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A palynological investigation of the Quaternary glaciogenic sediments of Welton-le-Wold quarry, Lincolnshire

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A palynological investigation of the Quaternary glaciogenic sediments of Welton-le-Wold quarry, Lincolnshire

James B. Riding

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Foreword

This report comprises a palynological study of six samples of the Quaternary glaciogenic sediments of Welton-le-Wold quarry, Lincolnshire.

Contents

Summary

All the samples yielded relatively abundant palynofloras; allochthonous palynomorphs of Carboniferous, Jurassic, Cretaceous, ?Palaeogene and Quaternary age are present. The organic contents of these associations are similar, hence the succession studied is interpreted as belonging to the same genetic unit. Carboniferous spores are normally the predominant component. The most common Carboniferous spores are *Densosporites* spp. and *Lycospora pusilla*, but other forms were also recognised. The majority of these spores are consistent with input from the Namurian-Westphalian interval and this association of Namurian and Westphalian forms is typical of the Quaternary of the UK. These spores were most likely to be derived from the Pennines, north-east England or southern Scotland. Jurassic miospores and microplankton are also present in relatively large proportions throughout, with miospores being more abundant than microplankton. The presence of key pollen genera indicates the incorporation of Toarcian and Mid-Late Jurassic strata respectively. This configuration is mirrored by the microplankton, which is indicative of input from the late Pliensbachian-early Toarcian. The remainder of the Jurassic dinoflagellate cysts are indicative of input from the Kimmeridge Clay Formation. No

late Kimmeridgian markers were observed, hence the majority of this input is probably from the Lower Kimmeridge Clay Formation. The source of this reworking is probably from the East Midlands Shelf and/or the Yorkshire Basin. Cretaceous palynomorphs were generally recorded in small numbers and most of these forms are relatively long-ranging dinoflagellate cysts. Some stratigraphically diagnostic dinoflagellate cysts were observed however, and these are indicative of the Hauterivian/Barremian interval. They are probably locally-derived from, for example, the Tealby Clay and/or the Tealby Limestone. Some of the longer ranging forms such as *Odontochitina operculata* may be from the Chalk Group. The previous discussion refers to the matrix of the till. Individual clasts of Chalk from four of the samples proved organically sparse. These associations are hence likely to be from the Lower and/or Middle Chalk Group. Low numbers of possible Palaeogene dinoflagellate cysts were recorded from samples 6 and 3 and these may represent the reworking of Palaeogene strata from the North Sea Basin. Typically Quaternary pollen is present and these elements were probably derived locally. Non age-diagnostic palynomorphs are also consistently present.

The Welton Till yielded the lowest proportion of Carboniferous spores, generally high levels of Cretaceous dinoflagellate cysts and the highest proportions of non age-diagnostic palynomorphs. The Calcethorpe Till appears to have a low palynological productivity and the Marsh Till is dominated by Carboniferous and Jurassic miospores.

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1 Introduction

Six samples collected from the Quaternary glaciogenic succession from Welton-le-Wold quarry, Linconshire were studied for their palynomorph content. This study aimed to determine the provenance of these glaciogenic sediments via allochthonous palynomorphs. This work has been undertaken in order to help better understand the glacial history of this area and to contribute to the geological mapping of this district.

2 Sample Details

The six samples studied are listed below. The columns are the (informal) sample number, the BGS micropalaeontological registration number (prefixed MPA), the collector's number (prefixed WLW w), the grid reference and the lithology respectively.

1	MPA 52856	WLW w03 (East) (d)	TF 2863 8813	massive, dark red/brown clay
2	MPA 52857	WLW w07 (West)	TF 2823 8838	massive, mid-brown clay with clasts
3	MPA 52858	WLW w08 (West)	TF 2823 8838	massive mid grey clay
4	MPA 52859	WLW w09 (West)	TF 2817 8842	massive brown sandy clay w. clasts
5	MPA 52860	WLW w10 (East)	TF 2863 8813	massive dark brown clay
6	MPA 52861	WLW w13 (East)	TF 2864 8813	massive dark brown clay with clasts

Samples ?1, 5 and 6 are from the youngest unit sampled, the Marsh Till (Straw) of the east end of the quarry; this has been correlated with the late Devensian deposits of east Yorkshire and north Norfolk. This unit contains Carboniferous Limestone, various Jurassic lithologies, crystalline rocks from northern Britain and sandstones, shales and coals that may be Carboniferous or Jurassic in age.

Samples 2 and 3 are from the lowermost part of the Welton Till at the west end of the quarry.

Sample 4 is questionably from the Calcethorpe Till from the west end of the quarry. The correlation of this unit with the unequivocal Calcethorpe Till is uncertain; for example it may represent a different weathering aspect of the Welton Till.

3 Palynology

In this section, the palynofloras are described in seven 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).

Tables 1 and 2 illustrate the numbers of palynomorphs per slide and the numbers and percentages of palynomorphs per slide in six age-related categories. The samples yielded relatively abundant organic residues and palynofloras. Wood fragments, other plant tissues and palynomorphs proved common to abundant throughout. Amorphous organic material was either absent or extremely rare. Allochthonous palynomorphs of Carboniferous, Jurassic, Cretaceous, ?Palaeogene and Quaternary age were observed. The taxonomic content and relative proportions

of these palynofloras are relatively similar. It therefore appears that the entire succession investigated belongs to the same broad genetic glaciogenic unit.

3.1 Carboniferous

Except for sample 3, Carboniferous spores are the predominant component (Table 1). Typically they account for between approximately 40 and 55% of the palynoflora. Sample 1 yielded the most Carboniferous grains (621 = 74.8%) and sample 3 the least (70 = 12,3%). By far the most common Carboniferous forms are *Densosporites* spp. and *Lycospora pusilla.* Also present are *Ahrensisporites guerickei* (sample 6), *Calamospora* spp., *Cirratriradites saturni* (sample 5), *Cristatisporites* sp., *Endosporites globiformis* (samples 1, 2, 5, 6), *Radiizonates* spp., ?*Reticulatisporites polygonalis, Reticulatisporites* spp., *Tripartites trilinguis* (samples 4, 5), *Tripartites vetustus* (samples 2, 5, 6), *Tripartites* spp., ?*Triquitrites protensus, Triquitrites tribullatus* (sample 4) and *Triquitrites trivalvis* (sample 6). *Densosporites* spp. and *Lycospora pusilla* are both long-ranging forms. The majority of these assemblages are consistent with input from the Namurian-Westphalian interval. *Endosporites globiformis* is a reliable Westphalian marker (Clayton and Butterworth, 1984), thus strata of this age were incorporated into samples 1, 2, 5 and 6. However, *Tripartites trilinguis* and *Tripartites vetustus* are both characteristic of the Viséan-Namurian transition (Owens *et al*., 1977), hence strata from this interval were incorporated to samples 2, 4, 5 and 6. This association of Namurian and Westphalian spores is typical of the Quaternary of the UK. These Carboniferous spores were most likely to have been derived from the north and/or the north-west of the region, probably the Pennines, north-east England or southern Scotland.

3.2 Jurassic

Jurassic miospores and microplankton are present throughout in relatively large proportions (Table 1). Miospores are consistently more abundant than microplankton. Spores and pollen typically represent *c*. 20% of the palynoflora, whereas dinoflagellate cysts and acritarchs account for < 5% (Table 1). The miospores include *Callialasporites* spp., *Cerebropollenites macroverrucosus, Chasmatosporites* spp., *Cibotiumspora juriensis, Classopollis classoides, Classopollis meyeriana, Dictyophyllidites* spp., *Ischysporites variegatus, Perinopollenites elatoides* and *Retitriletes austroclavatidites*. The presence of *Chasmatosporites* spp. in samples 1, 2, 3 and 5 strongly suggests the incorporation of Toarcian strata. The occurrence of significant levels of *Callialasporites* spp. throughout means that this input is largely of Mid-Late Jurassic age because the range base of this genus is at the Early-Mid Jurassic transition (Riding et al., 1991). The Jurassic dinoflagellate cysts observed include *Chytroeisphaeridia chytroeides, Cribroperidinium globatum, Endoscrinium luridum, Glossodinium dimorphum, Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica, Leptodinium* spp., *Luehndea spinosa, Nannoceratopsis deflandrei* subsp. *deflandrei, Nannoceratopsis deflandrei* subsp. *senex, Oligosphaeridium patulum, Pareodinia ceratophora, Perisseiasphaeridium pannosum, Prolixosphaeridium* sp. and *Systematophora areolata.* The prasinophyte *Halosphaeropsis liassica* was also observed in samples 1, 3, 5 and 6. The presence in samples 1, 3, 5 and 6. of *Halosphaeropsis liassica, Luehndea spinosa, Nannoceratopsis deflandrei* subsp. *deflandrei* and *Nannoceratopsis deflandrei* subsp. *senex* is indicative of input from the late Pliensbachian-early Toarcian interval (Riding and Thomas, 1992; Bucefalo Palliani and Riding, 2003). *Luehndea spinosa* was recorded from sample 5. This species is typical of the late Pliensbachian to earliest Toarcian (Riding and Thomas, 1992). The remainder of the Jurassic dinoflagellate cysts are indicative of input from the Kimmeridge Clay Formation. Species characteristic of the Kimmeridgian are *Cribroperidinium globatum, Endoscrinium luridum, Glossodinium dimorphum, Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica, Leptodinium* spp., *Oligosphaeridium patulum, Perisseiasphaeridium pannosum* and *Systematophora areolata. Endoscrinium luridum* and *Gonyaulacysta jurassica* subsp. *jurassica* var. *jurassica* are evidence that some input is from the

mid Oxfordian to early Kimmeridgian (Riding and Thomas, 1988; 1992). No late Kimmeridgian markers are observed so the majority of this input is probably from the Lower Kimmeridge Clay Formation. Markers from the early Toarcian and the Kimmeridgian are frequently observed in the tills of northern East Anglia (Riding et al., 2003). The source of this Jurassic reworking is interpreted as being from the north from the East Midlands Shelf and/or the Yorkshire Basin.

3.3 Cretaceous

Cretaceous palynomorphs were recorded in samples 6 to 2 inclusive. They are relatively minor, except in sample 3, where they account for 16.7% of the palynoflora (Table 2). Extremely small levels of the typically Lower Cretaceous spore genus *Cicatricosisporites* were encountered in samples 5, 4 and 3 (Table 2). Generally higher proportions of Cretaceous dinoflagellate cysts are present in samples 6-2 (Table 2). Most of these forms are relatively long-ranging and include *Cribroperidinium* spp., *Odontochitina operculata* and *Oligosphaeridium complex*. However, stratigraphically diagnostic dinoflagellate cysts are present in samples 6, 5 and 3. *Pseudoceratium pelliferum* is present in all three of these samples. *Oligosphaeridium asterigerum* was recorded in sample 5 and *Spiniferites dentatus* in sample 6. *Pseudoceratium pelliferum* ranges from the late Ryazanian to the late Barremian (Costa and Davey, 1992). However the elongate morphotypes observed are clearly from the younger part of the range of the species, i.e. Hauterivian/Barremian. *Spiniferites dentatus* is confined to the early Hauterivian–early Barremian (Costa and Davey, 1992). The range of *Oligosphaeridium asterigerum* is Valanginian to Aptian according to Heilmann-Clausen (1987). It seems therefore that the age of at least some of the Lower Cretaceous reworking is Hauterivian/Barremian and may be locally-derived from, for example, the Tealby Clay and/or Tealby Limestone. Some of the longer ranging forms such as *Odontochitina operculata* may be from the Chalk Group.

3.4 Palaeogene

Extremely low numbers of possible Palaeogene dinoflagellate cysts were recorded from samples 6 and 3 (Table 2). *Cordosphaeridium gracile* and *Glaphyrocysta* spp. were observed in sample 6 and ?*Wetzeliella* sp. is present in sample 3. These forms may represent the minor reworking of Palaeogene strata. This material was probably derived from the North Sea Basin.

3.5 Quaternary

Variable levels of typically Quaternary pollen such as *Pinus* are present in variable proportions in samples 6, 4 and 2 (Table 2). These elements are probably derived locally.

3.6 Non age-diagnostic palynomorphs

Significant proportions of palynomorphs that are not age-diagnostic are present throughout. These include pre-Quaternary bisaccate pollen grains and smooth trilete spores, largely *Cyathidites* spp. These forms vary from 12.1% in sample 1 to 45.8% in sample 3 (Table 2).

3.7 The Chalk clasts of samples 6, 4, 3 and 2

Samples 6, 4, 3, and 2 are all rich in clasts of Chalk. These were isolated and prepared separately using HCl in order to attempt to determine the stratigraphical position of the incorporated Chalk. All four Chalk preparations proved extremely sparse in organic material and palynomorphs. The long ranging dinoflagellate cyst genus *Spiniferites* and bisaccate pollen are present in low numbers. *Odontochitina operculata* and *Xenascus* sp. were recorded from sample 4. Sample 3 proved palynologically barren. These sparse associations do not allow for a

detailed stratigraphical assessment of the Chalk incorporated. However it is likely to be from the Lower and/or Middle Chalk Group as the Upper Chalk Group is relatively organic-rich.

3.8 Characteristic features of the three lithostratigraphical units analysed

In this section the principal differences between the palynofloras from each of the three units investigated are summarised.

3.8.1 The Welton Till (samples 3 and 2)

The two samples of the Welton Till yielded the lowest proportion of Carboniferous spores, generally high levels of Cretaceous dinoflagellate cysts and the highest proportions of non age-diagnostic palynomorphs (Tables 1, 2). It is possible that quantitative analyses may reveal consistent differences between the palynological content of the three units at this locality.

3.8.2 The Calcethorpe Till (?sample 4)

Sample 4 yielded the lowest number of palynomorphs per slide in this study (Table 1). The residue is dominated by Carboniferous, Jurassic and Quaternary miospores and non age-diagnostic forms (Tables 1, 2)

3.8.3 The Marsh Till (samples 6, 5, and ?1)

The Marsh Till is dominated by Carboniferous and Jurassic miospores (Table 1) and this signature appears to be diagnostic of this unit.

4 Conclusions/Summary

All the samples yielded relatively abundant palynofloras; allochthonous palynomorphs of Carboniferous, Jurassic, Cretaceous, ?Palaeogene and Quaternary age are present. The organic contents of these associations are similar, hence the succession studied is interpreted as belonging to the same genetic unit. Carboniferous spores are normally the predominant component. The most common Carboniferous spores are *Densosporites* spp. and *Lycospora pusilla*, but other forms were also recognised. The majority of these spores are consistent with input from the Namurian-Westphalian interval and this association of Namurian and Westphalian forms is typical of the Quaternary of the UK. These spores were most likely to be derived from the Pennines, north-east England or southern Scotland. Jurassic miospores and microplankton are also present in relatively large proportions throughout, with miospores being more abundant than microplankton. The presence of key pollen genera indicates the incorporation of Toarcian and Mid-Late Jurassic strata respectively. This configuration is mirrored by the microplankton, which is indicative of input from the late Pliensbachian-early Toarcian. The remainder of the Jurassic dinoflagellate cysts are indicative of input from the Kimmeridge Clay Formation. No late Kimmeridgian markers were observed, hence the majority of this input is probably from the Lower Kimmeridge Clay Formation. The source of this reworking is probably from the East Midlands Shelf and/or the Yorkshire Basin. Cretaceous palynomorphs were generally recorded in small numbers and most of these forms are relatively long-ranging dinoflagellate cysts. Some stratigraphically diagnostic dinoflagellate cysts were observed however, and these are indicative of the Hauterivian/Barremian interval. They are probably locally-derived from, for example, the Tealby Clay and/or the Tealby Limestone. Some of the longer ranging forms such as *Odontochitina operculata* may be from the Chalk Group. The previous discussion refers to the matrix of the till. Individual clasts of Chalk from four of the samples proved organically sparse. These associations are hence likely to be from the Lower and/or Middle Chalk Group. Low

numbers of possible Palaeogene dinoflagellate cysts were recorded from samples 6 and 3 and these may represent the reworking of Palaeogene strata from the North Sea Basin. Typically Quaternary pollen is present and these elements were probably derived locally. Non age-diagnostic palynomorphs are also consistently present.

The Welton Till yielded the lowest proportion of Carboniferous spores, generally high levels of Cretaceous dinoflagellate cysts and the highest proportions of non age-diagnostic palynomorphs. The Calcethorpe Till appears to have a low palynological productivity and the Marsh Till is dominated by Carboniferous and Jurassic miospores.

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Sample no.	Reg. No. (MPA)	Lithology	Grains/slide	Carb. spores	Jur. miospores	Jur. microplankton
1	52856	massive, dark red/brown clay	830	621 (74.8%)	68 (8.2%)	41 (4.9%)
2	52857	massive, mid brown clay	665	257 (38.6%)	98 (14.7%)	3 (0.5%)
3	52858	massive, mid grey clay	570	70 (12.3%)	113 (19.8%)	31 (5.4%)
4	52859	massive, brown clay w. Chalk clasts	279	118 (42.3%)	43 (15.4%)	2 (0.7%)
5	52860	massive, dark brown clay	833	461 (55.3%)	214 (25.7%)	10 (1.2%)
6	52861	massive, brown clay w. clasts	658	300 (45.6%)	152 (23.1%)	23 (3.5%)

Table 1. Details of sample numbers, lithologies, overall numbers of palynomorphs per microscope slide and the numbers and percentages (in parentheses) of Carboniferous spores, Jurassic miospores and Jurassic microplankton respectively in the 6 samples in this study.

Sample no.	Reg. No. (MPA)	L. Cret. spores	Cret. dino. cysts	P.gene dino. cysts	Quat. miospores	Non age-diagnostics
1	52856	…	…	…	…	100 (12.1%)
2	52857	…	19 (2.9%)	…	56 (8.4%)	232 (34.9%)
3	52858	16 (2.8%)	78 (13.7%)	?1 (?0.2%)	…	261 (45.8%)
4	52859	2 (0.7%)	1 (0.4%)	…	48 (17.2%)	65 (23.3%)
5	52860	3 (0.4%)	30 (3.6%)	…	…	115 (13.8%)
6	52861	…	10 (1.5%)	?5 (0.8%)	15 (2.3%)	153 (23.2%)

Table 2. The numbers and percentages (in parentheses) respectively of Lower Cretaceous spores, Cretaceous dinoflagellate cysts, ?Palaeogene dinoflagellate cysts, Quaternary miospores, and non age-diagnostic palynomorphs in the 6 samples in this study. Three dots (...) indicates that the respective palynomorph group is not represented.