PENNSYLVANIAN BIOSTRATIGRAPHY OF THE BASU RIVER SECTION WITH EMPHASIS ON THE BASHKIRIAN-MOSCOVIAN TRANSITION

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Introduction

Establishment the GSSP for the base of the Global Moscovian Stage in the International Time Scale is one of the main tasks of the International Subcommission on Carboniferous Stratigraphy (SCCS) [Groves, 2005, 2006]. The leading marker that is considered for the boundary is the conodont species *Declinognathodus donetzianus* Nemirovskaya, designated from the Moscovian of the Donets Basin and occurring in the type sections in the Moscow Basin [Makhlina et al., 2001]. In the Moscow Basin, however, the underlying the Moscovian sediments are continental facies and therefore no origination and phylogeny of the species can be observed. In the Donets Basin from which the index was originally described, marine carbonates consists of less than 2% of the entire succession which is mostly siliciclastic and often continental in origin.

In the Southern Urals, the region where the Bashkirian Stage has been established, the Bashkirian-Moscovian transition is entirely marine and without noticeable gaps. The distribution of conodonts within the transition has been studied in several sections [Nemirovskaya, Alekseev, 1994; Kulagina et al., 2001; Kulagina, Pazukhin, 2002b]. However, conodont assemblages there are quite specific and conodont index has been found only in the Basu section. V. Pazukhin was the first who find *D. donetzianus* Nemirovskaya in the Basu section during a 1996 joint scientific study on incipient metamorphism [Matenaar et al., 1999]. Subsequent, more detailed sampling confirmed the occurrence of the species in the section [Pazukhin et al., 2006]. Other major fossils, such as foraminifera and brachiopods are also known in the section. The Basu section appears in the Zilim-Zigan area of the West-Uralian structural Zone of the Southern Urals near Askyn and other well-known early-middle Pennsylvanian key-sections in the Urals (Fig. 1). In this paper, a short description of the regional stages of the Bashkirian and Moscovian is given; new data on sedimentology and distribution of foraminifera and conodonts are documented within the Bashkirian-Moscovian transition; an interregional correlation of the newly proposed boundary is suggested.

Biostratigraphy of the Carboniferous in Zilim-Zigan area

The Bashkirian, Moscovian, Kasimovian and Gzhelian Stages of the Pennsylvanian Series of Global Time Scale correspond to the Middle and Upper Carboniferous Series of the General Stratigraphic Scale of Russia (GSSR). The latter divided in the Urals into substages and Horizons (regional stages), all of which were designated in the Southern Urals. Thanks to work of S.V Semikhatova [1934, 1941], G.I. Theodorovich [1935, 1936], D.L. Stepanov [1941], V.D. Nalivkin [1949], O.L. Einor [1955, 1958] and many other geologists in the Zilim-Zigan area of the Southern Urals, a solid framework for Pennsylvanian stratigraphy and biostratigraphy has been established. Brachiopods, and later foraminifera were used in these studies [Theodorovich et al., 1959].

In the Zilim-Zigan area the Pennsylvanian deposits stretch out in a sub-meridional belt along the western Bashkirian Meganticlinorium. Bashkirian sediments of total thickness 190–280 m consist of shallow-water carbonates enriched with avariety of fossils. The Moscovian is 180–285 m thick and is less fossilliferous and represented by shallow-water to deeper water, sometimes cherty carbonates, intercalated with silty carbonates and pure siliciclastic. The Kasimovian and Gzhelian deposits are even more basinal and consist of micritic limestones, siltstone and chert of total thickness up to 80 m. Z.A. Sinitsyna with assistance from N.K. Mescheryakova (Unpublished report "The stratigraphy of the Carboniferous of the West slope of Bashkirian Urals", Ufa, 1971) provided stratigraphy and foraminiferal biostratigraphy of the Pennsylvanian

in the Zilim-Zigan area. Several sections were studied, including Askyn, Basu, Zilim, Zigan, Usolka and others resulting in the recognition of five horizons in the Bashkirian and four horizons in the Moscovian [Sinitsyna et al., 1984]. An outcrop of Moscovian near the Kurgash village along the Kurgash River, left tributary of the Basu River has been described as, and some similarities in lithology and fauna of this outcrop and the Askyn section have been noted [Sinitsyna, Sinitsyn, 1987]. Currently the Bashkirian and Moscovian Stages are divided into substages [Decisions ..., 2003, 2006]. In this work the following horizons are used (Fig. 2).

Bashkirian Stage

The Syuranian Substage [Librovich, 1947] in the its type locality, in the Bolshoi Syuren River (Central Uralian Structural zone) consists of micritic limestones with ammonoids, with rare layers of silty mudstones and lithoclastic grainstone. The latter include foraminifers, ostracods, and conodonts. The horizon is up 100 m thick. Syuranian is divided into the Bogdanovkian Horizon that is corresponding to the *Homoceras – Hudsonoceras* ammonoid genozone [Einor et al., 1973] and the Kamennogorian Horizon that corresponds to *Reticuloceras – Bashkortoceras* ammonoid genozone in the same type locality [Kulagina et al., 2001]. The Bogdanovkian is 44 m thick, the Kamennogorian — is up to 45 m thick [Kulagina et al., 2000]. In the Zilim-Zigan area the Syuranian with a stratigraphic gap overlies the Serpukhovian limestone yielding brachiopod *Striatifera* shellstones and the lower Bogdanovkian (Lower *Declinognathodus noduliferus* Subzone) is missing there. The Bogdanovkian represented there by oolite and bioclastic grainstone, dolomitized limestone and dolomite; the Kamennogorian consist of predominantly foraminiferal wackestone and packstone. Fossils include foraminifers, corals, brachiopods, ostracods and conodonts. Total thickness of the Syuranian in the Zilim-Zigan area is 30–50 m.

The Akavassian (Substage and Horizon) was established by Einor [1955] in the middle reaches of the Belaya River as an equivalent of the *Pseudostaffella antiqua* foraminiferal zone. It consists of bioclastic grainstone with abundant foraminifers, oolite grainstone, algae bafflestones and rare micritic limestones. Thickness of the Horizon in the type section is 50–85 m, in the hypostratotype (Askyn section) — 67 m [Sinitsyna, Sinitsyn, 1987].

The Askynbashian (Substage and Horizon) was established in the Askyn section [Theodorovich et al., 1959], where horizon consists of bioclastic algal-foraminiferal grainstone and packstone, algal baflstones, oolite grainstone, rare wackestone; fossils are brachiopods, corals, gastropods, ostracods, spongy, conodonts. In Askyn section the thickness of the Horizon is 39 m, in Zilim-Zigan area — up 60 m.

The Arkhangelskian Substage (name was suggested by E.I. Kulagina et al. [2001]) for the Upper Bashkirian substage) includes the Tashastian and Asatauian Horizons. The type section of this unit is in the Askyn section. **The Tashastian Horizon** [Theodorovich et al., 1959] was established in the basins of the the Zilim and Inzer Rivers, the stratotype is in the Zilim River nearly Tashasty village, where Horizon consists of limestone with chert nodules. Thickness of the Tashastian Horizon in Askyn section is 54 m. **The Asatauian Horizon** [Sinitsyna et al., 1972] with stratotype in Askyn section consists there of medium to thick-bedded algal wackestone and few units (1–2 m thick) of thin-bedded micro-bioclastic grainstone and packstone with small chert nodules. Algae-bearing rock with *Donezella lutugini* and *Ungdarella* are common in the horizon. Algal and foraminiferal grainstone occur at the top of the horizon. The Asatauian Horizon is equal to the *Aljutovella tikhonovichi* foraminiferal zone [Sinitsyna et al., 1984, 2002; Sinitsyna, Sinitsyn, 1987]. The assemblage of this zone includes diverse

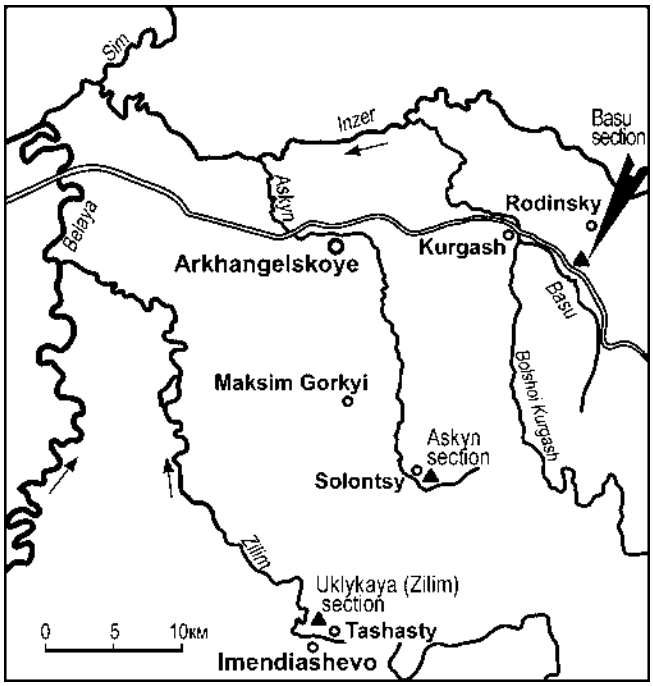


Fig. 1. Location of the studied sections of Zilim-Zigan area

pseudostaffellids and other forms from underlying strata. *Profusulinella rhombiformis* Brazhnikova et Potievskaya, *Pr. rhomboides* (Lee et Chen), *Pr. (Tikhonovichiella)* cf. *tikhonovichi* (Rauser), *Depratina praeprisca* (Solovieva) are appearing in this Horizon. The thickness of the Asatauian Horizon in the Askyn section is 27 m. In other sections the composition and thickness of the horizon is similar, with the exclusion of the Belaya River section

GSS			Generals stratigraphic scale of Russia, 2003, 2006				Local units of South Urals
Subsystem	Series	Stage	Substage	Ammonoids	Foraminifers	Conodonts	
Upper Carboniferous (Pennsylvanian)	Upper Pennsylvanian	Gzelian		Shumardites - Vidrioceras	Daixina bosbytauensis - Globifusulina robusta	Str. wabaunsensis	Martukian
					Daixina sokensis	Str. bellus	
					Jigulites jigulensis	Str. virgilicus	Azantashian
					Triticites rossicus - Rauserites stuckenbergi	Streptognathodus vitali	
						Str. simulator	
						Str. firmus	
		Kasimovian		Dunbarites - Parashu-mardites	Rauserites quasiarcticus	Str. toretzianus	Kerzhakovian
					Montiparus montiparus	Str. cancellosus	Orlovian
						Idiognathodus sagitalis	
					Protriticites pseudomontiparus - Obsoletes obsoletes	Str. makhlinae	
						Str. subexcelsus	
	Middle Pennsylvanian	Moscovian	Myachkovian	Pseudopara-legoceras - Wellerites	Fusulina cylindrica - Protriticites oyatus	Neognathodus roundyi	Tashlian
					Fusulinella bocki	Neognathodus inaequalis	Zilimian
			Podolskian		Fusulinella colaniae - F. vozhgalensis - Beedeina kamensis	I. podolskensis - N. medexultimus	
			Kashirian	Paralegoceras - Eowellerites	Fusulinella subpulchra	S. concinnus - I. robustus	Imendiashevian
					Priscoidella priscoidea	Neognathodus medadultimus	
						Neognathodus bothrops	
			Vereian	Diaboloceras - Winslowoceras	Aljutovella aljutovica	Streptognathodus transitivus	Soloncian
						D. donetzianus - Id. postsulcatus	
	Lower Pennsylvanian	Bashkirian	Archangel-skian	Diaboloceras - Axinolobus	Verella spicata - A. tikhonovichi	Declinognathodus marginodosus	Asatauian
				Branneroceras - Gastrioceras	Pr. rhombiformis		Tashastian
					Pr. primitiva- Ps. gorskyi		
			Askynbashian	Bilinguites - Cancelloceras	Ps. praegorskyi - St. staffelaeformis	Idiognathodus sinuosus	Askynbashian
			Akavassian		Pseudostaffella antiqua	Neognathodus askynensis- N. symmetricus	Akavassian
			Sjuranian	Reticuloceras - Bashkortoceras	Semistaffella variabilis	Idiognathoides sinuatus	Kamennogorian
				Homoceras - Hudsonoceras	S. minuscularia Plectostaffella bogdanovkensis	Declinognathodus noduliferus (Later / Early)	Bogdanovkian

Fig. 2. Subdivisions of the Bashkirian and Moscovian Stages in General Stratigraphic Scale of Russia (GSSR) [Decisions ..., 2003, 2006] and regional units of the South Urals [Srtatigraphic schemes ..., 1993; Chuvashov et al., 1990; Kulagina et al., 2001]

where the Horizon is much thicker with frequent dolomite in the succession [Chuvashov et al., 1990; Kulagina et al., 2001].

Moscovian Stage

The Solontsian Horizon (named after Solontsy village) was established by Sinitsyna [Uniform schemes, 1980] with stratotype in Askyn section [Sinitsyna et al., 1984]. **The Solontsian** consists of thin medium-bedded micritic limestone and bioclastic algae-foraminiferal wackestone-packstone; while chert nodules and layers are frequent throughout. The Horizon is subdivides into the *Depratina prisca* and *Aljutovella aljutovica* foraminiferal zones [Kulagina, 2008] and *Neognathodus atokaensis* and *N. uralicus* conodont zones [Pazukhin, 2007]. The thickness of the horizon in the type-section is 67—71 m, elsewhere it is 75—80 m. The Solontsian Horizon correlates with the Vereian Horizon in the Moscow Basin.

The Imendiashevian Horizon (named after the Imendiashevo village) was established by Sinitsyna [Uniform schemes ..., 1980] with a stratotype in the Uklykaya section, along the Zilim River opposite of the Imendiashevo village, Gafuryisky County, Bashkortostan. In the type section the horizon is 51 m thick and consists of bioclastic limestone inter-bedded with oolitic layers, calcareous siltstone and chert nodules [Furduj, Einor, 1984]. In the Askyn and Kurgash sections, according to Sinitsyna (unpublished report, 1971), the Imendiashevian Horizon consists of thin- to medium-bedded microbioclastic packstone, wackestone and micritic limestone with thin layers and nodules of chert. Smaller foraminifera *Tuberitina callosa* Reitlinger, *Globivalvulina* sp., *Ammodiscus* sp., *Ammovertella* sp., and others are found in the succession. Near the bottom, there is a bed of light-grey to grey bioclastic crinoidal limestone with diverse assemblage of *Priscoidella priscoidea* foraminiferal zone and poorly preserved brachiopods. Abundant brachiopods *Chonetes* ex gr. *carboniferous* Keyserling are present in the micritic limestone. The thickness of the Imendiashevian Horizon in the Askyn section is 69 m, while in the Kurgash section the horizon is poorly exposed and its thickness there is 100 m. The Imendiashevian Horizon correlates with the Kashirian Horizon in the Moscow Basin.

The Zilimian Horizon (named after the Zilim River) was established by Theodorovich [1936] with a stratotype in the Uklykaya section, along the Zilim River. The horizon consists of micritic limestone with layers of brachiopod limestone. In the upper part dolomite and dolomitized limestone with chert nodules are frequent. The thickness of the horizon in the type section is 108 m. According to Sinitsyna (unpublished report, 1971), in the Askyn and Basu sections the Zilimian consists of micritic sometimes dolomitized limestone, silty limestone with chert nodules and frequent bioclastic limestone with bryozoans, crinoids, foraminifers and fragments of brachiopods. The thickness of the horizon in the Askyn section is 53 m, in the Basu and Kurgash sections — 70 m. The Zilimian characterized by fusulinids of *Fusulinella praebocki* and *Wedekindellina uralica* foraminiferal zones and *Idiognathoides planus* conodont zone [Furduj, Einor, 1984]. The Zilimian Horizon correlates with the Podolian and lower Myachkovian Horizons in the Moscow Basin.

The Tashlian Horizon (originally Formation; named after the Tashly village) was established by Stepanov [1941]. In the type section near the Tashly village the horizon consists of micritic limestone with pea-size chert concretions and layers of cherty siltstone. In thin-sectionswe observed the pea-size chert concretions filled with concentric chalcedony. The thickness of the Tashlian in the type-section is 57 m, in the Askyn section it is 23 m and in the Basu section — 16 m. Sinitsyna determined foraminifers *Schubertella galinae* Safonova, *Fusiella typica* Lee et Chen, *Pseudostaffella parasphaeroidea* (Lee et Chen), *Ozawainella* aff. *angulata* (Colani), *O. mosquensis* Rauser, *Wedekindellina uralica* (Dutkevich), *Parawedekindellina* aff. *pechorica* Rauser from the bioclastic limestone in the middle part of Tashlian Horizon. In addition to that, Ivanova [2008] identified foraminifers *Beedeina dumbari* (Sosnina) and near the top — *Neostaffella paradoxa* (Dutkevich) inform Basu section. The Tashlian Horizon correlates with the upper Myachkovian Horizon in the Moscow Basin.

Upper Pennsylvanian (**Kasimovian** and **Gzhelian**) in the area from the Inzer to Belaya Rivers consists if thin laterally unstable mixed carbonate-siliciclastic sequences. According to Sinitsyna (unpublished report, 1971) cherty siltstone 30 m thick with few thin micritic and cherty limestone beds is exposed on the right bank of Basu River opposite the Kurgash village in the road cut. They overlie the micritic limestone with pea-size chert concretions. Poorly preserved brachiopods *Choristites* sp., Productidae, *Dielasma* sp. are found in the micritic limestone. Only long-ranging foraminifera *Ammodiscus* sp., *Glomospira* sp., *Globivalvulina* sp., *Schubertella* sp. were found there. Upwardsin the sextion, dark-grey siltstone with phosphate concretions

and dolomite 28–30 m thick are poorly exposed and were trenched. The upper part of the Upper Pennsylvanian consist of inter-bedding of cherty siltstone, silty micrite and dolomite 20 m thick. The Total thickness of the Upper Pennsylvanian in the Basu River area 78–80 m.

Description of the Basu section and preliminary biostratigraphy

The section studied is exposed in a small limestone quarry, which was mined in the 1990th during construction works on the Ufa – Beloretzk highway. The quarry is located on right bank of the Basu River, 16 km upstream from confluence of the Basu and Inzer Rivers. The section is exposed on the east wing of the anticline of 75–80° N–S strike and 30–40° dip. The lowermost layers in the section are trenched (Fig. 3–4). Fossils were observed in the field, in the thin-sections and were colored from the insoluble residue in a insoluble residue of residue conodont samples. The succession in the quarry consists of dark-gray, medium to thinly bedded micritic limestone that is sometimes dolomitized and changes color to light-gray. Medium to coarse turbiditic grainstones are rare throughout the succession.

Bashkirian Stage, Arkhangelskian Substage, Asatauian Horizon

1. Weakly and evenly dolomitized wackestone and packstone with chert nodules. Fossils include foraminifers, bryozoans, brachiopods, ostracods, crinoids, bivalves, holothurians, and fish teeth. Chalcedon micro-concretions and glauconitic grain are found in the insoluble remains of the limestone. The bottom strata are excavated and exposed in the trench (Samples 1b, 1v, 1g). Upper 0.2 m of the unit (Samples 1a, 1, 1/2, 08VD-16) are bioclastic fine grainstone to packstone with foraminifers *Ozawainella digitalis* (Manukalova), *Pseudostaffella gorskyi* (Dutkevich), *Ps. krasnopolskyi* (Dutkevich), *Neostaffella khotunensis* (Rauser), *Hanostaffela* ex gr. *subquadrata* (Grozdilova et Lebedeva), *Depratina* sp.,[1] *Neoarchaediscus probatus* (Reitlinger) and other (Pl. 1). Conodonts (Samples 1, 1a–g,): *Declinognathodus marginodosus* (Grayson), *Idiognathodus aljutovensis* Alekseev et al., *I. incurvus* Dunn, *I.* cf. *volgensis* Alekseev et al., *Idiognathoides corrugatus* Harris et Hollingsworth, *Id. lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth, *Id. tuberculatus* Nemirovskaya, *Neognathodus atokaensis* Grayson, *Neognathodus* sp. 1, *Streptognathodus* aff. *einori* Nemirovskaya, Alekseev, *Streptognathodus* sp., *Hindeodus minutus* (Ellison). Thickness 0.9 m.

Moscovian Stage, Vereian Substage, Solontsian Horizon

2. Bioclastic wackestones and packstone sometimes weakly dolomitized, with thin layers of siltstone (Samples 3, 4, 6) and grainstone (Sample 2/1). The latter contain foraminifers, bryozoans, crinoids, rugosa corals, brachiopods, ostracods. Foraminifers are (Samples 1a, 1v, 2, 2/1, G14a, 08VD-17, 08VD-18): *Eostaffella grozdilovae* Maslo and Vachard, *Ozawainella laxa* Grozdilova et Lebedeva, *Oz. crassiformis* Putrja, *Oz. umbona* (Putrja and Leontovich) and other ozawainellids (Pl. 2), *Pseudostaffella gorskyi* (Dutkevich), *Ps. ozawai* (Lee et Chen), *Neostaffella* aff. *confusa* (Lee et Chen), *Staffellaeformes staffellaeformis* (Kireeva), *Profusulinella parva* (Lee et Chen), *Pr. rhombiformis* Brazhnikova et Potievskaya, *Pr. pararhomboides* Rauser and Belyaev, *Pr.* cf. *oblonga* Potievskaja, *Pr. (Tikhonovichiella) tikhonovichi* (Rauser). *Skelnevatella subaljutovica* (Safonova), *Depratina prisca* (Deprat), archaediscids. Conodonts (Samples 2, G14a, 3, 5, 6, 7): *Declinognathodus marginodosus* (Grayson), *Idiognathodus aljutovensis* Alekseev et al., *I. incurvus* Dunn, *I. cf. volgensis* Alekseev et al., *Idiognathoides corrugatus* Harris et Hollingsworth, *Id. lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth, *Id. sulcatus sulcatus* Higgins et Bouckaert, *Id. tuberculatus* Nemirovskaya, *Neognathodus* sp., *Streptognathodus* aff. *einori* Nemirovskaya, Alekseev, *Streptognathodus* sp., *Hindeodus minutus* (Ellson). 3 m.

3. Fine-bioclastic wackestone-mudstone with rare fragments of brachiopods, pelmatozoans (Sample 7); in upper part — peloidal fine-grained wackestone-packstone, evenly dolomitized with rare fragments of algae Donezella sp., brachiopods, pelmatozoans, bryozoans. Foraminifers are (Samples 7, 8, 08VD-20, 08VD-21): *Climacammina* sp. *Palaeotextularia* sp. *Pseudostaffella nikolaevskiensis* (Manukalova), *Neostaffella kchotunensis* Rauser, *Asteroarchaediscus* sp., *Neoarchaediscus postrugosus* (Reitlinger). Conodonts are (Samples 7–8): *Declinognathodus marginodosus* (Grayson), *Idiognathodus* sp., *Idiognathoides corrugatus* Harris et Hollingsworth, *Id. lanei* Nemirovskaya, *Id. sinuatus* Harris et Hollingsworth, *Id. sulcatus sulcatus* Higgins et Bouckaert, *Neognathodus atokaensis* Grayson, *Streptognathodus sp.* 1.5 m.

[1] Foraminifera generic taxonomy is given according to the views of the senior author and is not entirely shared by V. Davydov.

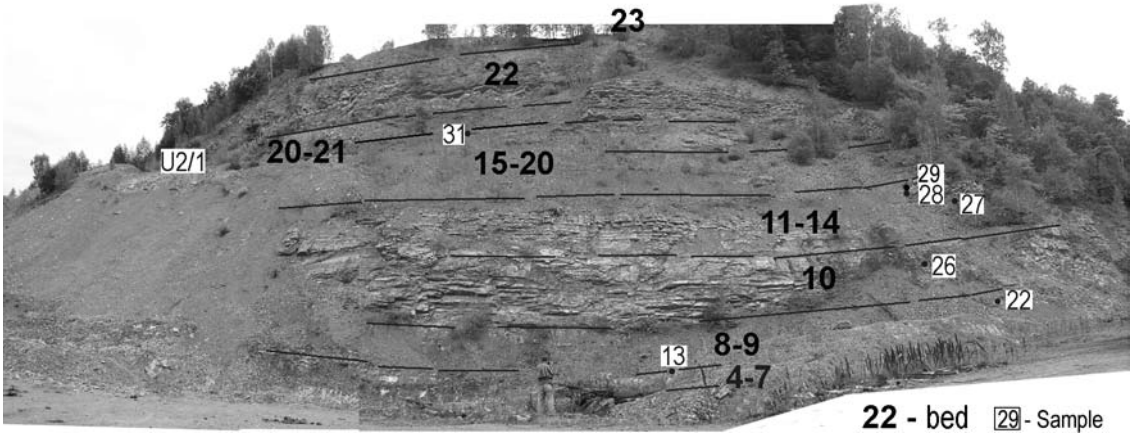


Fig. 3. General view of the entire succession in the Basu section

4. Algal wackestone and bafflestone formed by *Donezella* sp. Other fossils are bivalves, brachiopods, crinoids, conodonts, and fish teeth. Rare chalcedonic micro-concretions and glauconitic grains are found in insoluble residue of the limestone. Foraminifers are (Samples 9, 08VD-22): *Eostaffella korobcheevi* Rauser, *Ozawainella crassiformis* Putrja, *Pseudostaffella gorskyi* (Dutkevich), *Neostaffella polasnensis* (Rauser), *Staffellaeformes* sp. Conodonts are (Sample 10): *Idiognathoides ouachitensis* (Harlton). 0.8 m.

5. Bryozoan-crinoidal wackestone with dark silty-micritic cement. Fossils include algae *Donezella* sp. (rare), bivalves, brachiopods, crinoids, intraclasts of bryozoans (rare), fish teeth, and conodonts (Fig. 5)

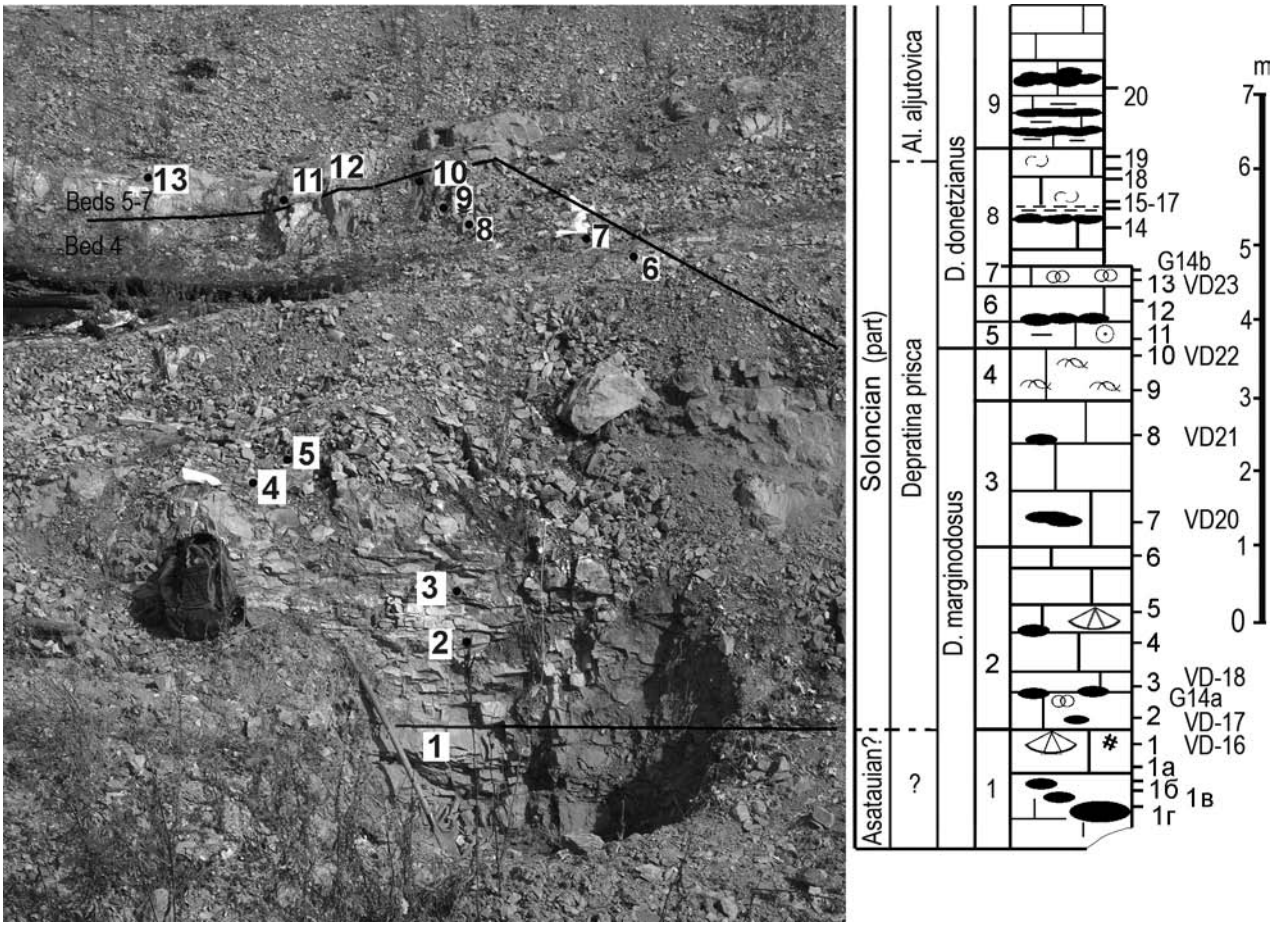
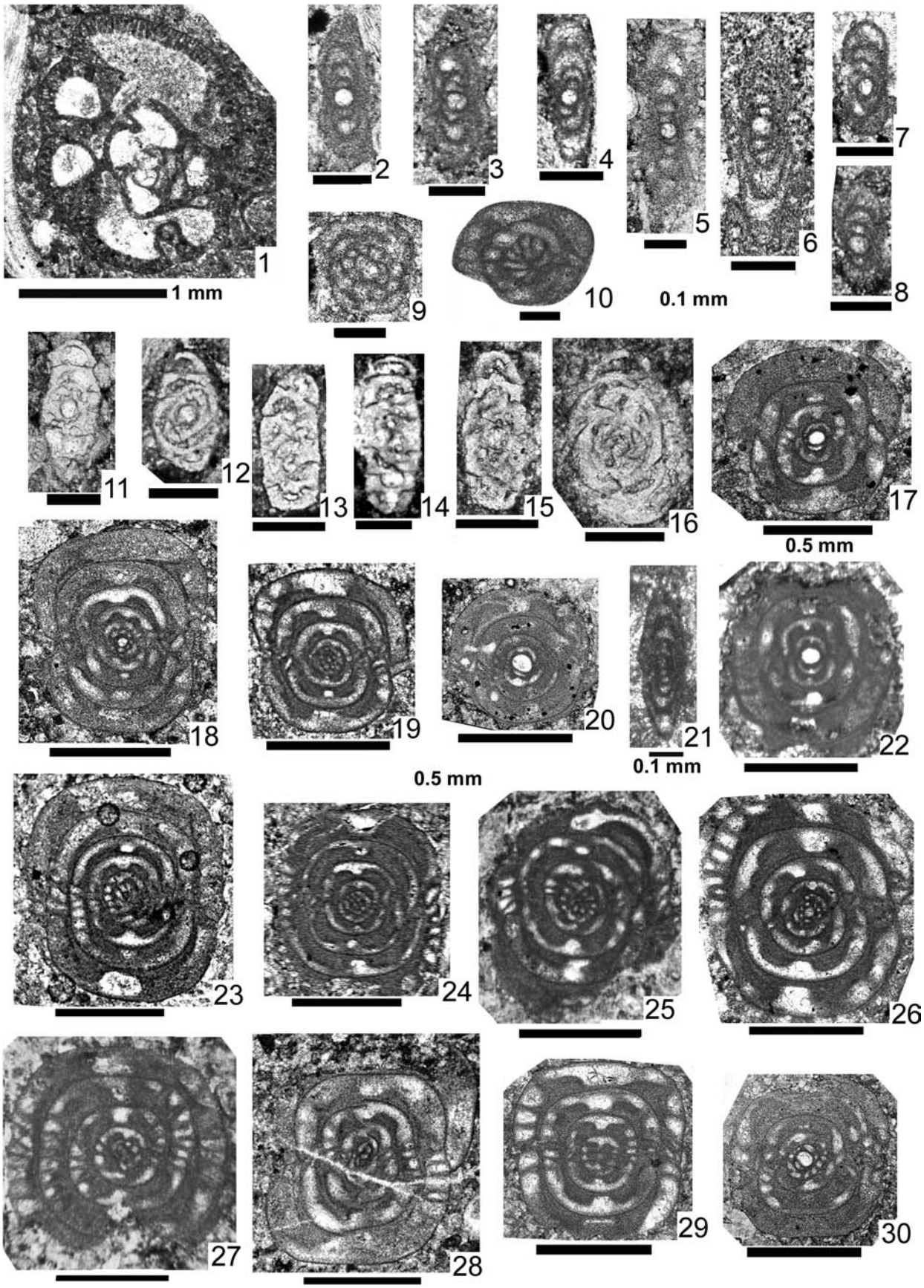


Fig. 4. The lowermost beds of the Basu section exposed in the trench

Plate 1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(Sample 11): *Declinognathodus donetzianus* Nemirovskaya, *D. marginodosus* (Grayson), *Idiognathoides lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. tuberculatus* Nemirovskaya, *Id. sinuatus* Harris et Hollingsworth, *Idiognathodus aljutovensis* Alekseev et al., *I.* cf. *volgensis* Alekseev et al., *Neognathodus atokaensis* Grayson, *Neognathodus* sp., *Streptognathodus* sp. 0.4 m.

6. Mudstone-wackestone with crinoids and conodonts (Sample 12): *Declinognathodus marginodosus* (Grayson), *Idiognathoides lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth, *Id. sulcatus sulcatus* Higgins et Bouckaert, *Idiognathodus* sp., *Neognathodus atokaensis* Grayson, *Neognathodus* sp., *Streptognathodus einori* Nemirovskaya et Alekseev. 0.6 m.

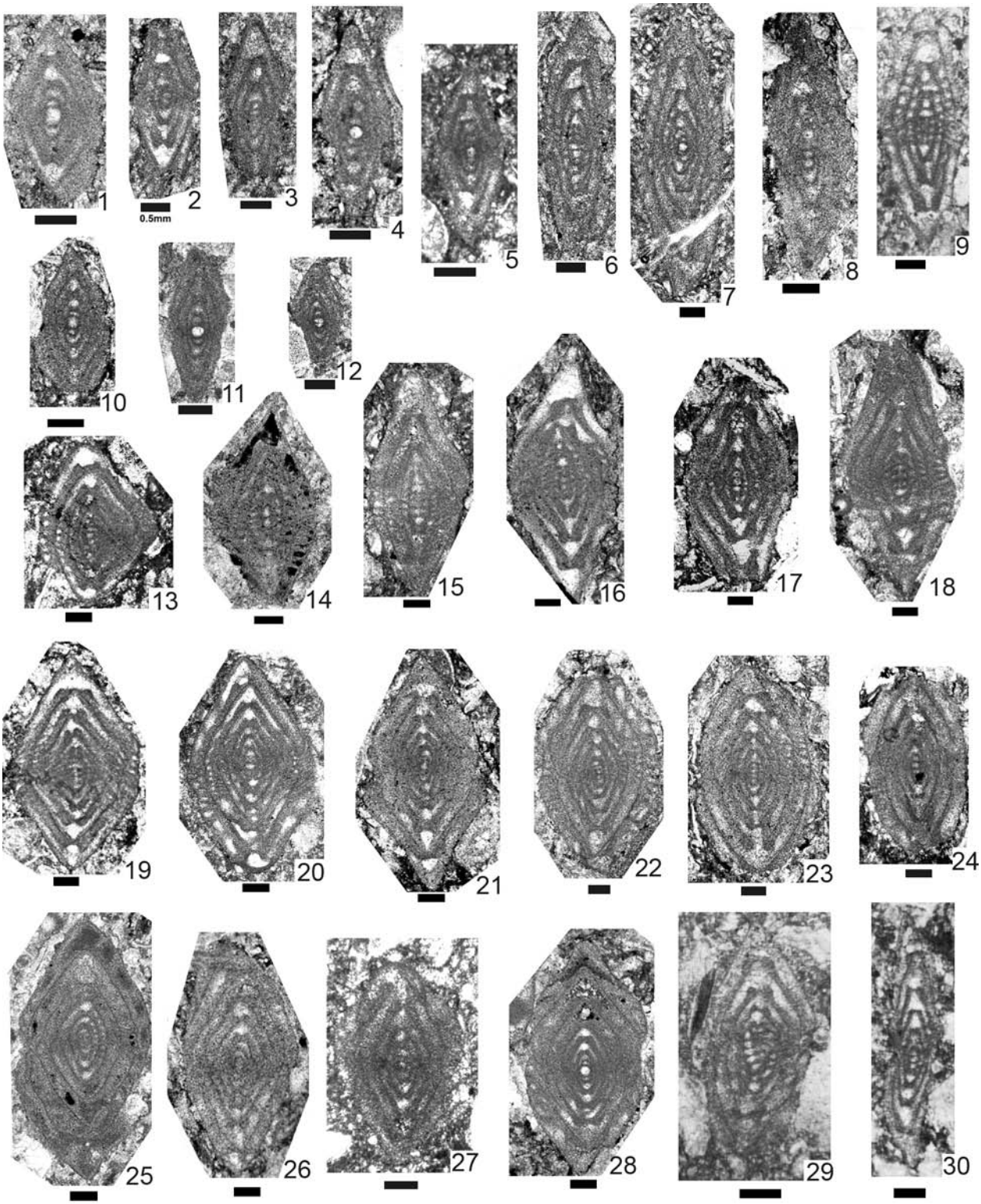
7. Bioclastic silty wackestone with dark and micrite-microbioclastic; cement include pellets and peloids, fragments of crinoids, rounded litoclasts of the foraminifera fragments, bryozoans, single corals, bivalves, brachiopods, conodonts, fish teeth. Foraminifers are (Samples G14b, 13, 13a, 08VD23; Pl. 4): *Eostaffella kashirica* Rauser, *Schubertella gracilis* Rauser, *Haostaffella* ex gr. *subquadrata* (Grozdilova et Lebedeva), *Profusulinella pararhomboides* Rauser et Belyaev, *Profusulinella* cf. *rhomboides* (Lee et Chen), *Staffellaeformes* sp., *Depratina praeprisca* (Solovieva), *D.* cf. *prisca* (Deprat), *D.* cf. *sphaeroidea* (Rauser), *Skelnevatella subaljutovica* (Safonova), *Aljutovella fallax* Rauser, *Neoarchaediscus probatus* (Reitlinger). Conodonts: *Declinognathodus donetzianus* Nemirovskaya, *D. marginodosus* (Grayson), *Idiognathoides lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. tuberculatus* Nemirovskaya, *Id. sinuatus* Harris et Hollingsworth, *Idiognathodus aljutovensis* Alekseev et al., *I.* cf. *volgensis* Alekseev et al., *Neognathodus* aff. *atokaensis* Grayson, *Neognathodus uralicus* Nemirovskaya et Alekseev, *Streptognathodus* sp., *Hindeodus minutus* (Ellison). 0.4 m.

8. Micritic limestones thin-bedded with chert nodules. Thin horizons of micrograin bioclastic packstone/wackestone with coarse fragments of bryozoans, brachiopods, pelmatozoans, ostracodes, trilobites (Sample 14) and foraminifers *Archaediscus* cf. *timanicus* (Grozdilova et Lebedeva); clayey wackestone with rare coarse bioclasts of pelmatozoans (Sample 15); coarse-grained bioclastic-litoclastic packestone with clasts of foraminifers, algae, pelmatozoa, with micritic matrix (Sample 17); micrograin bioclastic packestone-wackestone (Sample 18); micrograin spongolite consist of fine spongy spicules in micritic matrix with accumulations of silicified bioclastes (Samples 19). Foraminifers (Samples 17) are: *Ozawainella* sp., *Pseudostaffella* cf. *gorskyi* (Dutkevich), *Pseudostaffella* sp., *Profusulinella* sp. At the top of the 8 bed (Sample 19/2) axial sections of large *Pr.* cf. *ovata* Rauser with completely silicified wall is found. Conodonts (Samples 14–18) are: *Declinognathodus* aff. *donetzianus* Nemirovskaya, *D. marginodosus* (Grayson), *Idiognathoides corrugatus* Harris et Hollingsworth, *Id. lanei* Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth, *Id. sulcatus sulcatus* Higgins et Bouckaert, *Id. tuberculatus* Nemirovskaya, *Idiognathodus aljutovensis* Alekseev et al., *Idiognathodus* sp., *Neognathodus atokaensis* Grayson, *Streptognathodus einori* Nemirovskaya et Alekseev. 1.5 m.

9. Mudstone (Samples 20–22) and microgranular bioclastic wackestones with *Archaediscus* sp. (Sample 23), then silty, silicified micrite at the bottom (0.8 m) and silty-calcareous yellowish-brown friable micrite near the top (0.01 m, Sample 24). Mudstone includes rare glauconitic grains. Brachiopods, fish teeth and conodonts are found in sample 24. The conodonts are (Samples 21–23): *Declinognathodus* cf. d*onetzianus* Nemirovskaya, *D. marginodosus* (Grayson), *Idiognathoides corrugatus* Harris et Hollingsworth, *Id. lanei*

Plate 1. For 2–16, 21 scale bar = 0.1 mm, for 17–20, 22–30 scale bar = 0.5 mm **1.** *Bradyina cribrostomata* Rauser-Chernousova et Reitlinger, 1936, Sample 08VD-16(1-2), bed 1. **2–8.** *Eostaffella grozdilovae* Maslo et Vachard, 1997 (new replasment name for *E. acuta* Grozdoliva et Lebedeva, 1950; preoccupied by *E. mosquensis* var. *acuta* Rauser-Chernousova, 1948), 2 — Sample 08VD-17(8-8), 3 — Sample 08VD-17(1-10), 4 — Sample 08VD-17(14-5), 5 — Sample 08VD-17(1-2), 6 — Sample 08VD-17(5-7), 7 — Sample 08VD-17(11-4), 8 — Sample 08VD-17(2-8), 7–8 — juvenile specimens. **9.** *Eoschubertella mosquensis* (Rauser-Chernousova, 1951), Sample 08VD-16(3-3). **10.** *Eoschubertella obscura* (Lee et Chen, 1930), Sample 08VD-16(2-4). **11.** *Neoarchaediscus* ex gr. *incertus* (Grozdilova et Lebedeva, 1954), Sample 08VD-17(7-1). **12.** *Rugosoarchaediscus akchimensis* (Grozdilova et Lebedeva, 1954), Sample 08VD-17(11-1). **13–15.** *Neoarchaediscus probatus* (Reitlinger, 1950), 13 — Sample 08VD-17(1-5), 14 — Sample G14a(3), 15 — Sample 08VD-16(3-2). **16.** *Neoarchaediscus* sp., oblique section, Sample 08VD-16(3-1). **17, 22, 26.** *Pseudostaffella krasnopolskyi* (Dutkevich in Grozdilova et Lebedeva, 1950). 17 — 08VD-16(3-4), 22 — Sample 1(1), 26 — Sample 08VD-21(2-12). **18, 19, 23.** *Pseudostaffella gorskyi* (Dutkevich, 1934). 18 — Sample 08VD-17(13-1), 19 — Sample 08VD-16(4-3), 23 — Sample 08VD-22(4-3). **20.** *Neostaffella* aff. *confusa* (Lee et Chen, 1930), Sample 08VD-18(2-1). **21.** *Eostaffella acutissima* Kireeva, 1951, Sample 2/1(1). **24, 25.** *Neostaffella khotunensis* (Rauser-Chernousova, 1951). 24 — 08VD-(3-2), 25 — Sample 1(2). **27–30.** *Hanostaffella* ex gr. *subquadrata* (Grozdilova et Lebedeva, 1954). 27 — Sample 1(1), 28 — Sample 08VD-16(4-6), 29 — Sample 08VD-18(3-6), 30 — Sample 08VD-18(5-2).
1 — saggital section; 2–9, 11–15, 17–24, 26, 28, 30 — axial sections; 10, 16, 25, 27 — oblique section; 29 — tangential section

Plate 2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Nemirovskaya, *Id. ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth, *Id. sulcatus sulcatus* Higgins et Bouckaert, *Id. tuberculatus* Nemirovskaya, *Streptognathodus sp.* 1.5 m.

10. Wackestone siliceous, with lenses and nodules of chert of funky shape. Grains of glauconite are found in insoluble residue of the limestone. Fossils include brachiopods, bivalves, fish teeth, and foraminifers (Samples 25, 26): *Tuberitina* sp., *Pseudoglomospira elegans* Lipina, *Biseriella* sp., *Neoarchaediscus probatus* (Reitlinger); conodonts (Sample 25): *Declinognathodus marginodosus* (Grayson), *Idiognathoides ouachitensis* (Harlton), *Id. sinuatus* Harris et Hollingsworth. 6.6 m.

11–12. Package of mudstones dolomitized in the upper part and chert lenses. Chert is thin-laminated, laterally changes its thickness from 0.03 to 0.15 m. 9.9 m.

13. Foraminiferal, graded bioclastic grainstone, silty at the top. Fusulinids often arebroken and/ or micritized. The following taxa are identified (Sample 28): *Staffellaeformes staffellaeformis* (Kireeva), *Profusulinella parva* (Lee and Chen), *Skelnevatella subaljutovica* (Safonova), *Depratina sphaeroidea* Rauser, *D. sitteri* (Ginkel), *D.* cf. *paratimanica* Rauser. 0.25 m.

14. Thick-bedded (0.35–0.6 m) micrite to wackestone with lenses and layers of the chert. The wackestone (Sample 29, 0.25 m above the bed base) contains algae *Donezella* sp., Pl. 5) and foraminifers *Eostaffella* aff. *amabilis* (Grozdilova et Lebedeva), *Novella* sp., *Profusulinella parva* (Lee et Chen), *Pr. tikhonovichi* (Rauser), *Depratina* sp., *Skelnevatella subaljutovica* (Safonova), *Sk.* cf. *skelnevatica* (Putrja), *Aljutovella aljutovica* (Rauser), *Neoarchaediscus probatus* (Reitllinger) are identified. 3 m.

? Imendyashevian Horizon

15–18. Micritic grey limestone, dolomitized light-grey mudstones with spotted silicification and dolomitization. Frequent lenses and layers of chert are present in this sequence. Sample 30 (0.6 m from bottom). Total thickness is about 20 m.

19. Fusulinid grainstone. Fusulinids poorly preserved, often broken and micritized (Sample 31). Following species are recognized: *Staffellaeformes staffellaeformis* (Kireeva), *Profusulinella* cf. *parva* (Lee et Chen), *Skelnevatella* cf. *postaljutovica* (Safonova), *Depratina sitteri* (Ginkel) ?, *Aljutovella* cf. *constans* (Safonova). 2.1 m.

20. Alternation of the middle-bedded limestone and siltstone. Thickness of siltstone layers is 0.02–0.09 m, thickness of limestone layers is 0.5–2.0 m. 4 m.

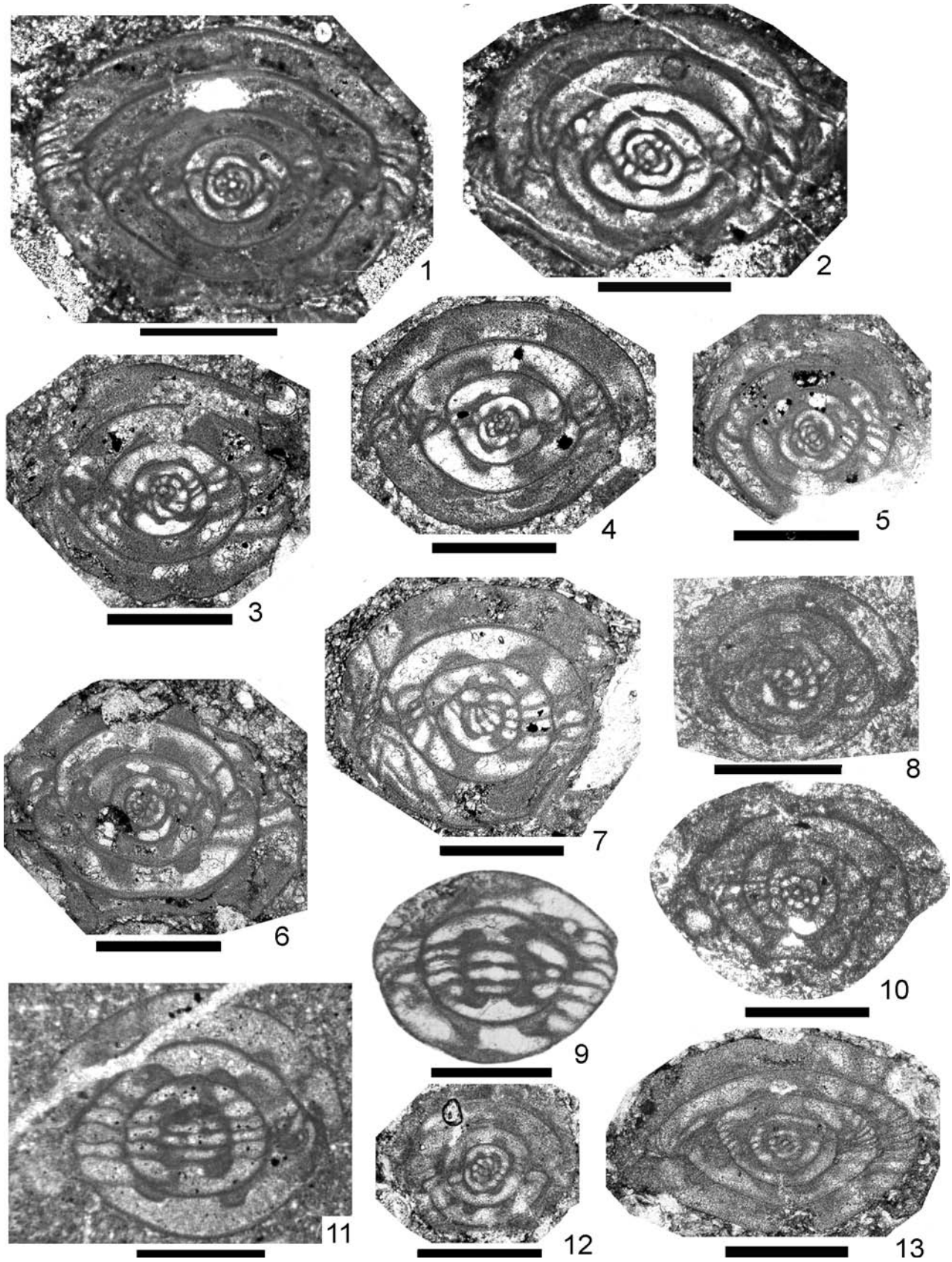
The continuous sequences in this section described in the small quarry, immediately at the top of unit 20.

Zilimian Horizon

21. Crinoidal-bryozoan graded-lamellar grainstone with unsteady thickness of 0.02–0.15 m is exposed at the base of the cliff in the quarry. Grainstone include grains of glauconite and bioclasts of bivalves, holothurians, brachiopods, fish teeth and conodonts. These beds are overlain by micritic medium bedded limestone (Sample U2/2) with thin, 0.05–0.07 m layers of silty, foliated chertly limestone with rare chert nodules. The ichnofossil tracks are sometimes present in the micrite. The fusulinids are found in the grainstone (Samples VD-25, U2/1): schubertellids, *Fusiella praecursor* Rauser, *F. praetypica* (Safonova), *Depratina sitteri* (Ginkel), Aljutovella spp., *Wedekindellina uralica* (Dutkevich) (Pl. 6). Conodonts are found in the finer fraction of grainstone (Sample U2/1, U2/2): *Gondolella donbassica* Kossenko, *Idiognathodus obliquus* Kossenko et Kozitskaya, *I. podolskensis* Goreva, *Idiognathoides tuberculatus* Nemirovskaya. 3.9 m.

Plate 2. 1, 2. *Ozawainella* cf. *aurora* Grozdilova et Lebedeva, 1954, 1 — Sample 08VD-18(3-7), 2 — Sample 08VD-17(7-9). **3–5, 11, 12.** *Ozawainella umbonata* (Brazhnikova et Potievska, 1948). 3 — Sample 08VD-17(5-6), 4 — Sample 08VD-17(8-1), 5 — Sample 3A(G14a-2), 11 — Sample 08VD-17(9-4), 12 — Sample 08VD-17(5-8). **6, 30.** *Ozawainella digitalis* (Manukalova, 1950), 6 — Sample 08VD-17(3-2), 30 — Sample 1(2). **7–9.** *Ozawainella* aff. *angulata* (Colani, 1924), 7 — Sample 08VD-17(8-6), 8 — Sample 08VD-17(14-2), 9 — Sample G14a(6). **10, 23, 24.** *Ozawainella* aff. *leei* (Putrja, 1939), axial sections, 10 — Sample 08VD-17(14-4), 23 — Sample 08VD-17(12-3), 24 — Sample 08VD-17(4-5). **13, 14.** *Ozawainella* cf. *pararhomboidalis* Manukalova, 1950. 13 — Sample 08VD-17(6-1), 14 — tangential section, Sample 08VD-17(1-8). **15–18.** *Ozawainella laxa* Grozdilova et Lebedeva, 1950. 16, 17 — axial sections. 15 — Sample 08VD-17(4-3), 16 — Sample 08VD-17(2-4), 17 — Sample 08VD-17(12-5), 18 — Sample 08VD-17(11-2). **19–22, 25, 26.** *Ozawainella crassiformis* Putrja, 1956, axial sections. 19 — Sample 08VD-17(3-2), 20 — Sample 08VD-17(5-5), 21 — Sample 08VD-17(3-4), 22 — 08VD-17(9-2), 25 — 08VD-17(9-3), 26 — 08VD-17(14-1). **27–29.** *Ozawainella umbilicata* Grozdilova et Lebedeva, 1950, 27 — Sample G14a(2), 28 — Sample 08VD-18(1-6), 29 — Sample G14a(8).
1–5, 8, 11, 12, 27, 28, 30 — axial section; 6 — oblique section; 9, 15, 18, 29 — tangential section; 13 — oblique section

Plate 3



22. Thin- and medium-bedded (0.2–0.4 m) mudstone and wackestones with abundant thin (0.03 m) to thick (0.3 m) chert nodules. Wackestone contain bivalves, holothurians, crinoids, fish teeth, and conodonts (Sample 22/1): *Gondolella donbassica*, *Idiognathodus obliquus*, *I. podolskensis*, *Idiognathoides planus* Furduj, *Neognathodus bothrops* Merrill, *Streptognathodus dissectus* Kossenko, *Hindeodus minutus* (Ellisson). Total thickness of this unit is approximately 45 m.

Tashlian Horizon

23–24. Homogeneous, medium-bedded, micrite limestone with pisiform concretions of chert. Thickness is approximately 15 m.

25. Micritic limestones with layers of yellowish-brown siltstones and one thin (0.05 m) layer of yellow ash. Limestone contain fragments of brachiopods, ostracods, crinoids, mica fragments, rounded and semi-rounded quarts grains. Conodonts: *Gondolella laevis* Kossenko et Kozitskaya, *Idiognathodus obliquus*, *I. podolskensis*, *Idiognathodus* sp. 1 m.

Entire thickness of this section is approximately 120 m.

Biostratigraphy

Foraminifers

***Hanostaffella subquadrata* and *Ozawainella digitalis* Assemblage** with diverse *Pseudostaffella* is established in the Bed 1. The dominant taxa are *Eostaffella*, *Pseudostaffella* and *Neoarchaediscus*; commonly occur *Pseudostaffella gorskyi*, which first appear in the upper Bashkirian, Tashastinian and Asatauian Horizons and ranged into lower Moscovian. The first index species in this unit as well as one specimen of *Depratina* sp. (Pl. 3, fig. 9), are more typical for the Moscovian, although their FAD is in the uppermost Bashkirian [Sinitsyna, Sinitsyn, 1987; Davydov, 2009, this volume] *Ozawainella digitalis* originally described from Vereian K_7 Limestone in the Donets Basin [Manukalova, 1950] and also have been reported from the lower Kashirian Limestone L_4–L_6 [Manukalova-Grebenyuk et al., 1969; Fohrer at al., 2007]. Latest Bashkirian age conventionally assigned to this zone, but Moscovian age cannot be entirely excluded.

***Depratina prisca* Zone** (beds 2–7 and 8 lower part). The following species found in samples 2/1, 2, G14a, 08VD-17, 08VD-18 are most characteristic for this Zone: *Profusulinella (Tikhonovichiella) tikhonovichi*, *Skelnevatella subaljutovica*, *Depratina prisca*, *Aljutovella fallax*. Abundant *Profusulinella rhombiformis*, *Pr. pararhomboides*, *Pr.* cf. *oblonga* that are first appear in the upper Bashkirian also found in this Zone. Similar assemblages with dominant *Depratina prisca*, rare *Skelnevatella* and *Aljutovella* are also known from beds 31–34 in the lower part of Solontsian Horizon in the type-section at Askyn River [Sinitsyna, Sinitsyn, 1987]. At that section *Depratina prisca* first occurs 2.0 m above the base of bed 31, whereas rich assemblage with *Profusulinella (T.) tikhonovichi*, *Pr. (T.) pseudoaljutovica*, *Skelnevatella* cf. *skelnevatica*, *Sk. subaljutovica* occurs 4.5 m above the base of the bed 31 [Sinitsyna, Sinitsyn, 1987; Kulagina, 2008]. 0.5 m above the base of the bed 31 *Schubertella gracilis* has been found. This species in the Moscow Basin reported from the Aljutovo Fm [Makhlina et al., 2001] and in the Donets Basin — from Limestone I_4 [Davydov, this volume].

***Aljutovella aljutovica* Zone** (top of bed 8 through bed 14). The zone was established conventionally bases on the occurrence of *Profusulinella* cf. *ovata* (Sample 19/2). The major assemblage of this zone is found in samples 28–29 (beds 13–14, Pl. 5), almost 20 m above the designated bottom of the zone. In this assemblage Pseudostaffella and Neostaffella are not as abundant as in previous zone, aljutovellids become common and septal fluting of Aljutovella can be recognized even in saggital sections. *Depratina sphaeroidea*, *Aljutovella aljutovica* first found in this zone. Rare and small *Neoarchaediscus* and *Asteroarchaediscus* are still present there. This zone corresponds to upper part of the Solontsian Horizons (beds 35–37) that are exposed in the Askyn section above the bed 34 and 11 m of covered interval. The assemblage from beds 35–37 in the Askyn section includes *Aljutovella aljutovica*, *Profusulinella ovata*, *Pr. nytvica*, *Depratina chernovi*, *D. sphaeroidea*.

Plate 3. Scale bar = 0.5 mm. **1, 3, 4, 6, 7, 10, 11.** *Depratina prisca* (Deprat, 1912), 4, 6, 10 — axial sections, 3, 7 — oblique sections, 11 — tangential section, 4 — Sample 08VD-18(3-2), 3 — Sample 08VD-18(1-5), 6 — Sample 08VD-18(4-3), 7 — Sample 08VD-18(4-4), 10 — Sample G14b(2-3), 11 — Sample 2(1), **2.** *Depratina sitteri* (Ginkel, 1987), Sample 08VD-23(11a). **5, 12.** *Staffellaeformes staffellaeformis* (Kireeva, 1951), 5 — oblique section, 08VD-18(1-6), 12 — axial section, Sample 08VD-17(10-7). **8.** *Depratina praeprisca* (Solovieva, 1986), oblique section, Sample G14b(2-1) (= Sample 13). **9.** *Depratina* cf. *prisca* (Deprat, 1912), Sample 1(3). **13.** *Profusulinella* sp., almost axial section, Sample 08VD-17(2-1)

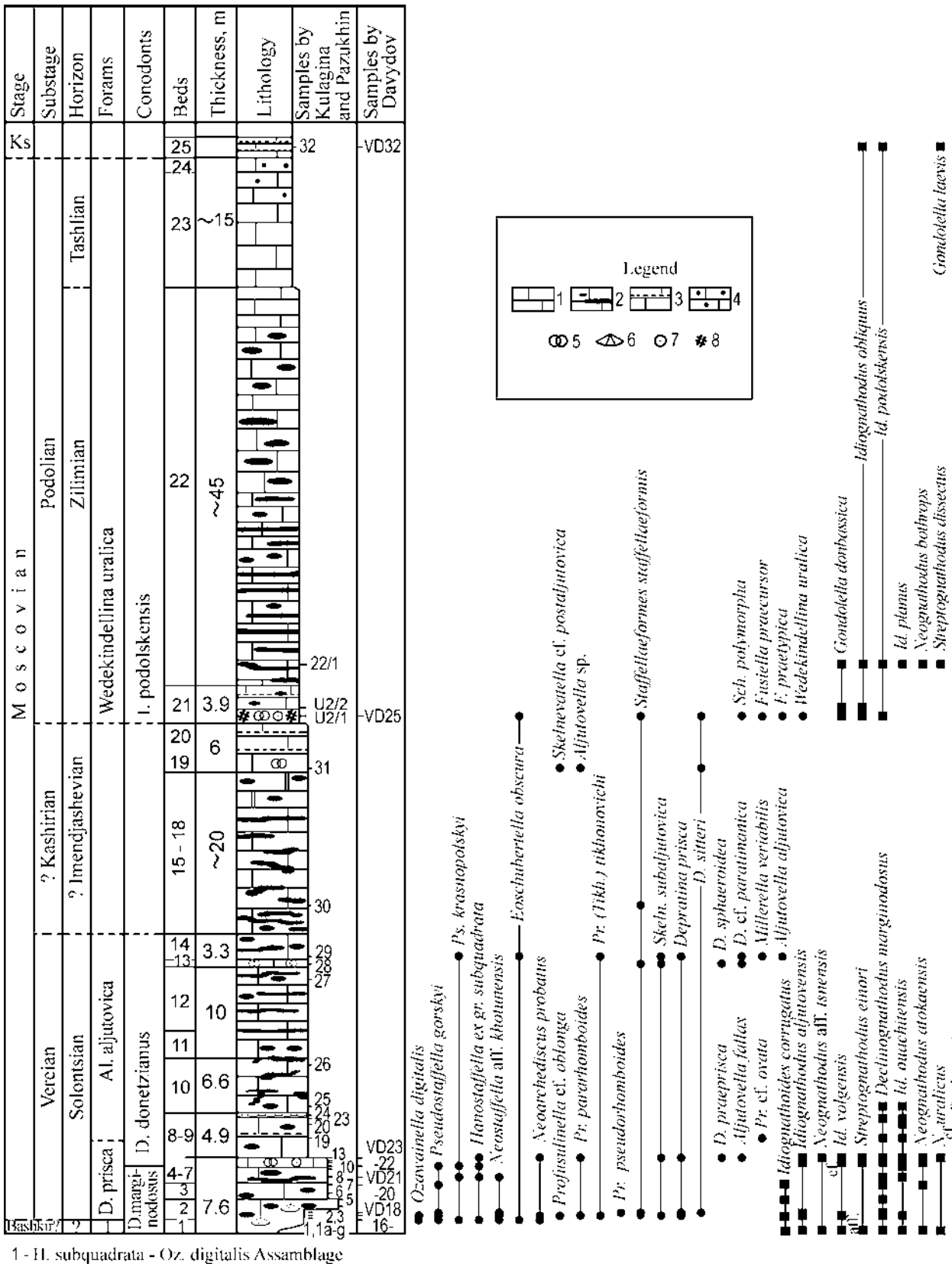
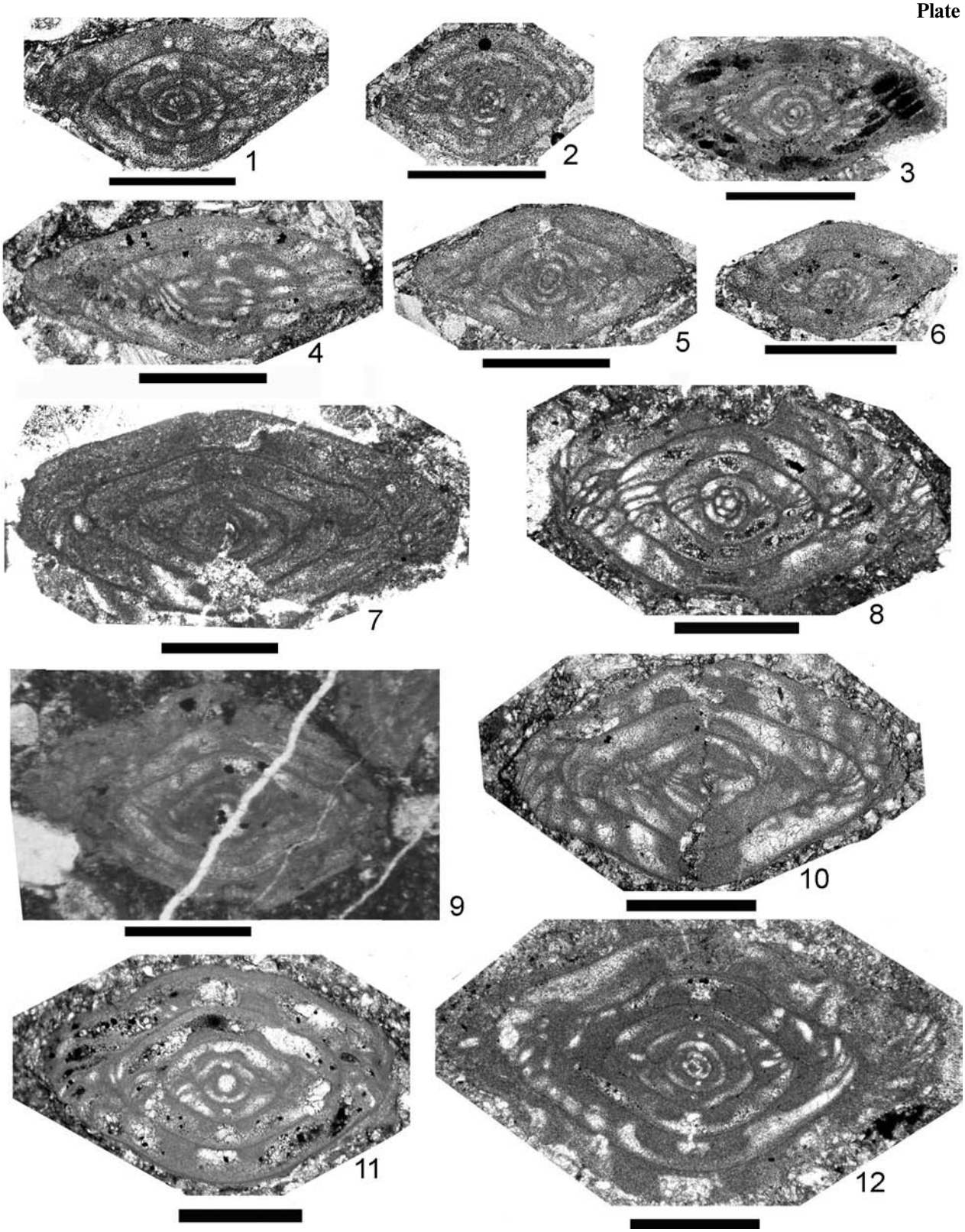


Fig. 5. Range of the major foraminifers and conodonts in the Basu section

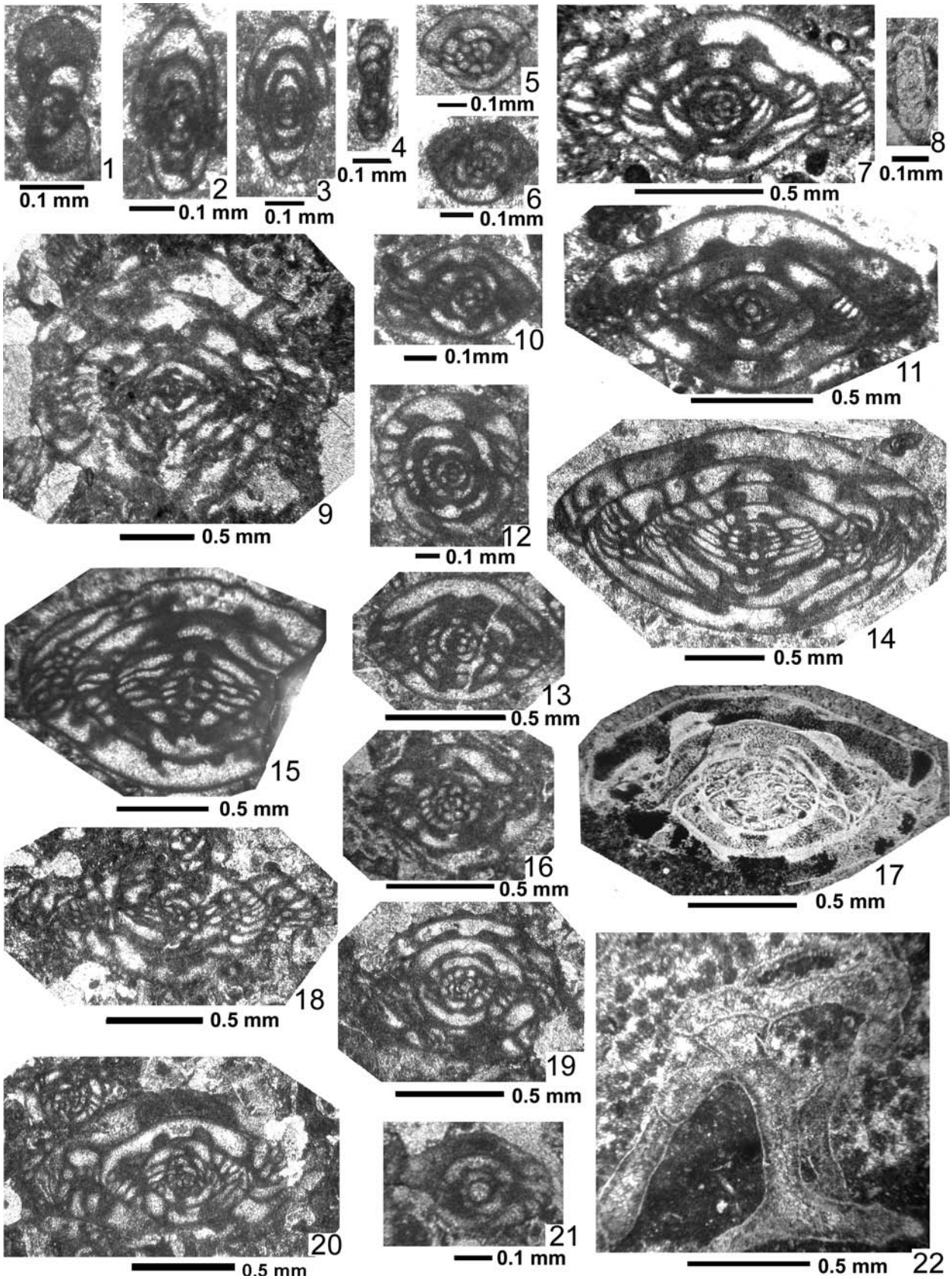
1–4 — limestones: 1 — wackestones, packstones, 2 — with cherty nodules and lenses, 3 — with layers of silty, foliated cherty rock 4 — with pisiform cherts; 5— foraminifers; 6 — brachiopods; 7 — crinoids; 8 — bryozoans

Plate 4



Scale bar = 0.5 mm. **1, 2.** *Profusulinella* (*Tikhonovichiella*) *tikhonovichi* (Rauser-Chernousova, 1951). 1 — almost axial sections, Sample 08VD-17(5-9), 2 — Sample 08VD-17(14-6). **3, 5, 6.** *Profusulinella rhombiformis* Brazhnikova et Potievskaya, 1948, axial sections, 3 — 08VD-17(10-2), 5 — Sample 08VD-17(4-2), 6 — Sample 08VD-17(3-5). **4.** *Profusulinella* cf. *oblonga* Potievskaja, 1964, tangential section, Sample 08VD-17(12-2). **7.** *Aljutovella fallax* Rauser-Chernousova, 1951, axial section, Sample 08VD-23(12a). **9, 11.** *Profusulinella pararhomboides* Rauser-Chernousova et Beljaev, 1936, axial sections, 9 — Sample 13a (2), 11 — 08VD-18(1-1). **8, 10.** *Skelnevatella subaljutovica* (Safonova, 1951), 8 — slightly oblique section, Sample 08VD-23(3a), 10 — axial section, Sample 08VD-17(5-9). 12. *Profusulinella pseudorhomboides* Putrja, 1956, axial section, Sample 08VD-18(2-4)

Plate 5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The next fusulinid grainstone has been found 20 m above the top of the *Aljutovella aljutovica* Zone. It is contains large shells of fusulinids with fluted septa. This interval requires additional study and conventionally included into the Imedyashevian Horizon.

Wedekindellina uralica Beds (bed 21). The assemblage from these beds has been found in sample U2/1 and include *Fusiella praecursor* and *F. praetypica* in addition to the species index. All these species indicate the upper Moscovian Stage, Zilimian and Tashlian horizons of the Urals [Sinitsyna et al., 1984].

Conodonts

? Declinognathodus marginodosus Zone (beds 1–4, Samples 1–10, Pl. 7, 8). The assemblage of this Zone consists of following species: *Declinognathodus marginodosus*, *Idiognathodus aljutovensis*, *I. incurvus*, *Idiognathoides corrugatus*, *Id. lanei*, *Id. ouachitensis*, *Id. sinuatus*, *Id. sulcatus sulcatus*, *Id. tuberculatus*, *Neognathodus atokaensis*, *Hindeodus minutus*. Most species found in the assemblage of this Zone were first found in the Tashastian and Asatauian horizons of the Bashkirian Stage and their analogues elsewhere. *Idiognathodus volgensis* is known only from the Vereian Horizon in the Moscow Basin [Makhlina et al., 2001]. *Neognathodus* sp. 1 resembling *N. tsnensis* known from upper part of the Solontsian Horizon of Moscovian in the Urals and from the Kashirian Horizon in the Moscow Basin and most probably is a ancestral form for the species [Makhlina et al., 2001]. Only four specimens, including holotype at the medium stage of ontogeny were studied in the original designation of *Streptognathodus einori* Nemirovskaya et Alekseev, 1994. Specimens in this assemblage similar to this species found in this assemblage differ from typical forms by better developed both accesory lobes and might just represent the adult stage of development of the species.

Declinognathodus donetzianus Zone (beds 5–9, samples 11–21). The bottom of this Zone defined by FAD of *Declinognathodus donetzianus*. Some species ranged to this Zone from the Tashastian and Asatauian of Bashkirian, i. e. *Declinognathodus marginodosus*, *Idiognathoides lanei*, *Id. ouachitensis*, *Id. sinuatus*, *Id. sulcatus sulcatus*, *Id. tuberculatus*, *Idiognathodus aljutovensis*, *Neognathodus atokaensis*, *Hindeodus minutus. Species I. volgensis*, *Streptognathodus* aff. *einori*, *Neognathodus uralicus*, that are known from the Solontsian Horizon, also found in this Zone.

The position of bed 10 in not certain as it is characterized by transitional assemblage.

Idiognathodus podolskensis Zone (beds 20–22, samples U2/1, U2/2, 22/1). Both lower and upper boundaries of this Zone in the section are conventional. Assemblage from beds 20–22 includes: *Idiognathodus obliquus*, *I. podolskensis*, *Idiognathoides planus*, *Neognathodus bothrops*, *Streptognathodus dissectus*. All these species, except *I. podolskensis*, appear at different levels within the Kashirian Horizon [Makhlina et al., 2001]. The latter species appears in the Kashirian-Podolian transition and ranged higher. Rare specimens of Bashkirian *Idiognathoides tuberculatus* and *Hindeodus minutus* and Vereian *Gondolella donbassica* are also found.

Gondolella laevis Beds (bed 25). Following species characterized this unit: *Gondolella laevis*, *Idiognathodus obliquus*, *I. podolskensis*, *Idiognathodus* sp. The assemblage have been found in silty micrite that overlays the Tashly limestone with pea-like concretion and designated previously as Kasimovian (Sinitsyna et al., 1984). However, all the above mentioned conodonts are characteristic for Moscovian Stage only. The youngest species *Idiognathodus obliquus* ranged up to mid-Myachkovian beds [Makhlina et al., 2001]. Thus, this unit requires additional study and it cannot be excluded that conodonts there are reworked.

Correlation

The assemblages of the *Depratina prisca* Zone in the Basu section and *Aljutovella aljutovica* Zone in the Moscow Basin possess many common species, such as *Hanostaffella subquadrata*, *Schubertella gracilis*, *Skelnevatella* cf. *skelnevatica*, *Sk. subaljutovica*. Nevertheless, no *Aljutovella* with clearly fluted septa are

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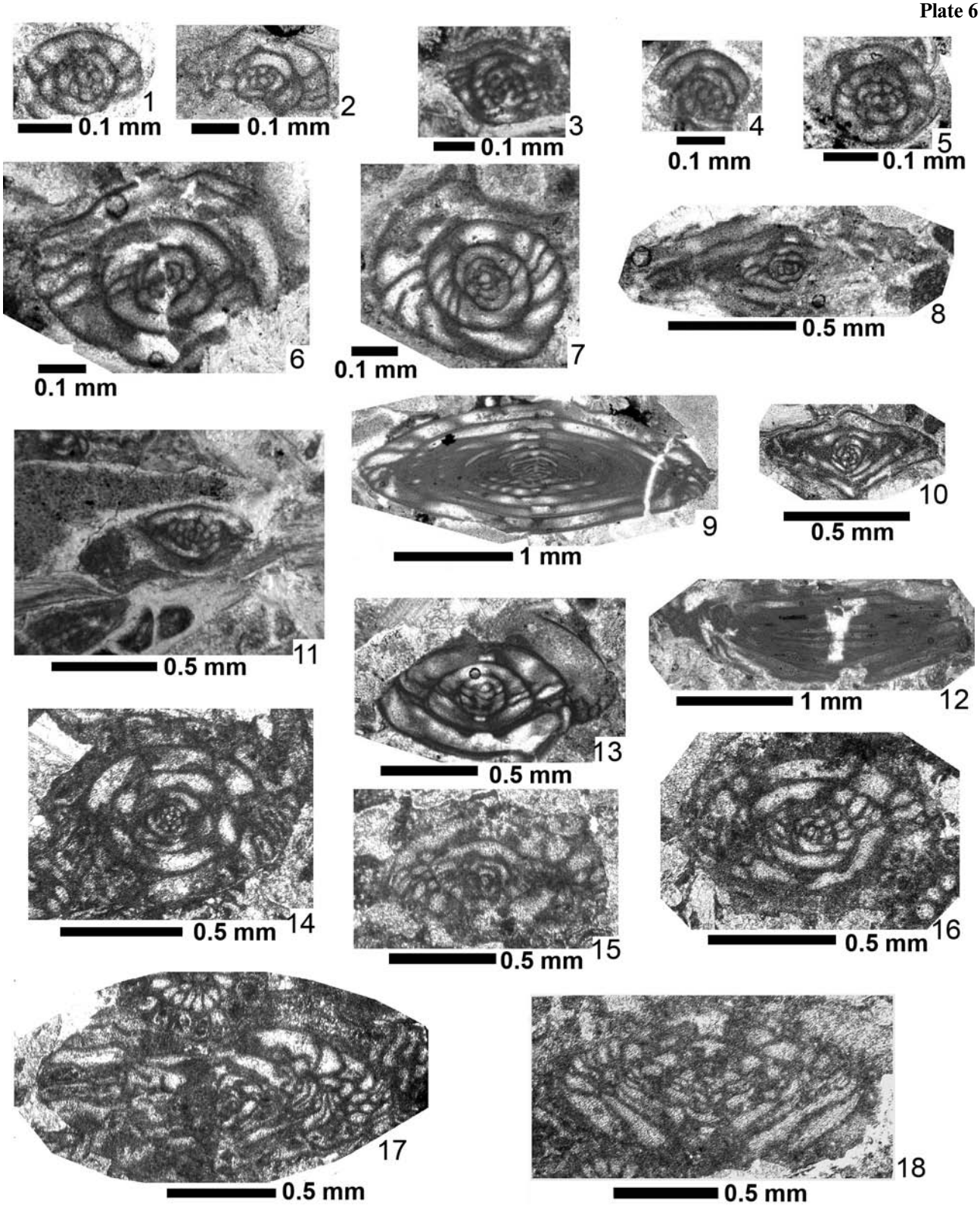
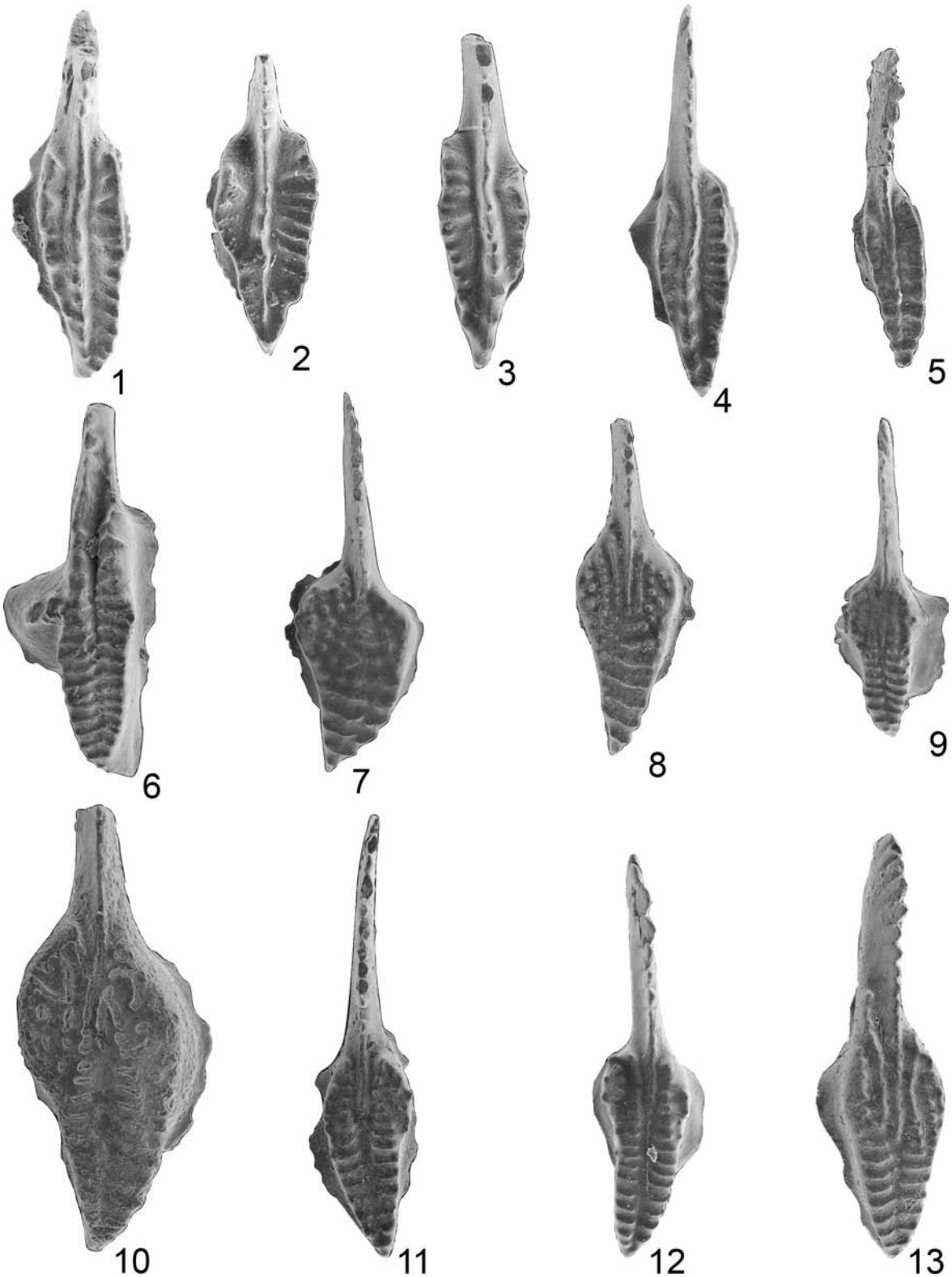
Plate 5. All figures from sample 29 exept those specially noted. **1**. *Endothyra* sp. **2.** *Eostaffella amabilis* Grozdilova et Lebedeva, 1954. **3.** *Ozawainella aurora* Grozdilova et Lebedeva, 1954. **4.** Millerella variabilis Rauser-Chernousova, 1951. **5, 6.** *Eoschubertella obscura* (Lee et Chen, 1930). **7, 20.** *Skelnevatella subaljutovica* (Safonova, 1951). 20 — Sample 28(1). **8.** *Neoarchaediscus probatus* (Reitlinger, 1950). **9.** *Depratina sphaeroidea* (Rauser-Chernousova, 1951), Sample 28(1). **10, 21.** *Schubertella gracilis* Rauser-Chernousova, 1951. **11.** *Skelnevatella skelnevatica* Putrja, 1956. **12.** *Pseudostaffella antiqua* (Dutkevich, 1934). **13, 16.** *Profusulinella parva* (Lee et Chen, 1930). **14.** *Aljutovella aljutovica* (Rauser-Chernousova, 1951). **15.** *Aljutovella* cf. *postaljutovica* (Safonova, 1951). **17.** *Profusulinella* cf. *ovata* (Rauser-Chernousova, 1938), Sample 19/2. **18.** *Aljutovella* sp., Sample 28(1). **19.** *Depratina sitteri* (Ginkel, 1987), Sample 28(1). **22.** *Donezella lutugini* Maslov. 1–11, 13, 16, 19, 21 — axial sections; 12, 18 — oblique sections; 14, 15, 17 — tangential section

Plate 6



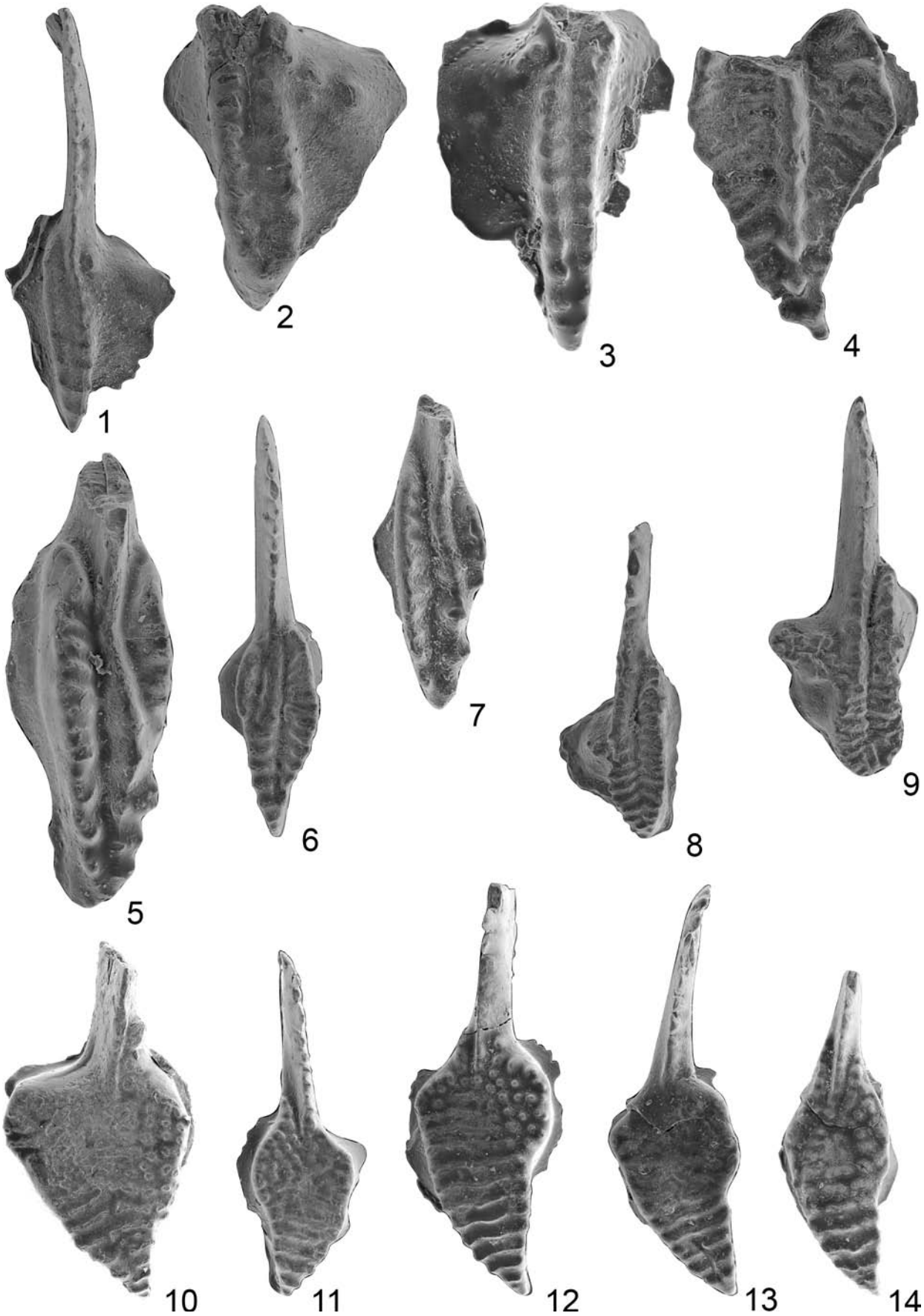
1–4. *Eoschubertella* ex gr. *obscura* (Lee et Chen, 1930), 1 — Sample 08VD-25(2-2), 2 — Sample 08VD-25(1-2), Sample U2/1(1), 4 — Sample 08VD-25(3-2). **5.** *Schubertella gracilis* Rauser-Chernousova, 1951, Sample 08VD-25(3-5). **6, 7.** *Schubertella polymorpha* Safonova, 1951, Sample 08VD-25(3-3), Sample 08VD-25(3-4). **8.** *Fusiella praecursor* Rauser-Chernousova, 1951, Sample 08VD-25 (2-1). **9, 12.** *Wedekindellina uralica* (Dutkevich, 1934), Sample 08VD-25(5-3), Sample 08VD-25(5-1). **10.** *Fusiella praetypica* Safonova, 1951, Sample 08VD-25(3-1). **11.** Bryozoan granestone with *Schubertella gracilis* Rauser-Chernousova, 1951, Sample. U2/1(1). **13.** *Profusulinella* sp., Sample 08VD-25(5-2). **14.** *Staffellaeformes staffellaeformis* (Kireeva, 1951), Sample 31(1). **15.** *Skelnevatella* sp., Sample 31(1). **16.** *Depratina sitteri* (Ginkel, 1987), Sample. 31(1). **17, 18.** *Aljutovella* spp., 17 — broken shell, both from Sample 31(1). 1, 2, 5, 6, 8–10, 14 — axial sections; 3, 12, 13, 18 — tangential sections; 5, 7 — saggital sections; 15, 16 — oblique sections

Plate 7



1, 3–5. *Neognathodus* aff. *tsnensis* Alekseev et Gerelzezeg, 2001. 1 — ×60, 3 — ×50, 4 — ×60, 5 — ×45. Sample 14A. **2.** *Neognathodus* sp. ×60. Sample 14A. **6.** *Idiognathoides tuberculatus* Nemirovskaya, 1978. ×70. Sample 14A. **7.** *Idiognathodus volgensis* Alekseev, Barskov et Kononova, 1994. ×40. Sample 14A. **8.** *Idiognathodus* sp. ×50. Sample 14A. **9–13.** *Streptognathodus* aff. *einori* Nemirovskaya et Alekseev, 1993. 9 — ×35, 10 — ×65, 11 — ×50, 12 — ×47, 13 — ×53. Sample 14A

Plate 8



found in the Basu section. At the same time abundant and large subspherical *Depratina* from *D. prisca* Zone are not known from *Aljutovella aljutovica* Zone in the Moscow Basin [Makhlina et al., 2001]. This assemblage is distinguished from the assemblage of the Vereian in the type region [Isakova, 2001] also by common *Profusulinella (Tikhonovichiella)*, rare occurrences of *Aljutovella*. *D. prisca* Zone in the Basu section perhaps corresponds to lower Aljutovo Formation in the Moscow Basin that is lack of fusulinids. In the Cantabrian Mountains the analogues of the *D. prisca* Zone can be distinguished in the terminal part of the Valdeteja Fm where *Profusulinella* cf. *sitteri*, *Pr.* ex gr. *prisca*, *Pr.* cf. *rhomboids* are found [Villa et al., 2001]. In Kyrgyzstan, Central Asia this Zone possibly corresponds to the lower part of the *A. aljutovica* Zone from where *D. prisca* and *Skelnevatella subaljutovica* are recorded [Dzhenchuraeva, 1979], and to lower part of the *A. aljutovica* Zone of the Southern Turkey where *Aljutovella* are yet rare [Dzhenchuraeva, Okuyucu, 2007]. The base of the *D. prisca* Zone or the Solontsovsky Horizon is correlates approximately with mid-Atokan FAD of *Profusulinella* in North America [Groves et al., 1999; Davydov et al., 2004].

Aljutovella aljutovica Zone in the Basu section generally contains the same species as the Vereian Horizon in the Moscow Basin and corresponds there to both *A. aljutovica* and *Ovatella arta* local Zones [Makhlina et al., 2001], to K_3–K_5 Limestone in the Donets Basin, to the upper part of the *A. aljutovica* Zone in Kyrgyzstan, Central Asia [Dzhenchuraeva, 1979] and to the *A. aljutovica – Pr. prisca – Sch. pauciseptata* Zone or its part in Kazakhstan [Zhaimina, 2006].

The assemblage of the *Declinognathodus donetzianus* Zone from Basu is close to that from the lower Solonitsian Horizons in the Urals. It has several species in common with the assemblage from the K_1–K_5 Limestone in the Donets Basin [Nemirovskaya, 1999; Ueno, Nemirovskaya, 2008], with assemblage of the Aljutovo Formation in the Moscow Basin [Makhlina et al., 2001] and the lower Vereian Horizon in the Volga-Urals oil-bearing Province [Sungatullina, 2002; Pazukhin, 2007].

Conclusion

The Basu section apparently represents deeper water setting compared to other sections of the Zilim-Zigan zone in the Southern Urals, which is suggested by dominance of micritic limestone with abundant conodonts, rare turbiditic grainstone horizons and the overall thinner but complete Moscovian sequence. The upper part of the Moscovian is poorly studied and requires additional examination. The foraminiferal *Hanostaffella subquadrata* and *Ozawainella digitalis* Assemblage, *Depratina prisca*, *Aljutovella aljutovica* Zones and beds with *Wedekindelina uralica* and conodont *?Declinognathodus marginodosus*, *D. donetzianus*, *Idiognathodus podolskensis*, and *Gondolella laevis* beds are established in the section. The lower boundary of *D. prisca* Zone placed 0.9 m from the base of the section and defined by the FAD of the index-species. The first appearance of the conodont *Declinognathodus donetzianus* is documented 6.2 m above the base of the section. The proposed base of the *Aljutovella aljutovica* Zone is 2.5 m from the first appearance of *D. donetzianus* although the index-species *A. aljutovica* is found 22.6 m above the FAD of *D. donetzianus*.

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Plate 8: 1. *Declinognathodus marginodosus* (Grayson, 1984). ×70. Sample 14 B. **2, 3.** *Declinognathodus donetzianus* Nemirovskaya, 1990. 2 — ×90, 3 — ×100. Sample 14 B. **4.** *Neognathodus atokaensis* Grayson, 1984. ×70. Sample 14 B. **5–7.** *Neognathodus* aff. *tsnensis* Alekseev et Gerelzezeg, 2001. 5 — ×100, 6 — ×50, 7 — ×100. Sample 14 B. **8, 9.** *Idiognathoides tuberculatus* Nemirovskaya, 1978. 8 — ×70, 9 — ×65. Sample 14 B. **10, 13.** *Idiognathodus* sp. A. 10 — ×50, 13 — ×47. Sample 14 B. **11, 12, 14.** *Idiognathodus* sp. B. 11 — ×35, 12 — ×50, 14 — ×60. Sample 14 B

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