

## Erratic palynomorphs from some British tills

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**ABSTRACT**—The palynological investigation of tills (boulder clays) may provide considerable information about the direction of ice movement in lowland areas during the Pleistocene. Tills from Dyfed, Cheshire, Devon, Suffolk and Lincolnshire were subjected to palynological investigation. The palynomorphs recovered enabled some of the formations traversed by the ice-sheets to be identified, and thus an estimate of the direction of ice movement to be made. In most cases these estimates agreed with estimates based upon other methods of determining the direction of ice movement.

### INTRODUCTION

During the Pleistocene glaciations, ice-sheets spread over large lowland areas in Europe and North America. The behaviour of these ice-sheets is not yet well-known; it has been studied by examining:

1. the morphology of the deposits and erosive features left by the ice;
2. the orientation of clasts in glacial deposits;
3. the provenance of older deposits entrained by the ice, using either petrological or heavy-mineral analysis.

Palynology offers another method of analysing the derivation of glacial deposits. Clasts from tills (boulder clays) were examined palynologically by early workers such as Eisenack and Wetzel. Palynomorphs were first recovered from the matrix of tills by Iversen (1936) and subsequently by, among others, Hyypä (1936), Brander (1941), Heinonen (1957), Van Gijzel, Overweel & Veenstra (1960), Norris (1962), Cushing (1964), Andersen (1965), Miller & Benninghoff (1969) and Hansen (1979). For various reasons (e.g. insufficient biostratigraphic and systematic information or unfavourable geology) none of these authors was able to state the direction of movement of the ice-sheets that deposited the tills. The potential of till palynology is, however, well-illustrated by the work of Hansen (1979) who demonstrated that the matrix of Danish tills came from within 20 km of its point of deposition.

This study consists of a palynological investigation of six British tills from five localities: Aberaeron, Dyfed; Chelford, Cheshire; Fremington, Devon; Great Blakenham, Suffolk and Tattershall Thorpe, Lincolnshire.

### METHODS

Standard palynological techniques were used in sample preparation. The samples were mounted in 'cellosize' and Canada Balsam. The slides are lodged in the collections of the Palynology Laboratory in the Department of Geology, University of Sheffield.

Palynomorphs were identified to specific level, whenever possible. Their ranges were determined by reference to the palynological literature. The outcrop from which the palynomorphs could have come was established by reference to Geological Survey maps of the relevant areas. It was assumed that the ice-sheets passed over all the formations represented in the palynomorph assemblages.

### LOCALITIES

1. **Aberaeron.** Blue-grey Devensian till of Irish Sea origin is exposed on the foreshore and is overlain by about 6 m of head which forms a low cliff. The sample came from SN464634, about 1 km northeast of the mouth of the Afon Aeron. The glacial deposits at Aberaeron were described by Williams (1927), and subsequently by Mitchell (1962) and Watson & Watson (1967).

2. **Chelford.** Two tills of Devensian age are known from the sand pits of Chelford, Cheshire (SJ824720). The Lower Till (of uncertain age) overlies 'Ipswichian' shelly clays and is itself overlain by the Chelford Sands and Interstadial Deposit (60,800 BP). The Upper Till overlies these deposits. It contains erratics from the Pennines, Lake District and Irish Sea (Simpson & West, 1958; Coope, 1959). Mr. T. Good supplied the author with samples from the deposits at Chelford.

3. **Fremington.** Isolated remnants of till at Fremington, near Barnstaple, north Devon, described by Maw (1864), Stephens (1966), Wood (1970), Edmonds (1972) and Kidson & Wood (1974), are older than the local raised beaches (Kidson & Wood, 1974), which are of Ipswichian age (Andrews, Bowen & Kidson, 1979; Keen, Harmon & Andrews, 1981). The Fremington Till is thus Wolstonian or older. It contains rare 'giant' erratics of Scottish origin (Dewey, 1910; Taylor, 1956), and foraminifera and heavy minerals derived from the Irish Sea (Wood,

1970). The samples studied came from Brannam's Brickpit, Fremington (SS529371).

4. **Great Blakenham.** Chalky Lowestoft Till of Anglian age at Great Blakenham (TM115499) is overlain by fluvial sands and gravels (Rose, 1977; Rose, Allen & Hey, 1976). West & Donner (1956) and West (1963) show the Anglian ice-sheet entering East Anglia from the west and northwest using data from measurements of clast orientations. Perrin, Rose & Davies (1979), working with the distribution of heavy minerals, show the Anglian ice-sheet entering East Anglia and radiating out from the Wash. The sample of Lowestoft Till from Great Blakenham was given to the author by Mr. I. Bryant.

5. **Tattershall Thorpe.** Wragby Till (the chalky Boulder Clay of Wood, 1880 and Jukes-Brown, 1885) at Tattershall Thorpe (TF225599) is overlain by Ipswichian interglacial deposits (I. Bryant, pers. comm., 1981) and Devensian sands and gravels. Straw (1979) states that the Wragby Till is of Wolstonian age, whereas Perrin, Rose & Davies (1979) suggest that it is of Anglian age. Perrin, Rose & Davies (1979) also challenge the other author's assumption that the Wragby Till was deposited by a southwards-moving ice-sheet. They show that heavy-mineral distribution in the Wragby Till is more likely to be the result of an ice-sheet moving northwest from the Wash into Lincolnshire. Mr. I. Bryant supplied the author with a sample of Wragby Till.

## RESULTS

Palynomorphs of many different ages were present in all samples. In most cases forms derived from the local bedrock were very common. Each till is discussed separately below.

1. **Aberaeron.** Palynomorphs of Tremadoc-Ashgill, Silurian, Carboniferous, Permo-Triassic, Jurassic, Cretaceous, Tertiary and Quaternary age are present. The Silurian taxa are likely to be derived from the local bedrock (Llandovery); other forms must have been brought into the area by Irish Sea ice. Rocks of Permo-Triassic age (represented by striate bisaccates), Jurassic age (represented by taxa such as *Classopollis*, *Cycadopites*, *Callialasporites* and rare spores and dinocysts), Tertiary age (represented by forms such as *Wetzelia* and much pollen) and Quaternary age (represented by pollen, and dinocysts such as *Spiniferites septentrionalis* Harland and *Leptodinium multiplexum* Wall & Dale) are known from Cardigan Bay (Garrard, 1977; Wilkinson & Halliwell, 1979). Tremadoc-Ashgill rocks (represented by forms such as *Stelliferidium* and *Cymatiogalea*) outcrop on the Lleyn Peninsula and around the Harlech Dome, and the Carboniferous outcrop (represented by forms such as *Lycospora* and

*Densosporites*) runs along the north Wales coast and across Anglesey into the Irish Sea northwest of the island (Wilkinson & Halliwell, 1979). The Cretaceous forms (such as *Parvisaccites radiaus* Couper, *Oligosphaeridium complex* (White) Davey *et al.*, *Cicatricosisporites venustus* Deak, *Microdinium setosum* Sarjeant and *Odontochitina* spp.) are problematical, since no Cretaceous outcrop was reported from Cardigan Bay by Wilkinson & Halliwell (1979) or Garrard (1977). The nearest Cretaceous outcrop to the north of Aberaeron is probably that of Northern Ireland (Hancock, 1961). The ice-sheet that deposited the Aberaeron Till may therefore have travelled past the Cretaceous outcrop in Northern Ireland before crossing the Lleyn Peninsula and moving south across Cardigan Bay to Aberaeron. This is similar to the direction of ice movement in Cardigan Bay suggested from the distribution of erratic boulders by Garrard (1977).

2. **Chelford Lower Till.** The Lower Till at Chelford is dominated by Quaternary pollen and freshwater algal spores. It also contains a few Permo-Triassic forms, mostly striate bisaccates, and some Carboniferous spores. The Quaternary species are mostly derived from the underlying Ipswichian shelly clays (two samples from the Ipswichian deposits had markedly similar pollen spectra); the Permo-Triassic species are likely to be derived from the local bedrock and the Carboniferous species are probably from the Pennines. The ice-sheet that deposited the Lower Till thus probably originated in the Pennines.

3. **Chelford Upper Till.** The Upper Till at Chelford is dominated by Carboniferous spores (98%) with rare Permo-Triassic, Jurassic and Quaternary species. The Carboniferous assemblage includes many long ranging forms, as well as species confined to the Visean and Namurian (such as *Walzisporea polita* (Hoffmeister, Staplin & Malloy) Smith & Butterworth, *Convolutispora* spp.) and species confined to the Westphalian (such as *Florinites* spp., *Endosporites globiformis* (Ibrahim) Schopf, Wilson & Bentall.) The Permo-Triassic forms are mostly long-ranging striate bisaccates. The Jurassic forms are all long-ranging species (*Classopollis*, *Callialasporites dampieri* (Balme) Sukh Dev., *Duplexisporites problematicus* (Couper) Playford & Dettmann, *Gleicheniidites senonicus* Ross). The Quaternary species include marine dinocysts such as *Operculodinium centrocarpum* (Deflandre & Cookson) Wall, *Spiniferites ramosus* (Ehrenberg) Loeblich & Tappan, *Bitectatodinium tepikiense* Wilson, and some pollen. The presence of the Quaternary dinocysts and Jurassic miospores indicates that the Chelford Upper Till is at least partly of Irish Sea origin, thus reinforcing the findings of Simpson & West (1958) who found Irish Sea erratic clasts within the Till.

4. **Fremington.** The Fremington Till contains palynomorphs of Carboniferous, Rhaetic, Jurassic, Cretaceous, Palaeogene and Pleistocene age. The Carboniferous suite is probably derived from the local bedrock; the other taxa are derived from outcrops in the Bristol Channel and Celtic Sea (Evans & Thompson, 1979; Wilkinson & Halliwell, 1979). Rocks of Rhaetic age (represented by forms such as *Ovalipollis ovalis* Krutzsch) and Jurassic age (represented by forms such as *Valensiella ovula* (Deflandre) Eisenack, *Dinopteridium absidatum* Drugg, and *Ctenidodinium panneum* (Norris) Lentin & Williams) outcrop over much of the length of the Bristol Channel, therefore these suites of palynomorphs offer little directional information. The Tertiary (represented by angiosperm pollen) offers more information, since all the Tertiary outcrops in the Bristol Channel and southern Irish Sea are to the west and northwest of Fremington. The key outcrop is that of the Cretaceous (represented by taxa such as *Oligosphaeridium complex* (White) Davey & Williams, *Dinogymnium* spp., *Palaeoperidinium cretaceum* Pocock, *Polysphaeridium laminaspinosum* Davey & Williams and *Microdinium ornatum* Cookson & Eisenack), since this outcrops only northwest of Fremington (Wilkinson & Halliwell, 1979). The Fremington glacier must therefore have come from a direction of between 275° and 300°, and have been travelling nearly due east; a conclusion which agrees well with the geomorphological results of Edmonds (1972) and Kidson & Wood (1974).

5. **Great Blakenham.** The Lowestoft Till from Great Blakenham contains Carboniferous, Permo-Triassic, Rhaetic, Jurassic, Cretaceous and Pleistocene (pollen only) palynomorphs. The presence of Carboniferous spores such as *Densosporites* spp., *Lycospora* spp., *Cristatisporites* sp., suggests that some of the Anglian ice may have originated in the Pennines and moved in a general southeasterly direction towards Great Blakenham. This probable northwesterly origin for the Lowestoft Till agrees with both the clast-orientation data of West & Donner (1956) and the heavy-mineral analyses of Perrin, Rose & Davies (1979); however, the suggestion by Perrin, Rose & Davies (1979) that the Lowestoft ice-sheet came into East Anglia from the North Sea cannot be confirmed on palynological grounds, since no Pleistocene dinocysts (which would be expected if the Lowestoft Till had a North Sea origin) were encountered in the sample.

6. **Tattershall Thorpe.** Palynomorphs of Rhaetic, Jurassic (mostly Upper), Lower and Upper Cretaceous and Quaternary age are present in the Wragby Till. The Quaternary species are all pollen and freshwater algal spores. The Upper Jurassic palynomorphs are likely to

be derived from the local bedrock. The Rhaetic outcrops to the west and northwest of Tattershall Thorpe on land, and to the east and north in the North Sea, and is thus of little use in suggesting a direction of ice movement. The occurrence of Cretaceous forms suggests an origin from the sector from northwest through north to southeast, while the total absence of Carboniferous taxa suggests that the ice-sheet never passed over rocks of that age either in the Pennines or in Northumberland. The lack of Pleistocene marine dinocysts suggests that the Wragby ice-sheet had not come directly from the North Sea. It is therefore probable that the Wragby Till at Tattershall Thorpe was emplaced by an ice-sheet moving in a general southerly direction along the strike of the Mesozoic outcrop in Lincolnshire. There is no strong evidence, however, to decide whether this was the case; the assertion by Perrin, Rose & Davies (1979) that the Wragby Till was emplaced by an ice-sheet moving northwestward from the Wash is almost equally probable on the palynological evidence, except for the absence of Pleistocene dinocysts.

## DISCUSSION

In this paper it has been assumed that the ice-sheets carried with them identifiable palynomorphs from all the formations they traversed. This assumption may not always be valid, for instance the Fremington Till contains material derived from Permo-Triassic rocks (Wood, 1970), but no unequivocal Permo-Triassic species were found in the samples from Fremington.

The resolution of the direction of ice-movement is to a great extent dependent upon the accuracy of the resolution of the age of the derived palynomorphs and thus of the formations passed over by the glacier. It is also dependent upon the degree of detail of the geological maps available, especially in offshore areas.

The resolution of the 'age' of the derived palynomorphs may, in some instances, be complicated by earlier reworking, such as that reported by Muir (1967) and Phillips (1974). This reworking is impossible to detect, unless it has left palynomorphs in a very degraded state.

It is suggested, therefore, that although till palynology is capable of providing considerable information about the formations that an ice-sheet has traversed, it should be used in conjunction with the other techniques outlined in the Introduction, rather than in isolation.

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