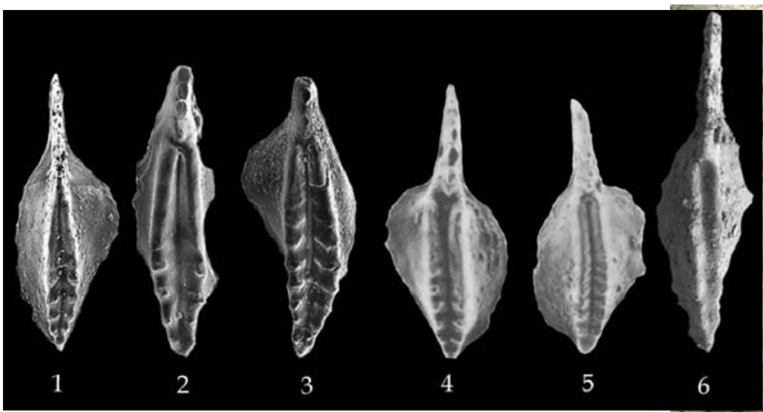
Permophiles

International Commission on Stratigraphy
International Union of Geological Sciences



Newsletter of the Subcommission on Permian Stratigraphy

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Contents

Explanation of cover: A, *Neostreptognathodus pnevi*, its FAD has been suggested as the base of the Kungurian Stage; 1-3: Mechetlino, Urals (Chernykh, 2006); 4-5: Conda Mine, Idaho (Behnken et al., 1986); 6: Ziyun, Guizhou, South China (from Jun Chen's PhD thesis). B, ICS Chair visited the Changhsingian-base GSSP at Meishan Section D with SPS secretary Shuzhong Shen. C, the SPS executive attended the ICCP in 2011 in Perth. D. ICS Chair Stan Finney (in the front middle) and ICS Vice-Chair Shanchi Peng (in the second on the left) in front of the monument for the Permian-Triassic boundary at Meishan Section D with SPS secretary Shuzhong Shen and local officials from Zhejiang Province and Changxing County. E. Participants attending the Kungurian workshop at Wells, Nevada; from left to right: Shuzhong Shen, Charles Henderson, Bruce Wardlaw, Mark Schmitz, Kate Tierney, Tamra Schiappa, Alexander Biakov and Vladimir Davydov.

EXECUTIVE NOTES

Notes from the SPS Secretary

Shuzhong Shen

Introduction and thanks

First of all, we are honored that the current Chair of the International Commission on Stratigraphy, Prof. Stanley Finney, visited the Nanjing Institute of Geology and Palaeontology on the 10th, July, 2012 and had an extensive discussion with the members of all subcommissions in the institute on the progress and plans of the ICS. On the second day, Stan Finney, the ICS Vice-Chair Shanchi Peng and I visited the two GSSPs and the Geopark at the Meishan Section D in Zhejiang Province. Stan appreciated a lot for the excellence of the work on the GSSPs and end-Permian mass extinction at the Meishan section, Zhejiang. The local officials from the Department of Land and Resources of Zhejiang Province and Changxing County kindly accompanied Stan's visit (see photos on the cover).

We have a long delay of this issue of Permophiles to be published. We received fewer contributions from our Permian colleagues recently. We also wait for some data on the Kungurian-base GSSP candidates from the Mechetlino section in southern Ural and Rockland section in Pequop Mountains, Nevada. Now they are both included in this issue. Your contributions will be important to keep going for future issues of Permophiles. Permophiles has published a lot of papers and reports of internationally broad interest and has received much attention from our colleagues. Papers and reports published in Permophiles are frequently cited. According to the ISI database, 300 papers/reports of Permophiles have been cited 453 times by other SCI papers. This issue was edited by Charles and I based on a few workshops and communications when we were together, including during the Kungurian workshop in Nevada and the 34th IGC in Brisbane. This is the last issue of this term of the executive committee of Subcommission of Permian Stratigraphy. We may publish one or two issues of Permophiles each year depending upon contributions we receive. As the secretary, I would like to thank SPS Chair Charles Henderson and Vice-Chair Vladimir Davydov for all their effort and good collaboration to move Permian studies forward and we have had a successful 8 years. Since 2004, the resolution of the Permian Timescale has been significantly improved (see the Permian Timescale in this issue). Great progress has been made as well for the establishment of the Cisuralian GSSPs. Thanks to Charles Henderson, Vladimir Davydov, Andrey V. Zhuravlev and Alexandr G. Iosifidi for their contributions to this issue.

Previous and forthcoming SPS Meetings

A business meeting was held during the 17th ICCP on the 7th of July 2011 in Perth, Australia following the business meeting of the Subcommission of Carboniferous Stratigraphy. The SPS executive committee including SPS Chair Charles Henderson, Vice-Chair Vladimir Davydov and myself met together during this meeting. Other attendees were Alexander Biakov, Jun Chen, Zhongqiang Chen, Olga Kossovaya, Yukio Isozaki, Guang R. Shi, Katsumi Ueno, Xiangdong Wang and Yue Wang. Charles Henderson gave a general report about the progress of Permian issues, especially the potential GSSPs in the Cisuralian in southern Urals.

Another SPS business meeting was held on the 8th of June, 2012 at Motel 6 in Wells, Nevada, USA during the Kungurian Workshop. I thank Charles Henderson who organized this workshop and we thank the support from the International Commission on Stratigraphy. Charles Henderson, Vladimir Davydov, Shuzhong Shen, Tamra Schiappa, Alexander Biakov, Bruce Wardlaw, Mark Schmitz, Kate Tierney and Chad Morgan attended the workshop. During this workshop, Bruce Wardlaw, Mark Schmitz, Vladimir Davydov, Kate Tierney, Tamra Schiappa, and Charles Henderson gave talks on the progress of the potential Kungurian GSSP including the new Mechetlino section in southern Urals and the Rockland section in the Pequop Mountains in Nevada. Boris Chuvashov and Valery Chernykh provided new detailed conodont data from the new Mechetlino section and Vladimir Davydov introduced the biostratigraphic data from this section on behalf of Boris and Valery. Charles, Bruce and Tamra introduced the detailed stratigraphy of the Rockland section in the Pequop Mountains, Nevada. Kate Tierney introduced the carbon and strontium isotopes from the Rockland section and the Tieqiao section of South China. Mark Schmitz presented the Sr isotope and geochronologic ages from the Cisuralian sections in southern Urals. I gave a brief talk on the progress of the Cisuralian Series in South China including some new discoveries of the index conodont species *Neostreptognathodus pnevi*. During this workshop, all participants visited Carlin Canyon to see the Pennsylvanian and Cisuralian sequences there. We also went to the Rockland section, but for various reasons only Vladimir Davydov, Kate Tierney and Alexander Biakov got to the potential GSSP section after the workshop.

Other important business discussed during this workshop was the replacement of new voting members of SPS before the next new executive committee becomes established. Based on suggestions from distinguished senior colleagues and the SPS executive committee, Valery Chernykh will replace Prof. Ernst Leven, Alexander Biakov will replace Boris Chuvashov, and Ausonio Ronchi will replace Marc Durand as new voting members. We sincerely thank our senior colleagues for their great contributions to Permian issues during the past decades. We also warmly welcome our new voting members.

A joint SPS and SCS business meeting will be held between 19:00 and 20:30 pm on the 7th of August during the 34th International Geological Congress, which will be held in Brisbane, Australia. During this business meeting, the new SPS executive committee will take over the work of SPS to continue our studies on Permian issues. We wish good luck and all the best to the new executive committee members in the upcoming years.

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This issue contains the reports of the progress on the base-Kungurian GSSP. Valery Chernykh, Boris Chuvashov, Vladimir Davydov and Mark Schmitz report the progress of the conodont and fusulinid biostratigraphy, high-precision geochronologic ages and strontium isotope from the Mechetlino section in southern Urals. Charles Henderson, Bruce Wardlaw, Vladimir Davydov, Mark Schmitz, Tamra Schiappa, Kate Tierney and Shuzhong Shen reported the biostratigraphic, and geochemical progress on the Rockland section in Nevada. The report in this issue presents all the data available from the Mechetlino section in southern Urals and the Rockland section in Nevada, USA. We would welcome any comments and suggestions on these two sections for future detailed proposals for the base-Kungurian GSSP.

Andrey V. Zhuravlev and Alexandr G. Iosifidi provided a report on the stratigraphic gap between the Carboniferous and Permian in the lithologically monotonous sequence in Central Pay-Khoy, NW Russia. Vladimir Davydov et al. present a report on the fusulinid biostratigraphy of the Lower Permian Zweikofel Formation in Carnic Alps, Austria. They provided a discussion on the Early Permian Tethyan chronostratigraphy.

The XVII International Congress on the Carboniferous and Permian (ICCP2011) was successfully held in Perth, Australia, from July 3rd to 8th, 2011. A few special issues are being organized for the congress. In addition, announcements of the international meeting "The Carboniferous-Permian Transition" which is hosted by the New Mexico Museum of Natural History and Science, Albuquerque, New Mexico, USA between May 20-22, 2013 and ICCP 2015, which will be held at Kazan, Russia, are released in this issue.

Future issues of Permophiles

The next issue of Permophiles is the 57th issue and will be produced by the new SPS subcommission. We hope our colleagues in the Permian community can contribute papers, reports, comments and communications. The deadline for submission to Issue 57 is Feb. 15, 2013. Manuscripts and figures can be submitted via my email address (szshen@nigpas.ac.cn or shen_shuzhong@yahoo.com) as attachments. Please follow the format on page 3 of Issue 44 of Permophiles.

Finally, we have had a new SPS webpage at http://www.stratigraphy.org/permian/. We welcome your contributions, advice to improve the webpage from time to time.

State Key Laboratory of Palaeobiology & Stratigraphy
Nanjing Institute of Geology & Palaeontology
39 East Beijing Road
Nanjing, Jiangsu 210008
China
E-mail: szshen@nigpas.ac.cn
shen_shuzhong@yahoo.com
Tel/Fax: +86-25-83282131

Notes from the SPS Chair

Charles M. Henderson

This issue is long delayed and I apologize – I guess it is time for a new executive. Some reasons for this delay include busy travel schedules and concerted effort to complete GSSP proposals including waiting for publication of various papers pertinent to the proposals. The most controversial GSSP is the base-Kungurian and progress has been reported in past issues of Permophiles. A 2007 field workshop in Russia demonstrated that there were many problems with the Mechetlino section. Since then Boris Chuvashov and Valery Chernykh have completed additional work in the region including a new section nearby where conodonts are more abundant. These data are reported herein. In 2009 SPS decided that the Rockland section in Nevada should be seriously considered and new work was undertaken. The results are included herein in the base-Kungurian preliminary GSSP proposal that is offered to SPS voting and corresponding members for comment. The base-Kungurian Working Group chaired by Bruce Wardlaw voted 6-4 in favour of Rockland as the GSSP and Mechetlino as a supplementary GSSP reference section for the purposes of this preliminary proposal. This preliminary proposal will be revised based on any new strontium data and especially based on feedback from the Permian community. I therefore ask for any comments to be sent directly to the new chair (Shuzhong Shen) no later than January 1, 2013. These comments will be communicated in Permophiles and considered during revisions of a final proposal including which section will become the primary GSSP. If you have concerns please communicate them and if you like the proposal, please also communicate.

My annual report to ICS was submitted in December 2011 and is included in this issue. The time scale near the back of this issue is modified from the previous issue and this is the current version in the new Global Time Scale book (GTS 2012) with modifications.

Finally, Shuzhong Shen in his notes indicates that the SPS executive has made some changes to the voting membership. It is my honour to acknowledge the considerable accomplishments of Boris Chuvashov and Ernst Leven toward the establishment of a detailed Permian Time Scale by naming both as Honourary Members, which is reflected in the SPS voting membership indicated in this issue.

REPORTS

SUBCOMMISSION ON PERMIAN STRATIGRAPHY ANNUAL REPORT 2011

1. TITLE OF CONSTITUENT BODY and NAME OF REPORTER
International Subcommission on Permian Stratigraphy (SPS)
SUBMITTED BY: Charles M. Henderson
Chairman SPS, Department of Geoscience, University of Calgary, Calgary, AB Canada T2N 1N4
Phone: 403-220-6170; Fax: 403-284-0074;
Email: charles.henderson@ucalgary.ca
Website: www.ucalgary.ca/conodont/

2. OVERALL OBJECTIVES, AND FIT WITHIN IUGS SCIENCE POLICY
Subcommission Objectives: The Subcommission's primary objective is to define the series and stages of the Permian, by means of internationally agreed GSSP's, and to provide the international

forum for scientific discussion and interchange on all aspects of the Permian, but specifically on refined regional correlations.

Fit within IUGS Science Policy: The objectives of the Subcommission involve two main aspects of IUGS policy: 1. The development of an internationally agreed chronostratigraphic scale with units defined by GSSP's where appropriate and related to a hierarchy of units to maximize relative time resolution within the Permian System; and

2. Establishment of framework and systems to encourage international collaboration in understanding the evolution of the Earth during the Permian Period.

3. ORGANIZATION

The Subcommission has an Executive consisting of a Chairman, a Vice-Chairman, and a Secretary; all three are Voting Members of the Subcommission. There are seventeen total Voting Members representing most regions of the world where Permian rocks are exposed. The objectives of the Subcommission are pursued by both stratigraphic and thematic Working Groups that are retired upon completion of their directed task. For example, the Working Groups on the Carboniferous-Permian Boundary, on the Guadalupian stages (Middle Permian), on the base-Lopingian boundary (base-Wuchiapingian Stage), and on base-Changhsingian have been retired upon the successful establishment of their defining GSSP's and ratification by IUGS. The current working groups include the following: 1. Cisuralian stages, 2. Continental Permian, 3. Transitional biotas as gateways for global correlation, 4. Neotethys, Paleotethys, and S. China Correlations, and 5. International Lopingian Working Group.

3a. Officers for 2008-2012:

Chair: Professor Charles M. Henderson, University of Calgary

Vice-Chair: Dr. Vladimir Davydov, Boise State University

Secretary: Dr. Shuzhong Shen, Nanjing Institute of Geology and Palaeontology

SPS website is located at www.nigpas.ac.cn/permian/web/index.asp (Now a new SPS webpage is available at http://www.stratigraphy.org/permian/index.asp). This site includes all back issues of Permophiles in downloadable PDF format (#1 in 1978 to #54 December 2009). A link to Permophiles/Permian research has also been established at www.ucalgary.ca/conodont/sps.

4. INTERFACES WITH OTHER INTERNATIONAL PROJECTS

SPS interacts with many international projects on formal and informal levels. SPS has taken an active role on the development of integrated chronostratigraphic databases by participating with CHRONOS and PALEOSTRAT (now GeoStratSys), which are NSF funded initiatives. Vladimir Davydov and Walter Snyder are concentrating on developing their system to include improved taxonomic dictionaries, database sharing and manipulation with GeoStratSys. SPS is also involved in a NSFC supported study comparing the Proterozoic-Cambrian transition with the Permian-Triassic transition.

5. CHIEF ACCOMPLISHMENTS AND PRODUCTS IN 2011

GSSPs: Progress was made on the three remaining Lower Permian (Cisuralian) stage GSSPs including base-Sakmarian, base-Artinskian, and base-Kungurian. The section and point for the base-Sakmarian has been changed to the Usolka section in Russia and a proposal was to have been voted on in 2011, but there have been some delays. The Kondurovsky section failed to reproduce the requisite conodont results and problems about the evolution of Sweetognathus merrilli were discussed during ICOS2009. Fortunately, the Usolka section had been fully worked up as a potential parastratotype and we have excellent carbon isotope, U-Pb isotopic ages and abundant conodonts to define the boundary. Detailed conodont samples from the approximate GSSP interval were collected by V. Davydov and were processed in Calgary during 2011. The isotopic ages are now in press in a paper by Mark Schmitz and Vladimir Davydov in GSA Bulletin. This material will form the basis of a report that will be prepared early in 2012 and then followed by a vote. A penultimate proposal for the base-Artinskian is appeared in Permophiles 55, and some input was received. At both of these sections the Sr isotopes of conodonts have also been shown to be an accurate correlation tool. A revised proposal will be submitted to SPS voting members early in 2012. The Mechetlino section in Russia is not satisfactory for a base-Kungurian GSSP – samples did not yield conodonts, zircons are all reworked, and the rocks are too deeply weathered to produce meaningful carbon isotopic values. New work on a nearby section has shown better conodont recoveries and Sr-isotopic values are being analysed. It is possible that the Mechetlino section will be named as a supplementary reference section. The primary section under consideration for base-Kungurian GSSP is the Rockland section in northern Nevada, USA. The GSSP will be defined using the same point (FAD of *Neostreptognathodus pnevi*) as considered in Russia; hopefully, Sr-isotopic values will match. Funds were requested and granted from ICS for a workshop on this proposal. It was determined that June 2011 was too soon as originally planned; instead a workshop with Bruce Wardlaw, Charles Henderson, Vladimir Davydov and Mark Schmitz was held at Boise May 29 to June 3. Two sets of samples were previously collected and processed separately in Boise and Calgary. During the workshop Wardlaw and Henderson picked all samples and independently picked the same sample/point within the chronomorphocline from *N. pequopensis* to *N. pnevi*. This narrowed the interval to about 2 metres and V. Davydov collected continuous samples later in the summer and these are currently being processed in Calgary. Invitations have gone out for an international workshop to be held June 7-10, 2012. This workshop will include presentations and a field excursion to the proposed GSSP. We anticipate that a vote can go out following this meeting. It remains the goal that this will be the last GSSP vote for the Permian System and hopefully it can be completed in time to be reported at Brisbane.

Publications: The December 2010 issue of Permophiles (#55) was produced online during the Fall of 2010 and was distributed as a pdf document to a mailing list of 280. Owing to reduced submissions SPS is producing only one issue in 2010 (#55), which went online early in 2011. We have a complete series of Permophiles on our website (1978 to 2009). Issue 56 is not complete as of this report, but is planned for December 2012.

Meetings: The SPS conducted a business meeting in association with the ICCP meeting in Perth Australia, July 2011.

Membership: There were no changes to the membership in 2011. We have 17 voting members representing Argentina (1), Australia

(2), Canada (1), China (3), France (1), Germany (1), Italy (1), Japan (1), Russia (3), and United States (3). We also have five honourary Members.

6. CHIEF PROBLEMS ENCOUNTERED IN 2011
There were no major problems in 2011, but progress was slow because of sample processing delays and major commitments by all individuals associated with this work.

7. SUMMARY OF EXPENDITURES IN 2011:
INCOME
University of Calgary (1): $1444.00
NIGPAS (2): $1000.00
ICS (3): $ 3000.00
TOTAL: $5444.00 (quoted in US$; divided by 1.02 to convert to Canadian$). (1) University of Calgary support from NSERC grant to Charles Henderson for travel to Nanjing China March 2011. (2) NIGPAS (Nanjing Institute of Geology and Palaeontology) support from NSF-C grant to Shuzhong Shen in support of Henderson in Nanjing. (3) ICS allocation to SPS for international workshop.
EXPENDITURES
Printing, Mailing, and Web support Permophiles: $196.05
Travel Costs for Henderson to Nanjing: $2444.00
Travel costs for Boise Workshop (for Henderson and partially for Wardlaw) $1803.20
TOTAL: $4443.25 (quoted in US$)
BALANCE: $1000.75

8. WORK PLAN, CRITICAL MILESTONES, ANTICIPATED RESULTS AND COMMUNICATIONS TO BE ACHIEVED NEXT YEAR (2012):
1. Production of Permophiles #56 in Calgary Dec 2011 and #57 in March 2012 in Nanjing.
2. Vote on base-Artinskian in February 2012.
3. Vote on base-Sakmarian in April 2012.
4. Submit two GSSP proposals to ICS for ratification in March and May 2012.
5. Workshop for base-Kungurian in Boise Idaho and Wells Nevada June 7-10, 2012.
6. SPS business meeting during IGC meeting in Brisbane Australia during August 2012.
7. Vote for base-Kungurian late June 2012 and hopefully submit to ICS for voting at Brisbane.
8. Vote for new SPS executive in 2012. Nominating committee has been set with Bruce Wardlaw (USGS) as Chair and Galina Kotlyar (Russia) and Ausonia Ronchi (Italy) as members.

9. BUDGET AND ICS COMPONENT FOR 2012 EXPENDITURES
We have sufficient leftover funds for the minor cost of website and printing. The primary budget request for 2012 is for a workshop at Boise Idaho with field excursion to the Rockland Section near Wells Nevada. This workshop is essential if we are to convince the international Permian community that the Rockland section is appropriate for the base-Kungurian GSSP. This is the biggest hurdle confronting SPS because we have rejected a long viewed potential section in Russia. This workshop is essential for SPS to complete the GSSP process before IGC in 2012. Financial support is necessary to bring at least 3 foreign researchers (including Kotlyar, Chernykh and Biakov from Russia) to Boise Idaho by paying for airfare and subsidizing accommodation ($5000). Other SPS members will be invited, but subsidies will be limited ($1000). Workshop will be conducted over two days at Boise State University between June 7-10 with fieldtrip to the potential GSSP field site and a look at Carlin Canyon. Fieldtrip costs will include vehicle rentals and 2 night's accommodation in Wells Nevada ($2000) for the group. Samples can be collected by participants. Workshop at Boise State will include presentations and viewing of conodonts and fusulinids as well as the isotope labs of Mark Schmitz. SPS Executive will attend using their research funding. They will also attend the IGC meeting in Brisbane in August 2012.

TOTAL 2012 BUDGET
(This does not include costs associated with travel to IGC in Brisbane for current Chair/executive and incoming Chair/executive). Funds requested for SPS Workshop $8,000.00
Funds left over from last year's contribution $1000.75
Requested ICS contribution $6999.25
TOTAL BUDGET REQUEST (ICS) $6999.25

10. REVIEW CHIEF ACCOMPLISHMENTS OVER PAST FIVE
YEARS (2007-2011)
The SPS has approved the general divisions of the Permian and has now had 6 GSSP's ratified by ICS and IUGS (Asselian, Roadian, Wordian, Capitanian, Wuchiapingian, Changhsingian).
Proposals for the latter two stages were published in Episodes in 2006. Support for documentation (fieldwork and publications) of the various chronostratigraphic methods for the establishment of the GSSP's has been the most outstanding and differentiating character of this Subcommission. Substantial work has been conducted toward producing excellent proposals for the remaining stages. Permophiles has become an internationally respected newsletter and bears an ISSN designation (1684-5927) and is deposited in the National Library of Canada; eight issues were published during the five year period.

11. OBJECTIVES AND WORK PLAN FOR NEXT 2 YEARS (2011-2013)
The primary objectives are to complete the GSSP's for the last three GSSP's (Sakmarian, Artinskian, and Kungurian. We will produce one or two issues of Permophiles each year depending on input. The schedule for the next year is indicated in section 8 above. The agenda for 2013 will be set by the incoming Chair and Executive, but will likely focus on testing correlation of the GSSPs, especially in Tethys sections and extending correlations into the terrestrial realm.

12. WEBSITE STATUS AND ACTIVITIES:
SPS website is located at www.nigpas.ac.cn/permian/web/index.asp (note: Now at http://www.stratigraphy.org/permian/index.asp). This site is updated regularly and includes all back issues of Permophiles in downloadable PDF format (#1 in 1978 to #55 December 2010) as well as other information about SPS

activities including annual reports, membership.... Shuzhong Shen at Nanjing China maintains the site and Henderson and Shen both have administrator rights.

13. FOUR YEAR SUMMARY OF ACTIVIES:

GSSP's: The base-Wuchiapingian and base-Changhsingian (Upper Permian or Lopingian Series) GSSPs were published in Episodes (volume 29, No. 3&4) in 2006. Progress was made on the three remaining Lower Permian (Cisuralian) stage GSSPs including base-Sakmarian, base-Artinskian, and base-Kungurian. An international field excursion was conducted in early July 2007 (reported in *Permophiles* #49; p. 4-6) and samples for carbon isotopes, geochronology and biostratigraphy were collected and have now been processed. The geochemical samples will provide further correlation potential for the proposed GSSPs; these materials are being analyzed at Boise State University and the Nanjing Institute of Geology and Palaeontology. The biostratigraphy samples will determine reproducibility of GSSP definitions. Decisions have been made on the basis of this new work and this is described above in section 5. The most significant decision was to reject the base-Kungurian section at Mechetlino. Detailed samples were collected at the Rockland section in Nevada and a workshop is proposed to "sell" the merits of this section.

Publications: The June 2006 issue of *Permophiles* (#47) was produced at Nanjing China during June 2006 and distributed as a pdf document to a mailing list of 280. The December 2006 issue of *Permophiles* (#48) was produced at the University of Calgary during November 2006 and distributed as a pdf on our website. We now have a complete series of Permophiles on our website (1978 to 2006). The June 2007 issue of Permophiles (#49) was produced at Nanjing China during June 2007 and distributed as a pdf document to a mailing list of 280. The December 2007 issue (#50) was produced in January 2008 after a field excursion to Australia. June 2008 issue (#51) was produced in Calgary in July 2008. December 2008 (#52) was produced online in January 2009 and #53 was produced in July 2009 in Calgary and #54 was produced online. We now have a complete series of Permophiles on our website (1978 to 2009).

Meetings: The SPS conducted one business meeting at the 2nd International Palaeontology Congress in Beijing, China in June 2006. The SPS conducted one business meeting at the XVI International Congress on the Carboniferous and Permian in Nanjing, China in June 2007 and is reported in *Permophiles* #49. Business meetings were held in Sydney Australia (January 2008; *Permophiles* #50) and IGC in Oslo (August 2008). In 2009 business meetings were held in Trelew Argentina and at ICOS2009 in Calgary. A business meeting was held at Prague, Czech Republic in late May 2010 during the ICS workshop.

Membership: Two changes were made to voting membership in 2006. Dr. John Utting retired as a voting member and was named by the SPS Executive as a Honourary Member given his long service to SPS (past Secretary) and distinguished research record in Late Paleozoic palynology. Dr. Lucia Angiolini was nominated by the executive to fill this vacancy. This increased the membership from Europe bringing it more in line with other major regions. Secondly, we sadly lost our distinguished colleague and friend Professor Jin Yugan who died in June 2006 (see Permophiles 48 for a tribute). His was a very distinguished career in Late Paleozoic paleontology and service including as a past-Secretary and past-Chairman of SPS. He has been replaced as a voting member by Professor Yue Wang. There were no changes to the membership in 2007, but as noted in the 4 year summary we have made several changes over the past four years. In addition, the current executive will continue for a second term. We currently have 16 voting members representing Australia (2), Canada (1), China (3), France (1), Germany (1), Italy (1), Japan (1), Russia (3), and United States (3). We also have five honourary Members. No changes in 2008. In 2009 we added one new voting member, Dr. Nestor R. Cuneo from Argentina to add to our complement noted above. There were no changes to the membership in 2010.

Summary (2006-2010): Two GSSP proposals for the base-Wuchiapingian (also base-Lopingian Series) and base-Changhsingian were prepared, voted, ratified and published in Episodes during the past four years. Significant progress has been made on the last three Cisuralian GSSP proposals for the base-Sakmarian, base-Artinskian, and base-Kungurian stages. An international workshop was conducted in July 2007 to determine reproducibility and accessibility as well as collect new geochemical data. During the reporting period, *Permophiles* #47 to #54 have been produced with #55 to come later this year. In addition, a website was constructed and hosted by the Nanjing Institute of Geology and Palaeontology during the reporting period. Among other items, this website has pdf versions of all issues of *Permophiles* dating back to #1 in 1978.

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APPENDIX "Officers and Voting Members as of November 2011"

Dr. Lucia Angiolini
Dipartimento di Scienze Terra "A. DEsio"
Via Manggiagalli 34, 20133
Milano, Italy

Dr. Boris I. Chuvashov
Institute of Geology and Geochemistry
Urals Branch of
Russian Academy of Science
Pochtovy per 7
Ekaterinburg 620154 Russia

Dr. Nestor R. Cuneo
Director, Museo Paleontologico Egidio Feruglio
(U9100GYO) Av. Fontana 140,
Trelew, Chubut, Patagonia Argentina

Dr. Vladimir Davydov, SPS Vice-Chairman
Department of Geosciences
Boise State University
1910 University Drive
Boise ID 83725 USA

Dr. Marc Durand
Universite de Nancy-I, GES, BP239
54506 Vandoeuvre-les-Nancy cedex
France

Dr. Yoichi Ezaki
Department of Geosciences
Osaka City University
Sugimoto 3-3-138
Sumiyoshi-Ku, Osaka, 558-8585, Japan

Dr. Clinton B. Foster
Australian Geological Survey Organization
G.P.O. Box 378
Canberra 2601 Australia

Prof. Charles M. Henderson, SPS Chairman
Department of Geoscience
University of Calgary
NW Calgary, Alberta
Canada T2N1N4

Dr. Galina Kotlyar
All-Russian Geological Research Institute
Sredny pr. 74
St. Petersburg 199026 Russia

Prof. Ernst Ya. Leven
Geological Institute
Russian Academy of Sciences
Pyjevskyi 7
Moscow 109017 Russia

Dr. Tamra A. Schiappa
Department of Geography, Geology and the Environment
Slippery Rock University
Slippery Rock, PA 16057 USA

Prof. Joerg W. Schneider
Freiberg University of Mining and Technology
Institute of Geology, Dept. of Palaeontology, Bernhard-von-Cotta-Str.2 Freiberg, D-09596, Germany

Dr. Shuzhong Shen, SPS Secretary
Nanjing Institute of Geology and
Paleontology, 39 East Beijing Rd.
Nanjing, Jiangsu, China 210008

Dr. Guang R. Shi
Deakin University, Resden Campus
School of Aquatic Science and Natural Res. Management
662 Blackburn Rd.
Clayton, Victoria, Australia 3168

Dr. Xiangdong Wang
Nanjing Institute of Geology and
Paleontology, 39 East Beijing Rd.

Prof. Yue Wang
Nanjing Institute of Geology and
Paleontology, 39 East Beijing Rd.
Nanjing, Jiangsu, China 210008

Dr. Bruce R. Wardlaw
U.S. Geological Survey
926A National Center
Reston, VA 20192-0001 USA

Honourary Members

Prof. Giuseppe Cassinis
Earth Sciences Dept.
University of Pavia, 1 Via Ferrata,
27100 Pavia, Italy

Prof. Brian F. Glenister
Department of Geology
University of Iowa
Iowa City, IA 52242 USA

Dr. Heinz Kozur
Rezsu u 83
Budapest H-1029 Hungary

Prof. Claude Spinosa
Department of Geosciences
Boise State University
1910 University Drive
Boise ID 83725 USA

Dr. John Utting
Geological Survey of Canada
3303 - 33rd Street N.W.
Calgary Alberta T2L2A7 Canada

New officers and Voting Members since August, 2012

Prof. Lucia Angiolini (New Secretary from Aug. 2012)
Dipartimento di Scienze Terra "A. Desio"
Via Manggiagalli 34, 20133, Milano, Italy
E-mail: lucia.angiolini@unimi.it

Dr. Alexander Biakov (New Voting Member)
Northeast Interdisciplinary Scientific Research Institute
Far East Branch, Russian Academy of Sciences,
Portovaya ul. 16, Magadan, 685000 Russia
E-mail:abiakov@mail.ru

Dr. Valery Chernykh (New Voting Member)
Institute of Geology and Geochemistry
Urals Baranch of Russian Academy of Science
Pochtovy per 7,
Ekaterinburg 620154 Russia
E-mail: vtschernich@mail.ru

Dr. Nestor R. Cuneo
Museo Paleontologico Egidio Feruglio
(U9100GYO) Av. Fontana 140,
Trelew, Chubut, Patagonia Argentina
E-mail: rcuneo@mef.org.ar

Dr. Vladimir Davydov
Department of Geosciences, Boise State University
1910 University Drive, Boise ID 83725 USA
E-mail: vdavydov@boisestate.edu

Dr. Clinton B. Foster
Australian Geological Survey Organization
G.P.O. Box 378, Canberra 2601 Australia
E-mail: clinton.foster@ga.gov.au

Prof. Charles M. Henderson
Dept. of Geoscience, University of Calgary,
Calgary, Alberta, Canada T2N1N4
E-mail: cmhender@ucalgary.ca

Dr. Galina Kotlyar
All-Russian Geological Research Institute
Sredny pr. 74,
St. Petersburg 199026 Russia
E-mail: Galina_Kotlyar@vsegei.ru

Dr. Ausonio Ronchi (New Voting Member)
Dipartimento di Scienze della Terra e dell'Ambiente
Università di Pavia - Via Ferrata 1, 27100 PV, ITALY
E-mail: ausonio.ronchi@dst.unipv.it

Dr. Tamra A. Schiappa
Department of Geography, Geology and the Environment
Slippery Rock University
Slippery Rock, PA 16057 USA
E-mail: tamra.schiappa@sru.edu

Prof. Joerg W. Schneider (New Vice-Chair from Aug. 2012)
Freiberg University of Mining and Technology
Institute of Geology, Dept. of Palaeontology,
Bernhard-von-Cotta-Str.2
Freiberg, D-09596, Germany
E-mail: Joerg.Schneider@geo.tu-freiberg.de

Prof. Shuzhong Shen (New Chair from Aug. 2012)
Nanjing Institute of Geology and Paleontology,
39 East Beijing Rd. Nanjing, Jiangsu 210008, China
E-mail: szshen@nigpas.ac.cn

Prof. Guang R. Shi
School of Life and Environmental Sciences,
Deakin University
Melbourne Campus (Burwood), 221 Burwood
Highway, Burwood
Victoria 3125, Australia
E-mail: grshi@deakin.edu.au

Prof. Ueno Katsumi (New Voting Member)
Department of Earth System Science
Fukuoka University, Fukuoka 814-0180 JAPAN
E-mail: katsumi@fukuoka-u.ac.jp

Prof. Xiangdong Wang
Nanjing Institute of Geology and Paleontology,
39 East Beijing Rd. Nanjing, Jiangsu 210008, China
E-mail: xdwang@nigpas.ac.cn

Prof. Yue Wang
Nanjing Institute of Geology and Paleontology,
39 East Beijing Rd. Nanjing, Jiangsu 210008, China
E-mail: yuewang@nigpas.ac.cn

Dr. Bruce R. Wardlaw
U.S. Geological Survey
926A National Center
Reston, VA 20192-0001 USA
E-mail: bwardlaw@usgs.gov

Honourary Members

Prof. Giuseppe Cassinis
Earth Sciences Dept.
via Abbiategraso N. 217
Pavia 27100 Italy
E-mail: cassinis@unipv.it

Dr. Boris I. Chuvashov
Institute of Geology and Geochemistry
Urals Baranch of
Russian Academy of Science
Pochtovy per 7
Ekaterinburg 620154 Russia
E-mail: chuvashov@igg.uran.ru

Dr. Heinz Kozur
Rezsu u 83
Budapest H-1029 Hungary
E-mail: kozurh@helka.iif.hu

Prof. Ernst Ya. Leven
Geological Institute
Russian Academy of Sciences
Pyjevskyi 7
Moscow 109017 Russia
E-mail: erleven@yandex.ru

Prof. Claude Spinosa
Department of Geosciences
Boise State University
1910 University Drive
Boise ID 83725 USA
E-mail: cspinosa@boisestate.edu

Dr. John Utting
Geological Survey of Canada
3303 - 33rd Street N.W.
Calgary Alberta T2L2A7 Canada
E-mail: jutting@nrcan.gc.ca

Proposal for base-Kungurian GSSP

Charles M. Henderson
Dept. of Geoscience, University of Calgary, Calgary, Alberta, Canada T2N1N4,
E-mail: cmhender@ucalgary.ca

Bruce R. Wardlaw
U.S. Geological Survey, 926A National Center, Reston, VA 20192-0001 USA,
E-mail: bwardlaw@usgs.gov

Vladimir I. Davydov
Department of Geosciences, Boise State University, 1910 University Drive, Boise ID 83725 USA,
E-mail: vdavydov@boisestate.edu

Mark D. Schmitz
Department of Geosciences, Boise State University
1910 University Drive, Boise ID 83725 USA
E-mail: MarkSchmitz@boisestate.edu

TamraA. Schiappa
Department of Geography, Geology and the Environment, Slippery Rock University, Slippery Rock, PA 16057 USA,
E-mail: tamra.schiappa@sru.edu

Kate E.Tierney
Department of Geosciences, Denison University, 307 Olin Science Hall, Granville, Ohio 43032, USA,
E-mail: tierneyk@denison.edu

Shuzhong Shen
State Key Laboratory of Palaeobiology& Stratigraphy, Nanjing Institute of Geology & Palaeontology, 39 East Beijing Road, Nanjing, Jiangsu 210008, China
E-mail: szshen@nigpas.ac.cn

Introduction

The base-Kungurian has long been a problematic boundary to correlate because the interval is characterized by a lowstand of sea-level with restricted, relatively endemic biota. A type section for the Kungurian Stage was not defined when the stage was originally established (Stuckenberg, 1890). Later, the carbonate–sulphate evaporite section exposed along the Sylva River, upstream of the town of Kungur, was arbitrarily accepted as a "stratotype". The problem with such deposits however is their lack of global correlatability. As a result, marine sections that traditionally may have been correlated as Upper Artinskian have been considered as potential GSSPs. Recently, the First Appearance Datum (FAD) of *Neostreptognathodus pnevi* at the Mechetlino section in Russia has been proposed as a potential boundary stratotype. A field workshop was conducted June 25-July 4, 2007 as part of the process to establish this GSSP. The workshop investigated the reproducibility of the potential Lower Permian GSSP sections for the base-Sakmarian, base-Artinskian and base-Kungurian. This workshop was reported in *Permophiles* #49 (Davydov and Henderson, 2007) with Boris Chuvashov, ValeryChernykh and Viktor Puchkov as hosts and Vladimir Davydov, Emir Gareev, Charles Henderson, Elena Kulagina, Tamra Schiappa, Mark Schmitz, Shuzhong Shen and Michael Stephenson also in attendance. The Mechetlino section failed the reproducibility test as key conodont samples processed in both Calgary and Nanjing were barren. Furthermore the section was too weathered to yield meaningful carbon isotopic values and all "ash" beds yielded only detrital zircons. During the Subcommission on Permian Stratigraphy (SPS) meeting in Calgary (July 2009) it was determined that another section near Wells, Nevada should be considered as a potential GSSP in addition to the Mechetlino section. This Rockland section has a long history of study from the late 1950's as a Permian reference in Western USA (Robinson, 1961; Bissell, 1962, 1964). Moreover, conodonts, fusulinaceans, ammonoids, carbon and strontium isotopes and sedimentology have recently been extensively studied at the Rockland section by B.R.Wardlaw, V.I.Davydov, W.S. Snyder, M. Schmitz, Kate Tierney, and Tamra Schiappa.

It is important to note that at Mechetlino and Rockland sections the potential GSSP level is represented by the same evolutionary event, within the chronomorphocline of *Neostreptognathodus pequopensis* to *N. pnevi*. The ancestor was first named for specimens from Nevada (Behnken, 1975) and the descendant was first named for material from the Saranian Horizon in the Urals (Kozur and Movshovich in Movshovich et al., 1979). At Rockland, this point was first identified in a 55 m interval between two samples collected by Bruce Wardlaw in 1997. In July 2010 Charles Henderson, Bruce Wardlaw, Vladimir Davydov, Mark Schmitz and students collected 20 samples within this interval to better define the first occurrence of *N. pnevi* (FO). Two identical sets of samples were collected and processed separately at Boise State and the University of Calgary. A workshop was conducted in Boise in May 2011 in which Bruce Wardlaw and Charles Henderson independently arrived at the same level for the FO of *N. pnevi* thereby bringing our uncertainty level to only 2.5 metres. Vladimir Davydov collected 10 additional samples within this interval later in 2011, thereby reducing our uncertainly to about 40 cm. A workshop sponsored by ICS was conducted in Wells, Nevada during June 2012 in order to integrate all of the various studies toward producing a GSSP proposal. The workshop was chaired by Charles Henderson and included Bruce Wardlaw, Tamra Schiappa, Mark Schmitz, Vladimir Davydov, Kate Tierney, Alexander Biakov, and Shuzhong Shen. Valery Chernykh and Boris Chuvashov contributed and voted by proxy, but were not in attendance. This group of ten, which includes 7 SPS voting members, constitutes the base-Kungurian Working Group (chaired by Bruce Wardlaw). This working group, following two days of discussion, was charged with determining the best section (Rockland or Mechetlino) to serve as the GSSP, with the other serving as a secondary reference section. In a 6-4 vote it was decided that the FAD of *N. pnevi* at Rockland will serve as GSSP for the purpose of this preliminary proposal and the FAD at Mechetlino as the secondary reference. It was decided

Fig. 1. Location of potential Kungurian GSSP on Google (upper) and view looking down section toward the west (lower).

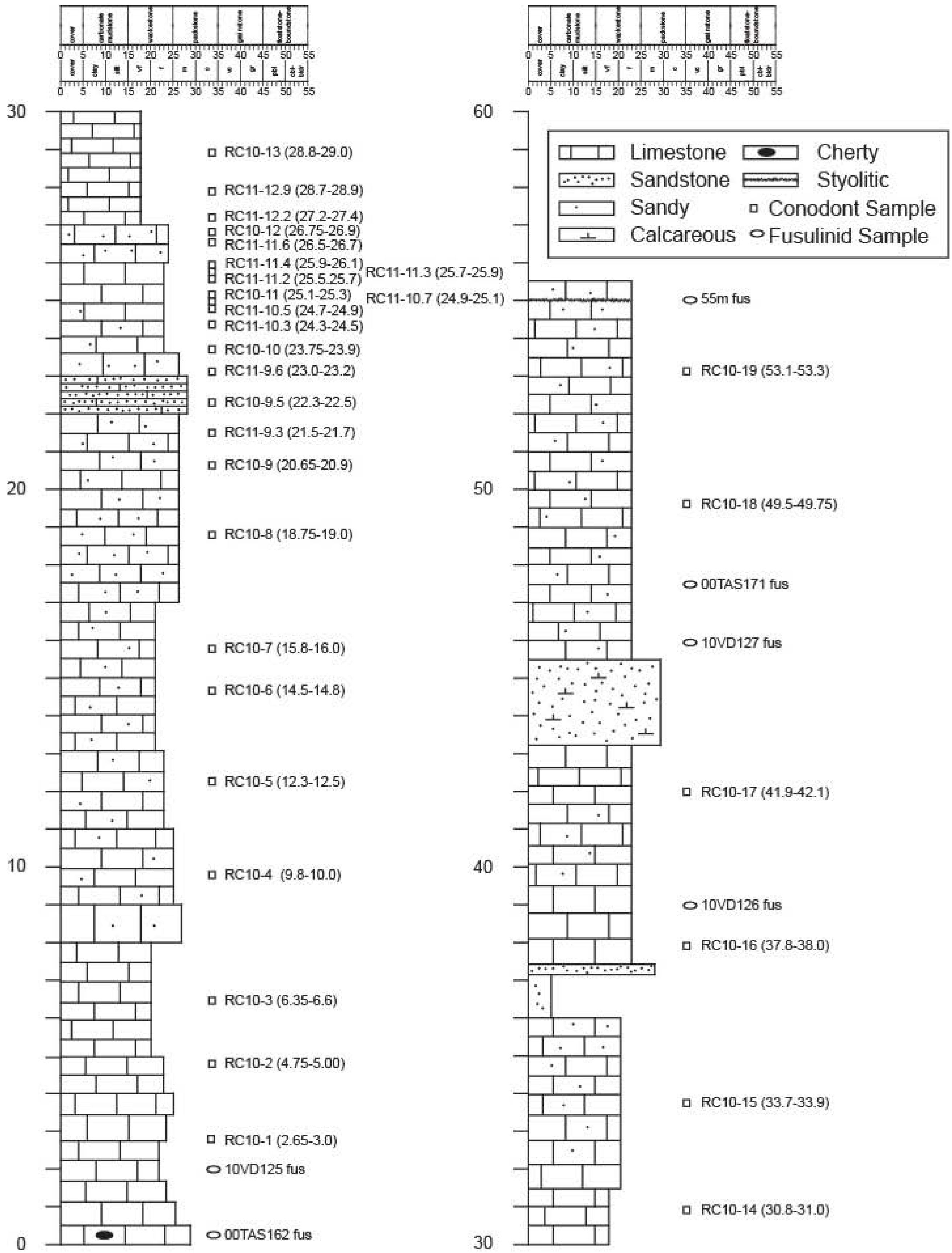

Fig. 2. Sample positions for material reported herein. There are several generations of samples including very detailed sampling at the GSSP level.

Fig. 3. Shuzhong Shen (right) standing on potential GSSP level at original Mechetlino section (note the intense weathering and trench). In contrast carbonate rocks are well preserved and 100% exposed, but with a very thin veneer of talus. Vladimir Davydov is pointing at sample RC10-6 and base of section in foreground.

that a preliminary proposal would be prepared for *Permophiles* and that the community would be invited to comment. This paper represents that preliminary proposal and was prepared by Charles Henderson based on material presented at the Workshop. Valery Chernykh and Boris Chuvashov in the intervening time decided to prepare their own proposal for the Mechetlino section and their report follows this proposal. A final determination and proposal for voting by SPS voting members will be prepared on the basis of comments from the Permian community.

Rockland Section

The Rockland Section is located near Wells, Nevada within the Pequop Mountains (Fig. 1). The base of our detailed section is at 40.77904º N and 114.60646º W (Fig. 2). The potential GSSP level is at 26.5 metres (1813.5 metres in the overall section) and is located at 40.77904º N and 114.60604º W. The Rockland section is a very thick succession dominated by carbonate rocks that seem to be continuously deposited from Sakmarian to at least Roadian, but there are also older rocks at the site. There is a strong probability that the entire Kungurian is represented at this location within marine facies.

Mechetlino Section

The original Mechetlino Section that was proposed is located on the bank of the Yuryuzan River with the potential GSSP level at 55.36192 N and 057.99035 E. Apparently, recovery of conodonts is better at the nearby newly proposed potential GSSP section. The original, visited by several of us in 2007, did not yield conodonts and was poorly exposed and deeply weathered in a trench (see Figure 3 for a comparison of outcrop at the Mechetlino and Rockland sections).

Conodonts

The potential GSSP level at both sections is the FAD of *Neostreptognathodus pnevi* within the chronomorphocline of *N.pequopensis* to *N. pnevi*. This chronomorphocline is recorded by the reduction of distinct circular nodes or denticles on the parapets of *N. pequopensis* into smooth anterior parapets with pointed or slightly ridged parapet denticles posteriorly. Transitional forms occur, and the evolution of *N. pnevi* is defined when both anterior parapets are smooth in a majority of specimens within a population (Fig. 4). Remarkably the morphotypes within sample populations at both sections are nearly identical (Fig. 5), providing significant confidence that we are truly sampling an identical and broadly correlatable level. Chernykh has proposed a new species *N. lectulus* to account for slight variation in shape of parapet denticles, but Henderson and Wardlaw both consider this as variation within a single species and would refer all specimens to occur within a population of *N. pnevi*. This difference in taxonomic philosophy does not detract from the correlation potential as the "population" concept and "species splitting" concept yield the same result. Specimens from the actual potential GSSP defining sample at Rockland are illustrated in Figure 6.

This lineage can be recognized in many locations including western and arctic Canada, but was recently thought to be missing from the Tethys. During the workshop Shuzhong Shen and Jun Chen reported that *N. pnevi* had been recovered from two sections in South China including the Luodian section. The ancestor *N. pequopensisis* missing from the region, indicating that this occurrence is probably attributable to a migration event, but this

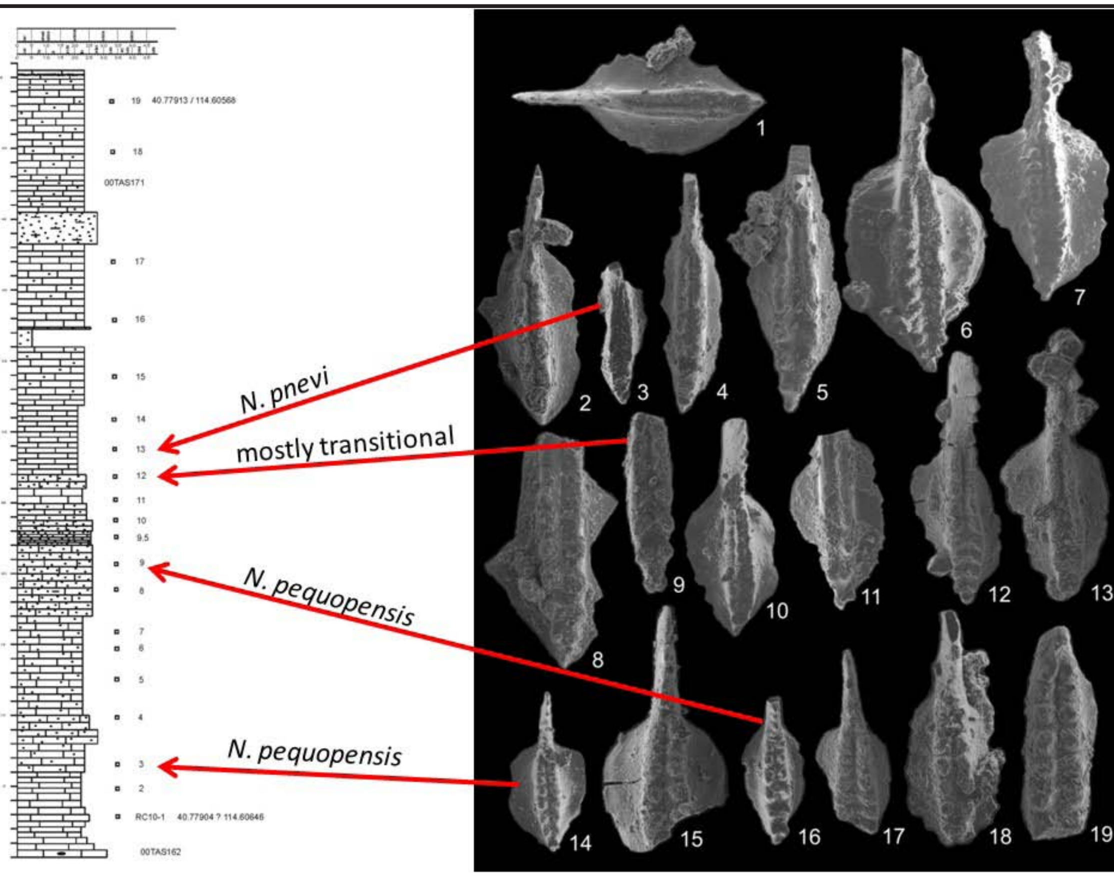

Fig. 4. Selected conodonts from samples indicated. Specimen 1 is an advanced form of *N. pnevi*, well above the detailed section of Figure 2.

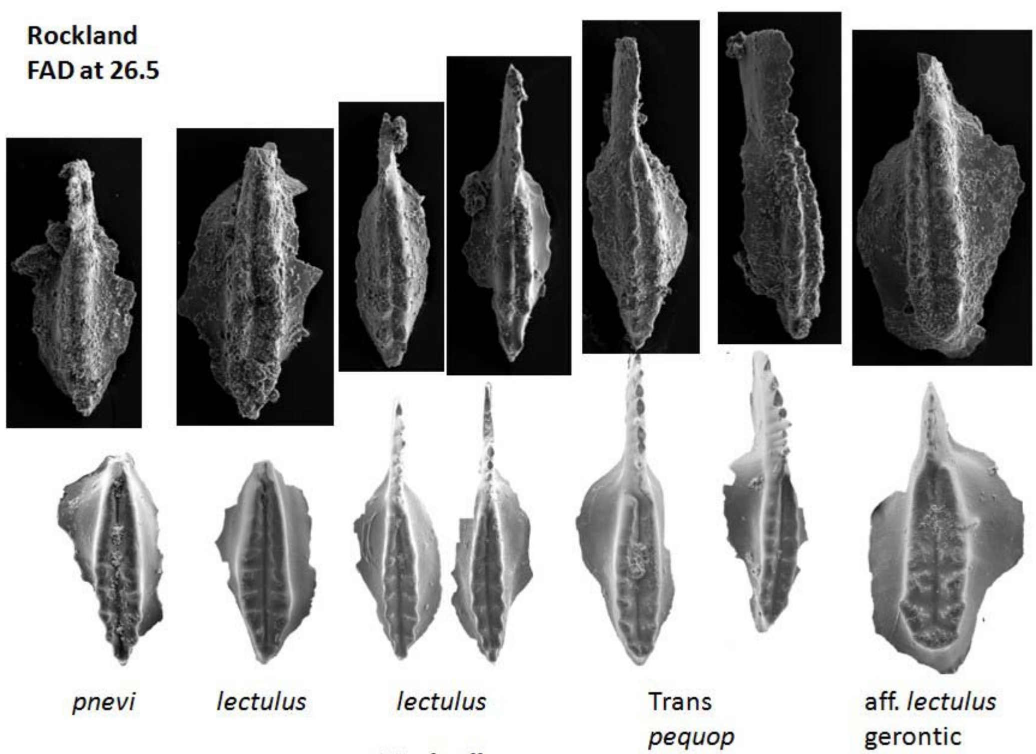

Fig. 5. Comparison of morphotypes of specimens from the potential GSSP at Mechetlino and Rockland. Note the strong similarity. Henderson and Wardlaw would regard all specimens as *N. pnevi*.

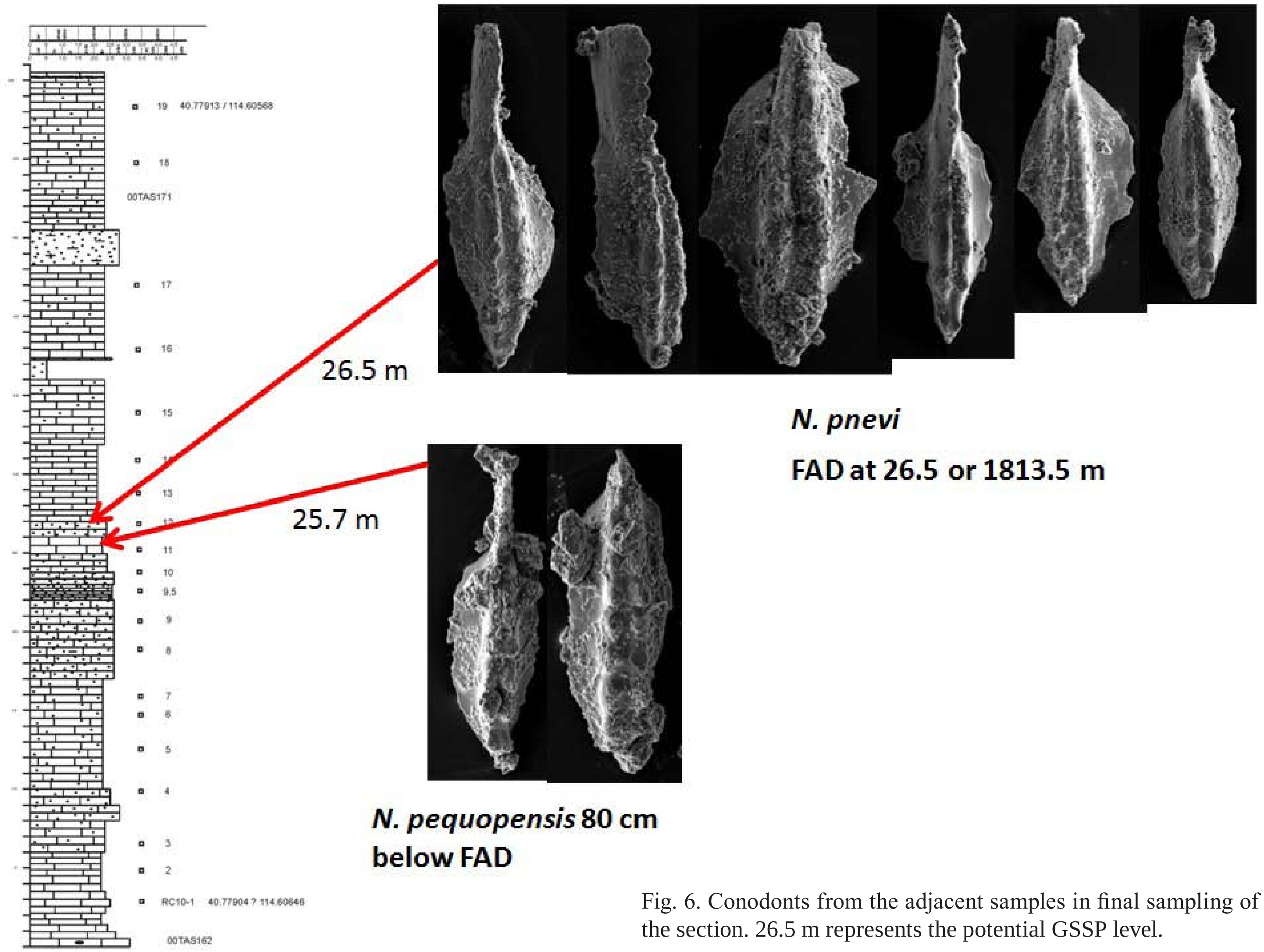

Fig. 6. Conodonts from the adjacent samples in final sampling of the section. 26.5 m represents the potential GSSP level.

occurrence can, at least, indicate proximity to the boundary and aid global correlation.

Ammonoids

Ammonoids have not been reported from the Rockland Section. They do occur in at least one horizon at the new Mechetlino section including *Paragastrioceras verneuli*, *P. karpinski*, *Uraloceras* cf. *bogoslovskayae*, *U. tchuvashovi*, and *U. fedorovi* below the potential GSSP.

Fusulinaceans

During the workshop, V.I. Davydov reported that for the first time *Pamirina* was recovered from a North American section. Specimens of *Pamirina* ex gr. *darvasica* were recovered at 55 metres at Rockland (28.5 m above the proposed GSSP level) (Fig. 7). Most of the species at Rockland below and above the boundary are endemic species of *Parafusulina*. The only previously-reported fusulinacean level at Mechetlino is within the Upper Artinskian and also includes endemic provincial species. The recovery of *Pamirina* provides a direct link to the Tethyan stage zonation and suggests that the base-Kungurian falls within the Upper Yakhtashian. The basal-Bolorian is therefore higher in the Kungurian. This, however, requires additional evaluation.

Carbon isotopes

Carbon isotopic data for whole carbonate rock have been performed on the Rockland section (K. Tierney presentation at Wells Workshop based on her Ph.D. research). These data show a series of excursions through the Cisuralian and a 2 per mil positive shift at or very close to the proposed GSSP level (Fig. 8). Additional samples have been collected and are being analyzed to fill in gaps.

Strontium isotope stratigraphy

Strontium from individual conodont elements has been integrated with geochronologic ages to produce a time model (Schmitz in progress). The approximate value for the base-Kungurian is 0.7074.

An apparently rapid, unidirectional decrease in the Sr isotopic composition of seawater beginning near the base of the Permian provides a potential chronostratigraphic proxy. The Sr isotopic compositions of well-preserved (CAI<2) conodont platform elements were measured for numerous stratigraphic horizons in the Usolka, Dal'ny Tulkas quarry, and Dal'ny Tulkas roadcut

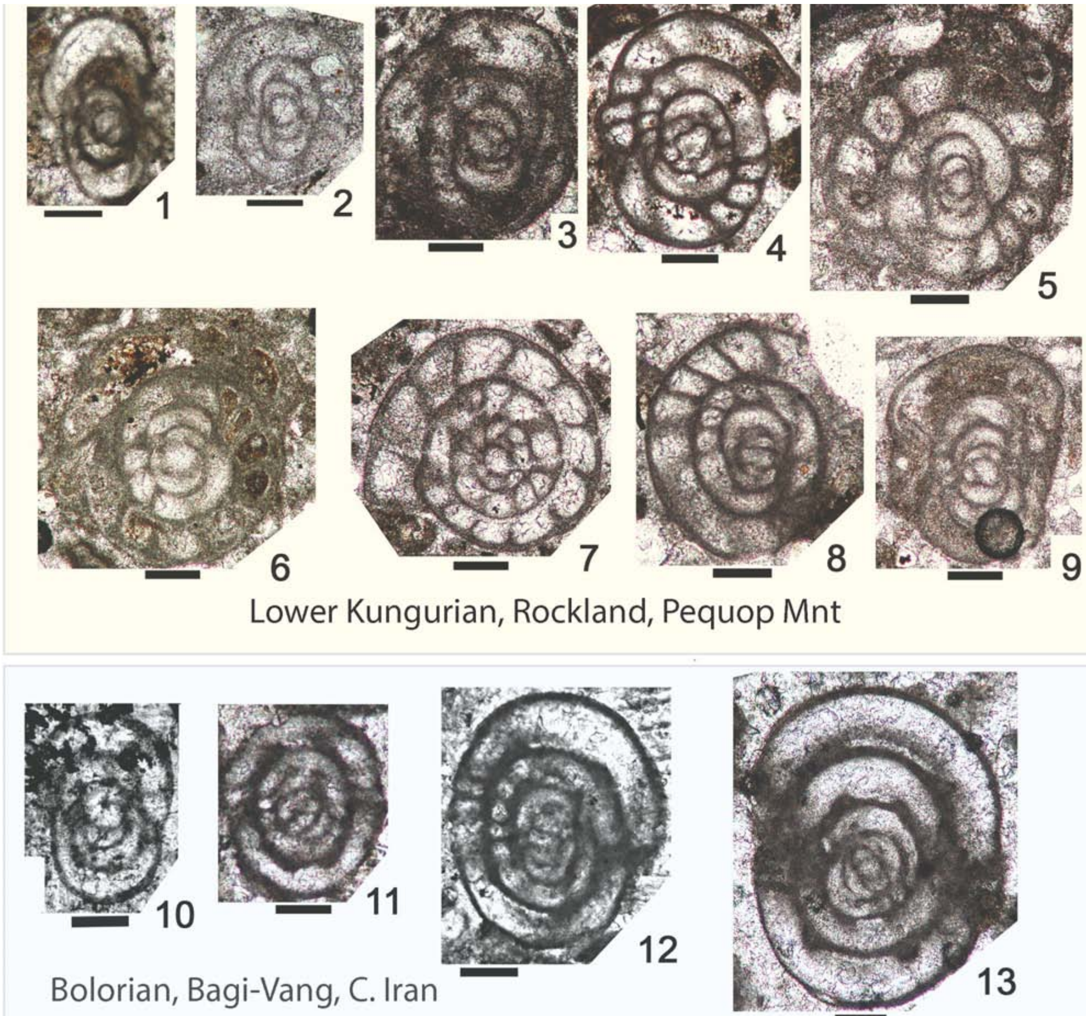

Fig. 7. *Pamirina* from Rockland, Nevada and Bagi-Vang, Centrla Iran. 1- *Grovesella*; 2, form transitional from *Grovesella* to *Pamirina*; 3-9, *Pamirina* from; 1-9, lower Kungurian at Pequop. 10, form transitional from *Grovesella* to *Pamirina*; 11-13, *Pamirina*; 10-13 from lower Bolorian, Bag-Vang, C. Iran.

sections. From one to ten conodont elements were pooled on a generic basis (*Streptognathodus*, *Mesogondolella*, or *Hindeodus*), ultrasonically cleaned in ammonium acetate and ultrapure water, and partially dissolved in dilute acetic acid to remove labile Sr. The residual elements were rinsed in ultrapure water and completely dissolved in concentrated nitric acid, dried with hydrogen peroxide to destroy organics, and redissolved in dilute nitric acid for separation of Sr via ion chromatography on Sr-spec crown ether resin (Pin and Bassin, 1991). Sr isotope ratios were measured by thermal ionization mass spectrometry with a reproducibility of $\pm$ 0.00001 (2σ).

The strontium measurements were placed within a quantitative age model based upon twenty-four high-precision CA-TIMS U-Pb zircon ash bed ages from the same stratigraphic sections (Schmitz and Davydov, 2012). The resulting chemostratigraphic curve is interpreted to represent the evolving isotopic composition of seawater, based upon the reproducibility of measurements in individual horizons, the stratigraphic consistency of the results, matrix-independent (carbonate, shale, volcanic ash) isotopic compositions, and the comparison with available literature data for brachiopod shells, which fall on or to more radiogenic values compared to the conodont measurements.

A smoothed spline fit to these data, with 95% confidence interval uncertainties provides a chronostratigraphic proxy with a resolution of approximately 0.5 to 1 Ma from the base of the Asselian through the lower Artinskian Stage (Fig. 9). The strontium isotopic composition of seawater at the base of the Artinskian Stage is $^{87}Sr/^{86}Sr$ = 0.70767. Unfortunately there are no U-Pb ages for late Artinskian to Kungurian strata of the Urals, however we may estimate the age of the base Kungurian via extrapolation of the available curve to younger ages; the dashed line in Figure 9 illustrates this extrapolation of the decreasing Sr isotopic composition through the Lower Permian. To estimate the age of the base of the Kungurian Stage, single conodont platforms from strata within the Artinskian-Kungurian transition of the Mechetlino section(s) were subject to the analytical methods outlined above; these conodonts yielded reproducible $^{87}Sr/^{86}Sr$ = 0.70743 to 0.70739. Projecting these compositions onto the extrapolated seawater curve yields an apparent age for the boundary of 283.5 $\pm$ 0.5 Ma (Fig. 9).

Kate Tierney also conducted Sr isotopic analysis on whole rock and reported some findings during the workshop. Samples near the proposed GSSP have not been analyzed, but an extrapolation from the slope (assumes continuous sedimentation rates) suggests

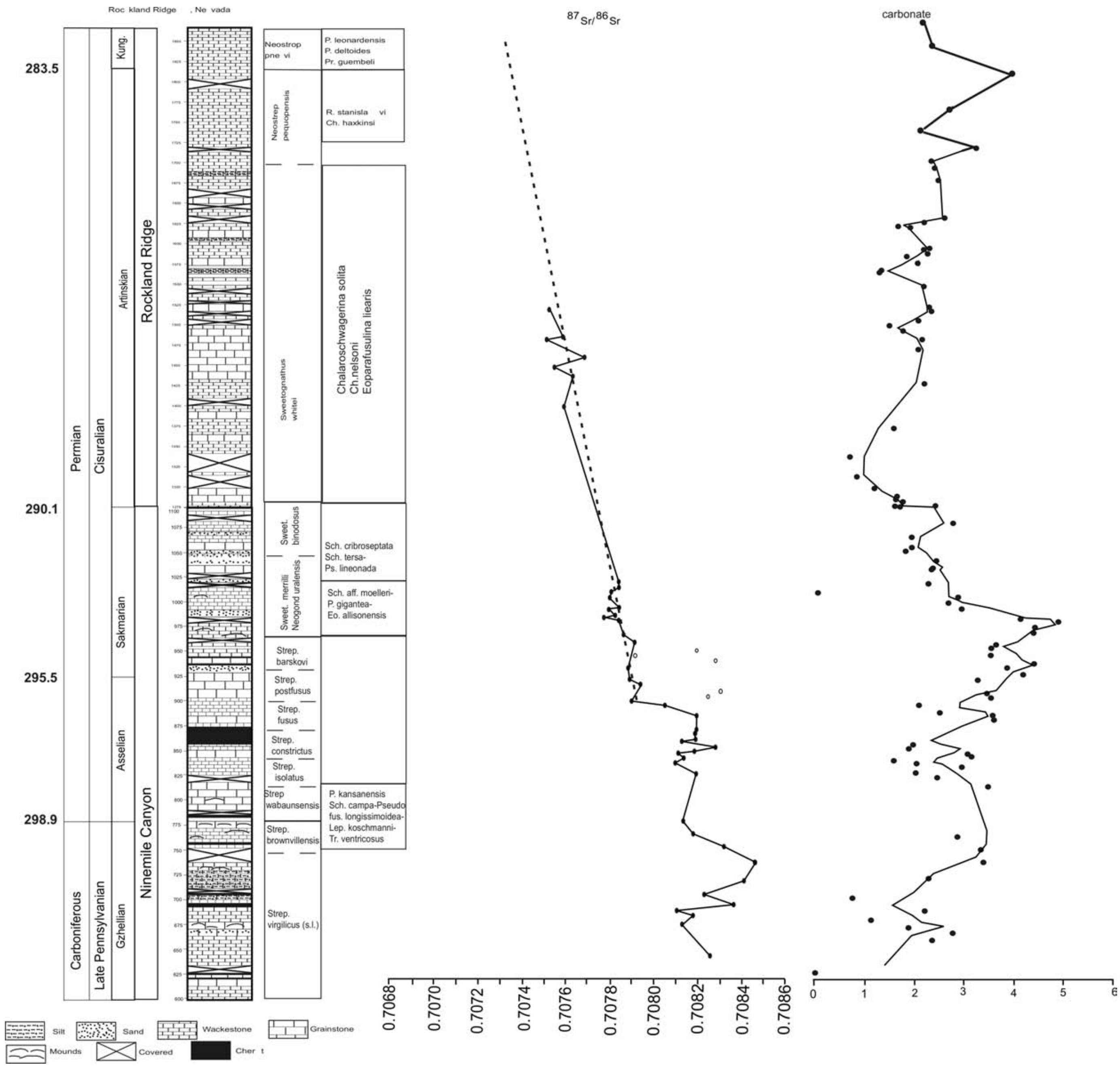

Fig. 8. Data from Kate Tierney regarding whole rock Strontium isotopic values (left) and carbon isotopic values (right). The dashed line is an extrapolation of the general slope of lower samples. This extrapolation provides a value near .70735 for the potential GSSP (compared to .7074 at Mechetlino), but this may be just "Smoke on the Water, fire in the sky". Additional samples higher in the section are available and still need to be analyzed.

that the approximate Rockland GSSP rocks would have values near 0.70735. This suggests that despite the possible diagenetic influence on values, there is correlation potential for the Sr isotopic technique.

U-Pb geochronology

The age of the base-Kungurian was set at 279.3 Ma in GTS 2012 (Henderson et al., 2012). This age is based on extrapolations between known ages within a Composite Standard produced by Davydov (in Henderson et al., 2012). Based on an integrated Sr age model, it is suggested that the base-Kungurian may be 283.5 or 283 (the whole rock value at Rockland would translate to 282 Ma). All of these ages are older than the GTS 2012 value making the Kungurian at least 3 Myrs longer in duration than previously suggested. GTS 2012 indicates that the base-Artinskian is 290.1 Ma and the base-Roadian is 272.3 Ma. Based on the new Sr age for the base-Kungurian, this suggests that the Artinskian is about 7 Myrs in duration and the Kungurian about 11 myrs in duration.

Relative comparison of the two sections

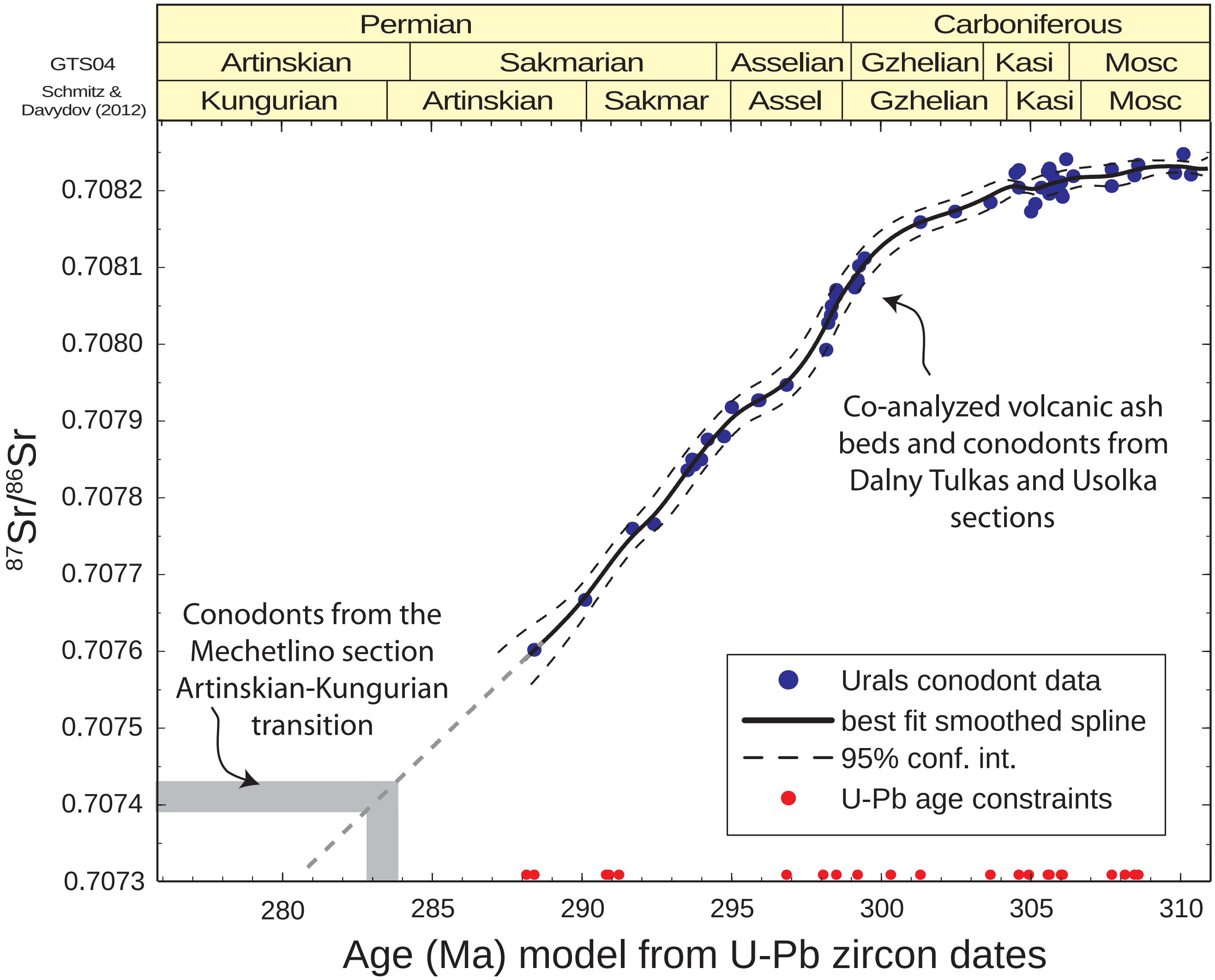

Fig. 9. Age model for Sr-isotopic work by Mark Schmitz Russian sections.

The lithologic descriptions of the two sections are provided in Appendix 1. The general lithologic characteristics of the Rockland section indicate intermediate to distal shelf with fine grained wackestone and bioclasticpackstone and an admixture of very fine grained sand probably defining some higher frequency cycles. A variety of other pelagic and benthic fossils including fusulinaceans, brachiopods, and ammonoids are present and provide additional biostratigraphic correlation tools although provincial limits this potential. The marl (carbonate mudstone) at Mechetlino section suggests slightly more distal depositional conditions compared with Rockland, but terrigenous material are also present in the form of sand and plant detritus. Mechetlino section also contains “ash” beds, but the zircons in these beds are all detrital. Associated fossils are not common, but include pelagic ammonoids and an occurrence of provincial fusulinaceans below the boundary. The input of terrigenous material at both sections is not surprising given the lowstand setting.

The Mechetlino section appears to be significantly condensed compared to the Rockland section. One estimate was the thickness from FAD to advanced *N. pnevi*. At Rockland this is 153.5 metres (1813.5 to 1967 m) and at Mechetlino it is 3.64 m suggesting that the latter is 42 times as condensed (Fig. 10). It was generally agreed during the workshop that the Rockland section was superior from a rock perspective and that Mechetlino may be superior from a time perspective given the potential of Sr-isotopic resolution because conodonts at Mechetlino are better preserved (no overgrowths) and exhibited a lower CAI making these specimens superior for obtaining original Sr-isotopic signatures.

The Mechetlino section is located in the historical type area for the Kungurian, but the section includes only the late Artinskian and early Kungurian. In contrast, the Rockland section includes nearly complete deposition through the Artinskian and Kungurian. The relative merits of the two sections are highlighted in Table 1. Overall the Rockland section appears to be a better GSSP (see Fig. 11 for photo of proposed GSSP site) with 10 points in favour compared to 7 for the Mechetlino section. This is comparable to our straw vote at the workshop. Given the problems associated with a lowstand and marked provincialism it is likely that no perfect section will emerge. The working group voted for Rockland as the primary GSSP. Given the correlation problems it is considered valuable to have a supplementary reference section at Mechetlino. SPS will produce a ballot following comments by SPS corresponding and voting members for one of these sections.

Summary

Compare and contrast Rockland (R) and Mechetlino (M) sections as GSSP	R	M
Conodont morphotypes and chronomorphoclines are identical at both projected GSSP sections indicating similar stage of evolution. *N. pnevi* is most common in cool-water settings, but has been recovered from warm-water settings in China and Texas.	√	√
Conodont frequency is comparable at both sections ranging from zero to 20/kg.	√	√
Conodonts exhibit pristine preservation and low CAI (1.5) at Mechetlino and are partially recrystallized and higher CAI (4.0) at Rockland.		√
Conodonts at Mechetlino are suitable for strontium isotopic analysis that can be utilized to project an age model for the GSSP level. Whole rock strontium isotopic analysis is possible for Rockland carbonate.		√
The Pequop Formation at Rockland is 1305 metres thick and represents almost the entire Artinskian and Kungurian. The section at Mechetlino is 88 m thick and includes upper Sarginian, Saranian and Phillipovian.	√	
The lithologic succession at both sections is monofacial, dominated by carbonate mudstone (M) and wackestone (R) with some siliciclastics at both. Dominantly suspension sedimentation with few tempestites at both sections.	√	√
Boundary interval is condensed at Mechetlino and expanded at Rockland (estimated expansion is 42 times).	√	
Carbonate deeply weathered at main Mechetlino section and unsuitable for C-isotopic study, but well preserved at only boundary level at quarry section. Rockland carbonate may be influenced by diagenesis, but suitable for whole rock C-isotopic study.	√	
Carbonate carbon isotopic data available at Rockland and show a 2 per/mil positive shift near GSSP level. No analysis for Mechetlino.	√	
Upon further examination, beds previously identified as volcanic ashes at Mechetlino are now identified as detrital siltyclaystone and bearing Late Devonian detrital zircons. No volcanic ashes at Rockland.		
Sections are well exposed, but trenching required at both sections. Both are accessible and on public land. Access is probably easier for the Rockland Section.	√	√
Benthic fossils include fusulinaceans, brachiopods, bryozoans and echinoderms at Rockland. Mechelino has fusulinaceans in Upper Artinskian and two horizons with ammonoids.	√	
Most fossils, other than conodonts, are provincial and endemic to each region. Fusulinaceans at Rockland include *Pamirina* providing a correlation with the Tethys.	√	
Mechetlino section is within the historical type area, although original Kungurian is dominated by evaporites near the city of Perm.		√

Table 1. Comparison of GSSP characteristics of the two sections. This analysis favours Rockland section 10 to 7.

The base-Kungurian GSSP is proposed to be defined at the FAD of *Neostreptognathodus pnevi* within the chronomorphoclinefrom *N. pequopensis* to *N. pnevi* at the Rockland Section, Nevada with the Mechetlino Section in Russia serving as a secondary reference. An extrapolated geochronologic age (283 to 283.5 Ma), Sr isotopic value (0.7074), carbon isotopic trends and other fossils (primarily fusulinaceans) provide additional means for correlation.

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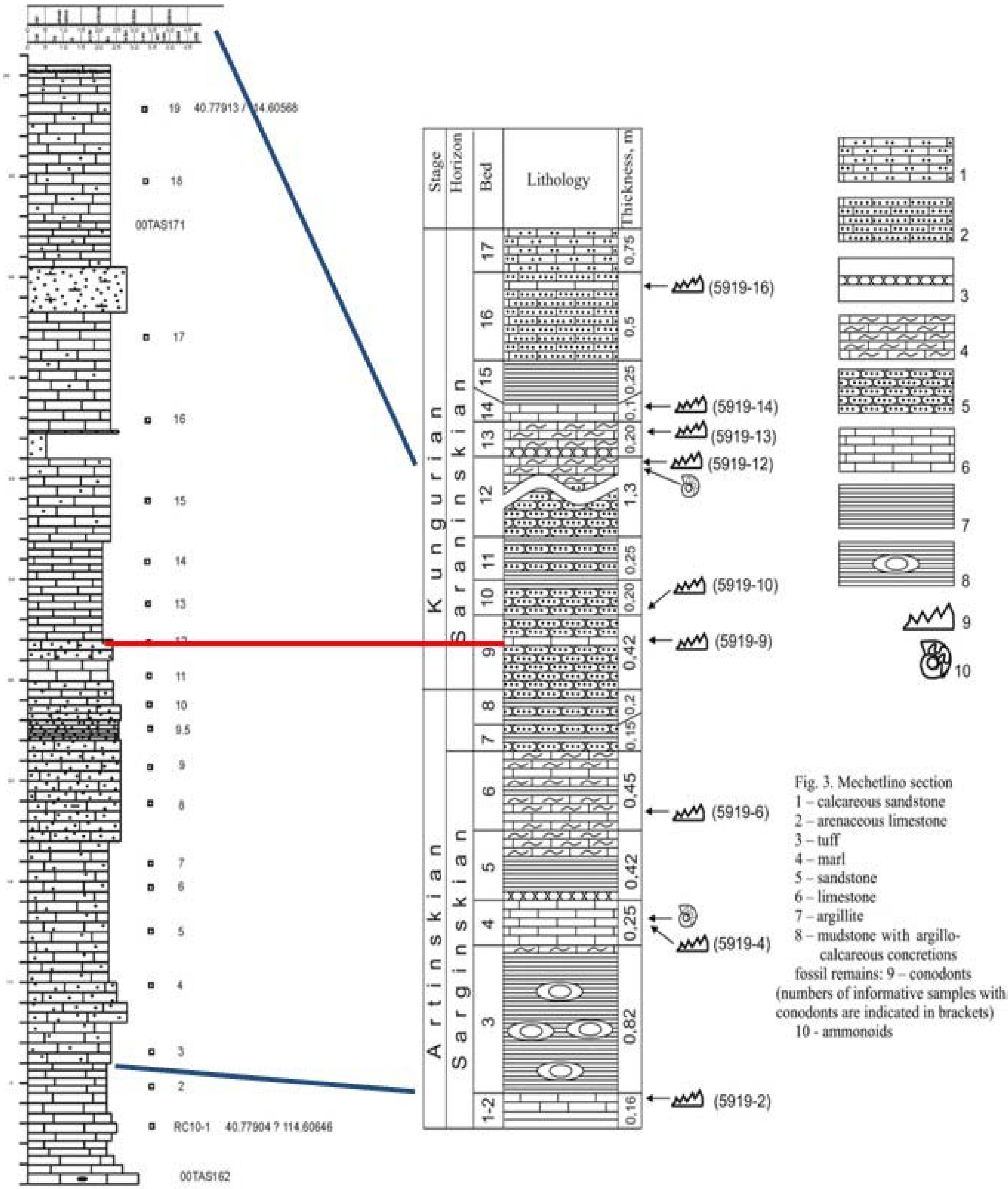

Fig. 10. Comparison of the two sections. Notice the condensation at Mechetlino. Blue lines represent corresponding points (well above section at Rockland) and red line the GSSP level. Note GSSP at Mechetlino should be a limestone bed with conodonts (5919-9) and not at the "bed" base. Only 2010 sampling is shown for Rockland; Fig. 2 shows detailed 2011 sampling near GSSP level."

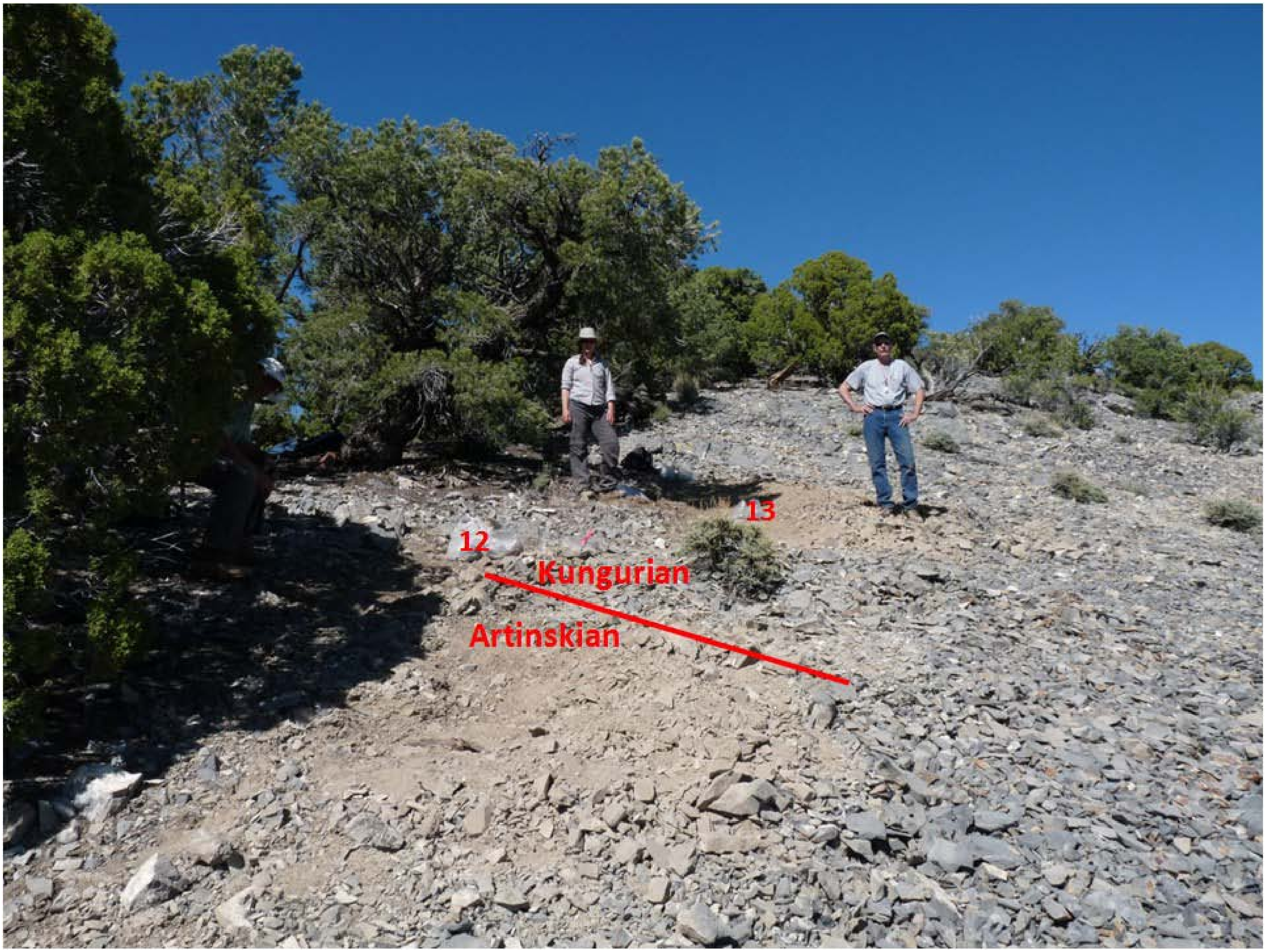

Fig. 11. Close up of the GSSP level at . Kate Zubin-Stathopoulos and Bruce Wardlaw for scale.

Appendix 1 (Lithologic descriptions)

Rockland section, Nevada, USA

Mab Description

0.0 – 0.5 Brownish grey, sandy, fusulinidpackstone with bryozoans at base.

0.5 – 1.7 Medium grey, bioclasticpackstone fining upward to wackestone.

1.7 – 2.65 Medium grey, bioclasticwackestone.

2.65 – 3.2 Grey bioclastic wacke-packstone, sample RC10-1 (2.65-3.0).

3.2 – 5.0 Grey, fusulinid wacke-packstone, sample RC10-2 (4.75-5.00).

5.0 – 8.0 Medium grey, slightly sandy, sparsely fossiliferous-wackestone, sample RC10-3 (6.35-6.60).

8.0 – 9.0 Brownish grey, sandy, fine-grained, bioclastic packstone.

9.0 – 11.0 Brownish grey, sandy, fine-grained, bioclastic wacke-to-packstone, sample RC10-4 (9.8-10.0).

11.0 – 13.5 Medium grey, slightly sandy, bioclastic wackestone, sample RC10-5 (12.3-12.5).

13.5 – 17.0 Medium grey, slightly sandy, fine-grained, bioclastic wackestone, samples RC10-6 (14.5-14.8), RC10-7 (15.8-16.0).

17.0 – 18.5 Brownish grey, very sandy, fine-grained, bioclastic packstone.

18.5 – 19.0 Brownish grey, sandy, bioclastic packstone with silt filled burrows, sample RC10-8 (18.75-19.0).

19.0 – 20.65 Brownish grey, very sandy, fine-grained, bioclasticpackstone.

20.65 – 21.0 Brownish grey, sandy, bioturbated, bioclastic packstone, sample RC10-9 (20.65-20.90).

21.0 – 22.0 Brownish grey, very sandy, fine-grained bioclastic-packstone, sample RC11-9.3 (21.5-21.6).

22.0 – 23.0 Brownish grey, platy, calcareous sandstone with floating fusulinids.

23.0 – 23.7 Brownish grey, very sandy, fine-grained bioclastic packstone, sample RC11-9.6 (23.0-23.1).

23.7 – 24.9 Brownish grey, sandy, bioclastic wackestone, samples W97-17 (23.72-24.0) *Neostreptognathodus pequopensis*, RC10-10 (23.75-23.90), RC11-10.3 (24.3-24.4), RC11-10.5 (24.7-24.8),

RC11-10.7 (24.9-25.0).
24.9 – 26.0 Medium grey, clean, fine-grained, bioclastic wackestone, samples RC10-11 (25.1-25.3), RC11-11.2 (25.5-25.6), RC11-11.3 (25.7-25.8), RC11-11.4 (25.9-26.0).
26.0 – 27.0 Brownish grey, very sandy, tight, bioclastic wackestone, samples RC11-11.6 (26.5-26.6) *Neostreptognathodus pnevi*, RC10-12 (26.75-26.9).
27.0 – 31.6 Medium grey, fine-grained, bioclastic wackestone, samples RC11-12.2 (27.2-27.3), RC11-12.9 (28.7-28.8), RC10-13 (28.8-29.0), RC10-14 (30.8-31.0).
31.6 – 32.2 Medium grey, medium-grained, bioclastic wackestone.
32.2 – 36.0 Grey, sandy, medium-graindeded, bioclastic wackestone, sample RC10-15 (33.7-33.9).
36.0 – 37.8 Light olive brown, fine-to-medium grained sandstone (36.0-37.7 covered and trenched).
37.8 – 40.0 Medium grey, slightly sandy, bioclastic wackestone, sample RC10-16 (37.8-38.0).
40.0 – 41.5 Brownish grey, sandy, bioclastic wackestone.
41.5 – 43.3 Medium grey, bioclastic wackestone, sample RC10-17 (41.9-42.1).
43.3 – 45.5 Light olive brown, fusulinid, calcareous sandstone.
45.5 – 47.0 Brownish grey, sandy, fusulinid wackestone, sample W97-18 (46.58-47.0) *Neostreptognathodus pnevi*.
47.0 – 54.5 Brownish grey, sandy, bioclastic wackestone, samples RC10-18 (49.5-49.75), RC10-19 (53.1-53.3).
54.5 – 55.5 Brownish grey, styolitic, sandy, bioclastic wackestone, *Pamirina darvasica* at 55 m.

Mechetlino section, Southern Urals, Russia
1. Argillite dark greenish-grey with lumpy jointing, slightly calcareous with visible thickness up to 10 cm.
2. Limestone, brownish-grey fine-grained, detrital, organogenic, with an uneven surface and variable thickness from 5 to 8 cm. Fossils present are tiny (2 mm) segments of crinoids and tubular attached foraminifers. Sample 5919-2 is taken here. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* (Kozur). 0.10 m.
3. Grey calcareous argillite, strongly transitioning to marl. In this layer there are flat-oval concretions up to 10 cm long and of 3-5 cm in thickness. They have distinct Liesegang rings. Small charred fragments of organic remains are present. 0.82 m.
4. Limestone, dark-brown, grey, thin-bedded (in the lower part 5 cm, upper up to 10 cm) with irregular bedding planes with 3-5 mm interlayers of dark grey marl-argillite. Sample 5919-4 is taken here. Conodonts: *Neostreptognathodus pequopensi* Behnken, *N. ruzhencevi* Kozur, *Sweetognathus somniculosus* Chernykh; ammonoids: *Paragastrioceras verneili* (Ruzhencev), *P. karpinski* (Ruzhencev), *Uraloceras* cf. *U. bogoslovkayae* (Voronov), *U. tchuvashovi* Bogoslovskaya, *U. fedorovi* (Karpinsky). 0.25 m
5. Argillite, in the lower part dark grey, thin-plated, with a thickness of the plates 0.5 cm. Organic remains are represented by charred plant detritus (1-2 mm). The bottom layer (10 cm) has a series of small (1-5 mm) layers of yellow tuff. In the upper part of this bed is a 1-cm band of fine-detrital limestone. In the upper part of the unit the argillite passes into marl 10-12 cm thick. Tuff sample 5919-5a was taken in this unit. 0.42 m.
6. Marl, grey to dark grey, thin-bedded. Homogeneous grey layers of 3-4 cm thick replaced by argillite (1-2 cm) interbedded with thin-bedded (up to 3 cm) detrital limestone. Sample 5919-6 was taken here. Conodonts: *Sweetognathus somniculosus* Chernykh. 0.45 m.
7. Greenish-grey sandstone with thin (2-5 cm) interbeds of black argillite with plant detritus. 0.15 m
8. Sandstone, greenish-grey to black. Platy loose rock with alternating of intercalations of coal like rock with thickness up to 1-1.5 cm. Sandstone layers are denser, coal is loosely compacted. 0.20 m.

The trenched section ends here and remaining part of the section is in the exposed part of the quarry.

9. Sandstone, grey and greenish-grey, fine-grained to silt-grained (below), massive, highly calcareous. There is frayed plant detritus. The sample 5919-9 is taken here. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. lectulus* Chernykh, *N. pnevi* Kozur. 0.42 m.
10. Sandstone, greenish-grey with a rusty stain on the surface layers. In the lower part of the unit the bed has a thickness of 5-7 cm where there is an alternation of sandstone with interbedded argillite (the thickness of the upper layer is 0.2 m). Above is exposed up to 0.25 m of fine-grained sandstone that splits into irregular plates of thickness of 1- 3cm. Sample 5919-10 is taken here. Conodonts: *Sweetognathus* aff. *S. whitei* (Rhodes), *Neostreptognathodus ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N.* cf. *N. pnevi* Kozur. 0.45 m.
11. Greenish-grey fine-grained sandstone at the base with an admixture of coarser sandy material. The layer loses its integrity and is divided into plates of thickness up to 5cm. 0.25 m
12. Uniform layer of fine-grained sandstone, in the lower part massive, in the upper part laminated. At the top, the bed is bounded by a tuff bed. Inside of the lower part of the sandstone there is marl with thin (2-3 mm) interlayers of fine-grained grey limestone. To the right from the trench (when facing the face of the quarry), these layers of marl are transformed into lens with thickness up to 10 cm of brownish-grey very dense and hard limestone with rare ammonites. Sample 5919-12a is taken from the limestone lens. Sample 5919-12b is taken from a mixture of marl and limestone samples of this unit. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pnevi* Kozur. 1.3m.
13. A small bed of thin-bedded clayey limestone with thin stratification, in the upper part with a mixture of tuff material. Conodonts: *Neostreptognathodus ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pnevi* Kozur. 0.2 m.
14. Lenticular grey - greenish limestone with a mixture of detrital material. Conodonts: *Neostreptognathodus pequpensis* Behnken. 0.05 – 0.1m.
15. Argillite, dark greenish-grey strongly calcareous and strongly deformed. Organic material: small foraminifera, crinoids segments, bryozoans. 0.25 m.
16. A massive layer of sandy limestone (base of which is situated 3 m above the bottom of the quarry). Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pnevi*

Kozur. 0.5 m

17. Thick layer of calcareous monolithic sandstone: dark grey fine-grained with thickness up to 10 cm in the lower part. This lower part is situated approximately 75 cm above the tuff layer from unit 13. Sample 5919-17 is taken here. 0.70 m
18. Alternation of sandstone with rare interbedded argillite. 0.50 m
19. Greenish-grey argillite.0.27 m.
20. Sandstone.0.27 m.
21. Calcareous sandstone. 0.45 m.
22. Limestone. 0.72 m.
23. Thin-bedded limestone.0.32 m.
24. Argillite. 0.95 m.
25. Limestone.0.25 m.

Above this section there is a packet of the repetitious sandstone (thickness of beds 0.5 – 20 cm), which contains beds (thickness up to 10 - 15 cm) of limestone and argillite.

Mechetlino Section: A candidate for the Global Stratotype and Point (GSSP) of the Kungurian Stage (Cisuralian, Lower Permian)

Chernykh, V. V., Chuvashov, B. I.
Zavaritskii Institute of Geology and Geochemistry, Ural Branch, Russian Academy of Sciences, Pochtovyi per. 7, Yekaterinburg, 620219 Russia; e-mail: chernykh@igg.uran.ru

Davydov, V.I., Schmitz, M.D.
Boise State University, USA; vdavydov@boisestate.edu; MarkSchmitz@boisestate.edu

On the right bank of the Juryuzan River between the villages Mechetlino and Makhmutova (Southern Preurals), the strata of the upper part of the Artinskian Stage (Sarginian Horizon) are exposed, above which in the section is a thick unit of silty-carbonate deposits of the Saranian and Philippovian Horizons of the Kungurian Stage (Figs. 1, 2). This section contains fusulinids, ammonoids, conodonts, and presumably some layers of volcanic ash beds. We are proposing this section as a candidate of the Global Section Stratotype and Point (GSSP) for the base of the Kungurian Stage of the International Stratigraphic Time Scale.

The proposed section that we call Mechetlino Quarry (MQ), located about 600 m east from previously studied and described in the literature Mechetlino section (MS) (Chernykh, 2006; Chuvashov and Chernykh, 2007) that was demonstrated as a potential GSSP at the international field workshop in 2007 (Davydov and Henderson, 2007). Some of the biostratigraphic data from Mechetlino section, particularly conodonts and fusulinids are used in this proposal as Mechetlino and Mechetlino Quarry sections are correlated bed by bed (Fig. 3).

The Artinskian-Kungurian interval in the MQ section is exposed 500-600 m east the Mechetlino section (MS) in a small quarry and is represented by carbonate, marl, sandstone and sandy carbonate sediments with a total thickness of over 10 metres. The lower part of the section is exposed in a short trench (Fig. 3). In the QS there are thin layers of potential tuff, three in the Artinskian part of the section, and two in the Kungurian. Many layers of the rocks contain a considerable admixture of carbonate material, and can be processed by standard acid techniques to extract conodonts. The lithology, conodonts and other faunal elements of this section have been published recently with preliminary results (Chuvashov and Chernykh, 2011).

In 2011, the Artinskian – Kungurian interval in this quarry was excavated (Fig. 2) and additional samples for conodonts and ammonoid studies were taken. This collection narrows the interval of the occurrence of Artinskian species and the first Kungurian species of conodonts and thus constraining boundary within an interval less than one metre (Fig. 4). The potential volcanic tuff samples were taken from five levels and were sent to Boise State University to search the datable zircon crystals. However, the recovered zircons from all processed samples turns to be detrital. Devonian age has been obtained from zircons in one most promising sample.

The description of the studied section is given below. The conodonts (from MQ) and fusulinids (recovered in MS) are illustrated in the paleontological plates (Plates I-III).

Section description

1. Argillite, dark greenish-grey, with lumpy jointing, slightly calcareous with a visible. Thickness is up to 10 cm.
2. Limestone, brownish-grey, fine-grained, bioclastic, with an uneven surface and variable thickness from 5 to 8 cm. Preserved fossils are tiny (2 mm) fragments of crinoids and tubular attached foraminifers. Sample 5919-2 is taken here. Conodonts recovered include *Neostreptognathodus pequopensis* Behnken and *N.*

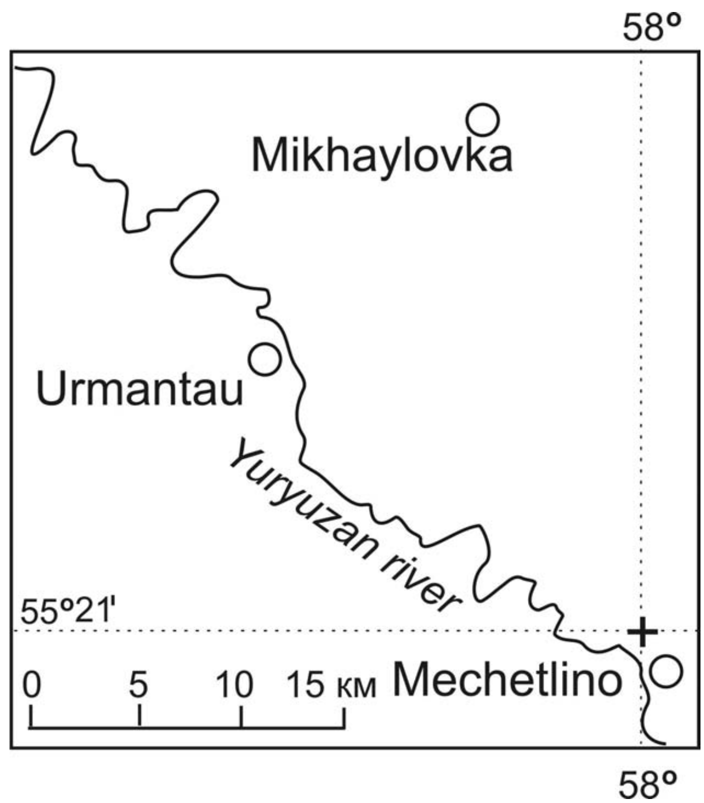

Fig. 1. Location of the Mechetlino quarry.

Fig. 2. View of the Mechetlino quarry (debris opened by trench).

ruzhencevi Kozur. 0.10 m.

3. Grey calcareous argillite passing into the marl. In this layer there are compressed along surface limestone nodules up to 10 cm long and of 3-5 cm in thickness. The nodules possess a distinct Liesegang rings. Small charred fragments of organic remains are present. 0.82 m

4. Bioclastic limestone, dark-brown, grey, thin-bedded (in the lower part 5 cm, upper up to 10 cm) with irregular bedding planes with 3-5 mm interlayers of dark grey marl-argillite. Sample 5919-4 is taken here. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *Sweetognathus somniculosus* Chernykh; ammonoids: *Paragastrioceras verneili* (Ruzhencev), *P. karpinski* (Ruzhencev), *Uraloceras* cf. *U. bogoslovskayae* (Voronov), *U. tchuvashovi* Bogoslovskaya, *U. fedorovi* (Karpinsky). 0.25 m

5. Argillite, in the lower part dark grey, thin-plated, with a thickness of the plates 0.5 cm. Organic remains are represented by charred plant detritus (1-2 mm). The bottom layer (10 cm) has a series of small (1-5 mm) layers of yellow tuff. In the upper part of this bed there is a 1-cm band of fine-bioclastic limestone. In the upper part of the unit the argillite passes into marl 10-12 cm thick. Tuff sample 5919-5a was taken in this unit . 0.42 m

6. Marl, grey to dark grey, thin-bedded. Homogeneous grey layers of 3-4 cm thick replaced by argillite (1-2 cm) interbedded with thin-bedded (up to 3 cm) bioclastic limestone. Sample 5919-6 was taken here. Conodonts: *Sweetognathus somniculosus* Chernykh. 0.45 m

7. Greenish-grey sandstone with thin (2-5 cm) interbeds of black argillite with plant detritus. 0.15 m.

8. Sandstone, greenish-grey to black. Platy loose rock with alternating of intercalations of coal like rock with thickness up to 1-1.5 cm. Sandstone layers are denser, coal is loosely compacted . 0.20 m.

The trenched section ends here and remaining part of the section is in the exposed part of the quarry.

9. Sandstone, grey and greenish-grey, fine-grained to silt-grained (below), massive, highly calcareous matrix. There is frayed plant detritus. The sample 5919-9 is taken here. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. lectulus* Chernykh, *N. pnevi* Kozur et Movshovitsch.

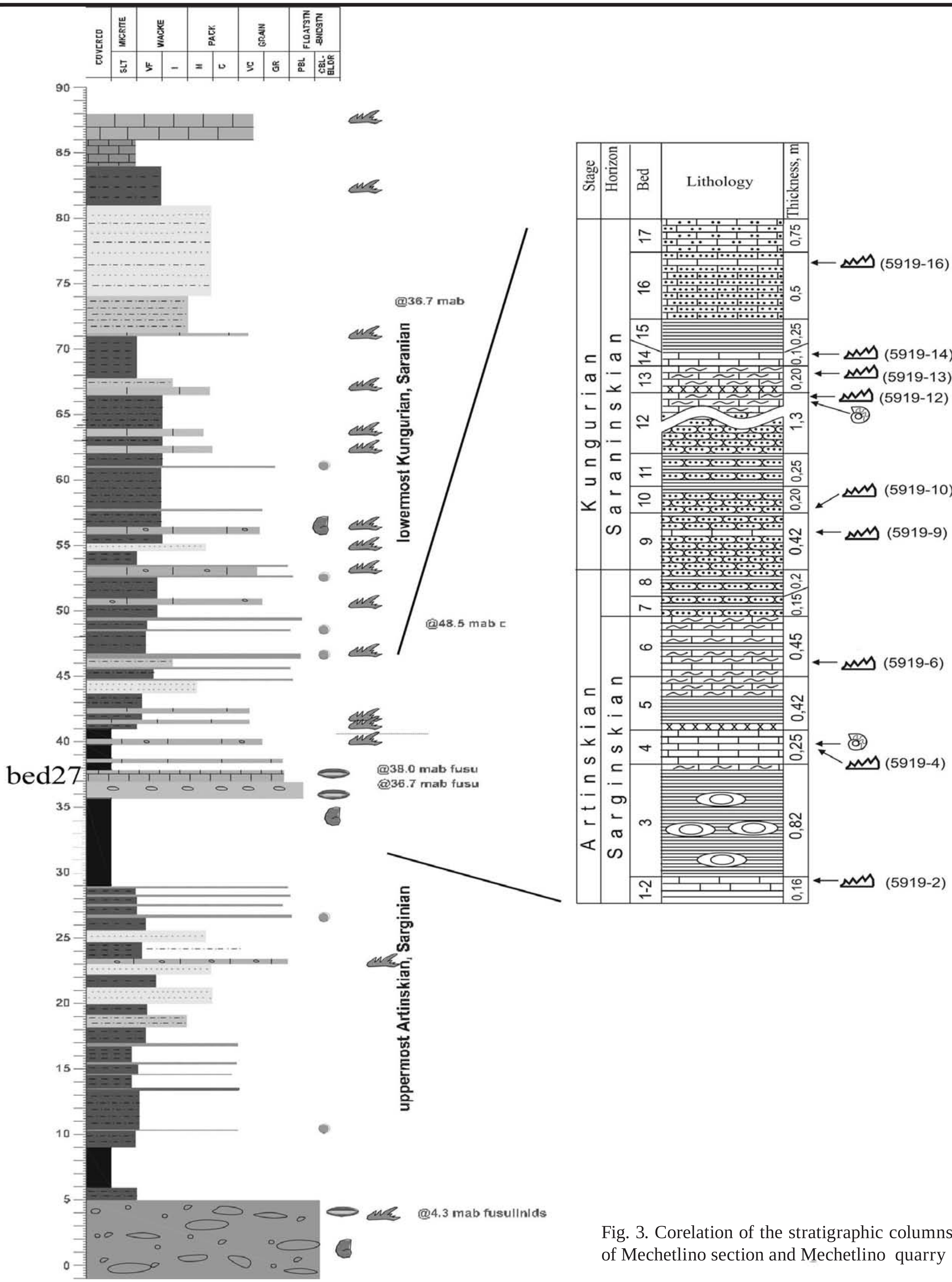

Fig. 3. Corelation of the stratigraphic columns of Mechetlino section and Mechetlino quarry

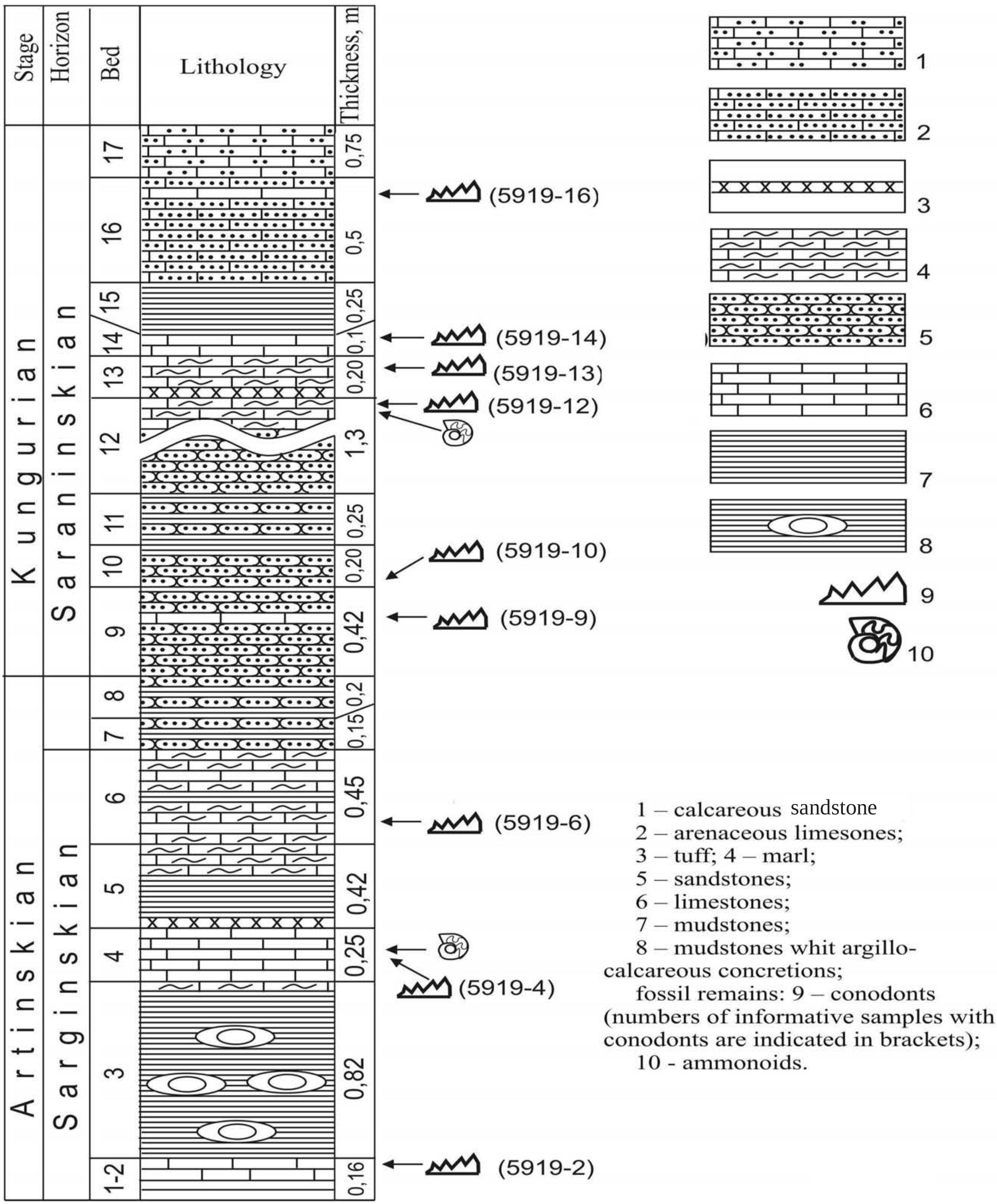

Fig. 4. Stratigraphic column with distribution of samples taken for conodonts and ammonoids.

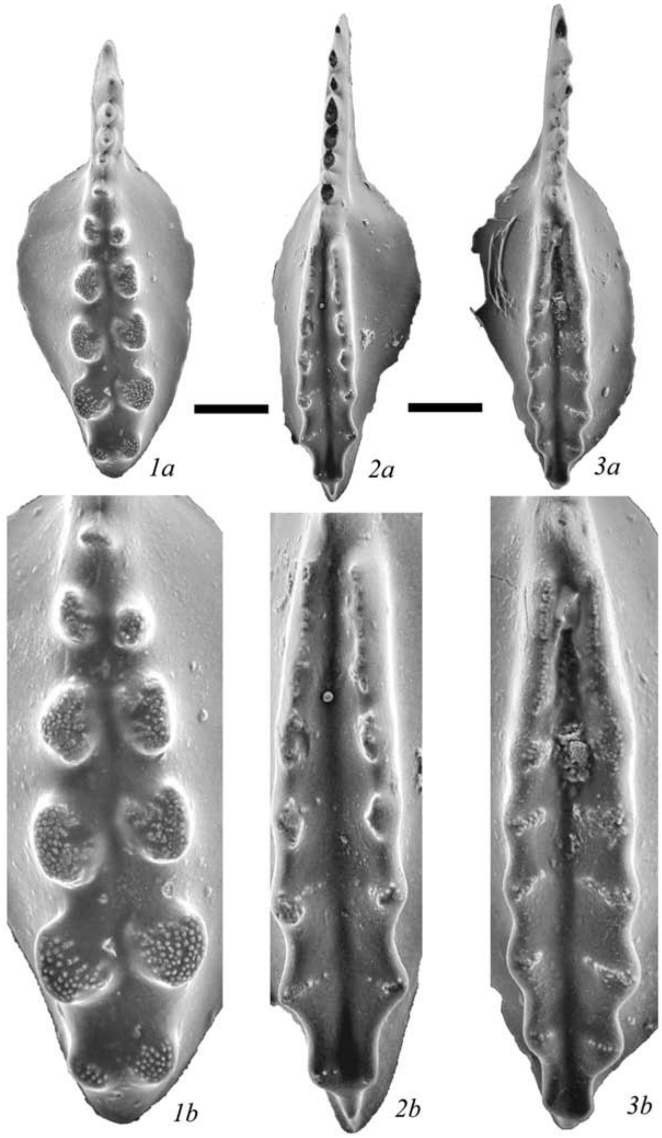

Fig. 5. The evolutionary lineage of *Neostreptognathodus pequopensis* Behnken – *N. pnevi* Kozur et Movshovitsch Chernykh. 1 - *Neostreptognathodus pequopensis*, from Bed 4; 2 - transitional from *N. pequopensis* to *N. pnevi*, from Bed 9; 3 – *N. pnevi*, from Bed 9.

0.42 m.

10. Sandstone, greenish-grey with a rusty stain on the surface layers. In the lower part of the unit the bed has a thickness of 5-7 cm where there is an alternation of sandstone with interbedded argillite (the thickness of the upper layer is 0.2 m). Above is exposed up to 0.25 m of fine-grained sandstone that splits into irregular plates of thickness of 1-3 cm. Sample 5919-10 is taken here. Conodonts: *Sweetognathus* aff. *S. whitei* (Rhodes), *Neostreptognathodus ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N.* cf. *N. pnevi* Kozur et Movshovitsch. 0.45 m.

11. Greenish-grey fine-grained sandstone at the base with an admixture of coarser sandy material. The layer loses its integrity and is divided into plates of thickness up to 5 cm . 0.25 m.

12. Uniform layer of fine-grained sandstone, in the lower part massive, in the upper part laminated. At the top, the bed is bounded by a tuff bed. Inside of the lower part of the sandstone there is marl with thin (2-3 mm) interlayers of fine-grained grey limestone. To the right from the trench (when facing the face of the quarry), these layers of marl are transformed into compressed nodule of brownish-grey very dense and hard limestone with rare ammonites. The thickness of this nodule is up to 10 cm. Sample 5919-12a is taken from the limestone lens. Sample 5919-12b is taken from a mixture of marl and limestone samples of this unit. Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pseudoclinei* Kozur et Movshovitsch, *N. pnevi* Kozur et Movshovitsch. 1.3m

13. A small bed of thin-bedded silty limestone with thin stratification, in the upper part with a mixture of tuff material. Conodonts: *Neostreptognathodus ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pnevi* Kozur and Movshovitsch. 0.20 m.

14. Lenticular grey - greenish limestone with a mixture of bioclastic material. Conodonts: *Neostreptognathodus pequopensis* Behnken. 0.05 – 0.10m.

15. Argillite, dark greenish-grey strongly calcareous and strongly deformed. Organic material: small foraminifers, crinoid segments, bryozoans. 0.25 m.

16. A massive layer of sandy limestone (base of which is situated 3 m above the bottom of the quarry). Conodonts: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *N. labialis* Chernykh, *N. lectulus* Chernykh, *N. pnevi* Kozur et Movshovitsch.50 m

17. Thick layer of calcareous monolithic sandstone: dark grey fine-grained with thickness up to 10 cm in the lower part. This lower part is situated approximately 75 cm above the tuff layer from unit 13. Sample 5919-17 is taken here. 0.70 m.

18. Alternation of sandstone with rare interbedded argillite. 0.50 m.

19. Greenish-grey argillite. 0.27 m.

Above this section there is a packet of alteration of thinly bedded sandstone (thickness of beds 0.5 – 20 cm) with limestone and argillite (thickness up to 10 - 15 cm).

Conodonts

The officially accepted definition the Artinskian-Kungurian boundary proposed to coincide with evolutionary event of the appearance of the conodont species *Neostreptognathodus pnevi* within the *N. pequopensis- N. pnevi* chronocline (Kozur, 1995; The decisions …, 1998).

All conodonts recovered in both MS and MQ sections are belonging to two genera: *Sweetognathus* and *Neostreptognathodus*. Several evolutionary trends in both genera were recognized. In MQ section in the Artinskian part *Neostreptognathodus pequopensis* Behnken and *N. ruzhencevi* Kozur were found. The difference between these two species is mainly in the structure of the carinal teeth. In *N. pequopensis* – the teeth are tuberculate, more or less vertically standing, in *N. ruzhencevi* – the carinal denticles are in the form of slightly inclined short ribs (Pl. I, figs. 1, 2). This latter type is sometimes marked by a variation in the

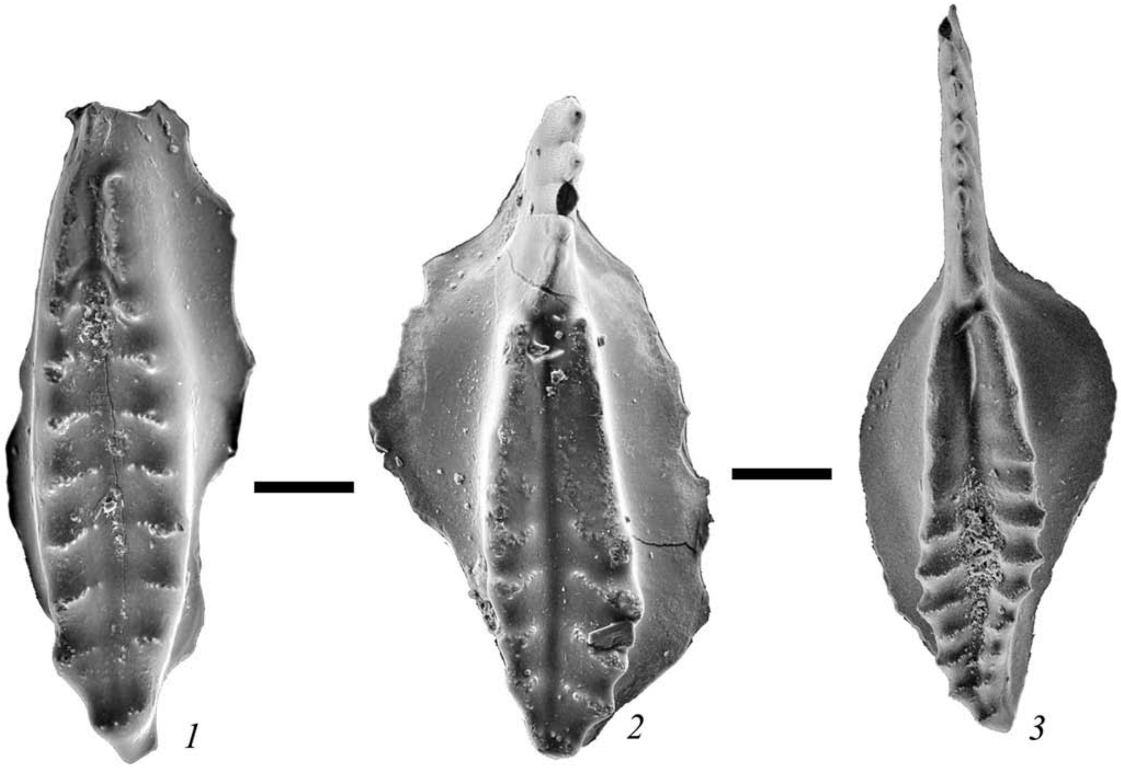

Fig. 6. The evolutionary lineage of *Neostreptognathodus ruzhencevi* Kozur – *N. lectulus* Chernykh
1 - *Neostreptognathodus ruzhencevi*, from Bed 2; 2 - *N. lectulus*, from Bed 9; 3 - *N. lectulus*, from Bed 13.

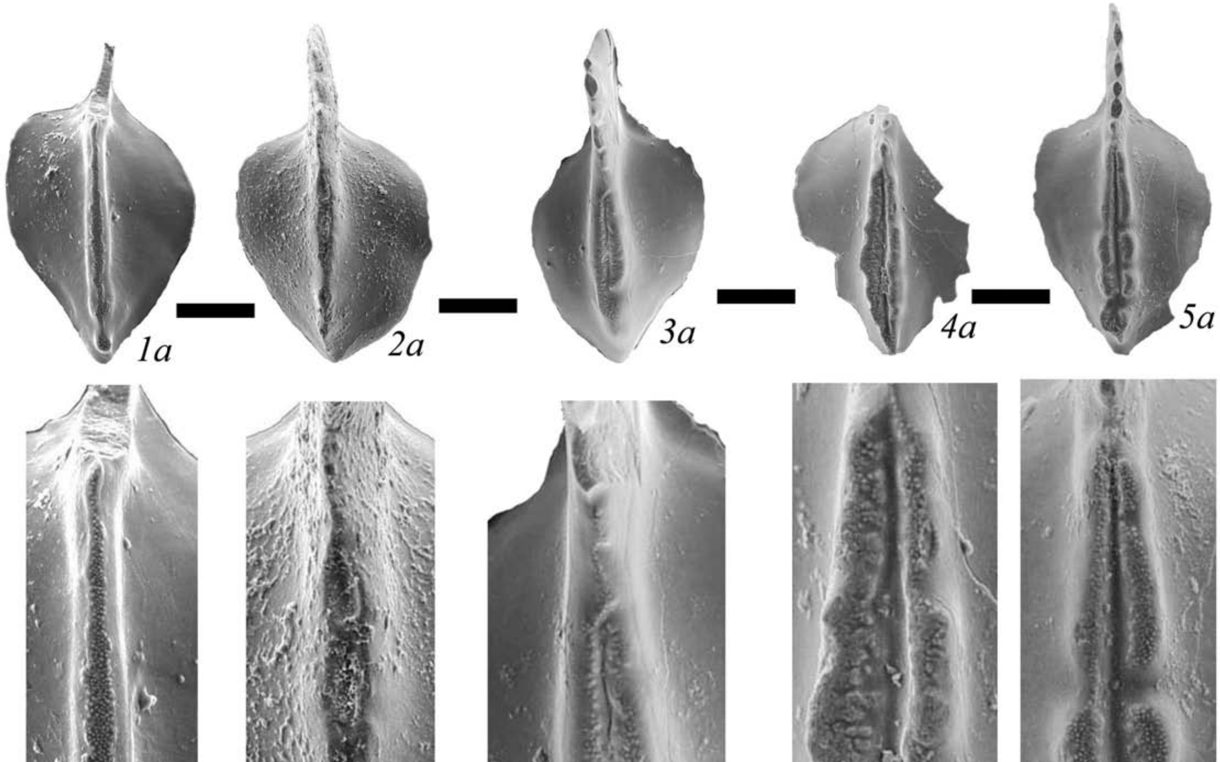

Fig 7. The evolutionary lineage of *Sweetognathus somniculosus* Chernykh – *Neostreptognathodus labialis* Chernykh
1 – *Sw. somniculosus*, form from Bed 6; 2, 3, 4 – *N. pseudoclinei* Kozur et Movshovitsch: 2 – transitional from *Sw. somniculosus* to *N. psedoclinei*; 3, 4 – transitional from *N. pseudoclinei* to *N. labialis*; 5 – *N. labialis* Chernykh (all forms from the Bed 12).

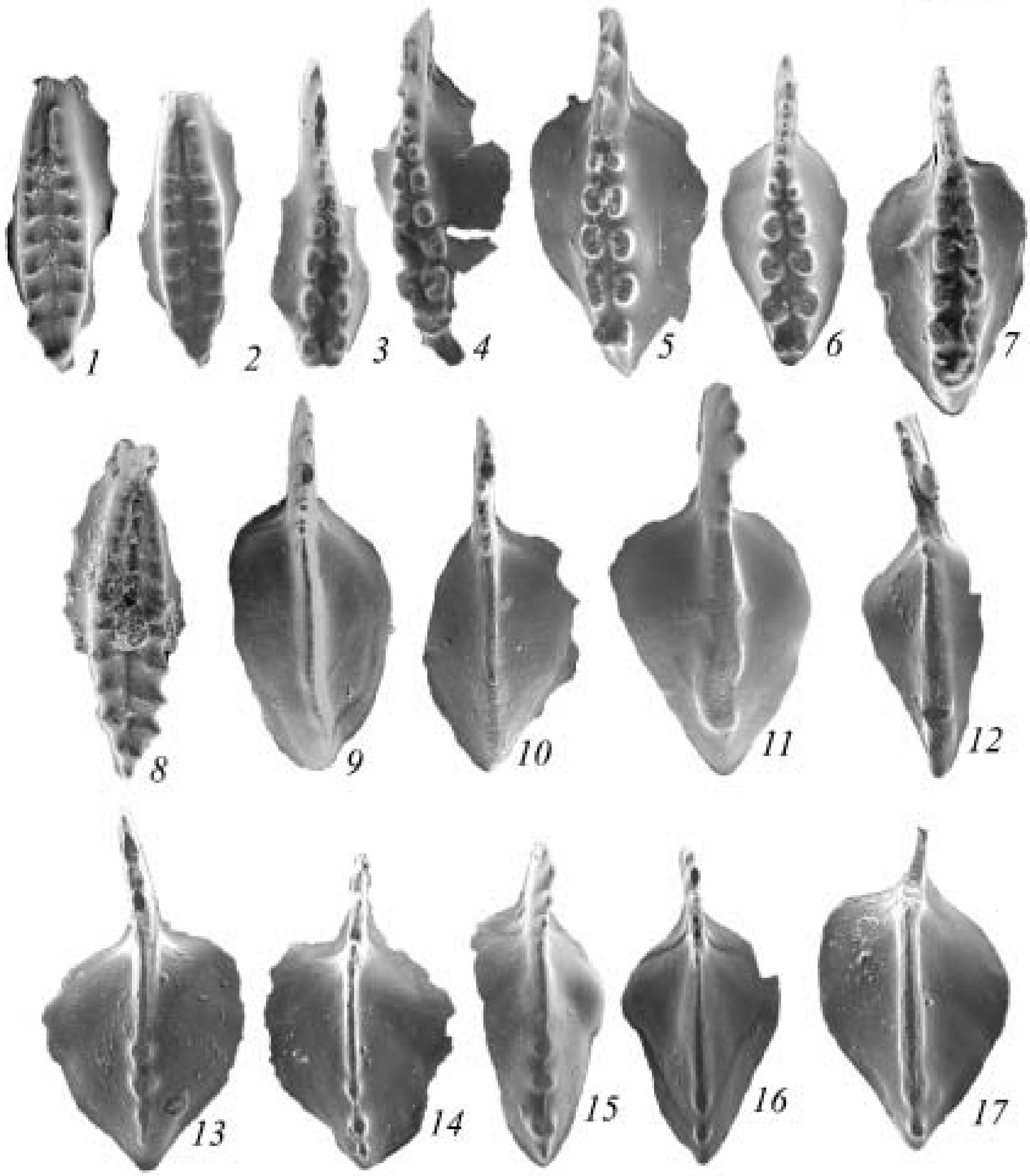

Plate I. The Artinskian conodonts (all x 90)

Bed 2: Figs. 1, 2. *Neostreptognathodus ruzhencevi* Kozur. Figs. 3, 4. *Neostreptognathodus pequopensis* Behnken.
Bed 4: Figs. 5-7. *Neostreptognathodus pequopensis* Behnken. Fig. 8. *Neostreptognathodus ruzhencevi* Kozur. Figs. 9-16. *Sweetognathus somniculosus* Chernykh.
Bed 6: Fig. 17. *Sweetognathus somniculosus* Chernykh.

Plate II

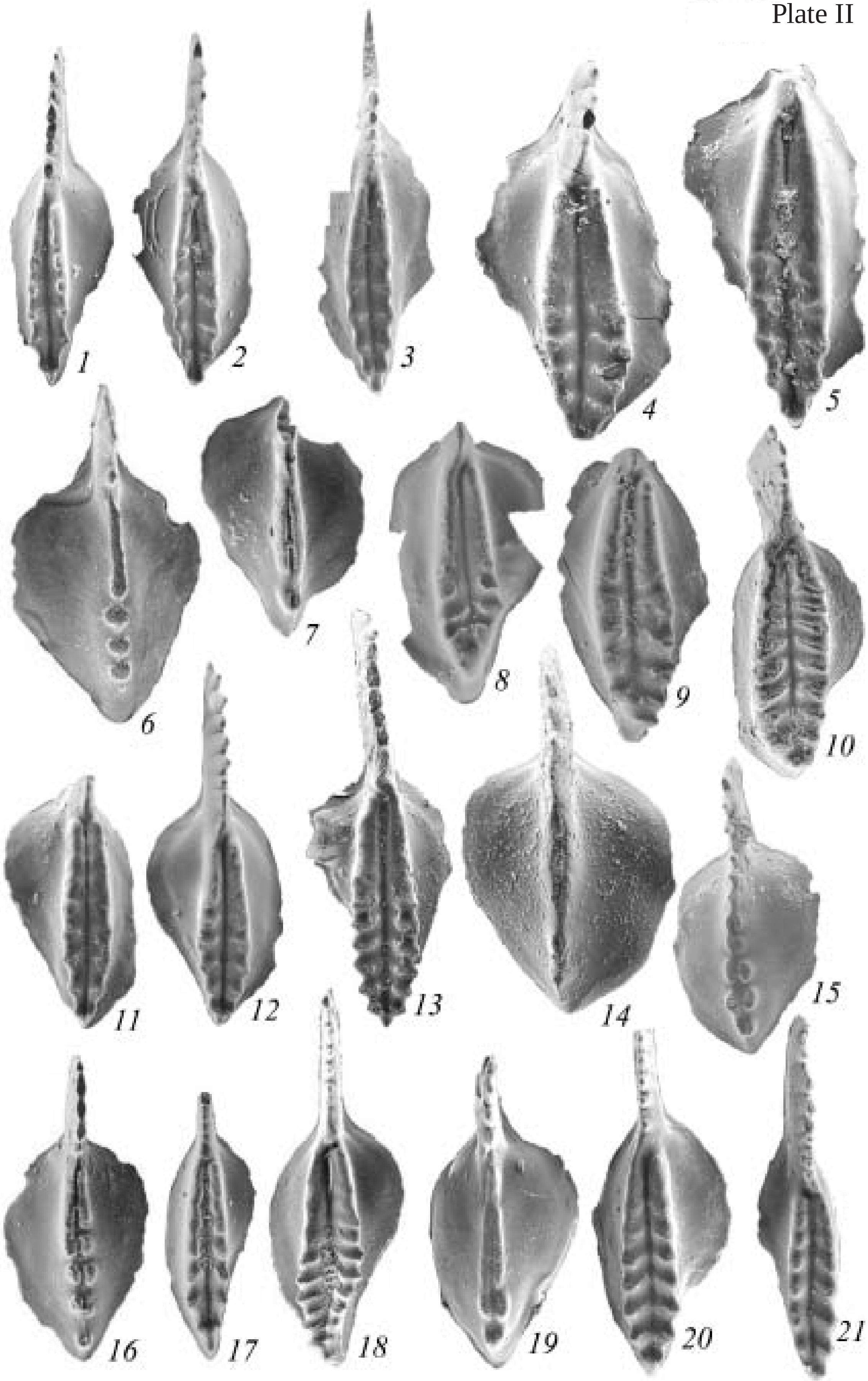

Plate III

Plate II. The Kungurian conodonts (all x 85)

Bed 9: Fig. 1. *Neostreptognathodus pequopensis* Behnken (transitional from *N. pequopensis* to *N. pnevi*). Figs. 2, 3. *Neostreptognathodus pnevi* Kozur and Movshovitsch. Fig. 4, 5. *Neostreptognathodus lectulus* Chernykh.

Bed 10: Fig. 6. *Sweetognathus* n. sp. 1 (Chernykh, 2006). Fig. 7. *Neostreptognathodus pseudoclinei* Kozur and Movshovitsch (transitional from *N. pseudoclinei* to *N. labialis*). Figs. 8, 9. *Neostreptognathodus lectulus* Chernykh, 8 – advanced form. Fig. 10. *Neostreptognathodus ruzhencevi* Kozur.

Bed 12: Fig. 11. *Neostreptognathodus pequopensis* Behnken (transitional from *N. pequopensis* to *N. pnevi*). Figs. 12, 13. *Neostreptognathodus lectulus* Chernykh, 13 – advanced form. Fig. 14. *Neostreptognathodus pseudoclinei* Kozur and Movshovitsch (transitional from *Sweetognathus somniculosus* Chernykh to *N. pseudoclinei*). Fig. 15. *Neostreptognathodus labialis* Chernykh.

Bed 13: Fig. 16. *Neostreptognathodus labialis* Chernykh. Fig. 17. *Neostreptognathodus pnevi* Kozur and Movshovitsch. Fig. 18. *Neostreptognathodus lectulus* Chernykh.

Bed 16: Fig. 19. *Neostreptognathodus labialis* Chernykh (reduction of anterior carinal denticles). Fig. 20. *Neostreptognathodus lectulus* Chernykh. Fig. 21. *Neostreptognathodus pequopensis* Behnken.

Plate III. Fusulinids from the Mechetlino section

Fig. 1. *Protonodosaria* sp., Bed 1 (4.3 m above the base).

Fig. 2. *Hemigordius* sp., Bed 1 (4.3 m above the base).

Fig. 3. *Grovesella nevadaensis* Davydov, Bed 1 (4.3 m above the base).

Fig. 4. *Uralofusulinella arkaulensis* Tschuvashov, Bed 1 (4.3 m above the base).

Fig. 5. *Uralofusulinella arkaulensis* Tschuvashov, Bed 27 (36.3 m above the base).

Fig. 6. *Uralofusulinella ajuensis* Tschuvashov, Bed 27 (36.3 m above the base).

Fig. 7. *Pseudofususlina russiensis* Rauser, Bed 1 (4.3 m above the base).

Fig. 8. *Pseudofususlina russiensis* Rauser, Bed 1 (4.3 m above the base).

Fig. 9. *Pseudofusulina paraconcavutus* Rauser, Bed 1 (4.3 m above the base).

Fig. 10. *Pseudofusulina fallax* Rauser, Bed 1 (4.3 m above the base).

Fig. 11. *Pseudofusulina ordinata* Kireeva, Bed 1 (4.3 m above the base).

Fig. 12. *Pseudofusulina alaguvatovi* Rauser, Bed 1 (4.3 m above the base).

Fig. 13. *Pseudofusulina makarovi* Rauser, Bed 27 (36.3 m above the base).

Fig. 14. *Pseudofusulina curtata* Rauser, Bed 27 (36.3 m above the base).

Fig. 15. *Parafusulina solidissima* Rauser, Bed 27 (36.3 m above the base).

Fig. 16. *Parafusulina solidissima* Rauser, Bed 27 (36.3 m above the base).

relative position of the free blade and the carinal parapets. In most cases, the free blade is in a sub-central position, or can be merged with one of the parapets. These variations are considered to be intraspecific (Chernykh, 2006) and not included in the taxonomic consideration.

Both species appeared in the Artinskian but evolved into the Kungurian, and from that time an increasing number of forms begin to lose the anterior carinal teeth. The morphotype of *N. pequopensis* Behnken evolved by the reduction of teeth into *N. pnevi* Kozur et Movshovitsch (Fig. 5), and *N. ruzhencevi* Kozur also by the reduction of teeth evolved into the morphotype of *N. lectulus* Chernykh (Fig. 6). The level of the first appearance of this last form is equally able to play the role of markers of the lower boundary of the Kungurian Stage.

Within the genus *Sweetognathus* two groups can be distinguished. The first group is made up of forms of the morphotype *Sweetognathus whitei* (Rhodes), but with a greater or lesser reduction of the anterior carinal nodes, which remain in the place of a pustular narrow carinal stripe (Pl. II, fig. 6). Less often, instead of this reduction there is a marked decrease in the size of the carinal teeth, especially in front part of the carina.

Another group of forms based on *Diplognathodus* morphotypes is distinguished by the appearance of numerous pustules on the carinal ridge. Late Artinskian members of this group often have a poorly differentiated carina, due to small lateral swelling in the back area of the pustules (Pl. I, figs. 11-17). Such forms are designated as *Sweetognathus somniculosus* Chernykh (Chernykh, 2012). In some of these forms the crest is flattened, and in its middle part there is a hint of a depression zone – the rudiments of the future median groove. Later, apparently, already in early Kungurian such forms at first are transformed into those deprived of teeth *N. pseudoclinei* Kozur et Movshovitsch, and these latter in turn pass in *N. labialis*. The development of the line "*Sw. somniculosus-N. pseudoclinei-N. labialis*" is observed in great detail in the MQ (Fig. 7).

At first *Sw. somniculosus* appear to evolve into *N. pseudoclinei* with the incompletely developed median groove and only single constriction of the parapets at the back of carina (Pl. II, figs. 7, 14). Then morphotypes *N. labialis* with a fully formed carina consisting of five or six pairs of lip-like opposed teeth, separated by a deep median groove joining them (Pl. II, figs. 15, 16, 19).
The origin of fully developed forms of *N. labialis* is somewhat delayed with respect to the time of the appearance of *N. pnevi* and *N. lectulus*. But this delay is negligible, and the discovery of *N. labialis* dates the enclosing rocks as Lower Saraninian.

Possibly, *N. pseudoclinei*, whose first appearance is not accurately established in the section, but which appears in Kungurian earlier than *N. labialis*, will be also useful for determining lower boundary of the Kungurian Stage.

Therefore, in the upper part of the Artinskian stage, the following species are present: *Neostreptognathodus pequopensis* Behnken, *N. ruzhencevi* Kozur, *Sweetognathus* aff. *S. whitei* (Rhodes) and *Sw. somniculosus* Chernykh.

All of these species pass into the Kungurian, except for the species *Sweetognathus somniculosus*. They are joined by the actual types of Kungurian species as *N. pseudoclinei* Kozur et Movschovitsch, *N. pnevi* Kozur, *N. lectulus* Chernykh and *N.*

Table 1. Conodont distribution on the bed in the Mechetlino quarry

Bed number				2	4	6	9	10	12	13	14	16
m above base				0,16	1,10	1,80	2,75	3,00	4,52	4,70	4,85	5,57
weight in kilograms				5	5	5	8	5	10	5	3	5
Taxon						Number of elements						
Sweetognathus somniculosus				8	3							
Sweetognathus aff. *whitei*							2	1				
Neostreptognathodus pequopensis				4	3		2	1	6		4	5
Neostreptognathodus ruzhencevi				4	2			2				
Neostreptognathodus pseudoclinei								1	4			
Neostreptognathodus labialis								17	3		7	
Neostreptognathodus pnevi						5	1	22	9			
Neostreptognathodus lectulus						10	8	11	8		4	
Neostreptognathodus fastigatus								1				
Sc element		2	4	5		1						
Pb element				6		2			5			
M element			2	3		2						
Total = 180	8	15	9	31	10	67	20	4	16			

Table 2. The fusulinid distribution in Mechetlino section

Meters above the base in Mechetlino_1	4.3	36.1	38
Taxon			
Protonodosaria sp.	x	x	x
Hemigordius sp.	x	x	x
Grovesella nevadaensis Davydov, 2011	x	x	x
Uralofusulinella arkaulensis Tschuvashov, 1980	x	x	x
Uralofusulinella ajuensis Tschuvashov, 1980		x	
Pseudofusulina fallax Rauser 1949	x	x	
Pseudofusulina paraconcessa Rauser 1949	x	x	
Pseudofusulina russiensis Rauser 1949	x		
Pseudofusulina paraconcavutas Rauser 1949	x		
Pseudofusulina ordinata Kireeva 1949	x		
Pseudofusulina alaguvatovi Rauser 1949		x	
Pseudofusulina makarovi Rauser 1949	x	x	x
Pseudofusulina urushbaevi Rauser 1949			x
Pseudofusulina kusjanovi Rauser 1949			x
Pseudofusulina curtata Rauser 1949			x
Pseudofusulina postsolida Tschuvashov, 1980	x		
Parafusulina solidissima Rauser, 1949	x	x	
Parafusulina solida (Schellwien), 1950	x		

labialis Chernykh. This group marks the distribution of conodonts in the transitional Artinskian-Kungurian interval in the Urals, which permits one to quite confidently identify the lower boundary of the Kungurian Stage by the appearance of species such as *N. pnevi* Kozur and *N. lectulus* Chernykh and, possible, *N. pseudoclinei* Kozur and Movschovitsch. The first two species are known in sections of coeval sediments in the USA (Behnken, 1975; Clark et al., 1979; Wardlaw and Collinson, 1986) and Canada (Henderson, 1999).

A special comment should be made about the representation and preservation of conodonts in the described section. The upper Artinskian interval is characterized by the low frequency of the occurrence of conodonts (Table 1). The total number of specimens of the Artinskian conodonts in the studied collection is from fifteen to twenty. If we add them to the conodonts collected from MS (Chernykh, 2006), that number increase to three dozen. It should be noted that the study of other sections of the Artinskian of the Urals shows the same picture of conodont diversity at this time in the Urals.

In the lowermost part of Kungurian in the MQ section, the abundance of conodont remains approximately the same as in the upper Artinskian, i.e. they are rare. However, almost immediately above the boundary the frequency of the occurrence of the conodonts quite significantly increases (Table 1). More than

100 specimens were recovered in bed 12 at the MQ section and upwards the number of recovered specimens usually exceeds 40 platform elements. All together within 5 m of transitional beds more than 200 specimens were found. Most of this material has been shown to participants in the workshop on the 8th of June, 2012 in Wells, Nevada, USA.

The preservation of the conodonts is very good in most samples. Almost all of the Pa elements found are complete, transparent, and without any foreign particles with CAI around 1.0-1.5, so they can successfully be used to determine Sr isotope ratios. We are convinced that in the proposed MQ section the lower boundary of the Kungurian Stage is nailed down quite precisely and correlated worldwide. The relatively low representation of conodonts near the Artinskian –Kungurian boundary could be improved by the collection of larger samples.

Fusulinids

Several species fusulinids were reported from upper Artinskian in Mechetlino and Arkaul sections (Chuvashov, 1980; Chuvashov et al., 1990). The latter section is located about 3 km north-west from Mechetlino. Fusulinids in Mechetlino section were recovered from three horizons (Fig. 3) and are typical for the upper Artinskian (Table 2, Plate III, this study and Chuvashov et al., 1990). Two horizons of fusulinids were recovered in Ismagilov Fm about 40-50 m above the proposed base of the Kungurian near Arkaul village west from Mechetlino section. These samples are still under current study. Preliminary evaluation suggests their taxonomy being close to the Artinskian one. Similar conclusion can be made from the Kungurian record reported from the Nevolian member of Irenian Horizon of Kungurian near Kungur City (Zolotova and Baryshnikov, 1978). Although nine new species were designated the authors considered that these fusulinids are closely similar to the late Artinskian. In fact, all these new species were never recognized elsewhere outside of the topotype. Thus, in the Urals and specifically in Mechetlino section fusulinids cannot be used to designate the proposed boundary as in Tethys and Nevada, North America. The distribution of the forms of conodonts is shown in Table 1 and the distribution of the forms of fusulinids into the Mechetlino section is shown in Table 2.

Ammonoids

In MQ section the ammonids were found in Bed 4, which is equal to Bed 28 in MS. Among collected forms were identified *Uraloceras tchuvaschovi* Bogoslovskaya, 1976, *U. fedorowi* (Karpinsky, 1889), *U.* sp. nov., *Paragastrioceras verneuili* Ruzhencev, 1956, *P. karpinskii* (Fredericks, 1915). In this assemblage *Uraloceras tchuvaschovi* is the most prominent species. According to M. Boiko (2010) it has never been found below the Saranian Horizon in the Urals. Thus, at least in the region this species is a very good index of the Kungurian. *Neostreptognathodus pnevi*, however, in the MQ section occurs 1.5 m above the collected *Uraloceras tchuvaschovi*.

In MS section diverse assemblage of ammonoids has been recovered below Bed 28. It is includes *Neopronorites permicus* Tchernov, 1907, *Paragastrioceras verneuili* Ruzhencev, *Uraloceras fedorowi* (Karpinsky), *U.* aff. *fedorowi*, *U. posterum* Bogoslovskaya et Boiko, 2002, *U. vietum* Ruzhencev, 1956, *U. bogoslovskayae* Voronov, *U.* sp. (identifications of M.F. Bogoslovskaya and M. Boiko). About two metres above bed XX in the lenses of cephalopod's limestone were found *Paragastrioceras* cf. *karpinskii*, *Uraloceras bogoslovskayae* Voronov, 1991 and *U.* cf. *suesi* (Karpinsky, 1889).

U-Pb geochronology

Three U-Pb zircon ash-bed ages were obtained from the Dal'ny Tulkas roadcut section to constrain the radiometric age of the Sakmarian– Artinskian transition (Schmitz and Davydov, 2012). Dated volcanic ash samples from –4.0, 10.5, and 12.5 mab, with respect to the proposed boundary datum (the FAD of Sweetognathus whitei (Rhodes sensu Chernykh) within the chronocline *Sw. binodosus– Sw. anceps–Sw. whitei*) at 0.2 mab within bed 4 (and ~10 m above the subsequently trenched base of the section).

As in the equivalent portion of the Usolka section, the zircon crystals from these ash beds are small and equant, although of high quality and uniformity. An ash layer was sampled near the top of Bed 2, four metres below the base of the original measured section. Excluding one anomalously young crystal and another with an inherited Precambrian core, six grains yielded a weighted mean 206Pb/238U date of 290.81 ± 0.09 Ma. Another ash layer (DTR905) sampled 10.5 m above the base of the original measured section produced a weighted mean 206Pb/238U date of 288.36 ± 0.10 Ma for seven single grains. A third ash layer at 12.5 mab (01DES-403) yielded a weighted mean 206Pb/238U date of 288.21 ± 0.06 Ma for eight single grains. The three dated samples allow calculation of a relatively constant rock accumulation rate through the lower portion of the section.

Strontium isotope stratigraphy

An apparently rapid, unidirectional decrease in the Sr isotopic composition of seawater beginning near the base of the Permian provides a potential chronostratigraphic proxy. The Sr isotopic compositions of well-preserved (CAI of <2) conodont platform elements were measured for numerous stratigraphic horizons in the Usolka, Dal'ny Tulkas quarry, and Dal'ny Tulkas roadcut sections. From one to ten conodont elements were pooled on a generic basis (*Streptognathodus*, *Mesogondolella*, or *Hindeotus*), ultrasonically cleaned in ammonium acetate and ultrapure water, and partially dissolved in dilute acetic acid to remove labile Sr. The residual elements were rinsed in ultrapure water and completely dissolved in concentrated nitric acid, dried with hydrogen peroxide to destroy organics, and redissolved in dilute nitric acid for separation of Sr via ion chromatography on Sr-spec crown ether resin (Pin and Bassin, 1991). Sr isotope ratios were measured by thermal ionization mass spectrometry with a reproducibility of ± 0.00001 (2σ).

The strontium measurements were placed within a quantitative age model based upon twenty-four high-precision CA-TIMS U-Pb zircon ash bed ages from the same stratigraphic sections (Schmitz and Davydov, 2012). The resulting chemostratigraphic curve is interpreted to represent the evolving isotopic composition of seawater, based upon the reproducibility of measurements in individual horizons, the stratigraphic consistency of the results, matrix-independent (carbonate, shale, volcanic ash) isotopic

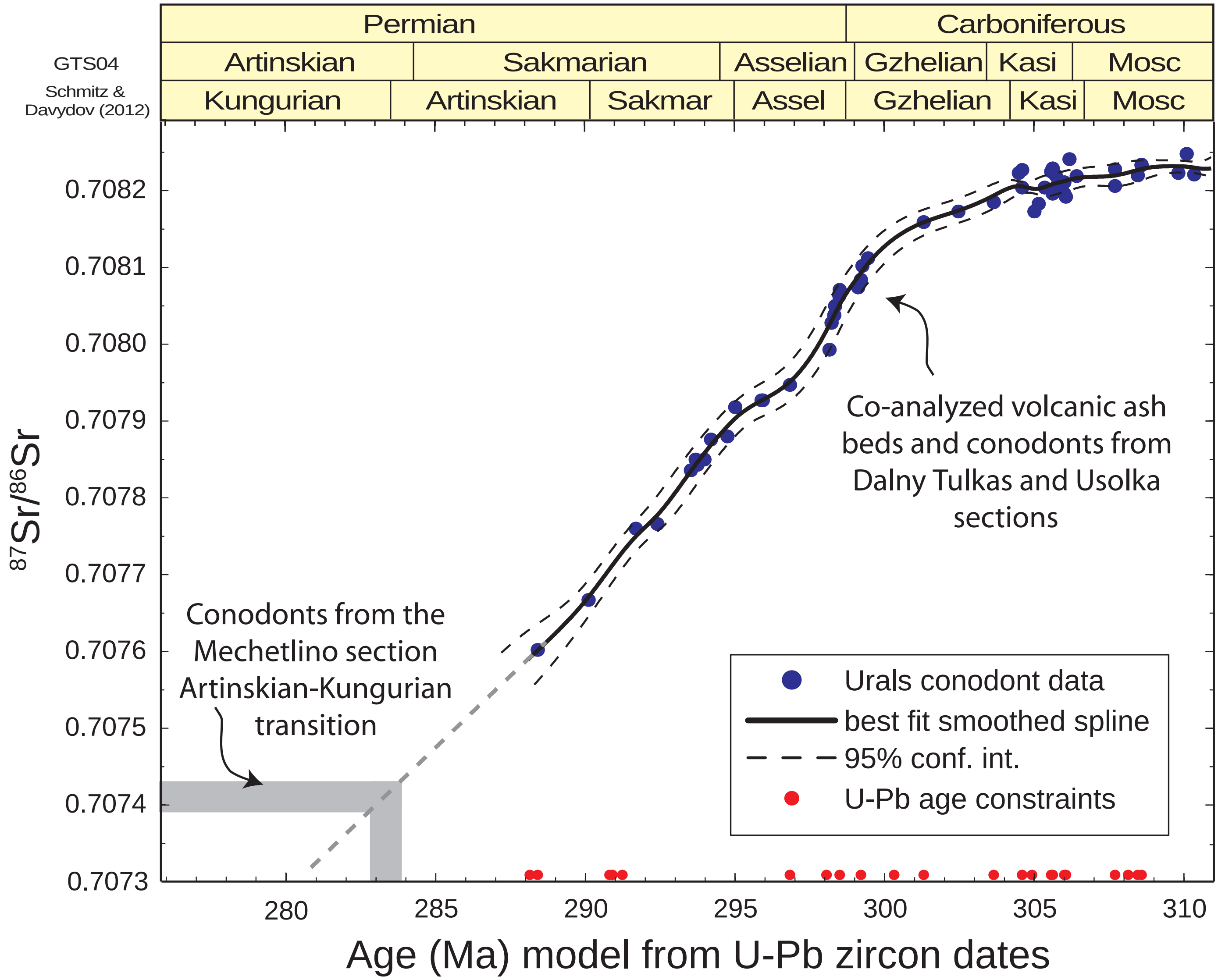

Fig. 8. The dating of lower boundary of Kungurian on the relationship of isotopes Sr. Explanation in the text

compositions, and the comparison with available literature data for brachiopod shells, which fall on or to more radiogenic values compared to the conodont measurements.

A smoothed spline fit to these data, with 95% confidence interval uncertainties provides a chronostratigraphic proxy with a resolution of approximately 0.5 to 1 Ma from the base of the Asselian through the lower Artinskian Stage (Fig. 10). The strontium isotopic composition of seawater at the base of the Artinskian Stage is $^{87}Sr/^{86}Sr$ = 0.70767. Unfortunately there are no U-Pb ages for late Artinskian to Kungurian strata of the Urals, however, we may estimate the age of the base Kungurian via extrapolation of the available curve to younger ages; the dashed line in Figure Y illustrates this extrapolation of the decreasing Sr isotopic composition through the lower Permian. To estimate the age of the base of the Kungurian Stage, single conodont platforms from strata within the Artinskian-Kungurian transition of the Mechetlino section(s) were subject to the analytical methods outlined above; these conodonts yielded reproducible $^{87}Sr/^{86}Sr$ = 0.70743 to 0.70739. Projecting these compositions onto the extrapolated seawater curve yields an apparent age for the boundary of 283.5 ± 0.5 Ma (Fig. 8).

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Stratigraphic gap between the Carboniferous and Permian in the lithologically monotonous sequence (Central Pay-Khoy, NW Russia) – paleotectonic implications

Andrey V. Zhuravlev, Alexandr G. Iosifidi

All Russia Petroleum Research Exploration Institute (VNIGRI), Liteyniy Pr. 39, St. Petersburg, Russia [micropalaeontologyr@gmail.com]

Basal Early Permian deposits of the NW shelves of Paleouralian Ocean demonstrate three main facies types: biohermal carbonate, shallow-water biolithoclastic carbonate, and deep-water marl. These deposits overlay Carboniferous carbonate of various ages – from the Early Carboniferous up to the Late Carboniferous (Fig. 1) (Timonin and Belyaev, 2002).

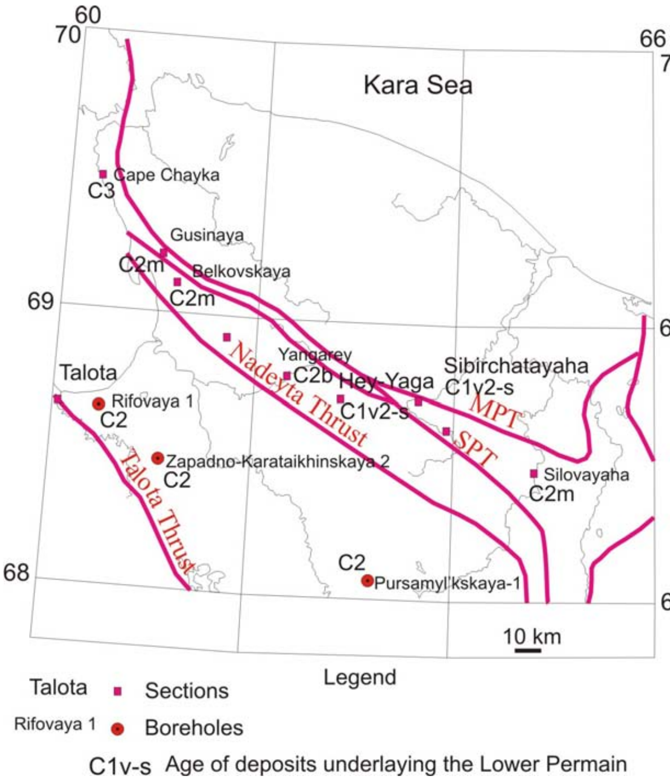

Fig. 1. Locality map.

The western part of the Central Pay-Khoy demonstrates specific Late Paleozoic successions composed of intercalated shallow-water and deep-water carbonate. The Carboniferous/Permian boundary interval is composed of a shallow-water carbonate succession.

The studied section is located on the right bank of the Sibirchata River (NE), in a strongly folded and faulted tectonic block overlain by thrust sheets (Fig. 2).

Mudstone containing lenses of packstone comprise the succession. The succession in ascending order is represented by the following units (Fig. 3):

1. Cycles composed in the lower part by fine-grained dark grey limestone (pack- and wackestone) containing lenses of organic detritus; and in the upper part - by microlaminated mudstone containing algae and crinoids. The cycles are 1.2-4.5 m thick. Visable thickness of the member is about 30 m. (Beds 16-7).

2. Grey limestone (mud- and wackestone), wavy laminated, containing calcareous algae. 5 m thick. (Bed 6).

--------Unconformity---------

3. Cycles similar to member #1. The cycles are 8.5-12.5 m thick. Unit is 20 m thick. (Beds 5-1).

Rare conodont elements were recovered from the packstone lenses and mudstone.

The uppermost part of the Carboniferous succession is dated as the Early Carboniferous, Late Visean – Serpukhovian, on the basis of the conodonts *Lochriea nodosa* (Bischoff) and *Lochriea commutata* (Branson and Mehl) in association with Kamaenid algae (sample 7313/6). The lowermost Permian carbonate contains middle Asselian conodonts: *Mesogondolella* cf. *dentiseparata*

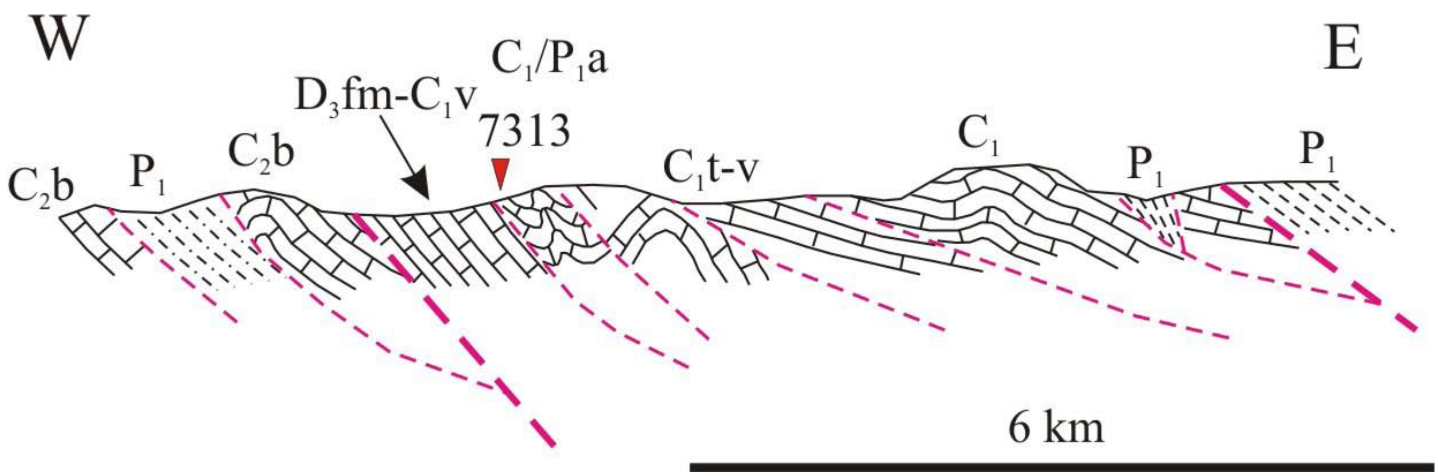

Fig.2. Profile section of the locality area. Studied section is marked by red triangle.

Age	Component Jn		Predicted		Supposed age of magnetization	Attitude during magnetization		Recent attitude	
	D	I	D	I		Az.	Deep angle	Az.	Deep angle
	Hey-Yaga River section								
D3-C1	218	-64	242	-55	P1	288	17	24	72
P1a-kg	230	-55	242	-56	P1	330	10	326	19
	Talota River section								
D3-C1	228	-69	240	-54	P1	257	16	18	26

Table 1. Paleomagnetic data.

Chernykh and Reshetkova, *Mesogondolella* cf. *praebisselli* Kozur, *Streptognathodus verus* Chernykh, *Streptognathodus asselicus* Isakova, *Streptognathodus* cf. *longus* Chernykh, and *Gondolelloides* cf. *canadensis* Henderson and Orchard (sample 7313/5). The conodont association is characteristic of the *fusus* conodont zone of the Asselian. The Early Permian conodont *Hindeodus typicalis* (Sweet) was found in the uppermost part of the section (upper part of the unit #1, sample 7313/1).

Cycle composition and fossil associations including calcareous algae, numerous crinoids, and solitary rugosa suggest shallow-water shelf margin environment. Facies similarity of Early Carboniferous and Early Permian deposits suggests long-existing shoal environment at this locality. A Carboniferous\Permian unconformity corresponding to the Middle and Upper Carboniferous, and lowermost Asselian is recognized. It can be explained by deep erosion during the latest Carboniferous – earliest Permian. Other sections of the C\P boundary interval in the region demonstrate the presence of at least Middle Carboniferous sediments. Interpreted thickness of the eroded sediments is about 250 m. Taking account of the facies identity of the Lower Carboniferous and the Early Permian deposits, one can suggest that the eroded thickness is equal to the uplift amplitude.

The data suggest tectonic uplift in the Late Gzhelian - Early Asselian that led to deep erosion of the Carboniferous deposits in the shelf margin belt. This tectonic event is supported by paleomagnetic data. According to the paleomagnetic data obtained from the Talota River section (Eremenko et al., 2009) and Hey-Yaga River section, Devonian and Carboniferous deposits were remagnitized during the Early Permian. Inclinations of the detected Early Permian component of natural remnant magnetization are higher than predicted (inclinations converted to the sampling site coordinates from the Early Permian key paleomagnetic pole for East European Platform) (Eremenko et al., 2009; Iosifidi et al., 2005). This difference can be explained by remagnitizing of Devonian and Carboniferous deposits in non-horizontal position caused by tectonics. During the Early Permian the beds were deepening westward (Az. 257°-288°) at the angle of 10-17 degrees (Table 1).

Spatial distribution of the erosion depth, accompanied with paleomagnetic data, allow us to locate the uplifted block boundaries (Fig. 4).

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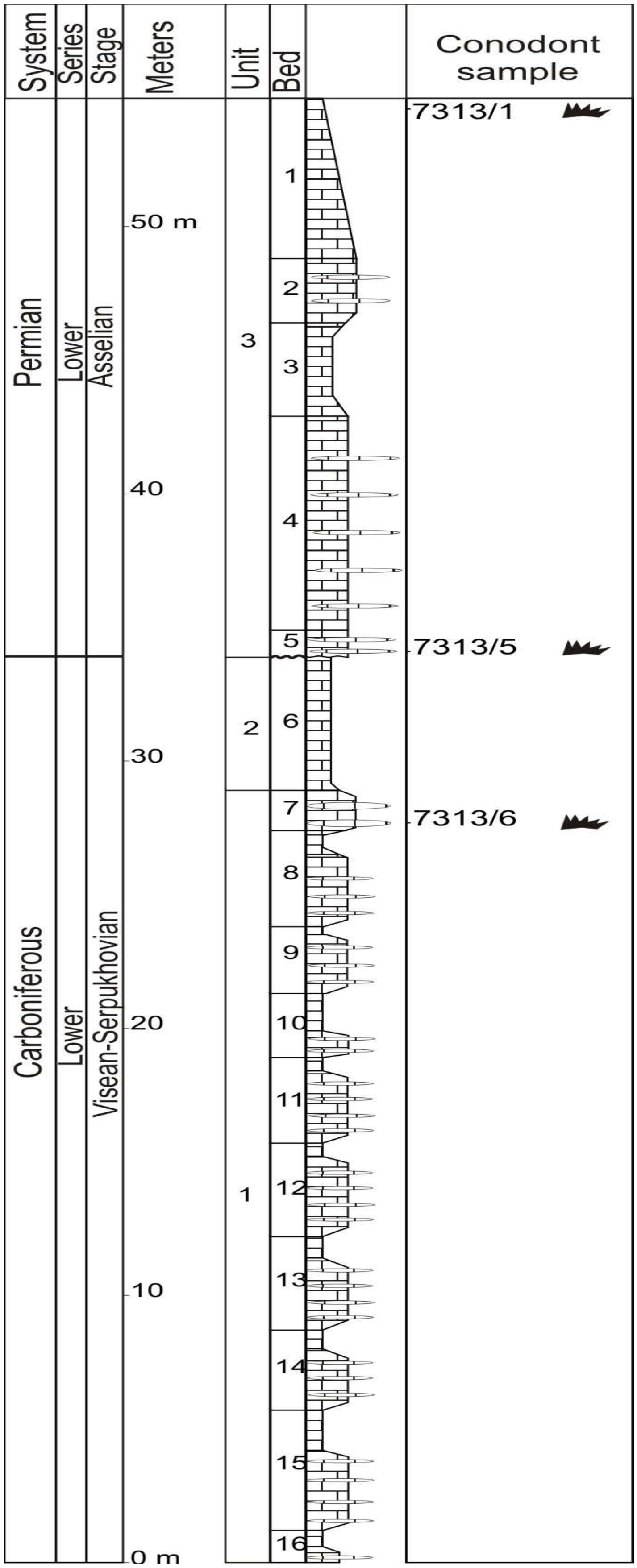

Fig. 3. Stratigraphic column of locality 7313, C/P boundary beds.

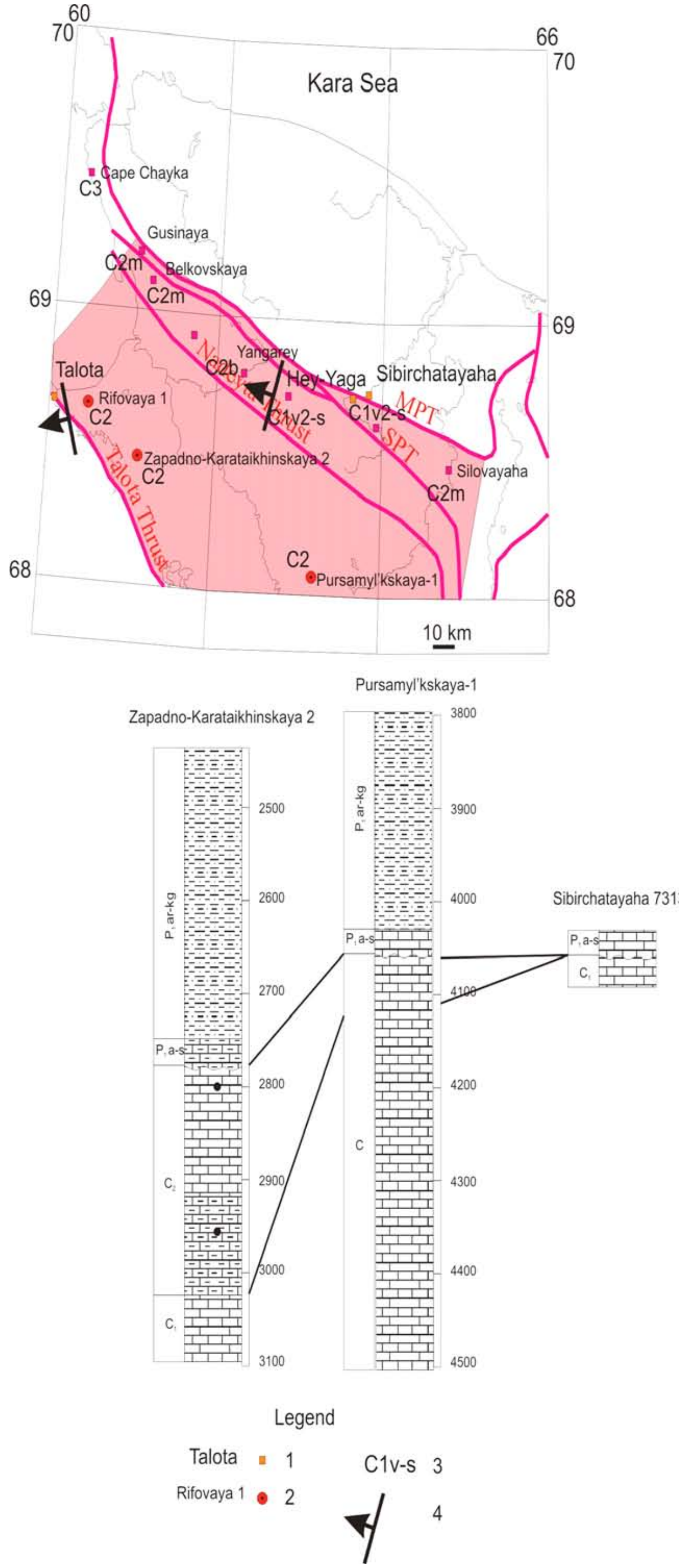

Fig. 4. Spatial distribution of the Late Carboniferous-earliest Permian tectonic uplift.
Legend: 1 - localities; 2 - boreholes;
3 - age of rocks underlaying the Lower Permian;
4 - attitude of the deposits in the Early Permian.

Fusulinid biostratigraphy of the Lower Permian Zweikofel Formation (Rattendorf Group; Carnic Alps, Austria) and Lower Permian Tethyan chronostratigraphy

Davydov, Vladimir I.
Permian Research Institute, BSU, Dept. of Geosciences, Boise State University, 1910 University Drive, Boise, ID, 83725, USA

Krainer Karl
Institute of Geology and Paleontology, University of Innsbruck, Innrain 52, A-6020 Innsbruck

Chernykh Valery
Institute of Geology and Geochemistry, Uralian Branch of Russian Academy of Sciences, Pochtovy, Pereulok 7, Ekaterinburg, Russia, 620151

The Zweikofel Formation of the Rattendorf Group in the Carnic Alps (Austria) is 95-102 m thick and consists of a cyclic succession of thin- to thick-bedded fossiliferous limestone and intercalated thin intervals of siliciclastic sediment. The siliciclastic intervals were deposited in a shallow marine nearshore environment. The variety of carbonate facies indicates deposition in a shallow neritic, normal-saline, low- to high-energy environment. The Zweikofel Formation is characterized by a paracyclic vertical arrangement of facies and represents sedimentary sequences that are not well understood elsewhere in the Tethys. Fusulinids and conodonts from the upper Grenzland and Zweikofel formations in the Carnic Alps clearly suggest that what has been called 'Sakmarian' in the Tethys includes both the Sakmarian and Artinskian stages of the Global Time scale. Fusulinids from the lower part of the Zweikofel Formation at Zweikofel closely resemble those of the Grenzland Formation and approximately correlate with the upper part of the Sakmarian and lower part of the Artinskian of the Global Time scale. The upper part of the Zweikofel Formation correlates approximately with the lower-middle (?) parts of the Artinskian Stage of the Global Time scale. A new regional Hermagorian Stage of the Tethyan scale is proposed between the Asselian and Yakhtashian. The lower boundary of the Hermagorian Stage is proposed to be located at the base of bed 81 in the 1015 section, Darvaz, Tadzhikistan (Leven and Scherbovich, 1978). The boundary between the Hermagorian and Yakhtashian stages is placed at the base of bed 73 (162 m above the base of the section, (Kahler and Krainer, 1993) in the Zweikofel section at Garnitzenbach, Carnic Alps. In the Darvaz region, Tadzhikistan, the type area for the Yakhtashian Stage, this boundary has never been precisely defined. The entire fusulinid assemblage of the upper part of the Grenzland and Zweikofel formations reported herein includes 62 species of 18 genera, of which one subgenus and 12 species and subspecies are new. They figured in 14th plates. This paper is published on-line at http://onlinelibrary.wiley.com/doi/10.1002/gj.2433/pdf.

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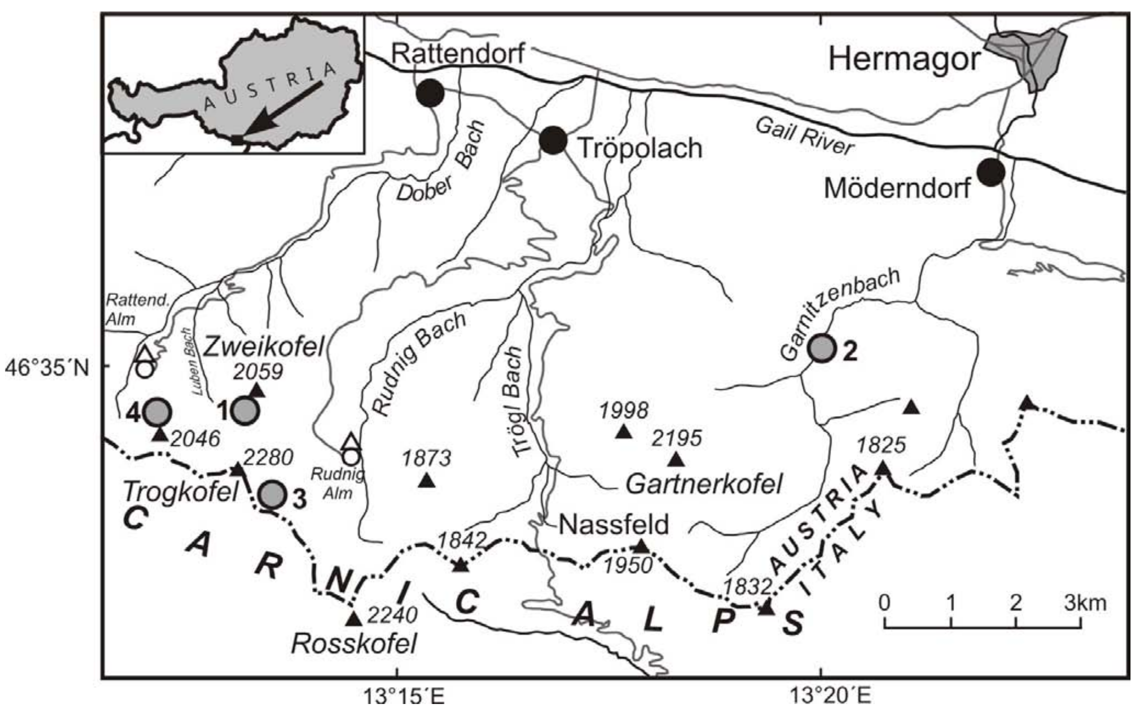

Fig. 1. Location map of the Zweikofel area, 1 - type section at Zweikofel, 2 - reference section at Garnitzenbach, 3 - Locality Troghöhe of Forke (1995), 4 – Zottachkopf type- section, Carnic Alps, southern Austria.

Species, subspecies					Upper Grenzland Formation														Zweikofel Formation								
					Assemblage 1																Assemblage 2						
					152	153	**ZK9**	ZK20	ZK26	155	**ZK28**	**ZK29**	156	157	158	ZK30	ZK32	159	160	161	ZK37	ZK38	ZK39	162	164	ZK48	165
							F				F	F															
1 *Darvasites (Alpites)*	*afghanensis*	*afghanensis*	Leven,	1997	x					x																	
2 *Darvasites (Alpites)*	*deminuatus*		sp. nov.		x				x	x				x	x				x	x					x	x	x
3 *Darvasites (Alpites)*	*shengi*		(Chang),	1963	x		x																				
4 *Leeina*	*callosa*		(Rauser),	1940	x								x	x				x									
5 *Quasifusulina*	*nimia*		Kochansky-Devidé,	1959	x	x			x	x			x		x	x			x	x		x					
6 *Quasifusulina*	*tenuissima*		(Schellwien),	1898	x	x	x				x																
7 *Zellia*	*praeheritschi*	*praeheritschi*	Forke,	2002	x																					x	x
8 *Leeina*	*postcallosa*		(Bensh),	1962		x							x	x											x		x
9 *Schubertina*	*australis*		(Thompson and Miller),	1949			x																				
10 *Zellia*	*praeheritschi*	*elongata*	Forke,	2002			x																				
11 *Zellia*	*praeheritschi*	*inflata*	Forke,	2002			x																				
12 *Darvasites (Alpites)*	*afghanensis*	*calvescensis*	subsp. nov.,				x			x																	
13 *Boultonia*	sp.						x		x																		
14 *Boultonia*	*willsi*		Lee,	1927				x			x	x	x	x													
15 *Schubertina*	*paramelonica*		(Suleimanov),	1949					x				x					x									
16 *Darvasites (Alpites)*	*eocontractus*		Leven and Scherbovich,	1980					x																		
17 *Likharevites*	*nitidus*		(Kahler and Kahler),	1937					x																		
18 *Sakmarella*	*devexa*	*devexa*	(Rauser),	1949					x																		
19 *Sakmarella*	*devexa*	*acalossa*	(Kireeva),	1949					x																		
20 *Sakmarella*	*blochini*		(Korzhenevsky),	1940					x															x			
21 *Sakmarella*	*conspiqua*		(Rauser),	1949					x																		
22 *Sakmarella*	*moelleri*		(Schellwien),	1908					x	x			x	x	x			x		x	x	x	x	x			x
23 *Darvasites (Alpites)*	*bianpingensis*		(Zhang, Rui, Wang and Li)	1988						x								x									
24 *Darvasites (Alpites)*	*parashengi*		(Chang),	1963						x																	
25 *Sakmarella*	*blochini*	*belatula*	(Korzhenevsky),	1940						x			x	x													
26 *Schubertina*	*staffelloides*		(Suleimanov),	1949									x													x	
27 *Likharevites*	*kahleri*		sp. nov.,										x		x												
28 *Leeina*	*effusa*		(Bensh),	1962									x	x													
29 *Leeina*	*lasulla*		(Bensh),	1962									x	x				x									
30 *Paraschwagerina*	*dlakshanensis*		Chang,	1963									x	x						x							
31 *Leeina*	*havana*		(Forke),	2002									x	x													x
32 *Dutkevitchia*	sp.														x												
33 *Nankinella*	*hunanesis*		(Chen),	1956													x										
34 *Boultonia*	*europae*		Kochansky-Devidé,	1973														x									
35 *Darvasites (Alpites)*	*pseudosimplex*		(Chen),	1934														x	x	x							
36 *Rugosochusenella*	*pseudogregaria*		(Bensh),	1962															x							x	
37 *Sakmarella*	*fluegeli* (= "Ps." sp. 3 Forke, 2002)		sp. nov																		x	x	x				
38 *Zellia*	*galatea*		(Ciry),	1943																				x			
39 *Paraschwagerina*	*inflata*		Chang,	1963																				x			
40 *Zellia*	*heritschi*	*heritschi*	Kahler and Kahler,	1941																				x			
41 *Zellia*	*colanii*		Kahler and Kahler,	1937																						x	
42 *Rugosochusenella*	*zelleri*		Skinner and Wilde,	1965																						x	
43 *Zellia*	*heritschi*	*magna-sphaerae*	(Kahler and Kahler),	1937,																						x	
44 *Perigondwania*	sp. A																									x	
45 *Zellia*	*heritschi*	*media*	(Kahler and Kahler),	1937,																							x
46 *Sakmarella*	*lubenbachensis* (= "Ps." sp. 2, Forke, 2002) sp. nov																										
47 *Darvasites (Alpites)*	*contractus*	*contractus*	(Schellwien),	1908																							
48 *Darvasites (Alpites)*	*contractus*	*alpiensis*	subsp. nov.,																								
49 *Leeina*	aff. *exigua*		(Schellwien),	1909																							
50 *Robustoschwagerina*	*nucleolata*		(Ciry),	1941																							
51 *Robustoschwagerina*	*kahleri*		Miklukho-Maclay,	1949																							
52 *Leeina*	*pseudofragilis* (= *Pseudochusenella cushmani*, Forke, 2002) sp. nov																										
			(Leven),	1992																							
53 *Schubertella*	*transitoria*		Staff and Wedekind,	1910																							
54 *Paraschwagerina*	*inflata*		Chang,	1963																							
55 *Perigondwania*	*tersa*		(Ross) sensu Leven,	1992																							
56 *Biwaella*	*shiroishiensis*		(Morikawa and Kobayashi),	1960																							
57 *Paraschwagerina*	*tsharymdarensis*		Leven,	1992																							
58 *Leeina*	*leveni*		sp. nov.,																								
59 *Leeina*	*pseudodivulgata*		sp. nov.,																								
60 *Biwaella*	*omiensis*		Morikawa and Isomi,	1960																							
61 *Leeina*	*franzgustavia*		sp. nov.,																								
62 *Chalaroschwagerina*	*incomparabilis*		Leven,	1992																							
63 *Perigondwania*	*forkii* (='Ps.' sp. 1, Forke, 2002)		sp. nov																								
64 *Pseudoreichelina*	sp.																										
65 *Chalaroschwagerina*	*solita floccosa*		subsp. nov.,																								
66 *Toriyamaya*	*zweikofelica*		sp. nov.,																								
67 *Leeina*	aff. *havana*		(Forke),	2002																							
68 *Robustoschwagerina*	*simplex*		(Yang and Hao),	1991																							
69 *Robustoschwagerina*	*longliensis* (=*R. spatiosa*, Forke, 2002)		Dong,	1984																							
70 *Perigondwania*	aff. *niouensis*		(Leven),	1992																							
71 *Darvasites (Alpiites)*	*vozginensis*		Leven,	1992																							
72 *Darvasites (Alpiites)*	*vandae*		Leven and Scherbovich,	1980																							
73 *Schubertella*	*simplex*		(Lange),	1925																							
metres above the base of the section					-100	5	18	82	89	92	92.5	93	94	94.5	95	97	99	100	102.5	104	105.5	106	107	110	118	118.5	119.5
					152	153	**ZK9**	ZK20	ZK26	155	**ZK28**	**ZK29**	156	157	158	ZK30	ZK32	159	160	161	ZK37	ZK38	ZK39	162	164	ZK48	165

Table 1. Distribution of fusulinid species in Zweikofel section (combined data of Forke, 2002 and from present study)

Zweikofel Formation																													
Assemblage 3																				Assemblage 4			Assemblage 5							
ZK56	168	**ZK57**	ZK58a	ZK58b	ZK58c	170	ZK60	**ZK65**	171	**ZK66**	172	173	174	**ZK71A**	ZK81	ZK82	ZK92	178	ZK195	ZK197	ZK198	ZK204	ZK205	ZK206	ZK207	ZK214	182	**ZK225**	**ZK223**
F		F	F					F		F				F										F				F	F
																						x							
																									x				
									x		x	x	x																
																		x											
	x																												
x			x																										x
																						x		x	x				
																							x						
													x											x					
																						x							
x			x/x																										
	x		x						x		x	x			x		x						x						
																		x				x		x	x				
																									x				
				x		x						x																	
			x		x		x													x		x	x						
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				x	x		x	x	x	x	x	x		x		x							x						
												x	x									x							
			x			x								x				x				x							
	x		x	x						x													x						
					x																								
	x																												
			x	x						x																			
				x	x		x	x	x	x	x	x	x	x															
					x																		x				x		
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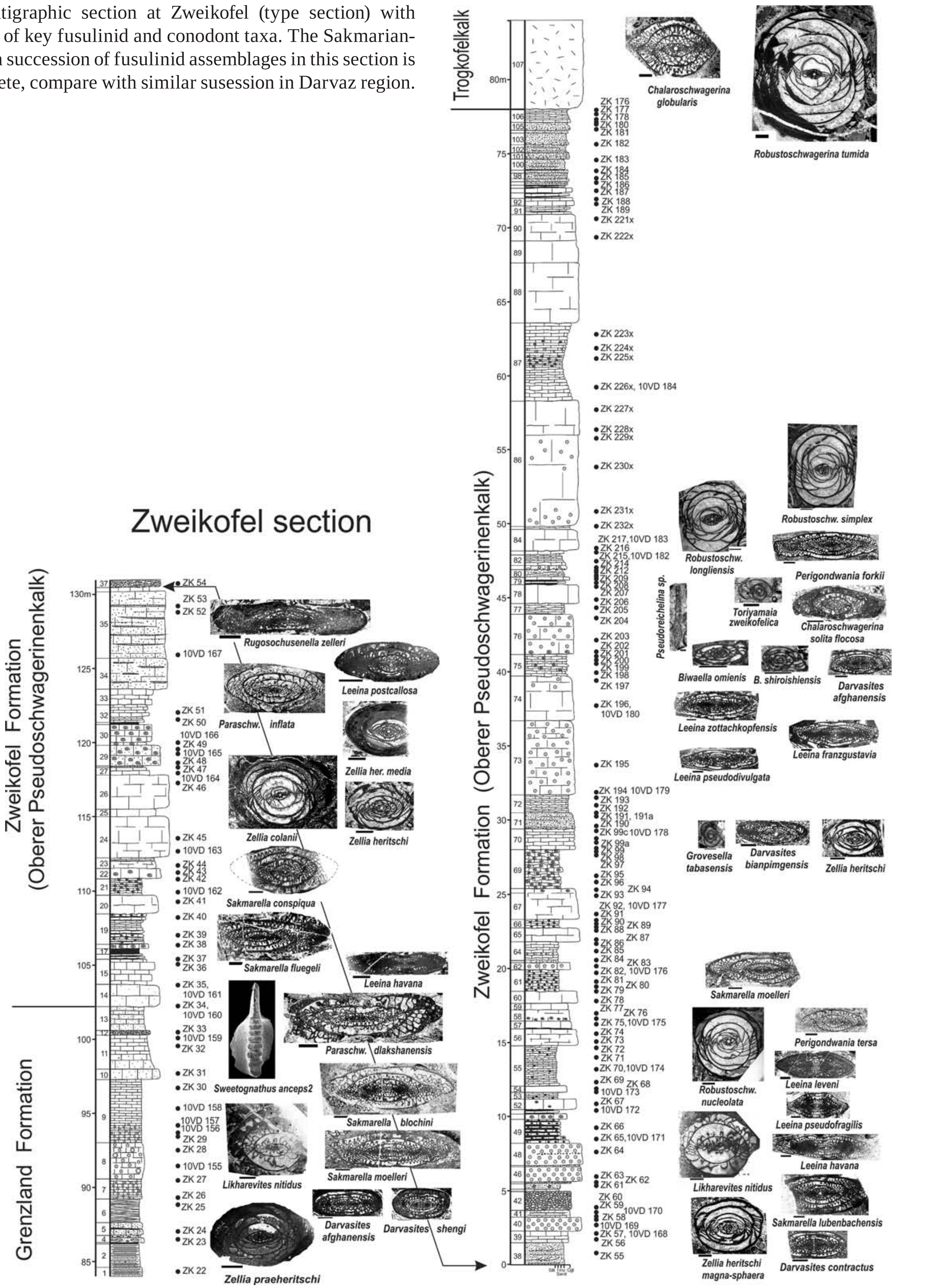
131.5	132	132.2	132.5	133	133.5	133.7	134	137.7	138.2	138.5	140.5	142	144	145	149	149.5	154	159	164	169.5	170	174	174.5	175	176	177	189	212	214
ZK56	168	**ZK57**	ZK58a	ZK58b	ZK58c	170	ZK60	**ZK65**	171	**ZK66**	172	173	174	**ZK71A**	ZK81	ZK82	ZK92	178	ZK195	ZK197	ZK198	ZK204	ZK205	ZK206	ZK207	ZK214	182	**ZK225**	**ZK223**

Table 1 continued. Bold samples and letter F below the sample number means that data came from Forke (1995, 2002), but we are responsible for all taxonomic interpretations. The samples studied in the current project are typed with regular font. Stratigraphic position of all samples can be found in Figure 2. The distinguished zonal assemblages described in Biostratigraphy chapter.

	Species					Trogkofel Formation				
								10VD		
						246	247A	247B	248	249
						2.0 m	3.0m	3.2 m	5.0 m	8.5 m
1	*Grovesella*	*tabasensis*		Davydov and Arefifard	2007		x		x	x
2	*Schubertella*	*paramelonica*		Suleimanov,	1949	x		x		
3	*Schubertella*	*exilis*		Suleimanov,	1949	x	x		x	x
4	*Boultonia*	*willsi*		Lee,	1927	x	x		x	
5	*Boultonia*	*europae*		Kochansky-Devidé,	1973	x	x			
6	*Quasifusulina*	*nimia*		Kochansky-Devidé,	1959	x		x	x	x
7	*Darvasella*	sp. nov.				x		x	x	
8	*Darvasella*	*praecox*		Leven,	1992	x	x	x	x	
9	*Laxifusulina*	sp.						x		
10	*Darvasites* (*Alpiites*)	*deminuatus*		sp. nov.,		x	x		x	
11	*Perigondwania*	*forkii*		sp. nov.,		x	x			
12	*Leeina*	*niouensis*		(Leven),	1992	x	x	x		x
13	*Robustoschwagerina*	*longliensis*		Dong,	1984	x	x	x		
14	*Robustoschwagerina*	*geyeri*		(Kahler and Kahler),	1938		x	x		
15	*Biwaellaomiensis*			Morikawa and Isomi,	1960		x			
16	*Rugosochusenella*	*pseudogregaria*		(Bensh),	1962		x			x
17	*Darvasites (Alpiites)*	*afghanensis*	*afghanensis*	Leven,	1997		x			x
18	*Darvasites (Alpiites)*	*afghanensis*	*calvescensis*	subsp. nov.,				x		
19	*Darvasella*	ex gr. *prima*		Leven,	1992		x	x		
20	*Paraschwagerina*	*tsharymdarensis*		Leven,	1992		x	x	x	
21	*Robustoschwagerina*	aff. *tumida*		(Licharev),	1934			x	x	
22	*Rugosochusenella*	*zelleri*		Skinner & Wilde,	1965			x		
23	*Chalaroschwagerina*	*solita*	*flocosa*	subsp. nov.,				x		
24	*Paraschwagerina*	*inflata*		Chang,	1963				x	

Table 2. Distribution of fusulinid species in classical red limestone from locality 'Höhe 2004'

Fig. 2: Stratigraphic section at Zweikofel (type section) with illustrations of key fusulinid and conodont taxa. The Sakmarian-Yakhtashian succession of fusulinid assemblages in this section is more complete, compare with similar susession in Darvaz region.



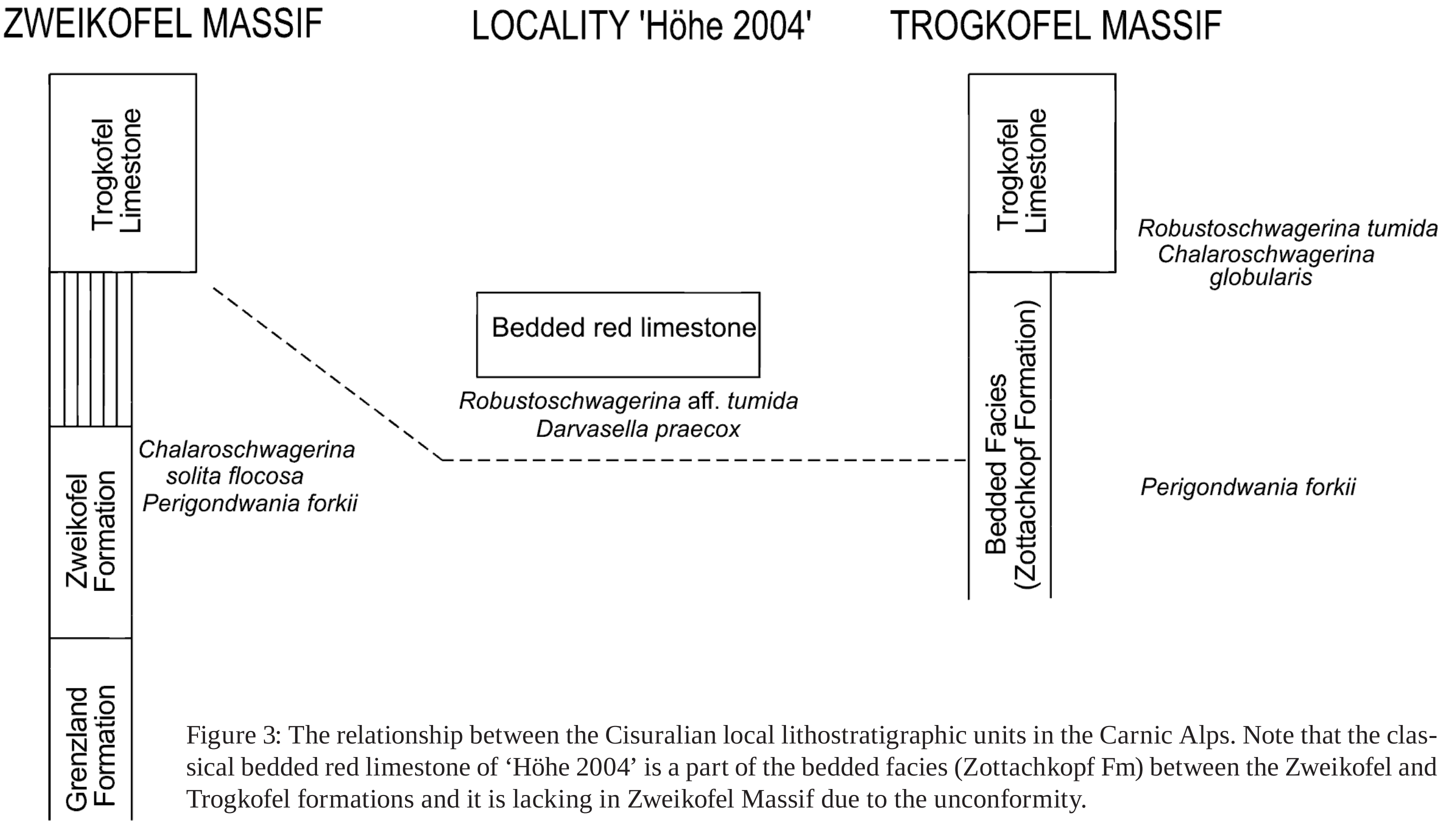
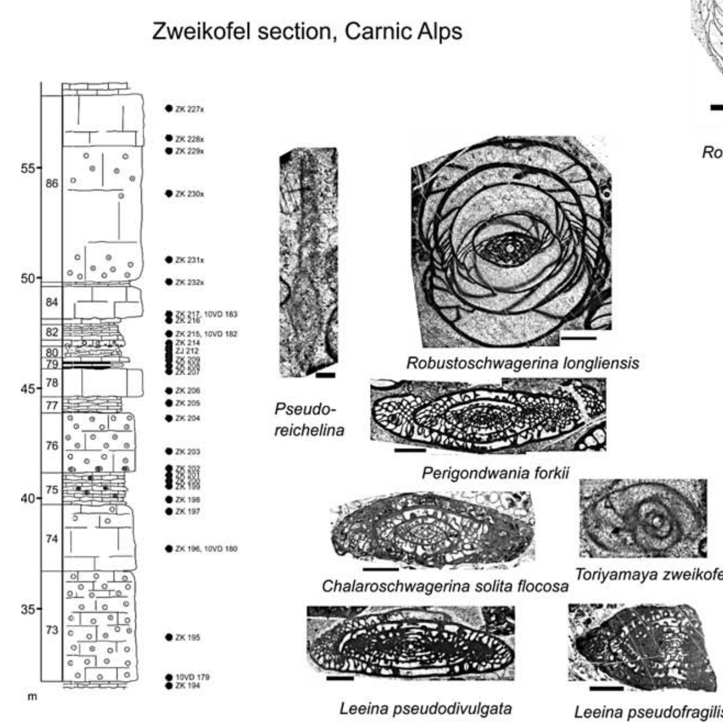


Figure 3: The relationship between the Cisuralian local lithostratigraphic units in the Carnic Alps. Note that the classical bedded red limestone of 'Höhe 2004' is a part of the bedded facies (Zottachkopf Fm) between the Zweikofel and Trogkofel formations and it is lacking in Zweikofel Massif due to the unconformity.

Fig. 4: Comparison of the lower Yakhtashian fusulinid assemblages in Darvaz and the Carnic Alps (on the left - enlarged part of Figure 2). The fusulinid assemblages from upper Zweikofel Formation in Carnic Alps and from the middle part of Zigar Formation in the type section of Darvaz shows significant similarity and thus are considered being similar in age.



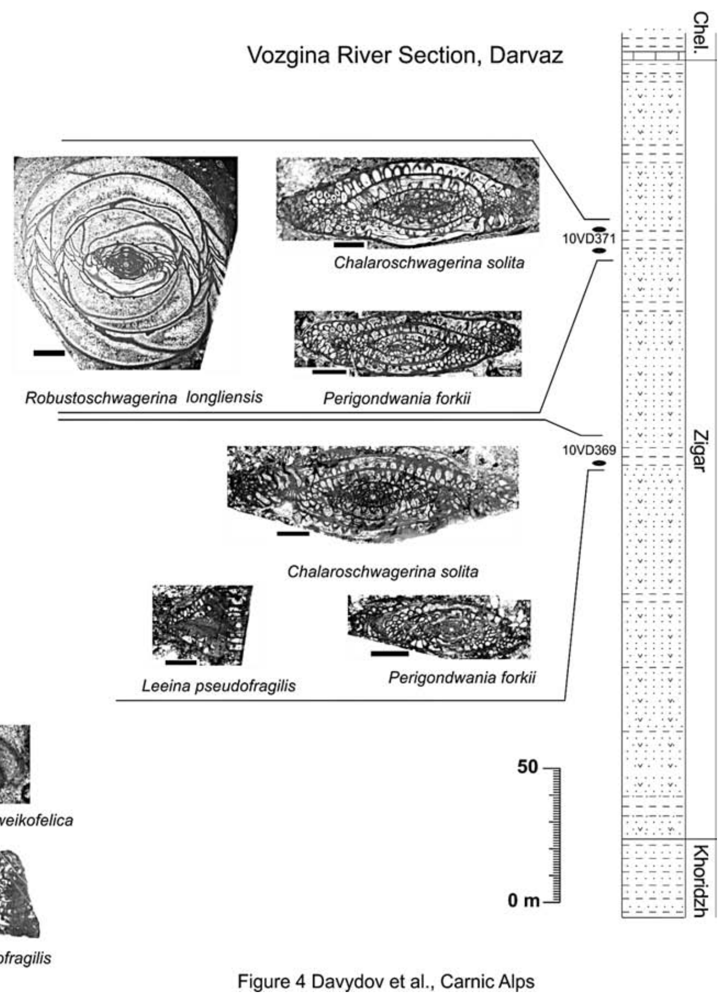


Figure 4 Davydov et al., Carnic Alps

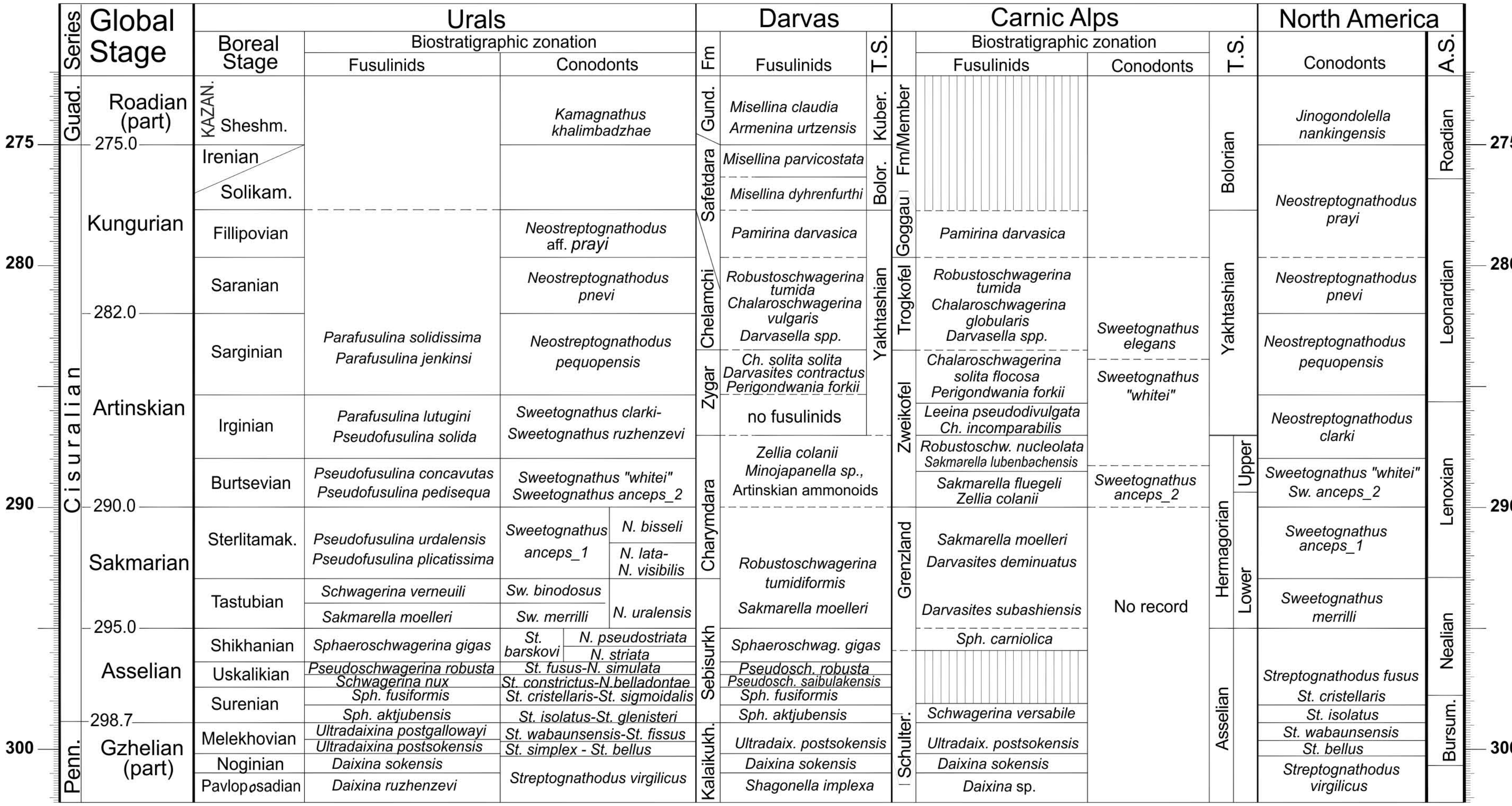


Figure 5: Correlation chart of the Cisuralian (Lower Permian) in the Carnic Alps, other regions in Western Tethys and North American Scales. Urals (Davydov, 1996; Chernykh, 2006); Darvaz (Leven et al., 1992 and this paper); Carnic Alps (this paper); North America (Boardman et al., 2009) (Stratigraphic abbreviations: T.S. - Tethyan Chronostratigraphic Scale; A.S. - American Chronostratigraphic Scale; Penn. - Pennsyllvanian, Guad. – Guadalupian, Sterlitamak – Sterlitamakian, Solikam. – Solikamian, Sheshm. – Sheshmian, Kazan. – Kazanian, Bolor. – Bolorian, Kuber. – Kubergandian, Gund. – Gundara, Schulter. - Schulterkofel. Fossils *abbreviations: Ch. – Chalaroschwagerina, Pseudoschw. – Pseudoschwagerina, Neogond. - Neogondolella; Robustoschw. – Robustoschwagerina; Sw. - Sweetognathus; St. - Streptognathodus; Sph. - Sphaeroschwagerina; Ultradaix. – Ultradaixina.*

The first record of tetrapod tracks in Permian alevrolites of vicinity of Donji Milanovac (Eastern Serbia)

Miodrag Jovanović
Natural History Museum, Belgrade, Njegoševa 51
E-mail: jovmiod@nhmbeo.rs

Abstract. This paper presents a track of Paleozoic tetrapod preserved in a piece of brown Permian alevrolite collected at Glavica Hill in vicinity of Donji Milanovac. This is the first ichnofossil of a Paleozoic vertebrate recorded in Serbia to the present day.
Keywords: Ichnofossil, Amniota, Permian alevrolite, Donji Milanovac, Eastern Serbia.

Geological setting

The Permian red sandstones of vicinity of Donji Milanovac have been poorly studied and there are few literature data. Report on field research performed in vicinity of Donji Milanovac by Simić and Kostić (in 1967) includes a reference on gabbro layer pushing through Permian sediments at Glavica hill (Archives of Natural History Museum in Belgrade).

Bogdanović and Rakić (1980) have stated that Permian of Donji Milanovac was represented by terrigenous sediments (conglomerates, conglo-breccia, sandstones and clays with plant detritus). The final layers of terrigenous sediments include red sandstones and clays with intercalations of freshwater limestone, lacking any fossil remains (ibid).

There is a greater amount of data on Permian alevrolites of Stara Planina. Anđelković et al. (1996) and Nadežda Krstić (viva voce) described the Permian alevrolites of Stara Planina as thin-layered to flaky, brittle, with traces of rain drops, bioglyphs and symmetrical traces of wave activity. They were formed in oxidation environment, with warm and hot climatic conditions and occasional precipitation (ibid).

For the Romanian part of Banat (Ciudano Vita fm.), Cassinis et al. (2000) have set apart a series of Lower Permian red sandstones composed of lacustrine sediments.

During the Permian era, climate in parts of land crust that is presently included in Eastern Serbia was dry, of desert type (Pantić 1984). This belief is shared by Milićević (1998) – in the Permian of Eastern Serbia the climate was very warm and dry.

Description and comparisons

In 1967, Vojislav Simić, curator-petrologist from Natural History Museum, brought a plate of Permian alevrolite from Glavica hill in vicinity of Donji Milanovac. It was reddish brown in color, approximately rectangular in shape, 180 mm long, 125 mm wide and 47 mm thick. In time it cracked along the plate and revealed a part of track made by a plantigrade right foot of a larger tetrapod vertebrate.

The length of the whole track is 95 mm. The imprint of last toe (IV or V) is 43 mm long and 11 mm wide. The penultimate toe (III or IV) is 55 mm long and 12 mm wide. Only the top part, 29 mm long and 12 mm wide, remained of the middle toe (II or III). The toe imprints are almost parallel to each other. Their tops are rounded and did not leave deeper imprint in the substrate. Claw marks are also absent. The continuation of imprint of the last toe includes an elongated, slightly curved shallow depression, most probably left by the outer edge of palm or foot of this animal while it was standing on the substrate.

Discussion

Permian was characterized by low diversity of tetrapods and therefore these vertebrates do not have biostratigraphic importance (Lucas, Schneider, Cassinis 2006).

According to Ronchi, Santi (2003) and Ronchi, Santi and Confortini (2005) tracks of several different tetrapods were recorded in the Orobic and Collio basins (Lower Permian, central part of Southern Alps, northern Italy): *Amphisauropus imminutus*, *Amphisauropus latus*, *Batrachichnus salamandroides*, *"Batrachichnus" salamandroides*, *Batrachichnus sp.*, *Camunipes cassinisi*, *Dromopus didactylus*, *Dromopus lacertoides*, *Ichniotherium cottae* and Varanopus curvidactylus.
According to Ptaszyński and Niedźwiedzki, tracks of amphibians: *Batrachichnus* cf. *salamandroides*, *Limnopus* cf. *zeilleri* and *Amphisauropus* cf. *latus*, as well as reptiles: *Varanopus* aff. *microdactylus*, *Chelichnus* cf. *duncani*, *Dimetropus* sp., *Rhynchosauroides, Palmichnus, Paradoxichnium, Phalangichnus, Amphisauropus* cf. *latus*, *Rhynchosauroides kuletae, Palmichnus lacertoides*, *Paradoxichnium tumlinense, Phalangichnus gradzinskii*, and *Phalangichnus gagoli* were recorded in the Upper Permian sandstones of Poland.

In the part of Bochum Formation of western Germany belonging to Permian period there are tracks and trails of tetrapod vertebrates from ten different families (Voigt, Ganzelewski 2010).

In the Carboniferous and Permian lacustrine basins of Czech Republic there were 47 recorded species of amphibians and 13 species of reptilians (Štamberg, Zajic 2008).

According to Avanzini et al. (2008), tracks of Amphisauropus from red Permian sandstones were recorded at several sites in Europe, while foot imprints of Dromopus were the commonest Lower Permian lacertoid tracks in Europe (ibid).

Tracks of Permian tetrapods are also known from Spain, France, Russia, China, India, Northern Africa, Texas and Brazil (Golubev 2005, Lucas 2004, Lucas, Schneider and Cassinis 2006).

According to all these sources it may be concluded that tracks of Permian tetrapods and their fossils should not be considered to be rarities in much of Europe. In Serbia they were not previously recorded, probably for the single reason of lack of systematic study of Permian sandstones in our country.

Although according to Pantić (1984) and Milićević (1998) the parts of land forming the present-day Eastern Serbia had very warm, dry, desert climate, Cassinis et al. (2002) have recorded Lower Permian lacustrine sediments in the Romanian part of Banat (Ciudano Vita fm.). Anđelković et al. (1996) and Krstić (in manuscript) have recorded Permian alevrolites with traces of raindrops, bioglyphs and traces of wave action, formed in oxidation environment with warm and hot climate with accidental precipitation.

According to the cited relevant facts it was possible to make this model: the land of present-day Eastern Serbia was in the Permian period characterized by dry, warm desert with rare, small, shallow water basins and banks overgrown with Permian plants; in some of these shallow water basins there were not only plants

Fig. 1. Photograph of a track of Permian tetrapod in a piece of alevrolite

but also the Permian tetropods; due to presence of warm dry desert climate such water basins lasted for a short time and relatively quickly became desiccated, but new, very similar, basins appeared in proximity or further afield; new basins were first colonized by plants and later by tetrapods; frequent desiccation and reappearance of similar water basins turned the Permian tetrapods into nomadic animals with small diversity.

It may be expected that previously unknown remains of primitive Permian tetrapods would be discovered in Eastern Serbia, in brown and reddish alevrolites, particularly those containing remains of fossilized plants, as these sites used to host shallow, warm lakes with well-developed paleovegetation during the Permian period.

Conclusion

The petrological collection of Natural History Museum includes a specimen of Permian alevrolite, reddish brown in color, collected in vicinity of Donji Milanovac. This specimen bears the track of some larger Upper Paleozoic tetrapod. This is the oldest ichnofossil of tetrapods recorded in Serbia to the present day.

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ANNOUNCEMENTS

The Carboniferous-Permian Transition

An international meeting devoted to all aspects of Carboniferous-Permian geology with special emphasis on the Carboniferous-Permian transition.

May 20-22, 2013

Hosted by the New Mexico Museum of Natural History and Science, Albuquerque, New Mexico, USA

Organizing Committee: Spencer G. Lucas (Albuquerque), James E. Barrick (Lubbock), Vladimir Davydov (Boise), William DiMichele (Washington, D. C.), Karl Krainer (Innsbruck), John Nelson (Champaign) and Joerg W. Schneider (Freiberg)

Schedule:

19 May: Pre-meeting fieldtrip to the Carboniferous-Permian transition section at Carrizo Arroyo, central New Mexico (limited to 25 participants)

20-22 May: Talks and posters.

21 May: Afternoon fieldtrip to Late Pennsylvanian Kinney Brick quarry

23-25 May: Post-meeting fieldtrip to Pennsylvanian-Permian rocks exposed in Joyita Hills-Cerros de Amado east of Socorro, New Mexico

Fieldtrips:

Trip 1: Carrizo Arroyo is one of the most paleontologically diverse localities across the Carboniferous-Permian boundary. It exposes mixed marine and nonmarine strata of the Bursum Formation that yield everything from plants and insects to fusulinids and brachiopods. This section plays a key role in global marine/nonmarine correlations because of the co-occurrence of conodonts and insect-zone species. Access is difficult, by 4-wheel-drive vehicle over difficult roads, so the number of participants is limited to 25 persons.

Trip 2: The Kinney Brick quarry is a world class Late Pennsylvanian Lagerstätte, located just east of Albuquerque. It is also important for marine/non-marine correlations due to the occurrence of conodonts, fusulinid, branchiosaur and insect zone species. All participants will take an afternoon excursion to the quarry as a break in the meeting technical program

Trip 3: East of Socorro, marine and nonmarine sedimentary rocks of Middle Pennsylvanian-Early Permian age are exposed along the eastern margin of the Rio Grande rift. This is one of the best exposed and most studied Pennsylvanian-Permian sections in New Mexico, and recent work has brought forth diverse paleofloras, detailed conodont biostratigraphy, extensive ichnofossil assemblages, and much more. The three-day trip, headquartered in Socorro, will work through this entire section, focusing on issues of stratigraphy, sedimentation and paleontology.

Symposium proceedings:

Proceedings of the symposium and a field guide will be published by the New Mexico Museum of Natural History and Science. Contributions on all aspects of Carboniferous and Permian geology are appropriate for the proceedings. Contributions to the proceedings can range from abstracts to full length articles. Also, you do not need to attend the meeting to contribute to the proceedings volume.

Editors of the symposium proceedings are the meeting organizers, so please contact one of the organizers for further information.

Deadline for publishable contributions in the proceedings volume will be January 1, 2013.

To register for the Carboniferous-Permian transition meeting next May in Albuquerque, please go to this link:

http://www.brownpapertickets.com/e/297322

For further information contact:

Spencer G. Lucas	spencer.lucas@state.nm.us
James E. Barrick	jim.barrick@ttu.edu
Vladimir Davydov	vdavydov@boisestate.edu
William DiMichele	dimichel@si.edi
Karl Krainer	karl.krainer@uibk.ac.at
John Nelson	jnelson@isgs.uiuc.edu
Joerg W. Schneider	schneidj@geo.tu-freiberg.de

1st International Congress on Stratigraphy, Lisbon, 1-7 July, 2013

It is with pleasure that the Organizing Committee announces the 1st International Congress on Stratigraphy (STRATI 2013), to be held in Lisbon, 1–7 July 2013.

This congress follows the decision to internationalize the conferences previously organized by the French Committee of Stratigraphy (STRATI), the last one of which was held in Paris in 2010. Thus, the congress possesses both the momentum gained from an established conference event and the excitement of being the first International Congress on Stratigraphy. It is being held under the auspices of the International Commission on Stratigraphy (IUGS), and it is envisaged that this first congress will lead to others being held in the future.

Stratigraphy is a geoscience specialism that involves numerous researchers and practitioners worldwide and has many applications, with growing importance in scientific, technological, economic, and environmental fields. The Organizing Committee welcomes all interested parties to this event and intends to hold a congress of high scientific quality in a friendly and professional environment.

Deatiled information see: **http://www.strati2013.org/**

XVIII INTERNATIONAL CONGRESS ON CARBONIFEROUS AND PERMIAN

KAZAN, RUSSIA, August 7-15, 2015

Dear colleagues:
It is the honor and our pleasure to invite you to the XVIII International Congress on Carboniferous and Permian to be held in the Kazan Federal University, city of Kazan, Russia, in August 2015.

Venue
The city of Kazan is one of the ancient cities in Russia . The population is 1,2 million people. It is cultural and industrial center included in UNESCO World Heritage list. The combination of the Muslims and Christian monuments create the unique atmosphere and scenery. The city of Kazan is easy available from Europe through Frankfurt, Moscow and Saint-Petersburg. The location of Kazan in the center of the European Russia allows to propose the observation of the variety of sections and outcrops located in the several districts of Russia.

Host and Conference Language
The XVIII ICCP will be held in the Kazan Federal University on August 7-15, 2015. The official congress language will be English.

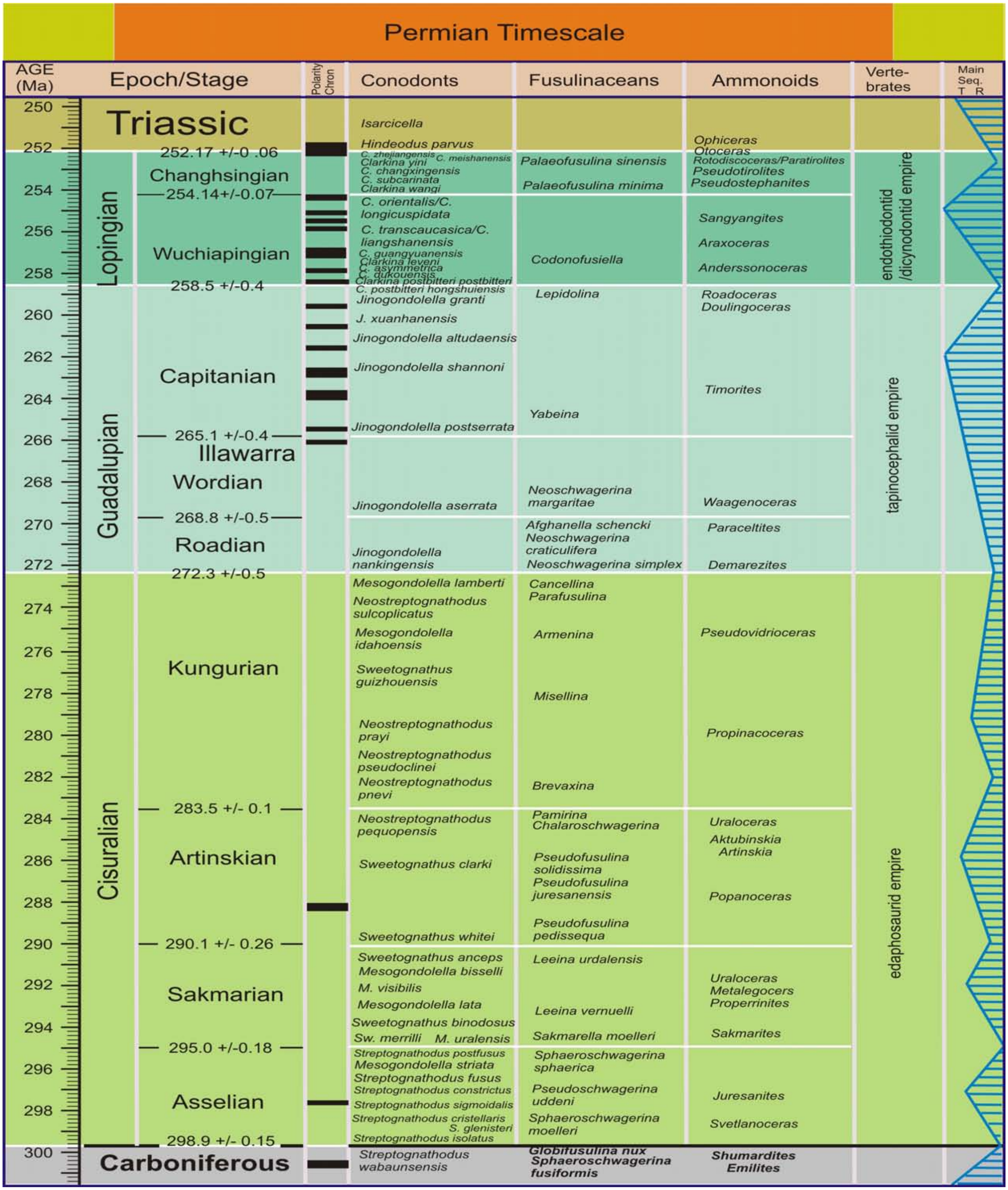
Congress topics
Carboniferous and Permian high resolution stratigraphy
Carboniferous and Permian stage boundaries and worldwide correlation - progress and perspectives
Climatic and biotic changes during Late Paleozoic glaciation
Permian continental biota- approach to a new geochronological scale
Non-marine Late Paleozoic world - paleogeography, migration, fauna and flora
Sedimentary sequences and depositional environments during Carboniferous and Permian
Carboniferous and Permian marine biota

Geological excursions:
Pre-congress excursions:
1a. Lower Carboniferous of the Saint-Petersburg region (northwestern Russia).
1b.Moscow basin. Stratotypes of the Serpukhovian, Moscovian, Kasimovian and Gzhelian stages.
1c. Southern Urals. Deep water successions of the Carboniferous and Permian.
1d. Middle Permian – Lower Triassic continental sequences in Vologda and Arkhangelsk regions (North of the European Russia) and localities of flora, tetrapods, non-marine fishes and invertebrates.
Post-congress excursions
2a. Volga and Kama Region. Middle and Upper Permian.
2b. Central Urals. Carboniferous-Permian marine succession.
2c. Carboniferous reference sections, Southern Urals.
2d. Permian of Omolon massif, North-Eastern Russia
Mid-congress excursion:
3. Permian deposits along the Volga River.
Accommodations. A large variety of hotels is available in the city of Kazan.
Organizing committee
A.S.Alekseev, I.V.Budnikov, A.S.Byakov, B.I.Chuvashov, I.R.Gafurov, V.G.Golubev, N.V.Goreva, O.L.Kossovaya, G.V.Kotlyar, E.I.Kulagina, D.K.Nourgaliev, S.V.Nikolaeva, V.V.Silantiev
For further information, please contact: iccp2015@ksu.ru
The information will be also available through web site: www.iccp2015.ksu.ru
Organizers: Russian Academy of Sciences, Interdepartmental Stratigraphical Committee of Russia, Carboniferous and Permian Subcommissions of Russia, Kazan Federal University, Moscow State University, All-Russian Research Geological Institute, International Subcommission on Carboniferous Stratigraphy
International Subcommission on Permian Stratigraphy

SUBMISSION GUIDELINES FOR ISSUE 57

It is best to submit manuscripts as attachments to E-mail messages. Please send messages and manuscripts to Lucia Angiolini's E-mail addresses. Hard copies by regular mail do not need to be sent unless requested. Please refer to Issue #46 of Permophiles (*e.g.* Nurgalieva *et al.*) for reference style, format, *etc.* Please provide your E-mail addresess in your affiliation. All manuscripts will be edited for consistent use of English only.

Prof. Lucia Angiolini (new SPS secretary)
Università degli Studi di Milano
Dipartimento di Scienze della Terra "A. Desio"
Via Mangiagalli 34, 20133 MILANO Italy
E-mail: lucia.angiolini@unimi.it
Submission Deadline for Issue 57 is
Feburary 15, 2013



Note: This is the latest version of the Permian timescale which SPS suggests to use. All the information will be updated from time to time at the SPS website (http://www.stratigraphy.org/permian/). Geochronologic ages are combined from Shen et al., 2011 (Science) for the Lopingian; Schmitz and Davydov, 2012 (GSA Bulletin) for the Cisuralian, Zhong et al. in press (Journal of Asian Earth Sciences) for the Guadalupian/Lopingian boundary and current ICS International Chronostratigraphic Chart for the Guadalupian.