wang Zhi-hao, Zacharov, Y., 1996: Permian--Triassic boundary at Meishan of Changxing County, Zhejiang Province, China--A proposal on the Global Stratotype Section and Point (GSSP) for the base of Triassic. Acta Micropalentologica Sinica, **13**(2):109-124.

Yang Zun-yi, Yin Hong-fu, Wu Shun-bao et al. 1987: Permian Triassic boundary stratigraphy and fauna of South China. People's Republic of China, Ministry of geology and mineral resouces. Geological memoirs Series **2**(6):1-379.Geological publishing House, Beijing.

Yang Zun-yi, Sheng Jin-zhang and Yin Hong-fu, 1995: The Permian- Triassic boundary: the global stratotype section and point (GSSP). Episodes, **18**(1-2):49-53.

Yin Hong-fu,1993: A proposal for the global stratotype section and point (GSSP) of the Permian- Triassic boundary. Albertiana, **12**:45-49.

Yin Hong-fu, 1994: Reassessment of the index fossils at the Paleozoic- Mesozoic boundary. Palaeoworld, **4**:152-171.

Yao Zhao-qi, Xu Jun-tao, Zheng Zhuo-guan, Zhao Xiu-hu and Mo Zhuang guan. 1980: Late Permian biostratigraphy and Permian--Triassic boundary in western Guizhou and eastern Yunnan. In Coal-bearing strata and palaeontology from Late Permian of western Guizhou and eastern Yunnan, 1-70. Science Press, Beijing.

Zhang Ke-xin, 1984: New data on the conodont fauna from the *Otoceras* bed in the Baoqing section of Changxing, Zhejiang. Earth Science- Journal of Wuhan College of Geology, **26**(3):38,104.

Zhang Ke-xin, Lai Xu-long, Ding Mei-hua and Liu Jin-hua,1995: Conodont sequence and its global correlation of Permian--Triassic boundary in Meishan section, Changxing, Zhejiang Province. Earth Science-- Journal of China University of Geosciences, **20**(6): 669-676.

Zhu Xiang-shui, Wang Cheng-yuan, Lu Hua at al., 1994: Permian--Triassic boundaries in Jiangxi, China. Acta Micropalaeontologica Sinica, **11**(4):439-452.

Wang Cheng-yuan
Nanjing Institute of Geology and Paleontology,
Academia Sinica,
Nanjing, 210008 China

Conodont biostratigraphy of the Nikolsky section (southern Urals): a progress report

By V. V. Chernykh and S. M. Ritter

Introduction

The Nikolsky section is located on the north bank of the Ural River approximately 2 km west of the village of Nikolsky, Russia. It comprises one of the most complete exposures of Gzhelian (as well as immediately super- and subjacent) strata in the entire southern Ural Mountains and was at one time the stratotype for the now obsolete Orenburgenian Stage (Ruzhencev, 1945). Ammonoids and fusulinids are abundant in this section and both groups have been the focus of detailed studies. Until now, however, conodonts have received only cursory examination (Barskov et al., 1981). In this article we summarize the occurrence of Nikolsky conodonts, offer a preliminary *Streptognathodus*-based zonation, and suggest tentative correlations with the Midcontinent USA.

Location and Stratigraphic Framework

The Nikolsky section comprises 1133 m of east-dipping, prodeltaic shales, calcareous sandstones, conglomerates, and limestones that crop out on the north bank of the Ural River. Davydov and Popov (1991) subdivided the section into 48 field units or beds, which we retain as a working stratigraphic framework herein. Beds 1 through 14 are largely covered, but fossiliferous sandstone ribs provided opportunities for adequate sampling. The interval from the base of bed 15 to the top of bed 46 is completely exposed. Bed 47 was exposed with earth moving equipment and test pits were dug in bed 48. Above bed 48, the section is covered by thick colluvium except for ledgy outcrops at the very top of the section immediately west of Nikolsky village.

	bed numbers									
species	2-4	5-17	18-35	36-43	44-46	47	48/1,2	48/3,4	48/5	48/6
G. sublanceolata	1	7								
I. tersus	3	3								
S. gracilis	2									
S. excelsus	2									
S. zethus	4									
S. firmus		88								
S. pawhuskaensis		39	154							
S. p. deflectus		11								
I. lobulatus		33								
I. simulator		6								
S. holtensis		1								
S. bitteri		2								
S. sp. A		>100	>100							
Go. kanadaensis			3							
S. virgilicus			23	15						
S. sp. B			3	3						
S. sp. C				4						
S. sp. D				4						
S. sp. E				41	20	2	18	2	3	3
G. kazakhstanica				2						
S. sp. F					125	120				
S. wabaunsensis						2	18			
S. flangulatus							4			
S. nodulinearis							20			
S. acuminatus							4	4	1	
isolated nodular *S.*							11	3	2	
S. sp. G							1	52	2	
S. cristellaris								14	10	
S. sp. H									35	
S. longissimus										34
S. constrictus										12
S. barskovi										2
M. belladontae										2

Table 1. Stratigraphic distribution and abundances of key conodont species in the Nikolsky section.
S.= Streptognathodus, I=Idiognathodus, G.=Gondolella, Go.=Gondolelloides and *M.=Mesogondolella*

Upper Carboniferous					
Kasim.	Gzhelian				
gracilis Zone	*firmus* Zone	*virgilicus* Zone	unorn. strepto. Zone	*S.* sp. F Zone	*wabaunsensis* Zone
2-4	5-17	18-35	36-43	44-46	47

Lower Permian			
lower Asselian			mid. Assel.
zone of isolated nodular *Streptog.*	*cristellaris* Zone	*S.* sp. G Zone	*constrictus-barskovi* Zone
48/1,2	48/3,4	48/5	48/6

Table 2. Conodont and zonal subdivision of the Nikolsky section

Conodonts

During the 1994 field season we made systematic collections from 66 horizons at the Nikolsky section. Of these, 55 samples yielded conodont elements with abundances ranging from 20 to 500 elements per kilogram. Faunas are dominated by well-preserved specimens of *Streptognathodus* spp. with minor occurrences of *Gondolella*, *Idiognathodus*, *Mesogondolella*, and *Gondolelloides* (Table 1). The recovery of the latter genus is of paleobiogeographic interest because all previous occurrences were from the Arctic regions (Henderson and Orchard, 1991) of Canada and the northern Urals (Novaya Zemlya and Shugor River).

We divide the Nikolsky section into six Upper Carboniferous and four Lower Permian phylozones based entirely upon first occurrences of name-bearing streptognathodids (Table 2). The lower zone contains typical late Kasimovian (late Missourian) species including *Streptognathodus gracilis*, *S. excelsus*, *Idiognathodus tersus*, *I.* aff. *I. lobatus*, and *Gondolella sublanceolata*. A major faunal change occurs in bed 5 with the introduction of *S. firmus* and *S. pawhuskaensis*. These species dominate faunas from beds 5 through 18, which we assign to the *S. firmus* Zone. *Idiognathodus simulator* occurs in the lower part of the zone in bed 7. *Idiognathodus lobulatus* ranges throughout the zone but is most abundant in beds 11-17. The upper part of the zone is also characterized by the occurrence of a streptognathodid morphotype (*S.* sp. A) with an axial row of nodes reminiscent of *S. brownvillensis*. The latter is distinguished, however, by its more gracile platform and younger age. The disappearance of *Idiognathodus* and inception of *S. virgilicus* in bed 18 distinguishes the base of the *S. virgilicus* zone. This is a relatively low diversity zone characterized by unornamented streptognathodids such as the name-bearing species and *S.* sp. A. A dramatic increase in the variety of unornamented streptognathodids occurs in beds 36-43. Included in this minor adaptive radiation are *S. insignitus* as well as four new species (*S.* sp. B-E) recognized in Gzhelian strata at Aidaralash Creek (Chernykh and Ritter, 1997). Since these species names are as yet unavailable, we opt for an informal designation; the "zone of unornamented streptognathodids". Most of the important species of this informal zone continue into overlying beds 44-47. This interval is divided into two additional zones, however, on the first occurrence of *S.* sp. F (a previously unrecognized species with a nearly flat platform and continuous transverse ridges), and *S. wabaunsensis*, respectively. Beginning at the base of the *S. wabaunsensis* Zone and continuing to bed 48/5, conodont faunas reflect the inception and subsequent phyletic development of ornamented streptognathodids. *S. acuminatus*, *S. nodulinearis*, *S. flangulatus*, and two novel forms that will also be described by Chernykh and Ritter (1997). One of these, a streptognathodid with a broad platform and isolated inner node field (isolated nodular *Streptognathodus* of Chernykh and Ritter, 1994) has been recommended as the index for the Carboniferous-Permian boundary (Davydov et al., 1995). The phyletic development of ornamented streptognathodids provides the logic for subdividing beds 47 through 48/4 into three zones (Table 2). A return to dominance by unornamented species of *Streptognathodus* characterizes the upper part of the Nikolsky section. Two zones are recognized; the S. sp. G Zone (bed 48/5) and the *S. constrictus-S. barskovi* Zone (bed 48/6).

The aforementioned conodont sequence permits tentative recognition of the upper and lower boundaries of the Gzhelian Stage. The base of the Gzhelian is informally recognized as the base of the *Daixina fragilis* fusulinacean Zone. This corresponds to the lower boundary of the *Streptognathodus* Zone at the base of bed 7. The Gzhelian-Asselian (Carboniferous-Permian) boundary is drawn at the first occurrence of isolated nodular *Streptognathodus*, 100 m above the base of bed 48.

Most of the taxa recovered from Nikolsky are well known North American and Uralian species. Consequently, correlations with the strata from the North American Midcontinent are possible. Based on the common occurrence of *Streptognathodus gracilis* group faunas, beds 2-4 of Nikolsky are correlated with the Kansas City and lower Lansing Groups of Kansas. The upper Lansing, Douglas and Lower Shawnee beds (up to the base of the Queen Hill Shale) correspond to Nikolsky beds 5-18 . The disappearance of *Idiognathodus* and appearance of *S. virgilicus*, which occurs in the Lecompton Limestone of Kansas, has its counterpart in bed 18 of Nikolsky. Faunas from the upper Shawnee, Wabaunsee, and lower Admire Groups reflect the dominance of unornamented streptognathodids and on that basis are correlated with the Nikolsky *virgilicus*, n. sp. C, and sp. F Zones (beds 18-46). The appearance of *S. wabaunsensis* in the Falls City Limestone and appearance of isolated nodular *Streptognathodus* in the Bennett Shale suggest correlation with beds 47 and 48/1, respectively. These correlations highlight the feasibility of constructing a global, conodont-based chronostratigraphy for the Late Carboniferous.

References

Barskov, I. S., T. N. Isakova, and N. P. Schastlivtseva, 1981. Conodonts of the Gzhelian-Asselian boundary beds (south Urals). Proceedings., USSR Academy of Science, Geological Division, 5:78-87.

Davydov, V. I. and A. V. Popov, 1991. Nikolsky Section. In, Chuvashov, B. I., and A. E. M. Nairn, Permian System of the World, Field Excursion Guide:106-122.

Chernykh, V. V. And S. M. Ritter, 1995. Preliminary biostratigraphic assessment of conodonts from the proposed Carboniferous-Permian boundary stratotype, Aidaralash Creek, northern Kazakhstan. Permophiles 25:4-6.

Chernykh, V. V. And S. M. Ritter, 1997. Conodont succession at the proposed Carboniferous-Permian boundary stratotype section, Aidaralash Creek, northern Kazakhstan. Journal of Paleontology, 71 (March issue).

Henderson, C. M., and M. J. Orchard, 1991. Gondolelloides, a new Lower Permian conodont genus from western and northern Canada. In, M. J. Orchard and A. D. McCracken (eds.), Ordovician to Triassic conodont paleontology of the Canadian Cordillera, Geological Survey of Canada Bulletin, 417:253-267.

Ruzhencev, V. E., 1945, On subdividing the upper Carboniferous. (In Russian)Doklady Acad. Sci. USSR, vol.46, n.7, p. 314-317.

V. V. Chernykh
Uralian Branch
Russian Academy of Science
Potchvoyi, Per. 7, 620219
Ekaterinburg, Russia

S. M. Ritter
Department of Geology
Brigham Young University
Provo, Utah 84602 U.S.A.

A possible North-South Correlation of the Permian

By Jin Yu-gan and M. Menning

A north-south correlation of Permian chronostratigraphic successions has been a difficult problem for Permian biostratigraphers. The correlation of the Permian successions above the Artinskian Stage is especially problematic because of the strong latitudinal differentiation of biogeographic realms. Consequently, to establish reliable chronostratigraphic correlation between the Permian of latitudinally controlled palaeobiogeographic realms, we need to resort to other means, such as isotopic dating and magnetostratigraphy. Recent progress on isotopic age of the Permian in Eastern Australia and the Urals allows us to see the matter in a new light (Roberts, 1991, Roberts et al., 1996: Chuvashov et al., 1996).

Among isotopic dates reported from Eastern Australia, that of the bentonite within the Mulbering Siltstone is particularly interesting. It was dated as 264.1 + 2.2 Ma. The Mulbering Siltstone is commonly referred to as Ufimian in the time scale of the Permian in Australia (Archbold et al., 1991). The regression reflected by sedimentation of conglomerate and sandstone of the underlying Muree Sandstone is regarded as a very important episode which may be coeval to the middle Ufimian regression of the Northern Hemisphere (Chuvashov et al., 1996). The microfloras from the overlying Wittingham Coal Measure\ Tomago Coal Measure are assigned to the palynozones AAP4 and AAP5 of Price (in Drape, 1994), which are assumed to be of Ufimian and Kazanian-Dzhulfian age respectively. Based on the correlation mentioned above, an age of 264.1+-2.2 Ma is referred to the Ufimian Stage.

A magnetostratigraphic study locates the top of Carboniferous-Permian Reverse Superchrone (CPRS) in the lower part of the Wittingham Coal Measure in northwestern

Sydney Basin (Theveniaut et al., 1994). Since the upper part of a mixed polarity succession in the Wittingham Coal Measures is assigned to the Kazanian-Dzhulfian, a probable Ufimian age is given to the level corresponding with the top of Carboniferous-Permian Reverse Superchrone (CPRS), or to the Illawarra Reversal (IR).

We suggest an alternative correlation for the Mulbering Siltstone and the lower part of the Wittingham Coal Measure in Eastern Australia, that is late Guadalupian or early Tatarian age. The Pb/U zircon age of 264.1+-2.2Ma and the mixed polarity Wittingham Coal Measure might be reliable. The IR has been well documented as a consistent level in the Lower part of the Tatarian in the Urals. It also has been located in the Wargal Formation of Capitanian (the *Neoschwagerina margaritae* Zone) in Salt Range (Haag and Heller, 1991), the uppermost part of Maokou Formation of Capitanian (the *Yabeina* Zone) in South China (Heller et al., 1995). The age of 265Ma also suggests a Late Guadalupian age. Based on a numerical calibration, an age of 265 Ma for the IR has been documented (Menning, 1994; Menning et al. 1996).

Additional radiometric ages from Eastern Australia, 272.2 +-3.2 Ma for the base of the Kungurian, and 253.4+-3.2 Ma for the intra-Kazanian tuff (Chuvashov et al., 1996) do not fit the time scale of Menning(1995) whereas the Pb/U ages from the traditional standard section in the Urals (Chuvashov et al., 1996), 290.6 +-3.0 Ma for the middle Asselian and 280.3+-2.4 Ma for the Sakmarian\Artinskian boundary, show a difference only 3 Ma between the measured and the predicted ages. The age 253.4 +- 3.2Ma for the Kazanian bentonite bed in Eastern Australia is fairly close to the age of the Permian-Triassic boundary in the Meishan Section of South China, i.e. 251.2+-3.4Ma.

The apparent discrepancy between the isotopic age from Eastern Australia (Roberts. 1991, Roberts et al., 1996: Chuvashov et al., 1996) and the time scale of Menning (1995), as well as the different assignment of the IR to the Ufimian in Eastern Australia (Theveniaut et al., 1994) and to the late Guadalupian in other areas resulted from existing North-South correlation of the Permian chronostratigraphic subdivisions (Archbold et al., 1991). This correlation appears to be in need of major revision, because except for the foraminifers of the *Pseudonodosaria borealis* zone from the Ingelara Formation of Bowen Basin, "almost all the other Permian biota in eastern Australia are Gondwanan: they ....can not be used to correlate with type Russian Permian" (Roberts, Claoue-Long & Foster, 1996, p. 401).

The suggested correlation implies that the base of Permian marine sequence in Eastern Australia probably coincides with the global transgression of Early Kungurian or Late Artinskian and therefore, as proposed by Roberts et al. (1991), the Carboniferous-Permian boundary has to be shifted down into the beds which are currently referred to as Upper Carboniferous. The unconformity below the Muree Sandstone, is correlatable with the global regression of end Guadalupian, and that below the Greta Coal Measures with the Ufimian regression.

References

Archbold, N. W. and J. M. Dickins, 1991. Australian Phanerozoic Timescales: 6. A standard for the Permian System in Australian. Bureau of Mineral Resources, Australian Record 1989, 36.

Draper, J. J., Palmieri, V., Price, P.I., Briggs, D.J.C. & Parfrey, S.M. 1990. A biostratigraphic framework for the Bowen Basin. Bowen Basin Symposium 1990 Geological Society of Australia Inc., 26-35.

Haag, M. & Heller, F., 1991. Late Permian to Early Triassic magnetostratigraphy. Earth Planet. Sci. Letter., 107, 42-54.

Heller, F., Chen, H. H., Dobson, J. & Haag, M., 1995. Permian-Triassic magnetostratigraphy-- new results from South China, Phys. Earth Planet. Int., 89:281-295.

Jin Yu-gan, B. F. Glenister, C. K. Kotlyar & Sheng Jin-zhang, 1994. An Operational Scheme of Permian Chronostratigraphy , Palaeoworld, vol.4;1-14.

Jin Yu-gan.1996 A global chronostratigraphic scheme for the Permian System. Permophiles 28: 4-10.

Menning, M. 1995. A Numerical Time Scale for the Permian and Triassic Periods. An integrated Time Analysis. in Permian of the Northern Continents, 1:77-97, eds. Scholle, Peryt, T.M. & Ulmer-scholle, Springer-Verlag, Berlin.

Menning, M., Jin Yu-gan & Shen Shu-zhong, 1996, The Illawarra Reversal (265 Ma) in the marine Permian, Guangxi, South China, Abstract, 30th Int. Geol. Congre., 4-14, 1996, Beijing, 2:9.

Roberts, J. Claoue'-Long, Jones, P.J. 1991, Calibration of the Carboniferous and Early Permian of New England by SHRIMP Ion Microprobe Zircon analysis. 25th Newcastle Symposium and advance in the study of the Sydney Basin, April 1991, 38-43.

Roberts, J. Claoue'-Long, J. C. Foster C.B. 1996 SHRIMP zircon dating of the Permian System of eastern Australia. Australian J. Earth Sci., 43, 401-421.

Theveniaut, H., Klootwiijik, C., Foster, C. & Giddings, J., 1994. Magnetostratigraphy of the Late Permian coal measures, Sydney & Gunnedah Basin: A regional & global correlation tool. Proc. 28th Newcastle Symposium on "Advance in the study of the Sydney Basin", 15-17 April, 1994, Univ., Newcastle, Newcastle, N.S.W. 11-23.

Jin Yu-gan
Nanjing Institute of Geology & Palaeontology
Nanjing 210008, China

M. Menning
GeoForschungsZentrum Potsdam
Telegrafenberg A26, D-14473
Potsdam, Germany

Carbon and oxygen isotope variations in the Permian-Triassic boundary carbonate sequence from the Idrijca Valley (W. Slovenia)

By Tadej Dolenec and Antonio Ramovš

The stable isotope composition of the Upper Permian and Lower Triassic beds in the Idrijca Valley has been used to investigate $\delta^{13}C$ and $\delta^{18}O$ variations of the well exposed undisturbed Permian - Triassic carbonate boundary sequence (Fig. 1). The lithostratigraphic and biostratigraphic boundary between the Lower Triassic-Scythian and underlying Upper Permian-Žažar beds is well defined and should be drawn between the black, well bedded Žažar limestone very rich in microfossils, algal fragments of Gymnocodiacea and foraminifers Glomospira sp. and light grey sparitic Scythian limestone containing only conical tube-like fossils which are not known in the Upper Permian beds (Ramovš, A., 1986). The transition from Permian to Triassic is characterized by an abrupt shift of $\delta^{13}C$ values from + 4.08 to - 0.69 ‰. The corresponding oxygen isotope excursion is less pronounced and is characterized only by a shift of $\delta^{18}O$ toward slightly lower values, followed by a gradual enrichment of the overlying beds with heavy oxygen isotope (Fig. 2).

The $\delta^{13}C$ and $\delta^{18}O$ anomalies are not confined strictly to the biostratigraphically defined Permian - Triassic boundary. A detailed sampling of the boundary interval shows that the decrease of $\delta^{13}C$ which begins about 5 m below the biostratigraphically determined Permian - Triassic boundary continues smoothly through the boundary to the Lower Scythian beds. A negative $\delta^{13}C$ excursion of inorganic and organic carbon isotopes across the Permian - Triassic boundary has been also reported from different localities all over the world (Magaritz et al., 1988, 1992; Magaritz and Holser, 1991; Holser and Magaritz, 1985, 1987, 1992; Baud et al., 1989; Magaritz and Stemmerick, 1989; Erwin, 1993; Xu and Zheng, 1993; Wang et al., 1994; Faure et al., 1995). Several possible explanations for these global permutations in the carbon cycle have been considered. They might have been caused by a combination of factors including degradation and oxidation of organic matter (Magaritz and Holser, 1991), burning of terrestrial biomass (Ivany and Salawitch, 1993), changes in biological productivity of the ocean surface (Magaritz, 1989; Magaritz et al., 1991) or volcanic activity (Javoy and Michard, 1990; Renne and Basu, 1991). According to Faure et al., (1995) the oxidation of peat on large areas of Gondwana and Asia, and the possible expulsion of oil and gas from the foreland basins must have resulted in major ^{13}C depleted CO_2 flux into the atmosphere at the end of the Permian. The shape of the carbon isotope curve and the magnitude of a more than 4 ‰ decrease in $\delta^{13}C$ across the investigated boundary sequence, thus probably reflect permutations in the global carbon cycle induced by the postulated CO_2 flux into the atmosphere. Strong negative $\delta^{13}C$ anomaly at the Permian-Triassic transitions might also indicates evidence for a major biotic crisis at the end of the Permian. The $\delta^{13}C$ values characteristically decrease to minimum values at and immediately following the mass extinction, and then increase to more positive values (Magaritz, 1989). However, in the Idrijca Valley section where the only 20m thick basal part of the Lower Triassic sedimentary sequence is exposed, there is no evidence of the shift of $\delta^{13}C$ back to its preexcursion level.

The study of oxygen isotopic composition shows that the Upper Permian limestone is considerably depleted in ^{18}O (up to 7 ‰) relative to the marine limestones of Recent age (Faure, 1977), as well as to the Upper Permian dolomite from the Karavanke Mountains which exhibits $\delta^{18}O$ values mostly in the range between + 24.75 ‰ and + 30.58 ‰ (Dolenec et al., 1995). This depletion cannot be interpreted only in terms of water temperature. It may has also been caused by a change in $\delta^{18}O$ of the seawater, decrease of salinity, changes in the depositional environment, post depositional alterations, or some combinations of all the mentioned possibilities. The variations in $\delta^{18}O$ across the Permian - Triassic boundary show trends distinctly different of those in $\delta^{13}C$. The transition is characterized by a relatively high variability of $\delta^{18}O$ which started of about 1.6 m below the boundary. A general trend of $\delta^{18}O$ toward more positive values which span a boundary interval of about 3.5 m might also suggests a slightly cooling conditions at and across the boundary probably induced by the eruption of the Siberian flood basalts, very soon followed by warming in the Scythian. The results we have presented here indicate that the transition from Permian to Triassic is characterized by a strong disturbance in the global carbon cycle accompanied also by changes of $\delta^{18}O$ values in carbonates. We suppose a causal connection between the isotopic anomalies and the global regression during the terminal Permian which lead to increased erosion of organic matter, oceanic anoxia and to the suggested end-Permian mass extinction.

Acknowledgements

This research was performed with financial support from the Ministry of Science and Technology - Republic of Slovenia and Geoexp. d.o.o. Tržič, Slovenia. To both these institutions we express our sincere thanks.

References cited

Baud, A., Magaritz, M., and Holser, W. T., 1989, Permian-Triassic of the Tethys: Carbon isotope studies: Geologishe Rundshau, v. 78, p. 642 - 677.

Dolenec, T., Ogorelec, B., and Pezdiè, J., 1995, The Permian-Triassic boundary in the Karavanke Mountains (Slovenia): Stable isotope variations: First Croatian Geological Congress, Proceedings, v. 1, p. 163 - 165.

Erwin, D. H., 1993, The great Paleozoic crisis: Life and death in the Permian: New York, Columbia University Press, 327. p.

Erwin, D. K., 1994, The end-Permian mass extinction: A complex multicausal extinction: In New Developments Regarding the K/T Event and Other Catastrophes in Earth History: LPI Contribution No. 825, Lunar and Planetary Institute, Houston. 138p.

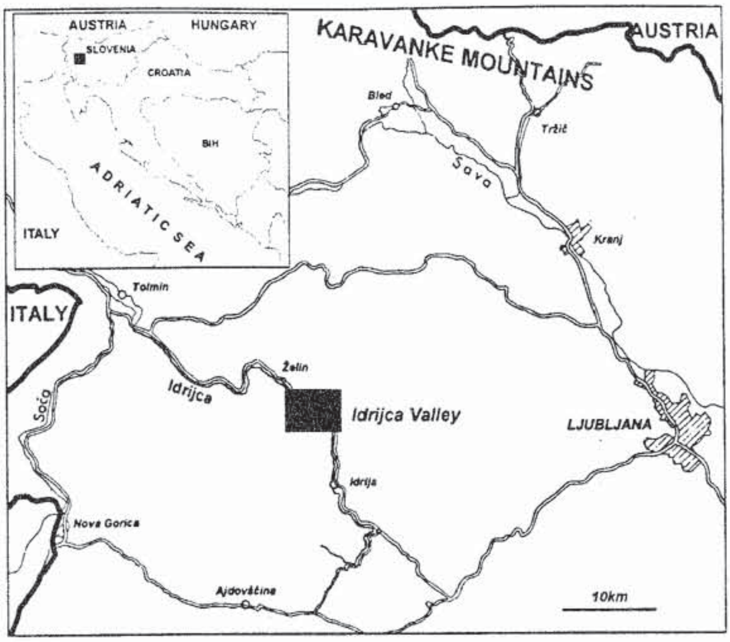


Figure 1. Map showing location of the Idrijca Valley section.

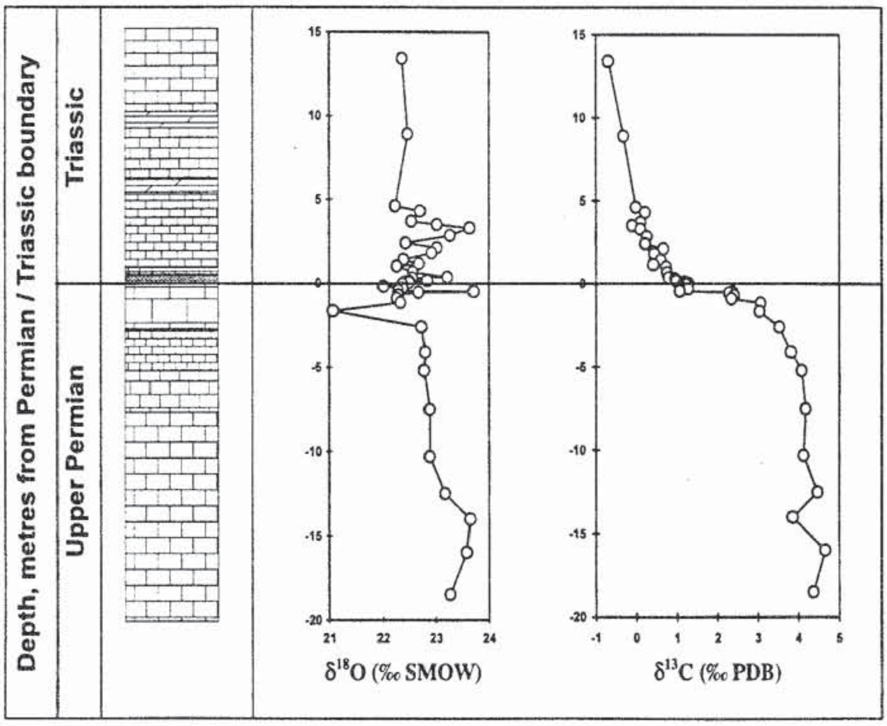


Figure 2. $\delta^{18}O$ and $\delta^{13}C$ stratigraphy from the Permian - Triassic boundary in the Idrijca Valley.

Faure, G., 1977, Principles of Isotope Geology. John Wiley and Sons, New York, p. 464.

Faure, K., Maarten J. de Wit, and Willis, J. P., 1995, Late Permian global coal hiatus linked to ^{13}C-depleted CO_2 flux into the atmosphere during the final consolidation of Pangea: Geology, v. 23, p. 507 - 510.

Holser, W. T., and Magaritz, M., 1985, The Late Permian carbon isotope anomaly in the Bellerophon basin, Carnic and Dolomite Alps: Jb. Geol. B. - A., v. 128, p. 75 - 82.

Holser, W. T., and Magaritz, M., 1987, Events near the Permian-Triassic boundary: Mod. Geol., v. 11, p. 155 - 180.

Holser, W. T., and Magaritz, M., 1992, Cretaceous/Tertiary and Permian/Triassic boundary events compared: Geochem. Cosmochem. Acta, v. 56, p. 3297-3309.

Ivany, L. C., and Salawitch, R. J., 1993, Carbon isotope evidence for biomass burning at the K-T boundary: Geology, v. 21, p. 487 - 490.

Javoy, M., and Michard, G., 1990, Global catastrophes and volcanic events: A comparison of volcanic and industrial outgassings under normal and catastrophic conditions. 7 th Int. Conf. Geochron. Cosmochron. Isotop. Geol., Geol. Soc. Aust. Abstr. Ser., v. 27, p: 51.

Magaritz, M., 1989, ^{13}C minima follow extinction events: A clue to faunal radiation: Geology, v. 17, p. 373 - 340.

Magaritz, M., and Stemmerik, L., 1989, Oscillation of carbon and oxygen isotope composition of carbonate rocks between evaporative and open marine environments, Upper Permian of East Greenland: Earth Planet. Sci. Lett., v. 93, p. 233 - 240.

Magaritz, M., and Holser, W. T., 1991, The Permian-Triassic of the Gartnerkofel - 1 Core (Carnic Alps, Austria): Carbon and Oxygen Isotope Variation: Abh. Geol. B. - A., v. 45, p. 149 - 163.

Magaritz, M., Bar, R., Baud, A., and Holser, W. T., 1988, The carbon-isotope shift at the Permian-Triassic boundary in the Southern Alps is gradual: Nature, v. 331, p. 337 - 339.

Magaritz, M., Kirschvink, J. L., Latham, A. J., Zhuravlev, A. Yu, and Rozanov, A. Yu., 1991, Precambrian/Cambrian boundary problem: Carbon isotope correlation for Vendian and Tommotian time between Siberia and Morocco: Geology, v. 19, p. 847 - 850.

Magaritz, M., Krishnamurthy, R. V., and Holser, W. T., 1992, Parallel trends in organic and inorganic carbon isotopes across the Permian/Triassic boundary: American Journal of Science, v. 292, p. 727 - 739.

Ramovš, A. 1986, Marine development of the uppermost Žažar beds and the lowermost Scythian beds: In Permian and Permian-Triassic boundary in the South Alpine segment of the Western Tethys, Excursion Guidebook, Italian IGCP 203 Group (Ed.), p. 39-42.

Renne, P.R., and Basu, A.R., 1991, Rapid eruption of the Siberian Traps flood basalts at the Permo-Triassic boundary: Science, v. 253, p. 176-179.

Wang, E., Geldsetzer, H. H. J., and Krouse, H. R., 1994, Permian-Triassic extinction: Organic $\delta^{13}C$ evidence from British Columbia, Canada: Geology, v. 22, p. 580 - 584.

Xu, D.Y., and Zheng, Y., 1993, Carbon isotope and iridium event markers near the Permian/Triassic boundary in the Meishan section Zhejiang Province, China: Palaeogogr. Palaeoclimatol. Palaeoecol., v. 104, p. 171-176.

Tadej Dolenec
University of Ljubljana,
Faculty for Natural Sciences and Engineering,
Department of Geology,
Aškerèeva 12, 1000 Ljubljana, Slovenia.
Jožef Stefan Institute, Jamova 39, 1000 Ljubljana, Slovenia.

Antonio Ramovš
University of Ljubljana,
Faculty for Natural Sciences and Engineering,
Department of Geology,
Aškerèeva 12, 1000 Ljubljana, Slovenia.

Approaches to Permian world climates and biogeography

By Alfred M. Ziegler and Mark T. Gibbs

The purpose of this article is to provide background on the Permian research of the Paleogeographic Atlas Project, and to outline our strategy for expanding this work during the next few years. Our hope is to involve Permian specialists as collaborators, data contributors and as critics in an effort to understand this period at the broadest possible scale. Our approach is to compile the lithologic and taxonomic data generated by specialists, to delineate the geographical patterns in this data, to relate the units so defined to present day analogs, and to use this information to test general circulation models (GCMs). The Permian is especially suitable for this approach because it is similar to the Present in terms of the degree of continentality, the equator-to-pole temperature gradient, and the level of terrestrial and marine biotic provincialism. Also, Permian fossiliferous rocks are exceptionally widely distributed, allowing for a detailed understanding of the paleogeography and vegetation, essential for any paleoclimate study.

Our initial papers focusing on the Permian were presented in 1988 at the Oxford Symposium on Palaeozoic Palaeogeography and Biogeography and dealt with three subjects, the orientation of Pangaea, the location of the Asian microcontinents and worldwide phytogeographic patterns. The Pangaea paper (Lottes & Rowley, 1990) reviewed the data available at the time on continental fits and paleomagnetic orientations, and presented maps for stages representative of the Early and Late Permian (Sakmarian and Kazanian). The Asian microcontinents paper (Nie et al., 1990) drew on our own specialization in Chinese geology and considered the structural constraints on the location and timing of suturing, and the paleobotanical and paleomagnetic pole data bearing on the paleo-latitudinal paths of the microcontinents that were yet to become part of Pangaea. The phytogeography paper (Ziegler, 1990) took published information on floral provinces and their collective physiognomic attributes, and presented a unified biome classification for Permian world climates based on a present-day model: 1. tropical everwet, 2. tropical summerwet, 3. subtropical desert, 4. winterwet (=Mediterranean), 5. warm temperate, 6. cool temperate, 7. midlatitude desert, 8. cold temperate, 9. arctic, and 10. glacial. Together, these three papers illustrate our multifaceted approach to paleogeography--we view the world as a system and its diverse aspects can only be understood by relating each to the whole.

For paleontologists, there are a number of lessons in this work. 1, Permian floral provinces were primarily differentiated by climatic and not geographic barriers. This is indicated by the fact that the floral realms (Angaran, Euramerican, Cathaysian and Gondwanan) are gradational and are not always restricted to the continents for which they are named. 2, The wet-to-dry climate contrast between the Carboniferous and Permian often assumed by European and North American workers is a dubious generalization. In reality the northward motion of continents in the Late Paleozoic transported the Euramerican Province out of the equatorial rainy belt, but these conditions remained in low latitudes in a zone including Venezuela, southern Spain, Turkey and particularly China in the Permian. 3, In the literature, paleobiogeographers have used a diverse array of terms derived from geography, climate, latitude and taxonomy to define provinces. These terms become confusing when applied through long intervals of geologic time because the effects of continental motion and evolution render the terms invalid. In our approach to classification, a finite set of climate conditions is defined as a biome and each floral association or province is matched to a biome based on the adaptations characterisic of the flora. Individual assignments may be changed with new information, but at least a framework exists for comparison through geologic time.

In the early 1990's three papers on Permian climate were published that followed on from our initial paleogeographic and phytogeographic work. A new semi-quantitative climate model was applied to the Sakmarian map generating atmospheric circulation maps for opposite seasons as well as a precipitation continuity map; results were evaluated using the distribution of climate-sensitive sediments such as coals, evaporites and phosphorites (Patzkowsky et al., 1991). Later, the Kazanian map was used as a boundary condition in a GCM numerical simulation which generated a full set of maps showing diverse climate parameters (Kutzbach & Ziegler, 1993). This output was used to produce a biome prediction map so that direct comparisons could be made with the on-the-ground floral data. Good agreement was found in most areas, although it must be realized that the results depend on the model working properly and on the paleogeography being correct in essential details. In this connection, some other model studies published about this time overestimated the annual temperature range in South Africa yielding climates that could not have been tolerated by the well-known vertebrate faunas (e.g., Ziegler, 1993). It was hypothesized that the presence of large lakes in this area might have had an ameliorating effect on temperature. Thus in our modeling study we presented simulations with, and without, these features and showed these expectations to be well founded (Kutzbach & Ziegler, 1993).

In view of the fact that paleoclimate reconstructions are only as good as the paleogeography on which they are based, we have just completed a new set of four color maps (see enclosure; Rowley et al., 1996; Ziegler et al., in press). Paleotopography has been depicted to much greater detail than in any other pre-Quaternary paleogeographic map. In this work we update the paleomagnetic pole data and review the available evidence--structural, volcanic, geochronologic, stratigraphic and sedimentational--for the existence of some 63 mountain ranges throughout the Permian. The movement of Pangaea was such that many basins exhibit a northward progression of 15° latitude, so climate change exhibited in individual basins seems generally to be due to this effect. An exception is the deglaciation in the southern hemisphere early in the period, which certainly proceeded at a far greater rate than the continental motion would imply, even though it could have been ultimately triggered by the motion of Gondwana off the pole. The paleotopographic features shown on these maps will allow for more realistic climatic simulations as well as for an examination of migration pathways for plants and animals. For instance, organisms today use meridional mountain ranges, like the Andes, to move from cool northern to cool southern latitudes, and the bipolarity described in some Permian floral genera may indicate similar dispersal patterns. Another interesting point is the clear relationship between high elevation and ice-sheet centers.

With the completion of these new paleogeographic maps, we have begun a multivariate analysis of some 600 floral lists assembled from the world literature (Rees & Ziegler, 1996). We are using Correspondence Analysis, a technique which detects the natural gradations in a data matrix, unlike Cluster Analysis which artificially forces floras into groups. The data matrix consists of generic lists by locality, where the locality concept is generalized to include the available lists from a single formation over a region approximately 100 km across. By using the generic level we avoid problems associated with geographically limited species as well as variance in taxonomic usage, while by grouping the lists regionally we hope to average out community level distinctions. In short, we are only interested in the climate signal, unlike most taxonomists who are concerned with the finest scale morphological variations. In fact, with some judicious synonymizing, we have found that we can analyze all the Permian floral samples in a single group, thereby insuring standardization throughout the period. This is because there is very little taxonomic change in terrestrial floras during the Permian, in marked contrast to marine faunas where change due to evolution would overshadow the variance due to biogeography. The primary conclusion of our statistical analysis is that the main variance in the data is proportional to latitude and presumably temperature. This is in agreement with other periods we have worked on, but it does mean that the Angaran and Gondwanan floras, once regarded as distinct, do show considerable similarity. Also, the biomes discussed earlier may be defined by combining the statistics with a treatment of the adaptive strategies of their consituent genera. For instance, biomes with a high proportion of elements with reduced leaves and thick cuticles would suggest arid climates. This aspect of the work is the reponsibility of paleobotanist Allister Rees of the Open University, England, who is a frequent visitor to Chicago.

A lithofacies database has also been assembled that can be used to test GCM predictions directly, to constrain the climate parameters controlling the terrestrial biomes, and to begin to assess the salinity and temperature of the various oceanic water masses (Ziegler et al., 1996). The Permian epeiric seas, like the Russian and Yangzte platform seas, were extensive and must have had limited exchange with the adjacent deep ocean basins. High salinities characterized the former and the opposite was true of the latter, to judge by the contrast in evaporites and coals between the basins. These deposits, associated with the coastal zone, contain valuable information on the local precipitation balance. Sea surface temperatures (SSTs) can be deduced by reference to shelf margin environments dominated by reefs (warm) as opposed to upwelling deposits like phosphorites, cherts and organic rich shales (cool). In addition to the obvious restrictions on bottom dwelling faunas, cold upwelling currents depress precipitation along adjacent coasts, so have an important effect on regional climate. Our database allows us to separate out different environments for oil source rock formation, e.g., upwelling zones, resticted stratified marine basins with a neutral or negative precipitation balance, and lacustrine environments.

At this point we have begun an NSF-funded GCM study using our new Permian paleogeographies. Current GCMs now have sufficient spatial resolution to be able to utilise our new detailed paleotopography. The work will be led by Mark Gibbs, recently arrived from Penn State, along with John Kutzbach at the Center for Climate Research, University of Wisconsin-Madison. Our initial goal is to evaluate the relative importance of changes in paleogeography and the level of atmospheric CO_2 in explaining the Permian deglaciation. This transition from an ice-house to a hot-house climate is the most recent analog in the geological record for the likely effect of current human perturbations to the Earth system. Later work will investigate the potential role of Milankovitch orbital variations, and eventually we will use a fully-coupled ocean-atmosphere model that will predict areas of upwelling and SST anomalies. Model output will be extensively tested against lithofacies data and our biome determinations derived from the floral data. The temporal component represented by a sequence of GCM simulations will be a key advantage, since trends of climatic change are often readily discernible in the geologic record. This study should produce the most comprehensive comparisons yet made between numerical models and geologic proxy data on climate.

In the near future we hope to broaden our scope to integrate marine faunal provinces into the Permian world picture. Initial funding has been gained for joint work with Drs. T. Grunt and T. Leonova of the Palaeontological Institute, Russian Academy of Sciences, Moscow, but the topic is so vast that we need the help of others as well. The exact approach has yet to be determined, but it will certainly involve diverse animal groups in a quantitative analysis. We will try to chart the various water masses using the climate-sensitive sedments mentioned before, and we will relate the marine provinces to these categories, as well as to latitude and geography. We believe that the biome approach to classification is applicable to the oceans, but it will mean integrating across phyla and employing far more general taxonomic categories. The effort will be worthwhile simply because it will provide the geographic and climatic framework for examining evolutionary relationships of animal and plant taxa.

Paleogeographic Atlas Project References on the Permian
(In chronological order)

1990, Lottes, A.L., & D.B. Rowley, Reconstruction of the Laurasian and Gondwanan segments of Permian Pangaea. In: Palaeozoic Palaeogeography and Biogeography, W.S. McKerrow and C.R. Scotese (eds.). Geological Society of London Memoir 12: 383-395.

1990, Nie, S., D.B. Rowley, & A.M. Ziegler, Constraints on the locations of Asian micro-continents in the Palaeo-Tethys during the Late Palaeozoic. Geol. Soc. Mem. 12:397-409 (see above).

1990, Ziegler, A.M., Phytogeographic patterns and continental configurations during the Permian Period. Geol. Soc. Mem. 12: 363-379 (see above).

1991, Patzkowsky, M.E., L.H. Smith, P.J. Markwick, C.J. Engberts, & E.D. Gyllenhaal, Application of the Fujita-Ziegler paleoclimate model: Early Permian and Late Cretaceous examples. In: Fossils, Models and Climate, A.M. Ziegler (ed.). Palaeogeography, Palaeoclimatology, Palaeoecology 86: 67-86.

1993,Kutzbach, J.E., & A.M. Ziegler, Simulation of Late Permian climate and biomes with an atmosphere/ocean model: comparisons with observations. In: Palaeoclimates and Their Modeling with Special Reference to the Mesozoic Era. Philosophical Transactions of the Royal Society of London, Ser. B, 341.

1993, Ziegler, A.M., Models come in from the cold. Nature 361: 16-17.

1996, Ziegler, A.M., M.L. Hulver, & D.B. Rowley, (in press), Permian world topography and climate. In: Late Glacial and Post-Glacial Environmental Changes—Quaternary, Carboniferous-Permian and Proterozoic, I.P. Martini (ed.), New York: Oxford University Press.

1996, Rowley, D.B., A.M. Ziegler, & M.L. Hulver, Revised reconstructions of Permian paleo-continental positions and paleogeography. Abstract, 30th International Geological Congress, August 4-14, 1996, Beijing, China. 2:106.

1996, Rees, P.McA. & A.M. Ziegler, Permian floras and climate signals. Abstract, 30th IGC, 2:106 (see above).

1996, Ziegler, A.M., J.P. Trice & D.L. Parker, Climate-sensitive sediment patterns through the Permian. Abstract, 30th IGC, 2:107 (see above).

Alfred M. Ziegler and Mark T. Gibbs
Paleogeographic Atlas Project
Department of Geophysical Sciences
The University of Chicago

Fusulinid biostratigraphy and the correlation of Moscovian-Guadalupian North American, Tethyan and Boreal (Russian Platform/Uralian) standards.

By V. I. Davydov

Several suggestions regarding the Permian Global scale have been discussed recently by members of the Permian Subcommission (Jin et al.,1994; Permophiles, Nov. 1996). Compromise has provided the opportunity for progress in building such a scale. In this paper, I will demonstrate how this global time scale will be projected on the classic North American standard on the basis of fusulinid data. This will reveal certain problems and offer some resolutions.

Historically global correlation for the Upper Paleozoic was based on the concept of fusulinid genozones correspondence. In North America, as well as in the Ural Mountains - Russian Platform, Central Asia and Japan similar genozone successions were established (fig. 1). Fusulinid workers considered Late Paleozoic fusulinids to be cosmopolitan and that the genera in different regions were the same and had similar ranges. Recently, much progress has been made in the studies of fusulinid successions, but the view on generic range correspondence between different provinces still predominates.

There are two important reasons that limit the use of fusulinids in global biostratigraphic studies: provincialism in geographic distribution and homeomorphy in evolution. Fusulinids as benthic organisms show strong provincialism in distribution. Comparative analysis of fusulinid taxonomy in the Midcontinent-Andean, Boreal (or Franklinian-Uralian) and Tethyan provinces at the family and subfamily level indicate that they are relatively the same. At genus level, there are many differences with a significant increase in differentiation at the species level. For example, in the Midcontinent-Andean and Boreal provinces during the Desmonesian-Wolfcampian there are very few common species. Fusulinid species in the Tethyan and Boreal provinces during the Moscovian-Early Sakmarian are more similar but differentiation in species distribution exist. Therefore allowing for correlation of the Moscovian-Asselian in the Tethyan and Boreal provinces to be gradual, from one region to another. This can be demonstrated by comparing the Asselian fusulinid assemblages of the Canadian Arctic and South China. The two Asselian faunas are completely different and impossible to correlate, but a more precise correlation study can be conducted on a gradual basis from the S. China trough to the N. China, through Central Asia, along the Ural Mountains, to Timan and Spitsbergen and eventually to Greenland and Canadian Arctic. Correlation between the Tethyan and Boreal province based on fusulinids for the middle Sakmarian and Artinskian is more difficult because the Boreal province became isolated from the Tethyan province during the Early Sakmarian therefore the development of fusulinids in Boreal province was independent from the Tethyan fusulinids. Fusulinids in the Midcontinent-Andean province also developed independently during the Late Paleozoic, with rare influences from the Boreal (until Artinskian) and Tethyan provinces.

The fact that some important fusulinid taxonomic and systematic problems are not yet resolved results in many correlation difficulties. Miklukho-Maclay (1957) was the first to point out a high rate of fusulinid homeomorphy during their evolution, meaning that similar or identical morphological types originated from different lineages and at different times. Uniting these similar morphotypes under one name creates formal genera that have a broad stratigraphic range or diachronic correlation. One example is the *Pseudoschwagerina* genus. This genus included (by different authors and at different times): *Carbonoschwagerina* (Late Kasimovian-Gzhelian in Tethyan province), some *Triticites* (*Tr. expressus*) - (Kasimovian in Tethyan province), *Ultradaixina* and *Occidentoschwagerina* (latest Gzhelian in Tethyan and south of Boreal provinces), *Sphaeroschwagerina* (Asselian--Sakmarian in Tethys and Boreal provinces), *Zellia,* (Sakmarian - in Tethyan province), *Parazelia, and Eozellia* (Asselian), *Robustoschwagerina* (Sakmarian - Bolorian in Tethyan, only Leonardian in Midcontinent-Andean province), and *Rugososchwagerina* (Midian - Tethyan province).

Pseudoschwagerina (s. str.) in each province has a different range, for example: in the Tethyan province the range is Middle Asselian - Sakmarian, in the Boreal province the range is Middle-Upper Asselian, and in the Midcontinent-Andean province the range is Late Asselian-Artinskian. *Pseudofusulina, Parafusulina, Schwagerina, Triticites, Fusulina* and a few other genera, that are most useful in Upper Paleozoic biostratigraphy are heterogenetic and also have different ranges in each province. The information presented concludes that the same genozone successions, established in different provinces, represent a different time range for each genozone. Precise correlation can be performed only by the combination of pelagic (conodonts, ammonoids, radiolarians) and benthic fauna data on the species concept basis.

The following global fusulinid correlation chart is suggested for the Upper Carboniferous through Upper Permian (Fig. 2). The most of Desmonesian stage can be correlated with the Lower-Middle Kasimovian because of similar fusulinid genozones at the base of Missourian and Upper Kasimovian, and the discovery of Desmonesian type *Wedekindellina* and *Plectofusulina* in Lower and Middle Kasimovian of the Russian Arctic (Remizova, 1995, Davydov, 1994) and *Protriticites* in the Desmonesian of Western US (G. Wahlman, Amoco, personal comm.). Ammonoid data (Ruzhentsev, 1974) also suggested correlation of Middle Desmonesian (Wewoka Fm.) and Early Kasimovian.

Correlation of the North American stages, Missourian-Virgilian to the Russian Platform/Uralian stages, Upper Kasimovian-Gzhelian is unclear, due to an increase in provincialism. Preliminary data suggests that the Missourian stage possibly corresponds to the Upper Kasimovian and Lower Gzhelian, the Virgilian correlates to the Middle and Upper Gzhelian, and the Uppermost Gzhelian is equivalent to the lower portion of the Bersumian (Ross 1994).

The C/P boundary has been identified in Kansas on the basis of a conodont succession and is located at the base of the Bennet Shale member or the top of Glenrock Limestone member of the Red Eagle Limestone formation (Chernykh &

North America

Stage	Genozone
Ochoan	not zoned
Guadalupian	*Polydiexodina*
	large *Parafusulina*
Leonardian	small *Parafusulina*
Wolfcampian	*Pseudoschwagerina*
	Schwagerina-Triticites
Missourian	
Desmonesian	*Fusulina*
	Fusulinella
Atokan	*Profusulinella*

Urals - Russian Platform

Stage	Genozone
Tatarian	not zoned
Kazanian	
Kungurian	
Artinskian	*Parafusulina*
Sakmarian	High *Pseudofusulina*
Asselian	*Pseudoschwagerina*
	"Schwgerina" *(=Sphaeroschwagerina)*
Kasimovian	
Moscovian	*Fusulina-Fusulinella*
Bashkirian	*Profusulinella*

Central Asia

Stage	Genozone
Pamirian	*Reichelina-Codonofusiella*
Murgabian	*Yabeina*
	Neoschwagerina Polydiexidina
Darvasian	*Parafusulina, Cancellina*
Karachatyrian	*Pseudoschwagerina*
	"Schwgerina" (=Sphaeroschwagerina)
Moscovian	*Fusulina-Fusulinella*
Bashkirian	*Profusulinella*

Figure 1. Global correlation "on the basis of genozone correspondence" by Dunbar, Thompson, Miklukho-Maclay, Toiriyama, etc.

Ritter, 1994; Boardman et al., 1994). But questions still remain regarding the Asselian fusulinid assemblages in Western US, because of the different characteristics in the faunas from the Neal Ranch Fm. in West Texas and Council Grove Group of Kansas. Preliminarily it can be suggested that the Asselian is represented at the lower portion of Neal Ranch Fm. in the Glass Mountains, the upper portion of Bersum Fm in Hueco Mountains, and the middle portion of Council Grove Group of Kansas (from Bennet Shale mbr. of the Red Eagle Lms. through the Beattie Lms.). In most sections of the Western US the Asselian is absent or reduced. Fusulinids at the C/P boundary transition in Kansas and perhaps in the other regions developed without significant morphological changes. This succession should be studied in more detail before defining the precise position of the C/P boundary on the basis of fusulinid species. The important investigation on this way was done by Wilde (1984).

Precise position of the Asselian/Sakmarian boundary in North America is unclear. In the Urals, Upper Asselian and Lower Sakmarian fusulinids, as well as ammonoids developedontinuous and are closely related. Also in the Urals, this boundary is still not defined based on fossils found world-wide (e. g. conodonts, radiolarians or ammonoids). Conodont workers suggest placing the Asselian/Sakmarian boundary at the base of *Streptognathodus postfusus* (or its equivalent *S. barskovi s. str.*) zone, which perhaps coincides with the base of Shikhanian (Upper Asselian). In the Kansas section, *Sweetognathus merrilli* and *Streptognathodus barskovi (s. str.)* first appear in the Bader Limestone (Ritter, 1995; Kozur, 1995), which correlates with the base of Shikhanian and *Streptognathodus barskovi-postfusus* zone in the Urals. If so, we can conclude, that Lower-Middle Asselian of the Urals is equivalent to the Bersumian. In the Midcontinent-Andean province the Asselian may be defined by numerous inflated, big *Triticites*, developed *Leptotriticites* and *Dunbarinella*, first primitive *Pseudofusulina* and *Schwagerina* (*Schw. emaciata*, *Schw. campa* etc.)

The Sakmarian/Artinskian boundary position in the North American scale is also questionable because in the Urals the relationship between fusulinid, ammonoid and conodont zonations in the Urals are not well studied. Conodont workers have suggested to place the boundary at the base of *Sweetognathus whitei* zone, but the relationship of this zone with the Uralian stratigraphic scale and the fusulinid zonation is unclear. I suggest that the Shikhanian and Tastubian

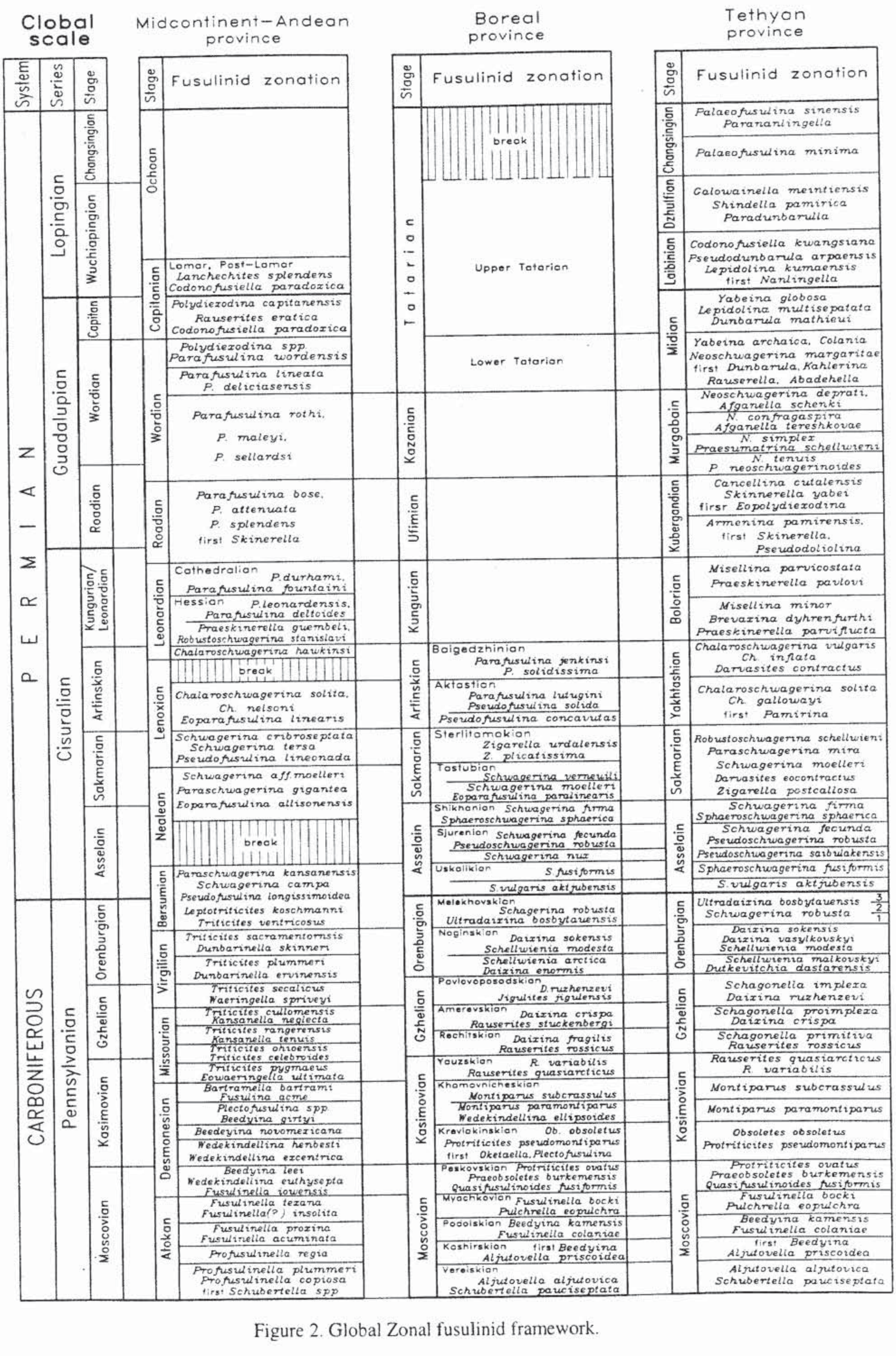


Figure 2. Global Zonal fusulinid framework.

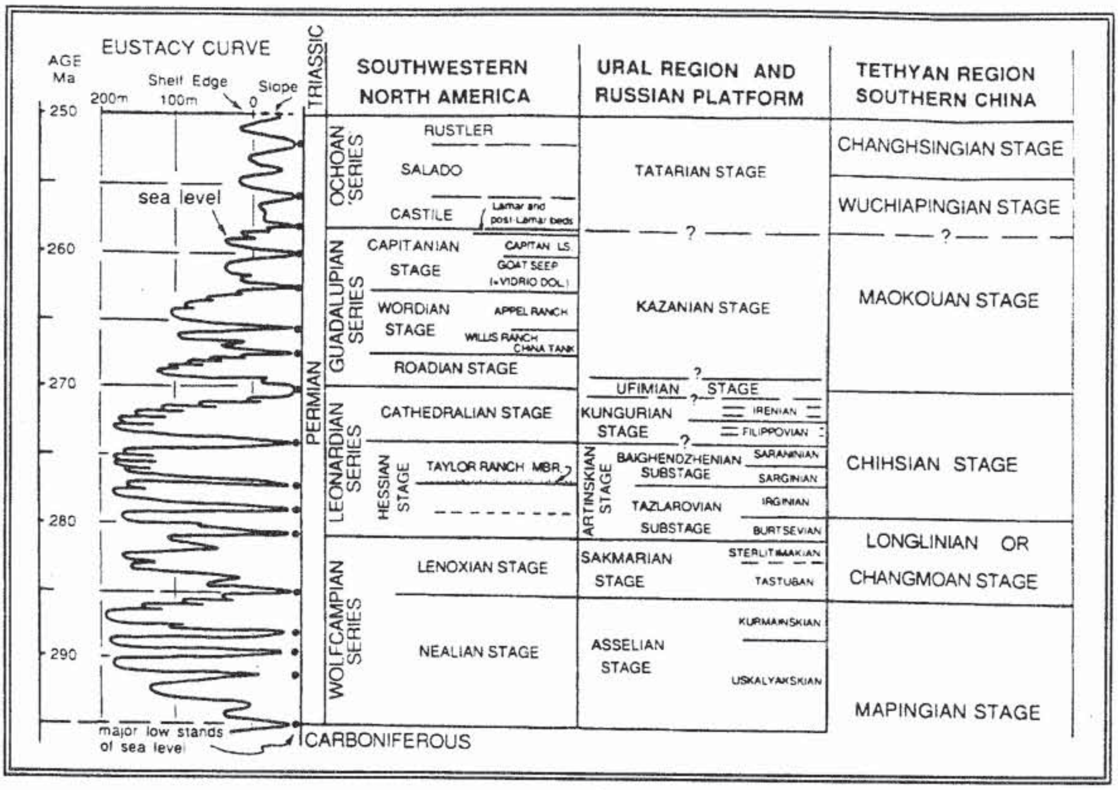


Figure 3. Permian Eustasy curve with series and stages for southwestern North America, south Urals, Russian Platform, and South China (from Ross and Ross, 1994)

substages correspond to the upper portion of Nealian, based on the first appearance of the *Eoparafusulina* and *Schwagerina moelleri* group during Late Nealian time. Conodont data and the stratigraphic position of Nealian agree with this.

The base of the Lenoxian and Sterlitamakian may coincide, because the fusulinid fauna from the lower portion of the Lenox Hill Fm. is similar to the Sterlitamakian fauna. I have studied Lower Lenoxian fusulinids from Nevada and on the basis of this material and published data I suggest to divide Lenoxian into two parts. The lower portion, characterized by *Schwagerina tersa, S. wellsensis, S. cribrosepta, S. youngquisti* corresponding to the Sterlitamakian. The upper portion of Lenoxian, from the first appearance of *Eoparafusulina linearis* and *Chalaroschwagerina* (*Ch. solita, Ch. nelsoni* group) and characterized by *Pseudofusulina huecoensis, Schwagerina aff. diversiformis, Pseudoschwagerina convexa*, correlates to the Yakhtashian, where *Chalaroschwagerina* also first appears. Ammonoid and conodont data suggest that the Yakhtashian correlates to the Artinskian (Leven et al. 1992; Kozur, 1995). So, the upper portion of Lenoxian is perhaps equivalent to the Artinskian, more precisely the lower Artinskian (Aktastian). Fusulinid characteristics and boundaries of the Artinskian equivalent in North America should be studied in detail, because the upper Lenoxian is perhaps equivalent to the Aktastian and logically the Leonardian should corresponds to the Baigedzhinian. But the conodont data near the base of Leonardian are Kungurian (Wardlaw, 1996). The Nevada fusulinid material suggests that the Baigedzhinian correlates to the break between the Lenox Hill and Skinner Range Fms. in Glass Mtns., West Texas.

The base of Leonardian should correlate to the base of Bolorian or Kungurian, because of similar fusulinid species (*Praeskinerella guembeli, P. parviflucta*) and conodonts (*Neostraptognathodus pnevi*). The base of Roadian perhaps coincides with the base of Kubergandian based on the first appearance of the fusulinid *Skinerella* and the ammonoid *Paraceltites*. Recently, in the Loudian section of South China, at the base of the Kubergandian, equivalent with Kubergandian fusulinids *Skinerella yannanica, Misellina confragaspira*, the Roadian conodont *Mesogondolella nankingensis* was identified (Leven and Kozur personal communications). The problem of Kubergandian-Roadian correlation needs to be evaluated and should be studied in more detail.

Murgabian correspondence to the Lower Wordian, is based primarily on the stratigraphic placement of the Lower Wordian between an equivalent of the Kubergandian and Lower Midian. Upper Wordian correlates with the Lower Midian, because of Wordian ammonoids and conodonts in Sicily and Wordian ammonoids in Cache Creek of British Columbia which occur together with lower Midian fusulinids (Kozur, Davydov 1996; Rui & Nassichuk, 1996).

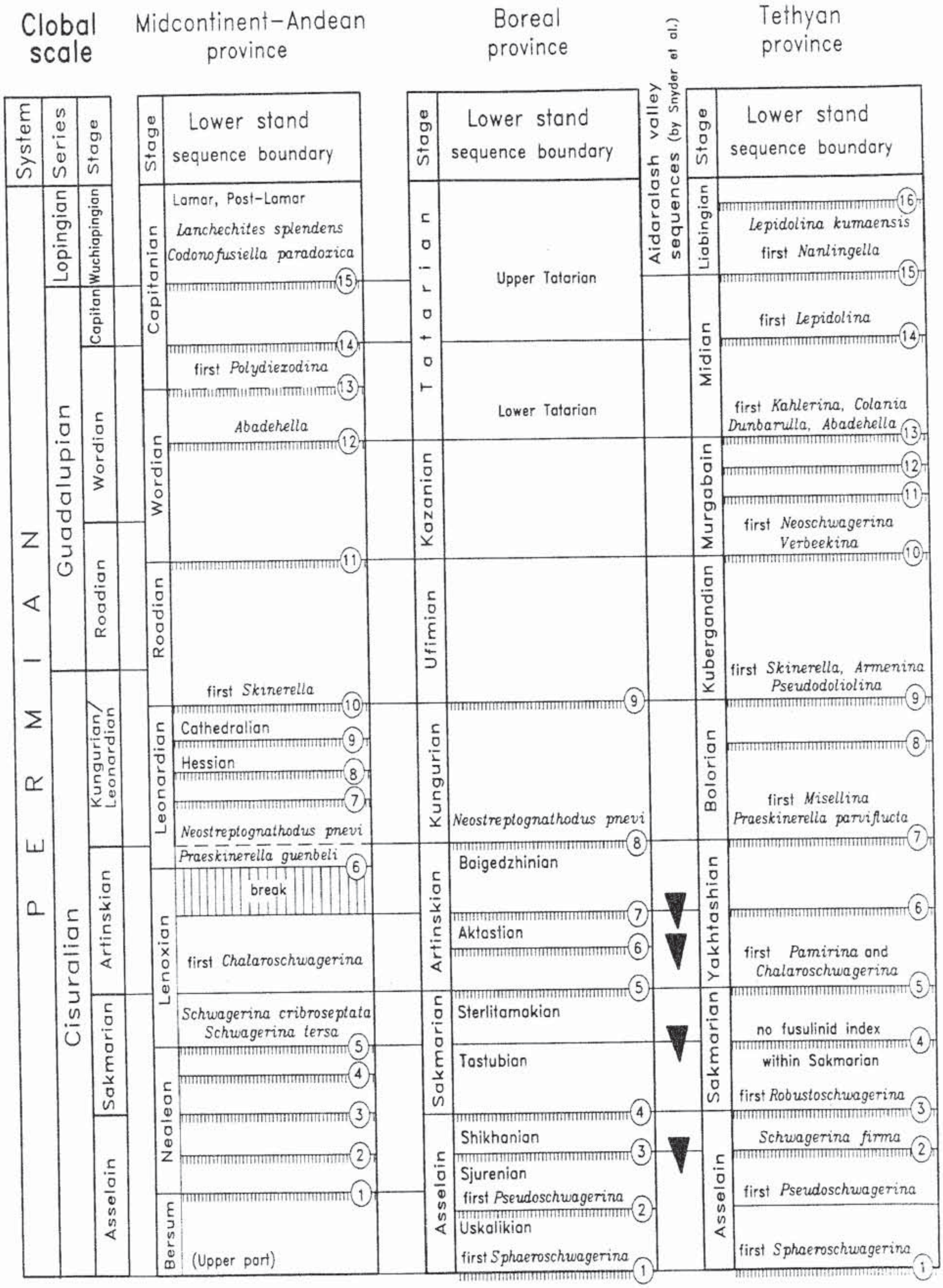


Figure 4. Correlations based on global fusulinid framework incorporating sequence lowstands according to Ross and Ross, 1994.

Lamar and post-Lamar *Lanchechites* and *Codonofusiella* fusulinids similar to the Lower Wuchiapingian or pre-Dzhulfian (new Laibinian stage), is controlled by the conodont *Jinogondolella altudaensis* (Wardlaw, 1996), but precise correlation is still needed.

The correspondence of eustatic sequence boundaries and eustatic curves in different provinces needs mentioning. Ross & Ross (1987) were the first to propose a eustatic pattern for the Late Paleozoic. This pattern serves to further developing of sequence stratigraphy concept and our knowledge. Sea level change is a global process. Ross used sequence boundaries that were established in Texas and Midcontinent and recognized them as real eustatic boundaries and applied them globally. I took Ross's data published in last Pangaea volume (Ross, 1994) and was used and numbers were placed at lowstands from the base of Permian to the top. Each of these boundaries was placed on the fusulinid correlation chart (Fig. 3).

Sequence boundaries can have different origins. They can be produced by regional tectonism, as well as by global sea level change. But even in global sea level changes sequence boundaries can have and seemingly do have different facial characteristics. The same boundary found in different regions can be characterized differently. Thus, it can be stated that sequences boundaries are not an accurate source of chronologic information. We can get this information only using biostratigraphic and radiometric methods.

In conclusion, Late Paleozoic eustatic patterns can not be established before precise global correlation is carried out and before detail sedimentological and sequences stratigraphy investigations in stratotype areas are performed. The first step in this direction includes a detail study of sequence stratigraphy in the Urals and Russian Platform. This is already being done by the Permian Research Institute (Snyder et al. in press). The sequences boundaries established in the Permian type sections of Southern Urals are marked by black triangle (Fig. 4). No sea level change at the C/P boundary transition was recognized. This contradicts Ross's conclusion that system and series boundaries, even stage boundaries, coincide with sequence boundaries. Preliminary we can estimate that the boundaries at the base of Shikhanian, base of Sterlitamakian, base of Baigedzhinian, base of Roadian, within the Wordian (base of Midian?) and at the base of Laibinian as real eustatic lowstands.

References

Boardman, D.R., Nestell, M.K., and Wardlaw, B.R. 1994. Uppermost Pennsylvanian and lowermost Permian deposits and conodont biostratigraphy of Kansas, U.S.A. Internat. Symposium on Permian Stratigr., Environm. and Resources. Abstracts and Program, Guiyang, China, p. 1-2.

Chernykh, V.V., and Ritter, S.M. 1994. Preliminary biostratigraphic assessment of conodonts from the proposed Carboniferous-Permian boundary stratotype, Aidaralash Creek, Northern Kazakhstan. Permophiles, **25**, p. 4-6.

Davydov, V.I. 1994: Fusulind biostratigraphy of the Upper Paleozoic of Kolguev Island and Franz Josef Land. - Abst. Int. Symp. Biostratigraphy of Oil-Gaz bearing Basins. St. Petersburg. p. 29 (In Russian).

Jin Yugan, Glenister, B.R., Kotlyar, G.V. and Jin-zhang, Sheng. 1994: An Operational Scheme of Permian Chronostratigraphy. Palaeoworld, v. 4, p. 1-14.

Kozur, H. 1995: Permian conodont zonation and its importance for the Permian stratigraphic Standard Scale. Geol. Paleontol. Mitt. Innsbruck, Bd. 20, s. 165-205.

Kozur, H., and Davydov, V.I. 1996: The importance of the Permian of the Sosio valley (Western Sicily, Italy) for Guadalupian stratigraphy. Abstracts and Proc. Second Internat. Guadalupian Symposium, April 10--13, 1996, Alpine Texas, p. 11-15.

Miklukho-Maclay, A.D. 1957. On fusulinid homeomorhy.-- Annual volume of Paleont. Soc. USSR, vol. 16, pp. 48-57, pl. 1-2, Nauka, Leningrad.

Remizova, S.T. 1995: Foraminifers and biostratigraphy of the Upper Carboniferous of Northern Timan. Komi Scientific Centre, Uralian branch of RAS, Syktivkar, 128 p., 16 pl. (In Russian).

Ritter, S. 1995: Upper Missourian-Lower Wolfcampian (Upper Kasimovian-Lower Asselian) conodont biostratigraphy of the Midcontinent, U.S.A. - J. Paleontol. **69** (6), pp. 1139-1154.

Ross Ch.A., 1994. The need for a Bursum stage, Uppermost Carboniferous, North America. Permophiles, No 24, pp. 3-6.

Ross, Ch.A. and J.R.P. Ross 1987. Biostratigraphic zonation of late Paleozoic depositional sequences. In: Timing and depositional history of eustatic sequences: constraints on seismic stratigraphy. Cushman Found. for Foram. Res., Spec. Publ. **24**, p. 151-168.

Ross, Ch.A. and J. R.P. Ross, 1994. Permian sequence stratigraphy and fossil zonation. In: Beauchamp, B., Embry, A., Glass, D. (eds) Pangea: Global Environments and Resources. Canadian Soc. Petrol. Geol., Mem. 17, p. 219-231.

Rui Lin, and Nassichuk, W.W. 1996: Upper Permian (Wordian) fusulinaceans from the Cache Creek Terrane, northern British Columbia. Canadian Journ. og Earth Sciences, **33** (7), p. 1022-1036.

Ruzhentsev, V.E. (1974): On Late Carboniferous ammonoids of the Russian Platform and Pre-Urals. - Paleontol. Journ., (3), p. 32-46 (In Russian).

Snyder, W.S., Spinosa, C., Davydov, V.I., Ritter, S.M., Schiappa, T., Gallegos, D.M., Schwarz, D.L. (in press): Sequence stratigraphy within the Pre--Uralian foredeep of the Southern Ural Mountains, Kazakhstan - a preliminary assessment (submitted to the American Association Petroleum Geologists Bulletin).

Wardlaw, B.R. 1996: Range charts for the Permian of West Texas. Abstracts and Proc. Second Internat. Guadalupian Symposium, April 10--13, 1996, Alpine Texas, p. 61-80

Wilde, G.L. 1984: Systematics and the Carboniferous-Permian boundary. In Sutherland, P.K., & Manger, W.L. (eds), Neuvieme Congress Internat. de Startigr. et de Geol. du Carbonifere 1979, vol. 2, IX-ICC, p. 543-558.

V. I. Davydov
VSEGEI
St. Petersburg, Russia
and
Permian Research Institute
Boise State University
Boise, Idaho, USA

Multi-Episodal Extinction and Ecological Differentiation of Permian Ammonoids

By Zuren Zhou, Brian F. Glenister, W. M. Furnish and Claude Spinosa

Introduction

Biotic changes across the Permo-Triassic boundary have been noted for over one and one-half centuries, and constitute the basis for delimitation of the Paleozoic and Mesozoic eras. However, several recent papers have suggested that a comparable mass extinction characterizes the end of the terminal Middle Permian (Guadalupian/Maokouan Series) Capitanian Stage. This "double mass extinction" has been reputed to apply to ammonoid distributions, with generic extinction rates of 94.6% and 95.2% attributed respectively to the end-Guadalupian (Maokouan) and end-Permian (Changhsingian Stage) of South China (Yang Fengqing, 1991). Data we have compiled for the forthcoming Paleozoic Ammonoid revision volume of the Treatise on Invertebrate Paleontology (Glenister et al., manuscript) confirm the mass extinction across the Erathem boundary. However, when taxonomic revisions are provided in relation to world-wide occurrences and the refined chronostratigraphic standards, the end-Capitanian extinction is recognized as comparable in intensity to those of the other Permian stage boundaries, and unlike the end-Paleozoic mass extinction. The purpose of the present report is to document the summary distribution data upon which these interpretations are based. A full analysis will be provided in a forthcoming publication.

Data Quality

Taxonomy. Evaluation of the biologic validity of the ammonoid taxonomy that we have developed cannot be pursued adequately until publication of the Paleozoic Ammonoidea Treatise revision. However, it is appropriate to note that the authors are active specialists from China and North America who have benefited from the generous advice and assistance of other ammonoid specialists, particularly those from Russia, Europe and Canada. With this collaboration, the taxonomy should be of higher quality than in previous presentations, many of which were non-specialist generalizations from the literature.

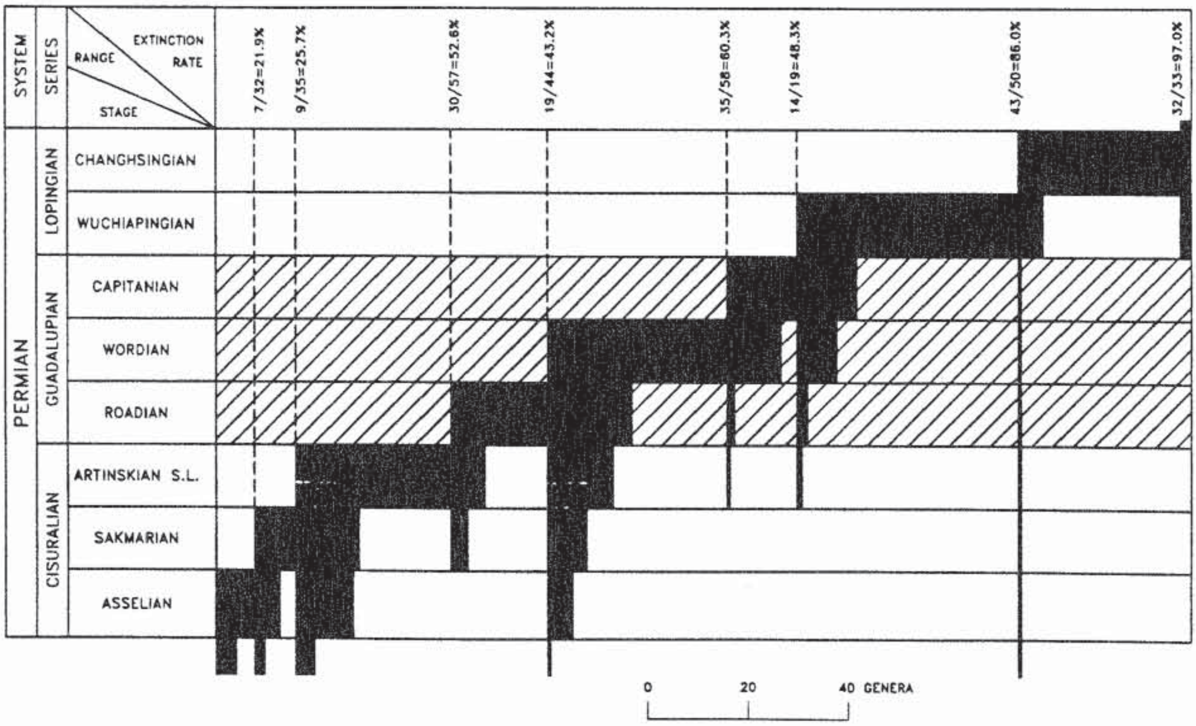


Figure 1. Geochronologic ranges and extinction rates for genera of Permian ammonoids

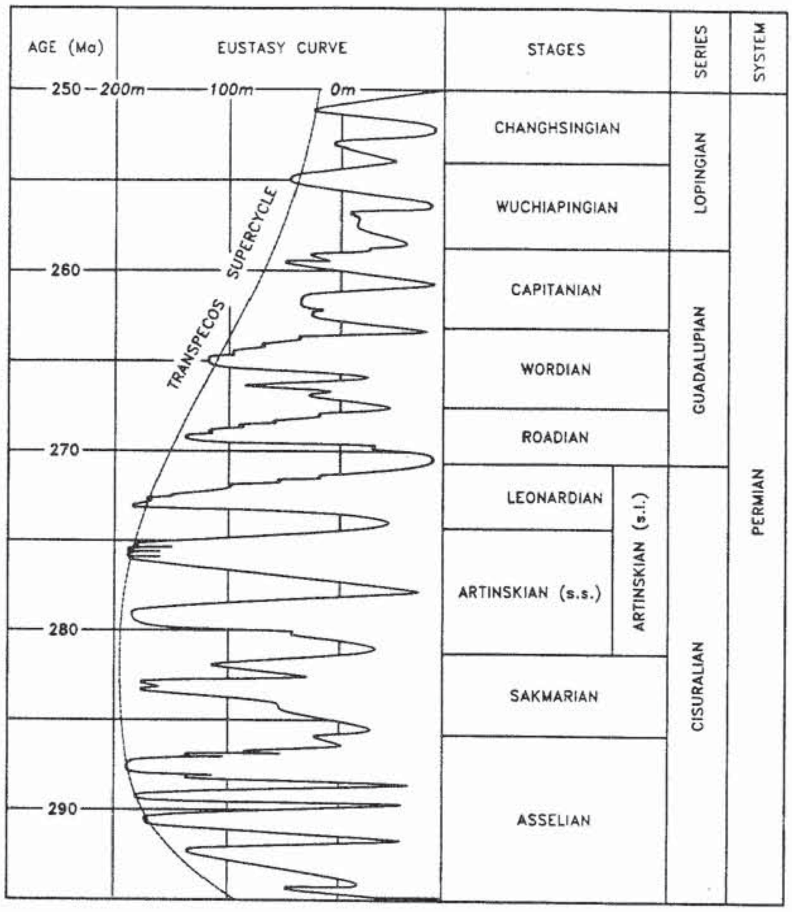


Figure 2. Eustasy curves related to international standard subdivisions of the Permian System. Overall regression that characterizes the upper part of the Transpecos Supercycle broadened restricted seas and resulted in increase in the number of short-ranging endemic ammonoid genera (modified after Ross and Ross, 1994).

Chronostratigraphy. Members of the Subcommission on Permian Stratigraphy have been aggressively involved for two decades in selection and additional study of the most promising sequences, world-wide, for standardization of the subdivisions of Permian time. Recent contributions in Permophiles, including results of formal votes of SPS Titular Members, suggest that international consensus (Fig. 1) is close to achievement. Without unnecessary digression into detailed review, two of many recent examples of inadequacy of stratigraphic control for extinction documentation can be cited: 1), use of the entire Maokouan (Guadalupian: Roadian, Wordian and Capitanian stages) interval (Yang Fengqing, 1991), and 2), adoption of the Tatarian as reference for the whole of the post-Guadalupian Lopingian Series (Stanley and Yang, 1994), comprising Wuchiapingian and Changhsingian stages.

Although the standard chronostratigraphic subdivisions that we are employing appear to be the most realistically useful choice, some limitations remain. Firstly, the duration of individual standard subdivisions of Permian time are still uncertain: only a few reliable radiometric ages ("tie points") are available for the entire System (upper and lower boundaries, plus one or two internal boundaries), and other ages are based on stratigraphic inference (Ross et al., 1994).

Consequently, duration of stages will inevitably be somewhat unequal. Additionally, the entire post-Artinskian pre-Roadian interval (Fig. 1) is considered herein as Artinskian sensu lato, based on inadequacy of the Kungurian stratotype and the general similarity of Kungurian ammonoids to those of the Artinskian sensu stricto.

Geographic Coverage. Mass extinctions such as that at the Erathem boundary are by definition global in extent. In compiling our ammonoid distributions (Tab. 2), we have utilized all available lines of biostratigraphic as well as non-biologic evidence to afford precise world-wide chronostratigraphic correlation of different ecologic provinces. Reliance on a single area, such as South China (Yang Fengqing, 1991) invites misinterpretation of regional extinction as equivalent to the mass extinction phenomenon that characterizes the end of the Permian.

Table 1. Taxonomy and geochronologic ranges of Permian ammonoid taxa (sources: Glenister, Furnish, and Zhou, ms.; Zhao, Liang, and Zheng, 1978; Zhao and Zheng, 1977; Ruzhentsev, 1959, 1962, 1963; Spinosa et al., 1970, 1975; Boardman et al., 1994).

Superfamily-Prolecanitaceae	Tournaisian-?Griesbachian
Family Daraelitidae	Viséan-Wordian
Daraelites=Prodaraelites	Asselian-Wordian
Boesites	Namurian/Morrowan-Sakmarian
Superfamily Medlicottiaceae	Viséan-Griesbachian
Family Pronoritidae	Viséan-Wuchiapingian
Subfamily Pronoritinae	Viséan-Artinskian
Metapronorites	Atokan/Moscovian-Artinskian
Subfamily Neopronoritinae	Virgilian/Gzhelian-Artinskian
Neopronorites=Epipronorites	Virgilian/Gzhelian-Artinskian
Paedopronorites	Wuchiapingian
Parapronorites	Artinskian-Wordian
Sakmarites	Asselian-Artinskian
Shikhanites	Asselian
Family Sundaitidae	Wuchiapingian
Sundaites	Wuchiapingian
Family Medlicottiidae	Virgilian/Gzhelian-Griesbachian
Subfamily Medlicottiinae	Virgilian/Gzhelian-Wuchiapingian
Medlicottia?=Prosicanites	Sakmarian-Wordian
Artinskia=Promedlicottia=Prosicanites	Virgilian/Gzhelian-Artinskian
Eumedlicottia	Artinskian-Wuchiapingian
Neogeoceras	Wordian-Wuchiapingian
Syrdenites	Capitanian-Wuchiapingian
Subfamily Episageceratinae	Wordian-Griesbachian
Episageceras	Wuchiapingian-Griesbachian
Nodosageceras	Wuchiapingian
Subfamily Propinacoceratinae=Miklukhoceratinae=Darvasiceratidae	Assel.-Wuchiap.
Propinacoceras	Artinskian-Wordian
Akmilleria	Asselian-Artinskian
Bamyaniceras	Artinskian-Wordian
Darvasiceras	Artinskian
Difuntites	Capitanian-Wuchiapingian
Miklukhoceras	Artinskian
Subfamily Sicanitinae	Asselian-Wordian
Sicanites	Asselian-Wordian
Artioceras	Artinskian
Artioceratoides	?Artinskian
Synartinskia=Parasicanites	Sakmarian-Roadian
Subfamily Uddenitinae	Desmoinesian/Moscovian-Artinskian
Daixites	Gzhelian-Sakmarian
Neouddenites	Artinskian
Superfamily Xenodiscaceae	Roadian-Changhsingian
Family Paraceltitidae	Roadian-Wuchiapingian
Paraceltites	Roadian-?Wuchiapingian
Cibolites=Xenodiscites	Wordian-Wuchiapingian
Nielsenoceras	?Wordian-Capitanian
Kingoceras	Capitanian-Wuchiapingian
Doulingoceras	Wuchiapingian
Family Xenodiscidae	Capitanian-Changhsingian
Xenaspis	Capitanian
Xenodiscus	Wuchiapingian-Changhsingian
Phisonites	Changhsingian
Iranites	Changhsingian
Shevyrevites	Changhsingian
Family Dzhulfitidae	Changhsingian
Dzhulfites	Changhsingian
Paratirolites	Changhsingian
Abichites	Changhsingian

Family Huananoceratidae	Wuchiapingian-Changhsingian
Huananoceras	Wuchiapingian-Changhsingian
Family Liuchengoceratidae	Changhsingian
Liuchengoceras	Changhsingian
Rongjiangoceras	Changhsingian
Family Tapashanitidae	Changhsingian
Tapashanites	Changhsingian
Sinoceltites	Changhsingian
Pseudostephanites	Changhsingian
Mingyuexiaceras	Changhsingian
Family Pseudotirolitidae	Changhsingian
Pseudotirolites	Changhsingian
Chaotianoceras	Changhsingian
Schizoloboceras	Changhsingian
Dushanoceras	Changhsingian
Pachydiscoceras	Changhsingian
Trigonogastrites	Changhsingian
Pernodoceras	Changhsingian
Family Pleuronodoceratidae	Changhsingian
Pleuronodoceras	Changhsingian
Longmenshanoceras	Changhsingian
Qianjiangoceras	Changhsingian
Rotodiscoceras	Changhsingian
Pentagonoceras	Changhsingian
Superfamily Otocerataceae	Wuchiapingian-Lower Triassic
Family Anderssonoceratidae	Wuchiapingian
Subfamily Anderssonoceratinae	Wuchiapingian
Anderssonoceras	Wuchiapingian
Xiangulingites	Wuchiapingian
Pericarinoceras	Wuchiapingian
Pachyrotoceras	Wuchiapingian
Subfamily Planodiscoceratinae	Wuchiapingian
Planodiscoceras	Wuchiapingian
Leptogyroceras	Wuchiapingian
Fengchengoceras	Wuchiapingian
Lenticoceltites	Wuchiapingian
Family Araxoceratidae	Wuchiapingian
Subfamily Araxoceratinae	Wuchiapingian
Araxoceras	Wuchiapingian
Eoaraxoceras	Wuchiapingian
Rotaraxoceras	Wuchiapingian
Prototoceras	Wuchiapingian
Discotoceras?	Wuchiapingian
Urartoceras	Wuchiapingian
Pseudotoceras	Wuchiapingian
Vescotoceras	Wuchiapingian
Dzhulfoceras	Wuchiapingian
Vedioceras	Wuchiapingian
Avushoceras	Wuchiapingian
Periptychoceras	Wuchiapingian
Anfuceras	Wuchiapingian
Subfamily Konglingitinae	Wuchiapingian
Konglingites	Wuchiapingian
Jinjiangoceras	Wuchiapingian
Kiangsiceras	Wuchiapingian
Sanyangites	Wuchiapingian
Superfamily Dimerocerataceae	Famennian-?Changhsingian
Family Pseudohaloritidae	Missourian/Kasimovian-Changhsingian
Subfamily Pseudohaloritinae	Artinskian
Pseudohalorites	Artinskian
Zhonglupuceras	Artinskian
Subfamily Shouchangoceratinae	Missourian/Kasimovian-Changhsingian
Shouchangoceras	Wordian-Capitanian
Aulacaganides	?Roadian
Elephantoceras	Wordian-Capitanian
Erinoceras	Wordian-Capitanian
Lianyuanoceras	Artinskian
Neoaganides	Missourian/Kasimovian-Changhsingian

Qinglongites	Changhsingian
Sangzhites	Wordian-Capitanian
Shangraoceras	Wordian-Capitanian
Sosioceras	Wordian
SubfamilyYinoceratidae	Roadian-?Wordian
Yinoceras=Shaoyangoceras	?Roadian
Lanceoloboceras	?Wordian
Superfamily Goniatitaceae	Viséan-Wordian
Family Agathiceratidae	Viséan-Wordian
Agathiceras	Moscovian-Wordian
Gaetanoceras	Artinskian
Superfamily Gonioloboceratacea	Morrowan/Westphalian-Asselian
Family Gonioloboceratidae	Westphalian-Asselian
Mescalites	?Gzhelian-Asselian
Superfamily Adrianitaceae	Desmoinesian-Wuchiapingian
Family Adrianitidae	Missourian-Wuchiapingian
Subfamily Adrianitinae	Missourian-Wuchiapingian
Adrianites	Wordian
Aricoceras	Artinskian-Wordian
Crimites	Asselian-Wordian
Doryceras	Wordian
Emilites=Plummerites	Missourian-Asselian
Epadrianites=Basleoceras	Wordian-Wuchiapingian
Neoaricoceras	Wordian
Neocrimites=Metacrimites	Artinskian-Capitanian
Palermites	Wordian
Pamiritella?=Pamirioceras	Artinskian
Pseudagathiceras	Wordian
Pseudoemilites	Artinskian(s.l.)
Sizilites	Wordian
Sosiocrimites?=Subcrimites	Wordian
Veruzhites	Artinskian(s.l.)
Subfamily Hoffmanniinae	Wordian
Hoffmannia	Wordian
Subfamily Texoceratinae	Roadian
Texoceras	Roadian
Superfamily Shumarditaceae	Moscovian-Roadian
Family Somoholitidae	Desmoinesian/Moscovian-Artinskian
Somoholites	Desmoinesian-Artinskian
Andrianovia	Asselian-Sakmarian
Neoshumardites	Artinskian
Family Perrinitidae	Asselian-Roadian
Perrinites=Perrimetanites	Artiskian-Roadian
Metaperrinites=Paraperrinites	Artinskian
Properrinites=Subperrinites	Asselian-Artinskian
Superfamily Gastrioceratacea	Chesterian/Namurian-Asselian
Family Glaphyritidae	Chesterian/Namurian -Asselian
Glaphyrites	Namurian-Asselian
Neoglaphyrites	Orenburgian-Asselian
Superfamily Cyclolobaceae	Missourian-Changhsingian
Family Cyclolobidae	Roadian-Changhsingian
Subfamily Cyclolobinae	Roadian-Changhsingian
Cyclolobus=Krafftoceras	?Wuchiapingian-Changhsingian
Changhsingoceras	Changhsingian
Demarezites	Roadian-Wordian
Kurdiceras	Wordian
Newellites	Wordian
Timorites=Hanieloceras	Capitanian-Wuchiapingian
Waagenoceras	Wordian-Capitanian
Subfamily Kufengoceratinae	Roadian-Capitanian
Shengoceras=Kufengoceras	Roadian-Capitanian
Guiyangoceras	Roadian
Liuzhouceras	Roadian-Wordian
Mexicoceras	Wordian-Capitanian
Paramexicoceras	Wordian-Capitanian
Paratongluceras=Shimenites	Roadian-Wordian
Tongluceras	Roadian

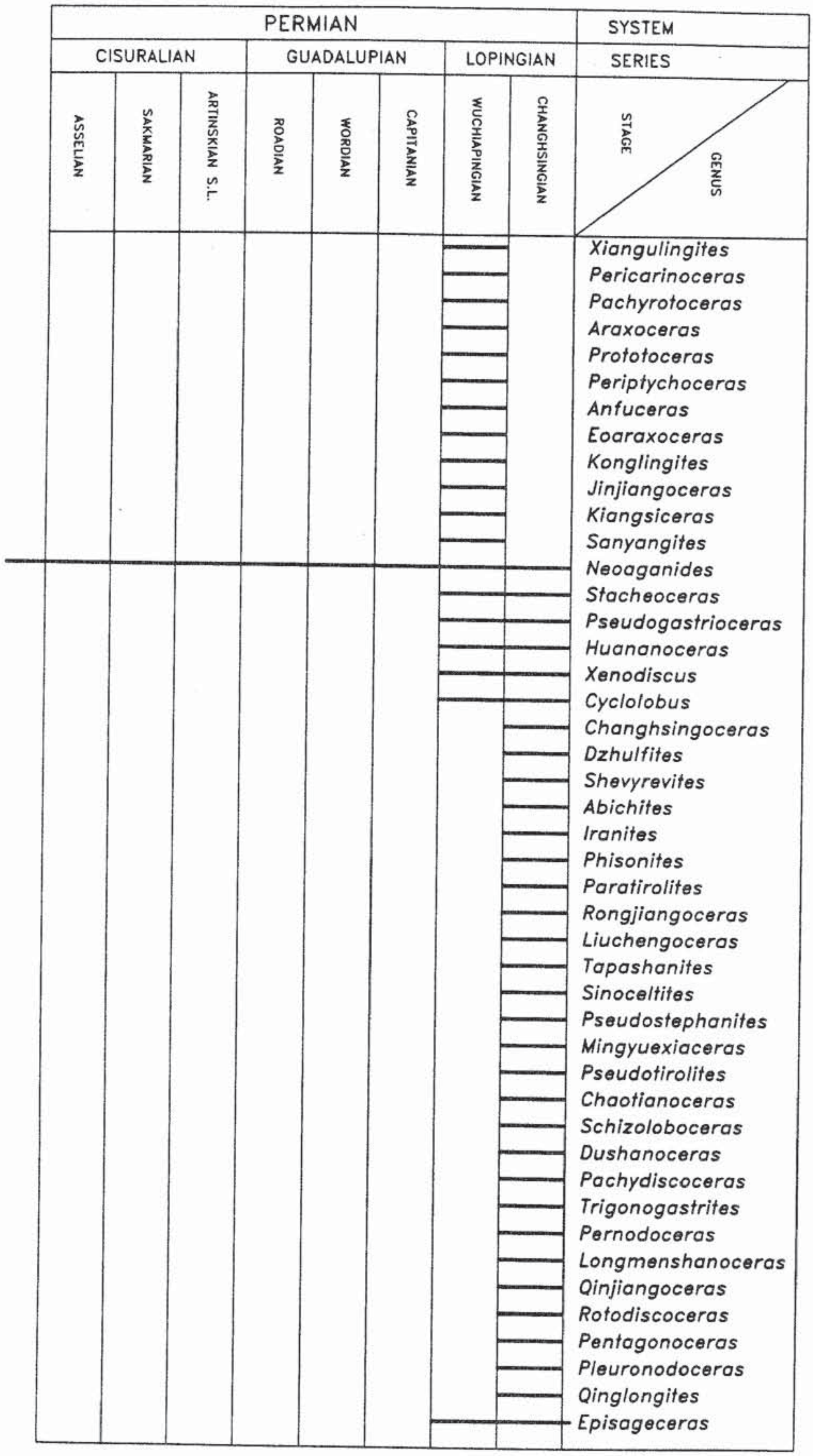
Family Vidrioceratidae	Missourian-Changhsingian
Glassoceras=Subglassoceras	Roadian
Martoceras=Pamirites=Waagenina	Asselian-Wordian
Peritrochia	Roadian
Prostacheoceras	Asselian-Wordian
Stacheoceras=Waagenia=Neostacheoceras	Artinskian-Changhsingian
Tabantalites	Asselian-Sakmarian
Superfamily Marathonitaceae	Atokan-Wordian
Family Marathonitidae	Atokan-Wordian
Almites=Neomarathonites?=Paraperrinites	Asselian-Artinskian
Cardiella	Missourian-Artinskian
Kargalites	Asselian-Artinskian
Jilingites	?Wordian
Pseudovidrioceras	Roadian-Wordian
Suakites	Artinskian
Family Hyattoceratidae	Sakmarian-Wuchiapingian
Hyattoceras=Abichia	Artinskian-Wuchiapingian
Eohyattoceras=Prohyattoceras	?Sakmarian-Roadian
Superfamily Neoicocerataceae	Moscovian/Morrowan-Changhsingian
Family Paragastrioceratidae	Asselian-Changhsingian
Subfamily Paragastrioceratinae	Asselian-Artinskian
Paragastrioceras?=Eotumaroceras=Girtyites	Asselian-Artinskian
Epijuresanites?=Bulunites	Artinskian
Svetlanoceras	Asselian-Sakmarian
Synuraloceras	Sakmarian
Tumaroceras	Artinskian
Uraloceras	Sakmarian-Artinskian
Subfamily Pseudogastrioceratinae	Sakmarian-Changhsingian
Pseudogastrioceras=Grabauites	Wuchiapingian-Changhsingian
Altudoceras=Hengshanites	Wordian-?Wuchiapingian
Aulacogastrioceras	?Roadian
Chekiangoceras	Roadian
Daubichites	Roadian
Roadoceras	Wordian-Wuchiapingian
Stenolobulites	Sakmarian-Roadian
Strigogoniatites=Retiogastrioceras?=Metagastrioceras	Wordian-Wuchiapingian
Family Metalegoceratidae	Asselian-Wordian
Subfamily Metalegoceratinae	Asselian-?Wordian
Metalegoceras	Sakmarian-?Wordian
Bransonoceras=Pericycloceras=Eolegoceras	Artinskian-?Roadian
Juresanites	Asselian- Sakmarian
Pseudoschistoceras?=Gaoyaonites	Artiskian-?Roadian
Subfamily Spirolegoceratinae	?Sakmarian-Roadian
Spirolegoceras=Gobioceras	Roadian
Sverdrupites	?Sakmarian-Roadian
Subfamily Eothinitinae	Artinskian-Wordian
Eothinites=Uralites	Artinskian
Epiglyphioceras	Wordian
Subfamily Clinolobinae	Artinskian-Wordian
Clinolobus	Artinskian-Wordian
Superfamily Popanocerataceae	Asselian-Wuchiapiangian
Family Popanoceratidae	Asselian-Wuchiapingian
Popanoceras=Pamiropopanoceras	Artinskian-Roadian
Epitauroceras	Wuchiapingian
Propopanoceras	Sakmarian
Protopopanoceras	Asselian
Tauroceras=Gemmellaroceras	Wordian
Family Mongoloceratidae	Wordian-Capitanian
Mongoloceras	Wordian-Capitanian
Angrenoceras	Capitanian
Family Thalassoceratidae	Missourian/Kasimovian-Wordian
Thalassoceras	Sakmarian-Wordian
Prothalassoceras	Missourian/Kasimovian-Sakmarian
Epithalassoceras	Wordian
Aristoceras	Missourian/Kasimovian-Asselian
Aristoceratoides	Wordian

Table 2. Geochronologic ranges of Permian ammonoid genera.

	PERMIAN								SYSTEM
	CISURALIAN			GUADALUPIAN			LOPINGIAN		SERIES
	ASSELIAN	SAKMARIAN	ARTINSKIAN S.L.	ROADIAN	WORDIAN	CAPITANIAN	WUCHIAPINGIAN	CHANGHSINGIAN	STAGE / GENUS
—	—								*Emilites*
—	—								*Glaphyrites*
—	—								*Neoglaphyrites*
—	—								*Aristoceras*
—	—								*Mescalites*
	—								*Protopopanoceras*
	—								*Shikhanites*
—	—	—							*Boesites*
—	—	—							*Daixites*
—	—	—							*Prothalassoceras*
	—	—							*Andrianovia*
	—	—							*Svetlanoceras*
	—	—							*Juresanites*
	—	—							*Tabantalites*
		—							*Propopanoceras*
		—							*Synuraloceras*
—	—	—	—						*Somoholites*
—	—	—	—						*Artinskia*
—	—	—	—						*Metapronorites*
—	—	—	—						*Neopronorites*
—	—	—	—						*Cardiella*
	—	—	—						*Akmilleria*
	—	—	—						*Paragastrioceras*
—	—	—	—						*Almites*
—	—	—	—						*Kargalites*
	—	—	—						*Sakmarites*
	—	—	—						*Properrinites*
		—	—						*Uraloceras*
			—						*Miklukhoceras*
			—						*Metaperrinites*
			—						*Darvasiceras*
			—						*Artioceras*
			—						*Neouddenites*
			—						*Pseudohalorites*
			—						*Zhonglupuceras*
			—						*Lianyuanoceras*
			—						*Epijuresanites*
			—						*Tumaroceras*
			—						*Gaetanoceras*
			—						*Eothinites*
			—						*Suakites*
			—						*Pamiritella*
			—						*Neoshumardites*
			—						*Veruzhites*
			—						*Pseudoemilites*
			—						*Artioceratoides*
		—	—	—					*Stenolobulites*
		—	—	—					*Synartinskia*
		—	—	—					*Eohyattoceras*
		—	—	—					*Sverdrupites*

PERMIAN								SYSTEM
CISURALIAN			GUADALUPIAN			LOPINGIAN		SERIES
ASSELIAN	SAKMARIAN	ARTINSKIAN S.L.	ROADIAN	WORDIAN	CAPITANIAN	WUCHIAPINGIAN	CHANGHSINGIAN	STAGE / GENUS
		X	X					*Perrinites*
		X	X					*Popanoceras*
		X	X					*Bransonoceras*
		X	X					*Pseudoschistoceras*
			X					*Aulagastrioceras*
			X					*Texoceras*
			X					*Chekiangoceras*
			X					*Daubichites*
			X					*Spirolegoceras*
			X					*Tongluceras*
			X					*Glassoceras*
			X					*Peritrochia*
			X					*Aulacaganides*
			X					*Yinoceras*
			X					*Guiyangoceras*
X	X	X	X	X				*Agathiceras*
X	X	X	X	X				*Martoceras*
X	X	X	X	X				*Daraelites*
X	X	X	X	X				*Crimites*
X	X	X	X	X				*Sicanites*
X	X	X	X	X				*Prostacheoceras*
	X	X	X	X				*Thalassoceras*
	X	X	X	X				*Medlicottia*
	X	X	X	X				*Metalegoceras*
		X	X	X				*Aricoceras*
		X	X	X				*Propinacoceras*
		X	X	X				*Parapronorites*
		X	X	X				*Clinolobus*
		X	X	X				*Bamyaniceras*
			X	X				*Demarezites*
			X	X				*Paratongluceras*
			X	X				*Liuzhouceras*
			X	X				*Pseudovidrioceras*
				X				*Kurdiceras*
				X				*Newellites*
				X				*Sosioceras*
				X				*Tauroceras*
				X				*Adrianites*
				X				*Doryceras*
				X				*Neoaricoceras*
				X				*Palermites*
				X				*Pseudagathiceras*
				X				*Sizilites*
				X				*Sosiocrimites*
				X				*Hoffmannia*
				X				*Aristoceratoides*
				X				*Epithalassoceras*
				X				*Epiglyphioceras*
				X				*Jilingites*
				X				*Lanceoloboceras*

PERMIAN								SYSTEM
CISURALIAN			GUADALUPIAN			LOPINGIAN		SERIES
ASSELIAN	SAKMARIAN	ARTINSKIAN S.L.	ROADIAN	WORDIAN	CAPITANIAN	WUCHIAPINGIAN	CHANGHSINGIAN	STAGE / GENUS
		X	X	X	X			*Neocrimites*
			X	X	X			*Shengoceras*
				X	X			*Waagenoceras*
				X	X			*Mexicoceras*
				X	X			*Shouchangoceras*
				X	X			*Elephantoceras*
				X	X			*Erinoceras*
				X	X			*Sangzhites*
				X	X			*Paramexicoceras*
				X	X			*Shangraoceras*
				X	X			*Mongoloceras*
				X	X			*Nielsenoceras*
					X			*Xenaspis*
					X			*Angrenoceras*
		X	X	X	X	X		*Hyattoceras*
		X	X	X	X	X		*Eumedlicottia*
			X	X	X	X		*Paraceltites*
				X	X	X		*Roadoceras*
				X	X	X		*Neogeoceras*
				X	X	X		*Strigogoniatites*
				X	X	X		*Epadrianites*
				X	X	X		*Cibolites*
				X	X	X		*Altudoceras*
					X	X		*Kingoceras*
					X	X		*Syrdenites*
					X	X		*Timorites*
					X	X		*Difuntites*
						X		*Sundaites*
						X		*Doulingoceras*
						X		*Paedopronorites*
						X		*Epitauroceras*
						X		*Nodosageceras*
						X		*Rotaraxoceras*
						X		*Discotoceras*
						X		*Urartoceras*
						X		*Pseudotoceras*
						X		*Vescotoceras*
						X		*Dzhulfoceras*
						X		*Vedioceras*
						X		*Avushoceras*
						X		*Planodiscoceras*
						X		*Leptogyroceras*
						X		*Fengchengoceras*
						X		*Lenticoceltites*
						X		*Anderssonoceras*


PERMIAN
SYSTEM
CISURALIAN
GUADALUPIAN
LOPINGIAN
SERIES
ASSELIAN
SAKMARIAN
ARTINSKIAN S.L.
ROADIAN
WORDIAN
CAPITANIAN
WUCHIAPINGIAN
CHANGHSINGIAN
STAGE
GENUS
Xiangulingites
Pericarinoceras
Pachyrotoceras
Araxoceras
Prototoceras
Periptychoceras
Anfuceras
Eoaraxoceras
Konglingites
Jinjiangoceras
Kiangsiceras
Sanyangites
Neoaganides
Stacheoceras
Pseudogastrioceras
Huananoceras
Xenodiscus
Cyclolobus
Changhsingoceras
Dzhulfites
Shevyrevites
Abichites
Iranites
Phisonites
Paratirolites
Rongjiangoceras
Liuchengoceras
Tapashanites
Sinoceltites
Pseudostephanites
Mingyuexiaceras
Pseudotirolites
Chaotianoceras
Schizoloboceras
Dushanoceras
Pachydiscoceras
Trigonogastrites
Pernodoceras
Longmenshanoceras
Qinjiangoceras
Rotodiscoceras
Pentagonoceras
Pleuronodoceras
Qinglongites
Episageceras

Multi-Episodal Permian Ammonoid Extinctions

Taxonomy and chronostratigraphic distribution of the 190 genera of Permian ammonoids recognized in the Treatise revision are represented in the accompanying Tables (1, 2). Generic originations and extinctions are summarized (Fig. 1), at the stage level, for the 8 primary subdivisions of the Permian System. Since mondial ranges cannot generally be refined within stage boundaries, all originations and extinctions are represented as occurring at these boundaries; consequently, the stepped occurrence pattern to some extent represents stage boundaries rather than strictly isochronous changes in distribution. Black blocks portray the ranges of genera, and the width of each is in direct proportion to the number of genera represented. Genera that became extinct in each stage are grouped into two categories. Those with relatively short ranges (no greater than one stage) are arranged on the right side of the stage-level distribution plots, whereas those with ranges of two or more stages are plotted on the left. Numbers of genera that became extinct in each stage, divided by total numbers present are expressed at the top as percentage extinction rates. The following basic characteristics of Permian ammonoid extinctions can then be recognized:

1. Extinctions were probably episodic, although this appearance of periodicity is enhanced by the practical necessity of recording ranges at stage level. However, note that Permian stage boundaries correspond approximately to major owstands of sea level (Fig. 2); this eustatic cyclicity inevitably contributed in turn to originations and extinctions.

2. Rates of extinction increased spectacularly throughout the Permian.
3. There is no global peak at the end of the Capitanian in either the absolute number of genera becoming extinct or the generic level extinction rate. In fact, rates are higher in the preceding Wordian (60%), and markedly so in the succeeding Wuchiapingian Stage (86%). No "double mass extinction" is recognizable.
4. It has been contended elsewhere (Zhou, 1986) that short-ranging genera of Permian ammonoids tend to be characterized by bizarre and diverse morphologies and occurred in ephemeral epicontinental "Restricted-Seas", whereas long-ranging genera generally displayed standardized morphology and favored "Open-Sea" environments. Increase in the number of short- ranging genera (Fig. 1) coincides with the regressive terminal phase of the Transpecos Supercycle (Ross and Ross, 1994; see Fig. 2 herein).
5. Episodes of Permian ammonoid extinction appear to coincide with regressions of the third- order eustatic cycles, whereas Carboniferous/Permian boundary originations and Permian/Triassic extinctions relate in a general way to the second order Transpecos Supercycle (Fig. 1, 2).

References

Glenister, B. F., Furnish, W. M., and Zhou Zuren, ms. Permian Ammonoidea: In, Treatise on Invertebrate Paleontology, (L) Mollusca 4, revised edition.

Ross, C, A., and Ross, J. R. P., 1994. Permian sequence stratigraphy and fossil zonation. In, Pangea: Global Environments and Resources; Canadian Society of Petroleum Geologists, Mem. 17, p. 219-231.

Ross, C. A., Baud, A., and Menning, F., 1994. A time scale for Project Pangea. In, Pangea: Global Environments and Resources; Canadian Society of Petroleum Geologists, Mem. 17, p. 81-83.

Stanley, S. M., and Yang, X., 1994. A double mass extinction at the end of the Paleozoic Era. Science, v. 266, p. 1340-1344.

Yang Fengqing, 1991. Middle Permian to Early Triassic ammonoid genera and families found in South China. In, Yang Zunyi, Wu Shunbao, Yin Hongfu, Xu Guirong, and Zhang Kexin, Geological Publishing House, Beijing, p. 111.

Zhou Zuren, 1986. Two ecological patterns of the Permian ammonoids. Scientia Sinica, Ser. B, v. 29, no. 1, p. 96-112.

Zuren Zhou
Nanjing Institute of Geology and Paleontology
Academia Sinica
Nanjing 210008, PR China

Brian F. Glenister
W. M. Furnish
Department of Geology
The University of Iowa
Iowa City, Iowa 52242, U.S.A.

Claude Spinosa
Department of Geosciences
Boise State University
Boise, Idaho 83725, U.S.A.

Late Permian fauna from the Khuff Formation, South Oman

By Lucia Angiolini, Alda Nicora, Hugo Bucher, Aymon Baud, Daniel Vachard, Jean-Pierre Platel, Jack Roger, Jean Broutin, Jean Marcoux, Alain Pillevuit, and Haroub Al Hashmi

The Huqf area is located on the southeastern margin of the Arabian Plate, in the Sultanate of Oman. Late Paleozoic rocks are well exposed along the western side of the uplifted Huqf massif (Le Metour et al., 1994).
The Late Paleozoic terranes of the Huqf area, representing a surface equivalent of adjacent subsurface reservoir, had long provided a privileged study for petroleum geologists. However the stratigraphy of the Late Paleozoic unit was chiefly established on subsurface data, which led to a 3 fold division composed of the Permo-Carboniferous Al Khlata, Gharif and Khuff Formations (Hughes-Clarke, 1988).

In the course of a 1:250.000-scale geological mapping of Oman, the BRGM geologists added a fourth unit, the Saiwan Fm., between the Al Khlata and Gharif Fms. (Dubreuilh et al., 1992).

Two stacked mega-sequences, separated by a regional unconformity, have been detected (Dubreuilh et al., 1992; Roger et al., 1992):

- the first begins with the Wesphalian to Sakmarian glacial-lacustrine deposits of the Al Khlata Fm. succeeded by the transgressive marine Saiwan Fm., Sakmarian in age according to Angiolini et al. (in press);
- the unconformable second mega-sequence consists of the fluvial terrigenous Gharif Fm., followed by the marine marly limestones of the Khuff Fm. The age of this mega-sequence spans the ?Artinskian to Early Murgabian time interval (Broutin et al., 1995). More specifically the age of the Khuff Fm. was considered Late Artinskian or in any case not younger than Early Permian by Hudson & Sudbury (1959), Archbold & Burrett (1990), Grant (1976), Shi et al. (1995). However the occurrence of Upper Permian brachiopods, conodonts (Angiolini et al., in progress) and bivalves (Dickins, in press) clearly indicates a Late Permian age and more specifically an Early Murgabian age.

The lithological succession of the Khuff Fm. begins with thin-bedded quartz sandstones interpreted as transgressive intertidal depositional environment. The succession then comprises laminated and bioturbated micritic limestones deposited below wave base followed by bioclastic marls and cross-bedded limestones suggesting deposition above wave base. The succession ends with thin-bedded sandstones, indicating intertidal deposition. The non marine Minjur Fm. of Triassic/Jurassic age rests on top of the Khuff Fm. with a marked angular unconformity.

The Khuff Fm. is very rich in brachiopods, gastropods, bivalves, conodonts, foraminifers, ammonoids, trilobites. The brachiopod fauna of the Khuff Fm., partially described as Lusaba fauna by Hudson & Sudbury (1959), consists of Perigeyerella sp., Derbyia cf. diversa Reed, 1944, Neochonetes (Sommeriella) arabicus (Hudson & Sudbury, 1959), Celebetes sp., Haydenella sp., Dyschrestia sp., Kozlowskia tescorum (Hudson & Sudbury, 1959), Juresania omanensis Hudson & Sudbury, 1959, Bilotina sp., Calliprotonia sp., Grandaurispina sp., Linoproductus aff. kaseti Grant, 1976, Magniplicatina sp., Cyclacantharia sp., Acritosia sp., Orthotichia cf. bistriata Reed, 1944, Cleiothyridina cf seriata Grant, 1976, Dielasma spp. and Hemiptychina sp.

The Khuff brachiopod fauna is thus represented by 31% of cosmopolitan genera, 44% of Tethyan genera, 12.5 % of Gondwanan genera and 12.5% of endemic genera and it can be defined as a mixed/transitional fauna (Shi et al. 1995), dominated by Tethyan genera. The brachiopods of the Khuff Fm. are very similar to those of the Amb Fm. of Salt Range (Reed, 1944) and of the Rat Buri Lmst. of S Thailand (Grant, 1976).

The conodonts of the Khuff Fm. consists of species of Hindeodus and Merrilina very similar to those of the Amb Fm. of Salt Range (Wardlaw & Pogue, 1995).

Finally the foraminifers are represented by Diplosphaerina ex gr. inaequalis (Derville, 1931), Earlandia ex gr. minor (Rauzer, 1948), Calcitornella sp., Hemigordius ex gr. permicus (Grozdilova, 1956), Nodosaria sp., Geinitzina spp., Pachyphloia robusta Miklukho-Maclay, 1954, Dentalina cf. ampullaeformis Zolotova & Shiryaeva, 1982, Rectoglandulina salebra Baryshnikov, 1982, Langella lepida Wang, 1988, Langella elongata Wang, 1988.

References

Angiolini L., Bucher H., Platel J.P., Roger J., Broutin J., Baud A., Marcoux J. and Al Hashmi H. - Early Permian (Sakmarian) brachiopods from southeastern Oman. Submitted to Geobios.

Archbold N.W. & Burret C.F. 1990 - Re-assessment of the Arabian Permian chonetid brachiopod Chonetes arabicus Hudson & Sudbury, 1959. Royal Society of Victoria Proceedings, 102, 2: 121-122.

Broutin J., Roger J., Platel J.P., Angiolini L., Baud A., Bucher, Marcoux J. & Al Hashmi H. 1995 - The Permian Pangea. Phytogeographic implications of the new paleontological discoveries in Oman (Arabian Peninsula). Comptes Rendus de l'Acad,mie des Sciences, Paris, 321, IIa: 1069-1086.

Dubreuilh J., Platel J.P., Le Metour J., Roger J., Wyns R., Bhechennech F. and Berthiaux A. 1992 - Explanatory notes to the Geological map of Khaluf, Sheet NF 40-15, scale 1:250000. Directorate General of Minerals, Oman Ministry of Petroleum and Minerals.

Grant R.E. 1976 - Permian brachiopods from southern Thailand. The Paleontological Society Memoirs, 9: 1-254.

Hudson R.G.S. & Sudbury M. 1959 - Permian Brachiopoda from south-east Arabia. Notes et memoires sur le Moyen-Orient, 7: 20-53.

Hughes-Clarke M.W. 1988 - Stratigraphy and Rock Unit Nomenclature in the oil-producing area of interior Oman. Journ. of Petroleum Geology, 11: 5-60.

Le Metour J., Bechennec F., Platel J.P. and Roger J. 1994 - Late Permian birth of the Neotethys and development of its Southern continental margin in Oman. The Middle East Petroleum Geosciences, Selected middle East apers from the Middle East Geosciences Conference, Bahrain, April, II: 643-654.

Reed F.R.C. 1944 - Brachiopods and Mollusca from the Productus Limestone of the Salt Range. Palaeontologia Indica N.S., 23, 2: 1-678.

Roger J., Chevrel S., Platel J.P., Bechennec F., Dubreuilh J., Le Metour J. & Wyns R. 1992 - Geological Map of Mafraq Sheet NF 40-11, scale 1:250.000. Directorate General of Minerals, Oman Ministry of Petroleum and Minerals.

Shi G.R., Archbold N.W. & Zhan L.P. 1995 - Distribution and characteristics of mixed (transitional) mid-Permian (Late Artinskian-Ufimian) marine faunas in Asia and their palaeogeographical implications. Palaeogeography, Palaeoclimatology, Palaeoecology, 114: 241-271.

Wardlaw B.R. & Pogue K.R. 1995 - The Permian of Pakistan. In Scholle P.A., Peryt T.M., Ulmer-Scholle D.S.: The Permian of Northern Pangea. Springer Verlag: 215-224.

Lucia Angiolini and Alda Nicora
Dip. Scienze della Terra,
Via Mangiagalli 34, Milano, Italy

Hugo Bucher
Centre des Sciences de la Terre, CNRS UMR 5565,
Universite Claude Bernard Lyon Ie
27-43 Bd. du 11 Novembre, F-69622 Villeurbanne Cedex

Aymon Baud
Muse cantonal del Geologie
UNIL-BFSH2, CH-1015 Lausanne, Switzerland

Daniel Vachard
Univ. des Sciences et Technologie de Lille
59655 Villeneuve d'Ascq, France

Jean-Pierre Platel
BRGM SGR/AQI F-33600 Pessac

Jack Roger
BRGM SGN/I2G, B.P. 6009
F-45060 Orleans Cedex 2

Jean Broutin
UPMC, Paleobotanique et Paleoecologie
12 Rue Cuvier, Paris, F-75005 France

Jean Marcoux
Universit, Denis Diderot-Paris 7 et IPGP Geologie
2 Place Jussieu, F-75251, Paris Cedex

Alain Pillevuit
Institut de Geologie, Universite de Lausanne
UNIL-BFSH2, CH-1015 Lausanne, Switzerland

Haroub Al Hashmi
Directorate of Petroleum and Minerals
Muscat, P.O. Box 551, Oman

BOOKS AND MISCELLANEOUS

Bibliography of Gondwana Palynology by Roseline H. Weiss, December 1995.

communicated by H. Wopner

A compilation of papers dealing Gondwana palynology entitled **Bibliography of Gondwana Palynology** was published late last year as number 94 in the Series of Special publications of our Cologne Institute. The bibliography covers the period from the commencement of palynological research in the last century until the beginning of 1995. It contains 3214 literature citations concerning the palaeopalynology of all former parts of the ancient Gondwanan supercontinent, as well as those related to mixed microfloral assemblages containing typical Gondwanan elements from the areas surrounding Gondwana.

The bibliography reveals that palynological work in different countries is often proceeding more or less independent of progress in other areas. The cited publications were written in 11 languages. Obviously one of the reasons for an imperfect knowledge of published information is the language barrier. A great deal of work needs to be done in order to improve international scientific communication.

For a better support of scientific study it would be advantageous to find out quickly which palynological papers have been written referring to a certain country for one ore more determined periods of time. Further having knowledge of as much as possible results of researches in different countries referring to a certain period of time is essential for solving questions of inernàtional and inter-regional correlations.

For these reasons a new type of infobase in tabulated form has been conceived and is being presently compiled. These tables will be published as a separate volume and will deliver detailed information on the geographical and sratigraphical occurrence of the palynomorphs covered by the publications included in the bibliography.

The fundamental aim for creating the infobase has been the completion of cross references to the bibliography with geographical and stratigraphical indices, so that the scientists could take advantage of the cited papers independently of their language.

Bibliography of Gondwana Palynology by Roseline H. Weiss, December 1995. Geologisches Institut der Universität zu Köln, Sonderveröffentlichung No. 94, ISSN 0069-5874, 323 pages, DM 80 (postage and bank charges not included). Inquiries should be directed to Dr. R. H. Weiss, Geologisches Institut der Universität zu Köln, Zuelpicher Str. 49a, D-50674 Koeln, Germany.

Prof. Dr. H. Wopner
Geologisches Institut
Univesität zu Köln
Köln, Germany

The Palaeozoic-Mesozoic Boundary--candidates of The Global Stratotype Section and Point (Gssp) of the Permian-Triassic Boundary

Edited by Yin Hongfu (1996)
137 pages. 13 plates

Part I - Overview
1. Global correlation and defination of the Permian-Triassic boundary (PTB) The Meishan section, Changxing County,
Part II - Zhejiang, South China
2. The Meishan section, candidate of the Global stratotype section and Point (GSSP) of Permian-Triassic Boundary (PTB)
3. The ammonoid *Hypophiceras* fauna near the Permian-Triassic boundary at Meishan section and in South China
4. Conodont sequences of the Permian-Triassic boundary strata at Meishan section, South China
5. Evolution of *Clarkina* lineage and *Isarcicella* lineage at Meishan section, South China.
6. Sequence stratigraphy near the Permian-Triassic boundary at Meishan section, South China
7. Eventostratigraphy of Permian-Triassic boundary at Meishan section, South China
Part III - The Guryul Ravine section, Kashmir
8. The Guryul Ravine section, candidate of the Global Stratotype Section and Point(GSSP) of the Permian-Triassic boundary (PTB)
Part IV - The Shangsi section, Guanyuan County, Sichuan Province, South China
9. The Shangsi section, candidate of the Global Stratotype Section and Point (GSSP) of the Permian-Triassic boundary (PTB)
Part V - The Xishan(west hills) section, Selong, Xizang(Tibet)
10. The Xishan(western hills) section, Selong, candidate of the Global Stratotype
Section and Point (GSSP) of the Permian-Triassic boundary (PTB)

Order Form
China University of Geosciences Press Yujiashan, Wuhan, Hubei Province 430074, China

I order ____ copy(copies) of the book **The Palaeozoic-Mesozoic Boundary--candidates of the Global Stratotype Section and Point (Gssp) of the Permian-Triassic Boundary** (edited by YIN Hongfu, 1996).

I attach herewith the cheque of $_______($45.00 per copy).
Name:-------------------
Address:-----------------

Yin Hongfu
School of Earth Sciences
China University of Earth Sciences
Wuhan 430074, China

**International Conference on
PERMIAN OF EASTERN TETHYS:
BIOSTRATIGRAPHY, PALAEOGEOGRAPHY AND RESOURCES**

INVITATION:
The Organising Committee cordially invites you to join your colleagues at the first international conference on **The Permian of Eastern Tethys: Biostratigraphy, Palaeogeography and Resources**, to be held at Deakin University, Melbourne, between 30 November-3 December '97.

OBJECTIVES:
In many respects, the Permian Period has been regarded as a critical turning point in geological history. Economically, the Permian System is also extremely important as it contains extensive black coals, metalliferous deposits and locally significant quantities of oil and gas. This conference is designed to improve our current understanding of the System, with particular emphasis on the Eastern Tethys region.

FOR MORE INFORMATION:
The Secretariat
PERMIAN OF EASTERN TETHYS CONFERENCE
School of Aquatic Science and Natural Resources Management
Deakin University, Rusden Campus
662 Blackburn Road
CLAYTON VIC AUSTRALIA 3168
Tel: 61 3 9244 7429
Fax: 61 3 9244 7480
Email: asnrm@deakin.edu.au

REGISTRATION, EXCURSION AND ACCOMMODATION:
Registration fee for the Conference (including abstracts volume, proceedings and morning and afternoon teas) will be $150 Australia dollars ($75 for student participants). Details of fees for field excursions and accommodation will be distributed in the second circular.

DATES TO REMEMBER:
July 1996: Release of First Circular
1 February 1997: Deadline for submission of response to first circular
15 April 1997: Release of second circular and registration form
1 July 1997: Deadline for submission of abstracts
1 August 1997: Deadline for submission of pre-registration.

FINAL NOTE

As of the preparation of this newsletter, the following SPS members have contributed to the Permophiles publication fund:

Giuseppe Cassinis
Douglas Erwin
Ernest H. Gilmour
Brian F. Glenister

Alain Izart
Norman Newell
Corrado Venturini
Gordon Wood

These were joined by eight other members who made anonymous contributions. Bruce Wardlaw will provide the postage costs. All of us are indebted for this support

---

SUBCOMMISSION ON PERMIAN STRATIGRAPHY

I would like to make a donation to offset part of the cost of publishing *Permophiles*.

I am enclosing a check or bank draft for the sum of:____________________________.

I would prefer to be______ (not to be_____) acknowledged in the next issue of *Permophiles*

Name:____

Address:____
____
____
____

Kindly make checks or drafts payable to:
Boise State University - Permophyle account and please return to:

Claude Spinosa
Permian Research Institute
Department of Geosciences
Boise State University
Boise, Idaho 83725, USA

I would be_____ (would not be________) interested in purchasing a volume containing all the back issue of *Permophiles*. Please send me additional information when it becomes available.

My institutional library would be_____ (would not be________) interested; Please send additional information to the following individual:

____
____
____
____