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Biostratigraphy and paleoecology of the Lower Cretaceous sediments in the Outer Western Carpathians (Silesian Unit, Czech Republic)

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Abstract: Almost black shale filling fissures in the Štramberk Limestone belonging to the Silesian Unit, Outer Western Carpathians contain prolific and poorly to moderately well preserved spores, pollen, organic-walled dinoflagellate cysts, foraminifers, and calcareous nannofossils. A detailed micropaleontological analysis of the proved stratigraphical interval from the Valanginian to the Albian indicated sedimentary conditions of brackish, restricted marine, shallow-marine and neritic sedimentation. Moreover, it drew attention to occasional influence from the Boreal province in the depositional area of the NW part of Tethys, especially during the Early Valanginian and Hauterivian, as supported by the presence of high-latitude nannofossils and organic-walled dinoflagellate cysts. Terrestrial miospores form a significant component of palynoassemblages and give evidence of continent proximity in the Valanginian-Barremian interval. Samples were acquired from isolated fissure fills in the Štramberk Limestone and, therefore, they do not represent a continuous section.

Key words: Lower Cretaceous, Outer Western Carpathians, Czech Republic, Silesian Unit, paleoecology, biostratigraphy, microfossils.

Introduction

The western part of the Silesian Unit, situated in the NE of the Czech Republic (Fig. 1), includes marine clastic sediments which consist predominantly of dark grey, black and light green-grey claystones. These rocks are generally rich in marine microfossils, including foraminifers, organic-walled dinoflagellate cysts and calcareous nannofossils, but they are rather poor in spore-pollen content. This study presents the results of an integrated biostratigraphic and paleoecological analysis of the Lower Cretaceous deposits from the Štramberk vicinity. Cretaceous sediments together with the Štramberk Limestone form isolated tectonic slices grouped within three complexes — Kotouč, Skalky and Trúba (Fig. 2). Picha et al. (2006) included all local Cretaceous deposits and local lithostratigraphic units in the area of Štramberk under the name "Kotouč Facies" of the Hradiště and Baška Formations with stratigraphical range of Hauterivian to Cenomanian. The carbonate sediments have been intensively studied previously (Houša & Vašíček 2005). The Lower Cretaceous pelitic deposits of the Štramberk area have been periodically studied with the focus on biostratigraphy, but no similar integrated study has been presented yet. The object of this study are pelitic deposits in two quarries and their biostratigraphy, paleoenvironmental interpretation and correlation with regional stratigraphic succession. This paper follows the study of the Albian-Cenomanian microfossils in the Štramberk area by Svobodová et al. (2004), Švábenická & Hradecká (2005) and nannoplankton stratigraphy of the Silesian Unit (Švábenická 2008).

Geological background

The Silesian Unit represents a nappe in the structure of the Outer Western Carpathians thrust over the Subsilesian Nappe and partly over the Miocene fill of the Carpathian Foredeep from east to west. This unit consists of Upper Jurassic to Oligocene-Miocene sediments. Three developments were distinguished by Eliáš (1970): frontal slope setting (Baška Subunit), basinal setting (Godula Subunit) and the Kelč Subunit.

Initial sedimentation in the Baška Subunit is connected with the Štramberk Limestone representing a part of the original

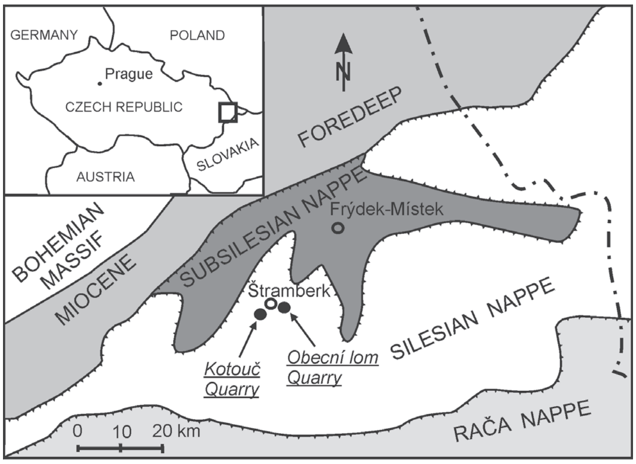

Fig. 1. A sketch map of the structural outline of the Silesian Unit with the Štramberk-Kotouč Quarry and Obecní lom Quarry indicated.

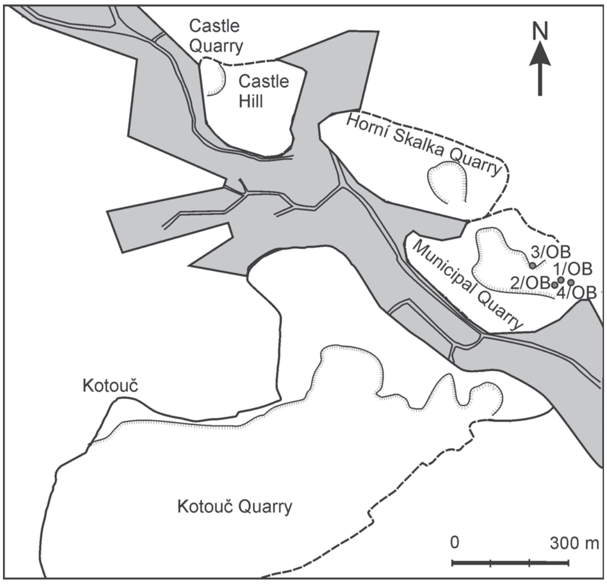

Fig. 2. A map of the main limestone bodies in the vicinity of Štramberk with the position of quarries. Position of samples in the Obecní lom Quarry (Municipal Quarry).

reef complex which probably bordered the SE margin of the West European Platform. Deposition of the Štramberk Limestone probably lasted from the latest Kimmeridgian to the Early Berriasian (Houša & Vašíček 2005).

According to Picha et al. in Picha & Golonka (2006), the Štramberk carbonate platform, rimmed by coral reefs, was the source of clastics and debris. Gravitational slides and turbidite currents transported smaller and larger blocks or fragments from the rim (edge) of the platform as far as the floor of the adjacent basin during the Early and mid-Cretaceous. Moreover, in the course of later tectonic transport, large tectonic slices of carbonate platform were separated from softer, less competent rocks situated on the slopes of the platform. This process resulted in a melange, with larger blocks from the carbonate platform having the character of klippen. Eliáš & Stráník (1963) and Picha et al. (2006) assigned the limestones, together with grey to black-grey pelitic deposits of the Štramberk area, to the Kotouč Facies. The Kotouč Facies generally corresponds to the Hradiště and the Baška Formations of the Silesian Unit.

Concerning the Štramberk area, Houša (1975, 1990) and Houša & Vašíček (2005) proved that during the Early Cretaceous, deposition of the Štramberk Limestone intermittently passed into carbonate sedimentation (the Olivetská hora and Kopřivnice Limestone). This is proved by calpionellids and ammonites. The Olivetská hora Formation occupies the middle to lower parts of the Upper Valanginian. The Kopřivnice Limestone contains, in addition to abundant brachiopods and echinoderms, Upper Valanginian ammonites. Here, besides carbonate deposits, black-grey claystones and siltstones are also found. Deposits which contain ammonites of the Valanginian and Early Hauterivian age (Houša & Vašíček 2005) were designated as the Plaňava Formation (Houša 1975). In addition to them, still other similar grey or green-grey pelites exist: they alternate with sandstones and conglomerates (containing pebbles, cobbles and blocks of Štramberk Limestone) or form infillings of cavities in the Štramberk Limestone. These sediments are of Albian to Cenomanian age (Svobodová et al. 2002). Houša (1975) assigned this sediment to the Chlebovice Member (sometimes also Chlebovice Conglomerate). Block accumulations in the Štramberk area consist of two major groups of bodies (Fig. 2):

a) The western part of Kotouč Hill (Figs. 3, 4) which consists of block accumulations (over 400 m thick before their exploitation by the Štramberk-Kotouč Quarry) and forms a continuous strata succession from the uppermost Jurassic (Tithonian) to the Cenomanian or Lower Turonian. These accumulations (in the so-called Kotouč Facies) pass laterally into the stratigraphic units of the Hradiště Formation. Many fissures, open joints and cavities in the limestone are filled with different clayey limestones and claystones (grey, dark grey, green-grey, red, Fig. 3). Houša (1975) distinguished three major bodies of the Štramberk Limestone separated by the Mendocino and Clarion faults.

b) The massif of "Skalky" (Horní Skalka Quarry) and "Zámecký vrch Hill" (Castle Hill, Castle Quarry) consists of several independent bodies of block accumulations, exposed in the abandoned Obecní lom Quarry (Municipal Quarry) (Fig. 2).

Relevant micropaleontological studies

Miospores of the Lower Cretaceous deposits of the Silesian Unit from the localities of Štramberk-Kotouč and Obecní lom Quarries have been described by Vavrdová (1964a,b, 1981), Svobodová (1998) and partly by Svobodová et al. (2004). Organic-walled dinoflagellate cysts from the Baška Subunit were studied by Svobodová & Vavrdová (1987), Svobodová et al. (2004), and those from the Godula Subunit by Skupien (1997, 1998, 1999, 2003a,b, 2004), Skupien et al. (2002, 2003a,b, 2009), Skupien & Vašíček (2002), and Boorová et al. (2004). Early Cretaceous foraminifers from the Baška Subunit of the Silesian Unit in the vicinity of Štramberk were studied by Homola & Hanzlíková (1955), Hanzlíková (1962, 1966, 1969), Hanzlíková & Roth (1963) and Švábenická & Hradecká (2005). Hanzlíková (in her monograph of 1972) mentioned a sporadic occurrence of foraminifers in the Godula Subunit. Twenty years later, Hanzlíková returned to her previous study of the Lower Cretaceous sediments by her presentation in the Excursion Guidebook of the 18th European Colloquium on Micropaleontology in Czechoslovakia (Menčík et al. 1983). Calcareous nannofossils from black claystones of the Hradiště Formation (Nová Dědina site near Frýdlant nad Ostravicí) were studied by Švábenická (in Skupien et al. 2003a). The distribution of nannofossil species, their abundance and biostratigraphic interpretation from both quarries was partly published by Švábenická (2008).

Material

Material was obtained from sediments of the Kotouč Facies, Baška Subunit, that fill fissures in the Štramberk Limestone of the abandoned Obecní lom Quarry (Fig. 2) and the Štramberk-Kotouč Quarry (Figs. 3, 4). Samples were obtained from isolated exposures of fissure fillings, from the tectonically deformed depressions and from infillings of cavities in the Štramberk-Kotouč Quarry (Fig. 3). Pelitic sediments reach their largest extent and highest thickness near the Mendocino and Clarion faults. They belong to the Plaňava Formation; samples were collected from its lower, middle and upper parts. No continuous exposures of these deposits have been found yet because sediments of the Štramberk area are represented by breccia, tilloid conglomerate and oligostrome. Samples 1, 2 and 4/OB were taken in the claystones of the Hradiště Formation at the southern limit of the limestone body of the Obecní lom Quarry. Sample 3/OB was obtained from a fissure in the NE wall (Fig. 2). The samples are represented by fine detrital sediments (red-brown, light green-grey, dark grey to black claystones and siltstones) (Table 1, Fig. 3).

Coding of the samples from the Obecní lom Quarry consists of two parts — the first part denotes the sample number and the second one the sampling site (Obecní lom Quarry — OB). Coding of the samples from the Štramberk-Kotouč Quarry consists of three parts: the first part denotes the sam-

Fig. 3. Štramberk-Kotouč Quarry; the Štramberk Limestone with dark clay fills of the Plaňava Formation near the Mendocino fault (middle part of the figure). Photo P. Skupien.

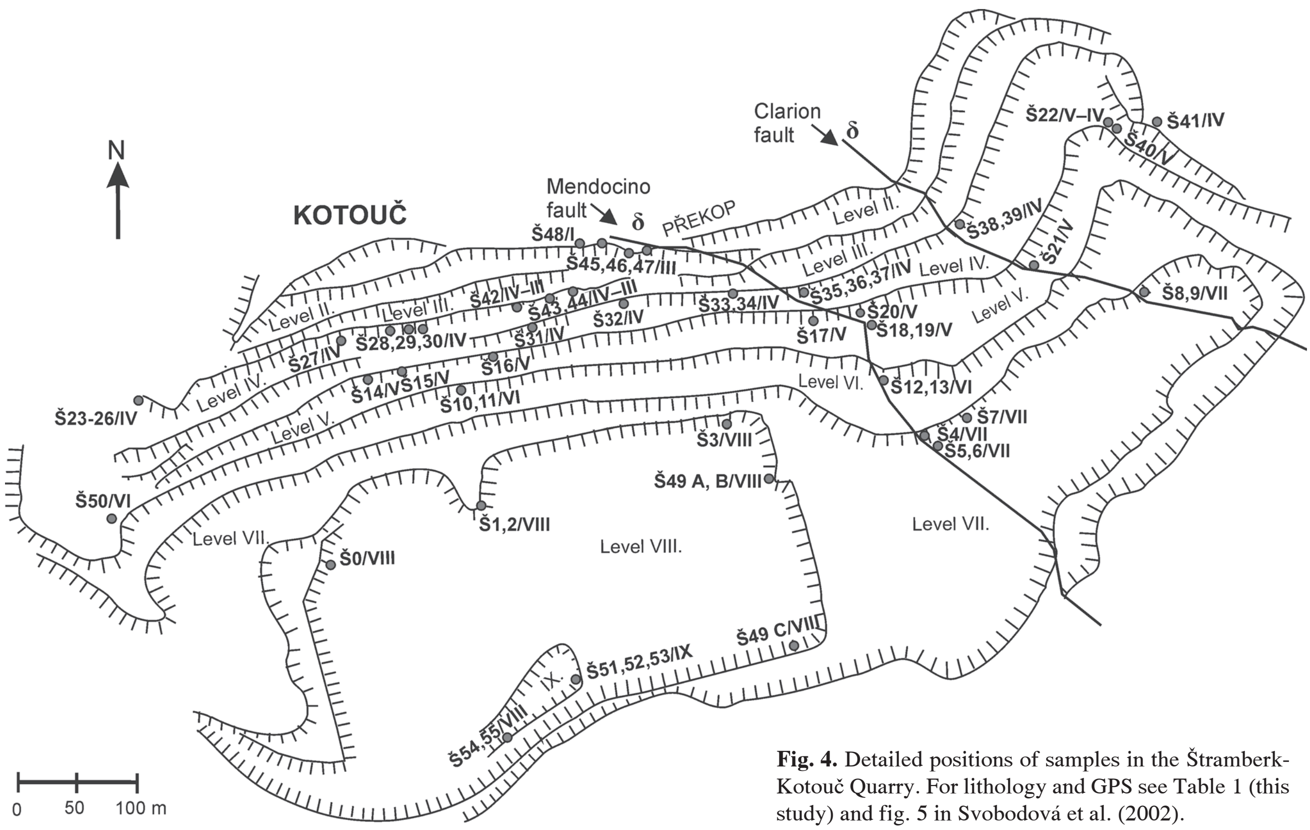

Fig. 4. Detailed positions of samples in the Štramberk-Kotouč Quarry. For lithology and GPS see Table 1 (this study) and fig. 5 in Svobodová et al. (2002).

Table 1: Position and lithology of the Lower Cretaceous samples in the Štramberk-Kotouč Quarry and Obecní lom Quarry (positions measured using GPS, the error of the measurement 5–7 meters).

Sample	Latitude N	Latitude E	Altitude	Lithology and sample localization
Š3/VIII	49°34´59´´	18°7´5´´	432 m	grey claystone, small fissure
Š4/VII	49°34´59´´	18°7´45´´	357 m	light grey siltstone, upper part of the large fissure, Plaňava Formation
Š5/VII	49°34´59´´	18°7´4´´	345 m	dark grey-black claystone, Plaňava Formation
Š6/VII	49°34´59´´	18°7´4´´	337 m	light grey calcareous claystone, lower part of the large fissure, Plaňava Formation
Š7/VII	49°35´0´´	18°7´12´´	354 m	dark grey claystone, Plaňava Formation, slumped body
Š8/VII	49°35´2´´	18°7´17´´	347 m	dark grey claystone, near the Clarion Fault, Plaňava Formation
Š9/VII	49°35´2´´	18°7´17´´	346 m	dark grey claystone near the Clarion Fault, Plaňava Formation
Š10/VI	49°34´59´´	18°6´52´´	368 m	dark grey claystone, northern wall, small cavity in the conglomerate, Chlebovice Member
Š12/VI	49°34´59´´	18°7´6´´	361 m	dark grey claystone, big exposure in the curve of the road, lower part, Plaňava Formation
Š13/VI	49°34´59´´	18°7´6´´	366 m	dark grey claystone, dtto Š12/VI, upper part
Š14/V	49°34´59´´	18°6´51´´	402 m	grey claystone, small fissure, Chlebovice Member
Š15/V	49°34´59´´	18°6´52´´	397 m	dark grey silty to sandy claystone, small fissure, Chlebovice Member
Š16/V	49°34´59´´	18°6´52´´	395 m	light green-grey silty to sandy claystone, small fissure, Chlebovice Member
Š17/V	49°35´1´´	18°7´0´´	400 m	grey-black claystone, cross fault near the curve of the road, Plaňava Formation
Š18,19/V	49°35´1´´	18°7´5´´	403 m	black claystone with pyrite near Mendocino Fault, big exposure, lower part, Plaňava Formation
Š20/V	49°35´1´´	18°7´4´´	406 m	black claystone with pyrite near Mendocino Fault, big exposure, upper part, Plaňava Formation
Š21/V	49°35´3´´	18°7´13´´	397 m	dark grey claystone near Clarion Fault, Plaňava Formation
Š22/V–IV	49°35´5´´	18°7´15´´	407 m	dark grey claystone near the top of the wall, ?Plaňava Formation
Š23–26/IV	49°34´58´´	18°6´40´´	425 m	grey siltstone, tectonically deformed big exposure near western part of the Kotouč Quarry (samples taken every 4 m), ?Hradiště Formation
Š27/IV	49°34´59´´	18°6´44´´	423 m	green-grey claystone, northern wall, 10 m from the crossroads to V. level
Š28/IV	49°34´59´´	18°6´46´´	429 m	dark green-grey claystone, small fissure, Chlebovice Member
Š31/IV	49°35´1´´	18°6´54´´	420 m	green-grey claystone inside limestone, Chlebovice Member
Š32/IV	49°35´1´´	18°6´57´´	416 m	grey claystone, small fissure, Chlebovice Member
Š33/IV	49°35´1´´	18°6´59´´	421 m	red-brown claystone, large fissure of grey and red-brown claystones
Š34/IV	49°35´1´´	18°6´59´´	421 m	light grey claystone
Š35/IV	49°35´2´´	18°7´3´´	422 m	black claystone, big exposure, lower part, Plaňava Formation
Š36/IV	49°35´2´´	18°7´3´´	422 m	red-brownish claystone, dtto Š35/IV, middle part, Plaňava Formation
Š37/IV	49°35´2´´	18°7´3´´	422 m	grey claystone, dtto Š35/IV, upper part, Plaňava Formation
Š38/IV	49°35´4´´	18°7´11´´	418 m	dark grey claystone near the Clarion Fault, big exposure, Plaňava Formation
Š39/IV	49°35´4´´	18°7´11´´	417 m	grey claystone with pyrite near the Clarion Fault, dtto Š38/IV, Plaňava Formation
Š40/V	49°35´7´´	18°7´16´´	412 m	dark grey non-calcareous claystone with limonite corresponds to sample Š22/V–IV, ?Plaňava Formation
Š41/IV	49°35´7´´	18°7´18´´	423 m	weathered grey non-calcareous claystone, rests of the eastern wall
Š42/IV–III	49°35´1´´	18°6´50´´	397 m	block of dark grey claystone inside green-grey claystone of the Chlebovice Member
Š43/IV–III	49°35´1´´	18°6´52´´	426 m	green-grey claystone, small fissure, Chlebovice Member
Š44/IV–III	49°35´1´´	18°6´52´´	425 m	dark grey to black claystone under rock shelter, northern wall near crossing to IV. level, ?Plaňava Formation
Š45/III	49°35´2´´	18°6´55´´	440 m	dark grey claystone, big depression, ?Plaňava Formation
Š46/III	49°35´2´´	18°6´56´´	437 m	grey claystone, big depression (eastern part), ?Plaňava Formation
Š47/III	49°35´2´´	18°6´54´´	432 m	light green-grey claystone, east of sample Š46/III
Š48/I	49°35´2´´	18°6´52´´	452 m	grey claystone, ?Plaňava Formation
Š49A, B/VIII	49°34´59´´	18°7´6´´	432 m	black claystone, big fissure, ?Plaňava Formation
Š50/VI	49°34´59´´	18°7´39´´	424 m	brown-grey claystone, tectonically deformed small exposure near western part of the Štramberk-Kotouč Quarry
Š51/IX	49°34´51´´	18°6´54´´	432 m	light green-grey claystone, SE part of the eastern wall, small cavity in limestone
Š52/IX	49°34´51´´	18°6´54´´	432 m	light green-grey claystone, dtto Š51/IX
Š53/IX	49°34´48´´	18°6´51´´	384 m	light green-grey claystone, layer between conglomerates, Chlebovice Member
Š54/VIII	49°34´50´´	18°7´3´´	315 m	light green-grey claystone, southern wall, cavity 2 m in diameter
Š55/VIII	49°34´50.7´´	18°7´3.0´´	318 m	light green-grey claystone, dtto 54/IX
1/OB	49°35´19.2´´	18°7´38.3´´	405 m	dark grey claystone, ?Hradiště Formation
2/OB	49°35´19.2´´	18°7´38.3´´	407 m	grey claystone, ?Hradiště Formation
3/OB	49°35´18.2´´	18°7´34.5´´	415 m	grey claystone, big fissure inside limestone, Plaňava Formation
4/OB	49°35´19.7´´	18°7´39.3´´	423 m	grey claystone, ?Hradiště Formation

pling site (Štramberk — Š), the second one the sample number (e.g. 22), and the third one the quarry level (VII).

Extremely rare sporomorphs and organic-walled dinocysts without biostratigraphic evaluation were recorded in Štramberk-Kotouč Quarry — Š8/VII, Š22/V–VI, Š38/IV, Š41/IV, Š42/IV–III, Š50/VI. Rare organic-walled dinoflagellates were observed in Š23/IV, Š26/IV, relicts of spines in Š28/IV and Š31/IV, and some radiolarians were found in black sediments (Š7/VII, Š8/VII). Remains of agglutinated foraminifers without taxonomic determination were present in Š55/VIII (Fig. 12). Many samples contained no foraminifers (Š7/VII, Š8/VII, Š14/V, Š23/VI, Š24/VI, Š25/VI, Š26/IV, Š27/IV, Š28/IV, Š31/IV, Š32/IV, Š51/IX, Š54/VIII) or plant microfossils of either terrestrial or marine origin (Š37/VII, Š11–12/VI, Š14/V, Š16/V, Š27–34/IV, Š36–37/IV, Š43/IV–III, Š47/III, Š48/I, Š51–55/IX). Calcareous nannofossils were observed in dark grey, dark green, red-brown and black pelites (Švábenická 2008).

All microfossil groups were recovered from the same samples.

Methods

Samples for the study of foraminifers, calcareous nannofossils and palynomorphs were subjected to conventional laboratory procedures (following the methodology described in Svobodová et al. 2004) in the Laboratory of the Czech Geological Survey. Palynomorphs were studied in the glycerine-jelly slides in the OPTON (light) and CAMECA (scanning electron) microscopes. Small foraminiferal tests were obtained using a sieve with 0.06 mm mesh size. Foraminiferal assemblages were studied under a binocular light microscope NIKON 102. Photographs were taken using a scanning electron microscope in the Laboratory of the Czech Geological Survey. The European and Mediterranean planktonic zonation of Robaszynski & Caron (1995) was used for the foraminiferal stratigraphic correlations. Calcareous nannofossils were studied from simple smear-slides at 1000× magnification, using Nikon Microphot-FXA transmitting light microscope. Data were correlated with the BC zones of Bown et al. (1998). Interpretations of province preferences of the individual nannofossil species were based on Mutterlose (1992, 1993), Bown et al. (1998), Mutterlose & Kessels (2000), and Melinte & Mutterlose (2001).

The deposits provided poorly to moderately well preserved sporomorphs, organic-walled dinoflagellate cysts, foraminifers and calcareous nannofossils. Diversification and abundance of these microfossils are variable, depending on lithology and genesis of the sediment, weathering, and calcium carbonate and pyrite content. Generally, light, green-grey sediments with elevated calcium carbonate content yielded foraminifers and calcareous nannofossils, while dark, grey to black sediments yielded miospores and dinocysts. Due to the predominantly marine character and the high calcium carbonate content of the deposits, the preservation of most miospores was poor with the exception of the thick-walled sporomorph types.

Results

Obecní lom Quarry

Dark grey claystones sampled from the fills of the Štramberk Limestone provided a well-preserved and diverse foraminiferal assemblage, but poor and poorly preserved calcareous nannofossils. Only some sediments contained dinocysts and sporomorphs.

Organic-walled dinoflagellate cysts

The most common organic-walled dinoflagellate cysts are *Circulodinium vermiculatum*, *Cribroperidinium orthoceras, Kiokansium unituberculatum*, *Oligosphaeridium complex* and *Odontochitina operculata* in 1/OB and by *Bourkidinium* sp., *Pseudoceratium pelliferum*, *Systematophora scoriacea* and others in 3A/OB (Fig. 5).

Miospores

Sporomorphs are represented by prevailing fern spores (1A/OB) — *Cicatricosisporites minutaestriatus*, *Staplinisporites caminus*, *Concavissimisporites verrucosus*, *C. robustus*, and conifer species *Callialasporites dampieri*, *C. trilobatus*, *Corollina torosa*. Small tricolpate angiosperm pollen *Psilatricolpites* sp. occurred only in this sample. The spore-pollen assemblage in 2A/OB is less common but well-preserved (Fig. 6). Spores *Aequitriradites spinulosus*, *Pilosisporites* cf. *crassiangulatus*, *Concavissimisporites informis* prevail, gymnosperm pollen *Callialasporites dampieri*, *C. trilobatus*, *Cerebropollenites macroverrucosus* are common. Dark pelites in 3A/OB provided the taxa *Auritulinasporites deltaformis*, *Baculatisporites comaumensis*, *Concavissimisporites robustus*, *Foraminisporites wonthaggiensis.* No angiosperms were recorded.

Foraminifers

Foraminiferal microfauna contained high numbers of agglutinated specimens of genera *Ammodiscus*, *Ammobaculites* and *Marssonella* and diversified calcareous benthos. Planktonic foraminifers were not found. Reworked foraminifers possibly indicate Jurassic strata (Fig. 7). Forty benthic species were determined (1/OB, 2A/OB and 2B/OB) but the number of specimens was very low. The assemblages are characterized by *Lenticulina nodosa*, *Lingulonodosaria nodosaria*, *Psilocitharella kochi kochi*, *P. costulata*, *Citharina striatula*, *Astacolus schloenbachi.*

Calcareous nannoflora

Poor and poorly preserved calcareous nannofossils are characterized by a high number of *Watznaueria barnesiae*, by the presence of "long-ranging species" *W. britannica*, *Zeugrhabdotus erectus*, *Rhagodiscus nebulosus*, *Lithraphidites carniolensis* and *Cretarhabdus conicus*, and by stratigraphically

Dinoflagellate cysts	**Late Valanginian–Hauterivian**	**Late Barremian**
Sample No.	**3A/OB**	**1/OB**
Achomosphaera neptunii	•	x
Bourkidinium sp.	•	
Circulodinium distinctum	•	
Circulodinium vermiculatum	•	xx
Cleistosphaeridium? *multispinosum*	•	
Cribroperidinium edwardsii		x
Cribroperidinium orthoceras		xx
Endoscrinium campanula		x
Gonyaulacysta sp.	•	x
Hystrichodinium pulchrum		x
Kiokansium unituberculatum	•	xx
Kleithriasphaeridium eoinodes		x
Muderongia sp.	•	x
Odontochitina operculata		xx
Oligosphaeridium? *asterigerum*	•	xx
Oligosphaeridium complex	•	xxx
Pseudoceratium pelliferum	•	
Spiniferites ramosus		x
Systematophora scoriacea	•	
Systematophora sp.		xxx

Fig. 5. Distribution of organic-walled dinoflagellate cysts in samples from the Obecní lom Quarry. • — single occurrence of poorly preserved cysts, **x** — less than 4 %, **xx** — 4–15 %, **xxx** — 15–30 %.

Miospore taxa Obecní lom Quarry Sample No.	**Barremian 1/OB**	**?Hauterivian 2A/OB**	**Hauterivian 3A/OB**
Spores			
Aequitriradites spinulosus		●	
Auritulinasporites deltaformis			●
Baculatisporites comaumensis			
Cicatricosisporites minutaestriatus	●		
Cicatricosisporites spp.			●
Clavifera triplex	●●		●
Concavissimisporites informis			
Concavissimisporites robustus			●
Concavissimisporites verrucosus	●		
Cyathidites australis	●		●
Densoisporites velatus			●
Echinatisporites varispinosus	●		●
Foraminisporites wonthaggiensis			●
Foveosporites subtriangularis	●		
Gleicheniidites minor			
Gleicheniidites senonicus	●●		●
Klukisporites sp.			●
Neoraistrickia truncata			●
Osmundacidites wellmanii	●		
Pilosisporites cf. *crassiangulatus*		●	
Pilosisporites trichopapillosus	●		
Plicatella cf. *cristata*			●
Plicatella pseudomacrorhyza	●		●
Retitriletes austroclavatidites	●		
Staplinisporites caminus	●		
Stereisporites antiquasporites	●		●
Todisporites minor	●		
Gymnosperm pollen			
Alisporites similis	●●		●
Callialasporites dampieri	●	●	●
Callialasporites trilobatus	●	●	
Cerebropollenites macroverrucosus	●	●	●
Corollina torosa	●		●
Cycadopites cf. *carpentieri*			●
Cycadopites sp.	●		
Eucommiidites minor	●		●
Pinuspollenites spp.	●●		●●
Podocarpidites ellipticus	●●		●
Taxodiaceaepollenites hiatus	●		
Vitreisporites pallidus	●		●●
Angiosperm pollen			
Tricolpites sp.	●		

Fig. 6. Distribution of spore-pollen species in samples from the Obecní lom Quarry. ● — 1–5 %; ●● — 6–10 %.

important species *Eiffellithus striatus*, *Cruciellipsis cuvillieri* and *Tubodiscus jurapelagicus* and some nannoconids (2A and 2B/OB) (Švábenická 2008).

Štramberk-Kotouč Quarry

Dark grey, greenish-grey and black pelites provided sporomorphs and organic-walled dinocysts (Figs. 8, 9).

Miospores

The microflora has a predominant spore component (particularly schizeacean, gleicheniacean, lycopodiacean affinity) together with common gymnosperm pollen, both saccate and inaperturate types. Within the herein studied assemblage, the following filicaceous types are represented by large forms, namely *Concavissimisporites robustus*, *C. verrucosus*, *C. variverrucatus*, thick-walled types — *Cicatricosisporites* (*C. hannoverana*, *C. minutaestriatus*, *C. hughesii*, *C. recticicatricosus*), and *Baculatisporites comaumensis, Foraminisporites wonthaggiensis*, *Auritulinasporites deltaformis* (Fig. 8). Conifers are particularly well represented by abundant *Callialasporites dampieri*, associated with inaperturate forms *Eucommiidites troedsonii*, *Cerebropollenites macroverrucosus*. *Corollina torosa* is consistently present but in low numbers. None of these samples provided any angiosperm pollen.

Organic-walled dinoflagellate cysts

Organic-walled dinoflagellate cyst assemblages are moderately well to well preserved. The diversity and abundance of the taxa are variable (Fig. 9). Proximate to proximochorate dinoflagellate cysts predominate: *Circulodinium*, *Cribroperidinium*, *Muderongia*, *Pseudoceratium*. Chorate cysts are represented by abundant genus *Kiokansium*, *Oligosphaeridium*, *Systematophora*. Acritarchs were found in only a few samples (Š5/VII, Š9/VII, Š10/VI, Š18/V, Š35/IV, Š40/V, Š44/III–IV), being represented by *Wallodinium krutzschii* and *W. luna*.

Biostratigraphic interpretations

Age interpretation of the studied samples was determined on the basis of the presence of index microfossils.

Obecní lom Quarry

Sediments were evaluated in the stratigraphical range from the Late Valanginian to the Late Barremian.

The Late Valanginian age is documented by the occurrence of foraminifers *Lenticulina roemeri*, *L. dunkeri* and *L. pulchella* (Meyn & Vespermann 1994).

Interval Late Valanginian–?Hauterivian is evaluated by dinocysts of *Bourkidinium* sp., *Pseudoceratium pelliferum* and *Systematophora scoriacea* (Leereveld 1997; Skupien 2003b; Skupien & Smaržová 2011).

The Hauterivian age was proved by foraminifers *Lenticulina muensteri* and *L. pulchella.* This age is also supported by the presence of *Psilocitharella truncata* described by Reuss (1863) as *Vaginulina truncata* from the Hauterivian of SE Germany. Many foraminiferal benthic species and their stratigraphic range were correlated with foraminifers from the Lower Cretaceous sediments in southeastern Germany. Some of the Reuss' and Roemer's species, emended by Meyn & Vespermann (1994), such as *Laevidentalina sororia* (synonym *Dentalina sororia* Reuss), *Psilocitharella recta* (synonym *Vaginulina recta* Reuss), *Lenticulina subangulata* (synonym *Cristellaria subangulata* Reuss), *L. roemeri* (syno-

Foraminifera Obecní lom Quarry	**Valanginian**	**–**		**Hauterivian**		**(Aptian) ?**
Sample No.	**2A/OB**	**3A/OB**	**3B/OB**	**4/OB**	**2B/OB**	**1/OB**
Gaudryina sp.						●
Ammodiscus gaultinus				●		
Ammobaculites subcretaceus		●				
Marssonella subtrochus		●	●			
Triplasia sp.						●
Psilocitharella truncata					●	●
Psilocitharella kochi	●					
Psilocitharella costulata	●				●	
Lenticulina nodosa		●				●
Lenticulina polonica						**R**
Lenticulina dunkeri	●					●
Lenticulina pulchella						●
Lenticulina roemeri						●
Lenticulina muensteri	●			●	●	
Gavelinella barremiana			●			
Lingulonodosaria nodosaria						●
Saracenaria triangularis						●
Saracenaria pyramidata					●	●
Marginulinopsis jonesi	**R**					**R**
Marginulina declivis						●
Lagena globosa			●			●
Tristix acutangula						●
Tristix aff. *reesidei*						●
Vaginulinopsis radiata	**R**	**R**				**R**
Frondicularia nikitiny						**R**
Frondicularia concinna					●	
Citharina lepida						**R**
Citharina striatula					●	
Astacolus cf. *gratus*					●	●
Astacolus djaffaensis	●					
Astacolus schloenbachi				●	●	●
Hemirobulina cephalotes						●
Pyramidulina sceptrum	●					
Pseudonodosaria humilis	●					
Laevidentalina linearis	●				●	
Laevidentalina nana	●					
Laevidentalina siliqua	●					
Laevidentalina pseudochrysalis	●					
Dentalina distincta		●			●	
Planularia tricarinella	●				●	
Hemirobulina linearis					●	
Epistomina ornata		●		●	●	
Epistomina caracolla					●	
Trocholina aff. *remesiana*		●	●	●		
Trochammina cf. *inflata*		●	●	●		
Patellina subcretacea			●	●		
Conorotalites aff. *intercedens*			●			
Pseudopyrulinoides sp.			●		●	

Fig. 7. Distribution of foraminiferal species in samples from the Obecní lom Quarry. ● — rare occurrence, **R** — redeposition.

nym *Cristellaria Römeri* Reuss), *L. nodosa* (*Robulina nodosa* Reuss) were also found here. The Valanginian and Hauterivian foraminiferal assemblages were correlated with foraminifers of the same age from the so-called "Wildflysch" development of the Gutrathsberg Quarry in Gartenau, Austria (Hradecká in Egger et al. 1997; Hradecká 2003). The presence of *Gavelinella barremiana* may document the Late Hauterivian — lower part of Early Barremian interval, according to Holbourn & Kaminski (1995), (Fig. 7).

The latest Hauterivian to Early Barremian (Zone BC11–13, CC5b–c) is indicated by the nannofossil species *Assipetra terebrodentarius, Perissocyclus plethotretus*, *Watznaueria* cf. *biporta* accompanied by higher numbers of nannoconids and *Micrantholithus* spp.

The Late Barremian is documented in sample 1/OB by the dinocyst species *Odontochitina operculata* (Leereveld 1995) (Fig. 5) and small primitive angiosperm pollen of *Psilatricolpites* sp. (Fig. 6). This age has already been supposed based on previous dinocyst records (Leereveld 1995, 1997; Skupien 1999; Torricelli 2000; Skupien & Vašíček 2002).

Based on these results, it can be assumed that sediments of the Plaňava Formation in the fissures of the quarry are of Hauterivian, probably latest Hauterivian age. Claystones of the Hradiště Formation in the southern part of the quarry represent a tectonic melange of the Hauterivian and Barremian sediments.

Štramberk-Kotouč Quarry

Integrated biostratigraphic interpretation of the Štramberk-Kotouč Quarry is shown in Fig. 14.

The Jurassic age was indicated only by calcareous nannofossils and foraminifers. Reworking of these fossil groups into the stratigraphically younger (Early Cretaceous) deposits is highly probable. This is confirmed by the occurrence of organic-walled dinocysts of the Valanginian age in the same samples (Š7/VII, 23/IV, 24/IV, 25/IV, 42/V–III).

Early Valanginian is documented by rare nannofossil species *Speetonia colligata* and *Calcicalathina oblongata*, and the Late Valanginian by the influx of *Speetonia colligata*, and by nannoconids and rare pentaliths of *Micrantholithus speetonensis* (BC4 Zone). The presence of calcareous foraminiferal benthos *Astacolus linearis* and *Lenticulina subangulata* confirms this interpretation.

The Late Valanginian–Late Hauterivian interval is supported by organic-walled dinoflagellate cysts of *Systematophora scoriacea*, *Circulodinium vermiculatum* and *Cymososphaeridium validum* (Leereveld 1995, 1997; Skupien et al. 2003a; Skupien & Smaržová 2011) together with pteridophyte spores of *Auritulinasporites deltaformis*, *Foraminisporis wonthaggiensis* and *Cardioangulina crassiparietalis* and by the benthic foraminifer *Lenticulina nodosa.*

Miospore taxa displayed in Fig. 8 fall within the interval of the Valanginian–Hauterivian according to comparison with the so-called Wealden sediments in Germany, Great Britain and the Netherlands (Döring 1965, 1966; Burger 1966; Hughes & Moody-Stuart 1969; Kemp 1970; Dörhöfer 1977; Dörhöfer & Norris 1977; Grebe 1982). A similarity exists between the upper part of the Bückeberg Formation (Hils 4 — up to Upper Valanginian) of the Lower Saxony Basin from NW Germany (Dörhöfer 1977; Dörhöfer & Norris 1977) and the Štramberk-Kotouč Quarry characterized by the diversification of

Štramberk-Kotouč Quarry / Sample No. / Miospores	Valanginian–Hauterivian													
	Š9/VII	Š10/VI	Š13/VI	Š17/V	Š18/V	Š20/V	Š21/V	Š35/IV	Š37/IV	Š39/IV	Š40/V	Š44/IV-III	Š45/III	Š46/III
Spores														
Aequitriradites spinulosus		●			●									
Auritulinasporites deltaformis				●	●									
Baculatisporites comaumensis	●								●					
Biretisporites sp.			●								●	●	●	
Cardioangulina cf. *crassiparietalis*			●									●		
Cibotiumspora juncta									●					
Cibotiumspora jurienensis							●					●		●
Cicatricosisporites dorogensis	●													
Cicatricosisporites cf. *hannoverana*	●													
Cicatricosisporites hughesii										●				
Cicatricosisporites minutaestriatus	●											●		
Cicatricosisporites recticicatricosus										●				
Cicatricosisporites spp.	●	●	●	●			●						●	●
Clavifera rudis												●	●	
Clavifera triplex											●		●	
Concavissimisporites multituberculatus							●							
Concavissimisorites robustus							●							
Concavissimisporites variverrucatus						●								
Concavissimisporites verrucosus					●	●								
Concavissimisporites sp.				●		●			●	●	●	●	●	
Contignisporites sp.												●		●
Coronatispora telata				●										
Cyathidites australis	●		●		●	●	●			●	●			
Cyathidites minor	●		●	●	●	●			●	●	●			
Densoisporites velatus								●	●			●		
Dictyophyllidites equiexinus			●					●					●	
Echinatisporites varispinosus	●	●			●	●		●	●				●	
Foraminisporites wonthaggiensis				●	●		●	●		●				
Foveotriletes sp.			●											
Foveosporites pseudoalveolatus														●
Foveosporites subtriangularis										●				
Gleicheniidites minor		●			●	●		●						
Gleicheniidites senonicus	●	●		●	●	●		●	●	●		●	●	●
Klukisporites pseudoreticulatus	●	●												
Klukisporites variegatus	●				●					●				
Impardecispora apiverrucata					●							●		
Laevigatosporites ovatus			●								●			
Osmundacidites wellmanii								●			●		●	
Neoraistrickia truncata							●				●			
Pilosisporites semicapillosus	●				●	●	●		●	●	●		●	
Plicatella crimensis	●	●			●	●								
Plicatella macrorhyza	●		●									●		
Plicatella pseudomacrorhyza											●		●	
Plicatella sp.					●	●	●				●		●	
Retitriletes austroclavatidites							●	●			●	●	●	
Retitriletes semimuris														●
Staplinisporites caminus	●				●	●	●						●	
Stereisporites antiquasporites									●		●		●	
Stoverisporites cf. *lunaris*						●								
Todisporites minor											●			
Trilobosporites hannonicus												●		
Trilobosporites sp.				●								●		
Verrucosisporites major					●	●								
Verrucosisporites rarus													●	
Gymnosperm pollen														
Alisporites similis	●	●	●	●	●	●	●				●	●		●
Araucariacites australis	●							●	●	●	●			
Callialasporites dampieri	●	●	●		●	●	●	●	●	●	●	●		●
Callialasporites trilobatus					●			●			●	●	●	
Cerebropollenites macroverrucosus					●	●				●				
Corollina torosa	●			●	●		●	●		●		●		
Cycadopites cf. *carpentieri*							●	●		●				
Cycadopites cf. *follicularis*							●					●		
Cycadopites sp.	●		●		●	●	●	●			●	●	●	●
Eucommiidites minor	●		●	●	●	●				●	●	●	●	
Eucommiidites troedsonii				●	●		●		●		●	●		
Podocarpidites ellipticus	●					●		●	●		●	●	●	●
Taxodiaceaepollenites hiatus				●		●	●	●	●	●	●		●	
Vitreisporites pallidus	●	●	●	●		●	●	●	●	●	●	●	●	

Fig. 8. Distribution of spore-pollen species in samples from the Štramberk-Kotouč Quarry. ● — present.

schizeacean spores. Contrary to Hils 4 spore content, specimens of *Trilobosporites* fsp. are very rare in dark pelites of the Kotouč Quarry. This fact is probably due to the older age of the Bückenberg locality (most of the samples from the Štramberk-Kotouč Quarry correspond to the Late Valanginian–Hauterivian age).

Planktonic foraminifers *Hedbergella delrioensis* and *H. sigali* (Fig. 13) allow us to parallel these deposits with the *Hedbergella delrioensis/sigali* planktonic Zone that spans the interval from the latest Valanginian to the Hauterivian/Barremian boundary. The stratigraphic range of the planktonic Zone *Hedbergella delrioensis–H. sigali* (samples 6/VII and 49A/VII, Fig. 13) was determined using the planktonic zonation of Robaszynski & Caron (1995). Nevertheless, according to later research (Coccioni et al. 2007), *H. delrioensis* is limited to the Albian. Thus, based on the newly proposed planktonic zonation by Coccioni et al. (2007), the planktonic Zone *Hedbergella infracretacea* and *H. semielongata* corresponds to *H. sigali–H. delrioensis* by Robaszynski & Caron (1995).

The Early Hauterivian age is indicated by the first occurrence of dinocyst species *Muderongia staurota* (Duxbury 1977; Leereveld 1997; Skupien & Smaržová 2011), by benthic foraminifers *Astacolus bronni, Lingulonodosaria nodosaria*, *Lenticulina* sp. and by the first occurrence of *Lenticulina saxocretacea* and *L. roemeri* (Figs. 10, 11).

The Late Hauterivian age is proved by the nannofossil species *Eiffellithus striatus* (BC8–BC9 Zone) accompanied by *Perissocyclus plethrotretus*, *Tegumentum octiformis* and *Tegulalithus septentrionalis.* This age is supported by dinoflagellate assemblages with *Batioladinium jaegeri*, *Cymososphaeridium validum*, *Gardodinium trabeculosum*, *Hystrichosphaerina schindewolfii* and *Kleithriasphaeridium fasciatum* (Prössl 1990; Stover et al. 1996; Leereveld 1997), and by pteridophyte spores of *Baculatisporites comaumensis*, *Cicatricosisporites hannoverana*, *Concavissimisporites robustus*, and *C. verrucosus.*

The Aptian age is documented only by organic-walled dinoflagellate cysts, namely *Chlamydophorella nyei*, *Palaeotetradinium silicorum*, *Protoellipsodinium touilis*, *Stephodinium coronatum.* Biostratigraphically most important are the species *Pseudoceratium polymorphum* and *Hystrichosphaerina schindewolfii* (Davey 1982; Below 1984; Costa & Davey 1992; Skupien & Vašíček 2002; Skupien 2003b).

The latest Aptian-EarlyAlbian age is supported by nannofossil species *Prediscо-*

Dinoflagellate cysts Štramberk-Kotouč Quarry	Late Valanginian–Late Hauterivian										Hauterivian											Aptian
											Early		latest Early–Late					Late				
Sample No.	Š5/VII	Š7/VII	Š13/VI	Š18/V	Š21/V	Š23/IV	Š24/IV	Š25/IV	Š38/IV	Š42/IV–III	Š39/IV	Š45/III	Š10/VI	Š12/VI	Š35/IV	Š44/IV–III	Š46/III	Š9/VII	Š17/V	Š20/V	Š40/V	Š50/VI
Achomosphaera neptunii		●		●	x	●			●				x	x		x	x				xx	x
Aptea polymorpha																						x
Batioladinium jaegeri																		x	x	●		
Bourkidinium granulatum									●		x	x				x	x			●	x	
Callaiosphaeridium asymmetricum																x						x
Cassiculosphaeridia magna											x											
Cauca parva											x					x						
Chlamydophorella nyei																						x
Chlamydophorella sp.											x		x									xx
Circulodinium brevispinosum	●				x			●					x						xxx			
Circulodinium distinctum		●			xx			●			x	xx	x	xx	xx	xx	xx		xxx			x
Circulodinium sp.						●	●		●	●							x				xx	
Circulodinium vermiculatum	●	●				●		●				x		xxx	x	xx	x	x			x	
Cleistosphaeridium? multispinosum												x				x					xxx	xx
Cometodinium habibii	●				xx							x	x		x	x						xxx
Cometodinium? whitei						●																
Coronifera oceanica																					x	
Cribroperidinium edwardsii				●	x		cf.								xxx	x						
Cribroperidinium orthoceras		●		●	xx	cf.					xx		xx			x	x	xx	x	●		
Ctenidodinium elegantulum											xx				xxx							
Ctenidodinium sp.																x						
Cyclonephelium vannophorum															x							
Cymososphaeridium validum	●	●	●	●	x		cf.						x	x		x	xx	x	x	●		
Dapsilidinium multispinosum											x							x		●		x
Desmocysta sp.																x						
Dichadogonyaulax sp.															x							
Dissiliodinium globulus														x		x						
Dinogymnium albertii	●							cf.										x				
Endoscrinium cf. *campanula*								●			x			x	x							
Exochosphaeridium sp.					x	●						x							x	●		
Florentinia mantellii																					x	
Gardodinium trabeculosum																		x				
Gonyaulacysta cretacea											x											
Gonyaulacysta extensa																						x
Gonyaulacysta sp.					x						x		x	x	x			x				
Hystrichodinium pulchrum											xx	x			x	x		x				x
Hystrichodinium voigtii															x							
Hystrichosphaerina schindewolfii						cf.					x			x			x	x		●		x
Kallosphaeridium sp.							●															
Kiokansium unituberculatum	●	●			xx			cf.			x	x	xx	x	x	xxx	x	xx		●	xx	
Kiokansium sp.								●						xxx		x						
Kleithriasphaeridium eoinodes			●					●					x	x			x		x			x
Kleithriasphaeridium fasciatum				●									x					x				
Muderongia neocomica				●	x				●					x								
Muderongia macwhaei								●					x		xxx							
Muderongia microperforata								●							xx							
Muderongia pariata													x	x	xx	x						
Muderongia staurota											x	x										
Muderongia tabulata	●										xx	x					x			●	x	
Muderongia sp.								●								x						x
Occisucysta sp.													x									
cf. *Occisucysta tentoria*														x								
Odontochitina operculata																						x
Oligosphaeridium cf. *albertense*														x								
Oligosphaeridium? asterigerum									●			xx	xx	x		x	x			●		x
Oligosphaeridium complex	●	●		●				●	●			xx	xx	xx	x	x	xx	xx	x	●	x	xx
Oligosphaeridium dividuum														x								
Oligosphaeridium perforatum								●														
Oligosphaeridium poculum																					x	
Oligosphaeridium pulcherrimum																						x
Palaeotetradinium silicorum																						x
Pareodinia sp.						●		●		●												
Pervosphaeridium sp.															x							
Prolixosphaeridium sp.																x						
Protoellipsodinium clavulum																					x	
Protoellipsodinium spinosum											xx											xx
Protoellipsodinium touile																						x
Pseudoceratium gochtii																x						

Fig. 9. Distribution of organic-walled dinoflagellate species in samples from the Štramberk-Kotouč Quarry. ● — single occurrence of poorly preserved cysts, **x** — less than 4 %, **xx** — 4–15 %, **xxx** — 15–30 %, **xxxx** — more than 30 %.

Dinoflagellate cysts Štramberk-Kotouč Quarry	**Late Valanginian–Late Hauterivian**										**Hauterivian**											**Aptian**
											Early		**latest Early–Late**					**Late**				
Sample No.	**Š5/VII**	**Š7/VII**	**Š13/VI**	**Š18/V**	**Š21/V**	**Š23/IV**	**Š24/IV**	**Š25/IV**	**Š38/IV**	**Š42/IV–III**	**Š39/IV**	**Š45/III**	**Š10/VI**	**Š12/VI**	**Š35/IV**	**Š44/IV–III**	**Š46/III**	**Š9/VII**	**Š17/V**	**Š20/V**	**Š40/V**	**Š50/VI**
Pseudoceratium pelliferum			●	●							xx			x	xx	x	x	x	x	●		
Sentusidinium sp.						●	●				x						x					
Spiniferites ramosus						●								x				x			x	x
Spiniferites sp.					x				●		x		x		x						x	xx
Stephodinium coronatum																						x
Subtilisphaera perlucida																x	x					
Subtilisphaera sp.						●		●					x		x						x	
Surculosphaeridium sp.											xx				x							
Systematophora areolata															x							
Systematophora complicata								●														
Systematophora cf. *cretacea*								●	●		x							x				x
Systematophora scoriacea	?	●	●	●	xxxx		cf.		●		x		xxx	xxx	x	xx	xxxx	xxxx	xxxx	●	xx	
Systematophora silybum											x	x		x		xxx						
Systematophora sp.						●	●			●	xxx	xx						x				x
Tanyosphaeridium boletus																x						x
Tanyosphaeridium isocalamus											x						x				x	
Tanyosphaeridium magneticum											x				x							
Tanyosphaeridium sp.																x				●		
Tenua hystrix															x							
Wallodinium krutzschii	●												x		xx	x		x		●		
Wallodinium luna																					x	

Fig. 9. *Continued from previous page.*

Foraminifera Štramberk-Kotouč Quarry	**Early Hauterivian**		**Hauterivian–Albian**					
Sample No.	**Š16/V**	**Š17/V**	**Š5/VII**	**Š 21/V**	**Š22/V–IV**	**Š36/IV**	**Š37/IV**	**Š44/IV– III**
Ammodiscus gaultinus	○			○				
Spirillina sp.	■			■	■			
Patellina subcretacea	■			■			■	
Astacolus bronni	■							
Trocholina remesiana	■							
Saracenaria triangularis	■							
Astacolus humilis	■	■						
Dentalina sp.	■							
Verneuilinoides neocomiensis	■							
Epistomina ornata		■					■	
Lenticulina nodosa		■						
Lenticulina saxocretacea		■	○	○	■			■
Planularia complanata		■		■				
Gaudryina trochus		■			■			
Marssonella subtrochus			■					
Tritaxia plummerae			■					
Ramulina aculeata			■					
Marginulina bullata			■					
Lenticulina muensteri				○		■		■
Ammobaculites subcretaceus				■				
Dentalina sororia				■				
Tristix acutangula				■				
Marssonella oxycona					■			
Lenticulina subangulata						■		
Lenticulina roemeri						■	■	

Fig. 10. Distribution of foraminiferal species in samples from the Štramberk-Kotouč Quarry. ■ — rare occurrence, ○ — frequent.

sphaera columnata (BC23 Zone) sensu Kennedy et al. (2000).

The Albian age is indicated by foraminifers *Gavelinella cenomanica* and *Lingulogavelinella pazdroae* (Fig. 14) (Gawor-Biedowa 1972). Nannofossils with *Eiffellithus turriseiffelii* indicate the youngest age, Late Albian (BC27/UC0 Zone).

The first occurrence of nannofossil species *Watznaueria biporta* is usually mentioned from the Albian (Burnett 1998); nevertheless, this species has been observed already in the lower part of the Early Cretaceous in association with *Micrantholithus speetonensis* in the Early Valanginian, and in the overlying strata.

Biostratigraphic affinities of spore-pollen assemblages are not always obvious. Only some miospore taxa of the present assemblage have stratigraphic correlative significance within the Neocomian, in terms of their restricted vertical range or appearance/disappearance. Distribution of the organic-walled dinoflagellate cysts is similar to assemblages from the Pieniny Klippen Belt and Central Carpathians (Skupien 2003c; Skupien et al. 2003c).

Paleoenvironmental interpretations (Štramberk-Kotouč and Obecní lom Quarries)

Paleoenvironmental interpretation of the Štramberk-Kotouč Quarry is shown in Fig. 14.

Organic-walled dinoflagellate cysts

From the paleoecological point of view, the assemblage of organic-walled dinoflagellate cysts reflects the conditions of a shallow neritic sea (Wilpshaar & Leereveld 1994; Leereveld 1995; Michalík et al. 2008). A brackish environment is represented by the genus *Muderongia* (up to 35 % of the assemblage in sample Š35/IV) and *Odontochitina* (12 % in sample 1/OB). Shallow-marine (littoral) types (e.g. *Circulodinium*, *Cribroperidinium* and *Pseudoceratium*) markedly prevail only in samples Š35/IV, Š39/IV and characterize the nearshore sedimentation. Open-marine dinoflagellate types (*Achomosphaera*, *Spiniferites*, *Oligosphaeridium*) occur in low numbers.

Foraminifera Štramberk-Kotouč Quarry	**Late Valanginian –Late Hauterivian**			**Albian**	**Hauterivian**	
Sample No.	**Š19/V**	**Š38/IV**	**Š45/III**	**Š4/VII**	**Š35/IV**	**Š39/IV**
Ammodiscus gaultinus	■	■				■
Psilocitharella recta	■				■	■
Epistomina ornata	■					
Lenticulina sp.	■					
Ammobaculites subcretaceus	■					■
Marssonella subtrochus	■	■				
Lenticulina saxocretacea	○				○	■
Tristix acutangula	■					■
Spiroloculina sp.		■				
Marssonella oxycona		■			■	
Lenticulina roemeri		■	■			
Trocholina aff. *remesiana*		■				
Turrispirillina sp.		■				
Verneuilinoides sp.		■				■
Astacolus bronni		■	■			■
Astacolus linearis			■			
Astacolus gratus			■		■	
Hemirobulina linearis			■		■	■
Triplasia sp.			■			■
Laevidentalina linearis			■			
Laevidentalina sororia			■		■	■
Lenticulina sp.				■	■	
Bigenerina sp.				■		■
Patellovalvulina sp.				■		
Frondicularia sp.					■	■
Lenticulina muensteri					■	○
Gaudryina sp.					■	
Psilocitharella kochi					■	
Planularia complanata					■	■
Ramulina sp.						
Nodosaria nuda						■
Citharina striatula						■
Psilocitharella sp.						■
Textularia sp.						■
Haplophragmium aequale						■
Lingulonodosaria nodosaria						■
Pyramidulina sp.						■

Fig. 11. Distribution of foraminiferal species in samples from the Štramberk-Kotouč Quarry. ■ — rare occurrence, ○ — frequent.

Organic-walled dinoflagellate cysts consist almost entirely of the warm-water (Tethyan) taxa that indicate a relatively high surface temperature of the sea. Rare cold-water (Boreal, Leereveld 1995) organic-walled dinoflagellate cysts *Batioladinium jaegeri*, *Hystrichosphaerina schindewolfii* and *Oligosphaeridium perforatum* were also found in several samples (Š9/VII, 12/VI, 17/V, 20/V, 39/IV, 44/IV–III, 46/III).

The proximity of a continent is documented by miospore terrestrial admixture in marine sediments. Rather humid climate conditions during the Early Cretaceous have been similarly recorded in southern Britain and the Netherlands (Sladen & Batten 1984).

Calcareous nannoflora

Generally, calcareous nannofossils provide only sporadic information about paleoecological conditions and the paleogeographic situation of the depositional area. In any case, if present, calcareous nannoflora documents marine water of normal salinity.

Foraminifera Štramberk-Kotouč Quarry	**Lower Cretaceous**					
Sample No.	**Š3/VIII**	**Š40/V**	**Š41/ IV**	**Š42/IV–III**	**Š43/IV–III**	**Š55/VIII**
Ammodiscus sp.	○	■		■		
Ammodiscus gaultinus		■				■
Trochammina depressa		■	●			
Guttulina sp.	■					
Lenticulina sp.	■			■		
Bigenerina sp.				■		
Turrispirilina sp.				■	■	
Trocholina aff. *remesiana*				■		■
Marssonella subtrochus				■		
Textularia sp.				■		
Marssonella oxycona						■

Fig. 12. Distribution of foraminiferal species in samples from the Štramberk-Kotouč Quarry. ■ — rare occurrence, ○ — frequent, ● — abundant.

Nannofossil assemblages are usually dominated by *Watznaueria barnesiae*, an eurytopic and environmentally tolerant cosmopolitan species. The most common occurrence of this species accompanied by *W. britannica* was recorded in the lowermost part of the Lower Cretaceous (sample Š16/V). According to Melinte & Mutterlose (2001), the dominance of *W. barnesiae* reflects cooler, humid conditions and well mixed surface waters.

Nannoconus is usually mentioned as an index of neritic or shallow continental marine and epicontinental sea conditions (Roth & Krumbach 1986). Its occasional occurrence can highlight the depth fluctuation and shallowing in the depositional area. According to Melinte & Mutterlose (2001), high numbers of nannoconids reflect warmer conditions and rather stable surface stratification. These authors described periods with dominance of nannoconids alternating periods with dominance of *W. barnesiae* in the Berriasian–Valanginian interval. Unfortunately, it was impossible to verify this hypothesis in the studied material because no continuous section was available.

Some assemblages contain nannofossils mentioned as "predominantly Tethyan taxa" (*sensu* Bown et al. 1998). They include higher numbers of nannoconids (only occasional component of assemblages — see Fig. 15) and placoliths of *Cruciellipsis cuvillieri*, *Speetonia colligata*, *Tubodiscus* spp. and *Calcicalathina oblongata.* Mutterlose (1992) and Melinte & Mutterlose (2001) marked the genera *Nannoconus*, *Micrantholithus* (here *M. obtusus* and *M. hoschulzii*) and *Conusphaera* (here *C. rothii*) as typical Tethyan genera.

Boreal influx was recorded in the following stratigraphic horizons (Fig. 15):

1. Upper Valanginian (upper part), Zone BC4, rare occurrence of penthaliths of *Micrantholithus speetonensis* (endemic Boreal species *sensu* Bown et al. 1998) and placoliths of *Sollasites horticus*. These species are accompanied by Tethyan taxa such as common nannoconids, *Conusphaera rothii*, and others (Š39/IV).

Štramberk-Kotouč Quarry Foraminifera	**Valanginian–Albian**							**Valanginian–?Hauterivian**			
								?		**H. sigali/delrioensis**	
Sample No.	**Š10/VI**	**Š12/VI**	**Š13/VI**	**Š18/V**	**Š34/IV**	**Š46/III**	**Š47/III**	**Š 20/V**	**Š9/ VII**	**Š 6/VII**	**Š49A/VIII**
Ammodiscus sp.	■	■	■		●	■	■				
Psilocitharella striolata	■										
Marginulina elongata	■										
Guttulina sp.	■										
Turrispirillina sp.	■				■	■	■				
Planularia complanata	■	■						■			■
Frondicularia sp.	■							■			
Trocholina aff. *solecensis*		■		■							
Lenticulina sp.		■	■	■	■				■		
Nodosaria sp.		■		■					■		
Saracenaria triangularis		■						■			
Dorothia sp.		■									
Ammodiscus gaultinus			■		○	■					■
Gaudryina trochus			■	■		■					
Spirillina sp.				■	■		■		■		
Trocholina sp.					■	■			■		
Lenticulina muensteri					■	■					■
Astacolus linearis					■						
Tristix acutalgula					■	■		■			
Marssonella oxycona						■					
Globulina prisca						■		■			
Lenticulina subangulata							■				
Spiroloculina sp.							■			■	
Triplasia sp.							■			■	
Lenticulina nodosa								■	■	■	■
Hedbergella delrioensis										■	
Dentalina sororia							■	■		■	
Hyperammina gaultina									■		
Ramulina aculeata									■		
Marssonella subtrochus									■		
Trocholina aff. *remesiana*									■		
Epistomina ornata								■			
Lenticulina saxocretacea								■			
Ammobaculites subcretaceus								■			
Dorothia filiformis								■			
Lingulonodosaria nodosaria								■			
Spiroplectammina sp.								■			
Lenticulina roemeri											■
Hedbergella sigali											■
Haplophragmium aequale											■
Citharina striatula											■
Globigerinelloides sp.											■

Fig. 13. Distribution of foraminiferal species in samples from the Štramberk-Kotouč Quarry. ■ — rare occurrence, ○ — frequent, ● — abundant.

2. Hauterivian, Zone interval BC6–BC8–9. The occurrence of high-latitude (Boreal) species *Crucibiscutum salebrosum* and *Sollasites horticus* (Š5/VI and 2A/OB) is obvious.

Late Hauterivian high-latitude (Boreal) species *Crucibiscutum salebrosum* (Š9/VII) and *N. inornatus* (Š12/VI) were recorded in Zone interval BC8–BC9, and species *Seribiscutum primitivum*, *Tegulalithus septentrionalis*, *Nannoconus inornatus* (Š10/VI), and *Vagalapilla matalosa* (Š45/III) in Zone BC9.

A similar "Boreal nannoplankton excursion" observed in Romanian Carpathians during the Valanginian was explained by Melinte & Mutterlose (2001) rather as a sea-level fluctuation than a climate change.

The endemic Boreal nannofossil species *Micrantholithus speetonensis* was also observed in the Tlumačov Marl, Magura Group of Nappes, Outer Western Carpathians (Švábenická et al. 1997). Its presence documents an influx of high-latitude nannoflora into the depositional area of the NW part of the Tethys during the Valanginian. However, boreal nannofossils including *M. speetonensis* have not been recorded in the Central Western Carpathians (Halásová in Skupien et al. 2003b). This phenomenon reflects the different paleogeographical position of the two depositional areas. The depositional area of the Outer Group of Nappes was situated on the southeastern passive margin of the European Platform (Stráník et al. 1996), about 100 km SE from its present location, and was probably occasionally influenced by cold waters from the Boreal realm. Melinte & Mutterlose (2001) mentioned *M. speetonensis* accompanied by few other Boreal nannofossil species from the Eastern and Southern Carpathians, Romania, and South Dobrogea area (Moesian microplate), Romania, in the Late Valanginian.

Foraminifers

Light grey or greenish claystones with high content of gypsum grains (probably of diagenetic origin) in washed material contain a high proportion of the foraminiferal genus *Lenticulina* (Š34/IV, Š35/IV, Š36/IV) (Figs. 10, 12, 13). The depositional environment indicates well oxygenated shelf water. This is documented by the rare presence of small tests of planktonic genus *Hedbergella* (Š6/VII, Š49A/VIII). *Lenticulina*, *Astacolus* and *Saracenaria* together with high conical trocholinids (*Trocholina* and *Turrispirillina*) are relatively common in the deposits of both quarries. They represent epifaunal deposit-feeders typical of neritic environments (Koutsoukos & Hart 1990). Inner to middle shelf environments of the Early Albian age are characterized mainly by *Marssonella* (Koutsoukos & Hart 1990). These autors defined several morphogroups according to the shape of foraminiferal tests and used them for a paleoenvironmental reconstruction of the Cretaceous marine successions. An oxygen-depleted zone was recorded in black shales of the Valanginian and Hauterivian age.

This is indicated by pyrite grains present not only in washed material but also in palynological slides. Moreover, relative abundance of scolecodonts (jaws of worms of the Annelida Polychaeta), which adapt to extreme habitats with minimum oxygen content according to the Courtinat hypothesis (Courtinat et al. 1989), was observed.

No.	Age	Calcareous nannofossils	Foraminifers	Miospores	Dinoflagellates	Paleoenvironmental interpretation
Š48/I	Albian – Late	BC27/UC0 *Eiffellithus turriseiffelii*		no palynomorphs		neritic sea
Š53/IX	Albian – Early	BC23* *Prediscosphaera columnata*	poor benthos* *Gavelinella cenomanica* *Lingulogavelinella pazdroae*			
Š4/VII	Albian	reworked from older Cretaceous strata	poor calcareous benthos* *Lenticulina acuta* *Lenticulina grata*			
Š50/VI	Aptian	no data		rare miospores	rich assemblage* *Pseudoceratium polymorphum* *Hystrichosphaerina schindewolfii*	
Š40/V	Hauterivian – Late	not present	agglutinated specimens exclusively	rich assemblage *Foraminisporites wonthaggiensis* *Concavissimisporites robustus* *Auritulinasporites deltaformis*	rich assemblage* *Batioladinium jaegeri* (FO) *Systematophora scoriacea* *Cymososphaeridium validum* (LO)	inner neritic sea
Š17/V Š20/V		reworked specimens from older Cretaceous strata	*Lenticulina nodosa* and agglutinated specimens			
Š9/VII		BC8–BC9* *T. octiformis* (*Eiffellithus striatus*)	calcareous benthos common gen. *Lenticulina*			
Š10/VI		BC9* *T. septentrionalis* scarce nannoconids	poor benthos with low to high conical epifaunal morphotypes *Conoralites* *Psilocitharella* *Turrispirillina*	rich assemblage *Concavissimisporites verrucosus* *Cicatricosisporites hannoverana* *Baculatisporites comaumensis*	rich assemblage* *Kiokansium unituberculatum* *Circulodinium vermiculatum*	shallow to inner neritic sea
Š12/VI		BC8–BC9* with nannoconids *T. octiformis*				neritic sea with terrestrial input
Š5/VII		BC6–BC8–9* with nannoconids	poor calcareous benthos gen. *Lenticulina* prevails	poor assemblage	*Cymososphaeridium validum*	neritic sea
Š45/III		BC9* *R.* cf. *windleyae* scarce nannoconids	calcareous plankton and benthos with *Hedbergella sigali** *Lenticulina roemeri*	*Plicatella pseudomacrorhyza* *Verrucosisporites rarus*	rich assemblage* FO *Muderongia staurota*	
Š49A/VIII		BC8–BC9* *P. plethotretus* scarce nannoconids		rare specimens		
Š34/IV	Early to lower part of Late	BC6 to BC8–9*	benthos *Astacolus linearis* *Tristix acutangula*	no palynomorphs		
Š3/VIII		scarce nannoconids	rare benthos *Ammodiscus* sp. *Lenticulina*			
Š/6VII			plankton *Hedbergella sigali**			
Š36/IV	Hauterivian	*Cruciellipsis cuvillieri** (LO Hauterivian)	poor calcareous benthos *Lenticulina roemeri**	no palynomorphs		neritic sea
Š35/IV	uppermost Early and Late Hauterivian	BC4a influx *Speetonia colligata* no nannoconids	rich calcareous benthos prevails over agglutinated *Psilocitharella kochi* *Lenticulina saxocretacea*	rare miospores gymnosperms prevail *Foraminisporites wonthaggiensis* *Callialasporites trilobatus*	shallow water species* prevails over brackish ones *Cymososphaeridium validum* *Systematophora scoriacea*	neritic sea with shallow-marine to brackish input
Š44/IV-III	uppermost Early to late Hauterivian	"long-ranging" Lower Cretaceous species	calcareous benthos with *Lenticulina* spp. (*L. saxocretacea*)	rich assemblage *Cardioangulina* cf. *crassiparietalis* *Trilobosporites hannonicus*	rich assemblage* *Kiokansium* sp. *Muderongia pariata*	neritic sea with terrestrial input
Š46/III	dtto	BC6–BC8–9* *E. striatus* rare nannoconids *Braarudosphaera* sp.	calcareous and agglutinated benthos *Lenticulina muensteri*	rare miospores *Callialasporites muensteri* *Foveosporites pseudoalveolatus*		
Š22/V-IV	dtto	BC6–BC8–9* *Cruciellipsis cuvillieri* *E. striatus*	poor benthos *Lenticulina saxocretacea*	rare palynomorphs no biostratigraphically significant taxa		neritic sea
Š16/V	Early Hauterivian		low to high conical epifaunal morphotypes *Astacolus humilis**	no palynomorphs		
Š39/IV		# BC4b with *Micrantholithus speetonensis*	rich benthos *Astacolus bronni* *Lingulonodosaria nodosaria*	common *Foraminisporites wonthaggiensis* *C. macroverrucosus*	shallow water species *Muderongia staurota**	neritic sea with terrestrial input

Fig. 14. Biostratigraphic ranges of the studied calcareous nannofossils, foraminifers, miospores and organic-walled dinoflagellate cysts from the Štramberk-Kotouč Quarry and their paleoenvironmental interpretation.

No.	Age	Calcareous nannofossils	Foraminifers	Miospores	Dinoflagellates	Paleoenvironmental interpretation
Š38/IV	lower part of Early Hauterivian	assemblage with *Calcicalathina oblongata* *C. margerellii* (common)	benthos *Lenticulina roemeri** *Astacolus bronni*	rare sporomorphs	no dinocysts	neritic sea
Š37/IV	Early Hauterivian to Barremian		poor calcareous benthos *Lenticulina roemeri**	rare sporomorphs *Baculatisporites comaumensis* *Eucommiidites troedsonii*		shallow neritic sea
Š47/III	Valanginian to Hauterivian	*Cruciellipsis cuvillieri**	poor benthos *Lenticulina subangulata**	no palynomorphs		neritic sea
Š24/IV Š25/IV	L. Valanginian L. Hauterivian	reworked from Jurassic strata	no foraminifers	rare sporomorphs	rich assemblage* *Oligosphaeridium complex* *Muderongia* sp.*	inner neritic to littoral sea
Š23/IV					rare dinocysts	
Š42/IV–III	L. Valanginian L. Hauterivian		rare agglutinated and calcareous benthos	rare sporomorphs	rare dinocysts	?inner neritic sea
Š7/VII			no foraminifers (radiolarians exclusively)	no sporomorphs	rich assemblage* *Cymososphaeridium validum* *Kiokansium unituberculatum*	neritic sea
Š13/VI Š21/V	dtto	Berriasian–Barremian nannoconids *Micrantholithus* *W. britannica* (few)	poorly preserved benthos with common *Ammodiscus* spp. *Lenticulina* spp.	poor assemblage *Plicatella macrorhyza* *Cardioang. crassiparietalis* *Concavissimisp. robustus* *Foram. wonthaggiensis*		
Š18/V	L. Valanginian L. Hauterivian	BC3b–BC5 with nannoconids	rare, badly preserved benthos	common *Foraminisp. wonthagg.* *Auritulinasporites deltaformis*	rare dinocysts *Systematophora scoriacea* *Cymososphaeridium validum*	neritic sea with terrestrial input
Š19/V	Valanginian – Late	BC4–BC5* with nannoconids	well preserved benthos *Epistomina ornata** *Lenticulina saxocretacea*	rare sporomorphs *Auritulinaspor. deltaformis* *Concavissimisporites verrucosus*	no dinocysts	
Š33/IV	Valanginian – Early	BC3b–BC4a* before influx *Speetonia colligata*	poor assemblage overgrowned tests	no palynomorphs		neritic

Fig. 14. *Continued from previous page.*

Discussion

As the Štramberk-Kotouč and Obecní lom Quarries do not allow sampling of the Lower Cretaceous deposits in a complete section, a precise superposition of the collected samples in the stratal succession is unknown. It can be reconstructed and inferred from micropaleontological content. Stratigraphic interpretations of the various microfossils are not always consistent. The studied sediments belong mainly to the Valanginian–Hauterivian (this study) and Albian–Cenomanian (Svobodová et al. 2004).

In some cases, nannofossils indicate stratigraphically older ages of deposits than suggested by other microfossils (compare Figs. 14 and 15). This can be explained by reworking of nannofossils into stratigraphically younger strata, perhaps into environments where paleoecological conditions were not optimal for nannoflora bloom (caused for instance by salinity fluctuation). Relative abundance of *W. barnesiae* ranges between 45 % and 90 % (sample Štramberk-Kotouč Quarry Š16/V). Jeremiah (2001) mentioned nannofossils dominated by *Watznaueria* sp. from the lowermost Cretaceous (Upper Ryazanian) of the North Sea Basin and correlated it approximately with the lower part of the zone BC1. Moreover, *W. barnesiae* has been regarded (by Melinte & Mutterlose 2001) as the Cretaceous nannofossil taxon most resistant to diagenesis. Assemblages containing more than 40 % of *W. barnesiae* are therefore thought to be heavily altered by diagenesis (Roth & Krumbach 1986).

The dominant part of the studied samples consist of dark grey to black claystones. Their occurrences within a limestone body belong to the Plaňava Formation (all samples near the Mendocino and Clarion faults in the Kotouč Quarry (Fig. 4), sample 3/OB in the Obecní lom Quarry (Fig. 2)). These sediments were evaluated by microfossils in the stratigraphical range from the Late Valanginian to the Late Hauterivian. The small thickness of sediments confirms the interpretation of Houša (in Houša & Vašíček 2005). In his opinion, the Plaňava Formation represents slumps of the eroded and redeposited Valanginian and lowermost Hauterivian (based on ammonites which are redeposited in claystones) sedimentary material. He expected redeposition in the Early Hauterivian. Our data show that the destruction of sediments took place in the Late Hauterivian and probably earliest Barremian. Boreal elements in the Late Hauterivian, documented by nannofossils and organic-walled dinoflagellate cysts in the grey claystones, have not been reported from the Silesian Unit yet. Communication of the Outer Carpathian Silesian depositional area with the Lower Saxony Basin in Germany (across the Danish-Polish Furrow) has been documented by the ammonites in the Valanginian and earliest Hauterivian (Houša & Vašíček 2005). Younger migration of subboreal ammonites is indicated in the Early Aptian, probably through a sea passage between northern France and southern England. A shallow neritic environment with brackish and terrestrial input is documented in the Valanginian and Hauterivian.

Age			Nanno-zones	Sample No.	Nannofossil assemblage characterization		
Lower Cretaceous	Albian	Upper	BC27/UC0	Š48/I	*Eiffellithus turriseiffelii*		
	Albian	Lower	BC23	Š53/IX	*Prediscosphaera columnata*		
	?Aptian	uppermost					
	Upper Hauterivian (lower part)		BC9	Š10/VI	*Eiffellithus striatus*	*T. septentrionalis*	scarce nannoconids
				Š45/III		*R.* cf. *windleyae*	
			BC8–BC9	Š49A/VIII		*P. plethotretus*	
				Š9/VII, 12/VI		*T. octiformis*	nannoconids
	Hauterivian (Lower and lower Upper)		BC6–BC8–9	Š5/VII	*Eiffellithus striatus*		nannoconids
				Š34/IV			
				Š3/VIII, 6/VII		*Braarudosphaera* sp.	nannoconids (rare)
				Š46/III			
				Š16/V	*Cruciellipsis cuvillieri*		no nannoconids
				Š22/V–IV			
	Valanginian		BC4–BC5	Š19/V	*Eiffellithus windii, S. colligata, C. cuvillieri*		nannoconids
			BC4b	Š39/IV	*M. speetonensis, C.rothii, E. windii*		
			BC4a	Š35/IV	influx *S. colligata, C. cuvillieri, T. jurapelagicus*		no nannoconids
			BC3b–BC4a	Š33/IV	before influx *S. colligata*		scarce nannoconids
			BC3b–BC5	Š18/V	*C. oblongata, C. cuvillieri*		nannoconids
	Lower Valanginian (up to Lower Aptian?)			Š37,38/IV	*Cyclagelosphaera margerelii* (common) rare *C. oblongata, Micrantholithus* sp.		scarce nannoconids
	?Berriasian–Lower Valanginian		BC1–BC5	Š17,20*/V	*S. colligata, C. cuvillieri, T. jurapelagicus*		
	Berriasian–Hauterivian		BC1–BC10	Š44/IV–III	*Cruciellipsis cuvillieri, Tubodiscus* sp.		no nannoconids
	Lower Berriasian			Š36/IV	*Cruciellipsis cuvillieri*		small nannoconids
				Š47*/III, Š55*/VIII	*Favioconus multicolumnatus, Nannoconus compressus, N. kamptneri minor, N. steinmanii minor, N. globulus*		
	Berriasian (up to ?Barremian)			Š13/VI	*Micrantholithuss* sp., nannoconids (*N.steinmanii, N. globulus*)		
				Š21/V	*Zeugrhabdotus embergerii, Watznaueria britannica* (few)		
Cretaceous (not distinguished)				Š4/VII, Š15/V, Š27,32/IV	*Watznaueria barnesiae* prevails over *W. britannica*		
Jurassic (Bajocian–Tithonian)				Š7, 8/VII, Š23, 24*/IV, Š25*,26/IV, Š42/IV–III	*Watznaueria britannica* prevails over *W. barnesiae*; scarce *Cyclagelosphaera margerelii* and *Watznaueria manivitiae*		

Fig. 15. Štramberk-Kotouč Quarry. Occurrence of significant calcareous nannofossils and their biostratigraphic and paleoenvironmental interpretation. Nannofossil zones BC and their stratigraphic correlation by Bown et al. (1998), stratigraphic correlation of zone BC23 by Kennedy et al. (2000). ▌ — input of boreal nannofossils, * — nannofossils of the marked age were reworked into younger sediments. After Švábenická (2008), modified.

Claystones of the Hradiště Formation around the limestone bodies are tectonic melange of the Hauterivian and Barremian sediments. This material was tectonically overthrust by the neighbouring limestone blocks thereby actually becoming incorporated within the limestone body.

Younger rocks represent green, green-grey and grey claystones in the conglomerates (Chlebovice Member) or fills of primary cavities in the Štramberk Limestone. Microfossils document sedimentation of conglomerates and fill of cavities by claystones in an interval between the Early Albian and the Late Cenomanian (Svobodová et al. 2004). Redeposited grey claystones of Valanginian to Hauterivian age (redeposition after lithification as blocks) were identified in the conglomerates. These claystones are similar to claystones of the Plaňava Formation. We were unable to demonstrate reworking of sediments of Barremian to Aptian age. It seems that the chaotic accumulation in the Štramberk area originated by reworking of limestones and claystones (carbonate platform and the coeval slope deposits) during the Albian to Cenomanian. Gavelinellids, organic-walled dinocysts and poor nannofossil assemblages document inner shelf and shallow neritic sea in the Albian. The deepening of the sedimentary basin during the Cenomanian is supported by higher numbers of planktonic foraminifers and nannofossils. This confirms earlier findings of the quantitative composition of dinocyst assemblages which reflects a gradual deepening of the sedimentary basin of the Silesian Unit from the Berriasian to the Cenomanian (Skupien 2003b). This is, however, also a reflection of the rising sea level in the late Early Cretaceous (according to the 2nd-order eustatic curve).

From paleogeographic viewpoint, the block accumulations form a part of the succession of the continental rise facies of the Baška Development below the hypothetical Baška Cordillera (Eliáš 1979). They include slumps, slides, fallen blocks (olistoliths), rarely also turbidites (especially proximal), the material of which comes from both the carbonate platform and the reef complex on the Baška Cordillera and its slopes. The intervals between gravity flows were characterized by hemipelagic deposition. The redeposition occurred in two intervals: probably in the Late Hauterivian to ?earliest Barremian (the Plaňava Formation) and in the Albian to Cenomanian (the Chlebovice Member). Lateral and vertical transitions of these block accumulations into the ambient sediments did not confirm the classical idea that they represent tectonic klippen incorporated into the Silesian Unit.

Conclusions

In the depositional area of the Silesian Unit, Baška Subunit, Kotouč Facies:

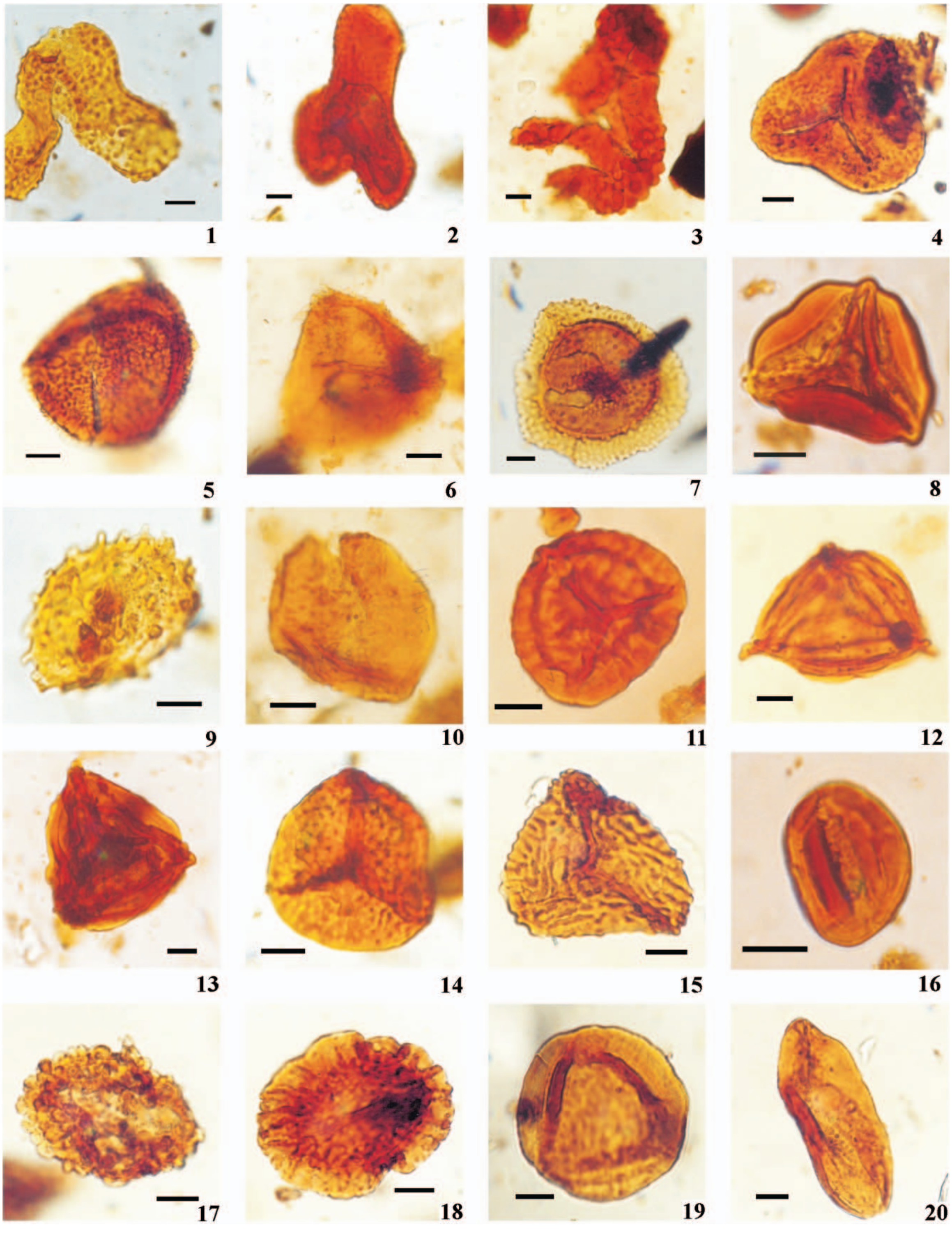

Fig. 16. Spores and pollen from Štramberk-Kotouč Quarry and Obecní lom Quarry (scale bar 10 μm). **1** — *Concavissimisporites verrucosus* (Delcourt & Sprumont) McKellar, sample Š21/V; **2** — *Concavissimisporites robustus* Dörhöfer, Š21/V; **3** — *Impardecispora apiverrucata* (Couper) Venkatachala, Kar & Raza; **4** — *Concavissimisporites informis* Döring, 2A/OB; **5** — *Pilosisporites* cf. *crassiangulatus* (Ivanova) Dörhöfer, 2A/OB; **6** — *Pilosisporites semicapillosus* Dörhöfer, Š9/VII; **7** — *Aequitriradites spinulosus* (Cookson & Dettmann) Cookson & Dettmann, 2A/OB; **8** — *Gleicheniidites minor* Döring, 3A/OB; **9** — *Neoraistrickia truncata* (Cookson) Potonié, Š21/V–VI; **10** — *Foraminisporis* cf. *wonthaggiensis* (Cookson & Dettmann) Dettmann, Š9/VII; **11** — *Staplinisporis caminus* (Balme), Š9/VII; **12** — *Plicatella macrorhyza* Maljavkina, 3A/OB; **13** — *Plicatella pseudomacrorhyza* (Markova) Dörhöfer, 3A/OB; **14** — *Coronatispora telata* (Balme) Dettmann, Š17/V; **15** — *Retitriletes semimuris* (Danzé-Corsin & Laveine) McKellar, Š46/III; **16** — *Eucommiidites troedsonii* Erdtman, OB/3A; **17** — *Cerebropollenites macroverrucosus* (Thiergart) Schulz, 2A/OB; **18** — *Callialasporites dampieri* (Balme) Dev, 2A/OB; **19** — *Callialasporites trilobatus* (Balme) Dev, 2A/OB; **20** — *Cycadopites* sp., Š46/III.

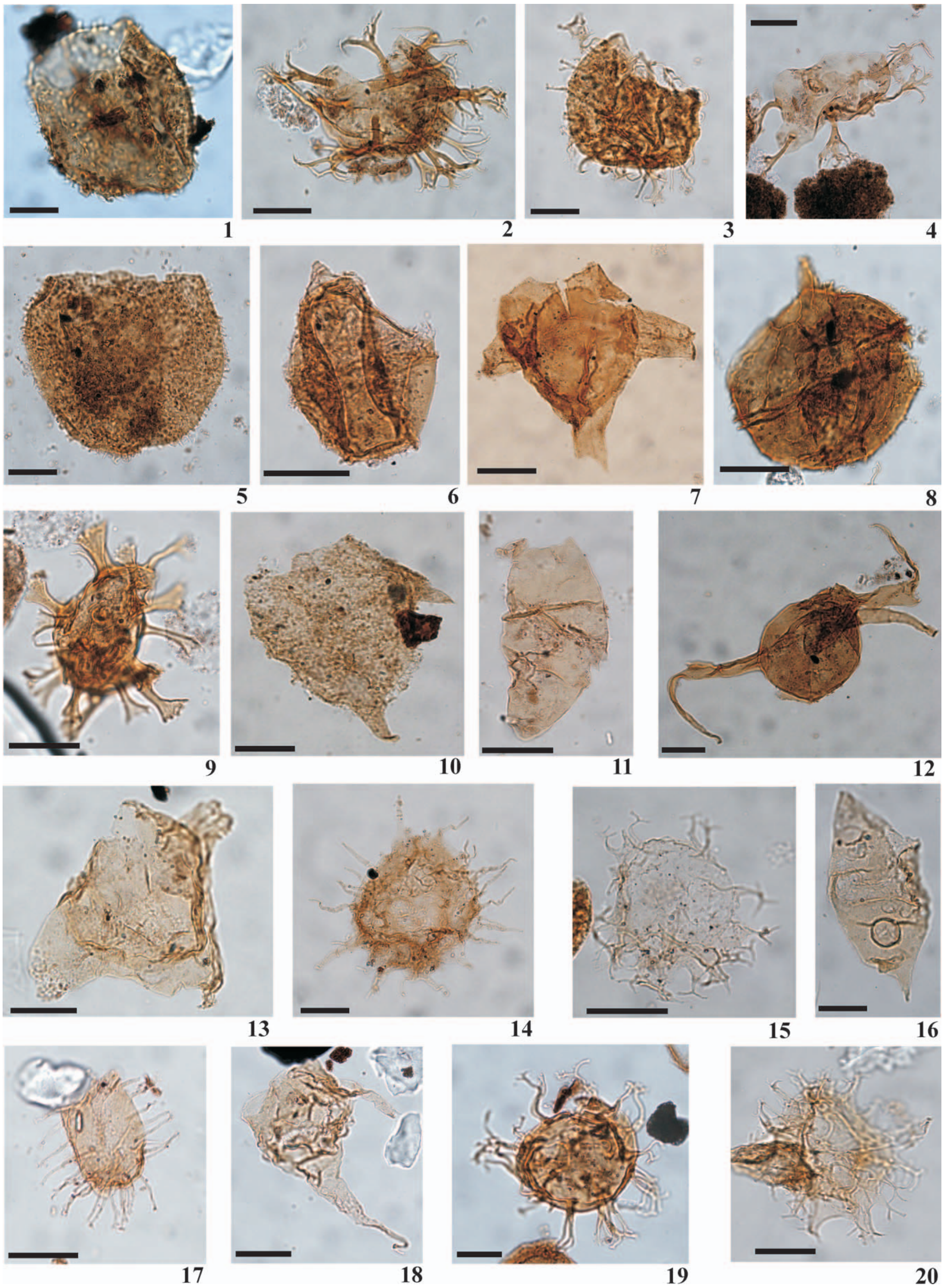

Fig. 17. Organic-walled dinoflagellate cysts from Štramberk-Kotouč Quarry and Obecní lom Quarry (scale bar 20 μm). **1** — *Circulodinium distinctum* (Deflandre & Cookson) Jansonius, 2A/OB; **2** — *Cymososphaeridium validum* Davey, Š5/VII; **3** — *Systematophora scoriacea* (Raynaud) Monteil, Š5/VII; **4** — *Oligosphaeridium complex* (White) Davey & Williams, Š5/VII; **5** — *Circulodinium brevispinosum* (Pocock) Jansonius, Š17/V; **6** — *Gonyaulacysta* sp., Š21/VI; **7** — *Muderongia microperforata* (Davey) Monteil, Š35/IV; **8** — *Cribroperidinium orthoceras* (Eisenack) Davey, Š10/VI; **9** — *Kleithriasphaeridium eoinodes* (Eisenack) Davey, Š10/VI; **10** — *Pseudoceratium pelliferum* Gocht, Š35/IV; **11** — *Wallodinium krutzschii* (Alberti) Habib, Š35/IV; **12** — *Muderongia macwhaei* Cookson & Eisenack, Š35/IV; **13** — *Muderongia tabulata* (Raynaud) Monteil, Š39/IV; **14** — *Hystrichodinium pulchrum* Deflandre, Š39/IV; **15** — *Achomosphaera neptunii* (Eisenack) Davey & Williams, Š50/IV; **16** — *Batioladinium jaegeri* (Alberti) Brideaux, Š17/V; **17** — *Tanyosphaeridium boletus* Davey, Š50/IV; **18** — *Odontochitina operculata* (O. Wetzel) Deflandre & Cookson, Š50/IV; **19** — *Systematophora silybum* Davey, Š44/III; **20** — *Spiniferites ramosus* (Ehrenberg) Mantell, Š50/IV.

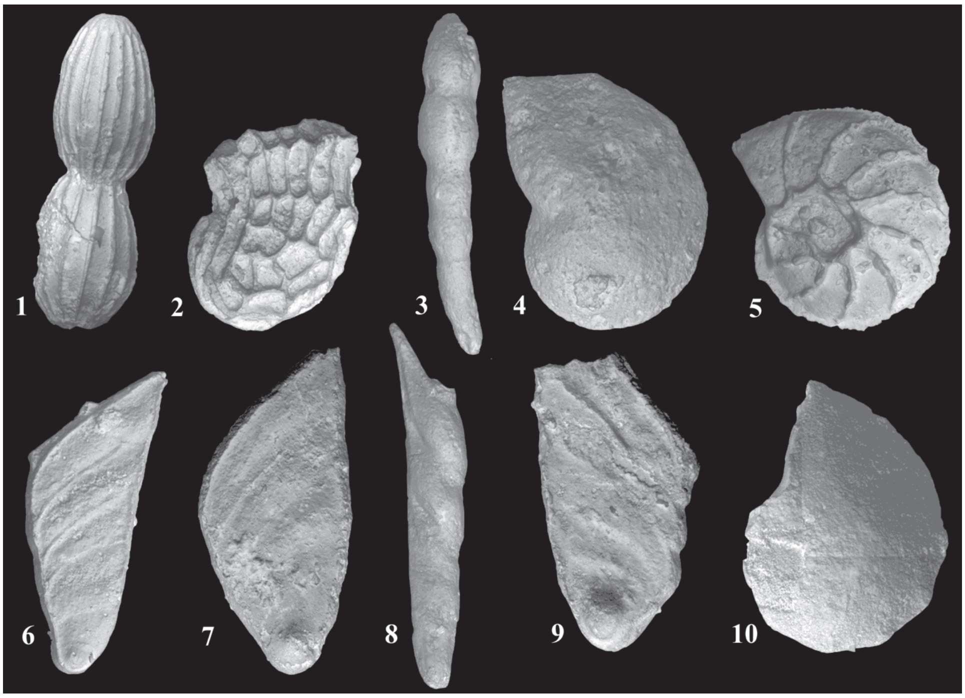

Fig. 18. Foraminifers from the Obecní lom Quarry. **1** — *Pyramidulina sceptrum* (Reuss), 2A/OB, ×90; **2** — *Astacolus djaffaensis* (Sigal), 2A/OB, ×80; **3** — *Laevidentalina linearis* (Roemer), 2A/OB, ×80; **4** — *Lenticulina pulchella* (Reuss), 2A/OB, ×90; **5** — *Lenticulina muensteri* (Roemer), 2B/OB, ×60; **6, 7** — *Psilocitharella striolata* (Reuss), 2A/OB, ×60; **8** — *Laevidentalina* sp., 2A/OB, ×70; **9** — *Psilocitharella* cf. *truncata* (Reuss), 2A/OB, ×80; **10**— *Lenticulina nodosa* (Reuss), 1/OB, ×70.

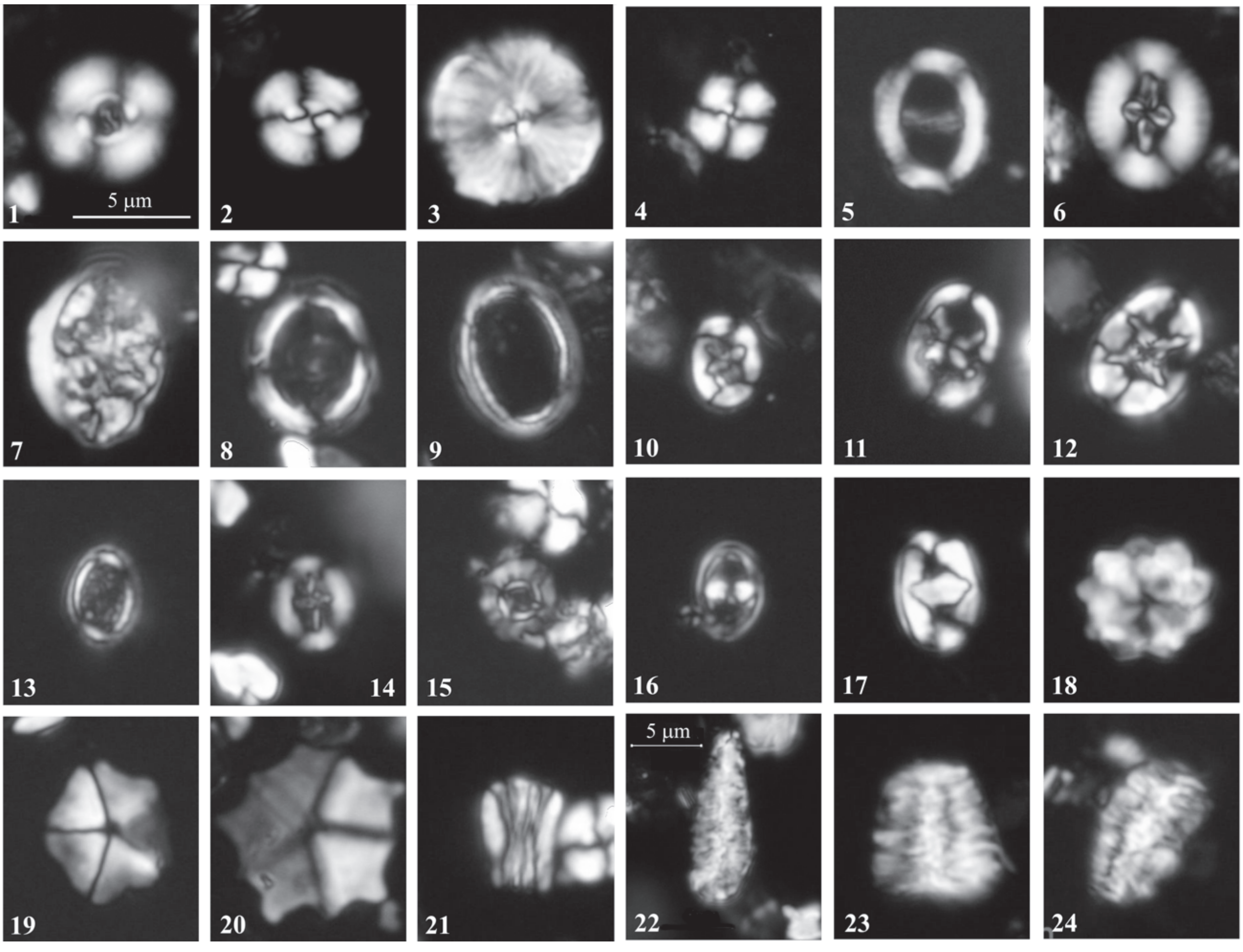

Fig. 19.

1. Although a continuous section could not be studied, and samples were obtained from isolated exposures, microfossils document two intervals of sedimentation: Valanginian–Hauterivian and Albian–Cenomanian.

2. Chaotic accumulation in the Štramberk area originated by reworking in two stages: the older stage (probably Late Hauterivian to ?earliest Barremian) occurred in the Plaňava Formation and the younger stage (Albian to Cenomanian) in the Chlebovice Member.

3. Depositional conditions varied through time. Evidence supports a changeable brackish and littoral to shallow neritic marine environment.

4. A shallow marine environment is documented by foraminifers *Psilocitharella recta*, *P. kochi*, *Citharina striatula* and organic-walled dinocysts (*Circulodinium*, *Muderongia*, *Pseudoceratium*, *Systematophora*) in the Valanginian-Hauterivian deposits.

5. Deeper sedimentation was recorded in the Aptian–Albian(?) by the presence of rare planktonic foraminifers *Hedbergella* and *Globigerinelloides*.

6. Oxygen depletion was recorded in black shales of Valanginian and Hauterivian age. Evidence provided by the presence of sulfide/pyrite grains in washed material and palynological slides, scolecodonts (worm jaws of the Polychaeta group) and chitinous linings of microforaminifers as well as low-oxygen-tolerating benthic foraminifers, namely *Marssonella*, *Trocholina*.

7. The presence of low-latitude organic-walled dinoflagellate cysts (*Bourkidinium*, *Cometodinium*, *Florentinia*, *Oligosphaeridium*, *Protoellipsodinium*, *Systematophora*, and others) and calcareous nannoflora (*Cruciellipsis cuvillieri*, *Speetonia colligata*, *Tubodiscus* spp., *Calcicalathina oblongata*, *Nannoconus*, *Micrantholithus obtusus*, *M. hoschulzii*, *Conusphaera rothii*, and majority of nannoconids) document pertinence to the Tethyan province.

8. The scarce presence of high-latitude nannoflora (*Micrantholithus speetonensis*, *Seribiscutum primitivum*, *Crucibiscutum salebrosum*, *Nannoconus inornatus*, *Tegulalithus septentrionalis*, and *Vagalapilla matalosa*) and organic-walled dinoflagellate cysts (*Batioladinium jaegeri*, *Hystrichosphaerina schindewolfii* and *Oligosphaeridium perforatum*) in some samples reflects occasional excursions of Boreal elements into the depositional area of the Silesian Unit, namely NW part of the Tethys during the Valanginian and Hauterivian.

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Fig. 19. Stratigraphically significant calcareous nannofossils from the Štramberk-Kotouč Quarry. Light microscope, cross-polarized light, for scale see Fig. 1. **1** — *Watznaueria britannica* (Stradner) Reinhardt, Š23/IV; **2** — *Watznaueria barnesiae* (Black) Perch-Nielsen, Š4/VII; **3** — *Watznaueria manivitiae* Bukry, Š6/VII; **4** — *Cyclagelosphaera margerelii* Noël, Š33/IV; **5** — *Speetonia colligata* Black, 0° and 45°, Š35/IV; **6** — *Calcicalathina oblongata* (Worsley) Thierstein, Š18/V; **7** — *Cruciellipsis cuvillieri* (Manivit) Thierstein, Š35/IV; **8** — *Tubodiscus jurapelagicus* (Worsley) Roth, Š39/IV; **9** — *Ethmorhabdus hauterivianus* Black, Š6/VII; **10** — *Eiffellithus windii* Applegate & Bergen, Š39/IV; **11** — *Eiffellithus striatus* (Black) Applegate & Bergen, Š5/VII; **12** — *Eiffellithus turriseiffelii* (Deflandre) Reinhardt, Š48/I; **13** — *Clepsilithus* cf. *maculosus* Rutledge & Bown, Š45/III; **14** — *Helenea chiastia* Worsley, Š39/IV; **15** — *Prediscosphaera columnata* (Stover) Perch-Nielsen, Š53/IX; **16** — *Zeugrhabdotus erectus* (Deflandre) Reinhardt, Š39/IV; **17** — *Zeugrhabdotus cooperii* Bown, Š39/IV; **18** — *Eprolithus floralis* (Stradner) Stover, Š53/IX; **19** — *Micrantholithus obtusus* Stradner, Š39/IV; **20** — *Micrantholithus speetonensis* Perch-Nielsen, Š39/IV; **21** — *Conusphaera rothii* (Thierstein) Jakubowski, Š39/IV; **22** — *Favioconus multicolumnatus* Bralower, Š47/III; **23** — *Nannoconus kamptneri kamptneri* Brönnimann, Š39/IV; **24** — *Nannoconus* ex gr. *steinmanii* Kamptner, Š39/IV.

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Appendix

Miospore taxa mentioned in the text

Aequitriradites spinulosus (Cookson & Dettmann) Cookson Dettmann, 1961
Alisporites similis (Balme) Dettmann, 1963
Araucariacites australis Cookson, 1947
Auritulinasporites deltaformis Burger, 1966
Baculatisporites comaumensis (Cookson) Potonié, 1956
Biretisporites sp.
Callialasporites dampieri (Balme) Sukh Dev, 1961
Callialasporites trilobatus (Balme) Sukh Dev, 1961
Cardioangulina cf. *crassiparietalis* Döring, 1965
Cerebropollenites macroverrucosus (Thiergart) Schulz, 1967
Cibotiumspora juncta (Kara-Murza) Zhang, 1978
Cibotiumspora jurienensis (Balme) Filatoff, 1975
Cicatricosisporites dorogensis (Kara-Murza) Pocock, 1964
Cicatricosisporites cf. *hannoverana* Dörhöfer, 1977
Cicatricosisporites hughesi Dettmann, 1963
Cicatricosisporites minutaestriatus (Bolch.) Pocock, 1964
Cicatricosisporites recticicatricosus Döring, 1965
Cicatricosisporites spp.
Clavifera rudis Bolchovitina, 1968
Clavifera triplex (Bolch.) Bolchovitina, 1968
Concavissimisporites informis Döring, 1965
Concavissimisporites multituberculatus (Bolch.) Döring, 1965
Concavissimisporites robustus Dörhöfer, 1977
Concavissimisporites variverrucatus (Couper) Brenner, 1963
Concavissimisporites verrucosus (Del. & Spr.) Delcourt, Dettmann & Hughes ,1963
Contignisporites sp.
Corollina torosa (Reissinger) Cornet & Traverse, 1975
Coronatispora telata (Balme) Dettmann
Cyathidites australis Couper, 1953
Cyathidites minor Couper, 1953
Cycadopites cf. *carpentieri* Nilsson
Cycadopites cf. *follicularis* Wilson & Webster, 1946
Cycadopites sp.
Densoisporites velatus Weyland & Krieger, 1953
Dictyophyllidites equiexinus (Couper) Dettmann, 1963
Echinatisporites varispinosus (Pocock) Srivastava, 1975
Eucommiidites minor Groot & Penny, 1960
Eucommiidites troedsonii Erdtman, 1948
Foraminisporites wonthaggiensis (Cookson & Dettmann) Dettmann, 1963
Foveosporites subtriangularis (Brenner) Döring, 1966
Foveotriletes sp.
Foveosporites pseudoalveolatus (Couper) McKellar
Gleicheniidites minor Döring, 1965
Gleicheniidites senonicus Ross, 1949
Impardecispora apiverrucata (Couper) Venkatachala, Kar & Raza, 1969
Klukisporites pseudoreticulatus Couper, 1958
Klukisporites variegatus Couper, 1958
Klukisporites sp.
Laevigatosporites ovatus Wilson & Webster, 1946
Neoraistrickia truncata (Cookson) Potonié, 1956
Osmundacidites wellmanii Couper, 1953
Pilosisporites cf. *crassiangulatus* (Ivanova) Dörhöfer, 1977
Pilosisporites semicapillosus Dörhöfer, 1977
Pilosisporites trichopapillosus (Thiergart) Delcourt & Sprumont, 1955
Pinuspollenites spp.
Plicatella cf. *cristata* (Markova)
Plicatella crimensis (Bolchovitina) Dörhöfer, 1977
Plicatella macrorhyza Maljavkina, 1949
Plicatella pseudomacrorhyza (Markova) Dörhöfer, 1977
Plicatella sp.
Podocarpidites ellipticus Cookson, 1947
Retitriletes austroclavatidites (Cookson) Döring et al., 1963
Retitriletes semimuris (Danzé-Corsin & Laveine) McKellar
Staplinisporites caminus (Balme) Pocock, 1962
Stereisporites antiquasporites (Wilson & Webster) Dettmann, 1963
Stoverisporites cf. *lunaris* (Cookson & Dettmann) Burger, 1976
Taxodiaceaepollenites hiatus (Potonié) Kremp, 1949
Todisporites minor Couper, 1958
Tricolpites sp.
Trilobosporites hannonicus (Delcourt & Sprumont) Potonié, 1956
Trilobosporites sp.
Verrucosisporites major (Couper) Burden & Hills, 1989
Verrucosisporites rarus Burger
Vitreisporites pallidus (Reissinger) Nilsson, 1958

Organic-walled dinoflagellate cyst taxa mentioned in the text. Taxonomic citations can be found in Williams et al. (1998)

Achomosphaera neptunii (Eisenack, 1958) Davey & Williams, 1966
Aptea polymorpha Eisenack, 1958a
Batioladinium jaegeri (Alberti, 1961) Brideaux, 1975
Bourkidinium granulatum Morgan, 1975
Bourkidinium sp.
Callaiosphaeridium asymmetricum (Deflandre & Courteville, 1939) Davey & Williams, 1966
Cassiculosphaeridia magna Davey, 1974, emend. Harding, 1990b
Cauca parva (Alberti, 1961) Davey & Verdier, 1971
Chlamydophorella nyei Cookson & Eisenack, 1958
Chlamydophorella sp.
Circulodinium brevispinosum (Pocock, 1962) Jansonius, 1986
Circulodinium distinctum (Deflandre & Cookson, 1955) Jansonius, 1986
Circulodinium sp.
Circulodinium vermiculatum Stover & Helby, 1987
Cleistosphaeridium? *multispinosum* (C. Singh, 1964) Brideaux, 1971
Cometodinium habibii Monteil, 1991
Cometodinium? *whitei* (Deflandre & Courteville, 1939) Stover & Evitt, 1978
Coronifera oceanica Cookson & Eisenack, 1958, emend. May, 1980
Cribroperidinium edwardsii (Cookson & Eisenack, 1958) Davey, 1969a
Cribroperidinium orthoceras (Eisenack, 1958) Davey, 1969
Ctenidodinium elegantulum Millioud, 1969
Ctenidodinium sp.
Cyclonephelium vannophorum Davey, 1969
Cymososphaeridium validum Davey, 1982a
Dapsilidinium multispinosum (Davey, 1974) Bujak et al., 1980
Desmocysta sp.
Dichadogonyaulax sp.
Dissiliodinium globulus Drugg, 1978
Dinogymnium albertii Sarjeant, 1966
Endoscrinium campanula (Gocht, 1959) Vozzhennikova, 1967
Exochosphaeridium sp.
Florentinia mantellii (Davey & Williams, 1966b) Davey & Verdier, 1973
Gardodinium trabeculosum (Gocht, 1959) Alberti, 1961

Gonyaulacysta cretacea (Neale & Sarjeant, 1962) Sarjeant, 1969
Gonyaulacysta extensa Clarke & Verdier, 1967
Gonyaulacysta sp.
Hystrichodinium pulchrum Deflandre, 1935
Hystrichodinium voigtii Alberti, 1961
Hystrichosphaerina schindewolfii Alberti, 1961
Kallosphaeridium sp.
Kiokansium unituberculatum (Tasch, 1964) Stover & Evitt, 1978
Kiokansium sp.
Kleithriasphaeridium eoinodes (Eisenack, 1958a) Davey, 1974
Kleithriasphaeridium fasciatum Davey & Williams, 1966
Muderongia neocomica Gocht, 1957
Muderongia macwhaei Cookson & Eisenack, 1958
Muderongia "*microperforata*"
Muderongia pariata Duxbury, 1983
Muderongia staurota Sarjeant, 1966c, emend. Monteil, 1991b
Muderongia tabulata (Raynaud, 1978) Monteil, 1991
Muderongia sp.
Occisucysta sp.
cf. *Occisucysta tentoria* Duxbury, 1977
Odontochitina operculata (O. Wetzel, 1933) Deflandre & Cookson, 1955
Oligosphaeridium cf. *albertense* (Pocock, 1962) Davey & Williams, 1969
Oligosphaeridium? *asterigerum* (Gocht, 1959) Davey & Williams, 1969
Oligosphaeridium complex (White, 1842) Davey & Williams, 1969
Oligosphaeridium dividuum Williams, 1978
Oligosphaeridium perforatum Duxbury, 1983
Oligosphaeridium poculum Jain, 1977b
Oligosphaeridium pulcherrimum (Deflandre & Cookson, 1955) Davey & Williams, 1966b
Palaeotetradinium silicorum Deflandre, 1936
Pareodinia sp.
Pervosphaeridium sp.
Prolixosphaeridium sp.
Protoellipsodinium clavulum Davey & Verdier, 1974
Protoellipsodinium clavulum Davey & Verdier, 1974, emend. Duxbury, 1983
Protoellipsodinium spinosum Davey & Verdier, 1971
Protoellipsodinium touile Below, 1981a
Pseudoceratium gochtii Neale & Sarjeant, 1962
Pseudoceratium pelliferum Gocht, 1957
Sentusidinium sp.
Spiniferites ramosus (Ehrenberg, 1838) Mantell, 1854
Spiniferites sp.
Stephodinium coronatum Deflandre, 1936a
Subtilisphaera perlucida (Alberti, 1959b) Jain & Millepied, 1973
Subtilisphaera sp.
Surculosphaeridium sp.
Systematophora areolata Cookson & Eisenack, 1965
Systematophora complicata (Cookson & Eisenack, 1965a) Eisenack, 1969a
Systematophora cf. *cretacea* Davey, 1979b
Systematophora scoriacea (Raynaud, 1978) Monteil, 1992b
Systematophora silybum Davey, 1979
Systematophora sp.
Tanyosphaeridium boletus Davey, 1974
Tanyosphaeridium isocalamus (Deflandre & Cookson, 1955) Davey & Williams, 1969
Tanyosphaeridium magneticum Davies, 1983
Tanyosphaeridium sp.
Tenua hystrix Eisenack, 1958
Wallodinium krutzschii (Alberti, 1961) Habib, 1972
Wallodinium luna (Cookson & Eisenack, 1960a) Lentin & Williams, 1973

Foraminiferal taxa mentioned in the text

Ammobaculites subcretaceus Cushman-Alexander, 1930
Ammodiscus gaultinus Berthelin, 1880
Ammodiscus sp.
Astacolus bronni (Roemer, 1841)
Astacolus djaffaensis (Sigal, 1952)
Astacolus gratus (Reuss, 1862)
Astacolus humilis (Reuss, 1863)
Astacolus linearis (Reuss, 1863)
Astacolus schloenbachi (Reuss, 1863)
Bigenerina sp.
Citharina lepida (Schwager, 1863)
Citharina striatula (Roemer, 1842)
Conorotalites intercedens (Bettenstaedt, 1952)
Dentalina distincta (Reuss, 1860)
Dentalina sp.
Dorothia filiformis (Berthelin, 1880)
Dorothia sp.
Epistomina caracolla (Roemer, 1841)
Epistomina ornata (Roemer, 1841)
Frondicularia concinna Koch, 1851
Frondicularia nikitiny Uhlig, 1883
Frondicularia sp.
Gaudryina trochus (d'Orbigny, 1840)
Gaudryina sp.
Globigerinelloides sp.
Globulina prisca Reuss, 1845
Guttulina sp.
Haplophragmium aequale (Roemer, 1933)
Hedbergella delrioensis (Carsey, 1926)
Hedbergella sigali Moullade, 1966
Hemirobulina cephalotes (Reuss, 1863)
Hemirobulina linearis (Reuss, 1863)
Hyperammina gaultina Ten Dam, 1950
Laevidentalina linearis (Roemer, 1841)
Laevidentalina nana (Reuss, 1863)
Laevidentalina pseudochrysalis (Reuss, 1863)
Laevidentalina siliqua (Reuss, 1863)
Laevidentalina sororia (Reuss, 1863)
Lagena globosa (Montagu, 1803)
Lenticulina dunkeri (Reuss, 1839)
Lenticulina muensteri (Roemer, 1839)
Lenticulina nodosa (Reuss, 1839)
Lenticulina polonica Wiśniowski, 1890
Lenticulina pulchella (Reuss, 1839)
Lenticulina roemeri (Reuss, 1839)
Lenticulina saxocretacea Bartenstein, 1954
Lenticulina subangulata (Reuss)
Lenticulina sp.
Lingulonodosaria nodosaria (Reuss, 1863)
Marginulina bullata Reuss, 1845
Marginulina declivis (Schwager, 1865)
Marginulina elongata d'Orbigny, 1840
Marginulinopsis jonesi (Reuss, 1863)
Marssonella oxycona (Reuss, 1860)
Marssonella subtrochus (Bartenstein, 1962)
Nodosaria nuda Reuss, 1863
Nodosaria sp.
Patellina subcretacea Cushman-Alexander, 1930
Patellovalvulina sp.
Planularia complanata (Reuss, 1845)
Planularia tricarinella (Reuss, 1862)
Pseudonodosaria humilis (Roemer, 1841)
Pseudopyrulinoides sp.
Psilocitharella costulata (Roemer, 1863)

Psilocitharella kochi (Roemer, 1863)
Psilocitharella recta (Reuss, 1863)
Psilocitharella striolata (Reuss, 1863)
Psilocitharella sp.
Psilocitharella truncata (Reuss, 1863)
Pyramidulina sceptrum (Reuss, 1863)
Pyramidulina sp.
Ramulina aculeata (d'Orbigny, 1840)
Ramulina sp.
Saracenaria pyramidata (Reuss ,1863)
Saracenaria triangularis (d'Orbigny, 1840)
Spirillina sp.
Spiroloculina sp.
Spiroplectammina sp.
Textularia sp.
Triplasia sp.
Tristix acutangula (Reuss, 1863)
Tristix reesidei Loeblich & Tappan, 1950
Tritaxia plummerae Cushman, 1936
Trochammina depressa Lozo, 1944
Trochammina inflata (Montagu, 1808)
Trocholina remesiana (Chapman, 1900)
Trocholina solecensis Bielecka & Poźaryski, 1954
Trocholina sp.
Turrispirillina sp.
Vaginulinopsis radiata (Terquem, 1886)
Verneuilinoides neocomiensis (Mjatliuk, 1939)
Verneuilinoides sp.

Calcareous nannofossil taxa mentioned in the text

Lower Cretaceous

Assipetra terebrodentarius (Applegate et al. in Covington & Wise, 1987); Rutledge & Bergen in Bergen, 1994
Calcicalathina oblongata (Worsley, 1971) Thierstein, 1971
Conusphaera rothii (Thierstein, 1971) Jakubowski, 1986
Cretarhabdus conicus Bramlette & Martini, 1964
Crucibiscutum salebrosum (Black, 1971) Jakubowski, 1986
Cruciellipsis cuvillieri (Manivit, 1966) Thierstein, 1971
Cyclagelosphaera margerelii Noël, 1965
Eiffellithus striatus (Black, 1971) Applegate & Bergen, 1988
Eiffellithus turriseiffelii (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1965
Eiffellithus windii Applegate & Bergen, 1988
Lithraphidites bollii (Thierstein, 1971) Thierstein, 1973
Lithraphidites carniolensis Deflandre, 1963
Micrantholithus hoschulzii (Reinhardt, 1966) Thierstein, 1971
Micrantholithus obtusus Stradner, 1963
Micrantholihus speetonensis Perch-Nielsen, 1979
Nannoconus compressus Bralower & Thierstein in Bralower et al., 1989
Nannoconus globulus Brönnimann, 1955
Nannoconus inornatus Rutledge & Bown, 1996
Nannoconus kamptneri minor Bralower in Bralower et al., 1989
Nannoconus steinmanii minor Deres & Archéritéguy, 1980
Nannoconus steinmanii steinmanii Kamptner, 1931
Perissocyclus plethotretus (Wind & Čepek, 1979) Crux, 1989
Prediscosphaera columnata (Stover, 1966) Perch-Nielsen, 1984
Rhagodiscus asper (Stradner, 1963) Reinhardt, 1967
Rhagodiscus nebulosus Bralower et al., 1989
Rucinolithus windleyae Rutledge & Bown, 1996
Seribiscutum primitivum (Thierstein, 1974) Filewicz et el. in Wise & Wind, 1977
Sollasites horticus (Stradner et al. in Stradner & Adamiker, 1966
Speetonia colligata Black, 1971
Tegulalithus septentrionalis (Stradner, 1963) Crux, 1968
Tegumentum octiformis (Köthe, 1981) Crux, 1989
Tubodiscus jurapelagicus (Worsley, 1971) Roth, 1973
Vagalapilla matalosa (Stover, 1966) Thierstein, 1973
Watznaueria biporta (Black, 1959) Perch-Nielsen, 1968
Zeugrhabdotus erectus (Deflandre in Deflandre & Fert, 1954) Reinhardt, 1965

Jurassic–Cretaceous

Watznaueria barnesiae (Black, 1959) Perch-Nielsen, 1968
Watznaueria britannica (Stradner, 1963) Reinhardt, 1964
Watznaueria manivitiae Bukry, 1973
Zeugrhabdotus embergerii (Noël, 1958) Perch-Nielsen, 1984