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A palynological study of palaeokarst deposits near Asby, Cumbria

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A palynological study of palaeokarst deposits near Asby, Cumbria

James B. Riding

Key words

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Front cover

Photograph of the pit from which the samples in batch 2 were taken. The containers, with the samples *in situ* are 10 cm in length.

Bibliographical reference

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Foreword

This report comprises the results of a palynological study of a suite of eight clay samples from palaeokarst deposits in pits in the Carboniferous Limestone of the Asby area, Cumbria. In the Asby region, some Carboniferous Limestone sink-holes are filled with tenacious, mottled clays. The origins, provenance and age of the clays are unknown.

Contents

Summary

The palaeokarst clays of Asby are enigmatic deposit; they cannot be wayboard clays or tills deposit due to the low smectite content and the absence of illite respectively. The presence of kaolinite is consistent with deep weathering. It is possible that this area of Cumbria underwent extensive weathering during the Palaeogene, then a Quaternary ice sheet moved the weathered materials from Shap to Asby, squeezing it into any pre-glacial karst features.

The Carboniferous spores are assumed to have had a local source. The indigenous flora appears to be Quaternary and is indicative of a herbaceous flora. The large levels of dispersed cuticle indicates that the plants grew nearby.

1 Introduction

A suite of eight samples from palaeokarst deposits in pits in the Carboniferous Limestone of the Asby area, Cumbria were submitted for palynological analyses in order to attempt to determine the age, origin and provenance of the clays. In the Asby region, some large sink-holes in the Carboniferous Limestone are filled with chaotic fills of tenacious, mottled clays. These clays are red, yellow and/or grey in colour and their origins, provenance and age are unknown; they have not been documented in the literature. No macrofossils or sedimentary structures have been discovered, however, several striated small pebbles have been recovered. It is anticipated that the palynological content of these deposits will help to determine the age and provenance of these enigmatic deposits. The samples are listed in the Appendix. A sample of the clay has also been submitted for X-ray diffraction analysis in order to determine the mineralogy of the deposit.

2 Palynology

In this section, the palynological content of the samples is described. The palynomorphs encountered are documented in Table 1.

2.1 SAMPLE BATCH 1

Samples 1 to 3 were collected from a pit at NGR 3649 5095. At this locality, the lithology is relatively variable, varying from limestone-rich clay, to mottled clay of various colours (red, grey, yellow). They were prepared for palynological analysis using the traditional method of mineral acid dissolution (Wood *et al*., 1996).

The three samples produced variable residues and palynofloras. Samples 1 and 2 yielded sparse organic material and palynomorphs (Table 1). The organic matter is dominated by light plant tissue, mainly dispersed cuticle. Other plant material such as wood fragments and resinite are present, but in lower proportions. Palynomorphs are extremely sparse. Sample 3 differs only in productivity; it produced an abundant kerogen assemblage again dominated by cuticle. Palynomorphs were also much more common than in samples 1 and 2. Amorphous organic material is absent throughout.

The palynofloras comprise pollen and spores of Quaternary aspect. Bisaccate pollen grains, *Chenopodium*, Compositae, *Erica, Laevigatosporites* and *Selaginella* are prominent (Table 1). This association largely comprises herbaceous pollen and pteridophytic spores and is indicative of a damp environment which has few, if any, trees. No distinctly Neogene, Palaeogene or older palynomorphs were recognised and marine microplankton is entirely absent.

2.2 SAMPLE BATCH 2

Samples 4 to 8 were taken from a temporary pit close to the pit sampled for batch 1 (see cover photograph), which exposed c. 80 cm. of red clay facies. Eight undisturbed clay samples were taken (see Appendix), five of which were analysed palynologically. The samples were prepared using a dissagregation technique which involves treatment with sodium hexametaphosphate and/or hydrogen peroxide. Sodium hexametaphosphate and hydrogen peroxide can be used to break down/deflocculate relatively soft, clay-rich sediments, thereby isolating microfossils of all types. The principal difference to the mineral acid technique being that the silicate and carbonate fraction of the rock/sediment is not destroyed. However hydrogen peroxide can destroy some organic matter via oxidation. This technique has recently been developed at BGS.

The five samples produced broadly similar residues and palynofloras. They all yielded abundant residues, including common to abundant palynomorphs. The kerogen assemblages are rich in varied plant tissues such as dispersed cuticle and wood fragments. All five samples are rich in dispersed cuticle, however sample 5 is dominated by wood. Some mineral grains are present and fungal material (spores, hyphae etc.) are consistently present. No amorphous organic material is present. The palynofloras are dominated by Quaternary aspect pollen and spores. They are of higher abundance and diversity than samples 1 to 3 (batch 1) and include *Betula*, bisaccate pollen, *Chenopodium*, *Cyathidites*, *Erica,* Gramineae*,* various inaperturate types, *Laevigatosporites*, *Lycopodium*, *Selaginella*, *Stereiosporites* and *Verrucatosporites* (Table 1). The assemblage is largely of herbaceous pollen and pteridophyte spores; it is indicative of a damp environment with few trees. The high levels of inaperturate pollen may be spurious. It is possible that some of these bodies may not be pollen grains, but artefacts made of clay minerals; these are not present in batch 1. Carboniferous spores were recorded from samples 8 to 5 (Table 1). These are dominated by the genus *Densosporites* and are interpreted as being sourced locally. These are being further investigated by Dr M. H. Stephenson. No other pre-Quaternary palynomorphs were recognised and marine microplankton is entirely absent.

3 Mineralogy

John McKervey (BGS, Keyworth) performed X-ray diffraction (XRD) analysis on the sample from 'monolith' 7 at 60 cm-70 cm depth in locality 2 (see Appendix). Preliminary findings on bulk XRD indicate that the suggests that the mineralogy is quartz, albite, orthoclase, undifferentiated mica, kaolinite, ?chlorite, ?haematite and ?pyrite. The <2 micron XRD has yet to be completed and this will clarify the clay mineralogy. The surface area of the sample is 80 m2/g, indicating that the overall smectite content of the sample is no more than 10%, and probably significantly less than this figure.

4 Discussion

The palaeokarst clays of Asby are enigmatic in that their age, provenance and mode of formation are unknown. They are formed of dense, tenacious, chiefly red clay and do not appear to have any sedimentary structures or macrobiotas. Because it occurs in Carboniferous Limestone it is possible that it represents a 'wayboard clay' deposit. Clay wayboards (an old quarrying term) are thin clay layers of volcanic clay interbedded in Carboniferous Limestone. However, the low smectite content precludes this. The dominant red colour suggests a possible Permian-Triassic age; this is supported by the presence of iron minerals. The appearance, colour and absence of illite in the clay rules out it being a till deposit. The presence of kaolinite is consistent with deep weathering of granite. It is possible that this area of Cumbria underwent deep weathering during the Palaeogene then a Quaternary ice sheet moved the weathered materials from the Shap inlier onto the karst escarpment at Asby. It was then squeezed into the pre-glacial karst features and preserved as these small 'pocket deposits'. It is well known that high ground in Cornwall was deeply weathered during the Palaeogene. There are erratic blocks of Shap granite on the Asby karst pavement; these are well rounded and may have been released from the ice as rounded, deeply-weathered blocks of Shap granite. The mineralogy of chlorite and kaolinite and the occasional presence of small, striated stones appears to be consistent with this theory. Ford and King (1969, fig. 4), in explaining the origin of the Neogene 'pocket deposits' of Derbyshire demonstrated that in pre-glacial times there were extensive sheets of unconsolidated sediments which were stripped away during ice advances but preserved in karstified hollows.

The kerogen and palynomorph evidence has to be fitted into the explanation. The Carboniferous spores are assumed to have a local source from Carboniferous strata in the Asby region. It is most likely that they were transported in to the Asby karst platform rather than being sourced *in situ* in the Carboniferous Limestone. Carboniferous Limestone is typically organic-lean and yields few spores per unit volume. The indigenous miospore floras include several long-ranging types and are not especially age-diagnostic. No distinctive Neogene types were recognised (Boulter, 1971) and the flora is most likely to be Quaternary in age. As discussed in section 2, the flora is indicative of a largely herbaceous flora consistent with a damp environment with few trees. The abundant plant material is significant; the large, poorly-sorted dispersed cuticle indicates that the plants grew nearby. Leaf cuticle is delicate and is extremely susceptible to mechanical damage during transport and to oxidation during weathering. Its presence attests to the closeness of the plants to the pits.

Higgs and Jones (2000) described Jurassic-Early Cretaceous clays of the Piltdown Clay Formation from karst cavities in County Kilkenny, Ireland. These are significantly older than the Asby clays and these also have yielded reworked Carboniferous spores. Drew and Jones (2000) also reviewed post-Carboniferous karstification in Ireland. The clays at Asby invite comparison with the Neogene 'Pocket Deposits' of Derbyshire. These are much larger silica sand and clay deposits which fill extensive solution pockets in the Carboniferous Limestone west of Matlock (Ford and King, 1969). These sand-dominated deposits were formed in the Neogene due to the infilling by sand and gravel cover of collapsed caverns (Ford and King, 1969, fig. 4).

5 Conclusions

The mineralogical and palynological evidence is intriguing. The presence of chlorite and kaolinite is consistent with deep weathering of rocks, in the Shap area. These include Carboniferous sedimentary rocks due to the presence of Carboniferous spores. The Quaternary pollen and the abundant plant tissue were probably incorporated into the clays *in situ,* perhaps palaeosols developed on the Shap area clays. Glaciogenic action then moved the resultant clays to Asby, where it filled hollows in the karstified surface.

Appendix 1 - Sample Details

Batch 1 is from locality 1, a pit in a palaeokarst deposit at NGR NY 3649 5095, Asby, Cumbria

The columns give the (informal) sample number, the BGS micropalaeontological registration number (prefixed MPA), the lithology, the depth in metres and the position in pit where this is known respectively.

1	MPA 50299	grey/yellow clay	0.95	
2	MPA 50301	red, mottled clay	1.00	(south end of pit)
3	MPA 50303	red, mottled clay	1.50-1.80	

Batch 2, all taken from locality 2, a temporary pit also at NGR NY 3649 5095, Asby, Cumbria which exposes red clay facies. Note that each sample was collected by pressing a metal container (a 'monolith') into the clay, thereby obtaining an undisturbed sample. The 'monoliths' are 10 cm long and eight were used in this pit; they were inserted lengthways and are adjacent. The *in situ* 'monoliths' are illustrated in the cover photograph.

The columns give the (informal) sample number, the 'monolith number, the BGS micropalaeontological registration number (prefixed MPA) and the depth in centimetres respectively.

4	'Monolith' 1	MPA 50672	0 10
5	'Monolith' 3	MPA 50674	20-30
6	'Monolith' 5	MPA 50676	40-50
7	'Monolith' 6	MPA 50677	50-60
8	'Monolith' 8	MPA 50679	70-80

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Table 1. Quantitative palynological data for the eight samples of the Asby clays. The numbers refer to counts of the respective form per microscope slide. Three dots (…) indicates the absence of that genus, taxon etc.

Sample Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Batch no.	**1**	**1**	**1**	**2**	**2**	**2**	**2**	**2**
Quaternary miospores:								
Alnus	…	…	…	…	…	…	…	1
Betula	…	…	…	1	…	9	…	…
bisaccates	2	4		63	17	2	17	3
Compositae	2 + ?1	3	5	…	…	…	…	…
Chenopodium	…	…	6	1	10	23	…	…
Cyathidites	…	…	3	3	32	1	4	…
Diporate pollen	…	…	…	…	…	…	…	1
Erica	…		22	…	5	…	…	…
Gramineae	…	…	4	…	…	…	27	32
Helianthus	…	…	1	…	…	…	…	…
inaperturate pollen - undiff.	…	…	…	2973	972	629	1044	389
'knobbly pollen' - indet.	1	…	…	2	17	17	1	…
Laevigatosporites	…	1 + ?1	17	227	571	145	29	62
Lycopodium	…	…	1	1	7	10	2	…
pollen - indeterminate	4	5	6	5	19	4	9	2
Selaginella	…	…	24	172	298	76	19	17
spores indeterminate	?1	2	1	79	4	2	4	11
Stereisporites	…	…	…	69	287	54	5	24
tricolpate pollen	…	…	1	4	…	…	…	…
triporate pollen	…	…	2	…	…	…	…	…
Valerianella	…	…	…	…	7	…	…	…
Verrucatosporites	…	…	…	202	52	37	7	1
Carboniferous spores:								
Carboniferous spores - indet.	…	…	…	…	1	…	47	…
Densosporites spp.	…	…	…	…	9	42	20	2
Lycospora pusilla	…	…	…	…	…	…	4	…