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A palynological investigation of eight samples from the Jurassic of the Bedford District

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A palynological investigation of eight samples from the Jurassic of the Bedford District

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Foreword

This report comprises a palynological study of eight samples of the Jurassic succession from the Bedford area.

Contents

Summary

Samples 1 and 2 from Oakley and Bromham respectively are thought to be from the Kellaways Clay Member. The occurrence of *Callialasporites* spp., *Ctenidodinium* sp., ?*Gonyaulacysta jurassica* and *Leptolepidites* spp. indicates that these samples are of Bathonian-Callovian (Mid Jurassic) age. A detailed lithostratigraphical determination cannot be made, however they are probably from the Cornbrash or Kellaways formations. Correlation to the Blisworth Clay Formation is deemed unlikely.

Sample 3 from Box End is believed to be from the Whitby Mudstone Formation. The presence of *Callialasporites* spp. and *Leptolepidites* spp. indicates that this sample is of Mid-Late Jurassic age, thus an attribution to the Whitby Mudstone Formation is untenable. The sample is a dark grey mudstone, hence it is most likely that it is from the Northampton Sand, Grantham, Rutland or Blisworth Clay formations.

Sample 4 is also from Box End and is assumed to be from the Rutland Formation. The assemblage is dominated by *Meiourogonyaulax reticulata*. This, and other, dinoflagellate cysts recovered are indicative of a Bathonian age. The acme occurrence of *Meiourogonyaulax reticulata* is characteristic of the lowermost Blisworth Clay Formation of the English Midlands.

Sample 5 from Oakley is also presumed to be from the Rutland Formation. The dinoflagellate cysts are dominated by *Ctenidodinium sellwoodii*, and this is characteristic of the Bathonian. The occurrence of *Gonyaulacysta jurassica* subsp. *adecta* and *Meiourogonyaulax reticulata* means that this horizon is also interpreted as being from the Blisworth Clay Formation.

Sample 6 from Bromham is supposed to be from the lowermost Oxford Clay Formation. It produced a sparse palynoflora including *Mendicodinium groenlandicum* and *Nannoceratopsis pellucida*, which are characteristic of the Callovian. The low diversity of this sample means that it is from the Peterborough Member of the Oxford Clay Formation.

Sample 7 is thought to be from the Oxford Clay Formation of Ravensden. Many key dinoflagellate cyst taxa were recorded which indicate an early Oxfordian age. This means that this sample is from the Weymouth Member of the Oxford Clay Formation. This conclusion is surprising because the Oxford Clay Formation in this area is largely Peterborough Formation. This sample is not thought to be of a till and more sampling is needed to determine the lateral extent of the Weymouth Member at Ravensden.

Sample 8 from Bozeat is supposed to be from the Whitby Mudstone Formation. The spores and pollen indicate that the sample is late Pliensbachian to Toarcian in age. The dinoflagellate cysts are consistent with this assessment and refine this to early Toarcian, probably the *D. tenuicostatum* or the *H. falciferum* ammonite subzones. Sample 8 is therefore from the Whitby Mudstone Formation, specifically from the Grey Shale or Jet Rock members or equivalents.

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1 Introduction

Eight samples of Jurassic sedimentary rock from the Bedford district were studied for their palynomorph content. This study aimed to determine the age of the samples. It has been undertaken in order to contribute to the geological mapping of this region and to help better understand the geological history.

2 Sample Details

The eight samples studied are listed below in two tables. In the upper table, the columns are the (informal) sample number, the collector's number (prefixed AMB), the BGS micropalaeontological registration number (prefixed MPA), the grid reference and the locality respectively. In the lower table, details of the lithology where appropriate, and the probable lithostratigraphical unit are given.

TABLE 1:

1	AMB 730	MPA 53304	TL 00318 53763	SE corner of Fox Covert near Oakley. Auger hole; +45 m OD
2	AMB 731	MPA 53305	TL 00229 50324	Temp. excavation, New Road, Bromham (BA 165); +40 m OD
3	AMB 732	MPA 53306	TL 0141 4824	Newly dug lake, Box End, 280 m on 333º from Kempston Church
4	AMB 733	MPA 53307	TL 0144 4837	Newly dug lake, Box End, 380 m on 345º from Kempston Church
5	AMB 734	MPA 53308	TL 0121 5282	River bank section, College Farm, Oakley; c. +32 m OD
6	AMB 744	MPA 53309	TL 0228 5181	Nursery, Lower Farm Road, Bromham; auger hole
7	AMB 745	MPA 53310	TL 06321 56138	Brook Farm, Ravensden, auger hole in ditch
8	AMB 746	MPA 53311	SP 89864 60644	Drainage ditch at base of working sand and gravel pit. Bozeat Pit, NNW of Bozeat Church (BA 160)

TABLE 2:

1	Probable Kellaways Clay from immediately above Cornbrash/Blisworth Limestone
2	Probable Kellaways Clay
3	Dark grey mudstone; probable Whitby Mudstone Formation
4	Grey mudstone from interbedded limestone and mudstone succession; probable Rutland Formation
5	Greenish grey clay with shells; probable Rutland Formation
6	Olive clay; probable basal Oxford Clay Formation (Peterborough Member)
7	Olive clay; probable Oxford Clay Formation
8	Dark grey mudstone; probable Whitby Mudstone Formation

3 Palynology

In this section, the palynofloras are described in seven sections. Full listings of the palynomorphs identified, including semiquantitative data, are held on the respective BGS micropalaeontology/palynology data sheets, which have been archived. The samples were all prepared using the sodium hexametaphosphate method of Riding and Kyffin-Hughes (2004).

3.1 SAMPLES 1 AND 2 (MPA 53304 AND MPA 53305)

Samples 1 and 2 are thought to be from the Kellaways Clay Member. They both produced moderately rich, low diversity palynofloras. Woody material and plant fragments are also common. The palynomorphs are dominated by spores and pollen; dinoflagellate cysts are rare and poorly-preserved.

The spore/pollen component includes bisaccate pollen, *Callialasporites* spp. *Cerebropollenites macroverrucosus*, *Cibotiumspora juriensis*, *Classopollis classoides*, *Cyathidites* spp., *Dictyophyllidites* spp., and *Leptolepidites* spp. The dinoflagellate cysts *Ctenidodinium* sp. (sample 1) and ?*Gonyaulacysta jurassica* (sample 2) were also observed. Indeterminate dinoflagellate cysts, largely spine-bearing forms, were noted in both samples in low numbers. Some Quaternary pollen grains and fungal material were recorded in both samples. These contaminants are assumed to have been introduced during the sampling process.

The occurrence of *Callialasporites* spp. indicates that these samples are of Mid-Late Jurassic age; the range base of this genus is at the Early-Mid Jurassic boundary (Riding et al. 1991). *Leptolepidites* spp. are also characteristic of the Mid Jurassic. *Ctenidodinium* sp., ?*Gonyaulacysta jurassica* and indeterminate chorate dinoflagellate cysts are consistent with the Bathonian-Callovian interval. However, because of the paucity and equivocal nature of the microplankton associations, a detailed lithostratigraphical determination cannot be made. Riding (1987) reported abundant and diverse dinoflagellate cysts from the Kellaways Clay Member of the Nettleton Bottom Borehole, Lincolnshire. Similar associations are known from the Walks Farm Borehole, also in Lincolnshire (unpublished data). It seems likely that the samples are from the Cornbrash or Kellaways formations due to the presence of ?*Gonyaulacysta jurassica* in sample 2. The Blisworth Clay Formation cannot be entirely ruled out, but the occurrence of ?*Gonyaulacysta jurassica* in sample 2 makes this unlikely.

3.2 SAMPLE 3 (MPA 53306)

Sample 3 is thought to be from the Whitby Mudstone Formation of Box End on lithological evidence. It produced a relatively rich, moderately well-preserved palynoflora. Woody material and plant fragments are dominant, however palynomorphs, largely pteridophyte spores, are also present.

The spore/pollen component includes bisaccate pollen, *Callialasporites* spp. *Cibotiumspora juriensis*, *Classopollis classoides*, *Coronatispora valdensis*, *Cyathidites* spp., *Dictyophyllidites* spp., *Leptolepidites* spp., and *Perinopollenites elatoides*. *Cyathidites* spp., are the most prominent elements. No unequivocal dinoflagellate cysts were observed. Some Quaternary pollen grains were recorded; these contaminants are assumed to have been introduced during sampling.

The presence of *Callialasporites* spp. indicates that this sample is of Mid-Late Jurassic age, hence a correlation with the Whitby Mudstone Formation is untenable. The range base of this genus is at the Early-Mid Jurassic transition (Riding et al. 1991). *Leptolepidites* spp. are also characteristic of the Mid Jurassic. Unfortunately, the ranges of the miospores are not suitable for a detailed (substage) breakdown, hence are not characteristic of an individual lithostratigraphical unit between the Northampton Sand and Blisworth Clay formations. The sample cannot be referable to the Cornbrash Formation or any younger units because these are characterised by abundant and diverse dinoflagellate cyst floras. However, given that the sample is a dark grey mudstone, it is most likely that it is from the Northampton Sand, Grantham, Rutland or Blisworth Clay formations.

3.3 SAMPLE 4 (MPA 53307)

This sample is thought to be from the Rutland Formation of Box End based on lithological evidence. It produced an abundant, well-preserved palynoflora. Woody material and plant fragments are present, however palynomorphs, largely dinoflagellate cysts, dominate the residue.

The spores and pollen include bisaccate pollen, *Callialasporites* spp., *Cerebropollenites macroverrucosus, Cibotiumspora juriensis, Classopollis classoides, Concavissimisporites verrucosus, Coronatispora valdensis, Cyathidites* spp., *Ischysporites variegatus, Perinopollenites elatoides* and *Sestrosporites pseudoalveolatus. Callialasporites* spp., are most prominent and indicate that this sample is of Mid-Late Jurassic age.

The dinoflagellate cysts are overwhelmingly dominated by *Meiourogonyaulax reticulata*. Other forms include *Ctenidodinium combazii, Ctenidodinium sellwoodii, Gonyaulacysta jurassica* subsp. *adecta, Korystocysta gochtii, Leptodinium* sp., *Pareodinia ceratophora,* and *Wanaea acollaris*. This association is highly characteristic of the Bathonian Stage (Riding et al., 1985; 1991; Riding and Thomas, 1992). The best reference section for this sample is the Nettleton Bottom Borehole, Lincolnshire (Riding, 1983; 1987). An acme of *Meiourogonyaulax reticulata* was discovered in the lowermost Blisworth Clay Formation of the latter borehole Riding (1983; 1987). Bradshaw and Penney (1982) also reported large numbers of *Meiourogonyaulax reticulata* from the lower part of the Blisworth Clay Formation. The uniqueness of this bioevent means that sample 4 is positively correlated with this horizon at the base of the Blisworth Clay Formation. Further evidence for this conclusion comes from the BGS Walks Farm Borehole where *Meiourogonyaulax reticulata* is confined to the uppermost Rutland Formation, Blisworth Limestone Formation and Blisworth Clay Formation (unpublished information). Moreover, palynomorph assemblages from the Rutland Formation are dominated by miospores and the marine microplankton associations, where present, are of low diversity and do not contain certain of the dinoflagellate cysts recorded here, such as *Ctenidodinium combazii* and *Gonyaulacysta jurassica* subsp. *adecta*.

3.4 SAMPLE 5 (MPA 53308)

This sample is presumed to be from the Rutland Formation of Oakley on lithological evidence. It produced an abundant and well-preserved palynoflora. Woody material and plant fragments are also present. The spores and pollen include bisaccate pollen, *Callialasporites* spp., *Cerebropollenites macroverrucosus, Classopollis classoides, Coronatispora valdensis, Cyathidites* spp., Dictyophyllidites spp., *Ischysporites variegatus, Perinopollenites elatoides* and *Retitriletes austroclavatidites*. Species of *Callialasporites* are the most prominent, and this indicates a Mid-Late Jurassic age.

The dinoflagellate cysts are dominated by *Ctenidodinium sellwoodii*; other forms present comprise *Gonyaulacysta jurassica* subsp. *adecta, Meiourogonyaulax reticulata* and *Pareodinia ceratophora*. This association is characteristic of the Bathonian Stage (Riding et al., 1985; 1991; Riding and Thomas, 1992). In terms of the lithostratigraphical interpretation, the material is from the uppermost Rutland Formation, the Blisworth Limestone Formation or the Blisworth Clay Formation due to the occurrence of *Meiourogonyaulax reticulata.* However, the range base of *Gonyaulacysta jurassica* subsp. *adecta* in the Midlands is typically in the Cornbrash Formation; this form has never been recorded from the Rutland Formation. Therefore, sample 5 is interpreted as being from the Blisworth Clay Formation.

3.5 SAMPLE 6 (MPA 53309)

Sample 6 is supposed to be from the lowermost Oxford Clay Formation of Bromham on lithological and regional evidence. It produced a sparse, poorly-preserved palynoflora. Woody material and plant fragments are dominant. The palynomorphs include the dinoflagellate cysts

Mendicodinium groenlandicum and *Nannoceratopsis pellucida.* The latter species is relatively common. Other forms include the spore *Dictyophyllidites* spp., undifferentiated bisaccate pollen grains and prasinophytes. Minor levels of the reworked Carboniferous spore such *Densosporites* spp. were also observed. Some Quaternary pollen grains, such as the arboreal genera *Alnus* and *Tilia*, are also present, and are assumed to be contaminants from the auger hole.

The dinoflagellate cysts *Mendicodinium groenlandicum* and *Nannoceratopsis pellucida* are characteristic of the Callovian Stage. The relative abundance of *Nannoceratopsis pellucida*, in the absence of late Callovian marker species such as *Gonyaulacysta centriconnata*, is indicative of the early and early mid Callovian. This means that sample 6 was collected from the Peterborough Member of the Oxford Clay Formation.

3.6 SAMPLE 7 (MPA 53310)

Sample 7 is believed to be from the Oxford Clay Formation of Ravensden on lithological grounds. It produced an extremely abundant and well-preserved palynoflora. Woody material and plant fragments are present, however palynomorphs, largely dinoflagellate cysts and gymnospermous pollen grains, dominate the residue.

The spore/pollen component includes bisaccate pollen, *Callialasporites* spp., *Cerebropollenites macroverrucosus, Classopollis classoides, Cyathidites* spp., *Ischysporites variegatus, Perinopollenites elatoides* and *Retitriletes austroclavatidites.* The occurrence of *Callialasporites* spp. indicates that this sample is of Mid-Late Jurassic age. Minor levels of presumed reworked Carboniferous spores such as *Densosporites* spp. and *Lycospora pusilla* were also observed.

Dinoflagellate cysts are extremely diverse and include *Batiacasphaera* spp., *Chytroeisphaeridia cerastes, Chytroeisphaeridia chytroeides, Cleistosphaeridium* spp., *Compositosphaeridium polonicum, Cribroperidinium globatum, Ctenidodinium ornatum, Fromea tornatilis, Gonyaulacysta centriconata, Gonyaulacysta eisenackii, Gonyaulacysta jurassica* subsp. *adecta, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Gonyaulacysta jurassica* subsp. *jurassica, Korystocysta gochtii, Leptodinium* spp., ?*Endoscrinium luridum, Meiourogonyaulax* spp., *Mendicodinium groenlandicum, Nannoceratopsis pellucida, Pareodinia halosa, Pareodinia* sp., *Prolixosphaeridium* sp., *Rhynchodiniopsis cladophora, Rigaudella aemula, Scriniodinium crystallinum, Sentusidinium* spp., *Sirmiodinium orbis, Surculosphaeridium vestitum, Systematophora areolata, Systematophora* spp., *Tubotuberella dangeardii,* and *Wanaea thysanota.* These include many key markers for the early Oxfordian Substage, including *Gonyaulacysta centriconata, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Gonyaulacysta jurassica* subsp. *jurassica, Leptodinium* spp., *Rigaudella aemula, Scriniodinium crystallinum, Systematophora areolata* and *Wanaea thysanota*. The early Oxfordian age assessment is based on the overlapping ranges of reliable marker taxa with early Oxfordian range tops (e.g. *Gonyaulacysta centriconata* and *Wanaea thysanota*) with index species with inceptions within this substage (such as *Gonyaulacysta jurassica* subsp. *jurassica*, *Leptodinium* spp. and *Systematophora areolata*) (Riding and Thomas, 1992; 1997). This means that sample 7 is from the Weymouth Member of the Oxford Clay Formation. The early Oxfordian interpretation is significantly strengthened by the absence of exclusively Callovian taxa such as *Ctenidodinium continuum, Pareodinia prolongata* and *Wanaea acollaris*.

The apparent attribution to the Weymouth Member is somewhat surprising as, on regional mapping evidence, the Oxford Clay Formation in this area belongs to the Peterborough Member. It is possible there is a structure that has preserved the entire Oxford Clay Formation in the Ravensden area; alternatively, sample 7 may be till. The till of this district is known to be formed dominantly from local Oxford Clay Formation and hence is lithologically similar. There are small numbers of allochthonous Carboniferous spores in sample 7 such as *Calamospora* sp., *Densosporites* spp. and *Lycospora pusilla*. The presence of Carboniferous spores is not unequivocal evidence of a glaciogenic origin because these recycled grains are known from the

in situ Oxford Clay Formation. There are also small numbers of grains that are younger than early Oxfordian in sample 7. A single specimen of the dinoflagellate cyst *Glossodinium dimorphum* and low numbers of questionable specimens of *Endoscrinium luridum* were observed. These species have inceptions in the mid Oxfordian (Riding and Thomas, 1992). Furthermore a single specimen of the Palaeogene dinoflagellate cyst *Dracodinium* sp. is also present. These few mid Oxfordian and Palaeogene forms may be contaminants from the overlying till introduced during the augering process. In summary, the relative paucity of the Carboniferous and mid Oxfordian/Palaeogene grains means that they can be explained by Carboniferous reworking into the early Oxfordian and sampling contamination respectively. If sample 7 was a till, a much more heterogenous palynoflora would be expected. Typically this would yield significant numbers of Carboniferous spores and a mixed Jurassic assemblage. The early Oxfordian dinoflagellate cyst association is robust and coherent; this sample is interpreted as being from the Weymouth Member. Because of the unexpected nature of the occurrence of the Weymouth Member at Ravensden, it is strongly recommended that more auger samples are collected in this region to confirm the occurrence of this unit and to help determine its spatial extent. Ideally, a shallow borehole should be drilled to help resolve the thickness and structure of the Oxford Clay Formation and till succession in this area.

3.7 SAMPLE 8 (MPA 53311)

Sample 8 is thought to be from the Whitby Mudstone Formation of Bozeat on lithological evidence. It produced an extremely rich, well-preserved palynoflora. Woody material and plant fragments are present, however palynomorphs, largely gymnospermous pollen grains, overwhelmingly dominate the residue.

The spore/pollen component includes *Cerebropollenites macroverrucosus, Chasmatosporites* spp., *Classopollis classoides, Contignisporites* sp., *Coronatispora valdensis, Cyathidites* spp., *Dictyophyllidites* spp., *Ischysporites variegatus, Kekryphalospora distincta, Perinopollenites elatoides* and *Retitriletes austroclavatidites. Cerebropollenites macroverrucosus, Chasmatosporites* spp. and *Classopollis classoides* are the most prominent elements. The occurrence of *Cerebropollenites macroverrucosus* and *Chasmatosporites* spp., and the absence of *Callialasporites* spp., indicates that this sample is of Early Jurassic age. The presence of *Kekryphalospora distincta* is also significant. This spore is confined to the late Pliensbachian to early Bajocian interval (Fenton and Riding, 1987). Hence on spore-pollen evidence, sample 8 is late Pliensbachian to Toarcian in age.

The microplankton assemblage includes the dinoflagellate cysts *Mancodinium semitabulatum, Nannoceratopsis deflandrei* subsp. *deflandrei, Nannoceratopsis deflandrei* subsp. *senex, Nannoceratopsis gracilis* and ?*Scriniocassis priscus*. Also present are *Botryococcus* sp., *Micrhystridium* spp., *Schizocystia rare, Tasmanites newtoni* and *Tasmanites* spp. The dinoflagellate cyst association is indicative of the Toarcian Stage (Riding and Thomas, 1992). The range base of *Nannoceratopsis gracilis* is typically intra-early Toarcian (Riding et al., 1999). The sample is unlikely to be from the 'bituminous' part of the *D. tenuicostatum* or the *H. falciferum* ammonite zones because it lacks the characteristic association of amorphogen and prasinophytes typical of the early Toarcian oceanic anoxic event (OAE) (Bucefalo Palliani et al., 2002). Because of the absence of the *Parvocysta* suite, the sample is unlikely to be of latest early Toarcian or late Toarcian age (Riding et al., 1991; Bucefalo Palliani and Riding 2003). This means that sample 8 is interpreted as being from strata referable to the *D. tenuicostatum* or the *H. falciferum* ammonite zones, but not in the OAE facies. This means that sample 1 is most likely to be from the *D. tenuicostatum* or the *H. falciferum* ammonite subzones (Bucefalo Palliani et al., 2002). Therefore sample 8 is confirmed as being from the Whitby Mudstone Formation, specifically from the Grey Shale or Jet Rock members or equivalents.

4 Summary

Samples 1 and 2 from Oakley and Bromham respectively are thought to be from the Kellaways Clay Member. The occurrence of *Callialasporites* spp., *Ctenidodinium* sp., ?*Gonyaulacysta jurassica* and *Leptolepidites* spp. indicates that these samples are of Bathonian-Callovian (Mid Jurassic) age. A detailed lithostratigraphical determination cannot be made, however they are probably from the Cornbrash or Kellaways formations. Correlation to the Blisworth Clay Formation is deemed unlikely.

Sample 3 from Box End is believed to be from the Whitby Mudstone Formation. The presence of *Callialasporites* spp. and *Leptolepidites* spp. indicates that this sample is of Mid-Late Jurassic age, thus an attribution to the Whitby Mudstone Formation is untenable. The sample is a dark grey mudstone, hence it is most likely that it is from the Northampton Sand, Grantham, Rutland or Blisworth Clay formations.

Sample 4 is also from Box End and is assumed to be from the Rutland Formation. The assemblage is dominated by *Meiourogonyaulax reticulata*. This, and other, dinoflagellate cysts recovered are indicative of a Bathonian age. The acme occurrence of *Meiourogonyaulax reticulata* is characteristic of the lowermost Blisworth Clay Formation of the English Midlands.

Sample 5 from Oakley is also presumed to be from the Rutland Formation. The dinoflagellate cysts are dominated by *Ctenidodinium sellwoodii*, and this is characteristic of the Bathonian. The occurrence of *Gonyaulacysta jurassica* subsp. *adecta* and *Meiourogonyaulax reticulata* means that this horizon is also interpreted as being from the Blisworth Clay Formation.

Sample 6 from Bromham is supposed to be from the lowermost Oxford Clay Formation. It produced a sparse palynoflora including *Mendicodinium groenlandicum* and *Nannoceratopsis pellucida*, which are characteristic of the Callovian. The low diversity of this sample means that it is from the Peterborough Member of the Oxford Clay Formation.

Sample 7 is thought to be from the Oxford Clay Formation of Ravensden. Many key dinoflagellate cyst taxa were recorded which indicate an early Oxfordian age. This means that this sample is from the Weymouth Member of the Oxford Clay Formation. This conclusion is surprising because the Oxford Clay Formation in this area is largely Peterborough Formation. This sample is not thought to be of a till and more sampling is needed to determine the lateral extent of the Weymouth Member at Ravensden.

Sample 8 from Bozeat is supposed to be from the Whitby Mudstone Formation. The spores and pollen indicate that the sample is late Pliensbachian to Toarcian in age. The dinoflagellate cysts are consistent with this assessment and refine this to early Toarcian, probably the *D. tenuicostatum* or the *H. falciferum* ammonite subzones. Sample 8 is therefore from the Whitby Mudstone Formation, specifically from the Grey Shale or Jet Rock members or equivalents.

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