

Ostracods and fore-reef sedimentology of the Frasnian–Famennian boundary beds in Kielce (Holy Cross Mountains, Poland)

JEAN-GEORGES CASIER, XAVIER DEVLEESCHOUWER, FRANCIS LETHIERS, ALAIN PRÉAT,
and GRZEGORZ RACKI



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Four major microfacies have been recognized in the Psie G rki section and the bioclastic content indicates an open marine environment in the photic zone close to an algal shole. Sedimentological studies point to a regressive episode starting close to the Frasnian–Famennian boundary. The regressive microfacies pattern is revealed by the presence of semi-restricted algal microbreccias that compose all of the lower part of the Famennian. The regression was accompanied by meteoric water invasion as the sea level fell. Seventy-six ostracod species are recorded. The ostracod assemblage, dominated by podocopids, belongs to the Eifelian ecotype and is indicative of a well-oxygenated marine environment below fair-weather wave base in the Frasnian part of the section, and of shallower environments in the base of the Famennian. No ostracod assemblage characteristic of hypoxic or semi-restricted water conditions has been recorded. The rate of extinction of ostracod species (>70%) close to the Frasnian–Famennian boundary is comparable with that known on the same level in several other sections investigated in the world. Five new ostracod species are proposed by J.-G. Casier and F. Lethiers: *Selebratina vellicata*, *Samarella? minuta*, *Bairdiocypris ventrorecta*, *Acratia pentagona*, and “*Bairdia*” *psiegorkiensis*.

Key words: Ostracoda, sedimentology, mass extinction, Frasnian, Famennian, Holy Cross Mountains, Poland.

Jean-Georges Casier [casier@naturalsciences.be], Department of Palaeontology, Belgian royal Institute of natural Sciences, Vautier Str., 29, B-1000 Brussels, Belgium;

Xavier Devleeschouwer [xdevlees@ulb.ac.be], Geological Survey of Belgium, Jenner street, 13, B-1000 Brussels, Belgium; Francis Lethiers [Lethiers@ccr.jussieu.fr], Department of Sedimentary Geology, Paris VI University, 4 Jussieu PL, F-75252 Paris Cedex 05, France;

Alain Pr at [apreat@ulb.ac.be], Department of Earth and Environmental Sciences, Free University of Brussels, F.D. Roosevelt Av., 50, B-1050, Brussels, Belgium;

Grzegorz Racki [racki@us.edu.pl], Wydzia l Nauk o Ziemi, Uniwersytet S laski, B dzi nska Str., 60, PL-41-200 Sosnowiec, Poland.

Introduction

The Late Devonian mass extinction is one of the five largest (Sepkoski 1986), and probably the second major one during the Phanerozoic (Casier and Lethiers 1998a; Copper 1998). Approximately 75 percent of all marine ostracod species were wiped out during this crisis in lower latitudes (Casier et al. 1996; Lethiers and Casier 1996), and in the Schmidt quarry (Kellerwald, Germany) the extinction took place during the last step of the Upper Kellwasser Event (Casier and Lethiers 1998a). The faunal change at the Frasnian–Famennian boundary (FFB) was related in part to the appearance of dysoxic water conditions in the Palaeotethys (Casier 1987; Casier and Lethiers 1998a) and also with a fall in global sea level that resulted in the reduction of shallow-marine habitats (Casier and

Devleeschouwer 1995; Casier and Lethiers 1998b). The relatively greater abundance of ostracods belonging to the Thuringian ecotype at the base of the Famennian shows that the event was perhaps responsible for a global cooling of the biosphere (Lethiers and Raymond 1991; Streele et al. 2000). Principal results concerning the disappearance and the renewing of the ostracod fauna during and following the FFB crisis have been summarized recently by Lethiers and Casier (1999) and Casier and Lethiers (2001).

First account on ostracods and on the sedimentology at the FFB in Holy Cross Mountains was based on materials from Kostom oty section (Casier et al. 2000). The goal of the present paper is to provide more data on the FFB crisis in the Holy Cross Mountains basing on samples from Psie G rki section at Kielce, the stratigraphy of which has been refined by Racki (1990).

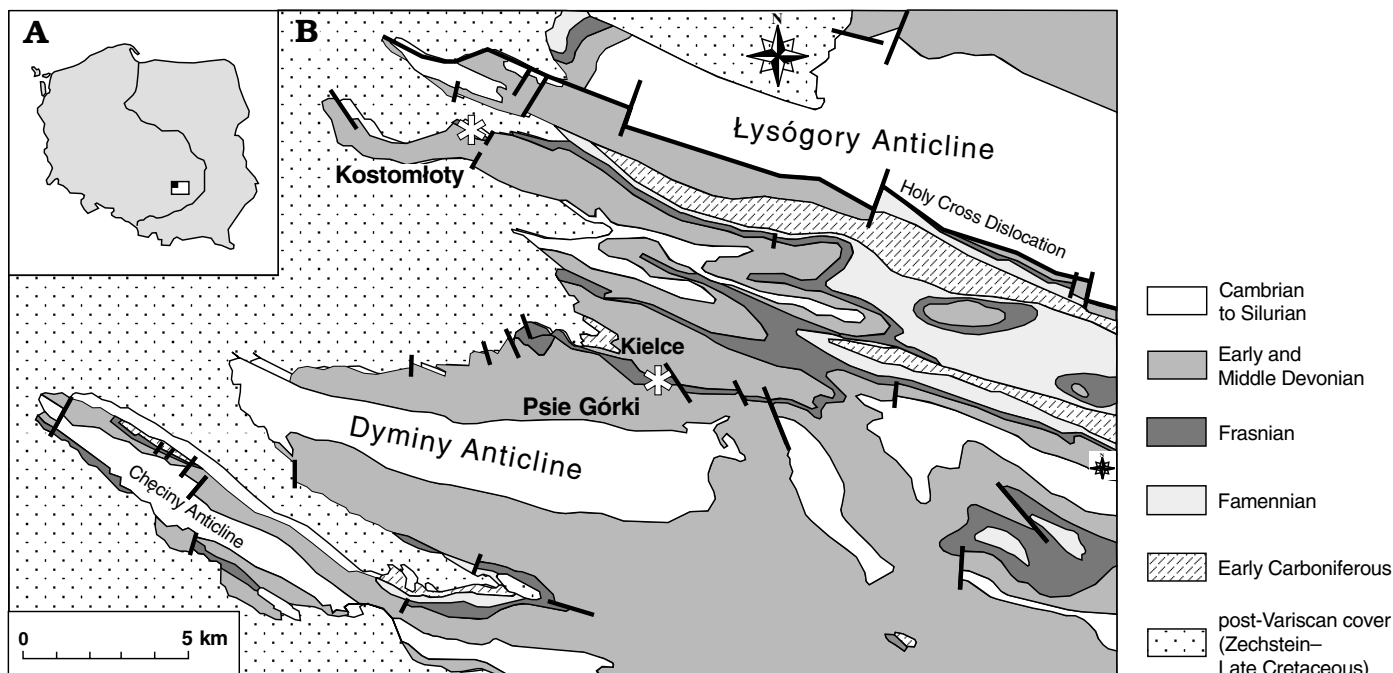


Fig. 1. A. General map of Poland with the location of the Holy Cross Mountains. B. Position of the Psie Górkki section at a geological map of the Kielce area (modified after Szulczewski 1971).

The Psie Górkki section

(G. Racki and X. Devleeschouwer)

The Frasnian deposits are exposed mainly in the western part of the Holy Cross Mountains (central Poland) along chains of hills. Famennian sediments, however, occur essentially in synclinal zones. The Psie Górkki Hill lies within the Kadzielnia Range (Szulczewski 1971), and more precisely in the Kielce suburbs (Fig. 1A, B). A few abandoned small quarries are exposed in the Frasnian (sets C to H in Racki 1990; Gawlik in Racki et al. 1993) of Psie Górkki Hill. The investigated section has been sampled at the top of the hill, close to Zakopiańska Street.

Szulczewski (1971) stated that the entire profile of the Upper Devonian section at Psie Górkki is developed in the detrital facies. Sedimentation of these detrital limestones persists at Psie Górkki into the Famennian until the *Palmatolepis crepida* conodont Zone. No change in the lithology of the deposits is thus recorded at the FFB.

Racki (1990) subdivided the Psie Górkki sequence into seven lithologic units (sets C to I) comprising mainly varieties of detrital limestones. The Psie Górkki succession is seen as representative of a shallow northern foreslope of the evolving Dyminy Reef (Racki 1990). The early Frasnian, composed of coral and stromatoporoid limestones (sets A, B), crops out at the adjacent Góra Cmentarna (Gawlik in Racki et al. 1993). The late Frasnian of the Psie Górkki section exposes a series of thick-bedded limestones enriched in fragmental debris of corals and stromatoporoids. The coarse-

grained limestones of the reef-cap stage (see e.g., Narkiewicz and Hoffman 1989), corresponding to the lithologic unit G (or set G), are observed only below the FFB. The basal part of the Famennian (set H) corresponds to massive, fine-grained limestones with an impoverished fauna.

The contact between sets G and H corresponds to an erosional discontinuity surface close to the FFB (Racki 1990). This author reported evidence for an erosive phase along this depositional break: presence of large intraclasts, and filling of substrate depressions and pockets by crinoid, brachiopod and nautiloid accumulations suggesting a strong lateral variability. Thus, the exact position of the FFB is uncertain. Moreover, a prolonged condensation and several hiatuses occur also at this level. A thickness probably not exceeding 0.5 meters for the *Palmatolepis linguiformis* and Early *Palmatolepis triangularis* zones is clearly deduced from conodont data (Racki 1990).

Currently, without additional conodont sampling, the FFB is placed at the base of bed 8, between samples PG30 and PG31 (Fig. 2). This is in agreement with previously published palaeontological (conodonts, corals, and atrypids last occurrences) determinations (Racki 1990; Racki and Baliński 1998).

Sedimentology

(X. Devleeschouwer and A. Prétat)

The Eifelian to Famennian carbonate succession of the Holy Cross Mountains has been studied intensively in recent years

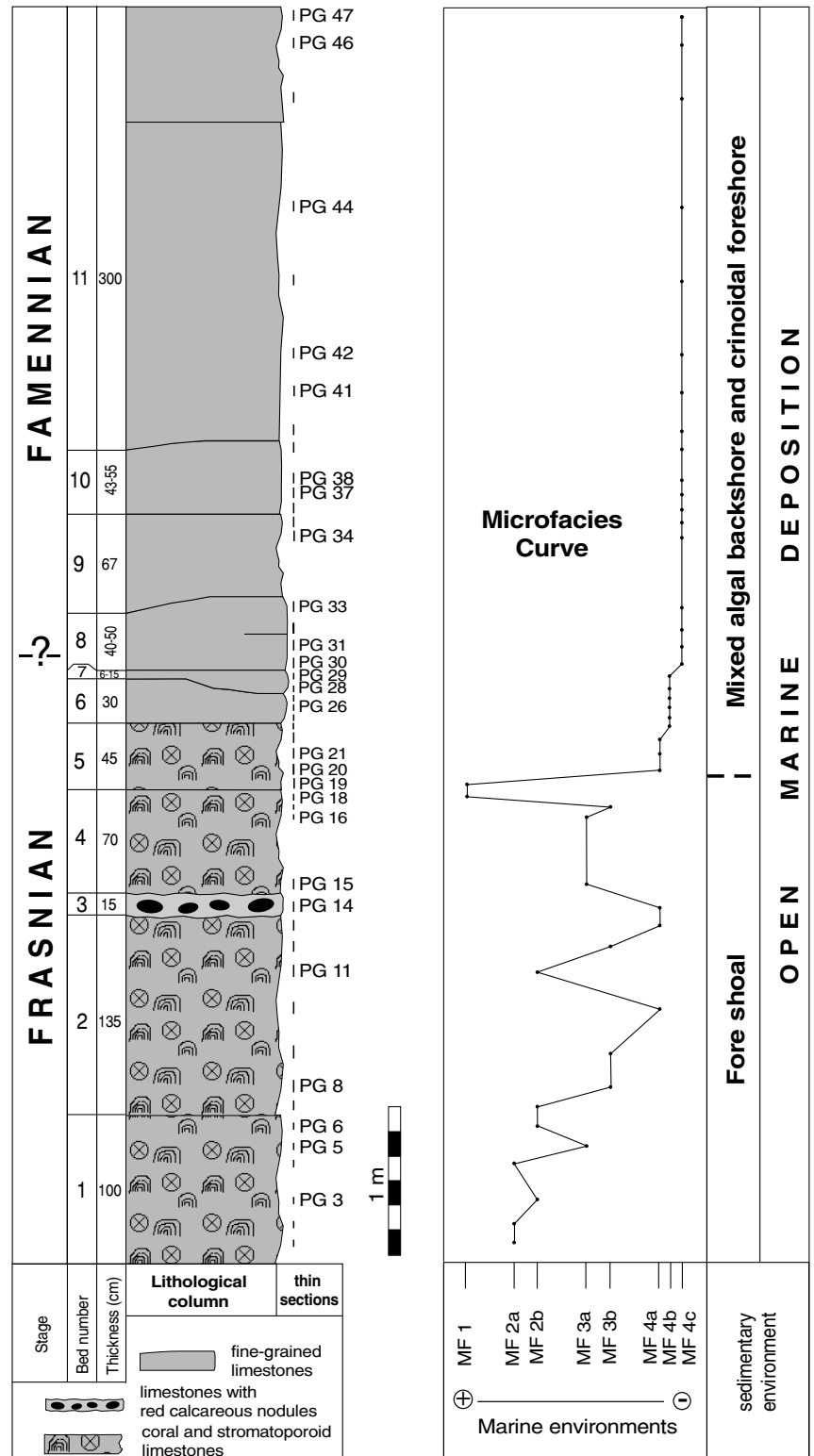


Fig. 2. Lithological column of the Psie Górki section, position of ostracod samples (PG) and microfacies curve deduced from the sedimentological study.

(e.g., Szulczewski 1971; Narkiewicz and Hoffman 1989; Hałas et al. 1992; Narkiewicz and Narkiewicz 1992; Racki 1998; Racki and Baliński 1998; Devleeschouwer 1999). However, only a few publications have been concerned with sedimentological microfacies analyses near the FFB in Poland. Nevertheless, a first contribution by Casier et al. (2000)

reveals a clear regressive change in microfacies curve in the Kostomłoty section near Kielce. This sea level drop is marked by a change from open-marine fore-shoal environments during the Frasnian to supratidal environments at the base of the Famennian. Ostracod assemblages changed with this drop in the sea level.

This paper defines more precisely the change of microfacies across the FFB in the Psie Górki section, and compares the palaeoenvironmental changes with those of the ostracod assemblages as well as with previous results from the Kostomłoty section (Casier et al. 2000).

Within a thickness of nearly 8.5 metres, 47 samples were collected from the Psie Górki section for sedimentological analysis. Petrographical study has established a standard sequence composed of 4 major microfacies that record a shallowing-upward trend of relative sea level during this interval.

Fore-shoal environment. — Microfacies 1 consists of burrowed bioclastic wackestones and packstones. The bioclasts are comprised of medium-sized perforated crinoids, variously-sized brachiopods and small molluscan shells, foraminifers (*Eogeinitzina* [Fig. 3G], *Eonodosaria*, *Nanicella* [Fig. 3H], *Frondilina* and *Tikhinella*; see also Racki and Soboń-Podgórska 1993), various dasycladacean algae (issinelids and kamaenids), and a few ostracods. Rare bryozoans and stromatoporoids occur as fragments. Phosphate grains are observed rarely. The burrows are infilled with micro-biostrophic and peloidal hashes similar to the one constituting part of microfacies 2. With the exception of the burrowed zones the micritic matrix is dense and homogeneous.

Microfacies 2 consists of burrowed bioclastic peloidal packstones. Two lithotypes are recognized on the basis of grain size. Microfacies 2a consists of fine-grained packstones that are heavily bioturbated. The bioclasts are abundant, diversified and very fine-grained ("shell hash"); they are composed of perforated crinoids, brachiopods, molluscan shells, ostracods, and the same foraminifer assemblage and algae as in microfacies 1, with some *Girvanella*. Rare intraclasts, stromatoporoids and calcisphaerids were observed. Micritized grains (crinoids, brachiopods and stromatoporoids) are present. Microfacies 2b (Fig. 3A) is composed of coarser-grained packstones with larger bioclasts. The bioclasts are the same as microfacies 2a with the addition of coral and trilobite fragments. A few algal fragments (*Litanaia?* *sensu* Maslov, 1956 in Mamet and Pr eat 1994) are also present. Despite the burrowing the facies displays oblique stratifications and normal grading as well as numerous grain size variations. The grain sorting varies from quite well to poor.

Microfacies 3 comprises peloidal laminated bioclastic grainstones. Two lithotypes are recognized based on grain size. Microfacies 3a consists of fine grainstones with the same bioclasts as those present in the microfacies 2. Stromatoporoid fragments are more abundant as well as micritized grains. Microfacies 3b is coarser and displays cross-stratifications with alternation of fine and coarse bioclastic laminae. The bioclastic content is the same as in the microfacies 2 and the dominant fossils are crinoids, brachiopods and issinellids.

Mixed algal back-shoal/crinoidal fore-shoal environment. —Microfacies 4 consists of coarse grained floatstones and grainstones. Three lithotypes have been distinguished on the base of grain type.

Microfacies 4a (Fig. 3E) consists of microconglomeratic floatstones with various corals (mostly tabulates) and stromatoporoids. The bioclasts are the same as in the microfacies 2. Intraclasts are abundant and consist of subangular millimeter to centimeter-sized packstones and grainstones of the preceding microfacies. A few intraclasts contain sponges not seen before. Numerous umbrella cavities are present and filled with thick fibrous cements.

Microfacies 4b (Fig. 3F) is a coarse grainstone-rudstone with a few oncoids and rare micritized ooids. The bioclasts are the same as in the microfacies 2 except a strong decrease in dasycladaceans, ostracods and foraminifers. Crinoids and brachiopods dominate the bioclastic content. Intraclasts are also present and a few of them are encrusted by small tubular algae (*Girvanella?*). *Paleomicrocodium* algae (Mamet and Pr eat 1985) are present. Erosional discontinuities, keyvug structures and irregular cavities are associated with the oblique stratifications. Graded bedding is also present. Internal sediment (vadose silt) is associated mainly with these cavities. The grainstone texture is episodically interrupted by thin stromatolitic mudstone laminae, and the thicker mudstone intercalation is reported by Racki (1990: his level H-1a). The erosive basal surface of bed 7 (Fig. 2) and discontinuity surfaces observed in thin sections are present only in a few beds just below the Frasnian–Famennian boundary.

Microfacies 4c (Fig. 3B–D) is a medium- to coarse-grained crinoidal grainstone rich in subrounded microbreccias. Microbreccias are composed of algal mats only with irregular thin fenestrae and a few peloids. The grains are well to poorly sorted and composed mainly of crinoids with a few brachiopods, ostracods, molluscs, *Paleomicrocodium* and red? algae. Micritized grains and peloids are present. The cement is composed of three well developed phases, the first two consist of lamellar and syntaxial calcite, the third one corresponds to equant calcite. No pressure solution or compaction features were observed.

Interpretation.—The bioclastic content of all the microfacies suggests an open marine environment within the photic zone. The communities were dominated by crinoid meadows associated with brachiopod shelly banks (see Gawlik in Racki et al. 1993) and algal shoals (dasycladaceans). The environment was quiet and below the fair-weather wave base level for microfacies 1 and above for the others. The general energy level was high and marine waters were well oxygenated. The general environment corresponds to a shallow open marine shoal near small bioconstructions as indicated by the regular presence of reefal fragments. Most of the sediments of microfacies 4 have probably undergone a vadose? meteoric diagenesis as suggested by very well developed lamellar and equant calcite cements. These cements correspond to early diagenetic phases as no compactional features are observed in these original porous sediments. The presence of numerous cavities infilled with internal sediments and vadose silts, as well as particular corrosive discontinuities, support this interpretation.

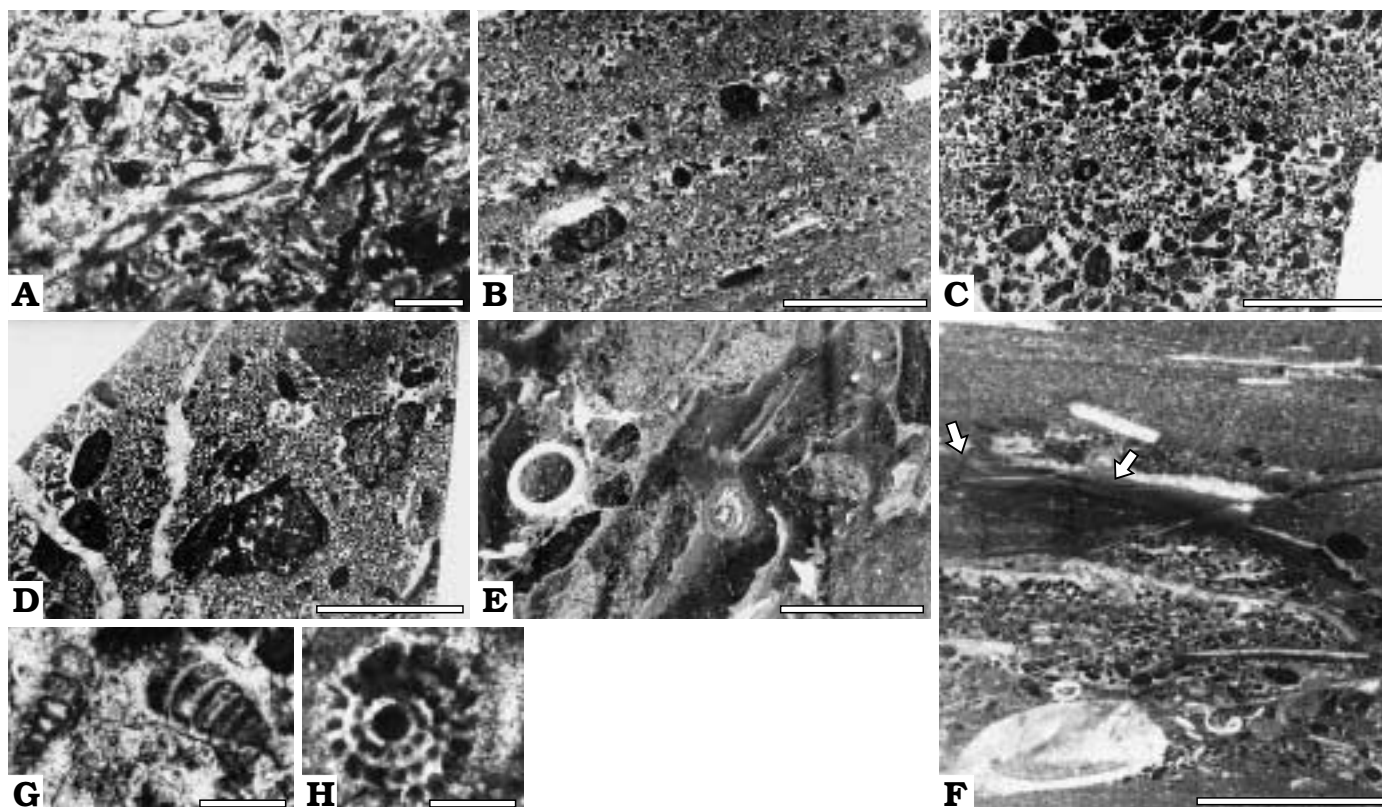


Fig. 3. Upper Devonian (upper Frasnian to lower Famennian) calcareous beds of the Psie Górki section (Holy Cross Mountains, Poland). Microfacies. **A**. Microfacies 2b (or MF2b) consists of a fine-grained bioclastic and peloidal packstone. Abundant dasycladaceans algae (center of the picture), ostracods and foraminifers. Thin section PG7. **B–D**. Microfacies 4c (or MF4c) corresponds to a medium- to coarse grained crinoidal grainstone rich in subrounded microbreccias. The microbreccias are composed of algal mats with irregular thin fenestrae and a few peloids (center of D). The grains are well to poorly sorted and composed mainly of crinoids with few ostracods and molluscs. Micritized grains and peloids are present. Thin sections PG43 (**B**), PG39 (**C**) and PG35 (**D**). **E**. Microfacies 4a (or MF4a) consists of microconglomeratic floatstones with stromatoporoids fragments. The intraclasts are abundant and consist of subangular millimeter to centimeter-sized packstones and grainstones of microfacies 1 to 3. Thin section PG13. **F**. Microfacies 4b (or MF4b) is a coarse grainstone-rudstone with rare micritic oolites. The bioclasts are dominated by crinoids and brachiopods, rare dasycladaceans algae, ostracods and foraminifers. Intraclasts are present, and a few are encrusted by small tubular algae (*Girvanella?*). A small syndepositional inverse fault is observed in the center of the picture. Graded bedding is present. The grainstone texture is episodically interrupted by thin stromatolitic mudstone laminae (white arrows). Thin section PG27. **G**, **H**. Foraminifers from Psie Górki: *Eogeinitzina* Lipina, 1950 (**G**) and *Nanicella* Henbest, 1935 (**H**). Thin section PG6. **A**, **G**, **H**, scale bars 250 μ m; **B–F**, scale bars 1 cm.

As mentioned by Szulczewski (1971) and Gawlik in Racki et al. (1993), detrital limestones in these section are clearly of very shallow-water origin and brachiopods, echinoderms, ostracods, foraminifers and algae are characteristic organisms living there in normal salinity waters. Locally, shoal environments reaching the intertidal zone are present. The results of these authors are in agreement with interpretations based on our microfacies, especially in faunal content. Moreover, the fore-reef environment close to an algal shoal deduced from the petrographical analyses is here reinforced.

The microfacies curve (Fig. 2) shows that the invasion of the marine sediments by meteoric waters started before the FFB. This diagenetic alteration is related to the sea level fall that started near the FFB as shown on Fig. 2. The regression is similar to the one revealed in the Kostomłoty area (Casier et al. 2000). In the case of Psie Górki, the general regressive pattern of microfacies is indicated mainly by the presence of

semi-restricted algal microbreccias constituting all of the lower part of the Famennian. In this case, the sea level trend is also highlighted by meteoric water invasion accompanying the sea level fall and by erosional discontinuities present close to the FFB. These features indicate the presence of a sedimentary gap close to the boundary that was linked with the beginning of the regression. These relationships were first described by Racki (1990) who observed the presence of bioclastic pockets of nautiloid shells and a discontinuity surface at the base of the Famennian (set H-1). Furthermore, a majority of the Famennian particles, especially crinoidal bioclasts, were obliterated by nutrient-triggered bioerosion (see Racki 1990; Peterhansel and Pratt 2001).

Frasnian limestones contain a relatively rich and diversified fauna of foraminifers, which has not been observed in the Famennian (see Racki and Soboń-Podgórska 1993). This faunal difference change has been observed in the Kostomłoty section also.

Table 1 – continued.

Psie Górki PG sample numbers	Frasnian										Famennian													
	3	5	6	8	11	14	15	16	18	19	20	21	26	28	29	30	31	33	34	37	41	42	44	47
<i>Ponderodictya?</i> sp. A											+													
Acratiidae sp. nov. A Casier and Lethiers, 2000											+													
<i>Entomozoe (Nehdentomis) pseudophthalma</i> (Volk, 1939)											+													
<i>Coelonella</i> cf. sp. 18 Braun, 1968											+													
" <i>Cavellina</i> " sp. A, aff. <i>dushanensis</i> Shi, 1964 <i>sensu</i> Casier and Lethiers (2000)											+													
<i>Orthocypris</i> sp. indet.											+													
<i>Acrattia</i> sp. A, aff. <i>gassanovae</i> Egorov, 1953												+												
<i>Famenella postkairovaensis</i> Lethiers and Casier, 1996												?	+				+							
<i>Bairdia</i> sp. E, aff. <i>curta</i> Kummerow, 1939 <i>sensu</i> Blumenstengel (1970)												+												
<i>Famenella angulata</i> Rozhdzstvenskaja, 1972													?	+	+			+					+	
" <i>Cytherellina</i> " sp. nov. A																	+							+
<i>Bairdiacypris</i> sp. A, aff. <i>zigulensis</i> (Polenova, 1953)																	+	+		?				
<i>Samarella</i> sp. nov. A Casier and Lethiers, 1998																	+							
<i>Microcheilinella voronensis</i> Samoiloova, 1970																	?						+	
<i>Marginia</i> sp. A Casier and Lethiers, 1998																			+				+	
Primitiopsioidea sp. indet. Lethiers and Casier, 1999?																				+				
<i>Bairdia</i> cf. <i>kelleri</i> Egorov, 1953																					+		+	
<i>Bairdia</i> cf. <i>eleziana</i> Egorov, 1953 <i>sensu</i> Casier and Lethiers (1998)																							+	
<i>Bairdia</i> gr. <i>turgida</i> Buschmina, 1969																							+	
<i>Chamishaella?</i> sp. indet. Casier and Lethiers, 2000																							+	
<i>Sulcella (Postsulcella) kostomlotyensis</i> Casier and Lethiers, 2000																							+	

Ostracods of the Psie Górki section

(J.-G. Casier and F. Lethiers)

Previous work on ostracods occurring close to the FFB in Poland.—Some late Frasnian and early Famennian ostracods from the Holy Cross Mountains were described by Olempska (1979), and from northwestern Poland by Żbikowska (1983). But except for our recent paper on ostracods and sedimentology of the Kostomłoty section near Kielce in the Holy Cross Mountains (Casier et al. 2000), no ostracod study has focused on the FFB exclusively in Poland.

In the Kostomłoty section, 68 ostracod species belonging to the Eifelian ecotype were recorded. In this 6.5 meters thick section, the ostracod fauna is rich and diverse in the Frasnian, but scarce and poorly diversified in the Famennian. Podocopids, with numerous Bairdiocypridacea and Bairdiacea, dominate in the Frasnian, and palaeocopids (with Kløedenellacea) prevail in the Famennian. Mydocopids occur very rarely and metacopids are absent.

In 1979 Olempska recorded a few poorly preserved ostracods in the *Entomozoe (Richteria) serratostrata–Nehdentomis nehdensis* Zone of the entomozoid zonation on the northern slope of the Psie Górki Hill. Three ostracod species were recognized by this author: *Marginohealdia sobolewi* Olempska, 1979, *Entomozoe (Richteria) serratostrata* (Sandberger, 1845) and *Entomozoe (Nehdentomis) tenera* (Gürich, 1896).

Material and methods.—Some 2,500 valves and carapaces

of ostracods were extracted by the hot acetolysis method (Lethiers and Crasquin-Soleau 1988) from 25 samples selected during the sedimentological analysis of thin sections (Fig. 2). All samples produced ostracods, although those in samples PG38 and PG46 were indeterminable. The abundance of ostracods is about four times greater in the Frasnian part of the section than in the Famennian. Seventy-six ostracod species have been recognized and almost all are figured (Figs. 4–10). Their distribution is shown in Table 1.

Type specimens and reference material are deposited in the type collections of the Micropalaeontology-Palaeobotany Section of the Department of Palaeontology of the Belgian royal Institute of natural Sciences (abbreviated IRScNB) in Brussels.

Description of five new ostracod species

(J.-G. Casier and F. Lethiers)

Genus *Selebratina* Polenova, 1953

Type species: Gravia (Selebratina) dentata Polenova, 1953.

Selebratina vellicata Casier and Lethiers, sp. nov.

Fig. 4G–J.

v ?*Selebratina* sp. Lethiers and Casier, 1996; pl. 1: 10–13.

v. *Selebratina* sp. Lethiers and Casier, 1996; Casier and Lethiers 2000: pl. 1: 5.

Derivation of the name: From Latin *vellicare*, to pinch. Allusion to morphology of the carapace.

Holotype: Carapace. (Fig. 4G, H). PG3. IRScNB n° b3774. L = 0.47 mm; H = 0.30 mm; W = 0.28 mm.

Type locality: Psie Górki section at Kielce, Holy Cross Mountains of Poland.

Material.—27 carapaces and valves.

Diagnosis.—Differs from most known species of *Selebratina* in having regularly arched free borders from anterior to posterior cardinal angles, only one very small posteroventral spine on each valve, a fine admarginal ridge on each valve, and in the dorsal flattening of valves.

Description.—In lateral view, carapace small and slightly preplete with a long straight dorsal margin. Free border regularly arched with posterior elongation of the radius of curvature. Cardinal extremities slightly pinched. Anterior cardinal angle = 130°; posterior cardinal angle = 100°. Surface of valves flattened between the two cardinal extremities and the widest point of the carapace. Maximum length at dorsal third of maximum height, which occurs at anterior two fifths of the length. Very small spine in the posteroventral sector of valves, and delicate admarginal ridges. Carapace biconvex in dorsal view and triangular with the ventral part of the carapace gently curved in anterior view. Maximum width is equal to the maximum height and located slightly posteriorly at the level of spines. Surface of valves smooth.

Occurrence.—In the Psie Górki section, *Selebratina velligata* sp. nov. is present in the late Frasnian (PG3, PG5, PG6, PG11, PG14, PG15, PG20, PG21, PG28, P29, PG30) and in the early Famennian (PG31, PG33?). The species is also known in the late Frasnian and the early Famennian of the Kostomłoty section and maybe also in the Frasnian of the FFB GSSP at Coumiac, in the Montagne Noire (Lethiers and Casier 1996).

Genus *Samarella* Polenova, 1952

Type species: *Samarella crassa* Polenova, 1952.

Samarella? minuta Casier and Lethiers, sp. nov.

Fig. 4K–N.

Derivation of the name: From the Latin *minutus*, small. Allusion to the small dimension of the carapace.

Holotype: Carapace. (Fig. 4K, L). PG21. IRScNB n° b3778. L = 0.34 mm; H = 0.22 mm; W = 0.19 mm.

Type locality: Psie Górki section at Kielce, Holy Cross Mountains of Poland.

Material.—13 carapaces.

Diagnosis.—*Samarella? minuta* sp. nov. differs from other species of the genus in having an amplete and truncated circular outline, and a biconvex outline in dorsal view.

Description.—In lateral view, small, amplete and truncated circular carapace. Dorsal border gently arched. Ventral border regularly rounded. Anterior border slightly more rounded than the posterior one. The left valve overreaches the right one dorsally, and the dorsal border of the right valve is straight. Overlap along the free border indistinguishable. Maximum length at mid-height. Fine admarginal ridges. In dorsal view, regu-

larly biconvex but more rounded posteriorly. Hinge line scarcely incised. Maximum width at mid-length, and at dorsal third of the height. Surface of valves smooth.

Remarks.—The species belongs questionably to the genus *Samarella* owing to the absence of a distinguishable overlapping along the free border.

Occurrence.—*Samarella? minuta* sp. nov. is presently only known from the late Frasnian of the Psie Górki section (PG5, PG11, PG14, PG20, PG21).

Genus *Bairdiocypris* Kegel, 1932

Type species: *Bythocypris (Bairdiocypris) gerolsteinensis* Kegel, 1932.

Bairdiocypris ventrorecta Casier and Lethiers, sp. nov.

Fig. 5O–Q.

v. *Bairdiocypris* sp. nov. B, aff. *angulata* Janbulova in litt. *sensu* Kotschetkova and Janbulova, 1987; Casier and Lethiers 2000: pl. 2: 10a, b.

Derivation of the name: From Latin *venter*, venter and *rectus*, straight. Referring to the straight ventral border of the carapace.

Holotype: Carapace (Fig. 5O, P). PG14. IRScNB n° b3795. L = 0.65 mm; H = 0.49 mm; W = 0.41 mm.

Type locality: Psie Górki section at Kielce, Holy Cross Mountains of Poland.

Material.—15 carapaces.

Diagnosis.—*Bairdiocypris ventrorecta* sp. nov. differs from other species of the genus *Bairdiocypris* in having a mid-sized, high, slightly preplete carapace with straight ventral and posterodorsal margins, a regularly arched dorsal border, and a diamond-shaped dorsal view with the anterior and the posterior extremities of the right valve depressed.

Description.—In lateral view, mid-sized, high, slightly preplete carapace. Dorsal margin strongly arched close to the mid-length. Ventral margin straight. Anterior margin regularly curved with the anterior extremity at mid-height. Posterior margin nearly straight dorsally, and strongly curved ventrally with the posterior angular extremity at lower third of height. Dorsal part of the posterior margin of the left valve straight and forming an angle with the dorsal margin. Ventral border of the right valve straight or slightly sinuous anteriorly. Maximum length at ventral third of height. Maximum height slightly anterior to the mid-length. Left valve overreaching the right one all around, except at the junction of the posterior and dorsal margins of the left valve. Slight ventral overlap. In dorsal view, carapace wide and diamond-shaped with the anterior and posterior extremities of the right valve depressed. Maximum width at mid-length. Carapace surface smooth.

Remarks.—*Bairdiocypris ventrorecta* sp. nov. resembles *Bekena angulata* Janbulova in litt. *sensu* Kotschetkova and Janbulova (1987) from the late Famennian (doVI) of Southern Ural, but differs from that species by a less angular dorsal border and posterior extremity not so much angular. In *Bairdiocypris* sp. nov. A, present in the Psie Górki and the

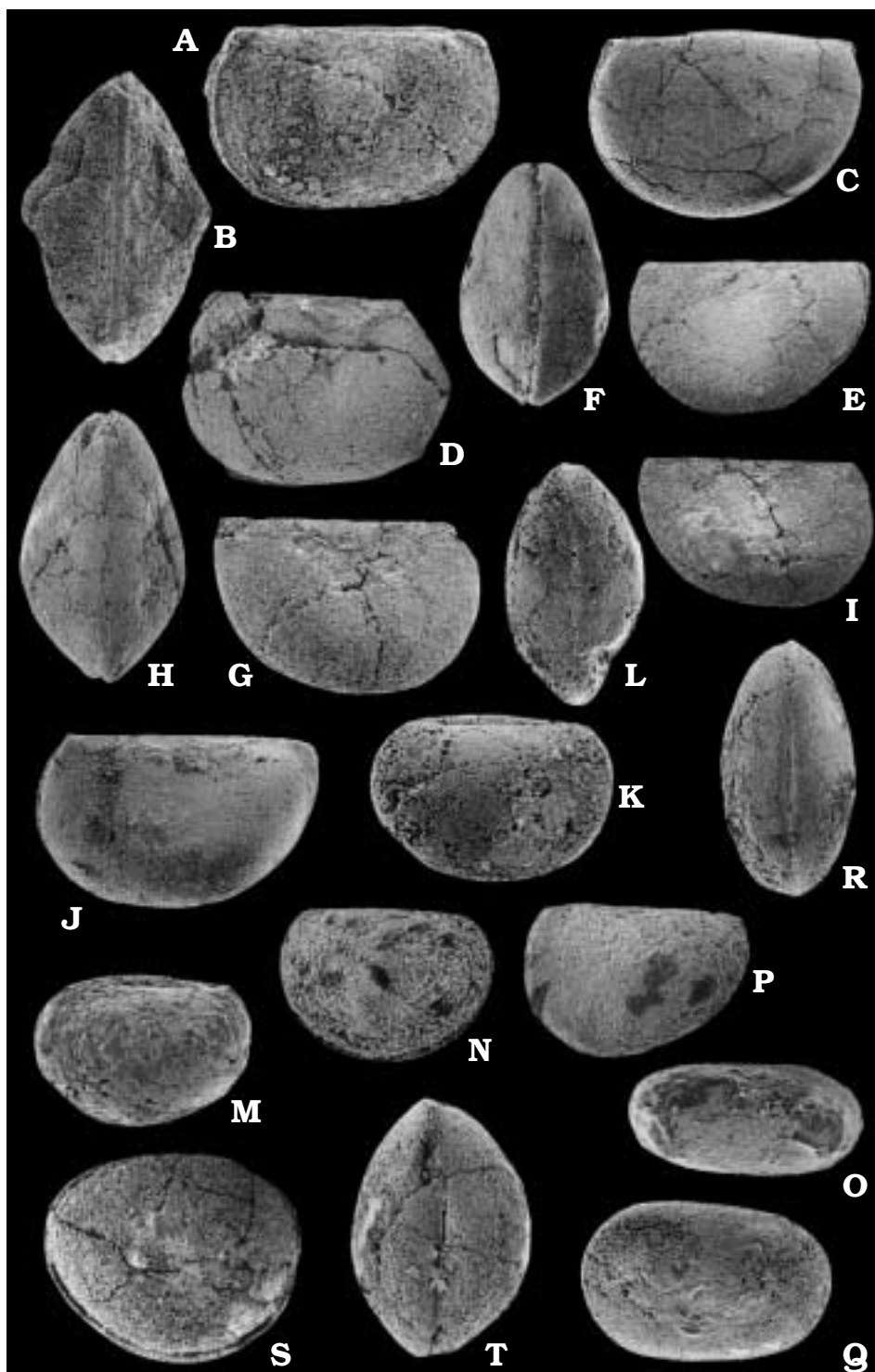


Fig. 4. **A, B.** *Amphissites* cf. *parvulus* (Paeckelmann, 1913). Right lateral and dorsal views of a carapace. PG15. IRScNB n° b3770, × 80. **C.** *Parapribylites?* sp. indet. Left valve. PG5. IRScNB n° b3771, × 70. **D.** *Primitiopsacea* sp. indet. Lethiers and Casier, 1999? Left lateral view of a poorly preserved carapace. PG41. IRScNB n° b3772, × 60. **E, F.** “*Gravia?*” sp. A Casier and Lethiers, 1998? Left lateral and dorsal views of a carapace. PG11. IRScNB n° b3773, × 100. **G–J.** *Selebratina vellicata* sp. nov. **G, H.** Right lateral and dorsal views of Holotype. PG3. IRScNB n° b3774, × 80. **I.** Right lateral view of Paratype A. PG11. IRScNB n° b3775, × 100. **J.** Left lateral view of Paratype B. PG3. IRScNB n° b3776, × 77. **K–N.** *Samarella? minuta* sp. nov. **K, L.** Right lateral and dorsal views of Holotype. PG21. IRScNB n° b3778, × 100. **M.** Right lateral view of Paratype A. PG21. IRScNB n° b3779, × 100. **N.** Right lateral view of Paratype B. PG20. IRScNB n° b3780, × 100. **O.** *Samarella* sp. nov. A Casier and Lethiers, 1998. Left lateral view of a carapace. PG31. IRScNB n° b3782, × 90. **P.** *Chamishaella?* sp. indet. Casier and Lethiers, 2000. Left lateral view of a carapace. PG47. IRScNB n° b3783, × 100. **Q, R.** *Coelonella?* sp. indet. *sensu* Casier and Lethiers (1999). Right lateral and dorsal views of a carapace. PG21. IRScNB n° b3784, × 80. **S, T.** *Coelonella crassa* Casier and Lethiers, 2000. Right lateral and dorsal views of a carapace. PG5. IRScNB n° b3785, × 70.

Kostomłoty sections, the ventral margin is concave and the anterior margin nearly straight.

Occurrence.—Frasnian (PG3, PG6, PG11, PG14, PG29, PG30) in the Psie Górki section. Also in the Frasnian (KYA12, KYA19, KYA 29) of the Kostomłoty section.

Genus *Acratia* Delo, 1930

Type species: *Acratia typica* Delo, 1930.

Acratia pentagona Casier and Lethiers, sp. nov.

Fig. 8C–F.

. *Acratia* sp. nov. C, aff. *A. longa* Zaspelova, 1959; Casier and Lethiers 2000: pl. 3: 8a, b.

Derivation of the name: From Greek *pente gonía*, five-angled. Allusion to the pentagonal outline of the carapace.

Holotype: Carapace. (Fig. 8C, D). PG21. IRScNB n° b3820. L = 0.44 mm; H = 0.22 mm; W = 0.22 mm.

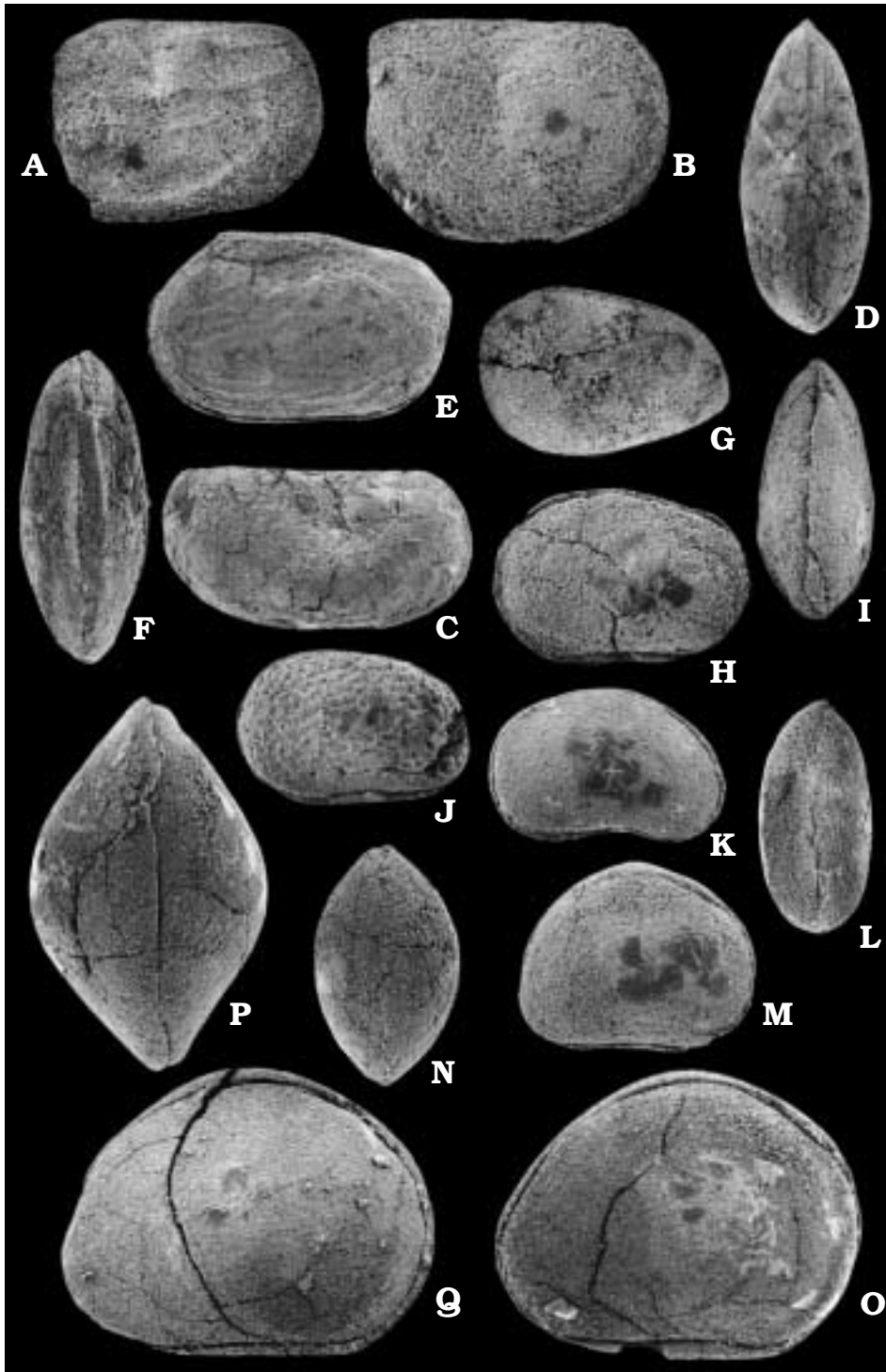


Fig. 5. **A.** *Marginia* sp. A, aff. *M. decora* Rozhdestvenskaja, 1972. Right lateral view of a broken valve. PG20. IRScNB n° b3786, × 90. **B.** *Marginia* sp. A Casier and Lethiers, 1998. Left lateral view of a carapace. PG37. IRScNB n° b3787, × 80. **C, D.** *Knoxella?* sp. indet. Right lateral and dorsal views of a carapace. PG8. IRScNB n° b3788, × 60. **E, F.** *Blessites* sp. nov. A. Left lateral and dorsal views of a carapace. PG15. IRScNB n° b3789, × 60. **G.** “*Cavellina*” sp. A, aff. *C. dushanensis* Shi, 1964, *sensu* Casier and Lethiers (2000). Left lateral view of a carapace. PG21. IRScNB n° b3790, × 90. **H, I.** *Sulcella (Postsulcella) kostomlotyensis* Casier and Lethiers, 2000. Left lateral and dorsal views of a carapace. PG47. IRScNB n° b3791, × 67. **J.** *Ponderodictya?* sp. A. Right lateral view of a carapace. PG20. IRScNB n° b3792, × 100. **K, L.** *Healdianella alba* Lethiers, 1981. Right lateral and dorsal views of a carapace. PG15. IRScNB n° b3793, × 100. **M, N.** *Bairdiocypris* sp. nov. A Casier and Lethiers 2000. Right lateral and dorsal views of a carapace. PG6. IRScNB n° b3794, × 90. **O–Q.** *Bairdiocypris ventrorecta* sp. nov. **O, P.** Right lateral and dorsal views of Holotype. PG14. IRScNB n° b3795, × 80. **Q.** Right lateral view of Paratype A. PG11. IRScNB n° b3796, × 80.

Type locality: Psie Górki section at Kielce, Holy Cross Mountains of Poland.

Material.—17 carapaces.

Diagnosis.—*Acratia pentagona* sp. nov. differs from other species of the genus in elongate pentagonal outline with a long and straight dorsal border, in the posterior margin nearly straight and strongly inclined, and in the biconvex shape in dorsal view with a pinched anterior extremity.

Description.—In lateral view, elongate, mid-sized, preplete pentagonal carapace. Dorsal border long and straight. Ventral border slightly curved to straight. Anterodorsal margin moderately curved and anteroventral margin straight. Pointed anterior extremity at mid-height. Dorsal part of posterior margin nearly straight and strongly inclined. Posterior extremity with a backward-pointing spine on each valve, at ventral third of height. Maximum length at mid-height, and maxi-

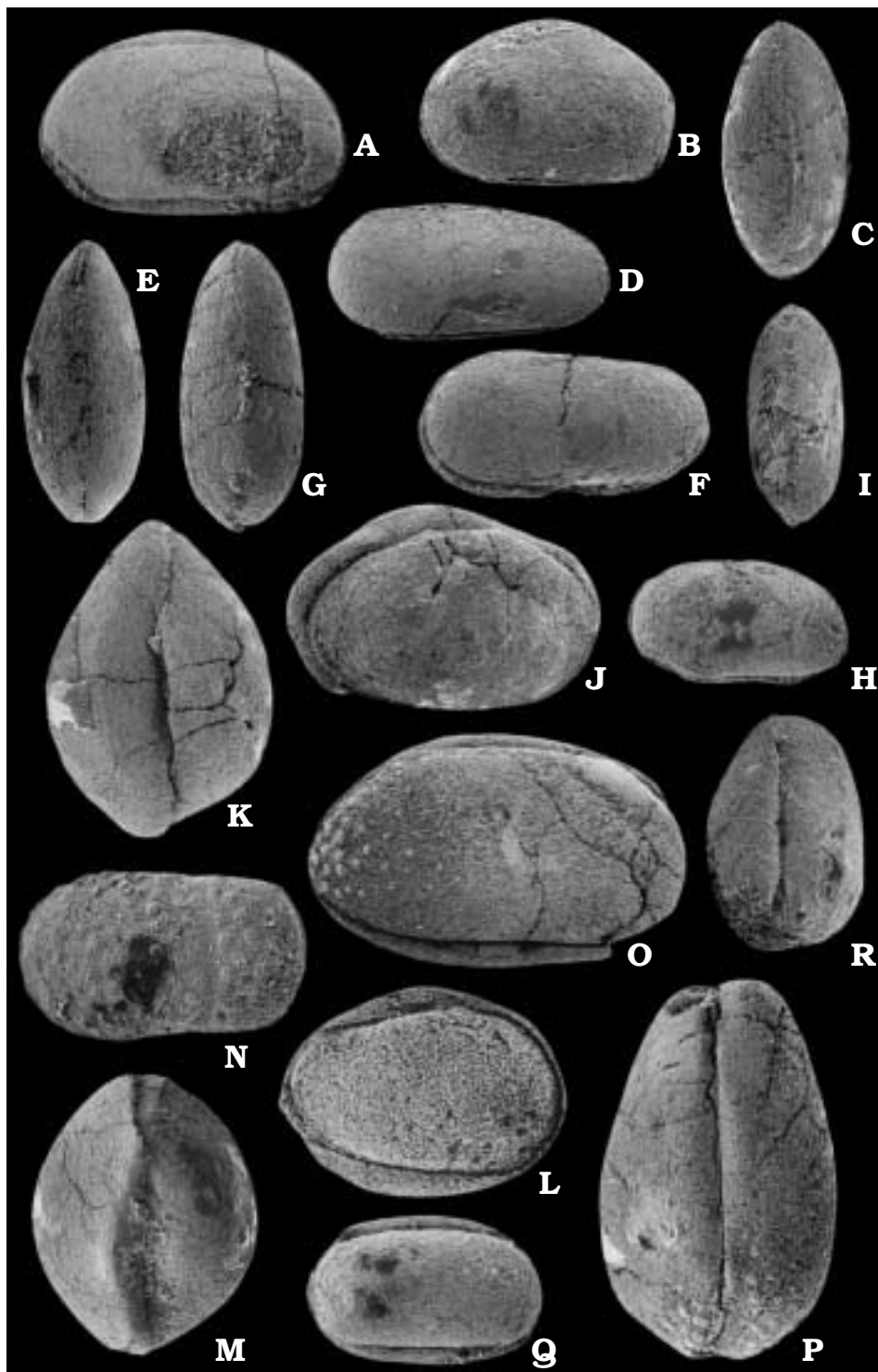


Fig. 6. **A.** *Bairdiohealdites gregalis* Rozhdestvenskaja, 1972. Right lateral view of a carapace. PG3. IRScNB n° b3798, × 55. **B.**, **C.** *Bairdiohealdites* sp. A, aff. *B. gregalis* Rozhdestvenskaja, 1972 *sensu* Casier and Lethiers (1999). Right lateral and dorsal views of a carapace. PG8. IRScNB n° b3799, × 67. **D.**, **E.** *Orthocypris* cf. *exemplaris* Rozhdestvenskaja, 1979. Right lateral and dorsal views of a carapace. PG11. IRScNB n° b3800, × 80. **F.**, **G.** *Orthocypris* sp. A *sensu* Becker (1971). Right lateral and dorsal views of a carapace. PG8. IRScNB n° b3801, × 80. **H.**, **I.** “*Cytherellina*” sp. nov. A. Right lateral and dorsal views of a carapace. PG29. IRScNB n° b3802, × 100. **J.**, **K.** *Decoranewsomites digitulistriata* (Lethiers, 1981). Right lateral and dorsal views of a carapace. PG6. IRScNB n° b3803, × 80. **L.**, **M.** *Micronewsomites* sp. nov. A. **L.** Right lateral view of a carapace. PG15. IRScNB n° b3804, × 100. **M.** Dorsal view of a carapace. PG14. IRScNB n° b3805, × 100. **N.** *Ampuloides* cf. *parvus* Blumenstengel, 1970. Right valve. PG11. IRScNB n° b3806, × 80. **O.**, **P.** *Microcheilinella postfecunda* Lethiers, 1996. Right lateral and dorsal views of a carapace. PG21. IRScNB n° b3807, × 60. **Q.**, **R.** *Microcheilinella voronensis* Samoilova, 1970. Right lateral and dorsal views of a carapace. PG44. IRScNB n° b3808, × 80.

mum height close to the anterior third of length. The left valve overreaches the right one all along the free margin, and the ventral overlap is slight. In dorsal view, biconvex-shaped with the anterior extremity slightly pinched. Maximum width at mid-length. Carapace surface smooth.

Remarks.—*Acratia pentagona* sp. nov. is most similar to *Acratia longa* Zaspelova, 1959, from the Frasnian of the

Russian Platform. But in this latter species the dorsal and ventral borders are not as long and straight, the posterior margin is less straight and inclined, and in dorsal view the carapace is less biconvex without a pinched anterior extremity.

Occurrence.—Frasnian (PG3, PG5, PG6, PG8?, PG16?, PG18, PG20, PG21, PG29) and Famennian (PG31) in the

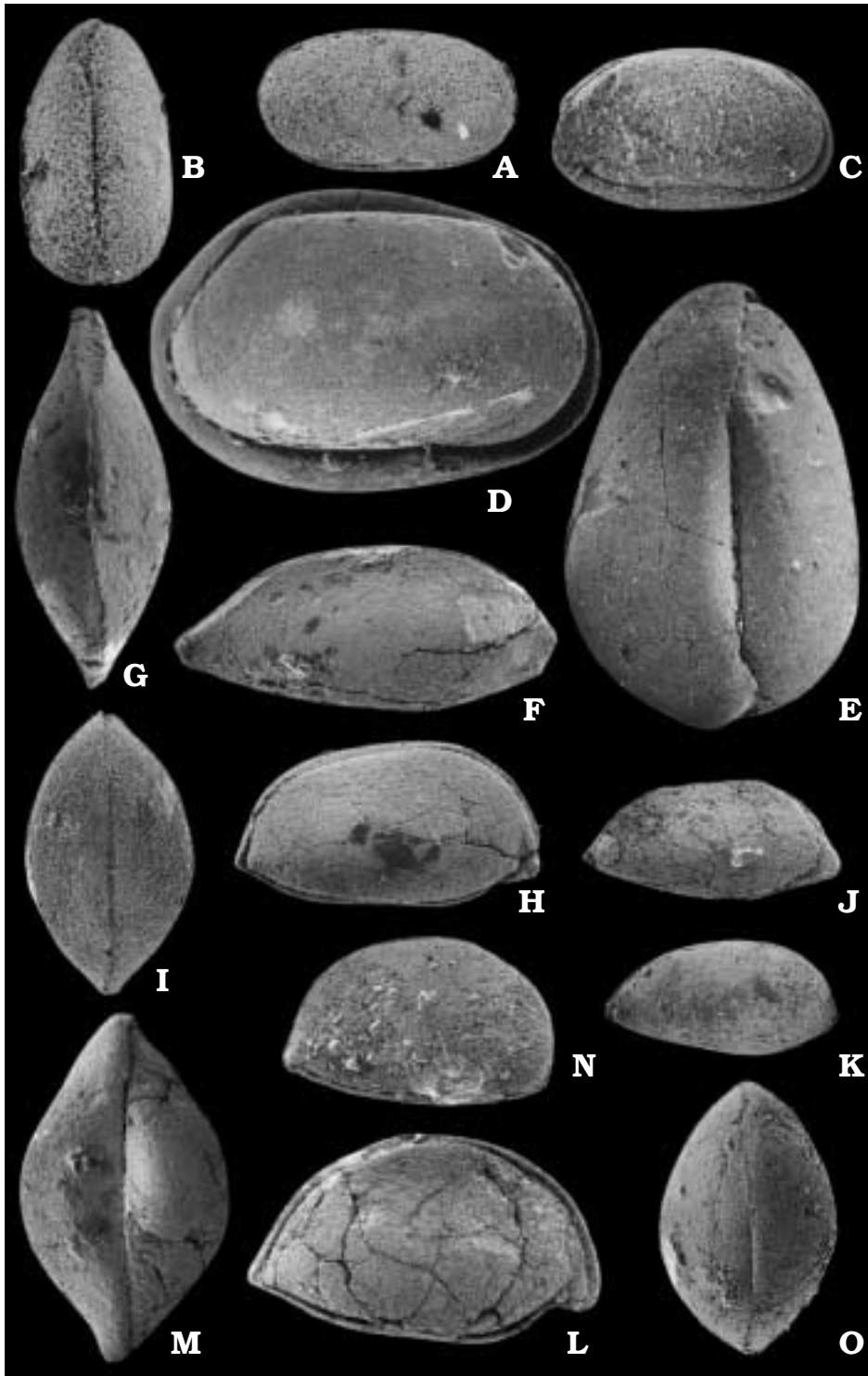


Fig. 7. **A, B.** *Microcheilinella frumentaria* Lethiers and Casier, 1996. Right lateral and dorsal views of a carapace. PG18. IRScNB n° b3809, × 95. **C.** *Microcheilinella* cf. *larionovae* Polenova, 1955 *sensu* Lethiers and Casier (1996). Right lateral view of a carapace. PG16. IRScNB n° b3810, × 50. **D, E.** *Microcheilinella* sp. nov. A, aff. *M. peculiaris* Rozhdestvenskaja and Netchaeva in Rozhdestvenskaja (1972). Right lateral and dorsal views of a carapace. PG5. IRScNB n° b3811, × 60. **F, G.** *Acrattia evlanensis* Egorov, 1953. Right lateral and dorsal views of a carapace. PG33. IRScNB n° b3812, × 70. **H, I.** *Acrattia nevadaensis* Casier and Lethiers, 1997. **H.** Right lateral view of a carapace. PG15. IRScNB n° b3813, × 100. **I.** Dorsal view of a carapace. PG44. IRScNB n° b3814, × 100. **J.** *Acrattia gassanovae* Egorov, 1953. Right lateral view of a carapace. PG15. IRScNB n° b3815, × 80. **K.** *Acrattia* sp. A, aff. *A. gassanovae* Egorov, 1953. Right lateral view of a carapace. PG26. IRScNB n° b3816, × 100. **L, M.** *Acrattia* cf. *zadonica* Egorov, 1953. Right lateral and dorsal views of a carapace. PG8. IRScNB n° b3817, × 60. **N, O.** *Acrattia* cf. *ljubzovi* Schischkinskaja, 1964. Right lateral and dorsal views of a carapace. PG21. IRScNB n° b3818, × 80.

Psie Górki section. Also in the Frasnian (KYA11, KYA39) of the Kostomłoty section.

Genus unknown

“*Bairdia*” *psiegorkiensis* Casier and Lethiers, sp. nov.

Fig. 9S–V.

v. “*Bairdia*” sp. nov. C; Casier and Lethiers 2000: pl. 4: 7a, b.

Derivation of the name: From the Psie Górki Hill at Kielce, in the Holy Cross Mountains.

Holotype: Carapace. (Fig. 9s, t). PG15. IRScNB n° b3844. L = 0.38 mm; H = 0.22 mm; W = 0.19 mm.

Type locality: Psie Górki section at Kielce, Holy Cross Mountains of Poland.

Material.—22 carapaces.

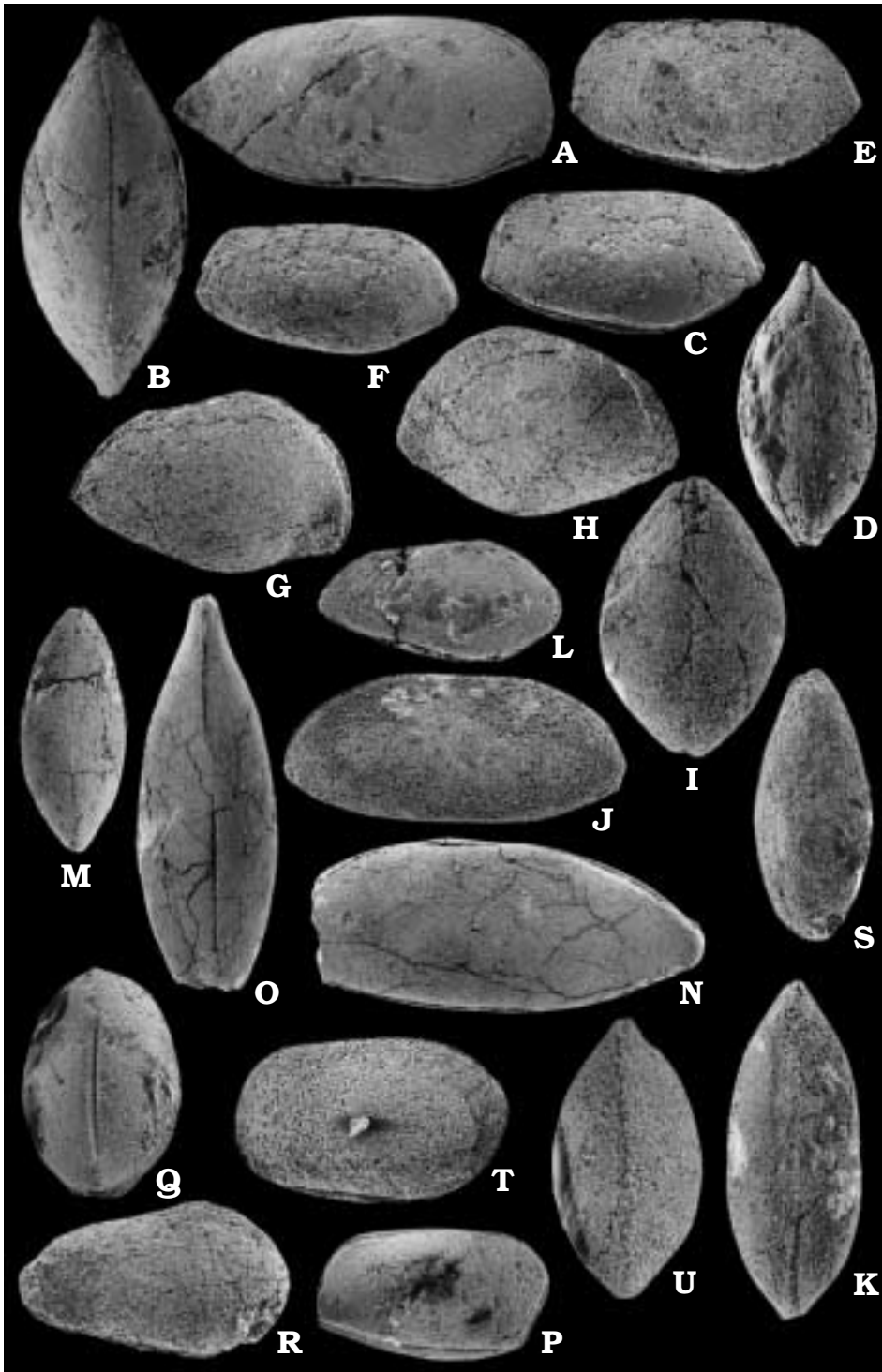


Fig. 8. A, B. *Acratia* sp. nov. B, aff. sp. 39 Braun, 1968. Right lateral and dorsal views of a carapace. PG15. IRScNB n° b3819, × 80. C–F. *Acratia pentagona* sp. nov. C, D. Right lateral and dorsal views of Holotype. PG21. IRScNB n° b3820, × 90. E. Right lateral view of Paratype A. PG21. IRScNB n° b3821, × 90. F. Right lateral view of Paratype B. PG20. IRScNB n° b3822, × 87. G. *Acratia supina* Polenova, 1953. Right lateral view of a carapace. PG11. IRScNB n° b3824, × 100. H, I. *Acratia supinaeformis* Lethiers, 1981. Left lateral and dorsal views of a carapace. PG3. IRScNB n° b3825, × 90. J, K. *Acratia feisti* Lethiers and Casier, 1995. Right lateral and dorsal views of a carapace. PG18. IRScNB n° b3826, × 70. L, M. *Acratia?* sp. sensu Lethiers and Casier (1999). Right lateral and dorsal views of a carapace. PG14. IRScNB n° b3827, × 80. N, O. *Acratia saggitaeformis* Lethiers and Casier, 1999? Right lateral and dorsal views of a broken carapace. PG6. IRScNB n° b3828, × 40. P, Q. *Acrafiidae* sp. nov. A Casier and Lethiers, 2000. Right lateral and dorsal views of a carapace. PG20. IRScNB n° b3829, × 100. R, S. *Famenella angulata* Rozhdestvenskaja, 1972. Right lateral and dorsal views of a carapace. PG44. IRScNB n° b3830, × 80. T, U. *Famenella postkairovaensis* Lethiers and Casier, 1996. Right lateral and dorsal views of a carapace. PG29. IRScNB n° b3831, × 100.

Diagnosis.—Small, elongate (L/H close to 1.7) carapace of a new genus close to *Bairdia* with a regularly rounded anterior margin at or under mid-height and with a small but well defined concavity at the ventral margin.

Description.—In lateral view, small, preplete carapace. Dorsal border straight and moderately inclined toward the posterior end. Ventral border sinuous: straight posteriorly, concave at mid-length and convex anteriorly. Anterodorsal margin

straight. Well rounded anterior margin with the anterior extremity at or just below mid-height. Posterodorsal margin nearly straight and strongly inclined. Posterior margin not very rounded and close to the ventral level. Maximum length below mid-height, and maximum height at anterior third of carapace. The left valve overreaches slightly the right one all along the free border, and the ventral overlap is slight. Biconvex in dorsal view with the maximum width at poste-

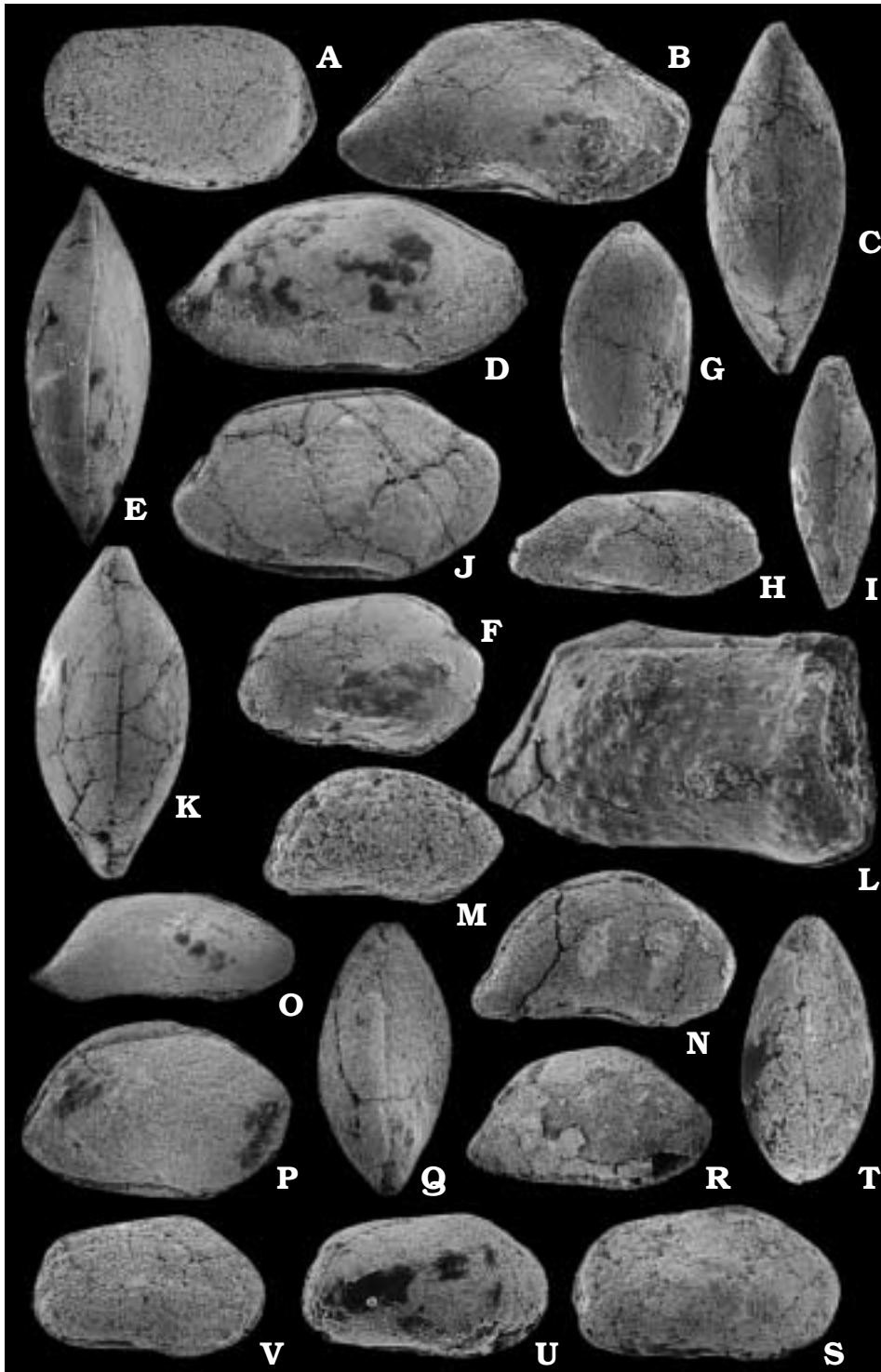


Fig. 9. **A.** *Famenella?* sp. nov. A Casier and Lethiers, 1998. Right lateral view of a carapace. PG14. IRScNB n° b3832, $\times 100$. **B, C.** *Bairdia fabaeformis* Polenova, 1953. Right lateral and dorsal views of a carapace. PG5. IRScNB n° b3833, $\times 60$. **D, E.** *Bairdia quasifabaeformis* Lethiers and Casier, 1999. Right lateral and dorsal views of a carapace. PG31. IRScNB n° b3834, $\times 60$. **F, G.** *Bairdia altodorsualis* Casier and Lethiers, 1998. Right lateral and dorsal views of a carapace. PG15. IRScNB n° b3835, $\times 80$. **H, I.** *Bairdia* sp. nov. A *sensu* Casier and Lethiers (1996)? Right lateral and dorsal views of a carapace. PG11. IRScNB n° b3836, $\times 70$. **J, K.** *Bairdia* sp. C, aff. *B. proxischimensis* Casier and Lethiers, 1998 *sensu* Casier and Lethiers (1999). Right lateral and dorsal views of a carapace. PG5. IRScNB n° b3837, $\times 70$. **L.** *Bairdia dorsoconstricta* Blumenstengel, 1970. Right lateral view of a broken carapace. PG5. IRScNB n° b3838, $\times 70$. **M.** *Bairdia* sp. B Lethiers and Casier, 1996. Right lateral view of a carapace. PG3. IRScNB n° b3839, $\times 100$. **N.** *Bairdia* sp. B, aff. *B. subeleziana* Polenova, 1953 *sensu* Casier and Lethiers (1998). Right lateral view of a carapace. PG8. IRScNB n° b3840, $\times 70$. **O.** *Bairdia* sp. E, aff. *curta* Kummerow, 1939 *sensu* Blumenstengel (1970). Right lateral view of a carapace. PG28. IRScNB n° b3841, $\times 60$. **P, Q.** *Bairdia* gr. *turgida* Buschmina, 1969. Right lateral and dorsal views of a carapace. PG47. IRScNB n° b3842, $\times 90$. **R.** *Bairdia sanctacrucensis* Casier and Lethiers, 2000. Right lateral view of a carapace. PG5. IRScNB n° b3843, $\times 90$. **S–V.** “*Bairdia*” *psiegorkiensis* sp. nov. **S, T.** Right lateral and dorsal views of Holotype. PG15. IRScNB n° b3844, $\times 100$. **U.** Right lateral view of Paratype A. Kostomłoty. KYA11. IRScNB n° b3845, $\times 90$. **V.** Right lateral view of Paratype B. IRScNB n° b3846, $\times 110$.

rior third of length and with rounded extremities. Carapace surface smooth.

Remarks.—“*Bairdia*” *psiegorkiensis* sp. nov., “*Bairdia*” sp. nov. A Casier and Lethiers, 2000 and “*Bairdia*” sp. nov. B Casier and Lethiers, 2000, from the Kostomłoty section, belong to a new genus characterized by straight, inclined dorsal borders, a small posterior margin close to the ventral

level, a straight dorsally and rounded anterior margin. “*B.*” *psiegorkiensis* sp. nov. is distinguished by the diagnosis characters.

Occurrence.—Frasnian of the Psie Górki section (PG3, PG5, PG6, PG8, PG11, PG14, PG15) and also in the Frasnian (KYA3?, KYA11, KYA19) of the Kostomłoty section.

Palaeoecology of ostracods

(J.-G. Casier and F. Lethiers)

Seventy-six ostracod species are identified in the Psie Górki section (Table 1) of which 58 are podocopids. Fourteen species belong to the palaeocopids, Kloedenellacea included. Two species belong to the platycopids and 2 others to the myodocopids.

The assemblage of ostracods in the Psie Górki section belongs to the Eifelian ecotype of Becker (in Bandel and Becker 1975), the definition of which has been recently emended by Casier and Lethiers (1998c) to take the occurrence of podocopids, occasionally in abundance, into account. That is also the case at Psie Górki where 76 percent of the ostracod species are podocopids. The Eifelian ecotype is indicative of neritic conditions, from semi-restricted or lagoonal environments to offshore environments according to several sub-ecotypes.

At Psie Górki the ostracod assemblage is indicative of a very well oxygenated marine environment below wave base in the Frasnian. True semi-restricted water conditions as revealed by few ostracod species occurring in great individual abundance are not found in the Famennian part of the Psie Górki section. Nevertheless, the presence in sample PG47 of several specimens belonging to the platycopid *Sulcella* (*P.*) *kostomlotyensis* Casier and Lethiers, 2000, and the impoverishment of ostracods in the Famennian (abundance of ostracods in more rare samples selected during the sedimentological study is about four times less in the Famennian part of the section!) are indicative of shallower environments occasionally in the wave zone. These conditions were also probably responsible for their poor preservation. The rarity of ostracods in the Famennian part of the section is perhaps also related to the extinction event.

In several recent papers on late Devonian ostracods we have used the name “myodocopid ecotype” for the “entomozoid ecotype” of Becker (in Bandel and Becker 1975). This ecotype is indicative of dysaerobic water conditions (Casier 1987; Lethiers and Casier 1995) and is observed close to the FFB in several sections in the Palaeotethys. We prefer to use the appellation “myodocopid ecotype” because cypridinoids are generally associated with entomozoids and indicate the same environmental conditions. Nevertheless, at Psie Górki the occurrence of two species of Entomozoea, *Entomozoe* (*Nehdentomis*) *pseudophthalma* (Volk, 1939) and *Entomozoe* (*Nehdentomis*) *tenera* (Gürich, 1896) in the Frasnian is inconclusive, because each species is represented by a single specimen. Consequently we conclude that the Devonian sea was not anoxic at Psie Górki. At Kostomłoty, no assemblage or lithology characteristic of hypoxic water conditions has been recorded as well (Casier et al. 2000).

Thirty-one ostracod species present at Psie Górki are known from the Kostomłoty section, where ostracods indicate a more pronounced regressive trend ranging from marine environments below fair-weather wave base in the late

Frasnian, to true semi-restricted water conditions in the early Famennian. Only 15 ostracod species present at Psie Górki are known from the Coumiac GSSP and 7 from the Schmidt quarry parastratotype, but these two sections represent deeper-water settings.

Extinction of ostracods near the FFB

(J.-G. Casier and F. Lethiers)

The extinction of ostracods close to the FFB is severe in marine environments below storm and fair-weather wave bases where the palaeontological study of ostracods demonstrates that environmental conditions do not differ notably across the boundary. For instance, 75 percent of the ostracod fauna disappears in the Schmidt quarry parastratotype and in the Coumiac FFB GSSP (Casier and Lethiers 1998a; Lethiers and Casier 1996).

In shallow marine environments the determination of the rate of extinction is more difficult due to generally considerable environmental change close to the boundary. Owing to the FFB regression, semi-restricted water conditions are the rule in the base of the Famennian of numerous sections investigated in the world, and such a great change is responsible for an overestimation of the extinction. The study of ostracods, in these shallow environments, is interesting because it is supposed that several Lazarus species survive the FFB crisis sheltered there (Lethiers and Casier 1999).

In the Kostomłoty section only 6 (8?) species out of the 53 occurring in the late Frasnian cross the boundary. However, a total of 12 (14?) species survived the Frasnian–Famennian event at Kostomłoty if “wrongly disappearing species” and “wrongly new arriving species” are taken into account. These false disappearances and appearances of ostracod species at the FFB in several sections (Lethiers and Casier 1999) are linked either to local palaeoecological factors or to the mobility of species during the FF event.

In the Psie Górki section the most important faunal change for ostracods indicates that the FFB is located between samples PG30 and PG31 (see Fig. 2) which is in good agreement with coral and atrypid last occurrences and the *Palmatolepis* *trangularis* first appearance (Racki 1990).

Sixty-seven ostracod species are recorded in the Frasnian of the Psie Górki section of which 12 (13?) survived in the Famennian. But 6 (7?) “wrongly disappearing species” are recorded: *Bairdiacypris* *martinae* Casier and Lethiers, 1997, and *Bairdia* sp. B, aff. *B. subeleziana* Polenova, 1953 *sensu* Casier and Lethiers (1998) are known from the Famennian of Nevada; *Acratia* *supinaeformis* Lethiers, 1981, from the Famennian of Canada, *Acratia* *feisti* Lethiers and Casier, 1996, *Bairdiacypris* gr. *irregularis* (Polenova, 1953), *Acratia?* sp. *sensu* Lethiers and Casier (1999) and maybe also

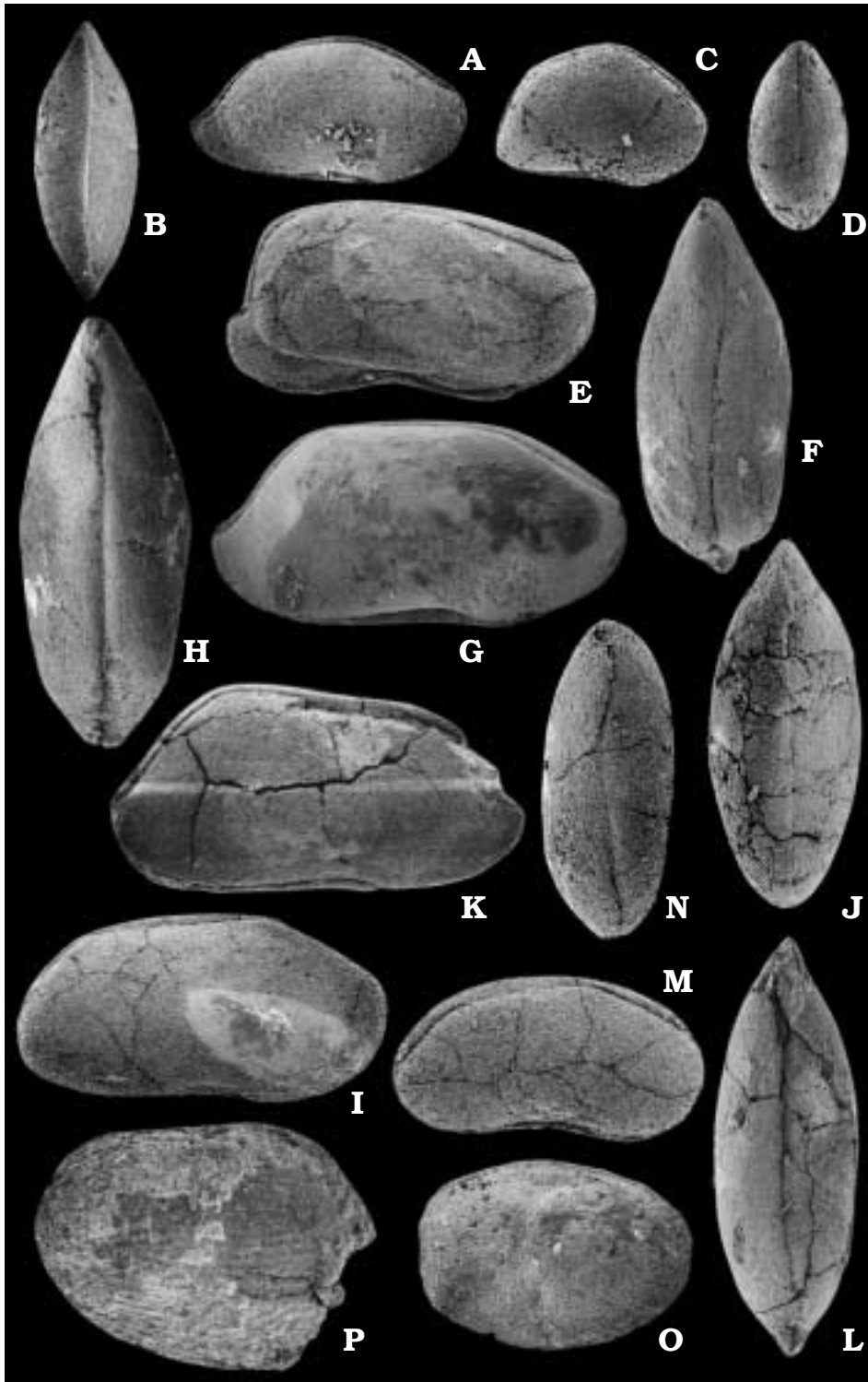


Fig. 10. **A, B.** *Bairdia* cf. *eleziana* Egorov, 1953 *sensu* Casier and Lethiers (1998). Right lateral and dorsal views of a carapace. PG44. IRScNB n° b3848, $\times 50$. **C, D.** "*Bairdia*" sp. nov. **B.** Right lateral and dorsal views of a carapace. PG5. IRScNB n° b3849. **C,** $\times 107$. **D,** $\times 102$. **E, F.** *Bairdiacypris sobiekuro-wiensis* (Olempska, 1979). Right lateral and dorsal views of a carapace. PG6. IRScNB n° b3850, $\times 60$. **G, H.** *Bairdiacypris quarziana* (Egorov, 1953). **G.** Right lateral view of a carapace. PG33. IRScNB n° b3851, $\times 50$. **H.** Dorsal view of a carapace. PG15. IRScNB n° b3852, $\times 50$. **I, J.** *Bairdiacypris* sp. nov. **A,** aff. *B. virga* Buschmina, 1969 *sensu* Kotschetkova and Janbulatova (1987). **I.** Right lateral view of a carapace. PG11. IRScNB n° b3853, $\times 50$. **J.** Dorsal view of a carapace. PG8. IRScNB n° b3854, $\times 55$. **K, L.** *Bairdiacypris* sp. A, aff. *B. zigulensis* (Polenova, 1953). Right lateral and dorsal views of a carapace. PG31. IRScNB n° b3855, $\times 40$. **M, N.** *Bairdiacypris martinae* Casier and Lethiers, 1997. Right lateral and dorsal views of a carapace. PG6. IRScNB n° b3856, $\times 82$. **O.** *Entomozoe (Nehdentomis) pseudophthalma* (Volk, 1939). Right lateral view of a broken carapace. PG21. IRScNB n° b3857, $\times 40$. **P.** *Entomozoe (Nehdentomis) tenera* (Gürich, 1896). Fragment of a left valve. PG14. IRScNB n° b3858, $\times 50$.

Bairdia sp. B Lethiers and Casier, 1996, have been recorded in the Famennian of Southern France. Consequently, 18 (20?) ostracod species actually survive the FFB crisis, and the rate of extinction is more than 70 percent. This rate is comparable to the rate of extinction known at the same level in the Coumiac GSSP (Lethiers and Casier 1996), the

Schmidt quarry parastratotype (Casier and Lethiers 1998a), and the Devils Gate Pass section in Nevada (Casier et al. 1996).

The recovery of the ostracod fauna was very slow at Psie Górki, probably due to poor environmental conditions in the early Famennian.

Conclusions

Four major microfacies have been recognized through the sedimentological analysis, and the bioclastic content indicates an open marine environment in the photic zone close to an algal shoal. The foreslope environment for microfacies 1 is relatively quiet near the wave base. Other microfacies correspond to higher energy environments. The general palaeo-environment corresponds to a shallow open marine shoal near bioconstructions. The communities are dominated by crinoidal meadows associated with brachiopod shells and algal shoals (dasycladaceans). A rich and diversified foraminiferal assemblage has been observed. This assemblage is very similar to the one found in the Kostomłoty section, with the exception that *Frondilina* is present only in the Psie Górki section. In both cases foraminifers flourish during the Frasnian and disappear near the FFB. Extremely poor environmental conditions are caused by sea level fall during the base of the Famennian. This fall in sea level probably explains the disappearance of the foraminifers.

Sedimentological studies point to a regressive event starting close to the FFB. The regressive microfacies pattern is particularly revealed by the presence of semi-restricted algal microbreccias constituting all of the lower part of the Famennian. The microfacies curve shows that the invasion of the marine sediments by meteoric waters started before the FFB. This diagenetic alteration is related to the decrease in sea level.

The ostracod assemblage present in the Psie Górki section belongs to the Eifelian ecotype indicative of a well oxygenated marine environment below fair-weather wave base in the Frasnian, and shallower environments occasionally in the base of the Famennian. No ostracod assemblage indicating semi-restricted or hypoxic water conditions has been recorded in the Psie Górki section. Consequently, the anoxia generally proposed to explain the late Devonian mass extinction seems to be absent in the shallow-water Kostomłoty and Psie Górki sections as it is in the Devils Gate Pass section in Nevada (Casier and Lethiers, 1998b). Other disaster factors such as sea water temperature drop, eutrophication (e.g., Peterhansel and Pratt 2001), or sea level variations may explain the extinctions at Kostomłoty and Psie Górki.

More than 70 percent of the ostracod species, “wrongly disappearing species” taken into account, disappear in the Psie Górki section close to the FFB. Such a rate of disappearance is the rule close to the FFB in all open marine facies and in all provinces we have investigated. This confirms that the late Devonian mass extinction was a global marine event.

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Appendix

List and systematic placement of species occurring in the Psie Górki section:

Subclass Ostracoda Latreille, 1802
 Order Palaeocopida Henningsmoen, 1953
 Suborder Palaeocopina Henningsmoen, 1953
 Superfamily Kirkbyacea Ulrich and Bassler, 1906
 Family Amphissitidae Knight, 1928
Amphissites cf. *parvulus* (Paeckelmann, 1913) (Fig. 4A, B)
 Superfamily Primitiopsacea Swartz, 1936
 Primitiopsacea sp. indet. Lethiers and Casier, 1999? (Fig. 4D)
 Family Primitiopsidae Swartz, 1936
Parapribylites? sp. indet. (Fig. 4C)
 Family Graviidae Polenova, 1952
 “*Gravia*” sp. A Casier and Lethiers, 1998? (Fig. 4E, F)
Selebratina vellicata sp. nov. (Fig. 4G–J).
 Suborder Paraparchiticopina Gramm in Gramm and Ivanov (1975)
 Superfamily Paraparchitacea Scott, 1959
 Family Paraparchitidae Scott, 1959
Samarella? *minuta* sp. nov. (Fig. 4K–N)
Samarella sp. nov. A Casier and Lethiers, 1998 (Fig. 4O)
Chamishaella? sp. indet. Casier and Lethiers, 2000 (Fig. 4P)
 Family Coelonellidae Sohn, 1971
Coelonella? sp. indet. *sensu* Casier and Lethiers (1999) (Fig. 4Q, R)
Coelonella crassa Casier and Lethiers, 2000 (Fig. 4S, T)
Coelonella cf. sp. 18 Braun, 1968
 Suborder Kloedenellocopina Scott, 1961 *sensu* Lethiers (1981)
 Superfamily Kloedenellacea Ulrich and Bassler, 1908
 Family Kloedenellidae Ulrich and Bassler, 1908
Marginia sp. A aff. *decora* Rozhdestvenskaja, 1972 (Fig. 5A)
Marginia sp. A Casier and Lethiers, 1998 (Fig. 5B)
 Family Knoxitidae Egorov, 1950
Knoxella? sp. indet. (Fig. 5C, D)
 Family Glyptopleuridae Girty, 1910
Blessites sp. nov. A (Fig. 5E, F)
 Order Platycopida Sars, 1866
 Suborder Platycopina Sars, 1866
 Superfamily Cytherellacea Sars, 1866
 Family Cavellinidae Egorov, 1950
 “*Cavellina*” sp. A aff. *dushanensis* Shi, 1964 *sensu* Casier and Lethiers (2000) (Fig. 5G)
Sulcella (*Postsulcella*) *kostomlotyensis* Casier and Lethiers, 2000 (Fig. 5H, I)
 Order Podocopida Müller, 1894
 Suborder Metacopina Sylvester-Bradley, 1961
 Superfamily Thlipsuracea Ulrich, 1894
 Family Quasillitidae Coryell and Malkin, 1936
Ponderodictya? sp. A (Fig. 5J)

Suborder Podocopina Sars, 1866
 Superfamily Bairdiocypridacea Shaver, 1961
 Family Bairdiocyprididae Shaver, 1961
Healdianella alba Lethiers, 1981 (Fig. 5K, L)
Bairdiocypris sp. nov. A Casier and Lethiers 2000 (Fig. 5M, N)
Bairdiocypris ventrorecta sp. nov. (Fig. 5O–Q)
Bairdiohealdites gregalis Rozhdestvenskaja, 1972 (Fig. 6A)
Bairdiohealdites sp. A aff. *gregalis* Rozhdestvenskaja, 1972 *sensu* Casier and Lethiers (1999) (Fig. 6B, C)
Orthocypris cf. *exemplaris* Rozhdestvenskaja, 1979 (Fig. 6D, E)
Orthocypris sp. A *sensu* Becker (1971) (Fig. 6F, G)
Orthocypris sp. indet.
 “*Cytherellina*” sp. nov. A (Fig. 6H, I)
 Family Pachydomellidae Berdan and Sohn, 1961
Decoranewsomites digitulistriata (Lethiers, 1981) (Fig. 6J, K)
Micronewsomites sp. nov. A (Fig. 6L, M)
Ampuloides cf. *parvus* Blumenstengel, 1970 (Fig. 6N)
Microcheilinella postfecunda Lethiers and Casier, 1996 (Fig. 6O, P)
Microcheilinella voronensis Samoilova, 1970 (Fig. 6Q, R)
Microcheilinella frumentaria Lethiers and Casier, 1996 (Fig. 7A, B)
Microcheilinella cf. *larionovae* Polenova, 1955 *sensu* Lethiers and Casier (1996) (Fig. 7C)
Microcheilinella sp. nov. A aff. *M. peculiaris* Rozhdestvenskaja and Netchaeva in Rozhdestvenskaja (1972) (Fig. 7D, E)
 Superfamily Bairdiacea Sars, 1888
 Family Acratiidae Gründel, 1962
Acratia evlanensis Egorov, 1953 (Fig. 7F, G)
Acratia nevadaensis Casier and Lethiers, 1997 (Fig. 7H, I)
Acratia gassanovae Egorov, 1953 (Fig. 7J)
Acratia sp. A aff. *gassanovae* Egorov, 1953 (Fig. 7K)
Acratia cf. *zadonica* Egorov, 1953 (Fig. 7L, M)
Acratia cf. *ljubzovi* Schischkinskaja, 1964 (Fig. 7N, O)
Acratia sp. nov. B aff. sp. 39 Braun, 1968 (Fig. 8A, B)
Acratia pentagona sp. nov. (Fig. 8C–F)
Acratia supina Polenova, 1953 (Fig. 8G)
Acratia supinaeformis Lethiers, 1981 (Fig. 8H, I)
Acratia feisti Lethiers and Casier, 1995 (Fig. 8J, K)
Acratia? sp. *sensu* Lethiers and Casier (1999) (Fig. 8L, M)
Acratia saggitaeformis Lethiers and Casier, 1999? (Fig. 8N, O)
Acratia sp. indet.
 Acratiidae sp. nov. A Casier and Lethiers, 2000 (Fig. 8P, Q)
 Family Acratiidae Gründel, 1962?
Famenella angulata Rozhdestvenskaja, 1972 (Fig. 8R, S)
Famenella postkairovaensis Lethiers and Casier, 1996 (Fig. 8T, U)
Famenella? sp. nov. A Casier and Lethiers, 1998 (Fig. 9A)
 Family Bairdiidae Sars, 1888
Bairdia cf. *kelleri* Egorov, 1953
Bairdia fabaeformis Polenova, 1953 (Fig. 9B, C)
Bairdia quasifabaeformis Lethiers and Casier, 1999 (Fig. 9D, E)
Bairdia altodorsualis Casier and Lethiers, 1998 (Fig. 9F, G)
Bairdia sp. nov. A *sensu* Casier and Lethiers (1996)? (Fig. 9H, I)
Bairdia sp. C aff. *B. proxischimensis* Casier and Lethiers, 1998 *sensu* Casier and Lethiers (1999) (Fig. 9J, K)
Bairdia dorsoconstricta Blumenstengel, 1970 (Fig. 9L)
Bairdia sp. B Lethiers and Casier, 1996 (Fig. 9M)

Bairdia sp. B aff. *B. subeleziana* Polenova, 1953 *sensu* Casier and Lethiers (1998) (Fig. 9N)
Bairdia sp. E aff. *B. curta* Kummerow, 1939 *sensu* Blumenstengel (1970) (Fig. 9O)
Bairdia gr. *turgida* Buschmina, 1969 (Fig. 9P, Q)
Bairdia sanctacrucensis Casier and Lethiers, 2000 (Fig. 9R)
“*Bairdia*” *psiegorkiensis* sp. nov. (Fig. 9S–V)
Bairdia cf. *eleziana* Egorov, 1953 *sensu* Casier and Lethiers (1998) (Fig. 10A, B)
“*Bairdia*” sp. nov. B (Fig. 10C, D)
Bairdiacypris sobiekurowiensis (Olempska, 1979) (Fig. 10E, F)
Bairdiacypris quarziana (Egorov, 1953) (Fig. 10G, H)

Bairdiacypris sp. nov. A aff. *B. virga* Buschmina, 1969 *sensu* Kotschekova and Janbulatova (1987) (Fig. 10I, J)
Bairdiacypris gr. *irregularis* (Polenova, 1953)
Bairdiacypris sp. A aff. *B. zigulensis* (Polenova, 1953) (Fig. 10K, L)
Bairdiacypris martinae Casier and Lethiers, 1997 (Fig. 10M, N)

Order Myodocopida Sars, 1866
Suborder Myodocopina Sars, 1866
Superfamily Entomozacea Přibyl, 1951
Family Entomozoidae Přibyl, 1950
Entomozoe (Nehdentomis) pseudophthalma (Volk, 1939) (Fig. 10O)
Entomozoe (Nehdentomis) tenera (Gürich, 1896) (Fig. 10P)