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# Upper Bajocian to Callovian (Jurassic) dinoflagellate cysts from central Poland

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ABSTRACT:

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The Upper Bajocian – Bathonian organic-rich claystone succession and the Lower Callovian sandy, marly and gaize (dispersed biogenic silica) deposits of central-southern Poland yield diverse and well-preserved dinoflagellate cyst floras dominated by ctenidodinioids, principally *Ctenidodinium combazii, Dichadogonyaulax sellwoodii* and *Korystocysta* spp. *Atopodinium* and *Wanaea* are also common. The stratigraphical distribution of dinoflagellate cysts within the Upper Bajocian to Lower Callovian has provided a detailed correlation between the Polish area and the North Sea area (chronostratigraphy and dinoflagellate cyst zonation). The dinoflagellate cyst biostratigraphical events are of correlative value and are consistent with interpretations based on the macrofaunas. The Middle-Late Callovian yielded no dinoflagellate cysts. The British zonation (RIDING & THOMAS 1992, POULSEN & RIDING, *in press*) is demonstrated to be useful for the Polish sections. Some marker species have differences in their first or last appearances in Poland compared to those reported from England.

## INTRODUCTION

This paper represents the palynological input to the research project "The Polish Middle-Upper Jurassic Epicratonic Basin, Stratigraphy, Facies and Basin History" (Danish Energy Agency EFP-1995 project), which is a part of research at the University of Warsaw and the Geological Survey of Denmark and Greenland (GEUS) into Jurassic stratigraphy. Other parts of the project were ammonite stratigraphy presented by KUTEK (1998), MATYJA & GŁOWNIAK (1998), MATYJA & WIERZBOWSKI (1997, 1998), palaeogeographic evolution, by MATYJA & WIERZBOWSKI (1998), clay sedimentology by MERTA & DREWNIAK (1998) and carbonate sedimentology by INESON *& al.* (1998).

There are only few published reports (from eastern Poland, *e.g.*, GÓRKA, 1970) on dinoflagellate cysts from the Polish Middle Jurassic sediments. The Upper Jurassic of Poland has received more attention recently in POULSEN (1992, 1993, 1994, 1996). This study embodies descriptions of Middle Jurassic dinoflagellate cyst floras from central-southern Poland (Text-Fig. 1). Abundant dinoflagellate cyst associations have been extracted from the Upper Bajocian to Bathonian claystones and the lower part of the Callovian sandstones, marls and gaizes (dispersed biogenic silica). Middle Callovian – Oxfordian samples from Poland are barren of dinoflagellate cysts. The reason for the organic poor samples is believed to be poor preservation.

The standard ammonite zones are treated here as chronostratigraphical units (CALLOMON 1984, WIMBLEDON & COPE 1978, COX 1990). The ammonite zones are referred to by the species name alo-

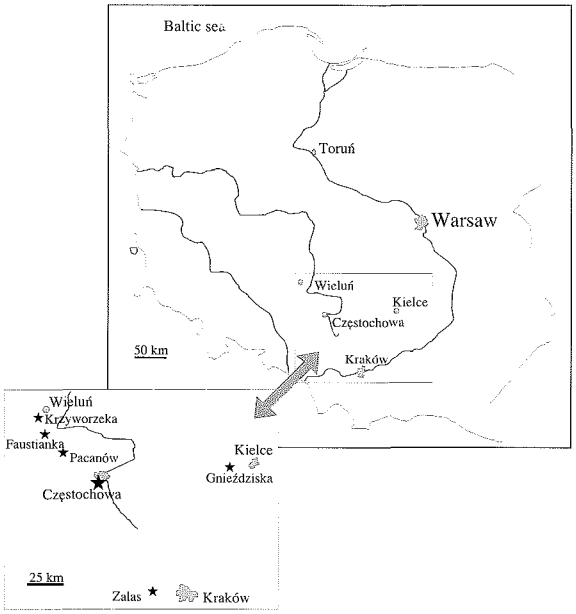


Fig. 1. Location map showing the central-southern Polish localities studied for this project: the clay pits at Częstochowa (Alina clay pit, Anioł clay pit, Sowa & Gliński clay pits, Leszczyński clay pit, Gnaszyn clay pit, and Kawodrza clay pit; *see* Text-fig. 2 of MATYJA & WIERZBOWSKI 1998), Faustianka clay pit (*see* Text-fig. 3 of MATYJA & WIERZBOWSKI 1998), Krzyworzeka clay pit, Pacanów clay pit, and Zalas quarry

ne and written in Roman, for example, Tenuicostatum Zone. This is the convention followed by working groups of the International Subcommission on Jurassic Stratigraphy (ISJS) and the International Commission on Stratigraphy (ICS).

The dinoflagellate cyst zones are indicated either, by the generic and specific names of the index taxon in italics, e.g., *Scriniodinium crystallinum* Zone, or by a code, for example, DSJ18 Zone [*D* for dinoflagellate cysts, *S* is added to emphasise that it is a Subboreal zonation (though part of the British – Danish Jurassic belongs to the Submediteranean Province, *see* CALLOMON, 1985) and *J* for Jurassic, see Table 1], following the proposals of POULSEN & RIDING (*in press*).

## Investigated exposures

The majority of the sections sampled for this project were described in POULSEN *& al.* (1995). Geological and stratigraphical descriptions of the Bathonian localities in the south-western part of Częstochowa were given in MERTA & DREWNIAK (1998) and *in* MATYJA & WIERZBOWSKI (1998). The samples were prepared for palynological study using the method described by POULSEN *& al.* (1990) and DESEZAR & POULSEN (1994).

Clay pits excavated into the Bajocian – Bathonian sequence, which is known as the "Ore-Bearing Clay" formation, are situated in the Częstochowa Upland (south western part of the city of Częstochowa), and the Wieluń Upland in central-southern Poland, north-west of Częstochowa (about 5-20 km south of Wieluń; Text-fig. 1). The Faustianka clay pit (Text-fig. 1) is undescribed, whereas the Krzyworzeka clay pit (Text-fig. 1) was described briefly by DECZKOWSKI & JURKIEWICZOWA (1960). The lithologies are dark grey to black claystone with many horizons of sideritic concretions; bioturbation is evident at certain levels. The ammonites of these deposits are described in detail by MATYJA & WIERZBOWSKI (1998).

The marine Bathonian sediments are followed by Callovian sandstones and conglomerates. Within the Mesozoic margin of the Holy Cross Mountains (Gnieździska Quarry, west of Kielce, described *in* DREWNIAK & MATYJA 1992, *see* Fig. 1) gaize (dispersed biogenic silica, mostly loose sponge spicules, in a carbonate matrix) overlies the Bathonian clays. The basal gaize is overlain by clay intercalated with gaize.

In the south-eastern part of the Krakow-Wieluń Upland, Lower Callovian strata rest unconformably on Permian porphyrite (Zalas Quarry; described *in* GIŻEJEWSKA & WIECZOREK 1977, MATYJA & TARKOWSKI 1981). The Callovian consists of a basal kaolinitic sandstone, locally showing trough cross-bedding and pebbly layers, which passes up into sandy limestone (grainstone). The boundary with the overlying Oxfordian is abrupt and represents a complex hiatal surface, with several phases of sedimentation, erosion and corrosion.

## STRATIGRAPHICAL BACKGROUND

The zonal correlation of the strata sampled in the present study is substantially similar to that of POULSEN & RIDING (*in press*, Table 1) though work during this project has further subdivided this zonal scheme. The zonation used for describing the Polish sections is therefore the zonation of POULSEN & RIDING (*in press*), however, the definitions of some of the DSJ zones are for

improved herein, and a further subdivision of some of the DSJ zones is proposed.

## DINOFLAGELLATE CYST STRATIGRAPHY

All Bajocian – Bathonian localities consistently yielded abundant, well-preserved dinoflagellate cyst assemblages. Small numbers of foraminiferal test linings and acanthomorph acritarchs, mainly referable to the genus *Micrhystridium*, are consistently present. Comparison with other areas suggests that the geographical distribution of the dominant species reflects the general evolution in the northwestern European assemblages, though some differences in first appearances occur. The stratigraphic conclusions based on dinoflagellate cysts are consistent with interpretations based on ammonites.

The Polish Early Callovian dinoflagellate cyst assemblages show a marked change from the ctenidodinioid-dominated Bathonian associations. There are a significant number of forms that are not present, or were recorded in much smaller numbers in the Polish sections (see below). The Early Callovian assemblages are dominated by proximate species with apical archeopyles, for example, the *Sentusidinium* suite, *Lithodinia,* and *Epiplosphaera*; the only ctenidodinioid recorded in the Callovian of Poland is *Dichadogonyaulax sellwoodii*. These taxa mark the top of the of the Middle Jurassic dinoflagellate cyst assemblages in Poland (Text-figs 2-3).

The mid-Callovian to mid-Oxfordian strata in the Kraków-Wieluń Upland (central-southern Poland) and Holy Cross Mountains area (Gór Świętokrzyskich, central-southern Poland) were sampled intensively both in earlier investigations (POULSEN 1992, 1993, 1994, 1996) and for this project. All material, however, proved almost devoid of dinoflagellate cysts. As most of the samples examined from the Middle Jurassic in this project and from the Late Jurassic of Poland (POULSEN 1996) were rich in dinoflagellate cysts, it is believed that the reason for unproductive Callovian-Oxfordian samples in central-southern Poland is weathering.

### DSJ14

**The DSJ14 Zone** was defined as the interval from the last appearance datums (LADs) of *Durotrigia daveyi* and *Mancodinium semitabulatum* to the LAD of *Cribroperidinium crispum* (POULSEN & RIDING, *in press*). For identifying the upper boundary in Poland, the definition is extended to include the first appearance datum (FAD) of *Ctenidodinium cornigera* in the definition of the upper boundary.

**Poland:** The Bajocian Pacanów clay pit dinoflagellate cyst assemblages (Text-figs 2-3) are dominated by *Dissiliodinium* spp., and *Korystocysta* spp. with *Ctenidodinium combazii, Dichadogonyaulax sellwoodii* and *Lithodinia jurassica* present in lower proportions. The three latter species have their inceptions in the DSJ14 Zone. In the overlying Alina section *D. sellwoodii* becomes abundant. *Korystocysta* spp. are consistently common in the Early Bathonian and occur throughout the Bathonian. *Ctenidodinium combazii* increases in proportion upsection in the Alina section. *Atopodinium polygonalis*, a species that also has its first occurrence in the DSJ14 Zone, is present from the base of the Alina section. *Ctenidodinium*

| **Zonation** after: POULSEN & RIDING, *in press* | **Formal zonal names** (after: WOOLLAM & RIDING (1983), RIDING & THOMAS (1988, 1992) | **Age** |
|---|---|---|
| DSJ19 | *Wanaea thysanota* Zone | Late Callovian |
| DSJ18 | *Ctenidodinium continuum* Zone | mid-Early-Middle Callovian |
| DSJ17 | *Dichadogonyaulax sellwoodii* Zone, Subzone c | Late Bathonian- earliest Callovian |
| DSJ16 | *Dichadogonyaulax sellwoodii* Zone, Subzone b | Middle-Late Bathonian |
| DSJ15 | *Dichadogonyaulax sellwoodii* Zone, Subzone a | Early-Middle Bathonian |
| DSJ14 | *Cribroperidinium crispum* Zone, Subzone b | Late Bajocian |

Table 1. The Late Bajocian-Oxfordian dinoflagellate cyst zonation for the British-Danish area *after* POULSEN & RIDING (*in press*); the zonation is based on the zonations of WOOLLAM & RIDING (1983) and RIDING & THOMAS (1988, 1992)

*cornigera* is not recorded at the Pacanów section or in the overlying Alina section. This species is indicative of the DSJ15 Zone, and the Pacanów and the Alina sections are therefore correlated with the DSJ14 Zone.

## DSJ15

**The DSJ15 Zone** was defined as the interval between the LADs *of Cribroperidinium crispum* and *Carpathodinium predae* (POULSEN &

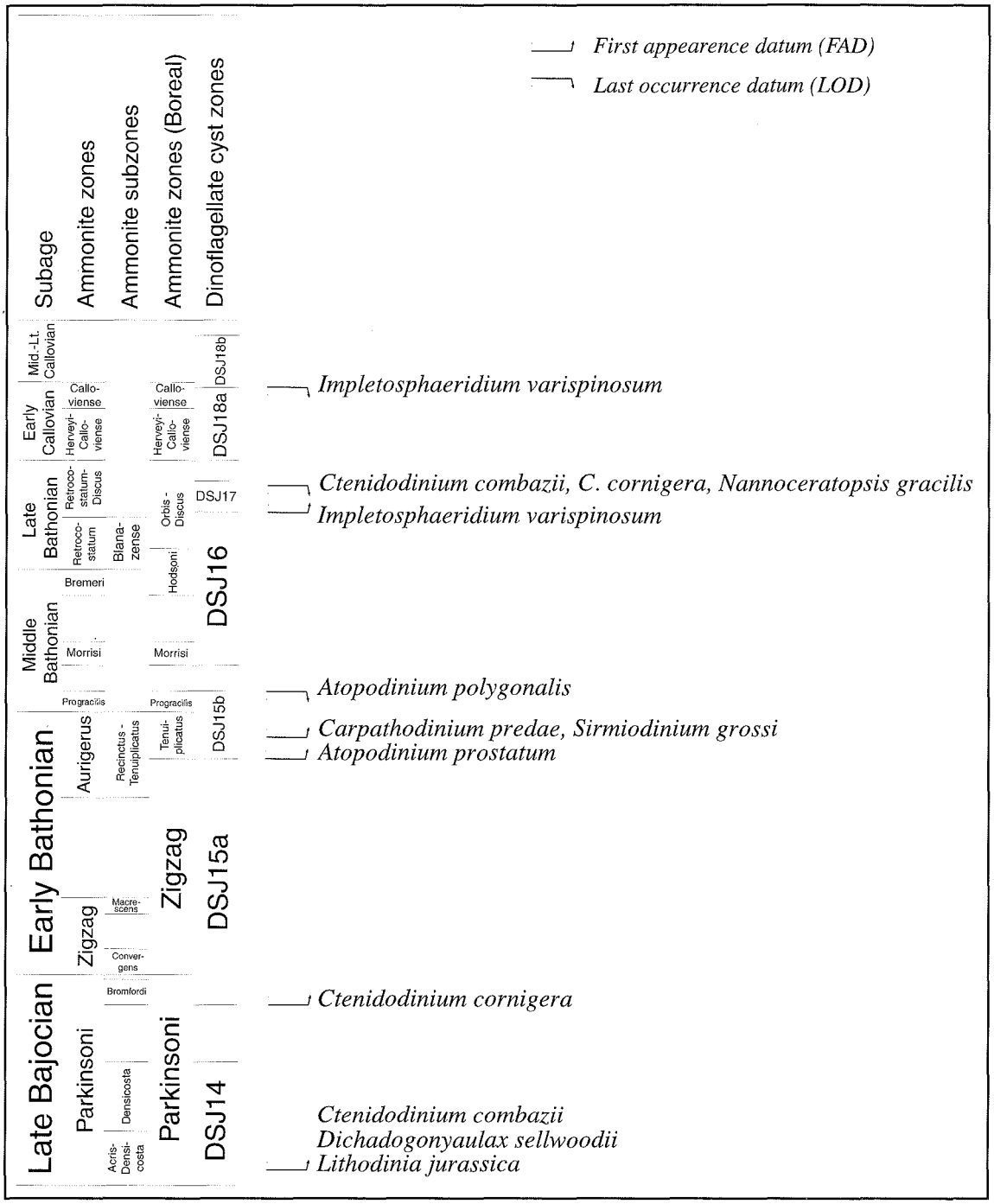


Fig. 2. First appearance datums (FAD) and Last occurrence datums (LOD) of some stratigraphically important dinoflagellate cyst occurring throughout the Late Bajocian to Callovian in central-southern Poland in the Krakow-Wieluń Upland and the Holy Cross Mountains

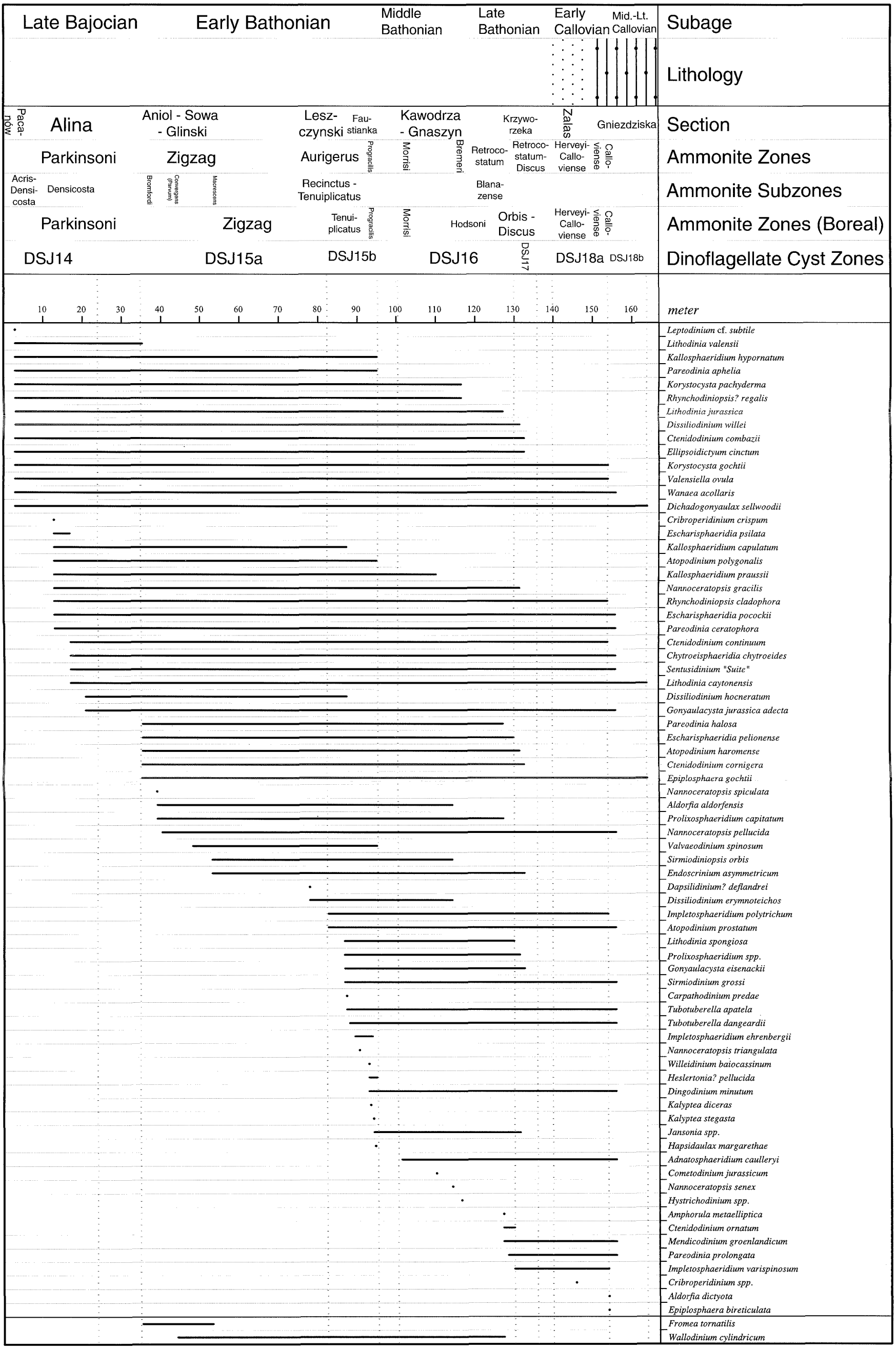


Fig. 3. Composite range chart showing the dinoflagellate cyst to occur throughout the Late Bajocian to Callovian in central-southern Poland in the Kraków-Wieluń Upland and the Holy Cross Mountains

RIDING, *in press*). To recognise the lower boundary in Poland, the definition is extended to include the first appearance datum (FAD) of *Ctenidodinium cornigera* in the definition of the lower boundary. For the upper boundary, the LAD of *Atopodinium polygonalis* is included in the definition. The zone is here divided into the DSJ15a and DSJ15b subzones. The base of the zone, defined by the first occurrence of *Ctenidodinium cornigera,* appears slightly diachronous. The inception of the marker species is recorded within the Bomfordi Subzone (Parkinsoni Zone, uppermost Bajocian). In England, the first occurrence of *C. cornigera* is at the base of the Zigzag Zone (RIDING & THOMAS 1992).

***DSJ15a Subzone*:** The interval defined from the base of DSJ15 Zone to the first appearance of *Atopodinium prostatum*. The subzone can be recognised both in England and Poland.

***DSJ15b Subzone*:** The interval defined from the FAD of *Atopodinium prostatum* to the top of the zone. The subzone can be recognised both in England and Poland. The base of DSJ15b Subzone is recorded in Poland in the mid-Aurigerus Zone, approximately at the boundary of the Recinctus and Tenuiplicatus subzones. In England, the base of the DSJ15b Subzone is at the base of the Tenuiplicatus Zone. The top of the zone corresponds to the top of the Progracilis Zone in both England and Poland. In Germany *A. prostatum* is recorded from the Upper Bathonian to Kimmeridgian (PRAUSS 1989, FEIST-BURKHARDT & WILLE 1992).

**Poland:** *Ctenidodinium cornigera* has its inception in the latest Bajocian Bomfordi Subzone at the Anioł-Sowa-Gliński section (Text-figs 2-3). This species is the stratigraphical marker for the DSJ15 Zone and is considered to be a reliable marker for the Bathonian in Britain; however, in the Polish sections it occurs in low numbers in the uppermost Bajocian. *Ctenidodinium combazii* is continuously low in relative abundance until the base of the Bathonian, where it starts to dominate the dinoflagellate cyst assemblages. The dinoflagellate cyst assemblages become gradually more diverse from the base of the DSJ15 Zone upwards, especially through the DSJ15b Subzone. Several taxa have appearances at the base of the DSJ15 Zone and at the base of the Bathonian, for example, *Atopodinium haromense* and *Epiplosphaera gochtii* are present at the base, whereas for example *Aldorfia aldorfensis, Nannoceratopsis pellucida* and *Endoscrinium asymmetricum* occur for the first time in the Polish sections within the earliest Bathonian. The latter three species are known from older strata in England (RIDING & *al.* 1985), and from younger strata in Germany (FEIST-BURKHARDT & WILLE 1992). *Carpathodinium predae* has been found to be characteristic of the late Bajocian – early Bathonian interval in Britain (RIDING & WOOLLAM *in:* RIDING & THOMAS 1992). This species is rare in Poland. In England ctenidodinioid dinoflagellate cysts, especially *Ctenidodinium* spp., are dominant in the Lower Bathonian (RIDING *& al.* 1985, RIDING & THOMAS 1992). *Ctenidodinium combazii* is considered indicative of open marine situations in England, whereas *Dichadogonyaulax sellwoodii* was interpreted as being more euryhaline (RIDING *& al.* 1985, RIDING & THOMAS 1992). In Poland, *C. combazii* and *D. sellwoodii* are common to abundant from the base of the Bathonian, with *C. combazii* being more common than *D. sellwoodii*. At the top of the DSJ15a Subzone (Leszczyński section, Text-figs 2-3), *C. cornigera* becomes common, and it becomes abundant to dominant within the DSJ15b Subzone (Leszczyński-Faustianka sections, Text-figs 2-3). Ammonites also become more diverse from the Aurigerus Zone, and dinoflagellate cysts indicate more open marine facies. The ammonites indicate less restricted marine facies than in the earliest Bathonian (MATYJA & WIERZBOWSKI, *pers. commun.*, 1997; MATYJA & WIERZBOWSKI 1998; MATYJA & WIERZBOWSKI 1998).

## DSJ16

**The DSJ16 Zone** was defined as the interval between the LAD of *Carpathodinium predae,* and the FADs of *Impletosphaeridium varispinosum* and *Sirmiodinium grossii* and the LAD of *Valvaeodinium spinosum* (POULSEN & RIDING, *in press*). The lower boundary is in Poland is defined by the LAD of *Atopodinium polygonalis*. The FAD of *S. grossii* is, in Poland within the DSJ15b Subzone (Tenuiplicatus Subzone) i.e. earlier than in Britain. In Germany the FAD of *S. grossii* also occurs earlier than in Britain, in the Orbis Zone (PRAUSS 1989).

**Comments:** *Ctenidodinium combazii* is continuously dominant, but other ctenidodinioids are less common compared to the DSJ15 Zone. Only in the upper part of the zone, equivalent to the

Hodsoni Zone, does *Ctenidodinium ornatum* again become abundant, and *Dichadogonyaulax sellwoodii* becomes abundant again at the top of the DSJ16 Zone, equivalent to the Orbis Zone. FENTON & FISHER (1978) and RIDING & THOMAS (1992) discussed regional differences in the Bathonian dinoflagellate cyst assemblages of north-west Europe. Migrations of species from southern Europe took place in the mid-Bathonian, resulting in cosmopolitan floras throughout Europe in the mid- to Late Bathonian. RIDING & THOMAS (1992) noticed that, *C. combazii* seems to migrate northwards in Late Bathonian and Early Callovian times.

**Poland:** In the Kawodrza, Gnaszyn and Krzyworzeka sections (Text-figs 2-3), as in the underlying sections, *C. combazii* and/or *D. sellwoodii* are normally the dominant constituents of the assemblages, with the remainder of the taxa comprising a remarkably uniform subordinate association, including such species as *Adnatosphaeridium caulleryi*, *Korystocysta* spp., *Pareodinia ceratophora* and *Ctenidodinium ornatum*, the last mentioned has a FAD at the base of the overlying DSJ17 Zone equivalent to the Discus Zone in Britain, whereas Gocht (1970) recorded *Ctenidodinium ornatum* from the early Bathonian of north-west Germany. The FAD of *A. caulleryi* is later in Poland than reported from Britain (RIDING & THOMAS 1992), but apparently has an older range base than in Germany (FEIST-BURKHARDT & WILLE 1992).

## DSJ17

**The DSJ17 Zone** is defined as the interval between the FADs of *Impletosphaeridium varispinosum* and *Sirmiodinium grossii* and the LAD of *Valvaeodinium spinosum,* and the LADs of *Aldorfia aldorfensis* and *Ctenidodinium combazii*. As described above, *S. grossii* makes its first appearance earlier in Poland than in Britain, and is therefore not stratigraphically useful for defining the DSJ17 Zone in Poland. *Aldorfia aldorfensis* has apparently an older range top in Poland than in Britain as reported by RIDING & THOMAS (1992). TAUGOURDEAU-LANTZ & LACHKAR (1984) considered *Aldorfia aldorfensis* to be a good marker for the late Middle to Late Bathonian in the Aquitaine region. In Poland, this species is rare and is therefore not stratigraphically useful for defining the DSJ17 Zone. The first appearance of *I. varispinosum* is, as in Britain, at the base of the Discus Zone. It is here considered to be a good marker for the DSJ17 Zone, in Britain as well as in Poland, although PRAUSS (1989) reported the inception of the marker species *I. varispinosum* one zone earlier (Orbis Zone) in Germany.

**Poland:** There are several events worthy of note despite the apparently monotonous nature of the assemblages, and the fact the Krzyworzeka section (Text-figs 2-3) is highest sampled section of the Bathonian, though the Bathonian-Callovian boundary or the top of the DSJ17 Zone (equivalent to the top of the Herveyi Zone) was not sampled. The LADs of *Nannoceratopsis gracilis* and *Ctenidodinium cornigera* are confined to the top of the Bathonian in Britain. In the sections studied in Poland, the Upper Bathonian Krzyworzeka section represents the youngest recorded occurrence of these species. The FAD of *Pareodinia prolongata* in Poland is recorded within the DSJ17 Zone. In Britain the FAD of *P. prolongata* is at the base of the Upper Bathonian (RIDING & THOMAS 1992).

## DSJ18

**The DSJ18 Zone** is defined as the interval between the LADs of *Aldorfia aldorfensis* and *Ctenidodinium combazii,* and the FADs of *Trichodinium scarburghensis, Limbodinium absidatum, Scriniodinium crystallinum* and *Wanaea thysanota*. As described above, *Aldorfia aldorfensis* has apparently an older range top than in Britain, and *Sirmiodinium grossii* makes its first appearance earlier in Poland than in Britain; both are therefore not stratigraphically useful for defining the DSJ17-18 zonal boundary in Poland. The DSJ18 Zone is divided into two subzones:

***The DSJ18a Subzone*** is defined as the interval from the base of the DSJ18 Zone to the LAD of *I. varispinosum*. The age of the DSJ18a Subzone in both Britain and Poland spans the Koenigi and Calloviense zones. Although the base of the DSJ18 Zone has not been identified, the presence of the marker species *I. varispinosum* in the DSJ17-DSJ18a Zones is here considered to be a good marker.

***The DSJ18b Subzone*** is defined as the interval from the LAD of *I. varispinosum* to the top of the DSJ18 Zone.

**Poland:** The Polish Callovian dinoflagellate cyst assemblages from the Zalas and

Gnieździska sections (Text-figs 2-3) reveal a noticeable switch from the largely monotonous Bathonian assemblages of which the ctenidodinioids constituted the most significant group. There are a notable number of forms that are not present, or were recognised in much smaller numbers in the Polish sections; these include *Adnatosphaeridium caulleryi, Atopodinium prostatum, Chytroeisphaeridia* spp., *Ctenidodinium continuum, C. ornatum, Gonyaulacysta jurassica adecta, Limbodinium absidatum, Mendicodinium groenlandicum, Nannoceratopsis pellucida, Pareodinia ceratophora, Rhynchodiniopsis cladophora, Rigaudella aemula, Scriniodinium crystallinum, Stephanelytron* spp., *Trichodinium scarburghensis, Tubotuberella apatela, Wanaea acollaris, Wanaea fimbriata,* and *Wanaea thysanota*. The Early Callovian assemblages are dominated by proximate species with apical archeopyles for example, the *Sentusidinium* suite, *Lithodinia caytonensis,* and *Epiplosphaera gochtii*; the only ctenidodinioid recorded in the Callovian of Poland is *Dichadogonyaulax sellwoodii;* these taxa mark the top of the of the Middle Jurassic dinoflagellate cyst assemblages in Poland. The mid-Callovian to mid-Oxfordian strata in the Kraków-Wieluń Upland and Holy Cross Mountains area were sampled intensively for this project and earlier investigations (POULSEN 1996), but all material proved devoid of dinoflagellate cysts.

## CONCLUSIONS

The investigation of Middle – Late Jurassic dinoflagellate cysts from ammonite-dated samples from Poland has made it possible to use many of the dinoflagellate cyst zones and subzones from the British – Danish area, and, to show that the zonation may be generally isochronous. There are, however, some exceptions in the ranges of the guide and other stratigraphically important fossils compared to the British – Danish area, and more data are required to establish precise datums for all the taxa in Europe.

The late Bajocian and Bathonian sediments of the Częstochowa region (central-southern Poland) yield dinoflagellate cyst floras similar to coeval associations from Britain and continental Europe. The dinoflagellate cyst assemblages are dominated by ctenidodinioids with representatives of *Ctenidodinium, Dichadogonyaulax* and *Korystocysta*. The diversity appears to increase from the latest Bajocian – earliest Bathonian to the late Early – Late Bathonian.

The dinoflagellate cyst floras from the Callovian gaizes and sandstones in the Holy Cross Mountains region and the Krakow-Wieluń Upland illustrate the change from ctenidodinioid dominance, which typifies the Bajocian-Bathonian clays, to poorer assemblages from sandstones. The youngest part of the Callovian sandstones and gaizes yielded no dinoflagellate cysts. The Callovian Stage was a transgressive interval (HAQ *& al.* 1987), and much of Europe was covered by sea. The marked uniformity of the dinoflagellate cyst floras recorded from coeval European floras is, as a result, not recorded in Poland.

The chart (Text-fig. 2) illustrates the stratigraphically significant dinoflagellate cyst datums recognised throughout the sequence investigated.

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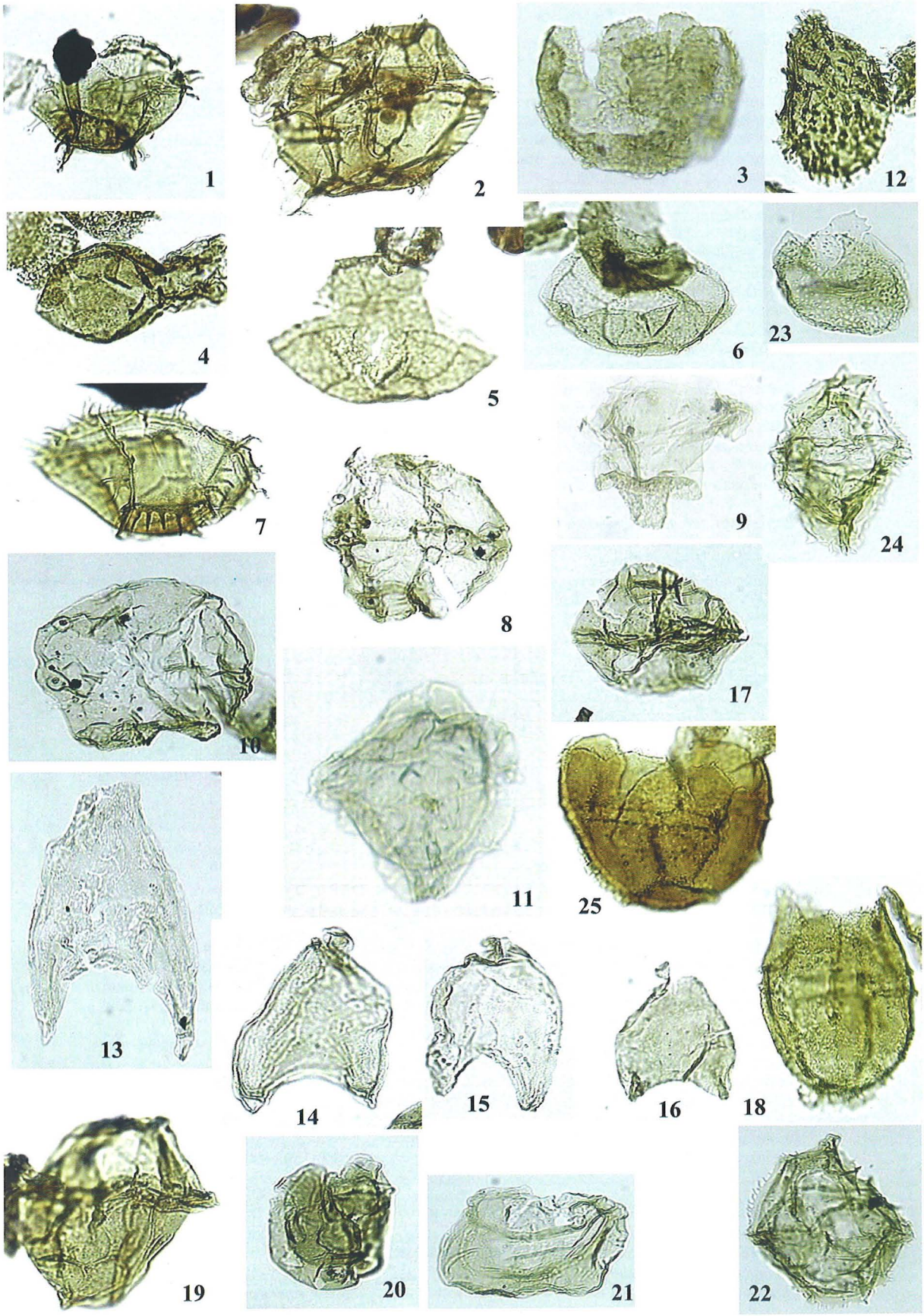
# PLATE 1

1 – *Ctenidodinium combazii*; Specimen GEUS, Catalogue no. NEP-1998-001; Alina clay-pit (sample Np-Al-1); Parkinsoni Zone, Bajocian
2 – *Dichadogonyaulax sellwoodii*; Specimen GEUS, Catalogue no. NEP-1998-002; Alina clay-pit (sample Al-15); Parkinsoni Zone, Bajocian
3 – *Lithodinia jurassica*; Specimen GEUS, Catalogue no. NEP-1998-003; Pacanów clay-pit (sample Pa1); Parkinsoni Zone, Bajocian
4 – *Dissiliodinium willei*; Specimen GEUS, Catalogue no. NEP-1998-004; Alina clay-pit (sample Np-Al-1); Parkinsoni Zone, Bajocian
5 – *Korystocysta gochtii*; Specimen GEUS, Catalogue no. NEP-1998-005; Alina clay-pit (sample Al-15); Parkinsoni Zone, Bajocian
6 – *Korystocysta pachyderma*; Specimen GEUS, Catalogue no. NEP-1998-006; Pacanów clay-pit (sample Pa1); Parkinsoni Zone, Bajocian
7 – *Ctenidodinium cornigera*; Specimen GEUS, Catalogue no. NEP-1998-007; Aniol clay-pit (sample NPX-1); Parkinsoni Zone, Bajocian
8 – *Atopodinium prostatum*; Specimen GEUS, Catalogue no. NEP-1998-008; Leszczyński clay-pit (sample NPL-10); Aurigerus Zone, Bathonian
9 – *Atopodinium polygonalis*; Specimen GEUS, Catalogue no. NEP-1998-009; Faustianka clay-pit (section C, sample 7.6 m); Progracilis Zone, Bathonian
10 – *Atopodinium polygonalis*; Specimen GEUS, Catalogue no. NEP-1998-010; Alina clay-pit (sample Al-15); Parkinsoni Zone, Bajocian
11 – *Endoscrinium asymmetrichum*; Specimen GEUS, Catalogue no. NEP-1998-011; Faustianka clay-pit (section C, sample 6.4 m); Progracilis Zone, Bathonian
12 – *Epiplosphaera gochtii*; Specimen GEUS, Catalogue no. NEP-1998-01;. Leszczyński clay-pit (sample NPL-18); Aurigerus Zone, Bathonian
13 – *Nannoceratopsis pellucida*; Specimen GEUS, Catalogue no. NEP-1998-013; Gnieździska Quarry (sample GQ-7, 16 m below top of the Callovian); Calloviense Zone, Callovian
14 – *Nannoceratopsis gracilis*; Specimen GEUS, Catalogue no. NEP-1998-014; Anioł clay-pit (sample NPX-1); Parkinsoni Zone, Bajocian
15 – *Nannoceratopsis spiculata*; Specimen GEUS, Catalogue no. NEP-1998-015; Anioł clay-pit (sample NPA-1); Parkinsoni Zone, Bajocian
16 – *Nannoceratopsis raunsgaardii*; Specimen GEUS, Catalogue no. NEP-1998-016;. Alina clay-pit (sample Al-15); Parkinsoni Zone, Bajocian
17 – *Atopodinium haromense*; Specimen GEUS, Catalogue no. NEP-1998-017; Anioł clay-pit (sample NPX-1); Parkinsoni Zone, Bajocian
18 – *Lithodinia caytonensis*; Specimen GEUS, Catalogue no. NEP-1998-043; Gnieździska Quarry (sample GQ-7, 16 m below top of the Callovian); Calloviense Zone, Callovian
19 – *Leptodinium* cf. *subtile*; Specimen GEUS, Catalogue no. NEP-1998-045; Pacanów clay-pit (sample Pa1;. Parkinsoni Zone, Bajocian
20 – *Sirmiodiniopsis orbis*; Specimen GEUS, Catalogue no. NEP-1998-048; Leszczyński clay-pit (sample NPL-18); Aurigerus Zone, Bathonian
21 – *Sirmiodinium grossii*; Specimen GEUS, Catalogue no. NEP-1998-049; Gnieździska Quarry (sample GQ-6); Calloviense Zone, Callovian
22 – *Gonyaulacysta jurassica adecta*; Specimen GEUS, Catalogue no. NEP-1998-042; Kawodrza clay-pit (sample NPKw-1); Morrisi Zone, Bathonian
23 – *Dingodinium minutum*; Specimen GEUS, Catalogue no. NEP-1998-039; Gnieździska Quarry (sample GQ-7, 16 m below top of the Callovian); Calloviense Zone, Callovian
24 – *Gonyaulacysta eisenackii*; Specimen GEUS, Catalogue no. NEP-1998-041; Gnieździska Quarry (sample GQ-7, 16 m below top of Callovian); Calloviense Zone, Callovian
25 – *Lithodinia jurassica*; Specimen GEUS, Catalogue no. NEP-1998-044; Leszczyński clay-pit (sample NPL-18); Aurigerus Zone, Bathonian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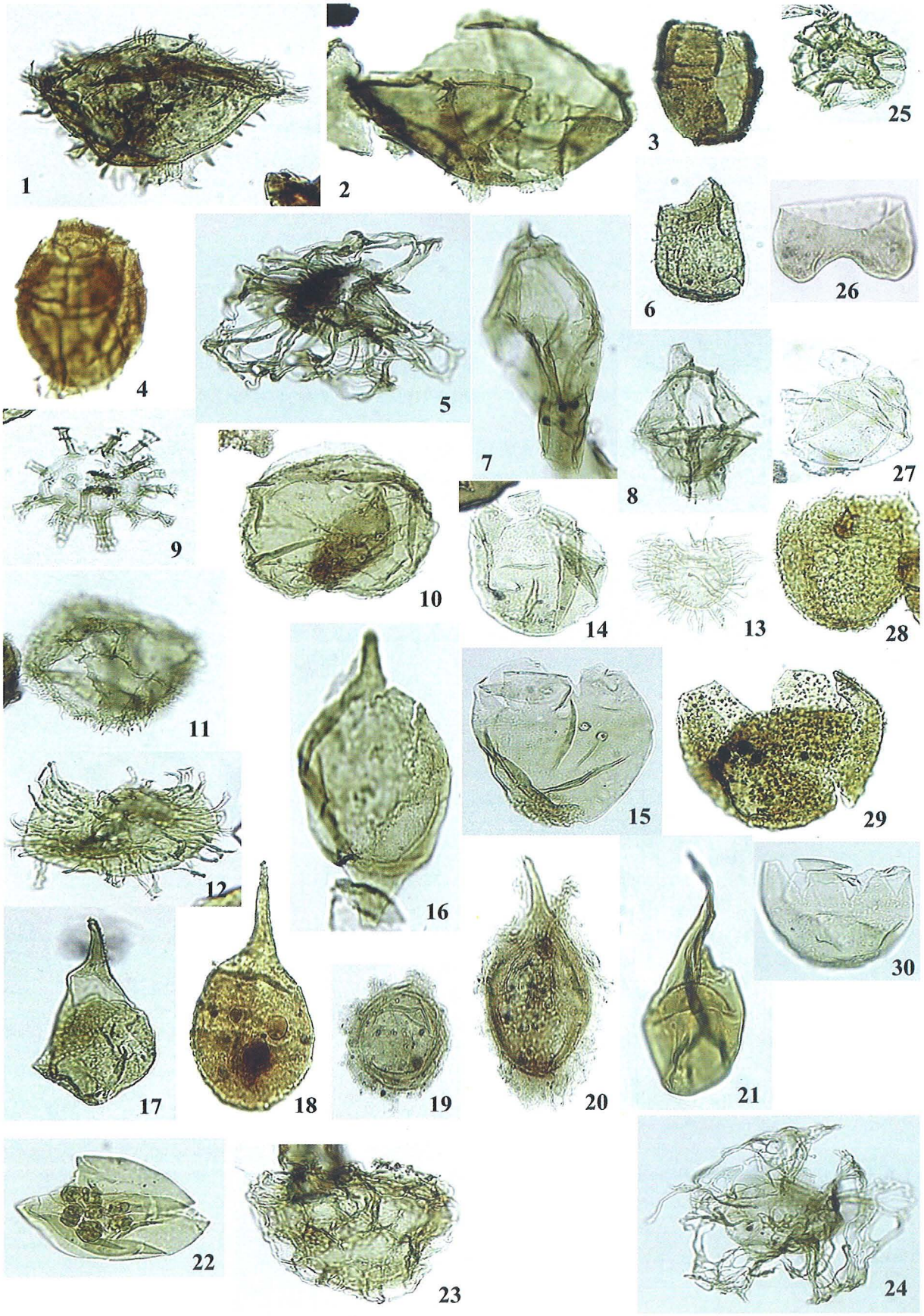
# PLATE 2

1 – *Ctenidodinium combazii*; Specimen GEUS, Catalogue no. NEP-1998-018; Kawodrza clay pit (sample NPKw-1); Morrisi Zone, Bathonian
2 – *Ctenidodinium continuum*; Specimen GEUS, Catalogue no. NEP-1998-019; Kawodrza clay-pit (sample NPKw-1); Morrisi Zone, Bathonian
3 – *Jansonia* sp. ; Specimen GEUS, Catalogue no. NEP-1998-020; Kawodrza clay-pit (sample NPKw-1); Morrisi Zone, Bathonian
4 – *Carpathodinium predae*; Specimen GEUS, Catalogue no. NEP-1998-021; Leszczyński clay-pit (sample NPL-18); Aurigerus Zone, Bathonian
5 – *Adnatosphaeridium caulleryi*; Specimen GEUS, Catalogue no. NEP-1998-022; Gnaszyn clay-pit (sample NPG-7);, Morrisi Zone, Bathonian
6 – *Valvaeodinium spinosum*; Specimen GEUS, Catalogue no. NEP-1998-023; Leszczyński clay-pit (sample NPL-18); Aurigerus Zone, Bathonian
7 – *Tubotuberella apatela*; Specimen GEUS, Catalogue no. NEP-1998-024; Gnaszyn clay-pit (sample NPG-7); Morrisi Zone, Bathonian
8 – *Tubotuberella dangeardii*; Specimen GEUS, Catalogue no. NEP-1998-025; Gnaszyn clay pit (sample NPG-23); Morrisi Zone, Bathonian
9 – *Compositosphaeridium polonicum*; Specimen GEUS, Catalogue no. NEP-1998-026; Leszczynski clay pit (sample NPL-1); Aurigerus Zone, Bathonian
10 – *Wanaea acollaris*; Specimen GEUS, Catalogue no.: NEP-1998-027; Kawodrza clay pit (sample NPKw-1); Morrisi Zone, Bathonian
11 – *Rhynchodiniopsis? regalis*; Specimen GEUS, Catalogue no. NEP-1998-028; Pacanów clay pit (sample Pa1); Parkinsoni Zone, Bajocian
12 – *Impletosphaeridium varispinosum*; Specimen GEUS, Catalogue no. NEP-1998-029; Gniezdziska Quarry (sample GQ-6, ammonite layer, 18 m below top of Callovian gaizes); Calloviense Zone, Callovian
13 – *Impletosphaeridium polytrichum*; Specimen GEUS, Catalogue no. NEP-1998-030; Faustianka clay-pit (section C, sample 6.4 m); Progracilis Zone, Bathonian
14 – *Kallosphaeridium praussii*; Specimen GEUS, Catalogue no. NEP-1998-031; Sowa & Glinski clay-pits (sample NPE-3); Zigzag Zone, Bathonian
15 – *Kallosphaeridium hypornatum*; Specimen GEUS, Catalogue no. NEP-1998-032; Aniol clay-pit (sample NPX-1); Parkinsoni Zone, Bajocian
16 – *Kalyptea stegasta*; Specimen GEUS, Catalogue no. NEP-1998-033; Faustianka clay-pit, (section C, sample 6.8 m); Progracilis Zone, Bathonian
17 – *Pareodinia aphelia*; Specimen GEUS, Catalogue no. NEP-1998-034; Pacanów clay-pit (sample Pa1); Parkinsoni Zone, Bajocian
18 – *Pareodinia aphelia*; Specimen GEUS, Catalogue no. NEP-1998-035; Alina clay-pit (sample Al-15); Parkinsoni Zone, Bajocian
19 – *Pareodinia halosa*; Specimen GEUS, Catalogue no. NEP-1998-036. Anioł clay-pit (sample NPX-1); Parkinsoni Zone, Bajocian
20 – *Pareodinia ceratophora*; Specimen GEUS, Catalogue no. NEP-1998-037; Leszczyński clay-pit (sample NPL-1); Aurigerus Zone, Bathonian
21 – *Pareodinia prolongata*; Specimen GEUS, Catalogue no. NEP-1998-038; Gnieździska Quarry (sample GQ-6, ammonite layer, 18 m below top of Callovian gaizes); Calloviense Zone, Callovian
22 – *Mendicodinium groenlandicum*; Specimen GEUS, Catalogue no. NEP-1998-047; Gnieździska Quarry (sample GQ-7, 16 m below top of Callovian); Calloviense Zone, Callovian
23 – *Epiplosphaera bireticulata*; Specimen GEUS. Catalogue no. NEP-1998-040; Gnieździska Quarry (sample GQ-6, ammonite layer, 18 m below top of Callovian gaizes); Calloviense Zone, Callovian
24 – *Adnatosphaeridium caulleryi*; Specimen GEUS, Catalogue no. NEP-1998-050; Gnaszyn clay-pit, (sample NPG-7); Morrisi Zone, Middle Bathonian
25 – *Heslertonia? pellucida*; Specimen GEUS, Catalogue no. NEP-1998-051; Faustianka clay-pit (section C, sample 7.6 m); Aurigerus Zone, Lower Bathonian
26 – *Schizocystia lundii*; Specimen GEUS, Catalogue no. NEP-1998-052; Faustianka clay-pit (section C, sample 7.6 m); Aurigerus Zone, Lower Bathonian
27 – *Kallosphaeridium praussii*; Specimen GEUS, Catalogue no. NEP-1998-053; Faustianka clay-pit (section C, sample 6.8 m); Aurigerus Zone, Lower Bathonian
28 – *Epiplosphaera reticulata*; Specimen GEUS, Catalogue no. NEP-1998-054; Alina clay-pit (sample NP-Al-9); Parkinsoni Zone, uppermost Bajocian
29 – *Barbatacysta creberbarbata*; Specimen GEUS, Catalogue no. NEP-1998-055; Alina clay-pit (sample Np-Al-1); Parkinsonia Zone, uppermost Bajocian
30 – *Escharisphaeridia pocockii*; Specimen GEUS, Catalogue no. NEP-1998-046; Gnieździska Quarry (sample GQ-7, 16 m below top of the Callovian); Calloviense Zone, Callovian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