Bashkirian conodonts of the Donets Basin, Ukraine

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The present study reports upon the conodont fauna of the Upper Serpukhovian through Lower Moscovian of the Donets Basin, Ukraine. Three new species are described: *Declinognathodus? pseudolateralis, Idiognathodus praedelicatus* and *Idiognathoides postsulcatus.* The relatively continuous, rhythmic succession of shales, siltstones and sandstones, with limestone interlayers and coal seams contains a wide variety of fossils: foraminifers, conodonts, brachiopods, ostracods, corals, gastropods, ammonoids, crinoids, bivalves, bryozoans, plant remains etc. It is therefore the key or standard section for interregional and intercontinental correlations. Additionally, the Bashkirian Stage is significant in Late Carboniferous conodont evolution as during this interval all of the Late Carboniferous and Early Permian genera originated.

At the Mid-Carboniferous boundary almost all of the Early Carboniferous conodont genera became extinct. The descendants of the Early Carboniferous genus *Gnathodus* appeared. The species of *Declinognathodus* and *Idiognathoides*, which derived from the *Gn. bilineatus* s.l.-*Gn. postbilineatus* lineage, radiated and were widespread throughout the Bashkirian and Early Moscovian. *Neognathodus* species, which possibly originated from *G. girtyi* s.l., appeared a little later and played a subordinate role in the Donets Basin. In the middle of the Bashkirian, or a little earlier, *Idiognathodus* and then *Streptognathodus* joined the above-mentioned genera. They dominated from Moscovian through Early Permian times.

The Bashkirian conodonts in the Donets succession are diverse, but *Idiognathoides* species prevail. As *Idiognathoides* seems to have had a broad environmental adaptibility it may have a correlative value together with other important Bashkirian conodonts, and thus increase the potential of the Donets Bashkirian section as a bridge for the correlation between Western and Eastern Europe, America and Asia.

Ten conodont zones are distinguished here as follows: 1) *Gn. bilineatus bollandensis-Ad. unicornis*, 2) *Gn. postbilineatus*, 3) *Decl. noduliferus*, 4) *Id. sinuatus-Id. sulcatus*, 5) *I. sinuosus-Id. sulcatus parvus*, 6) *Str. expansus*, 7) *Id. tuberculatus-Id. fossatus*, 8) *Decl. marginodosus*, 9) *Decl. donetzianus*, and 10) *Str. transitivus*.

The first two zones with the subjacent *Lochriea ziegleri* Zone comprise the Serpukhovian, the next six zones, starting with the *Decl. noduliferus* Zone, correspond to the Bashkirian, and the last two of those belong to the Early Moscovian, although the conodonts of the *Decl. donetzianus* Zone resemble the latest stage of the Bashkirian conodont evolution.

The lower boundary of the Bashkirian Stage coincides with the Mid-Carboniferous Boundary as defined by the appearance of *Decl. noduliferus* s.l. (Lane & Manger, 1985; Nemirovskaya & Nigmadganov, 1994; pers. commun. of Rich Lane, August, 1998) and is drawn at the base of the limestone D_5^8upper (Nemirovskaya et al., 1990).

The upper boundary of the Bashkirian in the Donets Basin is drawn at the base of limestone K_3 of the C_2^5(K) Suite. This suite (formation) contains the same conodont association as the Vereisky Horizon of the Moscow Syneclise and the Asatausky and Vereisky horizons of the Bashkirian stratotype, South Urals. It might probably be correlated with the Aegiranum Marine Band (basal Bolsovian or basal Westphalian C) of Western Europe. The uppermost Bashkirian/Lower Moscovian deposits of the Donets Basin seem to correspond to the Atokan of North America.

Contents

Introduction

The Donets Basin is part of a large geological structure at the southern margin of the East-European Platform known as the Don-Dnieper Downwarp (aulacogene) (Figs.1-2). It is the only area in Eastern Europe where the whole of the Carboniferous, and the Middle Carboniferous in particular, are well exposed.

The Bashkirian of the Donets Basin is represented by thick terrigenous strata of interbedded argillites, siltstones and sandstones with thin limestone interlayers and coal seams. According to the Resolution of the Interdepartmental Regional Stratigraphic Meeting (Kagarmanov & Donakova, 1990), it embraces the interval between the limestone D_5^{10} of the C_1^4(D) Suite, or the uppermost part of the Zapaltyubinsky Horizon, and the limestone K_3 of the C_2^5(K) Suite, that is the base of the Vereisky Horizon. The thickness is from 1000-1200 m in the west to 2500-4000 m in the east. The Bashkirian deposits contain rich assemblages of various marine and fresh-water fossils as well as plant remains. The conodonts are widely distributed throughout the section. They were documented for the first time in the seventies when Professor Aisenverg organised the conodont studies of the whole of the Carboniferous in the Donets Basin (Nemirovskaya, 1974; Aisenverg et al., 1976; Nemirovskaya, 1978; Kozitskaya et al., 1978). Since that time very little has been published concerning the Middle and Upper Carboniferous conodont biostratigraphy, as all attention was focused on the Mid-Carboniferous Boundary or the Lower Bashkirian. Nevertheless, the preliminary conodont zonation of the Donets Bashkirian was worked out and used in various papers (Nemirovskaya, 1982, 1983, 1987; Nemirovskaya & Nigmadganov, 1994; Poletaev et al., 1990; Barskov et al., 1987).

The lower boundary of the Bashkirian coincides with the Lower/Middle Carboniferous boundary of the Soviet Scheme. The position of this boundary and the scope of the Bashkirian Stage were the subject of much discussion for many years. It should be noted that soon after the Bashkirian Stage was established in the Mountainous Bashkiria, South Urals by Semikhatova (1934) as the Carboniferous beds underlying the deposits of the Moscovian Stage and characterized by coarse-ribbed *Choristites*. Rotai (1941, 1956) proposed as an alternative in the Donets Basin the Kayalsky Stage, which was regarded as the interval between the Namurian and Moscovian strata,

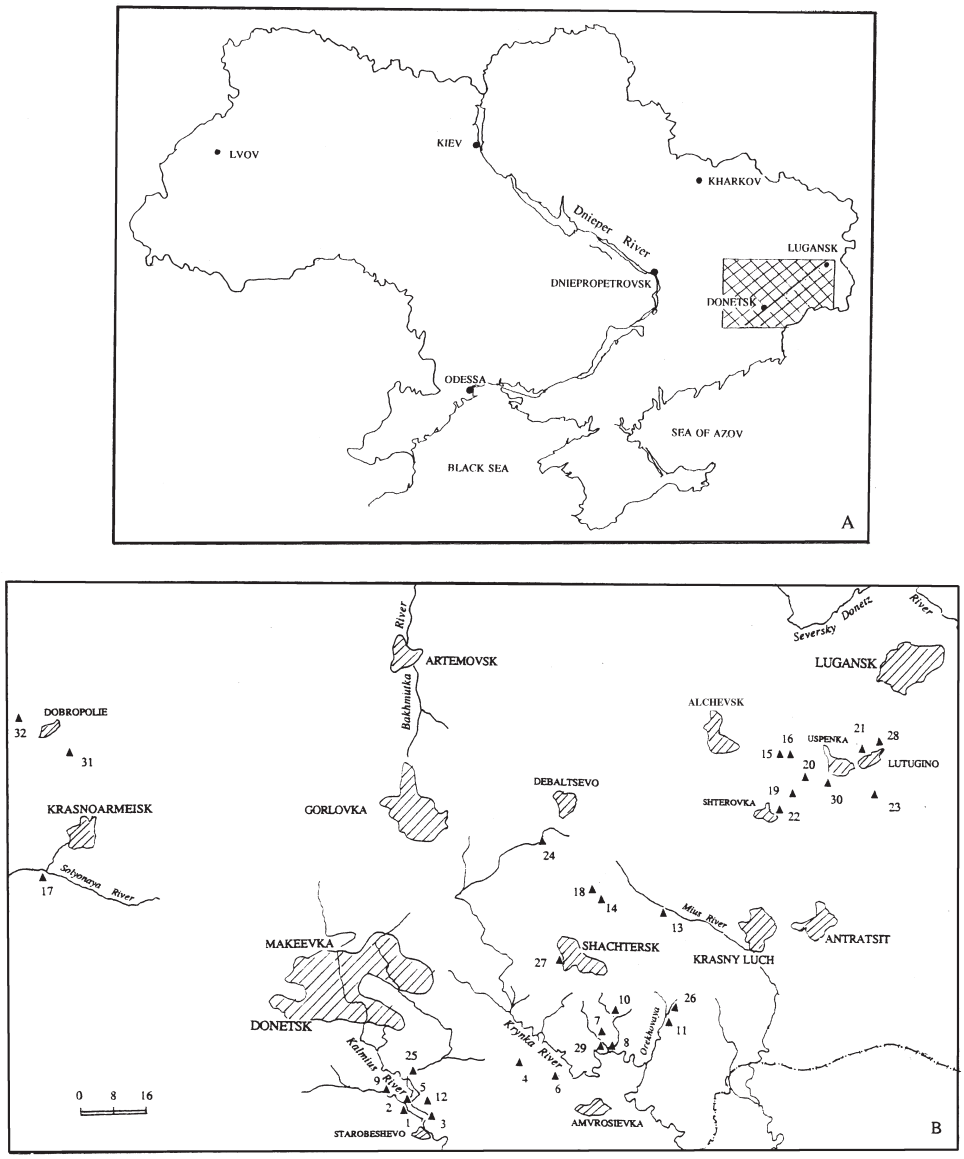


Fig. 1. Generalized map showing the studied area of the Donets Basin with uppermost Serpukhovian, Bashkirian and lowermost Moscovian deposits; A: area of investigation; B: location of the most important sections sampled.

including the C_2^1(F), C_2^2(G), C_2^3(H), C_2^4(I), and C_2^5(K) suites, i.e. Kinderscoutian through Bolsovian stages (by Rotai, the Bolsovian, i.e. Westphalian C, was not considered at that time). The result of the long-term discussions was in favour of the Bashkirian Stage which was accepted and included later in the International Unified Classification of the Carboniferous (Einor, 1955; Einor et al., 1979). The position of its

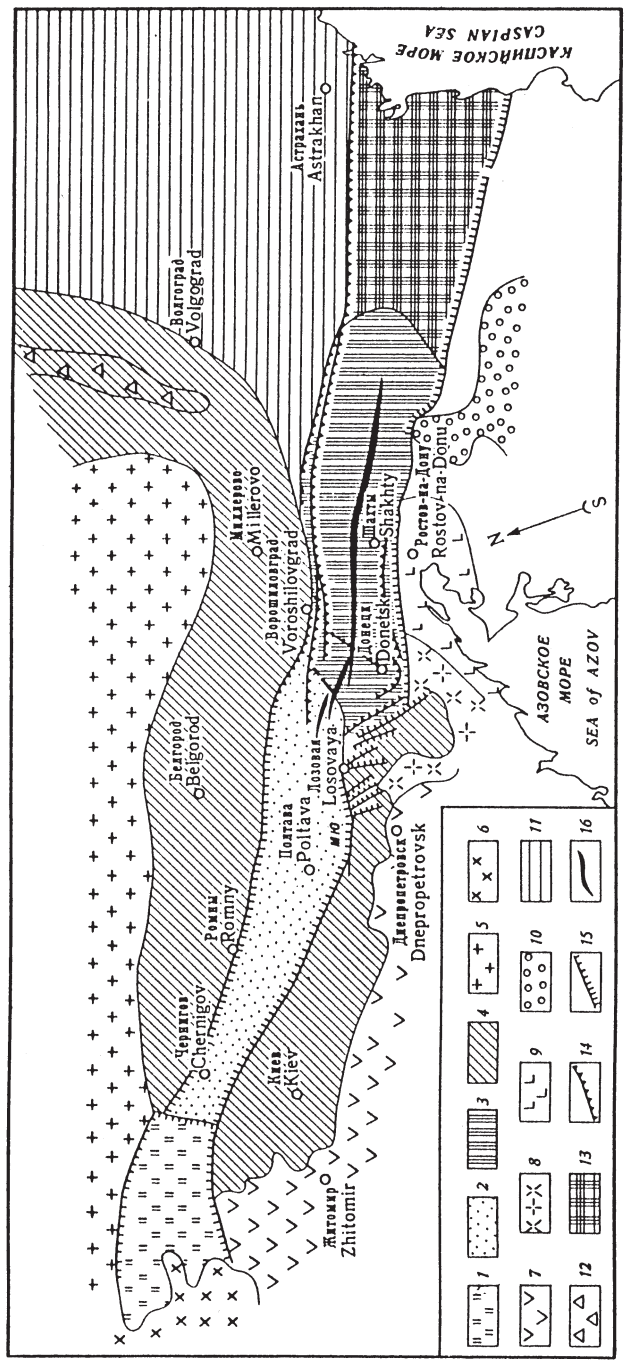


Fig. 2. Sketch of the Don-Dniepr Downwarp; 1: Pripyat trough; 2: Dnieper graben (Dnieper-Donets Depression); 3: Donets folded area; 4: flanges of the downwarp (platform slopes); 5: Voronezh Crystalline Massif; 6: Pripyat Anteclise; 7: Ukrainian Crystalline Shield; 9: Azov Anticline; 10: Stavropol Anticline with the Salsky projection; 11: North Caspian Syneclise; 12: Don-Medveditsky Arch; 13: Karpinsky Arch ('val Karpinskogo'); 14: overthrusts; 15: other dislocations (mainly faults); 16: Glavnaya (Principal) Anticline (Field excursion Guidebook for the Donets Basin, 1975; Voroshilovgrad = Lugansk).

lower boundary has been changed many times (Einor, 1992). In 1974 the Interdepartmental Stratigraphic Committee of the USSR abolished the Namurian Stage in favor of the Serpukhovian with the upper boundary at the base of the *Reticuloceras* Zone.

The Donets Basin was one of the first regions where the significant faunal turnover within the Namurian or Serpukhovian was recognised (Brazhnikova, unpubl. report; Nemirovskaya, 1974; Aisenverg et al., 1976) and the only region in Eastern Europe where the Upper Serpukhovian is complete. In 1983 the Mid-Carboniferous Boundary, that divides the Carboniferous into two parts and coincides with the Mississippian/Pennsylvanian boundary, was established between the Arnsbergian and Chokierian stages or at the bounary between the *Eumorphoceras* and *Homoceras* ammonoid zones and determined by the first appearance of the conodont *Declinognathodus noduliferus* (Lane & Manger, 1985). Since then the boundary between the Serpukhovian and Bashkirian in the Donets Basin has been changed to the lower position. It is now defined by the first appearance of *Declinognathodus noduliferus* s.l. (Nemirovskaya, 1987), and occurs in the uppermost part of the Zapaltyubinsky Subhorizon of the Ukrainian Carboniferous Stratigraphic Scheme (1992), or the Zapaltyubinsky Horizon of the General Stratigraphic Scheme of the Russian Platform, at the base of limestone D_5^8upper (Nemirovskaya et al., 1990; Nemirovskaya & Nigmadganov, 1994). But in the General Carboniferous Stratigraphic Scheme of Ukraine it is drawn recently at the base of limestone D_5^{10}, or a the base of the Voznesensky Subhorizon of the Ukrainian Scheme or the Voznesensky Horizon of the General Carboniferous Stratigraphic Scheme of the Russian Platform, where the first *Homoceras* sp. was found. The Kalmius section of the Donets Basin was proposed as a candidate for the Mid-Carboniferous Boundary stratotype (Nemirovskaya et al., 1990). And although it was not included in the final list of the candidates for the election, it is still regarded as one of the best Mid-Carboniferous boundary sections being easily accessible, having a negligible gap and yielding various groups of fossils which allow correlation with other areas. The position of the lower boundary of the Bashkirian in the Donets Basin is based on data from the Kalmius section.This is a great advantage over the Bashkirian stratotype where the lower boundary is unclear and coincides with an unconformity (Nemirovskaya & Alekseev, 1994).

The upper boundary of the Bashkirian Stage (i.e. the Bashkirian/Moscovian boundary) in the Donets Basin is recognised mainly by comparison with foraminifera of the Moscovian stratotype. The Bashkirian/Moscovian boundary is drawn at the base of limestone K_3 of the C_2^5(K) Suite and corresponds to the base of the Vereisky Horizon in the Moscow Basin. Lithologically the lower part of the Suite C_2^5(K), containing limestone K_3, is similar to the underlying C_2^4(I) Suite.

The Bashkirian in the Donets Basin contains rich assemblages of foraminifera, conodonts, brachiopods, crinoids, corals, ostracods, bivalves, bryozoans, etc. Ammonoids and plant remains characteristic of the Namurian and Westphalian of Western Europe also occur.

The Bashkirian Stage is significant in Late Carboniferous conodont evolution as during this period all of the Late Carboniferous and Permian genera originated. A relatively complete sequence and rather high frequencies of conodonts, occurring together with the other fossils, make the Bashkirian conodont succession the key or standard section for interregional and intercontinental correlation.

Regional stratigraphic setting

The Donets Basin is the southeastern part of the Don-Dnieper aulacogene which came into existence at the beginning of the Middle Devonian near the southern margin of the East-European Platform between the Ukrainian Crystalline Shield in the west and the Voronezh Massif in the northeast (Fig. 2). It was an area of continuous, paralic sedimentation during the Carboniferous. The subsidence of the aulacogene during the Late Palaeozoic was differentiated by movements of discrete blocks separated by faults. A subgeosynclinal regime was characteristic for the Donets Basin, and platform regime for the Pripyat and Dnieper-Donets depressions. The thickness of the Carboniferous succession is much greater in the Donets Basin. Facies are more contrasting, marine facies more persistent, limestone beds more numerous. The downwarp was entirely compensated by sedimentation.

The predominantly carbonate deposits of the Lower Carboniferous were replaced by terrigenous sediments from the latest Visean onwards. Regular sea-level fluctuations resulted in fully developed cycles in a coal-bearing formation with a considerable number of coal seams and limestone intercalations.The change of the sedimentary regime in the Dnieper-Donets Downwarp was caused mainly by the Saalian phase of the Hercynian folding. Earlier movements are also manifested as unconformities along the margins of the downwarp and by the increasing thickness of marine rocks towards the centre. As a result of the Saalian phase the aulacogene was subdivided into new structures: the Donbas fold belt in the east and the Dnieper-Donets Depression in the west.

The complicated fold belt of the Donets Basin formed within the downwarp between marginal faults at the end of the Early Permian. In the general tectonic pattern of the Donets fold belt, the strike of folds is subordinated to the strike of both the whole aulacogene and its deep marginal faults that were responsible for the orientation of the main tectonic forms of the Donets Basin. The sublatitudinal direction of folds and faults peculiar to the whole Donbas, is complicated by transverse diagonal structures. The central part of the basin is composed of linear structures: the Glavnaya (Principal) Anticline, the Glavnaya Syncline and Yuzhnaya (Southern) Syncline. In the north of the Donets Basin there is a wide zone of minor folding and overthrusts. A narrower zone of minor folds is located in the south of the Donets Basin. To the east the Carboniferous is covered by younger rocks, and the tectonic forms are more simple. The Northern Zone of minor folding is not registered in the east. The coal-bering succession is succeeded by a thick argillaceous flyschoid succession (Aisenverg, 1953; Aisenverg, 1969; Aisenverg et al., 1975; Lukin et al., 1980).

The Serpukhovian, Bashkirian and Moscovian are represented by thick strata of rhythmically interbedded shales, siltstone and sandstones with subordinate limestone intercalations and coal seams. They reflect an alternation of marine and continental environments, between shallow sea and a coastal plane. In the east the Nagolny Ridge area with thick flyschoid strata of siltstones and shales with high content of pyrite and absence of fauna was probably a stagnant basin with presence of H_2S (Reznikov, 1978; Fissunenko & Reznikov, 1985).

The Carboniferous of the Donets Basin is subdivided into three series with four, eight and three suites, respectively. Each suites is given its own code number and a

letter, and includes a number of limestones and coals which are named by the letter of the respective formation, followed by a number. Lithological correlation of limestones by direct tracing was carried out at the beginning of the century, and was later supported by palaeontological evidence. The Carboniferous is also subdivided biostratigraphically into seven stages and a number of horizons and assemblage zones.

The discussed interval includes the upper part of the C_1^4(D) Suite of the Serpukhovian (the uppermost part of the Zapaltyubinsky Subhorizon of the Ukrainian Scheme or Zapaltyubinsky Horizon of the General Scheme of the Russian Platform) through the C_2^5(K) Suite or the Vereisky Horizon of the Moscovian (Fig. 3). The studied localities are in the Southern Zone of minor foldings, Donetsk County, and in the Glavnaya Anticline, Lugansk County (Fig. 1). The conodonts were extracted mainly from limestones. Near the Mid-Carboniferous boundary shales have also been sampled and treated.

The upper part of the Lower Carboniferous (upper part of the C_1^4 Suite) and the lowermost part of the Bashkirian (lower part of the C_2^0 Suite) were formed in a mobile region where the western part underwent uplift and the eastern part, or the Kalmius area, progressively subsided. Near-shore, lagoon facies and river sediments of the westernmost part of Donbas were gradually replaced by open-sea facies in the Kalmius area. Here, the sandy material from the western source (Ukrainian Crystalline Shield) was reworked, and the proximity of near-shore environments was expressed by a wide distribution of oolitic limestones with more or less rounded particles within the centres of oolitic grains (Feofilova & Lewenshtein, 1963). This interval is most complete in the Kalmius area. The marine character of the strata is proven by the great number of limestones with abumdant marine fossils, and a predominance of siltstone and shales with only few coal seams.

The limestone intercalations are irregularly distributed throughout the section. In the upper part of the Serpukhovian and in the Lower Bashkirian (Fig. 2) several closely spaced groups of limestones of the upper part of the C_1^4 Suite and lower part of the C_2^0 Suite occur. These are the limestones of the D_5 (D_5^1-D_5^{12}), D_7 (D_7^1-D_7^8) and E_1(E_1^l-E_1^u) groups. The limestones of group D_5 vary in their mud content with a poor abundance and low diversity of fossils. There are oolitic detrital limestones in the upper part of group D_5 (D_5^9, D_5^{11} and D_5^{12}). There are shales with crinoids, ostracods, brachiopods, bivalves, bryozoan, etc. between the limestones. Sparse thin coal seams occur 2-4 m above the top of limestone D_5^7. Within the shales there is a 'nodular horizon' - a layer of calcareous nodules with well preserved brachiopods, bivalves, ammonoids, and conodonts. This horizon is persistent laterally. It contains ammonoids of the lower part of the E2c ammonoid zone. Between normal marine muddy limestone D_5^8 lower and D_5^8 upper there is a ferruginous zone, 0.10 m thick, which is underlain by shales with numerous large crinoid ossicles and ostracods and is overlain by siltstones and fine-grained sandstones with plant remains (Skipp et al., 1989). Oolitic limestone D_5^9, is overlain by a conglomerate, consisting of coarse rounded pebbles of quartz, quartzite and dark cherts. It disappears westwards, but small pebbles of quartz and cherts are still observed in places (Aisenverg, 1958).

The D_5 group of limestones is overlain by a thick succession of quartzitic sandstones. Higher, in sandy-argillaceous strata, there is a dense fine-grained limestone D_6, and still higher, the D_7 group of closely spaced oolitic or muddy limestones

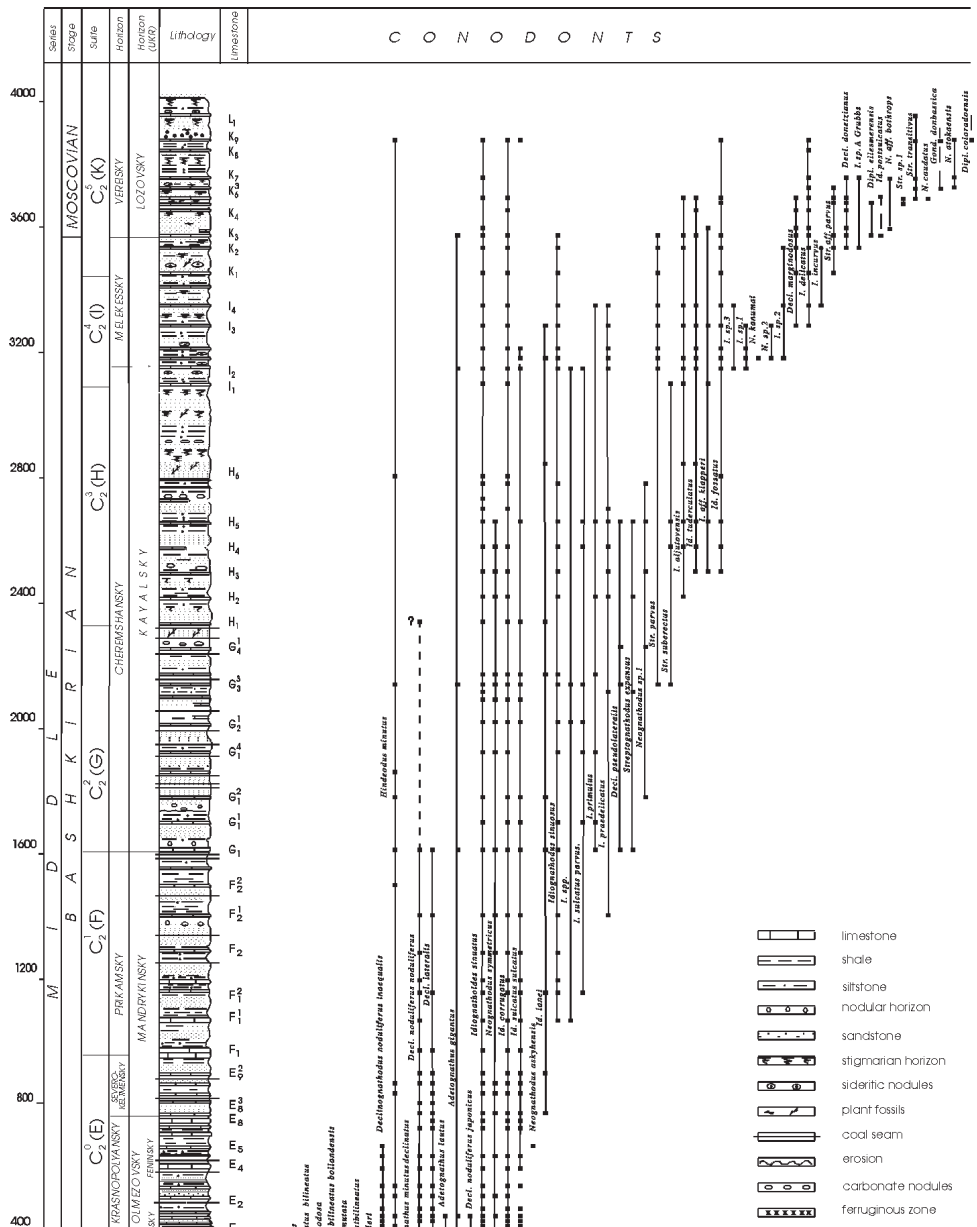


Fig. 3. Distribution chart of the Bashkirian conodonts in the Donets Basin.

occur. The limestones are separated by shales with several sandstones. The uppermost part of the C_1^4(D) Suite contains ammonoids of the R1 Zone. The upper part of the suite, with oolitic and detrital muddy limestone, was deposited in an open shallow marine basin with an unstable hydrodynamic regime. The lithology together with impoverished fossil assemblages demonstrate a regressive cycle of sedimentation with the lowest stand between the limestones D_5^8 lower and D_5^8 upper which coincides with the Mid-Carboniferous boundary and biotic overturn. The thickness of the studied part of the C_1^4 Suite (from limestone D_5^6 upwards) is c. 170 m.

During the time of the C_2^0(E) Suite the rate of subsidence in the studied area was slower The number of limestones decreases. The oolitic limestones disappeared, they were replaced by thin detrital and algal limestones. The base of the C_2^0(E) Suite is a rather thick quartzitic sandstone member which is overlain by 5 sandy-detrital limestones of the E_1 group. The overlying limestones E_2-E_9 are grey or yellowish-brown, platy, muddy or detrital, and rich in various fossils. The maximum of the Bashkirian transgression is expressed in the upper part of the C_2^0 Formation as thick limestones of the 'Mandrykinskaya Group' (E_9-F_1). They are of greater thickness than the underlying ones. Sandstones are common in this part of the section. Fine-grained sandstones of the middle part of the formation resulted from a rather quiet hydrodynamic regime of the basin. Medium to coarse-grained sandstones in the lowermost and upper part of the formation together with the relatively deep-water limestones of the upper part of the formation in the Kalmius area indicate an increasing tectonic mobility of the region. Very few coal seams occur (Feofilova & Lewenshtein, 1963). Ammonoids of the R2 Zone occur in the middle part of the C_2^0 Suite. Its upper part, including limestone F_1, contains ammonoids of the *Bilinguites-Cancelloceras* Ammonoid Genozone (Popov, 1979). The C_2^0 Suite is c. 740 m thick.

A thick (c. 10 m), massive, fine-grained algal limestone F_1 with brachiopods and crinoids and rare conodonts is the base of the C_2^1(F) Suite. This suite consists of sandy-argillaceous deposits with 8 mainly muddy, sometimes sandy, detrital shallow-water limestones and several thin coal seams which thicken westwards. The limestones contain impoverished fossil assemblages. Plant remains are found at the base of coal seams. The top of the formation belongs to the *Brannerоceras-Gastrioceras* Genozone (Popov, 1979).

The Upper Bashkirian starts from the C_2^2(G) Suite, which lithologically is very similar to the underlying one. It also contains mostly marine sandy-argillaceous deposits with 8 shallow-water and near-shore limestones and 10-12 thin coal seams. Grey limestone G_1, sandy in its lower part and muddy in the upper part, yields foraminifers, brachiopods and a rich assemblage of conodonts. Upwards in the section, the role of siltstones and sandstones increases. The limestones within these strata contain numerous algae, brachiopods, gastropods, and conodonts. The upper part of the formation is composed of siltstones and mudstones with intercalated fine-grained sandstones and ochreous leached limestones. The suite is c. 700 m thick. The C_2^1(F) and C_2^2(G) suites differ from the underlying rocks by their increasing thickness, gradual change of contrasting facies to monotonous marine shales and siltstones with few alluvial deposits. General subsidence was slower, erosion of the uplift area was negligible, income of clastic material was minimal.

The C_2^3(H) Suite differs from the underlying strata by a greater amount of coarse-

grained sandstones and many commercial coal seams. The facies are more variable, from marine to alluvial. The limestones are of relatively more deep water origin than those of the underlying formation. Thick alluvial sandstones belong to two river systems: from the west and southeast (Feofilova & Levenshtein, 1963). Near-shore and lagoonal facies dominate. Thin, mostly muddy limestones contain conodonts, foraminifers, algae, brachiopods and bivalves. Siltstones and coal seams yield rich plant assemblages of early Westphalian (Langsettian) age. The ammonoids are of the *Brannerоceras-Gastrioceras* Genozone (Popov, 1979). The dark-grey, fine-grained limestone H_5 contains rich foraminiferal and conodont assemblages. Numerous plant remains and bivalves were recorded from the coal seams of the thick sandy strata overlying the limestone H_5. Plant remains are of Duckmantian (ex Westphalian B) age (Fissunenko, 1991). The ammonoids from the uppermost part of the suite belong to the *Diaboloceras-Axinolobus* Genozone (Popov, 1979). The suite is c. 800-900 m thick.

The C_2^4(I) Suite is represented by predominantly marine deposits with thin coals. Alluvial facies decrease. Dark-grey, fine-grained, platy limestones among the homogenous terrigenous beds are usually *Donezella*-bearing and locally detrital. They are rather thin and contain foraminifera, brachiopods, conodonts, algae, bivalves, etc. Very abundant conodont and rather poor foraminiferal assemblages of the Late Bashkirian were recorded from limestones I_2, I_3 and I_4. Scarse ammonoids belong to the *Diaboloceras-Axinolobus* Genozone (Popov, 1979). The suite is c. 400 m thick.

The C_2^5(K) Suite is characterized by an alternation of thick coarse-grained sandstones and interlayers of boggy (marshy) facies with numerous limestones with abundant fossils as well as numerous coal seams. These contrasting facies were caused by a considerable amplitude of tectonic movements. In the lower part of the formation above the *Donezella*-bearing limestone K_1' greywacke sandstones with an admixture of effusive volcanic material, the so-called 'tabacco-sandstones', occur. They contain numerous plant remains of Duckmantian age (Fissunenko, 1991). Ammonoids of the *Diaboloceras-Axinolobus* Genozone were found in the lower part of the formation (Popov, 1979). The middle part of the formation contains plant remains of Bolsovian (ex Westphalian C) age (Fissunenko, 1991) and ammonoids of the *Diaboloceras-Winslowoceras* Genozone (Popov, 1979). The limestones are grey, platy, fine-grained, detrital or algal. They contain foraminifera, crinoids, conodonts, ostracods, bryozoans, brachiopods, etc. of Late Bashkirian — Early Moscovian age. The fine-grained, detrital limestone K_7 contains conodonts, corals and brachiopods. Foraminifera and conodonts of the upper part of the formation are of Early Moscovian age. In general, marine, tidal and lagoonal deposits dominate in the lower part of the suite. The upper part is characterized by the wide distribution of alluvial sandstones and more persistent and thick limestones K_7, K_8 and K_9. The suite is characterised by a great amount of coal seams. The maximum coal reserves of the Middle and Upper Carboniferous of the Donets Basin are concentrated in the C_2^5(K) and C_6(L) suites. Both are characterized by wide development of lagoonal facies. C_2^5(K) ends with a thick (over 60 m) white arkose sandstone and is c. 500-600 m thick.

Thirty one sections of uppermost Serpukhovian, Bashkirian and Lower Moscovian deposits were studied (Fig. 2). The sections (29 outcrops) are located south of Donetsk County in the area of the Kalmius and Krynka rivers, in Lugansk County, in outskirts of the town of Lutugino, Illiria village, along the Olkhovaya, Bulavin, Mius

and Lozovaya rivers. Several boreholes in the Bashkirian deposits were sampled, two in the western part of Donets Basin (Dobropolie area) and one in the eastern part (Belovodsk area).

Localities

1. Zhelvakovaya gully section, southern bank of the Starobeshevo Reservoir, c. 2 km N of Starobeshevo Village, Donetsk County.
2. Bezymyannaya gully section, western bank of the Starobeshevo Reservoir, south of the mouth of the Berestovaya River, Donetsk County.
3. Gluboky Yarok section, southeastern bank of the Starobeshevo Reservoir, c. 3 km E of Starobeshevo Village, Donetsk County.
4. Bolshaya Shyshovka section, along the left bank of the Shyshovka Valley, a left tributary of the Krynka River, near Bolshoe Meshkovo Village, N of Blagodatnoe Village, Donetsk County.
5. Chorna Skelya section, northwestern side of the Starobeshevo Reservoir, near the mouth of the Berestovaya River and on both sides of the river, within and around Fenino Village, Donetsk County.
6. Popovaya gully section, c. 2.5 km NW of Elizaveto-Nikolaevka Village, NW of Amvrosievka Village and NE of Kuteinikovo town, Donetsk County.
7. Malaya Shyshovka section, along the left side of the Malaya Shyshovka Valley, a left tributary of the Krynka River, southern outskirts of Malaya Shyshovka Village, Donetsk County.
8. Zhuravlevaya gully section, along the road from Bolshoe Meshkovo Village to the Zhuravlevaya gully which comes to the Krynka River (left side), Amvrosievka Village, Donetsk County.
9. Fenino section, left bank of the Berestovaya River, 1 km upstream of its fall into the Starobeshevo Reservoir. The limestones are exposed along the river, traced on the fields, in the ravines and around Fenino Village, Donetsk County.
10. Kisina gully section, eastern suburbs of Bolshaya Shyshovka Village. The gully falls into the Bolshaya Shyshovka Valley, the left tributary of the Krynka River, Donetsk County.
11. Sevastyanka section, located on the right bank of the Sevastyanka River, a left tributary of the Krynka River, at the northwestern outskirts of Petrovskoe Village, Donetsk County.
12. Novy Svet section, the eastern outskirts of Novy Svet Village, eastern side of the Starobeshevo Reservoir, Donetsk County.
13. Kruchik Valley section, the right side of the Mius River, near the village of Grabovo, Shakhtersk district, Donetsk County.
14 and 18. Kholodnaya and Khartsyzskaya gullies section, near the eastern outskirt of Blagodatnoe Village, left bank of the Krynka River, Amvrosievka district, Donetsk County.
15, 16. Rudnya and Zatsepa gullies section, c. 3 km N of Illiria Village, left bank of the Olkhovaya River, west of Lutugino Town, Lugansk County.
17. Novotroitskoe section, E of Novotroitskoe Village, on the opposite left bank of the Solyonaya River, Krasnoarmeisky district (SW of Krasnoarmeisk Town), Donetsk County.

19. Zolotaya Valley section, left bank of the Olkhovaya River, southeastern outskirt of Elizavetovka Village, 2.5 km S of Illiria Village, Lutugino district, Lugansk County.
20. Dolgy Valley section, right side of the Olkhovaya River, c. 7 km WSW of Lutugino Town, Lugansk County.
21. Karaguz Valley section, left bank of the Olkhovaya River, near the north-northeastern outskirts of Lutugino Town, Lugansk County.
22. Shterovka-Redkino section, left side of the Olkhovaya River, c. 3 km E of Shterovka Village, Lugansk County.
23. Volnukhino-Uspenka section, watershed between the Olkhovaya and Luganchik rivers, between Volnukhino and Uspenka villages, 5.5 km S of Lutugino Town, Lugansk County.
24. Sorochya gully section, right bank of the Bulavin River, near the northeastern outskirts of Bulavinskoe Village, Yenakievo district, Donetsk County.
25. Gruzskaya gully section, at the mouth of the Gruzskaya gully on the right side of the Kislichya Valley, left tributary of the Kalmius River, 0.5 km E of Menchugovo Village, c. 2 km from the southwestern suburbs of Mospino Village, Donetsk County.
26. Orekhovaya Valley section, left tributary of the Sevastyanka River, which is a left tributary of the Krynka River, north of Manuilovo Village, c. 2 km S of Torez Town, Donetsk County.
27. Klenovaya gully section, left side of the Krynka River, Davydovka Village, between Serditoe Village and Shakhtersk Town, Donetsk County.
28. Pashennaya Valley section, left bank of the Olkhovaya River, behind the northeastern suburbs of Lutugino Town, Lugansk County.
29. Blagodatnoe section, steep left bank of the Krynka River, northwestern outskirts of Blagodatnoe Village, Amvrosievka district, Donetsk County.
30. Kryvenky Yar section, located along the Kryvenky Yar gully, a right tributary of the Olkhovaya River, and on the watershed between the Olkhovaya and Luganchik rivers, south of Uspenka Village, Lugansk County.
31. Dobropolskaya borehole 9831.
32. Tereshkovskaya borehole 11593.
33. Belovodsk borehole 91-B is located NNE of Lugansk Town near the border between Ukraine and Russia.

Conodont succession

Conodonts were recovered mostly from the limestone beds of the thick terrigenous Lower and Middle Carboniferous strata. Shales were sampled only around the Mid-Carboniferous Boundary. The limestones were treated with acetic acid followed by separation with bromoform. Several thousands conodonts were recovered. Fifty-three species and subspecies of platform conodonts are investigated herein, belonging to the Early Carboniferous genera *Gnathodus*, *Lochriea* and *Cavusgnathus,* and the Middle Carboniferous genera *Declinognathodus*, *Neognathodus, Adetognathus, Idiognathodus, Streptognathodus*, and *Diplognathodus*. One species of *Rhachistognathus* was registered at the base of the Middle Carboniferous. *Hindeodus* was found throughout the Middle Carboniferous. Among the ramiform elements are representatives of *Syncladognathus* and the form genera *Neoprioniodus*, *Ligonodina, Magnilaterella*, which are common in

the Lower Carboniferous; *Ozarkodina*, *Roundya, Synprioniodina, Lonchodina, Metalonchodina, Idioprioniodus*, *Hibbardella,* and *Hindeodella* occur throughout the Lower and Middle Carboniferous. '*Neoprioniodus*','*Ligononodina*' and '*Hindeodella*' are most abundant in the uppermost Serpukhovian. In the Middle Carboniferous the ramiform elements are scarce. Only platform elements are listed in the distribution charts (Figs. 9, 11-13, 15-32). The distribution charts of the Kalmius section, which is important having been proposed as the candidate for the Mid-Carboniferous Boundary stratotype, and some other charts, include also the ramiform elements (Figs. 4-8, 10, 14).

The uppermost Serpukhovian is dominated by the last gnathodids: *Gnathodus bilineatus bilineatus*, *Gn. bilineatus bollandensis* and *Gn. postbilineatus*, with subordinate *Lochriea commutata*, *L. mononodosa* and *L. ziegleri*, and individual *Adetognathus unicornis* and *Cavusgnathus unicornis* Youngquist & Miller. *Gnathodus bilineatus bollandensis* is most common. It was recovered also from the shales between limestones D_5^7 and D_5^8lower in the Kalmius section (Zhelvakovaya gully, Fig. 4). The ammonoids *Cravenoceras subitus* Astakhova., *Nuculoceras donbassicum* A. Popov (synonomised as *Nuculoceras stellarum* by Riley, 1987), *Richardsonites baccans* A. Popov, and *Euroceras kalmiussense* A. Popov, of the E2c1 Ammonoid Subzone, were found in the 'nodular' horizon within these shales above limestone D_5^7.

The late Serpukhovian conodonts represent the last stage of the Early Carboniferous conodont evolution. The most common genera of the late Early Carboniferous, *Gnathodus*, *Lochriea* and *Cavusgnathus*, became extinct by the end of the Zapaltyubinsky (Nemirovskaya, 1987). Then the Late Carboniferous genera *Declinognathodus*, *Idiognathoides* and *Neognathodus* originated and later gave rise to all of the Late Carboniferous and Permian conodonts. At the uppermost Zapaltyubinsky and the beginning of the Voznesensky the extinction of other marine organisms, i.e. foraminifera, corals, ostracods, ammonoids, etc. was also registered (Aisenverg et al., 1976; Aisenverg et al., 1983). This biotic overturn is well known globally (Nemirovskaya & Nigmadganov, 1994). It coincides with one of the major Late Paleozoic eustatic events (Ramsbottom, 1977) and is fixed as the Mid-Carboniferous Boundary (Lane & Manger, 1985).

The first Middle Carboniferous conodonts were extracted from the marly part of limestone D_5^8 Upper. They are represented mostly by *Declinognathodus noduliferus inaequalis* Higgins and rare *Hindeodus minutus* (Ellison). The next (oolitic) limestone D_5^9 contains *Declinognathodus noduliferus inaequalis, Decl. noduliferus noduliferus*, *Decl. lateralis*, *Adetognathus lautus*, *Ad. gigantus*, *Rhachistognathus minutus declinatus,* and individual Early Carboniferous conodonts *Lochriea commutata* and *'Neoprioniodus' singularis* (Hass) (Figs. 4-6).

The oldest Middle Carboniferous ammonoid *Homoceras* sp. was found in limestone D_5^{10}, that is 10 m above the entry of *Declinognathodus*. This limestone is regarded as the base of the Voznesensky Horizon. The conodont association of the Voznesensky Horizon is impoverished taxonomically and yields only species of the genus *Declinognathodus*. In the uppermost part of the Voznesensky Horizon the first *Idiognathoides* together with the first ammonoids of the *Reticuloceras* Zone appear. In the Kalmius section (Bezymyannaya and Gluboky Yarok gullies, Figs. 7-8). *Idiognathoides sinuatus* Harris & Hollingsworth and *Neognathodus symmetricu*s Lane were found in limestone D_7^7 and *Id. corrugatus* in limestone D_7^8. In the Amvrosievka sections along

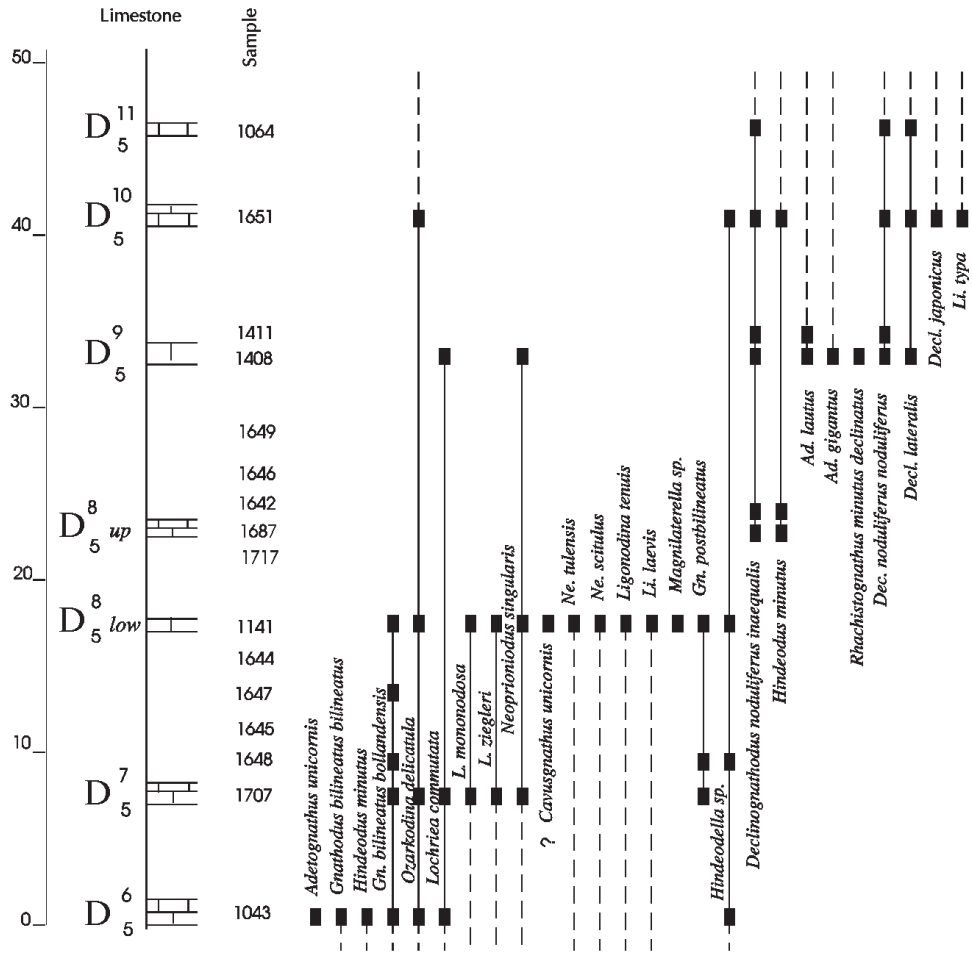


Fig. 4. Distribution of conodonts in the Zhelvakoya gully section (loc. 1).

the Krynka River the lowest occurrence of *Id. sinuatus, Id. corrugatus* and *Id. sulcatus sulcatus* was registered in limestone D_7^6. *Isohomoceras* sp. was recovered from the shales above the limestone D_7^6 in the Amvrosievka section (the Popovaya gully, Fig. 7), and *Homoceratoides divaricatus* (Hinde), *Vallites* sp., *Phillipsoceras* sp. and *Surenites beschevensis* Popov were found in argillaceous deposits above limestone D_7^7 in the Kalmius section (Popov, 1979; Aisenverg et al., 1983). The *Declinognathodus* assemblage continues to dominate in the Krasnopolyansky Horizon. Later, due to the great Bashkirian transgression and more favourable environments, *Idiognathoides* species prevailed from Severo-Keltmensky times through the Bashkirian until the Early Moscovian. The interval between limestones E_9^0 and F_1 contains numerous *Bilinguites superbilinguis* (Bisat) and *Cancelloceras cancellatum* (Bisat) (Popov, 1979).

In the latest Early Bashkirian the first *Idiognathodus* appear. These are *Idiognathodus sinuosus* and forms similar to the specimens illustrated and referred to *Idiognatho-*

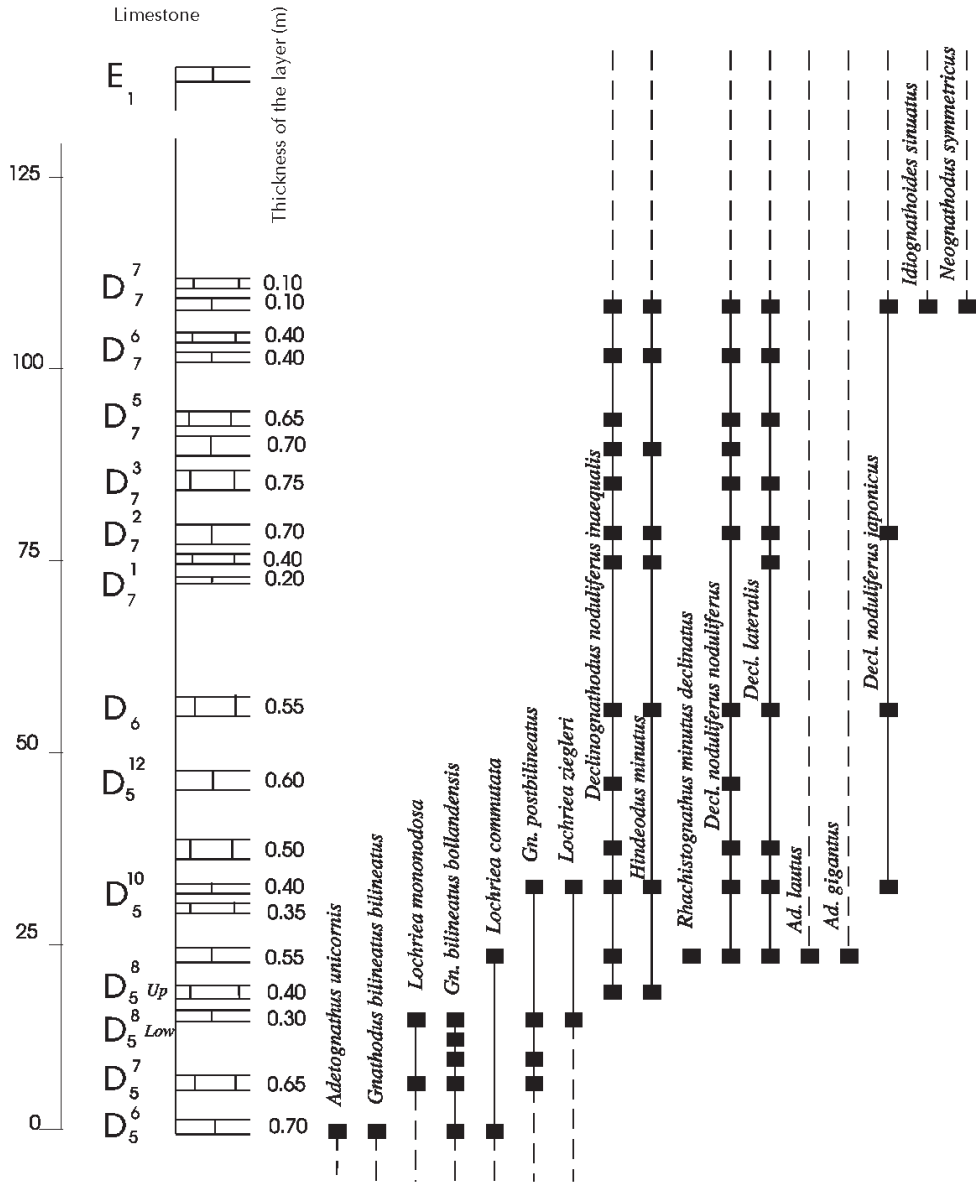


Fig. 5. Distribution of conodonts in the Kalmius section: Zhelvakoya (loc. 1) and Bezymyannaya (loc. 2) gully sections.

dus spp. by Higgins (1975). They registered from limestone F_1^1. Important foraminifera *Pseudostaffella (Ps.) antiqua* were found in limestone $E_{8'}$ and ammonoids *Branneroceras branneri* (Smith) from limestone F_2 (Aisenverg et al., 1979). *Idiognathodus praedelicatus* sp. nov. with already well developed accessory lobes but still with a simple anterior margin of the platform appeared in Prikamsky times. It is common in the

Section	Zhelvakovaya				Bezymyannaya												
Horizon	Zapaltyubinsky				Voznesensky			Voznesensky									
Limestone	D_5^6	D_5^7	'N'	D_5^8	D_5^9	D_5^{10}	D_5^{11}	D_5^9	D_5^{10}	D_5^{11}	D_5^{12}	D_6	D_7^1	D_7^2	D_7^3	D_7^4	D_7^5	D_7^6	D_7^7
Gnathodus b. bilineatus	3	1																	
Gnathodus b. bollandensis	26	12	2	15					1										
Paragnathodus mononodosus		1		1															
Paragnathodus commutatus	1				2														
Paragnathodus nodosus	1								1										
Adetognathus unicornis	3																		
Adetognathus lautus					4														
Adetognathus gigantus					4														
Rhachistognathus minutus declinatus					2			3											
Declinognathodus noduliferus inaequalis					17	28	11	12	30	5	6	68	1	20	31	26	7	37	21
Declinognathodus n. noduliferus						12	4		1	1	2	12		9	12	10	13	66	17
Declinognathodus n. japonicus						6	2		1			10	6	39	2		3	25	19
Declinognathodus lateralis						2						3		10					4
D. lateralis — Neognathodus japonicus										5						2			
Idiognathoides sinuatus																			1
Neoprioniodina singularis	1	2			1														
Spathognathodus minutus									2			4	3	1		1		14	12
Ligonodina tenuis				4															
Ligonodina levis				1															
Ligonodina typa						2			2										
Hibbardella acuta												1							
Hibbardella obtusa												1		1		1			
Synprioniodina microdenta	1													2					
Synprioniodina aff. *denticamura*																			1
Ozarkodina delicatula		3												5					
Ozarkodina curvata																			1
Scaliognathus elements														2					
Total weight of sample (kg)	15	12	2	12	30	9	6	9	9	2	1	15	6	15	17	6	11	33	10

Fig. 6. Numerical dsitribution of conodonts in the Zhelvakovaya (loc. 1) and Bezymyannaya (loc. 2) sections (Nemirovskaya, 1987); 'N' = nodular horizon.

Section	Gluboky Yarok								Popovaya							Bolshaya Shyshovka					
Horizon	Voznesensky								Voznesensky							Voznesensky					
Limestone	D_7^1	D_7^2	D_7^3	D_7^4	D_7^5	D_7^6	D_7^7l	D_7^7u	D_7^2	D_7^3	D_7^5l	D_7^6l	D_7^6u	D_7^7l	D_7^7u	D_7	D_7^2	D_7^3	D_7^5	D_7^6	D_7^8
Declinognathodus n. noduliferus	3	18	20	8	16	40	5	1			2	2		1	1	7	1	82	3	4	
Declinognathodus n. inaequalis	3	10	14	18	6	7	3		1	4	3	3	2		3	45	6	44	6		
Declinognathodus lateralis		7		3		11	4	5	1	2		5		3	1	9	1	23	1	4	
Idiognathoides sulcatus														1							1
Idiognathoides sinuatus							2								1						1
Idiognathoides corrugatus																					3
Spathognathodus minutus					2	3	1							1		1					
Synprioniodina microdenta			1																		
Synprioniodina aff. *denticamura*							1														
Ligonodina typa																1					
Ozarkodina delicatula			1													3					
Hibbardella obtusa																					1
Lonchodina singularis																1					
Scaliognathus elements							1	2								5					
Total weight of sample (kg)	5	10	9	10	9	12	18	2	2.5	2.5	2.5	2.3	2.5	2.3	3	3	3	58	4	5	6

Fig. 7. Numerical dsitribution of conodonts in the Gluboky Yarok (loc. 3), Popovaya gully (loc. 6) and Bolshaya Shyshovka (loc. 4) sections (Nemirovskaya, 1987).

Section	Zhuravlevaya					Malaya Shyshovka								Chorna Skelya					
Horizon	Voznesensky					Voznesensky						Krasnopolyansky							
Limestone	D_7	D_7^3	D_7^5	D_7^6	D_7^7	D_7^1	D_7^2	D_7^3	D_7^5	D_7^6	D_7^7	E_1^{III}	E_1^{IV}	$E_1^{III}E_1^{IV}1$		$E_1^{IV}uE_1^{V}$		E_2	E_2^1
Declinognathodus n. noduliferus	26	24	14	10	4		18	24	4	2	15	9	16	10	12	12	10	4	
Declinognathodus n. inaequalis	15	38	19	9	4			5	5		5	2	12	16	1	21	15	7	
Declinognathodus lateralis	11	11		2		4	8	9	5	4	10	11		10	1	12	19	10	18
Declinognathodus n. japonicus														1					
Idiognathoides sinuatus				1									7		1		1	7	8
Idiognathoides corrugatus										1		2	1				3	6	4
Idiognathoides sulcatus										2		2	31						2
Neognathodus symmetricus				1												1			9
Spathognathodus minutus			1	2				1										5	
Synprioniodina microdenta													1				1	1	
Synprioniodina sp.				1															
Ozarkodina delicatula		1		3									4			1	1	2	
Hindeodella sp.	3		3																
Hibbardella obtusa													1						
Roundya barnettana								1					1	1			1		
Ligonodina typa													2						
Matalonchodina bidentata												1	1		2				
Scaliognathus elements				3						5		4	4						
Total weight of sample (kg)	3	9	15	9	6	5	6	9	12	14	9	6	15	12	6	6	6	3	4

Fig. 8. Numerical dsitribution of conodonts in the Zhuravlevaya gully (loc. 8), Malaya Shyshovka (loc. 7) and Chorna Skelya (loc. 5) sections (Nemirovskaya, 1987).

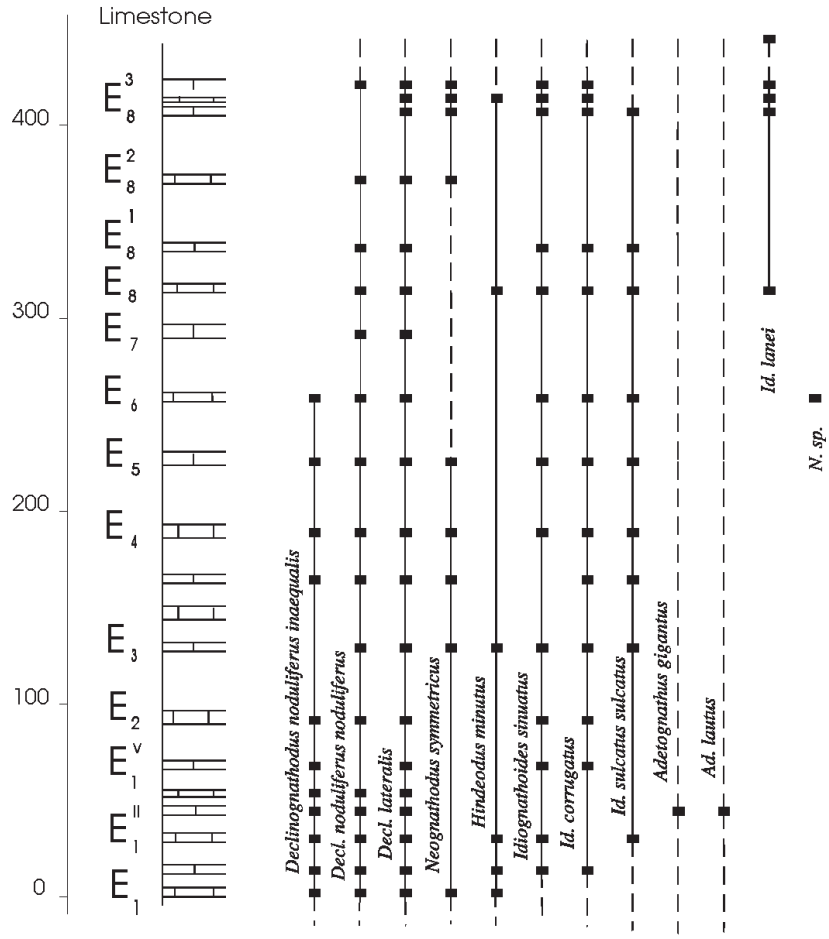


Fig. 9. Distribution of conodonts in the Fenino (loc. 9) and Kisina gully (loc. 10) sections.

overlying Cheremshansky and Melekessky horizons together with *I. primulus*, which still has a simple and primitive platform. *Idiognathoides lanei* and *Id. sulcatus parvus* joined the *Idiognathoides* association close to the end of the Early Bashkirian (Fig. 3).

The first *Streptognathodus* species, which bear the features of a more advanced fauna, already occur in the lower C_2^2(G) Suite of the Upper Bashkirian. These are the short-ranged species *Streptognathodus expansus* and *Str. suberectus*, *Declinognathodus pseudolateralis* sp. nov., and N*eognathodus* sp. 1. All the above mentioned short-ranged taxa are characteristic only of the C_2^2 and C_2^3 suites (Cheremshansky Horizon). The upper part of the Cheremshansky Horizon, the C_2^3(H) Suite, contains an abundant and diverse conodont assemblage that is dominated by idiognathoidids which include such biostratigraphically important taxa as *Id. fossatus* and *Id. tuberculatus*. The entry of *Idiognathodus aljutovensis* and *I.* aff. *klapperi* was also registered here. *Gastrioceras listeri* Martin is common throughout the section from limestone G^1 upwards (Popov, 1979).

Section	Fenino village															Kisina gully			
Horizon	Krasnopolyansky													Severokeltmensky					
Limestone	E_1^I	E_1^{II}	E_1^{III}	E_1^{IV}	$1E_1^{IV}u$	E_1^V	E_2	E_3	E_3^2	E_4	E_5	E_6	E_7	E_8	E_8^1	E_8^2	E_8^31	E_8^3m	E_8^3u
Declinognathodus n. noduliferus	15	14	17	8	6		5	2	4	8	1	6	6	1	1	1			2
Declinognathodus n. inaequalis	12	22	12	12	3	11	5		1	4	2	3							
Declinognathodus lateralis	18	7	8	8	3	14	18	15	4	16	1	13	6	1	4	3	5	1	7
Idiognathoides sinuatus		2	1			9	2	2		17	11	10		56	1		10	7	18
Idiognathoides corrugatus		1				6	6	3	3	8	4	12		64	3		16	14	38
Idiognathoides sulcatus			1					3	1	15	8	8		62	3		7		
Idiognathoides lanei														12			6	2	2
Neognathodus symmetricus	2							4	2	7	1					3	35	1	45
Adetognathus lautus				2															
Adetognathus gigantus				2															
Idiognathodus sp.												1							
Spathognathodus minutus	5	4	2					3						4				1	
Ligonodina typa	2										2			5			2	2	2
Neoprioniodus conjunctus	1		1											1					
Lonchodina clarkei			2							2	1			2					
Roundya barnettana	1							1		1	2							1	2
Ozarkodina delicatula			2					3			2			3	1			2	2
Synprioniodina microdenta						1		3				2							
Synprioniodina denticamura								1				1							
Hindeodella ibergensis						3													
Hindeodella aff. *uncata*																		1	
Scaliognathus elements																			
Total weight of sample (kg)	6	3	6	3	3	4	3	6	6	9	9	6	3	3	3	3	3	3	3

Fig. 10. Numerical dsitribution of conodonts in the Fenino (loc. 9) and Kisina gully (loc. 10) sections (Nemirovskaya, 1987).

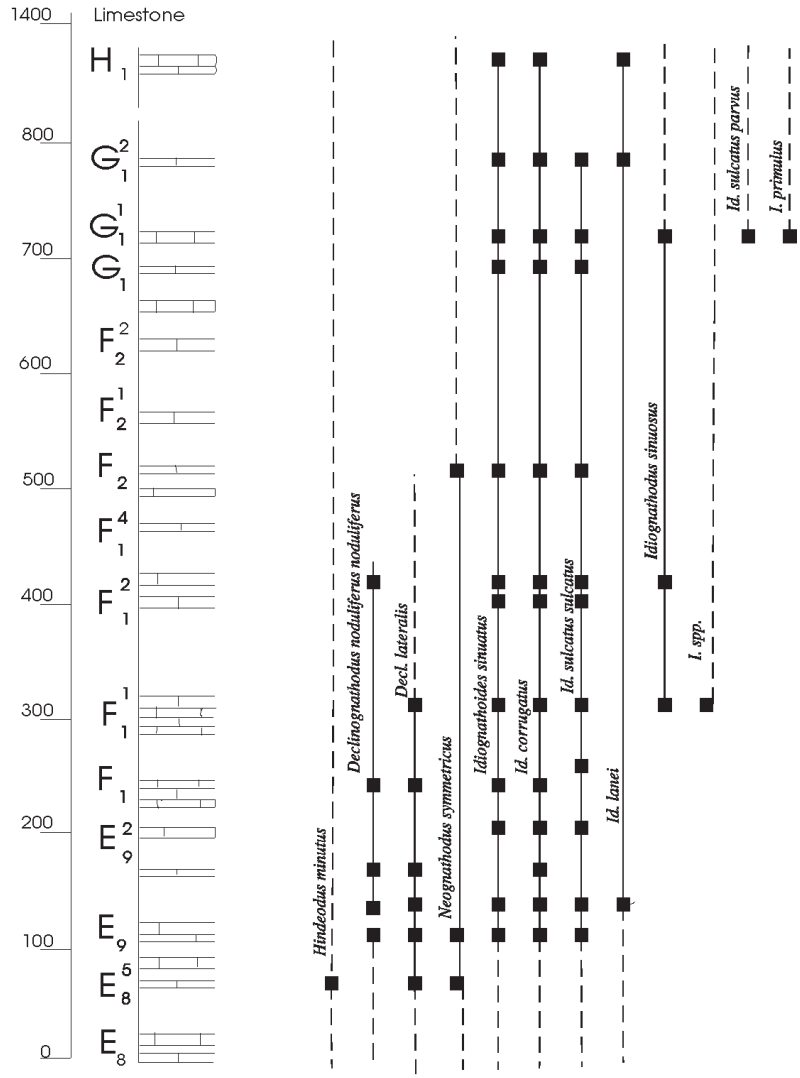


Fig.11. Distribution of conodonts in the Blagodatnoe (loc. 29) and Kruchik Valley (loc. 13) sections.

The Melekessky Horizon, C_2^4(I) Suite and lowermost part of C_2^5(K), is characterised by a rich conodont assemblage dominated by idiognathoidids and containing a majority of taxa known in the underlying deposits with their last occurrences here. These are *Idiognathoides sinuatus*, *Id. corrugatus, Id. tuberculatus, Id. fossatus*, as well as species of *Idiognathodus: I. sinuosus, I. aljutovensis I. praedelicatus, I. primulus, I.* sp. 1 and *I.* sp. 3. New advanced forms of *Neognathodus (N. kanumai* Igo and *N.* sp.) and *I.* sp. 2 appeared at the beginning of the Melekessky. The appearance of stratigraphically important *Declinognathodus marginodosus* Grayson and two species of *Idiognathodus: I. delicatus* Gunnell and *I. incurvus* Dunn, were fixed in this horizon. *Donetzoceras*

Stage	Bashkirian								
Substage	Lower							Upper	
Limestone	F_1	F_1^0	F_1^1	F_1^2	F_1^3	F_1^4	F_2	G_1	G_1^1
Declinognathodus n. noduliferus	1				3				
Decl. lateralis	1								
Idiognathoides sinuatus	4			13	21			1	9
Id. corrugatus	3		2	28	28			4	9
Id. sulcatus sulcatus		1		9	6				3
Id. sulcatus parvus									1
Idiognathodus spp. of Higgins			1						
I. sinuosus					5				
I. primulus									3
Total weight of the sample	4	3	3	3	3	3	3	3	3

Fig. 12. Numerical distribution of conodonts in the Blagodatnoe section (loc. 29).

Stage	Bashkirian						
Substage	Lower			Upper			
Limestone	E_8^5	F_1^1	F_2	G_1	G_1^1	G_1^2	H_1
Declinognathodus lateralis	1	2			1		
Neognathodus symmetricus	1		1				
Idiognathoides sinuatus		3	10	2		2	4
Id. corrugatus		1	1	7	1	1	2
Id. sulcatus sulcatus		1	1	1	2	3	
Id. sulcatus parvus					1		
Id. lanei						3	1
Idiognathodus sinuosus					2		
Total weight of the sample	3	4	4	4	4	4	4

Fig. 13. Numerical distribution of conodonts in the Kruchik Valley section (loc. 13).

donetzense (Librovich) and *Gastrioceras lupinum* A.Popov occur here. *Wiedeyoceras (= Donetzoceras?) aegiranum* (Schmidt) was found in the upper part of the C_2^4(I) Suite (Popov, 1979).

The Vereisky Horizon contains a conodont assemblage which is very close to that of the Melekessky with numerous idiognathoidids, but differing from the latter by the entry of several new elements and last occurences of the conodonts common in the Bashkirian. The latter are *Idiognathodus sinuosus, I. incurvus, I. aff. klapperi* and *Streptognathodus parvus*. The upper limit of their range is the base of the Vereisky Horizon (limestones K_3 and K_3^1). New fauna includes the stratigraphically important *Declinognathodus donetzianus* Nemirovskaya, the last short-ranged species of *Declinognathodus*, which is characteristic only of the C_2^5(K) Suite, and also *Diplognathodus ellesmerensis* Bender and *Str.* aff. *parvus*.

Idiognathoidids are still abundant up to limestone K_6. There is short-range new

Section	Petrovskoe village					Blagodatnoe village				Novotroitskoe village
Horizon	Severokeltmensky			Prikamsky		Severokeltmensky			Prikamsky	Prikamsky
Limestone	E_8^5	E_9	E_9^1	E_9^2	F_1	E_9	E_9^0	E_9^2	F_1	F_1
Declinognathodus n. noduliferus			1			2	4		1	
Declinognathodus lateralis			3	1	1	4	8		1	
Neognathodus symmetricus						13				
Idiognathoides sinuatus	1	2		2	2	15	93	12	4	5
Idiognathoides corrugatus	1	1	1	1	1	17	147	16	3	10
Idiognathoides sulcatus						13	45	6		
Idiognathoides lanei							8			
Spathognathodus minutus						3				
Spathognathodus —										
Paragnathodus commutatus										1
Ozarkodina delicatula	1						19	2		4
Hindeodella ibergensis								3		
Ligonodina typa							7			
Ligonodina lexingtonensis							2			
Roundya barnettana							5			1
Neoprioniodus conjunctus							3			
Scaliognathus elements					1				3	5
Total weight of sample (kg)	3	3	3	3	4	6	6	6	24	15

Fig. 14. Numerical dsitribution of conodonts in the Sevastyanka (loc. 11), Blagodatnoe (loc. 29) and Novotroitskoe (loc. 17) sections (Nemirovskaya, 1987).

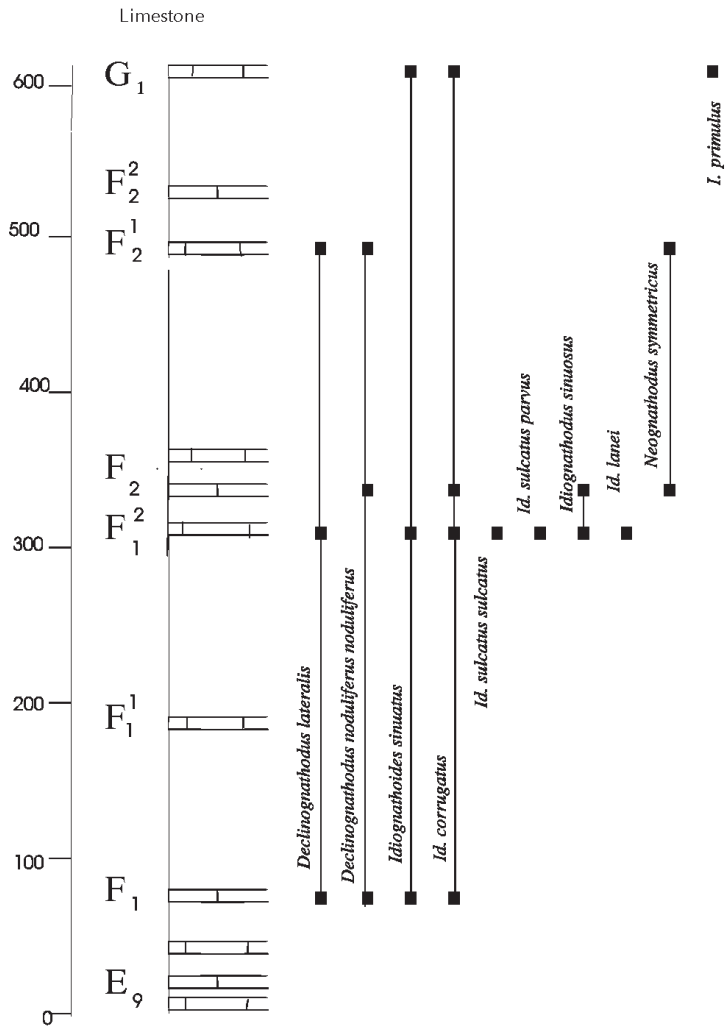


Fig. 15. Distribution of conodonts in the Krevenky Yar section (loc. 30).

but cosmopolitan species *Id. postsulcatus* sp. nov., which differ from the Bashkirian *Id. sulcatus sulcatus* by having a longer platform, narrower groove, and convex (swollen) platform sides. The ammonoids *Wiedeyoceras clarum* Popov and *W. (=?Donetzoceras) aegiranum* were found here. In general the conodonts of the greater part of the Vereisky Horizon represent the last stage of development of the Bashkirian conodonts, which are characterized mainly by *Idiognathoides* and *Declinognathodus* species.

Above limestone K_6 in the upper part of the C_2^5(K) Suite *Str. transitivus*, *Neognathodus atokaensis*, *N.* aff. *bothrops* Merrill, *N. caudatus* Lambert, *Gondolella donbassica* Kossenko, and *Diplognathodus coloradoensis* Murray & Chronic occur. *Idiognathoides sinuatus, Id. corrugatus* and *Id. fossatus* continue to occur, but they are scarse. This

Stage	Bashkirian					
Substage	Lower					Upper
Limestone	F_1	F_1^1	F_1^2	F_2	F_2^1	G_1
Declinognathodus lateralis	3		2		2	
D. noduliferus noduliferus					1	
Idiognathoides sinuatus			29			10
Id. corrugatus			57			14
Id. sulcatus sulcatus			7			
Id. sulcatus parvus			4			
Id. lanei			3			
Idiognathodus sinuosus			7			
Neognathodus symmetricus					2	
I. primulus						2
Total weight of the sample	3	3	3	3	3	3

Fig. 16. Numerical distribution of conodonts in the Kryvenky Yar gully section (loc. 30).

assemblage differs from the Bashkirian and is close to the younger Moscovian fauna.

Main trends of the Bashkirian conodont evolution

Bashkirian times are of great importance in conodont history, it provided a new phase of conodont evolution after the extinction of almost all of the Early Carboniferous conodonts. On the other hand the direct ancestors of all the Late Carboniferous conodonts originated during Bashkirian time. These are the species of the genera *Declinognathodus*, *Idiognathoides*, *Neognathodus*, *Idiognathodus*, and *Streptognathodus*. The first three appeared shortly after the Mid-Carboniferous Boundary, the other two are recorded from the Middle Bashkirian onwards. *Declinognathodus* and *Idiognathoides* are characteristic of the whole Bashkirian and very early Moscovian times. *Idiognathodus* and *Streptognathodus* however are characteristic for the whole Late Carboniferous until the Permian.

The first Middle Carboniferous conodonts of the genera *Declinognathodus, Idiognathoides* and *Neognathodus* derived from Early Carboniferous species of the genus *Gnathodus.* Whether one species of the genus *Gnathodus* or several species gave rise to *Declinognathodus, Idiognathoides* and *Neognathodus,* or the latter genera derived from each other, has been a subject of discussion. Most important among Mid-Carbonifrous conodonts are the relationships between *Gnathodus* and *Declinognathodus* and between *Declinognathodus* and *Idiognathoides.*

The first phylogenetic models for evolutionary relationships between the Mid-Carboniferous conodonts were proposed by Dunn (1970) and Straka & Lane (1970). These models are based on local ranges of conodonts (Pa elements) in the North American reference section. Dunn regarded *Gn. girtyi simplex* as the direct ancestor of *Declinognathodus* and *Neognathodus* and of *Idiognathoides* via *Gn. defectus* Dunn. Straka & Lane (1970) and later Lane & Straka (1974) and Lane et al. (1985) also believed that *Declinognathodus noduliferus* originated from *Gn. girtyi simplex* and later gave rise to

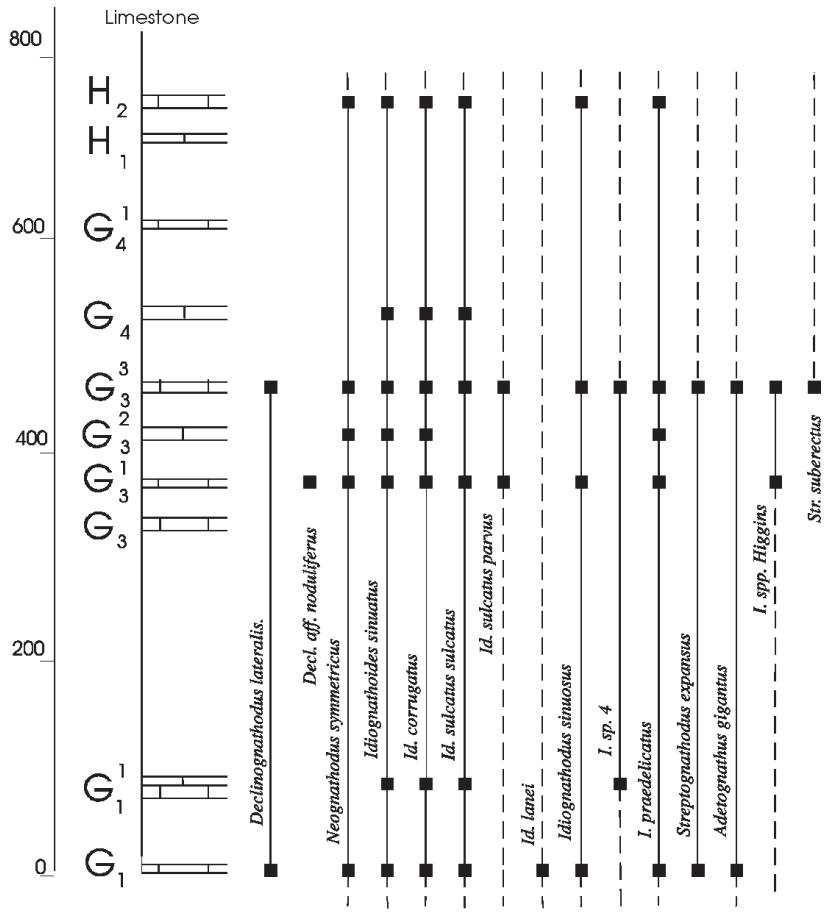


Fig.17. Distribution of conodonts in the Rudnya (loc. 15) and Zatsepa (loc. 16) gully sections.

Idiognathoides and *Neognathodus*. Thus according to these models all Pennsylvanian conodonts derived from *Gn. girtyi simplex* (Fig. 33-I, II).

Grayson, Merrill & Lambert (1990) have constructed a revised model for the Mid-Carboniferous multielement apparatuses of *Declinognathodus, Idiognathoides* and *Idiognathodus,* based on data from varying conodont successions around the world. They demonstrated three main trends of the evolution of the Mid-Carboniferous conodonts and reached the conclusion that *Declinognathodus* and probably *Idiognathodus* derived from *Gn. bilineatus*, and believed that *Declinognathodus* gave rise to *Idiognathoides.* They regard *Gn. girtyi simplex* as the ancestor only for *Neognathodus* (Fig. 33-III).

In 1994, Nemirovskaya & Nigmadganov proposed another phylogenetic model based on the distribution of Pa elements near the Mid-Carboniferous Boundary in the deep-water sediments of the Aksu section, South Tianshan (Fig. 34). They also regard *Gn. bilineatus* as a direct ancestor of *Declinognathodus (Gn. bilineatus bollandensis-Gn. postbilineatus-Decl. praenoduliferus-Decl. noduliferus*). The conodont data from the Aksu section have demonstrated that not only *Declinognathodus* but *Idiognathoides* also

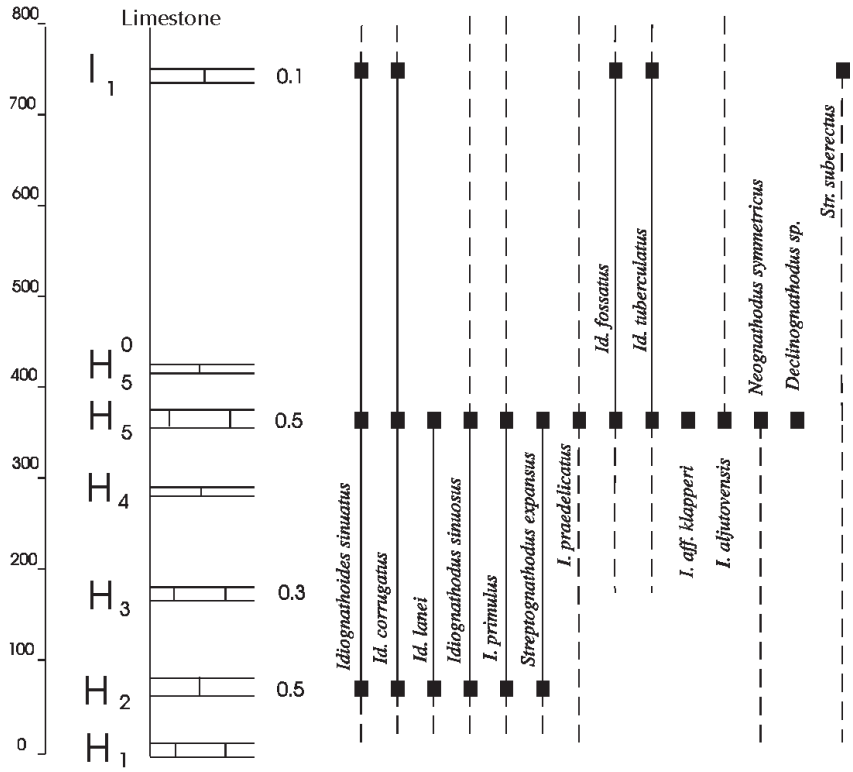


Fig. 18. Distribution of conodonts in the Dolgy Valley section (loc. 20).

derived from *Gn. bilineatus (Gn. bilineatus bollandensis-Gn. postbilineatus-Idiognathoides asiaticus-Id. sinuatus* and *Id. corrugatus*) (Nemirovskaya & Nigmadganov, 1994).

The distribution of conodonts in the Serpukhovian, Bashkirian and Moscovian deposits of the Donets Basin as well as in other areas around the world confirms the previously expressed point of view about the derivation of the genera *Declinognathodus* and *Idiognathoides* from *Gn. bilineatus.*

Five main trends of evolution of the Bashkirian conodonts can be distinguished:
1) *Declinognathodus* and *Idiognathoides sinuatus* and *Id. corrugatus* derived from *Gn. bilineatus* (Fig. 35).
2) *Neognathodus symmetricus* and the genus *Ferganaegnathodus* derived from *Gn. girtyi.*
3) *Adetognathus* derived from *Cavusgnathus.*
4) *Idiognathodus* could have derived either from *Decl. lateralis (Decl. lateralis-Decl. pseudolateralis-Idiognathodus*) (Pl. 4, fig. 2) or from *Ferganaegnathodus* (Nemirovskaya & Nigmadganov, 1993)*: Ferg. ferganaensis-Ferg. dzhenchuraevae* nom. nud. (paper on the Fergana Valley Carboniferous conodonts in prep.)-*Idiognathodus*. In the Donets Basin *Decl. pseudolateralis* which could have given rise to the first *Idiognathodus* was found higher in the section that the first *Idiognathodus*. In the South Fergana Valley, *Idiognathodus* and *Streptognathodus* appeared after *Decl. pseudolateralis* (Nemyrowska, in prep.).

Stage	Bashkirian		
Substage	Upper		
Limestone	H_2	H_5	I_1
Idiognathoides sinuatus	9	60	10
Id. corrugatus	10	45	2
Id. lanei	2	5	
Id. fossatus		18	16
Id. tuberculatus		3	9
Idiognathodus sinuosus	1	6	
I. praedelicatus		2	
I. primulus	1	6	
I. aff. *klapperi*		1	
I. aljutovensis		2	
Streptognathodus expansus	1	2	
Str. suberectus			1
Str. sp.			1
Declinognathodus marginodosus		3?	
Neognathodus sp.		1	
Total weight of the sample	3	3	3

Fig. 19. Numerical distribution of conodonts in the Dolgy Valley section (loc. 20).

Stage	Bashkirian							
Substage	Upper							
Limestone	G_1	$G_1{}^1$	G_3	$G_3{}^1$	$G_3{}^2$	$G_3{}^3$	G_4	H_2
Declinognathodus preudolateralis	2					1		
*D.*aff. *marginodosus*				1				
Neognathodus symmetricus	3			1	3	19		5
Idiognathoides sinuatus	60	8		49	3	30	2	20
Id. corrugatus	70	10		59	6	40	1	25
Id. sulcatus sulcatus	10	7		39		22	1	1
Id. sulcatus parvus				6		6		
Id. lanei	10							
Idiognathodus sinuosus	2			5		7		3
I.primulus		2				2		
I. praedelicatus				1	1	1		2
Streptognathodus suberectus						2		
Str. expansus	1					3		
Adetognathus gigantus	1					4		
I. spp. of Higgins				2		1		
Total weight of sample	4	4	4	4	4	4	4	4

Fig. 20. Numerical distribution of conodonts in the Rudnya (loc. 15) and Zatsepa (loc. 16) gully sections.

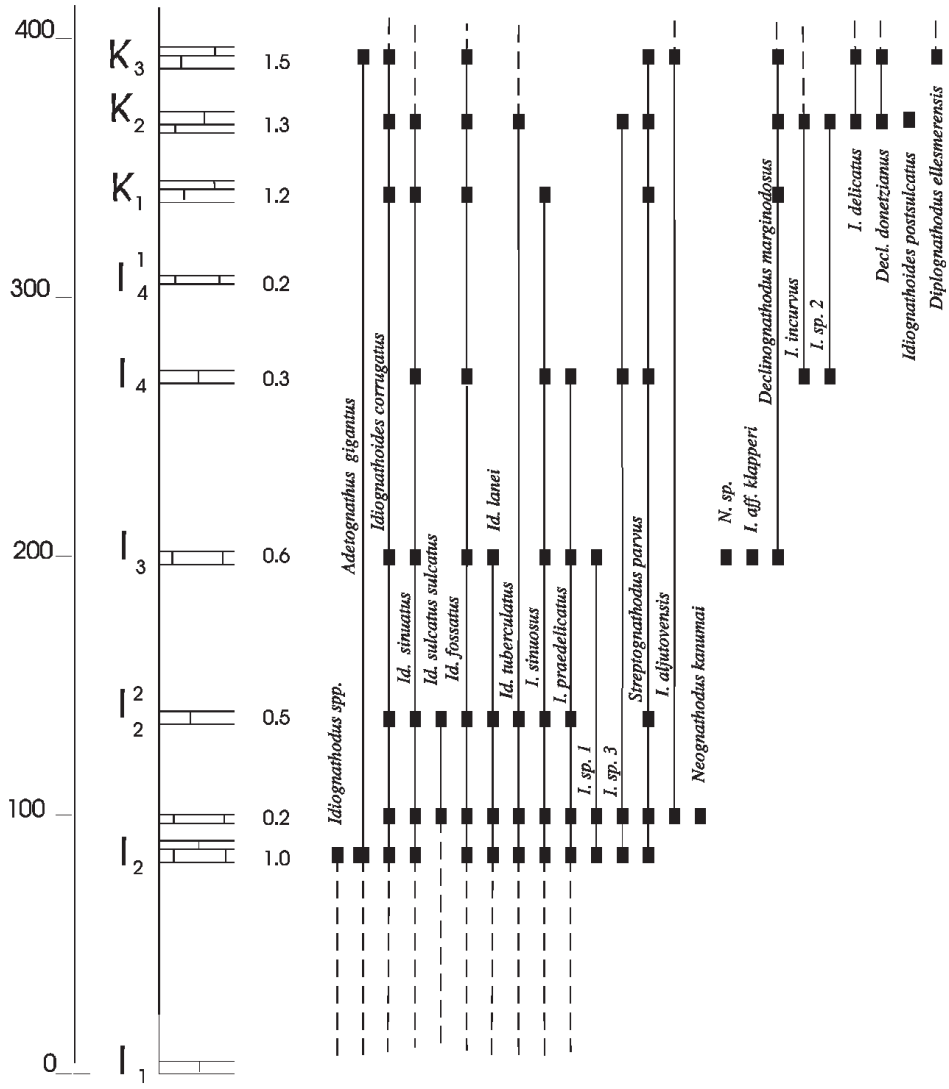


Fig. 21. Distribution of conodonts in the Zolotaya Valley section (loc. 19).

5) The origin of *Streptognathodus* is unknown. Like *Idiognathodus,* it could have derived either from *Decl. lateralis-Decl. pseudolateralis* or from *Ferganaegnathodus.* Barrick & Boardman (1989) might be right regarding Bashkirian *Streptognathodus* as a separate derivation from an ancestor of *Idiognathodus (Decl. lateralis*?) (Fig. 35).

In the Donets Basin there is no evidence that *Declinognathodus* and *Idiognathoides* derived from *Gn. bilineatus* as the transitional species *Decl. praenoduliferus* and *Id. asiaticus* were not found. Fortunately they occur in the Mid-Carboniferous boundary deposits of Central Asia. *Gn. girtyi simplex* was not found in Europe at all (Nemirovskaya & Nigmadganov, 1994).

Stage	Bashkirian									Moscov.
Substage	Upper									Lower
Limestone	I_1	I_2	I_2^1	I_2^2	I_3	I_4	I_4^1	K_1	K_2	K_3
Idiognathoides sinuatus		30	45	95	19	34		9	8	
Id. corrugatus		32	32	47	7	17		4	3	1
Id. sulcatus sulcatus			1	2						
Id. postsulcatus										2
Id. lanei		10	10	2	3					
Id. fossatus		7	19	46	18	30		15	7	2
Id. tuberculatus		3	1	2					1	
Idiognathodus sinuosus		3	5	5	3	14		12		
I. incurvus						4			2	
I. aljutovensis			12							1
I. praedelicatus		2		1	2	8				
I. delicatus									13	5
I. sp. 1		5	11		1					
I. sp. 2						9			1	
I. sp. 3		6				11				
I. aff. *klapperi*					1					
Streptognathodus parvus		2	3	2		1		2	1	
Str. aff. *parvus*										2
Declinognathodus marginodosus					2			12	1	10
Adetognathus gigantus		1								
Neognathodus kanumai			1							
N. sp. 1					1					
Decl. donetzianus									3	8
Diplognathodus ellesmerensis										1
Total weight of the sample	3	3	3	3	3	3	3	3	3	3

Fig. 22. Numerical distribution of conodonts in the Zolotaya Valley section (loc. 19).

The derivation of *Idiognathodus* and *Streptognathodus* from either *Decl. pseudolateralis* or from *Ferganaegnathodus* can as yet not be proven in the Donets sequence. *Decl. pseudolateralis* was found higher in the section (limestone G_1) than the first *Idiognathodus* (limestone F_1^1), and *Ferganaegnathodus* has not been found at all. In the South Fergana Valley Bashkirian carbonate succession *Ferg. dzhenchuraevae* (paper in preparation) which shows the transitional features between the Early Bashkirian *Ferg. ferganaensis* and *Streptognathodus* and *Idiognathodus* occurs a little higher than the first *Idiognathodus* but below the first *Streptognathodus*.

The origin of *Idiognathoides sulcatus* is also uncertain. By its nodular parapets and general shape of the platform it resembles only *Decl. noduliferus*. But it also might have been derived from *Gn. postbilineatus* via *Id. macer*.

Declinognathodus is one of the two most important genera during Bashkirian times. The first species in the Donets sequence is *Decl. noduliferus inaequalis* which changes into *Decl. noduliferus noduliferus* and later into *Decl. noduliferus japonicus* by the reduction of the outer parapet. *Decl. noduliferus noduliferus* is most common in Early Bashkirian times. In the Late Bashkirian it gives rise to *Decl. marginodosus.* By

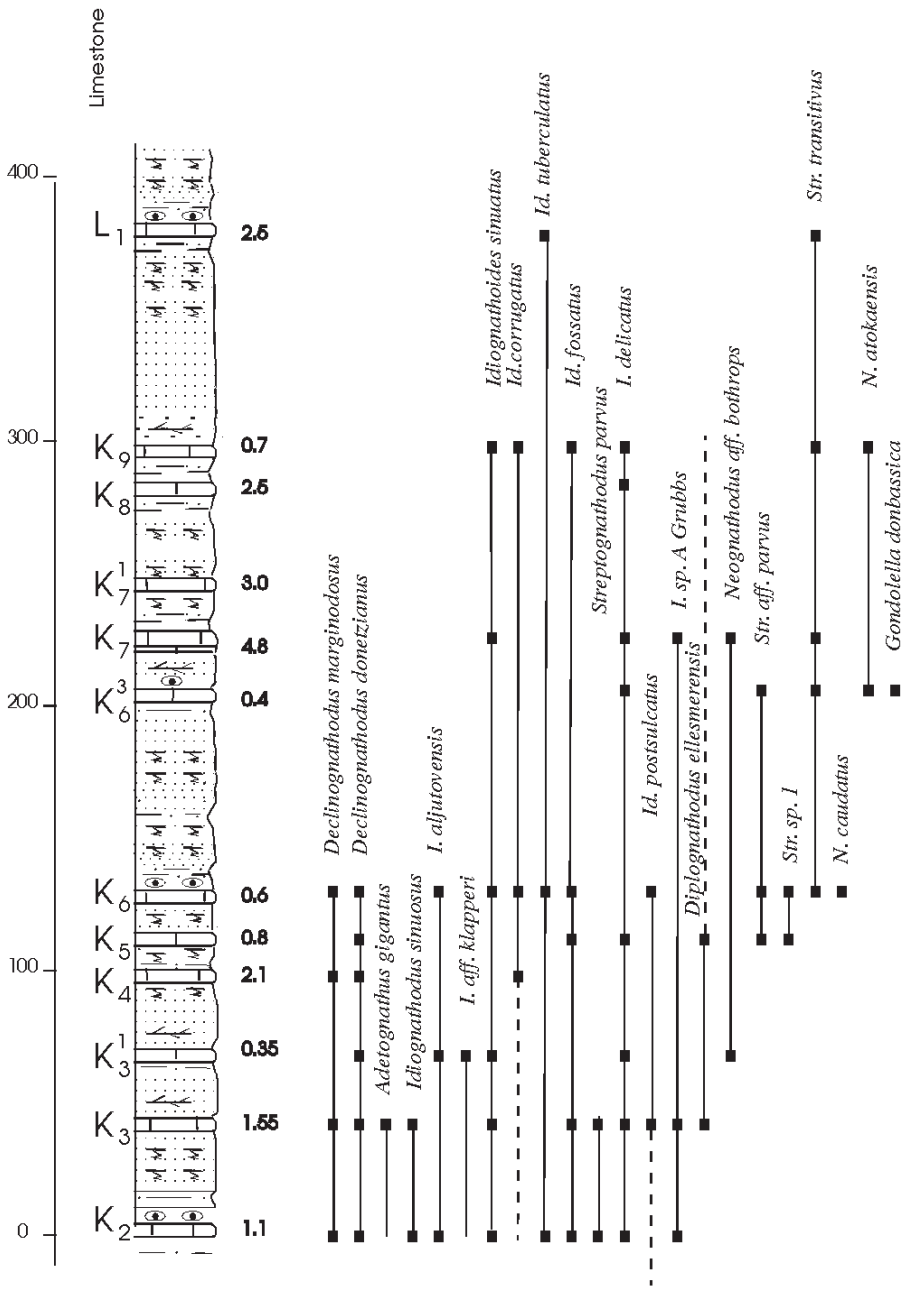


Fig. 23. Distribution of conodonts in the Karaguz Valley section (loc. 21).

Stage	Bashkirian		Moscovian
Substage	Upper		Lower
Limestone	K_2		K_3
Idiognathoides sinuatus	5		2
Id. tuberculatus	21		
Id. fosaatus	30		3
Declinognathodus marginodosus	3		
Decl. donatzianus	10		1
Idiognathodus sinuosus	27		6
I. delicatus	3		1
I. aljutovensis	1		
Streptognathodus parvus	5		3
Adethognatus gigantus		1	
I. sp. A of Grubbs	1		
Total weight of the sample	4		4

Fig. 24. Numerical distribution of conodonts in the Karaguz Valley section (loc. 21).

Stage	Moscovian									
Substage	Lower									
Limestone	K_3	K_3^1	K_4	K_5	K_6	K_6^3	K_7	K_8	K_9	L_1
Declinognathodus marginodosus	5		5		70					
Decl. donetzianus		8	2	4	10		1			
Idiognathoides sinuatus		1			15		1		2	
Id. corrugatus			1		20				10	
Id. fossatus				1	25				3	
Id. tuberculatus					20					
Id. postsulcatus					4					
Idiognathodus delicatus	1	8		5		39	3	1	3	
I. aljutovensis		1								
I. aff. *klapperi*		2								
I. sp. A of Grubbs							2			
Steptognathodus aff. *parvus*				1	3	50				
Str. sp.1				1	3					
Str. transitivus					2	10	4		8	1
I. magnificus								4	1	
Neognathodus atokaensis						1			1	
N. caudatus					1					
Gondolella donbassica						10				
Diplognathodus ellesmerensis				1						
N. aff. *bothrops*		1					1			
Total weight of sample	3	3	6	3	6	6	6	3	3	3

Fig. 25. Numerical distribution of conodonts in the Pashennaya Valley section (loc. 28).

Stage	Bashkirian								
Substage	Lower		Upper						
Limestone	F_1	F_2	H_1	H_2	H_3	H_4	H_5	H_5^1	K_1
Declinognathodus lateralis	2								
Decl. n. noduliferus	1	1	1						
Decl. pseudolateralis							4		
Idiognathoides sinuatus	5		10	10	53	17	140	10	
Id. corrugatus	6	2	11	12	17	17	59	13	2
Id. sulcatus sulcatus							4		
Id. lanei			1		16		12		
Id.fossatus			1?		70		43		2
Id. tuberculatus					4		22		
Neognathodus symmetricus		6			30	20	2		
N. sp. 1					5			6	
Idiognathodus sinuosus		1			3	1	4	1	1
I. praedelicatus					10		3	1	
I. aff. *klapperi*					2				
I. aljutovensis				1			8		
Streptognathodus expansus							1		
Str. suberectus							3		1
Decl. marginodosus									1
Total weight of the sample	6	4	4	4	4	4	4	4	5

Fig. 26. Numerical distribution of conodonts in the Volnukhino section (loc. 23).

Stage	Bashkirian						
Substage	Lower					Upper	
Limestone	F_1^2	F_1^4	F_2	F_2^1	F_2^2	G_1	G_1^1
Idiognathoides sinuatus	1		6	14	1	10	2
Id. corrugatus			9	24	1	8	10
Id. sulcatus sulcatus			4	3			
Declinognathodus noduliferus				1			1
Idiognathodus sinuosus			1	1			6
I. praedelicatus				1			1
Neognathodus symmetricus			1				
Id. sulcatus parvus							1
I. primulus							1
Total weight of the sample	3	3	6	3	6	6	6

Fig. 27. Numerical distribution of conodonts in the Gruzskaya Gully section (loc. 25).

Stage	Bashkirian						
Substage	Lower	Upper					
Limestone	F_2	G_1	G_1^1	G_1^2	G_1^4	G_2	G_4
Declinognathodus noduliferus			3				
D. pseudolateralis			1				
Idiognathoides sinuatus			9		5		
Id. corrugatus			13		4		
Id. sulcatus parvus					1		
Idiognathodus sinuosus			4		2		1
I. sp. 4							1
Neognathodus symmetricus					6		1
N. primulus							1
Total weight of the sample	3	3	3	4	3	3	3

Fig. 28. Numerical distribution of conodonts in the Orekhovaya Valley section (loc. 26).

Stage	Bashkirian						
Substage	Upper						
Limestone	H_3	H_4	H_5^0	H_5	H_5^1	H_6	H_6^1
Idiognathoides sinuatus	60	33	1	26			14
Id. corrugatus .	70	62		60			15
Id. sulcatus parvus		5		2			
Id. lanei	10	30	2	33			1
Id. fossatus		40		30			
Id. tuberculatus		3	1	12			1
Neognathodus symmetricus	20						
N. sp. 1				1			
Declinognathodus sp.			1				
Idiognathodus sinuosus	6			2			
I. praedelicatus	5	1		1			
I. aljutovensis		1					1
Streptognathodus suberectus		2					
Total weight of the sample	4	4	4	4	4	4	4

Fig. 29. Numerical distribution of conodonts in the Sorochya gully section (loc. 24).

Stage	Bashkirian									
Substage	Upper									
Limestone	G_4	H_4	H_5	H_5^0	H_6	I_1	I_2^1	I_2^2	I_2^3	I_3
Idiognathoides sinuatus	1		1		63					
Id. corrugatus	1				70					
Id. sulcatus parvus									1	
Id. lanei	4				4					
Id. fossatus					12					
Declinognathodus marginodosus									1	
Neognathodus symmetricus	1									
Idiognathodus sinuosus			1				2		1	
I. praedelicatus							1		2	
Steptognathodus parvus							2		1	
N. sp.							3			
I. sp. 2							5			
Total weight of the sample	3	3	3	3	3	3	3	3	3	3

Fig. 30. Numerical distribution of conodonts in the Klenovaya gully section (loc. 27).

Stage	Bashkirian				Moscovian	
Substage	Upper				Lower	
Limestone	I_2	I_3	I_4	K_1	K_5	K_7
Idiognathoides sinuatus	10	6	92	3		
Id. corrugatus	3	2	19	2		
Id. sulcatus parvus	1					
Id. sulcatus sulcatus	1					
Id. fossatus	10	6	79	2		
Id. tuberculatus	3	1	5			
Idiognathodus sinuosus	5		44	5		
I. primulus	1		1			
I. praedelicatus	1	1	1			
I. delicatus		4	3	11	1	9
I. adjutovensis	5	1				
I. sp. 1	4					
I. incurvus			2			
I. sp. A of Grubbs						2
Declinognathodus marginodosus		3		1		
Streptognathodus parvus	2	1	3	1		
Str. aff. *parvus*					1	
Str. transistivus						6
Neognathodus atokaensis						1
Diplognathodus ellesmerensis					2	
Total weight of the sample	3	3	3	3	3	3

Fig. 31. Numerical distribution of conodonts in the Kholodnaya (loc. 14) and Khartzy (loc. 18) gully sections.

Stage	Bashkirian				Moscovian		
Substage	Upper				Lower		
Limestone	I_3	I_4	K_1	K_2	K_3	K_3^1	K_3^1-K_4
Declinognathodus marginodosus				3	1		2
Decl. donetzianus					8		5
Idiognathoidus sinuatus	4						
Id. corrugatus	2						
Id. fossatus	1			1			
Id. tuberculatus							3
Idiognathodus sinuosus	3						
I. delicatus	1	1		2			1
I. aljutovensis		1					
Streptognathodus sp. 1		2					
Total weight of the sample	4	4	4	4	4	4	4

Fig. 32. Numerical distribution of conodonts in the Shterovka-Redkino section (loc. 22).

the end of the Bashkirian *Decl. donetzianus* derived from *Decl. marginodosus.* These last representives of the genus *Declinognathodus* show a resemblance with the species of the genus *Idiognathoides.* The convergence of two genera is expressed in similar shape of the platform and strong reduction of the outer parapet to one node. Both *Declinognathodus* and *Idiognathoides* platform elements bear the nodes on the outer side of the platform, close to its middle part. *Declinognathodus* probably did not give rise to the Moscovian conodonts.

Idiognathoides sinuatus gave rise to *Id. lanei* (limestone E_8^3, Lower Bashkirian) and by the end of the Bashkirian to *Id. tuberculatus. Id. corrugatus* gave rise to *Id. fossatus. Id. sulcatus sulcatus* gave rise to *Id. sulcatus parvus* which had a shorter range than *Id. sulcatus sulcatus.* By the beginning of the Moscovian *Id. sulcatus sulcatus* grades into a special form that differs from the latter by a more shallow trough and a more narrow platform with convex uplifted platform sides - *Id. postsulcatus*.

Neognathodus symmetricus grades into *N.* sp. 1 by reduction of the carina. Later, by the end of the Bashkirian and the beginning of the Moscovian the other *Neognathodus* species with a wider platform and asymmetrical slightly elevated parapets appeared (*N. kanumai, N.* aff. *bothrops, N. caudatus*, and *N. atokaensis*). *Neognathodus* shows the tendency to expand the platform due to increasing the width and height of the parapets and the width of the adcarinal grooves. In the Donets Basin the Moscovian *Neognathodus* are arched in lateral view. By the end of the Moscovian the *Neognathodus* species loose the ornamentation due to a reduction and even loss of the outer parapet.

Idiognathodus appeared with simple primitive forms by the end of the Early Bashkirian. During the second half of the Bashkirian a species with well developed, nodularly ornamented accessory lobes, but with a rather simple anterior platform margin occurs (*I. praedelicatus*). Later the anterior platform margin is more complicated, the rostral ridges show the tendency to extend beyond the anterior limit of the platform and turn away from the carina (*I. incurvus, I. aljutovensis*, etc.). At the end of the Bashkirian or beginning of the Moscovian the species of *Idiognathodus* bear the most advanced features: the rostra extend beyond the anterior margin of the platform

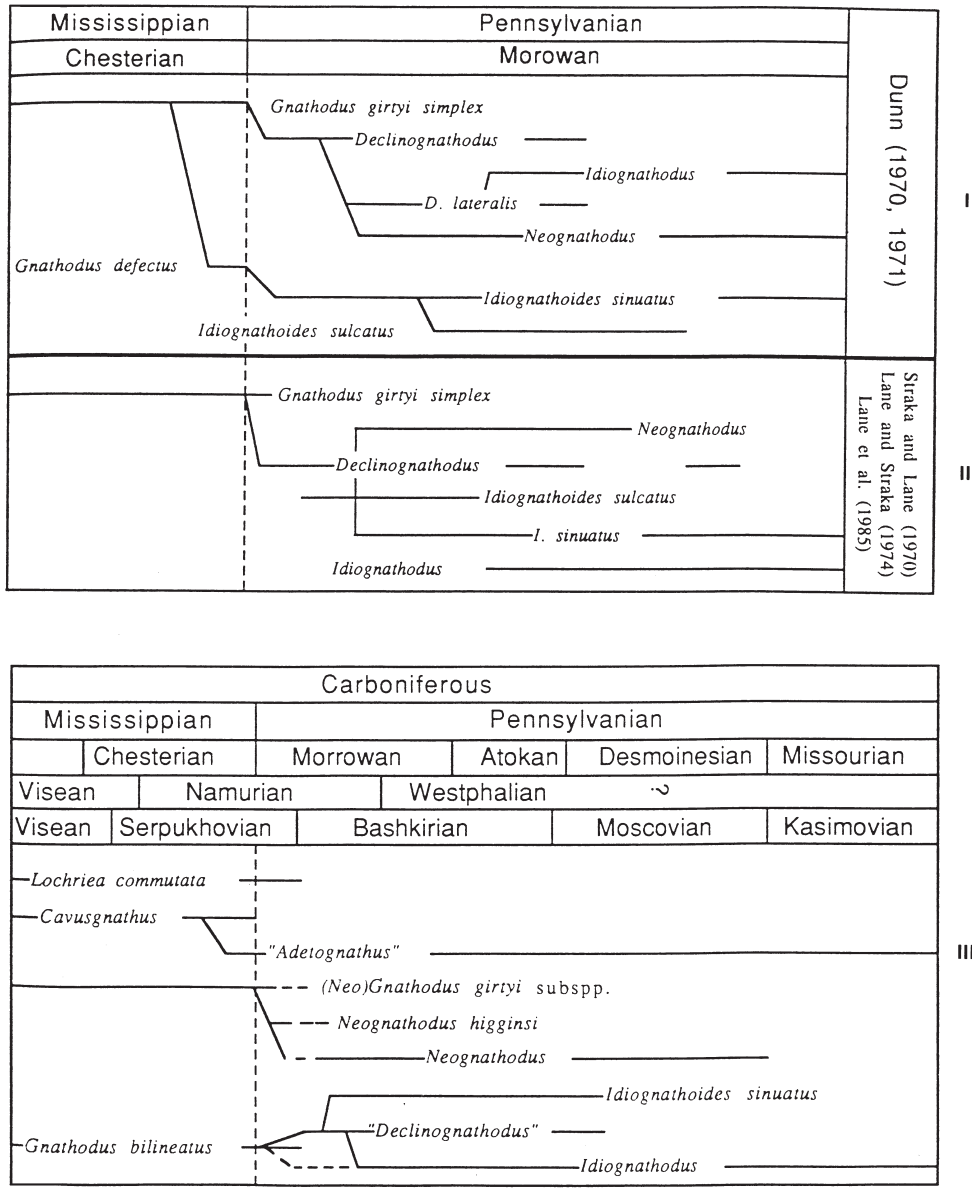


Fig. 33. Three phylogentic models (I-III)for the mid-Carboniferous boundary based on gnathodontid conodonts of North America; the third model was constructed by Grayson et al. (1990) (figure from Nemirovskaya & Nigmadganov, 1994).

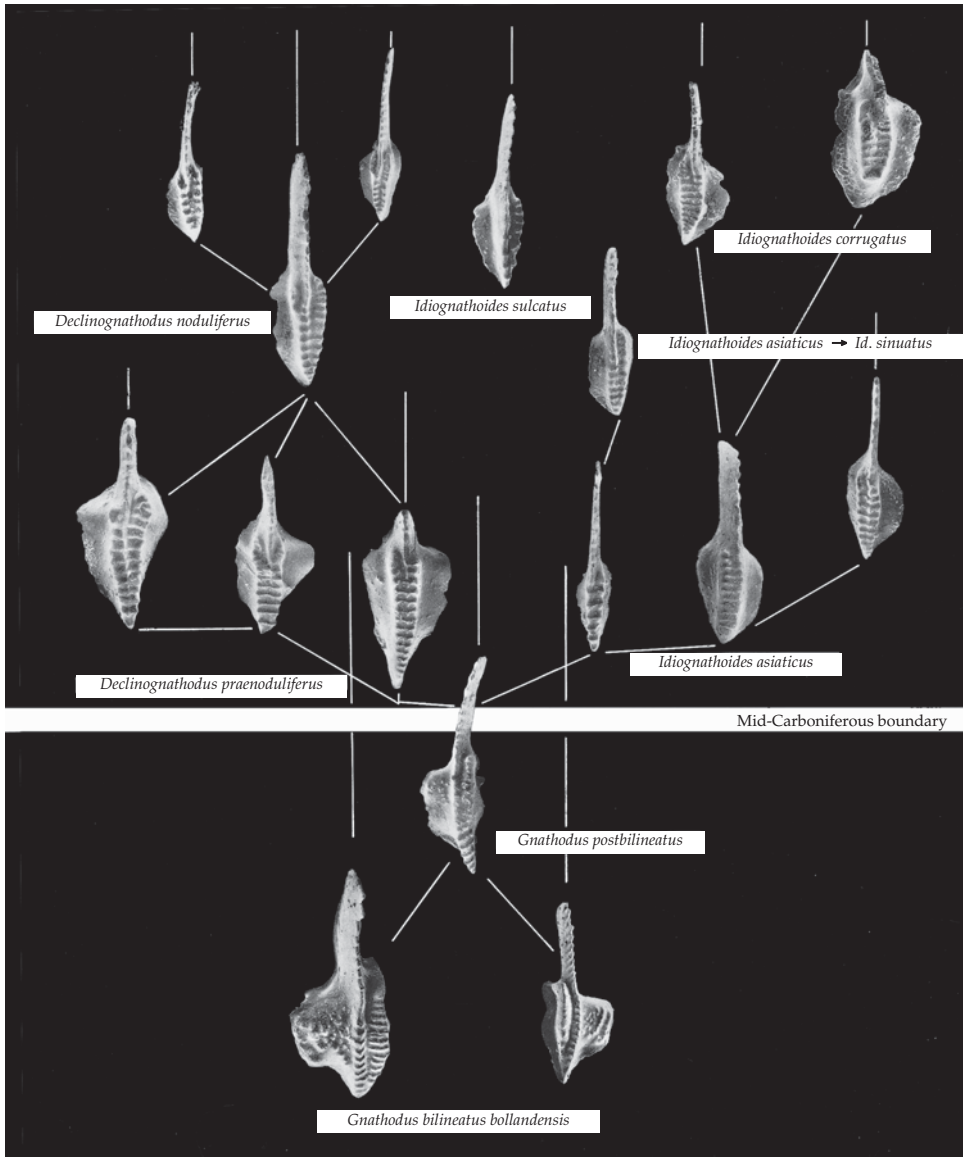


Fig. 34. Conodont evolution near the mid-Carboniferous boundary (from Nemirovskaya & Nigmadganov, 1994).

and turn away from the carina, the lobes are more prominent, but not incorporated in the platform (*I. delicatus, I. magnificus, I. obliquus*, etc.).

The first *Streptognathodus* species have a more complicated ornamentation than the younger ones. *Str. suberectus* and *Str. expansus* probably belong to the particularly ornamented group with accessory lobes, short carina and median groove. They could be the ancestors of such well-ornamented Moscovian forms as *Str. dissectus, Str. concinnus* Kossenko and *Str. cancellosus* (Gunnell), but the transitional forms were not

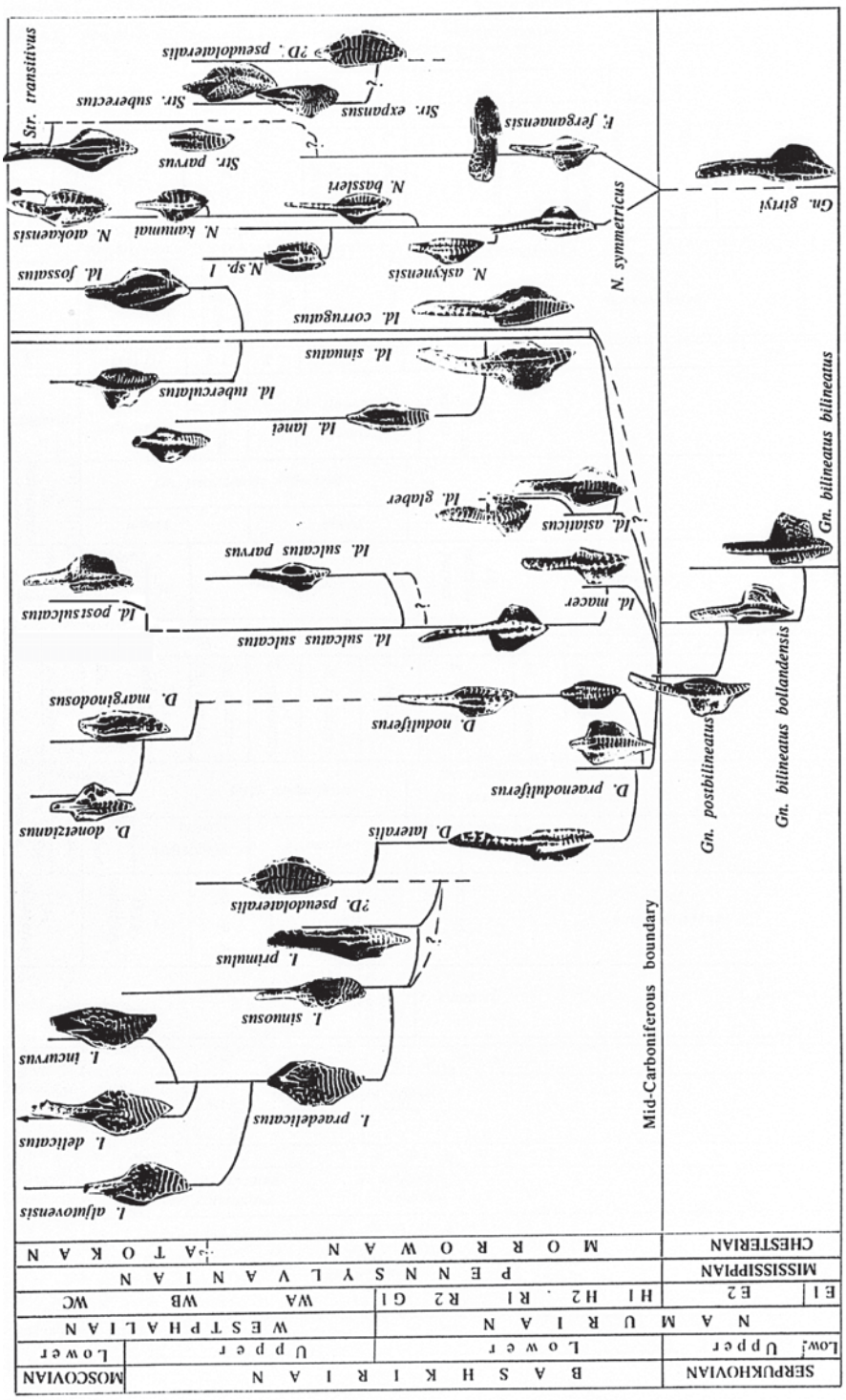


Fig. 35. Main evolutionary trends in Bashkirian conodonts (some pictures from Lane & Straka, 1974; Wirth, 1967; Higgins, 1975; van den Boogaard & Bless, 1985; Nemirovskaya & Nigmadganov, 1994).

found yet. According to Barrick & Boardman (1989) they also may represent a separate group which had a common ancestor with *Idiognathodus.* Another group includes *Str. parvus* which could have given rise to *Str.* aff. *parvus* and later to *Str. transitivus* and/or *Str. dissectus.* The *transitivus* group differs from the other streptognathodids by its simple forms having parapets and a rather long carina but no lobes. It resembles certain species of *Neognathodus. Str. transitivus* possibly was an ancestor of such simple Late Moscovian and Kasimovian forms as *Str. oppletus* and *Str. elongatus.*

Bashkirian conodont biostratigraphy of the Donets Basin

The preliminary phylogenetic models mentioned above show that it is possible to construct a monogeneric conodont zonation of the Bashkirian Stage using the species of the genus *Idiognathoides* as the latter seems to have a broad environmental adaptability and may have a significant correlative value. It is widespread in the Donets Basin, and together with other important Bashkirian conodonts increases the potential of the Donets Bashkirian section as a bridge for the correlation between Western and Eastern Europe, North America and Asia. Up to now there is not enough information from the Donets Basin as well as around the world to establish the monogeneric zonation. But unpublished data from China, Russian Arctic, Kirghizstan, and probably Spain, give a hope that such a zonation can be done either by *Idiognathoides* or by *Declinognathodus.*

In this paper a subdivision of the Bashkirian and Lower Moscovian deposits is given based on the evolutionary appearance (where it was possible) of the main important conodont taxa. This conodont zonation can serve as a basis for future work, when additional studies in the Donets Basin will be completed and more information from other areas will be available. Ten conodont zones can be distinguished from the Late Serpukhovian through to Early Moscovian interval (Fig. 36).

The first, the early Serpukhovian conodont zone, the *Lochriea ziegleri* Zone, comprises the upper part of the C_1^2(B) and the C_1^3(C) suites, or the Tarussky and Steshevsky horizons of the Russian Platform. The second, late Serpukhovian conodont zone is the *Gnathodus bilineatus bollandensis-Adetognathus unicornis* Zone, which is the oldest zone described in this paper.

Gnathodus bilineatus bollandensis-Adetognathus unicornis Zone

The lower boundary of this zone is defined by the first appearance of *Gn. bilineatus bollandensis* and *Ad. unicornis.* The upper boundary is determined by the first appearance of *Gn. postbilineatus*.

This zone comprises the lower half of the C_1^4(D) Suite, or the Protvinsky and Zapaltyubinsky horizons of the Unified Carboniferous scheme of the Russian platform (Kagarmanov & Donakova, 1990) or Starobeshevsky Horizon of the Ukrainian Carboniferous Scale (Poletaev et al., 1991). This zone includes a typical late Early Carboniferous conodont association with *Gn. bilineatus bollandensis*, *Gn. bilineatus bilineatus*, *Adetognathus unicornis*, *Lochriea commutata*, *L. mononodosa,* and *L. ziegleri.*

The *Gn. bilineatus bollandensis* Zone is widespread in Europe and Asia (Higgins, 1975; Higgins & Bouckaert, 1968; Higgins, 1985; Perret, 1993: England, Belgium, France ; Nemirovskaya, 1982, 198: Ukraine; Wang, Lane & Manger, 1987: China;

Pazukhin in Kulagina et al., 1992: Urals, Russia). In Germany it can be compared with the *Gn. bilineatus schmidti* Zone (Meischner, 1970). In North America this zone corresponds to the *Adetognathus unicornis* and *Rhachistognathus muricatus* zones, both containing *Gn. bilineatus bollandensis* as well as the other, latest Mississippian species (Lane, 1977). The *Gn. bilineatus bollandensis-Ad. unicornis* Zone is compared with the *Gn. bilineatus bollandensis* Zone of the Tatangian of South China and the Tsingyuan of NW China (Wang et al., 1987) and probably with the upper part of the *Gn. bilineatus-Gn. nodosus* Zone of the Nagoe Formation of Japan (Koike, 1967). This zone corresponds to most of the lower part of the Arnsbergian of Western Europe.

Gnathodus postbilineatus Zone

The lower boundary of this zone is defined by the first appperance of *Gn. postbilineatus*. Its upper boundary coincides with the Mid-Carboniferous Boundary, i.e with the entry of the species of the *Declinognathodus noduliferus* group.

The zone was distinguished in the South Tianshan deep-water Aksu section as the last Early Carboniferous conodont zone (Nemirovskaya & Nigmadganov, 1994). Such advanced species as *Gn. postbilineatus* later were identified also in the Donets Basin in the uppermost part of the Zapaltyubinsky Horizon or the uppermost part of the Starobeshevsky Horizon of the Ukrainian Carboniferous scheme, and in the Upper Arnsbergian of Western Europe (Riley et al., 1994). This zone comprises the interval between limestones D_5^7 and D_5^8lower and contains the same Early Carboniferous conodont assemblage as the underlying deposits.

This zone seems to correspond to the uppermost part of the *Gn. bilineatus bollandensis* Zone of the United Kingdom and to the *Gn. postbilineatus* Zone of the Central Asia, South Tianshan (Nemirovskaya & Nigmadganov, 1994). It might correspond to the upper part of the Arnsbergian. The ammonoids recovered from the 'nodular horizon' above limestone D_5^7 (see p. 13) indicate the E2c1 ammonoid subzone (Riley et al., 1987).

Declinognathodus noduliferus s.l. Zone

The lower boundary of the *Decl. noduliferu*s Zone is defined by the first appearance of *Decl. noduliferus* s.l. Its upper boundary is determined by the entry of *Idiognathoides* species which dominate throughout the Bashkirian.

This zone comprises the interval between the limestones D_5^8upper and D_7^6 of the upper part of the C_1^4(D) Suite, i.e. the uppermost part of the Zapaltyubinsky through the Voznesensky horizons of the General Scheme of the Russian Platform, or the lower part of the Olmezovsky Horizon of the Ukrainian Carboniferous Scheme. The conodont assemblage is not diverse and contains mainly representatives of the genus *Declinognathodus*, i.e. *Decl. noduliferus inaequalis*, *Decl. noduliferus noduliferus* and *Decl. lateralis; Hindeodus minutus* also occurs. The shallow-water conodonts recovered from the oolitic limestone D_5^9 include *Rhachistognathus minutus declinatus*, *Adetognathus gigantus*, and *Ad. lautus*. *Rh. minutus declinatus* was not found elsewhere in the Donets Basin, only in limestone D_5^9. This assemblage yields the first Middle Carboniferous conodonts, some Early Carboniferous species are still found in the oolitic limestone

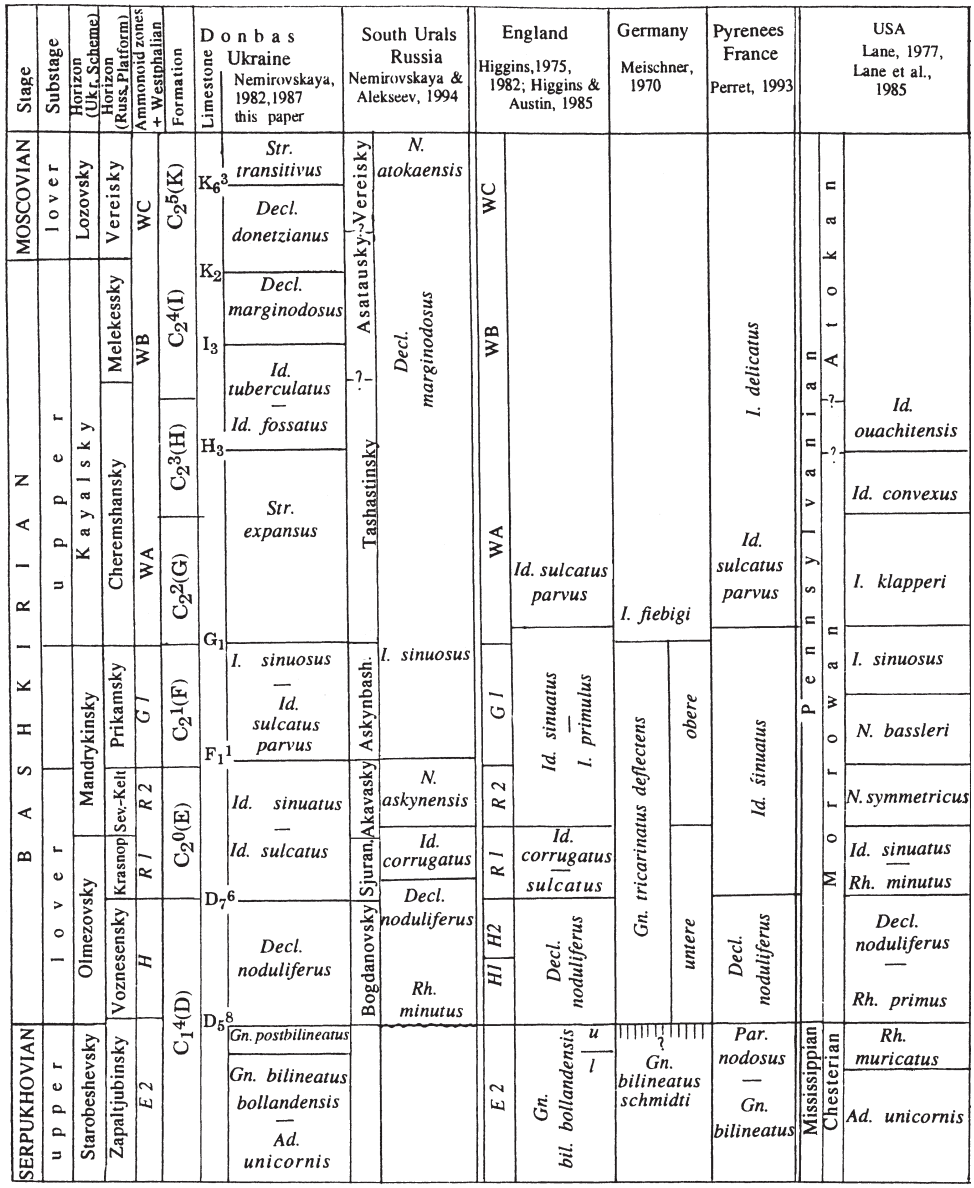
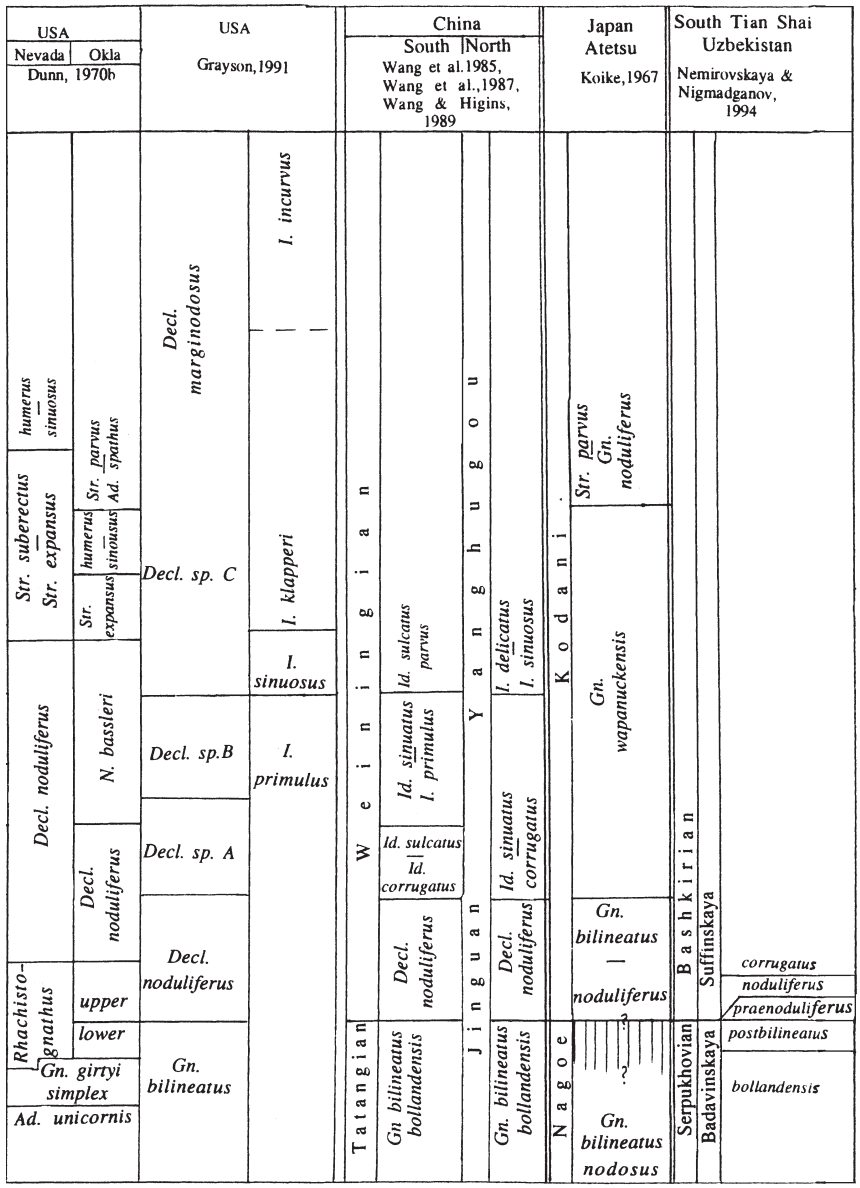


Fig. 36. Correlation chart of the Bashkirian conodont zones of the donets Basin with other areas.

D_5^9. These are *Lochriea commutata* and the ramiform element *Neoprioniodus singularis*, which is M element of *L. commutata*, both are probably reworked.

The *Decl. noduliferu*s Zone is widespread over the world in the areas which were not strongly affected by the Mid-Carboniferous eustatic event and where the Mid-Carboniferous boundary deposits do occur. This zone is known to correspond to the *Decl. noduliferus-Decl. lateralis* conodont Zone and the Chokierian-Alportian (the



Homoceras Zone) in Western Europe (Higgins, 1975; Higgins & Bouckaert, 1968; Higgins, 1985; Nemirovskaya, 1982, 1987) and probably corresponds to the *Rh. minutus* and part of the *Decl. noduliferus* Zone of the South Urals (Nemirovskaya & Alekseev, 1994). It is identified in the Pyrenees (Perret, 1993) and in the Cantabrian Mountains (Menéndez-Álvarez, in Sánchez de Posada et al., 1990). In Germany it corresponds to the lower part of the lower *Gn tricarinatus deflectens* Zone (Meischner, 1970). The *Decl. noduliferus* Zone of Donbas can be correlated with the same zone of China (Wang et al., 1987), with the *Gn. bilineatus-Gn. nodulifera* Zone of Japan (Koike, 1965), and the

Decl. noduliferus-Rh. primus Zone of North America (Dunn, 1970; Lane & Straka, 1974; Lane, 1977) as *Decl. noduliferus* was found together with *Rh. primus* at the base of the above mentioned zone.

In Uzbekistan, South Tianshan (the Hissar Range), the *Decl. noduliferus* Zone corresponds with the second conodont zone after the Mid-Carboniferous boundary, as the first zone is *Declinognathodus praenoduliferus* Zone. Both zones correspond only to the lowermost part of the *Homoceras* Zone (Nemirovskaya & Nigmadganov, 1994). The species of the genus *Idiognathoides* appeared there much earlier than in the other more shallow water basins. Therefore taking into account the ammonoid evolution, we can not regard the *Decl. noduliferus* s.l. Zone of Donbas and *Decl. noduliferus* Zone of the South Tianshan as coeval. At the Bashkirian stratotype, South Urals, the *Decl. noduliferus* Zone is the second Bashkirian zone after the *Rh. minutus* Zone. The lower part of the Bashkirian stratotype is represented by very shallow water algal facies; *Idiognathoides* appeared there much later than in deep-water and offshore environments. Thus the *Decl. noduliferus* Zone in the Askyn section is recognised in beds 8-11 that is in the lower half of the Syuransky Horizon, which corresponds to the *Reticuloceras* Ammonoid Zone (Kagarmanov & Donakova, 1990; Furduj, 1979).

In the studied area the *Decl. noduliferus* Zone includes two subzones: *Decl. noduliferus inaequalis* and *Decl. n. noduliferus*. The lower boundary of the first subzone is defined by the first appearance of *Decl. n. inaequalis*. Its upper boundary is marked by the entry of *Decl. n. noduliferus.* The subzone comprises the interval from the base of the limestone D_5^8upper up to the base of the limestone D_5^9. The conodont assemblage consists mainly of *Decl. n. inaequalis* . Several specimens of *Hindeodus minutus* also occur.

The lower boundary of the *Decl. noduliferus noduliferus* Subzone is defined by the first appearance of *Decl. n. noduliferus*. Its upper boundary coincides with the upper boundary of the *Decl. noduliferus* Zone. The subzone corresponds to the interval from limestone D_5^9 to limestone D_7^6 and is characterised by *Decl. n. noduliferus, Decl. n. inaequalis, Decl. n. japonicus*, and *Decl. lateralis*. It includes the species of the genera *Adetognathus* and *Rhachistognathus* mentioned above. *Decl. n. inaequalis* dominates in the lower part of the section, and *Decl. n. noduliferus* prevails in the uppermost part of the section. *Adetognathus* and *Rhachistognathus* species were found only in the oolitic limestone D_5^9. The ammonoid *Homoceras* sp. was found in limestone D_5^{10}.

The Carboniferous deposits in the Donets Basin do not contain *Decl. praenoduliferus,* which is the first *Declinognathodus* in the Aksu section of the South Tianshan, the Hissar Range. This species was also found recently in the Cantabrian Mountains (collection of Méndez & Menéndez-Álvarez, April 1995). The absence of *Decl. praenoduliferus* in the Donets Basin indicates either a sedimentological or a palaeontological gap. On the other hand *Decl. praenoduliferus* has ridged, not nodular parapets, and *Decl. noduliferus inaequalis* is absent from the Aksu section. Thus by the conodonts available from both sections of the Hissar Range and Donets Basin, we cannot estimate the size of the gap in the Donets Basin. Before, we thought that we missed the whole *Decl. praenoduliferus* Subzone in Donbas (Nemirovskaya & Nigmadganov, 1994). But the *Decl. n. inaequalis* Subzone, which is not registered in the Aksu section, may cover the *Decl. praenoduliferus* Zone or part of it.

As it was pointed out before (Nemirovskaya & Nigmadganov, 1994) additional

studies have to be made to understand the evolution of the first representatives of the *Declinognathodus noduliferus* Group. That is why the Mid-Carboniferous boundary is defined now by the first appearance of *Declinognathodus noduliferus* s.l.

Idiognathoides sinuatus-Idiognathoides sulcatus sulcatus Zone

The lower boundary of the zone is defined by the first appearance of *Id. sinuatus* and *Id. sulcatus sulcatus*. The upper boundary is determined by the first appearance of *Idiognathodus sinuosus.*

This zone embraces the interval between limestone D_7^6 of the C_1^4(D) Suite and limestone F_1^1 of the C_2^1(F) Suite, or the top of the Voznesensky, the Krasnopolyansky, the Severo-Keltmensky and the lowermost part of the Prikamsky horizons of the Russian Platform, or the upper part of the Olmezovsky and lowermost part of the Mandrykinsky horizons of the Ukrainian Carboniferous scheme. The conodont association is diverse, it includes *Decl. noduliferus noduliferus, Decl. n. inaequalis, Decl. n. japonicus, Decl. lateralis, Idiognathoides sinuatus*, *Id. sulcatus sulcatus*, *Id. corrugatus, Neognathodus symmetricus*, scarse *Ad. gigantus,* and *Ad. lautus. Id. sinuatus, Id. sulcatus sulcatus, Id. corrugatus*, and *N. symmetricus* were found for the first time at the level of limestone D_7^6 in several localities: *Id. sinuatus* was registered in limestone D_7^6 in the Bezymyannaya Gully, Kalmius section; *Id. sulcatus sulcatus* was found in the Popovaya and Bolshaya Shyshovka valleys, and *Id. corrugatus* and *Id. s. sulcatus* were found together in the Malaya Shyshovka Valley, Amvrosievka section at the same level (Figs. 5-8). The ammonoids of the *Reticuloceras* 1 Ammonoid Zone were found for the first time at the same level, limestone D_7^6 (see p. 9). *Decl. n. japonicus* occurs only in the lowermost part of the zone. *Decl. n. inaequalis* became extinct in the middle of the zone. *Neognathodus askynensis* Nemirovskaya & Alekseev occurs in limestone E_6, in the middle of the C_2^0(E) Suite, just above the first occurrence of the ammonoid *Reticuloceras reticulatum* (Phillips). The *Declinognathodus* species continue to dominate during the Krasnopolyansky Horizon. Since the Severo-Keltmensky the *Idiognathoides* started to prevail.

The *Id. sinuatus-Id. sulcatus sulcatus* Zone is well known all over the world. It corresponds to the same zone of the Kinderscoutian Stage, or *Reticuloceras* 1 Ammonoid Zone (Higgins, 1975; Higgins, 1985; Perret, 1993; Nemirovskaya, 1983, 1987), to the *Decl. noduliferus japonicus-Id. sinuatus* Zone of China (Wang et al., 1987) and to the *Gn. wapanuckensis* (= *N. symmetricus*) Zone of Japan (Koike, 1967) and probably to the *Id. sinuatus-Rh. minutus* Zone of North America (Lane, 1977). At the Bashkirian stratotype, South Urals, the *Id. corrugatus* Zone embraces the upper part of the Syuransky and the lower part of the Akavassky horizons. In Central Asia, South Tianshan, Hissar Range, the *Id. corrugatus* Zone was registered in the upper part of the Aksu section, that is late Early Chokierian in age. This zone was established in the Lower Pennsylvanian (Lower Morrowan) in North America (Lane, 1977).

Idiognathodus sinuosus-Idiognathoides sulcatus parvus Zone

The lower boundary of the zone is defined by the entry of the genus *Idiognathodus*, and *Id. sulcatus parvus,* in particular. Its upper boundary coincides with the entry of *Streptognathodus.*

This zone comprises the interval of almost the entire C_2^1(F) Suite without its lowermost beds, and corresponds to the Prikamsky Horizon of the Russian Platform (without the lowermost beds) or the greater part of the Mandrykinsky Horizon of the Ukrainian Carboniferous scheme. The characteristic species are *Idiognathoides sinuatus, Id. corrugatus, Id. s. sulcatus, Id. s. parvus, Decl. n. noduliferus, Idiognathodus sinuosus,* and *Neognathodus symmetricus. Decl. lateralis, Hindeodus minutus* and *Id. lanei*, known from the underlying deposits, also occur. The earliest species of *Idiognathodus* such as *I. sinuosus*, *I. primulus,* and *I. praedelicatus* sp. nov. appeared during this time.

The *I. sinuosus-Id. sulcatus parvus* Zone seems to correspond, to some extent, to the *Id. sinuatus-I. primulus* Zone of Great Britain (Higgins, 1985). *Id. s. parvus* appears there only in the Langsettian. In the Bashkirian stratotype the *I. sinuosus* Zone corresponds to the Askynbashsky and lowermost part of the Tashastinsky horizons, i.e. the upper part of the Lower Bashkirian and lowermost part of the Upper Bashkirian. By its position below the *Decl. marginodosus* Zone and due to the presence of *Str. suberectus,* just a little higher than *I. sinuosus*, we think that *I. sinuosus* Zone of the South Urals includes two Donets zones: *I. sinuosus* and *Str. expansus*. In North America the *I. sinuosus* Zone corresponds to the middle Morrowan (Lower Pennsylvanian). The *I. sinuosus* Zone is compared with the greater part of the *I. delicatus-I. sinuosus* Zone of North China (Wang et al., 1987).

Streptognathodus expansus Zone

The lower boundary of this zone is defined by the entry of *Streptognathodus*. Its upper boundary is determined by the first appearance of *Id. tuberculatus* and *Id. fossatus.*

This zone imbraces the interval of the C_2^2(G) Suite and the lowermost part of the C_2^3(H) Suite between the limestones G_1 and H_3. This interval corresponds to the lower half of the Cheremshansky Horizon of the Russian Platform or the lower part of the Kayalsky Horizon of the Ukrainian Scheme. The *Str. expansu*s Zone contains *Id. sinuatus, Id. corrugatus, Id. s. sulcatus, Id. s. parvus, N. symmetricus, Id. lanei, I. sinuosus, I. primulus, Str. expansus, Str. suberectus, N.* sp. 1, *Str. parvus*, and rare *I. praedelicatus*, *Decl. pseudolateralis* sp. nov., *Hindeodus minutus,* and in the uppermost part: *I. aljutovensis*.

Str. expansus and *Str. suberectus* are known in many regions as short-ranged species. *Str. expansus* was established in the Kodani Formation in Japan in the *I. parvus-Gn. noduliferus* Zone (Koike, 1967) which is correlated with the Upper Morrowan (Lower Pennsylvanian) of North America.

The *Str. expansus* Zone was established by Dunn, 1970 in the Middle Morrowan (Lower Pennsylvanian) of the Western United States below the *I. humerus-I. sinuosus* Zone. *Str. expansus* and *Str. suberectus* were found also below *I. sinuosus* in Oklahoma and Arkansas (Lane & Straka, 1974) but above *I. sinuosus* in China (Rui et al., 1987). *Str. suberectus* occurs in the middle of the Valdeteja Formation (= middle part of the Bashkirian) of Spain (collection of Menéndez-Álvarez, April 1995) and in the Middle Bashkirian deposits of the South Fergana Valley, section GAZ-50, Kirghyzstan (Nemyrowska, in prep.).

Idiognathoides tuberculatus-Id. fossatus Zone

The lower boundary of the zone is defined by the first appearance of advanced *Idiognathoides: Id. tuberculatus* and *Id. fossatus.* Its upper boundary is drawn at the entry of *Decl. marginodosus.*

This zone embraces the greater upper part of the C_2^3(H) Suite and lower part of the C_2^4(I) Suite between the limestones H_3 and I_3. It corresponds to the upper part of the Cheremshansky and lower part of the Melekessky horizons of the Russian Platform or to the middle part of the Kayalsky Horizon of the Ukrainian Scheme. Characteristic species are *Id. sinuatus, Id. corrugatus, Id. fossatus, Id. tuberculatus, Id. s. sulcatus, Id. s. parvus, Id. lanei, N. symmetricus, N.* sp. 1, *I. sinuosus, I. praedelicatus, I. aljutovensis, I.* aff. *klapperi, Str. suberectus,* and *Str. expansus.* In the upper part of the interval *I.* sp. 3, *I.* sp. 1, *I.* sp. 2, *N. kanumai,* and *N.* sp. were found. *Id. s. parvus, I.* spp., *Decl. pseudolateralis*, *Str. expansus, Str. suberectus,* and *N.* sp. 1 occur in this interval for the last time. *Id. sinuatus* and *Id. corrugatus* still dominate.

This zone could be recognized in NW Europe and the U.S. by its position below the *Decl. marginodosus* Zone which seems to correspond to the Duckmantian of Europe and to the uppermost Morrowan of North America.

Declinognathodus marginodosus Zone

The lower boundary of the zone is defined by the first appearance of *Decl. marginodosus*. Its upper boundary is determined by the entry of the youngest species of the genus *Declinogonathodus*: *Decl. donetzianus.*

This zone embraces the interval of the upper part of the C_2^4(I) and the lowermost part of the C_2^5(K) suites between the limestones I_3 and K_2 or the upper greater part of the Melekessky Horizon of the Russian Platform, or the uppermost part of the Kayalsky Horizon of the Ukrainian Scheme. The conodont assemblage contains *Id. marginodosus, Id. sinuatus, Id.corrugatus, Id.fossatus, Id. tuberculatus, Id. lanei, I. sinuosus, I. praedelicatus, I. aljutovensis, I.incurvus, I. delicatus, I.* aff. *klapperi, I.* sp. 2, and *I.* sp. 3. *Id. lanei, I. primulus, I. praedelicatus* , and *I.* sp. 3 occur only in the lower part of the above mentioned interval, i.e in the middle part of the C_2^4(I) Suite. *Id. sinuatus* and *Id. fossatus* dominate. *Id. corrugatus* still is common but *Id. fossatus* gradually replaces it in the *Decl. marginodosus* Zone.

Grayson (1984), who distinguished *Decl. marginodosus* from *Decl. noduliferus,* has registered the *Idiognathoides marginodosus* Assemblage at the base of the Atoka Formation in Oklahoma and Texas. The same assemblage occurs in the upper part of the Valdeteja Formation in the Cantabrian Mountains (collection of Méndez & Menéndez-Álvarez, April 1995). The *Decl. marginodosus* Zone was recognised in the Bashkirian stratotype, South Urals (Nemirovskaya & Alekseev, 1994), where it corresponds to the Tashastinsky and lower part of the Asatausky horizons. In the South Urals it probably includes two zones of the Donets Basin: *Decl. marginodosus* and *Decl. donetzianus* by its content, although *Decl. donetzianus* was not found in Urals.

Declinognathodus donetzianus Zone

The lower boundary of the zone is defined by the first appearance of *Decl. donetz-*

ianus. Its upper boundary is determined by the first appearance of *Str. transitivus* Kossenko and advanced species of *Neognathodus.*

The *Decl. donetzianus* Zone embraces the interval of the greater part of the C_2^5(K) Suite which corresponds to the uppermost part of the Melekessky and Vereisky horizons of the Russian Platform, or the uppermost part of the Kayalsky and the lower part of the Lozovsky horizons of the Ukrainian Scheme. It includes *Decl. donetzianus, Decl. marginodosus, Id. sinuatus, Id. corrugatus, Id. tuberculatus, Id. fossatus, Id. postsulcatus* sp. nov., *Diplognathodus ellesmerensis, Str.* aff. *parvus, I. delicatus, I. aljutovensis,* the last *I. sinuosus, I. incurvus, Str. parvus,* and individual *N.* aff. *bothrops. Id. sinuatus, Id. fossatus* and *Id. tuberculatus* dominate in general. *Decl. marginodosus* and *Decl. donetzianus* prevail locally (Fig. 24); *I. delicatus* is common.

This zone is easily recognized by the occurrence of *Diplognathodus ellesmerensis* together with *Id. postsulcatus* sp. nov. The assemblage including *Decl. donetzianus* together with *Dipl. ellesmerensis*, *Decl. marginodosus* and *Id. postsulcatus* was documented by Savage & Barkeley (1985) from Alaska. Conodonts characteristic of the *Decl. donetzianus* Zone, such as *Id. sinuatus, Id. fossatus, Id. tuberculatus, I. postsulcatus, Decl. marginodosus, Dipl. coloradoensis* (Murray & Chronic), occur in the Aegiranum Marine Band (base of the Bolsovian) of NW Europe (van den Boogaard & Bless, 1985, Riley et al., 1985), in the Asatausky Horizon of South Urals (Nemirovskaya & Alekseev, 1994), the Vereisky Horizon of the Moscow Basin (Goreva, 1984), in the Atoka Formation of North America (Merrill, 1973; Landing & Wardlow, 1981; Sutherland & Manger, 1983, 1984; Grayson, 1984; Savage & Barkeley, 1985), and in North Brasil (Lemos, 1992). There is a discrepancy in correlation of the East European Upper Bashkirian and Lower Moscovian with the Atokan of North America based on conodonts and foraminifers. By foraminiferal data (Groves, 1988; Groves et al., 1994; Solovieva, 1986; Sinitsyna & Sinitsyn, 1987) the base of the Atokan is correlated with the middle of the Bashkirian or even below. The correlation is done only at the generic level and therefore seems not to be reliable enough. By conodonts it coincides probably with the base of the *Decl. marginodosus* or even *Decl. donetzianus* zone, that is high in the Bashkirian or even close to the Bashkirian/Moscovian boundary. Recent comparison of the ammonoids and spores and pollen of the late Morrowan-Atokan and Westphalian marine bands of the Appalachians and Britain support the conodont correlation (Riley, pers. comm., August 1995). In North America the position of the Morrowan/Atokan boundary is not clear but we can certainly correlate the Vereisky and possibly the Upper Melekessky conodonts with those of the Atokan of North America and the Aegiranum Marine Band or the base of the Bolsovian of Western Europe.

*Streptognathodus transitiv*us Zone

The lower boundary of the zone is drawn at the first appearance of *Str. transitivus*, at the base of limestone K_6.

The studied interval of the section includes only the lower part of this zone and corresponds to the upper part of the C_2^5(K) Suite or the upper part of the Vereisky Horizon, i.e. the Lozovsky Horizon of the Ukrainian Scheme. The characteristic species of this part of the zone are the following: *Id. sinuatus, Id. corrugatus, Id.fossatus, Id. tuberculatus, Id. postsulcatus, I. delicatus, Str. transitivus, Str.* aff. *parvus, N. atokaensis*, *N.* aff. *bothrops, Dipl. coloradoensis*, and *Gondolella donbassica* Kossenko. The species of

Idiognathoides were registered in the Donets Carboniferous in the upper part of the C_2^5 Suite for the last time. *Id. postsulcatus, I. aljutovensis* and *Decl. donetzianus* were found only at the base of this interval. The most important species are *Str. transitivus, N. caudatus. N. atokaensis*, and *Gondolella donbassica*, which represent the Moscovian stage of the conodont evolution.

Main Stratigraphic Results

Conodont studies of the Bashkirian in the Donets Basin, which contains the most complete Bashkirian conodont sequence in Europe, are an important contribution to the investigation of the standard Carboniferous succession. Rather high frequencies of conodonts in a relatively complete sequence alow the subdivision of the Bashkirian, definition of its boundaries and correlation with other areas.

The lower boundary of the Bashkirian coincides with the Mid-Carboniferous Boundary which was recognised for the first time in the former Soviet Union in the Kalmius section. In spite of a negligible gap in sedimentation this section still is the best documented Mid-Carboniferous boundary section in Eastern Europe, which demonstrates the turnover of biota, including conodonts and other groups of marine organisms. The Early Carboniferous conodonts became extinct by the end of the Zapaltyubinsky Horizon. The last occurrences of representatives of *Gnathodus* and *Lochriea* species are registered mainly in limestone D_5^8lower. The first *Decl. noduliferus* s.l. appears in limestone D_5^8upper. Thus the lower boundary of the Bashkirian Stage is placed at the base of limestone D_5^8u. This level is regarded as the Mid-Carboniferous boundary, i.e. the boundary between the Lower and Upper Carboniferous of Eurasia which corresponds to the Mississippian/Pennsylvanian boundary of North America.

The base of the Moscovian is established at the base of limestone K_3, mainly by correlation of foraminiferal assemblages; it is not marked by a considerable change in the conodont associations. The most significant changes occur higher, in the upper part of the C_2^5(K) Suite, i.e. close to the top of the Vereisky Horizon. According to the conodont data the Vereisky Horizon conodonts represent the last stage of Bashkirian conodont evolution. The most important Bashkirian conodont genera *Declinognathodus* and *Idiognathoides* became extinct close to the end of the Vereisky, and younger Moscovian forms of *Streptognathodus* and *Neognathodus* and more advanced species of *Idiognathodus* appear. Inspite of the complicate correlation of the base of the Moscovian in the Moscovian stratotype with other areas and with the Bashkirian/Moscovian boundary deposits of the Bashkirian stratotype in particular (Nemirovskaya & Alekseev, 1994), by conodonts the Vereisky Horizon of the Moscow Basin can be correlated with the C_2^5(K) Suite of the Donets Basin and the Asataussky and lower part of the Solontsovsky (= Vereisky) horizons of the Urals. The conodont association is similar to that of the base of the Bolsovian of England and The Netherlands (Riley et al., 1985; Boogaard & Bless, 1985), to the Atokan conodonts of North America (Sutherland & Manger, 1983, 1984; Grayson, 1984; etc.), and northern Brasil (Lemos, 1992).

A more detailed study of the conodonts near the Bashkirian/Moscovian boundary together with other fossils will help to understand the relation between the Westphalian of Western Europe, the Atokan of North America and the Upper Bashkirian and Lower Moscovian of Eastern Europe and the Urals. The Donets Basin and the

Cantabrian Mountains seem to be the most promising areas for this aim as the Carboniferous deposits of both regions contain abundant marine fossils, as well as plant remains, that make the correlation more reliable. Taking into account that the correlation of the Westphalian intervals in Europe by marine fossils differs from that achieved with plant remains (Riley et al., 1985; Boogaard & Bless, 1985) between Western Europe and the Donets Basin (Wagner & Winkler Prins, 1994; Fisunenko, 1991), the detailed multidisciplinary study of the Bashkirian/Moscovian boundary deposits of Eastern Europe and of the Westphalian of Western Europe and the Atokan of North America is highly desirable.

Ten conodont zones are distinguished within the Bashkirian of the Donets Basin. They are correlated with conodont zones of the other areas. The present study shows that the Bashkirian sequence of the Donets Basin holds a potential for the future construction of a monogeneric standard conodont zonation for interregional correlations and it can serve as the basis for such a zonation.

Systematic palaeontology

Here the stratigraphically most important platform conodonts are described. The species of *Diplognathodus* Kozur & Merrill, 1975, and *Hindeodus* Rexroad & Furnish, 1964, are mentioned and illustrated but not described as they are easily identifiable.

Adetognathus Lane, 1967

Type species — *Cavusgnathus lauta* Gunnell, 1933; Pennsylvanian (Missourian?) of North America.

1967 *Adetognathus* Lane: 930.
1970a *Adetognathus*: Dunn: 325.
1974 *Adetognathus*: Lane & Straka: 63
1978 *Adetognathus*: Nemirovskaya, in Kozitskaya et al.: 15.

Diagnosis — Scaphate platform elements with lateral junction of free blade and two nodular or ridged parapets. Long, free blade continues onto the platform as an outer parapet. A short, fixed blade can occur between the free blade and a parapet. The parapets are divided by a deep median trough. Basal cavity is wide, relatively deep, but shallower than that of gnathodontids.

Remarks — *Adetognathus* differs from the ancestral, very similar genus *Cavusgnathus* Harris & Hollingsworth by the longer free blade and a shorter fixed one.

Range — Upper Mississippian-Pennsylvanian of North America; upper part of the Lower Carboniferous-Lower Permian of Eastern Europe. Namurian and Westphalian of Western Europe.

Adetognathus lautus (Gunnell, 1933)

Remarks — Lane (1967: 931, 933) assigned *Ad. lautus* (Gunnell) and *Ad. gigantus* (Gunnell) to one symmetrically paired species *Ad. lautus*. Here the two form-species are described separately to present more detailed data.

Adetognathus gigantus (Gunnell, 1933)
Pl. 1, figs. 10.

1933 *Cavusgnathus gigantus* Gunnell: 286, pl. 33, figs. 7-8.
1941 *Cavusgnathus giganta*: Ellison: 126, pl. 21, figs. 44-45, 49.
1969 *Cavusgnathus gigantus*: Webster: 26, pl. 4, fig. 6.
1970a *Adetognathus gigantus*: Dunn: 325, pl. 61, figs. 2-3.
1978 *Adetognathus gigantus*: Nemirovskaya, in Kozitskaya et al.: 15, pl. XV, figs. 3-4 (cum syn.).
1984 *Adetognathus gigantus*: Goreva: pl. 1, figs. 1-5.
1984 *Adetognathus lautus*: Grayson: pl. 3, figs. 9, 26.
1989 *Cavusgnathus lautus*:Whiteside & Grayson: pl. 1, figs. 16, 50 (non cet.).
1994 *Adetognathus gigantus*: Nemirovskaya & Alekseev: pl. 2, fig. 11.

Diagnosis — Dextral elongate elements with the largest denticle on the posterior end of the fixed blade.

Remarks — It differs from *Ad. unicornis* by a longer fixed blade gradually transforming into the parapet and by a wider and deeper median groove. It differs from its pair *Ad. lautus* by the presence of a fixed blade with the largest prominent denticle on its posterior end.

Range — Middle Carboniferous and the lower part of the Upper Carboniferous of Eastern Europe (Donets Basin, Moscow Syneclise and South Urals); the *Homoceras* Zone of England; Pennsylvanian-Lower Permian of North America.

Occurrence — Middle Carboniferous: top of the Zapaltyubinsky through Vereisky (Bashkirian and Lower Moscovian), limestones D_5^9-K_3.

Material — Twelve specimens.

Adetognathus lautus (Gunnell, 1933) s.f.
Pl. 1, fig. 4.

1933 *Cavusgnathus lautus* Gunnell: 286, pl. 31, figs. 67-68, pl. 33, fig. 9.
1941 *Cavusgnathus lauta*: Ellison: 126, pl. 21, figs. 47-48.
1967 *Adetognathus lauta*: Lane: 1933, pl. 121, figs. 1-3, 7, 10-11, 15, 17.
1970a *Adetognathus lautus*: Dunn: 327, pl. 61, figs. 1, 4.
1971 *Cavusgnathus lautus*: Merrill & King: 655, pl. 75, figs. 23-29.
1972 *Cavusgnathus lautus*: Von Bitter: 61, pl.4, fig. 3a-h, pl. 5, fig. 1a-h.
1975 *Adetognathus lautus*: Perlmutter: 101, pl. 3, figs. 34-39, 42-45.
1980 *Adetognathus lautus*: Bender: 8, pl. 4, figs. 26-33.
1984 *Adetognathus lautus*: Goreva: pl. 1, figs. 8-13
1984 *Adetognathus lautus*: Grayson: pl. 2, fig. 6, pl. 3, figs. 8-9, 26-27.
1989 *Cavusgnathus lautus*: Whiteside & Grayson: pl. 1, figs. 17, 31 (non cet.).
1992 *Adetognathus* sp.: Pazukhin, in Kulagina et al.: pl. 32, fig. 5.
1994 *Adetognathus lautus*: Nemirovskaya & Alekseev: pl. 2, fig. 6.

Diagnosis — Sinistral elongate elements with gradual transformation of free blade into the outer parapet; fixed blade absent. Maximum height of free blade in its anterior or middle part.

Remarks — It differs from its pair *Ad. gigantus* by lacking the fixed blade, with the largest denticle on its posterior end. Nevertheless they possibly belong to one asymmetrically paired multielement apparatus *Adetognathus lautus*.

Range — Middle-Upper Carboniferous of Eastern Europe (Donets Basin, Moscow Syneclise and Urals); lower Permian of Urals. Pennsylvanian-Lower Permian of North America.

Occurrence — Middle Carboniferous (Bashkirian): top of the Zapaltjubinsky through lower part of the Krasnopolyansky, limestones D_5^9-$E_1^{IV.}$

Material — Eight specimens.

*Adetognathus unicorni*s (Rexroad & Burton, 1961)
Pl. 1, fig. 11.

1961 *Streptognathodus unicornis* Rexroad & Burton: 1157, pl. 138, figs. 1-9.
1967 *Adetognathus unicornis*: Lane: 930, pl. 119, figs. 16-21.
1978 *Adetognathus unicornis*: Nemirovskaya, in Kozitskaya et al.: 17, pl. 15, figs. 1-2 (cum syn.).
1983 *Adetognathus unicornis*: Nemirovskaya: pl. 1, fig. 20.
1990 *‚Adetognathus' unicornis*: Grayson et al.: pl. 2, figs. 25-26.
1992 *Adetognathus unicornis*: Weibel & Norby: pl. 1, figs. 1-16.

Diagnosis — Elongate narrow elements lacking a fixed blade. The largest denticle is on the posterior end of free blade that is closer to the right (outer) parapet. Junction of the parapets forms a posterior tip.

Remarks — It differs from *Ad. gigantu*s and *Ad. lautus* by lacking a fixed blade and by having the largest prominent denticle on the posterior end of free blade.

Range — Lower Carboniferous (Upper Serpukhovian) of Eastern Europe; Upper Mississippian (Upper Chesterian) of North America.

Occurrence — Protvinsky and Zapaltyubinsky (Upper Serpukhovian), limestones D_1-D_5^6.

Material — Four specimens.

Declinognathodus (Ellison & Graves, 1941)

Type species — *Cavusgnathus nodulifer*a Ellison & Graves, 1941; Lower Pennsylvanian (Morrowan) of North America.

1966 *Declinognathodus* Dunn: 1300.
1977 *Declinognathodus*: Ebner: 464.
1978 *Declinognathodus*: Nemirovskaya, in Kozitskaya et al.: 28.
1983 *Declinognathodus*: Park: 59.
1990 "*Declinognathodus*": Grayson et al.: 362.

Diagnosis — Scaphate, symmetrically paired platform elements with elongate narrow platform, two unequal parapets and median position of junction of free blade with a platform. Median carina declines from the longitudinal axis and fuses with the outer parapet that can be reduced down to one or two nodes near the anterior margin of the platform. Basal cavity is deep, wide and slightly asymmetrical.

Remarks — *Declinognathodus* differs from *Gnathodus* and *Neognathodus* by declination of carina to the outer parapet and mergence with the latter. It differs from *Idiognathoides* by median junction of the blade with the platform.

Range — Middle Carboniferous of Eastern Europe, Urals and Central Asia; Namurian-Westphalian of Western Europe; Lower Pennsylvanian (Morrowan-Atokan) of North America; the Kodani Formation of Japan; the Weiningian of China.

Declinognathodus donetzianus Nemirovskaya, 1990
Pl. 2, figs. 7, 9, 14.

1984 *Declinognathodus noduliferus*: Goreva: pl. 1, figs. 15b, 16, 22-23 (non cet.).
1985 *Idiognathoides tuberculatus* : Boogaard & Bless: pl. 8, fig. 8 (non cet.).
1985 *Idiognathoides sulcatus*: Savage & Barkelly: 1467, figs. 10/1-4, 10/9-12 (non cet.).
1990 *Declinognathodus donetzianus* Nemirovskaya: pl. 1, figs. 1-4.

Diagnosis — Platform elongate, narrow. Carina short, declining to outer parapet at the anterior quarter of platform. Anterior part of outer parapet reduced to several nodes (5-6), 1 or 2 anterior ones located parallel to the axis of the platform, the others declined and arranged almost perpendicular to the parapet.

Remarks — It differs from all other species of *Declinognathodus* by the presence of additional nodes on the outer flange of the platform.

Range — Uppermost Bashkirian-lowermost Moscovian of the Donets Basin; lowermost Moscovian of the Moscow Syneclise; Aegiranum Marine Band (basal Bolsovian) of Great Britain; upper part of the Lower Pennsylvanian (Atokan) of North America.

Occurrence — Uppermost Melekessky-Vereisky (Bashkirian/Moscovian boundary deposits), limestones K_2-K_7.

Material — Sixty specimens.

Declinognathodus lateralis (Higgins & Bouckaert, 1968)
Pl. 1, figs. 13-14; Pl. 2, figs. 5, 13.

1968 *Streptognathodus lateralis* Higgins & Bouckaert: 45, pl. 5, figs. 1-4, 7.
1970a *Declinognathodus lateralis:* Dunn: 330, pl. 62, figs. 5-7.
1975 *Streptognathodus lateralis*: Higgins: 73, pl. 12, fig. 9; pl. 17, figs. 10-11, 13-14.
1977 *Declinognathodus lateralis*: Ebner: 466, pl. 4, figs. 12-15.
1978 *Declinognathodus lateralis*: Nemirovskaya, in Kozitskaya et al.: 29, pl. 15, figs. 5-6, 8 (cum syn.).
1980 *Declinognathodus lateralis*: Bender: 11, pl. 1, figs. 1-2, 4-7.
1983 *Declinognathodus lateralis*: Xiong: 322, pl. 76, fig. 17
1983 *Declinognathodus lateralis*: Nemirovskaya: pl. 1, figs. 24-25, 30, 32
1983 *Declinognathodus lateralis*: Park: 60, pl. 5, fig. 4-5 (cum syn.).
1985 *Declinognathodus lateralis*: Higgins: pl. 6.3, figs. 3, 5, 8.
1987 *Declinognathodus lateralis*: Nemirovskaya: pl. 1b, figs. 17-18, 22-24.
1989 *Declinognathodus lateralis*: Wang & Higgins: 276, pl. 1, figs. 10-13.
1990 *Declinognathodus lateralis*: Nemirovskaya et al.: pl. 4, figs. 19, 23.
1992 *Declinognathodus lateralis*: Pazukhin, in Kulagina et al.: pl. 30, figs. 16, 18-22.
1993 *Declinognathodus lateralis:* Nemirovskaya & Alekseev: pl. 4, fig. 8.
1993 *Declinognathodus lateralis*: Nigmadganov & Nemirovskaya: pl. 4, fig. 8.
1994 *Declinognathodus lateralis*: Nemirovskaya & Alekseev: pl. 1, figs. 5-6, 8.

Diagnosis — Elongate platform with pointed or rounded posterior end. Carina declining, touching the outer parapet and continuing to the posterior end of the ele-

ment as a longitudinal row of nodes on the transverse ridges of this parapet. Parapets are equally high, covered by straight parallel transverse ridges.

Remarks — It differs from *Decl. noduliferus, Decl. marginodosus* and *Decl. donetzianus* by slight declination of carina to the outer parapet (not mergence) and continuation of this transverse-ridged structure to the posterior end of the platform. *Decl. noduliferus* differs from *Decl. praenoduliferus* Nigmadganov & Nemirovskaya by the presence of a median groove between the parapets that does not exist yet in *Decl. praenoduliferus*. It differs from *Decl. pseudolateralis* sp. nov. by the shape of the platform, and equal hight of the parapets along the median groove.

Range — Bashkirian of Eastern Europe, Urals and Central Asia; Namurian of Western Europe; Pennsylvanian (Morrowan) of North America; Weiningian of China; the Kodani Formation of Japan.

Occurrence — Voznesensky through Prikamsky (Lower Bashkirian): limestones D_5^9-G_1.

Material — One thousand four hundred eighteen specimens.

Declinognathodus marginodosus (Grayson, 1984)
Pl. 2, figs. 2, 8, 11-12, 17.

1978 *Declinognathodus noduliferus*: Nemirovskaya, in Kozitskaya et al.: 30, pl. 25, figs. 10-14 (non cet.).
1981 *Declinognathodus noduliferus inaequalis*: Méndez & Menéndez-Álvarez: fig. 3: 1.
1981 *Declinognathodus noduliferus noduliferus:* Méndez & Menéndez-Álvarez: fig. 3: 2.
1984 *Idiognathoides marginodosus* Grayson: 50, pl. 1, figs. 3-4, 7, 9-11, 13-14, (non figs. 16, 18 = *Id. sulcatus*), pl. 2 figs. 8, 9, 17 (non fig. 4 = *Id. sulcatus)*.
1984 *Declinognathodus noduliferus*: Goreva: pl. 1, figs. 14, 17-21.
1990 *Declinognathodus marginodosus:* Nemirovskaya et al.: 42, pl. 1, figs. 5-11.
1990 *"Declinognathodus" marginodosu*s: Grayson et al.: 365, pl. 1, fig. 28 (non cet.).
1992 *Declinognathodus marginodosus:* Sutherland & Grayson: pl. 2, fig. 11.
1993 *Declinognathodus marginodosus:* Nemirovskaya & Alekseev: pl. 3, figs. 5-6.
1994 *Declinognathodus marginodosus*: Nemirovskaya & Alekseev: pl. 1, figs. 9-10.

Diagnosis — Platform long, narrow with pointed posterior end. Short carina declines to the outer parapet and fuses with it at the anterior quarter of the platform. Reduced anterior part of the outer parapet represented by a node or short longitudinal ridge, and isolated from the rest of the carina-parapet. Median groove wide and deep.

Remarks — *Decl. marginodosu*s differs from *Decl. noduliferus* s.l. by a distinct isolation of the large node, i.e reduced anterior part of the outer parapet, by smooth strong carina and more loosely spaced nodes on the parapets. It differs from very similar *Decl. donetzianus* by the absence of the additional nodes located at the angle to the outer parapet on the outer flange of the platform.

Range — Upper part of the Bashkirian-Lower Moscovian of Eastern Europe and Spain; Lower Pennsylvanian (uppermost Morrowan-Atokan) of North America.

Occurrence — The Melekessky-Vereisky (Bashkirian/Moscovian) boundary deposits, limestones I_3 (H_5?)-K_6.

Material — One hundred twenty-one specimens.

Declinognathodus noduliferus (Ellison & Graves, 1941) s.l.
Pl. 1, figs. 7, 9, 12; Pl. 2, figs. 1, 3-4, 6, 10.

1941 *Cavusgnathus nodulifera* Ellison & Graves: 4, pl. 3, fig. 4.
1970a. *Declinognathodus noduliferus:* Dunn: 330, pl. 62, figs. 1-2, text-fig. 90 (cum syn.).
1978 *Declinognathodus noduliferus*: Nemirovskaya, in Kozitskaya et al.: 30, pl. 15, figs. 7, 9-10 (non 12-14 = *Decl. marginodosus*) (cum syn.).
1983 *Declinognathodus noduliferus inaequalis:* Nemirovskaya: pl. 1, fig. 27.
1983 *Declinognathodus noduliferus noduliferus*: Nemirovskaya: pl. 1, fig. 28.
1983 *Declinognathodus noduliferus*: Park: 63, pl. 5, figs. 1-3.(cum syn.).
1987 *Declinognathodus noduliferus noduliferus:* Nemirovskaya: pl. 16, figs. 7, 9, 11, 20-21.
1987 *Declinognathodus noduliferus inaequalis*: Nemirovskaya: pl. 1, figs. 6, 9, 13-14.
1990 *"Declinognathodus" noduliferus*: Grayson et al.: 363, pl. 1, figs. 21-22.
1990 *Declinognathodus noduliferus inaequalis:* Nemirovskaya et al.: pl. 4, figs. 3-18, 20-22, 24-28.
1992 *Declinognathodus nosuliferus*: Pazukhin, in Kulagina et al.: pl. 30, figs. 2-4, 7-10.
1992 *Declinognathodus inaequalis*: Pazukhin, ibid.: pl. 30, figs. 5-6, 11.
1992 *Declinognathodus japonicus*: Pazukhin, ibid.: pl. 30, fig. 12 (non cet.).
1992 *Declinognathodus noduliferus*: Nigmadganov & Nemirovskaya: pl. 3, figs. 3-17.
1993 *Declinognathodus noduliferus*: Nemirovskaya & Alekseev: pl. 3, figs. 4, 12.
1994 *Declinognathodus noduliferus*: Nemirovskaya & Alekseev: pl. 1, figs. 2-4, 7.

Diagnosis — Platform elongate, narrow, oval in shape, with pointed or rounded posterior end. Nodular carina declining to outer parapet and merging with the latter at different distance from the posterior end. Nodular parapets are parallel. Shallow median groove gets deeper and wider posteriorly behind the declination of carina to the outer parapet.

Remarks — Higgins (1975) distinguished three subspecies within *Decl. noduliferus* based on the distance between the point of mergence of carina with the outer parapet and the posterior end of the element. *Decl. n. inaequalis* is the oldest one in the *noduliferus* group. It appears in the lower part of the *Homoceras* Zone and has the longest carina which merges with the parapet close to the posterior end of the element. The next subspecies *Decl. n. noduliferus* appears a little later and is characterized by a shorter carina that declines and merges with the parapet in the middle of the platform or even closer to the anterior end of the platform. The third subspecies *Decl. n. japonicus* (Igo & Koike, 1964) is the youngest one. The carina is very short. The outer parapet is strongly reduced to one node at the anterior end of the platform. This subspecies occurs mostly in the upper part of the *Homoceras* Zone (Higgins, 1975). In the Donets Basin the earliest occurrence of *Decl. n. inaequalis* is in limestone D_5^8upper, it dominates through the Voznesensky Horizon. *Decl. n. noduliferus* started from the next limestone D_5^9. Only in the upper part of the Voznesensky does *Decl. n. japonicus* join the abovementioned subspecies or species. In the distribution chart and palaeontological plates of this paper all three subspecies are given separately. They are not described here individually as they will be described in a special study of the *noduliferus* group, which is planned for the nearest future.

Decl. noduliferus s.l. differs from *Decl. praenoduliferus* by the presence of a groove between the nodular parapets. The platform of *Decl. praenoduliferus* is covered by transverse ridges. The groove is absent, only a split may occur at the anterior part of the platform. *Decl. noduliferus* s.l. differs from *Decl. lateralis* by the mergence of the

carina with the nodular outer parapet and continuation of this structure as a parapet to the posterior end of the element. It differs from *Decl. marginodosus* by the mergence of carina with parapet and by more closely spaced nodes on the parapets. *Decl. noduliferus* s.l. differs from *Decl. donetzianus* by smooth outer side of the platform, not ornamented with additional nodes.

Range — Bashkirian of Eastern Europe, Urals and Central Asia; Namurian of Western Europe; Lower Pennsylvanian (Morrowan) of North America; the Kodani Formation of Japan; Weiningian of China.

Occurrence — Voznesensky and Cheremshansky (Bashkirian), limestones D_5^8upper-G_1^1(H_1?).

Material — Four thousand ten specimens *(Decl. n. inaequalis:* 3495 specimens; *Decl. n. noduliferus:* 483 specimens and *Decl. n. japonicus:* 32 specimens).

Declinognathodus? pseudolateralis sp. nov.
Pl. 2, figs. 15-16.

1984 *Declinognathodus nodulife*rus: Grayson: pl. 3, fig. 20.

Holotype — Plate 2, fig. 16, specimen IGSU-661-2.

Type locality — Dobropolskaya borehole 9831, depth 200.3-200.6 m, limestone G_1^1, lower part of the Kayalsky (Cheremshansky) Horizon, Bashkirian.

Derivation of name — pseudo (Lat.) = not real. It is very close to *Decl. lateralis* in its platform shape and ornamentation, but bears the features which differentiate this species from *Decl. lateralis* and from the other species of the genus *Declinognathodus.*

Diagnosis — Platform elongate, oval, getting narrower at the posterior and anterior ends. Parapets wide, transversely ridged. Carina declines to the outer parapet at anterior quarter of platform and touchs the transverse ridge of the parapet in the anterior or middle part of the platform. Posterior part of the platform transversely ridged. Groove-like trough dissects the transverse ridges.

Description — Platform is elongate, lanceolate, anterior and posterior ends are narrower than the other parts of the platform, posterior end is pointed. Carina is short, it occurs in a groove dividing two mostly ridged parapets. At the anterior part, the outer parapet can be nodular. Carina gently declines to the outer parapet and forms a wide transversely ridged parapet. The inner part of this structure is often higher than the outer one. A groove gets shallower and very narrow posteriorly. Laterally the element is gently arched, and the posterior end declines downward. The basal cavity is deep, wide and asymmetrical.

Remarks — *Decl.? pseudolateralis* is very close by its structure and ornamentation to *Decl. lateralis* but differs from the latter by its narrower anterior part, higher inner margin of the outer parapet along its length, and by its arched lateral and curved oral outlines. In spite of lack of juvenile specimens *Decl.? pseudolateralis* can be easily distinguished from all other *Declinognathodus* species by its more arched laterally and curved orally platform (Pl. 2, fig. 16), thus resembling *Idiognathodus* and some species of *Streptognathodus*, but rostral ridges still are not formed and accessory lobes are not developed although there is some widening of the platform where the accessory lobes could develop (Pl. 2, fig. 15; Pl. 4, fig. 9). All the above-mentioned features of *Decl.*

pseudolateralis suggest it to be a link within the lineage *Decl. lateralis-Decl.? pseudolateralis-I. primulus-I. primitivus-I. sinuosus*. This was also a reason to distinguish the new species inspite of the small number of specimens. The assignment of this species to *Declinognathodus* is uncertain. *Decl.? pseudolateralis* was not found below the first occurrence of *I. primulus* and *I. sinuosus* in the Donets Basin, possibly because the underlying deposits are represented mostly by the *Idiognathoides* biofacies, and *Idiognathodus* species in general are rare.

Range — Upper Bashkirian-lowermost Moscovian of Urals; lower part of the Upper Bashkirian of the Donets Basin; Lower Pennsylvanian (Atokan) of North America.

Occurrence — The Cheremshansky (Upper Bashkirian), limestones G_1-H_5.

Material — Five specimens.

Gnathodus Pander, 1856

Type species — *Gnathodus bilineatus* (Roundy, 1926), by subsequent designation.

1856 *Gnathodus* Pander: 33.
1974 *Gnathodus:* Lane & Straka: 71.
1978 *Gnathodus*: Nemirovskaya, in Kozitskaya et al.: 32.
1979 *Gnathodus*: Lane & Ziegler: 75.
1983 *Gnathodus:* Park: 66.
1984 *Gnathodus*: Lane & Ziegler: 258.

Diagnosis — Scaphate platform elements. Long blade joins the platform in median position and extends to the posterior end as nodular carina. Posterior end pointed. One or two ridged or nodular parapets, the length of which varies. Outer flanking of the platform smooth, or ornamented with nodes. Basal cavity deep, wide and asymmetrical.

Remarks — *Gnathodus* is distinguished from *Protognathodus* Ziegler, 1969, *Lochriea* Scott, 1942, and *Pseudognathodus* Park, 1983, by presence of parapets. It differs from its descendant *Neognathodus* by the relative height of parapets and carina. The parapets are of greater height in *Neognathodus* but carina is higher in *Gnathodus.*

Range — Lower Carboniferous: cosmopolitan.

*Gnathodus bilineat*us (Roundy, 1926)
Gnathodus bilineatus bollandensis (Higgins & Bouckaert, 1968)
Pl. 1, fig. 8.

1968 *Gnathodus bilineatus bollandensis* Higgins & Bouckaert: 29, pl. 2, figs. 10-13; pl. 3, figs. 4-8, 10.
1974 *Gnathodus bilineatus* Morphotype g: Lane & Straka: 73, pl. 33, figs. 11, 32 (non cet.).
1974 *Gnathodus bilineatus* Morphotype a: Lane & Straka: 73, pl. 33, figs. 25, 30 (non cet.).
1974 *Gnathodus bilineatus bollandensis:* Austin: pl. 1, figs. 16, 17, 20.
1975 *Gnathodus bilineatus bollandensis*: Higgins: 29, pl. 11, figs. 5-13.
1978 *Gnathodus bilineatus bollandensis:* Nemirovskaya, in Kozitskaya et al.: 34, pl. 14, figs. 4-6 (cum syn.).
1983 *Gnathodus bilineatus bollandensis:* Park: pl. 3, fig. 6-8, 15-17.
1983 *Gnathodus bilineatus bollandensis:* Alekseev et al.: pl. 1, figs. 16-19.

1985 *Gnathodus bilineatus bollandensis:* Higgins: pl. 6.1, figs. 4-5.
1989 *Gnathodus bilineatus bollandensis*: Wang & Higgins: 278, pl. 12, figs. 8-11.
1990 *Gnathodus bilineatus bollandensis:* Nemirovskaya et al.: pl. 3, figs. 5, 10-12, 14.
1992 *Gnathodus bilineatus bollandensis:* Nigmadganov & Nemirovskaya: pl. 1, figs. 1-2, 4.
1992 *Gnathodus bilineatus bollandensis*: Pazukhin, in Kulagina et al.: pl. 27, figs. 8-12.
1992 *Gnathodus* spp. 1: Pazukhin, ibid.: pl. 27, fig. 10.
1993 *Gnathodus bilineatus bollandensis*: Nemirovskaya & Nigmadganov: pl. 2, fig. 1.

Diagnosis — Strongly asymmetrical high platform with one ridged parapet and strongly expanded outer cup. Oral surface of outer cup covered by nodes, arranged concentrically or as one or several nodes at an angle to the carina. The only parapet usually does not reach the posterior end of the element. A narrow groove between the carina and parapet occurs almost along the whole length of the platform, getting shallower posteriorly.

Remarks — It differs from its possible ancestor *Gn. bilineatus bilineatus* by less expanded and less ornamented outer cup (it could be smooth to weakly ornamented) and by the absence of a row of nodes close and parallel to the posterior third of the outer side of the carina. It can be distinguished from its possible descendant *Gn. postbilineatus* by a more expanded and more complicate ornamented outer cup, by shorter parapet which is not merged with the carina posteriorly as in *Gn. postbilineatus*. It differs from *Gn. raisae* Nemirovskaya & Nigmadganov, 1993, and *Gn. dieteri* Nemirovskaya & Nigmadganov, 1993, by its ridged not nodular parapet, and less expanded outer cup (Nemirovskaya & Nigmadganov, 1993)

Range — Upper Serpukhovian of Eastern Europe, Urals and Central Asia; Arnsbergian-basal Chokierian of Western Europe; Upper Mississippian (Upper Chesterian) of North America; the Nagoe Formation of Japan; Upper Tatangian-Lower Weiningian of China.

Occurrence — Protvinsky and Zapaltyubinsky (Upper Serpukhovian), limestones D_1-D_5^8lower.

Material — One hundred sixty specimens.

Gnathodus postbilineatus Nigmadganov & Nemirovskaya, 1993
Pl. 1, fig. 5.

1987 *Gnathodus bilineatus bollandensis*: Riley et al.: pl. 2, fig. 12.
1990 *Gnathodus bilineatus bollandensis*: Nemirovskaya et al.: pl. 2, figs. 1, 7(?).
1992 *Gnathodus* spp.2: Pazukhin, in Kulagina et al.: pl. 27, fig. 11.
1992 *Gnathodus* spp.3: Pazukhin, ibid.: pl. 27, fig. 13.
1993 *Gnathodus postbilineatu*s Nigmadganov & Nemirovskaya: 262, pl. 1, figs. 7-12; pl. 2, figs. 1-5.

Diagnosis — Pa element of the *bilineatus* group with high asymmetrical platform and 'long straight parapet which extends up to the posterior end, fusing with carina and forming a transversely ridged posterior part...'. Orally platform (expanded outer cup) is smooth or poorly ornamented (Nigmadganov & Nemirovskaya, 1993: 262).

Remarks — It is distinguished from the other representatives of the *bilineatus* group by having a transversely ridged posterior half of the platform and by a narrower and shorter groove between carina and the parapet, as well as by very poor orna-

mentation of small outer cup expansion. The illustrated specimen (Pl. 1, fig. 5) can also be regarded as transitional between *Gn. bilineatus bollandensis* and *Gn. postbilineatus* because of a shallow depression between carina and parapet. But still as the parapet and carina are fused, this specimen is considered a *Gn. postbilineatus*.

Range — Upper part of the Upper Serpukhovian of the Donets Basin, South Urals and Central Asia; Upper Arnsbergian of England.

Occurrence — Upper part of the Zapaltyubinsky (Upper Serpukhovian), limestones D_5^7-D_5^{10}.

Material — Six specimens.

Idiognathodus Gunnell, 1931

Type species — *Idiognathodus claviformis* Gunnell, 1931: 249 (by original designation); Lower Pennsylvanian (Desmoinesian) of North America.

1931 *Idiognathodus* Gunnell: 249.
1932 *Idiognathodus:* Stauffer & Plummer: 44.
1933 *Idiognathodus*: Gunnell: 269.
1933 *Idiognathodus:* Harris & Hollingsworth: 202 (partim).
1941 *Idiognathodus*: Ellison: 133.
1972 *Idiognathodus:* Ellison: 140.
1978 *Idiognathodus:* Kozitskaya, in Kozitskaya et al.: 47.
1979 *Idiognathodus*: Barskov & Alekseev: 111.
1983 *Idiognathodus:* Park: 96.
1987 *Idiognathodus:* Barskov et al.: 73.
1988 *Idiognathodus:* Sweet: 114.

Diagnosis — In 1931 Gunnell proposed the genus *Idiognathodus* and described it as follows: 'Plate subsymmetrically lanceolate to claviform, and connected posteriorly [Gunnell regarded posterior end as the anterior one] with denticle-bearing bar. Oral surface of plate flat to subconvex bearing nodes or ridges. Aboral surface of plate concave with longitudinal groove separating two subequal areas.' To the genus *Idiognathodus* Gunnell assigned the forms with transversely ridged posterior part of the platform. Later on Ellison (1941) made the diagnosis of Gunnell more definite. He emphasized that the groove or trough on the oral surface of the *Idiognathodus* species is absent. The blade, joining the platform in median position, 'may or may not be continued onto the platform as a median carina.' Ellison regarded the absence of the longitudinal groove or trough on the oral surface of the platform as the only difference between *Idiognathodus* and *Streptognathodus* Stauffer & Plummer.

Remarks — In 1972 Ellison gave the following characteristics of the genus: 'Straight to arched and slightly curved lanceolate platform with anterior blade meeting the platform in a median position and continuing on the platform for a short distance; oral surface of platform convex, flat or slightly concave, and covered with continuous transverse ridges; nodose lateral lobes present or absent on one or both sides at the anterior portion of the platform; sides of platform expanded as a basal apron over the gnathodid escutcheon; apex of escutcheon beneath the median part of the platform.' As well as the other workers Ellison noted the presence of intermediate

forms between *Idiognathodus* and *Streptognathodus*. To the main differences between two genera he added the presence of continuous transverse ridges on the greater posterior part of the platform in *Idiognathodus*. Barskov et al. (1987) specified the length of carina, limited it up to one-third of the platform length for *Idiognathodus*. Grayson et al. (1990) based on data from multielement reconstructions placed the genus *Streptognathodus* in synonymy with *Idiognathodus* as was done before by Baesemann (1973) but focused the attention only on the character of the anterior portion of the platform to distinguish the species. Barrick & Boardman (1989), studying the distribution of *Idiognathodus* and *Streptognathodus* species in Missourian-Lower Virgilian deposits of Texas, regard *Streptognathodus* as a valid genus with grooved posterior platform, relatively long carina, high parapet that fuses with the outer margin of the platform, but they consider the species, older than the Missourian ones, as separate and unrelated derivations from an *Idiognathodus* ancestor.

In this paper we distinguish *Idiognathodus* and *Streptognathodus* as two separate genera and accept the last diagnosis of Ellison (1972) and the other workers but also take into account the character of the anterior portion of the platform for speciation of *Idiognathodus*. The material that was available for study from several regions of Eastern Europe, Urals and Central Asia has supported the point of view of Grayson et al. (1990) concerning the anterior part of the platform. The rostral ridges of the first Bashkirian *Idiognathodus* are mostly parallel to the carina and incorporated within the platform or slightly extend beyond the anterior limit of the platform. In younger Moscovian species they tend to be extended downward and curved outward from the platform away from the blade. Concerning the Middle Bashkirian *Streptognathodus expansus* Igo & Koike and *Str. suberectus* Dunn, which were regarded as synonyms of *I. sinuosus* by Grayson et al. (1990), they have already the rostral ridges extended beyond the anterior limit of the platform and tend to be curved downward and outward of the carina-blade, and therefore, by the character of the anterior margin of the platform, they looked more advanced than the Bashkirian idiognathodids. This is another reason not to combine *Idiognathodus* and *Streptognathodus* into one genus.

Range — Upper Carboniferous of Europe and Asia, Pennsylvanian of North America.

Idiognathodus aljutovensis Alekseev, Barskov & Kononova, 1994
Pl. 10, figs. 1-4, 7, 10-11.

1994 *Idiognathodus aljutovensis* Alekseev et al.: 43, pl. 1, figs. 1-2, 5-6 (non cet.).

Diagnosis — Subsymmetrical, long, wedge-like platform. Posterior end pointed. Unequally developed (the inner is larger) accesory lobes are incorporated within the anterior part of the platform. The anterior margin of the outer lobe is slightly angular. The lobes are ornamented by nodes arranged almost parallel to the axis of the platform. The posterior part of the platform is covered by straight transverse rather loosely spaced ridges. Carina short (1/3-1/4 of the platform length). Rostral ridges mostly parallel to the carina. The inner rostral ridge longer and lower than the outer ones and extending beyond the anterior limit of the platform.

Remarks — *I. aljutovensis* differs from *I. sinuosus* by having two accessory lobes

and different ornamentation of the posterior part of the platform. It can be distinguished from *I. incurvus* by less curved inward platform, angular outer anterior margin and less advanced rostral ridges that still do not show downward and outward directed projections beyond the anterior limit of the platform. The last feature distinguishes *I. aljutovensis* from *I. delicatus*. Besides, *I. aljutovensis* has more anteriorly located lobes. *I. aljutovensis* differs from *I. praedelicatus* by the angular shape of the anterior outer margin, less developed lobes, and more loosely spaced transverse ridges on the posterior part of the platform.

Range — Upper Bashkirian-Lower Moscovian of the Moscow Syneclise and Donets Basin.

Occurrence — Cheremshansky-Vereisky (Upper Bashkirian) and Lower Moscovian, limestones H_2-K_6.

Material — Thirty-six specimens.

Idiognathodus delicatus Gunnell, 1931
Pl. 9, figs. 5-8, 10; Pl. 10, fig. 6 ; Pl. 11, fig. 17.

1931 *Idiognathodus delicatus* Gunnell: 250, pl. 29, figs. 235.-2
1941 *Idiognathodus delicatus:* Ellison & Graves: pl. 3, figs. 20, 23.
1941 *Idiognathodus delicatus*: Branson & Mehl: 246, pl. 94, figs. 56-58.
1967 *Idiognathodus delicatus:* Koike: 304, pl. 2, figs. 18-23.
1969 *Idiognathodus delicatus:* Webster: 35, pl. 6, figs. 6-12.
1972 *Idiognathodus delicatus:* von Bitter: 58, pl. 3, fig. 4.
1973 *Idiognathodus delicatus:* Baesemann: pl. 1, figs. 10-17, 19-20, 23-24.
1974 *Idiognathodus delicatus:* Igo: 234, pl. 1, figs. 1-9.
1975 *Idiognathodus delicatus:* Barskov & Alekseev: pl. 2, figs. 7-9.
1978 *Idiognathodus delicatus*: Kosenko, in Kozitskaya et al.: pl. 21, figs. 3, 5-10 (non cet.).
1979 *Idiognathodus delicatus:* Barskov & Alekseev: 112, pl. 8, figs. 30-34; pl. 9, figs. 1-4.
1981 *Idiognathodus delicatus:* Landing & Wardlaw: 1260, pl. 2, figs. 2-3 (non cet.).
1983 *Idiognathodus delicatus:* Barskov & Kononova: pl. 3, fig. 13
1983 *Idiognathodus delicatus*: Wan, Ding & Zhao: pl. 2, figs. 13-14.
1984 *Idiognathodus delicatus*: Grayson: 49, pl. 1, figs. 1-2, 12; pl. 3, figs. 2-3, 5-6, 21-23, 25; pl. 4, figs. 1, 6-8, 17, 24.
1984 *Idiognathodus delicatus*: Grubbs: 69, pl. 1, figs. 5-7.
1987 *Idiognathodus delicatus:* Wang et al.: 128, pl. 4, fig. 4 (non cet.).
1987 *Idiognathodus delicatus*: Chernykh & Reshetkova: pl. 1, figs. 1-2.
1989 *Idiognathodus delicatus:* Wang & Higgins: 279, pl. 6, figs. 1-6.

Diagnosis — Subsymmetrical, slightly curved elements with pointed posterior end. Two nodular well developed accessory lobes are slightly shifted posteriorly. The inner lobe is larger than the outer one. The rostral ridges being parallel to the carina extend beyond the anterior limit of the platform and decline outwards away from the blade.

Remarks — *I. delicatus* is known to have a subsymmetrical platform with two well developed lobes and no special features permitted to assign these forms to the other species. Many of them do not correspond with the illustration and description of Gunnell (1931). Here we assign to *I. delicatus* only specimens with rostral ridges extended beyond the anterior margin of the platform and declined downward and outward away from the blade. Well developed lobes are shifted slightly posterior-

ward. Even the juveniles of *I. delicatus* already bear the above-mentioned features. The first forms with 'collar'-like junction of a blade with a platform were found in the uppermost Bashkirian. But very similar specimens just with simple rostral ridges, mostly incorporated within the platform, occur already in the underlying deposits.To distinguish these two varieties *I. praedelicatus* was introduced. *I. delicatus* differs from *I. sinuosus* by having two well developed, shifted posteriorly lobes and by rostral ridges extending anteriorly beyond the limit of the platform and projected downwards and outwards away from the blade. It can be distinguished from *I. incurvus* Dunn by the last feature and much smaller curvature of the platform inwardly.

Range — Uppermost Bashkirian-Kasimovian of Eastern Europe and Urals; Pennsylvanian (Upper Morrowan-Desmoinesian) of North America; the Kodani Formation of Japan; Weiningian of China.

Occurrence — Upper Melekessky-Krevyakinsky (uppermost Bashkirian-Lower Kasimovian), limestones: I_3-O_4^1.

Material — One hundred fourteen specimens (up to K_9).

Idiognathodus incurvus Dunn, 1966
Pl. 9, figs. 3-4; Pl. 11, figs. 1-8, 10-12.

1966 *Idiognathodus incurvus* Dunn: 1301, pl. 158, figs. 1-2.
1987 *Idiognathodus delicatus*: Wang et al.: pl. 4, figs. 7-8.
1989 *Idiognathodus incurvus:* Whiteside & Grayson: pl. 1, fig. 34 (non cet.).

Diagnosis — Subsymmetrical, lanceolate, inwardly curved platform with pointed posterior end. Two narrow and long nodular accessory lobes are located on the anterior half of the platform. The nodes are arranged as longitudinal rows parallel to the platform margins. Inner lobe has concentrically arranged nodes in places. Carina takes 1/3 of the platform length. Rostral ridges are long, parallel to carina. The inner rostral ridge is longer than the outer one and extends a greater distance beyond the anterior limit of the platform. There is a tendency for down- and outward curvature of the rostral ridges. The posterior part of the platform is covered by parallel transverse ridges. A shallow groove or longitudinal concavity can be observed at the posteriormost part of the platform. The juvenile and intermediate sized specimens bear the same features as the adults.

Remarks — *I. incurvus* differs from *I. praedelicatus* sp. nov. and *I. delicatus* by the greater curvature of the platform inwards, and more simple ornamentation of more posteriorly shifted lobes. The structure of the rostral ridges is close to that of *I. praedelicatus.*

Range — Uppermost Bashkirian of the Donets Basin; Lower Pennsylvanian (Upper Morrowan-Atokan) of North America.

Occurrence — Melekessky (uppermost Bashkirian), limestones: I_4-K_2.

Material — Eight specimens.

Idiognathodus aff. *klapperi* Lane & Straka, 1974
Pl. 8, fig. 11.

1974 *Idiognathodus klapperi:* Lane & Straka: 80, fig. 42: 12-16.

1987 *Idiognathodus "klapperi"*: Grayson et al.: pl. 8, figs. 14, 18, 28.
1990 *Idiognathodus klapperi:* Grayson et al.: pl. 2, fig. 2 (non cet.).

Diagnosis — Short wide platform with rounded posterior end. Carina short. Rostral ridges incorporated in the platform. The inner one is much longer and turns outward away from carina. Accessory lobes are wide, rounded, poorly developed. Nodes are arranged irregularly. Sometimes only inner weakly developed lobe is located on the anteriormost part of the platform. Posterior part of the platform is covered by discontinuous transverse ridges.

Remarks — It differs from the similar *I. aljutovensis* by the platform shape, discontinuous transverse ridges on the posterior part of the platform, more weakly developed lobes and the character of rostra. They do not extend beyond the anterior margin, but the inner rostrum tends already to be curved outward away from carina in *I.* aff. *klapperi.*

Range — Upper Bashkirian of the Donets Basin; Lower Pennsylvanian (Upper Morrowan) of North America.

Occurrence — Cheremshansky (Upper Bashkirian), limestones H_3-$K_3{}^1$.

Material — Five specimens.

Idiognathodus praedelicatus sp. nov.
Pl. 8, figs. 2, 9, 13-14; Pl. 9, fig. 9.

Holotype — Plate 8, fig. 18, specimen IGSU-1490-1.

Type locality — Volnukhino section, limestone H_3, Kayalsky (Cheremshansky) Horizon, Upper Bashkirian.

Derivation of name — prae (Lat.) = previous.

Diagnosis — Subsymmetrical, wide, slightly curved inwardly elements with pointed posterior end and transversely ridged posterior half of the platform. Two nodular well developed lobes are located at the anterior half of the platform, and also occupy middle part of the element. Rostral ridges are short and do not extend beyond the anterior limit of the platform, but show the tendency to decline outward away from the carina.

Description — Subsymmetrical, large, wide elements with pointed posterior end. The greatest width is close to the anterior third. Carina is 1/3 of the platform length. Two nodular well developed lobes are in the anterior part of the platform, they can occupy also the middle part of the elements. Outer lobe can extend greater distance posteriorly than the inner one. The nodes are arranged concentrically or as rows parallel to carina. Rostral ridges usually are parallel to carina.and do not extend beyond the anterior margin of the platform. But they tend to be curved outwardly away of carina. The posterior part of the platform is covered by 10-12 rather closely spaced transverse ridges.

Remarks — *I. praedelicatus* is very similar to *I. delicatus*. The only difference is the character of the anterior portion of the platform. It is more advanced in *I. delicatus*. The rostral ridges extending beyond the anterior margin of the platform and curving outwards away from carina form the 'collar', which is still not developed in *I. praedelicatus.* The accessory lobes of *I. praedelicatus* are situated more anteriorly than in *I. deli-*

catus. I. *praedelicatus* differs from *I. incurvus* by more simple structure of the rostral ridges and less curved platform. From *I. aljutovensis* it can be distinguished by more equally developed lobes, which are longer than those of *I. aljutovensis*, and by more closely spaced transverse ridges of the posterior part of the platform.

Occurrence — Uppermost Prikamsky-lower part Melekessky (Upper Bashkirian), limestones F_2^1-I_4.

Material — Forty-five specimens.

Idiognathodus primulus Higgins, 1975
Pl. 8, figs. 1, 8.

1975 *Idiognathodus primulus* Higgins: 47, pl. 18, figs. 10-13.

Diagnosis — Almost symmetrical, very long and narrow, wedge-shaped elements with pointed posterior end. Accessory lobes absent. Posterior portion of platform covered by transverse ridges.

Description — Almost symmetrical, long and narrow wedge-shaped elements with pointed posterior end. Carina is very short. Several nodes can occur on the anterior part of the platform and resemble a poorly developed inner lobe. Very short rostral ridges, if they are preserved, are incorporated within the platform. The posterior part of the platform is covered by transverse ridges. Laterally the platform is gently convex.

Remarks — It differs from another simple *Idiognathodu*s without lobes, *I. primitivus* Nemirovskaya & Alekseev, 1994, by its triangular shape of the platform, its shorter carina, which is not shifted to the outer side as it is in *I. primitivus*, and much greater part of the platform covered by transverse ridges.

Occurrence — Upper part of Prikamsky-lower part of Melekessky (Upper Bashkirian), limestones G_1-I_4.

Material: — Seventeen specimens (mostly eroded and broken).

Idiognathodus sinuosus Ellison & Graves, 1941
Pl. 8, figs. 3-4, 6, 10, 12, 15; Pl. 11, fig. 13.

1941 *Idiognathodus sinuosus* Ellison & Graves: 6, pl. 3, fig. 22.
1966 *Idiognathodus humerus* Dunn: 1300, pl. 158, figs. 6-7.
1970a *Idiognathodus sinuosis*: Dunn: 334, pl. 63, figs. 3-4.
1970a *Idiognathodus humerus*: Dunn: 334, pl. 63, figs. 1-2.
1974 *Idiognathodus sinuosus*: Lane & Straka: 81, fig. 37: 10-13, 21; fig. 42: 1-11; fig. 43: 1, 4-8, 10-13, 20.
1978 *Idiognathodus sinuosis*: Nemirovskaya, in Kozitskaya et al.: pl. 21, fig. 4.
1978 *Idiognathodus humerus:* Nemirovskaya, ibid.: 49, pl. 21, fig. 1.
1980 *Idiognathodus sinuosis*: Bender: 11, pl. 3, figs. 17-19.
1983 *Idiognathodus sinuosus*: Nemirovskaya: pl. 1, figs. 37-38.
1987 *Idiognathodus sinuosus:* Wang et al.: pl. 6, fig. 9 (non cet.).
1987 *Idiognathodus sinuosus:* Grayson et al.: pl. 4, figs. 1, 13, 15-16, 19.
1987 *Idiognathodus sinuosus:* Barskov et al.: 80, pl. 18, figs. 4-9.
1989 *Idiognathodus sinuosus*: Wang & Higgins: 280, pl. 9, figs. 1-2; pl. 15, figs. 1-2.
1990 *Idiognathodus sinuosus:* Grayson: pl. 4, figs. 36-39 (non cet.).
1990 *Idiognathodus sinuosus:* Grayson et al.: 369, pl. 2, fig. 1 (non cet.).
1994 *Idiognathodus sinuosus*: Nemirovskaya & Alekseev: pl. 3, figs. 8, 11 (non cet.).

Diagnosis — Asymmetrical elements with slightly inwardly curved platform and pointed or slightly rounded posterior end. Outer side of platform convex, inner one almost straight. Carina more than one third of the platform length. Usually only inner nodular not prominent accessory lobe is present. On the anterior outer side of the platform several nodes parallel to the platform margin can occur. In right-sided specimens the outer platform behind the anterior third can curve outwards in form of 'shoulder'. Rostral ridges are parallel to carina and do not extend usually beyond the anterior limit of the platform. They tend to be declined outwards away from the carina in the late Bashkirian specimens. The posterior part of the platform is covered by parallel transverse, sinuosly declined ('chevron'-like) ridges. This part can be slightly concave along the platform axis.

Remarks — *I. sinuosus* differs from the other species by having only one accessory lobe and by sinuose ridges on the posterior part of the platform.

Range — Upper Bashkirian-basal Moscovian of the Donets Basin, Upper Bashkirian-Lower Moscovian of Urals, lowermost Moscovian of the Moscow Syneclise; Lower Pennsylvanian (Upper Morrowan-Atokan) of North America; Weiningian of China.

Occurrence — Prikamsky-Melekessky (Upper Bashkirian), limestones F_1^1-K_3.

Material — One hundred ninety-six specimens.

Idiognathodus sp. A Grubbs, 1984
Pl. 11, figs. 9, 16, 18.

1984 *Idiognathodus* sp. A: Grubbs: 69, pl. 1, figs. 12-15.

Diagnosis — Platform moderately wide, strongly curved inwardly, pointed posteriorly; greatest width in the anterior third. Carina extends more than 1/2 of the platform length. Two nodular lobes are present in the anterior part of the platform. Inner lobe is prominent, extends beyond the inner margin of the platform. The rostra slightly extend beyond the anterior limit of the platform, turning outward away from carina. Posterior part of the platform covered by transverse ridges which can be complicated by the projection of the carina to the posterior end of the platform.

Remark — It differs from the other species by a very long carina and its projection to the posterior end. The character of the anterior part is as in the other Moscovian species of *Idiognathodus.*

Range — Uppermost Bashkirian-lowermost Moscovian of the Donets Basin; Lower Pennsylvanian (uppermost Morrowan-Atokan) of North America.

Occurrence — Uppermost Melekessky-Vereisky (uppermost Bashkirian-Lower Moscovian), limestones K_2-K_7.

Material — Five specimens.

Idiognathodus sp. 1
Pl. 7, fig. 7-12, 14, 16, 18.

Diagnosis — Narrow symmetrical forms with weakly developed lobes and pointed posterior end. Inner lobe consists of a row of nodes and extends beyond the platform lateral margin. Outer one represented by one or two nodes. Carina long. Rostral ridges long, high, parallel to carina, not extending beyond the anterior platform margin.

Description — Narrow, long, symmetrical, laterally compressed platform with pointed posterior end. Carina is long, 1/2-2/3 of the platform length. Accessory lobes are very weakly developed. The inner one is outside the platform and shifted posteriorly. It consists of one row of nodes arranged parallel to the platform margin. Outer lobe consists of one or two nodes and is incorporated within the platform. Rostral ridges are long, high, parallel to carina, slightly decline outward away from carina and do not extend beyond the anterior limit of the platform. Posterior part is covered by few (5-7) loosely spaced straight transverse ridges. Laterally element is almost straight.

Remarks — Long high rostral ridges resemble the parapets. This feature together with long carina makes *I.* sp. 1 close to *Streptognathodus* and different from the other *Idiognathodus* species, but absence of a median groove, position of lobes and general outlines support the assignment of this species to *Idiognathodus.*

Occurrence — Melekessky (Upper Bashkirian), limestones I_2-I_3.

Material — Twelve specimens.

Idiognathodus sp. 2
Pl. 7, figs.1-2, 13, 15, 17.

Diagnosis — Subsymmetrical straight elements with one small narrow accessory lobe located outside of the platform, long carina, and long, high rostral ridges turned outwards away from carina.

Description — Rather narrow, long, straight, subsymmetrical platform pointed posteriorly. Carina is long, extends more than 1/2 of the platform length. There is mostly only one inner lobe represented by a row of 3-5 fused nodes parallel to the platform margin. They are separated from the platform by small groove. One node can be present on the outer anterior part of the platform. Rostral ridges are long and high. The inner rostrum extends a greater distance beyond the anterior margin of the platform than the outer one. The rostra strongly decline outward away from carina. The grooves between carina and rostral ridges are deep and wide. The posterior part of the platform is covered by 4-5 loosely spaced transverse parallel ridges. Laterally the element is gently arched.

Remarks — *I.* sp. 2 differs from the other species of *Idiognathodus* by long carina and very small accessory lobe isolated from the platform It is close to *I.* sp.1, but differs from the latter by shorter carina and more advanced anterior part of the platform. Rostral ridges are strongly declined outward away from carina and extend greater distance beyond the anterior platform margin.

Occurrence — Melekessky (uppermost Bashkirian), limestones I_2-K_2.

Material: — Fifteen specimens.

Idiognathodus sp. 3
Pl. 9, figs. 1, 2, 11-13.

Diagnosis — Long, large, straight, susbymmetrical. lanceolate elements with slightly rounded or pointed posterior end. Carina very short. Poorly developed accessory lobes, located on the anterior part of platform, consist of irregularly arranged nodes. Inner lobe occupies the lateral margin of the platform. Rostral ridges extend

beyond the anterior margin of the platform and turn outward away from the carina. The greater long and narrow posterior part of the platform is covered by numerous closely spaced transverse continuous ridges. Laterally element is almost straight or gently arched.

Remarks — It is difficult to give complete characteristics of these elements as only gerontic forms were found. Nevertheless they could be distinguished from the others by their long straight platform, covered by numerous closely spaced transverse ridges and poorly developed accessory lobes, inner of which is located onto the anterior-lateral side of the platform.

Occurrence — Melekessky-basal Vereisky (Upper Bashkirian-basal Moscovian), limestones I_2-I_4.

Material — Seventeen specimens.

Idiognathoides Harris & Hollingsworth, 1933

Type species — *Idiognathoides sinuata* Harris & Hollingsworth, 1933 by original designation; Lower Pennsylvanian (Morrowan) of North America.

1933 *Idiognathoides* Harris & Hollingsworth: 201.
1933 *Polygnathodella* Harlton: 15.
1941 *Polygnathodella:* Branson & Mehl: 103.
1941 *Polygnathodella*: Ellison & Graves: 8.
1959 *Idiognathoides*: Hass: 379.
1960 *Polygnathodella*: Clarke: 8.
1967 *Idiognathoides*: Lane (partim): 936.
1968 *Idiognathoides:* Higgins & Bouckaert: 38.
1974 *Idiognathoides:* Lane & Straka: 83 (partim).
1977 *Idiognathoides:* Ebner: 471.
1978 *Idiognathoides*: Nemirovskaya, in Kozitskaya et al.: 58.
1983 *Idiognathoides*: Park: 101

Diagnosis — Scaphate platform elements with lateral junction of free blade with the platform. High platform bears two ridged or nodular parapets, the outer one is a contiuuation of the blade onto the platform and extends to the posterior end of the element. The parapets are separated by a median groove of different length. Basal cavity is wide, deep, asymmetrical.

Remarks — *Idiognathoides* differs from gnathodids by the lateral junction of blade with a platform. It is distinguished from *Adetognathus* and *Rhachistognathus* by shape and size of the basal cavity, and by the absence of fixed blade (from *Adetognathus*) and by the structure of the platform (*Rhachistognathus*).

Range — Middle Carboniferous of Eastern Europe, Urals and Central Asia; Kinderscoutian-Bolsovian of Western Europe; Lower Pennsylvanian (Morrowan-Atokan) of North America; the Kodani Formation of Japan; Weiningian of China.

Idignathoides fossatus (Branson & Mehl, 1941)
Pl. 4, figs. 1, 3-5, 11.

1941 *Polygnathus fossata* Branson & Mehl: 103, pl. 19, figs. 27-28.

1970a *Idiognathoides corrugatus:* Dunn: 315, pl. 63, fig. 18 (non cet.)
1978 *Idiognathoides fossatus*: Nemirovskaya, in Kozitskaya et al.: 62, pl. 16, figs. 8-10.
1984 *Idiognathoides ouachitensis*: Grayson: 50, pl. 3, figs. 13, 15 (non cet.)
1984 *Idiognathoides ouachitensis:* Grubbs: 70, pl. 2, figs. 9, 13 (non cet.).
1993 *Idiognathoides fossatus*: Nemirovskaya & Alekseev: pl. 3, fig. 24.
1994 *Idiognathoides fossatus*: Nemirovskaya & Alekseev: pl. 2, figs. 4-5.

Diagnosis — Right-sided, mostly wedge-shaped elements with pointed posterior end. Platform covered by transverse parallel ridges. Deep and wide median trough pressed the ridges and commonly dissects them in the anterior part of the platform; getting shallow to the posterior end of the platform; 2-3 last transverse ridges can be continuous.

Remarks — *Id. fossatus* differs from very similar *Id. ouachitensis* (Harlton, 1933) by deeper median trough and laterally by acute declination of the platform downward to the posterior end. It differs from *Id. corrugatus* by wide and deep median trough that dissects the continuous ridges of the platform.

Range — Upper part of the Upper Bashkirian and Lower Moscovian of Eastern Europe, Urals and Central Asia; Lower Pennsylvanian (Atokan) of North America.

Occurrence — Cheremshansky-lowermost Tsninsky (Upper Bashkirian-Lower Moscovian), limestones H_3-L_5.

Material — Five hundred thirty-six specimens.

Idiognathoides lanei Nemirovskaya, 1978
Pl.3, figs. 11, 14, 19-20; Pl. 4, fig. 7.

1974 *Idiognathoides* n. sp. Lane & Straka: pl. 39, figs. 11-13.
1978 *Idiognathoides lanei* Nemirovskaya, in Kozitskaya et al.: 63, pl. 16, figs. 8-10.
1983 *Idiognathoides sinuatus*: Park: 104, pl. 5, figs. 18-19 (non cet.)
1987 *Idiognathoides lanei*: Nemirovskaya: pl. 2, figs. 20, 27, 29.
1992. *Idiognathoides sinuatus:* Pazukhin, in Kulagina et al.: pl. 31, figs. 8, 16 (non cet.)

Diagnosis — Sinistral elements with continuous transverse ridges on a flat posterior end. Ridged or partially nodular narrow parapets are subdivided by shallow trough which does not exceed half of the platform length. The posterior half of the platform is ornamented by straight or slightly sinuose ridges. It looks like transversely ridged tongue in places.

Remarks — It is very close to *Id. sinuatus* but differs from the latter by transversely ridged posterior half of the platform and shorter trough.

Range — Bashkirian of the Donets Basin and Urals; Lower Pennsylvanian (Lower Atokan) of North America.

Occurrence — Severo-Keltmensky through Cheremshansky (Bashkirian), limestones $E_8{}^3$-I_3.

Material — Ninety specimens.

Idiognathoides postsulcatus sp. nov.
Pl. 3, figs. 9, 18.

1964 *Gnathodus opimus* Igo & Koike: 189, pl. 28, figs. 15-17 (only)

1965 *Gnathodus opimus* Igo & koike: 89, pl. 9, figs. 1-3 (only).
1980 *Gnathodus opimus* sensu lato, Morphotype 1: Bender: 12-13, pl. 2, figs. 8-9, 15-16, 23-24, 29-31, 34, 38.
1981 *Idiognathoides sulcatus sulcatus*: Méndez & Menéndez-Álvarez, fig. 3: 7.
1984. *Idiognathoides marginodosus* morphotype C, Grayson: 50, pl. 1, figs. 16, 18; pl. 2, fig. 19; pl. 3, figs. 4, 10, 12, 14; pl. 4, figs. 16, 21, 23.
1985 *Idiognathoides sulcatus*: Boogaard & Bless: 150, fig. 9: 6-7.
1985. *Idiognathoides sulcatus*: Savage & Barkeley: 1467-1469, fig. 10: 5-8 (only).
1994 *Idiognathoides sulcatus*: Nemirovskaya & Alekseev: pl. 1, fig. 19 (only).

Holotype — Pl. 3, fig. 18, specimen IGSU-Pash-1, left-sided Pa element.

Type locality — The Pashennaya Valley section, limestone K_6, Lozovsky Horizon (Vereisky), Lower Moscovian.

Derivation of name — post (Lat.) = after (after *Id. sulcatus*).

Diagnosis — Pa element with long, closely spaced, noded parapets of equal height and a narrow and shallow groove between them. The outer and inner sides of the cup are asymmetrically swollen.

Description — Pa element has narrow, long platform with closely spaced, long-noded parapets. They are straight along whole length of the platform or slightly turned inwards posteriorly. The parapets are equal in height and separated by narrow, mostly shallow groove. Both sides of the platform are asymmetrical and very convex (swollen). The greater convexity is in the anterior third of the platform. The blade is of the same lenght as the platform or a little longer. The basal cavity is large, wide, asymmetrical. Laterally the specimens are slightly arched.

The present small collection includes only right-sided elements. Interestingly, the above-mentioned authors reported rigth- and left-sided elements, but illustrated only right-sided ones.

Remarks — *Id. postsulcatus* is very similar to *Id. sulcatus sulcatus* and usually was assigned to the latter. Nevertheless it can be distinguished from the latter by very asymmetrical convex platform sides, by longer parapets, sometimes curved inwards (*Id. sulcatus* is always straight), and by a shallow and narrow long groove between the parapets. It differs from *Id. sulcatus parvus* by an equal length of long parapets and swollen asymmetrical platform sides.

Although we have a very limited number of specimens up to now, the worldwide distribution and relatively short range of this species makes it an important marker for correlation. This species was registered in coeval deposits in many regions, and was assigned either to *Id. sulcatus* or *Gn. opimus*, or *Id. marginodosus* morphotype C. The illustrated holotype of *Id. opimus* was actually *Id. sinuatus* since it has ridged not noded parapets and therefore the species is not valid. Grayson (1984) regarded his *marginodosus* as a member of *Idiognathoides* and that is why he distinguished sevaral morphotypes. One of them, a real *Idiognathoides* with lateral junction of blade and platform, was named *Id. marginodosus* morphotype C. I regard *marginodosus* as a species of *Declinognathodus* as it is characterized by a central position of the blade and platform junction, having two parapets even though one of them is reduced down to one big node, and include *Id. marginodosus* morphotype C of Grayson in *Id. postsulcatus.*

Occurrence — *Id. postsulcatus* is known from the Omi and Akioshi Limestones of

Central Japan (Igo & Koike, 1964, 1965), from the lowermost Moscovian of the Urals (Askyn section, type Bashkirian), Russia (Nemirovskaya & Alekseev, 1994), and the Cantabrian Mountains (Picos Formation), Spain (Méndez & Menéndez-Álvarez, 1981). It was found in the Aegiranum Marine Band (basal Bolsovian) of Northern Europe (Boogaard & Bless, 1985), Atokan deposits of North America: Sverdrup Group of the Canadian Arctic Archipelago (Bender, 1980), Klawak Formation of Alaska (Savage & Barkeley, 1985) and Atokan of Arbuckle Mountains, Oklahoma (Grayson, 1984).

In the Donets Basin *Id. postsulcatus* was found in the limestones K_2-K_6 of the C_2^5(K) Suite, lower part of the Lozovsky Horizon (Vereisky), Lower Moscovian.

Material — Fourteen specimens.

*Idiognathoides sinuat*us Harris & Hollingsworth, 1933 s.f.

As sinistral and dextral elements possibly are biologically related, *Id. sinuatus* is regarded as an asymmetrically paired unit (Lane, 1968) or 'parasymmetry pair' (Landing & Wardlaw, 1981). To present more detailed data the sinistral and dextral elements are described here separately.

Idiognathoides corrugatus (Harris & Hollingsworth, 1933)
Pl. 3, figs. 2, 4, 21; Pl. 4, fig. 8.

1933 *Idiognathoides corrugatus* Harris & Hollingsworth: 202, pl. 1, figs. 7-8.
1975 *Idiognathoides corrugatus*: Higgins: 48, pl. 15, fig. 1.
1978 *Idiognathoides corrugatus*: Nemirovskaya, in Kozitskaya et al.: 60, pl. 16, figs. 1-8 (cum syn.).
1977 *Idiognathoides corrugatus*: Ebner: 472, pl. 5, fig. 10 (non cet.), pl. 6, fig. 7 (non cet.).
1980 *Idiognathoides corrugatus*: Bender: pl. 1, fig. 23
1981 *Idiognathoides corrugatus*: Méndez & Menéndez-Álvarez, pl. 1, fig. 6.
1981 *Idiognathoides corrugatus:* Barskov et al.: pl. 1, fig. 4
1983 *Idiognathoides corrugatus*: Nemirovskaya: pl. 1, fig. 39
1983 *Idiognathoides sinuatus*: Park: 104, pl. 5, figs. 21-24 (non cet.).
1983 *Idiognathoides corrugatus:* Wang & Wang: 441, pl. 1, fig. 7.
1984 *Idiognathoides corrugatus*: Goreva: pl. 16, figs. 28, 35.
1984 *Idiognathoides corrugatus:* Grayson: pl. 4, figs. 4, 10.
1984 *Idiognathoides sinuatus*: Grubbs: 70, pl. 2, figs. 3-4 (non cet.).
1984 *Idiognathoides ouachitensis*: Grubbs: 70, pl. 2, fig. 12 (non cet.).
1987 *Idiognathoides corrugatus:* Wang et al.: pl. 2, figs. 1-2, 6-11.
1987 *Idiognathoides corrugatus*: Nemirovskaya: pl. 2, figs. 10, 21, 25-26, 30-31
1989 *Idiognathoides corrugatus:* Wang & Higgins: 280, pl. 2, figs. 10-13.
1992 *Idiognathoides sinuatus*: Pazukhin, in Kulagina et al.: pl. 31, figs. 10-11 (non cet.).
1992 *Idiognathoides corrugatus:* Pazukhin, ibid.: pl. 31, figs. 14, 17 (non cet.).
1993 *Idiognathoides corrugatus*: Nemirovskaya & Alekseev: pl. 3, fig. 3, 15
1993 *Idiognathoides corrugatus:* Nigmadganov & Nemirovskaya: pl. 5, figs. 6-11.
1994 *Idiognathoides corrugatus*: Nemirovskaya & Alekseev: pl. 1, figs. 1, 13, 15.

Diagnosis — Dextral elements of *Idiognathoides sinuatus* with lanceolate platform ornamented by continuous parallel transverse ridges. Platform flat or gently concave along the axis, posterior end pointed. Blade merges with the right side of the platform and continues as an outer side of the platform. At the anterior end of the platform the

transverse ridges are interrupted by a short deep groove. Laterally, in its anterior third, the platform declines downward to the posterior end at an acute angle.

Remarks — It differs from *Id. sinuatus* s.f., *Id. sulcatus*, *Id. lanei*, and *Id. tuberculatus* by having most of the platform covered by continuous transverse ridges and shorter antero-medial groove between the parapets. It differs from *Id. glaber* Wirth, 1967, *Id. convexus* (Ellison & Graves, 1941), *Id. planus* Furduj, 1979, and *Id. asiaticus* Nigmadganov & Nemirovskaya, 1993, by a longer groove and more straight transverse ridges. It is close to *Id. fossatus* but could be distinguished from the latter by a more flat platform with continous transverse ridges and shorter and a shallower antero-medial groove.

Range — Bashkirian and Lower Moscovian of Eastern Europe, Urals and Central Asia; Kinderscoutian-Bolsovian of Western Europe; Lower Pennsylvanian (Morrowan-Atokan) of North America; the Kodani Formation of Japan; Weiningian of China.

Occurrence — Uppermost part of Voznesensky through Vereisky (Bashkirian-Lower Moscovian), limestones D_7^6-K_9.

Material — One thousand five hundred twenty-one specimens.

Idiognathoides sinuatus Harris & Hollingsworth, 1933
Pl. 3, figs. 3, 8,10, 13.

1933 *Idiognathoides sinuata* Harris & Hollingsworth: 201, pl. 1, fig. 14.
1977 *Idiognathoides sinuatus*: Ebner: 474, pl. 6, figs. 4-6.
1977 *Idiognathoides sinuatus:* Perret: pl. 51, fig. 26.
1978 *Idiognathoides sinuatus*: Nemirovskaya, in Kozitskaya et al.: 64, pl. 18, figs. 1-3 (cum syn.).
1979 *Idiognathoides sinuatus*: Buchroitner: pl. 3, fig. 5.
1980 *Idiognathoides sinuatus:* Bender: 13, pl. 1, figs. 17-33.
1981 *Idiognathoides sinuatus*: Méndez & Menéndez-Álvarez, pl. 1, fig. 6
1981 *Idiognathoides sinuatus:* Barskov et al.: pl. 1, fig. 2.
1983 *Idiognathoides sinuatus*: Park: 104, pl. 5, figs. 14-17.
1983 *Idiognathoides sinuatus*: Nemirovskaya: pl. 1, figs. 34-35.
1984 *Idiognathoides sinuatus:* Goreva: pl. 1, figs. 25-26 (non cet.)
1984 *Idiognathoides sinuatus:* Grayson: pl. 4, figs. 3, 13-14, 19-20.
1984 *Idiognathoides sinuatus*: Grubbs: 70, pl. 2, figs. 1-2 (non cet.).
1984 *Idiognathoides convexus:* Grubbs: 70, pl. 2, figs. 5-6 (non cet.).
1984 *Idiognathoides ouachitensis:* Grubbs: 70, pl. 2, figs. 10-11 (non cet.).
1985 *Idiognathoides sinuatus:* Rexroad & Merrill: 4, figs. 1, 4-6 (non cet.).
1985 *Idiognathoides sinuatus:* Boogaard & Bless: pl. 9, figs. 1-2 (non cet.).
1987 *Idiognathoides sinuatus*: Nemirovskaya: pl. 2, figs. 8, 12, 17, 22, 24.
1989 *Idiognathoides sinuatus:* Wang & Higgins: 281, pl. 10, fig. 10; pl. 15, figs. 11-15
1990 *Idiognathoides sinuatus:* Grayson, Merrill & Lambert: 366, pl. 1, fig. 26 (non cet.)
1992 *Idiognathoides sinuatus*: Nigmadganov & Nemirovskaya: pl. 5, figs. 4-5.
1993 *Idiognathoides sinuatus:* Nemirovskaya & Alekseev: pl. 1, figs. 9, 16, 22.
1994 *Idiognathoides sinuatus:* Nemirovskaya & Alekseev: pl. 1, figs. 14, 16.

Diagnosis — Sinistral elements of *Idiognathoides sinuatus* with a narrow, long platform and ridged, step-like parapet. Medial groove very narrow, not deep, long, getting shallower posteriorly. Outer parapet higher than inner one.

Remarks — It differs from *Id. sulcatus* by ridged parapets and being only left-sided.

It differs from its right-sided part of the pair, *Id. corrugatus,* and its younger relative *Id. lanei* by the presence of two parapets and a groove between them which extends to the posterior end. From its descendant *Id. tuberculatus* it is distinguished by a smooth outer surface of the cup.

Range —Bashkirian and Lower Moscovian of Eastern Europe, Urals and Central Asia; Kinderscoutian-Bolsovian of Western Europe; Lower Pennsylvanian (Morrowan-Atokan) of North America; Weiningian of China.

Occurrence — Uppermost Voznesensky through Tsninsky (Bashkirian-Lower Moscovian), limestones D_7^6-K_9.

*Materia*l — One thousand three hundred forty-seven specimens.

Idiognathoides sulcatus Higgins & Bouckaert, 1968
Idiognathoides sulcatus parvus Higgins & Bouckaert, 1968
Pl. 3, figs. 6, 16.

1968 *Idiognathoides sulcata parva* Higgins & Bouckaert: 41, pl. 6, figs. 1-6.
1974 *Idiognathoides sulcatus parvus*: Lane & Straka: 92, pl. 39, figs. 5-6, 9-10 (non cet.).
1975 *Idiognathoides sulcatus parvus:* Higgins: 56, pl. 13, figs. 13-14, 18; pl. 14, figs. 2-3.
1985 *Idiognathoides sulcatus parvus*: Higgins: pl. 6.6, figs. 6-7.
1987 *Idiognathoides sulcatus:* Nemirovskaya: pl. 2, fig. 12.
1993 *Idiognathoides sulcatus*: Nemirovskaya & Alekseev: pl. 3, fig. 18 (non cet.).

Diagnosis — Sinistral and dextral narrow elements with nodular parapets of equal height and pointed posterior end. Inner parapet is much shorter than the outer one and does not extend to the posterior end. It is commonly smooth, flares slightly outwards in the anterior-central part of the platform and tapes posteriorly to the outer parapet.

Remarks — *Id. sulcatus parvus* differs from *Id. sulcatus sulcatus* by its shorter and mostly smooth inner parapet. It is distinguished from *Id. macer* (Wirth, 1967) and *Id. sinuatus* by its nodular, not ridged inner parapet. It also differs from left-sided *Id. sinuatus* by equal height of parapets and being both left- and right-sided.

Range — Bashkirian of Eastern Europe, Urals and Central Asia; Langsettian of Western Europe; Lower Pensylvanian (Upper Morrowan) of North America.

Occurrence — Prikamsky and Cheremshansky (Middle Bashkirian), limestones F_1^2-I_3.

Material — Thirty-five specimens.

Idiognathoides sulcatus sulcatus Higgins & Bouckaert, 1968
Pl. 3, figs. 1, 5, 7, 12, 15, 17.

1967 *Gnathodus opimus:* Koike: 298, pl. 1, figs. 20-21.
1968 *Idiognathoides sulcata* Higgins & Bouckaert: 41, pl. 4, figs. 6-7.
1974 *Idiognathoides sulcatus sulcatus*: Lane & Straka: 92, figs. 36: 1-16, 18-20, 23-24.
1975 *Idiognathoides sulcatus sulcatus:* Higgins: 56, pl. 13, figs. 11-12, 16; pl. 15, fig. 15.
1977 *Idiognathoides opimus:* Ebner: pl. 6, figs. 1, 3, 8.
1978 *Idiognathoides sulcatus*: Nemirovskaya, in Kozitskaya et al.: 66, pl. 18, figs. 4-6.
1983 *Idiognathoides opimus*: Park: 101, pl. 5, figs. 6-11.
1983 *Idiognathoides sulcatus:* Nemirovskaya: pl. 1, fig. 36.
1985 *Idiognathoides sulcatus sulcatus:* Higgins: pl. 6.3, fig. 6.

1987 *Idiognathoides sulcatus*: Nemirovskaya; pl. 2, figs. 13-14, 16, 23, 28.
1987 *Idiognathoides sinuatus:* Wang et al.: pl. 2, fig. 5 (non cet.).
1992 *Declinognathodus* sp. C: Sutherland & Grayson: pl. 2, fig. 27.
1993 *Idiognathoides sulcatus*: Nemirovskaya & Nigmadganov: pl. 5, figs. 1-3.
1993 *Idiognathoides sulcatus*: Nemirovskaya & Alekseev: pl. 3, figs. 14, 25 (non cet.).
1994 *Idiognathoides sulcatus:* Nemirovskaya & Alekseev: pl. 1, figs. 12, 17 (non cet.).

Diagnosis — Sinistral and dextral forms with narrow platform and straight, parallel, nodular parapets of equal height; rather deep narrow groove between the parapets.

Remarks — *Id. sulcatus sulcatus* differs from *Id. sulcatus parvus* having the straight parallel parapets of equal length. It differs from *Id. sinuatus* by nodular, not ridged, parapets of equal heigth and from *Id. macer* Wirth, 1967, by its two nodular parapets. It differs from *Id. postsulcatus* sp. nov. as the platform sides of Id. postsulcatus are much more swollen and longer, and the groove is shallower and narrower, not as marked as in *Id. sulcatus*.

Range — Bashkirian and lowermost Moscovian of Eastern Europe, Urals and Central Asia; Kinderscoutian-Bolsovian of Western Europe; Lower Pennsylvanian (Morrowan-Atokan) of North America; Bashkirian of Japan and China.

Occurrence — Uppermost Voznesensky through Vereisky (Bashkirian-lowermost Moscovian), limestones D_7^6-K_9.

Material — Three hundred fourty specimens.

Idiognathoides tuberculatus Nemirovskaya, 1978
Pl. 4, figs. 6, 9-10, 12-13.

1978 *Idiognathoides tuberculatus* Nemirovskaya: 67, pl. 17, figs. 3-6.
1984 *Idiognathoides tuberculatus:* Goreva: pl. 1, figs. 30-31.
1985 *Idiognathoides tuberculatus*: Boogaard & Bless: pl. 8, figs. 9-10 (non cet.)
1993 *Idiognathoides tuberculatus:* Nemirovskaya & Alekseev: pl. 3, figs. 13, 23.

Diagnosis — Lanceolate platform with mostly ridged parapets and one node or series of nodes at the centre of the swollen outer flaring of the platform. The nodes can be arranged perpendicular to the outer parapet or subconcentrically as a small circle in the middle of the platform side. Medial groove is deep, it gets shallower posteriorly. The basal cavity is very wide, deep and asymmetrical.

Remarks — *Id. tuberculatus* is close to *Id. sinuatus* but differs from the latter by having nodes on the swollen outer flaring of the platform.

Range — Upper Bashkirian-lowermost Moscovian of Eastern Europe, Urals and Central Asia; Duckmantian-Bolsovian of Western Europe.

Occurrence: Melekessky-Vereisky (Upper Bashkirian-lowermost Moscovian), limestones H_3-K_6 (last occurrence: limestone L_5).

Material — One hundred seven specimens.

Lochriea Scott, 1942

Type species — *Lochriea montanaensis* Scott, 1942 = *Spathognathodus commutatus* Branson & Mehl, 1941; Mississippian of North America.

1970 *Paragnathodus* Meischner: 1173 (nom. nud.).
1975 *Paragnathodus* Higgins: 70.
1982 *Lochriea*: Horovitz & Rexroad: 966.
1983 *Paragnathodus:* Park: 119.
1987 *Paragnathodus:* Barskov et al.: 61.
1994 *Lochriea*: Nemirovskaya et al.: 311.

Diagnosis — Scaphate platform elements with isometrically oval platform. Almost rectangular denticulate blade joins the platform in median position and extends to the posterior end as a nodular carina. Parapets absent. Upper surface of the platform either smooth, or ornamented by nodes or small ridges. Laterally elements almost rectangular, posterior tip of carina drops vertically to meet the posterior tip of the basal cavity, which is deep.

Remarks — *Lochriea* differs from *Protognathodus* by more symmetrical platform, and wider and higher carina. It differs from *Pseudognathodus* by rectangular shape of the posterior end in lateral view.

Range — Lower Carboniferous (Viséan-Serpukhovian), cosmopolitan.

Lochriea commutata (Branson & Mehl, 1941)

1941 *Spathognathodus commutatus* Branson & Mehl: 98, pl. 19, figs. 1-4.
1970a *Gnathodus commutatus commutatus:* Dunn: 331, pl. 62, figs. 11-12, text-fig. 11A (cum syn.).
1977 *Gnathodus commutatus commutatus:* Ebner: 468, pl. 3, fig. 1.
1978 *Gnathodus commutatus:* Lipnyagov & Nemirovskaya, in Kozitskaya et al.: 35, pl. 12, figs. 1-6 (cum syn.).
1983 *Paragnathodus commutatus:* Nemirovskaya: pl. 1, fig. 13.
1984 *Paragnathodus commutatus:* Alekseev et al.: pl. 1, fig. 2.
1985 *Paragnathodus commutatus*: Grayson et al.: 189, pl. 1, fig. 24; pl. 2, fig. 19.
1987 *Paragnathodus commutatus:* Wang et al.: 130, pl. 2, fig. 12.
1987 *Paragnathodus commutatus*: Barskov et al.: 62, pl. 16, figs. 7-13.
1989 *Paragnathodus commutatus:* Wang & Higgins: 285, pl. 8, figs. 4-5.
1992 *Paragnathodus commutatus*: Pazukhin, in Kulagina et al.: pl. 29, fig. 1 (non cet.).
1994 *Lochriea commutata:* Nemirovskaya et al.: pl. 2, fig. 1.

Diagnosis — Platform low, smooth, unornamented, slightly asymmetrical.

Remarks — It differs from other species of *Lochriea* by the absence of ornamentation. It is distinguished from *L. cracoviensis* Belka, 1985, by simple narrow carina.

Range — Lower Carboniferous: Viséan-Serpukhovian of Europe, Urals, Central Asia; upper part of the Lower Carboniferous of Japan and China; Upper Mississippian (Chesterian) of North America.

Occurrence — Upper part of the $C_1^{v}e$ Zone through Zapaltyubinsky (Upper Viséan-Serpukhovian), up to limestone D_5^{9}.

Material — Two hundred thirty specimens from the whole range, six specimens in the interval between limestones D_5^{6} and D_5^{9}.

Lochriea cruciformis (Clarke, 1960)

1960 *Gnathodus cruciformis* Clarke: 25, pl. 4, figs. 10-12.
1975 *Paragnathodus cruciformis:* Higgins: 71, pl. 7, fig. 10.

1983 *Paragnathodus cruciformis:* Nemirovskaya: pl. 1, fig. 11.
1993 *Paragnathodus cruciformis:* Perret: 288, pl. C9, figs. 12-14.
1994 *Lochriea cruciformis*: Nemirovskaya et al.: pl. 1, fig. 13; pl. 2, fig. 13.

Diagnosis — Asymmetrical platform with ridges or rows of fused nodes developed on both sides of the platform (cup). They are fused to the carina in the posterior or middle part of the platform at the right to acute angle, opened anteriorwards.

Remarks — *L. cruciformis* is close to *L. nodosa* (Bischoff, 1957) and *L. costata* (Pazukhin & Nemirovskaya, in Kulagina et al., 1992) but differs from them by junction of lateral ridges or rows of nodes with carina.

Range — Serpukhovian of Eastern Europe, Urals and Central Asia; uppermost Brigantian-Arnsbergian of Western Europe.

Occurrence — Protvinsky through Zapaltyubinsky (Upper Serpukhovian), limestones D_1^5-D_5^8lower.

Material — Eight specimens.

Lochriea mononodosa (Rhodes, Austin & Druce, 1969)

1961 *Gnathodus commutatus nodosus:* Higgins: pl. 10, fig. 7 (non cet.)
1968 *Gnathodus commutatus nodosus*: Higgins & Bouckaert: pl. 2, fig. 4.
1969 *Gnathodus mononodosu*s Rhodes et al.: 103, pl. 19, figs. 13-15.
1975 *Paragnathodus mononodosus* Higgins: 71, pl. 7, fig. 14
1977 *Gnathodus commutatus mononodosus:* Ebner: 469, pl. 3, fig. 3.
1978 *Gnathodus mononodosus:* Lipnyagov & Nemirovskaya, in Kozitskaya et al.: 40, pl. 13, figs. 1-4, 6.
1979 *Gnathodus mononodosus:* Barskov & Alekseev: 110, pl. 8, figs. 19-20.
1983 *Paragnathodus mononodosus*: Park: 123, pl. 4, figs. 6-11.
1983 *Paragnathodus mononodosus:* Nemirovskaya: pl. 1, figs. 10, 14.
1983 *Paragnathodus mononodosus*: Belka: pl. 1, fig. 10.
1987 *Paragnathodus mononodosus:* Wang et al.: 131, pl. 1, figs. 1-2.
1987 *Paragnathodus mononodosus*: Barskov et al.: 64, pl. 16, figs. 14-15 (non cet.).
1989 *Paragnathodus mononodosus:* Wang & Higgins: 285, pl. 8, figs. 1-2 (non cet.).
1992 *Paragnathodus mononodosus:* Pazukhin, in Kulagina et al.: pl. 29, fig. 4 (non cet.).
1994 *Lochriea mononodosa:* Nemirovskaya et al.: pl. 2, fig. 2.

Diagnosis — Asymmetrical platform with one node on the inner cup.

Remarks — It differs from the other species of *Lochriea* by having only one node on the inner cup. The elements with one short ridge instead of node are distinguished as *L. monocostata* Pazukhin & Nemirovskaya, 1992 (in Kulagina et al., 1992). They have almost the same range as *L. mononodosus* but detailed distribution in the Donets Basin has not yet been studied.

Range — Lower Carboniferous: Upper Viséan-Serpukhovian of Eastern Europe, Urals and Central Asia; Upper Viséan-Alportian of Western Europe and China.

Occurrence — Upper Viséan through Serpukhovian: the upper part of the C_1^vf Zone through Zapaltyubinsky, up to the limestone D_5^8lower.

Material — Thirty-five specimens (together with *L. monocostata)*; six specimens within the interval D_5^6-D_5^8lower.

*Lochriea ziegler*i Nemirovskaya, Perret & Meischner, 1994
Pl. 1, fig. 6.

1962 *Gnathodus commutatus* var. *multinodos*us Higgins: pl. 2, figs. 17 -18 (non cet.).
1967 *Gnathodus commutatus nodosus:* Wirth: pl. 19, figs. 14, 17 (non cet.).
1969 *Gnathodus nodosus:* Rhodes et al.: pl. 19, figs.16, 19 (non cet.).
1975 *Paragnathodus cruciformis*: Higgins: pl. 7, fig. 10 (non cet.)
1977 *Gnathodus commutatus multinodosus*: Perret: pl. LI, fig. 23.
1982 *Paragnathodus multinodosus*: Higgins & Wagner-Gentis: pl. 32, figs. 12, 15 (non cet.).
1983 *Paragnathodus* sp.1 Nemirovskaya: pl. 1, figs. 15, 19
1983 *Paragnathodus nodosus:* Park: pl. 4, fig. 21 (non cet.).
1987 *Paragnathodus nodosus:* Riley et al.: pl. 2, figs. 10, 14.
1987 *Paragnathodus multinodosus:* Barskov et al.: pl. 16, figs. 23-25 (non cet.).
1990 *Paragnathodus nodosus*: Nemirovskaya et al.: pl. 3, figs. 3, 9.
1992 *Paragnathodus cruciformis*: Pazukhin, in Kulagina et al., pl. 29, fig. 14 (non cet.).
1993 *Paragnathodus cruciformis:* Perret: pl. 9, fig. 14 (non cet.).
1994 *Lochriea ziegler*i Nemirovskaya et al.: 312, pl. 1, figs. 1-4, 6-7, 11-12; pl. 2, fig. 11.

Diagnosis — Platform ornamented by large, discrete nodes, located on ridge-like elevations, or thick, long ridges on both sides of the cup close to its posterior margin.

Remarks — This species was first distinguished as *Paragnathodus* sp. 1 by Nemirovskaya (1983, pl. 1, figs. 15, 19), but usually the specimens of this species were assigned to *L. multinodosa, L. cruciformis* and *L. nodosa. L. ziegleri* differs from *L. nodosa* by the postero-lateral position of its high and long nodular ridges, instead of nodes, located close to the centres of the platform sides that is typical of *L. nodosa*. *L. ziegleri* differs from *L. cruciformis* by large nodes on the ridges which are not fused to the carina. *L. ziegleri* differs from *L. multinodosa* by fewer number of much larger nodes located on the ridges; *L. multinodosa* bears nodes arranged subconcentrically close to the centres of the platform sides. *L. ziegleri* is very close to *L. senckenbergica* Nemirovskaya, Perret & Meischner, 1994, but can be distinguished from the latter by having smaller size of nodes-ridges located more posteriorly, than high, thick and steep projections of *L. senckenbergica*.

Range — Serpukhovian of Eastern Europe; uppermost Viséan and Namurian A of Western Europe.

Occurrence — Serpukhovian: the Protvinsky through Zapaltyubinsky and the base of the Voznesensky, limestones D_1^5-D_5^{10}.

Material — Seven specimens.

Neognathodus Dunn, 1970

Type species — *Polygnathus bassler*i Harris & Hollingsworth, 1933; Lower Pennsylvanian (Morrowan) of North America.

1970a *Neognathodus* Dunn: 335.
1975 *Neognathodus*: Merrill: 64
1978 *Neognathodus:* Nemirovskaya, in Kozitskaya et al.: 68.
1985 *Neognathodus*: Grayson et al.: 126
1987 *Neognathodus*: Barskov et al.: 66.

Diagnosis — Scaphate platform elements with lanceolate, subtriangular or arrow-like platform and medial position of the blade-platform junction. Nodular carina extends commonly to the posterior tip, or can be expressed as discrete nodes in the posterior part of the element. High platform consists of two parapets, the outer can be strongly reduced. Deep adcarinal grooves are developed. Basal cavity is large, deep, asymmetrical.

Remarks — *Neognathodus* differs from its ancestor, the closely related genus *Gnathodus* by the presence of deep adcarinal grooves and by a less prominent carina. From the genus *Ferganaegnathodus* Nemirovskaya & Nigmadganov, 1993, it differs by longer parapets and shorter carina. In *Ferganaegnathodus* the carina is prominent, smooth, beak-like, extended beyond the parapets posteriorly.

Range — Upper Carboniferous (Middle-Upper Carboniferous), cosmopolitan.

Neognathodus atokaensis Grayson, 1984
Pl. 5, figs. 18, 22.

1941 *Gnathodus wapanuckensis*: Ellison & Graves: pl. 2, fig. 14 (non cet.).
1984 *Neognathodus atokaensis:* Grayson: 52, pl. 1, fig. 8; pl. 2, figs. 1, 5, 10-12, 16, 23; pl. 3, figs. 1, 7, 11, 16, 18, 22 (cum syn.).
1985 *Neognathodus atokaensis:* Grayson et al.: 126, pl. 1, figs. 2, 34.
1990 *Neognathodus atokaensis*: Grayson: pl. 4, figs. 14-16.
1992 *Neognathodus atokaensis:* Sutherland & Grayson: pl. 2, fig. 15.
1993 *Neognathodus atokaensis*: Nemirovskaya & Alekseev: pl. 4, figs. 20-21.
1994 *Neognathodus atokaensis*: Nemirovskaya & Alekseev: pl. 4, fig. 9.

Diagnosis — Wide, asymmetrical platform pointed posteriorly. Ridged parapets of unequal length. Inner parapet extending to posterior tip. Outer parapet shorter and a little higher that inner one. At the anterior margin of the platform the parapets tend to decline downwards anteriorly. Long carina, consisted of fused nodes, extends to the posterior tip. Laterally element is arched, the highest point is in the anterior third.

Range — Lowermost Moscovian of theDonets Basin and Urals; Lower Pennsylvanian (Atokan) of North America.

Occurrence — Upper part of the Vereisky (Lower Moscovian), limestones K_6^3-L_2.

Material — Three specimens.

*Neognathodus symmetric*us Lane, 1967
Pl. 5, figs. 1-9, 11, 13-14.

1941 *Gnathodus wapanuckens*is Ellison & Graves: pl. 2, fig. 13 (non cet.).
1967 *Gnathodus bassleri symmetricus* Lane: 935, pl. 120, figs. 2, 13-14, 17; pl. 121, figs. 6, 9.
1967 *Gnathodus wapanuckansis*: Koike: 300, pl. 1, figs. 22, 24 (non cet.).
1969 *Gnathodus bassleri*: Webster: 29, pl. 5, fig. 14 (non cet.).
1970a *Neognathodus bassleri*: Dunn: 336, pl. 64, fig. 13 (non cet.).
1978 *Neognathodus bassleri symmetricus*: Nemirovskaya, in Kozitskaya et al.: 70, pl. 19, figs. 1-8 (cum syn.).
1980 *Neognathodus bassleri*: Merrill: pl. 6, figs. 10-12.
1983 Neognathodus symmetricus: Nemirovskaya: pl. 1, figs. 29, 31.
1987 *Neognathodus symmetricus:* Barskov et al.: 73, pl. 17, figs. 1-6

1987 *Neognathodus symmetricus*: Nemirovskaya: pl. 2, figs. 1-5, 7, 9, 11, 18-19.
1987 *Neognathodus symmetricus*: Wang et al.: 130, pl. 3, figs. 6-7; pl. 7, figs. 3-4, 12 (non cet.); pl. 8, figs. 3-4 (non cet.).
1989 *Neognathodus symmetricus*: Wang & Higgins: 282, pl. 2, figs. 1-4.
1990 *Neognathodus symmetricus:* Grayson: pl. 3, figs. 8-13.
1990 *Neognathodus symmetricus:* Grayson et al.: 378, pl. 3, fig. 23 (cum syn.).
1992 *Neognathodus symmetricus:* Sutherland & Grayson: pl. 4, figs. 34-35.
1992 *Neognathodus symmetricus:* Nigmadganov & Nemirovskaya: pl. 4, figs. 1, 7.
1994 *Neognathodus symmetricus:* Nemirovskaya & Alekseev: pl. 8, fig. 14.

Diagnosis — Narrow elongate almost symmetrical platform pointed posteriorly. Nodular or ridged in the anterior portion parapets are of equal height. Medial nodular carina extends, as a rule, to the posterior tip, it could be replaced posteriorly by discrete nodes. Deep adcarinal grooves developed.

Remarks: — *N. symmetricus* differs from *N. bassleri* Harris & Hollingsworth, 1933, by narrower symmetrical platform with central position of carina and less elevated parapets of almost equal height.

Range — Bashkirian of Eastern Europe, Urals and Central Asia; Alportian-Kinderscoutian of Western Europe; Lower Pennsylvanian (Morrowan) of North America; lower part of the Kodani Formation of Japan; Weiningian of China.

Occurrence — Uppermost Voznesensky through Cheremshansky (Bashkirian), limestones D_7^6-H_5^1.

Material — Two hundred forty-four specimens.

Neognathodus sp. 1
Pl. 5, figs. 15-17, 19-20.

Diagnosis — Platform is small, symmetrical, moderately wide, high. Ridged or nodular elevated parapets of almost equal length. Inner parapet extends a little further anteriorly than outer one, and is swollen in its median-posterior part. Posterior tip is formed by junction of two parapets and is blunt or rounded. Adenticulate carina thick, low and short, occupying only half of the platform length and ending in a deep trough which is expressed anteriorly as two adcarinal grooves. Two or three small nodes can replace the carina posteriorly.

Remarks — *N.* sp. 1 is a member of the *symmetricus-bassleri* group but differs from the other species of this group by its short and low carina which ends at the mid-length of the platform. It also differs from *N. symmetricus* by its more elevated inner parapet.

Occurrence — Cheremshansky (Upper Bashkirian), limestones G_1^2-H_5^1.

Rhachistognathus Dunn, 1966

Type species — *Rhachistognathus prim*us Dunn, 1966, by original designation; Mississippian/Pennsylvanian boundary deposits of North America.

1966 *Rhachistognathus* Dunn: 1301.
1974 *Rhachistognathus:* Lane & Straka: 96.
1985 *Rhachistognathus:* Baesemann & Lane: 93.

Diagnosis — Scaphate elements with long, lanceolate platform. Blade joins the platform in a median position, or very close to it. Platform ornamented by two ridged or nodular parapets and carina, which can be expressed only at the posterior end of the element. The basal cavity is large, slightly asymmetrical.

Remarks — The genus is close to Early Carboniferous bilineate spathognathids *(Bispathodus*), but differs from the latter by structure of the basal cavity and the platform. It differs from *Cavusgnathus*, *Adetognathus* and *Idiognathoides* by a (close to) median position of its blade-carina junction and by the ornamentation of the platform.

Range — Uppermost Mississippian (Chesterian) — Lower Pennsylvanian (Morrowan) of North America; lower part of the Chokierian of England and Belgium; lowermost Bashkirian of Donets Basin and Urals.

*Rhachistognathus minut*us *minut*us (Higgins & Bouckaert, 1968)
Rhachistognathus minutus declinatus Baesemann & Lane, 1985
Pl. 1, figs. 1-2.

1985 *Rhachistognathus minutus declinatus* Baesemann & Lane: 108, pl. 1, figs. 1-10
1987 *Rhachistognathus minutus declinatus*: Nemirovskaya: pl. 1, figs. 1, 4.
1990 *Rhachistognathus minutus declinatus*: Nemirovskaya et al.: pl. 4, figs. 1-2.

Diagnosis — Platform is lanceolate, symmetrical, commonly pointed posteriorly. Blade meets platform almost in a median position, closer to its outer side, and extends a very short distance on it. Deep medial trough between the nodular or ridged parapets. Anteriormost part of the outer parapet is strongly declined outward away from the blade. The posterior end can bear several nodes behind the median trough.

Remarks — The subspecies differs from the other subspecies of *Rh. minutus* by more median position of its blade-platform junction and by a considerable declination of the anteriormost part of the outer parapet outwards away from the blade.

Range — Lower Pennsylvanian (Lower Morrowan) of North America; basal part of the Bashkirian Stage of the Donets Basin.

Occurrence — Uppermost Zapaltyubinsky (lowermost Bashkirian), limestone D_5^9.

Material — Five specimens.

Streptognathodus Gunnell, 1933

Type species — *Streptognathodus excelsus* Stauffer & Plummer, 1932; Pennsylvanian (Missourian) of North America.

1932 *Streptognathodus* Stauffer & Plummer: 47.
1933 *Streptognathodus*: Gunnell: 280.
1933 *Polygnathus* Harris & Hollingsworth: 202 (partim)
1941 *Streptognathodus:* Ellison: 127.
1972 *Streptognathodus:* Ellison: 127-146.
1978 *Streptognathodus:* Kosenko & Kozitskaya, in Kozitskaya et al.: 89.
1979 *Streptognathodus*: Barskov & Alekseev: 112.

Diagnosis — According to the first description of Stauffer & Plummer (1932), the platform is 'somewhat lanceolate, subsymmetrical, with a deep axial furrow, toward which the eight to dozen or more lateral ridges marking the upper surface, extend from each side and in which they disappear'. Usually shelf-like processes extend out from each side at the base of the plate and may bear nodes. Blade enters the platform and extends as a carina 'into the furrows and usually ends at some point between the base and middle of the plate'. Gunnell (1933) noted that the upper surface of the plate has 'longitudinal, median groove on each side of which occur nodes or ridges'. Later on Ellison (1941, 1972) gives a revised diagnosis of the genus *Streptognathodus*as as follows: 'Straight to arched and slightly curved lanceolate elongate platform with the anterior blade meeting the platform in a median position and continuing posteriorly onto the platform as a carina for about one-third the length of the platform; an oral trough then continues posteriorly for the remainder of the length of the plate; parapets on both sides of the median trough have transverse corrugations; nodes lateral lobes on one or both sides may or may not be present at the anterior part of the platform; sides of the platform expanded as a basal apron over the excutcheon; apex of the excutceon beneath the median trough'. Barskov et al. (1987) include in the genus also the forms with long carina that 'can reach the posterior end of the platform'. Barrick & Boardman (1989) distinguish *Streptognathodus* from *Idiognathodus* mainly by the same features but they consider the Bashkirian-early Moscovian streptognathodids as 'separate and unrelated derivations from an *Idiognathodus* ancestor'. Such point of view might be reasonable, taking into account the advanced structure of the first Bashkirian *Streptognathodus* and the considerable difference between them and the early Moscovian streptognathodids.

Here the diagnosis of Stauffer & Plummer, 1932, emended by Ellison, 1972, and Barskov et al., 1987, is accepted.

Remarks — Inspite of *Streptognathodus* having intergradational forms with *Idiognathodus* (see characteristics of *Idiognathodus* above) it differs from the latter by having a median trough and parapets and by the absence of continuous transverse ridges on most of the platform.

Range — Middle Carboniferous-Lower Permian, cosmopolitan.

Streptognathodus expansus Igo & Koike, 1964
Pl. 6, figs. 1-2.

1964 *Streptognathodus expansus* Igo & Koike: 189, pl. 28, fig. 14.
1974 *Streptognathodus expansus:* Lane & Straka: figs. 43: 9, 16-18, 21-26 (cum syn.).
1978 *Streptognathodus expansus:* Nemirovskaya, in Kozitskaya et al.: 96, pl. 25, fig. 1.
1983 *Streptognathodus expansus:* Park: pl. 5, figs. 33-34.
1984 *Streptognathodus expansus:* Grubbs: 71
1984 *Idiognathodus expansus*: Grayson: pl. 4, fig. 18.
1979 *Streptognathodus expansus:* Wang & Higgins: 286, pl. 3, figs. 8-11.
1990 *Idiognathodus expansus:* Grayson: pl. 4, fig. 28.

Diagnosis — Lanceolate, wide, subsymmetrical platform with very short carina. Numerous transverse ridges cover most of the platform. Shallow narrow medial groove dissects the ridges or strongly depresses them. Rostral ridges-parapets at the

anterior part of the platform parallel to the carina, extending beyond the anterior margin of the platform. On the outer sides of the parapets nodes can be observed. They extend parallel to the parapets and look like weakly developed accessory lobes. Adcarinal grooves deep and U-shaped. Laterally the element is strongly angular with the highest point in the anterior third where carina ends.

Remarks — *Str. expansus* differs from the other species of genus *Streptognathodus* by its wide transversely ridged platform with split-like groove along the axis. It differs from *Str. wabaunsensis* Gunnell by the presence of two weakly developed lobes and distinct short rostral ridges-parapets. As only sinistral forms were found, and they have almost the same range as the dextral *Str. suberectus*, they could be symmetry paired (Class IV symmetry, according to Lane, 1968 and Lane & Straka, 1974). But morphologically they differ considerably.

Range — Upper Bashkirian of Donbas and Central Asia; Upper Bashkirian of the Cantabrian Mountains (Western Europe); the Kodani Formation of Japan; Weiningian of China.

Occurrence — Cheremshansky Horizon of the Upper Bashkirian, limestones G_1-H_5.

Material — Eight specimens.

Streptognathodus parvus Dunn, 1966
Pl. 6, figs. 8-11.

1966 *Streptognathodus parvus* Dunn: 1302, pl. 158, figs. 9-10.
1978 *Streptognathodus parvus*: Nemirovskaya, in Kozitskaya et al.: 104, pl. 25, figs. 4, 6-8 (non cet.; cum syn.).
1987 *Streptognathodus parvus:* Barskov et al.: pl. 20, fig. 5 (non cet.).
1994 *Streptognathodus parvus*: Nemirovskaya & Alekseev: pl. 3, figs. 5-10.

Diagnosis — Platform small, narrow, symmetrical, pointed posteriorly. Carina long, can extend 2/3 of the platform length. Adcarinal grooves narrow and shallow. Posterior part of the platform covered by 2-6 continuous, straight, parallel transverse ridges. Very small accessory lobe can be expressed as a longitudinal row of 1-4 discrete nodes arranged parallel and close to the inner margin of the platform, close to its middle part. This lobe is not incorporated into the platform.

Remarks — It differs from the other species of *Streptognathodus* with continuous transverse ridges on the posterior part of the platform (*Str. oppletus* Ellison,1941, *Str. transitivus* Kossenko and *Str.* sp. 1, this paper) in having a small accessory lobe which is not incorporated in the platform. It is difficult to distinguish *Str. parvus* from juvenile forms of *Idiognathodus* and some species of *Streptognathodus*, the only difference may be the median position of several discrete nodes extended parallel to the lateral platform margin which are not incorporated in the platform.

Range — Upper Bashkirian of Eastern Europe and Urals; Lower Pennsylvanian (Upper Morrowan-?Atokan) of North America.

Occurrence — Uppermost Cheremshansky-Melekessky (Upper Bashkirian), limestones I_2-K_2.

Material — Twenty-five specimens.

Streptognathodus suberectus Dunn, 1966
Pl. 6, figs. 3-5, 7.

1966 *Streptognathodus suberectus* Dunn: 1303, pl. 157, figs. 4-6.
1974 *Streptognathodus* spp.*:* Lane & Straka: fig. 40:20 (non cet.).
1978 *Streptognathodus suberectus*: Nemirovskaya, in Kozitskaya et al.: 106, pl. 25, fig. 3 (cum syn.).
1987 *Streptognathodus suberectus:* Barskov et al.: 92, pl. 20, figs. 1-3.
1989 *Streptognathodus suberectus*: Wang & Higgins: 287, pl. 13, figs. 8-11.
1993 *Streptognathodus suberectus*: Nemirovskaya & Alekseev: 72.

Diagnosis — Asymmetrical, not wide, curved inwards right-side elements, which are pointed posteriorly. Carina is very short, ends in a narrow medial groove which extends up to the posterior tip. Two long, mostly unevenly developed nodular accessory lobes are considerably shifted posteriorly. They are located close to the middle of the platform. Rostral ridges are low, decline outwards away from the carina, and extend a short distance beyond the anterior margin of the platform and then again turn to the carina. Outer margin of the platform is higher than the inner one. The juvenile specimens bear all of the above-mentioned features but of smaller size. They can have only one lobe consisting of 1 to 2 nodes.

Remarks — *Str. suberectus* differs from the other species of *Streptognathodus* by its strongly posteriorly shifted lobes.

Range — Upper Bashkirian of the Donets Basin, Urals and Central Asia. *Str. suberectus* was also found in the Cantabrian Mountains, Spain (collection of Dr C. Méndez, April 1995); Lower Pennsylvanian (Morrowan) of North America; Weiningian of China.

Occurrence — Cheremshansky (Upper Bashkirian), limestones G_3^3-I_1.

Material — Eight specimens.

Streptognathodus transitivus Kossenko, 1978
Pl. 6, figs. 13, 16, 18.

1978 *Streptognathodus transitivus* Kossenko, in Kozitskaya et al.: 107, pl. 25, figs. 9-13.
1984 *Streptognathodus transitivus:* Goreva: pl. 3, figs. 1-6.
1987 *Streptognathodus transitivus*: Barskov et al.: 92, pl. 20, figs. 7-10.

Diagnosis — Platform lanceolate, symmetrical, taped, pointed posteriorly. Nodular or ridged parapets parallel to carina, they can converge a little anteriorly. Carina long, extending more than half of the platform length. Posterior part of the platform covered by 3-5 straight, parallel, continuous transverse ridges. Accessory lobes absent.

Remarks — By the posterior portion of the platform covered with transverse ridges Str. *transitivus* resembles *Str. oppletus*, but differs from the latter by the shape of the anterior part of the platform and by the absence of declination in the anterior part in lateral view. *Str. transitivus* is distinguished from *Str. parvus* by its deeper adcarinal grooves, more prominent parapets and by the absence of an accessory lobe.

Range — Lower Moscovian of Eastern Europe.

Occurrenc — Tsninsky (Lower Moscovian), limestones K_6-L_7.

Material — Thirty-one specimens.

Streptognathodus sp. 1
Pl. 7, figs. 3-6.

Diagnosis — Platform long, narrow, subsymmetrical. Anterior part of platform includes two nodular parapets (elevated margins) and thick carina which extends a half of the platform length, or a little more. Adcarinal grooves narrow and shallow. Small inner accessory lobe, consisting of 1-3 nodes, located in the anterior third of the platform. It is formed by a splitting of the inner parapet and is partially incorporated in the platform. Inner parapet transforms into a rostral ridge and extends beyond the anterior margin of the platform. The outer rostral ridge can also be present. Inner rostral ridge demonstrates the tendency to decline outward away from the blade for some distance and then turns to the blade. Laterally the element is gently arched.

Remarks — This species represents an example of intergadation between *Idiognathodus* and *Streptognathodus,* but due to its thick long carina and elevated margins of the platform, resembling the parapets, it can be assigned to *Streptognathodus.* Very similar forms, which may be more advanced descendants of the specimens described here, were extracted recently from the limestone M_1 of the Upper Moscovian. This additional material has to be studied in more detail to prove the identity of all of these forms. Possibly Kossenko (in Kozitskaya et al., 1978) assigned such forms like *Str.* sp. 1 and specimens similar to those discovered from limestone M_1 to *Str. parvus* expanding the range of *Str. parvus* by more than half of the Moscovian Stage. *Streptognathodus* sp. 1 differs from the closely related *Str. parvus* by its thick carina, more anterior position of a lobe incorporated partially into the platform, and by the presence of an inner rostral ridge (or two rostral ridges) extended beyond the anterior margin of the platform.

Occurrence — Upper part of Vereisky (Lower Moscovian), limestones K_5-K_6. The range might be expanded up to the base of the Podolsky Horizon (limestone M_1).

Material — Five specimens.

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