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A palynological investigation of the chalk-rich diamicts of north Norfolk

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A palynological investigation of the chalk-rich diamicts of north Norfolk

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Foreword

This report comprises a palynological study of eight samples of chalky diamicts and associated sediments from northwest and north Norfolk.

Contents

Summary

Except for sample 4, the samples examined are either rich in Kimmeridgian or Late Cretaceous dinoflagellate cysts. This conclusion would support two distinct ice flow directions for this chalk-rich till facies in this area. Samples 1, 2, 3, 6 and 8 are rich in Kimmeridgian dinoflagellate cysts. They also have similar palynomorph signatures in that the Kimmeridgian dinoflagellate cyst floras are generally associated with low levels of Carboniferous and Lower Cretaceous spores and, unsurprisingly, significant levels of Jurassic miospores. Sample 8 yielded the most diverse Kimmeridgian dinoflagellate cysts that are indicative of the input of Lower Kimmeridge Clay Formation. The other Kimeridgian rich samples (1, 2, 3 and 6) are similar in species makeup, so these are also assumed to have been derived from the Lower Kimmeridge Clay. Samples 5 and 7 are dominated by Late Cretaceous dinoflagellate cysts indicative of substantial input from the Chalk Group. The association in sample 5 is indicative of the Campanian to early Maastrichtian, indicating input from the Upper Chalk. The flora from sample 7 is similar to that of sample 5 and is also assumed to have been derived from the local Upper Chalk. Sample 4 is unlike the remainder of the samples and is dominated by Quaternary

pollen and non-age diagnostic forms, with lesser proportions of early Toarcian, Late Cretaceous and Palaeogene dinoflagellate cysts.

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1 Introduction

Eight samples collected from five sites in north-west and north Norfolk 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. In particular, it is the intention to test two possible flow-directions of these highly chalk-rich tills, and to test if there is strong variation in the Jurassic palynomorph content.

2 Sample Details

The eight samples studied are from six localities. They are listed below. The columns are the (informal) sample number, the collector's number, the BGS micropalaeontological registration number (prefixed MPA), the grid reference, the metres OD and the lithology respectively.

NEWTON:					
1	NwC-13	MPA 53695	TF 84177 15988	57.2	Clast-rich, chalk-rich muddy diamict
2	NwC-12	MPA 53696	TF 84177 15988	56.8	Clast-rich, intermediate (sandy silt) diamict
3	NwB-2	MPA 53697	TF 84188 15950	58.7	Clast-rich, intermediate (sandy silt) diamict
BARROW COMMON:					
4	BcA-1	MPA 53698	TF 7901 4293	39.0	Clast-rich, intermediate (sandy silt) diamict
TELEGRAPH PLANTATION:					
5	TP-5	MPA 53699	TF 7889 4253	68.0	Clast-rich, chalk-rich muddy diamict
STODY:					
6	STO-1	MPA 53700	TG 05626 34579	42.5	Clast-rich, chalk-rich intermediate diamict
WHIN HILL:					
7	CHN-7	MPA 53701	TF 87079 38089	39.8	Clast-rich, chalk-rich muddy diamict
BITTERING:					
8	BIT-LT	MPA 53704	TF 92580 17190	60.0	Dark grey chalky and clay-rich diamicton

3 Palynology

In this section, the palynofloras are described in six 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 eight age-related categories. The samples yielded variably abundant organic residues and palynofloras. Allochthonous palynomorphs of Carboniferous, Jurassic, Cretaceous, Palaeogene and Quaternary age were observed.

3.1 NEWTON - SAMPLES 1 TO 3

Samples 1 to 3 are from Newton in west Norfolk. They were collected from a highly chalky-rich, banded diamict. Sample 1 is of typical 'marly-drift' facies; samples 2 and 3 are from glaciotectonically drawn-out bands of slightly sandier till. The diamict is thrust over a gravel succession with a thrust/ice movement from SW to NE. The clasts are largely chalk, but with small proportions of (?Jurassic) oolite.

Samples 1 and 2 proved palynologically productive and are dominated by allochthonous Jurassic palynomorphs (76.7% and 33.3% respectively) (Table 1). Jurassic miospores are subordinate to dinoflagellate cysts and include the long-ranging forms *Callialasporites* spp., *Cerebropollenites macroverrucosus* and *Perinopollenites elatoides*. Dinoflagellate cysts include *Cribroperidinium globatum, Cribroperidinium longicorne, Leptodinium* sp., ?*Occisucysta balios, Senoniasphaera jurassica* and *Systematophora areolata*. This association is indicative of input of the Kimmeridge Clay Formation (Kimmeridgian). Most of these are typical of the entire Kimmeridgian Stage, however, *Cribroperidinium longicorne* ranges from the early Kimmeridgian (Cymodoce Zone) to the late Kimmeridgian (Hudlestoni Zone) (Riding and Thomas, 1992). *Senoniasphaera jurassica* is most typical of the late Kimmeridgian (Riding and Thomas, 1988; Poulsen and Riding, 1992). The source of this Kimmeridgian material is thus possibly from the Upper Kimmeridge Clay (late Kimmeridgian). However, the Kimmeridgian dinoflagellate cysts in sample 8 are similar in character (see section 3.6), and are unequivocally from the Lower Kimmeridge Clay. It seems likely therefore that this Kimmeridgian flora is also early Kimmeridgian. Sample 3 is significantly less productive than samples 1 and 2 (Tables 1, 2). It is possible that this is due to sample 3 being more sand-rich. Sample 3 yielded the typically Kimmeridgian dinoflagellate cysts *Cribroperidinium globatum* and *Leptodinium* sp.

Minor levels of Carboniferous spores are present in samples 1 and 3 (Table 1). These are all representatives of the long-ranging genus *Densosporites*. Rare *Cicatricosisporites* spp. were recorded from sample 1 and this indicates extremely minor input from the Lower Cretaceous. Only sample 1 yielded indications of the Late Cretaceous. This sample yielded 3.9% typically Late Cretaceous dinoflagellate cysts including *Odontochitina operculata*. These taxa are not age-diagnostic within the Late Cretaceous. The relatively low levels of Quaternary miospores are dominated by *Pinus* (Table 2). The palynoflora of sample 2 is poorly-preserved and many unidentifiable dinoflagellate cysts are present. This is reflected in the large proportion (63.9%) of non-age diagnostic forms in this sample (Table 2).

3.2 BARROW COMMON - SAMPLE 4

Sample 4 is from Barrow Common in north-west Norfolk. It was collected from a highly fractured, sandy brown diamict. The fracturing and thrusting came from the north-west.

It yielded a relatively rich palynoflora that is dominated (51.7%) by Quaternary pollen, predominantly *Pinus* and non-age diagnostic forms (35.3%). Low levels (0.5%) of the typically early Toarcian dinoflagellate cyst *Nannoceratopsis deflandrei* subsp. *senex* are present. Late Cretaceous dinoflagellate cysts such as *Canningia* spp., *Exochosphaeridium* spp. and *Odontochitina operculata* are relatively common (10.0%). Small levels of the characteristic dinoflagellate cyst *Homotryblium* were observed (Table 2), which represent the reworking of minor levels of Palaeogene material.

3.3 TELEGRAPH PLANTATION - SAMPLE 5

This sample is from Telegraph Plantation in north-west Norfolk and is of typical 'marly-drift' facies, i.e. a highly chalky-rich diamict. This chalky diamict is interpreted as a subaqueous debris flow in a standing body of water because it is underlain by glaciomarine silts and clays.

The diamict and the underlying lake sediments are deformed by large water escape structures that cut through folds. The limbs of the folds are variable and dip towards the SW and SE.

The sample yielded a relatively rich palynoflora that is overwhelmingly dominated (86.9%) by Late Cretaceous dinoflagellate cysts (Table 2). The only other elements observed are Quaternary pollen (*Pinus*) and non age-diagnostic forms. The Late Cretaceous dinoflagellate cysts include *Canningia* spp., *Cordosphaeridium gracile*, *Cribroperidinium wetzelii*, *Cribroperidinium* spp., *Exochosphaeridium* spp., *Odontochitina operculata*, *Odontochitina porifera* and *Xenascus* spp. This association is indicative of the Campanian to early Maastrichtian interval. The range bases of *Cordosphaeridium gracile* and *Cribroperidinium wetzelii* are intra-Campanian (Wilson, 1974; Stover et al., 1996). The range top of *Odontochitina* spp. is at the early-late Maastrichtian boundary. This means that the majority of the chalk in this diamict is derived locally, from the Upper Chalk.

3.4 STODY - SAMPLE 6

Sample 6 from Stody in north Norfolk is from a sheared slab of chalky diamict that is incorporated between two thrust sand and gravel slabs of the Briton's Lane Formation. The thrusting was from the north-west and the site is situated close to the ice-contact margin of the Kelling outwash fan.

Sample 6 produced a palynoflora that is similar to those from samples 1 and 2. The sample yielded a relatively rich palynoflora that is dominated (63.4%) by Jurassic palynomorphs (Table 1). These are largely dinoflagellate cysts. The Jurassic miospores are subordinate to dinoflagellate cysts and include the long-ranging forms *Callialasporites* spp. and *Cerebropollenites macroverrucosus*. The dinoflagellate cysts include *Cribroperidinium globatum, Cribroperidinium longicorne, Gonyaulacysta dualis, Senoniasphaera jurassica, Systematophora areolata*, *Systematophora penicillata* and *Systematophora* spp. This association is indicative of input of the Kimmeridge Clay Formation (Kimmeridgian). These forms are largely typical of the entire Kimmeridgian Stage. *Cribroperidinium longicorne* ranges from the early Kimmeridgian (Cymodoce Zone) to the late Kimmeridgian (Hudlestoni Zone) (Riding and Thomas, 1992). Furthermore, *Senoniasphaera jurassica* is most typical of the late Kimmeridgian (Riding and Thomas, 1988; Poulsen and Riding, 1992). The source of this Kimmeridgian material is thus possibly from the Upper Kimmeridge Clay (late Kimmeridgian). However, the Kimmeridgian dinoflagellate cysts in sample 8 are similar in character (see section 3.6), and are unequivocally from the Lower Kimmeridge Clay. It seems likely therefore that this Kimmeridgian flora is also early Kimmeridgian. Low levels (0.6%) of Carboniferous spores are also present in this sample (Table 1); these are species of *Cristatisporites* and *Densosporites*. No Lower Cretaceous input was observed, however extremely small proportions (0.8%) of Late Cretaceous dinoflagellate cysts were encountered. These forms are not age-diagnostic. The low levels (6.0%) of Quaternary miospores are dominated by *Pinus* (Table 2). Relatively high proportions (29.2%) of non-age diagnostic forms such as acritarchs and prasinophytes are present in sample 6.

3.5 WHIN HILL - SAMPLE 7

This sample was collected from a poorly exposed diamict at Whin Hill, north-west Norfolk. The diamict is underlain by sands and gravels of the Briton's Lane Formation. The diamict is chalky, but significantly sandier than the other samples in this study and resembles the Runton Till/Third Cromer Till.

Sample 7 produced a sparse palynoflora that is dominated (68.0%) by Late Cretaceous dinoflagellate cysts (Table 2). This Late Cretaceous palynoflora includes *Areoligera* spp., *Canningia* spp., *Odontochitina operculata* and *Xenascus ceratioides*. This assemblage is not age diagnostic, but somewhat resembles that in sample 5 which is interpreted as being derived from the Upper Chalk. Other forms comprise Quaternary miospores (16.5%, largely *Pinus*) and non age-diagnostic forms (15.5%, Table 2).

3.6 BITTERING - SAMPLE 8

Sample 8 from Bittering in west Norfolk is from a dark grey chalky diamict that underlies a succession of flint cobbles and boulder gravels referred to the Hungry Hill Gravel.

This sample yielded an association that is similar to those reported from samples 1, 2 and 6. It produced an extremely rich, relatively well-preserved palynoflora that is dominated (69.6%) by a diverse suite of Jurassic palynomorphs, largely dinoflagellate cysts (Table 1). The Jurassic miospores are subordinate and include *Callialasporites* spp., *Cerebropollenites macroverrucosus, Chasmatosporites* spp., *Cibotiumspora juriensis*, *Classopollis classoides, Coronatispora valdensis, Ischysporites variegates*, *Perinopollenites elatoides* and *Retitriletes austroclavatidites*. This flora is typical of the Mid-Late Jurassic interval except that *Chasmatosporites* spp. are indicative of the Early Jurassic.

The dinoflagellate cysts are especially diverse and include *Chytroeisphaeridia chytroeides, Cribroperidinium globatum, Cribroperidinium longicorne, Endoscrinium luridum, Glossodinium dimorphum, Gonyaulacysta dualis, Hystrichosphaerina orbifera, Leptodinium subtile, Mendicodinium groenlandicum, Pareodinia* spp., *Perissieasphaeridium pannosum, Protobatioladinium westburiensis, Rhynchodiniopsis cladophora, Sentusidinium* spp., *Sirmiodinium grossii*, *Systematophora areolata, Systematophora daveyi, Systematophora* spp. and *Tubotuberella apatela*. This association is indicative of input of the Kimmeridge Clay Formation (Kimmeridgian). Many of these taxa are relatively long-ranging within the Kimmeridgian Stage. However, *Endoscrinium luridum* is indicative of the early Kimmeridgian (Riding and Thomas, 1988; 1992). Other characteristic early Kimmeridgian taxa are *Gonyaulacysta dualis*, *Protobatioladinium westburiensis* and *Rhynchodiniopsis cladophora*.

The occurrences of *Cribroperidinium longicorne* and *Perissieasphaeridium pannosum* indicate that, assuming the Kimmeridgian reworking is from a single horizon or a short interval, the lowermost Kimmeridgian is precluded. These species have range bases in the Cymodoce and Mutabilis zones respectively (Riding and Thomas, 1988; 1992). This means that this stratigraphical recycling is from the Lower Kimmeridge Clay (Lower Kimmeridgian), Mutabilis to Autissiodorensis zones, again assuming that this material is from a single, discrete source. The similarity to the Kimmeridgian floras in samples 1, 2 and 6 strongly suggests that there associations are also likely to be of early Kimmeridgian age.

Low numbers of *Cicatricosisporites* spp. were recorded from this sample 1, thereby indicating minor input from the Lower Cretaceous. Sample 8 also yielded a single specimen of the typically Late Cretaceous dinoflagellate cyst *Odontochitina operculata*. This probably represents extremely low levels of Chalk Group input. Non age diagnostic forms account for 29.6% of the assemblage (Table 2).

4 Conclusions

Except for sample 4, the samples examined are either rich in Kimmeridgian or Late Cretaceous dinoflagellate cysts. This conclusion would support two distinct ice flow directions for this chalk-rich till facies in this area. Samples 1, 2, 3, 6 and 8 are rich in Kimmeridgian dinoflagellate cysts. They also have similar palynomorph signatures in that the Kimmeridgian dinoflagellate cyst floras are generally associated with low levels of Carboniferous and Lower Cretaceous spores and, unsurprisingly, significant levels of Jurassic miospores. Sample 8 yielded the most diverse Kimmeridgian dinoflagellate cysts that are indicative of the input of Lower Kimmeridge Clay Formation. The other Kimeridgian rich samples (1, 2, 3 and 6) are similar in species makeup, so these are also assumed to have been derived from the Lower Kimmeridge Clay. Samples 5 and 7 are dominated by Late Cretaceous dinoflagellate cysts indicative of substantial input from the Chalk Group. The association in sample 5 is indicative of the Campanian to early Maastrichtian, indicating input from the Upper Chalk. The flora from sample 7 is similar to that of sample 5 and is also assumed to have been derived from the local Upper Chalk. Sample 4 is unlike the remainder of the samples and is dominated by Quaternary pollen and non-age diagnostic forms, with lesser proportions of early Toarcian, Late Cretaceous and Palaeogene dinoflagellate cysts.

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Sample no.	Reg. No. (MPA)	Lithology	Grains/slide	Carb. spores	Jur. miospores	Jur. microplankton
1	53695	Clast-rich, chalk-rich muddy diamict	355	4 (1.15)	54 (15.2%)	218 (61.5%)
2	53696	Clast-rich, intermediate diamict	580	…	61 (10.5%)	132 (22.8%)
3	53697	Clast-rich, intermediate diamict	109	1 (0.9%)	…	19 (17.5%)
4	53698	Clast-rich, intermediate diamict	439	…	…	2 (0.5%)
5	53699	Clast-rich, chalk-rich muddy diamict	457	…	…	…
6	53700	Clast-rich, intermediate diamict	514	3 (0.6%)	38 (7.4%)	288 (56.0%)
7	53701	Clast-rich, chalk-rich muddy diamict	97	…	…	…
8	53704	Dark grey, chalky and clayey diamict	926	…	224 (24.2%)	420 (45.4%)

Table 1. Details of sample/registration 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 8 samples of this study. Three dots (...) indicates that the respective palynomorph group is not represented.

Sample no.	Early Cret. spores	Late Cret. dino. cysts	P.gene dino. cysts	Quat. miospores	Non age-diagnostics
1	4 (1.1%)	14 (3.9%)	…	27 (7.6%)	34 (9.6%)
2	…	…	…	16 (2.8%)	371 63.9%)
3	…	…	…	2 (1.8%)	42 (38.5%)
4	…	44 (10.0%)	11 (2.5%)	227 (51.7%)	155 (35.3%)
5	…	397 (86.9%)	…	47 (10.3%)	13 (2.8%)
6	…	4 (0.8%)	…	31 (6.0%)	150 (29.2%)
7	…	66 (68.0%)	…	16 (16.5%)	15 (15.5%)
8	7 (0.7%)	1 (0.1%)	…	…	274 (29.6%)

Table 2. The numbers and percentages (in parentheses) respectively of Early Cretaceous spores, Late Cretaceous dinoflagellate cysts, Palaeogene dinoflagellate cysts, Quaternary miospores, and non age-diagnostic palynomorphs in the 8 samples of this study. Three dots (...) indicates that the respective palynomorph group is not represented.