Chapter 6: Palaeoenvironmental analysis and taphonomy

6.1 Palaeoenvironmental sample stratigraphy

Before a discussion can begin of the preservation and taphonomy of the environmental samples, the basic sample stratigraphies need to be summarised, in conjunction with their dating. The sample locations with their basal dates are shown (Fig. 6.1). All of the dates on these cores/tins were produced through radiocarbon dating. The stratigraphy of the samples is shown against organic content, carbonate content and magnetic susceptibility in one figure, with the pollen sample locations and the radiocarbon dates shown against stratigraphy on a second figure.

6.1.1 Core MFC2

This core was sampled in a palaeochannel on the modern floodplain. MFC2 has a dark red brown clayey silt A horizon underlain by a reddish brown silty clay. Below this at 56 – 82cm is dark grey/black silty clay, which shows elevated organic and carbonate contents and a higher magnetic susceptibility. Below this at 82 – 116cm is a red brown silty clay, underlain by a reduced grey brown silty clay. A grey brown silty sandy clay is between 151 – 163, with a black clayey sand at 163 – 172cm and a grey brown coarse sand at the base. The unit between 56 – 82cm stands out as having a higher organic content. There was no sand within this unit suggesting a very low energy depositional environment. It is also a notable break between two units of red brown clay and appears to reflect a change is depositional history (Fig. 6.2).

The pollen was evaluated at every 14cm down the core MFC2, starting at 14cm. The date near the base of MFC2 is at 178 – 179cm, which gives a date of 445+/-345, which is consistent with the date predicted through the original chronostratigraphic model from phase 1.

6.1.2. Core T1C7

This core was sampled in a palaeochannel of the river Soar, located on terrace 1 (Fig. 6.1). Core T1C7 has an A horizon between 0 – 6 cm, underlain between 6 – 45cm by a brown silty clay. After this point (45cm) the core is dominated by two main sediment units. Firstly, there is an upper blue grey with Fe inclusions between 45 – 140cm. Below this between 140 – 225cm is a blue grey clay with visible organic fragments. The organic content is relatively high throughout the core, but does not vary drastically or in a systematic way. The magnetic susceptibility shows a notable peak in the blue grey unit between 45 – 140cm, but this does not correspond with a recognised change in sediment composition (Fig. 6.4).

The pollen samples were taken at 14cm intervals, starting at 14cm. The original basal date for this core was shown to be unreliable (modern radiocarbon age) and further material has been sent for re-dating. Two radiocarbon dates appear coherent with

each other. The date at 90cm is 1020BP +/-35, with the date at 151cm being 1406BP +/-30 (Fig. 6.5).

6.1.3   Core T1C10

This core was taken from a palaeochannel that runs east/west through an area of terrace 1 (Fig. 6.1). This core has a brown silty clay A horizon between 0 – 22cm, underlain by a red brown loam (silt, clay with sand) between 22 – 58cm. Below this a unit extends past the redox boundary, between 58 – 142cm. The upper 58 – 100cm is red brown increasingly gleyed clay with depth. From 100 – 142cm, this unit is grey clay. Between 142 – 158cm is a dark grey clayey silt, with fine sand and heavy Fe and Mn staining. At the base is a dark grey clay with a trace of sand between 158 – 185cm.   Overall the organic content through the core is low, with the carbonate content showing no systematic variation with stratigraphy.   The organic content is slightly elevated in the basal dark grey clay until between 158 – 185cm. Magnetic susceptibility shows little variation, except an elevation in the A horizon and elevation in the dark grey clay basal unit (Fig. 6.6).

Pollen was sampled at 14cm intervals along the core length, starting at 14cm. The low general organic content of the core meant that finding plant macrofossils to date was problematic and only two dates were recorded on the core, both coming from direct dating of sediment. At 145cm a bulk sediment sample gave a date of 3920BP +/-35, whilst a sample dated from the humin fraction at 180cm gave a date of 4334 BP +/-30. These dates prove that this palaeochannel is considerably older than most of the other palaeochannels on terrace 1 (Fig. 6.7).

6.1.4 Core T1C12

This core was located in the palaeochannel that denotes the boundary between terrace 2 and terrace 1 (Fig. 6.1). The core stratigraphy has a 10cm A horizon of red brown clayey silty, underlain between 10 – 29cm by an organic brown black silty clay. A thin unit of reddish brown silty clay is located between 29 – 37cm. Below this is a large unit of red brown silty clay, stretching from 37 – 139cm. At 139 –183cm a dark grey clay is encountered, with a basal unit of black grey clay between 183 – 214cm. The organic content is consistently high throughout the core, with elevated levels seen between 10 – 37cm.   Magnetic susceptibility also shows elevate values between 10 – 37cm (Fig. 6.8).

Pollen was sampled at 14cm intervals along the core length, starting at 14cm. The dating of the core is not clear, with three dates that are of similar age (within 144 years of the central ages), but their chronological relationship is suspect. The depth of 193cm provides a date on monocotyledon fragments of 1174BP +/-35, whilst the depth of 214cm provides a date of 1030BP +/-40, also on monocotyledon fragments. A further sample at 204 – 206cm was dated at 1275BP +/-35, indicating that the date at 214cm is suspect (Fig. 6.9). Channel abandonment can be placed around AD 660 to AD860.

6.1.5 Core T1C14

Core T1C14 was located in a palaeochannel located on terrace 2, although the palaeochannel was suspected to date to the early Holocene in the original chronostratigraphic model produced in Phase 1 (Fig. 6.1). Core T1C14 is relatively short at 90cm, with a dark red brown AP horizon between 0 – 5cm. Below this is a dark red brown silty clay with a trace of sand between 5 – 28cm. A red brown silty clay unit is located between 28 – 54cm, with a basal blue grey clay with a trace of silt and sand, and Fe and Mn mottling between 54 – 90cm. The organic content is low throughout the core. The upper two units (0 – 5cm and 5 – 28cm) both show relatively elevated organic and magnetic susceptibility contents (Fig. 6.10).

 Pollen was sampled at 14cm intervals along the core length, starting at 14cm. The date from the base of the core at 90cm is 3005BP +/-35, with a date at 45cm of 1309BP +/-28. This basal date confirms a Holocene age for the channel abandonment (Fig. 6.11).

6.1.6 Core TFGC14

This core was located on an area of terrace 1, where there was no visible expression of a palaeochannel within the field (Fig. 6.1). The most striking feature of this core is its depth, with a recovered sampled to 385cm (the core stratigraphy is actually slightly longer, but there was incomplete recovery from the base of core). This core length is much greater than the cores retrieved from other palaeochannels within the study area.

The stratigraphy shows a 0 – 27cm A horizon of dark brown silt, underlain by a red brown clay with a trace of sand and occasional small clasts between 27 – 132cm. At 132 – 164cm is a grey clay with visible organic flecks and Fe mottling. Below this between 164 – 227cm is a blue grey clay with a trace of sand and visible organic matter. At 227 – 234cm is a grey clayey medium sand, underlain by olive brown peaty clay, with a trace of sand and silt, at 234 – 305cm. This unit had abundant organic material contained within its matrix and a charcoal fragment at 262cm. Below this at 305 – 318cm is an olive brown clayey sand. Below this the olive brown peaty clay unit is again evident at 318 – 319cm. At 349 – 362cm is a olive grey clayey medium sand and the basal unit is an olive brown/grey clayey medium sand (Fig. 6.12).

The organic content of the core shows a marked increase in the peaty clay unit 234 – 305cm, which confirms the field observations of the abundant organic matter within the matrix. The olive brown peaty clay at 318 – 319cm shows elevated organic values, although they are not as high as the organic values for the 234 – 305cm unit. The carbonate contents and magnetic susceptibility contents do not appear to relate to the stratigraphy in a systematic way.

The stratigraphy of this palaeochannel is interesting on two counts. First the depth of the core is much greater than other palaeochannels seen in the study area. Secondly, there are three sand units within the stratigraphy (349 – 362cm, 305 – 318cm and 227 – 234cm) interspersed with clay-dominated units. This stratigraphy suggests a

sequential process of channel re-occupation and abandonment, with 3 phases of abandonment, each represented by a clay unit above a sand unit.

This can be summarised as:

Phase 1: Unit 349 – 362cm represents channel occupation.
Phase 1: Unit 318 – 349cm represents channel abandonment.

Phase 2: Unit 305 – 318cm represents channel occupation.
Phase 2: Unit 3234 – 305cm represents channel abandonment.

Phase 3: Unit 227 – 234cm represents channel occupation.
Phase 3: Units from 164cm upwards represent channel abandonment.

Due to this palaeochannel being discovered at a relatively late phase of fieldwork, after the pollen assessment from the other palaeochannels had begun, a limited pollen evaluation was conducted with sampling starting at 266cm, and then every 14cm until 378cm (Fig 6.13).

The radiocarbon dates produce an excellent sequence for the lower portion of this core, with the following dates:

250cm 3300BP +/-40
300cm 3410BP +/-60
300cm 3880BP +/-35
380cm 4725bp +/-40

From these dates the phase 1 channel occupation can be shown to have occurred at 4725BP +/-40, and the phase 2 channel abandonment to just before 3410BP +/-60.

6.1.7 WQFC1

A series of three tins were taken from an exposed section in Warren Farm quarry (Fig. 6.1). The stratigraphy reveals an upper unit of light grey clay, with a trace of sand, Fe nodules and visible plant remains between 0 – 42cm. Underneath this unit at 42 – 69cm is dark grey with a trace of sand and silt, underlain by a dark grey/black clay unit between 69cm and 72cm. Below this is a dark grey clay unit with visible plant macrofossils at 72 – 117cm, with the lowest unit of dark grey clay with small clasts at 117cm. The organic content shows a spike in the dark grey unit between 69 – 72cm and generally elevated levels in the units between 42 – 69cm and 72 – 117cm (Fig. 6.14).

Pollen was sampled at 14cm intervals, starting at 14cm. Three samples were dated using radiocarbon. The first of these is a humic acid date at 75cm, which pre-dates the two dates below this at 2989BP +/-28. Both dates below this are from monocotyledon fragments and produce dates of 2580BP +/-35 at 95cm, and 2730BP +/-160 at 118cm. These two bottom dates shows some internal consistency (Fig. 6.15).

6.1.8 WQFC2

A series of three tins were taken from an exposed section in Warren Farm quarry (Fig 6.16). The stratigraphy reveals an upper grey brown clay between 0 – 47cm. Beneath this is a thin lense of red brown clay with small clasts <2cm at 47 – 50cm, underlain by grey clay with a trace of sand between 50 – 69cm. Underneath this is a dark grey/black silty clay with a trace of sand at 69 – 97cm, with a dark grey silty clay with abundant organic matter at 97 – 119cm. The lowest unit sampled is a dark grey silty clay with small clasts between 119 – 124cm. The organic content is relatively low in the units 0 – 47cm, 47 – 50 cm and 50 – 69cm. High organic contents are seen in the units at 69 – 97cm, 97 – 199cm, both of which are dark grey silty clays. The organic content decreases in the lowest unit at 119 – 124cm.

Pollen was sampled at 14cm intervals, starting at 14cm, in each of the three tins, so there is some uneven spacing of samples in the bottom tins M2 and M3, as the tins overlapped. Two samples were radiocarbon dated, giving a base date on tin M2 of 2500BP +/-35 and a base date on tin M3 of 2820BP +/-35 (Fig. 6.17), dates that agree with their relative stratigraphic order.

6.1.9 WQFC3

One tin sample was taken from this exposed palaeochannel at Warren Farm quarry (Fig. 6.1). The stratigraphy is relatively simple with a upper grey clay, with a trace of sand and Fe nodules between 0 – 31cm, a middle unit of dark grey silty clay, with some fine laminations at 31 – 46cm and a lower unit of grey brown clayey sand, with small clasts between 46 – 50cm. The organic content, carbonate content and magnetic susceptibility all display a rise in the dark grey/black silty clay unit between 31 – 46cm (Fig. 6.18). Two dates were produced at 50cm at the base of the tin. The first using the humic acid fraction, producing a date of 4078BP +/- 30, whilst the second date used monocotyledon fragments and produced a date of 3075BP +/-35. This again emphasises the difficulties of comparing humin acid dates with those from visible plant macrofossils, with humin fractions giving significantly older dates (Fig. 6.19).

6.10 WQFC5

One tin sample was taken from this exposed palaeochannel at Warren Farm quarry (Fig. 6.1). This was an extremely interesting section, as the palaeochannel WQFC5 clearly lay in a deposit just above gravels interpreted as Devensian gravels, which themselves formed a compound terrace with later Holocene gravels. The stratigraphy of the palaeochannel revealed a grey black silty clay upper unit between 0 – 21cm, with a thin black grey sand band at 21 – 22cm, possibly representing a hiatus in channel infilling and reoccupation of this channel. Below this grey black silty clay at 22 – 34cm, underlain by a grey black silty clay with small clasts and sand bands between 34 – 40cm. The lowest sampled unit is a grey black sandy clay at 40 – 50cm with small clasts. The organic content of the upper 0 – 21cm unit is elevated compared to the rest of the tin, with low values being recorded in the lower four units
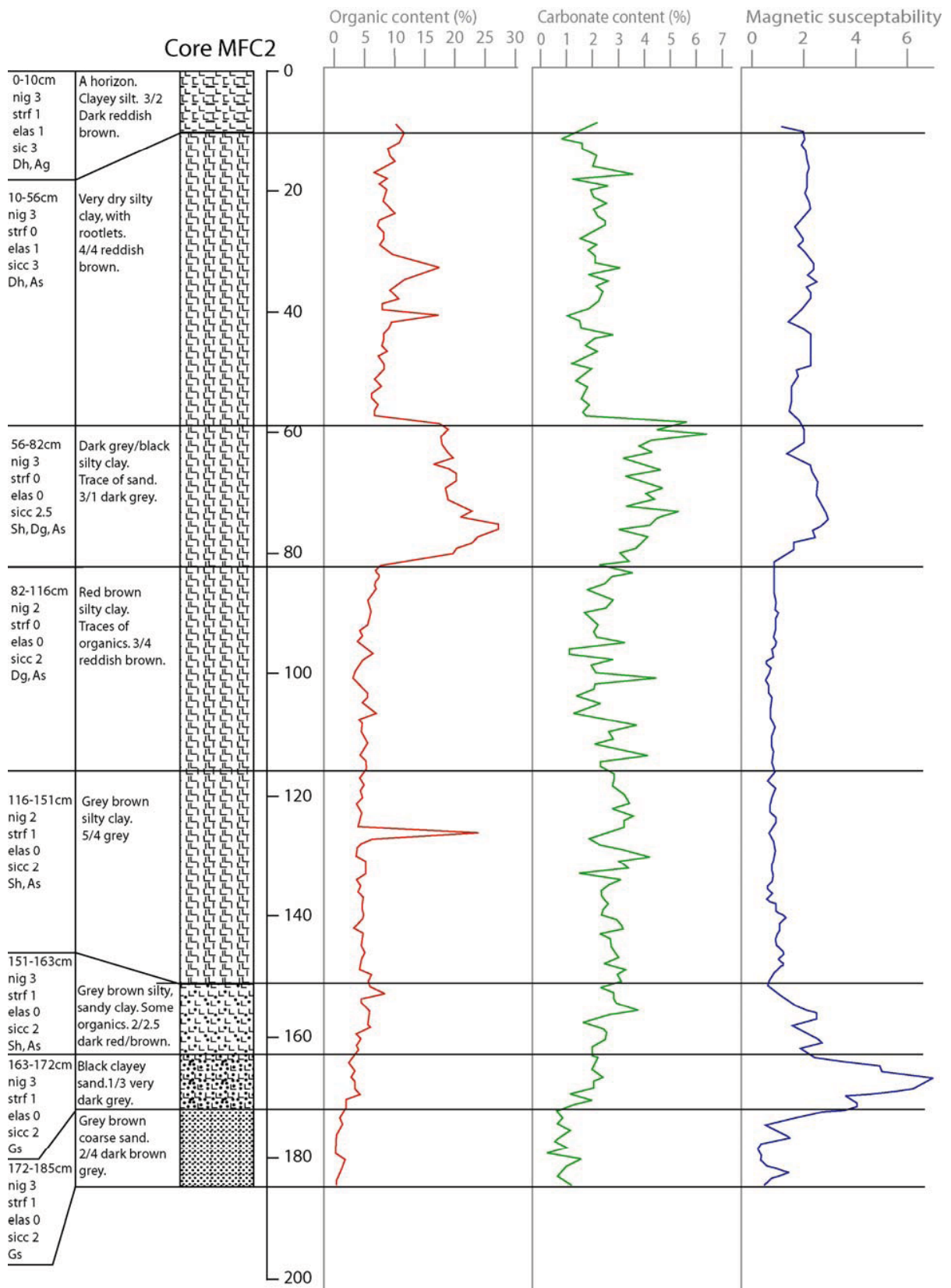
(Fig. 6.20). Pollen was again sampled at every 14cm, with sampling starting at 14cm (Fig. 6.21). Two dates from the top of the tin at 0cm revealed a date from monocotyledon fragments of 11, 505BP +/- 55 and a date from bulk sediment of 12,060BP +/-50. A bulk sediment date from 36cm produced a date of 13, 870BP +/- 60.

6.11 Comparison of palaeoenvironmental samples organic contents

In order to produce an initial assessment of the palaeochannels, a bar chart was produced to show their average organic content (Fig. 6.22). Whilst this clearly represents a clear oversimplification of palaeoenvironmental potential and effectively ignores changes in stratigraphy, sediment accumulation rates and taphonomic processes, it does provide a useful means of comparison. The graph clearly shows that the palaeochannel samples from Warren Farm Quarry display elevated organic levels, with WQFC2, having the highest mean value. This is clearly a product of selective sampling of the palaeochannel fills within the quarry. Not surprisingly WQFC5 has the lowest value for the WQF series samples, a product of its early age. From the cores retrieved by gouge from the rest of the study area T1C7 and T1C12 stand out as having high mean organic contents. Both MFC2 and TFGC14 show intermediate organic content, with T1C10 and T1C14 having the lowest mean organic contents.
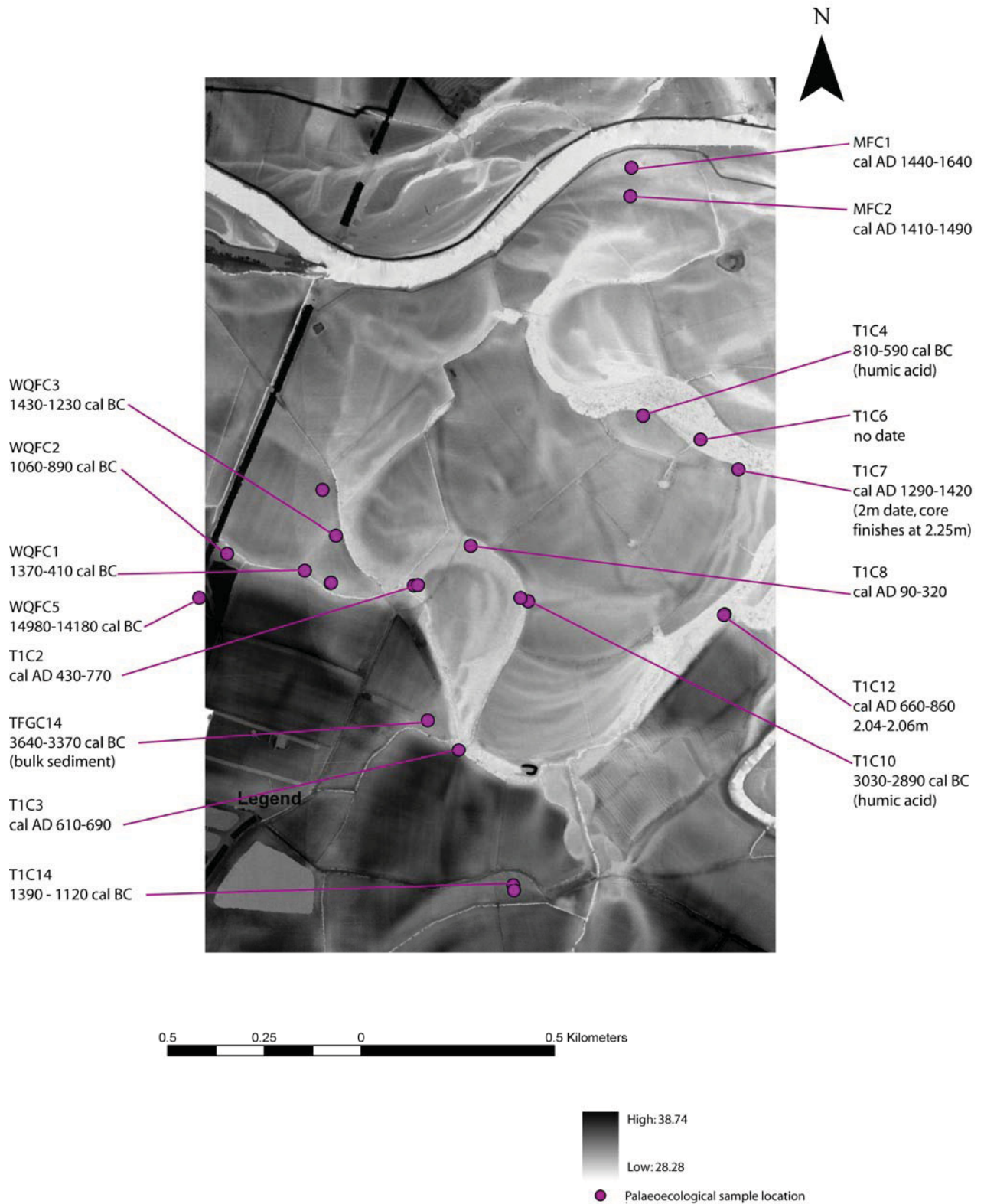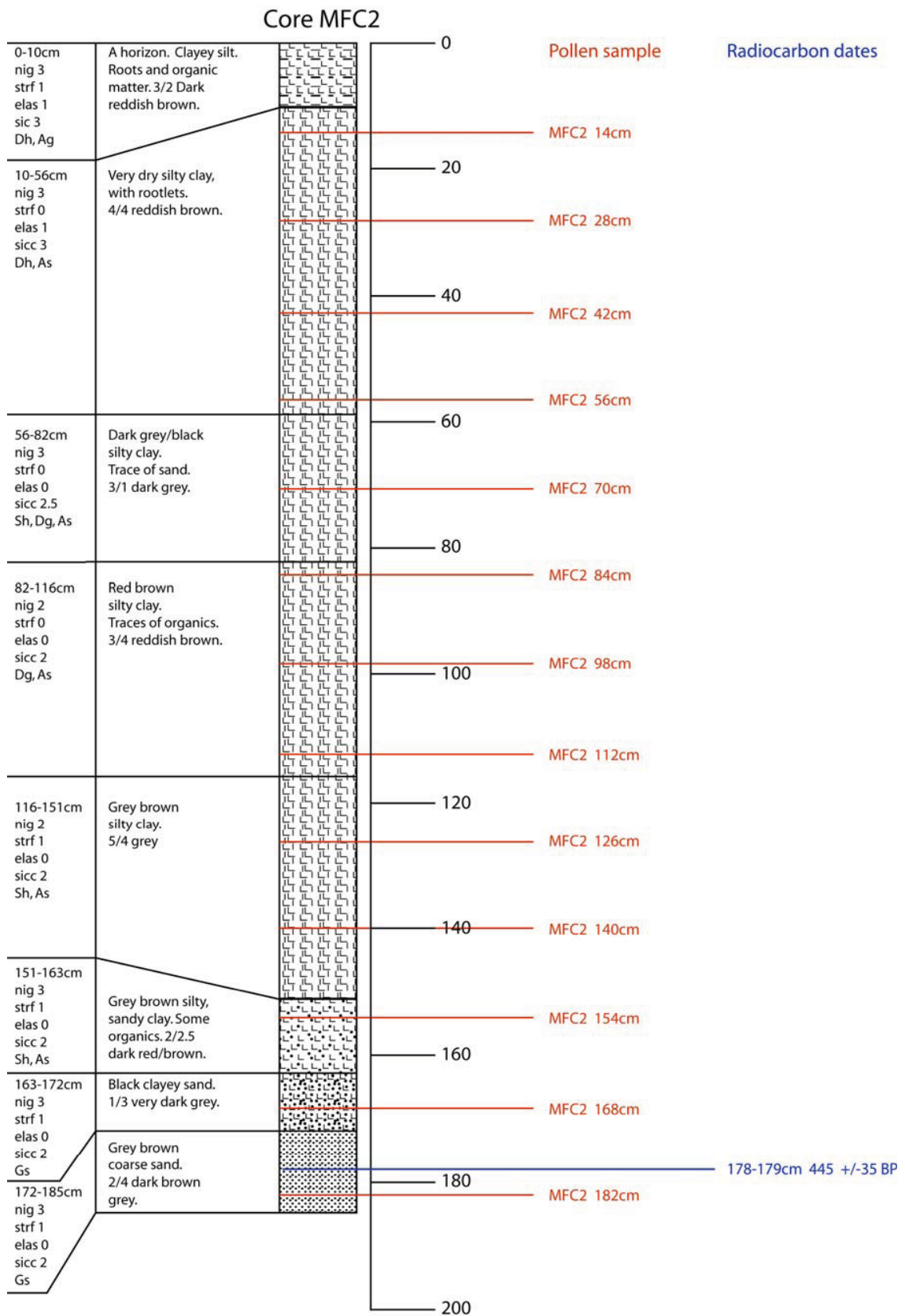
Fig 6.1: The location of the palaeoenvironmental samples and their basal dates ascertained through radiocarbon dating.
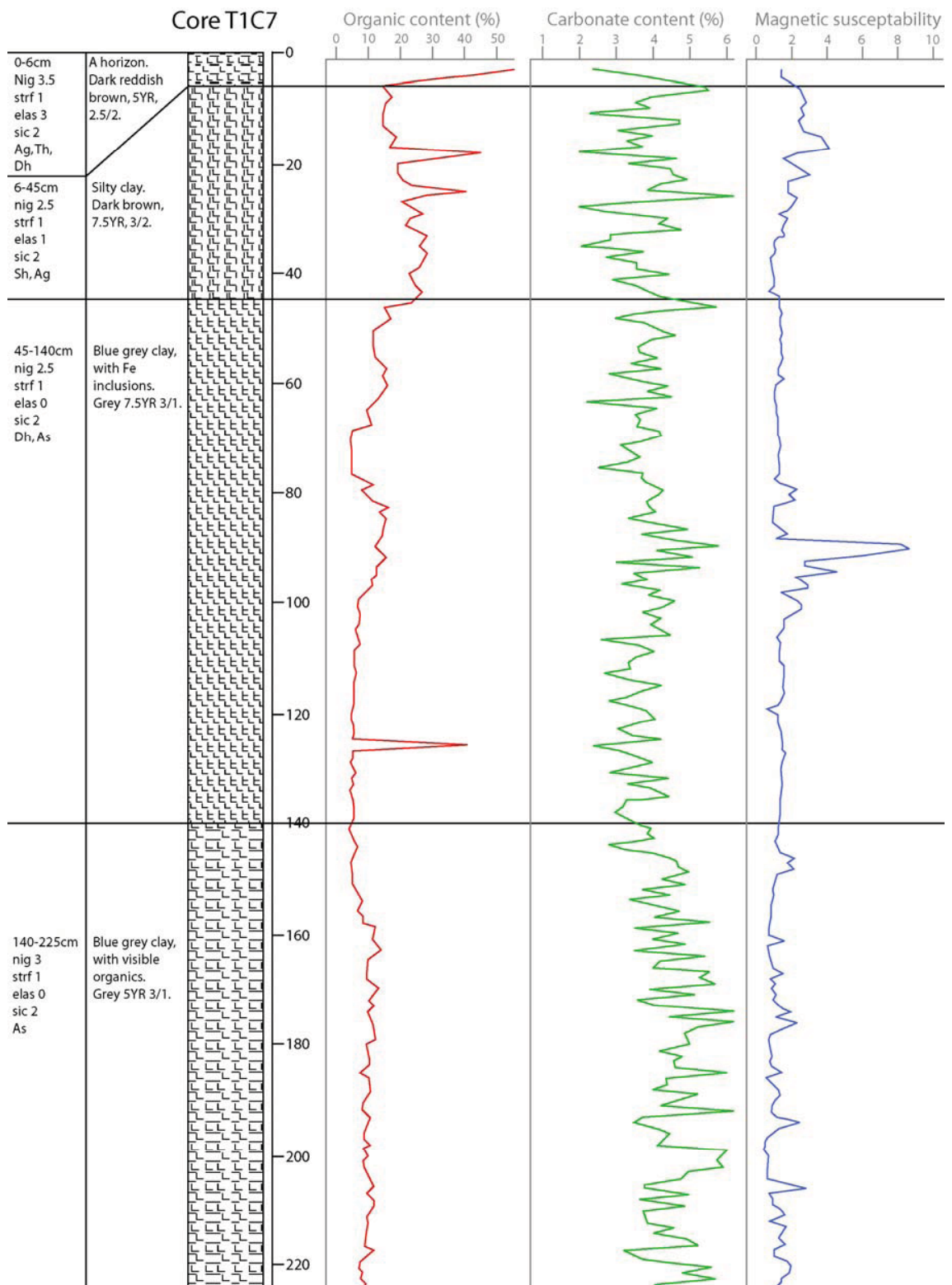
Fig 6.2: Core MFC2 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.
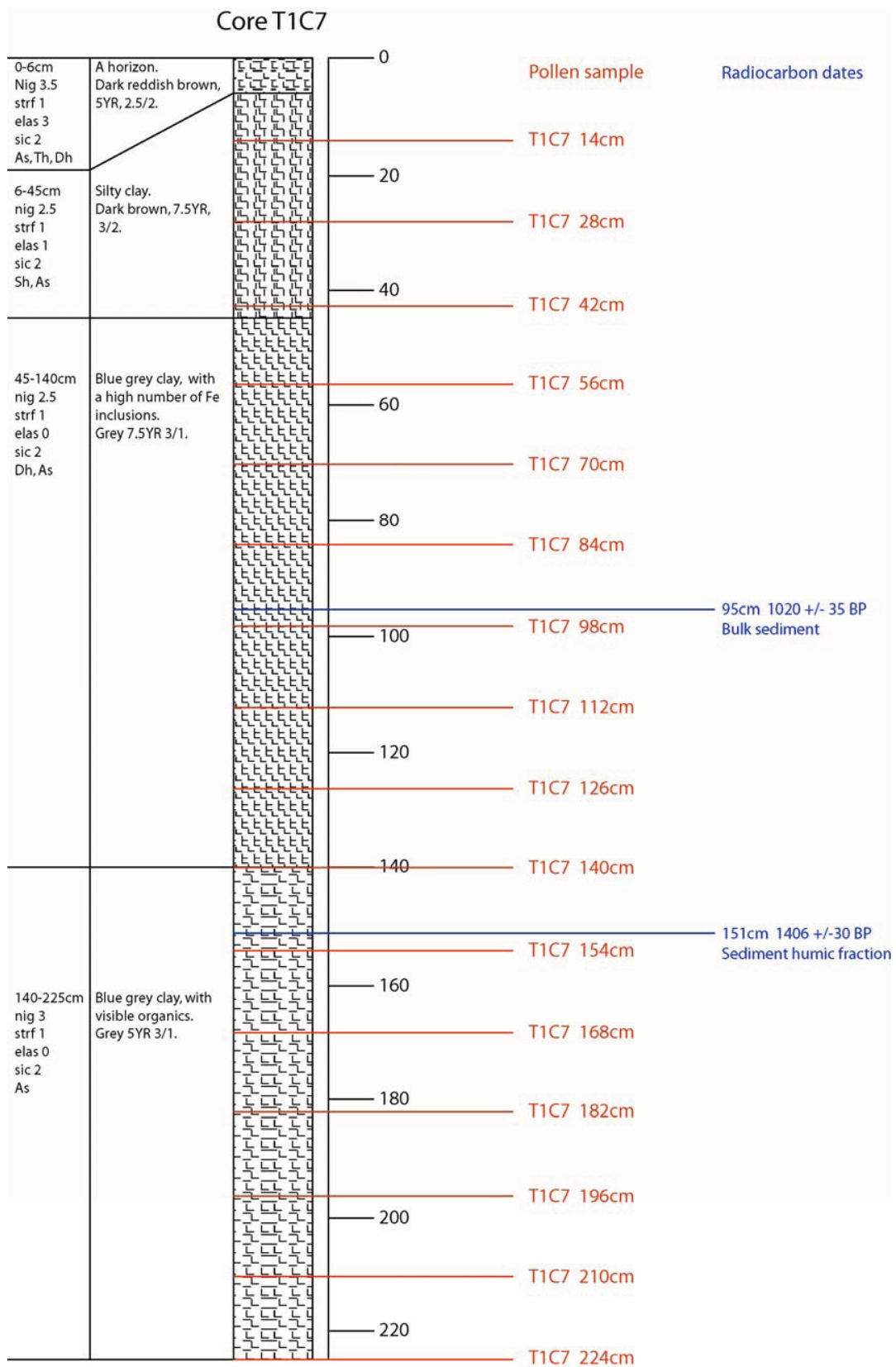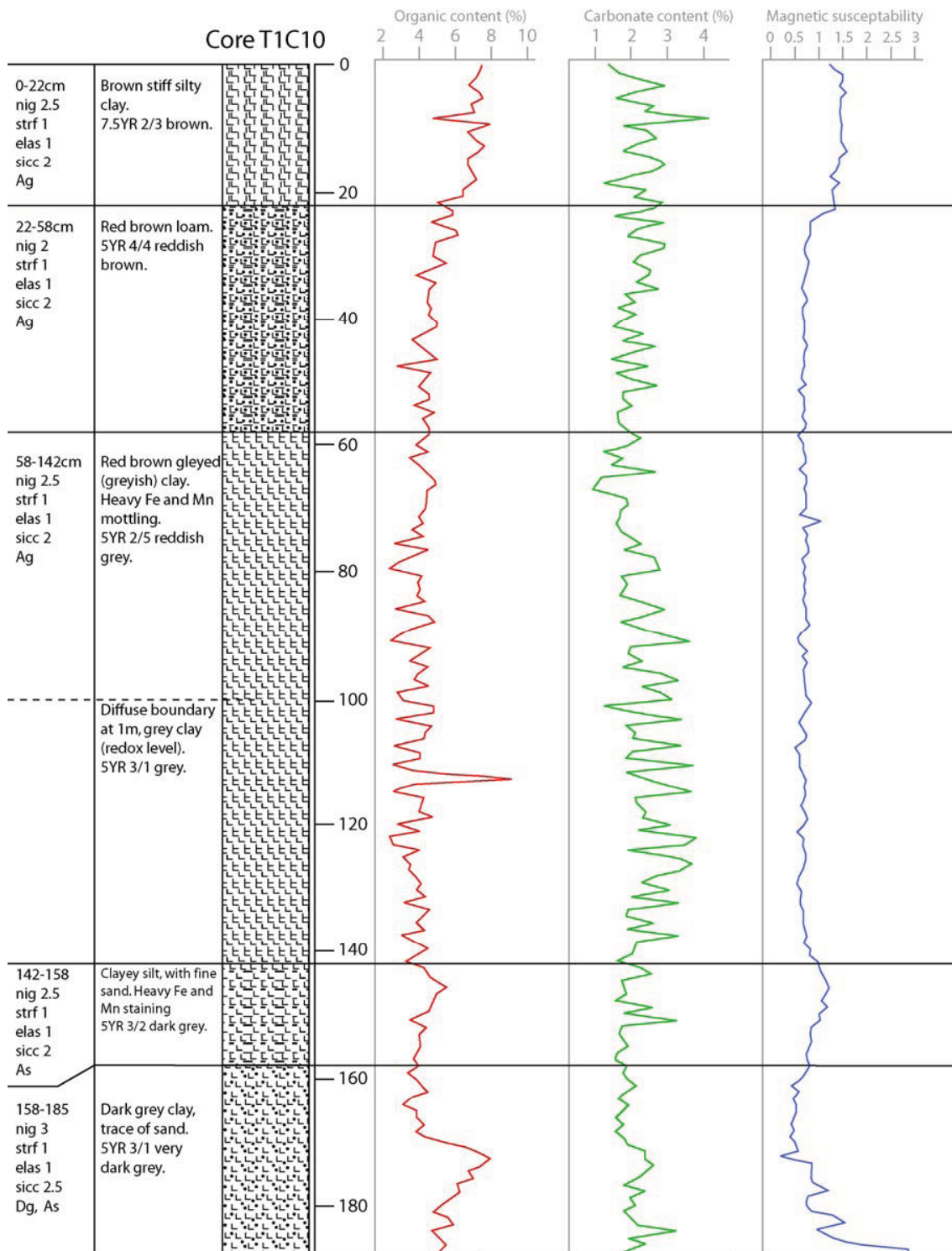
Core MFC2

Depth / Description		
0-10cm nig 3 strf 1 elas 1 sic 3 Dh, Ag	A horizon. Clayey silt. Roots and organic matter. 3/2 Dark reddish brown.	
10-56cm nig 3 strf 0 elas 1 sicc 3 Dh, As	Very dry silty clay, with rootlets. 4/4 reddish brown.	
56-82cm nig 3 strf 0 elas 0 sicc 2.5 Sh, Dg, As	Dark grey/black silty clay. Trace of sand. 3/1 dark grey.	
82-116cm nig 2 strf 0 elas 0 sicc 2 Dg, As	Red brown silty clay. Traces of organics. 3/4 reddish brown.	
116-151cm nig 2 strf 1 elas 0 sicc 2 Sh, As	Grey brown silty clay. 5/4 grey	
151-163cm nig 3 strf 1 elas 0 sicc 2 Sh, As	Grey brown silty, sandy clay. Some organics. 2/2.5 dark red/brown.	
163-172cm nig 3 strf 1 elas 0 sicc 2 Gs	Black clayey sand. 1/3 very dark grey.	
172-185cm nig 3 strf 1 elas 0 sicc 2 Gs	Grey brown coarse sand. 2/4 dark brown grey.	

Pollen sample

Radiocarbon dates

MFC2 14cm

MFC2 28cm

MFC2 42cm

MFC2 56cm

MFC2 70cm

MFC2 84cm

MFC2 98cm

MFC2 112cm

MFC2 126cm

MFC2 140cm

MFC2 154cm

MFC2 168cm

178-179cm 445 +/-35 BP

MFC2 182cm

Fig 6.3: Core MFC2 stratigraphy with pollen sample points and radiocarbon dates.

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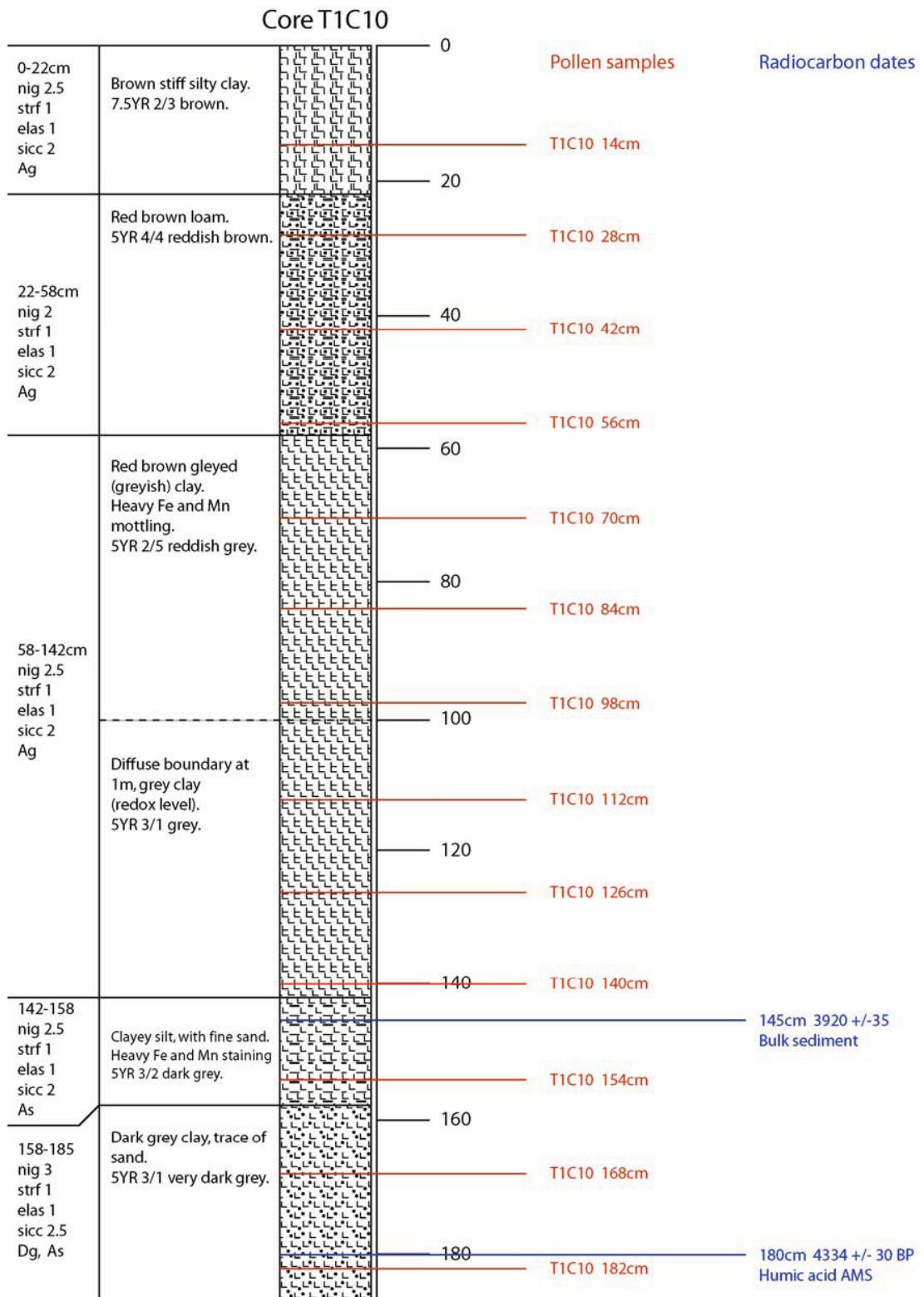
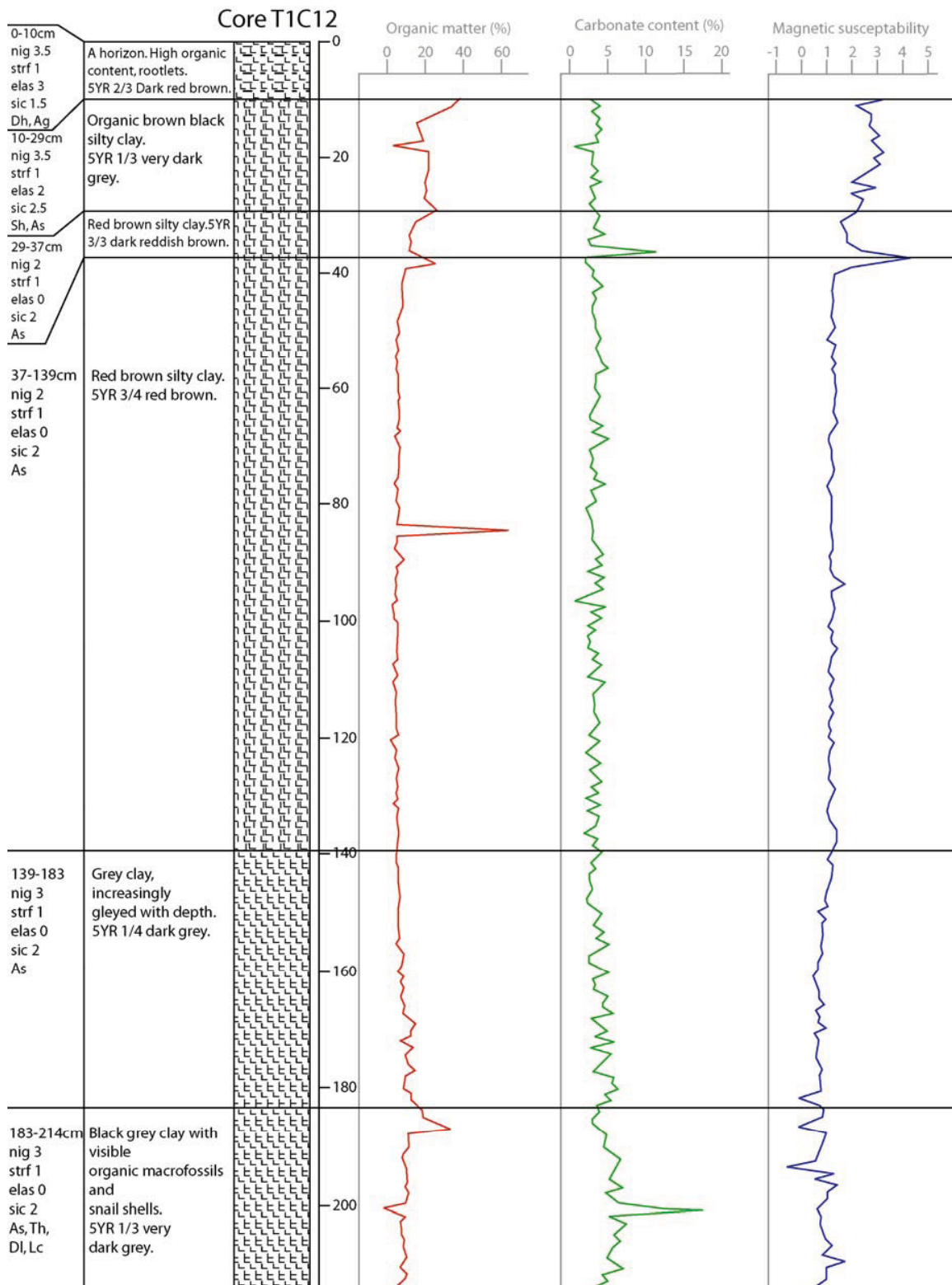**Fig 6.4:** Core T1C7 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.

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Core T1C7

0-6cm Nig 3.5 strf 1 elas 3 sic 2 As, Th, Dh	A horizon. Dark reddish brown, 5YR, 2.5/2.		
6-45cm nig 2.5 strf 1 elas 1 sic 2 Sh, As	Silty clay. Dark brown, 7.5YR, 3/2.		
45-140cm nig 2.5 strf 1 elas 0 sic 2 Dh, As	Blue grey clay, with a high number of Fe inclusions. Grey 7.5YR 3/1.		
140-225cm nig 3 strf 1 elas 0 sic 2 As	Blue grey clay, with visible organics. Grey 5YR 3/1.		

Pollen sample   Radiocarbon dates

- 0
- T1C7 14cm
- 20
- T1C7 28cm
- 40
- T1C7 42cm
- T1C7 56cm
- 60
- T1C7 70cm
- 80
- T1C7 84cm
- 95cm 1020 +/- 35 BP Bulk sediment
- T1C7 98cm
- 100
- T1C7 112cm
- 120
- T1C7 126cm
- 140
- T1C7 140cm
- 151cm 1406 +/-30 BP Sediment humic fraction
- T1C7 154cm
- 160
- T1C7 168cm
- 180
- T1C7 182cm
- T1C7 196cm
- 200
- T1C7 210cm
- 220
- T1C7 224cm

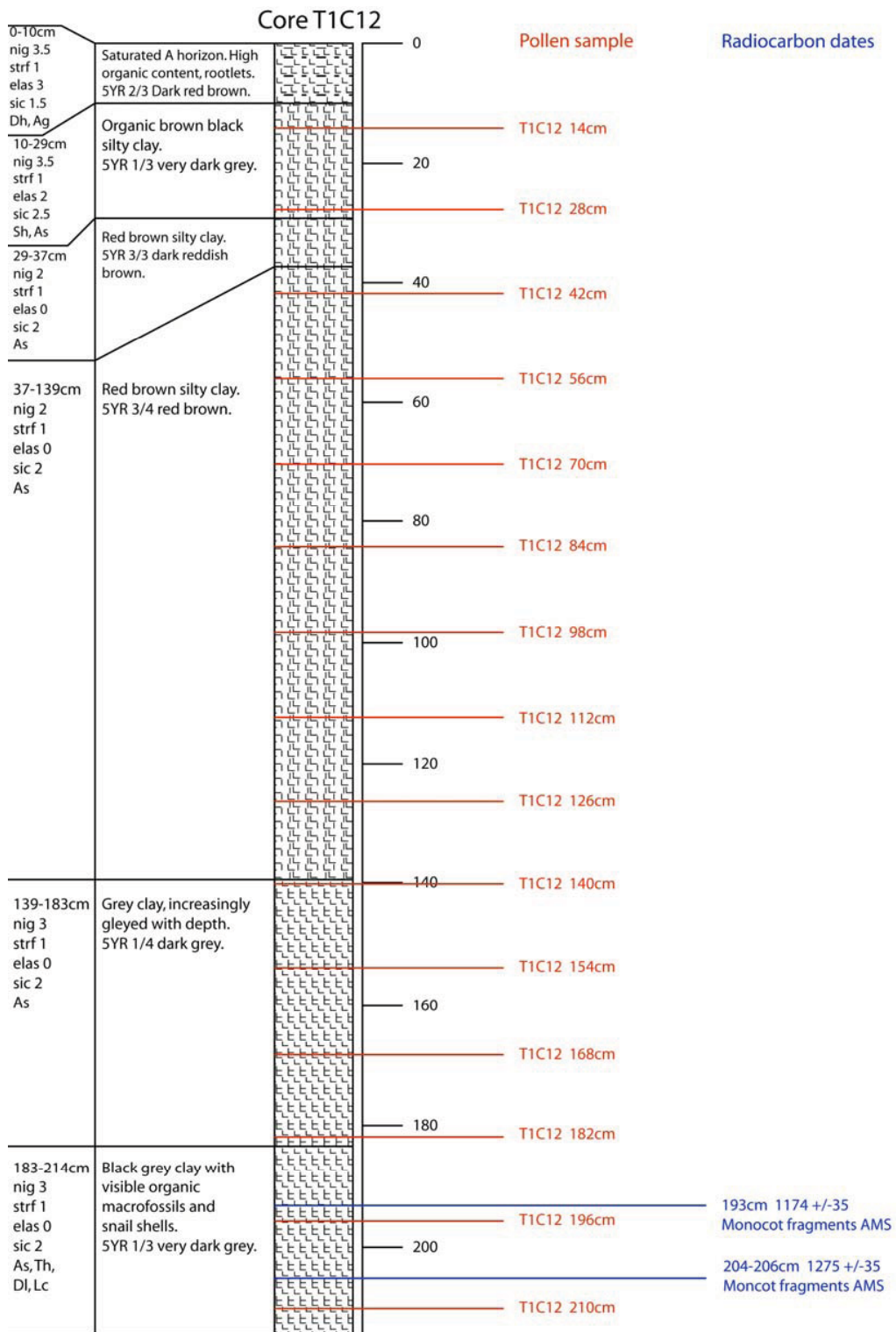**Fig 6.5:** Core T1C7 stratigraphy with pollen sample points and radiocarbon dates.

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Fig 6.6: Core T1C10 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.
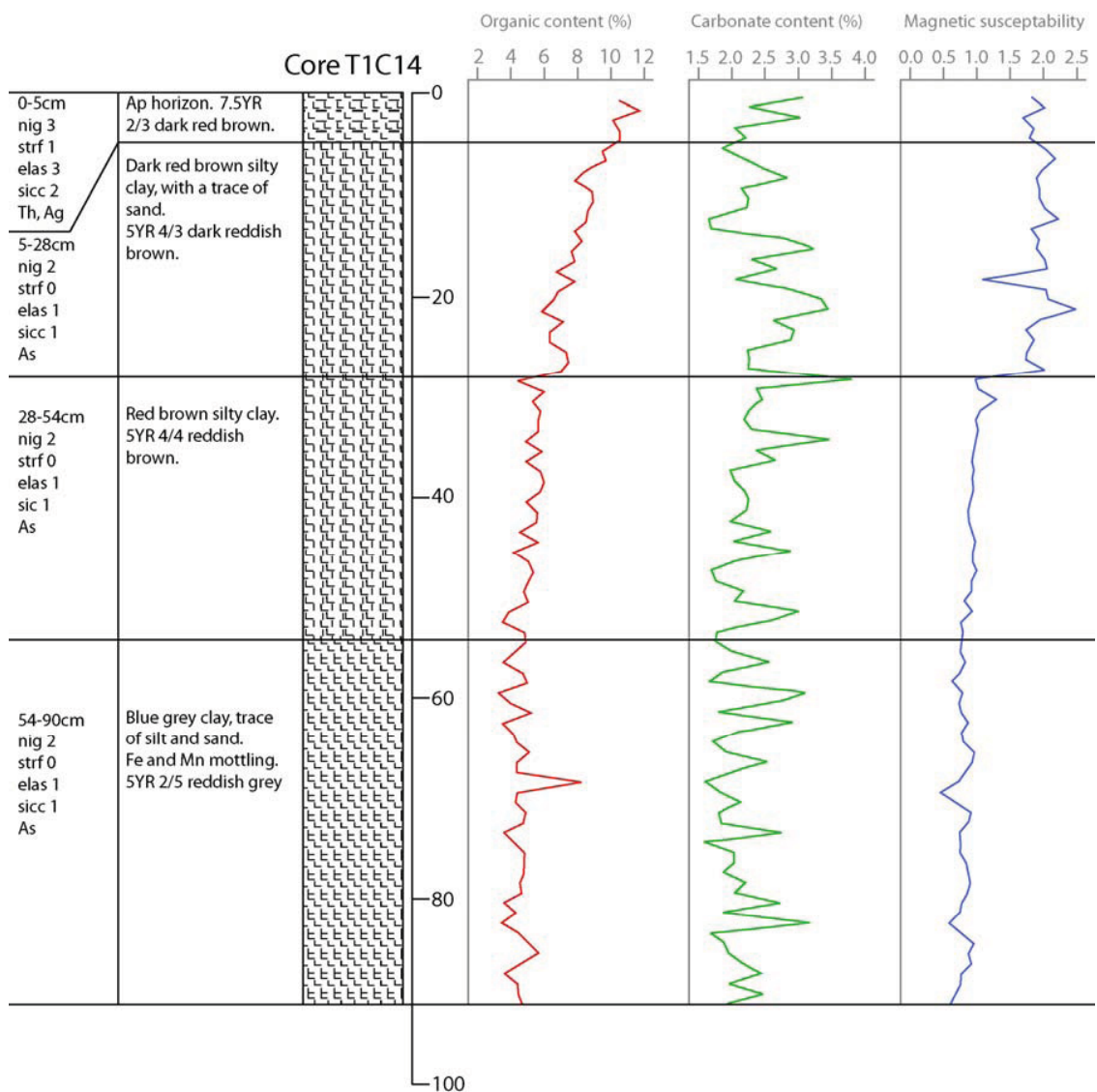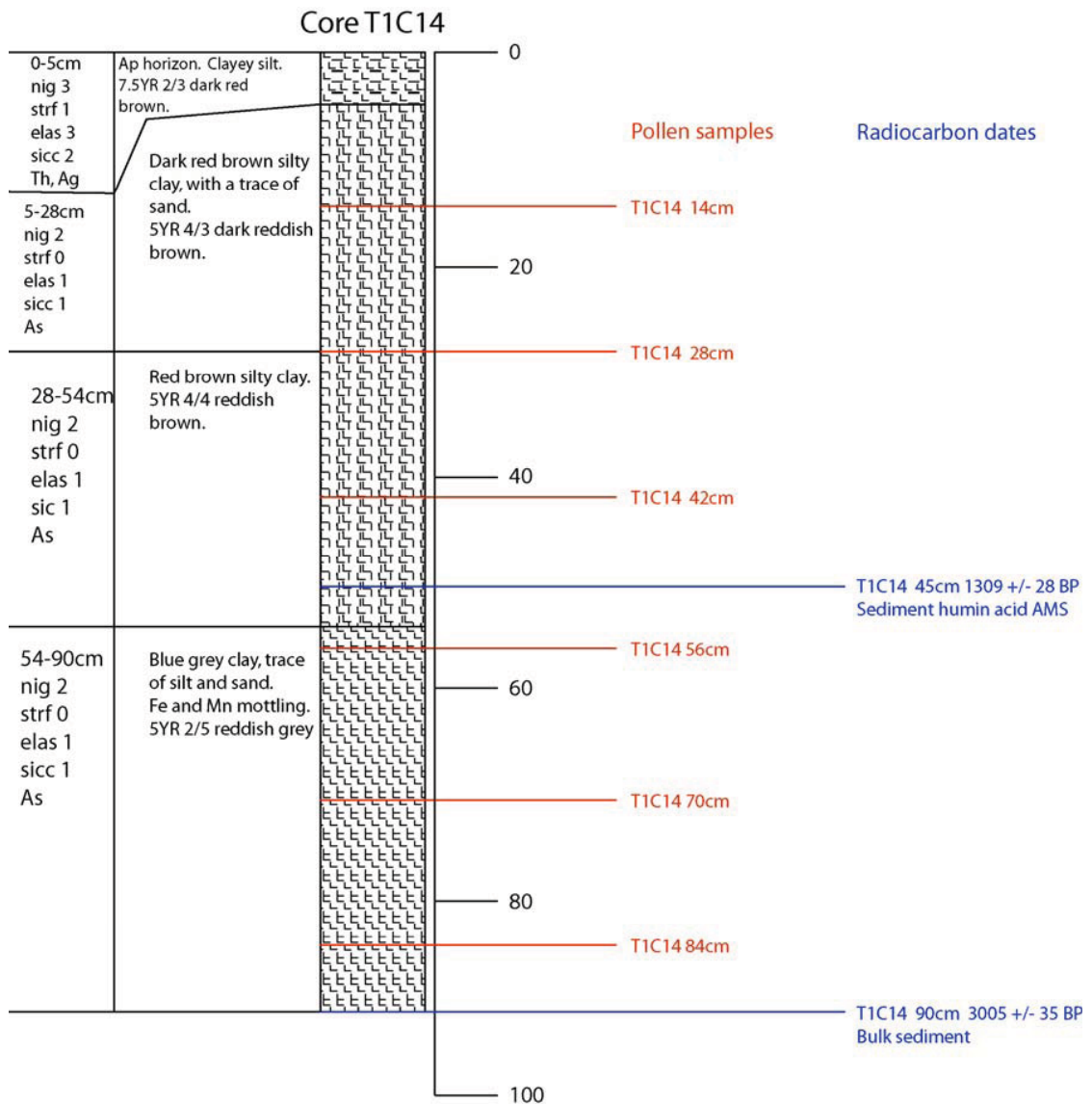
Fig 6.7: Core T1C10 stratigraphy with pollen sample points and radiocarbon dates.

Fig 6.8: Core T1C12 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.

Fig 6.9: Core T1C12 stratigraphy with pollen sample points and radiocarbon dates.
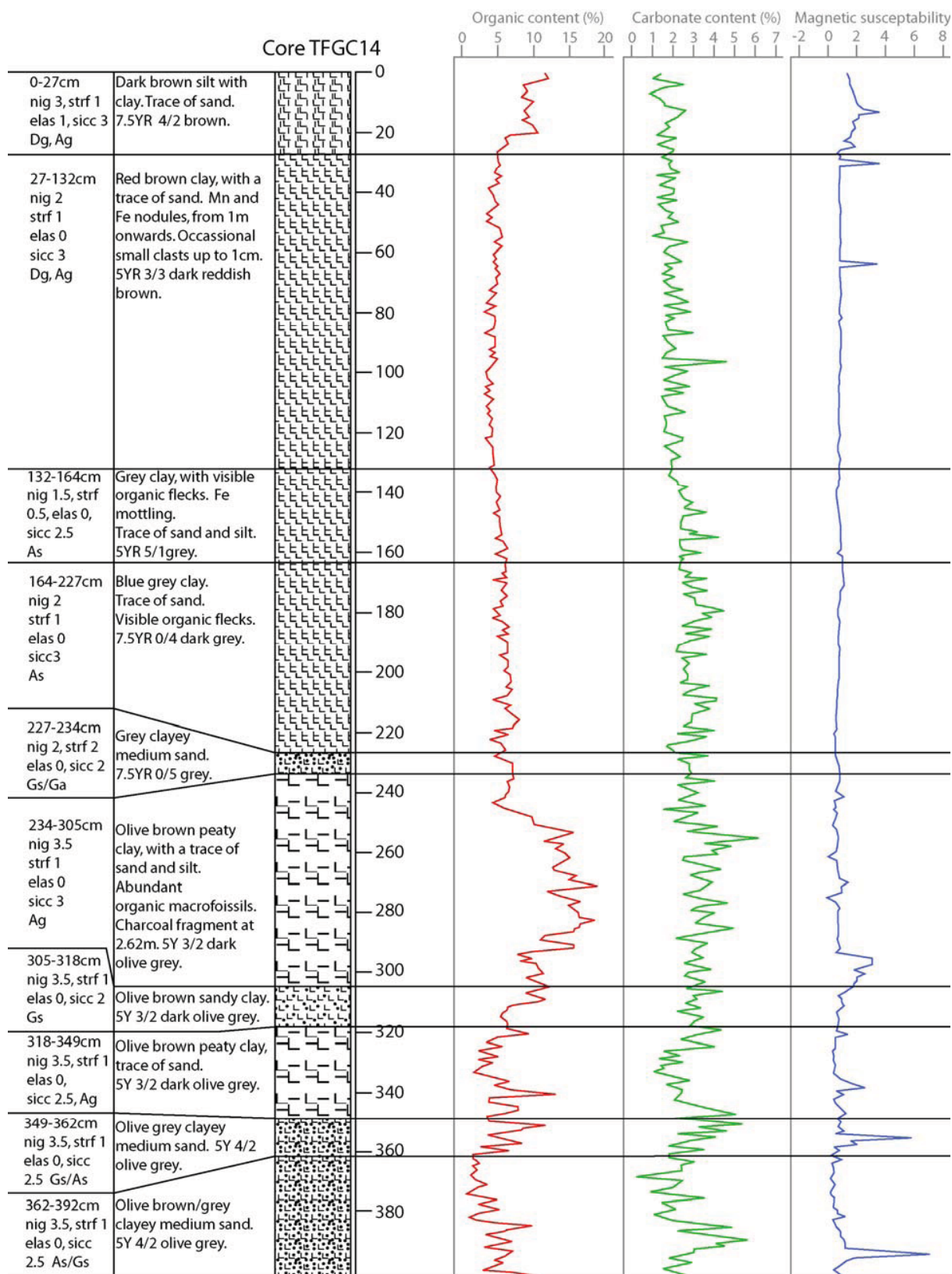
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Fig 6.10: Core T1C14 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.
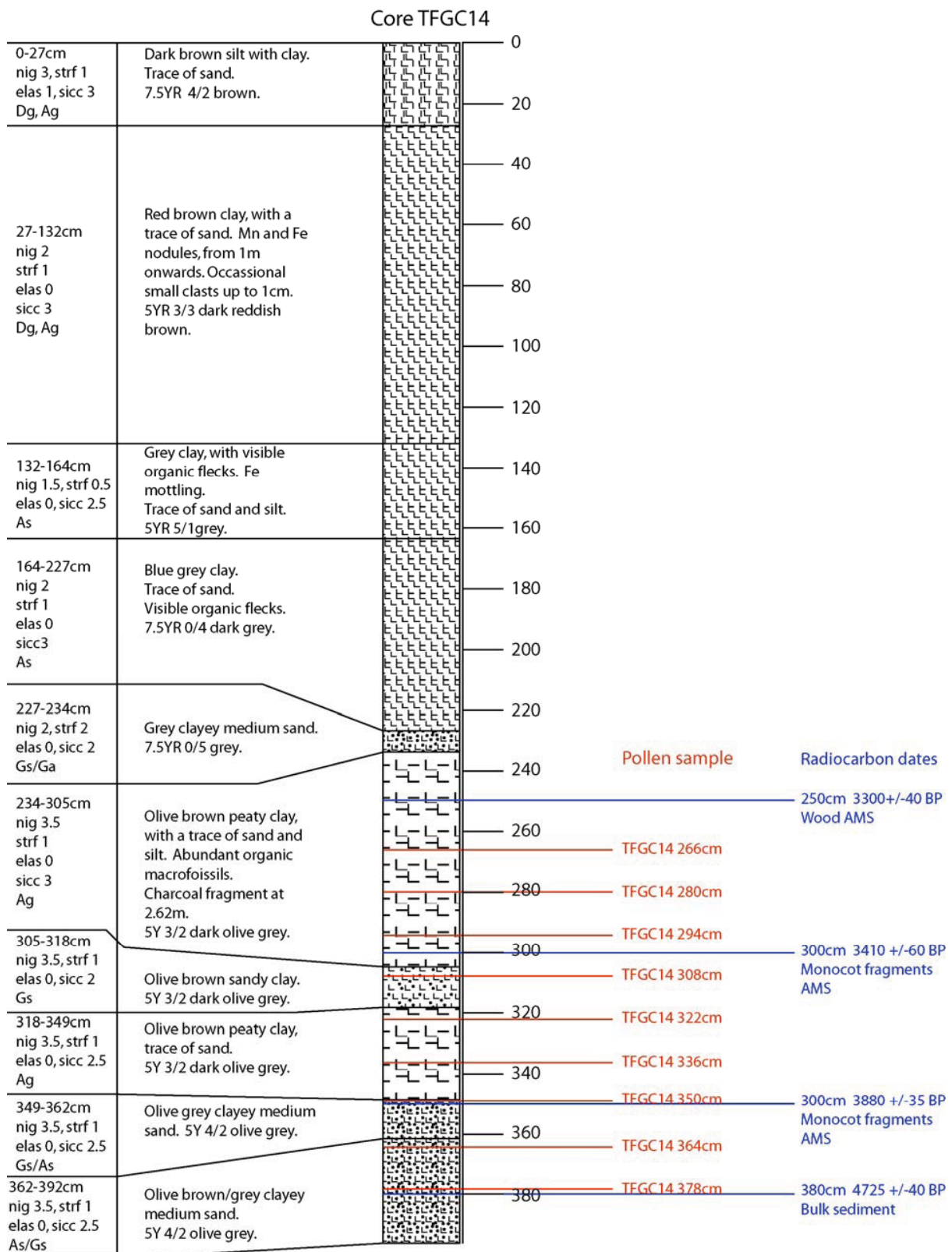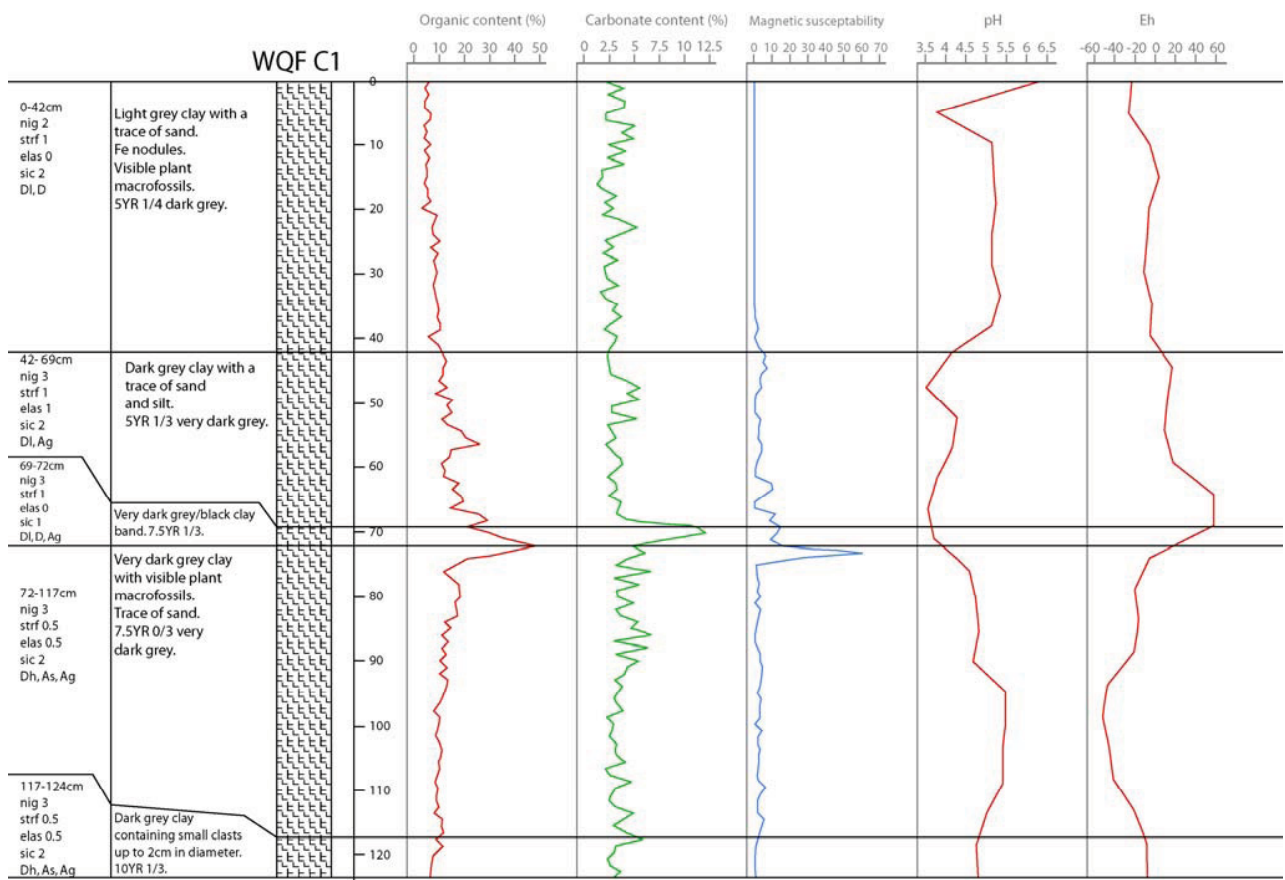
Fig 6.11: Core T1C14 stratigraphy with pollen sample points and radiocarbon dates.

0-27cm nig 3, strf 1 elas 1, sicc 3 Dg, Ag	Dark brown silt with clay. Trace of sand. 7.5YR 4/2 brown.	
27-132cm nig 2 strf 1 elas 0 sicc 3 Dg, Ag	Red brown clay, with a trace of sand. Mn and Fe nodules, from 1m onwards. Occassional small clasts up to 1cm. 5YR 3/3 dark reddish brown.	
132-164cm nig 1.5, strf 0.5, elas 0, sicc 2.5 As	Grey clay, with visible organic flecks. Fe mottling. Trace of sand and silt. 5YR 5/1grey.	
164-227cm nig 2 strf 1 elas 0 sicc3 As	Blue grey clay. Trace of sand. Visible organic flecks. 7.5YR 0/4 dark grey.	
227-234cm nig 2, strf 2 elas 0, sicc 2 Gs/Ga	Grey clayey medium sand. 7.5YR 0/5 grey.	
234-305cm nig 3.5 strf 1 elas 0 sicc 3 Ag	Olive brown peaty clay, with a trace of sand and silt. Abundant organic macrofoissils. Charcoal fragment at 2.62m. 5Y 3/2 dark olive grey.	
305-318cm nig 3.5, strf 1 elas 0, sicc 2 Gs	Olive brown sandy clay. 5Y 3/2 dark olive grey.	
318-349cm nig 3.5, strf 1 elas 0, sicc 2.5, Ag	Olive brown peaty clay, trace of sand. 5Y 3/2 dark olive grey.	
349-362cm nig 3.5, strf 1 elas 0, sicc 2.5 Gs/As	Olive grey clayey medium sand. 5Y 4/2 olive grey.	
362-392cm nig 3.5, strf 1 elas 0, sicc 2.5 As/Gs	Olive brown/grey clayey medium sand. 5Y 4/2 olive grey.	

Fig 6.12: Core TFGC14 stratigraphy shown against organic content, carbonate content and magnetic susceptibility.
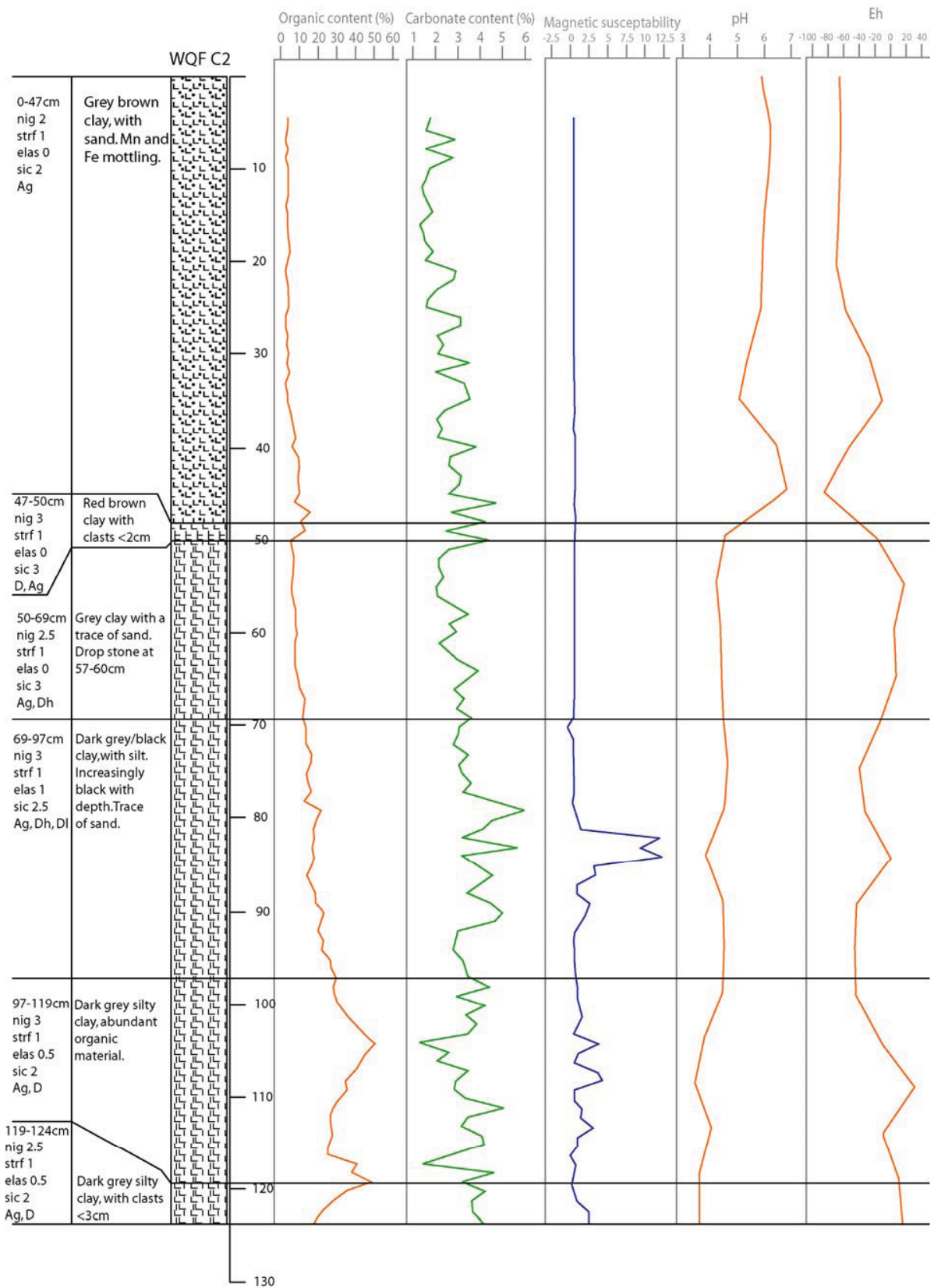
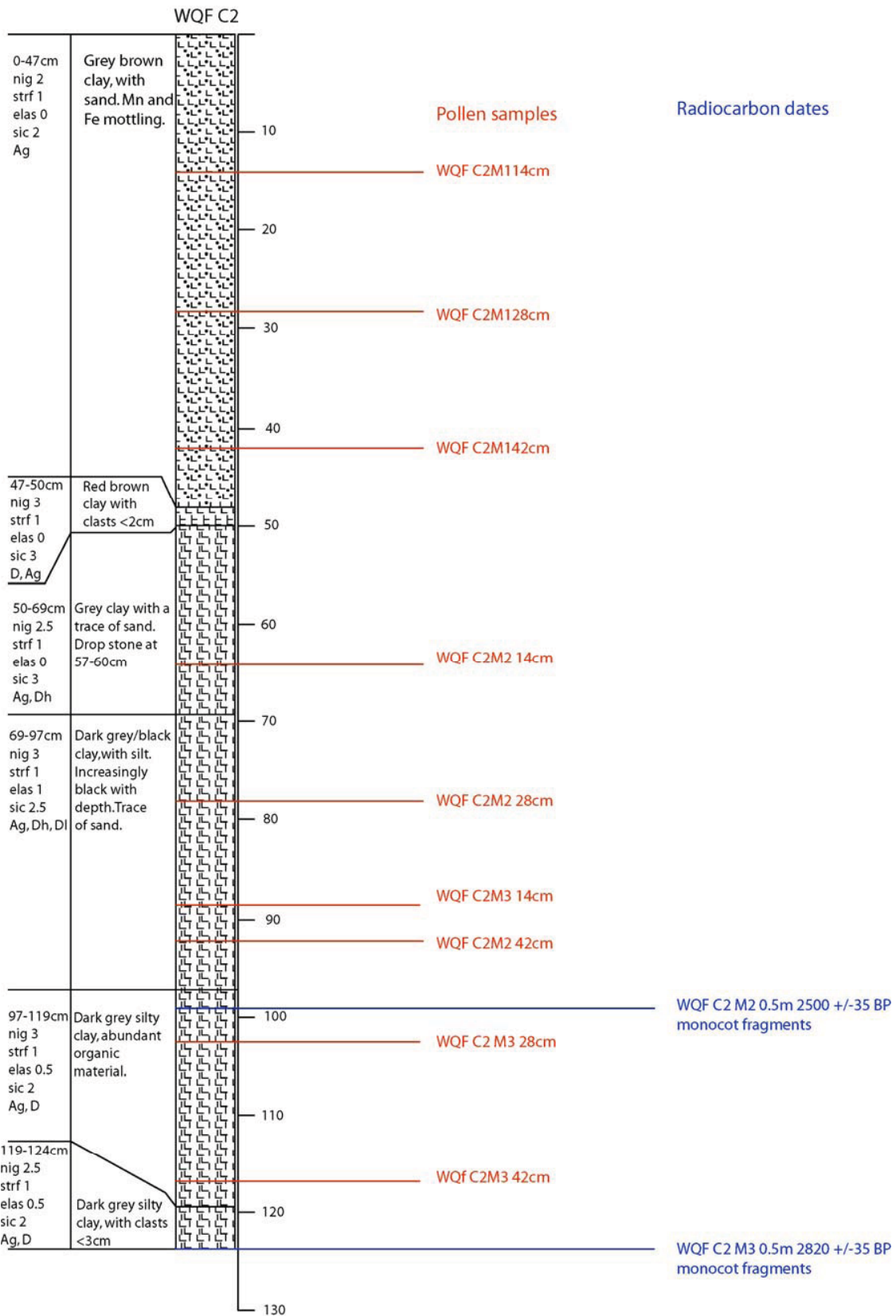**Fig 6.13:** Core TFGC14 stratigraphy with pollen sample points and radiocarbon dates.

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Fig 6.14: Core WQFC1 stratigraphy shown against organic content, carbonate content, magnetic susceptibility Eh and Ph.
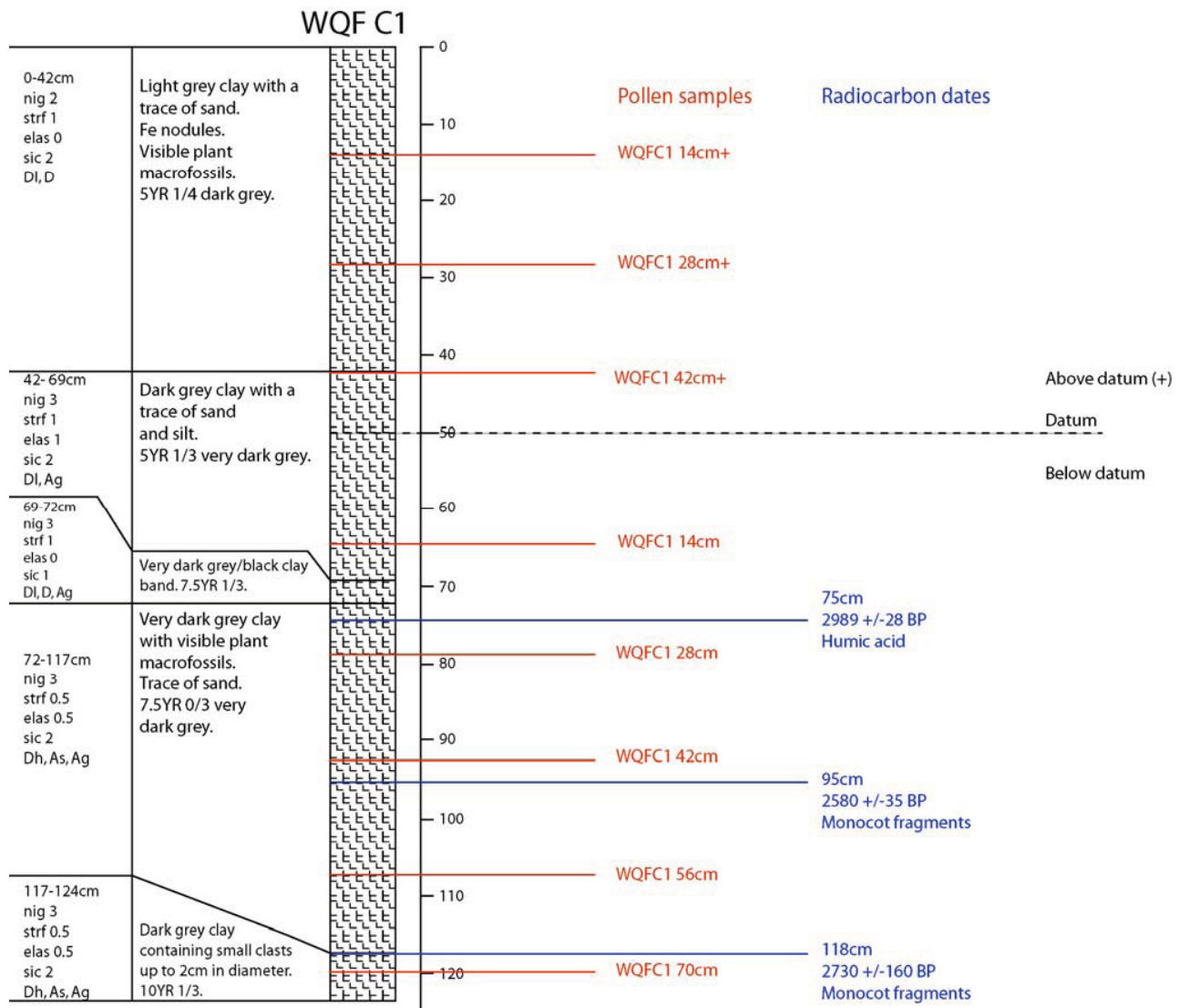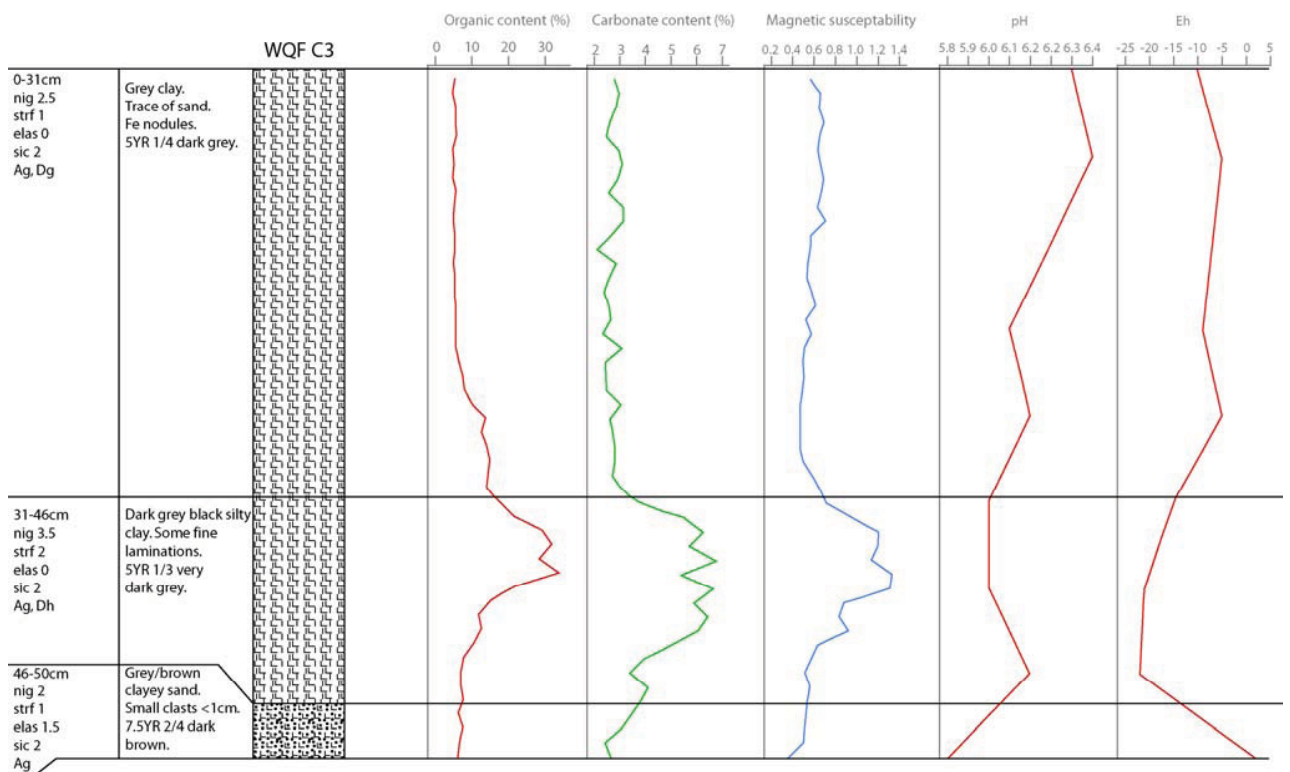
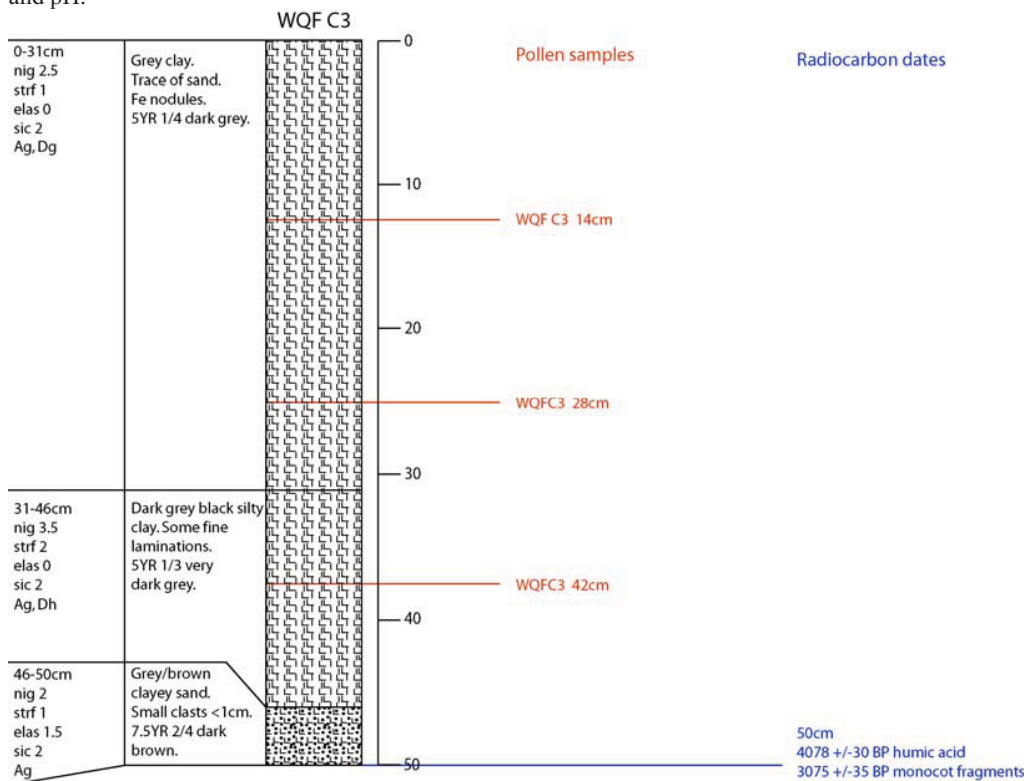**Fig 6.15:** WQFC1 stratigraphy with pollen sample points and radiocarbon dates.

Fig 6.16: WQFC2 stratigraphy shown against organic content, carbonate content, magnetic susceptibility Eh and pH.

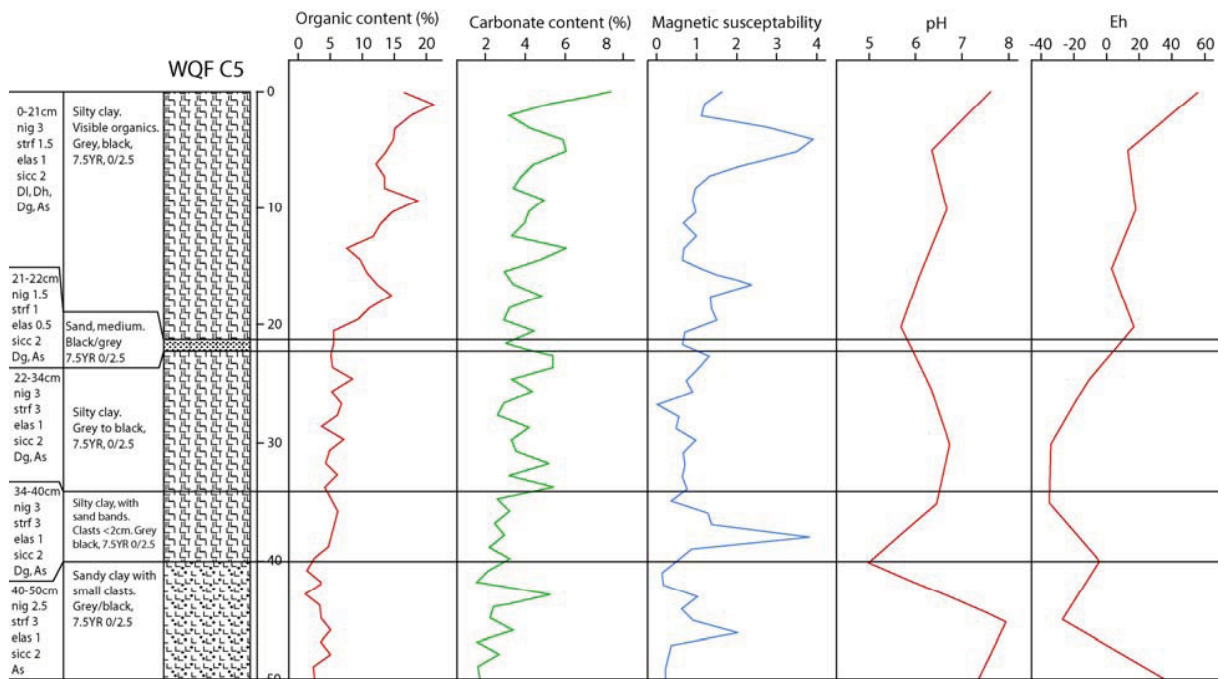**Fig 6.17:** WQFC2 stratigraphy with pollen sample points and radiocarbon dates.

Fig 6.18: WQFC3 stratigraphy shown against organic content, carbonate content, magnetic susceptibility Eh and pH.
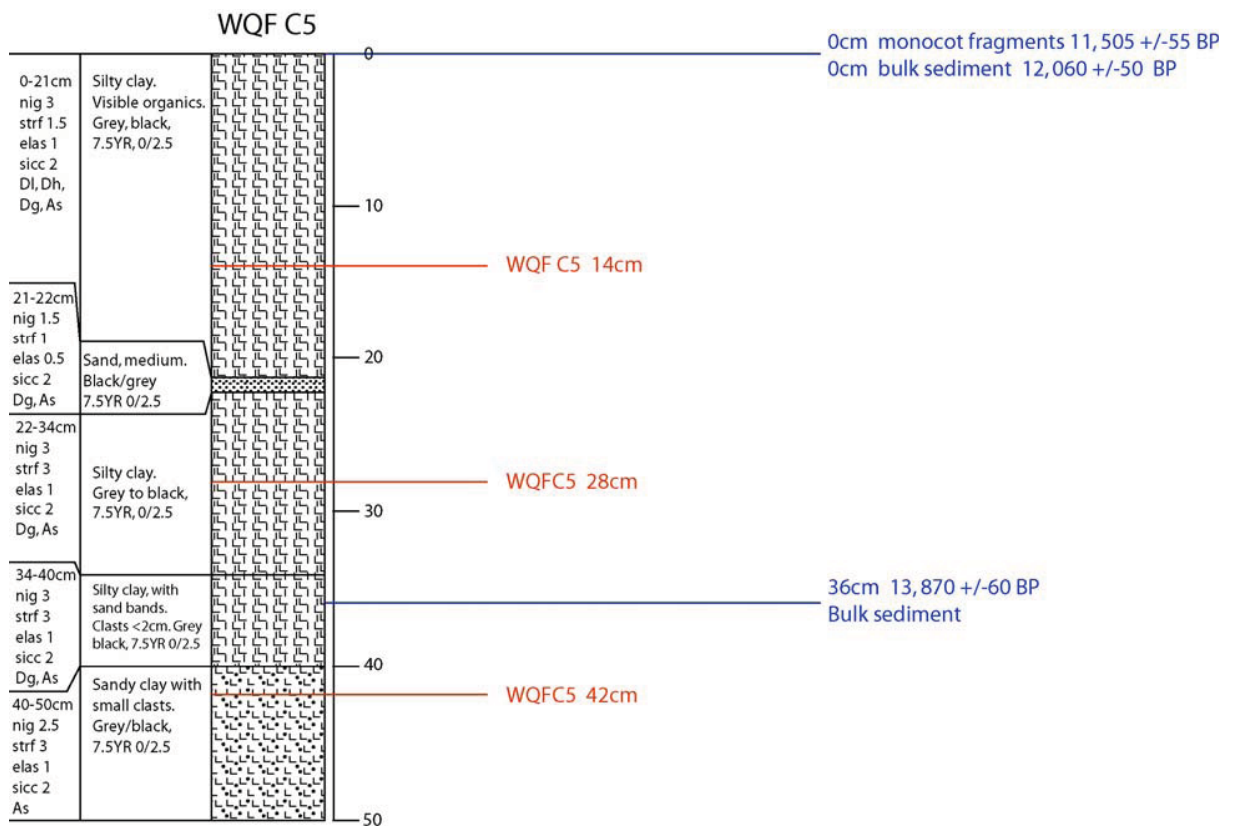

Fig 6.18: WQFC3 stratigraphy with pollen sample points and radiocarbon dates.
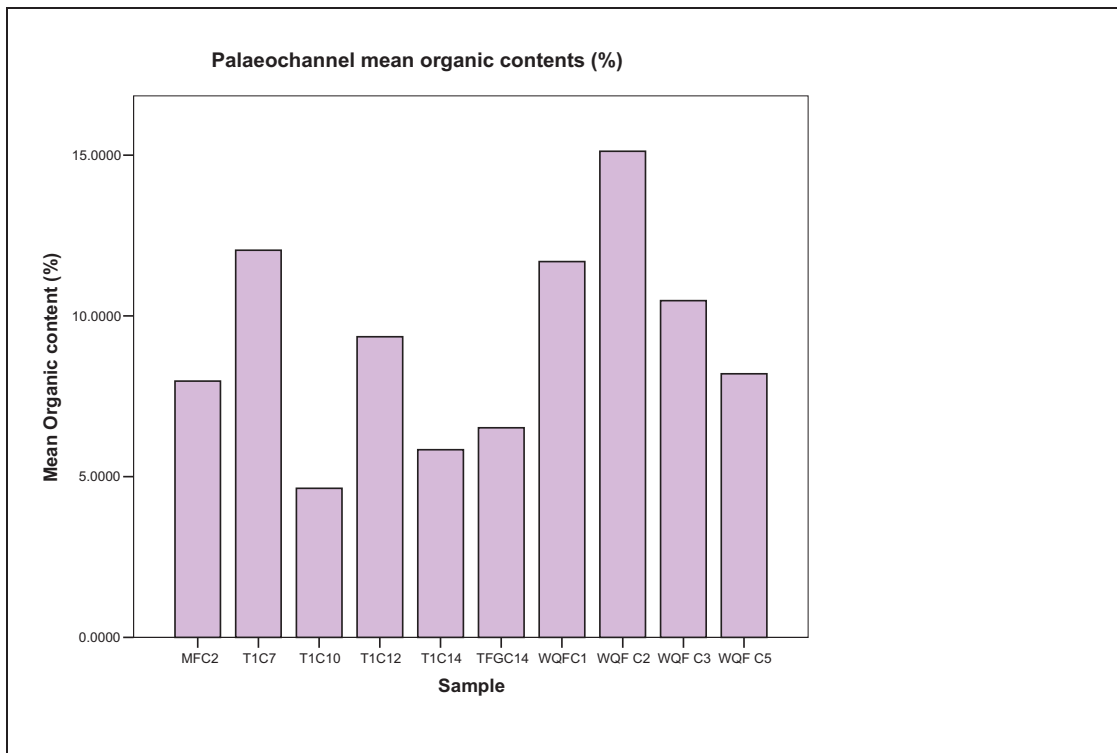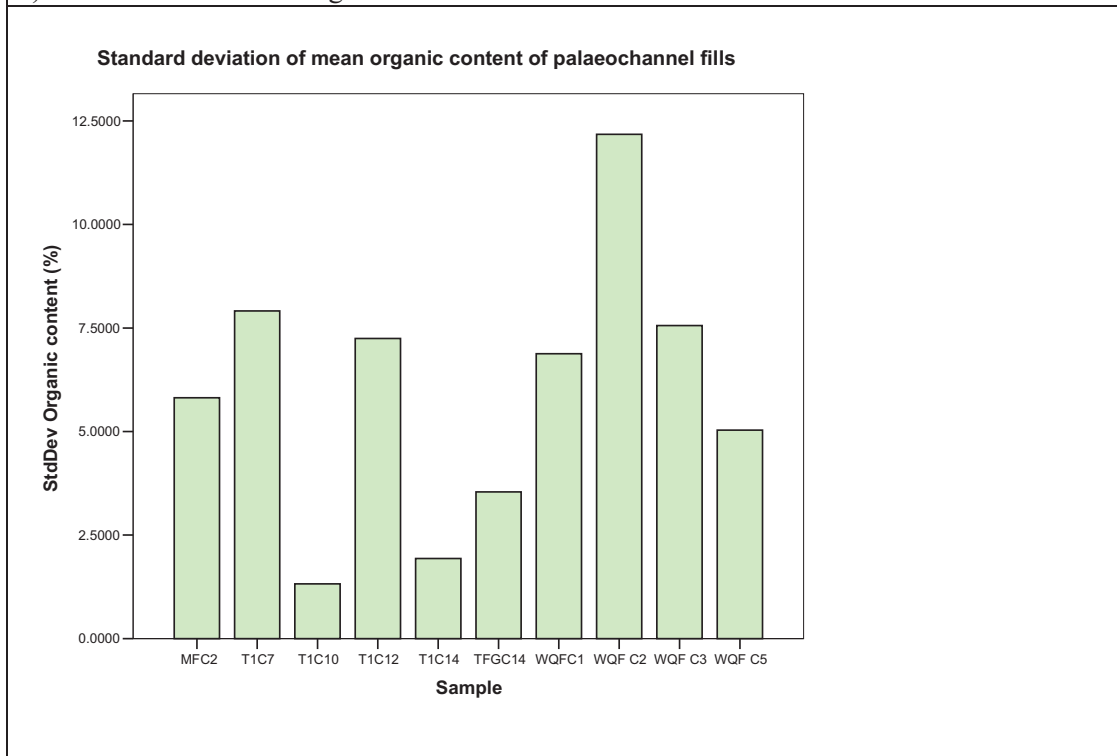
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Fig 6.20: WQFC5 stratigraphy shown against organic content, carbonate content, magnetic susceptibility Eh and pH.

Fig 6.21: WQFC5 stratigraphy with pollen sample points and radiocarbon dates.

a) Palaeochannel mean organic contents.

b) Standard deviation of me an organic content of palaeochannel fills.

Fig 6.22: The palaeoenvironmental samples shown by mean organic content and standard deviation of organic content. The samples from Warren Farm quarry, T1C7 and T1C12 clearly stand out as having elevated organic contents.

6.2 Coleopteran analysis

6.2.1 Preservation

A series of samples recovered from cores and monolith tins were processed from across the site to establish, if any, variations in preservation of insect scelera and any possible relationship with factors such as pH, Eh, carbonate content etc.

This exercise enjoyed varying degrees of success; bulk samples recovered directly from the quarry face with a standard volume of 10 litres produced abundant, well-preserved and incredibly diverse assemblages. A notable exception is WFQ 5, preservation of insect sclera in both bulk and test samples was highly variable, this will be discussed in greater detail below.

Core Log
A sequence of eight samples were extracted to compare the preservation of insect remains, core-by-core. All samples were less than 250ml in size. The results of this study are discussed below (Tab. 6.1).

WFQ C1 (0-50cm):
With the exception of the basal sample (40-50cm), preservation of coleopteran sclera in the remaining four samples (0-40cm) was assessed as good to excellent. The organic nature of the matrix, combined with fine-grained alluvium, coupled with a low energy depositional regime, clearly provided optimal conditions for preservation. The nature of deposit formation would also have facilitated the accumulation of insect remains over a prolonged temporal scale, hence larger numbers of sclera recovered from these fine-grained deposits. The basal sample consisted of sands and gravel, no sclera were recovered from this sample. It seems likely that there are two reasons. Firstly, the free draining, coarser sands and gravels provide a less than favourable environment for preservation (Fig. 6.14). The second is that the initial, higher energy regime did not facilitate the accumulation of fragile insects remains that were simply swept away.

WFQ C1+ (0-10cm):
No insect remains were recovered from any of the five samples. All five samples from this suite were composed of sands and gravels, once again, it seems likely that this is a combined result of the nature of the minerogenic matrix and the initial depositional regime.

WFQ C1 (24-74cm):
The results from this sequence were similar to those of WFQ C1 (0-50cm), the upper samples, which were highly organic, combined with fine grained alluvium produced preservation deemed good to excellent. The basal sample, composed of sands and gravels, precluded preservation and deposit accumulation.

WFQ C2 M1:
The upper samples in this suite (0-40) all consisted of sands and gravels and no insect remains were recovered from any of the four upper samples. Preservation of sclera from the basal sample, (40-50cm), was excellent, once again, this was composed of organic rich alluvium.

Core	Depth cm	No. of samples	No preservation	Poor	Fair	Good	Excellent	Comments
WFQ C1	0-10	1				Y		
WFQ C1	10-20	1					Y	Abundant
WFQ C1	20-30	1					Y	Abundant
WFQ C1	30-40	1					Y	
WFQ C1	40-50	1	Y					Sand & gravel
WFQ C1 +	0-10	1	Y					Sand & gravel
WFQ C1 +	10-20	1	Y					Sand & gravel
WFQ C1 +	20-30	1	Y					Sand & gravel
WFQ C1 +	30-40	1	Y					
WFQ C1 +	40-50	1	Y					
WFQ C1	24-34	1					Y	
WFQ C1	34-44	1				Y		
WFQ C1	44-54	1					Y	
WFQ C1	54-64	1				Y		
WFQ C1	64-74	1	Y					
WFQ C2 M1	0-10	1	Y					Sand & gravel
WFQ C2 M1	10-20	1	Y					Sand & gravel
WFQ C2 M1	20-30	1	Y					Sand & gravel
WFQ C2 M1	30-40	1	Y					Sand & gravel
WFQ C2 M1	40-50	1					Y	
WFQ C2 M2	0-10	1				Y		
WFQ C2 M2	10-20	1			Y			
WFQ C2 M2	20-30	1					Y	
WFQ C2 M2	30-40	2				Y		
WFQ C2 M2	40-50	2			Y			
WFQ C2 M3	0-10	1		Y				
WFQ C2 M3	10-20	1					Y	
WFQ C2 M3	20-30	1					Y	
WFQ C3	0-10	1	Y					
WFQ C3	10-20	1	Y					
WFQ C3	20-30	1	Y					Sandy
WFQ C3	30-40	1				Y		
WFQ C3	40-50	1	Y					Sandy
WFQ C5	0-10	1				Y		
WFQ C5	10-20	1			Y			
WFQ C5	20-30	1	Y					
WFQ C5	30-40	1				Y		Sandy
WFQ C5	40-50	1	Y					Sandy

Tab 6.1: Preservation of insect sclera from the Warrens Farm Quarry cores.

WFQ C2 M2:
Preservation of insect remains in this suite varies considerably, from fair to excellent. None of the samples contained were of a particularly sandy nature, they did, however, contain a greater component of sandy, alluvial sediment than previously seen in the other four suites of samples. The sample, which contained significantly larger proportions of organic sediment (20-30cm), produced sclera deemed to be of excellent preservation.

WFQ C2 M3:
Once again, the sands and gravel base of the suite produced a poorly preserved and limited assemblage. In contrast, the assemblages from the organic rich alluvium enjoyed excellent preservation and sclera were abundant in the samples.

WFQ C3:
With the exception of a single sample, 30-40cm, primarily composed of alluvium with some organic component, insect remains were absent from the remaining four sand and gravel samples.

WFQ5:
Preservation in this core is similar to that seen in WFQ C2 M2 and preservation varies considerably between samples. Samples 40-50cm and 30-40cm were significantly sandier in comparison to the remaining three samples. Whilst sample 40-50cm produced no viable remains, the upper sandier sample, 30-40cm produced a reasonably large assemblage, the preservation of which was deemed as 'good'. Whilst organics were limited, the alluvial content of this sample was relatively high. The preservation in the upper two samples also varies, this does not, however appear to be associated with sedimentology as the composition of both was similar.

Discussion

In many cases, preservation and overall absence of insect remains in a single sample cannot simply be ascribed to taphonomic process, in many cases it also relates to the original depositional regime and sample size. WFQ C1+ for example which was largely composed of dark, highly organic alluvium, produced samples which produced good to excellent preservation, and only the basal sample, predominantly composed of yellow/brown sand and with a limited organic component, produced no viable sclera.

Similar preservation was observed in sand and gravel samples from WFQ C2 M1. Whilst the preservation of organic remains in these samples, such as wood and fragments of sedge and grass, was good, no insect remains were recovered. Only a single, organic rich sample at the base produced insect remains that, whilst limited due to sample size, were exceptionally well preserved. With a notable exception, the recovery of *any* insect remains from sand and gravel deposits was unusual.

Samples with mixed sedimentology, e.g. sand and alluvium did produced large, well-preserved assemblages. Bulk samples from channels WFQ 3b and WFQ 8 highlight the depositional issues from channels with higher energy flow regimes. Whilst preservation was good, the assemblages were more restricted than those were from channels that contained slow moving or standing water. It is also highly likely that these assemblages accumulated during slower periods of flow and that the sand in these deposits is a result of flood pulses.

Preservation of sclera from alluvial and organic rich deposits were generally good to excellent. Once again, this would appear to be directly related to the depositional regime. The slow moving or

standing waters that deposited these fine-grained sediments and permitted the development of backswamp vegetation would also have facilitated the accumulation of large assemblages of well-preserved insects. This is clearly illustrated by the bulk samples from Palaeochannels WFQ 1 and WFQ 2.

Conversely, preservation in the much older deposits of palaeochannel WFQ 5 is likely to be related to taphonomic process. Preservation of sclera from the organic rich, alluvial deposits varied greatly. Good to fair preservation is related to the stratigraphy of the tin WQFC5. The stratigraphy reflects changes in post depositional conditions of the varying sediment units, which themselves has affected the preservation of insect sclera. The physical impact of this preservation on insect sclera caused degradation and fragmentation; the sample from 20-30cm was most affected. However the remains from 10-20cm were considerably more degraded than the remaining two (0-10 and 30-40cm), this corresponds well with the geochemical data.

Sample size has been alluded to, and the importance of having large quantities (5l – 10l/3kg) of sediment to provide a representative assemblage cannot be underestimated (Coope and Osborne 1968, Kenward *et al.* 1980). Small quantities, such as those processed here, recovered from manual augers or monolith tins can only ever be used to gain an overview of site and preservation potential. Such small quantities should not be used to cast conclusive aspersions about a site.

6.2.2 *Coleopteran analysis: palaeoecology*

To aid interpretation, where applicable, the taxa have been assigned ecological groups following those of both Kenward (1978), Kenward and Hall (1995), Robinson (1981, 1983) and more particularly Smith, Osborne and Barrett (1997, 2000). The occurrence of each of the ecological groups is expressed visually (Fig 6.23). These totals have been calculated as percentages of the entire assemblage from each individual sample. The meaning of each ecological code is explained.
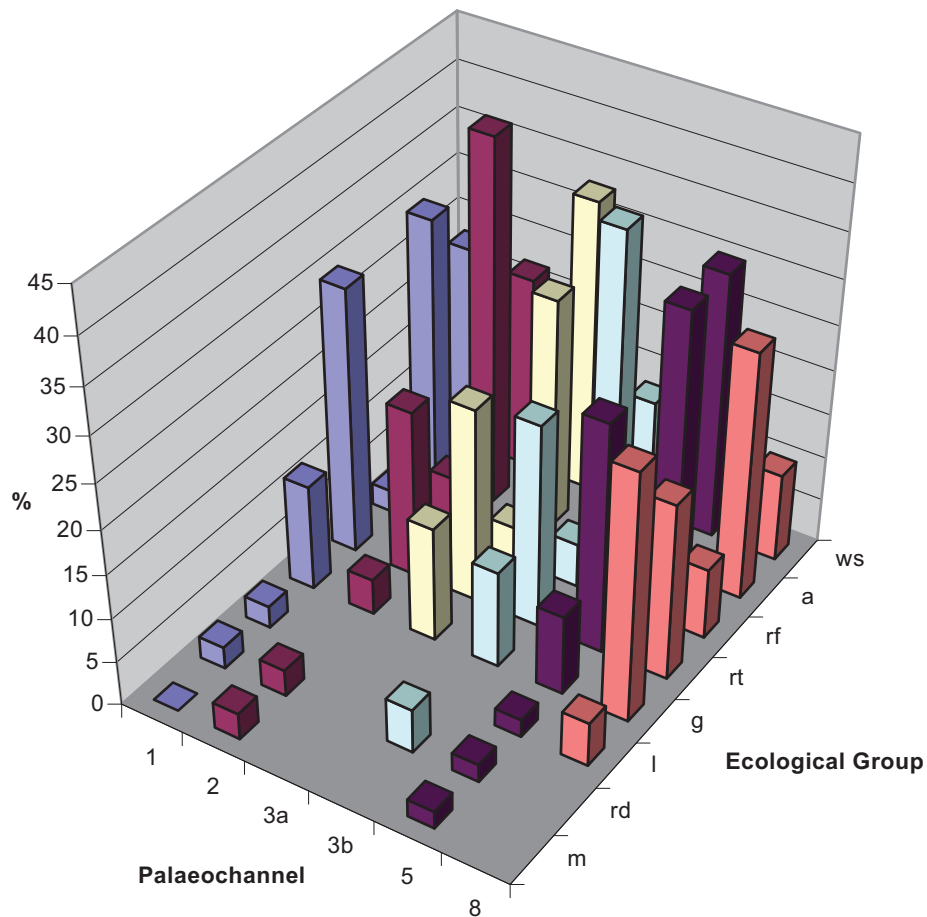
Fig 6.23: Warren Farm Quarry species ecological groups. Key: ws=waterside; a=aquatic species; rd=species primarily associated with drier organic matter; rt=species primarily associated with rotting organic matter; species primarily associated with foul organic, often dung; g=species associated with grassland; l=species associated with woodland.

WFQ 1

The assemblages from all seven samples of the palaeochannel 1 samples (Tab. 6.1) were exceptional, in both species abundance and diversity; they are exceeded only by the assemblages from palaeochannel 2. Evidence indicates the environment changes little throughout deposit formation, and suggests large grazing animal roamed the floodplain. Changes to the aquatic regime, whilst evident, are subtle.

The lowermost samples (70-50cm) are characterised by less specialised taxa, generally associated with damp, well vegetated country, such as the Carabidae, *Dyschirius globosus* and *Bembidion guttula* (Lindroth 1974, 1985) and muddy, ephemeral pools such as the Hydraenid family (Hansen 1987). The period directly after channel abandonment is clearly illustrated by the disappearance of the Elmidae or 'riffle beetles'. A small assemblage of this family, including *Limnius volkmari* and *Esolus parellelepipedus* were recovered from the basal sample, both are found in well oxygenated, flowing waters with sand and gravel armoured substrates (Holland 1972).

Above 50cm, the taxa include a number of phytophagous species, all commonly associated with sedges and other taller reeds, such as the Chrysomelidae, *Donacia obscura* and *Plateumaris*

discolor, and the Curculionidae, *Notaris* spp. and *Thryogenes* spp. (Koch 1992, Hyman 1992, Menzies and Cox 1996).

Other curculionids recovered from the upper samples, are associated with drier grassland such as the Apionidae and *Sitona* spp., both families are found upon vetches (*Vicia* spp, *Lathyrus* spp.), clovers (*Trifolium* spp.) and other leguminous vegetation (Koch 1992). A number of Carabidae or 'ground beetles' are found on sparsely vegetated, dry, sands and gravels such as *Agonum mulleri, Amara aenea* and *A. familliaris* (Lindroth 1974, 1986). These three species probably lived at the periphery of the palaeochannel, on the exposed sands and gravels of the former riverbank.

Throughout the formation of this deposit, the floodplain is increasingly utilised for grazing, a comprehensive suite of dung beetles or Scarabaeidae is recovered from all seven samples and are particularly abundant in the upper samples. Taxa associated with dung and other, foul rotting material are limited which does not suggest large accumulations of this type of material.

Species found on distinctly aquatic vegetation are scant, as are aquatic coleoptera associated with deep, permanent pools or slow moving water. The Elmidae, which are virtually absent after the small assemblage recovered from the basal sample are replaced by the Hydraenidae and the Hydrophilidae. Both families are largely composed of semi-aquatic and hygrophilous species associated with muddy, ephemeral pools and the muddy banks and shores of ponds and streams (Hansen 1987). A single, largely aquatic hydrophilid, *Hydrobius fuscipes*, is relatively abundant in the upper samples, these species is most commonly associated with the well-vegetated shallows of stagnant and slow moving water (Hansen 1987).

WFQ 2
Palaeochannel 2 produced the most diverse, abundant and well-preserved assemblages recovered from any of the Warrens Farm palaeochannels. Unlike palaeochannel 1, the depositional environment in the basal samples appears to have been waterlain. The basal samples (60-30cm) are particularly rich in taxa associated with aquatic plants and deep standing or slow moving waters.

The Chrysomelidae, *Donacia crassipes* and *Plateumaris sericea* are both found on white water lily (*Nymphea alba*), the latter is also associated with yellow flag (*Iris pseudocorus*) and carices (Menzies and Cox 1996), a third chrysomelid, *Donacia versicolorea*, is found on broad leaved pondweed (*Potamogeton natans*) (Menzies and Cox 1996). The aquatic taxa are less indicative of this, the Dytiscidae or 'predacious diving beetles' form this sample are associated with shallower waters with lush, emergent vegetation.

Whilst there is little evidence from the lower samples that indicates the type of environments that surround the palaeochannel, the few that do are associated with marshy, sedge-dominated biomes, the upper samples (30cm+) clearly indicate increasingly dry conditions. Whilst phytophagous taxa associated sedge and taller reeds persist, such as the curculiond family *Thryogenes* spp. and to a lesser degree *Notaris* spp. persist; many taxa found in these samples are associated with drier grassland. A small component suggestive of mixed deciduous woodland was also recovered.

Many of the Curculionidae are phytophagous beetles associated with a variety of plants commonly found in both meadows and disturbed ground and include the Curculionidae or weevils of the *Apion* and *Sitona* families. *Apion urticarium* is found on nettles (*Urtica* spp.) as is the nitidulid *Brachypterous urticae* Other phytophagous beetles associated with a variety of plants commonly found in both meadows and disturbed ground include the Curculionidae or weevils of the *Apion* and *Sitona* families. *Apion aeneum* and *Apion radiolus* are found on mallows (Malvaceae), in disturbed

ground, waysides and hedgerows, *Apion ervi* is found in hedgerows with vetches (*Vicia* spp.) (Bullock 1993, Koch 1989b, 1992). *Sitona puncticolis* and *Sitona tibilalis* are both found with vetches, clovers (*Trifolium* spp.) and trefoils (*Lotus* spp.) (Koch 1992). Finally, *Mecinus pyraster* is found on plantains, particularly ribwort plantains *(Plantago lanceolata)* (Bullock 1993). *Apion viciae* is found in hedgerows with tufted vetch (*Vicia cracca*), whilst both *Apion ervi* and *Apion subulatum* are found on meadow vetchling (*Lathyrus pratense*) (Bullock 1993, Koch 1992). *Sitona puncticolis* and *Sitona tibilalis* are both found with vetches, clovers (*Trifolium* spp.) and trefoils (*Lotus* spp.) (Koch 1992). Finally, *Mecinus pyraster* is found on plantains, particularly ribwort plantains *(Plantago lanceolata)* (Bullock 1993). The Carabidae *Clivina fossor*, *Harpalus tenebrosus* and the nitidulid *Brachypterolus pulicarnis, C. fossor* was recovered in some abundance, all three species are commonly found in open country on sands and gravels (Lindroth 1974, 1985, 1986). Analogous to these drier conditions are the increasingly large numbers of dung beetles that are found throughout the profile but become particularly abundant in the upper samples (30+).

Lignacious taxa are found in all five samples. Whilst none are found in large numbers, their presence in the assemblages, particularly species associated with alder, is significant. The greatest concentration of woodland taxa is found in samples from the middle of the section (50-20cm). Three species are associated with alder carr. The chrysomelid, *Melasoma aenaea* and the curculionid, *Anoplus roboris*, are both phytophages which feed upon alder, a third species found in alder-dominated woodland is the carabid *Leistus rufascens*, as is the coccinelid *Chilocorus renipustulatus* which is also found with willows (*Salix* spp.) (Koch 1989b, 1992). The Scolytidae, *Scolytus multistriatus*, found on elm (*Ulmus* spp.) and *Kissophagus hederae*, found on ivy (*Hedera helix*) were also recovered (Koch 1992).

WFQ 3
WFQ3 both samples from this palaeochannel produced relatively small assemblages, preservation was good and both assemblages are readily interpretable. The environment changes little throughout the formation of the deposit; hence both samples will be discussed together.

The Carabidae, *Bembidion guttula* and *B. unicolor* suggest a damp well vegetated floodplain, the Chyrsomelidae, *Plateumaris discolor* and the Curculionidae, *Notaris acridulus* and *Thryogenes* spp. suggest is dominated by carices and other damp-grassland species such as *Glyceria* spp. (Koch 1992, Lindroth 1974, 1985). Drier ground is indicated by the carabidae *Harpalus* spp (Lindroth 1974, 1986). The presence of scarabaeids or 'dung beetles' clearly suggest grazing herbivores nearby.

Distinctly aquatic species are restricted to the Elmidae or 'riffle beetles', which are abundant in the basal sample, these are replaced in the upper sample by members of the Hydraenidae which are particularly abundant and are associated with muddy, ephemeral pools (Hansen 1987). Two species do indicate that the palaeochannel contained deeper pools of standing water, the chrysomelid *Donacia crassipes*, previously found in palaeochannel 2 and associated with white water lily was recovered. The curculionid, *Eubrychius velatus,* is found on water milfoils (*Myriophyllum* spp.), whilst this aquatic plant does not require particularly deep water, much of the biomass *is* submerged (Haslam *et al.* 1982), hence deeper, more permanent water is required.

WQF 4
The insect remains from palaeochannel 4 produced well preserved but relatively restricted assemblage, despite this, it produced the most comprehensive and informative series of assemblages associated with aquatic conditions and flow regime at the site. The assemblages change little throughout formation of the deposit.

The assemblage is dominated by the Elmidae or 'riffle beetles', which clearly suggest regular influxes of water from a fast flowing source. Many Elmidae, are associated with well oxygenated, swiftly flowing streams and rivers which flow over gravel and sand armoured substrates. The quartet of elmids, *Limnius volkmari*, *Esolus parallelipepidus*, *Oulimnius* spp. and *Machronychus quadrituberculatus* are no exception, the latter is particularly associated with submerged wood (Holland 1972).

The remainder of the assemblage provides little information on the environments surrounding the channel. Many species are cosmopolitan taxa associated with damp, wetland habitats from woodlands to marshy meadows, such as the Carabidae, *Trechus secalis* and *Trichocellus placidus* (Lindroth 1974, 1985, 1986). The nitidulid, *Brachypterus urticae*, which is found with nettles (*Urtica dioica*) and suggests areas of disturbed ground (Koch 1989b).

WFQ 5
The palaeochannel 5 deposits produced cold stage insects assemblages clearly associated with a stadial event and contain several stenothermic taxa and species tolerant of cooler climates. The assemblages were less well preserved than those of the other five samples, in many cases the scelera were fragmented and in a considerably more degraded condition. In many cases, the sclera were still identified to species level and have produced a diverse and readily interpretable assemblage.

Once more, the environment changes little during the formation of the deposit. The area surrounding the palaeochannel is vegetated by low growing mosses and sedges, with tall reeds fringing the periphery of the palaeochannel itself. Further away from the channel, several taxa hint at drier heathland type vegetation.

Phytophagous taxa, found in sedge-dominated communities, include the chrysomelid, *Plateumaris sericea*, which is particularly associated with cotton grasses (*Eriophorum* spp.), whilst more generalised wetland coleoptera include the Carabidae or 'ground beetles', *Loricera pilicornis*, and the *Bembidion* spp. (Lindroth 1974, 1985; Menzies and Cox 1996). The stenothermic staphylinidae, *Pycnoglypta lurida*, and the carabid, *Agonum thoreyi*, are both found amongst tall reeds, particularly the common reed (*Phragmites australis*) and club-rush *(Schoenoplectus lacustris)* (Koch 1989a, Lindroth 1974, 1985). Indicators of tall reeds continue throughout the profile, in the upper samples, *A. thoreyi* persists and is joined by *Donacia impressa* and *Donacia simplex* (Menzies and Cox 1996). This perhaps suggests tall reed swamp has begun to encroach upon much of the site and the area immediately surrounding the palaeochannel.

Species from drier localities, probably situated relatively close to the palaeochannel are heath and moorland taxa, two of these, *Haltica britteni*, and a second stenothermic staphylinidae, *Eucnecosum brachypterum*, are both phytophagous and found on heather (Koch 1989a, 1992). The curculionid, *Phyllobius pyri*, is found on birch (*Betula* spp.).

Probably the most significant component of this assemblage are the stenothermic species, two distinct stenophilous taxa were present in all four samples, the Staphylinidae, *Pycnoglypta lurida* and *Arpedium brachypterum. Arpedium brachypterum* persist in the British Isles in northern and montane habitats (Tottenham 1954) and is found in is found in swamps and damp meadows, beneath reed and flood debris in Europe (Koch 1989b). Insects associated with cooler environments but not distinct stenotherms include the chrysomelid, *Chrysomela cerealis*, which feeds at the roots of wild thyme (*Thymus* spp.) and is found in upland and montane habitats (Shirt 1987). The current range of this species in modern Britain is restricted to Snowdonia (Hyman 1992,

Shirt 1987). The curculionid, *Otiorhynchus rugifrons*, most commonly found in montane and upland environments in north, central and eastern Europe and finally, the scarabaeid, *Aphodius lapponum*, a species found with dung in upland habitats (Jessop 1972).

WFQ 6
Palaeochannel 6 produced two, well preserved and diverse assemblages. Conditions surrounding this channel are subtly different to those seen around the other five channels. Conditions are significantly drier, the assemblages are composed of grassland and disturbed ground taxa, those of flowing water and a comprehensive bevy of Scarabaeidae.

Aquatic conditions are strikingly similar to those seen in palaeochannel 4. The large assemblage of Elmidae clearly indicates regular influxes of water from a rapidly flowing source. Indicators of reeds, sedges and other wetland flora are absent, which suggests that the channel was relatively free of aquatic and emergent plants throughout deposition.

A variety of Curculionidae indicate species rich grassland, a profusion of *Apion* and *Sitona* spp. occur in both samples and indicate a rich mix of vetches including tufted vetch (*Vicia cracca*) and meadow vetchling (*Lathyrus pratense*), clovers (*Trifolium* spp.) and medicks (*Medicago* spp.) (Koch 1992). There is also some limited evidence for areas of disturbance, suggested by a further two Apionidae, *Apion urticarium*, as the name suggests if found with nettles (*Urtica dioica*), whilst *Gymnetron pascuorum* is found with plantains (*Plantago* spp.) (Koch 1992). The large numbers of Scarabaeidae recovered from both samples, clearly suggest that this lush, verdant grassland provided nutritious grazing for herbivorous animals.

Finally, the Scolytidae, *Scolytus ratzbergi* and *Scolytus scolytus* both suggest nearby woodland. Both are species specific, *S. ratzbergi* to birch and *S. scolytus* to elm. The former is restricted to dead specimens, whilst the latter is associated with living trees (Bullock 1993).

6.2.3   Discussion

Vegetation and the surrounding environment:
Chronostratigraphically the oldest palaeochannel is WFQ5, which radiocarbon dating currently suggests developed *c*. 16ka BP, during GS-2a (Björk *et al*. 1998). This would place palaeochannel development at the height of the Devensian glaciation, comparison between the assemblages from the channel and other sites in the Trent Valley and other British sites, also suggest a slightly later date. Climatic implications of this fauna will be discussed in greater detail below.

The vegetation is characteristic of this type of a cooler climate ecotone and indicates a mosaic of wetland species composed of lower growing sedges and taller reeds which, probably fringed the palaeochannel and encroached upon the wetter areas of the riparian zone. Scrubby heathland species such as heather (*Calluna* spp.) and birch (*Betula* spp.) colonise the drier gravel terraces. Comparable 'cold stage' fauna's sites in the Trent Valley include Bellmoor (Howard *at al*. 1999, Tetlow 2005), Birstall (Ripper 2005), Croft, Hemington and Yoxall (Greenwood and Smith 2005, Smith and Howard 2004).

Similarities between the later palaeochannels vary. Several channels indicate damp, well-vegetated marshland with few indicators of specific herbaceous taxa.   The basal samples of both palaeochannels 1 and 2 and all three samples from palaeochannel 3b are particularly ambiguous. As succession continues, similarities between palaeochannels 1 and 2 diverge. The environs of

palaeochannel 1 and 3a demonstrate a degree of similarity with sedge and reed-dominated vegetation becoming established.

In the upper samples of palaeochannels 1 and 2 and palaeochannel 6, conditions become increasingly dry. Many of the insect taxa indicate considerably drier conditions, with large numbers of Curculionidae or 'weevils' such as the Apionidae and *Sitona* spp. which suggest species rich grassland. It is also clear grazing animals increasingly used the floodplain, with the exception of palaeochannels 3a and 3b, it seems likely that the floodplain directly adjacent to the palaeochannels was subject to grazing.

Evidence of grazed pasture, directly fringing the channel was found in early Bronze Age contexts at Staythorpe, Nottinghamshire (Davies 2001) and later Bronze Age contexts at South Ings, Rampton (Howard and Knight 2001). At Kirby Muxloe, close to the headwaters of the Soar, insects from Iron Age contexts indicate clearance and grazing by this period (Cooper 1994, Greenwood and Smith 2005). At Waycar Pasture, near Girton, Nottinghamshire, clear evidence of pastoral farming is evident in the insect record from 2000 BC to the Romano-British period (Howard *et al*. 1999).

Direct and unequivocal evidence of pasture and grazing of the floodplain directly adjacent to channels at a number of locations in the Trent and Soar Valleys is limited. At Croft, Neolithic and Iron Age contexts produced limited assemblages of dung beetles and few indicators of open grassland (Smith and Howard 2004, Smith *et al*. 2005). Similarly, at Bole Ings, assemblages from very late Mesolithic to Iron Age contexts of produced little evidence of grassland or grazing (Dinnin 1997). At Langford, Howard *et al*. (1999) suggest the grassland and dung beetle assemblages are a result of grazing in clearances and glades amongst the dense woodland that covered the site during the Neolithic and the early Bronze Age.

The key at these other three sites would appear to be the dense areas of well developed woodland which covered the banks of both the Rivers Trent and Soar during later prehistory. At Croft, the Bronze Age contexts are more indicative of open grassland, however the assemblages are less than conclusive and a small woodland assemblage persists (Smith *et al*. 2005). Conversely, entomological evidence of dense woodland at the confluence zone of the Trent and Soar is limited. Whilst lignacious and saproxylic taxa are present, they are restricted to Scolytidae, which are ready fliers and which were recovered in very restricted numbers and several indicators of alder carr.

The definition of alder carr in the archaeological record using entomological methods is problematic and has previously been discussed at length (Girling 1985, Paddock 2001, Robinson 1993, Tetlow 2003, 2005, Smith *et al*. 2000, Smith and Whitehouse 2005). Two factors compound this issue, the first relates to the limited number of taxa (14) associated with alder in comparison with other tree e.g. Oak (93) (Bullock 1993). The second relates to the lack of modern entomological knowledge of this habitat. Several species recovered from the palaeochannel 2 samples are obligate phytophages of alder, several others, whilst not restricted to alder, the species is their tree of preference. Establishing the presence of alder carr at other notable wetland sites e.g. Goldcliff, Goldcliff East, the Somerset Levels and Mingies Ditch has been problematic (Girling 1985, Robinson 1993, Tetlow 2003, 2005, Smith *et al*. 2000). At sites such as Goldcliff, the presence of large tracts of alder carr has been established by wood identification, whilst any indicators in the entomological record have been entirely absent (Tetlow 2003, 2005). When considering the significant degree of entomological ambiguity at Goldcliff and these other sites, the presence of alder-dwelling creatures at Lockington can be taken as unequivocal indicators of alder carr, close to palaeochannel 2.

This, in itself is intriguing considering the paucity of lignacious or saproxylic taxa in virtually every other palaeochannel and the contemporaneous nature of deposit formation, channel by channel. The implications for deposit and channel relationship, will be discussed in greater detail in Chapter 7.

In the wider context of the Trent and Soar Valley, alder carr appears to persist much later into the Bronze Age at Lockington than has been recorded at other sites. At Birstall, in the middle reaches of the Soar, the potential for a wooded floodplain persists until the early Bronze Age (3530±70 ^{14}C years BP, SRR-3507, Brown *et al*. 1994). By the later Bronze Age, this woodland had given way to open pasture (Smith and Tetlow 2004), with a suite of coleoptera strongly reminiscent of those from Warren's Farm. In the Trent Valley at Yoxall, Staffordshire, dense woodland is still recorded 2780±60 ^{14}C years BP (Beta-73350, 1110-800 cal BC). Further afield, cleared floodplains are recorded at Staythorpe, woodland has been cleared from the site in the early Bronze Age (Davis 2001) and in the later Bronze Age at Shardlow and Aston, Derbyshire (Greenwood and Smith 2005, Howard *et al*. Forthcoming). In the middle and lower Trent, clearance of the floodplain at Bole Ings and Girton is evident by 2690±100 ^{14}C years BP (Beta-75720, 1050-540 cal BC) and 2890±60 ^{14}C years BP (AA-29321, 1290-900 cal BC) (Brayshay and Dinnin 1999, Dinnin 1997, Howard *et al*. 1999). At a second site in the Staffordshire Trent Valley at Fisherwick, a dramatic decline in arboreal pollen is recorded from the mid Bronze Age (Smith 1979). At Repton in the lower Trent, a mosaic of reedswamp, woodland and pasture is recorded between 1000-400 cal BC (Greenwood and Smith 2005).

It is possible that the alder carr at Lockington is a result of a brief episode of carr regeneration. Both woodland regeneration and wetland re-expansion are recorded in the Trent Valley during the first millennium BC (Knight and Howard 2004). The onset of cooler and wetter conditions is associated with later Bronze Age and would have produced increasingly unstable floodplain conditions. The impact would have been particularly intense when coupled with increased over-land run off associated with woodland clearance and primitive agricultural practices and rising groundwater tables. At sites such as Scaftworth, close to the confluence of the Trent and Idle Valley, overbank floods and paludification cause significant broadening and expansion of the floodplain (Dinnin and Weir 1997). It is not unfeasible that similar expansion was experienced at the Trent/Soar confluence. At South Ings, Rampton, alder carr clearly exploits and expanding wetland niche, perhaps encroaching upon an already established area of drier woodland as conditions become increasingly wet (Knight and Howard 2001).

Aquatic Regime:
The aquatic regime in each channel divides the palaeochannels at Warrens Farm Quarry into three, distinct groups. In palaeochannel 1 and 3a, the episode of abandonment is clearly illustrated, relatively large assemblages of Elmidae, or 'riffle beetles' are found at the base of both channels. In subsequent samples this family appear in considerably restricted numbers that suggest that regular influxes of water from rapidly flowing sources has ceased. This is replaced by species associated with leaf filled, muddy, detrital pools. Palaeochannel 3a is a much shallower feature, which appears to have infilled relatively rapidly. In contrast, alluviation in palaeochannel 1, particularly in the top most deposits, appears to have been relatively slow. There appears to have been no further catastrophic reactivation, which would have scoured the channel but a period of relatively slow alluviation. This is particularly pronounced in the upper two samples. Throughout this accumulation of these deposits, the palaeochannel acted as a natural 'pitfall trap', facilitating the accumulation of the large and diverse insect assemblages recovered, a trend reflected in the upper deposits of palaeochannel 2.

Conditions within palaeochannel 2 are subtly different; indicators of flowing waters are virtually absent in all six samples. During early stages of deposition, the channel appears to have been filled with relatively deep, standing or very slow moving water. This is suggested not only by a relatively diverse and abundant assemblage of insects associated with permanent, deeper pools of water which are considerably more limited in palaeochannels contemporary with WFQ (WFQ1, 3a, 3b, 6) but by a further group of species associated with specific aquatic and emergent vegetation.

Several of the Chrysomelidae found in this sample are found on specific species of aquatic plant, white water lily and broad-leaved pondweed. Both the lily and pondweed require water between 30 and 50 cm deep (Haslam *et al*. 1982), which suggests an expanse of relatively deep, open water, ultimately adding further depth to this argument. It is quite possible that such conditions prevailed in WFQ2 throughout the formation of the deposit.

In total contrast to the other three channels, diverse assemblages of Elmidae in both WFQ3b and WFQ8 suggest rapidly flowing water, in both channels throughout deposit development. This regime would also explain the relatively limited nature of the assemblages from both of these deposits. Rapidly flowing water would have scoured any significant deposits and precluded any further extensive deposition.

Comparison between the aquatic assemblages from this site and others in the Trent and Soar Valleys, particularly those studied by Smith and Howard (2004) has produced a significant dichotomy. This dichotomy has implications for both the depositional regime and the application of entomology in alluvial locations.

The aquatic assemblages from Warrens Farm Quarry, provides good corroborative evidence for defining flow regime using biometric data, in this case coleoptera. Both palaeochannel WFQ3b and WFQ8 strongly indicate deposition in a higher energy regime; two factors lead to this conclusion. The first is the abundance of coleopteran taxa associated with flowing water and higher energy conditions, juxtaposed with those of stagnant and standing waters in samples from both channels. The second relates to the abundance of coleoptera found on emergent and aquatic vegetation which, are virtually absent in both WFQ 3 and 8 and prevalent in palaeochannels WFQ1, 2, 3a, particularly palaeochannel 2. All of which produce coleopteran taxa characteristic of standing water. A further suite of coleoptera associated with aquatic vegetation such as white water lily (*Nymphaea alba*), water dropwort (*Oenanthe aquatica*) and taller reeds such as clubrush (*Schoenoplectus* ssp.) and bulrush (*Typha* spp.) was also recovered from WFQ 1, 2 and 3a and are absent in WFQ 3b and 8. These herbaceous species are clear indicators of standing water; many are also associated with silty substrates (Haslam *et al*. 1982), sedimentological conditions anathema to the elmid family.

Hence this combined data conclusively suggests rapidly flowing water in WFQ 3b and 8 and a much more pedestrian regime in channels 1, 2 and 3a. Due to the much earlier deposition of WFQ 5, this palaeochannel has been omitted from the general discussion, it does fall into the same category as WFQ 1, 2 and 3a. Whilst a number of elmids were recovered, the aquatic insects are those of relatively shallow standing water, muddy detrital pools and aquatic vegetation unable to withstand a rapid flow regime.

The palaeochannels at Lockington contain a coleopteran assemblage completely in contrast to that Croft, Langford, Hemington, Yoxall and Castle Donnington (Brown *et al*. 2001, Cooper and Ripper 1994, Forthcoming, Howard *et al* 1999, Smith and Howard 2004, Smith *et al*. 2001, Smith *et al.* 2005). These five sites were divided into two, sites where sedimentology and coleoptera indicated a

flowing aquatic regime (Croft, Langford and Hemington) and standing or slow moving water (Yoxall and Castle Donnington). The aquatic assemblages used to infer these conditions are comparable to those used to imply aquatic conditions at Warrens Farm Quarry, it is at this point the similarity ends. In complete contrast to the palaeochannels at Lockington, the channels from sites that suggested a flowing aquatic regime produced the largest and most diverse assemblages, whilst those from the slower channels produced considerably more restricted faunas (Smith and Howard 2004).

The disparity between these two data sets has produced a significant interpretative issue that can only be resolved by further assimilation of coleoptera from the Trent, its tributaries and other catchments in the British Isles.

6.1.4   Palaeochannel Relationships

Comparison between the aquatic and terrestrial coleoptera from WFQ 1, 2, 3a, 3b and 8 and their spatial and temporal relationship allow several tentative extrapolations to be drawn.

Coleoptera suggest that palaeochannel WFQ 3a may have developed contemporaneously with the upper samples (30+) from WFQ 1. Both aquatic and terrestrial components from both samples are strikingly similar. Radiocarbon dates from the base of the channels indicate a reasonable overlap, whilst OSL dates suggest greater degree of synchronicity, WFQ 3a formed after 1150±300 and WFQ 1 after 1050±300.

Further similarities exist between WFQ 3b and WFQ 8, both suggest flowing water and similar bankside vegetation. Whilst the dates for WFQ 3b can be taken as the same as those of 3a (they were recovered from a single, potentially continuous channel), complex stratigraphy precludes any firm assertions. Stratigraphy is complex and the area from which sample 3b was recovered is possibly a re-cut, the result of scouring associated a flood-pulse and followed by a more prolonged period of flowing water. Similarities between the two samples are strong, hence the relationship between these two samples, particularly considering the stratigraphic evidence, possible scouring and re-cutting make this hypothesis plausible.

No distinct correspondence exist between the assemblages from WFQ 2 and those from the WFQ 1, 3a/b, 8 complex. Conditions in the upper deposits of WFQ 2 (30-10cm) display similarities to those from WFQ 1 (50cm+), it is the differences between WFQ 2 and the other suites of samples that are outstanding. These include the woodland fauna and greater numbers of Scarabaeidae and other species associated with dung and rotting material. Radiocarbon dates support this theory and suggest formation several hundred years later than that of the other palaeochannels, *c*. 1060-890 cal BC, no OSL dates are available for this channel.

The climatic implications of Palaeochannel WFQ 5:
two distinct stenophilous taxa were present in all four samples, the Staphylinidae, *Pycnoglypta lurida* and *Arpedium brachypterum* collectively, they may be assigned a mutual climatic range or 'MCR' of between T_{min} –35 to +3°C (T_{min} range 38) and T_{maz} 7-16°C (T_{maz} range 9) (Elias 2000). The second staphylinid, is *Pycnoglypta lurida*, a taxa absent from the modern British fauna, whilst this species cannot be described as an 'Arctic stenotherm', its current distribution is in montane and northern regions of Europe (Osborne 1973). Despite its absence from the modern British fauna, the climatic range of *Pycnoglypta lurida* is less extreme than that of *Arpedium brachypterum*. The

MCR of *Pycnoglypta lurida* is between T_{min} –34.5 to +4.75°C (T_{min} range 39.25) and T_{maz} 9.5-24°C (T_{maz} range 14.5) (Elias 2000).

Both *Pycnoglypta lurida* and *Arpedium brachypterum have* been recovered from a number of sites throughout Britain particularly associated with climatic cooling at the end of the Lateglacial and the beginning of the Loch Lomond stadial *c.* 12,000-11,500 ^{14}C BP. In the main body of the Trent Valley, sites include Repton, Langford, Holme Pierrepoint and Hemington (Greenwood and Smith 2005, Tetlow 2007). Comparable cold stage faunas have been recovered from several tributaries of the Trent, Birstall and Barrow on Soar in the Soar catchment (Smith and Tetlow 2004, Tetlow 2007) and at Bellmoor on the River Idle in North Nottinghamshire (Howard *et al.* 1999, Tetlow *et al.* 2005). A further site, north of Wroxeter on the east bank of the River Dove has also recently been identified (Challis *et al*. 2006). Other sites are in the English Midlands at Church Stretton, West Bromwich, Abingdon and Glanllynnau, Gwynedd (Aalto *et al*. 1984, Coope and Brophy 1972, Osborne 1972, 1973).

At Glanllyau, Coope and Brophy suggest that *Pycnoglypta lurida*, *Arpedium brachypterum* and other insects also recovered from Holme Pierrepoint, indicate that *c*. 11,300±300 ^{14}C BP (14,087-12,771 cal BP, 12,137- 10,821 cal BC[*]) the mean July temperature at Glanllynnau was 14°c, several degrees lower than that of the present July mean (Coope and Brophy 1972, Lowe and Walker 1997). Of the other taxa associated with cooler conditions, no are as distinct as this pair of Staphylinidae. Several are of note, the Chrysomelid, *Chrysomela cerealis* or 'rainbow leaf beetle' is currently endangered in the British Isles and is found only in the area of Y Wyddfa in Snowdonia (Hyman 1992).

6.1.5 Conclusions

The assemblages from Warrens Farm Quarry have been informative on a number of levels. The exceptional preservation and abundance of insect remains from the majority of samples has the potential to produce a detailed picture of changing conditions within the palaeochannels and vegetative succession during deposit formation from the Lateglacial to the late Bronze Age. Contrary too much of the Trent and Soar Valley, the floodplain at Lockington was not heavily wooded. A significant impact on vegetative succession at the site is the highly dynamic nature of the Trent/Soar confluence during later prehistory. It is not difficult to conclude that this instability precluded succession further than damp, open grassland. This lush, verdant grassland would have provided an area of prime pasture, which was grazed during both major periods of organic deposition. Evidence also indicates alder carr encroachment or regeneration during the very late Bronze Age and the early Iron Age, a phenomenon recorded a several other sites during this period and likely to be associated with climatic deterioration and the onset of cooler and wetter conditions during this period.

6.2 Pollen and Spore Assessment

The results of the assessment are discussed in the same order as given (Tab. 6.3) and for ease of description the following terms are used to describe the concentration values (Tab. 6.2):

No. of pollen & spore grains per 100 exotics	Pollen & spore concentration Grains ml^{-1}	Descriptive class
0-50	0-5000	very low
50-100	5000-10,000	low
100-300	10,000-30,000	moderate
300-500	30,000-50,0000	high
>500	>50,0000	very high

Tab. 6.2: Pollen and spore concentrations and descriptive classes.

MFC2
Pollen concentrations vary from very low to very high with the majority in the moderate class. The lowest values occur at adjacent levels mid core (98cm, 112cm) and at the base of the core (168cm, 184cm). These levels correspond with a relatively inorganic (c. 5% LOI) red-brown silty clay with a trace of fine sand. Conversely the highest concentration, which is very high at 70cm, corresponds with a band of dark grey-black silty clay with an average LOI of 20-25%. This is most likely an artefact of a variable accumulation rate as the percentage of damaged grains is high throughout the core suggesting poor conditions of preservation with alternating wet and dry soil moisture conditions.

T1C7
Pollen and spore concentrations vary from low to moderate. There is a distinctly lower concentration in the central part of the core from 154cm to 98cm depth. These levels also have generally higher percentages of unidentified grains and damaged grains, which reaches a peak at 126cm of 51.8%. These levels correspond with the lowest organic contents in the profile at the base of the blue-grey clay unit.

T1C12
Pollen and spore concentrations vary from very low to high with the lowest values from the upper part of the core (112cm-42cm) excluding the uppermost levels. The percentage unidentified are very erratic with adjacent values varying from 1.4% to 14.2% with similar pollen concentrations. The percentage damaged is less variable but consistently higher than the other cores, with the exception of the basal three levels. Again the lowest concentrations correspond with the lowest organic matter percentages and the upper part of the red-brown silty-clay unit. The highest concentrations and lowest percentage unidentified and damaged correspond with grey clay increasingly gleyed with depth and a transition to black-grey clay with organic macrofossils.

T1C10
Pollen and spore concentrations vary from very low to moderate but are heavily biased to the very low concentration class. The very low concentrations below 10 grains per 100 exotics encountered unfortunately made the % unidentified and % damaged figures rather erratic varying for example from 0% to 33% or 66% between two levels with 2 and 3 grains respectively on the basis of one or

two grains. However, it is noteworthy that the % damaged grains remained high when the pollen concentration had risen to moderate at the base of the core.

TFGC14
Pollen and spore concentrations vary from very low to moderate with a distinct pattern – higher concentrations in the upper part of the samples section of the core (266cm-294cm) in comparison with the lower sections (294-378cm). This variation is not surprising given the stratigraphy of the core although the pertinent variation is subtle. At 305cm the stratigraphy changes from olive brown peaty clay with a trace of sand and abundant organic fragments to olive brown sandy clay. The sand remains a significant component of the sediment to the base of the core (392cm). Despite its probably waterlogged accumulation the presence of significant sand probably indicates very rapid deposition thus reducing pollen concentrations. However, despite the generally low concentrations the percentage unidentified and the percentage damaged are all low with one exception (level 336cm) again suggesting the concentration curve is related to the sediment accumulation rate.

T1C14
Pollen and spore concentrations vary from very low to moderate with all but two being of low concentration. The percentage unidentified is variable and has some small number effects, however, the percentage damaged grains are all high. The core is entirely composed of silty clays and there is no discernable relationship between the stratigraphic units and pollen and spore values.

WFQC1
The pollen and spore concentrations from this channel in Warren Farm Quarry vary from moderate to high. The level-to-level variation is low and the percentage unidentified and damaged are also uniformly low. This is probably related to the protection of the relatively organic rich palaeochannel sediments by a silty clay and accords with the good preservation of plant macrofossils.

WFQC2M1, WFQC2M2 and WFQCH2M3
The pollen and spore concentrations from this channel in Warren Farm Quarry vary from moderate to high/very high. The level-to-level variation is very low and the percentage unidentified and damaged are also generally low but with the exception of WFQC2M1 where uniformly higher levels are revealed. This is probably related to the protection of the relatively organic rich palaeochannel sediments by a silty clay and accords with the good preservation of plant macrofossils.

WFQC3
All four samples from this palaeochannel in Warren Farm Quarry had moderate pollen and spore concentrations, with percentage unidentified being low but the two upper samples having a moderately high (c. 20%) percentage of damaged grains. Both of these levels occur in the upper unit of grey clay with a trace of sand and it is most likely that the cause of this high value is due to sand abrasion.

WFQC5
Pollen and spore concentrations in this intra-gravel palaeochannel fill at Warren Farm Quarry vary from low to moderate with the highest concentration being 165 grains per 100 exotics. However, despite these concentrations few grains were unidentified or damaged. By far the highest percentage damaged occurred in the uppermost level and this is probably due to the high Eh reading (60) and the sediments were all organic-rich silty clays.

Core and monolith comparisons can be made by reference to summary statistics (Tab. 6.3).

Core Number	Mean conc.	St dev of conc.	Mean % unid.	St. deviation of % unid.	Mean % damaged	St deviation of % damaged	Mean pH	Mean Eh
MFC2	213	177	20.1	12.5	69.0	17.0	5.4	2.8
T1C7	143	82	4.3	4.9	19.9	13.6	5.3	-6.4
T1C12	163	142	9.5	11.2	34.4	27.7	7.1	-12.4
T1C10	39	47	20.4	28.0	48.0	28.6	6.5	-4
TFGC14	83	72	3.7	4.1	10.2	11.8	5.2	12.0
T1C14	56	34	16.2	10.6	47.7	11.9	7.1	-46.3
WFQC1	338	92	1.1	0.75	10.2	7.3	4.8	-2
WFQC2	342	91	10.5	4.03	25.9	22.3	4.8	-24
WFQC3	279	167	2.8	1.8	13.2	8.5	5.5	5.5
WFQ5	121	41	3.1	2.3	6.3	3.7	6.3	5.3

Tab 6.3: Summary statistics for pollen and spore assessment.

As can be seen above the mean concentrations vary by over a factor of x8. There is also a tendency for the standard deviation to decrease relative to the concentration, however, caution must be exercised here as the number of observations also varies by a factor of x3 (4-16). Secondly, the sites with the lower number of observations (Warren Farm Quarry sites) did not include pollen assessment of the overburden. However, the tendence of the standard deviation to decrease as the values increase for % unidentifiable and % damaged (i.e. in opposite direction to concentration) suggests that this is a real phenomenon and is due to the greater variation associated with overall less well preserved sequences. As might be expected there are some reasonable internal relationships in the dataset with strong correlations between:

mean % damaged & mean % unidentified (0.9)
mean % unidentified & mean % damaged (0.8)
st. dev. damaged & st. dev. unididentified (0.7)
st dev. damaged & mean % concentration (0.7)

As expected both the means and variations of damaged and unidentified grains are related and they are both correlated less strongly with the mean concentration. This suggests that two measures would probably be used to capture the taphanomic variance; the concentration and a measure of damaged grains. Relationships with environmental and sedimentary variables are examined in section 6.3. Exploratory data analysis of was performed on the data set (Tab. 6.4).

Depth	*Organic*	*Carbonate*	*Mag sus*	*rel conc*	*% unid*	*%*	*pH*	*Eh*

		content					*degraded*		
Depth	1								
Organic content	-0.10711	1							
Carbonate	-0.08521	0.174054	1						
Mag sus	-0.06655	0.150102	0.081744	1					
rel conc	-0.26269	0.273563	0.176238	0.119556	1				
% unid	-0.10533	-0.22807	-0.33175	-0.07693	-0.31635	1			
% degraded	-0.20516	-0.12907	-0.36292	0.037632	-0.16484	0.752024	1		
pH	-0.11562	-0.19689	0.012868	-0.15603	-0.3517	0.184801	0.244623	1	
Eh	0.179676	0.100916	-0.12139	0.131256	0.038662	0.022806	0.049315	-0.28324	1

Tab 6.4: Correlation matrix for sediment, pollen and environmental variables.

As can be seen above all the correlations are very low with the exception of internal relationships between the taphanomic variables. This probably because of the range of values contained in the different cores created overwhelming noise. However, there are certainly no clear correlations between depth and the pollen variables, although on a core-by-core basis this can be seen. A probable additional cause of the poor relationships in the total dataset is the difference in environmental conditions in the exposed faces in Warren's Farm Quarry (particularly affecting Eh but also possibly pH). The correlation was therefore repeated using only the core data (Tab. 6.5).

	Depth	Organic content	Carbonate	Mag sus	rel conc	% unid	% degraded	pH	Eh
Depth	1								
Organic content	-0.18569	1							
Carbonate	-0.04071	0.207769	1						
Mag sus	-0.20588	0.17273	0.078291	1					
rel conc	-0.09994	0.300442	0.343797	0.281331	1				
% unid	-0.20971	-0.1984	-0.35312	-0.06036	-0.29016	1			
% degraded	-0.41751	-0.02222	-0.34437	0.114564	0.02087	0.73623	1		
pH	-0.26526	-0.01767	-0.00098	-0.16234	-0.14183	0.078259	0.091004	1	
Eh	0.266523	-0.00994	-0.30763	0.04996	0.019346	0.13883	0.195161	-0.29158	1

Tab 6.5: Correlation matrix for sediment, pollen and environmental variables, core samples only.

As can be seen above the correlations are improved but not substantially. Particularly improved are the correlations with depth as illustrated by Figs. 6.24 and 6.25.
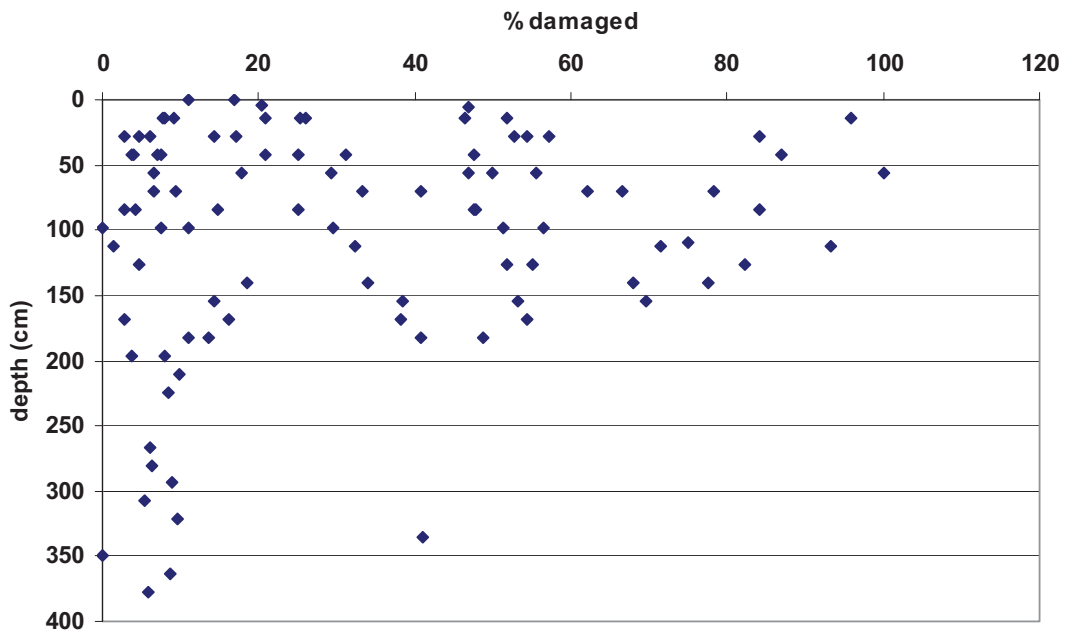
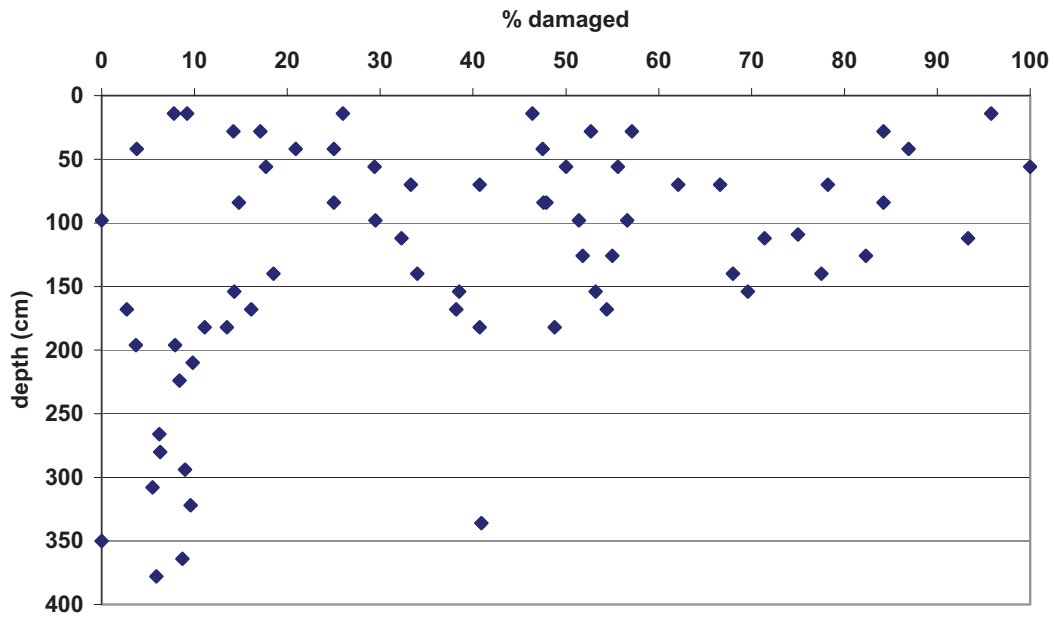**Fig 6.24:** Variation of % damaged (grains) with depth all data.

Fig 6.25: Variation of % damaged (grains) with depth cores only.

It was therefore decided to look at the relationships on a core by core basis using the descriptive data. EDA suggested that the only relationship between the environmental variables and the mean pollen data is between mean pH and the mean pollen and spore concentration (Fig. 6.26: Tab. 6.6).
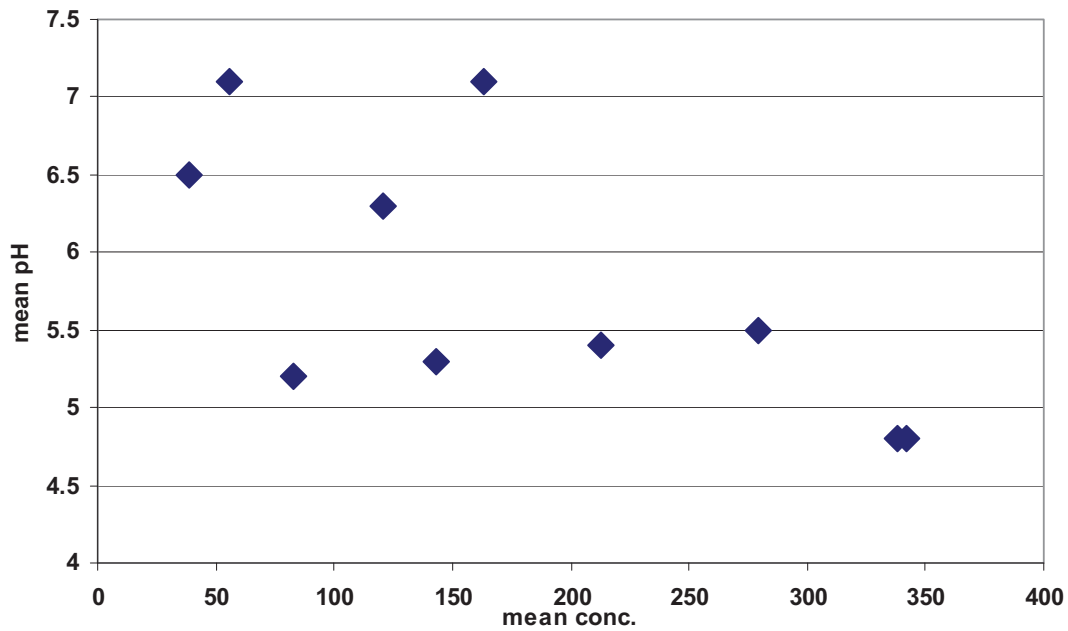
Fig 6.26: Mean concentration of pollen and spores against mean core pH.

	Mean conc.	St dev of conc.	Mean % unid.	St. deviation of % unid.	Mean % damaged	St deviation of % damaged	Mean pH	Mean Eh
Mean conc.	1							
St dev of conc.	0.545485	1						
Mean % unid.	-0.36646	0.006148	1					
St. deviation of % unid.	-0.56347	-0.15076	0.839052	1				
Mean % damaged	-0.25461	0.226981	0.949565	0.720448	1			
St deviation of % damaged	-0.15506	0.13346	0.639511	0.736572	0.56625	1		
Mean pH	-0.67645	-0.25994	0.415751	0.522644	0.362077	0.30371	1	
Mean Eh	0.089786	0.332775	-0.40273	-0.16418	-0.37099	-0.25084	-0.41988	1

Tab 6.6: Mean values for pollen taphanomic variables against mean core pH and Eh.

This relationship is probably an indirect one through the difference between the higher pollen concentration of the more organic-rich exposures and the lower mean concentrations of the clastic-rich cores. However, an unusual element in this area is that the groundwater is known to be sulphur-rich and through oxidation the oxidation of autogenic pyrite weak sulphuric acid can be formed (Ellis and Brown, 1999; Brown et al. in prep.) and this would almost certainly help preserve pollen and spore grains from microbial attack.

6.3 Map of palaeoenvironmental potential over the study area

The cores have been ordered in terms of their average palaeoenvironmental by using the mean concentration, as this factor is crucial in achieving statistically reliable counts. Some of the cores with the higher mean concentrations had high % damaged grains but these were often crumpled and the percentage unidentified is not significantly higher (Tab. 6.7).

Core	Rank	Period covered
MFC2	1	Bronze Age-
T1C12	2	Later Medieval-
T1C7	3	Later Medieval-
TGFC14	4	Neolithic-
T1C14	5	Bronze Age-
T1C10	6	Roman-British-

Tab 6.7: Ranks of the palaeoenvironmental (pollen and spore) potential of the cores.

6.4 Summary

Both the Coleopteran and pollen assessment show that there are strong taphonomic factors affected in the preservation of both beetles and pollen and spores. However, the beetles data also suggests an important role for depositional regime as recently demonstrated by *Davis et. al* (2007). . The pollen data is poorly explained by environmental factors with the possible exception of pH and it is likely that the taphonomic effect is partial through a combination of factors and the depositional regime and immediate post depositional history. More work is underway with this dataset to explore these factors thoroughly.