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# SCOTTISH UNIVERSITIES RESEARCH AND REACTOR CENTRE RADIOCARBON MEASUREMENTS I

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## INTRODUCTION

The Radiocarbon Laboratory at the Scottish Universities Research and Reactor Centre was established in August 1971. The laboratory is funded by the Natural Environment Research Council and its main function is geochemical investigations in collaboration with the component bodies of the Council and with grant-aided associations. A dating service is also provided to others.

$C^{14}$ measurement is by liquid scintillation with two counting systems. Details of laboratory design and operational procedures and parameters are described in Harkness and Wilson (1972).

Dubious carbon fractions are carefully removed from all samples and pretreatment is determined in collaboration with the collectors after considering composition, environment, and scientific context of each sample.

Mass spectrometric analysis is carried out for all samples. $C^{13}/C^{12}$ ratios are quoted relative to the PDB limestone standard with a precision of $\pm 1.0‰$ ($\pm 2\sigma$). In certain cases, e.g., marine shell and groundwater carbon, the standard age adjustment for isotopic fractionation is considered invalid although $\delta C^{13}$ values are still quoted for general information. Where reported, such sample ages are calculated from $\delta C^{14}$ and are so indicated in the text. Otherwise, calculations are based on the Lamont formulae (Broecker and Olson, 1961) using the Libby half-life ($5570 \pm 30$ years) and 95% of the isotopically corrected activity of NBS oxalic acid as the modern reference standard. Standard deviations quoted ($\pm 1\sigma$) describe only the compounded uncertainties associated with sample, background, modern standard, and mass spectrometric measurements (Callow *et al.*, 1965); similarly age limits are defined by the $4\sigma$ criterion.

## ACKNOWLEDGMENTS

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## SAMPLE DESCRIPTIONS

### I. INTERCALIBRATION SAMPLES

Prior to routine measurement of $C^{14}$ ages, a number of samples were requested from other laboratories for intercalibration.

**SRR-1. Mad Brook Valley, Shropshire** **3500 ± 70**
**1550 B.C.**
$\delta C^{13} = -29.4‰$

Wood from buried tree trunk in Mad Brook Valley at Telford, Shropshire previously dated by Radioactive Dating Lab., Stockholm, IGS—C14/60 (St 3392); 3180 ± 100 (Welin *et al.*, 1972).

**SRR-2. Madeley Court, Shropshire** **1282 ± 60**
**A.D. 668**
$\delta C^{13} = -29.1‰$

Peat from thrust bore tunnel N of Madeley Court, Telford, Shropshire previously dated by Radioactive Dating Lab., Stockholm, IGS—C14/63; 1130 ± 100 (unpub.).

**SRR-3. Kilphedir hut circles, Sutherland, Scotland** **2100 ± 50**
**150 B.C.**
$\delta C^{13} = -26.2‰$

Charcoal (*Birch-Betula*) from hut circle at Kilphedir site previously dated by Lamont Geol. Observatory, Columbia Univ., L-1061; 2100 ± 80 (unpub.), and by Glasgow Univ., GU-10; 1908 ± 60, GU-11; 2064 ± 55 (Baxter *et al.*, 1969), GU-67; 1922 ± 60 (Ergin *et al.*, 1970).

**SRR-4. Elloughton Beck, Yorkshire** **4029 ± 70**
**2079 B.C.**
$\delta C^{13} = -25.7‰$

Wood fragment from layer of organic silt at Elloughton Beck previously dated by Radioactive Dating Lab., Stockholm, IGS—C14/59 (St 3397); 3905 ± 105 (Welin *et al.*, 1972).

**SRR-5. Wadji** **4656 ± 60**
**2706 B.C.**
$\delta C^{13} = -20.8‰$

Wood from Egyptian tomb previously described and dated by the the British Mus., BM-321; 4496 ± 80 (Barker *et al.*, 1971).

**SRR-6. Teti** **3940 ± 80**
**1990 B.C.**
$\delta C^{13} = -21.2‰$

Wood from Egyptian tomb previously described and dated by the British Mus., BM-331; 3770 ± 85 (Barker *et al.*, 1971), and by Belfast Radiocarbon Lab., UB-66; 3950 ± 70 (Smith *et al.*, 1973).

**SRR-7. Wakefield, Yorkshire** **2569 ± 80**
**619 B.C.**
$\delta C^{13} = -23.3‰$

Wood (*Quercus*) from gravel pit in valley of R. Calder, Wakefield previously dated by Radioactive Dating Lab., Stockholm, IGS—C14/65 (St 3399); 2585 ± 100 (Welin *et al.*, 1972).

**SRR-8. Wood** **5643 ± 80**
**3693 B.C.**
*$\delta C^{13} = -23.3‰$*

Unid. wood supplied and previously dated by Teledyne Isotopes, I-4987; 5710 ± 115 and 5660 ± 120 (unpub.).

**SRR-9. Redkirk Point, Dumfriesshire** **12,064 ± 120**
*$\delta C^{13} = -26.8‰$*

Peat from Redkirk Point previously dated by Birmingham Univ., Birm-41; 11,205 ± 177 (Shotton *et al.*, 1968), and Glasgow Univ., GU-14; 11,828 ± 105, GU-15; 12,158 ± 218 (Baxter *et al.*, 1969).

## II. GEOLOGIC SAMPLES

### *A. United Kingdom*

**SRR-10. Loch Clair, 200 to 210cm** **3525 ± 80**
**1575 B.C.**
*$\delta C^{13} = -28.1‰$*

Non-calcareous fine detritus lake mud from Core 1, Loch Clair, Wester Ross, Scotland (57° 40′ N Lat, 5° 25′ W Long). Coll. 1969 and subm. by W. Tutin (W. Pennington), Univ. Leicester. *Comment* (W.T.): date falls on linear depth-time scale for pollen zone boundaries in NW Scotland (Pennington *et al.*, 1972). Adjacent secs. of core dated, I-4816; 2900 ± 100, and I-4815; 4700 ± 100. These 3 dates span period during which pine forest disappeared from catchment of Loch Sionascaig. There is no pollen evidence for any contemporaneous deforestation around Loch Clair.

**SRR-11. Burnmoor Tarn, 405 to 415cm** **7258 ± 100**
**5308 B.C.**
*$\delta C^{13} = -29.6‰$*

Non-calcareous fine detritus lake mud overlying expansion of alder (*Alnus*) at Godwin Zone Boundary VIc/VIIa, Core 5, Burnmoor Tarn, Cumberland, England (54° 25′ N Lat, 3° 17′ W Long). Coll. 1965 and subm. by W. Tutin. *Comment* (W.T.): date agrees closely with that of underlying core sec., Y-2361; 7560 ± 160 (Stuiver, 1969) and with other dates for this horizon in NW England.

**Loch Sionascaig series, Scotland**

Non-calcareous fine detritus lake mud from Core 6, Loch Sionascaig, Wester Ross, Scotland (58° 3′ N Lat, 5° 10′ W Long). Depth intervals relate to present mud surface. Coll. 1967 and subm. by W. Tutin.

**SRR-12. Loch Sionascaig, 275 to 285cm** **4485 ± 100**
**2535 B.C.**
*$\delta C^{13} = -21.2‰$*

*Comment* (W.T.): sample represents topmost 10cm of sec. of core within which sediments contain 50 to 60% pine pollen (as % of total pollen). Local deforestation must have begun soon after this date. The pollen zone boundary N Scotland Vii/VI at Loch Sionascaig is drawn at the upper limit of this sample.

**SRR-13. Loch Sionascaig, 400 to 410cm** **7136 ± 130**
**5186 B.C.**
$\delta C^{13} = -24.9‰$

*Comment* (W.T.): date agrees with Y-2364; 7880 ± 160 in that increase in pine pollen to 50 to 60% of the total began soon after 6000 B.C. and was completed by 5186 ± 130 B.C. at this site.

**SRR-14. Loch Sionascaig, 460 to 470cm** **8523 ± 120**
**6573 B.C.**
$\delta C^{13} = -25.3‰$

*Comment* (W.T.): sample represents middle of birch-hazel pollen zone (N Scotland III) which preceded Pine Zones IV and V.

**SRR-15. Loch Sionascaig, 500 to 510cm** **9474 ± 160**
**7524 B.C.**
$\delta C^{13} = -23.1‰$

*Comment* (W.T.): sample represents middle of juniper zone (N Scotland II) below birch-hazel zone, and indicates delay in expansion of postglacial birch forest in N Scotland as compared with S Britain.

*General Comment* (W.T.): data fall on linear depth-time scale indicated by Y-2362; 4020 ± 100, Y-2363; 6250 ± 140, and Y-2364; 7880 ± 160 (Stuiver, 1969) and confirm sediment accumulation rates as uniform over the period studied. Data establish dates for pollen zone boundaries in NW Scotland (Pennington *et al.*, 1972).

**Blea Tarn series, England**

Postglacial non-calcareous fine detritus lake mud from Blea Tarn, Westmorland, England (54° 21′ N Lat, 3° 5′ W Long). Core 1 obtained from deepest part of tarn (8.25m water) with 6m Mackereth corer. Depth intervals relate to present mud surface. Coll. 1971 and subm. by W. Tutin.

**SRR-16. Blea Tarn, 94 to 100cm** **4476 ± 70**
**2526 B.C.**
$\delta C^{13} = -29.7‰$

**SRR-17. Blea Tarn, 120 to 126cm** **4956 ± 60**
**3015 B.C.**
$\delta C^{13} = -30.1‰$

**SRR-18. Blea Tarn, 140 to 150cm** **5235 ± 55**
**3285 B.C.**
$\delta C^{13} = -29.3‰$

**SRR-19. Blea Tarn, 210 to 215cm** **6374 ± 90**
**4424 B.C.**
$\delta C^{13} = -29.8‰$

**SRR-20. Blea Tarn, 250 to 260cm** **7264 ± 70**
**5314 B.C.**
$\delta C^{13} = -29.2‰$

**SRR-21. Blea Tarn, 290 to 300cm** **8514 ± 85**
**6564 B.C.**
$\delta C^{13} = -30.0‰$

**SRR-22. Blea Tarn, 320 to 330cm** **9012 ± 100**
**7062 B.C.**
$\delta C^{13} = -29.9‰$

**SRR-23. Blea Tarn, 352 to 357cm** **9872 ± 180**
**7922 B.C.**
$\delta C^{13} = -29.6‰$

*General Comment* (W.T.): data provide a time scale for annual pollen deposition rates (Pennington *et al.*, 1972). Dates for Elm Decline, Godwin Zone Boundary VIIa/VIIb, as given by SRR-17 and SRR-18, agree closely with this horizon in a previous Blea Tarn core, K-957; 5100 ± 120, K-958; 5320 ± 120, and K-959; 5530 ± 120 (Tauber, 1966) and with many dates for this horizon in NW Europe (Hibbert *et al.*, 1971). Detailed absolute pollen analysis over Elm Decline horizon is in press (Pennington, 1973). Remainder of profile is being analyzed and a complete postglacial absolute pollen diagram will be pub. later.

**Loch a'Chroisg series, Scotland**

Non-calcareous fine detritus lake mud from Loch a'Chroisg, Wester Ross, Scotland (57° 30′ N Lat, 5° 10′ W Long). Samples coll. with 6m Mackereth corer, depth intervals relate to present mud surface. Coll. 1971 and subm. by W. Tutin.

**SRR-53. Loch a'Chroisg, 290 to 300cm** **2893 ± 60**
**943 B.C.**
$\delta C^{13} = -29.1‰$

**SRR-54. Loch a'Chroisg, 340 to 346cm** **3583 ± 75**
**1633 B.C.**
$\delta C^{13} = -28.7‰$

**SRR-55. Loch a'Chroisg, 390 to 400cm** **4149 ± 70**
**2199 B.C.**
$\delta C^{13} = -28.5‰$

*General Comment* (W.T.): dates span sec. of core in which pollen content of sediments record a steep decline in ann. deposition of pine pollen per unit area. This is accompanied by an absolute increase in the numbers of grains/yr of bog plant pollen. Replacement of pine forest by blanket bog on this catchment, therefore, probably took place at approx. same time as deforestation at Loch Sionascaig. The absolute pollen diagram for this horizon is in press (Pennington, 1973).

**Valley Bog series, England**

Peat from Valley Bog, Moorhouse Natl. Nature Reserve, Upper Teesdale, England (54° 42′ N Lat, 2° 22′ W Long), Natl. Grid Ref. 35763331, at alt. 549m (Newlyn). Sample profile coll. using Russian peat borer, and depths relate to present ground surface. Coll. 1970 and subm. by C. Chambers and J. Turner, Univ. Durham.

This series is assoc. with a pollen diagram from Valley Bog constructed by C. C. with a view to dating major vegetational changes already apparent on Johnson and Dunham's diagram (1963).

**SRR-88. Valley Bog, 152.5 to 157.5cm** — **2212 ± 55**, **262 B.C.**, $\delta C^{13} = -26.3‰$

Sample overlies 1st major rise in *Plantago* pollen.

**SRR-89. Valley Bog, 157.5 to 162.5cm** — **2175 ± 45**, **225 B.C.**, $\delta C^{13} = -26.5‰$

Sample underlies 1st major rise in Plantago pollen. *Comment* (J.T.): SRR-88 and -89 indicate that woodland of region was cleared for 1st time during Iron age.

**SRR-90. Valley Bog, 302.5 to 307.5cm** — **4596 ± 60**, **2646 B.C.**, $\delta C^{13} = -26.9‰$

Sample overlies 2nd elm decline.

**SRR-91. Valley Bog, 312.5 to 317.5cm** — **4794 ± 55**, **2844 B.C.**, $\delta C^{13} = -27.1‰$

Sample underlies 2nd elm decline. *Comment* (J.T.): SRR-90 and -91 indicated that 2nd decrease in elm pollen frequency occurred ca. 4700 B.P., a little later than average date for this horizon in Britain but not significantly outside range of dates.

**SRR-92. Valley Bog, 421 to 426cm** — **5950 ± 60**, **4000 B.C.**, $\delta C^{13} = -27.1‰$

Sample overlies 1st elm decline.

**SRR-93. Valley Bog, 426 to 431cm** — **5945 ± 50**, **3995 B.C.**, $\delta C^{13} = -26.2‰$

Sample underlies 1st elm decline. *Comment* (J.T.): SRR-92 and -93 indicate that 1st decrease in elm pollen frequency occurred ca. 5950 B.P., significantly earlier than normal range of dates for this horizon in Britain.

**SRR-94. Valley Bog, 502.5 to 507.5cm** — **6714 ± 74**, **4764 B.C.**, $\delta C^{13} = -27.0‰$

Sample overlies decrease in pine pollen.

**SRR-95. Valley Bog, 512.5 to 517.5cm** **6779 ± 75**
**4829 B.C.**
$\delta C^{13} = -26.4‰$

Sample underlies decrease in pine pollen. *Comment* (J.T.): SRR-94 and -95 indicate that pine remained important in forests of area until ca. 6700 B.P., substantially later than in Cow Green Reservoir area, further down the Tees Valley, where it began to decrease after 8070 ± 170 B.P. and completely disappeared by 5770 ± 110 B.P.

**Neasham Fen series, England**

Peat and detritus mud from infilled kettle hole at Neasham Fen, Darlington, England (54° 30′ N Lat, 1° 29′ W Long), Natl. Grid Ref. NZ 331116. Sample core coll. using Russian peat borer; depths relate to present ground surface. Coll. 1971 by C. Chambers; subm. by J. Turner. Series is assoc. with pollen diagram prepared by C. C. and dates all the major vegetational changes.

**SRR-96. Neasham Fen, 55 to 60cm** **1213 ± 60**
**A.D. 737**
$\delta C^{13} = -25.9‰$

Sedge peat related to final expansion of *Cyperaceae, Gramineae,* and *Plantago* pollen frequencies. *Comment* (J.T.): indicates extensive forest clearance in area during 8th century A.D.

**SRR-97. Neasham Fen, 100 to 105cm** **2804 ± 80**
**854 B.C.**
$\delta C^{13} = -30.7‰$

Muddy peat dating end of 1st main clearance phase.

**SRR-98. Neasham Fen, 105 to 110cm** **2850 ± 60**
**900 B.C.**
$\delta C^{13} = -22.7‰$

Muddy peat, sec. dated in view of apparent age/depth anomaly between SRR-97 and -100.

**SRR-99. Neasham Fen, 135 to 140cm** **2538 ± 50**
**588 B.C.**
$\delta C^{13} = -27.1‰$

Muddy peat, sec. dated in view of apparent age/depth anomaly between SRR-97 and -100.

**SRR-100. Neasham Fen, 140 to 145cm** **2488 ± 75**
**538 B.C.**
$\delta C^{13} = -28.4‰$

Muddy peat, corresponds to beginning of 1st major phase of forest clearance.

*General Comment* (J.T.): dates SRR-97-100 are not in expected order of depth, and even after adjustment to Bristlecone Pine calibration curve (Suess, 1970) remain anomalous. However, series indicates some forest clearance during 1st half of 1st millennium B.C.

**SRR-101. Neasham Fen, 245 to 250cm**

**3242 ± 70**
**1292 B.C.**
$\delta C^{13} = -27.2‰$

Detritus mud, dates minor phase of forest clearance to Bronze age.

**SRR-102. Neasham Fen, 335 to 340cm**

**5468 ± 80**
**3518 B.C.**
$\delta C^{13} = -31.6‰$

Detritus mud corresponds to level at which *Ulmus* pollen frequency falls to <5% total tree pollen. *Comment* (J.T.): date seems early side for elm decline in Britain.

**SRR-103. Neasham Fen, 410 to 415cm**

**6962 ± 90**
**5012 B.C.**
$\delta C^{13} = -31.2‰$

Detritus mud corresponds to level at which *Alnus* pollen frequencies rise. *Comment* (J.T.): date is similar to others obtained for VI/VIIa pollen zone boundary in Britain.

**SRR-104. Neasham Fen, 530 to 535cm**

**8202 ± 95**
**6252 B.C.**
$\delta C^{13} = -29.5‰$

Detritus mud corresponds to horizon at which *Quercus* pollen frequencies reach 1st high level *viz.* VIa/b pollen zone boundary.

**SRR-105. Neasham Fen, 580 to 585cm**

**8829 ± 120**
**6879 B.C.**
$\delta C^{13} = -28.2‰$

Detritus mud corresponds to horizon at which *Ulmus* pollen frequencies reach 1st high level *viz.* beginning of Pollen Zone VIa.

**SRR-106. Neasham Fen, 590 to 595cm**

**9082 ± 90**
**7132 B.C.**
$\delta C^{13} = -29.4‰$

Detritus mud corresponds to level of 1st high *Corylus* pollen frequencies *viz.* Pollen Zone V.

**Weelhead Moss series, England**

Sedge peat from Weelhead Moss, Upper Teesdale, England (54° 40′ N Lat, 2° 18′ W Long), Natl. Grif Ref. NY 805305. Samples coll. from peat block cut from side of freshly dug pit; depths relate to present bog surface. Coll. 1969 and subm. by J. Turner. Dates support a series previously measured by Gakushuin Lab. *viz.* GaK-2913 to -2919, and are assoc. with a pollen diagram (Turner *et al.*, in press).

**SRR-107. Weelhead Moss, 239cm**

**6202 ± 70**
**4252 B.C.**
$\delta C^{13} = -29.6‰$

Sample from junction of moderately humified layer (70 to 239cm) and a partly humified layer (239 to 360cm), and corresponds to broad transition on pollen diagram from Zone VI to VIIa.

**SRR-108. Weelhead Moss, 337cm** **8057 ± 85**
**6107 B.C.**
$\delta C^{13} = -30.1‰$

*Comment* (J.T.): sample contained a Zone VI pollen assemblage and indicates that peat from 337cm to 280cm formed rapidly.

**SRR-26. Muirfad Flow, Kirkcudbrightshire** **4746 ± 50**
**2796 B.C.**
$\delta C^{13} = -20.3‰$

Wood fragments from junction of thick peat bed above and Flandrian estuarine/marine deposits below, +7.92m alt., 300m SE of confluence of Palnure Burn and R. Cree. Kirkcudbrightshire, Scotland (54° 55′ N Lat, 4° 25′ W Long), Natl. Grid Ref. NX 453620. Coll. 1971 and subm. by W. G. Jardine, Univ. Glasgow. *Comment* (W.G.J.): date is approx. minimum for end of main Flandrian marine transgression in Wigtown Bay area of Solway Firth.

**SRR-24. Chesil Beach, Abbotsbury** **4023 ± 50**
**2073 B.C.**
$\delta C^{13} = -28.3‰$

*Phragmites* peat from eroded raft, 2.3 x 2.1 x 0.8m, deposited on Abbotsbury Beach, England (50° 39′ N Lat, 2° 36′ W Long), Natl. Grid Ref. SY 568838. Coll. Dec. 1970 by M. W. Blackley; subm. by A. P. Carr, Unit Coastal Sedimentation, Taunton, Somerset. Alternative sample previously dated by Teledyne Isotopes, I-5670; 5270 ± 110 (unpub.).

**SRR-25. Chesil Beach, Abbotsbury** **4095 ± 60**
**2145 B.C.**
$\delta C^{13} = -28.5‰$

Further determination of peat, above, in view of age discrepancy between I-5670 and SRR-24. SRR-24 was washed in hot 0.5M KOH and acidified with HCl before $C^{14}$ assay. Simultaneous analysis by Univ. Cambridge of various carbonaceous fractions from this sample source gave, Q-1028; 4234 ± 60, Q-1029; 4251 ± 60, and Q-1030; 5058 ± 70 (Switzur and West, 1972).

*General Comment* (D.D.H.): non-contemporaneous fractions of plant debris are apparent in these peat rafts. Wood fragments, reported by Univ. Cambridge, were absent in material forwarded to SURRC. Date range measured for this source emphasizes importance of careful sample selection and identification and of lab. pretreatment.

### *B. Norway*

**Tunsbergdal series, S Norway**

Peat and wood fragments from interstadial stratum buried in glacial till at ca. 150m beyond snout of Tunsbergdalsbre/Jostedals ice cap, Tunsbergdal Amphitheatre, Jostedals, S Norway (61° 31′ N Lat, 7° 20′ E Long), Norwegian Natl. Grid Ref. 401/6823, alt. 500m. The raft of erractic peat ca. 1.5m thick overlies ca. 1.8m weathered till and is covered by ca. 4.0m fresh till. Coll. 1971 and subm. by D. N. Mottershead, Portsmouth Polytech.

Possible age variation among carbonaceous fractions of a sample coll. from base of peat raft was investigated after chemical separation.

**SRR-50. Tunsbergdal, basal layer** **8083 ± 100**
**6133 B.C.**
$\delta C^{13} = -25.0‰$

Composite sample washed in hot water, homogenized.

**SRR-51. Tunsbergdal, basal layer** **8092 ± 125**
**6142 B.C.**
$\delta C^{13} = -23.7‰$

Alkali insoluble fraction, recovered after multiple washing in hot 1.0 M KOH, final residue acidified with HCl and washed in water.

**SRR-52. Tunsbergdal, basal layer** **7661 ± 105**
**5711 B.C.**
$\delta C^{13} = -27.0‰$

Alkali soluble fraction (humics), recovered after acidification of supernatant from caustic leach.

*General Comment* (D.D.H.): composite wood and peat are contemporaneous; contamination by humic acids appears insignificant.

**SRR-166. Tunsbergdal, Upper layer** **3855 ± 55**
**1905 B.C.**
$\delta C^{13} = -24.3‰$

Sample from ca. 10cm below top surface of peat raft. Pretreated as for SRR-50.

*General Comment* (D.N.M.): initial peat accumulation ca. 8400 B.P. indicates glacier of smaller extent than at present. Readvance of ice ca. 4000 B.P. moved peat to its present position and deposited overlying till.

*C. Greece*

**SRR-82. Lake Kopais, S Greece** **5205 ± 120**
**3255 B.C.**
$\delta C^{13} = -30.0‰$

Peat from temporary excavation at Lake Kopais, S Greece (38° 28′ N Lat, 24° 07′ E Long). Date assoc. with a pollen diagram and indicates 1st major clearance of trees in area. Coll. 1964 by J. Turner and C. Turner; subm. by J. Turner.

**Lake Philippi series, NE Greece**

Muddy peat from Sites I and III at Lake Philippi, NE Greece (40° 57′ N Lat, 24° 18′ E Long). Samples assoc. with pollen diagrams Philippi I and Philippi III; depths quoted relate to present ground surface. Coll. 1970 by J. Greig and C. Chambers; subm. by J. Turner.

**SRR-83. Lake Philippi Site I, 200cm** **5031 ± 180**
**3081 B.C.**
$\delta C^{13} = -27.0‰$

Dates base of pollen diagram Philippi I.

**SRR-84. Lake Philippi Site III, 70cm** **2867 ± 60**
**917 B.C.**
$\delta C^{13} = -27.3‰$

Dates decrease in tree pollen and increase in grass pollen.

**SRR-85. Lake Philippi Site III, 140cm** **3740 ± 60**
**1790 B.C.**
$\delta C^{13} = -27.1‰$

Dates level for increase in *Cyperaceae* pollen.

**SRR-86. Lake Philippi Site III, 345 to 350cm** **7556 ± 85**
**5606 B.C.**
$\delta C^{13} = -27.3‰$

Dates base of pollen diagram Philippi III.

*D. Libya*

**Groundwater series**

Dissolved carbonate/bicarbonate coll. from groundwater using ion exchange columns (Crosby and Chatters, 1965). Data reported are measured $C^{14}$ ages, no attempt is made here to adjust these ages for dead carbonate contribution. Samples coll. 1972 and subm. by W. M. Edmunds, Hydrogeol. Dept. Inst. Geol. Sci., London.

**SRR-75. Kufra, Well 9** **24,100 ± 150***
$\delta C^{13} = -10.1‰$

Groundwater pumped from Nubian sandstone at depth 122 to 320m below ground level, Kufra Agric. Project Well 9, Kufra Oasis, S Libya (24° 13′ N Lat, 23° 17′ E Long).

**SRR-76. Kufra, Well 11** **>47,800***
$\delta C^{13} = -10.7‰$

Groundwater pumped from Nubian sandstone at depth 122 to 232m below ground level. Well 11 ca. 1km from Well 9, above.

**SRR-77. Libya D Field, Well 52-103D** **14,130 ± 425***
$\delta C^{13} = -10.4‰$

Groundwater pumped from Quaternary sands at depth 137 to 168m below ground level. Occidental Oil Co., water Well 52-103 D, Surt Basin Libya (28° 54′ N Lat, 20° 56′ E Long).

**Kufra series, S Libya**

Wood fragments from extensive horizon buried in quartz sand, sampled during drilling operations at Kufra Oasis, S Libya (24° 13′ N Lat, 23° 17′ E Long). Coll. 1971 by A. Craig; subm. by W. M. Edmunds.

* Age is not adjusted for isotopic fractionation.

**SRR-78. Kufra Borehole C81, 265 to 267m** **>45,000**
$\delta C^{13} = -23.8‰$

**SRR-79. Kufra Borehole C81, 186 to 210m** **>48,000**
$\delta C^{13} = -22.4‰$

**SRR-80. Kufra Borehole C53, 192 to 198m** **>48,000**
$\delta C^{13} = -21.7‰$

**788 ± 50**
**SRR-81. Angila D Field** **A.D. 1162**
$\delta C^{13} = -16.7‰$

Plant debris (palm) in sand/clay/gypsum matrix, excavated from ca. 1.5m below top of isolated soil pedestal NE of exploratory oil Well D18-102, Angila D Field, Libya (29° 10′ N Lat, 21° 32′ E Long). Coll. 1972 and subm. by W. M. Edmunds.

REFERENCES

Barker, H., Burleigh, R., and Meeks, N., 1971, British Museum natural radiocarbon measurements VII: Radiocarbon, v. 13, p. 157-188.
Baxter, M. S., Ergin, M., and Walton, A., 1969, Glasgow University radiocarbon measurements I: Radiocarbon, v. 11, p. 43-52.
Broecker, W. S. and Olson, E. A., 1961, Lamont radiocarbon measurements VIII: Radiocarbon, v. 3, p. 176-204.
Callow, W. J., Baker, M. J., and Hassal, G. I., 1965, National Physical Laboratory radiocarbon measurements III: Radiocarbon, v. 7, p. 156-161.
Crosby, J. W., III and Chatters, R. M., 1965, New techniques of water sampling for carbon-14 analysis: Jour. Geophys. Research, v. 70, p. 2839-2844.
Ergin, M., Harkness, D. D., and Walton, A., 1970, Glasgow University radiocarbon measurements II: Radiocarbon, v. 12, p. 486-495.
Harkness, D. D. and Wilson, H. W., 1972, Some applications in radiocarbon measurement at the Scottish Research Reactor Centre: 8th internatl. conf. on radiocarbon dating Proc., Lower Hutt, New Zealand.
Hibbert, Switzur, V. R. and West, R., 1971: Royal Soc. [London] Proc., ser. B, 177, p. 174.
Johnson, G. A. L. and Dunham, K. C., 1963, The geology of Moor House: Nature Conservancy Mon., no. 2, HMSO, London.
Pennington, W., 1973, Absolute pollen frequencies in the sediments of lakes of different morphometry: Jour. Ecology, in press.
Pennington, W., Haworth, Bonny, and Lishman, 1972, Lake sediments in northern Scotland: Royal Soc. [London] Philos. Trans., ser. B, in press.
Shotton, F. W., Blundell, D. J., and Williams, R. E. G., 1968, Birmingham University radiocarbon dates II: Radiocarbon, v. 10, p. 200-206.
Smith, A. G., Pearson, G. W., and Pilcher, J. R., 1973, Belfast radiocarbon dates V: Radiocarbon, v. 15, p. 212-228.
Stuiver, Minze, 1969, Yale natural radiocarbon measurements IX: Radiocarbon, v. 11, p. 545-658.
Suess, H. E., 1970, Bristlecone pine calibration of the radiocarbon time-scale 5200 B.C. to the present: 12th Nobel symposium Proc., Stockholm, Almquist and Wiksell, p. 303-311.
Switzur, V. R. and West, R. G., 1973, University of Cambridge natural radiocarbon measurements XI: Radiocarbon, v. 15, p. 156-164.
Tauber, Henrik, 1966, Copenhagen radiocarbon dates VII: Radiocarbon, v. 8, p. 213-234.
Turner, J., *et al.*, 1973, History of the vegetation and flora of Wittybank Fell and the Cow Green Reservoir Basin: Royal Soc. [London] Proc., ser. B, 265, p. 327-408.
Welin, E., Engstrand, L., and Vaczy, S., 1972, Institute of Geological Sciences radiocarbon dates III: Radiocarbon, v. 14, p. 331-335.