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UNIVERSITY OF CAMBRIDGE NATURAL RADIOCARBON MEASUREMENTS XII

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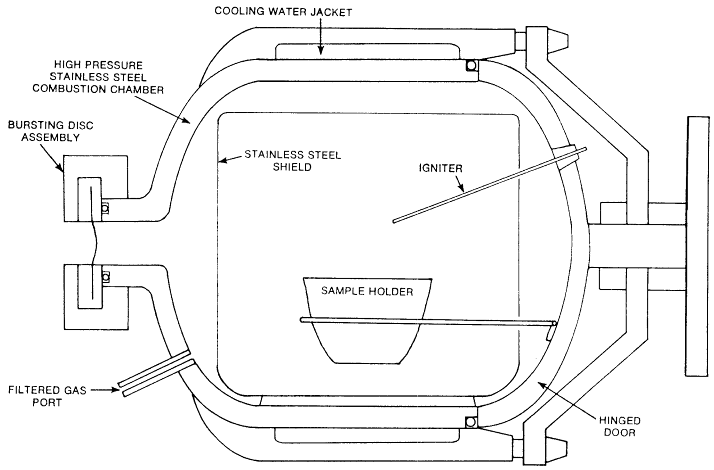
The dates presented here comprise results obtained since our last list (R., 1973, v. 15, p. 156-164). Pure carbon dioxide prepared from the samples is used to fill copper proportional counters at two atmospheres pressure. The detectors are protected from environmental radiation by a massive lead shield inside which, and completely surrounding the proportional counters, is a high efficiency plastic scintillation anticoincidence screen (Switsur, Hall, and West, 1970). Modern sample gas is obtained from combustion of A.D. 1845 to 1855 rings of an oak tree grown near Cambridge, felled in 1950. Background samples are prepared from Welsh anthracite or Connemara limestone. The contemporary standard is compared frequently with the activity of NBS oxalic acid international standard. Age calculations are based on the ^{14}C half-life of 5568 years and the uncertainty stated as one standard deviation calculated from the statistical analysis of sample and standard counting rates.

Dating projects during this period have been in conjunction with members of the Sub-department of Quaternary Research, Univ. of Cambridge, as well as archaeologists from Cambridge and other institutions.

For some years most of our samples have been oxidized in high pressure oxygen in a bomb combustion unit. The Mk I version of this bomb was described briefly in Switsur, Hall, and West (1970). Recently this method of combustion was actively developed at this laboratory, for it has pronounced advantages over the conventional quartz-tube combustion technique: 1) it is very rapid, requiring only a few minutes from loading the sample to production of CO_2; 2) the gas is usually very clean; 3) the oxidation is complete. The CO_2, after drying, is sufficiently pure for use in the synthesis of acetylene and, hence, benzene for liquid scintillation counting. For proportional counting as CO_2, only a minimum of purification is necessary since most acidic impurities are retained in a small quantity of water placed in the combustion chamber prior to oxidation.

The equipment has developed through several stages; the preferred unit now is the improved version of the combustion bomb Mk III (Switsur, 1972), see Fig. 1. The 5.5L stainless steel, horizontal, combustion chamber is smoothly contoured for cleaning ease and no sharp angles exist to cause areas of high stress. Surrounding this is a strong outer casing of mild steel. The heat of combustion released by the sample is removed by cooling water passing through channels in the walls. The domed access door is hinged, the locking mechanism being engaged by the simple rotation of a hand-wheel. Rigidly attached to the door is the removable silica sample carrier and ignition circuit connections. An internal stainless steel liner protects the main body of the chamber



CAMBRIDGE BOMB
HORIZONTAL DESIGN.

Fig. 1

from hot acid spray and may be withdrawn for cleaning between combustions. The liner contains an integral container for distilled water for solution of the gaseous impurities. A replaceable stainless steel bursting disc of special design is located in the rear wall of the combustion chamber. The unit is mounted in a robust metal console containing control valves, filter, proximate electrical circuit and a monitoring pressure gauge fitted with feedback contacts for the control firing circuits. Provision is made for firing the sample from a remote position and indications of the state of the combustion are relayed to the control panel. Normally after two minutes oxidation is complete and a 'combustion success' signal is received.

The advantages of bomb combustion in ^{14}C dating are beginning to be recognized, and a dozen laboratories are installing such units. Ease of operation, saving of technicians' time compared with the quartz tube technique, minimal gas purification and increased rate of sample processing more than justify the initial expense of a high pressure combustion unit. Future planned improvements include: 1) a special stage for oxidation of difficult samples of very low carbon content such as soils and lake muds; 2) a unit for the rapid recovery of counting gases from the combustion chamber.

ACKNOWLEDGMENTS

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. British Isles

Pollen Zone Boundary determinations (Din Moss series)

Fourth site of project by F. A. Hibbert and V. R. Switsur to determine extent of synchroneity for pollen zone boundaries in the British Isles and N Europe. 5cm diam core from a raised bog, Din Moss, Roxburghshire, Scotland (55° 35′ N Lat, 2° 20′ W Long, Natl. Grid Ref. NT 805315) was pollen-analyzed and radiocarbon dated. A core was taken through a sequence extending from close to beginning of Flandrian to Late Flandrian Time. The core was extruded in the lab. where small samples were taken every 2cm for pollen analysis. Subsequently additional samples were taken as thin slices at each pollen zone boundary and other samples were taken at intermediate points corresponding to significant changes in the pollen spectra.

The lower layers were muds of low organic content, but the greater part of the sequence was raised bog peat. After pretreatment, mud samples were oxidized as a suspension in hot potassium permanganate, while the peat was readily oxidized in the high pressure combustion bomb unit. Results will be discussed elsewhere and compared with results from Nant Ffrancon (Switsur and West, 1973), Tregaron SE Bog (Switsur and West, 1972), and other sites in this study (see Hibbert, Switsur, and West, 1971). Collection and pollen analysis by F. A. Hibbert; radiocarbon measurements by V. R. Switsur.

Q-1062. Din Moss, 50 to 54cm **5341 ± 70**
3391 B.C.

Sphagnum-Eriophorum-Calluna peat. Pollen diagram shows final step of *Ulmus* decline. Last of 3 samples defining this decline, see Q-1063 and -1064.

Q-1063. Din Moss, 54 to 58cm **5392 ± 70**
3442 B.C.

Sphagnum-Eriophorum-Calluna peat from point of inflection of *Ulmus* decline curve on pollen diagram.

Q-1064. Din Moss, 58 to 62cm **5441 ± 70**
3491 B.C.

Sphagnum-Eriophorum-Calluna peat. Pollen diagram indicates onset of *Ulmus* decline. 1st of 3 samples defining this decline, see Q-1062 and -1063.

6008 ± 100
Q-1065. Din Moss, 106 to 110cm **4058 B.C.**

Sphagnum-Eriophorum-Calluna peat, representing middle of Chronozone FII and serving as check on rate of moss growth.

6528 ± 100
Q-1066. Din Moss, 180 to 184cm **4578 B.C.**

Sphagnum-Eriophorum-Calluna peat. 1 of series Q-1066-1068, dating latest of 2 rises of *Alnus* pollen curve.

6708 ± 100
Q-1067. Din Moss, 184 to 188cm **4758 B.C.**

Sphagnum-Eriophorum-Calluna peat. Middle sample for series dating later of the 2 rises of *Alnus* pollen curve.

6778 ± 100
Q-1068. Din Moss, 188 to 192cm **4828 B.C.**

Sphagnum-Eriophorum-Calluna peat. Final sample of series dating later rise of *Alnus* pollen frequencies.

6858 ± 100
Q-1069. Din Moss, 240 to 244cm **4907 B.C.**

Raised bog peat, more highly humified than Q-1062-1068. 1 of series of 3 samples, Q-1069 to Q-1071 dating earlier *Alnus* rise in the pollen diagram.

7146 ± 120
Q-1070. Din Moss, 244 to 248cm **5196 B.C.**

Humified raised bog peat taken at mid-point of earlier *Alnus* rise.

7360 ± 140
Q-1071. Din Moss, 248 to 252cm **5410 B.C.**

Humified raised bog peat. 1st of series Q-1069 to Q-1071 dating earlier rise of *Alnus* pollen frequencies.

7670 ± 150
Q-1072. Din Moss, 286 to 290cm **5720 B.C.**

Phragmites peat. In pollen diagram, values of *Quercus* frequencies rise considerably above *Ulmus* in this region, but there is no *Pinus* peak as at Red Moss.

8684 ± 170
Q-1073. Din Moss, 318 to 322cm **6734 B.C.**

Phragmites peat. This is a check on Moss growth rate at mid-point of Chronozone FIc. Pollen diagram shows a *Corylus* maximum and beginning of rise of *Quercus* frequencies.

8940 ± 170
Q-1074. Din Moss, 368 to 372cm **6990 B.C.**

Phragmites peat. 1 of series spanning expansion of *Corylus* pollen frequencies.

Q-1075. Din Moss, 372 to 376cm **9120 ± 170**
7170 B.C.

Phragmites peat from the mid-point of *Corylus* rise.

Q-1076. Din Moss, 376 to 380cm **9275 ± 170**
7325 B.C.

Phragmites peat. 1st of series, Q-1074 to Q-1076 defining *Corylus* expansion. Curve of *Juniperus* pollen terminates just as *Corylus* begins to rise.

Q-1077. Din Moss, 402 to 406cm **9824 ± 190**
7874 B.C.

Coarse detritus mud. At this point on pollen diagram *Corylus* 1st appears.

Q-1078. Din Moss, 412 to 416cm **10,337 ± 200**
8387 B.C.

Fine detritus mud. On pollen diagram, *Juniperus* exhibits a maximum.

Q-1080. Din Moss, 452 to 460cm **12,251 ± 250**
10,301 B.C.

Fine detritus mud; dates early Flandrian deposits.

General Comment: results are internally very consistent and are fully comparable with those from Scaleby Moss (R., 1959, v. 1, p. 63-65), Red Moss (R., 1970, v. 12, p. 590-598), Tregaron (R., 1972, v. 14, p. 239-246) and Nant Ffrancon (R., 1973, v. 15, p. 156-159). Dates from Tregaron, Nant Ffrancon and Din Moss will be discussed by V. R. Switsur and F. A. Hibbert, (ms. in preparation).

Bodmin Moor series

This is a continuation of the collaboration between A. P. Brown and V. R. Switsur in determining the course of vegetational changes during the Late Weichselian and Early Flandrian time. Samples are from a peat monolith which reached down to granite boulders forming the basin of the original lake at Hawks Tor (50° 33′ N Lat, 4° 37′ W Long, Natl. Grid Ref. SX 153747). Pollen diagram indicated 2 periods of climatic amelioration similar to those described by Coope *et al.* (1971) and Pennington (1970). Samples id. by depth in the pollen diagram.

Q-977. Hawks Tor 3, 15 to 17cm **12,553 ± 280**
9603 B.C.

Sec. of monolith consisting of moderately humified sedge peat containing *Betula* wood and *Carex* nutlets. Pollen diagram showed *Betula* rise; the normal basis for dividing classical Pollen Zones I and II.

Q-978. Hawks Tor 3, 28 to 30cm **12,354 ± 300**
10,404 B.C.

Moderately humified sedge peat, dating appearance of *Juniperus* in pollen diagram.

12,635 ± 300
Q-967. Hawks Tor 3, 32 to 34cm **10,685 B.C.**

Dark, coarse, detritus mud with broad rippled kaolin bands. Pollen diagram shows 1st continuous appearance of *Juniperus* prior to the *Betula* rise.

11,758 ± 300
Q-975. Hawks Tor 3, 38 to 40cm **9808 B.C.**

Blotched and banded light buff silt. Contains fruits and seeds indicating an amelioration of the climate, but this occurs 22cm below point in monolith at which pollen diagram shows *Betula* rise, Q-977. Sample contained rootlets of non-contemporaneous origin; not all could have been removed, which produced a date later than expected.

13,088 ± 300
Q-979. Hawks Tor 3, 49 to 51cm **11,138 B.C.**

Blotched light buff silt containing seeds, at base of deposit. Date helps estimate time of lake's existence.

General Comment: apart from Q-975, affected by rootlet contamination, series is consistent internally and with other dates from the region. Dates span pre-Alleröd amelioration.

Hockham Mere series

Core of limnic muds obtained by a Livingstone type borer from Hockham Mere, Norfolk (52° 29′ N Lat, 0° 52′ E Long, Natl. Grid Ref. TL 935937). Sections, thickness based on carbon content were dated by reference to pollen diagram and assoc. archaeologic artifacts. Pollen analysis by R. E. Sims and radiocarbon measurements by V. R. Switsur, both of Sub-dept. Quaternary Research, Univ. Cambridge.

734 ± 30
Q-1093. Hockham Mere, 52 to 62cm **A.D. 1216**

Coarse detritus mud.

1145 ± 30
Q-1090. Hockham Mere, 80 to 90cm **A.D. 805**

Coarse detritus lake mud. Pollen diagram shows rise of *Cannabis Humulus* frequencies.

1929 ± 35
Q-1091. Hockham Mere, 110 to 120cm **A.D. 21**

Coarse detritus lake mud. Assoc. with Roman settlement.

3022 ± 45
Q-1094. Hockham Mere, 170 to 180cm **1072 B.C.**

Coarse detritus lake mud.

3901 ± 55
Q-1095. Hockham Mere, 210 to 220cm **1951 B.C.**

Coarse detritus lake mud. Assoc. with Bronze age settlement.

4585 ± 120
Q-1045. Hockham Mere, 265 to 274cm **2635 B.C.**

Detritus lake mud. Marks end of elm decline where forest reached 2nd mature phase.

4750 ± 115
Q-1046. Hockham Mere, 281 to 289cm **2800 B.C.**

Detritus lake mud. Marks end of phase with increased concentrations of herbs and *Pteridium* spores.

4794 ± 115
Q-1047. Hockham Mere, 290 to 298cm **2844 B.C.**

Detritus lake mud. Concentration of tree and shrub pollen starts to increase.

4986 ± 115
Q-1048. Hockham Mere, 300 to 308cm **3036 B.C.**

Detritus lake mud. Marks mid-point of elm decline.

5210 ± 120
Q-1049. Hockham Mere, 316 to 324cm **3260 B.C.**

Detritus lake mud. Marks beginning of fall in concentration of pollen of trees and shrubs.

5830 ± 90
Q-1089. Hockham Mere, 352 to 364cm **3880 B.C.**

Fine detritus lake mud. Dates the lowered lake level.

7447 ± 125
Q-1088. Hockham Mere, 432 to 448cm **5495 B.C.**

Fine detritus lake mud. Marks Mesolithic clearance phase.

6730 ± 120
Q-1087. Hockham Mere, 377 to 394cm **4780 B.C.**

Fine detritus mud, taken at rise of *Alnus* in the pollen diagram.

General Comment: dates are internally consistent and serve as basis for calculation of absolute pollen influx (Sims, 1972).

Q-1100. Hoxne, Suffolk **>43,000**

Wood from depth ca. 5m from Oakley Park pit, Hoxne, Suffolk (52° 21′ N Lat, 1° 12′ E Long Natl. Grid Ref. TM 174766). Wood was from Stratum D (West, 1956) of sump pit, XXIII test of J. Wymer's excavations. Coll. July 1972 by C. Turner, J. Wymer, and N. J. Shackleton to investigate cause of anomalous ages reported by Page (1972), and, if necessary, to further study pretreatment methods. Portion of sample also dated by Univ. Birmingham Radiocarbon Dating Lab. (Birm-365: >47,600). See also Birm-387: >48,500 (Shotton, 1973). *Comment*: because no radioactivity was detected after normal pretreatment, we are unable to comment on the source of activity in T-1030: 24,100 ± 400 and T-932: 24,500 ± 560 (Page, 1972), but we emphasize importance of careful collection of suitable material, from a fresh exposure with good stratigraphic control, if anomalous ^{14}C activity in old samples is to be avoided.

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It is certain that deposit is much >100,000 yr and that ^{14}C activity reported in Page (1972) in no degree derives from time of formation of deposits. It would be of value to determine source of activity in Hoxne samples of Page to aid interpretation of dates which are important for the Devensian.

Editorial Comment: only 5% modern carbon in an "impurity" sample would produce dates quoted by Page. This might be a lab error, rather than sampling, since a 10^{-2}cc/min leak would provide adequate carbon in a 4-hr synthesis.

B. North America

Wolf Creek (Minnesota) series

Calculating pollen influx depends on rate of sediment accumulation, which in turn requires a series of radiocarbon dates through the sediment. Eleven samples were dated by Teledyne Isotopes (I-5435 to I-5441), but the following series of 4 samples was required for critical calculations at pollen analytic transitions. Samples were coll. by H. J. Birks and H. E. Wright from Wolf Creek (94° 07′ N Lat, 46° 07′ W Long) 12km NNW of Pierz, Morrison Co., Minnesota, U.S.A. using a 10cm diam piston borer with 1.25cm diam. drive rods, driving with 2 1-ton chain hoists, 4 earth anchors and 'Cushing' drive frame. Samples showed large loss on ignition, mostly from sulphur, necessitating thorough pretreatment.

Q-1081. Wolf Creek, 496 to 498cm **10,534 ± 200**
8584 B.C.

Fine detritus mud from within a long series of late Wisconsin sediments. Dates transition from *Picea-Larix* zone to *Pinus-Pteridium* zone.

Q-1082. Wolf Creek, 595 to 598cm **11,722 ± 220**
9772 B.C.

Humified marly copropel, slightly calcareous, within *Picea-Larix* zone.

Q-1083. Wolf Creek, 775 to 780cm **13,350 ± 270**
11,400 B.C.

Sideritic marly copropel, slightly calcareous and rich in iron sulphide. Lies within *Picea-Larix* zone.

Q-1084. Wolf Creek, 825 to 839cm **13,775 ± 310**
11,825 B.C.

Silty sideritic copropel near base of *Picea-Larix* zone.

General Comment: Q-1081 to -1803 are consistent with other dates from intermediate depths obtained from Teledyne Isotopes, and permit calculation of a more reliable sediment accumulation rate, and hence, pollen influx than hitherto possible. Q-1084 is slightly older compared with I-5046 (852.5 to 857.5cm, 13,600 ± 200 B.P.) and I-5910 (847.5 to 852.5cm, 13,670 ± 210) for samples 27.5 and 22.5cm below sample

Q-1084, although differences between the dates are all within errors quoted, indicating very rapid sediment accumulation at this time.

II. ARCHAEOLOGIC SAMPLES

Q-1085. Nelson Bay Cave **10,256 ± 210**
8306 B.C.

Ash containing charcoal from brown soil below Midden Jake at depth ca. 2.5m below surface of complex series of middens in Nelson Bay Cave, (34° 06′ S Lat, 23° 24′ E Long) in Cape Province, South Africa. One sample from many being dated at Univ. Washington, CSIRO Lab. Pretoria and Teledyne Isotopes. Dates concern late quaternary environment and cultural change in S Africa. This dates earliest use of Midden Jake. Sample coll. summer 1971 by R. G. Klein, Dept. Anthropol., Univ. Washington.

Q-973. Greenham Dairy Farm **8779 ± 110**
6829 B.C.

Red deer bone from 15cm layer of fine silt stratified with Mesolithic artifacts. Forms part of filling of what was probably a cut-off meander in Kenner Valley flood plain at Greenham Dairy Farm, Newbury, Berkshire (51° 24′ N Lat, 1° 19′ W Long, Natl. Grid Ref. SU 474676). Discovered during a rescue excavation in 1963 by R. Sheridan (Sheridan *et al.*, 1967). Subm. by R. M. Jacobi, Gonville and Caius College, Cambridge. Sample dates assoc. Mesolithic Industry.

Q-1039. Mildenhall Fen **4204 ± 60**
2254 B.C.

Bog oak from just under bark unearthed during cultivation of the Fen near Mildenhall, Suffolk (52° 22′ N Lat, 0° 32′ E Long, Natl. Grid Ref. 52/714774). One of many oaks killed by transgression of sea. Age agrees well with other determinations from the area towards sea. Subm. by R. Bonnett, Queen Mary College, London. Part of a joint project with V. R. Switsur to investigate chemical degradation in fossil wood.

Sweet Trackway series

Earliest of trackways so far discovered in Somerset Levels, SW England. Built across reed swamp between Polden Hills and Mendip-Wedmore heights. Samples coll. 1971 and 1972 by J. M. Coles in joint program with V. R. Switsur and F. A. Hibbert dating Somerset trackway complex. Samples from track at Shapwick (51° 10′ N Lat, 2° 50′ W Long, Natl. Grid Ref. ST 423404). Dates associate track construction, peat stratigraphy in area, and many artifacts of Early Neolithic character (Coles, 1973).

Q-962. Sweet Track, Shapwick, 303 **5150 ± 65**
3200 B.C.

Wooden peg (unid.) driven beside track surface into clay-peat interface.

Q-963. Sweet Track, Shapwick, 325 **5218 ± 75** **3268 B.C.**

Wooden peg (hazel) driven deep into clay-peat interface adjacent to the track.

Q-966. Sweet Track, Shapwick, 180 **5159 ± 76** **3209 B.C.**

Wooden slat (hazel) driven deep into peat beside the track.

Q-967. Sweet Track, Shapwick, R 5 **5108 ± 65** **3158 B.C.**

Raised bog peat overlying upper timbers of track.

Q-968. Sweet Track, Shapwick, R 10 **5224 ± 75** **3274 B.C.**

Raised bog peat overlying upper timbers of track.

Q-1044. Brno-Bohunice **40,172 ± 1200** **38,222 B.C.**

Charcoal from area exposed beneath 'Kejbaly' building site in Brno, Moravia, Czechoslovakia (49° 10′ N Lat, 16° 37′ E Long). Charcoal occurred in lentils in fossil soil in loess beneath a cover of 1 to 2m loess. Also at this level a rich early Upper Palaeolithic assemblage with leaf points, probably the oldest Palaeolithic Industry in Central Europe, was found. Coll. and subm. by K. Valoch, Anthropos Inst. Moravske Mus., Brno, CSSR. Charcoal id. as *Abies* sp. and *Picea* vel *Larix* by Em. Opravil, Opava, CSSR.

North Elmham, Norfolk series

During excavations at North Elmham Park, Norfolk (52° 45′ N Lat, 0° 56′ E Long, Natl. Grid Ref. TF 987215), P. Wade-Martins, Winchester Research Unit, discovered a well or cistern of Saxon age. The lower part was lined with large timbers of oak, subsequently shown to be from the same large tree. The combination of radiocarbon dating techniques, by V. R. Switsur, Univ. Cambridge, and dendrochronology by J. M. Fletcher, Research Lab. for Archaeol., Univ. Oxford led to determination of felling date of the timber and the probable date for sinking the cistern. Timber was from W side of cistern at depth 5.2m below surface. Plank was 1.5m long by 30cm wide. Four samples were taken, each ca. 10 annual rings wide and separated by 50 to 60 growth rings.

Q-1043. North Elmham Cistern, W 11/P **1315 ± 40** **A.D. 635**

Oak wood, 11 annual growth rings wide, of average year No. 20.

Q-1041. North Elmham Cistern, W 11/M1 **1266 ± 40** **A.D. 684**

Oak wood, 15 annual growth rings wide, of average yr. No. 75.

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Q-1042. North Elmham Cistern, W 11/M2 **1220 ± 40**
A.D. 730

Oak wood, 15 annual growth rings wide, of average Yr. No. 109.

Q-1040. North Elmham Cistern, W 11/S **1172 ± 40**
A.D.778

Oak wood, 7 annual growth rings wide, of average Yr. No. 167.

General Comment: series is remarkably consistent. Results yield felling date of A.D. 831 ± 20 yr. Dates will help fix floating tree-ring chronology for SE England of middle Saxon times. Full descriptions of the cistern and its dates appear elsewhere (Wade-Martins *et al.*, 1972; 1973).

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