

MIDDLE URALS
CARBONIFEROUS AND PERMIAN
MARINE AND CONTINENTAL
SUCCESSIONS

Editors:
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MIDDLE URALS. CARBONIFEROUS AND PERMIAN MARINE AND CONTINENTAL SUCCESSIONS

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The descriptions and biostratigraphic analyses of the important type and reference sections of the Famennian, Carboniferous and Lower Permian. The foraminifers, conodonts, Rugosa corals are illustrated. For geologists and paleontologists who study Carboniferous and Permian stratigraphy, paleontology.

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On the cover: the sketch by Roderick I. Murchison 'The Gurmaya Hills, South Urals, approaching from the Steppes' (Murchison et al., 1845).

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INTRODUCTION

GEOLOGICAL SETTING AND CARBONIFEROUS AND PERMIAN STRATIGRAPHY OF THE MIDDLE URALIAN TRIP AREA (PERM REGION)

Area of Middle Urals excursion includes three structural zones: eastern part of the East-European craton, Preuralian foredeep and West Uralian zone (fig. 1–3).

East part of the East-European platform. Volgo-Uralian area

In this area two large structural stages can be distinguished (Puchkov, 2010). The ground stage is Archean-Paleoproterozoic basement with Meso- and Neoproterozoic aulacogens. The upper stage is the platform Vendian (Neoproterozoic) – Upper Paleozoic cover. The Vendian is overlapped by the middle and upper series of Devon and by the Carboniferous and Perm systems. In the Early Palaeozoic Volgo-Uralian area was upstanding. Starting from the late Emsian a thicker and continuous sedimentary sequences start to form. Sedimentation was ruled by the interaction of the slow lowering of the peripherals and eustatic movements. In general sedimentary complex is a combination of the shallow water shelf carbonate (dolomitic limestones) and terrigenous sediments. One can see a transition into lagoon and continental sediments. On the detailed seismic profile facies of reef mass and abyssal trough of Kamskian-Kinelskian type are distinguished together with the terrigenous clinoform facies of the filling these troughs (low Vise). Almost on the whole territory of the Volgo-Uralian area carboniferous formation of the low Vise. Terrigenous-carbonate complex finishes with the limestones of the Asselian- Artinskian age. Upper the lithology change is happening because of the appearance of Kungur evaporite and Middle and Upper Permian terrigenous sediments (fig. 4). In the Volgo-Uralian area extensive isometric anteklises predominate with troughs which go around them (fig. 5). There are principal differences between the structure of the self section and the Ural foreland. Differences are limited by the gradual increase of completeness and thickness of the section to the continent side and presence of the barrier reefs which appeared in the regression conditions. Western Ural represents the continental shelf which was entrained by the folded dislocations in the end of Paleozoic.

The Urals are a Late Palaeozoic orogenic belt (Puchkov, 2009). It is located at the western flank of a huge intracontinental Uralo-Mongolian mobile belt. The orogen developed mainly between the Late Devonian and the Late Permian, with a brief resumption of orogenic activity in the Lower Jurassic and Pliocene – Quaternary time.

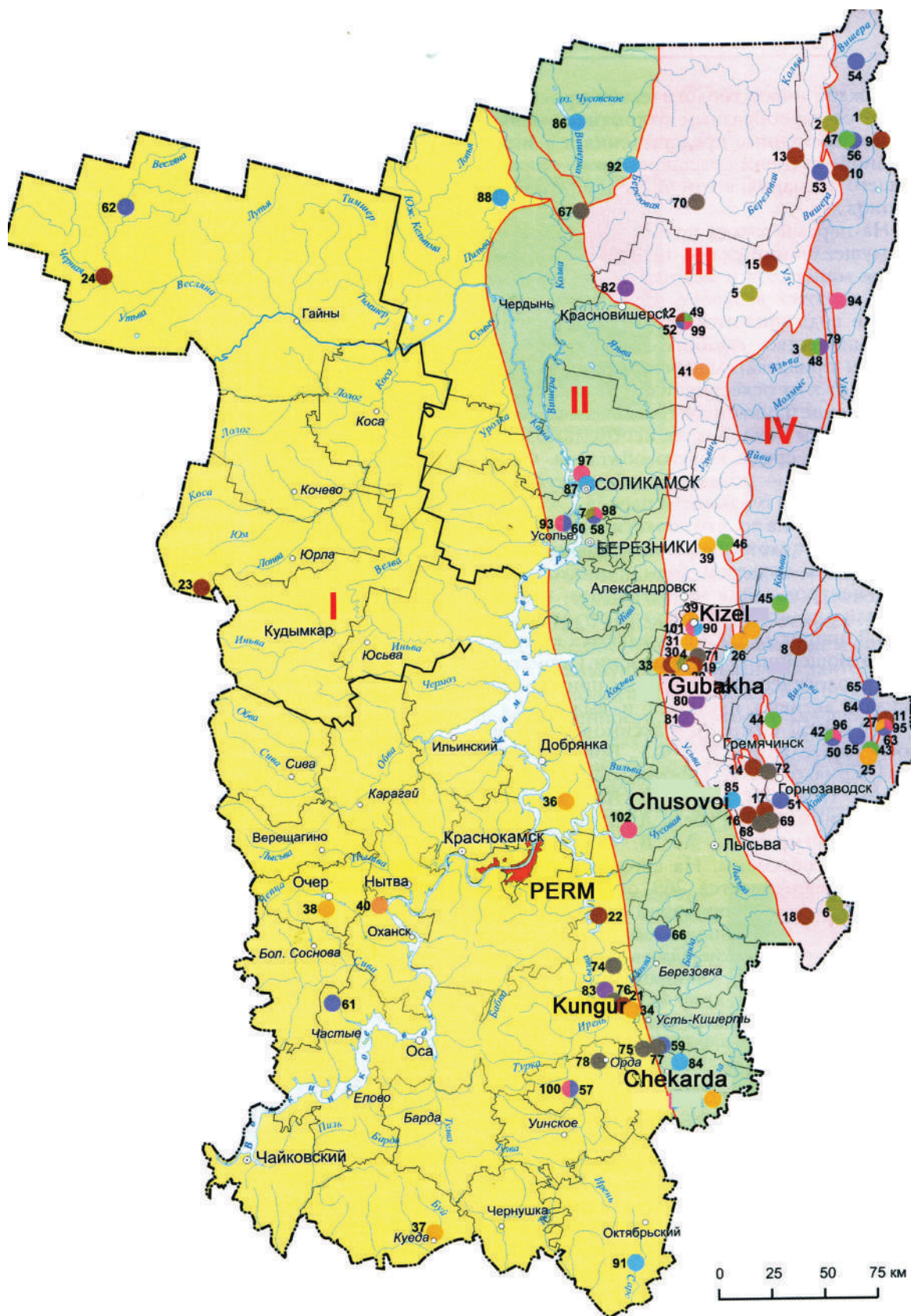


Fig. 1. Tectonic scheme of the Perm region (Permian krai, Chaykovsky, 2009)
 Symbols. I – East-European platform; II – Preuralian foredeep; III – West Uralian folded zone;
 IV – Central Uralian zone; ●, ○ – Geological monuments of Perm region

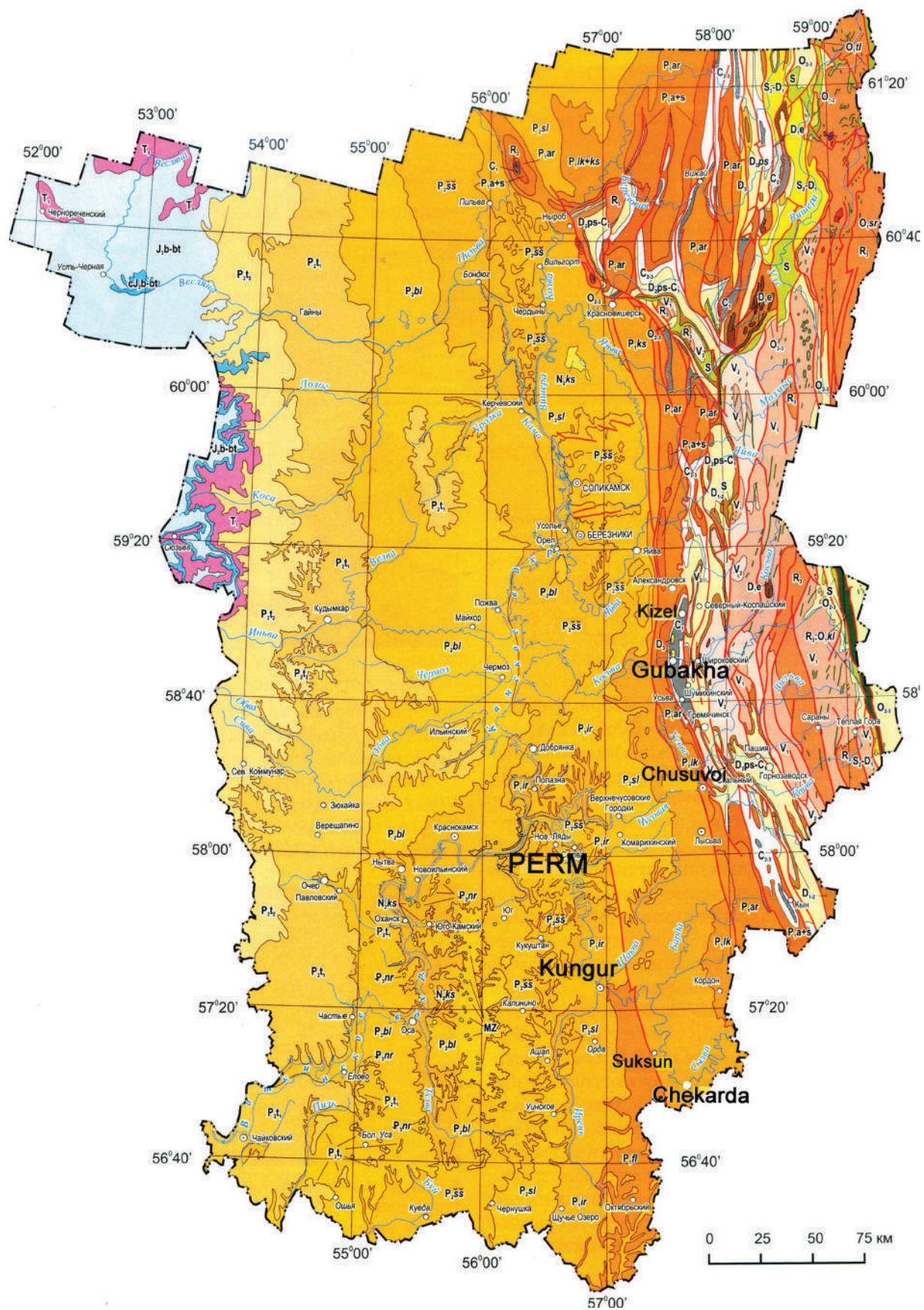


Fig. 2. Geological map of the Perm region. After B.K. Ushkov (Symbols, see fig. 3)

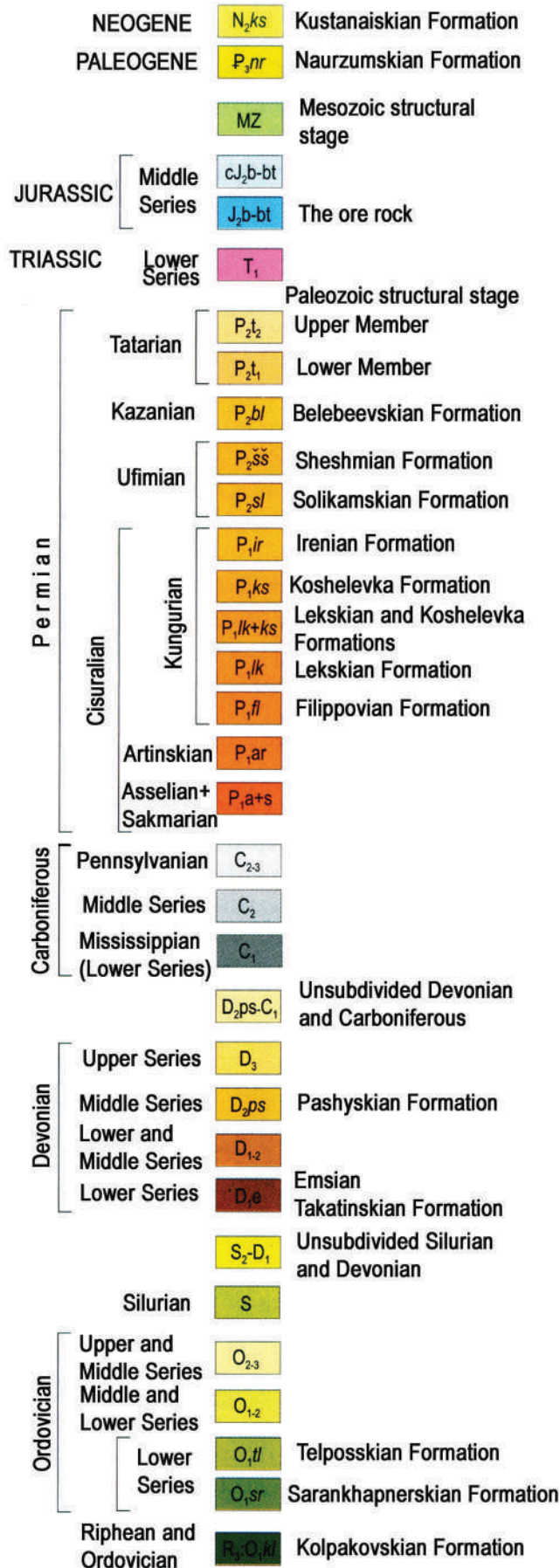


Fig. 3. Legend for Geological map of the Perm region

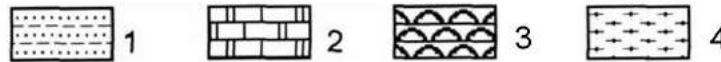
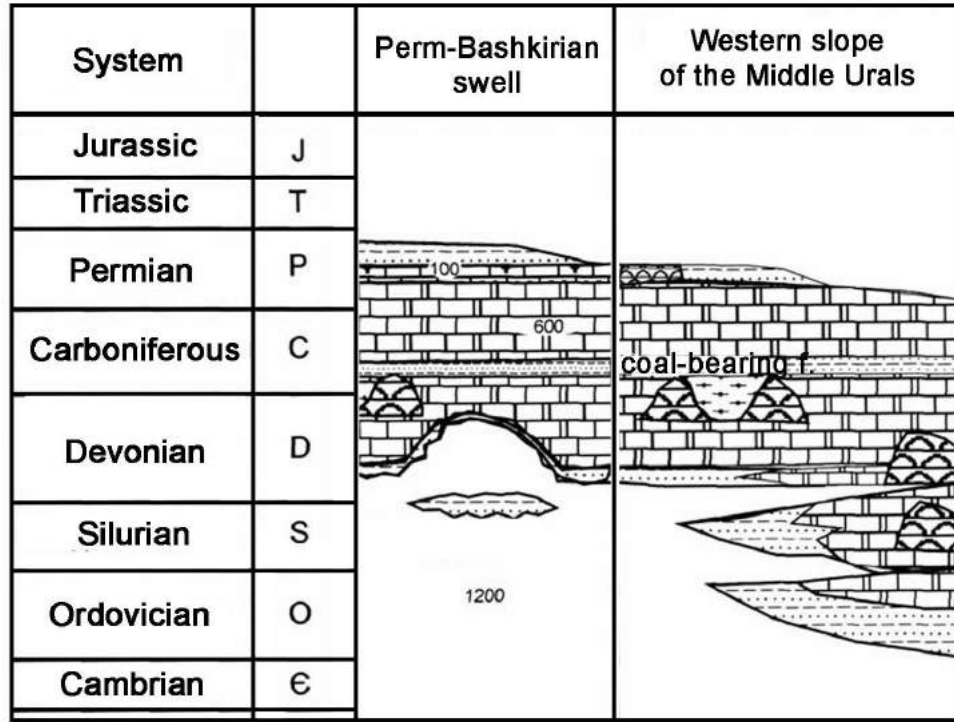


Fig. 4. Seismostratigraphic scheme of shelf complexes at the eastern margin of the Volgo-Uralian area (Puchkov, 2010) Symbols: 1 – terrigenous Formations, 2 – layered carbonates with intercalations of quartz sandstones, siltstones and shales, 3 – carbonate biogermers, 4 – Domanik facies and fill-ups of the Kama-Kinel basins

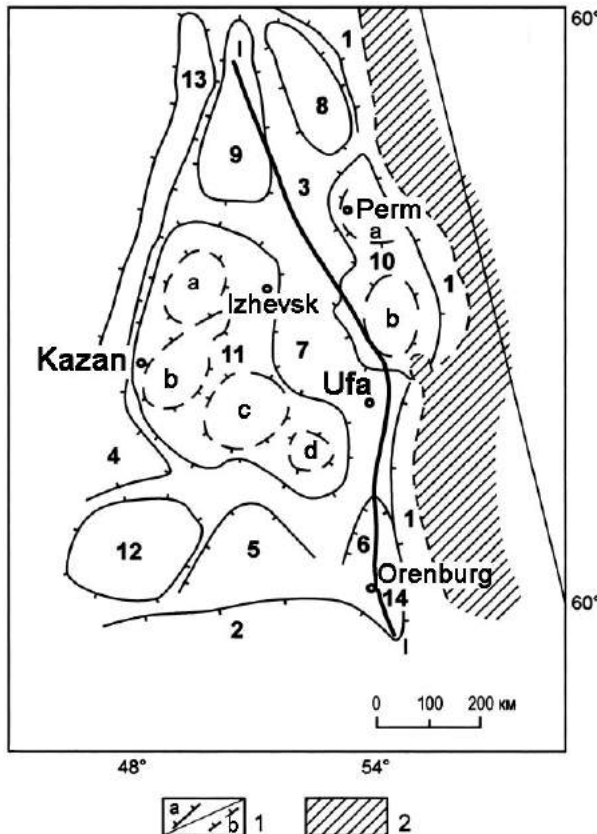


Fig. 5. A simplified structural scheme of the Volgo-Uralian area (VUA) for the end of the Paleozoic (Puchkov, 2010)

Symbols:

- 1 – outlines of the biggest structures: a – first order, b – second order; 2 – fold-and-thrust structures of the Uralides.
- 1–14 – structures for VUA: 1 - Preuralian foredeep, 2 – the margin of the Pricaspian basin, 3–6 – depressions: 3 – Upper Kama, 4 – Melekes, 5 – Buzuluk, 6 – Salmysh;
- 7 – Birsk saddle;
- 8–12 – swells: 8 - Upper Kama, 9 – Komi-Perm, 10 – Perm-Bashkirian, 11 – Tatarian, 12 – Pugachev;
- 13 – Vyatka inverted anticline;
- 14 – Sol-Iletsk uplift

Preuralian foredeep – a typical foredeep, filled with Permian flysch and molasse of the Eastern provenance, underlain Carboniferous shelf deposits. The western boundary is marked in the Middle Urals by a chain of barrier reefs of Early Permian age. The eastern boundary was affected by westward thrusting. The foredeep began with the establishment of a “preflysch” deep-water basin on shelf sediments. The basin was filled then by flysch and molasse sediments grading westward into deep-water facies and still further west into reefs and biostromes. The basin was filled with depositional evaporates of Kungurian stage. The Middle and Late Permian are represented in the foredeep in the Perm region continental sediments, mostly terrigenous, red-colored. The outer (western) subzone of the foredeep is characterized mostly by smooth, open nonlinear folds typical for platform areas. The inner (eastern) subzone belongs to the foreland thrust and fold belt. Trough is divided into a series of isolated or half isolated depressions by transverse upheavals. In the Middle Ural these are Yuresanian-Sylvenian and Solikamskian depressions. There Kungur terrigenous evaporite mass with sulphates and salt influence the tectonic structure.

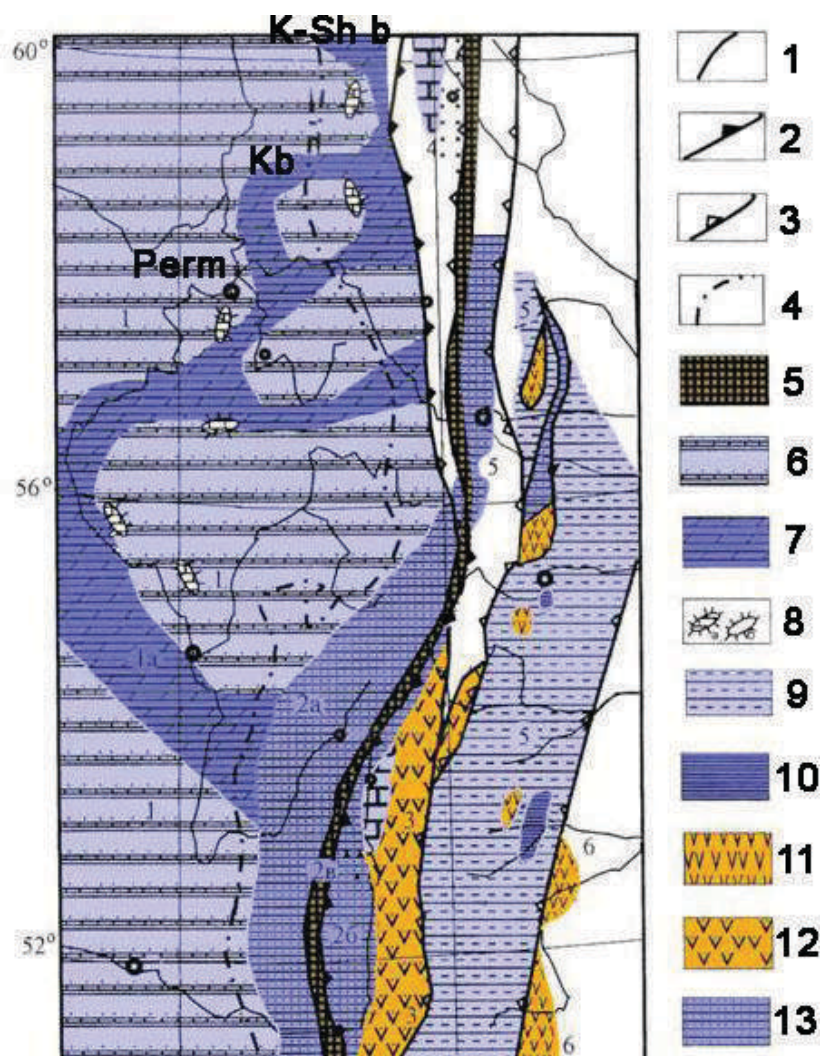


Fig. 6. The character of sedimentation in the Famennian at the eastern margin of the East-European platform and Urals (Puchkov, 2000) Symbols: 1–3 – boundaries of structural-facial zones, 4 – Western boundary of the West Uralian zone, 5 – chain uplift, 6 – shallow-water shelf, 7 – the Domanik deep shelf, 8 – barrier reefs, 9 – shallow-water and continental sediments of the cover of the Microcontinent, 10 – deep-water sediments of the cover of the Microcontinent, 11 – Upper Devonian island-arc complexes, 12 – alkaline complexes of the Magnitogorsk arc, 13 – flysch. Kb – Kizel basin of the Kama-Kinel system of deep-water troughs, K-Sh b - Kolva-Shchugor basin of the Kama-Kinel system of deep-water troughs

The West Uralian folded zone comprises predominantly intensely folded and thrustured Upper Palaeozoic sediments characterizing the former passive margin of the East European continent. Zone composed mostly of Paleozoic shelf, continental slope and rise carbonate and terrigenous sediments. Constitutes the bigger part of the west-vergent foreland thrust and fold belt.

Shelf sediments are up to 2.5-3 km in the Middle Urals. In the western sections of zone Lower Palaeozoic and Lower Devonian sediments are absent, so the Middle Devonian strata unconformably overlie Riphean and Vendian (Meso- and Neoproterozoic). In the Frasnian time in the eastern part of the East European continent was established the Kama-Kinel system of deep-water troughs (fig. 6). The trough can be observed from the platform to the folded zone of the modern western Ural slope, which emphasizes the common past of these sharply different in structure zones. If we look from Perm Pre-Urals to the Western Urals we can see Kizel palaeodepression. The basinal "domanik" facies in the axial parts of the troughs represented by a starved, condensed unit of marls, cherts and oil shales. Reef limestones border the troughs. This type of sediment distribution persisted trough the Famennian and Tournaisian, related to the high stand of sea level across platform. The regressive Lower Visean and transgressive Upper Visean sediments are characterized by the wide development of terrigenous and carbonate-terrigenous facies, including quartzites, shales and siltstones with coal layers. The Kama-Kinel troughs were filled with Early Visean sediments and ceased to exist. A strong connection is again observed between Serpukhovian stage and Frasnian-Tournaisian structure plan. To

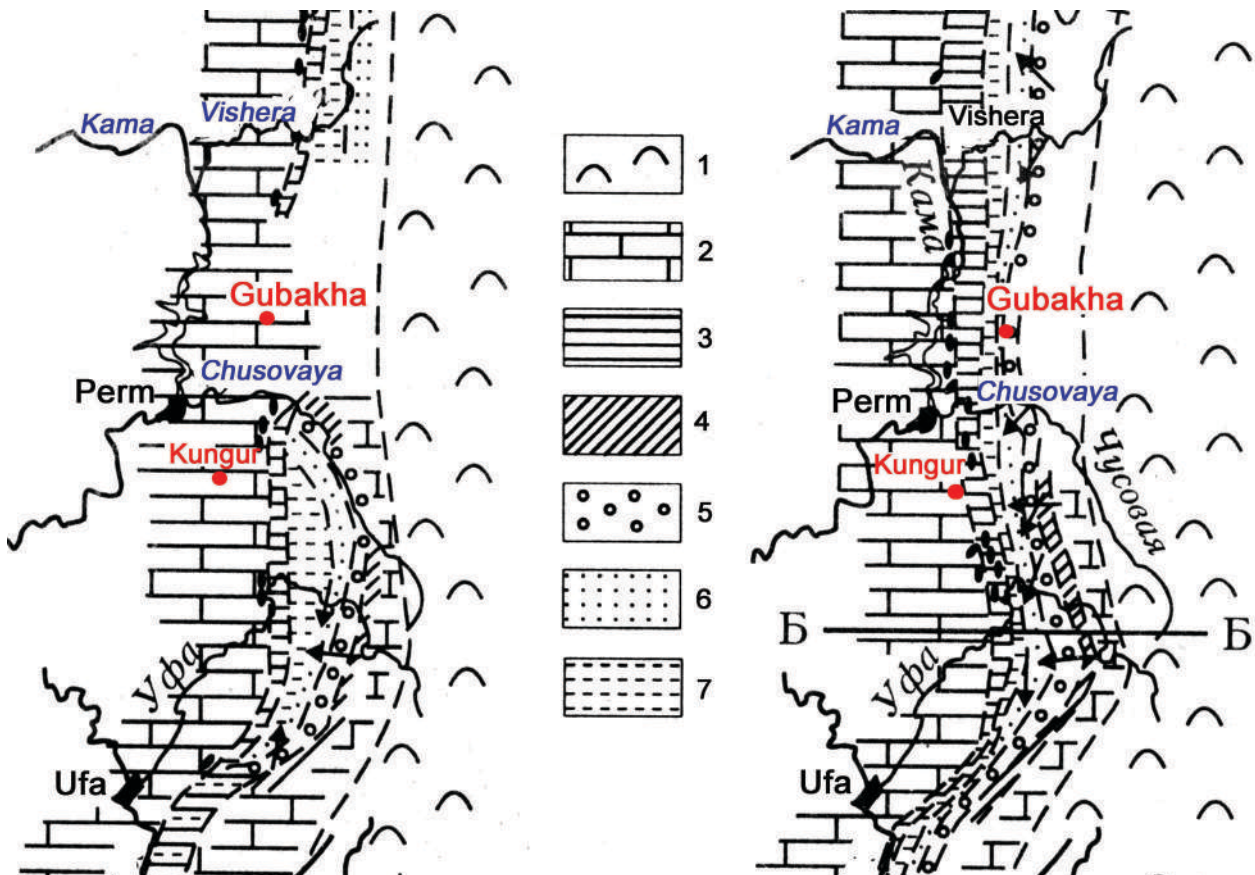


Fig. 7. Paleogeography of the West Urals during the Asselian (left) and the Late Artinskian (from Mizens, 1997) Symbols: 1 – mountains, 2 – platform (shallow-water sea); 3 – zone of the western shelf of the foredeep; 4 – a slope of the active margin on the foredeep, 5 – upper part of the deep-water cone, 6 – middle part of the deep-water cone, 7 – lower part of the deep-water cone and lower part of the passive margin on the foredeep. Б–Б – line of the profile (fig. 8)



the full extent Serpukhovian stage was developed only in the palaeodepression. Bottom part of the Serpukhovian stage is represented by the depression type of section of Kurmakovskian formation. The Kurmakovskian Formation traces the development only in the Kama-Kinel troughs: Kizel trough and Kolva-Shchugor trough (Northern Urals, fig. 6). The Late Visian, Serpukhovian and Bashkirian stage in the West Uralian zone are represented mostly by shallow-water limestones.

In the middle Carboniferous, starting from the Moscovian age, due to the inversion of the Uralian mobile belt a gradual restructuring happens, which formed structure of the Urals course.

A very important transgressive – regressive boundary of the stratigraphic sequences, marked by unconformity and the deposition of terrigenous sediments is within the Moscovian. On the territory of the Middle and partly Northern Ural, Early Moscovian formation is spread (Elovian and Kremenian formation of Gubakha suburbs) which is carbonate-argillaceous mass with interbeds of distal tempestites of polymictic composition. Formation reflects a starting stage of the formation of the trough in the Middle Urals (Mizens, 1997).

The Upper Carboniferous and a part of Lower Permian are represented predominantly by shallow-water limestones. In the Asselian, Sakmarian, Early Artinskian ages abyssal flysch basins existed to the South from the middle watercourse of Chusovaya river (the South of the territory observed) and in the North Urals (fig. 7, 8). In the middle of the Artinskian age a unified abyssal basin was formed within the trough, the subtraction of the rudaceous material was reinforced. In the middle part of the Artinskian stage in the sections of the Basin of Kosva River distal turbidites lay.

In the Kungurian age West Urals flysch basin was gradually filled with sediments and was emerged above the sea level. The process of filling the basin was not even, it was accompanied with the strong axis shift to the West. Folded Ural structures gradually were moving on the trough (fig. 9). Starting from the Middle Permian territory developed in the subaerial conditions.

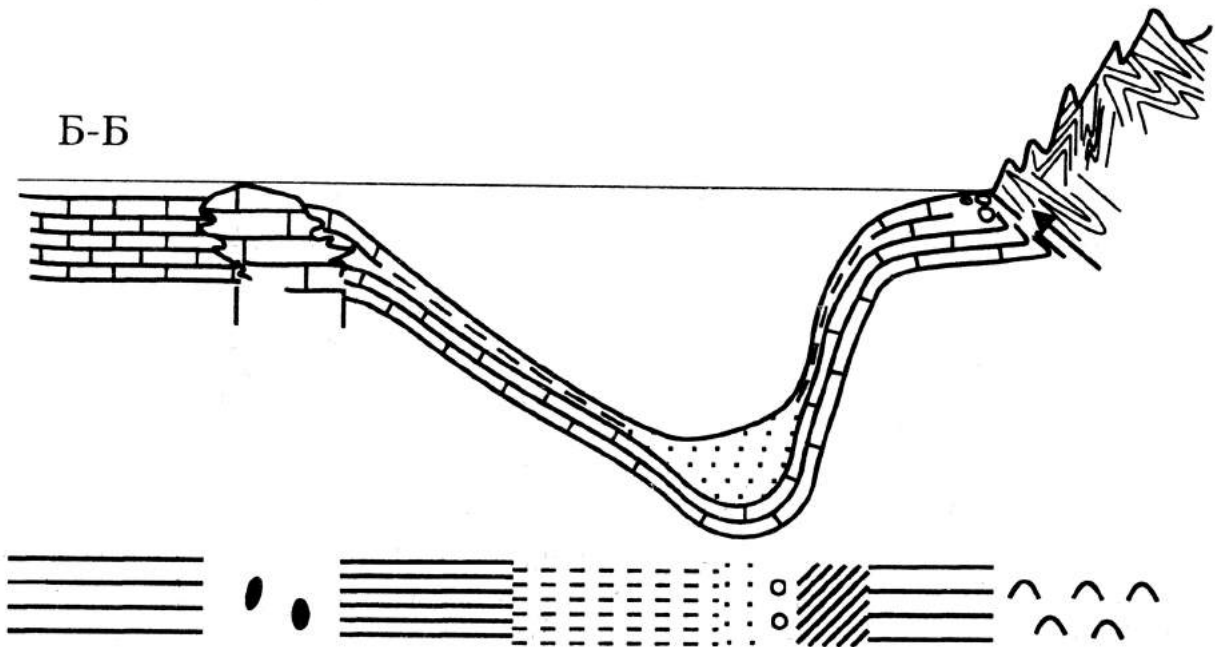


Fig. 8. Schematic facies profile of the Late Artinskian Uralian foredeep (from Mizens, 1997)

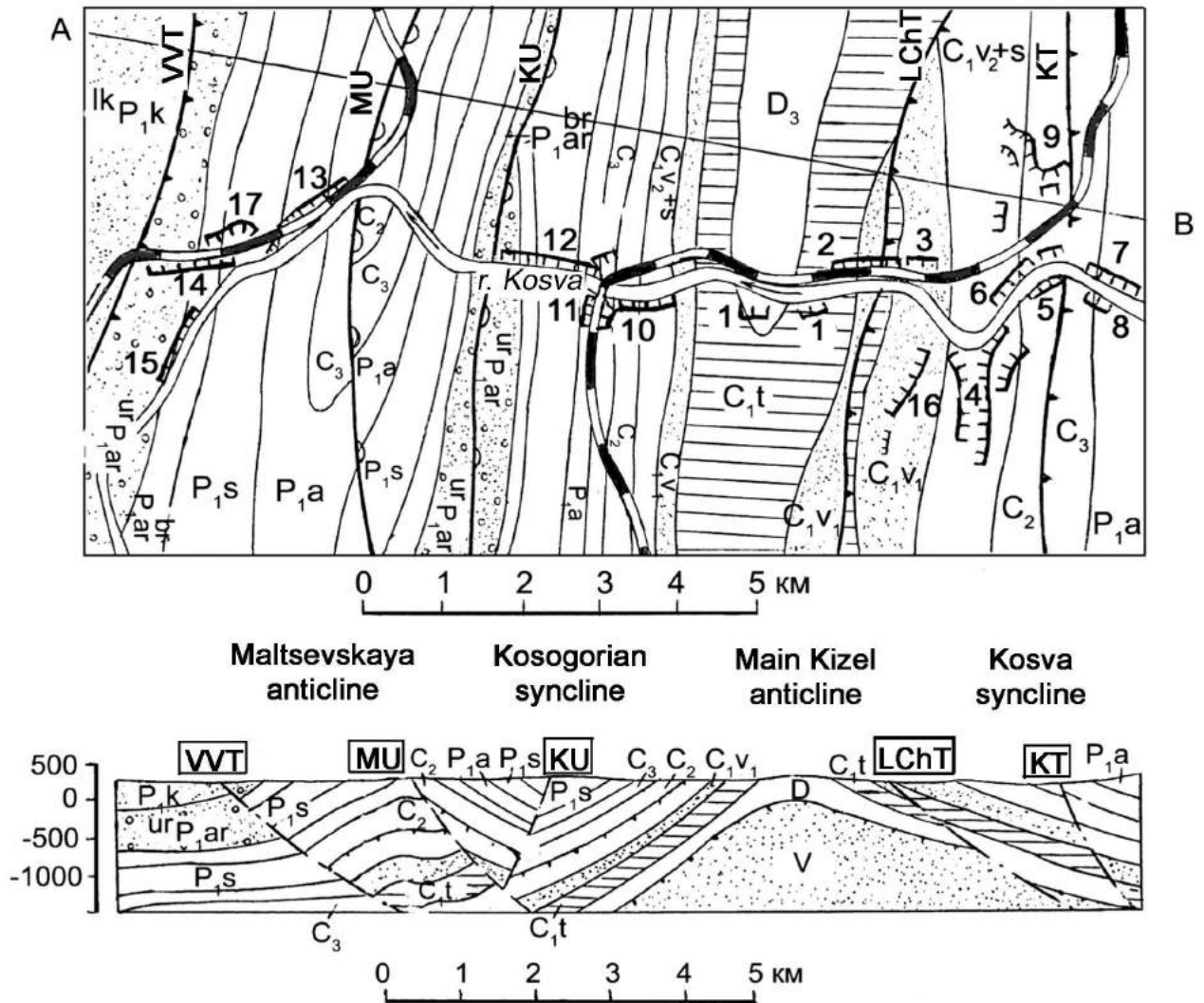


Fig. 9. Schematic geologic map and cross-section of the Gubakha area (after O.A. Shcherbakov)
 Legend: 1–17 – section: 1 – Yadro (a core), 2 – Gubakha, 3 – Bunker, 4 – Ladeyny Log (Ladeyny ravine), 5 – Kremenny, 6 – Verkhnyaya (upper) Gubakha, 7 – Kholodny Log (cold ravine), 8 – Ostanets (relic), 9 – Mariinsky Log, 10 – Nizhnaya (lower) Gubakha, 11 – Povорот (turn), 12 – Belaya Gora (White Mountain), 13 – Maltsevka, 14 – Rassolny, 15 – Karpikha, 16 – Krestovaya Gora (Crusade Mountain), 17 – Verkhnyaya (upper) Karpikha. Faults: VVT – Vsevolodo-Vilvensky thrust, MU – Maltsevsky upthrust, KU – Kosogorian upthrust, LChT – Lunyevsko-Chusovskoy thrust. Stratigraphic indexes: P_{1arbr} – Burtsevskian Substage, urP_{1ar} – Urminskian Formation (Iriginian and Saranian substages), lkP_{1k} – Lekskian Formation (Filippovian Substage)



GSS		Regional units					
System	Series	Stage	Western Urals		Russian platform		
			Substage (horizon)	Vishera-Chusovaya zone (Formation)	Substage (horizon)		
CARBONIFEROUS	Upper Pennsylvanian	Gzhelian	Melekhovian		Melekhovian		
			Noginskian		Noginskian		
			Azantashian	Pavlovoposadian		Pavlovoposadian	
				Amerevian		Amerevian	
				Rechitsian		Rechitsian	
		Kasimovian	Lomovskian	Dorogomilovian		Kerzhakovian	
	Khamovnikian			Lomovskian			
	Krevyakinian						
	Middle Pennsylv.	Mosco-vian	Myachkovian		Myachkovian		
			Podolskian		Podolskian		
			Kashirian	Martyanovian	Kremenian	Kashirian	
			Vereian		Elovian	Vereian	
	Lower Pennsylvanian	Bashkirian	Arkhangelskian	Asatauian		Mariinian	
				Tashastian			
			Askynbashian		Melekessian		
			Akavassian		Cheremshankian		
			Sjuranian	Kamennogorian		Prikamian	
				Bogdanovkian		Severokeltmenian	
	Upper Mississip.	Serpu-khovian	Brazhkinian	Staroutkinskian		Krasnopolanian	
				Protvian		Voznesenkian	
			Kosogorian		Kosogorian		Zapaltyubian
					Kurmakovskian		Protvian
	Middle Mississippian	Visean	Okskian	Venevian		Kosogorian	
				Mikhailovian		Ladeynian	
Aleksinian				Gubashkinian			
Tulian				Kurtymian			
Kozhimian			Bobrikian	Druzhininian	Shishikhinian	Bobrikian	
				Ilychian			
			Radaevkian	Kluchevian		Radaevkian	
				Pesterkovian			
Lower Mississippian	Tournaisian	Kosvian		Kosvinian			
		Kizelian	Upper	Kizelian	Kizelian		
			Lower				
		Cherepetian		Kynovian	Kosorechenian	Cherepetian	
		Upian			Karakubian		
		Kalapovian	Malevkian		Upian		
Gumerovian			Malevkian				

Table. 1. Stratigraphic subdivision of the Carboniferous System in the Perm region

GSS			Regional units						
System	Series	Stage	EEP and WU	East-European platform		Preuralian foredeep	Western Urals		
			Substage (horizon)	East margin of the VUA (Formation)		Solikamskian and Silvian basins	Vishera-Chusovaya zone (Formation)		
PERMIAN	CISURALIAN	Kungurian	Sheshmian (?)	Sheshmian (?)		–	–		
			Solikamskian	Solikamskian		Solikamskian	–		
			Irenian	Irenian	Popovian	Koshelevka	Koshelevka		
			Filippovian	Filippovian	Karnaukhovian	Mysovian	Leks kian		
		Artinskian	Saranian	Churtanian	Silvian reefs	Divya	Divya	Urminian	Urminian
			Sargian	Kamaian					
			Irginian	Irginian		Volimian reefs	Marl shales Divya (?)		
			Burtsevskian	Yuresanian					
			Sterlitamakian						
			Tastubian			*Duvanian reefs	*Ustkoyvian	Limestones	
			Asselian	Shikhanian	Urmantauian				*Duvanian reefs
		Kholodnologia n							

* - Formations developed only in the Silvian basin of the Preuralian foredeep.

The Burtsevskian – Kholodnologia n substages represented in the Solikamskian basin by shallow marine limestones (bioclastic limestones and boundstones with Palaeoaplysina and corals)

Table 2. Stratigraphic subdivision of the Permian System in the Perm region

1. **Mizens G.A.** Upper Paleozoic flysch of the Western Urals. Ekaterinburg: UrD of RAS, 1997. 231 p.
2. **Puchkov V.N.** Paleogeodynamic of the Southern and Middle Urals. Ufa: Dauria, 2000. 146 p.
3. **Puchkov V.N.** Structure of the Urals (with a special reference of the Carboniferous complexes) / Carboniferous Type Sections in Russia and Potential Global Stratotypes: Proceedings of the International Field Meeting “The historical type sections, proposed and potential GSSP of the Carboniferous in Russia”. Southern Urals Session. Ufa – Sibai, 13–18 August, 2009. Ufa: DesignPoligraphService, 2009. P. 7–11.
4. **Puchkov V.N.** Geology of the Urals and Cis-Urals (actual problems of stratigraphy, tectonics, geodynamics and metallogeny). Ufa: DesignPoligraphService, 2010. 280 p.

August 16 • Stop 1

CHEKARDA SECTION

KUNGURIAN

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The Chekarda section is known worldwide as the richest locations of the Early Permian entomofauna and flora. The section is situated in the vicinity of the Chekarda village, near by the mouth of the Chekarda River and the Sylva River, in the Suksun district of the Perm krai. The locality was discovered in 1925 by G. Mauer, a forestry specialist and amateur naturalist from the town of Kungur. His collections were described by A.V. Martynov, M.D. Zalessky and Yu.M. Zalessky. The section represents a bedrock exposure with a total length of about 650 m and a height of 0.5 to 14 m. The rocks form small flat folds with a dip to the north-west and north-east at angles of up to 20°.

Chekarda is located in the axial zone of the Sylva basin of the Preuralian foredeep and exhibits the Chekardinian Pack (Chuvashov et al., 1990) of the Koshelevka Formation (Irenian Substage, Kungurian Stage of the early Permian). The deposits were formed in the arid lithogenesis and represent submarine fans delta of the Ural River.

The section consists of three outcrops. The first outcrop is located 150 meters above the mouth of the river Chekarda and has a length 50 m of frontage and forms a closed talus. The second outcrop begins immediately behind the mouth of Chekarda River and extends for 550 m to the islands on the Sylva River. The first two outcrops overlap each other and contain a pack of ashy-gray marl with a unique complex of fossils of insects and plants. A third outcrop, located to 850 meters down the Sylva River from the mouth of the Chekarda River opposite Sylva's islands, has a length of 120 m and ends at the mouth of a large ravine. The outcrop builds upon the section of the first two and contains the second pack marl with well-preserved fossils.

The largest volume of all types of rocks occupy sandstones, which belong to the feldspar-quartz greywackes (Mizens, 1997). The main cementing mineral is calcite with pore type cementation. Siltstones differ with increased amount of grains of quartz and containing typically less than 10% rock fragments. The latter are represented by siliceous varieties. The main clay minerals in argillites are dioctahedral hydromica and swelling chlorite, the latter are representing siliceous differences. The main clay minerals in argillites are hydromica dioctahedral chlorite and swelling. The mixed clastic-carbonate rocks are

marl and clay marl, among which are very coherent varieties, with the smell of bitumen at sliver enriched dispersed organic matter, contains the remains of insects, and contain examples of the best preservation.

The Chekardian Pack succession is represented by first-order, second-order and third-order sedimentary sequences (Ponomareva et al., 1997; Zhuzhgova et al., 2015). Mikrotsiklity (tape cyclites) are very thin alternating shales and marl. Packages of micro species occur in conjunction with graded-bedded sandstones and siltstones up to several centimeters. Cyclites III order include all major petrographic and genetic types of rocks involved in the structure of the sedimentary massive or intermittent horizontal stratification, with plenty of plant detritus and clay pebbles; top cyclites complex I and II order (interbedded siltstones and sandstones with interbedded shales and marl tape). Deposits are the first element cyclite turbidite origin. Second, fine-clastic element, which is associated olistostromes probably accumulated in desalinated deep lagoon, situated in the delta of the river. Chekardinskaya Pack's origin is associated with deep alluvial fans and characterizes the final phase of the flysch trough of the Ural (fig. 1 – 5).

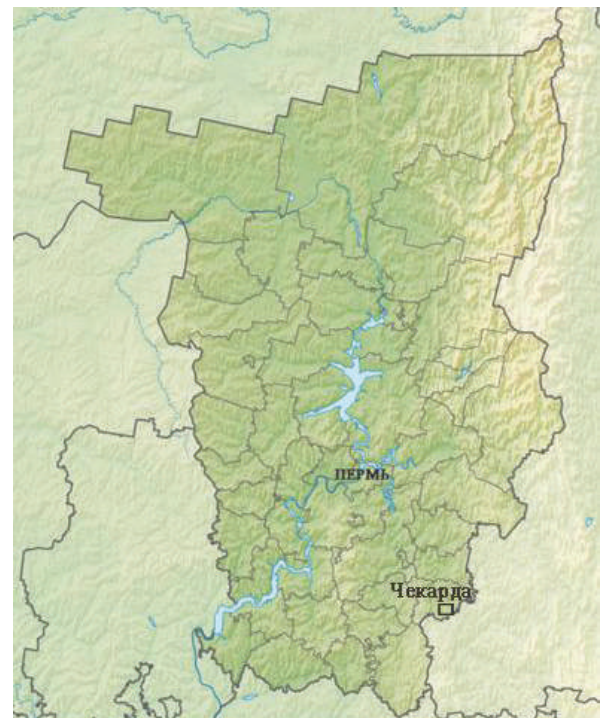
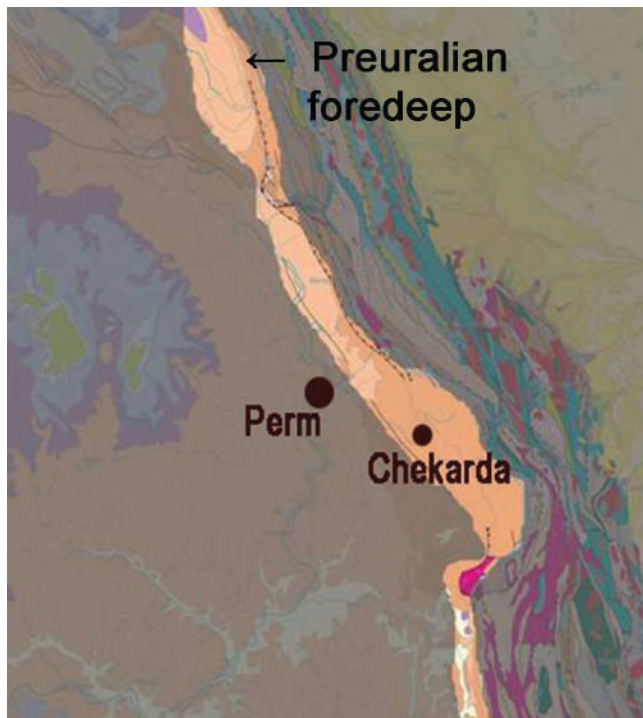


Fig. 10. Location of the Chekarda section



System	Series	Stage	Substage	Formation	Beds	Meters	Sections	Lithology column	Lithology	Fossil remains
Permian	Cisuralian	Kungurian	Irenian	Koshelevka	13	2,9	3		Marl, siltstones, sandstones	Plants, insects
					12	1,6	3		Sandstones	Plant detritus
					11	3,4	2		Sandstones, siltstones, shales	Plant detritus
					10	6,2	1; 2		Sandstones massive and layered with clay pebbles, olistoliths, interbedded siltstones and shales	Plant detritus, makroflora
					9	2,2	1; 2		Siltstones, sandstones	Plant detritus
					8	1,8	1; 2		Massive sandstones with clay pebbles	Plant detritus
					7	1,5	1; 2		Sandstones, siltstones	Plant detritus
					6	5,3	1; 2		Massive sandstones with clay pebble and a package of siltstones and sandstones	Plant detritus, makroflora
					5	1,3	2		Olistostrome	Plants
					4	2,5	1; 2		Marl, shales, sandstones	Plants, insects
					3	1,7	1; 2		Olistostrome with olistoliths	Plant detritus
					2	2,2	1; 2		Sandstones, marl, siltstones	Plants, insects
					1	1,3	2		Sandstones	Plants

Fig. 11. Columnar of the Chekarda section

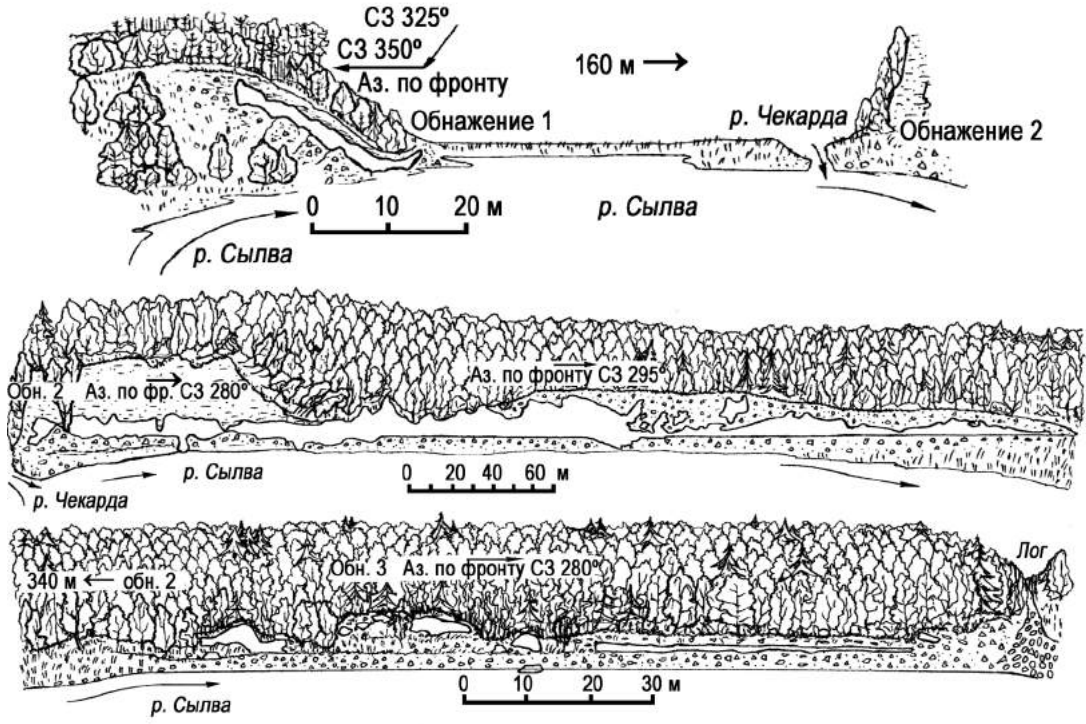
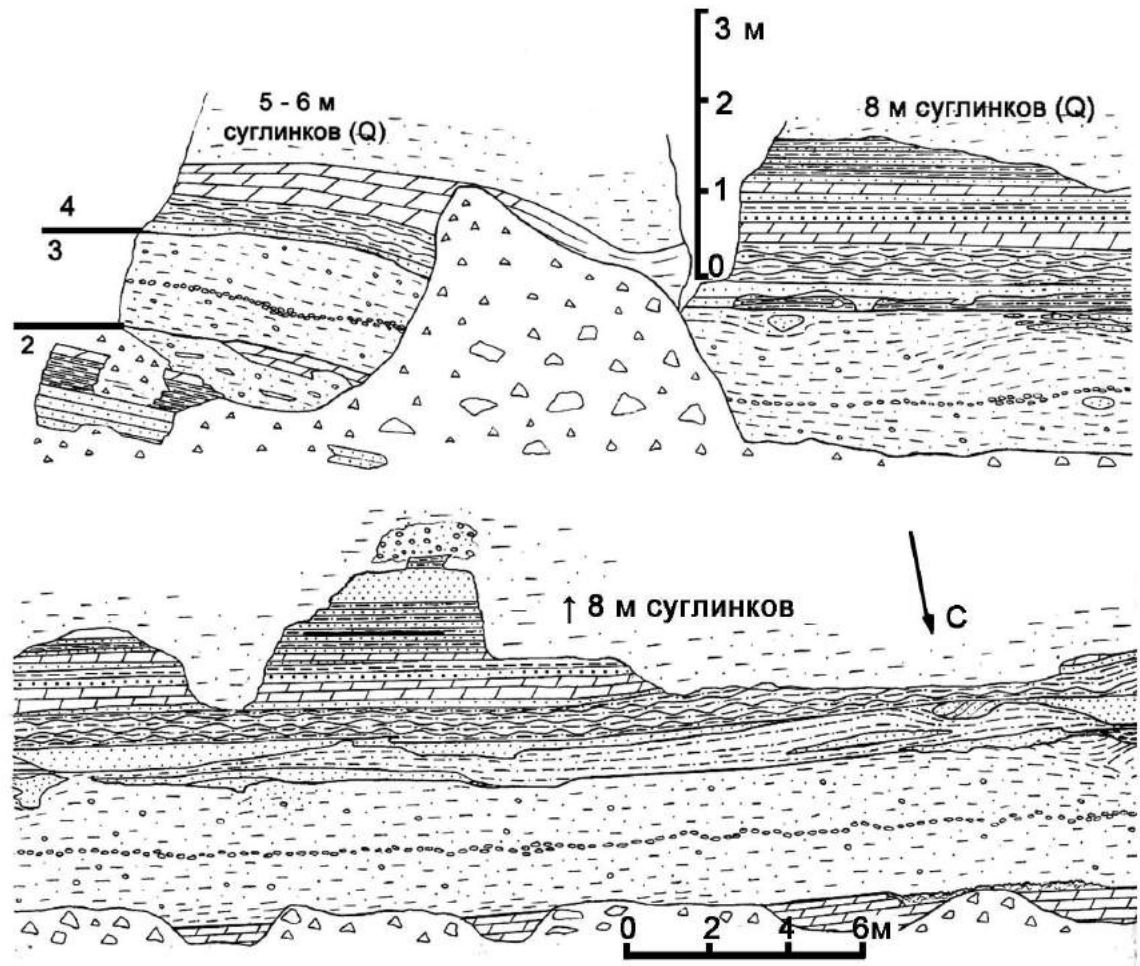


Fig. 12. Structure of the Chekarda section



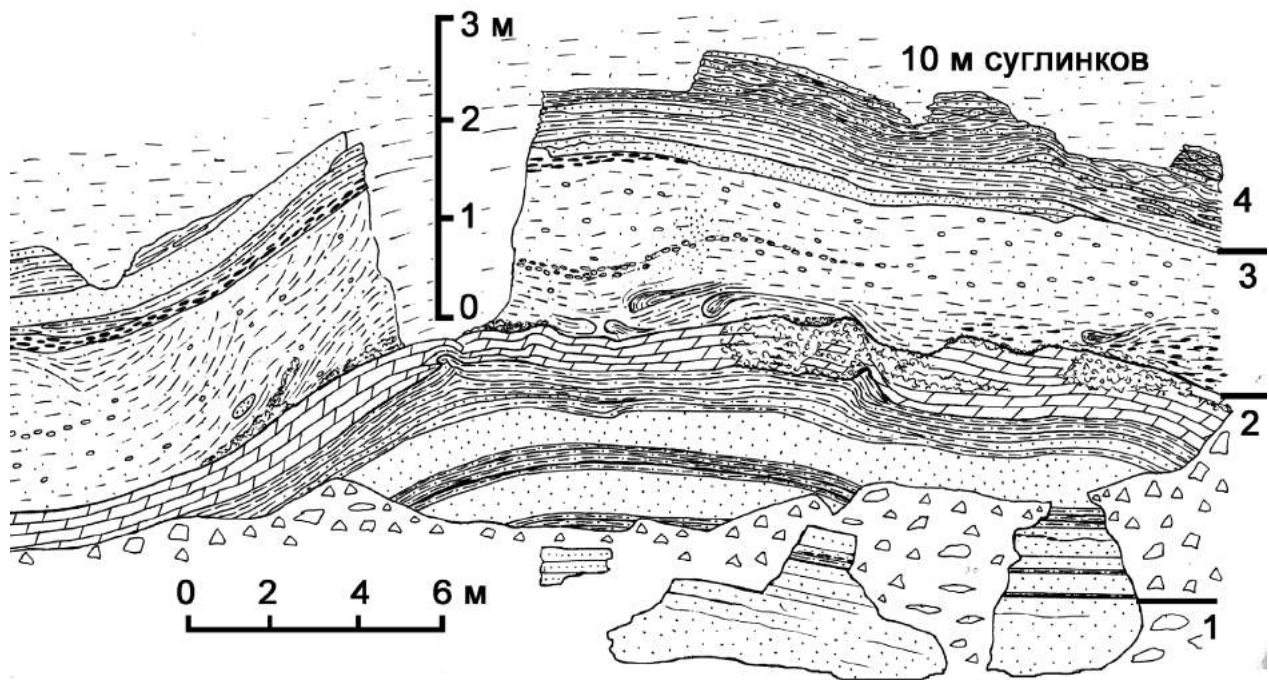


Fig. 13. Start of outcrop of 2 the Chekarda section. Cyclit III order (beds 1–4)

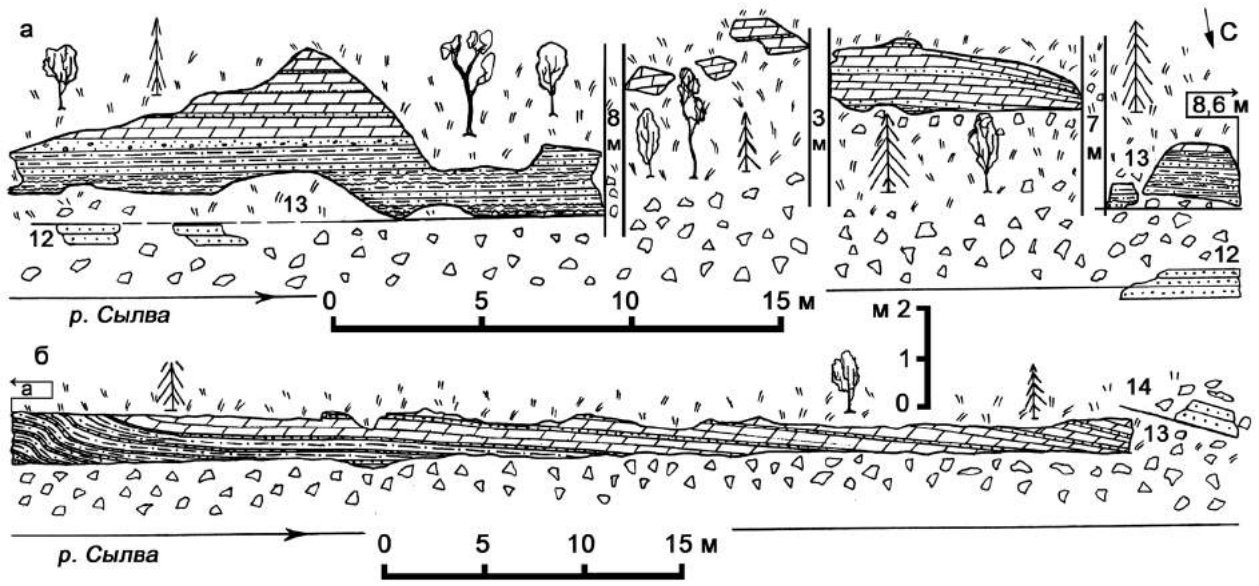


Fig. 14. Structure of outcrop of 3 the Chekarda section

The fossil flora of the Chekarda locality shows practically almost all high taxa of the plants, which are characteristic of the Late Palaeozoic plant world. The most typical representatives of the Chekarda flora include isoetalean lycopodiopsids *Sadovnikovia belemnoides* Naug.; equisetophytes *Equisetinostachys peremensis* (Zalessky) Naug., *Phyllothea campanularis* Zalessky emend. Naug., *Paracalamites decoratus* (Eichwald) Zalessky, etc; sphenophylls *Bowmanites biarmensis* Naug., *Sphenophyllum biarmicum* Zalessky emend. Naug.; calamostachyan *Calamites gigas* Brongniart; ferns *Acrogenotheca ramificata* Naug., *Convexocarpus distichus* (Naug.) Naug., *Corsinopteris dicranophorus* (Naug.) Doweld, *Pecopteris uralica* Zalessky, *P. helenaeana* Zalessky, *P. anthriscifolia* (Goepfert) Zalessky, *P. tchekardensis* Vladimirovich; peltasperms *Permocallipteris retensoria* (Zalessky) Naug., *P. artipinnata* (Zalessky) Naug., *Peltaspermum* spp.; pteridophylls of uncertain affinity *Gracilopteris lonchophylloides* Naug.; ginkgophytes *Psygmyphyllum expansum* (Brongniart) Schimper, *P. intermedium* Naug., *P. cuneifolium* (Kutorga) Schimper, *Alternopsis stricta* Naug., *Psygmyphyllodendron uralensis* Naug., *Bardia mauerii* Zalessky, *Kerpia macroloba* Naug., *Karkeniania permiana* Naug., *Mauerites* spp.; male reproductive organs of ginkgoopsid affinity *Permotheca disparis* (Zalessky) Naug., *P. fimbriata* (Zalessky) Naug., *P. colovratia* Naug., *P. bifurcata* Naug., *P. deodara* Naug.; angaropeltians *Sylvocarpus armatus* Naug., *Permoxylocarpus trojanus* Naug., *Praephylladoderma leptoderma* Naug., voinovskyopsids *Astrogaussia imbricata* (Naug.) Naug., *Vojnovskya* sp., *Rufloria derzavinii* (Neuburg) S. Meyen, *R. recta* (Neuburg) S. Meyen, *R. lanata* Gluchova, *R. cf. rasskasovae* S. Meyen, *Nephropsis crinita* Gluchova, *Lepeophyllum sabanakovae* Vladimirovich; conifers *Walchia appressa* Zalessky, *W. bardaeana* Zalessky, *Uralostrobos vltzioides* Naug., *Bardella splendida* Zalessky; various other gymnosperms and their isolated seeds.

In Koshelevka testing found more than 8,000 specimens of insects belonging to 25 orders and 99 families, comprising 205 genera and 284 species of insects. Work at Chekarda has uncovered one of the largest and most diverse assemblages of Paleozoic insects. An objective assessment of diversity is the ratio of the number of families found in the location, to the natural logarithm number of copies of this location. For Chekarda this value is 9.8 (this is the maximum value for the Permian) to Wellington (USA) Location is 6,5 (Rasnitsyn et al., 2015). The high diversity in Chekarda can be explained by the unique preservation of the material. In most Paleozoic locations arthropods represented by single, separated wing, whilst in Chekarda these finds are rare and it is more typical to discover fossils of complete insects.

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KUNGUR AREA MEZHEVOI LOG SECTION

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ARTINSKIAN KUNGURIAN STRATOTYPE OF THE KUNGURIAN STAGE

Near Kungur town on a certain distance to Ust-Kishert village up the Sylva River there are typical sections of the Artinskian and Kungurian stages. Here historical stratotype of the Kungur stage is situated (fig. 1).

Section Mezhevoy Log is situated in Kungur suburbs, where in 1890. A. Shtukenberg identified Kungurian stage. Mezhevoy is a typical section of local and regional subdivisions of the upper part of the Artinskian and Kungurian stages

The basic geomorphologic elements of the territory are deep canyon like incised valley of the Sylva River and upstanding ridged and hilly plain Ufimian plateau with the absolute heights of the surfaces up to 240-250 m.

Tectonically, Kungur town and its suburbs are situated in the eastern margin of the Volgo-Uralian antecises of the Russian plate of the East European Craton, on its contact with the Uralian foredeep, in the northern part of the low angle anticlinal fold Ufimian shaft.

Mezhevoy Log section is situated on the right bank the Sylva River, 8 km upstream from Kungur. It is represented by rocky outcrops up to 40 m height on the both sides of the mouth of Mezhevoy ravine. Yermak Stone is situated on the right slope of Mezhevoy ravine. It is a bioherm of the Sylvanian formation (Sylvanian reef). On the left slope upstream the Sylva River one can see low original outcrops in the car hollow road which is finished with the Mezhevoy stone in 160 m near the mouth of the ravine. Section is situated in the core of the anticline Ufimian shaft that is why there the most ancient rocks of the Artinskian stage are cropped out. There is a description of this part of the section below (it is described for the first time).

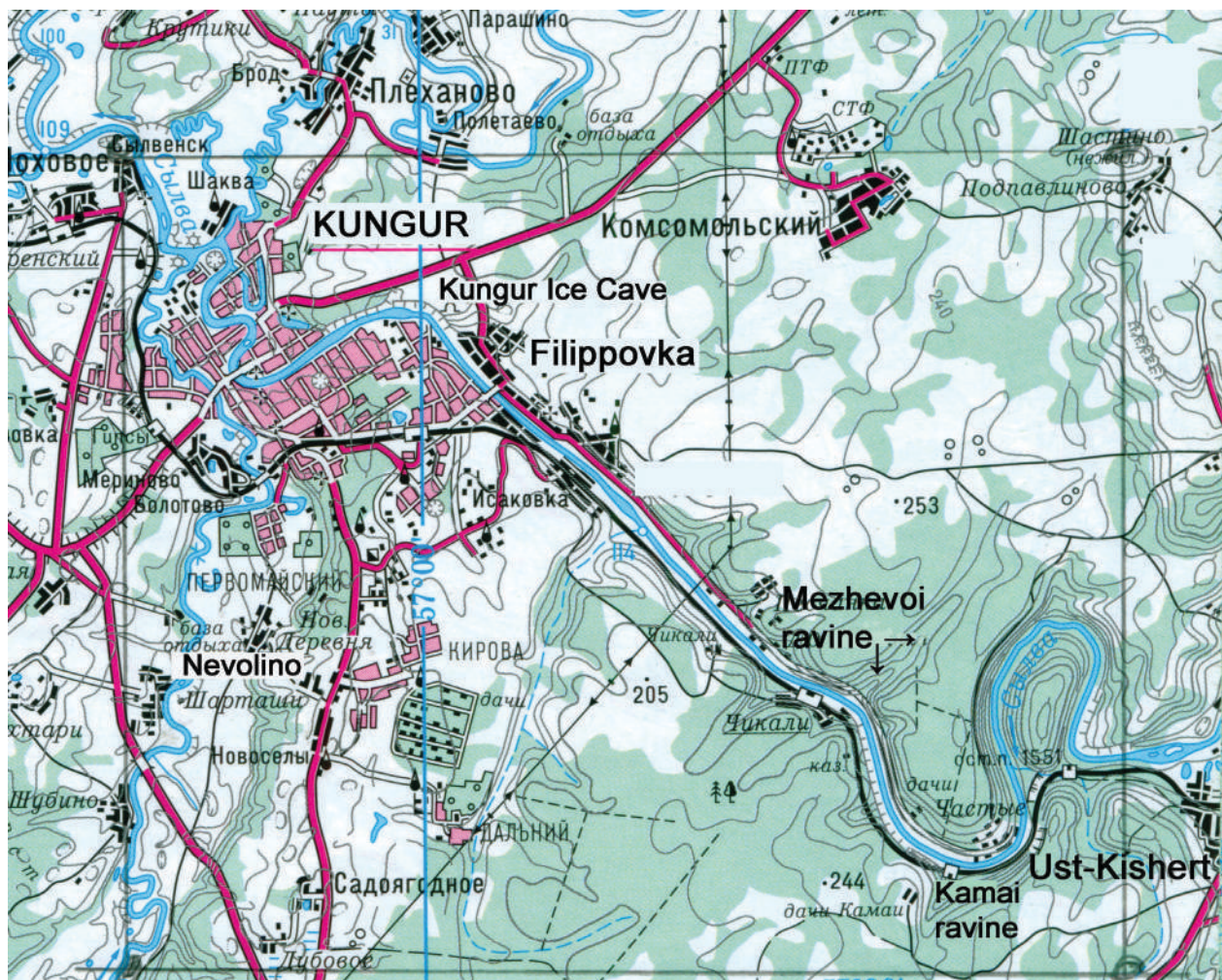


Fig. 15. Location of the Mezhevoi Log section and other mentioned Artinskian and Kungurian sections

Artinskian stage
Sargian substage
Kamaian formation

Kamaian formation is cropped out near the mouth of Mezhevoi ravine only on the right slope of the ravine (under Yermak stone); on the left slope it does not reach the surface. Hollow monoclinical folding is with the fall to the East. It is composed by interbedded limestones, highly dolomitic, silicified, calcareous dolomites, silicified, bluish-light-gray, predominantly coarse- and middle-bedded (5-30 m), turning into spongolite with interbeds of brown argillaceous limestones or dolomites (1-5 sm). In all rocks spongolites, brachiopod shells, colonies of branching and fenestrate bryozoas, fragments of crinoid stems, ostracodes and small foraminifers are found. Especially single stone spongolites of spherical or flattened form with the welded skeleton are widely spread in the Kamaian formation *Kazania elegantissima* Stukenberg and *Scheia tuberosa* Tschernyshev. The description of fauna is given according to the Guidebook (1991). Bryozoas *Polypora sargaensis* Trizna, *Rhombotrypella arbuscula* (Eichw.), *Permoheloclema dunaevae* Ozhg., *Lioclema heckeri* Trisna, *Batostomella tshikaliensis* Trisna are numerous (Guidebook, 1974).

Brachiopods: *Waagenoconcha irginae* (Stuck.), *Buxtonia saraneanus* (Freckes.), *Liosotella septentrionalis* (Tschern.), *Marginifera uralica* Tschren., *Jakovlevia artiensis* (Tschern.), *Chaoiella gruenewaltdi* (Krot.), *Spiriferella saranae* Vern., *Dielasma elongata* Schlot. The following corals are met: *Amplexocarina muralis* Soshk., *A. irginae* Soshk., *A. socialis* Sochk., *Ufimia aster celindroconica* Soshk.

The penetrated thickness is approximately 14 m; width of outcrop is approximately 70 m. Stratotype of the **Kamaian formation** is situated on the left bank of the Sylva River, 3.8 km upstream from the Mezhevoy stone, in the mouth of Kamaian ravine.

Kungurian stage

Kungurian stage (“classic” Kungur) is identified on the base of three substages (from lower to upper): Saranian, Filippovian and Irenian.

Saranian stage

Saranian stage in the northern part of the Ufimian shaft consists of two formations of one age: Sylvanian and Churtanian. But Mezhevoy log section differs from a standard scheme (fig.2).

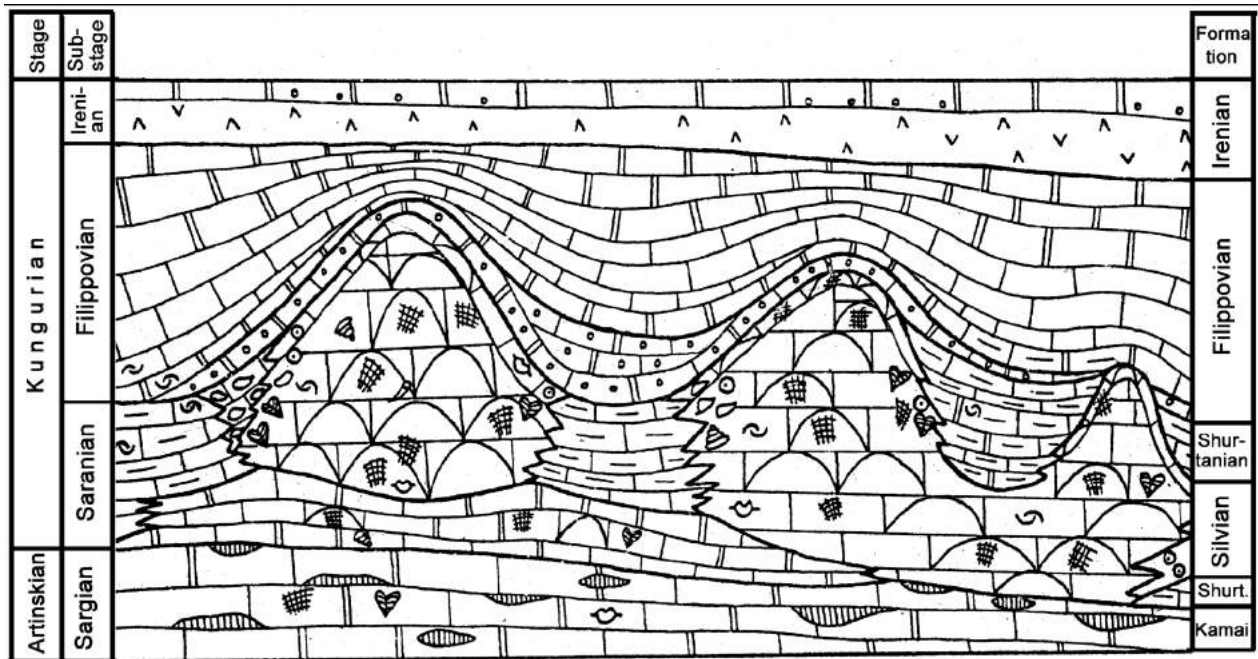


Fig. 16. Scheme of relations of the stratigraphic units and facies in the suburbs of Kungur town (according to the Guidebook, 1991).

“Divya” formation

Divya formation is not typical for sections of Ufimian plate and it is not fixed in Kungur suburbs. It is a facial analogue of platform formations of Saranian and Sargian substages and it was developed to the east from the Uralian foredeep.

On the observed territory only in two sections (Mezhevoy Log and Kamaian Log) a rock mass is identified which does not correspond to any formation of the “classic Kungur”. Lithologically this mass resembles Divya formation. These sediments are studied more precisely in the Kamaisky log 3.6 km upstream the Sylva river where they are well cropped out (fig.17). Transition from the Kamaian formation is gradual, which forces thickness of the argillaceous interbeds and reduces width of silicified limestones. Divya formation is composed by argillaceous limestones, marls and argillites (in the upper part). Rocks in the Mezhenoy ravine have got unclear bedding, fine and middle bedding is typical, and surfaces of the bedding are uneven, hogbacked, with numerous burrow marks. Argillaceous limestones are dark-gray, greenish-gray micro-grained, silicified, with nodules of black flint, middle-bedded to thick-bedded, with numerous spicules of spongioids (mainly monoaxonic, rarely with four or six axes), brachiopods, ostracodes, crinoids, vegetative detritus, rare single rugosas, remains of fish and echinoids. In Kamaisky ravine **Kungur conodonts** are received from such limestones *Neostreptognathodus cf. kamajensis* Chernykh.



Fig. 17. "Divya" Formation in the Kamaisky Log section

Marls and argillites, gray, greenish-gray, in the upper parts brown, silty, silicified, unclearly bedded, in the upper part micro-bedded, platy, with the remains of small brachiopods, burrow marks, numerous vegetative detritus, fragments of stems *Paracalamites* sp., remains of Chondrichthyes and Actinopterygii (fin spines, teeth, scale). Remains of fish in Mezhevoy Log section: teeth and scales *Janassa* cf. *bituminosa* (Schlotheim), *J. bituminosa* (is known from the Middle Permian in Germany and Great Britain), fin spine of the **Xenacanthus** shark *Anodontacanthus* sp., scales of the Actinopterygii shark paleonisc *Elonichthys* sp. *Anodontacanthus* is met in Russia (Arkhangelsk reg.), Great Britain, Czech Republic, the USA (Middle Carboniferous – Kazanian stage, Middle Permian). Thickness is 7.5 m.

Divya formation is overlapped in the Mezhevoy log by rocks of biostrome of the Sylvania formation, in the Kamaisky Log – of the Churtanian formation.

Sylvanian formation

Organogenic buildups are identified in the Sylvania formation. Generation of the Sylvania reefs was formed in the finishing stage of development of the Uralian foredeep (filling of the Uralian foredeep) and it is situated on its west part. Sylvania formation includes biostrom and bioherm mass of a low thickness (approximately 40 m). The main reef builders are organisms of genus

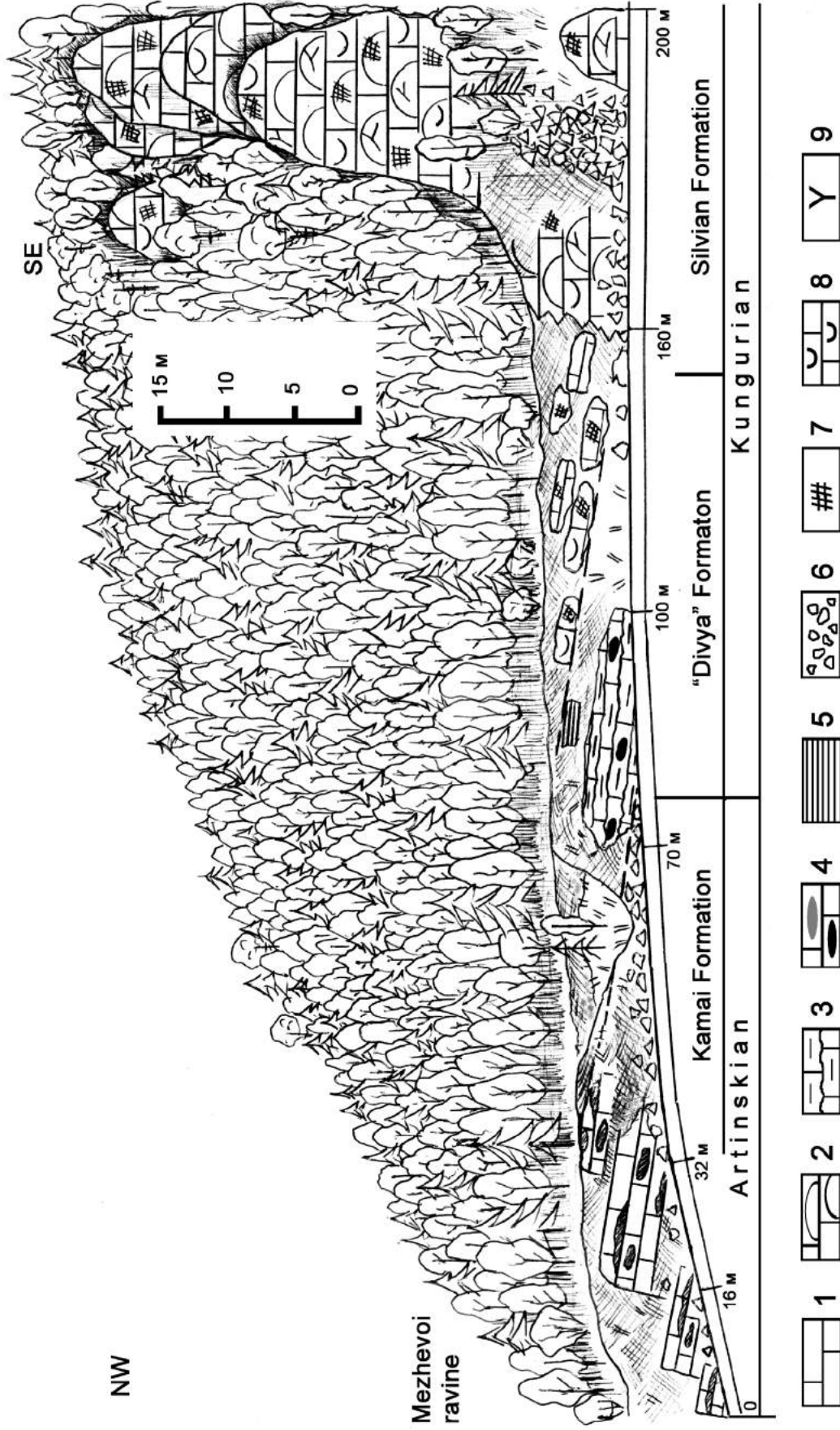


Fig. 18. Scheme of the eastern part of Mezhevoi Log section
 Legend: 1 – bedded limestones, 2 – massive limestones 3 – hogbacked bedded argillaceous limestones and marls
 4 – gray and black flints, 5 – argillites, 6 – scree; organic remains: 7 – bryozoans, 8 – brachiopods, 9 – algae.

Tubiphytes, algae and bryozoas. Cores of bioherms with the sharp increase in thickness are composed by light-gray limestones, gray, organogenic, massive, cavernous, algae and brachiopod-bryozoa-algae. In the peripheral parts of bioherm masses alongside with organogenic-detrital limestones there are shell limestones. Further following the lateral crinoids limestones are developed. **Biostrume mass** are represented by gray, dolomitic, partly silicified, detrital or organogenic, bedded limestones with fenestrate bryozoas, articulate brachiopods, fragments of crinoids, algae.

In Sylvanian formation there were algae, bryozoas, brachiopods, ostracodes, tetracoralla, crinoids, bivalves, small foraminifers, gastropods, cephalopods, trilobites, conodonts.

For bioherms a sustainable community of bryozoas is typical (Guidebook, 1991): *Polypora sargaensis* Trizna, *Polyporella repens* (Trizna), *P. russiensis* Sch.-Nest., *Exfenestella marie* (Trizna), *Streblascopora vulgaris* (Sch.-Nest.). Small foraminifers form glomospira-nodosatiida-hemigordius complex with geinitzina and small bradiin, 48 species are identified: *Geinitzina chapmani sylvae* Bar., *G. spandeli plana* Lip., *G. pusilla* Grozd., *Nodosaria catelliniformis* Grozd, *N. ninae* Grozd., *N. uralica* Grozd., *N. telum minima* Schest., *Hemigordius longus* Grozd., *H. chikalensis* Grozd., *H. permicus* Grozd., *H. nalivkini* Grozd., *H. saranensis* Bar., *Trepeilopsis kasisbi irregularis* Bar. For the first time genus *Ussania* appears, it is represented by *Ussania reitlingerae* Grozd. Single corals: *Hexalasma hexaseptem* Soshk., *Amplexocarina irginae* Soshk., *A. muralis* Soshk. Out of gastropods 14 are found, they are *Plearotomaria kungurensis* Stuck., *P. kyshertiana* Stuck., *P. permiana* Stuck., *Murchisonia angulata* Phill., *Capulus permocarbonicus* Stuck. 35 species of bivalves, the most typical are *Pseudomonotis sexocostata* Stuck., *Aviculopecten elegantulus* Stuck., *Av. licharevi* Fricks., *Lithophaga gigantea* (Stuck.), *Pleurophorus braevis* Bogosl., *Cardiomorpha striata* Münst., *C. sulcata* Kon. Brachiopods: *Derbyia regularis* Waag., *Krotovia pseudoaculeata* (Krot.), *Waagenoconcha irginae* (Stuck.), *Liosotella septentrionalis* (Tschern.), *Chaoiella gruenevaltdi* (Krot.), *Stenoscisma mutabilis* (Tschern.), *Rhynchopora variabilis* Stuck., *Hustedia remota* (Eichw.), *Dielasma elongata* Schlot., *D. moelleri* Tschern., *Hemiptychina orientalis* Tschern., *Dictyoclostus uralicus* (Tschern.), *Krotovia pustulata* (Keys.), *Kochiproductus porrectus* (Kut.). Ostracodes are numerous: *Paraparchites delicatus* Kotsch., *Polycope perminuta* (Kellett.), *P. paula* Kotsch., *Microcheilinella tschikalensis* Kotsch., *Bairdia plebeia* Reuss., *B. aliger* Guss., *B. reussiana* Kirkby, *Basslerella firma* Kellett, *Macrocypris lenticularis* Cooper. Out of Nautiloidea *Uraltoceras sp* is known. Thickness of the Sylvanian formation in Kungur town area is 25-66 m.

Rock mass lying between organogenic buildups and their tops is identified into Churtanian formation. **Churtanian formation** is between reef facies, which overlap rocks of Divya formation in the Kamaisky ravine. It is composed by light-gray, yellowish, pelitomorph, middle- and fine-bedded, with ostracodes, small articulate brachiopods, gastropods, rare fragments of crinoids, bryozoas, corals and bivalves. Ostracodes are *Paraparchites burkemis* (Mart.O.), *P. kamajicus* Guss., *P. sylvaeanus* Guss., *Healdia distributa* Guss., *H. enerviformis* Guss. Thickness is up to 25 m.



Fig. 19. Sylvanian Formation in the Stone Ermak

Filippovian substage Filippovian formation

Filippovian substage is represented not in the full volume of the Filippovian formation. Its top is destroyed as a result of denudation during the after Permian period. Filippovian formation and Filippovian substage have stratotype in the immediate proximity to Mezhevoy log section, near Filippovka village. In the section formation is represented by two carbonate members: which are cropped out in the upper part to the west from Yermak stone and in the Kamaisky ravine.

Petropavlovskian member is clearly identified in the section due to the oolitic structure of the limestones and dolomites. Oolites in the rocks are spread not equally. There are eutaxic-detrital and pelitomorph differences. Texture is massive, in some areas there is cross bedding with the remains of bivalves, bryozoas and ostracodes. Thickness is up to 12 m.

Ust-Kamenskian member consists of limestones and yellowish-gray pelitomorph dolomites with inclusions of gypsum, middle- and fine-bedded, with rare organic remains. It is developed in the section of Filippovskian quarry, in the upper part of the slope, to the west from Yermak stone. Thickness of the band is up to 30 m.

There is a road from Mezhevoy log section to Kungur city which goes along Filippovskian quarry (fig.20).

Section Filippovskian quarry

Section is the stratotype of the Filippovian formation and Filippovian substage, it is situated on the right bank of Sylva river near Filippovskoe village. Description of the section (fig.21) is written according to B. Chuvashov and V. Chernyh (2009). Filippovskian quarry is important for stratigraphy of Kungur stage as a compound part of its stratotype. A successful correlation of different facies of Saranian and Filippovian substages is made on the base of its ostracode and foraminifer complexes.

Plenty foraminifers of the genus *Globivalvulina* is typical for the Filippovian formation, fauna has nodosatiida-frondicularia image. Filippovian outcrop is stratotype of the ostracode zone Paraparchites numerous. For conodont correlation it species of the new genus *Uralognathus cochleatus* Chernykh are important which were found in the limestones of the second bench of the quarry. Similar conodonts are found in the carbonate terrigenous sediments of Mechetlino section on the Yuruzan River, which is stated as the global stratotype of the lower border of Kungur stage.

At the base of the section near the roadbed **bioherm of the Sylvania formation** is cropped out which is similar to Yermak Stone and Mezhevoy.



Fig. 20. Filippovian Formation in the Filippovskian quarry



Stage	Substage	Formation	Bed no.	Lithology column	Thickness, m
Kungurian	Filippovian	Filippovian	26	[Lithology symbol]	> 3
			25	[Lithology symbol]	3,6
			24	[Lithology symbol]	3,5
			23	[Lithology symbol]	0,7
			22	[Lithology symbol]	3,5
			21	[Lithology symbol]	2,5
			20	[Lithology symbol]	3,5
			19	[Lithology symbol]	4
			18	[Lithology symbol]	3,5
			17	[Lithology symbol]	1,5
			16	[Lithology symbol]	0,85
			15	[Lithology symbol]	1
			14	[Lithology symbol]	0,8
			13	[Lithology symbol]	1,5
			12	[Lithology symbol]	0,4
			11	[Lithology symbol]	0,9
			10	[Lithology symbol]	0,2
			9	[Lithology symbol]	4,8
	8	[Lithology symbol]	3,5		
	7	[Lithology symbol]	1		
	6	[Lithology symbol]	0,75		
	5	[Lithology symbol]	0,7		
	4	[Lithology symbol]	5		
	3	[Lithology symbol]	3		
	2	[Lithology symbol]	9		
	Saranian	Silvian		1	[Lithology symbol]

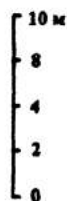
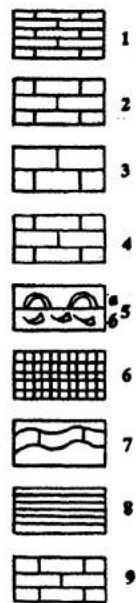


Fig. 21. Columnar section of the Filippovskian quarry (Chuvashov, Chernikh, 2009). 1 – flagstone limestone; 2 – bedded limestone; 3 – tick-bedded limestone; 4 - clayey limestone; 5a - stromatholitic limestone; 5b – shell limestone; 6 – reef limestone; 7 – hummocky limestone; 8 – shale; 9 - detrital limestone.

Thickness is 12 m (8 m above the road and 4 m below the road level) on the level of 4 m from the top of bioherm conodonts are found: *Neostreptognathodus pequopensis* Behnk., *N. brevicaudatus* Chern., rod conodonts *Hindeodella* sp. Top part of the bioherm is combined with the bottom of the quarry and base of the Filippovian substage.

Filippovian substage, Filippovian formation

The first bench (beds 2-3, fig. 21). Yellowish-gray, mottled, close- and fine-grained limestone with black bitumen, thick-bedded (15-30 sm) with the remains of foraminifers, ostracodes, small brachiopods, noncalcic algae. In the base of the quarry conodonts *Neostreptognathodus pequopensis* Behnk. And (Sc-element), rod conodonts *Hindeodella* sp. nov., *Hindeodella* sp. are identified. Thickness is 12 m.

The second bench (beds 4-8) almost white, in the upper part gray, chalky or close-grained limestones with organogenic-detrital interbeds, with mottles and lenses of bitumen, fine-bedded, platy of hogbacked bedded, massive in the upper part of the bench, pore, cavernous with the remains of bivalves (interbeds).

In beds 5-7 conodonts are indented. **In bed 5** there are rod **conodonts** *Stepanovites* sp. (Sb), *Roundina* sp., *Lonchodina* sp., *Hindeodella* sp. **In bed 7: *Uralognathus cochleatus*** Chern., *Lonchodina* sp., *Hindeodella* sp. Thickness is 11 m.

The third bench (beds 9-17, bottom 0.8 m) Limestones from light to dark-gray, opoka-like, close-grained or stromatolithic, interbedded argillaceous, with lenses of bitumen, massive, up to the bench interchange with platy and micro-bedded with the remains of algae, foraminifers, ostracodes and small bivalves (interbeds of micro-shells). Thickness is 11 m.

The fourth bench (beds 14 (upper part) -22). Limestones gray, dark-gray, fine-grained, opoka-like, pelitomorph, interbedded argillaceous, thick-bedded (15-30 sm), pore, interbedded with bioclastic grainstone (upper part of bed 19) with algae Tubiphytes and foraminifers. There conodonts *Neostreptognathodus* cf. *pequopensis* Behnk are identified. Thickness is 17.7 m.

The fifth bench (beds 23-26). The border is unclear. Limestones gray, white, close-grained, pelitomorph organogenic-detrital at the base (bioclastic grainstone), platy (3-10 sm) or massive-bedded, pore, cavernous, interbedded remains of *Tubiphytes*, foraminifers, bivalves, brachiopods and geophytes. Thickness is 11 m.

To the west Filippovian formation is covered with evaporites of Irenian formation. Irenian formation in the west wing of the Ufimian shaft is represented by four thick members of gypsum and anhydrite: ledyanopeshcherian, shalasniskian, demidkovian, lunezhskian. They interchange with carbonate members nevolinian, yolkinskian and tuyskian. Gypsum-anhydrite masses lack organic remains and differ by the location relatively to the carbonate members which play role of marking substages.

Excursion “Kungur Ice Cave”

Kungur Ice Cave is situated on the right bank of Sylva River in the eastern suburb of Kungur town. Cave was formed at the base of the gypsum-anhydrite ice-cave member of Irenian formation. In the grotto Vyshka-1, Vyshka-2 and Kosmichesky ceilings reach the first carbonate member (Nevolinian member).

Entrance to the cave is situated at the bottom of the rocky bench of 25 m height (fig.22). In the rocky outcrops there is the following sequence of (according to the Guidebook, 1991 r.).

Irenian substage

Irenian formation

Ledianopeshcherian member

1. Anhydrite bluish-gray with argillaceous-dolomite traces, massive. Thickness is 20 m.
2. White gypsum. Thickness is 4 m.

Nevolinian member

3. Dolomite gray, organogenic-oolitic, fine-bedded. Thickness is 2.33 m.

The rest part of the section is observed 70 to the east from the entrance to the cave. (fig. 22)



Formation	Member	Bed	Thickness, m	Lithology column
Irenian	Shalashnian	11	16,5	
		7-10	2,8	
	Nevolnian	6	6,5	
		3-5	4,6	
		2	4	
	Ledyanopeshcherian	1	20	

Fig. 22. Ledyanaya Gora section

4. Dolomite gray with inclusions of gypsum crystals, fine-bedded. Thickness is 1.3 m.
5. Dolomite gray, middle-bedded with cores of brachiopods. Thickness is 1.3 m.
6. Gypsum white, weatherworn. Thickness is 6.5 m.
7. Dolomite gray, dark-gray, fine-bedded. Thickness is 0.5 m.
8. Dolomite light-gray, oolitic. Thickness is 0.3 m.
9. Dolomite from light-gray to dark-gray, with inclusions of gypsum. Thickness is 1.85 m.
10. Dolomite yellowish-gray with ostracodes. Thickness is 0.2 m.

In the dolomites of Nevolnian member there are foraminifers (28%), ostracodes, bivalves (6.5%), brachiopods (47%) found. in the Nevolnian member there are 170 species of invertebrate mentioned.

A renewal of the fauna is observed compared to Filippovian substage.

Shalasniskian member

11. Gypsum light-gray, almost, massive. Thickness is 16.5 m.

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GUBAKHA SECTION

UPPER TOURNAISIAN KIZELOVSKIAN AND KOSVINSKIAN SUBSTAGES

Edited by

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The Gubakha Section is visible from the local hotel complex. It is located on the right bank of the Kosva River near to the highway bridge, represents railway cutting between the Upper and Lower Gubakha. It is geologically located to the east of the Main Kizel Anticline fold axis. It is composed of argillites with interbedded siltstone and limestone of the upper part of the Tournasian stage. Rocks of Tournasian stage are conformable with the Famennian. Given the complexity of the tectonic structure of this section, and to improve the ease in understanding the stratigraphy, Smirnov G.A. gives the names of some rocky outputs: **Sisters, Ruslan and Lyudmila, Large tent, Slab.**

The most ancient layers compose of the cliffs **Sisters, Ruslan** and the axial part folds in the cliff **Large tent**, they belong to **the top of the Kizelovsky substage**, represented by limestone with interbedded clastic rocks. Brownish-gray limestone, organogenic-detrital, have medium to heavy bedding, with interbedded argillites containing abundant fauna typical of Kizel's foraminifera, including corals and brachiopods. In cliff **Large tent** the limestone up the section is replaced by calcareous argillites with interbedded quartz siltstone and coal. Where argillites are identified, rare trilobites, bivalves, brachiopods and corals are identified in a state of poor preservation. These are defined by complex spores. In section use marking by guidebook (1972). At the Kizelovsky substage there are **beds 39-32** with a total thickness of 27.7 m.

Kosvinsky substage is associated with a gradual transition Kizel, exposed in the cliff **Lyudmila** and in the wings of the anticline **Large tent**.

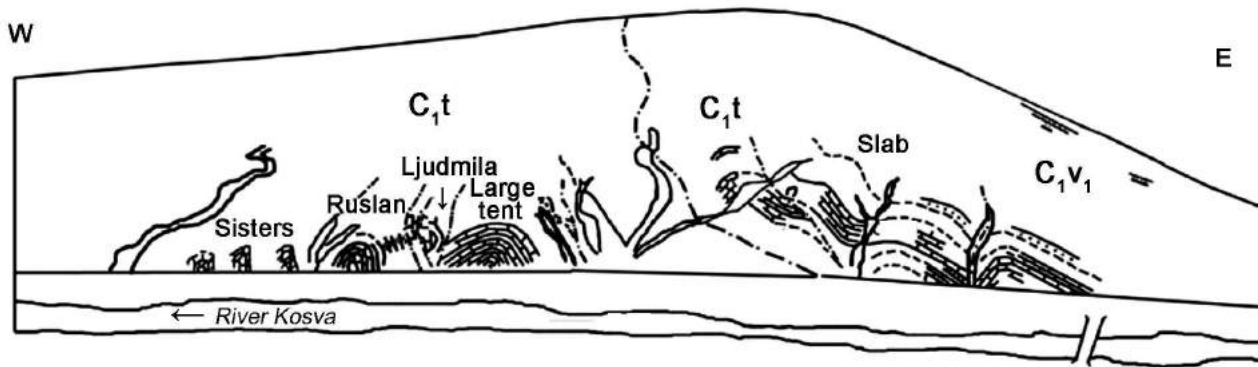


Fig. 23. Scheme of Gubakha section

Beds 31-30. Limestone gray organogenic-detrital, tolstosloistye, with inclusions and interbedded flint, characterized by a complex of foraminifera, corals and brachiopods. Thickness 11,1m.

Beds 29-18. Terrigenous strata, tends to lean on the limestone cliff **Large tent**. calcareous Argillite with occasional thin interbeds of quartz siltstone, dolomite limestone and clay, have been shown to contain remains of brachiopods, foraminifers, corals tabulyatnyh. In the argillites base sequences, clearly defined complex spores identify the Kosvinsky substage. Thickness of 35 m.

Directly to the east and stratigraphic ally above (beds 17-14) there is over 100 m of exposed quartz siltstones and sandstones with interbedded coals containing **Lower Visean** (radaevsky) complex spores.

All thickness gathered in small disharmonic folds are complicated by tectonic fractures. In the east it is bounded by plane thrust in allochthon that extends the limestones with subordinate interlayer of siltstone allocated as titled "**Slab**" (beds 7-3). They form a series of rocky outcrops in the eastern section and contain a rich fauna of brachiopods, corals, and foraminifera, are compared with those of the limestone cliff **Large tent**.

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1. **Guidebook** of stratigraphic excursions to Carboniferous the Urals. The western slope of the Middle Urals, Kosva route. Perm, 1972. 110 p.

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KHOLODNY LOG SECTION

GZHELIAN ASSELIAN STRATOTYPE OF KHOLODNOLOGIAN SUBSTAGE

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The Kholodny Log (Cold Ravine) section is a stratotype of the Kholodnologistic Regional Substage of the Asselian Stage and a parastratotype of some fusulinoid zones. The section is located on the east flank of the Main Kizel anticline. It is situated on the right bank of the Kos'va River 5 kilometers upstream from the Gubakha railway station. It is represented by rocky outcrops up to 120 meters high on both sides of the ravine.

The layers have a south-east fall of 100 – 120° with an angle of 12-20°. In the outcrop there are carbonate rocks of the Gzhelian Stage and Asselian Stage (Kholodnologistic and Shikhanian Regional Substages) of the Cisuralian series, the Permian System. The description of the section was published by O.A. Shcherbakov et al. (1972), Permian part of the section was studied in detail by V.P. Zolotov, Yu. A. Ekhlakov and Y. Provorov (1974). Subsequently, the description has been supplemented and corrected (Ekhlakov, Zolotov, 1986; Ekhlakov in "Guide ...", 2010; Vilesov, 2000).

The Lower Permian deposits of the Kos'va River is a good example of the entire succession of the fusulinid complexes which contain both elements of the South Uralian assemblages and the genera and species of "northern type". The boundary of the Carboniferous and Permian systems is studied in detail in Outcrop 24. There is almost entirely open Melekhovian Regional Substage (Gzhelian). The lower part of the Kholodnoligian Regional Stage is also exposed. The latest description of the outcrop with detailed bed-by-bed sampling for fusulinids was carried out in 1996–1999 by A.I. Vilesov (Vilesov, 2000). Below there are mostly results of these investigations. Results of the sequences study and microfacies analysis of the section were published at the same time by Izart et al., 1999.

Carboniferous System.

Upper Series

Gzhelian Stage

Melekhovian Regional Stage

Ultradaixina bosbytauensis - Globifusulina robusta Standard Zone

Occidentoschwagerina ancestralis local zones

Outcrop 24 (fig. 24).

Bed 1. Light gray with a yellowish tinge, algal-detrital, or bryozoan-crinoid-detrital fine-grained limestone. In the upper part the limestone is slightly bituminous. Limestone is solid and massive-bedded. Fossil remains include calcareous algae, small foraminifers, reticulate and branched bryozoans, solitary corals, crinoids, brachiopods. Schwagerinids are rare. Among them are: *Globifusulina vozghalensis biconica* (Polozh.), *G. tumifacta* (Echlak. Et Scherb.), *G. robusta* (Raus.), *G. pechorica* (Volozh.), *Occidentoschwagerina ancestralis* Echlak., *O. acerba* Vilesov. Thickness is 4.9 m.



Fig. 24. Position the lower boundary of the Permian system in the outcrop 24 of the Kholodny log section.

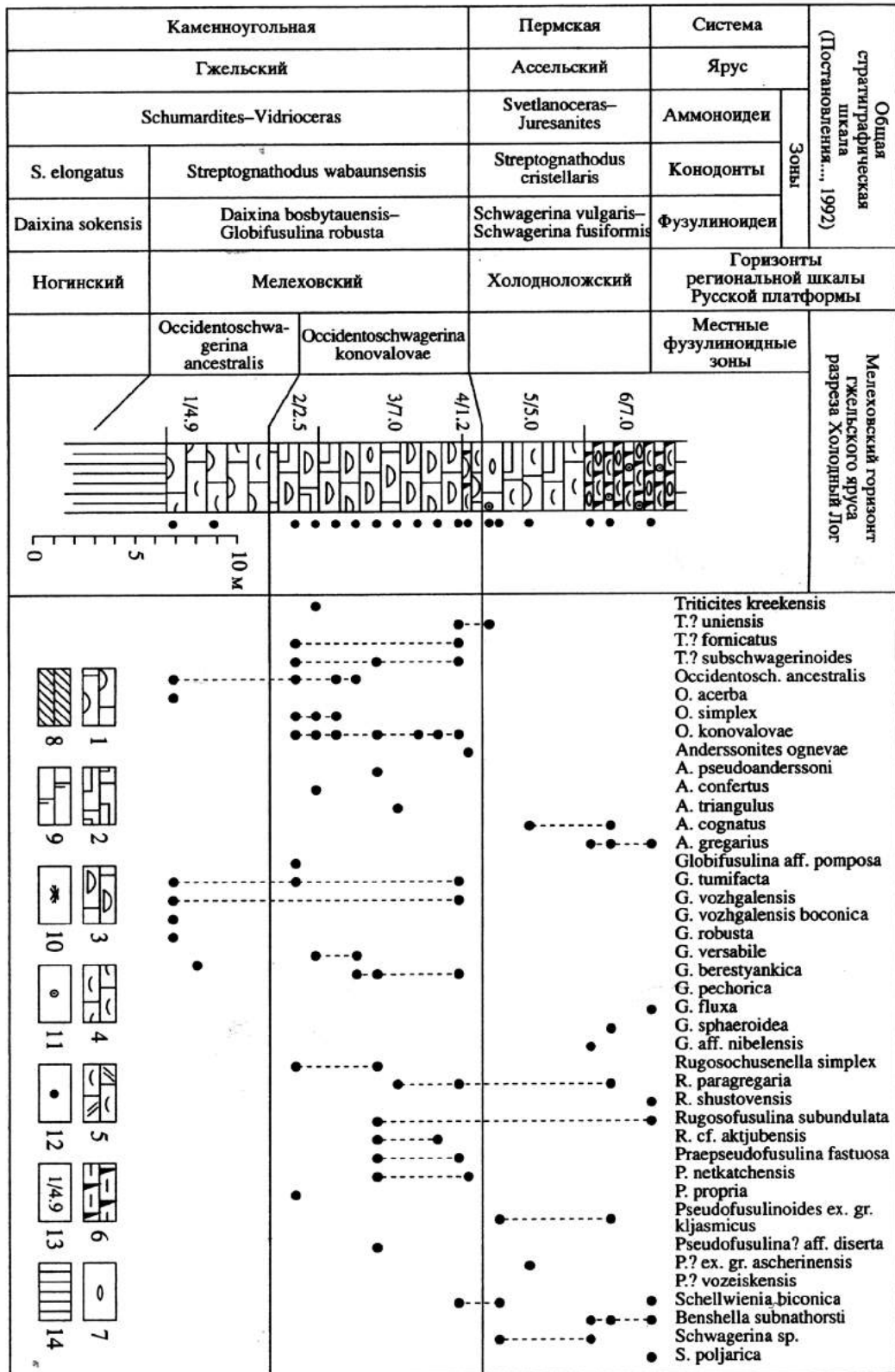


Fig. 25. Distribution of fusulinids in Outcrop 24 at the Kholodny Log section.

1-7 limestones: 1 - massively and heavy-bedded, algal, 2 - massively and heavy-bedded limestone with *Palaeoaplysina*, 3 - association *Palaeoaplysina* and algae, 4 - detrital, 5 - mud-detrital, 6 - medium and thin-layer, bituminous, clay, 7 - fusulinids; 8 - medium and thin-layer dolomite; 9 - dolomitic limestone; 10 - bryozoans; 11 - crinoids; 12 - point sampling for fusulinids; 13 - number and thickness of the layer, m; 14 - covered areas and scree.



Occidentoschwagerina konovalovae local zone

Bed 2. Yellowish- gray and yellowish-light gray, algal-palaeoaplisina limestone. It is strongly fractured and massive bedded. It includes calcareous algae *Globuliferoporella symmetrica* (John.), *Pseudoepimastopora* sp., *Giroporella dissecta* Tchuv. Small foraminifera are represented by *Tetrataxis* sp., *Ammovertella* sp., *Climacammina* sp., *Globivalvulina* sp.. Fauna remains include crinoids, brachiopods, gastropods, branched bryozoans. Schwagerinids are numerous in the upper part: *Globifusulina* aff. *pomposa* (Sjom.), *G.* cf. *tumifacta* (Echlak. et Scherb.), *G. versabile* (Bensh), *Rugosochusenella simplex* (Mikh.), *Triticites* (?) *fornicatus* (Kan.), *T.* (?) *subschwagerinoides grandis* (Grozd.), *T.* (?) *uniensis* (Grozd. et Leb.), *T. kreekensis* Thom., *Occidentoschwagerina* cf. *simplex* (Volozh.), *O. konovalovae* Vilesov, *Praepseudofusulina propria* (I. Thern.). Thickness is 2.5 m.

Bed 3. Gray, light gray limestone, rarely foraminiferal-algae, with abundant and varied detritus. Cement is thin- and fine-grained, massive and porous. In the upper part of the bed, the limestone is weakly bituminous. Fossils: calcareous algae *Globuliferoporella* sp., *Pseudoepimastopora* sp., *Epimastopora grandis* Tchuv. et Anf., *Giroporella* sp., *Tubiphytes* sp. ; small foraminifera *Ammovertella* sp., *Bradyina* sp., *Climacammina* sp., *Tikhinella* sp., *Mesolasiodiscus* sp. Among the others: solitary rugose corals, brachiopods, crinoids, branching and reticulate bryozoans. Schwagerinids: *Globifusulina vozbgalensis* Raus., *G. tumifacta* Echlak. et Scherb., *G. versabile* (Bensh), *G. berestyankica* (Vilesov), *Rugosochusenella simplex* (Mikh.), *R. paragregaria* (Raus.), *Triticites* (?) *fornicatus* Kanmera, *T.* (?) *subschwagerinoides* f. *grandis* (Grozd.), *Tr.* cf. *uniensis* Grozd. et Leb., *Occidentoschwagerina ancestralis* Echlak., *O. alpina* (Kahler et Kahler), *O. kosvaensis* Echlak., *O. echlakovi* Vil., *O. aff. simplex* (Volozh.), *O. konovalovae* Vilesov, *Rugosofusulina subundulata* Sjom., *R. cf. aktjubensis* Raus., *Praepseudofusulina impersepta* (Jagof.), *P. netkatchensis* (Ketat), *P. fastuosa* (Ketat), *Anderssonites triangulates* (Zol.), *Pseudofusulina* (?) aff. *diserta* Scherb. Thickness - 7,0 m.

Bed 4. Dark gray algal detrital indistinctly laminated limestone with fine-grained cement. In the lower part, the limestone is clayey and bituminous. At the top, it is silicified and dolomitized. Fossil remains include calcareous algae, small foraminifera (*Bradyina*, *Ammodiscoides*), large solitary rugose corals, tabulate, brachiopods. Schwagerinids: *Anderssonites ognevae* Vil. Thickness is 1.2 m.

The most numerous fauna in biohermal limestone of the Melekhovian Regional Substage of the Kholodny Log section is represented by swelled thin shells bearing a weak septal folding, thin walled juvenarium and wide outer volutions: *Occidentoschwagerina* Genus and *Triticites* (?) *fornicates* Group.

Permian System

Cisuralian Series

Asselian Stage

Sphaeroschwagerina vulgaris – S. fusiformis Zone

Bed 5. Gray and light gray organogenic detrital limestone. It is thin- to medium-grained, thick-bedded and highly recrystallized. At the bottom, there is brownish-gray, crinoid-fusulinoid limestone interlayer of 0.20 m thick. Fossil remains: calcareous algae, palaeoaplisina, small foraminifera, crinoids, brachiopods, tabulates. Schwagerinids are recrystallized and deformed. The assemblage includes: *Schwagerina* sp., *Anderssonites cognatus* (Echlak.), *Schellwienia biconica* (Scherb.), *Pseudofusulinoides ex gr. kljasmicus* (Sjom.), *Pseudofusulina* (?) ex gr. *ascherinensis* Sjom., *Ps.* (?) *voseiskensis* Konov., *Globifusulina nibelensis* (Vol.). Thickness is 5,0 m.

Bed 6. Dark gray to black, organogenic-detrital limestone with fine-grained cement, bituminous, micro and thin-bedded, with the remains of algae, *Syringopora* tabulate colonies, numerous crinoids (often large fragments of stems), brachiopods, branched bryozoans and *Tubiphytes* sp. The assemblage of numerous Schwagerinids includes: *Schwagerina* sp., *Sch. poljarica* (Grozd.), *Schellwienia uberata* (Kon.), *Rugosofusulina subundulata* Sjom., *R. cf. burkemensis* Vol., *Rugosochusenella shustovensis* (Scherb.), *R. paragregaria* (Raus.), *Pseudofusulinoides ex gr. kljasmicus* (Sjom.), *Pseudofusulina* (?) ex gr. *ascherinensis*

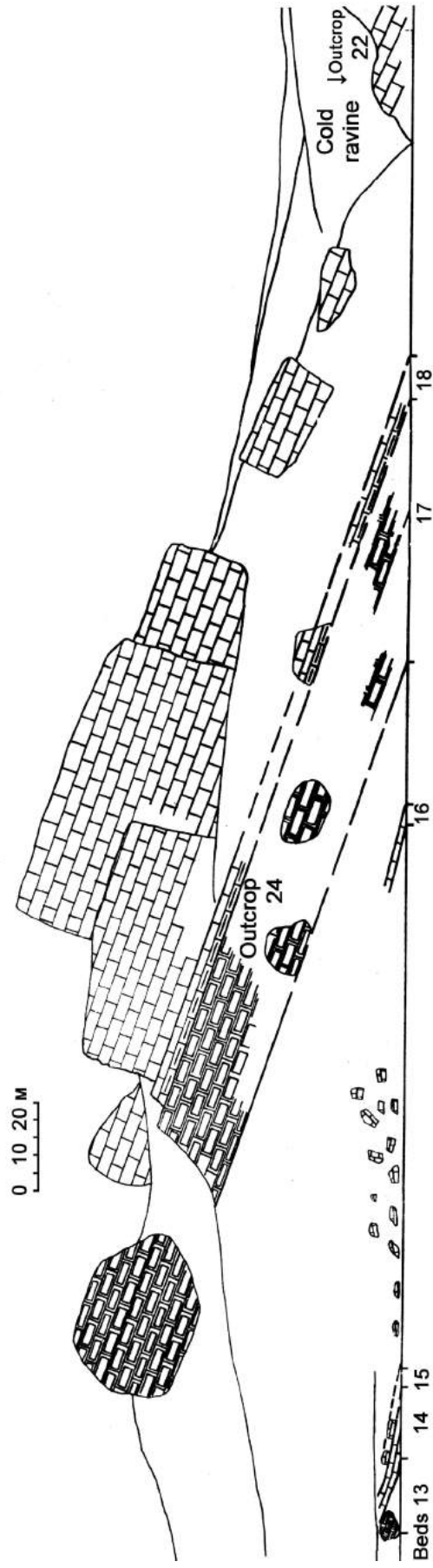


Fig. 26. The draft of western part of the Kholodny Log section (outcrop 415 on materials of O.A. Shcherbakov (1972) and outcrops 24 and 22 (Zolotova et al., 1974))



Fig. 27. Kholodny Log section. View of the outcrops beds 24 and 18, where the border Carboniferous and Permian systems



Sjom., *P. (?) netchaevi* Dav., *P. (?) signata* Kon., *P. (?) vosejskensis* Kon., *Benshella subnathorsti* (Lee), *Anderssonites cognatus* (Echlak.), *A. gregarius* (Lee), *Globifusulina fluxa* (Grozd.), *G. sphaeroidea* (Raus.), *G. aff. nibelensis* (Vol.). Thickness is 7.0 m.

Study of stratigraphic distribution of Schwagerinids in the Gzhelian – Asselian boundary deposits in the vicinity of Gubakha town enabled A.P. Vilesov to identify local fusulinid zones and correlate them with local zonal subdivisions of the South Urals and southern Timan. Representatives of *Occidentoschwagerina* and *Schwagerina* were selected as zonal index species. This option allows justifying the position of the Gzhelian - Asselian boundary based on phylogeny of Schwageriniidae in the transition from *Occidentoschwagerina* to *Schwagerina*. In species transition, the boundary is within the phylogenetic lineage *Occidentoschwagerina ancestralis* Echlak. → *O. konovalovae* Vilesov → *Schwagerina fusiformis* Krotow.

In the same location, there are small outcrops near the water edge at the base of the slope, with section markings according to O.A. Shcherbakov et al. (1972). The Carboniferous – Permian deposits are easily accessible there.

Carboniferous System

Upper Series (= Upper Pennsylvanian)

Gzhelian Stage

Noginskian Substage

Daixina sokensis Zone

Outcrop 415, Bed 13. Light gray, organogenic, palaeoaplysina thick- and massive-bedded limestone. Some interlayers are crinoid. Fauna remains include: fusulinid, solitary rugose corals, tabulates, small brachiopods, reticular and branched bryozoans. Fusulinids: *Profusulinella annae* (Grozd.), *P. pulchra* (Raus et Bel.), *P. mesopachys* Raus et Bel., *Rauserites stuckenbergi* Raus., *R. rossicus* (Schel.), *R. pseudoarcticus* Raus., *R. dictyophorus* Ros., *Daixina* cf. *sokensis* (Raus.), *D.* cf. *enormis* Scherb., *D. timanensis atypica* Zol., *D. recava* Zol., *Anderssonites anderssoni* (Schel.), *Pseudofusulina eliseevi* Z. Mikh. Thickness is 4.2 m.

Outcrop 415, beds 14, 15. Light gray organogenic and palaeoaplysina limestone. Structure is massive. Remains of crinoids and brachiopods are rare. At the bottom, there is brownish-gray dolomite with residual organogenic structure, calcareous and medium-bedded. Remains of small brachiopods and solitary rugose corals occur. Fusulinids: *Profusulinella annae* (Grozd.), *P. usvae* (Dutk.), *P. obtusa* (Grozd.), *Triticites karlensis* Ros., *T. panteleevi* Raus., *T. dictyophorus* Ros., *Jigulites longus* Ros., *J. longus* Ros., *J.* cf. *jigulensis* Raus., *Daixina sakmarensis* Ros., *D.* cf. *sokensis* (Raus.), *D.* cf. *enormis* Scherb., *Anderssonites subovata* (Kon.), *Pseudofusulina ascherinensis* Sjom., *Ps. excessa* Alksne, *Ps. fusina* Scherb. Thickness is 5.9 m. Further eastwards 39.4 m are grass-covered.

Daixina sokensis Zone

Outcrop 415, Bed 16. Dark gray, fine-grained, calcareous, argillaceous, laminated dolomite with remnants of rugose corals *Fomichevella* sp., brachiopods, crinoids, fusulinids *Daixina* ex gr. *tchernovi* Z. Mikh. Thickness is 1.0 m. 17.2 m are grass-covered.

Melekhovian Substage, Daixina bosbytaensis – Globifusulina robusta Zone.

Outcrop 415, Bed 17. Light gray, organogenic, palaeoaplysina, crinoid-palaeoaplysina-crinoid, partly dolomitized limestone. Structure is massive. Fauna remains include crinoids, brachiopods *Dielasma* sp., bryozoans, solitary rugose corals. Fusulinids: *Triticites* cf. *uniensis* Grozd. et Leb., *T.* cf. *astus* Grozd., *Rugosofusulina akjubensis* Raus., *R.* cf. *praevia* Schlyk., *R. agregia* Schlyk., *R.* ex gr. *stabilis* Raus., *R. pandae* Volozh., *Daixina robusta* (Raus.), *D. robusta raznicini* (Volozh.), *D. vohgalensis* (Raus.), *D. pomposa* (Sem.), *Rugosochusenella paragregaria* (Raus.), *R. pechorica* (Volozh.), *Anderssonites* aff. *anderssoni* (Schel.), *Occidentoschwagerina* sp. Thickness 20,0 m.

Carboniferous – Permian boundary deposits are exposed upstream the Kos'va River. In 2014, we cleaned and measured part of the section labeled "Layer 18" outcropped near the water edge of the Kos'va River. It was sampled for conodonts and fusulinids. The interval is subdivided into 4 beds (up the section) (Fig. 28).

Carboniferous System

Upper Series

Gzhelian Stage

Melekhovian Regional Substage

Ultradaxina bosbytauensis – U. robusta Zone

Layer 1 is located at the top of Bed 17 described above (it corresponds to the upper part of Bed 3, Outcrop 24 according to Y.A. Ekhlakov, 2010 and Vilesov, 2000).

Limestone is light gray, algal-palaeoaplysina, massive, with the remains of solitary corals, bryozoans, brachiopods. Foraminifers: *Daixina robusta robusta* Raus., *Daixina robusta* aff. *raznicini* Volozh., *Daixina* cf. *vozhgalensis* Raus., *Pseudofusulina* ex gr. *cognata* Echl., *Rugosofusulina aktjubensis* Raus., *Rauserites* sp., *Occidentoschwagerina* ex gr. *simplex* Vol., *Lateenoglobivalvulina nassichuki* (Pinard et Mamet), *Schubertella sphaerica* Sul., *Schubertella* ex gr. *paramelonica* Sul., *Tetrataxis bashkirica* Mor., *Bradyina lucida* Mor. Penetrated bed thickness is 0.53 m.

Permian System

Cisuralian Series

Asselian Stage

Kholodnogiian Regional Substage

Sphaeroschwagerina vulgaris – Sph. fusiformis Zone

Layer 2 is at the base of Bed 18 (corresponds to the bottom of Bed 4, Outcrop 24 according to Y.A. Ekhlakov, 2010, A. Vilesov 2000). Dark gray to black organogenic detrital, or organogenic clastic, clayey and bituminous limestone. The latter contains hydromica fragments. Cement is fine-grained. There is abundant carbonaceous detritus in the form of flakes and plates with fusinized particles of humus, with inclusions of iron hydroxides. The limestone is micro- and thin-bedded. In the middle part, the structure is thick-bedded (one interlayer is up to 0.40 m). At the top, the limestone is foliated.



Fig. 28. Position lower boundary of the Permian system in Kholodny Log section on cleared fields with marks PPI "415-18" near the water's edge Kosva River.

Organic content in the foliated part is 0.5–1% up to 2%. Faunal remains are represented by algae *Tubiphytes* sp., foraminifers, brachiopods, branched bryozoans, small solitary rugose corals, tabulates, gastropods, rare ophiuroids, and echinoderm spines. Foraminifers in the middle part: *Rugosochusonella paragregaria* (Raus.), *Pseudofusulina cognata* Echl., *Ps. cf. dissimilis* Scherb., *Daixina robusta robusta* Raus., *Quasifusulina longissima* Moell., *Schubertella ex gr. paramelonica* Sul., *Schubertella sphaerica* Sul., *Nodosinelloides ex gr. nechajevi* (Tcherd.), *Lateenoglobivalvulina nassichuki* (Pinard et Mamet), *Deckerella elegans* Mor., *Climacammina aff. bashkadakensis* Mor., *Cl. gigas* Sul., *Bradyina major* Mor., *B. lucida* Mor., *Pseudoendothyra* sp. At the top the following species are found: *Schwagerina* (?) sp. pressed, *Rugosochusonella gregaria inconstans* (Scherb.), *Rugosochusonella paragregaria* (Raus.), *Globifusulina cf. nux* (Schellw.), *Nodosinelloides nechajevi* (Tcherd.), *N. conspecies* (Mor.), *N. aff. longissimus* (Sul.), *N. aff. grandis* (Mor.), *Climacammina bashkadakensis* Mor. Conodonts – *Adetognathus* sp. (1 specimen). The occurrence of *Adetognathus* evidenced the extremely shallow water environments. Thickness is 0.85 m.

Layer 3 (corresponds to the upper part of Bed 4 of Outcrop 24 according to Y.A. Ekhlakov, 10). Brownish-gray limestone. At the top it is gray organogenic detritus with fine-grained cement. The limestone is dolomitized, bituminous and weakly silicified. The structure is medium and thick-bedded (10-34 cm). Remains of tabulates, solitary rugose corals, brachiopods, crinoids occur. Foraminifers: *Nodosinelloides* sp., *Globivalvulina* sp. Conodonts were not found. Thickness is 1.5 m.

Layer 4. Limestone is black crinoid-polidetrital strongly bituminous, with characteristic smell, stratified, with the remains of brachiopods and branched bryozoans. Thickness is 0.5 m.

Layer 5 (corresponds to the bottom of Bed 5, Outcrop 24 according to Y. A. Ekhlakov, 2010). Gray, organogenic-detrital, palaeoaplysina limestone. Structure is massive. Remains of algae *Tubiphytes* sp. were found. Foraminifers: *Pseudofusulina cognata* Echl., *Pseudofusulina antropovi* Malk., *Pseudofusulina ex gr. fecunda* Sham. et Scherb., *Daixina dualis* Echl., *Rugosofusulina aktjubensis* Raus., *Schubertella transitoria* Staff et Wed., *Climacammina ex gr. gigas* Sul., *Climacammina praecursor* Mor., *Bradyina cf. major* Mor. Penetrated bed thickness is 1.0 m.

The section of the Kholodnologist Regional stage is increased with organogenic detrital, fusulinid, palaeoaplysina and algal limestone of outcrops 22 and 23 situated on the eastern slope of the Kholodny Log. Deposits lie along the Kos'va River. Description of Outcrop 22 was given by Y.A. Ekhlakov (2010).

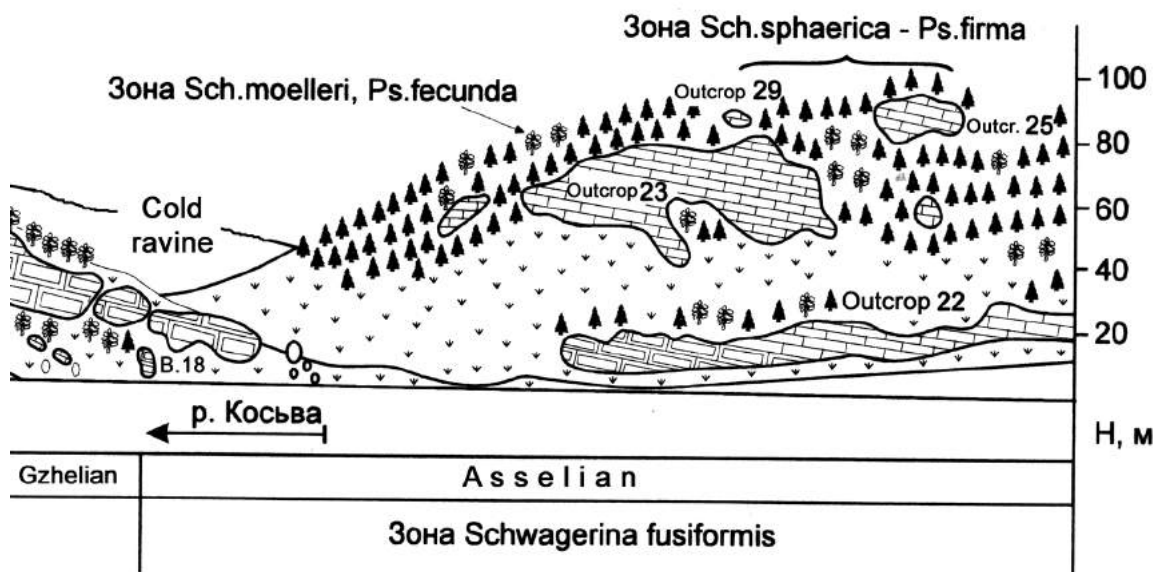


Fig. 29. Eastern part of the Kholodny Log section.

Outcrop 22

Bed 0. Gray fusulinid-crinoid limestone with rare palaeoaplysina and *Tubiphytes*. Fusulinids: *Triticites thompsoni* Grozd., *Rugosofusulina alpina* (Schell.), *R. pseudovalida* Volozh., *R. burkemensis* Volozh., *Daixina rosovskayae* Volosh., *Schwagerina* ex gr. *vulgaris* Scherb., *Schw. kolvica* Scherb., *Schw.* ex gr. *fusiformis* Krot., *Pseudofusulina anderssoni* (Schellw.), *Ps. pseudoanderssoni* Sjom., *Ps. paragregaria* Raus., *Ps. cognata* Echlak., *Ps. barkhatovae* Grozd., *Ps. ex gr. gregaria* (Lee). Thickness is 4.0 m.

Bed 1. Light gray, almost white with a yellowish tinge palaeoaplysina limestone. Structure is massive, with joint blocks, thin cavernous. Remnants of fusulinid, echinoderm spines and plates, brachiopods, crinoids and algae segments are recorded in the deposits. Following fusulinids were identified: *Daixina gracilis* Sjom., *Pseudofusulina cognata* Echlak., *Ps. aff. gregaria* (Lee), *Ps. regularis* (Schell.). Thickness is 8.9 m.

Bed 2. Light gray organogenic detrital, crinoid limestone with remains of rare fusulinids and and large brachiopods. Fusulinids: *Daixina cf. rosovskayae* Volozh., *Pseudofusulina cf. krotowi* (Schell.). Thickness is 0.9 m.

Bed 3. Gray with brownish tinge limestone. At the bottom, there is palaeoaplysina limestone, at the top, crinoid and crinoid-fusulinid limestone. It is massive-bedded. Deposits contain small solitary rugose corals, gastropods, branched bryozoans, brachiopods and fusulinids with thinly plicate wall. Fusulinids: *Triticites* (?) sp., *Pseudofusulina* ex gr. *gregaria* (Lee). Thickness is 2.5m.

Bed 4. Gray with brownish tinge organogenic-detrital limestone. It is small- and medium grained and fine-cavernous. The caverns are partially filled with calcite. The limestone contains remains of branching tabulate, small solitary rugose corals, reticulate bryozoans, brachiopods (*Martinia* sp.), stems of crinoids, and fusulinids. Fusulinid assemblage includes: *Rugosofusulina cf. pandae* Volozh., *Schwagerina fusiformis* Krot., *Schw. fusiformis crassa* Scherb., *Schw. fusiformis elongata* Bensch., *Schw. vulgaris vulgaris* Scherb., *Pseudofusulina aff. rhomboides* Sham. et Scherb. Thickness is 1.5m.

Bed 5. Dark brownish-gray, almost black fusulinid, partly algal, clayey, and bituminous limestone. Some interlayers are foliated. Fossil remains include solitary rugose corals, tabulate, small brachiopods, tubular algae and fusulinids. Assemblage of fusulinids includes: *Quasifusulina cayeuxi* (Deprat), *Schubertella* ex gr. *sphaerica* Sul., *Sch. ex gr. kingi* Dunb. et Skin., *Rugosofusulina stabilis* Raus., *R. aff. stabilis longa* Raus., *R. dastarensis* Bensch., *R. cf. burkemensis* Volozh., *R. cf. pandae* Volozh., *Schwagerina vulgaris vulgaris* Scherb., *Schw. belajaensis* Grozd., *Schw. fusiformis* Krot., *Pseudofusulina subnathorsti* (Lee), *Ps. ex gr. paragregaria* Raus., *Ps. cf. krotovi* (Schell.). Thickness is 1.6 m.

Bed 6. Dark gray with brownish tinge limestone. Some interlayers are clayey and bituminous. Remnants of fusulinids, solitary corals, tabulate, gastropods, rare brachiopods were found. Fusulinids: *Schubertella sphaerica* Sul., *Rugosofusulina angustospiralis* Scherb., *R. stabilis longa* Raus., *R. stabilis stabilis* Raus., *R. pandae* Volozh., *Schwagerina vulgaris vulgaris* Scherb., *Schw. lagitima* Grozd., *Schw. cf. fusiformis* Krot., *Pseudofusulina paragregaria paragregaria* Raus., *Ps. ex gr. rhomboides* Sham. et Scherb. Rugose corals: *Bothrophyllum* sp., *Ferganophyllum* sp. Brachiopods: *Jurusania jurusanensis* (Tschern.), *Dictyoclostus* sp., *Stenoscisma mutabilis* (Tschern.). Thickness is 2.4 m.

Sphaeroschwagerina moelleri – Pseudofusulina fecunda Zone

Bed 7. Dark gray almost black fusulinid limestone with *Quasifusulina cayeuxi* (Deprat), *Q. ex gr. longissima* (Moell.), *Schwagerina lagitima* Grozd., *Schw. shamovi gerontica* Scherb., *Pseudofusulina subnathorsti* (Lee), *Ps. cf. sphaeroidea* Raus., *Ps. rhomboides* Sham. et Scherb., *Ps. gregaria* var. *shustovens* Scherb., *Ps. cf. portentosa* Sham., *Ps. barkhatovae* Grozd. Thickness is 0.6 m.

Bed 8–9. Light gray- and gray, algae, fusulinid limestone. At the base, it is fusulinid- bryozoan, medium-bedded with remains of brachiopods, gastropods and tabulate. Fusulinids: *Rugosofusulina serrata* Raus., *R. ex gr. prisca* (Ehrenb. emend. Moell.) *R. burkemensis* Volozh., *Schwagerina* sp., *Pseudofusulina nux* (Schell.), *Ps. barkhatovae* Grozd., *Ps. paragregaria paragregaria* Raus., *Ps. anderssoni galinae* Volozh., *Ps. cf. fecunda* Sham. et Scherb., *Ps. cf. paradoxa* Sham. et Scherb., *Ps. ex gr. rhomboides* Sham. et Scherb.



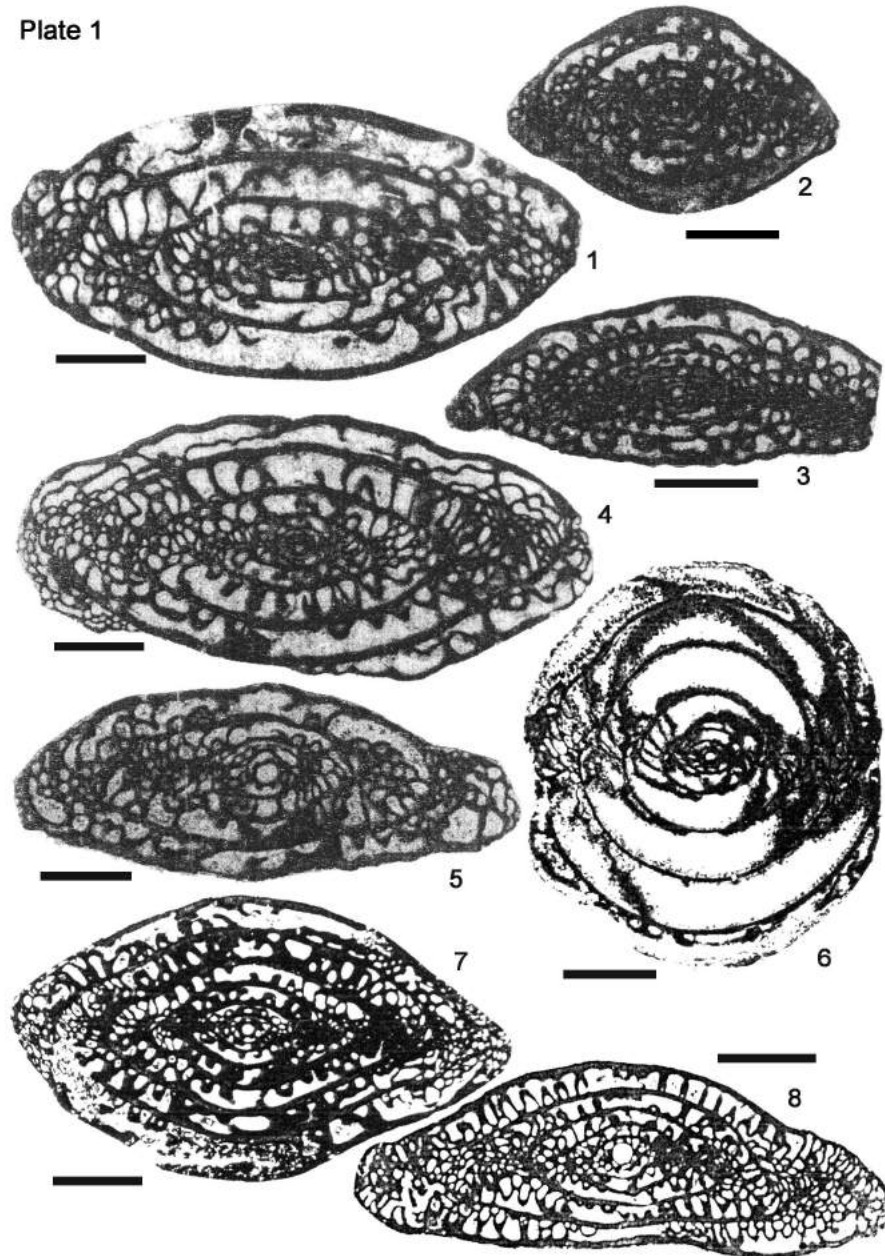
Thickness is 10.2 m.

Bed 10–11. Gray and light gray crinoid-fusulinidal and fusulinidal limestone. It is thick- and thin-bedded. At the top, the limestone is fine-cavernous. In Bed 10, there are bluish siliceous nodules of irregular shape. Numerous fusulinids, segments of crinoids, branched and reticular bryozoans, rare brachiopods, solitary and fasciculate rugose corals, massive and fasciculate tabulate colonies, and algae were found. Fusulinids: *Fusulinella (Pseudofusulinella) pulchra* Raus. et Bel., *Quasifusulina cayeuxi* (Deprat), *Schubertella sphaerica* Sul., *Sch. ex gr. klnki* Dunb. et Skin., *Rugosofusulina* sp., *Pseudofusulina anderssoni galinae* Volozh., *Ps. caudata* Raus., *Ps. globulus* Raus., *Ps. nux* (Schell), *Ps. sphaeroidea* Raus., *Ps. subnathorsti* (Lee), *Ps. krotowi* (Schell.), Tabulates: *Syringopora* sp. Rugose corals: *Tschussovskenia vesiculosa* Dobr. Thickness is 6.0 m.

Bed 12–15. Light gray with brownish tinge and gray algae limestone. Some interlayers are organogenic detrital, thick-bedded with rare light gray siliceous nodules. Remnants of fusulinid, solitary and fasciculate rugose corals, tabulates, and crinoid stems occur. Fusulinids: *Quasifusulina longissima* (Moell.), *Schubertella sphaerica* Sul., *Sch. kingi exilis* Sul., *Triticites subschwagerinoides* Grozd., *Schwagerina moelleri* Raus., *Pseudofusulina* cf. *accurata* Volozh., *Ps. caudata* Raus., *Ps. nux* (Schell.), *Ps. sphaeroidea* Raus., *Ps. fecunda suleimanovi* Sham. et Scherb., *Ps. ex gr. rhomboides* Sham. et Scherb., *Ps. paragregaria* Raus., *Ps. conspecta* Sham. et Scherb. Fasciculate rugose corals: *Tschussovskenia* (?) sp. Thickness is 8.3 m.

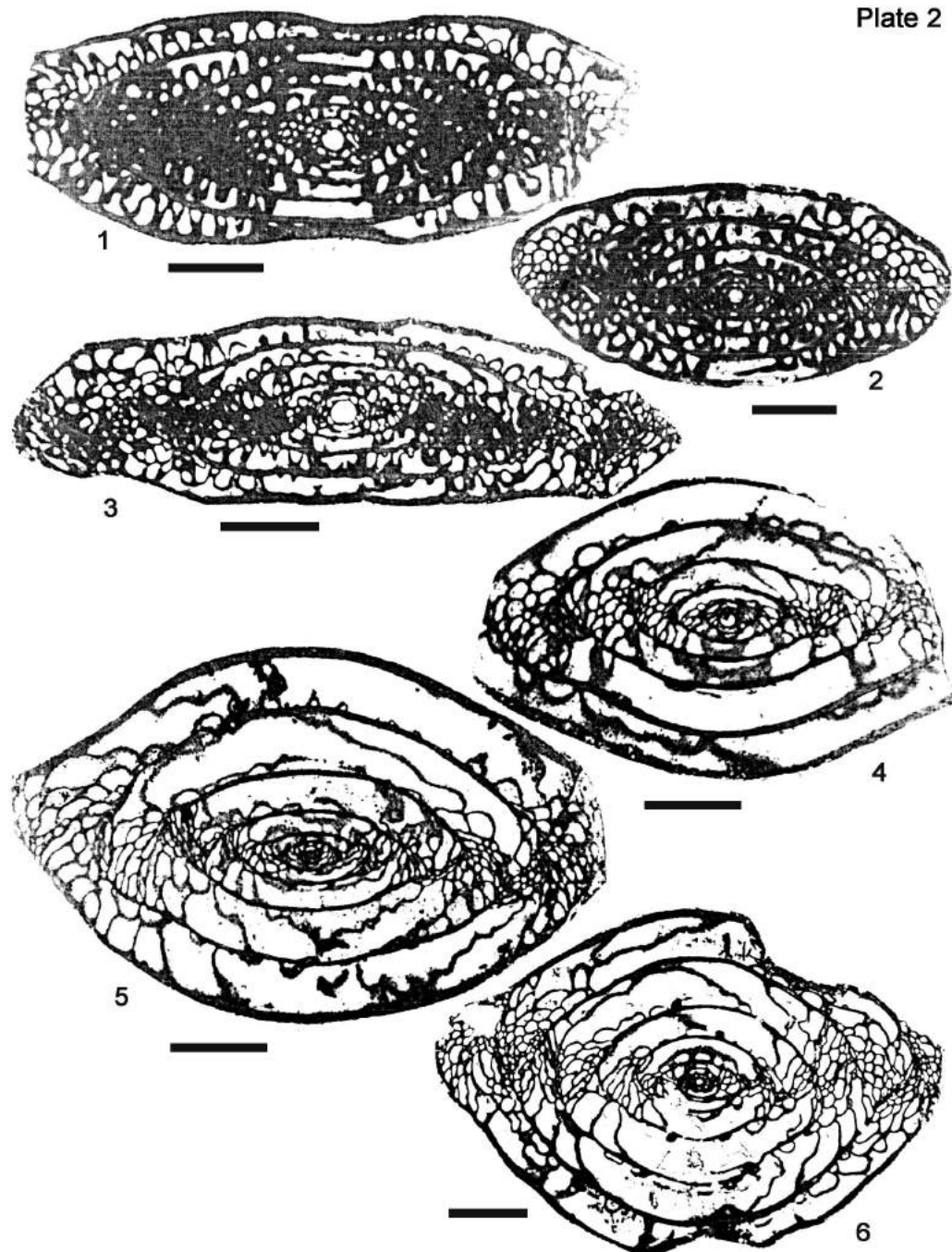
Shikhonian Regional Substage is identified in the Sphaeroschwagerina sphaerica – Pseudofusulina firma Zone. It is outcropped in the upper part of the slope (outcrops 29, 25, Fig. 29).

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1. **Guidebook** of the stratigraphic excursion to Carboniferous deposits of the Urals. Western slope of the Central Urals, Kosva trip. Perm, 1972. 110 p.
 2. **Ekhllakov Yu.A.** “Kholodny Log” section / Guidebook of the geological excursion to the type Carboniferous and Permian sections. Kosva trip. / Perm. State Univ. Perm, 2010. P. 19–23.
 3. **Ekhllakov Yu.A., Zolotova V.P.** Section of Carboniferous and Permian boundary deposits on the Kosva and Beryozovaya rivers // Carboniferous and Permian boundary deposits of the Urals, Cisurals and Central Asia. M. Nauka, 1986. P. 12–18.
 4. **Izart, A., Kossovaya, O., Vachard, D., Vaslet, D.** (1999) Stratigraphy, sedimentology and sequence stratigraphy of the Early Permian along the Kosva River (Gubakha area, Central Urals, Russia). Bull. Soc. Géol. Fr. 170: 799-820
 5. **Vilesov A.P.** Zonal subdivisions of the Melekhovian Regional Stage (Upper Carboniferous, Gzhelian Stage) of the Permian Cisurals from fusulinids. / Stratigraphy. Geological correlation. V. 8, No 5, 2000. M: Nauka. P. 29–42.
 6. **Zolotova V.P., Ekhllakov Yu.A., Provorov Yu.A.** “Kholodny Log” section / Guidebook of the excursion to Lower Permian deposits on the Kosva, Cylva and Kama rivers. Perm. 1974. P. 25–34.
 7. **Vilesov A.P.** Schwagerinids of Kholodnologist Substage of the Asselian Stage, the Lower Permian, in the Permian Cisurals Perm, 1997. 240 p. Stock reference of Department of Regional and Oil and Gas Geology Perm State National Research University (manuscript).



Fusulinids from the Kholodny Log section. Scale 1 mm.

- Fig. 1.** *Occidentoschwagerina konovalovae* Vilesov in Vilesov, 2000; holotype № 24-2-3/3, axial section, Outcrop 24, Bed 2; Melekhovian Substage (Gzhelian).
- Fig. 2.** *Triticites* (?) *subschwagerinoides* f. *grandis* (Grozdilova) in Vilesov, 2000; No 24-2-2/6, axial section, Outcrop 24, Bed 2; Melekhovian Substage (Gzhelian).
- Fig. 3.** *Rugosochusenella simplex* (Z. Mikhailova), in Vilesov, 2000; No 24-3-3/17, axial section, Outcrop 24, Bed 3; Melekhovian Substage (Gzhelian).
- Fig. 4.** *Occidentoschwagerina echlakovi* Vilesov in Vilesov, 2000; holotype No 24-2-2/5, axial section, Outcrop 24, Bed 2; Melekhovian Substage (Gzhelian).
- Fig. 5.** *Rugosofusulina aktjubensis* Raus., in Vilesov, 2000; No 24-3-8/3, subaxial section, Outcrop 24, Bed 3; Melekhovian Substage (Gzhelian).
- Fig. 6.** *Schwagerina kolvica* Scherbovich in Vilesov, 1997; No 3034 – collection of Yu.A. Ekhlakov, axial section, Outcrop 22, Bed 0; Kholodnologian Substage (Asselian).
- Fig. 7.** *Globifusulina nibelensis* (Voložhanina) in Vilesov, 1997; No 24-5-5/1, axial section, Outcrop 24, Bed 5; Kholodnologian Substage (Asselian).
- Fig. 8.** *Pseudofusulina* (?) *voseiskensis* Konovalova in Vilesov, 1997; No 24-5-9/16, axial section, Outcrop 24, Bed 5; Kholodnologian Substage (Asselian).



Fusulinids from the Asselian of the Kholodny Log section. Scale 1mm.

Fig. 1. *Anderssonites gregarius* (Lee) in Vilesov, 1997; No 24-5-5/5, axial section, Outcrop 24, Bed 5; Kholodnologian Substage.

Fig. 2. *Pseudofusulina* (?) *cognata* Echlakov in Vilesov, 1997; No 24-5-3/1, axial section, Outcrop 24, Bed 5; Kholodnologian Substage.

Fig. 3. *Rugosofusulina gubachica* Echlakov et Vilesov in Vilesov, 1997; holotype No 24-5-9/17, axial section, Outcrop 24, Bed 5; Kholodnologian Substage.

Fig. 4. *Schwagerina* aff. *kumajica* Scherbovich in Vilesov, 1997; No 3234, collection of Yu.A. Ekhlakov, axial section, Outcrop 22, Bed 4; Kholodnologian Substage.

Fig. 5. *Schwagerina fusiformis* Krotov in Vilesov, 1997; No 3236, collection of Yu.A. Ekhlakov, subaxial section, Outcrop 22, Bed 4; Kholodnologian Substage.

Fig. 6. *Schwagerina shamovi* Scherbovich in Vilesov, 1997; No 3220, collection of Yu.A. Ekhlakov, axial section, Outcrop 22, Bed 7; Kholodnologian Substage.

August 18 • Stop 4

BELAYA GORA SECTION

GZHELIAN
ASSELIAN
SAKMARIAN
ARTINSKIAN

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Belaya Gora section is located on the right bank of the Kos'va River opposite the Belyi Island near the railway bridge in the vicinity of the Gubakha town. It is represented by the cliff rock for the space of over 1 km. The layers have a southwestern dip of 250-260° with a dip angle of 46-60°. Carbonate deposits of the Upper Carboniferous Gzhelian Stage, upper Asselian, Sakmarian and Artinskian stages of the Cis-Uralian Series of the Permian System are exposed in the section (Fig. 30, 31). Tectonically, the section is in the west flank of the Main Kizel Anticline and the east flank of the Kos'vai Syncline. Description is done stratigraphically bottom-upwards and downstream the river Kosva.

Shikhonian deposits are represented by shallowing upward sequence represented by small foraminiferal wackstone-packstone-grainstone. Tastubian Substage was subdivided into two third order sequences composed of small foraminiferal packstone-grainstone-packstone with colonial corals deposited in the inner ramp during the transgressive system tract. Palaeoaplysina small build-ups – fusulinacean limestone deposited on the mid-ramp, fusulinacean limestone with colonial corals deposited on mid-ramp during high system tract. Sterlitamakian represented by Palaeoaplysina small



build-ups-fusulinacean wackstone and bryozoan wack-packstone deposited in mid-ramp during transgressive system tract and outer platform during maximal flooding period. During Sakmarian and Artinskian the paleoenvironments evolve from mid-ramp to belt of build-ups, outer ramp and turbidite basin with a migration of facies belt westwards (Izart et al., 1999)

Carboniferous System

Upper Series

Gzhelian Stage

Melekhovian Substage

Daixina bosbytauensis – Globifusulina robusta Zone

Upper Carboniferous is exposed in some rocky outcrops on the right bank of the Kosva River near the railway bridge (fig. 30). In the Belaya Gora section, the Melekhovian Substage is represented by light gray, thick-bedded Palaeoaplysina limestone, a biostrome (Vilesov, 2002), which has a length of about 400 m and a Thickness is of 13 m. The taxonomic composition of benthic assemblages in the biostrome is poorer than in bioherms of the Kholodnyi Log section. The assemblage includes foraminifers, palaeoaplysina, calcareous Pseudoepimastopora algae, rare brachiopods, bryozoans, crinoids, gastropods. The Upper Carboniferous is exposed in the separate cliff outcrops on the left bank of the Kos’va River near the railway bridge. Schwageriniid assemblage found by A.P. Vilesov in the Palaeoaplysina biostromes of the Belaya Gora section includes five genera: *Praepseudofusulina*, *Schelwienia*, *Anderssonites*, *Globifusulina*, *Pseudofusulinoidea*. The genetic impoverishment of the assemblage is combined with essential species diversity of *Praepseudofusulina*, *Schelwienia* and *Globifusulina* genera. All the types belong to the same environmental group – lithophilic benthos, which lived on stony ground of the flat bottom with active hydrodynamic regime. Rugose corals are one of main components of the benthic association in this section.

The boundary of Carboniferous and Permian systems is not exposed. In 2012, all individual rocky outcrops near the railway bridge were sampled for conodonts by O.L. Kossovaya (10 samples). **Conodonts** were not found.

Permian System

Cisuralian Series

Asselian Stage

Shikhanian Substage

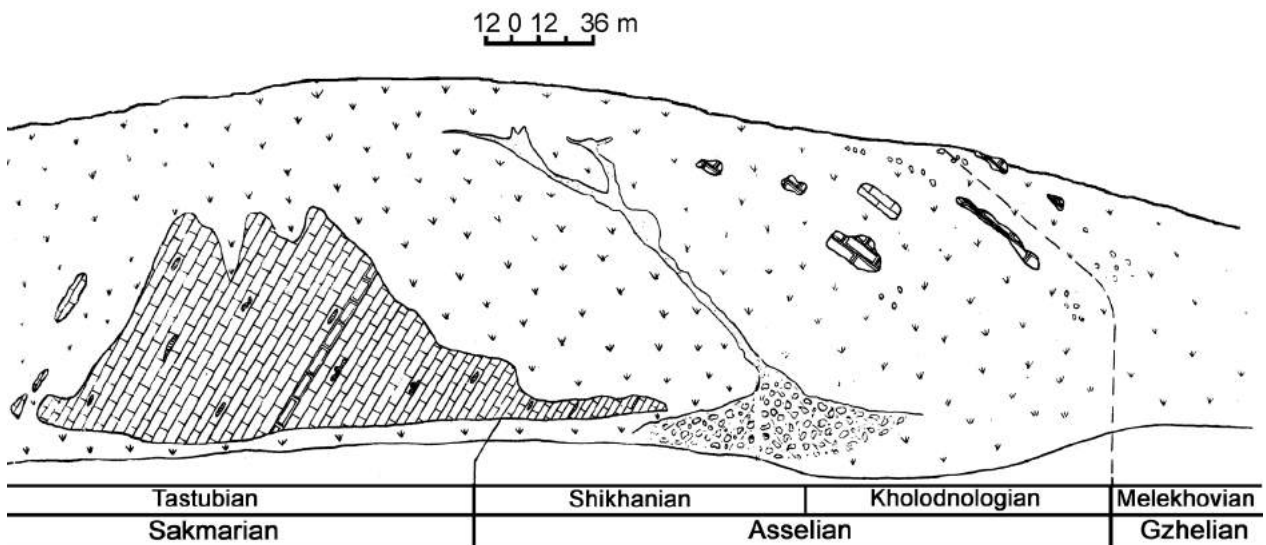


Fig. 30. The beginning of the Belaya Gora section near the railway bridge (Guidebook..., 1974)

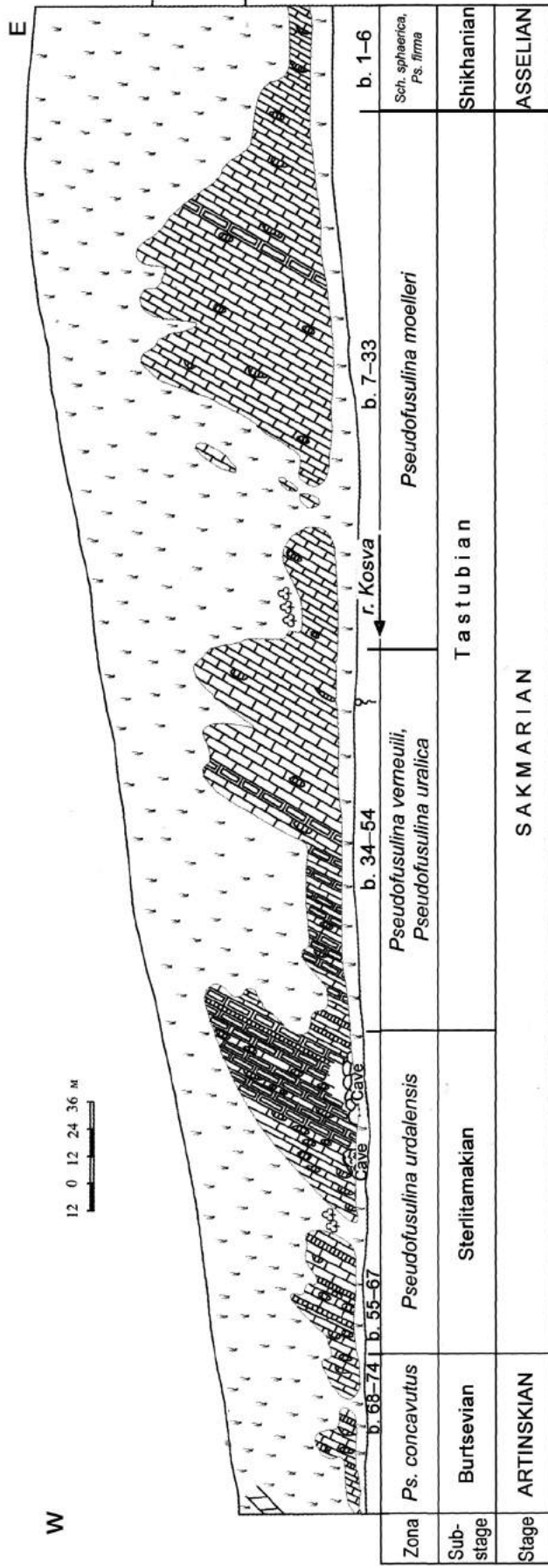


Fig. 31. Stratigraphy of the Lower Permian in the Belaya Gora section (Ekhlakov, 2009)



Beds 1-3 (fig. 31, 32). Gray and dark gray, crinoid-algae, bituminous, thin- and medium bedded limestone. At the top it is silicified. Limestone contains rare fusulinids, colonial and solitary, rugose corals, gastropods, small brachiopods. Foraminifers: *Tolypammia fraudulenta* mor., *Bradyina turgida* Kon., *Br. major* var. *ordinata* Kon., *Endothyra moelleri* (Ozawa), *Pseudoendothyra* aff. *permiana* (Kon.), *Ozawainella angulata* (Col.), *Schubertella sphaerica* Sul., *Rugosofusulina* ex gr. *shaktauensis* Sul., *Pseudofusulina* sp., *Nodosaria bella* Lip., *Cancrinella koninckiana* (Vem.). Rugose corals: *Protowentzelella* sp., *Tschussovskenia minor* Fed., *Ferganophyllun uralicum* Koss. Thickness is 11.9 m.

Beds 4-5. Light- and dark gray with brownish tinge partly crinoid limestone. With massive-bedded structure. Some layers are silicified. Inclusions of calcite geodes are common. The limestone includes fusulinids, solitary and colonial rugose corals (colonies are 1.0×0.1 m and 1.0×0.7 m), and brachiopods. Foraminifers: *Pseudoendothyra moelleri* (Ozawa), *P. pseudosphaeroidea* (Dutk.), *Ozawainella* ex gr. *angulata* (Col.), *Bradyina major* var. *ordinata* Kon., *Br. subsphaerica* var. *milvica* Kon., *Glomospira ovalis* Kon.. Rugose corals: *Protowentzelella vesiculosa* (Porf.), *Pr. byporiphaeum* (Porf.), *Pr. major* (Dobr.). Thickness is 12.9 m.

Bed 6. Light gray, slightly bituminous, crinoid-algae limestone with thick-bedded structure. Some layers are gray with brownish tinge, fine-grained, highly bituminous. Some areas are silicified with nodules of flint, clay interlayers, thin-bedded. Fauna assemblage includes: foraminifers, solitary rugose corals (diameter of corallite is 2 to 5 cm), large colonial rugose corals (colony is 2.0×0.6 m), tabulates colonies, small brachiopods, gastropods. Identified: *Pseudofusulina* aff. *polymorpha* Sem., *Schwagerina* ex gr. *moelleri* Raus., *Schw. sphaerica* Scherb., *Schw. sphaerica* var. *ovoides* Scherb., Rugose corals: *Protowentzelella cystosum* Dobr., *Pr. major* (Dobr.) (Plate 3). Thickness is 3,5 m.

Sakmarian Stage

Tastubian Substage

Pseudofusulina moelleri Zone

Bed 7. Limestone is dark gray with brownish tint, bituminous, partly foraminiferal-algae, fine-grained. Some layers are crinoid-foraminiferal. Fauna remains include rare fusulinids, solitary and colonial rugose corals and small brachiopods. Fusulinids: *Pseudofusulina moelleri* (Schell.), *Ps.* ex gr. *moelleri* (Schell.). Rugose corals: *Protowentzelella major* (Dobr.), *Tschussovskenia captiosa* Dobr. Thickness is 7.3 m.

Beds 8-9. Dark gray with brownish tinge fine-grained bituminous limestone. Bedding is unclear. Some layers are organogenic detrital. Siliceous nodules of loaf-like shape. Fusulinids occur mostly in the upper part. Colonial and solitary corals are abundant. Colonies are 0.3×0.4 m. Reticular and branched bryozoans, small brachiopods, gastropods also occur. Rugose corals: *Protowentzelella simplex* Porf., Brachiopods: *Liosotella septentrionalis* (Tschern.), *Phricodothyris pyriformis* Pav1., *Cleiothyridina pectinifera* (Sow.) Thickness is 17.1 m.

Beds 10-12. Gray and dark gray, bituminous limestone with unclear bedding. Large siliceous nodules and lenses occur. Limestone hosts abundant fusulinids in the upper part. Fauna remains: rare solitary corals with diameter up to 7 cm, large colonies of rugose corals, small tabulate colonies, reticular bryozoans, brachiopods, and gastropods. Fusulinids: *Fusulinella* ex gr. *pulchra* Raus. et Bel., *Pseudofusulina* ex gr. *tschernyschewi* (Schell.), *Ps. tschernyschewi obtusa* Grozd. et Leb., *Ps.* cf. *tschernyschewi oblonga* Grozd. et Leb. Rugose corals *Protowentzelella aseptatum* (Dobr.), *Pr. cystosum* (Dobr.) Brachiopods: *Calliprotonia sterlitamakensis* (Step.), *Krotovia curvirostris* (Schell.), *Liosotella septentrionalis* (Tschern.), *Septacamera plicata* (Kut.) Thickness is 11.0 m.

Bed 13. Gray with brownish tinge, bituminous, fusulinidae and crinoid-algae limestone. Structure is massive-bedded. Solitary and colonial rugose corals (colony size is 0.7×0.3 m), tabulate, brachiopods, and gastropods were found. Fusulinids: *Pseudofusulina* ex gr. *moelleri* (Schell.), *Ps. moelleri* (Schell.), *Ps. aequalis* (Schell.), *Ps. moelleri implicata* (Schell.), *Ps.* ex gr. *sulcata* Korzh., *Ps. mirabilis* Raus., *Ps.*

blochini Korzh. Rugose corals: *Protowentzelella aseptatum* (Dobr.), Brachiopods: *Septacamera plicata* (Kut.), *Crurithyris planoconvexa* (Shom.) Thickness is 10.0 m.

Bed 14. Light gray with brownish tinge, slightly bituminous, organogenic-detrital (crinoid-algae, algal, foraminiferal, coral) limestone with thick bedding. Siliceous interlayers of 10 to 12 cm thick occur. Fauna remains are represented by colonial rugose corals, gastropods, small brachiopods. Fusulinids: *Pseudofusulina moelleri* (Schell.), *Ps. ex gr. moelleri* (Schell.), *Ps. embolicus* Jzot., *Ps. ischimbajevi* Korzh. Rugose corals: *Protowentzelella major* (Dobr.), *Pr. aseptatum* (Dobr.), *Pr. cf. regulare* (Porf.). Thickness is 7.0 m.

Bed 15. Gray with brownish tinge, bituminous, medium- and massive-bedded limestone with siliceous nodules of irregular shape. Fauna remains include: cerioid and fasciculate colonial rugose corals, rare fusulinids, brachiopods, rare reticular bryozoans, and gastropods. Rugose corals: *Tschussovskenia captiosa* Dobr. Brachiopods: *Meekella recta* Ivan., *Derbyia regularis* Waag. Thickness is 4.6 m.

Bed 16. Brownish-gray, bituminous, anisomeric medium-bedded limestone with streaks of dark gray and strongly bituminous and silicified limestone. Bedding surfaces are wavy. Layers form a microfold. Large solitary and colonial corals were found. Colonies are overturned. Fusulinids: *Pseudofusulina ex gr. blochini* Korzh., *Ps. aequalis* (Schell.) Rugose corals: *Protowentzelella hyporipaeum* (Porf.), *Pr. cystosum* Dobr., *Pr. aseptatum* (Dobr.), *Pr. simplex* Porf. Brachiopods: *Septacamera plicata* (Kut.) Thickness is 12.5 m.

Bed 17–18. Gray with brownish tinge, bituminous, fine-grained, thick-bedded limestone. Rounded and loaf-shaped siliceous nodules occur. Cerioid colonial corals (size of colonies is 2.0×1.5 m) are in living and overturn position. Rare fusulinid, gastropods, small brachiopods, bryozoans, crinoids and algae also occur. Foraminifers: *Bradyina subsphaerica milvica* Kon., *Pseudoendothyra ex gr. moelleri* (Ozawa). Rugose corals: *Protowentzelella cystosum* (Dobr.), *Pr. perpastum* (Dobr.). Thickness is 11.8 m.

Beds 19–20. Gray and dark gray with brownish tinge, bituminous, fine-grained organogenic-detrital (crinoid- algae - palaeoaplysina) limestone. Structure is thick-bedded. Clayey interlayers greatly bituminous. Silicification is in the form of irregular spots partly silicified portions in the form of irregular spots and nodules. Fauna remains: foraminifers, gastropods, colonial corals (0,5 × 0,7 m), tabulate colonies (25 x 15 cm), small brachiopods, reticular bryozoans. Foraminifers: *Bradyina delicata* Kon., *Climacammia longissimoides* Lee et Chen. Rugose corals: *Protowentzelella major* (Dobr.), *Pr. cystosum* (Dobr.) Thickness is 8.6 m.

Beds 21–22. Gray, foraminiferal, crinoid, bituminous limestone with different thickness of interlayers. Siliceous nodules of irregular shape. Fauna remains: gastropods, cerioid rugose corals (size of colonies is 1.4×0.75 m), tabulates, brachiopods. Fusulinids: *Pseudofusulina ex gr. moelleri* (Schell.), *Ps. cf. moelleri* (Schell.), *Protowentzelella cf. regulare* (Porf.), *Pr. major* (Dobr.), *Kleopatrina grandis* (Dobr.) Thickness is 17.2 m.

Beds 23–26. From light gray to dark gray with a brownish tinge, organogenic-detrital (algae, algae-crinoid, palaeoaplysina, crinoid-palaeoaplysina) cavernous limestone. Structure is thick-bedded. Small siliceous nodules are oval. Remains of fauna include foraminifers, rugose corals, gastropods, brachiopods. Foraminifers: *Pseudofusulina ex gr. moelleri* (Schell.) Rugose corals: *Protowentzelella major* (Dobr.) Thickness is 8.5 m. Two meters are covered with vegetable soil.

Bed 27. Dark gray with brownish tinge, organogenic-detrital, thick-bedded limestone. Limestone includes oval siliceous nodules. Fauna remains: large solitary corals, tabulate, gastropods, brachiopods and small crinoids. Fusulinids: *Globivalvulina arguta* Kon. Fasciculate rugose corals: *Tschussovskenia captiosa* Dobr. Brachiopods: *Phricodothyris pyriformis* Iavl. Thickness is 2.2 m. 5.7 m are covered with vegetable soil.

Bed 28. Dark gray with brownish tinge, fine-grained limestone. Thickness of layers varies. Siliceous nodules are of irregular shape. Limestone is interbedded with dark-gray clayey and organogenic-detrital limestone with fauna represented by colonial rugose corals (size of colonies is 1.0-1.5 m),

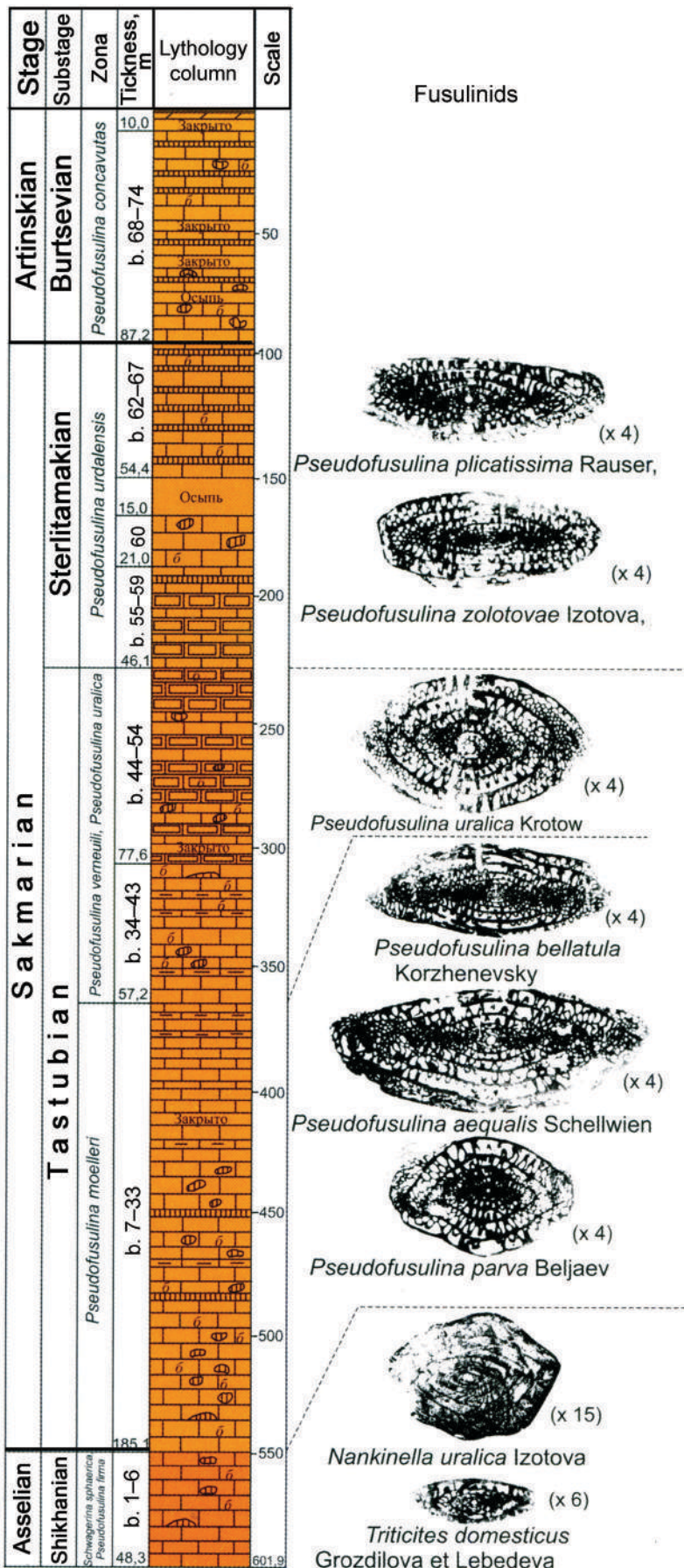


Fig. 32. Stratigraphic column and fusulinids of the Belaya Gora section (Ekhlakov, 2009)



Fig. 33. Panoramic view of the Belaya Gora section

fasciculate tabulate, brachiopods. Cerioid rugose corals: *Protowentzelella aseptatum* Dobr. Thickness is 15.0 m. One meter is covered with vegetable soil.

Bed 29. Light gray with a yellowish tinge, organogenic-detrital (crinoid) thick-bedded limestone. Fauna remains: brachiopods, palaeoaplysina, cerioid rugose corals. Rugose corals: *Protowentzelella cystosum* (Dobr.). Thickness is 2.1 m.

Bed 30. The intercalation of dark gray with brownish tinge, algal and foraminiferal fine-grained, silicified limestone characterized by variable thickness of layers and clayey, strongly bituminous, foliated (10 to 25 cm thick) limestone. The latter includes oval and loaf-shaped siliceous nodules. Fauna remains are small solitary and cerioid and astreoid colonial rugose corals, fasciculate tabulate. Foraminifers: *Bradyina major* var. *ordinata* Kon., *Pseudoendothyra permiana* Kon., *P. pseudosphaeroidea* (Dutk.), *P. leei* (Dutk.), *P. preobrajenskyi* (Dutk.), *Pseudofusulina* sp. Rugose corals: *Protowentzelella major* (Dobr.), *Pr. noinskyi vasiculosa* Porf. Thickness is 12.0 m.

Bed 31. Intercalation of light gray and gray with a brownish tinge, detrital, thick-bedded, cavernous limestone with a clayey limestone interlayer. Limestone is cavernous in the top. Fauna remains: paleoaplysina, rare solitary and colonial rugose corals, brachiopods, crinoids and algae. Foraminifers: *Bradyina turgida* Kon. Cerioid rugose corals: *Protowentzelella simplex* Porf. Thickness is 5.5 m.

Bed 32-33. Dark gray with brownish tinge, fine-grained to thin-grained, thin-bedded limestone interbedded with clayey limestone enveloping coral colonies. Fauna remains: large colonies and small colonies rugose colonies, tabulate, brachiopods, crinoids and algae. Foraminifers: *Bradyina* aff. *delicata* Kon., *Pseudofusulina aequalis* (Schell.). Rugose corals: *Protowentzelella cystosum* (Dobr.), *Pr. major* (Dobr.) Thickness is 9.0 m.

Pseudofusulina verneuili – Ps. uralica Zone

Bed 34-35. Gray with brownish tinge, bituminous, fine-grained, thick-bedded, organogenic-detrital (crinoid-fusulinid) limestone. In the upper part, there is an interlayer of dark gray argillaceous



limestone (5-10 cm). Fauna remains: solitary and colonial corals, foraminifers, crinoids. Foraminifers: *Pseudoendothyra pseudosphaeroidea* (Dutk.), *Triticites pensus* Grozd. et Leb., *Pseudofusulina pseudouralica* Jzot., *Ps. ex gr. uralica* (Krot.), *Ps. uralica uralica* (Krot.), Rugose corals: *Protowentzelella major* (Dobr.). Thickness is 6.1 m.

Bed 36–37. Light gray, slightly bituminous, organogenic detrital (crinoid-algal-foraminiferal), medium- and thick-bedded limestone. At the bottom, the limestone is light gray, brecciated (0.2 m). Fauna remains: colonial (1.5×0.5 m) and solitary rugose corals, gastropods, palaeoaplysina. Foraminifers: *Pseudofusulina uralica uralica* (Krot.), *Ps. uralica volongaensis* Grozd. et Leb., *Ps. confusa* Raus., *Krotovia tuberculata* (Moell.) Brachiopods: *Dictyoclostus sp.*, *Septacamera plicata* (Kut.). Thickness is 12.5 m.

Bed 38–39. Light - and dark gray with brownish tinge, fine-grained, bituminous, multilayer, partly cavernous limestone. Thickness of interlayers varies. Siliceous streaks and nodules are common. Fauna remains are represented by fusulinids, gastropods, brachiopods, crinoids. Foraminifers: *Bradyina subsphaerica milvica* Kon., Brachiopods: *Krotovia tuberculata* (Moell.), *Linoproductus cora* (d,Orb.), *Liosotella septentrio-nalis* (Tschern.), *Retaria orientails* (Fred.). Thickness is 5.1 m.

Bed 40–41. Light - and dark gray with brownish tinge, bituminous, fine-grained limestone with abundant thin-layer argillaceous limestone interlayers. In the middle part, the limestone is detrital. Thickness of interlayers varies. Fauna remains are algae, solitary and colonial corals, gastropods, bryozoans, brachiopods, crinoids. Fusulinids: *Pseudofusulina blochini bellatula* Korzh., *Ps. ex gr. devexa* Raus., *Ps. cf. devexa acuta* Raus. Rugose corals: *Protowentzelella cystosum* Dobr., *Pseudocystophora complexa* (Dobr.) Brachiopods: *Derbyia regularis* Waag., *Krotovia tuberculata* (Moell.), *Linoproductus cora* (d,Orb.), *Reticulatia moelleri* (Stuck.), *Stenosisma mutabilis* (Tschern.), *Rhynchopora nikitini* Tschern., *Crurithyris planoconvexa* (Shum.), *Phricodothyris pyriformis* Pavl., *Nothothyris mediterranea* Gemm., *Dielasma elongatum* Schloth. Thickness is 3.0 m.

Bed 42–43. Dark gray with brownish-yellowish tint, bituminous limestone with variable thickness of interlayers, with intercalations of silicified limestone up to 0.4 m thick. Fauna remains are fasciculate rugose corals, foraminifera, brachiopods, crinoids. Foraminifers: *Bradyina aff. subsphaerica* Mor., *Globivalvulina paula* Kon., *Pseudoendothyra aff. preobrajenskyi* (Dutk.) Rugose corals: *Protolonsdaleiastraea biseptata* (Dobr.), *Permastraea campophylloides* (Dobr.) (Plate 3, fig. 6), *P. solida* (Stuck.), *Protowentzelella hyporiphaeum* (Porf.). Thickness 8.5 m.

Bed 44. Light gray with a brownish tinge, bituminous, organogenic detrital (palaeoaplysina) limestone, medium-bedded. Fauna remains include fusulinids, colonial cerioid rugose corals (0.5×0.5 m), crinoids. Thickness is 3.0 m. Further 5 m are covered with vegetable soil.

Bed 45. Dark - to light gray with a brownish tinge, strongly bituminous, medium-grained massive limestone with palaeoaplysina silicified limestone interlayers hosting silica nodules of irregular shape. Fauna remains: gastropods, large tabulate colonies (0.3×0.3 m), massive spherical colonies of rugose corals. Rugose corals: *Protowentzelella aseptatum* (Dobr.), *Permastraea campophylloides* (Dobr.). Thickness is 11.5 m.

Bed 46. Light gray with a yellowish tinge, slightly bituminous, organogenic-detrital limestone. Thickness of interlayers varies. Foraminifers: *Bradyina major var. ordinata* Kon., *B. subsphaerica var. milvica* Kon., *Pseudoendothyra pseudosphaeroidea* (Dutk.), *P. preobrajenskyi* (Dutk.). Thickness is 2.4 m. Further there is a talus of 3.0 m.

Bed 47–48. Dark gray with brownish tinge, fine-grained, bituminous limestone. Thickness of interlayers varies. Some interlayers up to 1.4 m thick contain Palaeoaplysina. Siliceous nodules of rounded and loaf-like shape are common. Fauna remains: foraminifers, tabulate colonies (size of colonies is 0.3×0.25 m), astreoid rugose colonies, crinoids and algae. Foraminifers: *Tetrataxis plana* mor., *Pseudoendothyra pseudosphaeroidea* (Dutk.). Rugose corals: *Permastraea campophylloides* (Dobr.). Thickness is 5.2 m.

Bed 49. Light gray with a yellowish tinge, strongly bituminous, palaeoaplysina, fine-grained, massive-bedded limestone with siliceous nodules. Fauna remains: rugose corals (size 0.2×0.3 m) and tabulate, rare foraminifers, reticular bryozoans, crinoids. Thickness is 11.2 m.

Bed 50. Dark gray with brownish tinge, fine-cavernous, with interlayers of Palaeoaplysina limestone. The limestone hosts siliceous nodules. Fauna remains: rare foraminifers, gastropods, colonial corals, reticular bryozoans, crinoids. Thickness is 8.4 m.

Bed 51. Light gray- and gray with brownish tinge, slightly bituminous, fine-grained thick-bedded limestone. Some interlayers include Palaeoaplysina. Siliceous nodules are common. Fauna remains: Solitary and colonial corals, rare brachiopods, reticular bryozoans, and numerous crinoids. Foraminifers: *Tetrataxis hemisphaerica* Mor., *Bradyina delicata* Kon., *Pseudoendothyra bradyi* (Moell.), *P. aff. preobrajenskyi* (Dutk.), *Pseudofusulina callosa* Raus., *Ps. cf. fixa* Kir., *Ps. ex gr. urdalensis* Raus. Thickness is 6.5 m. Further, there is a talus of 1.4 m.

Bed 52–53. Dark-gray with brownish ting bituminous limestone with palaeoaplysina interlayers and black siliceous nodules. Thickness of limestone varies. Fauna remains: foraminifers, tabulate colonies (0.2×0.3 m), small colonies of cerioid rugose corals, solitary corals, brachiopods, algae and crinoids. Thickness is 11.0 m.

Bed 54. Gray with a yellowish tinge, bituminous, organogenic detrital (crinoid-palaeoaplysina) limestone. Some interlayers represented by dark-gray strongly bituminous. Fauna remains; algae, foraminifers, small cerioid rugose coral colonies. Fusulinids: *Pseudofusulina aff. callosa* Raus. Thickness is 9.0 m.

Sterlitamakian Substage

Pseudofusulina urdalensis Zone

Bed 55. Gray with brownish tinge, bituminous, granular, thick-bedded limestone. It is interbedded with black flint layers. Fauna remains: fusulinids, tabulate, small brachiopods. Foraminifers: *Pseudofusulina ex gr. callosa* Raus., *Ps. callosa proconconvatas* Raus. Thickness is 3.0 m.

Bed 56. Light gray with a brownish tinge, bituminous, organogenic detrital (palaeoaplysina, crinoid), partly cavernous limestone. Thickness of interlayers varies. Fauna remains: fusulinids, brachiopods, bryozoans, corals. Fusulinids: *Pseudofusulina ex gr. confusa* Raus., *Ps. callosa* Raus., *Ps. cf. callosa proconconvatas* Raus., *Ps. callosa distenta* Kir., *Ps. cf. proplicatissima* Raus., *Ps. urdalensis* Raus., *Ps. urdalensisiformis* Kir. Colonial corals: *Permastraea monoseptata* (Dobr.), *P. campophylloides* Dobr. Thickness is 6.5 m.

Bed 57. Light gray, slightly bituminous, palaeoaplysina limestone. In some areas the limestone is fine-grained, massive-bedded, includes large fasciculate tabulate colonies. Foraminifers: *Ammodiscus semiconstrictus regularis* Waters. Brachiopods: *Stenosisma mutabilis* (Tschern.), *Phricodothyris pyriformis* Pavl. Thickness is 15.4 m.

Bed 58. Gray and dark gray with brownish tinge organogenic (palaeoaplysina, crinoid-fusulinid) limestone. Inclusions of flint form lenses or lenticular interlayers. Fauna remains: colonial corals, fusulinids, brachiopods. Brachiopods: *Cruritnyris planoconvexa* (Shum.). Rugose corals: *Permastraea monoseptata* (Dobr.). Thickness is 13.0 m.

Bed 59. Light- and dark-gray with brownish-yellow tinge bituminous, partly crinoid and palaeoaplysina medium-grained, medium- to thick-bedded limestone. It bears caverns of organic remains. Thickness of dark-gray, almost black siliceous intelayers is 0.1 to 0.4 m. Fauna remains: gastropods, brachiopods. Brachiopods: *Cleiothyridina pectinifera* (Sow.). There is a cave in this bed. Thickness is 8.2 m.

Bed 60. Light gray with yellowish tinge organic detrital partly brecciated limestone. Some layers are darker. They are fine-grained and massive-bedded. Black siliceous nodules are common. Fauna remains include crinoids, reticular bryozoans, solitary corals, brachiopods, foraminifers. Brachiopods: *Septacamera plicata* (Kut.), *Crurithyris planoconvexa* (Shum.). Thickness is 21.0 m. Further, there is a talus of 8.0 m.



Bed 61. Dark-gray with brownish tinge bituminous crinoid-foraminifera, granular limestone. Thickness of interlayers varies from 5 to 30cm. Structure is medium-bedded. Fauna remains: gastropods, brachiopods. Fusulinids: *Pseudofusulina callosa* Raus., *Ps. urdalensis* Raus. Rugose corals: *Pseudocystophora wischeriana* (Stuck.). Thickness is 1.0 m. Further, there is a talus of 5.0 m.

Bed 62-64. Light gray and gray with a yellowish and brownish tinge, granular, crinoid-fusulinid bituminous limestone. Thickness of interlayers varies from 5 to 30 cm. Blue-gray siliceous streaks are common. Fauna remains: small rugose colonies, brachiopods and bryozoans. Fusulinids: *Pseudofusulina urdalensis* Raus., *Ps. plicatissima* Raus. Brachiopods: *Krotovia curvirostris* (Schell.), *K. wallaciana* (Derby.), *Canocrinella cancriniformis* (Tschern.), *Liosotella septentrionalis* (Tschern.). Thickness is 16.1 m.

Bed 65. Light gray with a yellowish tinge, slightly bituminous limestone interbedded with dark gray organogenic-detrital and bryozoan limestone with irregular inclusions and streaks of bluish-gray flint. Limestone is fine-grained, thin-bedded (0.1-0.2 m). Fauna remains: fusulinids, brachiopods, fasciculate and reticular bryozoans, crinoids, rare sponges and solitary corals. Fusulinids: *Pseudofusulina urdalensis* Raus., *Ps. cf. urdalensis abnormis* Raus., *Ps. plicatissima* Raus. Brachiopods: *Phricodothyris pyriformis* Pavl., *Krotovia tuberculata* (Moell.), *K. pustulata* (Keys.), *K. pseudoaculeata* (Krot.), *Linoproductus cora* (d,Orb.), *Canocrinella cancriniformis* (Tschern.), *Liosotella septentrionalis* (Tschern.). Thickness is 9.5 m. Further, there is a talus of 2.0 m.

Bed 66. Light gray and gray with a yellowish tinge, slightly bituminous, fine-cavernous, medium to thin-bedded limestone. Numerous inclusions and streaks of bluish flint constitute 50% of the limestone. Fauna remains: fusulinids, bryozoans, brachiopods, crinoids. Fusulinids: *Pseudofusulina cf. confusa* Kir., *Ps. urdalensis* Raus., *Ps. plicatissima irregularis* Raus., *Ps. urdalensis abbreviata* Raus., *Ps. plicatissima* Raus. Brachiopods: *Canocrinella cancriniformis* (Tschern.), *Liosotella septentrionalis* (Tschern.). Thickness is 19.0 m.

Bed 67. Gray and light gray with a yellowish tinge, slightly bituminous, organogenic-detrital, fine-cavernous, thin- to medium-bedded limestone. Inclusions and streaks of bluish-gray and dark gray flint constitute 50% of the rock. Fauna remains: fusulinids, bryozoans, small brachiopods, crinoids. Fusulinids: *Pseudofusulina urdalensis* Raus., *Ps. plicatissima* Raus. Brachiopods: *Krotovia pustulata* (Keys.), *Liosotella septentrionalis* (Tschern.) Thickness is 7.8 m.

Artinskian Stage

Burtzevkian Substage

Pseudofusulina concavutas – *Ps. pedissequa* Zone

Bed 68. Light gray with a yellowish tinge, slightly bituminous, fine-grained, thick- to massive-bedded limestone with small siliceous concretions and nodules. At the bottom, bryozoan-fusulinid limestone changes to crinoid-fusulinid. Fauna remains: brachiopods. Fusulinids *Pseudofusulina urdalensis* Raus., *Ps. plicatissima* Raus., *Ps. schellwieni* Viss., *Ps. shidensis* Raus. were found in the lower part of the bed. *Pseudofusulina fallax* Raus., *Ps. monstrata* Viss., *Ps. vissarionovae* Raus., *Ps. cf. kutkanensis* Raus., *Ps. ex gr. concavutas* Viss., *Ps. concavutas minor* Viss., *Ps. paraconcavutas* Raus. are recorded in the upper part of the bed. Thickness is 14.5 m. Further, there is a talus of 1.0 m.

Bed 69. Light gray, crinoid, medium-grained, strongly silicified limestone. Fauna remains: solitary and colonial corals, rare brachiopods. Rugose corals: *Pseudocystophora pseudowischeriana* (Porf.) Thickness is 2.0m. Further, there is a talus of 4.5 m.

Bed 70. Gray, slightly bituminous, partly crinoid medium- to thick-bedded limestone with numerous siliceous layers and nodules. Fauna remains: fusulinids, solitary and colonial rugose corals, brachiopods. Fusulinids: *Pseudofusulina* aff. *curtata* Raus., *Ps. ex gr. pedissequa* Viss. Rugose corals: *Pseudocystophora wischeriana* (Stuck.). Brachiopods: *Derbyia regularis* Waag, *Stenosisma mutabilis* (Tschern.) Thickness is 9.2 m. 5.6 m are covered with vegetable soil.



Fig. 34. Bed 74 in the Belaya Gora section



Irginian Substage

Pseudofusulina juresanensis – Eoparafusulina lutugini Zone

Bed 71. Light gray with a yellowish tinge, slightly bituminous, crinoid-fusulinid limestone with thin siliceous lenses and interlayers. Fauna remains include solitary corals, bryozoans. Fusulinids: *Pseudofusulina* ex gr. *concessa* Viss., *Ps.* ex gr. *concovntas* Vies., *Ps. substricta* Kon., *Ps. shidensis* Raus., *Ps.* cf. *juresanensis* Raus., *Ps.* aff. *kutkanensis* Raus. Brachiopods: *Reticulatia moelleri* (Stuck.) Thickness is 8.4 m. 5.6 m are covered with vegetable soil.

Bed 72. Light gray with a yellowish tinge, slightly bituminous crinoid-bryozoans thin-bedded limestone with siliceous lenses and layers. Fauna remains: fusulinids, colonial rugose corals, brachiopods, single trilobites. Fusulinids: *Pseudofusulina* ex gr. *schellwieni* Viss., *Ps.* ex gr. *concovntas* Viss. Rugose corals: *Pseudocystophora wischeriana* (Stuck.) Brachiopods: *Liosotella septentrionalis* (Tschern), *Retaria orientalis* (Fred.), *Stenosisma mutabilis* (Tschern), *Neospirifer poststriatus neocameratus* (Step.). Thickness is 22.4 m.

Sargian Substage

Sargian Formation

Bed 73. Light gray with a yellowish tinge, slightly bituminous crinoid medium- to massive-bedded limestone with siliceous nodules and layers. Fauna remains: single fusulinids, small solitary corals, brachiopods, bryozoans. Brachiopods: *Krotovia pustulata* (Keys.), *K. pseudoaculeata* (Krot.), *Stenosisma pentameroides* (Tschern.). Solitary corals: *Soshkineophyllum artiense* Soshk., *Ufimia carbonaria* Stuck., *Ufimia* sp. 1, *Cyathocarinia multituberculata* Soshk., *Cyathaxonia* ex gr. *C. cornu* Mich., *C. dobrolyubovae* Sim., *Lophophyllidium* (Lophbillidium) *magnocolumnare* (Fedor.), *L. (L.) cyathaxoniforme* Fedor., *Pseudowannerophyllum* sp. 1. Ostracods: *Healdia arcuata* Coryell & Osario, *Bairdia magna* Kotsch., *B.* cf. *B. kaschewarovae* Mart., *B. perlonga* Kash., and *B. aculeata* Coope. (Kossovaya et al., 2001). Thickness is 14.0 m. Five meters are covered with vegetable soil.

Urmy Formation

Bed 74. Along the river in the middle of the log, there are outcrops representing intercalation of mudstone and greenish-gray marl, calcareous, partly ferruginized, micro- to thin-layered, with remnants of poorly preserved goniatite, fish and terrestrial plants (fragments of Paracalamites sp. stems, seeds, fine detritus). Exposed thickness of the rocks at the mouth of the log is 5 meters. In 2015, heavy rainfall resulted in the opening of the 20 m of terrigenous rocks of the Sargian Substage (Fig. 34).

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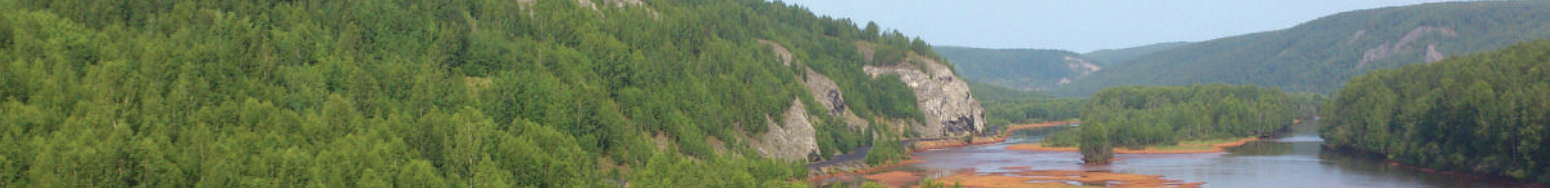
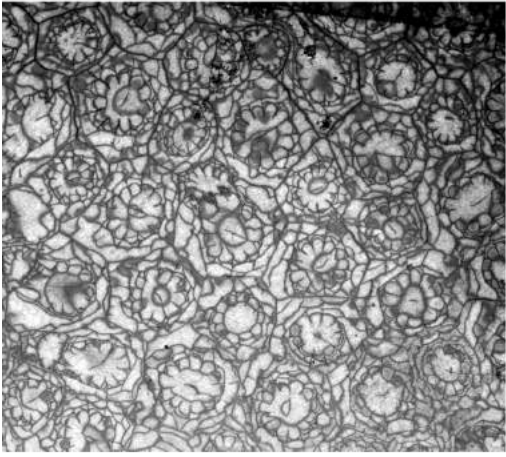
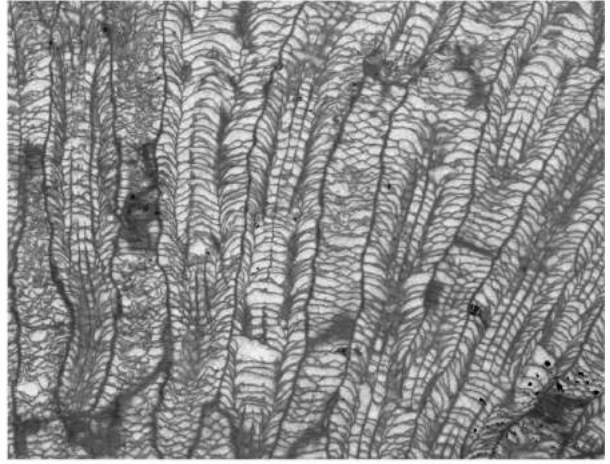


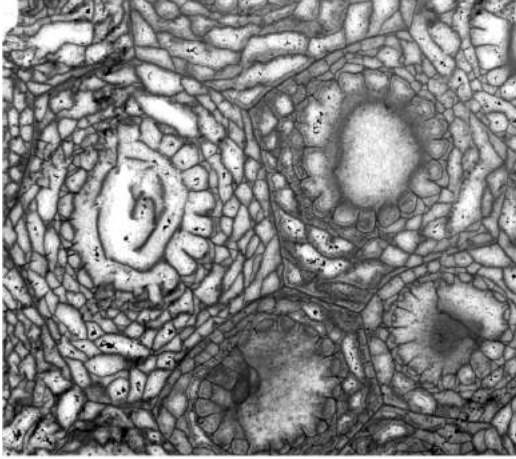
Plate 3



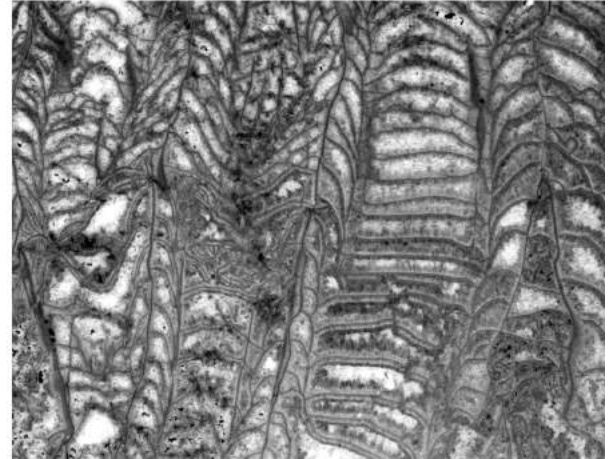
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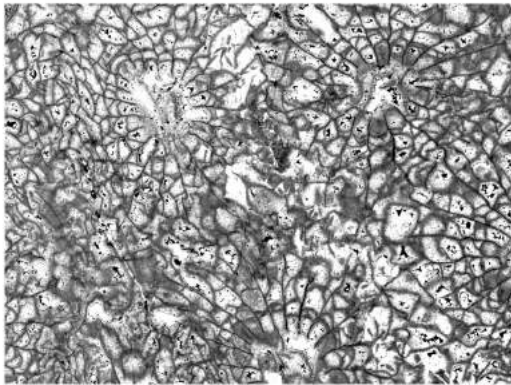
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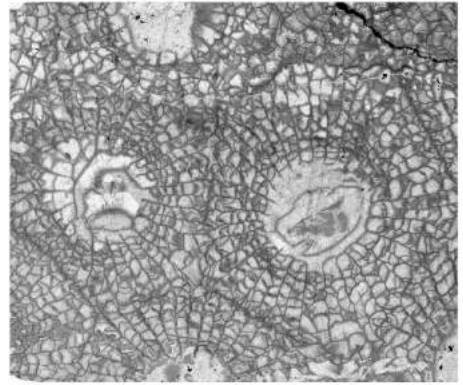
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Plate 3

Corals

Fig. 1, 2. *Protowentzelella* sp. Specimen 1. Transverse and longitudinal sections. Section Belaya Gora, Asselian Stage, Shikhanian Substage, bed 1. x 3.

Fig. 3, 4. *Protowentzelella major* (Dobr.) Specimen 30-1. Transverse and longitudinal sections. Section Belaya Gora, Asselian Stage, Shikhanian Substage, bed 6. x3.

Fig. 5. *Pseudocystophora wischeriana* (Stuck.). Transverse section. Specimen 113-2. Transverse section. Section Belaya Gora, Sakmarian Stage, Sterlitamakian Substage, bed 61 (upper part). x3.

Fig. 6. *Permstraea campophylloides* (Dobr.) Specimen 95-1. Transverse section. Specimen 113-2. Transverse section. Section Belaya Gora, Sakmarian Stage, Tastubian Substage, Pseudofusulina moelleri Zone, bed 42. x3.

Fig. 7, 8. *Lophophyllidium (Lophbillidium) magnocolumnare* Fedor., Specimen 134-58. Two successive transverse sections. Section Belaya Gora, Artinskian Stage, Sargian Substage, bed 73. x3.

Fig. 9. *Ufimia carbonaria* Stuck. Specimen 134-58. Transverse sections. Section Belaya Gora, Artinskian Stage, Sargian Substage, bed 73. x3.

August 18 • Stop 5

YADRO SECTION

FAMENNIAN

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The Yadro (the Core) section includes bedrock outcrops on the left bank of the Kosva River, and is located on a road adjacent to the road bridge, which is cut into the bedrock. The section composes the core of the Main Kizel Anticline. The azimuth frontage exposure varies from N 0° to NE 45°. It is a stratotype Gubachinskaya Formation, with a capacity of which reaches 100-120 m, associated to the Famennian stage. The section is composed of interbedded bituminous limestone, marl, clay shales and flints, and containing remnants of thin-walled brachiopods, bivalves, ammonoids, tentaculites, fillopods, ostracods and radiolarians. Dark gray, micro and fine-grained limestone, which silicified and clayey, platy and is densely bituminous. The marl and clay shales make comprise 50-60% of the section thickness. They are dark to black, silicified portions with interlayers of black flint. The rock can be seen to be contorted into small isoclinal folds. The Gubachinskaya Formation refers to dipping Domanik facies, which are rich in oil resources and mark the inner zone of the Kizel foredeep Kama-Kinel system. This section is considered to be promising for the detection of the boundary of the Devonian and Carboniferous.

Samples were studied to see if there was any evidence present of the remains of conodonts, and samples were examined in the lower (8 samples), middle and upper (2 samples) parts of the section. Conodonts were identified in 6 of the 10 samples. In the lower part of the section (Fig. 36) contained within carbonate concretions, remains of following were positively identified: *Palmatolepis regularis*



Fig. 35. Panoramic view on the Yadro

Cooper, *Palmatolepis perlobata perlobata* Ulrich et Bassler, *Palmatolepis glabra glabra* Ulrich et Bassler, *Palmatolepis subperlobata helmsi* Ovnatanova, *Palmatolepis quadrantinosalobata* M. Sannemann, *Palmatolepis minuta wolskae* Szulczewski, *Palmatolepis minuta minuta* Branson et Mehl, *Polygnathus nodocostatus* Branson et Mehl. The middle portion of the section is defined by the following: *Palmatolepis* cf. *glabra pectinata* Ziegler, *Palmatolepis minuta minuta* Branson et Mehl. The upper portion of the section is defined by the following: *Palmatolepis perlobata schindewolfi* Muller, *Palmatolepis inflexoidea* Ziegler, *Palmatolepis glabra acuta* Helms, *Palmatolepis glabra pectinata* Ziegler, *Palmatolepis glabra lepta*

Ziegler et Huddle, *Palmatolepis marginifera marginifera* Helms, *Palmatolepis marginifera utahensis* Ziegler et Sandberg, *Palmatolepis minuta minuta* Branson et Mehl, *Palmatolepis perlobata sigmoidea* Ziegler, *Polygnathus glaber* Ulrich et Bassler.

In the most ancient part of the section (Fig. 36) the following has been identified: *Palmatolepis regularis* Coop., *Pa. glabra glabra* Ul. et Bas., *Pa. subperlobata helmsi* Ovn., *Pa. quadrantinosalobata* M. Sann., and *Pa. minuta wolskae* Szul. The age of the deposits can be considered to be from the lower Famennian stage as identified by the **crepida-rhomboida**.

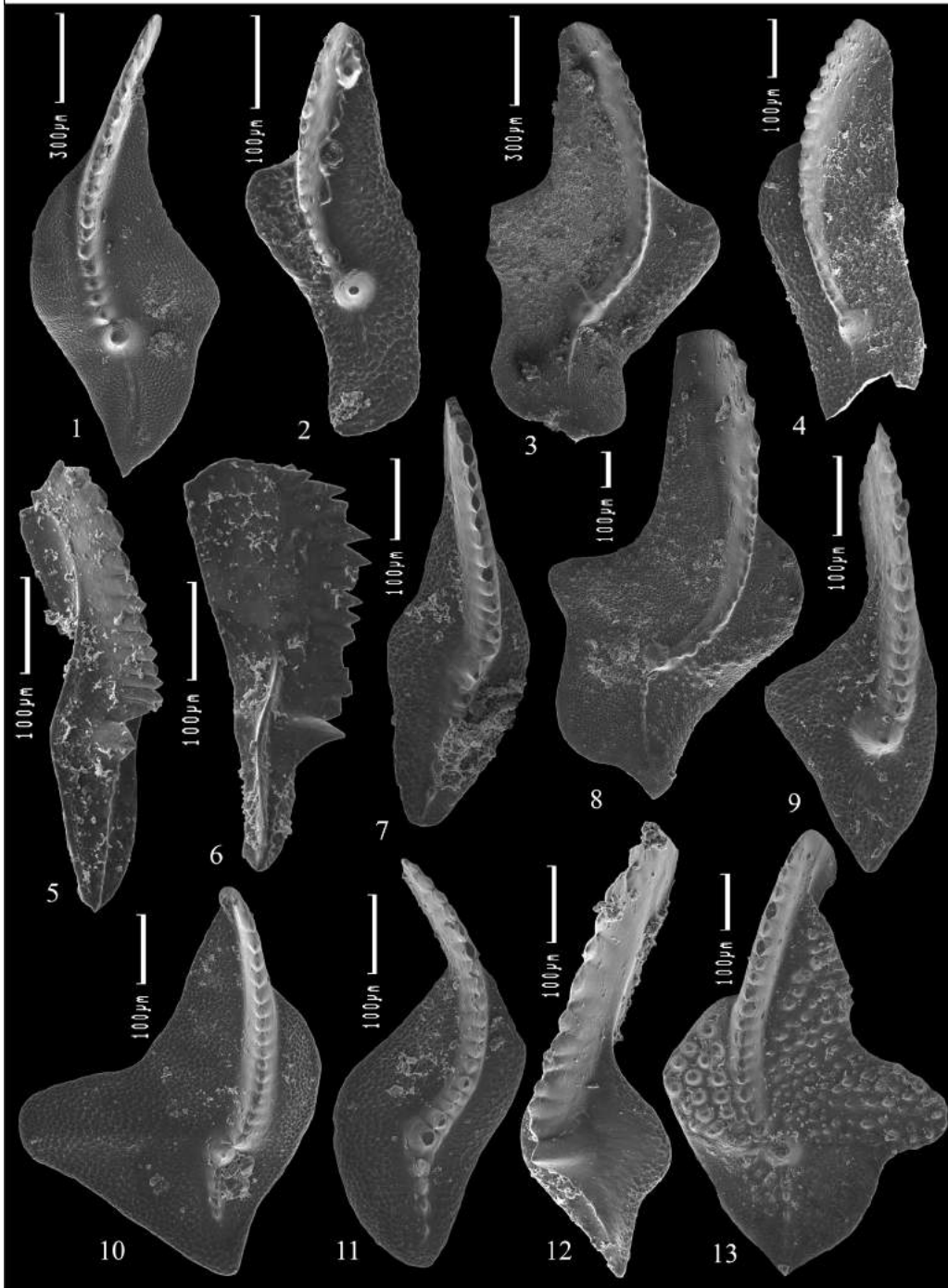
Conodonts found at other points, help to identify the zonal type, including *Palmatolepis marginifera marginifera* Helms and guide conodonts *Palmatolepis marginifera utahensis* Zieg. et Sand., *Pa. glabra pectinata* Ziegl., *Pa. glabra lepta* Zieg. et Hud., *Pa. perlobata schindewolfi* Mul. These species all typical of the middle Famennian, around the time of the **marginifera-trachytera zone** (Fig. 37).



Fig. 36. The oldest section of the Yadro (lower Famennian, zone *Pa. crepida-rhomboida*)



Fig. 37. The upper section of sampling the Yadro



Conodonts

Figs. 1-13 - Upper Devonian, Famennian, Gubachinskaya Formation

fig. 1. *Palmatolepis perlobata perlobata* Ulrich et Bassler, 1926 (sample Ya-4)

fig. 2, 3. *Palmatolepis perlobata sigmoidea* Ziegler, 1962 (2 - sample Ya-1, 3 - sample Ya-9)

fig. 4. *Palmatolepis inflexoidea* Ziegler, 1962 (sample Ya-8)

fig. 5-7, 12. *Palmatolepis minuta minuta* Branson et Mehl, 1934 (5, 6 - sample Ya-8, 7, 12 - sample Ya-4)

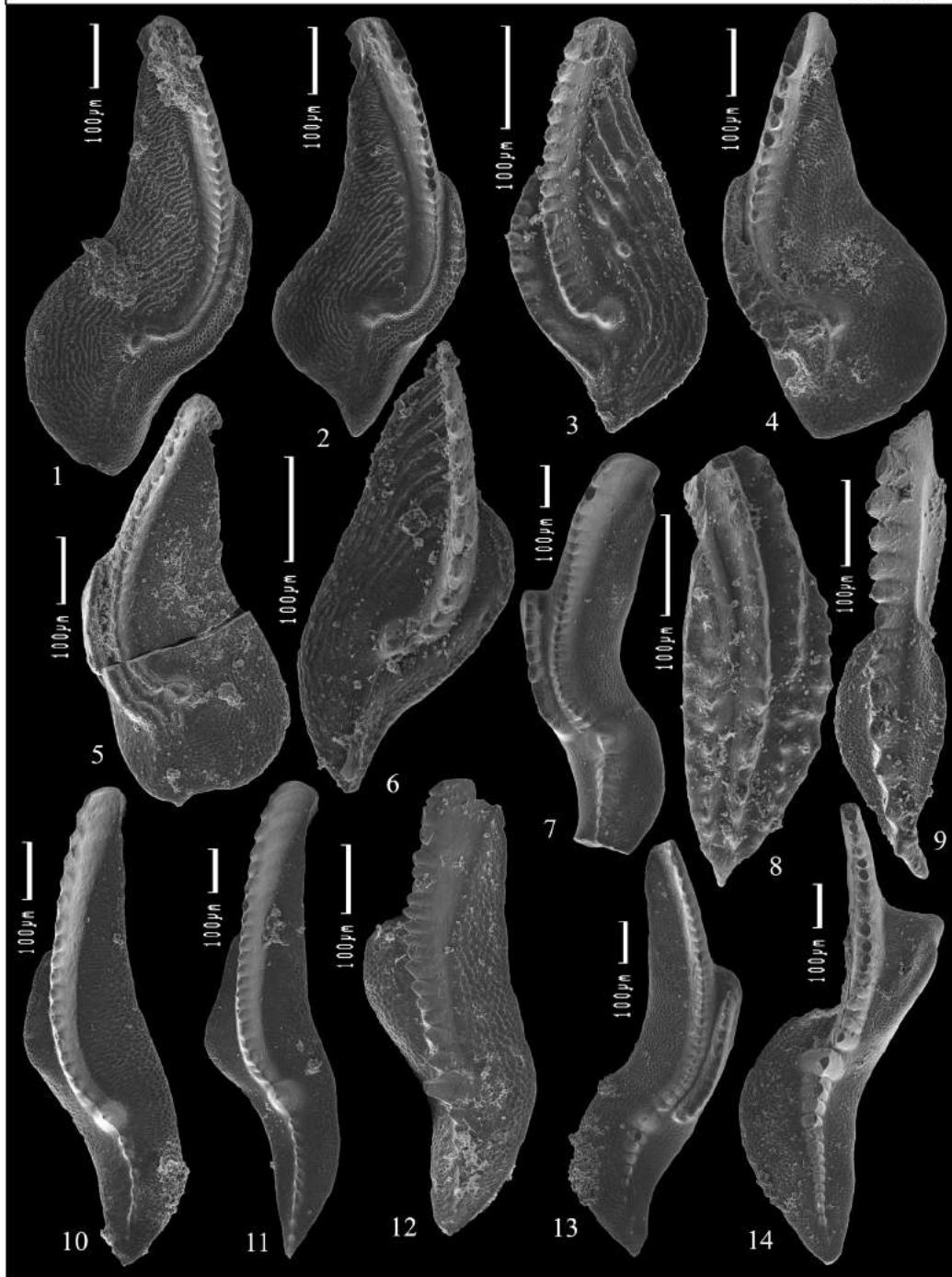
fig. 8. *Palmatolepis perlobata schindewolfi* Muller, 1956 (sample Ya-1)

fig. 9. *Palmatolepis minuta wolskai* Szulczewski, 1971 (sample Ya-4)

fig. 10. *Palmatolepis subperlobata helmsi* Ovnatanova, 1976 (sample Ya-4)

fig. 11. *Palmatolepis regularis* Cooper, 1931 (sample Ya-4)

fig. 13. *Palmatolepis quadrantinosalobata* M 1 Sannemann, 1955 (sample Ya-4)



Conodonts

Figs. 1-14 - Upper Devonian, Famennian, Gubachinskaya Formation

fig. 1, 2, 4, 5. *Palmatolepis marginifera marginifera* Helms, 1959 (1, 2 - sample Ya-1, 4 - sample Ya-9, 5 - sample Ya-8)

fig. 3, 6. *Palmatolepis marginifera utahensis* Ziegler et Sandberg, 1984 (3, 6 - sample Ya-9)

fig. 7, 13. *Palmatolepis glabra pectinata* Ziegler, 1962 (7, 13 - sample Ya-1)

fig. 8. *Polygnathus nodocostatus* Branson et Mehl, 1934 (sample Ya-4)

fig. 9. *Polygnathus glaber* Ulrich et Bassler, 1926 (sample Ya-8)

fig. 10, 11. *Palmatolepis glabra lepta* Ziegler et Huddle, 1969 (10, 11 - sample Ya-1)

fig. 12. *Palmatolepis glabra glabra* Ulrich et Bassler, 1926 (sample Ya-4/5)

fig. 14. *Palmatolepis glabra acuta* Helms, 1963 (sample Ya-8)

August 19 • Stop 6

MARIINSKY LOG SECTION

SERPUKHOVIAN BASHKIRIAN LOWER MOSCOVIAN

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The Mariinsky Log section is situated on the western bank of the Gubashka River, right tributary of the Kosva River. It is represented by natural rocky outcrops and abandoned quarries located on the slopes of the Belaya Mountain (Fig. 38). Belaya Mountain is situated in 2-km north-east of the mouth of the Ladeiny Ravine. White Mountain is composed of carbonate rocks of the Serpukhovian, Bashkirian and Moscovian stages. The section is considered to be poorly known and previous studies were not published. The initial study was carried out in the summer of 1977 by the members of the Department of Oil and Gas Geology of the Perm Polytechnic Institute (PPI) according to the task of the Kizel Geological Prospecting Survey. In this guidebook, we mostly used the numbering of outcrops and, in one case even the layers numbers of the previous study (Professional report: "Lithological and stratigraphic study of coal deposits of the Belaya Mountain", 1978). The section is of scientific interest because the outcrops are easily accessible there. "Mariinsky log" as well as sections of "Ladeiny Log", "Upper Gubakha" and "Kremennoi" (Guidebook, 1972) belong to the same structure - the western wing of the Kosva syncline (Fig. 39), thereby enabling accurate correlation between Mariinsky log section and mentioned above well-studied sections. Bed by bed description of the studied outcrops and quarries see below.

The oldest rocks are exposed in the outcrop 1237. They are not visible on panoramic images of the section, but is located directly below the Quarry Ist. Here the carbonate rocks of the Kurmakov

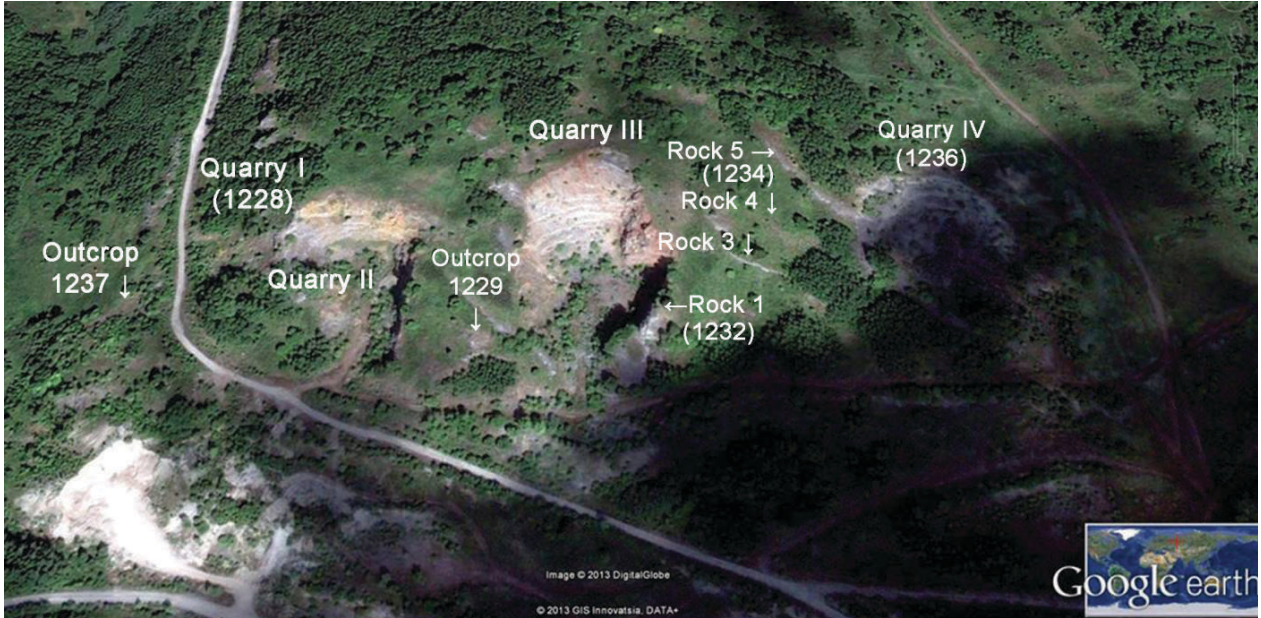


Fig. 38. Top view of the Mariinsky Log section. The number of outcrops are used in the given Guidebook.



Fig. 39. Panoramic view of the Mariinsky Log section. The quarries 2, 3, 4, and some outcrops are visible.

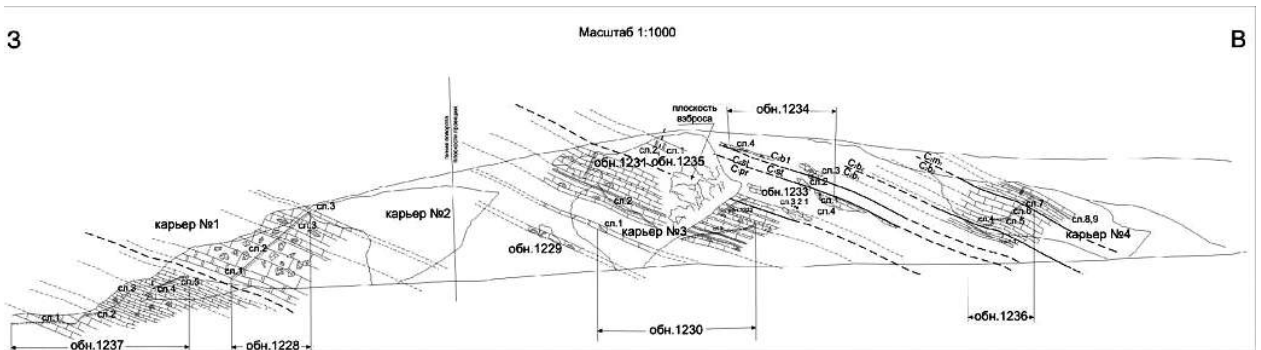


Fig. 40. The draft of the Mariinsky Log section (Guidebook, 2010).

Formation (Kosogorian Substage) are outcropped completely without covered intervals (in comparison with Lodeinyi Log section). A part of the Kurmakov Fm. exposed at the bottom of the outcrop is the Lower Serpukhovian. Marking of “PPI” is preserved nowadays in outcrop, so description is made on its basis (Fig. 40). In 2012-2014 the section was re-studied. Conodonts, corals and foraminifera samples were collected bed by bed.

Carboniferous System

Lower Series (= Missisipian)

Serpukhovian Stage

Kosogorian Substage

Kurmakov Formation

Outcrop 1237.

Bed 1. (It is located in a separate block.) Brown-gray, dark gray, clayey, bituminous, strongly dolomitized, massive and thick-bedded limestone, with crinoids, echinoderm spines, ophiures, holothurians, gastropods, brachiopods, bryozoans, indefinable remnants of conodonts, fish, algae. Micro- and fine-grained pore cement. In thin sections – bioclastic packstone. Algae: *Ungdarella uralica* Masl. Foraminifers: *Earlandia vulgaris* (Raus.), *Earlandia sp.*, *Archaeodiscus moelleri* Raus., *A. gigas* Raus., *Paraarchaeodiscus stilus* (Grozd. et Leb.), *Asteroarchaeodiscus rugosus* Raus., *Neoarchaeodiscus parvus* (Raus.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Planospirodiscus minimus* (Grozd. et Leb.), *Permodiscus vetustus* Dutk., *Rugosoarchaeodiscus agapovensis* (Iv.), *Howchinia gibba* (Moell.), *Similisella similis* (Raus. et Reitl.), *Endothyranopsis compressa* (Raus. et Reitl.), *Tetrataxis acutus* Durk., *Eostaffella prisca settella* Gan., *Pseudoendothyra illustrata* (Viss.). **Conodonts:** *Gnathodus bilineatus* (Roundy), *Lochriea zieglerei* Nemirovskaya et al., *Lochriea senckenbergica* Nemirovskaya et al., *L. monocostata* Pazukhin et



Fig. 41. The description of the beds 2 and 3 in the outcrop 1237.

Nemirovskaya, *Synchydogmathus* sp., *Cavusgnathus* sp., *Kladognathus* sp. Rock height is about 4 m. Dip azimuth 270° W, angle of dip 18–20°. Advanced *Lochriea* were found in sample 1237-1.1 (base of the rock). They correspond to sample 26.2 of the Ladeiny Log section (Protvian Substage). Thickness 4.0 m. Covered - 3.2 m.

At the point and further along the outcrop asimuth NE 23°.

Bed 2. Brown-gray, detrital limestone with silty pore cement, clay, bituminous, strongly dolomitized, thick-bedded (15-27 cm), at the base - massive (50-53 cm) with crinoids, echinoderm spines (echinoderm with the **stereome** structure), articulate and inarticulate brachiopods, bryozoans, gastropods. In thin sections - bioclastic dolomitized packstone. Foraminifers are rather rare: *Planospirodiscus* sp., *Neoarchaediscus parvus* (Raus.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Rectocornuspira* sp. Conodonts are abundant at the top: *Gnathodus bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *L. mononodosa* (Rhodes et al.), ***L. ziegleri*** Nemirovskaya et al., *Lochriea cruciformis* (Clarke), *L. monocostata* Pazukhin et Nemirovskaya, *Vogelgnathus campbelli* (Rexroad), *Synchydogmathus* sp., *Idioproniodus* sp. Thickness is 2.1 m. Azimuth of dip E 85°, angle of dip 22–25°. According to the fauna content, sample 1237-2.1 (top of bed 2) corresponds to sample 18.7 of the Ladeiny Log section. The level is the base of reliable correlation.

Bed 3 is very thick and consists of different types of limestone. It is subdivided into several units.

Bed 3, unit 3a. Dark gray, slime-detrital limestone with basal thin grained cement, bituminous, dolomitized, with dark gray flint nodules. Massive in the lower part and middle-bedded in the upper part, with rare crinoids, bryozoans, brachiopods, ostracods, and algae. In thin sections – bioclastic wackestone, packstones. Foraminifers: abundant *Eotuberitina reitlingerae* M. Maclay, *Paraarchaediscus convexus* (Grozd. et Leb.), *P. kottjubensis* (Raus.), *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), *N.*



Fig. 42. Bed 3. The exposure of the Kurmakov Formation of the Kasaya Gora Regional Stage (Serpukhovian) in the outcrop 1237 of the Mariinsky Log section.

incertus (Grozd. et Leb.), *Planospirodiscus minimus* (Grozd. et Leb.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Rugosoarchaediscus sp.*, *Howchinia gibba* (Moell.), *Rectoendothyra ex gr. donbassica* Brazhn., *Tetrataxis lata* Bog. et Juf. Thickness 0.89 m.

Unit 3b. Brown-gray, fine-grained, bioclastic limestone with basal micro-grained cement, in the middle part of the unit – algal, irregularly dolomitized, bituminous, with nodules of flint, thick-bedded and massive (20-70 cm), porous, with remains of crinoids, echinoderm spines, articulate and inarticulate brachiopods, bryozoans, fish remains, trace fossils, and coprolites. In thin sections: bioclastic wackestone. Algae: *Girvanella wetheredii* Chap., *Fasciella ivanovae* Salt., *Calcifolium okense* Schw. et Bir., *Aphralysia carbonaris* Garw. Foraminifers: abundant *Eotuberitina reitlingerae* M. Maclay, *Earlandia elegans* (Raus. et Reitl.), *Neoarchaediscus parvus* (Raus.), *Paraarchaediscus convexus* (Grozd. et Leb.), *P. vischerensis* (Grozd. et Leb.), *P. koltjubensis* (Raus.), *Rectocornuspira sp.*, *Howchinia gibba* (Moell.), *Monotaxinoides subplanus* (Brazhn. et Jar.), *M. transitorius* (Brazhn. et Jar.), *Haplophragmina angularis* Brazhn., *Globoendothyra globulus* (Eichw.), *Omphalotis omphalota* (Raus. et Reitl.), *Bradyina modica* Gan., *Janischewskina rovnensis* Gan., *Endotaxis brazhnikovae* (Bog. et Juf.), *Tetrataxis lata* Bog. et Juf., *T. pusilla* Conil et Lys, *T. ex gr. conica* Ehren., *Mediocris mediocris* (Viss.), *M. breviscula* Gan., *Endostaffella fucoides* Ros., *Eostaffella ex gr. postmosquensis* Kir., *Millerella pauperis* Durk. Advanced representatives of *Monotaxinoides* typical of the upper part of the Serpukhovian (Yuldabaevskian Regional Stage of the South Urals) were found in the upper part of the Unit 3b. They occur rather rarely in the sections of the Vishero-Chussovaya region of the Urals. Rare conodonts include *Gnathodus bilineatus* (Roundy), *L. mononodosa* (Rhodes et al.), *L. ziegleri* Nemirovskaya et al., *Syncladognathus sp.*, *Kladognathus sp.* Thickness 2.40 m.

Unit 3c. Dark gray, almost black, micro- and fine-grained limestone, with maximal detritus and mud at the base of the layer, bituminous, irregularly clayey, with nodules and streaks of black flint, thin- and thick-bedded (5-38 cm), with remains of crinoids, echinoderm spines, ophiures, holothurians, ostracods, brachiopods, sponge spicules, conulariids, small fragments of algae. Besides, numerous spiral gastropods and trace fossils occur at the bottom. In thin sections - bioclastic mudstone, wackestone. Foraminifers *Eotuberitina reitlingerae* M. Maclay, *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), *N. cf. postrugosus* Reitl., *N. volynicus* Vdov., *N. incertus* (Grozd. et Leb.), *Planospirodiscus minimus* (Grozd. et Leb.), *Howchinia gibba* (Moell.), *Pseudoammodiscus sp.*, *Omphalotis minima* Raus., *Mediocris breviscula* Gan., *Eostaffella prisca settella* Gan. In the middle part of the unit – dark brownish gray to black dolomite (dolomitic mudstone), thin and fine-grained cement, irregularly clayey and bituminous, calcareous, micro- and thin-bedded, and micro- and thin-bedded limestone with structure of bioturbation. Fauna:

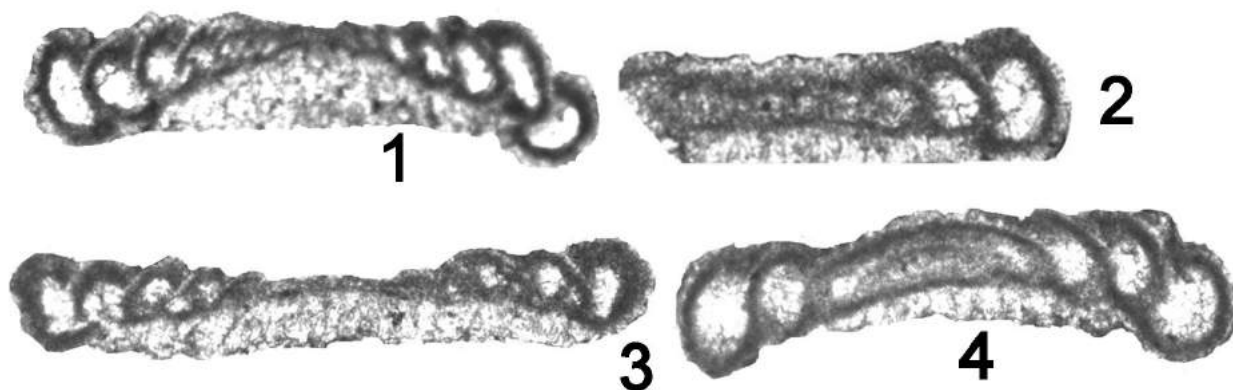


Fig. 43. *Monotaxinoides* (small foraminifera) from the Mariinsky Log section (outcrop 1237, bed 3b, specimen 3b.2-1) 1, 4 – *Monotaxinoides subplanus* (Brazhn. et Jar.), D = 0,4 mm. 2, 3 – *Monotaxinoides transitorius* Brazhn. et Jar.; D (2) = 0,22 mm, D (3) = 0,4 mm.



crinoids, bryozoans, and ostracods. Foraminifers: *Neoarchaediscus parvus* (Raus.), ***N. postrugosus*** Reitl. **Conodonts** are rare: *Gnathodus* sp., *Gnathodus bilineatus* (Roundy), ***L. ziegleri*** Nemirovskaya et al., *Lochriea senckenbergica* Nemirovskaya et al., *Lochriea commutata* (Branson et Mehl), *L. nodosa* (Bischoff), *L. mononodosa* (Rhodes et al.), *Lochriea monocostata* Pazukhin et Nemirovskaya, *Vogelgnathus campbelli* (Rexroad), *Kladognathus* sp., *Idioproniodus* sp. Thickness 6.47 m. In samples 3c.1 and 3c.2 (upper part of the Unit 3c) rather smooth advanced *Gnathodus bilineatus* typical of the upper part of the Serpukhovian were found.

Unit 3d. Alternation of micro bedded, clayey, bituminous limestone and thick-bedded limestone (14–23 cm). Dark gray, almost black, micro granular limestone, with detritus and mud, clayey, irregularly dolomitic, with nodules and streaks of black flint. Sludge contains crinoids, ophiures, inarticulate brachiopods, ostracods, bryozoans, fish remains. In thin sections: mudstone with small bioclasts. Foraminifers are rare: *Paraarchaediscus* sp., *Neoarchaediscus parvus* (Raus.), *N. volynicus* Vdov. **Conodonts** are also rare: *Gnathodus* sp., *Lochriea commutata* (Branson et Mehl), *L. mononodosa* (Rhodes et al.), *L. cruciformis* (Clarke), *L. monocostata* Pazukhin et Nemirovskaya. *Idioproniodus* sp. Thickness 2.4 m.

Unit 3e. Dark brownish-gray, thin and micro-grained limestone with detritus and mud, irregularly bituminous, clayey, dolomitized, with flint nodules and streaks, medium- and thick-bedded (7–19 cm), with fine detritus and small fragments of crinoids, articulate and inarticulate brachiopods, ostracods, bryozoans, fish remains. In thin sections – mudstone and wackestone with small bioclasts. In the middle part of the unit – brownish-gray, fine-grained, clayey, bituminous, calcareous dolomite, with rare fragments of crinoids and bryozoans. Foraminifers: *Paraarchaediscus koktjubensis* (Raus.), *Neoarchaediscus parvus* (Raus.), ***N. postrugosus*** Reitl., *Eostaffella ex gr. postmosquensis* Kir., *E. prisca* Raus. **Conodonts:** *Gnathodus* ex gr. *bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *Kladognathus* sp., *Syncladognathus* sp. Thickness 4.50 m.

Unit 3f. Dark gray, almost black, brown, gray, spotted, micro-grained, clayey, bituminous, weakly silicified limestone, with mud admixture. In the upper part detrital-sludge, micro and thin-bedded, splintery, in some interlayers - brachiopod coquina with *Martinia glabra*. Crinoids, ophiures, echinoderms, articulate and inarticulate brachiopods, ostracods, fish remains, algae debris are determined in the detritus. In thin sections – mudstone and wackestone with small bioclasts. Foraminifers: *Paraarchaediscus convexus* (Groz. et Leb.), *P. itinerarius* (Schlyk.), *P. koktjubensis* (Raus.), ***P. vischerensis*** (Groz. et Leb.), ***Asteroarchaediscus subbaschkiricus*** (Reitl.), *A. baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *N. volynicus* Vdov., ***N. postrugosus*** Reitl., ***Planospirodiscus minimus*** (Groz. et Leb.), *Endostaffella asymmetrica* Ros., *Eostaffella prisca* Raus. Among algae *Calcifolium okense* Schw. et Bir. **Conodonts** are rare: *Gnathodus* ex gr. *bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *Kladognathus* sp. Thickness is about 4 m.

Unit 3g. Dark gray, almost black, micro grained limestone, with admixture of mud, bioclastic, clayey, bituminous, irregularly dolomitized, from thin- to thick-bedded (1–28 cm), with remains of articulate and inarticulate brachiopods, crinoids, echinoderm spines, ophiures, fish. In thin sections – mudstone and wackestone with small bioclasts. Foraminifers: *Paraarchaediscus koktjubensis* (Raus.), ***P. vischerensis*** (Groz. et Leb.), *Neoarchaediscus parvus* (Raus.), *N. volynicus* Vdov., ***N. postrugosus*** Reitl., ***Planospirodiscus minimus*** (Groz. et Leb.), *Rectocornuspira cf. pseudoprisca* Vdov., *Eostaffella schwetzerovi* Gan. Singular conodonts: *Gnathodus* ex gr. *bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *Lochriea monocostata* Pazukhin et Nemirovskaya, *Kladognathus* sp., *Syncladognathus* sp. Thickness 3.4 m.

Total thickness of bed 3 is 24.1 m.

Bed 4 is subdivided into two units. **Unit 4a.** Dark gray limestone, with basal fume sludge cement, interbeds are lighter, bioclastic, with micritic cement. Some layers are lighter, but also bioclastic, irregularly bituminous and clayey, with flint nodules and streaks, massive, bearing crinoid, ostracod, and brachiopod remains. In thin sections – wackestone with small bioclasts, micro laminated. Foraminifers:

Paraarchaediscus koktjubensis (Raus.), *P. convexus* Grozd. et Leb., ***P. vischerensis*** (Grozd. et Leb.), *Neoarchaediscus volynicus* Vdov., ***Planospirodiscus minimus*** (Grozd. et Leb.), *Euxinita efremovi* (Vdov. et Rost.), *Endostaffella asymmetrica* Ros., *Eostaffella oldae* Durk. Thickness 1.20 m.

Unit 4b. Brownish-gray limestone, bioclastic or bio detrital with micritic cement. Limestone is irregularly bituminous and silicified, medium to thick-bedded (8-29 cm), with remains of crinoids, echinoderm spines, ophiures, holothurians, ostracods, articulate and inarticulate brachiopods, **conulariids**. In thin sections – wackestone with small bioclasts, packstone, bioturbated packstones. Foraminifers *Neoarchaediscus volynicus* Vdov., *N. regularis* (Sulei.), ***N. gregorii*** (Dain), *N. incertus* (Grozd. et Leb.), *N. latispiralis* (Grozd. et Leb.), *Eostaffella ex gr. prisca* Raus. **Conodonts** are rare: *Gnathodus ex gr. bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *Vogelgnathus campbelli* (Rexroad), *Syncladognathus* sp., *Kladognathus* sp. Thickness 1.86 m. Thickness of bed 4 is 3.06 m.

Covered – 4.9 m (Thickness is based on Guidebook, 2010).

Bed 5. Alternation of brown-gray limestone, algal-bioclastic with biosparitic cement and bioclastic limestone with bisparitic cement, unevenly silicified, clayey and bituminous. Middle and thick-bedded (8-29 cm). Limestone contains remains of crinoids, echinoderms spines, ophiures, holothurians, brachiopods, solitary rugose corals, tabulate corals - *Michelinia*. In thin sections – bioclastic packstone and grainstone. Algae: *Fasciella ivanovae* Salt., *Calcifolium okense* Schw. et Bir., *Pseudostacheoides loomisi* Petr. et Mam. Foraminifers: *Eotuberitina reitlingerae* M. Maclay, *Paraarchaediscus convexus* (Grozd. et Leb.), *P. koktjubensis* (Raus.), ***P. vischerensis*** (Grozd. et Leb.), *P. stilus* (Grozd. et Leb.), *Asteroarchaediscus subbaschkiricus* (Reitl.), *A. rugosus* Raus., *A. baschkiricus* (Krest. et Theod.), *Neoarchaediscus regularis*



Fig. 44. Quarry 1 (outcrop 1228) of the Mariinsky Log section.



(Sulei.), *N. gregorii* (Dain), *Howchinia gibba* (Moel.), *H. bradyana* (How.), *Pseudoammodiscus volgensis* (Raus.), *Priscella prisca* (Raus. et Reitl.), *Tetrataxis quasiconica* Brazhn., *Endostaffella asymmetrica* Ros., *Eostaffella ex gr. pseudostruvei* (?) (Raus.), *Eostaffellina sp.* Thickness of the studied part of the bed – 1.86 m. Small isolated outcrops with thickness about 0.5 m are visible above. Total thickness 7.0m (based on Guidebook, 2010).

Beds 1-5 of the Mariinsky Log section correspond to beds 17-21 of the Ladeiny Log section.

Quarry I (Outcrop 1228 fig x) continues the sequence of outcrop 1237. The succession starts with dolomite (bed 1), which refers to the Kurmakov Formation. Gray, partly light gray and dark gray, fine-grained, silicified, massive and thick-bedded dolomite. It contains productids shells of bad preservation. Thickness 6.8 m.

Dolomite is overlain by breccia that is correlated with bed 22 of the Ladeiny Log section. Nowadays, rocks are exposed badly and are partly covered. The quarry was not re-studied. The assemblage of foraminifers: *Earlandia minor* (Raus.), *Asteroarchaediscus rugosus* (Raus.), *Monotaxinoides sp.*, *Omphalotis omphalota* (Raus. et Reitl.), *Globoendothyra globulus* (Eichw.), *Endothyranopsis cf. sphaerica* (Raus.), *Palaeotextularia longiseptata* Lip. (Guidebook, 2010)

Quarry II is not studded. Rocks outcrop along the strike, nearly horizontal. The quarry duplicates and partly builds on section of Quarry I. Only the beds at the outcrop base are available.

Outcrop 1229 is at the base of the western wall of Quarry III. Two beds are distinguished (from bottom to top). They are assigned to the **upper part of the Kosogorian Substage (Lower Serpukhovian)**.

Bed 1. Light yellowish-gray, bioclastic, clotted limestone, with sparitic cement, massive, at the top with solitary and colonial rugose corals. Branched bryozoans, brachiopods, crinoids, ostracods are widely distributed in the bed. Under the microscope - packstones with small bioclasts, at the top of the bed – packstone and grainstone. Algae: *Koninckopora inflata* (Koninck), *Calcifolium okense* Schw. et Bir., *Sphaeroporella antropovi* Berch., *Ungdarella uralica* Masl., *Fourstonella fusiformis* (Brady), *Masloviporidium delicata* (Berch.). Foraminifers: *Earlandia vulgaris* (Raus.), *Pseudoammodiscus volgensis* (Raus.), *Pseudoglomospira ulutchurica* Rum., *Rectocornuspira pseudovolgensis* Vdov., *Paraarchaediscus convexus* (Grozd. et Leb.), *P. stilus* (Grozd. et Leb.), *P. donetzianus* (Sosn.), *Neoarchaediscus parvus* (Raus.), *N. postrugosus* (Reitl.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Planospirodiscus minimus* (Grozd. et Leb.), *Globoendothyra globulus* (Eichw.), *Endothyranopsis compressa* (Raus. et Reitl.), *E. sphaerica* (Raus. et Reitl.), *E. crassa* (Raus. et Reitl.), *Janischewskina rovnensis* Gan., *Palaeotextularia longiseptata* Lip., *Climacammina simplex* Raus., *Globivalvulina ex gr. granulosa* Reitl., *Eostaffella pseudoovoidea* Raus., *Eostaffella ex gr. ikensis* Viss. Thickness 1.34 m.

Bed 2. Limestone is light gray, bioclastic with sparitic cement, irregularly dolomitized, strongly silicified at the base, massive- and thick-bedded (23-78 cm), porous, with numerous solitary and colonial rugose corals, branched bryozoans, brachiopods, interbedded with limy dolomite. In thin sections – bioclastic packstone with concentration of smaller bioclasts at the top. Fauna: branched bryozoans, brachiopods, rugose corals, crinoids, echinoderm spines, ostracods. Algae: *Koninckopora inflata* (Koninck), *Beresella machaevi* Kulik. Foraminifers: *Pseudoammodiscus volgensis* (Raus.), *Pseudoglomospira ulutchurica* Rum., *Ps. elegans* Lip., *Archaediscus moelleri* Raus., *A. krestovnikovi* Raus., *Paraarchaediscus convexus* (Grozd. et Leb.), *P. itinerarius* (Schlyk.), *Permodiscus vetustus* Dutk., *Neoarchaediscus parvus* (Raus.), *N. gregorii* (Dain.), *Endothyra bradyi* Mikh., *En. cf. phrissa* (D. Zeller), *En. ex gr. eostaffelloides* Reitl., *Similisella lenociniosa* (Schlyk.), *Endothyranopsis compressa* (Raus. et Reitl.), *E. crassa* (Raus. et Reitl.), *Globoendothyra globulus* (Eichw.), *Endothyranopsis cf. sphaerica* (Raus. et Reitl.), *Pojarkovella nibelis* (Durk.), *Euxinita efremovi* (Vdov. et Rost.), *Climacammina padunensis* Gan., *Mediocris minima* Durk., *Eostaffella pseudoovoidea* Raus., *E. ex gr. prisca* Raus., *Pseudoendothyra globosa* Ros., *Ps. parasphaerica* Reitl., *Ps. averinensa* Post., *Parastaffella angulata* Raus., brachiopods: *Actinoconchus adpressiora* (Ein.).

Thickness 2.3 m.

Outcrop 1230 is located in the eastern wall of Quarry III.

Bed 1. Light yellowish-gray limestone, bioclastic with biosparitic and micritic cement, porous, with remains of algae, crinoids, echinoderm spines, spiral gastropods, large brachiopods *Latiproductus* sp., ostracods, bryozoans. In thin sections - bioclastic packstones. Algae: *Fourstonella fusiformis* (Brady), *Praedonezella cespeformis* Kul., *Anthracoporella insolita* R. Ivan., *Fasciella* sp., *Crassikamaena* sp. Foraminifers: *Eotuberitina reitlingerae* M. Maclay, *Earlandia* (*Quasiearlandia*) *vulgaris* (Raus.), *Paraarchaediscus convexus* (Grozd. et Leb.), *P. donetzi* (Sosn.), *Rugosoarchaediscus agapovensis* (Iv.), *Endothyra* ex gr. *bradyi* Mikh., *Similisella lenociniosa* (Schlyk.), *Endothyranopsis sphaerica* (Raus. et Reitl.), *Janischewskina rovnensis* Gan., *Palaeotextularia longiseptata* Lip., *Climacammina simplex* Raus., *Eostaffella mosquensis* Viss., *E. proikensis* Raus., *E. tenebrosa* Viss., *E. cf. chomatifera* Kir., *Parastaffella densa* Ros. Thickness 1.0 m.

Protvian Substage.

Bed 2. Limestone is light gray, slightly brownish, with sparitic and micritic cement, porous, massive-bedded, bioclastic with bioclast of small size, with stylolite distributed along the bed surfaces. Pores are filled with bitumen. Fauna remains: of algae, large brachiopods, solitary rugose corals, branched bryozoans, crinoids, holothurians, ophiures. In thin sections - bioclastic packstones. Algae: *Fasciella kizilia* R. Ivan., *Calcifolium okense* Schw. et Bir., *Praedonezella cespeformis* Kul. Foraminifers: *Earlandia vulgaris* (Raus.), *Rugosoarchaediscus agapovensis* R. Iv., *Endothyranopsis crassa* (Brady), *Bradyina cf. cribrostomata* Raus. et Reitl., *Parastaffella concinna* Schlyk. **Conodonts:** *Gnathodus* ex gr. *bilineatus* (Roundy) juv., *Cavusgnathus* sp. Thickness 2.45 m.

Bed 3. Light gray limestone, in the middle part brecciated, in the upper part organogenic-detrital with thin-grained cement, dolomitized, massive-bedded, at the top detrital with small bioclastic fragments, dolomitized, massive-bedded, with stylolites distributed horizontally along the bed surfaces, with remains of algae, large brachiopods, branched bryozoans, crinoids and solitary rugose corals. In

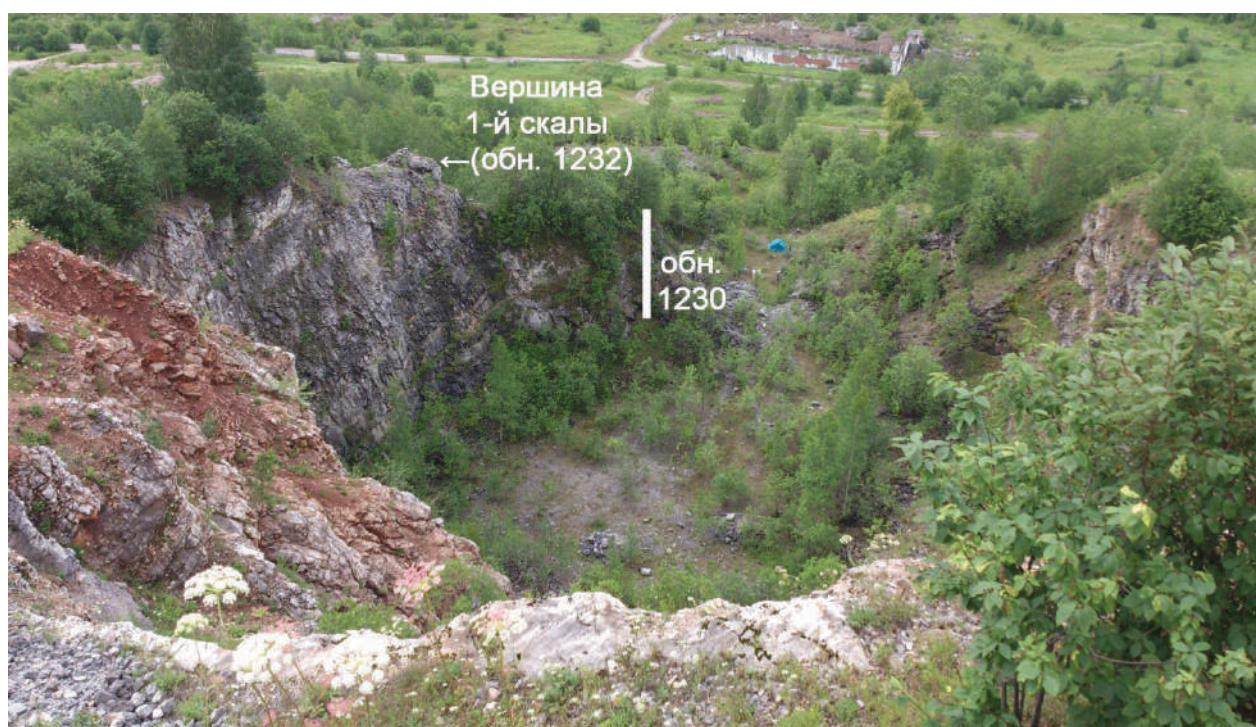


Fig. 45. The view of the Quarry III from its northern wall. The red limestone is corresponded with of the reverse fault surface.

thin sections - bioclastic packstones, wackestone with small bioclasts. Algae: *Fasciella kizilia* R. Ivan., *Ungdarella uralica* Masl. Foraminifers: *Earlandia vulgaris* (Raus.), *Paraarchaediscus itinerarius* (Schlyk.), *P. koktjubensis* (Raus.), *P. donetzianus* Sosn., *P. convexus* (Grozd. et Leb.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus regularis* (Sulei.), *N. timanicus* (Reitl.), *N. incertus* (Grozd. et Leb.), *Planospirodiscus minimus* (Grozd. et Leb.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *T. hosiensis* Cozar, *Betpakodiscus kentarensis* Marf., *Endothyra excellens* (D. Zeller), *E. ex. gr. fominae* Ros., *Similisella similis* (Raus. et Reitl.), *Endothyranopsis sphaerica* (Raus. et Reitl.), *En. intermedia* Raus., ***En. plana*** Brazhn., *Globoendothyra globulus* (Eich.), ***Bradyina cribristomata*** Raus. et Reitl., *Euxinita efremovi* (Vdov. et Rost.), *Tetrataxis pusilla* Conil et Lys, *Palaeotextularia longiseptata* Lip., *Climacammina ex gr. simplex* Raus., *Eostaffella pseudoovoidea* Raus., *Parastaffella bona* (Ros.) *lata* Vdov. Thickness 2.1 m.

Bed 4. Limestone is light gray, fine detrital, with thin-grained cement, in the upper part limestone is detrital with small bioclastic fragments, dolomitized, thick-bedded (14-15 cm), with stylolite seams filled with bitumen. Bioclasts: brachiopods, ostracods, crinoids, bryozoans, gastropods. In thin sections – bioclastic packstones. Algae: *Fasciella kizilia* R. Ivan., *Ungdarella uralica* Masl., *Aoujgalia variabilis* Term. et Term., *Beresella* sp., *Kulikia sphaerica* Gol. Foraminifers: *Earlandia vulgaris* (Raus.), *Planospirodiscus minimus* (Grozd. et Leb.), *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Grozd. et Leb.), *P. donetzianus* Sosn., *P. itinerarius* (Schlyk.), *P. stilus* (Grozd. et Leb.), *Asteroarchaediscus subbaschkiricus* (Reitl.), *Neoarchaediscus regularis* (Sulei.), *N. gregorii* (Dain.), *N. postrugosus* Reitl., *N. timanicus* (Reitl.), *N. volynicus* Vdov., *N. incertus* (Grozd. et Leb.), *Planospirodiscus minimus* (Grozd. et Leb.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), ***Eosigmoilina* (?) *explicata*** Gan., ***Brenkleina* sp.**, *Rugosoarchaediscus akchimensis* (Grozd. et Leb.), *Betpakodiscus chuensis* Marf., *Endothyra cf. phrissa* (D. Zeller), *E. tantala* (D. Zeller), *E. fominae* Ros., *Omphalotis minima* (Raus.), ***Endothyranopsis plana*** Brazhn., *Endotaxis brazhnikovae* (Bog. et Juf.), *Climacammina simplex* Raus., *Eostaffella proikensis* Raus., *E. pseudoovoidea* Raus., *E. angularis* Brazhn., *Parastaffella ornata* Durk. Thickness 2.83 m.

Bed 5. Limestone is light gray, organogenic-clotted with micro-porous and fine-grained cement.



Fig. 46. Outcrop 1232 (The first rock of the III Quarry).

Organogenic-detrital, thick-bedded. The interlayer of limestone breccia occurs in the middle part. Numerous whole shells of brachiopods, solitary and colonial rugose corals occur in the upper part. In thin sections - bioclastic-peloidal packstones. Algae: *Fasciella kizilia* R. Ivan., *Calcifolium okense* Schw. et Bir., *Ungdarella uralica* Masl., *Beresella machaevi* Kulik. Foraminifers: *Earlandia vulgaris* (Raus.), *Tolypammmina fortis* Reitl., *Insoletitheca variabilis* (Brazhn.), *Similisella similis* (Raus. et Reitl.), *Pojarkovella nibelis* (Durk.), *Tetrataxis regularis* Brazhn., *T. lata* Bog. et Juf., *T. izhimica* Durk., *Globivalvulina* sp., *Eostaffella mosquensis* Viss., ***E. mirifica*** Brazhn., *E. rotunda* Durk. Thickness 2.0 m.

Small rocky outcrops are located on the mountain slope in between III and IV quarries. According to the Guidebook, 2010, they were assigned to different beds of outcrops 1232-1234. In this publication the outcrops are considered as separate localities in the direction from west to east, along the transition from III to IV quarry (fig. 45).

Outcrop 1232 (The first rock of III Quarry).

Bed 1. Limestone is light gray, organogenic-clotted with micro- and fine-grained pore cement, irregularly dolomitized, massive-bedded, with numerous brachiopods, solitary and colonial rugose corals, crinoids, echinoderm spines, bryozoans, ostracods, fish remnants. In thin section - bioclastic-peloidal packstones. Algae: *Girvanella wetheredii* Chap., *Calcifolium okense* Schw. et Bir., *Fasciella kizilia* R. Ivan., *Ungdarella uralica* Masl. Among foraminifera the fouling biloculine forms are predominant: *Earlandia vulgaris* (Raus. et Reitl.), *Tolypammmina fortis* Reitl., *Pseudoglomospira elegans* Lip., *Paraarchaediscus koktjubensis* (Raus.), *Rugosoarchaediscus* sp., *Haplophragmina beschevensis* Brazhn., *Haplophragmella tetraloculi* Raus., *Endothyra versabilis* (D. Zeller), *E. irregularis* Reitl., *Similisella similis* (Raus. et Reitl.), *S. lenociniosa* (Schlyk.), ***Planoendothyra spirilliniformis*** (Brazhn. et Pot.), *Mikhailovella* sp., *Rectoendothyra priscoidea* Brazhn., *Pojarkovella pura* (Sim.), *Endothyranopsis sphaerica* (Raus. et Reitl.), *Janischewskina* sp., *Euxinita efremovi* (Vdov. et Rost.), *Consobrinella intermedia* (Lip.), *Palaeotextularia longiseptata* Lip., *P. crassa* Lip., *Cribrostomum bradyi* (Moell.), *Koskinobigerina* cf. *confusa* (Durk.), *K. postprisca* (Brazhn. et Vinn.), *Climacammina simplex* Raus., *Biseriella parva* (N. Tchern.), *Mediocris breviscula* (Gan.), ***Eostaffella mutabilis*** Raus., *E. parastruvei subvasta* Gan., *E. ex gr. ikensis* Viss., ***E. angusta*** Kir., *Eostaffellina paraprotvae* Raus., *Millerella pauperis* Durk., *Pseudoendothyra averinensia* Post., ***Ps. parasphaerica*** Reitl. Thickness 1.5 m.

Bed 2 (the cave layer, fig. 46). Limestone is light gray, organogenic, organogenic-detrital, unevenly silicified, massive-bedded with crinoids and solitary corals. Large brachiopods shell bank occurs in the middle part of the bed. In thin sections – bioclastic packstones. Algae: *Mametella* sp., *Crassikamaena* sp., *Beresella* sp., *Ungdarella uralica* Masl. Foraminifera: *Earlandia vulgaris* (Raus.), *Pseudoglomospira elegans* Lip., *P. postserenae* Brazhn., *P. subquadrata* (Pot. Et Vak.), *Paraarchaediscus koktjubensis* (Raus.), *Haplophragmina beschevensis* Brazhn., *Omphalotis minima* Raus., *Endostaffella fucoides* Ros., *Globivalvulina* sp., *Consobrinella intermedia* (Lip.), *Palaeotextularia longiseptata* Lip., *Koskinobigerina prisca* (Lip.), *Climacammina obsoleta* Reitl. Thickness 2.3m.

Bed 3. Limestone is light gray, organogenic-detrital, bioclastic-clotted with micro-pore and fine-grained cement in the bottom of limestone breccia consisting of small limestone fragments (0.6 m), and massive- and thick-bedded, with remains of crinoids, brachiopods and echinoderm spines, many algae. In thin sections - bioclastic-peloidal packstones (just above the breccia) and bioclastic packstones containing large crystals of dolomite. Algae: *Girvanella wetheredii* Chap., *Calcifolium okense* Schw. et Bir., *Praedonezella cespeformis* Kulik., *Claracrusta catenoides* (Hom.), *Ungdarella uralica* Masl. Foraminifers: *Tolypammmina fortis* Reitl., *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Endothyra versabilis* (D. Zeller), *Endothyranopsis sphaerica* (Raus. et Reitl.), *Janischewskina minuscularia* Gan., ***Bradyina cribrostomata*** Raus. et Reitl., *Consobrinella intermedia* (Lip.), *Koskinobigerina prisca* (Lip.), *Climacammina padunensis* Gan., *Eostaffella angularis* Brazhn. Thickness 1.6 m.

Bed 4. At the base of the bed - yellow-gray dolomite, fine- and medium-grained, incoherent, porous

(0.48 m). Limestone is light gray, organogenic (brachiopod), organogenic-clotted with crustified-pore cement, massive, with rugose corals, crinoids, bryozoans, and ostracods. In thin sections - bioclastic-peloidal packstones, grainstones, with rare ooids, porous. Algae: *Ortonella fruticulata* R. Iv. Foraminifers: *Pseudoglomospira postserenae* Brazhn., *P. subquadrata* (Pot. et Vak.), *Ps. pusilliformis* Reitl., *Endothyra irregularis* Reitl., ***Globivalvulina kamensis*** Reitl., *Eostaffella parastruvei* Raus., *E. ex gr. pseudostruvei* (Raus.), *E. mosquensis* Viss., *E. postmosquensis* Kir., *Eostaffellina paraprotvae* Raus., *Parastaffella moderata* Durk., *P. nautiliformis* Durk. Thickness 1.42 m.

Bed 5. Limestone is light gray, organogenic detrital, organogenic-clotted with pore and basal cement, massive, with remains of crinoids, echinoderm spines, brachiopods, ostracods. Within the bed the detritus is covered with cyanobacterial crust (*Ortonella sp.*). In thin sections - bioclastic-peloidal wackestone, packstone. Foraminifers: *Tolypammmina fortis* Reitl., *Haplophragmina beschevensis* Brazhn., ***Endothyra irregularis*** Reitl., *Globivalvulina sp.*, *Eostaffella pseudoovoidea* (Raus.), *Eostaffellina paraprotvae* Raus. Thickness 0.92 m.

Bed 6. Limestone is light gray, almost white, organogenic detrital, stained, bioclastic-clotted with basal or crustified micro-pore and fine-grained cement. It is thick-bedded (25 cm). Fauna remains include crinoids, echinoderm spines, ostracods. In thin sections - bioclastic, bioclastic-peloidal packstones. Algae: *Calcifolium okense* Schw. et Bir., *Praedonezella cespeformis* Kulik., *Beresella machaevi* Kulik., *Dvinella secunda* Kulik, *Sphaeroporella antropovi* Berch., *Ungdarella uralica* Masl. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *E. vulgaris* (Raus.), *Tolypammmina fortis* Reitl., *Pseudoglomospira subquadrata* (Pot. et Vak.), *Paraarchaediscus convexus* Grozd. et Leb., *P. grandiculus* (Schlyk.), *P. itinerarius* Schlyk., *P. vischerensis* (Grozd. et Leb.), *Asteroarchaediscus ovoides* (Raus.), *A. subbaschkiricus* Reitl., *Haplophragmina angularis* Brazhn., *Insoletitheca horridus* (Brazhn.), *Endothyra bradyi* Mikh., *Similisella lenociniosa* (Schlyk.), *Mikhailovella popleformis* Durk., ***Rectoendothyra priscoidea*** Brazhn., ***R. donbassica*** Brazhn., *Endothyranopsis sphaerica* (Raus. et Reitl.), ***Bradyina cribrostomata*** Raus. et Reitl., ***B. nana*** Pot., ***Globivalvulina kamensis*** Reitl., *Consobrinella intermedia* (Lip.), *Palaeotextularia longiseptata* Lip., *P. ex gr. angusta* Reitl., *Cribrostomum fortis* Durk., *Cr. bradyi* (Moell.), *Koskinobigerina postprisca* (Brazhn. et Vinn.), *K. prisca* (Lip.), *Climacammina simplex* Raus., *Endostaffella shamordini* (Raus.), *Mediocris medicris* Viss., *Eostaffella ovesa* Gan., *E. pseudoovoidea* (Raus.), *E. parastruvei* Raus., *E. proikensis* Viss., *E. mosquensis acuta* Raus., *E. mosquensis attenta* Gan., ***E. pseudostruvei chomatifera*** Kir., ***E. pseudostruvei angusta*** Kir., ***E. postmosquensis*** Kir., ***E. postmosquensis acutiformis*** Kir., ***Millerella umbilicata*** Kir., *Parastaffella struvei* (Moell.). Thickness 1.75 m.

Bed 7. Limestone is light gray, almost brown, bioclastic-clotted (lower 0.34 m) with crustified, thin-, small- or medium pore cement, middle-bedded, with remains of echinoderms, crinoids, gastropods, ostracods, trace fossils. It is overlapped by yellow-gray, fine-grained, soft, porous dolomite (0.14 m). At the top of the bed, there is a bank of large solitary corals and brachiopods (1.29 m). In thin sections of the basal part of the bed – bioclastic-spines grainstone, peloidal packstone with trace fossils. Algae: *Dvinella secunda* Kulik. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *E. vulgaris* (Raus.), *Pseudoammodiscus volgensis* (Raus.), *Tolypammmina fortis* Reitl., ***Bradyina cribrostomata*** Raus. et Reitl., ***B. nana*** Pot., ***Globivalvulina kamensis*** Reitl., *Palaeotextularia longiseptata* Lip., *Cribrostomum juditchevi* Durk., *Cr. bradyi* (Moell.), *Consobrinella intermedia* (Lip.), *Mediocris ovalis* (Viss.), *Eostaffella prisca* Raus., *E. parastruvei* Raus., ***E. parastruvei chusovenski*** Kir., ***E. postmosquensis acutiformis*** Kir., ***E. pseudostruvei chomatifera*** Kir., ***Millerella umbilicata*** Kir., *Parastaffella crassa* Ros. Thickness 1.77 m.

Bed 8 is dropped at the cliff of the eastern wall of Quarry III (in the highest part). Limestone is light gray, almost white or slightly brownish, brachiopod coquina with rugose corals or algal with thin- and micro-grained pore cement. Limestone is interbedded with organogenic detrital, clotted with basal fine- and micro-grained cement, thick-bedded and massive (10-60 cm). In thin sections – bioclastic-peloidal wackestone with cyanobacterial nodules, bioclastic packstone with crinoids,

ostracods, brachiopods, gastropods, bryozoans, fish. Algal limestones are bafflestone with brachiopods, crinoids, echinoderm spines, rugose corals. Algae: *Malachovella malachovae* Mam. et Roux., *Ortonella* sp., *Calcifolium okense* Schw. et Bir., *Fasciella kizilia* R. Ivan., *Claracrusta catenoides* Mam. et Roux., *Stacheoides tenuis* Petr. et Mam., *Ungdarella uralica* Masl. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *Pseudoglomospira postserenae* Brazhn., *Pseudoammodiscus volgensis* (Raus.), *Archaeodiscus moelleri* Raus., *Asteroarchaediscus ovoides* (Raus.), *A. subbaschkiricus* Reitl., *Neoarchaediscus parvus* (Raus.), *N. timanicus* (Reitl.), *Rugosoarchaediscus akchimensis* (Groz. et Leb.), *Insoletithea horridus* (Brazhn.), *Endothyra bradyi* Mikh., *E. phrissa* (D. Zeller), *Similisella lenociniosa* (Schlyk.), *Endothyranopsis crassa* (Raus. et Reitl.), *En. sphaerica* (Raus. et Reitl.), *En. plana* Brazhn., *Bradyina nana* Pot., *Euxinita efremovi* (Vdov. et Rost.), *Globivalvulina scaphoidea* Reitl., *Consobrinella intermedia* (Lip.), *C. confusa* (Durk.), *Palaeotextularia longiseptata* Lip., *Cribrostomum fortis* Durk., *Cr. bradyi* (Moell.), *Climacammina simplex* Raus., *Mediocris breviscula* Gan., *Endostaffella shamordini* (Raus.), *Eostaffella pseudoovoidea* (Raus.), *E. postmosquensis acutiformis* Kir., *Millerella pauperis* Durk., *M. anfractuosa* Post., *Parastaffella struvei* (Moell.). **Conodonts** are rare: *Gnathodus* ex gr. *bilineatus* (Roundy) juv., *Cavusgnathus* sp. Thickness 3.60 m.

Covered interval. **The second and third rocks of Quarry III** duplicate each other. Two beds are subdivided.

Bed 1. Light gray, almost white, yellow, organogenic detrital limestone, with pore or basal cement, massive bedded, stylolite seams are developed parallel to bedding, with fragments and whole shells of brachiopods, crinoids, with colonial rugose corals at the top. Foraminifers: *Earlandia minor* (Raus.), *Endothyranopsis sphaerica* (Raus. et Reitl.), *Palaeotextularia longiseptata* Lip. etc.; brachiopods *Striatifera striata* (Fisch.), *Actinoconchus adpressiora* (Ein.). Thickness 2.90 m.

Bed 2. Light gray, mostly organogenic, brachiopod limestone with solitary and colonial rugose corals, tabulates and Chaetetidae. At the top of the bed, there is an interlayer of limestone breccia with small limestone fragments (30 cm), above - stromatolite limestone (40 cm) and at the top - coral - brachiopod limestone (27 cm). Foraminifers: *Earlandia minor* (Raus.), *Endothyranopsis sphaericus* (Raus. et Reitl.), *Palaeotextularia longiseptata* Lip. etc. Thickness 2.77 m.

Further, up the hillside 9 m are covered. **The fourth rock in quarry III** is low stepped outcrops, which are not distinguishable on panoramic pictures. By foraminifers data the limestones are attributed to the Staroutkinskian Substage (Serpukhovian). Two beds were distinguished.

Staroutkinskian Substage

Bed 1. Brown-gray, bioclastic limestone, bioclasts of small size, pore fine-grained cement, pink siliceous nodules, thick-bedded. Remains of bryozoans, crinoids, echinoderm spines, ostracods, brachiopods occur. In thin sections - bioclastic packstones with bioclasts of small size. Breccia (30 cm) accumulated at the top is formed by dark gray rubbles up to 3 cm and detritus. Unevenly silicified, cement is basal pore or fine-grained, breccia contains remains of algae, gastropods, echinoderm spines, cyanobacterial nodules. Assemblage of foraminifers is typical of bioclastic-detrital limestone: *Earlandia elegans* (Raus. et Reitl.), *Ammovertella* ex gr. *inversa* Schellw., *Palaeonubecularia uniserialis* Reitl., *Archaeodiscus moelleri* Raus., *A. krestovnikovi* Raus., *Paraarchaediscus koktjubensis* (Raus.), *P. stilus* (Groz. et Leb.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), *N. postrugosus* (Reitl.), *N. incertus* (Groz. et Leb.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Eosigmoilina explicata* Gan., *Haplophragmina beschevensis* Brazhn., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Eostaffella acuta nana* Kir., *E. mutabilis* Raus., *E. ex gr. mirifica* Brazhn. The fragments of the algae *Pseudostacheoides* sp. were found. Assemblage of foraminifers, found in the limestone breccia includes: *Palaeonubecularia uniserialis* Reitl., *Pseudoglomospira subquadrata* (Pot. et Vak.), *Archaeodiscus variabilis* Reitl., *A. krestovnikovi* Raus., *Planospirodiscus* sp., *Neoarchaediscus regularis* (Sulei.), *N. postrugosus* (Reitl.), *N. incertus* (Groz. et Leb.), *N. volynicus* Vdov., *N. timanicus* (Reitl.), *Tubispirodiscus*



Fig. 47. Fourth rock from the Quarry III. Staroutkinskian Substage of the Upper Serpukhovian.

attenuatus (Marf.), *T. cornuspiroides* (Brazhn. et Vdov.), *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), ***Globivalvulina bulloides*** (Brady), *Mediocris breviscula* Gan., ***Eostaffella acuta nana*** Kir., ***E. pseudostruvei angusta*** Kir., ***E. postmosquensis*** Kir., ***E. postmosquensis acutiformis*** Kir., *Eostaffellina paraprotvae* Raus., *Eos. vischerensis* (Grozd. et Leb.), ***Plectostaffella reitlinger*** Grov., ***P. varvariensis lata*** Brazhn. et Vdov., *Millerella pressula* Gan., ***Parastaffella utkaensa*** Post., *P. bona* Ros., *P. nautiliformis* Durk. Algae: *Praedonezella cespeformis* Kulik., *Cuneiphycus* sp., *Masloviporidium delicata* (Berch.). Thickness 1.6 m. Bed 1 corresponds to bed 30 of the Ladeiny Log section.

Bed 2. Brown-gray, yellow-gray, spotted, organogenic-detrital limestone (fragments and gruss were found throughout the layer; fragments at the top are rounded). Limestone is irregularly silicified, thick-bedded and massive (11-45 cm), with fragments and whole shells of brachiopods, gastropods, echinoderm spines, crinoids, ostracods, stromatolite nodules. Organic remains are often covered by stromatolite crusts. Algae: *Praedonezella cespeformis* Kulik., *Palaeoberesella* sp., *Masloviporidium delicata* (Berch.). Foraminifers: *Neoarchaediscus parvus* (Raus.), *N. postrugosus* (Reitl.), *N. gregorii* (Dain), *N. timanicus* (Reitl.), *N. incertus* (Grozd. et Leb.), *N. volynicus* Vdov., *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Pojarkovella* sp., *Biseriella parva* (N. Tcher.), *Palaeotextularia longiseptata magna* Lip., *Mediocris minima* Durk., ***Eostaffella pseudostruvei*** (Raus.), ***E. postmosquensis*** Kir., ***E. postmosquensis acutiformis*** Kir., *E. ulutchurica* Rum., *Eostaffellina paraprotvae* Raus., ***Plectostaffella tenuissima*** Brazhn. et Vdov., ***Pl. reitlinger*** Grov., *Pseudoendothyra averinensa complanata* Post., *Parastaffella struvei* (Moell.), ***P. utkaensa*** Post., *P. ornata* Durk., *P. nautiliformis* Durk. **Conodonts** were not found. Thickness 1.74 m.

Fifth Rock has the number **1234**. This outcrop is a long ridge at the western wall of Quarry IV. Three beds are measured.

Carboniferous system

Middle Series (= Lower Pennsylvanian)

Bashkirian Stage



Fig. 48. Outcrop 1234. Lower Bashkirian



Fig. 49. The Upper Bashkirian substage in outcrop 1236 (IV quarry).

Akavasskian Substage (upper part)

Bed 1. Light gray, almost white, algal, foraminiferal-algal limestone, with pore, rare basal fine- and middle-grained cement, with siliceous nodules, massive, rarely basal small- and medium-cement, with nodules of flint, massive, with remains of crinoids, bryozoans, brachiopods, and algae. In thin sections - algal, foraminiferal-algal bindstone. Algae: *Donezella lutugini* Masl., *Dvinella* sp., *Ungdarella gracilissima* Kulik. Foraminifers: *Archaeodiscus variabilis* Reitl., *Asteroarchaeodiscus subbaschkiricus grandis* Reitl., *A. subbaschkiricus* (Reitl.), *Neoarchaeodiscus postrugosus* (Reitl.), *Endothyra irregularis* Reitl., *E. versabilis* (D.Zeller), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Bradyina concinna* Reitl., *Globivalvulina kamensis* Reitl., *Palaeotextularia primitiva* Reitl., *Climacammina aljutovica* Reitl., *Eostaffella postmosquensis* Kir., *E. postmosquensis acutiformis* Kir., *E. ex gr. pseudostruvei* (Raus.), *E. acuta*

Grozd. Et Leb., *Eostaffellina protvae* Raus., *E. paraprotvae* Raus., *Plectostaffella varvariensis* (Brazhn. et Pot.), *Semistaffella inconstans* Reitl., *S. variabilis* (Reitl.), ***Pseudostaffella antiqua*** (Dutk.). Conodonts - *Adetognathus lautus* (Gunnell). Thickness 1.15 m.

Bed 2. Light gray, fine clotted limestone with rounded detritus of algae and foraminifera, with thin- and fine-grained pore cement, interbedded with lenticular nodules and interlayers of stromatolite limestone and lenticular siliceous interlayers. Algae: *Donezella lutugini* Masl., *Beresella erecta* Masl. et Kulik, *Dvinella* sp., *Pseudoungdarella linearis* R. Iv. Foraminifers: *Pseudoglomospira subquadrata* (Pot. et Vak.), *Neoarchaediscus postrugosus* (Reitl.), *N. gregorii* (Dain), *N. gregorii acutiformis* (Grozd. et Leb.), *N. incertus* (Grozd. et Leb.), *N. timanicus* (Reitl.), *Asteroarchaediscus subbaschkiricus* (Reitl.), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Bradyina ex gr. nautiliformis* (Möller), *Eostaffella postmosquensis* Kir., *Plectostaffella bogdanovkensis* Reitl., *P. jakhensis* Reitl., *P. cf. evolutica* Rum., *Semistaffella variabilis* (Reitl.), ***Pseudostaffella antiqua*** (Dutk.), ***Topilinia proozawai*** Kir., *Parastaffella* sp. Thickness 0.21 - 0.30 m.

Askynbashyan Substage

Bed 3. Light gray, brownish, organogenic detrital limestone, detritus of large size, massive at the bottom; algae and clotted with small rounded detritus, middle- and thick-bedded at the top, with numerous crinoids, echinoderm spines, brachiopods, gastropods, rugose corals, fusulinids. All kinds of limestone have sparitic cement. In thin sections: bioclastic grainstones dominate. At the base – a plate of coral limestone with fasciculate colonial corals and Chaetetidae. Algae: *Donezella lutugini* Masl., *Anthracoporella* sp., *Beresella erecta* Masl. et Kulik, *Dvinella* sp., *Ungdarella gracilissima* Kulik., *U. uralica* Masl., *Pseudoungdarella linearis* R. Iv. Foraminifers: *Tolypammina fortis* Reitl., *Pseudoglomospira pusilliformis* Reitl., *Paraarchaediscus donetzianus* Sosn., *Neoarchaediscus postrugosus* (Reitl.), *N. incertus* (Grozd. et Leb.), *Asteroarchaediscus subbaschkiricus grandis* Reitl., *A. subbaschkiricus* (Reitl.), *Endothyra irregularis* Reitl., *E. baschkirica* Pot., *Planoendothyra spirilliniformis evoluta* Reitl., *Bradyina concinna* Reitl., *B. cf. pauciseptata* Reitl., *Tetrataxis parviconica* Lee et Chen., *Globivalvulina ex gr. mosquensis* Reitl., *G. kamensis* Reitl., *Palaeotextularia longiseptata* Lip., *P. angusta elongata* Reitl., *P. gibbosaeformis* Reitl., *Climacammina fragilis* Reitl., *Eostaffella postmosquensis* Kir., *E. postmosquensis acutiformis* Kir., *Eostaffella acuta* Grozd. et Leb., *E. acuta nana* Kir., *E. pseudostruvei angusta* Kir., *E. ex gr. kashirica* Raus., *Millerella uralica* Kir., *M. umbilicata* Kir., *Novella aperta* Grozd. et Leb., *Plectostaffella ex gr. varvariensis* (Brazhn. et Pot.), *Semistaffella variabilis* (Reitl.), ***Eoschubertella mosquensis*** (Raus.), *Pseudostaffella antiqua* (Dutk.), ***Ps. grandis*** Schlyk., *Ps. varsanofievae* (Raus.), ***Ps. praegorskyi*** Raus., ***Profusulinella parva*** (Lee et Chen), *Pseudoendothyra ex gr. parasphaerica* Reitl., *Parastaffella dagmarae* (Dutk.), *P. keltmensis* Raus., *P. preobrajenskyi* (Dutk.), *P. aff. mathildae* (Dutk.). Rugose corals: ? *Heintzella singularis* (Gorsky), *Amygdalophylloides bashkiricus* (Gorsky). **Conodonts:** *Adetognathus lautus* (Gunnell), *Idiognathoides cf. sinuatus* Harris et Hollingsworth. Thickness 2.8 m.

Occurrence of *Adetognathus lautus* in two specimens in out. 1234 shows very shallow water environments.

IV Quarry (outcrop 1236, Fig. 49).

16 beds are distinguished.

Kamennogorian Substage

Mariinsky Formation

Lower subformation

Bed 1. Light gray, brecciated limestone. Fragments are covered with red clay. The fragments are represented by organogenic clotted limestone with pore thin- and fine-grained crystalline cement, in some parts organogenic-detrital with basal micro grained cement. Limestone is dolomitized. It includes stromatolite nodules and remains of algae, brachiopods, ostracods, brachiopods. In thin sections: bioclastic-peloidal grainstone, packstone. Algae: *Donezella lutugini* Masl., *Dvinella* sp. Foraminifers: *Tolypammina fortis* Reitl., *Globivalvulina kamensis* Reitl., *Plectostaffella ex gr. varvariensis* (Brazhn. et

Pot.), *Parastaffella struvei* (Moell.). Conodonts are not found. Thickness 0.40 m.

Bed 2. Light gray, brownish, organogenic detrital limestone, cement basal micro- and fine-grained. Limestone grades into organogenic-clotted with fine-grained cement. Siliceous nodules occur in the upper part. Massive-bedding or unclear thick-bedding is characteristic. Remnants of algae, brachiopods, gastropods were found. At the top surface it is overcovered by a thin interlayer of green clay. In thin sections – bioclastic wackestone, bioclastic-peloidal grainstone. The assemblage of algae and foraminifera is similar with layer 1. Algae: *Dvinella distorta* Kulik., *Kavaena* sp., *Dvinella* sp., *Ungdarelloides* cf. *squalidis* Tchuv et Anfim, *Stacheoides* sp., *Dvinella* ex gr *bifurcate* Maslov et Kulik, *Ungdarella uralica* Maslov. Foraminifera: *Eostaffella postmosquensis acutiformis* Kir., *Millerella uralica* Kir., *Pseudostaffella* sp., *Eostaffella pseudoovoides* Reitl., *Eostaffella pseudostruvei* (Raus et Bel.),? *Archaeodiscus* sp., *Biseriella* sp., *Pseudoglomospira* sp., *Plectostaffella* sp., *Biseriella parva* (N. Tchernysheva), *Pseudoglomospira* sp., *Mediocris* sp., *Palaeonubecularia* sp. (ex gr *rustica* Reitl.). Conodonts were not found. Thickness 1.04 m.

Bed 3. Light gray limestone breccia, with fragments of dark gray or brown-gray limestone. Fragments are of rubble and gravel size. The amount of debris decreases upward. Cement is crystalline, fine- to coarse-grained. Breccia is vaguely thick-bedded. The bedding surface is rough and bumpy. Remains of crinoids, echinoderms spines, brachiopods were observed. Algae: *Donezella lutugini* Masl., *Dvinella* sp., *Ungdarella gracilissima* Kulik., *U. uralica* Masl. Foraminifera: *Tolypammina fortis* Reitl., *Neoarchaeodiscus postrugosus* (Reitl.), *N. gregorii* (Dain), *Asteroarchaeodiscus subbaschkiricus* (Reitl.), *Bradyina cribrostomata* Raus. et Reitl., *B. nana* Pot., *Globivalvulina kamensis* Reitl., *Climacammina* sp., *Eostaffella postmosquensis* Kir., *Millerella uralica* Kir., *Parastaffella dagmarae* (Dutk.). In wreckage of limestone *Semistaffella variabilis* (Reitl.) and *Pseudostaffella* sp. (Dutk.). Rugose corals: ?*Heintzella* aff. *singularis* (Gorsky) (Plate 9, Fig. 9-10). Thickness 1.00 m.

Bed 4. Brown-gray, algal-foraminiferous, massive-bedded limestone (bindstone). Cement is pore thin-, fine- and medium grained. Rocks are dolomitized. Remains of crinoids, echinoderms, branched bryozoans, brachiopods, gastropods, with stromatolite nodules were found. The top is rough. The interlayer surfaces are covered with green clay bearing limestone fragments. Bioclasts and algae fragments are surrounded by crust of dark micro-grained calcite. Algae: *Donezella lutugini* Masl., *Dvinella* sp., *Komia* sp., *Ungdarella gracilissima* Kulik., *U. uralica* Masl., *Pseudoungdarella linearis* R. Iv. Foraminifera: *Paraarchaeodiscus donetzianus* Sosn., *Asteroarchaeodiscus subbaschkiricus* (Reitl.), *Neoarchaeodiscus* ex gr. *incertis* (Grozdn et Leb.), *Bradyina cribrostomata* Raus. et Reitl., *Millerella umbilicata* Kir., *Parastaffella dagmarae* (Dutk.), *P. composita* (Dutk.), *Eostaffella pseudostruvei chomatifera* Kir., *Pseudostaffella* aff. *krasnopolskyi* (Dut.), *Biseriella* sp.,? Sponges: *Chaetetes fisheri* Stuckenberg (Plate 9, Fig. 1). *Pseudoendotyra* sp. Conodonts are not found. Thickness 0.80 m.

Bed 5. Light gray, organogenic detrital, clotted, massive-bedded limestone with some rounded lithoclasts, bioclasts, and algae fragments. Cement is basal, micro- and fine-grained. Rocks are partly dolomitized. Remains of fasciculate and solitary rugose corals, small brachiopods, gastropods, crinoids, echinoderms, and fish occur. In thin sections: foraminiferal algae pack-grainstone with rugose, corals, Chaetetidae, gastropods. Algae: *Donezella lutugini* Masl., *Anthracoportella* sp., *Beresella erecta* Masl. et Kulik, *Dvinella* sp., *Ungdarella uralica* Masl. Foraminifera: *Eostaffella pseudostruvei* (Raus. et Bel.), *Eostaffella pseudostruvei chomatifera* Kir., *Plectostaffella* sp (ex gr. *orbiculata* R. Ivan.), *Millerella uralica* Kir., *Biseriella* sp., *Tolypammina* sp., *Pseudoendotyra* sp. Sponges: *Chaetetes fisheri* Stuckenberg. Conodonts are rare and represented by ramiform elements. Rugose corals: ?*Heintzella kosvense* (Gorsky) (Plate 9, Fig. 2-3). Thickness 1.10 m.

Bed 6. Light gray and gray limestone, micro-grained in the lower part. It grades into clotted limestone with fine-grained cement. In this part limestone bears isolated thin valves and whole shells of ostracods. At the top - organogenic detrital limestone with thin, fine- and medium-grained cement,



dolomitized, middle- and thick-bedded. All interlayer surfaces are underlined by stylolite seams and are covered by very a thin seam of green clay (this gives a specific pattern to the bed). The remnants of fasciculate rugose corals, brachiopods, crinoids, echinoderm spines, and algae were found. In thin sections: brachiopod-crinoid grain – and rudstone with foraminifers, fasciculate rugose corals. Foraminifers are represented by abundant *Bradyina* and *Textulariidae*. Rugose corals: ? *Heintzella stuckenbergi* (Dobr.) (Plate 9, Fig. 12-13). Conodonts were not found. Thickness 2.1 m.

Akavassian Substage

Bed 7. Yellowish gray, organogenic detrital (detritus partly rounded), foraminiferal-algal limestone with mixed cement. At the bottom limestone is fine-grained, pelitomorphic, with trace fossils. Upward it grades into organogenic clotted one. Cement is pore fine-grained. At the top – stromatolite limestone, with thick and massive bedding. Fauna remains include crinoids, echinoderms, brachiopods. At the top interlayers are separated by green clay including more calcareous clots. Algae: *Komia* sp. Foraminifers: *Eostaffella pseudostruvei* (Raus. et Bel.), *Pseudostaffella antiqua* (Dut.), *Ps. antiqua posterior* Saf., *Plectostaffella varvariensis* (Brazh. et Pot.). Thickness 1.65 m.

Bed 8. White, yellowish-gray organogenic detrital brecciated limestone bearing fine lumpy rounded detritus. Cement is crystalline (fine, coarse) and basal fine-grained, medium. Limestone is thick-bedded at the bottom. At the top it is massive-bedded. Remains of brachiopods, crinoids, bryozoans occur. The upper limestone (1.60 m) bears siliceous nodules. At the top surface it is shown by stromatolite limestone covered with green bentonite clay up to 15 cm (Fig. 50). In thin section: foraminifers grainstone with remains of brachiopod valves, rare bryozoans, rugose corals, echinoderm spines, sponges (Plate , Fig. 15), fragments of ooid-foraminifers pack- and wackestone. Algae: *Kamaena* cf. *magna* R. Ivan, *Ungdarella uralica* Maslov. Foraminifers: *Neoarchaediscus* ex gr. *incertis* (Grozdet et Leb), *Biseriella* sp., *Pseudoglomospira* sp., *Tolypammmina* sp. Rugose corals: Cyathopsidae gen. et sp. Indet., ? *Heintzella* sp. (Plate 9, fig.14) Conodonts were not found. Thickness 3.05 m.

Tashastinian Substage

Mariinskyi Formation

Upper Subformation

Bed 9. Strongly bioturbated, detrital, oolitic limestone with lithoclasts and numerous detritus. Limestone is light brownish-gray with darker strips, with interlayers of limestone breccia in the lower part, thick- and massive-bedded (23–66 cm), with siliceous nodules. Remains of crinoids, brachiopods, algae and colonial rugose corals were found. At the bottom – algae grainstone with rare foraminifers, pack-wackestone with ooids and lithoclasts. The number of foraminifers increases upwards. Algae: *Ungdarella uralica* Maslov, *Dvinella distorta* Kulik, Foraminifers: *Pseudostaffella* cf. *antiqua* (Dut.), *Eostaffella vasta* Ros., *Eo.* aff. *paraprotva* (Raus.), *Plectostaffella* sp. *Bradyina* aff. *cribrostomata* Raus. et Reitl , *Climacammina* sp. (ex gr. *obsoleta* Reitl.), *Haplophragmina* sp. Rare conodonts are represented by *Declinognathodus marginodosus* (Grayson), *Idiognathoides sinuatus* Harris et Hollingsworth, *Idiognathodus* cf. *sinuosus* Ellison et Graves. Thickness 2.31 m.

Bed 10. Light brownish-gray, oolitic limestone, with plenty of detritus, massive-bedded (50-167 cm). The bed surface is shown by stromatolite crust. The remains of brachiopods, crinoids, echinoderm spines, gastropods were found. At the top – yellowish-gray, fine-grained and medium-grained, soft, porous dolomite. Thickness 0.84 m. Foraminifers: *Eostaffella vasta* Ros., *Plectostaffella* sp., *Climacammina* sp, *Parastaffella timanica* Raus., *Parast. moelleri* (Ozawa) , *Pseudostaffella* ex gr. *antiqua* Dut., *Ps. antiqua posterior* Saf., *Eostaffella rotunda* Dur., *Eostaffella pseudostruvei* (Raus. et Bel.), *Semistaffella* sp., *Glomospira pusilliformis* Reitl., *Bradyina* sp. Conodonts were not found. Thickness 5.48 m.

Bed 11. Light, yellowish-gray, algal, massive-bedded (53-71 cm) limestone. Remains of crinoids, brachiopods occur. In thin sections foraminifers-algae bioturbated grain-packstone, with small crinoids. Algae: *Dvinella* sp, *Donezella* sp. Foraminifers: *Archaediscus grandiculus* Schlyk., *Semistaffella*



Fig. 50. The interlayer of bentonite clay between beds 8 and 9 in outcrop 1236

aff. *primitive* Reitl., *Eostaffella postmosquensis* Kir., *Pseudostaffella antiqua posterior* Saf., *Pseudostaffella* ex gr. *antiqua* Dut., *Millerella* aff. *uralica* Kir., *Pseudoendothyra* sp., *Biseriella* aff. *parva* (N. Tchern.), *Bradyina* sp., *Br.* aff. *cribrostomata* Raus. et Reitl. (abundant), *Climacammina* sp. Conodonts were not found. Thickness 2.70 m.

Bed 12. Light gray, oolitic limestone with plenty of detritus. Limestone is dolomitized, thick- or massive-bedded (11-48 cm). In the layers where dolomitization is stronger, the bed is represented by yellow-gray dolomite, fine- and medium-grained, with detritus (0.54 m). Remains of crinoids, echinoderm spines were found. The erosion surface of the top is marked with disintegrated weathered dolomite. In thin sections: at the bottom – crinoid rudstone. At the top – porous dolomite. Conodonts *Idiognathoides sinuatus* Harris et Hollingsworth. Thickness 1.13 m.

Bed 13. Yellowish-gray, almost white dolomite, with lenses and interlayers of organogenic detrital limestone. Dolomite is thick-bedded (28-29 cm). Remains of brachiopods and crinoids are characteristic. In thin sections: intercalation of dolomite or dolomitized mudstone with stromatolite crusts. Conodonts were not found. Thickness 0.80 m.

Asatauian Substage

Bed 14. Brown-gray organogenic detritus and algal limestone. Rocks are brecciated, with clay interlayers. Limestone is lenticular, medium- and thick-bedded (6-18 cm). Remains of brachiopods, ostracods, gastropods, bryozoans, ostracods, crinoids and algae were found. Foraminifers: *Planoendothyra* sp., *Eostaffella mutabilis* Raus., *E. postmosquensis* Kir., *E. ex gr. parastruvei* (Raus.), *Plectostaffella ex gr. varvariensis* (Brazh. et Pot.), *Ozawainella umbonata* Brazh. et Pot., *Novella* sp (? *evoluta mosquensis* Raus.), *Pseudostaffella* sp. (ex gr. *larionovae*?), *Ps. aff. nikolaevskiensis* Man., Iliyna et Serezh. Conodonts: *Idiognathoides ouachitensis* (Harlton), *Idiognathodus aljutovensis* Alekseev et al.,

Idiognathoides sinuatus Harris et Hollingsworth, *Neognathodus* cf. *atokaensis* Grayson, *Neognathodus* sp., *Hindeodus minutus* (Ellison). Thickness 1.14 m.

Bed 15. Limestone is banded, gray and dark-gray, organogenic-clastic, organogenic detrital, brecciated, with a touch of green clay, medium and thick-lenticular-bedded (12-22 cm). Interlayer of breccia is located at the base of the upper part of the bed (22 cm). Remains of brachiopods were found. In thin sections: bioturbated wackestone and spiculous-foraminifers packstone with hummocky palaeosoil surface. Conodonts were not found. Thickness 0.73 m.

Elovka Formation

Bed 16 (Fig. 51). Greenish-gray, green, pelitomorphous, thin-bedded, foliated marl and mudstone. The interlayer surface is smooth. They are interbedded with gray organogenic detrital, sludge, clayey limestone. Remains of sponge spicules, conulariid, small gastropods, crinoids, brachiopods, and fish occur. The number of limestone layers increases in the upper part of the unit. Numerous pyrite cubes occur. In thin sections: brachiopod bufflestone. The space between shells is filled with mudstone or foraminiferous grainstone. Small crinoids occur rather rarely. Foraminifers: *Eostaffella ex gr. mutabilis* Raus. (rare), *Millerella* sp., *Novella ex gr. evoluta* Grozd. et Leb., *Endothyra ex gr. similis* Raus., *Planoendothyra* sp., *Pseudoglomospira* sp. (numerous), *Biseriella* sp., *Eotuberitina plana* (Reitl.). Conodonts: *Idiognathoides fossatus* (Harris et Hollingsworth) and ramiphorm elements. Thickness 2.7 m.

The block of rocks lithologically similar with Elovka Formation was found in the debris of the bed 16. It contains conodonts of the Kashirian Substage such as *Idiognathodus aljutovensis* Alekseev et al., *Id. voltensis* Alekseev et al., *Neognathodus tsnensis* Alekseev et Gerelzezeg, *N. aff. tsnensis* Alekseev et Gerelzezeg.

Probably the boundary with the Moscovian Stage is in the upper part of the outcrop of the Elovka Formation in the Mariinsky Log section, but it has not been confirmed by biostratigraphic data.



Fig. 51. Base of the Moscovian (bed 16) in outcrop 1236



Plate 6

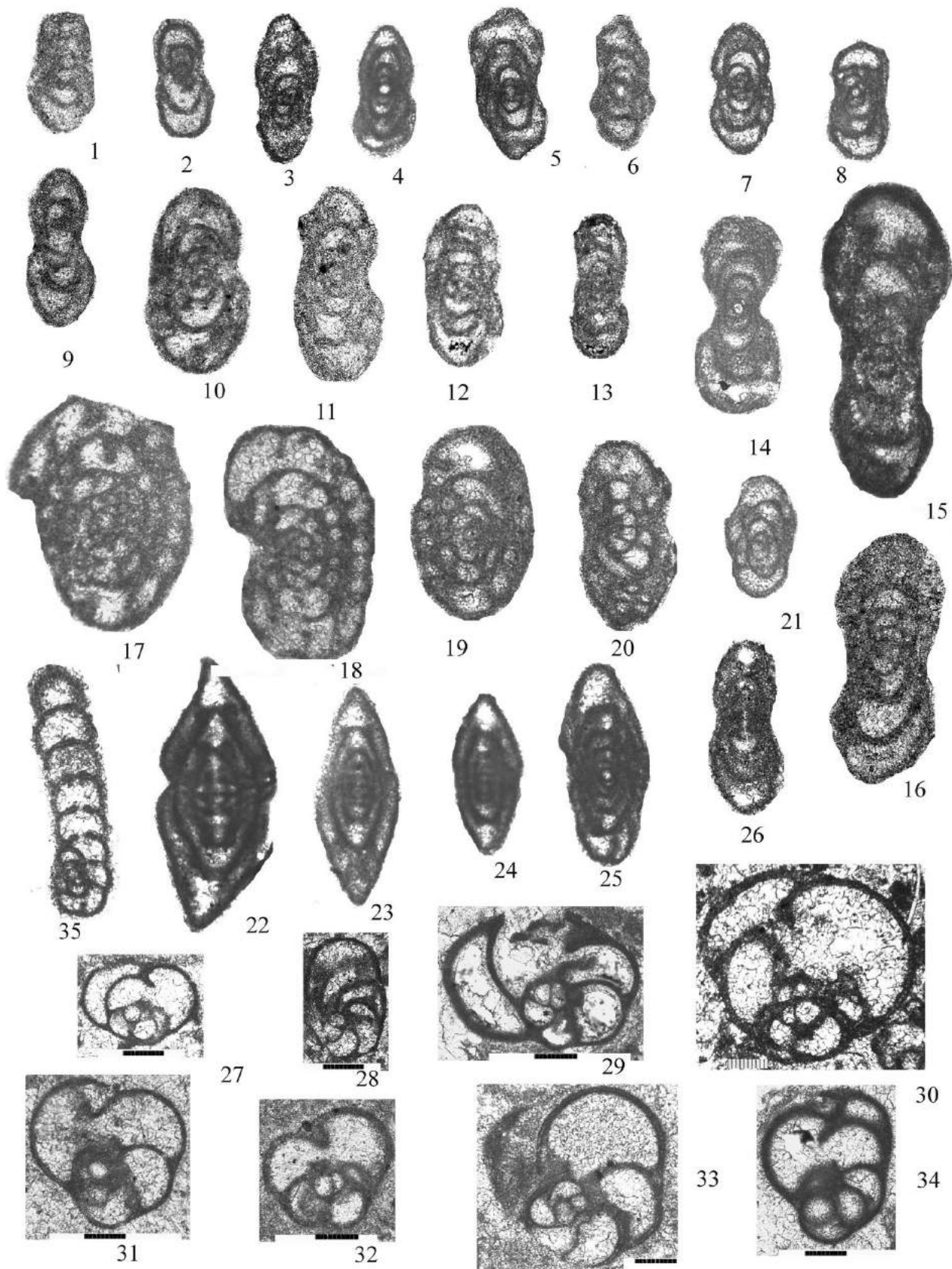
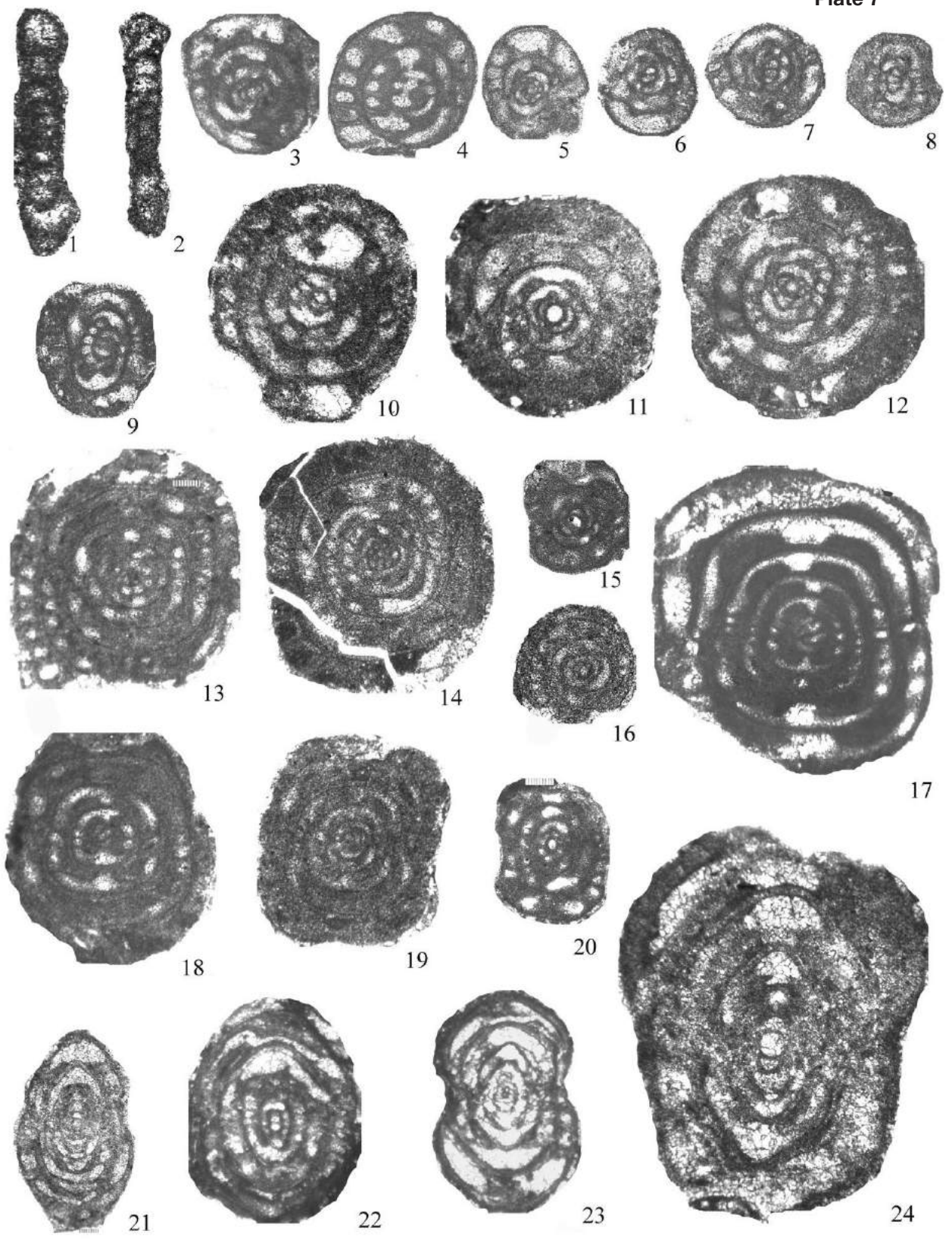




Plate 7



Explanation of Plate 6**Foraminifers**

All figures with an increase of 75

Figs. 1, 2. *Eostaffella postmosquensis* Kir. (sample 10.1, 11.1)

Figs. 3, 4. *Eostaffella postmosquensis acutiformis* Kir. (sample 11.2b, 14.1)

Figs. 5, 6. *Eostaffella pseudostruvei* Raus. (sample A-7.2)

Figs. 7, 8. *Eostaffella pseudostruvei chomatifera* Kir. (sample 11.2b)

Fig. 9. *Eostaffella pseudostruvei* (Raus. et Bel.) (sample A-5.2)

Figs. 10-12. *Eostaffella pseudoovoidea* Reitl. (sample A-2.2, A-7.2)

Fig. 13. *Eostaffella* sp. (sample 11.1)

Fig. 14. *Millerella elegantula* (Raus.) (sample 11.1)

Figs. 15, 16, 26. *Millerella variabilis* Raus. (sample A-5.2, A-2.2, 11.1)

Figs. 17-19. *Plectostaffella bogdanovkensis* Reitl. (sample A-5.2, A-7.2)

Fig. 20. *Plectostaffella* sp. (sample 11.2b)

Fig. 21. *Plectostaffella varvariensis* (Brazh. et Pot.) (sample A-8.1)

Fig. 22. *Eostaffella* ex gr. *mutabilis* Raus. (sample 14.2)

Figs. 23, 24. *Eostaffella mirifica* Brazh. (sample 14.2, 14.1)

Fig. 25. *Eostaffella* sp. (sample 14.1)

Figs. 27, 28, 31, 32. *Biseriella parva* Tchern. (sample 11.2b, A-5.2, A-2.2)

Figs. 29, 30, 33, 34. *Biseriella* aff. *moderata* Reitl. (sample A-8.1, 11.2b, A- 4.1, A-5.2)

Figs. 35. *Endothyranella gracilis* Raus. (sample 1236-16)

Explanation of Plate 7**Foraminifers**

Figures 1-20 with an increase of 50; figures 21-24 with an increase of about 30.

Figs. 1, 2. *Novella* aff. *intermedia* Raus. (sample 1236-16)

Figs. 3, 4. *Pseudostaffella antiqua* (Dut.) (sample A-7.2, 11.2b)

Figs. 5-7. *Pseudostaffella primaeva* Put. (sample 10.1, 11.2b)

Figs. 8, 9. *Pseudostaffella uralica* Kir. (sample 11.2b)

Figs. 10-12. *Pseudostaffella antiqua grandis* Shlyk. (sample A-7.2, 1236/ 10-2, 1236-11/2b)

Figs. 13, 14. *Pseudostaffella nikolaevskiensis* Man. (sample 11.1)

Figs. 15, 16. *Pseudostaffella* ex gr. *needhani* Thomps. (sample 11.1)

Fig. 17. *Pseudostaffella* aff. *quadrata* Deprat (sample 14.2)

Fig. 18, 19. *Pseudostaffella subquadrata* Grozd. et Leb. (sample 11.1)

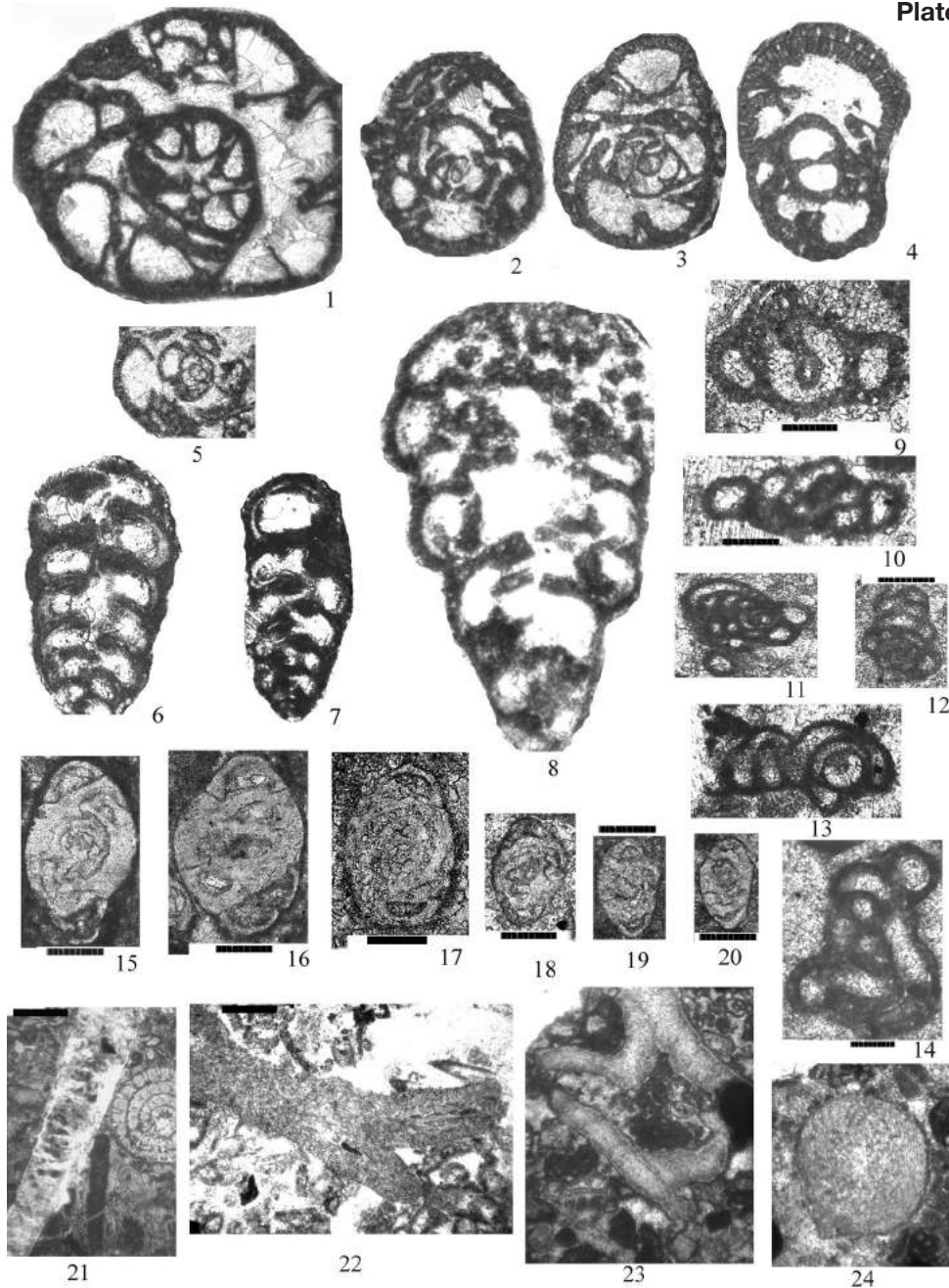
Fig. 20. *Pseudostaffella compressa* (Raus.) (sample 11.1)

Fig. 21. *Pseudoendothyra timanica* (Raus.) (sample 10.1)

Fig. 22. *Pseudoendothyra moelleri* (Ozawa) (sample 10.1)

Fig. 23. *Pseudoendothyra keltmensis* (Raus) (sample 10.1)

Fig. 24. *Pseudoendothyra bradyi* (Moell.) (sample 10.1)



Explanation of Plate 8

Foraminifers

Figs. 1-5. *Bradyina* (x20): 1 - *B. ex gr. cribrostomata* Raus. et Bel. (sample 10-3.2), 2-4 - *B. cf. pseudonautiliformis* Reitl. (sample 10-3.2, 11.1), 5- *Bradyina* sp. (sample 1236-9/2b)

Figs. 6-8. *Climacammina* sp. (sample 11.1 x50, 14.2 x50, 9.3 x40)

Figs. 9, 10. *Brunsia*(?) aff. *pseudopulchra* (Lip.), x100. (sample. 11.2b, 14.2)

Figs. 11. *Pseudoglomospira* sp., x100 (sample 1236-16)

Fig. 12, 13. *Ammovertella vaga* Reitl., x100, слой 16, обр. 1236-16)

Fig. 15, 16. *Archaediscus karreriformis* Reitl., x100, нижняя часть слоя 10, обр. 10.1)

Fig. 17. *Archaediscus* sp., x100, (sample A-8.1)

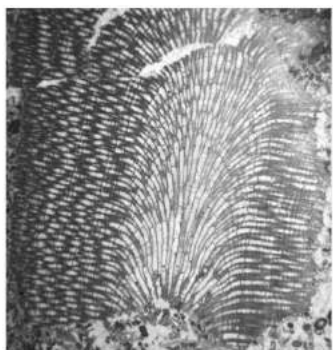
Fig. 18, 19. *Rugosoarchaediscus akchimensis* (Grozd.), x100, (sample 11.2b)

Fig. 20. *Neoarchaediscus parvus* (Raus.), x100, (sample A-8.1)

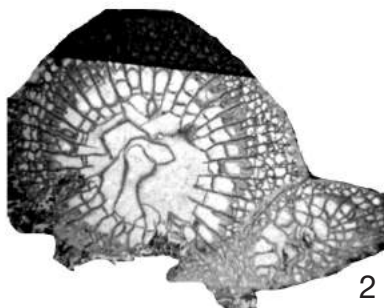
Figs. 21-24. Algae: 21 - *Dvinella* (?) sp., (sample 1236/ 10-2); 22 - *Ungdarella* sp. (sample 9.3); 23 - *Beresella* sp. (sample 10.1); 24 - *Komia* sp. (sample A- 4.1)



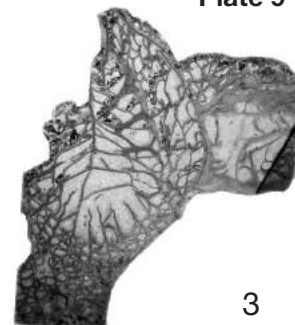
Plate 9



1



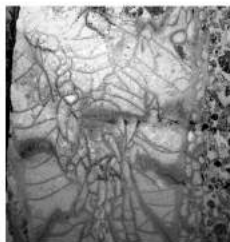
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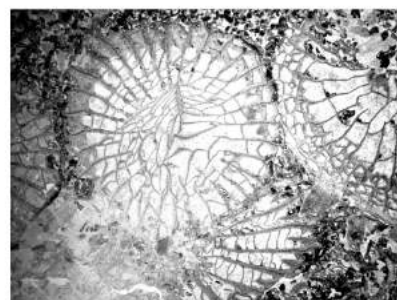
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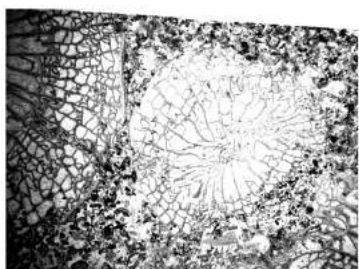
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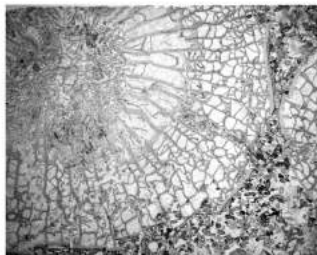
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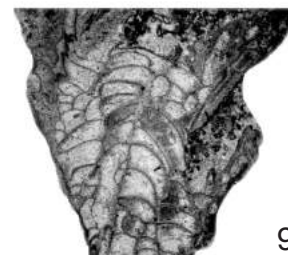
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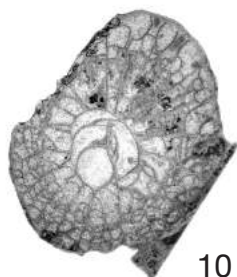
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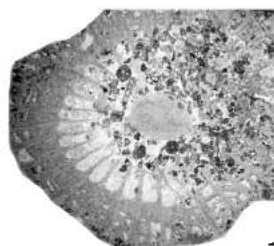
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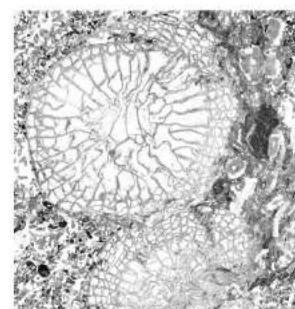
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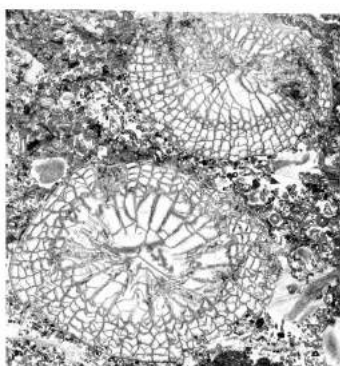
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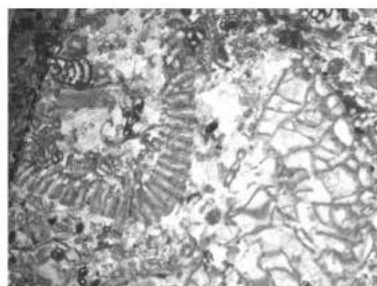
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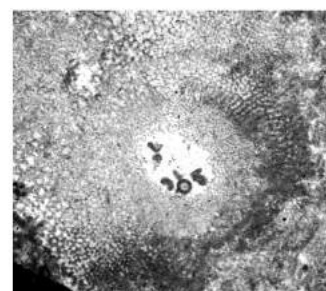
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13



14



15



Plate 9

Corals

Fig.1. *Chaetetes fisheri* Stuckenberg, Specimen 5/1, x 4, Mariinsky Log section, Quarry IV, outcrop 1236, bed 5, Mariinsky Formation, Bashkirian, Kamennogorian Regional Substage.

Fig.2 3. ? *Heintzella kosvense* (Gorsky) 2-Specimen 5/1-1 Transverse section of two corallies. X3, ,3 - specimen 5-1-1a, oblique longitudinal section from the same fragment as fig.2, x3. Mariinsky Log section, Quarry 4, outcrop 1236, bed 5, Mariinsky Formation, Bashkirian, Kamennogorian Regional Substage.

Fig. 4 -6. ? *Heintzella singularis* (Gorsky), specimen 1234-3-1, x 3. Mariinsky Log section, above the Quarry III, outcrop 1234, bed 3, Mariinsky Formation, Bashkirian, Kamennogorian or Akavassian Regional Substage.

Fig. 7, 8. *Koninckophylloides regularis* (Gorsky), specimen 1234-3-2a, x 3, Mariinsky Log section, above the Quarry III, outcrop 1234, bed 3, Mariinsky Formation, Bashkirian, Kamennogorian or Akavassian Regional Substage.

Fig. 9, 10. ? *Heintzella aff. singularis* (Gorsky) Mariinsky Log section, specimen A-3-1, x 3. Mariinsky Log section, Quarry IV, outcrop 1236, bed 3, Mariinsky Formation, Bashkirian, Kamennogorian Regional Substage.

Fig. 11. *Amygdalophylloides bashkiricus* (Gorsky), specimen 1234-3-1, transverse section x 4. Mariinsky Log section, above the Quarry III, outcrop 1234, bed 3, Mariinsky Formation, Bashkirian, Kamennogorian or Akavassian Regional Substage.

Fig. 12-13. *Heintzella stuckenbergi* (Dobr.), specimen A-6-2-2. x 3. Mariinsky Log section, Quarry IV, outcrop 1236, bed 6, Mariinsky Formation, Bashkirian, Kamennogorian Regional Substage (upper most part).

Fig. 14. Cyathopsidae gen. et sp. indet., *Heintzella sp.* x 5. Thin section 1236-8.1. Mariinsky Log section, Quarry IV, outcrop 1236, bed 8, Mariinsky Formation, Bashkirian, Akavassian Regional Substage (uppermost part).

Fig. 15. Sponge. Real size 3 mm. Magnification here – x15. Thin section 1236-8-1. Mariinsky Log section, Quarry IV, outcrop 1236, bed 8, Mariinsky Formation, Bashkirian, Akavassian Regional Substage (uppermost part).

August 19 • Stop 7

LADEYNAYA MOUNTAIN

UPPER VISEAN SERPUKHOVIAN LOWER BASHKIRIAN STRATOTYPE OF KURMAKOVSKIAN FORMATION

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Rocky outputs of Ladeinaya Mountain are part of the "Ladeiny Log" section. There are stratotypes of the local units: Ladeinian substage and Kurmakovskian formation. Due to the inaccessibility of the Kosogorian substage stratotype, section Lower Gubakha, Ladeinaya Mountain can be classified as the potential gipostatotype of the Kosogorian substage of the Lower Serpukhovian substage. Tectonically section is located in the east wing of the Main Kizel Anticline (Fig. 52).

"Ladeiny Log" section is located on the left bank of the Kosva River near Gubakha city. It includes outcrops located in the Ladeiny Ravine and the adjoining slopes of Krestovaya and Ladeinaya mountains, including the rocky outcrops of Ladeinaya Mountain itself. There Upper Visean substage rocks, full Serpukhovian stage of the Lower Carboniferous period and the base of the Bashkirian stage of the Middle Carboniferous period crop out. Beds 9-31 are cropped out in the rocky outcrops of the Ladeinaya Mountain. They are discussed below.

Section was re-examined for several times, but mostly on the samples of the old data collected in the 60s. In 2013-2014 Ladeinaya Mountain was again sampled and described. In the beds 9-31 samples for the analysis of micro fauna (conodonts - 70 samples and foraminifera - 110 samples) and geochemical investigations of organic matter (for pyrolysis) were taken. Section is marked, so there is a connection of the samples to the substages of Guide to Carboniferous of the Urals (1972). For the first time conodont characteristic of the section is received.

Carboniferous System

Visean Stage

Mikhailovsky substage

Zone *Eostaffella ikensis*

Ladeinian suite (discovered for the first time, beds 9–17.1)

Bed 9. Brown-gray, fine-grained, bituminous, massive-bedded dolomite. Thickness is 3.4 m.

Bed 10. Gray, organogenic-detrital, poor fine-grained cement, slightly silicified, bituminous, massive-bedded limestone with the remains of brachiopods, crinoids, echinoid spines and algae *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.). Characteristic foraminifers: *Earlandia vulgaris* Raus., *Archaeodiscus moelleri* Raus., *Permodiscus sp.*, *Asteroarchaeodiscus baschkiricus* (Krest. et Theod.), *A. ovooides* (Raus.), *A. rugosus* (Raus.), ***Neoarchaeodiscus parvus*** (Raus.), *Brunsia irregularis* (Moell.), *Forshia mikhailovi* Dain., *Lituotubella magna* Raus., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Mikhailovella sp.*, *Omphalotis minima* Raus., *Globoendothyra globulus* (Eichw.), *G. numerabilis* (Viss.), *Endothyranopsis crassa* (Brady), *Pojarkovella nibelis* (Durk.), *Janischewskina sp.*, *Mediocris mediocris* (Viss.), *M. ovalis* (Viss.), *Tetrataxis eominima* Raus., *Palaeotextularia longiseptata* Lip., *Cribrostomum eximiformis* (Lip.), *Cr. bradyi* (Moell.), *Eostaffella parapriscia* Durk., *E. mosquensis* Viss., *E. proikensis* Raus., *Parastaffella concinna* Schlyk., *P. schlykovae* Durk., *P. ornata* Durk. **Conodonts are not found** (1 sample). Thickness 1.0 m.

Bed 11. Gray organogenic-detrital limestone with crustified-pore cement, coral-brachiopod, slightly silicified, bituminous, massive-bedded, with the remains of brachiopods, crinoids, echinoid spines, in the upper half - oolitic limestone with fine-grained cement, with admixture of the rounded fragments. The following algae were found: *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.), *Anthracoporellopsis machaevi* Masl., *Anthracoporella insolita* R. Iv. Foraminifers: *Earlandia vulgaris* (Raus.), *Archaeodiscus moelleri* Raus., *Paraarchaeodiscus itinerarius* (Schlyk.), *Permodiscus sp.*, *Asteroarchaeodiscus baschkiricus* (Krest. et Theod.), *A. ovooides* (Raus.), *A. rugosus* Raus., ***Neoarchaeodiscus parvus*** (Raus.), *Lituotubella magna* Raus., *Forshia mikhailovi* Dain., *Endothyra bradyi* Mikh., *Omphalotis minima* Raus., *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), *Janischewskina sp.*, *Mediocris mediocris* (Viss.), *M. ovalis* (Viss.), *Endostaffella parva* (Moell.), *Palaeotextularia longiseptata* Lip., *Koskinobigerina prisca* Lip., *Eostaffella parastruvei* Raus., *E. mosquensis* Viss., *E. proikensis* Raus., *Parastaffella concinna* Schlyk., *P. bona* (Ros.), *P. struvei* (Moell.). Thickness 1.25 m.

Bed 12. Gray, oolitic with fine-grained cement limestone at the bottom, organogenic-detrital and organogenic-clotted with pore fine-grained cement and slightly silicified, massive-bedded, with the remains of algae, brachiopods (massively), crinoids, echinoid spines, rare holothurians: in the upper part there are rugose and tabulate corals. Algae are presented by: *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.), *Anthracoporella insolita* R. Iv. Foraminifers: *Earlandia vulgaris* (Raus.), *Archaeodiscus moelleri* Raus., *A. krestovnikovi* Raus., *Paraarchaeodiscus koktjubensis* (Raus.), *P. grandiculus* (Schlyk.), *Permodiscus vetustus* Dutk., *Asteroarchaeodiscus rugosus* Raus., *A. baschkiricus* (Krest. et Theod.), *A. ovooides* (Raus.), ***Neoarchaeodiscus parvus*** (Raus.), *Lituotubella magna* Raus., *Forshia mikhailovi* Dain., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Mikhailovella popleformis* Durk., *Omphalotis minima* Raus., *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), *E. cf. compressa* (Raus. et Reitl.), *Mirifica mirifica* (Raus.), *Pojarkovella sarata* Vdov., ***Janischewskina minuscularia*** Gan., *Palaeotextularia longiseptata* Lip., *Cribrostomum cribriformis* Eick., *Cr. eximiformis* (Lip.), *Mediocris mediocris* (Viss.), *M. ovalis* (Viss.), *Eostaffella parastruvei* Raus., *E. proikensis* Raus., *E. ikensis pressa* Durk., *E. mosquensis attentata* Gan., *Millerella pauperis* Durk., *Parastaffella bona* (Ros.), *P. struvei* (Moell.), *P. angulata* Raus. In the upper part (1.15 m from superface of the stratum, sample 12.5) there is algal limestone, which foraminifers found which are poorly preserved, but resembling Venev forms: *Eostaffella sp.* (cf. *tenebrosa*, no banded chromates, inherent to the group *E. ikensis*) and *Pseudoendothyra*

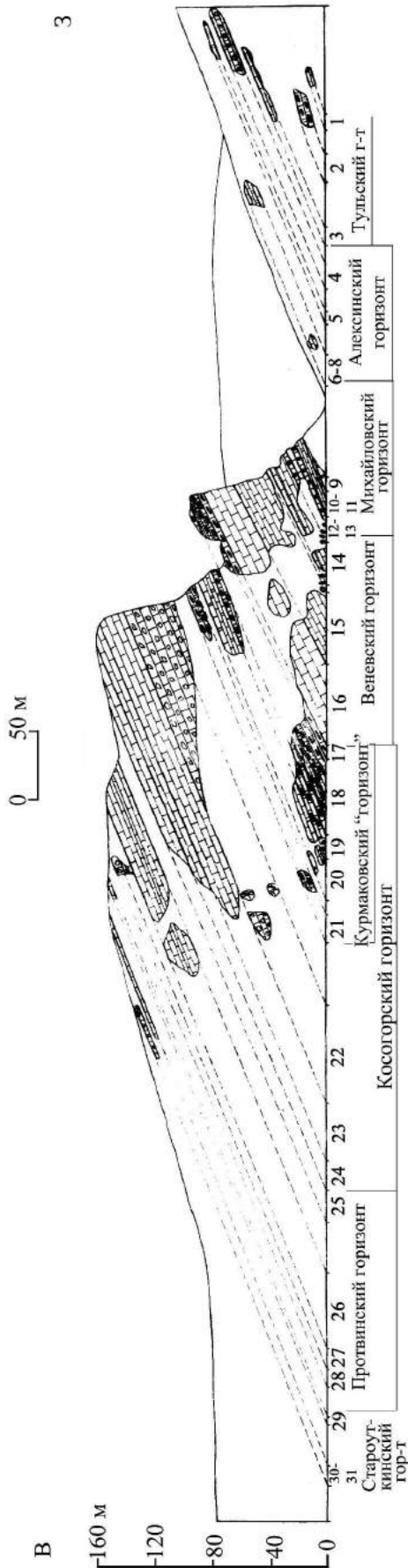


Fig. 52. Ladeiny Log section scheme



Fig. 53. Ladeinaya mountain. On the photographs one can see beds 9–12, 17–18, 22–23

cf. *averinensa* Post. (peripherals of the last whorl which are one of the diagnostic features destroyed). Thickness is (1 slab) 4.8 m.

Venev substage

Zone *Eostaffella tenebrosa* – *Endothyranopsis sphaericus*

Bed 13. Brownish-gray, organogenic-clotted limestone with pore fine-grained cement, bituminous, in the middle part argillaceous, stromatolite, silicified, massive-bedded, at the bottom thick-bedded (10-15 cm), with nodules of *Girvanella sp.*, with the remains of brachiopods, crinoids, echinoids and brittle stars. Algae *Koninckopora inflata* (Kon.). Foraminifers: *Earlandia vulgaris* (Raus.), *Paraarchaediscus convexus* (Grozd. et Leb.), *Asteroarchaediscus rugosus* Raus., *Forshia mikhailovi* Dain, *Mirifica mirifica* (Raus.), *Omphalotis infrequentis* Schlyk., *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), ***Biseriella parva*** (N. Tchern.), *Consobrinella gibbosa minima* (Lip.), *Endostaffella delicata* Ros., *En. fucoides* Ros., *Eostaffella mosquensis* Viss., ***Pseudoendothyra averinensa*** Post. *Parastaffella struvei supressa* Schlyk., *P. nautiliformis* Durk., *P. ornata* Durk., *P. composita* (Dutk. In Raus.). **Conodonts are not found** (3 samples). Thickness is 2.6 m.

Bed 14. Brownish-gray, organogenic-detrital limestone with fine- and micro-grained cement, interbedded with crinoids, brachiopods, corals, uneven bituminous with nodules of flint in the lower half thick and massive-bedded, with the remains of algae, brachiopods, ostracods, crinoids, echinoid spines and brittle stars. Identified algae are: *Calcifolium okense* Schw. et Bir., *Palaeoberesella lahuseni* (Moell.), *Anthracoporellopsis machaevi* Masl., *Anthracoporella insolita* R. Iv. Numerous foraminifers *Earlandia spp.*, *E. vulgaris* (Raus.), *Pseudoammodiscus volgensis* (Raus.), *Archaediscus moelleri* Raus., *Ar. krestovnikovi* Raus., *Paraarchaediscus convexus* (Grozd. et Leb.), *P. itinerarius* Schlyk., *Asteroarchaediscus rugosus* Raus., *Neoarchaediscus parvus* (Raus.), *N. volynicus* Vdov. *Forschia sp.*, *Forschiella prisca* Mikh., *Haplophragmina angularis* Brazhn., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *S. lenociniosa* (Schlyk.), *Mirifica mirifica* (Raus.), *Mikhailovella sp.*, *M. popleformis* Durk., *Omphalotis minima* Raus., *Om. pannusaeformis* (Schlyk.), *Globoendothyra globulus* (Eichw.), *G. aff. elegantula* Durk., *Endothyranopsis compressa* (Raus. et Reitl.), *E. crassa* (Brady), *Cribrospira mikhailovi* Raus., *Janischewskina sp.*, *Bradyina modica* Gan., *B. rotula* (Eichw.), *Consobrinella consobrina* Lip., *Palaeotextularia longiseptata* Lip., *P. brevisseptata* Lip., *Cribrostomum ex gr. eximium* (Moell.), *Cr. juditchevi* Durk., *Koskinobigerina prisca* Lip., *Tetrataxis paraminima* Viss., *T. acutus* Durk., *Mediocris mediocris* (Viss.), *Endostaffella parva* (Moell.), *E. asymmetrica* Ros., *Eostaffella ikensis* Viss., *E. proikensis* Raus., ***E. tenebrosa*** Viss., *E. mosquensis acuta* Raus., ***Pseudoendothyra carinata*** Post., *Parastaffella struvei* (Moell.), *P. angulata* Raus., *P. densa* Ros., *P. spectata* Durk. **Conodonts** are detected only at the substage's base: *Cavusgnathus sp.*, *Lochriea sp.* (only 6 samples). In the thin sections there are polybioclastic packstones and rudstones. Thickness is 19.4 m.

Bed 15. Brown-gray, organogenic-detrital limestone with pore or basal fine- and micro-grained cement, detrital-slime with basal micro-grained cement, clotted-lumpy with crustiform pore cement with nodules of cyanea, to varying degrees dolomitic, slightly bituminous, with small inclusions of fluorite with nodules and lenses of light gray flint, thick- and massive-bedded (0.27-1.0 m), with numerous algae (in all rocks), brachiopods, branched bryozoans, ostracods, crinoids, echinoid spines, tabulates, colonial rugosas; at the bottom there is brownish gray and fine grained interbed of dolomite (1.5 m). Identified algae are: *Ortonella sp.*, *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.), *Anthracoporella insolita* R. Iv., *Fourstonella irregularis* Mam. et Roux. Foraminifers: *Earlandia spp.*, *Earlandia vulgaris* (Raus.), *Pseudoammodiscus volgensis* (Raus.), *Paracaligella sp.*, *Archaediscus krestovnikovi* Raus., *A. supressus* Schlyk. forma *involuta*, *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Grozd. et Leb.), *P. grandiculus* (Schlyk.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *A. ovoides* (Raus.), *Neoarchaediscus parvus* (Raus.), ***N. regularis*** (Sulei.), *Rugosoarchaediscus agapovensis* (Iv.), *Forshia sp.*, *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *S. lenociniosa* (Schlyk.), *Mikhailovella gracilis* (Raus.), *Omphalotis tantilla* (Schlyk.), *O. minima* Raus., *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), ***E.***

sphaerica (Raus. et Reitl.), *Janischewskina typica* Mikh., *J. minuscularia* Gan., *Bradyina rotula* (Eichw.), *Pojarkovella nibelis* (Durk.), *Mediocris mediocris* (Viss.), *Endostaffella shamordini* (Raus.), *Palaeotextularia longiseptata* Lip., *P. crassa* Lip., *Cribrostomum eximiformis* Lip., *Cr. juditchevi* Durk., *Koskinobigerina prisca* Lip., *Climacammina simplex* Raus., *Biseriella parva* (N. Tchern.), *Tetrataxis acutus* Durk., *T. cf. regularis* Brazhn., *T. pusilla* Conil et Lys., *Eostaffella tenebrosa* Viss., *E. ikensis pressa* Durk., *E. interposita* Post., *E. oblonga* Gan., *E. mosquensis* Raus., *E. ex gr. parastruvei* Raus., *E. cf. constricta* Gan., *E. rotunda* Durk., *E. oldae* Durk., *E. prisca settella* Gan., *E. pseudoovoidea* Raus., *Eostaffellina irenae* (Gan.), *Pseudoendothyra carinata* Post., *P. illustria* (Viss.), *Parastaffella struvei* (Moell.), *P. struvei supressa* Schlyk., *P. nautiliformis* Durk., *P. angulata* Raus., *P. densa* Ros., *P. bella* (Ros.), *P. composita* (Dutk. in Raus.), *P. ornata* Durk. In thin sections there are polybioclastic and pelloid packstones and wackstones, to varying degrees, dolomitic. **Conodonts** found are (5 samples from the upper 6.94 m) *Syncladognathus* sp. Thickness is 15.5 m.

Bed 16. The bed consists of two rocks: 16A - the first rock thickness is 9.63 m; 16B - the second rock thickness is 2.36 m.

Rock 16A. Brownish-gray, gray, organogenic-detrital limestone with pore fine-grained cement, areas with the contrusive texture, detrital-slime with pore micro-grained cement, interbedded with organogenic-clotted with nodules of cyanea, to varying degrees dolomitic, bituminous, with inclusions of fluorite, slightly silicified, massive-bedded, with hogbacked and medium-bedded with numerous algae, tabulates, bryozoans, remains of crinoids, echinoid spines, brittle stars, brachiopods, ostracods and rare gastropods. Identified algae are: *Girvanella* sp., *Calcifolium okense* Schw. et Bir., *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.), *Anthracoporellopsis machaevi* Masl., *Nanopora fragilissima* Masl., *Exvotarissella index* (Ehren. emend Moell.), *Stacheia* sp., *Stacheoides tenuis* Petr. et Mam., *S. polytrematoides* Brady. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *Earlandia vulgaris* Raus., *Pseudoammodiscus volgensis* (Raus.), *P. priscus* (Raus.), *Archaeodiscus moelleri* Raus., *A. gigas* Raus., *A. karreri* Brady, *A. krestovnikovi* Raus., *Paraarchaeodiscus koktjubensis* (Raus.), *P. convexus* (Grozd. et Leb.), *P. grandiculus* (Schlyk.), *Asteroarchaeodiscus rugosus* Raus., *A. baschkiricus* (Krest. et Theod.), *A. baschkiricus pressulla* (Grozd. et Leb.), *A. ovoides* (Raus.), *Neoarchaeodiscus parvus* (Raus.), *N. regularis* (Sulei.), *N. volynicus* Vdov., *N. ex gr. timanicus* (Reitl.), *Rugosoarchaeodiscus agapovensis* (Iv.), *Planospirodiscus* sp., *Permodiscus vetustus* Dutk., *Haplophragmina angularis* Brazhn., *Forschia mikhailovi* Dain, *Lituotubella magna* Raus., *Similisella similis* (Raus. et Reitl.), *S. lenociniosa* (Schlyk.), *Mikhailovella uchtovica* Durk., (Raus.), *Omphalotis tantilla* (Schlyk.), *O. omphalota* (Raus. et Reitl.), *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), *E. sphaerica* (Raus. et Reitl.), *Cribrospira* sp., *Janischewskina typica* Mikh., *Bradyina rotula* (Eichw.), *Bradyina modica* Gan., *Euxinita efremovi* (Vdov. et Rost.), *Palaeotextularia longiseptata* Lip., *P. crassa* Lip., *Cribrostomum paraeximia* Lip., *Climacammina simplex* Raus., *Cl. padunensis* Gan., *Tetrataxis parviconica* Lee et Chen, *Mediocris mediocris* (Viss.), *Endostaffella shamordini* (Raus.), *En. delicata* Ros., *Eostaffella tenebrosa* Viss., *E. ikensis pressa* Durk., *E. proikensis* Raus., *E. mosquensis* Viss., *E. pseudoovoidea* Raus., *E. rotunda* Durk., *E. parastruvei* Raus., *E. schwetzovi* Gan., *Parastaffella struvei supressa* Schlyk., *P. nautiliformis* Durk., *P. angulata* Raus., *P. kerka* Durk., *Millerella rossica* Ros. In the thin sections there are polybioclastic packstones and wackstones, to varying degrees dolomitic, interbedded with close bioclastic pelloid packstones. **Conodonts** in rock 16A (lower 2.7 m) are presented by *Syncladognathus* sp., *Kladognathus* sp. total amount of conodont samples is 5. Thickness is 9.63 m.

Rock 16B. Brownish-gray, gray, organogenic-detrital limestone with pore or basal fine-grained cement, in top algal, to varying degrees dolomitic, bituminous, slightly silicified, hogbacked and heavy-bedded (12-46 cm), massive-bedded, with uneven bedding, with numerous algae, branched bryozoans, remains of crinoids, echinoid spines, brachiopods, ostracods, fish, gastropods, single rugosas and tabulates. Identified algae are: *Girvanella* sp., *Calcifolium okense* Schw. et Bir., *Koninckopora inflata* (Kon.), *Palaeoberesella lahuseni* (Moell.), *Anthracoporellopsis machaevi* Masl., *Nanopora fragilissima* Masl.,

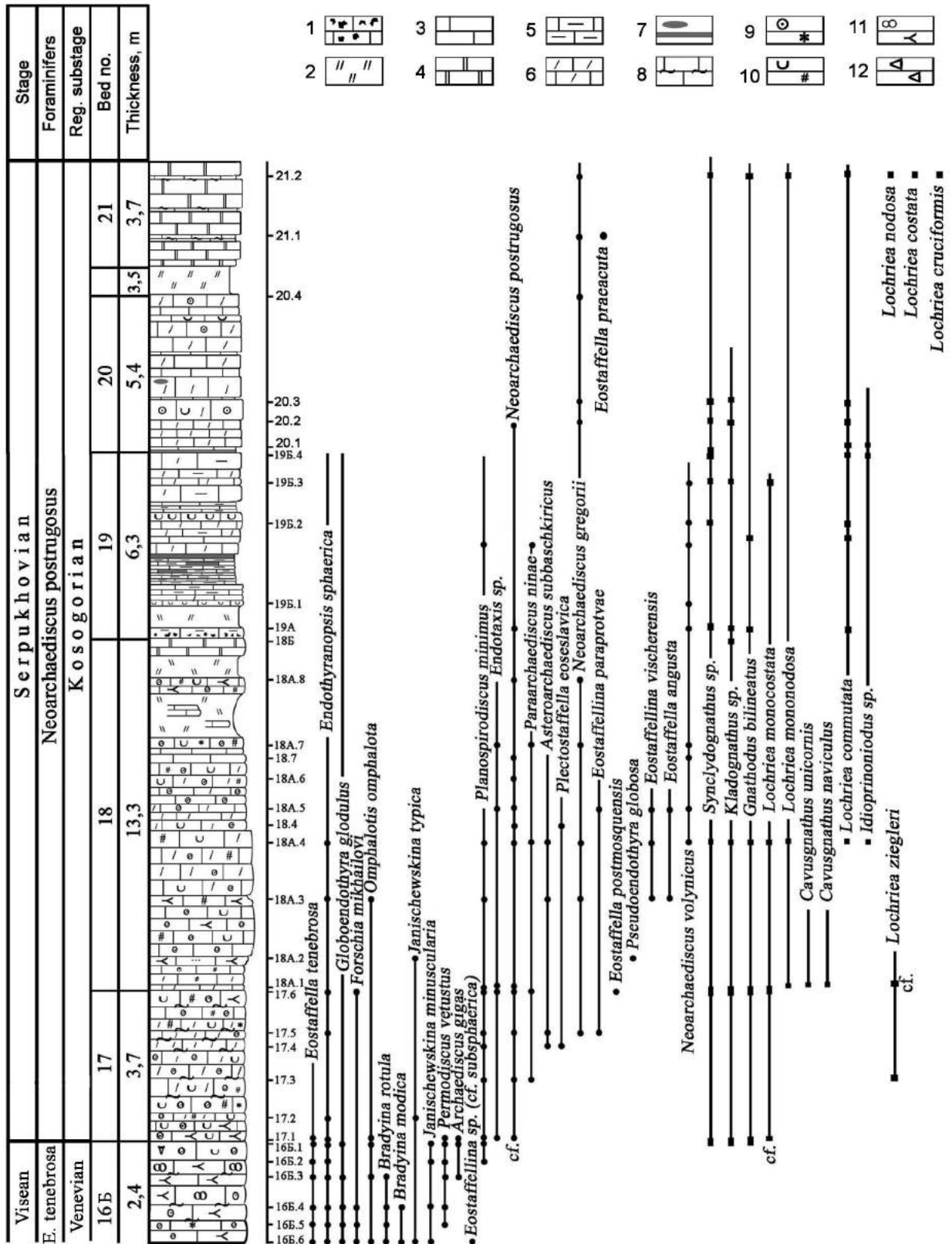


Fig. 54. Distribution of foraminifers and conodonts in the border interval of Visean and Serpukhov stages in the sections of Ladeinaya Mountain.

Legend: 1 – limestone breccia; 2 – closed intervals; 3 – limestone; 4 – dolomite; 5 – argillous limestone; 6 – slime limestone; 7 – nodules and interbeds of flint; 8 – hogbacked bedded limestone; 9 – crinoids and echinoid spines; 10 – brachiopods and bryozoans; 11 – foraminifers and algae; 12 – rogosa corals.

Exvotarissella index (Ehren. emend Moell.), *Stacheia* sp., *Stacheoides tenuis* Petr. et Mam., *S. polytrematoides* Brady. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *Earlandia vulgaris* Raus., *Pseudoammodiscus volgensis* (Raus.), *Archaediscus moelleri* Raus., *A. gigas* Raus., *A. krestovnikovi* Raus., *P. convexus* (Grozd. et Leb.), *P. grandiculus* (Schlyk.), *Asteroarchaediscus rugosus* Raus., *A. baschkiricus* (Krest. et Theod.), *A. ovoides* (Raus.), *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), ***Planospirodiscus minimus*** (Grozd. et Leb.), *Permodiscus vetustus* Dutk., ***Tubispirodiscus cornuspiroides*** (Brazhn. et Vdov.), *Rectocornuspira pseudovolgensis* Vdov., *Howchinia gibba* (Moell.), *Haplophragmina angularis* Brazhn., *Forschia mikhailovi* Dain, *Lituotubella magna* Raus., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Mikhailovella gracilis* (Raus.), *Omphalotis omphalota* (Raus. et Reitl.), *Globoendothyra globulus* (Eichw.), *Endothyranopsis crassa* (Brady), *E. sphaerica* (Raus. et Reitl.), *E. compressa* (Raus. et Reitl.), *Cribrospira* sp., *Janischewskina typica* Mikh., ***J. cf. rovnensis*** Gan., *J. minuscularia* Gan., *Bradyina rotula* (Eichw.), *Bradyina modica* Gan., *Tetrataxis parviconica* Lee et Chen, *Palaeotextularia longiseptata* Lip., *Climacammina simplex* Raus., *Cl. padunensis* Gan., *Mediocris mediocris* (Viss.), ***Eostaffella tenebrosa*** Viss., *E. proikensis* Raus., *E. mosquensis* Viss., ***Eostaffellina subsphaerica*** (Gan.), *Pseudoendothyra propinqua* Viss., ***Ps. averinensa*** Post., *Millerella rossica* Ros. **Conodonts** are rare (4 samples) and found mainly at the top of the bed: *Gnathodus bilineatus* (Roundy) juv., *Synchydogathus* sp., *Kladognathus* sp. Thickness of the rock 16B is - 2.36 m.

Thickness of the bed is 12.0 m.

Serpukhovian stage

Kosogorian substage

Zone Neoarchaediscus postrugosus

Bed 17. The base of the bed 17 (0.52 m) lithologically is similar to the rocks of the upper part of the bed 16. These are algal limestones, which higher are replaced by organogenic-detrital and detrital-slime limestones. By the presence of the Serpukhovian foraminifers *Neoarchaediscus cf. postrugosus* (Reitl.) and *Endotaxis* sp. lower border of the Serpukhovian stage is fixed at the base of the bed 17. There are defined **conodonts** *Gnathodus bilineatus* (Roundy), *Synchydogathus* sp., *Kladognathus* sp., *Lochriea* cf. *monocostata* Pazukhin et Nemirovskaya and ramiform elements.

Kurmakovskian formation

Bed 17 (upper part, plate x). Brownish-gray limestone, detrital-slime with micro-grained cement, bituminous, silicified, slightly gypsified, thick- and massive-bedded (16-58 cm), with small nodules of flint, with the remains of algae, conularias, rugosas, ostracods, inarticulate brachiopods, gastropods, bryozoans, crinoids, small echinoid spines, brittle stars (often), holothurians and fish. At the bottom part and at the top there are organogenic-fragmental limestones, fragments are weakly rounded.

Foraminifers are: *Earlandia vulgaris* Raus., *Pseudoammodiscus volgensis* (Raus.), *Archaediscus moelleri* Raus., *A. krestovnikovi* Raus., *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Grozd. et Leb.), ***P. ninae*** (Grozd. et Leb.), ***P. stilus*** (Grozd. et Leb.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), ***N. postrugosus*** (Reitl.), *N. incertus* (Grozd. et Leb.), ***N. timanicus*** Reitl., *N. latispiralis* (Grozd. et Leb.), ***N. gregorii*** (Dain), ***Planospirodiscus minimus*** (Grozd. et Leb.), *Permodiscus vetustus* Dutk., *Haplophragmina angularis* (Brazhn.), *Pojarkovella* sp., *Similisella similis* (Raus. et Reitl.), *S. lenociniosa* (Schlyk.), *Endothyranopsis ex gr. crassa* (Brady), *En. sphaerica* (Raus. et Reitl.), *Janischewskina typica* Mikh., *Euxinita efremovi* Vdov. et Rost., *Palaeotextularia longiseptata* Lip., ***Endotaxis brazhnikovae*** (Bog. et Juf.), *Eostaffella tenebrosa* Viss., *E. pseudoovoidea* Raus., *E. mosquensis* Viss., *E. constricta* Gan., *E. cf. postmosquensis acutiformis* Kir., *Eostaffellina paraprotvae* Raus., ***Plectostaffella eoselavica*** Vdov., ***Millerella cf. anfractuosa*** Post., *Millerella ex gr. lyschnjanskiensis* Brazhn., *Parastaffella ornata* (Durk.). Determined conodonts (just 6 samples): *Gnathodus bilineatus* (Roundy), *Gnathodus* sp. (narrow), *Lochriea mononodosa* (Rhodes, Austin et Druce), *L. nodosa* (Bischoff), *L. monocostata* Pazukhin et Nemirovskaya, ***L. ziegleri*** Nemirovskaya et al. (sample 17.3), *L.*



Fig. 55. Bed 16 of Ladeinaya mountain. Top of the Visean stage



Fig. 56. Bed 17 of Ladeinaya Mountain. Base of the Serpukhov stage



Fig. 57. Bed 18 of Ladeinaya Mountain

commutata (Branson et Mehl), *Vogelgnathus campbelli* (Rexroad), *Cavusgnathus* sp., *Synclydognathus* sp., *Kladognathus* sp., *Idioprioniodus* sp. Thickness is 3.07 m.

Bed 18 consists of two rocky outcrops: 18A thickness is 8 m and thickness of 18B is 0.47 m. 5 m are covered between two outcrops.

Rock 18A. Dark gray, brown-gray, detrital-slime limestone with micro-cement and fine-grained, highly bituminous, with strong smell, unevenly argillaceous, slightly silicified, with inclusions of fluorite and glauconite, thick- and middle-bedded (10-34 cm), interbedded with massive-bedded (44-72 cm), with the remains of crinoids, bryozoans, brachiopods, fish, rarely with the echinoid spines, brittle stars, conularias, spicules, fragments of colonial rugosas. Foraminifers: (plate xx): *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Grozd. et Leb.), ***P. donetzianus*** (Sosn.), ***P. vischerensis*** (Grozd. et Leb.), *P. ninae* (Grozd. et Leb.), ***Asteroarchaediscus subbaschkiricus*** Reitl., *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), ***N. timanicus*** Reitl., *N. latinspiralis* (Grozd. et Leb.), *N. volynicus* Vdov., ***N. postrugosus*** (Reitl.), ***N. gregorii*** (Dain), ***Planospirodiscus minimus*** (Grozd. et Leb.), *Rugosoarchaediscus akchimensis* (Grozd. et Leb.), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Rectocornuspira pseudovolgensis* Vdov., *Howchinia gibba* (Moel.), ***Haplobragnina beschevensis*** Brazhn., *Euxinita efremovi* Vdov. et Rost., *Mediocris mediocris* (Viss.), *Similisella similis* (Raus. et Reitl.), *Endothyranopsis compressa* (Raus. et Reitl.), *E. crassa* (Brady), *Tetrataxis* sp., ***Endotaxis brazhnikovae*** (Bog. et Juf.), *Palaeotextularia longiseptata* Lip., *Eostaffella pseudoovoidea* Raus., *E. proikensis* Raus., *E. pseudostruvei chomatifera* Kir., *Eostaffellina vischerensis* (Grozd. et Leb.), ***Plectostaffella eoseslavica*** Vdov., ***Millerella anfractuosa*** Post. **Conodonts** (9 samples): *Gnathodus bilineatus* (Roundy), *Gnathodus* sp. (narrow parapet), *Lochriea mononodosa* Rhodes, Austin et Druce, *L. nodosa* (Bischoff), *L. commutata* (Branson et Mehl), *L. monocostata* (Pazukhin et Nemirovskaya), *L. costata* (Pazukhin et Nemirovskaya), *Cavusgnathus unicornis* Youngquist et Miller, *Cavusgnathus naviculus* (Hinde), *Geniculatus* sp., *Synclydognathus* sp., *Kladognathus* sp., *Idioprioniodus* sp., ramiform elements.

Sample 18.7 (top of the the rock 18A) contains numerous remains of echinoderms, mostly fine-pore, with clearly visible stereome identical to those of sample 1237-2.1 of Mariinsky Log section. This allows a precise correlation of these two sections.

At the bottom and top of the rock 18A (samples 18A.2-18A.3 and 18A.8, Fig. 57) there are two interbeds of algal limestone with a special complex of foraminifers, where *Parastaffella* and *Pseudoendothyra* are often found and no conodonts are found: *Archaediscus moelleri* Raus., *Neoarchaediscus parvus* (Raus.), ***N. gregorii*** (Dain), *Planospirodiscus minimus* (Grozd. et Leb.), *Valvulinella lata* Grozd. et Leb., *Mediocris mediocris* (Viss.), *Pojarkovella nibelis* (Durk.), *Omphalotis* sp., *Endothyranopsis sphaerica* (Raus. et Reitl.), *Janischewskina typica* Mikh., *Tetrataxis pressula* Mal., ***Globivalvulina* sp.**, *Eostaffella pseudoovoidea* Raus., *E. rotunda* Durk., *E. pseudostruvei angusta* Kir., *Parastaffella ornata* (Durk.), *P. cf. composita* (Dutk.), *P. bona* (Ros.), ***Pseudoendothyra globosa*** Ros., ***Pseudoendothyra ex gr. parasphaerica*** Reitl., ***Ps. averinensa*** Post.

A small rocky **18B** is bedded with brown-dark gray dolomite, fine-grained, calcareous, with fragments of articulate and inarticulate brachiopods, ostracods, with remains of fish and rare conodonts *Kladognathus* sp.

In the old collections of the 1960s in bed 18 ***Eolasiiodiscus* sp.** is defined as an important form to state the lower boundary of Serpukhovian stage.

Thickness of the bed is 18 – 13.3 m.

- Out of the 20 samples of boundary interval conodonts were found in 11 of them, which are dominated by ramiform. The general appearance of conodont fauna is quite unusual. Firstly, it is dominated by small, juvenile elements. This also refers to this species of *Gnathodus bilineatus*, which usually are quite big. Secondly, there are many elements of species *Synclydognathus*, which tends to exist in the shallow water environment, for example, in Upper Kardailovka it is absent. Thirdly, typical shallow

water *Cavusgnathus* are found only in the one level in two samples in the base of the bed. Fourthly, *Gnathodus girtyi* Hass is completely absent - species that in a varying amount ubiquitously accompanies *Gnathodus bilineatus* in this stratigraphic level. Important for determining of the boundaries of the Serpukhov and Visean stages species of the genus *Lochriea* are not numerous.

Bed 19. Dark gray, brown, gray, black, micro- and fine-grained limestone with an admixture of sludge (mudstone) interbedded with sludge (wackstone), highly bituminous, argillaceous, with inclusions of fluorite, from middle- to micro-bedded, with nodules and interbed of black flint, with small crinoids, echinoid spines, articulate and inarticulate brachiopods, with remains of bryozoans, holothurians, conularias and fish. In the bottom of the bed there is fine crushed stone limestone breccia. Foraminifers are inconsiderable in number and presented by very small forms: *Neoarchaediscus parvus* (Raus.), *N. volynicus* Vdov., *Rectocornuspira pseudovolgensis* Vdov., *Endotaxis* sp. **Conodonts** are not numerous (6 samples): *Gnathodus bilineatus* (Roundy), *Gnathodus* sp. (narrow parapet), *Gnathodus* sp. juv., *Lochriea commutata* (Branson et Mehl), *L. monocostata* (Pazukhin et Nemirovskaya), *Vogelgnathus campbelli* (Rexroad), *Synchlydognathus* sp., *Kladognathus* sp.

Thickness is 6.3 m; in the lower half of substage 3 m are covered.

Bed 20. Gray, dark gray, fine- and micro-grained limestone, up through the bed it turns into slime and detrital-slime with basal cement, dolomitic, tar, with a characteristic odour, silicified limestone, from medium to massiv-bedded (8-67 cm), interbedded with fine-grained dolomite, with inclusions of fluorite and detritus of articulate and inarticulate brachiopods, conularias, crinoids, brittle stars, holothuria, small gastropods, bryozoans and fish. Foraminifers are represented by small forms: *Archaediscus krestovnikovi* Raus., *Paraarchaediscus itinerarius* Schlyk., *P. koktjubensis* (Raus.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *N. postrugosus* (Reitl.), *N. incertus* (Grozd. et Leb.), *N. gregorii* (Dain), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Rectocornuspira pseudovolgensis* Vdov., *Endostaffella asymmetrica* Ros. At the top the fixed forms appear: *Eotuberitina reitlingerae* M-Mac.,



Fig. 59. Black bituminous limestones of the bed 19 of Ladeinaya mountain. The most abyssal part of Kurmakovskian formation



Fig. 58. Foraminifers of the bed 19 of Ladeinaya Mountain: 1, 4-5. *Neoarchaediscus volynicus* Vdov. 1 - almost axial section, №. 19Б.1-2 (D= 0,1 мм); 4 - almost axial section, №. 19Б.1-2a (D= 0,12 мм); 5 - almost axial section, №. 19Б.2-1 (D= 0,12 мм). 2-3. *Rectocornuspira pseudovolgensis* Vdov., 2 -axial section, №. 19Б.1-1б (D= 0,24 мм); 3 - cross section, №. 19Б.1-1в (D=0,25 мм).

Earlandia minima Bir. In the thin sections there are bioclastic wackstones and mudstones. Conodonts are rare (3 samples in the lower half of the bed): *Gnathodus* sp. (narrow), *Lochriea commutata* (Branson et Mehl), *Vogelgnathus campbelli* (Rexroad), *Synchlydognathus* sp., *Kladognathus* sp., *Idioproniodus* sp. Thickness is 5.4 m. Upper 3.5 m. are covered.

Bed 21 (isolated rock). Yellowish-gray, fine-grained, bituminous massive-bedded (63-99 sm) dolomite, with nodules and lenses of flint and three interbeds of brownish-gray, fine fragmental, slime-detrital with micro-grained cement, placic, hogbacked bedded limestones (3-4 sm), with the remains of conularias, articulate and inarticulate brachiopods, echinoids, holothurians, brittle stars and fish. Microscopically there is dolomite and micro-bioclastic wackstone. Foraminifers are represented by: *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Groz. et Leb.), *Neoarchaediscus volynicus* Vdov., *N. parvus* (Raus.), *N. gregorii* (Dain), *Tubispirodiscus hosiensis* Cozar, *Tchuisodiscus unduliformis* Marf., *Mediocris breviscula* (Gan.), *Endostaffella parva* (Moell.), *En. delicata* Ros., *Eostaffella praeacuta* Durk., *E. proikensis* Raus., *E. schwetzovi* Gan., *Millerella infulaeformis* Gan. Conodonts are numerous (1 sample in the upper part of the rock): *Gnathodus bilineatus* (Roundy), *Lochriea commutata* (Branson et Mehl), *Lochriea mononodosa* (Rhodes, Austin et Druce), *Lochriea nodosa* (Bischoff), *Lochriea costata* (Pazukhin et Nemirovskaya), *Lochriea cruciformis* (Clarke), *Vogelgnathus campbelli* (Rexroad), *Synchlydognathus* sp. In sample 21.2 there are many well sculpted *Lochirea ziegleri* which are typical for Serpukhov stage. Thickness is 3.7 m. It is followed by a covered area (17.0 m)

Kosogorian Formation (discovered for the first time, beds 22–24)

Bed 22 is represented by thick rocky outcrop, which is clearly seen on every panoramic photo of the upper part of Ladeinaya mountain. It stretches as a monolithic wall for more than 500 m in South and North-East directions. It consists of two parts which are separated by uneven erosion surface with pockets and cuts.

Limestone breccias, light-gray, almost white, coarse fragmental, less frequently fine fragmental, massive. Fragments are angular, size of 0.4-1.5 m, less frequently 0.05-0.30 m. lithological features of fragments and cement are the same. In the thin section there are light-gray, organogenic-detrital limestones with pore or crustified pore cement with the remains of algae, brachiopods, crinoids, echinoid spines. Algae are: *Praedonezella cespeformis* Kulik., *Ungdarella uralica* Masl. Foraminifers are: *Earlandia minor* Raus., *Pseudoammodiscus volgensis* (Raus.), *P. priscus* (Raus.), *Pseudoglomospira elegans* Lip., *Archaeodiscus krestovnikovi* Raus., *Paraarchaediscus koktjubensis* (Raus.), *P. convexus* (Groz. et Leb.), *P. grandiculus* (Schlyk.), *P. stilus* (Groz. et Leb.), *Asteroarchaediscus subbaschkiricus* (Reitl.), *Neoarchaediscus parvus* (Raus.), *N. regularis* (Sulei.), *N. volynicus* Vdov., *Haplophragmina angularis* Brazhn., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Mikhailovella gracilis* (Raus.), *Omphalotis* sp., *Globoendothyra globulus* (Eichw.), *Endothyranopsis* sp., *Pojarkovella* sp., *Mediocris mediocris* (Viss.), *Palaeotextularia longiseptata* Lip., *Cribrostomum bradyi* Moel., *Cr. paraeximia* Lip., *Climacammina simplex* Raus., *Koskinobigerina prisca* Lip., *K. confusa* Durk., *Globivalvulina eogranulosa* Reitl., *Eostaffella proikensis* Raus., *E. mosquensis* Viss., *E. parastruvei* Raus., *E. constricta* Gan., *E. postmosquensis* Kir., *E. ex gr. pseudostruvei* (Raus.), *Eostaffellina paraprotvae* Raus., *Eos. actiosa* Reitl., *Pseudoendothyra illustria* (Viss.), *Ps. globosa* Ros., *Ps. parasphaerica* Reitl., *Ps. parasphaerica stricta* Reitl., *Ps. propinqua* Viss., *Parastaffella struvei* (Moell.), *P. spectata* Durk., *P. ornata* Durk., *P. nodus* Durk., *Millerella rossica* Ros. In the thin sections there are bioclastic packstones grainstones. Thickness is approximately 22 m.

Bed 23. Light-gray limestones with the yellowish shade, in the bottom half of the bed detrital-slime with fine- and micro-grained cement, in the upper half organogenic clotted with fine-grained cement, dolomitic with nodules of light-gray flint, thick- and massive-bedded (0.14-1.22 m), with nodules of cyanea, with the remains of bryozans, articulate and inarticulate brachiopods, crinoids, echinoid spines, brittle stars, holothurians and fish. Algae are: *Girvanella* sp., *Calcifolium okense* Schw.

et Bir., *Koninckopora inflata* (Kon.), *Anthracoporella baschkirica* Rulik., *Aoujgalia variabilis* Term. et Term., *Nanopora fragilissima* Masl., *Stacheoides tenuis* Petr. et Mam., *Epistacheoides* sp., *Ungdarella uralica* Masl. Foraminifers are: *Earlandia elegans* (Raus. et Reitl.), *Earlandia minor* Raus., *E. vulgaris* Raus., *Pseudoammodiscus* sp., *P. volgensis* (Raus.), *P. priscus* (Raus.), *Pseudoglomospira elegans* Lip., *Archaeodiscus krestovnikovi* Raus., *Paraarchaeodiscus convexus* (Grozd. et Leb.), ***P. vischerensis*** (Grozd. et Leb.), ***P. ninae*** (Grozd. et Leb.), *P. grandiculus* (Schlyk.), *P. stilus* (Grozd. et Leb.), *Asteroarchaeodiscus subbaschkiricus* Reitl., *Neoarchaeodiscus parvus* (Raus.), *N. regularis* (Sulei.), *N. volynicus* Vdov., ***N. postrugosus*** (Reitl.), *N. incertus* (Grozd. et Leb.), *N. timanicus* (Reitl.), ***N. gregorii*** (Dain), *N. ex gr. pohli* Browne, ***Planospirodiscus minimus*** (Grozd. et Leb.), *Rugosoarchaeodiscus akchimensis* (Grozd. et Leb.), *Haplophragmina beschevensis* Brazhn., *Endotaxis* cf. *planiformis* Brazhn., *Endothyra* ex gr. *bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Omphalotis* sp., *Globoendothyra globulus* (Eichw.), *Endothyranopsis* sp., ***Janischewskina* cf. *delicata*** Mal., *Endostaffella shamordini* (Raus.), *Palaeotextularia longiseptata* Lip., *P. crassa* Lip., *Cribrostomum* sp., *Climacammina simplex* Raus., *Cl.* cf. *padunensis* Gan., *Koskinobigerina postprisca* Brazhn. et Vinn., *Tetrataxis pusilla* Conil et Lys, ***Globivalvulina eogranulosa*** Reitl., *Eostaffella rotunda* Durk., *E. mosquensis* Viss., *E. postmosquensis* Kir., *E. pseudostruvei* (Raus.), *E. pseudostruvei angusta* Kir., *E. pseudostruvei chomatifera* Kir., *Eostaffellina protvae minima* (Grozd. et Leb.), *Pseudoendothyra illustria* (Viss.), ***Ps. illustria grandis*** Reitl., *Ps. ex gr. parasphaerica* Reitl., *Parastaffella densa* Ros. Microscopically it is represented by fine and close bioclastic wackstones, in the upper part of the bed close bioclastic and pelloid packstones. Conodonts are rare (1 sample in the bottom part of the bed): *Gnathodus bilineatus* (Roundy), *Ferganognathodus* sp., *Lochriea commutata* (Branson et Mehl), *Lochriea mononodosa* (Rhodes, Austin et Druce), *Syncladognathus* sp., *Idioproniodus* sp. Thickness is 17.2 m. Covered area is 2.2 m.

Bed 24 (isolated rock). Light-gray, almost white, yellowish, organogenic-detrital limestones with basal fine and close grained cement, dolomitic, interbedded with highly dolomitic, thick bedded (10-36 cm) with the remains of crinoids, brachiopods, ostracods, gastropods, bryozoans, there are numerous algae in the interbeds: *Calcifolium okense* Schw. et Bir., *Beresella machaevi* Kulik., *Koninckopora inflata* (Kon.), *Stacheoides tenuis* Petr. et Mam., *Stacheia* sp., *Ungdarella uralica* Masl. Foraminifers: *Earlandia elegans* (Raus. et Reitl.), *Earlandia (Quasiearlandia) vulgaris* (Raus.), *Pseudoammodiscus volgensis* (Raus.), *Archaeodiscus moelleri* Raus., *A. krestovnikovi* Raus., *Paraarchaeodiscus koktjubensis* (Raus.), *Asteroarchaeodiscus baschkiricus* (Krest. et Theod.), *A. subbaschkiricus* Reitl., *Neoarchaeodiscus gregorii* (Dain), *N. volynicus* Vdov., *N. postrugosus* (Reitl.), *N. incertus* (Grozd. et Leb.), *Planospirodiscus minimus* (Grozd. et Leb.), *Rugosoarchaeodiscus akchimensis* (Grozd. et Leb.), *Howchinia gibba* (Moel.), *Forschia mikhailovi* Dain, *Haplophragmina angularis* Brazhn., *Endothyra. bradyi* Mikh., *E. cf. pseudobradyi* Brazhn., *Haplophragmella tetraloculi* Raus., *Endothyranopsis sphaerica* (Raus. et Reitl.), *E. compressa* (Raus. et Reitl.), *Globoendothyra globulus* (Eichw.), *Janischewskina* cf. *typica* Mikh., *Mediocris mediocris* (Viss.), *Tetrataxis pusilla* Conil et Lys, *T. ex gr. parviconica* Lee et Chen., *Palaeotextularia ex gr. longiseptata* Lip., *Cribrostomum* sp., *Cr. ex gr. bradyi* Moell., *Climacammina* cf. *conquisita* Gan., *Koskinobigerina postprisca* Brazhn. et Vinn., *Biseriella parva* (N. Tchern.), *Eostaffella postmosquensis acutiformis* Kir., *E. postmosquensis compressa* Brazhn., *E. pseudostruvei chomatifera* Kir., ***Pseudoendothyra globosa*** Ros. In the thin sections there are dolomitic polybioclastic foraminifer-algae packstone, in some areas packstones grainstones. Conodonts (3 samples) are represented by the only one species: *Kladognathus* sp. Thickness of the rocks is 6.2 m. 2.6 m are covered.

Bed 25 (bottom 2.84 m). Light-gray, almost white, organogenic-detrital, slime limestones with basal fine- and close-grained cement, dolomitic, gypsified, thick- and massive-bedded (0.27-1.17 m) with the remains of crinoids, echinoid spines, holothurians, ostracodes, brachiopods and algae. Algae are: *Calcifolium okense* Schw. et Bir., *Ungdarella uralica* Masl. The amount of foraminifers is small: *Earlandia vulgaris* Raus., *Paraarchaeodiscus ninae* (Grozd. et Leb.), *P. convexus* (Grozd. et Leb.),

Planospirodiscus minimus (Grozd. et Leb.), *Endothyra bradyi* Mikh., *Rectoendothyra donbassica* Brazhn., *Endothyranopsis sphaerica* (Raus. et Reitl.), *Tetrataxis ex gr. parviconica* Lee et Chen., *Climacammina confusa* Durk. **Conodonts** (1 sample) are represented by *Hindeodella* sp.

Bottom border of the Protvin substage is fixed at the point where the sample 25.3 was taken (2.84 m from the base of the rock of the bed 25) because of the appearance of the via index *Bradyina cribrostomata* in the bed 25.

Protvian Substage

Zone *Bradyina cribrostomata*

Bed 25 (upper 3.10 m). Light-gray, almost white, organogenic-detrital limestones with basal fine and close grained cement, dolomitic, silicified, with the admixture of glauconite, massive bedded, with the remains of bryozoans, gastropods, ostracodes, brachiopods, crinoids, echonoids and holothurians. Foraminifers are numerous: *Earlandia vulgaris* Raus., *Endothyranopsis crassa* (Brady), *Bradyina cribrostomata* Raus. et Reitl., *Janischewskina delicata* Mal., *Climacammina simplex* Raus., *Eostaffella mirifica* Brazhn., *Pseudoendothyra averinensa* Post., *Parastaffella struvei* (Moell.). At the top of the bed 25 after dissolution of the conodont sample heavy residue with ore minerals is found (mainly brown iron ore). **Conodont** is represented by only one sample: *Gnathodus bilineatus* (Roundy), *Synclydogathus* sp. 10.5 m. are covered.

Bed 26. A large rocky outcrop. Light-gray, almost white organogenic clotted limestones with basal fine- and close-grained (to middle grained) cement, interbedded with organogenic clotted with pore cement clotted crumbling with crustified pore cement, in the middle part coral brachiopodal (with rugosas and big brachiopods), slightly dolomitic, slightly silicified, from middle to massive bedded (0.07-2.1 m), interbedded with yellowish-gray close-grained, loose, with nodules of cyaneas, algae, ostracodes, crinoids, echinoid spines, bryozoanes and gastropods. The following algae are found: *Ortonella* sp., *Malachovella malachovae* Mam. et Roux., *Calcifolium okense* Schw. et Bir. (sample 26, organogenic-detrital limestone), *Beresella polyramosa* Kulik., *B. machaevi* Kulik., *Stacheoides tenuis* Petr. et Mam., *Ungdarella uralica* Masl. Foraminifers are: *Earlandia vulgaris* Raus., *Pseudoglomospira elegans* Lip., *P. postserenae* Brazhn., *P. subquadrata* (Pot. et Vak.), *Tolypammmina fortis* Reitl., *Archaediscus moelleri* Raus., *Paraarchaediscus convexus* (Grozd. et Leb.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *Planospirodiscus minimus* (Grozd. et Leb.), *Haplophragmina beschevensis* Brazhn., *Endothyra irregularis* Reitl., *Endothyranopsis sphaerica* (Raus. et Reitl.), *Euxinita ex gr. efremovi* (Vdov. et Rost.), *Janischewskina delicata* Mal., *J. typica* Mikh., *Bradyina cribrostomata* Raus. et Reitl., *Consobrinella consobrina* Lip., *C. consobrina intermedia* Lip., *Palaeotextularia longiseptata* Lip., *P. crassa* Lip., *Climacammina simplex* Raus., *Cl. padunensis* Gan., *Koskinobigerina cf. confusa* Durk., *Biseriella parva* (N. Tchern.), *Globivalvulina eogranulosa* Reitl., *Eostaffella mosquensis* Viss., *E. ex gr. parastruvei* Raus., *E. subtilis* Durk., *E. angusta* Kir., *E. mirifica* Brazhn., *E. pseudoovoidea* Raus., *E. sp. (cf. postproikensis* Vdov.), *Eostaffellina ovaliformis* Meln., *Eos. subsphaerica* (Gan.), *Parastaffella struvei* (Moell.), *P. ex gr. nautiliformis* Durk., *P. ornata* Durk., *P. cf. kremenskensis* (Ros.). In the thin sections there are close bioclastic pelloid packstones - grainstones, at the top there are slightly micrified skeletal elements. Conodonts are not found.

Thickness is approximately 16 m. Up to the hil 3 m are covered.

Bed 27 (small rock). Light-gray, almost white limestones, in the bottom part organogenic clotted with fine- and micro-grained or crustified pore cement, micro- and fine-grained, organogenic detrital with fine and close grained, dolomitic, hogbacked bedded, middle-bedded (7-9 sm) with the remains of algae, echinoid spines, crinoids, brachiopods, bryozoanes and ostracodes. The following algae are found: *Dvinella secunda* Kulik., *Ungdarella uralica* Masl. Foraminifers are: *Earlandia vulgaris* Raus., *Tolypammmina fortis* Reitl., *Haplophragmina beschevensis* Brazhn., *Endothyra bradyi* Mikh., *Similisella similis* (Raus. et Reitl.), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Endothyranopsis* (?) sp., *Euxinita*

efremovi (Vdov. et Rost.), *Pojarkovella* sp., *Consobrinella* ex gr. *consobrina* Lip., *Cribrostomum eximiformis* Lip., *Biseriella parva* (N. Tchern.), *Globivalvulina* sp., *Endostaffella parva* (Moell.), *Eostaffella pseudoovoidea* Raus., *E. angusta* Kir., *E. ex gr. pseudostruvei* (Raus.). In the thin sections there are close bioclastic pelloid packstones, less frequently packstones grainstones and dolomitic polybioclastic wackestones. At the top part limestone breccias, bulky crushed stone, lentiform and massive bedded (lenses of 0.7 m). Conodont is not found (1 sample).

Thickness is 3.0 m. Approximately 3 m are covered.

Bed 28 (isolated rocky outcrop). Light-gray limestone, close clotted with fine grained cement, massive-bedded (80-85 sm), at the top part thick bedded (12 sm), at the bottom part limestone breccias with ostracodes and brachiopod spines. Foraminifers identified are: *Tolypammina fortis* Reitl., *Endotaxis brazhnikovae* (Bog. et Juf.), *Globivalvulina* ex gr. *granulosa* Reitl. In the thin sections there are pelloid packstone with bioclasts. Conodont is represented by only one sample: *Kladognathus* sp.

Thickness is 3.0m. 3 m are covered.

Staroutkinsk substage

Zone *Monotaxinoides transitorius* – *Eosigmoilina explicata*

Bed 29. At present time the bed is destroyed, there are only rock outbursts of slightly silicified light-gray striatifera bearing limestone marked accordingly. In the old samples foraminifers are identified: *Eoplectostaffella solida* Post., *Eop. acuminulata* Post., *Plectostaffella* cf. *varvariensis* Brazhn. et Pot., *Millerella anfractuosa* Post. **Conodont** is not found.

Thickness according to the “Guide...” (1972) is 2.3 m. 2 m. are covered.

Bed 30. Gray, dark-gray, organogenic-detrital, organogenic clotted, with pore fine- and close-grained cement limestones with nodules of light, pinkish flint with an admixture of green clay, middle-bedded (9-12 sm) with the remains of algae, echinoid spines, crinoids, brachiopods, bryozoans, ostracodes, fish and a few gastropods. Rocks are similar to those in the bottom part of the fourth rock between III and IV open cut mining of “Mariinsky log” section. Algae are: *Girvanella* sp., *Donezella delicata* Berch., *Beresella polyramosa* Kulik., *Ungdarella uralica* Masl., *Pseudostacheoides* sp. Foraminifers: *Palaeonubecularia uniserialis* Reitl., *Pseudoglomospira postserenae* Brazhn., *Archaediscus moelleri* Raus., *Paraarchaediscus donetzianus* (Sosn.), *P. ninae* (Groz. et Leb.), *P. convexus* (Groz. et Leb.), *P. stilus* (Groz. et Leb.), *Asteroarchaediscus subbaschkiricus* (Reitl.), *Neoarchaediscus parvus* (Raus.), *N. incertus* (Groz. et Leb.), *N. postrugosus* (Reitl.), *N. volynicus* Vdov., *Planospirodiscus minimus* (Groz. et Leb.), *Rugosoarchaediscus akchimensis* (Groz. et Leb.), ***Eosigmoilina* sp.**, *Haplophragmina variabilis* Brazhn., *Endothyra* ex gr. *obsoleta* Raus., *Similisella similis* (Raus. et Reitl.), *Endothyranopsis* ex gr. *crassa* (Brady), *Bradyina cribratomata* Raus. et Reitl., *Bradyina* sp., *Palaeotextularia longiseptata* Lip., *Globivalvulina eogranulosa* Reitl., *Endotaxis planiformis* Brazhn., *Tetrataxis* cf. *regularis* Brazhn., *T. cf. acuta* Durk., *E. postmosquensis acutiformis* Kir., *E. mutabilis* Raus., *E. chomatifera* Kir., *E. pseudoovoidea* Raus., ***Millerella anfractuosa*** Post. Conodonts are (2 samples): *Gnathodus bilineatus* (Roundy), *Lochriea* sp., *Kladognathus* sp., *Gnathodus* cf. *bilineatus* – 2, *G. cf. bollandensis* – *G. postbilineatus* – 5, *Lochriea monodosa* – 1, *L. ziegleri* – 1, *L. sp. indet.* – 1, *Sybclidognathus* sp. – 2, *Kladognathus* sp. – 2, *Idioproniodus* sp. – 1, ramiforms – 20, fragments – 11. Thickness is 2.4 m.

After a covered area of 1.7 m there is bed 31, which finishes Ladeinaya mountain.

Middle part

Bashkirsky stage

Akvas substage

Zone *Pseudostaffella antiqua*

Bed 31. Brown-gray, organogenic clotted limestone with nodules of cyaneas, in the middle part stromatolithic, with bitum on the stiolites and admixture of flint, with inclusion of greenish-gray clay, gypsum, middle- and thick-bedded (7-20 sm), interbedded with limestone breccias. Out



of foraminifers bilocular forms predominate. The identified foraminifers are: *Earlandia minima* Bir., *Tolypammia fortis* Reitl., *Pseudoglomospira subquadrata* (Pot. et Vak.), *Asteroarchaediscus baschkiricus* (Krest. et Theod.), *Neoarchaediscus parvus* (Raus.), *N. postrugosus* (Reitl.), *N. incertus* (Grozd. et Leb.), *N. gregorii* (Dain), *Tubispirodiscus cornuspiroides* (Brazhn. et Vdov.), *Planoendothyra spirilliniformis* (Brazhn. et Pot.), *Endotaxis brazhnikovae* (Bog. et Juf.), ***Globivalvulina ex gr. mosquensis*** Reitl., *G. kamensis* Reitl., *G. scaphoidea* Reitl., *Palaeotextularia ex gr. angusta* Reitl., *Climacammina volgensis* Reitl., *Mediocris evolutis* Ros., *Eostaffella angusta* Kir., *Eostaffellina paraprotvae* Raus., *Plectostaffella cf. evolutica* Rum., ***Millerella umbilicata*** Kir., *Semistaffella sp.*, ***Pseudostaffella antiqua*** (Dotk.), *Parastaffella cf. mathildae* (Dutk.), *P. ex gr. struvei* (Moell.), *P. struvei umbilicata* Raus. *Brachiopods* *Choristites ex gr. bisulcatiformis* Semich., *Ch. ex gr. mansuyi* Chao. **Conodonts** are not found (1 sample).

Thickness is 2.8 m.

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1. **Guidebook** of stratigraphic excursions to Carboniferous the Urals. The western slope of the Middle Urals, Kosva route. Perm, 1972. 110 p.

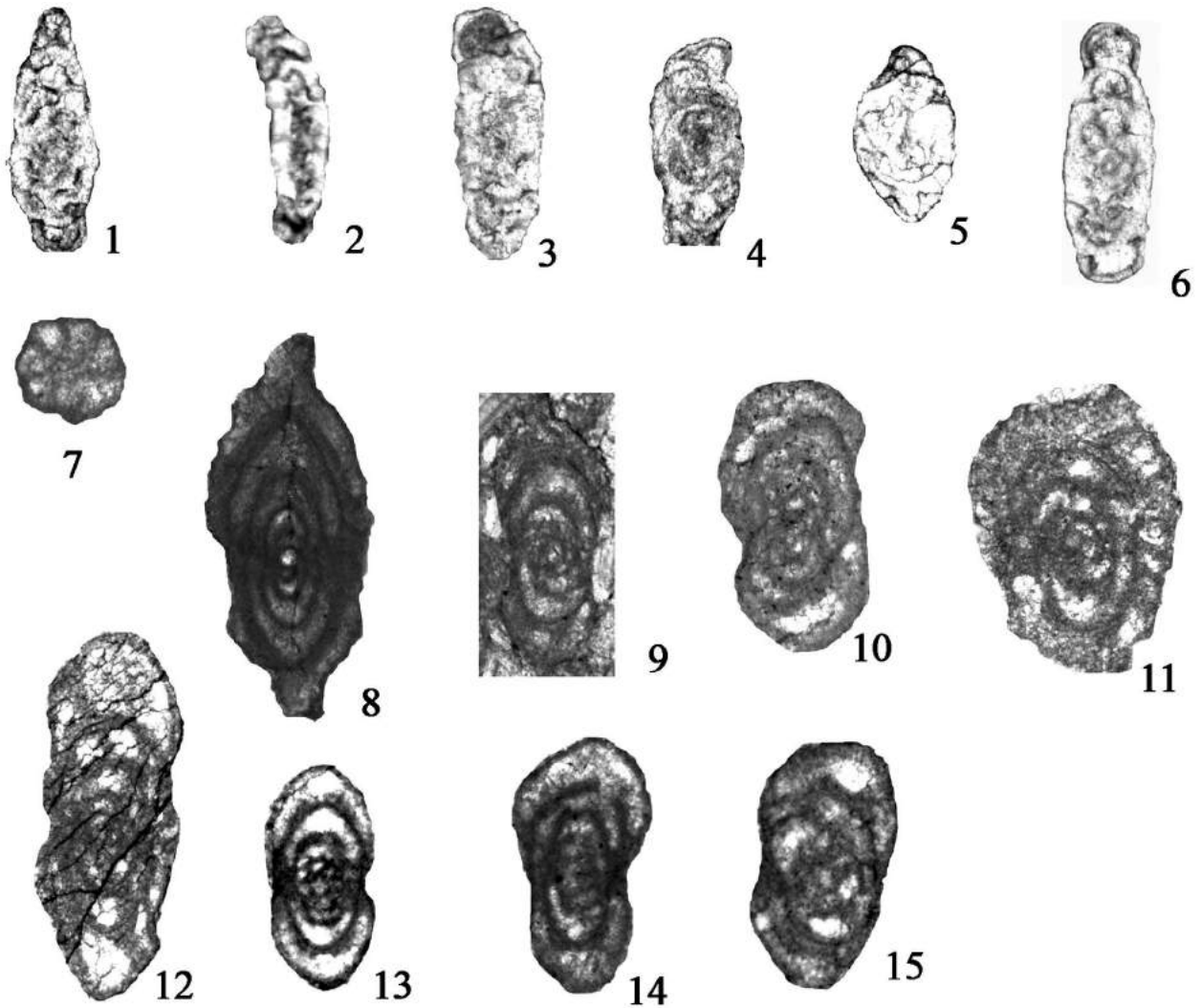


Plate 10. Foraminifers from the bed 17 (Kurmakovskian Formation) of the Ladeinaya section.

Fig. 1. *Neoarchaediscus* cf. *postrugosus* (Reitl.), № 17.1-1, subaxial section, D = 0,25 mm.

Fig. 2. *Planospirodiscus minimus* (Grozd. et Leb.), № 17.3-2, subaxial section, D = 0,15 mm.

Figs. 3, 6. *Neoarchaediscus postrugosus* (Reitl.); fig. 3 - subaxial section, № 17.3-3, D = 0,17 mm; fig. 6 - axial section, № 17.6-1, D = 0,38 mm.

Fig. 4. *Paraarchaediscus niniae* (Grozd. et Leb.), № 17.3-4, subaxial section, D = 0,31 mm.

Fig. 5. *Astroarchaediscus baschkiricus* (Krest. et Theod.), № 17.4-4, subaxial section, D = 0,26 mm.

Fig. 7. *Endotaxis* cf. *brazhnikovae* (Bog. et Juf.), № 17.1-2, sagittal section, D = 0,16 mm.

Fig. 8. *Eostaffella tenebrosa* Viss., № 17.1-3, axial section, D = 0,56 mm.

Fig. 9. *Millerella* ex gr. *lyschnjanskiensis* Brazhn., № 17.4-2a, axial section, D = 0,32 mm.

Fig. 10. *Plectostaffella eoseslavica* Vdov., № 17.4-6, axial section, D = 0,34 mm.

Fig. 11. *Pseudoendothyra globosa* Ros., № 17.5-3, subaxial section, D = 0,34 mm.

Fig. 12. *Millerella* cf. *anfractuosa* Post., № 17.6-3, subaxial section, D = 0,51 mm.

Figs. 13, 14. *Eostaffella postmosquensis acutiformis* Kir., fig. 13 - axial section, № 17.6-4, D = 0,32 mm; fig. 14 - subaxial section, № 17.6-4a, D = 0,33 mm.

Fig. 15. *Euxinita efreмовi* Vdov. et Rost., № 17.4-3, axial section, D = 0,26 mm.

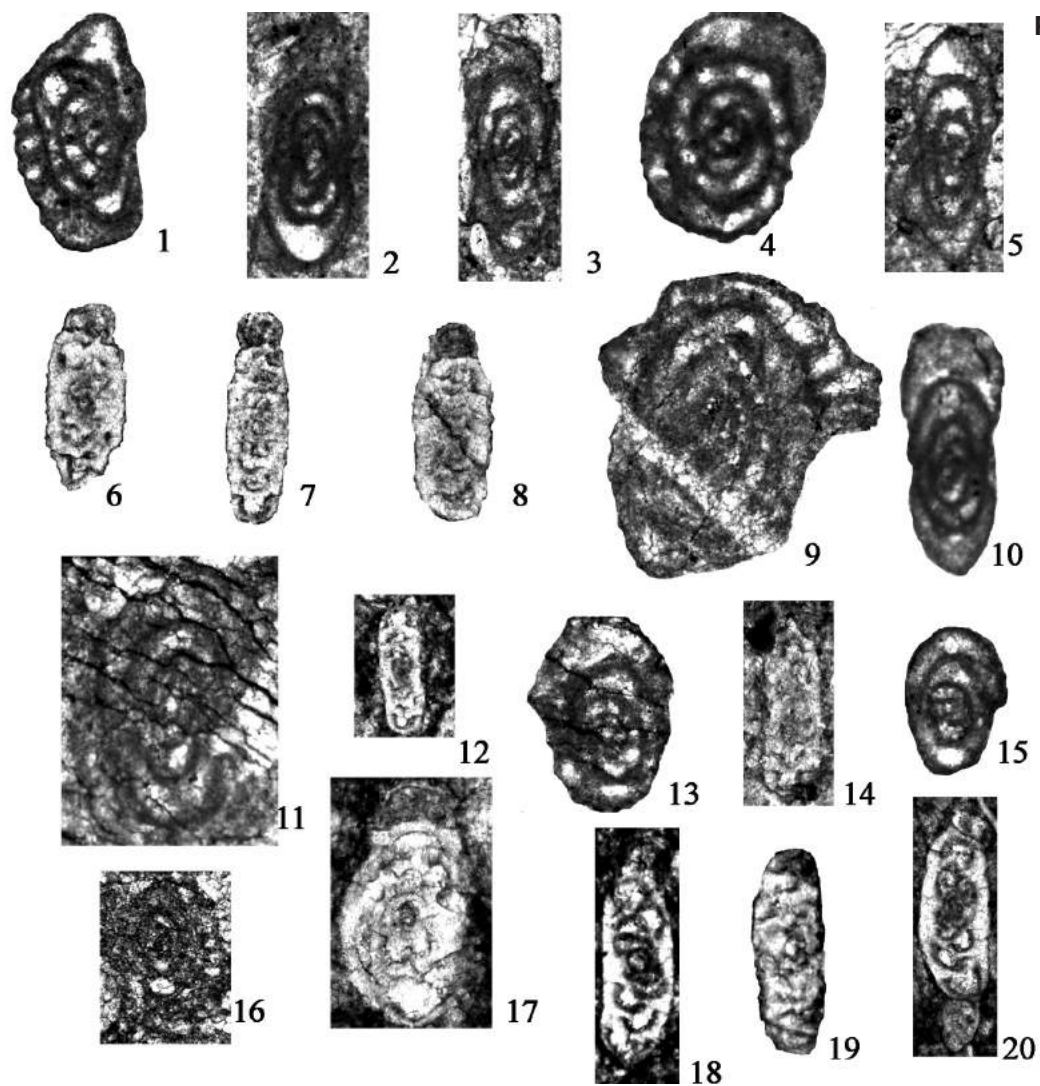
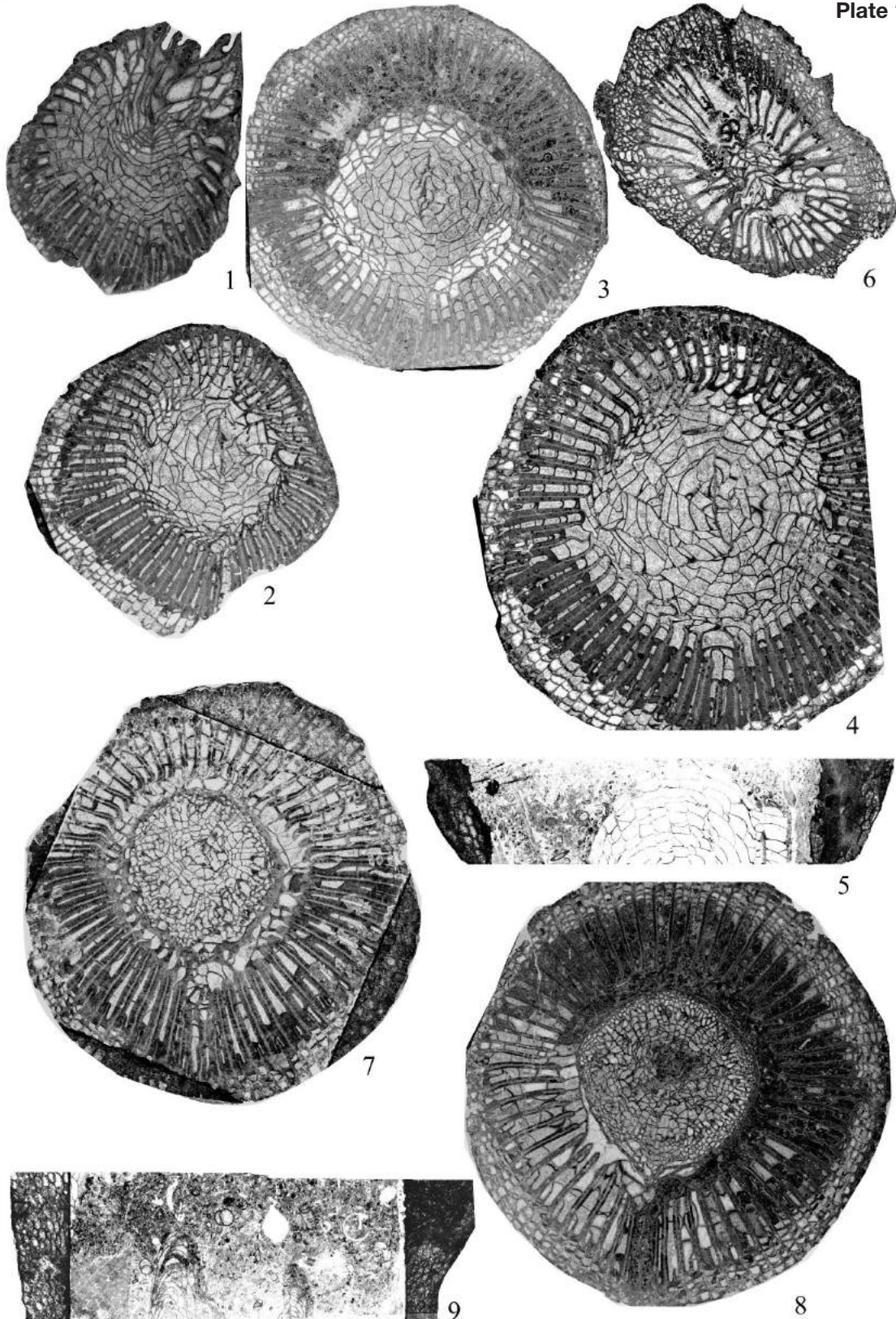


Plate 11. Foraminifers from the bed 18 (Kurmakovskian Formation) of the Ladeynaja section.

- Fig. 1.** *Plectostaffella eoseslavica* Vdov., № 18.4-3, subaxial section, D = 0,37 mm.
- Fig. 2.** *Eostaffella pseudostruvei chomatifera* Kir., axial section, № 18A.1-2, D = 0,36 mm.
- Fig. 3.** *Millerella anfractuosa* Post., №18A.1-4, axial section, D = 0,43 mm.
- Fig. 4.** *Dainella* sp., № 18A.1-7, subaxial section, D = 0,32 mm.
- Figs. 5, 10.** *Eostaffella pseudostruvei angusta* Kir.; fig. 5 – subaxial section, № 18A.3-1, D = 0,33 mm; fig. 10 – subaxial section, № 18A.3-4, D = 0,42 mm.
- Figs. 6–8.** *Neoarchaediscus postrugosus* (Reitl.); fig. 6 - axial section, № 18A.1-3, D = 0,33 mm; fig. 7 - axial section, № 18A.1-5, D = 0,33 mm; fig. 8 - subaxial section, № 18A.1-6, D = 0,27 mm.
- Fig. 9.** *Pseudoendothyra globosa* Ros., № 18A.2-1, axial section, D = 0,58 mm.
- Fig. 11.** *Pseudoendothyra* ex gr. *parasphaerica* Reitl., № 18A.2-10, subaxial section, D = 0,57 mm.
- Fig. 12.** *Planospirodiscus minimus* (Grozd. et Leb.), № 18A.3-3, axial section, D = 0,19 mm.
- Fig. 13.** *Eostaffellina paraprotvae* Raus., № 18A.3-5, axial section, D = 0,32 mm.
- Figs. 14, 19.** *Neoarchaediscus gregorii* (Dain); fig. 14 - subaxial section, № 18A.3-6, D = 0,28 mm; fig. 19 – axial section, № 18A.4-3, D = 0,15 mm.
- Fig. 15.** *Eostaffellina vischerensis* (Grozd. et Leb.), № 18A.4-2, axial section, D = 0,20 mm.
- Fig.16.** *Pseudoendothyra averinensa* Post., № 18A.2-4, axial section, D = 0,30 mm.
- Fig. 17.** *Asteroarchaediscus subbaschkiricus* Reitl., № 18A.3-7, axial section, D = 0,32 mm.
- Figs. 18, 20.** *Tchuisodiscus unduliformis* Marf.; fig. 18 – axial section, № 18.4-2a, D = 0,32 mm; fig. 20 – subaxial section, № 18A.4-2a, D = 0,31 mm.



Corals

Fig. 1-5. *Auloclisia* sp. x3. Ladeiny Log section. Collection of Galina Ponomareva, 2013. Upper Visean.

Fig.6. *Koninckophylloides* sp. Mariinsky Log section, Quarry 4, outcrop 1236, bed 5, Mariinskyi Formation, Bashkirian, Kamennogorian Regional Substage.

Fig. 7-9. *Aulophyllum fungites* (Fleming) x3. Ladeiny Log section Collection of Galina Ponomareva, 2015. Upper Visean



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