FACIES	46	1-26	Pl. 1-4	8 Figs.	--	Erlangen 2002

Late Serpukhovian (Namurian A) Microfacies and Carbonate Microfossils from the Carboniferous of Nötsch (Austria)

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Summary

The Carboniferous of Nötsch (Austria), divided into Erlachgraben, Badstub and Nötsch Formations, is composed of a thick sequence of dominantly siliciclastic deep-sea sediments. Intercalated marly and silty limestones in the upper Erlachgraben Formation consist of bioclastic wackestones and algal wackestones/packstones which contain a diverse fossil assemblage of foraminifers, algae and pseudo-algae. These microfossils are accurately described and documented, and three species of algae are established: *Principia fluegeli* n. sp., *Paraepimastopora noetschensis* n. sp., and *Nanopora pseudofragilissima* n. sp.

Based on the occurrence of both important species of the foraminifers Lasiodiscoidea (*Howchinia gibba* and *Eolasiodiscus dilatatus*), and also on the presence of *Endothyranopsis plana*, of the last *Earlandia* ex gr. *vulgaris* and of the first *Eostaffella* ex gr. *postmosquensis*, the upper Erlachgraben Formation is dated as late Serpukhovian (goniatite biozone E 2 of the Namurian A; Arnsbergian stage, corresponding to the Zapaltyubinsky of the standard Russian sequence; foraminiferal biozones 18 or Cf 7 of Belgium, or Cf 16 of the Donbass).

Compared to the Pyrenees and the Donbass region, the algal flora of the Carboniferous of Nötsch seems to be relatively endemic. Algae and foraminifers originally inhabited a shallow carbonate ramp and were transported and redeposited in a deep-water environment by gravity flows. The foraminifers most probably migrated from the Donbass region along the shelf of a narrow seaway to Nötsch.

1 INTRODUCTION

The locally very fossiliferous sedimentary sequence of the Carboniferous of Nötsch, containing abundant brachiopods, bivalves, gastropods, trilobites, echinoderms, bryozoans, corals and plant fossils, is well known for almost 200 years and attracted many paleontologists (see summary in Schönlaub 1985).

Despite the extensive paleontologic literature (e.g. De Koninck 1873, Heritsch 1934, Flügel and Kodsi 1968, 1971, Flügel 1972, Sieber 1972, Schönlaub 1985, Hahn and Hahn 1987, Amerom and Schönlaub 1992, Yochelson and Schönlaub 1993, Schraut 1996, 1999, Amerom and Kabon 1999, 2000), the age of this sequence is not well established and the biostratigraphic data are controversial.

According to Schönlaub (1985) the fossiliferous upper part of the Erlachgraben Formation is most probably of latest Viséan to early Namurian age.

Limestone clasts from amphibolite breccias of the Badstub Formation yielded late Viséan conodonts (Schönlaub 1985). Trilobites from the fossiliferous mudstones of the lower Nötsch Formation point to latest Viséan (Aprathian = cu III) age according to Hahn and Hahn (1987). From exotic limestone clasts a Serpukhovian age is assumed for the Badstub Formation by E. Flügel and Schönlaub (1990).

Recently a well preserved megaplant fossil assemblage from the uppermost Erlachgraben Formation, characterized by the occurrence of *Sphenocyclopteridium bertrandii* and *Archaeopteridium tschermakii* indicates Namurian (Arnsbergian) age (Amerom and Kabon, 1999). The fossil flora from the lower part of the Nötsch Formation contains *Neuropteris obliqua*, *Renaultia gracilis*, *Eusphenopteris hollandica*, *Pecopteris aspera* and *Sphenopteris elegans* (index fossil for the Namurian A), but lacks *Archaeopteridium*, *Rhodea* and *Sphenocyclopteridium*, pointing to Namurian A (Alportian) according to Amerom and Kabon (2000).

The aim of this paper is (1) to describe and document the microfossil assemblage (algae and foraminifers) from marly limestones of the uppermost Erlachgraben Formation and lowermost Nötsch Formation, and (2) to discuss their biostratigraphic and paleogeographic significance.

2 GEOLOGICAL SETTING

The Carboniferous of Nötsch comprises a more than 1000 m thick, dominantly siliciclastic sedimentary sequence exposed at the southern margin of the Upper Austroalpine Drau Range in southern Austria (Carinthia), approximately 15 km west of Villach (Fig. 1).

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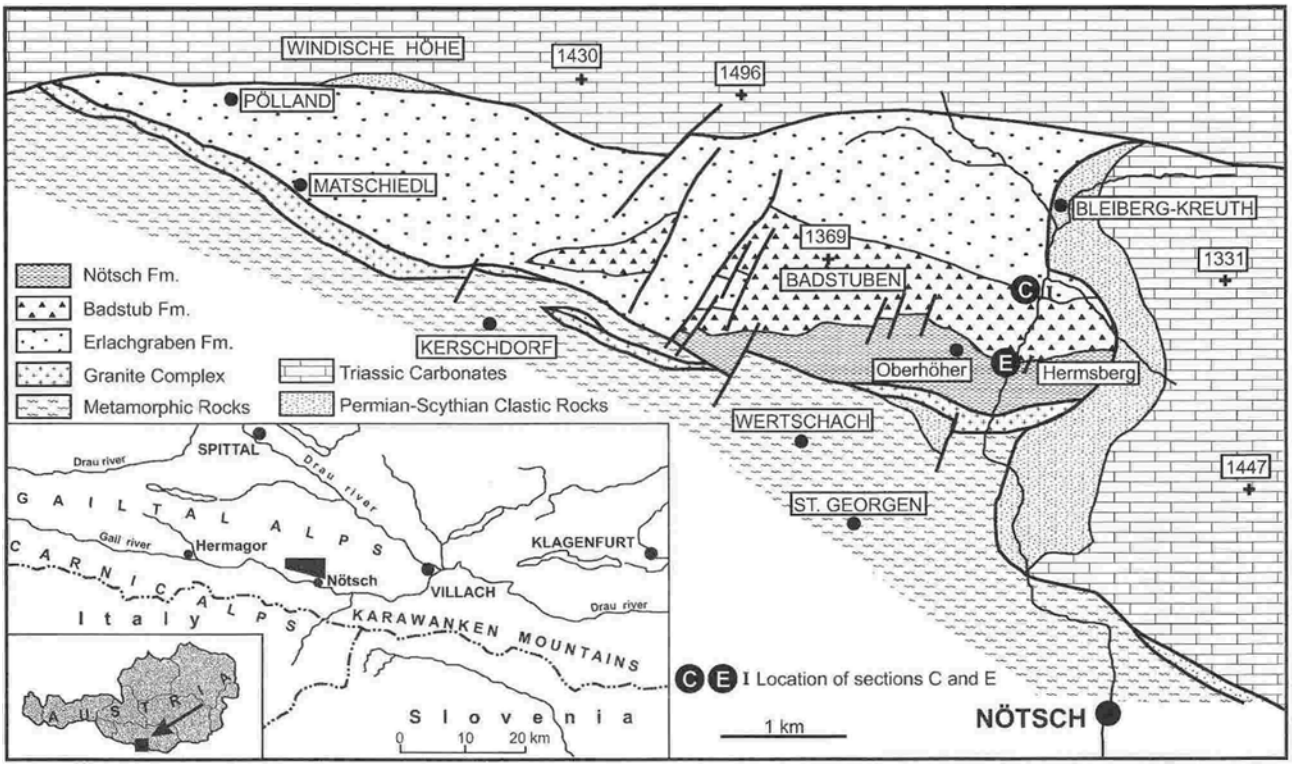


Fig. 1. Simplified geologic map of the Carboniferous of Nötsch with location of the studied sections C and E (see Fig. 2).

These Carboniferous deposits extend about 9 km in east-west direction and 3 km in north-south direction. They are fault-bounded to the south and north, and is overthrusted at their eastern margin by Permian - Triassic sediments of the Dobratsch Massif (see also Kodsi and Flügel 1970, Schönlaub 1985, Krainer 1992, 1993).

The Carboniferous sequence of Nötsch is divided into (1) Erlachgraben Formation, (2) Badstub Formation and (3) Nötsch Formation, from base to top (Krainer 1992).

The Erlachgraben Formation is several hundred meter thick. In the lower part it is composed of polymict conglomerates, immature sandstones (lithic arenites and lithic wackes), siltstones and shales.

The conglomerates are interpreted as submarine debris flows; the sandstones and siltstones were formed by turbidity currents. These lithofacies form pronounced fining-upward sequences up to some tens of meters thick. From shales and siltstones Tessensohn (1972) reported trace fossils of the *Nereites* Association indicating a deep marine environment. The sediments were probably deposited in a lower slope environment (for details see Krainer 1992).

The upper part of the Erlachgraben Formation is composed of fossiliferous siltstones and mudstones which constitute the background sediment and are interpreted as hemipelagic deposits. Intercalated are sandstones and pebbly mudstones, both formed by gravity flows, and grey, fossiliferous marly and silty limestones composed of bioclastic wackestones and algal wackestones/packstones. The presence of the trace fossil *Dictyodora liebeana* within the mudstones and siltstones, and intercalated gravity flow deposits, indicate sedimentation in a deep water environment, most likely on the upper slope (Krainer 1992).

The Erlachgraben Formation is overlain by the Badstub Formation ("Badstubbreccie"), an approximately 400 m thick sequence of amphibolite breccias, conglomerates, sandstones and fossiliferous siltstones.

Due to the high amount of amphibolite clasts in the conglomerates and breccias, and reworked amphibolite material in the sandstones and siltstones, this sequence has been interpreted as diabase, volcanic breccia, diabase breccia, tectonic breccia, metamorphic tholeiitic basalt and sedimentary breccia in the past (see Krainer and Mogessie 1991, Krainer 1992). Structural and textural features as well as the fossil content in the upper part of the sequence (brachiopods, crinoid fragments, plant fossils) point to a sedimentary origin of these rocks.

According to Krainer and Mogessie (1991) and Krainer (1992) the sediments of the Badstub Formation are interpreted as submarine resedimented breccias, conglomerates, sandstones and siltstones formed by sediment gravity flows in a proximal fan or slope environment along an active fault zone.

The several hundred meters thick Nötsch Formation in the lower part is composed of fossiliferous shales and siltstones with intercalated sandstones and conglomerates of turbidite origin, thin brachiopod coquina layers and a fossiliferous silty limestone horizon. The facies is similar to the upper part of the Erlachgraben Formation. In the lower part, the sediments contain a rich fauna of brachiopods, echinoderms, bivalves, bryozoans, trilobites, gastropods, ostracods and others (see Schönlaub 1985, Schraut 1996, 1999; and for trilobites Hahn and Hahn 1987). The uppermost part of the Nötsch Formation consists of polymict conglomerates and sandstones, similar to the lower part of the Erlachgraben Formation.

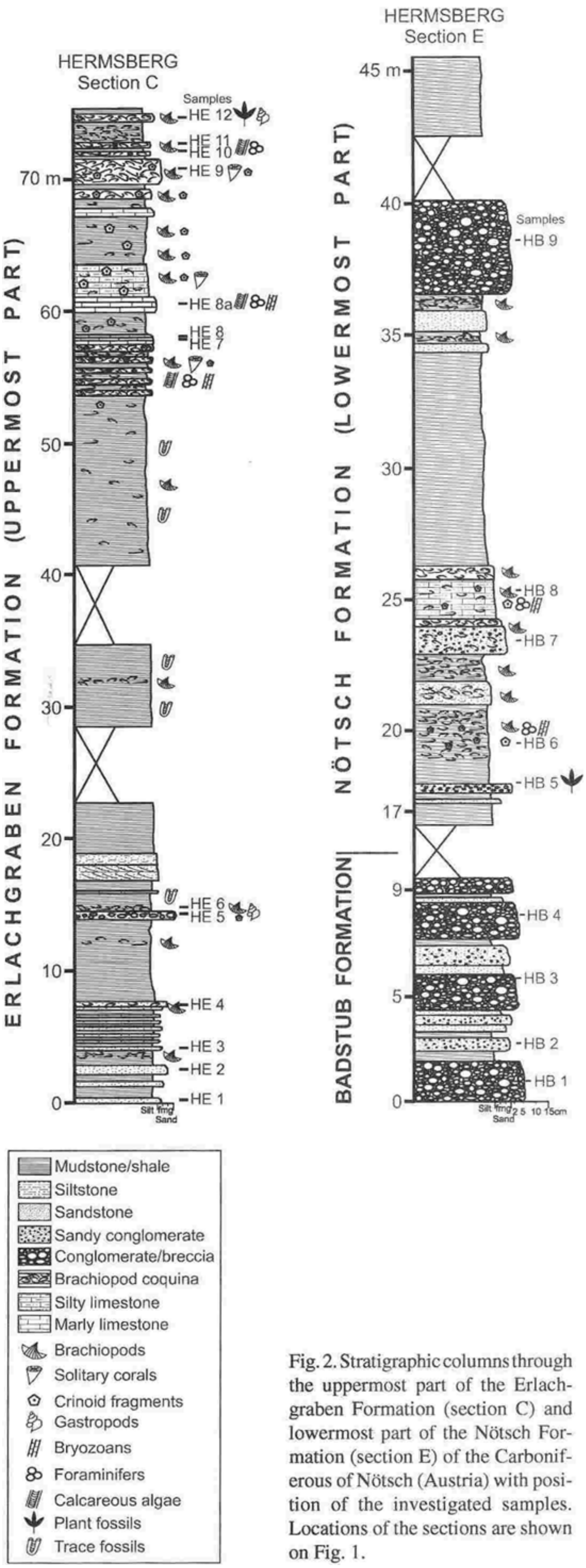


Fig. 2. Stratigraphic columns through the uppermost part of the Erlachgraben Formation (section C) and lowermost part of the Nötsch Formation (section E) of the Carboniferous of Nötsch (Austria) with position of the investigated samples. Locations of the sections are shown on Fig. 1.

3 LITHOFACIES OF THE MICROFOSSIL-BEARING SEQUENCE

Calcareous algae and foraminifers occur in the uppermost part of the Erlachgraben Formation, a few foraminifers have been recognized in a thin coquina layer in the upper Badstub Formation and in the lowermost part of the Nötsch Formation.

3.1 Erlachgraben Formation

The uppermost part of the Erlachgraben Fm., exposed along the road to Hermsberg (section C in Fig. 2, location see Fig. 1), is composed of dark grey and brownish-grey mudstone/siltstone, frequently containing productid brachiopods and crinoid fragments, locally trace fossils *(Dictyodora liebeana)*.

In the lower part of the investigated section (C in Fig. 2) several thin, immature sandstone layers and a fine-grained polymict conglomerate are intercalated. Mudstones/siltstones in the uppermost part of the section contain large fossil plant fragments. Sandstones are poorly sorted lithic arenites and lithic wackes, composed of metamorphic rock fragments, quartz, detrital feldspar, accessory garnet and a few bioclasts, particularly echinoderm fragments, gastropods, brachiopods, and foraminifers. The groundmass consists of carbonate cement and some phyllosilicate matrix. Siltstones are frequently bioturbated, indistinctly laminated and contain a few bioclasts: algal fragments (*Paraepimastopora noetschensis* n. sp.), foraminifers, shell fragments, crinoids, brachiopod spines and bryozoans.

In the upper part of section C several brachiopod coquina layers which subordinately contain crinoids and solitary corals, and dark grey silty and marly limestones are intercalated. These limestones consist of bioclastic wackestones and algal wackestones/packstones:

(a) Bioclastic wackestones are composed of dark grey, bioturbated groundmass of micrite and mudstone/siltstone. Bioclasts of various sizes are floating in the groundmass: brachiopod shells and spines, echinoderm fragments, bryozoans, calcareous algae, gastropods, ostracods, foraminifers, and solitary corals (*Hexaphyllia*) with diameters up to several centimeters. Some corals, brachiopod spines and echinoderm fragments are encrusted by pseudo-algae [mostly *Fasciella* (?)]. Some micritic intraclasts are present (Pl. 1/1).

(b) Algal wackestones/packstones composed of abundant fragments of calcareous algae (mostly *Principia fluegeli*, subordinately *Paraepimastopora noetschensis*). Algal fragments are partly well preserved, partly recrystallized. Shell fragments, corals, echinoderms, gastropods, brachiopod spines and foraminifers are present in small amounts. Some algal fragments are encrusted by *Fasciella* (?) (Pl. 2/2, 3/6).

3.2 Badstub Formation

In the upper part of the Badstub Formation, exposed along a forest road northwest of Oberhöher (location see Fig. 1), a 60 cm thick coquina layer is intercalated, which contains abundant brachiopods and brachiopod spines, subordinate solitary corals, and a few foraminifers in the micritic-siltitic groundmass (Pl. 1/8) (see Krainer 1992).

3.3 Nötsch Formation

The uppermost part of the Badstub Formation and the lowermost part of the Nötsch Formation are exposed along a forest road west of Hermsberg (Section E in Fig. 2).

The uppermost Badstub Formation is composed of poorly sorted breccias and conglomerates rich in amphibolite clasts, of immature sandstones and thin siltstone layers.

The overlying lowermost Nötsch Formation consists of dark grey and brownish-grey mudstone/siltstone, locally containing brachiopods and crinoid fragments, rarely plant fossils.Intercalated are conglomerates rich in amphibolite clasts, immature sandstones, brachiopod coquinas, fossiliferous siltstones and a fossiliferous silty limestone horizon. The latter are bioturbated and consist of micritic-siltitic groundmass, some siliciclastic grains (quartz, feldspar, amphibole, epidote, metamorphic rock fragments) and strongly recrystallized bioclasts: brachiopod shells, echinoderm fragments, ostracods, foraminifers, especially *Eostaffella chomatifera*, and ?bryozoans (Pl. 1/6). A more accurate determination of the foraminiferal assemblage was not possible.

Bioturbated mudstones contain shell fragments (mostly derived from brachiopods), echinoderm fragments, small foraminifers and bryozoans.

The facies of the lowermost Nötsch Formation is very similar to that of the uppermost Erlachgraben Formation.

4 MICROFOSSIL ASSEMBLAGE (ALGAE AND FORAMINIFERS)

The late Serpukhovian microfacies of the uppermost Erlachgraben Formation and basal Nötsch Formation exhibit silty and marly limestones, probably all of calciturbiditic origin: bioclastic wackestones, packstones and floatstones, and some *Principia* rudstones. Shell fragments are derived from brachiopods, bivalves, ostracods, trilobites and crinoids. A few Heterocorallia (*Hexaphyllia* sp.) are present (Pl. 4/37).

As classically admitted, the ecological distribution of calcareous algae depends on several factors, among which light, water depth, salinity, water circulation and water temperature are the most important. Most algae are restricted to the photic zone of the shelf with water depths of less than about 30 m, according to Johnson (1961) and Roux (1985) dasycladacean algae are restricted to water depths of less than 12 m. The foraminifers are all benthic, probably epiphytic on algae, and consequently originally lived in a shallow-water shelf environment. Both, calcareous algae and foraminifers, have been transported and redeposited from a shallow-water shelf environment to a deep marine environment by gravity flows. We assume that transportation and redeposition caused some selection processes, and therefore the microfossil assemblage of the silty and marly limestones and coquina layers of the Carboniferous of Nötsch most probably does not represent the assemblage of the original shelf environment from where they are derived. The microfossil assemblage of the uppermost Erlachgraben

Plate 1 Thin section photomicrographs showing microfacies of marly and silty limestones from the uppermost part of the Erlachgraben Formation, a brachiopod coquina from the upper Badstub Formation, and the lowermost Nötsch Formation, Carboniferous of Nötsch, Austria. Plane polarized light, all x18.

Fig. 1. Bioclastic wackestone, composed of dark grey, micritic groundmass, a few intraclasts and abundant bioclasts, particularly fragments of echinoderms, bryozoans, brachiopods, and ostracods. Section Hermsberg C, sample HE 8.

Fig. 2. Bioclastic wackestone composed of dark grey, bioturbated, micritic groundmass and bioclasts: fragments of echinoderms, brachiopod shells and spines, ostracods, and rarely spicules. Section Hermsberg C, sample HE 8.

Fig. 3. Algal packstone composed of densely packed, recrystallized fragments of calcareous algae *Principia fluegeli* n. sp., a few shell fragments and micritic groundmass. Section Hermsberg C.

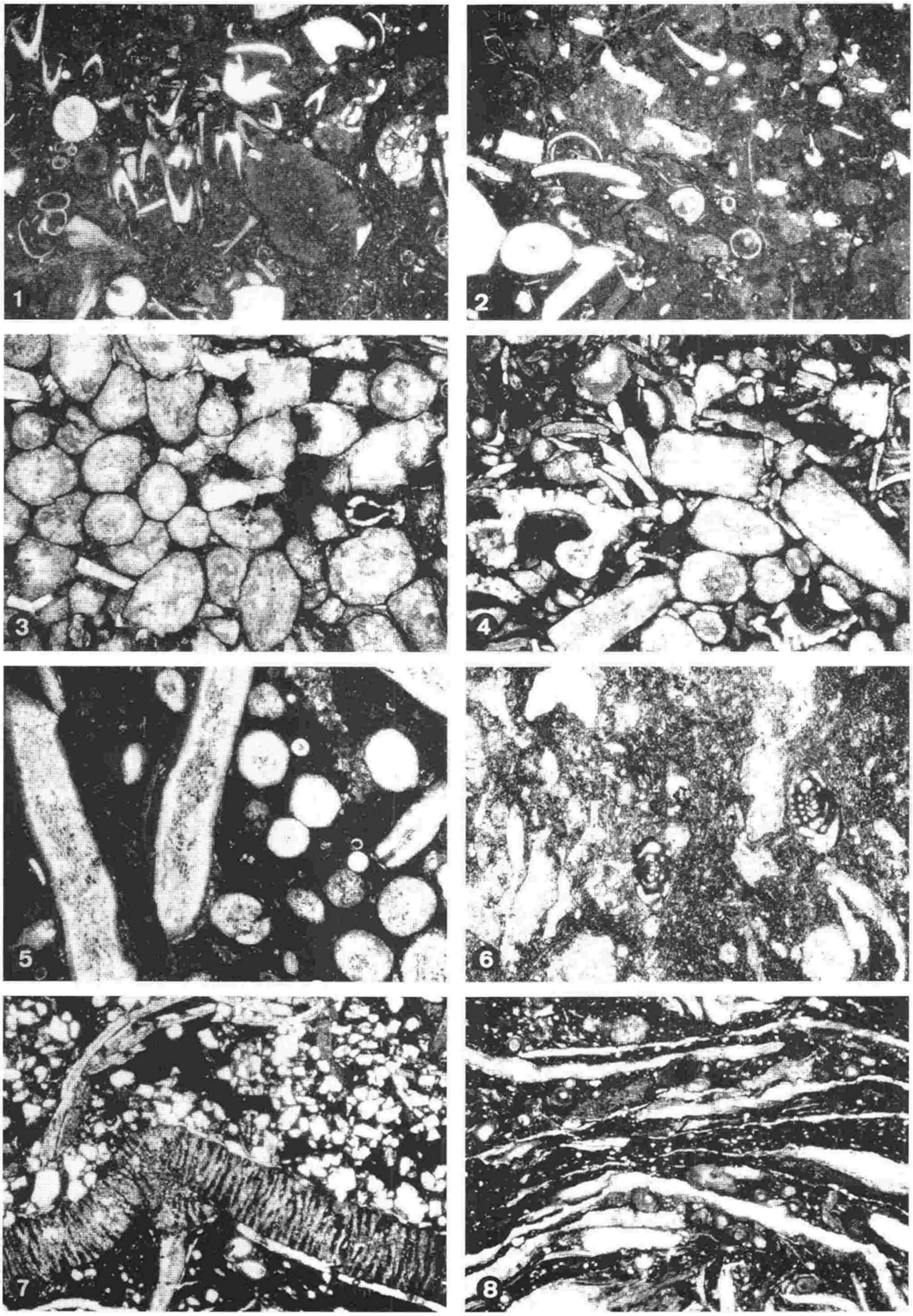
Fig. 4. Algal wackestone consisting of dark grey, micrite and bioclasts, mostly calcareous algae *Principia fluegeli* n. sp, subordinately *Paraepimastopora noetschensis* n. sp., shell fragments and echinoderms. Section Hermsberg C.

Fig. 5. Algal wackestone with well preserved, large fragments of the alga *Principia fluegeli* n. sp., embedded in micritic groundmass. Section Hermsberg C, sample HE 11 (i. e. type sample of *P. fluegeli* n. sp.).

Fig. 6. Bioclastic wackestone composed of silty groundmass, recrystallized shell and echinoderm fragments, and a few foraminifers. Lowermost Nötsch Formation NW of Oberhöher.

Fig. 7. Siltstone containing a large fragment of the alga *Paraepimastopora noetschensis* n. sp. and a few shell fragments. Section Hermsberg C, sample HE 12 (i. e. type sample of *P. noetschensis* n. sp.).

Fig. 8. Bioclastic wackestone (brachiopod coquina) composed of abundant brachiopod shell fragments and brachiopod spines, embedded in micritic and siltitic dark grey groundmass. Upper Badstub Formation NW of Oberhöher.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Formation (section C in Fig. 2) is composed of the following species :

Algae: *Ortonella* ex gr. *kershopensis* Garwood, 1931 (Pl. 2/1), *Principia fluegeli* n. sp. (Pl. 1/3-5, 2/2-4, 8, 14, 3/6), *Paraepimastopora noetschensis* n. sp. (Pl. 1/7, 2/5, 9-11), *Nanopora pseudofragilissima* n. sp. (Pl. 2/6-7, 12-13).

Pseudo-algae: *Stacheoides* ex gr. *polytrematoides* (Brady, 1876) (Pl. 2/15), *Fourstonella* cf. *irregularis* Mamet and Roux, 1977 (Pl. 3/2-3), *Fasciella* cf. *kizilia* Ivanova, 1973 (Pl. 2/2?, 3/4, 6?, 10), *Frustulata* cf. *asiatica* Saltovskaya, 1984 (Pl. 3/1, 5).

Foraminifers: *Earlandia* ex gr. *vulgaris* (Rauzer-Chernousova and Reitlinger in Rauzer-Chernousova and Fursenko, 1937) (Pl. 3/7-8), *Endothyra* ex gr. *bowmani* Phillips, 1846 emend. Brady, 1876, emend. China, 1965 (Pl. 3/9), *Endothyranopsis plana* Brazhnikova, 1967 (Pl. 3/11-19), *Bradyina* cf. *concinna* Reitlinger, 1950 (Pl. 4/2), Palaeotextulariidae indet. (Pl. 4/3-4), *Tetrataxis* ex gr. *palaeotrochus* (Ehrenberg, 1854) emend. Nestler, 1973 (Pl. 4/1), *Howchinia gibba* (von Moeller, 1879) (Pl. 4/5-8), *Eolasiodiscus dilatatus* Potievskaya, 1964 (Pl. 4/10-13), *Archaediscus* ex gr. *convexus* Grodzilova and Lebedeva in Dain and Grozdilova, 1953 (Pl. 4/9,14-15), *Betpakodiscus* cf. *donetzianus* (Sosnina in Dain and Grozdilova, 1953)(Pl. 4/16-17), *B.* (?) aff. *variabilis* (Reitlinger, 1950) (Pl. 4/18), *Tubispirodiscus* ex gr. *cornuspiroides* (Brazhnikova and Vdovenko in Brazhnikova et al., 1967) (Pl. 4/19-20), *Asteroarchaediscus parvus* (Rauzer-Chernousova, 1948a) (not figured), *Eostaffella chomatifera* Kireeva in Rauzer-Chernousova et al., 1951 (Pl. 1/6, 4/21-32), *E.* ex gr. *postmosquensis* Kireeva in Rauzer-Chernousova et al., 1951 (Pl. 4/33-35, 37), *Plectostaffella* (?) sp. (Pl. 4/36).

5 BIOSTRATIGRAPHICAL REMARKS

The late Serpukhovian age of the uppermost Erlachgraben Formation is determined essentially by the occurrence of the Lasiodiscoidea *Howchinia gibba* and *Eolasiodiscus dilatatus:* i.e. a species of the group *E. donbassicus* Reitlinger, 1956, itself probably synonymous to the group *Eolasiodiscus transitorius* (Brazhnikova and Yartseva, 1956), which has the priority, see discussion in Vachard and Beckary (1991). The microflora seems to be relatively endemic compared to that of the Pyrenees (Perret and Vachard 1977) and Donbass (Aizenverg et al. 1983), but contains a form of the genus *Principia* intermediate between latest Viséan and earliest Bashkirian taxa.

A good summary about the Serpukhovian stage in the former USSR can be found in Einor et al. (1996: 42-54).

In the Carboniferous of Nötsch the Zapaltyubinsky stage is also well characterized by *Endothyranopsis plana*, and by the occurrence of the last *Earlandia* ex gr. *vulgaris* and the first *Eostaffella* ex gr. *postmosquensis*, like in the Donbass (compilation in Vachard and Maslo 1996: 396, Fig. 1). Any taxon of the latest Serpukhovian/earliest Bashkirian (goniatite zone H = Chokierian + Alportian = Voznesensky stage), like *Seminovella elegantula* Rauzer-Chernousova, in Rauzer-Chernousova et al., 1951, or *Plectostaffella* ex gr. *bogdanovkensis* Reitlinger, 1980 has been evidenced; and according to our observations, *Hexaphyllia* disappears prior to the *Homoceras* Zone.

The upper Erlachgraben Formation probably corresponds to the early Zapaltyubinsky stage (limestones D_3 and D_5) of the Donbass (Aizenverg et al. 1983) or Cf 16 or Se assemblage zones of the same area (Poletaev et al. 1991). The

Plate 2 Late Serpukhovian algae and pseudo-algae from the uppermost Erlachgraben Formation (samples HE, HEX, section Hermsberg C) and upper Badstub Formation (samples B, BX), Carboniferous of Nötsch (Austria).

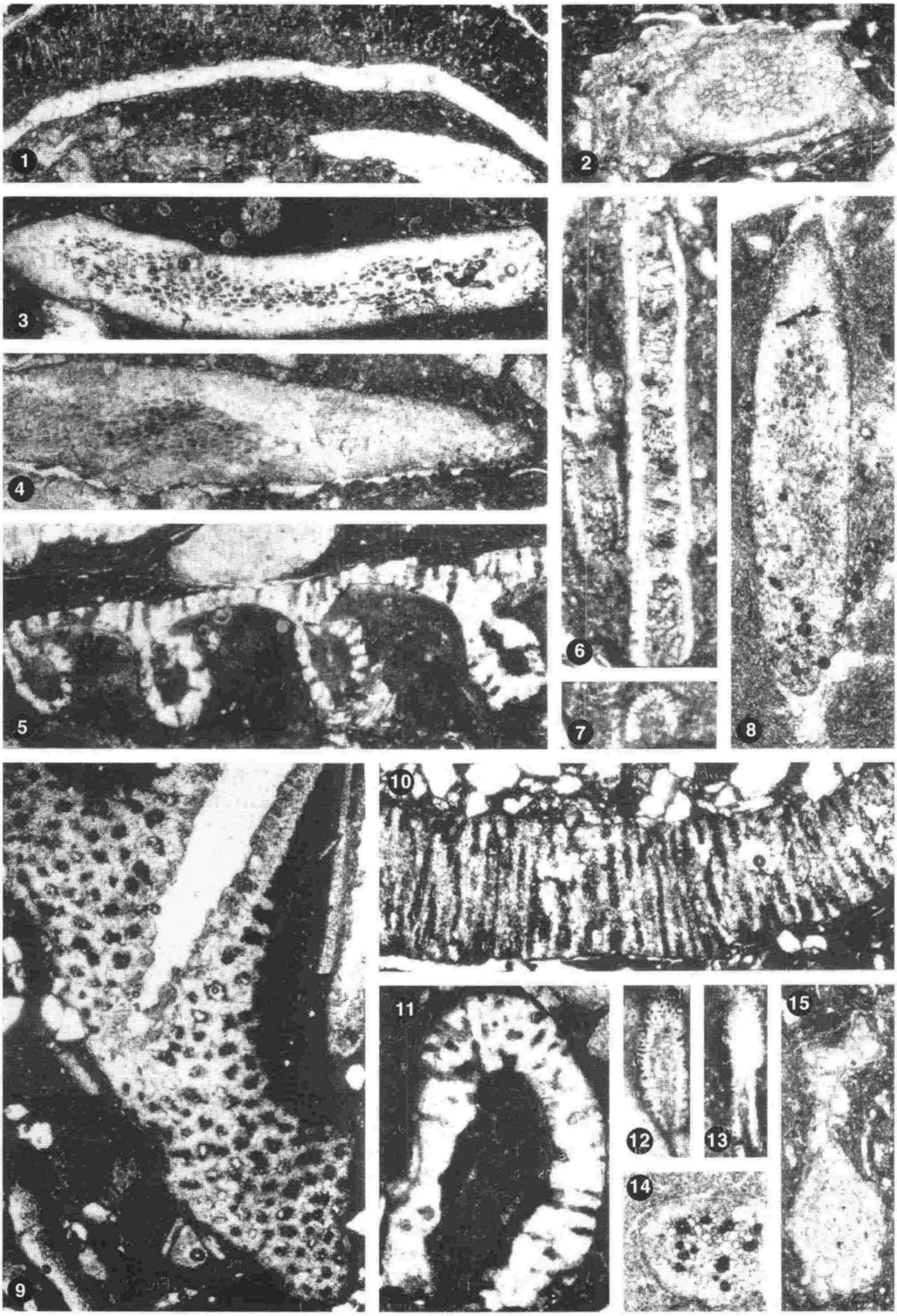
Fig. 1. *Ortonella* ex gr. *kershopensis* Garwood, 1931; axial section of a crust around a bivalve, sample BX 2, x 36.

Figs. 2-4, 8, 14. *Principia fluegeli* n. sp.; Fig. 2, paratype, transverse section encrusted by *Fasciella* (?) sp. (see also Pl. 3/6), sample HE 8/4, x 36; Fig. 3, holotype, longitudinal section showing the hypothallus and the emplacement of the perithallus, and the elongate not bifurcated section of the thallus, sample HE 11, x 36; Fig. 4, paratype, longitudinal section with rather acute extremities, sample HE 8/2, x 36; Fig. 8, paratype, partially recrystallized elongate axial section, sample HE 10, x 36; Fig. 14, paratype, transverse section with an obvious hypothallus, sample HE 10, x 36.

Figs. 5, 9-11. *Paraepimastopora noetschensis* n. sp.; Fig. 5, paratype, longitudinal section showing the wall and its perforations and the intusannulations which are perforated too, sample HEX/2, x 36; Fig. 9, holotype, longitudinal section through the wall and the laterals, rather similar to *Paraepimastopora kansasensis* (Johnson, 1946), sample HE 12, x 36; Fig. 10, paratype, oblique to tangential section showing the pores (extremities of the laterals), complete aspondyl (therefore differing from *P. kansansensis* with an euspondyl tendency), sample HE 12, x 36; Fig. 11, paratype, hypothetical extremity of a juvenile thallus (cf. "small forms" of Vachard 1993), two and probably three ramifications of the laterals are visible, sample HEX/1, x 36.

Figs. 6-7, 12-13. *Nanopora pseudofragilissima* n. sp.; Fig. 6, holotype, longitudinal section, laterals poorly visible, sample HE 11, x 90; Fig. 7, paratype, oblique section with laterals, sample HE 12/3, x 90; Fig. 12, paratype, typical sublongitudinal section, sample HEX/2, x 36; Fig. 13, paratype, sublongitudinal oblique section, sample HE 11, x 36.

Fig. 15. *Stacheoides* cf. *polytrematoides* (Brady, 1876); longitudinal section with well visible development of test, sample BX 2, x 36.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	WESTERN EUROPE (BELGIUM, ENGLAND)			DONETZ BASIN (UKRAINE) STAGES	LIMESTONE MEMBER	"ASSEMBLAGE ZONES"	FORAM. ZONES	AUSTRIA
NAMURIAN A	ALPORTIAN	H2	19 = Cf 8 (pars)	VOZNESENSKY (=BOGDANOVSKY)	D_7^7	Sg	Cf 17	upper Nötsch Fm.
	CHOKIERIAN	H1			D_5^{10}			
	ARNSBERGIAN	E2	18 = Cf 7 (pars)	ZAPALTYUBINSKY	D_5^9	Sf	Cf 16	lower Nötsch/ upper Erlachgraben Formation
					D5 D3	Se		
	PENDLEIAN	E1	17 = Cf 7 (pars)	PROTVINSKY	D2	Sd	Cf 15	lower Erlachgraben Formation
					C5	Sc		
				STESHEVSKY	C4	Sb	Cf 14	
				TARUSSKY	C1=B12	Sa		
WARNANTIAN (pars)	BRIGANTIAN	V3c	16s = Cf 6δ	VENEVSKY	B5	$C_1^V 9$	Cf 13	Kirchbach Limestone
					B1		Cf 12	
	ASBIAN	V3bγ	16i = Cf 6γ	MIKHAILOVSKIY		$C_1^V f2$	Cf 11	

Fig. 3. Correlation table of the Serpukhovian (= Namurian A) according to Kagarmanov and Donakova (1990), Poletaev et al. (1991) and Krainer and Vachard (work in progress).

Zapaltyubinsky stage can be correlated with the middle and upper parts of the Arnsbergian (Kagarmanov and Donakova 1990: Tab. 25), and consequently, the early Zapaltyubinsky with the middle Arnsbergian, i.e. the goniatite zone E 2b. The classical foraminiferal biozones 18 or Cf 7 are more imprecise and not used herein (Fig. 3).

Compared to the early Zapaltyubinsky of the Donbass, the absence of *Eosigmoilina, Brenckleina, Warnantella, Pseudoglomospira* ex gr. *subquadrata* (Potievskaya and Vakarchuk in Braznikova et al., 1967), *Haplophragmina* ex gr. *beshevensis* (Brazhnikova in Braznikova et al., 1967), *Rectoendothyra* and *Globivalvulina* is noticeable for the Carboniferous of Nötsch, but can probably be explained by paleoecological controls (more distal and/or more turbiditic deposits in Nötsch).

6 SYSTEMATIC PALEONTOLOGY (by D. Vachard)

Except additional precisions, the classification of Cyanobacteria is adopted from Chuvashov et al. (1987); that of Dasycladales from Bassoullet et al. (1979) and Roux (1985); the classification of the pseudo-algae Algospongia Aoujgaliida follows Termier et al. (1975, 1977); that of the Foraminiferida follows Vdovenko et al. (1993) and Rauzer-Chernousova et al. (1996). These papers contain a detailed list of bibliographic references for the suprageneric ranges which are consequently omitted in our descriptions.

Plate 3 Pseudo-algae and foraminifers of the uppermost Erlachgraben Formation (section Hermsberg C). Late Serpukhovian, Carboniferous of Nötsch (Austria)

Figs. 1, 5. *Frustulata* cf. *asiatica* Saltovskaya, 1984; Fig. 1, numerous longitudinal sections, sample HE X/2, x 36; Fig. 5, atypical section looking like a *Fasciella* (left) and a *Frustulata* (right), sample HE 8/2, x 36.

Figs. 2-3. *Fourstonella* cf. *irregularis* Mamet and Roux, 1977 ; Fig. 2, sublongitudinal section, sample B 22a, x 36; Fig. 3, sublongitudinal section, sample HE 8/4, x 90.

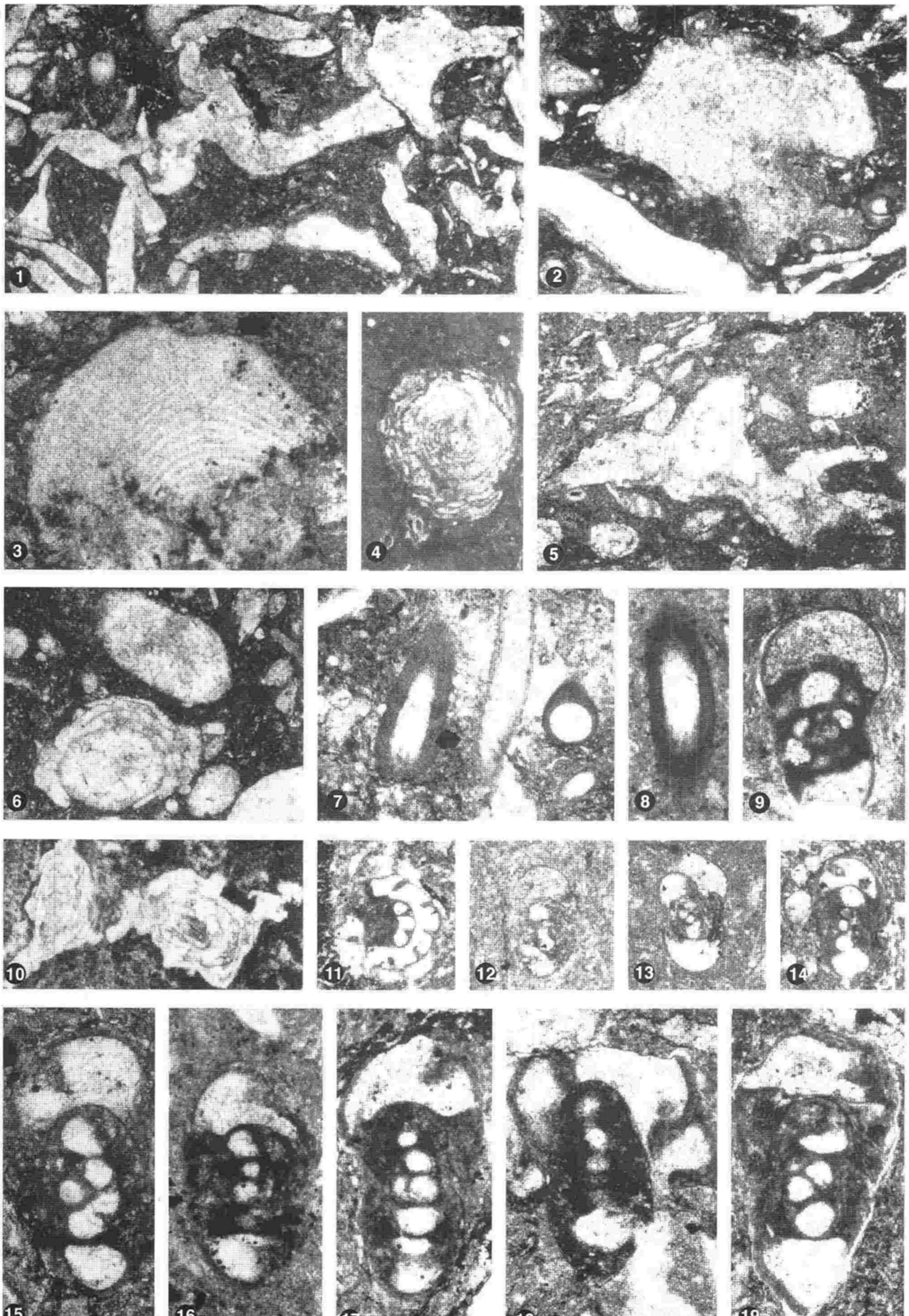
Figs. 4, 10. *Fasciella* cf. *kizilia* Ivanova, 1973; Fig. 4, transverse irregular section, sample HE X/b, x 36; Fig. 10, a transverse section with numerous laminae, sample HE 7, x 36.

Fig. 6. *Fasciella* (?) sp.; an axial section encrusting a *Principia fluegeli* n. sp. (below) with a free section of the same alga (above), sample HE 8/2, x 36.

Figs. 7-8. *Earlandia* ex gr. *vulgaris* (Rauser and Reitlinger, 1937); Fig. 7, an oblique section (left) and a proloculus (right), sample B 22a, x 90; Fig. 8, oblique section, sample HE 7, x 90.

Fig. 9. *Endothyra* ex gr. *bowmani* Phillips, 1846 emend. Brady, 1876 emend. China, 1965; axial section , sample HE 8/3, x 90.

Figs. 11-19. *Endothyranopsis compressa plana* Brazhnikova in Brazhnikova et al., 1967; Fig. 11, transverse section, sample HE 8/2, x 36; Fig. 12, subtransverse section, sample HE 7, x 90; Fig. 13, axial section, sample HE 7, x 90; Fig. 14, subaxial section, sample HE 8, x 36; Fig. 15, subtransverse section, sample HE 8/4, x 90; Fig. 16, subaxial section, sample HE 7, x 90; Fig. 17, subaxial section, sample HE 8/3, x 90; Fig. 18, oblique section, sample HE 8/3, x 90; Fig. 19, subaxial section, sample HE 8, x 90.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Cyanobacteria
Superfamily *Girvanellacea*
Family *Garwoodiaceae*
Genus *Ortonella* Garwood, 1914

Type-species: *Ortonella furcata* Garwood, 1914.
Range: Probably all the Paleozoic and Mesozoic, if admitted the synonymy with *Cayeuxia* (see Roux 1985: 557).

Ortonella ex gr. *kershopensis* Garwood, 1931
Pl. 2, Fig. 1

1931 *Ortonella kershopensis* Garwood, p. 139, Pl. 13, Fig. 3.
1972 *Ortonella kershopensis* - Mamet and Rudloff, p. 81, Pl. 1, Fig. 9.
1975a *Ortonella kershopensis* - Mamet and Roux, p. 152, Pl. 8, Figs. 4-5, 7, 10.
1985 *Ortonella kershopensis* - Roux, p. 557 (not illustrated).
1989 *Ortonella* ex gr. *kershopensis* - Vachard et al., p. 702, Pl. 1, Figs. 1-2.
1990 *Ortonella kershopensis* - Bogush et al., p. 78-79, Pl. 1, Figs. 1-6 (with synonymy).

Remarks: As indicated by Vachard et al. (1989), *Ortonella* with small tubes (10-30 µm in diameter) can be attributed to the group *O. kershopensis*. Our unique specimen belongs to this group, showing the following dimensions: length more than 2.000 mm, heigth of colony = 0.500 mm; diameter of filaments = 0.020-0.030 mm.
Range: Ordovician - Permian. Canada, U.S.A., Great Britain, Kuzbass, Pyrenees, Boulonnais, Belgium. Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Rhodophyta
Family *Archaeolithophyllaceae* Chuvashov in Chuvashov et al., 1987
Genus *Principia* Brenckle in Brenckle et al., 1982

Type-species: *Archaeolithophyllum donbassicum* Kosenko in Kosenko et al., 1972.
Range: Early? - late Viséan - late Serpukhovian. Europe, North Africa, North America.

Plate 4 Foraminifers and hexaphyllids of the uppermost Erlachgraben Formation (samples HE, HEX, section Hermsberg C) and upper Badstub Formation (samples B, BX). Late Serpukhovian, Carboniferous of Nötsch (Austria).

Fig. 1. *Tetrataxis* ex gr. *palaeotrochus* (Ehrenberg, 1854) emend. Nestler, 1973; axial section, sample B 22a, x 36.

Fig. 2. *Bradyina* ex gr. *concinna* Reitlinger, 1950; fragment of subaxial section, sample B 22a, x 36.

Figs. 3-4. Palaeotextulariidae; Fig. 3: Subaxial section of *Koskinobigenerina* sp., sample HE 8/1, x 36; Fig. 4, subaxial section of *Palaeotextularia* or young *Climacammina* sp., sample HE 8/4, x 90.

Figs. 5-8. *Howchinia gibba* (von Moeller, 1879); Fig. 5, subaxial section, sample HE 8/3, x 90; Fig. 6, subaxial section, sample HEX/2, x 90; Fig. 7, oblique section, sample HEX, x 90; Fig. 8, subaxial section, sample HEX/2, x 90.

Figs. 9, 14-15. *Archaediscus* (= *Archaediscus* at concavus stage) ex gr. *convexus* Grozdilova and Lebedeva in Dain and Grozdilova, 1953; Fig. 9, typical axial section, sample HE 8/3, x 90; Fig. 14, axial section becoming aligned, and corresponding therefore to *A. convexus sarbaicus* or *A. koktjubensis*; sample HE 8/3, x 90; Fig. 15, subaxial section, sample HE 8/3, x 90.

Figs. 10-13. *Eolasiodiscus dilatatus* Potievskaya, 1964; Fig. 9, transverse oblique section, sample HE 7, x 90; Fig. 10, subaxial section, sample HE 8/2, x 90; Fig. 11, tangential section with chamberlets (i. e. typical *Eolasiodiscus*), sample HE 8/2, x 90; Fig. 12, tangential section (without visible chamberlets, i.e. "true" *Monotaxinoides* auctoris), sample HE 8/4, x 90.

Figs. 16-17. *Betpakodiscus* (= *Archaediscus* at angulatus stage) cf. *donetzianus* (Sosnina in Dain and Grozdilova, 1953); Fig. 16, transverse section, sample HE 8/1, x 90; Fig. 17, axial section, sample B X, x 90.

Fig. 18. *Betpakodiscus* (?) aff. *variabilis* (Reitlinger, 1950); subaxial section, sample HE 8, x 90.

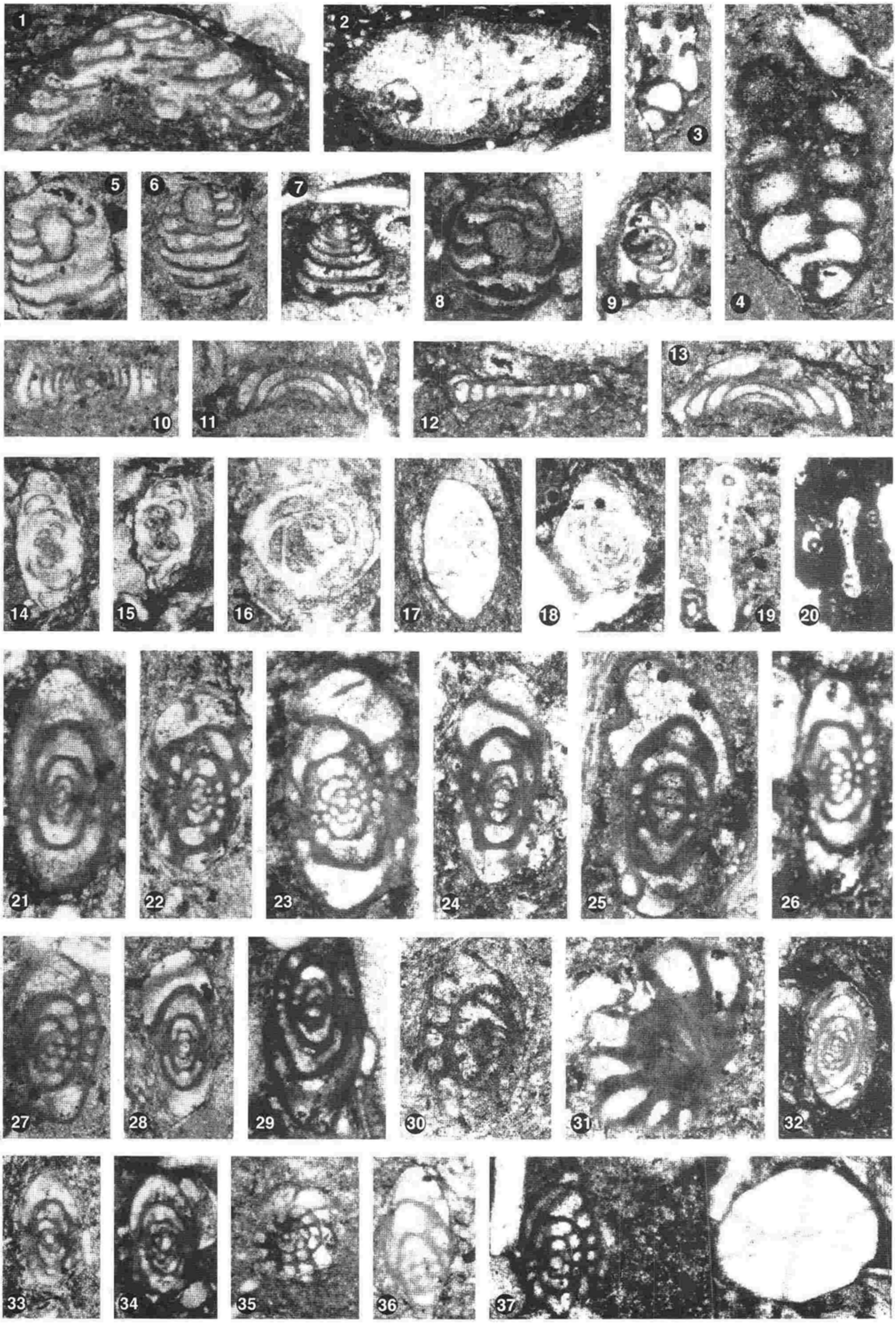
Figs. 19-20. *Tubispirodiscus cornuspiroides* (Brazhnikova and Vdovenko in Brazhnikova et al., 1967); Fig. 19, axial section, sample HE 5, x 90; Fig. 20, axial section, sample HE 5, x 36.

Figs. 21-32. *Eostaffella chomatifera* Kireeva in Rauzer-Chernousova et al., 1951; Fig. 21, axial section, sample B 22, x 90; Fig. 22, subaxial section, sample BX 1, x 90; Fig. 23; subtransverse section showing the initial deviated whorl, sample HE 11, x 90; Fig. 24, axial section, sample BX, x 90; Fig. 25, subaxial section, sample B 22a, x 90; Fig. 26, subaxial section, sample HE 11, x 90; Fig. 27, subtransverse section, sample HE 8/3, x 90; Fig. 28, axial section, sample HE 8/1, x 90; Fig. 29, subaxial section, sample HEX/1, x 90; Fig. 30, subtransverse section, sample HE 10/4, x 90; Fig. 31, subtransverse section showing the chomata, sample HE 7, x 90; Fig. 32, axial section with greyish wall, sample HE 8, x 36.

Figs. 33-35. *Eostaffella* ex gr. *postmosquensis* Rauzer-Chernousova in Rauzer-Chernousova et al., 1951; Fig. 33, axial section, sample BX, x 90; Fig. 34, subaxial section, sample HEX/2, x 90; Fig. 35, transverse section, sample BX, x 90.

Fig. 36. *Plectostaffella* (?) sp.; subaxial section, sample HE 8/4, x 90.

Fig. 37. *Hexaphyllia* sp. Transverse section with *Eostaffella* ex gr. *postmosquensis* (subaxial section), sample HEX/2, x 36.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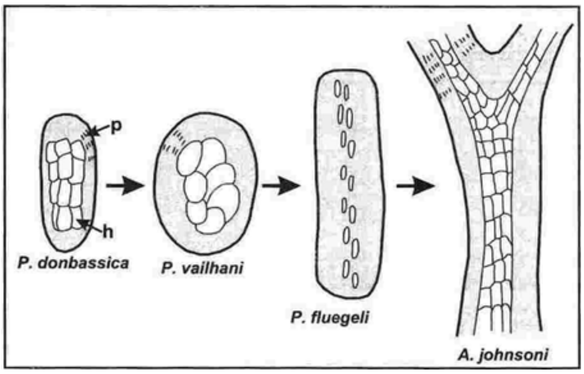

Fig. 4. Hypothetical evolution of *Principia (P.)* and *Archaeolithophyllum (A.)* from the latest Viséan to the early Bashkirian (h = hypothallus, p = perithallus).

Principia fluegeli n. sp.
Pl. 1, Figs. 3-5, Pl. 2, Figs. 2-4, 8, 14, Pl. 3, Fig. 6

Derivatio nominis: Dedicated to Prof. Dr. Erik Flügel, Erlangen, eminent algologist.
Holotype: Pl. 2, Fig. 3 (an axial section in thin section HE 11, housed in the Paleontological Collection of the Institute for Geology and Paleontology, University of Innsbruck).
Paratypes: Pl. 1, Figs. 3-5 (thin section HE 11); Pl. 2, Figs. 2 (HE 8/4), 4 (HE 8/2), 8 (HE 10), 14 (HE 10); Pl. 3, Fig. 6 (same repository).
Type-material: Several hundreds of specimens in 12 great thin sections (some of them are bioclastic packstones, probably calciturbiditic, only composed of *Principia fluegeli* n. sp.).
Locus typicus: Road to Hermsberg (section C on Fig. 2) near Nötsch (Austria).
Stratum typicum: Uppermost Erlachgraben Formation of the Carboniferous of Nötsch, Late Serpukhovian E 2 (= Namurian A pars = Arnsbergian = Zapaltyubinsky).
Diagnosis: *Principia fluegeli* is characterized by its large, elongate articles, showing a rather narrow hypothallus with elongate cells.
Description: The thallus is probably segmented, but the articles are always separated, largely influenced by currents, transportation and redeposition. Articles are large, narrow, cylindrical, with smooth extremities. Cross-sections are circular. The hypothallus consists of polygonal or rectangular cells. The rows of cells are irregularly arranged. The perithallus is recrystallized, relatively thick; cells cannot be distinguished. Conceptacles were not observed.
Dimensions of the holotype: length = 2.830 mm; diameter = 0.420 mm; hypothallus width = 0.110 to 0.270 mm; cell dimensions of hypothallus = 0.015 x 0.050 mm; perithallus thickness = 0.080/0.110 mm. Type-material: length up to 3.120 mm; diameter = 0.420-0.640 mm; hypothallus width = 0.110-0.500 mm; cell dimensions of hypothallus = 0.015-0.030 x 0.050-0.055 mm; perithallus thickness = 0.070-0.110 mm.
Comparisons: *Principia fluegeli* n. sp. differs from other species of the genus *Principia* (*P. donbassicum*, *P.* cf. *donbassicum*, *P. vailhani*) by its great size, the elongate shape of the segments, a rather narrow hypothallus and a proportionally wide perithallus. From *P. donbassicum* sensu Skompski 1986 (Pl. 1, Figs. 1-3), also elongate, *P. fluegeli* differs in shape and size of the hypothallus cells. *Archaeolithophyllum johnsoni* Racz, 1964 is distinguished by an arched, wavy and bifurcated thallus.
Remarks: *P. fluegeli* n. sp. appears as a phylogenetic link between the first Viséan *Principia* (*P.* cf. *donbassicum*, *P. vailhani*) with ellipsoidal articles and the first Bashkirian ribbon-shaped and bifurcated *Archaeolithophyllum* (Fig. 4). *Principia donbassica* (Kosenko, 1972) emend. Brenckle et al., 1982, probably polyphyletic, is now known from the Viséan (late Osagean-middle Meramecian) of North America (Brenckle et al., 1982); the Serpukhovian C_1 3 to the Moscovian C_2 7 of the Donbass (Kosenko, 1972); the late Viséan of the Lublin Basin in Poland (Skompski 1986); and the Serpukhovian E 2 of the Pyrenees (Perret and Vachard, 1977, as aff. *Petschoria* sp.). *Principia vailhani* (Mamet and Roux, 1977) is of latest Viséan age (and/or latest Viséan/earliest Namurian age) in the Montagne Noire, southern France, southern Spain, central and eastern Morocco, Algeria, and South China (Vachard et al. 1989, 1991b; Vachard and Berkli 1992; Delvolve et al. 1994). *Archaeolithophyllum johnsoni*, the first typical representative of this genus, appears exactly at the base of the Bashkirian sensu stricto (= Feninsky substage = goniatite biozone R 1) (Vachard and Maslo 1996: 361, Fig. 2).
Range: Serpukhovian E 2 of the Carboniferous of Nötsch, Austria.

Chlorophyta
Order *Dasycladales*
Family *Seletonellaceae*
Tribe *Cyclocrineae*
Subtribe *Mastoporinae*
Genus *Paraepimastopora* Roux, 1979

Type-species: *Epimastopora kansasensis* Johnson, 1946.
Remarks: *Paraepimastopora kansasensis* is well known owing to the descriptions of Mamet et al. (1987: 35-36, Pl. 7, Figs. 1-4); Roux (1989: 325-332, Pl. 1, Figs. 1-6; Pl. 2, Figs. 1-8; Pl. 3, Figs. 1-2); and Granier and Grgasovic (2000: 118). The species was also anonymously illustrated in the Moscovian of South-Tunisia as "Algues" by Glintzboeckel and Rabate (1964: Pl. 12, Fig. 2; Pl. 26, Figs. 1-2).
Range: Late Serpukhovian (Algeria: Sebbar and Mamet 1976, 1999) to early Sakmarian (with *Epimastopora kanumai* from the "Upper Pseudoschwagerina Limestone" of the Carnic Alps described by Homann 1972). Tethys and North America.

Paraepimastopora noetschensis n. sp.
Pl. 1, Figs. 4, 7, Pl. 2, Figs. 5, 9-11

Derivatio nominis: Discovered in the Carboniferous of Nötsch, Austria (with the latinized orthograph: Noetsch).
Holotype: Pl. 2, Fig. 9 (an axial section in thin section HE 12, housed in the Paleontological Collection of the Institute for Geology and Paleontology, University of Innsbruck).
Paratypes: Pl. 1, Figs. 4 (thin section HE 11), 7 (HE 12); Pl. 2, Figs. 5 (HEX/2), 10 (HE 12), 11 (HEX/1) (same repository).
Type-material: About 30 specimens in 10 great thin sections.

Locus typicus: Road to Hermsberg (section C on Fig. 2) near Nötsch (Austria).
Stratum typicum: Uppermost Erlachgraben Formation, Late Serpukhovian E 2 (= Namurian A pars = Arnsbergian = Zapaltyubinsky), Carboniferous of Nötsch.
Diagnosis: *Paraepimastopora noetschensis* is characterized by its hollow intusannulations, rather frequently ramified laterals, and the complete aspondyly in cross sections.
Description: The new species is represented by four types of sections, whose combination permits its reconstruction (Fig. 5). Most numerous are longitudinal sections (Pl. 2/10) through the wall showing the aspondyl laterals (or primary branchs or R 1) which are sometimes ramified. Some of the sections are cross- or oblique sections (Pl. 2/9), showing irregular rows of the "pores" (i.e. the cross sections of the laterals). Very rare sections show the calcified projections (the so-called "annulation structure" of Roux 1989, and intusannulations for us: Pl. 2/5). A small specimen may correspond to the top of a thallus (the "small forms" of Vachard 1993) (Pl. 2/11). Three orders of ramification can be observed in this section.
Dimensions of the holotype: wall thickness = 0.110 mm; diameter of laterals = 0.030 mm; loops of the intusannulations = 0.410-0.550 x 0.330-0.380 mm with a wall thickness of 0.055 to 0.085 mm. Type-material: length to 3.000 mm; diameter = not estimated (1.000 mm for the small form: Pl. 2/11); wall thickness = 0.100-0.720 mm; diameter of laterals ("pores ") = 0.020-0.030 mm (up to 0.070); interpores = 0.045-0.060 mm.
Comparisons: *Paraepimastopora noetschensis* n. sp. differs from *P. kansasensis* (Johnson, 1946) Roux, 1989 by the hollow and perforated intusannulations, the smaller and more frequently ramified laterals, and the complete irregularity of the aspondyly.
Phylogeny: *P. noetschensis* n. sp. appears prior to "*Epimastopora" bodoniensis* Racz, 1964 from the late Bashkirian of Spain. Therefore *P. noetschensis* is the first known representative of the group of the epimastoporid forms, which constitute the most productive algae during the late Carboniferous - early Permian.
Range: Late Serpukhovian E 2 of the Carboniferous of Nötsch, Austria.

Family *Dasycladaceae*
Tribe *Salpingoporelleae*
Subtribe *Salpingoporellinae*
Genus *Nanopora* Wood, 1964

Type-species: *Nanopora anglica* Wood, 1964.
Range: Rare in the early Viséan (V1a or Cf4α: Hance 1988, Pl. 1, Fig. 4). Relatively abundant from the middle Viséan V2a to the late Serpukhovian (E2) (Perret and Vachard 1977; C_1 n d_1 of the Donbass: Vachard unpublished; Austria: this study).

Nanopora pseudofragilissima n. sp.
Pl. 2, Figs. 6-7, 12-13

p.1972 *Nanopora* cf. *fragilissima* (Maslov) – Mamet and Rudloff, Pl. 13, Figs. 11-12 (non Figs. 7-10, 13-14 = *N. anglica* or *N.* aff. *fragilissima* sensu Mamet and Roux 1975b).
1975b *Nanopora* cf. *fragilissima* (Maslov) – Mamet and Roux, p. 250, Pl. 1, Figs. 1-14.
? 1977 *Nanopora anglica* Wood – Perret and Vachard, p. 24-25, Pl. 4, Figs. 6-7 (the illustrated specimens seem to belong to *N. anglica*, but the indicated pore diameter is 0.003 mm).

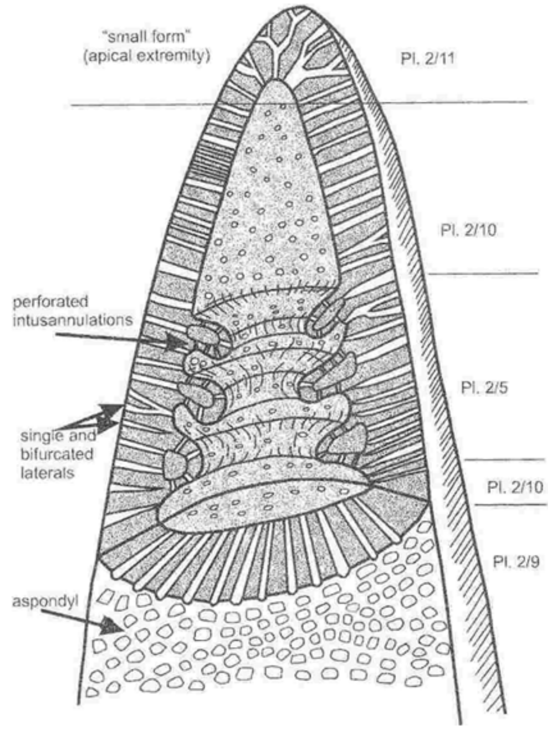

Fig. 5. Idealized reconstruction of *Paraepimastopora noetschensis* n. sp.

Derivatio nominis: Often confused with "*Anthracoporella" fragilissima* Maslov, a homeomorph pseudo-alga belonging to the Issinellids.
Holotype: Pl. 2, Fig. 6 (an axial section in thin section of sample HE 11, housed in the Paleontological Collection, Institute for Geology and Paleontology, University Innsbruck).
Paratypes: Pl. 2, Figs. 7, 12-13 (thin sections HE 12/3, HEX/2 and HE 11; same repository).
Type-material: Two hundred specimens in 10 great thin sections.
Locus typicus: Road to Hermsberg (section C on Fig. 2) near Nötsch (Austria).
Stratum typicum: Uppermost Erlachgraben Formation of the Carboniferous of Nötsch, Late Serpukhovian E 2 (= Namurian A pars = Arnsbergian = Zapaltyubinsky).
Diagnosis: *Nanopora pseudofragilissima* is characterized by the very small diameter of its laterals.
Description: The thallus is cylindrical with a rather large inner cavity and very small euspondyl cylindrical simple laterals.
Dimensions of the holotype: length = 0.970 mm; outer diameter = 0.110 mm; inner diameter = 0.070 mm; wall thickness = 0.020 mm; diameter of laterals = 0.003 mm. Type-material: length up to 1.000 mm; outer diameter = 0.100-0.120 mm; inner diameter = 0.050-0.070 mm; wall thickness = 0.020-0.030 mm; diameter of laterals = 0.003-0.005 mm.

Remarks: The existence of several species of *Nanopora* was admitted by Mamet and Roux (1975b), but negated by Perret and Vachard (1977). *Nanopora pseudofragilissima* n. sp. differs from *Nanopora anglica* Wood by its significantly smaller pore diameter (3 versus 10 microns), and from *Anthracoporella fragilissima* (Maslov) by the nature of the wall; *A. fragilissima* is not a true *Anthracoporella*, but an Issinellid pseudo-alga, more or less similar to *Serrisinella* Vachard, 1991 (compare especially with the material of Bogush et al. 1990: 112-113, Pl. 13, Figs. 5-8). We therefore describe the species *Nanopora pseudofragilissima* n. sp., as a true *Nanopora,* but a false *fragilissima.*
Range: Like that of the genus. Discovered in the late Serpukhovian Erlachgraben Formation of the Carboniferous of Nötsch (Austria).

Phylum indeterminate ("Pseudo-algae")
Class *Algospongia*
Order *Aoujgaliida*
Family *Aoujgaliidae*
Genus *Stacheoides* Cummings, 1955b

Type-species: *Stacheia polytrematoides* Brady, 1876.
Range: Latest Tournaisian (Tn 3c) - Latest Permian (Dorashamian).

Stacheoides cf. *polytrematoides* (Brady, 1876)
Pl. 2, Fig. 15

1876 *Stacheia polytrematoides* Brady, p. 118-119, Pl. 9, Figs. 10-13.
1955b *Stacheoides polytrematoides* - Cummings, p. 344, Figs. 2-3, 7-8.
1977 *Stacheoides polytrematoides* - Mamet and Roux, p. 224-225, Pl. 3, Figs. 3-12.
1977 *Stacheoides polytrematoides* - Perret and Vachard, p. 115-116, Pl. 5, Figs. 2, 7.
1983 *Archaeolithophyllum vailhani* - Mamet and Roux – Aizenverg et al., Pl. 82, Figs. 3, 6-7.
1986 *Stacheoides polytrematoides* - Skompski, p. 270, Pl. 11, Figs. 1-9, Pl. 12, Figs. 1-5, Pl. 14, Figs. 3-4.
1990 *Stacheoides polytrematoides* - Bogush et al., p. 129-130, Pl. 28, Figs. 1-6 (with synonymy).
1991a *Stacheoides polytrematoides* - Vachard et al., Pl. 1, Fig. 16.
1991b *Stacheoides polytrematoides* - Vachard et al., Pl. 1, Fig. 24.
1992 *Stacheoides polytrematoides* - Vachard and Berkhli, Pl. 1, Fig. 22.
1994 *Stacheoides polytrematoides* - Delvolvé et al., Fig. 2: 2.

Remarks: Only a few specimens were observed in the samples BX of the Badstub Formation. The cells are more hemispherical than that of the true *S. polytrematoides*. The investigated taxon is probably identical to the misinterpreted *Archaeolithophyllum vailhani* in the sense of Aizenverg et al. 1983.
Range: Discovered in the late Serpukhovian (E 2) Badstub Formation of the Carboniferous of Nötsch (Austria).

Family *Stacheiidae*
Genus *Fourstonella* Cummings, 1955a

Type-species: *Stacheia fusiformis* Brady, 1876.

Remarks: Two genera are similar to *Fourstonella* Cummings, 1955a by its endoskeleton, but differ by the general morphology and the mode of attachment on the substrate. They are *Eflugelia* Vachard in Massa and Vachard, 1979; and *Chuvashovia* Vachard, 1980. However, the enigmatic *Amorfia jalinki* Racz, 1964 and *Parastacheia iglii* Mamet and Roux, 1977, are probably both diagenetic aspects of *Fourstonella irregularis*.
Range: Late Viséan (zone 16i) - early Moscovian (Kashirsky). Western and Central Tethys, Urals, questionable in North America.

Fourstonella cf. *irregularis* Mamet and Roux , 1977
Pl. 3, Figs. 2-3

?1964 *Amorfia jalinki* Racz, p. 86, Pl. 8, Figs. 1-5.
1977 *Fourstonella irregularis* Mamet and Roux, p. 223, Pl. 2, Figs. 5-7.
?1977 *Parastacheia iglii* Mamet and Roux, p. 221, Pl. 2, Figs. 2-3.
1979 *Fourstonella irregularis* - Massa and Vachard, Pl. 8, Fig. 2, Pl. 9, Fig. 6.
1986 *Fourstonella fusiformis* (Brady) - Skompski, p. 269, Pl. 15, Figs. 1-5.
1990 *Fourstonella irregularis* - Bogush et al., p. 127, Pl. 27, Figs. 6-7.
1999 *Fourstonella irregularis* - Sebbar and Mamet, Pl. 1, Fig. 11.

Remarks: This taxon is very rare; all the observed material is illustrated herein.
Range: Late Viséan (zone 16i) - early Moscovian (Kashirsky). Spain, Algeria, Morocco, Libya, southern France, Poland, Russia (Taymir, Karaulak). Discovered in the late Serpukhovian (E 2) Erlachgraben Formation of the Carboniferous of Nötsch (Austria).

Family *Donezellidae*
Genus *Fasciella* Ivanova, 1973

Type-species: *Fasciella kizilia* Ivanova, 1973.
Range: Very rare and questionable in the latest early Viséan (upper V1b) with a taxon probably intermediate between *Pseudostacheoides* and *Fasciella* (Vachard, unpublished). Middle Viséan (V2a: Vachard 1976) - earliest Bashkirian (Voznesensky); cosmopolite.

Fasciella cf. *kizilia* Ivanova, 1973
Pl. 2, Fig. 2?, Pl. 3, Figs. 4, 6?, 10

1973 *Fasciella kizilia* Ivanova, p. 39, Pl. 21, Fig. 2, Pl. 27, Figs. 1-6.
1973 *Shartymophycus fusus* Kulik in Einor, p. 45-46, Pl. 3, Fig. 7, Pl. 4, Figs. 2-6.
1975a *Shartymophycus fusus* - Mamet and Roux, p. 168-170, Pl. 4, Figs. 2-17, Pl. 15, Figs. 1-16.
1977 *Fasciella kizilia* - Mamet and Roux, p. 246.
1980 *Shartymophycus fusus* - Buchroithner et al., p. 27-28, Figs. 3.1, 8, 4.9.
1983 *Shartymophycus fusus* - Aizenverg et al., Pl. 79, Figs. 1-3.
1984 *Fasciella kizilia* - Saltovskaya, p. 157, Pl. 39, Figs. 3-5.
1990 *Fasciella kizilia* - Bogush et al., p. 120-121, Pl. 17, Figs. 4-7 (with synonymy).

Remarks: Additional to the typical sections illustrated herein (Pl. 3/4, 10)some forms occur which may correspond to an atypical *Fasciella* or to an initial attached stage of *Frustulata*

or *Praedonezella* (Pl. 2/2, Pl. 3/6). We have encountered the same problem in the Pyrenees (Perret and Vachard 1977), and indicated a possible synonymy of this stage of development with *Iberiaella* Racz, 1984. Some relations may also exist with *Claracrusta* Vachard, 1980.
Range: Like that of the genus. Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Genus *Frustulata* Saltovskaya, 1984

Type-species: *Frustulata asiatica* Saltovskaya, 1984.
Synonyms: ? *Calcifolium* sensu Kulik 1973 and sensu Perret and Vachard 1977 (pars); ? *Donezella* sensu Buchroithner et al. 1980 (pars); ? *Pseudodonezella* Mamet and Herbig, 1990.
Range: Late Viséan (?) - Serpukhovian, western and central Tethys.

Frustulata cf. *asiatica* Saltovskaya, 1984
Pl. 3, Figs. 1, 5

?1973 *Calcifolium okense* (Shvetsov and Birina) – Kulik, p. 40, Pl. 2, Figs. 3-4; tabl. 1 on p. 49.
?1980 *Donezella lutugini* Maslov – Buchroithner et al., p. 25-26, Pl. 2, Fig. 5, Pl. 5, Figs. 7-9.
cf.1984 *Frustulata asiatica* Saltovskaya, p. 39, Pl. 21, Fig. 2, Pl. 27, Figs. 1-6.
cf.1990 *Frustulata asiatica* - Bogush et al., Pl. 18, Fig. 8, Pl. 19, Figs. 1-5.
?.1990 *Pseudodonezella tenuissima* (Berchenko) - Mamet and Herbig, p. 202-203, Pl. 1, Figs. 1-7, Pl. 2, Figs. 1-18.
? 1991a *Calcifolium okense* - Vachard et al., p. 253, Pl. 1, Figs. 14-15.
? 1994 *Calcifolum okense* - Delvolvé et al., Fig. 2: 5.

Remarks: This poorly known phylloid yellow pseudo-alga is rather rare in the Serpukhovian of Nötsch. Some misinterpreted *Calcifolium okense* of the literature are probably *Frustulata*. *Pseudodonezella tenuissima* is probably also a synonym of *Frustulata asiatica*.
Range: Viséan (?) of Tian Shan; early Serpukhovian of the eastern slope of the southern Urals and of Spain; late Viséan - Serpukhovian of other parts of Russia; late Serpukhovian of the French Pyrenees. Discovered in the late Serpukhovian Erlachgraben Fm. of the Carboniferous of Nötsch, Austria.

Kingdom *Animalia*
Order *Foraminiferida*
Suborder *Fusulinina*
Family *Earlandiidae*
Genus *Earlandia* Plummer, 1930

Type species: *Earlandia perparva* Plummer, 1930.
Range: Tournaisian - early Permian (up to the Mesozoic if admitted the synonym of *Earlandia* and *Aeolisaccus*); cosmopolite.

Earlandia ex gr. *vulgaris* (Rauzer –Chernousova and Reitlinger, 1937)
Pl. 3, Figs. 7-8

1937 *Hyperammina vulgaris* Rauzer–Chernousova and Reitlinger in Rauzer–Chernousova and Fursenko, p. 256, Fig. 190.
1955c *Earlandia pulchra* Cummings, p. 228-229, Pl. 1, Figs. 1, 15, 21.
1956 *Hyperammina vulgaris* - Brazhnikova, p. 19, Pl. 2, Figs. 4-5.
1964 *Earlandia vulgaris* var. *vulgaris* - Conil and Lys, p. 53, Pl. 7, Fig. 95.
1977 *Earlandia* of the group *E. vulgaris* - Armstrong and Mamet, p. 26-27, Pl. 1, Fig. 7, Pl. 13, Figs. 2, 6, Pl. 14, Fig. 5, Pl. 20, Fig. 5.
1983 *Gigasbia gigas* Strank, p. 436, Pl. 54, Figs. 1-5.
1998 *Earlandia* du groupe *E. vulgaris* - Pinard and Mamet, p. 11-12, Pl. 1, Fig. 8 (with synonymy).

Remarks: The large forms of *Earlandia* (diameter of the tubes 0.300-0.400 mm) belong to *E.* ex gr. *vulgaris*. The rare specimens occurring in the Erlachgraben Formation of the Carboniferous of Nötsch show the following dimensions: length = 0.830-1.000 mm; external diameter = 0.320-0.330 mm; internal diameter = 0.170-0.180 mm; wall thickness = 0.075 mm; diameter of proloculus = 0.280 mm.
Range: Late early Viséan (V1b) - late Serpukhovian (E2). Discovered in the late Serpukhovian Erlachgraben Formation of the Carboniferous of Nötsch, Austria.

Family *Endothyridae*
Genus *Endothyra* Phillips, 1846
emend. Brady, 1876 emend. China, 1965

Type species: *Endothyra bowmani* Phillips, 1846 emend. Brady, 1876 emend. China, 1965.
Range: Late (?) Tournaisian - early Permian (in the Devonian or early-middle Tournaisian other genera are present e.g. *Laxoendothyra*, *Latiendothyra*, *Spinoendothyra* and, *Inflatoendothyra*; all with glomospiranelloid juvenaria; true *Endothyra* appear probably in the late Tournaisian, derivating from *Chernyshinella*. In the middle-late Permian only *Neoendothyra* is present. The *Endothyra* of the Triassic must be reinterpreted).

Endothyra ex gr. *bowmani* Phillips, 1846
emend. Brady, 1876 emend. China, 1965
Pl. 3, Fig. 9

non 1843 *Endothyra bowmani* Phillips in Brown, p. 17, Pl. 4, Fig. 2 (invalid, opinion 724, Cinz 1965).
non? 1846 *Endothyra bowmani* Phillips, p. 279, Pl. 7, Fig. 1 (*Endothyranopsis* or *Latiendothyranopsis*).
1876 *Endothyra bowmani* Phillips – Brady, p. 92-94, Pl. 12, Figs. 2, 5.
1939 *Endothyra bradyi* Mikhailov, p. 51-52, Pl. 4, Figs. 1-2.
1977 *Endothyra* of the group *E. bowmani* Phillips? emend. Brady – Armstrong and Mamet, p. 67-68, Pl. 31, Figs. 14-16 (with synonymy).
1998 *Endothyra* du groupe *E. bowmani* Phillips emend. Brady emend. Cinz -Pinard and Mamet, p. 70-72, Pl. 33, Figs. 11, 14-15, Pl. 34, Fig. 13, Pl. 35, Figs. 1?, 7 (with synonymy).

Remarks: As a result of a particularly sterile discussion, *Endothyra bowmani* has been fixed with a holotype which does neither correspond to the figure of Phillips (1846) (a *Latiendothyranopsis* or an *Endothyranopsis*, not an *Endothyra*), nor to the figure of Brown (1843) (an *Eostaffella* or *Pseudoendothyra* in transverse section). Despite the official decision (China 1965), this species should better be

named *Endothyra bradyi* Mikhailov, 1939, as during a long time in the Russian literature, or even *Plectogyra bradyi*.
Dimensions: The figured specimen, representative of all the material, exhibits the following dimensions: diameter = 0.430 mm; width = 0.310 mm; ratio width/diameter = 0.72; whorls = 3; height of last whorl (h) = 0.110 mm; wall thickness (w) = 0.005 mm; proloculus diameter = 0.040 mm.
Range: Latest Tournaisian - early Viséan (?). Middle Viséan - Artinskian or Kungurian (late early Permian); cosmopolite.

Genus *Endothyranopsis* Cummings, 1955a

Type species: *Involutina crassa* Brady in Moore, 1870.
Range: Questionable in the late early Viséan (late V 1b); middle Viséan (V 2a) to late Serpukhovian (E 2); principally late Viséan (V 3bγ).

Endothyranopsis plana Brazhnikova
in Brazhnikova et al., 1967
Pl. 3, Figs. 11-19

1967 *Endothyranopsis compressa plana* Brazhnikova in Brazhnikova et al., p. 152-153, Pl. 49, Figs. 1-4, 7, 10-11.
1983 *Endothyranopsis plana* - Aizenverg et al., Pl. 8, Figs. 5-6.
?1997 *Endothyranopsis* aff. *compressa* - Lisrak and Ross, Pl. 1, Figs. 15-18.

Remarks: *Endothyranopsis plana* is probably the last species of the genus. Poorly signalized, it exists probably in all the Tethys region, and perhaps in America (Lisrak and Ross 1997).
Dimensions: diameter = 0.440-0.640 mm (diagnosis = 0.370-0.600); width = 0.270-0.360 mm (diagnosis = 0.260-0.460); ratio width/diameter = 0.50-0.61 (diagnosis = 0.58-0.67); whorls = 2.5 (rarely 3) (diagnosis = 2.5-3); chambers : 8 (diagnosis = 8-9); height of last chamber (h) = 0.130-0.170 mm (diagnosis = 0.150); wall thickness (w) = 0.030-0.060 mm (diagnosis = 0.040-0.060); proloculus diameter = 0.030-0.060 mm (diagnosis = 0.040-0.060).
Range: Horizon VIII, C_1n c-C_1n d_1, limestones D_3 and D_5 of Donetz Basin (Ukraine); late Viséan of Thailand and Morocco.

Family *Bradyinidae*
Genus *Bradyina* von Moeller, 1878

Type species: *Bradyina nautiliformis* von Moeller, 1878.
Range: Late Viséan (V3bγ = 16 i = Cf6γ) to Sakmarian. The last "*Bradyina*" of the middle-late Permian in fact belong to another genus: *Postendothyra*.

Bradyina cf. *concinna* Reitlinger, 1950
Pl. 4, Fig. 2

1950 *Bradyina concinna* Reitlinger, p. 39, Pl. 8, Fig. 7.
1998 *Bradyina concinna* - Pinard and Mamet, p. 123-124, Pl. 38, Fig. 12, Pl. 40, Fig. 4, Pl. 41, Figs. 1, 6, Pl. 42, Figs. 3-4.

Remarks: A unique section of a deformed *Bradyina* of 1.400 mm in diameter, and a wall thickness of 0.050 mm, can be assigned to the group *B. concinna*, and not to the groups *B. rotula* or *B. cribrostomata* (as defined by Pinard and Mamet 1998).
Range: Serpukhovian - Kasimovian - Gzhelian? Tethys and North America.

Family *Tetrataxidae*
Genus *Tetrataxis* Ehrenberg, 1854

Type species: *Tetrataxis conica* Ehrenberg, 1854 emend. Nestler, 1873.
Range: Latest Tournaisian (Tn 3c) - latest Permian (Changxingian).

Tetrataxis ex gr. *palaeotrochus*
(Ehrenberg, 1854) emend. Nestler, 1973
Pl. 3, Fig. 1

1854 *Textilaria palaeotrochus* Ehrenberg, p. 25, Pl. 37, Figs. X/A 1-4.
1876 *Valvulina palaeotrochus* - Brady, p. 83-85, Pl. 4, Figs. 1-4, Pl. 12, Fig. 4.
1879 *Tetrataxis conica* - von Moeller, p. 107-109, Pl. 2, Figs. 3 a-g, Pl. 7, Figs. 1-2, Fig. 30 in text on p. 108.
1973 *Tetrataxis palaeotrochus* - Nestler, Pl. 1, Figs. 6-8.
1975 *Tetrataxis palaeotrochus* - Termier et al., p. 50, Pl. 5, Fig. 10, Pl. 6, Fig. 3.
1977 *Tetrataxis* of the group *T. conica* - Armstrong and Mamet, p. 97-98, Pl. 35, Figs. 11-13.
1993 *Tetrataxis* du groupe *conica* - Perret, p. 430.
1998 *Tetrataxis* du groupe *T. conica* - Pinard and Mamet, p. 95-97, Pl. 23, Figs. 11-13, Pl. 24, Fig. 10, text-fig. 10.1-2 on p. 89.

Remarks: The illustrated specimen is representative of all the sections, displaying the following dimensions: diameter = 1.500 mm; height = 0.670 mm; ratio height/diameter = 0.45; whorls = 6; apical angle = 90°.

The Carboniferous *Tetrataxis conica* does not correspond to the species described by Ehrenberg, 1854, which is a late Permian species, but is generally similar to *T. palaeotrochus* (Brady, 1876) (see the revision of Nestler 1973). Well preserved true *Tetrataxis conica* have been illustrated by Fontaine et al. (1994, Pl. 4, Figs. 1-6, Pl. 17, Figs. 1, 3-5). There is probably no true specific limit between *T. palaeotrochus* and *T. bogushi* Ueno and Nakazawa, 1993 (= *T. lata* Bogush and Juferev, 1962, preoccupied), *T. quasiconica* Brazhnikova, 1956, and all the other "species" summarized by Armstrong and Mamet (1977) and Pinard and Mamet (1998).
Range: Early - middle Carboniferous.

Family *Palaeotextulariidae*
Pl. 4, Fig. 3-4

Very few sections were observed. One is a *Palaeotextularia* sensu stricto or a young *Climacammina* (Pl. 4/4); the second one is an oblique section of *Koskinobigenerina* (Pl. 4/3). Serpukhovian Palaeotextulariidae are well described by Aizenverg et al. (1983).

Superfamily *Lasiodiscoidea*

Composition: (1) Howchiniidae Martini and Zaninetti, 1988 = Vissariotaxidae Reitlinger in Vdovenko et al., 1993; (2) Lasiodiscidae Reitlinger, 1956 =? Turrispiroidae Mamet and Pinard, 1992; (3) Pseudovidalinidae Altiner, 1988 emend. Pinard and Mamet, 1998.

Remarks: For the Howchiniidae/Lasiodiscidae the Serpukhovian is a significant period of diversification (Fig. 6). The Carboniferous of Nötsch, containing *Howchinia gibba* and *Eolasiodiscus dilatatus*, is important for the knowledge of the group, like the Donbass (Reitlinger 1956, Brazhnikova and Yartseva 1956, Aizenverg et al. 1983) and the French Pyrenees (Perret 1993).

In our opinion *Howchinia* and *Vissariotaxis* belong to the same family: Howchiniidae. However, Turrispiroidae sensu Pinard and Mamet 1998 is theoretically synonymous to Lasiodiscidae, but we think that "*Turrispiroides*" is not a Lasiodiscoidea but a Miliolina Cyclogyridae, therefore a homeomorph of another suborder.

Range: Late Viséan V3bβ with *Vissariotaxis* to latest Permian (Dorashamian) with *Lasiodiscus* and various Pseudovidalinidae.

Family *Howchiniidae*
Genus *Howchinia* Cushman, 1927

Type species: *Patellina bradyana* Howchin, 1888.

Range: Late Viséan (V3bγ) - late Serpukhovian (E2). Up to the Bogdanovsky stage (= *Homoceras* zone = Voznesensky) in the southern Urals (Kulagina et al. 1992, Fig. 4 p. 10 and Fig. 8 p. 15).

Howchinia gibba (von Moeller, 1879)
Pl. 4, Figs. 5-8

p. 1879 *Tetrataxis conica* var. *gibba* von Moeller, p. 110, Pl. 7, Fig. 3 (not Pl. 2, Figs. 4a-c: a true *Tetrataxis*).
1948 *Monotaxis gibba* - Vissarionova, p. 193-194, Pl. 8, Figs. 9-11.
1956 *Monotaxis gibba* - Brazhnikova, p. 56-57, Pl. 2, Fig. 8, Pl. 10, Fig. 16, Pl. 13, Fig. 5.
1962 *Howchinia (Monotaxis) gibba* - Bogush and Juferev, p. 211, Pl. 9, Fig. 24.
1964 *Howchinia gibba* - Conil and Lys, p. 98, Pl. 14, Fig. 264.
1967 *Howchinia gibba* - Brazhnikova et al., Pl. 15, Fig. 9, Pl. 17, Figs. 9-10.
1968 *Howchinia bradyana = H. gibba* - Mamet, p. 125, Pl. 5, Figs. 5-6.
1983 *Howchinia gibba* - Aizenverg et al., Pl. 14, Figs. 14-15.
non 1993 *Howchinia gibba* - Ueno and Nakazawa, p. 15-16, Figs. 3.25-26 (= *H. bradyana*) (with synonymy).
1993 *Howchinia bradyana* - Perret, p. 421, Pl. F 5, Fig. 11 (with synonymy).
p.2000 *Howchinia bradyana* - Cózar, p. 206, Pl. 2, Figs. 11, 15.

Remarks: Like Mamet (1968: 125), we have always regarded *H. gibba* as a synonym of *H. bradyana*. Apparently, Ueno and Nakazawa (1993) consider *H. bradyana* and *H. gibba* as two different species. Evidently, our investigated samples correspond only to the small species, i.e. *H. gibba*. We accept therefore this species herein to be different to *H. bradyana* by several parameters: length, apical angle, number of whorls, greater number of perforations on the surface.

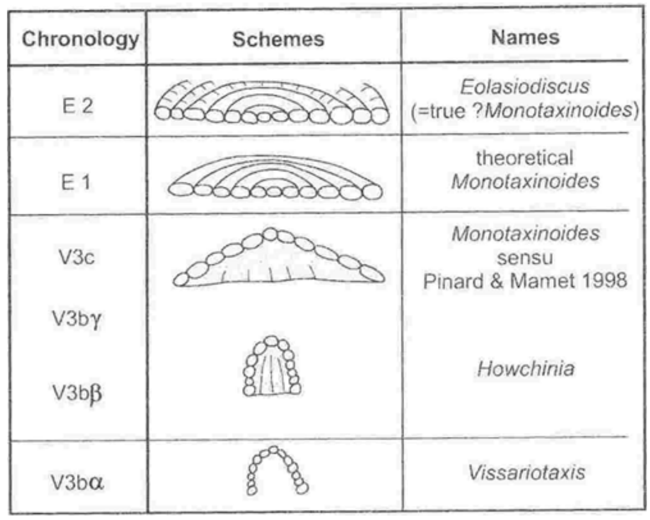

Fig. 6. The phylogenetic evolution of the Lasiodiscacea.

In fact, three species are very similar: *H. gibba* (von Moeller, 1879 emend. Vissarionova, 1948) with 7-8 whorls, *H. bradyana* (Howchin, 1888) with 9-12 whorls and *H. longa* (Brazhnikova, 1956) with 13-14 whorls.

Dimensions: height = 0.420-0.720 mm; diameter = 0.470-0.550 mm; ratio H/D = 0.77-1.19; whorls = 7-8; proloculus diameter = 0.030 mm; umbilicus diameter = 0.070-0.190 mm; height of last chamber = 0.100-0.110 mm; wall thickness = 0.030-0.050 mm.

Range: Well known in the late Viséan, the species occurs also in the Serpukhovian (Aizenverg et al., 1983: limestones C_4 and $D_1 2^{inf}$)

Family *Lasiodiscidae*
Genus *Eolasiodiscus* Reitlinger, 1956

Type-species: *Eolasiodiscus donbassicus* Reitlinger, 1956.

Range: Serpukhovian (E 2) to Permian (as "*Lasiodiscus*" or "*Hemidiscus*").

Eolasiodiscus dilatatus Potievskaya, 1964
Pl. 4, Figs. 10-13

1964 *Eolasiodiscus dilatatus* Potievskaya, p. 40-42, Pl. 2, Figs. 3-8.
1967 *Eolasiodiscus dilatatus* - Brazhnikova et al., Pl. 23, Fig. 3.
1983 *Eolasiodiscus* ex gr. *donbassicus* Reitlinger – Aizenverg et al., Pl. 12, Figs. 30-39.

Remarks: This small species differs from *E. donbassicus* by the smaller number of whorls.

Dimensions: diameter = 0.280-0.380 mm (diagnosis = 0.280-0.590); width = 0.110 mm (diagnosis = 0.040-0.080); ratio width/diameter = 0.40; whorls = 5-7 (diagnosis = 5-6); proloculus diameter = 0.015 mm (diagnosis = 0.040-0.060); wall thickness = 0.005-0.007 mm (diagnosis = 0.005-0.015); height of the last chamber = 0.025-0.030 mm (diagnosis = 0.022-0.044).

Range: Donbass: suite C_1 5, limestones E_6, suite C_1 5 limestones E_7, E_8, E_8 3; $C_2 b^{h+c}$ (lower part); limestones D_3, D_5 D_5 4, D_5 7. Discovered in the Erlachgraben Fm. (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Family *Archaediscidae*
Genus *Archaediscus* Brady, 1873

Type species: *Archaediscus karreri* Brady, 1873.
Remarks: Two main conceptions exist for the genus *Archaediscus*: *Archaediscus* sensu lato (Pirlet and Conil 1974, Vachard 1988), and *Archaediscus* sensu stricto (Brenckle et al. 1987). An attempt to conciliate the two classifications is presented on Fig. 7.
Remarks: It is very difficult to separate practically aligned coilings becoming planispiral at the end of the growth, with planispirally coiling slightly deviated at the beginning. Particularly the boundary between *Betpakodiscus* and *Tubispirodiscus* is imprecise.
Range: *Archaediscus* (sensu lato) appears at the late early Viséan (late V1b) and disappears in the earliest Moscovian (Vereisky).

Archaediscus (at concavus stage) ex gr. *convexus*
Grozdilova and Lebedeva in Dain and Grozdilova, 1953
Pl. 4, Figs. 9, 14-15

1953 *Archaediscus convexus* Grozdilova and Lebedeva in Dain and Grozdilova, 1953, p. 91-92, Pl. 2, Fig. 11.
1964 *Archaediscus convexus* var. *convexa* - Conil and Lys, p. 108-109, Pl. 15, Figs. 276-281.
1993 *Paraarchaediscus convexus* - Brenckle and Grelecki, p. 29-30, Pl. 6, Figs. 7-8.

Remarks: The observed *Archaediscus* at the concavus stage generally show the characteristics of *A. convexus*. Diameter (D) = 0.200-0.220 mm; width (w) = 0.120-0.130 mm; w/D = 0.55-0.65; whorls = 5-6. One specimen (Pl. 4/14) is aligned at the end of the coiling and looks like *A. koktjubensis*, but it can be also *A. convexus sarbaicus* Popova and Reitlinger in Einor (1973) (nomen nudum). Dimensions: diameter = 0.300 mm; width = 0.140 mm; width/diameter = 0.47; whorls = 7.5.
Range: Poorly known (probably middle Viséan to Bashkirian).

Genus *Betpakodiscus* Marfenkova, 1983

Type species: *Propermodiscus (?) attenuatus* Marfenkova, 1978.
Range: Latest Viséan to Bashkirian.

Betpakodiscus cf. *donetzianus* (Sosnina
in Dain and Grozdilova, 1953)
Pl. 4, Figs. 16-17

1953 *Archaediscus donetzianus* Sosnina in Dain and Grozdilova, p. 93-94, Pl. 2, Figs. 13-16.
1958 *Archaediscus donetzianus* - Potievskaya, p. 26-27, Pl. 4, Fig. 7.
1979 *Archaediscus donetzianus* - Massa and Vachard, Pl. 7, Figs. 18, 24.
1983 *Archaediscus donetzianus* - Aizenverg et al., Pl. 21, Figs. 18, 22.

Remarks: *B. donetzianus* is an oscillating *Archaediscus* (*chernoussovensis* group) at angulatus stage.
Range: Serpukhovian-Bashkirian from Donbass and North Africa. Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Betpakodiscus (?) aff. *variabilis* (Reitlinger, 1950)
Pl. 4, Fig. 18

1950 *Archaediscus variabilis* Reitlinger, p. 86, Pl. 18, Figs. 1-3.
1983 *Archaediscus* ex gr. *variabilis* - Aizenverg et al., Pl. 21, Figs. 19-20.
1993 *Archaediscus variabilis* = *Archaediscus ? variabilis* - Brenckle and Grelecki, p. 28, Pl. 4, Figs. 17-19.

Remarks: A very questionable section is related herein with *B. (?) variabilis*, itself poorly described.
Range: Bashkirian of Timan and Donbass. Discovered in the late Serpukhovian Erlachgraben Formation of Nötsch.

Genus *Tubispirodiscus* Browne and Pohl, 1973

Type species: *Tubispirodiscus simplicissimus* Browne and Pohl, 1973 emend. Vachard, 1980.
Range: Apparently from the latest Viséan (V3c) to lthe ate Serpukhovian (E2), and considered as characteristic of the early Serpukhovian E1 by Vachard (1980). The actually known distribution is puzzling: Ukraine, Spain, Italy?, Belgium?, North Africa?, Afghanistan, North America. Discovered in the Serpukhovian Erlachgraben Formation of the Carboniferous of Nötsch, Austria.

Tubispiroides ex gr. *cornuspiroides*
(Brazhnikova and Vdovenko in Brazhnikova et al., 1967)
Pl. 3, Figs. 19-20

1967 *Archaediscus* (?) *cornupiroides* Brazhnikova and Vdovenko in Brazhnikova et al., p. 162-163, Pl. 16, Figs. 13-14, 18, 21, Pl. 54, Figs. 11, 14-19, Pl. 55, Fig. 1.
? 1980b [Archaediscids] – Pasini, p. 344-345, Figs. 1a-e in text on p. 344.
1980 *Tubispirodiscus cornupiroides* - Vachard, p. 303-304, Pl. 17, Figs. 3, 11-12.
1993 *Tubispirodiscus cornuspiroides* - Perret, Pl. F 10, Figs. 1-2, Pl. F 11, Fig. 7.
1996 *Tubispirodiscus cornuspiroides* - Vachard and Montenat, Pl. 2, Figs. 23-25.
2000 *Browneidiscus simplissimus* (Browne and Pohl) – Cózar, p. 200, Pl. 1, Fig. 15.

Remarks: In general, the material is strongly recrystallized but its dimensions and shape are characteristic of the group *T. cornuspiroides*, despite the late rounded whorls which are more similar to *Browneidiscus*.
Range: Like that of the genus.

Genus *Asteroarchaediscus* Miklukho-Maclay
in Kiparisova et al., 1956

Type species: *Archaediscus baschkiricus* Krestovnikov and Teodorovich, 1936.
Range: Latest Viséan (V3c) to earliest Moscovian.

Asteroarchaediscus parvus (Rauzer-Chernousova, 1948a)
(not figured)

1948a *Archaediscus parvus* Rauzer-Chernousova, p. 233, Pl. 16,

Stages of development (PIRLET & CONIL 1974)	no planispirally coiling (sigmoidal to aligned)	planispirally coiling (or dominantly planispiral)
Archaediscus involutus stage	***Propermodiscus*** proposed herein (= ***Paraarchaediscus*** sensu BRENCKLE et al. 1987)	***Conilidiscus***
Archaediscus concavus stage	***Archaediscus*** sensu stricto (BRENCKLE et al., 1987)	***Pirletidiscus***
Archaediscus angulatus stage	***Betpakodiscus*** proposed herein	***Tubispirodiscus***
Archaediscus tenuis stage	not named	***Browneidiscus***

Fig. 7. New proposals for classifying the genus *Archaediscus* and closely related forms (synonyms?).

Figs. 9-12.
1953 *Archaediscus parvus* var. *parvus* - Grozdilova in Dain and Grozdilova, p. 104-105, Pl. 4, Fig. 6.
1973 *Asteroarchaediscus parvus* - Popova and Reitlinger in Einor, p. 57.
1977 *Neoarchaediscus parvus* - Armstrong and Mamet, p. 39, Pl. 27, Figs. 11-12.
1983 *Neoarchaediscus parvus* - Aizenverg et al., Pl. 22, Figs. 12-13.
1993 *Archaediscus parvus* = *Asteroarchaediscus rugosus* - Brenckle and Grelecki, p. 21-22, Pl. 2, Figs. 13-17, 22.
1993 *Neoarchaediscus parvus* - Ueno and Nakazawa, p. 14-15, Figs. 4.13-17 (with synonymy).
1993 *Neoarchaediscus parvus* - Vdovenko and Zhulitova in Makhlina et al., p. 155-156, Pl. 20, Figs. 9-13, 14?, 15?
2000 *Neoarchaediscus parvus* - Cózar, p. 203, Pl. 2, Fig. 9.

Remarks: *Asteroarchaediscus* is rare in the Carboniferous of Nötsch. The specimens belong to the group of small, discoidal and aligned forms, i. e. *A. parvus*.
Range: Latest Viséan to Bashkirian; probably cosmopolitan.

Family *Ozawainellidae*
Subfamily *Eostaffellinae*
Genus *Eostaffella* Rauzer-Chernousova, 1948b

Type-species: *Eostaffella parastruvei* Rauzer-Chernousova, 1948b.
Range: Early Viséan (V1a) to latest Carboniferous (Orenburgian); cosmopolitan.

Eostaffella chomatifera Kireeva, 1951
Pl. 1, Fig. 6, Pl. 4, Figs. 21-32

1951 *Eostaffella pseudostruvei* var. *chomatifera* Kireeva in Rauzer-Chernousova et al., p. 59, Pl. 1, Figs. 11-13.
?1961 *Eostaffella constricta* Ganelina – Saurin, p. 223, Pl. 7, Fig. 10.
1962 *Eostaffella pseudostruvei* var. *chomatifera* - Bogush and Juferev, p. 177-178, Pl. 7, Fig. 1.
?1962 *Eostaffella constricta* - Bogush and Juferev, p. 169-170, Pl. 6, Fig. 21.
1967 *Eostaffella (Eostaffella) pseudostruvei* var. *chomatifera* - Brazhnikova et al., Pl. 21, Figs. 10-11.
1970 *Eostaffella pseudostruvei* var. *chomatifera* - Rumyantseva, Pl. 7, Figs. 5-7.
1970 *Eostaffella constricta asiatica* Rumyantseva, p. 150-151, Pl. 6, Figs. 8-11.
1979 *Eostaffella pseudostruvei chomatifera* - Bensaid et al., Pl. 17, Figs. 1-2.
1983 *Eostaffella pseudostruvei* var. *chomatifera* - Aizenverg et al., Pl. 11, Fig. 10.
?1993 *Eostaffella constricta* - Vdovenko and Zhulitova in Makhlina et al., Pl. 21, Figs. 17-18?
1997 *Eostaffella chomatifera* - Maslo and Vachard, p. 44 (with synonymy).

Remarks: *Eostaffella chomatifera* is a compressed form of the group *E. parastruvei-mosquensis*. It is very similar to *E. constricta* Ganelina, 1951, which differs only by the smaller chomata, although some *E. constricta* of the literature seem to belong to *E. chomatifera*.
Dimensions: diameter = 0.330-0.520 mm (diagnosis = 0.380-0.610); width = 0.144-0.245 mm (diagnosis = 0.140-0.250); ratio width/diameter = 0.40-0.50 (diagnosis = 0.41-0.50); number of whorls = 3-5 (diagnosis = 4-5); diameter of proloculus = 0.010-0.022 mm (diagnosis = 0.025-0.030) number of chambers = 12-14 (not mentioned in the diagnosis); height of the last whorl = 0.080-0.120 mm; wall thickness = 0.005-0.017 mm (diagnosis = 0.007-0.012).
Range: Late Serpukhovian-Bashkirian. Known from the former USSR, North Africa, Spain. Questionable in south-east Asia (Saurin 1961) and in central Asia (Bogush and Juferev 1962), where the species is effectively present with *Eostaffella constricta asiatica* Rumyantseva, 1970. Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Eostaffella ex gr. *postmosquensis* Kireeva, 1951
Pl. 4, Fig. 33-35, 37

1951 *Eostaffella postmosquensis* Kireeva in Rauzer-Chernousova et al., p. 48-49, Pl. 1, Figs. 1-2.
1962 *Eostaffella postmosquensis* - Bogush and Juferev, p. 178-179, Pl. 7, Fig. 3.
1970 *Eostaffella postmosquensis* - Rumyantseva, p. 151-152, Pl. 6, Figs. 12-14.
1973 *Eostaffella postmosquensis* - Popova and Reitlinger in Einor, p. 62, Pl. 10, Figs. 1-2.
1983 *Eostaffella postmosquensis* - Aizenverg et al., Pl. 11, Figs. 18-19.
1988 *Eostaffella postmosquensis* - Groves, p. 372, 388, Figs. 13: 14-25 (with synonymy).
1993 *Eostaffella postmosquensis* - Vdovenko and Zhulitova in Makhlina et al., Pl. 21, Figs. 26, 27?
1997 *Eostaffella postmosquensis* - Maslo and Vachard, p. 45 (with synonymy).

Remarks: The investigated specimens correspond exactly to *E. postmosquensis* sensu Groves (1988), but (1) differ sligthly from the original figurations of *E. postmosquensis*; (2) may correspond to juvenile stages of *E. chomatifera* described above.

Dimensions: diameter = 0.200-0.300 mm (diagnosis = 0.220-0.330); width = 0.095-0.145 mm (diagnosis = 0.120-0.220); ratio width/diameter = 0.47-0.54 (diagnosis = 0.50-0.56); number of whorls = 3-4; generally 3.5 (diagnosis = 3.5-4.5; generally 4); diameter of proloculus = 0.015-0.022 mm (diagnosis = 0.027-0.035; generally 0.030); number of chambers = 10-16 (not mentioned in the diagnosis); height of the last whorl = 0.040-0.072 mm; wall thickness = 0.005-0.010 mm (diagnosis = 0.010-0.015).

Range: Early Serpukhovian - early Moscovian. Tethys, South and North America.

Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

Genus *Plectostaffella* Reitlinger, 1971

Type-species: *Eostaffella (Plectostaffella) jakhensis* Reitlinger, 1971.

Range: Questionable in the late Serpukhovian. Early to late Bashkirian.

Plectostaffella (?) sp.
Pl. 4, Fig. 36

Remarks: We identified only one incomplete section, affected by pressure solution phenomena at its periphery (approximative diameter = 0.400 mm).

Several compressed species of *Plectostaffella* are relatively similar: *Plectostaffella evolutica* (Rumyantseva, 1970); *P. berestovensis* Brazhnikova and Vdovenko in Aizenverg et al., 1983; *P. varvariensiformis* Brazhnikova and Vdovenko in Aizenverg et al., 1983; *P. grandissima* Rumyantseva in Kulagina et al., 1992 or *P. longa* Rumyantseva in Kulagina et al., 1992.

Range: Discovered in the Erlachgraben Formation (Serpukhovian, E 2) of the Carboniferous of Nötsch (Austria).

7 PALEOGEOGRAPHICAL CONSEQUENCES

Few exposures with late Serpukhovian foraminifera are known in Europe and North Africa, except in the Donbass Basin in Ukraine. These locations of foraminifera-bearing outcrops are: Tramaka (Austin et al. 1974, Groessens 1983, Laloux 1988) in Belgium, Boulonnais (material A. Prud'homme, unpublished), Ardengost in the Pyrenees (Perret and Vachard 1977), Ferréol in the Mouthoumet Massif (Mamet and Roux 1975a), Ich ou Mellal in Morocco (Bensaid et al. 1979), and the Guadiato area (Cozar 2000). At many European localities, like in the Lublin Basin in Poland (Skompski 1986, 1996), sedimentation was entirely siliciclastic. The first transgressive carbonate levels occur in the late Bashkirian (*Profusulinella* zone), for example in Italy (Pasini 1980a), where Serpukhovian *Tubispirodiscus* and *Praedonezella* are also reported (Pasini 1980b, Ferraresi and Pasini 1996), and in the early Bashkirian in Serbia (Filipovic 1995). Although latest Viséan deposits are well documented in Turkey (Argyriadis et al. 1976; Dil et al. 1977), no true Serpukhovian foraminifers are known. The early Serpukhovian formerly signalized by Argyriadis et al. (1976) is in fact latest Viséan (late V 3c) in age (Vachard and Argyriadis, work in progress). Small microfaunal assemblages were also reported from eastern Morocco, but not yet illustrated (Berkhli 1993).

In North America, the Bangor Limestone contains rich algal and foraminiferal assemblages (Mamet and Roux 1978, Rich 1980).

In Russia, excellent exposures were described in the Southern Urals, especially along the Shartym river (Kulik 1973, Popova and Reitlinger 1973, Kulagina et al. 1992).

The endemism of the Serpukhovian algae and pseudo-algae of the Carboniferous of Nötsch is confirmed by the numerous differences to the French Pyrenees (Perret and Vachard 1977) and the Donbass assemblages (Aizenverg et al. 1983).

The foraminifers of Nötsch are relatively similar to those of the Donbass, but Eosigmoilinid archaediscids are absent. The distribution of the Eosigmoilinae (*Eosigmoilina* and *Brenckleina)* is particularly puzzling and leads to a potential paleogeographic reconstruction as depicted in Fig. 8. *Eosigmoilina*, whose center of speciation is probably located in the Donbass (Brazhnikova 1964), seems to have migrated into three directions: (1) to the Urals, Arctic Canada, Alaska and North America (Uralian – Mid-Continent Provinces); (2) to North Africa: Libya (Massa and Vachard 1979), Algeria and the Sahara (Sebbar 1997, 1998; Sebbar et al. 2000), and perhaps to the Pyrenees, where it is very rare (2 specimens found in thousands of thin-sections: Perret 1993), and up to England, where Brenckle considers *Trochammina robertsoni* Brady, 1876 as a prioritary synonym of *Eosigmoilina explicata* (references in Brenckle and Grelecki, 1993), and finally *Brenckleina* is reported from Belgium (Laloux 1988: 220, Tab. 1) but not illustrated; (3) to the central Tethys. Although documented neither from Iran nor from the Turkish Taurus (we have observed that the "*Eosigmoilina*" of Argyriadis et al. 1976 are in fact tranverse sections of small *Fasciella*), Eosigmoilininae are well known from the North-Caspian region (Gibshman and Akhmetshina 1991), from Kazakhstan (Marfenkova 1991), Tian-Shan (Bensh et al. 1996: 130, Pl. 34, Figs. 7, 9-11, 13-15), the Pamir (Miklukho-Maclay 1960: as *Quasiarchaediscus*) and from Central Afghanistan (Vachard 1980), but the Eosigmoilininae seem to be completely lacking in South-east Asia and Japan. Serpukhovian exposures are also well documented from central and eastern Morocco, Spain, Germany, Northern France, and Poland.

According to Krainer (1992) the sedimentary rocks of the Carboniferous of Nötsch were deposited on the northern slope of a narrow, deep-sea basin, which formed during an extensional phase ("transform rifting phase" sensu Vai and Cocozza 1986) in the foreland of the "Noric Terrane" during the Viséan and Namurian.

The Noric Terrane split off from Gondwana and drifted towards the north, closing the Rheic Ocean (Neubauer 1988, Frisch and Neubauer 1989, Frisch et al. 1990). Sediments of the deep-sea basin which formed in the foreland of the Variscan belt, are represented by the Hochwipfel Formation

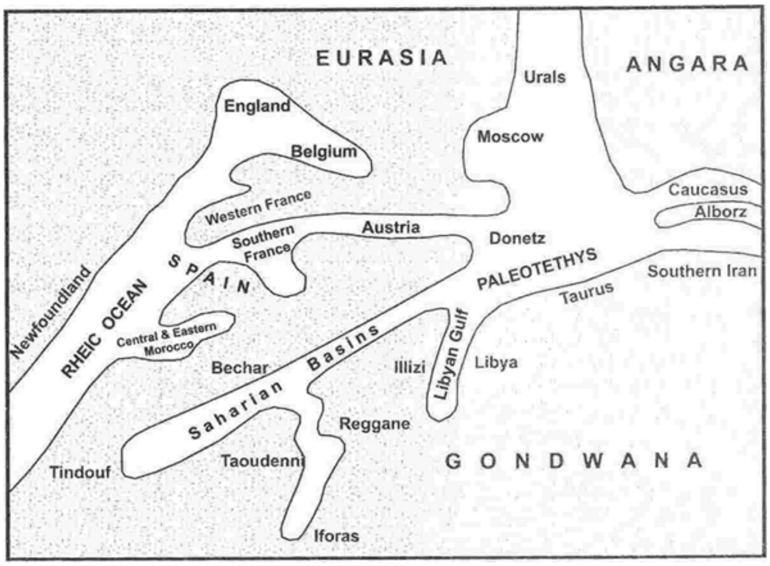

Fig. 8. - A palinspastic reconstruction of the western Tethys during the Serpukhovian.

of the Carnic Alps and Karawanken Mountains, and by the Carboniferous of Nötsch. This is indicated by the occurrence of exotic limestone clasts of similar microfacies and age in submarine debris flows of the Hochwipfel Formation (Carnic Alps) and Badstub Formation (E. Flügel and Schönlaub 1990, Amler et al. 1991). According to E. Flügel and Schönlaub (1990) and Krainer (1992) these exotic limestone clasts were derived from a shallow marine shelf environment on the northern margin of this deep-sea basin. This shelf is also considered as the source area for the calcareous algae and foraminifers occuring in the Kirchbach Limestone of the Hochwipfel Formation (Amler et al. 1991) and in the silty and marly limestones and coquinas of the Carboniferous of Nötsch described herein. Our re-examination of thin sections from the Kirchbach Limestone (collection of M. Amler, University of Marburg, Germany) indicates a little older age: V3c and/or E1, i.e. the Kirchbach Limestone was deposited near the Viséan/Serpukhovian boundary. The supposed narrow deep-sea basin extended to the east ("Carboniferous Trough of Nötsch-Ochtina" according to Flügel 1990), and it seems that during the late Viséan and early Namurian an open seaway existed further to the east connecting the Carboniferous of Nötsch with the Donbass region.

However, more investigations are necessary in the Carboniferous of Nötsch and in the Kirchbach Limestone of the Hochwipfel Formation in the Carnic Alps for concluding on the real absence of *Eosigmoilina* and the paleogeographic reconstructions of the Serpukhovian European seas and oceans.

8 CONCLUSION

The Carboniferous of Nötsch (Austria) is composed of a thick sequence of dominantly siliciclastic sediments deposited in a deep-sea environment, most probably on the slope. Silty and marly fossiliferous limestones and coquina layers, intercalated in the upper Erlachgraben Formation, upper Badstub Formation and lower Nötsch Formation, are interpreted to be derived from sediment gravity flows (i.e. calciturbidites). These limestones contain calcareous algae and foraminifers which originally inhabited a shallow-water shelf environment and were transported and redeposited in a deep-water environment. The foraminiferal assemblage of the upper Erlachgraben Formation indicates late Serpukhovian (Arnsbergian) age which is in agreement with age determinations based on plant fossils by Amerom and Kabon (1999, 2000). The new algae, especially *Principia* and *Paraepimastopora*, are phyllogenetically important.

The limestones of the Carboniferous of Nötsch show some similarities to the microfacies and age of limestones ("Kirchbach Limestone") of the South Alpine Hochwipfel Formation of the Carnic Alps, described by E. Flügel and Schönlaub (1990) and Amler et al. (1991). We assume that bioclasts (particularly algae and foraminifers) as well as exotic limestone clasts which are present in submarine debris flows of the Kirchbach Limestone and Badstub Formation, derived from a shallow-water shelf environment on the northern margin of a narrow, deep-sea basin. This narrow, deep-sea basin (Carboniferous trough of "Nötsch-Ochtina" according to Flügel 1990) was probably open to the east, allowing the foraminifers to migrate from the Donbass region to the west (Nötsch and Carnic Alps).

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