Permophiles

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Subcommission
on
Permian Stratigraphy

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International Commission
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International Union
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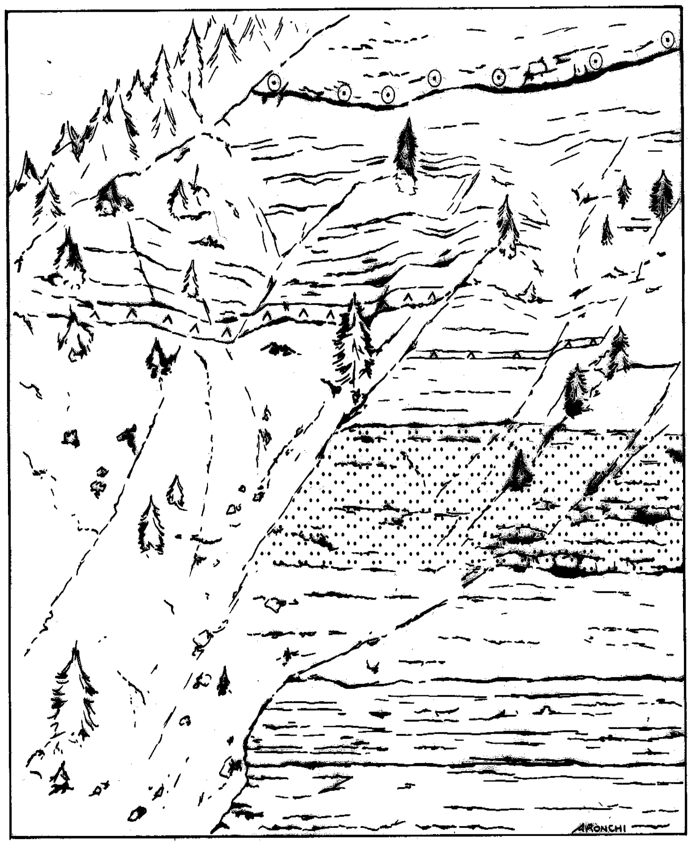
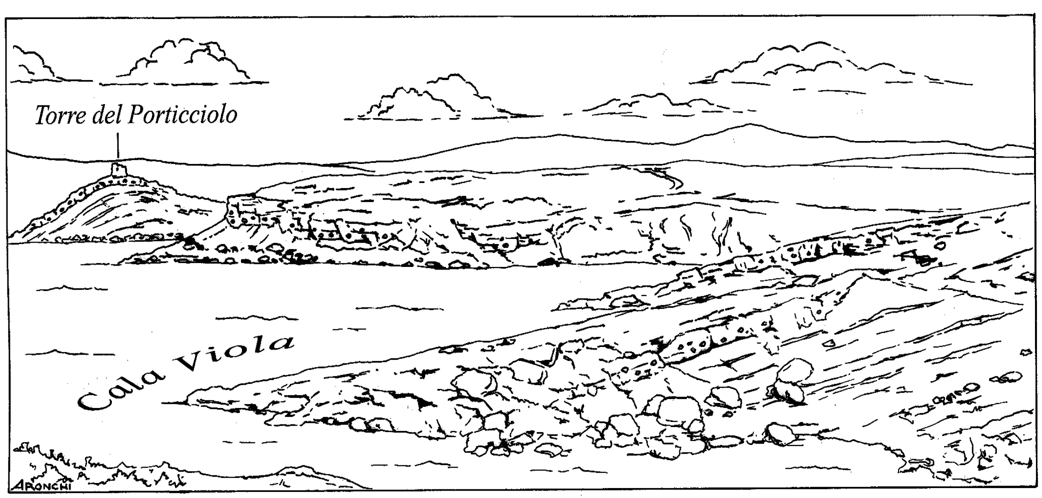
Front Cover Explanation



Upper Photo
Interfingering between Upper Permian evaporitic to shallow-marine Bellephon formation and the alluvial clastic redbeds of the Val Gardena Sandstone. The photo shows Butterloch-Bletterbach canyon, western Dolomites, Southern Alps, Italy.

1. Alternating marls and dolomite, with sandstone intercalations,
2. Dolomite with nautiloids,
3. Alternating marls and dolomite with upward-increasing sandstone contents,
4. Red and gray sandstone-siltstone with tetrapod footprints (Val Gardena Sandstone Tongue),
5. Dolomite, dolomitic limestone, and marls with gypsum. Foraminera and algae occur near the top. Total thickness of the sequence is about 100 meters.
6. Werfen Formation (Lower Triassic) represented at the base by the oolitic Tesero Member.



Lower Photo
Permian-Triassic redbed sequence in the Nurra Region, northwestern Sardinia, Italy, consisting mainly of continental alluvium. The photo shows Cala Viola-Porticciolo coastal area near Alghero where the upper units of the sequence are characterized by typically Buntsandstein Germanic facies; these extend to the Middle Triassic Muschelkalk (not shown).

EXECUTIVE NOTES

Notes from the SPS Secretary

by Claude Spinosa

I want to thank all those who contributed to the 33rd issue of Permophiles and those who assisted in its preparation. We are indebted to Bruce R. Wardlaw, Brian F. Glenister, John Utting and Vladimir Davydov for editorial contributions and to Joan White for coordinating the compilation of this issue. Tatyana Leonova and Natalia Esaulova provided detailed information regarding the International Symposium - Upper Permian Stratotypes of the Volga Region. The next issue of Permophiles is scheduled for June 1 1999; readers are encouraged to send contributions. These should arrive before May 15, 1999. It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to cspinosa@boisestate.edu and please note that this is a new E-mail address – once again a new address. Please see page 6 for details regarding the preferred method of submitting manuscripts.

We are indebted to the following individuals and 7 anonymous donors for contributing a total of $1250.00 to the Permophiles publication fund this year.

Lucia Angiolini, Neil Archbold, Stephen L. Benoist, Don W. Boyd, Giuseppe Cassinis, J. Filatoff, Henri Fontaine, John Groves, Tatyana Grunt, David Hawk, Igo Hisayoshi, Yin Hongfu, Gary D. Johnson, Takeshi Isibashi, Hans Kerp, Norman D. Newell, Robert Nicoll, Calvin Stevens, Greg Wahlman, Garner L. Wilde, H. G. Wopfner, Tom Yancey, Shizuo Yoshida, and Alfred M. Ziegler. We also thank Bruce Wardlaw for covering cost of mailing Permophiles.

Future SPS meetings

The next meeting of the SPS will be held in conjunction with the "XIV International Congress on Carboniferous and Permian" (XIV-ICCP) to be held in Calgary, Canada, August 17-21, 1999. A theme session will focus on Boundaries/ Chronostratigraphy of the Lower-Middle Permian"; Bruce R. Wardlaw and Brian F. Glenister are the conveners. An additional poster session is planned with the same theme. A call for abstracts has been received for the XIV – ICCP; deadline for abstracts is March 1, 1999.Additional information and details of abstract submission are available from Charles M. Henderson, Meeting Chairman, Department of Geology and Geophysics, University of Calgary. N. W., Calgary, Alberta, Canada T2N 1N4. Tel: 403-220-6170. Fax: 403-284-0074. E-mail: henderson@geo.ucalgary.ca. Persons interested in the meeting should refer to www.geo.ucalgary.ca/iccp.

Following the XIV-ICCP meeting there will be a SPS meeting in Brescia, and Sardinia, Italy in conjunction with the meeting of the "Continental Permian of the Southern Alps and Sardinia (Italy) - Regional Reports and General Correlations", September 15-21. A pre-meeting excursion (September 15-18), will examine the continental sequence in Sardinia and the post-meeting trip (September 23-25 will concentrate on the Upper Permian and Lower Triassic sequence in the Southern Alps of Italy. Abstract deadline is May 31, 1999. More information is available from Professor G. Cassinis, Dipartimento di Scienze della Terra, Universita' degli Studi, Via Ferrata No. 1, 27100 Pavia, Italy. Tel: 39 0382 505834. Fax: 39 0382 505890. E-mail: cassinis@unipv.it. The first circular has been sent out and is available at http://manhattan.unipv.it/sem_conf_new.htm. The cover of this Permophiles issue includes photographs from the sections that will be visited during these excursions.

In the year 2000, the SPS will meet in conjunction with the 31st International Geological Congress in Rio de Janeiro, Brazil, August 6-17. The SPS will sponsor the general symposium "International Standard References for the Permian System: Cisuralian of Southern Ural Mountains, Guadalupian of Southwestern North America, Lopingian of South China". Brian F. Glenister, Bruce R. Wardlaw, and Tamra A. Schiappa are the conveners. The general symposium consists of an afternoon poster session accommodating all accepted contributions followed by a morning oral session consisting of five invited keynote speakers. Information regarding the Congress and the SPS Symposium is available at the site: http://www.31igc.org or from Tamra A. Schiappa: tschiapp@boisestate.edu.

Permophiles on line

Recent issues of Permophiles are being made available, online, at the homepage of the Permian Research Institute. Select http://pri.boisestate.edu/ and then click on Subcommission on Permian Stratigraphy. At this time only Issue 29 is available, however, additional issues will be available soon. This site will provide information regarding submission of articles to Permophiles.

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Notes from the SPS Chair

by Bruce R. Wardlaw

The following is an excerpt from the Chair's formal annual report to the ICS; of the original report, the front part with a table of the current stages, officers of the Subcommission, and the full budget is deleted. The SPS spent $ 18,930 for calendar year 1998.

Extent of National/Regional/Global Support of projects.

The SPS receives strong support from Russian, Chinese, and American governments and individuals when working on the specific Series and Stages proposed in each country. In addition, the marine-terrestrial correlation activity, especially for the Upper Permian receives strong support from European countries, specifically this year from Russia for the Kazan Upper Permian Stratotypes of the Volga Region meeting and next year from Italy for the International Field Conference on the Continental Permian of the Southern Alps and Sardinia.

Interface with other International Projects.

I G C P Project 359: Correlation of Tethyan, Circum-Pacific and marginal Gondwanan Permo-Triassic.

The marine-terrestrial working group of the SPS is establishing a working relationship with the new working groups of the Subcommission on Gondwana Stratigraphy specifically, those under the umbrella of Event Stratigraphy: Floral Correlation, Faunal Correlation, and Physical Correlation with the common aim toward resolution of global correlation of late Paleozoic- early Mesozoic terrestrial and marine sequences.

Accomplishments:

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

Glenister, B F., Wardlaw, B. R., and Lambert, L. L., 1998, Guadalupian Series: International standard for Middle Permian time: Guadalupe Mountains National Park, Research and Resource Management Symposium, presentation of a permanent poster for the visitor center for the significance and establishment of the Guadalupian stratotype in Guadalupe Mountains National Park and guided field trip for National Park Service members and symposium attendees to understand the stratotype.

Supported the development of refined biostratigraphy in the southern Urals by aiding two graduate students theses: (1) The sequence stratigraphy and biostratigraphy of the Lower Permian of Aktasty Hills, Kazakhstan; (2) The refined stratigraphy and biostratigraphy of the Sakmarian at Kondurovka and Novogafarovo, Russia.

Continued Support for the Special Project "The Permian: from glaciation to global warming to mass extinction" to use detailed biostratigraphy and numerical age dates to create an initial framework for correlating and evaluating global events during the Permian. This special project will help in the development of the Permian GSSP's by providing important stratigraphic, biostratigraphic and numerical age dates to the specific subcommission working groups.

Established a new working group on critical correlations that bridge basin to basin and continent to continent to better understand the marked provincialism displayed in the Permian. This working group is being organized by Neil Archbold and G. R. Shi and is titled "Using Permian transitional biotas as gateways for global correlation."

Conducted annual business meeting at the Upper Permian Stratotypes of the Volga Region International Symposium in Kazan, Russia, July 28-August 3, 1998.

Problems encountered in year of the Report.

There were difficulties with some of the Russian corresponding members of the subcommission. The Kazanian and Tatarian stages are based on allostratigraphic units, synthems, and, as defined, these units will not serve as international stratotypes. Many of the Russian workers refuse to use the Guadalupian and Lopingian, already approved by the subcommission. The subcommission conceded that the many Russian workers would continue to use Kazanian and Tatarian but suggested that evolutionary lineages above the bounding unconformities be used to define the chronostratigraphic units and serve to refine the definition and correlation of these classic Permian sections.

Work Plan:

1999

- Sponsor and conduct annual business meeting at the Carboniferous-Permian Congress in Calgary, Canada.
- Sponsor and participate in the International Conference on Pangea and the Paleozoic-Mesozoic Transition, Wuhan, China; co-lead a field trip with past Chair Jin Yugan to the proposed stratotype of the Upper Permian, Lopingian, Series.
- Sponsor and participate in the International Field Conference on the continental Permian of the Southern Alps and Sardinia (Italy): regional reports and general correlations in Brescia, Italy.
- Compile, digitize, reprint, and distribute the second ten issues of *Permophiles.*
- Formally propose the Middle and Upper Permian Series boundary stratotypes; formally propose the constituent stages of the Lower Permian and the Upper Permian.

2000

- Conduct annual business meeting at IGC in Rio de Janeiro
- Convene the international symposium on the International Standard References for the Permian System: Cisuralian of Southern Ural Mountains, Guadalupian of Southwestern North America, Lopingian of South China, sponsored by the International Commission on Stratigraphy and the SPS.
- Have all stages in at least preliminary formal proposal process.

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Proposal of Guadalupian and Component Roadian, Wordian and Capitanian Stages as International Standards for the Middle Permian Series

by Brian F. Glenister

Introduction. An abbreviated journal proposal of the Middle Permian Guadalupian Series and component Roadian, Wordian, and Capitanian stages is being prepared for publication in Permophiles #34, and concurrent distribution to SPS Titular Members for formal vote. Qualifications of the Guadalupian as international standard references have been presented previously (Glenister et al., 1992), but the new formal proposal will add critically important new data on conodont, morphoclines, absolute dates, and paleomagnetics. The present statement is restricted to historic review of proposals of the Guadalupian and constituent stages.

Historic Preamble. Prolonged deliberation of SPS members culminated in the mandated formal postal vote by Titular (voting) Members that approved subdivision of the Permian System into three series, in ascending order Cisuralian, Guadalupian and Lopingian (Report of President Jin Yugan, Permophiles #29, p. 2). The "---usage of the Guadalupian Series and constituent stages, i.e., the Roadian, the Wordian, and the Capitanian Stage for the middle part of the Permian." was approved unanimously by 15 voting members. Proposal of the Guadalupian as a chronostratigraphic unit of series rank (Girty, 1902) predates any potential competitors by decades (Glenister et al., 1992). Of the three component stages currently recognized, the upper two (Wordian and Capitanian) enjoy comparable priority. Capitanian was first employed in a lithostratigraphic sense by Richardson (1904) for the massive reef limestones of the Guadalupe Mountains of New Mexico and West Texas, and Word was used by Udden et al. (1916) for an interbedded clastic/carbonate sequence in the adjacent Glass Mountains. Both were first used in a strictly chronostratigraphic sense by Glenister and Furnish (1961) as substages of the Guadalupian Stage, referenced by their nominal formation and recognized elsewhere through "ammonoid and fusuline faunas". In studying the Permian faunas of Arctic Canada, Nassichuk et al. (1965) concluded "--- that probably a separate stage between Artinskian and Guadalupian could be recognized." The "First limestone member" of the Word Formation, Glass Mountains, was renamed the Road Canyon Member (Cooper & Grant, 1964) and served subsequently as reference for the post-Artinskian/pre-Wordian Roadian Stage (Furnish and Glenister, 1968; Furnish and Glenister, 1970: Furnish, 1973). At the same time, Wilde and Todd (1968) suggested that the basal unit of the original Guadalupian Series, the Cutoff Formation, is correlative with the Road Canyon. Wilde (1990) subsequently placed the Roadian as the basal unit of the Guadalupian Series, a practice now favored by others. The Kubergandian of Central Asia is at least a partial correlative of the Roadian. Although Kubergandian has priority as a named stage, the Roadian "Black, thin bedded-limestone" (=Cutoff Formation) forms the original base of the Guadalupian Series (Girty, 1902).

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Wilde, G. L., and Todd, R.G., 1968, Guadalupian biostratigraphic relationships and sedimentation in the Apache Mountain region, West Texas. In B. A. Silver (Ed.), Guadalupian Facies, Apache Mountain Area, West Texas. Society of Economic Paleontologists and Mineralogists, Permian Basin Section, Publication 68-11, p. 10-31.

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SPS New Working Group: "Using Permian Transitional Biotas as Gateways For Global Correlation"

by G. R. Shi and N. W. Archbold

Introduction

At the recently held 'Upper Permian Stratotypes of the Volga Region International Symposium' (Kazan, Russia), a new SPS international working group was formally established. The new Working Group aims to investigate the significance of Permian transitional biotas as gateways for global correlation. In this context, a transitional biota is defined as "a distinct biogeographical entity characterized by an admixture of taxa found in two or more synchronous biogeographical realms or regions" (Shi et al., 1995, p. 139). More specifically, a transitional biota or zone would have the following characteristics: a moderate diversity, a predominance of wide-ranging genera, a significant portion of endemic genera, and a high level of mixed immigrant genera from adjacent realms or regions including some diagnostic elements of those realms or regions. Thus, a transitional zone or biota implies a naturally mixed fauna or flora between two or more adjacent realms or regions. This concept, as defined above, precludes confusion with tectonically displaced and mixed, or otherwise chaotic, faunal or floristic assemblages which usually occur in great disharmony with autochthonous faunas/floras. Stratigraphically mixed biotic assemblages, such as the Permian-like faunas found at the base of Triassic, are also excluded from the definition of 'transitional biotas' as defined here.

Background and objectives

As far as the Permian is concerned, several such transitional or mixed faunas have been identified. For instance, Shi et al. (1995) has recognized five transitional faunas or zones on a global scale, to which an additional fauna may now be added (see Figure attached). Because of their transitional nature, the transitional faunas should have the potential to serve as gateways to assist with the alignment of regional or provincial Permian chronostratigraphical schemes with the recent proposal of a global Permian timescale based primarily on conodonts (Jin et al., 1997). However, the potential of the transitional faunas to assist in global correlation has not been realized because many of these transitional faunas remain poorly studied. This has hindered the recognition of their importance in serving as gateways for global correlation. With this in mind, the new Working Group intends:

1. To progressively and systematically document the Permian transitional biotas;
2. To investigate the spatio-temporal distribution of the Permian transitional biotas;
3. To investigate the origin of the Permian transitional faunas in relation to contemporaneous climatic conditions, palaeogeography and/or tectonic constraints;

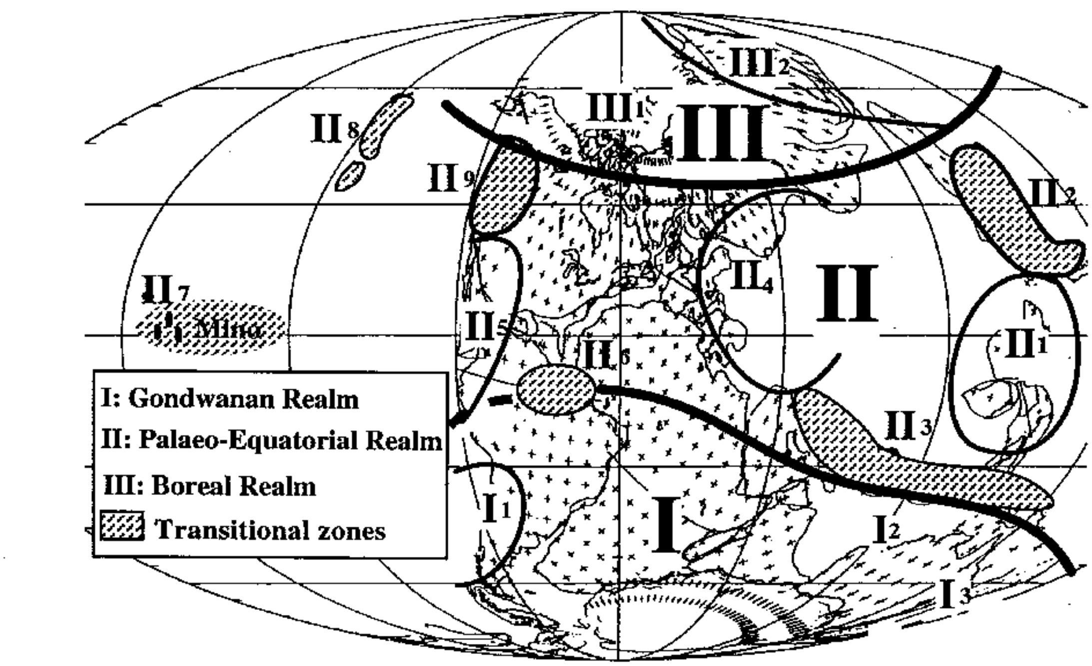

Figure 1. Generalized framework of Permian global marine biogeography and the distribution of Permian transitional faunas/provinces referred to in the text (based on Shi 1995; Shi, 1995 and Grunt and Shi, 1997). The addition of the Mino transitional/mixed fauna to the framework is based on Tazawa, 1997. The Permian marine biotic provinces/regions are as follows: I_1, Paratinan Province, I_2, Westralian Province, I_3, Austrazean Province, II_1, Cathaysian Province, II_2, Sino-Mongolian Province, II_3, Cimmerian Region (containing Sibumasu and other provinces), II_4, Mediterranean Region (with several provinces), II_5, Texas Province, II_6, Amazonian Province, II_7, Mino Province, II_8, McCloud Province, II_9, Cordilleran Province, III_1, Euro-Canadian Region, III_2, Taimyr-Kolyma Region. *[Please note that the references provided herein are not meant to be exhaustive, nor do we intend by any means to impose the framework to the agenda of the working group. On the contrary, we would welcome any alternative interpretations].*

4. Having achieved the above, to investigate the role of the transitional faunas in assisting with global correlations.

Provisional project plan

It is anticipated that an active international working group on the above project will soon be established. Field work by the working group is being planned at several strategically selected areas where transitional biotas have been documented/reported or are known to exist, such as the Salt Range, the Shan-Thai terrane (especially Western Yunnan), the Sino-Mongolian Province in NE China, SE Mongolia, parts of Japan and the Primorye region of the Russian Far East, and the Phosphoria Formation of western USA. In this phase of the project, particular attention will be paid to the composition and nature of association of taxonomic groups of the complete fauna (e.g., relative proportion of each fossil group in the whole fauna, abundance and diversity of key taxa). This is considered to be an important aspect of the work because it will help determine how associated taxonomic elements other than conodonts, fusulinids and/or ammonoids can assist in correlating stratotypic sequences/stages with regional or provincial stratigraphical schemes where the primary biomarkers are absent or poorly developed. Formal (in the form of international symposia) and informal gatherings of the working group and interested workers are being planned. Data and information derived from the Project will be disseminated regularly among participating members of the working group as well as to the general 'Permophiles' community, with a view to publishing a monograph towards the end of the project.

Call for participation and contribution

On behalf of the new working group, we cordially invite all interested members to join the working group. In particular, we would welcome any suggestions as to the planning and selection of target fieldwork areas and the venue for hosting international conferences (and field excursions) on topics pertinent to the themes of the project. Please pass on your contact details and/or suggestions to us at the address given below.

References

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SUBMISSION GUIDELINES FOR ISSUE 34

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to my E-mail address cspinosa@boisestate.edu. Please note that this is a new E-mail address; those who have been using my old one are asked to discard it and begin using the new address.

Manuscripts may also be sent to the address below on diskettes prepared with WordPerfect or MSWord; printed hard copies should accompany the diskettes. Word processing files should have no personalized fonts or other code. Specific and generic names should be *italicized*. Please refer to recent issues of Permophiles (numbers 30 or 31) for reference style, format, etc. Maps and other illustrations are acceptable in tif, jpeg, or bitmap format. If hard copies are sent, these must be camera-ready, i.e., clean copies, ready for publication. Typewritten contributions may be submitted by mail as clean paper copies; these must arrive well ahead of the deadline, as they require greater processing time.

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SUBMISSION DEADLINE FOR ISSUE 34 IS MAY 15, 1999.

INTERNATIONAL SYMPOSIUM
UPPER PERMIAN STRATOTYPES OF THE VOLGA REGION

Comments on the International Symposium Upper Permian Stratotypes of the Volga Region.

By Claude Spinosa

The **International Symposium Upper Permian Stratotypes of the Volga Region** was held in Kazan, Tatarstan Republic, Russia on July 28 – August 3, 1998. The meeting, consisting of oral reports, poster sessions and excursions to classic Tatarian and Kazanian strata, was hosted by the Ministers of the Republic of Tatarstan and by Kazan State University. All presentations and discussions were held on the ship "K. Tsiolkovsky" which also provided housing and meal facilities for participants in a very pleasant setting on the Volga River. On behalf of all the SPS corresponding and voting members who attended the symposium, I wish to express my appreciation to the organizing committee for an excellent, well-organized and successful meeting, and a long-awaited opportunity to visit classic Tatarian and Kazanian strata of the Volga region. An excellent summary of the purposes and results of this meeting is presented by our colleague, Dr. Natalia Esaulova in this issue. Please see page 8.

Extensive discussions took place at the "Volga Symposium" regarding the recent SPS decision to recognize a three-part subdivision of the Permian System – a Lower Permian Series, Cisuralian, (with stratotypes in the southern Urals of Russia and Kazakhstan), a Middle Permian Series, Guadalupian, (with stratotypes in the Guadalupe Mountains of the American Southwest), and an Upper Permian Series, Lopingian (with stratotypes in South China). Additionally, extensive discussions ensued regarding whether the traditional Kazanian and Tatarian stages can serve as international standards. A positive aspect of this disagreement is that absolute dates and paleomagnetic data (particularly the Illawarra Reversal) provide useful bridges. Another is the creation of a new working group on "Transitional Biotas" (see Shi and Archbold, this issue p. 5) as gateways to global correlation. Further, common ground was sought in a memorandum by Bruce R. Wardlaw (Chair, SPS), E. Leven (Vice-chair, SPS), A. Rozanov (Deputy chair, ISC), G. Kotlyar (Chair, ISCPS), and B. Burov (Deputy chair, Symposium Program Committee) recognizing the difficulty of correlation between the marine scale accepted by the SPS and the continental, Biarman and Notal areas. The general impression is that some workers will continue to use these traditional terms, whereas others insist on use of the new single international standard.

These discussions are important and the SPS agreed to publish summaries in this issue of Permophiles. Unfortunately communication between the participants and the SPS secretary has not been easy and to date we are only able to include comments by our colleagues Dr. Natalia Esaulova, Dr. E. A. Molostovsky and Dr. S. S. Lazarev (see pages 9 and 10). We have communications from our good colleagues Dr. Inna Dobruskina and Dr. Marina Durante that will be included in the next issue. The latter did not arrive in time to be included in this issue and the former presented problems that could not be resolved in time for inclusion in this issue. Both will be included in the next issue.

This is a call to all who attended the **International Symposium Upper Permian Stratotypes of the Volga Region** to send comments to be included in the next issue of Permophiles. To facilitate communication we solicit comments in either English or Russian and we plan to include those comments in both Russian and English. Please note that the deadline for the next issue is May 15.

Перевод двух последующих параграфов:

Наиболее интенсивное обсуждение было сконцентрировано на недавнем решении Международной Пермской подкомиссии о принятии трехчленного деления Пермской системы с выделением нижнепермского приуральского отдела (Cisuralian) со стратотипами на Южном Урале, среднепермского гваделупского отдела (Guadalupian) со стратотипами в Гваделупских горах, Техас, США и верхнепермского лопинского отдела (Lopingian) со стратотипами в Южном Китае. Весьма горячие дискуссии также возникли относительно предпочтительности в качестве международного стратиграфического стандарта казанского и татарского ярусов, а также относительно гваделупского отдела и его подразделений. Понимая важность подобных дискуссий Международная Пермская подкомиссия считает необходимым кратко опубликовать наиболее важные выступления в журнале «Пермофил». К сожалению коммуникационные ограничения позволили включить в этот номер журнала лишь коментарий нашего коллеги С. С.Лазарева (см. стр.36 в данном номере журнала). Нам удалось связаться с нашей уважаемой коллегой др-ром Мариной Викторовной Дуранте, но ее комментарий прибыл позже чем мы рассчитывали, когда данный номер уже был готов. Этот комментарий будет включен лишь в следующий номер (июнь, 1999) «Пермофилов».

Я как секретарь подкомиссии обращаюсь ко всем кто тем или иным обазом участвовал в международном симпозиуме «Верхнепермские стратотипы Волжского региона» с предложением присылать свои комментарии, с тем чтобы они были включены в июньский номер «Пермофилов». Для того чтобы облегчить возможность высказаться мы решили в виде исключения принимать ваши комментарии на русском также как и на английском языках. Для того чтобы избежать разночтений мы планируем помещать подобные комментарии на обоих языках. Пожалуйста отметьте для себя еще раз, что **15 мая является крайним сроком получения ваших комментариев**, для опубликования их в июньском номере.

(Translation courtesy of V. I. Davydov)

Report on the International Symposium Upper Permian Stratotypes of the Volga Region

by Natalia Esaulova

The International Symposium on the Upper Permian was held, 28 July - 3 August 1998, in Kazan, Russia. The Symposium, organized by Kazan State University in cooperation with the Ministers' Cabinet, Republic of Tatarstan, was attended by 32 international participants from Australia, Bangladesh, China, U.S.A., Germany, Israel, Italy, Poland, Saudi Arabia, and Switzerland. Sixty-one participants from Russia also attended representing Moscow, St. Petersburg, Kostroma, Siktivkar, Vorkuta, Inta, Kotelnich, Ekaterinburg, Perm, Saratov, Tomsk, and Novosibirsk. Sixty-nine participants, including members of the Organizing Committee, were from Tatarstan. Unfortunately, our pre-registered colleagues from Turkey, Vietnam, Mongolia, New Zealand, Great Britain, Hungary and Japan were unable to attend.

To accommodate Symposium activities, the following issues were published:

1. Programme of the Symposium,
2. Volume of abstracts (in Russian and English),
3. Guidebook of Geological Excursions (in Russian and English).

The following Monographs were also published:

4. Permian/Triassic Boundary in Continental Series of Eastern Europe, (246 p.),
5. Stratotypes and Reference Sections of the Kazan Region, (104 p.),
6. Stratotypes and Reference Sections of the Upper Permian in the Regions of the Volga and Kama Rivers, (300 p.),
7. Permian Algae from the Aktyuba Region, (71 p.),
8. Catalogue of Originals (Permian System), vol. 1: Catalogue of Monographic Collections of the Mineralogical Museum of the Kazan State University (61 p.),
9. Catalogue of Originals (Permian System), vol. 2: A.V. Nechaev. Upper Permian Fauna from the East European Russia (96 p.),
10. Catalogue of Originals (Permian System), vol. 3: P.I. Krotov. The Artinskian Stage (34 p.),
11. E. Sukhov. Memoirs about geologists from Kazan, (66 p.),
12. Lower/Upper Permian Boundary from the East Russian Plate, (510 p.).

These articles may be ordered from the Organizing Committee of the Symposium.

The Symposium was dedicated to a problem of studying the Ufimian, Kazanian and Tatarian of the Republic of Tatarstan. The opening and plenary meeting took place at the Kazan State University. The Symposium itself was held on board the ship "Tsiolkovsky". During the plenary meeting, participants had an opportunity to listen to seven reports from the world's leading geologists about current problems of Permian stratigraphy and possible solutions.

Fifty-three oral presentations and 53 posters of the symposium consisted of the following sections

The Upper Permian of the stratotypical region (marine Permian),
The Upper Permian of the stratotypical region (continental Permian),
The Upper Permian of the Biarmian region,
The Upper Permian of the equatorial and Natal climatic zones, and Lithology, Rhythmostratigraphy, Correlation.

Geological excursions to classic Permian sections - Ufimian, Kazanian and Tatarian stages - along the Volga and Kama rivers and the Kama region were an important part of the Symposium. Participants sampled sections for later lithological and palaeontological studies. Many were able to study monographic collections of the Kazan State University Geological Museum, and with private collections, including bryozoans, foraminifers, brachiopods, nautilids, and conodonts. Four videos (15 minutes each) were shown about geological monographic collections and Ufimian, Kazanian and Tatarian sections in more distant areas of the Volga-Ural region which could not be visited during the symposium. The films contributed substantially to understanding of the geological structure of the Volga-Ural basin.

Following the Symposium, 4 - 6 August, eleven paleontologists from Tatarstan, other regions of Russia, Australia, and Saudi Arabia participated in the colloquium on the Upper Permian macroflora of the stratotypical region. Five reports were presented; a macrofloral collection from the stratotypical region was reviewed; and the correlation of Angarian and Gondwanian Late Permian floras was considered. Monographic collections of Late Permian flora from the stratotypical region were presented at the Geological Museum.

One of the Symposium's outcomes was a memorandum that marked substantial achievements in studying the classic Upper Permian sections during the preparation of the Symposium. Conodonts and nautiloids from a number of outcrops were studied. Monographic investigations of ostracods, bivalves, small foraminifers, bryozoans, fish, brachiopods, macroflora, and miospores were carried out; world-famed collections of A.V. Nechaev and P.I. Krotov were revised. Palaeomagnetic investigations of the Kazan State University were highly estimated. The section of the Monastirsky Ravine (Tetyushi village) was recommended to be a Kiama/Illawarra reference boundary (Kiama/Illawarra contact was first revealed in Australia). Newest and most complete edition of a series of scientific monographs (including English version) on the Upper Permian stratotypes of the Volga-Ural basin should be considered a most important result of the Symposium.

Participation by stratigraphy leaders permitted us to organize meetings of 1) Regional Stratigraphic Committee on the central and southeast European Platform, 2) Inter-department Stratigraphic Committee of Russia, 3) International Subcommission on the Continental Permian, and 4) Subcommission on Permian Stratigraphy. The meetings resulted in the decisions about: 1. retaining till the year 2000 (Geological Congress in Brazil) the two parallel scales (Boreal East European and Tethyan complex that includes Ural, American, Chinese sections); 2. necessity for drawing a zonal Upper Permian scale on all the groups of flora and fauna within the Volga-Urals basin; 3. necessity for special thematic collections of ammonoids, a group of paramount importance; 4. necessity for works on chemostratigraphy, sequence stratigraphy, absolute dating of the levels (points) of global correlation; 5. presentations of acquired material at international geological symposia and congresses in 1998, 1999 and 2000; 6. organization of an international group, consisting of USA, Chinese, Australian and Tatarstan representatives to work on the global correlation of the two parallel scales.

The Symposium has confirmed the global importance of the classic Permian stratotypes, their correlative potential, and a need for the stratotypes to be studied using up-to-date techniques. Such studies must be conducted by leading specialists from both Russia and other countries.

The Symposium has brought many field and research geologists, postgraduate researches and students to actively participate and receive good training through listening to the reports, discussions, and field excursions throughout the Republic of Tatarstan.

The Organizing Committee is wholeheartedly thankful to those who made this Symposium possible and contributed to its success.

Scientific Secretary of the
Organizing Committee of the Symposium
Prof. Natalia Esaulova

Decision of the RAS Scientific Council for Geomagnetism and the Council's Magnetostratigraphic Working group

The Borok Geophysical Observatory
October, 26, 1998

The joint meeting of the RAS Scientific Council for geomagnetism and its Magnetostratigraphic Working Group was attended by: Professor G.N. Petrova – Member of the RANS (the chairman of the Council), Prof. E.A. Molostovsky (the chairman of the Working Group), Prof. A.N. Khramov – Member of the RANS (the chairman of the MSK Comission on magnetostratigraphy), D.M. Pechersky – Dr. of geology, G.Z. Gurarij – Dr. of geology, V.A. Shapiro – Dr. of physics and mathematics, V.P. Scherbakov – Dr. of physics and mathematics, S.V. Shipunov – Cand. of physics and mathematics, V.M. Trubikhin – Cand. of geology, A.Yu. Guzhikov – Cand. of geology, E.I. Virina – Cand. of geology, V.E. Pavlov – Cand. of geology, A.K. Gapeyev – Cand. of chemistry, A.Yu. Kurazhkovsky – Cand. of physics and mathematics, V.A. Bolshakov – Cand. of geology.

The discussion on the principles of using paleomagnetic data and on the prospects of the method in stratigraphy has resulted in the following statements:

– Paleomagnetic information is acquiring an ever-growing importance in solving fundamental problems of modern stratigraphy. Owing to their nature, reversal boundaries represent planetary chronostratigraphic levels that may be used for stratigraphic correlations accurate to within 10^3 years.

– Among the planetary datum points of such kind are: the boundary between the Kiama and Illawara hyperzones in the Upper Permian, the MO chron at the Barremian/Aptian boundary, the 33 chron in the Upper Cretaceous. Some promising reference points are outlined in other intervals of the scale as well.

– Some cases were revealed of defective paleomagnetic data used in producing stratigraphic constructions and of incorrect geologic interpretations of quite reliable paleomagnetic definitions. As a consequence, the method itself becomes gratuitously discredited.

The Scientific Council and the Working Group for Magnetostratigraphy has resolved:

1. To urge upon researchers the importance of producing stratigraphic constructions on the basis of paleomagnetic data obtained from the study of sound collections and necessary tests for confirming the primary nature of magnetization and for statistical analyses.
2. To regard the following as the highest priority in magnetostratigraphy: to develop the procedures for selecting and grounding the reference reversal levels and paleomagnetic stratotype sections for the subdivisions of the general stratigraphic scale and regional schemes.
3. To solve this problem, it is recommended to the Interdepartment Stratigraphic Committee of the Russian Federation to organize complex investigations of some stratigraphic and reference sections with thorough referencing of biostratigraphic and paleomagnetic boundaries.
4. The analyses of the world bank of paleomagnetic data demonstrate that the Upper Permian interval of the stratigraphic scale has been studied most completely over European Russia. The sequence of magnetozone alternations here has been traced in dozens of sections; thorough referencings of biostratigraphic and paleomagnetic boundaries have been performed. This allows to recognize the stratotype region of the Permian system as the paleomagnetic stratoregion. The section of the Monastyrskij ravine on the Volga (the Tetyushi region in Tatarstan) is proposed as the type section for the Kiama/Illawara hyperzone boundary. The section of the Tatarian stage on the Sukhona River in Vologda region is proposed as the stratotype section of the Illawara Upper Permian part.

The Chairman of the RAS Scientific
Council for Geomagnetism
Member of RANS, Prof. Petrova G.N.
The Chairman of the Working Group
for Magnetostratigraphy
Prof. Molostovsky E.A.

How to Save the Traditional Nomenclature of Upper Permian Stages?

by S. S. Lazarev

Why does the choice of the competing names of stratigraphic units in stratigraphy, opposite to the analogical procedure in biology, depend on decisions of commissions and congresses, intrigues, national interests, and at the end is decided by vote? The same question may be asked another way: why have the nomenclatural codes in biological classification become possible and work successfully, while the International Code of Stratigraphical Nomenclature is not even constructed? The answer to these questions is tightly connected with the answer to another question: why the principle of priority works successfully in biological classification, but it can not work in stratigraphical classification (and during the last years became the mere sound)?

On the definition of the term "type" in classification and typification

During the discussion of the problems mentioned above my opponents, supporters of the official stratigraphical paradigm (chronostratigraphy), refer to the special characteristics of stratigraphy and its objects. I do understand these special aspects of stratigraphy. That is why I have no intention to write the nomenclatural stratigraphical code taking the International Code of Zoological Nomenclature as a model. But I am sure, there are some general principles, invariant to specific character of any particular science, in the procedures of classification and typification, and those general problems are being solved in stratigraphy in an unusual and ugly way.

In this context one should consider the two approaches to biological classification reflected in the "typological" and "populational" understanding of types. For a typologist the type (archetype) - is a reality, and variability is an illusion; for a populationist - quite the opposite, the variability is real, and an average, typical, invariant (archetype) is always the scientific abstraction (synthesis). As far as the typologists can not connect the archetype directly with something physical, substantial, they have no problem to combine both notions within some common physical object (unit-stratotype). A good illustration for this is the question A. I .Zhamojda put for V. A. Krassilov after publication of his famous book "Evolution and Biostratigraphy": "If the nomenclatural type is necessary for typification, why not the stratotype?" (Zhamojda, 1980, p.36). During past decades this methodology, based on analogy to typology, has become useful in stratigraphic nomenclature.

I am repeating, the nomenclatural type is not the standard of substantial characteristics of the object of classification - such a condition can not be part of any classification of substantial nature, but as the standard for keeping the name only. In this sense, the stratotype as the concrete interval (and not the point!) in the concrete section is the perfect analog of the holotype in biology. However, one can speak about the perfect analogy only after the hierarchy in the procedure of typification is introduced. Remember, please, the holotype in its substantial aspect is absolutely equal as a specimen to all other specimens of this species.

The contents of the holotype (irrespective of how well preserved and studied it is) will never be sufficient for understanding the species and its boundaries with related species. Understanding of the species (or straton) and its boundaries is our synthesis not requiring such material base as any standard specimen (or section). Just this aspect was meant by O. Shindewolf and V. E. Ruzhentsev, the classic authors of populational (compositional, systemic) approach in stratigraphy, when they raised objections to understanding the stratotype as a standard of substantial characters of straton. In one sentence, their main idea was that there is not and cannot be a section that can serve as a substantial standard (archetype) of straton. Hence it follows, it is possible to allow the unit-standard only one function, the retention of the name of the straton. As such, the stratotype (like holotype) is not necessarily the best section, and its defects (always inevitable) can not justify the choice of a new stratotype.

The fundamental quality of nomenclatural type is its uniqueness, because only this peculiarity of the type guarantees unambiguous attachment of the name through any perturbations of classified objects. Therefore the use of other, secondary types (typoids), for example hypostratotypes in stratigraphy, is an atavism inherited from the typological way of thinking, abandoned in biology but still retained in stratigraphy. Now typoids in biology can serve only one purpose: this is the store (syntypes, topotypes) from which one should select a nomenclatural type if it was not indicated by the author of the taxon, or the original type was subsequently lost. In this sense, the sections in the stratotypical region play a part of syntypes and topotypes in stratigraphy.

The global stratotype section and point (GSSP) and chronostratigraphical conception

Fundamental to the chronostratigraphic approach is a concept of abstract physical time. Recently, the methods of construction of general stratigraphical notions and terms changed greatly after chronostratigraphy gradually changed the methodology (paradigm) in stratigraphy. The essence of chronostratigraphy is difficult to understand because of the complicated nature of time, one of the eternal mysteries of the human mind. Nevertheless it is very attractive for stratigraphers who are aspiring for stability and objectivity of stratigraphic boundaries.

The problem of stratigraphical boundaries in traditional stratigraphy was that contents were tied to evolutionary phenomena, one of the most convenient bases for correlation, but incapable of remaining constant and unchanged. Chronostratigraphy changed the logic of substantiation of boundaries and adopted a policy of building a temporal succession of the absolute and objective points: it is a method of GSSP. Superficially it looks logical and good: after normal (traditional) research aimed at choosing boundary-phenomenon one takes one more step, fixing a selected phenomenon and building a series of such phenomena, placing this chronostratigraphical paradigm into stratigraphy, gradually replacing the objects of classification (stratons) by standard time intervals. That is why the general notions of classification, particularly the notion "type", became superfluous in official stratigraphy. But this is not connected with the specific of stratigraphy in its traditional understanding and depends on methodology of the now ruling paradigm.

On the contrary, I am sure that concrete sections are always necessary as the base of our ideas; they are analogs of experiments in exact sciences and necessary for verification and falsification of the corresponding scientific hypotheses. In this sense reference sections are especially useful (we can not study all sections in detail). I insist on yet another thing: we can not select one of these sections as a standard for fixing a point-boundary, because this procedure is obviously a rejection of the subjective scientific idea in favor of an absolute and non-changing system of standards of time. With acceptance of the GSSP method the stratigraphical unit (straton) completely turns from the object of stratigraphical classification into a standard of the abstract time interval between two standard points.

Finally, let's return to the specific of stratigraphy. There are different specifics. The most general notions of hierarchical classification such as archetype, nomenclatural type, priority principle and (technical) problem in choice of competing names for classified objects harkens back to an atavism inherited from the last period of development of traditional stratigraphy. True classification with substantial hierarchy is disappearing, typification therefore becoming superfluous. It is not difficult to foresee the logic of this development (Lazarev, 1997, submitted in 1994), when the unit-stratotype (stratotype of interval) became superfluous (see the part "Boundary-stratotypes instead of Unit-stratotypes" in a new edition of "Guidelines...", 1997). The nomenclatural types are superfluous for this scale too because it is not a classification, but merely conventional line of the time intervals. This time line may be definite and constant if the hiatus at the selected point was not found.

Conclusion

The result of this report is short answers to the questions put at the beginning (from the last to the first). The principle of priority in stratigraphical classification will not work until one sets an absolutely impossible requirement that the type of straton should be a standard of its contents. During the last decades a three-in-one system "type-name-contents" had finally formed in stratigraphy. Separation from this system the contents, which does not need a material standard-type, would let us to "switch on" the principle of priority properly (priority of name, not of contents) and the context of a GSSP has no relationship to the notion "type of straton" nor to its name.

Introducing the jurisdiction in stratigraphical nomenclatural we will avoid a useless dispute about which sequences are the best and the best studied. The traditional names of all Permian stages must be preserved in the general scale, and their stratotypes stay in Ural region forever, if the concept of the stratigraphical classification is not mere words and if we are permophiles but not permophobes.

P.S. The retorts of Dr. B. F. Glenister at the Kazan conference did not touch the problems raised in my report: first, the notion of type in any classification, and stratigraphical classification in particular; second, methodological (philosophical) meaning of the procedure of GSSP method grounded on the understanding of time as such and not concerning the notion of type in classification nor the name of stratigraphical unit (=straton). Instead the logical harmony of GSSP procedure itself was discussed. I agree that this method is logical in many (not all) respects. But I have discussed not the "architecture" of visible part of stratigraphical "building" erected with GSSP method but methodological foundations of this "building". I hope my opponents will shift their objections just to the sphere, which was discussed in the report. Only then a hope for understanding and fruitful discussions will appear.

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REPORTS

Evolution of *Jinogondolella* and the Definition of Middle Permian Stage Boundaries

by Bruce R. Wardlaw and Lance L. Lambert

The evolution of *Jinogondolella* characterizes the Guadalupian (Middle Permian) and the first appearances of *Jinogondolella nankingensis*, *J. aserrata*, and *J. postserrata* define the component stages.

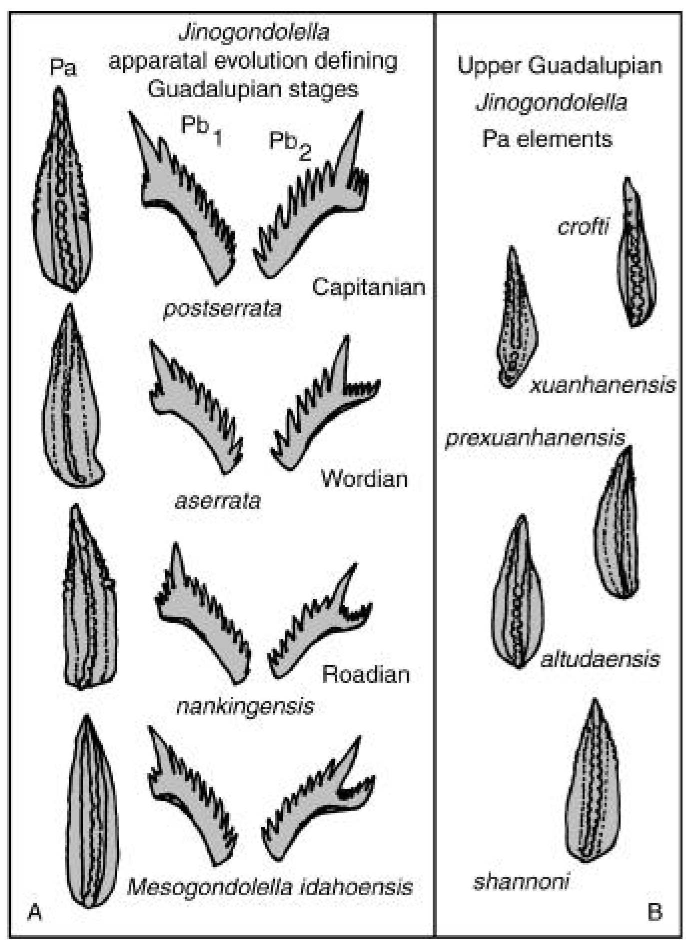
The first member of the genus, *Jinogondolella nankingensis*, evolved from *Mesogondolella idahoensis* through a transitional succession, demonstrated by the Pa element to be a mosaic paedomorphocline (Lambert and Wardlaw, 1992). Lambert (1994) and Lambert and Wardlaw (1996) documented this transitional morphocline and pointed out that *Jinogondolella aserrata* and *J. postserrata* also evolved through a transitional morphocline from their predecessors (Fig. 1a). Wardlaw (1999) has illustrated many examples of these transitional morphotypes. Adult specimens of the Pa element of *M. idahoensis* are characterized by smooth lateral margins, fused anterior most denticles, a large round, erect cusp, wide well-defined furrows, and a short, open anterior keel on the lower surface. The Pa element of *J. nankingensis* is characterized by common anterior serrated margins on a broad platform with a sharp anterior narrowing, a blunt posterior platform termination with a small cusp and discrete denticles, sharp, narrow well-defined furrows, and a well-defined anterior keel. The transitional morphotype shows progressively longer retention of lateral serrations with growth, increased tapering and narrowing of the anterior platform, narrowing of the lower attachment surface developing a more consistent elevated keel, denticles that progressively become less fused and more discrete, a cusp that subtly migrates posterolaterally and becomes less pronounced, and furrows that thin and become more shallow.

The Pa element of *Jinogondolella aserrata* is characterized by a broad platform with no sharp anterior narrowing, shallow, poorly-defined furrows, few anterior serrations along its platform margin, and a rounded posterior platform termination (typically with an inner lateral indentation). The transitional morphotype from *J. nankingensis* to *J. aserrata* displays a rounded posterior termination, intermediately developed furrows, and a moderately narrowing platform in the anterior with common margin serrations.

The Pa element of *Jinogondolella postserrata* is characterized by a relatively narrow platform with a marked anterior narrowing, sharp, well-defined furrows, common anterior serrated margins (restricted to the anteriorly narrowing part), and a relatively blunt posterior platform termination. The transitional morphotype from *J. aserrata* to *J. postserrata* displays a relatively blunt posterior termination, intermediately developed furrows, and a moderately narrowing platform in the anterior with few serrations on the margin.

The evolution of *Jinogondolella* continues through transitional morphotypes in a fairly rapid succession from *J. shannoni*, characterized by a Pa element with a broad platform, shallow, poorly-defined furrows, common anterior serrations, and a rounded posterior platform termination; to *J. altudaensis* characterized by a Pa element with a moderately broad platform, well-defined furrows, only relict to faint serrations, and an intermediate posterior termination, to *J. prexuanhanensis* characterized by a Pa element with a narrow platform, widest in its middle, tapering to both ends, common anterior serrations, followed by *J. xuanhanensis* with the reduction of the inner posterior platform and anterior serrations, and *J. crofti* with the reduction of both platform margins to an extremely thin platform and only relict serrations along the anterior portion of the platform (Fig. 1b). Through all the changes in the breadth, posterior termination, and degree of serration of the platform there is a steady increase in the elevation and length of the anterior keel on the lower surface and the development of an increasingly complex posterior loop. *Jinogondolella crofti* gave rise to *Clarkina postbitteri* through a transitional morphocline (Wardlaw and Mei, 1999), and its first appearance is proposed as the marker for the base of the overlying Upper Permian (Lopingian) Series. The first appearance of *Jinogondolella nankingensis* has been proposed as the base of the Middle Permian (Guadalupian) Series (Glenister et al., 1992). Therefore, the range of the genus *Jinogondolella* characterizes the Guadalupian.

Mesogondolella, *Jinogondolella*, and *Clarkina* have a septimembrate apparatus. Previously, Permian species of *Xaniognathus* were recognized as a separate apparatus because of the presence of two P elements, thought similar to a "nude" *Gondolella* apparatus, but distributional data strongly suggests that the *Xaniognathus* apparatus belongs to the Pa elements of *Mesogondolella*, *Jinogondolella*, and



Clarkina. Therefore, our reconstruction of the apparatus contains two types of Pb elements; one with a short generally straight posterior process and one with a longer, twisted posterior process. Carboniferous species assigned to *Mesogondolella* have a septimembrate apparatus similar to that for *Gondolella* (Von Bitter and Merrill, 1998) with one type of Pb element and two Sb elements.

Reconstruction of each species apparatus is difficult because of the heavy over- representation of Pa elements (Merrill and Powell, 1980). Our material is abundant enough to make the analysis, but on the average, for every 1,000 Pa's there are only 2-3 well preserved specimens of each of the other elements. Fortunately, we have many samples with an excess of 1,000 specimens. The Sa, Sb, Sc, and M elements are only subtly different for each species. We suspect that the length of the posterior process of the Sa and the number of denticles it bears may be significant, but this is the least preserved part of any element. The Pb's, however, show significant differences. For convention, we refer to the Pb element with a short, straight posterior process as Pb_1 (the Pa element of Permian "*Xaniognathus*") and the Pb element with a longer, twisted posterior process as Pb_2 (the Pb element of Permian "*Xaniognathus*"). The posterior process of the Pb_1 of *Mesogondolella idahoensis* bears two denticles. The posterior process of the Pb_2 is only slightly twisted laterally, is long and bears numerous denticles. The posterior process of the Pb_1 for *Jinogondolella nankingensis* bears 4 denticles. The posterior process of the Pb_2 is very twisted both laterally and vertically and bears 6-8 denticles. The posterior process of the Pb_1 of *Jinogondolella aserrata* bears 2 denticles. The posterior process of the Pb_2 is twisted laterally and bears 5 denticles. The posterior process of the Pb_1 of *Jinogondolella postserrata* bears 2 posterior denticles. The Pb_2 is slightly twisted laterally and bears 3 denticles.

In our abundant material used to study the transitional succession from *Mesogondolella idahoensis* to *Jinogondolella nankingensis*, the Pb_1 occurs with 2, 3, and 4 denticles on the posterior process; 3 being the most common number. In our abundant material of the transition succession from *Jinogondolella aserrata* to *J. postserrata*, the Pb_2 occurs with 5, 4, and 3 denticles on the posterior process; here those bearing 4 and 3 occur in about equal numbers and are more common than those with 5. So, it appears that other parts of the *Jinogondolella* apparatus reflect the transitional morphocline observed in the Pa elements. We are compiling our data of abundant yielding samples to illustrate the apparatus of the remaining species of *Jinogondolella*.

The first appearances of adult forms that retain the characteristics of the *Jinogondolella nankingensis, J. aserrata,* and *J. postserrata* in transitional evolutionary morphoclines are used to define the base of the Roadian, Wordian, and Capitanian Stages of the Guadalupian Series. Each of these appearances is documented in sections preserved in Guadalupe Mountains National Park that serve as the stratotypes. Specifically, the first appearance of *Jinogondolella nankingensis* is just below the shale break in the upper part of the limestone unit of the El Centro Member of the Cutoff Formation in Stratotype Canyon. The first appearance of *Jinogondolella aserrata* is just below the top of the Getaway Limestone Member of the Cherry Canyon Formation in Guadalupe Canyon. The first appearance of *Jinogondolella postserrata* is in the upper part of the Pinery Limestone Member of the Bell Canyon Formation at the top of Nipple Hill. All of these occurrences are within 1 m of the top of the unit or the shale break in the El Centro Member and demonstrated by tight sampling.

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The Permian Lopingian and Basal Triassic Sequence in Northwest Iran

by Walter C. Sweet and Shilong Mei

In July 1968, Curt Teichert and Bernhard Kummel spent two weeks studying Permian and Triassic rocks in the Kuh-e-Ali Bashi, a mountainous area several miles west of Julfa in northwest Iran. Their studies focused on sections at four localities, some 500 m apart and on the east side of a strike valley about 10 km due west of the town of Julfa. Stepanov, Golshani and Stocklin (1969, fig. 2) provide a sketch map depicting the general geology of the Kuh-e-Ali Bashi, and Teichert, Kummel and Sweet (1973, fig. 2) include a sketch map that provides general location of the four sections studied in 1968. We have combined information from these maps in Fig. 1 of our report.

In the autumn of 1968, Kummel shipped Sweet 47 bulk carbonate samples collected from three of the four Iranian sections studied earlier that year. Samples were accompanied by a panel diagram depicting positions in the three sections of the samples submitted. A refined version of that diagram was subsequently published as Figure 5 in the report by Teichert, Kummel and Sweet (1973), and it (Fig. 2 of the present report) and section descriptions in the 1973 report constitute all the information we have on derivation of the samples. In the Ohio State University catalog, the three Iranian localities are named 69SA, 69SB, and 69SC. Samples from those localities are identified by number, in ascending order -- for example, sample 69SA-1 is from bed 1of the Ali Bashi Fm. at Teichert, Kummel and Sweet's locality 1 (=69SA). Content of these samples is given in Table 7 of the 1973 publication and we refer to samples here by the same letter and number designations. Positions and thicknesses of beds with these numbers are shown in Fig. 2.

In late 1968 and early 1969, the Kuh-e-Ali Bashi samples were processed and found to contain ostracodes, fish plates, and well-preserved conodont elements. Conodont elements in collections from Kuh-e-Ali Bashi localities 1, 2 and 4 were subsequently described and illustrated by Sweet *(in* Teichert, Kummel and Sweet, 1973) and represent the first major late Permian conodont fauna to have been reported from anywhere in the world.

In Sweet's early reports (1973; *in* Teichert, Kummel and Sweet, 1973) on Kuh-e-Ali Bashi conodonts, segminiplanate elements, which dominate collections from all three sections, were treated as representatives of two broadly conceived species of *Neogondolella*, *N. orientalis* (Barskov and Koroleva) and *N. carinata* (Clark). A subset of quite variable elements, intermediate morphologically and stratigraphically between those typical of *N. orientalis* and *N. carinata*, were described as a subspecies of the latter, *N. carinata subcarinata* Sweet. Subsequently, extensive studies have been made of segminiplanate elements from Changhsingian (Wang and Wang, 1981; Mei, Zhang and Wardlaw, 1998) and Wuchiapingian rocks (Mei, Jin and Wardlaw, 1994a, 1994b, 1994c, 1998) in South China. In these studies, it has been discovered that consistent, very subtle, morphologic differences distinguish segminiplanate elements in stratigraphically successive collections and that these differences enable recognition of several new species and subdivision of the stratigraphic sequence into a number of zones. Species based on segminiplanate elements from Wuchiapingian rocks are described and named by Mei, Jin and Wardlaw (1994a, 1994b, 1994c, 1998) and Wardlaw and Mei are monographing the entire sequence of Lopingian forms, which they include in a single genus, *Clarkina.*

In October 1997, with specific concepts derived from South Chinese materials in mind, Mei restudied Sweet's Kuh-e-Ali Bashi collections. In collections from locality 1, he recognized representatives of all the *Clarkina* species reported from the upper Longtan Fm. and the Changxing Ls. at Meishan; and in collections from locality 4 representatives of species characteristic of all but the lowermost of the *Clarkina* -based zones reported from the Wuchiapingian in South China.

The Ali Bashi Fm. at Teichert, Kummel and Sweet's (1973) Kuh-e-Ali Bashi locality 1 and the Changxing Ls. at Meishan, South China share the same conodont succession. This confirms the correlation reached graphically by Sweet (1992) but is contrary to the one based on ammonoids by Zhao et al. (1981) or on conodonts by Wang and Wang *(in* Zhao et al., 1981), both of whom correlated the Ali Bashi Fm. of NW Iran with only the lower and middle Changhsingian. Consequently, we now conclude that an almost complete Lopingian sequence may exist in the Kuh-e-Ali Bashi region of NW Iran. The sequence of Wuchiapingian conodonts we now recognize in the section at Kuh-e-Ali Bashi locality 4 (Fig. 2) is almost the same as that in bed 5 through the upper part of bed 7 of the Hambast C section, Abadeh, central Iran, which has been regarded (Iranian-Chinese Research Group, 1995) as an important Lopingian reference section in Iran. However, only the lower part of the Changhsingian conodont sequence we recognize in the section at Kuh-e-Ali Bashi locality 1 is represented in the topmost bed of bed 7 in the Hambast C section. As a result, Lopingian sections in the Kuh-e-Ali Bashi seem currently to be the most important Lopingian reference sections in Iran.

Beds in the Permian-Triassic succession at Kuh-e-Ali Bashi locality 1 (Fig. 2) may also be correlated bed by bed with those at Meishan, Changxing, South China, and turn out to be another very important reference section for the Permian-Triassic boundary.

Sections at Kuh-e-Ali Bashi localities 1 and 4 (Fig. 2) are separated laterally by only about 500m. Beds at locality 4 were correlated by Teichert and Kummel *(in* Teichert, Kummel and Sweet, 1973) with the Ali Bashi Fm. at locality 1 and regarded as one of the two type sections for the Ali Bashi Fm., which has subsequently been assigned to the Changhsingian. Neither of the present authors has visited these sections; however, restudy of collections from them shows that conodont sequences in the two sections differ subtly in detail. The sequence at locality 4 is probably Wuchiapingian, whereas that in the Ali Bashi Fm. at locality 1 is definitely Changhsingian. Furthermore, bed 7 at locality 4, correlated by Teichert and Kummel with the *Paratirolites* Limestone, and the lowest bed sampled at locality I (69SA-0), both yielded abundant representatives of *Clarkina orientalis* (Barskov and Koroleva), the most distinctive species of *Clarkina*. Although *C. orientalis* is shown by Kozur et al. (1978) to range to the top of the *Paratirolites* Zone or equivalent beds in the Dorasham, Kuh-e-Ali Bashi, and Hambast sections, the absence of this species in the Ali Bashi Fm. at locality 1 and the abundance of its elements at the top of the section at locality 4 suggests to us that the lithic sequences at localities 1 and 4 may be the upper and lower parts, respectively, of a continuous succession, not laterally equivalent parts of the Ali Bashi Fm. Our suggestion appears to be supported by the fact that sections at localities 1 and 4 differ in thickness, lithic detail, and fossil content even though they are separated by only about 500 m. From information available to us, we are unable to explain Teichert and Kummel's probable miscorrelation of the sections at these two localities. Perhaps the beds with Wuchiapingian (or Dzhulfian) conodonts at locality 4 have been uplifted along an undetected fault so as to occupy a position that would suggest correlation with the Ali Bashi Fm.

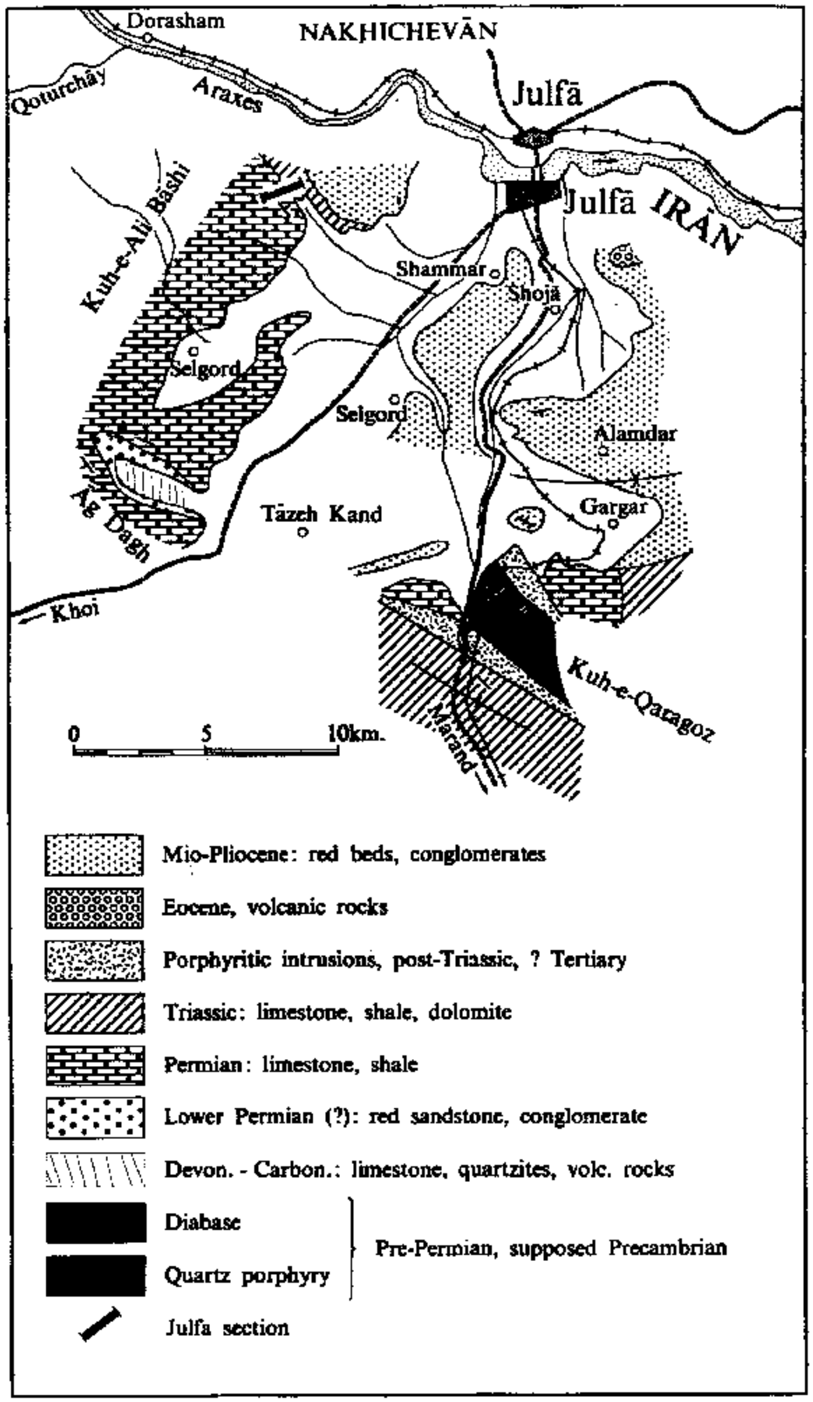

Figure 1. Sketch map of the Julfa region, northwest Iran. Bar about 10 km. W of Iranian Julfa marks approximate location of sections studied by Teichert and Kummel and considered in this report. Map adapted from Stepanov, Golshani & Stocklin, 1969.

Correlation of conodonts from Kuh-e-Ali Bashi Locality 4 with those from South China.

Segminiplanate elements in sample 69SC-1, from bed 1 at locality 4, represent *Clarkina dukouensis* Mei and Wardlaw, and *C. daxianensis* Mei and Wardlaw, and the sample also contains elements of *Hindeodus sp.* Thus, bed 1 may be correlated with the *Clarkina dukouensis* Zone of South China. Elements of *Clarkina dukouensis* occur in the basal bed of the Wuchiaping Limestone in the Nanjiang, Dukou, Penglaitan and Tieqiao sections in South China (Mei, Jin and Wardlaw, 1994b, 1994c). This species as well as *Clarkina postbitteri* Mei and Wardlaw has also been reported from the basal part of the *Araxilevis* Bed in the Hambast C section, central Iran (Iranian-Chinese Research Group, 1995). In the basinal Penglaitan and Tieqiao sections and the slope Fengshan section of central Guangxi, the *Clarkina postbitteri* Zone precedes the *Clarkina dukouensis* Zone. *C. postbitteri is* the earliest representative of *Clarkina*, a genus that typifies the Lopingian (Mei and Wardlaw, 1996). The likely transitional form between *C. postbitteri* and *Jinogondolella crofti*, has been found in the Bird Mine Section, Alpine, West Texas (Wardlaw and Mei, 1998). Thus, it would be important to make a detailed restudy of bed 1 and underlying beds at Kuh-e-Ali Bashi locality 4 to establish a candidate section for stratotype for the base of the Lopingian Series in Iran.

Segminiplanate elements from bed 2, at Kuh-e-Ali Bashi locality 4 (sample 69SC-2) represent *Clarkina asymmetrica* Mei and Wardlaw and *C. daxianensis* Mei and Wardlaw. Bed 2 thus correlates with the *C. asymmetrica* Zone in South China. Samples from beds 3 and 4 (69SC-3 and 69SC-4) were barren of conodonts. However, they may correlate with the *C. leveni* Zone in South China because overlying bed 5 (sample 69SC-5) yielded numerous elements of *C. guangyuanensis* (Dai and Zhang) and *C. liangshanensis* (Wang) and may thus represent the *C. guangyuanensis* Zone of South China. Only one sample (69SC-6) was collected from bed 6, the thickest unit in the section at locality 4, but this sample contains many elements of *C. liangshanensis* and *C. transcaucasica* Gullo and Kozur and thus may represent the *C. transcaucasica* Zone of South

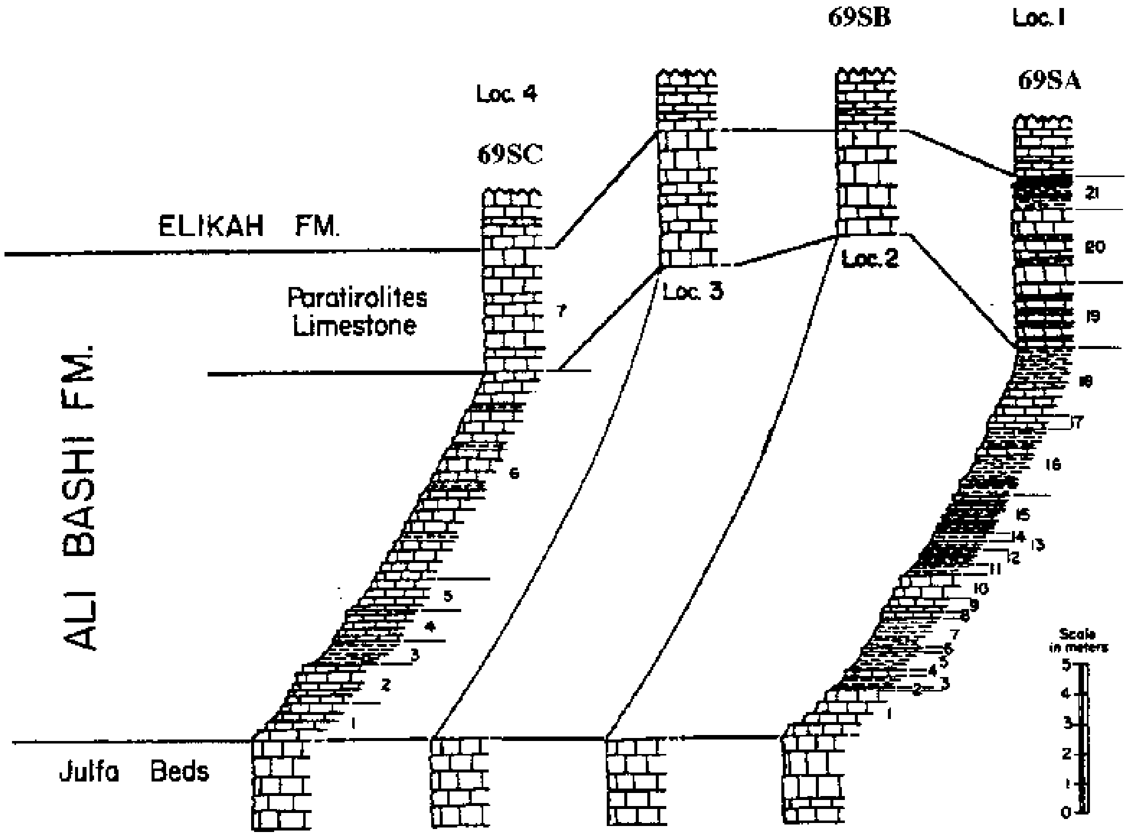

Figure 2. Permian and Triassic sections in the Kuh-e-Ali Bashi, northwest Iran, studied by Teichert and Kummel and considered in this report. Adapted from Teichert, Kummel & Sweet, 1973.

China. Bed 7 yielded abundant *C. orientalis* (Barskov and Koroleva) the defining species of the *C. orientalis* Zone *sensu* Wang and Wang (1981), or the *C. orientalis* Zone *sensu* Mei et al. (1994b) and the *C. inflecta* Zone of Mei et al. (1994b). The *C. inflecta* Zone is not represented in collections from Kuh-e-Ali Bashi locality 4, probably because of coarse sampling.

Correlation of conodonts from Kuh-e-Ali Bashi Locality 1, with those from the Meishan Section, Changxing, South China

The conodont succession in the Ali Bashi Fm. at Kuh-e-Ali Bashi locality 1 is as the same as that in the Meishan Section. The Changxing Ls. at Meishan was originally subdivided into two conodont assemblage zones by Wang and Wang (in Zhao et al., 1981), namely the *Neogondolella subcarinata-Neogondolella elongata* Zone (below) and the *Neogondolella deflecta-Neogondolella changxingensis* Zone (above). Mei, Zhang and Wardlaw (1998) have revised the taxonomy of Changhsingian conodonts with segminiplanate P elements and propose a more detailed zonation at Meishan, which includes, in ascending order, the *Clarkina subcarinata-C. wangi-C. prechangxingensis-C. predeflecta* Zone, the Transitional Zone, the *C. parasubcarinata-C.posrwangi-Cxhangxingensis-C.deflecta* Zone and the *C. changxingensis yini-C. meishanensis zhangi* Zone. As indicated by Mei, Zhang and Wardlaw (1998), the form species combined in the names of these zones are parts of single apparatus species. Wardlaw and Mei (1998a) used the first appearing and most distinct form species to name these zones, in ascending order: the *C. subcarinata* Zone (Wardlaw referred to the lower part of this zone as the *C. wangi* Zone by using a narrower definition for *C. subcarinata), C. changxingensis* Zone (including the Transitional Zone and the *C. parasubcarinata-C. postwangi-C. changxingensis-C. deflecta* Zone mentioned above) and *C. yini* Zone respectively (Fig. 3).

At Kuh-e-Ali Bashi locality 1, the top of the Julfa beds underlying the Ali Bashi Fm. has abundant *Clarkina orientalis* and correlates with the top of the Longtan Fm. at Meishan, which underlies the Changxing Ls. Detailed study shows that the Ali Bashi Fm. at Kuh-e-Ali Bashi locality 1 and the Changxing Ls. at Meishan, South China share the same conodont succession. Beds 1 and 2 represent the *C. subcarinata* Zone. Sample 69SA-3 from bed 3 is barren. Sample 69SA-4 through 69SA-15 from bed 4 through upper part of bed 18 belong to the *C. changxingensis* Zone. In this interval, samples 69SA-4 through 69SA-15 from bed 4 through bed 15 represent the Transitional Zone of Mei et al. (1998) and samples 69SA-161 through 69SA-18m, from bed 16 through the upper part of bed 18, belong to the *Clarkina parasubcarinata-C. postwangi-C. changxingensis-C, deflecta* Zone of Mei et al. (1998).The top of bed 18 through bed 20 represent the *C. yini* Zone (Fig.3).

The Permian-Triassic boundary beds at Kuh-e-Ali Bashi locality 1 may also correlate closely with those at Meishan, Changxing, South China (Fig. 3). The top of bed 20 corre-

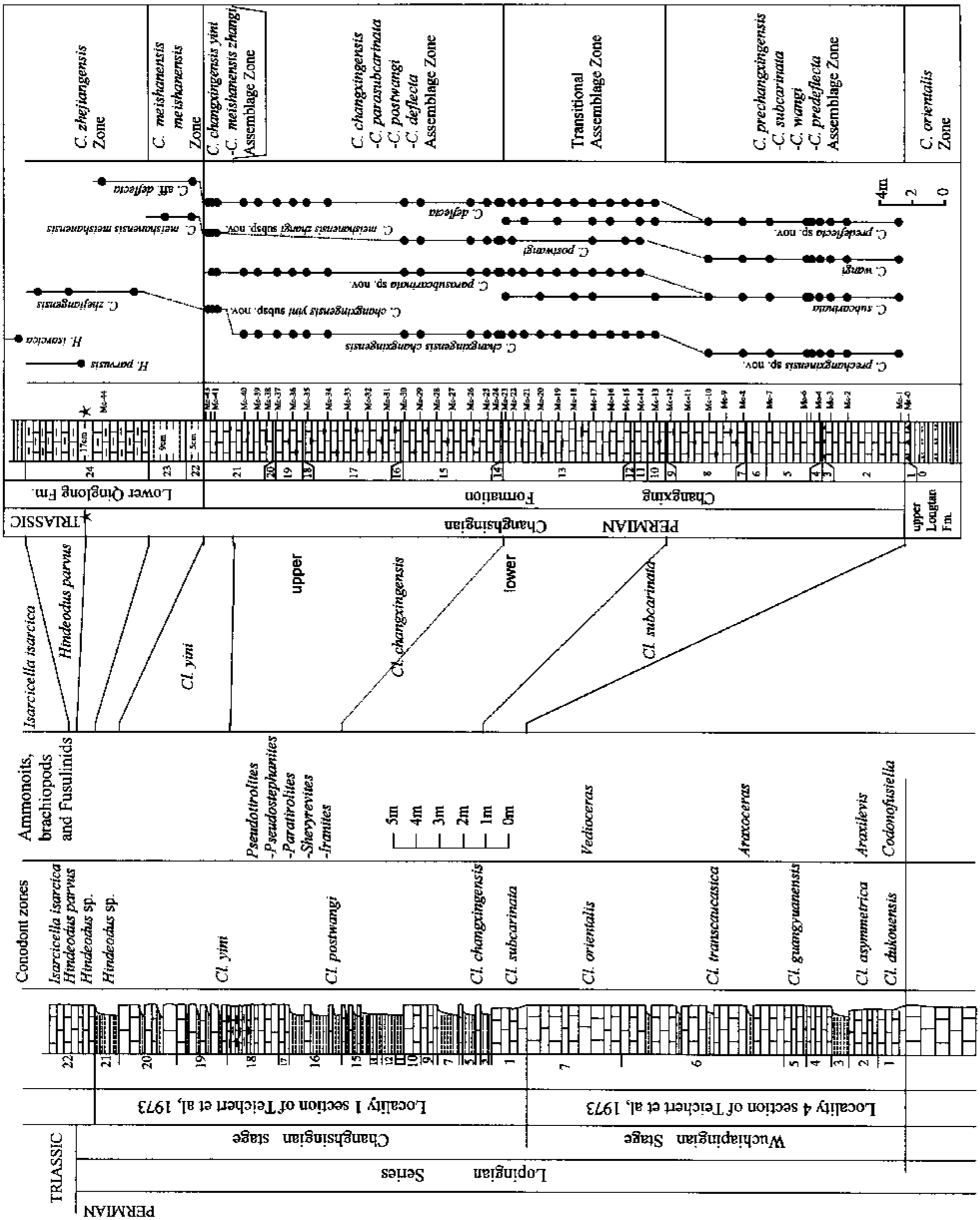

Figure 3. Correlation of Upper Permian (Lopingian) and lowermost Triassic strata in the Kuh-e-Ali Bashi, northwest Iran, with those at Meishan, Changxing, South China. Columnar section at Meishan is from Sheng *et* al. (1984). Asterisk indicates position of GSSP of basal Triassic boundary recommended by Yin *et al*. (1996).

lates with the top of bed 24e *sensu* Yin et al. (1996), or the top of bed 21 *sensu* Sheng et al. (1984) at Meishan, for both beds represent the *Clarkina yini* Zone. Bed 21 (69SA-21) and bed 22L (69SA-22L) at locality 1 yielded only 4 broken Pa elements of *Hindeodus* ; however, these beds may correlate with Meishan beds 25, 26 and perhaps the lower part of bed 27 *sensu* Yin et al. (1996), or with Meishan beds 22, 23 and the lower part of bed 24 *sensu* Sheng et al. (1984) , because overlying Bed 22M at locality 1 yielded typical *Hindeodus parvus* (Kozur and Pjatakova) and may thus correlate with the upper part of bed 27 at Meishan. Bed 22U (69SA-22U) and the overlying bed, which produced sample 69SA-Cl, yielded *Isarcicella isarcica* (Huckriede), and thus correlates with beds 28 and 29 *sensu* Yin et al. (1996), or Meishan beds 25 and 26 *sensu* Sheng et al. (1984), from which *L isarcica* has also been collected (Tong and Yang, 1997). As a result, the section at Kuh-e-Ali Bashi locality 1 is another important reference section for the base of Triassic.

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A Large Carbon Isotope Anomaly at the Carboniferous-Permian Boundary: the Usolka River Section of Russia

by Stephen T. Nelson and Scott M. Ritter

Introduction

The purpose of this communication is to inform our colleagues of a recently discovered, large carbon isotope excursion that occurs across the Carboniferous-Permian (C-P) boundary at the Usolka River section in Russia. This deep-water section was briefly considered as the Global Stratotype Section and Point (GSSP) for the Carboniferous-Permian (C-P) boundary because of its abundant and well-preserved conodont faunas. Because this section is an important locality for workers interested in the C-P boundary, we undertook an experiment to determine whether isotope stratigraphy held any potential as an additional correlation tool.

The Usolka River section consists of over 50 m of Gzhelian through Sakmarian strata, of which we analyzed 26 m, including the upper half of the Gzhelian and lower two thirds of Asselian stages. This section includes thin-bedded shales, carbonate mudstones, and thin ashes deposited in the deep-water axis of the Uralian Geosyncline. The lower half of the Usolka section is dominated by dark brown to greenish-brown shale with sparse, thin (5-20 cm) beds of structureless to burrowed carbonate mudstones. Oxidized clay seams and cm-thick bentonites are also present. The upper half comprises thin interbedded carbonate mudstones and shale. Overall, the depositional environment produced low sedimentation rates on a dysaerobic basin floor. It also represents an interval of continuous deposition across the C-P boundary.

Isotope Stratigraphy

An unexpectedly large (>15‰) excursion in $\delta^{13}C_{PDB}$ from light (-12.6‰) Gzhelian to heavier (2.9‰) Asselian values coincides with the Carboniferous-Permian boundary (Fig. 1a). Few isotope excursions of this magnitude have been observed for the entire Phanerozic Era. For example, Berner's (1989) compilation shows long-term variations for global seawater are on the order of 8‰, and minimum $\delta^{13}C_{PDB}$ values of -2‰, although a few large short term excursions are documented. These observations raise two fundamental issues. The first is whether the "Usolka anomaly" is a primary signature or whether it is the result of diagenesis. The second is if the signature is primary, what is its origin?

Previous Observations

Berner (1989) shows a steady increase in $\delta^{13}C_{PDB}$ upward through the Carboniferous with high values being attained by latest Carboniferous time. High values persist through the Lower and Middle Permian before becoming about 5‰ lighter over the course of Late Permian to Triassic time. The shift from lighter Carboniferous to heavier Permian $\delta^{13}C_{PDB}$ values is well established by the work of others, but has never been observed to be larger than 3.4‰ (Veizer et al., 1980; Carpenter and Lohmann, 1997; Arneth, 1984; Beauchamp et al., 1987; and Magaritz and Holser, 1990). Therefore, a smaller shift to more positive $\delta^{13}C_{PDB}$ values would not have been unexpected. Very large isotope excursions are relatively rare in the Phanerozoic Era. Holser and Magaritz (1985) noted a shift of +9‰ toward heavier values in the Late Permian rocks of the Carnic Alps, but none of the sections exhibited $\delta^{13}C_{PDB}$ lighter than 6‰. Oberhänsli et al. (1989) discussed $\delta^{13}C_{PDB}$ data from the Permo-Triassic Schuchert Dal section of Greenland which exhibited a regular decrease from -3 to -9‰ up-section. However, just above the system boundary an excursion to extremely light values of -13‰ was recorded, although this was attributed to diagenesis.

Preservation Of The Marine Signature

We believe the Usolka River section generally records an original isotopic signature. In other words, despite some evidence for limited diagenetic overprint of $\delta^{13}C_{PDB}$ values, the overall trend appears to be primary. This is *critical* in interpreting the meaning of the carbon isotope anomaly. Evidence for and against diagenetic modification of the $\delta^{13}C_{PDB}$ signature are summarized below.

The depositional setting and character of the rocks indicates $\delta^{13}C_{PDB}$ values are more-or-less primary. The rocks consist of fine-grained carbonate deposited in several hundred meters of water with varying degrees of detrital material, mostly quartz. Thus, it is very unlikely that any rocks from this section were emergent during early diagenesis. In addition, there is no evidence for large-scale recrystallization and coarsening of the texture of these rocks.

The isotope systematics also seem to indicate a primary origin. Meteoric diagenesis may result in reduction of both $\delta^{13}C_{PDB}$ and $\delta^{18}O_{VSMOW}$, or $\delta^{18}O_{VSMOW}$ alone (e.g. Beauchamp et al., 1987; Carpenter and Lohmann, 1997; Banner and Hanson 1990). Thus, where $\delta^{18}O_{VSMOW}$ is not grossly perturbed, it is difficult to account for anomalous $\delta^{13}C_{PDB}$ values by diagenesis. In the Usolka River section, $\delta^{13}C_{PDB}$ and $\delta^{18}O_{VSMOW}$ are not positively correlated (Fig. 1b), and show $\delta^{18}O_{VSMOW}$ values that are fairly typical of marine carbonate (average = 28.4 ± 1.8‰).

A diagenetic event of sufficient magnitude (high water/rock ratio) to produce the light carbon should not preserve mineralogical and isotopic gradients within a single bed. However, two turbidite clasts, one of which is 100% dolomite and the other is nearly pure limestone, differ in $\delta^{13}C_{PDB}$ by 1.5 ‰ (although both are very light, < 11‰). It is difficult to conceive of pervasive fluid flow preserving both a distinctive mineralogy and isotopic gradient. However, it is perfectly reasonable to expect turbidite clasts to retain such primary differences.

As an additional test for diagenetic overprinting on carbon isotopes, we conducted a stepwise dissolution experiment on a mixed dolomite-calcite similar to Magaritz and Kafri (1981). This experiment allowed us to compare the composition of gas evolved early (calcite) to gas evolved late (dolomite) (Al-Aasm et al., 1990). $\delta^{13}C_{PDB}$ was lighter by about 2‰ in the dolomite fraction. This is a significant shift that is difficult to explain unless the primary signal of the dolomite was so light that meteoric effects resulted in deposition of *heavier* carbon in calcite. The presence of two isotopically distinct carbonate phases is permissive of some diagenetic modification on end member calcite and dolomite $\delta^{13}C_{PDB}$ values. However, both dolomite and calcite endmembers are still very light and seem to require that the primary Late Carboniferous $\delta^{13}C_{PDB}$ isotopic values were very light in the Usolka section.

Origin of the Usolka Anomaly

Excursions in the isotope stratigraphy of marine carbonate rocks are usually interpreted as changes in the global mass balance between organic and inorganic carbon. At other locations, however, no similar excursions have been seen at the C-P boundary to date. Since we believe that a diagenetic overprint was not responsible for the unusually light carbon in the Usolka section, we tentatively suggest that the Usolka anomaly must reflect local conditions. Perhaps it represents large-scale input of oxidized organic matter into the dissolved inorganic carbon budget of the Uralian trough under conditions of restricted circulation with the open ocean during Gzhelian time and that barriers to circulation collapsed in the early Asselian. We are currently attempting to further test the hypothesis. However, should this hypothesis prove to be correct, it may represent an important tool for investigating the history of sedimentary basins where isotope stratigraphy is temporally well constrained by concurrent biostratigraphic studies.

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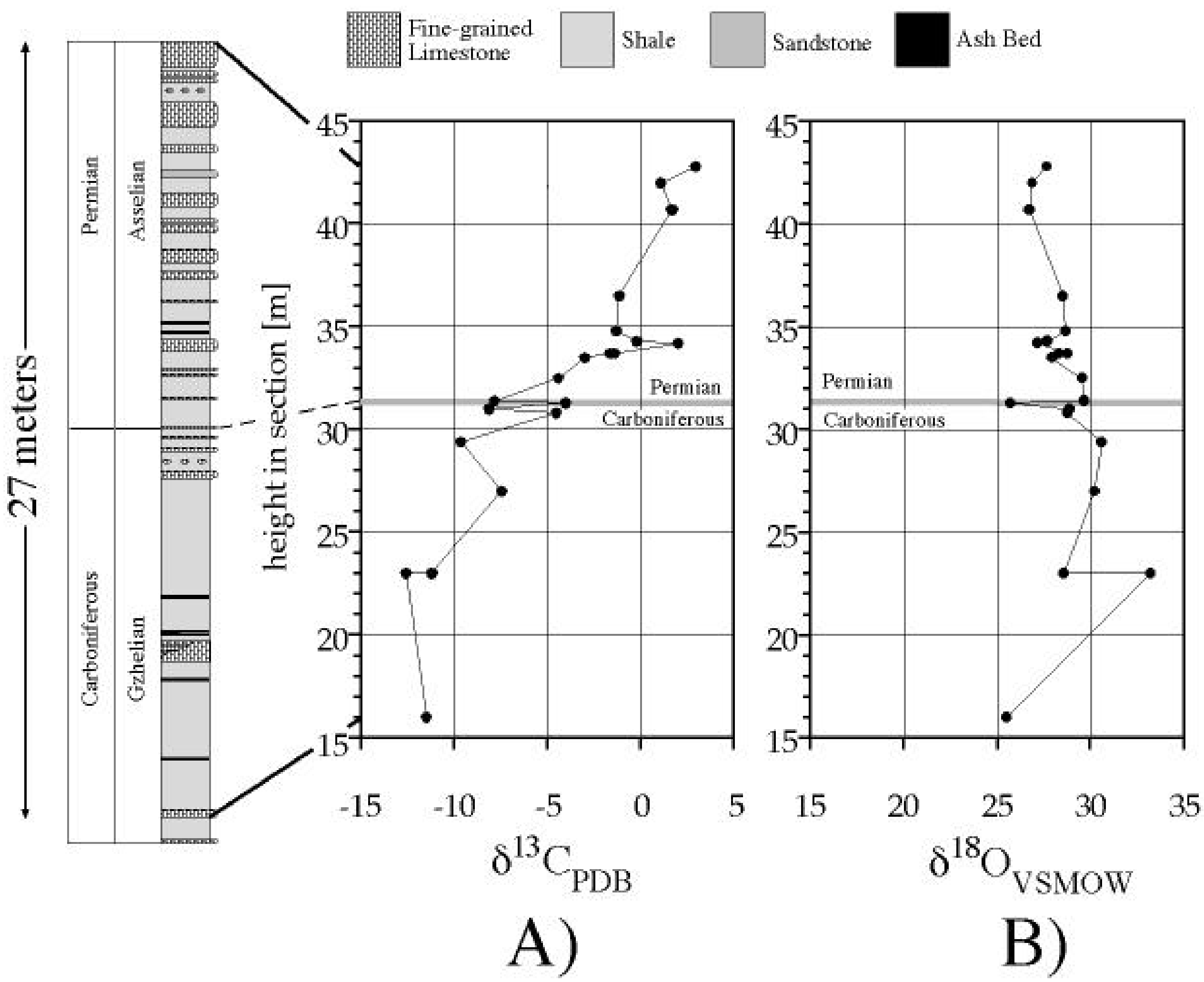

Figure 1. A) Carbon isotope stratigraphy of the Usolka River section. B) Oxygen isotope stratigraphy of the Usolka River section.

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A Brief Discussion on the Occurrences of *Scutasporites unicus* and *Lueckisporites virkkiae* Complexes in the Northern Hemisphere

by Ouyang Shu

Scutasporites Kl. and *Lueckisporites* Pot. & Kl., pollen of conifers (Meyen, 1987; Balme, 1995), are two important index taxa of the Upper Permian. The first appearances of their type species, viz. *S. unicus* Kl. and *L. virkkiae* Pot. & Kl., were assumed to have high potential in recognizing the base of the Tatarian, although with cautious reservations (Foster & Jones, 1994). Gomankov (1994) noted that "the first appearance of *S. unicus* in the Russian Platform occurs much higher than that of *L. virkkiae* and if the latter event coincides with the base of the Tatarian, then the appearance of *S. unicus* would be somewhere in the middle of the Severodvinsky horizon". However, recent advances through the studies of Permian palynology in N. Xinjiang and Gansu, NW China, combined with the relevant published data cast some doubts on their correlation value as claimed by the above mentioned authors and raise some new problems.

First, the taxonomic problem. For *Scutasporites*, in addition to *S. unicus*, two other species have been proposed, viz. *Scutasporites* (*Gardenasporites*) *xinjiangensis* (Hou & Wang, 1986) Ouyang 1993 and *S. nanuki* Utting 1994. In the author's opinion, it seems reasonable to make such a separation because amongst the three species, some differences (thickness of endexine, texture and shape of sacci, breadth of taenia) do exist although some features (a central taenia and size) overlap one another. The Greenland specimens were treated as *S.* cf. *S. unicus* (Balme, 1980), and it is interesting to note that the latter name was listed in the synonym of *S. nanuki* (Utting, 1994). On the other hand, the specimens from Russia, N. Xinjiang and Gansu, are almost identical and show a higher similarity to *S.* cf. *S. unicus* of Balme and can be assigned to *S. xinjiangensis*, but one specimen of this species from the Shihchienfeng Fm. in Gansu is very close to *S. nanuki*. It is thus evident that some transitional forms bridged these species. So if a "lump" standpoint is adopted, these species may also be conventionally indicated as *S. unicus* s.l. or *S. unicus* complex. To some extent, the same can be applied to *L. virkkiae*. In the Subangara Area (e.g. N. Xinjiang and Cis-Urals), the specimens identified as this species (e.g. Hou & Wang,1986, pl. 30, figs.9-11; Molin & Koloda, 1972, pl. 12, fig.8) also show some differences (generally smaller size and thinner cap) compared with their typical European counterparts. Like wise, we also can ascribe them to the *L. virkkiae* complex.

Secondly, the known data indicate that the "first appearance" of *S. unicus*- and *L. virrkiae*-complexes in different regions or phytogeographical provinces are not necessarily synchronous. The spatial and stratigraphical distribution of *S. unicus* complex is given in the following Table.

Some notes about the Table:

1. As Foster & Jones (1994) commented, " the age of the upper Grodner Sandstone and Bellerophon Formation is difficult to determine, without involving circular arguments".

2. The *Martinia* Shale was palynologically considered to be? Dzhulfian in age (Balme, 1980), however, in association with the *Vittatina* Association (including *S. unicus* and *L. virkkiae*) it yields the conodont *Neogondolella rosenkrantzi* which "has a maximum possible age of the Wordian" (Foster & Jones, 1994).

3. Based on palaeontological and stratigraphical grounds, the Lower Shihhotse Formation in N. China was traditionally assigned to the upper part of Lower Permian (twofold division of Permian) and correlated with the Kungurian or Kungurian-Ufimian (Sheng & Jin, 1994), at any rate, its age cannot be younger than Ufimian. The presence of *S. xinjiangensis* or *S. unicus* s.l. in this formation thus demonstrates that this species first appeared in beds older than Tatarian (possibly Ufimian or Wordian as *S. nanuki* Utting in Arctic Canada).

In the Cathaysian Province, *L. virkkiae* occurs occasionally in the Lungtan Formation and fairly commonly in the Changxing Formation of S. China, and sporadically in the Upper Shihhotse Formation and abundantly in the Shihchienfeng Formation of N. China, both possibly ranging from the late Kazanian to Tatarian or entirely belonging to the Tatarian (Sheng & Jin, 1994). It is noteworthy that the specimens from S. China are morphologically much closer to the European counterparts, while those from N. China are more similar to the specimens of this species in N. Xinjiang. It occurs in the Tatarian Wutonggou and Guodikeng Formations and has not been observed in the underlying Quanzijie Formation, while in the latter *S. xinjiangensis* occasionally appears (Hou & Wang, 1986), and a specimen very similar to *S. xinjiangensis* was even recorded in the Lucaogou Formation of the Upper Chiechietsao (Jijicao) Group. As will be discussed in the following paper, the Lucaogou Formation is possibly of Ufimian age. In the Longshoushan area of Gansu, we have the same story. *S. xinjiangensis* first appeared in the Lower Shihhotse Formation, but its association with *L. virkkiae* is found in the

Name	Region	Strata	Age	Author(s)
Scutasporites unicus	S. Alps	upper Grodner S. S. & Bellerophon Fm.	uncertain (? Ufimian - Kazanian)	Klaus,1963
Scutasporites cf. S. unicus	Greenland	Martinia Shale	?Dzhulfian or ?Wordian	Balme,1980
"*Taeniaesporites ortisei* Kl."	Russian platform	Severodvinsky Horizon	mid.Tatarian	Molin and Koloda,1972
Gardenasporites xinjiangensis	N.Xinjiang	Lower Cangfanggou Group	Tatarian	Hou and Wang,1986
Scutasporites xijiangensis (Hou & Wang)	N. Xinjiang	the same as above & Lucaogou Fm.	Tatarian & ?Ufimian	Ouyang, Wang, Zhan and Zhou,1998,MS
Gardenasporites xinjiangensis	SW.Tarim	Duwa Fm. & Pusige Fm.	Tatarian & ?Kazanian	Zhu,1996
Scutasporites xijiangensis	Gansu	Shihchienfeng Fm. & Lower Shihhotse Fm.	Tatarian & ?Ufimian	Ouyang, Zhu and Wang,1998
Scutasporites nanuki	Sverdrup Basin, Arctic Canada	Trold Fiord Fm. & upper van Hauen Fm.	Wordian	Utting,1994

Table 1.

Shihchienfeng Formation. These facts seem to indicate that *S. unicus* had an earlier history than *L. virkkiae* in N. Xinjiang and Gansu.

In the Cis-Urals and Russian platform, the first appearance of *L. virkkiae* has been repeatedly reported from the Upper Kazanian by Russian authors (e.g. Faddeeva, 1990; Koloda & Kanev, 1996: both without illustration) although such kinds of records are a little doubtful to non-Russian readers. For example, *L.* cf. *L. virkkiae* appears in the Tatarian plates (Warjukhina, 1971, pl. 23, fig.3), but the same specimen identified as *L. virkkiae* was noted to be derived from the Lower Kazanian (the Upper Chevijusky) (Molin & Koloda, 1972, pl. 12, fig.8). In fact, Utting (1996) discovered L. *virtkiae* from the Lower Kazanian in the stratotype area and he pointed out that "the sporadical occurrence of *L. virkkiae* in the Baitugansky Horizon...indicates that the species first appears in rocks older than Tatarian". A record of *L. virkkiae* var.*carbonica* Inosova (in Inosova et al., 1974) from the Upper Carboniferous (Stephanian) in the Donetz Basin was not formally described and its real relation with *L. virkkiae* remains unclear.

In the United States, *L. virkkiae* abundantly occurs in the Flowerpot Formation of Oklahoma (Wilson, 1962). But the precise age of this formation is also subject to dispute as Utting mentioned it "was assigned a Wordian age and tentatively correlated with the Ufimian to early Kazanian of the Commonwealth of Independent States..." and "reptile fossils indicate a Kazanian age", while Wood et al. (1991) noted it "is questionably assigned to the Lower Guadalupian.... However, it may be late Leonardian in age". Anyhow, judging from the foregoing statements and the stratigraphical order, it is obvious that the age of this formation must be older than the Tatarian even if a record of *L. virkkiae* in the Lower Leodardian (? or upper Wolfcampian) was not taken into account (see Wood et al.,1991).

In Europe, *L. virkkiae* is an abundant element of Upper Rotliegend and especially Zechstein or their rough equivalents (e. g. "Thuringian", Upper Grodner S.S. and Bellerophon Formation, etc.). However, as Kozur (1978) pointed out, that "the Lower and Upper Rotliegend as facial terms and superordinate lithostratigraphic units have conventionally defined various chronostratigraphic contents in the different basins. ... The use of these terms in a 'parachronostratigraphic' scale for the continental Permocarboniferous of Europe is therefore impossible"; and "Vissicher (1971) defined the Thuringian as range zone of *L. virkkiae*. The Thuringian sensu Visscher (1971) does not only comprise the Zechstein (and therefore the Upper Permian), but also the whole Middle Permian (e.g. the Val Gardena Sandstone of the Southern Alps or the Eisleben Formations, higher Upper Rotliegend at the eastern margin of Harz Mountains". But recently Visscher & Van Houte (1996) mentioned that "the continental Rotliegend deposits of the Mid-European Permian basin comprise four distinctive tectonosequences (TS I-IV). The time of formation of these units is constrained by limited paleomagnetic, palynological and radiometric data". They assigned the TS III in Germany and Poland to the early Tatarian, and the TS IV (The Netherlands, North Sea) to post-Kazanian (late Tatarian and post-Tatarian hiatus of Russia). *L. virkkiae* is obviously absent from their TS II ("an essentially Asselian age ...with a possible extension into the Sakmarian), this means that *L. virkkiae* occurs in strata not older than the Tatarian although its first appearance is unable to be confirmed due to the hiatus between the TS II and III.

From the foregoing discussion, some preliminary conclusions are (1) the spatial distribution of *S. unicus* complex is mainly confined to the Subangara Area (the Cis-Urals, N. Xinjiang, Gansu, E. Greenland and Sverdrup Basin of Arctic Canada) and not so widespread as the *L. virkkiae* complex which has not only been reported from the Euramerica Province, but also from the Subangara, Cathaysia and in some cases Gondwana Provinces (e.g. the Wargal Limestone in Pakistan, which is also possibly of Wordian age, Balme, 1970; Jin,1996); (2) in some regions, *S. unicus* seems to have had an earlier history than *L. virkkiae* (N. Xinjiang, Gansu) for it appeared as early as the Ufimian (Wordian), but in the Russian platform, *L. virkkiae* probably first appeared in the Lower Kazanian, and *S. unicus* in the mid-Tatarian; (3) before the precise age of some key sections (e.g. Rotliegend-Zechstein or Grodner-Bellerophon Fms.; El Reno Group with the Flowerpot Formation) can be determined, the problem of when *L. virkkiae* first appeared needs to be established. However, the data available show that it must be earlier than Tatarian; and (4) although both *S. unicus* and L. *virkkiae* might have had an earlier history than Tatarian, it was not until the upper parts of Tatarian that they became abundant or prominent in the palynofloras of some areas of Eurasia (e.g. *L. virkkiae* in S. and N. China and *L. virkkiae* and *S. unicus* in N. Xinjiang and the Cis-Urals). Thus their significance in correlation of strata of this time interval still deserves special attention.

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Palynostratigraphic Correlation of the Permian System of Northern Xinjiang and the Cis-Urals

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As a continuation of the Permian palynological study in N. Xinjiang by Hou and Wang (1986, 1990), we have worked intermittently for a cooperative project since the middle eighties. The results will be published in a book entitled "A Systematic Study on the Carboniferous and Permian Spores and Pollen grains of N. Xinjiang". In this book a large number of taxa were formally described and 15 palynological assemblages, ranging from the lowermost Carboniferous to the uppermost Permian were established; also some relevant problems were discussed, involving the subdivision and correlation of the Permian System.

Representative sequences of the Permian in N. Xinjiang are well exposed in the suburb of Urumqi City and the Fukang-Jimsar area and the nine lithostratigraphic units established have been widely accepted (see Sheng & Jin, 1994). Nevertheless, precise dating and correlation of these formations are still problems waiting for solution. Palynologically, the Late Carboniferous - Permian floras of N. Xinjiang belonged to the Subangara Area in Meyen's sense. The assemblages (late Bashkirian through into the Permian) are generally characterized by the dominance of diversified gymnosperm pollen, especially striate forms of presumed peltaspermalean origin, and have close relationship with those known from the E. Russian platform and the Cis-Urals (cf. Faddeeva, 1990; Koloda, Shelekhova, Gomankov, Utting in Esaulova & Lozovsky, 1996). These data provide advantages for palynostratigraphic correlations between N. Xinjiang and the Cis-Urals. On this topic two papers dealing with the Upper Permian have appeared in Permophiles (Esaulova, 1995; Koloda & Kanev, 1996). Correlation with the stratotypes is difficult because of differences in taxonomy and nomenclature and the parallel long-range distributions of many taxa as well as the difference in lithofacies and ecological backgrounds (e.g. usually higher content of *Vittatina* in the Cis-Urals versus abundance and high diversity of *Hamiapollenites* in N. Xinjiang). However, correlation is still feasible if we concentrate our focus on some palynological events and relatively short-range key taxa, which can be easily identified by diagnostic morphology (something like the concurrent range zones) integrated with the general characteristics of assemblages. Some examples are attempted below in descending order of stratigraphic stages:

(1). Tatarian: Existence of *Lueckisporites virkkiae* Pot. & Kl. and/or *Scutasporites* cf. *S. unicus* Kl. of Balme 1980 = *S. xinjiangensis* (Hou & Wang) Ouyang, *Klausipollenites schaubergeri* (Pot. & Kl.), *Falcisporites zapfei* (Pot. & Kl.), *Inaperturopollenites nebulosus*, *Eucommmidites* and other pollen and spores of Mesophytic conifers and ferns, including sometimes abundant small bisaccate pollen (*Vitreisporites*, etc.) as well as marked decline of *Hamiapollenites*.

(2). Kazanian: First but sporadic occurrence of *L. virkkiae*, *F. zapfei* and *Striatopodocarpites tojmensis* Sedova in Lower Kazanian and presence of *Hamiapollenites erebi* Utting and *Gnetaceaepollenites* in Upper Kazanian of the Cis-Urals; presence of spores with a Mesophytic aspect such as *Osmundacidites*, *Neoraistrickia*, *Densoisporites* and *Kraeuselisporites* and pollen of *Vitreisporites* and *Gnetaceaepollenites*.

(3). Ufimian: Marked increase in diversityof laevigate, granuloic, spinoic, verrucate and baculate triletes spores when compared with the Kungurian, and local development of Zonotriletes (e.g. *Cirratriradites and Lycospora*).

(4). Possible Ufimian or Wordian: First appearance of *S.* cf. *unicus*, presence of *Crucisaccites variosulcatus* Djupina and *Samoilovitchisaccites turboreticulatus* Samoil. in N. Xinjiang

(5). Kungurian: First appearance of *S. turboreticulatus*, *C. variosulcatus* and *Florinites luberae* Samoil are widespread.

(6). Artinskian: First appearance of *Urmites incrassatus* Djupina, *Hamiapollenites radiatus* Djupina, *C. variosulcatus* and *F. luberae*.

(7). Asselian- Sakmarian: Marked decrease of Zonotriletes (mostly lepidophyte spores) and large forms of *Potonieisporites* and *Florinites*; dominance or abundance of Striatiti; first appearance of *Iunctella* and *Pseudocircella* in Sakmarian.

The subdivision of the Permian and its correlation mainly with the Cis-Urals is shown in Table 1(See previous paper). In the following are some explanatory notes.

1. The upper part of the Guodikeng Formation together with the overlying Jiucaiyuan Formation is Early Triassic (Induan) based on the presence of the *Lundbladispora- Aratrisporites- Lunatisporites* assemblage, (Hou and Wang (1986). However, the Permian-Triassic boundary may still be drawn a little lower (about 40 m below the top of the formation in the section of north limb of the anticline at Dalongkou) (Ouyang & Norris, 1992, MS).

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2. The lower-middle parts of the Guodikeng Formation and its underlying Wutonggou Formation are readily correlative with a large part of the Tatarian of the Cis-Urals due to the common presence of (1). *Lueckisporites virkkiae* and *Scutasporites xinjiangensis* (Hou & Wang) (= *S.* cf. *unicus* of Balme = *Taeniaesporites ortisei* Kl. of Molin & Koloda, 1972,pl.21, fig.1), these two species are mainly confined to the Tatarian (Foster, 1992; Gomankov,1994); (2). other typical late Late Permian (e.g. Zechstein) taxa, viz. *Klausipollenites schaubergeri* and *Falcisporites* cf. *zapfei* and (3). some other forms with an aspect of the Mesophyte, including the marked increase of diversified small bisaccate pollen (*Vitreisporites*, *Alisporites* and *Klausipollenites*, etc.) and spores of *Dictyophyllidites*, *Osmundacidites*, *Kraeuselisporites* as well as some with spinate-baculate-conate ornaments known in the Tatarian of the Kuznetsk Basin (Yerunakovsky Suite).

3. The assemblage of the Quanzijie Formation is transitional in character between those of the Guodikeng + Wutonggou Formations on the one hand and the underlying Upper Chiechietsao (Jijicao) Group on the other. It is characterized by small amounts (5-9%) of moderately diverse spores and overwhelming dominance of pollen, especially Striatiti (*Vittatina* included) and Monosaccites (mainly *Cordaitina*). It shows a closer relationship with the underlying Lucaogou + Hongyanchi assemblages as demonstrated by mostly the same specific composition as well as the high content of *Cordaitina* (29% on average) and *Hamiapollenites* (generally 16-18%). On the other hand, 1/3 of the species are identical to those of the Wutong + Guodikeng Formations, including *S. xinjiangensis*, *F.* cf. *zapfei*, *Potonieisporites turpanensis* Hou & Wang, *Kraeuselisporites spinulosus* Hou & Wang and *Tuberculatosporites homotubercularis* Hou & Wang, etc. as well as some small bisaccate forms. The Quanzijie Formation was considered to be Kazanian in age (Hou & Wang,1986; Koloda & Kanev,1996). Now we are more inclined to correlate it with the lower Tatarian (Urshumsky) on account of the common presence of such species as *Protohaploxypinus perfectus* (Naum.), *P. suchonensis* (Sedova), *P. jacobii* (Jansonius), *P. minor* (Klaus), *Vittatina costabilis* Wilson, *V. subsaccata* Samoil., *Falcisporites zapfei*, *Striatoabieites multistriatus* (Balme & Hennelly), *S. richteri* (Klaus), *Platysaccus papilionis* Pot. & Kl. *and Cyclogranisporites aureus* (Loose) as well as such genera as *Alisporites*, *Vesicaspora, Striatolebachiites*, *Limitisporites*, *Gardenasporites*, *Vitreisporites*,

Lophotriletes, *Apiculatisporis* , *Kraeuselisporites* and *Laevigatosporites* . The absence of *L. virkkiae* in the Quanzijie Formation, which may also be the result of individuals being too rare to be seen in statistics or ecological un-adaptability for its parent plants, is a little curious because it possibly first appeared in the Lower Kazanian and extended upwards into the Tatarian in Russia. The occasional occurrence of *Scutasporites* cf. S. *unicus* (*S. xinjiangensis*) and other spores with an aspect of the Mesophyte seems to be in accordance with the above dating. Furthermore, the freshwater faunas, including bivalves (*Palaeanodonta*) and ostracods (*Darwinula*, *Vymella*), have a closer relation with those derived from the overlying Wutonggou and Guodikeng Formations. These considerations lead us to conclude that the age of the Quanzijie Formation is most likely to be early Tatarian although the possibility of it belonging to late Kazanian can not be excluded.

4. The assemblages of the Lucaogou and Hongyanchi Formations are very close and difficult to be divided, both are characterized by overwhelming dominance and high (the highest in Permian) diversity of gymnosperm pollen, especially monosaccate and striate pollen. 60-70% species are the same, notably *Zonalasporites delicatus* Wang, *Samoilovitchisaccites sinensis* (Zhang), *Potonieisporites turpanensis*, *Florinites luberae*, *Crucisaccites variosulcatus*, *Cycadopites tunguskensis* Samoil. and *Urmites incrassatus.*

The assemblage of the Lucaoggou Formation shares the characteristics of both the Kungurian and Ufimian assemblages in the Cis-Urals. For instance, in the former occurs *Samoilovitchisaccites turboreticulatus* which has been taken as the most important marker of the Kungurian (Samoilovich, 1953; Faddeeva, 1990), and some components are also the same. However, these do not necessarily guarantee their correlation because *S. turboreticulatus* has been found in the Wulabo Formation below the Lucaogou Formation, we have no solid ground to suggest it cannot extend up into younger strata. On the other hand, compared with the assemblages of the Ufimian from the stratotype area (Koloda & Kanev, 1996), the Lucaogou assemblage shares the following taxa: *Leiotriletes subintortus* (Waltz), *Cyclogranisporites polypyrens* (Luber), *Punctatisporites*, *Verrucosisporites*, *Vittatina striata* (Luber), *V. vittifera* (Luber), *V. subsaccata* Samoil., *V. persecta* Zauer, *Protohaploxypinus perfectus* (Naum.), *P. latissimus* (Luber), *P. suchonensis*, *Hamiapollenites tractiferinus* (Samoil.), *H. bullaeformis* (Samoil.), *Striatoabieites brickii* Sedova, *S. striatus* (Luber), *Florinites luberae*, *Cordaitina uralensis* (Luber), C. *convallata* (Luber), *C. subrotata* (Luber), *Crucisaccites ornatus (Samoil.)*, *Striatolebachiites*, *Limitisporites monstruosus* (Luber), *Alisporites sublevis* (Luber) and *Gardenasporites*, etc. These taxa are not confined to the Ufimian, however the common presence of so many taxa in both the Cis-Urals and N. Xinjiang strengthens the case for their correlation. In the Lucaoggou assemblage the absence of “lepidophytic spores” (e.g. *Cirratriradites* and *Lycospora*) which is one of the main features of the Ufimian in Russia might be explained by strict ecological conditions required by their parent plants (e.g. *Viatcheslavia*). As Meyen (1987, p. 308) pointed out “the Ufimian flora of the Fore-Urals...is dominated by heterosporous lepidophytes *Viatcheslavia*. Evidently they grew in dense thickets along the coast of the sea .... Identification of the Ufimian deposits in other regions is fraught with difficulties”. The Lucaogou Formation was deposited in coastal lacustrine environments. The occasional occurrence of *Scutasporites xinjiangensis* (*S.* cf. *unicus*) in the Lucaogou Formation deserves special attention because the species, even the genus, suggests a younger age. The co-existence of *S. xinjiangensis* and *Crucisaccites variosulcatus* is another noticeable clue, which is correlatable with their co-existence in the Lower Shihhotse Formation of Gansu (Ouyang et al., 1998). The latter formation has been traditionally assigned to the upper part of Lower Permian (twofold division) and correlated with the Kungurian or Kungurian-Ufimian (Sheng & Jin, 1994). In addition, in the upper part of Jijicao Group from the Ilin Basin of N. Xinjiang was found the diagnostic species *Parasaccites panjimensis* Wang, which is very similar to *Polarisaccites tricamarus* Djupina 1974 (pl. V, figs.5, 6) with type material derived from the Ufimian in the Middle Urals. Considering other evidence, for instance, palaeomagnetism, the onset (?) of a normal polar zone probably corresponding to the Illawarra Reversal was located in the upper part of Lucaogou Formation (Sheng & Jin, 1994), and “ the Illawarra Reversal occurred in the upper part of the Maokou Formation in South China and the lower part of the Wargal Formation in the Salt Range, which corresponds with the *Neoschwagerina magaritae* Zone and the *Jinogondolella aserrata* zone of the Wordian Stage” (Jin, Y. G., 1996), and faunally, the bivalves indicate an Ufimian age (Koloda & Kanev, 1996), we conclude that the Lucaogou Formation should be correlated with the Ufimian.

The assemblage of the Hongyangchi Formation contains, in addition to some gymnospermous pollen taxa shared with the underlying Lucaogou Formation and the Ufimian, some spores identical to those from the Lower Kazanian in the stratotype area (Koloda & Kanev, 1996), such as *Calamospora breviradiata* Kosanke, *Cyclogranisporites aureus*, *Raistrickia obtusosaetosa* (Luber), *Leiotriletes*, *Apiculatisporis* and *Acanthotriletes*. The assemblage of the Upper Kazanian from the stratotype is rather poor in composition and largely the same as those of the Lower Kazanian except there are rarer spores and a few peculiar pollen taxa. These seem to lend support to correlate this formation with the Lower Kazanian or the whole Kazanian.

5. The age of the Jingjingzigou Formation is difficult to determine for the miospores are not very diverse or well preserved. However, considering that (1) compared with the Artinskian assemblages, the sudden increase of “ Cordaitales” pollen (=20.5%, mainly *Cordaitina*) is one of the noticeable features of the Kungurian assemblages in the Cherdyn’ and Aktyubinsk areas of the Cis-Urals (Samoilovich, 1953). In

		Stage	Group	Formation
Permian	Upper Permian	Tatarian	Lower Cangfanggou	Guodikeng
				Wutonggou
				Quanzijie
	Middle Permian	Kazanian	Upper Jijicao	Hongyanchi
		Ufimian		Lucaogou
	Lower Permian	Kungurian		Jingjingzigou
				Wulabo
		Artinskian	Lower Jijicao	Tashikula
		Sakmarian		Shirenzigou
		Asselian		

Table 1: Correlation of the stratigraphical schemes of the Permian in the Cis-Urals & E. Russian platform and N. Xinjiang, NW China.

N. Xinjiang the marked increase of *Cordaitina* first occurred in the Jinjinzigou Fm. (13% on average) although this genus, unlike its generally low quantity upwards in the Cis-Urals, continually flourished through the whole Middle Permian and (2) the overlying Lucaogou Formation correlated with the Ufimian already shows some features of the Kungurian and the underlying Wulabo Formation yields *S. turboreticulatus.* It seems appropriate therefore to ascribe the Jingjingzigou Formation to the Kungurian.

6. The first appearance of *S. turboreticulatus* in the assemblage of the Wulabo Formation is in favor of correlating this formation with the Kungurian, other taxa in common with those from the Kungurian of the Cherdyn' and Akyubinsk areas (Samoilovich, 1953), in addition to a few trilete spores, include *Cordaitina uralensis*, *C. subrotata*, *C. rotata* (Luber), *Crucisaccites ornatus*, *Florinites luberae*, *Cycadopites tunguskensis*, *Protohaploxypinus latissimus*, *P. perfectus*, *Striatoabieites silvestritypus* (Samoil.), *Vittatina subsaccata*, *V. vittifera* and *Hamiapollenites parviextensisaccus*: This lends support to , or at least does not contradict the above correlation.

7. The Artinskian assemblages from the Urals vary greatly, especially in the content of pteridophyte spores and acritarchs, but excluding the acritarchs, all are dominated by gymnosperm pollen, especially *Vittatina*, bisaccate Striatiti and *Cordaitina.* One of the important features is the first occurrence of paucistriate *Hamiapollenites*, *Bascanisporites* and *Urmites* (Djupina, 1974a,b; Faddeeva, 1974, 1990). *Urmites incrassatus* first appeared in the Artinskian and became more common in the late Artinskian- Kungurian (Djupina, 1974a), while this species first appeared in the Tashikula Formation (except its upper part which is possibly equivalent to the Wulabo Formation) of N. Xinjiang and existed continually upwards in the Jingjingzigou Formation. Paucistriate *Hamiapollenites* (e.g. *H. radiatus*) is also first seen in the Tashikula Formation. Consequently, in spite of the strong local color (e.g. the high content of *Calamospora*), the Tashikula Formation with thick sequences (718-2593 m) of esturine facies may be partly Artinskian.

8. The palynological data of the Asselian in the western slopes of the Urals are rather meager, and the assemblages are difficult to distinguish from those of the Sakmarian. As Chuvashov & Djupina (1973) mentioned, if they were taken as a whole, it actually differs from those of Late Carboniferous by (1) the disappearance of large monosaccate (possibly referring to *Potonieisporites* , *Florinites*, *Plicatipollenites*, *Parasaccites*, and particularly "*Remysporites*" =*Noeggerathiopsidozonotriletes*) and bisaccate (e.g. *Gardenasporites*) forms; (2) the appearance of typical and new representatives of *Cordaitina*, *Cycadopites* and acritarchs (Azonaletes); (3) the further development of bisaccate striate forms and *Vittatina*. The assemblages of the Shirenzigou and Tashikula Formations share these features, such as (1) the disappearance of *Remysporites*, *Illinites*, large forms of *Potonieisporites*, *Striatolebachiites* , *Crucisaccites*, *Plicatipollenites* and *Gardenasporites isotomus* Ouyang— more characteristic of early Late Carboniferous (Bashkirian- Moscovian) in N. Xinjiang as well as the absence of *Lycospora*, *Auroraspora*, *Spinozonotriletes* and large *Samoilovitchisaccites* which are more significant in the latest Carboniferous (Stephanian) Au'ertu Formation; (2) the dominance (76%) of bisaccate Striatiti in the Shirenzigou Formation and the high diversity in the Tashikula Formation. Thus the Shirenzigou Formation may be assigned to the Asselian. In addition, *Limitisporites bilabiatus* Ouyang of the Tashikula Formation is not unlike *Gardenasporites tonsus* Krusina, one of the indices of the Sakmarian assemblage. As stated above, the Tashikula Formation also contains some forms with an aspect of Artinskian, therefore, this formation possibly straddles the Sakmarian and Artinskian.

9. The Au'ertu Formation below the Shirenzigou Formation yields cephalopods belonging to the *Prouddenites* zone and roughly corresponds to Zhigulian and lower Orenburgian (the lower *Dunbarites-Parashumadites-Emilites* Zone), i.e. Kasimovian-Gzelian or Stephanian in age (Liang and Wang, 1991). This dating is not in conflict with the assumed Asselian age of the Shirenzigou Formation based on palynology.

We are in agreement with the threefold division of the Permian System in N. Xinjiang, not only because the lithostratigraphy displays such a rhythmic tendency, but also the palynofloras show roughly three stages in progressive evolution. The Lower (l), Middle (2) and Upper (3) Permian palynofloras are characterized respectively by (1) overwhelming dominance of bisaccate striate pollen, (2) high content of *Cordatina* (and bisaccate Striatiti) and (3) appearance of many newly evolved forms with a Mesophytic aspect, including pollen and spores of advanced conifers and ferns. Some Russian palynologists agree with this , for instance, Faddeeva (1990) once said that, the palynological data were not in contradiction with, or rather in corroboration of, the viewpoint of many stratigraphers proposing to divide the Permian into three series, and she took the Kungurian and Ufimian as the Middle Permian. In this paper, the Ufimian and Kazanian are treated as the Middle Permian, and in Table 1 the Cisuralian, Guadalupian and Lopingian Stages as proposed by the Subcommission on Permian Stratigraphy (Jin, 1996) are equivalent respectively to the Lower, Middle and Upper Permian.

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(Note: The other works that have been given in the previous paper as marked by an asterisk are not listed here)

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Paleobotany of the Upper Carboniferous/Lower Permian of the Southern Urals. Part 1. Seeds and Enigmatics

by Naugoinykh S.V.

The Aidaralash section is situated on the western slope of the southern Urals. This section is well known among the stratigraphic community due to intensive and very fruitful work of several international scientific working groups during the last few years. Chief attention was given to Carboniferous/ Permian boundary, which is marked by all the most important taxa, characteristic of Upper Paleozoic biostratigraphy including conodonts, foraminifers, ammonoids etc. Moreover, there appeared the first data on palynological assemblages of this section (Dunn, 1998).

Information about plant megafossils of the Aidaralash section is meager (Asselian-Sakmarian: Vladimirovich, 1986; Artinskian: Dunn, 1997) or completely absent (Gzhelian interval of Aidaralash section). Nevertheless, detailed bed-by-bed collecting of plant megafossils produced quite abundant stems, leaves, roots, generative organs and seeds in Upper Carboniferous and lowermost Permian of the Aidaralash section.

This paper focuses on the preliminary description of seeds from the Upper Carboniferous of the Aidaralash section. Much of the material was collected by A. A, Shkolin (Paleontological Institute, Russian Academy of Sciences, Moscow). Almost all specimens described and figured herein (Fig. 1, Pl. 1) originated from bed 17/2 according to the description of section (cf. Bogoslovskaya et al., 1995), which belongs to *Daixina bosbytauensis-D.robusta* zone of Gzhelian (Upper Carboniferous). The age determination is also supported by the presence of numerous ammonoids *Aristoceras appressum* and *Almites reverendus*. These orictocoenoses, the so-called "goniatite bullions", are characteristic for other flishoid Carboniferous formations (Scott et al., 1997). One specimen (Fig. 2) came from bed 21 (lowermost Asselian, *Sphaeroschwagerina vulgaris-S. fusiformis* zone). Fossil seeds of the present collection can be divided into seven morphotypes preliminarily determined in open nomenclature:

Cardiocarpus sp. A (Fig. 1, B). Seeds of this type are round or almost cylindrical to ovoid, with round base and pointed acute apex, shaped like a sharp "beak". The inner "cast" probably corresponds to upper surface of sclerotesta. The cast is covered by more friable organic tissues, slightly deformed by sediment pressure. This layer may be sarcotesta, i. e. a soft outer cover of integument.

Cardiocarpus sp. B (Fig. 1, D). These seeds are similar to *Cardiocarpus* sp. A by the presence of two distinctive zones (inner "cast" and more soft outer zone). The inner zone may be nucellus with the integumental cover (endotesta and sclerotesta). The outer zone, according to such interpretation, is sarcotesta. The difference between these morphotypes is in the general outline of the seeds. *Cardiocarpus* sp B is much bigger and bears a concave base. One specimen of this morphotype has dense tissues at the base part of seed, which must correspond to chalaza.

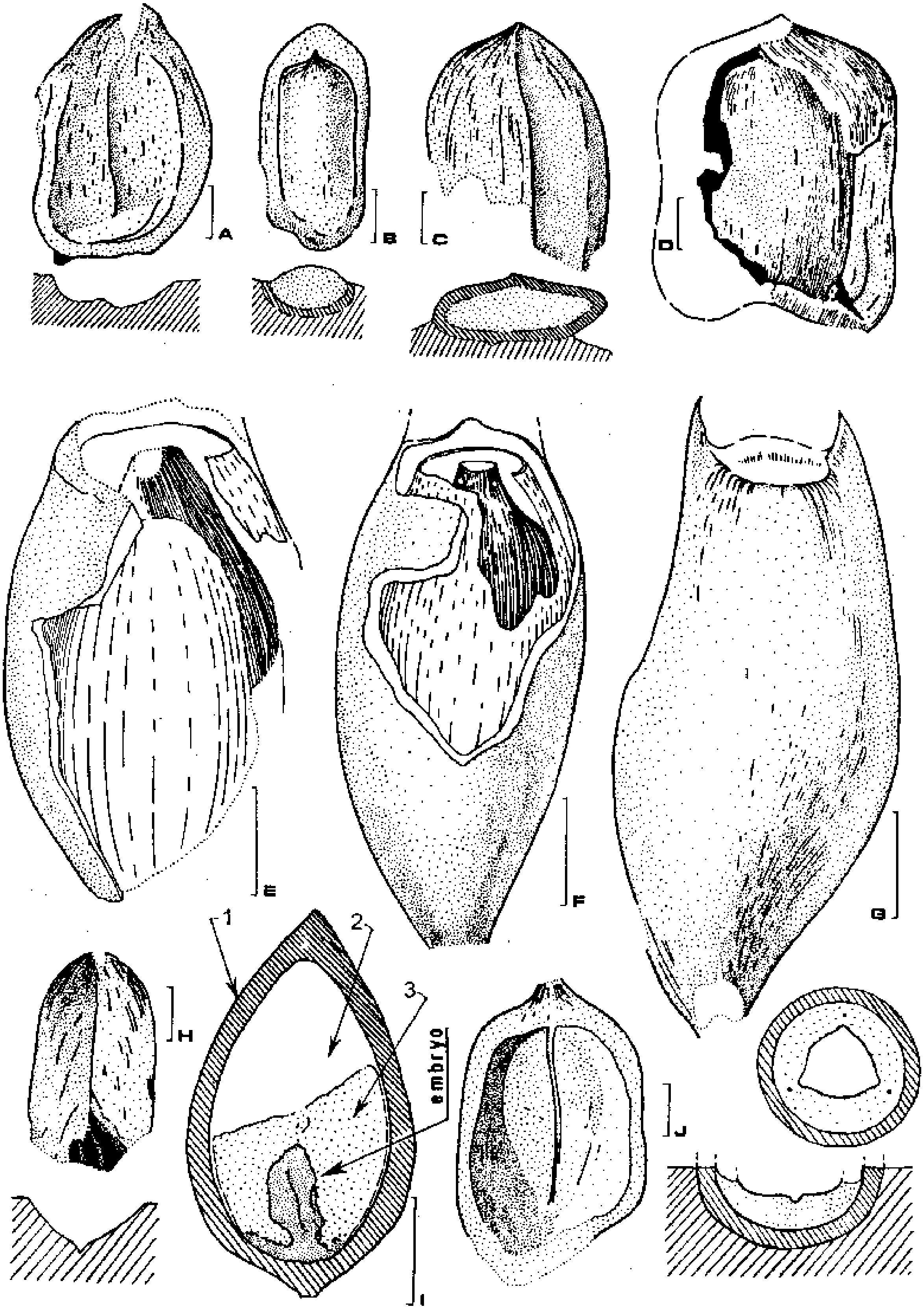

Fig. 1. Seeds from the Gzhelian of Aidaralash section, Southern Urals. General morphology.
A, J - *Trigonocarpus* sp. A; B - *Cardiocarpus* sp. A; C, H - *Trigonocarpus* sp. B; D - *Cardiocarpus* sp. B; E-G - "*Cornucarpus*" sp. (F-interpretation of inner structure); I - Carpolithes sp.
All figured specimens came from one concretion, spec. N 4856/1, Aidaralash, bed 17/2 (*Daixina bosbytauensis* - *D. robusta*). Scale - 1 mm.

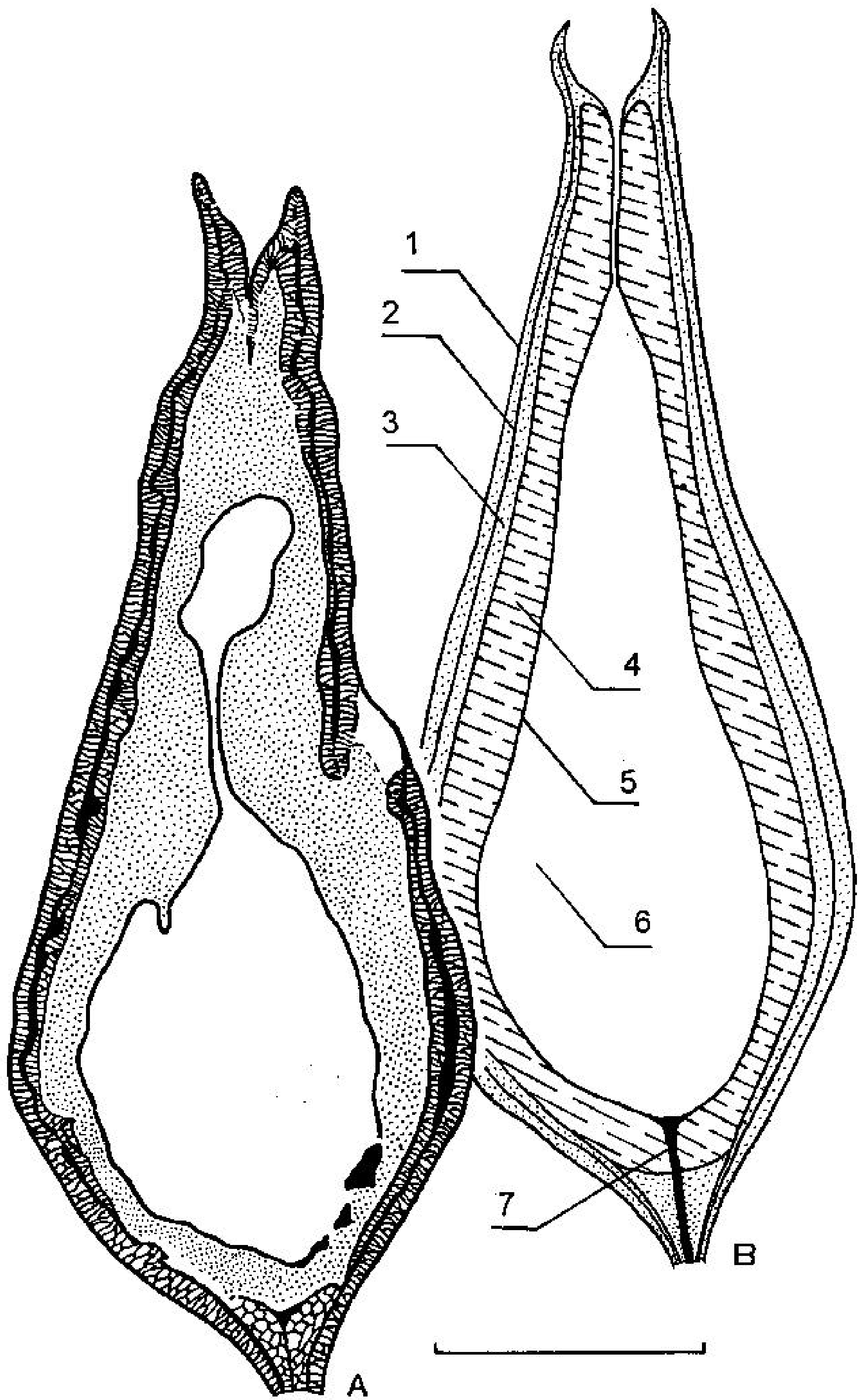

Fig. 2. *Cardiocarpus* (?) sp. C, the seed from the lowermost Asselian of Aidaralash section, Southern Urals. General morphology and inner structure. A - real section, B - interpretation of inner structure: 1 - sarcotesta, 2 -sclerotesta, 3 - endotesta, 4 - nucellus (?), 5 - megaspore membrane, 6 -zone of megagametophyte development, 7 - chalazal conducting tissues.
Figured specimen N 4856/2 came from bed 21 (*Sphaeroschwagerina vulgaris-S. fusiformis* zone). Scale – 0.5 mm.

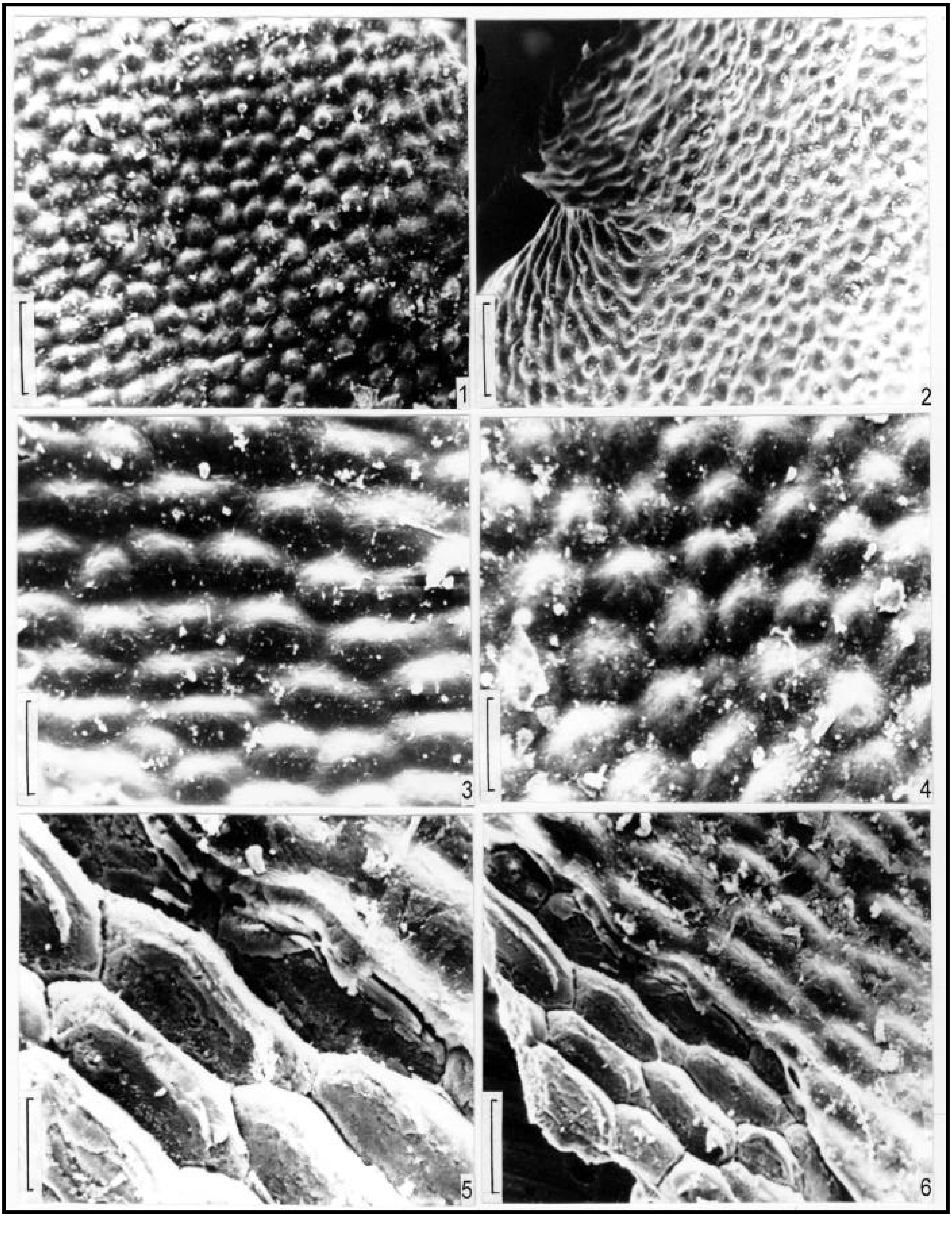

Plate 1. *Cornucarpus* sp. Microstructure of supposed scleroteste surface. 1-2, 4 - basal part of the seed; 3, 5-6 - apical part of the seed, Spec. N GIN 4856/1, Aidaralash, bed 17/2 (*Daixina bosbytauensis D. robusta*). Scale - 100 mkm (1, 2); 40 mkm (3-4, 6); 20 mkm (5).

Cardiocarpus ? sp. C (Fig. 2). In general outline, these seeds are fusiform, with the seed base slightly wider. The apex is narrow, and acute. The integument consists of three zones: sarcotesta, sclerotesta and endotesta. The sarcotesta is constructed of prolonged cells, which are perpendicular to sclerotesta surface. The thin sclerotesta is represented by very dense tissues, probably sclereids. The inner zone of' integument (endotesta) is constructed of ovoid and prolonged cells, which are similar to cells of sarcotesta. The inner zone of integument (endotesta) is constructed of ovoid and prolonged cells, which are similar to cells of sarcotesta. The nucellus of *Cardiocarpus* ? sp. C conforms to the inner surface of the integument. The nucellus is not well preserved and consists of parenchyma cells. The only well distinguished structure is the thin-walled, slightly deformed megaspore membrane.

Trigonocarpus sp. A (Fig. 1, A, J). Very particular seeds with three distinct layers. The inner zone (see Fig. 1, J, right) is obviously nucellus. The nucellus bears longitudinal ribs, which correspond to vascularisation of integumental endotesta (Fig. 1, J, shown by points area). The next one is a very thin layer, which probably is sclerotesta. This layer lies between endotesta and sarcotesta. Sarcotesta is represented by soft organic tissues, which are shown by lined area (Fig. 1, J).

Trigonocarpus sp. B (Fig. 1, C, H). Seeds with short fusiform outlines bear three robust prolonged ribs and covered by fine striae. One specimen (Fig. 1, C) has two layers, but the latter are difficult to interpret.

Carpolithes sp.(Fig. 1, I). This morphotyte is represented by one single specimen in my collection. The seed is broken along its main axis. The ovoid seed has two well-developed layers. The outer layer, the sclerotesta of integument, is very dense. The inner layer is nucellus. Some organic matter is deposited on the lower part of the seed in the nucellus area. This matter can be interpreted as megaspore membrane with megagametophyte tissues. In the middle part of proposed megagametophyte can be seen a prolonged structure with several (maybe three?) longitudinal folds. Probably it is an embryo with embryonic cotyles. Quite similar structures were described as embryos in the conifer seeds of the Walchiaceae family (Mapes et al., 1989).

Cornucarpus sp. (Fig.1, E-G). These enigmatic remains can be preliminarily interpreted as seeds, but their nature is still unclear. These remains are similar to the seeds described as *Cornucarpus kojimensis Neub*. (Neuburg, 1965; Ignatiev, 1983). These specimens have ovoid outlines, a prolonged base and bicornuted apex (Fig.1, G). One of the specimens (Fig. 1, E) is chopped off at an oblique angle, the circumstance that allowed us to study its inner structure. The innermost layer (on fig, E- F shown by dense lines) may be interpreted as megaspore membrane. More outer layer may correspond to the outer surface of the nucellus. The top layer is integment. Integumental surface was studied by a scanning electron microscope (Plate 1). We can see a membrane covered by specific papillate relief. The papillae are round and isometrical at the seed's basal part (Plate 1, 1-2, 4), or prolonged ovoid at the apical part of the seed (Plate 1, 3, 5-6). The stratificated nature of this membrane is clearly seen in several places (Plate 1, 5-6). Seeds with specific papillary relief of sclerotesta were described by the present author (Naugolnykh, 1997) as *Cardiocarpus* sp. SVN-1 from the Urminskian formation (Sarginian horizon, Upper Artinskian) of the Middle Cis-Urals. It is possible that two morphotypes belonged to related plants.

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Conclusions

Upper Carboniferous floras of the Southern Cis-Urals were taxonomically quite diverse and included conifers (seeds of conifer affinity and undescribed stems of Tylodendron type), trigonocarpoid pteridosperms (*Trigonocarpus* sp. A, *Trigonocarpus* sp. B) and, most probably, cordaites (Dadoxylon woods and some seeds of *Cardiocarpus* sp.). Good preservation and considerable amount of plant megafossils let us hope that our knowledge about Late Carboniferous/ Early Permian vegetation of the Southern Urals will rapidly extend in the near future.

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Degraded Permian Palynomorphs from North-East Himalaya, India

by Suresh C. Srivastava, A. K. Srivastava, A. P. Bhattacharyya and Rajni Tewari

The Permian sequence of West Siang District, Arunachal Pradesh in the North-East Himalayan region of India is divided into the Rangit and Garu formations (Text-figures 1, 2). Each is further divided into different members and lithounits (Srivastava *et al*., 1980). The Following lithological succession is recognized in the area:

Siwalik Group (Miocene-Oligocene)				
---Thrust---				
PERMIAN	Garu Formation		3.	Coarse grained ferruginous sandstone, shale with concretions.
			2.	Fine to medium grained white feldspathic sandstone, intercalated carbonaceous shale and coal with coal ball.
			1.	Bluish grey medium to coarse grained sandstone intercalated carbonaceous shale and coal with coal ball.
	Rangit Formation	Rilu Member		Olive green splintery shale greenish siltstone and mudstone with scattered clasts
		Diamictite Member		Massive conglomeratic rock with poorly sorted angular clast set in dark grey or greenish argillaceous matrix.
---Thrust---				
	Miri Formation			Dominantly quartzite and limestone

The Garu Formation, represented by alternating sequences of sandstone, carbonaceous shale and coal, contains numerous faunal coal balls (Anand-Prakash *et al*. 1988) as well as brachiopods, gastropods, cephalopods and crinoids. The coal balls have yielded spore-pollen assemblages, acritarchs, scolecodont jaws, chitinozoa (?) and foraminifera. The evidence suggests the deposition in marginal swamps with periodic marine incursions during Early Permian (Srivastava & Bhattacharyya, 1998).

Palynological studies of carbonaceous shales belonging to different lithounits of the Permian sequence of West Siang indicate presence of five palynozones (Srivastava & Bhattacharyya, 1996).

Palynozone-1, characterized by *Plicatipollenites stigmatus*, is derived from the Rilu Member of the Rangit Formation. The other four zones are represented by *Callumispora gretensis*, *Crucisaccites indicus*, *Pseudoreticulatispora barakarensis*, and *Primuspollenites* plus *Rhizomaspora* belong to the Garu Formation. The assemblages are similar to the mioflora of the Talchir, Karharbari and Barakar formations of the Permian Gondwana sequence of Peninsular India.

Morphotaxonomic investigations of palynological assemblages indicate frequent occurrences of degraded spores and pollen. Some of the grains show the presence of the fungal colonies over their surfaces. Other patterns are comparable with pyritic degradation and structures known to be developed due to attack by the saprophytic fungal organism *Palynomorphites diversiformis*. The following types of degradation and microbial activity are recorded in the assemblages.

Pyritic Degradation

The surfaces of pyrite affected grains exhibit different patterns ranging from variously shaped cavities/perforations/holes/pits or circular to rosette type grooves and meandering scratches. Pyritization of spore-pollen results in intense damage of assemblages. Although the pyrite crystals are dissolved during the process of maceration, sites of deposition are discernible under transmitted light in the form of blisters. Neves and Sullivan (1964) described three types of modification patterns of spore exine structure due to pyrite crystalization. The present flora contains all three types of pyritic degradation.

i. <u>Simple Polygonal Cavities</u> (Plate 1, figures 1-3.)

This is the most common degradation observed in almost all types of spores and pollens - trilete, zonate-cingulate spores; mono - bisaccate, striate non striate pollens. The affected grains bear circular to irregularly shaped perforations/holes or pits. Their borders are normally smooth but occasionally slight thickening is noticed. The cavities range in size from 2-25µm in diameter; interestingly, the outer margin and shape of the degraded grains are well preserved and their body and saccus ornamentation are also perfectly demarcated.

Affected grains : *Callumispora*, *Granulatisporites*, *Densoisporites*, *Indotriradites*, *Parasaccites*, *Cahenisaccites*, *Rhizomaspora*, *Scheuringipollenites*, *Faunipollenites*, *Striatopodocarpites*, *Striatites*.

ii. <u>Compound Faviform Cavities</u> (Plate 1, figures 4, 5)

Simple perforations surrounded by clusters of small, 1-20µm in diameter spherical structures are also present in the assemblage. Strands of residual exine that are separated from the adjacent polygonal perforations are well displayed. Neves and Sullivan (1964) have discussed the host-mineral relationship which ultimately produces such structures.

Affected grains: *Callumispora*, *Parasaccites*, *Paravesicaspora*, *Scheuringipollenites*.

iii. <u>Compound Cribrate Cavities</u> (Plate 1, figures 6-8.)

Commonly, mono and bisaccate pollen grains possess a number of cavities in a row or in branches scattered over the surface, generally over the zone of attachment of body and saccus. The cavities are normally circular, 5-15 µm in diameter and with a well defined margin. The characteristic features and blisters of cribrate cavities were studied in detail by Neves and Sullivan (1964), who suggested that they are caused by aggregates of large pyrite crystals.

Affected grains: *Potonieisporites*, *Plicatipollenites*, *Parasaccites*, *Caheniasaccites*, *Rhizomaspora*, *Scheuringipollenites*, *Paravesicaspora*, *Faunipollenites*, *Striatites*, *Striatopodocarpites*, *Tiwariasporis*, *Crescentipollenites*.

Pyrite degradation is well-known in fossil spore-pollen assemblages (Love 1958, 1962; Elsik 1966, 1971; Moore 1963; Neves & Sullivan 1964; Lele & Shukla 1980; Tiwari *et al*, 1990). While investigating the Gondwana palynomorphs of India, Tiwari *et al*. (1990) demonstrated that the formation of pyrite inside pollen and spores is the result of bacterial activity during early diagenetic stage under specific conditions. Neves and Sullivan (1964) also favored bacterial action for pyrite precipitation. Bacterial decay releases sulfide ions, and as a result affected spore exine becomes a center for pyrite formation. During the process crystals develop inside the spaces formed by bacterial action.

Fungal Degradation

Spores-pollen possessing spherical cells and skeletonization of body exine and saccus have been attributed to fungal degradation.

i. Fungal Colony (Plate 1, figures 9-11.)

Randomly distributed coccoid cells measuring 1-2 μm in diameter are observed over the surface of affected grains. The cells normally occupy the saccus of mono and bisaccate grains. Aggregates of cells are large in number and their distribution over the entire surface commonly obscures the original shape of the grain, forming a deceptive undulating margin. In between the cells, there is delusive evidence of filaments. However, it is difficult to mark their distribution pattern and nature due to overcrowding of cellular structures. Cells are well defined, dark and contain pale yellow to colorless contents.

Affected grains : *Parasaccites, Virkkipollenites, Faunipollenites, Striatites, Scheuringipollenites, Paravesicaspora, Rhizomaspora.*

ii. Skeletonization Of Exine (Plate 1, figures 12-15.)

In a few trilete and saccate grains the sculpture of the exine has been converted into a reticulate pattern. The structure possibly represents fungal growth on thick walled spores, where initial destruction of spore exine was followed by development of reticulate pattern by skeletonization of the filaments of the decaying fungal organism.

Affected grains: *Callumispora, Leiotriletes, Indotriradites, Densoisporites, Scheuringipollenites, Rhizomaspora*.

The occurrences of coccoid cells and skletonization of spore exine were reviewed fully by Moore (1963) whom considered them to represent the saprophytic fungus *Palynomorphites diversiformis*. The organism attacks the exine, sometimes completely destroying the spores, but commonly leaving a skeletal pattern reflecting the structure of the exine. Thick walled spores produce a *Palynomorphites* skeleton with the concentric development or filaments around cavities of holes (Plate 1, figure 13) whereas, thin walled laevigate spores show a network of filaments.

The saprophytic fungus *Anthracomyces cannellensis* on the surface of micro and megaspores is known from Carboniferous and Permian occurrences (Renault, 1900). Well documented evidence of fungal hyphae and colonies over the surface of Carboniferous miospores, e.g. *Schulzospora, Lycospora, Densosporites, Leiotriletes, Granulatisporites, Convolutispora, Punctatisporites, Microreticulatisporites, Knoxisporites, Auroraspora* and *Diatomozonotriletes*, favors a saprophytic role (Moore, 1963). The experimental work of Goldstein (1960) and Sangster and

EXPLANATION OF PLATE 1

Pyritic Degradation

Figure 1	*Callumispora gretensis* showing simple circular cavities.
Figure 2	*Callumispora gretensis* with irregular shaped large cavities.
Figure 3	*Parasaccites korbaensis*, saccus with polygonal cavities indicating the site of pyrite crystals.
Figure 4	*Callumispora tenuis* showing compound faviform cavities near the point of attachment of saccus and body.
Figure 5	*Callumispora tenuis* showing faviform cavities with distinct margin.
Figure 6-8	Different grains of *Callumispora gretensis* showing compound cribrate cavities.

Fungal Degradation

Figures 9-10	*Scheuringipollenites maximus* showing randomly distributed coccoid cells of *Palynomorphites diversiformis* over the entire surface of saccus and body.
Figure 11	*Caheniasaccites indicus* showing cells of *Palynomorphites diversiformis* mainly over the saccus.
Figure 12	*Callumispora tenuis* spore showing initial destruction of exine by fungi in the form of circular to polygonal areas.
Figure 13	Complete damage of *Callumispora* spore in the form of skeleton.
Figure 14	*Vesicaspora* sp. Pollen showing reticulation of saccus.
Figure 15	*Scheuringipollenites maximus* showing skeletonization of saccus.

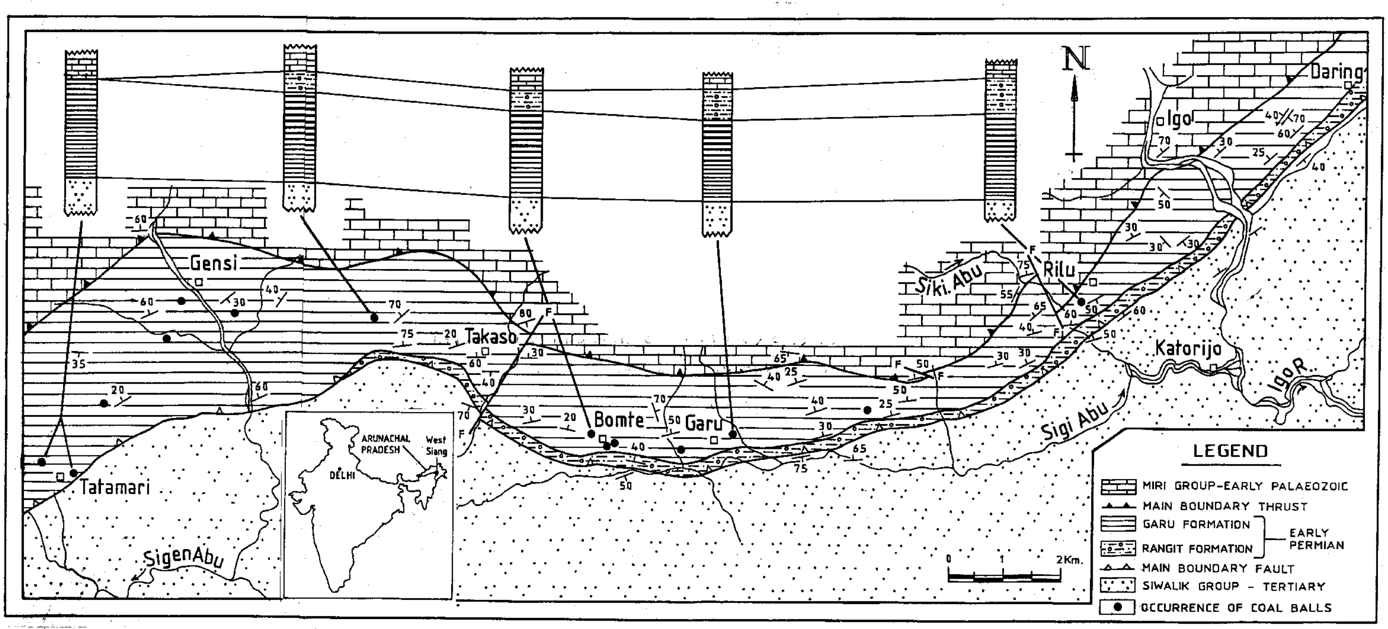

Figure 1 Geological map of the area indicating five lithounits. Inset shows the location of Arunachal Pradesh and West Siang District (Srivastava & Bhattacharyya, 1998).

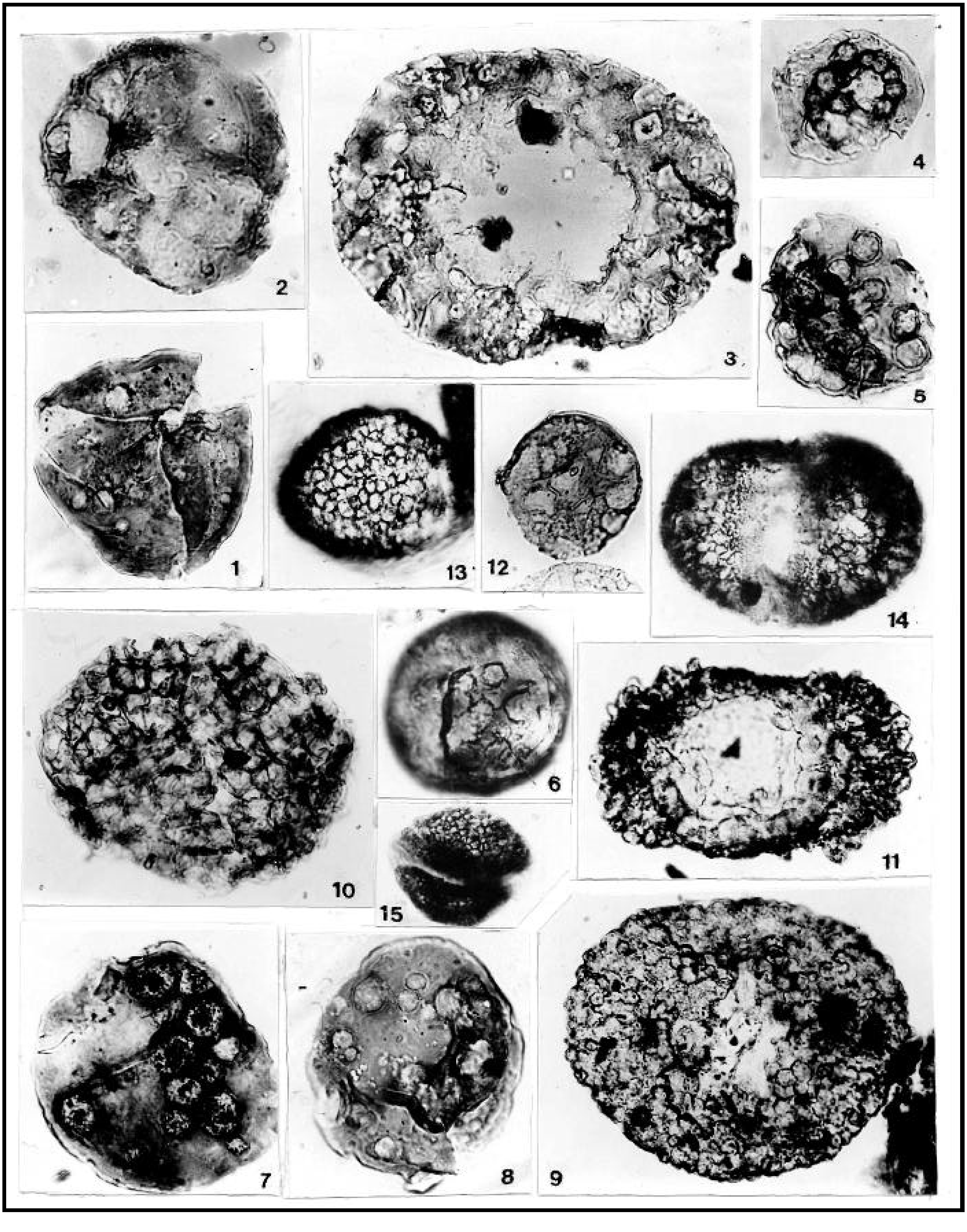

Plate 1.

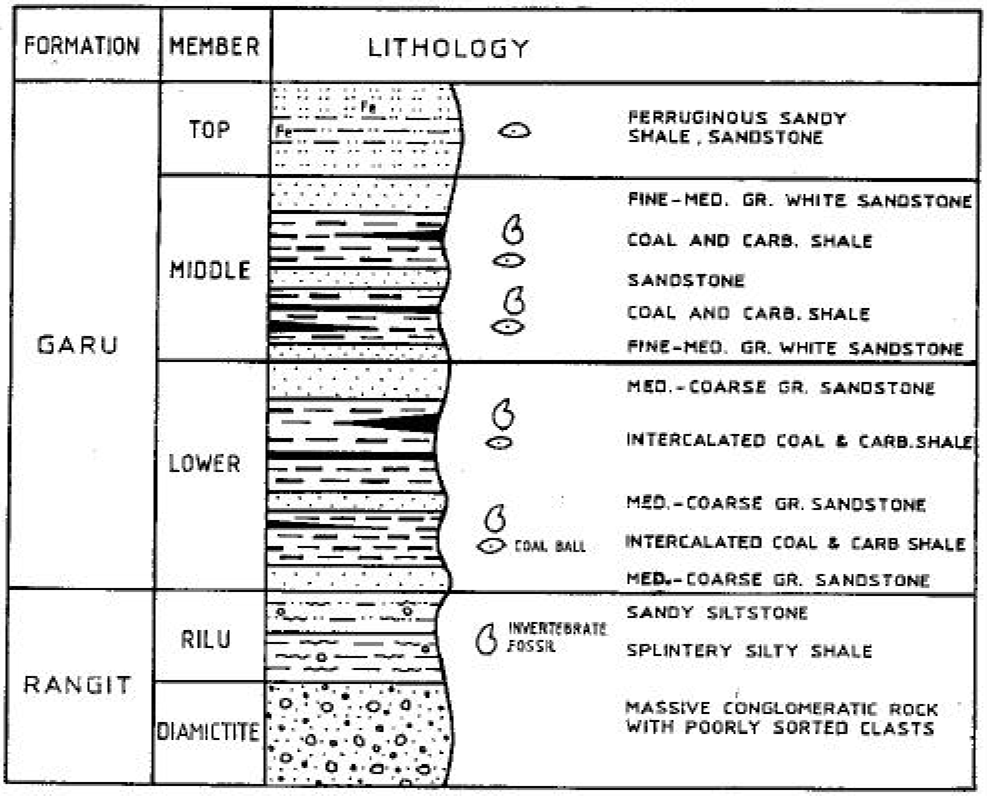

Figure 2 Permian lithological succession of West Siang District.

Rale (1961) clearly demonstrates that phycomycetaceous fungi, especially chytrids, attack the pollen of modern plants. Chytrid-like organisms discovered on the Cordaitean pollen *Sullisaccites*, of Pennsylvanian age, exemplify the parasitic association of fungi in fossil specimens (Millay & Taylor, 1978).

Discussion

Biodegraded spore-pollen assemblages are common in the Permian sequence of India (Bharadwaj & Tiwari 1977; Tiwari & Singh 1986) but they have not been analyzed due to poor preservation. However, Lele & Shukla (1980) have described the degraded pollen from the Talchir Formation and direct and indirect microbial action and pyritic degradation of exine have been evaluated by them. Tiwari *et al.* (1990) have observed that the exine is preferentially affected by pyrite precipitation in gymnospermous pollen whereas in pteridophytic spores pyritic growth is frequently found in the contact area and on the germinal aperture.

The present assemblage provides for the first time the direct evidence of fungal attack in Permian spores and pollen of Arunachal Pradesh, India. Studies on the degradation of Permian plant fossils of India have brought out the significance of fungi and bacteria as degrading agents. The plaque/pit-like structures over the surface of seed cuticle recovered from glossopterid fruitification showing possession of bacterial colony and degraded damaged cellular tissues suggest the possible evidence of bacterial degradation (Srivastava & Tewari 1994). Occurrence of fungal hyphae and spores along with degraded cellular tissues in leaf specimens indicate the parasitic nature of fungi (Srivastava, 1993).

This assemblage containing degraded and damaged palynomorphs in all probability reflects bacterial and fungal activities. However, critical investigation (at present under progress) at electron microscopic level will help to determine the specific host-pathogenic relationship.

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Diverse Permian Coral Faunas are Widely Distributed in Thailand

by Henri Fontaine

Permian corals are common in Thailand. They have been observed at more than one hundred localities. They are prolific in many areas where they are associated with diverse faunas and abundant algae. They may locally form reefs. However, their stratigraphic distribution is not uniform. The variation of the coral fauna composition provides information on Permian paleogeography.

1 - Biostratigraphy

Corals have been found in all the stages of the Permian, but not in the same quantity and the same diversity.

1A - Upper Permian or Lopingian

In the Upper Permian rocks of Thailand, corals show a low diversity and are generally not abundant. They have been found only at a few localities.

Dorashamian (Changhsingian) rocks are not widespread in Thailand and are known in a few small areas of north Thailand (Lampang area), northwest Thailand (Chiang Dao area) and east Thailand (Klaeng area according to new data of a current study). Corals have been noticed only in Lampang area. An argillaceous limestone exposed along Huai Thak stream has yielded rare solitary Rugosa which have been assigned to *Asserculinia* (Fontaine and Vachard 1988, p. 17). A sample of *Waagenophyllum* cf. *virgalense* (Waagen et Wentzel) has been collected from the same area; it might also belong to the Dorashamian (Yanagida 1988).

Dzhulfian (Wuchiapingian) rocks are well dated only in a few areas of north and east Thailand. In north Thailand (Lampang area), two localities (Phra That Muang Kham and Ban Cham Kha) have yielded solitary (*Lophophyllidium*) and fasciculate (*Liangshanophyllum*) corals (Fontaine and Vachard 1988). In east Thailand, solitary (*Paracaninia*) and fasciculate (*Waagenophyllum*) corals have also been found; in addition to that, a massive coral (*Aridophyllum*) has been collected from limestone that is close to the boundary between Capitanian and Dzhulfian; it is not certainly Dzhulfian in age (Fontaine et al., 1997, new data). In northwest Thailand in Sop Pong area between Chiang Dao and Mae Hong Son, *Waagenophyllum* cf. *virgalense* (Waagen et Wentzel) has been collected from a limestone which belongs probably to the Dzhulfian, but might be a little older (Fontaine et al., 1993).

1B - Middle Permian or Guadalupian

Middle Permian limestones contain the richest and the most diverse Permian coral faunas of Thailand. They are distributed all over the country, without being perfectly uniform. At an important number of localities, large coral colonies are prominent and massive Rugosa are in abundance.

Midian limestones containing *Yabeina* and *Lepidolina* are widespread in east Thailand along the Cambodian border (Fontaine et al., 1997). They are locally rich in corals: Tabulata (*Sinopora*), solitary Rugosa (*Tachylasma*, *Lophocarinophyllum*, *Khmerophyllum*), fasciculate Rugosa (*Waagenophyllum*) and massive Rugosa (*Multimurinus*, *Parawentzelella*). *Multimurinus* is represented so far by a single species. In Peninsular Thailand, corals are also present, but are less diverse; they consist of Tabulata (*Sinopora*, *Protomichelinia*) and fasciculate Rugosa (*Waagenophyllum*). They are associated with *Hemigordiopsis* and *Shanita* (Fontaine and Suteethorn, 1988).

Murgabian limestones are widespread in a large part of Thailand; they are richer in corals than the Midian limestones. Corals have been found at many localities of central, northeastern, northern, northwestern Thailand as well as in Peninsular Thailand where the composition of the fauna is peculiar. In northern Thailand, the coral fauna appears to be poor, as compared with the faunas of the other areas, maybe because of a lack of intensive studies. At two localities of Nan area, Tabulata (*Sinopora*) and fasciculate Rugosa (*Pseudohuangia* aff. *aberrans* Fontaine and *Chihsiaphyllum* aff. *kanmerai* Sugiyama) have been observed (Fontaine et al., 1994). In northwest Thailand along the road from Chiang Dao to Mae Hong Son, *Multimurinus khmerianus* Fontaine has been found at Ban Mae Suya and is associated with *Neoschwagerina margaritae* and *Kahlerina* sp, foraminifers indicating a Late Murgabian age (Fontaine et al., 1993). Flugel (1997) has identified 3 species of *Multimurinus* from the same area. In central Thailand (areas of Muak Lek, Saraburi, Lopburi, Lam Narai, Khok Samrong, Takfa, Ta Khli, Phetchabun), many localities contain rich and diverse coral faunas; this paper is not the place to go into detail about these faunas. The corals consist of Tabulata (*Sinopora*, *Protomichelinia*, *Tetraporinus*), solitary Rugosa without dissepiments (such as *Lophophyllidium*), solitary Rugosa with dissepiments (*Pavastehphyllum*, *Laophyllum*, *Iranophyllum*), fasciculate Rugosa (4 species of *Pseudohuangia*, rare *Waagenophyllum*, *Chaophyllum*, *Chihsiaphyllum*, *Yatsengia*) and massive Rugosa (7 species of *Ipciphyllum*, 5 species of *Multimurinus*, 3 species of *Crassiparietiphyllum*, 1 species of *Paraipciphyllum* and of *Wentzelophyllum*). *Khmeria* has been found in a Murgabian-?Midian limestone. In northeast Thailand, the

Murgabian is less developed than in central Thailand. The coral fauna is slightly different. It is composed of Tabulata (*Sinopora*), solitary Rugosa (*Lophophyllidium*, *Pavastehphyllum*), fasciculate Rugosa (*Pseudohuangia*, *Chihsiaphyllum*) and massive Rugosa (*Ipciphyllum*, *Phaphungia*, *Multimurinus*, *Crassiparietiphyllum*). In Peninsular Thailand, the Murgabian is very poor in corals at its base and moderately rich at its top with a part of the corals continuing into the Midian. The corals consist of Tabulata (common *Sinopora*, very rare *Protomichelinia*), common solitary Rugosa (*Amplexocarinia*, *Ufimia*, *Lophophyllidium*, *Paracaninia*, *Plerophyllum*, *Pavastehphyllum*, *Iranophyllum*), fasciculate Rugosa (*Waagenophyllum*) and massive Rugosa (*Chombungia*, *Paraipciphyllum*, *Wentzelella*).

Corals have been collected from limestone of northeast Thailand considered Kubergandian or partly Kubergandian in age; they consist of Tabulata (*Protomichelinia*, *Sinopora*), solitary Rugosa (*Lophophyllidium*) and fasciculate Rugosa (*Chihsiaphyllum*, *Pseudohuangia*).

1C - Lower Permian or Cisuralian

The Lower Permian of Peninsular Thailand is composed mainly of shale, pebbly mudstone and sandstone; it contains no coral. In central and northeast Thailand, corals are present at several localities.

The upper part of Lower Permian (Artinskian) in northeast and central Thailand has yielded a coral fauna which is not diverse and consists generally of Tabulata (*Protomichelinia*) which are locally in abundance. *Pseudohuangia* has been found at a locality of central Thailand (small hill southeast of Khao Amorn Rat).

The lower part of the Permian (Asselian – Sakmarian) of northeast Thailand (Ban Na Din Dam, Phu Khao) contains a diverse fauna composed of solitary Rugosa without dissepiments (*Cyathaxonia*, *Paraduplophyllum*, *Amplexocarinia*, *Calophyllum*, *Lophophyllidium*) and with dissepiments (*Caninia*, *Caninophyllum*, *Pseudozaphrentoides*, *Amygdalophylloides*), fasciculate Rugosa (*Densicolumnophyllum*) and massive Rugosa (*Anfractophyllum*, *Nephelophyllum*, *Antheria*; these three genera belong to the same family, the Kepingophyllidae, which has been recognised in China since 1974). In central Thailand, *Pseudozaphrentoides* has been found south of Khao Pang Sawong in Muak Lek area. At Khao Tham Rusi Laat west of the road from Lam Narai to Phetchabun (Coordinates: 15°48'10"N, 100°57'45"E), a more diverse fauna is present without being in abundance; it consists of: solitary Rugosa (*Pseudozaphrentoides*, ?*Caninophyllum*), fasciculate Rugosa (*Akagophyllum*) and massive Rugosa (*Chusenophyllum*). It is associated with few foraminifers which do not indicate a precise age; the corals focus on an Early Permian age (Fontaine and Suteethorn, 1995).

1D - Biotic crisis of the end of the Permian

This crisis is already clear in the preceding paragraphs. The Rugosa as well as the fusulinaceans disappeared completely at the closure of the Permian. Before that, the corals experienced high casualties in two events. At the end of Middle Permian ("Pre-Lopingian crisis" of Jin, 1993), the cerioid Rugosa disappeared almost completely. In Thailand, only a single specimen of a cerioid colony (*Aridophyllum*) has been found in a level corresponding to the boundary between Capitanian and Dzhulfian. This colony is possibly Early Dzhulfian in age, but a further study is necessary to decipher precisely its age. A severe incidence of extinction occurred also at the end of the Murgabian with the disappearance of the important *Ipciphyllum* assemblage.

2 - Paleobiogeography

Forty years ago, the Permian of Thailand appeared to be monotonous and a single term "Ratburi Limestone" was used to designate all the Permian limestones of Thailand. This is no longer so. Two regions in particular are recognised as very different from each other: 1 - a region covering a large part of Thailand (east Thailand along the Cambodian border, a great part of central Thailand and northeast Thailand); this region displays large autochthonous accumulations of limestone deposited on a broad shelf and is rich in corals; the fossils are similar to those found in Cambodia, Laos, Vietnam and South China. 2 - Peninsular Thailand; this region extends to northwest Peninsular Malaysia and has been the subject of a short note in Permophiles (Fontaine, 1991) and of a longer paper in another periodical (Fontaine et al., 1994). Genera of corals such as *Ipciphyllum* or *Pseudohuangia* as well as genera of fusulinaceans such as *Lepidolina*, *Yabeina*, *Neoschwagerina* or *Verbeekina* are absent from this region.

Corals are different in the two regions as well as foraminifers; this difference exists for almost all the stages of the Permian. The list of the fossils mentioned in the previous paragraphs gives an idea of this difference. Fontaine et al. (1994) gave more detailed information.

Lower Permian of Peninsular Thailand is barren of corals; it consists of clastic rocks which are partly glacial deposits for some authors. On the contrary, carbonate dominated facies are well developed in the first region and contain corals with diverse forms of Rugosa, and in particular, massive Rugosa.

Middle Permian of Peninsular Thailand is very poor in corals at its base and growth bands have been noticed in the rare samples of massive corals collected from this part of the Permian (Fontaine and Jungyusuk, 1997); these bands appear to suggest a seasonal climate. At the top of Middle Permian, corals do not display growth bands; they may be locally in a relative abundance, they are largely peculiar. They suggest a warmer, less-seasonal climate than that of the beginning of Middle Permian. In the first region, coral faunas are prolific and diverse in all the Middle Permian stages, reefal environments are suggested. This high diversity indicates a uniform warm climate and a shallow sea. The affinities of the corals are clearly with faunas of Cambodia, Laos, Viet Nam and South China. Growth bands have yet to be observed in the corals of all the Middle Permian of this first region.

Corals of the Upper Permian are a strongly declining fauna. They do not provide much information on biogeography.

The corals of north and northwest Thailand remain poorly known. The large deposition of limestone during all the Permian (Fontaine et al., 1988) and the characteristics of the coral and fusulinacean faunas collected so far, however suggest a dissimilarity of northwest Thailand with Peninsular Thailand, which has been indicated in some common paleogeographic reconstructions.

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New Paleontological Data from the Early Kazanian Type Area

by V.M. Igonin and O.N. Klevtsov

According to a decision of the Russian Stratigraphic Committee, the composite Early Kazanian type section is defined as located in the upper reaches of the Sok River, at the settlements of Baitugan, Kamishla, Krasny Yar (Samara region of Russian Federation). The area is well known among geologists, and has been extensively studied paleontologically. However, we could not find in available geological literature any information about one of the most important Late Permian biological groups, foraminiferids, before conducting this study.

The authors recovered a rich foraminiferal complex, including approximately 70 species of 26 genera and 15 families, mainly represented by Nodosariidae (genera *Nodosaria*, *Pseudonodosaria*, *Lingulonodosaria*, *Geinitzina*, *Jchtyolaria*). Within the Early Kazanian, foraminiferia are confined to three stratigraphic levels: Baituganian ($P_2kz_1^1$), Kamishlinian ($P_2kz_1^3$), and Krasnoyarian ($P_2kz_1^3$).

Baituganian foraminiferia are most abundant and diverse. They include 54 species, 17 genera, 9 families among which are *Nodosaria hexagona* (Tscherd.), *N. elabugae* Tscherd., *Lingulonodosaria clavata* Paalz., and *L. kamaensis* K.M.-Macl.

Kamishlinian complex is the least diverse. It includes 16 species, 10 genera, 12 families among which, including secretory calcareous forms, are such agglutinated species as *Hyperammina borealis delicatula* Gerke, *Reophax compositus compositus* Voron., and *Glomospira artictdosa* (Plumm.).

Krasnoyarian layers were found to contain 30 species of 13 genera and 7 families including *Pseudonodosaria elongata* K. M.-Macl. and *Falsopalmula permiana* (Tscherd.). The complex is similar to Baituganian but only half as diverse.

There are four species groupings: endemic, relict, cosmopolitan forms, and immigrants.

Endemic forms from the East European Platform are *Nodosaria urmarensis* KM.-Macl., *Pseudonodosaria nodosariaeformis* KM.-Macl., *Lingulonodosaria kamaensis* KM.-Macl., *Falsopalmula permiana* (Tscherd.) and others.

Relict forms are represented by *Hemigordius schlumbergeri* Howch., *Syzrania samarensis* (Raus.), *Geinitzina postcarbonica* Spand, and others.

The immigrants include three species groups:

- Biarmian (North Russian Platform, Taimyr, Novaya Zemlya, Spitsbergen) *Hyperammina borealis delicatula* Gerke, *Hyperamminoides affectus* Voron., *Pseudoammodiscus megasphaericus* (Gerke), *Rectoglandulina borealis* Gerke, and others.
- Species which are widespread in the Zechstein of Western Europe: *Ammodiscus bradynus* Spand., *Tetrataxis lata* Spand., *T. corona* Cushm. et Wat., *Lingulonodosaria clavata* Paalz, and others.
- Australian species: *Reophax aff. belfordi* Cresp., *Glomospira articulosa* (Plumm.), *Trepeilopsis australiensis* Cresp.

Pseudoammodiscus kinkelini Spand., *Nodosaria krotowi* Tscherd., *Geinitzina postcarbonica* Spand. and some others are cosmopolitan forms.

The immigrants and cosmopolitans offer an opportunity to correlate the Early Kazanian of this type area with other regions of the world.

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Uniform Usage of Upper Carboniferous and Lower Permian Stage Names

by V. I. Davydov and Claude Spinosa

The International Commission on Stratigraphy recently ratified a standard Permian Time Scale consisting of three series: (Lower Permian) Cisuralian Series with stratotypes in the southern Ural Mountains of Russia and Kazakhstan, (Middle Permian) Guadalupian Series with stratotypes in the Guadalupe Mountains of southwestern U.S.A. and (Upper Permian) Lopingian Series with stratotypes in south China. Having approached international consensus on the subdivisions of Permian time, it is now appropriate to seek agreement on English spelling of geographic and stratigraphic names involved. We are close to achieving a common international language, and should now seek consensus on spelling.

The present report suggests standards for spelling of Upper Carboniferous and Lower Permian terms that were originally published in Russian. Many of the Russian stratigraphic terms appear in the literature in several different forms: as many as five different English spellings have been employed for the same term. Some differences can be attributed to simple case changes that occur with words in the Russian language. We offer a standard English spelling and invite suggestions and corrections from our colleagues. Future reports will seek to develop uniformity for Chinese terms.

Stages, Substages, Horizons (or Regional Stages) of the Russian Upper Carboniferous and Lower Permian

Stage, substage or horizon names of Russian origin are transliterated directly into English, letter by letter and the "an" or "ian" ending is added. For example, ? ???????? transliterates directly as Artinskyi and translates into Artinskian. However, historically, certain transliterations have been made without the "sk." For example, Sakmarskyi is usually translated as Sakmarian rather than "Sakmarskian." Terms that are widely used in literature in one form should continue with such usage; those occurring in both forms - with the "sk" and without, should be used without "sk."

Formations, Members, Beds and Sections

We suggest direct transliteration of these terms from Russian into English as the most expeditious procedure. In some cases, the name of the section and the geographic name providing that name are the same, for example the Nikolsky section derives its name from Nikolsky village. In this case the name of the village and the name of the section are the same. Some confusion arises when the names of the section and the village differ slightly. For example, the Kondurovsky (? ???????????) section derives its name from Kondurovka (? ?????????) village. ? ??????????? should be transliterated as the Kondurovsky section, rather than Kondurovka (? ?????????).

The term"Gorizont", for example the Tastubskyi Gorizont, Tastubsky Horizon, or Tastubian, has been used in Russian Literature with a regional connotation. Some terms, however, such as Baigendzhinian and Aktastinian, are being recognized as international standards for substages.

Russian Upper Carboniferous and Lower-Middle Permian Terms and Suggested Usage

Direct Transliteration of Russian	Translation into English
Tatarskyi Yarus	**Tatarian Stage**
Vyatskyi Gorizont	Vyatsky Horizon or Vyatskian
Severodvinskyi Gorizont	Severodvinsky Horizon or Severodvinian
Urzhumskyi Gorizont	Urzhumsky Horizon or Urzhumian
Kazanskyi Yarus	**Kazanian Stage**
Ufimskyi Yarus	**Ufimian Stage**
Sheshminskyi Gorizont	Sheshminsky Horizon or Sheshminian
Solikamskyi Gorizont	Solikamsky Horizon or Solikamian
Kungurskyi Yarus	**Kungurian Stage**
Iren´skyi Gorizont	Irensky Horizon or Irenian
Fillippovskyi Gorizont	Fillippovsky Horizon or Fillippovian
Artinskyi Yarus	**Artinskian Stage**
Baigendzhinskyi Gorizont	Baigendzhinsky Horizon or Baigendzhinian
Aktastinskyi Gorizont	Aktastinsky Horizon or Aktastinian
Saraninskyi Gorizont	Saraninsky Horizon or Saranian
Sarginskyi Gorizont	Sarginsky Horizon or Sarginian
Irginskyi Gorizont	Irginsky Horizon or Irginian
Burtsevskyi Gorizont	Burtsevsky Horizon or Burtsevian
Sakmarskyi Yarus	**Sakmarian Stage**
Sterlitamakskyi Gorizont	Sterlitamaksky Horizon or Sterlitamakian
Tastubskyi Gorizont	Tastubsky Horizon or Tastubian
Assel´skyi Yarus	**Asselian Stage**
Shikhanskyi Gorizont	Shikhansky Horizon or Shikhanian
Uskalykskyi Gorizont	Uskalyksky Horizon or Uskalykian
Sjuren´skyi Gorizont	Sjurensky Horizon or Sjurenian
Sokol´egorskyi Gorizont	Sokolegorsky Horizon or Sokolegorian
Kholodnolozhskyi Gorizont	Kholodnolozhsky Horizon or Kholodnolozhian
Orenburgskyi Yarus	**Orenburgian Stage**
Melekhovskyi Gorizont	Melekhovsky Horizon or Melekhovian
Noginskyi Gorizont	Noginsky Horizon or Noginian
Gzhel´skyi Yarus	**Gzhelian Stage**
Pavlovoposadskyi Gorizont	Pavlovoposadsky Horizon or Pavlovoposadian
Amerevskyi Gorizont	Amerevsky Horizon or Amerevian
Rechitskyi Gorizont	Rechitsky Horizon or Rechitian
Kasimovskyi Yarus	**Kasimovian Stage**
Yauzskyi Gorizont	Yauzsky Horizon or Yauzian
Dorogomilovskyi Gorizont	Dorogomilovsky Horizon or Dorogomilovian
Khamovnicheskyi Gorizont	Khamovnichesky Horizon or Khamovnichian
Krevyakinskyi Gorizont	Krevyakinsky Horizon or Krevyakinian
Moscovskyi Yarus	**Moscovian Stage**
Myachkovskyi Gorizont	Myachkovsky Horizon or Myachkovian
Podol´skyi Gorizont	Podolsky Horizon or Podolian
Tsninskyi Gorizont	Tsninsky Horizon or Tsninian
Kashirskyi Gorizont	Kashirsky Horizon or Kashirian
Vereyskyi Gorizont	Vereysky Horizon or Vereyian