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Progress report on the base of the Artinskian and base of the Kungurian by the Cisuralian Working Group

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Potential base-Artinskian GSSP

Introduction

The following is paraphrased from Chuvashov *et al*. (2002). "A potential stratotype for the Artinskian lower boundary is located in the Kondurovsky section. The Artinskian Stage corresponds here to the Kondurovka Formation, which is about 100 metres thick and composed of alternating thick units (30-40 m) of sandy-clayey rocks and thin (1-9 m) limestone and limestone breccia units. Earlier, Chuvashov *et al*., (1991) substantiated the position of the Artinskian lower boundary based on the first occurrence of the fusulinid *Pseudofusulina pedissequa* Viss. group in

the upper part of the section. The additional study allowed the boundary to be specified.

First Artinskian fusulinids *Pseudofusulina prima* Ogneva and Mor., *P. adelpha* (Raus.), and *P. irginaeformis* Shirink. are found in the detrital limestone interlayer of Bed 46, slightly below where a diverse assemblage of Sakmarian ammonoids occur. At 13 metres above the base of Bed 46, an interlayer of sandy limestone yields the first Artinskian cephalopods including *Neopronorites skvorzovi* Ruzh., *Artinskia artiensis* (Gruen.), *Neoshumardites triceps* Ruzh., *Paragastrioceras tchernovi* Ruzh., and *Eothinites* sp. Sediments located 20 metres above this level include Artinskian ammonoids and the conodonts *Sweetognathus whitei* (Rhodes) and *Mesogondolella bisselli (*Clark and Behnken).

The Sakmarian-Artinskian boundary deposits are well represented in the Dal"ny Tulkus section, a counterpart of the Usolka section. The upper part of the Sakmarian Stage (Beds 28-31) at the Usolka River and Bed 18 at the Dal"ny Tulkus Section are composed of dark-coloured marl, argillite, and carbonate mudstone, or less commonly, detrital limestone with fusulinids, radiolarians, rare ammonoids, and bivalves. The upper part of the stage encloses fusulinids characteristic of the Sterlitamakian Horizon including *Pseudofusulina longa* Kir., *P. fortissima* Kir., *P. plicatissima* Raus., *P. urdalensis* Raus. and *P. urdalensis abnormis* Raus.

The Artinskian Stage begins with a member of brecciated landslide limestones (0-6 metres) overlain by the Tyul'kas Formation (Chuvashov *et al*., 1990) mainly composed of calcareous argillites and marls with rare interbeds and concretions of carbonate mudstone and single layers of detrital limestone. The upper boundary of the formation is placed at the appearance of sandstone beds.

The brecciated limestone (Bed 19) located 1.5 metres above the formation base yields fusulinids including *P. callosa* Raus., *P. urdalensis* Raus., *P. karagasensis* Raus., *P. concavatus* Raus., *P.* ex. gr. *jurasanensis* Raus., and *P. uralensis* (Raus.) that characterize the Artinskian Stage. The fusulinids are accompanied by the conodont assemblage including *Mesogondolella bisselli* (Clark and Behnken), *Sweetognathus obliquidentatus* (Chern.), *N.* ex.gr. *ruzhencevi* Kozur and Movsh., and *Sweetognathus whitei* (Rhodes). The upper part of the brecciated layer includes the ammonoids *Popanoceras annae* Ruzh., *P. tchernowi* Max., and *Kargalites* sp.; *Neopronorites skvorzovi* (Tschern.), *Popanoceras annae* Ruzh., and *P. congregale* Ruzh. are found 3.5 m higher and characterize the lower part of the Artinskian Stage. The brecciated limestone of Bed 19 and several levels in the formation yielded the conodonts *Mesogondolella bisselli* (Clark and Behnken) and *Sweetognathus whitei* (Rhodes). Several levels within the Tyul'kas Formation at the Usolka section have yielded radiolarians of the *Enactinosphaera crassicalthrata-Quinqueremis arundinea* Zone. Given the above biostratigraphic characteristics, the Usolka Section could be considered as a supplementary reference section for the base of the Artinskian.

The historical stratotype of the Artinskian Stage is in the vicinity of the Arti Settlement along the Ufa River. Karpinskii (1891) who defined the stage studied abundant and diverse ammonoids in several exposures along the right-hand bank of the Ufa River between the Pristan' and Kordon villages. The so-called Gora Kashkabash exposure of sandstones and conglomerate is located in the same area. Ammonoids studied by Karpinskii were sampled from natural exposures and small quarries. The taxonomically diverse ammonoid assemblage from the indicated area was distinctly more advanced than the Sakmarian one in terms of cephalopod evolution and this stimulated Karpinskii (1874) to define two belts with ammonoids; the lower at the Sakmara River and the upper at the Ufa River. The Artinskian ammonoid assemblage was so distinctly advanced that the corresponding name was extrapolated onto the entire sequence with ammonoids. Within the framework of the modern biostratigraphic scheme, the upper belt of Artinskian ammonoids at the Ufa River section is correlated with the Sarga and Sarana horizons. According to current views, the Sarana Horizon is referred to the Kungurian Stage."

Conodont Definition

The best section appears to be the Dal"ny Tulkas section in Russia, but a point cannot be defined precisely except that the definition will be the FAD of *Sweetognathus whitei* within a chronomorphocline from *S. binodosus.* Additional samples are required from the lower part of the section including from a trench below the current section base before a precise point can be defined. A sample from the Dal"ny Tulkas section (5045-8a) includes *S. binodos*us n.sp. and *S. whitei* (including specimens with well defined pustulose fields and others with poorly developed and irregular fields). In a lower sample (5045-4a), *Sweetognathus obliquidentatus* and *S. sulcatus* co-occur; these taxa represent a near homeomorph of *Neostreptognathodus* by developing a shallow and partial sulcus separating the nodes. *Sweetognathus sulcatus* was previously reported from the Cerro Alto Formation in the Franklin Mountains of West Texas in an interval associated with *Diplognathodus stevensi* and *S. binodosus* n.sp. (his *S. inornatus*). It is possible that these neostreptognathodid-like elements represent evolutionary experimentation during the speciation event leading to *S. whitei* in which the bilobed nodes of *S. binodosus* n. sp. separate in a very irregular fashion. This is reminiscent of the irregular nodes of *S. merrilli* in the lower part of its range and of *Sweetognathus clarki* (which includes *S. transitus, S. ruzhencevi, S. tschuvaschovi* in synonymy) during the evolution of *Neostreptognathodus pequopensis*.

The defining chronomorphocline can be recognized also in the lower Great Bear Cape Formation on southwestern Ellesmere Island, Sverdrup Basin, Canadian Arctic (Henderson, 1988; Beauchamp and Henderson, 1994, Mei *et al*., 2002) and in the Schroyer to Florence limestones of the Chase Group in Kansas, USA (Wardlaw *et al.,* 2003).

Potential base-Kungurian GSSP
Introduction

The following is paraphrased from Chuvashov *et al*. (2002). "The stratotype of the Kungurian Stage was not defined when the stage itself was established (Stuckenberg, 1890). Later on, the carbonate-sulphate section exposed along the Sylva River upstream of the town of Kungur was arbitrarily accepted for the stratotype. In line with a new position of the Kungurian lower boundary at the base of the Sarana Horizon (Chuvashov *et al.,* 1999), the stratotype section in this area spans the following units (from the base upward): (1) the Sarana Horizon including the Sylva Formation of reefal limestones and its lateral equivalent Shurtan Formation composed of marls and clayey limestone, (2) the Filippovskian Horizon

including clayey limestone, marl, dolomitic marl, and argillite, (3) the Iren' Horizon consisting of three carbonate and four sulphate members. The last horizon is represented in the stratotype section only by three members including in ascending order the Ledyanaya Peshchera (gypsum-anhydrite), Nevolino (dolostone), and Demidkovo (gypsum-anhydrite) members.

A disadvantage of the section is the poor paleontologic characteristics of the limy Kamai Formation underlying the Sarana Horizon; it contains only small foraminifers, bryozoans, and brachiopods inappropriate for age determination. Nevertheless, many features indicate that the formation corresponds to the Sarga Horizon.

The Shurtan Formation and lateral facies of Sylva bioclastic limestone yield conodonts of the *Neostreptognathodus pnevi* Kozur and Movsh. Zone. The section under discussion could be considered as the stage stratotype, but it does not meet requirements of the GSSP project, according to which a substantial paleontological characteristic is needed for the underlying stratigraphic unit. Thus, another section of the Artinskian-Kungurian boundary deposits located near the Mechetlino settlement at the Yuryuzan' River was selected for a probable stratotype of the Kungurian lower boundary. Units exposed here are the upper part of the Gabdrashitovo Formation, overlying Sarana layers, and Ismagilovo Member of carbonate mudstone referred to the Filippovskoe Horizon.

Previously, the section was repeatedly described (Chuvashov *et al*., 1990, Chuvashov and Chernykh, 2000) and a description of key parts of the section as exposed along the right bank of the Yuryuzan' River downstream of the Mechetlino settlement follows. Beds 1-18 are Artinskian Stage, Sarga Horizon, Gabdrashitovo Formation. Bed 13 comprises dark grey argillite with irregularly alternating thin layers of fine-grained sandstone and includes ammonoids and conodonts including *Neopronorites permicus* (Tchern.), *Medlicottia orbignyana* (Vern.), *Uraloceras fedorowi* (Karp), *Sweetognathus* aff. *whitei* (Rhodes), and *Stepanovites* sp. (Sb and Sc elements), all characteristic of the Sarga Horizon. Bed 15 is an olistostrome with a matrix comprising fusulinids, solitary rugose corals, brachiopods, bryozoa, crinoids, and calcareous algae. The fusulinid assemblage includes abundant *Pseudofusulina kutkanensis* Raus., *P.* aff. *kusjanovi* Raus., *P. franklinensis* Raus., *P. postsolida* Tchuv., *P. makarovi* Raus., and *Parafusulina solidissima* Raus. Bed 17 is composed of highly calcareous, dark grey argillite with grey, calcareous, fine-grained sandstone. This bed has yielded the conodonts *Neostreptognathodus kamajensis* Chern., *N. pequopensis* Behnken, *N*. aff. *ruzhencevi* Kozur, and *Sweetognathus* ex. gr. *whitei* (Rhodes) represented by aberrant specimens with reduced carinae. Bed 18 is a highly calcareous, yellowish-grey sandstone with thin interbeds of greenish-grey argillite and abundant plant detritus, but lacks conodonts and fusulinids. Beds 19-20 are Kungurian Stage, Sarana Horizon, Mysovsk Formation, Transitional Member. Bed 19 comprises steel-grey carbonate mudstone with an admixture of extremely fine-grained clastics and rare argillite interbeds. The basal part includes *Neostreptognathodus clinei* Behnken, *N. pnevi* Kozur and Movsh., *N. kamajensis* Chern., *N. pequopensis* Behnken, and *Stepanovites* sp. (M element). Bed 20 is a yellowish-grey, thin-bedded, fine-grained, calcareous sandstone with thin argillite interbeds and abundant plant debris. Beds 21-22 are Filippovskoe Horizon, Mysovoi Formation, Ismagilovo Member. Bed 21 is composed of steel-grey carbonate mudstone and rare interbeds of microclastic limestone that yield the ostracod *Paraparchites burkemis* (Mart.) characteristic of the *Paraparchites humerosus* Zone and the conodonts *Neostreptognathodus pequopensis* Behnken, *N. pnevi* Kozur and Movsh., *N*. aff. *ruzhencevi* Kozur, and *N. tschuvashovi* Kozur."

Conodont Definition

The best section appears to be the Metchetlino section or a nearby section in Russia, but a point cannot be defined precisely except that the definition will be the FAD of *Neostreptognathodus pnevi* within a chronomorphocline from advanced *Neostreptognathodus pequopensis*. Bed 17 yields *N. kamajensis* and *N. pequopensis* and bed 19 includes *N. kamajensis*, *N. pequopensis*, *N. clinei*, and *N. pnevi*. Bed 18 is a sandy lithofacies that has not yielded conodonts. A laterally equivalent section includes limestone facies within Bed 18; additional samples from this section are required from bed 18 and 19 in this section near the Metchetlino section before a precise point can be defined.

The defining chronomorphocline can also be recognized in the upper Great Bear Cape Formation and upper Trappers Cove Formation on southwestern Ellesmere Island, Sverdrup Basin, Canadian Arctic (Henderson, 1988; Beauchamp and Henderson, 1994, Mei *et al*., 2002).

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Radiolarian biostratigraphy of the Sakmarian Stage (Lower Permian) in Southern Urals

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Abstract

In sediments of Lower Permian Sakmarian Stage in the Southern Urals region, five radiolarian biozones are revealed in stratigraphic succession from the top, down: *Rectotormentum fornicatum, Camptoalatus monopterygius, Entactinia pycnoclada – Tormentum circumfusum, Helioentactinia ikka – Haplodiacanthus perforatus, Copicyntra sp. / Tetragregnon vimineum – Copiellintra diploacantha*. The characteristics, geographic distribution, correlation possibilities, and problems of these are discussed.

Introduction

In the Upper Paleozoic deposits of the Uralian region, radiolarians are largely restricted to the Southern Urals and Southern Preduralie (Cis-Urals), and to a smaller degree they are found in Mid Urals and Mid Preduralie areas (Nazarov, 1988; Nazarov, Ormiston, 1985, 1993; Amon, 1999; Chuvashov *et al*., 1999; Afanasieva, Amon, 2002) (fig. 1). In Southern and Mid Preduralie radiolarians are found in various rocks of Late Carboniferous and Early Permian age (ranging from Kasimovian up to the Kungurian Stage), but there are no reliable data on radiolarian presence in sediments of Mid and Early Carboniferous age, nor in sediments of Late Permian age here. Distribution of radiolarians to the north from the named areas can be assumed, but is not yet proved. Currently there are no distribution data for radiolarians in Upper Paleozoic sediments in the extensive territory of the Eastern slope of Urals and Zauralie (Trans-Urals). In adjacent regions it is possible to name the territory Northern PreCaspian where Late Paleozoic sections with radiolarians occur frequently, starting from Mid-Carboniferous to the Artinskian Stage inclusive (Afanasieva, Zamilatskaya, 1993; Afanasieva, Amon, 2002). In Late Paleozoic sections of the Russian platform, Western Siberia and Central Asia, radiolarians of Permian age are not as yet recognized.

Radiolarian abundance varies within different facies. Their fossil remains frequently occur in thin-bedded, fine-grained terrigenous rocks, their abundance is reduced in medium- and coarse-grained siliciclastics, and they are almost completely absent in clean reef limestones and dolostone. Radiolarians appeared in Late Paleozoic Preduralian Sea coincident with basin formation during the mid-Carboniferous when a relatively deep-water marine basin with clayey-siliceous sediments grading upward into sandy-argillaceous flysch-like sediments during the Late Carboniferous (Chuvashov *et al*., 1999; Amon, 1999).

The east border of radiolarian distribution served as the coastal zone, which currently is only fragmentary in the Preduralie. The western border of radiolarian distribution is defined by a linear trend of bioherms up to, and including Artinskian time. During Kungurian time and later this border was a zone of increased water salinity. At the western and eastern limits of the area of radiolarian distribution they exhibit sporadic occurrences during the Permian and are frequently absent for significant stratigraphic intervals. Sections of the east slope of the Preduralian foredeep in a thin flysch zone and depressional zone show the most complete distribution of radiolarians (Chuvashov *et al*., 1999).

Radiolarians began to be used for practical Lower Permian stratigraphy in the region after the detailed research made by Drs. B. Nazarov and A. Ormiston (Nazarov, Ormiston, 1985, 1993, 1990; Nazarov, 1988). Local radiolarian faunas or biozones were singled out and described by B. Nazarov in the territory of the Western slope of Southern Urals, in the Southern part of the Preduralian foredeep and in the Southern Preduralie. The stratotypes for these faunas or biozones are located in an extended strip of thick Upper Carboniferous - Permian sedimentary rocks in the Orenburg-Aktyubinsk region from Aidaralash River in the south up to Malaya Syuren in the north. Late Carboniferous (Gzhelian Stage) and Lower Permian (Asselian, Sakmarian, Artinskian Stages) radiolarian associations or complexes are here described from rare continuous sections and more often from fragmentary sections. Reference sections are located in outcrops along the following rivers and creeks: Ural, Sakmara, Akma, M. Syuren, Akberda, Alimbet, Chiili, Sintas, Zhaman-Kargala, Ortash, Assel, and Uskalyk. The exact stratigraphic position of several radiolarian layers within the preliminary radiolarian biozonation scheme developed by B. Nazarov, was not absolutely correct. Nazarov did not trace the lateral limits of geographical distribution of his biozones and was not clear how far they could be traced outside of the stratotype area.

In the present report we provide the results of additional