Chelford

[SJ 824 717]

Potential GCR site

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Introduction

The sediments at Chelford, in Cheshire, constitute one of the key Devensian sequences in Great Britain and the site is considered as the stratotype for the Chelford Formation (Bowen, 1999). The importance of Chelford to the British Quaternary record is underlined by the fact that the site was proposed originally by the Geological Society of London Quaternary Working Group as the type locality for the last glaciation in Britain (Shotton and West, 1969), although it was later replaced by Four Ashes (Mitchell *et al.,* 1973). An organic layer within the Chelford Formation has provided biostratigraphical evidence for an Early Devensian Interstadial event known as the Chelford Interstadial (Simpson and West, 1958) and the site is now recognized both nationally and internationally as the stratotype for the 'Chelford Interstadial'. Biostratigraphical evidence for this interstadial event has been presented by Coope (1959) and by Simpson and West (1958). The importance of the site was increased further by the discovery of glaciogenic sediments (Figure 5.26) belonging to the Oakwood Formation beneath the Chelford Formation (Worsley *et al.,* 1983). The Oakwood Formation provides evidence of a stadial event prior to the Chelford Interstadial.

The precise chronostratigraphical position of the Chelford Interstadial within the British Quaternary record has been the subject of much controversy. This primarily is because the age of the organic remains that constitute the biostratigraphical horizon in the Chelford Formation lies at or beyond the limits of conventional radiocarbon dating methods and because of doubts about possible contamination of samples (Worsley, 1980). Radiocarbon dating of the Chelford organic layer was also first conducted at a time when laboratory procedures for the technique were at the pioneer stage, the limitations of the technique were not fully understood and when British Quaternary stratigraphy was not fully established. Recent advances in the dating of organic material have allowed independent dating of the Chelford organic layer. This has now confirmed that the organic material was deposited around 86 ka, well beyond the limits of conventional radiocarbon dating (Heijnis and Vanderplicht, 1992). Other technological advances, including those in thermoluminescence dating techniques that can be applied to quartz and feldspar mineral fractions in sand, also mean that the host sediment can be dated directly. Thermoluminescence dating of the Chelford Formation has yielded an absolute age for the Chelford Interstadial of 90–100 ka (Rendell *et al.,* 1991; Rendell, 1992) and generally it is now accepted that the Chelford Interstadial is of Early Devensian age. More recently, data from the site have been used in a wide ranging assessment of the palaeoclimatic conditions prevailing in north-western Europe during the last interglacial to glacial transition, assembled from palaeobotanical, coleopteran and periglacial evidence (Aalbersberg and Litt, 1998).

Description

The village of Chelford is located approximately 10 km west of Macclesfield in Cheshire. Descriptions of the Pleistocene deposits in the area come from three separate but closely spaced sand quarries south-east of the village. The original site described by Simpson and West (1958) was the working sand quarry at Farm Wood, Chelford [SJ 812 731]. This quarry was worked between 1955 and 1973 but is now 'restored', all faces have been graded and no permanent exposures exist. More recent descriptions of the Chelford deposits (e.g. Worsley *et al.,* 1983; Rendell *et al.,* 1991; Rendell, 1992) are from sand quarries at Dingle Bank [SJ 807 718] and Oakwood Farm Quarry [SJ 824 717].

Lithostratigraphy

The original succession described by Simpson and West (1958) from Farm Wood Quarry is as follows:

Unit	Thickness (m)
4. Upper Sands	0–1
3. Upper Boulder Clay	0–5
2. Middle Sands (including a bed of organic mud up to 1 m thick	16–20
1. Lower Boulder Clay	not exposed by quarrying

A complete description of the Quaternary sediments down to bedrock was never obtained from the original Farm Wood Quarry owing to the nature of the working practices at the site. Partly because of this, Simpson and West (1958) considered the Chelford Formation to be a glaciofluvial deposit sandwiched between two glacial tills (an Upper Boulder Clay above and a Lower Boulder Clay below). Boulton and Worsley (1965), however, disputed the existence of this Lower Boulder Clay beneath the Chelford Formation on the basis of borehole data. Boulton and Worsley (1965) concluded that the Chelford Formation lay directly on weathered Mercia Mudstone bedrock. Subsequent exposures at the new Oakwood Quarry (Figure 5.26) in the late 1960s, however, required a reappraisal of this conclusion when a second glaciogenic deposit (the Oakwood Formation) was recorded beneath the Chelford Sands (Worsley *et al.,* 1983). This glaciogenic deposit comprises a thin bed of red till including shale fragments, locally derived Carboniferous and Permo-Triassic sandstone and quartzite pebbles, together with igneous clasts of a presumed Lake District origin (Worsley *et al.,* 1983). The upper surface of the till has scattered ventifacts, suggesting a period of subaerial wind deflation (Thompson and Worsley, 1967). This thin, patchy till is also recognized in the area surrounding Chelford, although it is rarely more than 1.7 m thick (Evans *et al.,* 1968). The stratigraphical position of this till (informally named the 'Oakwood Till' by Worsley *et al.* (1983), and now formally known as the 'Oakwood Formation' (Bowen, 1999)), is difficult to explain as anything other than a stadial event prior to the deposition of the Chelford Formation itself. The precise timing of this glacial event is unknown (Worsley *et al.,* 1983). Finally, immediately beneath the Oakwood Till, Worsley *et al.* (1983) described a thin sequence of in-situ fossil-rich gravel and silt (the Lapwing Bed) resting directly on unweathered Mercia Mudstone bedrock. Pollen, plant macrofossils, Mollusca, Coleoptera and Ostracoda assemblages have all been recovered from this gravel and silt horizon.

Biostratigraphy

Two important biostratigraphical horizons occur at Chelford. The first of these, the organic lenses within the Chelford Formation, have yielded the abundant floral and faunal remains that represent the Chelford Interstadial. Simpson and West (1958) and Coope (1959) have published detailed accounts of this flora and fauna. The second important biostratigraphical horizon is the thin sequence of fossiliferous silt and gravel of the Lapwing Bed, immediately below the Oakwood Till. This unit lies stratigraphically well below the Chelford Formation. The biological evidence in this sequence includes pollen, plant macrofossils, Mollusca, Coleoptera and Ostracoda assemblages (Worsley *et al.,* 1983). The floral and faunal assemblages in these two horizons are described below.

Biostratigraphical evidence in the Chelford Formation

The insect fauna from the Chelford Formation consists almost entirely of Coleoptera (beetle) remains, described in detail by Coope (1959). A summary of the Chelford insect fauna is given in (Table 5.3) and a full species list can be found in Coope (1959). The largest family present is Carabidae, members of which inhabit sandy, damp or marshy ground. Other important species represented include the carnivorous water beetle family Dytiscidae, the carnivorous beetle family Staphilinidae and the click beetle family Elateridae. The palaeobotany of the organic mud is provided in Simpson and West's (1958) account of the site. The vegetation is dominated by conifer and birch forest with a ground flora chiefly of *Callum, Empetrum* and other ericaceous plants.

(Table 5.3) Coleoptera from the Chelford Formation (data from Coope, 1959).

Family	Number of species
Carabidae	30
Dytiscidae	12
Hydrophilidae	4

Silphidae	3
Leiodidae	1
Staphilinidae	13
Elateridae	8
Helodidae	1
Byrrhidae	4
Coccinellidae	2
Scarabaeidae	2
Cerambycidae	1
Chrysomelidae	7
Curculionidae	10
Scolytidae	2

Biostratigraphical evidence for a glacial event prior to the Chelford Interstadial

The silt and gravel of the Lapwing Bed have also yielded important fossil material useful for biostratigraphy (Worsley *et al.,* 1983). Although pollen is sparse and generally poorly preserved, a pollen record from the silt has been produced. The pollen assemblage is dominated by non-arboreal species such as Cyperaceae and Gramineae, with a scarcity of tree pollen. Aquatic plants are well represented, with *Alisma, Lemna, Nuphar* and *Nymphaea* suggesting the occurrence of standing or slow-flowing water of between 0.5 and 1 m in depth. Plant macrofossils also have been obtained from the silt, and are again dominated by aquatic plants that require slow-flowing water. *Potamogeton filiformis, Eleocharis palustris* and *Hippuris vulgaris* grow in shallow water around 0.5 m in depth at the margins of pools. The mosses *Drepanocladus aduncus* and *Scorpidium scorpioides* are represented by abundant leafy stems, suggesting that they were growing in shallow water rather than in marshes. The molluscan fauna is also dominated by aquatic species. The abundance of *Lymnaea* spp., *Anisus leucostoma* and *Armiger crista* is indicative of shallow standing or slow-flowing water with abundant submerged vegetation. Species characteristic of large bodies of open water such as *Valvata piscinalis* are notably absent. The three species of *Pisidium* recorded all prefer muddy substrates. The terrestrial mollusca are all of species that generally live in proximity to water bodies, such as *Oxyloma pfeifferi, Succinea oblonga* and *Vertigo genesii,* and have modern ranges that extend into Arctic areas. The Ostracoda assemblage is dominated by species of *Candona, Ilyocypris* and *Limnocythere.* Their occurrence together again indicates a stagnant or slow-flowing water body, such as a stagnant vegetated pool. The insect fauna, although dominated by a total of 55 coleopteran taxa, also contains Diptera, Hymenoptera and Trichoptera. Aquatic, riparian and terrestrial communities are all present in the silt. The overall picture from the coleopteran evidence is one of a shallow, perhaps ephemeral, pool surrounded by marsh plants such as sedges and mosses. Farther away from the marsh the soil became gradually better drained with patchily developed vegetation of grass and weeds. There is no evidence that trees grew in the vicinity and a meagre mammalian fauna must have lived at this time. The absence of trees suggests an average July temperature below 10°C, and the climatic regime indicated is boreal or boreo-montane with an element of continentality. Overall, the faunal and floral assemblages indicate that the deposits accumulated in a shallow pool within a treeless, open landscape (Worsley *et al.,* 1983).

Chronostratigraphy

Determining the exact age of events at the site has proved problematic and somewhat controversial. No less than 14 separate radiocarbon dates have been obtained for the Chelford Interstadial from laboratories in the UK, the USA, Holland and Germany. Dates for the organic remains at Chelford lie across a wide range between 25 and 65 ka. As the limits of conventional radiocarbon dating lie at around 45 ka, it became apparent as far back as the late 1960s that the organic remains within the Chelford Formation lay at or beyond the limits of this dating technique. Worsley (1980) has discussed in some detail the problems associated with previous attempts to date the Chelford Interstadial using conventional radiocarbon methods. Recent advances in dating techniques, in particular in the field of thermoluminescence dating, mean that it is now possible to obtain dates directly from the quartz and feldspar mineral fractions of sands. These techniques, when applied to the Chelford Formation, have yielded an absolute age for the Chelford Interstadial of 90–100 ka (Rendell *et al.,* 1991; Rendell, 1992). Independent support for this age also comes from uranium-series dating of the Chelford organic layer itself, which has yielded an age of 86 ka (Heijnis and

Vanderplicht, 1992). The lower part of the Chelford Formation probably pre-dates the Ipswichian interglacial (Oxygen Isotope Sub-stage 5e) (Bowen, 1999). The age of the interstadial pre-dating the Chelford Interstadial is less certain, but is ascribed to Oxygen Isotope Stage 6 by Bowen (1999).

Interpretation

According to Worsley *et al.* (1983) the Pleistocene succession in the Cheshire–Shropshire area consists of two basic formations. These are the Stockport Formation and the Chelford Formation. The Stockport Formation is a suite of glaciogenic deposits including till, glaciolacustrine and glaciofluvial facies. The Stockport Formation is effectively the formal lithostratigraphical equivalent of the old tripartite sequence (Upper Boulder Clay, Middle Sands and Gravels, Lower Boulder Clay) that is recognized throughout the north-west of England and Wales (Bowen, 1999). Below the glaciogenic Stockport Formation, and separated from it by a major unconformity, is the Chelford Formation. The Chelford Formation is exposed only in deep excavations and is an exceptionally pure and well-sorted sand succession, containing in places lenses of organic peats and muds. The Chelford Formation is now known to occupy a SE–NW orientated palaeovalley, and the organic remains are confined to the fill of palaeochan-nels within the sands (Worsley, 1977; Worsley *et al.,* 1983). Simpson and West (1958) originally considered the Chelford Formation and associated organic remains to be part of a glaciogenic succession, although Boulton and Worsley (1965) later interpreted the sands as a fluvio-aeolian succession of alluvial fans with a dominant east to west flow direction. They regarded the organic deposits as belonging to a brief interstadial within this periglacial regime.

In his study of the organic remains within the Chelford Formation, Coope (1959) concluded from the good levels of preservation indicated that the beetles had not undergone significant post-mortem transportation. The Chelford fauna therefore can be regarded as a community of species that did in fact co-exist in the immediate vicinity. He further summarized the detailed environmental conditions that best fit the present-day requirements of the coleopteran assemblage at Chelford. The organic mud represents sedimentation in a pond choked with vegetation debris and partially overgrown by *Sphagnum.* There was little open water in the pond, which was primarily stagnant and acidic. Sporadic floods were required in order to carry in tree trunks and dead leaves. Immediately adjacent to the pond was marshy ground dominated by reeds, rushes and willow with sandy banks in places. More open sandy heath surrounded the pond with abundant birch and conifers, with numerous fallen trees and stumps. The scarcity of dung and carcass beetles suggests that there were few large animals in the area. Most of the Coleoptera have northern affinities, suggesting a colder climate than at present. Although most of the beetles found at Chelford are cosmopolitan species, Coope (1959) found that the entire faunal assemblage occurred in parts of present-day Fennoscandia. In particular, the faunal list closely matches that of southern Finland between 60° and 64°N. Average annual precipitation in this area is 600 to 650 mm. The palaeoclimatic interpretation is that of a mean annual temperature around 1°C, with temperatures during the warmest month (July) around 15°C and temperatures during the coldest month (February) around −11°C. The overall climatic reconstruction is therefore that of a continental climate with long, cold and dry winters. This is remarkably similar to the climatic reconstruction made from the palaeobotanical evidence by Simpson and West (1958). In particular, the presence of *Picea abies,* no longer native to the UK, is a clear indication of the continentality of the climate.

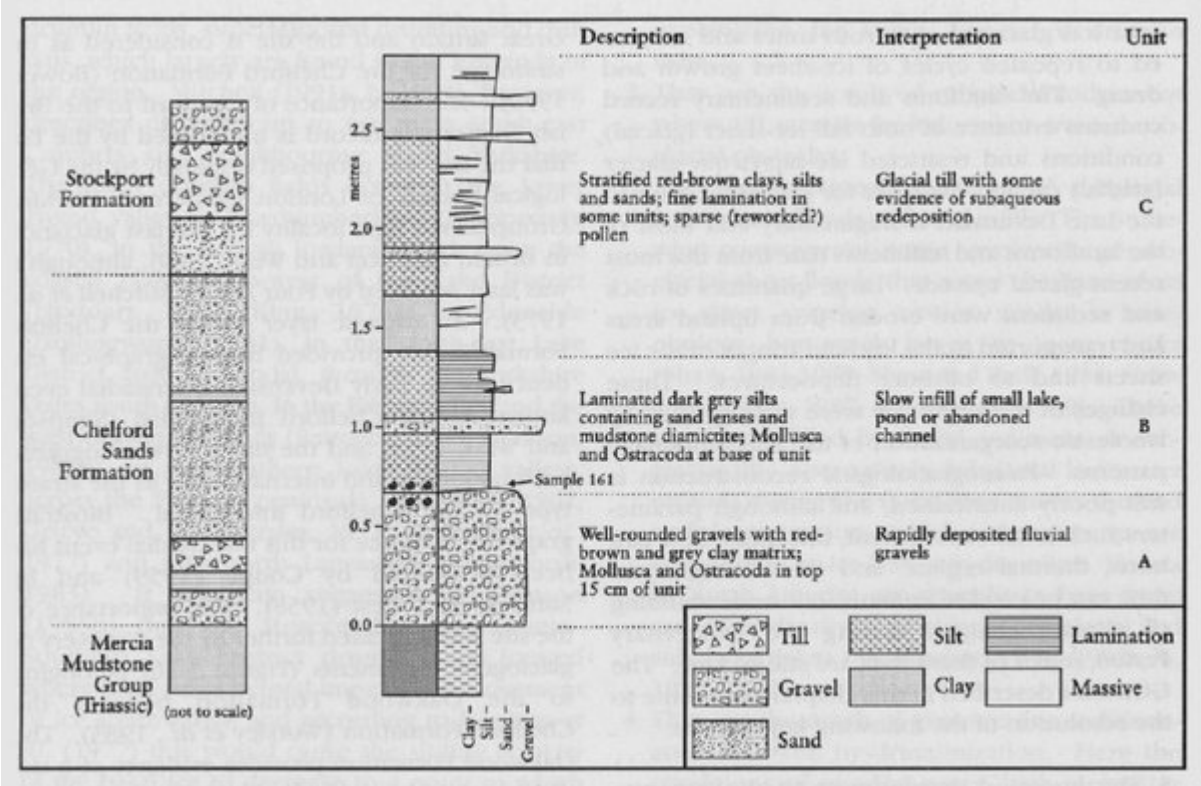
Mutual Climatic Range analyses of the coleopteran evidence from the Lapwing Bed (pre-dating the Chelford Interstadial) suggest that during Oxygen Isotope Stage 6 (Bowen, 1999), the mean temperature of the warmest month (July) was around 9.5°C (Worsley *et al.,* 1983). The mean temperature of the coldest months (January and February) lay somewhere between −19°C and −28°C (Worsley *et al.,* 1983). These estimates indicate an increase in continentality, with a temperature amplitude between the warmest and coldest months approaching 30°C.

Conclusions

Chelford is clearly a site of the utmost importance to British Quaternary stratigraphy. Two separate interstadial events are represented at this locality, one of which (the Chelford Interstadial) has been the subject of a concerted dating campaign. Beneath this, the Oakwood Formation contains the only reliable evidence in this part of the country for a glaciation prior to the Middle Devensian. The lithostratigraphical, chronostratigraphical and biostratigraphical evidence from Chelford is widely used in comparisons with other Quaternary sites both in the UK and in continental Europe. The volume of

published material on the site, its rich and varied floral and faunal assemblages that serve as biostratigraphical reference markers, and its status as the stratotype for the Chelford Interstadial make the site of great significance to the British Quaternary record.

References



(Figure 5.26) The stratigraphy recorded at Oakwood Quarry, Chelford (after Worsley et al., 1983).

Family	Number of species
Carabidae	30
Dytiscidae	12
Hydrophilidae	4
Silphidae	3
Leiodidae	1
Staphilinidae	13
Elateridae	8
Helodidae	1
Byrrhidae	4
Coccinellidae	2
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