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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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Foreword

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

Contents

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-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 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.

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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.

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

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 macroverrucosus, Chasmatosporites* spp., *Classopollis classoides, Coronatispora valdensis, Cyathidites* spp., *Cycadopites* sp., *Dictyophyllidites* spp., *Ischysporites variegatus, Leptolepidites* sp., *Neoraistrickia gristhorpensis, Perinopollenites elatoides* and *Retitriletes austroclavatidites*. Gymnospermous pollen is more prominent that pteridphytic 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, *Chytroeisphaeridia cerastes, Chytroeisphaeridia chytroeides, Chytroeisphaeridia hyalina, Chytroeisphaeridia* spp., *Cleistosphaeridium* spp., *Compositosphaeridium polonicum, Cribroperidinium globatum, Ctenidodinium continuum, Ctenidodinium ornatum, Ellipsoidictyum cinctum, Endoscrinium galeritum, Endoscrinium luridum, Fromea tornatilis, Gonyaulacysta centriconata, Gonyaulacysta jurassica* subsp. *adecta* var. *adecta, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica, Hystrichodinium pulchrum, Korystocysta gochtii, 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 orbis, Stephanelytron caytonense, Stephanelytron redcliffense, Stephanelytron scarburghense, Stephanelytron* sp., *Surculosphaeridium 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 *Chytroeisphaeridia hyalina, Cribroperidinium globatum, Ctenidodinium continuum, Endoscrinium luridum, Gonyaulacysta centriconnata, Gonyaulacysta jurassica* subsp. *adecta* var. *longicornis, Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica, Leptodinium subtile, Rigaudella aemula, Scriniodinium crystallinum, Systematophora areolata* 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.

Chytroeisphaeridia hyalina is a marker for the early Callovian (Riding and Thomas, 1997). Other Callovian indicators are *Ctenidodinium continuum, Gonyaulacysta jurassica* subsp. *adecta* var. *adecta, Korystocysta gochtii, Meiourogonyaulax caytonensis,* and *Wanaea acollaris*. *Ctenidodinium continuum* 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 Stewartby 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 Stewartby 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 centriconnata, 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 Stewartby 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 Stewartby 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. Input from the Cornbrash Formation, the Kellaways Formation and/or the Peterborough and Stewartby members is 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 *Chytroeisphaeridia 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* var. *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., *Micrhystridium* 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 juriensis, Classopollis classoides, Coronatispora valdensis, Cyathidites* spp., *Dictyophyllidites* spp., *Ischysporites variegatus, Leptolepidites* spp., *Neoraistrickia gristhorpensis, Perinopollenites elatoides, Retitriletes austroclavatidites* 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 terrestrially-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.

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