



Lithological and Palynostratigraphical correlations between Silurian Deposits from the Dnestr Basin (Podolia) and the North of the Moldavian Platform (Romania)

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Abstract

The Silurian deposits from the Podolia Region outcrop very clearly along the valley of the Dnestr river and its left-side tributaries. Some of the outcrop deposits are represented by the Malynivtsy Formation (Middle-Upper Ludlowian in age) and the Skala Formation (Upper Ludlowian in age). The ages of these formations have been established through the rich fauna, with tabulate and rugose corals, stromatoporoids and brachiopods, characteristic for a Ludlowian age. Our palynological and palynostratigraphical study (acritarchs, chitinozoans and miospores) have focused on these geological formations (Middle – Upper Ludlowian in age) outcropping on the Dnestr Valley (Zhvanets locality area) and the Smotrych brook (Kamenets Podolskyj locality).

The chitinozoan assemblage represents the basis for the stratigraphical correlation of Silurian deposits between the Dnestr Valley (Podolia) and the north of the Moldavian Platform (Romania). The Silurian deposits of Romania have been studied by numerous authors and have focused on diverse stratigraphical Silurian layers intercepted by means of drillings from Iași, Grănicești, Todireni, Bătrânești, Popești, Preutești, Bosanci and Rădăuți.

The chitinozoan species analyzed are present in both the studied regions, but with certain particularities and local individualities. We have separated species of the following genera: *Angochitina*, *Belanochitina*, *Conochitina*, *Eisenachitina*, *Linochitina*, *Urnochitina* a.o. The chitinozoan species analyzed have been found in various regions from Gondwanaland, Laurentia, Baltica, where they represent the biozone species, but some of them are typical for the Silurian of the East-European Platform. The large spread of these species has great importance for the palynostratigraphical correlation between different regions of the East-European Platform and the north of the Moldavian Platform, respectively.

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Keywords: palynological correlation, Podolia, Moldavian Platform, chitinozoans, Silurian.

Introduction

The Podolic Basin (Ukraine) lays in the southern area of the East-European Platform, being bordered in the E-SE by the Ukrainian Shield, while in the W-SW it reaches a monocline (1-2°) towards the Teisseyre-Tornquist zone (TTZ), its neighbour (Teller, 1997).

In the N-NE, the Podolic Basin stretches towards the E of Poland, Belarus, Lithuania, Latvia, from the Baltic Basin area. Along the monocline descending direction, the Podolic Basin extends towards the west of our country, on the territory of the Moldavian Platform, and sinks along with the platform, initially at an angle of 5-6°, and then, close to the Carpathians, the gradual sinking becomes sudden. The typical Silurian geological formations are mostly calcareous, dolomitic, turning to argillaceous-marly with calcareous intercalations in the west. The succession of the Silurian deposits was studied in drillings (Moldavian Platform) and in outcrops (Dnestr River Basin, Podolia). Based on the corroboration of these results, a good lithological and paleontological correlation was noticed (Pătruț, 1982).

Lithological correlation between the Silurian deposits from the Podolia Region (Ukraine) and those from the Moldavian Platform (Romania)

In the Podolic Basin, the Silurian shows a fair outcrop on the route between the valley of the Dnestr and its left tributaries (Fig. 1). Apart from the outcrops, the Silurian deposits were encountered in several drillings. In our country, the drillings from Iași (Nicolina, 3501, 3502 wells), Grănicești, Todireni, Bătrânești, Popești, Preutești, Bosanci and Rădăuți allowed the interception and subsequent study of the different Silurian terms from a lithological and paleontological point of view.

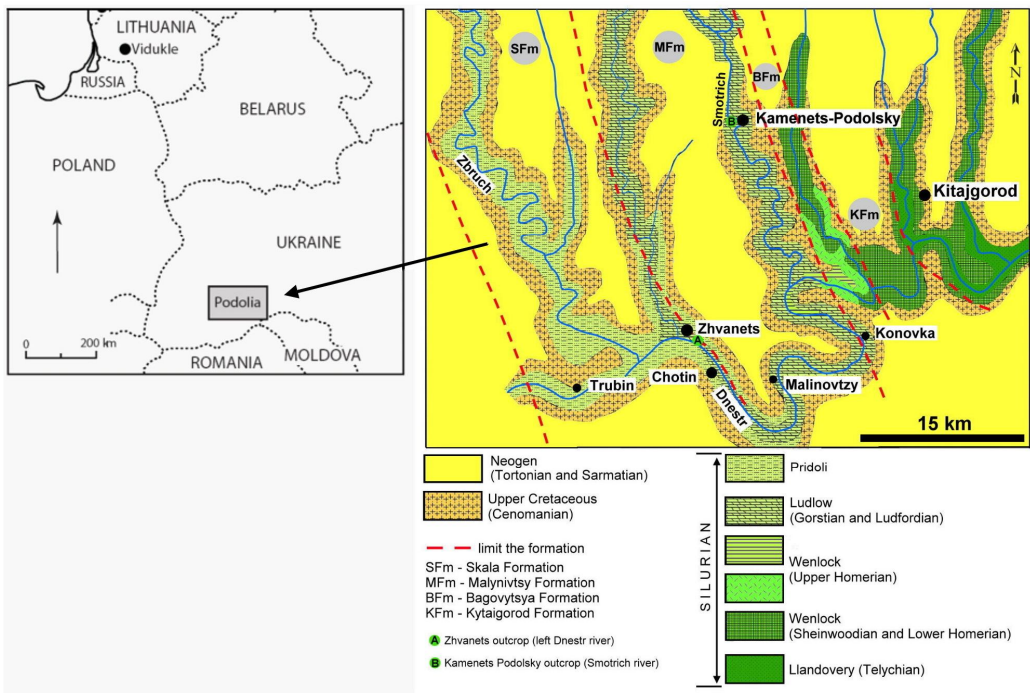


Fig. 1 Geological map of Podolia in the area of the Dnestr River and its tributaries (after Teller, 1997; Skompski et al., 2008; modified).

Lithologically, in the area of Podolia (in the region of the two localities we studied), the Silurian is represented by two formations (Fig. 2):

1. the Malynivtsy Formation, representing the Middle-Upper Ludlowian age;
2. the Skala Formation, Upper Ludlowian in age (Kaljo et al., 2007).

The Malynivtsy Formation

The succession of the Silurian formations in Podolia follows the oldest (lower) ones, which outcrop in the north-east, towards the newer (upper) ones, intercepted in the western – south-western part (Fig. 1).

The Malynivtsy Formation, of Middle-Upper Silurian age, crops on the Smotrych brook, a left tributary of the Dnestr River (Fig. 1). The study of this formation followed the stream of the river (with canyon aspects), and the samples for the palynological analyses were collected from the left slope, under the location of the medieval fortress of Kamenets Podolskyj (N 48°40'26.5''; E 26°34'10.4''). In this outcrop, the Malynivtsy Formation (with the Sokol Member) includes nodular limestone with intercalations (5–10cm) of dolomitic marls and limestone with thin metabentonitic intercalations at the basement (Fig. 3). The succession of calcareous stones includes a rich fauna of stromatoporoids and rugose corals, which form nodules, apart from which the brachiopod fauna prevails and is characteristic for the Ludlowian (Tsegelnjuk et al., 1983; Skompski et al., 2008). We can state that this formation, given the lithological content, belongs to a calcareous-dolomitic facies, which exists near the palaeoshore. The limestone comes from the recifal biostromes with stromatoporoids, corals and crinoids, visible here on the Smotrych brook, having formed in a marine shallow water environment, or by redepositing the calcareous elements as a result of the erosional phenomenon of these reef barriers.

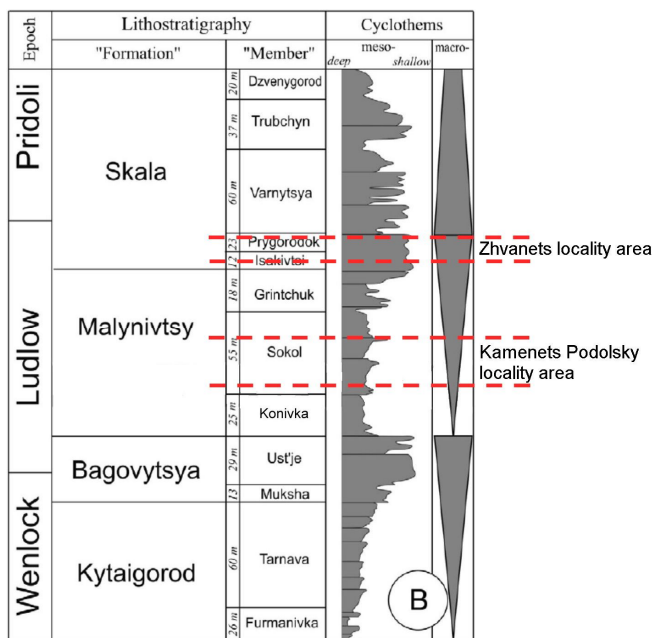


Fig. 2 Silurian lithostratigraphy from Podolia (Tsegelnjuk et al., 1983; Nikiforova et al., 1972) and stratigraphical position of the studied outcrops in the Podolia area.

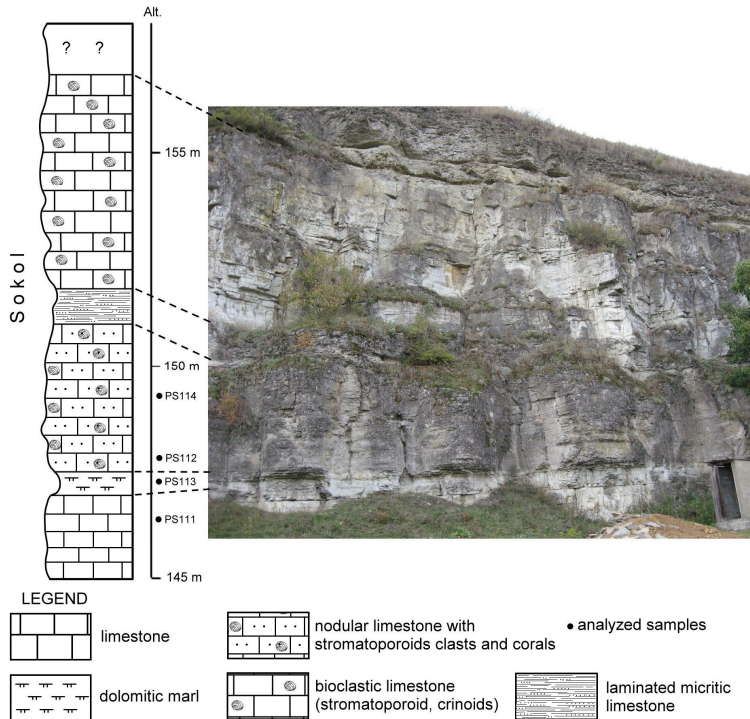


Fig. 3 Lithological column of the Sokol Member (Malynivtsy Formation), outcropping on the Smotrych brook, near the locality of Kamenets Podolskyj.

If we follow the W–SW spreading of this formation, which outcrops at altitudes between 145-160m on the Smotrych brook, we find that it shows a general descending trend of 1-2° for the entire series of platform sedimentary formations. The Malynivtsy Formation was encountered in drillings about 100m thick located at a depth of 300m in Iași, in Todireni and Bătrînești. Due to the rapid dive in front of the Eastern Carpathians, the depth at which it is intercepted sud-denly rises, being registered at a depth of 2195m and a thickness of 240m in Rădăuți (2195-2400m). This formation preserves its carbonatic features, being known as an “Upper carbonated horizon with Brachiopods” (Pătruț, 1982). Lithologically, argillaceous limestone prevails, being disposed in a facies far away from the shore.

The Skala Formation

The Skala Formation includes three members: Isakivtsi, Rashkov (in Romania – Rașcu, fide Pătruț, 1982) and Dzwingorod (Nikiforova and Predtechenskij, 1968). Later, Tsegelnjuk et al. (1983) attached the Isakivtsi Member to the Malynivtsy Formation, as its last lithological term. Koren et al. (1989) also include the lowest part of the Rashkov Member (= Prygorodok Member) in the Malynivtsy Formation.

The Skala Formation is well exposed along the Dnestr Valley and on the Zbruch and Zhvanchik brooks, left tributaries of the Dnestr River (Fig. 1). Generally, the Skala Formation mostly includes limestone with dolomite alternations, dolomitic marls and argillities. On the

whole, the thickness of this formation is 150m, if it also includes the Isakivtsi Member (Nikiforova and Predtechenskij, 1968), or just 136m, according to the definition provided by Koren et al. (1989).

The Isakivtsi Member is 32–34m thick (Nikiforova and Predtechenskij, 1968), 5–6m thick (Tsegelnjuk et al., 1983) or 6–9m thick (Koren et al., 1989). At its base, it includes massive dolomites (2–4.5m) with intercalations of dolomitic and bentonitic marls, while at the upper part the prevalence of bentonites over dolomites was noticed. The presence of drying facies on the surfaces of the dolomite strata, as well as on the ripple marks formations, constitutes proof of the deposition of these sediments in an area closed to the shore (inner shelf) or in one with shallow waters near the shore (Koren et al., 1989). The specific fauna is represented by brachiopods and ostracods, being poor in trilobites and cystoides, while the algae are common within dolomites. The age of this member was considered Upper Ludlow (Koren et al., 1989).

The Rashkov Member (Rașcu), including the Prygorodok Member (at the basal part), is 98m thick (Nikiforova and Predtechenskij, 1968), 170–250m thick (Tsegelnjuk et al., 1983) or 94–106m thick (Koren et al., 1989). Lithologically, this member is characterized by nodular dolomites rich in stromatoporoids, bituminous limestone, tuffitic sandstones and bentonites. It displays numerous drying tracks with a polygonal outline on the surface of the strata. The conditions are seen as being the same sedimentary ones as in the case of the Isakivtsi Member, pointing to an area closed to the shore (inner shelf) or an open shore area, but with shallow waters. The fossil fauna is dominated by stromatoporoids, corals and ostracods, which are rock constructors here and there. Apart from these, there are important fossil remains of bivalves, nautiloids, bryozoans, brachiopods, trilobites and crinoids. The age of this member is considered Upper Ludlow (Nikiforova and Predtechenskij, 1968; Tsegelnjuk et al., 1983) or Upper Ludlow – Lower Pridoli (Koren et al., 1989).

Our studies followed the outcrops on the Dnestr Valley from Zhvanets (about 250m downstream the bridge). In these outcrops, the Isakivtsi Member is visible along a 10–15m stratigraphical thickness, including grey, tough dolomites (Fig. 4).

Under this member, along the Dnestr River, the calcareous, 12m-thick Grintchuk Member mentioned in the literature is probably also outcropping (Tsegelnjuk et al., 1983; Paris and Grahn, 1996), but in the outcrop we studied it is not visible, being covered by debris fallen from the slope (Fig. 4).

The Prygorodok Member stands on the Isakivtsi Member (Fig. 4), including grey dolomites alternating with blackish dolomitic marls with a slate aspect. On the stratification of the dolomites, drying tracks with a polygonal aspect could be noticed. In the upper part of this lithological member, the thickness of the dolomitic intercalations decreases, the rock becoming mostly marly and blackish. The thickness of this member is 20–23m, and the total thickness of the two members from the basement of the Skala Formation reaches about 30–35m (Fig. 2). The age of these sediments, as mentioned above, is Upper Ludlow.

If we attempt a lithological correlation with the Silurian formations from the north of the Moldavian Platform, we find that the succession mentioned on the Dnestr Valley is partially preserved here as well, but with higher thickness values due to the sudden diving of all platform formations in front of the Carpathians and to the subsidence effect. A change from the prevailing calcareous-argillitic facies from the Dnestr Valley to an open sea argillitic-marly facies distant from the shore could also be noticed.

The Rashkov Member (herein named “Rașcu”), represented by microsandy argillites with ostracods, extends to the Carpathians, being intercepted in the following drillings: in Iași, at a depth of 350m; at Todireni, at a depth of 234m; at Bătrânești, at a depth of 245m, and in Rădăuți at a depth of 1477m. The thickness of this member varies between 50m in Iași and 297m in Rădăuți (Pătruț, 1982). It is considered an “Argillitic horizon with ostracods,” which

defines the main lithological content, as well as the specific fossil fauna. Here, the Rashkov Member includes, at its basement, the Prygorodok Member, found on the Dnestr Valley, but undifferentiated as a distinct lithological member.

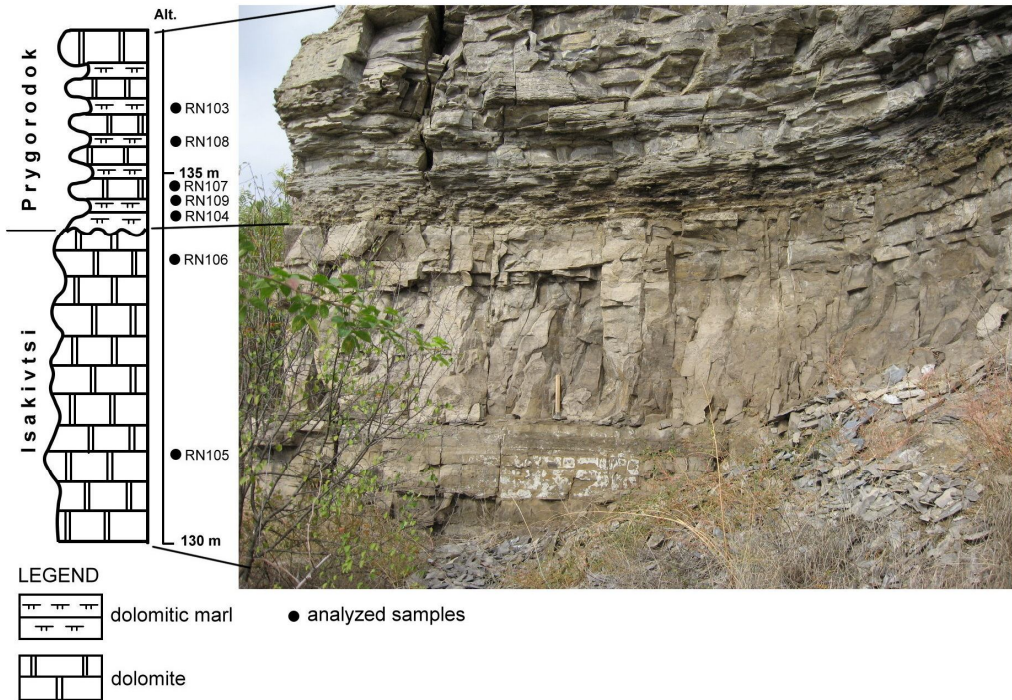


Fig. 4 Lithological section of the Isakivtsi and Prygorodok Members (Skala Formation), on the left side of the Dnestr, south of the Zhvanets locality.

The Isakivtsi Member shows in the lithological columns east of the Prut Valley, on the territory of the Republic of Moldova, but, as we move towards the SW, it becomes thinner so that the drillings from Iași do not encounter it anymore. It emerges again near the Eastern Carpathians, in the Bătrânești well, and in Rădăuți it reaches a maximum thickness of 421m, called the “Argillitic horizon with graptolites.” In the Rădăuți well, this member was encountered at depths between 1774m and 2195m. Between 1961m and 2100m, this member is mainly represented by calcareous, argillitic-sericitic schists, sometimes with quartzitic intercalations and microcrystalline limestone. We carried out a geological study of this stratigraphical interval as intercepted in the Grănicești (Suceava) drilling, about 10km SE of Rădăuți (Fig. 5).

If we analyze the entire column of Silurian deposits from the Rădăuți and Grănicești drillings, we find a continuity of the geological situation from the Podolia Region (especially in the Dnestr Valley), with a noticeable thickness of the deposits at the contact with the Eastern Carpathians. Here, the total thickness of both formations (Malynivtsy and Skala) reaches 958m, throughout the 1477–2435m depth interval (Rădăuți drilling).

Palynostratigraphical correlation of the Silurian formations based on the palynomorph assemblages

As a result of the above-mentioned details from this study, one may notice the continuous existence of the Silurian formations from the East-European Platform, allowing a comparison and a correlation between the basin of the Dnestr River (Podolia) and the northern part of the Moldavian Platform (Romania).

The common Silurian sedimentary basin for both regions ensured the development of a similar chitinozoan assemblage, which, in turn, allows a palynostratigraphical correlation between the two areas. The stratigraphical importance of chitinozoans stems from the fact that they do not represent facies fossils and are small-sized, and, as a result, in a small amount of rock we could find taxonomic diversity and a relatively large number of specimens. They are considered “soft fossils,” very resistant from a chemical point of view during the fossilisation process, as well as in the laboratory, during the sample preparation process, with an opaque chitinous brownish-black membrane.

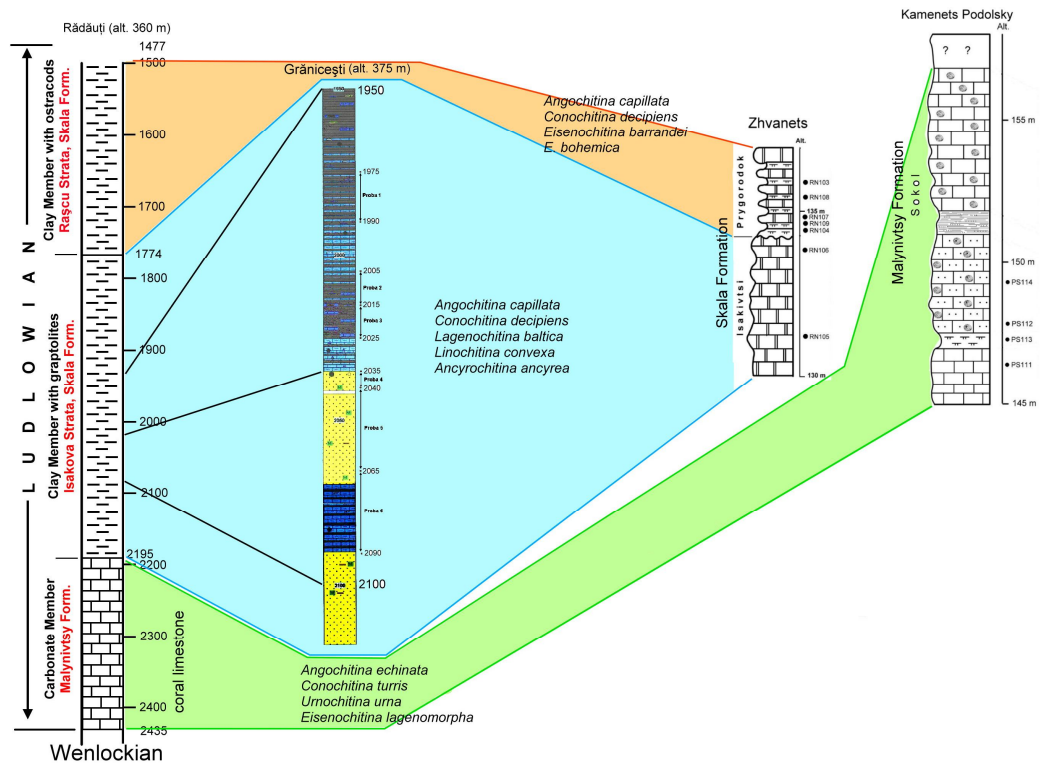


Fig. 5 Lithostratigraphical correlation between the Silurian deposits from the Rădăuți and Grănicești drillings (Romania) and those intercepted in the outcrops from the Podolia Region (Zhvanets and Kamenets Podolsky localities). The lithological column of the Rădăuți drilling (after Pătruț, 1982).

Chitinozoans are marine organisms, with a wide spreading in most environments: lagunar, inner shelf, outer shelf, steep area and open sea area. Some authors consider them benthonic organisms (Eisenack, 1931; Kozłowski, 1963), but the majority see them as planktonic, starting

with Deflandre (1952). They span over a large geographical area (Gondwana, Baltica, Laurentia, China), which offers them a good correlation between great distances. All these elements are controlled by three important factors:

1. The microorganism production, controlled by physical and chemical factors (water temperature, salinity, water pH, light intensity, nutrient content).

2. The high energy of the sea hydrodynamic regime (currents) does not allow the particles to deposit on the basement of the sedimentary basin. For example, in well-sorted sediments, such as porous, coarse sandstones or pure bioclastic limestone, chitinozoans are missing. On the other hand, the reduced regime of hydrodynamic energy could concentrate the chitinozoans together with small argillaceous mineral particles, and also as deposits – their presence is larger in muds, marls, limestone and micritic limestone.

3. In well-oxygenated waters with reefs, porous deposits, red deposits from the area near the shore, chitinozoans are missing or are present in small numbers because they are destroyed before being included in recent sediments, deposited by numerous bacteria and endofauna. Subsequently, the metamorphism process also contributes to the partial destruction of chitinozoans, through erosion, fragmentation or chemical destruction.

The taxonomic composition of chitinozoans could also be a control factor of the sedimentation environment. Some taxa prevail in outer shelf areas or in slope areas, as in the case of *Urnochitina urna* species in the Pridolian. Other species, such as *Pterochitina priveolata*, *Margochitina elegans* or *Plectochitina carminae*, are abundant in shallow water environments. The abundance of spores and other continental vegetal fragments indicates an area near the shore, where chitinozoans are few or completely missing. Given these general problems related to paleoecology and paleoenvironment, a palynostratigraphical correlation based on chitinozoans could be very useful in the analysis of the process of deposition and palynostratigraphical evolution of geological formations.

For the Malynivtsy Formation, the Sokol Member, on the Smotrych brook, we established a chitinozoan assemblage specific for the Middle-Upper Ludlowian. This includes the following species (Tab. 1): *Angochitina echinata*, *Conochitina turris*, *Linochitina klonkensis*, *Eisenachitina lagenomorpha*, *E. barrandei*, *E. bohémica*, *E. elongata*, *Rhabdochitina magna* and *Urnochitina urna*. Among these, in the 3502 Nicolina-Iași well we found *Rhabdochitina magna* and *Angochitina echinata*, apart from a series of species typical for this area, such as: *Ancyrochitina fragilis*, *Conochitina conulus*, *C. decipiens*, *Lagenochitina baltica*, *L. elegans*, *Sphaerochitina sphaerocephala* a.o. (Tab. 1) (Macarovici et al., 1965).

For the drillings from Bosanci 86, Preutești 80 and Lespezi 91, from the carbonatic facies of the Lower-Middle Ludlowian, a chitinozoan assemblage was mentioned (Beju and Dăneț, 1962), including *Conochitina decipiens*, *C. brevis*, *C. elegans*, *C. conulus*, *C. lagenomorpha*, *Angochitina echinata*, *Cyathochitina* cf. *kukersiana*, *Rhabdochitina magna*, *Sphaerochitina sphaerocephala* a.o. (Tab. 1).

The Upper Ludlowian formations are richer in taxa. For the Isakivtsi Member from the Dnestr Basin (Zhvanets locality), we could mention species such as: *Eisenachitina lagenomorpha*, *E. bohémica*, *E. barrandei*, *E. philipi*, *E. elongata*, *Sphaerochitina sphaerocephala*, all zone species for the upper part of the Ludlowian (Ludfordian) (Tab. 1).

From the Prygorodok Member (the entire outcrop from Zhvanets), the chitinozoan assemblage is typical for the Upper Ludlowian. Among the determined species we could mention the following: *Urnochitina urna* (zone species for the Upper Ludlowian – Pridolian), *Eisenachitina lagenomorpha*, *E. bohémica*, *E. philipi*, *Linochitina klonkensis* (zone species for the Upper Ludlowian), *Sphaerochitina sphaerocephala* a.o. (Tab. 1).

Table 1. Palynological correlation of Silurian deposits from the Dnestr River Basin with those from the Moldavian Platform.

Correlated regions	Dnestr River Basin											North of the Moldavian Platform															
	Middle Ludlowian				Upper Ludlowian							Upper Ludlowian						Middle Ludlowian			Upper Ludlowian						
	Malynivtsy Fm.				Skala Fm.,													Bosanci			Rădăuți 51; 50; 49; 49a						
	Sokol Member				Isakivtsi Mb.		Prygorodok Member					Grănicești						Preutești			Popești 1						
	Smotrych brook				Zhvanets													Lespezi									
Number of samples / identified species	PS111	PS112	PS113	PS114	RN105	RN106	RN104	RN109	RN107	RN108	RN103	1	2	3	4	5	6	BO86	Pr.80	Le.91	R51	R50	R49	R49a	Po.1		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	
<i>Ancyrochitina ancyrea</i> Eis.																•					•	•	•		•	•	
<i>A. fragilis</i> var. <i>brevis</i> T.& J.												•										•	•	•		•	•
<i>Angochitina capillata</i> Eis.								•					•									•	•	•		•	•
<i>A. cf. capillata</i> Eis.								•				•	•										•	•			•
<i>A. echinata</i> Eis.	•	•	•												•	•		•									•
<i>A. cf. echinata</i> Eis.		•												•		•											•
<i>Conochitina decipiens</i> T.& J.								•					•			•		•	•	•							•
<i>C. elegans</i> Eis.													•						•	•			•		•		•
<i>C. lagenomorpha</i> Eis.													•			•				•				•			•
<i>C. cf. Intermedia</i> Eis.																	•				•						•
<i>Conochitina</i> sp.													•					•	•	•	•	•	•				•
<i>Conochitina intermedia</i> Eis.																				•							•
<i>Conochitina turris</i> Taug.	•														•												
<i>Cyathochitina kukersiana</i> Eis.																•											
<i>C. cf. kukersiana</i> Eis.																	•	•									
<i>Lagenochitina baltica</i> Eis.																•				•	•	•	•	•	•	•	•
<i>L. elegans</i> B.& T.													•	•	•					•	•	•	•	•	•	•	•
<i>L. cf. macrostoma</i> T.&J.												•				•	•									•	
<i>L. prussica</i> Eis.												•				•											
<i>L. cf. prussica</i> Eis.													•			•							•	•	•		
<i>Linochitina convexa</i> Eis.												•	•														
<i>Rhabdochitina magna</i> Eis.				•								•	•			•	•	•	•	•							•
<i>Rhabdochitina</i> sp.															•								•		•		•
<i>Sphaerochitina cf. sphaerocephala</i> Eis.								•									•	•		•	•	•	•	•	•	•	•

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For the Moldavian Platform, the chitinozoan assemblage is rich, indicating the Upper Ludlowian age in all the wells which intercepted the following equivalent formations: the “Argillitic horizon with graptolites” (*sensu* Pătruț, 1982), equivalent to the Isakivtsi Member, and the “Argillitic horizon with ostracods” (*sensu* Pătruț, 1982), equivalent to the Rashkov Member (Skala Formation), which also includes the Prygorodok Member in its lower part (Koren et al., 1989).

Apart from the species shared with the Podolic Basin, the chitinozoan assemblages from Romania also include numerous local species. In the drillings from Rădăuți, the chitinozoan assemblage is rich and it includes species typical for the Upper Silurian (Ludlowian). Among these, we could mention the following: *Acyrochitina ancyrea*, *Angochitina capillata*, *Conochitina elegans*, *Lagenochitina baltica*, *Rhabdochitina magna*, *Sphaerochitina sphaerocephala*, *Lagenochitina cf. prussica*, *L. elegans* (zone species). In the drilling from Grănicești (Olaru et al., 2006) which intercepted the “Argillitic horizon with graptolites” (equivalent to the Isakivtsi Member), the chitinozoan assemblage is similar to that encountered in the drillings from Rădăuți. Among the species identified, we could mention the following: *Angochitina capillata*, *Linochitina convexa*, *Lagenochitina cf. prussica*, *Conochitina elegans* (zone species), as well as biozone species (*Lagenochitina elegans*, *Cyathochitina kukersiana*, *Lagenochitina baltica*, *Urnochitina urna*, *Angochitina echinata*, *Sphaerochitina sphaerocephala*).

For the Upper Silurian (Ludlowian) from the Nicolina-Iași drilling (3502 well), we could mention a typical chitinozoan assemblage, which is similar to that from Grănicești. *Ancyrochitina ancyrea*, *Angochitina capillata*, *Conochitina decipiens*, *C. lagenomorpha*, *Lagenochitina elegans*, *Rhabdochitina magna*, *Sphaerochitina sphaerocephala* a.o. (Tab. 1) are among the common species.

Species similar to those of the chitinozoan assemblage from Nicolina-Iași were identified in the drilling from Popești (Huși). Among these, we could mention the following: *Ancyrochitina ancyrea*, *Lagenochitina elegans*, *Angochitina cf. capillata*, *Ancyrochitina fragilis*, *Conochitina conulus*, *Sphaerochitina sphaerocephala* a.o. (Tab. 1).

Conclusions

In the chitinozoan assemblages of the Ludlowian formations from the Dnestr River Basin, the presence of species from genera such as *Eisenachitina*, *Angochitina*, *Urnochitina*, *Sphaerochitina* a.o. is clear, whereas in the assemblages from the Moldavian Platform prevail species from genera such as *Angochitina*, *Lagenochitina*, *Conochitina*, *Urnochitina*, *Sphaerochitina* a.o.

Numerous species which are present in the chitinozoan assemblages are zone species, also encountered within other assemblages from different areas on the Globe. Among these, we could mention the following: *Belonechitina latifrons* (Ludlowian – Baltica); *Angochitina echinata* (Ludlowian – cosmopolite species); *Eisenachitina barrandei* (Ludlowian – Gondwanaland); *E. lagenomorpha* (Ludlowian – cosmopolite species); *E. philipi* (Ludlowian – Gondwanaland); *Sphaerochitina sphaerocephala* (Ludlowian, Pridolian – cosmopolite species); *Urnochitina urna* (Pridolian – cosmopolite species); *Lagenochitina elegans* (Ludlowian – cosmopolite species); *Cyathochitina kukersiana* (Ludlowian – Baltica); *Lagenochitina baltica* (Ashgill – cosmopolite species) (Tab. 1).

What could also be noticed is the fact that not all the chitinozoan assemblages have the same composition, each assemblage being characterized by numerous local species. Some species from these assemblages represent the Gondwanaland type, others – the Baltic type, while other species are cosmopolite.

The importance of the present study is that it attempts, for the first time, to draw a parallel between Silurian (Ludlowian) formations found throughout a large area from the SW of the East-European Platform, aiming at both a lithological correlation and a palynostratigraphical one, using the chitinozoan assemblages.

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CAPTION OF PLATES**Plate I**

1. *Eisenackitina bohémica* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
2. *Fungochitina kosoviensis* Paris & Kříž, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
3. *Vinnalochitina suchomastiensis* Paris & Laufeld, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
4. *Moyera* cf. *capotti* (Cramer) Miller & Eames, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
5. *Urnochitina urna* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
6. *Angochitina* cf. *capillata* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
7. *Eisenackitina bohémica* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
8. *Urnochitina urna* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
9. *Linochitina klonkensis* Paris & Laufeld, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
10. *Eisenackitina lagenomorpha* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
- 11, 12. *Linochitina klonkensis* Paris & Laufeld, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
- 13, 14. *Angochitina* cf. *capillata* Eisenack, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
15. *Conochitina* cf. *decipiens* Taugourdeau, (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
16. *Eupoikilofusa* cf. *striatifera* (Cramer), (RN109), Dnestr River, Upper Ludlow (Prygorodok Member).
17. *Eisenackitina lagenomorpha* Eisenack, (RN103), Dnestr River, Upper Ludlow (Prygorodok Member).
18. *Linochitina klonkensis* Paris & Laufeld, (RN103), Dnestr River, Upper Ludlow (Prygorodok Member).
19. *Eisenackitina intermedia* Eisenack, (RN103), Dnestr River, Upper Ludlow (Prygorodok Member).
20. Diverse miospore group, (RN103), Dnestr River, Upper Ludlow (Prygorodok Member).
21. *Linochitina klonkensis* Paris & Laufeld, (RN103), Dnestr River, Upper Ludlow (Prygorodok Member).
22. *Sphaerochitina* cf. *sphaerocephala* Eisenack, (RN104), Dnestr River, Upper Ludlow (Prygorodok Member).
23. *Ambitisporites avitus* Hoffmeister, (RN105), Dnestr River, Upper Ludlow (Isakivtsi Member).
- 24 (a, b). *Ambitisporites avitus* Hoffmeister, (RN104), Dnestr River, Upper Ludlow (Prygorodok Member).
25. a – *Archaeozonotriletes chlus* (Cramer) Richardson & Lister, (RN105), Dnestr River, Upper Ludlow (Isakivtsi Member).
- b – *Clypeolus tortudaites* (Cramer) Miller et al. 1997, (RN105), Dnestr River, Upper Ludlow (Isakivtsi Member).
26. *Eisenackitina philipi* Laufeld, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
27. *Clathrochitina aquitanica* Taugourdeau, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
28. *Linochitina klonkensis* Paris & Laufeld, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
29. *Archaeotriletes chlus* (Cramer) Richardson & Lister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
30. a – *Pterospermella onondagaensis* Deunff, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
- b – *Ambitisporites avitus* Hoffmeister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).

Plate II

1. *Ambitisporites avitus* Hoffmeister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
- 2, 4. *Cymbosporites catillus* Allen, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
3. *Pterospermella onondagaensis* Deunff, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
5. a - *Cymbosporites catillus* Allen, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
- b – *Pterospermella hermosita* Cramer, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
- c - *Ambitisporites avitus* Hoffmeister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
6. *Ambitisporites avitus* Hoffmeister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
7. *Cymbosporites catillus* Allen, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).

8. *Pterospermella onodagaensis* Deunff, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
- 9, 10. *Ambitisporites avitus* Hoffmeister, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
11. *Linochitina klonkensis* Paris & Laufeld, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
12. *Eisenackitina elongata* Eisenack, (RN106), Dnestr River, Upper Ludlow (Isakivtsi Member).
13. *Archaeozonotriteles chlus* (Cramer) Richardson & Lister, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
14. *Eisenackitina barrandei* Paris & Křiž, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
15. *Eisenackitina barrandei* Paris & Křiž, (RN108), Dnestr River, Upper Ludlow (Prygorodok Member).
- 16 – 19. *Ambitisporites avitus* Hoffmeister, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
- 20 (a, b). – *Cymbosporites* cf. *catillus* Allen, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
21. *Eisenackitina lagenomorpha* Eisenack, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
22. *Eisenackitina elongata* Eisenack, (RN108), Dnestr River, Upper Ludlow (Prygorodok Member).
23. *Moyeria* cf. *cabotti* (Cramer) Miller & Eames, (RN107), Dnestr River, Upper Ludlow (Prygorodok Member).
- 24, 25. *Urnochitina urna* Eisenack, (RN108), Dnestr River, Upper Ludlow (Prygorodok Member).
26. *Eisenackitina lagenomorpha* Eisenack, (RN108), Dnestr River, Upper Ludlow (Prygorodok Member).
27. *Eisenackitina lagenomorpha* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
28. *Eisenackitina bohémica* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
29. *Conochitina turis* Taugourdeau, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
30. *Belonechitina latifrons* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).

Plate III

1. *Eisenackitina* aff. *elongata* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
2. *Urnochitina urna* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
3. *Angochitina echinata* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
4. *Eisenackitina barrandei* Paris & Křiž, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
5. Microscopic field with chitinozoans, spores and dyades, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
6. *Eisenackitina philipi* Laufeld, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
7. *Eisenackitina elongata* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
8. *Angochitina* cf. *tzegelnjuki* Paris & Grahn, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
9. *Angochitina elongata* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
10. *Eisenackitina lagenomorpha* Eisenack, (PS111), Smotrych Brook, Upper Ludlow (Sokol Member).
11. *Eisenackitina barrandei* Paris & Křiž, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
12. *Urnochitina urna* Eisenack, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
13. *Conochitina* cf. *parvicola* Taugourdeau, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
14. *Angochitina* cf. *tzegelnjuki* Paris & Grahn, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
15. *Angochitina echinata* Eisenack, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
16. *Ambitisporites avitus* Hoffmeister, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
17. *Belonechitina latifrons* Eisenack, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
18. *Eisenackitina bohémica* Eisenack, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
19. *Archaeozonotriteles chlus* (Cramer) Richardson & Lister, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
20. *Eisenackitina* cf. *barrandei* Paris & Křiž, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
21. *Angochitina* cf. *echinata* Eisenack, (PS112), Smotrych Brook, Upper Ludlow (Sokol Member).
22. *Rhabdochitina magna* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
23. *Angochitina elongate* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
24. *Angochitina echinata* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).

Plate IV

1. *Eisenackitina bohémica* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
2. *Urnochitina urna* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
3. *Linochitina klonkensis* Paris & Laufeld, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).

4. *Eisenackitina lagenomorpha* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
5. *Eisenackitina bohémica* Eisenack, (PS113), Smotrych Brook, Upper Ludlow (Sokol Member).
6. *Dictyotidium* cf. *dictyotum* Eisenack, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).
7. *Eisenackitina lagenomorpha* Eisenack, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).
- 8 – 10. *Dictyotidium* cf. *dictyotum* Eisenack, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).
11. *Eisenackitina bohémica* Eisenack, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).
12. *Eisenackitina lagenomorpha* Eisenack, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).
13. *Eisenackitina barrandei* Paris & Kříž, (PS114), Smotrych Brook, Upper Ludlow (Sokol Member).

Plate I

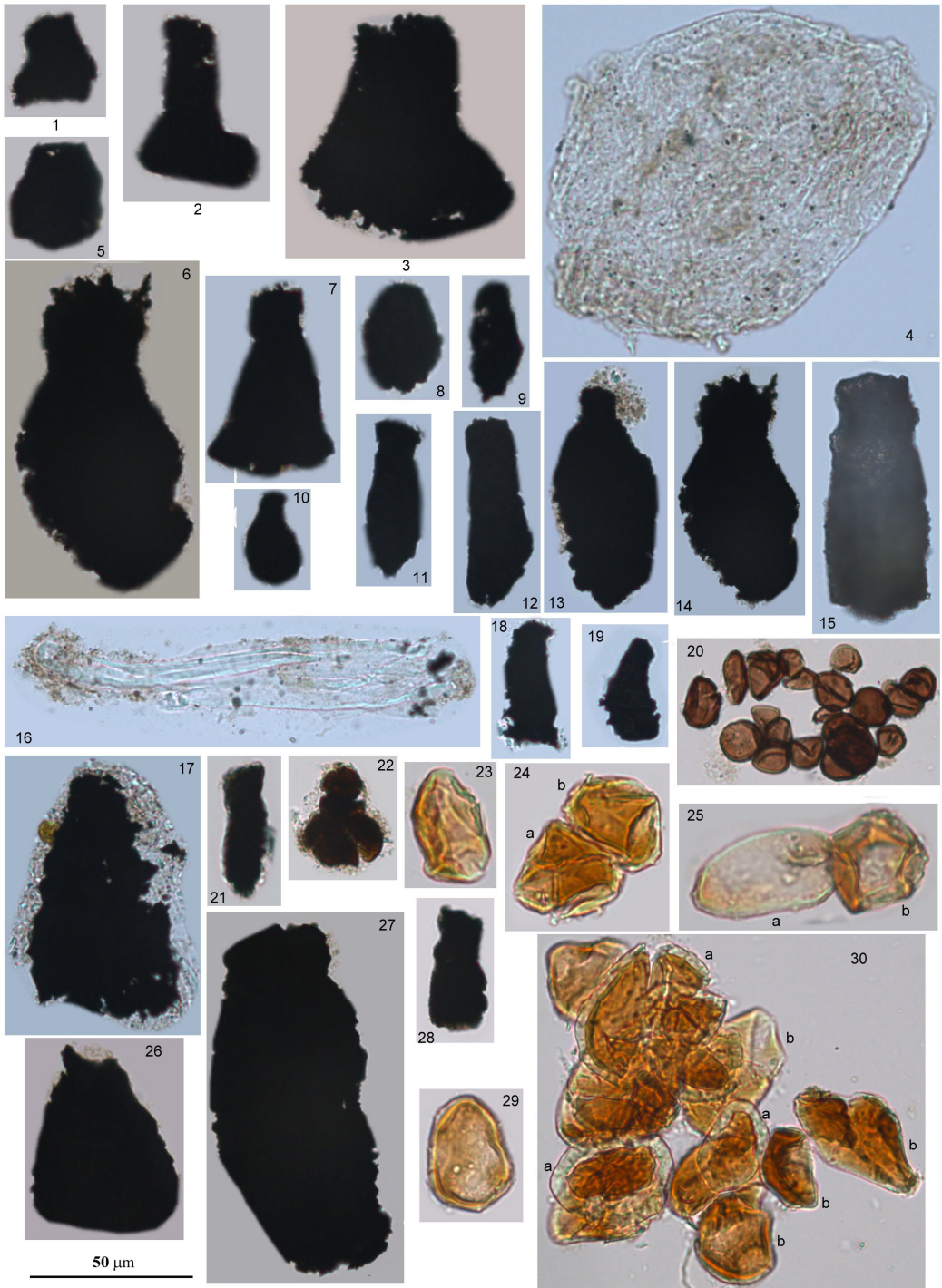


Plate II

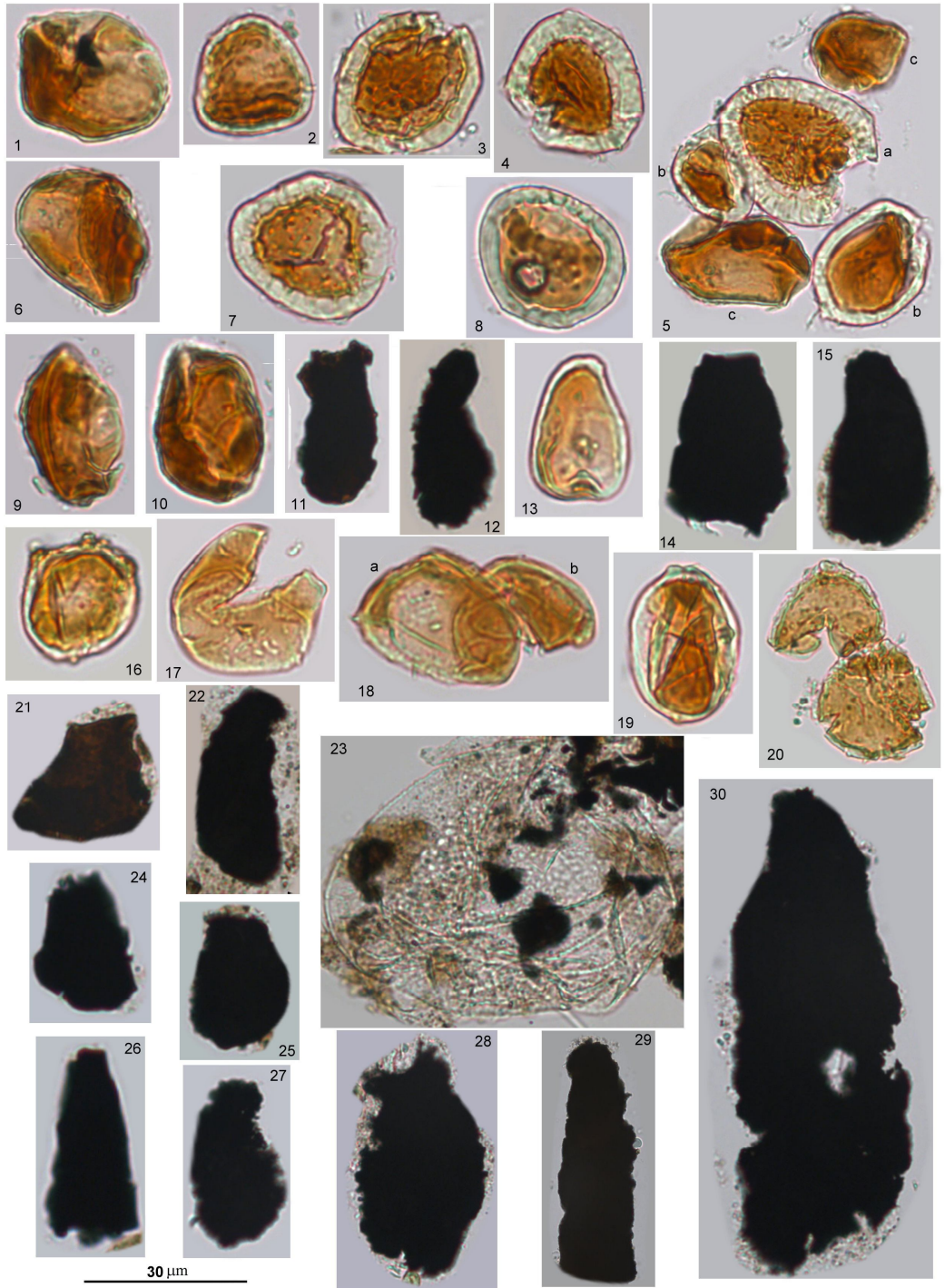


Plate III

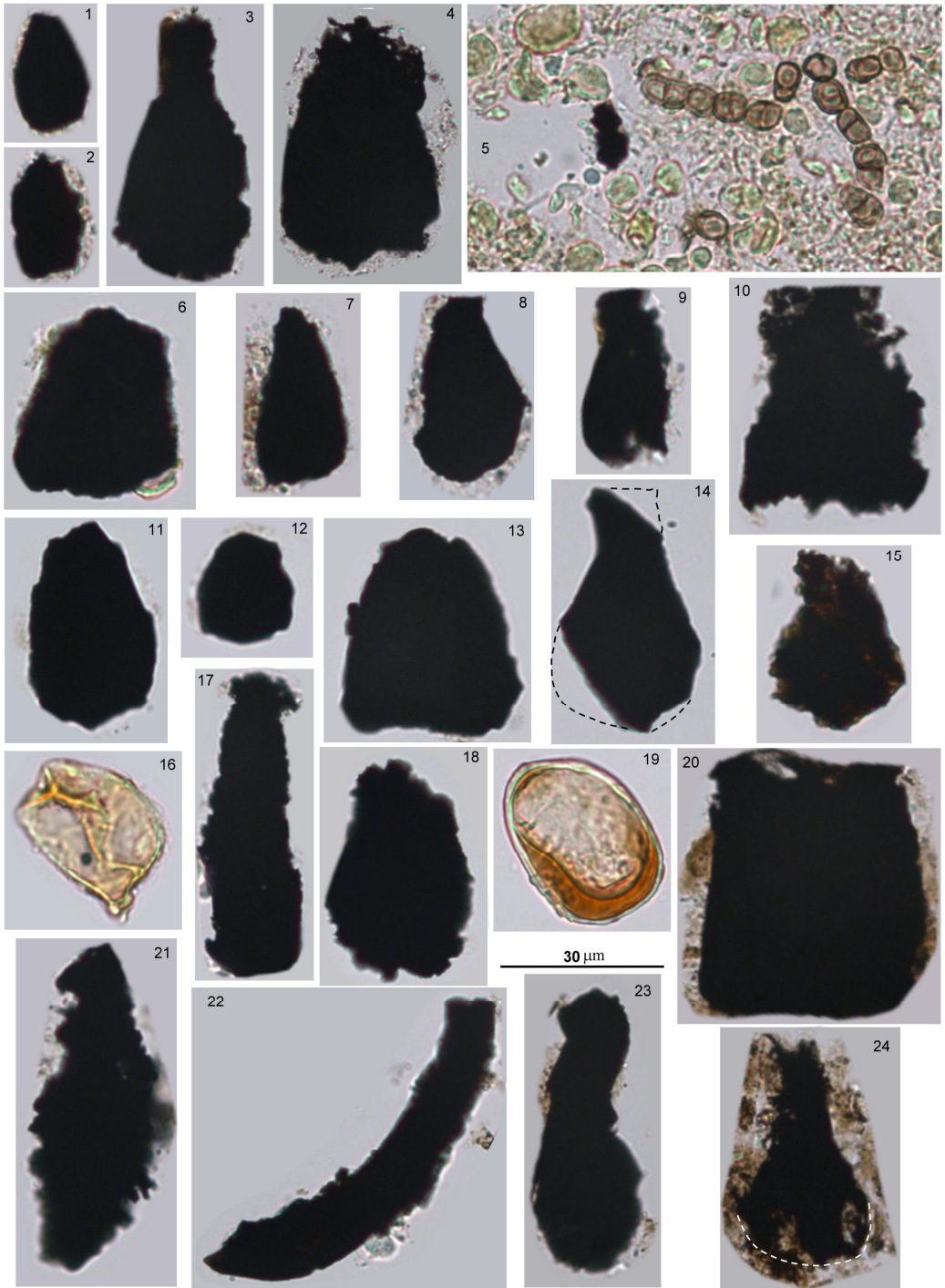


Plate IV

