A palynological investigation of the glaciogenic sediments of Clipsham Quarry, Rutland

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A palynological investigation of the glaciogenic sediments of Clipsham Quarry, Rutland

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Key words
palynomorphs, Carboniferous, Mesozoic, Quaternary, glacial sediments, provenance, biostratigraphy, England.

Bibliographical reference

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Foreword

This report comprises a palynological study of ten samples of the glaciogenic sediments of Clipsham Quarry, Rutland.

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Summary

Jurassic palynomorphs dominate samples 1, 3-6 and 10; these are virtually all of Callovian-Oxfordian age. Some minor evidence of Carboniferous and Toarcian reworking was also observed. Exclusively Callovian and Oxfordian index species are common, and forms that are indicative of the late Callovian-early Oxfordian interval are especially abundant. This indicates the incorporation of significant levels of the Oxford Clay Formation. Smaller levels of recycling from the Cornbrash and Kellaways formations are also present. These lithostratigraphical assessments indicate that this Jurassic input was local, and probably derived from the Spalding-Sleafor area of south Lincolnshire to the north-east. Sample 2 yielded a sparse palynoflora, indicating some input from probable marine Quaternary sediments; no evidence of the reworking of Palaeozoic or Mesozoic strata is present. Sample 7 produced a sparse palynoflora indicating input from Carboniferous, Jurassic/?Cretaceous and probable terrestrial Quaternary strata. Sample 8 comprises isolated chalk pebbles from a chalky till and produced a sparse palynoflora. No stratigraphically diagnostic taxa were encountered. The sparseness of the dinoflagellate cyst associations indicates that the Chalk in this sample is not from the Upper Chalk. Sample 9 produced an abundant palynoflora that is dominated by Jurassic miospores; no marine Jurassic microplankton were observed. Low numbers of ?Rugospora spp., a Lower Carboniferous spore,
and indeterminate dinoflagellate cysts were also observed. The presence of forms such as *Leptolepidites* spp. and *Neoraistrickia gristhorpensis* indicates that this sample was derived from Middle Jurassic strata deposited in a terrestrial/freshwater regime. The source is most likely to be the Rutland Formation, a Bathonian heterolithic, rhythmic unit. The Rutland Formation outcrop is local to Clipsham Quarry. Sample 9 is significantly different to samples 1, 3-6 and 10, which are characterised by younger Jurassic material.
1 Introduction

Ten samples collected from the glaciogenic succession from Clipsham Quarry, Rutland were studied for their palynomorph content. This study aimed to determine the provenance of the different glaciogenic units via allochthonous palynomorphs. This work has been undertaken in order to help better understand the glacial history and to contribute to the geological mapping of this district.

2 Sample Details

The ten samples studied are listed below. The columns are the (informal) sample number, the collector’s number (prefixed JS-CLIP-N), the BGS micropalaeontological registration number (prefixed MPA), the unit/pit number as appropriate and the lithology/lithological details respectively.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Collector’s Number</th>
<th>BGS Micropalaeontological Registration Number</th>
<th>Unit/Pit Number</th>
<th>Lithology/Lithological Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>JS-CLIP-N68</td>
<td>MPA 53283</td>
<td>Unit 4</td>
<td>Lower Till - dark grey, clay-rich till with small clasts</td>
</tr>
<tr>
<td>2</td>
<td>JS-CLIP-N69</td>
<td>MPA 53284</td>
<td>Unit 3</td>
<td>Sandy silt - mid brown, clay-rich sandy silt</td>
</tr>
<tr>
<td>3</td>
<td>JS-CLIP-N72</td>
<td>MPA 53285</td>
<td>Unit 7</td>
<td>Fine gravels - dark brown sandy clay with abundant gravel</td>
</tr>
<tr>
<td>4</td>
<td>JS-CLIP-N73</td>
<td>MPA 53286</td>
<td>Unit 9</td>
<td>Deformed sand - dark brown sand</td>
</tr>
<tr>
<td>5</td>
<td>JS-CLIP-N75</td>
<td>MPA 53287</td>
<td>Unit 11</td>
<td>Stratified diamict – mottled, brown-grey clay with clasts</td>
</tr>
<tr>
<td>6</td>
<td>JS-CLIP-N76</td>
<td>MPA 53288</td>
<td>Unit 12</td>
<td>Chalky till - light grey clay-rich till</td>
</tr>
<tr>
<td>7</td>
<td>JS-CLIP-N78</td>
<td>MPA 53289</td>
<td>Unit 14</td>
<td>Reddy gravels - iron stained sandy gravel</td>
</tr>
<tr>
<td>8</td>
<td>JS-CLIP-N93</td>
<td>MPA 53290</td>
<td>Unit 12</td>
<td>Chalky till - white chalk pebbles</td>
</tr>
<tr>
<td>9</td>
<td>JS-CLIP-N56</td>
<td>MPA 53291</td>
<td>Unit 6</td>
<td>Silty clay - massive, dark grey silty clay</td>
</tr>
<tr>
<td>10</td>
<td>JS-CLIP-N61</td>
<td>MPA 53292</td>
<td>Pit 3</td>
<td>Lower diamicton - light brown, clay-rich diamicton</td>
</tr>
</tbody>
</table>

3 Palynology

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

3.1 SAMPLES 1, 3-6 AND 10

Sample 1, 3-6 and 10 are from units 4, 7, 9, 11, 12 and Pit 3 and produced variably rich palynofloras. The samples 1 and 3-6 all yielded abundant and well-preserved kerogen associations and palynomorphs. Wood, plant fragments and palynomorphs dominate the residues. The palynofloras are overwhelmingly dominated by diverse suites of Jurassic dinoflagellate cysts and miospores. Significantly lower proportions of Carboniferous palynomorphs were recorded. Sample 10 was relatively sparse, markedly less diverse and the palynomorphs are poorly-preserved.

Carboniferous spores were recorded throughout in relatively low numbers. These are dominated by Densosporites spp. and Lycospora pusilla. Other genera such as Cristatosporites are also
present. These are long ranging and indicate input from the Namurian/Westphalian. Some Carboniferous reworking is known in Jurassic units such as the Oxford Clay Formation hence some or all of this may not represent direct input from Carboniferous strata. However, the consistency and level of Carboniferous spores strongly suggests a direct glacial input.

Spores and pollen of Jurassic aspect proved common. The taxa identified comprise *Alisporites* spp., *Callialasporites* spp., *Cerebropollenites macrovulcosus*, *Chasmatosporites* spp., *Classopolis classoides*, *Coronatispora valdensis*, *Cyathidites* spp., *Cycadopites* sp., *Dictyophyllidites* spp., *Ischyosporites* variegatus, *Leptolepidites* sp., *Neoraistrickia gristhorpensis*, *Perinopollenites elatoïdes* and *Retitriletes austroclavatidites*. Gymnospermous pollen is more prominent than pteridophytic spores. The presence of *Chasmatosporites* spp. in sample 1 strongly suggests the incorporation of Toarcian strata. Furthermore, the occurrence of *Callialasporites* spp. means that this input is of Mid-Late Jurassic age; the range base of this genus is at the Early-Mid Jurassic transition (Riding et al., 1991).

Jurassic dinoflagellate cysts are extremely diverse. These are dominantly of Callovian-Oxfordian aspect and include *Adnatosphaeridium caulleryi*, *Aldorfia dictyota*, *Batiacasphaera* spp., chorate cysts – indeterminate, *Chytroeisphaerida cerastes*, *Chytroeisphaerida chytroeides*, *Chytroeisphaerida hyalina*, *Chytroeisphaerida hyalina*, *Chytroeisphaerida sp.*, *Cleistosphaeridium* spp., *Compositosphaeridium polionicum*, *Cribroperidinium globatum*, *Ctenidodinium craterum*, *Ellipsoidictyum cinctum*, *Endocrininum galericatum*, *Endocrininum liridum*, *Fromea tornatilis*, *Gonyaulacysta centrotorum*, *Gonyaulacysta jurassica var. adecta*, *Gonyaulacysta jurassica var. adecta*, *Gonyaulacysta jurassica var. longicornis*, *Gonyaulacysta jurassica subsp. jurassica*, *Hystrichodinium pulchrum*, *Korystocysta gochii*, *Leptodinium subtile*, *Leptodinium* spp., *Meiourogonyaulax caytonensis*, *Meiourogonyaulax* spp., *Mendicodinium groenlandicum*, *Nannoceratopsis deflandrei subsp. deflandrei*, *Nannoceratopsis deflandrei subsp. senex*, *Nannoceratopsis pellucida*, *Pareodinia ceratophora*, *Pareodinia halosa*, *Pareodinia* spp., *Prolixosphaeridium* sp., *Rhynchodiniopsis cladophora*, *Rigaudella aemula*, *Scriniodinium crystallinum*, *Sentusidinium creberbarbatum*, *Sentusidinium* spp., *Sirmiodiniopsis grossii*, *Sirmiodinium orbitis*, *Stephanelytron caytonense*, *Stephanelytron redcliffense*, *Stephanelytron scarburghensis*, *Stephanelytron* sp., *Surcolosphaeridium vestitum*, *Systematophora areolata*, *Systematophora valensii*, *Systematophora* spp., *Trichodinium scarburghensis*, *Tubotuberella apatela*, *Tubotuberella dangeardii*, *Wanaea acollaris* and *Wanaea fimbriata*. These include many key marker taxa for the Callovian and Oxfordian stages, including *Chytroeisphaerida hyalina*, *Cribroperidinium globatum*, *Ctenidodinium craterum*, *Endocrininum liridum*, *Gonyaulacysta centrotorum*, *Gonyaulacysta jurassica var. adecta*, *Korystocysta gochii*, *Meiourogonyaulax caytonensis*, and *Wanaea fimbriata*. The dinoflagellate cysts *Nannoceratopsis deflandrei subsp. deflandrei* and *Nannoceratopsis deflandrei subsp. senex* were recorded in small numbers in samples 4, 5, 6 and 10. These indicate the reworking of Toarcian sediments.

*Chytroeisphaerida hyalina* is a marker for the early Callovian (Riding and Thomas, 1997). Other Callovian indicators are *Ctenidodinium craterum*, *Gonyaulacysta jurassica* subsp. *adecta* var. *adecta*, *Korystocysta gochii*, *Meiourogonyaulax caytonensis*, and *Wanaea acollaris*. *Ctenidodinium craterum* has its range top at the Callovian/Oxfordian transition; the remainder of these forms are typical of Callovian strata. This means that the Cornbrash Formation, the Kellaways Formation and the Peterborough and Stewardby members of the Oxford Clay Formation may all have been incorporated into these samples. It is considered that the majority of the Callovian input is of late Callovian age, and hence represents the Stewardby Member of the Oxford Clay Formation. This is because of the consistent occurrence of species with range bases or abundances in the late Callovian such as *Gonyaulacysta centrotorum*, *Mendicodinium*.
groenlandicum, Rigaudella aemula, Scriniodinium crystallinum and Trichodinium scarburghensis. The overall aspect of the associations is of the Oxford Clay Formation.

There are also markers that indicate the Oxfordian Stage, and do not occur in older strata. These include Cribroperidinium globatum, Endoscrinium luridum, Gonyaulacysta jurassica subsp. jurassica var. jurassica, Leptodinium subtile, Leptodinium spp., Systematophora areolata, Systematophora valensii, Systematophora spp. and Wanaea fimbriata (see Riding and Thomas, 1992). All these except Cribroperidinium globatum and Endoscrinium luridum, which have inceptions in the mid Oxfordian, have range bases in the early Oxfordian. Wanaea fimbriata was only recorded in sample 6; this species is confined to the early Oxfordian (Riding and Thomas, 1992). This is unequivocal evidence for the input of the Weymouth Member of the Oxford Clay Formation into this horizon. Support for this is the occurrence of Gonyaulacysta centriconata in sample 6; the range top of this species is early Oxfordian.

In conclusion, Jurassic palynofloras overwhelmingly dominate samples 1, 3-6 and 10. These forms are virtually all of Callovian-Oxfordian age. Minor evidence of Toarcian reworking is also present. Exclusive Callovian and Oxfordian index taxa are common, and forms that are indicative of the late Callovian-early Oxfordian are abundant. This points to the incorporation of several intervals from the Oxford Clay Formation. The Stewartry and Weymouth members of the Oxford Clay Formation have been positively identified. Lesser levels of input from the Cornbrash and Kellaways formations and the Peterborough Member of the Oxford Clay Formation are also indicated. Some mid Oxfordian markers indicate input from the West Walton Beds/Ampthill Clay succession, overlying the Oxford Clay Formation. These lithostratigraphical determinations indicate that the Jurassic input was local, and derived from the north-east, i.e. probably from the Spalding-Sleaford area of south Lincolnshire.

Notes on the Callovian-Oxfordian input to each of these samples are given below in this section.

3.1.1 Sample 1

Callovian strata were incorporated into sample, indicated by the occurrences of Chytroeisphaeridia hyalina, Ctenidodinium continuum and Wanaea acollaris. Oxfordian input is also present because of the presence of Cribroperidinium globatum, Gonyaulacysta jurassica subsp. jurassica var. jurassica, Leptodinium spp. and Systematophora areolata. Input from the Weymouth Member is indicated by the occurrence of Oxfordian markers. The presence of Chytroeisphaeridia hyalina is indicative of the Cornbrash Formation, the Kellaways Formation or the lowermost Peterborough Member. Ctenidodinium continuum and Wanaea acollaris may be from any Callovian unit, but probably from either or both of the Peterborough and Stewartry members of the Oxford Clay Formation. Minor levels of Carboniferous and Lower Jurassic (probably Toarcian) input are also present.

3.1.2 Sample 3

Early/Mid Callovian (i.e. Cornbrash Formation, Kellaways Formation or lowermost Peterborough Member) input in sample 3 is evidenced by the occurrence of Chytroeisphaeridia hyalina. Small levels of mid Oxfordian elements are also present because of the presence of Endoscrinium luridum. This probably indicates some reworking of the West Walton Beds/Ampthill Clay succession, overlying the Oxford Clay Formation. Minor levels of Carboniferous input are also present.

3.1.3 Sample 4

Input from Callovian strata are present in sample 4 because of the occurrence of Chytroeisphaeridia hyalina, Ctenidodinium continuum and Wanaea acollaris. Oxfordian input is also present indicated by the presence of Gonyaulacysta jurassica subsp. jurassica var. jurassica and Systematophora areolata. Thus the Cornbrash Formation, the Kellaways
Formation or the lowermost Peterborough, and the Weymouth Member are unequivocally present. Input from the Stewartby Member is probably also present. Minor levels of Carboniferous and Lower Jurassic (early Toarcian) input are also present.

3.1.4 Sample 5
Callovian strata were incorporated into sample 5 because of the occurrence of *Ctenidodinium continuum*. Oxfordian input is also present indicated by the presence of *Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica*, *Leptodinium* spp., *Systematophora areolata*, *Systematophora valensii* and *Systematophora* spp. Therefore the Weymouth Members is unequivocally present. Minor levels of mid Oxfordian elements are present because of the presence of *Endoscrinium luridum*. This probably indicates reworking of the West Walton Beds/Ampthill Clay that overlies the Oxford Clay Formation. Minor levels of Carboniferous and Lower Jurassic (early Toarcian) input are also present.

3.1.5 Sample 6
Callovian strata were incorporated into this sample because of the occurrences of *Chytroesphaeridia hyalina*, *Ctenidodinium continuum*, *Meiourogonyaulax caytonensis* and *Wanaea acollaris*. This is indicative of contributions from the Cornbrash Formation, the Kellaways Formation and/or the Peterborough Member and probably also the Stewartby Member. Oxfordian input is also present indicated by the presence of *Endoscrinium luridum*, *Gonyaulacysta jurassica* subsp. *jurassica*, *Leptodinium subtile* and *Systematophora areolata* and *Wanaea fimbriata*. The occurrence of the early Oxfordian marker *Wanaea fimbriata* indicates unequivocal input from the Weymouth Member of the Oxford Clay Formation. Minor levels of *Endoscrinium luridum* indicates some input of Middle Oxfordian strata, probably from the West Walton Beds/Ampthill Clay that overlies the Oxford Clay Formation. Minor levels of Carboniferous and Lower Jurassic (early Toarcian) input are also present.

3.1.6 Sample 10
This sample yielded a relatively sparse association of Callovian/Oxfordian elements. The presence of *Cribroperidinium globatum* means that there was definite Oxfordian input. This taxon is also prominent in the Kimmeridgian. Minor levels of Carboniferous and Lower Jurassic (early Toarcian) input are also present.

3.2 Sample 2
Sample 2 from a sandy silt in unit 3 yielded relatively abundant levels of dark wood fragments and an extremely sparse palynoflora. Low numbers of pale, indeterminate dinoflagellate cysts were recorded. The occurrence of a single specimen of the typically Quaternary dinoflagellate cyst *Bitectatodinium tepikiense* indicates that the indeterminate forms are likely to be of Quaternary age. Low numbers of terrestrially-derived palynomorphs were also observed. These include bisaccate pollen and other indeterminate pollen grains. The freshwater/brackish alga *Botryococcus* is also present in small numbers.

This sparse palynoflora indicates some input from probable marine Quaternary sediments. No conclusive evidence of the recycling of Palaeozoic or Mesozoic strata is present and the organic signature of unit 3 is a sparse, low diversity one, dominated by probable Quaternary palynomorphs.
3.3 SAMPLE 7

Sample 7 from iron-stained gravels in unit 14 produced relatively sparse kerogen and palynomorph associations. A single grain of the Carboniferous spore *Lycospora pusilla* was noted. Low proportions of typically Mesozoic forms are also present. These include *Cerebropollenites macroverrucosus*, *Classopollis* spp., *Cyathidites* spp., and *Tasmanites* spp. None of these types are stratigraphically diagnostic, however the occurrence of *Cerebropollenites macroverrucosus* is strongly suggestive of the Jurassic. Pollen of Quaternary aspect is present and, despite being relatively sparse, is the most prominent palynological element. Taxa identified include Compositae pollen, *Pinus* and *Polypodium vulgare*.

The sparse palynoflora indicates some input from Carboniferous, Jurassic/?Cretaceous and probable terrestrial Quaternary strata. The reddened and coarse nature of this deposit probably explains the sparseness of the organic content.

3.4 SAMPLE 8

This sample comprised separated chalk pebbles from the chalky till of unit 12. These pebbles produced a relatively sparse palynoflora and kerogen assemblage. Wood fragments were present, together with moderately sparse proportions of palynomorphs, largely dinoflagellate cysts. Dinoflagellate cyst taxa identified include *Batiacasphaera* spp., *Cribroperidinium* sp., *Gonyaulacysta* spp., indeterminate chorate cysts, *Odontochitina operculata*, *Spiniferites ramosus* and *Spiniferites* spp. Miospores proved subordinate and include bisaccate pollen and *Cyathidites* spp.

The palynoflora is entirely consistent with the Chalk Group. However, no stratigraphically diagnostic taxa were encountered, hence the lithostratigraphical unit(s) from which the pebbles came cannot be identified. The relative sparseness of the dinoflagellate cyst associations strongly suggests that the Upper Chalk did not input to unit 12.

3.5 SAMPLE 9

This sample is from a massive, dark grey silty clay from unit 6. It produced an abundant kerogen assemblage and palynoflora. Woody fragments are relatively abundant. The palynomorphs are overwhelmingly dominated by miospores of Jurassic aspect including *Alisporites* spp., *Callialasporites dampieri*, *Callialasporites microvelatus*, *Callialasporites turbatus*, *Callialasporites* spp., *Cerebropollenites macroverrucosus*, *Cibotiumspora jurien*is, *Classopollis classoides*, *Coronatispora valdensis*, *Cibotium* spp., *Dictyophyllidites* spp., *Ischysporites variegatus*, *Leptolepidites* spp., *Neoraistrickia gristhorpensis*, *Perinopollenites elatooides*, *Retitriletes australocavatidites* and *Sestrosporites pseudoalveolatus*. Low numbers of questionable *Rugospora* spp. were recognised; this genus is typical of the Lower Carboniferous. Additionally, low numbers of indeterminate dinoflagellate cysts were observed. No marine microplankton of Jurassic age were noted.

Species of *Cyathidites* spp. proved most common. The presence of *Callialasporites* spp., *Ischysporites variegatus*, *Leptolepidites* spp. and *Neoraistrickia gristhorpensis* indicates that this horizon was derived from terrestrial-derived strata of Mid Jurassic age. The range base of *Callialasporites* is at the Lower-Middle Jurassic boundary (Riding et al., 1991). The Middle Jurassic of the Midlands include certain freshwater intervals. These include parts of the Lincolnshire Limestone Formation, and the Rutland Formation (Riding, 1987). The Lincolnshire Limestone Formation is largely organic-lean; this, and the clay lithology of sample 9, indicates that the source for the Middle Jurassic miospores is the Rutland Formation, a Bathonian heterolithic, rhythmic unit. The Rutland Formation occurs close to Clipsham Quarry and hence unit 6 is dominated by local material. The palynological content of unit 6 is markedly different.
to that of samples 1, 3-6 and 10, which are characterised by significantly younger Jurassic material (i.e. Callovian-Oxfordian, see section 3.1).

4 Conclusions

Jurassic palynomorphs dominate samples 1, 3-6 and 10; these are virtually all of Callovian-Oxfordian age. Some minor evidence of Carboniferous and Toarcian reworking was also observed. Exclusively Callovian and Oxfordian index species are common, and forms that are indicative of the late Callovian-early Oxfordian are especially abundant. This indicates the incorporation of significant levels of Oxford Clay Formation. Smaller levels of recycling from the Cornbrash and Kellaways formations are also indicated. These lithostratigraphical assessments indicate that this Jurassic input was local, and probably derived from the Spalding-Sleaford area of south Lincolnshire to the north-east.

Sample 2 yielded a sparse palynoflora, indicating some input from probable marine Quaternary sediments; no evidence of the reworking of Palaeozoic or Mesozoic strata is present.

Sample 7 produced a sparse palynoflora indicating input from Carboniferous, Jurassic/?Cretaceous and probable terrestrial Quaternary strata.

Sample 8 comprises isolated chalk pebbles from a chalky till and produced a sparse palynoflora. No stratigraphically diagnostic taxa were encountered. The sparseness of the dinoflagellate cyst associations indicates that the Chalk in this sample is not from the Upper Chalk.

Sample 9 produced an abundant palynoflora that is dominated by Jurassic miospores; no marine Jurassic microplankton were observed. Low numbers of ?Rugospora spp., a Lower Carboniferous spore, and indeterminate dinoflagellate cysts were also observed. The presence of forms such as Leptolepidites spp. and Neoraistrickia gristhorpensis indicates that this sample was derived from terrestrial Mid Jurassic strata. The source is most likely to be the Rutland Formation, a Bathonian heterolithic, rhythmic unit. The Rutland Formation outcrop is local to Clipsham Quarry. Sample 9 is significantly different to samples 1, 3-6 and 10, which are characterised by younger Jurassic material.

5 References


