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Biozonation of the Syuran Horizon of the Bashkirian Stage in the South Urals as Indicated by Ammonoids, Conodonts, Foraminifers, and Ostracodes

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Abstract—Comprehensive biostratigraphic studies of the Syuran and Bogdanovskii horizons were undertaken in the type area of both horizons in the South Urals. Successions of ammonoid, conodont, foraminiferal and ostracode assemblages were thoroughly studied in the stratotypes of the horizons. A new refined correlation of the ammonoid *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones to coeval zones of foraminifers, conodonts, and ostracodes in the South Urals and other regions is suggested.

Key words: *Bashkirian Stage, Bogdanovskii Horizon, Syuran Horizon, stratotype, ammonoids, conodonts, foraminifers, ostracodes, biostratigraphy.*

INTRODUCTION

In connection with the elaboration of the global Carboniferous scale, the detailed characterization of its units, the substantiation of their boundaries, and the precise determination of stratigraphic ranges are the most important objectives. The Bashkirian Stage, which was recognized by S.V. Semikhatova in the mountains of Bashkortostan in 1934, is the lower unit of the Middle Carboniferous in the North Eurasian stratigraphic scale and, undoubtedly, can be used worldwide. The lower boundary of the unit coincides with the Mid-Carboniferous boundary, the GSSP of which was chosen in the Arrow Canyon section, Nevada, USA (Lane *et al.*, 1994). The boundary is drawn at the bases of the ammonoid *Homoceras-Hudsonoceras* Genus-zone and the conodont *Declinognathodus noduliferus* Zone. Since 1968, stratigraphic scales of the Bashkirian Stage begin in the Urals with the Syuran Horizon. The attributive "Syuran" was first used by Librovich (1947, p. 59) to describe the limestone facies at the Suren' (Syuran) River in the western slope of the South Urals. The facies is characterized by the coexistence of goniatite and foraminifer faunas. The Bol'shaya Suren' River section near the Bogdanovskii Farmstead (now the Novyi Bogdanovskii Settlement) was proposed by Librovich and Sultanaev (1977, p. 362) as the stratotype of the Syuran Horizon and became a site of long-term investigations. Ammonoids of the section were first described by Krestovnikov (1935) and later studied by Librovich (1947), Ruzhentsev and Bogoslovskaya (1978). Along the left tributary of the Bol'shaya Suren' River, 1 km to the south of the Bogdanovka Village (now the Novo-Bogdanovskii Settlement), Einor *et al.* (1973a, 1973b) recognized the lower part of the Syuran beds with ammonoids of the *Homoceras* Zone as the independent Bogdanovskii Horizon, which they studied in two sections. The stratotype of the horizon was established in the Novyi Bogdanovskii Settlement section (Exposure 4), the upper part of which corresponds, according to the cited authors, to the ammonoid zone H_2 (Fig. 1). The lower part of the horizon is exposed 2 km to the east, in the section near the Kugarchi Village. Reitlinger (1980) described foraminifers from the Bogdanovskii Horizon. Later, Einor (1992) found here some ammonoids characteristic of zone H_1. However, his unique section, where ammonoids are associated with conodonts, foraminifers, and ostracodes at several stratigraphic levels, has never been adequately studied. The differently interpreted stratigraphic range of the Syuran Horizon was a subject of long-lasting discussions (Nikolaev, 1989; Einor, 1992). For example, in the early stratigraphic schemes for the Urals (*Unifitsirovannye…*, 1968, 1980), the horizon corresponds to the *Reticuloceras* Zone, whereas, according to the latest scheme (*Stratigraphicheskie…*, 1993), it spans the interval of two *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones. In this work, we use the latter one. We studied and described in detail the section, which can be proposed as a stratotype of both the Syuran and Bogdanovskii horizons. We also studied the bed-by-bed collections of ammonoids, conodonts, foraminifers, and ostracodes.

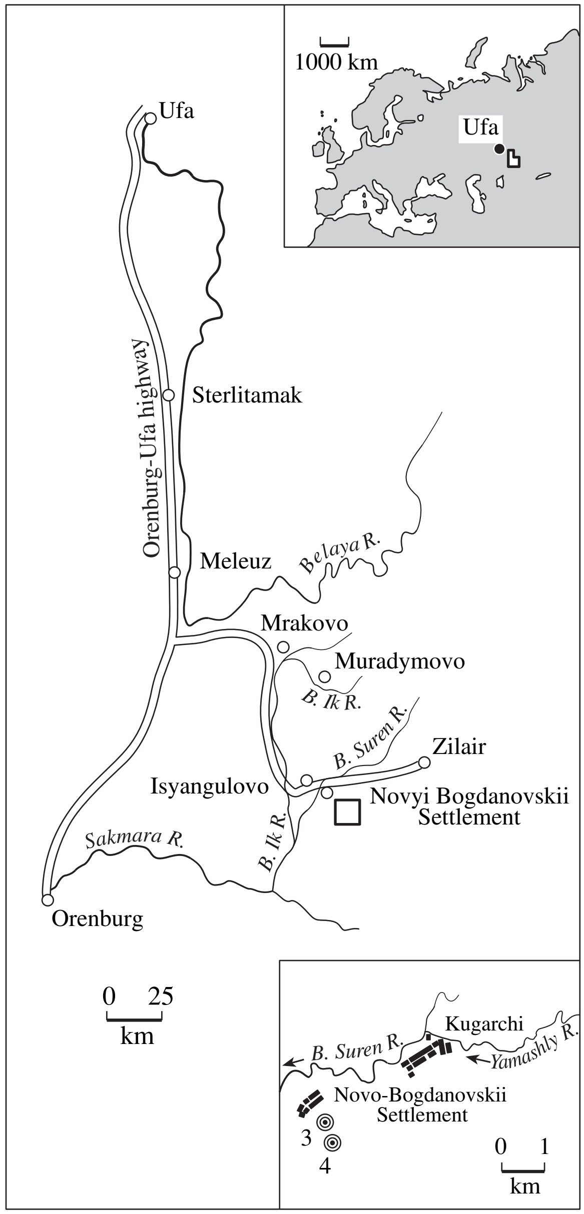


Fig. 1. Locality of the Bogdanovskii Horizon stratotype in Bashkortostan.

MATERIAL

In 1986–1997, we investigated the Syuran and Bogdanovskii type sections using the bed-by-bed method. To establish the ammonoid succession, we revised their specimens collected by Einor, Furdui and Aleksandrov in 1971 from the same exposures and deposited at the Paleontological Institute of Russian Academy of Sciences. The studied ammonoids are stored at this Institute as collection no. 4715, whereas the collections of conodonts, foraminifers and ostracodes are stored under nos. 104, 121, and 66 at the Institute of Geology of the Ufa Scientific Center, Russian Academy of Sciences.

DESCRIPTION OF THE SECTION

The section is located on the western slope of the South Urals in the Zilair subzone of the Central Uralian structural-facial zone (*Stratigraficheskie…*, 1993), 1 km to the southeast of the Novo-Bogdanovskii Settlement at the left bank of the Bol'shaya Suren River (Fig. 1). The meridional anticlinal structure (the Bogdanovskii anticline) can be traced here in two main exposures (Fig. 2). The anticline is composed of thin- to medium-bedded, locally foliated carbonate and terrigenous-carbonate deposits. In our work, we followed the exposure numeration after Einor and co-authors (Einor *et al.*, 1973a; 1973b; Einor, 1992). Exposure 3 is

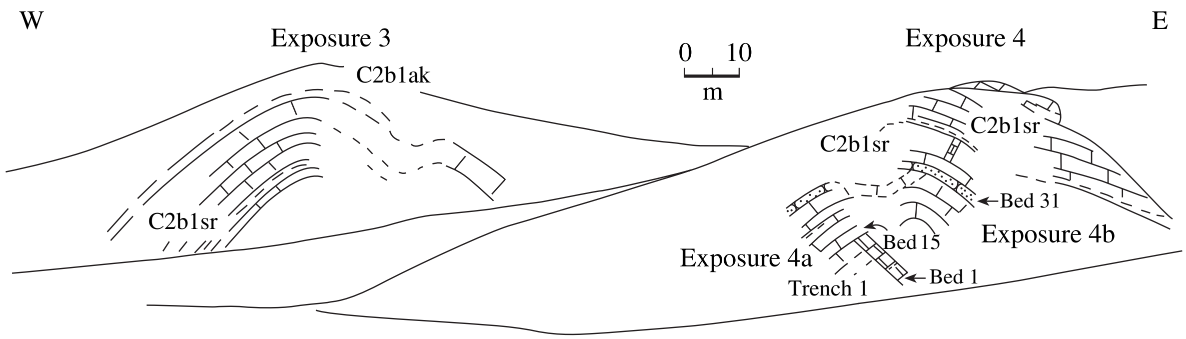


Fig. 2. Schematic profile of the Mt. Kamennaya demonstrating relations between exposures 3 and 4 (a and b).

nearest to the Novyi Bogdanovskii Settlement, and Exposure 4 is located 200 m to the south of it.

Exposure 4 reveals the oldest beds.

EXPOSURE 4

The exposure is located on the southeastern slope of the Mt. Kamennaya, where the beds yield ammonoids of the *Homoceras-Hudsonoceras* Genus-zone. The exposure can be suggested as the stratotype of the Bogdanovskii Horizon. It consists of two parts (4a and 4b) situated in the western and eastern limbs of the anticlinal structure, respectively, being separated by a 20-m-wide unexposed interval (Fig. 2). The composite column of the exposure was presented in the previous publication (Kulagina *et al.*, 1992); numbers of beds in the present description are the same.

Western Part of Exposure 4 (Exposure 4a)

Exposure 4a in the western limb of the anticlinal fold, where attitude of limestone beds corresponds to azimuth 270–295° and dip angle 25–30°, is studied in the recent prospecting trench, where neither Librovich nor Einor were able to observe the lowermost beds 1–13 (Fig. 3). At the base, there are yellow clays (0.05 m) resting on almost black cherts. The following succession of members and beds can be observed here (from the base upward).

Member 1:

(1) gray organogenic clastic limestone (litho-bioclastic grainstone) siliceous in the lower part and bearing bryozoans, algae, crinoids, foraminifers, and ostracodes (0.45 m thick, samples P-05B, P-05A, P-05);

(2) yellow clay with fragments of siliceous limestones and cherts (0.05 m thick);

(3) gray detrital limestone (grainstone) with siliceous-clayey interbeds at the base, which contain crinoids, brachiopods, ammonoid larvae, and sponge spicules (0.25 m thick, Sample P-1B);

(4) gray organogenic-detrital limestone with pelitomorphic fine-grained cement (wackestone) bearing small brachiopods, foraminifers, and ostracodes. The thickness is 0.65 m (Sample P-1A);

(5) gray organogenic-detrital limestone with the clastic upper part (wackestones to litho-bioclastic grainstones) containing foraminifers, algae, fragments of brachiopods, bryozoans, echinoderms, corals, clastic material (lithoclasts and sandy grains), and rare ooliths (0.83 m thick, samples P-2, P-3ab, 04).

Member 2:

(6) gray, slightly clayey micritic limestone (micrite) with rare unilocular foraminifers and spheres (0.35 m thick, Sample P-4).

Member 3:

(7) gray organogenic-clastic limestone (litho-bioclastic grainstone and packstone) grading into calcareous breccia and bearing ooliths, foraminifers, bryozoans, crinoids, and brachiopod fragments (0.15 m thick, Sample 03/2);

(8) spicule-bearing gray micritic clayey to silty wackestone (0.1 m thick, Sample P-5);

(9) gray fine-grained to clotted micritic limestone (mudstone-wackestone) with foraminifers, ammonoids, and sponge spicules (0.57 m thick, Sample P-6, P-7);

(10) gray organogenic-clastic limestone with pelitomorphic fine-grained matrix (bioclastic wackestone-packstone); the bed yields ooliths, oncolites, foraminifers, and ammonoids (0.3 m thick, Sample 03);

(11) gray, slightly clayey micritic limestone (mudstone) with rare fine detritus (0.85 m thick, Sample 02).

Member 4:

(12) gray spicule-bearing clayey micritic limestone (0.2 m thick, Sample P-8);

(13) gray clotted micritic limestone (1 m thick, Sample 01).

Member 5:

(14) gray clotted micritic limestone with spheres (biopelsparite) and small foraminiferal shells (0.85 m thick, Sample P-9);

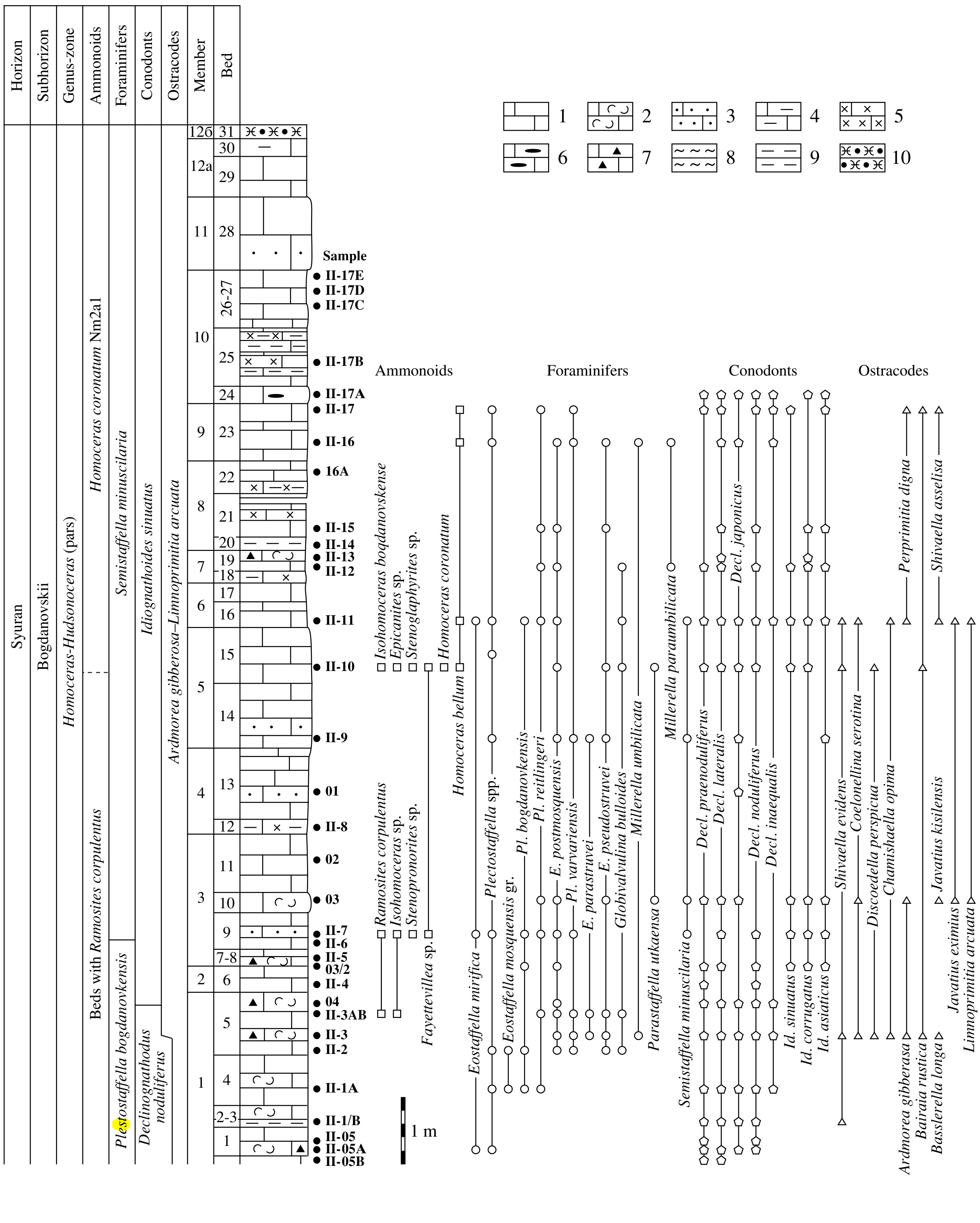


Fig. 3. Middle Carboniferous section of the Mt. Kamennaya (Exposure 4a) and distribution of ammonoids, foraminifers, and conodonts: (1) micritic limestone or organogenic wackestone; (2) organogenic and bioclastic limestone or packstone and greenstone; (3) clotted limestone or pelmicrite and pelsparite); (4) clayey limestone; (5) spicule-bearing limestone; (6) limestone with chert concretions; (7) clastic (bio-lithoclastic) limestone; (8) clayey-siliceous and siliceous shales; (9) mudstone; (10) sandstone.

(15) dark gray micritic limestone (wackestone) with accumulations of foraminifers and ammonoids (0.65 m thick, Sample P-10).

Member 6:

(16) gray micritic limestone with sporadic organogenic interbeds and insignificant sandy admixture; the bed (bioclastic wackestone) bears frequent foraminifers, ostracodes, and fragments of brachiopods and ammonoids (0.5 m thick, Sample P-11);

(17) gray micritic limestone (micrite) 0.42 m thick.

Member 7:

(18) gray slightly clayey micritic limestone with sponge spicules (0.2 m thick);

(19) gray fine-grained spherical-clotted micritic limestone; the upper part of the bed includes an interbed of organogenic-clastic limestone (litho-bioclastic packstone) with algae, crinoids, brachiopods, and ammonoids (0.4 m thick, samples P-12, P-13).

Member 8:

(20) limy mudstone with rare sponge spicules and a silty admixture (0.2 m thick, Sample P-14);

(21) gray micritic limestone (micrite) and clotted limestone (biopelmicrite) with a thin (0.02 m) interbed of spicule-bearing limestone (1.4 m thick, Sample P-15);

(22) gray micritic limestone (micrite) with accumulations of foraminifers, ammonoids, ostracodes, brachiopods, and bryozoan fragments (wackestone); at the base of the bed, there is an interbed (0.02 m) of brownish gray clayey spicule-bearing limestone (0.65 m thick, Sample 16a).

Member 9:

(23) gray micritic limestone, the upper part of which is organogenic and encloses foraminifers and ammonoids (0.9 m thick, samples P-16, P-17).

Member 10:

(24) gray fine-grained ammonoid-bearing limestone with thin chert lenses (0.3 m thick, Sample P-17A);

(25) interlaminated micritic, clayey, and spicule-bearing limestones (0.8 m thick, Sample 17B);

(26–27) gray micritic limestone (1.2 m thick, Sample P-17C, P-17D, P-17E).

Member 11:

(28) micritic and clotted limestone with detrital accumulations; along the strike, the bed is divided into two parts visible in places at the slope further toward Exposure 4b, where it forms at first synclinal, and then anticlinal folds (1.3 m thick, samples 174, 172, 173 in Exposure 4b).

Member 12a:

(29) gray micritic limestone 0.65 m thick;

(30) gray clayey micritic limestone 0.35 m thick.

Member 12b:

(31) brownish gray fine-grained microlaminated sandstone (0.15–0.2 m thick, Sample 28A from Exposure 4b).

Eastern Part of Exposure 4 (Exposure 4b)

The exposure is located in the right limb of the anticlinal fold, where the attitude of the beds corresponds to azimuth 70–95° and dip angle 30–40° (Fig. 4). The exposure includes members 5–12b of the Exposure 4a. The higher stratigraphic levels are divided into successive members 12–20.

Member 12b:

(32) gray micritic limestone with sponge spicules (0.15 m thick, Sample P-28);

(33) brownish gray fine- to medium-grained sandstone 0.4 m thick;

(34) gray micritic limestone with clayey interbeds and sponge spicules (0.6 m thick, Sample P-29).

Member 13:

(35) gray micritic limestone 1.1 m thick.

Member 14:

(36) organogenic-clastic limestone grading into calcareous breccia in the lower part and micritic limestone in the upper part (0.85 m thick, samples P-30, P-30A, P-31).

Members 15–17 and beds 37–40 are exposed in the prospecting trench.

Member 15:

(37) fine intercalation of micritic and clayey limestones and cherts (0.9 m thick, Sample P-32);

(38) gray micritic limestone (1.7 m thick, Sample P-33A).

Member 16:

(39) gray micritic limestone, an upper part of the bed (0.5 m) is seen in the natural exposure (1.8 m thick, Sample P-35).

Member 17:

(40) gray micritic limestone with clayey interbeds (2.7 m thick, Sample 36).

Member 18:

(41) gray micritic limestone (1.7 m thick, Sample 37);

(42) Gray spicule-bearing micritic limestone with clayey interbeds (3 m thick, samples 38, 39);

(43–44) gray micritic limestone with clayey interbeds and rare sponge spicules (4.9 m thick, Sample 40).

Member 19:

(45) micritic limestone (0.7 m) at the base and frequently alternating micritic and clayey limestones above (3.8 m thick, samples 41, 41A, 42);

(46) gray micritic fine-grained limestone, locally pachyspherical-clotted and bearing rare foraminifers and organic detritus (4.8 m thick, samples 43, 44).

Member 20:

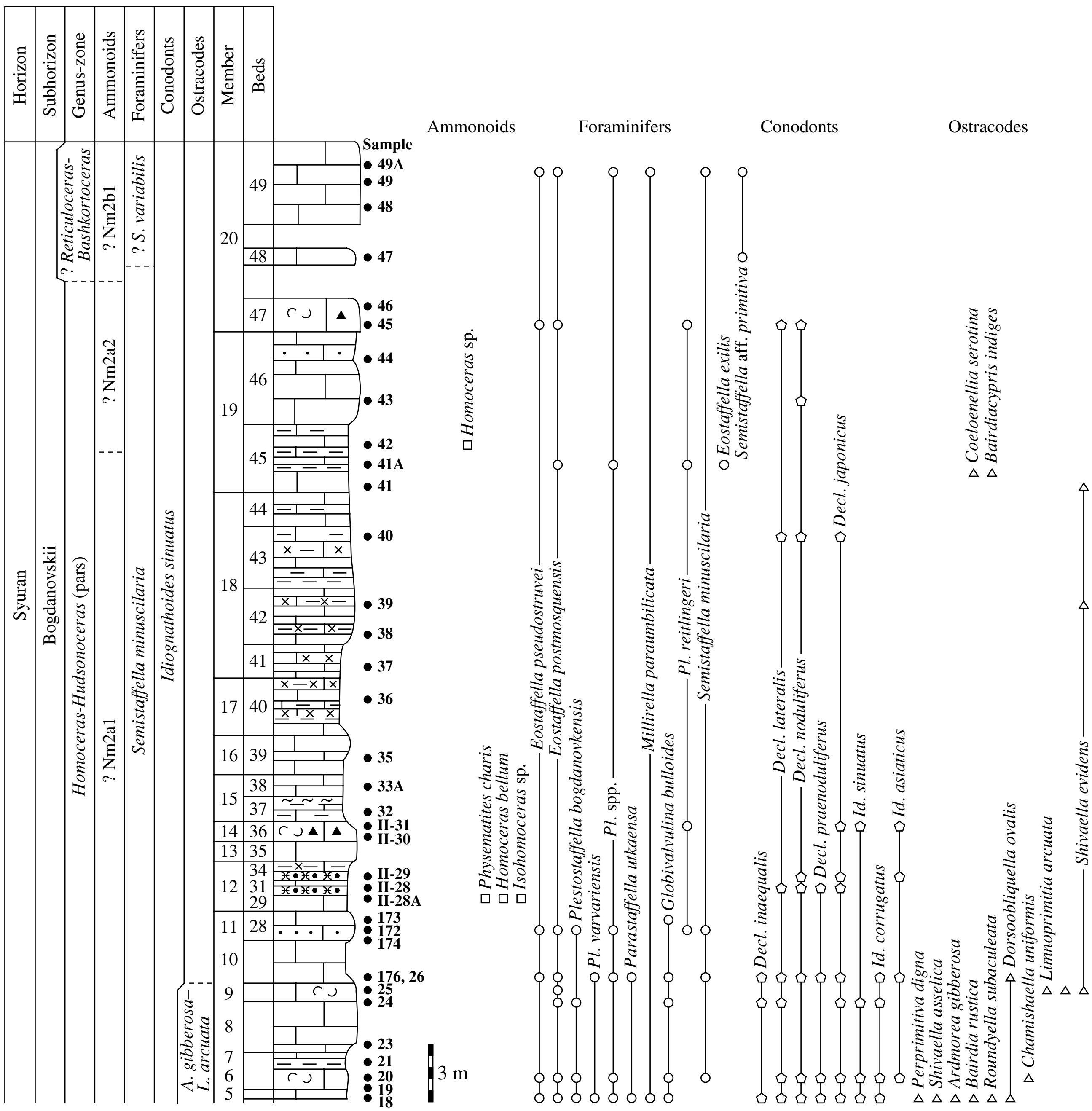


Fig. 4. Middle Carboniferous section of the Kamennaya Mountain (Exposure 4b) and distribution of ammonoids, foraminifers, and conodonts (symbols as in Fig. 3).

(47) gray organogenic-detrital limestone with pelitomorphic fine-grained matrix; the bed yielding foraminifers, bryozoans, and echinoderms forms synclinal and anticlinal folds traceable along the slope (1 m thick, samples 45, 46).

The unexposed interval 1.4 m wide.

(48) gray micritic clayey limestone (0.2 m thick, Sample 47).

The unexposed interval 1.2 m wide.

(49) gray micritic limestone with rare interbeds of organogenic-detrital limestone and fine-grained matrix (4 m thick, samples 48, 49, 49A, 50). The bed is destroyed during work in the quarry.

EXPOSURE 3

The exposure is located 200 m to the northwest of Exposure 4 on the southern slope of a mountain near Mt. Kamennaya (Fig. 2). Deposits of the site bear

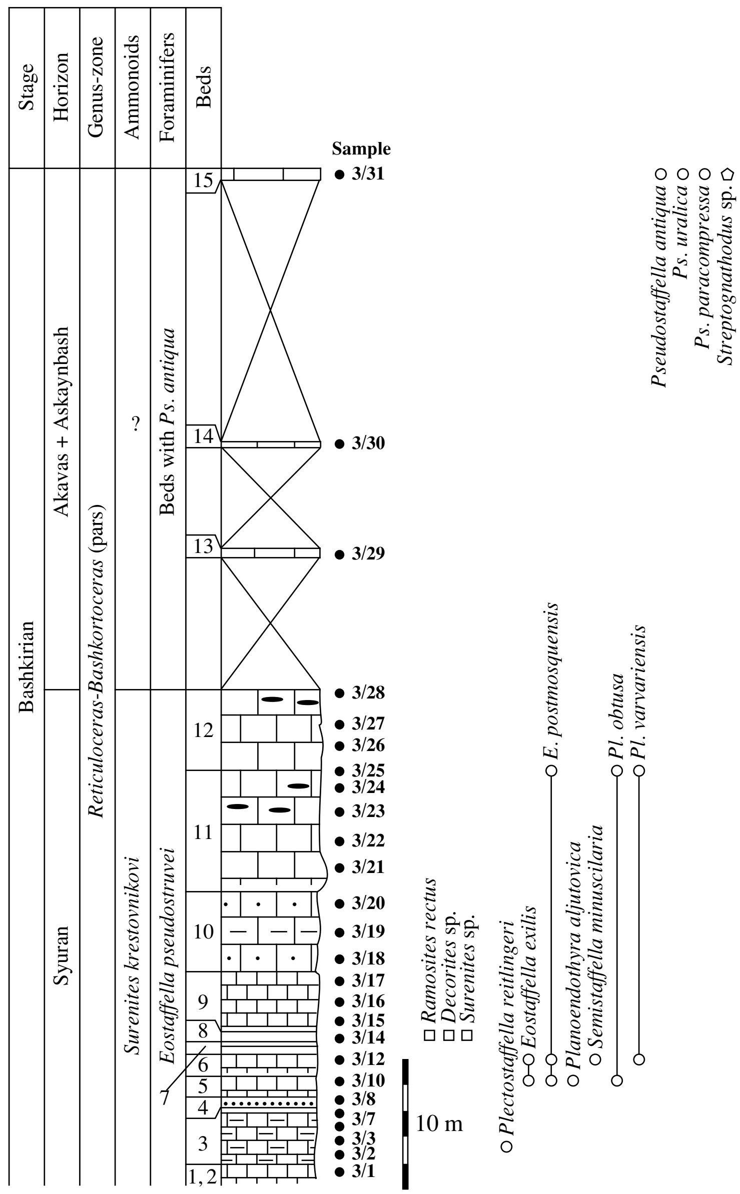


Fig. 5. Middle Carboniferous section of the Mt. Kamennaya (Exposure 3) and distribution of ammonoids, foraminifers, and conodonts (symbols as in Fig. 3).

ammonoids characteristic of the *Reticuloceras-Bashkortoceras* Genus-zone (Fig. 5). In the western wing of the fold, the following beds are exposed (from the base upward).

(1) Gray micritic limestone (0.25 m thick, Sample 3/1).

(2) Gray micritic limestone enclosing interbeds with small foraminiferal shells and accumulations of fine detritus along bedding planes (1.3 m thick, Sample 3/2).

(3) Gray micritic, silty-clayey limestone with sponge spicules, fine-grained interbeds, and local carbonaceous and clayey microlaminae (3.8 m thick, samples 3/3–3/7).

(4) Organogenic calcarenite (0.3 m thick, Sample 3/8).

(5) Gray spicule-bearing micritic and weakly clayey limestone with an interbed of fine-grained micritic limestone bearing foraminifers and sponge spicules (1.8 m thick, samples 3/9, 3/10).

(6) Gray micritic, clayey and microlaminated limestone with sponge spicules accumulated along bedding planes (1.4 m thick, samples 3/11, 3/12).

(7) Gray organogenic-detrital limestone with pelitomorphic fine-grained matrix; the bed yields foraminifers, ammonoids, and sponge spicules (0.2 m thick, Sample 3/13).

(8) Gray organogenic-clastic limestone with micritic matrix (bio-lithoclastic wackestone-pack-

stone) consisting of partly rounded large tests of foraminifers *Tolypammina*, ammonoids, detritus, ooliths, pellets, and intraclasts (0.25 m thick, Sample 3/14).

(9) Gray micritic clayey limestone with sponge spicules (3.6 m thick, samples 3/15–3/17).

(10) Alternating micritic and clayey spicule-bearing limestones (8 m thick, samples 3/18, 3/20).

(11) Gray micritic limestone with chert nodules and brownish gray clayey spicule-bearing interbeds (9.1 m thick, samples 3/21, 3/22, 3/23, 3/24, 3/25).

(12) Gray micritic limestone (6 m thick, samples 3/26, 3/27, 3/28).

The unexposed interval 10 m wide.

(13) Gray micritic limestone (0.2 m thick, Sample 3/29).

The unexposed interval 7 m wide.

(14) Gray micritic limestone with small cherty concretions (0.2 m thick, Sample 30).

The unexposed interval 19 m wide.

(15) Gray organogenic-clastic limestone (bioclastic wackestone) with abundant foraminifers, algae, and bryozoans (0.3 m thick, Sample 3/31).

BIOSTRATIGRAPHY

The ammonoid, conodont, foraminifer, and ostracode zonations were recognized in the exposures studied. They were correlated with those characterizing the boundary intervals between the Upper and Middle Carboniferous in other sections of the Urals and Central Asia, and also between the Lower and Upper Carboniferous in Western Europe and between Mississippi and Pennsylvania in North America.

AMMONOIDS

Ammonoids were found in exposures 4a (six levels), 4b (two levels), and 3 (one levels). The ammonoids from Exposure 3 are similar to the assemblage described by Ruzhentsev and Bogoslovskaya (1978, p. 15) from their Sample 3. Other samples studied by Ruzhentsev and Bogoslovskaya were collected in the Bogdanovskii section to the east of Sample 3 in the same exposure. Analysis of ammonoids from nine levels allowed us to establish six successive assemblages typical of two ammonoid *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones (Plate I).

The first genus-zone includes ammonoids from beds 5, 9, 15, 16, 23, and 24 of the Exposure 4a and from Bed 31 of the Exposure 4b. The assemblage is similar to that of the *Homoceras coronatum* Zone (the lower part of the *Homoceras-Hudsonoceras* Genus-zone), which was first recognized in Sholak-Sai (Ruzhentsev and Bogoslovskaya, 1978). The 1.8 m-thick limestone (Sample 3a, 3b) below Bed 5 is lacking in ammonoids, and we conventionally referred this interval to the *Homoceras-Hudsonoceras* Genus-zone. In general, the assemblage is very similar to that from the Sholak-Sai and includes the same or similar species. In the generic composition, it appears to be more similar to the coeval highly diverse fauna of Central Asia (Nikolaeva, 1994b, 1995) rather than to the assemblage of Western Europe (Bisat, 1924; Riley, 1987) including only genera *Isohomoceras* and *Homoceras.* In Central Asia, the ammonoid fauna is characterized by the coexistence of the genus *Fayettevillea*, typical of the Early Carboniferous and genus *Isohomoceras* characteristic of the Middle Carboniferous. It is noteworthy that the genus *Proshumardites* is found, together with the genus *Isohomoceras*, in the Sholak-Sai and localities of Central Asia.

The *Reticuloceras-Bashkortoceras* Genus-zone comprises beds of the Exposure 3. The assemblage includes ammonoids *Surenites krestovnikovi, Decorites* sp. and *Ramosamples rectus* characteristic of the *Surenites krestovnikovi* Zone (Ruzhentsev and Bogoslovskaya, 1978).

Homoceras-Hudsonoceras Genus-Zone

(1) *Ramosites corpulentus* Beds. Assemblage 1 characterizes beds 5 and 9 located approximately 1.8 m (Sample 3A and 3B) and 3.4 m (Sample 7) above the section base. The assemblage contains representatives of genera *Stenopronorites, Isohomoceras, Fayettevillea*, and *Ramosites*, about 50 specimens altogether.

The assemblage is dominated by *Ramosites corpulentus* Ruzh. et Bogosl. (about 40 specimens), which marks together with *Isohomoceras* forms the lower beds of the *Homoceras-Hudsonoceras* Genus-zone. As the genus *Fayettevillea* is present here, whereas the genus *Homoceras* is missing, this level presumably corresponds to the 0.75-m-thick interval of barren limestones between the latest ammonoids of the *Fayettevillea-Delepinoceras* Zone (Sample 3, the *Delepinoceras bressoni* Zone) and the earliest ammonoids of the *Homoceras-Hudsonoceras* Genus-zone (Sample 4, the *Homoceras coronatum* Zone) in the Sholak-Sai section (Ruzhentsev and Bogoslovskaya, 1978). Assemblage 1, in contrast to that of the Sholak-Sai section, does not contain *Homoceras coronatum*. Therefore, the enclosing deposits are referred to as the *Ramosites corpulentus* Beds. The assemblage is supposed to be coeval with that of the *Isohomoceras ventrosum* Zone of Central Asia (Nikolaeva, 1994b) and younger than that of the *Isohomoceras subglobosum* Zone of Central Asia and England (Riley *et al.*, 1987; Nikolaeva, 1994a, 1994b).

The *Ramosites corpulentus* Beds are 4.06 m thick in Exposure 4a.

(2) *Homoceras coronatum* Beds. Assemblage 2 was found at two levels: one corresponding to beds 15 and 16 (samples 10 and 11) and another located 6.6 to 7.25 m above the section base. Einor *et al.* (1973a)

reported on ammonoids of the genus *Homoceras* occurring, as we think, at the same levels.

The assemblage includes *Epicanites* sp., *Stenoglaphyrites* sp., *Isohomoceras bogdanovkense* Nikolaeva, *Homoceras bellum* Nikolaeva, *H. coronatum* (Haug), and *Fayettevillea* sp. Coexisting genera *Homoceras* and *Isohomoceras* were first recorded in the Sholak-Sai (Ruzhentsev and Bogoslovskaya, 1978), but this atypical of many sections in Europe and Asia (Riley *et al.*, 1987; Nikolaeva and Nigmadganov, 1992; Nikolaeva, 1994a, 1994b). Manger *et al.* (1985) reported on association of these genera in basal beds of the *Homoceras* Zone in Algeria, but the Algerian assemblage may appear to be younger than the described one. The presence of the genus *Homoceras* evidences that Assemblage 2 is younger than the assemblages of the *Isohomoceras subglobosum* and *Isohomoceras ventrosum* zones described by Nikolaeva (1994b) from sections 1–4 at the left bank of the Aksu River and from Section 13 at the Peshkaut Creek of the Tien Shan; the same is correct with respect to the *Isohomoceras subglobosum* Zone of the Stonehead Beck section in England (Riley *et al.*, 1987).

Due to the occurrence of the genus *Fayettevillea* (Plate I, Fig. 9) in Assemblage 2, the enclosing beds of the Bogdanovskii section may be considered somewhat older than the level of Sample 4 in the Sholak-Sai section, in which this genus is missing

Assemblage 3 was found at two levels of Bed 23 (samples P-16, P-17) approximately 10.9 and 11.4 m above the section base. The assemblage includes *Homoceras bellum* Nikolaeva (Nikolaeva, 1999), which was earlier identified as *Homoceras* aff. *haugi* Ruzh. et Bogosl. (Kulagina *et al.*, 1992). This form, very much resembling *Homoceras coronatum*, suggests that the enclosing bed belongs to the *Homoceras coronatum* Zone. In Exposure 4a, the zone is slightly more than 10 m thick.

Assemblages 4 and 5 were found in Exposure 4b.

Assemblage 4 is recovered from Bed 32 (Sample P-28) 11.5 m above the exposure base. it includes *Homoceras bellum, Isohomoceras* sp., and *Physematites charis* Ruzh. et Bogosl. (Plate I). This assemblage is attributable to the *H. coronatum* Zone because the combination of *Homoceras* and *Physematites charis* was found in this zone of the Sholak-Sai section (Ruzhentsev and Bogoslovskaya, 1978).

In Exposure 4b, the beds referred to the *Homoceras coronatum* Zone are approximately 11 m thick. The upper zone boundary has not been established. The overall thickness of deposits spanning the *Homoceras coronatum* Zone is about 33 m.

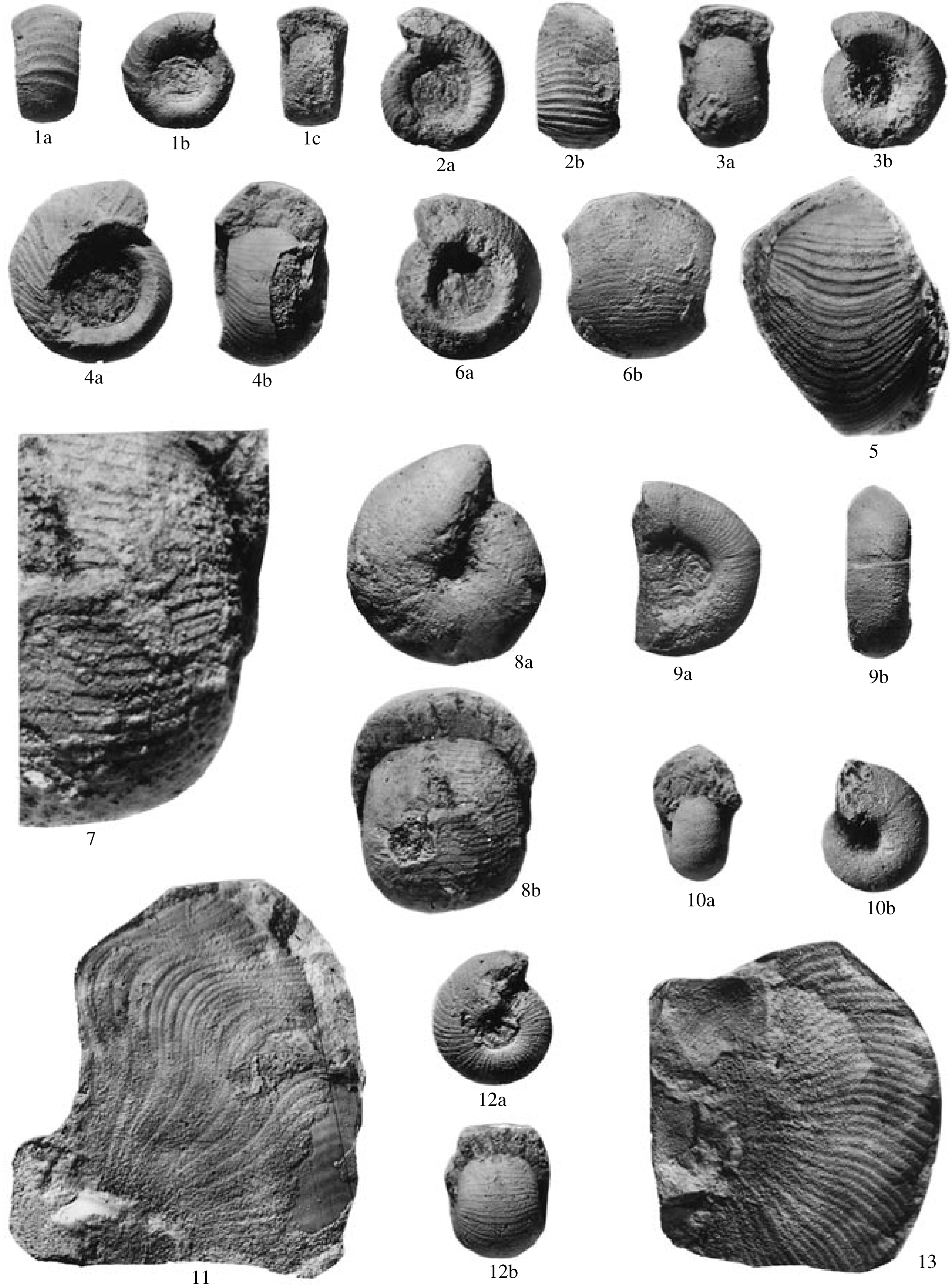
(3) *Homoceras* sp. Beds yield the Assemblage 5. Poorly preserved shells of *Homoceras* sp. were found 1 m higher than Sample 42 (Bed 45), i.e., at the level of 35 m above the section base. The fine sculpture makes these representatives of the genus *Homoceras* similar to the species of the Western European Zone H2 (for example, to *Homoceras undulatum* (Brown). However, the preservation degree is unfavorable for reliable species identification, and we conventionally attributed the beds with this form to the upper part of the *Homoceras-Hudsonoceras* Genus-zone (probably, the *Hudsonoceras proteum* Zone). Thus, we have revised the previous age determination for the 34-m-thick members 13–19 (beds 35–46) overlying Member 12, the sandstone bed of which was considered earlier by Einor *et al.* (1973a) as bearing ammonoids of the *Reticuloceras-Bashkortoceras* Genus-zone. They also considered Member 12 as the uppermost marker of the Bogdanovskii Horizon. The *Homoceras* sp. Beds can correspond to Zone H_2, and the overall thickness of the *Homoceras-Hudsonoceras* Genus-zone is more than 44 m.

Reticuloceras-Bashkortoceras Genus-zone, the Surenites krestovnikovi Zone

The boundary between the *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones is supposed to be recognizable in Exposure 4b, because ammonoids characteristic of the *Reticuloceras-Bashkortoceras* Genus-zone, which are stored at the Paleontological Institute, originate from this exposure (Einor, 1992; Einor *et al.* 1973b). However, at the top of the mountain, the upper part of the section is destroyed by recent quarry works that are now inaccessible. Assemblage 6 from Bed 8 of Exposure 3 includes *Ramosites rectus* Ruzh. et Bogosl., *Decorites* sp., and *Surenites* sp. and characterizes the lower part of the *Reticuloceras-Bashkortoceras* Genus-zone. Ruzhentsev and Bogoslovskaya (1978) reported on *Surenites krestovnikovi* Ruzh. et Bogosl. from the same bed (Sample 3). According to Ruzhentsev and Bogoslovskaya (1978, p. 15), the beds lying above bear *Baschkirites planus* Ruzh. et Bogosl., *Proshumardites karpinskii* Raus., *Paraschartymites repens* Ruzh. et Bogosl., *Fallacites* aff. *portentosus* Ruzh. et Bogosl., *Phillipsoceras gammarhipaeum* Ruzh. et Bogosl., *P. carinatum* Ruzh. et

Plate I. Ammonoids from the right bank of the Bol'shaya Suren' River, site near the Novyi Bogdanovskii Settlement.

(1–5) *Homoceras bellum* Nikolaeva: (1) Specimen 4475/15, ×3; (2) Holotype 4475/18, ×3; (3) Specimen 4475/30, ×5; (4) Specimen 4475/13, ×3; (5) Specimen 4475/14, ×3; Exposure 4a, (1 and 2) Sample 4/1, (3) Sample P-28, (4 and 5) Sample P-16; (6) *Homoceras coronatum* (Haug), Specimen 4475/20, ×3; Exposure 4a, Sample 4/1 (P-10); (7–8) *Physematites charis* Ruzhencev et Bogoslovskaya, Specimen 4475/40b, ×10 for (7) and ×5 for (8), Exposure 4b, Sample P-28; (9) *Stenoglaphyrites* sp., Specimen 4475/16, ×3, Exposure 4a, Sample 4/1 (P-10); (10) *Fayettevillea* sp., Specimen 4475/17, ×3, Exposure 4a, Sample 4/1 (P-10); (11) *Isohomoceras* sp., Specimen 4475/41, ×3, Exposure 4a, Sample P-7; (12) *Isohomoceras bogdanovskense* Nikolaeva, Holotype 4475/19, ×3, Exposure 4a, Sample 4/1 (P-10); (13) *Ramosites corpulentus*, Specimen 4475/35, ×3; Exposure 4a, Sample P-7.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Bogosl., and *Reticuloceras exultum* Ruzh. et Bogosl.. This assemblage characterizes the upper part of the *Reticuloceras-Bashkortoceras* Genus-zone and can be correlated with assemblages from the *Reticuloceras reticulatum* Zone and, partly, from the *Phillipsoceras gracile* Zone of Western Europe.

CONODONTS

Conodonts of the Bogdanovskii and Syuran horizons of the Suren' River basin were first detected by Furdui (Einor *et al.*, 1973a). In the cited and later publications, Furdui summarized data on conodont assemblages from the Bogdanovka, Yamashly, Uskalyk, and Askyn sections, but without their zonation (Furdui, 1975). The assemblages include forms characteristic of the Serpukhovian and Bashkirian stages.

The conodont collection studied in this work is from Exposure 4, including its oldest, formerly unexposed interval. The collection includes over 1500 specimens from 33 samples. More than 90% of the specimens are represented by platform elements, and about 8% of them correspond to conodonts redeposited mainly from the Serpukhovian, and to a lesser degree, from Famennian and Visean strata. The Bogdanovskii Horizon of Exposure 4 yielded conodonts of the *D. noduliferus* and *Id. sinuatus* zones (Plate II). The first unit is represented by the upper *Late D. noduliferus* Subzone (Pazukhin, 1995). The lower *Early D. noduliferus* Subzone is unexposed. The first occurrence level of *Declinognathodus noduliferus* has not been identified in the type area of the Bogdanovskii and Syuran horizons.

Declinognathodus noduliferus Zone

Late Declinognathodus noduliferus Subzone

The *Late Declinognathodus noduliferus* Subzone spans beds 1–5 of Exposure 4a (thickness 2.6 m). Species of stratigraphic significance are *Declinognathodus inaequalis* (Hig.), *D. lateralis* (Hig. et Bouck.), *D. japonicus* (Igo et Koike), *D. noduliferus* (Ell. et Grav.), and *D. praenoduliferus* Nigm. et Nem. Redeposited *Lochriea cruciformis, Gnathodus bilineatus bollandensis, Lochriea commutatus*, and *Gnathodus texanus* occur throughout the zone. The assemblage of the *Late D. noduliferus* Subzone was also found on the western and eastern slopes of the South Urals (Kulagina *et al.*, 1992, 1997). It corresponds to the assemblage of the *D. noduliferus* Zone in England (Higgins, 1995; Ramsbottom *et al.*, 1979).

Idiognathoides sinuatus Zone

The *Id. sinuatus* Zone extends throughout beds 6–31 of Exposure 4a and all beds of Exposure 4b. The conodont assemblage is represented here by species inherited from the *D. noduliferus* Zone and combined with *Idiognathoides asiaticus* Nigm. et Bem., *Id. corrugatus* Har. et Holl., *Id. sinuatus* Har. et Holl., and with redeposited *Gnathodus bilineatus bollandensis, Gnathodus bilineatus bilineatus, Lochriea nodosus, Lochriea mononodosus, Lochriea commutatus*, and *Polygnathus inornatus.* In Exposure 4a, the lower zone boundary lies within the beds with ammonoids characterizing the lower part of the *Homoceras coronatum* Zone. It is drawn at probably isochronous levels in many sections of the western and eastern slopes of the South Urals (Kulagina *et al.*, 1992, 1997; *Putevoditel'…*, 1995).

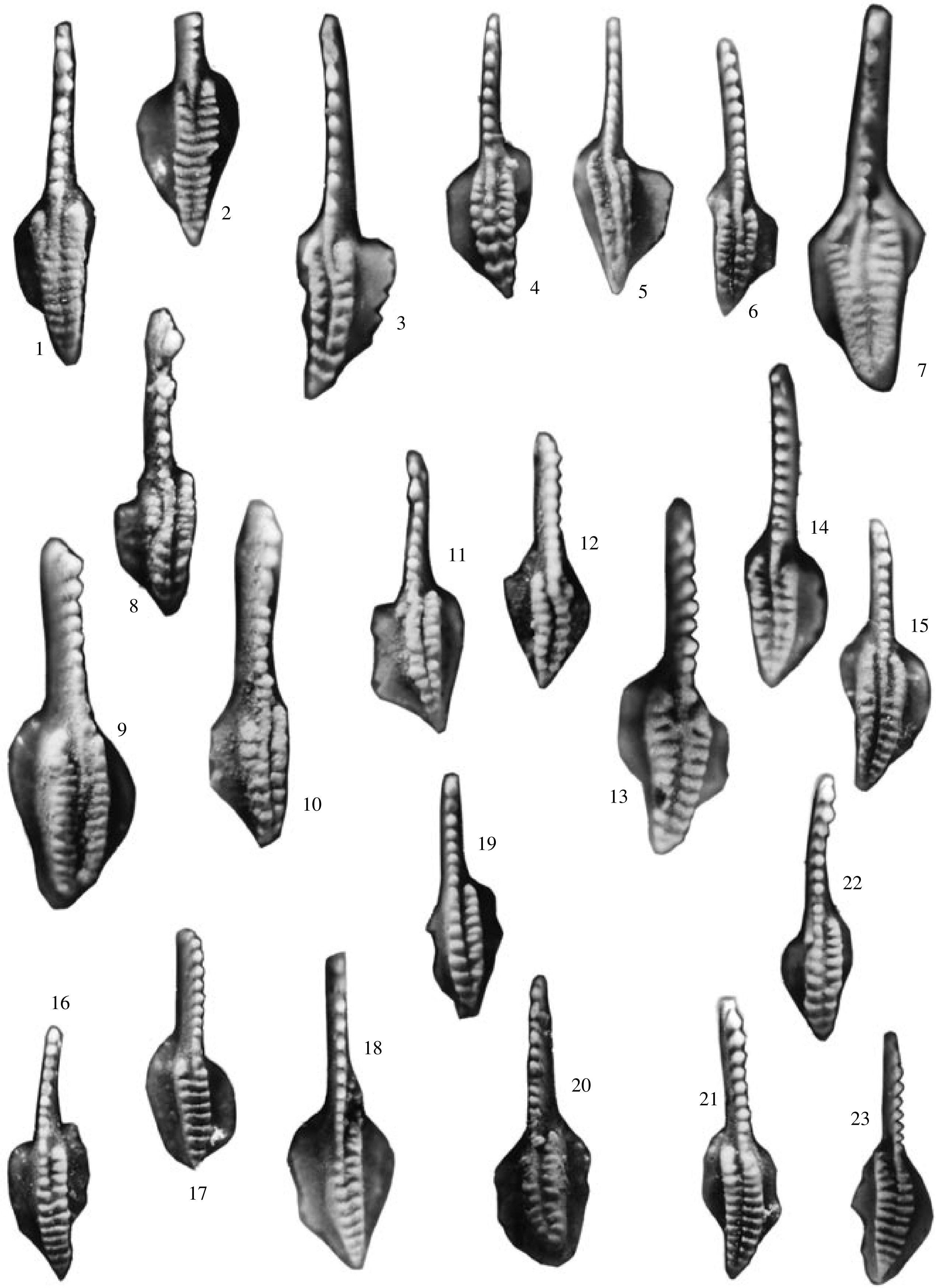
The conodont assemblage is not very comparable to that from the Bashkirian hyperstratotype at the Askyn River, because the last section contains rare conodonts of the shallow-water *Rachystognathus-Declinognathodus* biofacies. The assemblage of the *Early D. noduliferous* Subzone has not yet been found in the lower Bogdanovskii Horizon of the Askyn section, whereas the assemblage of the *Id. sinuatus* Zone appears there at a much higher level than in sections of deep-water deposits (Nemirovskaya and Alekseev, 1995; *Putevoditel'…*, 1995).

FORAMINIFERS

Foraminifers of the Bol'shaya Suren' River were studied by Kireeva, Minyaeva, and Reitlinger (see in Einor *et al.*, 1973a, 1973b). Reitlinger (1980) described

Plate II. Conodonts from the right bank of the Bol'shaya Suren' River, site near the Novyi Bogdanovskii Settlement (×50 for all specimens).

(1–3) *Declinognathodus praenoduliferus* Nigmadganov et Nemirovskaya: (1) Specimen 104/600, Exposure 4A, Sample P-1; (2) Specimen 104/601, Exposure 4a, Sample P-11; (3) Specimen 104/602, Exposure 4b, Sample P-18. (4–6, 14) *Declinognathodus inaequalis* (Higgins): (4) Specimen 104/603, Exposure 4b, Sample P-26; (5) Specimen 104/604, Exposure 4a, Sample P-11; (6) Specimen 104/605, Exposure 4a, Sample P-17; (14) Specimen 104/621, Exposure 4a, Sample P-11. (7, 13, 15) *Declinognathodus lateralis* (Higgins et Bouckaert): (7) Specimen 104/606, Exposure 4b, Sample P-18; (13) Specimen 104/607, Exposure 4a, Sample P-11; (15) Specimen 104/608, Exposure 4a, Sample P-11. (8, 10) *Declinognathodus noduliferus* (Ellison et Graves): (8) Specimen 104/609, Exposure 4a, Sample P-1; (10) Specimen 104/610, Exposure 4a, Sample P-04. (9) *Declinognathodus* aff. *lateralis* (Higgins et Bouckaert), Specimen 104/620, Exposure 4a, Sample P-11. (11, 12, 22) *Declinognathodus japonicus* (Igo et Koike): (11) Specimen 104/611, Exposure 4a, Sample P-04; (12) Specimen 104/612, Exposure 4a, Sample P-1; (22) Specimen 104/622, Exposure 4a, Sample P-7. (16–18) *Idiognathoides asiaticus* Nigmadganov et Nemirovskaya: (16) Specimen 104/613, Exposure 4a, Sample P-7; (17) Specimen 104/614, Exposure 4a, Sample P-03; (18) Specimen 104/615, Exposure 4a, Sample P-11. (19, 20) *Idiognathoides sinuatus* Harris et Hollingsworth: (19) Specimen 104/616, Exposure 4b, Sample P-28; (20) Specimen 104/617; Exposure 4a, Sample P-03. (21, 23) *Idiognathoides corrugatus* Harris et Hollingswort: (21) Specimen 104/618, Exposure 4a, Sample P-7; (23) Specimen 104/619, Exposure 4a, Sample P-03.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the foraminiferal assemblage of the Bogdanovskii Horizon from three sections (Bogdanovka, Yamashly, and Uskalyk). This assemblage contains the characteristic form *Plectostaffella bogdanovkensis*, which was subsequently used as a zonal index species. Kireeva (1978) noted a similarity in the foraminiferal assemblage from the Bogdanovskii Horizon with that of the Krasnaya Polyana Horizon of the Russian platform. According to Sinitsyna *et al.* (1984), who studied the Bashkirian hypostratotype at the Askyn River, the *Pl. bogdanovkensis* Zone corresponds to the lower part of the *Eostaffella pseudostruvei-E. postmosquensis-E. varvariensis* Zone of the general Russian scale. The beds of the Askyn section, which were earlier referred to the Syuran Horizon, were included in the last publication into the Bogdanovskii Horizon. M.B. Postoyalko (see in *Stratigraficheskie…*, 1993) reported that the species *Pl. bogdanovkensis* is associated with the typical "Syuran" assemblage of foraminifers in many sections of the Bashkirian Stage, and, accordingly, the Bogdanovskii Horizon was not accepted as the independent stratigraphic unit. The assemblage of *E. pseudostruvei-E. postmosquensis-E. varvariensis* Zone can be traced up to the top of the Syuran Horizon without being significantly changed. Within this interval, however, the genus *Semistaffella* appeared and evolved. Therefore, it would be more correct to introduce the *Eostaffella pseudostruvei s. 1* Zone with three subzones (Kulagina and Sinitsyna, 1997). In the sections studied, foraminifers were found in clotted limestones (biopelsparites), organogenic-clastic limestones (litho-bioclastic packstones and grainstones), and organogenic limestones (bioclastic wackestones and packstones). The clotted limestones (samples P-7, P-9, P-15, P-24, P-25, 172–174, P-41, P-44, P-48, 3/10, and 3/24) yielded an assemblage consisting of very small shells of genera *Mediocris* and *Endostaffella* in association with less frequent *Eostaffella, Plectostaffella, Biseriella*, and *Asteroarchaediscus* forms, whose identification is often difficult. This endosstaffellid biofacies is widespread in both the Serpukhovian and lower Bashkirian deposits. The foraminiferal-detrital limestones (wackestones and bioclastic packstones, samples P-1–P-3, 03, P-10–P-12, P-17, P-18, P-20, P-22, P-24, P-26, 176) of the endothyrid-eostaffellid biofacies bear characteristic species *Tolipammina fortis* Reitl., *Haplophragmina beschevensis* Brazhn., *Pseudoglomospira* spp., *Endothyra bowmani* Phill., *E. phrissa* Zeller, *Semiendothyra surenica* Reitl., *Endotaxis brazhnikovae* (Bog. et Juf.), *Eostaffellina paraprotvae* Raus., *Eostaffella postmosquensis* Kir., *E. pseudostruvei* (Raus. et Bel.) with subspecies, *E. ovoidea* Brazhn. et Pot., *E. pseudoovoidea* Reitl., the group of *E. parastruvei* Raus, *Plectostaffella bogdanovkensis* Reitl., *Pl. reitlingeri* Groves, *Pl. varvariensis* (Brazhn. et Pot.), *Biseriella minima* Reilt., and *Globivalvulina bulloides* (Brady). Less frequent species are *E. (Rectoendothyra) donbassica* Brazhn., *Bradyina cribrostomata* Raus. et Reitl., *Br. concinna* Reitl., archaeodiscids, howchiniids, tetratixiids, and paleotextulariids. The less diverse endothyrid-eostaffellid assemblage (Plate III) is confined to the organogenic-clastic limestones (samples 05B, 04, 03/2, P-13, P-30).

The foraminiferal assemblage described generally corresponds to the *Eostaffella pseudostruvei s.1* Zone consisting of subzones characterized below.

The *Plectostaffella bogdanovkensis* Subzone includes beds 1–9 of Exposure 4a, which are predominantly composed of organogenic-detrital limestones with the rich foraminiferal assemblage of the endothyrid-eostaffellid biofacies. In addition, there occur rare *Plectostaffella evolutica* (Rum.), *Pl.* aff. *varvariensiformis* Brazhn. et Vdov., *Pl. jakhensis* Reitl., *Eostaffella parastruvei* Raus., *E. mirifica* Brazhn., *E. mosquensis* Viss., *Archaediscus krestovnikovi* Raus., *A. vicherensis* (Grozd. et Leb.), *Asteroarchaediscus bashkiricus* Krest. et Theod., *Ast. rugosus* (Raus.), *Neoarchaediscus postrugosus* (Reitl.), *Monotaxinoides tran-*

Plate III. Foraminifers from the right bank of the Bol'shaya Suren' River, site near the Novyi Bogdanovskii Settlement (all specimens, except for those specially indicated, are from Exposure 4).

(1–3) *Eostaffella pseudostruvei* (Rauzer et Belayev), ×85: (1) Specimen 121/847, Sample P-1A; (2) Specimen 121/443, Sample P-18; (3) Specimen 121/848, Sample P-2. (4, 5) *Eostaffella pseudostruvei angusta* Kireeva: (4) ×85, Specimen 121/849, Sample 3b; (5) Specimen 121/446, Sample P-20. (6) *Eostaffella ovoidea* Brazhnikova et Potiyevskaya, ×75, Specimen 121/438, Sample P-18. (7) *Eostaffella pseudoovoidea* Reitlinger, ×85, Specimen 121/850, Sample P-3. (8) *Eostaffella postmosquensis* Kireeva, ×85, Specimen 121/851, Exposure 3, Sample 3/13. (9) *Eostaffella postmosquensis acutiformis* Kireeva, ×85, Specimen 121/852, Sample P-10. (10) *Eostaffella nauvalia* Rumjanzeva, ×85, Specimen 121/853, Sample P-1A. (11) *Millerella paraumbilicata* Manikalova, ×85, Specimen 121/854, Sample P-20. (12) *Plectostaffella evolutica* (Rumjanzeva), ×75, Specimen 121/442, Sample P-26. (13, 14) *Plectostaffella varvariensis* Brazhnikova et Poliyevskaya, ×85, Exposure 3, Sample 3/25; (13) Specimen 121/855; (14) Specimen 121/856. (15, 16) *Plectostaffella* ex gr. *varvariensis* Brazhnikova et Potiyevskaya, ×75, (15) Specimen 121/456, Sample 176; (16) Specimen 121/857, Sample P-20. (17) *Plectostaffella* sp., ×85, Specimen 121/858, Sample 172. (18, 19) *Plectostaffella bogdanovkensis* Reitlinger: (18) ×85, Specimen 121/859, Sample P-1A; (19) ×75, Specimen 121/453, Sample P-20. (20) *Plectostaffella jakhensis* Reitlinger, ×85, Specimen 121/860, Exposure 3, Sample 3/14. (21) *Plectostaffella obtusa* Reitlinger, ×75, Specimen 121/837, Exposure 3, Sample 3/10. (22) *Plectostaffella* aff. *varvariensiformis* Brazhnikova et Vdovenko, ×85, Specimen 121/861, Sample P-2. (23) *Semistaffella?* sp., ×100, Specimen 121/862, Sample P-2. (24, 25, 28, 29) *Semistaffella minuscilaria* Reitlinger, ×100: (24) Specimen 121/863, Sample 03; (25) Specimen 121/864, Sample 172; (28) Specimen 121/865, Sample P-11; (29) Specimen 121/866, Sample P-45. (26, 27) *Plectostaffella reitlingeri* Groves, ×100: (26) Specimen 121/867, Sample P-3B; (27) Specimen 121/868, Sample 03. (30) *Pseudostaffella* aff. *primitiva* Reitlinger, ×100, Specimen 121/869, Sample P-47. (31) *Pseudostaffella antiqua* (Dutkevich), ×85, Specimen 121/870, Exposure 3, Sample 3/31. (32) *Pseudostaffella uralica* Kireeva, ×85, Specimen 121/871, Sample 3/31.


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Plate IV. Middle Carboniferous ostracodes from the Mt. Kamennaya site (all specimens are from Exposure 4a located to the southeast of the Novo-Bogdanovskii Settlement, ×50):

(1) *Ardmorea gibberosa* (Knight), Specimen 66-53, Sample 04/1; (2) *Perprimitia digna* N. Kochetova, Specimen 66-210, Sample P-11; (3) *Chamishaella opima* Kotschetkova; (4) *Limnoprimitia arcuata* (Bean), Specimen 66-26, Sample 04/1; (5) *Javatis kisilensis* (Kochetkova), Specimen 66-1, Sample 03. Symbols: (r) right valve view, (l) left valve view, (b) dorsal view.

sitorius Brazhn. et Pot., *Eolasiodiscus donbassicus* Reitl., single *Howchinia gibba* (Moell.), and *Mesolasiodiscus?* sp. Paleotextulariids and tetrataxiids are also present. This zone is comparable in stratigraphic range with beds 5–7 of the Bashkirian stratotype at the Askyn River (Sinitsyna and Sinitsyn, 1987).

The *Semistaffella minuscilaria* Subzone corresponds to beds 10–37 of Exposure 4a, beds 10–47 of Exposure 4b, and, probably, to beds 1–6 of Exposure 3. In Exposure 4a, the dominant species are those inherited from the underlying deposits. *Millerella paraumbilicata* Man. and *Globivalvulina kamensis* Reitl. appear there for the first time. Some interbeds (samples 10, 18) contain *Parastaffella struvei* (Moell.), *Par. utkaensa* Post., *Pseudoendothyra illustria* (Viss.), and *Ps. schlykovae* (Durk.). Beds 29–47 of Exposure 4b and beds 1–11 of Exposure 3 are not rich in foraminifers. Rare interbeds of fine-grained detrital limestones present in this interval yielded species characteristic of the *Eostaffella pseudostruvei* Zone. The subzone under consideration is correlative with the interval of the Askyn section from the upper part of Bed 7 to Bed 11 (Kulagina and Sinitsyna, 1997). According to occurrence of *Semistaffella* aff. *primitiva* Reitl. (Sample 47), beds 48–49 of Exposure 4b presumably correspond to the *Semistaffella variabilis* Zone. The beds are predominantly composed of pelitomorphic limestones lacking foraminifers. Rare interbeds at this level contain *Eostaffella postmosquensis, Millerella paraumbilicata, Plestostaffella* sp., and *Semistaffella* sp. Beds 7–11 of Exposure 3 with scarce foraminifers can be attributed to the same subzone. In Exposure 3, the considerable unexposed interval is succeeded by the limestone outcrops, where we identified *Pseudostaffella antiqua* (Dutk.), *Ps. uralica* Raus., *Ps. paracompressa* Raus., and other species characteristic of the Akavas and overlying horizons of the Bashkirian Stage. Taking into consideration the thickness of the Syuran Horizon in this structural-facial zone, we believe that its upper boundary is between beds 12 and 13.

The foraminiferal zonation of the Syuran Horizon is well correlative with that established in the central Tien Shan (Rumyantseva, 1989). The described assemblages are very similar to those known in the Donets basin and North America (Table 2).

OSTRACODS

The stratotype of the Bogdanovskii and Syuran horizons near the Novyi Bogdanovskii Settlement is characterized by the ostracode assemblage of the *Ardmorea gibberosa-Limnoprimitia arcuata* Zone recognized by Kochetkova (1983) in many sections of the South Urals. The assemblage consists of more than 50 species from 31 genera and 18 families of paleocopids, cladocopids, platicopids, metacopids, and podocopids (Plate IV). The lowermost beds of the Syuran horizon (Exposure 4a, samples 05-B, 05-A, P-1/B) yielded the paraparchytid-bairdiid assemblage of scarce shells of *Polycope perminuta* (Kellett), *Shishaella claytonensis* (Knight), *Shis. circinata* N. Kotch., *Shivaella evidens* Kotsch., *Chamishaella uniformis* Kotsch., *Microcoeloenella orbiculata* Kotsch., *Healdia procerula* Kotsch., *Bairdia alula* Kotsch., *B. laklyensis* Kotsch., *B. chudolasensis* Kotsch., and *Acratia* cf. *grandis* Kotsch. The overlying beds (Exposure 4a, sample 0-4/1 and others from higher levels; Exposure 4b, samples P-18, P-25, P-26, P-39, P-41) contain the most representative assemblage of the zone, which includes, along with the forms listed above, *Javatius eximius* Kotsch.,

Table 1. Relationships between ammonoid, foraminifer, conodont, and ostracode zonations in the Syuran Horizon of the South Urals

Series	Stage	Horizon	Ubhorizon	Ammonoid genus-zone	Ammonoid zone of West Europe	Zones, subzones, beds: foraminifers		Zones, subzones, beds: conodonts		Zones, subzones, beds: ostracodes	Sections: Novo-Bogdanovskii, Exposure 3	Sections: Novo-Bogdanovskii, Exposure 4	Sections: Muradymovo	Sections: Askyn
Middle Carboniferous	Bashkirian	Akavas		*Bilinguites-Cancelloceras*	G1	*Pseudostaffella antiqua*		*Neognathodus askynensis*		*Coryellina inflata-Kirkbyella aperta*				
					R2									
		Syuran	?	*Reticuloceras-Bashkortoceras*	R1	*E. pseudostruvei*	*Semistaffella variabilis*	*Idiognathoides sinuatus*		*Ardmorea gibberosa-Limnoprimitia arcuata*				
					H2		*Semistaffella minuscilaria*							
			Bogdanovskii	*Homoceras-Hudsonoceras*	H1		*Plectostaffella bogdanovkensis*	*D. noduliferus*	Late					
						E. explicata M. subplana	*Plectostaffella varvariensis*		Early	*Fellerites gratus* Beds				
Lower Carboniferous	Serpukhovian	Staroutkinskii		*Fayettevillea-Delepinoceras*	E2		*Monataxinoides transitorius*	*Gnathodus bilineatus bollandensis*		*Carbonita ? subquadrata-Aurigerites solitarius* *Anachuacia rara*				

Coeloenellina ultima Kotsch., *C. serotina* Kotsch., *Glyptopleura* cf. *subvarians* Kotsch., *Idiomorphina subsimplex* N. Kotch., *Polycope? rugosa* Kotsch., *Discoidella perpicua* Kotsch., *Shivaella asselica* Jag., *Bairdia rustica* Kotsch., *B. bogdanovkaensis* N. Kotch., *B. gibbus* Kotsch., *Bairdiacypris subconspicuus* Kotsch., *B. indiges* Kotsch., *B. obtusus* Kotsch., *Acratia demissa* Kotsch., *Roundyella subaculeata* N. Kotch., *Macrocypris lenticularis* Cooper, and *M.* cf. *menardensis* Harlton, as well as *Ectodemites planus* Cooper, *Kirkbuina tenella* N. Kotch., *Bolbozoella inflata* Grundel, *Rectonaria accepta* N. Kotch., *Triplacera imperspicua* N. Kotch., and *Basslerella longa* N. Kotch. These species are typical of the upper Serpukhovian deposits. The presence of the genera *Kirkbyella, Coryellina, Cavellina*, and *Paraberounella* is remarkable. Also indicative is the coexistence of index-species *Limnoprimitia arcuata* (Bean) and *Ardmorea gibberosa* (Knight) with single *Javatius kisilensis* (Kotsch.), *Perprimitia digna* N. Kotch., and *Chlamishaella opima* Kotsch.

The upper part of Exposure 4b (Sample 49) and beds 5–11 of Exposure 3 (samples 3/10, 3/13, 3/24, 3/25) yielded an impoverished assemblage of the *Ard. gibberosa-L. arcuata* Zone, which includes rare *Perprimitia* sp., *Glyptopleura* sp., *Microcoeloenella orbiculata* Kotsch., and *Dorsoobliquella ovalis* Kotsch. Exposure 3 also yielded *Coryellina* sp., *Kirkbya* sp., *Limnoprimitia* cf. *arcuata* (Bean), *Idiomorphina* sp., and *Glyptolichwinella postuma* Kotsch. In association with poorly preserved and incomplete shells of paraparchytids and bairdiids, few of which are identifiable at the species level.

On the basis of ostracodes, the Syuran Horizon is correlative with coeval deposits of the central Tien Shan, where two assemblages characterize the *Perprimitia digna* and *Javatius kisilensis-Chlamishaella opima* beds. The described assemblages are similar in species composition to that of the *Ard. gibberosa-L. arcuata* Zone of the Urals, but they lack the index-species of the latter.

DISCUSSION

The detailed investigations in the type area of the Syuran and Bogdanovskii horizons showed that both can be recognized in the same limestone succession exposed at the left bank of the Bol'shaya Suren' River. The Bogdanovskii Horizon corresponds to the lower part of Exposure 4 (according to the terminology of Einor *et al.*, 1973a, 1973b), and the Syuran Horizons to the upper part of Exposure 4 and to Exposure 3 (Table 1). The Bogdanovskii Horizon, as established by Einor *et al.* (1973a, 1973b), actually represents the lower part of the Syuran Horizon and is equal in the stratigraphic range to the ammonoid *Homoceras* Zone

Table 2. Correlated foraminiferal zonations in different regions

<table>
<tr><th>General foraminiferal zonation in Russia (Reshenie…, 1990)</th><th colspan="2">The Urals (Strati-graphicheskie…, 1993), western and eastern subregions</th><th colspan="2">South Urals (Kulagina and Sinitsyna, 1997)</th><th>Central Tien Shan (Rumyantseva, 1989)</th><th>Donbas (Vdovenko et al., 1989)</th><th>North America, Arrow Canyon (Brenckle et al., 1997; Ross, 1997)</th></tr>
<tr><td>Ps. antiqua</td><td colspan="2">Ps. antiqua</td><td colspan="2">Ps. antiqua</td><td>Ps. antiqua</td><td>Ps. antiqua</td><td>Pseudostaffella sp.</td></tr>
<tr><td rowspan="2">Pl. varvariensis
E. pseudostruvei
E. postmosquensis</td><td colspan="2" rowspan="2">E. postmosquensis
Pl. jakhensis</td><td rowspan="3">E. pseudostruvei</td><td>S. variabilis</td><td>S. variabilis</td><td rowspan="2">E. postmosquensis
E. pseudostruvei
Pl. varvariensis</td><td rowspan="2">Millerella marblensis</td></tr>
<tr><td>S. minuscillaria</td><td>Pl. seslavica</td></tr>
<tr><td>Pl. bogdanovkensis</td><td rowspan="3">Parastaffella utkaensa–Eoplect. acuminata</td><td rowspan="3">Br. cribrostomata
Pl. varvariensis</td><td>Pl. bogdanovkensis</td><td>Pl. bogdanovkensis</td><td>Pl. berestovensis-E. angusta</td><td>Mill. pressa</td></tr>
<tr><td rowspan="2">Eosigmoilina explica-ta–Monotaxinoides subplana</td><td colspan="2">Pl. varvariensis*</td><td>Pl. posochovae*</td><td rowspan="2">Loeblichia* minima–M. tran-sitorius
Eos. explicata</td><td rowspan="2">Breckleina rugosa*
Eosigmoilina robertsoni</td></tr>
<tr><td colspan="2">M. transitorius</td><td>Eos. explicata</td></tr>
</table>

* First occurrence level of *Declinognathodus noduliferus*.

(the *Homoceras-Hudsonoceras* Genus-zone of the Carboniferous stratigraphic scale of Russia). It was long deemed that the *Reticuloceras-Bashkortoceras* Genus-zone spans the greater part of Exposure 4, while the *Homoceras-Hudsonoceras* Genus-zone is restricted to the rest small portion of the section (beds 16–34). Beds 1–15 were distinguished in the recent prospecting trench (Kulagina *et al.*, 1992). However, recent ammonoid findings suggest that the Bogdanovskii Horizon should be extended upward throughout the 34-m-thick overlying beds. In the stratotype of the Bogdanovskii Horizon, its lower boundary drawn at the base of the ammonoid *Homoceras* Genus-zone is not observable, and the lowermost beds corresponding to the ammonoid *Isohomoceras subglobosum* Zone and to the conodont *Early D. noduliferus* Subzone are missing. This interval was recognized in some sections of western and eastern slopes of the South Urals. It is completely represented in the Muradymovo Village section correlative with the stratotype and located in the same structural-facial zone (Kulagina *et al.*, 1992; *Putevoditel'*…, 1995).

In the Muradymovo section, the lower boundary of the Syuran Horizon is placed at the base of the *Early D. noduliferus* Subzone, where conodonts *D. noduliferus* (Ell. et Grav.) and *D. inaequalis* (Hig.) appear. The assemblage of the subzone is dominated by species that first appeared in Visean and Serpukhovian times, such as *Gnathodus bilineatus bilineatus* (Roundy), *Gn. bilineatus bollandensis* Hig. et Bouck., *Gn. postbilineatus* Nigm. et Nem., *Lochriea commutata* (Br. et Mehl), *L. costata* (Paz. et Nem), *L. monocostata* (Paz. et Nem.), *L. mononodosa* (Rh., Aust. et Dr.), *L. nodosa* (Bisch.), and *L. ziegleri* Nem., Per. et Meisch. Less frequent are *Cavusgnathus uniformis* Youngq. et Mill. and *Mestognathus bipluti* Hig. The subzone can be correlated with lower beds of the Voznesensk Horizon of the Donets basin (Limestones D58–D59), which contains *D. noduliferus* and *Gn. bilineatus bollandensis* (*Verkhneserpukhovskii*…, 1983; Nemirovskaya and Nigmadzhanov, 1994). In the southern Tien Shan, the Suffa Formation of the Gissar Ridge (the Aksu 1 and Aksu 4 sections) includes an interval, which yields both the Serpukhovian and Bashkirian conodonts (Nigmadganov and Nemirovskaya, 1992; Nemirovskaya and Nigmadganov, 1994). In contrast to the Urals, *D. praenoduliferus* appears in Tien Shan at a lower level than other representatives of the genus *Declinognathodus* being almost concurrent with *Idiognathoides asiaticus* and *I. sulcatus.* In the stratotype of the mid-Carboniferous boundary (the Arrow Canyon section), the lower *D. noduliferus* Subzone is confined to the shallower marine biofacies characterized by representatives of the genera *Declinognathodus, Adetognathus, Rhachistognathus*, and *Gnathodus* (the group of *girtyi* and *deflectus* after Brenckle *et al.*, 1997). In the stratigraphic schemes of the Urals (*Stratigraficheskie*…, 1993), the lower boundary of the Bashkirian Stage is drawn at the base of the foraminiferal *E. postmosquensis-Pl. jakhensis* Zone corresponding to the *P. bogdanovkensis* and *E. pseudostruvei-E. postmosquensis-Pl. varvariensis* zones of the general stratigraphic scale of Russia. The *Pl. bogdanovkensis* Zone is correlative with the ammonoid *Homoceras* Zone. However, the thorough investigations of sections in the South Urals revealed that *D. noduliferus* appeared for the first time (Table 2) in the beds bearing Serpukhovian foraminifers (Kulagina *et al.*, 1992). The same distribution patterns are recorded in the Donets basin (*Verkhneserpukhovskii*…, 1983; Vdovenko *et al.*, 1989). In the Muradymovo section with abundant Late Serpukhovian species, the earliest *D. noduliferus* is found in association with rare *Plectostaffella varvariensis* Brazhn. and *Planoendothyra aljutovica* Reitl. We recognized the last level as the *Pl. varvariensis* Subzone correlative with the upper part of the *Eosigmoilina* *explicata-Monotaxinoides subplanus* Zone of the general scale (Table 1). This zone may correspond to the *Plectostaffella posochovae* Zone (Rumyantseva, 1989; Kulagina *et al.*, 1992) underlying the *Pl. bogdanovkensis* Zone of central Tien Shan.

In the Muradymovo section, the earliest conodonts *D. noduliferus* (beds 9a and 9b) are associated with a transitional ostracode assemblage characteristic, in our nomenclature, to the *Fellerites gratus* Beds. The assemblage includes the rare early Bashkirian forms, such as *Bairdia chudolasensis* Kotsch., *Bairdiacypris indiges* Kotsch., *Basslerella simonovae* Kotsch., and *Bass. subcrassa* Kotsch., all associated with predominant Serpukhovian species *Kirkbyina tenella* N. Kotch., *Healdia uralica* N. Kotch, *H. ikensis* N. Kotch., *Bolbozoella nodosa* Robinson, *Bolb. inflata* Grundel, and *Bairdiocypris subalia* N. Kotch., and also with a peculiar facies-restricted association of kirkbyaceans consisting of representatives of genera *Kirkbya, Amphissamples, Ectodemites, Amphizona*, and *Kellettina.* Rare specimens of *Fellerites gratus* N. Kotch. et Vak. are characteristic of this level as well. The overlying bed yielded scarce ostracode shells characteristic of the *Admorea gibberosa-Limnoprimitia arcuata* Zone, its index-species included (Kulagina *et al.*, 1992). Thus, the Syuran Horizon corresponds to two ammonoid *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones, to two conodont zones of *Declinognathodus noduliferus* (with the *Early D. noduliferus* and *Late D. noduliferus* subzones) and *Idiognathoides sinuatus*, to the foraminiferal *Plectostaffella varvariensis* Subzone and *Eostaffella pseudostruvei* Zone (with three subzones), and to the *Fellerites gratus* Beds and *Ardmorea gibberosa-Limnoprimitia arcuata* Zone of ostracodes (Table 1). The important change in the conodont assemblages (the appearance of *Idiognathoides sinuatus*) almost coincides in time with the appearance of *Semistaffella minuscilaria* within Zone H_1. The Syuran Horizon comprises the greatest number of ammonoid genus-zones as compared to the Serpukhovian and Bashkirian horizons corresponding either to a one genus-zone or to a part of such subdivision. The Bogdanovskii Horizon spanning the range of the *Homoceras-Hudsonoceras* Genus-zone and representing a part of the Syuran Horizon can be incorporated as a subhorizon into the stratigraphic scheme of the Urals. According to our data, the Bogdanovskii Horizon is about 44 m thick in the stratotype. The overlying deposits of the *Reticuloceras-Bashkortoceras* Genus-zone should be recognized as a new subhorizon, whose lower boundary is coincident with the lower boundary of the ammonoid *Surenites krestovnikovi* Zone is probably located close to that of the foraminiferal *Semistaffella variabilis* Subzone.

The problem of recognizing a new horizon in the considered part of the section was discussed in earlier publications (Nikolaev, 1989; Einor, 1992). The problem of positioning the upper boundary of the Syuran Horizon on the basis of ammonoid zonation remains open at present, unless the ammonoid succession will be adequately studied in the basal beds of the overlying Akavas Horizon.

CONCLUSIONS

(1) The stratotype of the Syuran Horizon does not exhibit its lower boundary coincident with the base of the Middle Carboniferous. The stratotype lacks the lowermost beds of the horizon, which correspond to the ammonoid *Isohomoceras subglobosum* Zone, to the conodont *Early D. noduliferus* Subzone, to the foraminiferal *Pl. varvariensis* Subzone, and to the ostracode *Fellerites gratus* Beds. This interval is completely represented in the section near the Muradymovo Village, which is suggested as the hypostratotype of the Syuran Horizon.

(2) The Syuran Horizon corresponds to the following biostratigraphic units: the ammonoid *Homoceras-Hudsonoceras* and *Reticuloceras-Bashkortoceras* genus-zones; the conodont *D. noduliferus* Zone (with two, Late and Early Subzones) and *Id. sinuatus* Zone; the foraminiferal *Pl. varvariensis* Subzone (the upper part of the *Monotaxinoides subplanus-Eosignoilina explicata* Zone), the *E. pseudostruvei* Zone with three subzones (*Pl. bogdanovkensis, S. minuscilaria*, and *S. variabilis*); the *Fellerites gratus* Beds and *Ardmorea gibberosa-Limnoprimitia arcuata* Zone of ostracode zonation.

(3) The Bogdanovskii Horizon actually represents the lower part of the Syuran Horizon and should be included into the Unified stratigraphic scheme of the Urals as the subhorizon equal in scope to the ammonoid *Homoceras-Hudsonoceras* Genus-Zone. In the stratotype of the Bogdanovskii Subhorizon, the *Homoceras-Hudsonoceras* Genus-Zone is characterized by ammonoids of the *Homoceras coronatum* Zone; whereas the *Hudsonoceras proteum* Zone is conventionally recognized by the presence of the fine-sculptured *Homoceras* forms.

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REFERENCES

Bisat, W.C., The Carboniferous Goniatites of the North of England and Their Continental Equivalents, *Proc. Yorkshire Geol. Soc., New Ser.*, 1924, vol. 20, part 1, pp. 40–124.

Brenckle, P.L., Baesemann, J.F., and Lane, H.R., *et al.*, Arrow Canyon, the Mid-Carboniferous Boundary Stratotype, *Guidebook: Arrow Canyon Range, Nevada*, Brenckle, P.L. and Rage, W.R., Eds., *Spec. Publ. Cushman Found. Foram. Res.*, 1997, no. 36, pp. 13–32.

Einor, O.L., Problems of the Bashkirian Biostratigraphy in the Stratotype Area, Mountainous Bashkiria, *Byull. Mosk. O–va Ispyt. Prir., Otd. Geol.*, 1992, vol. 67, no. 2, pp. 67–79.

Einor, O.L., Furdui, R.S., and Aleksandrov, V.A., The Syuran Horizon and the Problem of Lower-Middle Carboniferous Boundary in the South Urals, in *Materialy po geologii, gidrogeologii, geokhimii i geofizike Ukrainy, Belorussii, Armenii, Urala, Kazakhstana i Sibiri* (Materials on Geology, Geochemistry, and Geophysics of the Ukraine, Byelorussia, Armenia, the Urals, Kazakhstan, and Siberia), Kiev: Kiev Gos. Univ., 1973a, pp. 92–102.

Einor, O.L., Furdui, R.S., Aleksandrov, V.A., *et al.*, The Bogdanovskii and Syuran Horizons of the Carboniferous System in the Bol'shaya Suren' River Basin, Mountainous Bashkiria, *Dokl. Akad. Nauk SSSR*, 1973b, vol. 213, no. 5, pp. 1155–1157.

Furdui, R.S., Conodont-Based Subdivision of the Carboniferous in the South Urals, in *Stratigrafiya i Biogeografiya morei i sushi kamennougol'nogo perioda na territorii SSSR* (The Carboniferous Stratigraphy and Biogeography of Seas and Land in the USSR), Kiev: Vishcha Shkola, 1975, pp. 104–109.

Higgins, A.C., Conodont Zonation of the Late Visean-Early Westphalian Strata of the South and Central Pennines of Northern England, *Bull. Geol. Surv. Great Britain*, 1975, vol. 53, pp. 1–90.

Kamennougol'naya sistema (The Carboniferous System), Leningrad: Vses. Geol. Inst., 1990.

Kireeva, G.D., Evolution of Foraminifers at the Lower-Middle Carboniferous Boundary, in *Voprosy stratigrafii paleozoya* (Problems of the Paleozoic Stratigraphy), Moscow: Nauka, 1978, pp. 164–167.

Kochetkova, N.M., *Ostrakody srednego karbona Yuzhnogo Urala* (Middle Carboniferous Ostracodes of the South Urals), Moscow: Nauka, 1983.

Krestovnikov, V.N., Stratigraphy of the Goniatite-Bearing Carboniferous Deposits at the Syuran River of the South Urals, *Byull. Mosk. O–va Ispyt. Prir., Otd. Geol.*, 1935, vol. 13, no. 1, pp. 15–27.

Kulagina, E.I., Pazukhin, V.N., Kochetkova, N.M., and Kochetova, N.N., Biostratigraphy of the Lower-Middle Carboniferous Boundary in the South Urals, in *Biostratigrafiya neftegazonosnykh basseinov* (Biostratigraphy of Oil-and-Gas Basins), St. Petersburg: Vseross. Nauchn.-Issled. Geol.-Razved. Inst., 1997, pp. 125–133.

Kulagina, E.I., Rumyantseva, Z.S., Pazukhin, V.N., and Kochetova, N.N., *Granitsa nizhnego-srednego karbona na Yuzhnom Urale i Srednem Tyan'-Shane* (The Lower-Middle Carboniferous Boundary in the South Urals and Central Tien Shan), Moscow: Nauka, 1992.

Kulagina, E.I. and Sinitsyna, Z.A., Foraminiferal Zonation of the Lower Bashkirian in the Askyn Section, South Urals, Russia, *Spec. Publ. Cushman Found. Foram. Res.*, 1997, no. 36, pp. 83–87.

Lane, H.R., Brenckle, P., and Higgins, A.C., Mid-Carboniferous Boundary: Working Group Decision, *Newslett. Carboniferous Stratigr.*, 1994, vol. 12, p. 3.

Librovich, L.S., The Carboniferous Goniatite Faunas of the USSR and Their Stratigraphic Significance, *Byull. Mosk. O–va Ispyt. Prir., Otd. Geol.*, 1947, vol. 22, no. 5, pp. 51–68.

Librovich, L.S. and Sultanaev, A.A., The Syuran Horizon (Facies, Beds, or Formation), in *Stratigraficheskii slovar' SSSR. Karbon. Perm'* (Stratigraphic Dictionary of the USSR: The Carboniferous and Permian), Leningrad: Nedra, 1977, p. 362.

Manger, W.L., Weyant, M., and Pareyn, C., Mid-Carboniferous Ammonoid Biostratigraphy, Bechar Region, Algeria, *Cour. Forsch. Inst. Senckenberg*, 1985, vol. 74, pp. 181–196.

Nemirovskaya, N.I. and Alekseev, A.S., Bashkirian Conodonts of the Askyn Section, Bashkirian Mountains, Russia, *Bull. Geol. Soc. Belg.*, 1994, vol. 103, nos. 1–2, pp. 109–133.

Nemirovskaya, T.I., Conodonts of the Lower Bashkirian Stage of the Donetsk Basin, *Byull. Mosk. O–va. Ispyt. Prir., Otd. Geol.*, 1987, vol. 62, no. 4, pp. 104–126.

Nigmadganov, I.M. and Nemirovskaya, N.I., Mid-Carboniferous Boundary Conodonts from the Gissar Range, *Cour. Forsch. Inst. Senckenberg,* 1992, vol. 154, pp. 253–275.

Nikolaev, A.I., The Refined Correlation of Bashkirian Deposits in the Western Slope of the Urals and Eastern Russian Platform as Evidenced by Foraminifers, in *Metodicheskie aspekty stratigraficheskikh issledovanii v neftegazonosnykh basseinakh* (Methodological Aspects of Stratigraphic Investigations in Oil-and-Gas Basins), Leningrad, 1989, pp. 92–112.

Nikolaeva, S.V., Ammonoid Biostratigraphy for the Proposed Mid-Carboniferous Boundary Stratotype, Aksu River, South Tien Shan, Central Asia, *Ann. Soc. Geol. Belg.*, 1994a, vol. 116, pp. 265–273.

Nikolaeva, S.V., The Serpukhovian and Bashkirian Ammonoids of Central Asia, *Tr. Paleontol. Inst. Ross. Akad. Nauk*, 1994b, vol. 259, pp. 1–143.

Nikolaeva, S.V., Ammonoids from the Late Lower and Early Upper Carboniferous of Central Asia, *Cour. Forsch. Inst. Senckenberg*, 1995, vol. 179, pp. 1–90.

Nikolaeva, S.V., Ammonoids from the Bogdanovskii Horizon of the Middle Carboniferous in the South Urals, *Paleontol. Zh.*, 1999, no. 1, pp. 10–18.

Nikolaeva, S.V. and Nigmadganov, I.M., The Lower-Middle Carboniferous Deposits in Southern Tien Shan, *Izv. Ross. Akad. Nauk, Ser. Geol.*, 1992, no. 2, pp. 97–104.

Pazukhin, V.N., Conodont Biostratigraphy of the Lower Carboniferous at the Western Edge of the Zilair Megasynclinorium, in *Ezhegodnik-1994. Informatsionnye materialy* (Yearbook-1994. Informative Materials), Ufa: Ural. Nauchn. Tsentr Ross. Akad. Nauk, 1995, pp. 37–38.

Putevoditel geologicheskoi ekskursii po razrezam paleozoya i verkhnego dokembriya zapadnogo sklona Yuzhnogo Urala i Priural'ya (Guidebook: Geological Excursion to Paleozoic and Upper Precambrian Sections of the Western Slope of the South Urals and Adjacent Region), Kozlov, V.I. and Puchkov, V.N., Eds., Ufa, 1995.

Ramsbottom, W.H.C., Higgins, A.C., and Owens, B., Palaeontological Characterization of the Namurian in the Stratotype Area (A Report of the Namurian Working Group), in *Paleontologicheskaya kharakteristika osnovnykh podrazdelenii karbona* (Paleontological Characterization of the Major Carboniferous Subdivisions), Moscow: Nauka, 1979, pp. 85–99.

Reitlinger, E.A., A Problem Concerning the Boundary between the Bogdanovskii and Krasnaya Polyana Horizons (Foraminifers of the *Homoceras* Zone), in *Voprosy Mikropaleontologii* (Problems of Micropaleontology), Moscow: Nauka, 1980, issue 23, pp. 23–38.

Reshenie Mezhvedomstvennogo regional'nogo stratigraficheskogo soveshchaniya po srednemu i verkhnemu paleozoyu Russkoi platformy (Resolution of the Interdepartmental Regional Conference on the Middle-Upper Paleozoic Stratigraphy of the Russian Platform), Leningrad, 1988.

Riley, N.J., Type Ammonoids from the Mid-Carboniferous Boundary Interval in Britain, *Cour. Forsch. Inst. Senckenberg*, 1987, vol. 98, pp. 25–37.

Riley, N.J., Varker, W.J., Owens, B., *et al.*, Stonehead Beck, Cowling, North Yorkshire, England: A British Proposal for the Mid-Carboniferous Boundary Stratotype, *Cour. Forsch. Inst. Senckenberg*, 1987, vol. 98, pp. 159–177.

Rumyantseva, Z.S., Foraminiferal Zonation of the Serpukhovian and Bashkirian Stages in Central Tien Shan, *Byull. Mosk. O–va Ispyt. Prir., Otd. Geol.*, 1989, vol. 64, no. 3, p. 124.

Ruzhentsev, V.E. and Bogoslovskaya, M.F., The Namurian Evolution of Ammonoids: Late Namurian Ammonoids, *Tr. Paleontol. Inst. Akad. Nauk SSSR*, 1978, vol. 167, pp. 1–338.

Sinitsyna, Z.A., Lapina, N.N., and Sinitsyn, I.I., The Middle Carboniferous Section at the Askyn River, in *Putevoditel ekskursii 047. Yuzhnyi Ural. 27-i Mezhdunarodnyi geologicheskii kongress* (Guidebook: Excursion 047 to the South Urals. 27th Int. Geol. Congress), Moscow: Nauka, 1984, pp. 38–53.

Sinitsyna, Z.A. and Sinitsyn, I.I., *Biostratigrafiya bashkirskogo yarusa v stratotipe* (Biostratigraphy of the Bashkirian Stratotype), Ufa: Bashkir. Fil. Akad. Nauk SSSR, 1987.

Stratigraficheskie skhemy Urala (dokembrii, paleozoi) (Stratigraphic Schemes for the Urals: The Precambrian and Paleozoic), Yekaterinburg, 1993.

Unifitsirovannye i korrelyatsionnye stratigraficheskie skhemy Urala (Unified Stratigraphic and Correlation Schemes for the Urals), Leningrad: Vses. Geol. Inst., 1968.

Unifitsirovannye i korrelyatsionnye stratigraficheskie skhemy Urala (Unified Stratigraphic and Correlation Schemes for the Urals), Sverdlovsk: Ural. Nauch. Tsentr Akad. Nauk SSSR, 1980.

Vdovenko, M.V., Aizenverg, D.E., Brazhnikova, N.E., *et al.*, The Lower Carboniferous Zonation of the Donets Basin, in *Tektonika i Stratigrafiya.* (Tectonics and Stratigraphy), 1989, vol. 30, pp. 52–53.

Verkhneserpukhovskii pod'yarus Donetskogo basseina (paleontologicheskaya kharakteristika) (The Upper Serpukhovian Substage of the Donets Basin: Paleontological Characteristics), Kiev: Naukova Dumka, 1983.

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