Kazan Federal University

Institute of Geology and Petroleum Technologies

Kazan Golovkinsky Stratigraphic Meeting, 2014

Carboniferous and Permian Earth systems, stratigraphic events, biotic evolution, sedimentary basins and resources

October, 20–23, Kazan, Russia

Abstract Volume

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Казанский (Приволжский) федеральный университет

Институт геологии и нефтегазовых технологий

Ежегодная международная стратиграфическая конференция Головкинского, 2014

Каменноугольная и пермская планетарные системы, стратиграфические события, эволюция биоты, седиментационные бассейны и полезные ископаемые

20–23 октября 2014 года

Сборник тезисов

Научный редактор

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УДК 55
ББК 26
К 11

Научный редактор
Данис К. Нургалиев

Технические редакторы:
Владимир В. Силантьев,
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К 11 Ежегодная международная стратиграфическая конференция Головкинского «Каменноугольная и пермская планетарные системы, стратиграфические события, эволюция биоты, седиментационные бассейны и полезные ископаемые» (20–23 октября 2014 г.). Сборник тезисов. – Казань: Изд-во Казан. ун-та, 2014. – 104 с.

ISBN 978-5-00019-270-2

Международная конференция посвящена проблемам каменноугольной и пермской планетарных систем, стратиграфическим событиям, эволюции биоты, седиментационным бассейнам и полезным ископаемым.

УДК 55
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К 11 Proceeding of Kazan Golovkinsky Stratigraphoic Meeting «Carboniferous and Permian Earth systems, stratigraphic events, biotic evolution, sedimentary basins and resources» (October, 20–23 2014). – Kazan, 2014. – 104 p.

International Stratigraphic Meetinf is dedicated to the Carboniferous and Permian Earth systems, stratigraphic events, biotic evolution, sedimentary basins and resources.

ISBN 978-5-00019-270-2

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For financial support, we would like to thank:

Kazan Federal University
Russian Foundation for Basic Research

Content

Boundaries of Carboniferous stages in Russia: state of the art

Alexander S. Alekseev [1,2], Nataliya V. Goreva [3], Yuriy A. Gatovsky [1], Nilyufer B. Gibshman [2], Olga L. Kossovaya [4], Elena I. Kulagina [5], Svetlana V. Nikolaeva [2,6], Galina Yu. Ponomareva [7]

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Carboniferous deposits are widespread throughout Russia and are accessible for study in multiple outcrops and subsurface sections. Five of the seven stages of the Carboniferous System of the International chronostratigraphic scale have been recognized in Russia: Serpukhovian, Moscovian, Kasimovian and Gzhelian in the Moscow Basin and Bashkirian in the South Urals.

Sections exposing Devonian-Carboniferous-boundary beds are incomplete as was shown as early as the 1980s, either due to a large gap (in the Moscow Basin) or due to scarcity of conodont records in the boundary interval. However, some sections have recently been re-examined to establish the scale and precise stratigraphic level of the Hangenberg event.

Yu. A. Gatovsky re-examined and re-described the carbonate-cherty Shirokovsky section on the western slope of the Middle Urals, previously studied by V. N. Pazukhin, and traced the position of the boundary interval, but the succession contains many beds of chert, which cannot be dissolved for conodonts. On the western slope of the South Urals (Bashkortostan), Yu. A. Gatovsky and E.I. Kulagina re-examined the well known Sikaza and Zigan sections (Kochetkova et al., 1988). The Sikaza section contains an argillaceous member (Beds 6a, 6b, and 6c, 2 m) corresponding to the Hangenberg Event, but it is apparently underlain and overlain by unconformities, whereas *Siphonodella sulcata* enters only at a level when the carbonate sedimentation was resumed. Apparently, the Hangenberg Event can be traced in many regions of Russia, which increases its correlation potential.

A comprehensive biostratigraphic, lithological, and geochemical study has been completed for the Upper Viséan and Serpukhovian stages in the type Serpukhovian region in the Moscow Basin (Kabanov et al., 2012, 2013; in press). The successions were correlated with the subdivisions of the Upper Viséan of Belgium based on foraminiferans, and the appearance of *Lochriea ziegleri* has been confirmed to enter in the middle of the Venevian, i.e., in the terminal Viséan, as in Western Europe. The succession of conodonts and foraminifers appearances is studied in shallow-water Ladeiny Log section in the Middle Urals by G. Yu. Ponomareva, but *Lochriea* elements are scarce there. The biostratigraphy of the Viséan-Serpukhovian boundary beds in the Verkhnyaya Kardailovka section (Trench B, proposed GSSP candidate for the base of the Serpukhovian; South Urals, Russia) has been revised and amended based on new excavations in 2011-2014. The refined distribution ranges of ammonoids, conodonts, and foraminifers are presented, and the key taxa are photographed (Nikolaeva et al., 2014). The carbonate succession in Trench B is considered to be the most suitable for boundary fixation. The first occurrence of the conodont *Lochriea ziegleri*, which is considered as the most appropriate boundary marker, is fixed at a level of 19.63 m, also in the terminal Viséan, within the ammonoid *Hypergoniatites–Ferganoceras* Genozone. The succession of the ammonoid, conodont, and foraminiferal zones in the boundary beds is documented for the first time in a single section and correlated with the zonations in Western Europe, North America, and China. The Verkhnyaya Kardailovka section is shown to be a continuous succession with a variety of fossil groups allowing detailed litho- and biostratigraphy, which makes it the best of the proposed GSSP candidates for the base of the Serpukhovian.

The Serpukhovian-Bashkirian boundary in the hypostratotype of the Bashkirian Stage in the Askyn section on the western slope of the South Urals coincides with a gap, but in the more complete deep-water locations, the Bogdanovka and Muradymovo sections (Zilair Megasynclinorium, South Urals) (Kulagina et al., 2013), it was possible to trace the successive entries of more primitive to more derived representatives of *Declinognathodus noduliferus*. Data on the presence of the primitive members of this group in the mid-Serpukhovian (Sanz-López et al., 2013) and even in the Viséan of the North Africa need re-examination and confirmation.

The base of the Moscovian is traditionally placed at the bottom of the Vereian Substage, but in the type region it is not paleontologically substantiated. Uninterrupted sections are known in the South Urals (Basu), where one of the suitable boundary markers, the conodont *Declinognathodus donetzianus* (Kulagina et al., 2009) is present. However, at least 10 different markers have been proposed for the base of the Moscovian, so an accepted definition of the boundary is needed. Hence, it was proposed that the boundary should be placed higher in the section, at the base of the Kashirian Substage, at the level of the first appearance of the conodont *Neognathodus botrops* in the Yambirno section on the Oka-Tsna Swell (Alekseev and Goreva, 2013).

The Kasimovian Stage in the Moscow Basin begins with the Krevyakinian Substage (base of the Suvorovo Formation), at the level of entry of "*Swadelina*" *subexcelsa*, but this is an endemic species. A new section has been studied in the Kasimov Quarry (Oka-Tsna Swell) with beds transitional between the Moscovian and Kasimovian stages (O.L. Kossovaya). More it may have a higher position, up to the level of the first appearance of the conodont *Idiognathodus turbatus* group and typical foraminiferan species of the genus *Montiparus* (middle of the Khamovnikian Substage). This interval is studied by N.V. Goreva and A.S. Alekseev in the Shcherbatovka Section (Oka-Tsna Swell).

The base of the Gzhelian Stage was internationally defined by the first occurrence of conodont *Idiognathodus simulator* (Heckel et al., 2007), known from the stratotype of the Gzhelian Stage (Gzhel section), and in the Samara Bend and the South Urals, as well as in North America. The South Uralian Usolka section has been proposed as the possible stratotype of the base of the Gzhelian Stage (Chernykh et al., 2006) and now it is re-studied by G.M. Sungatullina.

All Pennsylvanian stage boundaries could not be traced in the Eastern Siberia and North-Eastern Russia territories, especially in the continental facies of the Angara phytogeographic province, where we are waiting for exact paleomagnetic frame and high resolution isotope dating of the volcanic ashes.

Isotopic characteristics $\delta^{13}C$ and $\delta^{18}O$ of the Severodvinian and the Vyatkian stages of Mutovino section (Moscow syneclise)

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Mutovino section (= Isady, Purtovino village, Sukhona River, Vologda region, Moscow syneclise) is boundary-stratotype (limitotype) of the Vyatkian stage at the general stratigraphic scale (GSS) in Russia. It is known as a rich locality of fossils of ostracods, bivalves, insects, fishes, tetrapods and plants. The outcrop includes an upper part of the Severodvinian stage and base of the Vyatkian stage. The analysis of the isotopic composition of carbon and oxygen of sedimentary and pedogenic carbonates has revealed the following regularities.

1. The $\delta^{13}C$ values ranging from 1,1 to 4,6 ‰ PDB occur in sedimentary carbonates at the main part of the Severodvinian stage. It is generally higher than in the lower part of the Severodvinian in the Sukhona formation (about 2 ‰). Above Bed 50 C-isotope values decrease from 4,2 ‰ (Fig. 1).
2. The minimum $\delta^{13}C$ value in sedimentary carbonates (Bed 76, –0,3 ‰) almost exactly coincides with the base of the Vyatkian stage. Weighting to 3,4 ‰ (Bed 91) and a new decreasing to 0,5 ‰ is observed above.
3. The $\delta^{18}O$ values in sedimentary carbonates fluctuate from 26,4 to 34,1 ‰ SMOW. The highest values set in the Bed 16 and Beds 46-50 of the Severodvinian as well as in the sediments of Vyatkian stage.
4. Progressive decreasing of C-isotope values is observed in pedogenic carbonates from the upper part of the Vyatkian. The $\delta^{18}O$ values (27,7–30,8 ‰ SMOW) are higher than in the underlying Strelna pedocomplex in the lower part of the Upper Severodvinian (22–23 ‰) and higher than in the overlying Klimovo pedocomplex in the upper part of the Lower Vyatkian (23–25 ‰).

The data allows saying about climatic cooling and humidification at the second half of the Severodvinian and about warming at the boundary between the Severodvinian and the Vyatkian. Late Severodvinian cooling can be correlated with the Kamura event in the Capitanian (Isozaki et al., 2007b). Level of Bed 50 with a maximum value of $\delta^{13}C$ probably correlates with the boundary between the Capitanian and Wuchiapingian. The boundary between the Severodvinian and Vyatkian correlates with the first negative shift of $\delta^{13}C$ in the Wuchiapingian in conodont zone *Clarkina postbitteri postbitteri* (Jin et al., 2006; Isozaki et al., 2007a).

The work was supported by the Russian Foundation for Basic Research, project no. 13-05-00592.

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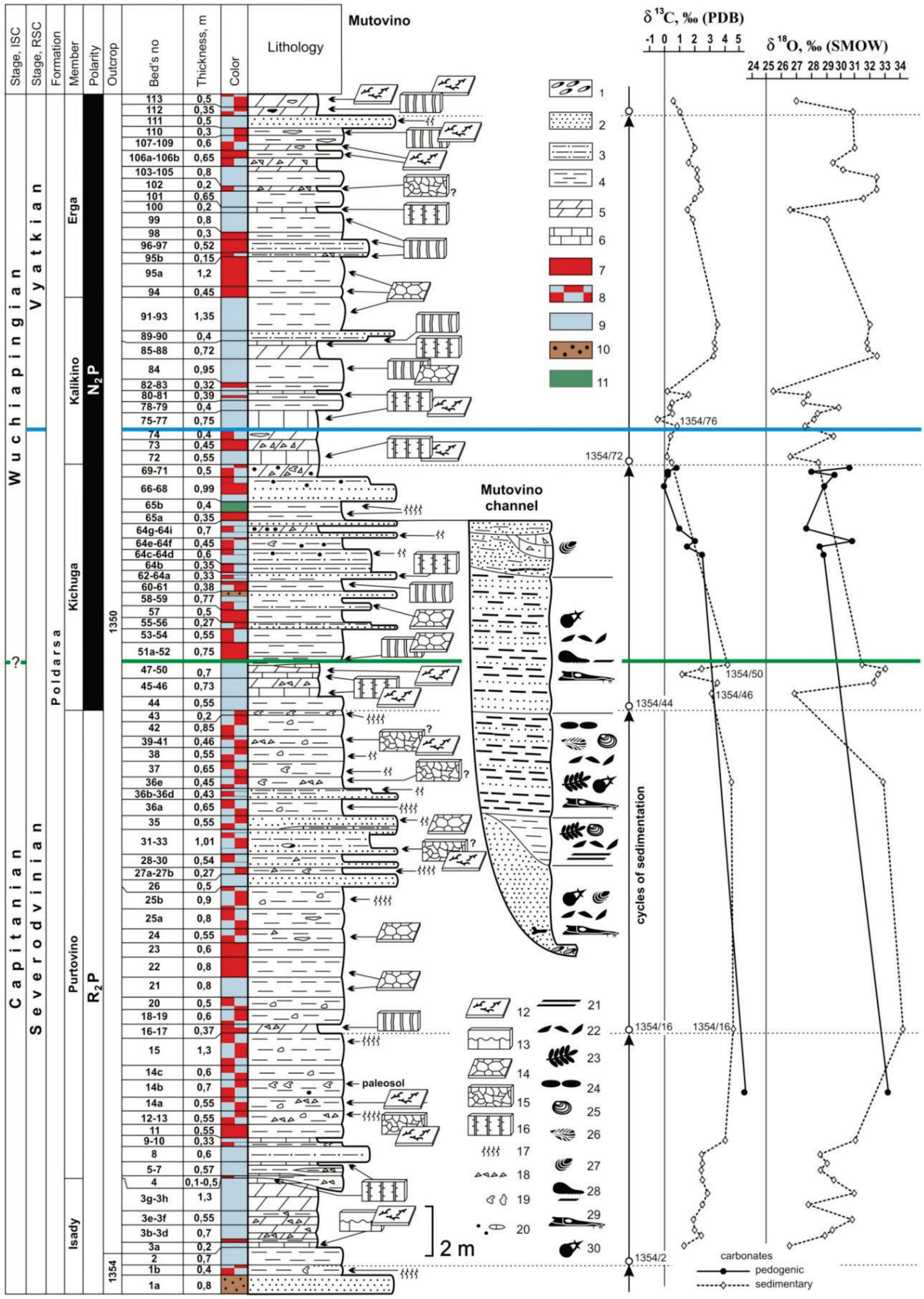

database**Fig. 1.** The Mutovino section and isotopic composition of carbon and oxygen within pedogenic and sedimentary carbonates. 1 – gritstone, 2 – sandstone, 3 – siltstone and mudstone, 4 –clay, 5 – marl, 6 – limestone, 7 - redstones, 8 - speckled rocks, 9 – light gray rocks and rocks with gleyed spots, 10 - brown and greenish-gray sandy rocks, 11 – green rocks, 12 – allochthonous plant roots, 13 – paleokarst, 14 – mud cracks, 15 – clay coating, 16 - large plant roots *in situ* in limestone, 17 – plant roots *in situ* in cambisols, 18 - clayey breccias, 19 - gleyed spots, 20 – soil nodules, 21 – shoots of plants, 22 – plant detritus, 23 – plant leaves, 24 – ostracods, 25 – conchostracans, 26 – insects, 27 - bivalves, 28 – fishes, 29 – aquatic tetrapods, 30 – terrestrial tetrapods

Biostratigraphy and Paleobiogeography of Carboniferous Brachiopods from North Iran

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A very rich brachiopod fauna comprising 54 taxa has been found in the Tournasian marly limestones and bioclastic limestones of the Mobarak Formation, Alborz Mountains, North Iran. It comprises: *Leptagonia* cf. L. *analoga* (Phillips, 1836), *Caenanoplia* cf. C. *burlingtonensis* (Carter, 1968), *Geniculifera* sp. ind., *Rhytiophora* sp. ind., *Antiquatonia* sp. ind., *Promarginifera* sp. ind., *Dictyoclostinae* gen. et sp. ind., *Buxtonia* sp. ind., *Marginatia vaughani* (Muir-Wood, 1928), *Marginatia* aff. *M. deruptoides* Sarytcheva in Sarytcheva, Sokolskaya, Beznosova & Maksimova, 1963, *Tomiproductus elegantulus* (Tolmatchoff, 1924), Tolmatchoffiini gen. et sp. ind., *Pustula* cf. *P. altaica* Tolmatchoff, 1924, *Pustula* sp. ind., *Pustulinae* gen. et sp. ind., *Brochocarina* sp. ind., *Orthotetoidea* fam. ind., *Schellwienella* sp. ind., *Rhipidomella michelini* (Léveillé, 1835), *Schizophoria (Schizophoria) resupinata* (Martin, 1809), *Hemiplethorhynchus crassus* Gaetani, 1968, Rossirhynchus adamantinus Gaetani, 1964, *Paraphorhynchus* aff. *P. elongatum* Weller, 1905, *Athyris* sp. ind., *Lamellosathyris lamellosus* (Léveillé, 1835), *Cleiothyridina kusbassica* Beznosova in Sarytcheva, Sokolskaya, Beznosova & Maksimova, 1963, *Cleiothyridina* sp. ind., *Gerankalasiella* sp. ind., *Carteridina* sp. ind., *Composita megala* (Tolmatchoff, 1924), *Composita subquadrata* (Hall, 1858), *Composita* aff. *C. pentagonia* (Weller, 1914), *Composita* cf. *C. caimaensis* Chen, Tazawa, Shi & Matsuda, 2005, *Composita* sp. ind., *Densalvus* sp. ind., *Iniathyris* sp. ind., *Sottofam. Spirigerellinae* gen. et sp. ind., Fam. *Athyrididae sottofam*., gen. et sp. ind., *Kisilia* sp. ind., *Tenisia* sp. ind., *Ectochoristites* sp. ind., *Parallelora* sp. ind., *Unispirifer (Unispirifer) striatoconvolutus* (Benson & Dun in Benson, Dun & Browne, 1920), *Unispirifer* cf. *U. (Septimispirifer) septimus* (Thomas, 1971), *Unispirifer* sp. ind., *Atylephorous* sp. ind., *Sottofam. Prospirinae* gen. et sp. ind., *Voiseyella* aff. *V. texana* (Carter, 1967), *Brachythyris* sp. ind., *Kitakamithyris* sp. ind., *Torynifer* sp. ind., *Syringothyris carteri* (Hall, 1857b), *Syringothyris skinderi* Sokolskaya in Sarytcheva, Sokolskaya, Beznosova & Maksimova, 1963, *Pseudosyrinx* sp. ind.

The fauna has been bed by bed collected along two sections: Abrendan section and Simeh Kuh section, whose correlation has been tempted using a quantitative biostratigraphy. Although mostly cosmopolitan, the brachiopods show close affinity to North America, Western Europe and the Russian Platform than to cold-water Australian faunas, confirming the affinity of foraminifers and another biota. This seems to contradict Early Mississippian paleomagnetic reconstructions placing the Alborz region at 45–50° South latitude. The answer to this discrepancy may lie in the circulation of Paleo-Tethyan currents to the south along the Gondwanan shelf.

Paleomagnetic characterization of the Middle and Upper Permian deposits based on the results from the key section in the Monastery Ravine

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The first paleomagnetic researches of the continental Permian succession in Volga-Ural Basin region were conducted by A. N. Khramov et al. in the 1957-1985. It was found out that four paleomagnetic zones (from bottom to top) were present: R_1P, N_1P, R_2P, N_2P. According to A. N. Khramov, the boundary between R_1P and N_1P zones corresponded to the contact between the Second and the Third formations of the Tatarian regional stage coinciding to the boundary between the Lower and Upper Tatarian (Khramov, 1963). The boundary between N_1P and R_2P zones was located slightly lower the base of the Fourth formation while the boundary between R_2P and N_2P zones coincided with the contact interval of Fourth and Fifth formations.

In the 70s of the XX century, the paleomagnetic researches in this region were conducted by scientists of Kazan University (Boronin et al., 1971; Burov et al., 1996; Zharkov *in* Silantiev et al., 1998). These researchers had used more detailed sampling, new laboratory equipment and sufficiently improved previous paleomagnetic characterization obtained by Khramov et al. For example, the alternating-sign zone (NRP zone) (thickness of 42 meters) was defined at the turn of the zones R_1P and N_1P. The base of NRP zone was established closely to the bottom of the Second formation. The upper boundary of the NRP zone was defined a little bit higher than the upper boundary of the Second formation. Moreover, the thickness of the N1P zone has risen significantly, whereas the thickness of the R_2P zone, on the contrary, has reduced. The boundary between N_1P and R_2P zones was drawn in the middle part of the Fourth formation.

Finally, the lower boundary of the N_2P zone was defined a little bit higher than the basement of the Fifth formation. The Kiaman-Illawarra Reversal interval was determined at the basis of the N_1P zone.

The latest data about asynchronism between biostratigraphic and paleomagnetic boundaries in the turn of Biarmian (Middle Permian) and Tatarian (Late Permian) in European Russia forced Kazan researchers to repeat the paleomagnetic analysis of the succession exposed in Monastery Ravine.

The most precise correlation of the alternating-sign zone (NRP zone) was established by A.K. Gusev (1996) who considered that first signs of the direct polarity appear in the lower part of the Green Clay Member of the Second (= Isheevskaya) formation in the section of Cheremushka Ravine. Disharmony imbalance of the geomagnetic field regime finishes in the Steep Gullies Member of the Second (= Isheevskaya) formation. Therefore, alternating-sign zone (NRP zone) fully coincides with the Second (= Isheevskaya) formation of Urzhumian regional stage (Gusev, 1996; Burov et al., 1996).

Later, I. Ya. Zharkov showed (Silantiev et al., 1998) that the normal polarity is prevalence in the upper part of the Second formation as well as in the main part of the Third formation. At the same time, the intervals of reverse polarity registered within the Third formation are characterized by significantly lower total thickness than in the second one.

Molostovskii E.A. et al. (2006) argued against indications (Burov et al., 1996; Silantiev et al., 1998) on the alternating-sign zone (NRP zone) in the Urzhumian deposits of Monastery Ravine' section and defined the boundary between Kiaman-Illawarra Reversal in the upper part of the Second formation. At the same time, quite reliable data (Gialanella et al., 1997; Westphal et al., 2005) confirm the presence of the alternating-sign zone (NRP zone) below the boundary between Kiaman-Illawarra Reversal in this section.

Nowadays, the analyses of published data (Balabanov et al., 2009) and additional detailed paleomagnetic study of the Second and Third formations reveal the strong metastable magnetism that mostly characterized the weak-magnetic rocks. This metastability does not permit to define the component of initial natural magnetization.

The usage of gradual thermal cleaning of the samples allowed to specify the composition of the alternating-sign zone (NRP zone) and showed in the most case the reverse remanent magnetization of rocks. Intervals of normal polarity are defined in the Crimson Clay Member and the upper part of the Steep Gullies Member of the Second formation and the lower part of the Third formation (Fig. 1). The boundary between Kiaman-Illawarra Reversal should be defined probably in the lower part of the Third formation according to stable normal magnetization of rocks. These data corresponds to the opinion of Burov et al. (1996). Thus, the thickness of the alternating-sign zone (NRP zone) in the Monastery Ravine' section in accordance with new data is about 27,2 m.

It's interesting to note that paleomagnetic research of the borehole № 1 (unpublished report of I. Ya. Zharkov, 2000) situated 20 km south from the Monastery Ravine have showed the presence of the same alternating-sign zone (NRP zone) of almost the same thickness (23,7 м). The biostratigraphic boundary between the Middle and the Upper Permian has not revealed by paleomagnetic data and located within N1P zone of the normal polarity. The overlapping of the lithostratigraphic, paleontological and paleomagnetic boundaries to the one stratigraphic level (e.g. Silantiev et al., 2007) cannot be considered as a correct conclusion.

Nowadays the fact that paleomagnetic boundaries have some lagging as compared with the lithostratigraphic ones is well-proven data (Gialanella et al., 1997). Paleontological boundary, on the contrary, should lag as compared to the paleomagnetic ones because evolution of the organic world is connected with the regime of the geomagnetic field.

The section in the Monastery ravine is of crucial importance because new paleontological data performed herein can doubt previous suppositions about the location of the boundary between Kiaman-Illawarra Reversal. Those doubts appear due to the data gathered by leading fossils pointing out that the Third formation belongs to the Urzhumian Stage (Silantiev, Esin, 1993; Silantiev et al., 2007, etc.).

So, the reconsidering of paleomagnetic data confirms previous ideas about bizonal paleomagnetic structure of the Urzhumian succession exposed in Monastery Ravine.

Deposits of the First formation possessed reversed initial natural magnetization, as well as alternating-sign zone (NRP zone) revealed from the upper part of the First formation up to the basement of the Third formation should be referred to Kiaman zone (R_1P). The main part of the Third formation should be referred to the Illawarra zone N_1P.

These conclusions agree with the data obtained from some sections of the Amanakskaya Formation (Urzhumian Stage) and Malokinelskaya Formation

(Severodvinian Stage) within the southeastern part of Volga-Ural basin (Molostovskii et al., 2006; Grishanov et al., 2007; Molostovskaya, Grishanov, 2008; Minikh et al., 2009).

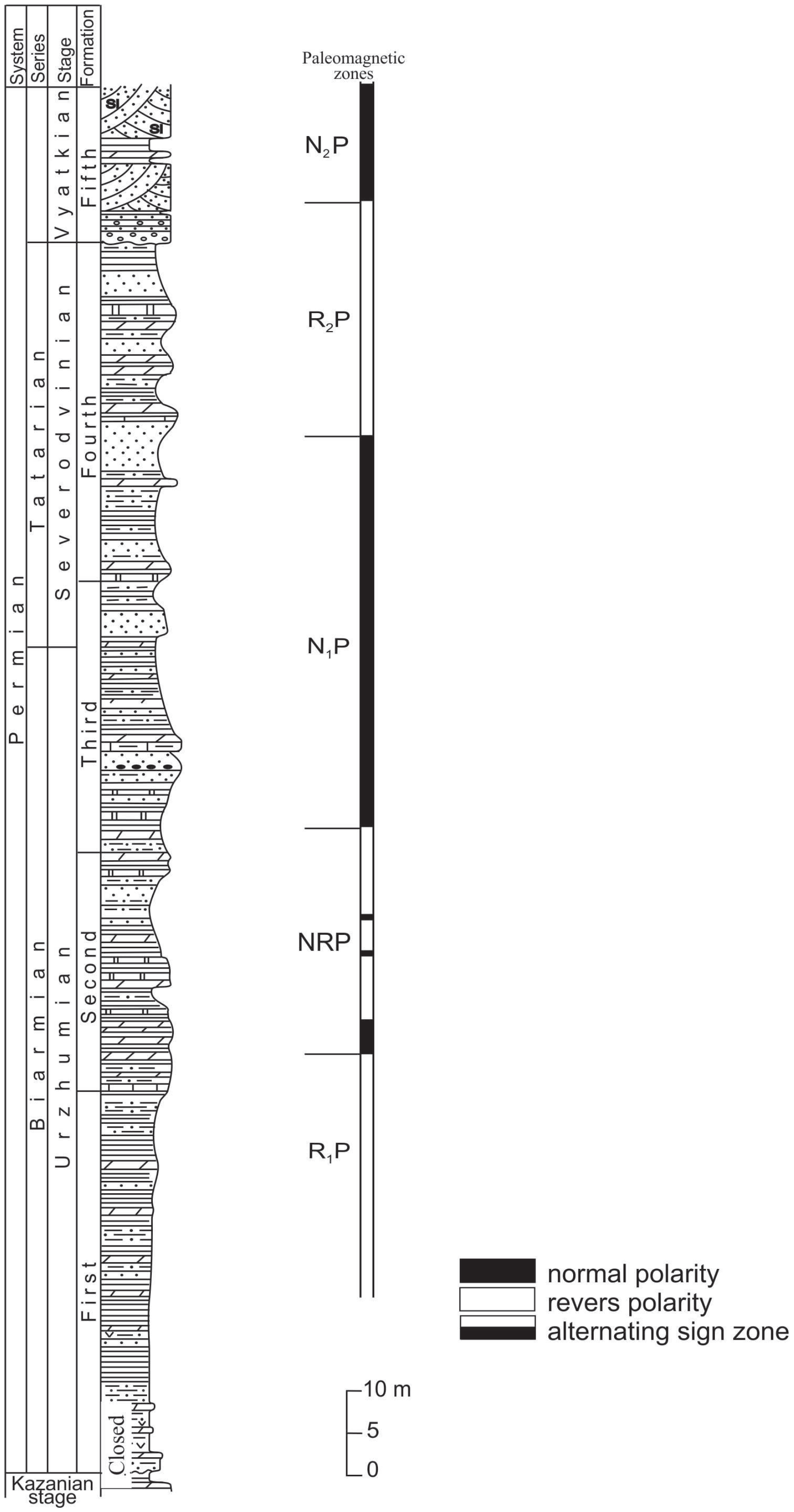

Fig. 1. Paleomagnetic zones established in the section of the Monastery and Ilyinsky Ravines (stratigraphic column is compiled from Silantiev et al., 2007)

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

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Preliminary results of the study of ferromagnetic characteristics inherent for Middle and Upper Permian deposits

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Detailed layer-by-layer study of the Permian deposits exposed in the Monastery Ravine near the town of Tetushi has been conducted. The study included five Formations established by N.N. Forsch in 1930-1940. The First and the Second Formations coincide to Urzhumian regional stage, the Third and the Fourth Formations coincide to Severodvinian regional stage and Fifth Formation coincide to Vyatkian regional stage.

Magnetic sensibility of the rocks (further referred to as χ) is defined mainly by the condition of their formation, ferromagnetic material and by the intensity with which it gets to the basins of sedimentation. Measurements of this characteristic were made from 353 levels with the help of the Bartington MS2 apparatus (Oxford England).

The results of the measurements are revealed in the Table 1. From these results we can conclude that average values of χ, calculated for separate Formations, gradually decrease from one Formation to another and then increase step by step. That proves by inference the strengthening of the tectonic power of the Urals by the end of the Permian period. Rather big range of change of χ value within separate Formations is defined by the lithological composition of the rocks – in carbonated marls there is less irony material than in siltstone clay ones.

As the differential thermomagnetic analysis shows the main bearers of the ferromagnetism are at the same time micronized hematite and leading stone. Hematite is the secondary formation having appeared in the process of transporting of the primary one magnetite by water flows.

Table 1. Magnetic sensibility of the rocks

Formation	$\chi_{min.}$ (SI)	$\chi_{max.}$ (SI)	$\chi_{average}$ (SI)
First	$1,9 \times 10^{-5}$	$19,4 \times 10^{-5}$	$9,85 \times 10^{-5}$
Second	$0,4 \times 10^{-5}$	$20,3 \times 10^{-5}$	$8,39 \times 10^{-5}$
Third	$0,5 \times 10^{-5}$	$78,6 \times 10^{-5}$	$13,46 \times 10^{-5}$
Fourth	$2,1 \times 10^{-5}$	$89,1 \times 10^{-5}$	$17,86 \times 10^{-5}$
Fifth	$6,8 \times 10^{-5}$	$38,5 \times 10^{-5}$	$19,5 \times 10^{-5}$

Analysis of the χ curve of the deposit exposure shows that when averaging some periodicity could be noted which in our opinion is defined probably by the tectonic regime of the territory. Breaking of the periodicity can mean a pause in deposition of sediments. The period during which the parameter was changing is estimated by us as a period of 2 mln years (duration of the Tatarian Series as it has been seen before together with the Urzhumian regional Stage with the regard of breaks in sediments deposition is about 15,0 mln years; the number of the periods distinguished during the period in Monastery ravine ~ 8, and the duration of formation of each Formation is almost 4,0 mln years. Such rhythm at the first sight may correspond the first cosmic cycle presupposed by the change of solar constant and polarity of magnetic field of the Earth, the cycle is estimated to be 1,38-1,88 mln years (Tyapkin K.F., 1998).

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Orogenesis: Cause of sedimentary formations

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Experiments on stratification discussed here have revealed the mechanical nature of lamination as well as the role of turbulent current as agent of stratification. They challenge Steno's principle that superposed strata are successive sedimentary layers. They show that relative chronology should not be referred to as "stages" but as "sequences" of the series. The latter scale corresponds to large marine transgressions and regressions that can result from the shift of the polar axis following such major orogeneses as the Caledonian, Hercynian and Alpine.

Much of sedimentology is based on Nicolas Steno's principle i.e. that superposition of strata leads to a succession of sedimentary layers. However, some stratification experiments discussed here call for questioning this principle. Performed lamination experiments (Berthault 1986, 1988) demonstrated that a lamination was immediately reconstituted in the ensuing deposit. Moreover, compelling evidence by McKee et al. (1967) strongly suggests that the graded-bedding of stratification results from turbulent flow, the variable velocity of which determining the successive deposit of particles of different sizes.

Further work by Julien et al. (1993), in which a pump circulated sand-laden water in a flume, showed that sand particles indeed deposited accordingly to the velocity of the turbulent current. The sedimentary deposit consisted of superposed and juxtaposed strata which prograded laterally in the direction of the current which contradicts Steno's principle of superposition.

Thus, the turbulent flow generates graded-bedding. When the velocity of the current increases, it becomes erosive, creating erosion surfaces in the deposit. These results show that the current is an essential agent of stratification, which has been overlooked in conventional stratigraphy. Therefore, Steno's principle has to be critically reviewed in light of new experimental data.

Golovinski and Walther's law of sequence stratigraphy (Middleton, 1973) states: "Only those facies and facies areas can be superimposed primarily which can be observed beside each other at the present time". As shown in (Berthault, 2002), the superposed and juxtaposed facies constitute a sequence resulting from a marine transgression or regression. A succession of sequences included between an initial transgression and a final regression is a "series".

The data from sequence stratigraphy and the afore-mentioned experiments show that a series corresponds to a period. Sedimentation, therefore, must be considered as the basic reference of relative chronology instead of stage.

The radioactive dating of eruptive rocks is based on the phenomenon of spontaneous decay of a radioactive element from a "parent" element into its "daughter" element. A well-known example is uranium (the parent element) which decays into lead (the daughter element). By measuring the quantity of parent element and comparing it to the daughter element, the age of the lava rock can be estimated. But radioactive decay exists in the liquid magma, where gravity exerts a differential separation between parents and daughters according to their density. When the magma erupts onto the Earth's surface, it solidifies into rock. A sample taken from this rock could therefore include unrelated parents and daughters. Moreover, the respective quantity of daughter decay elements produced in the magma cannot be distinguished from those produced in the rock. As a result, the age of the rock cannot be determined confidently. This is why a revision of time based on duration of sedimentation is necessary.

A process to determine sedimentation duration is as follows:

The “Lischtvan-Lebediev” (1959) table gives the critical velocity of current below which particles fall according to their size and the depth of water. Thus, it is possible, from the sizes of particles in a sedimentary rock formation, to determine the velocities of the paleocurrents. These velocities, integrated into the formula of sedimentary mechanics, give the sedimentary transport capacity by units of time and volume. Dividing the volume of the formation under study by this capacity, the time of sedimentation of the formation can be obtained by Einstein method. In particular, (Berthault, Lalomov, Tugarova, 2011) showed that Cambrian and Ordovician sandstone in the St. Petersburg region represents less than 0.05% of the time attributed to it by the stratigraphic time scale.

This result does not take into account the velocity of the erosive currents which created such rocks as conglomerates. Experiments on sedimentary slabs (sandstone, shale, limestone) were performed at the Saint Petersburg Institute of Hydrology (Berthault et al., 2010). For consolidated rocks, the erosion started when the velocity of current reached 27 m/s.

Importantly, Marchal (1996) has demonstrated that mountain orogenesis provoked a shift of the axis of rotation of the Earth triggering large marine series. It is significant that, in the geological column since the Cambrian period, eighteen marine series, or systems, are interbedded between nineteen orogeneses, which occurred in different places around the Earth.

As reported in the Bulletin of the Museum of Natural History of Paris (1996-1997), the North Pole in the Eocene, before the Himalayan orogenesis, was off the mouth of the river Yenisei in Siberia, by 72 degrees latitude (Marchal, 1996). After the orogenesis, it was near to its present position resulting in an eighteen-degree polar shift.

The direction of transgressions and regressions following each orogenesis corresponds to the succession of resulting sequential facies, such as sandstone, shale and limestone as seen from the surface of the deposit. An example was given in Berthault (2004). The Tonto group is assigned to Cambrian. It proceeded from the Cadomian orogenesis, at the beginning of the Cambrian, and resulted from a transgression going from the Pacific Ocean in the west to New Mexico in the east. Other directions can be determined from another orogenesis that occurred elsewhere around the Earth.

Contemporaneous marine fauna vary according to the depth, latitude, and longitude and such ecological diversification exists in the geological column. The apparent change of fossilized marine organisms from one series to another following an orogenesis can result from different fauna, transported by water flows from different locations resulting from successive orogeneses. What has been attributed to biological change could be ecological in nature explained by fauna coming from different orogeneses, taking into account the short time of sedimentation.

In conclusion, a relationship can be established between cause and effect. Orogenesis, which can result from periodic mantle plumes (Rampino, Prokoph, 2013), causes shifting of the polar axes, which then leads to consecutive marine series and sedimentary deposits. The duration of the latter is much shorter than given by the stratigraphic time scale and so calls for a serious revision of the foundation of historical geology (Berthault, 2012).

More details and main references can be observed at www.sedimentology.fr

New data on the age of zircons from the Permian of the North-East Asia (preliminary results)

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In recent years, the various methods of U-Pb dating of zircons from sedimentary strata all over the world are actively developed. Unfortunately, in Russia these methods are not commonly used due to the high cost and nearly complete lack of appropriate tools. Permian rocks of Northeast Asia in this regard are no exception. The traditional methods of correlation of the Permian from Northeast Asia with other regions, including Tethys, are not applicable because of lack of major fossils fusulinids and conodonts in the region. Here we are reporting first results of the zircon U-Pb geochronology from the region. Both *in situ* and detrital zircons were analyzed. The first one provides precise geochronologic calibration of the successions, whereas the second group provides provenance data. Very few results were known before our study: 3 samples from middle Permian diamictites of the Atkan Formation (Biakov et al., 2010) and one from Balygychan Formation (Khardikov, unpublished data).

The results were obtained during the past two years of Russian-USA scientific project (leaders from the Russian side – A.S. Biakov, and from American – by V.I. Davydov, and J. Isbell) and include 15 zircon-bearing samples (volcanic ashes, mixed volcanic-volcaniclastic and siliciclastic-volcaniclastic rocks) within the entire Permian from different tectonic units in the North-East of Russia: four samples from the Omolon Massif, five samples from the Ayan-Yuryakh anticlinorium, and five samples from north-east rim of the Okhotsk Massif.

Samples were processed and studied with LA-ICP-MS at the Universities of Boise and Stanford, Santa Cruz. The analyses revile the presence in the samples zircons the age of which are synchronous to sedimentation. The number of these zircons varies greatly from samples to sample with single grains in the Omolon Massif to several dozens in north-east rim of the Okhotsk Massif and the Ayan-Yuryakh anticlinorium. In the latter region we found the richest zircon-bearing rocks, including typical acidic ash beds. One sample from the ash in the middle Atkan Formation of the Matrosov Mine has been dated with ID-TIMS as middle Capitanian 262.1±0.5 Ma.

The presence of a large population of Precambrian zircon of age of 1.6–1.8 billion years is revealed in all studied samples. Middle Paleozoic population of zircons 360–420 Ma in age is very characteristic in the Omolon basin. Among the studied samples of the Ayan-Yuryakh and Okhotsk basins, the Middle Paleozoic zircons were found only in one sample. The third significant population of zircons is that the age of which is close to the age of sedimentation (Permian).

The sources of all discovered zircons are of great interest. The Precambrian and middle Paleozoic zircons in the Omolon Massif most probably came from the local sources and acidic magmatic rocks of this age (Kedon Series) is widely distributed in the region. The Precambrian and middle Paleozoic zircons in the Okhotsk Massif and Ayan-Yuryakh anticlinorium are also from local erosion as acidic volcanic rocks of these ages are known in the central part of the Okhotsk Massif. The most intriguing problem is the occurrence of the Permian zircons, as no volcanic rocks, except small locality of lower Permian acidic effusives in the Okhotsk Massif (Umitbaev, 1963), are reported in all regions under discussion. It is most likely that the source of the Permian zircons was the Okhotsk-Taigonos volcanic arc, the existence of which was confirmed lately (Biakov et al., 2010, 2011; Isbell et al., 2013).

Zircons from two samples collected from micro-diamictites in the middle Pionerskii Formation, at the Krasivyi Creek and middle Omchak Formation in the right bank of Tenke River in the Ayan-Yuryakh anticlinorium were also analyzed with SHRIMP-II at VSEGEI, St. Petersburg. In the former sample only PCm–lower Guadalupian zircons were found. In the latter sample, four zircons were PCm–lower Permian in age and seven grains were dated as 257.1±3.0 Ma that is lower Wuchiapingian of International Time Scale. This is well confined with the stratigraphic position of this sample in the lower Khivachian Horizon in the Regional Scale.

This work supported by RFBR projects 14-05-00217 and FEB RAS, project 12-III-A-08-189 for ASB and partially supported by NSF grants EAR-1124488 and EAR-0746107 for VID.

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Biostratigraphy of the terminal Permian (pre-Otoceras part) of the South Verkhoyansk Region (Northeast Asia)

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The South Verkhoyansk is the unique region in the eastern part of the Boreal biogeographical Superrealm where known the Otoceras beds. Until recently, it was believed that these layers mark the base of the Triassic. Here, on the Setorym River (tributary of the East Khandyga River) the best sections of the basal horizons of the Lower Triassic are located. Biostratigraphy of the Otoceras beds more than once and quite studied by several researchers (Zakharov, 1971; 2002; Dagis et al., 1986; Dagys, Ermakova, 1996; and others). However, the structure of the underlying Permian sediments, their biostratigraphic characteristics and nature of the contact between the Permian and Triassic rocks is almost were not studied.

The upper part of the known Permian sediments is presented here by sandstones and siltstones of the Imtachan Fm containing bivalves (mainly *Inoceramus*-like) and gastropods. In the summer of 2002 and 2003 we have studied PT boundary in the right bank of the Setorym River (the Suol Creek). These works have allowed to greatly clarify the structure of the upper part of the Imtachan Fm and the lower part of the Nekuchan Fm (Otoceras beds), to make a detailed description of their contact, find new Permian fossils and for the first time faunistically prove the presence here the uppermost layers of the Permian, corresponding to the Upper Wuchiapingian – Chanhsingian.

The lower part of examined sediments (members 1–4), where *Maitaia* cf. *tenkensis* Biakov have found, attributed to the lower half of the Khal`pirki regional stage of the Verkhoyansk region. Starting with member 5 rocks contain bivalves, represented mainly by *Inoceramus*-like bivalve of genus *Intomodesma*, characterizing the upper half of the Khal`pirki regional stage (Biakov, 2013). This regional stage is correlated with the Uppermost Permian (Kutygin et al., 2003). Hence identified: *Phestia* ex gr. *magna* (Popow), *Intomodesma* ex gr. *costatum* Popow, *I.* cf. *costatum* Popow, *I.* cf. *evenicum* Kusnezov, *Pachymyonia bicarinata* (Astafieva-Urbajtis), *Myonia gibbosa* (Maslennikow), *Cunavella etheridgeiformis* Astafieva-Urbajtis et al.

If we compare the bivalve complex from the Imtachan Fm with other relatively shallow complexes of terminal Permian from the Verkhoyansk-Okhotsk region, first of all with the complexes from the Khal`pirki Fm of the West Verkhoyansk (Kutygin et al., 2003) and Kulu Fm of the northeastern framing of the Okhotsk massif (Biakov, 2007), it may be noted their rather large affinity. The presence of such common bivalve species as *Intomodesma* ex gr. *costatum* Popow, *I.* cf. *evenicum* Kusnezov, *Pachymyonia bicarinata* (Astafieva-Urbajtis), *Myonia gibbosa* (Maslennikow), *Cunavella etheridgeiformis* Astafieva-Urbajtis leaves no doubt that the upper parts of the Imtachan, Khal`pirki, and Kulu Fm have the same age.

Stratigraphic distribution of intomodesms quite well agrees with the biostratigraphic materials from other Permian sections of the North-East Asia, and generally confirms the previously established the possibility of a more detailed subdivision the Costatum zone on the basis of phylogenetic trend in the four subzones: *Maitaia hurenensis*→ *Intomodesma costatum* → *Intomodesma evenicum* (Biakov, 2007). The interval devoid of *Intomodesma evenicum* and indexed as the *Intomodesma postevenicum* subzone stands out in the studied section directly above the *Evenicum* subzone, as well as in the sections on the Titan Creek, northeastern framing of the Okhotsk massif (Biakov, 2007). This interval can be compared with the upper part of the Pautovaya river section on the Balygychan block, where Late Changhsingian *Claraioides* aff. *primitivus* (Yin) was found together with the latest intomodesms (Biakov, 2001).

Correlation of the upper part of Permian section with the upper part of the Changhsingian is confirmed by recent studies of δ13 C_{org} of mudstone from the Imtachan and Nekuchan Fm (Zakharov et al., 2014). Top of the Imtachan Fm are characterized by high values of δ13 C_{org} (up to –26.3 ‰), characteristic for the uppermost Permian of different sections of the world (Wignall et al., 1998; Stemmerik et al., 2001; Grasby, Beauchamp, 2008; Hermann, et al., 2010), followed by a rapid decline of these values to –27.9 ‰ at the base of the Nekuchan Fm and well expressed negative excursion (up to –30.3 ‰) 6.3 m above the base of the Nekuchan Fm, just above where the alleged PTB passes. Rather high values of δ13 C_{carb} from kolymiid shells (up to + 4,8 ‰) with a characteristic negative trend at the top of the Imtachan Fm are agree with this.

Thus, for the first time the completeness of Permian deposits and the presence of the uppermost part of the Permian corresponding to the Changhsingian is substantiated on the basis of new findings of bivalves and with the study of the isotopic composition of C_{org}.

This work supported by RFBR projects 14-05-00217 and FEB RAS, project 12-III-A-08-189.

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The character of changes in aquatic tetrapod communities of the East Europe in the Late Urzhumian – Early Severodvinian time

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The Middle Permian event affected the continental vertebrate communities all around the world. In the East Europe it was happened at the end of Urzhumian, in the Middle-Upper Permian transitional time. During the crisis, the dinocephalian groups, both carnivorous and herbivorous, were removed out from dominate positions in the terrestrial ecosystems by similarly specialized theriodonts. The significant changes also were fixed in the aquatic community. The degree of renovation, according to data were available, has a catastrophic character. Indeed, the last dinocephalian and first theriodontian faunas (Isheevo and Kotel'nich Assemblages respectively) had no common families of tetrapods for a long time. It must be noted, that both assemblages were separated by vast stratigraphic gap poorly characterized by any tetrapod localities.

The newly discovered Sundyr' Assemblage of tetrapods (Golubev, Sennikov, 2011) prolongated the dinocephalian stage in the East Europe up to beginning of Late Severodvinian and showed the cascade character of crisis processes: the structure of the "dominant" and "subdominant" communities of Sundyr' fauna is mostly composed by dinocephalians, as the aquatic community is quite similar to that of theriodontian associations.

The most intriguing modification happened in the continental basins was an enigmatic disappearance of crocodile-like archegosauroid temnospondyls (Melosauridae, Archegosauridae), which previously occupied the ecological niche of specialized fish-eaters, and latest invasion of secondary aquatic, armored chroniosuchids (Anthracosauromorpha) instead them. In addition, the list of the amphibians of Sundyr' includes the brachyopid genus *Dvinosaurus*, the kotlassiid seymouriamorphs (Leptorophinae), and aberrant anthracosauromorphs of Enosuchidae family. The latter two, firstly discovered in Severodvinian, were inherited from older assemblages, whereas the *Dvinosaurus* is the typical genus post-Sundyr' amphibian associations.

In Sundyr' Assemblage, the rearrangement of the aquatic community seems to be nearly finished. However, the scenario of this renovation saves many uncertain circumstances due to the absence of data on amphibian distributions in the Lower Severodvinian beds. The gap in our knowledge began to fill due to some newly discovered localities placed within discussed interval. Firstly, in the Vozdvizhenka-B locality (Orenburg Region), the genus *Karpinskiosaurus* (Karpinskiosauridae, Seymouriamorpha), which have been previously recorded exclusively in Severodvinian Stage, was firstly established in Urzhumian beds alongside dinocephalians and temnospondyls like *Ugosuchus* (Bulanov, 2005).

The three important tetrapod localities were discovered in 2007 at the stratotype section of Middle-Upper Permian boundary located in Monastery Ravine in Tatarstan. The oldest of them, Monastery Ravine-D locality, belongs to the Upper Urzhumian part and contains the rich complex of amphibians, including karpinskiosaurids (*Karpinskiosaurus*), kotlassiids (*Leptoropha*), archegosauroid temnospondyls, and indeterminate anthracosauromorphs, which, unfortunately, are fragmental in the collected material. To the contrary, both *Karpinskiosaurus* and *Leptoropha* are presented in oryctocoenosis by numerous skulls and skeletons of juveniles that provide an actual data concerning the larval and early juvenile ontogenetic stages of these genera for the first time. The genus *Microphon* (*Microphon* cf. *exiguus*), earlier known from Iluinskoe and latest assemblages was firstly determined in the Lower Severodvinian Substage (Monastery Ravine -F locality).

The localities of the Monastery Ravine geological sections provide no data on the existence of the archegosauroids above the Middle-Upper Permian boundary. It is possible that such data may be obtained in perspective after preparing of the tetrapod collection from Povoyska locality (Vyatka Basin) which is located just above the Urzhumian-Severodvinian boundary. This collection includes in particular the separate bones of large amphibians covered with cellular surface ornamentation which is not typical of any brachyopids, but similar to that of archegosauroid amphibians. Additionally, the skulls and skeletons of juvenile temnospondyls and, presumably, seymouriamorphs were collected in Povoyska by author in 2013-2014. These specimens open an additional opportunities for the study of the Early Severodvinian tetrapod communities and the ontogeny of the amphibian species in particular.

In conclusion, it can be noted, that new data support the gradual evolution of aquatic assemblage of tetrapods in the Late Urzhumian-Early Severodvinian time. Most of the typical Late-Severodvinian amphibian families, such as Karpinskiosauridae, Kotlassiidae, and Dvinosauridae were members of dinocephalian assemblages as well, and some of them were traceable as early as Upper Urzhumian. The disappearance of archegosauroids is the main change of renovation observed, but this event, seems, does not correspond to approved boundary of Middle-Upper Permian in the East Europe.

This work is supported by the Russian Government Program of Competitive Growth of Kazan Federal University and the Russian Foundation for Basic Research, projects nos. 14-04-00115, 14-04-01128, and 14-04-00185.

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The new locality of the Late Urzhumian vertebrate fauna in Kazan Region (East European Platform, Russia)

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The new locality of vertebrate fauna was found during summer 2014 field work at the territory of Kazan Region on the right bank of the Volga River, near Pechishchi settlement. It is situated 1 km southward from the head of Cheremushka Ravine where the reference section of the Urzhumian Stage (Wordian) of the Middle Volga had been traditionally described since the beginning of XX century (Gusev, 1996; Silantiev et al., 2007). New locality is confined to the lithological «Crimson Clay Member" corresponding to the Late Urzhumian age.

The «Crimson Clay Member" in the reference section of the Cheremushka Ravine is represented by alternation of bacterial-algal limestones and bright speckled clays predominantly of soil origin. The limestones are usually permeated by the systems of root cavities produced by higher terrestrial plants.

The succession of the «Crimson Clay Member" in the new vertebrate locality, has more alluvial and lacustrine character. The intervals with palaeosoils are not clearly defined. The thin bed (0,3 m) of dark grey (coal-like) lacustrine clays exposed at the top of the succession clearly differs this section from the reference one. The accumulation of vertebrate fossil remains is located within this clay bed as well as in the thin (0,15 m) underlying band of greenish-grey sandstone that forms the "main bone bed".

The new locality has great importance due to its Late Urzhumian age because this stratigraphic interval has been poorly characterized by tetrapods for a long time.

During last years, the main author of this report discovered several tetrapod localities coincided with the transitional interval of Middle and Upper Permian on the territory of the East-European Platform. Most of those localities, e.g. at the Monastery and Cheremushka ravines (Volga Basin), Povoyska (Vyatka Basin) etc., predominantly contain the various lineages of juvenile amphibians, such as seymouriamorphs, anthracosauromorphs and temnospondyls. All these localities are confined to the carbonate and clay facies and could be attributed to subautochthonous type due to the preservation of slightly deformed skulls and skeletons of amphibian juveniles. At the same time, the bones of adult animals are rare or absent, and the percentage of reptilian taxa is minimal.

The new locality has probably the alluvial genesis. The bones of adult temnospondyls are clearly predominate but seymouriamorph and anthracoauromorph amphibians were not been found yet, at least during the first excavation. Both carnivorous and herbivorous reptiles of different size compose the essential part of collected material.

The numerous isolated remains of actinopterygian and chondrichthyan fishes are concentrated in the thin layer of sandstone closer to the base of "amphibian" productive horizon. The chondrichthyan remains include the teeth of such taxa as a new sphenacanthid shark earlier defined as *Xenosynechodus egloni* Glikman (Minikh, Minikh, 1996), "*Lissodus*" cf. *zideki* (Johnson), "*Polyacrodus*" sp., and a new shark - ancestor of Carcharhiniformes.

Some teeth of chondrichthyans possess the traces of abrasion but a few ones are well preserved. Moreover, most of bones including the actinopterygian scales, bear the clear traces of destruction that have preceded the burial, indicating the high energy of the water in the basin of sedimentation.

All bones were found in the disarticulation, so new locality could be attributed to allochthonous type. The lithological data also confirm the alluvial genesis of the "productive" sandstone.

The black clays overlain the main bone bed of sandstone also contain bones of amphibians included into the flat dark-beige nodules sometimes occurring in the form of aggregations. Nodules represent either coprolites saturated by bones, either skeletons of tetrapods buried in situ. So, the black clays provide an additional perspective for the next excavations.

New locality of vertebrate fauna founded in «Crimson Clay Member" expands the data of different terrestrial vertebrate communities at the turn of the Middle and Upper Permian. It also allows tracing 'step by step" the lithological, taphonomic and taxonomical differences of localities formed in diverse environments (e.g. lacustrine, alluvial etc.). Future studies will enable to use the data from this locality for detailing the biostratigraphic zonal scale of the Middle and Late Permian based on tetrapods.

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, 14-05-93964 and 14-04-01507.

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Periodicity of climate change, epeirogenic movements and the mathematical model of the geological N.A.Golovkinsky lentils

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Periodicity of climate change in the Earth's geological history has left its traces in alternating layers. General pattern is as follows: small rhythms combined to form larger, and they in turn are subject to cycles of higher order. Geology accumulates a lot of evidence of long-term cyclic climate. They are most clearly identified with the study of ancient glacial formations. In a classic Archean phyllite outcrop in Finland studied a series of shales were deposited over 40,000 years. Against the background of the three-year cycles is clearly apparent periodicity, repeated after 10–11 years. Studies show that runs through the entire Phanerozoic such change cycles, and the equally constant eleven-year climate variability. Diagrams layering Quaternary deposits with the final fullness emphasize this pattern. Characterized by periods of 3 ; 11 and 25–35 years. Distinct natural cycles appear, for example, the duration of the rhythms of 2,160 years, which corresponds to a complete revolution of the Earth's axis cone (precession). Undeniable influence on the rhythms of the layers also provides a variety of lunar, solar and planetary cycles.

First-order cycles composed of alternating winter and summer periods of sediment accumulation. As we know they are associated with the motion of the Earth around the Sun and the tilt of Earth's axis are explained with respect to the orbital plane. Cycles following the order must be associated with the precession of the Earth's axis. The cycles of higher order linked to solar activity. As figuratively Chizhevsky, we see in these periodic phenomena "earthly echo of solar storms ." The best known and studied is the 11 year solar cycle, the open G. Schwabe and confirmed R.Volf treatment observation for two and a half centuries. The resulting changes in activity of the sun have a period equal to an average of 11,1 years. It also assumes the existence of 22; 44 and 55 year solar cycles. The value of the maximum of these cycles varies with a period of about 80 years. It is easy to notice that the periodicity of solar activity is much the same with the above mentioned cycles of sedimentation. There is the synchronicity of Earth planetary motions with the periods of solar activity, which enhances the effects of cyclic layering. We note further that the circular planetary motions unfold along the time axis t in the form of a sine wave.

Recurrent epeirogenic (smooth vertical) movement of the earth 's crust, causing transgression and regression of the sea, are also associated with near-Earth space, most likely with the movement of the Moon in Earth orbit. Moon initiates its attraction epeirogenic movement, just as it does when coastal tides, but in the longer time frames. Unlike the mobile water in the hard crust sequences for accumulation of potential energy requires a certain time. After that will come the full moon becomes a trigger for its next activation. Such a working hypothesis can submit epeirogenic movement in the form of a sine curve.

The above prerequisites relationship cyclic phenomena with the laws of cosmic cycles allowed me summing sinusoidal influence of Earth's orbital motion for layering with a sine curve epeirogenic crustal movements during transgressions - regressions for an integrated curve, which is a graphical representation of a chain of equal lenses (lentils).

In epistemology similarity and analogy are considered one of the most effective techniques for extracting mathematically established patterns. We note that the initial assumptions in the derivation of the generalized Geological lentils N.A.Golovkinsky were phenomena of transgression - regression of the sea in the background epeirogenic movements (sine ② and regular climate (weather) change (sinusoida ① affecting the mode of accumulation of coastal sediments (in general, the periods of these sine waves are not the same, making the result of the addition are obtained beats form resembling lentils ③. Reported N.A.Golovkinsky' factors were taken as the base for the derivation of "mathematical formula of the Law of slips facies", which is in general shown on Fig. 1. Match forms of mathematical mapping idealized model of rhythmic sedimentation with the idealized form of the Geological Survey of lentils, in my opinion, can not be considered accidental. This general (non parametric) mathematical model can be detailed with the additional factors, such as described above, during sequence analysis of the real geological N.A.Golovkinsky lentils.

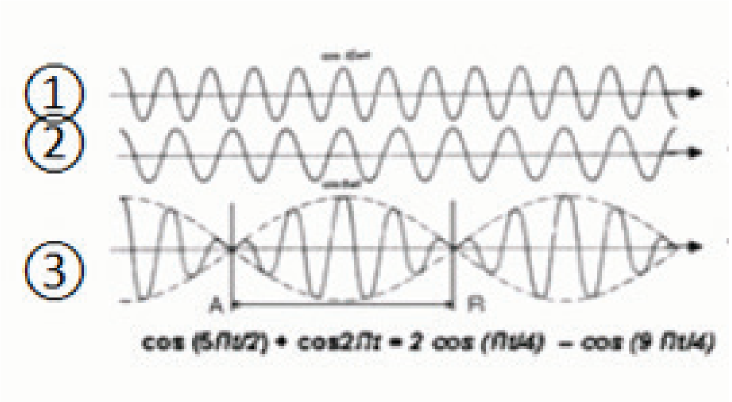

Fig. 1. The sum of two sine waves with different periods. The resulting function is composed of «lentils». AB – sequence boundaries

With the emergence of astrostratigrafy, it is possible to mathematically linking cosmic phenomena with sedimentation, to clarify the stratigraphic scale, global tectonics, and make a significant contribution to the search for hydrocarbon deposits by further developing sequence analysis.

The method of empirical generalizations and the Law of slip facies

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Methodological ideas represent desired item of science. Scientists bringing in basic science theories and laws, due to the specifics of his work pay special attention to the methodology. In the well-known work, together with a description of the Permian geological formation in the Kama- Volga basin, N. A. Golovkinsky deduces the law slip facies. Citing examples of different variations of the cuts, he also stops and methodological issues. When comparing the scientific worldview of N. A. Golovkinsky and V. I. Vernadsky, their community is set clear. This is especially evident when considering texts of Golovkinsky, first introduced in the scientific revolution. Of the draft letter to N.A.Golovkinsky, V.I. Vernadsky wrote: "I sincerely sympathize with your passion for the issue of polymorphism. From ancient times, keep the belief that it is not only important, but the only question crystallography. Everything else in the crystal – there is only the logical consequences of the side of the same essence. Let all complex substances represent different sides or form something one single, but that side is most visible and definite. Many times I have recalled our conversation on Castelli evening tea at the Ivy Wall ". Although here we are talking about the need to establish a common basis for the withdrawal of all possible structures of crystals (this is done, only in our time), but from the standpoint of epistemology, this argument on the basis of a single (single law) is a reflection of the methodological approach to the development of the laws of the biosphere (living matter) Vernadsky geological and lentils (slip facies) Golovkinsky. Vernadsky has repeatedly referred to his method of scientific analysis of factual material empirical generalization. The upper limit of such a generalization he thought the table and Mendeleev's periodic law. In modern parlance, it is a method of derivation of the generalized model of the law (Fig. 1) and focuses on the logic of science in general. This commitment to the wider scientific scope (how often expressed Vernadsky) in studies of the realities of the world is common to all the great scientists and, in particular, for Vernadsky, and for Golovkinsky. Both were not limited to highly specialized scientific field. The works of Vernadsky on space and time are well known. A lot of thinking about these problems and Golovkinsky – namely as a naturalist as opposed to mathematics. "In an abstract sense, a mathematician – he wrote – has reason to say, as a circle relates to the ball, so the ball belongs to the "ball&ball" (four-dimensional analogue of a sphere), "ball&ball" to its five-dimensional analogue, and so on. As well as create special geometry and all four of the number of measurements, but it is wrong to forget that this process of creation is only a contingent property of thinking which has no objective meaning." Einstein's General Relativity is based on the curvature of space-time and adopted a priori position that the material body can not move at a speed greater than the speed of light. In recent years, such rates are set by experience that, in my opinion, makes the General Relativity in a convenient model for the theoretical (mathematical) builds that do not have a full (absolute) analogies in the real world. In this sense, the position expressed Golovkinsky, sound quite modern. It is appropriate to recall that Vernadsky, referring to the general theory of relativity, in a letter to Fersman wrote that math here "philosophized". And Einstein himself stated that after his general theory of relativity took mathematics, he had ceased to understand his theory.

Vernadsky wrote: "The logic of natural science should primarily be taught how to build - to describe the concept – a natural body or a natural phenomenon ... it always takes into account the Naturalist – he keeps coming back to direct the real object or phenomenon – making scientific experience or repeated observation of the object corresponding to the concept." Golovkinsky independently come to the same conclusion. He recommends creating a geologist [working] hypothesis on the origin of precipitation and constantly refine it by a more detailed repeated observations.

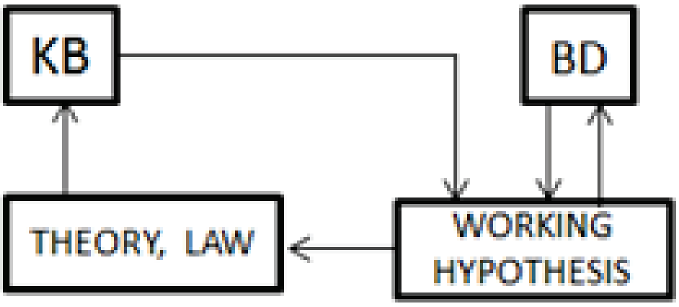

Fig. 1. Block diagram of the method of empirical generalizations. KB – knowledge base; BD – the

The Law of slip facies is a prime example of empirical generalization. Moreover, the author applied this method too creatively, which is characteristic of the true discoverers. In contrast to the Mendeleyev, who from the moment of conception in his table saw to its priority discoverer N.A.Golovkinsky did not. Apparently, therefore, to the present time, there is clearly a misconception according to which *an affirmative* (Mendeleev's term) of The Law of slip facies - I.Valter - and even his critics – A. A. Inostrantsev – were due to a misunderstanding among the sponsors of N.A.Golovkinsky. Comparison of Mendeleev's discovery and N.A.Golovkinsky is significant. Both laws are set at the same time, in 1898. Claims for pioneering to both authors were from the German scientists, as at that time to reach the German science, especially philosophy, in contrast to the Russian were recognized. Both laws are of global importance. What authors have pointed out quite clearly in their description? Confirmation law of Mendeleev physicists realized half a century later. Confirmation law of Golovkinsky geophysicists, applying sequence analysis occurred in our time, i.e. more than a century. Characteristically, the sequence analysis confirmed the slip time (paleontological) lithological boundaries regarding what "collaborators" at the time not even able to understand. Therefore, A.Valter supposedly clarifying the law, replaced in his formulation of the right word "slip" on inaccurate "correlation".

But even less hope in this regard [to understanding the essence] can impose on assumptions so dark that only because of this darkness invisible at first sight filling their inconsistencies."Summed up Golovkinsky incorrect understanding of the "fourth dimension". Perhaps it is better not tell about this case.

In the currently existing provisions on the recognition of the authorship on the opening states that can be considered a co-author of the man who at the time of the opening of the development has made it a significant creative contribution. Neither A. A. Inostrantsev (in 1872, i.e., 9 years later) or I. Walter (1894, i.e. 25 years later A.N.Golovkinsky) no real creative input is not made. On this basis, it should be considered that the including them to the co-authorship (common authorship) of the Law of slip facies is a historic mistake. Thus, this Law should continue to be only one name –- its real discoverer N.A.Golovkinsky.

It is my pleasant duty to thank Pavel K. Tygliyants-Golovkinsky as the active guardian of memory and scientific heritage of his great ancestor, for giving me the first time and materials posted here, as well as an invitation to participate in the correspondence of this conference.

Lithochemical features of the Lower Kazanian deposits within south-eastern Tatarstan

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Литохимические особенности нижнеказанских отложений юго-восточной части Татарстана

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Авторами изучены нижнеказанские отложения, вскрывающиеся в Каркалинском карьере, расположенном в Лениногорском районе Республики Татарстан. В 2013 г. В.В.Силантьев и Э.И.Фахрутдинов переописали разрез и произвели послойный отбор проб. Все пробы подверглись рентгенофлюоресцентному анализу, на основе которого был построен литолого-геохимический разрез с кривыми вариаций литохимических модулей. В разрезе Каркалинского карьера выделяются все три горизонта нижнеказанского подъяруса: байтуганский, камышлинский и барбашинский (красноярский).

Гидрохимический состав бассейна седиментации влияет на химический состав горных пород, и поэтому вариации литохимических параметров по разрезу можно использовать для выделения генетически обусловленных седиментологических границ (Скляров, 2001). Изученный разрез представлен ритмичным переслаиванием карбонатных и терригенных пород. Для карбонатных пород наиболее информативным является модуль CaO, MgO, Mn; для терригенных отложений наиболее информативным является титановый модуль (ТМ), включающий SiO_2, P_2O_5, Fe_2O_3, Al_2O_3, TiO_2 (Скляров, 2001; Юдович и др., 2000).

Графики вариаций модулей можно использовать для подтверждения границ горизонтов нижнеказанского подъяруса, выделенных по данным литологического описания. Наиболее отчетливо эти границы отбиваются по вариациям значений TiO_2, ТМ, Fe_2O_3, Al_2O_3; менее отчетливо это наблюдается на остальных кривых (SiO_2, P_2O_5, CaO, MgO, Mn).

Для реконструкции обстановки осадконакопления был использован модуль Fe/Mn, который является универсальным как для терригенных, так и для карбонатных отложений (Скляров, 2001). Для морских глубоководных отложений этот модуль имеет значения ≤ 40, для прибрежно-морских от 40 до 80, а для континентальных отложений от 80 до 160 и выше. Значения модуля Fe/Mn в разрезе Каркалинского карьера варьирует от 20 до 300, что позволяет сделать вывод о том, что в раннеказанское время осадконакопление на данной территории происходило в прибрежно-морских условиях, при периодическом повышении уровня моря.

Для анализа колебаний уровня моря были использованы значения CaO и SiO_2, являющихся индикаторами трансгрессий и регрессий (Габдуллин и др., 2008).

Ниже приведены основные результаты исследования.

Байтуганский горизонт. Нижняя граница горизонта выделена по подошве пачки лингуловых глин, согласно залегающей на кровле бугульминской толщи уфимского яруса; верхняя – проведена в кровле «колючего известняка». Разрез горизонта представлен толщей глинисто-карбонатных пород, включающих прослои известняков (до 2 м) и содержащих большое количество остатков морской фауны (фораминиферы, остракоды, брахиоподы, мшанки, моллюски, иглокожие). В породах горизонта зафиксированы повышенные значения SiO_2, минимальные значения CaO; а так же значения модуля Fe/Mn, характерные для прибрежно-морских условий.

Камышлинский и барбашинский (красноярский) горизонты. Подошва камышлинского горизонта выделена в кровле «колючего известняка»; подошва барбашинского (красноярского) горизонта выделена в кровле продуктивного оолитового известняка карьера. Отложения горизонтов представлены чередованием песчано-алевритовых и карбонатных пород, содержащих как морские, так и континентальные фаунистические остатки. Можно сделать предположение, что на протяжении камышлинского и барбашинского времени периодически происходили колебания уровня морского бассейна. Об этом свидетельствует чередование слоев, содержащих остатки морской и континентальной биоты, текстурные признаки (знаки ряби, линзовидная и волнистая слоистость), а также кривые вариаций литохимических модулей CaO, $SiO_{2,}$ Fe/Mn, имеющих более дифференцированную форму кривых и значения модуля Fe/Mn соответствующие морским и прибрежно-морским условиям.

В целом, совместное использование литохимических модулей и литологических данных позволяют более достоверно выделить генетически обусловленные седиментологические границы, а также реконструировать эволюцию бассейна осадконакопления.

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Sedimentology, palaeontology and palaeoclimate of a Middle Permian hinterland playa at the border of the Southern Permian mega-playa system

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The Middle Permian Hornburg Fm of the Hornburger Sattel (Saxony Anhalt, Germany) was deposited in a small playa basin close to the southern border of the mega-playa system of the Southern Permian Basin (GEBHARDT, 2011; GEBHARDT & LÜTZNER, 2012). In contrast to the very sparse fossil content in the SPB, surface outcrops of the Hornburg Fm offer a more diverse fossil content (EHLING & GEBHARDT, 2012). Here we present a comprehensive analysis of the litho- and biofacies pattern of the Hornburg Fm

The Hornburg Fm consists of two fining-up mega-cycles, which contain six different lithofacies types. The lower cycle starts with (1) the Lower Quarzite Conglomerate Mb. followed by (2) the Blankenheim Sandstone Mb. The upper cycle comprises in ascending order (3) the Upper Quarzite Conglomerate Mb., (4) the Round Grained Sandstone Mb., (5) the Fine Grained Sandstone Mb., and (6) the Blätterton Mb. ("Leave clay" – finely laminated).

(1) represents debris flow dominated progradating fan deposits coming from the hinterland and (2) its lateral and vertical equivalents as well as more distal sandy mudflat deposits. (3) constitutes a new progradating fan system, dominated by coarse sheet floods and intercalated bimodal sandstones. In the upper part fine grained filled clastic dykes (meter scale) point to seismic activity. (4) is a partially fluvial reworked saltation transport dominated sandflat deposit. (5) represents a locally restricted primarily aeolian generated but fluvial re-deposited sandstone. It is overlain by (6), fine laminated playa lake mudstones and siltstones. Up to two meter deep desiccation cracks, halite pseudomorphs and residual horizons of evaporites point on mainly dry conditions with high evaporation. Most possibly those deposits were formed under semiarid to arid, maybe monsoonal climate conditions during the Wordian/Capitanian wet phase and the transition into the Capitanian/Wuchiapingian dry phase (SCHNEIDER et al. 2006).

Highly remarkable, the playa lake deposits contain a rich fossil record, which has been excavated during a systematic study of the fossiliferous red beds near the city of Eisleben (Saxony-Anhalt, Germany). Imprints of *Medusina limnica* MÜLLER 1978 (hydromedusa) and traces of microbial mats are most common and indicative for those dry lake and pond deposits. Besides this, conchostracans (*Pseudestheria graciliformis* MARTENS 1983) are rare and restricted to single beds. Up to 21 different species of arthropod tracks have been described by WALTER (1983). Thereof 11 different species were excavated. Tetrapods are represented by six different morphotypes of tracks and swimming trails. The biota is referred to a new ichnofacies similar to *Scoyenia* Ichnofacies, but under much drier climatic conditions and without appearance of *Scoyenia* itself. Palecological interrelationships between the different organisms as well as potential food chains based on microbial mats will be discussed.

Altogether, the deposits of the Hornburg Fm form a complete fan and playa system with its biota which is rarely preserved in the Permian of Europe and requires therefore further investigations.

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Gondwanan nonmarine–marine cross-basin correlations utilizing palaeoclimate signatures recorded in Permian palynomorph assemblages

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Palynological data of Permian formations of the Sub-Saharan Karoo basins play a crucial role in the study and for the understanding of Gondwana's climate history and biodiversity in this time of major global changes in terrestrial and marine ecosystems. The palynological record of coal deposits reflects changes in land plant communities and vegetational patterns related to climate change, thus providing significant data for high-resolution palaeoclimate reconstructions in deep time. Marine black shale deposits contain marine and terrestrial organic particles that allow for nonmarine–marine correlations.

Here, we presented the first results of palynological investigations of Permian successions of South Africa and Mozambique documenting major changes in palaeoclimate. The spore/pollen ratios are used as a proxy for humidity changes. Stratal variations in the composition of the pollen group (monosaccate/bisaccate taeniate/bisaccate non-taeniate pollen grains) indicate warming and cooling phases. Variations in the amount and in the type, size and shape of phytoclasts reflect short-term changes in transport and weathering.

The detected palaeoclimate signals are used for high-resolution correlation on basin-wide, intercontinental and intra-Gondwanic scales. Established palynostratigraphic schemes for coal seam identification and correlation (Falcon et al., 1984a; Witbank Basin) are refined and applied to correlate coal deposits of the NE Main Karoo Basin, South Africa with the Tete Province, Mozambique and with marine black shale deposits of the N and S Karoo Basin (Fig. 1).

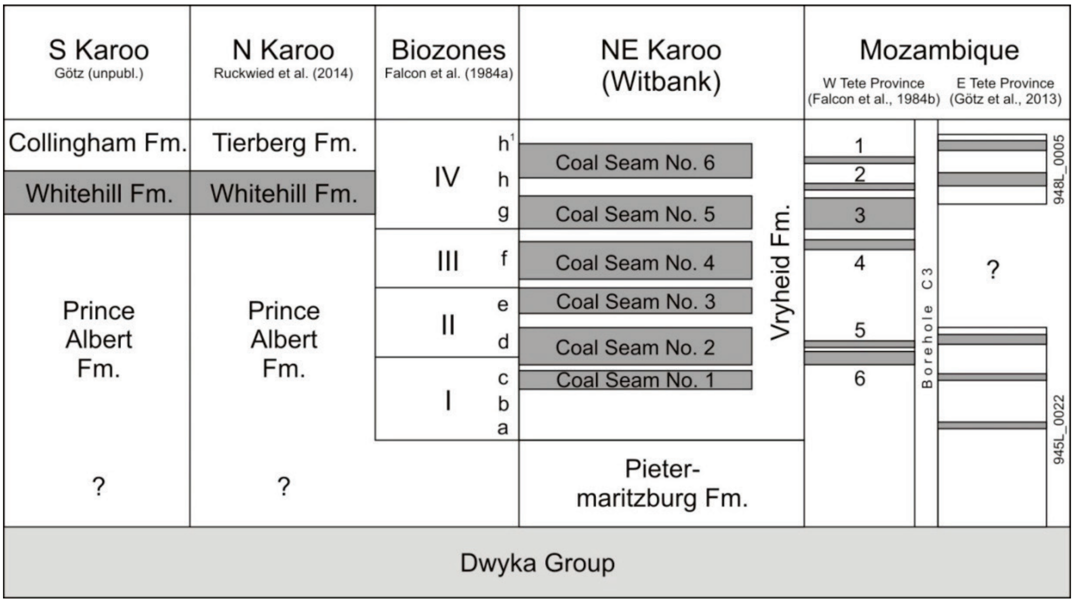

Fig. 1. Correlation of Permian nonmarine successions (coal deposits of the NE Karoo Basin, South Africa and Tete Province, Mozambique) with marine successions (black shale deposits of the N and S Karoo Basin, South Africa) utilizing palaeoclimate signatures recorded in palynomorph assemblages. For the Mozambique material the studied boreholes are indicated (borehole C3, W Tete Province; boreholes 945L_0022 and 948L_0005, E Tete Province, Moatize Basin).

This work is based on the research supported by the National Research Foundation of South Africa (Grant No. 85354), the DST-NRF Centre of Excellence in Palaeosciences, South Africa and the Russian Government Program of Competitive Growth of Kazan Federal University. The Council for Geoscience of South Africa is thanked for permit access to well DP 1/78 material. Exxaro Resources, South Africa is kindly acknowledged for giving permission to sample the No. 2 Coal Seam mined in the Witbank Coalfield and Rio Tinto Coal Mozambique is kindly acknowledged for giving permission to study core material from the E Tete Province (Moatize Basin), Mozambique.

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The Permian sequence of Russian Plate as a global standard of the continental Middle-Upper Permian

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Russian Plate is a type region for the Permian system. One of the largest Permian sedimentary basins in the world is located here. In this region the Permo-Triassic sequence presents stratigraphically continuous succession of continental deposits from the Kungurian of the Lower Permian to Ladinian of the Middle Triassic, an interval of some 40 Ma. The Kungurian-Severodvinian part of this sequence includes marine interbeds. The Middle-Upper Permian beds cover a large part of the Russian Plate (1.7 x 10^6 km^2) and range in thickness from a few meters to 700 m on the Plate, increasing to 1500 m in the Pre-Uralian foredeep and to 3500 m in the Pre-Caspian syneclise. They were formed in different facial zones in conditions of semiarid-subhumid climate. Today these depositions are exposed in many outcrops due to unevenness of the relief (up to 200 m) and economical activity of people.

The great importance of the Permian sequence of Russian Plate for global correlation of the Permian continental deposits follows from paleogeographic position of the basin. In the Permian period East European basin was situated in "central" part of Pangea. It linked Eurameria, Gondwana and Asia. So many significant migration routes of Pangean biota lay across its territory.

Since the 1860s, the Permian system of Eastern Europe is studied by numerous geologists and stratigraphers. The most active researches were conducted in the second half of the 20th century due to the geological mapping. During this time, many new data was obtained through extensive drilling works. The Russian Permo-Triassic continental beds are rich in fossil remains of all significant groups of non-marine organisms (plants, including palinomorphs and charophytes, bivalves, gastropods, ostracodes, conchostracans, insects, fishes, and tetrapods). From the second half of the 19th century to the present day, huge collections of fossils of plants, ostracodes, conchostracans, insects, bivalves, fishes, and tetrapods were amassed by many paleontologists and biostratigraphers. As a result, the Permian geological history of East European sedimentary basin and evolution of its biota were reconstructed in detail. On the basis of this vast geological and paleontological material a detailed magnitistratigraphic scheme and zonal schemes based on palynology, plants, charophytes, ostracodes, conchostracans, bivalves, fishes, and tetrapods were established and continue to be further refined (Fig. 1). These schemes can be used as the basis for global stratigraphic correlation of the continental Permian.

The work was supported by the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

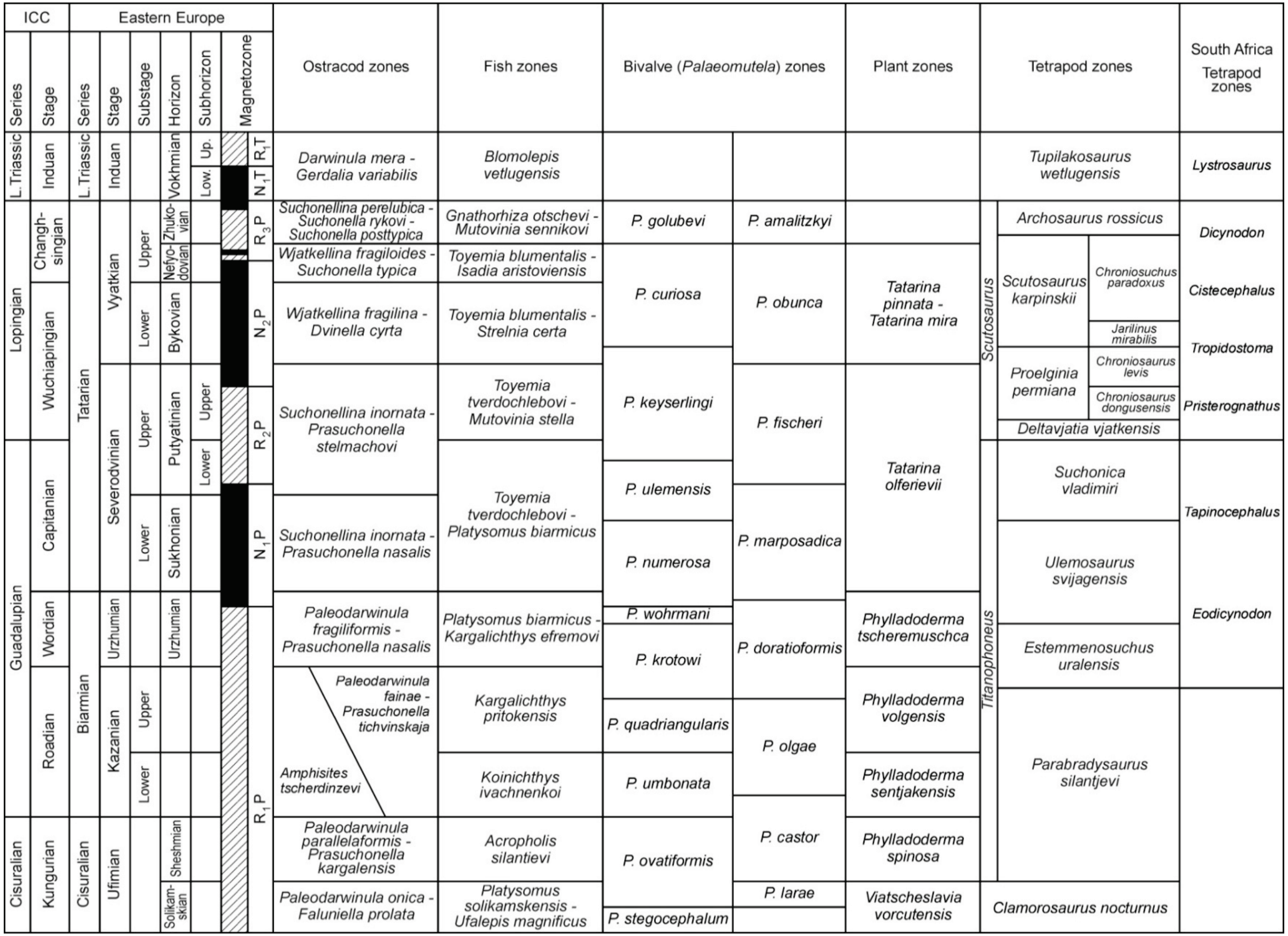

Fig. 1. Stratigraphic scheme of the East European continental Permo-Triassic and its correlation with the International Chronostratigraphic Chart and tetrapod zonal scheme of South Africa.

The Artinskian radiation of chondrichthyan fishes

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The Early Permian chondrichthyans are quite diverse among the Palaeozoic fish fauna. But the highest taxonomical diversity of chondrichthyans observes in the Artinskian time. The chondrichthyan assemblages of such age from the Middle and South Urals are most diverse and demonstrated the large variation of preservation: from numerous isolated teeth, scales and fin spines to well preserved endoskeletons (Fig. 1).

Recently the new findings of chondrichthyan fauna were recorded in some Artinskian localities of Urals, especially near towns of Krasnoufimsk and Krasnousol'sk. Besides, the famous symphysial tooth-whorls of *Helicoprion* and isolated teeth of ctenacanthids, symmoriids and hybodontids, these localities contain the well preserved endoskeletal parts: the fragment of new hybodontoid endoskeleton including part of neurocranium, jaw, gill arch elements, teeth and fin spines; the pectoral fin skeleton of symmoriid *Cobelodus* (Ivanov, 2013), as well as the jaws, pectoral fin skeleton and tooth plates of chochliodontid chondrichthyan (Fig. 1 D, E).

The chondrichthyans from the Artinskian of Middle and South Urals include elasmobranch and euchondrocephalian taxa (Ivanov, 1999, 2005, 2007; Kozlov, 2000). The elasmobranches are represented by various symmoriiforms *Cobelodus obliquus* Ivanov, *Cobelodus* sp., *Denaea* cf. *wangi* Wang, Jin & Wang, *Stethacanthulus decorus* (Ivanov), *Stethacanthus altonensis* (St. John & Worthen); ctenacanthiforms *Glikmanius occidentalis* (Leidy), *Heslerodus* sp., *Saivodus* sp.; jalodontid *Adamantina foliacea* Ivanov; a new sphenacanthid; hydodontiforms, lonchidiid "*Lissodus*" and polyacrodontid "*Polyacrodus*" sp.; and neoselachians: synechodontiform *Synechodus antiquus* Ivanov, anachronistids *Cooleyella fordi* (Duffin & Ward) and *C. amazonensis* Duffin, Richter & Neis. The euchondrocephalians comprise petalodontiforms *Tanaodus* sp. and *Permopetalodus frederixi* Kozlov; various eugeneodontiforms *Helicoprion bessonovi* Karpinsky, *Parahelicoprion clerci* (Karpinsky), *Campodus krasnopolskyi* Kozlov, *Campodus* sp., *Uralodus zangerli* Kozlov; orodontiform *Orodus* sp.; helodontids, as well as *Psephodus* sp. and cochliodontids.

The part of taxa of such Artinskian assemblage was distributed in the Carboniferous and persisted into the Early Permian. But some chondrichthyans such as oldest synechodontiform, most of eugeneodontiforms are characteristic of only that interval. The taxonomic diversity of chondrichthyans are increased in the Middle Permian, some groups occur rarely or disappeared. Most of symmoriids and ctenacanthids disappeared at the beginning of the Late Permian. A few taxa of that assemblage evolved until the end of the Late Permian.

The study was supported by RFBR, research project No. 14-04-01507a.

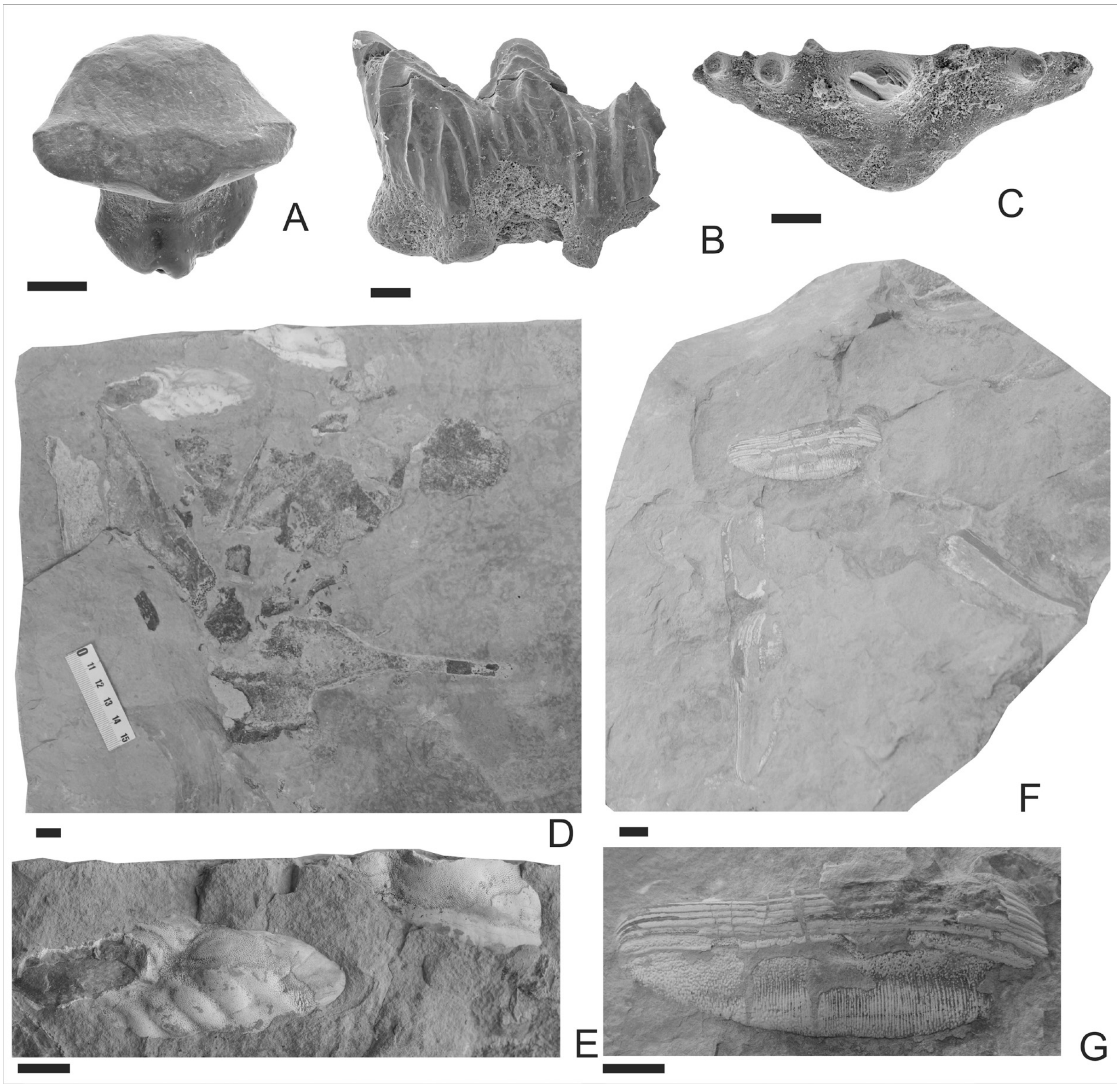

Fig.1. Chondrichthyans firstly occurring in the Artinskian of the Middle and South Urals.
A – Tooth of anachronistid *Cooleyella amazonensis* Duffin, Richter & Neis;
B – Tooth of jalodontid *Adamantina foliacea* Ivanov;
C – Tooth of symmriiform *Denaea* cf. *wangi* Wang, Jin & Wang;
D, E – Jaws, pectoral fin skeleton and tooth plates of cochliodontid chondrichthyan, E – tooth plates;
F, G – Teeth of petalodontiform *Tanaodus* sp., G – tooth.
Scale bars 100 μm for A-C, 1 cm for D-G.

The Kazanian Paleoclimate in southewestern Tatarstan

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The Kazanian Stage is the Russian regional stratigraphic analogue of the Roadian Stage of the Guadalupian Series (Middle Permian) of the International Chronostratigraphic Chart (2013). Kazanian time was characterized by wide transgression of the shallow epicontinental sea to the east part of the East European platform (Tikhvinskaya, 1946; Forsh, 1955, etc.). The modern territory of the southwestern Tatarstan was the west evaporitic part of this tropical basin.

One of the most important factors of the evaporite formation is the presence of the dry tropical or subtropical climate (Strakhov, 1962). According to Hammond (1976), Parkin (1976) and Wright (1978), the prolonged low solar activity conducts to the difficulty of transferring heat from the equator to the poles and generates cold periods in the Earth's history, which, in particular, applies to the Permian. This led to a sharp decrease in atmospheric precipitation in the tropic area (*Sonnenfeld*, Perthuisot,1989), the lack of which contributed to a keen reduction in permanent streams on the land and a minor demolition of terrigenous material in the Kazan Sea from the west bank.

An important condition for the evaporite sedimentation is the low humidity, because only dry continental air can absorb water vapor (*Sonnenfeld*, Perthuisot,1989). Therefore, the proximity of the huge plain areas at the west part of the East European platform contributed to the formation of a dry climate. On the contrary, in the east bank of Kazanian Sea, the Ural Mountains detained atmospheric moisture and was providing the development of a large number of rivers, which carried out a great job on the transfer of terrigenous material in the sea basin. This situation in Kazanian time led to the desalination of seawater in the East of the basin and its salinization in the West. In addition, the Ural Mountains enhanced meridional trade winds, which could increase the evaporation of water.

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Examination of the material composition and organic matter of bituminous strata by the electron paramagnetic resonance

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In the last years in scientific literature the amount of publications that deals with natural bitumen has increased. This can be explained firstly by the fact that in some countries due to the intense growth of production of conventional oil and gas, reserves are became strongly depleted. And secondly, the discovered reserves of natural bitumen were comparable or were even more in comparison with the oil and gas reserves. Such situation is the case for the Republic of Tatarstan.

Bitumen deposits are confined to the sand packs of Sheshminskiy Horizon of Ufimian regional Stage of Lower Permian Series. This horizon is divided into two strata: sandy-argillaceous and clayey sand. Host rocks for bitumen are represented by sands and sandstones. They are mainly small and medium granular, polymictic, samples colors from dark gray to light gray. Sands and sandstones are often cross-bedded, with inclusions of pyrite crystals. Clastic material in sandstones represented with debris chert, volcanic rocks, grains of quartz, feldspar, mica flakes. Grains has angular shape, their size from 0,03 mm to 0,4 mm predominant grain size from 0.1 mm to 0,2 mm. Cement in the sandstones of the clay-calcite, in dense varieties – calcite, basal. Depth of productive deposits varies in area from 48 to 124 m.

The Lingula Clays Member is a reliable tire for deposits of natural bitumen. Thickness of the Lingula Clays Member has regular dependence on its location and the structure of sand pack and varies substantially from 4 to 10 m.

The Electron Paramagnetic Resonance (EPR) method was used for studying geochemical characteristics of host rocks. Spectra were recorded on the spectrometer «EPR Spectrometer CMS 8400". On the basis of the interpretation of the spectra the following conclusions were made:

1) EPR spectra recorded the presence of Fe^{3+} in the structure of clay minerals and in the form of individual oxides and hydroxides, which in turn is indicative of the redox conditions of the environment.

2) The distribution of Mn^{2+} ions in the section is inhomogeneous. In the layers where bitumen is located the intensity of the EPR signal of Mn^{2+} ions is decreasing. In the underlying and overlying rocks the EPR signal of manganese is higher. It is known that during the oil migration processes occurs redeposition of calcite and removal of manganese ions. So this indicates the fact of migration.

3) Almost in all samples are observed EPR spectra of SO_3^- radical ion in the structure $CaCO_3$, that is indicating that the carbonate rocks are original.

Kungurian – Late Permian Rugose corals of the Boreal realm: comparison and biogeography

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The western part of the Boreal Realm was formed in the northern part of the east-European platform after the mid-Artinskian ecological event correlated with abrupt transgression of cool water from the Panthalassic Ocean. The event trigged the origination and quick radiation of the specific deep and cool - water coral assemblage. The composition of the Late Artinskian corals in many occurrences along the eastern margin of the East-European platform shows the great taxonomical similarity. The forms with pseudocolumella are predominant, but they are nearly totally absent in younger faunas. Typical morphology of the Late Artinskian assemblage is the pseudocolumella of various structure and configuration. Two morphologically different assemblages were sequentially found in the Kozhim section (Polar Urals). They belong to the Late Artinskian columellate fauna (1) and the Kungurian non-columellate one (2). The impoverished cold water assemblage (2) includes species of *Soshkineophyllum* and *Calophyllum*. The small size of corals is typical. The following radiation of *Calophyllum* occurred in the Roadian-Capitanian. Roadian (Lower Kazanian) started with predominating small forms at the base of Baytugan beds (Sok section), then followed by a mass appearance of *Calophyllum columnare* Schlotheim (sections Sok, Kamyshla) in Kamyshla beds in the stratotype regions of the Kazanian Stage. The same species occurred in the bed 5 of Kapp Starostin Fm in the Festingen section, Svalbard (Ezaki, 1992). The age of Kapp Starostin Formation is from Kungurian up to perhaps end Permian and is still under discussion. Regional comparison – also with Greenland, Canada – shows the main common feature of the appeared fauna – significant predominance of the non-columellate corals and occurrence of the genus *Calophyllum*. It was reported as an index taxon for the *Calophyllum* biogeographical province (Fedorowski et al., 2007) established for the Middle Permian. According to the great changes of fauna diversity at the end of Artinskian we consider the widening of the temperate belt from the Kungurian. The occurrence of *Calophyllum* in the Wordian-Capitanian of Timor (Niermann, 1975) and in the contemporaneous deposits of the Inner Mongolia (Northern China) (Ding, 1985) allows considering the cosmopolitic genus as characteristic for the temperate belts of both hemispheres (Kossovaya, 2009).

The Wordian-Capitanian assemblage found in the Kapp Starostin Formation (Chwieduk, 2007, 2013) and in Sverdrup Basin (Bamber, Fedorowski, 2001) includes *Euryphyllum, Allotropiochisma, Calophyllum* etc., and is remarkably more diverse then the Kungurian and Roadian ones.

The upper part of the Kapp Starostin Fm (unit 8) contains *Sassendalia turgidiseptata* Tidten (Tidten, 1972, Ezaki, 1992). Recently this species was found in the Hovtinden and Svenskeegga members of the Kapp Starostin Fm It is also known in upper part (130 m above the base) of the Trold Fiord Fm (Capitanian) and from the talus of the Dogerböls Fm (Bamber, Fedorowski, 2001). The Capitanian age is supported by occurrences of *Mesogondolella bitteri* (Beauchamp et al., 2009).

Large solitary corals were studied from the occurrence in the Pravyi Vodopadnyi Spring and Malaya Aulandzha River in Omolon Basin (North-East of Russia). They are known from the middle 20th, when corals were distinguished as *Soshkineophyllum zavadovskyi* Sokolov (Sokolov, 1960). The recent ontogenetic study of the fauna collected by V.G. Ganelin allows a revision as *Fedorowskites zavadovskyi* (Sokolov). *Fedorowskites spitsbergensis* Chwieduk (Chwieduk, 2013) was recently described from the Hovtinden and Svenskeegga members of the Kapp Starostin Fm in Blendadalen (west of Grønfjorden, Svalbard). The *g*enus *Fedorowskites* occurred in Capitanian or Early Wuchapinian in Svalbard and in the upper part of the Khivachian Horizon probably of Changsingian age. The found similarity allows the widening of the *Fedorowskites* biochore to the eastern Boreal province and demonstrates the connection of two parts of the Boreal realm at the end of Permian.

Upper Kungurian-Lower Kazanian transition deposits of the East Europian Platform and the Far East Russian

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The many transition of the Uppermost Cisuralian – Lower Kazanian Russian sequences have been restudied. The excellent reference sections of the Kozhim River, Sub-Polar Urals Northeast Pai-Khoy, Novaya Zemlya, Verkhoyanye and Kolyma-Omolon regions were examined. The distribution of ammonoids, small foraminifers, brachiopods and bivalves is recorded (Kotlyar, 2002). The several correlative levels have been established. The transition deposits in the lower part of the Late Kungurian-Early Kazanian of the Boreal Realm contain Angara type plant fossils, Boreal brachiopod, bivalve and ammonoid assemblages.

The Upper Kungurian-Solikamian (Lower Ufimian) is characterized by *Tumaroceras* and *Epijuresanites* (ammonoids), *Megousia kuliki* and *Kolymaella ogonerensis* (brachiopods), *Aphanaia andrianovi* and *A. korkodonica* (bivalvia) (Kotlyar, 2002; Kotlyar et al., 2004; Ganelin et al., 2001; Biakov, 2010). The Upper Kungurian-Solikamian is characterized by assemblages, diversification within all faunal groups of great taxonomic similarity, and the presence of the immigrant taxa. This stratigraphic interval can be found out in the Far-East sections, where it is represented by the Lower Abrek Subhorizon. It is the main correlative interval, containing Angara type plant fossils and brachiopod and ammonoid assemblages of Late Kungurian-Solikamian age (brachiopod beds with *Primorewia reshetnikovi-Tomiopsis atlanichus* and ammonoid beds with *Epijurisanites*), wide-spread within the Boreal Realm (Kotlyar et al, 2006).

The Lower Kazanian is defined by the forming of Roadian ammonoid assemblage (Sverdrupites, Daubichites at al.), which marked the begining of the Middle Permian ammonoid evolutionary stage. However, the Kazanian elements have been established in the Upper Ufimian (Sheshmian) Horizon of the Russian Platform. In the some marine layers within Sheshmian continental deposits the typical Kazanian foraminifers *Pseudoammodiscus megasphaericus* (Gerke), *P. microsphaericus* (K. M.-Maclay), *Lingulonodosaria fallax* (Tcherdyncev), *Lingulina* cf. *L. semivelata* Tcherdyncev, *Ichtiolaria longissima* (K. M-Maclay) were found (Igonin, 1965; Pronina, 1998). The Kazanian brachiopods were also found in the upper part of the Vikhtov Formation on the western Timan Ridge (Astafurov and Rosanov, 1988). N.K. Esaulova indicated the Kazanian flora elements in Sheshmian Horizon. She distinguished common Sheshmian-Urzhumian *Filladoderma* fossil plant association (Esaulova, 1998). The Sheshmian deposits of Pechora basin besides certain Kazanian species yields the very important genus *Vattia* which is characterized for Roadian of Texas USA (Di Michele et al., 2001). It is very important for interregional correlation. Some species of *Vattia* established on the Vorcuta/Pechora Series Boundary. They are wide distributed in the lower part of the Pechora Series (Pukhanto, 2007). The Lower Pechora Series corresponds to the Lower Eryaga Formation of Pai-Khoy on the base of the identical fossil plant associations. The Lower Eryaga Formation overlays the Tabju Formation. The latter yields *Epijuresanites* in the lower part and the Ufimian plant fossils in the upper part.

The Uppermost Kungurian-Lower Kazanian boundary sections from the Primorye region of the Far-East Russia and the distribution of the fauna and flora analogous to Pechora basin and the Sub-Polar sections. The non-marine Kungurian Upper Pospelovka Subformation of the Upper Abrekian Subhorizon contains the Middle Permian plant assemblage including *Wattia* species which is very similar to the Lower Pechora Series (Burago, 1990). The Upper Pospelovka Subformation lays on the Lower Pospelovka Subformation, containing *Epijuresanites* and is overlapped by the Vladivostok Formation with *Daubichites orientalis.*

The wide distributed *Wattia* can be additional non-marine marker of the Middle Guadalupian and Biarmian Series Boundary both in ISS and GSS. In the ISS this event coincides with Lower Roadian Boundary, In the GSS – with the Lower Sheshmian Boundary. In the Regional scales we can approve the Lower Pechora Series, Upper Abrekian Subhorizon and Sheshmian Horizon correspond to the Lower Roadian.

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and by the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

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General stratigraphic scale of the Permian marine-continental and continental formations of the East European Platform

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In the International Chronostratigraphic Chart, the Permian is divided into three Series: Cisuralian, Guadalupian and Lopingian. The Cisuralian consists of Russian stages: Asselian, Sakmarian, Artinskian and Kungurian. The Guadalupian is subdivided on regional stages of North America: Roadian, Wordian and Capitanian. The Lopingian is subdivided on regional stages of South China: Wuchiapingian and Changhsingian. The boundaries of all stages are defined in continuous marine successions by of index conodont species in a single phyletic line (Shen et al., 2013). East-European Sedimentary Basin contains an unique continuous succession of marine-continental (transitional) and continental (terrestrial) deposits which were formed at the temporal interval from the Kungurian to the Middle Triassic. Marine-continental and continental formations cover a large part of the East European Platform (about 2 mln km^2) and vary in thickness up to 700 m on the Platform, increasing to 1500 m in the foredeep along the western margin of the Urals. These formation were formed in different facies zones under semiarid to sub-humid climate conditions.

The marine part of the marine-continental formation contains a low diversified fauna of forams, corals, brachiopods, gastropods, bivalves, cephalopods, bryozoans, conodonts, and fishes. Continental beds are rich in fossil remains of all biostratigraphically significant non-marine groups. Sedimentological features of Permian succession greatly affect the Russian General Stratigraphic Scale of the Permian system which is validated for the whole territory of Russian Federation.

Russian Scale also includes three Series but remains still substantially different from the Permian International Chronostratigraphic Chart (Stratigraphic Code of Russia, 2006). The differences include the stratigraphic range of the Middle and Upper Series, the grouping of stages within these series and their naming.

The Middle Permian of the General stratigraphic scale is defined as Biarmian Series divided into the Kazanian and Urzhumian stages. The lower boundary of the Kazanian stage and Biarmian Series is defined by the First Appearance Datum (FAD) of the conodonts *Kamagnathus khalimbadzhae* already detected in many localities of the East European Platform (Chernykh et al., 2001). A Roadian assemblage of ammonoids containing *Sverdrupites*, *Biarmiceras*, *Medlicottia*, *Daubichites* appears in the section slightly above the lower boundary of the Kazanian, representing an additional biostratigraphic marker (Leonova, 2007).

The lower boundaries of the stages which are formed by continental red beds (Urzhumian, Severodvinian, Vyatkian), marked by the first occurrence of non-marine ostracod species in continuous phylogenetic lineages.

The base of the Urzhumian Stage is best represented in the Krasny Ovrag (Red Ravine) section (Orenburg Region), which is proposed as the regional GSSP marked by the FAD of non-marine ostracods *Paleodarwinula fragiliformis* and *Prasuchonella nasalis* (Molostovskaya, 2009).

The base of the Severodvinian Stage is best represented in the Monastery Ravine section (Kazan Region), which is proposed as the regional GSSP marked by the FAD of non-marine ostracods *Suchonellina inornata* (Minikh et al., 2009).

Evolutionary lineage of non-marine ostracods *Prasuchonella nasalis* – *Suchonella typica* have been chosen for the definition of the stage boundaries within Severodvinian and Vyatkian continental succession. The base of the Vyatkian Stage is best represented in the Mutovino Section on the Sukhona River (Vologda Region), which is proposed as the regional GSSP marked by the FAD of S*uchonella blomi* (Molostovskii, Minikh, 2001).

During recent years, many sections containing interval of Permian-Triassic boundary (PTB) were extensively studied (Sennikov, Golubev, 2011, 2012; Golubev et al., 2012; Lozovsky et al., 2014). Continuity of PTB sequence was established due to these researches. There is no regional gap on PTB on East European Platform as traditionally believe.

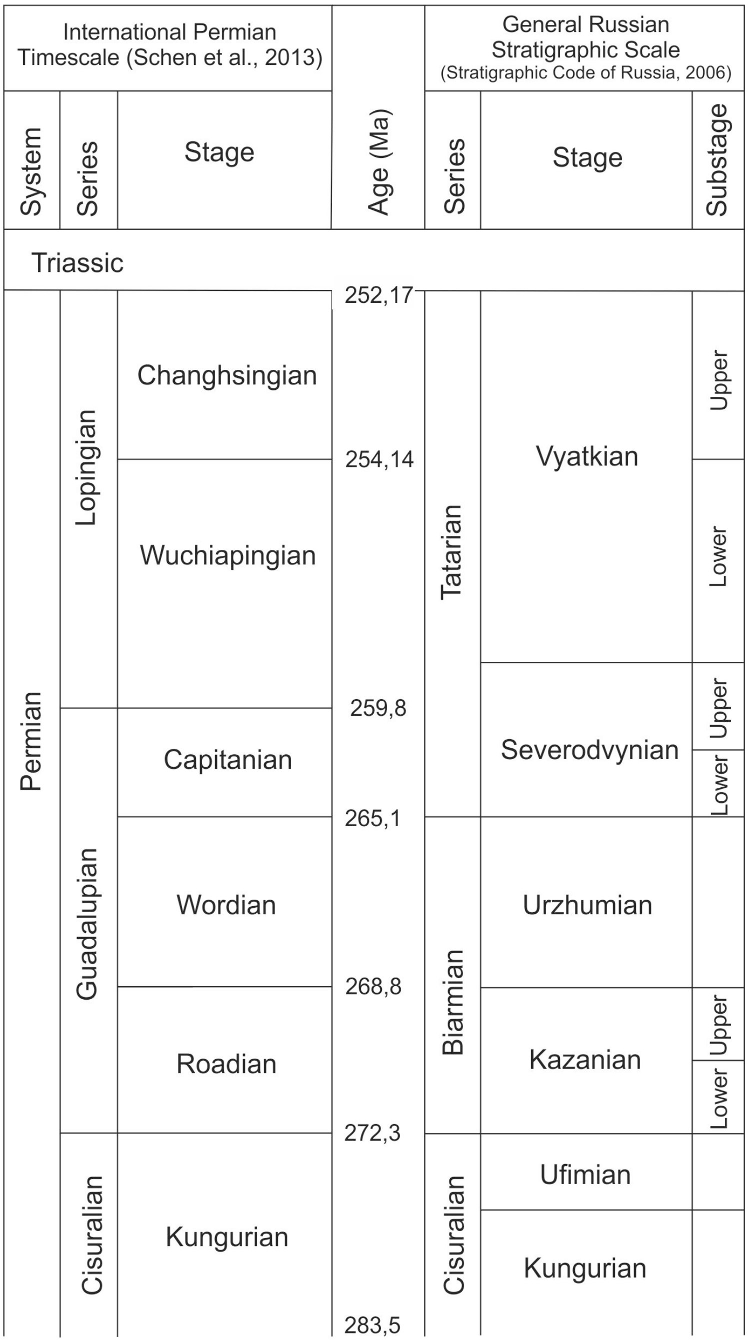

Fig. 1. Stratigraphy of the Permian marine-continental and continental formations of the East European Platform in relation to the International Permian timescale.

The main aim of this research is to build a multidisciplinary stratigraphic scheme of the Permian of European Russia including bio-, magneto-, chemostratigraphy and especially radiometric geochronology.

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and by the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

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Vertebrate trackways from Early Stephanian continental strata of Souss Basin (Western High Atlas Mountains, Morocco)

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The Late Pennsylvanian, Early Kasimovian, Souss basin, contain an approximately 2600 m tick sequence of fluvial and lacustrine deposits that have yielded so far a diverse fossil record including plant remains, insects, conchostracans, ostracods, jellyfishes, fish remains and rare tetrapod footprints. Recent exploration for fossil tetrapod footprints in floodplain-deposits of the basin revealed several trampled surfaces with a moderately diverse vertebrate ichnofauna composed of tracks assigned to the plexus *Batrachichnus* Woodworth, 1900 – *Limnopus* Marsh, 1894, *Dimetropus* isp. Romer and Price, 1940, cf. *Dromopus* Marsh, 1894 and *Ichniotherium cottae* (Pohlig, 1885). They can be referred to temnospondyl, non-therapsid synapsid (‘pelycosaur'), sauropsid and diadectomorph trackmakers.

This assemblage is important in at least two aspects: (1) it is the second oldest association of tetrapod footprints from Africa; (2) it is the second evidence of the rare ichnogenus *Ichniotherium* outside of North America and Europe. Judged from the variety of tetrapod tracks and previously collected floral and insect remains, the Souss basin must have represented a well-established continental ecosystem during Late Pennsylvanian time.

Reconstruction of sedimentary conditions of Middle Permian Kama-Ural basin studied by N.A.Golovkinsky

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Golovkinsky Law (also known in Europe as Walter's Law) is one of the fundamental regularities that characterize lithological and facial features of sedimentary formations. The essence of the Law is successive alternation of types and character of sedimentation processes in sedimentary basins according to changes of hydrodynamic and hydrochemistry of the sedimentation environment both in a lateral and vertical direction. N. Golovkinsky provided the conclusions based upon research of a succession of sedimentary rocks in the Permian sequence of the valley of the Kama River [1].

Detail research of lithological structure, granulometric content and textural features of Middle Permian strata of Ural-Kama basin allows providing reconstruction of paleohydraulic conditions of sedimentation. Obtained data gave quantity illustration of Golovkinsky law of facial substitution.

Researched area mainly belongs to zone of development of sedimentation basin of Middle Permian age. Sustainable negative tectonic movements had beginning westward of Ural Folded System in Middle Permian and reached maximal expansion in Kazan time. Consecutive change of facies forms mainly terrigeneous deposits in the east part and carbonate-clay, carbonate and carbonate-sulphate sequence in the west. In the zone of interrelations, it was complicated with shallow-sea lens-shape bodies of sandstones and conglomerates fixed geodinamically active structures of Tatar Arch, which divide the basin to terrigeneous (east) and mostly clay-carbonate-sulphate (west) parts. The Kazan sequence consists of two series: transgressive Lower Kazan and regressive Upper Kazan [2].

Analysis of paleoflows based on research of structures and textures of Kazan stage sediments allows revealing of paleohydraulic conditions in the sedimentary basin.

Diagram of Rubin and McCulloch (1980) allows estimation of the flow velocity by parameters of cross-beds; the same data are possible to receive from granulometric composition using Hjulstrom diagram (Hjulstrom, 1935). The directions of the flows were obtained from rose-diagram of cross-beds.

Whereas in the continental pre-Ural part velocity of the flows orientated mainly from east to west reached 1.8 m/s in the beginning of transgression and decreased to 0.2-0.8 m/s in the end of regression stage, the situation in the marine part was much more complicated.

In the western (carbonate) basin the velocities varied from 0.2 m/s in the beginning of transgression to zero in the upper point.

In the area of Tatar Arch during Ufa Stage the paleoflows had south and south-east directions and were orientated parallel to the coastline of paleobasin. Paleoflows of north-west to south-west prevailed in the Early Kazan Age.

The structure of paleoflows cardinally changed in Later Kazan Age. In the north part of Tatar Arch south-west directions of paleoflows had been prevailed. In the south part both south-east and south-west paleoflows are revealed, that is concerning with moderate development of Tatar Arch structures. Velocities of the currents in the Arch zone reached 1.8 v/s.

Facial interrelations in the zone of Tatar Arch and western basin were researched in detail by joint group of Kazan Ubiversity, Saint-Petersburg University and IGEM RAS. In the westward direction facial transition from coarse terrigeneous sediments (sandstones with pebbles) through siltstones and argillites to carbonate-gypsum sequence is observed. As the transgression developed, facial zones shifted after the coastline; therefore, coarser sediments had been overlay by finer ones.

For example, lower part of Early Kazan sequence near the axis of Tatar Arch (Elabuga – Krasny Bor) is represented by sandstones with pebbles of argillites up to 3-5 cm. Westward in the mouth of Vyatka the deposits are laterally changed into sandstone-siltstone-argillite strata. Far to the west the terrigeneous deposits change to carbonates. At the same time, in vertical direction sandstones changed to siltstones, argillites – to carbonates and carbonates – to carbonate-gypsum lowers consequently. The transgression sequence in the facial interrelations area of Tatar Arch is complicated by consedimentation tectonic movements.

Thus, observed lithological lowers are not corresponds to a single time interval, but belongs to different sliding geochronological divisions. The sedimentary genesis of the sequence is explained by simultaneous prograding of the strata both laterally and vertically and movement of facial zoning during transgression and regression cycles.

This explanation does not corresponds to the classical Stenon stratigraphic concept of successive horizontal layers, but agree with Golovkinsky law which become foundation of sequence stratigraphy.

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Early Carboniferous conodonts of the Melekesskaya depression

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For the first time, conodonts from the Lower Carboniferous deposits have been studied in the Groznenskaya 1192 borehole (Melekesskaya depression, Volga region). Here, at a depth of 1235,0 m, the following species of conodonts were found: *Bispathodus aculeatus* (Branson et Mehl), *Hibbardella* sp., *Hindeodella* sp., *Ligonodina* sp., *Ozarkodina* sp., *Siphonodella sulcata* Huddle, *S. praesulcata* Sandberg and *S.* sp. This conodont complex is characteristic for the *sulcata* zone of the Tournaisian Stage.

In the depth of 1226,4 – 1213,95 m, the complex of conodonts is more diverse and includes *Bispathodus aculeatus* (Branson et Mehl), *Hibbardella* sp., *Hindeodella* sp., *Ligonodina* sp., *Neopriniodus* sp. and *Ozarkodina* sp., *Siphonodella bella* Kononova et Migdisova, *S.* aff. *semichatovae* Kononova et Lipnjagov, *Siphonodella sulcata* Huddle and *S.* sp. The complex is typical for the Gumerovsky and Malevsky horizons of the Tournaisian Stage (*sulcata* zone). Similar conodont complex is characteristic for the Tournaisian deposits of the Moscow syneclise, Southern and Northern Urals.

This work was funded by the subsidy of the Russian Government to support the Program of competitive growth of Kazan Federal University among world class academic centers and universities.

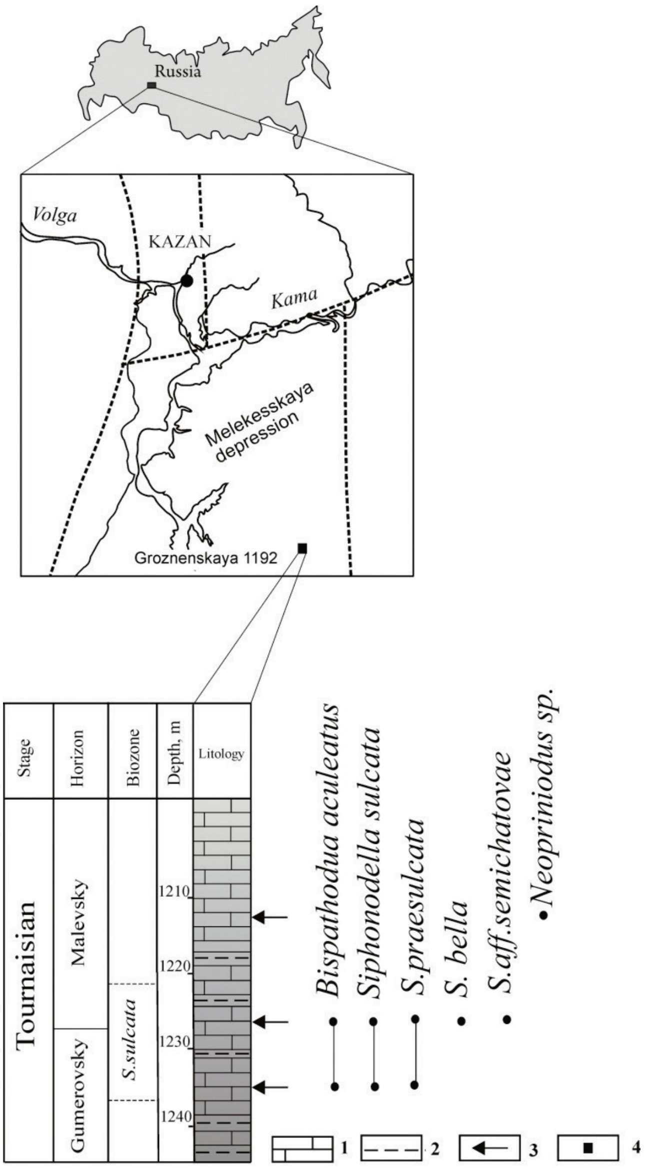

Fig. 1. Distribution of the conodonts in the Tournaisian strata of the Groznenskaya 1192 borehole. 1 – limestone; 2 – mudstone; 3 – samples with conodonts; 4 – location of the Groznenskaya 1192 borehole

Echinoderms from the Rusavkino Formation of the Gzhelian stratotype

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The Rusavkino Formation in Gzhelian stratotype (near the railway station “55th km”) is characterized by a rich and interesting macrofaunal asseblage. The first description of this complex was made by S.N. Nikitin in 1890. Unfortunately echinoderms from this locality have not been described for a long time. E.A. Ivanova (Ivanova, 1958: p. 233) noted the presence of two different types of crinoids in the “deposits of the inner zone of the peripheral region of the southwestern part of the basin (Gzhel, Rusavkino)”. The first (and still the only one) description of crinoids from the Gzhelian stratotype was made by Yu.A. Arendt and A.D. Zubarev in 1993. The authors noted the presence of at least 10 different species in this locality.

Echinoderms in this locality are represented by three different groups: crinoids, echinoids and ophiuroids. All the studied material comes from the 8 bed (according to Alekseev et al., 2009). The bed is represented an alternation of clay, green-brown partly compacted into shale with thin lenticular layers of yellow-brown coarse-grain tempestite limestone (Alekseev et al., 2009).

The material is hosted at the A.A. Borissiak Paleontological Institute RAS in Moscow. It was collected in various years by A.A. Erlanger, S.V. Grishin and V.L. Karchevsky. Additional materials were found by the author by sieving in water clay and shale from this bed.

Flexible crinoids are very rare in Gzhelian stratotype and represented by several fragments (including an infrabasal circlet) of an indeterminate large form. It is interesting that from the same strata in Rusavkino quarry there were found several cups and crowns of a medium-sized flexible *Pabianocrinus*. Currently a detailed description of these finds is prepared (Mirantsev, in prep.). The vast majority of the crinoid specimens in Rusavkino Formation in Gzhelian stratotype belong to cladid crinoids, as in other Upper Paleozoic Formations. One of the most abundant crinoids in the Gzhelian stratotype are agassizocrinids *Belashovicrinus gjeliensis* (Arendt, Zubarev, 1993). This species is represented by more than 120 cups, nearly 10% of which are aberrant (Arendt, Zubarev, 1993; Rozhnov, Mirantsev, in press); as well as numerous cup plates. The other less abundant crinods are apographiocrinids and ampelocrinids. Apographiocrinids are represented by a single undescribed species of the genus *Apographiocrinus* (10 cups and one nearly complete crown). It is larger than other species of this genus from Neverovo and Korobcheevo Formations and bears a specific sculpture. Ampelocrinids are represented by at least three different species: *Allosocrinus sp.* (large forms, known only from cup and arm plates), *Halogetocrinus sp.* (one nearly complete crown and several cups) and an undescribed genus, similar to *Aesiocrinus* and *Oklahomacrinus* (several incomplete cups and numerous cup plates). The last genus is unknown among other crinoid faunas in the Moscow Region; it is characterized by a round-pentagonal columnals, but not strictly pentagonal as in *Aesiocrinus*. There is a cup and numerous plates of a pelecocrinid similar to the North American *Exoriocrinus lasallensis* (Worthen, 1875). The later is known from the LaSalle Limestone of Bond Formation (Missourian). Medium-sized stems (with diameter up to 5 mm), round in transverse section, numerous in Rusavkino formation could probably belong to this taxon. There are two small cups of an undescribed genus belonged to *Graphiocrinidae*. The same genus was much more abundant and present in the older Neverovo Formation. It is interesting to note the presence of a catacrinid (probably a new genus) on the basis of a cup. Catacrinids were previously unknown in the Upper Carboniferous deposits in the Moscow Syncline, but they are abundant in the Midcontinet of the United States. Besides these crinoids there are also fragments of other species. Their incompleteness does not allow identifying them more accurately. Among them there are hyperpinnulated brachials from a small crinoid. Similar brachials are known in the Pennsylvanian exocrinids from the North America. The other finds includes radial plates as well as primibrachials with a distinctive sculpture.

Echinoids finds in the Gzhelian stratotype are abundant and are represented by a single undescribed species of an *Archaeocidaris*, represented by a numerous spines, interambulacral plates and fragments of the Aristotle's lantern. There are also several disarticulated specimens, belonged to this species. It should be noted that this species was formally described by A.V. Faas in his manuscript as "*Archaeocidaris nikitini*" that has not been published so the name is a *nomen nudum*. Later, that name was used by E.A. Ivanova (1958). Only one ophiuroid specimen (an arm fragment) was found in this locality.

All crinoids from the Rusavkino Formation are relatively small. The largest crinoids – *Allosocrinus sp*. didn't reach 2,5-3 cm. While this size is typical for other Upper Carboniferous crinoids. The reduction of size in crinoids could indicate probably on the atypical condition in that period (Ivanova, 1958). Many crinoids families (e.g. cromyocrinids, scytalocrinids, blothrocrinids), common for other Upper Carboniferous formation are absent in the Rusavkino assemblage. It is interesting that some large crinoids such as cromyocrinids appeared again in a younger Noginskian stage in Oka-Tsna Swell (Mirantsev, Rozhnov, 2011).

Some genera in the Rusavkino crinoid assemblage are similar to other crinoids from older crinoid assemblages, especially to crinoids from the Neverovo Formation. Both assemblages have *Exoriocrinus*, *Belashovicrinus* (*B. medvedkaensis* in Neverovo Formation and *B. gjeliensis* in Rusavkino Formation), *Allosocrinus*. *Halogetocrinus*, *Apographiocrinus* and graphiocrinids. Probably some crinoids from the Neverovo Formation were ancestors to some species from the Rusavkino Formation. The other part of the Rusavkino crinoid assemblage includes probably migrants from the North America (e.g. *Pabianocrinus*, catacrinids).

Another interesting fact is associated with the presence of a single anal plate in cup in nearly all crinoids of different lineages (ampelocrinids, apographiocrinids, catacrinids, graphiocrinids, *Belashovicrinus* and *Pabianocrinus*) in studied assemblage. The reduction of anal plates in cup is an evolutionary trend in Upper Paleozoic crinoids.

This work was supported by the Russian Fund of the Basic Research (grant No. 14-05-31464, "The composition and the dynamics of the echinoderm complexes in the Middle and Upper Carboniferous of the Moscow syneclise")

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Red-colour Permian paleosols in the reference section of Monastery and Cheremushka ravines, Russia

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Urzhumian (Wordian) and Severodvinian (Capitanian) sequences of Permian in Monastery and Cheremushka ravines are reference for the Volga-Ural province and represented by red-color continental lacustrine-alluvial deposits. These sections are well studied paleontologically in relation to tetrapods, fishes, bivalves, ostracods, terrestrial flora and provide essential geomagnetic hyperzones Kiaman-Illawarra reversal.

Paleosols were identified and described in more than twenty levels of this section by the paleopedology features: *in situ* roots, slickensides, gleyed zones, carbonate nodules, blocky peds, etc. The main paleosol orders from studied sections are eluvial-illuvial gleysols and paleoloesses, according to S.V. Naugolnykh (2004), or calcic gleysols and gleyed vertisols according to G.H. Mack (1993); host rocks are represented by red-colour siltstones and mudstones. There were identified more than 20 paleosol profiles; most of them concentrated nearby Urzhumian (Wordian) and Severodvinian (Capitanian) boundary. Permanent presence of carbonate nodules and gleyzation in paleosol profiles indicates pronounced climate seasonality. Paleosols on the floodplains subjected to periodic moistening due to monsoon rainfalls. A rough estimate of the mean annual precipitation, according to G.J. Retallack (2005) is up to 600 for Urzhumian and up to 800 mm/yr for Severodvinian paleosols.

In order to reveal a mineralogy and lithogenic features of pedogenic carbonates, we have studied carbonate nodules from Bk horizons of paleosols near the geomagnetic hyperzones Kiaman-Illawarra reversal. Samples were analyzed by an optical and scanning electron microscopy, δ 13C and δ 18O isotopic analysis, X-ray diffraction and x-band Electron Paramagnetic Resonance (EPR) method. Pedonodules occurring below the geomagnetic hyperzones Kiaman-Illawarra reversal consist mainly of dolomicrite whereas that one overlying this boundary consists of calcimicrite.

SEM study allowed detecting a widespread presence of fossilized bacteriomorphic filaments on the surface and edges of carbonate and clastic mineral grains. Secondary carbonate grains in calcitic and dolomitic nodules are represented by diagenetic calcisparite, the last contain, usually, not such filaments (Fig.1). The mineral composition of the filaments corresponds to mineral composition of the substrate grains, i.e. calcite/dolomite/silica. According to E.A. Zhegallo (Paleontological Institute RAS, personal communication), most of these filaments in carbonate nodules are fossilized remains of *Corynebacterium* or mycelium of *Actinomycetes*. These organisms in paleosols could leach mineral substrate and grow during the wet seasons, while during the dry seasons carbonate minerals precipitated and fossilized the filaments.

In carbonate nodules $\delta^{13}C$ and values vary from 0,6 to –5,2 ‰ (PDB) and $\delta^{18}O$ values vary from 21 to 35 ‰ (SMOW); in sedimentary carbonates $\delta\ ^{13}C$ and $\delta\ ^{18}O$ values vary from 2,6 to –3,2 ‰ (PDB) and from 22 до 35 ‰ (SMOW) respectively. There is a general regular facilitation of isotopic composition δ 13C in pedogenic carbonates compared with sedimentary ones that confirm the formation of first with the participation of the lighter carbon of biogenic origin.

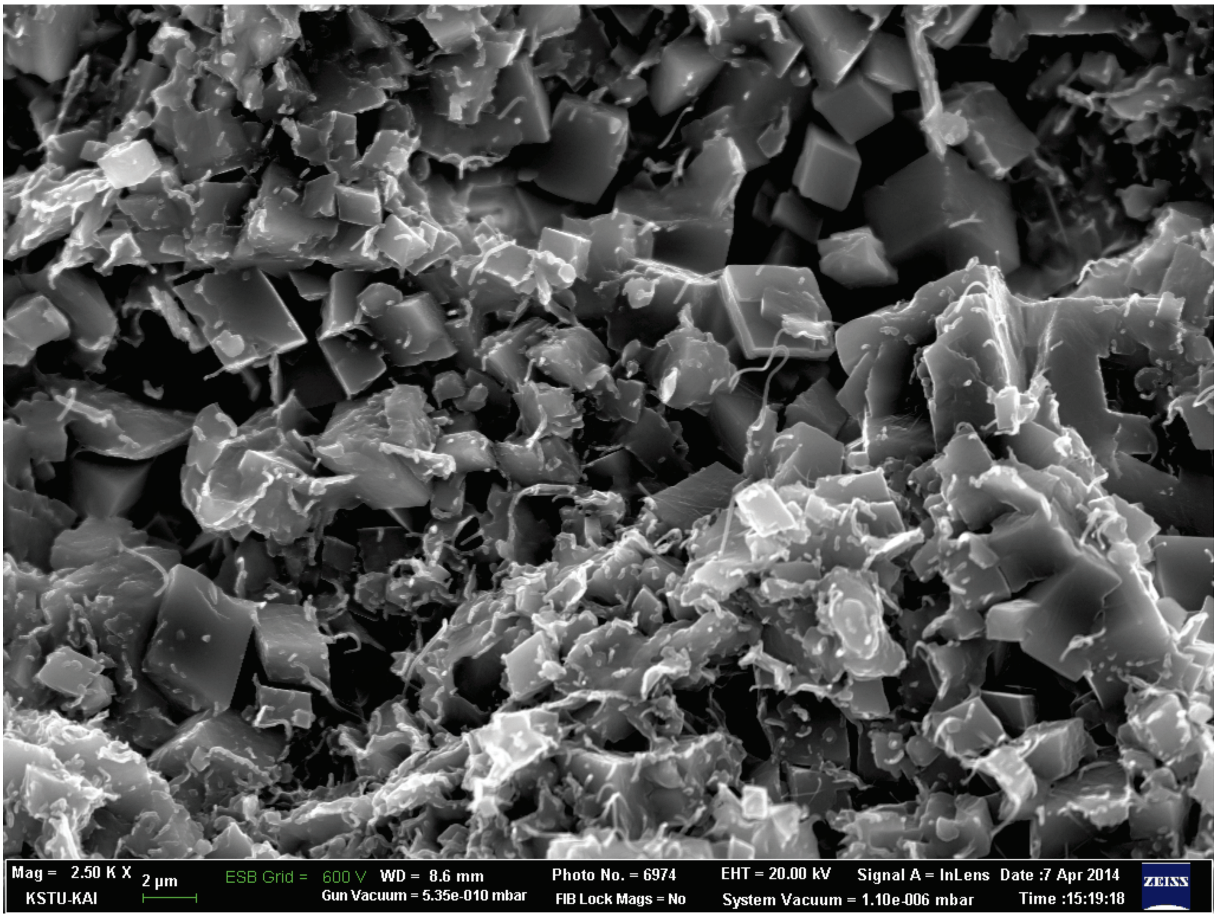

Fig. 1. SEM micrograph of dolomicrite pedonodule with *Corynebacteria* filaments on the surface of dolomite grains. Monastery ravine, Middle Permian, Urzhumian (Wordian) stage.

Thus, in the studied sections nearby the geomagnetic hyperzones Kiaman-Illawarra reversal, there is a transition from a predominantly dolomite pedogenesis (where the dolomite is the primary mineral) to predominantly calcite pedogenesis. Above the same boundary, alluvial-deltaic cross-bedded sandstones are common, and Severodvinian (Capitanian) species of tetrapods, fishes, non-marine ostracods, molluscs are frequently occur. These data may indicate a climatic change from arid conditions in Urzhumian (Wordian) time to semiarid conditions in Severodvinian (Capitanian) time. The reasons for such changes could serve, most likely, the paleogeographic reconstruction in river and basin morphology in the Volga-Ural region in earliest Upper Permian. A similar transition from a dolomite to calcite pedogenesis, only in the Permian-Triassic boundary, revealed Kearsey et al. (2011) in the sedimentary sequences of the Southern Urals.

Kazanian Flora (Middle Permian) of the Iva-Gora locality (Soyana River, Arkhangelsk region, Russia)

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ФЛОРА КАЗАНСКОГО ЯРУСА (СРЕДНЯЯ ПЕРМЬ) МЕСТОНАХОЖДЕНИЯ ИВА-ГОРА (Р. СОЯНА, АРХАНГЕЛЬСКАЯ ОБЛАСТЬ)

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В пределах Русской платформы располагается ряд разрезов пермских отложений, которые изучаются многими поколениями палеонтологов и стратиграфов, но по-прежнему дают возможность существенно расширить наши представления об органическом мире пермского периода. Не было обойдено вниманием специалистов местонахождение Ива-Гора, располагающееся в среднем течении на правом берегу р. Сояна в Архангельской области, в 50 км выше по течению от п. Сояна. Местонахождение Ива-Гора было открыто в 1926 г. М.Б. Едемским (подробнее см.: Щербаков, 2007). Разрезы пермских отложений по рекам Сояне и Кулою подробно изучались Я.Д. Зеккелем в 1935 г. (Зеккель, 1939; Щербаков, 2007). В 1937 г. выдающимся российским палеоботаником М.Д. Залесским были опубликованы первые описания ископаемых растений из местонахождения Ива-Гора: *Pecopteris attenta* Zalessky, *P. spiculosa* Zalessky, *P. conserrata* Zalessky, *Odontopteris sojanaeana* Zalessky, *Meristophyllum sojanaeanum* Zalessky (Zalessky, 1937). Обзорная статья о флоре Ивы-Горы в широком контексте рассмотрения флор казанского яруса Евразии была опубликована И.А. Игнатьевым и С.В. Наугольных (2001).

В основу исследований автора этого сообщения была положена коллекция растительных остатков, собранных на местонахождении Ива-Гора геологом В.Н. Кулешовым (Геологический институт РАН; подробнее см.: Наугольных, Кулешов, 2005) в 2004 г., переданная автору для изучения. Коллекция насчитывает более 70-ти экземпляров, сохранившихся в виде отпечатков и фитолейм. Изученные образцы хранятся в Геологическом институте РАН, в коллекции 4851. В качестве дополнительного материала были использованы материалы по ранее изучавшимся папоротникам (Naugolnykh, 2013) местонахождения Ива-Гора из сборов А.Г. Шарова, коллекция 4547.

Растительные остатки в местонахождении Ива-Гора приурочены к средней части разреза, к прослою плитчатых светло-бежевых мергелей (т.н. ивагорские слои), в которых также встречаются остатки беззамковых брахиопод *Lingula* sp., двустворчатых моллюсков, меростомовых (*Palaeolimulus* sp.; см. Щербаков, 2007, с. 2) и насекомых. Плитчатые мергели согласно налегают на красноцветные песчаники шешминского горизонта уфимского яруса. По латерали в восточном направлении ивагорские слои замещаются известняками и доломитами с остатками морских беспозвоночных, таксономический состав которых указывает на раннеказанский возраст ивагорских слоев (Лихарев, Миклухо-Маклай, 1977).

Учитывая своеобразие флоры местонахождения Ива-Гора, представляется оправданным выделить на основе этой флоры новый ивагорский флористический комплекс, имеющий, как это было показано выше, раннеказанский возраст.

Из споровых растений ивагорского флористического комплекса особенно часто встречаются листовые мутовки и облиственные побеги *Annularia* aff. *carinata* Gutbier. Заметную долю растительных остатков составляют остатки папоротников *Pecopteris* ex gr. *leptophylla* Bunbury. Встречаются филлоиды и спорофиллы гетероспоровых плауновидных, сохранность которых пока не позволяет дать их точное определение. Скорее всего, они близки плауновидному *Signacularia* Zalessky, характерному для отложений казанского яруса (Zalessky, 1937).

Отдельного упоминания заслуживают папоротники морфологической группы пекоптерид, остатки которых регулярно встречаются в ивагорском местонахождении (рис. 2). Остатки пекоптерид здесь обычно представлены небольшими фрагментами перьев последнего порядка или, реже, фрагментами перьев предпоследнего порядка. Первоначально на материале из местонахождения Ива-Гора М.Д. Залесским были установлены три новых вида пекоптерид: *Pecopteris attenta* Zalessky, *P. spiculosa* Zalessky, *P. conserrata* Zalessky (Zalessky, 1937). При изучении более представительной выборки листьев пекоптерид из местонахождения Ива-Гора выяснилось, что все три вида, установленных Залесским, вполне укладываются в пределы морфологической изменчивости листьев одного естественного или ботанического вида, причем все эти листья очень близки, а иногда и просто неотличимы от листьев глейхениевого папоротника *Oligocarpia leptophylla* (Bunbury) Grauvogel-Stamm et Doubinger, широко распространенного в нижнепермских отложениях Еврамерики (Wagner, Lemos de Sousa, 1985; Barthel, Rössler, 1995). Однако поскольку фертильные листья пекоптерид в ивагорском местонахождении пока не найдены, а также поскольку таксономическая тождественность листьев пекоптерид из Ива-Горы и еврамерийского вида *Oligocarpia leptophylla* остается под вопросом, было принято решение об определении их в открытой номенклатуре как *Pecopteris* ex gr. *leptophylla* Bunbury.

Среди растений ивагорского флористического комплекса часто встречаются облиственные побеги членистостебельных, определенные как *Annularia* aff. *carinata* Gutbier. Сходные растительные остатки встречаются и в других ископаемых флорах казанского возраста Европейской части России (Есаулова, 1986, табл. VII, фиг. 1-3, табл. VIII, фиг. 1, 2; Наугольных и др., 2014). В местонахождении Ива-Гора также был найден фрагмент мутовки, возможно, принадлежавшей репродуктивному органу членистостебельного.

Из ивагорских голосеменных следует упомянуть находки перистых листьев пельтаспермовых (морфологическая группа каллиптерид, семейство Peltaspermaceae), описанных М.Д. Залесским как *Odontopteris sojanaeana* Zalessky (Zalessky, 1937, p. 98, fig. 74, 75). Помимо каллиптерид в местонахождении Ива-Гора присутствуют листья ангаропельтовых *Praephylladoderma* Naugolnykh (семейство Angaropeltaceae, порядок Peltaspermales). В ивагорском местонахождении изредка встречаются облиственные побеги хвойных (см., например, Игнатьев, Наугольных, 2001, табл. I, фиг. 1, слева внизу), точное таксономическое положение которых остается не установленным. В составе ивагорского флористического комплекса также присутствуют листья *Rufloria* (*Alatorufloria*) S.Meyen, *Entsovia* S.Meyen, брактеи *Nephropsis* Zalessky, чешуевидные листья-катафиллы *Lepeophyllum* Zalessky, по представлениям автора, принадлежавшие голосеменным класса Vojnovskyopsida (Наугольных, 2010).

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Depositional settings and fossils of the Carboniferous Bukharcha Formation (Zilair Megasynclinorium, South Urals)

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The Bukharcha Formation was originally recognized by Khvorova (1961) as a horizon corresponding to the Upper Viséan and Namurian stages. At present the Bukharcha Formation is dated as the interval from the Serpukhovian Stage to Syuranian Substage of the Bashkirian Stage. It is developed in the western subregion of the South Urals, in the marginal trough of the Zilair Megasynclinorium (ZM), which was formed near the carbonate platforms of the continental shelf of Baltica during the beginning of its collision with the Kazakhstan continent. The Bukharcha Formation rests on the Itkulovo Formation (Viséan) and is overlain by the Unbetovo Formation (Upper Bashkirian). We re-examined Serpukhovian and Bashkirian successions and fossil localities in several ZM sections of the Bukharcha Formation (including the localities in Muradymovo, Kugarchi, Bogdanovka and Bolshoi Uskalyk) and analyzed fossil communities against the sedimentary settings. The Bukharcha Formation consists of rhythmic intercalation of bioclastic grainstone and packstone, thin-bedded wackestone and siliceous mudstones with interbeds of calcareous polymictic sandstone and sandy packstone with graded bedding showing the deposition of distal turbidites intercalating with contourites. Fossils include ammonoids, foraminifers, sponge spicules, gastropod protoconchs, ostracods, crinoids, and occasional bryozoans, brachiopods, and algae (Fig. 1).

In the southern ZM (Kugarchi, Bogdanovka), the lower part of the Bukharcha formation is composed of argillaceous carbonates, with beds of deep water shale and siltstone, sometimes clastic limestones and limestone breccia, while the upper part is mostly limestone with cherty interbeds. The Lower Bashkirian has many beds of spongolites. The section of folded beds 2 km to the east of the village of Kugarchi on the right bank of the Yamashla River contains stratotype of the Bogdanovkian Horizon (Lower Bashkirian). It is characterized by rich ammonoids and foraminiferal assemblages allowing broad correlations. Kulagina and Pazukhin (1986), Kulagina et al. (1992) Kulagina (2014) examined and described this section and its conodonts and foraminifers. The Serpukhovian stage in Kugarchi includes the local *Neoarchaediscus regularis* Zone, subregional *Eolasiodiscus donbassicus* Zone (together constituting the Kosogorian), local *Eostaffellina actuosa* (Protvian) and the standard *Monotaxinoides transitorius* Zone (Yuldybaevian).

In the north of the ZM, the formation contains considerably more carbonates. The lower portion of the Bukharcha Formation in the Muradymovo section contains the foraminiferal *Mediocris-Endostaffella* biofacies and conodonts of the *Lochriea ziegleri* Zone allowing its correlation with the Kosogorian (Kulagina et al, 2014). The middle part of the Bukharcha Formation is dated as Late Serpukhovian based on the foraminiferans of the *Eostaffellina actuosa* Zone (Protvian), *Monotaxinoides transitorius* Zone (Yuldybaevian), conodonts of the *Gnathodus bilineatus bollandensis* Zone and ostracods of the *Pseudoparaparchites celsus* Beds (Kulagina et al., 1992; 2001; 2014). The upper part of the Bukharcha Formation in the north and south of the ZM corresponds to the Syuranian Substage including the Bogdanovkian and Kamennogorian horizons. The Bogdanovkian portion includes the *Plectostaffella* *varvariensis, Pl. bogdanovkensis*, and *S. minuscilaria* zones; the ammonoid *Homoceras-Hudsonoceras Zone*; the conodont *Declinognathodus noduliferus* and *Idiognathoides sinuatus* zones (Kulagina et al. 2001). The uppermost (Kamennogorian) member of the Bukharcha Formation corresponds to the *Reticuliceras–Bashkortoceras* ammonoid Genozone the foraminiferal *Semistaffella variabilis* Zone, the ostracod *Glyptolichwinella postuma* Zone (Kochetova, 2008), and the *Idiognathoides sinuatus* Zone.

Ammonoids are found throughout the ZM in great abundance and diversity. The ZM ammonoid fauna is very distinct from most contemporary assemblages in its diversity and endemism, showing similarities with the Western Kazakhstanian and some Central Asian faunas. Ammonoids from the Muradymovo Section (north) and Kugarchi section (south) are scarce in the late Serpukhovian and the basal Bashkirian but their diversity and endemism increased by the end the *Homoceras* phase. Beds with ammonoids represent bioclastic grainstone lenses interbedded with packstones. This lithology suggests impulsive deposition of bioclastic debris by storms or gravity flows. The change in the succession of cycles in the Lower Bashkirian shows the transition from the marginal deep outer shelf facies to slope and depression deposits, which contributed to the considerable increase in abundance and diversification of the ammonoid biota.

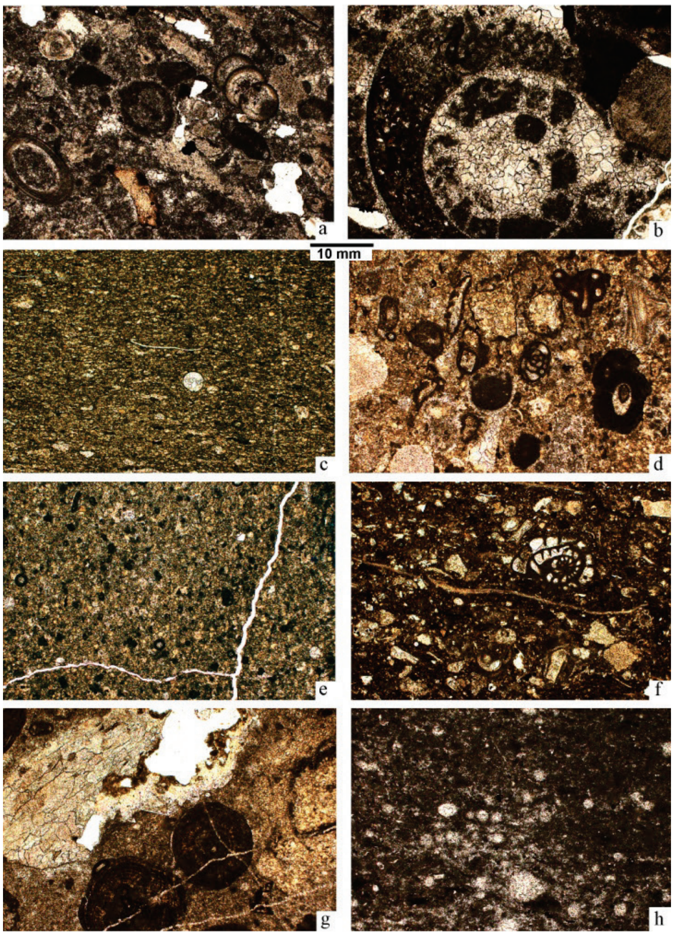

Fig. 1. Lithotypes of the Bashkirian portion of the Bukharcha Formation (Syuranian): (a-f) Bogdanovka section, (g, h) Bolshoi Uskalvk Section.

The study is supported by the Russian Foundation for Basic Research, project no. 14-05-00774 and the Program of Presidium of the Russian Academy of Sciences no. 28.

Lithological signs of cycles within some key sections of Permian rocks

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In present paper Permian rocks within Volga-Kama rivers region were considered in light of environments and mechanisms of sedimentary cycles during Middle and Late Permian. Cycles were reconstructed on a lot of lithological data series (grain size, carbonates, magnetic susceptibility) in variations along the sections and in statistical models of spectral analysis.

Permian basin of the Volga and Kama rivers is known as an interesting object for study of sedimentary cycles. Most of these cycles are quite thin (a few meters, a few tens of meters) units sequence.

We considered Permian sediments within Middle+Upper Permian sequence named further as Upper regional cycle.

The Upper cycle can be characterized as cycle of second order corresponding to the supercycle or sequence. It began to form after the fifth global regressive phase of the Late Paleozoic.

Three megacycles corresponding to Ufimian, Kazanian and Urzhumian+Severodvinskian+Vyatskian stages occurred inside this supercycle.

Stratigraphy of these units indicates at least three cycles of 4-5th order in the Lower Kazanian and three or four cycles of 4th order within Upper Kazanian. Two and four cycles of 4th order can be recognised in Urzhumian and Tatarian sections respectively.

We considered the cycles within three outcropped sections Monastyrskoe, Sheremetevka and Kzyl Bairak on banks of Volga and Kama rivers.

To detect cycles we used traditional, nevertheless expressive lithological parameters: grain size content; carbonate component (carbonate content and the ratio $CaCO_3/MgCO_3$); magnetic susceptibility.

Increasing of coarse grains zones can evidence about fall of relative sea level. Strongly magnetized sandstones point on sedimentary material influx. They can be used as event levels of significant changes in region, forming sharp stratigraphic boundaries, expressed by scores and interruptions in sedimentation. This reconstruction was controlled by plots of carbonate and fine grains contents cycles, because these parameters, in general, increase in main profile of sedimentation area from areas of weathering to sedimentary basin in the "seaward" environments.

Using the specified parameters on sections Monastery Ravine, Sheremetevka and Kzyl Bairak, we made a spectral analysis by the maximum entropy method (MEM) and Fourier analysis.

The results of spectral analysis of lithological data series allowed us to state that the variation of coarse grains content in the sediments is the most important and significant factor to reveal cycles. Analysis of cycles on other lithological properties should be carried out in parts of sections with no signs of major breaks and scores.

Evolution of Late Paleozoic Fusulinoida in the ecological context

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Foraminifera of the superorder Fusulinoida is one of the most common groups of organisms among Late Paleozoic marine benthic communities. Evolutionary stages of Fusulinoida are studied in detail by many Russian and foreign micropaleontologists. Traditionally, questions of evolution and ecology were considering independently each from other. However, the interaction of biotic and abiotic events in the evolution of organisms nobody is denied. At the present time, in connection with close attention to environmental problems, interest in questions of paleoecology has increased. Since foraminifera are sensitive to changes of temperature, salinity, chemistry and dynamics of marine water, the analysis of their morphological parameters can give indirect information about local and global environmental changes at the present and the past time.

The formation of the superorder Fusulinoida had during Early Carboniferous (Visean and Serpukhovian ages), when representatives of the ancestral superorder Endothyroida were dominated in foraminifera communities. Distinguishability of Fusulinoida from Endothyroida resulted in the formation of their shells with a stable septation, which probably indicates the uneven growth rate of Fusulinoida. This morphological feature is not characteristic of the Early Carboniferous Endothyroida. The formation of the observed innovation occurred against the backdrop of abiotic changes of the World Ocean, which took place at the turn of Serpukhovian and Bashkirian ages. In the fossil record this event was reflected in the decrease of other marine invertebrates' diversity.

Superorder Fusulinoida existed from Early Carboniferous to Late Permian. During this time there were 6 orders, more than 150 genera and about 2500 species. General evolutionary regularities in the history of the development of Fusulinoida are showed up in the complexity of the morphology and spatial organization of the shell. The direction of this process was formed under influences of changing external environments.

One of significant biological events in the evolution of Fusulinoida was associated with the emergence of innovations in the structure of the shell's wall, marking the appearance of the order Schwagerinida. Phylogenetic transition from Fusulinida to Schwagerinida represented the transformation of the four-layer wall with diaphanotheca in to the two-layer keriotheka wall with extensive porosity. This process occurred in Late Moscovian – Early Kasimovian age when global warming was observed according to some of geological and paleontological data. Probably in those conditions for Fusulinoida the wall structure with keriotheka was significant adaptive trait that has improved the communication of the organism with the environment. Thus, climate change at the turn of Moscovian and Kasimovian ages proved to be a stabilizing factor in retention of the morphological innovations of Fusulinoida.

Morphometrics (the quantitative analysis of organism form) is the key to understanding evolutionary, physiological, ontogenetic and functional processes in organisms both past and present, as noted at the TMS Joint Foraminifera and Nannofossil Spring Meeting (the Netherlands, 2014). The question "Which morphological parameters are most sensitive to environmental change?" is the most important in the ecological context. Earlier studies by M. N. Solovieva also have dealt with this problem. She introduced the concept of integrative foraminifera systems to analyze the structure of the shells from the point of view of their functioning. Integrative systems detect the presence of communication and ensure consistency between different structures and survival functions. There are three integrative systems: the gravity, the communication, and the generation one.

The gravitational system includes chomata, folded septa and axis deposits. These structures have functions both shell’s weighting and its mechanical strengthening. Mentioned structures are adaptive devices for the existence of organisms in a moving water environment. Such qualitative characteristics of the Fusulinoida structure as a shell’s shape and a chamber’s height that reflects a volume of a living chamber should be also included to the gravitational system.

A communicative system includes such shell’s structures, which are used by an organism to communicate with an external environment. These structures include apertures, septal pores and some features of wall structures. Communication system is needed to perform vital functions such as metabolism, nutrition, breathing, i.e. physiological processes.

General patterns of organisms’ phylogeny, revealed in the classic scientific works of A. N. Severtsov and I. I. Schmalhausen, are indicated in the historical development of Fusulinoida. The study of the Fusulinoida evolution allowed us to identify periods of idioadaptation, and the periods of aromorphosis.

Changes in the structures of the gravitational system took place mainly during periods of idioadaptation. They were adaptive in nature to specific biocenotic conditions and determine a local distribution of Fusulinoida.

Morphological structure of the communication system was changing mainly in periods of aromorphosis. Evolutionary innovations of the communication systems were raising a level of general vital functions of organisms, thereby ensuring their evolution towards biological progress on the background of global environmental changes.

Thus, the evolution path of Fusulinoida can be used as some tracer of global environmental changes during Late Paleozoic.

Depositional Features of Asselian-Sakmarian Argillaceous-calcareous Deposits in the northern part of the Western Slope of the Urals and Pre-Urals

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Several types of sections (lithofacies zones) have been identified in the northern part of the western slope of the Urals and Pre-Urals (= the Western Ural megazone and the Ural foredeep). In latitudinal direction these sections are represented by terrigenous deposits of the Kechpel' Fm, argillaceous-calcareous deposits of the Sherkyrta, Losinyi Ostrov and Sezym formations, reefogeneous complexes (organic buildups: Kozhym, Podcherem, Kosju, Un'y, Schugor) and layered siliceous and bioclastic limestones of the "Nijniye Vorota" succession on the Shchugor River. These deposits are similar to those of the Upper Carboniferous - Lower Permian ones located southward (Chuvashov et al., 1990). This paper is devoted to argillaceous-calcareous deposits.

Sections of this type are composed of clay, argillites, bioclastic and pelitomorphic limestones. Rocks vary in colour from yellowish-green to dark gray and purple. They commonly form alternating beds of 0.1 - 0.3 m in thickness. The argillaceous limestones are characterized by pseudoclastic (or cloddy) texture and loop-shaped structure formed by distribution of clay material. Authigenic pyrite is common. The argillaceous-calcareous deposits contain a variety of fossils (echinoderms, brachiopods, tetracorals, sponge spicules, bryozoans, small foraminifers, ammonoids, conodonts, ostracods, pelecypods, gastropods, and trilobites) which indicate a normal salinity of sea. The thickness varies from 8 to 60 m, and sometimes in comparison with other types of sections is much less. In the Urals stratigraphic chart such argillaceous-calcareous deposits are the part of different local stratigraphic units: the Sezym and Losinyi Ostrov formations of the Kosju-Rogov Depression, the Sherkyrta Fm of the Bolshesyny Depression. They always underlie terrigenous flysch deposits. Also, it has been suggested to allocate the argillaceous-calcareous deposits of the Upper Pechora Depression, which are located on the Ilych River as a separate stratigraphic unit – the "Ustjisperedju series" (Saldin, 2011).

These argillaceous-calcareous deposits are very similar in composition and structure, but they differ in mode of occurrence of underlying deposits, in stratigraphic range, in space-and- time relationship with organic buildups and, to some extent, composition. Therefore they could be divided into three subtypes: Sezym, Sherkyrtin and Ustjisperedju.

Sections of the Sezym subtype completely correspond with the Middle Asselian-Sakmarian Sezym Fm overlying the Middle Carboniferous shallow marine bioclastic limestones with a stratigraphic disconformity. Three uncommon sections of the Sezym Fm have been found. The first one is located on the Lek-Elec River. Organic buildup with thickness of 20 m and extension about 100 m is located inside of deposits of the Sezym Fm (Guidebook..., 1995). The second section was found in cement quarry in the Vorkuta region. In this section, lower part (about 14 m) of Sezym Fm is composed of silicified limestones and argillits. Colored clay with thickness of 0.4 m lies in the base of the Sezym Fm In the third section the deposits of the Sezym Fm including blocks of the underlying Middle Carboniferous limestones are rudaceous deposits with thickness about 20 m, although along the strike their bedding position is observed. The distribution of deposits of the Sezym Fm is associated with the Eastern shelf margin that raised and eroded during the Preasselian and then quickly dipped into relatively deep waters. The only Lekelets organic buildup being the part of the Sezym Fm indicates that the depth of formation of these deposits was not more than a few hundred meters.

Sections of the Sherkyrtin subtype combine the deposits of the Sherkyrtin and Losinyi Ostrov formations. The Kasimovian-Sakmarian Sherkyrta Fm overlies the Late Moscovian bioclastic limestones without apparent stratigraphical break (Chuvashov et al., 1999).The Losinyi Ostrov Fm is allocated on the Kozhim River. This formation does not have uncovered stratigraphic boundaries with the underlying and overlying deposits, and it is characterized only by Gzhelian-Asselian conodonts and fusulinids (Guidebook..., 1995). Thin interbedding of argillits with argillaceous and bioclastic limestones, dark gray colour of rocks, occurrence of turbidite layers, the presence of silicites with radiolarians and sponge spicules – all these features indicate that the deposits have formed in more deep-water conditions than the reef limestones. Since the Kasimovian argillaceous-calcareous deposits formed in open shelf in the depression. These deposits surrounded uplifts where organic buildups were formed.

Sections of the Ustjisperedju subtype. These Asselian-Sakmarian deposits are represented by dark-gray, rarely red-brown argillaceous and bioclastic limestones sometimes with nodules dark-gray silicium with apparent thickness about 15 m. The upper boundary of the Ustjisperedju series varies from the Tastubsky in the East to the Sterlitamaksky in the West (Saldin, 2011). The Ustjisperedyu series overlies the Asselian reef limestones. Perhaps, formation of the Ustjisperedju deposits corresponds to the model of sedimentation, explaining correlations between organic buildups and argillaceous-calcareous depression deposits. Thise model is suggested for the Southern depression of the Pre-Ural foredeep by Chuvashov (Chuvashov, 1998). During migration of the foredeep to western direction the reef limestones were overlied by argillaceous-calcareous deposits which were formed on the bottom.

Thus the depositional features of the similar in composition and structure Asselian-Sakmarian argillaceous-calcareous deposits of the western slope of the Urals and Pre-Urals could be interpreted by the difference in synsedimentary tectonics in different parts of the Northern Urals sedimentary basin. It can be seen in space-and-time relationship of considered deposits with organic buildups. In the Upper Pechora Depression (Ustjisperedju subtype) in the sequence argillaceous-calcareous deposits have replaced the organic buildups during migration of the foredeep in latitudinal direction from East to West. In the Large Synya Depression and in the southern part of the Kosju-Rogow Depression these deposits were formed in a stable tectonic setting around the organic buildup from Kasimovian to Sakmarian age (Sherkyrta subtype). In northern part of the Kosju-Rogov Depression the eastern margin of the shelf raised that led to erosion of Pre-Asselian deposits in subaerial conditions, and then it dipped relatively quickly. Apparently, the flat relief of bottom and depth did not contributed to the distribution of organic buildups in this area of the sedimentary basin.

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Carboniferous-Permian climate cyclicity – from wet to dry red beds

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The Carboniferous-Permian climate was marked by an increasing aridisation towards the Triassic super-hot house (Chumakov & Zharkov, 2002). This trend was interrupted by several wet phases in the Barruelian (Kasimovian), Stephanian C to Lower Rotliegend (Gzhelian/Asselian), late Lower Rotliegend and early Upper Rotliegend I (Sakmarian/Artinskian) and in the Upper Rotliegend I Artinskian/Kungurian and Kungurian/Rodian), in the Upper Rotliegend II (Wordian/Capitanian) and again by a strong wet phase caused by the Zechstein- and Bellerophon-transgressions in the Late Permian Early Wuchiapingian (Roscher & Schneider, 2006). These more humid phases can be traced in all European, North American, and North African sedimentary basins. All these wet phases are linked to orbital cycles which caused up to the end of the Gondwana glaciation in the Artinskian the waxing and waning of the Gondwana icecap. This is supported by correlations with the South African Karoo Basin. The melting of the icecaps caused eustatic sea level rises, which led to more humid climates in North Pangaea. A further wet phase in the Westphalian C/D (Late Moscovian) cannot be proven by the European dataset used here, but its existence is presumed because of its origin due the waxing and waning of the Gondwanan icecap. The wet phases themselves, as a part of the aridization trend, weakened over time – each new wet phase was dryer as the foregoing one. The aridization and the weakening of the wet phases were caused not only by the northward drift of the supercontinent and the shifting of North Pangaea to the arid climatic belt. A spreading-out of the arid/semi-arid belt in the Early to Middle Permian is traceable by the disappearance of ever-wet tropical associations (Ziegler, 1990). This spreading-out can only be explained by using a new reconstruction of the configuration of Pangaea (Roscher & Schneider, 2006). During the Late Carboniferous and the Early Permian, an oceanic embayment of the Panthalassic Ocean, a large remnant of the Rheic Ocean, existed between North and South America. This ocean was successively closed during the Permian. The retreat of this water body displaced the source area of moisture for central North Pangaea stepwise to the West. With increasing distance from the ocean, the aridization and the monsoon system strengthened. The stronger monsoon system transported more clouds to the offshore area. The result was less precipitation on the continent. Later, at the end of the Gondwana Glaciation in the Artinskian, oceanic circulation was rearranged. This led to a cold coast parallel ocean current that induced chert sedimentation on the shallow shelf along the west coast of North Pangaea. The cold-water surface temperatures blocked moisture coming with the westerly winds. Maxima of aridity were reached during Roadian and Wordian times and in the Late Capitanian and Early Wuchiapingian in Central Europe. A chief premise of all these hypotheses is that the major part of the precipitation was sourced to the west. The Trans-Pangaean Mountain Belt was non-existent in the new palaeogeographic reconstruction (Roscher & Schneider, 2006). The altitude of the Hercynian mountain system never exceeded an average of 2000 m, and the maximum elevation of the Trans-Pangaean orogeny shifted during time from the east to the west with the ongoing closure of the Rheic Ocean. The Hercynian orogen never acted as a large orographic barrier blocking moisture and precipitation from the west. The Variscian orogen was levelled down at least by the middle Stephanian (Kasimovian). The lack of an orographic East–West barrier led to a strong seasonality. The Inter-Tropical Zone of Convergence (ITC) was displaced over larger distances than today. This huge displacement of the associated precipitation area caused two seasons at the equator – a rainy and a dry season, proven by warved lake sediments. Outspreading red beds are typical for this increasing aridization. But those general term has to be more specified in the type of wet red beds (Schneider et al., 2010), appearing first in the Late Westphalian (Late Kasimovian), which are displaced by dry red beds appearing first in the Kungurian in Central Europe. Possibly, on the East European platform, in the Vjatskian area East of Moscow and in the Volga-Kama region nearby Kazan a further type of Permian red beds must be discriminated.

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Carboniferous and Permian nonmarine-marine correlation – methods, results, future tasks

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The Late Carboniferous and the Permian was a time in Earth's history of an exceptionally low global sea level because of the Late Palaeozoic glaciations and low sea floor spreading rates. Consequently, most of the sediments were stored on land, including widespread coal and salt deposits as well as source and reservoir rocks for hydrocarbons of high economic value. Additionally, the Carboniferous and Permian were the time of enhanced terrestrialization and rapid diversification of the biota on land, and the time when at the end of the Middle and the Late Permian the most severe mass extinctions occurred in both the marine and terrestrial ecosystems. Unfortunately, the understanding of the interactions of abiotic and biotic processes in the seas and on land and the interactions between both "mega-habitats" is still hampered by the largely missing correlation of marine and nonmarine stratigraphic scales. Additionally, biostratigraphic tools for the exploration of natural resources in the Middle and Late Permian mostly fossil-poor red beds are still missing.

During the last four years the Pennsylvanian-Cisuralian time scale was highly improved by numerous ID-TIMS U-Pb zircon ages from the Donets basin (Davydov et al., 2010) and the type region of the Carboniferous/Permian boundary in the Pre-Uralian foredeep (Schmitz and Davydov, 2012). Based on these isotopic ages, quantitative marine biostratigraphy, and cyclostratigraphy, a robust and consistent correlation chart for East Europe and North America (Davydov et al., 2012) as well as precise Carboniferous and Permian global timescales are available now (Davydov et al., 2012; Henderson et al., 2012; Shen et al., 2013).

Moreover, during the last three decades increasing progress has been made to correlate the exclusively terrestrial Late Pennsylvanian and Early Permian deposits of the European basins based on biozones of cockroachoid insects (Blattodea, Spiloblattinidae) and of small branchiosaurid amphibians (Temnospondyli, Dissorophoidea) (Schneider, 1982; Werneburg, 1989a,b; for details see Schneider & Werneburg, 2006, 2012). Despite this, the link to marine standard sections, as shown, for example, in the correlation charts of Roscher & Schneider (2005) and Schneider & Werneburg (2006), was based primarily on scattered and often ambiguous isotopic ages from the latest Stephanian and the Lower Rotliegend (Gzhelian to early Sakmarian) of Germany (cf. Menning et al., 2006; Lützner et al., 2007). Regrettably, for most of the Late Pennsylvanian and Early Permian, isotopic ages are rare in either terrestrial or marine deposits (Breitkreuz et al., 2009; Davydov et al., 2010; Falcon-Lang et al., 2011; Pointon et al., 2012). During the past few years the situation has improved considerably with the detailed investigation of nearshore coastal marine and terrestrial deposits with interbedded conodont- and/or fusulinid-bearing marine horizons and brackish water to freshwater insect-bearing deposits in New Mexico (Schneider et al., 2004, 2013; Lucas et al., 2011, 2013) as well as by the discovery of insect horizons in similar mixed marine/nonmarine strata in the Ukrainian Donets basin in 2012.

At present, the following levels can be correlated directly to the global marine scale by co-occurrences of marine and nonmarine zone fossils. Isotopic ages are used as support if they are consistent with the biostratigraphic data.

The marine-lagoonal deposits of the Tinajas Member, Atrasado Formation, of the Kinney Quarry, New Mexico, contain the spiloblattinid zone species *S. allegheniensis* form K (Schneider in Lucas et al., 2011). About 3 m below the stratigraphic level of the quarry a 0.3-m-thick fusulinid wackestone occurs, which is dated as Early/Middle Missourian (late Early Kasimovian). The conodont fauna from unit 1, a marine limestone at the quarry floor, is provisionally assigned to the Middle Missourian, Early to Middle Kasimovian, *Idiognathodus confragus* Zone of the Midcontinent conodont zonation by Barrick in Lucas et al. (2011). Consequently, the Western European Late Stephanian A/Early Stephanian B equates to the Middle Missourian or Middle Kasimovian, respectively, based on Schneider & Werneburg (2006, 2012).

The type horizon of the zone species *Syscioblatta lawrenceana* of the *Sysciophlebia rubida-Syscioblatta lawrencea* zone is the Lawrence Shale of the homonymous formation, Lower Douglas Group, Midcontinent basin of Kansas. This formation belongs to the Cass cyclothem at the base of the Virgilian and is assigned to the *Streptognatodus zethus* zone at the very base of the Virgilian or latest Kasimovian, respectively (Heckel, 2013; Barrick et al., 2013). The Early Virgilian Oread Limestone above the Lawrence Shale belongs to the *Idiognathodus simulator* zone, which defines the base of the Gzhelian (Barrick et al., 2008). With regard to Western Europe (occurrence in the Krkonoše-Piedmont basin, Czech Republic), the *S. rubida-Sbl. lawrenceana* zone is situated in the Stephanian B (Schneider & Werneburg, 2006, 2012).

The top of the Western European (biostratigraphic) Stephanian is tentatively set now at 300 Ma in the latest Gzhelian based on intrusion ages of volcanites published by Breitkreuz et al. (2009) and defined by the LAD of *Sysciophlebia euglyptica* (Schneider et al., 2013).The base of the European (lithostratigraphic) Rotliegend is marked by the FAD of the subsequent zone species *Sysciophlebia ilfeldensis* and the slightly higher base of the *Apateon dracyiensis-Melanerpeton sembachense* amphibian zone. Consequently, the *Sysciophlebia ilfeldensis* zone stretches across the Ghzelian/Asselian boundary, which is supported by the occurrence in the *Streptognathodus nevaensis* conodont zone of the Red Tanks Member, Bursum Formation, of New Mexico, which is Early to Middle Asselian in age (Lucas et al. 2013).

Accordingly, an Early or Middle Asselian to earliest Sakmarian range of both the subzones of the following *Sysciophlebia balteata* zone can be inferred. Given that the mean duration of a spiloblattinid insect zone is about 1.5 to 2 Ma, the upper limit of the *S. balteata* zone is Early Sakmarian. This is in good agreement with the 289 $\pm$ 4 Ma (Pb/Pb) transitional Asselian/Sakmarian age for the Upper Buxieres Formation of the Bourbon l'Archambault Basin in France, where the succeeding *S. alligans* zone together with the *Melanerpeton pusillum-M. gracile* amphibian zone was demonstrated (Werneburg, 2003; Schneider & Werneburg, 2012).

The last reliable isotopic age of 290.6 ± 1.8 Ma (SHRIMP U–Pb) for Central Europe and the whole Euramerica too comes from the Chemnitz Petrified Forest pyroclastics, but unfortunately no insect or amphibian zone species has been found so far in the ongoing excavations (Rößler et al., 2013). Unfortunately, this is the last direct link to the marine scale before the Late Permian marine Zechstein transgression into the Central European Southern Permian basin, which is dated by the conodont *Mesogondolella britannica* as Wuchiapingian (Legler et al., 2005; Legler and Schneider, 2008). That means that for about 30 my, beginning in the Middle Cisuralian and lasting up to the Early Lopingian, no link of Euramerican continental deposits to the marine standard scale exists! Promising areas for Middle to Late Permian continental biostratigraphy and links to the marine scale are the Lodéve basin in Southern France (Schneider et al., 2006), the classical type regions of the Permian on the Russian platform e.g. the Volga-Kama region in Tatarstan (Silantiev, 2014) as well as mixed marine/continental sequences in South and North China (Shen et al., 2011). We have increasing biostratigraphic data for correlations with North Africa (Hmich et al., 2006; Voigt et al., 2010) but not for the Gondwana-Euramercia correlation - this is one of the major gaps in our knowledge!

Of course, we have data for continental-continental correlations, as, for example, the land-vertebrate faunachrons of Lucas (2005, 2006), the tetrapod biostratigraphy of Russian workers, e.g., Golubev (2000), and some scattered isotopic ages from the Karoo basin (Bangert et al., 1999; Stollhofen et al., 2000). Fortunately Late Permian/Early Triassic conchostracan biostratigraphy supported by isotopic ages from South and North China is in progress by the Sino-German Cooperation group on Late Palaeozoic Palaeobiology, Stratigraphy and Geochemistry. Additionally, in the frame of an German Research Foundation project as well as an international project of the Kazan Federal University, Russian-German cooperation will provide valuable data in the nearest future for Middle Permian to Early Triassic conchostracan biostratigraphy in synthesis with the very detailed and sophisticated biostratigraphic, magneto- and chemostratigraphic data of Russian workers (e.g. Silantiev, 2014 and in prep. 2015; Golubev, 2000). Cooperation and sampling of all the scattered data will be the main task of the Nonmarine-Marine Correlation Working Group. The synthesis of those data from as many continental basins as possible, especially of those with mixed non-marine/marine deposits, will be the solution of problems of cross correlation of marine and continental chronologies, phenomena, and processes.

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Comparison of Late Permian to Early Triassic conchostracan faunas in Germany and Russia

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Late Permian to Early Triassic key-sections in Germany and central Russia have been sampled bed-by-bed for the study of conchostracans (Crustacea: Spinicaudata). The aim of this current research project is a stratigraphic correlation of nonmarine sections with the international marine scale. To achieve high stratigraphic resolution, conchostracan biostratigraphy is used in combination with litho-, chemo-, and magnetostratigraphy as well as radiometric age determinations.

In Germany the conchostracan fauna has been reinvestigated in classical and new outcrops in Saxony-Anhalt and Thuringia (e.g., sections at Caaschwitz quarry, Thale railway cut, Nelben clay pit, Sangerhausen highway cut, Bücheloh road cut, Beesenlaublingen quarry). The new results from the upper Fulda Formation (Zechstein Group) and the Calvörde Formartion (Lower Buntsandstein Subgroup) indicate a fauna consisting of *Palaeolimnadiopsis vilujensis* and *Euestheria gutta* (Fig. 1). The occurrences of *Falsisca eotriassica* or *Falsisca postera*, which have been reported by previous workers (e.g., Kozur & Weems, 2010), could not be confirmed. Instead, the new results suggest that *Falsisca postera* and *Falsisca eotriassica* in reality resemble *Palaeolimnadiopsis vilujensis* and morphologic high variable *Magniestheria mangaliensis*, respectively. The conchostracans from the overlying Bernburg Formation (Lower Buntsandstein Subgroup) include spined *Cornia germari* and radially ribbed *Estheriella marginostriata*.

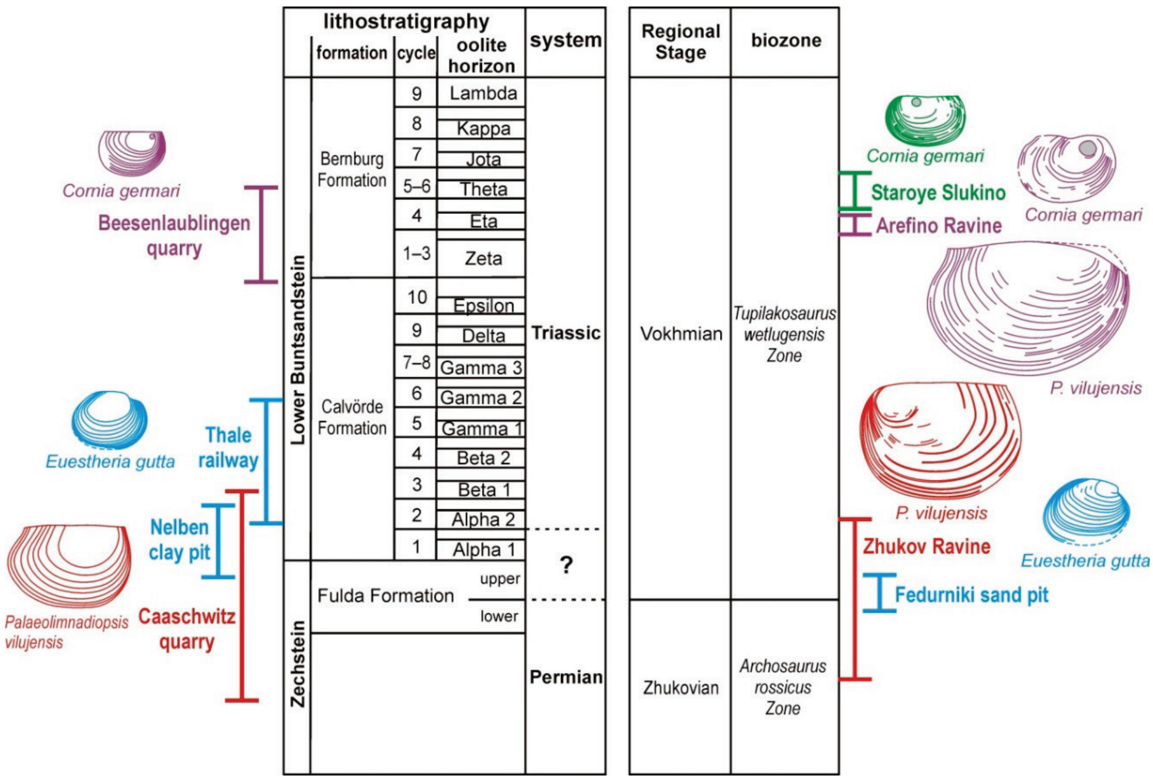

Fig. 1. Comparison of the Early Triassic conchostracan faunas in the studied sections in Germany and central Russia.

The new conchostracan material from central Russia (Vladimir region) was collected near Vyazniki and Gorokhovets during joint Russian–Polish–German ongoing field campaigns. The first results from the Vokhma Formation (Vokhmian Regional Stage, Early Triassic) in sections at Zhukov Ravine, Arefino Ravine, Staroye Slukino, and Fedurniki sand pit indicate a fauna consisting of *Euestheria gutta*, *Cornia germari* and *Palaeolimnadiopsis vilujensis*. Additionally, occurrences of *Magniestheria mangaliensis* and *Rossolimnadiopsis* sp. have been identified. Especially the presence of the *Euestheria gutta*–*Cornia germari* fauna in the Early Triassic intervals of the studied sections in both Germany and Russia demonstrate the great importance of conchostracan biostratigraphy in nonmarine environments.

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Depositional model of the East European Platform during Kazanian (Roadian) times

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The type area of the Kazanian regional stage (correlated with the Roadian stage) is located near Kazan in the Volga-Kama region, Tatarstan, Russia. Within this area, the Kazanian reaches a thickness of up to 100-200 m, with marine carbonates (limestones, dolomites) in the west-southwest and a progressive change from grey-coloured marine and lagoonal deposits (limestone, dolomite, marlstone with siltstone and gypsum intercalations) to continental red-coloured deposits (siltstone, claystone, marlstone, sandstone alternations) towards the east-northeast.

During Kazanian times, the eastern part of the East European Platform was covered by an elongated, bay-shaped marine basin (600-1200 x 3000 km) connected with the Boreal Ocean in the Northwest. The bay shows a south-east to north-west extension and was located approximately between 15° and 40° north latitude, in arid and semiarid climate zones in the south and sub-humid to humid climate zones in the north.

A desert plain composed of eroded sulfate and carbonate adjoined the bay from the southwest. The northeast coast of the bay was characterized by foothill lowlands (with a width of 50 to 500 km) with numerous lakes, which were filled by rivers flowing down from the Ural Mountains. The mountain slopes were covered by a red-coloured weathering crust whose materials were transported in large volumes by rivers to the plain. This process led to the formation of thick red-coloured continental successions containing lacustrine, alluvial and soil deposits. Thus, during Kazanian times, two different but connected sedimentary basins are located within the East European Platform: a marine and continental, each characterized by distinct biota. The entire Kazan Sea area can be subdivided into seven distinct depositional environments from the West to the East (Forsh, 1955; Golubev, 2001; Silantiev, 2001) (Fig. 1).

1. West Bank of the Kazan Sea. A flat, plateau-like area formed by Carboniferous and Early Permian carbonate rocks (“White desert”). This area is characterized by weak erosion due to weathering. The climate was hot and dry (arid). There was hardly river systems developed. Minor soil-forming processes and only sparse vegetation are assumed. Faunal elements are rare, only arthropods and small lizard-like forms of tetrapods were present.

2. Hypersaline, protected lagoons. The influx of freshwater and terrigenous material from the western shore of the Kazan Sea was strongly limited. The salinity of the water in the lagoons was periodically increased. During these times, gypsum and salt were accumulated. The climate was hot and fairly dry (arid). Biotic elements are rarely present by microbial bioherms. The characteristic lithologies are wavy-bedded limestones interbedded by gypsum and rock salt.

3. Bioherms and reefs. Large reefal bodies formed by bryozoans, crinoids, corals and brachiopods. In places these build-ups raised above the sea surface and built the ridges separating the lagoons with increased salinity from the open sea. It is assumed that the islands were covered with sparse vegetation. Faunal elements include also cephalopods, gastropods, bivalves, conodonts, and fishes.

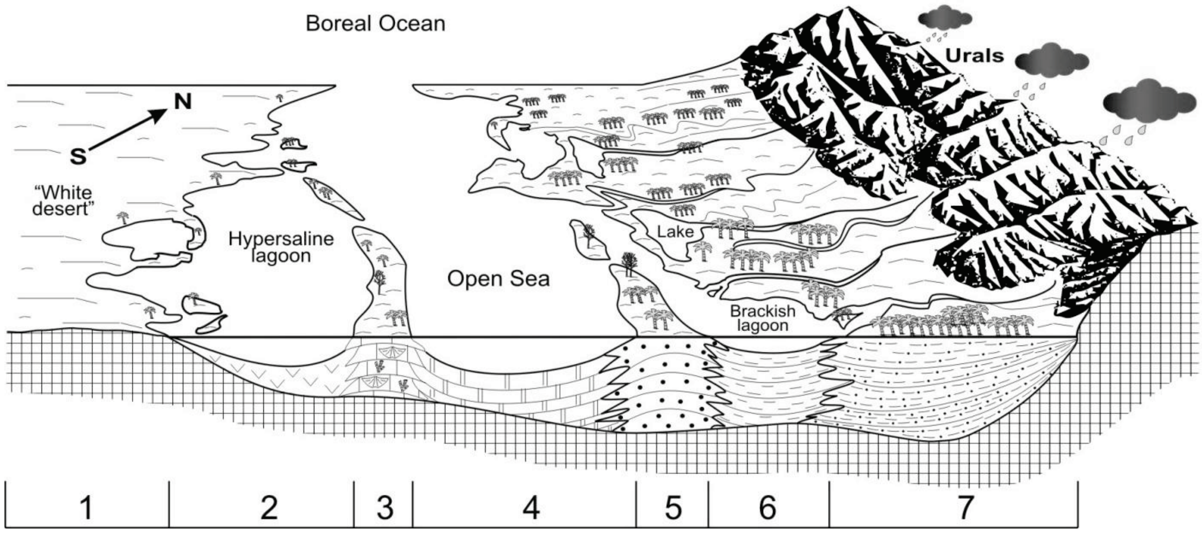

Fig. 1. Depositional model of the study area, modified after Golubev (2001) and Silantiev (2001). 1. West Bank of the Kazan Sea ("White desert"), 2. Hypersaline, protected lagoons, 3. Bioherms and reef buildups, 4. Open Sea, 5. Bars and barrier islands, 6. Brackish lagoons and deltas, 7. Alluvial-lacustrine plains.

4. Open Sea. A very narrow zone with predominantly carbonate sedimentation. The dominant lithologies are limestones and secondary dolomites. A high degree of bioturbation points to an oxic environment with diverse benthic biota.

5. Bars and barrier islands. These large ribbon-like sand bodies were elongated parallel to the coast, separating the open sea from the brackish lagoons. Due to humid climate conditions, the vegetation is diverse and lush. Invertebrates include various shallow-water forms of brachiopods and bivalves. The dominant lithologies are sandstones with wave ripple marks and oolitic limestones; the latter characterize the transitional zone from sand bars to the open sea. There are numerous fishes and rare aquatic tetrapods (temnospondyl amphibians) in this zone.

6. Brackish lagoons and deltas. Deltaic successions contain deposits of copper ore (copper sandstones), coal and bitumen. Floral and faunal elements are similar to those known from the alluvial plains. Lagoons were characterized by varying desalination. In some lagoons, clay and organic-rich sediments were accumulated; other lagoons contain mainly carbonate sediment. This depositional zone is characterized by shallow basins with a less agitated hydrological regime, partially or completely isolated from the open sea by sand bars and spits. Stagnant conditions periodically arose in these basins. Predominant lithologies are limestones with fine horizontal lamination, clays with thin layering, and numerous thin seams of coal. Limestones are often bituminous in varying degrees; coquinas are common. Faunal elements include euryhaline invertebrates (bivalves, gastropods, serpulids), insects, numerous fish (often complete skeletons) and exclusively aquatic tetrapods (temnospondyl amphibians, seymouriamorph parareptiles, and middle-sized carnivorous therapsid reptiles).

7. Alluvial-lacustrine plains forming the east bank of the Kazanian Sea. Vast lowland characterized by a perfectly aligned relief gradually rising towards the Urals. The climate is sub-humid and probably seasonal. This is an important feature of the east bank and different from the west bank zone.

Climatic differences between the east and west banks determine the asymmetric facial profile of the Kazanian Sea: a large amount of terrigenous sediments, sand bars, lagoons rich in organic matter, marshes and swamps, diverse and abundant terrestrial floral and faunal elements in the East; bioherms, saline lagoons, terrestrial environments with sparse vegetation in the West. Due to the high humidity, the eastern area was characterized by lush vegetation. Localities of fossil flora (including wood fragments in fluvial sandstones) are known from deposits which had been formed in lakes, oxbow lakes, floodplains and river channels. Fossil invertebrates (ostracods, conchostracans, non-marine bivalves) are abundant. Also, localities of fish and terrestrial vertebrate findings (amphibians and various herbivorous and carnivorous reptiles) are known in many places representing this eastern area, dominated by cross-bedded sandstones, sandstones with ripple marks, fluvial conglomerates, and paleosoils.

New palynological data from the Kazanian stratotype section (Götz & Silantiev 2014) support the above presented depositional model: different relative abundances of sporomorphs indicate changes in the upland and lowland vegetation, e.g. development of lake and river systems, moving of the shoreline, uplift in the hinterland as documented in the sedimentological record.

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and by the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

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Multidisciplinary stratigraphic research of the Middle and Upper Permian of East European Platform (preliminary results of 2013-2014)

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The main goal of research is to establish a complete record of non-marine correlation proxies including bio-, magneto-, chemostratigraphy and especially radiometric geochronology. The work is carried out in preparation for the XVIII International Congress on Carboniferous and Permian; Kazan, Russia, August 7-15, 2015.

Six key sections were studied: Monastery Ravine (Urzhumian-Severodvinian including Kiaman-Illawarra Reversal interval), Pechishchi (Kazanian), Cheremushka Ravine (Urzhumian), Sentyak (Ufimian-Urzhumian), Karkali (Ufimian-Kazanian), Shugurovo (Ufimian-Kazanian). In total more than 300 meters of the section have been measured and about 1,000 samples were taken for different analyses.

Detailed descriptions and photo documentation of stratigraphic units collection of oriented and georeferenced samples allowed to build a unique sample database. All samples are stored in Geological Museum of Kazan University.

The details were achieved by description of several outcrops within each section with their precise correlation with each other. For example, the section in the Monastery Ravine was constructed on the base of 18 outcrops where more than 400 layers were recognized.

Each sample has a unique high-altitude coordinate mark, to which all analytical data (existing and future) are tied. This enables to implement a consistent increment of analytical data, the addition of research methods, etc. New measurements required a new legend, which has been developed including textural features, the color of the rock, trace fossils, and palaeosoils.

Carried studies significantly updated sedimentological interpretation of the layers. For example, trace fossils and storm interlayers give more details to the section structure indicating, in some cases, a clear boundary of sedimentation.

Sedimentological and isotopic data changed our understanding of sedimentary environments and cyclicity (basin sediments, sabha, soil, etc. were interpreted).

Mineralogical and lithological studies reveal many new data on stratigraphic discontinuities, bioturbation, trace fossils, dolomitization-related imprinting-obliteration, etc.

In many cases, the newly found discontinuity surfaces in the Kazanian succession do not coincide with traditional unit boundaries.

Subaerial breccias mark changes and interruptions in sedimentation on the boundaries between marine and continental successions.

A variety of paleosoils are described from the Ufimian, Kazanian, Urzhumian, and Severodvinian continental successions.

Detailed samplings have led to new insights into the morphology of faunal groups and their phylogenetic relations. New locations of terrestrial tetrapods were found in the Monastery Ravine and Cheremushka Ravine. The phylogenetic schemes and zonal scales were refined on this basis.

New palynological data enable to interpret palaeoenvironmental changes and to perform high resolution palaeoclimatic reconstructions based on changes in palynofacies patterns and palynomorph assemblages.

Search for rocks containing syngenetic zircon is going to be conducted at Boise State University, USA. Search for juvenile datable material resulted in discovery of thin clay seams of supposed volcanigenic origin. Originally 8 kg of rock were sampled; if the shale were found to contain zircons, it was re-sampled and their weight had been increased to 80 kg.

Separation of zircons from clay samples reveals that percentage amount of zircon grains in the heavy fraction is less than 10% and their dimensions are less than 50 microns.

Syngenetic zircons would be examined by the methods of ionization mass spectrometry with thermal separation of isotopes (ID-TIMS) and thermal ionization mass spectrometry with chemical abrasion (CA-TIMS).

A synthesis of data and their integration into the international research is underway.

This work is based on the research supported by the Russian Government Program of Competitive Growth of Kazan Federal University and by the Russian Foundation for Basic Research, project nos. 13-05-00592, 13-05-00642, and 14-05-93964.

The Ural Mountains moving up on the Russian Platform and genesis of Golovkinsky's lens

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Надвиг Урала на Русскую платформу и формирование чечевицы Н.А.Головкинского

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В странах бывшего Советского Союза, тектоника литосферных плит (ТПЛ) долго не признавалась как новая парадигма геологической науки. Более того профессор МГУ В.В. Белоусов вплоть до Московской сессии МГГС 1971 года прямо называл ее лженаукой и преподавание ее в вузах СССР было запрещено. В Казанском университете на кафедре радиоэлектроники физического факультета (заведующий кафедрой профессор Н.Н. Непримеров) автор этих строк с 1968 г. преподавал ее для физиков, специализировавшихся по гидро- и термо-динамическим методам исследования нефтяных и газовых месторождений. На геологическом факультете КГУ тектоника плит тогда не преподавалась. В 1971 г он, единственный из казанских геологов присутствовал на XV сессии МГГС, где впервые речь шла о ТЛП и спрединге океанического дна. С юбилейной сессии Академии Наук 1995 года, посвященной 50-летию окончания Второй мировой войны и эвакуации Академии Наук в Казань, ситуация изменилась. На памятную сессию в Казанский университет прибыли все, кто еще смог приехать и вспомнить тяжелые, но прекрасные годы работы в эвакуации в Казани. Приехавший на сессию акад. А.Л. Яншин решил просветить местных геологов о достижениях ТЛП, где рассказал о надвигании Урала на Русскую платформу, подтверждая свои слова результатами сверхглубокого бурения в Зилаирском синклинории, о надвиге гор Копет-Дага на Туранскую плиту, где глубокая скважина на угольном месторождении дважды встретила палеогеновые угли, причем второй раз под отложениями платформенной юры. После его выступления уже никто из казанских профессоров не противился идеям глобальной тектоники. Много лет на дальней практике со студентами-географами Педагогического института мы знакомились с грандиозным надвигом Урала на складки Тимана в районе Полюдова кряжа. Многие из них тогда уже делали свои дипломные работы по тематике дрейфа материков и расшифровке лика Земли с помощью идей и методов тектоники плит. В Казанском университете профессор В. И. Игнатьев (1976 а, б) даже изложил свой вариант образования передового прогиба Урала на краю Русской платформы и показал динамику перемещения максимальных глубин прогибания в течение всего пермского периода. Его материалы остались почти без внимания и редко упоминаются в нашей науке. Мне посчастливилось обсудить с ним его данные и дать им свое толкование, на что В.И. Игнатьев в итоге ответил: «да, видимо я поторопился и недодумал тут до конца…». Можно было понять так, что он согласился с моей версией, и я предложил ему тогда вместе опубликовать статью или вообще отправить доклад на геологический конгресс. Он вскоре умер, а делать статью на его материале я один не решился просто по этическим соображениям. Теперь, по прошествии более пятнадцати лет, можно сказать, что идея была верной. Надвигание Урала на платформу, действительно привело к выжиманию пластичной астеносферы и медленному продвижению ее вала на запад. С такой же скоростью происходило накатывание прогиба на платформу (Рис. 1) и возникновение параллельных Уральскому хребту структур Вятского вала, Окско-Цнинского вала, Доно-Медведицких и др. структур, как обнаружил по палеогеографическим картам в свое время акад. А.П. Карпинский. Суть закона Карпинского и Эмиля Ога как раз и касается взаимодействия платформы с горно-складчатыми сооружениями на их контакте и хорошо укладывается в рамки тектоники литосферных плит.

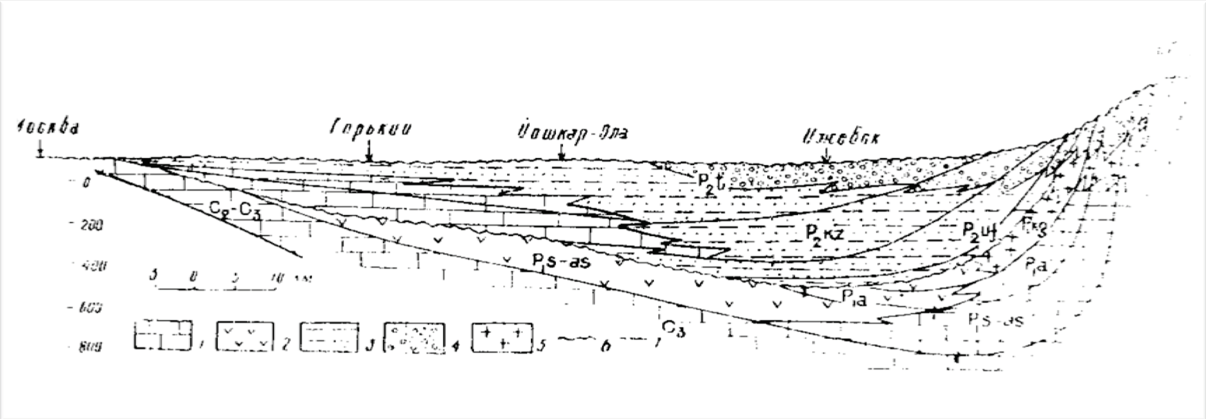

Рис.1. Накатывание передового прогиба на край платформы прослеживается по смещению максимальных глубин и мощностей осадков в прогибе и показывает формирование чечевицы Н.А. Головкинского в точности с его идеей связи процессов слоеобразования и тектонического прогибания (из книги В.И.Игнатьева, 1976 б).

Механизм образования прогиба оказался таким же, как и механизм образования глубоководного желоба в зоне субдукции. Только в случае образования передового прогиба происходит наползание аккреционной призмы осадков на гранитный край континента и прогибание последнего под тяжестью надвинутых складок до достижения изостатического состояния. Из данных В.И. Игнатьева (1976 б) имеем как глубину прогибания, так и скорость накатывания прогиба. Построенный график вскрывает динамику формирования и распределения мощностей осадкообразования в прогибе. Сопоставление скоростей этого процесса с гляциоизостатическим всплыванием блоков земной коры в Скандинавии указывает на роль астеносферы в этом процессе при значениях вязкости ее вещества примерно 10^{17} раз.

Игнатьев В.И. (1976а): Развитие Русской платформы в верхнем палеозое. Казань: Изд-во Казаню ун-та: 256 с.
Игнатьев В.И. (1976б): Формирование Волго-Уральской антеклизы в пермский период. Казань: Изд-во Казаню ун-та: 256 с.

The plate tectonic effect on geologic and geographic phenomenons

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Геолого-географические следствия тектоники литосферных плит

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В странах бывшего Советского Союза тектоника литосферных плит (ТЛП) долго не признавалась как новая парадигма геологической науки. Более того проф. МГУ В.В. Белоусов вплоть до Московской сессии МГГС 1971 года прямо называл ее лженаукой и преподавание ее, как и теории А. Вегенера, в вузах СССР было запрещено. Известно, что в МГУ ее достижения втайне и только в избранном составе изучались на семинарах океанолога С.А. Ушакова. В Саратовском университете – ее преподавал Васильев. В Казанском университете Г.В. Сонин на кафедре радиоэлектроники физфака с 1968 г. преподавал ее для физиков, специализировавшихся по методам исследования нефтяных и газовых месторождений. На геологическом факультете КГУ тектоника плит не преподавалась. После выхода на пенсию в 1980 г. В.В. Белоусова ситуация несколько изменилась, но отставание советской науки от запада в этом вопросе уже составляло 15-20 лет. В преподавании геолого-географических дисциплин оно почти не изменилось до сих пор. Министерство образования в 1985 г. провело Всесоюзное совещание в Челябинске, где было принято решение о введении преподавания элементов ТЛП для студентов педагогических вузов географического и биологического профилей. В Казани лекции и мой спецкурс на естественно-географическом факультете Педагогического института и на курсах повышения квалификации учителей географии в Институтах Казани, Пензы, Чебоксар и Йошкар-Олы очень долго оставались исключением. На геофаке КГУ ее начали преподавать только после 1995-го года, с момента Юбилейной сессии, посвященной 50-летию окончания войны и эвакуации Академии Наук в Казань. На памятную сессию Академии наук в университет прибыли все, кто еще смог приехать и вспомнить прекрасные годы работы в Казани. Приехавший на сессию акад. А.Л. Яншин решил просветить местных геологов о достижениях ТЛП, где рассказал о надвигании Урала на Русскую платформу и результатах глубокого бурения. Оказалось, что Зилаирский синклинорий, типично геосинклинальная структура, покоится на платформенном основании, он был надвинут на платформенные отложения карбона по листрическому надвигу. Это были первые достижения советской геологии, подтверждавшие идеи тектоники плит. С этого момента началось преподавание ТЛП на геологическом факультете и то искаженно - в виде эклектического гибрида с геосинклинальной теорией.

В географии, как современной, так и исторической, т.е. в палеогеографии, важной проблемой является вопрос размещения континентов и океанов на поверхности Земли. На лике Земли большой проблемой было и расположение горных хребтов. В статье Зюсса 1896 года, горы подразделялись на складчатые, глыбовые и складчато-глыбовые. В вузовских и школьных учебниках эта классификация гор присутствовала без малого сто лет. И даже сейчас географы не имеют представления о действительной природе гор, их строении и законе размещения на Земле.

Согласно ТЛП выделяется семь типов гор, три типа землетрясений и три типа вулканов. Выделяемые горно-складчатые сооружения, вулканы и типы землетрясений, в ТЛП хорошо связываются с зонами субдукции, с зонами дивергенции и с трансформными разломами. Их структурно-тектоническое положение и механизм образования тесно связаны и легко могут быть усвоены даже не специалистами. Отдельно от этой схемы стоят только вулканы «горячих точек».

Все землетрясения делятся на два класса: глубокофокусные, приуроченные к зонам субдукции и глубоководным желобам (преимущественно вокруг Тихого океана: Алеутская, Курило-Камчатская, о-ва Тонга и Кермандек и др.) и мелкофокусные, приуроченные к зонам дивергенции и трансформным разломам на срединно-океанических хребтах (Кларион, Клиппертон, Мендосино и др.).

Горно-складчатые сооружения семи типов следующие (Сонин, 2003).

1. Горы типа Срединно-океанических хребтов (длиной 70000 км, шириной 2-3 тысячи км, высотой до 4,5 км), приуроченные к зонам дивергенции.

2. Горы типа Анд, приуроченные к зоне субдукции океанической плиты под континентальную и обязанные своим происхождением процессу аккреции осадков дна океана перед форландом континента.

3. Горы типа Гималаев, связанные с субдукцией океанической плиты под континентальную, усложненной эффектом сжатия аккреционной призмы осадков в тисках между двумя кратонами: гранитной глыбой субконтинента Индии и континентом Азии.

4. Горы типа хребта Ломоносова, имеющего гранитный фундамент и являющегося частью шельфа Баренцева моря отторгнутого по расширяющейся трещине молодого срединно-океанического хребта Гаккеля.

5. Горы типа «островных дуг»- вулканических конусов, расположенных за зоной субдукции океанической плиты под океаническую и изливающих гибридную лаву, близкую к андезитовой.

6. Горы *типа хребта* 90^o (девяностого градуса), являющегося следом движения Индии на базальтовом ложе океана, изостатически не уравновешенным результатом работы двух гигантских трансформных разломов.

7. Горы типа Императорского и Гавайского вулканических хребтов, являющихся следом от работы «горячих точек».

Эти типовые горы встречаются и повторяются в виде других хребтов, как на континентах, так и на дне океана. Их можно видеть на прекрасной физиографической карте Мэри Тарп, Мориса Юинга и Брюса Хизена, являющейся блистательным итогом «золотого десятилетия» геологии Океана и тектоники литосферных плит.

Размещение континентов на Земле, не поддававшееся ранее никакому объяснению в тектонике плит получило логичное объяснение. Оно определяется топологией ячеек конвекции в мантии Земли, управляемой числом Релея $Ra = \alpha\beta g H^4 / \mu\eta \geq 10^3$. Конфигурация материков пермской суши наглядно показывает как выглядит расположение материков при двухячеестой конвекции на Земном шаре – оно похоже на двухлепестковое покрытие теннисного мяча: один лепесток представляет собой континент, другой океан, а линия шва между лепестками и есть срединный хребет единого океана.

Сонин Г.В. (2003): Горы, вулканы, землетрясения и другие явления в новой геологии. Изд. Казанского строительного колледжа, Казань: 76 с.

A hypothesis for archaeabacterian hydrocarbon biosynthesis in sulphidian hydrothermal vent

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О возможной роли архебактерий в синтезе углеводородов и происхождении нефти

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Теоретические разработки и полувековой опыт геотермических исследований на нефтяных месторождениях Поволжья, Северного Кавказа, Украины, Белоруссии, Средней Азии и на Камчатке (Непримеров Н.Н., Николаев С.А., Сонин Г.В., Штанин А.В., Ходырева Э.Я., Христофорова Н.Н. и др.) дали новые материалы, которые однозначно свидетельствуют о существовании вертикальной миграции флюидов в осадочном чехле. Опираясь на полученный опыт и открытия в морской геологии, авторы предлагают вниманию научного сообщества другую, альтернативную, быть может, более вероятную, но пока только рабочую – термально-бактериальную гипотезу происхождения нефти, способную по-иному осветить и может быть решать многие проблемы нефтяной геологии.

Приведем некоторые известные факты, на которых может быть основана новая термально-бактериальная гипотеза:

- явная парагенетическая связь челекенской, бакинской и татарской нефти с сульфидной телетермальной минерализацией (Миропольский,1954, Тимергазин, 1955);
- существование генетической связи АВПД и АВПТ нефтяных залежей (Осадчий, 1967; Голубятников, 1916) с притоком глубинных флюидов в нефтеносные структуры;
- наличие компонентной дифференциации углеводородов в пространстве и по глубине в каждом осадочном бассейне (Эллерн,1969);
- открытие дефицита органического вещества в нефтематеринских толщах для образования известных запасов нефти (Б.М. Юсупов, Р.Х. Муслимов и др.);
- открытие новых хемолитоавтотрофных бактерий из группы древнейших высокотемпературных сернистых и метановых архебактерий, связанных с деятельностью «черных» и «белых курильщиков» в рифтовых зонах срединных океанических хребтов (Лобье,1998; Келли, Карсон, 2008);
- вынос гейзерами и высокотемпературными гидротермами Камчатских и Курильских вулканов черных суспензий и маслянистых нефтяных пленок (Влодавец, 1949,) содержащих следы подземной микрофлоры (Заварзин,2001; Гептнер, 2002);
- совпадение диапазонов температур образования левовращающих нефтяных фракций, с термодинамическим диапазоном активности сернистых архебактерий (Леворсен и др);
- развенчание новейшими исследованиями ортодоксальной теории нефтяных биомаркеров (Гордадзе, Чудетский, Стадницкая, 2013) основного аргумента органогенно-осадочной теории генезиса нефти.

Можно предположить, что именно сернистые и метановые бактерии, являющиеся реликтами первичной анаэробной биоты Земли (подземной эндобиосферы), при необычно высоких температурах (свыше 200 градусов) и давлениях (в сотни атмосфер), способны синтезировать иное - «нефтеподобное» органическое вещество. Именно они, могут быть ответственны за генезис, по крайней мере, одной трети нефтяных фракций, имеющих температуру кипения от

225 до 300^{0}C и вращающих плоскость поляризации влево. Абиогенный хемосинтез создает термодинамически эквивалентные рацемические смеси L и D изомеров, но только живые организмы способны к синтезу и отбору левовращающих изомеров. А нефть, как известно, вращает плоскость поляризации влево, как живое вещество. При биосинтезе метана, архебактерии в качестве катализаторов используют минералы типа пирита, макинавита, молибденита и др., включая их в состав своих ферментов. Причем ионы Fe, Ni, Mo и V они получают прямо из растворов сульфидных гидротерм. Кроме того, архебактерии владеют хемоосмотическим механизмом накопления энергии электронов, протонов и ионов в виде мембранных потенциалов (от +200 до – 380 мВ), которые они используют для преодоления квантовых порогов активации молекул в биохимических процессах (Martin, 2003). Архебактерии, обитатели абиссальных глубин и предельно высокотемпературных гидротерм, «работают» и осуществляют свой метаболический цикл преимущественно в потоке гидротермального флюида в трещиноватой зоне глубинного разлома. Пока существует поток горячих углекислых или сернистых струй до тех пор существуют и неравновесные условия. Черные битумные пятна в карбонатных породах, изолированные от пластовых залежей, возможно, являются такими реликтами бактериальных колоний, запечатанных в породе последующими катагенетическими процессами (Рис.1). В нашем материале представлены три зоны развития подземной эндобиосферы, обнаруженные в пластах девона (песчаниках живетского яруса с глубины 1762 м, известняках франского яруса с глубины 1724 м и в карбонатах пермского возраста из битуминозной зоны Ромашкинского месторождения).

Исследование строения цитоплазматических мембран архебактерий из горячих источников привело к выявлению факта, что в структуре ЦПМ присутствуют термостойкие сложные углеводороды с C^{20} – C^{30} и даже с C^{40} , окруженные еще липидами и белками. А это подтверждает высказанную мысль, что нефть это и есть сама культура архебактерий вместе с продуктами своего метаболизма. Отсутствие клеточных оболочек у архей и их чрезвычайно малые размеры не позволили обнаружить их раньше, чем появились современные электронные микроскопы. Стерильная девонская нефть на самом деле состоит из сплошных архебактериальных культур и поэтому она оптически активна как живое вещество.

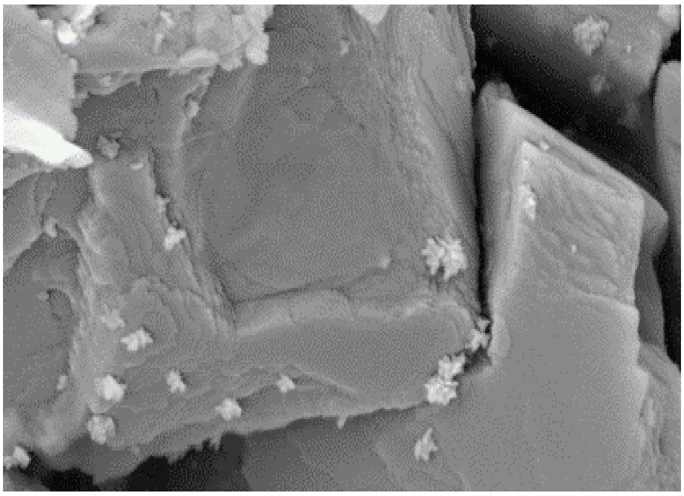

Рис.1. Колонии бактерий на кристаллах карбонатного коллектора. Размеры колоний около 100 наннометров.

Высказанная гипотеза устраняет проблему поиска нефтематеринских свит и нивелирует разницу между органической и неорганической теориями происхождения нефти.

Results of the research of the Kasimovian rocks of the Usolka section, South Ural

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The Usolka section (located near the Krasnousolsk city, Bashkortostan) is the very important object of the Carboniferous and Permian stratigraphy. The section is represented by thick series of the carbonate and terrigenous rocks of marine genesis. The deposits are characterized by abundance of conodonts (Chernykh 2010, 2011, 2012), presence of volcanic ash layers with zircon grains (radiometric age dates made by Shmitz, Davydov 2012). In preparation to the XVIII International congress on the Carboniferous and Permian, deposits of the Kasimovian stage were studied during the 2012-2014. In all, we studied 13 meters interval from upper part of the Moscovian stage to the base of the Gzhelian stage of the Carboniferous system (about 70 samples) (Fig. 1)

1. Paleontological researches. The fossil assemblages in the Usolka section containing conodonts, fishes and ammonoids. In the Moscovian stage, conodonts typical for Neognathodus roundyi Zone were found: *Gondolella elegantula* Stauffer et Plummer, *G. laevis* Kossenko et Kozitskaya, *G. magna* Stauffer et Plummer, *Idiognathodus claviformis* Gunnell, *I. obliquus* Kossenko et Kozitskaya, *I. podolskensis* Goreva, *I. trigonolobatus* Barskov et Alekseev, *N. dilatus* (Stauffer et Plummer), *N. roundyi* (Gunnell). In the Kasimovian deposits conodonts are widely distributed and are represented by the four biozones: Streptognathodus subexcelsus; Streptognathodus makhlinae, Idiognathodus sagittalis, Idiognathodus toretzianus – Streptognathodus firmus. In the upper part of the Kasimovian stage were found the ammonoids of the genus *Eoasianites* (family Gastrioceratidae), *Somoholites* (family Somoholitidae) и *Glaphyrites* (family Goniatitidae).

2. Lithological-geochemical researches include detailed lithological description of the section and study of the stable carbon isotopes behavior. Values o$\delta^{13}C$ changed from -9,32 to 3,29 ‰. Herewith, sediments of the Moscovian age and the lower part of Kasimovian age can be regarded to the normal-sedimented marine carbonates. Upper Kasimovian and Gzhelian rocks characterized by the extra-light values of the δ13C (-9,32…-4 ‰), that can point at the climate cooling in the Late Carboniferous in the studying region.

3. Research of the metallic micro particles (spiral intermetallids, magnetite microspheres) with sizes less than 1 mm. Their associated with ash beds, which can be indirect evidence of their volcanic origin. Nevertheless, we can’t exclude their meteoritic origin.

This work was funded by the subsidy of the Russian Government to support the Program of competitive growth of Kazan Federal University among world class academic centers and universities.

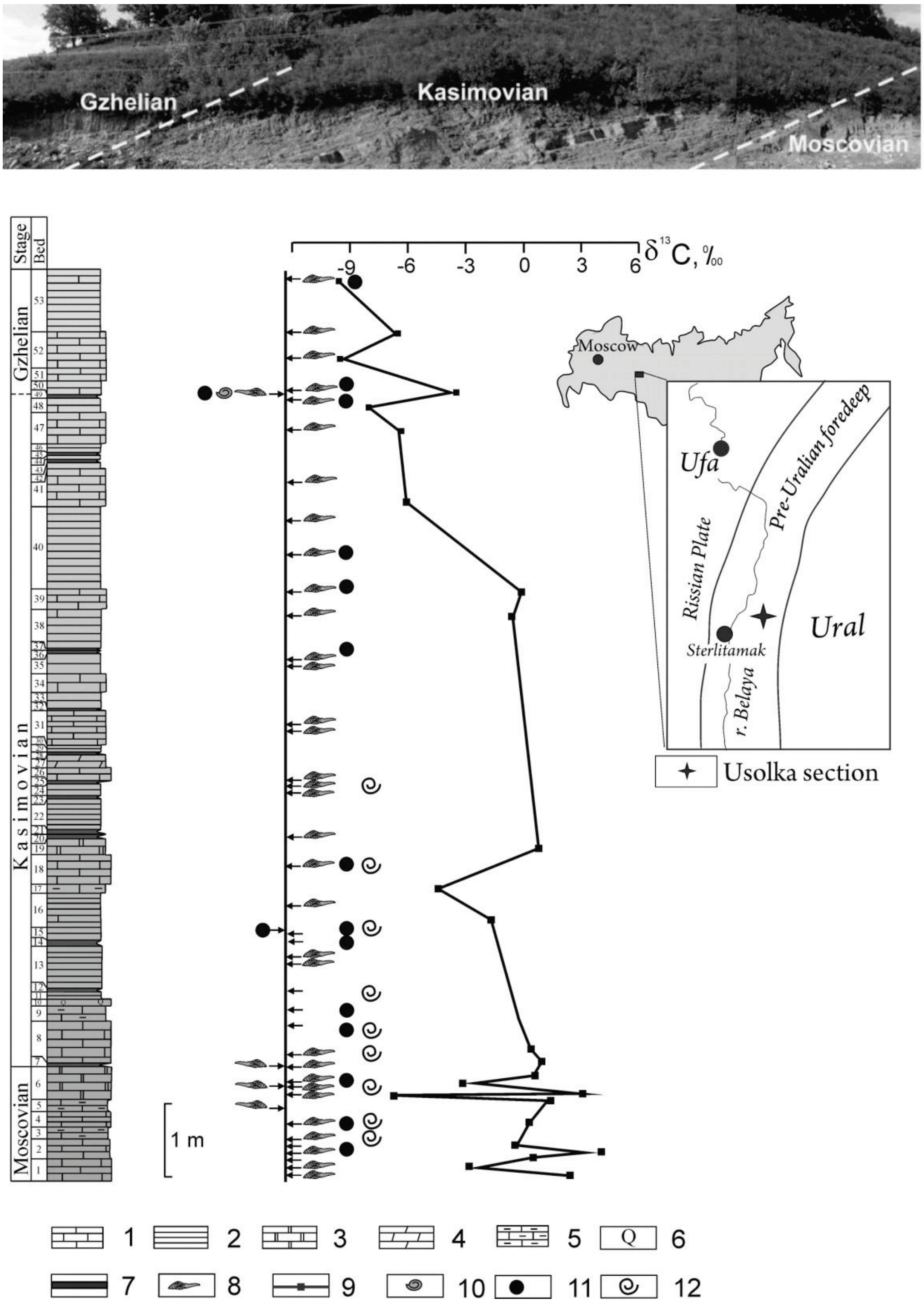

Fig. 1. The Usolka section: results of the paleontological and lithological-geochemical researches and data of researches of the metallic micro particles.
1 - limestone; 2-mudstone; 3 – dolomite; 4 – marl; 5- argillaceous limestone; 6 – silicification; 7 - ash bed; 8 – conodonts; 9 - $\delta^{13}C$; 10 - ammonoids; 11 - magnetite microspheres; 12 - spiral intermetallids

A Permian non-marine Palaeanodonta-like fauna from Eastern Europe: taxonomy, phylogeny and evolution, paleobiogeography, biostratigraphy

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Studying of Middle and Late Permian malacofauna from Eastern Europe continental basins (RFBR № 13-05-00592, № 13-05-00642; 14-04-01128) revealed a new non-marine fauna of special *Paleanodonta*-like bivalves. The basis of this fauna is the superfamily *Palaeanodontoidea*, which is coexisting with rare representatives of *Prokopievskioidea, Palaeomuteloidea, Anthracosioidea, Prilukiellioidea*. There is a big difference in morphology of taxa and taphonomy between *Paleanodonta*-like and *Palaeomutela*-like faunas, which were considered so far as the singular non-marine bivalve fauna of the Permian of Eastern Europe. Great taxonomic diversity and the original morphology of the shells suggest the presence in *Palaeanodonta*-like fauna new genera and higher taxa, some of which, according to preliminary estimates, have a resemblance with some typical genera (*Kidodia, Indomya* etc.) from Late Permian sediments of Angarida, South Africa and India Gondwana. Blooming of *Paleanodonta*-like fauna dates back to Late, Tatarian Series of Permian, and disappearance coincides with great Late Permian extinction.

Currently, a series of locations of *Paleanodonta*-like fauna – Mutovino, Ustje Strelni, Aristovo, Savvaty, located in the Vologda region had been studied.Modern microscopic, tomographic, biometric methods with using of all available features of shells are used.

This allows establishing the taxonomic diversity of the fauna and the variability of taxa, to determine the adaptive significance and homeomorphy of the individual morphological features, to reveal ethological trophical communities, to prove their phylogenetic relationships.

Deformed composite molds and imprints of separate valves, which are located subparallel to stratification planes, present the main type of bivalve taphocenosis from the Mutovino location. Shell material does not remain.

Four levels with non-marine bivalves were identified. *Concinella* Betekhtina, 1966, *Palaeomutela* Amalitzky, 1892, *Palaeanodonta* Amalitzky, 1895 and new genera with inequivalved shell (the left valve is subtriangular, the right valve is unio-like) were determined.

There are two levels with non-marine bivalves in Aristovo location.

The first level is located on the lower part of the sandy lens. Remains of bivalves are represented by the closed shells and separate valves, dispersed in the rock at different angles to the stratification planes. Shell material had been recrystallized in most cases. Association of bivalves includes *Opokiella ignatjewi* Gusev, 1990, and two morphological types, which are belonging to *Palaeomutela* Amalitzky, 1892. Morphotype with elongated shells, distinct growth lines and extending posterior end are related to *Palaeomutela fisheri* (Amalitzky) and *P.* aff. fisheri (Amalitzky); morphotype with gently elongated shells and tapered posterior end is related to *P.* keyserlingi Amalitzky.

The second level located in the lens of dark gray clays, which is situated in the middle part of the lens. Remains of bivalves are represented by deformed composite molds and prints of separated valves of unio-like shells, arranged parallel to the stratification planes. Shell material does not remain. The species *Palaeomutela fischeri* Amalitzky, *P*. sp. and *Palaeoanodonta* ex gr. *verneuli* Amalitzky are determined.

Remains of non-marine bivalves from variegated clays of Savvaty location are represented by deformed composite molds and prints of separate valves of unio-like shells and are dispersed in the rock at different angles to the stratification planes. Shell material recrystallized into thin reddish-brown clay-like film. There are two morphological types: morphotype with elongated shells related to *Palaeomutela curiosa* Amalitzky and morphotype with short subtriangular shells related to *P*. *golubevi* Silantiev. Molds and prints of large and small valves of *P*. *golubevi* have typical for this taxa ribbing. Some molds of subtriangular shells have a sharp curvature in the keel line, which is make them look like *Opokiella* Plotnikov, 1949.

As a result, two assemblages of non-marine bivalves: Severodvinian and Vyatskian were distinguished.

Inequivalved bivalves (gen. et sp. nov.) which probably can be referred to the superfamily Paleanodontoidea present the main percentage of the Severodvinian assemblage. Possibly, we can deal with a new superfamily having appeared as the result of invasion of marine bivalves into non-marine realm. Inequivalved bivalves (gen. et sp. nov.) occur with representatives of the genus *Concinella* Betekhtina, 1966, *Palaeomutela* Amalitzky, 1892, *Palaeanodonta* Amalitzry, 1895.

In the upper Vyatskian assemblage, the genus *Palaeomutela* Amalitzky, 1892 is prevailing having well defined hinge (*P. keyserlingi*) and hinge as well (*P. amalitzky*). Representatives of *Opokiella* scarcely occur in Vyatskian assemblage.

At the Savvatiy locality, species *P. golubevi* and *P. curiosa* characteristic to the terminal levels of the Late Permian have been found. These two species probably can present one biological species and that makes us suggest that the assemblage is monospecific.

Current research on the morphology, functional morphology, taphonomy and sinecology of *Paleanodonta*-like fauna allow to regulate the classification of Late Paleozoic non-marine bivalves in general, to compare *Paleanodonta*-like fauna with similar faunas from Late Permian continental basins of Angarida, Cathasia, Gondwana and to explain the reasons for the similarity of these faunas. The resulting biostratigraphic study aims to clarify the location of phylogenetic lineages of *Paleanodonta*-like faunas in the stratigraphic section, and then propose a new biozonal scale of Tatarian Series of Eastern Europe based.

Ostracods of the boundary-stratotype (limitotype) of the Vyatkian stage, Upper Permian, East-European platform

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The International Chronostratigraphic Chart (ICC) of the Permian system is based on marine sections. The Middle and the Upper Permian deposits in Russia are mainly represented by continental sediments, and that fact complicates using of the ICC because of global problems of the detailed correlation of the marine and the continental deposits. The general stratigraphic scale (GSS) is used for subdivision and correlation of the Permian system in Russia. It's based on sections on the East European platform (Fedonkin et al., 2013). The most numerous and widespread group of fossil organisms from the Permian continental deposits of the East European platform is represented by freshwater ostracods. Active research of this group was carried out by Russian micropaleontologists for more than 80 years. As a result a huge material on ostracods was collected (Molostovskaya, Lukin, 1998). At this point revision of all this materials was conducted. Specific, generic and familial features were marked. Sexual dimorphism, ostracod ontogeny and phylogeny were studied. The stages of development of ostracod fauna were reconstructed. On this basis the Middle and the Upper Permian deposits were subdivided into the six Assemblage Zones that form the baseline for the determination of stages and substages of the GSS (Molostovskaya, 2005). The boundary between the Severodvinian and Vyatkian stages of the Upper Permian (Tatarian) was fixed at the base of the *Wjatkellina fragilina - Dvinella cyrta* Assemblage Zone. The Mutovino section on the Sukhona River (Vologda region) was selected as the boundary-stratotype (limitotype) of the above-mentioned boundary. Currently active work is underway on clarifying the provisions of the boundary and search for additional markers for fixing it. During the last two years the Mutovino section was described in detail and tested on ostracods. We received the following ostracod assemblages of selected samples. *Prasuchonella stelmachovi* (Spizharskyi, 1939), *Pr. ex gr. stelmachovi* (Spizharskyi, 1939), *Suchonellina parallela* Spizharskyi, 1939, *S. cf. parallela* Spizharskyi, 1939, *S. inornata* Spizharskyi, 1939, *Sinusuella vjatkensis* (Posner, 1948) were found proximately below the boundary. *Prasuchonella cf. stelmachovi* (Spizharskyi, 1939), *Pr. cf. stelmachovi var. ovalis* (Kotschetkova, 1970), *Suchonella cf. blomi* Molostovskaya, 2001, *S. ex gr. auriculata* (Schneider, 1948), *Suchonella sp*., *Suchonellina inornata* Spizharskyi, 1939, *S. cf. inornata* Spizharskyi, 1939, *S. cf. parallela* Spizharskyi, 1939, *Darwinuloides cf. svijazhicus* (Sharapova, 1948), *Sinusuella vjatkensis* (Posner, 1948) occur at the base of the Vyatkian. The majority of species of ostracods from the above mentioned assemblage are transit. The last appearance of the Late Severodvinian ostracod assemblage was recorded in 0,4 m below the boundary. A change of conditions in this section is defined by the appearance of short-lived species *Suchonella blomi*, which is typical for bottom of the Vyatkian stage. The first appearance of this species was recorded in 1 m above the boundary. Samples of that interval were selected and are now in use.

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Stratigraphic significance of Visean erosional incision in the Lower Carboniferous terrigenous sediments of the western side of Melekesskaya Depression and their potential of hydrocarbons

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Стратиграфическое значение визейских эрозионных врезов в нижнекаменноугольном терригенном комплексе Западного борта Мелекеской впадины и их углеводородный потенциал

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В настоящее время достаточно хорошо изучен и опоискован Восточный борт Мелекеской впадины (МВ), однако существует ресурсный потенциал связанный с Западным бортом МВ, административно располагающимся в пределах Ульяновской области

МВ как крупная, сложнопостроенная структура первого порядка, основные черты строения которой, предопределены тектоникой кристаллического фундамента, четко выражена в современном региональном плане всех структурно-тектонических этажей.

Строение МВ осложнено влиянием внутриформационного Усть-Черемшанского прогиба Камско-Кинельской системы прогибов (ККСП), определившим особенности локального структурного плана территории – асимметричный характер строения валов (их крыльев и границ) и осложняющих их локальных поднятий, морфометрию последних, а также наличие «врезов», биогермов, рифов и т.д. Это привело к широкому развитию здесь разнообразных локальных форм – ловушек нефти различного морфогенетического типа: тектонических, седиментационных, тектоно-седиментационных, эрозионных, эрозионно-седиментационных и др. [1].

По имеющимся двум скважинам, вскрывшим терригеный девон более детально изучена литолого-стратиграфическая характеристика верхнедевонско-нижнекаменноугольных отложений в стратиграфическом диапозоне от верхнефранского подъяруса верхнего девона до тульского горизонта нижнего карбона. Именно литолого-фациальный облик этого комплекса отложений определяет строение Усть-Черемшанского прогиба.

Условия осадкообразования турнейского яруса в пределах исследуемой территории позволили выделить подтипы разрезов в отложениях турнейского яруса: билярский и саитовский (Шельнова, 1962).

Билярский тип характеризуется резким увеличением мощности турнейского яруса до 390 м (в скважине № 4 Северо-Камышевского поднятия толщина его достигает 230 м), обусловленной накоплением мощных толщ заволжских образований по склонам девонских обрамлений прогиба. Толщина заволжского горизонта составляет 140 м, при 60-90 м характерных для типичного разреза.

Саитовский тип разреза, характеризуется резким раздувом мощности турнейского яруса, происходящим, в отличие от билярского типа, в верхних звеньях разреза яруса. В скв. 2 (Поповкинское поднятие) мощность турнейского яруса составляет 317 м. Заволжские отложения мощностью не более 50 м представлены светлыми известковыми конгломератами и брекчиями.

Исследованиями и статистическими данными ранее было показано, что формирование залежей нефти в терригенных и особенно карбонатных комплексах турнейско-нижневизейского возраста обусловлено существованием во внешних прибортовых зонах межструктурных зон, контролируемых прилегающими структурно-эрозионными поднятиями. Тем самым подтверждалась необходимость уточнения условий образования «врезов», и их поисков в регионе. Наличие бобриковско-радаевского комплекса пород являются для нас индикатором для поиска залежей в нижнем карбоне.

Радаевско-бобриковский комплекс отложений составляет единый ритм осадконакопления. В бортовых частях прогиба наблюдается увеличение мощности песчаных образований, обусловленное как фациальным замещением верхней углисто-глинистой части горизонта, так и близостью на отдельных участках прибортовых зон ККСП подводных дельт. В силу накопления радаевских отложений в условиях резко асиметричной морфологии дна бассейна, заложенной еще в девоне, их мощности, максимальные в осевой зоне, сокращаются к северу и западу до 6,5 м (скв. 1) и 20 м (скв. 5). Наличие радаевских образований на исследуемой территории (Поповкинское и Крестовое поднятия) доказано палинологическими исследованиями. Этот факт позволяет предполагать, что нижние пачки сложены песчаными образованиями, заполняющими ложе палеорек («врезов»), в большинстве случаев имеющих радаевский возраст.

Следующий ритм осадконакопления представлен бобриковским горизонтом, характеризующимся переслаиванием песчаников и глинисто-углистых сланцев. Перерыва в осадконакоплении на границе радаевского и бобриковского времени не наблюдается. Мощности бобриковского горизонта на Поповкинско-Крестовской зоне поднятий колеблется от 7 до 35 м.

Несколько иная картина осадкообразования терригенной толщи визе наблюдается в районе Северо-Камышлинского поднятия. Здесь отсутствуют радаевские отложения, а бобриковские (толщиной 20 м) представлены лишь верхнебобриковской пачкой. По-видимому, это можно объяснить перерывом в осадконакоплении, так как предшествующая (позднедевонско-турнейская) геологическая история прибортовых зон прогибов ККСП характеризовалась высоким рельефом, обусловленным накоплением значительных толщ биогенных, в т.ч. девонских) образований.

Тульские отложения имеют среднюю мощность 10-12 м и являются началом нового ритма осадкообразования.

Нижнемалиновская толща (радаевский горизонт) слагается разнозернистыми песчаниками и алевролитами. Породы обычно отличаются постоянным присутствием смеси глинистой, алевритовой, песчанистой фракций и углистой примеси. Песчаники мономинеральные, кварцевые.

Отложения бобриковского горизонта сложены алевритовыми и песчаными породами. В этих пачках имеются углистые прослои (толщиной до 2 м) и углистые сланцы.

Открытые бобриковско-радаевских залежи нефти относятся к трудноизвлекаемым, так как нефти вязкие, тяжелые, что свидетельствует о процессах разрушения.

Необходимо отметить приуроченность зон высокой концентрации нефти и битумов в каменноугольных и пермских отложениях к мобильным тектоническим участкам МВ. Здесь установлено совпадение в плане нефтеносных и битуминозных площадей в стратиграфическом диапазоне от нижнего карбона до среднего карбона. Таким образом, установленные соотношения между нижне- и среднекаменноугольными зонами нефтебитумонакопления, выделение в разрезе практически одной основной нефтепроизводящей свиты, заставляет признать единство стратиграфически разновозрастных нефтей.

Однако знакомство с качеством нефтей отдельных многопластовых месторождений и сопоставление нефтей отдельных многопластовых месторождений на первый взгляд показывает наличие большого разнообразия.

На этом основании многие исследователи пытаются доказать как разновозрастность нефтей платформы, так и наличие различных источников ее генерации (Бадамшин, 1978).

Наблюдаемые различия зависят от степени геохимической разрушенности нефтей, которая, в свою очередь, зависит от физико-химических условий среды, минерализации пластовых вод и условий глубинного водообмена, заселенности пластов разрушающей нефть пластовой микрофлорой, степени изолированноси залежей от пластовых вод, размеров залежей и ряда других факторов.

Благоприятная обстановка для сохранения нефти и битумов связана с высокой минерализацией вод и наличием восстановительных условий.

Значительная геохимическая разрушенность нефтей перечисленных площадей, несомненно, связана также с интенсивностью и продолжительностью водообмена.

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Golovkinsky`s Law and tectonic-eustatic modeling

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Nikolai A. Golovkinsky (1834 – 1897), first professor and leader of the Kazan School of Geology, studied the Upper Paleozoic sedimentary deposits in the Volga-Kama basin near Kazan. He established that the Permian strata display a wide variety of facies as their paleogeographic and biotic evolution was associated with shoreline migration landward or basinward.

In the second part of the XIX century, a Swiss geologist A.Gressly introduced the Concept of Facies (1838), and it was a part of his significant contribution to the foundations of modern stratigraphy.

Professor N.A.Golovkinsky firstly gave the Russian equivalent to the term "Facies". He firstly discovered the Facies Migration Law (Golovkinsky, 1868), which says that facies migrate under the influence of the shoreline migrations. The main contribution of N.Golovkinsky to geology was his formulation of the main principle of the new trends in science, which was further called "Chronostratigraphy." He wrote that boundary surfaces of geologic bodies are not totally synchronous throughout their stretch. Moreover, the rate of age changes of these surfaces increases in the perpendicular direction from the shoreline.

Then the Law was updated by a famous German geologist J. Walther (1894). He discovered "The Facies Correlation Law" which postulates that only those facies can overlay each other in the geologic section, which lay beside each other now". Probably, the Swiss, Russian and Germain scientists worked in parallel directions, but undoubtedly their joint contribution to geologic science can not be overstated. There is no doubt that Gressly`s "Facies", Golovkinsky`s and Walthers`s Laws are actual in present days.

The prehistory of the Golovkinsky`s the Facies Migration Law is related to earlier work of Antoine Lavoisier (1789). "By 1789 Lavoisier recognized that gravel can only be moved by waves near the shore whereas finer sediment can be carried into deeper water, and that each environment had distinctive organisms" (Prothero and Schwab, 2004).

N.A.Golovkinsky discovered that when the shoreline of platform sea migrated cyclically, the shape of the lithologic body was similar to the lentil. Now we used to call the platform sequences like Golovkinsky called them – "Litho- and Bio-Lentils."

Modern sequences are defined as the continuous series of sedimentary rocks accumulated under the influence of eustasy and separated by unconformities (Van Wagoner et al., 1990). It is a well-known fact that facies architecture and space configuration of continental-margin sequences and platform sequences are different due to different basin profiles.

It is well known that interaction between global sea level changes and tectonics is responsible for changes in the regional sea level and, consequently, basin **deepening** or **shoaling**, on the one hand, and for transformation of the basin configuration with its expansion or reduction, i.e., **transgression** or **regression**, on the other.

The scheme on Fig. 1 shows that regional sea level fluctuations and transgressive–regressive regime of the basin together characterize the accommodation space available for sediments.

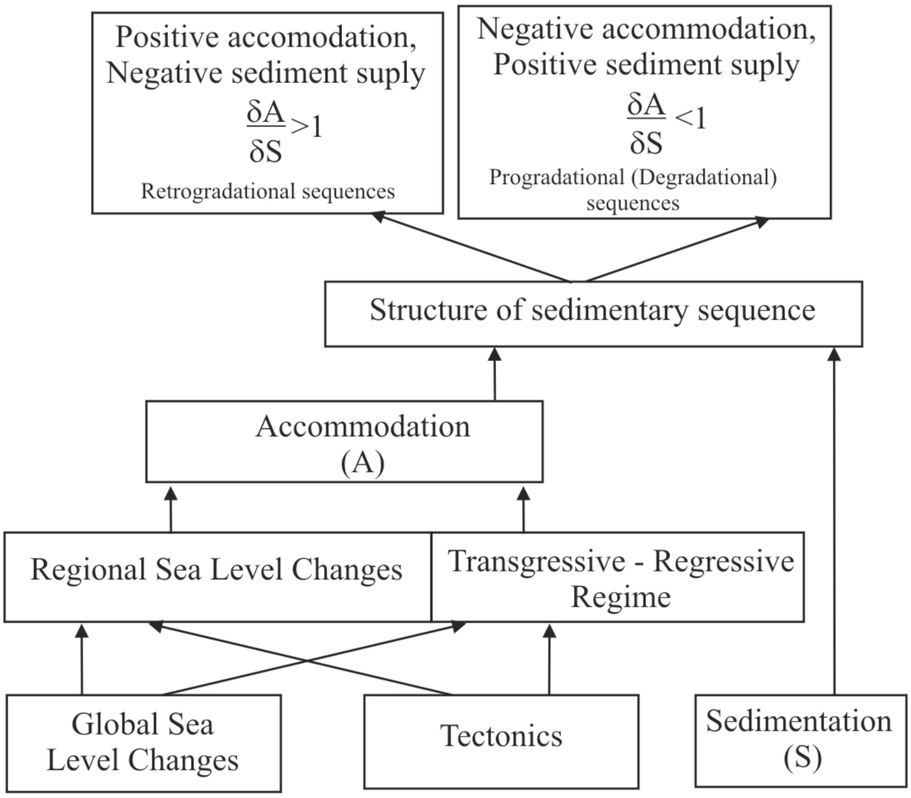

Fig. 1. The scheme illustrating the contribution of global sea level changes, tectonics, and sedimentation to the formation of different sedimentary successions (after Catuneanu et al., 1998, modified with account for Neal and Abreu, 2009 with additions).

Variations in the accommodation space (A) and the influx of sedimentary material (S) determine the structure of the formed sedimentary succession.

Three types of depositional models are represented in this study (Zorina, 2009). The lithologic-bathymetric time models demonstrate potential variations of regional sea level changes depending on different behaviour of global sea level and tectonic activity. The tectonic-eustatic time models were constructed especially to work with real chronostratigraphic sections. Such models help to separate the influence of eustasy and tectonics affecting with different amplitudes, at different times and from different directions. The eustatic time models ("Time Lentils") are used to reconstruct eustatic influence on sedimentation when tectonics stabilized. They can show that the section constitution reflects multi-speed changes of sea level in the sedimentary basin.

In conclusion, it should be noted that 145 years have passed after N.A.Golovkinsky discovered his Facies Migration Law, and it still works. It is confirmed that the "Lithologic and Biologic Lentils" really exist in platform sedimentary basins, but they are complicated now by the time component and transformed into Parasequences and "Time Lentils".

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We thank the attendees of the Kazan Golovkinsky Stratigraphic Meeting, 2014 for join us

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Ежегодная международная стратиграфическая конференция Головкинского, 2014

Каменноугольная и пермская планетарные системы, стратиграфические события, эволюция биоты, седиментационные бассейны и полезные ископаемые

20–23 октября 2014 года

Сборник тезисов

Научный редактор
Данис К. Нургалиев

Технические редакторы:
Владимир В. Силантьев,
Миляуша Н. Уразаева

Подписано в печать 09.10.2014.
Бумага офсетная. Печать цифровая.
Формат 60x84 1/16. Гарнитура «Arial». Усл. печ. л. 6.
Уч.-изд. л. 6,62. Тираж 100 экз. Заказ 39/10

Отпечатано с готового оригинал-макета
в типографии Издательства Казанского университета

420008, г. Казань, ул. Профессора Нужина, 1/37
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