AASP CONTRIBUTIONS SERIES
NUMBER 36

# JURASSIC AND LOWERMOST CRETACEOUS DINOFLAGELLATE CYST BIOSTRATIGRAPHY OF THE RUSSIAN PLATFORM AND NORTHERN SIBERIA, RUSSIA

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American Association of Stratigraphic Palynologists Foundation

1999

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ISSN 0160-8843

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## Abstract

The Jurassic to lowermost Cretaceous (Upper Pliensbachian to Ryazanian) strata of the Russian Platform and northern East Siberia have yielded well preserved and diverse palynomorph assemblages, including abundant dinoflagellate cyst floras.

The uppermost Pliensbachian to Upper Toarcian of northern East Siberia produced abundant dinoflagellate cyst floras of relatively low species diversity. This interval is subdivided into three dinoflagellate cyst interval biozones, one of which is subdivided into two dinoflagellate cyst interval subbiozones. The genus *Nannoceratopsis* normally dominates the associations and is especially prominent in the uppermost Pliensbachian and Lower Toarcian. The *Parvocysta* suite, including *Phallocysta,* is present throughout the Upper Toarcian of this region. At certain horizons in the Upper Toarcian, *Phallocysta eumekes* is extremely abundant. The latter species and *Valvaeodinium aquilonium* are deemed to have Boreal affinities. The Lower Callovian of Anabar Bay yielded typically Boreal dinoflagellate cyst associations with prominent *Crussolia dalei* and *Paragonyaulacysta retiphragmata.* This isolated assemblage is not assigned to a dinoflagellate cyst interval biozone.

Bathonian to Ryazanian sections from the Russian Platform yielded abundant dinoflagellate cyst floras. These assemblages from the central Russian Platform (Moscow-Volga Basin) and sections on the banks of the River Izhma and River Pizhma in the more northerly Pechora Basin are subdivided into eighteen dinoflagellate cyst interval biozones. The Bathonian dinoflagellate cyst associations are of relatively low species diversity. *Protobatioladinium elatmaensis* and *Protobatioladinium? elongatum* are biomarkers for the early-late and latest Bathonian respectively of the Russian Platform and appear to be endemic to this area. The Callovian and Oxfordian strata of the Russian Platform are characterised by abundant and diverse dinoflagellate cysts, many species of which have wide geographical distributions throughout the Northern Hemisphere. In the early and mid Callovian, the diversity is relatively low. Lower Callovian associations are interpreted to be mixed Boreal-Sub-Boreal and include prominent *Chytroeisphaeridia hyalina* and *Fromea tornatilis; Paragonyaulacysta retiphragmata* is also present. However, from the late Callovian to the mid Oxfordian, dinoflagellate cyst diversity increased markedly and the stratigraphic ranges of key taxa are virtually identical with those established throughout western and eastern Europe. These key taxa include *Chytroeispharidia cerastes, Crussolia deflandrei, Ctenidodinium continuum* and *Scriniodinium crystallinum.* At the Middle-Upper Oxfordian boundary, many Callovian-Oxfordian forms apparently became extinct. There is no similar species turnover at the Oxfordian-Kimmeridgian boundary and this situation is similar to that in western Europe. In the late Oxfordian, several typically Kimmeridgian elements emerged. *Cribroperidinium globatum, Dingodinium* spp. and *Subtilisphaera?* spp. are all common in the Kimmeridgian of the central Russian Platform. The late Oxfordian to Ryazanian of the Russian Platform typically yields lower diversity dinoflagellate cyst associations as compared with western Europe, however many taxa are present in both regions. These widespread forms include *Glossodinium dimorphum, Gochteodinia villosa, Occisucysta balios, Oligosphaeridium patulum, Perisseiasphaeridium pannosum* and *Senoniasphaera jurassica.* Certain Upper Jurassic taxa appear to have younger range bases in the Russian Platform than in western Europe.

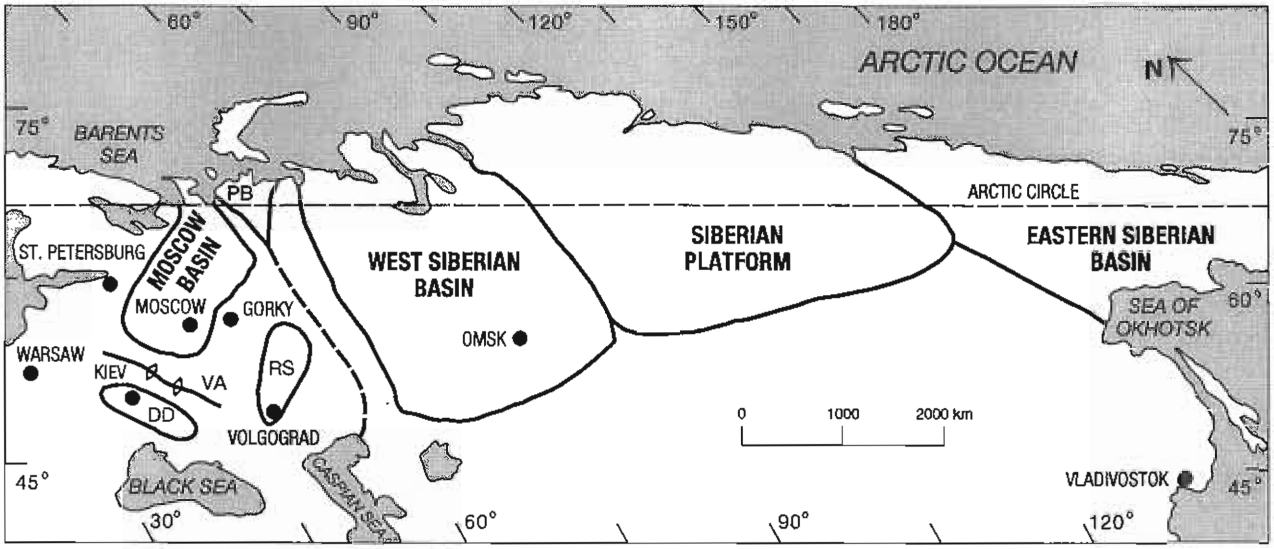
## 1 INTRODUCTION

The aim of this contribution is to present the initial results of an investigation into the Jurassic-lowermost Cretaceous dinoflagellate cyst biostratigraphy of the central and northern Russian Platform and northern East Siberia. A Pliensbachian to Ryazanian dinoflagellate cyst biozonation is proposed and the palynofloras are compared with coeval assemblages from northwest Europe and other regions. It is hoped that the results will help to assess microplankton provincialism in the Northern Hemisphere and contribute to the eventual formulation of a pan-European Mesozoic palynozonation. There are few published data in the western literature on the Jurassic and Cretaceous stratigraphic palynology of Russia and the surrounding states. Despite the relatively recent breakup of the Soviet Union, Russian scientific literature is still difficult to obtain in the west and language differences form another barrier to communication for English-speaking workers.

The samples studied are from the Russian Platform (the Moscow-Volga region of the central Russian Platform and the Pechora Basin) and northern East Siberia. Horizons were studied from the Upper Pliensbachian to Aalenian and the Lower Callovian of the River Lena Basin in northern East Siberia (Siberian Platform), the Lower Toarcian of the Eastern Siberian Basin and the Bathonian to Ryazanian of the Russian Platform. (Text-Figures 1-5). The majority of the 187 samples studied are assigned to ammonite zones or informal faunal associations. For each sample, quantitative systematic dinoflagellate cyst data was generated. This data, together with the existing literature, was used to formulate the zonal scheme. Three interval biozones, one of which is subdivided into two interval biosubzones, are proposed for the latest Pliensbachian and Toarcian of northern East Siberia. Eighteen interval biozones have been defined for the Bathonian to Ryazanian of the Russian Platform.

## 2 GEOLOGIC AND STRATIGRAPHIC BACKGROUND

The Jurassic and lowermost Cretaceous sedimentary rocks of Russia have a wide distribution and are present in




Text-Figure 1. Sketch map of the Russian Federation and adjacent states illustrating the principal Jurassic depocentres and structural features, which are enclosed by bold, solid lines. The intermittent bold line depicts the eastern boundary of the Russian Platform. DD - the Dnieper-Donetz Rift Basin; PB - the Pechora Basin; RS - the Ryazan-Saratov Basin; VA - the Voronezh Structural High. Adapted from Krymholts and Tazikhin (1972, text-fig. 1) and Krymholts et al. (1988, text-fig. 1).

a variety of facies types, from open marine to paralic. Several depocentres were developed during the Jurassic and earliest Cretaceous within the Russian Platform and throughout Siberia (Text-Figure 1); these were largely of platform type and were covered by Boreal epicontinental seas. Mesozoic strata drape the several major pre-Jurassic tectonic structures. However, the Jurassic successions generally conformably overlie Triassic or Paleozoic strata. The Jurassic stratigraphy of the former Soviet Union was reviewed by Krymholts et al. (1988).

## 2.1 THE RUSSIAN PLATFORM

### 2.1.1 History and scope of study of the Jurassic in the Central Russian Platform

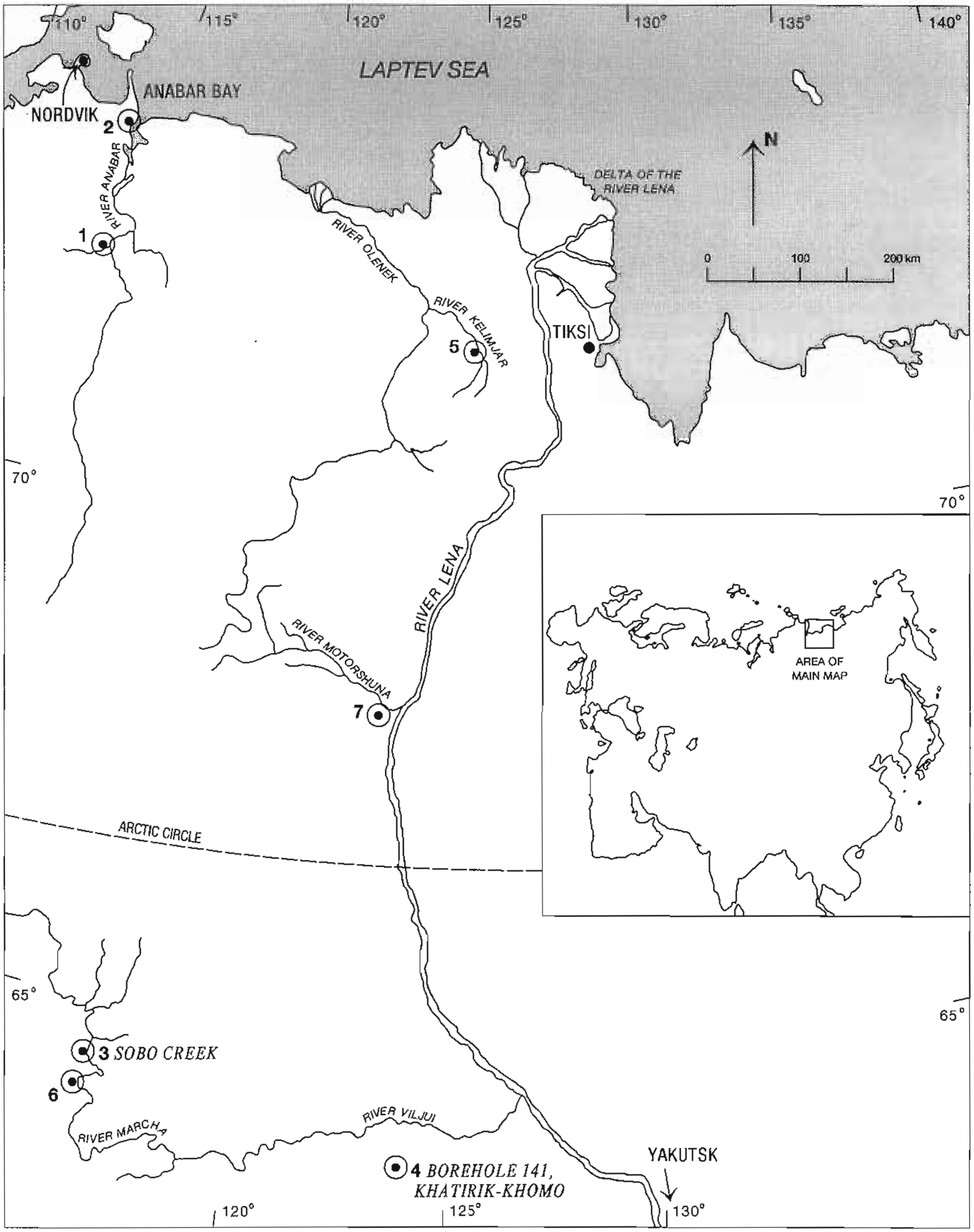
The Jurassic and lowermost Cretaceous sediments of the Central Russian Platform (Moscow Basin) were the subject of the earliest stratigraphic researches in Russia. For example, in the mid 19th century, L. Buch, E. Eichwald, K. F. Rouillier and H. Trautschold established the majority of the Russian Jurassic stage subdivisions and described various macrofossil faunas (e.g. Buch, 1840).

During the early 20th century, workers such as A. A. Borysjak, D. I. Ilowaiskyi, I. I. Laguzen, A. O. Mikhalskyi, S. P. Nikitin, A. P. Pavlov, A. N. Rosanov, I. F. Sintsov and D. N. Sokolov were involved in a second period of study (Krymholts and Tazikhin, 1972). S. P. Nikitin carried out geologic mapping in the Podmoscowje and Volga river basins. The uppermost Jurassic was referred to as the 'Volgian Formation' on macrofaunal evidence. A. P. Pavlov, while researching the Jurassic in Povolzhje, established the stage subdivision of the Upper Jurassic and made the first correlations with western Europe.

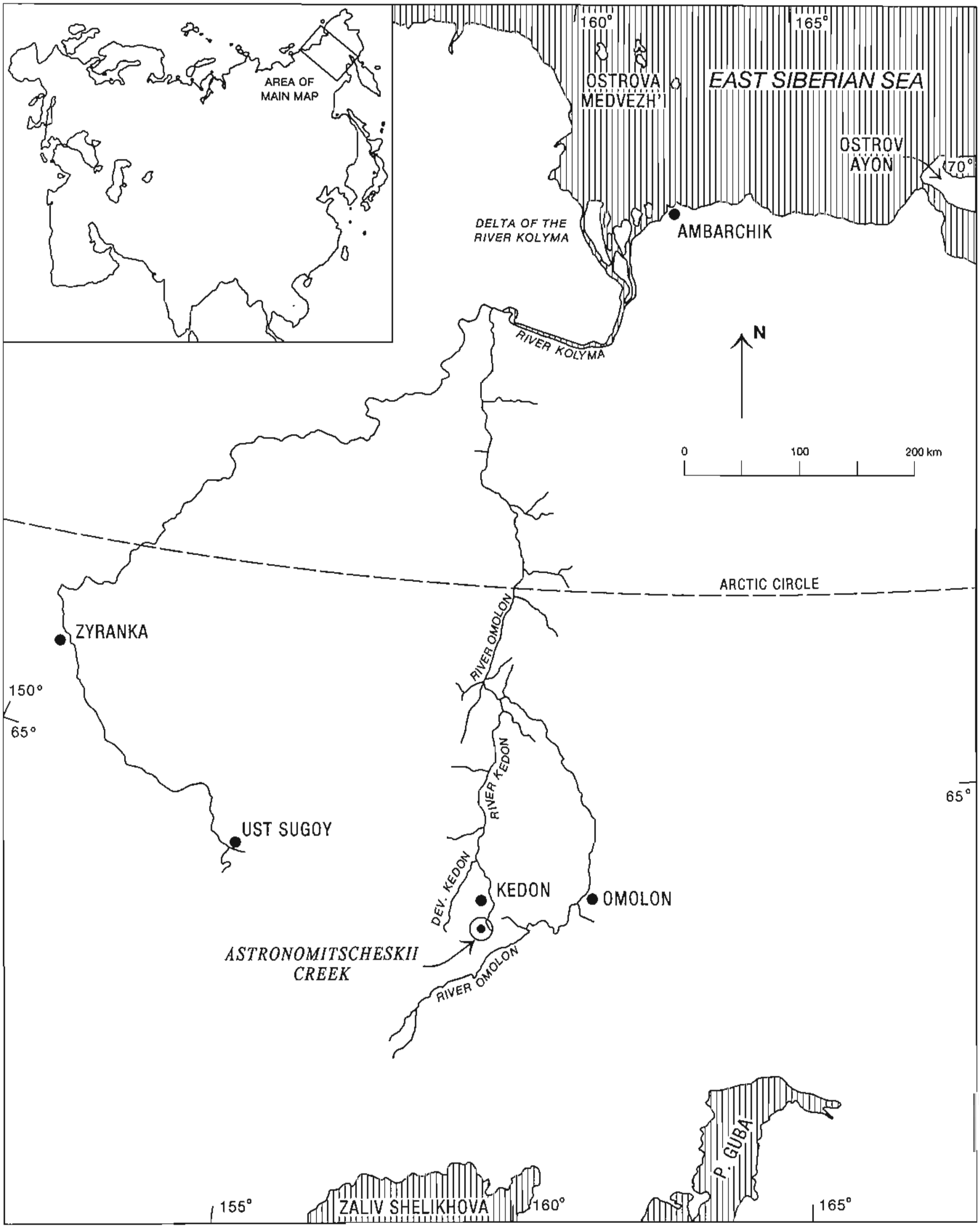
The third period of study began after the Second World War and was characterised by extensive geologic mapping. At this time, researches in European Russia were carried out by V. I. Bodylevskyi, P. A. Gerasimov, V. G. Kamysheva-Elpatjevskaja, V. P. Makridin, M. P. Mikhailov, N. P. Mikhailov, N. T. Sazonov, I. G. Sazonova and T. N. Zonov (Krymholts and Tazikhin, 1972). The marine Upper Jurassic was subdivided into ammonite zones and subzones which facilitated detailed correlations with surrounding regions in the Northern Hemisphere.

The present period, i.e. since the early 1970s, is characterised by the refinement of regional western Russian biostratigraphic schemes (Meledina et al., 1979; Mesezhnikov, 1984a,b; Mesezhnikov et al., 1989; Alexseev and Repin, 1986). There have been many studies of the Jurassic ammonite faunas of the entire Russian Platform and local zonations have been formulated (Meledina, 1987; 1994; Krymholts et al., 1988). These have largely been successfully correlated throughout Russia and with the standard ammonite zonation developed in western Europe; this has helped other correlations based on different fossil groups. The Jurassic biostratigraphy of other fossil groups has been developed, these include bivalves (Zakharov, 1981), belemnites (Nalnjaeva, 1986) and foraminifera (Grigjalis, 1978, 1985; Azbel et al., 1986).

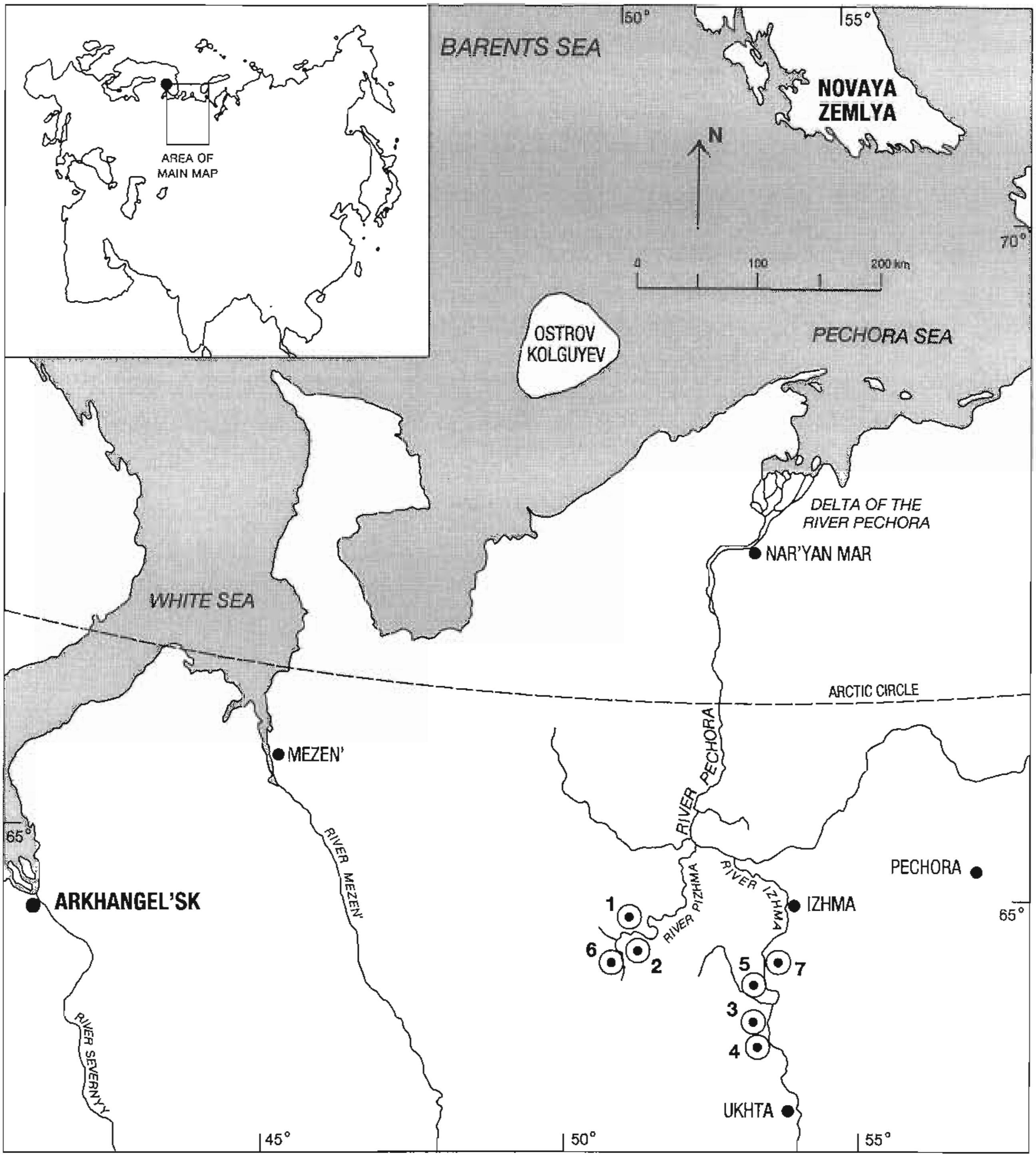
The Lower Jurassic and the Aalenian to Bathonian of the central Russian Platform is subdivided using isolated ammonite horizons. By contrast, the Callovian to Kimmeridgian ammonite zonation has been developed in detail, it comprises some local zones and can be readily correlated to the European standard. The central Volga River Basin is the stratotype for the Volgian Stage, the terminal stage of the Jurassic in the Boreal Realm (Text-Figure 5). The correlation of the Volgian and Portlandian stages is satisfactory (Casey and Mesezhnikov, 1986); however, profound problems remain in the correlation of the Volgian and Tithonian stages (Casey et al., 1977). Although the bases of the Volgian and Tithonian are



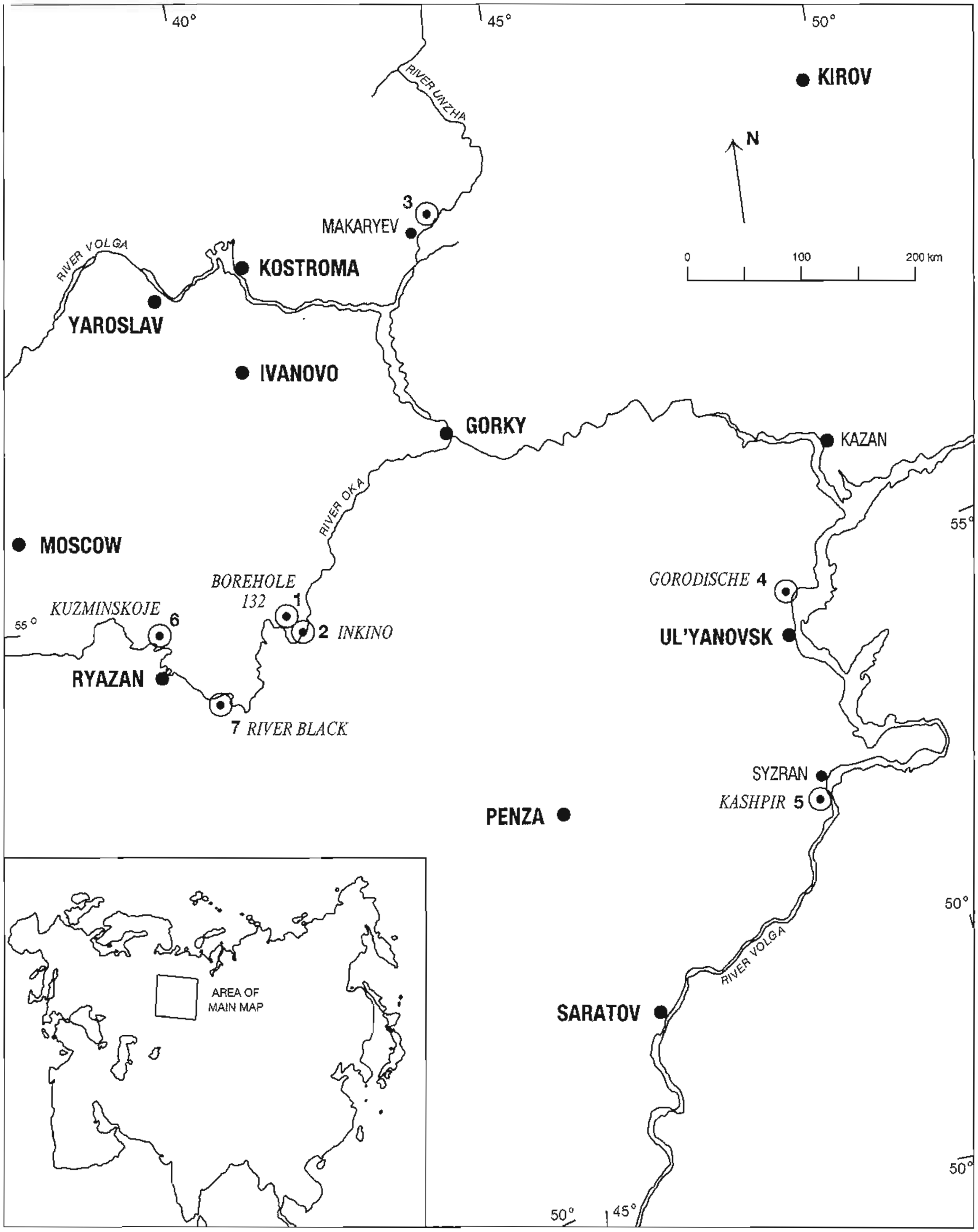

Text-Figure 2. Sketch map of the River Lena Basin, northern East Siberia illustrating seven of the eight Siberian sample localities. This region has an extremely complex drainage pattern. The major rivers are included, however, only the minor rivers etc. necessary to illustrate the positions of the sample localities are shown. The inset map illustrates the area depicted in the main map. Localities 1-7: 1 = West bank of the River Anabar; 2 = West coast of Anabar Bay; 3 = Sobo Creek, River Marcha; 4 = Borehole 141, Khatirik-Khomo; 5 = Bank of the River Kelimjar; 6 = Bank of the River Marcha; 7 = Bank of the River Motorshuna.




Text-Figure 3. Sketch map of part of Eastern Siberia, illustrating the position of the Astronomitscheskii Creek sample locality in the River Kedon Basin. This region has a complex drainage pattern. The major river, the River Kolyma, is illustrated; however, only the minor rivers etc. necessary to illustrate the position of Astronomitscheskii Creek are included. The inset map illustrates the area depicted in the main map.




Text-Figure 4. Sketch map of the seven sample localities on the banks of the Rivers Izhma and Pizhma in the Pechora Basin, northern Russian Platform. This region has a complex drainage pattern. Major rivers are included; only the minor rivers necessary to illustrate the positions of the sample localities are shown, however. The inset map illustrates the area depicted in the main map. Localities 1-7: 1 = outcrop 12, near Stepanov Village, west bank of the River Pizhma; 2 = outcrop 13, near Churkin Village, east bank of the River Pizhma; 3 = outcrop 9, west bank of the River Izhma; 4 = outcrop 7, west bank of the River Izhma; 5 = outcrop 15, west bank of the River Izhma; 6 = outcrops 12 and 13, west bank of the River Pizhma; 7 = outcrops 16 and 17, east bank of the River Izhma




Text-Figure 5. Sketch map of the seven sample localities in the central Russian Platform. The drainage pattern of the area has been simplified; only the rivers etc. necessary to illustrate the positions of the sample localities are shown. The inset map illustrates the area depicted in the main map. Localities 1-7: 1 = Borehole 132, near Elatma; 2 = Inkino; 3 = Banks of the River Unzha, near Makaryev; 4 = Gorodische; 5 = Kashpir; 6 = Outcrops 12 and 13, Kuzminskoje, River Oka Basin; 7 = Outcrop 6, River Black, River Oka Basin.

correlatable, the durations of these stages cannot be determined precisely. Part of the Upper Volgian (the Nodiger Zone in Mesezhnikov, 1984a) or all of this substage may be partially Ryazanian (Davey, 1979; Zeiss, 1979; 1986; Sey and Kalacheva, 1993; Fedorova, 1996).

### 2.1.2 History and scope of study of the Jurassic in the Pechora Basin

The Jurassic deposits of the Pechora Basin (Text-Figures 1 and 4) were first recognised by Keiserling (1846), who referred all the strata to the Oxfordian. Subsequently, I. I. Laguzen, S. N. Nikitin, A. A. Shtukenshcheider and F. N. Tchernyshev first researched the Jurassic macropalaeontology of this region (Krymholts and Tazikhin, 1972). The Timan expedition of F. N. Tchernyshev in 1889-1890 discovered Callovian to Volgian macrofaunas. Intensive geologic research on the Pechora Basin was initiated through the drilling of a series of boreholes in the 1960s and 1970s, which further improved the regional geologic framework (Krymgolts and Tazikhin, 1972). During the 1960s and 1970s, the modern Jurassic subdivision of this region was developed principally by Bodylevskyi (1963), Bodylevskyi et al. (1972); Sazonov (1965), Kravets (1966) and Kravets et al. (1976). Other modern works on the Jurassic and lowermost Cretaceous geology, biostratigraphy and paleontology of the Pechora Basin include: Golbert and Klimova, (1974); Jakovleva (1982; 1985); Tchirva and Jakovleva (1982; 1983); Mesezhnikov (1984a); Shulgina and Tchirva (1986); Tchirva and Kulikova (1986; 1993); Meledina (1987; 1994); Mesezhnikov et al. (1989); Tchirva (1989; 1990); Morakhovskaya and Tchirva (1990); Ilyina (1991a) and Meledina and Zakharov (1996).

In the Pechora Basin, the distribution of Jurassic and lowermost Cretaceous deposits is limited to the so-called Pechorian Syncline, where Jurassic sediments overlie Paleozoic and Triassic strata. In the Jurassic of this region, two principal facies are present. The oldest is Early and pre-Callovian Mid Jurassic and comprises dominantly lowstand sandstones and mudstones; the overlying complex is Callovian to earliest Cretaceous and is mainly highstand marine clays with diverse biotas. The Upper Jurassic outcrops on the rivers Izhma, Pizhma and Adzjva were used to formulate the ammonite and *Buchia* (bivalve) zonal schemes of Zakharov (1981). Abundant marine Jurassic foraminiferal assemblages have been recorded throughout the Pechora Basin (Jakovleva, 1982). Tchirva and Kulikova (1993) described the Lower and Middle Jurassic palynofloral succession of the basin. The latest biostratigraphic scheme for the marine Jurassic of the Pechora Basin includes twenty-nine ammonite zones, eight *Buchia* zones, fourteen foraminiferal associations and four palynoflorules (Tchirva and Kulikova, 1993).

### 2.1.3 Stage level syntheses of the entire Russian Platform

Throughout the Russian Platform (Text-Figure 1), the basal Jurassic strata are Bajocian paralic deposits which are underlain by Paleozoic and Triassic rocks (Olferjev, 1986; Tchirva and Kulikova, 1986). These Bajocian sediments include sandstones, siltstones and mudstones which are rich in miospores; plant macrofossils are especially common in the Pechora Basin (Text-Figure 4). The rare occurrences of ammonites and foraminifera in the uppermost Bajocian of the Voronezh Structural High and the Dnieper-Donetz Rift Basin indicate marine incursions.

There was a major marine transgression in the Bathonian. In the Moscow Basin (Text-Figure 1), there are alternating marine and non-marine Bathonian deposits. These beds contain miospores, dinoflagellate cysts, freshwater/brackish alga (*Botryococcus braunii*), foraminifera and rare bivalves (Olferjev, 1986; Ilyina, 1991a). In the Pechora Basin (Text-Figure 4), Bathonian sediments are fully marine and contain abundant ammonites, foraminifera and dinoflagellate cysts (Tchirva and Jakovleva, 1982; Ilyina, 1991a; Meledina, 1994; Meledina and Zakharov, 1996). The discovery of the ammonites *Oraniceras* and *Gonolkites* in the Lower Bathonian of the Pechora Basin permit correlation with the Zigzag Zone of northwest Europe (Meledina, 1994; Meledina and Zakharov, 1996; Meledina et al., 1998).

The early Callovian Boreal transgression in the Russian Platform deposited widespread strata yielding characteristic northern ammonite faunas which differ profoundly from coeval associations in northwest Europe. These highstand marine conditions continued throughout the succeeding Late Jurassic. The Callovian, Oxfordian and Kimmeridgian strata of the Russian Platform are subdivided into twenty ammonite zones which can be satisfactorily correlated with the European Standard Zonation. Significant publications on the Callovian and Upper Jurassic biostratigraphy of the Russian Platform include Mesezhnikov (1984a), Mesezhnikov et al. (1986) and Meledina (1987).

Callovian strata are thus widespread throughout the Russian Platform. In the Moscow Basin, heterolithic lowermost Callovian sediments unconformably overlie Bathonian strata. The early Callovian Boreal transgression brought cardioceratid ammonites as far as the southern part of the Russian Platform. The Lower Callovian is dominated by mudstones; sandstones are well developed in the overlying Middle Callovian. Ammonites, belemnites, other macrofauna and palynomorphs are present throughout. Shallow marine deposition, indicated by oolitic facies, was developed in the lowermost Upper Callovian (Athleta Zone) of the Moscow Basin. Freshwater/brackish alga and acritarchs (*Botryococcus braunii* and *Micrhystridium* respectively) are frequently associated with this facies (Olferjev, 1986; Ilyina, 1991a; Tchirva and Kulikova, 1986). The Upper Callovian of the Pechora Basin is characterized by mudstones containing the Boreal ammonite *Longaeviceras keyserlingi* and typically Middle Callovian dinoflagellate cysts (section 5.2.1.3 and Meledina et al., 1998). Similar dinoflagellate cyst assemblages have been observed from the Athleta Zone of the Moscow Basin(e.g. section 5.3.2.2). However in the uppermost Callovian the more diverse dinoflagellate cyst floras are similar to those from the Upper Callovian of northwest Europe.

The Bathonian and Callovian successions from the Pechora Basin yield ammonites characteristic of both western Europe and Siberia and this region is therefore a key area for interregional correlation. Five marker horizons have been established in the Pechora Basin, permitting calibration with the Zigzag, Herveyi, Koenigi, Jason and Lamberti zones of the European standard. Six ammonite markers (*Arcticoceras* spp., *Cadoceras variabile*, *Cadoceras falsum*, *Rondiceras-Erymnoceras*, *Longaeviceras* and *Eboraciceras-Quenstedtoceras* [*Soaniceras*]) have helped to determine the zonal correlation between the Bathonian and Callovian successions of the Pechora Basin and northern

Siberia (Text-Figures 2 and 3) (Meledina and Zakharov, 1996). Bathonian and Callovian belemnites and dinoflagellate cysts from the Pechora Basin have been linked to the standard ammonite zonal scheme and can be used as interregional markers (Meledina et al., 1998).

The Oxfordian sediments of the Russian Platform are also widespread and largely comprise grey/black mudstones which yield cardioceratid ammonite faunas of Boreal affinity. They are largely confined to the northern and central part of the Russian Platform, from the River Unzha in the north to the River Oka in the south (Text-Figure 5). Bituminous mudstones characterize the lowermost Upper Oxfordian. Several hiatuses have been observed, for example the significant hiatus at the base of the Upper Oxfordian in the northern central Russian Platform. Another unconformity has been traced within the uppermost Oxfordian (Ravni Zone). The most complete Oxfordian sections are relatively thin and outcrop in the River Unzha area (Text-Figure 5) (Mesezhnikov et al., 1986; 1989). Here, the Middle and Upper Oxfordian are especially well developed and the complete succession of Oxfordian ammonite zones are present. Lower and Middle Oxfordian strata outcrop in the River Oka region. In the Pechora Basin, Oxfordian successions are intensely condensed, largely due to low sedimentation rates.

Marine Kimmeridgian strata are present throughout most of northern Russia. The Lower Kimmeridgian is much more extensively developed than the Upper Kimmeridgian. In the Pechora Basin, Kimmmeridgian outcrops are small and isolated. Lithologies are monotonous dark, shaly mudstones with minor sandstone lenses, shell beds and septarian calcareous nodules (Mesezhnikov, 1984a).

Volgian strata also have a wide distribution throughout northern Russia. The principal outcrops are in the central Russian Platform (Text-Figure 5). Volgian sediments also are present in the Pechora Basin in the River Izhma and River Pizhma areas (Text-Figure 4) (Mesezhnikov, 1984a). In the depocenters, the principal lithologies are dark mudstones which are frequently bituminous. By contrast, on the basin margins, the sediments are relatively heterolithic and include calcareous mudstones, siltstones, sandstones and conglomerates. The central Russian Platform is the type area of the Volgian Stage. The Volgian lectostratotypes are located at Gorodische and Kashpir in the Ryazan-Saratov Basin in the middle part of the River Volga Basin (Text-Figure 5). The correlations of the type Tithonian, Portlandian and Volgian stages have been the subject of prolonged debate (Mesezhnikov, 1984b; Zeiss, 1979; 1986; Sey and Kalacheva, 1993; Fedorova, 1996). However, the type Volgian strata have been broadly correlated with the Portlandian of southern England by Casey and Mesezhnikov (1986) and Casey et al. (1977).

The lowermost Cretaceous (Ryazanian) is well developed throughout the Russian Platform. The Ryazanian stratotype is located in the River Oka Basin (Text-Figure 5) and comprises a composite series of small outcrops. The principal lithologies are rather condensed beds of sand and sandstones with glauconitic and phosphatic nodules. Notable publications on the sedimentology and paleontology of the type Volgian and Ryazanian include those of Mesezhnikov et al. (1979), Fedorova and Griazeva (1984), Mesezhnikov (1984a,b), Iosifova (1992; 1996) and Fedorova (1996).

## 2.2 NORTHERN SIBERIA

The earliest researches on the Jurassic of northern Siberia (Text-Figure 1) were undertaken in the late 19th and early 20th Centuries. The pioneers of this work were V. I. Bodilevsky, A. A. Borysiak, A. L. Chekanovsky, E. Eichwald, T. M. Emeliantsev, A. A. Gerke, P. K. Maak, Z. Z. Ronkina, V. N. Saks, V. A. Vakhrameev and M. S. Voronets. Reviews of these studies were given by Saks (1963; 1976). These were followed by more detailed investigations of the Siberian Jurassic from the 1960s onwards (e.g. Bodilevsky and Shulgina, 1958; Kara-Murza, 1960; Basov et al., 1970). At this time the Jurassic strata of northern Siberia and northeast Russia were subdivided into stages and certain successions were zoned using ammonite faunas. The most comprehensive account of the Jurassic stratigraphy and paleontology of northern Siberia was given by Saks (1976). Paleontologic monographs include those of Saks and Nalnjaeva (1964; 1970; 1975), Dagis (1974), Meledina (1977), Zakharov (1981), Ilyina (1985a) and Kirichkova (1985). Works on lithology and paleogeography include Kaplan (1976), Saks (1976), Zakharov et al. (1983; 1984) and Krymholts et al. (1988)

The Jurassic strata of Siberia are extensive; widespread Lower and lowermost Middle Jurassic sandstones and siltstones cover the Siberian craton in the west and northeast of this region. Marine strata of Early and early Mid Jurassic age are confined to northern Siberia. By contrast, in southern West Siberia only thin marine intercalations occur in the Lower and pre-Callovian Middle Jurassic. The extensive Callovian Boreal transgression initiated widespread marine clay deposition over northwest Siberia, which continued into and throughout the Late Jurassic. In northeast Siberia, Jurassic sedimentary rocks are principally developed in the Enisey-Lenskyi and Preverkhojanskyi Troughs and the Vilujskaya Syncline. In the Enisey-Lenskyi Trough, Lower Jurassic sediments comprise marine terrigenous strata which change laterally into littoral/continental facies in the lower Enisey River region. The Lower and Middle Jurassic of the Preverkhojanskyi Trough represent open marine deposition. The Upper Jurassic strata of this area are largely of continental facies and include the development of coals. The Upper Pliensbachian and Toarcian of the River Viljui Basin (Text-Figure 2) are fully marine. However, the Hettangian-Sinemurian, Bajocian-Bathonian and the Callovian to Kimmeridgian/Volgian strata are largely paralic and yield abundant plant fossils (Kirichkova, 1985; Ilyina, 1969; 1985a). In southwest Siberia, in the Angaro-Viljui Trough, the Lower-Middle Jurassic strata exhibit an alternation of littoral marine and freshwater/continental facies. This alternation passes southwards into fully paralic and continental deposition in the south Siberian coal basins. Detailed accounts of Siberian Jurassic geology and paleogeography were presented by Saks (1976), Resolutions (1981), Zakharov et al. (1983; 1984) and Gurari et al. (1988).

The Jurassic of Siberia normally unconformably overlies Paleozoic basement of various ages. Triassic-Jurassic boundary beds in marine facies are exposed in northern Siberia and northeast Russia. Continuous Jurassic-Cretaceous boundary sections in marine facies are developed at Anabar Bay (Text-Figure 2) and the Paksa Peninsula (Basov et al., 1970; Saks, 1976; Zakharov, 1981; Ilyina, 1985a; 1988). Kaplan (1976) and Levtchuk (1985) demonstrated large scale cyclic sedimentation in the Jurassic of Siberia. In the

Lower Toarcian of the River Viljui Basin and the Anabar region (Text-Figure 2), marine anoxic facies characterised by organic rich shales has been observed. This phenonenon is an extension of the Posidonia Shale event of northwest Europe (Morris, 1979; 1980; Loh et al., 1986). Marine anoxia was also developed in the latest Jurassic-earliest Cretaceous of the central Khatanga Basin in northeast Siberia (Kaplan et al., 1973; Zakharov, 1981; Ilyina, 1985a) and in the Bazhenov Formation of west Siberia (Braduchan et al., 1986). A zonal biostratigraphy was developed for the Jurassic of Siberia based on ammonites, other macrofauna and palynomorphs from the marine strata of northeast Siberia and northeast Russia (Saks and Nalnjaeva, 1970; 1975; Polubotko and Repin, 1972; 1994; Dagis, 1974; 1975; Saks, 1976; Meledina, 1977; Zakharov, 1981; Zakharov et al., 1984; Ilyina, 1985a; Shurygin, 1986 and Meledina et al., 1987).

The Triassic-Jurassic boundary is taken at the base of the Planorbis Zone in northern Siberia, as in the European standard. Polubotko and Repin (1981) described beds with the ammonite *Primapsilocaras primulum* from the base of the Planorbis Zone in northeast Russia. Rare Sinemurian ammonites have been discovered on the banks of the River Buur in the River Olenek Basin, northeast Siberia by Dagis et al. (1978). Upper Pliensbachian ammonites of the genus *Almatheus* have been extensively recognised throughout Northern Siberia. The Stokesi and Margaritatus zones are correlated with the European standard. The regional Viligaensis Zone was erected for the uppermost Pliensbachian in northeast Russia; this is approximately corrlated with the Spinatum Zone (Krymholts et al., 1988; Knjazev et al., 1991).

Lower Toarcian ammonites have been described from Northeast Russia and four ammonite zones are recognised. All of these zones except the Propinquum Zone can be traced throughout Northeast Siberia (Resolutions, 1981; Krymholts et al., 1988; Knjazev et al. 1991; Shurigin, Meledina et al., 1996). The lowermost Toarcian beds are devoid of ammonites and have been questionably attributed to the Propinquum Zone. Ilyina (1985a), Sapjanik (1986) and Ilyina in Ilyina et al. (1994) stated that these beds may be partially present in the River Anabar and the River Viljui basins (Text-Figure 2). However, Shurigin (1986; 1987) stated that the Propinquum Zone represents a depositional hiatus in northeast Siberia. The Upper Toarcian of northern Siberia was discovered by Knjazev (1991), Knjazev et al. (1991) and Ilyina in Ilyina et al. (1994) using ammonites, bivalves and dinoflagellate cysts. The ammonite zonal scheme of these beds is still under discussion. There are two different Upper Toarcian zonal schemes, one by Knjazev (1991) and Knjazev et al. (1991) and another by Polubotko and Repin (1994).

Meledina (1994) presented a detailed cardioceratid ammonite zonation for the Upper Bajocian, Bathonian and Callovian of eastern Siberia. This scheme is also correlated with the zonations of northwest Europe and North America. The correlation of provincial ammonite successions is problematic. The Bathonian and Callovian ammonites of the Pechora Basin include representatives characteristic of both western Europe and Siberia and therefore this is a crucial area in the correlation of these two regions (Meledina and Zakharov, 1996; Meledina et al., 1998).

The modern Jurassic ammonite zonation in Siberia includes over 70 zones together with 11 ammonite marker levels. These permit the correlation with the European Standard (Krymholts et al., 1988; Shurigin, Meledina et al., 1996; Zakharov et al., 1996; 1997). Independent zonations based on bivalves, belemnites, calcareous microfauna, dinoflagellate cysts and miospores erected in Northern Siberia have been linked to the ammonite zones (Ilyina, 1985a; Shurigin, 1986; 1987; Nikitenko, 1992; Ilyina in Ilyina et al., 1994; Zakharov et al., 1997). The Lower and Middle Jurassic palynostratigraphic scheme for Northen Siberia has been used as an independent biozonation for the detailed subdivision and correlation of non-marine oil-bearing sediments in the western Siberia (Kontorovich, Andrusevich et al., 1995; Kontorovich, Ilyina et al., 1995; Shurigin et al., 1995; Shurigin, Nikitenko et al., 1996).

# 3 PREVIOUS RESEARCH ON THE JURASSIC PALYNOLOGY OF RUSSIA

## 3.1 THE RUSSIAN PLATFORM

The first reports of Jurassic and Lower Cretaceous dinoflagellate cysts from the central Russian Platform and the Pechora Basin were by Yushko (1962) and Teodorovitch and Vozzhennikova (1971). Tamara F. Vozzhennikova of Novosibirsk was by far the most prominent worker on the taxonomy and morphology of fossil and recent dinoflagellates in Russia at this time and published three major monographs (Vozzhenikova, 1965; 1967; 1979). These works include the descriptions of many Upper Jurassic, Cretaceous and Palaeogene dinoflagellate cyst taxa from the Russian Platform and Siberia. Lentin and Vozzhennikova (1990) presented a restudy of selected Russian dinoflagellate cyst taxa which were originally described by Vozzhennikova. Kochetova et al. (1967) and Kochetova and Meikson (1976) described the quantitative distribution of Bathonian to Valanginian marine microplankton from central European Russia. Other relatively early studies of Jurassic-Cretaceous miospores and microplankton include, for example, those of Dobrutzskaja (1963) on the central Russian Platform and Grjazeva (1968; 1980) on the Pechora Basin (Text-Figure 1). Research on Volgian and Lower Cretaceous dinoflagellate cysts and prasinophytes was undertaken by Shakhmundes (1971a,b), Fedorova (1976, 1980, 1989) and Iosifova (1992, 1996). Furthermore, Shakhmundes (1973, 1974), Fedorova (1977) and Resolutions (1986) also studied the detailed regional biostratigraphy, sequence stratigraphy, palaeogeography and facies distribution of the Lower Cretaceous marine palynomorphs from the south-east Russian Platform. Shakhmundes (1973) published a regional integrated dinoflagellate cyst-miospore biostratigraphy principally based on the south-east Russian Platform and western Khazakstan. The Lower Cretaceous data from the latter work was included in the unified regional stratigraphic scheme for western Khazakstan (Resolutions, 1986). The Lower Cretaceous palynology of the Precaspian Lowland and the Pechora Basin was reviewed by Fedorova and Grjazeva, (1979; 1983).

During the 1980s, detailed studies of the Volgian and Ryazanian stratotypes and underlying strata in the the central River Volga Basin and the River Oka Basin (Text-Figure 5) were undertaken (Fedorova and Griazeva, 1984; Lord et al., 1987; Iosifova, 1992; 1996). Fedorova (1994; 1996) produced the first detailed biostratigraphic studies of microplankton from the Upper Kimmeridgian (Eudoxus Zone) to Lower Valanginian (Hoplitoides Zone) of the River

Volga Basin. The first dinoflagellate cyst zonation of the Bathonian to Middle Oxfordian of the central Russian Platform and the Pechora Basin was proposed by Ilyina (1991a,b). Ten dinoflagellate cyst zones which are correlated with the standard ammonite zonation were erected and are applicable to the Moscow Basin, the Voronezh Structural High and the Pechora Basin (Text-Figure 1). The dinoflagellate cyst data from the works referred to in this section by V. A. Fedorova and V. I. Ilyina were included in the Unified Jurassic Stratigraphic scheme for the Russian Platform (Jakovleva, 1993). Meledina et al. (1998) includes a Bathonian-Callovian dinoflagellate cyst zonation correlated with macrofaunal zones for the Pechora Basin and this scheme may prove useful for interregional correlations within the Boreal and Sub-Boreal provinces.

## 3.2 NORTHERN SIBERIA

The first reports of Jurassic and Lower Cretaceous marine microplankton from Siberia were included in papers largely on miospores that were published during the 1950s and early 1960s (e.g. Maljavkina, 1961; Mtchedlishvili, 1961; Rovnina, 1961 and Voitsel et al., 1966). Data on Jurassic, Cretaceous and Palaeogene miospores and microplankton from northern Russia, including Siberia, were used in the production of the paleogeographic and paleovegetational maps of Golbert et al. (1968). Siberian Jurassic dinoflagellate cysts were described by Vozzhennikova (1967) and Zatonskaja (1975). The important genus *Imbatodinium* was first described from the Upper Jurassic of West Siberia by Vozzhennikova (1967).

Ilyina (1969; 1971; 1973; 1976; 1978) described Lower Toarcian dinoflagellate cysts from the River Viljui and River Anabar basins in north-east Siberia (Text-Figure 2). Ilyina also worked on Hettangian to Volgian dinoflagellate cysts, acritarchs, prasinophytes and miospores, mainly from reference sections in northern Siberia (Ilyina, 1985a,b; 1986). These papers established that the oldest dinoflagellate cysts from this region are of latest Pliensbachian age and that marine microplankton is diverse and widespread in the Toarcian, Lower Callovian, Middle Volgian and lowermost Cretaceous. Detailed biostratigraphic, systematic and paleogeographic investigations of Upper Pliensbachian to Toarcian dinoflagellate cysts from northern Siberia were presented by Ilyina in Ilyina et al. (1994). In particular, the genus *Nannoceratopsis* was studied intensively and the species *Nannoceratopsis deflandrei* was revalidated and three subspecies (*anabarensis*, *deflandrei* and *senex*) recognized. Scanning Electron Microscope (SEM) studies established that the autophragm surfaces of *Nannoceratopsis deflandrei* and *Nannoceratopsis gracilis* are fundamentally different. Furthermore, Ilyina in Ilyina et al. (1994) established a zonal scheme comprising two dinoflagellate cyst zones, which were subdivided into five subzones, for the Upper Pliensbachian to Toarcian strata of northern Siberia. This zonation appears to have regional applicability (Ilyina et al., 1994; Pospelova, 1995; 1996; Ilyina, 1996). Ilyina in Ilyina et al. (1994) included data on latest Pliensbachian to Aalenian dinoflagellate cyst distribution and evolution and recorded the first occurrences of members of the family Heterocapsaceae in the Upper Toarcian of Siberia. Dinoflagellate cysts are extremely rare in the ?Aalenian, Bajocian and Bathonian in Siberia (V.I.I. and J.B.R., personal observations). Callovian dinoflagellate cyst assemblages from western and eastern Siberia were described by Rovnina et al. (1989) and Ilyina (1991a,b; 1996). The Boreal dinoflagellate cysts *Crussolia dalei* and *Paragonyaulacysta retiphragmata* were reported in the Lower Callovian (Falsum and Anabarense ammonite zones) in northeast Siberia (Ilyina, 1996). This dinoflagellate cyst association can be traced throughout Arctic Canada, Svalbard and other areas in the Boreal Realm (Davies, 1983; Smelror, 1988a; Smelror and Below, 1993). Lower Callovian dinoflagellate cyst assemblages from northeast Siberia and the Pechora Basin exhibit significant provincial differences (Meledina et al., 1998).

Upper Jurassic dinoflagellate cyst and miospore assemblages were recorded from west Siberia by Zatonskaja (1983) and Glushko (1987). Dinoflagellate cysts and abundant prasinophytes are present in the Volgian-Boreal Berriasian boundary beds of West Siberia (Rovnina et al, 1990). The palynological study of the Boreal Jurassic-Cretaceous boundary in northern Siberia has been extensively undertaken. The complete Middle Volgian to lowermost Cretaceous reference section of Urdjuk-Khaja Cape, Paxa Peninsula and Anabar Bay (Text-Figure 2) was studied by Ilyina (1985a; 1988). A *Paragonyaulacysta borealis-Tubotuberella rhombiformis* association was established and this can be traced throughout arctic Eurasia and arctic Canada. Furthermore, repeated alternations of dinoflagellate cyst and prasinophycean assemblages was found to be linked to changes in aerobic and anoxic deep marine environments respectively during the latest Jurassic and earliest Cretaceous in the central part of the Khatanga Basin.

Detailed multidisciplinary micropaleontological studies from the lowermost Cretaceous (Boreal Berriasian) reference sections from the River Jatria, the east slope of the polar Urals and the River Bojarka of the Khatanga Basin have been carried out by Fedorova et al. (1993). This work has demonstrated the widespread value of dinoflagellate cysts in the correlation of the Boreal Berriasian. Rich microphytoplankton and microforaminiferal assemblages are present in the Upper Volgian and Lower Cretaceous sections from the River Jatria in the Polar Urals (Lebedeva and Nikitenko, 1996). Changes in these associations during the Early Cretaceous in this area reflects the recognition of different water depth conditions. Lebedeva in Zakharov et al. (1997) erected five Upper Volgian to Lower Hauterivian dinoflagellate cyst zones in the River Jatria sections.

# 4 MATERIALS AND METHODS

This project is based on a sample suite comprising 187 Jurassic and lowermost Cretaceous horizons from 29 localities in northern East Siberia, the Pechora Basin and the central Russian Platform. The samples range in age from late Pliensbachian (Early Jurassic) to Ryazanian (Early Cretaceous). They are listed in Appendix 1 and were prepared for palynological analysis using the the standard preparatory techniques involving acid digestion and oxidative maceration (Wood et al., 1996). The resulting palynological slides were systematically studied in both the U.K. and Russia by the authors; Appendix 2 lists all the palynomorph taxa recognised throughout with author citations. The palynological data was then used to compile the spreadsheets (Appendix 3 comprising Text-Figures A3.1 to A3.20), the semi-quantitative range charts and in formulating the biozonation scheme (section 6). The recommendations of

Holland et al. (1978) and Callomon (1984) regarding Jurassic ammonite-based zones are followed. Although all ammonite zones do not have a formally defined boundary stratotype, each zone is here considered to be a chronozone (and/or 'standard' zone) and therefore is named after the respective index species and written in Roman font with an initial capital letter (see also Woollam and Riding, 1983; Riding and Thomas, 1992).

# 5 STRATIGRAPHIC PALYNOLOGY

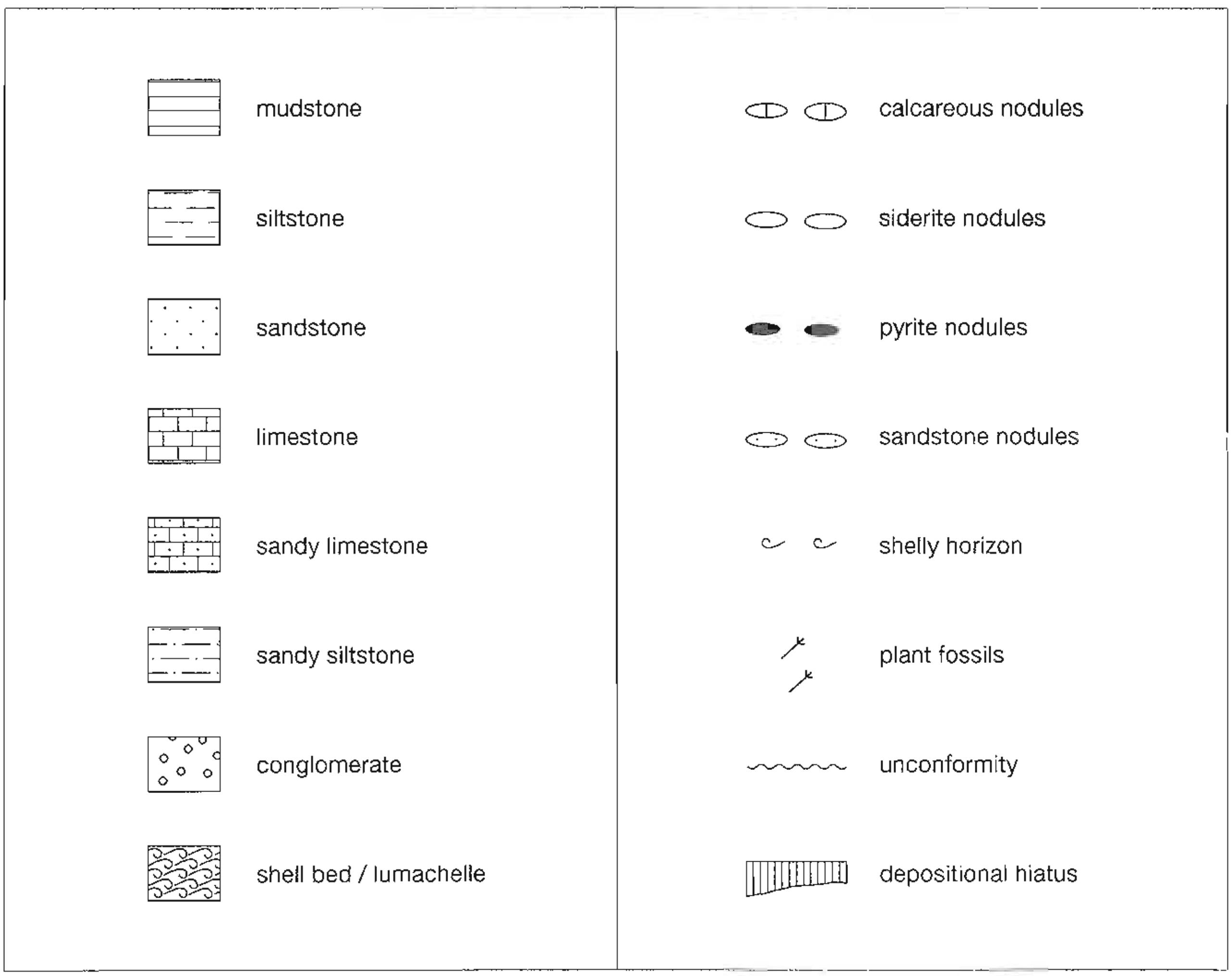
In this section, the late Pliensbachian to Ryazanian palynofloras from the 29 localities studied from northern East Siberia, the Pechora Basin, northern Russia and the central Russian Platform are described, succession-by-succession. A series of range charts are presented in order to illustrate the semi-quantitative stratigraphic distributions of dinoflagellate cysts in each section studied. Where space permits, the stratigraphic distributions of miscellaneous palynomorphs and miospores are also illustrated in these diagrams. Text-Figure 6 is the lithologic key pertaining to the successions illustrated in all these range charts. Selected palynomorphs, largely dinoflagellate cysts, are illustrated in Plates 1 to 35.

## 5.1 STRATIGRAPHIC PALYNOLOGY OF NORTHERN EAST SIBERIA

Fifty-nine Upper Pliensbachian, Toarcian, Aalenian and Lower Callovian samples from eight localities in northern East Siberia were studied. These horizons are listed in Appendix 1. Seven of the sample localities are in the River Lena Basin and these are illustrated in Text-Figure 2. In addition, two Lower Toarcian samples from Astronomitscheskii Creek in the River Kedon Basin in East Siberia were examined; this locality is illustrated in Text-Figure 3.

### 5.1.1 Upper Pliensbachian, Toarcian and Aalenian palynology

A suite of 53 Upper Pliensbachian to Aalenian samples from eight localities in East Siberia were examined (Text-




Text- Figure 6. Lithologic key for the semi-quantitative palynomorph range charts (Text-Figures 7-10, 12-14, 17-24).

Figures 2 and 3). The majority of these samples were included in the study of Ilyina in Ilyina et al. (1994). The Upper Pliensbachian to Aalenian spore and pollen biostratigraphy of this area was also studied by Ilyina (1985a).

The samples yielded mostly rich and well-preserved palynofloras, largely comprising gymnospermous pollen grains and dinoflagellate cysts. Woody tissue is common throughout and amorphogen was sporadically observed in significant proportions. The stratigraphic distribution of the palynomorphs recognised are illustrated in Text-Figures 7-11 and A3.1-A3.5.

### 5.1.1.1 West bank of the River Anabar

Sixteen Upper Pliensbachian to Lower Toarcian samples from strata exposed on the west bank of the River Anabar were studied (Text-Figure 2). The succession is 195.90 m thick and comprises largely ammonite-bearing interbedded nodular shales and sandstones (Text-Figure 7). The stratigraphic distribution of the palynomorphs recognised are illustrated in Text-Figures 7 and A3.1.

The seven Upper Pliensbachian samples, NS 16 to NS 10, yielded extremely sparse dinoflagellate cyst floras. *Nannoceratopsis deflandrei* subsp. *anabarensis* and *Nannoceratopsis deflandrei* subsp. *senex* were recorded rarely from two samples, NS 12 and NS 11, from the Viligaensis Zone (Text-Figures 7 and A3.1). Representatives of the acritarch genus *Leiofusa* are common in the Stokesi Zone (Text-Figure A3.1). *Tasmanites* spp. are also present in samples NS 16 to NS 14 and *Botryococcus braunii* occurs throughout the Upper Pliensbachian at this locality (Text-Figure A3.1). Miospores in the Upper Pliensbachian are of relatively low diversity; undifferentiated bisaccate pollen tends to be the numerically dominant element. The distinctive spore *Rogalskaisporites cicatricosus* is confined to this interval and possible reworked Carboniferous spores were observed in sample NS 12 (Text-Figure A3.1).

Samples NS 9 to NS 1 from the Lower Toarcian (?Propinquum and Falciferum-Commune zones) are all rich in subspecies of the dinoflagellate cyst *Nannoceratopsis deflandrei* (Text-Figures 7 and A3.1). The lowermost sample, NS 9, is questionably attributed to the earliest Toarcian Propinquum Zone. *Nannoceratopsis deflandrei* subsp. *anabarensis* is prominent in this sample, where it comprises 73.9% of the overall dinoflagellate cyst flora. *Nannoceratopsis deflandrei* subsp. *deflandrei* and *Nannoceratopsis deflandrei* subsp. *senex* are also common and respectively represent 13.3% and 12.6% of the dinoflagellate cyst assemblage at this horizon. *Mancodinium semitabulatum* was also rarely observed (0.2%) (Text-Figures 7 and A3.1).

The remaining 8 Lower Toarcian samples are assigned to the Falciferum and Commune zones. In all of these aside of NS 7, the dominant dinoflagellate cyst is *Nannoceratopsis deflandrei* subsp. *senex*. In samples NS 5, NS 3 and NS 1, this subspecies is the only dinoflagellate cyst present. In the remaining samples, the proportions of *Nannoceratopsis deflandrei* subsp. *senex* vary from 95% (NS 2) to 43.7% (NS 7). *Nannoceratopsis deflandrei* subsp. *deflandrei* is also present and is especially common in the three lowermost samples (NS 8 to NS 6). *Mancodinium semitabulatum* was recorded in low proportions (1.9%) in sample NS 4 (Text-Figures 7 and A3.1). The stratigraphical inception of *Nannoceratopsis gracilis* occurs in Bed 20, higher in the succession (Text-Figure 7). *Halosphaeropsis liassica*, associated with large amounts of amorphogen, was observed in samples NS 4 to NS 2 (Text-Figure A3.1). This palynofacies association is best developed in NS 4 and is also extensively developed in the Lower Toarcian of northwest Europe (Loh et al., 1986; Riding, 1987) and reflects the development of stratified marine water conditions with anoxia at the sea floor. These records from northern East Siberia indicate that this palynofacies association is of widespread stratigraphic significance throughout Europe and northern Asia. Riding (1987) reported the inception of this distinctive palynofacies in the uppermost Tenuicostatum Zone of eastern England. Hovever, Loh et al. (1986, text-fig. 4) noted that this facies association in Germany is developed throughout the Lower Toarcian, peaking in the Lias epsilon three (Bifrons Zone).

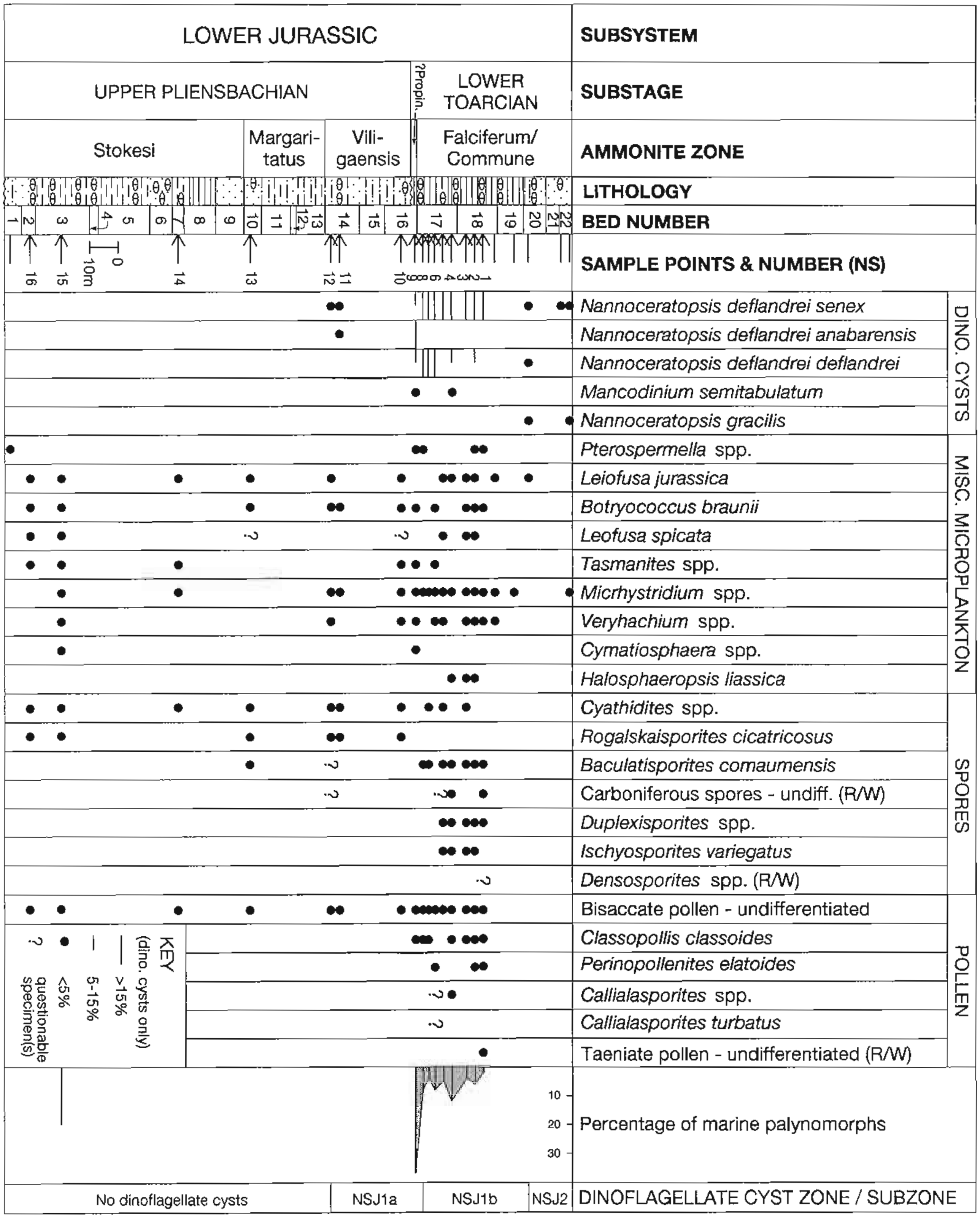
The Lower Toarcian miospore assemblages are of higher species diversity than those from the underlying Upper Pliensbachian; bisaccate pollen, and *Cyathidites* spp. being the most prominent elements. Common incoming taxa include *Classopollis classoides*, *Ischyosporites variegatus*, *Duplexisporites* spp. and *Perinopollenites elatoides* (Text-Figure A3.1). Unequivocal forms of the pollen genus *Callialasporites* were noted in sample NS 4. The inception of this genus in northwest Europe is within the late Toarcian (Riding et al., 1991). Occasional reworked Carboniferous spores were observed (Text-Figure A3.1). Furthermore, a striate bisaccate pollen grain, stratigraphically recycled from the Permian or Triassic was encountered in sample NS 1 (Text-Figure A3.1). For more information on the Pliensbachian to Toarcian miospore assemblages from the River Anabar area, see Ilyina (1973, 1981, 1985a,b, 1986).

### 5.1.1.2 West coast of Anabar Bay

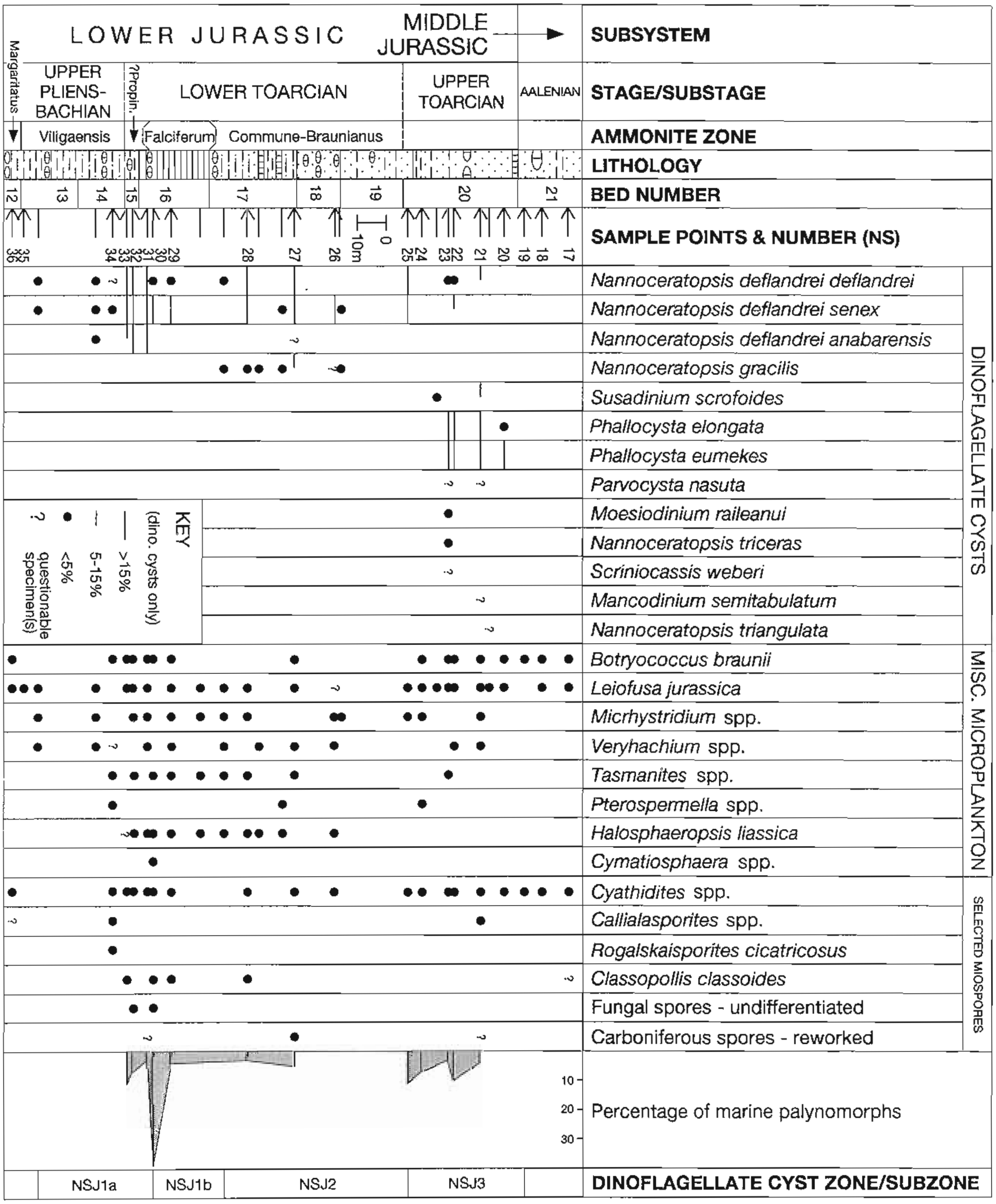
Twenty samples from the Upper Pliensbachian to Aalenian strata of west Anabar Bay were examined (Text-Figure 2). The samples were taken from an ammonite-bearing succession of nodular shales, siltstones and sandstones which is 247.10 m thick (Text-Figure 8). Gymnospermous pollen is normally the dominant palynomorph group and the palynomorph species diversity is relatively low. The stratigraphic distribution of the palynomorphs identified is illustrated in Text-Figures 8 and A3.2.

The three Upper Pliensbachian samples (NS 36, NS 35 and NS 34) yielded relatively sparse, low diversity palynofloras (Text-Figure A3.2). Sample NS 36 produced rare miospores and the freshwater/brackish alga *Botryococcus braunii*. Sample NS 34 is dominated by miospores, largely bisaccate pollen. *Nannoceratopsis deflandrei* is present in extremely low numbers; two specimens of *Nannoceratopsis deflandrei* subsp. *senex* and a single questionable specimen of *Nannoceratopsis deflandrei* subsp. *deflandrei* were recorded (Text-Figures 8 and A.2). The occurrence of these two subspecies in Bed 13 (Text-Figure 8) are the oldest reports of dinoflagellate cysts in this study. Therefore, the range base of the genus *Nannoceratopsis* in Siberia is deemed to be within the uppermost Pliensbachian (Viligaensis Zone). The miospores *Callialasporites* and *Rogalskaisporites cicatricosus* were also recorded in sample NS 34 (Text-Figure A3.2). *Callialasporites* spp. are normally confined to strata of late Toarcian and younger age in western Europe (Riding et al., 1991). The remainder of the samples at this locality are, however, virtually devoid of the genus (Text-Figure 3.2).

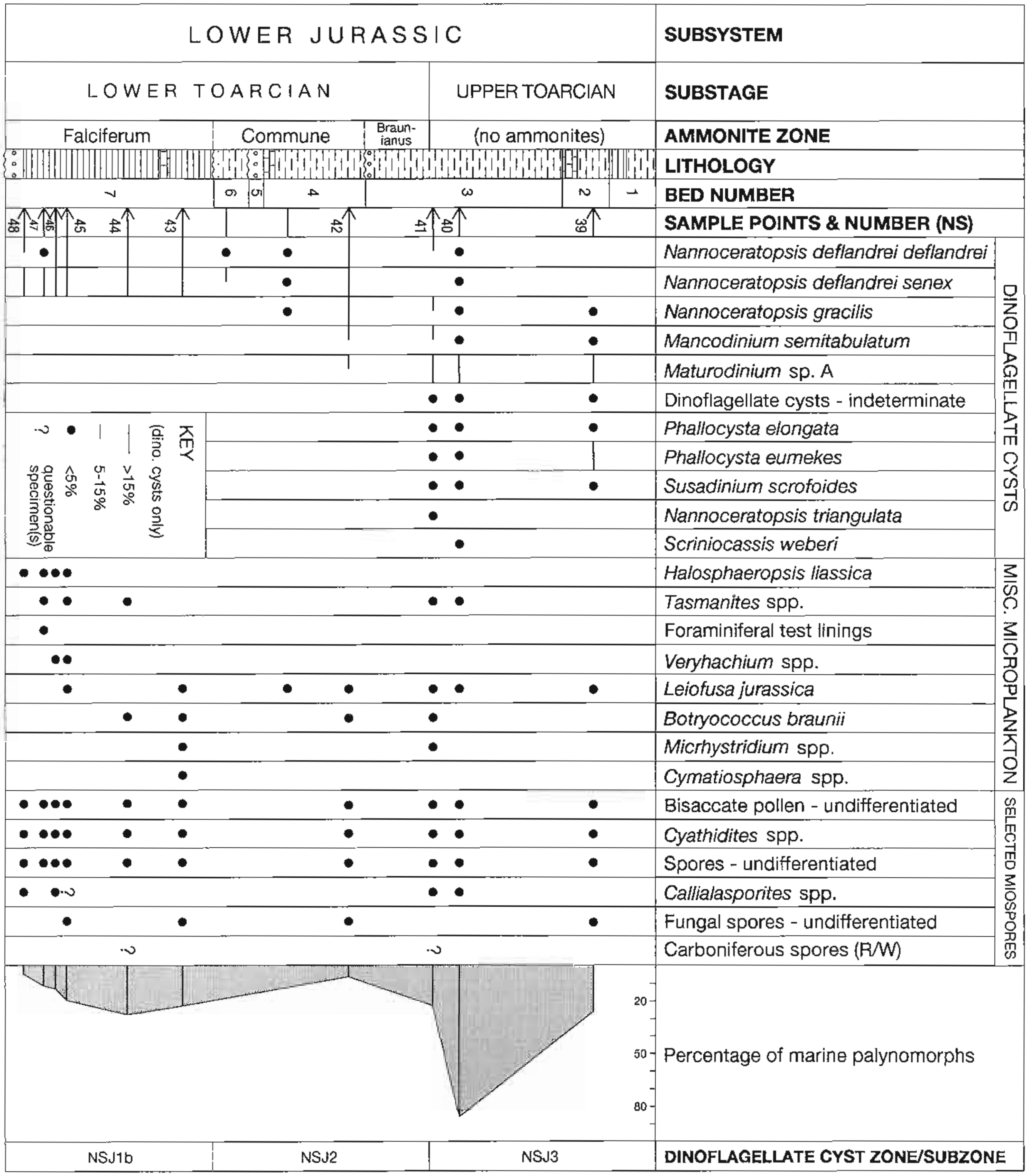
Three samples (NS 33, NS 32 and NS 31) are questionably attributed to the Lower Toarcian (?Propinquum Zone) The miospore floras are similar in content, proportions and



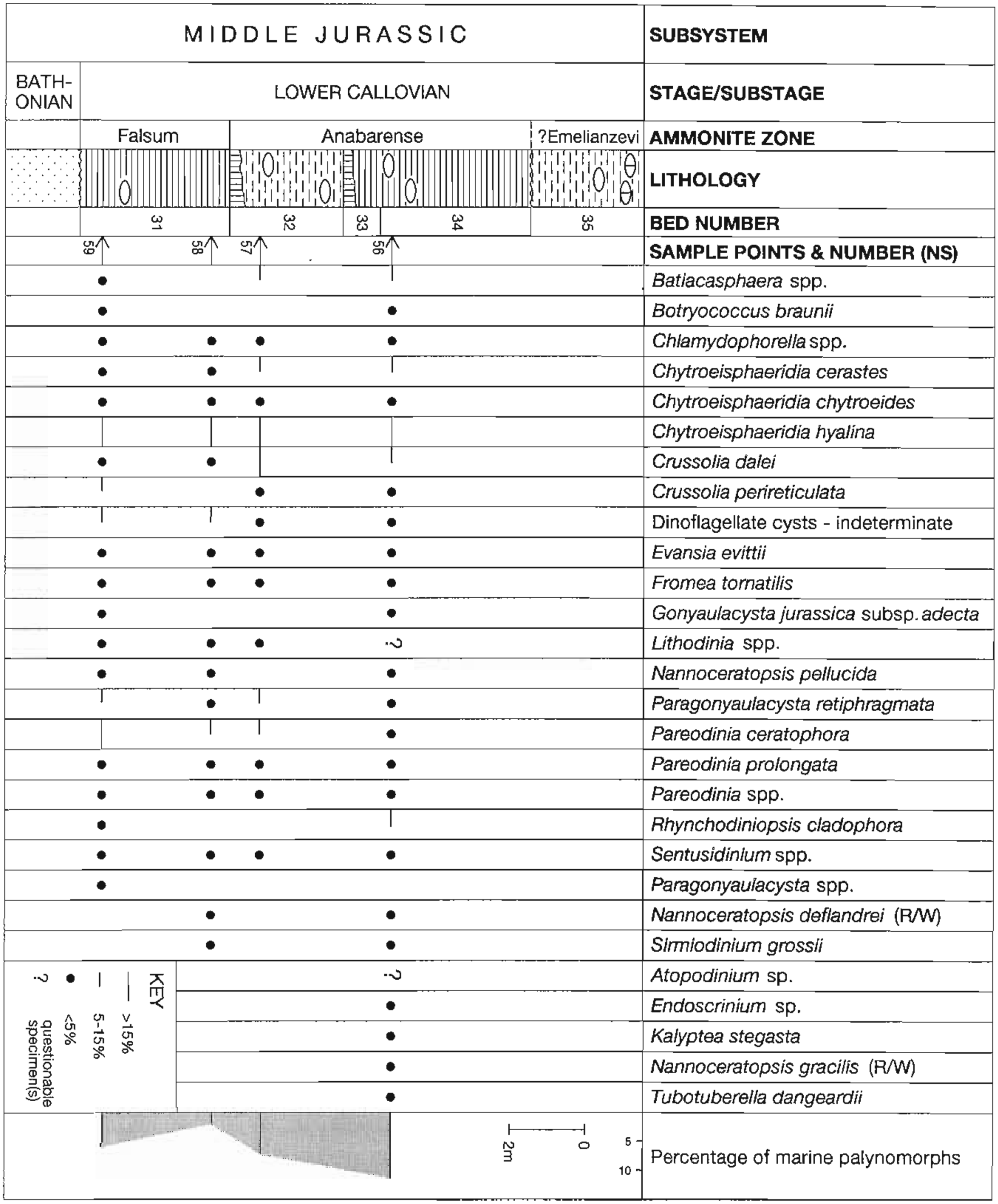

Text-Figure 7. The stratigraphic distribution of dinoflagellate cysts (semi-quantitative), miscellaneous microplankton and selected miospores from the Upper Pliensbachian and Lower Toarcian strata on the west bank of the River Anabar, northern East Siberia (locality 1 of Text-Figure 2). Samples NS16 to NS1 are illustrated by arrows in the 'Sample Points and Number' column; the data for the other six samples, depicted by simple lines, were supplied by V. I. Ilyina.



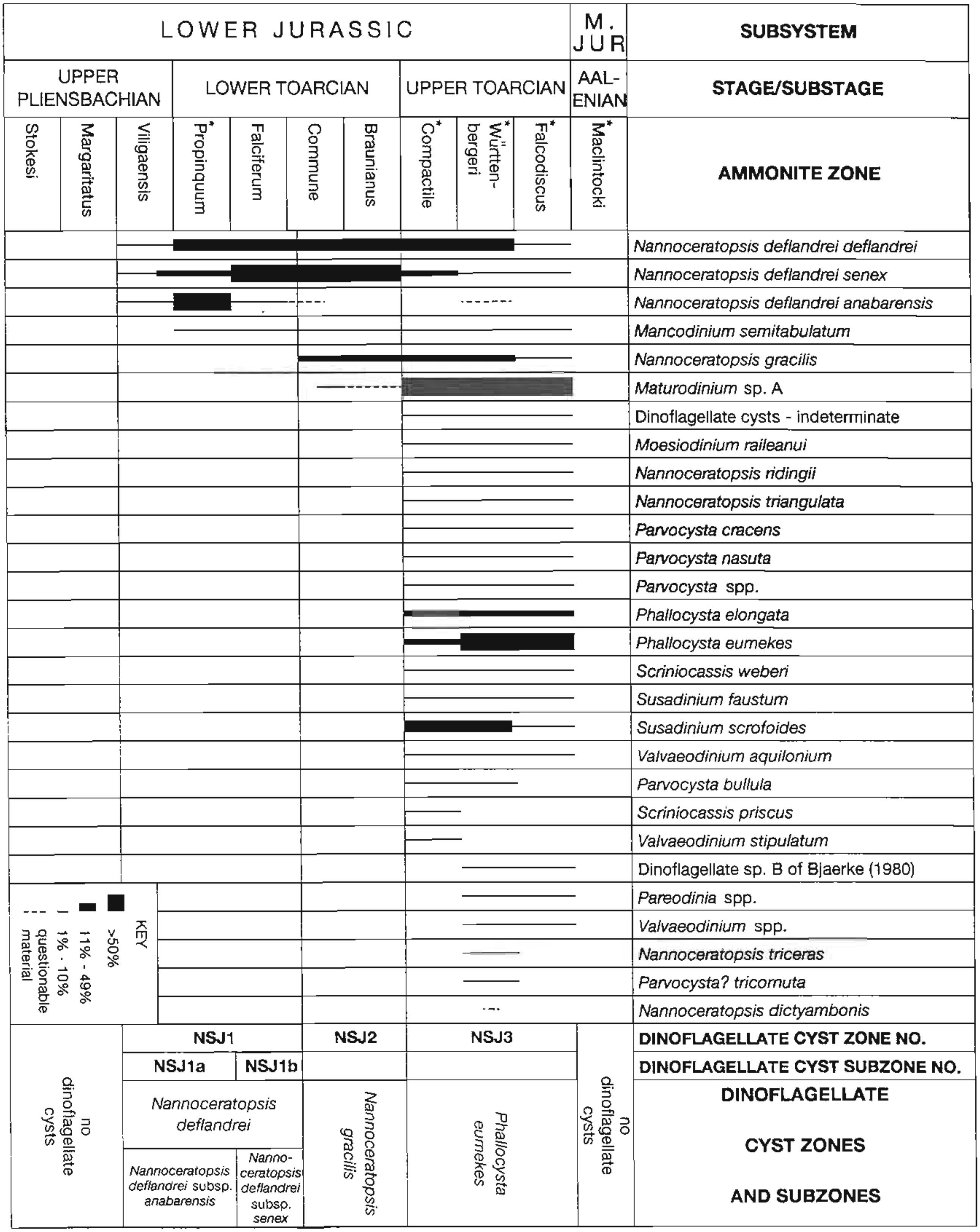

Text-Figure 8. The stratigraphic distribution of dinoflagellate cysts (semi-quantitative), miscellaneous microplankton and selected miospores from the Upper Pliensbachian to Aalenian strata of the west coast of Anabar Bay, northern East Siberia (locality 2 of Text-Figure 2). Samples NS36 to NS17 are illustrated by arrows in the 'Sample Points and Number' column; the data for the other nine samples, depicted by simple lines, were supplied by V. I. Ilyina.




Text-Figure 9. The stratigraphic distribution of dinoflagellate cysts (semi-quantitative), miscellaneous microplankton and selected miospores from the Toarcian strata of Sobo Creek, River Marcha, northern East Siberia (locality 3 of Text-Figure 2). Samples NS48 to NS39 are illustrated by arrows in the 'Sample Points and Number' column; the data for the other two samples, depicted by simple lines, were supplied by V. I. Ilyina.




Text-Figure 10. The semi-quantitative stratigraphic distribution of dinoflagellate cysts and *Botryococcus braunii* from the Lower Callovian strata of the west coast of Anabar Bay, northern East Siberia (locality 2 of Text-Figure 2).




Text-Figure 11. A compilation of dinoflagellate cyst ranges for the Upper Pliensbachian to Aalenian strata of northern East Siberia. Certain ammonite zones are not unequivocally present in the sections studied and these have been tentatively identified; these zones are asterisked.

diversity to those from the underlying samples. However, all three are rich in the three subspecies of *Nannoceratopsis deflandrei*. Sample NS 33 is dominated by *Nannoceratopsis deflandrei* subsp. *senex*, which accounts for 66.9% of the assemblage. *Nannoceratopsis deflandrei* subsp. *anabarensis* attained 53.5% of the dinoflagellate cyst flora in sample NS 31 (Text-Figures 8 and A3.2). This interval is interpreted as being Lower Toarcian on the basis of this distinctive dinoflagellate cyst flora. A possibly reworked specimen of the Upper Triassic-Lower Jurassic spore *Kraeuselisporites reissingeri* was noted from sample NS 32 and a ?Carboniferous spore was also reported from sample NS 31 (Text-Figure A3.2).

Samples NS 30 to NS 26 inclusive are unequivocally Lower Toarcian and *Nannoceratopsis deflandrei* subsp. *senex* dominates the marine palynofloras (Text-Figure A3.2). This subspecies comprises 99.8% of the dinoflagellate cyst flora in sample NS 30, which yielded, by far, the richest microplankton assemblage from this section. *Nannoceratopsis gracilis* appears in Bed 17 and it is common in NS 27 (Text-Figure 8). The Lower Toarcian association of common amorphogen and *Halosphaeropsis liassica* is not well developed in this section. *Halosphaeropsis liassica* was observed in relatively low proportions throughout the Lower Toarcian (Text-Figure A3.2). Amorphous kerogen was present only in significant proportions in samples NS 28 and NS 27. Pteridophyte spores are slightly more diverse in this interval. Rare reworked Carboniferous spores were observed in sample NS 27 (Text-Figure A3.2).

The dinoflagellate cyst floras are more diverse in the Upper Toarcian (samples NS 25 to NS 20) and representatives of the *Parvocysta* suite (Riding, 1984a) were recorded. The most prominent Upper Toarcian genus is *Phallocysta*. *Phallocysta eumekes* dominates samples NS 23 to NS 20 and *Phallocysta elongata* was recorded in significant proportions from NS 23 to NS 21. *Phallocysta eumekes* accounts for 72.1% of the dinoflagellate cyst flora in sample NS 22 (Text-Figure A3.2). These abundances confirm the Boreal affinities of *Phallocysta eumekes* first alluded to by Riding (1984a). ?*Parvocysta nasuta* and *Susadinium scrofoides* were also observed in sample NS 21. *Leiofusa jurassica* is prominent in samples NS 25 to NS 21 (Text-Figure A3.2). The Upper Toarcian gymnospermous pollen floras are low in diversity, being largely comprised of bisaccate grains. A questionable reworked Carboniferous spore was observed in sample NS 21 (Text-Figure A3.2). The pollen and spores of this locality are also described in Ilyina (1985a; 1986) and Pospelova (1995).

The Aalenian samples (NS 19 to NS 17) are entirely devoid of marine microplankton, however these horizons yielded the freshwater/brackish alga *Botryococcus braunii* (Text-Figure A3.2).

### 5.1.1.3 Astronomitscheskii Creek, River Kedon Basin

Two Lower Toarcian samples, numbers NS 38 and NS 37, from this locality (Text-Figure 3) were studied; both have been attributed to the Falciferum Zone. The palynofloras are abundant, yet are of relatively low species diversity. *Nannnoceratopsis deflandrei* subsp. *deflandrei* and *Nannnoceratopsis deflandrei* subsp. *senex* were recorded (Text-Figure A3.3), with *Nannoceratopsis deflandrei* subsp. *senex* consistently the dominant element. It accounts for 93.4% of the dinoflagellate cyst association in sample NS 38 and 91.9% in sample NS 37. *Nannoceratopsis deflandrei* subsp. *deflandrei* is distinctly subordinate, respectively comprising 6.6% and 8.1% of the assemblages in NS 38 and NS 37 (Text-Figure A3.3). Other microplankton proved extremely rare and miospores are also relatively sparse. The amorphogen-*Halosphaeropsis liassica* association was not observed in either sample. The low diversity pollen/spore floras include relatively prominent bisaccate pollen and *Cyathidites* spp. *Callialasporites turbatus* and a possible reworked Carboniferous spore were encountered in sample NS 38.

### 5.1.1.4 Sobo Creek, River Marcha, Viljui Syncline

Ten Toarcian samples were studied from Sobo Creek, on the River Marcha in northern East Siberia (Text-Figure 2). Samples NS 48 to NS 42 are of early Toarcian age and are correlated with the Falciferum and Commune zones (Text-Figure 9). The dinoflagellate cyst floras are abundant and consistently dominated by *Nannoceratopsis deflandrei* subsp. *senex*. In the most productive sample, number NS 44, 1129 dinoflagellate cyst specimens per microscope slide were counted; *Nannoceratopsis deflandrei* subsp. *senex* represents 74.1% of the dinoflagellate cyst flora (Text-Figure A3.4). In the remaining five samples from the Falciferum Zone, NS 48 to NS 45 and NS 43, the subspecies *senex* comprises 88.7%, 95.0%, 77.3%, 78.8% and 74.8% respectively. The subspecies *Nannoceratopsis deflandrei* subsp. *deflandrei* is distinctly subordinate in this interval, it ranges from between 5.0% (NS 47) and 25.9% (NS 44) (Text-Figures 9 and A3.4). Sample NS 42 is correlated with the uppermost Commune Zone and yielded a similar residue to the underlying samples. However, the dinoflagellate cyst flora is significantly more diverse. In addition to *Nannoceratopsis deflandrei*, which remains the dominant species, *Nannoceratopsis gracilis* has its stratigraphical inception within the Commune Zone (Text-Figure 9). *Mancodinium semitabulatum* and *Maturodinium* sp. A are also present in sample NS 42 (Text-Figure A3.4). *Halospheropsis liassica* is associated with common amorphogen in samples NS 48 to NS 45 in the lowermost beds of the Falciferum Zone. Indigenous miospores are sporadically diverse (11 taxa in sample NS 43) and a questionable allochthonous Carboniferous spore was observed in sample NS 44 (Text-Figure A3.4).

The three Upper Toarcian samples studied, NS 41, NS 40 and NS 39, yielded more diverse dinoflagellate cyst floras than the underlying samples (Text-Figure A3.4). Sample NS 41 is dominated by *Maturodinium* sp. A, which comprises 67.2% of the dinoflagellate cyst assemblage. Other species include *Mancodinium semitabulatum* (8.1%), *Nannoceratopsis gracilis* (8.6%), *Nannoceratopsis triangulata* (1.0%) and *Phallocysta eumekes* (2.5%). Sample NS 40 is also dominated (94.3%) by *Maturodinium* sp. A; a single specimen of *Scriniocassis weberi* was also recorded (Text-Figure A3.4). *Nannoceratopsis* proved relatively rare in sample NS 39, with only *Nannoceratopsis gracilis* present in low proportions (3.6%). *Maturodinium* sp. A and *Phallocysta eumekes* are the dominant dinoflagellate cysts from this rather sparse sample; each represents 45.5% of the dinoflagellate cyst flora. *Mancodinium semitabulatum* was also occasionally present (1.8%) (Text-Figures 9 and A3.4). Bisaccate pollen dominates the miospore associations of all three samples. *Callialasporites turbatus* and a possible reworked Carboniferous spore were observed in NS 41 (Text-Figure A3.4). The pollen and spore assemblages of this locality were also described by Ilyina (1985a).

### 5.1.1.5 Bank of the River Marcha, near the mouth of the River Lochaja

Two Upper Toarcian samples from this locality were analysed (Text-Figure 2). These siltstone horizons are tentatively correlated to the Thouarsense and Levesquei zones. Sample NS 50 yielded an abundant residue and palynoflora; *Phallocysta eumekes* dominates the dinoflagellate cyst flora, comprising 31.2%; *Phallocysta elongata* was also recorded in significant proportions (6.6%) (Text-Figure A3.3). Identical, somewhat granulate, morphotypes have been reported from the Upper Toarcian of western Europe (Riding, 1994). *Valvaeodinium aquilonium* and representatives of the *Parvocysta* complex are also present, including *Moesiodinium raileanui*, *Parvocysta* spp. and *Susadinium* spp. *Nannoceratopsis* is also prominent, the commonest forms being *Nannoceratopsis deflandrei* subsp. *deflandrei* (6.6%) and *Nannoceratopsis gracilis* (11.5%) (Text-Figure A3.3). *Nannoceratopsis triangulata* and *Scriniocassis weberi* were also rarely present and *Maturodinium* sp. A was observed in significant proportions (6.6%) (Text-Figure A3.3). The most abundant miospores are bisaccate pollen; *Callialasporites* spp. are also present.

Sample NS 49, by contrast, produced a relatively sparse organic residue and palynoflora. Dinoflagellate cysts proved correspondingly sparse with 44 specimens per microscope slide (Text-Figure A3.3). *Nannoceratopsis deflandrei* subsp. *deflandrei* and *Phallocysta* spp are prominently represented. *Phallocysta eumekes* dominates the dinoflagellate cyst association, comprising 56.9%; *Phallocysta elongata* (4.5%) was also observed (Text-Figure A3.3). Rare *Maturodinium* sp. A, *Nannoceratopsis deflandrei* subsp. *senex*, *Nannoceratopsis gracilis*, *Parvocysta* spp., *Scriniocassis weberi*, *Susadinium scrofoides* and *Valvaeodinium aquilonium* were also recorded (Text-Figure A3.3). *Tasmanites* spp., *Callialasporites turbatus* and a possible reworked Carboniferous spore were encountered.

### 5.1.1.6 Borehole 141, Khatarik-Khomo, Viljui Syncline

Two Upper Toarcian samples from Borehole 141 (Text-Figure 2) were studied; both yielded extremely rich residues and palynofloras. Sample NS 52 is dominated by *Nannoceratopsis deflandrei* subsp. *senex*, *Nannoceratopsis gracilis* and *Susadinium scrofoides*. *Nannoceratopsis deflandrei* subsp. *senex* represents 49.2% of the dinoflagellate cyst assemblage (Text-Figure A3.3). *Mancodinium semitabulatum* is also relatively common (6.6%). Other dinoflagellate cysts present are largely members of the *Parvocysta* complex and include *?Moesiodinium raileanui*, *?Parvocysta bullula*, *Parvocysta nasuta*, *Parvocysta* spp. and *Susadinium faustum* (Text-Figure A3.3). *Phallocysta eumekes* is relatively rare (2.2%) and *Nannoceratopsis triangulata*, *Scriniocassis prisca* and *Valvaeodinium stipulatum* were also recognised in low proportions. *Halosphaeropsis liassica* was observed, indicating that this sample is close to the boundary with the underlying Lower Toarcian. Bisaccate pollen is the dominant miospore type.

By contrast, sample NS 51 is extremely rich in *Phallocysta eumekes*; this dinoflagellate cyst taxon comprises 71.6% of the dinoflagellate cyst flora (Text-Figure A3.3). Species of *Nannoceratopsis* and the *Parvocysta* complex are also abundant and numerous. *Nannoceratopsis deflandrei* subsp. *senex* makes up 10.8% of the dinoflagellate cyst association. Representatives of the *Parvocysta* plexus recognised include *Parvocysta bullula*, *Parvocysta cracens*, *Parvocysta? tricornuta*, *Susadinium faustum* and *Susadinium scrofoides*. Other species recorded include *Mancodinium semitabulatum*, *Nannoceratopsis deflandrei* subsp. *deflandrei*, *?Nannoceratopsis dictyoambonis*, *Nannoceratopsis gracilis* and *Valvaeodinium aquilonium* (Text-Figure A3.3). Bisaccate pollen and *Botryococcus braunii* are common and the pollen grain *Callialasporites turbatus* was also recorded.

### 5.1.1.7 Bank of the River Kelimjar, downstream of Ulakhan-Kurung Creek

A single sample, number NS 53, of lowermost Upper Toarcian siltstone from this locality was studied (Text-Figure 2). The palynoflora largely comprises bisaccate pollen, dinoflagellate cysts and *Halosphaeropsis liassica*. The dinoflagellate cyst association is of moderate diversity (8 taxa) and is overwhelmingly dominated by *Phallocysta eumekes* and *Nannoceratopsis* spp. These elements comprise 43.8% and 54.8% of the dinoflagellate cyst flora respectively (Text-Figure A3.3). *Nannoceratopsis deflandrei* subsp. *deflandrei* (19.4%), *Nannoceratopsis deflandrei* subsp. *senex* (17.8%) and *Nannoceratopsis gracilis* (17.1%) are all common; *Nannoceratopsis ridingii* was recorded rarely (0.5%). Other rare elements comprise *Parvocysta cracens*, *Susadinium scrofoides* and *Valvaeodinium aquilonium* (Text-Figure A3.3). *Leiofusa jurassica* and *Halosphaeropsis liassica* are present and the miospore flora is of low species diversity.

### 5.1.1.8 Bank of the River Motorchuna, near the mouth of the River Balaganakh

Two samples, numbers NS 55 and NS 54, of Upper Toarcian claystone from this locality were studied (Text-Figure 2). The abundant palynoflora of NS 55 is overwhelmingly dominated by the dinoflagellate cyst *Phallocysta eumekes*; this species comprises 95.1% of the dinoflagellate cyst association (Text-Figure A3.3). Other dinoflagellate cysts present include *Nannoceratopsis deflandrei* subsp. *deflandrei*, *Nannoceratopsis deflandrei* subsp. *senex*, *Nannoceratopsis gracilis*, *Nannoceratopsis triangulata* and *Valvaeodinium aquilonium*. Representatives of the *Parvocysta* complex other than *Phallocysta eumekes* are present in small numbers; these comprise *Moesiodinium raileanui*, *Parvocysta cracens*, *Susadinium faustum* and *Susadinium scrofoides*. Other species present are Dinoflagellate sp. B of Bjaerke (1980), *Mancodinium semitabulatum*, *Nannoceratopsis deflandrei* subsp. *anabarensis*, *Nannoceratopsis ridingii* and *?Valvaeodinium* sp. (Text-Figure A3.3). The rare specimens of *Nannoceratopsis deflandrei* subsp. *anabarensis* are interpreted as having been reworked from the underlying uppermost Pliensbachian-lowermost Toarcian. Other palynomorphs proved relatively rare and are of low species diversity; bisaccate pollen and *Micrhystridium* spp. are the most common of these.

Sample NS 54 yielded, by contrast, a relatively sparse palynoflora. Dinoflagellate cysts proved rare and comprise *Nannoceratopsis deflandrei* subsp. *deflandrei*, *Nannoceratopsis deflandrei* subsp. *senex*, *Nannoceratopsis triangulata* and *Valvaeodinium aquilonium* in varying proportions (Text-Figure A3.3). The *Parvocysta* complex is entirely absent. The acritarch *Leiofusa jurassica* proved common and miospores, chiefly bisaccate pollen, were also observed relatively frequently.

### 5.1.2 Lower Callovian palynology of the west coast of Anabar Bay

A suite of 4 Middle Jurassic samples from the west coast of Anabar Bay, northern East Siberia were studied. These samples were collected from the Lower Callovian of outcrop 10, situated on the west side of Anabar Bay (Text-Figure 2). The samples are from a relatively thin (15.5 m) succession of fossiliferous, nodular mudstones and siltstones which have been dated as early Callovian on the basis of ammonite data (Text-Figure 10). The ammonite faunas indicate the presence of the Falsum and Anabarense zones; these zones have been correlated to the earliest Callovian Herveyi Zone of northwest Europe (Meledina, 1994).

The stratigraphic distributions of the palynomorph taxa identified are illustrated in Text-Figures 10 and A3.5. All four samples yielded abundant organic residues and palynofloras; wood fragments, plant debris and palynomorphs are all abundant throughout. Miospores consistently numerically dominate the marine microplankton. Bisaccate pollen, *Cerebropollenites macroverrucosus* and *Cyathidites* spp. are typically prominent in the miospore assemblages. A more detailed account of the Lower Callovian miospores of this area was given by Ilyina (1985a,b).

The dinoflagellate cyst floras are of similar composition throughout and are of relatively low species diversity. The most abundant species are *Chytroeisphaeridia hyalina*, *Crussolia dalei* and *Paragonyaulacysta retiphragmata*, which respectively attain maxima of 31.4% (sample NS 59), 35.7% (sample NS 57) and 13.6% (Sample NS 57) (Text-Figure A3.5). These acmes may have biostratigraphic significance in the Boreal Realm of Russia. Other common forms include *Batiacasphaera* spp., *Chytroeisphaeridia cerastes*, *Crussolia perireticulata*, *Pareodinia ceratophora* and *Rhynchodiniopsis cladophora*. Forms which were recorded in relatively low proportions comprise *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Evansia evittii*, *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta*, *Nannoceratopsis pellucida*, *Sentusidinium* spp. and *Sirmiodinium grossii*. Minor reworking from the Carboniferous and the Lower Jurassic (Upper Pliensbachian to Toarcian) was noted due to the presence of rare *Densosporites* spp. and *Nannoceratopsis deflandrei/gracilis* respectively (Text-Figures 10 and A3.5).

The indigenous dinoflagellate cyst floras are a mix of widespread and endemic Arctic/northern Boreal forms. The majority of the taxa are typical of the Sub-Boreal Realm and include *Chytroeisphaeridia* spp., *Gonyaulacysta jurassica* subsp. *adecta*, *Nannoceratopsis pellucida*, *Pareodinia* spp., *Rhynchodiniopsis cladophora*, *Sentusidinium* spp. and *Sirmiodinium grossii* (Woollam and Riding, 1983; Riding and Thomas, 1992). *Chytroeisphaeridia hyalina* is known to be a reliable marker for the early-mid Callovian in north-west Europe (Riding, 1990). *Crussolia dalei*, *Crussolia perireticulata* and *Paragonyaulacysta* spp., however, typify the Callovian of the arctic region (Johnson & Hills, 1973; Davies, 1983; Smelror, 1988a; Århus *et al.*, 1989; Smelror and Below, 1993). *Fromea tornatilis* was recorded in relatively low proportions throughout; this species is much more common in the early Callovian of the Russian Platform (see sections 5.2 and 5.3). Dinoflagellate cyst species diversity is low in comparison to coeval assemblages from England (Riding, 1987), east Greenland (Smelror, 1988b) and Azerbaijan (Smelror and Lominadze, 1989). However, they are most similar to Lower Callovian floras reported from Svalbard (Smelror, 1988a) and arctic Canada (Johnson and Hills, 1973; Davies, 1983). The assemblages herein are correlatable with the *Paragonyaulacysta calloviensis* Subzone of Johnson and Hills (1973), Oppel-Zone G of Davies (1983) and the *Lacrymodinium warrenii* Zone (subzones b/c) of Smelror (1988b). The samples lie close to the boundary between the *Sirmiodinium grossii* and the *Meiourogonyaulax planoseptata-Chlamydophorella ectotabulata* concurrent range-zones of Smelror and Below (1993).

### 5.1.3 Summary of the Upper Pliensbachian to Aalenian and Lower Callovian palynology of northern East Siberia

The composite Upper Pliensbachian to Toarcian dinoflagellate cyst ranges from all the localities studied from northern East Siberia are illustrated in Text-Figure 11. The dinoflagellate cyst record in northern Siberia appears to have its inception in the latest Pliensbachian (Viligaensis Zone). All three subspecies of *Nannoceratopsis deflandrei* are sporadically present in extremely low proportions. The Upper Pliensbachian palynofloras from this area are of low species diversity. Bisaccate pollen consistently dominates the terrestrially-derived elements. The pollen genus *Callialasporites* was observed in the Upper Pliensbachian section at Anabar Bay. This pollen has a late Toarcian inception in western Europe. *Leiofusa* is present, often commonly.

The four Lower Toarcian successions investigated generally yielded abundant palynofloras. The dinoflagellate cyst *Nannoceratopsis deflandrei* overwhelmingly dominates the microplankton associations. *Nannoceratopsis deflandrei* subsp. *anabarensis* is generally relatively rare and confined to the lowermost Lower Toarcian (?Propinquum Zone). The subspecies *deflandrei* and *senex* are, however, by far the most frequently recorded forms. *Nannoceratopsis deflandrei* subsp. *senex* is normally the most abundant and frequently occurs as monotaxic assemblages. Other taxa which were observed sporadically and in low proportions are *Mancodinium semitabulatum* and *Nannoceratopsis gracilis*. Indications of bottom water anoxia were observed in the Lower Toarcian of the River Anabar section. Other microplankton and miospores are of relatively low species diversity.

Dinoflagellate cyst associations become markedly more diverse in the Upper Toarcian (Text-Figures 8, 9 and 11). *Nannoceratopsis* continues to be common and diverse, but *Maturodinium* sp. A, the *Parvocysta* suite and *Phallocysta* spp. are also prominent. *Parvocysta* is diverse and related forms such as *Moesiodinium raileanui* and *Susadinium* spp. were recorded. Species of *Scriniocassis* and *Valvaeodinium* were also observed. Normally the most prominent species is *Phallocysta eumekes*, which attains 95.1% of the dinoflagellate cyst flora in Sample NS 55 at River Motorchuna. The diverse dinoflagellate cyst assemblages recovered, together with the abundance of *Phallocysta eumekes* and *Phallocysta elongata*, confirm the Boreal nature of the genus *Phallocysta* (Dörhöfer and Davies, 1980; Riding, 1984a). The relatively high diversity of the *Parvocysta* suite and the presence of *Valvaeodinium aquilonium* is also typical of high northerly latitudes (Dörhöfer and Davies, 1980; Davies, 1983; Riding, 1984a; Riding and Ioannides, 1996). *Maturodinium* sp. A is extremely prominent at Sobo Creek. The detailed regional biostratigraphic relationships of the acmes of *Maturodinium* sp. A and *Phallocysta eumekes* are not yet fully understood. However, the acme of the former species appears to begin consistently earlier than that of the latter. The acritarch *Leiofusa jurassica* is occasionally common and the miospore floras are of relatively low diversity.

The Aalenian of Anabar Bay is entirely devoid of marine microplankton. The three samples examined yielded relatively sparse palynofloras comprising long-ranging miospores and the freshwater/brackish alga *Botryococcus braunii*. These Upper Pliensbachian to Aalenian palynofloras are closely comparable to those recorded by Ilyina in Ilyina et al. (1994).

The four Lower Callovian samples from Anabar Bay yielded relatively low diversity dinoflagellate cyst floras largely of arctic/Boreal affinities. *Chytroeisphaeridia hyalina*, *Crussolia dalei* and *Paragonyaulacysta retiphragmata* are the most prominent taxa and acmes of these species may have biostratigraphic significance in the Boreal Realm of Russia. Minor levels of Carboniferous and Lower Jurassic (Upper Pliensbachian-Toarcian) reworking were encountered.

## 5.2 STRATIGRAPHIC PALYNOLOGY OF THE PECHORA BASIN

Forty-three Bathonian, Callovian, Kimmeridgian and Volgian samples collected from 11 localities on the banks of the rivers Izhma and Pizhma in the Pechora Basin, northern Russian Platform were examined. The samples are listed in Appendix 1 and the localities are illustrated in Text-Figure 4. The samples yielded mostly rich and well-preserved palynofloras, mainly of dinoflagellate cysts and gymnospermous pollen grains. The principal kerogen components are normally palynomorphs and woody tissue. The stratigraphic distribution of the palynofloras are illustrated in Text-Figures 12-14 and A3.6-A3.10. Text-Figures 15 and 16 depict the composite stratigraphic ranges of selected key dinoflagellate cyst taxa in the Bathonian and Callovian stages respectively of the Pechora Basin and the more southerly central Russian Platform (section 5.3).

### 5.2.1 The Bathonian to Upper Callovian palynology of the River Izhma and River Pizhma area

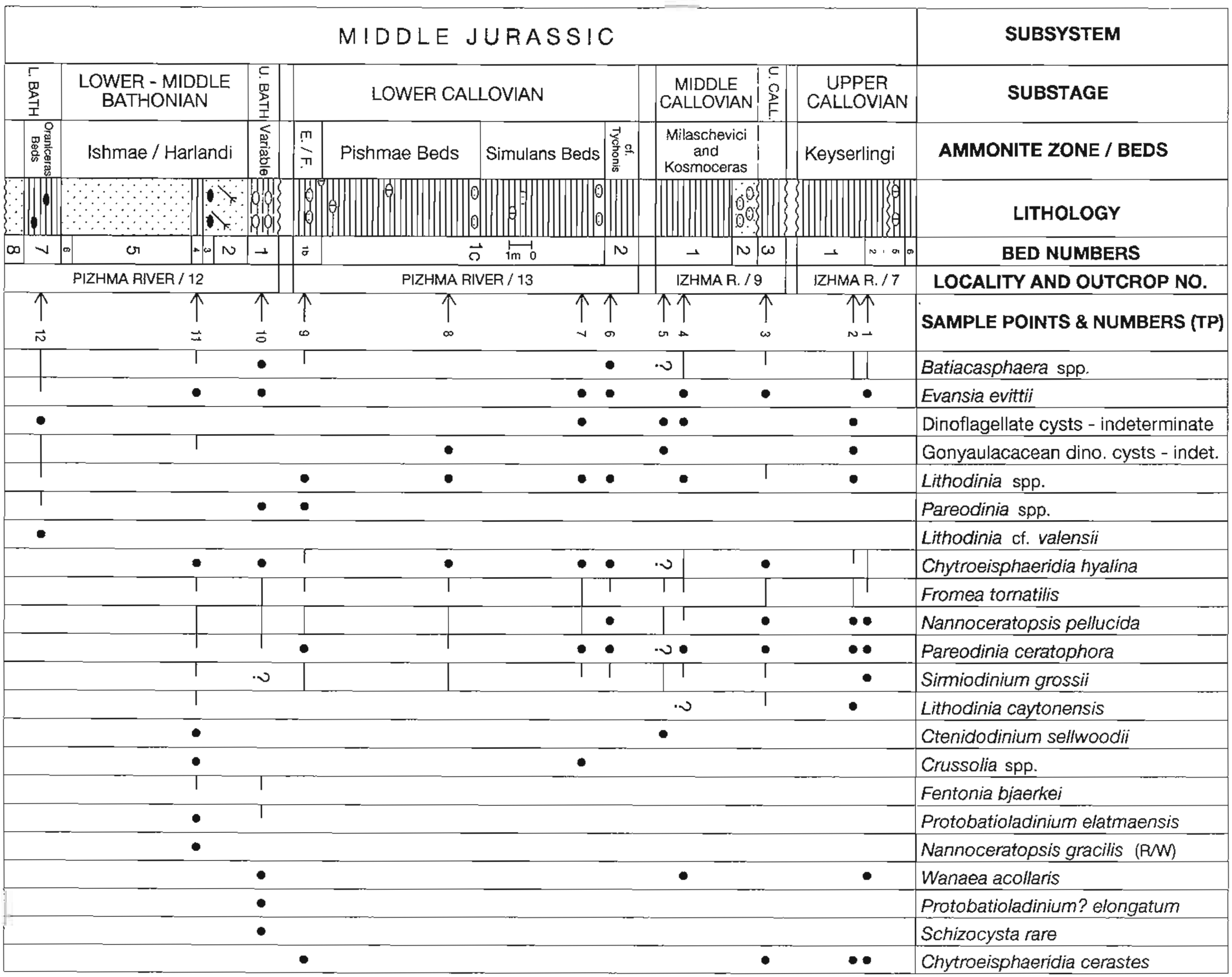
A suite of 12 Bathonian and Callovian samples collected from four localities from the banks of the rivers Izhma and Pizhma in the Pechora Basin were studied. The four sample localities are illustrated in Text-Figure 4 and the stratigraphic distributions of all palynomorph taxa identified are depicted in Text-Figures 12 and A3.6. Undifferentiated bisaccate pollen grains, *Callialasporites* spp., *Cerebropollenites macroverrucosus*, *Classopollis classoides*, *Cyathidites* spp. and *Perinopollenites elatoides* are consistently prominent elements in the miospore assemblages. Reworked Carboniferous spores were also frequently common.

The Bathonian yielded relatively sparse, low diversity microplankton assemblages. The Callovian dinoflagellate cyst floras are, however, more numerous and generally of relatively high diversity. *Batiacasphaera* spp., *Chytroeisphaeridia* spp., *Evansia evittii*, *Fromea tornatilis*, *Lithodinia* spp., *Nannoceratopsis pellucida*, *Pareodinia ceratophora* and *Sirmiodinium grossii* were present commonly throughout the succession (Text-Figure A3.6). Furthermore, the following taxa were consistently observed throughout the Callovian: *Endoscrinium* spp.; *Gonyaulacysta jurassica* subsp. *adecta*; *Lagenadinium callovianum*; *Paragonyaulacysta retiphragmata*; *Rhynchodiniopsis cladophora*; *Sentusidinium* spp. and *Tubotuberella dangeardii* (Text-Figures 12, A3.6).

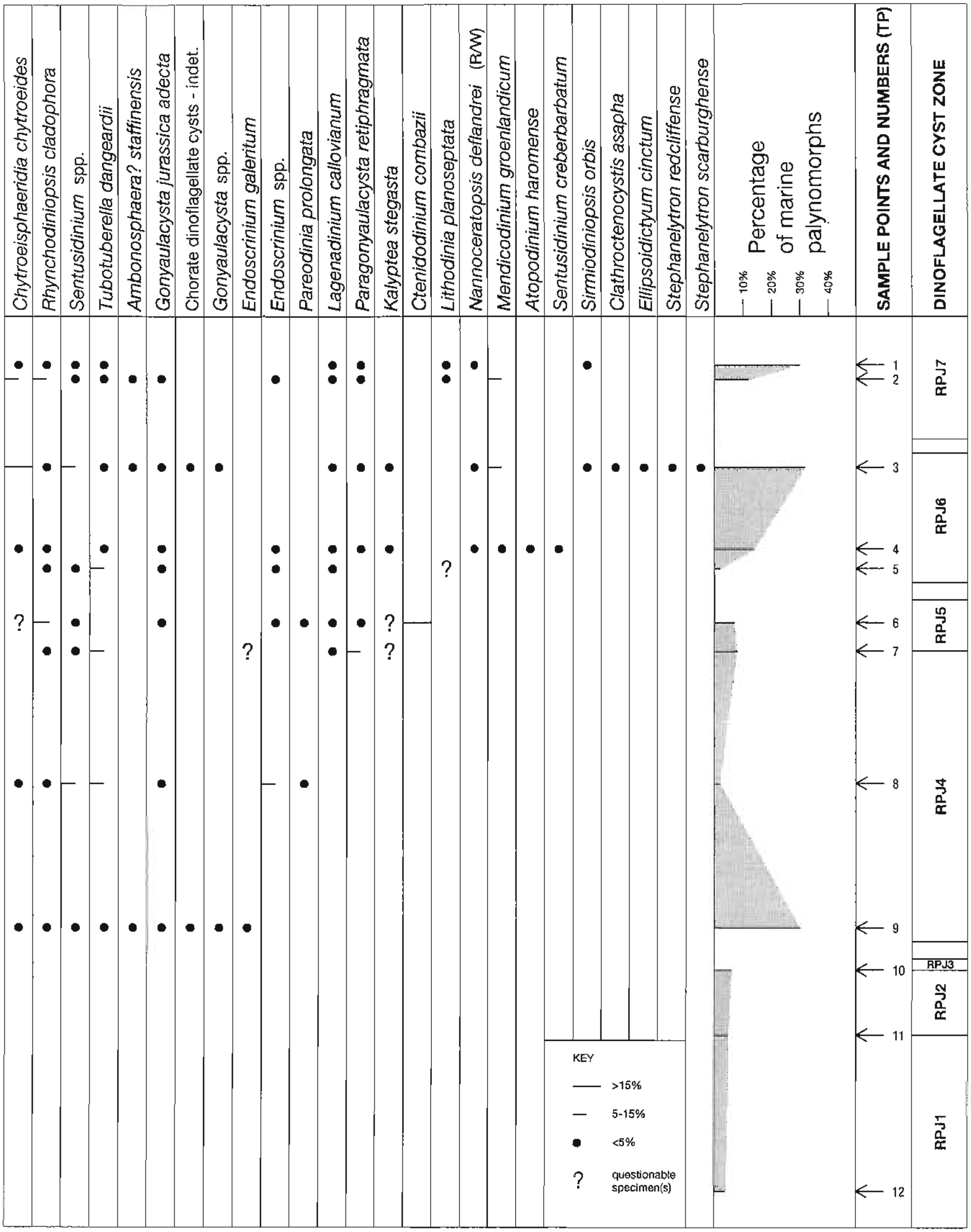
#### 5.2.1.1 West bank of the River Pizhma, near Stepanov Village, outcrop 12; samples TP 12 to TP 10 (Bathonian)

Three Bathonian samples from outcrop 12 were examined. Dinoflagellate cysts are sparse and the species diversities relatively low (Text-Figures 12 and A3.6). *Batiacasphaera* spp., *Evansia evittii* and *Pareodinia* spp. were recorded throughout. Sample TP 12 yielded a particularly low diversity association dominated by *Batiacasphaera* spp. and indeterminate gonyaulacacean forms. Rare *Lithodinia* cf. *valensii* were recorded from TP 12 (Text-Figure A3.6). *Lithodinia valensii* is a reliable marker for the late Bajocian to early Bathonian of western Europe (Riding and Thomas, 1992). *Ctenidodinium sellwoodii* was found in low proportions in sample TP 11. This species has been also been recorded from the Lower-Middle Bathonian of the nearby Sisol region (Ilyina, 1991a). *Chytroeisphaeridia hyalina*, *Fentonia bjaerkei* (acritarch), *Fromea tornatilis*, *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Protobatioladinium elatmaensis* and *Sirmiodinium grossii* were present in samples TP 11 and TP 10 (Text-Figures 12 and A3.6). The occurrence of *Chytroeisphaeridia hyalina* represents the oldest occurrence of this distinctive species in Russia; it is characteristic of the early-mid Callovian in northwest Europe (Riding, 1990). *Fentonia bjaerkei* was also recorded from samples TP 11 and TP 10. This species was recently transferred to an acritarch genus and ranges from the late Pliensbachian to Callovian of northwest Europe (Bailey and Hogg, 1995). *Fentonia bjaerkei* appears to be a typically Boreal form as it has been reported from northern Russia (herein), the Barents Sea region (Bjaerke, 1977; 1980a; Smelror, 1987) and northern England (Riding, 1984a). *Lithodinia* spp. were recorded from samples TP 12 and TP 11. *Nannoceratopsis pellucida* is prominent in samples TP 11 and TP 10, representing 35.1% and 29.2% of the dinoflagellate cyst flora respectively (Text-Figure A3.6). *Wanaea acollaris* is confined to sample TP 10. The two species of *Protobatioladinium* found in the River Oka Basin, Russian Platform herein (section 5.3.1.1) were both recorded from outcrop 12. *Protobatioladinium elatmaensis* is present in samples TP 11 and TP 10, thus appears to range throughout the Bathonian of Russia (section 5.3.1.1; Riding and Ilyina, 1996). *Protobatioladinium*? *elongatum* was observed in sample TP 10 (Upper Bathonian). This form has been recovered from the Upper Bathonian of the Russian Platform (section 5.3.1.1; Riding and Ilyina, 1998) and consistently has a markedly younger range than *Protobatioladinium elatmaensis* (Text-Figure 15). The species was misidentified as *Kalyptea diceras* by Ilyina (1991a,b). Low levels of *Nannoceratopsis gracilis*, reworked from the late Pliensbachian-Toarcian, were recovered in sample TP 11 (Text-Figure 12). Furthermore, Carboniferous spores of the genera *Cingulisporites* and *Densosporites* were observed, although rarely, in samples TP 11 and TP 10.

The low diversity dinoflagellate cyst associations are similar to those from the Bathonian of the River Oka Basin, Russian Platform (section 5.3.1.1). The floras proved mark-



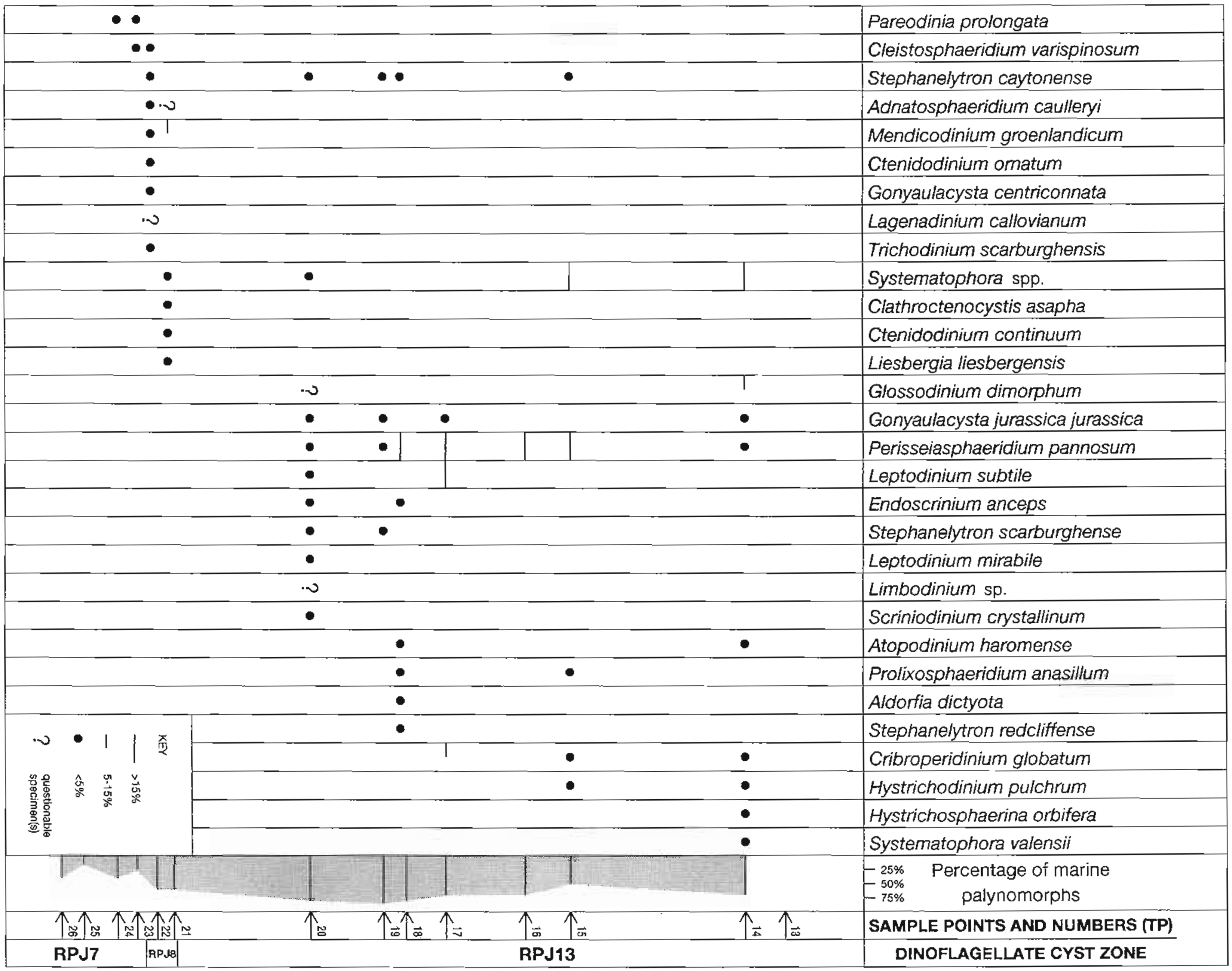

Text-Figure 12. The semi-quantitative stratigraphic distribution of dinoflagellate cysts and selected miscellaneous microplankton from the Bathonian and Callovian strata of the River Izhma (outcrops 9 and 7) and River Pizhma (outcrops 12 and 13) area, Pechora Basin, northern Russian Platform (localities 1 to 4 of Text-Figure 4). E/F = Beds with *Cadoceras* ex gr. *elatmae* and *C. falsum*.



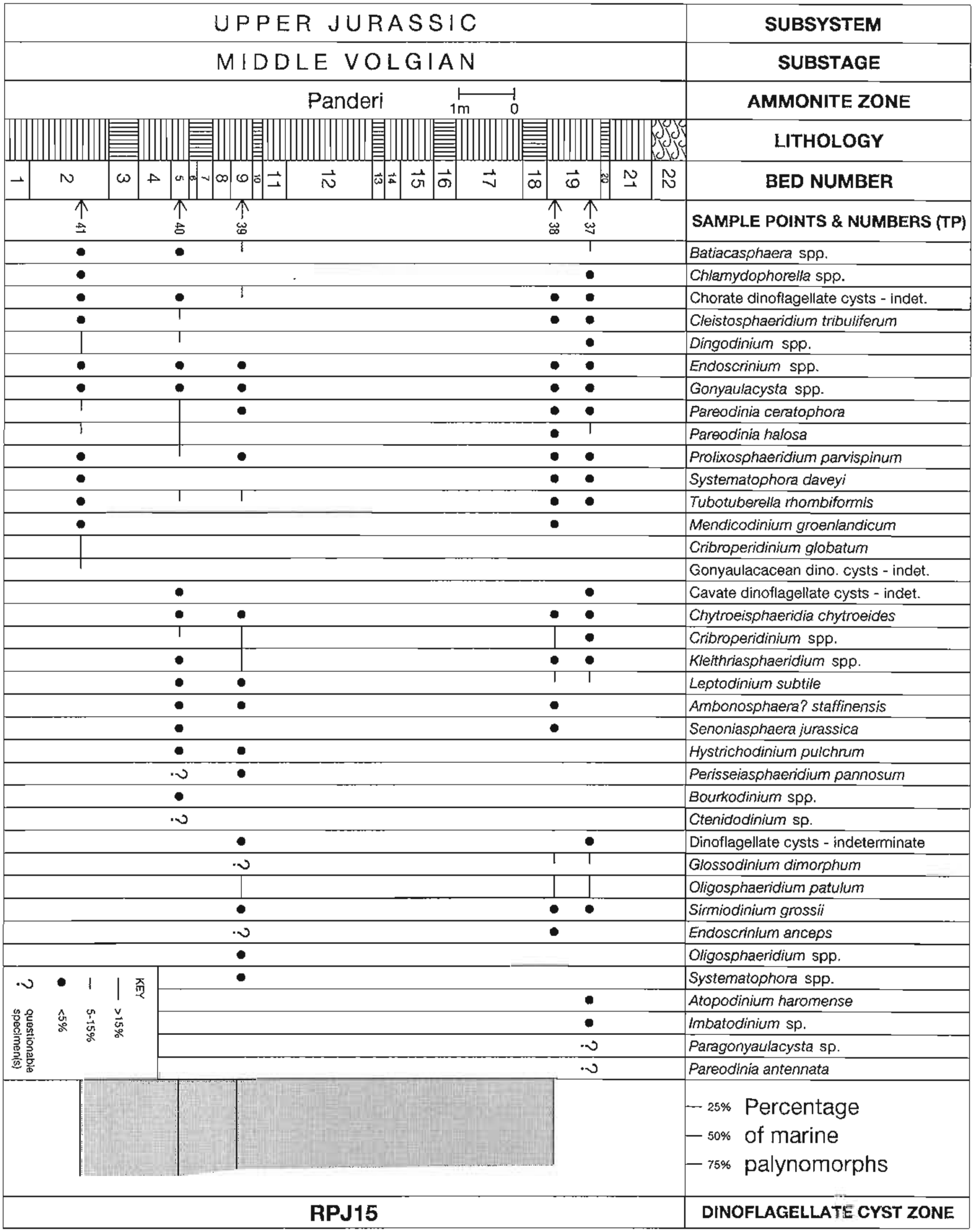

Text-Figure 12 (continued). The semi-quantitative stratigraphic distribution of dinoflagellate cysts and selected miscellaneous microplankton from the Bathonian and Callovian strata of the River Izhma (outcrops 9 and 7) and River Pizhma (outcrops 12 and 13) area, Pechora Basin, northern Russian Platform (localities 1 to 4 of Text-Figure 4). E/F = Beds with *Cadoceras* ex gr. *elatmae* and *C. falsum*.

| SAMPLE POINTS & NUMBERS (TP) | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SUBSYSTEM | M. JURASSIC | | | | | | UPPER JURASSIC | | | | | | | |
| SUBSTAGE | U. CALLOVIAN | | | | | | LOWER KIMMERIDGIAN | | | | | UPPER KIMMERIDGIAN | | |
| AMMONITE ZONE / BEDS | Keyserlingi | | | | S. | | Beds with *A. kitchini* | | | | | ? Eudoxus / Autissiodorensis | | |
| BED NUMBER | 1 | | | | 2 | | 6 | | | 7 | | 8 | | 9 |
| *Batiacasphaera* spp. | \| | \| | • | \| | • | • | | | | | | | • | |
| *Chytroeisphaeridia chytroeides* | • | • | • | • | • | \| | • | • | \| | \| | • | ? | \| | |
| *Kalyptea stegasta* | • | • | • | \| | • | | | | | | | | • | |
| *Paragonyaulacysta* spp. | • | • | • | | | • | | | | | | | • | |
| *Pareodinia halosa* | • | • | • | • | • | • | • | | • | | • | • | \| | |
| *Rynchodiniopsis cladophora* | • | \| | \| | \| | \| | \| | \| | \| | \| | • | | | • | |
| *Sirmiodinium grossii* | • | • | • | | • | | • | • | | \| | • | \| | • | |
| *Chytroeisphaeridia cerastes* | • | • | • | • | • | • | | | | | | | | |
| *Chytroeisphaeridia hyalina* | \| | \| | \| | \| | | ? | | | | | | | | |
| *Evansia evittii* | • | • | • | • | | • | | | | | | | | |
| *Fromea tornatilis* | • | • | • | • | \| | • | | | | | | | | |
| *Gonyaulacysta jurassica adecta* | • | • | • | • | \| | • | | | | | | | | |
| *Lithodinia caytonensis* | • | • | ? | • | \| | \| | | | | | | | | |
| *Pareodinia ceratophora* | • | • | • | • | • | • | | | | | | | | |
| *Tubotuberella dangeardii* | • | • | • | • | • | • | | | | | | | | |
| *Gonyaulacysta eisenackii* | • | • | | | • | | | | | | | | | |
| *Lithodinia planoseptata* | • | • | • | • | ? | | | | | | | | | |
| *Endoscrinium galeritum* | • | \| | • | | | | | | | | | | | |
| *Heslertonia* sp. | • | • | | | | | | | | | | | | |
| *Sirmiodiniopsis orbis* | ? | | | | | | | | | | | | | |
| *Tubotuberella rhombiformis* | | • | | | | | • | • | • | ? | • | ? | • | |
| *Cleistosphaeridium* spp. | | • | | • | • | • | | | • | | • | | | |
| *Nannoceratopsis pellucida* | | • | • | • | • | | | | | | | | | |
| *Sentusidinium creberbarbatum* | | • | • | | • | | | | | | | | | |
| *Wanaea acollaris* | | • | | | • | | | | | | | | | |
| *Ambonosphaera? staffinensis* | | | ? | | | | | | • | | | | • | |
| *Dingodinium* spp. | | | • | | | | • | | | | | | | |
| *Chlamydophorella* spp. | | | • | • | • | | | | | | | | | |

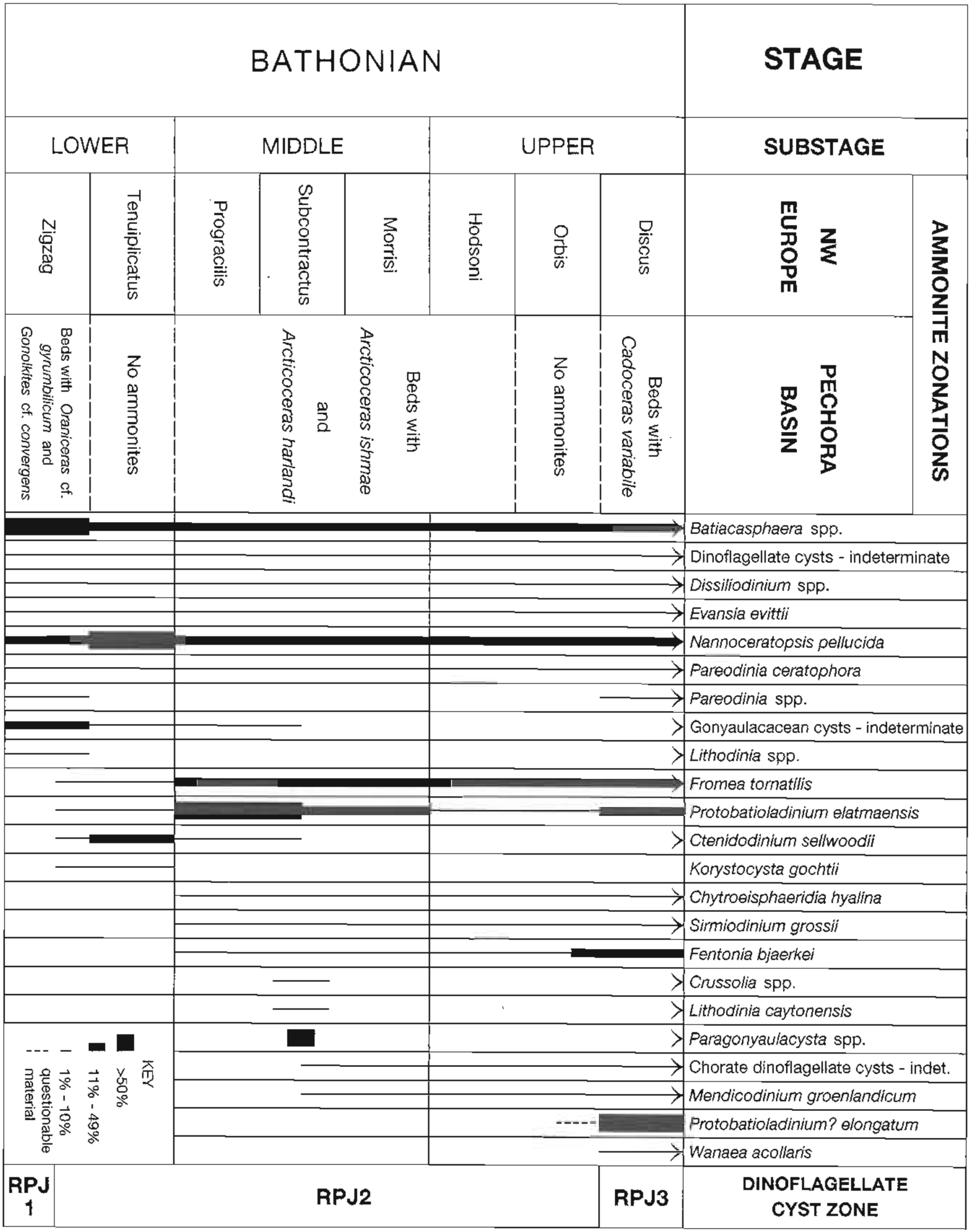
Text-Figure 13. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Upper Callovian and Kimmeridgian strata of outcrop 15, River Izhma, Pechora Basin, northern Russian Platform (locality 5 of Text-Figure 4). S = Subordinarium.




Text-Figure 13 (continued). The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Upper Callovian and Kimmeridgian strata of outcrop 15, River Izhma, Pechora Basin, northern Russian Platform (locality 5 of Text-Figure 4). S = Subordinarium.




Text-Figure 14. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Middle Volgian strata of outcrop 16, River Izhma, Pechora Basin, northern Russian Platform (locality 7 of Text-Figure 4).




Text Figure 15. A compilation of selected dinoflagellate cyst ranges for the Bathonian strata of the Russian Platform.


Text Figure 16. A compilation of selected dinoflagellate cyst ranges for the Callovian strata of the Russian Platform.

edly different to coeval associations from northwest Europe. The Bathonian was a time of known dinoflagellate cyst provincialism in the Northern Hemisphere (Riding et al., 1985) and this phenomenon appears to be linked to low eustatic levels (Haq et al., 1987).

#### 5.2.1.2 East bank of the River Pizhma, near Churkin Village, outcrop 13, samples TP 9 to TP 6 (Lower Callovian)

The 4 Lower Callovian samples from outcrop 13 produced variably abundant dinoflagellate cyst associations of relatively high species diversity (Text-Figure 12); sample TP 9 was by far the most productive (Text-Figure A3.6). There are a number of dinoflagellate cyst range bases, which have both local and regional significance, in the Lower Callovian of outcrop 13. These include the inceptions of *Ambonosphaera? staffinensis*, *Chytroeisphaeridia cerastes*, *Chytroeisphaeridia chytroeides*, *Endoscrinium galeritum*, common *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta*, *Lagenadinium callovianum*, *Paragonyaulacysta retiphragmata*, *Pareodinia prolongata*, *Rhynchodiniopsis cladophora*, *Sentusidinium* spp. and *Tubotuberella dangeardii* (Text-Figure A3.6). A number of these inceptions are consistent with ranges in northwest Europe, for example those of *Chytroeisphaeridia cerastes*, *Endoscrinium galeritum* and *Rhynchodiniopsis cladophora* (Woollam, 1980; Riding and Thomas, 1992). Furthermore, despite extremely rare records of *Gonyaulacysta jurassica* subsp. *adecta* in the Bathonian (Riding et al., 1985), the inception of consistent records of this subspecies is Lower Callovian throughout Europe (Riding, 1992). *Ambonosphaera? staffinensis* appears to be relatively long ranging; this species is found from the Callovian to the Lower Cretaceous of the Boreal and Subboreal realms (Poulsen and Riding, 1992). *Chytroeisphaeridia hyalina* was prominent in sample TP 9, where it attained 9.3% of the dinoflagellate cyst assemblage (Text-Figure A3.6). Low numbers of *Crussolia* spp. were observed in sample TP 7; this inception may also prove to be of correlative significance. Questionable specimens of *Kalyptea stegasta* were observed in samples TP 7 and TP 6 (Text-Figure A3.6). Furthermore, *Lagenadinium callovianum* is present in samples TP 7 and TP 6; this inception within the *Cadoceras simulans* beds (Koenigi Zone equivalent) is deemed to be stratigraphically significant. The range base of *Paragonyaulacysta retiphragmata* in sample TP 7 may be of local significance, since similar forms have been encountered in the Bathonian of the Russian Platform (section 5.3.1.1). The occurrence of *Pareodinia prolongata* in samples TP 8 and TP 6 may also be biostratigraphically important; this species is characteristic of the Callovian stage in northwest Europe (Woollam, 1980; Prauss, 1989). The large and distinctive species *Ctenidodinium combazii* was observed in significant proportions (32.4% of the relatively sparse dinoflagellate cyst flora) in sample TP 6 (Text-Figure A3.6). This species was facies-controlled (Riding et al., 1985); it preferred relatively stable, open marine conditions. In central and northern England and Scotland, where Bathonian strata represent marginal marine conditions, *Ctenidodinium combazii* is absent or extremely rare (Riding, 1987; Riding *et al.*, 1991). Because of the high eustatic levels throughout the Callovian, *Ctenidodinium combazii*, within its stratigraphic range, tends therefore to be consistently present. The range top of this species in northwest Europe is Lower Callovian (Herveyi Zone) (Riding and Thomas, 1992). The *Kepplerites* cf. *tychonis* Beds of the Pechora Basin have been correlated with the Calloviense Zone (Meledina et al., 1998). Therefore, if this correlation is sound, *Ctenidodinium combazii* ranges into younger strata in the Russian Platform than western Europe. The microplankton associations are similar in composition to coeval floras from the Russian Platform (sections 5.3.1.2 and 5.3.2.1). Lower Callovian dinoflagellate cyst associations from northern Siberia are broadly similar, but appear to be less diverse and to contain proportionately more Boreal elements such as *Crussolia* spp. and *Paragonyaulacysta retiphragmata*. (section 5.1.2).

All the four Lower Callovian samples yielded common reworked Carboniferous spores. Samples TP 9 to TP 7 produced the richest and most diverse floras. Species identified include *Apiculatisporites* sp., *Cingulizonates* spp., *Convolutispora* sp., *Densosporites rarispinosus*, *Densosporites spinifer*, *Diatomozonotriletes cervicornutus*, *Lophotriletes* sp., *Monilospora dignata*, *Murospora aurita*, *Punctatisporites* spp. and *Vallatisporites* spp. These associations are indicative of the stratigraphical recycling of strata of Late Viséan age (Ravn, 1991).

#### 5.2.1.3 West bank of the River Izhma, outcrop 9, samples TP 5-TP 4 (Middle-Callovian) and sample TP 3 (Upper Callovian)

The inceptions of *Atopodinium haromense*, *Clathroctenocystis asapha*, *?Lithodinia planoseptata*, *Sentusidinium creberbarbatum*, *Sirmiodiniopsis orbis*, *Stephanelytron* spp. and *Wanaea acollaris* in this section (Text-Figures 12, A3.6) reflect the increasing dinoflagellate cyst species diversity during the Callovian. This is a global phenomenon (Davey, 1987; Helby et al., 1987; Martill et al, 1994). Acmes of *Chytroeisphaeridia hyalina* (21.5% of the dinoflagellate cyst flora in sample TP 4) and *Chytroeisphaeridia chytroeides* (17.4% of the dinoflagellate cyst flora in sample TP 3) were observed (Text-Figure A3.6). *Kalyptea stegasta* was encountered in samples TP 4 and TP 3 (Text-Figure 12). This species is known to be relatively long-ranging but is especially prominent in the Middle Callovian in northwest Europe (Riley and Fenton, 1982; Partington et al., 1993; Riding and Thomas, 1997). The occurrence throughout of *Lagenadinium callovianum* here is entirely consistent with the mid-late Callovian range of this species (Piel, 1985). The range base of *Mendicodinium groenlandicum* was observed in sample TP 4 (Text-Figure 12). This species is known from the Callovian to the Volgian in Europe (Riding and Thomas, 1992). The Upper Callovian range bases of *Clathroctenocystis asapha*, *Sirmiodiniopsis orbis*, *Stephanelytron redcliffense* and *Stephanelytron scarburghense* in sample TP 3 (Text-Figure 12) are consistent with northwest Europe (Riding and Thomas, 1992). These bioevents are typically intra-Callovian (Woollam and Riding, 1983; Riding, 1987). The presence of *Clathroctenocystis asapha* and *Stephanelytron* spp. strongly suggests that sample TP 3 is of uppermost Callovian age (Subordinarium Zone) (section 5.2.2.1; Text-Figure 16).

Small proportions of *Nannoceratopsis deflandrei*, reworked from the late Pliensbachian-Toarcian were recorded in samples TP 4 and TP 3 (Text-Figure A3.6). Reworked Carboniferous spores were present throughout, but these floras are not as common or as diverse as those in the underlying Lower Callovian.

#### 5.2.1.4 West bank of the River Izhma, outcrop 7, samples TP 2, TP 1 (Upper Callovian)

Both these Upper Callovian samples are similar in species composition and relative proportions to coeval associations from north-west Europe (Riding, 1987; Prauss, 1989; Kunz, 1990). An acme (52.0% of the dinoflagellate cyst flora) of *Chytroeisphaeridia hyalina* was observed in sample TP 1 (Text-Figure A3.6). The range of this species in Russia is more extensive than in north-west Europe, where it is confined to the early-mid Callovian (Riding, 1990). *Chytroeisphaeridia hyalina* has been recorded from the Bathonian to the Middle Oxfordian of Russia (sections 5.2.1, 5.2.2, 5.3.1 and 5.3.2). *Lithodinia planoseptata* was recorded in both samples (Text-Figure 12). This distinctive species is confined to the early Callovian in England (Riding, 1987; Riding and Thomas, 1992). *Mendicodinium groenlandicum* was observed in significant proportions (7.8%) in sample TP 2 (Text-Figure A3.6). In western Europe this species is prominent throughout the late Callovian (Riding, 1987).

*Nannoceratopsis deflandrei*, reworked from the late Pleinsbachian-Toarcian, was recorded in small numbers from sample TP 1 (Text-Figure A3.6). Low diversity species associations of reworked Carboniferous spores were encountered rarely.

### 5.2.2 The Upper Callovian to Kimmeridgian palynology of the River Izhma area

A suite of 14 Upper Callovian and Kimmeridgian samples collected from outcrop 15 in the River Izhma area, Pechora Basin (Text-Figure 4) were studied. The delineation of samples to stages/substages was determined on foraminiferal evidence (unpublished data); there are no direct ammonite zonal correlations. It is therefore possible that the Upper Callovian samples herein (i.e. numbers TP 21 to TP 26) overlap stratigraphically with samples TP 1 to TP 3 of section 5.2.1, which are also from the River Izhma area. The stratigraphic distributions of all palynomorph taxa identified are illustrated in Text-Figures 13, A.7 and A3.8. The fourteen samples yielded abundant organic residues and variably abundant, well-preserved palynofloras. Woody tissue is abundant throughout and the dinoflagellate cyst floras are rich and of relatively high species diversity. Gymnospermous pollen such as undifferentiated bisaccate pollen grains, *Callialasporites* spp., *Cerebropollenites macroverrucosus*, *Classopollis classoides* and *Perinopollenites elatoides* consistently dominate the palynofloras. Reworked Carboniferous spores were also frequently common in the Upper Callovian samples (Text-Figure A3.8).

#### 5.2.2.1 Samples TP 26 to TP 21 (Upper Callovian)

Samples TP 26 to TP 21 produced palynofloras rich in dinoflagellate cysts and miospores; prominent dinoflagellate cysts include *Batiacasphaera* spp., *Chytroeisphaeridia* spp., *Lithodinia* spp. and *Rhynchodiniopsis cladophora* (Text-Figures A3.7, A3.8). Lesser proportions of *Cleistosphaeridium* spp., *Evansia evittii*, *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta*, *Kalyptea stegasta*, *Nannoceratopsis pellucida*, *Pareodinia* spp., *Sentusidinium* spp., *Sirmiodinium grossii* and *Tubotuberella dangeardii* were also observed (Text-Figure 13). *Chytroeisphaeridia hyalina* is a reliable index for the Lower-Middle Callovian of northwest Europe (Riding, 1990), however it occurs throughout the Callovian to Middle Oxfordian of the Russian Platform (sections 5.2.1, 5.2.2, 5.3.1 and 5.3.2). A similar situation pertains to *Lithodinia planoseptata*, which is confined to the Lower Callovian of England (Riding, 1987), but occurs throughout the stage in the Russian Platform (sections 5.2.1 and 5.3.2). Similarly, the consistent presence of *Kalyptea stegasta*, the numerous and diverse representatives of *Lithodinia* and the absence of characteristic Upper Callovian markers would strongly suggest the Middle Callovian in northwest Europe (Partington et al., 1993). Reworked Carboniferous spores were recovered throughout and include species of *Cingulizonates* and *Murospora* (Text-Figure A3.8). This reworking of common and diverse Carboniferous palynomorphs into the Callovian of the Pechora Basin has been previously noted (section 5.2.1).

Samples TP 22 and TP 21 are interpreted as uppermost Callovian and proved extremely palynologically productive; they yielded 700 and 818 dinoflagellate cysts per microscope slide respectively (Text-Figure A3.8). The occurrence of relatively common *Mendicodinium groenlandicum* is suggestive of the Upper Callovian (Riding and Thomas, 1992). Furthermore, the presence of certain known Upper Callovian markers are deemed to be stratigraphically significant. These include *Clathroctenocystis asapha* (sample TP 21), *Gonyaulacysta centriconnata* (sample TP 22), *Liesbergia liesbergensis* (sample TP 21), *Stephanelytron caytonense* (sample TP 22) and *Trichodinium scarburghensis* (sample TP 22) (Text-Figure 13). These forms have well established range bases in the Upper Callovian of northwest Europe (Riding, 1987; Riding and Thomas, 1992). Additional evidence of a late Callovian age comes from the occurrences of *Ctenidodinium continuum* in sample TP 21 and *Wanaea acollaris* in sample TP 22. Both these species have reliable intra-late Callovian range tops in northwest Europe (Riding, 1984b). The ocurrence of *Cleistosphaeridium varispinosum* in samples TP 23 and TP 22 (Text-Figures 13, A3.7) is interesting; this species in England is confined to the Lower Callovian (Woollam and Riding, 1983; Riding and Thomas, 1992). This species appears to range through the entire Callovian Stage in Russia, like several other British Lower-Middle Callovian markers.

In Russia, key Upper Callovian markers (with established range bases in Britain) such as *Clathroctenocystis asapha*, unequivocal *Scriniodinium crystallinum*, *Stephanelytron* spp. and *Trichodinium scarburghensis* are not present in the lowermost Upper Callovian (Athleta/Keyserlingi zones) (Text-Figure 16). These stratigraphically crucial taxa have inceptions within the uppermost Callovian Subordinarium Zone (section 5.2.1). This apparent heterochroneity of dinoflagellate cyst datums may possibly indicate that the range base of the index ammonites for the latest Callovian ammonite zone (i.e. Subordinarium/Lamberti) are possibly significantly diachronous, younging towards the southwest. A possible causal mechanism for this phenonenon is the presence of certain biotal barriers between the Subboreal and Boreal realms during the late Callovian (Smelror, 1993).

#### 5.2.2.2 Samples TP 20 to TP 13 (Kimmeridgian)

Samples TP 20 to TP 13 yielded variably abundant palynofloras (Text-Figures 13, A3.7 and A3.8). Dinoflagellate cyst species recorded in significant proportions are *Chytroeisphaeridia chytroeides*, *Cleistosphaeridium tribuliferum*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Pareodinia halosa*, *Perissieasphaeridium pannosum*, *Rhynchodiniopsis cladophora*, *Sirmiodinium grossii* and *Tubotuberella rhombiformis* (Text-Figure 13). Samples TP 20 and TP 19 are dominated by *Rhynchodiniopsis cladophora*; this species accounts for 64.9% and 90.7% of the dinoflagellate cyst assemblages respectively (Text-Figure A3.8); this acme may be be of correlative significance. The occurrences of *Aldorfia dictyota*, *Cribroperidinium globatum*, *Endoscrinium anceps*, *Glossodinium dimorphum*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Hystrichosphaerina orbifera*, *Leptodinium* spp., *Perisseiasphaeridium pannosum*, *Prolixosphaeridium anasillum*, *Stephanelytron* spp., *Systematophora* spp. and *Tubotuberella rhombiformis* (Text-Figure 13) are indicative of the Boreal Kimmeridgian Stage. Specifically, the occurrences of *Gonyaulacysta jurassica* subsp. *jürassica*, *Rhynchodiniopsis cladophora*, *Scriniodinium crystallinum* and *Stephanelytron* spp. provide direct evidence of the Kimmeridgian by comparison with southern England (Riding and Thomas, 1988). This age assessment can be significantly refined. The occurrence of *Scriniodinium crystallinum* in sample TP 20 (Text-Figure 13) means that this horizon is correlatable with the lowermost Kimmeridgian (Baylei Zone) at the type section (Riding and Thomas, 1988). This sample cannot be of Oxfordian age due to the presence of *Endoscrinium anceps* and *Perisseiasphaeridium pannosum* (Text-Figures A3.7, A3.8). Additionally, the presence of *Stephanelytron* spp. in samples TP 20, TP 19, TP 18, and TP 15 (Text-Figures 13, A3.8) is evidence that this interval is referable to the Baylei to Mutabilis zones (Riding and Thomas, 1988; 1992). Certain Boreal elements were observed including *Ambonosphaera? staffinensis* and *Paragonyaulacysta* sp. The associations observed here are substantially similar to other records of Kimmeridgian dinoflagellate cyst floras of central and northern Russia (sections 5.2.3 and 5.3.3.3).

### 5.2.3 The Kimmeridgian-Volgian palynology of the River Pizhma area

A suite of 10 Kimmeridgian-Volgian samples (TP 36 to TP 27) from the River Pizhma area in northern Russia (Text-Figure 4) were examined. The stratigraphic distribution of dinoflagellate cysts is given in Text-Figure A3.9. Samples TP36 to TP 28 yielded variably abundant and diverse palynofloras. Numbers TP 36, TP 32 and TP 28 proved relatively sparse organically; however, the remainder produced relatively abundant dinoflagellate cyst floras indicative of the Boreal Kimmeridgian. Species such as *Chytroeisphaeridia chytroeides*, *Cribroperidinium* spp., *Endoscrinium anceps*, rare *Glossodinium dimorphum*, *Leptodinium* spp., *Pareodinia halosa*, *Perisseiasphaeridium pannosum*, *Prolixospharidium parvispinum*, *Rhynchodiniopsis cladophora*, *Sirmiodinium grossii*, rare *Tubotuberella dangeardii* and *Tubotuberella rhombiformis* were recovered (Text-Figure A3.9). The presence of *Perisseiasphaeridium pannosum*, *Rhynchodiniopsis cladophora* and *Tubotuberella dangeardii* is indicative of a correlation with the Boreal Kimmeridgian (i.e. Lower Kimmeridgian *sensu anglico*) (Riding and Thomas, 1988; 1992). The overall assemblages are similar to those from northwest Europe, however, *Perisseiasphaeridium pannosum* is present consistently and relatively abundantly in the Kimmeridgian of the River Pizhma. In southern England it is a relatively minor constituent of coeval assemblages, aside of a stratigraphically restricted acme in the Eudoxus Zone (Riding and Thomas, 1988).

Sample TP 27 yielded an abundant and diverse dinoflagellate cyst assemblage (Text-Figure A3.9). Many species recorded also occur in samplesTP 36 to TP 28, however this sample appears to be significantly younger than the latter. This is evidenced by the occurrences of forms such as *Achomosphaera* sp., *Bourkodinium* sp., *Cassiculosphaeridia* sp., *Circulodinium compta*, *Circulodinium* spp., *Endoscrinium anceps*, *Endoscrinium glabrum*, *Gonyaulacysta helicoidea*, *Imbatodinium kondratjevii*, *Kleithriasphaeridium* sp. ?*Oligosphaeridium diluculum* and *Spiniferites* sp. Comparison with Britain indicates a correlation with the Early Cretaceous. The concurrent presence of *Achomosphaera* sp., *Circulodinium compta*, *Spiniferites* sp. and *Tubotuberella* spp. indicates the late Ryazanian/early Valanginian interval (Costa and Davey, 1992). The Ryazanian/Valanginian of northwest Europe typically yields far more diverse dinoflagellate cyst floras (Duxbury, 1977).

### 5.2.4 The Middle Volgian palynology of three localities from the River Izhma area

Seven Middle Volgian samples from three localities in the River Izhma area were studied (Text-Figure 4). The stratigraphic distributions of all dinoflagellate cysts identified are illustrated in Text-Figures 14 and A3.10. The samples yielded variably abundant organic residues and palynofloras.

#### 5.2.4.1 Samples TP 41 to TP 37 (Middle Volgian of outcrop 16)

Amorphous organic material was recovered throughout this interval and was especially common in samples TP 41 and TP 40. This strongly suggests that the Volgian "hot" shale facies of Rawson and Riley (1982) was developed in the Pechora Basin. The term "hot" refers to the typically high gamma values; the "hot" shale facies is an extensive potential source rock, developed due to bottom anoxia associated with marine water stratification. Sample TP 39 produced an extremely rich and well-preserved palynoflora; the remaining samples, however, proved to be significantly sparser (Text-Figure A3.10). Dinoflagellate cysts overwhelmingly dominate the palynofloras. *Cleistosphaeridium tribuliferum*, *Cribroperidinium* spp., *Dingodinium* spp., *Glossodinium dimorphum*, *Kleithriasphaeridium* spp., *Leptodinium subtile*, *Oligosphaeridium patulum*, *Pareodinia ceratophora*, *Pareodinia halosa*, *Prolixosphaeridium* spp. and *Tubotuberella rhombiformis* are common (Text-Figures 14, A3.10). The presence of species such as *Cribroperidinium* spp., *Endoscrinium anceps*, *Glossodinium dimorphum*, *Kleithriasphaeridium* spp., *Leptodinium subtile*, *Oligosphaeridium patulum* and *Senoniasphaera jurassica* indicates that the succession is of Volgian age by comparison with palynofloras from northwest Europe (Riding and Thomas, 1988; 1992). The presence of common to abundant *Oligosphaeridium patulum* in samples TP 39 to TP 37 (Text-Figure A3.10) is highly stratigraphically significant. The acme occurrence of this chorate species in England is within the early Volgian Hudlestoni Zone (Riding and Thomas, 1988, text-fig. 3). The range base of *Senoniasphaera jurassica* in sample TP 40 is also significant. Poulsen and Riding (1992) reported that the overall range of this species is Kimmeridgian to mid Volgian, however, Riding and Thomas (1988, text-fig. 3) proved that the range base of consistent occurrences of the species is within the early Volgian

Wheatleyensis Zone. Therefore, the presence of common *Oligosphaeridium patulum* and *Senoniasphara jurassica* indicates that samples TP 40 to TP 37 are of probable early-mid Volgian age.

The associations recovered are broadly similar in species content and relative proportions to samples from the Middle Volgian of Gorodische and Kashpir in the Russian Platform. *Oligosphaeridium patulum* and *Senoniasphaera jurassica* have been recorded from the Middle Volgian of both these localities (sections 5.3.4; 5.3.5; Lord et al., 1987).

#### 5.2.4.2 Samples TP 42 and TP 43 (Middle Volgian of outcrops 16a and 17)

Samples TP 42 and TP 43 produced abundant organic residues and variably rich palynofloras. *Batiacasphaera* spp., *Cribroperidinium* spp., *Dingodinium* spp., *Pareodinia ceratophora, Pareodinia halosa, Sirmiodinium grossii* and *Tubotuberella rhombiformis* were recovered in significant proportions (Text-Figure A3.10). The dinoflagellate cyst floras are similar to those recovered from samples TP 41 to TP 37 (section 5.2.4.1) and are indicative of an early-mid Volgian age. The samples cannot be younger than mid Volgian due to the presence of *Glossodinium dimorphum* (Riding and Thomas, 1992; Riding et al., 1993). Furthermore, the high abundances of *Cribroperidinium* spp. in both samples strongly suggests that the sample can be no older than Kimmeridgian-Volgian (Riding and Thomas, 1988; 1992).

### 5.2.5 Summary of the Bathonian to late Ryazanian/early Valanginian palynology of the Pechora Basin

The Bathonian of the Pechora Basin yielded low diversity dinoflagellate cyst floras rich in endemic forms such as *Protobatioladinium elatmaensis* and *?Protobatioladinium? elongatum*. This succession provided the first reports of *Chytroeisphaeridia hyalina* and the acritarch *Fentonia bjaerkei* in the Bathonian of the Russian Platform. The Lower Callovian produced rich and diverse dinoflagellate cyst floras; most forms are known from western Europe. The Lower Callovian dinoflagellate cyst floras from the Pechora Basin are similar to those from the Russian Platform and significantly more diverse than equivalents from northern Siberia (sections 5.3 and 5.1.2). The Middle and Upper Callovian samples exhibit increasing dinoflagellate cyst diversities; the species spectra are similar to those from north-west Europe. *Chytroeisphaeridia hyalina* and *Lithodinia planoseptata* were both recorded in the Upper Callovian. It appears that certain prominent northwest European Upper Callovian markers are absent in the Athleta/Keyserlingi zones in Russia. Species such as *Clathroctenocystis asapha* and *Trichodinium scarburghensis* appear to have inceptions in the uppermost Callovian (Subordinarium Zone) in Russia. It is possible that the latest Callovian ammonite faunas are diachronous, younging southwestwards. The Callovian samples yielded common and diverse reworked Carboniferous (chiefly Late Viséan) spores.

Several key regional dinoflagellate cyst markers were identified in the Boreal Kimmeridgian of the River Izhma area. The occurrence of forms such as *Scriniodinium crystallinum* and *Stephanelyton* spp. have enabled the subdivision of this stage. There is an acme of *Rhynchodiniopsis cladophora* in the lowermost Kimmeridgian of this region. The Kimmeridgian samples from the River Pizhma area appear to be largely of Boreal Kimmeridgian (i.e. early Kimmeridgian *sensu anglico*) age. *Perisseiasphaeridium pannosum* is especially numerous.

A suite of Middle Volgian samples from the River Izhma area produced residues rich in amorphogen. The majority of the dinoflagellate cyst assemblages indicate a correlation with the early-mid Volgian of western Europe. On the evidence of a single sample, the late Ryazanian/early Valanginian of the River Pizhma region exhibits marked differences to that of north-west Europe, in that dinoflagellate cyst diversity is relatively low. Additionally, some endemic Russian forms, such as *Imbatodinium kondratjevii,* were recovered.

## 5.3 STRATIGRAPHIC PALYNOLOGY OF THE CENTRAL RUSSIAN PLATFORM

Eighty-five Bathonian to lowermost Ryazanian samples from 10 localities in the central Russian Platform were studied. The sample localities are illustrated in Text-Figure 5 and all the sections and horizons are listed in Appendix 1. The samples largely yielded relatively rich and well-preserved palynofloras. The stratigraphic distributions of the palynomorphs recovered are illustrated in Text-Figures 17-24 and A3.11-A3.20. Text-Figures 25 and 26 illustrate the stratigraphic ranges of selected important dinoflagellate cyst taxa in the Oxfordian and Kimmeridgian-Ryazanian respectively of the central Russian Platform and the more northerly Pechora Basin (see section 5.2).

### 5.3.1 The Bathonian to Middle Oxfordian palynology of borehole 132, near Elatma, River Oka Basin

Sixteen samples from the Bathonian to Middle Oxfordian of Borehole 132 in the River Oka Basin, near Elatma (Text-Figure 5) were studied. The depth range of samples is 77.70m to 25.70m. The ammonite faunas indicate the unequivocal presence of the Lower Callovian Elatmae Zone and the Middle Oxfordian Densiplicatum and Tenuiserratum zones (Text-Figure 17). The stratigraphic distributions of all dinoflagellate cyst taxa identified are illustrated in Text-Figures 17 and A3.11. The samples generally yielded abundant organic residues and palynofloras; woody fragments are prominent throughout. Undifferentiated bisaccate pollen, *Cerebropollenites macroverrucosus, Classopollis classoides* and *Cyathidites* spp. are typically prominent in the miospore assemblages throughout. Pollen grains consistently dominate the assemblages in the Bathonian and Lower Callovian (samples RP 16 to RP 7). However, dinoflagellate cysts are the dominant palynomorph group in the Lower Oxfordian and Middle Oxfordian (samples RP 6 to RP 1).

#### 5.3.1.1 Samples RP 16 to RP 8 (Bathonian)

Palynomorph recovery throughout the Bathonian interval was generally good; however the dinoflagellate cyst floras are of relatively low diversity (Text-Figure A3.11). Numerically significant forms include *Batiacasphaera* spp., *Ctenidodinium sellwoodii, Mendicodinium groenlandicum, Pareodinia ceratophora* and *Protobatioladinium* spp. (Text-

Figure 17). *Ctenidodinium sellwoodii, Evansia evittii, Fromea tornatilis, Korystocysta gochtii* and *Nannoceratopsis pellucida* are confined to the lowermost Bathonian (samples RP 16 to RP 14) (Text-Figure A3.11). This association, together with *Protobatioladinium elatmaensis*, (samples RP 15 to RP 12) is characteristic of the Bathonian of the Pechora Basin (section 5.2.1.1; Riding and Ilyina, 1996; 1998). This distinctive morphotype comprises 88.7% and 82.9% of the dinoflagellate cyst floras in samples RP 14 and RP 13 respectively (Text-Figure A3.11). Another biostratigraphically significant species is *Protobatioladinium? elongatum* (samples RP 13 to RP 9). *Protobatioladinium? elongatum* appears to be confined to the Upper Bathonian (Riding and Ilyina, 1998), where it is abundant. This form comprises 75.0% and 66.6% of the dinoflagellate cyst assemblages in samples RP 10 and RP 9 respectively (Text-Figure A3.11). *Mendicodinium groenlandicum* was recorded from samples RP 14 to RP 8; the range base of this species is Lower Callovian in northwest Europe (Riding and Thomas, 1992). An acme (61.5% of the sparse dinoflagellate cyst flora) of *Paragonyaulacysta* sp. was recorded in sample RP 11 (Text-Figure A3.11). *Dissiliodinium* spp. are relatively prominent in the Upper Bathonian (sample RP 9). Small proportions of *Nannoceratopsis deflandrei* were recorded from samples RP 15 to RP 13, indicating reworking from the late Pliensbachian-Toarcian.

These low diversity dinoflagellate cyst assemblages are significantly different in species spectra and proportions to Bathonian palynofloras from elsewhere in the Northern Hemisphere. The Bathonian is known as a time of marked marine palynomorph provincialism (Riding et al. 1985), probably a result of the relatively low eustatic levels throughout this Stage (Haq et al., 1987).

#### 5.3.1.2 Sample RP 7 (Lower Callovian)

Marine microplankton in sample RP 7 is of moderate species diversity and abundance (Text-Figure A3.11). Prominent dinoflagellate cyst taxa at this horizon comprise *Batiacasphaera* spp., *Chytroeisphaeridia hyalina* and *Pareodinia ceratophora*. *Chytroeisphaeridia chytroeides, Ctenidodinium sellwoodii, Fromea tornatilis, ?Lithodinia caytonensis* and *Nannoceratopsis pellucida* were also recorded (Text-Figures 17, A3.11). Ilyina (1991a) recorded slightly more diverse floras from this interval, including *Rhynchodiniopsis cladophora, Sentusidinium* spp. and *Tubotuberalla dangeardii*. This association closely resembles early Callovian floras from northwest Europe (Riding, 1987) and elsewhere in the Russian Platform (section 5.3.2.1). The Lower Callovian marine microplankton of northern East Siberia, however, is more diverse, and rich in typically Boreal genera such as *Crussolia* and *Paragonyaulacysta* (section 5.1.2; Johnson and Hills, 1973; Davies, 1983; Århus *et al.*, 1989). *Chytroeisphaeridia hyalina* ranges from the Bathonian to the Middle Oxfordian in the Russian Platform (sections 5.2.1, 5.2.2 and 5.3.2); this species characterises the early-mid Callovian of northwest Europe (Riding, 1990). Reworked Carboniferous spores (e.g. *Cingulizonates* spp.) were observed rarely.

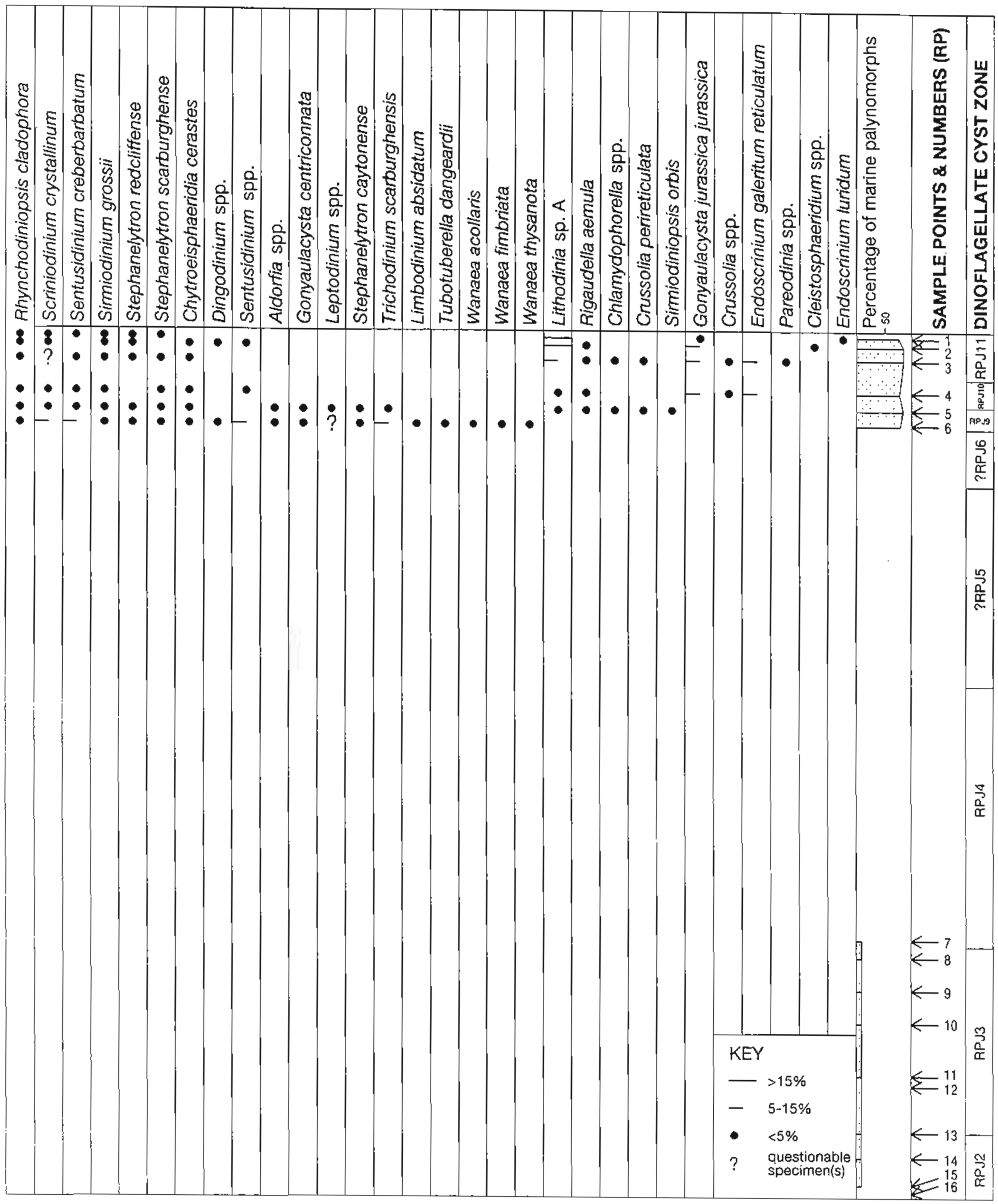
#### 5.3.1.3 Samples RP 6 to RP 1 (Lower and Middle Oxfordian)

The Lower and Middle Oxfordian palynofloras from Borehole 132 are of relatively high species diversity (Text-Figures 17, A3.11). The most prominent dinoflagellate cyst species include *Chytroeisphaeridia chytroeides, Endoscrinium galeritum, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Lithodinia* spp., *Scriniodinium crystallinum* and *Sentusidinium creberbarbatum*. Furthermore, *Ambonosphaera? staffinensis, Chytroeisphaeridia cerastes, Clathroctenocystis asapha, Crussolia deflandrei, Gonyaulacysta eisenackii, Nannoceratopsis pellucida, Rhynchodiniopsis cladophora, Rigaudella aemula, Sirmiodinium grossii* and *Stephanelytron* spp. were consistently present throughout (Text-Figures 17, A3.11). The floras are extremely similar, in both species content and relative proportions, to Lower-Middle Oxfordian floras from England, Scotland, France and Germany (Deflandre, 1938; Riding, 1987; Kunz, 1990; Riding and Thomas, 1997) and elsewhere in the Russian Platform (sections 5.3.2, 5.3.3).

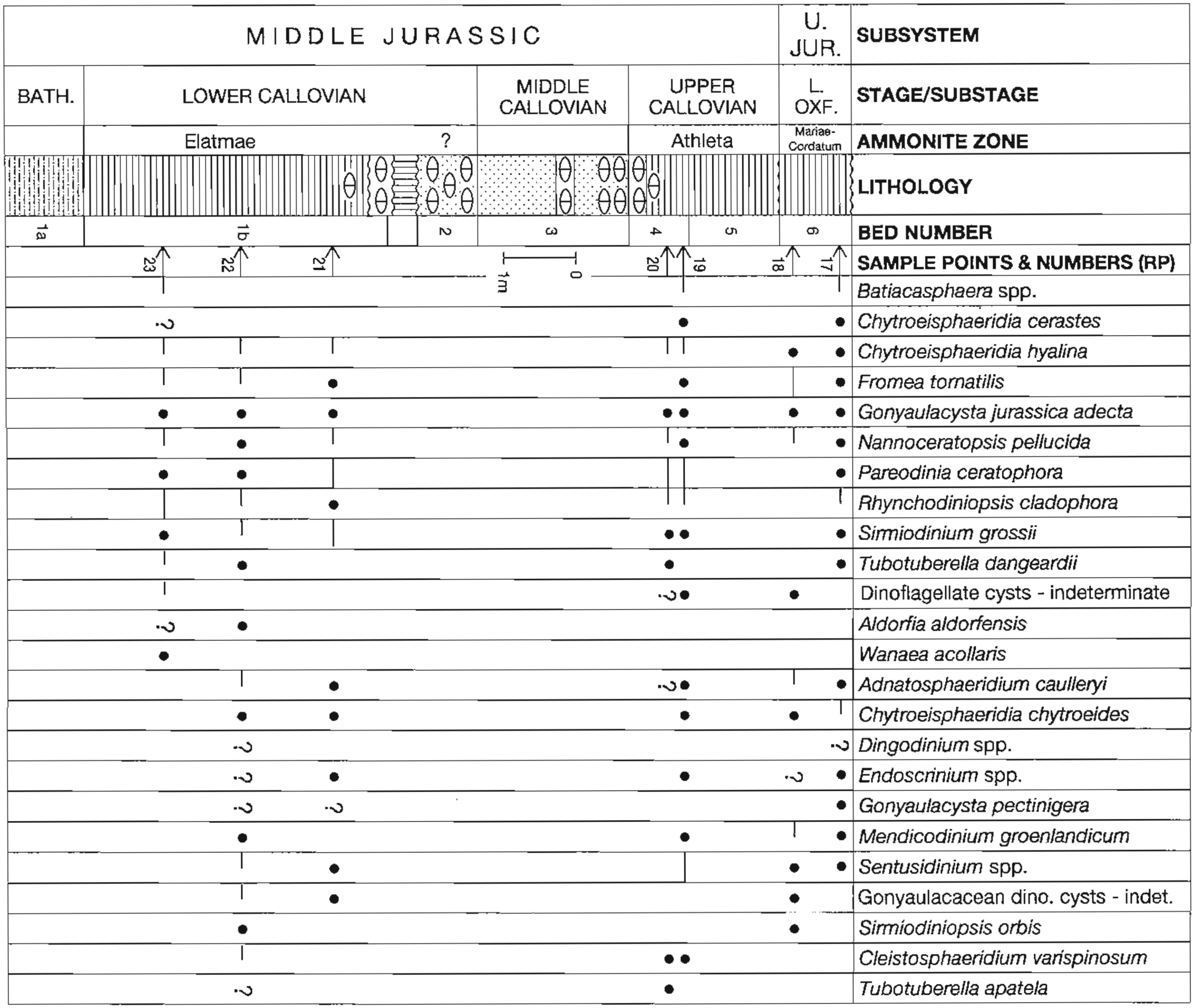
The range bases of several characteristic taxa confirm that samples RP 6 and RP 5 are no older than latest Callovian. These datums include the inceptions of *Clathroctenocystis asapha, Gonyaulacysta centriconnata, Limbodinium absidatum, Scriniodinium crystallinum, Trichodinium scarburghensis* and *Wanaea thysanota* (Riding and Thomas, 1992; section 5.2.2). Species which characterise the late Callovian-early Oxfordian of the Russian Platform are *Ambonosphaera? staffinensis, Chytroeisphaeridia hyalina, Crussolia deflandrei* and *Crussolia perireticulata* (sections 5.3.2; 5.3.3). *Wanaea acollaris* and *Wanaea thysanota* were both recorded from sample RP 6 (Text-Figure A3.11); this association is suggestive of the latest Callovian-early Oxfordian (Riding and Thomas, 1992). *Stephanelytron* spp. proved both relatively numerous and diverse in sample RP 6, accounting for 6.5% of the dinoflagellate cyst flora (Text-Figures 17, A3.11). *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* was observed in relatively small proportions (2.5%) in sample RP 6; this form is typically prominent in the Lower and Middle Oxfordian throughout the Northern Hemisphere (section 5.3.3). This variety dominates sample RP 5, comprising 62.2% of the dinoflagellate cyst flora (Text-Figure A3.11). The Oxfordian age of this sample is further supported by the presence of unequivocal *Leptodinium* spp.; this genus is known to be a reliable Upper Jurassic marker (Riding and Thomas, 1992). The range bases of *Lithodinia* sp. A and *Rigaudella aemula* also occur in sample RP 5. Species of *Crussolia* and *Stephanelytron* are relatively diverse at this horizon (Text-Figures 17, A3.11).

The presence of *Chytroeisphaeridia cerastes, Crussolia deflandrei, Endoscrinium luridum, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* and *Rigaudella aemula* in the four Middle Oxfordian samples (RP 4 to RP 1; Text-Figures 17, A3.11) positively confirms their mid Oxfordian age. The range base of *Endoscrinium luridum* (in sample RP 1) is known to be within the Densiplicatum Zone in England (Woollam and Riding, 1983). The remainder of the aforementioned taxa do not range above the Middle Oxfordian (Riding and Thomas, 1992). *Ambonosphaera? staffinensis* was recorded throughout; this species appears to be common and widespread in the Upper Jurassic of the Russian Platform (section 5.3.3). *Chytroeisphaeridia hyalina* was recorded in low proportions (0.2% of the dinoflagellate cyst flora) from sample RP 3. The genus *Crussolia* is relatively diverse; the species *Crussolia deflandrei, Crussolia perireticulata* and *Crussolia* sp. were observed (Text-Figures 17, A3.11). *Endoscrinium galeritum* subsp. *reticulatum* is confined to samples RP 4 and RP 3; this subspecies was also found in the Oxfordian of the River Unzha area, Russia (section 5.3.3). *Trichodinium scarburghensis*, a common element in the Middle Oxfordian of Europe, was not observed at this locality.

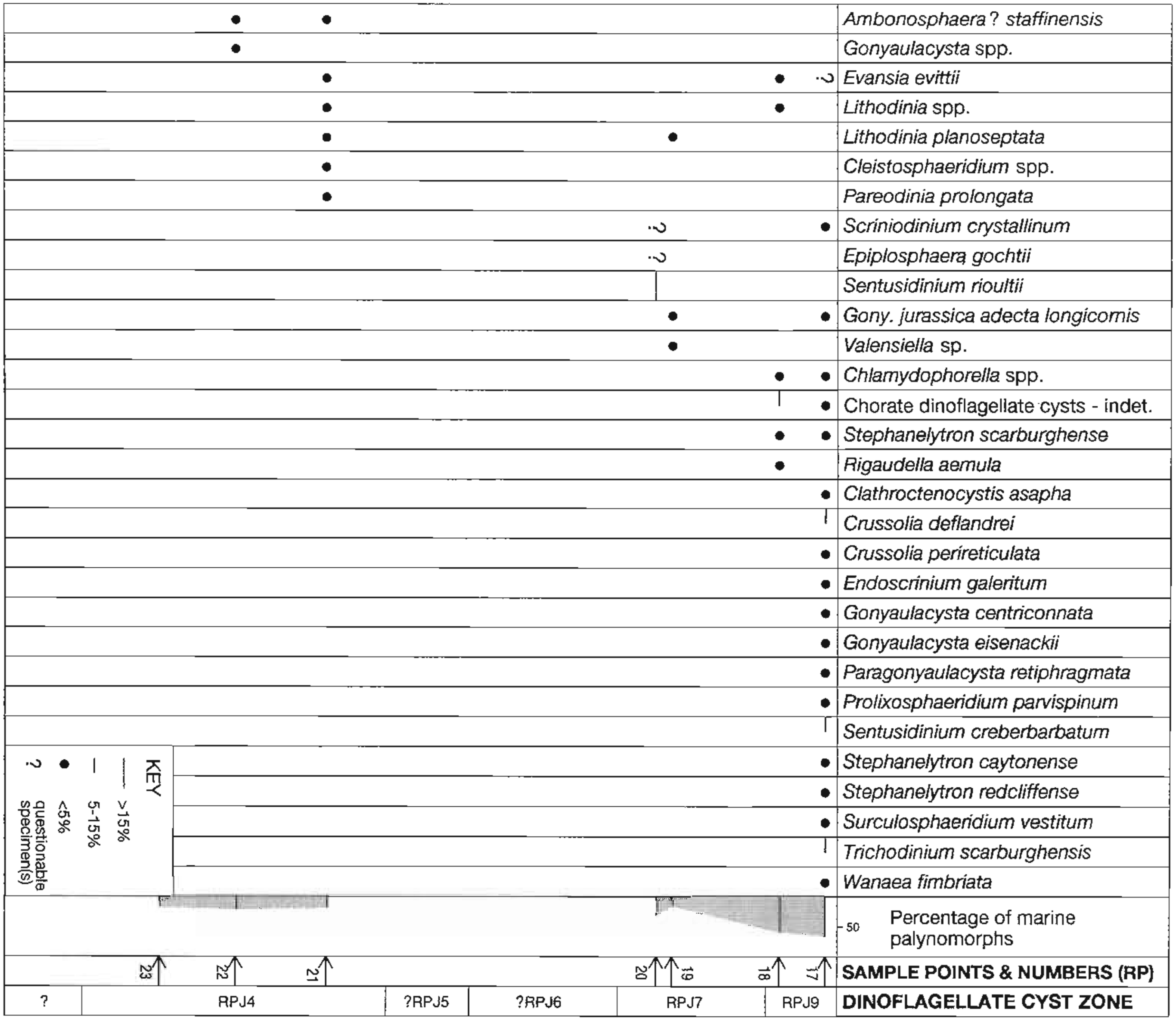

Text-Figure 17. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Bathonian to Middle Oxfordian strata of borehole 132, near Elatma, central Russian Platform (locality 1 of Text-Figure 5). L.O. = Lower Oxfordian; ?M = ?Mariae; De. = Densiplicatum; Ten. = Tenuiserratum.




Text-Figure 17 (continued). The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Bathonian to Middle Oxfordian strata of borehole 132, near Elatma, central Russian Platform (locality 1 of Text-Figure 5). L.O. = Lower Oxfordian; ?M = ?Mariae; De. = Densiplicatum; Ten. = Tenuiserratum.



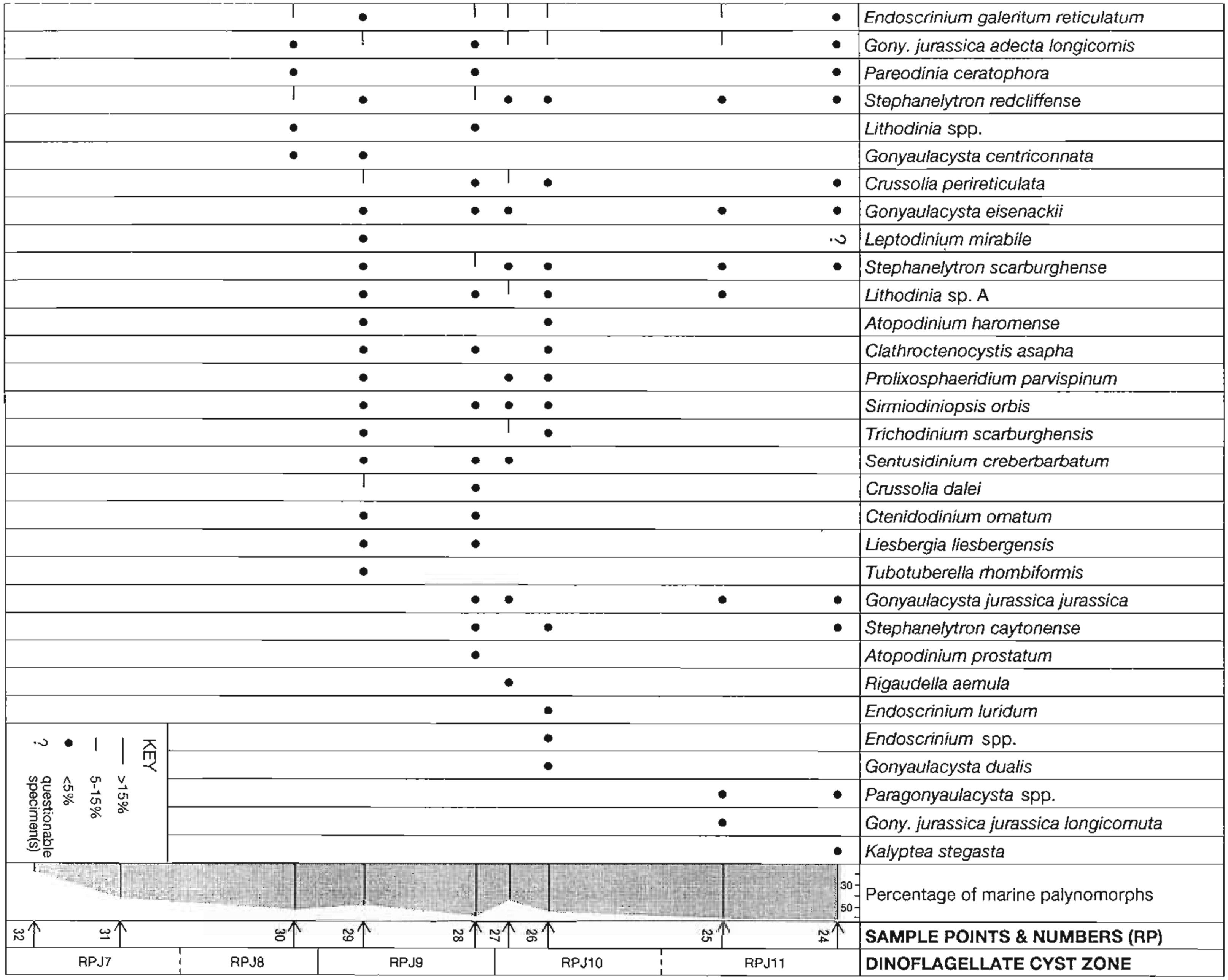

Text-Figure 18. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Callovian to Lower Oxfordian strata of a section near Inkino, central Russian Platform (locality 2 of Text-Figure 5).



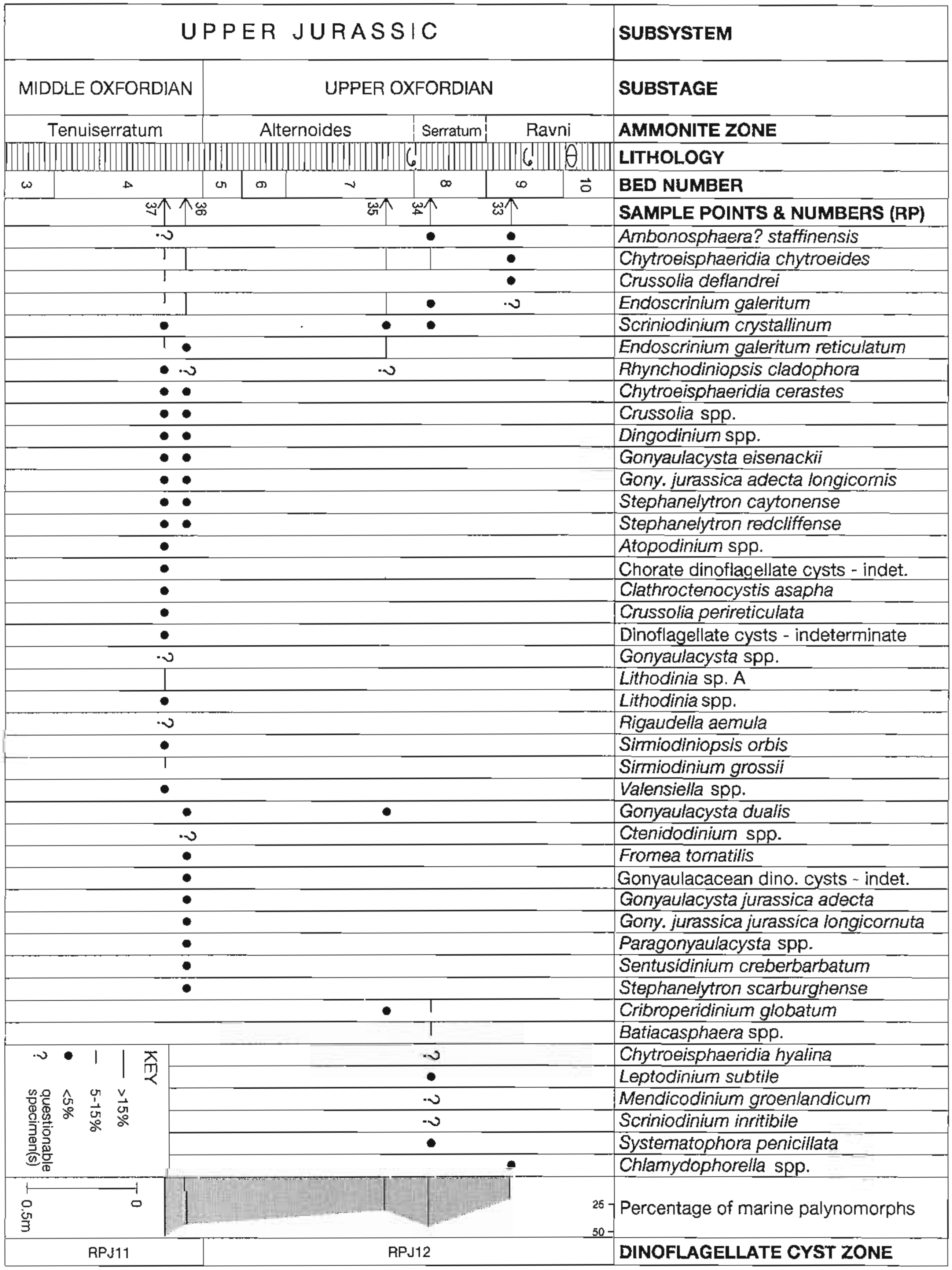

Text-Figure 18 (continued). The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Callovian to Lower Oxfordian strata of a section near Inkino, central Russian Platform (locality 2 of Text-Figure 5).

| SUBSYSTEM | MIDDLE JURASSIC | | | UPPER JURASSIC | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| SUBSTAGE | UPPER CALLOVIAN | | | LOWER OXFORDIAN | | MIDDLE OXFORDIAN | | | |
| AMMONITE ZONE | ?Athleta | | ?Lamberti | ?Mariae | | Densiplicatum | | Tenuiserratum | |
| LITHOLOGY | | | | | | | | | |
| BED NUMBER | 1 | 2 | 3 | | | 4 | | | |
| SAMPLE POINTS & NUMBERS (RP) | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 |
| *Chlamydophorella* spp. | • | \| | \| | • | \| | • | • | • | • |
| *Chytroeisphaeridia chytroeides* | \| | \| | \| | \| | \| | \| | \| | \| | \| |
| *Chytroeisphaeridia hyalina* | • | | | | | | | • | • |
| *Crussolia* spp. | • | • | | | | • | • | | • |
| Dinoflagellate cysts - indeterminate | • | • | | | | | • | | • |
| *Endoscrinium galeritum* | • | • | \| | \| | \| | \| | \| | \| | \| |
| *Nannoceratopsis pellucida* | \| | \| | • | • | • | • | • | • | • |
| *Scriniodinium crystallinum* | ? | | • | • | • | • | • | | • |
| *Sirmiodinium grossii* | • | • | • | • | \| | \| | \| | • | • |
| Gonyaulacacean dinoflagellate cysts - indet. | • | • | • | • | | • | | • | |
| *Mendicodinium groenlandicum* | • | • | ? | | | | | • | |
| *Fromea tomatilis* | \| | • | | | • | • | • | | |
| *Lithodinia caytonensis* | \| | ? | | | | | | | |
| *Evansia evittii* | • | | | | | | | | |
| *Chytroeisphaeridia cerastes* | | • | • | \| | • | • | \| | • | • |
| *Dingodinium* spp. | | • | | • | | | | | \| |
| *Gonyaulacysta jurassica adecta* | | • | • | | • | • | • | • | • |
| *Leptodinium subtile* | | • | | • | • | • | • | • | • |
| *Gonyaulacysta* spp. | | • | | | | | | • | |
| *Rhynchodiniopsis cladophora* | | • | | • | • | • | • | • | |
| *Sentusidinium* spp. | | • | | | • | | | | |
| *Tubotuberella dangeardii* | | • | | • | | | | | |
| *Cleistosphaeridium* spp. | | • | | | | | | | |
| *Ctenidodinium continuum* | | • | | | | | | | |
| *Korystocysta gochtii* | | ? | | | | | | | |
| *Batiacasphaera* spp. | | | • | • | | | \| | • | • |
| *Crussolia deflandrei* | | | ? | \| | | • | • | | • |

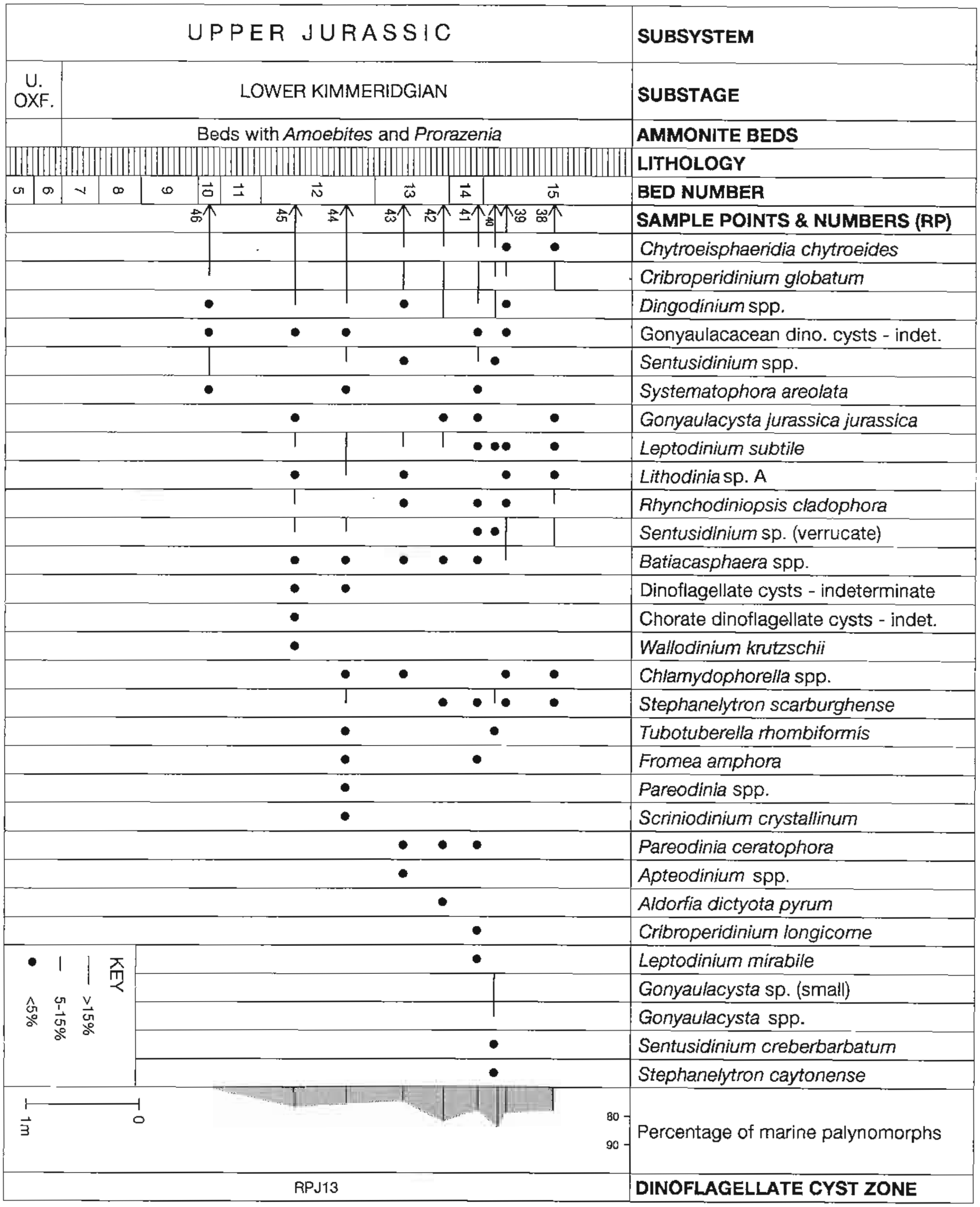
Text-Figure 19. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Upper Callovian to Oxfordian strata of section 2, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5).



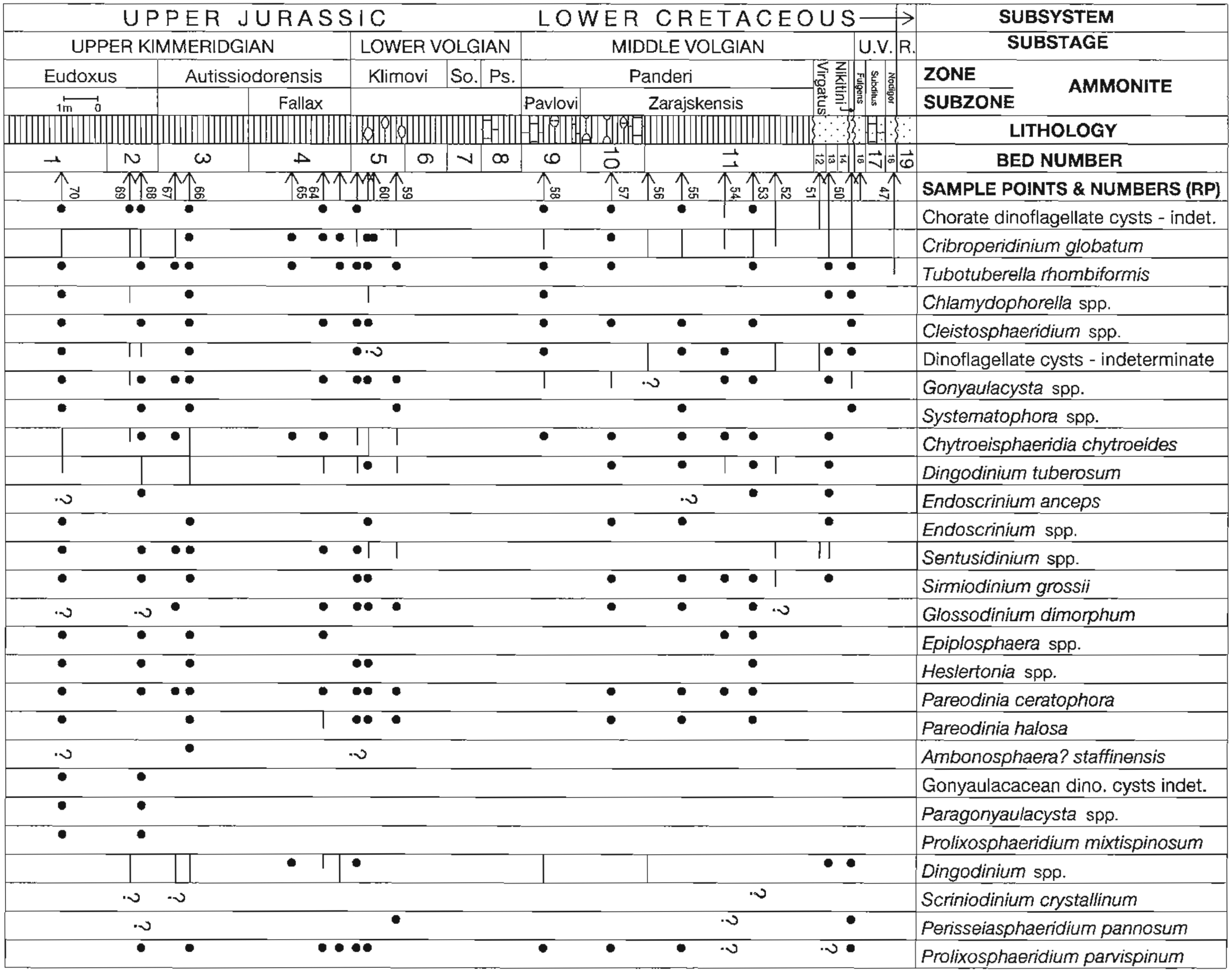

Text-Figure 19 (continued). The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Upper Callovian to Oxfordian strata of section 2, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5).



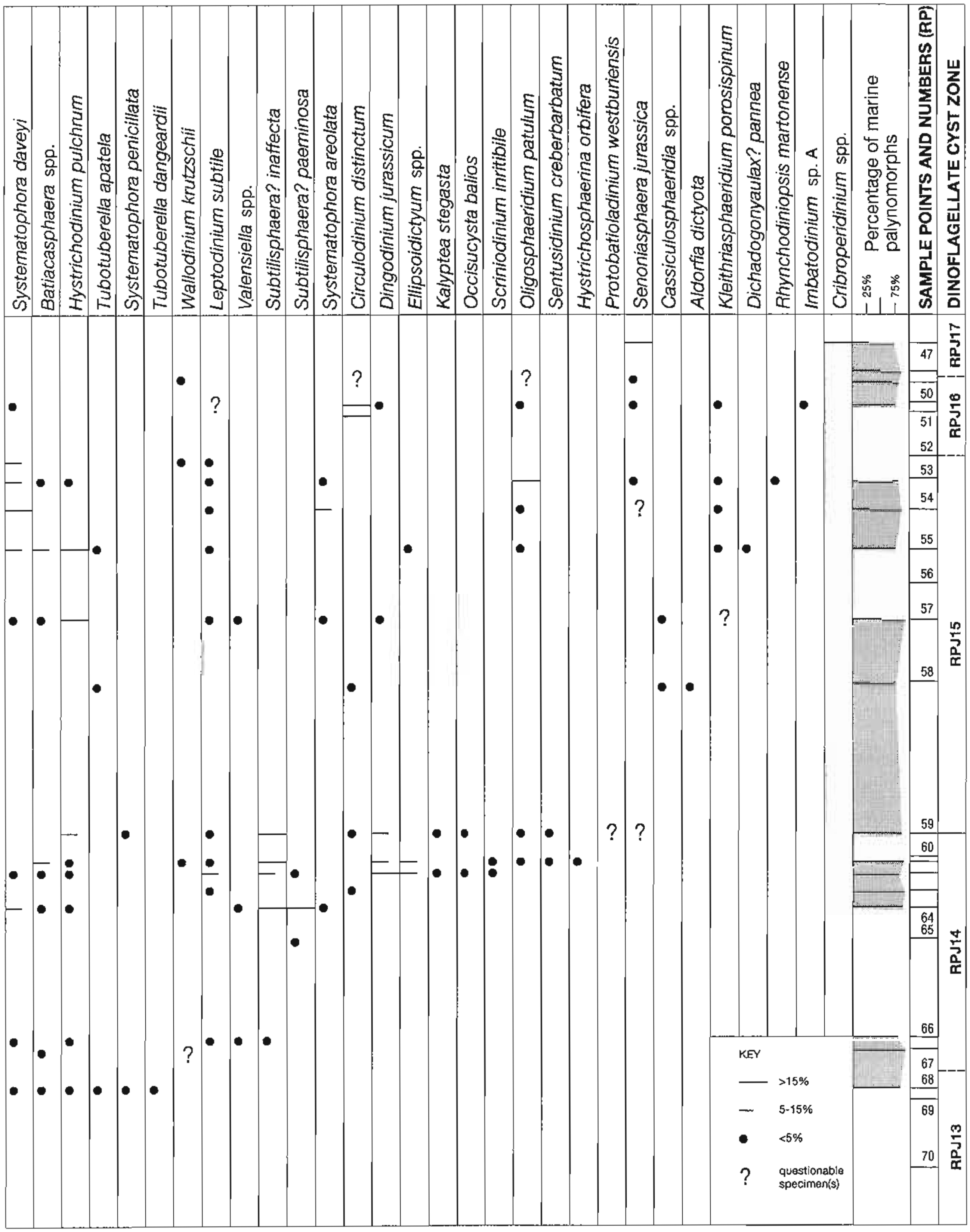

Text-Figure 20. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Oxfordian strata of section 1, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5).



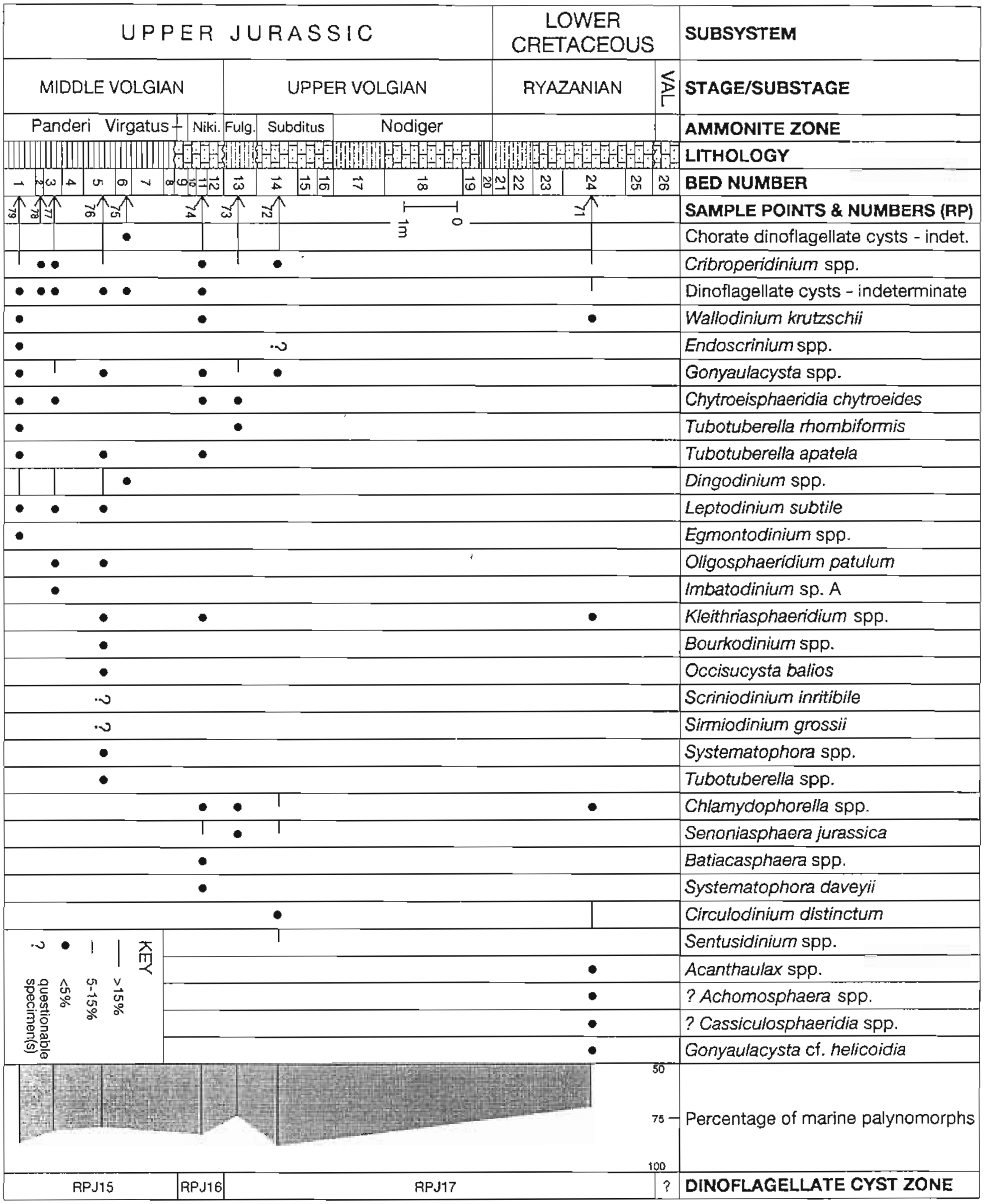

Text-Figure 21. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Lower Kimmeridgian strata of section 3/4, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5).



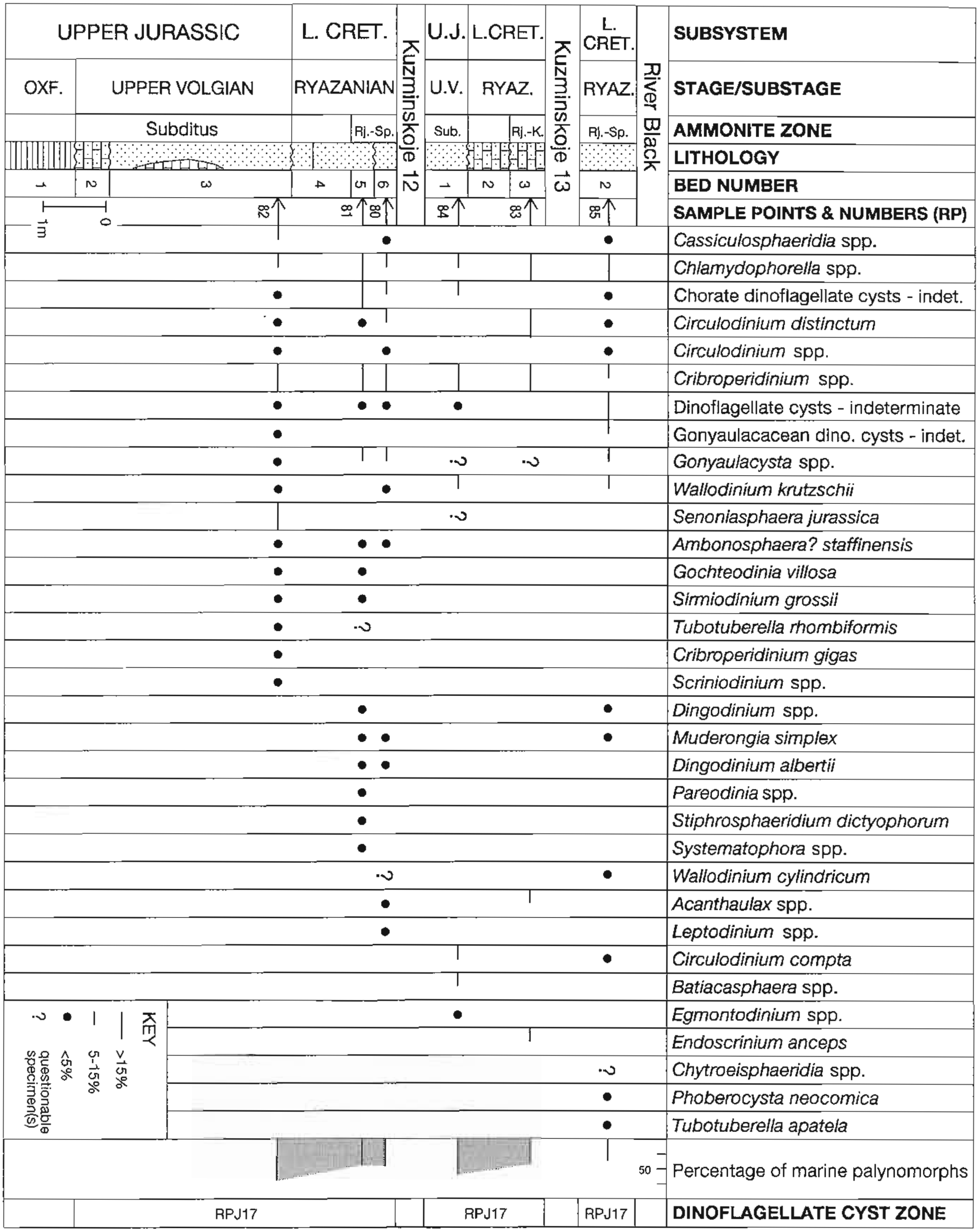

Text-Figure 22. The semi-quantitative stratigraphic distribution of the principal dinoflagellate cysts from the Kimmeridgian and Volgian strata of Gorodische, central Russian Platform (locality 4 of Text-Figure 5). U.V = Upper Volgian; R. = Ryazanian; So. = Sokolovi; Ps = Pseudoscythica.



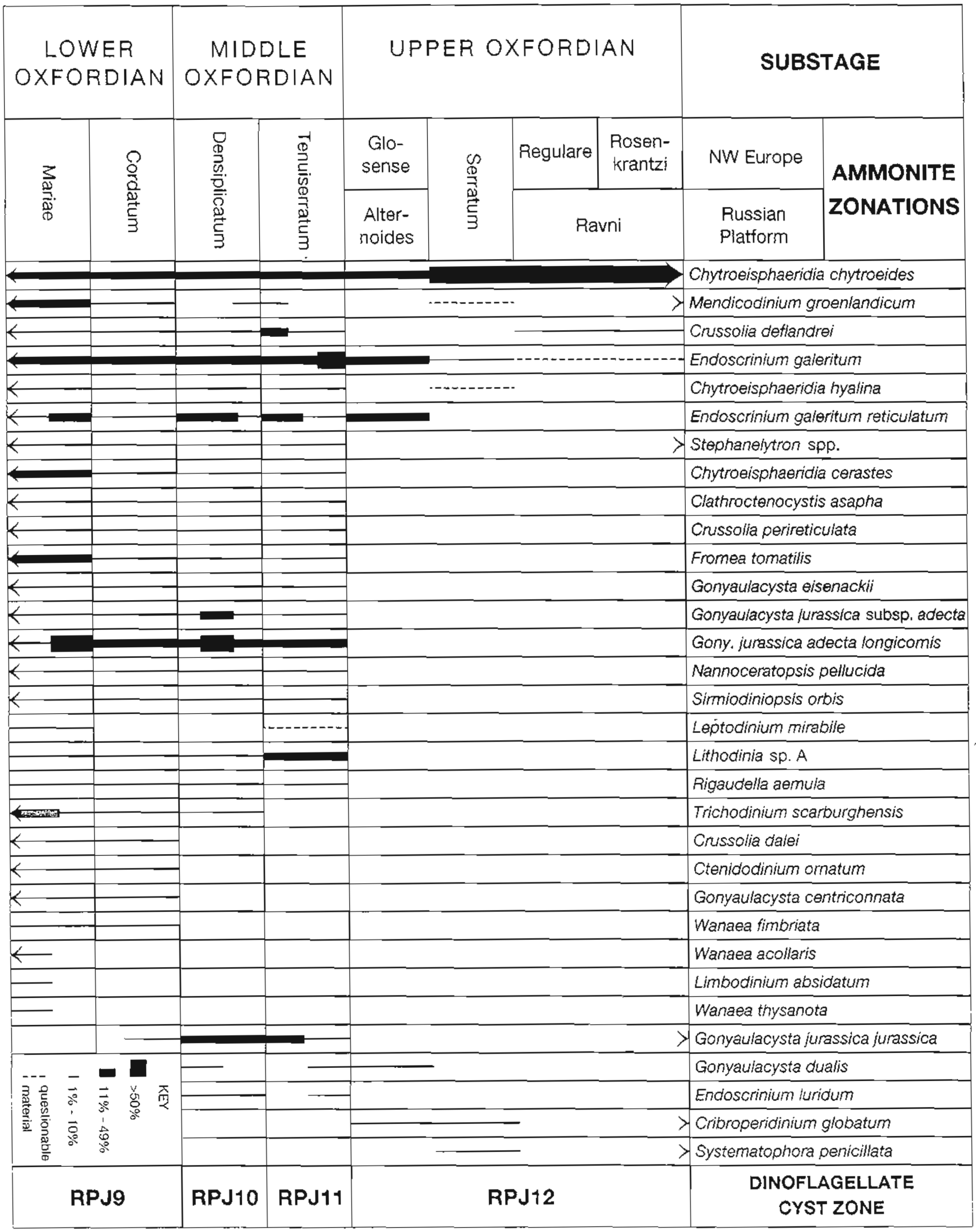

Text-Figure 22 (continued). The semi-quantitative stratigraphic distribution of the principal dinoflagellate cysts from the Kimmeridgian and Volgian strata of Gorodische, central Russian Platform (locality 4 of Text-Figure 5). U.V = Upper Volgian; R. = Ryazanian; So. = Sokolovi; Ps = Pseudoscythica.



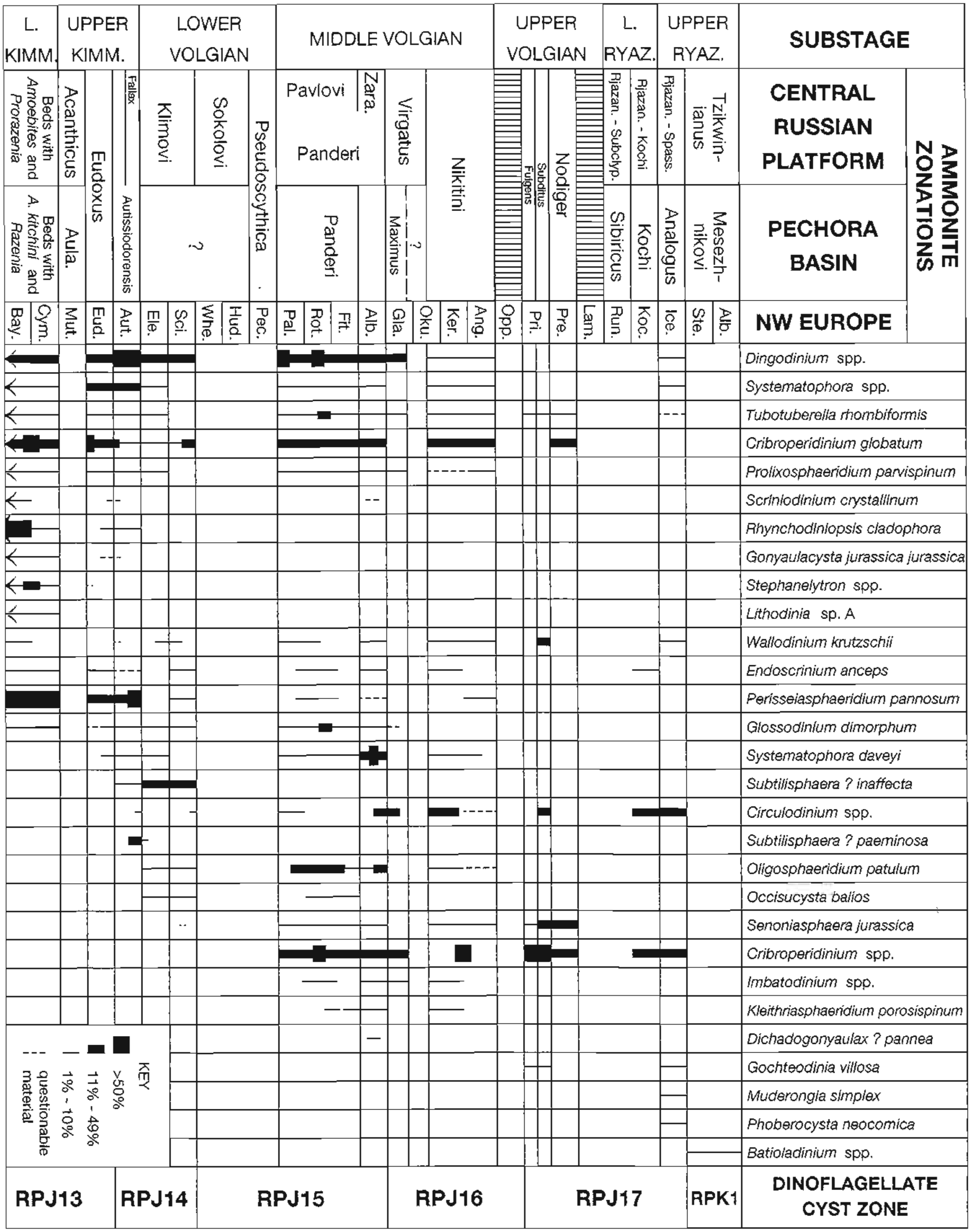

Text-Figure 23. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Volgian and Ryazanian strata of Kashpir, central Russian Platform (locality 5 of Text-Figure 5).




Text-Figure 24. The semi-quantitative stratigraphic distribution of dinoflagellate cysts from the Upper Volgian and Ryazanian strata of outcrops 6, 12 and 13 in the River Oka Basin, central Russian Platform (localities 6 and 7 of Text-Figure 5). U.J. = Upper Jurassic; U.V. = Upper Volgian; Rj.-Sp. = Rjazanensis-Spasskensis; Rj.-K. = Rjazanensis-Kochi.




Text Figure 25. A compilation of selected dinoflagellate cyst ranges for the Oxfordian strata of the Russian Platform.




Text Figure 26. A compilation of selected dinoflagellate cyst ranges for the Kimmeridgian to Ryazanian strata of the Russian Platform.

### 5.3.2 The Lower Callovian to Lower Oxfordian palynology of a section near Inkino, River Oka Basin

A suite of 7 Lower Callovian to Lower Oxfordian samples from outcrop 5, situated on the west bank of the River Oka near Inkino village in the Elatma region, River Oka Basin (Text-Figure 5), were examined. The samples are from an ammonite-bearing, mudstone-dominated succession (Text-Figure 18). The ammonite faunas indicate the presence of the Lower Callovian Elatmae Zone, the Upper Callovian Athleta Zone and the Lower Oxfordian (Mariae and Cordatum zones) (Appendix 1). The stratigraphic distributions of all dinoflagellate cysts identified are illustrated in Text-Figures 18 and A3.12. All the samples yielded relatively abundant residues and palynofloras; woody fragments and plant debris are common throughout. Miospores, particularly gymnospermous pollen, consistently numerically dominate the marine microplankton. Bisaccate pollen, *Cerebropollenites macroverrucosus*, *Classopollis classoides*, *Cyathidites* spp., *Perinopollenites elatoides* and *Vitreisporites pallidus* are typically prominent in the miospore assemblages. The dinoflagellate cyst floras are generally of relatively high species diversity (Text-Figure A3.12). Generally the associations are similar in composition and proportions to counterparts from northwest Europe. *Adnatosphaeridium caulleryi*, *Batiacasphaera* spp., *Chytroeisphaeridia chytroeides*, *Chytroeisphaeridia hyalina*, *Endoscrinium* spp., *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta*, *Mendicodinium groenlandicum*, *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Rhynchodiniopsis cladophora*, *Sentusidinium* spp. and *Sirmiodinium grossii* were present throughout the succession (Text-Figures 18, A3.12).

#### 5.3.2.1 Samples RP 23 to RP 21 (Lower Callovian, Elatmae Zone)

The occurrence of *Rhynchodiniopsis cladophora* in sample RP 23 (Text-Figures 18, A3.12) confirms that this succession is no older than Callovian as the range base of this species is within the earliest Callovian (Woollam, 1980; Riding, 1987; 1992). In Russia, *Chytroeisphaeridia hyalina* ranges from the Bathonian to the Middle Oxfordian (sections 5.2.1, 5.2.2, 5.3.1). At Inkino, however, *Chytroeisphaeridia hyalina* is most prominent in the lowermost Callovian (samples RP 23 and RP 22) (Text-Figure A3.12). *Aldorfia aldorfensis* was recognised in sample RP 22 and questionably in sample RP 23 (Text-Figure 18). This species has a known range top in the earliest Callovian (Herveyi Zone) in northwest Europe (Riding and Thomas, 1992). It appears, therefore, that this datum has widespread stratigraphic utility as the Herveyi Zone of western Europe is correlated with the Elatmae Zone of Russia (Meledina, 1994). *Ambonosphaera? staffinensis* was recorded from samples RP 22 and RP 21 (Text-Figures 18, A3.12); these occurrences are the first reports of this species in the Callovian. Poulsen and Riding (1992) gave the stratigraphic range of this species as Oxfordian to Volgian. *Cleistosphaeridium varispinosum* was recorded from sample RP 22 (Text-Figure A3.12). This species ranges from the uppermost Bathonian to the Lower Callovian in northwest Europe (Riding and Thomas, 1992). Sample RP 21 yielded *Lithodinia planoseptata;* this species is confined to the Lower Callovian in England (Riding, 1987; Riding and Thomas, 1992). The occurrence of *Pareodinia prolongata* in sample RP 21 is of interest. This distinctive form is typical of the Callovian Stage and, in high proportions, characterises the Lower Callovian (Riding, 1983a).

#### 5.3.2.2 Samples RP 20 and RP 19, (Upper Callovian, Athleta Zone)

These two Upper Callovian samples yielded relatively low diversity marine palynofloras in comparison with coeval floras from England, Scotland and continental Europe. Forms such as *Ctenidodinium ornatum*, *Gonyaulacysta centriconnata* and unequivocal *Scriniodinium crystallinum*, all present throughout the Upper Callovian of Europe (Woollam, 1980; Riding, 1987), are not represented at Inkino (Text-Figures 18 and A3.12). The stratigraphic inceptions of these and other key taxa seem to be in the uppermost Callovian (Subordinarium Zone) of the Russian Platform (section 5.2.2). *Scriniodinium crystallinum* is a good example of these apparently heterochronous taxa. This species is present throughout the Upper Callovian of England (Woollam 1980; Riding, 1987); in Scotland, however, the range base of this taxon is early Oxfordian (Riding and Thomas, 1997). A questionable specimen of *Scriniodinium crystallinum*, however, was observed from sample RP 20 (Text-Figure A3.12). There are several species present in samples RP 20 and RP 19 which are typically Lower/Middle Callovian markers in northwest Europe. These include *Chytroeisphaeridia hyalina*, *Cleistosphaeridium varispinosum* and *Lithodinia planoseptata* (Text-Figures 18 and A3.12). *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* was recorded from sample RP 19; this variety is extremely characteristic of the Lower and Middle Oxfordian (sections 5.3.1 and 5.3.3). Sample RP 19 also yielded *Mendicodinium groenlandicum* which comprises 2.1% of the dinoflagellate cyst flora (Text-Figure A3.12). In northern Europe, this species is abundant throughout the Upper Callovian (Riding, 1987).

#### 5.3.2.3 Samples RP 18 and RP 17, Lower Oxfordian (Mariae and Cordatum zones)

Sample RP 18 is rich in *Mendicodinium groenlandicum*, which comprises 13.4% of the dinoflagellate cyst flora at this horizon (Text-Figure A3.12). This abundance appears to be correlative with an acme of this species in the late Callovian-earliest Oxfordian of northwest Europe (Riding, 1987). Species common in sample RP 17 include *Crussolia deflandrei* (5.3%) and *Trichodinium scarburghense* (9.4%) (Text-Figure A3.12). *Chlamydophorella* spp. *Clathroctenocystis asapha*, *Prolixosphaeridium parvispinum* and *Sentusidinium creberbarbatum* are also confined to this interval (Text-Figure 18). Sample RP 17 proved relatively diverse, and consequently at this horizon there are the inceptions of several dinoflagellate cyst taxa. These range bases include those of *Crussolia deflandrei*, *Crussolia perireticulata*, *Endoscrinium galeritum*, *Gonyaulacysta centriconnata*, *Gonyaulacysta eisenackii*, *Paragonyaulacysta retiphragmata*, *Scriniodinium crystallinum*, *Stephanelytron caytonense*, *Stephanelytron redcliffense*, *Surculosphaeridium vestitum*, *Trichodinium scarburghensis* and *Wanaea fimbriata* (Text-Figures 18, A3.12). *Crussolia deflandrei* is deemed a reliable marker species for the earliest Oxfordian in England (Riding, 1987). However, it is present in the early Callovian of northern East Siberia (section 5.1.2), and thus appears to have a longer range in Russia. *Crussolia perireticulata* was also observed; this form is of definite Boreal affinity. It was described by Århus *et al.*

(1989) and ranges from the late Bathonian to early Oxfordian. *Paragonyaulacysta retiphragmata*, another typically Boreal form was also present in sample RP 17 (Text-Figure 18). The genus *Endoscrinium* proved common in sample RP 17, with *Endoscrinium galeritum* and *Endoscrinium* spp. present (Text-Figure A3.12). Certain taxa with inceptions in the Lower Oxfordian at Inkino are known to have Upper Callovian range bases in northwest Europe; these are *Gonyaulacysta centriconnata*, *Gonyaulacysta eisenackii*, *Rigaudella aemula*, unequivocal *Scriniodinium crystallinum*, *Stephanelytron* spp and *Trichodinium scarburghensis*. This phenonenon is due to the fact that the uppermost Callovian Subordinarium Zone was not sampled at this locality (section 5.2.2). The Lower Oxfordian marker *Wanaea fimbriata* was encountered in sample RP 17 (Text-Figure 18) and several reworked Carboniferous spores were observed in both samples RP 18 and RP 17.

### 5.3.3 The Upper Callovian to Kimmeridgian palynology of the River Unzha area, near Kostroma

Twenty-three Upper Callovian, Oxfordian and Lower Kimmeridgian samples from 3 localities on the banks of the River Unzha in the Makarjev region, east of Kostroma (Text-Figure 5) were studied. The Middle and Upper Jurassic sediments of the Russian Platform are relatively thin, reflecting slow sedimentation, due to low hinterland relief. The samples mostly yielded abundant, diverse and well-preserved palynofloras, comprising mainly dinoflagellate cysts. The stratigraphic distributions of the palynomorphs identified are illustrated in Text-Figures 19-21 and A3.13-A3.15.

#### 5.3.3.1 Section 2, samples RP 32 to RP 24 (Upper Callovian to Middle Oxfordian)

Nine samples from the Upper Callovian to Middle Oxfordian of section 2 were studied (Text-Figure 19). The three Upper Callovian samples yielded relatively low diversity associations (Text-Figure A4.13). The dinoflagellate cyst floras dominantly comprise forms originally described from western Europe. The acme of *Mendicodinium groenlandicum*, typical of western Europe, is not present and complex process-bearing forms are entirely absent. *Nannoceratopsis pellucida* is prominent in samples RP 32 and RP 31 (Text-Figure A3.13). Other common taxa include *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Endoscrinium galeritum*, *Fromea tornatilis* and *Lithodinia caytonensis* (Text-Figure 19). An apparently undescribed form of *Crussolia* was encountered in samples RP 32 and RP 31 (Text-Figure A3.13). *Leptodinium subtile* was recognised in RP 31; this species was hitherto deemed to be confined to the Upper Jurassic (Riding and Thomas, 1992).

Samples RP 29 and RP 28 are both Lower Oxfordian; these horizons proved relatively diverse, however the European zonal index *Wanaea* was not encountered (Text-Figure 19). Many species have inceptions in the Lower Oxfordian, including *Crussolia deflandrei*, *Crussolia perireticulata*, *Gonyaulacysta eisenackii* and *Gonyaulacysta jurassica* subsp. *jurassica* (Text-Figure A3.13). The genus *Crussolia* is at its most diverse during the early Oxfordian and *Crussolia dalei* is confined to this substage at this locality (Text-Figure 19). This genus typifies the early Oxfordian in western Europe (Riding and Thomas, 1997), and appears to be a typically Boreal genus. The stratigraphic ranges and relative proportions of dinoflagellate cysts, however, are closely comparable to coeval counterparts from western Europe; major biotic provincialism did not operate at this time (Smelror, 1993). Forms which are common include *Chytroeisphaeridia cerastes*, *Chytroeisphaeridia chytroeides*, *Endoscrinium galeritum*, *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis*, *Stephanelytron redcliffense* and *Stephanelytron scarburghense* (Text-Figures 19, A3.13). The range top of *Gonyaulacysta centriconnata* was observed in sample RP 29; this datum is consistent with western Europe (Riding, 1983b; Riding and Thomas, 1992). The range base of *Gonyaulacysta jurassica* subsp. *jurassica* in RP 28 also conforms to previous Lower Oxfordian records (Riding and Thomas, 1992).

The four samples assigned to the Middle Oxfordian (RP 27 to RP 24) also produced abundant dinoflagellate cyst floras (Text-Figure A3.13). *Crussolia deflandrei*, *Crussolia perireticulata* and *Crussolia* sp. are present, emphasizing the importance of this genus in the Boreal Oxfordian. *Chytroeisphaeridia cerastes*, *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* and *Trichodinium scarburghensis* are present throughout (Text-Figure A3.13); this is also consistent with western Europe. The European zonal index species *Endoscrinium luridum* was recovered from RP 26 (Text-Figure 19). This form is rare, and not consistently present, indicating that western European zonations cannot always be precisely applied in the Russian Platform. Common species include *Chytroeisphaeridia chytroeides*, *Chytroeisphaeridia cerastes*, *Endoscrinium galeritum* and *Sirmiodinium grossii* (Text-Figure A3.13). Sample RP 24 is dominated by species of *Dingodinium* (Text-Figures 19, A3.13).

#### 5.3.3.2 Section 1, samples RP 37 to RP 33 (Middle and Upper Oxfordian)

Samples RP 37 and RP 36 are similar in content to the Middle Oxfordian samples from section 2 (section 5.3.3.1). The typically Boreal species *Gonyaulacysta dualis* was recorded from RP 36 (Text-Figures 20, A3.14). The acme of *Dingodinium* sp. observed in section 2 was not encountered. An undescribed species, *Lithodinia* sp. A, with thick autophragm is common in RP 37 (Plate RP10, fig. 6; Text-Figure 20). Rare, poorly preserved chorate forms, questionably attributed to *Rigaudella aemula*, were recovered from sample RP 37 (Text-Figure A3.14).

The three Upper Oxfordian samples (RP 35 to RP 33) are characterised by relatively sparse, low diversity dinoflagellate cyst floras (Text-Figures 20, A3.14). *Chytroeisphaeridia chytroeides* and *Endoscrinium galeritum* are the most prominent elements. The range base of *Cribroperidinium globatum* was observed in sample RP 35 (Text-Figure A3.14). This event is consistent with western Europe (Riding, 1987) and appears to be of widespread regional correlative significance. *Systematophora penicillata* is present in RP 34 and *Crussolia deflandrei* appears to become extinct in the uppermost Oxfordian (sample RP 33) (Text-Figure 25).

#### 5.3.3.3 Sections 3/4, samples RP 46 to RP 38 (Lower Kimmeridgian)

The 9 Lower Kimmeridgian samples taken from sections 3/4, like those from the underlying Upper Oxfordian, are of relatively low species diversity (Text-Figures 21 and

A3.15). *Chytroeisphaeridia chytroeides*, *Cribroperidinium globatum*, *Leptodinium subtile* and *Sentusidinium* spp are prominent (Text-Figure A3.15). *Systematophora areolata* was recorded from samples RP 46, RP 44 and RP 41 (Text-Figure 21). Other notable occurrences include that of *Scriniodinium crystallinum* in RP 44 (Text-Figure A3.15). This is indicative that samples RP 46 to RP 44 are correlatable with the Baylei Zone by comparison with western Europe. (Riding and Thomas, 1992). Occurrences of *Cribroperidinium longicorne* (RP 41), *Fromea amphora* (RP 44 and RP 41) and *Wallodinium krutzschi* (RP 45) are also biostratigraphically important; all are characteristic of the Kimmeridgian. The presence of *Aldorfia dictyota* subsp. *pyrum*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Rhynchodiniopsis cladophora* and *Stephanelytron scarburghense* (Text-Figure A3.15) confirm that this section is of early Kimmeridgian age by comparison with western Europe (Riding and Thomas, 1988). *Leptodinium mirabile* was recorded from sample RP 41 (Text-Figure 21). A characteristically verrucate form of *Sentusidinium* was abundant from samples RP 45 to RP 38 and a small form of *Gonyaulacysta* occurs abundantly in RP 40 (Text-Figure A3.15). Furthermore, *Tubotuberella rhombiformis* (samples RP 44 and RP 40) is a typically Boreal element.

### 5.3.4 The Kimmeridgian to Volgian palynology of Gorodische, near Ul'yanovsk

Gorodische, near Ul'yanovsk, lies within the central Russian Platform (Text-Figure 5). Here, the Jurassic-Cretaceous sediments are relatively thin, reflecting slow sedimentation, due largely to low hinterland relief. The twenty-four samples (Text-Figure 22) yielded variably abundant organic residues and palynofloras. The palynomorphs are normally well preserved. The kerogen associations are dominated by amorphogen and/or woody tissue. Wood is abundant/dominant in samples RP 70-RP 65, RP 63-RP 61, RP 58 and RP 51-RP 47. Amorphogen is abundant/dominant in samples RP 64, RP 60 and RP 56-RP 52. Samples RP 59 and RP 57 comprise subequal proportions of wood and amorphogen. The consistent richness in amorphogen in samples RP 56-RP 52 reflects the dysaerobic conditions and oil shale deposition in the Zarajskensis Subzone of the Panderi Zone (Middle Volgian) in the Russian Platform. These radioactive/high gamma shales were deposited in anoxic conditions in stable, stratified marine waters. This distinctive palynofacies also indicates a correlation to the "hot" shales of the North Sea area (Rawson and Riley (1982). Samples RP 48 and RP 47 are dominated by prasinophycean algae (*Pterospermella* and *Tasmanites*), thereby also indicating correlation to the "hot" shales (Text-Figure A3.18).

The palynofloras are of relatively high species diversity and mainly comprise marine microplankton (Text-Figures A3.16-A3.18); dinoflagellate cysts typically dominate the palynofloras. The stratigraphic distributions of dinoflagellate cysts, other microplankton and miospores are illustrated in Text-Figures 22 and A3.16-A3.18. Dinoflagellate cysts which are prominent throughout are *Chytroeisphaeridia chytroeides*, *Cribroperidinium globatum*, *Dingodinium* spp., *Gonyaulacysta* spp., indeterminate chorate dinoflagellate cysts, *Sentusidinium* spp. and *Systematophora daveyi* (Text-Figure 22). *Tubotuberella rhombiformis* was encountered consistently in low numbers from the Kimmeridgian to the Upper Volgian (Text-Figure A3.17). The Upper Kimmeridgian-Volgian miospore floras of Gorodische are of low species diversity (Text-Figure A3.18).

The marine palynology of eight Kimmeridgian to Middle Volgian samples from Gorodische was studied by Lord et al. (1987). These authors recovered dinoflagellate cyst associations similar in species content and diversity to those reported herein.

#### 5.3.4.1 Upper Jurassic, Upper Kimmeridgian (Samples RP 70 to RP 63)

The 8 Upper Kimmeridgian samples yielded variably abundant palynofloras (Text-Figures A3.16 to A3.18). The dinoflagellate cyst assemblages are dominated by *Cribroperidinium globatum* and *Dingodinium* spp. (Text-Figure 22). The latter genus comprises 97.6% of the dinoflagellate cyst population in sample RP 63 (Text-Figure A3.16). *Dingodinium tuberosum* is prominent in samples RP 70, RP 68, RP 66 and RP 64; these samples also proved the most diverse (Figure 22). *Ambonosphaera? staffinensis*, *Batiacasphaera* spp., *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Cleistosphaeridium* spp., *Endoscrinium* spp., *Epiplosphaera* spp., *Glossodinium dimorphum*, *Gonyaulacysta* spp., *Heslertonia* spp., *Hystrichodinium pulchrum*, indeterminate chorate cysts, *Leptodinium subtile*, *Paragonyaulacysta* spp., *Pareodinia ceratophora*, *Pareodinia halosa*, *Prolixosphaeridium* spp., *?Scriniodinium crystallinum*, *Sentusidinium* spp., *Sirmiodinium grossii*, *Subtilisphaera? inaffecta*, *Subtilisphaera? paeminosa*, *Systematophora* spp. and *Tubotuberella rhombiformis* were also recognised throughout (Text-Figures A3.16 and A3.17). The association of *Ambonosphaera? staffinensis* (RP 66), *Apteodinium* sp (RP 69), *Circulodinium distinctum* (RP 63), common *Cribroperidinium globatum*, *Dingodinium* spp., *Endoscrinium anceps* (RP 68), *Epiplosphaera* spp., *Heslertonia* spp., *?Perisseiasphaeridium pannosum* (RP 70 and RP 68), *Prolixosphaeridium mixtispinosum* (RP 70 and RP 68), *Systematophora daveyi*, and *?Wallodinium krutzschii* (RP 67) is typical of the Kimmeridgian-Volgian interval (Riding and Thomas, 1988). *Glossodinium dimorphum* is a rare element in samples ?RP 70, ?RP 68, RP 67 and RP 64 (Text-Figure 22). This distinctive species is a prominent element of Middle Oxfordian to Middle Volgian palynofloras of northwest Europe (Riding and Thomas, 1992). It was reported from Gorodische by Lord et al. (1987) and appears to be far less prominent in the Russian Platform than in northwest Europe. The questionable specimens of *Scriniodinium crystallinum* in samples RP 69 and RP 67 may be reworked. This species ranges from the late Callovian to the earliest Kimmeridgian in northern Europe (Riding and Thomas, 1988; 1992). *Subtilisphaera? inaffecta* and *Subtilisphaera? paeminosa* were recorded in samples RP 66 to RP 64 (Autissiodorensis Zone) (Text-Figure 22). These species are known from the Kimmeridgian to Lower Volgian (Riding and Thomas, 1992) and are particularly common in the Autissiodorensis Zone in northwest Europe (Drugg, 1978; Poulsen, 1996; J.B.R., personal observations). *Subtilisphaera? paeminosa* was also recorded from the Upper Kimmeridgian (Autissiodorensis Zone) of Gorodische by Lord et al. (1978). The inception and acme of *Subtilisphaera? paeminosa*, therefore, appears to be a reliable marker species for the Autissiodorensis Zone throughout the Northern Hemisphere (Text-Figure A3.17). The inception of *Subtilisphaera? inaffecta* (sample RP 66) marks the base of the *Subtilisphaera? inaffecta* Interval Biozone for the Russian Platform (section 6.2). The range base of *Circulodinium* *distinctum* was observed in sample RP 63 (Text-Figure 22). This is the oldest occurrence of this species in the Russian Platform and the datum may be locally biostratigraphically significant. Rare questionable specimens of *Spiniferites* spp. were recovered from RP 66 (Text-Figure A3.17). This genus has a well established range base in the early Valanginian (Costa and Davey, 1992); thus the identification here is highly dubious. The dinoflagellate cyst Interval Biozone index for the Eudoxus Zone, *Gonyaulacysta jurassica* subsp. *jurassica*, was not observed in samples RP 70 to RP 68 (Text-Figure 22; section 6.2). Other forms characteristic of this interval, for example *Stephanelytron* spp., are also absent (Text-Figure A3.17).

### 5.3.4.2 Upper Jurassic, Lower Volgian (Samples RP 62 to RP 59)

The four Lower Volgian samples, RP 62 to RP 59, are all assigned to the Klimovi Zone. All except RP 60 produced abundant organic residues and palynofloras (Text-Figures A3.16 to A3.18). Amorphogen dominates sample RP 60 and is common in RP 59; woody tissue is the dominant kerogen maceral in RP 62 and RP 61. The abundant amorphous organic material in RP 60 indicates reducing depositional conditions, probably due to water stratification. The only palynomorphs positively identified in RP 60 were single specimens of *Cribroperidinium globatum*, an indeterminate dinoflagellate cyst and *Tasmanites* sp. (Text-Figures A3.16 and A3.18).

Samples RP 62, RP 61 and RP 59 yielded rich and relatively diverse dinoflagellate cyst floras (Text-Figures A3.16 to A3.18). *Batiacasphaera* spp., *Chytroeisphaeridia chytroeides*, *Cribroperidinium globatum*, *Dingodinium jurassicum*, *Dingodinium tuberosum*, *Ellipsiodictyum* spp., *Leptodinium subtile*, *Sentusidinium* spp. and *Subtilisphaera? inaffecta* are prominent throughout (Text-Figures A3.16 and A3.17). Also consistently present in lower numbers are *Cleistosphaeridium* spp., *Glossodinium dimorphum*, *Gonyaulacysta* spp., *Heslertonia* spp., *Hystrichodinium pulchrum*, *Kalyptea stegasta*, *Occisucysta balios*, *Oligosphaeridium patulum*, *Pareodinia* spp., *Prolixospharidium parvispinum*, *Scriniodinium inritibile*, *Sentusidinium creberbarbatum*, *Sirmiodinium grossii* and *Tubotuberella rhombiformis* (Text-Figure 22). The co-occurrences of *Circulodinium distinctum* (RP 59), *Cribroperidinium globatum*, *Dingodinium* spp., *Endoscrinium anceps* (RP 59), *Glossodinium dimorphum*, *Hystrichosphaerina orbifera* (RP 61), *Occisucysta balios*, *Oligosphaeridium patulum*, *Perisseiasphaeridium pannosum* (RP 59), *Subtilisphaera? inaffecta*, and *Wallodinium krutzschii* (RP 61) are characteristic of the Volgian Stage (Riding and Thomas, 1988; 1992). The range tops of *Subtilisphaera? inaffecta* (RP 59) and *Subtilisphaera? paeminosa* (RP 62) both occur in this interval (Text-Figure 22). The former datum marks the top of the *Subtilisphaera? inaffecta* Interval Biozone in the Russian Platform (section 6.2). The acme occurrence of *Subtilisphaera? inaffecta* is in RP 59, where it represents 21.7% of the dinoflagellate cyst assemblage (Text-Figure A3.17). The range base of *Oligosphaeridium patulum* was observed in RP 61 (Text-Figure 22). This datum occurs in the Kimmeridgian (Cymodoce/Mutabilis zones) in England (Riding and Thomas, 1988). The unequivocal range base of the apparently closely related *Perisseiasphaeridium pannosum* occurs in RP 59 at Gorodische (Text-Figure 22). The distinctive species *Occisucysta balios* was recorded from RP 62 and RP 59 and these represent the oldest occurrences in this study (Text-Figures 26, A3.17). Like *Oligosphaeridium patulum*, it occurs in older sediments (latest Oxfordian and Kimmeridgian) in southern England (Riding and Thomas, 1988). The inception of *Dingodinium jurassicum* occurs in RP 62 (Text-Figure 22); this bioevent may be of local correlative significance. Poulsen (1996) recorded this species from the late Callovian to Ryazanian of Denmark and Poland. The single record of *Hystrichosphaerina orbifera* in RP 61 is consistent with a Volgian age as this chorate species is known from the late Oxfordian to the mid Volgian (Riding and Thomas, 1992). Rare *Kalyptea stegasta* were observed in samples RP 62 and RP 59 (Text-Figure 22). This species is most common in the mid Callovian, but may be present sporadically in the Late Jurassic (Partington et al., 1993). Rare, questionable specimens of *Protobatioladinium westburiensis* were observed in RP 59 (Text-Figure A3.17). In western Europe, this species ranges from the Kimmeridgian to the Lower Volgian (Nøhr-Hansen, 1986; Ioannides et al., 1988).

### 5.3.4.3 Upper Jurassic, Middle Volgian (Samples RP 58 to RP 49)

The seven Middle Volgian samples from the Panderi Zone (RP 58 to RP 52) produced typical "hot" shale palynofacies, the residues being consistently rich in amorphogen and sporadically yielding prasinophycean alga (Text-Figure A3.18). This palynofacies is especially well-developed in the five samples from the Zarajskensis Subzone (RP 56 to RP 52). The three samples from the Virgatus and Nikitini zones, RP 51 to RP 49, produced wood-rich palynofacies. Apart from RP 56, RP 52, RP 51 and RP 49, all samples yielded abundant palynofloras rich in dinoflagellate cysts. The most prominent forms are *Cribroperidinium globatum*, *Dingodinium* spp., *Gonyaulacysta* spp., indeterminate chorate forms and *Systematophora daveyi* (Text-Figures A3.16, A3.17). Also present throughout in smaller proportions are *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Cleistosphaeridium* spp., *Endoscrinium* spp., *Glossodinium dimorphum*, *Kleithriasphaeridium porosispinosum*, *Leptodinium* spp., *Oligosphaeridium patulum*, *Pareodinia* spp., *Prolixosphaeridium parvispinum*, *Sirmiodinium grossii* and *Tubotuberella rhombiformis* (Text-Figure 22). Several species which are characteristic of the Middle Volgian of northwest Europe were encountered. These include *Aldorfia dictyota*, *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Cleistosphaeridium* spp., *Cribroperidinium globatum*, *Dingodinium tuberosum*, *Endoscrinium anceps*, *Glossodinium dimorphum*, *Prolixosphaeridium parvispinum*, *Senoniasphaera jurassica*, *Systematophora* spp., *Tubotuberella apatela* and *Wallodinium krutzschii* (Text-Figures A3.16, A3.17) (Riding and Thomas, 1988). The range base of *Cassiculosphaeridia* spp. is in sample RP 58 (Text-Figure 22), and this bioevent may be of local stratigraphic significance in the Russian Platform. In western Europe, this datum normally occurs close to the mid-late Volgian transition (J.B.R., personal observations). Rare *Cribroperidinium longicorne* are present in RP 57 (Text-Figure A3.16); the range top of this form in England is within the early Volgian (Hudlestoni Zone) (Riding and Thomas, 1988). *Rhynchodiniopsis martonense* was encountered in RP 53 (Text-Figure 22). This form may prove to be a reliable mid Volgian marker in the Russian Platform, however it was first reported from the early Volgian of North Yorkshire, UK (Bailey et al., 1997). Ctenidodinioid cysts are rare elements in the Middle Volgian of Gorodische. *?Cribroperidinium chondrum* was recovered from RP 57 and RP 50 and *Dichadogonyaulax? pannea* from RP 55 (Text-Figure 22). *Cribroperidinium chondrum* is common in the Kimmeridgian of western Europe (Drugg, 1978) and *Dichadogonyaulax? pannea* has an intra Volgian range base (Riding and Thomas, 1988). The range top of unequivocal *Glossodinium dimorphum* is in RP 53 (Text-Figure 22). This bioevent is a reliable marker for the Anguiformis Zone in northwest Europe (Riding and Thomas, 1992). Hence this important datum is younger in western Europe than the Russian Platform. The undescribed form *Imbatodinium* sp. A was observed in RP 50 (Text-Figure A3.17). The chorate dinoflagellate cyst *Kleithriasphaeridium porosispinum* is present in significant numbers in samples RP 55 to RP 50 (Text-Figure 22) and appears to be a potential marker for the Middle Volgian of the Russian Platform. In Britain, the range base of this species is close to the early-mid Volgian transition (J.B.R., personal observations). *Oligosphaeridium patulum* was also found in samples RP 55 to RP 50 (Text-Figure A3.17). This distinctive chorate form was also found in the Lower-Middle Volgian of Gorodische by Lord et al. (1978), as *Oligosphaeridium pulcherrimum* (*sensu* Ioannides et al., 1976). In England, this species ranges from the Kimmeridgian to the Lower Volgian (Riding and Thomas, 1988; 1992). The very similar *Perrisseiasphaeridium pannosum* was recorded in sample RP 49 (Text-Figure 22); this species is typical of the Kimmeridgian to lowermost Middle Volgian in England (Riding and Thomas, 1988, text-fig. 6). It therefore seems that *Oligosphaeridium patulum* and *Perrisseiasphaeridium pannosum* range slightly stratigraphically higher in the Russian Platform than in northwest Europe. Unequivocal specimens of *Senoniasphaera jurassica* were recorded from samples RP 53 to RP 49 (Text-Figure 22). This species ranges from the Kimmeridgian to the mid Volgian in western Europe (Poulsen and Riding, 1992); however, it is commonest in the Volgian in England and the North Sea. It seems to be a reliable marker for the mid-late Volgian of the Russian Platform.

#### 5.3.4.4 Upper Jurassic, Upper Volgian (Samples RP 48 and RP 47)

The two Upper Volgian samples produced similar organic residues which are dominated by wood fragments. Sample RP 48 also yielded abundant resistant mineral grains. The palynoflora from this horizon was overwhelmingly dominated by the prasinophytes *Pterospermella* and *Tasmanites*. The only other palynomorph taxa identified were rare bisaccate pollen and *Botryococcus braunii* (Text-Figure A3.18). The acme of *Pterospermella/Tasmanites* indicates a correlation with the "hot" shale palynofacies of the North Sea region (Rawson and Riley, 1982).

Sample RP 47, however, produced a relatively abundant palynoflora; prasinophycean alga again are the dominant elements; these comprise *Lancettopsis lanceolata, Pterospermella* and *Tasmanites* (Text-Figure A3.18). Additionally, dinoflagellate cysts and miospores are common and rare respectively. Prominent dinoflagellate cysts include *Cribroperidinium globatum, Cribroperidinium* spp., indeterminate chorate forms and *Senoniasphaera jurassica* (Text-Figures A3.16, A3.17). *Egmontodinium torynum, Oligosphaeridium* sp. and *Tubotuberella rhombiformis* are also present (Text-Figures A3.16, A3.17). The presence of common *Cribroperidinium* spp. and *Senoniasphaera jurassica* together with *Tubotuberella rhombiformis* is typical of the late Volgian (Davey, 1979).

### 5.3.5 The Middle Volgian to Ryazanian palynology of Kashpir

Nine Middle Volgian to Ryazanian samples, RP 79 to RP 71, from Kashpir (Text-Figure 5) were studied. The samples mostly yielded abundant and well-preserved palynofloras, largely comprising low diversity associations of marine microplankton; the kerogen associations are dominated by woody tissue. The stratigraphic distribution of the marine palynomorphs is illustrated in Text-Figures 23 and A3.19. The marine palynology of two Middle Volgian samples from Kashpir was described by Lord et al. (1987). The latter study yielded dinoflagellate cyst associations similar to those reported herein.

#### 5.3.5.1 Middle and Upper Volgian (Samples RP 79 to RP 72)

The Volgian strata of Kashpir are rich in amorphogen and/or prasinophycean algae and are thus correlatives of the Volgian-Ryazanian "hot" shales of the North Sea Basin (Rawson and Riley, 1982). Specifically, samples RP 78, RP 77, RP 75 and RP 74 proved extremely rich in *Tasmanites* spp. (Text-Figure A3.19), and amorphous organic material is present in sample RP 73. Prominent dinoflagellate cysts include *Chlamydophorella* spp., *Cribroperidinium* spp., *Gonyaulacysta* spp. *Senoniasphaera jurassica* and indeterminate chorate morphotypes. *Tubotuberella rhombiformis* and *Wallodinium krutzschii* were also encountered sporadically (Text-Figures 23 and A3.19).

Samples RP 79 to RP 75 are all from the Panderi Zone; dinoflagellate cysts confined to this interval include *Bourkodinium* sp., *Dingodinium* spp., *Egmontodinium* sp., *Imbatodinium* sp. A, *Leptodinium subtile, Occisucysta balios, Oligosphaeridium patulum* and *Systematophora* spp. (Text-Figures 23 and A3.19). The range tops of *Leptodinium subtile, Occisucysta balios* and *Oligosphaeridium patulum* are of most interest. The position of the extinction datum of *Occisucysta balios* is consistent with its location in northwest Europe; Riding and Thomas (1988; 1992) reported that this datum lies within the coeval Fittoni Zone of southern England. The range top of *Oligosphaeridium patulum* is approximately coeval in northwest Europe and the Russian Platform (section 5.3.4). Riding and Thomas (1988; 1992) stated that this event in England is within the Pectinatus Zone, i.e. slightly older than this datum at Kashpir. The range top of *Leptodinium subtile* in sample RP 76 may be of stratigraphic significance in the Russian Platform. This bioevent is coincident with most other European studies (e.g. Riding and Thomas, 1988, text-fig. 3).

The three samples RP 74 to RP 72 span the Nikitini to Subditus zones (Text-Figure 23). Species of *Cribroperidinium* are extremely abundant, reaching 85.1% in sample RP 74 (Text-Figure A3.19). *Senoniasphaera jurassica* is present in all three samples (Text-Figure 23). The range of this distinctive species appears to be significantly different in northwest Europe and the Russian Platform. Riding and Thomas (1988; 1992) and Poulsen and Riding (1992) gave the European range of this species as Kimmeridgian to mid Volgian (Baylei to Anguiformis zones). However, Poulsen and Riding (1992) stated that the precise range top of *Senoniasphaera jurassica* is uncertain. The species appears to be somewhat heterochronous, yet apparently is a good marker for the Middle and Upper Volgian of the Russian Platform (section 5.3.4). *Chlamydophorella* spp. (samples RP

74 to RP 72) may also prove to be of correlative significance. The inception of marginate forms such as *Circulodinium distinctum* is within the late Volgian; this species was encountered in sample RP 72. *Systematophora daveyi* was recorded in sample RP 74 (Text-Figure 23). This species is known from the Kimmeridgian to Ryazanian of northwest Europe (Riding and Thomas, 1988).

#### 5.3.5.2 Ryazanian (Sample RP 71)

The single Ryazanian sample yielded a residue rich in resistant mineral grains and amorphous organic material. The palynomorph yield was moderate and the preservation poor. Marine microplankton proved low in diversity; *Cribroperidinium* spp. and *Circulodinium distinctum* are the most abundant elements (Text-Figures 23, A3.19). A single specimen of ?*Achomosphaera* was encountered (Text-Figure A3.19), however the equivocal nature of this form precludes a conclusion regarding the stratigraphic significance of this genus in Russia. ?*Cassiculosphaeridia* spp. were observed; this genus is reminiscent of the earliest Cretacous; however, the sample lacks reliable Ryazanian marker species.

### 5.3.6 The Upper Volgian and Ryazanian palynology of the River Oka Basin

A suite of 6 Upper Volgian and Ryazanian samples (RP 85 to RP 80) from the River Oka Basin (Text-Figure 5) were studied. They mostly yielded abundant and well-preserved palynofloras, largely comprising low diversity dinoflagellate cyst and/or prasinophycean algae associations (Text-Figures 24 and A3.20). The kerogen associations are largely dominated by woody tissue. Species of *Pterospermella* are abundant in all the samples except RP 81 (Text-Figure A3.20); these high levels of prasinophytes indicate a correlation with the "hot" shales of the North Sea (Rawson and Riley, 1982). This palynofacies is interpreted as representing quiet, stratified marine shelfal conditions.

#### 5.3.6.1 Upper Volgian and Ryazanian of outcrop 12, Kuzminskoje

Three samples (RP 82 to RP 80), close to the Jurassic-Cretaceous boundary from this locality were studied. Prasinophycean algae, mostly *Pterospermella* spp. proved largely dominant (Text-Figure A3.20). The dinoflagellate cyst genera *Cassiculosphaeridia*, *Chlamydophorella*, *Circulodinium*, *Cribroperidinium*, *Dingodinium* and *Gonyaulacysta* are common throughout (Text-Figure 24). Other dinoflagellate cyst taxa present are *Ambonosphaera? staffinensis*, *Circulodinium distinctum*, *Gochteodinia villosa* and *Wallodinium krutzschii*; gymnospermous pollen are also common (Text-Figure A3.20).

Sample RP 82 is from the Upper Volgian (Subditus Zone); it produced a relatively abundant dinoflagellate cyst flora of moderate species diversity. Species confined to this sample include *Cribroperidinium gigas* and *Senoniasphaera jurassica* (Text-Figure 24). *Cribroperidinium gigas* ranges from the Kimmeridgian to Ryazanian (Bailey, 1993) and *Senoniasphaera jurassica* is prominent in the Kimmeridgian to Middle Volgian of northwest Europe (Riding and Thomas, 1988; Poulsen and Riding, 1992). The presence of *Senoniasphaera jurassica* in the Upper Volgian of the Russian Platform means, therefore, that the range top of this species exhibits some heterochroneity, assuming that the ammonite correlations are correct (section 5.3.5). The occurrence of the superficially similar *Ambonosphaera? staffinensis* is entirely consistent with the known range of this species (Poulsen and Riding, 1992). *Gochteodinia villosa* was also recorded from this sample (Text-Figures 24 and A3.20); its range base in England is latest mid Volgian (Riding and Thomas, 1992). It appears that this datum may be of widespread correlative value. The occurrences of *Tubotuberella rhombiformis* and *Wallodinium krutzschii* in this ammonite-dated material may also prove significant.

Samples RP 81 and RP 80 from the Ryazanian of outcrop 12 produced similar residues and palynofloras to those of sample RP 82 in terms of content and productivity (Text-Figure A3.20). The presence of prominent *Circulodinium* and *Cribroperidinium* are typical of the Ryazanian (Davey, 1982). *Dingodinium* spp. are confined to these Ryazanian samples (Text-Figure 24). The two samples are interpreted as being of late Ryazanian age due to the presence of *Muderongia simplex* (Text-Figures 24 and A3.20). This species has an inception in the late Ryazanian of northwest Europe (Woollam and Riding, 1983). Furthermore, the range top of *Stiphrosphaeridium dictyophorum* (sample RP 81) is intra-late Ryazanian (Costa and Davey, 1992). The co-occurence of *Muderongia simplex* and *Stiphrosphaeridium dictyophorum* in sample RP 81 is thus strong evidence of a late Ryazanian age. Other occurrences of potential stratigraphic importance are those of *Gochteodinia villosa* (sample RP 81) and *Wallodinium* spp. (sample RP 80). Both these forms are typical Ryazanian elements (Davey, 1982).

#### 5.3.6.2 Ryazanian of outcrop 13, Kuzminskoje

Two Ryazanian samples (RP 84 and RP 83) from this locality were examined. The residues and palynofloras proved similar to those recorded from the Ryazanian of outcrop 12 (section 5.3.6.1). The dominant elements are woody tissue and *Pterospermella* spp. Species of *Chlamydophorella* and *Cribroperidinium* are prominent in the relatively sparse dinoflagellate cyst associations (Text-Figures 24 and A3.20). *Circulodinium compta* (sample RP 84) is typically common in the Ryazanian of western European (Davey, 1982; Costa and Davey, 1992). *Endoscrinium anceps* was observed in sample RP 83; this form ranges from the mid Volgian to the Early Cretaceous (Raynaud, 1978). Questionable specimens of *Senoniasphaera jurassica* were recovered from sample RP 84 (Text-Figure 24). The range top of this species in northwest Europe is mid Volgian (Riding and Thomas, 1992). Poulsen and Riding (1992, text-fig. 2) demonstrated that occurrences of this species in the Early Cretacous are stratigraphically recycled, thus the ?*Senoniasphaera jurassica* specimens in sample RP 84 are therefore interpreted as having being reworked.

#### 5.3.6.3 Ryazanian of outcrop 6, River Black

The single Ryazanian sample, RP 85 from the banks of the River Black is dominated by *Pterospermella* and other prasinophytes (Text-Figure A3.20). Dinoflagellate cysts are subordinate; prominent genera comprise *Chlamydophorella*, *Circulodinium* and *Cribroperidinium* (Text-Figures 24 and A3.20). The presence of the ceratioid species *Muderongia simplex* and *Phoberocysta neocomica* (Text-Figure 24) is indicative of a late Ryazanian age. Woollam and Riding (1983) and Costa and Davey (1992) reported that a suite including these forms has its inception within the late Ryazanian Stenomphalus Zone. The occurrences of *Circulodinium compta* and *Tubotuberella apatela* (Text-Figure 24) indicate that the minimum age is late Ryazanian to early Valanginian by comparison with western Europe (Costa and Davey, 1992, text-fig 3.3). *Wallodinium cylindricum* and *Wallodinium krutzschii* were also recovered from this sample (Text-Figure A3.20). These forms are relatively long ranging and have been reported from the Ryazanian of northwest Europe (Heilmann-Clausen, 1987; Riding, 1994).

### 5.3.7 Summary of the Middle Jurassic to lowermost Cretaceous palynology of the central Russian Platform

The Bathonian strata of the central Russian Platform have produced abundant dinoflagellate cyst associations of relatively low species diversity. These include the endemic, biostratigraphically significant forms *Protobatioladinium elatmaensis* and *Protobatioladinium? elongatum*. *Ctenidodinium sellwoodii* is also present in significant proportions, together with occasional *Dissiliodinium* spp. and *Paragonyaulacysta* spp. The Callovian dinoflagellate cyst record from this area exhibits the familiar global trend of markedly increasing dinoflagellate cyst diversity from the early to late Callovian. The Lower Callovian normally yields rich associations, including *Chytroeisphaeridia hyalina*, *Fromea tornatilis*, *Nannoceratopsis pellucida* and *Pareodinia ceratophora*. Typically Boreal forms such as *Crussolia dalei* were not observed. The late Callovian to mid Oxfordian dinoflagellate cysts from the central part of the Russian Platform are abundant, diverse and similar to coeval floras from northwest Europe. The genera *Chytroeisphaeridia*, *Endoscrinium*, *Gonyaulacysta* and *Sentusidinium* are prominent. Many of the marker species defined elsewhere in the Northern Hemisphere are present and have similar stratigraphic ranges. These include *Ctenidodinium continuum*, *Endoscrinium luridum*, *Gonyaulacysta centriconnata*, *Gonyaulacysta jurassica* and *Wanaea* spp. As in the Pechora Basin, certain key late Callovian marker species are not present in the earliest late Callovian (Athleta Zone) of the central Russian Platform. The late Oxfordian of the River Unzha region produced relatively sparse, low diversity dinoflagellate cyst floras.

The Lower Kimmeridgian of the River Unzha, near Kostroma produced palynofloras of moderate diversity dominated by species typical of northwest Europe. *Cribroperidinium globatum* and *Dingodinium* spp. dominate the Upper Kimmeridgian of Gorodische. *Glossodinium dimorphum* proved rare and *Subtilisphaera? inaffecta* and *Subtilisphaera? paeminosa* are common around the Kimmeridgian/Volgian transition. Amorphous organic material and prasinophytes are common in the Volgian of this area. This widespread palynofacies is best developed in the Zarajskensis Subzone (Panderi Zone) and reflects marine water stratification which produced anaerobic conditions at the sea floor. Prasinophytes were especially common in the Upper Volgian of Gorodische, Kashpir and the River Oka Basin. Volgian dinoflagellate cyst assemblages from the central Russian Platform are generally abundant and comprise significant proportions of chorate forms such as *Oligosphaeridium patulum* and *Perisseaisphaeridium pannosum*. They also include prominent *Cribroperidinium* spp., *Hystrichodinium pulchrum*, *Prolixosphaeridium* spp., *Senoniasphaera jurassica* and *Tubotuberella rhombiformis*. The inception of *Gochteodinia villosa* occurs within the Upper Volgian.

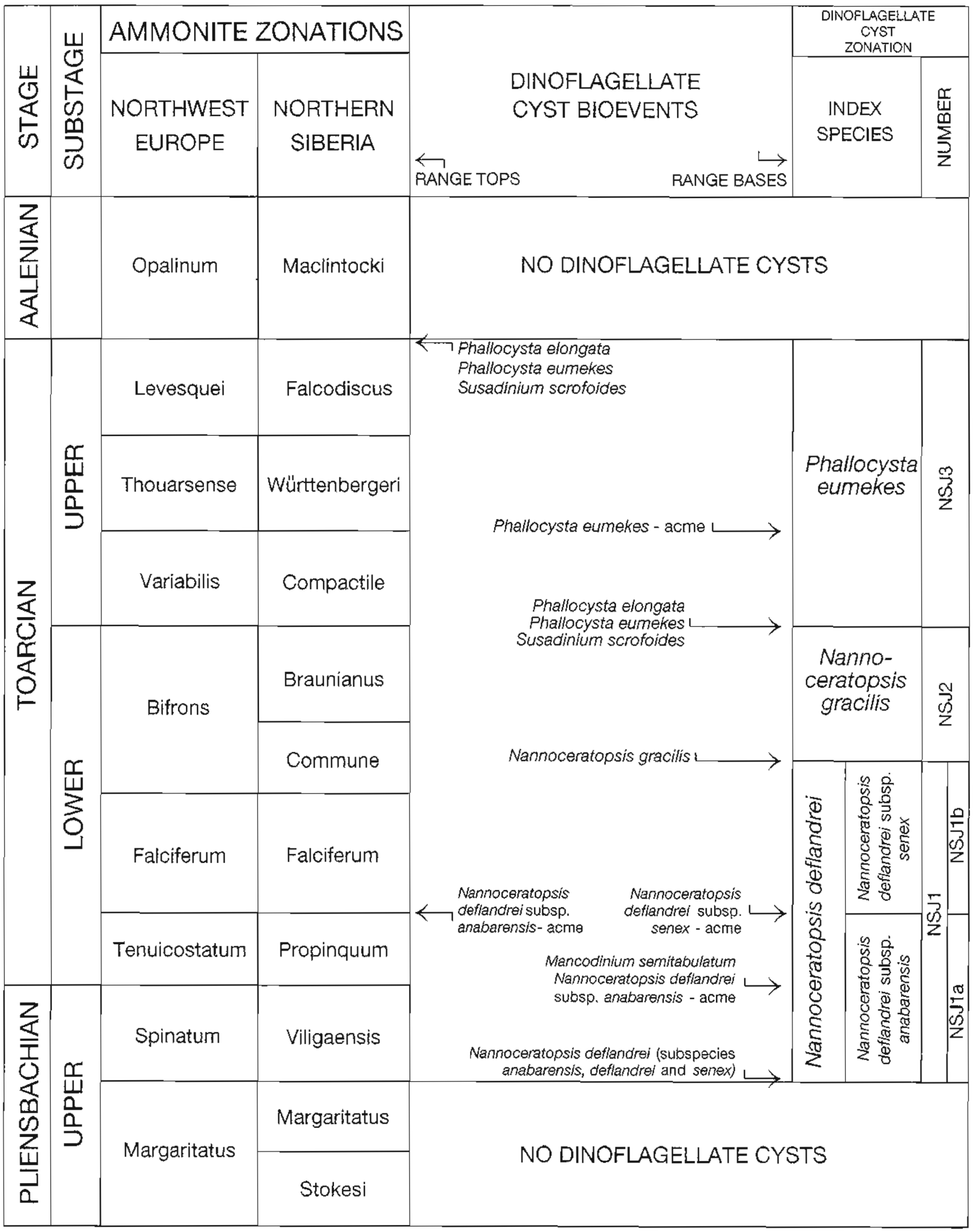
The Ryazanian of the River Oka Basin has produced relatively abundant dinoflagellate cyst floras including the ceratioid species *Muderongia simplex* and *Phoberocysta neocomica*.

# 6 DINOFLAGELLATE CYST ZONATION OF THE JURASSIC AND EARLIEST CRETACEOUS OF NORTHERN EAST SIBERIA AND THE RUSSIAN PLATFORM

In this section, three dinoflagellate cyst Interval Biozones (one of which is subdivided into two Interval Subbiozones) for the latest Pliensbachian to late Toarcian of northern East Siberia and eighteen dinoflagellate cyst Interval Biozones for the Bathonian to Ryazanian of the Russian Platform are proposed. The Biozones are all defined using the range tops and/or range bases of selected dinoflagellate cyst taxa. These taxa were selected for their abundance, ease of recognition, biostratigraphic reliability and wide geographic distribution. If possible, taxa which have previously been used as zonal indices in previous Northern Hemisphere dinoflagellate cyst biozonations were chosen. Wherever possible, the dinoflagellate cyst Interval Biozones are calibrated with regional ammonite successions which are in turn linked to the Standard Ammonite zonation. Where ammonites are sparse or lacking, the successions are linked to the Standard Zonation using comparisons of the Russian dinoflagellate cyst floras with western European palynozonations (e.g. Woollam and Riding, 1983; Riding and Thomas, 1992). The biozonations for the Lower Jurassic of northern East Siberia and the Bathonian-Ryazanian of the Russian Platform has drawn on data from previous dinoflagellate cyst zonal schemes for these regions (Ilyina, 1991a,b; Jakovleva, 1993; Ilyina in Ilyina et al., 1994; Meledina et al., 1998). Text-Figure 27 summarises the Upper Pliensbachian to Toarcian dinoflagellate cyst zonation proposed herein for northern East Siberia and Text-Figure 28 compares this scheme to the relevant ammonite and previous dinoflagellate cyst zonations. The Bathonian and Callovian dinoflagellate cyst zones defined for the Russian Platform are illustrated in Text-Figure 29; these are compared with other biozonations in Text-Figure 30. Text-Figures 31 and 32 illustrate respectively the Oxfordian to Ryazanian biozonation and its comparison to macrofaunal and other palynozonations.

## 6.1 NORTHERN EAST SIBERIA

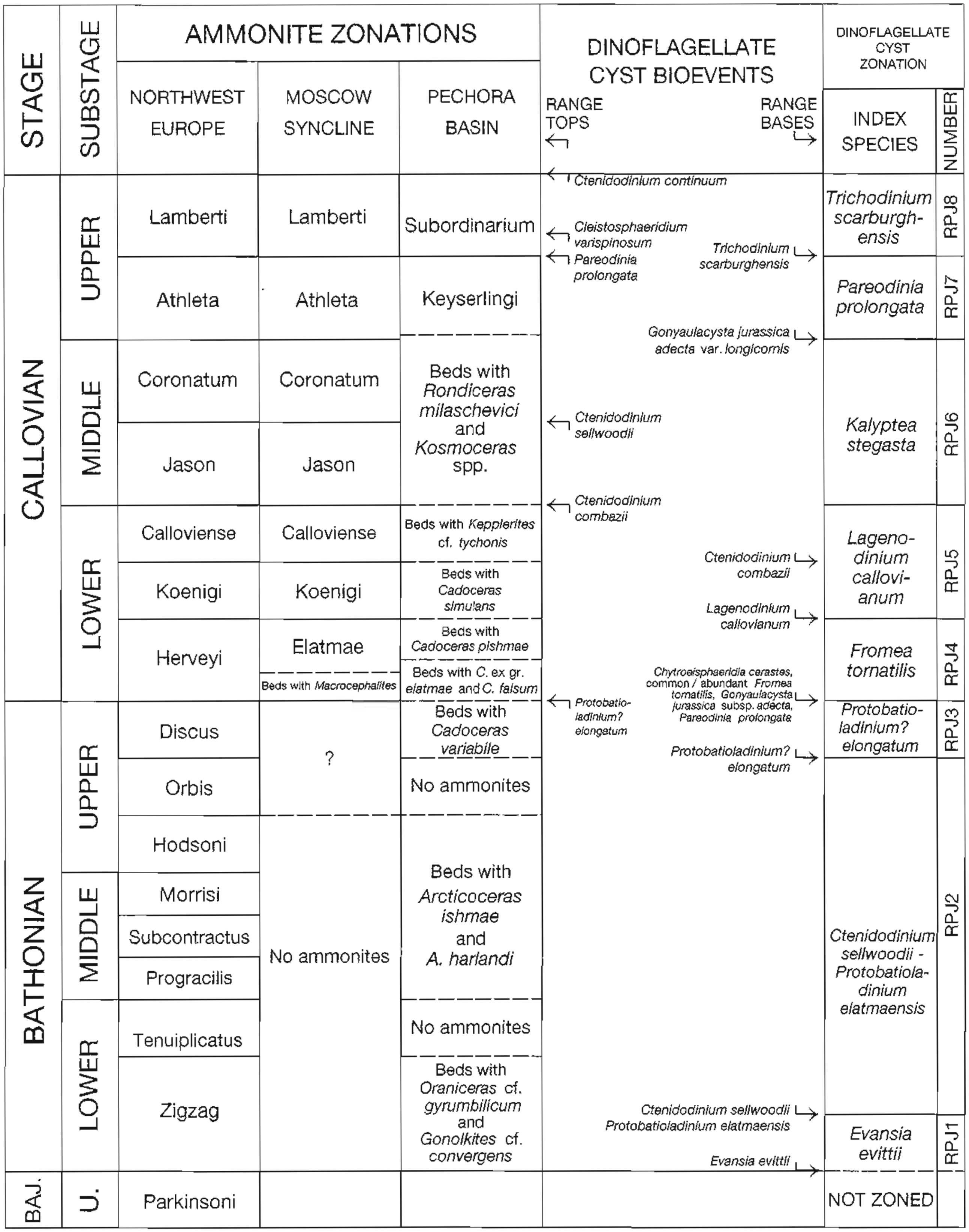
The definitions of the three dinoflagellate cyst Interval Biozones and the two dinoflagellate cyst Interval Subbiozones proposed for the latest Pliensbachian to late Toarcian of northern East Siberia are illustrated in Text-Figure 27. The relationships of these new biozones with the standard and the local ammonite zonations and the coeval dinoflagellate cyst biozonations of Riding and Thomas (1992) and Ilyina in Ilyina et al. (1994) are depicted in Text-Figure 28. The Interval Biozones and Subbiozones are numbered in ascending stratigraphic order; they are prefixed by 'NSJ', which is an acronym for 'Northern Siberia Jurassic'.




Text Figure 27. The Upper Pliensbachian to Toarcian dinoflagellate cyst zonation for northern East Siberia proposed herein, comprising the key dinoflagellate cyst bioevents and the relevant ammonite zonations.

| SYSTEM | SERIES | STAGE | SUBSTAGE | NW EUROPE: Standard (Ammonite) zones | NORTHERN SIBERIA: Ammonite zones (Zakharov et al., 1997) | NORTHERN SIBERIA: Dinoflagellate cyst zones and subzones (Ilyina in Ilyina et al., 1994) | | NORTHERN SIBERIA: Dinoflagellate cyst zones and subzones, Present Biozonation | | | | NORTHWEST EUROPE: Dinoflagellate cyst zones and subzones (Riding and Thomas, 1992) | | NORTHWEST EUROPE: Standard (Ammonite) zones | SUBSTAGE | STAGE | SERIES | SYSTEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JURASSIC | MIDDLE | AALE-NIAN | | Opalinum | Maclintocki | NO DINOFLAGELLATE CYSTS | | | | | | *Nannoceratopsis gracilis* (Ngr) (pars) | Ngr (c) | Opalinum | | AALE-NIAN | MIDDLE | JURASSIC |
| | LOWER | TOARCIAN | UPPER | Levesquei | Falcodiscus | *Phallocysta eumekes- Dodekovia scroloides- Valvaeodinium aquilonium* | V - *Valvaeodinium aquilonium - Nannoceratopsis* cf. *triangulata* | *Phallocysta eumekes* | | NSJ3 | | | | Levesquei | UPPER | TOARCIAN | LOWER | |
| | | | | Thouarsense | Württenbergeri | | | | | | | | Ngr (b) | Thouarsense | | | | |
| | | | | Variabilis | Compactile | | IV - *Phallocysta eumekes* | | | | | | | Variabilis | | | | |
| | | | LOWER | Bifrons | Braunianus | *Nannoceratopsis deflandrei- Nannoceratopsis gracilis* | III - *Nannoceratopsis gracilis* | *Nannoceratopsis gracilis* | | NSJ2 | | | | Bifrons | LOWER | | | |
| | | | | | Commune | | II - *Nannoceratopsis deflandrei* subsp. *senex* | *Nannoceratopsis deflandrei* | *Nannoceratopsis deflandrei* subsp. *senex* | NSJ1 | NSJ1b | | | | | | | |
| | | | | Falciferum | Falciferum | | | | | | | | Ngr (a) | Falciferum | | | | |
| | | | | Tenuicosta-tum | Propinquum | | I - *Nannoceratopsis deflandrei* subsp. *anabarensis* | | *Nannoceratopsis deflandrei* subsp. *anabarensis* | | NSJ1a | *Luehndea spinosa* (Lsp) | Lsp (b) | Tenuicosta-tum | | | | |
| | | PLIENS-BACHIAN | UPPER | Spinatum | Viligaensis | | | | | | | | Lsp (a) | Spinatum | UPPER | PLIENS-BACHIAN | | |
| | | | | Margaritatus | Margaritatus | NO DINOFLAGELLATE CYSTS | | | | | | | | Margaritatus | | | | |
| | | | | | Stokesi | | | | | | | | | | | | | |

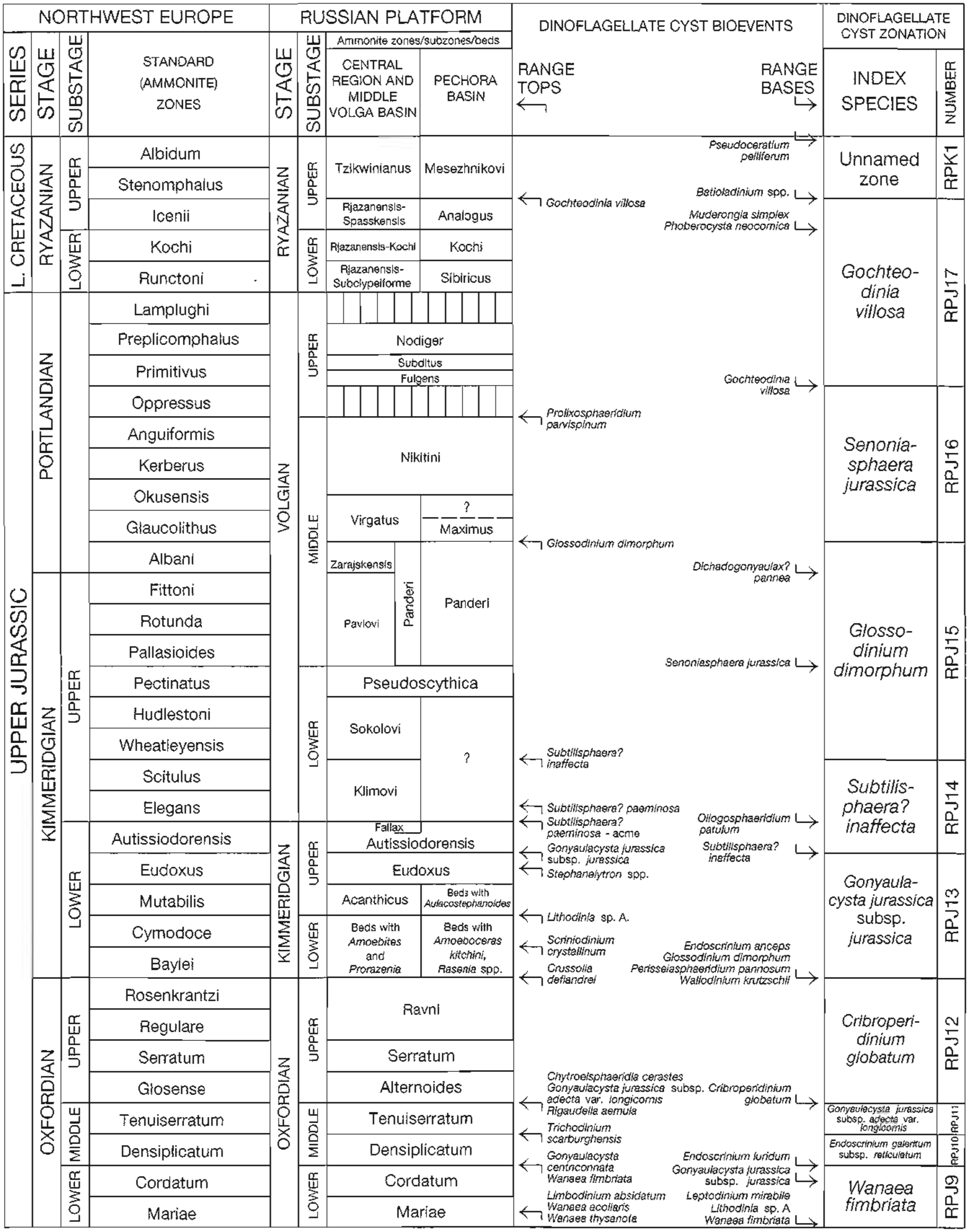
Text Figure 28. Comparison and correlation of the Upper Pliensbachian to Toarcian dinoflagellate cyst zonation for northern East Siberia proposed herein, with the dinoflagellate cyst zonations of Riding and Thomas (1992) and Ilyina in Ilyina et al. (1994) and the relevant ammonite zonations.




Text Figure 29. The Bathonian and Callovian dinoflagellate cyst zonation for the Russian Platform proposed herein, comprising the key dinoflagellate cyst bioevents and the relevant ammonite zonations.

| SYSTEM | SERIES | STAGE | SUBSTAGE | NW EUROPE Standard (Ammonite) zones | RUSSIAN PLATFORM Ammonite zones/beds: Moscow Syncline | Ammonite zones/beds: Pechora Basin | Dinoflagellate cyst zones/beds: Moscow Syncline, Pechora Basin and other regions (Ilyina, 1991a,b) | Dinoflagellate cyst zones/beds: Pechora Basin (Meledina et al., 1988) | Dinoflagellate cyst zones/beds: Present Biozonation | | NORTHWEST EUROPE Dinoflagellate cyst zones and subzones (Riding and Thomas, 1992) | | Standard (Ammonite) zones | SUBSTAGE | STAGE | SERIES | SYSTEM |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| JURASSIC | MIDDLE | CALLOVIAN | UPPER | Lamberti | Lamberti | Subordinarium | *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis*; VIII - Beds with *Belodinium asaphum* - *Lagenadinium scarburghensis* | ? | *Trichodinium scarburghensis* | RPJ8 | *Wanaea thysanota* | Wth | Lamberti | UPPER | CALLOVIAN | MIDDLE | JURASSIC |
| | | | | Athleta | Athleta | Keyserlingi | VII - *Rigaudella aemula* - *Cleistosphaeridium varispinosum* | VII - *Rigaudella aemula*, *Pareodinia prolongata* | *Pareodinia prolongata* | RPJ7 | | | Athleta | | | | |
| | | | MIDDLE | Coronatum | Coronatum | Beds with *Rondiceras milaschevici* and *Kosmoceras* spp. | VI - Beds with *Chytroeisphaeridia cerastes* - *Netrelytron stegastum* | VI - *Chytroeisphaeridia cerastes* - *Netrelytron stegastum* | *Kalyptea stegasta* | RPJ6 | *Ctenidodinium continuum* | Cco | Coronatum | MIDDLE | | | |
| | | | | Jason | Jason | | | | | | | | Jason | | | | |
| | | | LOWER | Calloviense | Calloviense | Beds with *Kepplerites* cf. *tychonis* | V - *Lagenadinium callovianum*, *Chlamydophorella* sp. | V - *Lagenadinium callovianum*, *Chlamydophorella* | *Lagenadinium callovianum* | RPJ5 | | | Calloviense | LOWER | | | |
| | | | | Koenigi | Koenigi | Beds with *Cadoceras simulans* | | | | | | | Koenigi | | | | |
| | | | | Herveyi | Elatmae; Beds with *Macrocephalites* | Beds with *Cadoceras pishmae*; Beds with *Cadoceras* ex gr. *elatmae* and *C. falsum* | IV - *Fromea tomatilis* - *Sentusidinium rioultii* | IV - *Fromea tomatilis*, *Sentusidinium* spp.: b - *Paragonyaulacysta retiphragmata*, *P. calloviensis*; a - *Fromea tomatilis* | *Fromea tomatilis* | RPJ4 | *Ctenidodinium sellwoodii* | Cse (c) | Herveyi | | | | |
| | | BATHONIAN | UPPER | Discus | ? | Beds with *Cadoceras variabile* | III - *Kalyptea diceras* | III - *Kalyptea diceras* | *Protobatioladinium?* *elongatum* | RPJ3 | | | Discus | UPPER | BATHONIAN | | |
| | | | | Orbis | No ammonites | No ammonites | II - *Dichadogonyaulax sellwoodii*, *Protobatioladinium* sp. | II - *Dichadogonyaulax (Ctenidodinium) sellwoodii*, *Protobatioladinium* sp. | *Ctenidodinium sellwoodii* - *Protobatioladinium elatmaensis* | RPJ2 | | Cse (b) | Orbis | | | | |
| | | | | Hodsoni | | Beds with *Arcticoceras ishmae* and *A. harlandi* | | | | | | | Hodsoni | | | | |
| | | | MIDDLE | Morrisi | | | | | | | | | Morrisi | MIDDLE | | | |
| | | | | Subcontractus | | | | | | | | | Subcontractus | | | | |
| | | | | Progracilis | | | | | | | | Cse (a) | Progracilis | | | | |
| | | | LOWER | Tenuiplicatus | | No ammonites | | | | | | | Tenuiplicatus | LOWER | | | |
| | | | | Zigzag | | Beds with *Oraniceras* cf. *gyrumbilicum* and *Gonolkites* cf. *convergens* | I - Beds with *Escharisphaeridia pocockii* - *Evansia evittii* - *Dichadogonyaulax* sp. | I - Beds with *Evansia evittii* - *Escharisphaeridia pocockii* | *Evansia evittii* | RPJ1 | | | Zigzag | | | | |
| | | BAJ. | UPPER | Parkinsoni | | | | | | | *Acanthaulax crispa* | Acr (b) | Parkinsoni | UPPER | BAJ. | | |

Text Figure 30. Comparison and correlation of the Bathonian and Callovian dinoflagellate cyst zonation for the Russian Platform proposed herein, with the dinoflagellate cyst zonations of Ilyina (1991a,b), Riding and Thomas (1992) and Meledina et al. (1998) and the relevant ammonite zonations.




Text Figure 31. The Oxfordian to Ryazanian dinoflagellate cyst zonation for the Russian Platform proposed herein, comprising the key dinoflagellate cyst bioevents and the relevant ammonite zonations.

| SYSTEM | SERIES | NORTHWEST EUROPE: STAGE | SUBSTAGE | Standard (Ammonite) zones | RUSSIAN PLATFORM: STAGE | SUBSTAGE | Ammonite zones/subzones (Krymholts et al., 1988) | Dinoflagellate cyst beds (Jakovleva, 1993) |
|---|---|---|---|---|---|---|---|---|
| CRETACEOUS | LOWER | RYAZANIAN | UPPER | Albidum | RYAZANIAN | UPPER | Tzikwinianus | Beds with *Sentusidinium, Muderongia* and *Batioladinium jaegeri* |
| | | | | Stenomphalus | | | | |
| | | | | Icenii | | | Rjazanensis-Spasskensis | *Gochteodinia villosa - Endoscrinium pharo* |
| | | | LOWER | Kochi | | LOWER | Rjazanensis-Kochi | |
| | | | | Runctoni | | | Rjazanensis-Subclypeiforme | |
| JURASSIC | UPPER | PORTLANDIAN | UPPER | Lamplughi | VOLGIAN | UPPER | | |
| | | | | Preplicomphalus | | | Nodiger | |
| | | | | Primitivus | | | Subditus / Fulgens | |
| | | | | Oppressus | | MIDDLE | | Beds with *Escharisphaeridia, Gonyaulacysta* and *Endoscrinium* sp. A. |
| | | | | Anguiformis | | | Nikitini | |
| | | | | Kerberus | | | | |
| | | | | Okusensis | | | Virgatus | |
| | | | | Glaucolithus | | | | |
| | | | | Albani | | | Zarajskensis (Panderi) | Beds with *Dingodinium, Gonyaulacysta* and *Endoscrinium campanula* |
| | | KIMMERIDGIAN | UPPER | Fittoni | | | Pavlovi (Panderi) | |
| | | | | Rotunda | | | | |
| | | | | Pallasioides | | | | |
| | | | | Pectinatus | | LOWER | Pseudoscythica | Beds with *Dingodinium* and *Cleistosphaeridium huguoniottii* |
| | | | | Hudlestoni | | | Sokolovi | |
| | | | | Wheatleyensis | | | | |
| | | | | Scitulus | | | Klimovi | Beds with *Dingodinium* and *Cribroperidinium saetigerum* |
| | | | | Elegans | | | | |
| | | | LOWER | Autissiodorensis | KIMMERIDGIAN | UPPER | Autissiodorensis | |
| | | | | Eudoxus | | | Eudoxus | |
| | | | | Mutabilis | | | Acanthicus | |
| | | | | Cymodoce | | LOWER | Beds with *Amoebites* and *Prorazenia* | ? |
| | | | | Baylei | | | | |
| | | OXFORDIAN | UPPER | Rosenkrantzi | OXFORDIAN | UPPER | Ravni | Beds with *Scriniodinium crystallinum* and *Tubotuberella eisenackii* |
| | | | | Regulare | | | | |
| | | | | Serratum | | | Serratum | |
| | | | | Glosense | | | Alternoides | |
| | | | MIDDLE | Tenuiserratum | | MIDDLE | Tennuiserratum | Beds with *Scriniodinium crystallinum* and *Crussolia deflandrei* |
| | | | | Densiplicatum | | | Densiplicatum | |
| | | | LOWER | Cordatum | | LOWER | Cordatum | Beds with *Liesbergia scarburghensis* and *Wanaea fimbriata* |
| | | | | Mariae | | | Mariae | |

Text Figure 32. Comparison and correlation of the Oxfordian to Ryazanian dinoflagellate cyst zonation for the Russian Platform proposed herein, with the dinoflagellate cyst zonations of Woollam and Riding (1983), Riding and Thomas (1992) and Jakovleva (1993) and the relevant ammonite zonations.

| RUSSIAN PLATFORM: Present Biozonation | | NORTHWEST EUROPE: Dinoflagellate cyst zones and subzones (Riding and Thomas, 1992; Woollam and Riding, 1983) | | STANDARD (Ammonite) zones | SUBSTAGE | STAGE | SERIES | SYSTEM |
|---|---|---|---|---|---|---|---|---|
| Unnamed zone | RPK1 | *Pseudoceratium pelliferum* | a | Albidum | UPPER | RYAZANIAN | LOWER | CRETACEOUS |
| | | *Gochteodinia villosa* (Gvi) | c | Stenomphalus | | | | |
| *Gochteodinia villosa* | RPJ17 | | | Icenii | | | | |
| | | | b | Kochi | LOWER | | | |
| | | | | Runctoni | | | | |
| | | | | Lamplughi | | PORTLANDIAN | UPPER | JURASSIC |
| | | | | Preplicomphalus | | | | |
| | | | a | Primitivus | | | | |
| *Senoniasphaera jurassica* | RPJ16 | | | Oppressus | | | | |
| | | *Dichadogonyaulax? pannea* (Dpa) | b | Anguiformis | | | | |
| | | | | Kerberus | | | | |
| | | | | Okusensis | | | | |
| | | | | Glaucolithus | | | | |
| *Glossodinium dimorphum* | RPJ15 | | a | Albani | | | | |
| | | *Glossodinium dimorphum* (Gdi) | e | Fittoni | UPPER | KIMMERIDGIAN | | |
| | | | | Rotunda | | | | |
| | | | d | Pallasioides | | | | |
| | | | c | Pectinatus | | | | |
| | | | b | Hudlestoni | | | | |
| | | | | Wheatleyensis | | | | |
| *Subtilisphaera? inaffecta* | RPJ14 | | a | Scitulus | | | | |
| | | | | Elegans | | | | |
| | | *Endoscrinium luridum* (Elu) | c | Autissiodorensis | LOWER | | | |
| *Gonyaulacysta jurassica* subsp. *jurassica* | RPJ13 | | | Eudoxus | | | | |
| | | | b | Mutabilis | | | | |
| | | | a | Cymodoce | | | | |
| | | *Scriniodinium crystallinum* (Scr) | d | Baylei | | | | |
| *Cribroperidinium globatum* | RPJ12 | | c | Rosenkrantzi | UPPER | OXFORDIAN | | |
| | | | b | Regulare | | | | |
| | | | | Serratum | | | | |
| | | | a | Glosense | | | | |
| *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* | RPJ 11 | *Liesbergia scarburghensis* (Lsc) | c | Tenuiserratum | MIDDLE | | | |
| *Endoscrinium galeritum* subsp. *reticulatum* | RPJ 10 | | b | Densiplicatum | | | | |
| *Wanaea fimbriata* | RPJ9 | | a | Cordatum | LOWER | | | |
| | | *Wanaea fimbriata* (Wfi) | | Mariae | | | | |

Text Figure 32 (continued). Comparison and correlation of the Oxfordian to Ryazanian dinoflagellate cyst zonation for the Russian Platform proposed herein, with the dinoflagellate cyst zonations of Woollam and Riding (1983), Riding and Thomas (1992) and Jakovleva (1993) and the relevant ammonite zonations.

### *Nannoceratopsis deflandrei* Interval Biozone (NSJ1)

**Definition:** The interval from the range base of *Nannoceratopsis deflandrei* (subspecies *anabarensis, deflandrei* and *senex*), to the range base of *Nannoceratopsis gracilis* (Text-Figure 27).

**Age:** Latest Pliensbachian (base of the Viligaensis Zone) to early Toarcian (lower part of the Commune Zone) (Text-Figure 27).

**Reference Section:** Anabar Bay (Text-Figure 8).

**Description of Assemblages:** The *Nannoceratopsis deflandrei* Zone is characterised by low diversity dinoflagellate cyst associations. The three subspecies of *Nannoceratopsis deflandrei* are all present in the latest Pliensbachian to early Toarcian (lower part of the Commune Zone) in northern East Siberia. Rare *Mancodinium semitabulatum* are also present in the early Toarcian part of this Interval Biozone (Text-Figures 11, 27).

**Comments:** This biozone is present at the reference section at Anabar Bay and also at the River Anabar (Text-Figures 8 and 7 respectively), the Viljui Syncline and at many other localities throughout northern East Siberia (Ilyina in Ilyina et al. 1994). This interval equates to the *Nannoceratopsis deflandrei* subsp. *anabarensis* and *Nannoceratopsis deflandrei* subsp. *senex* dinoflagellate cyst subzones of Ilyina in Ilyina et al. (1994) (Text-Figure 28). It is possible to recognise the presence of two subzones of the *Nannoceratopsis deflandrei* Interval Biozone, as described below. The base of this Interval Biozone is coincident with the base of the *Tancredia kuznetsovi* bivalve zone (Shurigin, 1986; 1987). This biozone is considered to be equivalent to the Spinatum to lowermost Bifrons zones of the European standard (Text-Figure 27).

### *Nannoceratopsis deflandrei* subsp. *anabarensis* Interval Biosubzone (NSJ1a)

**Definition:** The interval from the range base of *Nannoceratopsis deflandrei* (subspecies *anabarensis, deflandrei* and *senex*), to the range top of the acme occurrence of *Nannoceratopsis deflandrei* subsp. *anabarensis* and the range base of the acme occurrence of *Nannoceratopsis deflandrei* subsp. *senex* (Text-Figure 27).

**Age:** Latest Pliensbachian (base of the Viligaensis Zone) to earliest Toarcian (top of the Propinquum Zone) (Text-Figure 27).

**Reference Section:** River Anabar (Text-Figure 7).

**Description of Assemblages:** The three subspecies of *Nannoceratopsis deflandrei* all occur within this Interval Biosubzone, together with rare *Mancodinium semitabulatum* in the earliest Toarcian (Text-Figure 11). *Nannoceratopsis deflandrei* subsp. *anabarensis* is abundant in the upper part of the Interval Biosubzone (Text-Figures 7, 8, 11). This Interval Biosubzone represents the majority of the range of consistent *Nannoceratopsis deflandrei* subsp. *anabarensis* (Text-Figure 11).

**Comments:** This Interval Biosubzone was originally erected by Ilyina in Ilyina et al. (1994) as the *Nannoceratopsis deflandrei* subsp. *anabarensis* Subzone of the *Nannoceratopsis deflandrei-Nannoceratopsis gracilis* Zone (Text-Figure 28). This Interval Biosubzone is also present at Anabar Bay (Text-Figure 8) and it equates to the Spinatum and Tenuicostatum standard zones (Text-Figure 27).

### *Nannoceratopsis deflandrei* subsp. *senex* Acme Biosubzone (NSJ1b)

**Definition:** The interval from the range base of the acme occurrence of *Nannoceratopsis deflandrei* subsp. *senex* and the range top of the acme occurrence of *Nannoceratopsis deflandrei* subsp. *anabarensis*, to the range base of *Nannoceratopsis gracilis* (Text-Figure 27).

**Age:** Early Toarcian (Falciferum Zone and the lower part of the Commune Zone) (Text-Figure 27).

**Reference Section:** Sobo Creek, River Marcha (Text-Figure 9).

**Description of Assemblages:** In this Acme Biosubzone, the subspecies *deflandrei* and *senex* of *Nannoceratopsis deflandrei* are present in relatively high proportions (Text-Figure 11). Subspecies *senex*, however, is normally by far the most abundant (Text-Figure A3.4). Rare *Mancodinium semitabulatum* are also present (Text-Figure 11).

**Comments:** This Acme Biosubzone was originally erected by Ilyina in Ilyina et al. (1994) as the *Nannoceratopsis deflandrei* subsp. *senex* Subzone of the *Nannoceratopsis deflandrei-Nannoceratopsis gracilis* Zone (Text-Figure 28). This Acme Subbiozone is traceable throughout the Viljui Syncline and elsewhere in northeast Russia (V.I.I., personal observations).

### *Nannoceratopsis gracilis* Interval Biozone (NSJ2)

**Definition:** The interval from the range base of *Nannoceratopsis gracilis*, to the range bases of *Phallocysta elongata*, *Phallocysta eumekes* and *Susadinium scrofoides* (Text-Figure 27).

**Age:** Early Toarcian (upper part of the Commune Zone to the top of the Braunianus Zone) (Text-Figure 27).

**Reference Section:** Anabar Bay (Text-Figure 8).

**Description of Assemblages:** The *Nannoceratopsis gracilis* Interval Biozone is also characterised by relatively low diversity dinoflagellate cyst associations. *Nannoceratopsis deflandrei* subsp. *deflandrei*, *Nannoceratopsis deflandrei* subsp. *senex* and *Nannoceratopsis gracilis* are the most prominent elements; however, rare *Mancodinium semitabulatum* and *Maturodinium* sp. A may also be present (Text-Figure 11).

**Comments:** The *Nannoceratopsis gracilis* Interval Biozone was originally defined by Ilyina in Ilyina et al. (1994) as the *Nannoceratopsis gracilis* Subzone of the *Nannoceratopsis deflandrei-Nannoceratopsis gracilis* Zone (Text-Figure 28). This Interval Subzone is recognizable throughout the Viljui Syncline and other areas of northern East Siberia (Ilyina in Ilyina et al., 1994). The zone is considered to correlate with the northwest European Bifrons Zone (Text-Figure 27).

### *Phallocysta eumekes* Range Biozone (NSJ3)

**Definition:** The interval from the range bases of *Phallocysta elongata*, *Phallocysta eumekes* and *Susadinium scrofoides*, to the range tops of *Phallocysta elongata*, *Phallocysta eumekes* and *Susadinium scrofoides* (Text-Figure 27).

**Age:** Late Toarcian (?Compactile to ?Falcodiscus zones) (Text-Figure 27).

**Composite Reference Section:** The base and majority of this zone is well developed at Sobo Creek, River Marcha (Text-Figure 9). The upper part of the zone is also well developed at the Rivers Marcha and Motorchuna (Text-Figures 2, A3.3).

**Description of Assemblages:** The dinoflagellate cyst assemblages are much more diverse than in the underlying Interval Biozones NSJ1 and NSJ2 (Text-Figure 11). *Mancodinium semitabulatum*, *Maturodinium* sp. A, *Nannoceratopsis deflandrei* and *Nannoceratopsis gracilis* are present. However, *Nannoceratopsis ridingii*, *Nannoceratopsis triangulata*, *Nannoceratopsis triceras*, *Scriniocassis priscus*, *Scriniocassis weberi*, *Valvaeodinium aquilonium* and *Valvaeodinium stipulatum* are also represented, together with representatives of the *Parvocysta* complex of Riding (1984a) (Text-Figure 11). This distinctive suite of apparently closely-related forms includes *Moesiodinium raileanui*, *Parvocysta* spp., *Phallocysta* spp. and *Susadinium* spp. *Maturodinium* sp. A and *Phallocysta* spp. may be abundant. In particular, *Phallocysta eumekes* typically becomes abundant in the middle of this Range Biozone (Text-Figures 8, 9, 11, 27 and A3.3).

**Comments:** This late Toarcian Range Biozone is not subdivided into interval subbiozones because the dinoflagellate cyst floras are relatively conservative throughout. The ammonite zonation is difficult to apply in Northern Siberia because two different macrofossil zonations have been described (section 2.2). The equivalent European standard ammonite zones are the Variabilis to Levesquei zones (Text-Figure 27). This Range Biozone equates to the *Phallocysta eumekes-Dodekovia scrofoides-Valvaeodinium aquilonium* zone of Ilyina in Ilyina et al. (1994) (Text-Figure 28). The latter author recognised this Range Biozone throughout Northern Siberia and subdivided the zone into two subzones. These subzones are the *Phallocysta eumekes* Subzone for the earliest late Toarcian and the *Valvaeodinium aquilonium-Nannoceratopsis* cf. *triangulata* Subzone for the latest late Toarcian (Text-Figure 28). This subdivision was based partially on a comparison with late Toarcian dinoflagellate cyst floras from western Europe (Riding, 1984a; Prauss, 1989). As a result of this study, however, it was decided not to use this subzonal subdivision because *Nannoceratopsis triangulata* and *Valvaeodinium aquilonium* were recovered throughout the Upper Toarcian (Text-Figure 11). The intra-Upper Toarcian inceptions of these species were the principal subzonal criteria used by Ilyina in Ilyina et al. (1994, text-fig. 4).

## 6.2 RUSSIAN PLATFORM

The definitions of the 18 dinoflagellate cyst Interval Biozones proposed for the Bathonian to the Ryazanian of the Russian Platform are illustrated in Text-Figures 29 and 30. The relationships of these new biozones with the standard and local Russian ammonite zonations and the coeval dinoflagellate cyst zones/beds of Woollam and Riding (1983), Ilyina (1991a,b), Riding and Thomas (1992), Jakovleva (1993) and Meledina et al. (1998) are depicted in Text-Figures 31 and 32. The Interval Biozones are numbered in ascending stratigraphic order. They are prefixed by 'RPJ' or 'RPK', which are acronyms for 'Russian Platform Jurassic' and 'Russian Platform Cretaceous' respectively.

### *Evansia evittii* Interval Biozone (RPJ1)

**Definition:** The interval from the apparent range base of *Evansia evittii*, to the range bases of *Ctenidodinium sellwoodii* and *Protobatioladinium elatmaensis* (Text-Figure 29).

**Age:** Earliest Bathonian. This interval biozone represents the lowermost Beds with *Oraniceras* cf. *gyrumbilicum* and *Gonolkites* cf. *convergens* in the Pechora Basin; the equivalent strata in the Moscow are devoid of ammonites (Text-Figure 31). These strata correlate to the lowermost Zigzag Zone (Text-Figure 15).

**Reference Section:** West bank of the River Pizhma, near Stepanov Village (Text-Figure 12).

**Description of Assemblages:** The dinoflagellate cyst associations in this Interval Biozone are of low species diversity (Text-Figure 15). In addition to *Evansia evittii*, representatives of *Batiacasphaera*, *Lithodina* and *Pareodinia* are present (Text-Figure 12).

**Comments:** The base of this zone is described as being based on the "apparent" range base of *Evansia evittii* because it is present in the lowermost samples (Text-Figure 15). Ilyina (1991a) studied ?uppermost Bajocian-lowermost Bathonian material from the Voronezh Structural High and the Pechora Basin and termed this interval 'Beds with *Escharispharidia pocockii-Evansia evittii-Dichadogonyaulax* sp' (Text-Figure 31). The lower boundary of this Interval Biozone is not well constrained by ammonite faunas; it is possible, therefore, that it is within the uppermost Bajocian (Ilyina, 1991a). No unequivocal Bajocian samples have been included in this study, therefore, the inception of *Evansia evittii* may be within the Bajocian Stage in the Russian Platform.

### *Ctenidodinium sellwoodii-Protobatioladinium elatmaensis* Interval Biozone (RPJ2)

**Definition:** The interval from the range bases of *Ctenidodinium sellwoodii* and *Protobatioladinium elatmaensis*, to the range base of *Protobatioladinium? elongatum* (Text-Figure 29).

**Age:** Early-late Bathonian. This zone represents the uppermost Beds with *Oraniceras* cf. *gyrumbilicum* and *Gonolkites* cf. *convergens* to the non-ammonite bearing strata overlying Beds with *Arcticoceras ishmae* and *Arcticoceras harlandi* in the Pechora Basin. The equivalent strata in the Moscow Basin (central Russian Platform) appear to be barren of ammonite faunas (Text-Figure 29). This interval biozone is tentatively correlated to the uppermost Zigzag to Orbis standard zones (Text-Figure 31).

**Reference Sections:** West bank of the River Pizhma, near Stepanov Village (Text-Figure 12) and Borehole 132, near Elatma (Text-Figure 17).

**Description of Assemblages:** The dinoflagellate cyst assemblages are significantly more diverse than in the underlying *Evansia evittii* Interval Biozone. *Chlamydophorella* spp., *Chytroeisphaeridia hyalina*, *Ctenidodinium sellwoodii*, *Dissiliodinium* spp., *Fentonia bjaerkei* (acritarch), *Fromea tornatilis*, *Korystocysta gochtii*, *Mendicodinium groenlandicum*, *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Sirmiodinium grossii* and *Tubotuberella dangeardii* are present (Text-Figure 15; Ilyina, 1991a). The most prominent taxa are *Batiacasphaera* spp., *Nannoceratopsis pellucida* and *Protobatioladinium elatmaensis* (Text-Figure 15).

**Comments:** This Interval Biozone is defined by the inceptions of *Ctenidodinium sellwoodii* and *Protobatioladinium elatmaensis* to the range base of *Protobatioladinium? elongatum* (Text-Figure 29). It has been given two index species, *Ctenidodinium sellwoodii* and *Protobatioladinium elatmaensis*, because both these taxa occur in the early-late Bathonian of the Russian Platform (Ilyina, 1991a; Riding and Ilyina, 1996; 1998). *Ctenidodinium sellwoodii* is abundant in the Voronezh Structural High and it is considered that this area had a connection with western Europe during the Bathonian (Riding and Ilyina, 1998). In the Moscow Basin, for example the Lasicy Borehole, both the index species occur in alternating beds (Ilyina, 1991a). *Protobatioladinium elatmaensis* is abundant in Borehole 132, near Elatma (Text-Figures 17, A3.11; Riding and Ilyina, 1996). This Interval Biozone was originally erected as the *Dichadogonyaulax sellwoodii-Protobatioladinium* sp. zone by Ilyina (1991a) and Meledina et al. (1998) (Text-Figure 31).

### *Protobatioladinium? elongatum* Range Biozone (RPJ3)

**Definition:** The interval between the range base, and the range top of unequivocal *Protobatioladinium? elongatum* (Text-Figure 29).

**Age:** Latest Bathonian. The Range Biozone comprises the Beds with *Cadoceras variabile* in the Pechora Basin; the equivalent strata in the Moscow Basin are not zoned using ammonites (Text-Figure 29). These beds are considered to be correlative with the Discus Zone (Text-Figure 15).

**Reference Section:** West bank of the River Pizhma, near Stepanov Village (Text-Figure 12).

**Description of Assemblages:** The dinoflagellate cyst associations in the *Protobatioladinium? elongatum* Range Biozone are substantially similar in species content and proportions to those in the underlying RPJ2 Biozone (Text-Figure 15). The diversity, however, is somewhat higher. Complex chorate dinoflagellate cysts and the acritarch *Fentonia bjaerkei* are present in this Range Biozone (Text-Figure 15).

**Comments:** In the Pechora Basin, this Range Biozone is deemed to be approximately coincident with Beds with *Cadoceras variabile*, which Meledina (1994) stated were referable to the Discus Zone. Ilyina (1991a) termed this interval the latest Bathonian-earliest Callovian *Kalyptea diceras* dinoflagellate cyst zone due to the misidentification of the index species. Subsequently, Meledina et al. (1998) interpreted this interval as latest Bathonian (Text-Figure 31).

### *Fromea tornatilis* Interval Biozone (RPJ4)

**Definition:** Interval from the range bases of *Chytroeispharidia cerastes*, common to abundant *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta* and *Pareodinia prolongata*, to the range base of *Lagenadinium callovianum* (Text-Figure 29).

**Age:** Earliest Callovian. The Interval Biozone comprises Beds with *Cadoceras* ex group *elatmae* and *Cadoceras falsum* and Beds with *Cadoceras pishmae* in the Pechora Basin; in the Moscow Basin, it is represented by Beds with *Macrocephalites* and the Elatmae Zone (Text-Figure 31). These strata are considered to be the equivalent of the Herveyi Zone of the European Standard (Text-Figure 16).

**Reference Section:** East bank of the River Pizhma, near Churkin Village (outcrop 13) (Text-Figure 12).

**Description of Assemblages:** Earliest Callovian dinoflagellate cyst assemblages from the Moscow and Pechora basins are typically rich and diverse. *Batiacasphaera spp.*, *Chytroeispharidia hyalina*, *Fromea tornatilis*, *Lithodinia* spp., *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Sentusidinium* spp. and *Sirmiodinium grossii* are common to abundant. Many forms have inceptions at or close to the Bathonian-Callovian boundary in the Russian Platform. These include those of *Adnatosphaeridium caulleryi*, *Chytroeispharidia cerastes*, *Chytroeispharidia chytroeides*, *Gonyaulacysta jurassica* subsp. *adecta* and *Pareodinia prolongata* (Text-Figures 12, 16).

**Comments:** In the Callovian of the Russian Platform, rich and diverse dinoflagellate cyst assemblages appear for the first time. *Chytroeisphaeridia* spp. and the zonal index, *Fromea tornatilis* are especially common (Text-Figure 12). This Interval Biozone is traceable throughout the Russian Platform and is well constrained by ammonite faunas. In the Moscow Basin, the earliest Callovian sediments comprise Beds with *?Macrocephalites* and the Elatmae Zone (Jakovleva, 1993). In the Pechora Basin, the lowermost Callovian strata are represented by Beds with *Cadoceras* ex. group *elatmae* and *Cadoceras falsum* and Beds with *Cadoceras pishmae*. Both these faunal successions are correlatable with the standard Herveyi Zone according to Meledina (1994) and Meledina et al. (1998) (Text-Figures 29, 31). This Interval Biozone was originally erected as the *Fromea tornatilis-Sentusidinium rioultii*/spp. Zone by Ilyina (1991a) and Meledina et al. (1998) (Text-Figure 31).

The four samples studied from the earliest Callovian of Anabar Bay (section 5.1.2; Text-Figure 10) represent a Boreal dinoflagellate cyst association. These horizons are assigned to the Falsum and Anabarense zones, which are coeval with the Herveyi Standard Zone (Meledina, 1994). This means that the Boreal *Crussolia dalei*, *Paragonyaulacysta retiphragmata* Zone of Ilyina (1996) and Ilyina in Zakharov et al. (1997) is equivalent to the *Fromea tornatilis* Interval Biozone in the Russian Platform. The earliest Callovian *Crussolia dalei*, *Paragonyaulacysta retiphragmata* Zone of the Boreal Realm is broadly equivalent to the *Paragonyaulacysta calloviensis* Subzone of Johnson and Hills (1973), Oppel Zone G of Davies (1983) and the *Lacrymodinium warrenii* Zone (subzones b and c) of Smelror (1988b). A regional synthesis of these zonations and assemblages may help to correlate the lowermost Callovian of the Boreal and Subboreal provinces.

### *Lagenadinium callovianum* Interval Biozone (RPJ5)

**Definition:** The interval from the range base of *Lagenadinium callovianum*, to the range top of *Ctenidodinium combazii* (Text-Figure 29).

**Age:** Early Callovian, Koenigi and Calloviense zones and equivalents. In the Moscow Basin, the standard Koenigi and Calloviense zones can be recognised. However these are represented respectively by Beds with *Cadoceras simulans* and Beds with *Kepplerites* cf. *tychonis* in the Pechora Basin (Text-Figure 31).

**Reference Section:** East bank of the River Pizhma, near Churkin Village (outcrop 13) (Text-Figure 12).

**Description of Assemblages:** The *Lagenadinium callovianum* Interval Biozone throughout the Russian Platform yields rich microplankton floras; the species content and relative proportions being similar to those from the underlying *Fromea tornatilis* Interval Biozone (Text-Figure 16). *Kalyptea stegasta* has its inception at the base of this Interval Biozone (Text-Figure 16) and *Cleistosphaeridium varispinosum* may be common in many sections in the Russsian Platform (V.I.I., personal observations). *Ctenidodinium combazii* may be common in the Beds with *Kepplerites* cf. *tychonis* in the Pechora Basin (Text-Figures 12 and A3.6).

**Comments:** The *Lagenadinium callovianum* Interval Biozone is closely correlated to regional ammonite faunal successions in the Russian Platform. In the Pechora Basin, it comprises the Beds with *Cadoceras simulans* and Beds with *Kepplerites* cf. *tychonis* (Text-Figure 29; Meledina, 1994; Meledina and Zakharov, 1996). In the Moscow Basin, the European standard Koenigi and Calloviense zones may be applied. This Interval Biozone is coincident with the *Lagenadinium callovianum*, *Chlamydophorella* sp. Zone of Ilyina (1991a) and Meledina et al. (1998) (Text-Figure 31).

### *Kalyptea stegasta* Interval Biozone (RPJ6)

**Definition:** The interval from the range top of *Ctenidodinium combazii*, to the range base of *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* (Text-Figure 29).

**Age:** Mid Callovian, Jason and Coronatum zones and equivalents. In the Moscow Basin, the standard Jason and Coronatum zones can be recognised, however in the Pechora Basin, this interval is represented by the Beds with *Rondiceras milaschevici* and *Kosmoceras* spp. (Text-Figure 31).

**Reference Section:** West bank of the River Izhma (outcrop 9) (Text-Figure 12).

**Description of Assemblages:** The *Kalyptea stegasta* Interval Biozone throughout the Russian Platform yields abundant and diverse dinoflagellate cyst asociations. The overall species content is similar to those from the underlying RPJ4 and RPJ5 Interval Biozones. The following forms may be common: *Batiacasphaera* spp., *Chytroeisphaeridia chytroeides; Chytroeisphaeridia hyalina; Fromea tornatilis; Kalyptea stegasta; Lagenadinium callovianum; Nannoceratopsis pellucida; Pareodinia ceratophora; Sentusidinium* spp., *Sirmiodinium grossii* and *Tubotuberella dangeardii* (Text-Figures 12, 16, A3.6; Ilyina, 1991a). Also present are, for example, *Ctenidodinium sellwoodii, Endoscrinium* spp., *Evansia evittii, Gonyaulacysta jurassica* subsp. *adecta, Lithodinia* spp., *Mendicodinium groenlandicum, Paragonyaulacysta retiphragmata, Rhynchodiniopsis cladophora, Sentusidinium* spp. and *Wanaea acollaris. Ctenidodinium sellwoodii* has its range top within this Interval Biozone (Text-Figures 12, 16, 29).

**Comments:** The *Kalyptea stegasta* Interval Biozone has a close correlation to regional ammonite faunal successions. In the Pechora Basin, it largely comprises the Beds with *Rondiceras milaschevici* and *Kosmoceras* spp. (Meledina, 1994) and in the Moscow Basin, the European standard zones Jason and Coronatum may be recognised (Text-Figure 29). This Interval Biozone is equivalent to the *Chytroeisphaeridia cerastes-Netrelytron stegastum* Zone of Ilyina (1991a) and Meledina et al. (1998) (Text-Figure 31).

### *Pareodinia prolongata* Interval Biozone (RPJ7)

**Definition:** The interval from the range base of *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis*, to the range top of *Pareodinia prolongata* and the range base of *Trichodinium scarburghensis* (Text-Figure 29).

**Age:** Late Callovian (Athleta-Keyserlingi zones).

**Reference Section:** Inkino, River Oka Basin (Text-Figure 18).

**Description of Assemblages:** The Upper Callovian dinoflagellate cyst asemblages of the Russian Platform are normally abundant and diverse (Text-Figure 18). The large number of inceptions in this substage are also observed throughout the Northern Hemisphere (Woollam and Riding, 1983). The following forms have range bases in the Athleta / Keyserlingi zones (and thus in this biozone): *Ctenidodinium continuum; Gonyaulacysta eisenackii, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis; Leptodinium subtile* and *?Scriniodinium crystallinum* (Text-Figure 16). Forms which are common throughout this Interval Biozone include: *Batiacasphaera* spp., *Chytroeisphaeridia chytroeides, Chytroeisphaeridia hyalina, Fromea tornatilis, Lithodinia* spp., *Nannoceratopsis pellucida, Pareodinia ceratophora, Rhynchodiniopsis cladophora, Sentusidinium* spp. and *Sirmiodinium grossii* (Text-Figure A3.12). Furthermore, *Adnatosphaeridium caulleryi, Cleistosphaeridium varispinosum, Endoscrinium* spp., *Gonyaulacysta eisenackii, Lithodinia planoseptata, Sirmiodiniopsis orbis* and *Tubotuberella* spp. are also consistently present (Text-Figures 16; 18).

**Comments:** This Interval Biozone can be correlated to regional ammonite faunas throughout the Russian Platform. For example, in the Moscow Basin, the Athleta Zone is present; however, in the Pechora Basin, the approximate equivalent is the Keyserlingi Zone (Text-Figure 29; Meledina, 1994; Meledina et al., 1998). The *Pareodinia prolongata* Interval Biozone is equivalent to the *Rigaudella aemula-Cleistospharidium varispinosum* Zone of Ilyina (1991a) and the *Rigaudella aemula-Pareodinia prolongata* Zone of Meledina et al. (1998) (Text-Figure 31).

### *Trichodinium scarburghensis* Interval Biozone (RPJ8)

**Definition:** The interval from the range top of *Pareodinia prolongata* and the range base of *Trichodinium scarburghensis*, to the range top of *Ctenidodinium continuum* and the range bases of *Leptodinium mirabile, Lithodinia* sp. A and *Wanaea fimbriata* (Text-Figures 29, 30).

**Age:** Latest Callovian (Lamberti-Subordinarium zones).

**Reference Sections:** Section 2, Makarjev region, River Unzha and Outcrop 15, River Izhma (Text-Figures 19 and 13 respectively).

**Description of Assemblages:** Uppermost Callovian dinoflagellate cyst asemblages from the Russian Platform are abundant and diverse (Text-Figures 13, 19). The floras are relatively similar to those from the underlying *Pareodinia prolongata* Interval Biozone, however, the diversity in the RPJ8 interval biozone is significantly higher. Typical forms include *Chlamydophorella* spp., *Clathroctenocystis asapha*, *?Crussolia deflandrei*, *Ctenidodinium ornatum*, *Ctenidodinium continuum*, *Gonyaulacysta centriconnata*, *Gonyaulacysta jurassica* subsp. *adecta*, *Liesbergia liesbergensis*, *Scriniodinium crystallinum*, *Sirmiodinium grossii*, *Stephanelytron* spp. and *Wanaea acollaris* (Text-Figures 16; A3.7; A3.8; A3.13).

**Comments:** The inception of *Trichodinium scarburghensis* is an ideal datum for the definition of the base of this Interval Biozone. The species is common over much of the Northern Hemisphere and is relatively large and easily recognised (Woollam and Riding, 1983). In the Moscow Basin, the standard Lamberti Zone is recognisable, however, in the Pechora Basin, the equivalent is the Subordinarium Zone (Text-Figure 29; Meledina, 1994). The populations of *Sirmiodinium grossii* in this zone include significant proportions of the triangular morphotype (V.A.F., personal observations). Within this zone throughout the Russian Platform, the range top of *Cleistosphaeridium varispinosum* was observed (Text-Figures 16; 29). It is possible that this may allow the subdivision of the *Trichodinium scarburghensis* Interval Biozone, hovever a subzonal division is not effected here as more data are needed to confirm this bioevent. The *Trichodinium scarburghensis* Interval Biozone is approximately equivalent to the Beds with *Belodinium asaphum-Lagenadinium scarburghensis* of Ilyina (1991a) (Text-Figure 31).

### *Wanaea fimbriata* Range Biozone (RPJ9)

**Definition:** The interval from the range top of *Ctenidodinium continuum* and the range bases of *Leptodinium mirabile*, *Lithodinia* sp. A and *Wanaea fimbriata*, to the range tops of *Gonyaulacysta centriconnata* and *Wanaea fimbriata* and the range base of *Endoscrinium luridum* (Text-Figures 29, 30).

**Age:** Early Oxfordian (Mariae and Cordatum zones).

**Reference Sections:** Borehole 132, near Elatma, outcrop 5, near Inkino, River Oka Basin and section 2, Makarjev region, River Unzha (Text-Figures 17, 18, 19 respectively).

**Description of Assemblages:** Early Oxfordian dinoflagellate cyst floras from the Russian Platform are as rich and diverse as those from the late Callovian (Text-Figures A3.12, A3.13). As a result of high sea level stands during the early Oxfordian, the marine floras are virtually cosmopolitan throughout the Northern Hemisphere (Johnson and Hills, 1973; Berger, 1986; Riding, 1987). Throughout the Russian Platform, the following taxa are common to prominent in the early Oxfordian: *Chytroeisphaeridia cerastes; Chytroeisphaeridia chytroeides; Endoscrinium galeritum; Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* and *Trichodinium scarburghensis* (Text-Figures 25; A3.12; A3.13). Forms which are also present throughout include: *Aldorfia* spp., *Ambonosphaera? staffinensis; Chlamydophorella* spp.; *Ctenidodinium ornatum; Gonyaulacysta eisenackii; Leptodinium subtile; Mendicodinium groenlandicum; Prolixosphaeridium parvispinum; Scriniodinium crystallinum; Sirmiodiniopsis orbis; Sirmiodinium grossii; Stephanelytron* spp. and *Tubotuberella rhombiformis* (Text-Figures 17, 18, 19). Several forms characteristic of the early Oxfordian in western Europe were recovered, and these include *Crussolia deflandrei*, *Gonyaulacysta centriconnata*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Leptodinium mirabile*, *Limbodinium absidatum*, *Rigaudella aemula*, *Wanaea fimbriata* and *Wanaea thysanota* (Text-Figures 25, A3.11, A3.12; A3.13). In the Russian Platform, the range tops of *Limbodinium absidatum*, *Wanaea acollaris* and *Wanaea thysanota* occur within the Mariae Zone (Text-Figures 25, 30 and A3.11). Furthermore, the inception of *Gonyaulacysta jurassica* subsp. *jurassica* occurs in the Cordatum Zone (Text-Figures 19, 25, 30). It is considered that a subzonal subdivision based on these bioevents should not be made at this time; potential further subdivision of this Interval Biozone should await more data.

**Comments:** Ammonites characteristic of the Mariae and Cordatum zones have been described from the Russian Platform by Mesezhnikov et al. (1986; 1989), Krymholts et al. (1988) and Meledina (1987) (Text-Figure 32). Due to the widespread geographic distribution of the index taxa, the *Wanaea fimbriata* Range Biozone can be recognised over much of the Northern Hemisphere. The zone as defined here is coincident with the *Wanaea fimbriata* Zone of Smelror (1988b). It is also partially equivalent to the *Wanaea fimbriata* Zone of Riding and Thomas (1992). The *Wanaea fimbriata* Range Biozone defined here is approximately equivalent to both the *Liesbergia scarburghensis-Wanaea fimbriata* Zone of Ilyina (1991a,b) and the Beds with *Liesbergia scarburghensis* and *Wanaea fimbriata* of Jakovleva (1993) (Text-Figure 32).

### *Endoscrinium galeritum* subsp. *reticulatum* Interval Biozone (RPJ10)

**Definition:** The interval from the range tops of *Gonyaulacysta centriconnata* and *Wanaea fimbriata* and the range base of *Endoscrinium luridum*, to the range top of *Trichodinium scarburghensis* (Text-Figure 30).

**Age:** Mid Oxfordian (Densiplicatum Zone).

**Reference Sections:** Borehole 132, near Elatma and Section 2, Makarjev region, River Unzha (Text-Figures 17 and 19 respectively).

**Description of Assemblages:** Middle Oxfordian dinoflagellate cyst associations from the Russian Platform are consistently rich and diverse (Text-Figures 17, A3.11). Prominent forms in the Densiplicatum Zone include *Chytroeisphaeridia* spp., *Endoscrinium galeritum* subsp. *galeritum*, *Endoscrinium galeritum* subsp. *reticulatum*, *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis*, and *Gonyaulacysta jurassica* subsp. *jurassica* (Text-Figures 25, A3.11). Other morphotypes consistently present are *Crussolia* spp., *Endoscrinium luridum*, *Fromea tornatilis*, *Gonyaulacysta eisenackii*, *Leptodinium subtile*, *Nannoceratopsis pellucida*, *Rhynchodiniopsis cladophora*, *Rigaudella aemula*, *Scriniodinium crystallinum*, *Sirmiodiniopsis orbis*, *Sirmiodinium grossii* (triangular forms) and *Stephanelytron* spp (Text-Figures 25, A3.11, A3.13).

**Comments:** This dinoflagellate cyst Interval Biozone has a reliable correlation to the Densiplicatum Zone as Middle Oxfordian ammonite faunas in the Russian Platform are well studied (Mesezhnikov et al., 1986; 1989; Krymholts et al., 1988). Although this Biozone is of Interval type, a form which ranges above and below the zone, *Endoscrinium galeritum* subsp. *reticulatum* was chosen as the index because it is prominent in the lowermost Middle Oxfordian (Text-Figure 25). Furthermore, *Trichodinium scarburghensis* is the index of the RPJ8 Interval Biozone and *Endoscrinium luridum* is not prominent in the Middle

Oxfordian of the Russian Platform. Additionally, *Endoscrinium luridum* has been used as an index for Kimmeridgian dinoflagellate cyst zones by, for example, Woollam and Riding (1983), Riding and Thomas (1988; 1992) and Poulsen (1993; 1994). The *Endoscrinium galeritum* subsp. *reticulatum* Range Biozone is equivalent to the lower part of the *Scriniodinium crystallinum-Tubotuberella eisenackii* Zone of Ilyina (1991a) and the lowermost part of the Beds with *Scriniodinium crystallinum* and *Crussolia deflandrei* of Jakovleva (1993) (Text-Figure 32).

*Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* Interval Biozone (RPJ11)

**Definition:** The interval from the range top of *Trichodinium scarburghensis*, to the range tops of *Chytroeisphaeridia cerastes, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* and *Rigaudella aemula* and the range base of *Cribroperidinium globatum* (Text-Figure 30).

**Age:** Mid Oxfordian (Tenuiserratum Zone).

**Reference Sections:** Borehole 132, near Elatma and Section 2, Makarjev region, River Unzha (Text-Figures 17 and 19 respectively).

**Description of Assemblages:** The dinoflagellate cyst associations in the RPJ11 Interval Biozone are similar in overall species spectra to those from the underlying Interval Biozone RPJ10 (Text-Figures A3.11 and A3.13). *Chytroeisphaeridia* spp., *Crussolia deflandrei, Endoscrinium galeritum* subsp. *reticulatum, Gonyaulaxcysta eisenackii, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Lithodinia* spp. *Sentusidinium* spp., *Sirmiodinium grossii* (triangular forms) and *Stephanelytron redcliffense* are relatively common (Text-Figures 17, 19, 25).

**Comments:** The RPJ11 Interval Biozone is calibrated with the Tenuiserratum Zone via the work of Mesezhnikov et al. (1986; 1989) and Krymholts et al. (1988). Because *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* is extremely prominent throughout the Middle Oxfordian of the Russian Platform (Text-Figures A3.11, A3.13), this form was selected as the index for this Interval Biozone. The top of this Interval Biozone is also marked by the range tops of many important taxa including *Clathroctenocystis asapha, Crussolia perireticulata, Fromea tornatilis, Gonyaulacysta eisenackii, Gonyaulacysta jurassica* subsp. *adecta, Nannoceratopsis pellucida* and *Sirmiodiniopsis orbis* (Text-Figure 25). Furthermore, the range top of common triangular morphotypes of *Sirmiodinium grossii* is within this Interval Biozone (V.A.F., personal observations). The *Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* Interval Biozone is equivalent to both the upper part of the *Scriniodinium crystallinum-Tubotuberella eisenackii* Zone of Ilyina (1991a) and the and the uppermost Beds with *Scriniodinium crystallinum* and *Crussolia deflandrei* of Jakovleva (1993) (Text-Figure 32).

*Cribroperidinium globatum* Interval Biozone (RPJ12)

**Definition:** The interval from the range tops of *Chytroeisphaeridia cerastes, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis* and *Rigaudella aemula* and the range base of *Cribroperidinium globatum*, to the range top of *Crussolia deflandrei* and the range bases of *Endoscrinium anceps, Glossodinium dimorphum, Perisseiasphaeridium pannosum* and *Wallodinium krutzschii* (Text-Figure 30).

**Age:** Late Oxfordian (Alternoides to Ravni zones).

**Reference Section:** Section 1, Makarjev region, River Unzha (Text-Figure 20).

**Description of Assemblages:** The three samples of late Oxfordian age from Section 1, Makarjev region, River Unzha produced low diversity, relatively sparse dinoflagellate cyst associations (Text-Figures 20, A3.14). Prominent forms include *Ambonosphaera? staffinensis, Batiacasphaera* spp., *Chytroeispharidia chytroeides, Endoscrinium galeritum* subsp. *galeritum* and *Endoscrinium galeritum* subsp. *reticulatum* (Text-Figure 20). Forms present in lower proportions include *Chlamydophorella* spp., *Cribroperidinium globatum, Crussolia deflandrei, Gonyaulacysta dualis, Leptodinium subtile, Scriniodinium crystallinum* and *Systematophora penicillata* (Text-Figure A3.14). The inception of the zonal index, *Cribroperidinium globatum*, was observed at the base of this Interval Biozone (Text-Figure 25).

**Comments:** This Interval Biozone is calibrated with the Alternoides, Serratum and Ravni zones as a result of the work of Mesezhnikov et al. (1986; 1989) and Krymholts et al. (1988). The dinoflagellate cyst assemblages are of relatively low abundance and diversity by comparison to floras from the underlying Lower and Middle Oxfordian (Text-Figure 25). There appears to be a stratification event which led to anoxic conditions at the base of the Upper Oxfordian in the Russian Platform due to the presence of organic-rich ('hot') shales (Mesezhnikov et al., 1986; 1989). The RPJ12 Interval Biozone is approximately equivalent to the Beds with *Scriniodinium crystallinum* and *Tubotuberella eisenackii* of Jakovleva (1993) (Text-Figure 32).

*Gonyaulacysta jurassica* subsp. *jurassica* Interval Biozone (RPJ13)

**Definition:** The interval from the range top of *Crussolia deflandrei* and the range bases of *Endoscrinium anceps, Glossodinium dimorphum, Perisseiasphaeridium pannosum* and *Wallodinium krutzschii*, to the range top of *Gonyaulacysta jurassica* subsp. *jurassica* and the range base of *Subtilisphaera? inaffecta* (Text-Figure 30).

**Age:** Kimmeridgian (Beds with *Amoebites* and *Prorasenia* and Beds with *Amoebites kitchini* and *Rasenia* spp. to the top of the Eudoxus Zone).

**Reference Section:** A composite section comprising sections 3/4, Makarjev region, River Unzha, outcrop 15, River Izhma and Gorodische, mid River Volga Basin (Text-Figures 21, 13 and 22 respectively).

**Description of Assemblages:** The Kimmeridgian of the Russian Platform produces variably rich dinoflagellate cyst associations. The following taxa are common to abundant: *Chytroeisphaeridia chytroeides; Cribroperidinium globatum; Dingodinium* spp.; *Gonyaulacysta* spp., *Leptodinium subtile* and *Sentusidinium* spp (Text-Figures 9, A4.7, A4.8 and A4.15-A4.17). Also present are: *Batiacasphaera* spp.; *Chlamydophorella* spp.; *Endoscrinium anceps; Hystrichodinium pulchrum; Pareodinia ceratophora; Prolixosphaeridium mixtispinosum; Sirmiodinium grossii; Systematophora* spp. and *Tubotuberella rhombiformis* (Text-Figures A3.6, A3.12 and A3.13).

**Comments:** The Lower/lowermost Kimmeridgian of the Russian Platform yields significant numbers of species which are reminiscent of the Oxfordian. These include *Gonyaulacysta jurassica* subsp. *jurassica*, *Scriniodinium crystallinum* and *Stephanelytron* spp. (Text-Figure 26). This situation is similar to the Oxfordian-Kimmeridgian boundary in western Europe (Riding and Thomas, 1988). However, the late Oxfordian-earliest Kimmeridgian in the Russian Platform is significantly less diverse than in Europe. The Upper Kimmeridgian of the Russian Platform is typified by more characteristically Kimmeridgian marine palynofloras.

There are a number of apparently biostratigraphically useful datums within this Interval Zone. These include the range tops of *Lithodinia* sp. A and *Scriniodinium crystallinum* in the Beds with *Amoebites* and *Prorasenia* and Beds with *Amoebites kitchini* and *Rasenia* spp. (Text-Figures 26, 30). Furthermore, the range top of ?*Stephanelytron* spp. occurs within the Eudoxus Zone (Text-Figure 26). These bioevents are broadly consistent with western Europe (Riding and Thomas, 1988; 1992). The datums are not used here to further subdivide this interval Biozone into Interval Subbiozones; more detailed research is required. The inceptions of *Endoscrinium anceps*, *Glossodinium dimorphum*, *Perisseiasphaeridium pannosum* and *Wallodinium krutzschii* are also present at the base of this Interval Biozone (Text-Figure 30).

In the Russian Platform, the Lower Kimmeridgian yields ammonite faunas dominated by the genera *Amoebites* and *Prorazenia/Razenia* (Text-Figures 30, 31); a formal Zone is not recognised. However, the range top of unequivocal *Scriniodinium crystallinum* lies within these beds at the rivers Izhma and Unzha (Text-Figures 13 and 21 respectively), thereby indicating a correlation with the Baylei Zone of the Standard (Riding and Thomas, 1988; 1992). Only one Standard Zone, the Eudoxus Zone, is recognised throughout this Interval Biozone. The Kimmeridgian of this region is represented by isolated outcrops of limited stratigraphic extent. A complete succession through this stage is not present; furthermore, the boundary between the Lower and Upper Kimmeridgian is not exposed. This Interval Biozone approximately equates with the lowermost Beds with *Dingodinium* and *Cribroperidinium saetigerum* of Jakovleva (1993) (Text-Figure 32).

### *Subtilisphaera*? *inaffecta* Range Biozone (RPJ14)

**Definition:** The interval from the range top of *Gonyaulacysta jurassica* subsp. *jurassica* and the range base of *Subtilisphaera? inaffecta*, to the range top of *Subtilisphaera*? *inaffecta* (Text-Figure 30).

**Age:** Latest Kimmeridgian to earliest Volgian (Autissiodorensis and Klimovi zones).

**Reference Section:** Gorodische, mid River Volga Basin (Text-Figure 22).

**Description of Assemblages:** The uppermost Kimmeridgian-lowermost Volgian succession at Gorodische produced relatively abundant dinoflagellate cyst assemblages. These are dominated by *Batiacasphaera* spp., *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Cribroperidinium globatum*, *Dingodinium* spp. and *Subtilisphaera*? spp. (Text-Figures A3.16, A3.17) Also present are *Circulodinium distinctum*, *Cleistosphaeridium* spp., *Glossodinium dimorphum*, *Gonyaulacysta* spp., *Heslertonia* spp., *Hystrichodinium pulchrum*, *Leptodinim subtile*, *Occisucysta balios*, *Pareodinia ceratophora*, *Pareodinia halosa*, *Prolixosphaeridium parvispinum*, *Sentusidinium* spp., *Sirmiodinium grossii*, *Systematophora daveyii*, *Tubotuberella* spp. and *Wallodinium krutzschii* (Text-Figure 22). At Gorodische, *Subtilisphaera? inaffecta* and *Subtilisphaera? paeminosa* are prominent in this Interval Biozone (Text-Figure 22). This is especially the case in sample RP64 (Autissiodorensis Zone, Fallax Subzone), where an acme of *Subtilisphaera? paeminosa* occurs; here this species represents 20.4% of the dinoflagellate cyst assemblage (Text-Figure A3.17).

**Comments:** The abundance of *Subtilisphaera?* spp. in the uppermost Kimmeridgian to lowermost Volgian of the River Volga Basin is consistent with the situation in western Europe (Drugg, 1978; Riding and Thomas, 1988). *Subtilisphaera? paeminosa* is a reliable marker for the Autissiodorensis Zone in both western Europe and the Russian Platform (Drugg, 1978; Poulsen, 1996). The range top of *Rhynchodiniopsis cladophora* occurs at the top of the Kimmeridgian (Auttisiodorensis Zone) (Text-Figure 26), which equates with southern England (Riding and Thomas, 1988). Furthermore, the inception of *Oligosphaeridium patulum* lies at the base of the Klimovi Zone (Text-Figure 26). At Gorodische, the lectostratotype of the Volgian Stage, the range base of unequivocal *Glossodinium dimorphum* lies at the base of the Autissiodorensis Zone (Text-Figures 22, A3.16). This Interval Biozone equates with the uppermost Beds with *Dingodinium* and *Cribroperidinium saetigerum* of Jakovleva (1993) (Text-Figure 32).

### *Glossodinium dimorphum* Interval Biozone (RPJ15)

**Definition:** The interval from the range top of *Subtilisphaera? inaffecta*, to the range top of *Glossodinium dimorphum* (Text-Figure 30).

**Age:** Early to mid Volgian (?Sokolovi to Panderi zones).

**Reference sections:** Gorodische and Kashpir, mid River Volga Basin (Text-Figures 22 and 23 respectively).

**Description of Assemblages:** The Panderi Zone typically yields relatively rich dinoflagellate cyst assemblages; species diversity, however, is rather low. In this interval, *Cribroperidinium globatum*, *Dingodinium* spp., *Gonyaulacysta* spp., *Hystrichodinium pulchrum*, indeterminate chorate cysts and *Systematophora daveyi* are abundant (Text-Figures 22, A3.16 and A3.17). The following forms are present in generally lesser proportions: *Batiacasphaera* spp.; *Chytroeisphaeridia chytroeides*, *Endoscrinium* spp.; *Glossodinium dimorphum*; *Kleithriasphaeridium porosispinum*; *Leptodinium subtile*; *Oligosphaeridium patulum*; *Pareodinia* spp.; *Prolixosphaeridium parvispinum*; *Sirmiodinium grossii*; *Systematophora areolata* and *Tubotuberella rhombiformis* (Text-Figures A3.16, A3.17 and A3.19). At Gorodische, an acme occurrence of *Oligosphaeridium patulum* (29.3% of the dinoflagellate cyst assemblage in sample RP 53) was observed in the Panderi Zone, Zarajskensis Subzone (Text-Figure A3.17). A similar acme was recorded in the Hudlestoni Zone of southern England by Riding and Thomas (1988). Prasinophytes are intermittently common to abundant in the Panderi Zone at Kashpir (Text-Figure A3.19); these are largely species of *Pterospermella* and *Tasmanites*.

**Comments:** The ?Sokolovi and Pseudoscythica zones have not been studied here, however, palynofloras from the ?Sokolovi Zone at Gorodische are extremely sparse (V.A.F., personal observations). The ?Sokolovi Zone is included in this Interval Biozone because the prasinophyte associations are similar to those from the overlying Pseudoscythica Zone (V.A.F., unpublished data). The Pseudoscythica Zone has yielded dinoflagellate cysts similar to those from the Panderi Zone and including rare Boreal elements such as *Paragonyaulacysta capillosa* (V.A.F., personal observations). The top of this Interval Biozone is defined using the range top of *Glossodinium dimorphum* at the top of the Panderi Zone (Text-Figure 30). In western Europe, this bioevent is younger, occurring at the top of the Anguiformis Zone (Riding and Thomas, 1992); this datum is coincident with the top of the Nikitini Zone (Text-Figure 32). The range base of consistent *Senoniasphaera jurassica* was noted at the base of the Panderi Zone (Text-Figure 26). At Gorodische, *Dichadogonyaulax? pannea* was observed rarely in the Panderi Zone, Zarajskensis Subzone (Text-Figure 22). Therefore, there are significant numbers of typically western European forms in this interval. Jakovleva (1993) described this interval in the Russian Platform as Beds with *Dingodinium* and *Cleistosphaeridium huguoniotii* and Beds with *Dingodinium*, *Gonyaulacysta* and *Endoscrinium campanula* (Text-Figure 32).

*Senoniasphaera jurassica* Interval Biozone (RPJ16)

**Definition:** The interval from the range top of *Glossodinium dimorphum*, to the range top of *Prolixosphaeridium parvispinum* and the range base of *Gochteodinia villosa* (Text-Figure 30). The uppermost part of this interval Biozone is illustrated as extending to the base of the Fulgens Zone (late Volgian), at the point of the range base of *Gochteodinia villosa* (Text-Figure 30). There is a regional hiatus throughout the Russian Platform at the equivalent of the Oppressus Standard Zone, thus the effective top of the RPJ16 Interval Biozone equates with the range top of *Prolixosphaeridium parvispinum* at the top of the Nikitini Zone (Text-Figure 30).

**Age:** Mid Volgian (Virgatus and Nikitini zones).

**Reference Section:** Gorodische and Kashpir, mid River Volga Basin (Text-Figures 22 and 23 respectively).

**Description of Assemblages:** This Interval Biozone normally yields low diversity microplankton assemblages by comparison with the underlying RPJ15 Interval Biozone. *Circulodinium distinctum*, *Cribroperidinium globatum*, *Gonyaulacysta* spp., indeterminate chorate cysts and *Sentusidinium* spp. are abundant (Text-Figure 22). The following forms are also present: *Chytroeisphaerida chytroeides*, *Dingodinium* spp., *Endoscrinium* spp., *Imbatodinium* spp., *Kleithriasphaeridium porosispinum*, *Oligosphaeridium patulum*, *Perisseiasphaeridium pannosum*, *Prolixosphaeridium parvispinum*, *Senoniasphaera jurassica*, *Sirmiodinium grossii* *Systematophora* spp., *Tubotuberalla rhombiformis* and *Wallodinium krutzschii* (Text-Figure A3.16, A3.17 and A3.19). *Pterospermella* and *Tasmanites* are present in the Virgatus and Nikitini zones at Gorodische and Kashpir (Text-Figures A3.18 and A3.19 respectively).

**Comments:** The latest mid Volgian Oppressus Zone equivalent is not developed in the Russian Platform (Text-Figure 32; Casey and Mesezhnikov, 1986) (see above). The Interval Biozonal index, *Senoniasphaera jurassica*, occurs both below and above the Virgatus and Nikitini zones (Text-Figure 26). This Interval Biosubzone is largely defined using the datums of two taxa which are not present in this division, *Glossodinium dimorphum* and *Gochteodinia villosa* (Text-Figure 30). The absence of abundant *Dingodinium* spp. throughout most of this Interval Biozone enables the approximate differentiation of RPJ16 from the underlying RPJ15 Interval Biozone (Text-Figure 26). Jakovleva (1993) described this interval in the Russian Platform as Beds with *Escharisphaeridia*, *Gonyaulacysta* and *Endoscrinium* sp. A (Text-Figure 32).

*Gochteodinia villosa* Interval Biozone (RPJ17)

**Definition:** The interval from the range base of *Gochteodinia villosa*, to the range top of *Gochteodinia villosa* and the range base of *Batioladinium* spp. (Text-Figure 30).

**Age:** Late Volgian (Fulgens to Nodiger zones) to Ryazanian (Rjasanensis-Subclypeiforme to Rjasanensis-Spasskensis zones).

**Reference Sections:** Gorodische and Kashpir, mid River Volga Basin and Kuzminskoje, River Oka Basin (Text-Figures 22, 23 and 24 respectively).

**Description of Assemblages:** The late Volgian and Ryazanian of the Russian Platform yielded relatively rich and diverse dinoflagellate cyst and prasinophyte floras. Prominent forms include: *Batiacasphaera* spp., *Chlamydophorella* spp.; *Circulodinium distinctum*; *Cribroperidinium* spp.; *Gonyaulacysta* spp., *Senoniasphaera jurassica*; *Sentusidinium* spp.; *Tubotuberella rhombiformis* and *Wallodinium krutzschii* (Text-Figures A3.16, A3.17, A3.19 and A3.20). Also present in smaller proportions are: *Acanthaulax* sp.; *Ambonosphaera? staffinensis*; *Cassiculosphaeridia* spp.; *Chytroeisphaeridia chytroeides*; *Dingodinium* spp.; *Egmontodinium torynum*; *Gochteodinia villosa*; *Muderongia simplex*; *Phoberocysta neocomica*; *Sirmiodinium grossii* and *Wallodinium cylindricum* (Text-Figures 22, 23, 24). *Endoscrinium pharo* has also been recorded from the Upper Volgian-Ryazanian of the Russian Platform by Fedorova et al. (1993) and Jakovleva (1993). Prasinophytes are common to abundant throughout this Interval Biozone; the majority of these are representatives of *Pterospermella* and *Tasmanites* (Text-Figure A3.20; Fedorova, 1989). This palynofacies is similar the 'hot' shale organic facies reported for the North Sea by Rawson and Riley (1982) and the Danish Central Trough by Heilmann-Clausen (1987).

**Comments:** This Interval Biozone is numbered RPJ17, although much of the interval is of Ryazanian age. The zonal index, *Gochteodinia villosa*, was not recorded in the Fulgens Zone in the material studied herein. However, this species is known to be present in this Zone in the Russian Platform (V.A.F., personal observations). *Gochteodinia villosa* has also been used as a Volgian-Ryazanian zonal index by Davey (1979; 1982), Woollam and Riding (1983) and Poulsen (1994) in western Europe. Jakovleva (1993) erected an equivalent *Gochteodinia villosa-Endoscrinium pharo* zone for the Russian Platform. The key dinoflagellate cyst markers, such as *Gochteodinia villosa*, therefore are present in both western Europe and the Russian Platform; they thus transcend different ammonite faunal provinces. In the Russian

Platform, the range bases of *Muderongia simplex* and *Phoberocysta neocomica* are at the base of the Rjasanensis-Spasskensis Zone (earliest late Ryazanian) (Text-Figures 26, 30). In western Europe, this datum occurs at the same level (Costa & Davey, 1992). The majority of several undifferentiated forms of *Systematophora* become extinct within the earliest late Ryazanian (Text-Figure 26). The Lamplughi Zone equivalent is not present in the Russian Platform (Text-Figures 30, 32).

Unnamed Interval Biozone (RPK1)

**Definition:** The interval from the range top of *Gochteodinia villosa* and the range base of *Batioladinium* spp., to the range base of *Pseudoceratium pelliferum* (Text-Figure 30).

**Age:** Latest Ryazanian (Tzikwinianus/Mesezhnikovi zones).

**Reference Section:** River Oka Basin (Text-Figure 5).

**Description of Assemblages:** In the late Ryazanian of the Russian Platform, the dinoflagellate cyst asemblages are of relatively low species diversity. Abundant forms include *Circulodinium distinctum*, *Gonyaulacysta* spp. and *Sentusidinium* spp. Other morphotypes in this interval comprise *Batioladinium* sp., *Chlamydophorella* spp., *Chytroeisphaeridia chytroeides*, *Dingodinium* spp., *Fromea* spp., ?*Lanterna* sp., *Muderongia simplex*, *Oligosphaeridium complex*, ?*Polystephanephorus* sp., *Scriniodinium* sp. and *Tubotuberella rhombiformis* (Fedorova and Grjazeva, 1984; Jakovleva, 1993).

**Comments:** No material of late Ryazanian age was examined as part of this study. However, as the late Ryazanian of the Russian Platform has been well documented by Fedorova and Grjazeva (1984) and Jakovleva (1993), this Interval Biozone has been included in this zonal scheme. In the central Russian Platform, the uppermost Ryazanian (Tzikwinianus Zone) is marked at the base by the range top of *Gochteodinia villosa* and at the top by the range base of *Pseudoceratium pelliferum* (Fedorova and Grjazeva, 1984; Jakovleva, 1993). Therefore, it is possible to recognise an uppermost Ryazanian dinoflagellate cyst Interval Biozone between these two bioevents (Text-Figure 30). In western Europe, the range base of *Pseudoceratium pelliferum* is slightly older, being within the Stenomphalus Zone (Costa and Davey, 1992). Jakovleva (1993), referred to this interval as Beds with *Sentusidinium*, *Muderongia* and *Batioladinium jaegeri*.

The Ryazanian of central Russian Platform and the Boreal Berriasian of the Pechora Basin are characterised by strongly provincial ammonite faunas. Fedorova et al. (1993) decribed the Boreal Berriasian dinoflagellate cyst assemblages from the River Izhma in the Pechora Basin.

# 7 COMPARISON OF THE RUSSIAN PALYNOFLORAS WITH WESTERN EUROPE AND OTHER REGIONS

In this section, the Jurassic and lowermost Cretaceous dinoflagellate cyst associations from northern East Siberia, the Pechora Basin and the central Russian Platform are compared with coeval floras, principally from western Europe, but including other regions, for example North America.

## 7.1 LOWER AND MIDDLE JURASSIC OF NORTHERN EAST SIBERIA

The Lower Jurassic (Pliensbachian and Toarcian) of northern East Siberia yielded dinoflagellate cyst associations rich in the genus *Nannoceratopsis*. The species represented are *Nannoceratopsis deflandrei* (three subspecies), ?*Nannoceratopsis dictyambonis*, *Nannoceratopsis gracilis*, *Nannoceratopsis ridingii*, *Nannoceratopsis triangulata* and *Nannoceratopsis triceras* (Text-Figure 11). The three subspecies of *Nannoceratopsis deflandrei* and *Nannoceratopsis gracilis* have the longest ranges and are the most abundant. *Nannoceratopsis deflandrei* is the oldest species of this genus. Of the three subspecies, only *Nannoceratopsis deflandrei* subsp. *anabarensis* is endemic to northern East Siberia. This distinctive form is confined to the latest Pliensbachian and earliest Toarcian (Text-Figure 11). *Nannoceratopsis deflandrei* subsp. *senex* is, by contrast, a widespread form and is a reliable biomarker for the Lower Toarcian of northwest Europe and arctic Canada. The inception of *Nannoceratopsis gracilis* marks the upper part of the Lower Toarcian (Text-Figure 27; Ilyina in Ilyina et al., 1994). Apart from the presence of *Nannoceratopsis deflandrei* subsp. *anabarensis* in the latest Pliensbachian to earliest Toarcian, the *Nannoceratopsis* occurrences of northern East Siberia are substantially similar to those of other areas in the Northern Hemisphere. This distinctive genus dominates Pliensbachian to early Bajocian dinoflagellate cyst assemblages throughout the Northern Hemisphere. It has previously been described from North America (Van Helden, 1977; Davies, 1983) and western Europe (Woollam and Riding, 1983). Other Toarcian species with wide geographical distributions include *Mancodinium semitabulatum*, *Scriniocassis priscus*, *Scriniocassis weberi* and *Valvaeodinium stipulatum*. In the Upper Toarcian, the *Parvocysta* suite of Riding (1984a) was observed. This group of apparently closely-related cysts is relatively rich and diverse in northern East Siberia. Representative forms include *Moesiodinium raileanui*, *Parvocysta bullula*, *Parvocysta? cracens*, *Parvocysta nasuta*, *Parvocysta? tricornuta*, *Phallocysta elongata*, *Phallocysta eumekes*, *Susadinium faustum* and *Susadinium scrofoides* (Text-Figure 11). *Phallocysta eumekes* sporadically attained extremely abundant levels (Text-Figure A3.3). This situation confirms the observations of Riding (1984a), Riding et al. (1991), Ilyina in Ilyina et al. (1994) and Riding and Ioannides (1996) that this plexus is most abundant and diverse in the high northern latitudes. Studies of the Toarcian of arctic Canada (Dörhöfer and Davies, 1980; Davies, 1983) and Spitzbergen (Bjaerke, 1980) indicate equally diverse associations of this group. *Valvaeodinium aquilonium* was also recorded throughout the Upper Toarcian of Northern Siberia (Text-Figure 11); this taxon is also a typically Boreal species (Dörhöfer and Davies, 1980).

The earliest Callovian dinoflagellate cyst floras from Anabar Bay (section 5.1.2) are rich in both cosmopolitan and typically Boreal dinoflagellate cysts such as *Crussolia* spp. and *Paragonyaulacysta retiphragmata* (Text-Figure 10). Similar assemblages have been reported from elsewhere in the Boreal Realm by Johnson and Hills (1973) and Smelror (1988a).

## 7.2 RUSSIAN PLATFORM

In this section, the discussion is subdivided into five subsections; these comprise the Bathonian, Callovian, Oxfordian, Kimmeridgian/Volgian and Ryazanian stages.

### 7.2.1 Bathonian

In this study, three Bathonian samples were examined from the River Pizhma, in the Pechora Basin (section 5.2.1.1) and nine from Borehole 132 in the central Russian Platform (section 5.3.1.1). The dinoflagellate cyst floras recovered are of relatively low species diversity (Text-Figure 15). *Batiacasphaera* spp., *Ctenidodinium sellwoodii*, *Korystocysta gochtii*, *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Lithodinia* spp. and *Wanaea acollaris* are widespread Bathonian elements recorded throughout the Northern Hemisphere (Riding et al., 1985). The Russian palynofloras include several of the late Bathonian-earliest Callovian Boreal-northernmost Sub-Boreal elements mentioned by Smelror (1993); these include *Batiacasphaera* spp., *Pareodinia* spp. and *Sirmiodinium grossii*. In comparison to coeval floras from western Europe, the Russian Platform assemblages are markedly different. The abundant and diverse floras dominated by *Ctenidodinium* typical of England, France and Germany (Riding et al., 1985) were not encountered, although *Ctenidodinium sellwoodii* is present. Smelror (1993) stated that in northwest Europe, south of a line running between northeast Greenland and offshore mid Norway, Bathonian dinoflagellate cyst floras have more affinities to the Tethyan Realm. Smelror (1993) also suggested that pareodiniacean forms characterise the Boreal Bathonian, whereas the Tethyan Realm is rich in ctenidodonioid and lithodiniacean species. The Bathonian dinoflagellate cysts of the Russian Platform appear to be an intermediate flora between the true Boreal and Tethyan realms. Localities in northern and eastern England also have yielded intermediate Boreal-Tethyan Bathonian dinoflagellate cyst associations; these are different again in composition from the Russian Platform floras. For example, *Protobatioladinium elatmaensis* and *Protobatioladinium? elongatum* are common in the samples in this study and are apparently endemic to western Russia; Riding and Ilyina (1996; 1998) have noted this provincialism. Dinoflagellate cysts from the Bathonian of the Voronezh Structural High in the western Russian Platform, however, exhibit more affinities to central England as they are rich in *Ctenidodinium sellwoodii* and poor in *Protobatioladinium elatmaensis* (Ilyina, 1991a; Riding and Ilyina, 1996). Furthermore, *Chytroeisphaeridia hyalina*, *Evansia evittii*, *Fentonia bjaerkei* (acritarch), *Fromea tornatilis* and *Mendicodinium groenlandicum* are Boreal in affinity and are not known from the Bathonian of western Europe. The acritarch *Fentonia bjaerkei* appears to be a distinctly Boreal species during the Bathonian (Smelror, 1987). It is believed that the low sea level stands during the Bathonian (Haq et al., 1987) led to the formation of geographically isolated dinoflagellate cyst floras in this intermediate Boreal-Tethyan region. Smelror (1993) believed that both latitudinal gradients and salinity variations affected Bathonian dinoflagellate cyst species, following arguments for these individual factors by Fenton and Fisher (1978) and Riding et al. (1985) respectively.

### 7.2.2 Callovian

A total of 24 Callovian samples were studied from the central and northern Russian Platform in this study (sections 5.2 and 5.3) and these horizons generally produced abundant and diverse dinoflagellate cyst associations. The majority of the species are well known from western Europe and minimal evidence of provincialism between these regions was noted. These geographically widespread species include *Chytroeisphaeridia cerastes*, *Cleistosphaeridium varispinosum*, *Ctenidodinium ornatum*, *Fromea tornatilis*, *Gonyaulacysta eisenackii*, *Gonyaulacysta jurassica* subsp. *adecta*, *Lithodinia caytonensis*, *Lithodinia planoseptata*, *Nannoceratopsis pellucida*, *Pareodinia prolongata*, *Rhynchodiniopsis cladophora*, *Scriniodinium crystallinum*, *Sirmiodiniopsis orbis*, *Sirmiodinium grossii*, *Tubotuberella dangeardii* and *Wanaea acollaris* (Text-Figure 16). Eustatic levels were steadily rising during the Callovian Stage (Haq et al., 1987) and it is envisaged that the inundation by the sea of land barriers led to the establishment of extensive marine connections between the Tethyan and Boreal realms. This led to the establishment of wide geographical distributions of planktonic fossil groups by the mid to late Callovian. It is thought that the dinoflagellate cyst endemism within the Sub-Boreal Realm during the Bathonian (section 7.2.1) was rapidly ended by early Callovian eustatic rise. The only species of unequivocal Boreal affinity observed was *Paragonyaulacysta retiphragmata* (Text-Figure A3.6). Other species characteristic of the Russian Platform include *Chytroeispharidia hyalina*, *Evansia evittii* and *Fromea tornatilis*. The dinoflagellate cyst asemblages were most rich and diverse in the late Callovian. This situation mirrors that in northwest Europe and arctic Canada (Johnson and Hills, 1973; Davies, 1983; Woollam and Riding, 1983). Smelror (1993) also noticed this phenomenon, but noted that endemic Boreal species are present in the late Callovian. The Callovian dinoflagellate cysts from the Russian Platform generally have identical or substantially similar stratigraphic ranges to those known from northwest Europe. However, there are several exceptions to this. *Chytroeisphaeridia hyalina*, *Cleistosphaeridium varispinosum* and *Lithodinia planoseptata* range into Upper Callovian strata in the Russian Platform (Text-Figure 16). In western Europe, these forms are confined to the early-mid Callovian (Woollam and Riding, 1983; Riding, 1987; Riding and Thomas, 1997). Furthermore, several species in the present study are confined to the latest Callovian (Subordinarium Zone), whereas in northwest Europe they occur throughout the late Callovian. These species include *Clathroctenocystis asapha*, *Ctenidodinium ornatum* and *Stephanelytron* spp (Text-Figure 16). *Mendicodinium groenlandicum* is not as abundant in the late Callovian of the Russian Platform as in western Europe. Furthermore, the first appearances of *Dingodinium* spp., *Leptodinium subtile* and *Systematophora* sp. in the Russian Platform are noteworthy. These forms are known only from the Upper Jurassic in northwest Europe; *Leptodinium subtile* and *Systematophora* spp. are markers for the base of the Oxfordian (Riding and Thomas, 1992).

### 7.2.3 Oxfordian

An extensive Oxfordian sample suite from the Russian Platform was studied as part of this work (sections 5.2 and 5.3). The Lower and Middle Oxfordian are well represented (Appendix 1), however the only Upper Oxfordian samples are three from section 1 at the River Unzha, near Kostroma (section 5.3.3.2). Like the underlying Callovian, the Oxfordian dinoflagellate cyst assemblages from the Russian Platform are extremely similar in species spectra and proportions to coeval floras from western Europe and adjacent areas. Of all the stages studied, the Oxfordian produced the assemblages most similar to those reported from surrounding regions (Johnson and Hills, 1973; Woollam and Riding, 1983). This is interpreted as being a result of high sea levels during the entire Oxfordian stage (Haq et al., 1987). This resulted in extensive and shallow continental shelf areas which provided wide marine connections between the Boreal and Tethyan realms. Many early and mid Oxfordian dinoflagellate cyst biomarkers have relatively short, isochronous stratigraphic ranges and wide geographic distributions, e.g. *Wanaea fimbriata*. The plethora of reliable range tops and range bases in the early and mid Oxfordian means that high biostratigraphic resolution using dinoflagellate cysts is possible (Text-Figure 25). Some Oxfordian provincialism in the Northern Hemisphere, however, is known (Smelror, 1993), therefore certain forms were latitudinally-controlled. These include *Evansia alaskensis* (Wiggins 1975) Below 1990, *Evansia zabra* (Davies 1983) Jansonius 1986 and *Paragonyaulacysta* spp. for the Boreal Realm and *Ambonosphaera? staffinensis*, *Gonyaulacysta dentata* (Raynaud 1978) Lentin & Vozzhennikova 1990 and *Xylochoarion hacknessense* Erkmen & Sarjeant 1978 for the Boreal/Sub-Boreal areas. The Oxfordian of the Russian Platform has yielded the typically Boreal forms *Crussolia deflandrei*, *Crussolia perireticulata*, *Gonyaulacysta dualis* and *Paragonyaulacysta retiphragmata* (Text-Figure 25). It appears that these forms migrated southwards at this time. *Evansia evittii* and *Lithodinia* sp. A appear to be characteristic of the Russian Platform.

### 7.2.4 Kimmeridgian and Volgian

Kimmeridgian and Volgian material was studied from Gorodische, the River Izhma, Kashpir, sections 3/4 at the River Unzha, near Kostroma, the River Oka Basin and the River Pizhma in the Russian Platform. This material produced abundant dinoflagellate cyst assemblages which are generally of lower species diversity compared to counterparts from western Europe. However, the majority of the species recorded from the Russian Platform localities have wide geographic distributions. The earliest Kimmeridgian of Makarjev, near Kostroma is substantially similar to floras from the the lowermost Kimmeridgian of the United Kingdom and other Sub-Boreal localities (Riding and Thomas, 1988; 1997). Species common to both regions include *Aldorfia dictyota* subsp. *pyrum*, *Chytroeisphaeridia chytroeides*, *Cribroperidinium globatum*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Rhynchodiniopsis cladophora*, *Scriniodinium crystallinum*, *Stephanelytron* spp. and *Systematophora areolata* (Text-Figure 26). *Lithodinia* sp. A and *Tubotuberella rhombiformis* are, however, confined to the Russian Platform. The Kimmeridgian and Volgian dinoflagellate cysts of Gorodische, the River Izhma, Kashpir, the River Oka Basin and the River Pizhma are similarly close in content to European early Kimmeridgian floras. Known Tethyan forms such as *Amphorula metaelliptica* Dodekova 1969 and *Histiophora* spp. were not recorded. Furthermore, no representatives of the *borealis* assemblage of Brideaux and Fisher (1976) were noted. Acavate proximate/proximochorate forms with apical archeopyles such as *Sentusidinium* spp. are far more common in southern England than on the Russian Platform (Riding and Thomas, 1988). Dinoflagellate cyst floras from the Tethyan Realm are characterised by large proportions of chorate forms (Dürr, 1987; 1988). *Gonyaulacysta jurassica* subsp. *jurassica* is rare in the Kimmeridgian of the Tethyan region and *Rhynchodiniopsis cladophora* is absent according to Smelror et al. (1991). Species of *Dingodinium* are extremely abundant in the Middle Volgian of the central Russian Platform (Text-Figures 22, A3.16). These acmes are not present in the Volgian of the Pechora Basin. Chorate cysts are also common to abundant in the Volgian of the Russian Platform. Many distinctive taxa, however, are common to the Kimmeridgian-Volgian of both the Russian Platform and western Europe; these include *Dingodinium tuberosum*, *Glossodinium dimorphum*, *Occisucysta balios*, *Oligosphaeridium patulum*, *Perissieasphaeridium pannosum*, *Senoniasphaera jurassica*, *Subtilisphaera? inaffecta* and *Subtilisphaera? paeminosa*. The datums of these and other species allow pan-European correlations to be made. Sea levels were relatively high throughout the Kimmeridgian-Volgian (Haq et al., 1987), thus it is not surprising that there are few apparently endemic Russian Platform taxa present. However, Jurassic eustatic levels peaked in the early Volgian; subsequent to this event, a slow regressive trend was established (Haq et al., 1987).

### 7.2.5 Ryazanian

Five samples from the Lower Ryazanian of Kashpir and the River Oka Basin were examined as part of this work. The Kashpir material is relatively sparse (Text-Figure A3.17), however the samples from the River Oka Basin are relatively productive (Text-Figure A3.18; Fedorova and Grjazeva, 1984; Fedorova, 1994; Iosifova, 1992; 1996). These horizons produced relatively high diversity dinoflagellate cyst assemblages including *Ambonosphaera? staffinensis*, *Cassiculosphaeridia* spp., *Chlamydophorella* spp., *Circulodinium* spp., *Cribroperidinium* spp., *Endoscrinium* spp., *Fromea* spp., *Gochteodinia villosa*, *Gonyaulacysta* spp., *Muderongia simplex*, *Sirmiodinium grossii*, *Tubotuberella rhombiformis* and *Wallodinium* spp. (Text-Figures A3.15 and A4.18). No unequivocally endemic species were recorded. By comparison with floras from northwest Europe, these assemblages are of low species diversity. Prominent western European taxa not present in the River Oka Basin include *Batioladinium radiculatum* Davey 1982, *Dingodinium spinosum* (Duxbury 1977) Davey 1979, *Gochteodinia virgula* Davey 1982, *Isthmocystis distincta* Duxbury 1979 and *Rotosphaeropsis thula* (Davey 1982) Riding & Davey 1989 (see Duxbury, 1977; Costa and Davey, 1992). Representatives of the *borealis* assemblage of Brideaux and Fisher (1976) were observed in extremely low numbers.

## 8 CONCLUSIONS

This joint palynological study has resulted in a major synthesis of the Jurassic-lowermost Cretaceous dinoflagellate cyst biostratigraphy of northern East Siberia and the Russian Platform. A dinoflagellate cyst interval biozonation scheme, ranging from the latest Pliensbachian to the Ryazanian, is proposed on the basis of the results from this project. The present zonal scheme comprises 21 dinoflagellate cyst Interval/Acme Biozones. Three dinoflagellate cyst Interval Biozones for the latest Pliensbachian and Toarcian of northern East Siberia are erected; one of these Interval Biozones is subdivided into two Interval Subbiozones. Four lowermost Callovian samples from northern East

Siberia were also studied; the dinoflagellate cysts are of distinctly Boreal affinity. They differ from coeval floras in the Russian Platform, showing that marked provincialism operated at that time. Because of the low numbers of samples, this suite was not placed in an Interval Biozone. However, ammonite studies have enabled a correlation with the Subboreal earliest Callovian dinoflagellate cyst Interval Zone for the Russian Platform.

Eighteen dinoflagellate cyst Interval Biozones are erected for the Bathonian to Ryazanian of the Russian Platform. These interval biozones are, wherever possible, linked to both regional and Standard ammonite zones. Several dinoflagellate cyst species are zonal indices in both the western European scheme of Riding and Thomas (1992) and the biozonation proposed herein. Furthermore, the stratigraphic ranges of many Callovian to Ryazanian key dinoflagellate cyst taxa are identical in both western Europe and the Russian Platform.

The Bathonian palynofloras of the Russian Platform indicate that significant endemism operated at that time. However, rising eustatic levels during the succeeding Callovian and Oxfordian stages means that the Russian dinoflagellate cyst associations are similar to associations from western Europe and surrounding areas.

## ACKNOWLEDGEMENTS

This study was carried out as part of a collaborative research project entitled 'Northern Hemisphere Mesozoic Palynozonation', undertaken during the tenure of award number CT-93-0002 from the *International Association for the Promotion of Cooperation with Scientists from the New Independent States of the former Soviet Union* (INTAS), Brussels, Belgium, who are thanked for their generous financial support. Amoco, Elf-Aquitaine, Exxon and Unocal also provided generous and invaluable financial support. In particular, the authors thank Dr Nicos S. Ioannides (Exxon, Houston), Dr Merrell A. Miller (Amoco, Houston), Dr Christian Seyve (Elf-Aquitaine, Pau, France) and Dr Roger J. Witmer (Unocal, Houston) for their active interest in, and support of, the project. James B. Riding publishes with the permission of the Director, British Geological Survey (NERC).

Dr Valentina A. Fedorova expresses her thanks to the Academician of the Russian Academy of Natural Sciences, Dr Mikhail D. Belonin (Director of the All-Russia Petroleum Scientific-Research Geological-Exploration Institute [VNIGRI], St.-Petersburg) for permission to participate in this joint project and the authorisation to publish the scientific results.

Dr Vera I. Ilyina is grateful to the Academician of the Russian Academy of Sciences, Professor Alexei E. Kontorovich (Director of the Institute of Geology of Oil and Gas, Siberian Branch of the Russian Academy of Sciences, Novosibirsk) for encouragement and support during this study and permission to publish the results.

All three authors would like to express their most sincere thanks to the Member-Correspondents of the Russian Academy of Sciences, Professor Alexander V. Kanygin, Dr Anna I. Kirichkova and Dr Valentin K. Shimanskyi and for scientific support and advice. The authors are also endebted to Drs. Svetlana P. Jakovleva, Svetlana V. Meledina, and Svetlana A. Tchirva for the provision of samples from the Jurassic of northern East Siberia and the Russian Platform and for their invaluable scientific advice.

The authors also thank Dr Bernard Owens (British Geological Survey - BGS, Nottingham) for his support, encouragement and scientific overview of this project. Mr Paul Turner and Ms Sophie Wood of the BGS Cartography Section expertly drew the Text-Figures and Mr Mark Goddard (BGS Photography Department) printed the majority of the photomicrographs.

Dr Robert A. Fensome (Geological Survey of Canada, Dartmouth) and Dr Joanna E. Thomas (BGS, Nottingham) provided thorough and perceptive reviews of an initial draft of the manuscript.

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# APPENDIX 1 - SAMPLE DETAILS

Sample data on the 187 samples examined in this study are presented in the tables below. The samples are given informal sample numbers for the purposes of this work and these are referred to in the text and Text-Figures. These numbers are sequential within the three regions, i.e. northern East Siberia (prefixed NS), the Pechora Basin, northern Russia (prefixed TP) and the central Russian Platform, central Russia (prefixed RP). The data presented in the tables are, respectively and where appropriate, the informal sample number, the collector's number (prefixed VII or VAF depending upon who collected/ supplied the material), outcrop number/field number/bed number/depth in metres etc. data, Stage/Substage, ammonite zone/beds and lithology.

## 1 SAMPLES FROM NORTHERN EAST SIBERIA

These samples were studied by J. B. Riding and V. I. Ilyina. They were collected by various staff of the Institute of Geology, Geophysics and Mineralogy, Novosibirsk, Russia.

### 1.1 WEST BANK OF THE RIVER ANABAR

| | | | | | |
|---|---|---|---|---|---|
| NS 1 | VII 2675 | outcrop 5/bed 18 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 2 | VII 2674 | outcrop 5/bed 18 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 3 | VII 2673 | outcrop 5/bed 18 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 4 | VII 2670 | outcrop 5/bed 17 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 5 | VII 2669 | outcrop 5/bed 17 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 6 | VII 2668 | outcrop 5/bed 17 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 7 | VII 2667 | outcrop 5/bed 17 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 8 | VII 2666 | outcrop 5/bed 17 | Lower Toarcian | Falciferum/Commune zones | mudstone |
| NS 9 | VII 2381 | outcrop 3/bed 16 | Lower Toarcian | ?Propinquum Zone | siltstone |
| NS 10 | VII 2380 | outcrop 3/bed 16 | Upper Pliensbachian | Viligaensis Zone | sandstone |
| NS 11 | VII 2375 | outcroP 3/bed 14 | Upper Pliensbachian | Viligaensis Zone | sandstone |
| NS 12 | VII 2374 | outcrop 3/bed 14 | Upper Pliensbachian | Viligaensis Zone | siltstone |
| NS 13 | VII 2370 | outcroP 2/bed 10 | Upper Pliensbachian | Margatitatus Zone | nodular sst. |
| NS 14 | VII 2368 | outcrop 2/bed 7 | Upper Pliensbachian | Stokesi Zone | nodular shale |
| NS 15 | VII 2365 | outcrop 1/bed 3 | Upper Pliensbachian | Stokesi Zone | mudstone |
| NS 16 | VII 2363 | outcrop 1/bed 2 | Upper Pliensbachian | Stokesi Zone | nodular sst. |

### 1.2 WEST COAST OF ANABAR BAY (I)

| | | | | | |
|---|---|---|---|---|---|
| NS 17 | VII 6042 | outcrop 11/bed 21 | Aalenian | | sandstone |
| NS 18 | VII 6039 | outcrop 11/bed 21 | Aalenian | | sandstone |
| NS 19 | VII 6037 | outcrop 11/bed 21 | Aalenian | | sandstone |
| NS 20 | VII 6036 | outcrop 11/bed 20 | Upper Toarcian | | sandstone |
| NS 21 | VII 6082 | outcrop 11/bed 20 | Upper Toarcian | | sandstone |
| NS 22 | VII 6032 | outcrop 11/bed 20 | Upper Toarcian | | sandy siltstone |
| NS 23 | VII 6031 | outcrop 11/bed 20 | Upper Toarcian | | sandy siltstone |
| NS 24 | VII 6029 | outcrop 11/bed 20 | Upper Toarcian | | siltstone |
| NS 25 | VII 5015 | outcrop 11/bed 20 | Upper Toarcian | | sandstone |
| NS 26 | VII 6076 | outcrop 11/bed 18 | Lower Toarcian | Comm./Braun. zones | nodular sst. |
| NS 27 | VII 5019 | outcrop 11/bed 17 | Lower Toarcian | Comm./Braun. zones | mudstone |
| NS 28 | VII 5024 | outcrop 11/bed 17 | Lower Toarcian | Comm./Braun. zones | siltstone |
| NS 29 | VII 5032 | outcrop 11/bed 16 | Lower Toarcian | Falciferum Zone | mudstone |
| NS 30 | VII 5033 | outcrop 11/bed 16 | Lower Toarcian | Falciferum Zone | nodular mudst. |
| NS 31 | VII 6028 | outcrop 11/bed 16 | Lower Toarcian | ?Propinquum Zone | nodular muds. |
| NS 32 | VII 5037 | outcrop 12/bed 15 | Lower Toarcian | ?Propinquum Zone | nodular mudst. |
| NS 33 | VII 5039 | outcrop 12/bed 15 | Lower Toarcian | ?Propinquum Zone | nodular mudst. |
| NS 34 | VII 5041 | outcrop 12/bed 14 | Upper Pliensbachian | Viligaensis Zone | nodular siltst. |
| NS 35 | VII 5050 | outcrop 12/bed 13 | Upper Pliensbachian | Viligaensis Zone | mudstone |
| NS 36 | VII 5051 | outcrop 12/bed 12 | Upper Pliensbachian | Margaritatus Zone | mudstone |

## 1.3 ASTRONOMITSCHESKII CREEK, RIVER KEDON BASIN

| | | | | | |
|---|---|---|---|---|---|
| NS 37 | VII 7201 | outcrop 2/bed 12 | Lower Toarcian | Falciferum Zone | grey mudstone |
| NS 38 | VII 7163 | outcrop 2 | Lower Toarcian | Falciferum Zone | grey mudstone |

## 1.4 OUTCROP 6, SOBO CREEK, RIVER MARCHA, VILJUI BASIN

| | | | | | |
|---|---|---|---|---|---|
| NS 39 | VII 4018 | field no. 226/bed 2 | Upper Toarcian | | grey siltstone |
| NS 40 | VII 4019 | bed 3 | Upper Toarcian | | silty mudstone |
| NS 41 | VII 4020 | bed 3 | Upper Toarcian | | silty mudstone |
| NS 42 | VII 4021 | field no. 241/bed 4 | Lower Toarcian | Commune Zone | siltstone |
| NS 43 | VII 1809 | | Lower Toarcian | Falciferum Zone | black mudstone |
| NS 44 | VII 4028 | field no. 254/bed 7 | Lower Toarcian | Falciferum Zone | black mudstone |
| NS 45 | VII 4030 | field no. 257/bed 7 | Lower Toarcian | Falciferum Zone | black mudstone |
| NS 46 | VII 3481 | field no. 9/bed 7 | Lower Toarcian | Falciferum Zone | black mudstone |
| NS 47 | VII 3479 | field no. 8a/bed 7 | Lower Toarcian | Falciferum Zone | black mudstone |
| NS 48 | VII 3477 | field no. 5a/bed 7 | Lower Toarcian | Falciferum Zone | black mudstone |

## 1.5 OUTCROP 10, BANK OF THE RIVER MARCHA, NEAR MOUTH OF THE RIVER LOCHAJA

| | | | | | |
|---|---|---|---|---|---|
| NS 49 | VII 4025/2a | fld. no. 345/top bed 2 | Upper Toarcian | | nodular siltstone |
| NS 50 | VII 4024/2a | fld. no. 354/base bed 2 | Upper Toarcian | | nodular siltstone |

## 1.6 BOREHOLE 141, KHATIRIK-KHOMO, EASTERN VILJUI BASIN

| | | | | | |
|---|---|---|---|---|---|
| NS 51 | VII 3577 | 2489.00m | Upper Toarcian | | dark mudstone |
| NS 52 | VII 3599 | 2489.50m | Upper Toarcian | | dark mudstone |

## 1.7 BANK OF THE RIVER KELIMJAR, DOWNSTREAM OF ULAKHAN-KURUNG CREEK

| | | | | | |
|---|---|---|---|---|---|
| NS 53 | VII 4016 | bed 7 | Upper Toarcian | | siltstone |

## 1.8 BANK OF THE RIVER MOTORCHUNA, NEAR THE MOUTH OF THE RIVER BALAGANAKH

| | | | | | |
|---|---|---|---|---|---|
| NS 54 | VII 4035 | bed 3 (6m from base) | Upper Toarcian | | nodular mudst. |
| NS 55 | VII 4065 | bed 3 (3m from base) | Upper Toarcian | | mudstone |

## 1.9 WEST COAST OF ANABAR BAY (II)

| | | | | | |
|---|---|---|---|---|---|
| NS 56 | VII 3454 | bed 34 | Lower Callovian | Anabarense | siltstone |
| NS 57 | VII 3453 | bed 32 | Lower Callovian | Anabarense | siltstone |
| NS 58 | VII 3452 | bed 31 | Lower Callovian | Falsum | mudstone |
| NS 59 | VII 3451 | bed 31 | Lower Callovian | Falsum | mudstone |

# 2 SAMPLES FROM THE PECHORA BASIN, NORTHERN RUSSIAN PLATFORM

## 2.1 THE BATHONIAN TO CALLOVIAN PALYNOLOGY OF THE RIVER PECHORA BASIN, NORTHERN RUSSIAN PLATFORM

These samples were studied by J. B. Riding and V. I. Ilyina. They were collected by staff of the Institute of Geology, Geophysics and Mineralogy, Novosibirsk, Russia.

### 2.1.1 West bank of the River Izhma, outcrop 7

| | | | | | |
|---|---|---|---|---|---|
| TP 1 | VII 3166 | field 7/2/bed 2 | Upper Callovian | Keyserlingi | mudstone |
| TP 2 | VII 3165 | field 7/1/bed 1 (top) | Upper Callovian | Keyserlingi | mudstone |

### 2.1.2 West bank of the River Izhma, outcrop 9

| | | | | | |
|---|---|---|---|---|---|
| TP 3 | VII 3178 | field 9/3/bed 3 | Upper Callovian | | mudstone |
| TP 4 | VII 3169 | field 9/1b/bed 1 | Middle Callovian | Milaschevici/Kosmoceras | mudstone |
| TP 5 | VII 3168 | field 9/1a/bed 1 | Middle Callovian | Milaschevici/Kosmoceras | mudstone |

### 2.1.3 East bank of the River Pizhma, near Churkin Village, outcrop 13

| | | | | | |
|---|---|---|---|---|---|
| TP 6 | VII 3177 | field 13/2c/bed 2 | Lower Callovian | cf. Tychonis | mudstone |
| TP 7 | VII 3175 | field 13/2b/bed 1b | Lower Callovian | Simulans | mudstone |
| TP 8 | VII 3174 | field 13/2a/bed 1b | Lower Callovian | Pishmae | mudstone |
| TP 9 | VII 3173 | f13/1/bed 1a | Lower Callovian | Elatmae/Falsum | mudstone |

### 2.1.4 West bank of the River Pizhma, near Stepanov Village, outcrop 12

| | | | | | |
|---|---|---|---|---|---|
| TP 10 | VII 3170 | field 12/1/bed 1 | Upper Bathonian | Variabile | mudstone |
| TP 11 | VII 3171 | field 12/3/bed 3 | Lower-Middle Bathonian | Ishmae/Harlandi | mudstone |
| TP 12 | VII 3172 | field 12/7/bed 7 | Lower Bathonian | Oroniceras beds* | mudstone |

* - informal macrofossil association marker

## 2.2 THE UPPER CALLOVIAN TO KIMMERIDGIAN PALYNOLOGY OF THE RIVER IZHMA AREA (OUTCROP 15), RIVER PECHORA BASIN, NORTHERN RUSSIA

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia.

| | | | | | |
|---|---|---|---|---|---|
| TP 13 | VAF 36 | bed 9 | Upper Kimmeridgian | ?Eudoxus/Autiss. | mudstone |
| TP 14 | VAF 35 | bed 8 | Upper Kimmeridgian | ?Eudoxus/Autiss. | mudstone |
| TP 15 | VAF 32 | bed 8 | Upper Kimmeridgian | ?Eudoxus/Autiss. | mudstone |
| TP 16 | VAF 30 | bed 7 | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 17 | VAF 28 | bed 6 | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 18 | VAF 27 | bed 6 | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 19 | VAF 26 | bed 6 | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 20 | VAF 25 | bed 6 | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 21 | VAF 21 | bed 2 | Upper Callovian | Subordinarium | mudstone |
| TP 22 | VAF 20 | bed 2 | Upper Callovian | Subordinarium | mudstone |
| TP 23 | VAF 18 | bed 1 | Upper Callovian | Keyserlingi | mudstone |
| TP 24 | VAF 17 | bed 1 | Upper Callovian | Keyserlingi | mudstone |
| TP 25 | VAF 16 | bed 1 | Upper Callovian | Keyserlingi | mudstone |
| TP 26 | VAF 15 | bed 1 | Upper Callovian | Keyserlingi | mudstone |

## 2.3 THE UPPER JURASSIC PALYNOLOGY OF THE RIVER PIZHMA AREA, NORTHERN RUSSIA

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia. The samples are from three adjacent isolated outcrops, therefore no overall stratigraphic log is presented.

| | | | | | |
|---|---|---|---|---|---|
| TP 27 | VAF 224 | outcrop 12 | ?U. Kimmeridgian/M. Volgian | | mudstone |
| TP 28 | VAF 226 | outcrop 12 | ?U. Kimmeridgian/M. Volgian | | mudstone |
| TP 29 | VAF 200 | outcrop 12a | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 30 | VAF 201 | outcrop 12a | Lower Kimmeridgian | Beds with *A. kitchini* | mudstone |
| TP 31 | VAF 202 | outcrop 12a | Upper Kimmeridgian | ?Autissiodorensis | siltstone |
| TP 32 | VAF 203 | outcrop 12a | Upper Kimmeridgian | Autissiodorensis | siltstone |
| TP 33 | VAF 204 | outcrop 12a | ?Kimmeridgian | | clay |
| TP 34 | VAF 206 | outcrop 12a | Upper Kimmeridgian | | mudstone |
| TP 35 | VAF 207 | outcrop 12a | Upper Kimmeridgian | | mudstone |
| TP 36 | VAF 214 | outcrop 13 | ?Kimmeridgian | | mudstone |

## 2.4 THE MIDDLE VOLGIAN PALYNOLOGY OF THREE LOCALITIES FROM THE THE RIVER IZHMA AREA, PECHORA BASIN

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia.

| | | | | | | |
|---|---|---|---|---|---|---|
| TP 37 | VAF 49 | o/c 16 | bed 19 | Middle Volgian | Panderi | mudstone |
| TP 38 | VAF 47 | o/c 16 | bed 19 | Middle Volgian | Panderi | mudstone |
| TP 39 | VAF 44 | o/c 16 | bed 9 | Middle Volgian | Panderi | mudstone |
| TP 40 | VAF 43 | o/c 16 | bed 5 | Middle Volgian | Panderi | mudstone |
| TP 41 | VAF 41 | o/c 16 | bed 2 | Middle Volgian | Panderi | mudstone |
| TP 42 | VAF 52 | o/c 16a | | Middle Volgian | ?Panderi | mudstone |
| TP 43 | VAF 54 | o/c 17 | bed 15 | Middle Volgian | Maximus | clay |

# 3 SAMPLES FROM THE CENTRAL RUSSIAN PLATFORM

## 3.1 THE BATHONIAN TO MIDDLE OXFORDIAN PALYNOLOGY OF BOREHOLE 132, NEAR ELATMA, RIVER OKA BASIN

These samples were studied by J. B. Riding and V. I. Ilyina. They were collected by staff of the Institute of Geology, Geophysics and Mineralogy, Novosibirsk, Russia. The data given between the collector's numbers (prefixed VII) and the Stage/Substage are the field number, the bed number and the depth in metres respectively. The Elatmae Zone is equivalent to the Herveyi Zone of northwest Europe (Meledina, 1994).

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 1 | VII 3978 | 8/5 | 25.70 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 2 | VII 3977 | 9/5 | 26.20 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 3 | VII 3976 | 10/6(u) | 27.00 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 4 | VII 3975 | 11/6(l) | 29.00 | Middle Oxfordian | Densiplicatum | mudstone |
| RP 5 | VII 3974 | 12/7(u) | 30.00 | Lower Oxfordian | ?Mariae | mudstone |
| RP 6 | VII 3973 | 13/7(l) | 30.80 | Lower Oxfordian | ?Mariae | mudstone |
| RP 7 | VII 3962 | 24/12 | 62.00 | Lower Callovian | Elatmae | mudstone |
| RP 8 | VII 3961 | 25/13 | 63.00 | Upper Bathonian | | mudstone |
| RP 9 | VII 3960 | 26/14 | 65.00 | Upper Bathonian | | siltstone |
| RP 10 | VII 3958 | 28/15 | 67.00 | Upper Bathonian | | mudstone |
| RP 11 | VII 3956 | 30/16 | 70.50 | Bathonian | | mudstone |
| RP 12 | VII 3955 | 31/17 | 71.20 | Bathonian | | siltstone |
| RP 13 | VII 3953 | 33/18 | 74.00 | Bathonian | | mudstone |
| RP 14 | VII 3952 | 34/19 | 75.50 | Bathonian | | siltstone |
| RP 15 | VII 3950 | 36/21 | 77.20 | Lower Bathonian | | mudstone |
| RP 16 | VII 3949 | 37/21(l) | 77.70 | Lower Bathonian | | mudstone |

## 3.2 THE LOWER CALLOVIAN TO LOWER OXFORDIAN PALYNOLOGY OF A SECTION NEAR INKINO, RIVER OKA BASIN

These samples were studied by J. B. Riding and V. I. Ilyina. They were collected from outcrop 5 by staff of the Institute of Geology, Geophysics and Mineralogy, Novosibirsk, Russia. The data given between the collector's numbers (prefixed VII) and the Substage are the field number and the bed number respectively. The Elatmae Zone is equivalent to the Herveyi Zone of northwest Europe (Meledina, 1994).

| | | | | | |
|---|---|---|---|---|---|
| RP 17 | VII 3476 | 6b/6 (upper) | L. Oxfordian | Mariae-Cordatum | mudstone |
| RP 18 | VII 3475 | 6a/6 (lower) | L. Oxfordian | Mariae-Cordatum | mudstone |
| RP 19 | VII 3474 | 4a/4 | Upper Callovian | Athleta | mudstone |
| RP 20 | VII 3473 | 4b/4 (0.5m from base) | Upper Callovian | Athleta | mudstone |
| RP 21 | VII 3472 | 1c/1b | Lower Callovian | Elatmae | mudstone |
| RP 22 | VII 3471 | 1b/1b(2m from base) | Lower Callovian | Elatmae | mudstone |
| RP 23 | VII 3470 | 1a/1b (1m from base) | Lower Callovian | Elatmae | mudstone |

## 3.3 THE UPPER CALLOVIAN TO KIMMERIDGIAN PALYNOLOGY OF THE RIVER UNZHA AREA, NEAR KOSTROMA

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia. The data given between the collector's numbers (prefixed VAF) and the Substage is the VNIGRI registration number, prefixed N.

### 3.3.2 Section 2

| | | | | | |
|---|---|---|---|---|---|
| RP 24 | VAF 729 | N 2684/2 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 25 | VAF 728 | N 2683/2 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 26 | VAF 726 | N 2681/1 | Middle Oxfordian | Densiplicatum | mudstone |
| RP 27 | VAF 725 | N 2680/3 | Middle Oxfordian | Densiplicatum | mudstone |
| RP 28 | VAF 724 | N 2679/3 | Lower Oxfordian | ?Mariae | mudstone |
| RP 29 | VAF 723 | N 2678/3 | Lower Oxfordian | ?Mariae | mudstone |
| RP 30 | VAF 722 | N 2677/3 | Upper Callovian | ?Lamberti | mudstone |
| RP 31 | VAF 718 | N 2674/3 | Upper Callovian | ?Athleta | mudstone |
| RP 32 | VAF 717 | N 2673/3 | Upper Callovian | ?Athleta | siltstone |

### 3.3.1 Section 1

| | | | | | |
|---|---|---|---|---|---|
| RP 33 | VAF 715 | N 2672/4 | Upper Oxfordian | Ravni | mudstone |
| RP 34 | VAF 714 | N 2671/3 | Upper Oxfordian | Serratum | mudstone |
| RP 35 | VAF 713 | N 2670/3 | Upper Oxfordian | Alternoides | mudstone |
| RP 36 | VAF 707 | N 2667/3 | Middle Oxfordian | Tenuiserratum | mudstone |
| RP 37 | VAF 708 | N 2668/3 | Middle Oxfordian | Tenuiserratum | mudstone |

### 3.3.3 Sections 3/4

| | | | | | |
|---|---|---|---|---|---|
| RP 38 | VAF 754 | N 2699/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 39 | VAF 753 | N 2698/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 40 | VAF 742 | N 2690/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 41 | VAF 752 | N 2697/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 42 | VAF 751 | N 2696/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 43 | VAF 741 | N 2689/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 44 | VAF 740 | N 2688/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 45 | VAF 739 | N 2687/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |
| RP 46 | VAF 737 | N 2685/3 | Lower Kimmeridgian | Amoebites/Prorazenia | mudstone |

## 3.4 THE UPPER JURASSIC PALYNOLOGY OF GORODISCHE, NEAR UL'YANOVSK

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia.

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 47 | VAF 5010 | 33 | 18 | Upper Volgian | Nodiger | sandstone |
| RP 48 | VAF 6219 | 757 | 16 | Upper Volgian | Fulgens | sandstone |
| RP 49 | VAF 6218 | 756 | 15 | Middle Volgian | Nikitini | sandstone |
| RP 50 | VAF 5004 | 27 | 13 | Middle Volgian | Virgatus | sandstone |
| RP 51 | VAF 5003 | 26 | 12 | Middle Volgian | Virgatus | sandstone |
| RP 52 | VAF 5002 | 25 | 11 | Middle Volgian | Panderi/Zarajsk. | bitum. mudstone |
| RP 53 | VAF 5037 | 24 | 11 | Middle Volgian | Panderi/Zarajsk. | mudstone |
| RP 54 | VAF 5025 | 23 | 11 | Middle Volgian | Panderi/Zarajsk. | bitum. mudstone |
| RP 55 | VAF 5024 | 21 | 11 | Middle Volgian | Panderi/Zarajsk. | bitum. mudstone |
| RP 56 | VAF 6203 | 733 | 11 | Middle Volgian | Panderi/Zarajsk. | bitum. mudstone |
| RP 57 | VAF 5034 | 16 | 10 | Middle Volgian | Panderi | mudstone |
| RP 58 | VAF 6200 | 751 | 9 | Middle Volgian | Panderi/Pavlovi | mudstone |
| RP 59 | VAF 5033 | 12 | 5 | Lower Volgian | Klimovi | mudstone |
| RP 60 | VAF 6194 | 770 | 5 | Lower Volgian | Klimovi | mudstone |
| RP 61 | VAF 5032 | 11 | 5 | Lower Volgian | Klimovi | mudstone |
| RP 62 | VAF 5018 | 10 | 5 | Lower Volgian | Klimovi | mudstone |
| RP 63 | VAF 6192 | 768 | 4 | Kimmeridgian | Autissio./Fallax | mudstone |
| RP 64 | VAF 5029 | 8 | 4 | Kimmeridgian | Autissio./Fallax | mudstone |
| RP 65 | VAF 6189 | 765 | 4 | Kimmeridgian | Autissio./?Fallax | mudstone |
| RP 66 | VAF 5017 | 7 | 3 | Kimmeridgian | Autissio. | mudstone |
| RP 67 | VAF 6185 | 761 | 3 | Kimmeridgian | Autissio. | mudstone |
| RP 68 | VAF 5028 | 6 | 2 | Kimmeridgian | Eudoxus | mudstone |
| RP 69 | VAF 6184 | 760 | 2 | Kimmeridgian | Eudoxus | mudstone |
| RP 70 | VAF 5027 | 4 | 1 | Kimmeridgian | Eudoxus | mudstone |

## 3.5 THE UPPER JURASSIC-LOWER CRETACEOUS PALYNOLOGY OF KASHPIR

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia.

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 71 | VAF 5879 | field 710 | bed 24 | Ryazanian | | sandy limestone |
| RP 72 | VAF 5895 | field 726 | bed 14 | Upper Volgian | Subditus | sandy limestone |
| RP 73 | VAF 5894 | field 725 | bed 13 | Upper Volgian | Fulgens | siltstone |
| RP 74 | VAF 5892 | field 723 | bed 11 | Middle Volgian | Nikitini | sandy mudstone |
| RP 75 | VAF 5887 | field 718 | bed 6 | Middle Volgian | Panderi | shaley mudstone |
| RP 76 | VAF 5886 | field 717 | bed 5 | Middle Volgian | Panderi | mudstone |
| RP 77 | VAF 5884 | field 715 | bed 3 | Middle Volgian | Panderi | mudstone |
| RP 78 | VAF 5883 | field 714 | bed 2 | Middle Volgian | Panderi | shaly mudstone |
| RP 79 | VAF 5882 | field 713 | bed 1 | Middle Volgian | Panderi | mudstone |

## 3.6 THE UPPER JURASSIC-LOWER CRETACEOUS PALYNOLOGY OF THE RIVER OKA BASIN

These samples were studied by J. B. Riding and V. A. Fedorova. They were collected by staff of VNIGRI, St-Petersburg, Russia.

### 3.6.1 Outcrop 12, Kuzminskoje

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 80 | VAF 8996 | field 783 | bed 6 | Ryazanian | Rjazanensis-Spasskensis | sandstone |
| RP 81 | VAF 8997 | field 784 | bed 5 | Ryazanian | Rjazanensis-Spasskensis | sandstone |
| RP 82 | VAF 8999 | field 786 | bed 3 | Upper Volgian | Subditus | sand |

### 3.6.2 Outcrop 13, Kuzminskoje

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 83 | VAF 9000 | field 788 | bed 3 | Ryazanian | Rjazanensis-Kochi | sandstone |
| RP 84 | VAF 8994 | field 787 | bed 1 | Upper Volgian | Subditus | sand |

### 3.6.3 River Black, Outcrop 6

| | | | | | | |
|---|---|---|---|---|---|---|
| RP 85 | VAF 7600 | field 822 | bed 2 | Ryazanian | Rjazanensis-Spasskensis | sand |

# APPENDIX 2
# LIST OF PALYNOMORPH SPECIES WITH AUTHOR CITATIONS

In this Appendix, only palynomorph taxa identified from the 187 samples listed in Appendix 1 at species level and below are listed. Therefore, if an identification is made to generic level (e.g. *Acanthaulax* sp.), the genus is not listed. Furthermore, taxa not recognised in the Russian material and mentioned in the text for comparative purposes are not listed in this Appendix. The author citations of these species are given in the running text. Bibliographic references to the dinoflagellate cyst taxa published prior to December 1992 may be found in Lentin and Williams (1993). The dinoflagellate affinities of certain taxa, for example *Fromea amphora* and *Fromea tornatilis*, have been questioned by some authors (Fensome et al., 1993). For convenience, such species are regarded as unequivocal dinoflagellate cysts in this study.

## DINOFLAGELLATE CYSTS

*Adnatosphaeridium caulleryi* (Deflandre 1938) Williams & Downie 1969
*Aldorfia aldorfensis* (Gocht 1970) Stover & Evitt 1978
*Aldorfia dictyota* (Cookson & Eisenack 1960) Davey 1982 subsp. *pyrum* (Gitmez 1970) Jan du Chêne et al. 1986
*Ambonosphaera? staffinensis* (Gitmez 1970) Poulsen & Riding 1992
*Atopodinium haromense* Thomas & Cox 1988
*Atopodinium prostatum* Drugg 1978
*Chytroeisphaeridia cerastes* Davey 1979
*Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965
*Chytroeisphaeridia hyalina* (Raynaud 1978) Lentin & Williams 1981
*Circulodinium compta* (Davey 1982) Helby 1987
*Circulodinium distinctum* (Deflandre & Cookson 1955) Jansonius 1986
*Clathroctenocystis asapha* (Drugg 1978) Stover & Helby 1987
*Cleistosphaeridium tribuliferum* (Sarjeant 1962) Davey et al. 1969
*Cleistosphaeridium varispinosum* (Sarjeant 1959) Woollam & Riding 1983
*Cribroperidinium gigas* (Raynaud 1978) Helenes 1984
*Cribroperidinium globatum* (Gitmez & Sarjeant 1972) Helenes 1984
*Cribroperidinium longicorne* (Downie 1957) Lentin & Williams 1985
*Crussolia dalei* Smelror & Århus 1989
*Crussolia deflandrei* Wolfard & Van Erve 1981
*Crussolia perireticulata* Århus et al. 1989
*Ctenidodinium chondrum* Drugg 1978
*Ctenidodinium combazii* Dupin 1968
*Ctenidodinium continuum* Gocht 1970
*Ctenidodinium ornatum* (Eisenack 1935) Deflandre 1938
*Ctenidodinium sellwoodii* (Sarjeant 1975) Stover & Evitt 1978
*Dichadogonyaulax? pannea* (Norris 1965) Sarjeant 1969
*Dingodinium albertii* Sarjeant 1966
*Dingodinium jurassicum* Cookson & Eisenack 1958
*Dingodinium tuberosum* (Gitmez 1970) Fisher & Riley 1980
*Egmontodinium torynum* (Cookson & Eisenack 1960) Davey 1979
*Egmontodinium ovatum* (Gitmez & Sarjeant 1972) Riley 1979
*Ellipsoidictyum cinctum* Klement 1960
*Endoscrinium anceps* Raynaud 1978
*Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *reticulatum* (Klement 1960) Górka 1970
*Endoscrinium glabrum* (Duxbury 1977) Below 1981
*Endoscrinium luridum* (Deflandre 1938) Gocht 1970
*Epiplosphaera gochtii* (Fensome 1979) Brenner 1988
*Evansia evittii* (Pocock 1972) Jansonius 1986
*Fromea amphora* Cookson & Eisenack 1958
*Fromea tornatilis* (Drugg 1978) Lentin & Williams 1981
*Glossodinium dimorphum* Ioannides et al. 1977
*Gochteodinia villosa* (Vozzhennikova 1967) Norris 1978
*Gonyaulacysta centriconnata* Riding 1983
*Gonyaulacysta dualis* (Brideaux & Fisher 1976) Stover & Evitt 1978
*Gonyaulacysta eisenackii* (Deflandre 1938) Górka 1965
*Gonyaulacysta helicoidea* (Eisenack & Cookson 1960) Sarjeant 1966
*Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965
subsp. *adecta* Sarjeant 1982
subsp. *adecta* Sarjeant 1982 var. *longicornis* (Deflandre 1938) Sarjeant 1982
subsp *jurassica* (autonym)
subsp. *jurassica* var. *longicornuta* Sarjeant 1982
*Gonyaulacysta pectinigera* (Gocht 1970) Fensome 1979
*Hystrichodinium pulchrum* Deflandre 1935
*Hystrichosphaerina orbifera* (Klement 1960) Stover & Evitt 1978
*Imbatodinium kondratjevii* Vozzhennikova 1967
*Kalyptea stegasta* (Sarjeant 1961) Wiggins 1975
*Kleithriasphaeridium porosispinum* Davey 1982
*Korystocysta gochtii* (Sarjeant 1976) Woollam 1983
*Lagenadinium callovianum* Piel 1985
*Leptodinium mirabile* Klement 1960
*Leptodinium subtile* Klement 1960
*Liesbergia liesbergensis* Berger 1986
*Limbodinium absidatum* (Drugg 1978) Riding 1987
*Lithodinia caytonensis* (Sarjeant 1959) Gocht 1976
*Lithodinia planoseptata* Riding 1987) Williams et al. 1993
*Lithodinia valensii* (Sarjeant 1966) Gocht 1976
*Mancodinium semitabulatum* Morgenroth 1970
*Moesiodinium raileanui* Antonesçu 1974
*Mendicodinium groenlandicum* (Pocock & Sarjeant 1972) Davey 1979
*Muderongia simplex* Alberti 1961
*Nannoceratopsis deflandrei* Evitt 1962
subsp. *anabarensis* Ilyina 1994
subsp. *deflandrei* (autonym)
subsp. *senex* (Van Helden 1977) Ilyina 1994
*Nannoceratopsis dictyoambonis* Riding 1984
*Nannoceratopsis gracilis* Alberti 1961
*Nannoceratopsis pellucida* Deflandre 1938
*Nannoceratopsis ridingii* Poulsen 1992
*Nannoceratopsis triangulata* Prauss 1987
*Occisucysta balios* Gitmez 1970
*Oligosphaeridium diluculum* Davey 1982
*Oligosphaeridium patulum* Riding and Thomas 1988
*Paragonyaulacysta retiphragmata* Dörhöfer & Davies 1980
*Pareodinia antennata* (Gitmez & Sarjeant 1972) Wiggins 1975
*Pareodinia ceratophora* Deflandre 1947
*Pareodinia halosa* (Filatoff 1975) Prauss 1989
*Pareodinia prolongata* Sarjeant 1959
*Parvocysta bullula* Bjaerke 1980
*Parvocysta? cracens* Bjaerke 1980
*Parvocysta nasuta* Bjaerke 1980
*Parvocysta? tricornuta* Riding & Shaw in Riding et al. 1991
*Perisseiasphaeridium pannosum* Davey & Williams 1966
*Phallocysta elongata* (Beju 1971) Riding 1994
*Phallocysta eumekes* Dörhöfer & Davies 1980
*Phoberocysta neocomica* (Gocht 1957) Millioud 1969

*Prolixosphaeridium anasillum* Erkmen & Sarjeant 1980
*Prolixosphaeridium granulosum* (Deflandre 1937) Davey et al. 1966
*Prolixosphaeridium mixtispinosum* (Klement 1960) Davey et al. 1969
*Prolixosphaeridium parvispinum* (Deflandre 1937) Davey et al. 1966
*Protobatioladinium elatmaensis* Riding & Ilyina 1996
*Protobatioladinium? elongatum* Riding & Ilyina 1998
*Protobatioladinium westburiense* Nøhr-Hansen 1986
*Pseudoceratium pelliferum* Gocht 1957
*Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981
*Rhynchodiniopsis martonense* Bailey et al. 1987
*Rigaudella aemula* (Deflandre 1938) Below 1982
*Scriniocassis prisca* (Gocht 1979) Below 1990
*Scriniocassis weberi* Gocht 1964
*Scriniodinium crystallinum* (Deflandre 1938) Klement 1960
*Scriniodinium inritibile* Riley in Fisher & Riley 1980
*Senoniasphaera jurassica* (Gitmez & Sarjeant 1972) Lentin & Williams 1976
*Sentusidinium creberbarbatum* Erkmen & Sarjeant 1980
*Sentusidinium rioultii* (Sarjeant 1968) Sarjeant & Stover 1978
*Sirmiodiniopsis orbis* Drugg 1978
*Sirmiodinium grossii* Alberti 1961
*Stephanelytron caytonense* Sarjeant 1961
*Stephanelytron redcliffense* Sarjeant 1961
*Stephanelytron scarburghense* Sarjeant 1961
*Stiphrosphaeridium dictyophorum* (Cookson & Eisenack 1958) Lentin & Williams 1985
*Subtilisphaera? inaffecta* (Drugg 1978) Bujak & Davies 1983
*Subtilisphaera? paeminosa* (Drugg 1978) Bujak & Davies 1983
*Surculosphaeridium vestitum* (Deflandre 1938) Davey 1966
*Susadinium faustum* (Bjaerke 1980) Lentin & Williams 1985
*Susadinium scrofoides* Dörhöfer & Davies 1980
*Systematophora areolata* Klement 1960
*Systematophora daveyi* Riding & Thomas 1988
*Systematophora penicillata* (Ehrenberg 1843) Sarjeant 1980
*Systematophora valensii* (Sarjeant 1960) Sarjeant 1961
*Trichodinium scarburghensis* (Sarjeant 1964) Williams et al 1993
*Tubotuberella apatela* (Cookson & Eisenack 1960) Ioannides et al. 1977
*Tubotuberella dangeardii* (Sarjeant 1968) Stover & Evitt 1978
*Tubotuberella rhombiformis* Vozzhennikova 1967
*Valvaeodinium aquilonium* (Dörhöfer & Davies 1980) Below 1987
*Valvaeodinium stipulatum* (Wille & Gocht 1979) Below 1987
*Wallodinium cylindricum* (Habib 1970) Duxbury 1983
*Wallodinium krutzschii* (Alberti 1961) Habib 1972
*Wanaea acollaris* Dodekova 1975
*Wanaea fimbriata* Sarjeant 1961
*Wanaea thysanota* Woollam 1982

## MISCELLANEOUS MICROPLANKTON

*Botryococcus braunii* Kützing 1849
*Fentonia bjaerkei* (Smelror 1987) Bailey & Hogg 1995
*Halosphaeropsis liassica* Mädler 1963
*Lancettopsis lanceolata* Mädler 1963
*Leiofusa jurassica* Cookson & Eisenack 1958
*Leiofusa spicata* Wall 1965
*Schizocystia rara* Playford & Dettmann 1965

## MIOSPORES

### Indigenous pollen

*Callialasporites dampieri* (Balme 1957) Sukh Dev 1966
*Callialasporites turbatus* (Balme 1957) Schulz 1967
*Cerebropollenites macroverrucosus* (Thiergart 1949) Schulz 1967
*Classopollis classoides* (Pflug 1953) Pocock & Jansonius 1961
*Perinopollenites elatoides* Couper 1958
*Vitreisporites pallidus* (Reissinger 1938) Nilsson 1958

### Indigenous spores

*Baculatisporites comaumensis* (Cookson 1953) Potonié 1956
*Cibotiumspora juriensis* (Balme 1957) Filatoff 1975
*Concavissimisporites verrucosus* Delcourt & Sprumont 1955
*Coronatispora valdensis* (Couper 1958) Dettmann 1963
*Cyathidites australis* Couper 1953
*Cyathidites minor* Couper 1953
*Gleicheniidites senonicus* Ross 1949
*Ischyosporites variegatus* (Couper 1958) Schulz 1967
*Kraeuselisporites reissingeri* (Harris 1957) Morbey 1975
*Neoraistrickia gristhorpensis* (Couper 1958) Tralau 1968
*Retitriletes austroclavatidites* (Cookson 1953) Döring et al. 1963
*Rogalskaisporites cicatricosus* (Rogalaska 1954) Danzé-Corsin & Laveine 1963
*Sestrosporites pseudoalveolatus* (Couper 1958) Dettmann 1963

### Reworked Carboniferous spores

*Densosporites rarispinosus* Playford 1963
*Densosporites spinifer* Hoffmeister et al. 1955
*Diatomozonotriletes cervicornutus* (Staplin 1960) Playford 1963
*Diatomozonotriletes* cf. saetosus (Hacquebard & Barss 1957) Hughes & Playford 1961
*Lycospora pusilla* (Ibrahim 1932) Schopf et al. 1944
*Monilospora dignata* Playford 1963
*Murospora aurita* (Waltz 1938) Playford 1962
*Tripartites vetustus* Schemel 1950

# APPENDIX 3 - PALYNOMORPH DATA SPREADSHEETS

The following 20 spreadsheet diagrams principally illustrate the quantitative stratigraphic distributions of dinoflagellate cysts, section-by-section in the material studied. The dinoflagellate cyst diversity and the numbers of dinoflagellate cyst specimens per microscope slide are also included. Where space permits, the semi-quantitative stratigraphic distributions of miscellaneous palynomorphs and miospores are also presented.

Text-Figure A3.1. Spreadsheet diagram illustrating the stratigraphic distribution of palynomorphs from the Upper Pliensbachian and Lower Toarcian strata on the west bank of the River Anabar, northern East Siberia (locality 1 of Text-Figure 2). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the other palynomorph groups: Abundant - Ab; Common - C; Present - P; Rare - R. Three dots (...) indicate that the respective taxon is absent.

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | **Sample Number (NS)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.P. | U.P. | U.P. | U.P. | U.P. | U.P. | U.P. | L.T. | L.T. | L.T. | L.T. | L.T. | L.T. | L.T. | L.T. | L.T. | **Substage** |
| Stok. | Stok. | Stok. | Mar. | Vil. | Vil. | Vil. | ?Pro. | Fa./Co. | Fa./Co. | Fa./Co. | Fa./Co. | Fa./Co. | Fa./Co. | Fa./Co. | Fa./Co. | **Ammonite Zone** |
| | | | | | | | | | | | | | | | | **Dinoflagellate cysts:** |
| ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | 1.9 | ... | ... | ... | *Mancodinium semitabulatum* |
| ... | ... | ... | ... | ... | 50 | ... | 73.9 | ... | ... | ... | ... | ... | ... | ... | ... | *Nannoceratopsis deflandrei* subsp. *anabarensis* |
| ... | ... | ... | ... | ... | ... | ... | 13.3 | 26.1 | 56.3 | 45.8 | ... | 7.5 | ... | 5 | ... | *Nannoceratopsis deflandrei* subsp. *deflandrei* |
| ... | ... | ... | ... | 100 | 50 | ... | 12.6 | 73.9 | 43.7 | 54.2 | 100 | 90.6 | 100 | 95 | 100 | *Nannoceratopsis deflandrei* subsp. *senex* |
| 0 | 0 | 0 | 0 | 1 | 2 | 0 | 4 | 2 | 2 | 2 | 1 | 3 | 1 | 2 | 1 | **Dinoflagellate cyst diversity** |
| 0 | 0 | 0 | 0 | 2 | 2 | 0 | 482 | 246 | 128 | 96 | 88 | 53 | 78 | 340 | 82 | **No. of dinoflagellate cyst specimens per slide** |
| | | | | | | | | | | | | | | | | **Miscellaneous microplankton:** |
| R/P | Ab | ... | R | P | P | R | R | ... | ... | R | ... | ... | R | R | R | *Botryococcus braunii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | Ab | P/C | P | ... | *Halosphaeropsis liassica* |
| C | C/Ab | ... | R | ... | ... | R | ... | ... | ?R | ... | ... | ... | ... | ... | ... | *Leiofusa* spp. |
| ... | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Micrhystridium* spp. |
| R | R | R | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | ... | ... | ... | *Tasmanites* spp. |
| | | | | | | | | | | | | | | | | **Selected miospores:** |
| ... | ... | ... | R | R/P | ... | ... | ... | R | R | ... | R | R | R/P | R | R | *Baculatisporites comaumensis* |
| C/Ab | C | C/Ab | C | Ab/D | C | P/C | Ab | Ab | Ab/D | Ab | C | C | Ab | C/Ab | C/Ab | Bisaccate pollen - undifferentiated |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?R | ?R | R | ... | ... | ... | *Callialasporites* sp. |
| ... | ... | ... | ... | ?P | ... | ... | ... | | ... | ... | ?R | R | ... | ... | R | Carboniferous spores - undifferentiated - (reworked) |
| ... | ... | ... | ... | R | ... | ... | ... | ... | R | ... | ... | ... | R | ... | R | *Cibotiumspora juriensis* |
| ... | ... | ... | ... | ... | ... | ... | R | R | R | ... | ... | R | R | R/P | R | *Classopollis classoides* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?R | ... | R | ... | ... | ... | *Concavissimisporites verrucosus* |
| ... | R | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | ... | ... | ... | *Coronatispora valdensis* |
| ... | P | ... | R | P | R | P | R | C | C | P/C | C | C | C/Ab | C | P | *Cyathidites australis* |
| ... | ... | ... | ... | R | ... | ... | R | R/P | R | P | P | P | P | ... | R | *Cyathidites minor* |
| R | P | R | R | C | R | P | ... | ... | P | ... | C/Ab | ... | ... | P | ... | *Cyathidites* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?R | *Densosporites* spp. (reworked) |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | P | P | P/C | P | *Duplexisporites* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | R | P | R/P | ... | *Ischyosporites variegatus* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | *Leptolepidites* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | ... | R | R | *Perinopollenites elatoides* |
| ... | ... | ... | ... | ?R | ?R | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | *Retitriletes austroclavatidites* |
| R | P | ... | P | P | R/P | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Rogalskaisporites cicatricosus* |
| P | P | R | R | R | R | R/P | R | R | R | R/P | P | R/P | R | ... | ... | Spores - indeterminate |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | Striate bisaccate pollen - reworked |
| ... | ... | ... | ... | ... | ... | R | ... | ... | R | ... | .. | R | R | R | ... | *Todisporites* spp. |
| ... | ... | ... | ... | ... | ... | R | ... | ... | R | ... | ... | ... | ... | ... | ... | Trisaccate pollen - undifferentiated |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | R | ... | ... | ... | *Vitreisporites pallidus* |

Text-Figure A3.2. Spreadsheet diagram illustrating the stratigraphic distribution of palynomorphs from the Upper Pliensbachian to Aalenian strata of the west coast of Anabar Bay, northern East Siberia (locality 2 of Text-Figure 2). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the other palynomorph groups; the key is as for Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| 36 | 35 | 34 | 33 | 32 | 31 | 30 | 29 | 28 | 27 | 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | Sample Number (NS) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.P. | U.P. | U.P. | ?L.T. | ?LT | ?L.T. | L.T. | L.T. | L.T. | L.T. | L.T. | U.T. | U.T. | U.T. | U.T. | U.T. | U.T. | Aa. | Aa. | Aa. | Substage |
| Ma. | Vi. | Vi. | ?Pr. | ?Pr. | ?Pr. | Fa. | Fa. | Co./Br. | Co./Br. | Co./Br. | | | | | | | | | | **Ammonite Zone** |
| | | | | | | | | | | | | | | | | | | | | **Dinoflagellate cysts:** |
| ... | ... | ... | 10.8 | 26.9 | 53.5 | ... | ... | ... | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Nanno. deflandrei* subsp. *anabarensis* |
| ... | ... | ?33.3 | 22.3 | 30.1 | 21.2 | 0.2 | 0.8 | 21.5 | 24.9 | ... | 50 | ... | 3.6 | 4.7 | 9.5 | ... | ... | ... | ... | *Nanno. deflandrei* subsp. *deflandrei* |
| ... | ... | 66.7 | 66.9 | 43 | 25.3 | 99.8 | 99.2 | 75.8 | 60.9 | 94.4 | 50 | ... | ... | 6.9 | ... | ... | ... | ... | ... | *Nannoceratopsis deflandrei* subsp. *senex* |
| ... | ... | ... | ... | ... | ... | ... | ... | 2.7 | 13.8 | ?5.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Nannoceratopsis gracilis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?4.8 | ... | ... | ... | ... | *Parvocysta nasuta* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 42.8 | 16.3 | 28.6 | ... | ... | ... | ... | *Phallocysta elongata* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 53.6 | 72.1 | 42.8 | 100 | ... | ... | ... | *Phallocysta eumekes* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 14.3 | ... | ... | ... | ... | *Susadinium scrofoides* |
| 0 | 0 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 0 | 3 | 4 | 5 | 1 | 0 | 0 | 0 | **Dinoflagellate cyst diversity** |
| 0 | 0 | 3 | 130 | 323 | 146 | 929 | 367 | 232 | 369 | 18 | 2 | 0 | 28 | 43 | 21 | 4 | 0 | 0 | 0 | **No. of dino. cyst specimens per slide** |
| | | | | | | | | | | | | | | | | | | | | **Miscellaneous microplankton:** |
| R/P | ... | R/P | P | R | R | R | R/P | ... | R/P | ... | ... | R | R/P | R/P | C | C | P/C | C/Ab | P/C | *Botryococcus braunii* |
| ... | ... | ... | ... | ... | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Cymatiosphaera* spp. |
| ... | ... | ... | ... | R | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | Fungal spores - undifferentiated |
| ... | ... | ... | ?R | P | R | ... | R | R | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Halosphaeropsis liassica* |
| ... | ... | ... | R | R | R | ... | ... | ... | ... | ... | P | R/P | C/Ab | P/C | P | ... | ... | ... | ... | *Leiofusa jurassica* |
| ... | ... | ... | ... | R | R | ... | ... | ... | ... | ... | ... | R | ... | ... | R | ... | ... | ... | ... | *Micrhystridium* spp. |
| ... | ... | R | ... | ... | ... | R | R | R | R/P | ... | ... | ... | R | ?R | ... | ... | ... | ... | ... | *Tasmanites* spp. |
| | ... | ?R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Veryhachium* spp. |
| | | | | | | | | | | | | | | | | | | | | **Selected miospores:** |
| ... | ... | R | R | R/P | ... | ... | ... | R | ... | R/P | R | R | R/P | P | R/P | ... | ... | ... | P | *Baculatisporites comaumensis* |
| P/C | ... | C | P/C | C | C | C | C | C/Ab | C | C | C | P/C | C | C | C | P/C | P/C | C | C | Bisaccate pollen - undifferentiated |
| ?R | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | ... | ... | *Callialasporites* spp. |
| ... | ... | ... | R | ... | ... | P | P/C | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?C | *Classopollis classoides* |
| ... | ... | ... | ... | ... | ?R | ... | ... | ... | R | ... | ... | ... | ... | ... | ?R | ... | ... | ... | ... | Carboniferous spores (undiff.) - reworked |
| ... | ... | ... | ... | ... | ... | R | R | R | ... | ... | R | ... | R | ... | ... | ... | ... | ... | R | *Cibotiumspora juriensis* |
| ... | ... | ... | ... | R | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Coronatispora valdensis* |
| P | ... | ?R | P | R/P | R | P | P | P | P/C | R/P | P | P | P | P/C | P | P | P | P | P | *Cyathidites* spp. |
| ... | ... | ... | ... | ... | ... | R | R | ... | ... | ... | ... | ... | ... | R | ... | ... | ... | R | ... | *Dictyophyllidites* spp. |
| R | ... | R | R | ... | R | P/C | P | R | ... | ?R | ... | R | ... | R | R | ... | ... | R | ... | *Duplexisporites* spp. |
| ... | ... | ... | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Kraeuselisporites reissingeri* - reworked |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | R | ... | ... | ... | ... | ... | ... | ... | ... | *Perinopollenites elatoides* |
| ... | ... | ?R | R | ... | ?R | ... | ... | ?R | ?R | ... | ... | ... | ?R | ?R | ?R | ?R | ?R | ... | ?R | *Retitriletes austroclavatidites* |
| ... | ... | R/P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Rogalskaisporites cicatricosus* |
| ... | ... | ... | ... | ... | R | R | ... | ... | ... | ... | R | P | ... | R | ... | R | R | R | R | Spores - indeterminate |
| ... | ... | R | ... | ... | ... | R | R | R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Todisporites* spp. |

Text-Figure A3.3. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts from the Toarcian strata of Astronomitscheskii Creek, River Kedon Basin, northeast Siberia and River Marcha, Borehole 141 at Khatarik-Khomo, River Kelimjar and River Motorchuna in northern East Siberia (Text-Figure 3 and localities 6, 4, 5 and 7 of Text-Figure 2 respectively). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| Sample Number | NS 38 | NS 37 | NS 50 | NS 49 | NS 52 | NS 51 | NS 53 | NS 55 | NS 54 |
|---|---|---|---|---|---|---|---|---|---|
| Collector's Number | VII 7163 | VII 7201 | VII 4024/2a | VII 4025/2a | VII 3599 | VII 3577 | VII 4016 | VII 4065 | VII 4035 |
| Locality | Astron. Creek | Astron. Creek | R. Marcha | R. Marcha | Borehole 141 | Borehole 141 | R. Kelimjar | R. Motorch. | R. Motorch. |
| Substage | L. Toarcian | L. Toarcian | U. Toarcian | U. Toarcian | U. Toarcian | U. Toarcian | U. Toarcian | U. Toarcian | U. Toarcian |
| Ammonite Zone | Falciferum | Falciferum | | | | | | | |
| | | | | | | | | | |
| **Dinoflagellate cysts:** | | | | | | | | | |
| | | | | | | | | | |
| Dinoflagellate cyst sp. B of Bjaerke (1980) | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... |
| Dinoflagellate cysts - indeterminate | ... | ... | 3.2 | ... | 0.1 | ... | ... | ... | ... |
| *Mancodinium semitabulatum* | ... | ... | 1.6 | ... | 6.6 | 0.4 | ... | 0.1 | ... |
| *Maturodinium* sp. A | ... | ... | 6.6 | 2.3 | ... | ... | ... | ... | ... |
| *Moesiodinium raileanui* | ... | ... | 1.6 | ... | ?0.1 | ... | ... | 0.1 | ... |
| *Nannoceratopsis deflandrei* subsp. *anabarensis* | ... | ... | ... | ... | ... | 0.8 | ... | 0.1 | ... |
| *Nannoceratopsis deflandrei* subsp. *deflandrei* | 6.6 | 8.1 | 6.6 | 13.7 | ... | 4.4 | 19.4 | 0.4 | 41.7 |
| *Nannoceratopsis deflandrei* subsp. *senex* | 93.4 | 91.9 | 4.9 | 4.5 | 49.2 | 10.8 | 17.8 | 0.4 | 25 |
| *Nannoceratopsis dictyambonis* | ... | ... | ... | ... | ... | ?0.2 | ... | ... | ... |
| *Nannoceratopsis gracilis* | ... | ... | 11.5 | 4.5 | 24.1 | 3.8 | 17.1 | 0.4 | ... |
| *Nannoceratopsis ridingii* | ... | ... | ... | ... | ... | ... | 0.5 | 0.1 | ... |
| *Nannoceratopsis triangulata* | ... | ... | 1.6 | ... | 0.2 | ... | ... | 0.3 | 8.3 |
| *Pareodinia* spp. | ... | ... | 3.3 | ... | ... | ... | ... | ... | ... |
| *Parvocysta bullula* | ... | ... | ... | ... | ?0.1 | 0.2 | ... | ... | ... |
| *Parvocysta cracens* | ... | ... | ... | ... | ... | ... | 0.8 | 0.2 | ... |
| *Parvocysta nasuta* | ... | ... | ... | ... | 0.9 | 0.6 | ... | ... | ... |
| *Parvocysta? tricornuta* | ... | ... | ... | ... | ... | 0.6 | ... | ... | ... |
| *Parvocysta* spp. | ... | ... | 4.9 | 2.3 | 1 | 1.3 | ... | ... | ... |
| *Phallocysta elongata* | ... | ... | 6.6 | 4.5 | ... | ... | ... | ... | ... |
| *Phallocysta eumekes* | ... | ... | 31.2 | 56.9 | 2.2 | 71.6 | 43.8 | 95.1 | ... |
| *Scriniocassis prisca* | ... | ... | ... | ... | 1.1 | ... | ... | ... | ... |
| *Scriniocassis weberi* | ... | ... | 1.6 | 2.3 | ... | ... | ... | ... | ... |
| *Susadinium faustum* | ... | ... | 1.6 | ... | 0.4 | 0.4 | ... | 0.1 | ... |
| *Susadinium scrofoides* | ... | ... | 3.3 | 4.5 | 12.5 | 4.1 | 0.3 | 0.1 | ... |
| *Valvaeodinium aquilonium* | ... | ... | 9.9 | 4.5 | ... | 0.8 | 0.3 | 2.4 | 25 |
| *Valvaeodinium stipulatum* | ... | ... | ... | ... | 1.5 | ... | ... | ... | ... |
| *Valvaeodinium* sp. | ... | ... | ... | ... | ... | ... | ... | ?0.1 | ... |
| | | | | | | | | | |
| **Dinoflagellate cyst diversity** | 2 | 2 | 16 | 10 | 14 | 15 | 8 | 15 | 4 |
| **Number of dinoflagellate cysts per slide** | 137 | 62 | 61 | 44 | 783 | 521 | 381 | 2281 | 12 |

Text-Figure A3.4. Spreadsheet diagram illustrating the stratigraphic distribution of palynomorphs from the Toarcian strata of Sobo Creek, River Marcha, northern East Siberia (locality 3 of Text-Figure 2). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the other palynomorph groups; the key is as for Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| NS 48 | NS 47 | NS 46 | NS 45 | NS 44 | NS 43 | NS 42 | NS 41 | NS 40 | NS 39 | **Sample Number** |
|---|---|---|---|---|---|---|---|---|---|---|
| VII 3477 | VII 3479 | VII 3481 | VII 4030 | VII 4028 | VII 1809 | VII 4021 | VII 4020 | VII 4019 | VII 4018 | **Collector's Number** |
| L. Toarc. | L. Toarc. | L. Toarc. | L. Toarc. | L. Toarc. | L. Toarc. | L. Toarc. | U. Toarc. | U. Toarc. | U. Toarc. | **Substage** |
| Falciferum | Falciferum | Falciferum | Falciferum | Falciferum | Falciferum | Commune | | | | **Ammonite Zone** |
| | | | | | | | | | | **Dinoflagellate cysts:** |
| ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | Dinoflagellate cysts - indeterminate |
| ... | ... | ... | ... | ... | ... | 9.1 | 67.2 | 94.3 | 45.5 | *Maturodinium* sp. A |
| ... | ... | ... | ... | ... | ... | 6.8 | 8.1 | 0.1 | 1.8 | *Mancodinium semitabulatum* |
| 11.3 | 5 | 22.7 | 21.2 | 25.9 | 25.2 | 30.7 | 11.1 | 0.7 | ... | *Nannoceratopsis deflandrei* subsp. *deflandrei* |
| 88.7 | 95 | 77.3 | 78.8 | 74.1 | 74.8 | 32.9 | ... | 0.9 | ... | *Nannoceratopsis deflandrei* subsp. *senex* |
| ... | ... | ... | ... | ... | ... | 20.5 | 8.6 | 2.4 | 3.6 | *Nannoceratopsis gracilis* |
| ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | *Nannoceratopsis triangulata* |
| ... | ... | ... | ... | ... | ... | ... | 0.5 | 0.1 | 1.8 | *Phallocysta elongata* |
| ... | ... | ... | ... | ... | ... | ... | 2.5 | 1.3 | 45.5 | *Phallocysta eumekes* |
| ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | *Scriniocassis weberi* |
| ... | ... | ... | ... | ... | ... | ... | 0.5 | 0.1 | 1.8 | *Susadinium scrofoides* |
| 2 | 2 | 2 | 2 | 2 | 2 | 5 | 9 | 9 | 6 | **Dinoflagellate cyst diversity** |
| 53 | 121 | 75 | 99 | 1129 | 155 | 88 | 198 | 760 | 55 | **Number of dinoflagellate cyst specimens per slide** |
| | | | | | | | | | | **Miscellaneous microplankton:** |
| ... | ... | ... | ... | R/P | R | R | R/P | ... | ... | *Botryococcus braunii* |
| ... | ... | ... | ... | | R | ... | ... | ... | ... | *Cymatiosphaera* spp. |
| ... | R | ... | ... | ... | ... | ... | ... | ... | ... | Foraminiferal test linings |
| ... | ... | ... | R/P | | R | R | ... | ... | R | Fungal spores - undifferentiated |
| P | P/C | P | R | | ... | ... | ... | ... | ... | *Halosphaeropsis liassica* |
| ... | ... | ... | R | | R | ... | P | ... | P/C | *Leiofusa jurassica* |
| ... | ... | ... | ... | | R/P | ... | R/P | ... | ... | *Micrhystridium* spp. |
| ... | R | ... | R | R | ... | ... | R | R | ... | *Tasmanites* spp. |
| ... | ... | R | R | | ... | ... | ... | ... | ... | *Veryhachium* spp. |
| | | | | | | | | | | **Selected miospores:** |
| Ab | Ab | Ab | Ab | C/Ab | Ab | C/Ab | C/Ab | P/C | C | Bisaccate pollen - undifferentiated |
| R | ... | R | ?R | ... | ... | ... | R/P | R | ... | *Callialasporites* spp. |
| ... | ... | ... | ... | ?R | ... | ... | ?R | ... | ... | Carboniferous spores - undifferentiated (reworked) |
| ... | ... | ... | R | ... | R | ... | R | ... | ... | *Cibotiumspora juriensis* |
| P | C | C | C | P | C | C | P | R/P | R/P | *Cyathidites* spp. |
| ... | ... | ... | R | R/P | P | ... | R | ... | ... | *Duplexisporites* spp. |
| ... | R | ... | P | ... | R | ... | ... | ... | ... | *Ischyosporites variegatus* |
| ... | ... | ... | ... | R | ... | ... | ?R | ... | ... | *Perinopollenites elatoides* |
| R | R | R | R | R | R | R | R | R | R | Spores - indeterminate |
| ... | ... | ... | ... | R | P | ... | ... | ... | ... | *Todisporites* spp. |
| ... | ... | ... | ... | ... | C | ... | R | ... | ... | *Vitreisporites pallidus* |

Text-Figure A3.5. Spreadsheet diagram illustrating the stratigraphic distribution of palynomorphs from the Lower Callovian strata of the west coast of Anabar Bay, northern East Siberia (locality 2 of Text-Figure 2). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the other palynomorph groups; the key is as for Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| NS 59 | NS 58 | NS 57 | NS 56 | **Sample Number** |
|---|---|---|---|---|
| VII 3451 | VII 3452 | VII 3453 | VII 3454 | **Collector's Number** |
| L. Callovian | L. Callovian | L. Callovian | L. Callovian | **Substage** |
| Falsum | Falsum | Anabarense | Anabarense | **Ammonite Zone** |
| | | | | |
| ... | ... | ... | ?0.8 | *Atopodinium* sp. |
| 3.3 | ... | 7.6 | 5.8 | *Batiacasphaera* spp. |
| 1.1 | 4.2 | 0.8 | 1.6 | *Chlamydophorella* spp. |
| 2.2 | 4.2 | 5.3 | 9.9 | *Chytroeisphaeridia cerastes* |
| 1.1 | 4.2 | 0.8 | 0.8 | *Chytroeisphaeridia chytroeides* |
| 31.4 | 24.8 | 16.7 | 19.7 | *Chytroeisphaeridia hyalina* |
| 4.3 | 4.2 | 35.7 | 14.9 | *Crussolia dalei* |
| 9.8 | ... | 2.6 | 3.3 | *Crussolia perireticulata* |
| 6.5 | 8.2 | 3.8 | 3.3 | Dinoflagellate cysts - indeterminate |
| ... | ... | ... | 0.8 | *Endoscrinium* sp. |
| 2.2 | 4.2 | 2.3 | 1.6 | *Evansia evittii* |
| 1.1 | 4.2 | 1.5 | 1.6 | *Fromea tornatilis* |
| 1.1 | ... | ... | 1.6 | *Gonyaulacysta jurassica* subsp. *adecta* |
| ... | ... | ... | 0.8 | *Kalyptea stegasta* |
| 1.1 | 4.2 | 0.8 | ?0.8 | *Lithodinia* spp. |
| ... | 4.2 | ... | 0.8 | *Nannoceratopsis deflandrei* - reworked |
| ... | ... | ... | 0.8 | *Nannoceratopsis gracilis* - reworked |
| 3.3 | 4.2 | ... | 1.6 | *Nannoceratopsis pellucida* |
| 5.4 | 4.2 | 13.6 | 4.1 | *Paragonyaulacysta retiphragmata* |
| 3.3 | ... | ... | ... | *Paragonyaulacysta* spp. |
| 15.2 | 8.2 | 6.1 | 3.3 | *Pareodinia ceratophora* |
| 1.1 | 4.2 | 0.8 | 0.8 | *Pareodinia prolongata* |
| 1.1 | 4.2 | 0.8 | 3.3 | *Pareodinia* spp. |
| 4.3 | ... | ... | 13.2 | *Rhynchodiniopsis cladophora* |
| 1.1 | 4.2 | 0.8 | 1.6 | *Sentusidinium* spp. |
| ... | 4.2 | ... | 1.6 | *Sirmiodinium grossii* |
| ... | ... | ... | 1.6 | *Tubotuberella dangeardii* |
| | | | | |
| 20 | 17 | 16 | 26 | **Dinoflagellate cyst diversity** |
| 92 | 24 | 132 | 121 | **Number of dinoflagellate cyst specimens per slide** |
| | | | | |
| | | | | **Miscellaneous microplankton:** |
| P | ... | P | P | *Botryococcus braunii* |
| | | | | |
| | | | | **Pollen:** |
| C | C | C | C | Bisaccate pollen - undifferentiated |
| ... | R | ... | ... | *Callialasporites turbatus* |
| ... | R | R | R | *Callialasporites* spp. |
| ... | R/P | P | ... | *Cerebropollenites macroverrucosus* |
| ... | ... | ... | P | *Perinopollenites elatoides* |
| | | | | |
| | | | | **Spores:** |
| ... | P | ... | ... | *Baculatisporites comaumensis* |
| ?R | ... | ... | ... | Carboniferous spore - indeterminate - reworked |
| R | R | ... | ... | *Cibotiumspora juriensis* |
| C/Ab | C/Ab | P | P | *Cyathidites australis* |
| P/C | P/C | P | P | *Cyathidites minor* |
| R | ... | ... | R | *Densosporites* sp. - reworked |
| ... | ... | R | ... | *Duplexisporites* sp. |
| R | ... | R | R | *Neoraistrickia gristhorpensis* |
| ... | R | R | R | *Retitriletes austroclavatidites* |

Text-Figure A3.6. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Bathonian and Callovian strata of the River Izhma (outcrops 9 and 7) and River Pizhma (outcrops 12 and 13) areas, Pechora Basin, northern Russian Platform (localities 1 to 4 of Text-Figure 4). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | **Sample Number (TP)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 12 | 12 | 13 | 13 | 13 | 13 | 9 | 9 | 9 | 7 | 7 | **Outcrop Number** |
| L.B. | L./M.B. | U.B. | L.C. | L.C. | L.C. | L.C. | M.C. | M.C. | U.C. | U.C. | U.C. | **Substage** |
| Oro. | Is./Ha. | Var. | Elat./Fals. | Pis. | Sim. | Tyc. | Mi./Ko. | Mi./Ko. | | Key. | Key. | **Ammonite Zone/Beds** |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | **Dinoflagellate cysts:** |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | 0.6 | 1.6 | ... | *A? staffinensis* |
| ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | *A. haromense* |
| 50 | 5.4 | 2.1 | 7.6 | 6 | ... | 1.9 | ?1.9 | 23 | 11.9 | 21.7 | 20.5 | *Batiacasphaera* spp. |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | 0.3 | ... | ... | Chorate dino. cysts indet. |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | 0.9 | 1.6 | 1 | *C. cerastes* |
| ... | ... | ... | 0.6 | 3 | ... | ?1.9 | ... | 0.5 | 17.4 | 10.8 | 2.5 | *C. chytroeides* |
| ... | 2.7 | 2.1 | 9.3 | 3 | 2.9 | 3.8 | ?1.9 | 21.5 | 0.3 | 6.3 | 52 | *C. hyalina* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | *C. asapha* |
| ... | 2.7 | ... | ... | ... | 1.5 | ... | ... | ... | ... | ... | ... | *Crussolia* spp. |
| ... | ... | ... | ... | ... | ... | 32.4 | ... | ... | ... | ... | ... | *C. combazii* |
| ... | 2.7 | ... | ... | ... | ... | ... | 3.7 | ... | ... | ... | ... | *C. sellwoodii* |
| 3.3 | ... | ... | ... | ... | 1.5 | ... | 1.9 | 0.5 | ... | 1.6 | ... | Dino. cysts - indet. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.9 | ... | ... | *E. cinctum* |
| ... | ... | ... | 1.8 | ... | ?14.7 | ... | ... | ... | ... | ... | ... | *E. galeritum* |
| ... | ... | ... | ... | 9 | ... | 3.8 | 1.9 | 2.4 | ... | 1.6 | ... | *Endoscrinium* spp. |
| 6.7 | 2.7 | 2.1 | ... | ... | 1.5 | 1.9 | ... | 0.9 | 1.2 | ... | 2 | *E. evittii* |
| ... | 5.4 | 15.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *F. bjaerkei* |
| ... | 10.9 | 21.8 | 9.1 | 12 | 23.4 | 7.4 | 12.5 | 12.9 | 16.7 | 17.1 | 7 | *F. tornatilis* |
| 23.3 | 5.4 | ... | ... | 3 | ... | ... | 1.9 | ... | ... | 1.6 | ... | Gony. dino. cysts - indet. |
| ... | ... | ... | 0.2 | 3 | ... | 1.9 | 1.9 | 1.9 | 1.2 | 3.1 | ... | *G. jurassica adecta* |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | 0.3 | ... | ... | *Gonyaulacysta* spp. |
| ... | ... | ... | ... | ... | ?1.5 | ?1.9 | ... | 0.5 | 0.3 | ... | .. | *K. stegasta* |
| ... | ... | ... | ... | ... | 1.5 | 1.9 | 1.9 | 0.5 | 0.3 | 1.6 | 0.5 | *L. callovianum* |
| ... | 5.4 | ... | ... | ... | ... | ... | ... | ?1.9 | 6.2 | 1.6 | ... | *L. caytonensis* |
| ... | ... | ... | ... | ... | ... | ... | ?1.9 | ... | ... | 1.6 | 1.5 | *L. planoseptata* |
| 3.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *L.* cf. *valensii* |
| 6.7 | ... | ... | 3.5 | 3 | 2.9 | 3.8 | ... | 0.9 | 5.9 | 1.6 | ... | *Lithodinia* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | 1.4 | 12.1 | 7.8 | ... | *M. groenlandicum* |
| .. | ... | ... | ... | ... | ... | ... | ... | 0.5 | 0.3 | ... | 0.5 | *N. deflandrei* (R/W) |
| ... | 2.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *N. gracilis* (R/W) |
| ... | 35.1 | 29.2 | 33.3 | 19 | 20.6 | 3.8 | 29.6 | 10 | 1.9 | 3.1 | 1.5 | *N. pellucida* |
| ... | ... | ... | ... | ... | 5.9 | 3.8 | ... | 0.5 | 1.9 | 1.6 | 1.5 | *P. retiphragmata* |
| ... | 8.1 | 6.2 | 0.6 | 6 | 2.9 | 3.8 | ?1.9 | 1.4 | 0.6 | 1.6 | 1 | *P. ceratophora* |
| ... | ... | ... | ... | 3 | ... | 1.9 | ... | ... | ... | ... | ... | *P. prolongata* |
| 6.7 | ... | 2.1 | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | *Pareodinia* spp. |
| ... | 2.7 | 12.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P. elatmaensis* |
| ... | ... | 2.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P? elongatum* |
| ... | ... | ... | 1 | 3 | 1.5 | 5.5 | 1.9 | 2.4 | 1.2 | 7.8 | 2.5 | *R. cladophora* |
| ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | *S. creberbarbatum* |
| ... | ... | ... | 0.4 | 6 | 4.4 | 3.8 | 3.7 | ... | 7.7 | 3.1 | 1 | *Sentusidinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | 0.5 | *S. orbis* |
| ... | 8.1 | ?2.1 | 31.3 | 15 | 7.4 | 14.8 | 24.1 | 12 | 5.3 | ... | 1 | *S. grossii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | *S. redcliffense* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | *S. scarburghense* |
| ... | ... | ... | 0.2 | 6 | 5.9 | ... | 7.4 | 3.4 | 3.4 | 1.6 | 3 | *T. dangeardii* |
| ... | ... | 2.1 | ... | ... | ... | ... | ... | 0.5 | ... | ... | 0.5 | *W. acollaris* |
| | | | | | | | | | | | | |
| 6 | 14 | 12 | 19 | 15 | 16 | 18 | 16 | 23 | 28 | 21 | 18 | **Dino. cyst diversity** |
| 30 | 37 | 48 | 514 | 33 | 68 | 54 | 54 | 209 | 323 | 64 | 206 | **Dino. cysts per slide** |

Text-Figure A3.7. Spreadsheet diagram illustrating the stratigraphic distribution of the dinoflagellate cysts *Adnatosphaeridium caulleryi* to *Lagenadinium callovianum* (ordered alphabetically) in the Upper Callovian and Kimmeridgian strata of outcrop 15, River Izhma, Pechora Basin, northern Russian Platform (outcrop 5 of Text-Figure 4). Sample TP 13 proved entirely barren of palynomorphs, and is not illustrated here. The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| 26 | 25 | 24 | 23 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 15 | 14 | Sample Number (TP) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.C. | U.C. | U.C. | U.C. | U.C. | U.C. | L.K. | L.K. | L.K. | L.K. | L.K. | U.K. | U.K. | Substage |
| Key. | Key. | Key. | Key. | Sub. | Sub. | Kit. | Kit. | Kit. | Kit. | Kit. | ?E./A. | ?E./A. | Ammonite Zone |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | **Dinoflagellate cysts (1):** |
| ... | ... | ... | ... | 0.1 | ?0.1 | ... | ... | ... | ... | ... | ... | ... | *A. caulleryi* |
| ... | ... | ... | ... | ... | ... | ... | ... | 1.2 | ... | ... | ... | ... | *A. dictyota* |
| ... | ... | ... | ... | ... | ... | 2.8 | ... | ... | ... | ... | ... | ... | *Aldorfia* spp. |
| ... | ... | ?0.2 | ... | ... | ... | ... | ... | 1.2 | ... | ... | ... | 0.6 | *A? staffinensis* |
| ... | ... | ... | ... | ... | ... | 4.6 | ... | ... | ... | ... | ... | ... | *Apteodinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | 1.2 | ... | ... | ... | 2.4 | *A. haromense* |
| ... | ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | ... | ... | *Atopodinium* sp. |
| 14 | 11 | 4.3 | 12.5 | 4.6 | 3.7 | ... | ... | ... | ... | ... | ... | 3 | *Batiacasphaera* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.4 | 1.7 | ... | ... | Cavate dino. cysts - indet. |
| ... | ... | 3.4 | 0.2 | 1.3 | ... | ... | ... | ... | ... | ... | ... | ... | *Chlamydophorella* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | 4.8 | 1.1 | 6.1 | 3.6 | 16.5 | Chorate dino. cysts |
| 3.9 | 1.2 | 1.4 | 1.9 | 3.9 | 0.6 | ... | ... | ... | ... | ... | ... | ... | *C. cerastes* |
| 3.6 | 1.6 | 2 | 2.8 | 3.9 | 5.6 | 0.4 | 0.8 | 8.2 | 6.9 | 1.7 | ?1.2 | 5.3 | *C. chytroeides* |
| 36.1 | 32 | 48.5 | 36.5 | 0.3 | ?0.1 | ... | ... | ... | ... | ... | ... | ... | *C. hyalina* |
| ... | ... | ... | ... | ... | ... | ... | ... | 2.4 | ... | ... | ... | ... | *Chytroeisphaeridia* sp. |
| ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | *C. asapha* |
| 0.2 | 0.5 | 0.7 | ... | ... | ... | 0.1 | 0.2 | 2.4 | 2.3 | ... | ... | 2.4 | *C. tribuliferum* |
| ... | ... | ... | 1.6 | 2.6 | ... | ... | ... | ... | ... | ... | ... | ... | *C. varispinosum* |
| ... | 0.2 | ... | 0.9 | 0.4 | 0.2 | ... | ... | 2.4 | ... | 3.5 | ... | ... | *Cleistosphaeridium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 5.7 | ... | 3.6 | 1.8 | *C. globatum* |
| ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | *C. continuum* |
| ... | ... | ... | ... | 2.7 | ... | ... | ... | ... | ... | ... | ... | ... | *C. ornatum* |
| ... | ... | ... | ?0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Ctenidodinium* sp. |
| ... | ... | 0.2 | ... | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | *Dingodinium* spp. |
| 0.2 | ... | | ... | ... | 0.2 | 0.1 | ... | 2.4 | ... | ... | 2.4 | 0.6 | Dino. cysts - indet. |
| ... | ... | ... | ... | ... | ... | 0.1 | ... | 3.6 | ... | ... | ... | ... | *E. anceps* |
| 2.6 | 5.6 | 0.9 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *E. galeritum* |
| ... | ... | ... | ... | 1.3 | ... | ... | ... | ... | ... | 0.9 | 2.4 | ... | *Endoscrinium* spp. |
| ... | 0.7 | ?1.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Epiplosphaera* spp. |
| 0.5 | 0.2 | 0.9 | 0.5 | ... | 0.2 | ... | ... | ... | ... | ... | ... | ... | *E. evittii* |
| 2.1 | 0.9 | 3.6 | 1.2 | 6.7 | 4 | ... | ... | ... | ... | ... | ... | ... | *F. tornatilis* |
| ... | ... | ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | 5.8 | *G. dimorphum* |
| ... | ... | ... | 0.5 | 0.1 | ... | ... | ... | 8.2 | 1.1 | ... | 3.6 | 0.6 | Gony. dino. cysts - indet. |
| ... | ... | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | ... | *G. centriconnata* |
| 1.8 | 1.1 | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | ... | *G. eisenackii* |
| 1.8 | 1.6 | 2.6 | 3.3 | 5.3 | 4.3 | ... | ... | ... | ... | ... | ... | ... | *G. jurassica adecta* |
| ... | ... | ... | ... | ... | ... | 2.4 | 0.6 | ... | 1.1 | ... | ... | 1.2 | *G. jurassica jurassica* |
| 2.3 | ?0.2 | 1.6 | 0.5 | ... | ?0.1 | ... | ... | ... | ... | ... | ... | ... | *G. pectinigera* |
| 0.2 | ... | ... | ... | ... | ... | ... | ... | 2.4 | 1.1 | ... | ... | ... | *Gonyaulacysta* spp. |
| 0.5 | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Heslertonia* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.2 | 1.2 | *H. pulchrum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 4.1 | *H. orbifera* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 12.3 | *H.* cf. *orbifera* |
| ... | ... | ... | ... | ?0.7 | ... | ... | ... | ... | ... | ... | ... | ... | *Jansonia* sp. |
| 0.2 | 1.6 | 0.9 | 5.6 | 1.7 | ... | ... | ... | ... | ... | ... | ... | 3.6 | *K. stegasta* |
| ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | ... | *L. callovianum* |
| | | | | | | | | | | | | | |
| **27** | **29** | **29** | **23** | **33** | **25** | **25** | **12** | **20** | **13** | **9** | **14** | **25** | **Dino. cyst diversity** |
| **385** | **431** | **443** | **425** | **700** | **818** | **1126** | **1163** | **85** | **87** | **115** | **83** | **169** | **Dino. cysts per slide** |

Text-Figure A3.8. Spreadsheet diagram illustrating the stratigraphic distribution of the dinoflagellate cysts *Leptodinium mirabile* to *Wanaea acollaris* (ordered alphabetically) and selected miscellaneous palynomorphs in the Upper Callovian and Kimmeridgian strata of outcrop 15, River Izhma, Pechora Basin, northern Russian Platform (outcrop 5 of Text-Figure 4). Sample TP 13 proved entirely barren of palynomorphs, and is not illustrated here. The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the selected miscellaneous palynomorphs; the key is as for Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| **26** | **25** | **24** | **23** | **22** | **21** | **20** | **19** | **18** | **17** | **16** | **15** | **14** | **Sample Number (TP)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **U.C.** | **U.C.** | **U.C.** | **U.C.** | **U.C.** | **U.C.** | **L.K.** | **L.K.** | **L.K.** | **L.K.** | **L.K.** | **U.K.** | **U.K.** | **Substage** |
| **Key.** | **Key.** | **Key.** | **Key.** | **Sub.** | **Sub.** | **Kit.** | **Kit.** | **Kit.** | **Kit.** | **Kit.** | **?E./A.** | **?E./A.** | **Ammonite Zone** |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | **Dinoflagellate cysts (2):** |
| ... | ... | ... | ... | ... | ... | 1.7 | ... | ... | ... | ... | ... | ... | *L. mirabile* |
| ... | ... | ... | ... | ... | ... | 1.5 | ... | ... | 20.7 | ... | ... | ... | *L. subtile* |
| ... | ... | ... | ... | ... | ... | 10.6 | 4 | ... | ... | ... | ... | ... | *Leptodinium* spp. |
| ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | *L. liesbergensis* |
| ... | ... | ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | ... | *Limbodinium* sp |
| 0.5 | 0.7 | ?0.9 | 2.1 | 10.3 | 52.2 | ... | ... | ... | ... | ... | ... | ... | *L. caytonensis* |
| 4.7 | 2.3 | 2.7 | 1.6 | ?0.1 | ... | ... | ... | ... | ... | ... | ... | ... | *L. planoseptata* |
| 10.4 | 8.8 | 8.4 | ... | ... | 0.2 | ... | ... | ... | ... | ... | ... | ... | *Lithodinia* spp. |
| ... | ... | ... | ... | 2.8 | 7.5 | ... | ... | ... | ... | ... | ... | ... | *M. groenlandicum* |
| ... | 0.7 | 0.7 | 4 | 0.9 | ... | ... | ... | ... | ... | ... | ... | ... | *N. pellucida* |
| 0.8 | 0.2 | 0.5 | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | 0.6 | *Paragonyaulacysta* spp. |
| 2.3 | 4.6 | 2.3 | 3.8 | 1.6 | 1.7 | ... | ... | ... | ... | ... | ... | ... | *P. ceratophora* |
| 0.8 | 2.5 | 0.9 | 1.4 | 4.1 | 0.2 | 0.1 | ... | 1.2 | ... | 0.9 | 2.4 | 8.2 | *P. halosa* |
| ... | ... | 0.2 | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P. prolongata* |
| ... | ... | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Pareodinia* spp. |
| ... | ... | ... | ... | ... | ... | 4.2 | 1.8 | 28.5 | 45.2 | 79.1 | 45.9 | 3 | *P. pannosum* |
| ... | ... | ... | ... | ... | ... | ... | ... | 2.4 | ... | ... | 2.4 | ... | *P. anasillum* |
| ... | ... | ... | ... | ... | ... | 0.3 | 0.1 | ... | ... | ... | ... | 1.2 | *P. parvispinum* |
| 4.4 | 17.2 | 7.2 | 13.9 | 39.7 | 18.1 | 64.9 | 90.7 | 6 | 2.3 | ... | ... | 1.8 | *R. cladophora* |
| ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | *S. crystallinum* |
| ... | 0.7 | 0.5 | ... | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | *S. creberbarbatum* |
| 1.8 | ... | ... | 1.2 | 1.3 | ... | 0.6 | 0.6 | 17.6 | ... | ... | ... | ... | *Sentusidinium* spp. |
| ?0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S. orbis* |
| 0.8 | 1.2 | 1.1 | ... | 0.1 | ... | 0.4 | 0.4 | ... | 8 | 3.5 | 8.4 | 2.4 | *S. grossii* |
| ... | ... | ... | ... | 0.9 | ... | 1.4 | 0.4 | 1.2 | ... | ... | 1.2 | ... | *S. caytonense* |
| ... | ... | ... | ... | ... | ... | ... | ... | 2.4 | ... | ... | ... | ... | *S. redcliffense* |
| ... | ... | ... | ... | ... | ... | 1.9 | 0.1 | ... | ... | ... | ... | ... | *S. scarburghensis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.6 | *S. valensii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.8 | *S.* cf. *valensii* |
| ... | ... | ... | ... | ... | 0.1 | 0.8 | ... | ... | ... | ... | 19.3 | 16 | *Systematophora* spp. |
| ... | ... | ... | ... | 0.7 | ... | ... | ... | ... | ... | ... | ... | ... | *T. scarburghensis* |
| 3.1 | 1.6 | 1.6 | 3.3 | 0.3 | 0.4 | ... | ... | ... | ... | ... | ... | ... | *T. dangeardii* |
| ... | 0.2 | ... | ... | ... | ... | 0.2 | 0.2 | 1.2 | ?1.1 | 2.6 | ?2.4 | 3 | *T. rhombiformis* |
| ... | ... | ... | ... | ... | ... | 0.3 | 0.1 | ... | ... | ... | ... | ... | *Tubotuberella* spp. |
| 0.2 | 0.2 | 0.2 | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | ... | *Valensiella* spp. |
| ... | 0.2 | ... | ... | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | *W. acollaris* |
| | | | | | | | | | | | | | |
| **27** | **29** | **29** | **23** | **33** | **25** | **25** | **12** | **20** | **13** | **9** | **14** | **25** | **Dino. cyst diversity** |
| **385** | **431** | **443** | **425** | **700** | **818** | **1126** | **1163** | **85** | **87** | **115** | **83** | **169** | **Dino. cysts per slide** |
| | | | | | | | | | | | | | |
| | | | | | | | | | | | | | **Miscellaneous:** |
| R | P | P | P | P/R | R | ... | ... | ... | ... | ... | ... | ... | *Botryococcus* |
| C | P | P | C/Ab | R | R | ... | ... | ... | ... | ... | R | ... | Carbonif. spores (R/W) |
| R | R | R | ... | C | R | P/R | P | P | R/P | ... | P | R/P | Foraminiferal test linings |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | R | ... | ... | Fungal spores - undiff. |
| ... | ... | ... | ... | ... | R | ... | ... | ... | ... | ... | ... | ... | *Micrhystridium* spp. |
| R | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Schizocystia rare* |
| R | ... | ... | R | R | ... | R | ... | ... | ... | ... | ... | ... | *Tasmanites* spp. |

Text-Figure A3.9. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Kimmeridgian/ Middle Volgian strata of outcrops 12, 12a and 13, River Pizhma, Pechora Basin, northern Russian Platform (locality 6 of Text-Figure 4). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| TP 36 | TP 35 | TP 34 | TP 33 | TP 32 | TP 31 | TP 30 | TP 29 | TP 28 | TP 27 | Sample Nunber |
|---|---|---|---|---|---|---|---|---|---|---|
| 214 | 207 | 206 | 204 | 203 | 202 | 201 | 200 | 226 | 224 | Collector's Number (VAF) |
| 13 | 12a | 12a | 12a | 12a | 12a | 12a | 12a | 12 | 12 | Outcrop Number |
| ?K | UK | UK | ?K | UK | UK | LK | LK | ?UK/MV | ?UK/MV | Substage |
| | | | | Au. | ?Au. | Ki. | Ki. | | | Ammonite Zone |
| | | | | | | | | | | |
| | | | | | | | | | | Dinoflagellate cysts: |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | *Achomosphaera* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | 5.5 | ... | *Ambonosphaera? staffinensis* |
| ... | 1.8 | ... | 1.8 | ... | ... | ... | ... | ... | ... | *Apteodinium* spp. |
| ... | 0.7 | ... | 0.6- | ... | ... | ... | ... | ... | 0.3 | *Atopodinium* sp. |
| ... | 1.5 | 0.8 | 2.4 | ... | ... | ... | 1.2 | 11.1 | ... | *Batlacasphaera* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.8 | *Bourkodinium* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.3 | *Cassiculosphaeridia* sp. |
| ... | ... | 1.7 | ... | 6.3 | 2.2 | 1 | 1.5 | 5.5 | 28.4 | *Chlamydophorella* spp. |
| ... | ... | 0.8 | 4.3 | ... | ... | 3 | 0.3 | ... | 0.5 | Chorate dinoflagellate cysts - indeterminate |
| ... | 19.3 | 48.3 | 1.8 | 31.1 | ?1.1 | 14 | 7.7 | 11.1 | 1 | *Chytroeisphaeridia chytroeides* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.3 | *Circulodinium compta* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 8.8 | *Circulodinium distinctum* |
| ... | ... | ... | ?0.6 | ... | ... | ... | ... | ... | ... | *Circulodinium* spp. |
| ... | ... | 4.2 | ... | ... | 4.4 | ... | ... | ... | 1 | *Cleistosphaeridium tribuliferum* |
| ... | 4.1 | ... | 1.8 | ... | 3.3 | 3 | ... | ... | ... | *Cleistosphaeridium* spp. |
| ... | 2.2 | 2.5 | 3.5 | 12.5 | 2.2 | 4 | 1.8 | ... | ... | *Cribroperidinium globatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.3 | *Cribroperidinium* spp. |
| ... | ... | ... | ... | ... | 2.2 | ... | 0.9 | ... | 1 | *Dingodinium* spp. |
| 50 | ... | 1.7 | 1.7 | ... | ... | 2 | 1.2 | 5.5 | 0.5 | Dinoflagellate cysts - indeterminate |
| ... | ... | ?0.8 | ?0.6 | ... | ... | ?1 | 1.2 | ... | 1.8 | *Endoscrinium anceps* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | *Endoscrinium glabrum* |
| ... | ... | ... | ... | ... | ... | ... | 1.2 | ... | ... | *Endoscrinium* spp. |
| ... | ... | ... | ... | ?6.3 | 2.2 | 1 | 0.3 | ... | 0.3 | *Epiplosphaera gochtii* |
| ... | ... | ... | ... | ... | ... | ... | ?0.9 | ... | ... | *Epiplosphaera* spp. |
| ... | 1.1 | 1.7 | 5.6 | ... | 4.4 | 2 | 0.9 | 11.1 | 0.5 | Gonyaulacacean dinoflagellate cysts - indet. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | *Gonyaulacysta helicoidea* |
| ... | ... | ?0.8 | ... | ... | ... | ... | ... | ... | ... | *Gonyaulacysta jurassica* subsp. *jurassica* |
| ... | 0.4 | ... | ... | 12.5 | ... | ... | ... | ... | 1.3 | *Gonyaulacysta* spp. |
| ... | ... | ... | ... | ... | ... | 3 | ... | ... | ... | *Glossodinium dimorphum* |
| ... | ... | ... | 0.6 | ... | ... | ... | ... | ... | 8.8 | *Hystrichodinium pulchrum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.8 | *Imbatodinium kondratjevii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | *Kleithriasphaeridium* spp. |
| ... | ... | 0.8 | ... | ... | ... | ... | ... | ... | ... | *Leptodinium mirabile* |
| ... | ... | ... | ... | ... | ... | ... | 1.2 | 5.5 | ... | *Leptodinium subtile* |
| ... | 0.7 | ... | 3.1 | ... | ... | 1 | ... | ... | 0.8 | *Leptodinium* spp. |
| ... | ... | ... | 0.6 | ... | ... | ... | ... | ... | ... | *Mendicodinium groenlandicum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.5 | *Oligosphaeridium diluculum* |
| ... | ... | 0.8 | ... | ... | ... | ?1 | 1.6 | ... | ... | *Paragonyaulacysta* sp. |
| ... | 0.7 | 0.8 | ... | ... | ... | 2 | 2.6 | ... | 0.3 | *Pareodinia ceratophora* |
| ... | 32.3 | 1.7 | 3.7 | ... | 1.1 | ... | 6.8 | 5.5 | 10.7 | *Pareodinia halosa* |
| ... | ... | ... | ... | ... | ... | ... | 1.5 | ... | ... | *Pareodinia* spp. |
| ... | 10.4 | 23.4 | 55 | ... | 30.8 | 54 | 46.3 | ... | ... | *Perisseiasphaeridium pannosum* |
| ... | ... | 0.8 | 0.6 | ... | ... | ... | ... | ... | ... | *Prolixosphaeridium mixtispinosum* |
| 50 | 5.2 | 1.7 | 1.2 | ... | 1.1 | 4 | ?0.3 | ... | 0.5 | *Prolixosphaeridium parvispinum* |
| ... | 4.1 | 2.5 | ... | ?6.3 | ... | ... | 1.8 | ... | 0.8 | *Rhynchodiniopsis cladophora* |
| ... | ... | ... | 1.2 | ... | ... | ... | ... | ... | ... | *Sentusidinium creberbarbatum* |
| ... | 0.7 | 0.8 | 3.7 | 12.5 | ... | ... | 0.9 | 5.5 | 0.5 | *Sentusidinium* spp. |
| ... | 14.4 | 3.4 | 5.6 | 12.5 | 40.6 | 1 | 17 | 28.2 | 10.5 | *Sirmiodinium grossii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | *Spiniferites* sp. |
| ... | ... | ... | ... | ... | 2.2 | ... | ... | ... | 1.8 | *Trichodinium* sp. |
| ... | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | *Tubotuberella dangeardii* |
| ... | ... | ... | ... | ... | 1.1 | 3 | ?0.6 | ?5.5 | 9.3 | *Tubotuberella rhombiformis* |
| ... | ... | ... | ... | ... | ?1.1 | ... | 0.3 | ... | ... | *Valensiella* sp. |
| | | | | | | | | | | |
| 2 | | 20 | 21 | 8 | 15 | 17 | 24 | 11 | 33 | Dinoflagellate cyst diversity |
| 2 | 270 | 118 | 161 | 16 | 91 | 100 | 339 | 18 | 385 | Number of dinoflagellate cysts per slide |

Text-Figure A3.10. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Middle Volgian strata of outcrops 16, 16a and 17, River Izhma, Pechora Basin, northern Russian Platform (locality 7 of Text-Figure 4). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| **TP 43** | **TP 42** | **TP 41** | **TP 40** | **TP 39** | **TP 38** | **TP 37** | **Sample Number** |
|---|---|---|---|---|---|---|---|
| **VAF 54** | **VAF 52** | **VAF 41** | **VAF 43** | **VAF 44** | **VAF 47** | **VAF 49** | **Collector's Number** |
| **17** | **16a** | **16** | **16** | **16** | **16** | **16** | **Outcrop Number** |
| **M. Volg.** | **M. Volg.** | **M. Volg.** | **M. Volg.** | **M. Volg.** | **M. Volg.** | **M. Volg.** | **Substage** |
| **Maximus** | **?Panderi** | **Panderi** | **Panderi** | **Panderi** | **Panderi** | **Panderi** | **Ammonite Zone** |
| | | | | | | | |
| | | | | | | | **Dinoflagellate cysts:** |
| ... | 2.6 | ... | ... | ... | ... | ... | *Aldorfia dictyota* |
| ... | 1.3 | ... | 0.8 | 0.6 | 1.7 | ... | *Ambonosphaera? staffinensis* |
| 3.5 | 1.3 | ... | ... | ... | ... | 0.7 | *Atopodinium haromense* |
| 3.5 | 6.5 | 4.2 | 3.5 | 5.6 | ... | 5.7 | *Batiacasphaera* spp. |
| 0.7 | ... | ... | 0.8 | ... | ... | ... | *Bourkodinium* sp. |
| ... | 1.3 | ... | 1.7 | ... | ... | 1.4 | Cavate dinoflagellate cysts - indeterminate |
| 0.7 | 1.3 | 2.5 | ... | ... | ... | 0.7 | *Chlamydophorella* spp. |
| 6.3 | 3.9 | 4.2 | 3.5 | 6.3 | 1.7 | 5 | Chorate dinoflagellate cysts - indeterminate |
| 1.4 | 3.9 | ... | 0.8 | 1 | 0.8 | 0.7 | *Chytroeisphaeridia chytroeides* |
| 3.5 | 2.6 | 0.8 | 7.6 | ... | 0.8 | 2.8 | *Cleistosphaeridium tribuliferum* |
| ... | ... | 25.3 | ... | ... | ... | ... | *Cribroperidinium globatum* |
| 11.9 | 27.2 | ... | 9.9 | 15.6 | 15.8 | 2.8 | *Cribroperidinium* spp. |
| ... | ... | ... | ?0.8 | ... | ... | ... | *Ctenidodinium* sp. |
| 10.5 | 3.9 | 22.7 | 5.9 | ... | ... | 2.8 | *Dingodinium* spp. |
| 2.1 | 2.6 | ... | ... | 0.6 | ... | 2.1 | Dinoflagellate cysts - indeterminate |
| ... | ... | ... | ... | ?4 | 0.8 | ... | *Endoscrinium anceps* |
| ... | 1.3 | 3.4 | 4.2 | 1 | 0.8 | 2.1 | *Endoscrinium* spp. |
| 0.7 | ... | ... | ... | ... | ... | ... | *Epiplosphaera* sp. |
| ?2.1 | 3.9 | ... | ... | ?0.3 | 10.8 | 5.7 | *Glossodinium dimorphum* |
| ... | ... | 5.9 | ... | ... | ... | ... | Gonyaulacacean dinoflagellate cysts - indet. |
| 1.4 | 2.6 | 1.7 | 3.5 | 1.6 | 0.8 | 2.8 | *Gonyaulacysta* spp. |
| 2.8 | ... | ... | 1.7 | 2.3 | ... | ... | *Hystrichodinium pulchrum* |
| 2.1 | ... | ... | ... | ... | ... | 1.4 | *Imbatodinium* spp. |
| 2.8 | ... | ... | ... | ... | ... | ... | *Kalyptea stegasta* |
| ... | ... | ... | 0.8 | 18.5 | 1.7 | 2.8 | *Kleithriasphaeridium* spp. |
| 0.7 | ... | ... | 1.7 | 1.3 | 6.7 | 7.8 | *Leptodinium subtile* |
| ... | ... | 0.8 | ... | ... | 0.8 | ... | *Mendicodinium groenlandicum* |
| ... | ... | ... | ... | 25.5 | 46.8 | 26.7 | *Oligosphaeridium patulum* |
| ... | ... | ... | ... | 0.6 | ... | ... | *Oligosphaeridium* spp. |
| 3.5 | ... | ... | ... | ... | ... | ?0.7 | *Paragonyaulacysta* sp. |
| ... | ... | ... | ... | ... | ... | ?0.7 | *Pareodinia antennata* |
| 4.2 | 11.7 | 9.2 | 15.8 | | 1.7 | 4.2 | *Pareodinia ceratophora* |
| 6.3 | 10.4 | 11.8 | 14.9 | ... | 1.7 | 9.9 | *Pareodinia halosa* |
| ... | ... | ... | ?0.8 | 1.3 | ... | ... | *Perisseiasphaeridium pannosum* |
| ... | 1.3 | ... | ... | ... | ... | ... | *Prolixosphaeridium anasillum* |
| 6.3 | 3.9 | 2.5 | 9.3 | 4 | 0.8 | 4.2 | *Prolixosphaeridium parvispinum* |
| ... | ... | ... | 0.8 | ... | 0.8 | ... | *Senoniasphaera jurassica* |
| 16 | 3.9 | ... | ... | 0.6 | 1.7 | 0.7 | *Sirmiodinium grossii* |
| ... | ... | 0.8 | ... | ... | 0.8 | 1.4 | *Systematophora daveyi* |
| ... | ... | ... | ... | 0.3 | ... | ... | *Systematophora* spp. |
| 7 | 2.6 | 4.2 | 11 | 9 | 2.5 | 4.2 | *Tubotuberella rhombiformis* |
| | | | | | | | |
| **23** | **21** | **15** | **21** | **22** | **20** | **25** | **Dinoflagellate cyst diversity** |
| **143** | **77** | **119** | **118** | **302** | **120** | **141** | **Number of dinoflagellate cysts per slide** |

Text-Figure A3.11. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Bathonian, Lower Callovian and Oxfordian strata of borehole 132, near Elatma, central Russian Platform (locality 1 of Text-Figure 5). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| 16 | 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | Sample No. (RP) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| L.B. | L.B. | Ba. | Ba. | Ba. | Ba. | Ba. | U. B. | U. B. | L.C. | L.O. | L.O. | M.O. | M.O. | M.O. | M.O. | Stage/Substage |
| | | | | | | | | | El. | ?Ma. | ?Ma. | De. | Te. | Te. | Te. | Ammonite Zone |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 4.2 | ... | ... | ... | ... | *Aldorfia* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.5 | 0.5 | 0.4 | ... | 2.8 | 2.9 | *A? staffinensis* |
| 10 | ... | 4.3 | ... | 27.3 | 7.7 | ... | ... | 22.2 | 34.3 | 11 | ... | ... | ... | ... | ... | *Batiacasphaera* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.9 | ... | 0.2 | ... | ... | *Chlamydoph.* spp. |
| ... | ... | ... | 3.4 | ... | ... | ... | ... | 55.6 | ... | 1 | 0.9 | 0.7 | 0.3 | 8.1 | 0.8 | Chorate cysts - indet. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3 | 0.7 | 2.2 | 0.3 | 0.3 | ... | *C. cerastes* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 6.3 | 4.5 | 1.9 | 1.2 | 1.6 | 6.7 | 9.6 | *C. chytroeides* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 9.3 | 1.5 | ... | ... | 0.2 | ... | ... | *C. hyalina* |
| ... | 2.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Chytroeisphaeridia* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 7.5 | 0.1 | 0.1 | 0.1 | ... | 0.5 | *C. asapha* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | *Cleistosphaerid.* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 0.5 | ... | 1.8 | 4.2 | 1.8 | *C. deflandrei* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.4 | ... | 0.2 | ... | ... | *C. perireticulata* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | 0.2 | ... | ... | *Crussolia* sp. |
| 20 | 22.7 | 1.4 | ... | ... | ... | ... | ... | ... | 6.3 | ... | ... | ... | ... | ... | ... | *C. sellwoodii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | 0.8 | ... | *Dingodinium* spp. |
| ... | 2.3 | ... | 1.7 | 18.2 | 15.4 | 25 | ... | 11.1 | 6.3 | ... | ... | 0.1 | 0.2 | ... | ... | Dino. cysts - indet. |
| 10 | ... | ... | ... | ... | ... | ... | 33.4 | ... | ... | ... | ... | ... | ... | ... | ... | *Dissiliodinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 8.5 | 3.3 | 0.9 | 7.2 | 3.9 | 7.2 | *E. galeritum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 5 | 6 | ... | ... | *E galerit. reticulatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | *E. luridum* |
| 10 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Endoscrinium* spp. |
| 10 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.5 | ... | ... | ... | ... | ... | *E. evittii* |
| ... | 2.3 | 2.8 | ... | ... | ... | ... | ... | ... | 6.3 | 1 | ... | ... | ... | ... | ... | *F. tornatilis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 0.5 | ... | ... | ... | ... | *G. centriconnata* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3 | 0.5 | 1.9 | 0.4 | ... | 1.3 | *G. eisenackii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.5 | 9.2 | 11.9 | 3.9 | ... | 7 | *G. jurassica adecta* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.5 | 62.2 | 52.3 | 45.3 | 25.8 | 38.4 | *G. jur. ad. longicornis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 10.1 | 13.7 | 10.8 | 4.4 | *G. jurassica jurassica* |
| ... | 4.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *K. gochtii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.5 | 0.3 | ... | ... | ... | ... | *Leptodinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | *L. absidatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.1 | ... | ... | ... | ... | ... | ... | *L. caytonensis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.3 | 1.5 | 12.7 | 28.6 | 17.4 | *Lithodinia* sp. A |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.1 | *Lithodinia* spp. |
| ... | ... | 1.4 | ... | 9 | 7.7 | ... | ... | 11.1 | ... | ... | ... | ... | ... | ... | ... | *M. groenlandicum* |
| ... | 4.5 | 1.4 | 1.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *N. deflandrei* (R/W) |
| 30 | 54.6 | ... | ... | ... | ... | ... | ... | ... | 3.1 | 2 | 0.9 | ... | ... | 0.6 | ... | *N. pellucida* |
| ... | ... | ... | ... | ... | 61.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Paragonyaula.* spp. |
| 10 | 4.5 | ... | 3.4 | 18.2 | ... | ... | ... | ... | 25 | ... | 0.1 | ... | 0.1 | ... | ... | *P. ceratophora* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | *Pareodinia* sp. |
| ... | 2.3 | 88.7 | 82.9 | 27.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P. elatmaensis* |
| ... | ... | ... | 6.9 | ... | 7.7 | 75 | 66.6 | ... | ... | ... | ... | ... | ... | ... | ... | *P? elongatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.5 | 1.6 | 3.7 | 0.7 | 2.5 | 1.8 | *R. cladophora* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | 1.1 | 0.6 | 0.6 | ... | *R. aemula* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 6 | 0.5 | 2.3 | 0.1 | 0.6 | 0.8 | *S. crystallinum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 8.5 | 4 | 2.3 | 2.8 | ... | 1 | *S. creberbarbatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 5.5 | ... | 0.7 | ... | 1.4 | ... | *Sentusidinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | *S. orbis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 0.3 | 1.1 | 0.7 | 1.4 | 0.8 | *S. grossii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | 0.1 | ... | ... | ... | ... | *S. caytonense* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3 | 0.8 | ... | 0.3 | 0.6 | 0.5 | *S. redcliffense* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 2.5 | 0.7 | 0.4 | 0.3 | ... | 0.5 | *S. scarburghense* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 11 | 2 | ... | ... | ... | ... | *T. scarburghensis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | *T. dangeardii* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | *W. acollaris* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | ... | ... | ... | *W. fimbriata* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | *W. thysanota* |
| 7 | 9 | 6 | 6 | 5 | 5 | 2 | 2 | 4 | 9 | 32 | 28 | 21 | 26 | 18 | 19 | Dino. cyst diversity |
| 10 | 44 | 71 | 57 | 11 | 13 | 4 | 3 | 9 | 32 | 199 | 732 | 734 | 956 | 359 | 385 | Dino. cysts/slide |

Text-Figure A3.12. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Callovian and Lower Oxfordian strata of a section near Inkino, central Russian Platform (locality 2 of Text-Figure 5). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| RP 23 | RP 22 | RP 21 | RP 20 | RP 19 | RP 18 | RP 17 | Sample Number |
|---|---|---|---|---|---|---|---|
| VII 3470 | VII 3471 | VII 3472 | VII 3473 | VII 3474 | VII 3475 | VII 3476 | Collector's Number |
| L. Callov. | L. Callov. | L. Callov. | U. Callov. | U. Callov. | L. Oxf. | L. Oxf. | Substage |
| Elatmae | Elatmae | Elatmae | Athleta | Athleta | Ma./Co. | Ma./Co. | Ammonite Zone |
| | | | | | | | |
| | | | | | | | Dinoflagellate cysts: |
| ... | 7.3 | 2.7 | ?2.1 | 3.5 | 5.5 | 3.8 | *Adnatosphaeridium caulleryi* |
| ?9.7 | 1.2 | ... | ... | ... | ... | ... | *Aldorfia aldorfensis* |
| ... | 3.6 | 4.5 | ... | ... | ... | ... | *Ambonosphaera? staffinensis* |
| 6.5 | ... | ... | ... | 4.1 | ... | 8.4 | *Batiacasphaera* spp. |
| ... | ... | ... | ... | ... | 2.7 | 0.9 | *Chlamydophorella* spp. |
| ... | ... | ... | ... | ... | 13.3 | 1.3 | Chorate dinoflagellate cysts - indeterminate |
| ?3.2 | ... | ... | ... | 1.4 | ... | 2.5 | *Chytroeisphaeridia cerastes* |
| ... | 3.6 | 2.7 | ... | 0.7 | 2.7 | 9.1 | *Chytroeisphaeridia chytroeides* |
| 12.9 | 12.4 | 5.4 | 5.7 | 5.5 | 2.7 | 3.8 | *Chytroeisphaeridia hyalina* |
| ... | ... | ... | ... | ... | ... | 3.1 | *Clathroctenocystis asapha* |
| ... | 7.3 | ... | 1.4 | 1.4 | ... | ... | *Cleistosphaeridium varispinosum* |
| ... | ... | 0.9 | ... | ... | ... | ... | *Cleistosphaeridium* sp. |
| ... | ... | ... | ... | ... | ... | 5.3 | *Crussolia deflandrei* |
| ... | ... | ... | ... | ... | ... | 0.3 | *Crussolia perireticulata* |
| ... | ?1.2 | ... | ... | ... | ... | ?0.3 | *Dingodinium* spp. |
| 12.9 | ... | ... | ?0.7 | 4.8 | 4.2 | ... | Dinoflagellate cysts - indeterminate |
| ... | ... | ... | ... | ... | ... | 1.6 | *Endoscrinium galeritum* |
| ... | ?1.2 | 1.8 | ... | 1.4 | ?1.4 | ... | *Endoscrinium* spp. |
| ... | ... | ... | ?0.7 | ... | ... | ... | *Epiplosphaera gochtii* |
| ... | ... | 1.8 | ... | ... | 1.4 | ?0.3 | *Evansia evittii* |
| 6.5 | 13.7 | 1.8 | ... | 4.1 | 23.7 | 0.9 | *Fromea tornatilis* |
| ... | 6.1 | 1.8 | ... | ... | 1.4 | ... | Gonyaulacacean dinoflagellate cysts - indet. |
| ... | ... | ... | ... | ... | ... | 0.9 | *Gonyaulacysta centriconnata* |
| ... | ... | ... | ... | ... | ... | 1.6 | *Gonyaulacysta eisenackii* |
| 3.2 | 3.6 | 0.9 | 1.4 | 2.7 | 2.7 | 2.2 | *Gonyaulacysta jurassica adecta* |
| ... | ... | ... | ... | 1.4 | ... | 0.6 | *Gonyaulacysta jurassica adecta longicornis* |
| ... | ?1.2 | ?0.9 | ... | ... | ... | 0.3 | *Gonyaulacysta pectinigera* |
| ... | 1.2 | ... | ... | ... | ... | ... | *Gonyaulacysta* spp. |
| ... | ... | 1.8 | ... | 2.7 | ... | ... | *Lithodinia planoseptata* |
| ... | ... | 2.7 | ... | ... | 2.7 | ... | *Lithodinia* spp. |
| ... | 1.2 | ... | ... | 2.1 | 13.4 | 2.5 | *Mendicodinium groenlandicum* |
| 6.5 | 4.9 | 5.5 | 7.8 | 3.4 | 9.7 | 1.6 | *Nannoceratopsis pellucida* |
| ... | ... | ... | ... | ... | ... | 0.3 | *Paragonyaulacysta retiphragmata* |
| 3.2 | 2.4 | 22 | 29.2 | 29 | ... | 1.9 | *Pareodinia ceratophora* |
| ... | ... | 2.7 | ... | ... | ... | .... | *Pareodinia prolongata* |
| ... | ... | ... | ... | ... | ... | 0.9 | *Prolixosphaeridium parvispinum* |
| 19.3 | 8.5 | 2.7 | 9.9 | 11 | ... | 9.1 | *Rhynchodiniopsis cladophora* |
| ... | ... | ... | ... | ... | 4.2 | .... | *Rigaudella aemula* |
| ... | ... | ... | ?0.7 | ... | ... | 2.5 | *Scriniodinium crystallinum* |
| ... | ... | ... | ... | ... | ... | 9.9 | *Sentusidinium creberbarbatum* |
| ... | ... | ... | 33.4 | ... | ... | ... | *Sentusidinium rioultii* |
| ... | 7.3 | 3.6 | ... | 18.7 | 4.2 | 2.8 | *Sentusidinium* spp. |
| ... | 2.4 | ... | ... | ... | 1.4 | ... | *Sirmiodiniopsis orbis* |
| 3.2 | 6.1 | 33.8 | 2.1 | 1.4 | ... | 2.8 | *Sirmiodinium grossii* |
| ... | ... | ... | ... | ... | ... | 1.9 | *Stephanelytron caytonense* |
| ... | ... | ... | ... | ... | ... | 1.3 | *Stephanelytron redcliffense* |
| ... | ... | ... | ... | ... | 2.7 | 0.9 | *Stephanelytron scarburghense* |
| ... | ... | ... | ... | ... | ... | 2.2 | *Surculosphaeridium vestitum* |
| ... | ... | ... | ... | ... | ... | 9.4 | *Trichodinium scarburghensis* |
| ... | ?1.2 | ... | 2.1 | ... | ... | ... | *Tubotuberella apatela* |
| 9.7 | 2.4 | ... | 2.8 | ... | ... | 1.9 | *Tubotuberella dangeardii* |
| ... | ... | ... | ... | 0.7 | ... | ... | *Valensiella* sp. |
| 3.2 | ... | ... | ... | ... | ... | ... | *Wanaea acollaris* |
| ... | ... | ... | ... | ... | ... | 0.9 | *Wanaea fimbriata* |
| | | | | | | | |
| 13 | 22 | 19 | 14 | 19 | 18 | 36 | Dinoflagellate cyst diversity |
| 31 | 82 | 110 | 141 | 145 | 72 | 320 | Number of dinoflagellate cysts per slide |

Text-Figure A3.13. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Upper Callovian and Oxfordian strata of section 2, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| RP 32 | RP 31 | RP 30 | RP 29 | RP 28 | RP 27 | RP 26 | RP 25 | RP 24 | Sample Number |
|---|---|---|---|---|---|---|---|---|---|
| U. Call. | U. Call. | U. Call. | L. Oxf. | L. Oxf. | M. Oxf. | M. Oxf. | M. Oxf. | M. Oxf. | Substage |
| ?Ath. | ? | ?Lamb. | ?Mar. | ?Mar. | Densi. | Densi. | Tenui. | Tenui. | Ammonite Zone |
| ... | ... | ... | 0.9 | ... | ... | 0.9 | ... | ... | *Atopodinium haromense* |
| ... | ... | ... | ... | 0.8 | ... | ... | ... | ... | *Atopodinium prostatum* |
| ... | ... | 1.6 | 2.2 | ... | ... | 5.5 | 1.5 | 1.5 | *Batiacasphaera* spp. |
| 1.5 | 30 | 6.5 | 4.9 | 5.8 | 1.7 | 0.9 | 0.8 | 0.4 | *Chlamydophorella* spp. |
| ... | 2 | 1.6 | 15.9 | 1.1 | 3.4 | 7.1 | 1.5 | 0.2 | *Chytroeisphaeridia cerastes* |
| 13 | 15.7 | 8.1 | 6.2 | 12.3 | 10.9 | 16.9 | 19.2 | 14.5 | *Chytroeisphaeridia chytroeides* |
| 1.5 | ... | ... | ... | ... | ... | ... | 3.8 | 1.5 | *Chytroeisphaeridia hyalina* |
| ... | ... | ... | 1.8 | 0.8 | ... | 1.3 | ... | ... | *Clathroctenocystis asapha* |
| ... | 0.6 | ... | ... | ... | ... | ... | ... | ... | *Cleistosphaeridium* spp. |
| ... | ... | ... | 5.7 | 0.8 | ... | ... | ... | ... | *Crussolia dalei* |
| ... | ... | ?1.6 | 5.3 | ... | 2.9 | 0.9 | ... | 1.5 | *Crussolia deflandrei* |
| ... | ... | ... | 6.2 | 2.4 | 8 | 2.5 | ... | 0.1 | *Crussolia perireticulata* |
| 1.5 | 3.3 | ... | ... | ... | 1.1 | 1.3 | ... | 2 | *Crussolia* sp. |
| ... | 1.3 | ... | ... | ... | ... | ... | ... | ... | *Ctenidodinium continuum* |
| ... | ... | ... | 0.9 | 0.5 | ... | ... | ... | ... | *Ctenidodinium ornatum* |
| ... | 2.6 | ... | 1.3 | ... | ... | ... | ... | 47.1 | *Dingodinium* spp. |
| 1.5 | 1.3 | ... | ... | ... | ... | 0.4 | ... | 0.3 | Dinoflagellate cysts - indeterminate |
| 2.9 | 1.3 | 35.6 | 10.2 | 16.2 | 16.5 | 12.2 | 27 | 12 | *Endoscrinium galeritum* |
| ... | ... | 6.5 | 1.3 | 12.3 | 13.7 | 7.1 | 10 | 4.5 | *Endoscrinium galeritum reticulatum* |
| ... | ... | ... | ... | ... | ... | 0.4 | ... | ... | *Endoscrinium luridum* |
| ... | ... | ... | ... | ... | ... | 1.3 | ... | ... | *Endoscrinium* sp. |
| 1.5 | ... | ... | ... | ... | ... | ... | ... | ... | *Evansia evittii* |
| 18.7 | 4.6 | ... | ... | 0.8 | 0.6 | 1.3 | ... | ... | *Fromea tornatilis* |
| 1.5 | 0.6 | 4.8 | 0.9 | ... | 0.6 | ... | 0.8 | ... | Gonyaulacean dinoflagellate cysts - indet. |
| ... | ... | 1.6 | 2.2 | ... | ... | ... | ... | ... | *Gonyaulacysta centriconnata* |
| ... | ... | ... | ... | ... | ... | 0.4 | ... | ... | *Gonyaulacysta dualis* |
| ... | ... | ... | 1.3 | 2.1 | 0.6 | ... | 3.8 | 0.5 | *Gonyaulacysta eisenackii* |
| ... | 2 | 4.8 | ... | 3.7 | 4 | 0.9 | 0.8 | 0.3 | *Gonyaulacysta jurassica adecta* |
| ... | ... | 4.8 | 8.4 | 3.7 | 5.1 | 11.9 | 13.1 | 4.6 | *Gony. jurassica adecta longicornis* |
| ... | ... | ... | ... | 1.1 | 1.1 | ... | 0.8 | 1.5 | *Gonyaulacysta jurassica jurassica* |
| ... | ... | ... | ... | ... | ... | ... | 1.5 | ... | *Gony. jurassica jurassica longicornuta* |
| ... | 0.6 | ... | ... | ... | ... | ... | 0.8 | ... | *Gonyaulacysta* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | *Kalyptea stegasta* |
| ... | ?2.6 | ... | ... | ... | ... | ... | ... | ... | *Korystocysta gochtii* |
| ... | ... | ... | 0.4 | 0.8 | ... | ... | ... | ... | *Liesbergia liesbergensis* |
| ... | ... | ... | 0.4 | ... | ... | ... | ... | 0.2 | *Leptodinium mirabile* |
| ... | 1.3 | ... | 1.8 | 1.3 | 1.7 | 0.9 | 0.8 | 0.2 | *Leptodinium subtile* |
| 14.4 | ?2.6 | ... | ... | ... | ... | ... | ... | ... | *Lithodinia caytonensis* |
| ... | ... | ... | 2.7 | 1.1 | 8 | 2.5 | 3.1 | ... | *Lithodinia* sp. A |
| ... | ... | 1.6 | ... | 0.8 | ... | ... | ... | ... | *Lithodinia* spp. |
| 2.9 | 2 | ?1.6 | ... | ... | ... | ... | 0.8 | ... | *Mendicodinium groenlandicum* |
| 34.7 | 17.7 | 4.8 | 1.3 | 0.8 | 2.3 | 1.7 | 1.5 | 0.3 | *Nannoceratopsis pellucida* |
| ... | ... | ... | ... | ... | ... | ... | 0.8 | 2.5 | *Paragonyaulacysta* spp. |
| ... | ... | 1.6 | ... | 0.8 | ... | ... | ... | 0.1 | *Pareodinia ceratophora* |
| ... | ... | ... | 0.9 | ... | 0.6 | 0.4 | ... | ... | *Prolixosphaeridium parvispinum* |
| ... | 1.3 | ... | 2.7 | 1.1 | 0.6 | 1.3 | 1.5 | ... | *Rhynchodiniopsis cladophora* |
| ... | ... | ... | ... | ... | 0.6 | ... | ... | ... | *Rigaudella aemula* |
| ?1.5 | ... | 1.6 | 1.3 | 0.5 | 0.6 | 1.3 | ... | 0.1 | *Scriniodinium crystallinum* |
| ... | ... | ... | 2.7 | 2.4 | 2.3 | ... | ... | ... | *Sentusidinium creberbarbatum* |
| ... | 2 | ... | ... | 1.1 | ... | ... | ... | ... | *Sentusidinium* spp. |
| ... | ... | ... | 0.9 | 0.3 | 0.6 | 0.9 | ... | ... | *Sirmiodiniopsis orbis* |
| 2.9 | 3.3 | 4.8 | 1.8 | 7.7 | 5.1 | 11.9 | 0.8 | 0.3 | *Sirmiodinium grossii* |
| ... | ... | ... | ... | 1.1 | ... | 0.4 | ... | 1.7 | *Stephanelytron caytonense* |
| ... | ... | 6.5 | 1.8 | 6.3 | 1.1 | 2.1 | 1.5 | 1.2 | *Stephanelytron redcliffense* |
| ... | ... | ... | 0.4 | 9.5 | 0.6 | 0.9 | 3.8 | 0.8 | *Stephanelytron scarburghense* |
| ... | ... | ... | 2.2 | ... | 5.7 | 3.4 | ... | ... | *Trichodinium scarburghensis* |
| ... | 1.3 | ... | 2.2 | ... | ... | ... | ... | ... | *Tubutuberella dangeardii* |
| ... | ... | ... | 0.9 | ... | ... | ... | ... | ... | *Tubotuberella rhombiformis* |
| 14 | 22 | 18 | 34 | 30 | 27 | 30 | 23 | 27 | Dinoflagellate cyst diversity |
| 69 | 153 | 62 | 226 | 378 | 175 | 238 | 130 | 1158 | Number of dino. cysts per slide |

Text-Figure A3.14. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Oxfordian strata of section 1, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| **RP 37** | **RP 36** | **RP 35** | **RP 34** | **RP 33** | **Sample Number** |
|---|---|---|---|---|---|
| **VAF 708** | **VAF 707** | **VAF 713** | **VAF 714** | **VAF 715** | **Collector's Number** |
| **M. Oxfordian** | **M. Oxfordian** | **U. Oxfordian** | **U. Oxfordian** | **U. Oxfordian** | **Substage** |
| **Tenuiserratum** | **Tenuiserratum** | **Alternoides** | **Serratum** | **Ravni** | **Ammonite Zone** |
| | | | | | |
| | | | | | **Dinoflagellate cysts:** |
| ?0.2 | ... | ... | 4.8 | 9.1 | *Ambonosphaera? staffinensis* |
| 0.2 | ... | ... | ... | ... | *Atopodinium* sp. |
| ... | ... | ... | 14.5 | ... | *Batiacasphaera* spp. |
| ... | ... | ... | ... | 4.5 | *Chlamydophorella* spp. |
| 0.2 | ... | ... | ... | ... | Chorate dinoflagellate cysts - indet. |
| 4.3 | 1.5 | ... | ... | ... | *Chytroeisphaeridia cerastes* |
| 14.4 | 17.5 | 17.1 | 50.3 | 77.4 | *Chytroeisphaeridia chytroeides* |
| ... | ... | ... | ?6.4 | ... | *Chytroeisphaeridia hyalina* |
| 0.5 | ... | ... | ... | ... | *Clathroctenocystis asapha* |
| ... | ... | 1.1 | 6.4 | ... | *Cribroperidinium globatum* |
| 12.1 | ... | ... | ... | 4.5 | *Crussolia deflandrei* |
| 0.4 | ... | ... | ... | ... | *Crussolia perireticulata* |
| 0.4 | 1.5 | ... | ... | ... | *Crussolia* sp. |
| ... | ?0.5 | ... | ... | ... | *Ctenidodinium* sp. |
| 1.1 | 2.5 | ... | ... | ... | *Dingodinium* spp. |
| 0.2 | ... | ... | ... | ... | Dinoflagellate cysts - indeterminate |
| 13.2 | 51 | 35.2 | 3.2 | ?4.5 | *Endoscrinium galeritum* |
| 8.7 | 2 | 39.8 | ... | ... | *Endoscrinium galeritum reticulatum* |
| ... | 0.5 | ... | ... | ... | *Fromea tornatilis* |
| ... | 3.5 | ... | ... | ... | Gonyaulacacean dino. cysts - indet. |
| ... | 2 | 3.4 | ... | ... | *Gonyaulacysta dualis* |
| 0.5 | 3 | ... | ... | ... | *Gonyaulacysta eisenackii* |
| ... | 1 | ... | ... | ... | *Gonyaulacysta jurassica adecta* |
| 0.4 | 1 | ... | ... | ... | *Gony. jurassica adecta longicornis* |
| ... | 1 | ... | ... | ... | *Gony. jurassica jurassica longicornuta* |
| ?0.2 | ... | ... | ... | ... | *Gonyaulacysta* spp. |
| ... | ... | ... | 4.8 | ... | *Leptodinium subtile* |
| 26.5 | ... | ... | ... | ... | *Lithodinia* sp. A |
| 0.2 | ... | ... | ... | ... | *Lithodinia* spp. |
| ... | ... | ... | ?3.2 | ... | *Mendicodinium groenlandicum* |
| ... | 2 | ... | ... | ... | *Paragonyaulacysta* sp. |
| 1.1 | ?0.5 | ?2.3 | ... | ... | *Rhynchodiniopsis cladophora* |
| ?0.7 | ... | ... | ... | ... | *Rigaudella aemula* |
| 0.5 | ... | 1.1 | 3.2 | ... | *Scriniodinium crystallinum* |
| ... | ... | ... | ?1.6 | ... | *Scriniodinium inritibile* |
| ... | 1.5 | .. | ... | ... | *Sentusidinium creberbarbatum* |
| 2.7 | ... | ... | ... | ... | *Sirmiodiniopsis orbis* |
| 8.8 | ... | ... | ... | ... | *Sirmiodinium grossii* |
| 0.7 | 2.5 | ... | ... | ... | *Stephanelytron caytonense* |
| 1.3 | 3.5 | ... | ... | ... | *Stephanelytron redcliffense* |
| ... | 1.5 | ... | ... | ... | *Stephanelytron scarburghense* |
| ... | ... | ... | 1.6 | ... | *Systematophora penicillata* |
| 0.5 | ... | ... | ... | ... | *Valensiella* sp. |
| | | | | | |
| **26** | **20** | **7** | **11** | **5** | **Dinoflagellate cyst diversity** |
| **554** | **204** | **88** | **62** | **22** | **Total dino. cyst specimens per slide** |

Text-Figure A3.15. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts in the Lower Kimmeridgian strata of section 3/4, River Unzha, near Kostroma, central Russian Platform (locality 3 of Text-Figure 5). The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| **RP 46** | **RP 45** | **RP 44** | **RP 43** | **RP 42** | **RP 41** | **RP 40** | **RP 39** | **RP 38** | **Sample Number** |
|---|---|---|---|---|---|---|---|---|---|
| **VAF 737** | **VAF 739** | **VAF 740** | **VAF 741** | **VAF 751** | **VAF 752** | **VAF 742** | **VAF 753** | **VAF 754** | **Collector's Number** |
| L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | L. Kimm. | **Substage** |
| **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Amoe./Pror.** | **Ammonite Zone** |
| | | | | | | | | | |
| | | | | | | | | | **Dinoflagellate cysts:** |
| ... | ... | ... | ... | 0.6 | ... | ... | ... | ... | *Aldorfia dictyota* subsp. *pyrum* |
| ... | ... | ... | 1.7 | ... | ... | ... | ... | ... | *Aptedinium* spp. |
| ... | 2.1 | 4.5 | 0.6 | 2.6 | 2.5 | ... | 13.9 | ... | *Batiacasphaera* spp. |
| ... | ... | 0.6 | 1.1 | ... | ... | ... | 0.4 | 2.5 | *Chlamydophorella* spp. |
| ... | 0.7 | ... | ... | ... | ... | ... | ... | ... | Chorate dinoflagellate cysts - indeterminate |
| 63.4 | 26.7 | 17.5 | 9.8 | 12.4 | 10.6 | 8.7 | 2 | 1.9 | *Chytroeisphaeridia chytroeides* |
| 14.3 | 24.5 | 18.2 | 69.4 | 49.8 | 57.8 | 7.5 | 11.1 | 37 | *Cribroperidinium globatum* |
| ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | *Cribroperidinium longicorne* |
| 2 | 12.2 | 6.5 | 0.6 | 16.3 | 7.4 | 21.5 | 3.9 | ... | *Dingodinium* spp. |
| ... | 1.4 | 0.6 | ... | ... | ... | ... | ... | ... | Dinoflagellate cysts - indeterminate |
| ... | ... | 0.6 | ... | ... | 0.1 | ... | ... | ... | *Fromea amphora* |
| 2 | 0.7 | 0.6 | ... | ... | 0.1 | ... | 0.2 | ... | Gonyalacacean dinoflagellate cysts - indet. |
| ... | 0.7 | ... | ... | 4.6 | 0.6 | ... | ... | 0.1 | *Gonyaulacysta jurassica* subsp. *jurassica* |
| ... | ... | ... | ... | ... | ... | 34.4 | ... | ... | *Gonyaulacysta* sp. (small) |
| ... | ... | ... | ... | ... | ... | 5.2 | ... | ... | *Gonyaulacysta* spp. |
| ... | ... | ... | ... | ... | 0.3 | ... | ... | ... | *Leptodinium mirabile* |
| ... | 10.8 | 15.5 | 12.1 | 7.8 | 4.5 | 1.2 | 1.6 | 2.2 | *Leptodinium subtile* |
| ... | 4.3 | 5.8 | 2.9 | ... | ... | ... | 3.9 | 2.5 | *Lithodinia* sp. A |
| ... | ... | ... | 0.6 | 1.3 | 0.4 | ... | ... | .. | *Pareodinia ceratophora* |
| ... | ... | 1.3 | ... | ... | ... | ... | ... | ... | *Pareodinia* sp. |
| ... | 5.1 | ... | 0.6 | ... | 1.6 | ... | 1.1 | 6 | *Rhynchodiniopsis cladophora* |
| ... | ... | 0.6 | ... | ... | ... | ... | ... | ... | *Scriniodinium crystallinum* |
| ... | ... | ... | ... | ... | ... | 2.3 | ... | ... | *Sentusidinium creberbarbatum* |
| ... | 10.1 | 7.7 | ... | ... | 1.9 | 4.1 | 61.7 | 47.6 | *Sentusidinium* sp. (verrucate) |
| 16.3 | ... | 5.2 | 0.6 | ... | 7.4 | 4.1 | ... | ... | *Sentusidinium* spp. |
| ... | ... | ... | ... | ... | ... | 0.6 | ... | ... | *Stephanelytron caytonense* |
| ... | ... | 12.3 | ... | 4.6 | 4.3 | 8.7 | 0.2 | 0.2 | *Stephanelytron scarburghense* |
| 2 | ... | 0.6 | ... | ... | 0.4 | ... | ... | ... | *Systematophora areolata* |
| ... | ... | 1.9 | ... | ... | ... | 1.7 | ... | ... | *Tubotuberella rhombiformis* |
| ... | 0.7 | ... | ... | ... | ... | ... | ... | ... | *Wallodinium krutzschii* |
| | | | | | | | | | |
| **6** | **13** | **17** | **11** | **9** | **16** | **12** | **11** | **9** | **Dinoflagellate cyst diversity** |
| **49** | **139** | **155** | **174** | **153** | **671** | **172** | **440** | **783** | **No. of dino. cyst specimens per slide** |

Text-Figure A3.16. Spreadsheet diagram illustrating the stratigraphic distribution of the dinoflagellate cysts *Acanthaulax* sp. to *Hystrichodinium pulchrum* (ordered alphabetically) in the Kimmeridgian and Volgian strata of Gorodische, central Russian Platform (locality 4 of Text-Figure 5). Sample RP 48 proved barren of dinoflagellate cysts, and is not illustrated here. The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 47 | **Sample Number (RP)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | L.V. | L.V. | L.V. | L.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | U.V. | **Substage** |
| Eud. | Eud. | Eud. | Aut. | Aut. | Aut. | Aut. | Aut. | Kli. | Kli. | Kli. | Kli. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Vir. | Vir. | Nik. | Nod. | **Ammonite Zone** |
| | | | | | ?Fa. | Fal. | Fal. | | | | | Pav. | | Zar. | Zar. | Zar. | Zar. | Zar. | | | | | **Ammonite Subzone** |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | *Acanthaulax* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *A. dictyota* |
| ?0.2 | ... | ... | ... | 0.1 | ... | ... | ... | ?0.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *A? staffinensis* |
| ... | 3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Apteodinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *A. haromense* |
| ... | ... | 1.3 | 2 | ... | ... | 4.2 | ... | 3.3 | 5.3 | ... | ... | ... | 2.3 | ... | 5.3 | ... | 1.3 | ... | ... | ... | ... | ... | *Batiacasphaera* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | 0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Cassiculosphaeridia* spp. |
| 1.5 | 8.1 | ... | ... | 1.2 | ... | ... | ... | ... | 10.4 | ... | ... | 0.5 | ... | ... | ... | ... | ... | ... | ... | 0.4 | 0.5 | ... | *Chlamydophorella* spp. |
| 1.8 | 1 | 3.1 | ... | 0.5 | ... | 0.7 | ... | 0.6 | ... | ... | ... | 0.2 | 0.6 | ... | 4.3 | 10.1 | 4.3 | 30.8 | 34.5 | 31.1 | 34.1 | 24.5 | Chorate dino. cysts - indet. |
| 15.8 | 7.1 | 3.2 | 2 | 19.3 | R | 3.9 | ... | 8.5 | 24.5 | ... | 12.4 | 0.5 | 1.8 | ... | 1.8 | 3.4 | 0.9 | ... | ... | 0.8 | ... | ... | *C. chytroeides* |
| ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | 3.2 | 0.9 | ... | ... | ... | ... | ... | ... | 17.2 | 22.5 | ?0.9 | ... | *C. distinctum* |
| 1.2 | ... | 0.5 | ... | 0.1 | ... | 1 | ... | 1.2 | 0.2 | ... | 1.8 | 0.7 | 1 | ... | 0.5 | ... | 0.4 | ... | ... | ... | 0.9 | ... | *Cleistosphaeridium* spp. |
| 50.6 | 33.3 | 33.9 | 34.8 | 3.7 | R | 4.6 | 0.9 | 5.4 | 2.1 | R | 10 | 10.9 | 1.5 | 26.7 | 32 | 6.4 | 26.5 | 7.7 | ... | 16.8 | 39.9 | 19.4 | *C. globatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *C. longicorne* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 17.3 | *Cribroperidinium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | ... | ?0.3 | ... | ... | *C. chondrum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | *D? pannea* |
| ... | ... | ... | ... | ... | ... | ... | ... | 22.1 | 8.7 | ... | 12.9 | ... | 3.1 | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | *D. jurassicum* |
| 11.8 | ... | 23 | ... | 37.2 | ... | 8.1 | ... | 9.5 | 4.3 | ... | 6.3 | ... | 1.2 | ... | 3.5 | 5.7 | 4.3 | 5.1 | ... | 1.2 | ... | ... | *D. tuberosum* |
| ... | 28.3 | ... | 52.2 | 26.3 | R | 8.8 | 97.6 | 2.3 | ... | ... | ... | 76 | ... | 46.7 | ... | ... | ... | ... | ... | 0.1 | 1.9 | ... | *Dingodinium* spp. |
| 2.6 | 13.1 | 11 | ... | 0.7 | ... | ... | ... | 0.2 | ... | R | ... | 1.6 | ... | 20 | 1.8 | 1.1 | ... | 25.6 | 37.9 | 2.4 | 0.5 | ... | Dinofigellate cysts - indet. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Dissiliodinium sp.* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1 | *E. torynum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.3 | ... | ... | *E. ovatum* |
| ... | ... | ... | ... | ... | ... | ... | ... | 9.7 | 11.2 | ... | ... | ... | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | *Ellipsoidictyum* sp. |
| ?0.6 | ... | 2.6 | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | ... | ?0.3 | ... | 0.9 | ... | ... | 0.3 | ... | ... | *E. anceps* |
| 0.8 | ... | ... | ... | 0.1 | ... | ... | ... | ... | 0.1 | ... | ... | ... | 0.9 | ... | 1.5 | ... | ... | ... | ... | 0.8 | ... | ... | *Endoscrinium* spp. |
| 0.6 | ... | 2.7 | ... | 0.9 | ... | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 1.7 | 3.1 | ... | ... | ... | ... | ... | *Epiplosphaera* spp. |
| ?0.2 | ... | ?0.2 | 1 | ... | ... | 1.7 | ... | 0.2 | 0.1 | ... | 0.3 | ... | 0.8 | ... | 1 | ... | 0.2 | ?2.6 | ... | ... | ... | ... | *G. dimorphum* |
| ... | ... | ?0.3 | ... | ?0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *G. helicoidea* |
| 4.4 | 5.1 | 2.6 | 2 | 0.8 | ... | 1.9 | ... | 1.6 | 2 | ... | 2.1 | 6 | 6.1 | 6.6 | ... | 0.7 | 1.1 | ... | ... | 0.6 | 9.5 | ... | *Gonyaulacysta* spp. |
| 0.5 | ... | 0.5 | ... | 0.1 | ... | ... | ... | 1.6 | 0.1 | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | *Heslertonia* spp. |
| ... | ... | 0.5 | ... | 0.4 | ... | 1.2 | ... | 1.4 | 0.8 | ... | 5 | ... | 72.8 | ... | 18.5 | ... | 2.7 | ... | ... | ... | ... | ... | *H. pulchrum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *H. orbifera* |
| **24** | **9** | **29** | **11** | **27** | **5** | **22** | **5** | **28** | **28** | **2** | **25** | **14** | **25** | **4** | **24** | **17** | **26** | **10** | **4** | **25** | **15** | **7** | **Dino. cyst diversity** |
| **664** | **99** | **617** | **98** | **839** | **5** | **409** | **220** | **484** | **1324** | **2** | **379** | **432** | **1842** | **15** | **395** | **297** | **555** | **39** | **29** | **1568** | **211** | **98** | **Dino. cysts per slide** |

Text-Figure A3.17. Spreadsheet diagram illustrating the stratigraphic distribution of the dinoflagellate cysts *Hystrichosphaerina orbifera* to *Wallodinium krutzschii* (ordered alphabetically) in the Kimmeridgian and Volgian strata of Gorodische, central Russian Platform (locality 4 of Text-Figure 5). Sample RP 48 proved barren of dinoflagellate cysts, and is not illustrated here. The numbers represent percentages of the dinoflagellate cyst taxa within the overall assemblage. Three dots (...) indicate that the respective taxon is absent.

| 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 47 | **Sample Number (RP)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | L.V. | L.V. | L.V. | L.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | U.V. | **Substage** |
| Eud. | Eud. | Eud. | Aut. | Aut. | Aut. | Aut. | Aut. | Kli. | Kli. | Kli. | Kli. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Vir. | Vir. | Nik. | Nod. | **Ammonite Zone** |
| | | | | | ?Fa. | Fal. | Fal. | | | | | Pav. | | Zar. | Zar. | Zar. | Zar. | Zar. | | | | | **Ammonite Subzone** |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.4 | ... | ... | *Imbatodinium* sp. A |
| ... | ... | ... | ... | ... | ... | ... | ... | 1 | ... | ... | 0.8 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *K. stegasta* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.1 | ... | 4.1 | 2.4 | 4.7 | ... | ... | 0.8 | ... | ... | *K. porosispinum* |
| ... | ... | ... | ... | 0.7 | ... | 1.5 | ... | 6.6 | 3.2 | ... | 2.1 | ... | 0.9 | ... | 4.1 | 2.7 | 1.8 | 2.6 | ... | ?0.1 | ... | ... | *L. subtile* |
| ... | ... | ?0.2 | ... | ... | ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | *Leptodinium* spp. |
| ... | ... | ... | ... | ... | ... | ?0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *M. groenlandicum* |
| ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | ... | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *O. balios* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | 0.8 | ... | ... | ... | 0.5 | 4 | 29.3 | ... | ... | 0.3 | ?0.9 | ?3.1 | *O. patulum* |
| 0.2 | ... | 0.2 | 1 | 0.5 | ... | 1.2 | ... | 1.4 | 0.5 | ... | 1.3 | ... | 0.2 | ... | 2.3 | 2.4 | 2.2 | ... | ... | ... | ... | ... | *P. ceratophora* |
| 0.2 | ... | ... | ... | 1.4 | ... | 7.1 | ... | 0.8 | 0.5 | ... | 2.9 | ... | 1.9 | ... | 1.3 | ... | 0.7 | ... | ... | ... | ... | ... | *P. halosa* |
| 0.3 | ... | 0.2 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Paragonyaulacysta* sp. |
| ?0.8 | ... | ?0.3 | ... | ... | ... | ... | ... | ... | ... | ... | 1.3 | ... | ... | ... | ... | ?0.3 | ... | ... | ... | ... | 3.3 | ... | *P. pannosum* |
| 0.3 | ... | 1.6 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P. mixtispinosum* |
| ... | ... | 2.4 | ... | 1 | ... | 1.7 | 0.5 | 4.5 | 1.1 | ... | ... | 1.2 | 0.5 | ... | 1 | ?0.3 | ... | ... | ... | ?0.1 | 1.9 | ... | *P. parvispinum* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *P. westburiensis* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 3.4 | ... | ... | ... | ... | ... | *R. martonense* |
| ... | 1 | ... | 1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.7 | ... | ... | ... | ... | ... | *?S. crystallinum* |
| ... | ... | ... | ... | ... | ... | ... | ... | 1.6 | 0.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S. inritibile* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.3 | ... | ... | ... | ... | ?0.3 | 0.2 | ... | ... | 0.3 | 3.3 | 29.6 | *S. jurassica* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.2 | ... | 4.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S. creberbarbatum* |
| 3.5 | ... | 3.7 | 2 | 1.9 | ... | 4.6 | ... | 3.1 | 6 | ... | 5 | ... | ... | ... | ... | ... | ... | 5.1 | 10.4 | 13.3 | ... | ... | *Sentusidinium* spp. |
| 0.8 | ... | 1.1 | ... | 0.4 | ... | ... | ... | 0.6 | 0.7 | ... | ... | ... | 0.3 | ... | 1.3 | 0.3 | 0.5 | 5.1 | ... | 1.2 | ... | ... | *S. grossii* |
| ... | ... | ... | ... | ?0.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ?0.3 | ... | ?0.2 | ... | ... | ... | ... | ... | *Spiniferites* spp. |
| ... | ... | ... | ... | 0.7 | ... | 16.6 | ... | 8.1 | 15.3 | ... | 21.7 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S? inaffecta* |
| ... | ... | ... | ... | ... | R | 20.4 | ... | 2.1 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S? paeminosa* |
| ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | 7.1 | 0.2 | ... | ... | ... | ... | ... | *S. areolata* |
| ... | ... | 1 | ... | 0.1 | ... | 8.1 | ... | 0.8 | ... | ... | ... | ... | 1.7 | ... | 9.4 | 51.1 | 9.5 | 12.8 | ... | 2.4 | ... | ... | *S. daveyi* |
| ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *S. penicillata* |
| 0.2 | ... | 1.8 | ... | 0.2 | ... | ... | ... | ... | ... | ... | 2.6 | ... | ... | ... | 4.3 | ... | ... | ... | ... | ... | 0.5 | ... | *Systematophora* spp. |
| ... | ... | 0.5 | ... | ... | ... | ... | ... | ... | ... | ... | ... | 0.5 | ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | *T. apatela* |
| ... | ... | 0.3 | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *T. dangeardii* |
| 1.1 | ... | 1 | 1 | 1.2 | R | ... | 0.5 | 1 | 1.1 | ... | 1.3 | 0.7 | 0.9 | ... | ... | ... | 0.5 | ... | ... | 2.2 | 1.4 | 5.1 | *T. rhombiformis* |
| ... | ... | ... | ... | 0.2 | ... | 1.2 | ... | ... | ... | ... | ... | ... | 0.4 | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Valensiella* spp. |
| ... | ... | ... | ?1 | ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | ... | | ... | ... | ... | 2.6 | ... | ... | 0.5 | ... | *W. krutzschii* |
| **24** | **9** | **29** | **11** | **27** | **5** | **22** | **5** | **28** | **28** | **2** | **25** | **14** | **25** | **4** | **24** | **17** | **26** | **10** | **4** | **25** | **15** | **7** | **Dino. cyst diversity** |
| **664** | **99** | **617** | **98** | **839** | **5** | **409** | **220** | **484** | **1324** | **2** | **379** | **432** | **1842** | **15** | **395** | **297** | **555** | **39** | **29** | **1568** | **211** | **98** | **Dino. cysts per slide** |

Text-Figure A3.18. Spreadsheet diagram illustrating the semi-quantitative stratigraphic distribution of miscellaneous microplankton and miospores in the Kimmeridgian and Volgian strata of Gorodische, central Russian Platform (locality 4 of Text-Figure 5). The key is as used in Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| 70 | 69 | 68 | 67 | 66 | 65 | 64 | 63 | 62 | 61 | 60 | 59 | 58 | 57 | 56 | 55 | 54 | 53 | 52 | 51 | 50 | 49 | 48 | 47 | Sample Number (RP) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | U.K. | L.V. | L.V. | L.V. | L.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | M.V. | U.V. | U.V. | Substage |
| Eud. | Eud. | Eud. | Aut. | Aut. | Aut. | Aut. | Aut. | Kli. | Kli. | Kli. | Kli. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Pan. | Vir. | Vir. | Nik. | Ful. | Nod. | Ammonite Zone |
| | | | | | ?Fa. | Fal. | Fal. | | | | | Pav. | | Zar. | Zar. | Zar. | Zar. | Zar. | | | | | | Ammonite Subzone |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | **Miscellaneous microplankton:** |
| ... | ... | ... | P | ... | ... | ... | ... | ... | ... | | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | P | P | *Botryococcus braunii* |
| ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Cymatiosphaera* spp. |
| P | ... | P | P | P | P | P | ... | P | P | ... | P | ... | P | ... | P | P | P | ... | ... | ... | ... | ... | ... | Foraminiferal test linings |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | C | *Lancettopsis lanceolata* |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | *Micrhystridium* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | Scolecodonts |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | P | ... | ... | ... | P | ... | ... | P | P | ... | Ab | C/Ab | *Pterospermella* spp. |
| P | P | P | ... | P | ... | ... | P | P | P | P | ... | P | ... | P | ... | ... | ... | ... | P | ... | P | Ab | C/Ab | *Tasmanites* spp. |
| | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | **Miospores:** |
| P | P | P | P | P | ... | P | P | P | P | ... | P | P | P | P | P | P | P | P | P | P | P | P | P | Bisaccate pollen - undifferentiated |
| ... | ... | ... | ... | ... | ... | ... | ?P | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Callialasporites* spp. |
| ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | Carboniferous spores (R/W) |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Cerebropollenites macroverrucosus* |
| ... | P | P | ... | P | ... | ... | ... | ... | P | ... | ... | P | ... | ... | ... | ... | ... | P | ?P | ... | ... | ... | ... | *Classopollis classoides* |
| P | P | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | P | ... | P | ... | ... | ... | ... | ... | *Cyathidites* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Dictyophyllidites* sp. |
| ... | ... | P | P | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | P | ... | P | *Gleicheniidites senonicus* |
| P | ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | *Perinopollenites elatoides* |
| ... | ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Retitriletes* spp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | ... | ... | P | ... | ... | ... | ... | Spores - indeterminate |
| ... | P | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | *Vitreisporites pallidus* |

Text-Figure A3.19. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts and selected miscellaneous microplankton in the Volgian and Ryazanian strata of Kashpir, central Russian Platform (locality 5 of Text-Figure 5). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the selected miscellaneous palynomorphs; the key is as for Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| RP 79 | RP 78 | RP 77 | RP 76 | RP 75 | RP 74 | RP 73 | RP 72 | RP 71 | Sample Number |
|---|---|---|---|---|---|---|---|---|---|
| M. Volgian | M.Volgian | M. Volgian | M. Volgian | M. Volgian | M. Volgian | U. Volgian | U. Volgian | Ryazanian | Stage/Substage |
| Panderi | Panderi | Panderi | Panderi | Panderi | Nikitini | Fulgens | Subditus | | Ammonite Zone |
| ... | ... | ... | ... | ... | ... | ... | ... | 1.2 | *Acanthaulax* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ?1.2 | *Achomosphaera* sp. |
| ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | *Batiacasphaera* spp. |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | *Bourkodinium* sp. |
| ... | ... | ... | ... | ... | ... | ... | ... | ?2.4 | *Cassiculosphaeridia* spp. |
| ... | ... | ... | ... | ... | 1.6 | 4.2 | 12.8 | 3.6 | *Chlamydophorella* spp. |
| 5.5 | 33.34 | 2.7 | 14.6 | ... | 2.3 | 10.3 | 2.4 | 7.3 | Chorate dinoflagellate cysts - indeterminate |
| 4 | ... | 1.8 | ... | ... | 0.2 | 4.2 | ... | ... | *Chytroeisphaeridia chytroeides* |
| ... | ... | ... | ... | ... | ... | ... | 0.5 | 22 | *Circulodinium distinctum* |
| 33.3 | ... | 31.5 | 54.9 | 20 | 85.1 | 68.7 | 65.3 | 47.7 | *Cribroperidinium* spp. |
| 44.4 | ... | 51.4 | 21.9 | 20 | ... | ... | ... | ... | *Dingodinium* spp. |
| 0.8 | 66.66 | 0.9 | 0.4 | 60 | 0.4 | ... | ... | 8.6 | Dinoflagellate cysts - indeterminate |
| 1.6 | ... | ... | ... | ... | ... | ... | ... | ... | *Egmontodinium* sp. |
| 2.4 | ... | ... | ... | ... | ... | ... | ?0.5 | ... | *Endoscrinium* spp. |
| | ... | ... | ... | ... | ... | ... | ... | 3.6 | *Gonyaulacysta* cf. *helicoidea* |
| 4.8 | ... | 6.3 | 2 | ... | 2.8 | 6.3 | 3.3 | ... | *Gonyaulacysta* spp. |
| | ... | 0.9 | ... | ... | ... | ... | ... | ... | *Imbatodinium* sp. A |
| | ... | ... | 0.8 | ... | 0.2 | ... | ... | 1.2 | *Kleithriasphaeridium* spp. |
| 0.8 | ... | 3.6 | 2.2 | ... | ... | ... | ... | ... | *Leptodinium subtile* |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | *Occisucysta balios* |
| ... | ... | 0.9 | 1.4 | ... | ... | ... | ... | ... | *Oligosphaeridium patulum* |
| ... | ... | ... | ?0.2 | ... | ... | ... | ... | ... | *Scriniodinium inritibile* |
| ... | ... | ... | ... | ... | 6.6 | 4.2 | 8.1 | ... | *Senoniasphaera jurassica* |
| ... | ... | ... | ... | ... | ... | ... | 7.1 | ... | *Sentusidinium* spp. |
| ... | ... | ... | ?0.2 | ... | ... | ... | ... | ... | *Sirmiodinium grossii* |
| ... | ... | ... | ... | ... | 0.2 | ... | ... | ... | *Systematophora daveyi* |
| ... | ... | ... | 0.6 | ... | ... | ... | ... | ... | *Systematophora* spp. |
| 0.8 | ... | ... | 0.2 | ... | 0.2 | ... | ... | ... | *Tubotuberella apatela* |
| 0.8 | ... | ... | ... | ... | ... | 2.1 | ... | ... | *Tubotuberella rhombiformis* |
| ... | ... | ... | 0.2 | ... | ... | ... | ... | ... | *Tubotuberella* spp. |
| 0.8 | ... | ... | ... | ... | 0.2 | ... | ... | 1.2 | *Wallodinium krutzschii* |
| 12 | 2 | 9 | 15 | 3 | 12 | 7 | 8 | 11 | **Dinoflagellate cyst diversity** |
| 126 | 3 | 111 | 498 | 5 | 437 | 48 | 211 | 82 | **Number of dinoflagellate cysts per slide** |
| ... | P | ... | ... | P | ... | ... | ... | ... | *Cymatiosphaera* spp. |
| P | ... | P | ... | ... | ... | ... | P | P | *Micrhystridium* spp. |
| P | P | P | P | P | P | P | P | P | *Pterospermella* spp. |
| P | Ab | C | P | Ab | C | P | P | P | *Tasmanites* spp. |

Text-Figure A3.20. Spreadsheet diagram illustrating the stratigraphic distribution of dinoflagellate cysts, miscellaneous microplankton and selected miospores in the Upper Volgian and Ryazanian strata of outcrops 6, 12 and 13 in the River Oka Basin, central Russian Platform (localities 6 and 7 of Text-Figure 5). The numbers in the dinoflagellate cyst section represent percentages of the dinoflagellate cyst taxa within the overall assemblage. A semi-quantitative method is used for the other palynomorph groups; the key is as used in Text-Figure A3.1. Three dots (...) indicate that the respective taxon is absent.

| RP 82 | RP 81 | RP 80 | RP 84 | RP 83 | RP 85 | Sample number |
|---|---|---|---|---|---|---|
| 8999 | 8997 | 8996 | 8994 | 9000 | 7600 | Collector's Number (VAF) |
| O.crop 12 | O.crop 12 | O.crop 12 | O.crop 13 | O.crop 13 | R. Black | Locality |
| U. Volg. | Ryaz. | Ryaz. | U. Volg. | Ryaz. | Ryaz. | Stage/Substage |
| Subdit. | Rja./Spa. | Rja./Spa. | Subdit. | Rja./Koc. | Rja./Spa. | Ammonite Zone |
| | | | | | | |
| | | | | | | **Dinoflagellate cysts:** |
| ... | ... | 1.6 | ... | 9.1 | ... | *Acanthaulax* spp. |
| 0.9 | 1.8 | 0.8 | ... | ... | ... | *Ambonosphaera? staffinensis* |
| ... | ... | ... | 10 | ... | ... | *Batiacasphaera* spp. |
| 7.8 | ... | 3.1 | ... | ... | 3.7 | *Cassiculosphaeridia* spp. |
| 6.9 | 17.7 | 13.1 | 10 | 18.2 | 17.9 | *Chlamydophorella* spp. |
| 2.2 | 23.1 | 13.9 | 6.7 | ... | 1.5 | Chorate dinoflagellate cysts - indeterminate |
| ... | ... | ... | ... | ... | ?1.5 | *Chytroeisphaeridia* sp. |
| ... | ... | ... | 10 | ... | 2.2 | *Circulodinium compta* |
| 2.2 | 1.8 | 9.3 | ... | 18.2 | 2.2 | *Circulodinium distinctum* |
| 3 | ... | 1.6 | ... | ... | 2.9 | *Circulodinium* spp. |
| 0.9 | ... | ... | ... | ... | ... | *Cribroperidinium gigas* |
| 26.4 | 34.3 | 37.1 | 16.7 | 36.3 | 14.1 | *Cribroperidinium* spp. |
| ... | 1.2 | 1.6 | ... | ... | ... | *Dingodinium albertii* |
| ... | 2.9 | ... | ... | ... | 3.7 | *Dingodinium* spp. |
| 0.9 | 0.6 | 0.8 | 3.3 | ... | 16.4 | Dinoflagellate cysts - indeterminate |
| ... | ... | ... | 3.3 | ... | ... | *Egmontodinium* sp. |
| ... | ... | ... | ... | 9.1 | ... | *Endoscrinium anceps* |
| 0.5 | 0.6 | ... | ... | ... | ... | *Gochteodinia villosa* |
| 1.3 | 5.9 | 8.5 | ?3.3 | ?9.1 | 6.6 | *Gonyaulacysta* spp. |
| 0.9 | ... | ... | ... | ... | 12.7 | Gonyaulacacean dino. cysts - indeterminate |
| ... | ... | 0.8 | ... | ... | ... | *Leptodinium* sp. |
| ... | 4.7 | 3.9 | ... | ... | 2.2 | *Muderongia simplex* |
| ... | 0.6 | ... | ... | ... | ... | *Pareodinia* sp. |
| ... | ... | ... | ... | ... | 2.2 | *Phoberocysta neocomica* |
| 0.5 | ... | ... | ... | ... | ... | *Scriniodinium* sp. |
| 42.1 | ... | ... | ?23.4 | ... | ... | *Senoniasphaera jurassica* |
| 0.5 | 1.8 | ... | ... | ... | ... | *Sirmiodinium grossii* |
| ... | 0.6 | ... | ... | ... | ... | *Stiphrosphaeridium dictyophorum* |
| ... | 1.2 | ... | ... | ... | ... | *Systematophora* sp. |
| ... | ... | ... | ... | ... | 0.7 | *Tubotuberella apatela* |
| 1.3 | ?1.2 | ... | ... | ... | ... | *Tubotuberella rhombiformis* |
| ... | ... | ?0.8 | ... | ... | 0.7 | *Wallodinium cylindricum* |
| 1.7 | ... | 3.1 | 13.3 | ... | 8.8 | *Wallodinium krutzschii* |
| | | | | | | |
| **17** | **16** | **15** | **10** | **6** | **17** | **Dinoflagellate cyst diversity** |
| **116** | **169** | **129** | **30** | **11** | **135** | **Number of dinoflagellate cysts per slide** |
| | | | | | | |
| | | | | | | **Miscellaneous microplankton:** |
| | | | | | | |
| C | ... | P | R | P | P | *Botryococcus braunii* |
| ... | P | ... | ... | R | ... | *Cymatiosphaera* spp. |
| ... | C | ... | ... | P | ... | Foraminiferal test linings |
| P | R | R | P | R | P | *Michrystridium* spp. |
| P | ... | Ab | P | P | Ab | *Lancettopsis lanceolata* |
| D | P | D | D | Ab | Ab | *Pterospermella* spp. |
| C | ... | R | Ab | P | C | *Tasmanites* spp. |
| | | | | | | |
| | | | | | | **Selected miospores:** |
| Ab | C | C | C | C | Ab | Bisaccate pollen - undifferentiated |
| R | ... | P | R | ?R | R | *Callialasporites* spp. |
| R | R | R | ... | ... | ... | *Cicatricosisporites* spp. |
| P | P | R | ... | ... | R | *Classopollis classoides* |
| R | ... | ... | ... | ... | ... | *Densosporites* spp. (RW) |
| C | P | P | P | P | Ab | *Gleicheniidites senonicus* |
| R | ... | R | R | R | ... | *Sestrosporites pseudoalveolatus* |
| ... | ... | R | ... | ... | C | *Vitreisporites pallidus* |

# PHOTOGRAPHIC PLATES

Plates 1 to 35 illustrate selected palynomorphs, largely indigenous dinoflagellate cysts, from the Russian samples studied. This material comprises the Upper Pliensbachian to Aalenian and Lower Callovian of northern East Siberia (Plates NS1 to NS7), the Bathonian, Callovian, Kimmeridgian and Volgian of the Pechora Basin, northern Russian Platform (Plates TP1 to TP11) and the Bathonian to Ryazanian of the central Russian Platform (Plates RP1 to RP17). Normally, the specimens were taken using plain transmitted light and the magnification levels are X500; any departures from this format is stated in the respective plate explanations. A unique figured specimen number, prefixed 'MPK', is given for each photomicrograph.

## PLATE NS1

Dinoflagellate cysts (*Nannoceratopsis* spp., figures 1-18), indigenous spores (figures 19-22) and a reworked pollen grain (figure 23) from the Upper Pliensbachian to the Lower Toarcian of the west bank of the River Anabar, northern east Siberia (see section 5.1.1.1). Figures 19 and 20 only are from the Upper Pliensbachian, the remainder are from the Lower Toarcian.

1-9 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *anabarensis* Ilyina 1994. Note the extremely long dorsal antapical horn, and the absence of a ventral antapical horn or protuberance, which imparts an elongate cyst ambitus with a wide, slightly concave antapex.

1, 2 Specimen MPK 10202, sample NS 9, specimen in right lateral view; 1 - high focus, 2 - low focus

3 Specimen MPK 10203, sample NS 9, specimen in right lateral view.

4 Specimen MPK 10204, sample NS 9, specimen in right lateral view.

5 Specimen MPK 10205, sample NS 9, specimen in right lateral view.

6, 7 Specimen MPK 10206, sample NS 9, specimen in left lateral view; 6 - high focus, 7 - low focus

8 Specimen MPK 10207, sample NS 9, specimen in left lateral view.

9 Specimen MPK 10208, sample NS 9, specimen in left lateral view.

10-14 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *senex* (Van Helden 1977) Ilyina 1994. Note the small epicyst and the essentially biconical cyst ambitus imparted by the presence of a single, dorsal antapical horn/protrusion.

10 Specimen MPK 10209, sample NS 3, specimen in left lateral view.

11 Specimen MPK 10210, sample NS 7, specimen in right lateral view.

12 Specimen MPK 10211, sample NS 8, specimen in left lateral view.

13 Specimen MPK 10212, sample NS 7, specimen in left lateral view.

14 Specimen MPK 10213, sample NS 7, specimen in left lateral view.

15-18 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *deflandrei* (autonym). Note the subtriangular cyst ambitus and the noticeable 'shoulder' in the ventral antapical region.

15 Specimen MPK 10214, sample NS 6, specimen in right lateral view.

16 Specimen MPK 10215, sample NS 6, specimen in right lateral view.

17 Specimen MPK 10216, sample NS 7, specimen in right lateral view.

18 Specimen MPK 10217, sample NS 6, specimen in left lateral view.

19-20 *Rogalskaisporites cicatricosus* (Rogalaska 1954) Danzé-Corsin & Laveine 1963.

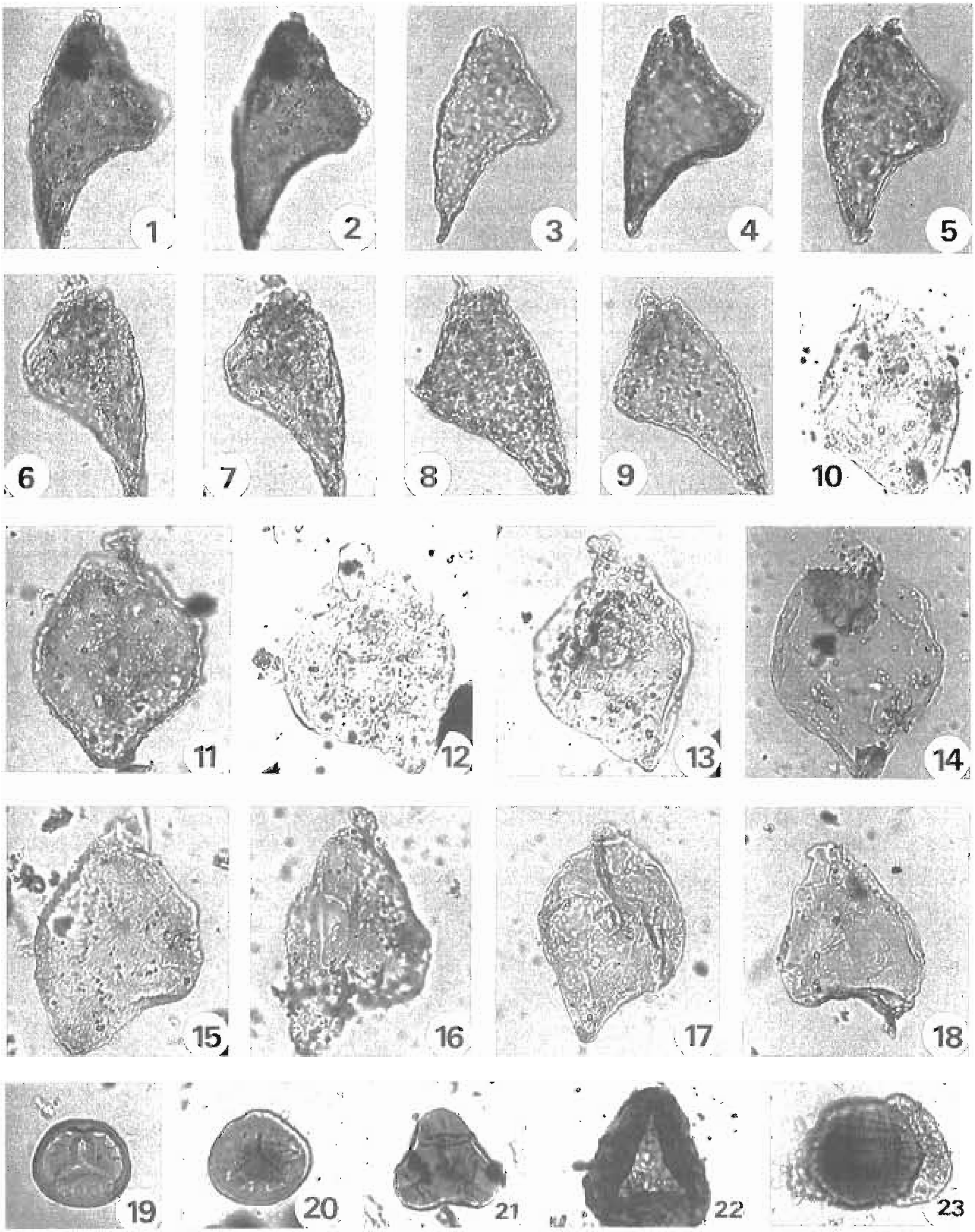
19 Specimen MPK 10218, sample NS 12, specimen in proximal view; note the equatorial ornamentation.

20 Specimen MPK 10219, sample NS 15, specimen in proximal view.

21 *Cibotiumspora juriensis* (Balme 1957) Filatoff 1975. Specimen MPK 10220, sample NS 3, specimen in proximal view.

22 *Concavissimisporites verrucosus* Delcourt & Sprumont 1955. Specimen MPK 10221, sample NS 4, specimen in proximal view; note the verrucate ornamentation.

23 Reworked taeniate pollen grain. Specimen MPK 10222, sample NS 1, note the striate central body.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# PLATE NS2

Dinoflagellate cysts (figures 1-14, 16) and a pollen grain (figure 15) from the Upper Pliensbachian, Lower Toarcian and Upper Toarcian of the west coast of Anabar Bay, northern east Siberia (see section 5.1.1.2). Figure 15 only is from the Upper Pliensbachian and figures 13 and 14 are from the Upper Toarcian; the remainder of the figures are from the Lower Toarcian.

1-3 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *deflandrei* (autonym). Note the subtriangular cyst ambitus, the 'shoulder' in the ventral antapical region and the gentle antapical concavity.

1 Specimen MPK 10223, sample NS 32, specimen in right lateral view.

2 Specimen MPK 10224, sample NS 33, specimen in right lateral view.

3 Specimen MPK 10225, sample NS 33, specimen in right lateral view.

4-5 *Nannoceratopsis deflandrei* Evitt 1961 subsp. cf. *deflandrei* (autonym). These specimens are close to *Nannoceratopsis deflandrei* subsp. *senex*.

4 Specimen MPK 10226, sample NS 32, specimen in left lateral view.

5 Specimen MPK 10227, sample NS 33, specimen in left lateral view.

6 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *senex* (Van Helden 1977) Ilyina 1994. Note the broadly biconical cyst ambitus imparted by the single, dorsal antapical horn. Specimen MPK 10228, sample NS 32, specimen in right lateral view.

7, 8, 12, 16 *Nannoceratopsis gracilis* Alberti 1961. Note the reticulate autophragm and the subtriangular cyst ambitus.

7 Specimen MPK 10229, sample NS 27, specimen in left lateral view.

8 Specimen MPK 10230, sample NS 27, specimen in right lateral view.

12, 16 Specimen MPK 10231, sample NS 27, specimen in left lateral view; 12 - high focus, 16 - low focus.

9-11 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *anabarensis* Ilyina 1994. Note the extremely prominent, long dorsal antapical horn, and the absence of a ventral antapical horn, which imparts an elongate cyst ambitus.

9 Specimen MPK 10232, sample NS 32, specimen in right lateral view.

10 Specimen MPK 10233, sample NS 32, specimen in right lateral view.

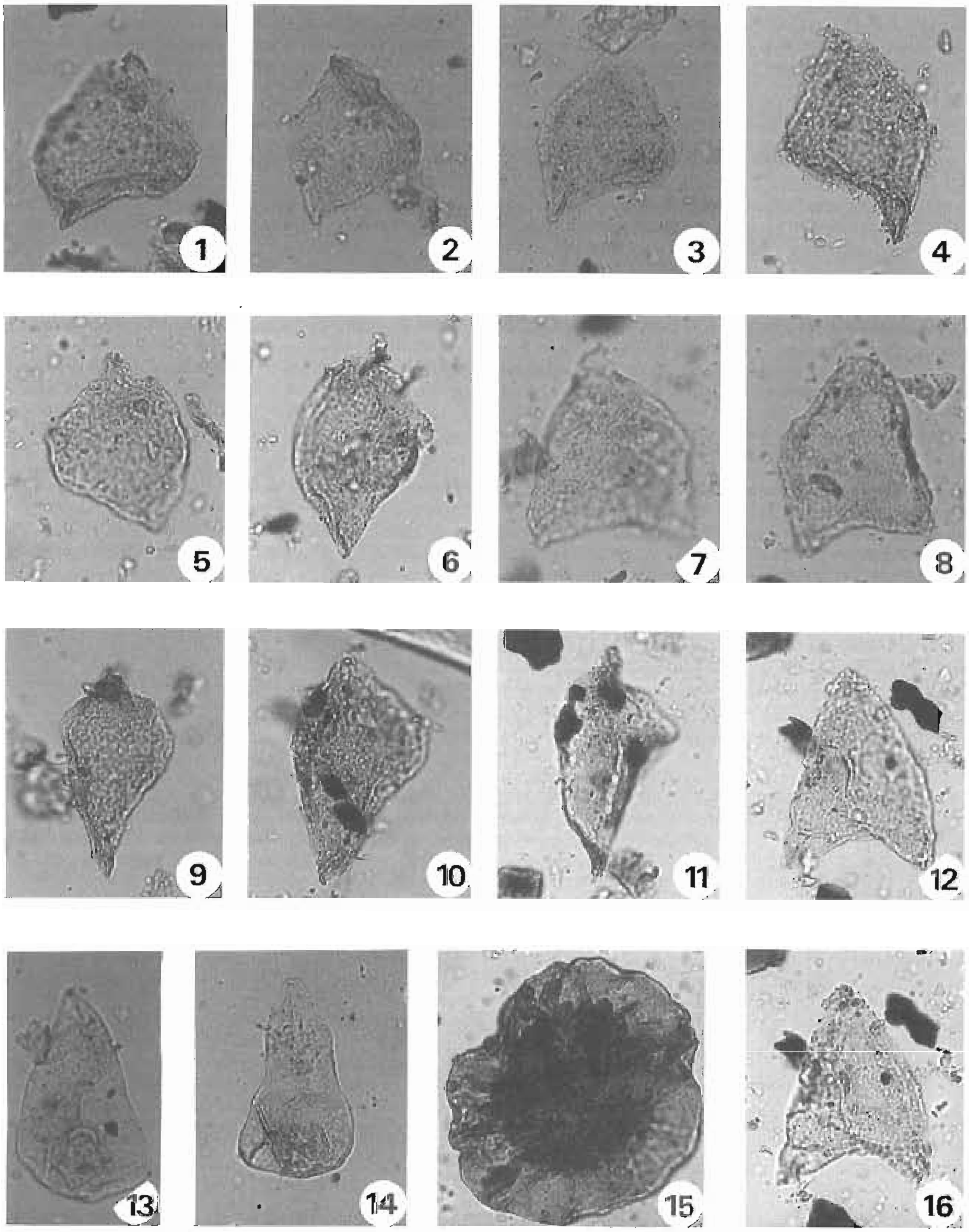
11 Specimen MPK 10234, sample NS 27, specimen in right lateral view.

13, 14 *Phallocysta eumekes* Dörhöfer & Davies 1980. Note the longitudinally elongate cyst ambitus, the epicavate cyst organisation and the anterior intercalary archeopyle.

13 Specimen MPK 10235, sample NS 22, specimen in dorsal view.

14 Specimen MPK 10236, sample NS 22, specimen in left lateral view.

15 *Callialasporites dampieri* (Balme 1957) Sukh Dev 1961. Specimen MPK 10237, sample NS 34, note the cavate nature of the grain.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# PLATE NS3

Dinoflagellate cysts from the Lower and Upper Toarcian of Sobo Creek, River Marcha, northern east Siberia (see section 5.1.1.4). Figures 4, 8 and 11-17 are from the Upper Toarcian; the remainder are from the Lower Toarcian. Figure 8 taken using phase contrast.

1-7 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *senex* (Van Helden 1977) Ilyina 1994. Note the small epicyst and the biconical cyst ambitus caused by the presence of a single, dorsal antapical horn or protrusion.

1 Specimen MPK 10238, sample NS 44, specimen in left lateral view.

2 Specimen MPK 10239, sample NS 44, specimen in left lateral view.

3 Specimen MPK 10240, sample NS 44, specimen in left lateral view.

4 Specimen MPK 10241, sample NS 40, specimen in left lateral view.

5 Specimen MPK 10242, sample NS 44, specimen in left lateral view.

6 Specimen MPK 10243, sample NS 44, specimen in right lateral view.

7 Specimen MPK 10244, sample NS 44, specimen in right lateral view.

8 *Nannoceratopsis triangulata* Prauss 1987. Note the relatively thin autophragm, the short antapical horns and the triangular cyst ambitus. Specimen MPK 10245, sample NS 41, specimen in right lateral view.

9-12 *Nannoceratopsis gracilis* Alberti 1961. Note the strongly reticulate autophragm and the subtriangular ambitus.

9, 10 Specimen MPK 10246, sample NS 42, specimen in right lateral view.

11 Specimen MPK 10247, sample NS 40, specimen in right lateral view.

12 Specimen MPK 10248, sample NS 41, specimen in left lateral view.

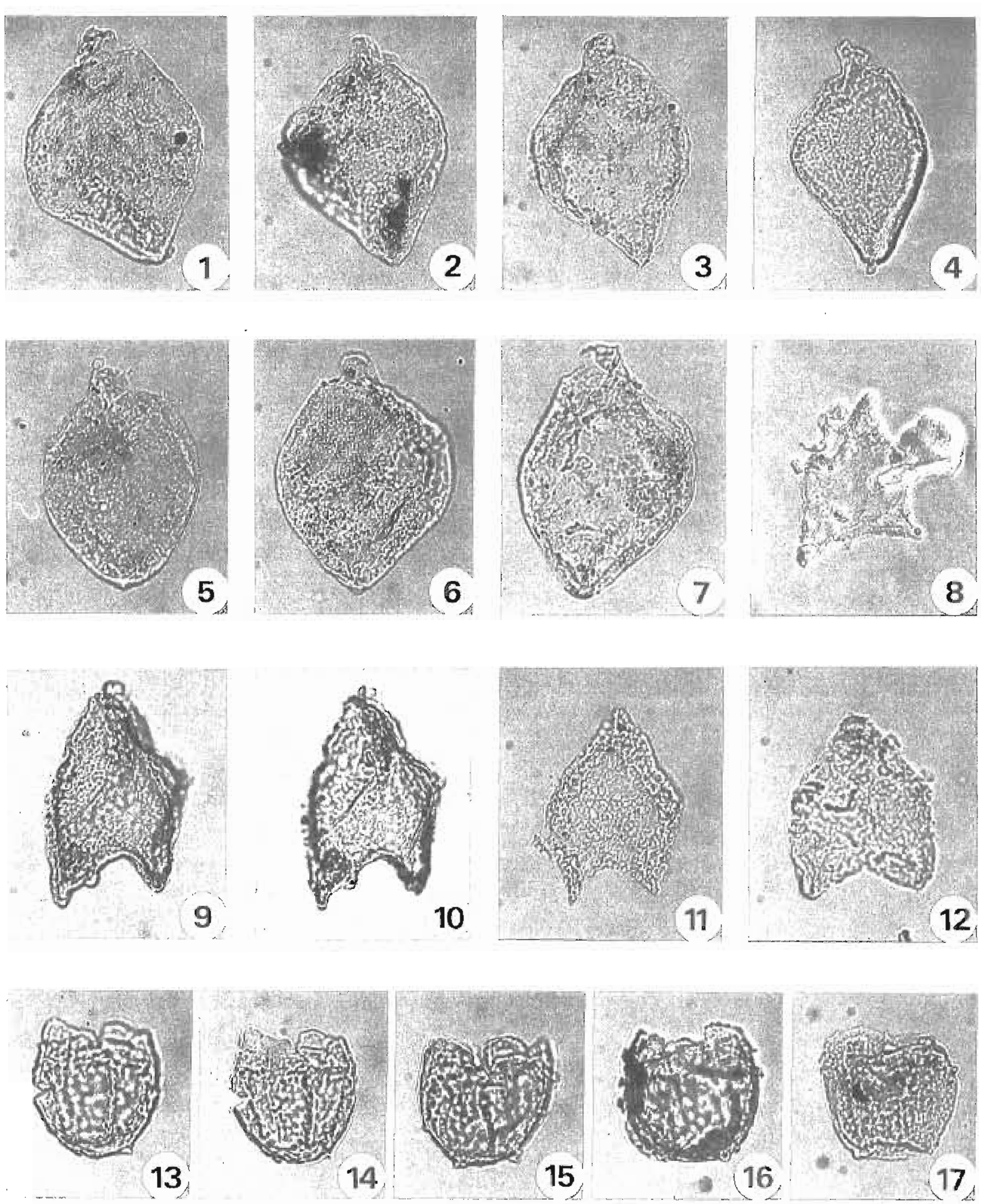
13-17 *Maturodinium* sp. A. Note the combination (apical/anterior intercalary) archeopyle and the clear paratabulation indicated by low parasutural ridges.

13, 14 Specimen MPK 10249, sample NS 40, specimen in dorsal view; 13 - high focus, 14 - low focus.

15 Specimen MPK 10250, sample NS 40, specimen in ventral view, median focus.

16 Specimen MPK 10251, sample NS 40, specimen in ventral view, low focus.

17 Specimen MPK 10252, sample NS 41, specimen in dorsal view, median focus.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## PLATE NS4

Dinoflagellate cysts from the Lower Toarcian of Astronomitscheskii Creek (figures 1-8) and the Upper Toarcian of the banks of the Rivers Kelimjar (figures 9-12; 17), Marcha (figures 13-15) and Motorshuna (figure 16), northern east Siberia (see sections 5.1.1.3, 5.1.1.7, 5.1.1.5 and 5.1.1.8 respectively). Figures 10-12 and 15 were taken using phase contrast.

1-8 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *senex* (Van Helden 1977) Ilyina 1994. Note the tear-shaped, biconical ambitus caused by the presence of a single, dorsal antapical horn or protrusion.

1 Specimen MPK 10253, sample NS 38, specimen in right lateral view.

2 Specimen MPK 10254, sample NS 38, specimen in right lateral view.

3 Specimen MPK 10255, sample NS 37, specimen in right lateral view.

4 Specimen MPK 10256, sample NS 38, specimen in right lateral view.

5 Specimen MPK 10257, sample NS 38, specimen in right lateral view.

6 Specimen MPK 10258, sample NS 37, specimen in left lateral view.

7 Specimen MPK 10259, sample NS 38, specimen in left lateral view.

8 Specimen MPK 10260, sample NS 37, specimen in left lateral view.

9, 10 *Phallocysta eumekes* Dörhöfer & Davies 1980. Specimen MPK 10261, sample NS 53, specimen in oblique left lateral view; note the epicavate cyst organisation and the prominent anterior intercalary archeopyle with a free perioperculum, best seen in figure 10.

11-12 *Parvocysta cracens* Bjaerke 1980.

11 Specimen MPK 10262, sample NS 53, note the single apical horn, the two antapical horns and the longitudinally elongate cyst ambitus.

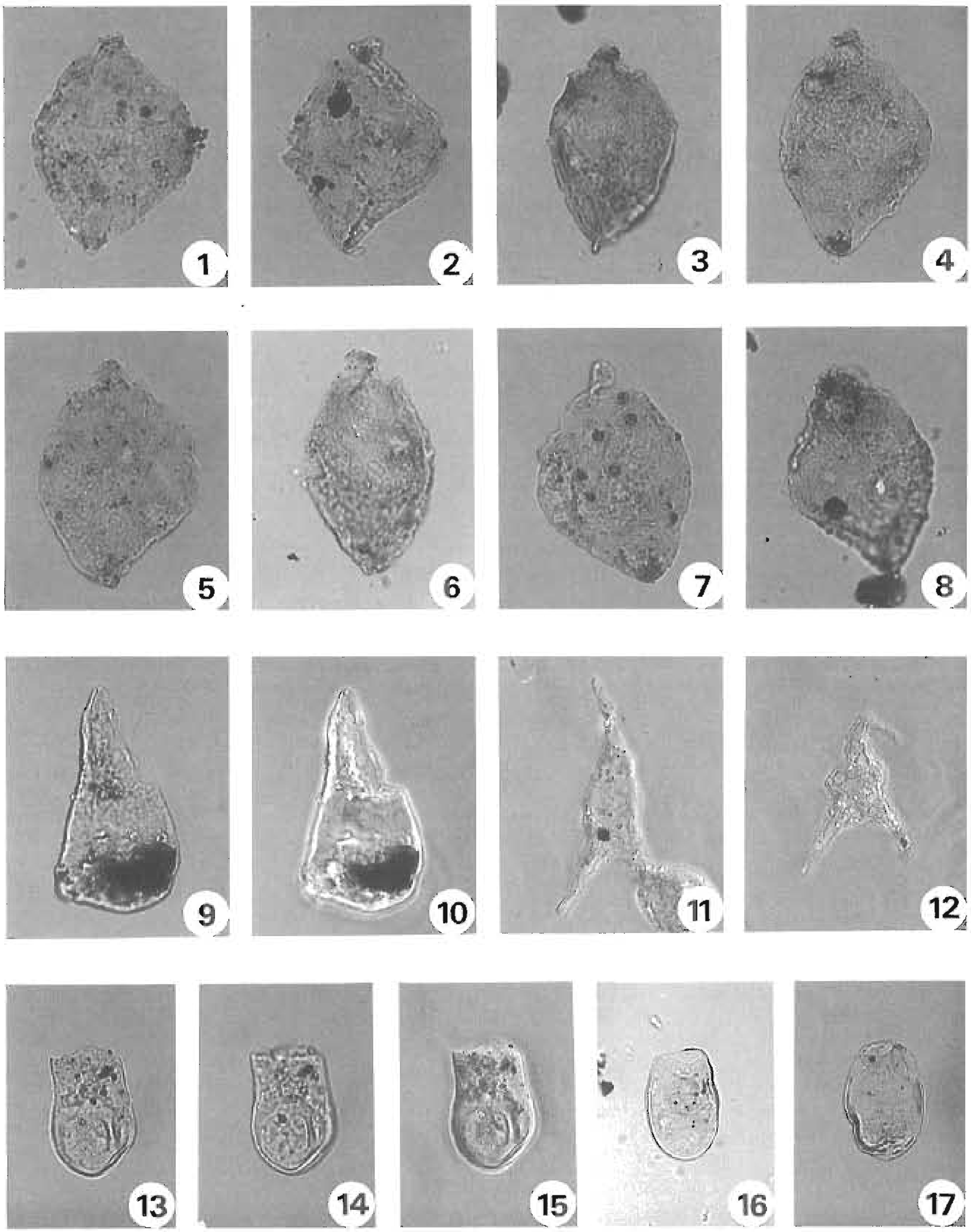
12 Specimen MPK 10263, sample NS 53, note the mechanically distorted apical horn.

13-15 *Phallocysta elongata* (Beju 1971) Riding 1994. Specimen MPK 10264, sample NS 50, a specimen with a damaged epicyst, apparently exhibiting an apical archeopyle; note the endocyst and the flask-shaped ambitus; 13 - high focus, 14 - low focus.

16-17 *Valvaeodinium aquilonium* Dörhöfer & Davies 1980. Specimens in oblique lateral view, note the smooth autophragm and the combination (apical/anterior intercalary) archeopyle.

16 Specimen MPK 10265, sample NS 54.

17 Specimen MPK 10266, sample NS 53.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## PLATE NS5

The dinoflagellate cyst *Phallocysta eumekes* Dörhöfer & Davies 1980 from the Upper Toarcian of River Motorshuna, northern east Siberia (see section 5.1.1.8). All specimens from sample NS 55. Figure 16 was taken using phase contrast. Note the elongate subconical ambitus, the epicavate cyst organisation and the bulbous protrusions in the antapical area.

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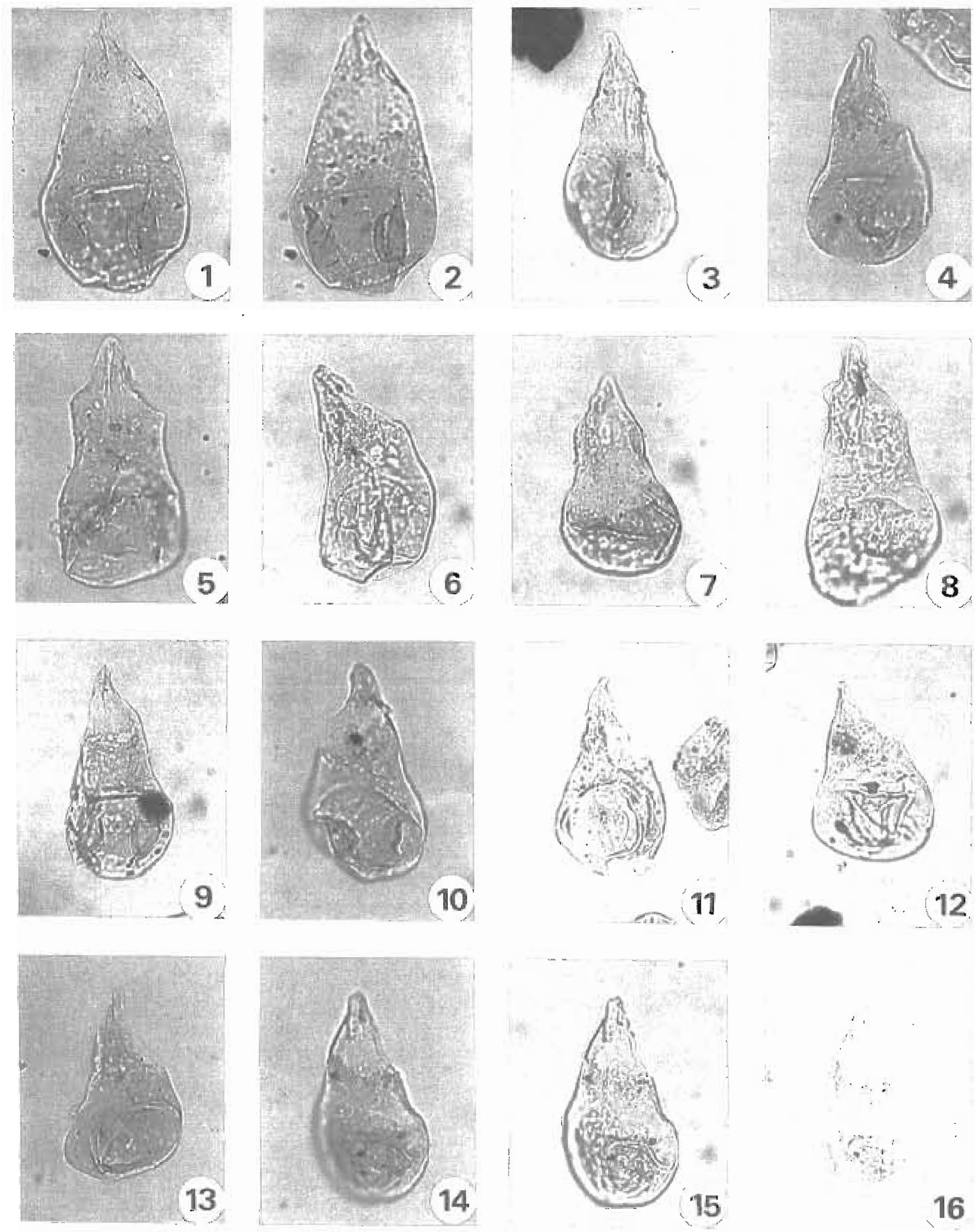
|---|---|
| 1-16 | *Phallocysta eumekes* Dörhöfer & Davies 1980. |
| 1, 2 | Specimen MPK 10267, specimen in dorsal view; 1 - high focus, 2 - median focus. |
| 3 | Specimen MPK 10268, specimen in oblique dorsal view, median focus. |
| 4 | Specimen MPK 10269, specimen in left lateral view, median focus. |
| 5 | Specimen MPK 10270, specimen in dorsal view, median focus. |
| 6 | Specimen MPK 10271, specimen in left lateral view, high focus. |
| 7 | Specimen MPK 10272, specimen in lateral view, high focus. |
| 8 | Specimen MPK 10273, specimen in lateral view, median focus. |
| 9 | Specimen MPK 10274, specimen in dorsal view, high focus. |
| 10 | Specimen MPK 10275, specimen in oblique dorsal view, high focus. |
| 11 | Specimen MPK 10276, specimen in left lateral view, high-median focus. |
| 12 | Specimen MPK 10277, specimen in oblique left lateral view, high focus. |
| 13 | Specimen MPK 10278, specimen in left lateral view, high-median focus. |
| 14, 15, 16 | Specimen MPK 10279, specimen in dorsal view; 14, 16 - high focus, 15 - median focus. |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# PLATE NS6

Dinoflagellate cysts from the Upper Toarcian of Borehole 141, Khatirik-Khomo, northern east Siberia (see section 5.1.1.6). Figures 3 and 15 were taken using phase contrast.

1-2 *Nannoceratopsis deflandrei* Evitt 1961 subsp. *senex* (Van Helden 1977) Ilyina 1994. Note the biconical ambitus caused by the presence of a single, dorsal antapical horn.

1 Specimen MPK 10280, sample NS 52, specimen in right lateral view.

2 Specimen MPK 10281, sample NS 51, specimen in left lateral view.

3 *Nannoceratopsis triangulata* Prauss 1987. Note the relatively thin autophragm, the relatively short antapical horns and the markedly triangular ambitus. Specimen MPK 10282, sample NS 52, specimen in left lateral view.

4, 8-12 *Phallocysta eumekes* Dörhöfer & Davies 1980. Note the longitudinally elongate, subconical ambitus, the epicavate cyst organisation and the bulbous protrusions in the antapical region.

4 Specimen MPK 10283, sample NS 52, specimen in dorsoventral view, median focus.

8 Specimen MPK 10284, sample NS 51, specimen in oblique dorsal view, high focus.

9 Specimen MPK 10285, sample NS 51, specimen in oblique left lateral view, high focus.

10 Specimen MPK 10286, sample NS 51, specimen in oblique dorsal view, median focus.

11 Specimen MPK 10287, sample NS 51, specimen in dorsal view, median focus.

12 Specimen MPK 10288, sample NS 51, specimen in left lateral view, high focus.

5-7 *Mancodinium semitabulatum* Morgenroth 1970. Note the combination archeopyle comprising all the epicystal paraplate series and the anterior parasulcal paraplate.

5, 6 Specimen MPK 10289, sample NS 52, specimen in dorsal view; 5 - median focus, 6 - high focus.

7 Specimen MPK 10290, sample NS 52, specimen in dorsal view, high focus.

13-15 *Valvaeodinium aquilonium* Dörhöfer & Davies 1980. Specimens in lateral view, note the smooth autophragm and the combination (apical/anterior intercalary) archeopyle.

13 Specimen MPK 10291, sample NS 51.

14, 15 Specimen MPK 10292, sample NS 51.

16 *Parvocysta nasuta* Bjaerke 1980. Specimen MPK 10293, sample NS 52, specimen in ventral view, median focus; note the subpentagonal cyst ambitus, the apical protrusion and the narrow paracingular area.

17 *Parvocysta bullula* Bjaerke 1980. Specimen MPK 10294, sample NS 51, specimen in ventral view, high focus, note the rounded pentagonal ambitus.

18-21 *Susadinium scrofoides* Dörhöfer & Davies 1980. Note the prominent rounded precingular and postcingular protrusions.

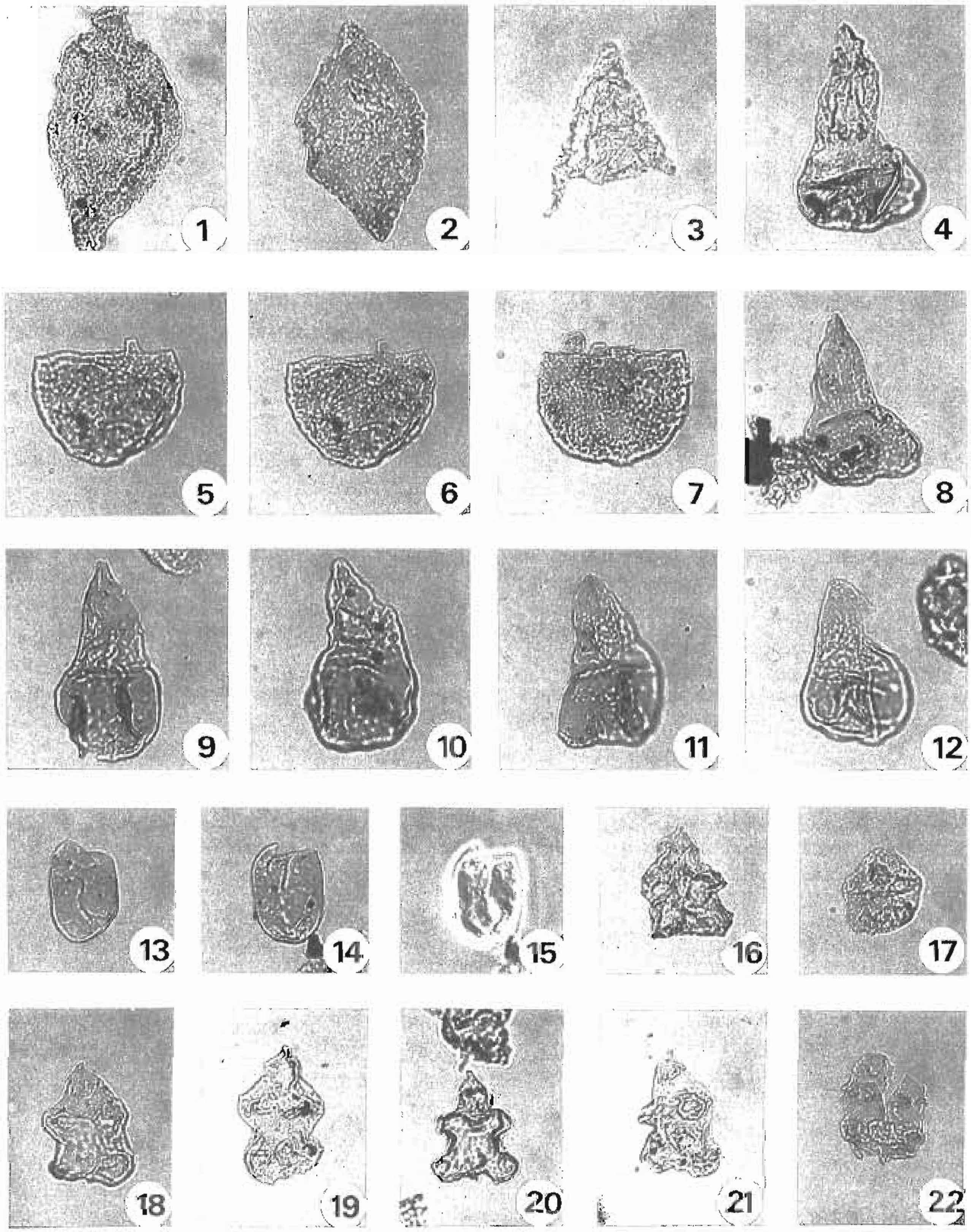
18 Specimen MPK 10295, sample NS 52, specimen in dorsoventral view, median focus.

19 Specimen MPK 10296, sample NS 52, specimen in dorsal view, high-median focus.

20 Specimen MPK 10297, sample NS 52, specimen in dorsal view, median focus.

21 Specimen MPK 10298, sample NS 52, specimen in dorsal view, median focus.

22 *Susadinium faustum* (Bjaerke 1980) Lentin & Williams 1985. Specimen MPK 10299, sample NS 51, specimen in dorsal view, high focus, note the rounded subpentagonal cyst ambitus and the baculate ornamentation.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# PLATE NS7

Dinoflagellate cysts from the Lower Callovian of the west side of Anabar Bay, northern east Siberia (see section 5.1.2). Figures 4 and 15 are composite photomicrographs.

1-2 *Chytroeisphaeridia hyalina* (Raynaud 1978) Lentin & Williams 1981. Note the large cyst size, the robust, smooth autophragm and the prominent precingular archeopyle.

1 Specimen MPK 10114, sample NS 57, specimen in dorsal view, high focus.

2 Specimen MPK 10115, sample NS 57, specimen in oblique left lateral view, high focus.

3 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Specimen MPK 10116. sample NS 56, specimen in right lateral view, high focus; note the large cyst size, the small apical horn and the denticulate/spinose parasutural ridges.

4-5, 8 *Crussolia dalei* Smelror & Århus 1989. Note the parasutural ridges, the cavate cyst organisation, the anterior intercalary archeopyle and the prominent apical horn

4 Specimen MPK 10117. sample NS 56, specimen in lateral view, composite photomicrograph.

5 Specimen MPK 10118. sample NS 56, specimen in dorsal view, high focus.

8 Specimen MPK 10121. sample NS 57, specimen in oblique dorsal view, high-median focus.

6-7 *Crussolia perireticulata* Arhus *et al.* 1989. Note the reticulate periphragm, the cavate cyst organisation and the prominent apical horn.

6 Specimen MPK 10119. sample NS 59, specimen in oblique dorsal view, median focus.

7 Specimen MPK 10120. sample NS 57, specimen in dorsal view, high focus.

9 *Pareodinia ceratophora* Deflandre 1947. Specimen MPK 10122. sample NS 59, specimen in oblique dorsal view, high focus; note the anterior intercalary archeopyle and the apical horn.

10 *Fromea tornatilis* (Drugg 1978) Lentin & Williams 1981. Specimen MPK 10123. sample NS 56, note the thick autophragm and the small apical archeopyle.

11 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10124. sample NS 56, specimen in right lateral view, high focus; note the apical protrusion and the prominent precingular archeopyle.

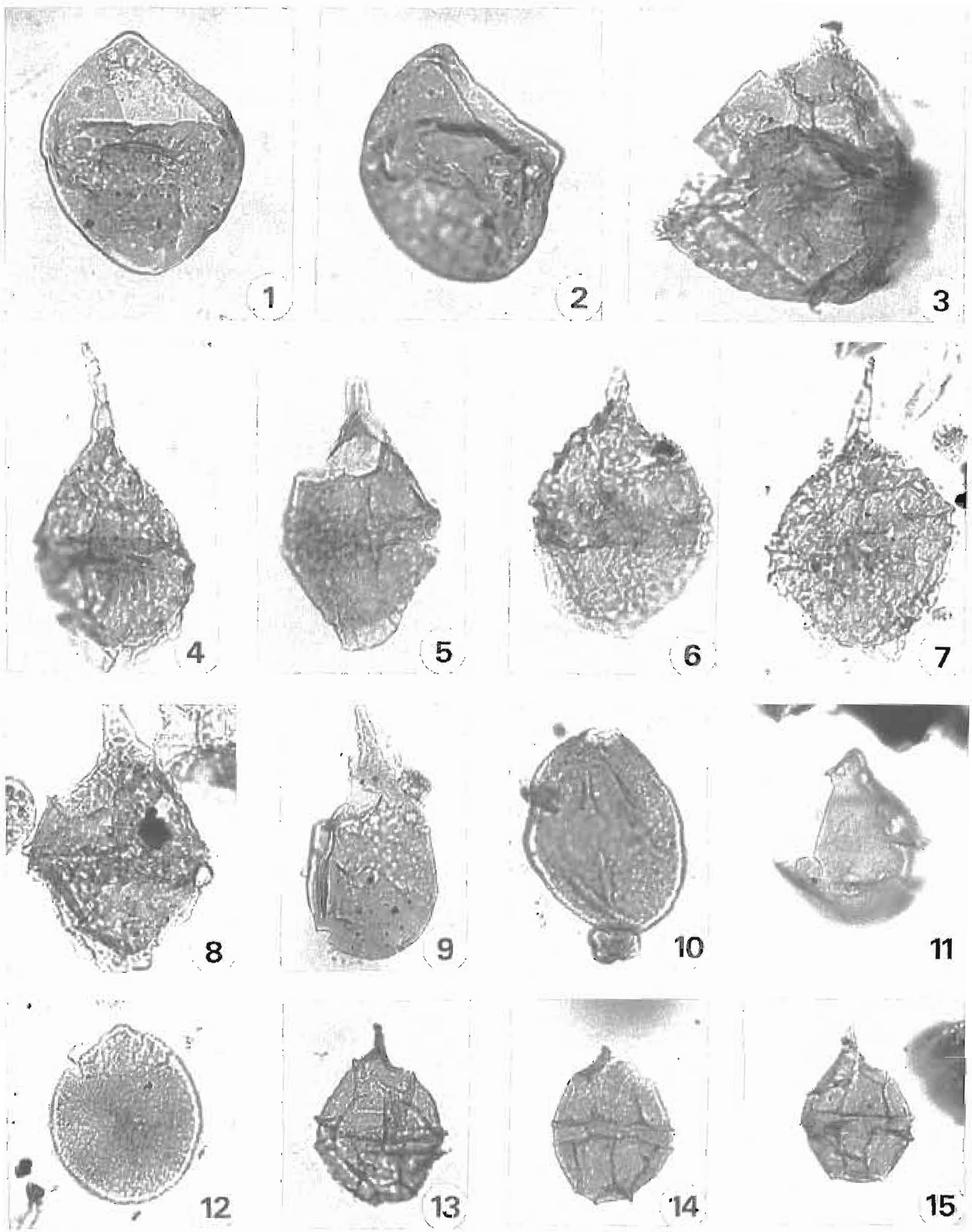
12 *Evansia evittii* (Pocock 1972) Jansonius 1986. Specimen MPK 10125. sample NS 59, specimen in dorsal view, median focus; note the ovoidal cyst ambitus and the anterior intercalary archeopyle.

13-15 *Paragonyaulacysta retiphragmata* Dörhöfer & Davies 1980. Note the apical horn, the prominent prarsutural ridges, the anterior intercalary archeopyle and the low-relief autophragm ornamentation.

13 Specimen MPK 10126. sample NS 57, specimen in oblique dorsal view, median/low focus.

14 Specimen MPK 10127. sample NS 57, specimen in left lateral view, median focus.

15 Specimen MPK 10128. sample NS 59, specimen in left lateral view, composite photomicrograph.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# PLATE TP1

Dinoflagellate cysts (figures 1-9), an acritarch (figure 10) and indigenous spores (figures 11, 12) from the Bathonian and Lower Callovian of the Pizhma River area, Pechora Basin (see section 5.2.1). Figures 3 and 7-10 were taken using phase contrast.

1-2 *Ctenidodinium combazii* Dupin 1968. Note the small antapical paraplate, the spinose/denticulate parasutural ridges and the epicystal archeopyle.

1 Specimen MPK 10300, sample TP 6, an isolated hypocyst in dorsal view, median focus.

2 Specimen MPK 10301, sample TP 6, an isolated hypocyst in antapical view, dorsal side uppermost, high focus; note the large dorso-lateral postcingular paraplates (Kofoidian numbers 3''' to 5''').

3 *Nannoceratopsis pellucida* Deflandre 1938. Specimen MPK 10302, sample TP 9, note the deep antapical concavity.

4 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Specimen MPK 10303, sample TP 9, specimen in dorsal view, median-low focus; note the denticulate parasutural ridges and the small apical horn.

5 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *adecta* Sarjeant 1982. Specimen MPK 10304, sample TP 6, specimen in ventral view, median focus; note the large epicyst, the epicavate cyst organisation and the short apical horn.

6 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10305, sample TP 6, specimen in dorsal view, high-median focus; note the disruption of the apical paraplates due to archeopyle formation, the wide pericoel in the hypocyst and the antapical opisthopyle.

7-9 *Protobatioladinium elatmaensis* Riding & Ilyina 1996. Note the lack of parasutural features and the antapical horn. These specimens all exhibit complete archeopyle formation; they have all lost the anterior intercalary and apical parapates.

7 Specimen MPK 10306, sample TP 11, specimen in dorsal view, median focus; note the accessory archeopyle sutures in the precingular paraplate series and the relatively small antapical horn.

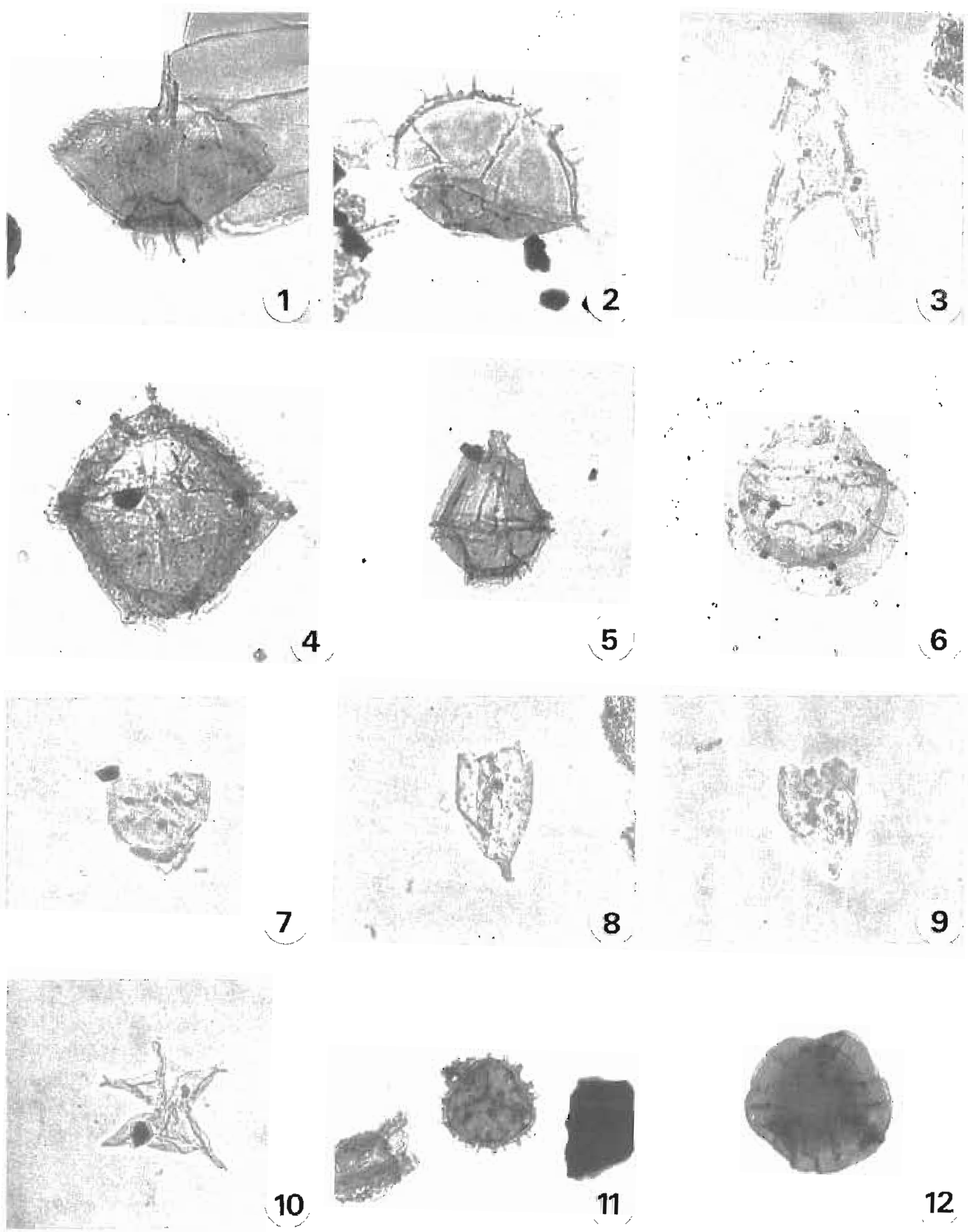
8 Specimen MPK 10307, sample TP 10, specimen in dorsal view, high focus.

9 Specimen MPK 10308, sample TP 10, specimen in dorsal view, high-median focus; a relatively small specimen with a short antapical horn.

10 *Fentonia* cf. *bjaerkei* (Smelror 1987) Bailey & Hogg 1995. Specimen MPK 10309, sample TP 10, note the apical horn, the equatorial constriction and the four relatively simple or bifurcate lateral protrusions. This specimen lacks the spinate/denticulate multifurcate protrusions which characterise this species.

11 *Neoraistrickia gristhorpensis* (Couper 1958) Tralau 1968. Specimen MPK 10310, sample TP 7, specimen in distal view, median focus; note the covering of tubercles.

12 *Callialasporites dampieri* (Balme 1957) Sukh Dev 1961. Specimen MPK 10311, sample TP 7, specimen in proximal view; note the cavate nature of the grain.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# PLATE TP2

Dinoflagellate cysts (figures 1-9), reworked Carboniferous spores (figures 10-12 and 14-16) and an indigenous spore (figure 13) from the Callovian of the River Izhma area, Pechora Basin (see section 5.2.1).

1-3 *Chytroeisphaeridia hyalina* (Raynaud 1978) Lentin & Williams 1981. Note the large overall cyst size, the smooth autophragm and the large precingular archeopyle.

1 Specimen MPK 10312, sample TP 1, specimen in oblique right lateral view, high focus; note the large operculum within the loisthocyst.

2 Specimen MPK 10313, sample TP 4, specimen in oblique dorsal/right lateral view.

3 Specimen MPK 10314, sample TP 1, an isolated operculum.

4 *Fromea tornatilis* (Drugg 1978) Lentin & Williams 1981. Specimen MPK 10315, sample TP 1, note the thick autophragm and the small apical archeopyle.

5 *Lithodinia planoseptata* (Riding 1987) Williams et al. 1993. Specimen MPK 10316, sample TP 1, specimen in dorsal view, median-low focus; note the relatively high, smooth parasutural crests.

6 *Paragonyaulacysta retiphragmata* Dörhöfer & Davies 1980. Specimen MPK 10317, sample TP 4, specimen in ventral view, high-median focus; note the prominent apical horn and the well defined paratabulation.

7 *Sirmiodiniopsis orbis* Drugg 1978. Specimen MPK 10318, sample TP 1, specimen in dorsal view, high focus; note the circumcavate cyst organisation and the apical archeopyle.

8 *Wanaea acollaris* Dodekova 1975. Specimen MPK 10319, sample TP 4, specimen in slightly oblique right lateral view; note the antapical horn, the epicystal archeopyle and the attached operculum.

9 *Evansia evittii* (Pocock 1972) Jansonius 1986. Specimen MPK 10320, sample TP 3, specimen in dorsal view, high focus; note the anterior intercalary archeopyle.

10 *Murospora aurita* (Waltz 1938) Playford 1962. Specimen MPK 10321, sample TP 4, specimen in proximal view, note the thick spore wall.

11 *Murospora/Tripartites* sp. Specimen MPK 10322, sample TP 4, specimen in proximal view; note the prominent thickened spore wall.

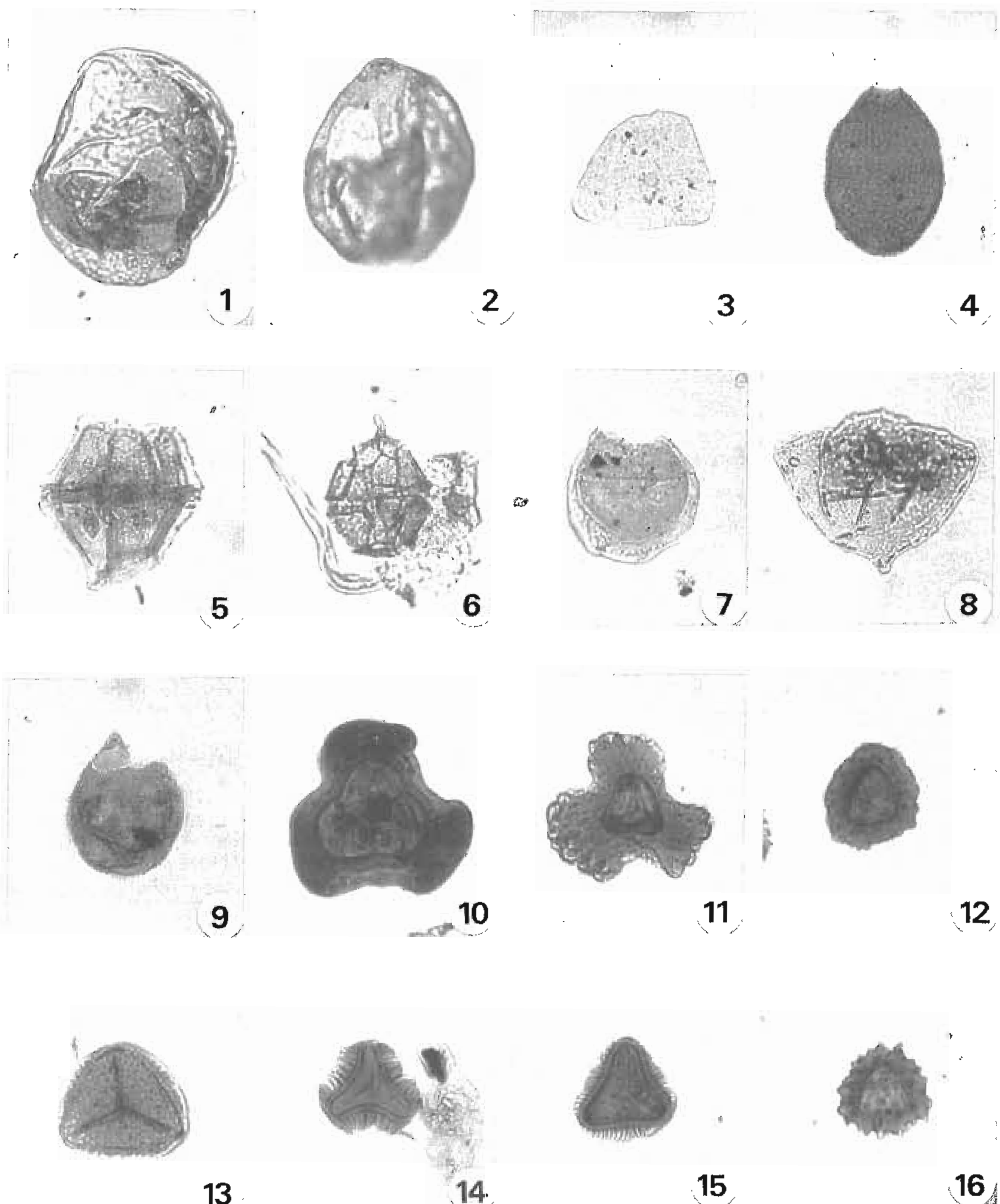
12 *Densosporites rarispinosus* Playford 1963. Specimen MPK 10323, sample TP 7, specimen in proximal view.

13 *Sestrosporites pseudoalveolatus* (Couper 1958) Dettmann 1963. Specimen MPK 10324, sample TP 1, specimen in proximal view.

14 *Diatomozonotriletes cervicornutus* (Staplin 1960) Playford 1963. Specimen MPK 10325, sample TP 6, specimen in proximal view.

15 *Diatomozonotriletes* cf. *saetosus* (Hacquebard & Barss 1957) Hughes & Playford 1961. Specimen MPK 10326, sample TP 1, specimen in proximal view.

16 *Densosporites spinifer* Hoffmeister et al. 1955. Specimen MPK 10327, sample TP 7, specimen in proximal view.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# PLATE TP3

Dinoflagellate cysts from the Upper Callovian of the River Izhma area, Pechora Basin (see section 5.2.2.1).

1-7 *Chytroeisphaeridia hyalina* (Raynaud 1978) Lentin & Williams 1981. Note the large size, the subovoidal cyst ambitus, the robust, smooth autophragm, the small apical horn or protrusion and the prominent, large precingular archeopyle.

1 Specimen MPK 10328, sample TP 26, specimen in left lateral view; note the operculum within the loisthocyst.

2 Specimen MPK 10329, sample TP 25, specimen in left lateral view; the operculum has dropped into the loisthocyst.

3 Specimen MPK 10330, sample TP 25, specimen in oblique right lateral view, median focus; note the large operculum.

4 Specimen MPK 10331, sample TP 26, specimen in slightly oblique left lateral view, high-median focus.

5 Specimen MPK 10332, sample TP 23, specimen in oblique left lateral view, high focus.

6 Specimen MPK 10333, sample TP 25, specimen in oblique dorsal view, median focus.

7 Specimen MPK 10334, sample TP 23, specimen in slightly oblique dorsal view, median focus; note the operculum within the loisthocyst.

8 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10335, sample TP 26, specimen in right lateral view; note the somewhat longitudinally elongate cyst ambitus, the apical protrusion and the prominent, large precingular archeopyle.

9 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10336, sample TP 24, specimen in left lateral view, high-median focus; note the subovoidal ambitus and the precingular archeopyle.

10 *Paragonyaulacysta* sp. Specimen MPK 10337, sample TP 24, specimen in right lateral view, median focus; note the apical horn and the faint indications of paratabulation.

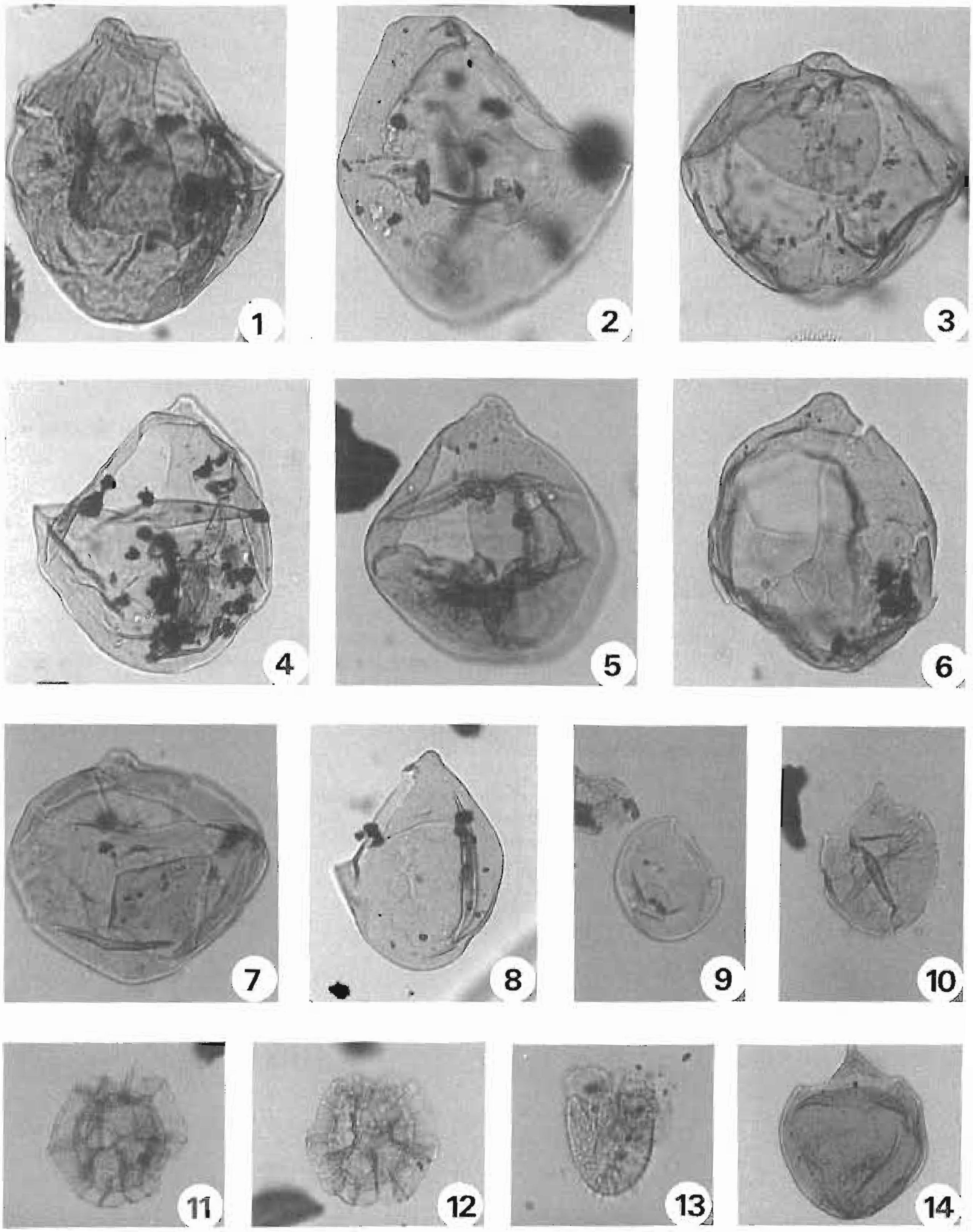
11-12 *Heslertonia* sp. Note the small cyst size and the prominent, wide, smooth parasutural septa.

11 Specimen MPK 10338, sample TP 25, specimen in oblique ventral view, median focus.

12 Specimen MPK 10787, sample TP 25, specimen in dorsal view, high-median focus.

13 *Sentusidinium creberbarbatum* Erkmen & Sarjeant 1980. Specimen MPK 10339, sample TP 24, specimen in dorsal view, median focus; note the apical archeopyle and the relatively dense covering of short, simple spines.

14 *Evansia evittii* (Pocock 1972) Jansonius 1986. Specimen MPK 10788, sample TP 25, specimen in dorsal view, high focus; note the apical horn and the anterior intercalary archeopyle.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# PLATE TP4

Dinoflagellate cysts (figures 1-14) and an acritarch (figure 15) from the Upper Callovian of the River Izhma area, Pechora Basin (see section 5.2.2.1). Figure 14 was taken using phase contrast.

1 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Specimen MPK 10340, sample TP 26, specimen in right lateral view, high-median focus; note the large size and the denticulate parasutural ridges.

2 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *galeritum* (autonym). Specimen MPK 10341, sample TP 26, specimen in ventral view, high focus; note the thick, robust endophragm and the cavate cyst organisation.

3 *Kalyptea stegasta* (Sarjeant 1961 Wiggins 1975. Specimen MPK 10342, sample TP 26, note the bipolar horns and the the kalyptra.

4-5 *Gonyaulacysta eisenackii* (Deflandre 1938) Górka 1965. Note the longitudinally elongate cyst ambitus, the bicavate organisation and the subequal epicyst and hypocyst.
4 Specimen MPK 10343, sample TP 25, specimen in ventral view, high focus.
5 Specimen MPK 10344, sample TP 26, specimen in dorsal view, low-median focus.

6 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *adecta* Sarjeant 1982. Specimen MPK 10345, sample TP 26, specimen in ventral view, median focus; note the large epicyst, epicavate cyst organisation and the prominent apical horn.

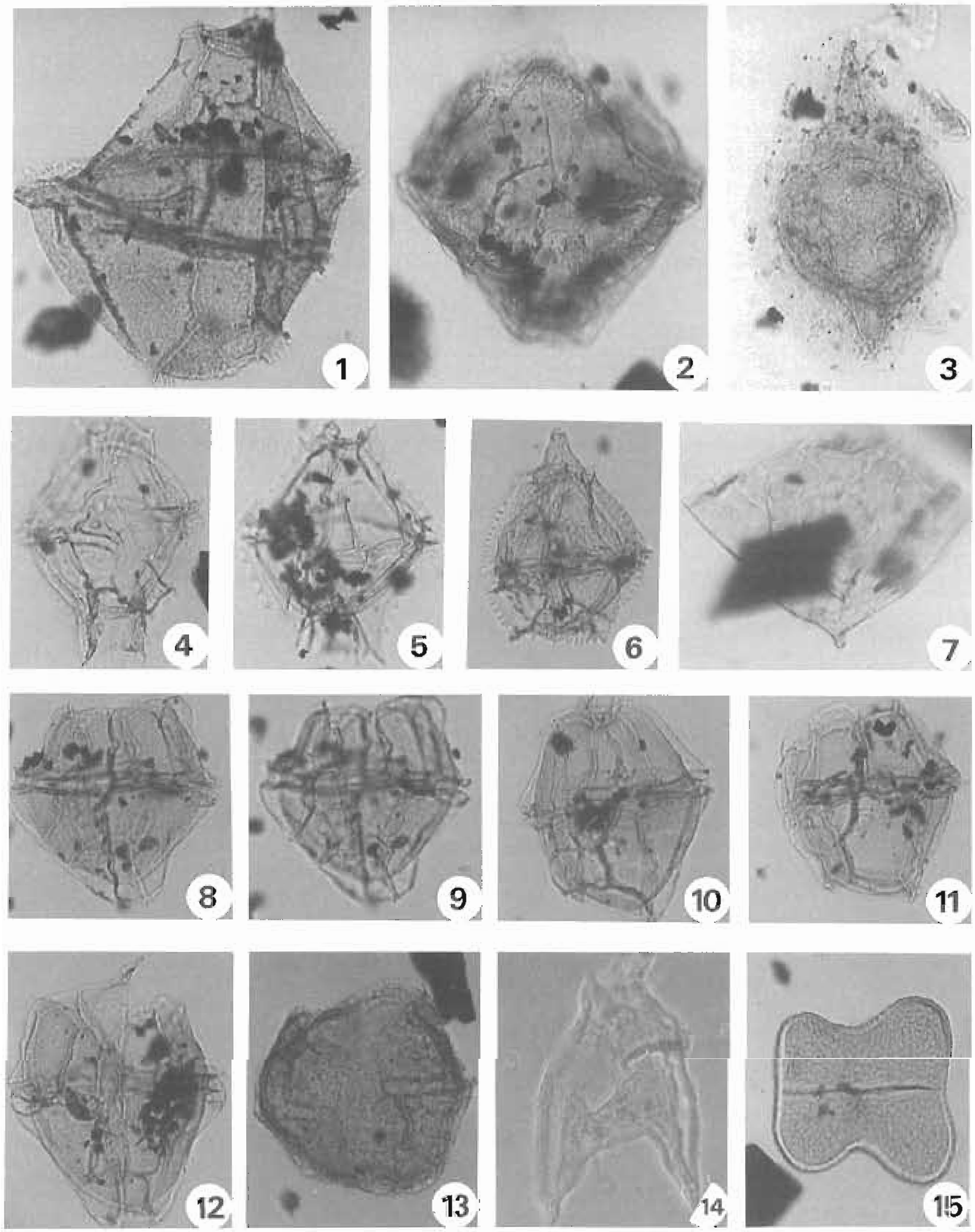
7 *Wanaea acollaris* Dodekova 1975. Specimen MPK 10346, sample TP 25, specimen in right lateral view, median focus; note the small antapical horn and the epicystal archeopyle.

8-12 *Lithodinia planoseptata* (Riding 1987) Williams et al. 1993. Note the regular, smooth parasutural crests and the apical archeopyle.
8, 9 Specimen MPK 10347, sample TP 26, specimen in oblique dorsal view; 8 - high focus, 9 - low-median focus.
10 Specimen MPK 10348, sample TP 26, specimen in oblique ventral view, median focus.
11 Specimen MPK 10349, sample TP 26, specimen in oblique left lateral view, high focus.
12 Specimen MPK 10350, sample TP 26, specimen in mid ventral view, high focus; note the parasulcus, which is subdivided into individual paraplates.

13 *Lithodinia caytonensis* (Sarjeant 1959) Gocht 1976). Specimen MPK 10351, sample TP 24, specimen in mid ventral view, high focus; note the low parasutural ridges/crests.

14 *Nannoceratopsis pellucida* Deflandre 1938. Specimen MPK 10352, sample TP 24, note the deep antapical concavity.

15 *Schizocystia rara* Playford & Dettmann 1965. Specimen MPK 10353, sample TP 26, an entire specimen.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# PLATE TP5

Dinoflagellate cysts from the uppermost Callovian of the River Izhma area, Pechora Basin 1 (see section 5.2.2.1).

1-3 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *adecta* Sarjeant 1982. Note the epicavate cyst organisation, the prominent apical horn, the unusually large epicyst with respect to the hypocyst, the precingular archeopyle and the wide, denticulate parasutural crests.

1, 2 Specimen MPK 10354, sample TP 21, specimen in slightly oblique dorsal view; 1 - high focus, 2 - median focus.

3 Specimen MPK 10355, sample TP 22, specimen in dorsal view, low focus.

4 *Ctenidodinium continuum* Gocht 1970. Specimen MPK 10356, sample TP 21, specimen in ventral view, low focus; note the wide, denticulate parasutural crests.

5-6 *Lithodinia caytonensis* (Sarjeant 1959) Gocht 1976.

5 Specimen MPK 10357, sample TP 21, specimen in ventral view, high focus; note the apical archeopyle and the denticulate parasutural crests.

6 Specimen MPK 10358, sample TP 21, specimen in dorsal view, low focus; note the parasulcal notch.

7 *Clathroctenocystis asapha* (Drugg 1978) Stover & Helby 1987. Specimen MPK 10359, sample TP 21, note the cavate organisation and the longitudinally elongate nature of this species.

8 *Paragonyaulacysta* sp. Specimen MPK 10360, sample TP 21, specimen in dorsal view, high focus; note the faint indications of paratabulation and the anterior intercalary archeopyle.

9 *Kalyptea stegasta* (Sarjeant 1961 Wiggins 1975. Specimen MPK 10361, sample TP 22, note the bipolar horns and the kalyptra.

10 *Fromea tornatilis* (Drugg 1978) Lentin & Williams 1981. Specimen MPK 10362, sample TP 22, note the small apical archeopyle.

11 *Cleistosphaeridium varispinosum* (Sarjeant 1959) Woollam & Riding 1983. Specimen MPK 10363, sample TP 22, specimen in ventral view, median focus; note the relatively dense covering of nontabular, capitate spines.

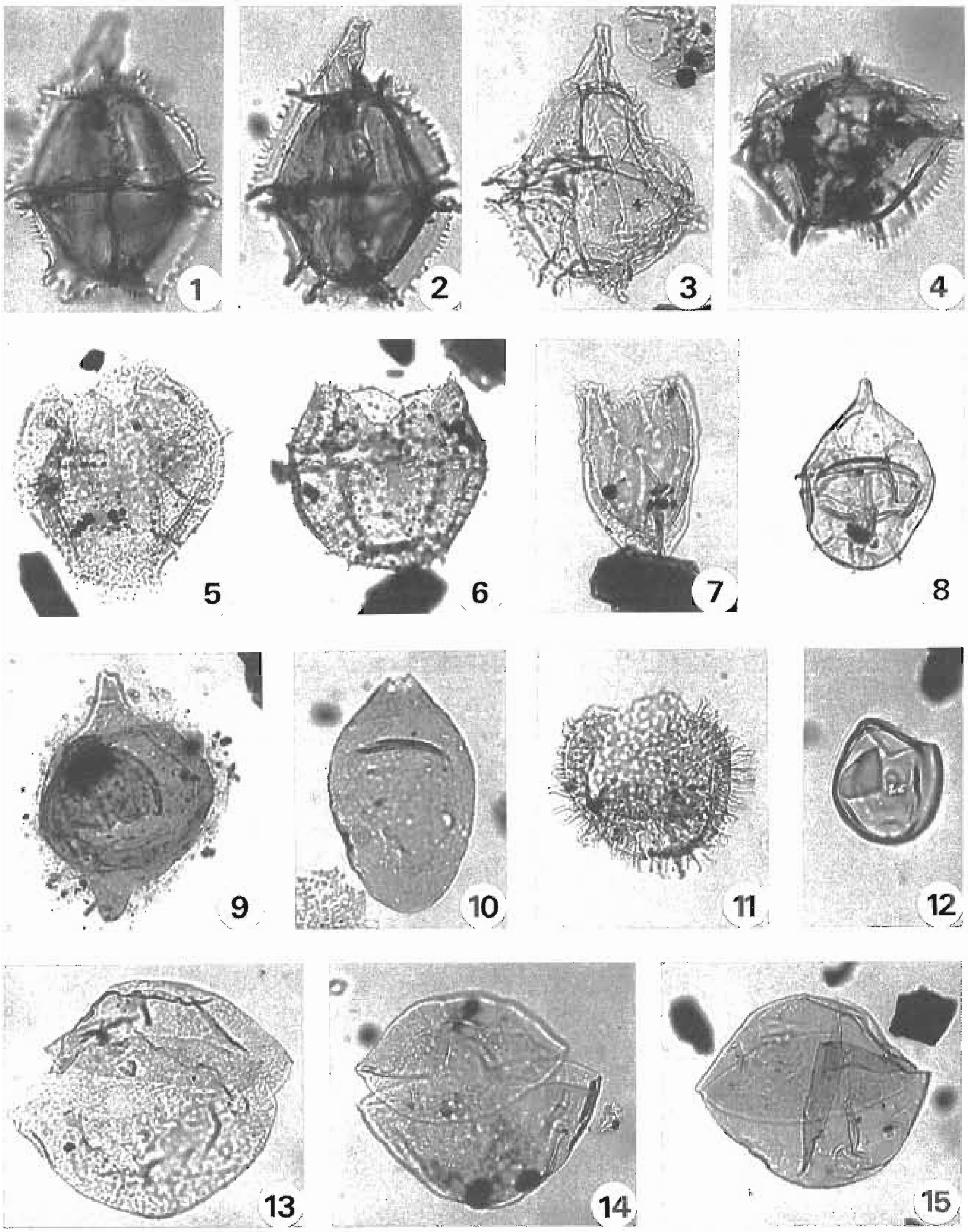
12 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10364, sample TP 21, specimen in slightly oblique left lateral view, median focus; note the operculum which has fallen back into the loisthocyst.

13-15 *Mendicodinium groenlandicum* (Pocock & Sarjeant 1972) Davey 1979. Note the large overall size, the wide, squat ambitus, the smooth autophragm and the epicystal archeopyle.

13 Specimen MPK 10365, sample TP 22, specimen in dorsal view, high-median focus.

14 Specimen MPK 10366, sample TP 22, specimen in ventral view, low focus.

15 Specimen MPK 10367, sample TP 21, specimen in dorsal view, high focus.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# PLATE TP6

Dinoflagellate cysts from the uppermost Callovian (figures 1-3, 6; see section 5.2.2.1) and the Kimmeridgian (figures 4, 5, 7-12; see section 5.2.2.2) of the River Izhma area, Pechora Basin.

1 *Gonyaulacysta centriconnata* Riding 1983. Specimen MPK 10368, sample TP 22, an isolated hypocyst in dorsal view, high focus; note the high, denticulate parasutural crests and the suturocavate cyst organisation.

2, 3, 6 *Ctenidodinium ornatum* (Eisenack 1935) Deflandre 1938. Note the prominent wide, densely spinose parasutural crests, the relatively large antapical paraplate and the epicystal archeopyle.

2 Specimen MPK 10369, sample TP 22 an isolated hypocyst in dorsal view, median focus.

3 Specimen MPK 10370, sample TP 22 an isolated hypocyst in ventral view, high focus.

6 Specimen MPK 10371, sample TP 22 specimen in dorsal view, low-median focus.

4 *Leptodinium mirabile* Klement 1960. Specimen MPK 10372, sample TP 20, slightly oblique dorsal view, low focus; note the large cyst size, the small apical horn, the low, smooth parasutural crests and the parasulcus which is subdivided into paraplates.

5, 8 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *jurassica* (autonym). Note the bicavate cyst organisation, the precingular archeopyle and the prominent apical horn

5 Specimen MPK 10373, sample TP 14, specimen in dorsal view, high focus; note the operculum inside the loisthocyst.

8 Specimen MPK 10374, sample TP 17, specimen in slightly oblique dorsal view, high focus.

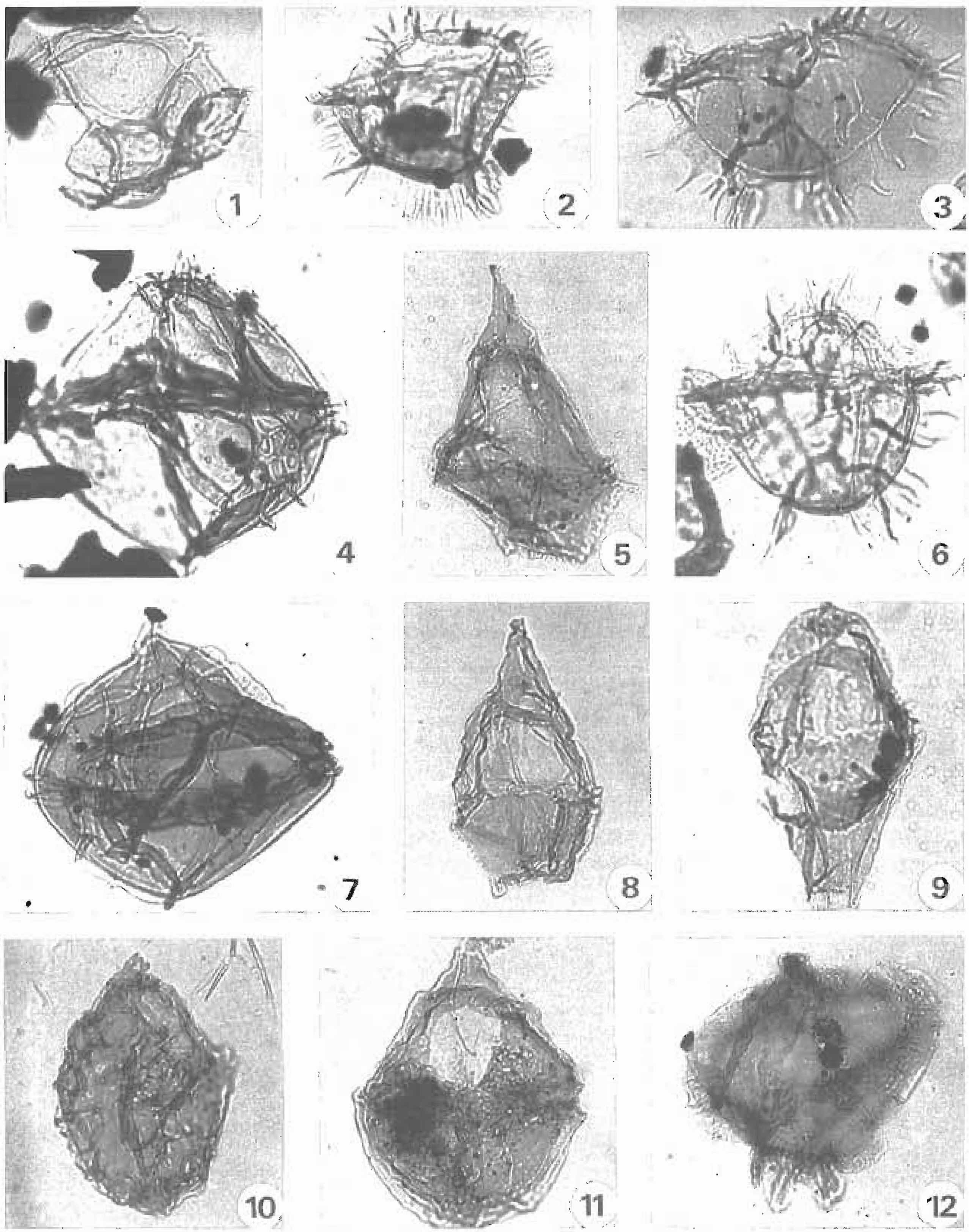
7 *Leptodinium* sp. Specimen MPK 10375, sample TP 19, specimen in oblique ventral view, high focus; note the gonyaulacacean paratabulation and the low, smooth parasutural crests. This specimen is probably referable to *Leptodinium mirabile*, however, the parasulcus is not visible in detail, thus the individual paraplates in this area which characterise this species, if present, cannot be determined.

9 *Tubotuberella rhombiformis* Vozzhennikova 1967. Specimen MPK 10376, sample TP 14, specimen in dorsal view, high focus; note the large epicavation and the precingular archeopyle.

10 *Aldorfia dictyota* (Cookson & Eisenack 1960) Davey 1982. Specimen MPK 10377, sample TP 18, specimen in oblique left lateral view, high focus; note the reticulate pericoel.

11 *Endoscrinium anceps* Raynaud 1978. Specimen MPK 10378, sample TP 18, specimen in dorsal view, high focus; note the relatively small apical horn and the precingular archeopyle.

12 *Glossodinium dimorphum* Ioannides et al. 1977. Specimen MPK 10379, sample TP 14, specimen in ventral view, median focus; note the prominent paracingular flange and the antapical protrusions.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# PLATE TP7

Dinoflagellate cysts from the Kimmeridgian of the River Izhma area, Pechora Basin (see section 5.2.2.2). Figure 10 was taken using phase contrast.

1-6 *Perisseiasphaeridium pannosum* Davey & Williams 1966. Note the apical archeopyle, the slender paracingular processes and the large, paraplate-centered, distally expanded processes on the remainder of the cyst

1 Specimen MPK 10380, sample TP 20, specimen in dorsal view, median focus.

2 Specimen MPK 10381, sample TP 19, specimen in lateral view, median focus.

3 Specimen MPK 10382, sample TP 18, specimen in dorsal view, high focus.

4 Specimen MPK 10383, sample TP 20, specimen in dorsal view, high-median focus.

5 Specimen MPK 10384, sample TP 17, specimen in lateral view, median focus.

6 Specimen MPK 10385, sample TP 18, specimen in dorsal view, high focus.

7 *Hystrichosphaeridina orbifera* (Klement 1960) Stover & Evitt 1978. Specimen MPK 10386, sample TP 14; note the distally trabeculate process complexes.

8 cf. *Hystrichosphaeridina orbifera* (Klement 1960) Stover & Evitt 1978. Specimen MPK 10387, sample TP 14; the process complexes are interconnected via distal trabeculae, therefore this specimen is not deemed to be *Hystrichosphaerina orbifera sensu stricto*.

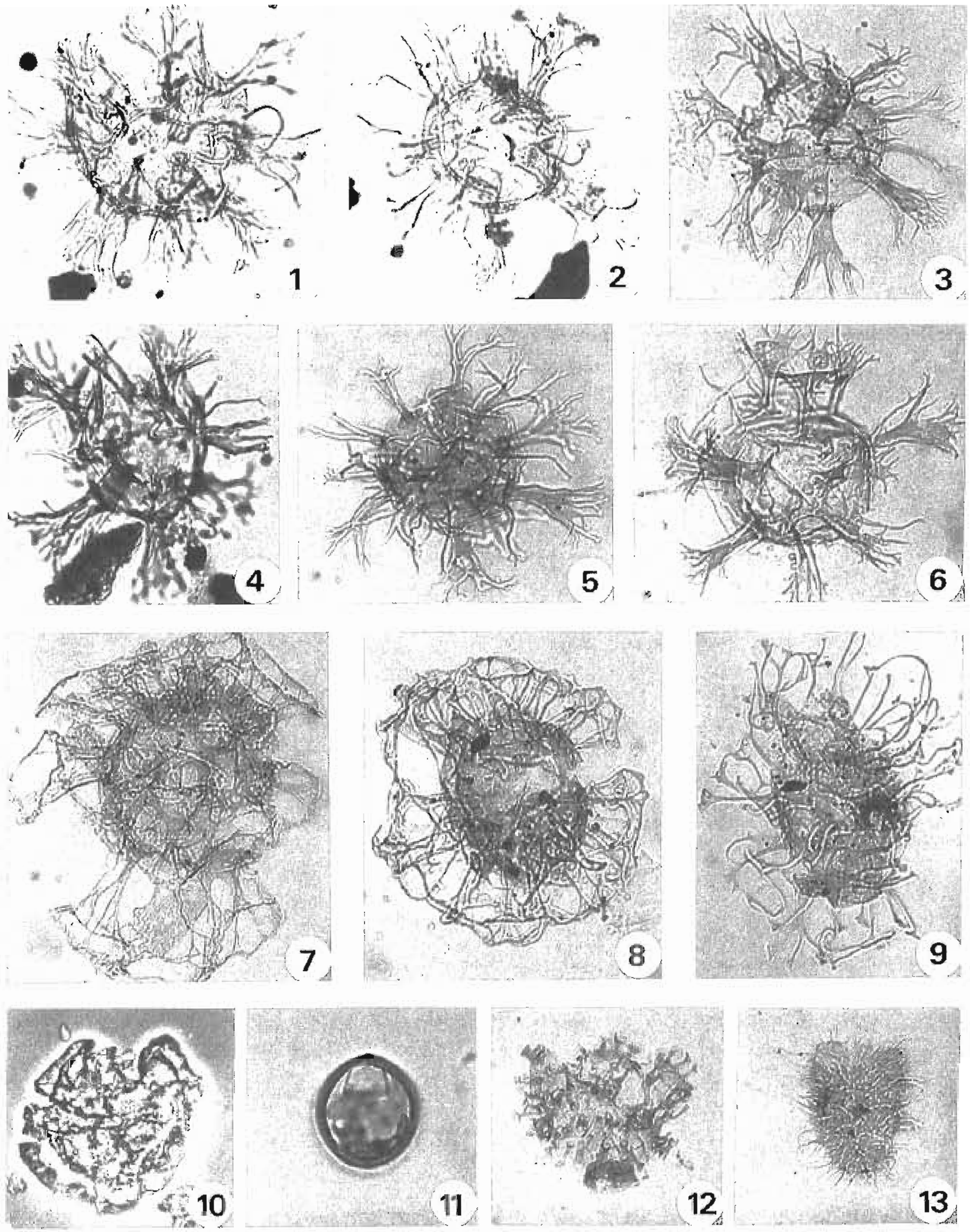
9 *Systematophora* sp. Specimen MPK 10388, sample TP 15, this specimen is possibly referable to *Systematophora areolata*, however, the process complexes are not distinctly separated and there are several distal trabeculae visible.

10 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10389, sample TP 16, specimen in dorsal view, high focus; note the prominent paracingulum and the antapical opisthopyle.

11 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10390, sample TP 17, ventral view, low focus; note the precingular archeopyle, the ovoidal ambitus and the smooth, relatively thick autophragm.

12 *Stephanelytron caytonense* Sarjeant 1961. Specimen MPK 10391, sample TP 15, note the antapical corona and the relatively sparse short processes.

13 *Prolixosphaeridium anasillum* Erkmen & Sarjeant 1980. Specimen MPK 10392, sample TP 15; note the apical archeopyle and the dense covering of simple spines.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# PLATE TP8

The dinoflagellate cyst *Rhynchodiniopsis cladophora* from the Lower Kimmeridgian of the River Izhma area, Pechora Basin (see section 5.2.2.2).

1-6 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Note the subovoidal to subquadrangular ambitus, the relatively thick, robust autophragm, the precingular archeopyle, the prominent apical horn and the spinose parasutural ridges of this large and distinctive taxon.

1 Specimen MPK 10393, sample TP 20, ventral view, high-median focus.

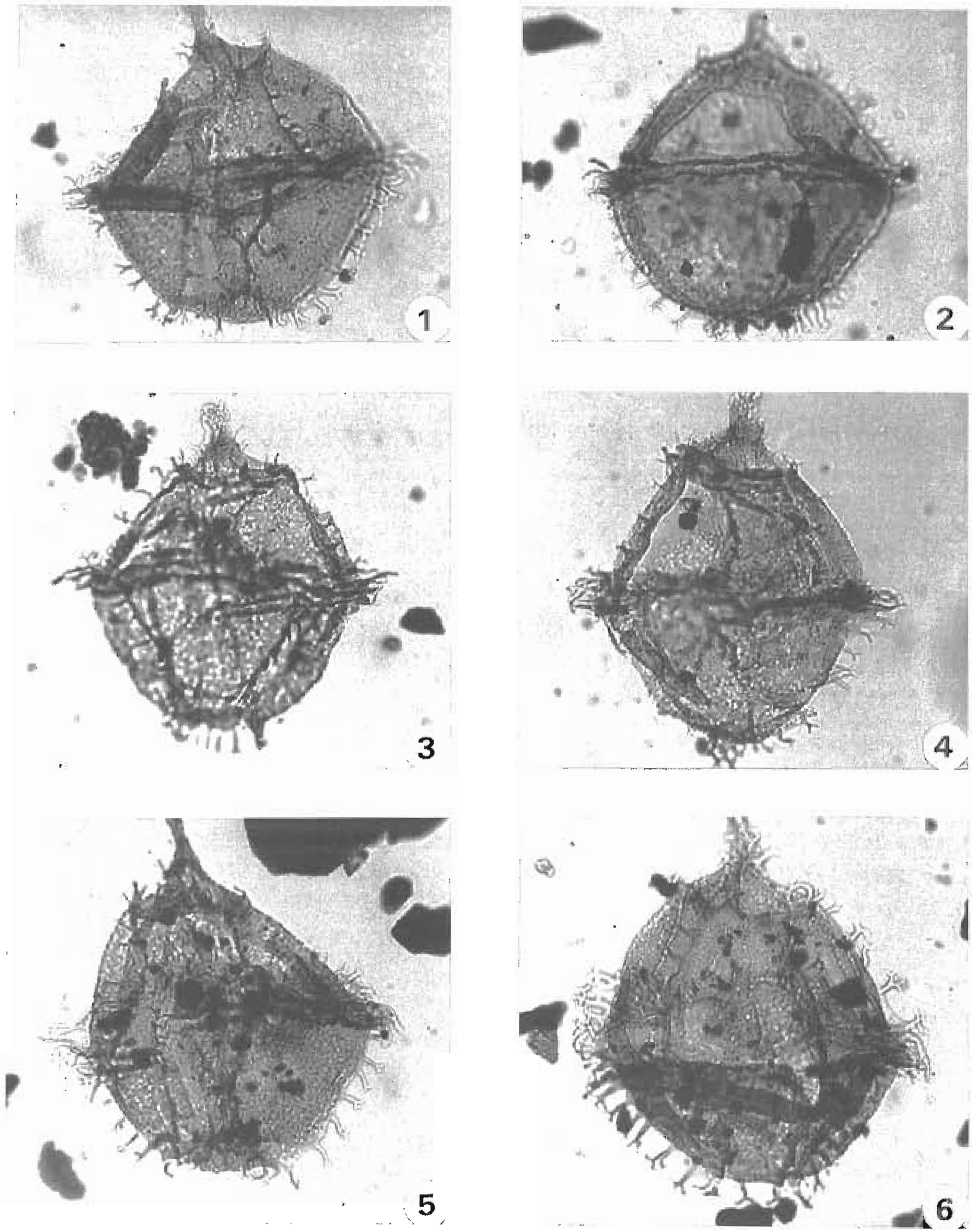
2 Specimen MPK 10394, sample TP 20, dorsal view, high focus.

3 Specimen MPK 10395, sample TP 20, dorsal view, low focus.

4 Specimen MPK 10396, sample TP 20, oblique dorsal view, high-median focus.

5 Specimen MPK 10397, sample TP 19, ventral view, high focus.

6 Specimen MPK 10398, sample TP 19, dorsal view, high focus.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# PLATE TP9

Dinoflagellate cysts from the Kimmeridgian of the River Pizhma area, Pechora Basin (see section 5.2.3). Figure 9 is a composite photomicrograph.

1 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Specimen MPK 10399, sample TP 29, specimen in oblique dorsal view, high focus; note the precingular archeopyle and the denticulate parasutural ridges.

2 *Leptodinium mirabile* Klement 1960. Specimen MPK 10400, sample TP 34, specimen in oblique dorsal view, low focus; note the mechanically damaged nature of this individual and the parasulcus which is subdivided into paraplates.

3 *Endoscrinium anceps* Raynaud 1978. Specimen MPK 10401, sample TP 29, specimen in slightly oblique dorsal view, median focus; note the cavate cyst organisation, the precingular archeopyle and the small apical horn

4-8 *Perisseiasphaeridium pannosum* Davey & Williams 1966. Note the apical archeopyle, the slender, solid paracingular processes and the prominent, cylindrical, distally expanded processes over the remainder of the cyst.
4 Specimen MPK 10402, sample TP 33, specimen in oblique dorsal view, median focus.
5 Specimen MPK 10403, sample TP 33, specimen in lateral view, high-median focus.
6 Specimen MPK 10404, sample TP 29, specimen in dorsal view, high focus.
7 Specimen MPK 10405, sample TP 29, specimen in dorsal view, high focus.
8 Specimen MPK 10406, sample TP 33, specimen in dorsal view, median focus.

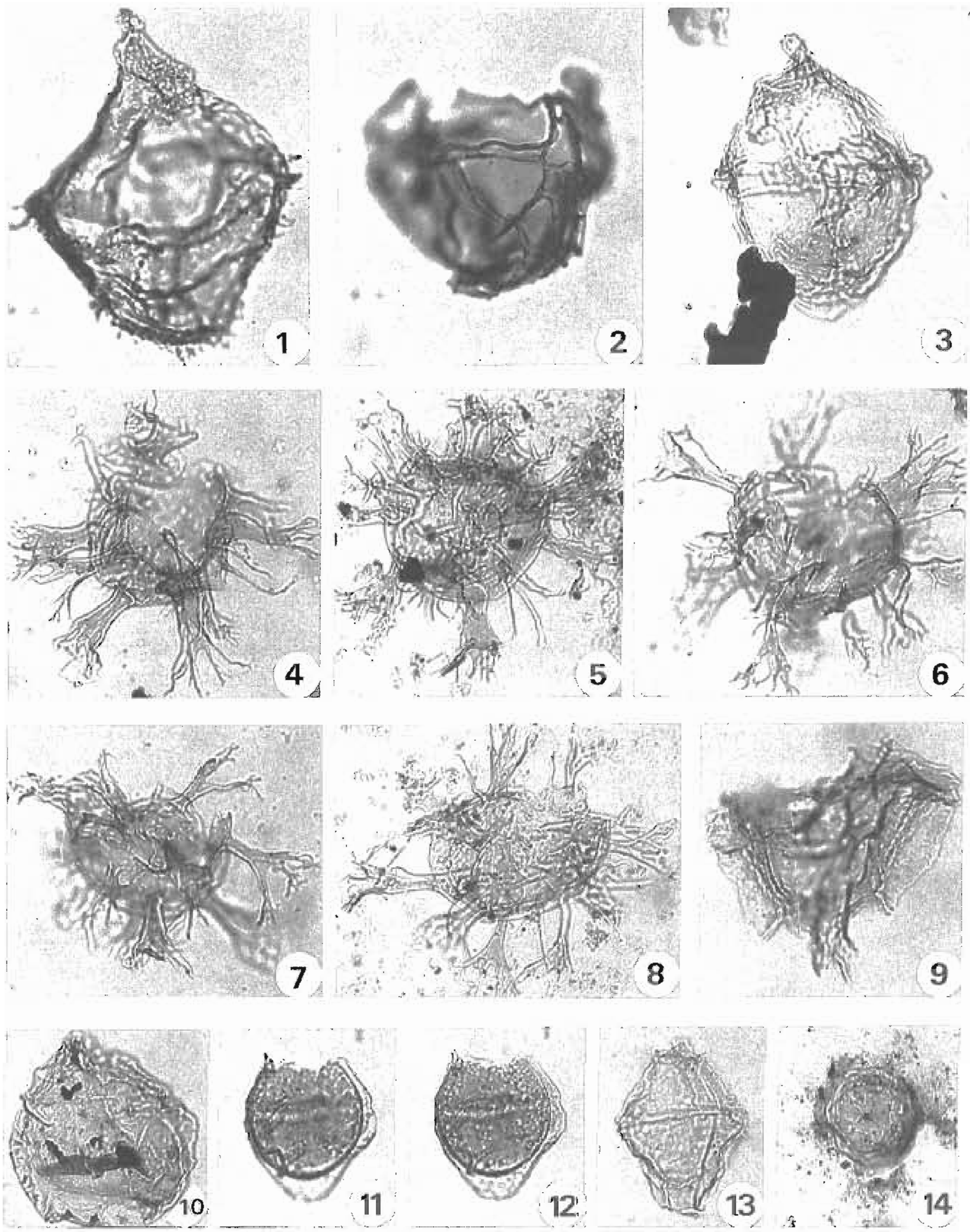
9 *Glossodinium dimorphum* Ioannides et al. 1977. Specimen MPK 10407, sample TP 30, composite photomicrograph, specimen in dorsal view; note the antapical protuberance and the high, smooth parasutural crests.

10 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10408, sample TP 29, specimen in ventral view, median focus; note the cavate cyst organisation.

11, 12 *Ambonosphaera? staffinensis* (Gitmez 1970) Riding & Poulsen 1992. Specimen MPK 10409, sample TP 28, specimen in dorsal view, 11 - median focus; 12 - low focus; note the apical archeopyle, the camocavate cyst organisation and the thick, scabrate endophragm.

13 *Tubotuberella dangeardi* (Sarjeant 1968) Stover & Evitt 1978. Specimen MPK 10410, sample TP 35, specimen in dorsal view, high focus; note the cavate cyst organisation, the gonyaulacacean paratabulation indicated by low, smooth ridges and the precingular archeopyle.

14 *Pareodinia halosa* (Filatoff 1975) Prauss 1989. Specimen MPK 10411, sample TP 33, note the main cyst and the irregular kalyptra.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# PLATE TP10

Dinoflagellate cysts from the late Ryazanian/early Valanginian of the River Pizhma area, Pechora Basin (see section 5.2.3). All specimens from sample TP 27. Figure 10 was taken using phase contrast.

1 *Endoscrinium anceps* Raynaud 1978. Specimen MPK 10412, specimen in dorsal view, high focus; note the small apical horn, the cavate cyst organisation and the precingular archeopyle.

2 *Tubotuberella rhombiformis* Vozzhennikova 1967. Specimen MPK 10413, specimen in dorsal view, high focus; note the large cyst size, the antapical opisthopyle and the precingular archeopyle.

3, 4 *Imbatodinium kondratjevii* Vozzhennikova 1967. Specimen MPK 10414, specimen in oblique dorsal/right lateral view, 3 - high focus, 4 - low focus; note the large cyst size, the longitudinally elongate ambitus, the dense, granulate-tuberculate ornamentation on the hypocyst and the anterior intercalary archeopyle.

5 *Cribroperidinium* sp. Specimen MPK 10415, specimen in ventral view, high focus; note the prominent apical horn.

6-8, 12 *Endoscrinium glabrum* (Duxbury 1977) Below 1981. Note the circumcavate cyst organisation, the precingular archeopyle and the gonyaulacacean paratabulation indicated by low ridges on the periphragm.
6 Specimen MPK 10416, specimen in dorsal view, median focus.
7, 8 Specimen MPK 10417, specimen in oblique ventral view, 7 - high focus, 8 - low-median focus.
12 Specimen MPK 10418, specimen in oblique right lateral view, high focus.

9, 13 *Achomosphaera* sp. Note the furcate, *Spiniferites*-type processes and the apparent lack of parasutural ridges.
9 Specimen MPK 10419, specimen in median focus.
13 Specimen MPK 10420, specimen in low focus.

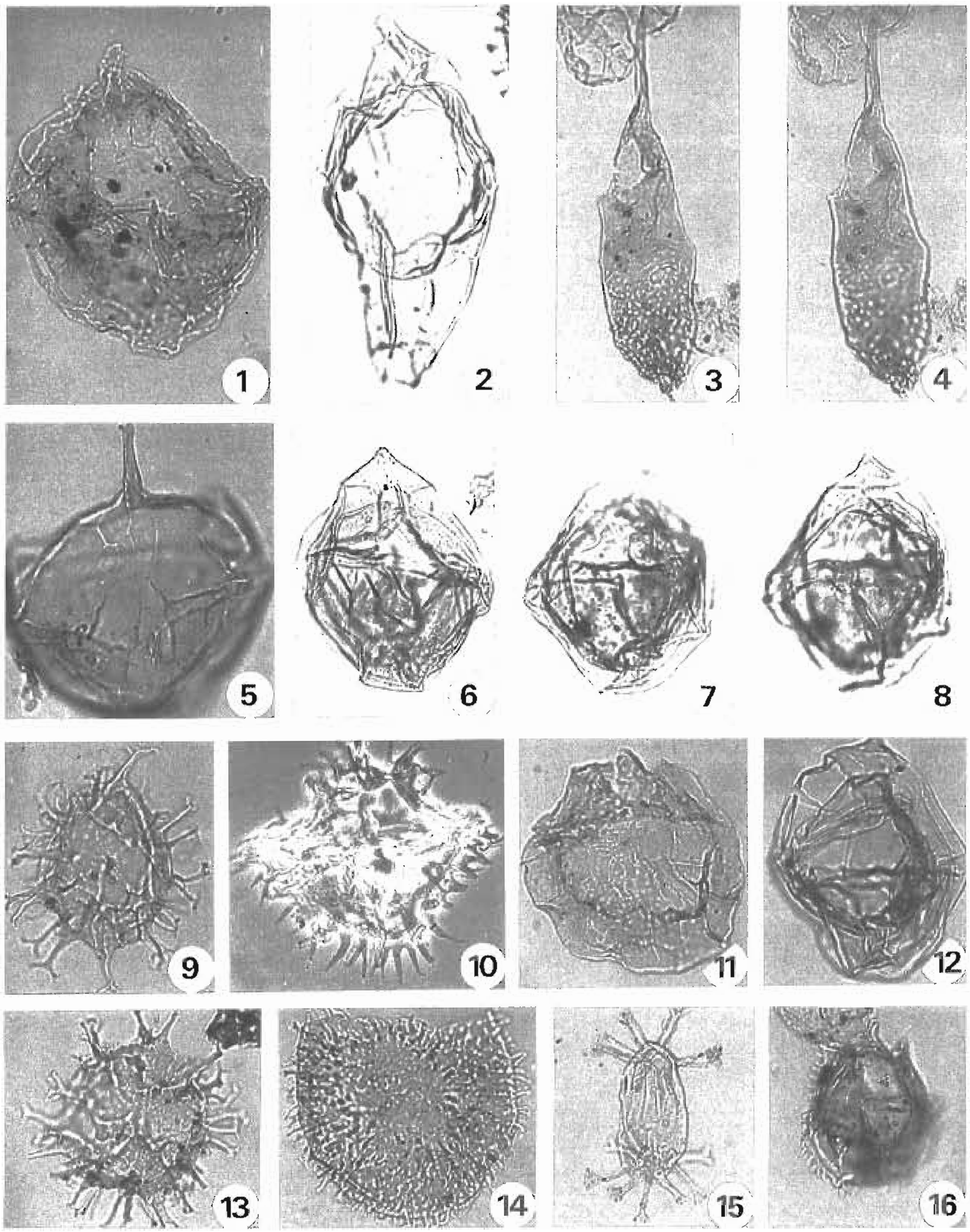
10 *Hystrichodinium pulchrum* Deflandre 1935. Specimen MPK 10421, specimen in oblique dorsal view, high focus; note the paracingulum and the prominent spinose parasutural crests.

11 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10422, specimen in dorsal view, high focus; note the cavate cyst organisation and the antapical opisthopyle.

14 *Circulodinium distinctum* (Deflandre & Cookson 1955) Jansonius 1986. Specimen MPK 10423, specimen in ventral view, median focus; note the marginate nature of the low-relief ornamentation, the apical archeopyle and the offset parasulcal area.

15 *Bourkodinium* sp. Specimen MPK 10424, note the bipolar concentation of the distally-expanded processes.

16 *Gonyaulacysta helicoidea* (Eisenack & Cookson 1960) Sarjeant 1966. Specimen MPK 10425, specimen in ventral view, high focus; note the intratabular tubercles, the denticulate parasutural crests and the profoundly laevorotatory paracingulum.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# PLATE TP11

Dinoflagellate cysts from the Volgian of the River Izhma area, Pechora Basin (see section 5.2.4).

1-2 *Glossodinium dimorphum* Ioannides et al. 1977. Note the antapical protuberance and the wide, smooth parasutural crests.

1 Specimen MPK 10426, sample TP 37, specimen in oblique dorsal view, high focus.

2 Specimen MPK 10427, sample TP 37, isolated hypocyst in antapical view, low focus.

3 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10428, sample TP 43, specimen in dorsal view, high focus; note the apical horn / protuberance, the cavate cyst organisation and the antapical opisthopyle.

4-5 *Tubotuberella rhombiformis* Vozzhennikova 1967. Note the elongate longitudinal ambitus, the apical horn and the cavate cyst organisation.

4 Specimen MPK 10429, sample TP 39, specimen in oblique dorsal view, high focus.

5 Specimen MPK 10430, sample TP 43, specimen in oblique dorsal view, high focus.

6, 7 *Imbatodinium* sp. A. This specimen is closely related to *Imbatodinium kondratjevii*, however, the granulate ornamentaion is concentrated in the antapical region. Note the anterior intercalary archeopyle and the prominent apical horn. Specimen MPK 10431, sample TP 43, specimen in ventral view, 6 - high focus; 7 - low focus.

8, 12-14 *Oligosphaeridium patulum* Riding & Thomas 1988. Note the apical archeopyle, the lack of paracingular processes and the large, cylindrical, distally expanded, paraplate-centered processes.

8 Specimen MPK 10432, sample TP 37, specimen in dorsal view, high focus.

12 Specimen MPK 10433, sample TP 39, specimen in ?ventral view, high focus.

13 Specimen MPK 10434, sample TP 37, specimen in dorsal view, high focus.

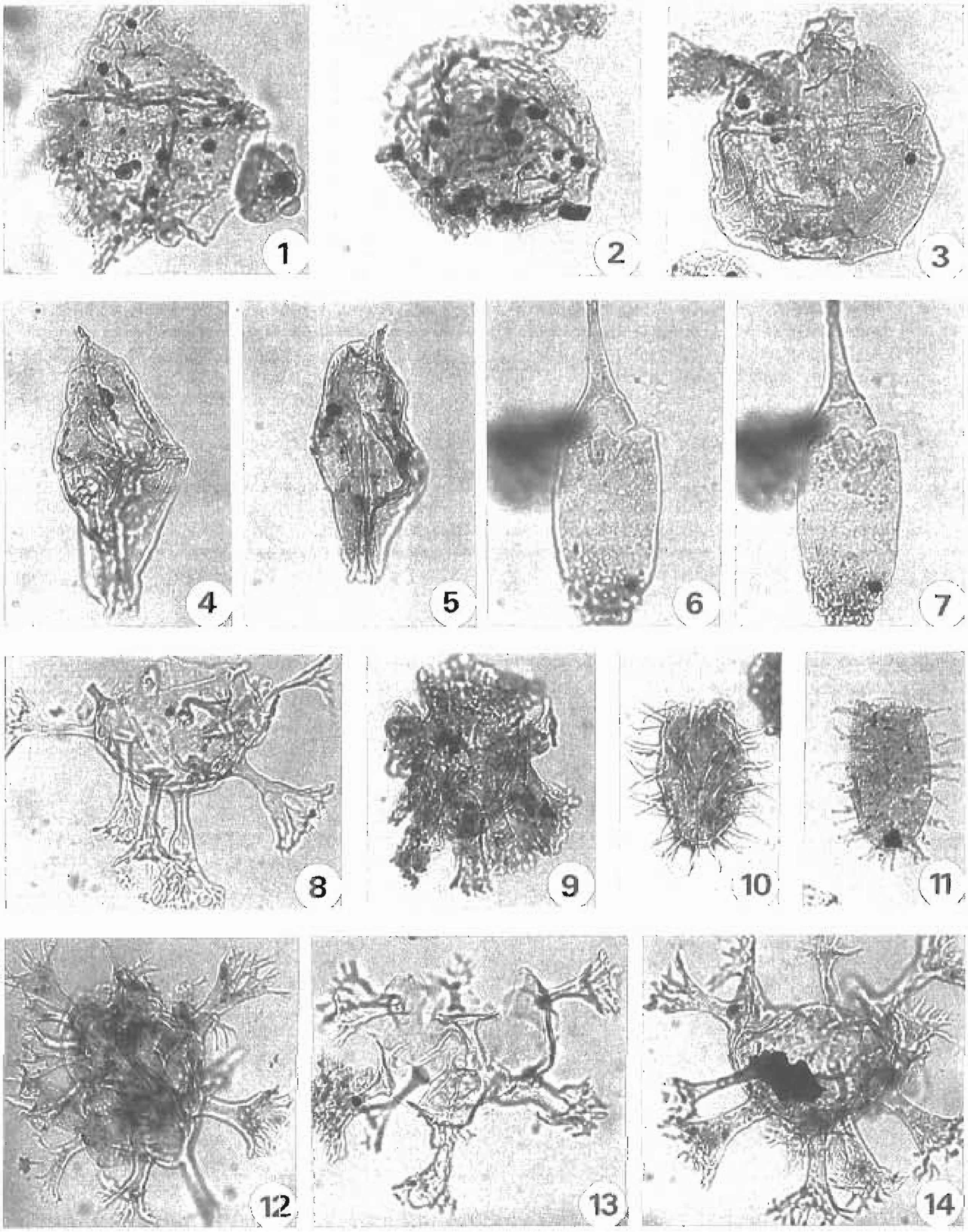
14 Specimen MPK 10435, sample TP 39, specimen in dorsal view, low focus.

9 *Kleithriasphaeridium porosispinum* Davey 1982. Specimen MPK 10436, sample TP 39, specimen in dorsal view, high focus; note the wide processes.

10-11 *Prolixosphaeridium parvispinum* (Deflandre 1937) Davey et al. 1969. Note the elongate nature of this species, the relatively short, simple spines and the apical archeopyle.

10 Specimen MPK 10437, sample TP 42.

11 Specimen MPK 10438, sample TP 43.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# PLATE RP1

The dinoflagellate cyst *Protobatioladinium* from the Bathonian of Borehole 132, near Elatma (see section 5.3.1.1). All figures taken using phase contrast except number 11.

1-12 *Protobatioladinium elatmaensis* Riding & Ilyina 1996. Note the acavate cyst organisation, the large apical horn and the significantly smaller antapical horn or protrusion, which is offset ventrally and the combination, type (tA) + (2I), archeopyle. The apical opercular paraplates, however, frequently remain attached to the loisthocyst. This species is not normally dorso-ventrally flattened, thus the equatorial portion of the hypocyst may form a distinctive subequatorial 'shoulder' in lateral/oblique lateral views.

1 Specimen MPK 10129, sample RP 14, a topotype in dorsal view, high focus; note the small antapical horn, offset to the right.

2 Specimen MPK 10130, sample RP 14, a topotype in lateral view, high focus; note the apparent lack of an archeopyle.

3 Specimen MPK 10131, sample RP 14, a topotype in right lateral view, high-median focus; note incipient archeopyle formation to the left of the epicyst.

4 Specimen MPK 10132, sample RP 14, a topotype in dorsal view, median focus; note the antapical horn, offset to the right.

5 Specimen MPK 10133, sample RP 14, a topotype in dorsal view; note the small antapical horn, offset to the right.

6 Specimen MPK 10134, sample RP 14, the holotype in left lateral view, high focus; note the disruption of the anterior intercalary paraplate series due to archeopyle formation.

7 Specimen MPK 10135, sample RP 14, a topotype in left lateral view, high-median focus; note the absence of the anterior intercalary paraplate series due to archeopyle formation.

8 Specimen MPK 10136, sample RP 14, a topotype in mid dorsal view, high-median focus; note the absence of the anterior intercalary paraplate series due to archeopyle formation.

9 Specimen MPK 10137, sample RP 11, specimen in mid dorsal view, high focus; note the relatively large archeopyle which may have been enlarged by mechanical damage.

10 Specimen MPK 10138, sample RP 13, specimen in dorsal view, high-median focus; note the complete archeopyle formation.

11 Specimen MPK 10139, sample RP 11, specimen in left lateral view, median focus; note incipient archeopyle formation to the right of the epicyst.

12 Specimen MPK 10140, sample RP 13, a badly mechanically damaged specimen in high-median focus.

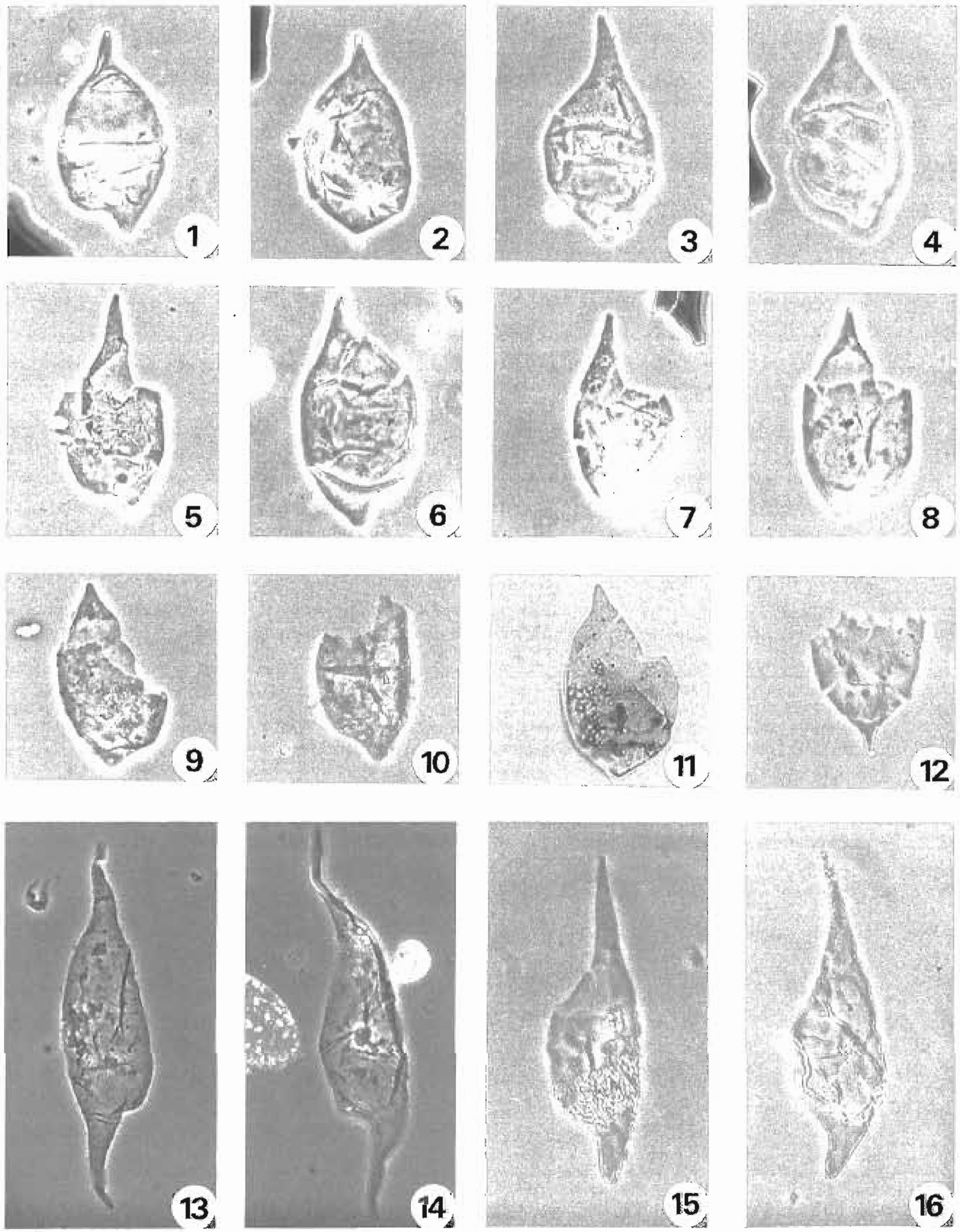
13-16 *Protobatioladinium? elongatum* Riding & Ilyina 1998. Note the acavate, slender, longitudinally elongate cyst organisation, the extremely large apical horn and the often smaller antapical horn, which is offset ventrally. This species is not dorso-ventrally flattened, thus the equatorial portion of the hypocyst may form a distinctive bulge or 'shoulder' in lateral and oblique lateral views. The archeopyle is anterior intercalary, apparently type (2I).

13 Specimen MPK 10141, sample RP 9, specimen in left lateral view, high focus; note the unusually homomorphic horns and the apparent lack of an archeopyle.

14 Specimen MPK 10142, sample RP 9, specimen in right lateral view, high-median focus; note the prominent apical horn and the apparent lack of an archeopyle.

15 Specimen MPK 10143, sample RP 13, the holotype in oblique dorsal/right lateral view, median focus; note the incipient archeopyle formation in the left of the epicyst.

16 Specimen MPK 10144, sample RP 13, a topotype in oblique right lateral view; note the archeopyle and the relatively small antapical horn.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# PLATE RP2

Dinoflagellate cysts (figures 1-6, 8, 9), an acritarch (figure 7), indigenous gymnosperm pollen (figure 10) and reworked Carboniferous spores (figures 11-13) from the Bathonian and Lower Callovian of Borehole 132, near Elatma (see sections 5.3.1.1 and 5.3.1.2). Figure 3 was taken using phase contrast.

1 *Korystocysta gochtii* (Sarjeant 1976) Woollam 1983. Specimen MPK 10439, sample RP 15, specimen in dorsal view, high focus; note the epicystal archeopyle and the gonyaulacacean paratabulation indicated by low parasutural ridges.

2 *Chytroeisphaeridia hyalina* (Raynaud 1978) Lentin & Williams 1981. Specimen MPK 10440, sample RP 7, specimen in left lateral view, high focus; note the smooth autophragm and the large precingular archeopyle.

3 *Nannoceratopsis pellucida* Deflandre 1938. Specimen MPK 10441, sample RP 15, photomicrograph taken using phase contrast; note the deep antapical concavity.

4-5 *Ctenidodinium sellwoodii* (Sarjeant 1975) Stover & Evitt 1978. Note the wide, squat nature of this species, the epicystal archeopyle and the low parasutural ridges which are often denticulate.

4 Specimen MPK 10442, sample RP 15, specimen in oblique ventral view, high focus.

5 Specimen MPK 10443, sample RP 15, an isolated hypocyst in dorsal view, high focus.

6 *?Lithodinia caytonensis* (Sarjeant 1959) Gocht 1976. Specimen MPK 10444, sample RP 7, specimen in dorsal view, high-median focus; note the apical archeopyle, the thick autophragm and the low parasutural ridges.

7 *Schizocystia rara* Playford & Dettmann 1965. Specimen MPK 10445, sample RP 16, a specimen in which the equatorial split has operated.

8 *Mendicodinium groenlandicum* (Pocock & Sarjeant 1972) Davey 1979. Specimen MPK 10446, sample RP 14, specimen in ventral view, high-median focus; note the smooth, relatively thin autophragm and the epicystal archeopyle.

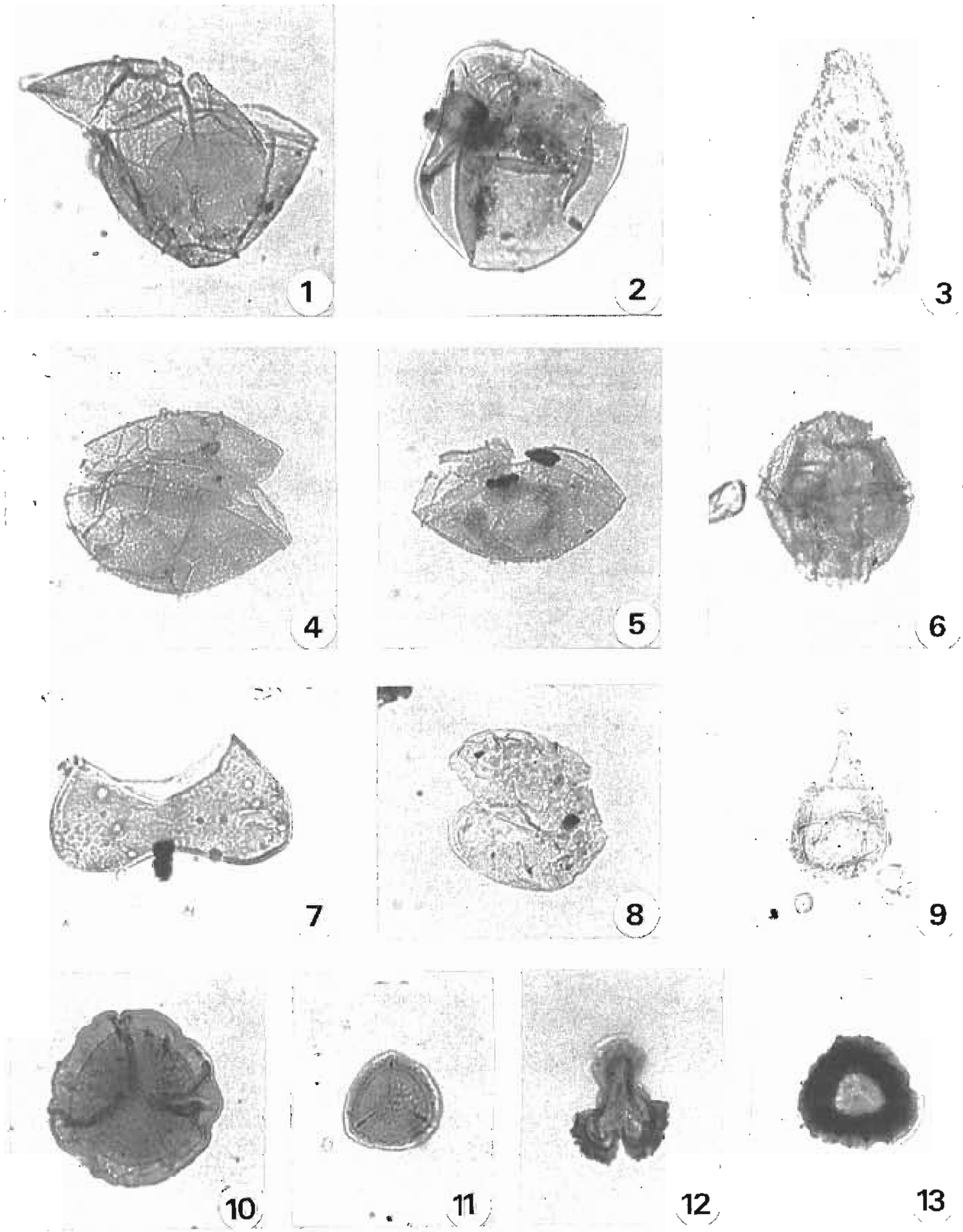
9 *Pareodinia ceratophora* Deflandre 1947. Specimen MPK 10447, sample RP 16, note the single apical horn.

10 *Callialasporites dampieri* (Balme 1957) Sukh Dev 1961. Specimen MPK 10448, sample RP 10, specimen in proximal view, high-median focus; note the cavate nature of this genus and the prominent vestigial trilete mark.

11 *Lycospora pusilla* (Ibrahim 1932) Schopf et al. 1944. Specimen MPK 10449, sample RP 14, specimen in proximal view.

12 *Tripartites vetustus* Schemel 1950. Specimen MPK 10450, sample RP 13, specimen in proximal view.

13 *Densosporites rarispinosus* Playford 1963. Specimen MPK 10451, sample RP 12, specimen in proximal view.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# PLATE RP3

Dinoflagellate cysts from the Lower and Middle Oxfordian of Borehole 132, near Elatma (see section 5.3.1.3). Figure 10 was taken using phase contrast.

1 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *reticulatum* (Klement 1960) Górka 1970. Specimen MPK 10452, sample RP 3, specimen in oblique dorsal view, high-median focus; note the strongly reticulate periphragm and the large cyst size.

2 *Trichodinium scarburghensis* (Sarjeant 1964) Williams et al. 1993. Specimen MPK 10453, sample RP 6, specimen in dorsal view, high-median focus; note the prominent apical horn and the extremely thick, differentiated autophragm.

3 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *adecta* Sarjeant 1982 var. *longicornis* (Deflandre 1938) Sarjeant 1982. Specimen MPK 10454, sample RP 3, specimen in ventral view, median focus; note the extremely large epipericoel.

4 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *galeritum* (autonym). Specimen MPK 10455, sample RP 6, specimen in dorsal view, median focus; note the granulate/scabrate ornamentation.

5 *Endoscrinium luridum* (Deflandre 1938) Gocht 1970. Specimen MPK 10456, sample RP 1, specimen in dorsal view, median focus, note the circumcavate cyst organisation.

6 *Scriniodinium crystallinum* (Deflandre 1938) Klement 1960. Specimen MPK 10457, sample RP 4, specimen in dorsal view, high-median focus; note the circumcavate nature of the cyst.

7 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *jurassica* (autonym). Specimen MPK 10458, sample RP 3, specimen in ventral view, median focus; note the bicavate cyst organisation.

8 *Lithodinia* sp. A. Specimen MPK 10459, sample RP 3, specimen in dorsal view, high focus, note the thick autophragm.

9 *Limbodinium absidatum* (Drugg 1978) Riding 1987. Specimen MPK 10460, sample RP 6, a fragment of an individual cyst in oblique dorsal/antapical view, high focus, note the prominent paracingular flange.

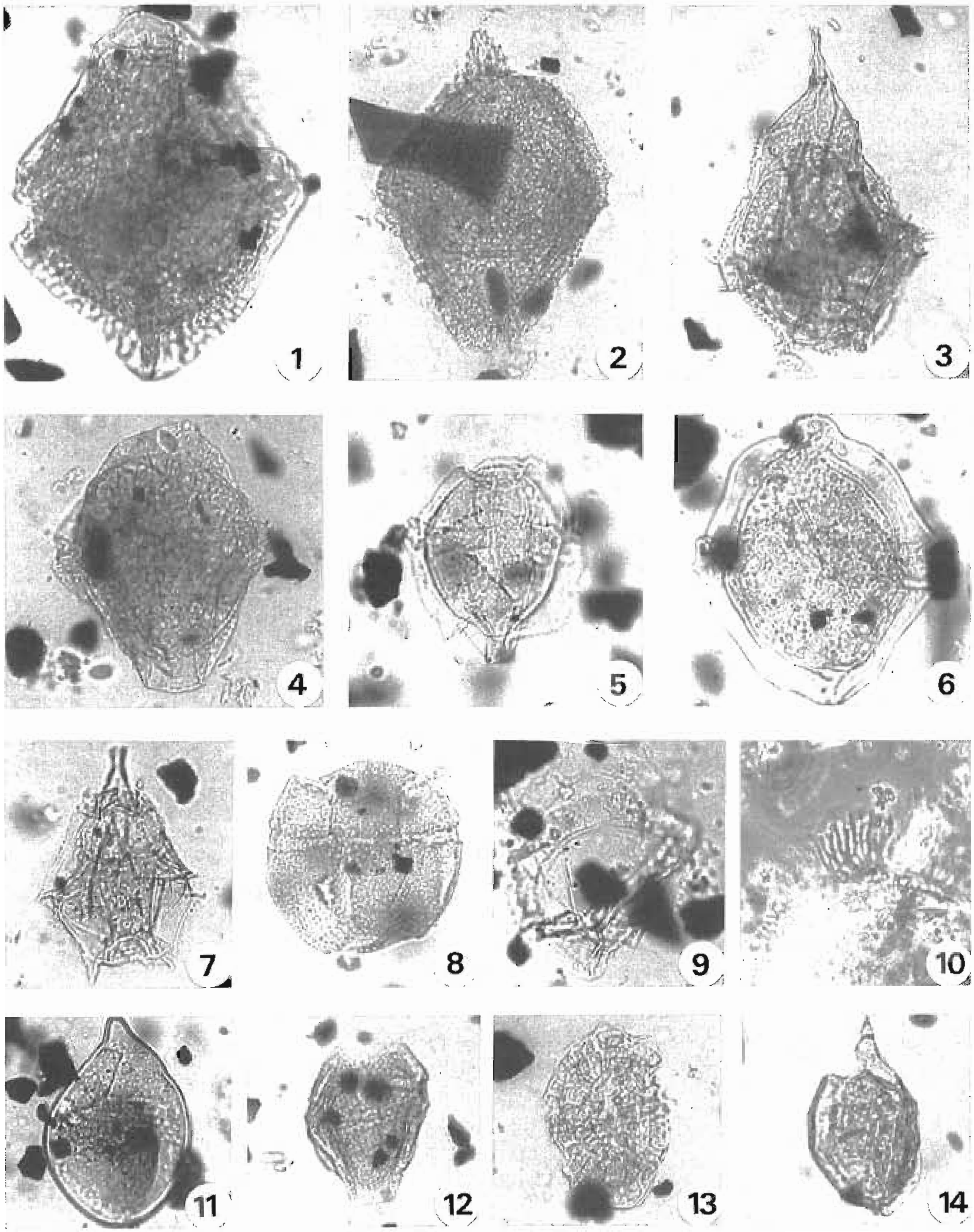
10 *Wanaea thysanota* Woollam 1982. Specimen MPK 10461, sample RP 6, a small fragment of an isolated hypocyst including part of the distinctive posterior paracingular flange, high focus.

11 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10462, sample RP 5, specimen in oblique dorsal/right lateral view, high/median focus, note the apical horn, the thick, smooth autophragm and the prominent precingular archeopyle.

12 *Ambonosphaera? staffinensis* (Gitmez 1970) Poulsen & Riding 1992. Specimen MPK 10463, sample RP 2, specimen in ventral view, median focus, note the narrow pericoel and the thick endophragm.

13 *Stephanelytron redcliffense* Sarjeant 1961. Specimen MPK 10464, sample RP 6, note the numerous short processes and the holocavate cyst organisation.

14 *Crussolia deflandrei* Wolfard & Van Erve 1981. Specimen MPK 10465, sample RP 3, specimen in dorsal view, high-median focus, note the large anterior intercalary archeopyle and the narrow pericoel.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# PLATE RP4

Dinoflagellate cysts from the Lower Callovian, Upper Callovian and Lower Oxfordian of outcrop 5, on the west bank of the River Oka, near Inkino village in the Elatma region (see section 5.3.2). Figure 1 is a composite photomicrograph and figure 3 was taken using phase contrast.

1-2 *Trichodinium scarburghensis* (Sarjeant 1964) Williams et al. 1993. Note the large cyst size and the prominent apical horn which comprises amastomosing fibrous ornamentation/processes.

1 Specimen MPK 10466, sample RP 17, composite photomicrograph; specimen in oblique dorsal view.

2 Specimen MPK 10467, sample RP 17, specimen in oblique dorsal view, high-median focus.

3, 6 *Wanaea fimbriata* Sarjeant 1961. Note the wide, fenestrate posterior paracingular flange.

3 Specimen MPK 10468, sample RP 17, hypocyst in anterior view.

6 Specimen MPK 10469, sample RP 17, damaged hypocyst in anterior view.

4 *Chytroeisphaeridia hyalina* (Raynaud 1978 Lentin & Williams 1981. Specimen MPK 10470, sample RP 22, specimen in left lateral view, high focus; note the subcircular ambitus, the precingular archeopyle and the large cyst size.

5 *Cleistosphaeridium varispinosum* (Sarjeant 1959) Woollam & Riding 1983. Specimen MPK 10471, sample RP 19, note the relatively short, distally capitate processes.

7 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10472, sample RP 17, specimen in oblique dorsal view, high focus; note the wide pericoel and the antapical opisthopyle.

8 *Sirmiodiniopsis orbis* Drugg 1978. Specimen MPK 10473, sample RP 22, specimen in dorsal view, median to low focus; note the apical archeopyle and the cavate cyst organisation.

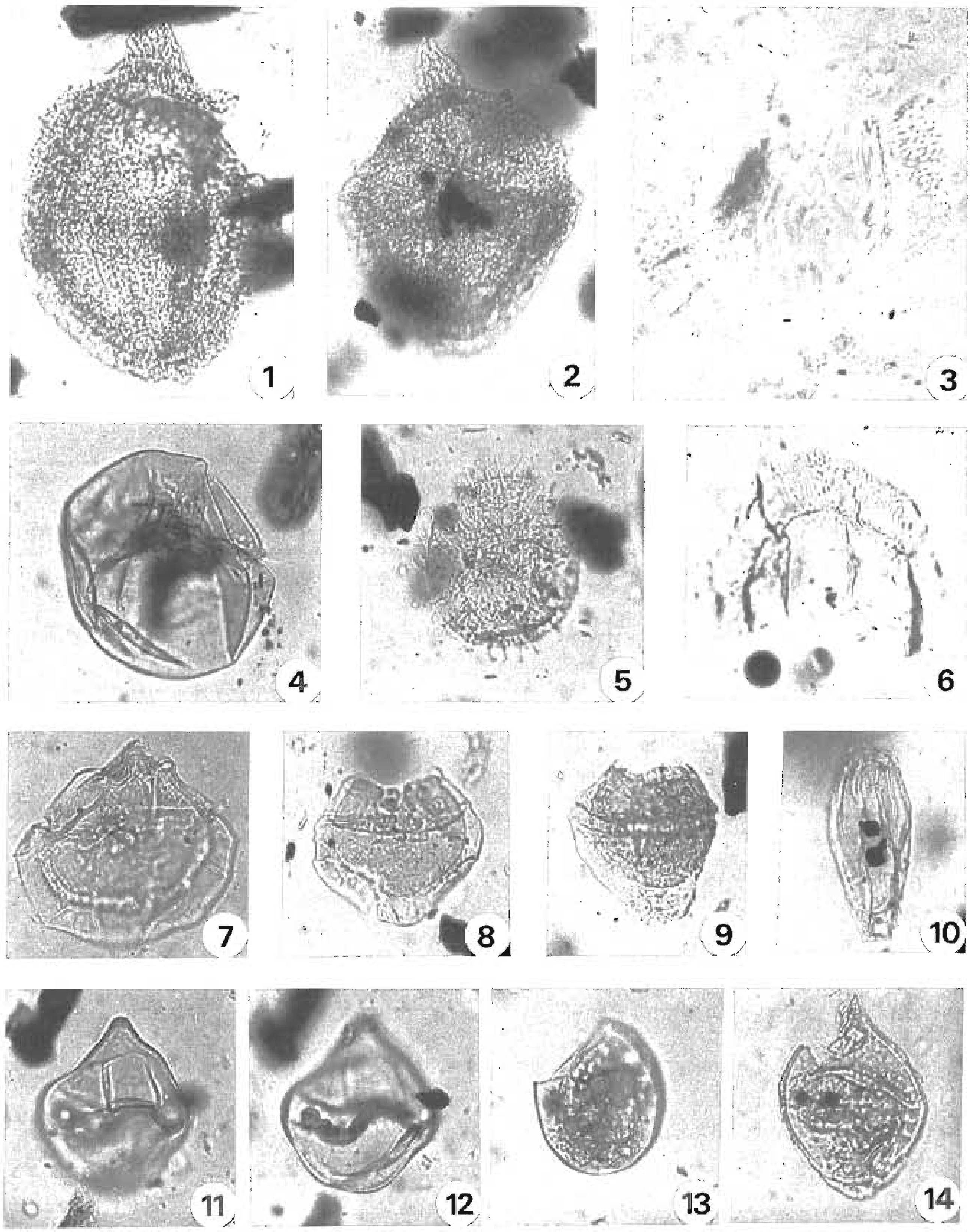
9 *Ambonosphaera? staffinensis* (Gitmez 1970) Poulsen & Riding 1992. Specimen MPK 10474, sample RP 17, specimen in dorsal view, median focus; note the camocavate cyst organisation, the relatively thick endophragm and the apical archeopyle.

10 *Clathroctenocystis asapha* (Drugg 1978) Stover & Helby 1987. Specimen MPK 10475, sample RP 17, note the apical archeopyle and the longitudinally elongate nature of this species.

11, 12 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10476, sample RP 17, specimen in dorsal view, 11 - high focus; 12 - low focus; note the prominent apical horn, the smooth autophragm and the precingular archeopyle.

13 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10477, sample RP 22, specimen in right lateral view, high focus, note the large precingular archeopyle.

14 *Crussolia deflandrei* Wolfard & Van Erve 1981. Specimen MPK 10478, sample RP 17, specimen in right lateral view, median focus, note the anterior intercalary archeopyle and the narrow pericoel.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# PLATE RP5

Dinoflagellate cysts (figures 1-15) and *Botryococcus braunii* (freshwater/brackish alga) (figure 16) from the Upper Callovian and Lower Oxfordian of section 2, River Unzha area, near Kostroma (see section 5.3.3.1).

1-5 *Crussolia dalei* Smelror & Århus 1989. Note the intercalary, type 3I, archeopyle and the bicavate cyst organisation

1, 2 Specimen MPK 10479, sample RP 28, specimen in dorsal view; 1 - high focus, 2 - low focus.

3, 4 Specimen MPK 10480, sample RP 29, specimen in oblique dorsal view; 3 - high focus, 4 - low focus.

5 Specimen MPK 10481, sample RP 29, specimen in oblique dorsal view, high focus.

6, 7 *Crussolia perireticulata* Århus et al. 1989. Specimen MPK 10482, sample RP 29, specimen in slightly oblique dorsal view; 6 - high focus, 7 - low focus; note the reticulate periphragm and the cavate nature of this species.

8 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10483, sample RP 29, specimen in dorsal view, high focus; note the large precingular archeopyle and the apical horn.

9, 10 *Crussolia deflandrei* Wolfard & Van Erve 1981. Specimen MPK 10484, sample RP 29, specimen in oblique dorsal view; 9 - high focus, 10 - low focus; note the large apical horn.

11 *Lithodinia* sp. A. Specimen MPK 10485, sample RP 29, specimen in dorsal view, median focus; note the extremely thick autophragm.

12 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10486, sample RP 32, specimen in right lateral view, high focus; note the precingular archeopyle and smooth autophragm.

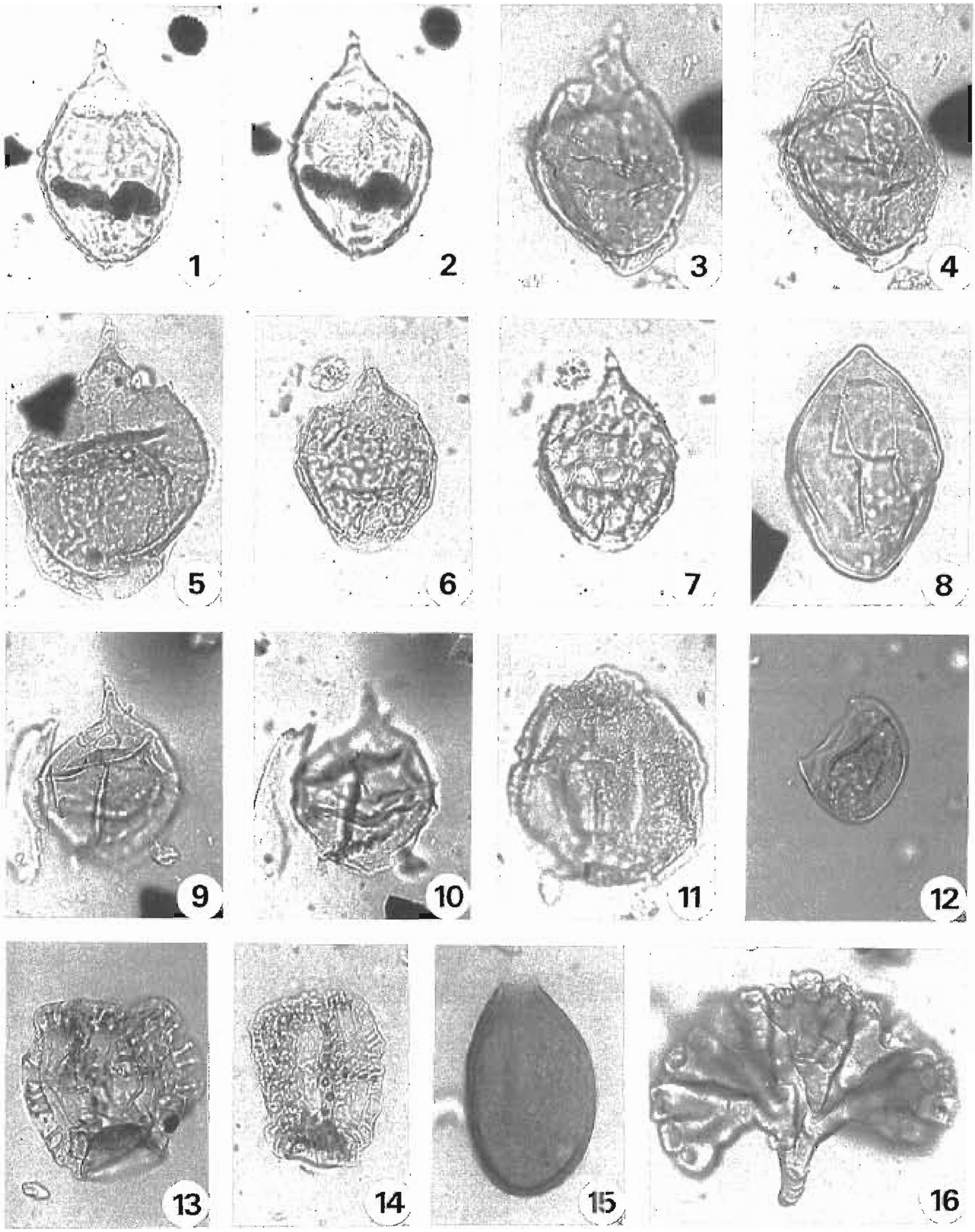
13-14 *Stephanelytron redcliffense* Sarjeant 1961. Note the antapical corona, the apical archeopyle and the parasutural configuration of the short processes.

13 Specimen MPK 10487, sample RP 30, specimen in dorsal view, median focus.

14 Specimen MPK 10488, sample RP 28, specimen in oblique dorsal view, high focus.

15 *Fromea tornatilis* (Drugg 1978) Lentin & Williams 1981. Specimen MPK 10489, sample RP 32, note the thick, smooth autophragm and small apical archeopyle.

16 *Botryococcus braunii* Kützing 1849. Specimen MPK 10490, sample RP 32, a colonial freshwater/brackish alga; note the distal cups attached to a proximal stem.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# PLATE RP6

Dinoflagellate cysts from the Upper Callovian and Lower Oxfordian of section 2, River Unzha area, near Kostroma (see section 5.3.3.1). Figures 6 and 10 taken using phase contrast.

1, 2 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *reticulatum* (Klement 1960) Górka 1970. Specimen MPK 10491, sample RP 28, specimen in dorsal view; 1 - high focus, 2 - low focus; note the strongly reticulate periphragm and the distinctly pentangular ambitus.

3 *Scriniodinium crystallinum* (Deflandre 1938) Klement 1960. Specimen MPK 10492, sample RP 29, specimen in dorsal view, high focus; note the wide pericoel and the circumcavate cyst organisation.

4 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *galeritum* (autonym). Specimen MPK 10493, sample RP 28, specimen in ventral view, median focus; note the large cyst size and the granulate/scabrate cyst walls.

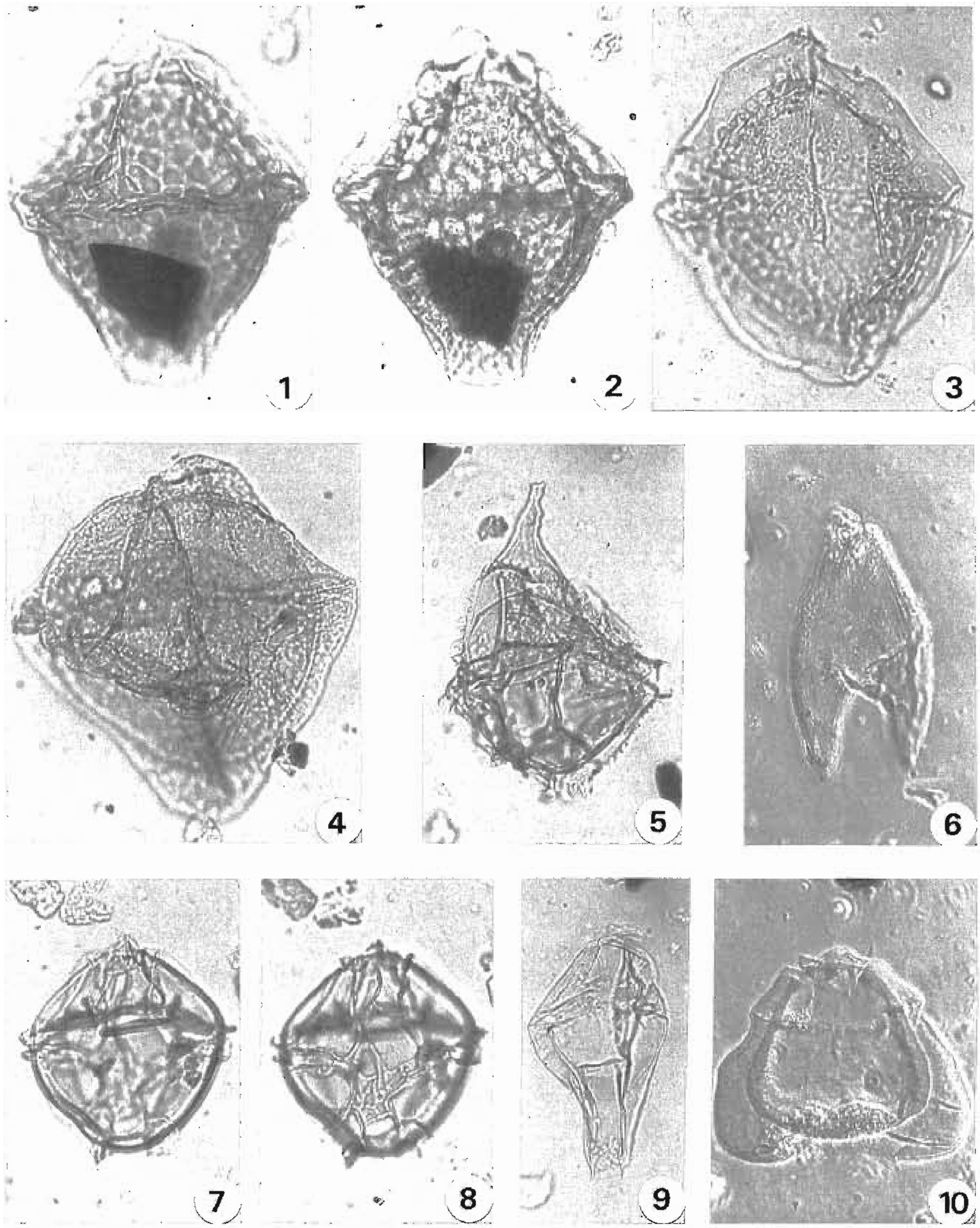
5 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 *adecta* Sarjeant 1982 var. *longicornis* (Deflandre 1938) Sarjeant 1982. Specimen MPK 10494, sample RP 29, specimen in left lateral view, high focus; note the large apical horn and the prominent epicoel.

6 *Nannoceratopsis pellucida* Deflandre 1938. Specimen MPK 10495, sample RP 32; note the large antapical horns.

7, 8 *Leptodinium subtile* Klement 1960. Specimen MPK 10496, sample RP 28, specimen in dorsal view; 7 - median focus, 8 - low focus; note the ovoidal ambitus and the smooth parasutural crests.

9 *Tubotuberella rhombiformis* Vozzhennikova 1967. Specimen MPK 10497, sample RP 29, specimen in dorsal view, high focus; note the prominent antapical extension of the periphragm.

10 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10498, sample RP 28, specimen in dorsal view, high focus; a subtriangular morphotype with wide pericoels, particularly on the hypocyst, note also the antapical opisthopyle.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# PLATE RP7

Dinoflagellate cysts from the Middle Oxfordian of section 2, River Unzha area, near Kostroma (see section 5.3.3.1).

1-2, 4, 7 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *reticulatum* (Klement 1960) Górka 1970. Note the large cyst size, the cavate cyst organisation and the reticulate periphragm.

1, 2 Specimen MPK 10499, sample RP 25, specimen in oblique dorsal view; 1 - median focus, 2 - low focus.

4 Specimen MPK 10500, sample RP 24, specimen in ventral view, median focus; note the prominent parasulcus.

7 Specimen MPK 10501, sample RP 27, specimen in ventral view, median/low focus.

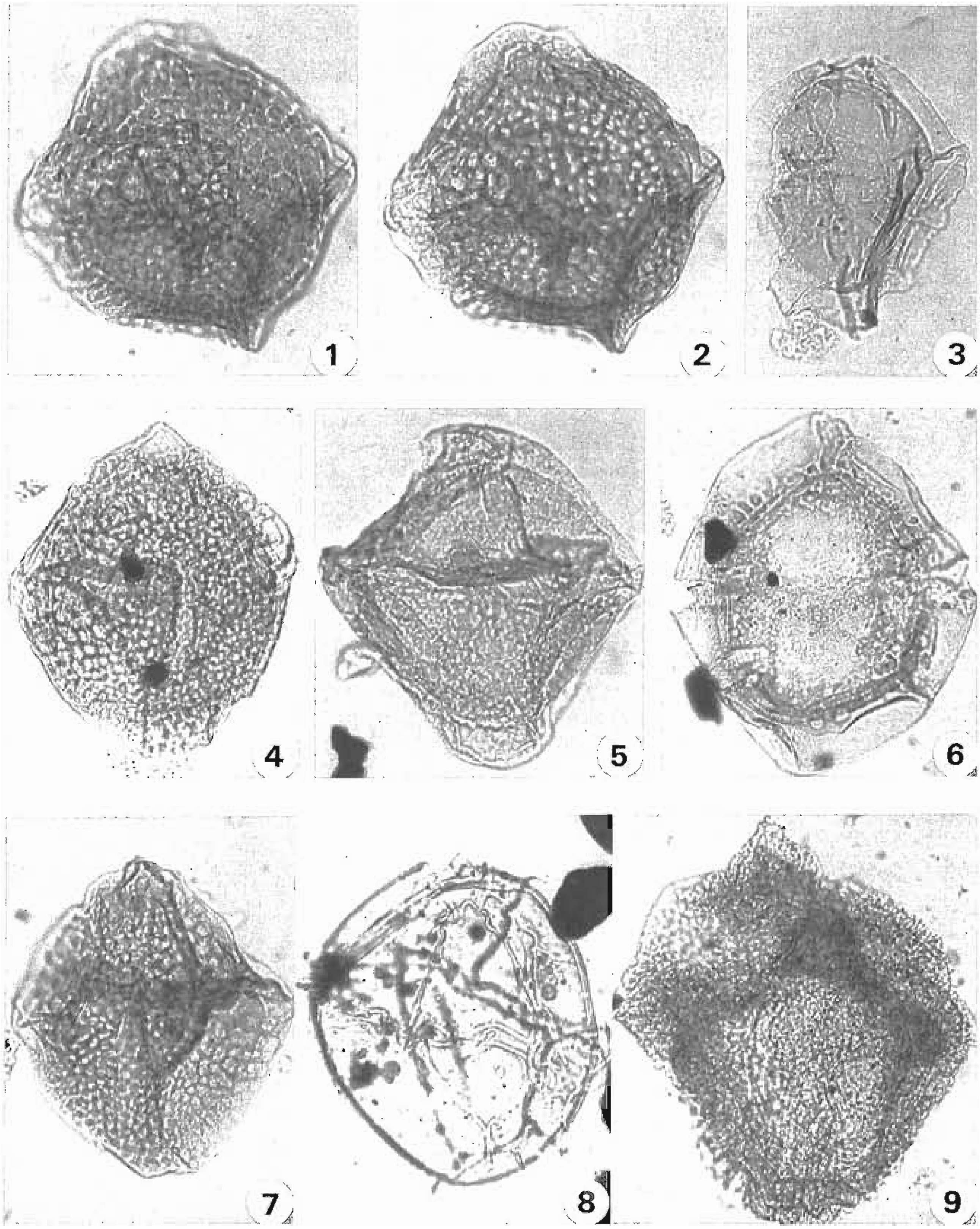
3 *Endoscrinium luridum* (Deflandre 1938) Gocht 1970. Specimen MPK 10502, sample RP 26, specimen in dorsal view, high focus; note the subpentangular cyst ambitus and the circumcavate cyst organisation.

5 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *galeritum* (autonym). Specimen MPK 10503, sample RP 25, specimen in dorsal view, high focus; note the precingular archeopyle and the scabrate/microgranulate periphragm.

6 *Scriniodinium crystallinum* (Deflandre 1938) Klement 1960. Specimen MPK 10504, sample RP 26, specimen in dorsal view, high/median focus; note the paired equatorial claustra, the wide pericoel and the large precingular archeopyle.

8 *Leptodinium mirabile* Klement 1960. Specimen MPK 10505, sample RP 24, specimen in oblique dorsal view, low focus; note the large cyst size, the low, smooth parasutural crests and the ovoidal ambitus.

9 *Trichodinium scarburghensis* (Sarjeant 1964) Williams et al. 1993. Specimen MPK 10506, sample RP 26, specimen in oblique dorsal view, median focus; note the large cyst size and the thick, differentiated autophragm.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# PLATE RP8

Dinoflagellate cysts from the Middle Oxfordian of section 2, River Unzha area, near Kostroma (see section 5.3.3.1). Figure 8 taken using phase contrast.

1 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 *adecta* Sarjeant 1982 var. *longicornis* (Deflandre 1938) Sarjeant 1982. Specimen MPK 10507, sample RP 27, specimen in dorsal view, high focus; note the prominent apical horn.

2-3 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 *jurassica* (autonym). Note the bicavate cyst organisation.
2 Specimen MPK 10508, sample RP 24, specimen in ventral view, median focus.
3 Specimen MPK 10509, sample RP 24, specimen in oblique dorsal view, high focus.

4 *Gonyaulacysta eisenackii* (Deflandre 1938) Górka 1965. Specimen MPK 10510, sample RP 24, specimen in dorsal view, high focus.

5 *Gonyaulacysta dualis* (Brideaux & Fisher 1976) Stover & Evitt 1978. Specimen MPK 10511, sample RP 26, left lateral view, high-median focus; note the smooth parasutural crests.

6-7 *Chytroeisphaeridia cerastes* Davey 1979. Note the smoth autophragm and the precingular archeopyle.
6 Specimen MPK 10512, sample RP 27, specimen in right lateral view, high focus.
7 Specimen MPK 10513, sample RP 26, specimen in oblique left lateral/dorsal view, high focus.

8 *Sirmiodinium grossii* Alberti 1961. Specimen MPK 10514, sample RP 26, specimen in dorsal view, high focus, a subcircular morphotype; note the prominent paracingulum and the antapical opisthopyle.

9, 10 *Paragonyaulacysta* sp. Specimen MPK 10515, sample RP 24, specimen in oblique dorsal view; 9 - high focus, 10 - low focus; note the short apical horn and the low parasutural ridges.

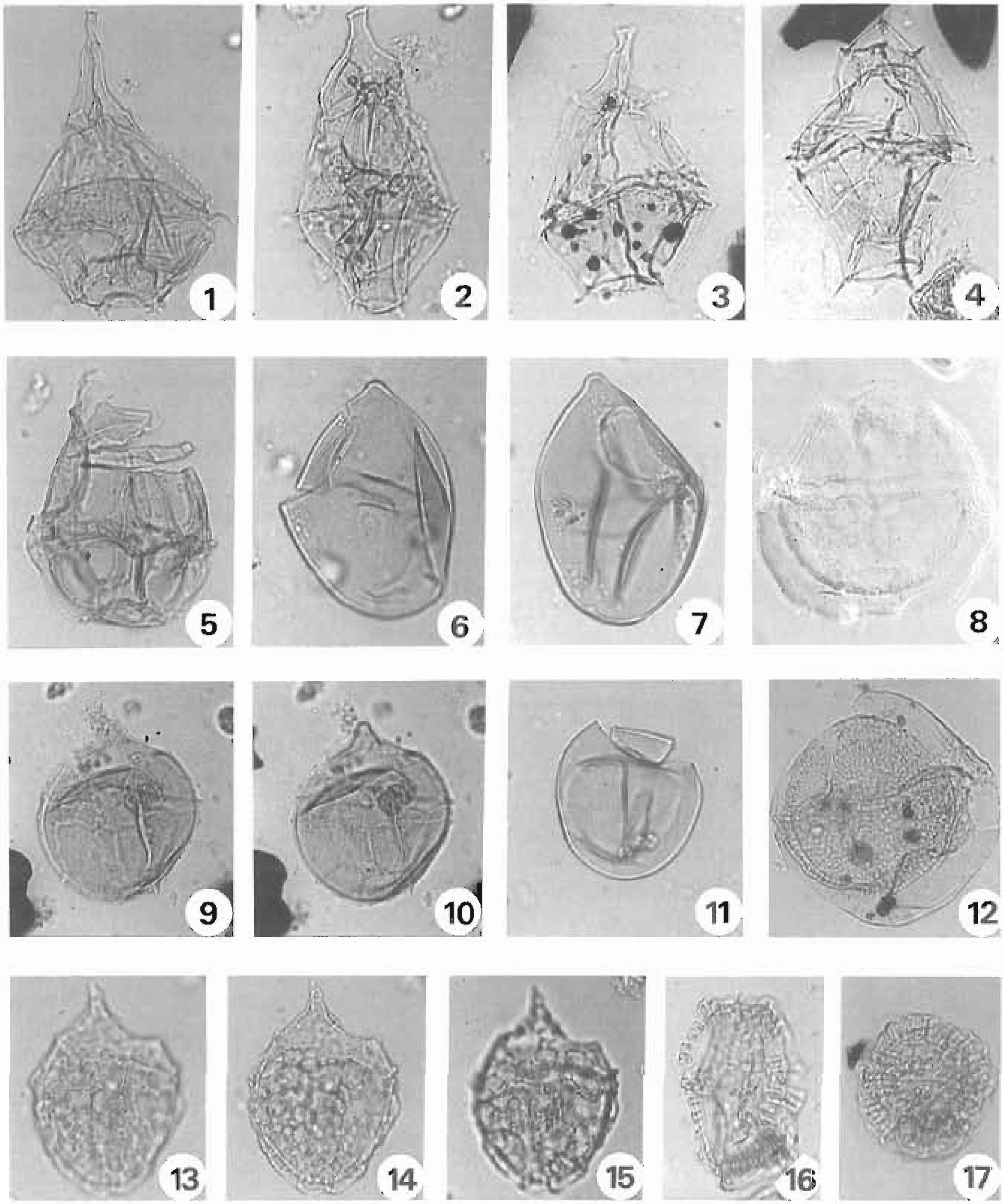
11 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10516, sample RP 26, specimen in left lateral view, high focus; note the precingular archeopyle.

12 *Dingodinium jurassicum* Cookson & Eisenack 1958. Specimen MPK 10517, sample RP 24, specimen in right lateral view, high focus; note the wide pericoel and the camocavate cyst organisation.

13-15 *Crussolia perireticulata* Århus et al. 1989. Specimen MPK 10518, sample RP 27, specimen in dorsal view, high to low focus sequence; note the wide reticulate periphragm.

16 *Stephanelytron redcliffense* Sarjeant 1961. Specimen MPK 10519, sample RP 26, specimen in dorsal view, high-median focus; note the antapical corona and the parasutural processes.

17 *Stephanelytron scarburghense* Sarjeant 1961. Specimen MPK 10520, sample RP 27; note the nontabular processes.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# PLATE RP9

Dinoflagellate cysts from the Middle and Upper Oxfordian of section 1, River Unzha area, near Kostroma (see section 5.3.3.2).

1 *Endoscrinium galeritum* (Deflandre 1938) Vozzhennikova 1967 subsp. *galeritum* (autonym). Specimen MPK 10521, sample RP 36, specimen in ventral view, high focus; note the large size and cavate cyst organisation.

2, 3, 6 *Gonyaulacysta dualis* (Brideaux & Fisher 1976) Stover & Evitt 1978. Note the smooth parasutural crests and the large apical horn.
2, 3 Specimen MPK 10522, sample RP 36, specimen in left lateral view; 2 - high focus, 3 - low focus.
6 Specimen MPK 10523, sample RP 36, specimen in dorsal view, median focus.

4-5 *Scriniodinium crystallinum* (Deflandre 1938) Klement 1960. Note the circumcavate cyst organisation and the precingular archeopyle.
4 Specimen MPK 10524, sample RP 37.
5 Specimen MPK 10525, sample RP 34.

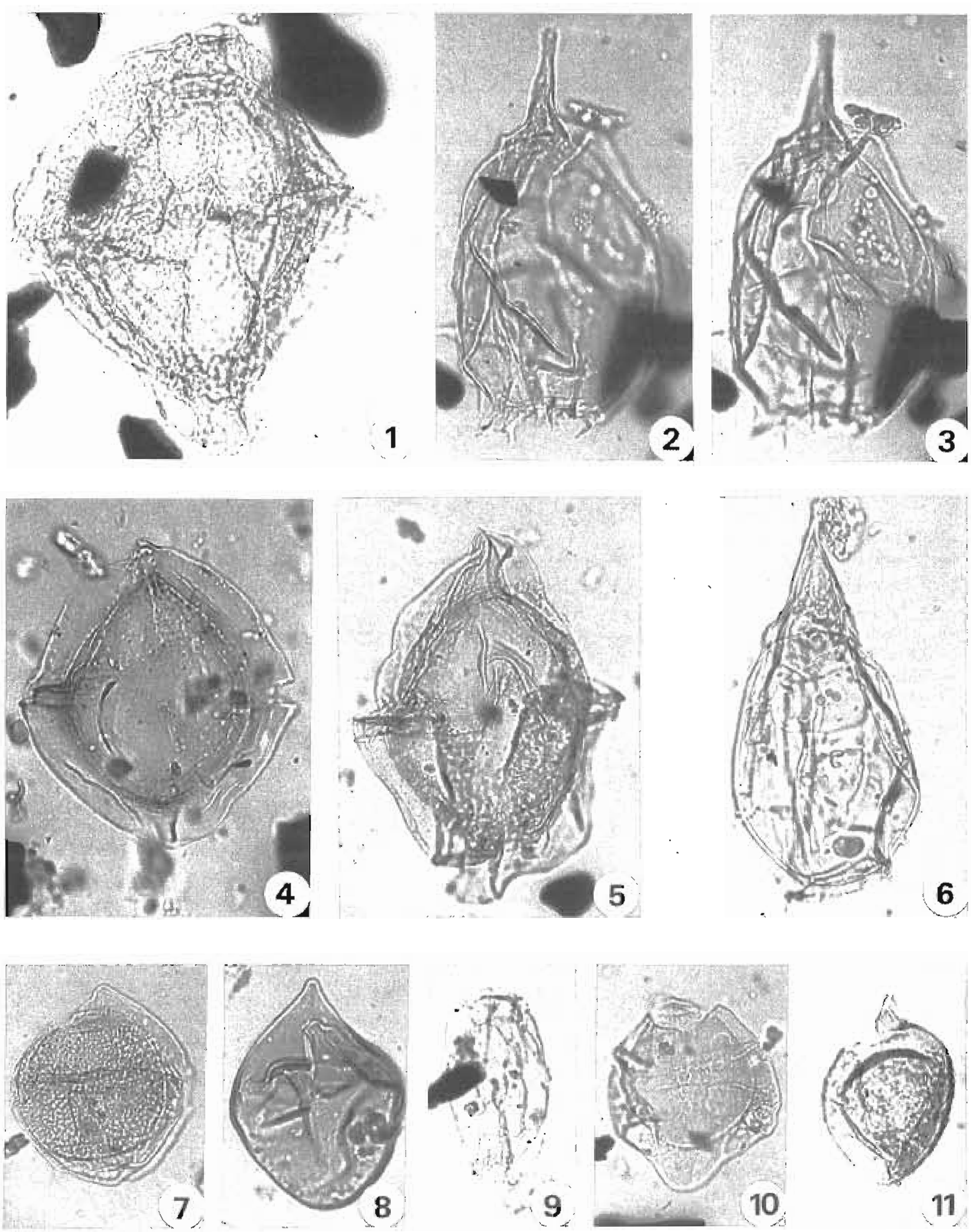
7 *Dingodinium jurassicum* Cookson & Eisenack 1958. Specimen MPK 10526, sample RP 37, specimen in oblique dorsal view, high-median focus; note the camocavate cyst organisation and the wide pericoel.

8 *Chytroeisphaeridia cerastes* Davey 1979. Specimen MPK 10527, sample RP 37, specimen in slightly oblique dorsal view, high focus; note the prominent apical horn and the precingular archeopyle.

9 *Clathroctenocystis asapha* (Drugg 1978) Stover & Helby 1987. Specimen MPK 10528, sample RP 37, note the elongate ambitus and the apical archeopyle.

10 *Sirmiodiniopsis orbis* Drugg 1978. Specimen MPK 10529, sample RP 37, specimen in dorsal view, high focus; note the apical archeopyle, the circumcavate cyst organisation and the paired claustra close to the antapex.

11 *Crussolia deflandrei* Wolfard & Van Erve 1981. Specimen MPK 10530, sample RP 37, right lateral view, high focus; note the epicavate cyst organisation.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# PLATE RP10

Dinoflagellate cysts from the Lower Kimmeridgian of sections 3/4, River Unzha area, near Kostroma (see section 5.3.3.3).

1, 4, 5 *Cribroperidinium globatum* (Gitmez & Sarjeant 1972) Helenes 1984.
1 Specimen MPK 10531, sample RP 44, specimen in ventral view, median focus; note the elongate apical horn.
4 Specimen MPK 10532, sample RP 46, specimen in dorsal view, high focus; note the thick autophragm.
5 Specimen MPK 10533, sample RP 46, specimen in dorsal view, median focus; note the thick autophragm.

2 *Rhynchodiniopsis cladophora* (Deflandre 1938) Below 1981. Specimen MPK 10534, sample RP 41, specimen in dorsal view, high-median focus; note the spinose parasutural ridges.

3 *Gonyaulacysta jurassica* (Deflandre 1938) Norris & Sarjeant 1965 subsp. *jurassica* (autonym). Specimen MPK 10535, sample RP 46, specimen in dorsal view, high-median focus; note the bicavate cyst organisation.

6 *Lithodinia* sp. A. Specimen MPK 10536, sample RP 38, specimen in dorsal view, high focus; note the thick autophragm.

7 *Tubotuberella rhombiformis* Vozzhennikova 1967. Specimen MPK 10537, sample RP 40, specimen in oblique dorsal view, high focus; note the bicavate cyst organisation.

8 *Leptodinium subtile* Klement 1960. Specimen MPK 10538, sample RP 42, specimen in ventral view, median focus; note the smooth parasutural crests.

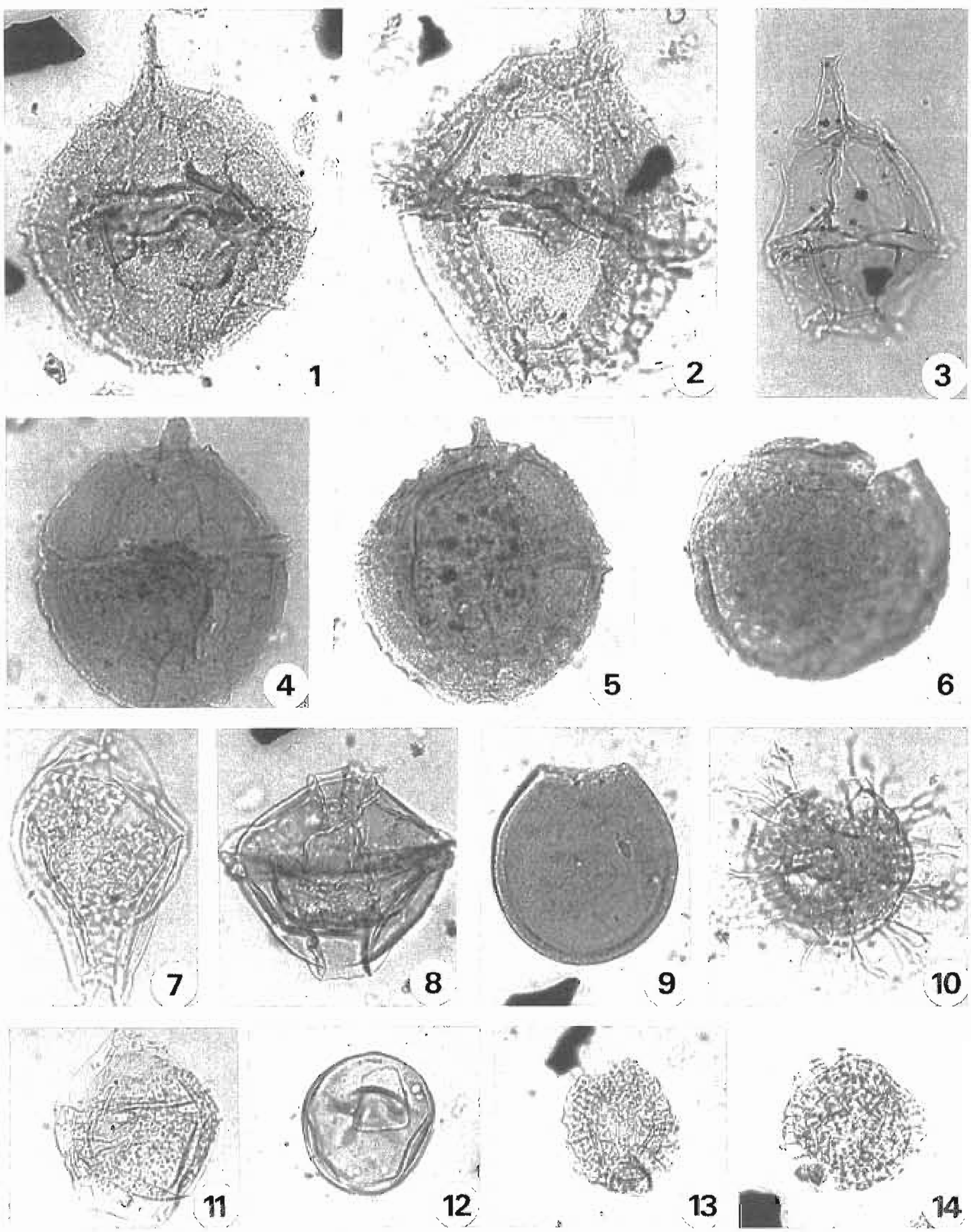
9 *Fromea amphora* Cookson & Eisenack 1958. Specimen MPK 10539, sample RP 41, note the thick autophragm and the apical archeopyle.

10 *Systematophora areolata* Klement 1960. Specimen MPK 10540, sample RP 41, specimen in dorsal view, high focus; note the apical archeopyle.

11 *Dingodinium jurassicum* Cookson & Eisenack 1958. Specimen MPK 10541, sample RP 40, specimen in dorsal view, high-median focus.

12 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10542, sample RP 42, specimen in dorsal view, high focus; note the large precingular, type P, archeopyle.

13-14 *Stephanelytron scarburghense* Sarjeant 1961. Note the dense cover of short, nontabular processes.
13 Specimen MPK 10543, sample RP 41.
14 Specimen MPK 10544, sample RP 44.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# PLATE RP11

Dinoflagellate cysts from the Kimmeridgian and Volgian of Gorodische (see section 5.3.4). Figures 9 and 10 were taken using phase contrast.

1, 2, 4 *Rhynchodiniopsis martonense* Bailey et al. 1997. Note the apical horn and the prominent paratabular processes at the paracingulum and the antapical paraplate.

1 Specimen MPK 10699 , sample RP 53, specimen in oblique dorsal view, median focus.

2 Specimen MPK 10700, sample RP 53, specimen in ventral view, median focus; note the clear standard gonyaulacacean paratubulation pattern.

4 Specimen MPK 10701, sample RP 53, specimen in dorsal view, low focus.

3 *Cribroperidinium* sp. Specimen MPK 10702, sample RP 57, specimen in dorsal view, high-median focus; note the prominent apical horn.

5 *Cribroperidinium globatum* (Gitmez & Sarjeant 1972) Helenes 1984. Specimen MPK 10703, sample RP 66, specimen in dorsal view, high focus; note the denticulate parasutural ridges and thick, robust autophragm.

6 *Glossodinium dimorphum* Ioannides et al. 1977. Specimen MPK 10704, sample RP 64, specimen in ventral view, high-median focus; note the antapical protuberance and the high parasutural crests.

7-8 *Senoniasphaera jurassica* (Gitmez & Sarjeant 1972) Lentin & Williams 1976. Note the offset parasulcus, the apical archeopyle and the circumcavate cyst organisation.

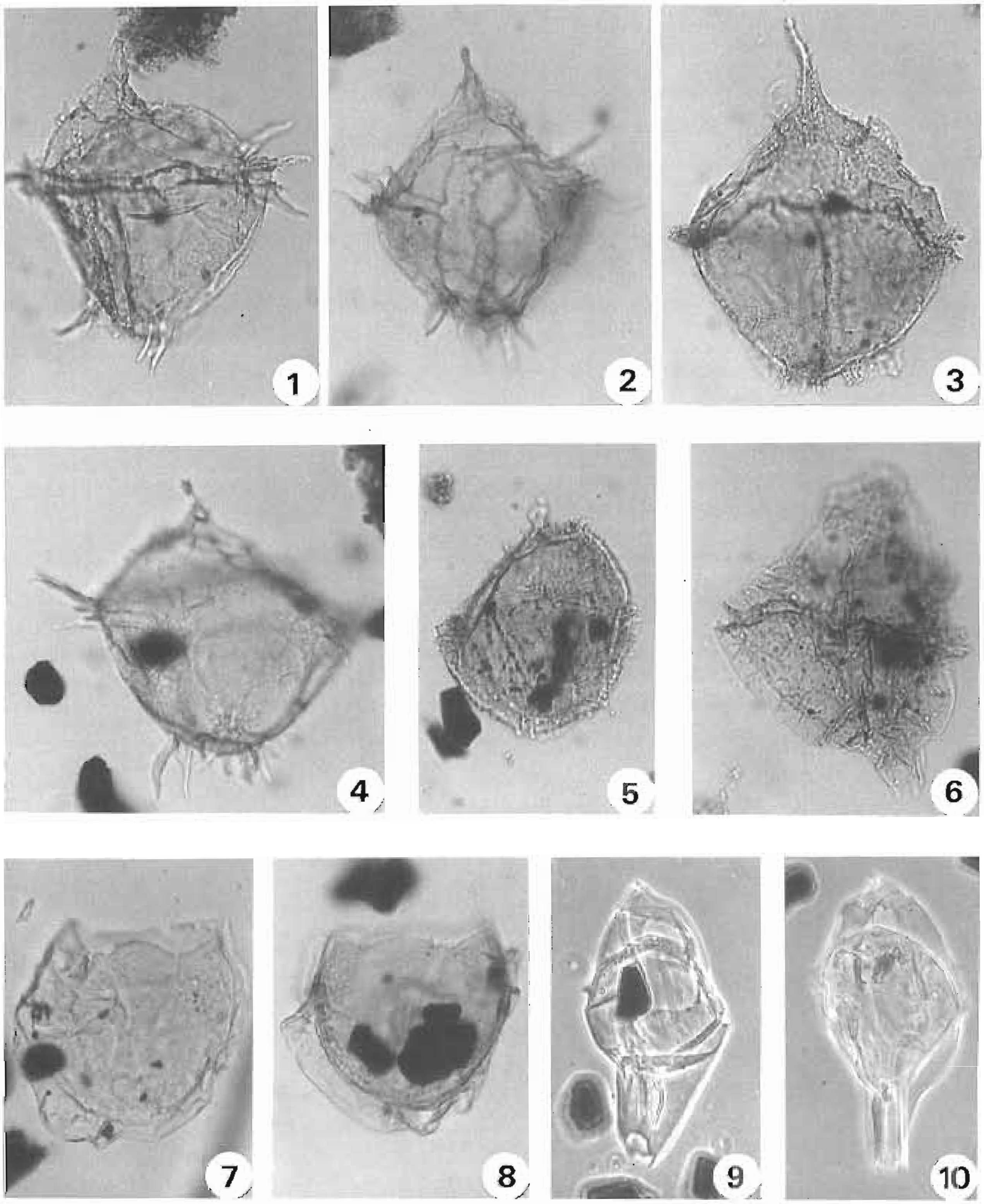
7 Specimen MPK 10705, sample RP 47, specimen in oblique left lateral-ventral view, high focus.

8 Specimen MPK 10706, sample RP 47, specimen in ventral view, high-median focus.

9-10 *Tubotuberella rhombiformis* Vozzhennikova 1967. Note the bicavate cyst organisation and the wide epipericoel.

9 Specimen MPK 10707, sample RP 61, specimen in dorsal view, high focus.

10 Specimen MPK 10708, sample RP 50, specimen in dorsal view, high focus.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# PLATE RP12

Dinoflagellate cysts (figures 1-13), prasinophytes (figures 14, 15) and a reworked Carboniferous spore (figure 16) from the Kimmeridgian and Volgian of Gorodische (see section 5.3.4). Figures 2 and 3 were taken using phase contrast.

1-2 *Sirmiodinium grossii* Alberti 1961. Note the antapical opisthopyle and the cavate cyst organisation.
1 Specimen MPK 10709, sample RP 53, specimen in dorsal view, high focus.
2 Specimen MPK 10710, sample RP 68, specimen in ventral view, high focus.

3 *Scriniodinium inritibile* Riley in Fisher & Riley 1980. Specimen MPK 10711, sample RP 61, specimen in dorsal view, high focus; note the narrow pericoel.

4, 8 *Leptodinium subtile* Klement 1960. Note the subpentangular dorsoventral cyst ambitus, the precingular archeopyle and the high, smooth parasutural crests.
4 Specimen MPK 10712, sample RP 61, specimen in dorsal view, high-median focus.
8 Specimen MPK 10713, sample RP 61, specimen in dorsal view, median focus.

5 *Pareodinia halosa* (Filatoff 1975) Prauss 1989. Specimen MPK 10714, sample RP 66, note the prominent kalyptra and lack of any horns.

6, 7 *Occisucysta balios* Gitmez 1970. Specimen MPK 10715, sample RP 59; specimen in right lateral view; 6 - high focus, 7 - low focus; note the epicavate cyst organisation and the precingular archeopyle.

9-10 *Dingodinium tuberosum* (Gitmez 1970) Fisher & Riley 1980. Note the tuberculate endophragm.
9 Specimen MPK 10716, sample RP 58, specimen in dorsal view, high focus.
10 Specimen MPK 10717, sample RP 66, specimen in oblique dorsal view, high focus.

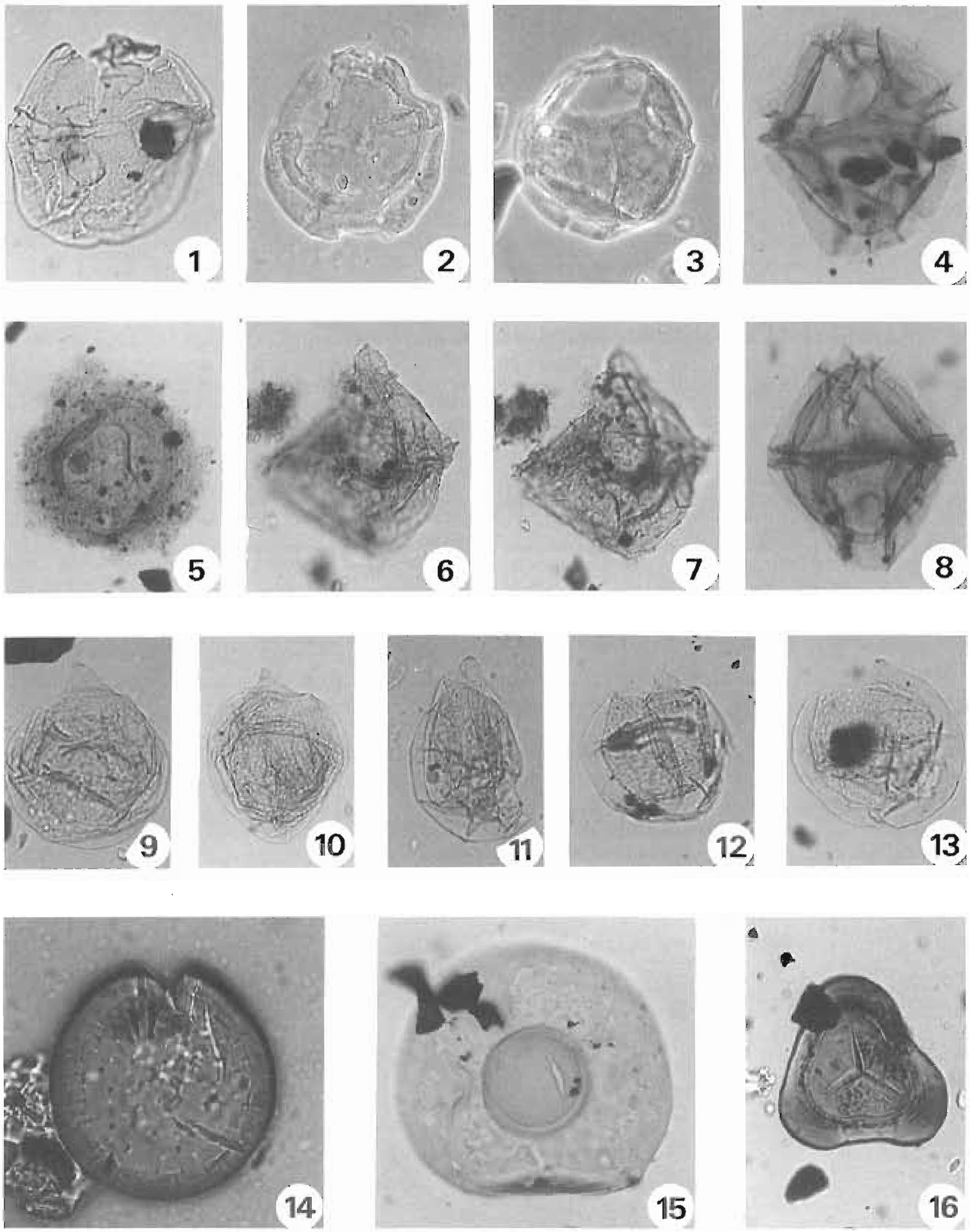
11 *Dingodinium* cf. *tuberosum* (Gitmez 1970) Fisher & Riley 1980. Specimen MPK 10718, sample RP 58, specimen in ?lateral view, high focus.

12, 13 *Dingodinium jurassicum* Cookson & Eisenack 1958. Note the relatively wide pericoel and the subcircular ambitus. Specimen MPK 10719, sample RP 62, specimen in dorsal view, high focus. Specimen MPK 10720, sample RP 57, specimen in dorsal view, high focus.

14 *Tasmanites* sp. Specimen MPK 10721, sample RP 48, specimen in median focus; note the thick wall.

15 *Pterospermella* sp. Specimen MPK 10722, sample RP 47; note the relatively small inner body.

16 *Murospora aurita* (Waltz 1938) Playford 1962. Specimen MPK 10723, sample RP 68, note the extremely thick spore wall.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# PLATE RP13

Dinoflagellate cysts from the Kimmeridgian and Lower Volgian of Gorodische (see section 5.3.4). All photomicrographs taken using phase contrast except figure 15. Figure 14 is a composite photomicrograph.

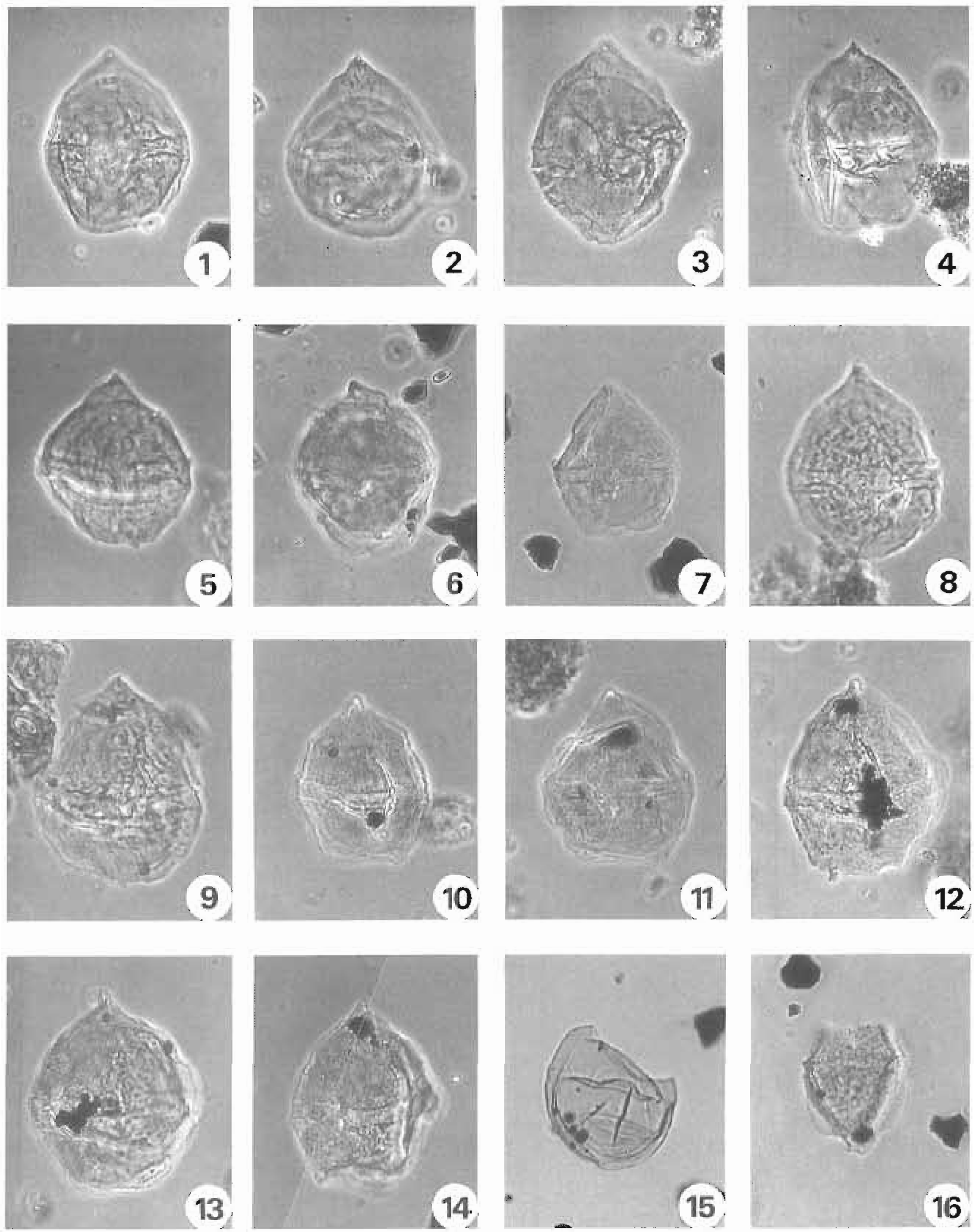
1-7 *Subtilisphaera? inaffecta* (Drugg 1978) Bujak & Davies 1983. Note the cavate cyst organisation, the short apical horn, the paracingulum, the smooth endophragm and periphragm and the apparent lack of an archeopyle.
1 Specimen MPK 10724, sample RP 61, specimen in ventral view, high focus.
2 Specimen MPK 10725, sample RP 61, specimen in dorsal view, high focus.
3 Specimen MPK 10726, sample RP 64, specimen in ventral view, high focus.
4 Specimen MPK 10727, sample RP 64, specimen in dorsal view, high focus.
5 Specimen MPK 10728, sample RP 64, specimen in dorsal view, high-median focus.
6 Specimen MPK 10729, sample RP 62, specimen in dorsal view, median focus.
7 Specimen MPK 10730, sample RP 66, specimen in ventral view, high focus.

8-11 *Subtilisphaera? paeminosa* (Drugg 1978) Bujak & Davies 1983. Note the apical horn which often appears to have a solid distal point, the apparent lack of an archeopyle and the low relief ornamentation (granules, verrucae etc.) on both cyst layers.
8 Specimen MPK 10731, sample RP 64, specimen in dorsal view, low focus.
9 Specimen MPK 10732, sample RP 64, specimen in dorsal view, high focus.
10 Specimen MPK 10733, sample RP 64, specimen in dorsal view, high focus.
11 Specimen MPK 10734, sample RP 64, specimen in dorsal view, high focus.

12-14 *?Subtilisphaera? paeminosa* (Drugg 1978) Bujak & Davies 1983. These specimens are probably referable to *Subtilisphaera? paeminosa*, however, they exhibit slightly atypical ornamentation.
12 Specimen MPK 10735, sample RP 64, specimen in dorsal view, high focus.
13 Specimen MPK 10736, sample RP 64, specimen in dorsal view, high-median focus.
14 Specimen MPK 10737, sample RP 64, composite photomicrograph; specimen in dorsal view.

15 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10738, sample RP 61, specimen in left lateral view, high focus, note the large precingular archeopyle.

16 *Ambonosphaera? staffinensis* (Gitmez 1970) Poulsen & Riding 1992. Specimen MPK 10739, sample RP 66, specimen in dorsal view, median focus; note the cavate cyst organisation and the apical archeopyle.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# PLATE RP14

Chorate and proximochorate dinoflagellate cysts from the Kimmeridgian and Volgian of Gorodische (see section 5.3.4).

1, 2 *Hystrichosphaerina orbifera* (Klement 1960) Stover & Evitt 1978. Specimen MPK 10740, sample RP 61, specimen in dorsal view; 1 - high focus, 2 - low focus; note the slender paracingular processes.

3 *Oligosphaeridium patulum* Riding & Thomas 1988. Specimen MPK 10741, sample RP 61, specimen in ventral view, low focus; note the lack of paracingular processes.

4-6 *Systematophora daveyi* Riding & Thomas 1988. Note the apical archeopyle, the arcuate process complexes, open toward the paracingulum and the slender paracingular processes.
4 Specimen MPK 10742, sample RP 64.
5 Specimen MPK 10743, sample RP 64.
6 Specimen MPK 10744, sample RP 55.

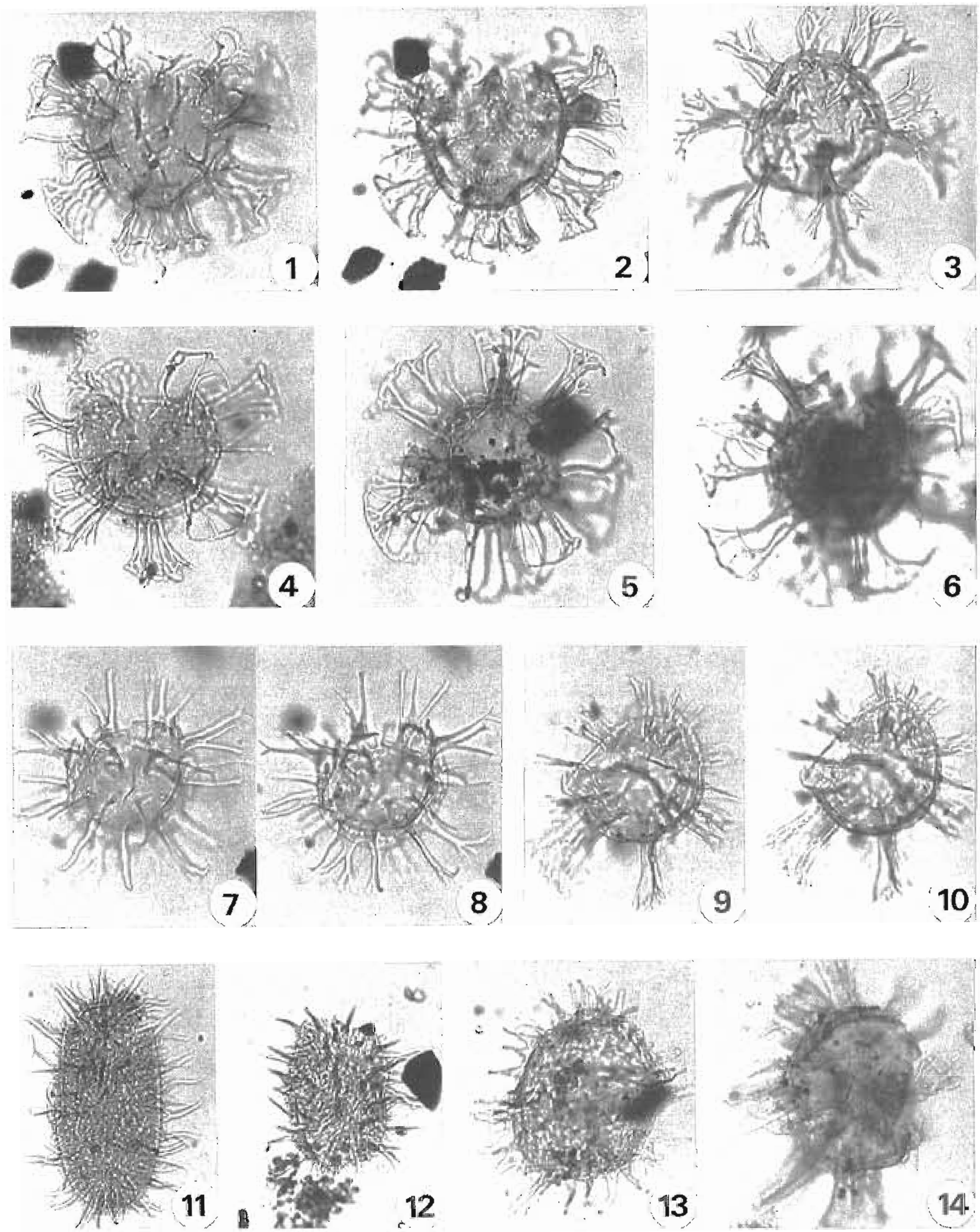
7, 8 *Systematophora areolata* Klement 1960. Specimen MPK 10745, sample RP 57, 7 - high focus, 8 - low focus; note the apical archeopyle and the relatively simple process complexes.

9, 10, 14 *Kleithriasphaeridium porosispinum* Davey 1982. Note the precingular archeopyle and the relatively wide processes.
9, 10 Specimen MPK 10746, sample RP 57, specimen in right lateral view; 7 - high focus, 8 - low focus.
14 Specimen MPK 10747, sample RP 53.

11 *Prolixosphaeridium parvispinum* (Deflandre 1937) Davey et al. 1969. Specimen MPK 10748, sample RP 66, specimen in ventral view; note the elongate nature of this genus and the simple nontabular processes.

12 *Prolixosphaeridium mixtispinosum* (Klement 1960) Davey et al. 1969. Specimen MPK 10749, sample RP 68, note the apical archeopyle and both the long and short processes.

13 *Hystrichodinium pulchrum* Deflandre 1935. Specimen MPK 10750, sample RP 57, note the paracingulum and the short, proximally-expanded processes.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# PLATE RP15

Dinoflagellate cysts (figures 1-8) and prasinophytes (figures 9-14) from the Middle and Upper Volgian of Kashpir (see section 5.3.5).

1-2 *Senoniasphaera jurassica* (Gitmez & Sarjeant 1972) Lentin & Williams 1976.

1 Specimen MPK 10545, sample RP 72, specimen in ventral view and focus; note the apical archeopyle, the offset parasulcus and the circumcavate cyst organisation.

2 Specimen MPK 10546, sample RP 73, specimen in dorsal view, median focus.

3 *Tubotuberella rhombiformis* Vozzhennikova 1967. Specimen MPK 10547, sample RP 73, specimen in dorsal view; note the expanded epipericoel.

4-5 *Oligosphaeridium patulum* Riding & Thomas 1988. Note the large, paraplate-centered processes, which are greatly expanded distally and the lack of paracingular processes/ornamentation.

4 Specimen MPK 10548, sample RP 76, composite photomicrograph.

5 Specimen MPK 10549, sample RP 76.

6 *Tubotuberella apatela* (Cookson & Eisenack 1960) Ioannides et al. 1977. Specimen MPK 10550, sample RP 76; note the prominent antapical cavation..

7 *Dingodinium* sp. Specimen MPK 10551, sample RP 76, note the camocavate cyst organisation.

8 *Chytroeisphaeridia chytroeides* (Sarjeant 1962) Downie & Sarjeant 1965. Specimen MPK 10552, sample RP 79, specimen in left lateral view, note the large precingular archeopyle.

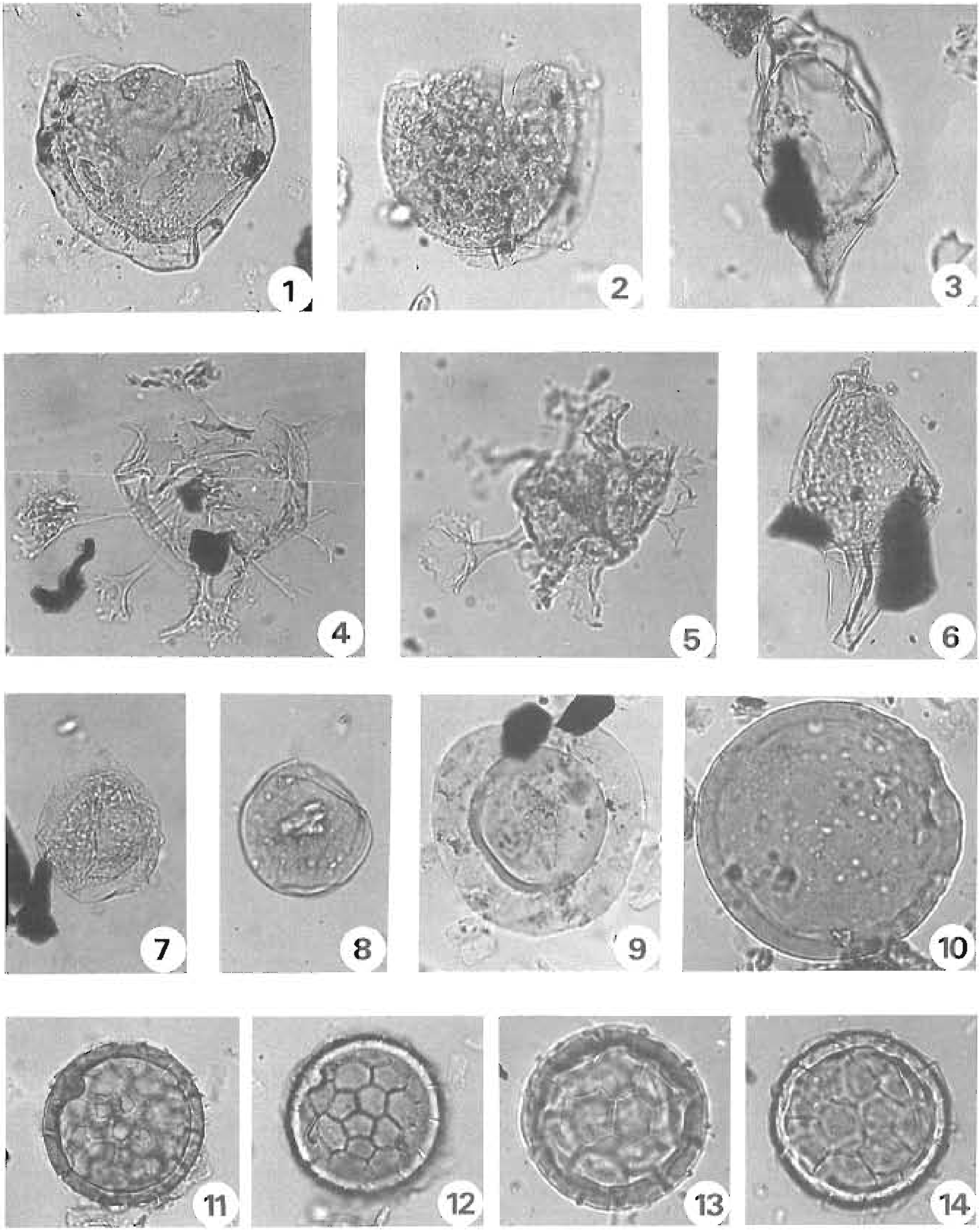
9 *Pterospermella* sp. Specimen MPK 10553, sample RP 75; note the thick wall to the inner body.

10 *Tasmanites* sp. Specimen MPK 10554, sample RP 75, note the punctate nature of the wall..

11-14 *Cymatiosphaera* spp. Note the polygonal pattern of low, smooth ridges.

11, 12 Specimen MPK 10555, sample RP 75; 11 - median focus, 12 - low focus.

13, 14 Specimen MPK 10556, sample RP 78; 13 - high focus, 14 - low focus.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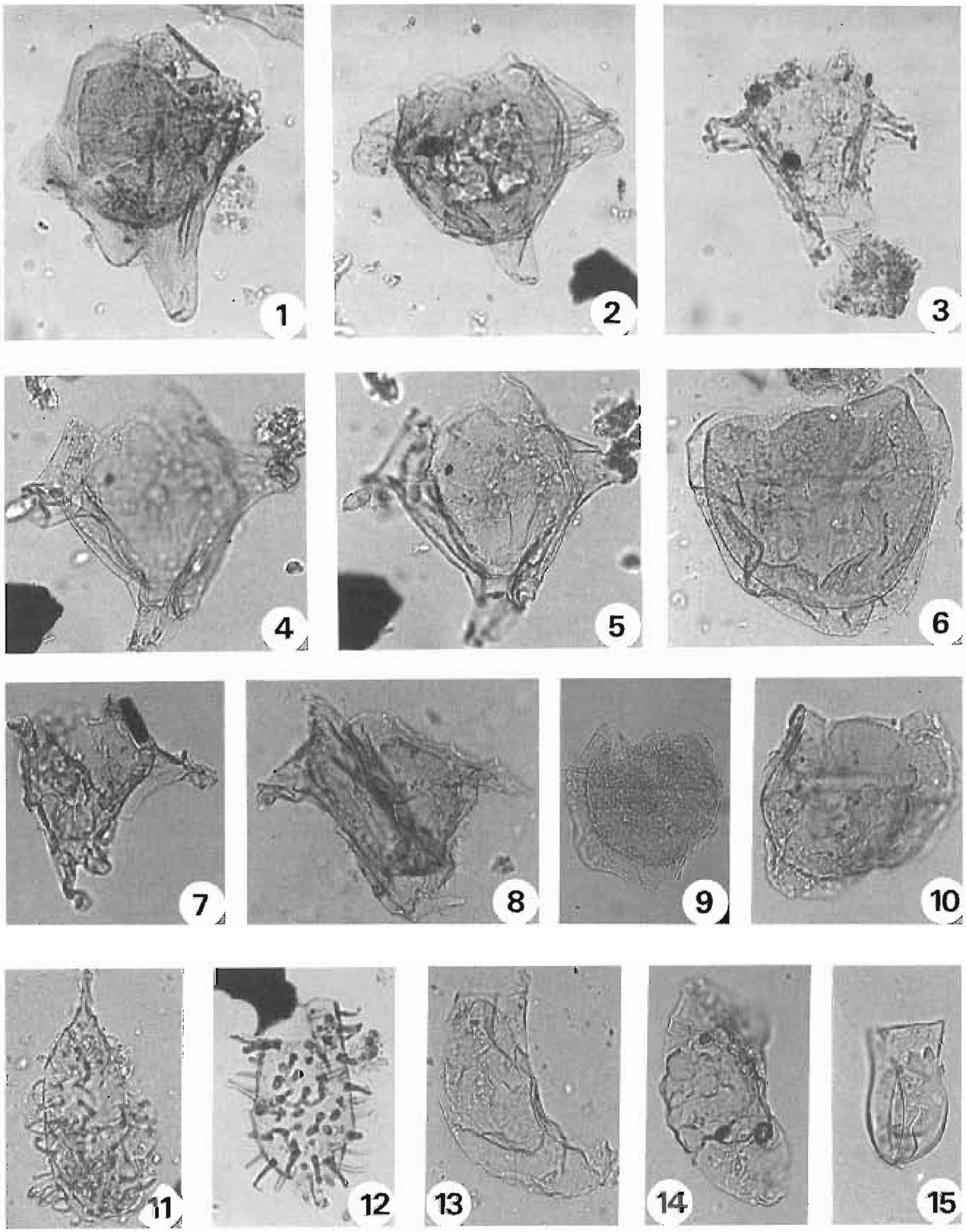
# PLATE RP16

Dinoflagellate cysts from the Upper Volgian and Ryazanian of the Upper Volgian and Ryazanian of outcrop 12 at Kuzminskoje (figures 1-3, 6, 7, 9-14) and River Black (figures 4, 5, 8, 15) in the River Oka Basin (see section 5.3.6).

| | |
|---|---|
| 1-5, 7 | *Muderongia simplex* Alberti 1961. Note the pseudoceratioid cyst organisation and the ovoidal shape of the endocyst. |
| 1 | Specimen MPK 10557, sample RP 81, specimen in ventral view |
| 2 | Specimen MPK 10558, sample RP 81, specimen in ventral view, high focus. |
| 3 | Specimen MPK 10559, sample RP 80, specimen in ventral view, median focus. |
| 4, 5 | Specimen MPK 10560, sample RP 85, specimen in dorsal view; 4 - high focus; 5 - median focus. |
| 7 | Specimen MPK 10561, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje, dorsal view. |
| 6, 10 | *Senoniasphaera jurassica* (Gitmez & Sarjeant 1972) Lentin & Williams 1976. Note the apical archeopyle, the offset parasulcus and the circumcavate cyst organisation. |
| 6 | Specimen MPK 10562, sample RP 82, specimen in ventral view, high focus. |
| 10 | Specimen MPK 10563, sample RP 82, specimen in ventral view, median focus. |
| 8 | *Phoberocysta neocomica* (Gocht 1957) Millioud 1969. Specimen MPK 10564, sample RP 85, specimen in dorsal view, median focus; note the cavate cyst organisation, the pseudoceratioid shape and the spinose/denticulate periphragm. |
| 9 | *Ambonosphaera? staffinensis* (Gitmez 1970) Poulsen & Riding 1992. Specimen MPK 10565, sample RP 80, specimen in dorsal view, median focus; note the apical archeopyle and the cavate cyst organisation. |
| 11-12 | *Gochteodinia villosa* (Vozzhennikova 1967) Norris 1978. Note the apical horn and the spinose autophragm. |
| 11 | Specimen MPK 10566, sample RP 82. |
| 12 | Specimen MPK 10567, sample RP 81, note the damaged apical part of the cyst. |
| 13-14 | *Wallodinium krutzschii* (Alberti 1961) Habib 1972. Note the longitudinally elongate, slightly curved ambitus and the bicavate cyst organisation. |
| 13 | Specimen MPK 10568, sample RP 82. |
| 14 | Specimen MPK 10569, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje. |
| 15 | *Wallodinium cylindricum* (Habib 1970) Duxbury 1983. Specimen MPK 10570, sample RP 85, note the apical archeopyle and the epicavate cyst organisation. |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# PLATE RP17

Dinoflagellate cysts (figures 1-10, 14) and prasinophytes (figures 11-13, 15, 16) from the Upper Volgian and Ryazanian of outcrops 12 and 13 at Kuzminskoje (figures 1-13, 16) and River Black (figures 14, 15) in the River Oka Basin (see section 5.3.6).

1, 2 *Endoscrinium anceps* Raynaud 1978. Specimen MPK 10571, sample RP 83, specimen in ventral view; 1 - high focus; 2 - low focus; note the circumcavate cyst organisation and the relatively short apical horn.

3-6, 9 *Circulodinium distinctum* (Deflandre & Cookson 1955) Jansonius 1986. Note the marginate, low-relief ornamentation and the offset parasulcus.

3, 6 Specimen MPK 10572, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje, specimen in oblique ventral view; 3 - high focus; 6 - low focus.

4, 5 Specimen MPK 10573, sample RP 80, specimen in ventral view; 4 - high focus; 5 - low focus.

9 Specimen MPK 10576, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje, specimen in dorsal view.

7 *Cribroperidinium* sp. Specimen MPK 10574, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje, an isolated operculum.

8 *Dingodinium* sp. Specimen MPK 10575, sample RP 81; note the small apical horn and the cavate cyst organisation.

10, 14 *Circulodinium compta* (Davey 1982) Helby 1987. Note the relatively low relief ornamentation, the apical archeopyle and the offset parasulcus.

10 Specimen MPK 10577, sample RP 84, specimen in oblique dorsal view, high focus.

14 Specimen MPK 10578, sample RP 85, specimen in ventral view, median focus.

11-12 *Tasmanites* spp. Note the thick, punctate wall.

11 Specimen MPK 10579, sample RP 82, high/median focus.

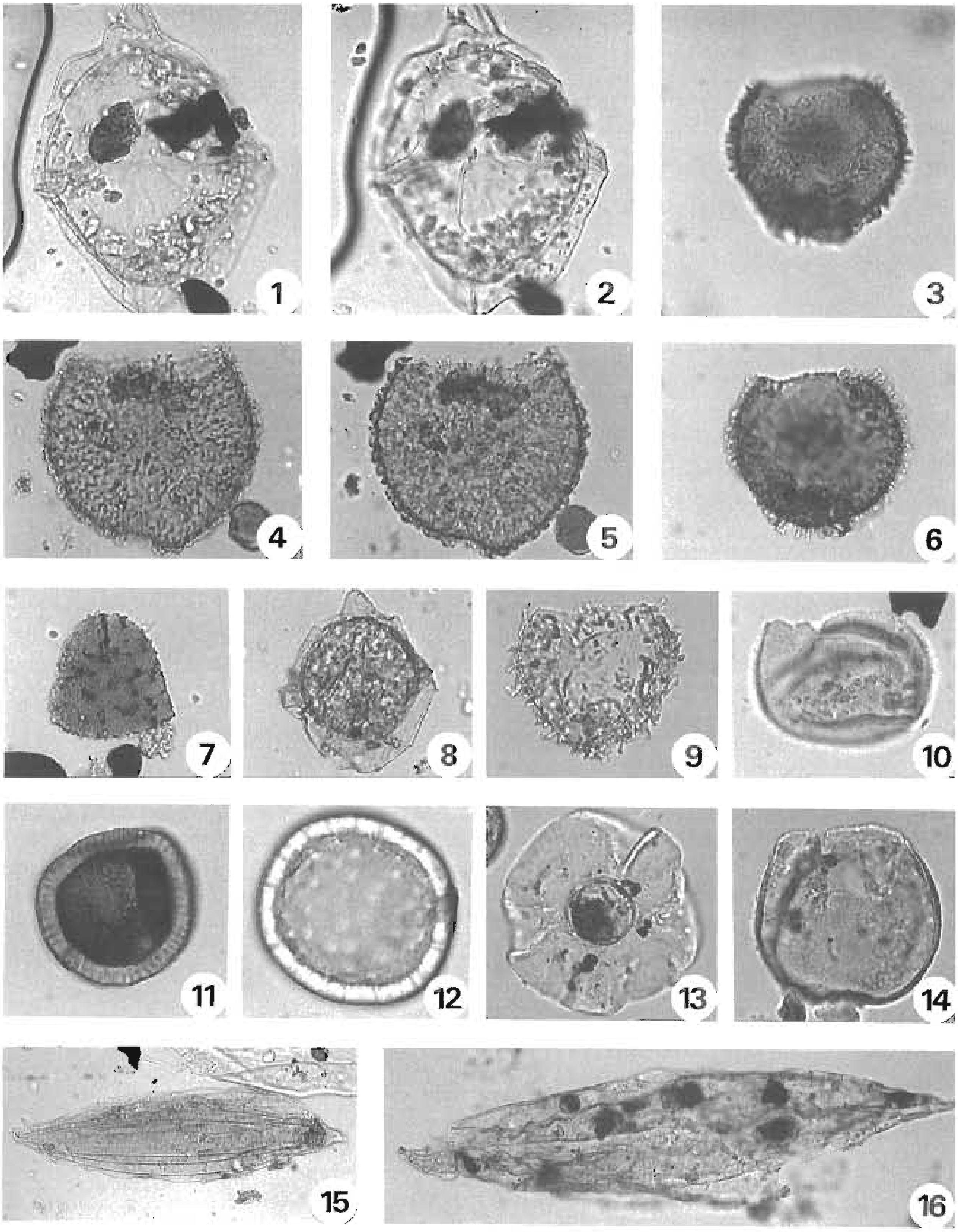
12 Specimen MPK 10580, sample RP 82, median focus.

13 *Pterospermella* sp. Note the small inner body. Specimen MPK 10581, unlisted Ryazanian sample from outcrop 12 at Kuzminskoje.

15-16 *Lancettopsis lanceolata* Mädler 1963. Note the longitudinally striate pattern of low, smooth ridges.

15 Specimen MPK 10582, sample RP 85, magnification X300.

16 Specimen MPK 10583, sample RP 82.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(December, 1999)