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Late Devonian Syv'yu River Section, Timan-Pechora Basin, Northwestern Russia

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ABSTRACT – *This paper deals with the Upper Devonian conodont biostratigraphy in the Syv'yu River section (western Subpolar Urals), one of the most complete Frasnian-Famennian sequences within the Timan-Pechora Basin (Russia). Lithostratigraphically, the Upper Devonian sequence in the section is subdivided, in ascending order, into the Kedzydshor, Vorota, Shar'yu and Domanicoid Formations. The following zones of the Late Devonian standard conodont zonation have been recognized: in the Frasnian, Early and Late falsiovalis, transitans, punctata, Early and Late hassi, jamieae, Early and Late rhenana, and linguiformis Zones; in the Famennian - Early, Middle and Late triangularis, Late crepida, and Early marginifera Zones. The Middle falsiovalis Zone is not recognizable because of an hiatus probably spanning an interval from the late Early(?) falsiovalis to the earliest part of the Late falsiovalis Zone. Ancyrodella and Ancyrognathus are rare. Icriodus is generally rare but common in argillaceous limestones at the Frasnian-Famennian boundary.*

RIASSUNTO – [La Sezione tardo-devoniana di Syv'yu River, Timan-Pechora Basin, NW Russia] – *Viene illustrata la biostratigrafia a conodonti della sezione di Syv'yu River, nella parte settentrionale degli Urali; la sezione studiata rappresenta una delle successioni Frasniane-Famenniane più complete del Timan-Pechora Basin (Russia). Da un punto di vista litostratigrafico, le rocce affioranti nella sezione vengono ricondotte alle seguenti formazioni, dalla base al tetto: Kedzydshor, Vorota, Shar'yu e Domanicoid. Le seguenti biozone a conodonti della Biozonatura Standard del Devoniano Superiore sono state identificate: nel Frasniano, Early e Late falsiovalis, transitans, punctata, Early e Late hassi, jamieae, Early e Late rhenana, and linguiformis; nel Famenniano, Early, Middle e Late triangularis, Late crepida, e Early marginifera. La Middle falsiovalis Zone non è stata riconosciuta a causa di uno hiatus, che probabilmente riguarda un intervallo compreso tra la parte superiore della Early(?) falsiovalis Zone e la parte basale della Late falsiovalis Zone. Ancyrodella and Ancyrognathus sono rari. Icriodus è di norma raro, ma diviene abbondante nei calcari argillosi attorno al limite Frasniano-Famenniano.*

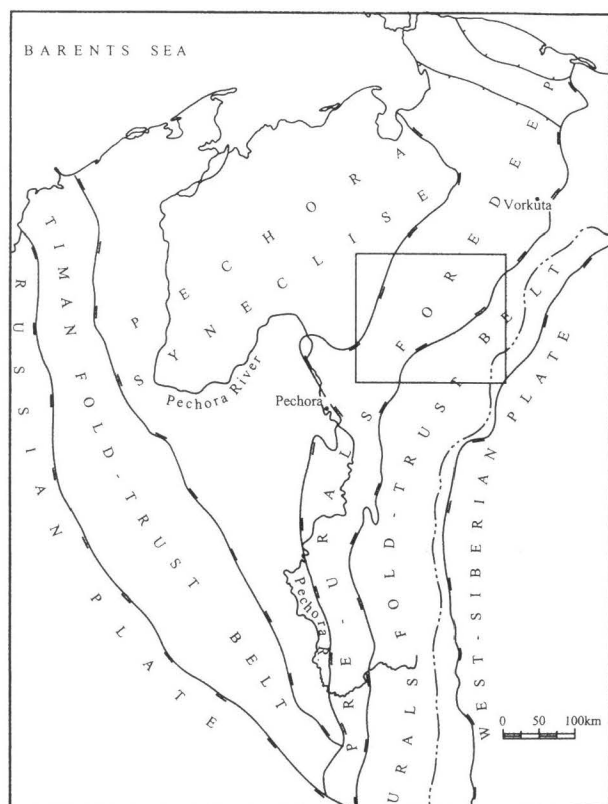
REGIONAL SETTING

The Timan-Pechora Basin is located in the north-east of the East European Platform. Structurally it is considered as the Pechora Plate, limited to the west by the East-Timan Thrust and to the east by the Main Urals Thrust (Text-fig. 1). The basin comprises an Upper Proterozoic basement overlain by Paleozoic-Cenozoic sedimentary cover. The basement consists of metamorphosed rocks represented by green schists, quartzites, sandstones, dolostones, limestones and intrusive rocks. Within the Timan Ridge and Urals, the rocks of the basement are exposed in the higher area, but on the platform they are buried to a significant depth and have been revealed only by deep drilling. The sedimentary cover consists of three structurally separated stratigraphic sequences: 1) Upper Cambrian-Lower Devonian, 2) Middle Devonian-Triassic (Lower Jurassic?), and 3) Middle Triassic-Recent. The thickness of cover changes from 4-7 km in the central part within the Pechora Syncline to 10-14 km in the Pre-Urals foredeep. Within some of the uplifts and domes the sedimentary thickness does not exceed 3-4 km, and on the Timan Ridge it is reduced to zero.

LATE DEVONIAN SYV'YU RIVER SECTION

In the Late Devonian the territory of the Pechora Plate was occupied by an epicontinental sea. In general, there are three structural-facies complexes, corresponding to three zones of the Urals palaeo-ocean: 1) shelf (inner shallow-water, middle, external deep shelves), 2) continental slope and 3) bathyal (so-called Lemva facial type) (Yudin & Dedeev, 1987; Yudin, 1994). The Upper Devonian facies plan was established as a result of the latest Givetian (?) - Frasnian onlap, drowning vast areas of the Russian Platform eastern margin, that was caused by both tectonic activities and eustatic sea-level fluctuations.

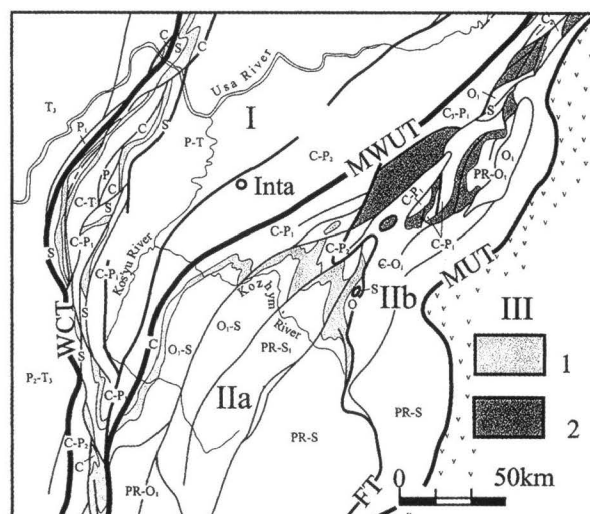
The Syv'yu River section studied is located in the western Subpolar Urals, and is one of the most complete Middle and Upper Devonian sequences of the Domanic type. Structurally, the area belongs to the West-Urals structural Zone where Devonian deposits are widespread (Text-fig. 2). The Upper Devonian deposits in the area are represented by three facial types (in Novakova, 1991; Text-fig. 3): 1) a Domanic type, wide-spread in the west of area, characterized by relatively deep-water bituminous sediments of a



Text-fig. 1 - Structural map of the Pechora Plate.

stagnant intra-shelf basin, with siliceous, terrigenous, and carbonate components; 2) a carbonate type, common in the eastern part of the area, represented by organo-clastic, organo-clotted, detritic, stromatoporeid-algal, and oncolitic limestones deposited within a shelf carbonate shoal; 3) relatively deep-water shale-carbonate deposits transitional to the bathyal (Lemva) type, that accumulated eastward from the carbonate shoal.

The Syv'yu River section is located about 38 km upstream from its junction with the Kozhim River. The Upper Devonian deposits in this section represent an



Text-fig. 2 - Geological and structural map of the Subpolar Urals and Pre-Urals, showing a distribution of Devonian deposits. Legend: Largest regional and large thrusts: WCT = West-Chernyshev, MWUT = Main West-Urals, FT = Frontal, MUT = Main Urals; 1-2) structure-formational complexes: 1 = carbonate shelf (Elets), 2 = shale bathyal (Lemva allochthonous); I) Pre-Urals foredeep; II-III) Urals fold-thrust belt: II = Western structure zone (a = Kozhim Uplift, b = Lemva depression), III = Eastern structure zone.

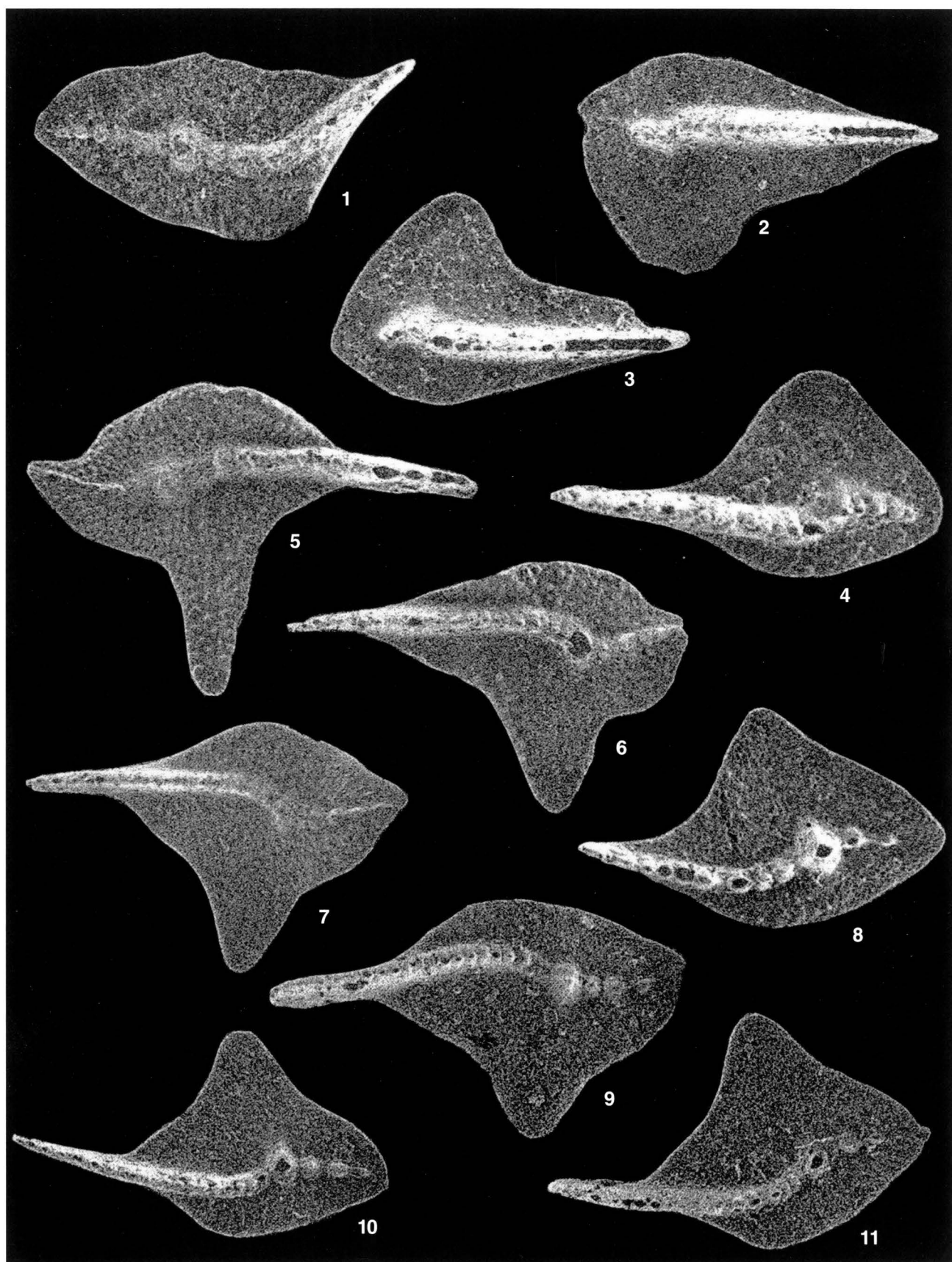
almost continuous sequence of the Domanic facies type through the Frasnian and Lower Famennian, and comprise thinly bedded, westerly dipping strata, without structural complications. They are exposed along the right bank of Syv'yu River in outcrops 1-4 (Text-fig. 4).

PREVIOUS WORKS

Modern stratigraphic studies of the Upper Devonian deposits in the Subpolar Urals stem from the work of A.I. Pershina (Pershina *et al.*, 1971), who subdivided the succession into regional horizons of the Urals Stratigraphic Chart. The Frasnian deposits were subdivided using the macrofauna into the Pashiya, Kyn

EXPLANATION OF PLATE 1

- Fig. 1 - *Palmatolepis linguiformis* Müller, 1956. x 80.
 Figs. 2-4 - *Palmatolepis juntianensis* Han, 1987. 2-3) x 80; 4) x 90.
 Figs. 5-6 - *Palmatolepis rhenana* Bischoff, 1956. 5) x 55; 6) x 60).
 Fig. 7 - *Palmatolepis nasuta* Müller, 1956. x 65.
 Fig. 8 - *Palmatolepis praetriaangularis* Ziegler & Sandberg, 1988. juvenile specimen; x 125.
 Figs. 9-11 - *Palmatolepis hassi* Müller & Müller, 1957. 9) x 110; 10) x 100; 11) x 105.
 All specimens from horizon CB2-125.

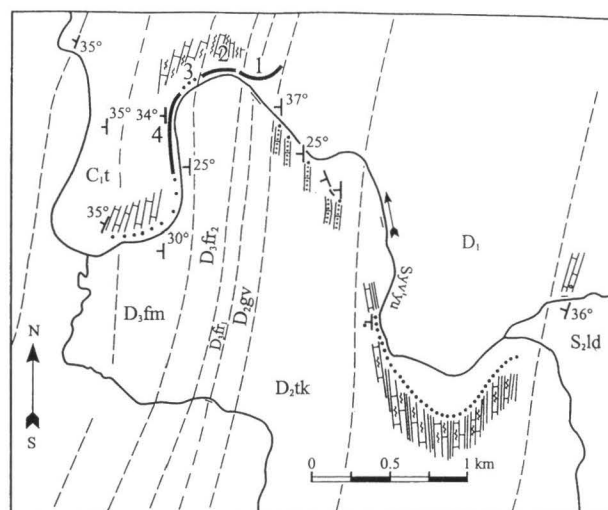




Text-fig. 3 - Map showing distribution of Frasnian and Famennian deposit types in the Kozhym River basin (Subpolar Urals). Legend: 1-4) deposits types: 1 = relatively deepwater depressional (clayey-siliceous-carbonate); 2 = shelf shoal carbonate; 3, 4 = relatively deepwater shale-carbonate one transitional to the Lemva type; 4 = the Syv'yu River section.

Horizons (Lower Frasnian), Sargaevo, Domanik Horizons and Shar'yu Suite (Middle Frasnian), and Askyn, and Barma Horizons (Upper Frasnian). The Famennian was subdivided into Lower and Upper Famennian Substages.

The Upper Devonian conodont faunas from the section were first studied by Yu. Deulin (1978). He recognized *Polygnathus asymmetricus asymmetricus*, *Ancyrognathus triangularis*, *Palmatolepis rhenana* and *Palmatolepis triangularis* Zones in Frasnian, and *Palmatolepis crepida*, *Pa. rhomboidea*, *Pa. quadrantinodosa*, *Scaphignathus velifer*, *Polygnathus styriaca* and *Spathognathodus costatus* Zones in Famennian. Later, in the course of large-scale mapping, the zonation was changed and correlated with regional horizons of the western Urals. These included in the Frasnian, the *Ancyrodella binodosa* Zone (Pashiya and Kyn Horizons), *A. rotundiloba* Zone (Sargaevo Horizon), *Polygnathus timanicus* and *Ancyrognathus triangularis* Zones (Domanic Horizon), *Palmatolepis gigas* Zone (Mendym Horizon), and *Palmatolepis triangularis* Zone (Askyn Horizon); and in the Famennian, the *Palmatolepis crepida*, and *Pa. rhomboidea* Zones (Makarovo Horizon), and the *Pa. marginifera* Zone (Murzakaveo



Text-fig. 4 - Outcrop map of the Syv'yu River section.

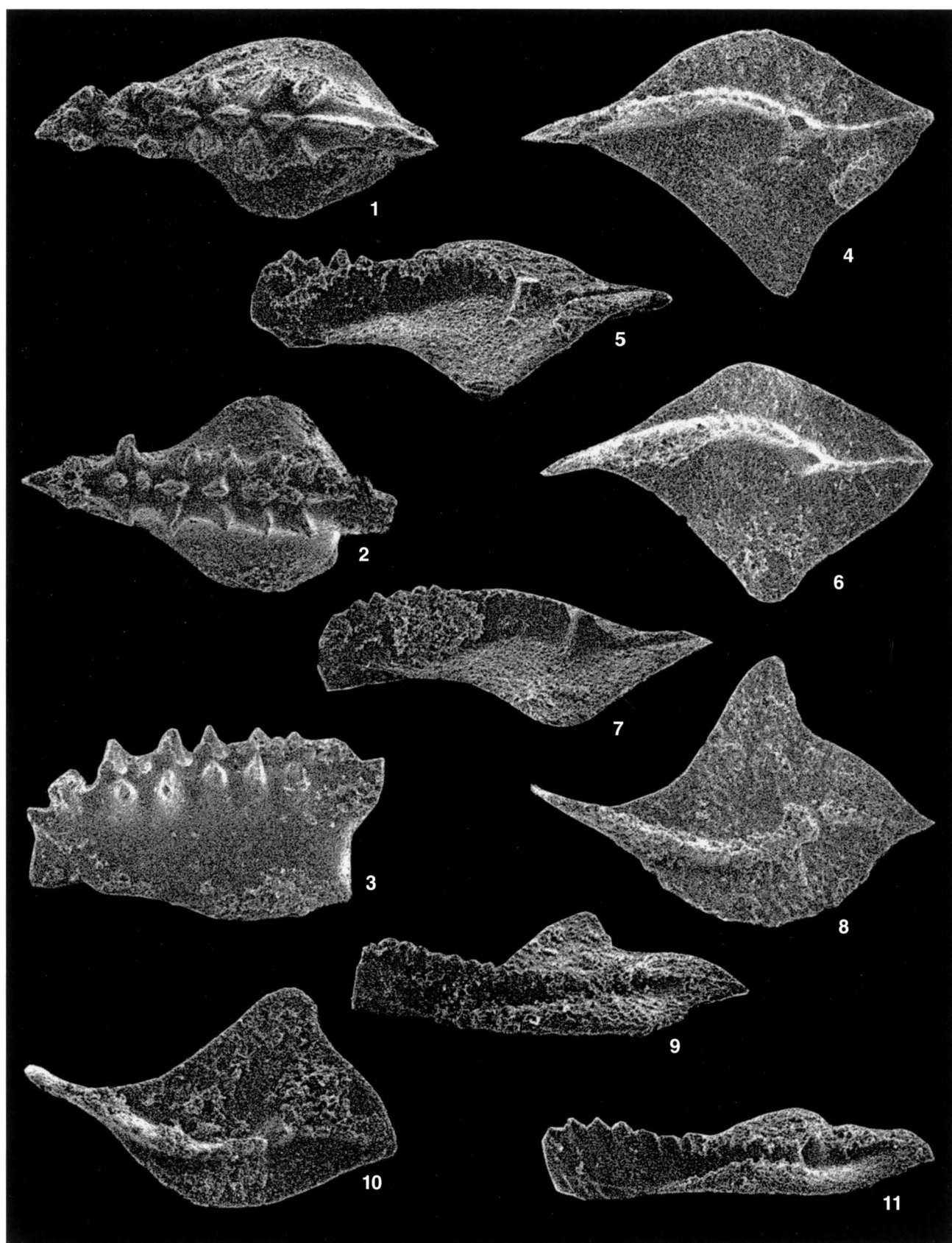
Horizon). Many of the conodonts from this section were simultaneously identified by L.S. Kolesnik. In the conodont study the carbonate-terrigenous deposits considered by A.I. Pershina as the Shar'yu Suite, Askyn and Barma Horizons were dated as being of Famennian age.

In 1987 the Frasnian and Lower Famennian succession in the Syv'yu River section was measured by A.B. Yudina together with V.S. Tsyganko. Some data on the Upper Devonian biostratigraphy and lithostratigraphy of the section were published earlier (Tsyganko 1994; Yudina 1989, 1994). A.B. Yudina has recognized the standard conodont zones and beds with faunas, including the *Ancyrodella pristina*, *A. rotundiloba*, *Polygnathus timanicus* and *Palmatolepis gigas* Zones in the Frasnian. It was noted that the *Ancyrognathus triangularis* Zone cannot be recognized in the section because of the index species of the zone first appears above in the *Pa. gigas* Zone. In the Famennian, the Middle and Upper *Pa. triangularis* Zones, the *Pa. crepida* - *Pa. rhomboidea* Zones, and the *Pa. marginifera* Zone were recognized (Yudina, 1996).

During a field trip in August 1996 the present authors collected a rich fauna of conodonts from the Syv'yu-River section. This paper describes that collection together with earlier material collected in 1987.

EXPLANATION OF PLATE 2

- Fig. 1 - *Icriodus alternatus alternatus* Branson & Mehl, 1934. x 145.
 Figs. 2-3 - *Icriodus alternatus helmsi* Sandberg & Dreesen, 1984. x 110.
 Figs. 4-7 - *Palmatolepis triangularis* Sannemann, 1955. 4-5) x 120; 6-7) x 150.
 Figs. 8-11 - *Palmatolepis praetrianularis* Ziegler & Sandberg, 1988. 8-9) x 90; 10-11) x 145.
 All specimens from horizon Syv96-138/1.



LITHOSTRATIGRAPHY

In the Syv'yu River section the Givetian is mostly represented by dark-gray to black bituminous detritic and argillaceous limestones, yellow clays and gray argillites with calcareous nodules. These limestones are richly fossiliferous, with brachiopods, bivalves, rugose corals, crinoids, ostracods and conodonts. On the basis of brachiopods and corals these deposits have been assigned to the Cheslavka Horizon (Perschina *et al.*, 1971).

The total thickness of exposed Upper Devonian sequence in the Syv'yu River section is about 201m. Lithostratigraphically, the Upper Devonian in the section is subdivided into the Kedzydshor, Vorota, Shar'yu and Domanikoid formations. The first three of these formations were earlier described in the Shar'yu River section (Chernyshev Ridge) which was proposed as the type section for these formations (Tsyganko, Perschina & Yudina, 1985). It should be noted, that contrary to previous studies (Tsyganko, 1994), the dark-gray organic-rich limestones that were considered the upper part of Kedzydshor Formation are now included in the Vorota Formation because of their colour and predominantly pelagic faunas. Moreover, the upper limit of the Vorota Formation is drawn at the top of the uppermost dark-coloured predominantly shale beds included earlier in the Shar'yu Formation. Thus, the Vorota Formation in the proposed lithostratigraphic unit corresponds to a single sedimentation phase, characterized by stagnant conditions. During this phase bituminous sediments rich in siliceous, terrigenous, and carbonate components, and with presumably pelagic faunas (Domanik facies) were formed within a stagnant relatively deep-water intra-shelf basin. The fourth formation is named here conditionally as the Domanikoid Formation. It was not selected as a separate unit during the earlier large-scale geological mapping and is shown on the latest geological map of the Subpolar Urals as part of the Famennian.

The *Kedzydshor Formation* is about 15m thick and consists of silty clays, siltstones, dark-gray silty limestones, and light-gray and yellow clays. Almost all of the rocks contain shamosite oolites. The limestones, often bioturbated, contain brachiopods, gastropods,

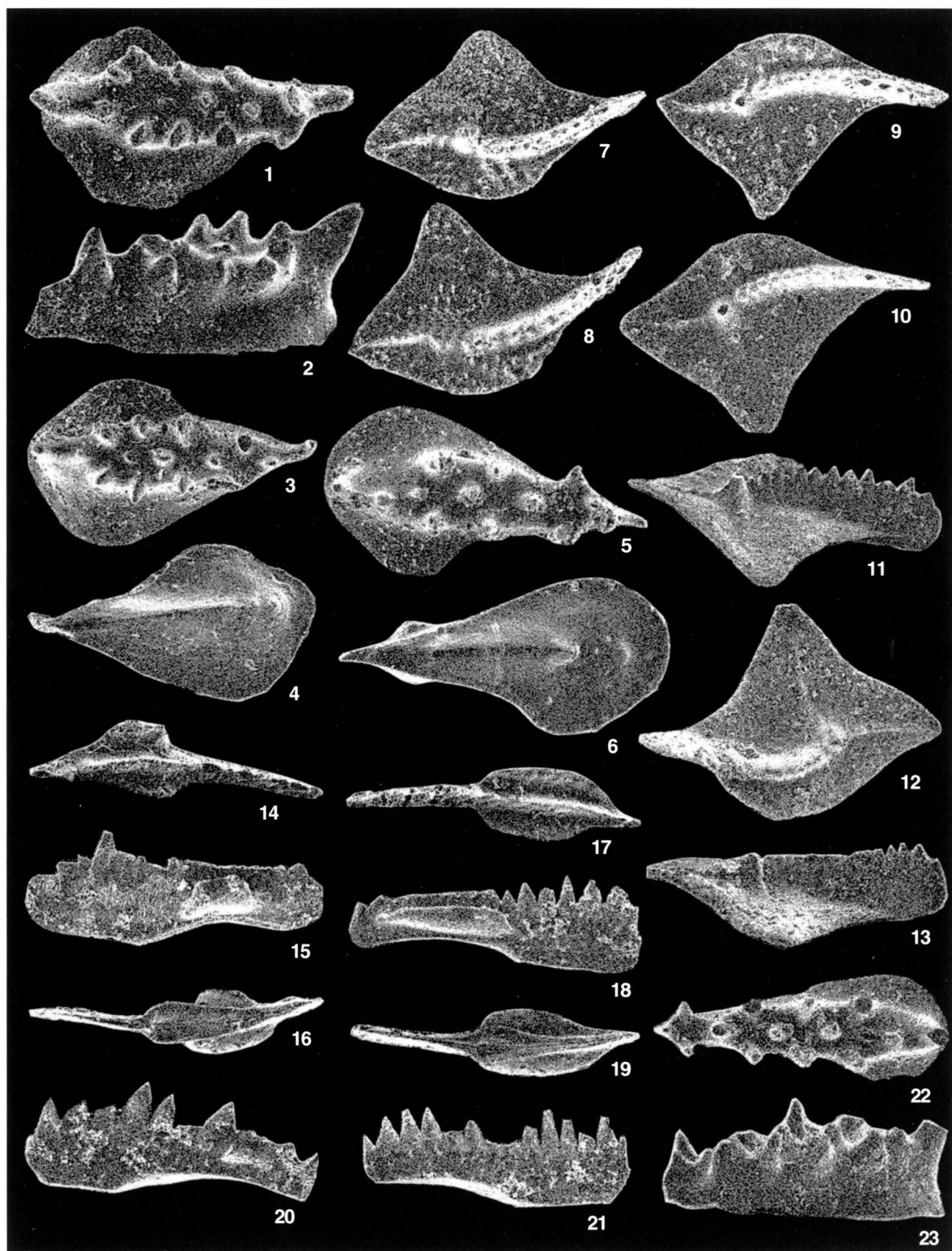
ostracods, crinoids, trilobites, sponge spicules, and scarce conodonts. It is possible that the upper part of the Kedzydshor Formation is still of latest Givetian age, but traditionally it is assigned to the regional Pashiya Stage (Horizon) and it is considered as basal transgressive beds of Frasnian Stage (Perschina *et al.*, 1971).

The *Vorota Formation* is about 45 m in thickness, and is comprised of three units. The lowest unit (Unit I) consists of black organic-rich and pyrite-rich thin bedded, often laminated, siliceous limestones, argillites, and siliceous shales with thin chert interlayers. The rocks contain tentaculites, radiolarians, goniatites, orthocone cephalopods, bivalves, ostracods, brachiopods, and conodonts. The thickness of Unit I is 8.2 m. The middle unit (Unit II) consists mostly of gray to dark-gray thin and thick-bedded limestones (wack- and mudstones) with interbeds of argillaceous limestones, thin interlayers of brownish-black organic matter-rich shales, and yellow to yellowish-gray calcareous clays. Very often the limestones contain black chert nodules and thin lens-like interbeds. In the unit there are some thick interbeds composed of thin intercalated shales and nodular limestones. Faunas comprise tentaculites, styliolines, radiolarians(?), thin-shelled brachiopods, ostracods, and conodonts. At the top of the unit yellow calcareous clays and gray to dark-gray marls are present. The thickness of the Unit II is about 14.5m. The upper unit (Unit III) consists of dark-gray to black organic-rich and pyrite-rich argillaceous and siliceous limestones, often with chert nodules and thin lens-like interbeds, and marly and siliceous-marly shales. Some interbeds are composed of nodular limestones thinly intercalated with argillites and shales. In the base of the unit limestone nodules of large size occur. The faunas in this unit are represented by sponge spicules, radiolarians(?), scarce thin-shell brachiopods assigned to *Orbiculoidea* sp., scolecodonts, ostracods, and conodonts. The thickness of Unit III is about 22m. On the basis of conodonts the base of the Vorota Formation age is earliest Frasnian and the top is early Famennian. The Middle-Upper Devonian boundary is drawn in the section near the base of the Vorota Formation at the lowest appearance of *Ancyrodella pristina* (Sandberg, Ziegler & Bultynck, 1989; Ziegler & Sandberg, 1990).

The *Shar'yu Formation* is about 123m thick and is

EXPLANATION OF PLATE 3

- Figs. 1-2 - *Icriodus deformatus asymmetricus* Ji, 1989. x 105.
 Figs. 3-4 - *Icriodus alternatus alternatus* Branson & Mehl, 1934. x 110.
 Figs. 5-6, 22-23 - *Icriodus alternatus helmsi* Sandberg & Dreesen, 1984. 5-6) x 150; 22-23) x 120.
 Figs. 7-13 - *Palmatolepis triangularis* Sannemann, 1955. 7) x 100; 8) x 90; 9) x 110; 10-11) x 115; 12-13) x 75.
 Figs. 14-19 - *Polygnathus angustidiscus* Youngquist, 1945. 14-16) x 85; 17-19) x 85.
 Figs. 20-21 - *Mehlina* sp. A. 20) x 125; 21) x 90.
 All specimens from horizon Syv96-132.



predominantly composed of gray to dark-gray, thin- to thick-bedded limestones, marls and marly shales. In the upper part thick (to 0.6 m) conglomerate-like limestone interbeds occur. Faunas are represented by very scarce, thin-shelled brachiopods assigned to *Orbiculoidea* sp., ostracods, and rare conodonts. The age of the Shar'yū Formation is early to middle Famennian.

The *Domanikoid Formation* is about 23m thick in the section studied. It consists of rhythmically interbedded dark-gray to black thick-bedded massive siliceous limestones with black chert nodules and lens-like nodular limestones. The nodular layers thinly intercalate with marls and carbonaceous-marly shales. The limestones contain scarce thin-shelled lingulid brachiopods, ostracods and diverse conodonts. The base of the formation is of middle Famennian age (the Early *marginifera* Zone) and the top extends into the latest Tournaisian- early Viséan. The sporadic outcrops of the upper part of this formation is known downstream on the Syv'yū River, and on the Kozhim River where Upper Devonian-Carboniferous boundary deposits are exposed (Chernnykh *et al.*, 1988; Nemirovskaya *et al.*, 1992).

LATE DEVONIAN CONODONTS FROM THE SYV'YU RIVER

The Syv'yū River section is richly fossiliferous, with brachiopods, bivalves, ammonoids, rugose corals, crinoids, ostracods, and conodonts. Because the section extends through much of the Famennian, as well as the underlying Frasnian, we have used the standard conodont zonation proposed by Ziegler and Sandberg (1990), and modified by Ji & Ziegler (1993), for zonal reference. Our identifications indicate the presence of: the Early *falsiovalis* Zone suggested by the association of *Ancyrodella pristina*, *Po. alatus*, *Po. decorosus*, and *Po. xylus xylus*; the Late *falsiovalis* Zone suggested by *Mesotaxis asymmetrica*, *M. falsiovalis*, *M. cf. M. falsiovalis*, *M. cf. M. ovalis*, *M. cf. M. dengleri*, *Ancyrodella alata*, *A. rotundiloba*, *Icriodus symmetricus*, *Polygnathus alatus*, *Po. cf. Po. alatus*, *Po. webbi*, and *Po. cf. Po. dubius*; the *transitans* Zone suggested by *Mesotaxis asymmetrica*, *M. cf. M. falsiovalis*, *M. cf. M. distincta*, *M. bogoslovskyi*, *M. ovalis*, *M. aff. M. johnsoni*, *Icriodus subterminus*, *I. aff. I. symmetricus*, *Ancyrodella alata*, *Ancyrodella rotundiloba*, *Polygnathus xylus xylus*, *Po. cf. Po. alatus*, *Po. aff. Po. ljaschenkoi*, and *Playfordia*.

EXPLANATION OF PLATE 4

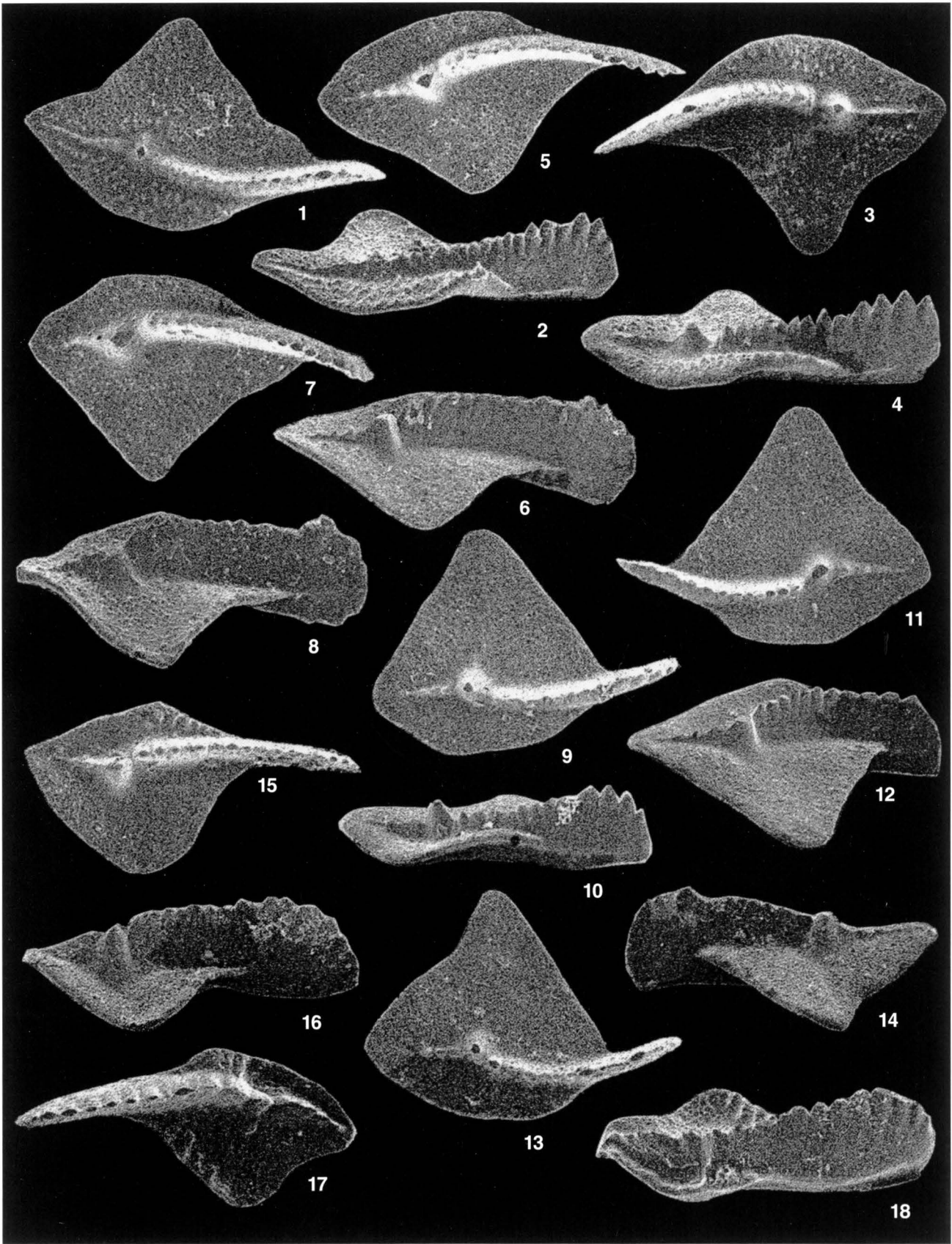
- Figs. 1-4 - *Palmatolepis triangularis* Sannemann, 1955. 1-2) x 85; 3-4) x 95;
 Figs. 5-6 - *Palmatolepis* cf. *P. triangularis* Sannemann, 1955. x 130.
 Figs. 7-14 - *Palmatolepis delicatula delicatula* Branson & Mehl, 1934. 7-8) x 120; 9-10) x 125; 11-12) x 115; 13-14) x 100.
 Figs. 15-18 - *Palmatolepis protorhomboides* Sandberg & Ziegler, 1973. 15-16) x 110; 17-18) x 115.
 All specimens from horizon Syv96-S23.

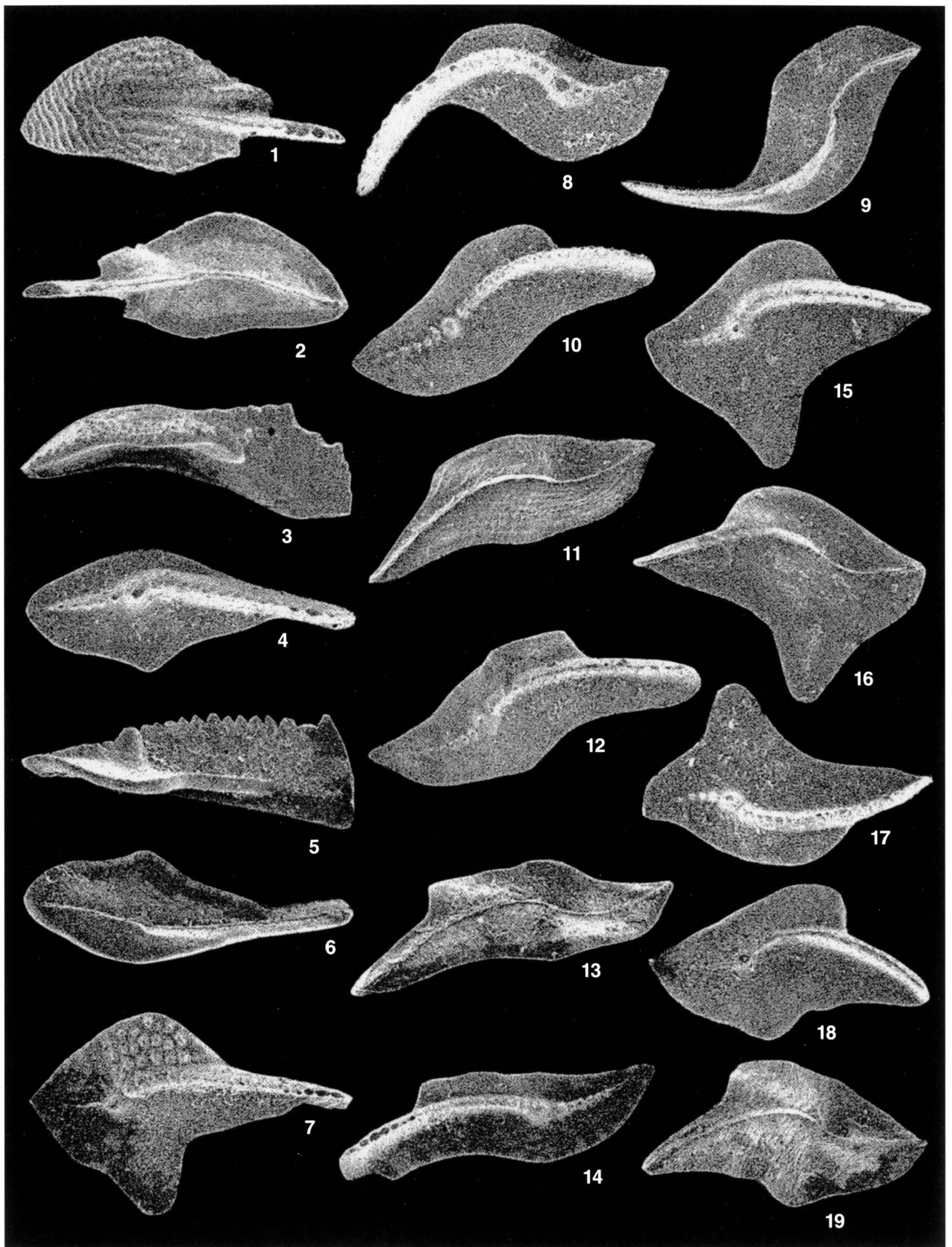
EXPLANATION OF PLATE 5

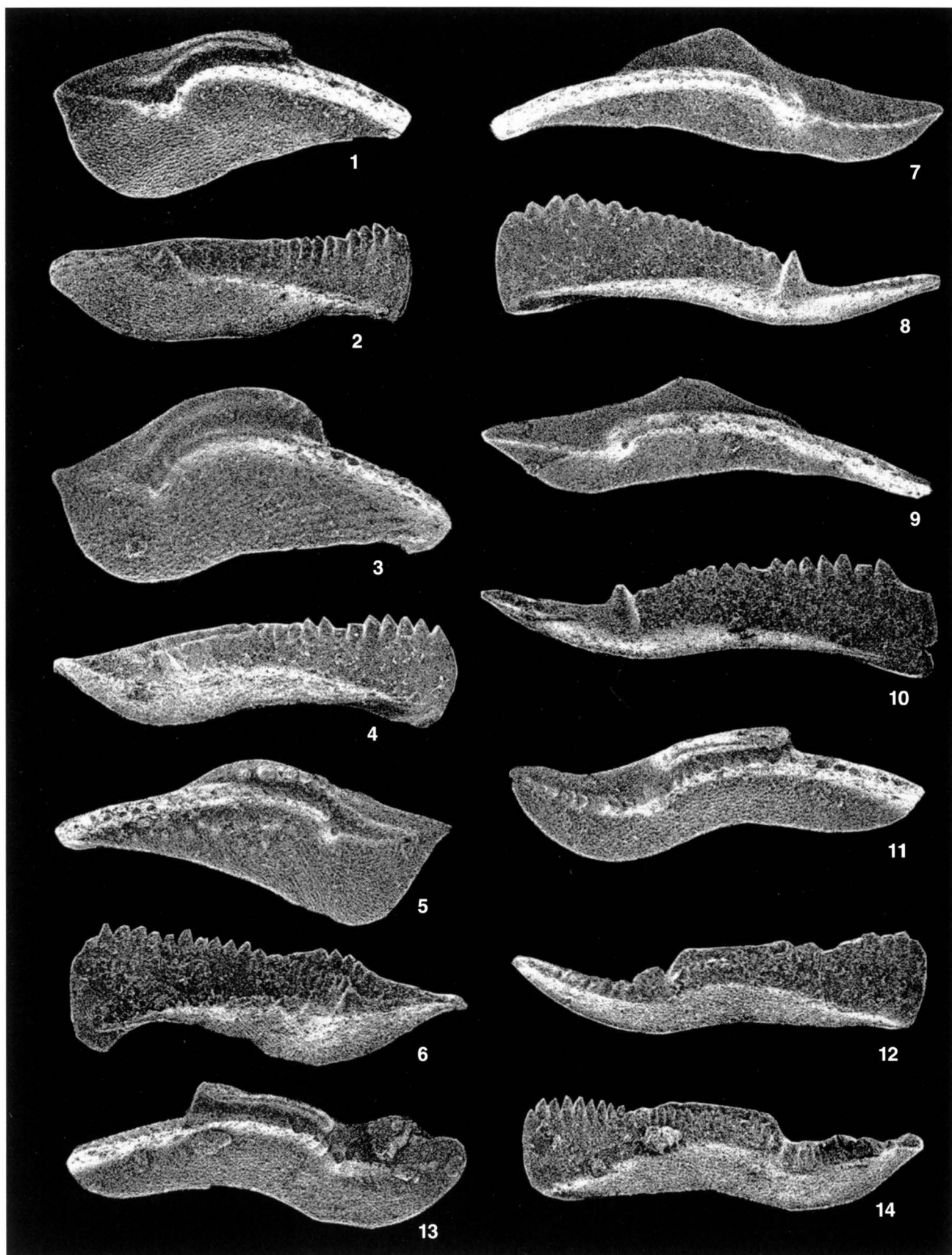
- Figs. 1-3 - *Polygnathus* cf. *P. nodocostatus* Branson & Mehl, 1934. x 60.
 Figs. 4-6 - *Palmatolepis minuta minuta* Branson & Mehl, 1934. x 80.
 Fig. 7 - *Palmatolepis quadrantinodosalobata* Sannemann, 1955 (Morphotype 2 of Ji & Ziegler, 1993). x 65.
 Figs. 8-9 - *Palmatolepis* cf. *P. regularis* Cooper, 1931. x 85.
 Figs. 10-11 - *Palmatolepis glabra prima* Ziegler & Huddle, 1969. x 60.
 Figs. 12-14 - *Palmatolepis glabra pectinata* Ziegler, 1962. 12) x 45; 13-14) x 55.
 Figs. 15-17 - *Palmatolepis subperlobata* Branson & Mehl, 1934. 15-16) x 70; 17) x 80.
 Figs. 18-19 - *Palmatolepis tenuipunctata* Sannemann, 1955. x 35.
 All specimens from horizon CB2-193.

EXPLANATION OF PLATE 6

- Figs. 1-4 - *Palmatolepis marginifera marginifera* Helms, 1959. 1-2) x 80; 3-4) x 120.
 Figs. 5-6 - *Palmatolepis marginifera marginifera* Helms, 1959 intermediate to *Palmatolepis marginifera utahensis* Ziegler & Sandberg, 1984. x 110.
 Figs. 7-10 - *Palmatolepis glabra lepta* Ziegler & Huddle, 1969. 7-8) x 70; 9-10) x 65.
 Figs. 11-14 - *Palmatolepis glabra distorta* Branson & Mehl, 1934. 11-12) x 80; 13-14) x 85.
 All specimens from horizon CB4-169.







primitiva; the *punctata* Zone suggested by *Palmatolepis punctata*, *Mesotaxis ovalis*, *Po.* cf. *Po. robustus*, *Po. angustidiscus*, and *Icriodus alternatus alternatus*; the Early *hassi* Zone suggested by *Mesotaxis ovalis*, *Palmatolepis gutta*, *Icriodus symmetricus*, *Polygnathus timanicus*, and *Po. xylus xylus*; the Late *hassi* Zone suggested by *Mesotaxis* cf. *M. ovalis*, *Polygnathus timanicus*, and *Po. pardecorosus*; the *jamieae* Zone suggested by *Palmatolepis proversa*, *Pa. jamieae*, *Pa. amplificata*, *Pa. domanicensis*, and *Polygnathus* cf. *Po. decorosus*; the Early *rhenana* Zone suggested by *Palmatolepis hassi*, *Pa. subrecta* (?=*winchelli*), *Pa. hassi*, *Pa. timanensis*, *Pa. muelleri*, *Pa. jamieae*, *Pa. semichatovae*, *Pa. proversa*, *Ancyrognathus amana*, *Ancyrognathus coeni*, *Polygnathus* cf. *Po. pardecorosus*, *Po. lodinensis*, and *Ancyrodella gigas*; the Late *rhenana* Zone suggested by *Palmatolepis hassi*, *Pa. eureka*, *Pa. jamieae*, *Pa. rhenana*, *Pa. nasuta*, and *Polygnathus decorosus*; the *linguiformis* Zone suggested by *Palmatolepis linguiformis*, *Pa. juntianensis*, *Pa. rhenana*, *Pa. nasuta*, *Pa. hassi*, *Pa. praetriangularis*, *Icriodus alternatus alternatus*, *I. alternatus helmsi*, and *Polygnathus decorosus*; the Early *triangularis* Zone suggested by *Palmatolepis triangularis*, *Palmatolepis praetriangularis*, *Icriodus alternatus helmsi*, *I. alternatus alternatus*, and *Polygnathus angustidiscus*; the Middle *triangularis* Zone suggested by *Palmatolepis triangularis*, *Pa. delicatula delicatula*, and *Pa. protorhomboidea*; the Late *triangularis* Zone suggested by *Palmatolepis triangularis*, *Palmatolepis sandbergi*, *Palmatolepis minuta minuta*, and *Palmatolepis wernerii*; the Late *crepida* Zone suggested by *Palmatolepis minuta minuta*, *Pa. subperlobata*, *Pa. quadrantinodo-salobata*, *Pa. glabra glabra*, *Pa. glabra pectinata*, *Pa. glabra prima*, *Pa.* cf. *Pa. regularis*, *Pa. tenuipunctata*, and *Polygnathus* cf. *Po. nodocostatus*; and the Early *marginifera* Zones suggested by *Palmatolepis glabra lepta*, *Pa. glabra distorta*, and *Pa. marginifera marginifera*.

Overlying samples contain conodonts that indicate the presence of higher zones.

CONODONTS AT THE FRASNIAN-FAMENNIAN BOUNDARY

Of particular interest are the conodonts at the Frasnian-Famennian boundary. The conodonts listed above from the *linguiformis* Zone, the Early *triangularis* Zone, and the Middle *triangularis* Zone are illustrated on Pls. 1-4. The Frasnian-Famennian boundary appears to occur within thinly bedded, argillaceous limestones and calcareous argillites 70 cm thick, that contain pyritized sponge spicules, rare styliolines, and abundant *Icriodus*. The beds were exposed by digging a trench into the steep face of the river bank where the softer argillaceous beds had become weathered. The boundary occurs above the conodonts illustrated in Plate 1 but just below those illustrated in Plate 2. Samples were taken at 2 cm intervals and the boundary is marked by

the first occurrence of *Palmatolepis triangularis*, which is associated in the sample with *Palmatolepis praetriangularis*, *Icriodus alternatus alternatus*, *Icriodus alternatus helmsi*, and *Polygnathus angustidiscus*. A 3 cm thick black chert is present 11 cm above the boundary bed.

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