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Biostratigraphy of the Lower Cretaceous limestones of the Godula facies of the Silesian Unit, Outer Western Carpathians

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Abstract. Microfacies and microfossils were studied in the isolated bodies of detritic limestone outcrops in the western part of the Silesian Unit near the town of Měrkovice. The total limestone thickness reaches up to ten metres. Fossil remnants observed in thin sections give clear evidence of a reef to sublittoral shallow-sea source area for these deposits, which the present authors believe to be the Baška ridge. Assemblages of calpionellids of the Middle Berriasian (representing the standard Calpionella Biozone, and the Elliptica and Longa Subzones) were identified in the fine-grained limestones. Transitional deposits between the limestones and the overlying dark grey pelitic flysch sediments yielded noncalcareous dinoflagellates of the Late Berriasian and lower Early Valanginian age.

Key words: Outer Western Carpathians, Silesian Unit, Těšín Limestone, Lower Cretaceous, microfacies, calpionellids, dinoflagellates, biostratigraphy

Introduction

Limestones of the Podbeskydská pahorkatina Upland in the western part of the Silesian Unit in the Czech Republic were studied in the course of ongoing research on Lower Cretaceous non-calcareous dinoflagellates and cephalopods of the grey pelites of the Outer Western Carpathians (Fig. 1). These limestones are poorly exposed, isolated bodies, occurring in a strip between the Měrkovice and Lhotka villages (west of Frýdlant nad Ostravicí). They represent the westernmost occurrences of the Lower Cretaceous limestones of the Godula facies of the Silesian Unit. These limestones have been regarded as being either identical to the Těšín Limestone, commonly present in deposits of the Těšín sub-nappe in the Těšín region, or as having been deposited in the basal part of the Těšín-Hradiště Formation. However, data concerning their stratigraphic position have so far been lacking.

Geological setting

The field area is west of the town Frýdlant nad Ostravicí, and is regarded as part of the Silesian Unit of the Outer Western Carpathian flysch belt. The area is assigned to the Godula facies of the Silesian Unit, which represents deep-sea turbidite fan deposits (the "Godula development" of authors such as Stráník et al. 1993). The limestone bodies occur near the lystric contact of the Silesian Nappe with the Subsilesian Nappe (Menčík and Tyráček 1985).

Fieldwork has revealed that the limestones occur in small, isolated, natural outcrops and as float on Kamenice and Strážnice hill near Měrkovice (northwest of Kozlovice). There are also exposures in a few small, inactive quarries, now completely overgrown. Detailed exploration of the outcrops near Lhotka village was not possible due to their poor degree of exposure.

The outcropping limestones are grey-white to brownish grey-white in colour, coarse to medium grained, detritic, and sandy in some places. The outcrops have been affected by cleavage, allowing their bedding planes to be deduced only in some areas and with considerable uncertainty. Fragments of thin, platy, fine-grained limestones, and others resembling mud limestones, are only found as float around the outcrops.

Previous works

The term Těšín Limestone was introduced by Pusch (1836). Hohenegger (1861) determined the stratigraphic position

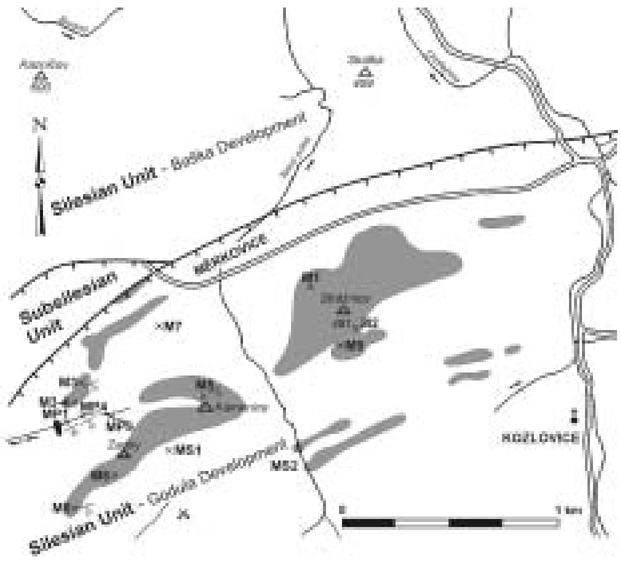

Figure 1. The Měrkovice locality. Grey fields represent limestone bodies.

of the Těšín Limestone more precisely and described its lithology in detail. Two lithofacies were distinguished in the limestones: the mud facies, which is occasionally finely detritic (Eliáš 1970), and the detritic facies that overlie them.

Menčík et al. (1983) has differentiated three lithofacies in the Godula facies of the Silesian Unit in the Czech Republic, based on their interrelations, distribution, and relation to the underlying and overlying formations:

1. The vicinity of Český Těšín town, where the underlying Lower Těšín Member is preserved. The mud facies is predominant in the entire Těšín Limestone sequence, displaying a stable thickness ranging from 20 to 30 m. The boundary with the overlying Těšín-Hradiště Formation is sharp.

2. The area between the town of Třinec and Nýdek Village, with the underlying Lower Těšín Member preserved. Two specific facies are present in this area: biodetritic deposits reaching a maximum thickness of 60 m, and the underlying mud facies (thickness of 20–30 m). The biodetritic facies develops gradually from the underlying deposits and passes into the overlying Těšín-Hradiště Formation. This sequence ends towards the west as the detritic facies diminishes in thickness.

3. The area of the Podbeskydská pahorkatina Upland, without the Lower Těšín Member. The Těšín Limestone, with a maximum thickness of 7 to 12 m, is present here as the oldest member at the base of the Těšín-Hradiště Formation, or as isolated layers in the oldest parts of this formation.

Eliáš (1970) included the limestones around Měrkovice and Lhotka villages as part of the Těšín-Hradiště Formation, but considered them to be deposits of the Baška facies of the Silesian Unit.

Materials and methods

During the fieldwork, all streams and ravines (Telecí creek and right tributaries of the Lubinka stream, Fig. 1) were investigated, as well as any promising surface features and slopes (Kamenice and Strážnice hills) around Měrkovice. The samples for thin sections were collected at small, natural outcrops of detritic limestones and at suitable places in the quarries. A total of eight sites were sampled. The most significant sites (M1–M9) are shown in Fig. 1. Samples of the fine-grained limestones present as float around the outcrops were also collected. Twenty thin sections from these samples were selected for the study of microfacies and index microfossils (especially calpionellids). Within the stream channel of Telecí creek is the only known outcrop of a limestone with a thin, considerably weathered, clayey layer (MS2).

The channel of an unnamed stream on the western Kamenice hillside has better outcrops than that mentioned above (Fig. 1). Its source area contains deposits of a transitional character between the limestones and the overlying Těšín-Hradiště Formation. A 300 m long loamy section is exposed within this channel. These sections terminate in an igneous ultrabasic rock of teschenitic composition. Samples for palynological study (MP1–MP9) were collected from nine places along this stream.

Flysch deposits consisting of alternating grey calcareous pelites and thin, platy layers of grey sandy limestones to calcareous sandstones occur in the stratigraphically lower outcrops of the stream channel (MP1–MP5). A poorly preserved, small valve of aptychus (*Lamellaptychus* sp.) and several other fragments of lamellaptychi were found on one of the limestone bedding surfaces (MP4). The calcareous psammitic layers disappear in the overlying part of the section. The pelites are less calcareous and of a darker grey colour than those mentioned above.

Between outcrop M6 (Zadky) and the top of Kamenice hill, dark grey claystones have been exposed due to ploughing. Palynological sample MS1 was taken from this location.

The thin sections were prepared from samples collected from isolated, disconnected outcrops and float.

The lithological character, microfacies and microfauna of these limestones were studied from discrete samples.

Palynological samples of non-calcareous dinoflagellates were processed by a standard palynological technique, involving dissolution in HCl and HF, with subsequent sieving with polyethylene sieves of a 15 μm mesh size. No oxidation was necessary. Permanent mounts were made in glycerine jelly.

Results

The study of thin sections produced from discrete samples of limestones from the outcrops or debris has shown that they represent two types of sediments:

a) muddy to fine-grained limestones,
b) detritic limestones.

Fine-grained to muddy limestones

Samples MS2, M3, M3kal, M3-4a, M3-4b, M5a, M7, respectively M5b, M8b and M9a represent muddy fine-grained to limestones (Plate I, fig. 2). Partially recrystallised limestones, which seem initially to have been a micritic (mudstone) matrix into which clastic components were deposited, is common to this group of sediments (Plate I, fig. 1). These samples show diverse allochem associations, and contain variable proportions of recrystallised detritus or biodetritus.

The sample from Měrkovice-Kamenice (M5) has a biomicrosparitic/intrabiopelmicrosparitic texture (biogenic, or intraclastic-biogenic-peloid wackestone). The allochems form smudges. Fine recrystallised detritus or biodetritus is common. Some of the smallest micrite clasts are difficult to observe, and their size approaches that of peloids. Though rare, calpionellids present in the matrix help to determine the stratigraphic position of this limestone. Both large and small forms of *Calpionella alpina* Lorenz, *Crassicollaria massu-*

Table 1. Distribution of biogenic compounds in the ground mass of sediments of the first group; cf. = confer, ? = questionable

BIOGENIC COMPOUNDS	sample No.										
	MS2	M3	M3kal	M3-4a	M3-4b	M5	M5a	M5b	M7	M8b	M9a
Calpionella sp.	●							●		●	
Calpionella alpina	●	●	●	●	●	●	●				●
Calpionella elliptica		●	●	●	●					cf. ●	●
Crassicollaria sp.											●
Crassicollaria brevis	●				●						
Crassicollaria intermedia		●	●								
Crassicollaria massutiniana	●	●	●		●	●					
Crassicollaria parvula	●	●	●			●					
Tintinnopsella carpathica				●	●	●					●
Tintinnopsella longa				●							
cf. *Remaniella* sp.											●
calcareous dinoflagellates	●		●	●	●						
Cadosina fusca						●	●	cf. ●			●
Cadosina fusca cieszynica				●				●			
Colomisphaera sp.									●		
Colomisphaera carpathica										●	●
Colomisphaera minutissima		●									
Colomisphaera nagyi											●
Globochaete alpina	●	●	●	●	●	●	●			●	●
Didemnoides moreti	●				●	●					●
benthic foraminifers	●		●	●	●	●		●		●	●
cf. *Protopeneroplis striata*	●										
radiolarians	●	●		●		●		●		●	
sponge spicules		●		●		●	●	●		●	●
echinoderm fragments	●		●	●			●	●		●	●
echinoid spines	●										
ostracodes		●	●	●	●		●	●		●	●
filaments	●	●	●	●			●		●		●
fragments of thick-shelled bivalves				? ●						? ●	●
aptychi	●										
brachiopod fragments		●									

tiniana (Colom), *Cr. parvula* Remane, *Tintinnopsella carpathica* (Murgeanu et Filipescu) were identified. The occurrence of fossils is shown in Table 1.

More conspicuous accumulations of detrital components were found in samples M3, M3kal, and M3-4a. The sediment texture of these samples is biomicritic or biomicrosparitic (biogenic wackestone). The partially recrystallised matrix contains some clasts and peloids (M3). These samples also contain well- and poorly-defined accumulations of allochems, comprised mainly of detritus. Some of these allochems are associated with incomplete laminae (M3kal) and rare clusters of coarser detritic material (M3, M3-4a), in the latter of which clear indications of grading (M3) are observed. These sediments are classified as intrabiopelmicrites/intrabiopelmicrosparites (intraclastic-calpionellid-peloid wackestone/packestone).

The clasts in these samples are micritic, intrabiopelmicritic (intraclastic-biogenic-peloid wackestone), and contain *Calpionella alpina* Lorenz, authigenic quartz, or echinoderm fragments (M3-4a).

Mildly deformed calpionellids occur in these samples, which include the common *Calpionella alpina* Lorenz, and the very rare *Calpionella elliptica* Cadisch and *Crassicollaria massutiniana* (Colom). The occurence of fossils is shown in Table 1. Additionally, oolites have been identified in sample M3-4a, and recrystallised detritus occurs in some samples.

The microfossils identified in the matrix also include calpionellids [in sample M3 (Plate I, figs 3, 4, 8) sporadic and in sample M3kal rare, partly deformed]. *Crassicollaria parvula* Remane [sample M3 (Plate I, fig. 6) and sample M3kal], *Tintinnopsella carpathica* (Murgeanu et Filipescu), and *T. longa* (Colom) [sample M3-4a (Plate I, fig. 7)] have been identified in addition to those mentioned above (see Table 1). Redeposited specimens of *Crassicollaria massutiniana* (Colom) and *Cr. intermedia* (Durand

Delga) were observed in samples M3a and M3kal. Recrystallised detritus is common. In sample M3-4a, deep-water micofossils are mixed with those from shallow water.

A cluster of intrabiomicrosparitic texture (intraclastic-biogenic wackestone/packestone), comprised of coarser shallow-water detrital material, was found in sample MS2. The matrix of this sample contains unsorted allochems that have the appearance of smudges. We classify this sample as intrabiomicrosparite (intraclastic-biogenic wackestone). Most of the micritic and biomicritic clasts that comprise the clusters (biogenic wackestone) are well rounded. Fossils present in these fragments are of the echinoderm and cf. *Cadosina fusca* Wanner.

Among the organic remains (see Table 1), *Calpionella alpina* Lorenz, foraminifers, and *Protopeneroplis striata* Weynschenk have been identified. Recrystallised biodetritus is also present.

The clasts scattered within the matrix are of the same character as those described above in the clusters, and contain remnants of *Globochaete alpina* Lombard.

The fossils further include sporadic calpionellids such as *Crassicollaria brevis* Remane, *Cr. intermedia* (Durand Delga), *Cr. massutiniana* (Colom), *Cr. parvula* Remane, *Calpionella alpina* Lorenz, *Calpionella* sp., and the benthic foraminifers *Protopeneroplis* cf. *striata* Weynschenk or its fragments, etc. (Table 1).

Although the concentration of allochems differs slightly in sample M5b, their distribution is similar to the case mentioned above. The allochems in this sample are mainly biogenic, being comprised of radiolarians and sponge spicules, and are scattered or irregularly accumulated into variously shaped nest-like structures. The rock texture is intrabiomicrosparitic (intraclastic-biogenic wackestone). Intraclasts comprise a substantial part of the redeposited material that form the allochem nests, and are irregularly scattered throughout the microsparitic matrix along with original radiolarian, or radiolarian-sponge microfacies. Radiolarians of the spumellarians group and spongi also occur as sparse nests among the intraclast accumulations. Other fossils identified in this sample include echinoderm fragments, a single *Calpionella* sp. (probably redeposited), *Cadosina fusca cieszynica* Nowak (Plate I, fig. 5), *Cadosina fusca* Wanner, foraminifers (*Spirillina* sp., *Nodosaria* sp.), Ostracoda div. sp., and recrystallised biodetritus.

The parts of the sample that contain the accumulated material are characterized by an intrabiomicrosparitic/intramicrosparitic texture (intraclastic-biogenic, or intraclastic wackestone/packestone). The variably reworked clasts are of a micritic or biomicritic texture (biogenic wackestone). They mainly include recrystallised fragments of echinoderms (two of which resemble to genus *Saccocoma*), or recrystallised fragments of unidentified fossils.

As this sample contains fossils of a wider stratigraphic range, an exact age determination is not possible.

In sample M8b the radiolaria and sponge spicules represent more numerous morphotypes together with rare, poorly preserved *Calpionella* sp. and *Calpionella* cf. *elliptica* Cadisch (Table 1). This sample also contains small clasts with micritic texture, and peloids that form irregular accumulations of intrabiopelmicritic/intrabiopelmicrosparitic texture (intraclastic-radiolarian-sponge-peloid wackestone).

Sample M9a represents a laminated limestone, comprised of two types of laminae, referred to below as Laminae No. 1 and No. 2. Their contacts range from being sharp, with an undulating contact, to gradual.

Lamina No. 1 is of biomicrosparite (biogenic wackestone). The microfossils include the rare calpionellids *Crassicollaria* sp., *Calpionella alpina* Lombard, *Calpionella elliptica* Cadisch, *Tintinopsella carpathica* (Murgeanu et Filipescu), and others mentioned in Table 1. Recrystallised detritus is also common. The thin layers are composed predominantly of recrystallised detritus.

Lamina No. 2 is of intrabiopelmicrosparite/intrabiopelsparite (intraclastic-calpionellid-peloid packestone/grainstone). The intraclasts of micritic texture are moderately sorted, and variously rounded. *Calpionella alpina* Lorenz occurs sporadically in clasts. Organic remnants in the groundmass mainly represent common calpionelids, of which *Calpionella alpina* Lorenz is predominant, and *C. elliptica* Cadisch, *Tintinnopsella carpathica* (Murgeanu et Filipescu), and *Remanella* sp. are rare. The occurrence of other fossils is shown in Table 1. The calcareous dinoflagelate *Colomisphaera nagyi* (Borza) was identified, which represents a redeposited Kimmeridgian specimen. Biodetritus is also present. Indications of local grading can be seen in this type of lamina.

Samples M5a and M3-4b are composed of the same types of material as the laminated limestone (see Table 1).

Authigenic quartz, pyrite, and rare glauconite and hydromica occur in the rocks of this group of limestones. Clastic quartz that came from the adjacent exposed zones is also present.

Detritic limestones

Samples M3detr, M5detr, and M6 are of detritic limestones. They represent shallow-water sediments characterized by an intrabiosparitic texture (intraclastic-biogenic grainstone). The matrix of these samples is strongly recrystallised, and contains a wide range of unsorted allochems (primarily in sample M5detr). Some of the allochems in sample M3detr are preserved only as ghosts. Some clasts are well rounded. These components are seldom densely distributed, and are rarely found in mutual contact; most contacts between them are cut by microstylolite. In sample M5detr rare fragments occur which are classed as rudites; their maximum size is around 4.5 mm.

The microfacies analysis of these samples has revealed the presence of clasts with the following textures:

1. Micrites (mudstone), some of which contain authigenic quartz (sample M3detr) and forms resembling pseudomorphs after gypsum or anhydrite.

2. Biomicrites (biogenic wackestone) in which biogens are represented by foraminifers (in sample M6 a fragment of *Charentia* sp., milliolid form was identified), thick-walled bivalves, or sections of gastropods (sample M5detr).

Other components include recrystallised detritus and authigenic quartz.

3. Intrabiomicrosparites (intraclastic-biogenic wackestone/packstone) with micritic fragments (some of which are gravels), fragments of echinoderms, and recrystallised detritus (sample M5detr).

4. Intrasparites/intrabiosparites (intraclastic/intraclastic-biogenic grainstone – Plate II, fig. 4), in which allochems are densely packed. These allochems include fragments of micrite (in sample M5detr), pseudomorphs of gypsum or anhydrite, foraminifers, and recrystallised detritus. A clast of siliceous rock containing heavy minerals was identified in sample M5detr, and a recrystallised fragment with local allochem ghosts was found in sample M6.

Fossils of a wider stratigraphic range occur within the matrix, some of which are strongly recrystallised. They include fragments of echinoderms, thick-walled bivalves (some of which in sample M3detr bear traces from boring organisms), gastropods (sample M6), foraminifers represented by milliolid and textulariid forms, *Trocholina alpina* (Leupold) (Plate II, fig. 5), *T. elongata* (Leupold), *Everticyclammina* sp. (samples M3detr and M5detr), *Pseudocyclammina lituus* (Yokoyama), (samples M5detr and M6), *"Conicospirillina" basiliensis* Mohler (sample M3detr), *Nautiloculina oolithica* Mohler (in samples M3detr and M5detr, see Plate II, fig. 4,), *"Siphovalvulina"* sp. (sample M6) and other thick-walled benthic forms (Plate II, fig. 3), fragments of shallow-water organisms, sponges, algae (dasycladaceans ones inclusive), and bryozoa (samples M3detr and M6). Sample M6 was found to contain *Permocalculus* sp. (Plate II, fig. 2), *Boueinia* sp. (Plate II, fig. 1), and a dasycladacean alga *Salpingoporella ?annulata* Carozzi.

Sporadic oolites and peloids are present in variable amounts in samples M3detr, M5detr. Some allochems are cut by microstylolites, with rims formed around other allochems.

The rare clastic quartz (maximum size ~1 mm) of the sandy fraction shows undulatory extinction under polarized light in samples M3detr and M5detr. Authigenic idiomorphic quartz also occurs in sample M3detr.

The sediment represented by samples M7b and M7b1 differs from that described above. Sample M7b1 is probably a stromatolite (sponge-stromatolitic laminite, Plate II, fig. 6). Microlamination occurs as thin, irregular, alternating layers of biopelmicrite/biopelmicrosparite (biogenic-peloid wackestone) with cyanophytes and pelsparite (peloid grainstone). The matrix is moderately recrystallised, and calcareous cement has developed around some of the clasts. Peloids are the principal allochem. Small micritic clasts are rare, as are foraminifers, filaments, and recrystallised, undertermined fossils and fossil fragments. The stratigraphic position of the sediment cannot be determined on the basis of these organic remnants.

A thin section from sample M7b shows both shallow- and deep-marine characteristics. The texture is intrabiopelmicritic/intrabiopelmicrosparitic (intraclastic-biogenic-peloid wackestone). The matrix is moderately recrystallised. The intraclasts are micritic, biomicritic (wackestone), and contain recrystallised organic remains. Fossils present in the deeper-marine material of this sample include ostracods and ostracod valves, fragments of echinoderms, benthic (*Gaudryina* sp.) and sessil foraminifers, fragments of dasycladacean algae, *Tubiphytes obscurus* Maslov (syn. *T. morronensis* Crescenti), *Globochaete alpina* Lombard, thick and thin-walled bivalves, radiolarians, rare sponge spicules, very rare sections resembling calpionellids, and miscellaneous biodetritus. Oolites and/or rims formed around allochems were also sporadically present. The quartz and pyrite identified in this sample are authigenic.

The matrix of the shallow-marine material in this thin section, along with the sponges and other shallow-water (reef-forming) components, are strongly recrystallised. Peloids are also abundant in some parts; small micritic clasts are less common. Other fossils, such as ostracod valves, foraminifers, *Globochaete alpina* Lombard, and algae occur rarely in this sample.

The biostratigraphic interpretation of the thin sections

The fine-grained to muddy limestone samples contain stratigraphically significant calpionellids.

Those in the matrix of sample M5 indicate an age either from the Late Tithonian or the base of Berriasian.

The calpionellids *Calpionella alpina* Lorenz and *C. elliptica* Cadisch represent the standard Elliptica Subzone of the Calpionella Biozone (Pop 1994). These specimens are indicative of the Middle Berriasian in samples M3 and M3kal. Redeposited specimens of *Crassicollaria massutiniana* (Colom) and *Cr. intermedia* (Durang Delga) were also identified. Sample M3-4a was found to contain *Tintinnopsella longa* (Colom), an index fossil of the Tintinnopsella Subzone within the Calpionella Biozone, which represents the upper Middle Berriasian.

The laminated limestone of sample M9a contains common calpionellids of the standard Calpionella Biozone, Elliptica Subzone (Pop 1994). The calpionellid population mainly includes *Calpionella alpina* Lorenz, but also contains rare *Calpionella elliptica* Cadisch, *Tintinnopsella carpathica* (Murgeanu et Filipescu), and cf. *Remaniella* sp.

No stratigraphically significant microfossils were found in the detritic limestone samples. They can therefore only be ranged within the wide Kimeridgian-Valanginian interval.

Palynological results

Several poorly preserved dinoflagellate specimens were found in samples from the higher part of the section MP4–MP8 (Table 2, Plate III). Samples collected from the lower part of the section (MP1–MP3), and sample MP9, were barren of dinoflagellates and other palynological specimens.

Samples MS1 and MS2 contain mostly plant detritus and some unidentifiable dinoflagellate cysts. They did not provided any palynological remnants.

Palynostratigraphic interpretation

Many stratigraphically significant species are present in the dinoflagellate assemblages (written in bold print in Table 2). According to Leereveld (1997), the earliest occurrence of the species *Kleithriasphaeridium fasciatum* (Plate III, fig. 5) and *Pseudoceratium pelliferum* (Plate III, fig. 1; samples MP4 and MP5b) is known from the Boissieri Zone (the upper part of the ammonite Picteti Subzone) of the Late Berriasian. Due to the presence of the species *Gonyaulacysta cretacea*, which, according to Leereveld (1997), corresponds to the ammonite Pertransiens Zone, sample MP4 can be considered as Early Valanginian in age. The same author holds the latest occurrence of the species *Dichadogonyaulax bensonii* (Plate III, fig. 3) and *Systematophora areolata* (Plate III, fig. 10; sample MP5b) to be indicative of to the Early Valanginian. According to the work of Monteil (1992), the given dinoflagellate assemblage can be assigned to the interval from the ammonite Otopeta Subzone (latest Berriasian) to the Pertransiens Zone (Early Valanginian).

As sample MP6 contains the first occurrence of the species *Oligosphaeridium complex*, it therefore corresponds to the uppermost part of the Early Valanginian (ammonite Campylotoxus Zone). It can thus be concluded that the studied sequence of pelitic sediments (MP1–MP6) represents the Early Valanginian; in the lowermost part, however, the possible presence of the latest Berriasian cannot be excluded.

The presence of *Cymososphaeridium validum* in samples MP7 and MP8 indicates the base of the Late Valanginian.

A similar dinoflagellate association was observed in the Těšín Limestone of the Silesian Unit. This association occurs in the detritic limestones of Horní Líštná and in the Skalice section; the former belonging to the classic detritic localities of the Těšín Limestone (Skupien 1996, 1999).

Conclusion

The limestone samples collected from the surroundings of Měrkovice fall into two categories.

The primary group is comprised of fine-grained limestones that are present as float around outcrops of the coarse detritic limestones. Varying degrees of gradation and lamination were observed in thin sections of these samples. Stratigraphically significant calpionellids, some of which have been deformed, occur in the matrix and clasts. Calcareous dinoflagellates were also identified. The material of these limestones seems to have been redeposited by turbidity currents.

The age of these limestones may be deduced according to the presence of the stratigraphically youngest calpionellids, mainly *Calpionella elliptica* and *Tintinnopsella longa*. Most of the samples can be assigned to the Elliptica Subzone of the standard Calpionella Biozone within the Middle Berriasian (Pop 1994). Samples that contain *Tintinnopsella longa* in association with other calpionellids indicate the Longa Subzone of the upper Middle Berriasian.

The coarse, detritic limestone outcrops comprise the second group of sediments. Thin sections of these rocks have revealed fragments of echinoderms, gastropods, thick-walled bivalves, bryozoans, miliolid and textulariid foraminifers, algae, and other organisms. These fossils are of less stratigraphical significance, ranging from the Kimmeridgian to the Valanginian. This group also includes limestones comprised of stromatolites, or other reef-forming components. Both limestone types in this group lack index fossils; therefore, their stratigraphic position cannot be precisely determined.

All thin sections reveal similar microfaunal associations. This would indicate that the limestones in the vicinity of Měrkovice correspond to nearly the same time level, and come from a deeply eroded source area.

Studies of the noncalcareous dinoflagellates found in samples from the overlying deposits confirm the stratigraphic assignation of these limestones to the Middle Berriasian. The lithology of these deposits represents a transition from limestone to dark grey pelitic deposits. However, no direct transition from the limestones to the overlying layers has yet been found. The lower sections of the flysch deposits contain noncalcareous dinoflagellates, corresponding to the Early Valanginian and to the lower Late Valanginian. The colour and lithological character of these deposits correspond to the Těšín-Hradiště Formation.

Field exploration and the study of thin sections has shown that the limestones around Měrkovice fall within the category of detritic limestones. Although their total thickness cannot be determined, it may be estimated to have been about ten metres. The fossil remnants give clear evidence of a reef to sublittoral shallow-water source area, which may have been situated on the Baška ridge, Silesian Unit.

With regard to the evidence indicating a Berriasian age for the limestones occurring around Měrkovice, we consider them to be equivalent to the Těšín Limestone, as opposed to layers representing the overlying Těšín-Hradiště Formation. As the overlying beds in the study area (to the east) lack any deposits corresponding to the Baška facies, yet are rich in material from the volcanic teschenite, the limestones considered in this paper are interpreted as part of the Godula facies of the Silesian Unit. This interpretation is consistent with the map of Matějka and Chmelík (1956, see also Fig. 1 in the present paper), in which a partial thrust plane is illustrated, along which the deposits of the Godula facies were thrust northwest over those of the

Table 2. Distribution of dinocysts in the samples from the Měrkovice locality

VALANGINIAN						STRATIGRAPHY
Early				Late		
MP4	MP5a	MP5b	MP6	MP7	MP8	Samples No. / DINOFLAGELLATE CYST TAXA
●		●		●	●	***Achomosphaera neptunii*** (Eisenack 1958) Davey and Williams 1966
		●				*Bourkidinium* sp.
●	●				●	*Circulodinium distinctum* (Deflandre and Cookson 1955) Jansonius 1986
		●				***Circulodinium vermiculatum*** Stover and Helby 1987
●						*Cometodinium habibii* Monteil 1991
					●	*Cribroperidinium orthoceras* (Eisenack 1958) Davey 1969
	●	●	●	●		*Cribroperidinium* sp.
				●	●	***Cymososphaeridium validum*** Davey 1982
			●			*Diacanthum hollisteri* Habib 1972
●						*Dapsilidinium warrenii* (Habib 1976) Lentin and Williams 1981
		●				***Dichadogonyaulax bensonii*** Monteil 1992
					●	*Dissiliodinium globulus* Dragg 1978
			●	●		*Endoscrinium campanula* (Gocht 1959) Vozzhennikova 1967
●		●				***Gonyaulacysta cretacea*** (Neale and Sarjeant 1962) Sarjeant 1969
	●					*Gonyaulacysta* sp.
		●				*Hystrichodinium pulchrum* Deflandre 1935
●			●	●		*Hystrichosphaerina schindewolfii* Alberti 1961
					●	*Kiokansium* sp.
●		●			●	***Kleithriasphaeridium fasciatum*** Davey and Williams 1966
			●		●	***Muderongia macwhaei*** Cookson and Eisenack 1958
●		●	●	●	●	*Muderongia tabulata* (Raynaud 1978) Monteil 1991b
		●				*Occisucysta tentoria* Duxbury 1977
●						*Occisucysta* sp.
			●		●	***Oligosphaeridium complex*** (White 1842) Davey and Williams 1969
					●	*Oligosphaeridium* sp.
		●				***Prolixosphaeridium*** sp. A sensu Monteil (1993)
					●	*Pseudoceratium gochtii* Neale and Sarjeant 1962
●		●	●	●		***Pseudoceratium pelliferum*** Gocht 1957
					●	***Spiniferites*** sp.
					●	*Stiphrosphaeridium* sp.
		●				***Systematophora areolata*** Cookson and Eisenack 1965
		●				*Systematophora palmula* Davey 1982
●	●		●		●	*Systematophora scoriacea* (Raynaud 1978) Monteil 1992
●					●	*Systematophora* sp.
		●				*Tanyosphaeridium isocalamus* (Deflandre and Cookson 1955) Davey and Williams 1969
●	●					*Tanyosphaeridium* sp.
		●				***Wallodinium cylindricum*** (Habib 1970) Duxbury 1983
		●				*Wallodinium krutzschii* (Alberti 1961) Habib 1972

Baška facies and/or partly over the Subsilesian Unit. The interpretation of the distribution of limestones as shown in the map of Menčík and Tyráček (1985) we regard as less probable.

Limestones of the Godula facies probably represent the maximum extent of the Těšín turbiditic limestone in the western part of the Silesian Unit. Older stratigraphic members were amputated by thrust movements.

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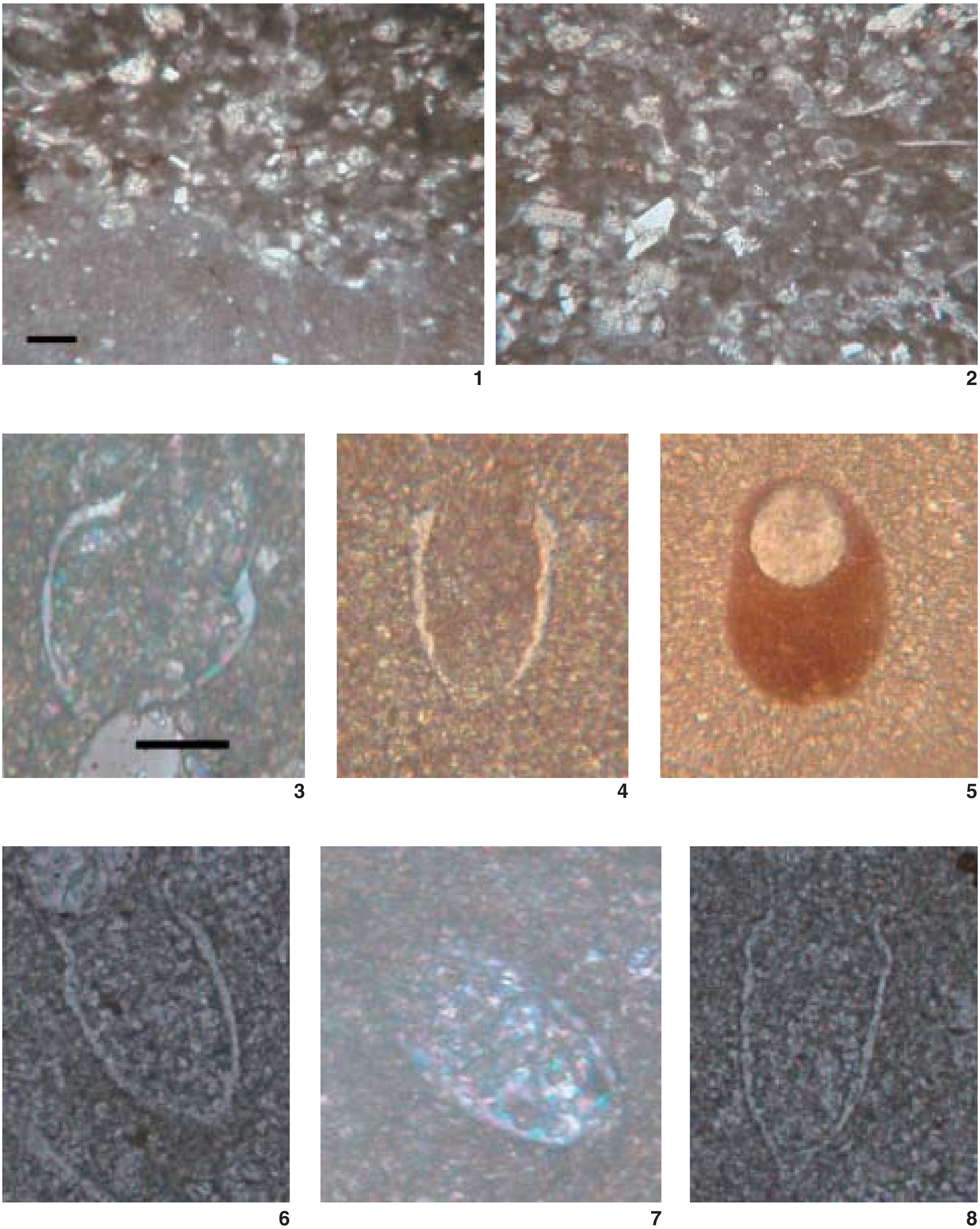

Plate I

1 – Contact between the matrix (lower part) with the transported detritic material (contact of two types of textures), sample M5a. 2 – Transported material, sample M5a. 3 – *Calpionella alpina* Lorenz, sample M3. 4 – *Crassicolaria massutiniana* (Colom), sample M3. 5 – *Cadosina fusca cieszynica* Nowak, sample M5b. 6 – *Crassicolaria parvula* Remane, sample M3. 7 – *Tintinopsella longa* (Colom), sample M3-4a. 8 – *Crassicolaria massutiniana* (Colom), sample M3.

Scale bar in fig. 1 indicates 100 µm for Plate I, figs 1 and 2, Plate II, figs 1, 2 and 6. Scale bar in fig. 3 indicates 20 µm for Plate I, figs 3–8, Plate II, figs 3–5.

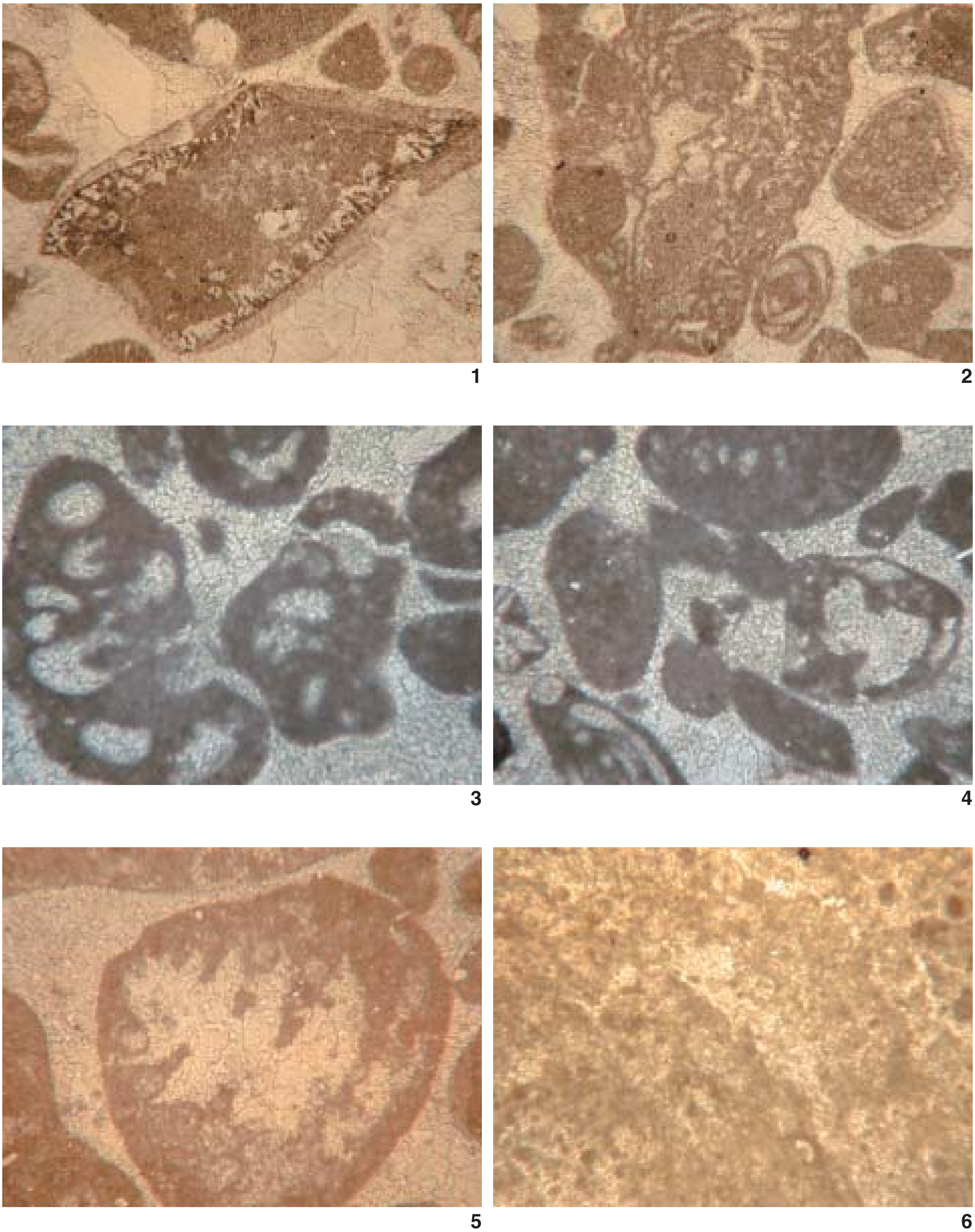

Plate II
1 – *Boueinia* sp., sample M6. 2 – *Permocalculus* sp., sample M6. 3 – Cross section of thick-walled, agglutinated foraminifer tests, sample M6. 4 – Intrabiosparite (intraclastic-biogenic grainstone), the allochems are contact in some places. The upper area shows part of *Nautiloculina oolithica* Mohler, while part of a milliolid foraminifer is visible in the bottom left. Sample M3. 5 – *Trocholina alpina* (Leupold), sample M5. 6 – Stromatolite (sponge-stromatolitic laminite), sample M7b1.

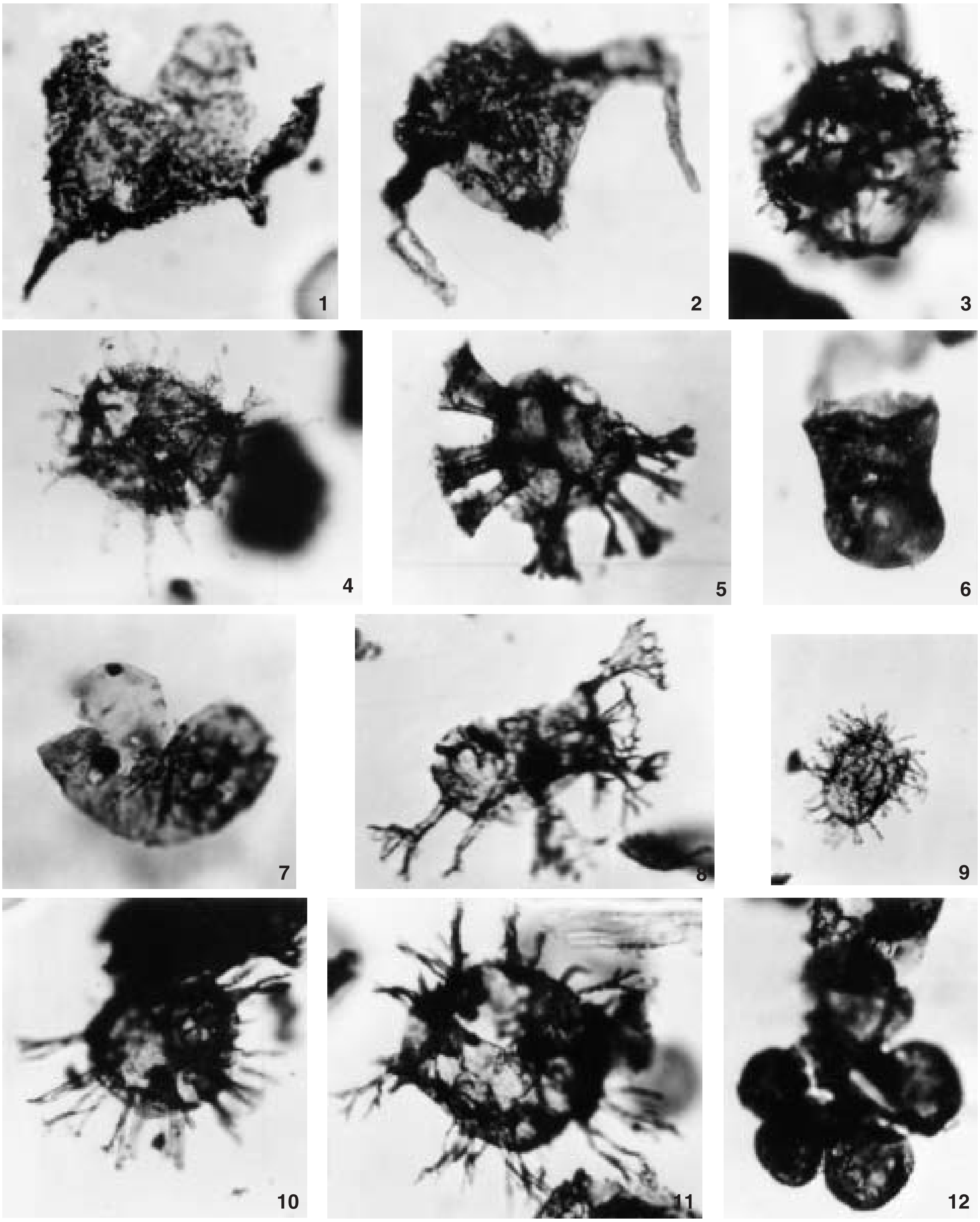

Plate III

Species name is followed by specimen size, slide number, and England Finder coordinates (for locating the specimen in the slide).

1 – *Pseudoceratium pelliferum* Gocht 1957; length 100 μm, M8/d, D30/31. 2 – *Muderongia macwhaei* Cookson and Eisenack 1958; width 93 μm, M8/f, L30/2. 3 – *Dichadogonyaulax bensonii* Monteil 1992; diameter 58 μm, M8/c, L39/3. 4 – *Hystrichodinium pulchrum* Deflandre 1935; length 74 μm, M8/c, K32/33. 5 – *Kleithriasphaeridium fasciatum* Davey and Williams 1966; length 72 μm, M8/b, K35. 6 – *Wallodinium cylindricum* (Habib 1970) Duxbury 1983; length 61 μm, M8/d, V32/3. 7 – *Dissiliodinium globulus* Drugg 1978; width 70 μm, M8/e, H49/2. 8 – *Oligosphaeridium* sp.; diameter 90 μm, M8/b, B47/2. 9 – *Tanyosphaeridium isocalamus* (Deflandre and Cookson 1955) Davey and Williams 1969; length 60 μm, M8/a, M46. 10 – *Systematophora areolata* Cookson and Eisenack 1965; diameter 82 μm, M8/b, K28. 11 – *Systematophora scoriacea* (Raynaud 1978) Monteil 1992; diameter 70 μm, M8/b, J41/1. 12 – Chitinous foraminifera lining; diameter 73 μm, M8/b, K39.

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