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# A palynological investigation of samples from the Oxford Clay Formation of the Bedford district (Sheet 203)

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# A palynological investigation of samples from the Oxford Clay Formation of the Bedford district (Sheet 203)

James B. Riding



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# Foreword

This report comprises a biostratigraphical study of eight samples from the presumed Oxford Clay Formation of the Bedford Sheet (203).

# Contents



# Summary

Samples 1 to 4 yielded variably productive palynofloras, the dinoflagellate cysts of which are characteristic of the late Callovian-early Oxfordian interval. Sample 1 is undifferentiated late Callovian-early Oxfordian, thus is deemed to be from either the Stewartby or the Weymouth members of the Oxford Clay Formation. Samples 2 and 3 are late Callovian on dinoflagellate cyst evidence, so are from the Stewartby Member of the Oxford Clay Formation. Sample 4 produced an early Oxfordian dinoflagellate cyst flora, hence is interpreted as being from the Weymouth Member of the Oxford Clay Formation.

Samples 5 to 8 produced diverse dinoflagellate cyst assemblages which are characteristic of the mid Callovian Coronatum Zone. This indicates a correlation with the middle part of the Peterborough Member (Oxford Clay Formation). Because there is no variation in the ages of the palynomorphs observed, the samples are interpreted as being from *in situ* Peterborough Member due to their purity and also the consistent relative proportions of palynomorphs.

# 1 Introduction

Eight samples thought to be from the Oxford Clay Formation from the 1:50 k geological sheet 203 (Bedford) were studied for their palynomorph content in order to determine both geological ages (and hence lithostratigraphy) and palaeoenvironment in order to help the detailed geological mapping of this region. The biostratigraphical resolution of Callovian-Oxfordian (Jurassic) dinoflagellate cysts is normally sufficient to enable the differentiation of the three members of the Oxford Clay Formation. Four of the samples (numbers 5 to 8) are possibly from a Till sheet. It is hoped that palynological analysis will determine if these samples are from the *in situ* Oxford Clay Formation or Till. Tills normally produce highly mixed palynofloras due to glacigenic mixing processes.

# 2 Sample Details

The eight samples studied are listed in the table below. The columns are, respectively, the (informal) sample number, the BGS micropalaeontological registration number (prefixed MPA), the collectors number (prefixed AMB), the grid reference, the depth below ground level in metres (where known), the locality and the supposed lithostratigraphical unit.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | MPA 51278 | AMB 700 | TL 1033 4537 | … | Manor Farm | Oxford Clay Fm. |
| 2 | MPA 51279 | AMB 701 | TL 10320 45369 | … | Manor Farm | Oxford Clay Fm. |
| 3 | MPA 51280 | AMB 702 | TL 0910 4408 | … | Herring's Green | Oxford Clay Fm. |
| 4 | MPA 51281 | AMB 703 | TL 0545 4101 | *c*. 3.0 | Bury Leys Farm | Oxford Clay Fm. |
| 5 | MPA 51282 | AMB 704 | TL 0922 5517 | 0.9 | Church End Farm | Ox. Clay Fm./Till |
| 6 | MPA 51283 | AMB 705 | TL 0823 5532 | 0.9 | Crow Hill Farm | Ox. Clay Fm./Till |
| 7 | MPA 51284 | AMB 706 | TL 0833 5541 | 1.0 | Crow Hill Farm | Ox. Clay Fm./Till |
| 8 | MPA 51285 | AMB 707 | TL 0861 5658 | 2.6 | Smartwick Farm | Ox. Clay Fm./Till |

# 3 Palynology

In this section, the palynofloras are described in two main sections. Full listings of palynomorphs, including quantitative data, are held on the respective BGS micropalaeontology/palynology data sheets, which have been archived.

### 3.1 SAMPLES 1 TO 4: OXFORD CLAY FORMATION

Samples 1 to 4 inclusive are all samples from the unequivocal Oxford Clay Formation. All four samples were collected from a pipeline trench. The aim of this study is to biostratigraphically determine which of the three members within this formation the samples belong to. The samples yielded variably abundant palynomorph and kerogen assemblages. Palynomorphs tend to dominate, with lesser proportions of wood, other plant tissues and amorphogen. The most numerous palynomorphs are gymnospermous pollen grains and dinoflagellate cysts, thereby confirming an open marine setting. The palynofloras are similar in species spectra and relative proportions. The pollen grains include bisaccate pollen, *Callialasporites* spp., *Cerebropollenites macroverrucosus, Classopollis classoides* and *Perinopollenites elatoides*. Pteridophytic spores are less common and include *Coronatispora valdensis, Cyathidites* spp., *Ischyosporites* *variegatus, Retitriletes austroclavatidites* and *Sestrosporites pseudoalveolatus*. The dinoflagellate cysts are diverse and include *Atopodinium prostatum, Batiacasphaera* spp., chorate cysts (undifferentiated), *Clathroctenocystis aspaha, Cleistosphaeridium* spp., *Compositosphaeridium polonicum, Chytroeisphaeridia chytroeides, Ctenidodinium continuum, Ctenidodinium ornatum, Ctenidodinium* spp., *Crussolia deflandrei, Endoscrinium galeritum, Fromea tornatilis, Gonyaulacysta centriconnata, Gonyaulacysta eisenackii, Gonyaulacysta jurassica* subsp. *adecta, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Gonyaulacysta jurassica* subsp. *jurassica, Korystocysta pachyderma, Korystocysta* spp*., Leptodinium* sp*., Limbodinium absidatum, Meiourogonyaulax spp., Mendicodinium groenlandicum, Paragonyaulacysta* sp., *Pareodinia ceratophora, Pareodinia* spp., *Prolixosphaeridium* spp., *Rhynchodiniopsis cladophora, Rigaudella aemula, Scriniodinium crystallinum, Sentusidinium creberbarbatum, Sentusidinium* spp., *Sirmiodiniopsis orbis, Sirmiodinium grossii, Stephanelytron caytonense, Stephanelytron redcliffense, Stephanelytron scarburghense, Surculosphaeridium vestitum, Systematophora aemula, Trichodinium scarburghensis, Tubotuberella dangeardii, Tubotuberella dentata, Valensiella* spp., *Wanaea acollaris* and *Wanaea thysanota*. There are minor levels of various marine microplankton that include foraminiferal test linings and *Micrhystridium* spp.

The dinoflagellate cyst assemblages contain many key marker species and indicate that all four samples are late Callovian to early Oxfordian in age. Typically mid Callovian forms such as *Kalyptea stegasta* are absent and species such as *Atopodinium prostatum, Clathroctenocystis asapha, Crussolia deflandrei, Gonyaulacysta centriconnata, Gonyaulacysta jurassica* subsp. *jurassica, Leptodinium* sp*., Limbodinium absidatum, Rigaudella aemula, Scriniodinium crystallinum, Systematophora aemula, Trichodinium scarburghensis, Tubotuberella dentata* and *Wanaea thysanota* are indicative of the late Callovian to early Oxfordian interval (Athleta to Cordatum zones) (Woollam and Riding, 1983; Riding and Thomas, 1992; 1997; Martill et al., 1994). Because these four samples have been attributed to the late Callovian to early Oxfordian, they are confidently attributed to the Stewartby and Weymouth members of the Oxford Clay Formation. These units were formerly termed the Middle and Upper Oxford Clay respectively (Cox et al., 1992). The detailed biostratigraphy/lithostratigraphy of these four samples are discussed below.

### 3.1.1 Sample 1

Sample 1 produced a relatively sparse organic residue with poorly-preserved palynomorphs. Wood and resistant mineral grains dominate the residue. The palynomorphs proved rare and the association is of low diversity. Dinoflagellate cysts include *Fromea tornatilis*, *Gonyaulacysta jurassica* subsp. *adecta* and *Mendicodinium groenlandicum*. The most biostratigraphcally significant form present is *Gonyaulacysta centriconnata*. The range of this form is late Callovian to early Oxfordian (Feist Burkhardt and Wille, 1992; Martill et al., 1994; Riding and Thomas, 1997), thus sample 1 is attributed to either the Stewartby Member or the Weymouth Member of the Oxford Clay Formation.

### 3.1.2 Sample 2

Sample 2 yielded a moderately abundant organic residue and palynoflora. Resistant mineral grains are dominant. Palynomorphs are relatively abundant and diverse. The dinoflagellate cyst flora is of late Callovian aspect. It includes *Clathroctenocystis asapha, Ctenidodinium continuum*, *Fromea tornatilis*, *Gonyaulacysta centriconnata*, *Gonyaulacysta jurassica* subsp. *adecta, Rigaudella aemula, Scriniodinium crystallinum* and *Wanaea acollaris.* The association of *Ctenidodinium continuum* and *Wanaea acollaris* is indicative of a late Callovian age; these forms typically have their range tops close to the Callovian/Oxfordian boundary (Riding, 1984; Feist Burkhardt and Wille, 1992; Martill et al., 1994). Because of this interpretation, this sample is deemed to be from the Stewartby Member of the Oxford Clay Formation.

### 3.1.3 Sample 3

Sample 3 produced a rich and diverse palynoflora. Palynomorphs dominate the residue. The dinoflagellate cyst association is indicative of the late Callovian (Athleta and Lamberti zones). This is due to the presence of forms that typically have late Callovian range tops such as *Ctenidodinium continuum* and *Wanaea acollaris* (see section 3.1.2), and species with range bases within this substage such as *Gonyaulacysta centriconnata*, *Limbodinium absidatum, Trichodinium scarburghensis* and *Wanaea thysanota* (Martill et al., 1994). Because of this late Callovian interpretation, sample 3 is considered to be from the Stewartby Member of the Oxford Clay Formation.

### 3.1.4 Sample 4

This sample produced an extremely rich, diverse and well-preserved palynoflora. The abundant dinoflagellate cyst association is indicative of the early Oxfordian (Mariae and Lamberti zones). The sample yielded several late Callovian-early Oxfordian markers such as *Atopodinium prostatum*, *Rigaudella aemula, Trichodinium scarburghensis* and *Wanaea thysanota.* Late Callovian markers such as *Ctenidodinium continuum* and *Wanaea acollaris* (see section 3.1.2) are absent. Furthermore, the occurrences of *Crussolia deflandrei, Gonyaulacysta jurassica* subsp. *jurassica*, *Leptodinium* sp., *Systematophora areolata* and *Tubotuberella dentata* indicate the early Oxfordian substage. The range bases of *Gonyaulacysta jurassica* subsp. *jurassica*, *Leptodinium* sp., *Systematophora areolata* are known to be within this interval (Riding and Thomas, 1992; Martill et al., 1994). *Crussolia deflandrei* and *Tubotuberella dentata* are typical of the early Oxfordian (Martill et al., 1994; Riding and Thomas, 1997). Unfortunately, the distinctive early Oxfordian species *Wanaea fimbriata* was not encountered. Because of this early Oxfordian interpretation, sample 4 is considered to be from the Weymouth Member of the Oxford Clay Formation.

## 3.2 SAMPLES 5 TO 8: OXFORD CLAY FORMATION OR TILL?

Samples 5 to 8 inclusive are all hand auger samples that were taken on farmland. The lithology (dark claystone) indicates that they are probably from the Oxford Clay Formation, but regional and other evidence suggests that the samples may be from a Till sheet. Normally, Till sheets yield mixed palynomorph assemblages due to the transport of erratic clasts and rock flour over significant distances. Ice sheets typically erode several lithostratigraphical units, thereby producing heterolithic glacigenic sediments which produce mixed palynofloras. The intention of this study is to examine the palynomorphs in order to assess palynomorph variability and thus whether the samples are *in situ* Oxford Clay Formation or Till.

All the samples yielded abundant palynomorph and kerogen assemblages. Palynomorphs dominate the associations, with lesser proportions of wood, other plant tissues and amorphogen. The most numerous palynomorphs are gymnospermous pollen grains and dinoflagellate cysts, therefore indicating an open marine depositional regime. The palynofloras are all extremely similar in both species spectra and relative proportions; they are therefore interpreted as being from the same genetic unit. The pollen grains include bisaccate pollen, *Callialasporites dampieri, Callialasporites microvelatus, Callialasporites segmentatus, Callialasporites trilobatus, Callialasporites turbatus, Cerebropollenites macroverrucosus, Classopollis classoides* and *Perinopollenites elatoides*. Pteridophytic spores are less common and diverse, but include *Coronatispora valdensis, Cyathidites* spp., *Ischyosporites variegatus* and *Retitriletes austroclavatidites*. The dinoflagellate cysts are relatively diverse and include *Atopodinium prostatum, Batiacasphaera* spp., chorate cysts (undifferentiated), *Chytroeisphaeridia cerastes, Cleistosphaeridium* spp., *Compositosphaeridium polonicum, Chytroeisphaeridia chytroeides, Ctenidodinium continuum, Ctenidodinium ornatum, Ctenidodinium* spp., *Endoscrinium galeritum, Fromea tornatilis,* ?*Gonyaulacysta centriconnata,* ?*Gonyaulacysta eisenackii,* *Gonyaulacysta jurassica* subsp. *adecta, Kalyptea stegasta, Korystocysta gochtii, Korystocysta pachyderma,* ?*Lagenadinium callovianum, Meiourogonyaulax caytonensis, Mendicodinium groenlandicum, Nannoceratopsis pellucida, Pareodinia ceratophora, Pareodinia* spp., *Prolixosphaeridium* spp., *Rhynchodiniopsis cladophora, Sirmiodiniopsis orbis, Sirmiodinium grossii, Stephanelytron redcliffense,* ?*Tabulodinium senarium, Tubotuberella apatela, Tubotuberella dangeardii, Valensiella* spp. and *Wanaea acollaris*. Various marine microplankton include foraminiferal test linings and *Micrhystridium* spp.

The dinoflagellate cyst assemblage is by far the most stratigraphically significant. The assemblage is of unequivocal Callovian aspect. For example, the consistent occurrences of forms such as *Ctenidodinium continuum, Fromea tornatilis, Gonyaulacysta jurassica* subsp. *adecta, Kalyptea stegasta, Korystocysta* spp., ?*Lagenadinium callovianum,* ?*Tabulodinium senarium* and *Wanaea acollaris* are indicative of the Callovian Stage (Woollam and Riding, 1983; Riding and Thomas, 1992; Riding and Helby, 2001). This can be refined considerably due to the presence and absence of certain key marker forms.

Samples 5 to 8 are not early Callovian because species such as *Aldorfia aldorfensis,* common *Chytroeisphaeridia hyalina, Cleistosphaeridium varispinosum, Ctenidodinium combazii* and *Meiourogonyaulax planoseptata* were not recorded. These species are all reliable early Callovian markers (Feist Burkhardt and Wille, 1992; Riding and Thomas, 1992; 1997). The samples are not late Callovian due to the absence of several important marker forms. Dinoflagellate cyst assemblages diversified significantly in the late Callovian and species such as *Clathroctenocystis asapha, Limbodinium absidatum, Reutlingia gochtii, Scriniodinium crystallinum, Trichodinium scarburghensis* and *Wanaea thysanota* all had inceptions in the Athleta and Lamberti zones (Riding and Thomas, 1992; Martill et al., 1994).

The occurrence of common *Kalyptea stegasta*, especially in sample 5, is indicative of the mid Callovian. This species is especially prominent in the Jason and Coronatum zones (Riley and Fenton, 1982; Riding and Thomas, 1997). Furthermore, the occurrence of consistent *Comopsitosphaeridium polonicum* and *Meiourogonyaulax caytonensis* is indicative of the mid Callovian; the range base and top of these forms are at the base and top respectively of the mid Callovian according to Feist Burkhardt and Wille (1992). The consistent differentiation of the Jason and Coronatum zones on dinoflagellate cyst evidence is somewhat problematical (Huault, 1999), and more detailed research needs to be done. However, evidence largely from Scotland indicates that the relatively high diversity of the associations and the occurrences of *Ctenidodinium ornatum*, ?*Gonyaulacysta centriconnata,* ?*Gonyaulacysta eisenackii* and *Sirmiodiniopsis orbis* is indicative of the Coronatum Zone (Riding and Thomas, 1997, fig. 2).

Because these four samples have been attributed to the Coronatum Zone, they are confidently attributed to the middle part of the Peterborough Member of the Oxford Clay Formation. This unit was formerly termed the Lower Oxford Clay (Cox et al., 1992). The principal question to be answered here is whether or not these samples are from *in situ* Oxford Clay Formation or a Till sheet. No pre-Jurassic palynomorphs were observed; a Till from this area would be expected to contain some Carboniferous spores derived from farther north. Two possible Palaeogene pollen grains referable to *Spinizonocolpites* were observed, one each in samples 5 and 7. These occurrences of ?*Spinizonocolpites* may represent contamination and are not significant enough numerically to indicate the unequivocal glacigenic mixing of sediment. Most Tills have a broad mixture of palynomorphs due to the incorporation of several lithostratigraphical units (Lee et al., 2002). Some Tills may occasionally yield virtually pure palynomorph associations. Examples of this are the highly chalky Tills of East Anglia (Riding, 2002a) that largely comprise Late Cretaceous dinoflagellate cysts and certain samples from the Lowestoft Till of Suffolk, which virtually entirely consist of Kimmeridgian palynomorphs (Riding, 2002b). These two examples of Tills that are apparently comprised of a single rock unit also contain minor proportions of other palynomorphs, thereby indicating some glacigenic mixing. Both include, for example, consistent, albeit low, proportions of Carboniferous spores and one of the highly chalky Till samples yielded Early Cretaceous and Palaeogene taxa (Riding, 2002a). Based on the mixed assemblages in these apparently pure Tills, samples 5 to 8 herein are deemed to be *in situ* Peterborough Member due to their purity and also the consistent relative proportions of palynomorphs.

# 4 Summary/Conclusions

Samples 1 to 4 yielded variably productive palynofloras, the dinoflagellate cysts of which are characteristic of the late Callovian-early Oxfordian interval. Sample 1 is undifferentiated late Callovian-early Oxfordian, thus is deemed to be from either the Stewartby or the Weymouth members of the Oxford Clay Formation. Samples 2 and 3 are late Callovian on dinoflagellate cyst evidence, so are from the Stewartby Member of the Oxford Clay Formation. Sample 4 produced an early Oxfordian dinoflagellate cyst flora, hence is interpreted as being from the Weymouth Member of the Oxford Clay Formation.

Samples 5 to 8 produced diverse dinoflagellate cyst assemblages which are characteristic of the mid Callovian Coronatum Zone. This indicates a correlation with the middle part of the Peterborough Member (Oxford Clay Formation). Because there is no variation in the ages of the palynomorphs observed, the samples are interpreted as being from *in situ* Peterborough Member due to their purity and also the consistent relative proportions of palynomorphs.

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