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# Radiocarbon

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## NOTICE TO READERS AND CONTRIBUTORS

Since its inception, the basic purpose of *RADIOCARBON* has been the publication of compilations of $^{14}C$ dates produced by various laboratories. These lists are extremely useful for the dissemination of basic $^{14}C$ information.

In recent years, *RADIOCARBON* has also been publishing technical and interpretative articles on all aspects of $^{14}C$. We would like to encourage this type of publication on a regular basis. In addition, we will be publishing compilations of published *and unpublished* dates along with interpretative text for these dates on a regional basis. Authors who would like to compose such an article for his/her area of interest should contact the Managing Editor for information.

Another section is added to our regular issues, "Notes and Comments." Authors are invited to extend discussions or raise pertinent questions to the results of scientific investigations that have appeared on our pages. The section includes short, technical notes to relay information concerning innovative sample preparation procedures. Laboratories may also seek assistance in technical aspects of radiocarbon dating. Book reviews will also be included for special editions.

Manuscripts of radiocarbon papers should follow the recommendations in *Suggestions to Authors** and *RADIOCARBON* Style Guide (R, 1984, v 26, p 152–158). Our deadline schedule for submitting manuscripts is:

| *For* | *Date* |
|---|---|
| Vol 31, No. 3, 1989 | May 1, 1989 |
| Vol 32, No. 1, 1990 | Sept 1, 1989 |
| Vol 32, No. 2, 1990 | Jan 1, 1990 |

*Half life of $^{14}C$.* In accordance with the decision of the Fifth Radiocarbon Dating Conference, Cambridge, 1962, all dates published in this volume (as in previous volumes) are based on the Libby value, 5570 ± 30 yr, for the half life. This decision was reaffirmed at the 11th International Radiocarbon Conference in Seattle, Washington, 1982. Because of various uncertainties, when $^{14}C$ measurements are expressed as dates in years BP the accuracy of the dates is limited, and refinements that take some but not all uncertainties into account may be misleading. The mean of three recent determinations of the half life, 5730 ± 40 yr, (Nature, v 195, no. 4845, p 984, 1962), is regarded as the best value presently available. Published dates in years BP can be converted to this basis by multiplying them by 1.03.

*AD/BC Dates.* In accordance with the decision of the Ninth International Radiocarbon Conference, Los Angeles and San Diego, 1976, the designation of AD/BC, obtained by subtracting AD 1950 from conventional BP determinations is discontinued in Radiocarbon. Authors or submitters may include calendar estimates as a comment, and report these estimates as cal AD/BC, citing the specific calibration curve used to obtain the estimate. Calibrated dates will now be reported as "cal BP" or "cal AD/BC" according to the consensus of the Twelfth International Radiocarbon Conference, Trondheim, Norway, 1985.

*Meaning of $\delta^{14}C$.* In Volume 3, 1961, we endorsed the notation Δ (Lamont VIII, 1961) for geochemical measurements of $^{14}C$ activity, corrected for isotopic fractionation in samples and in the NBS oxalic-acid standard. The value of $\delta^{14}C$ that entered the calculation of Δ was defined by reference to Lamont VI, 1959, and was corrected for age. This fact has been lost sight of, by editors as well as by authors, and recent papers have used $\delta^{14}C$ as the observed deviation from the standard. At the New Zealand Radiocarbon Dating Conference it was recommended to use $\delta^{14}C$ only for age-corrected samples. Without an age correction, the value should then be reported as percent of modern relative to 0.95 NBS oxalic acid (Proceedings 8th Conference on Radiocarbon Dating, Wellington, New Zealand, 1972). The Ninth International Radiocarbon Conference, Los Angeles and San Diego, 1976, recommended that the reference standard, 0.95 times NBS oxalic acid activity, be normalized to $\delta^{13}C = -19‰$.

In several fields, however, age corrections are not possible. $\delta^{14}C$ and Δ, uncorrected for age, have been used extensively in oceanography, and are an integral part of models and theories. For the present, therefore, we continue the editorial policy of using Δ notations for samples not corrected for age.

*Suggestions to Authors of the Reports of the United States Geological Survey, 6th ed, 1978, Supt of Documents, U S Govt Printing Office, Washington, DC 20402.

# CONTENTS

[RADIOCARBON, VOL 30, NO. 3, 1988, P 261–295]

Radiocarbon

*1988*

# ACCELERATOR MASS SPECTROMETRY RADIOCARBON MEASUREMENTS ON MARINE CARBONATE SAMPLES FROM DEEP SEA CORES AND SEDIMENT TRAPS

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# CONTENTS

## INTRODUCTION

This report was prepared to permit those interested in our accelerator $^{14}C$ results to get a complete listing of the abundance and radiocarbon age results that we have obtained during the first four years of our study. For these $^{14}C$ dates that have been published or are in press, reference numbers are given corresponding to those in the references cited at the end of this report. Results without reference numbers have not yet been incorporated into one of our papers.

The foram samples were prepared at Lamont as follows: the dried core sample is weighed and disaggregated in deionized water. The wet sediment is then rinsed through a 63$\mu$ mesh sieve. This wash-rinse procedure is repeated four times. The material (coarse fraction) retained in the sieve is dried and weighed. From the weight of the coarse fraction and the original sample weight, the per cent coarse fraction is calculated.

The >63$\mu$ coarse fraction is then split to yield a manageable size sample for picking. The split portion is then put through a 150$\mu$ sieve and the species of interest is counted to yield the total whole shells in the split.

The number needed for $^{14}C$ measurement (200 to 1000 specimens) is picked. This known number of shells is then weighed yielding the weight of the average shell. The number of specimens per gram of sediment and the milligrams of specimens per gram of sediment are calculated as follows:

$$\frac{\text{No. specimens}}{\text{Gm sediment}} = \frac{\text{No. of specimens in split}}{\text{Split fraction} \cdot \text{weight of original sample}}$$

$$\frac{\text{Mg forams}}{\text{Gm sediment}} = \frac{\text{Mass of picked sample (mg)}}{\text{No. specimens in picked sample}} \times \frac{\text{No. of specimens in split}}{\text{Weight of split (gm)}}$$

The samples listed in this report were converted to $CO_2$ gas at Lamont. This $CO_2$ was then converted in Bern to carbon targets by the zinc reduction method (Andrée *et al,* 1984). The carbon targets were then analyzed for $^{14}C/^{12}C$ ratio by AMS at the ETH facility in Zurich (Suter *et al,* 1984).

## REFERENCES

Andrée, M, Beer, J, Oeschger, H, Bonani, G, Hofmann, H J, Morenzoni, E, Nessi, M, Suter, M and Wolfli, W, 1984, Target preparation for milligram sized $^{14}C$ samples and data evaluation for AMS measurements: Nuclear Instruments & Methods, v B5, p 274–279.

Suter, M, Balzer, R, Bonani, G, Hofmann, H J, Morenzoni, E, Nessi, M, Wolfli, W, Andrée, M, Beer, J and Oeschger, H, 1984, Precision measurements of $^{14}C$ in AMS—some results and prospects: Nuclear Instruments & Methods, v B5, p 117–122.

# I. CORES FROM THE OPEN ATLANTIC

## CEARA RISE

### KNORR 110 82GGC

Giant gravity core raised from RV KNORR by Bill Curry of WHOI.
Holocene 0–19cm 65–75% $CaCO_3$
Glacial below 19cm 25–30% $CaCO_3$

The study of this core was carried out cooperatively with Bill Curry of Woods Hole Oceanographic. Our goal was to obtain benthic-planktonic age difference for the glacial section of the core (see Figs 1, 2, Table 1).


REFERENCES

Broecker, W S, Andrée, M, Bonani, G, Mix, A, Klas, M, Wolfli, W and Oeschger, H, ms in preparation, Differences between the radiocarbon age of coexisting planktonic foraminifera.

Broecker, W S, Andrée, M, Bonani, G, Wolfli, W, Oeschger, H, Klas, M, Mix, A and Curry, W, ms in preparation, The radiocarbon age of deep water in the glacial ocean.

Curry, W, Duplessy, J C, Labeyrie, L and Shackleton, N, in press, Changes in the distribution of deep water $\Sigma CO_2$ between the last glacial and the Holocene: Paleoceanography.


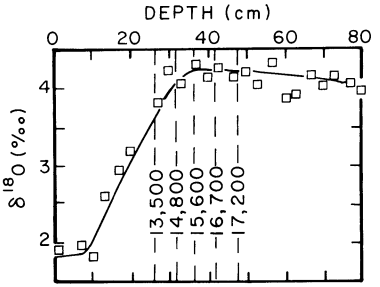


Fig 1. Oxygen isotope record on benthic foraminifera, for KNORR 110-82GGC obtained by Bill Curry of WHOI

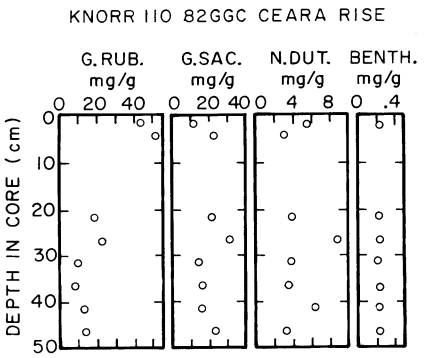


Fig 2. Abundance *vs* depth for the three planktonic and the mixed benthics on which $^{14}C$ measurements were made

TABLE 1

KNORR 110 82GGC Equatorial Atlantic Ceara Rise
Location (4°20.2'N, 43°29.2'W) Depth 2816m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 0-3** | 32.3 | G sacc | 265 | 11.2 | 216 | 12.3 | - | - | |
| " | " | G ruber | 2840 | 43.6 | 463 | 7.1 | - | - | |
| " | " | P obliq | 57.7 | 2.3 | 201 | 9.7 | - | - | |
| " | " | N duter | 93.2 | 5.4 | 161 | 9.4 | - | - | |
| " | " | M benth | 5.7 | 0.23 | 247 | 9.8 | - | - | |
| 3-5† | 31.8 | G sacc | 356 | 22.1 | 181 | 11.2 | - | - | |
| " | " | G ruber | 2810 | 52.1 | 522 | 9.7 | - | - | |
| " | " | P obliq | 49.8 | 3.0 | 161 | 9.7 | - | - | |
| " | " | N duter | 76.2 | 4.8 | 24 | 1.5 | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 6-8 | 32.8 | G sacc | 333 | 29.1 | 70 | 6.1 | - | - | |
| " | " | G ruber | 1720 | 33.1 | 349 | 6.7 | - | - | |
| " | " | N duter | 29.4 | 1.75 | - | - | - | - | |
| " | " | M benth | 3.8 | - | - | - | - | - | |
| 9-11 | 30.1 | G sacc | 464 | 20.6 | 153 | 6.8 | - | - | |
| " | " | G ruber | 1720 | 12.8 | 566 | 4.2 | - | - | |
| " | " | N duter | 41.0 | 2.31 | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 15-17 | 26.1 | G sacc | 454 | 28.4 | 152 | 9.5 | - | - | |
| " | " | G ruber | 1630 | 20.7 | 401 | 5.1 | - | - | |
| " | " | N duter | 103 | 5.37 | - | - | - | - | |
| " | " | M benth | 9.4 | 0.35 | 225 | 8.2 | - | - | |
| 20-23 | 15.4 | G sacc | 358 | 20.4 | 255 | 14.5 | April 86 | 12,360 ± 190 | 15 |
| " | " | G ruber | 804 | 17.8 | 521 | 11.5 | " | 12,040 ± 190 | 15 |
| " | " | P obliq | 110 | 6.25 | 274 | 15.6 | " | 11,950 ± 180 | |
| " | " | N duter | 58.2 | 3.9 | 221 | 14.8 | " | 13,350 ± 230 | 15 |
| " | " | M benth | 7.1 | 0.22 | 328 | 10.4 | " | 13,160 ± 210 | |
| 23-25 | 15.2 | G sacc | - | - | - | - | - | - | |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 25-28 | 14.5 | G sacc | 557 | 30.8 | 222 | 12.3 | June 86 | 14,150 ± 160 | 15,16 |
| " | " | G ruber | 1010 | 22.8 | 500 | 11.3 | Jan 87 | 13,870 ± 260 | 15,16 |
| " | " | P obliq | 38.2 | 2.0 | 254 | 13.2 | June 86 | 12,610 ± 140 | |
| " | " | N duter | 143 | 8.8 | 213 | 13.0 | July 86 | 13,860 ± 190 | 15,16 |
| " | " | M benth | 5.8 | 0.24 | 233 | 9.5 | June 86 | 14,930 ± 200 | 16 |

TABLE 1 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. Tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 28–30 | 12.3 | G sacc | – | – | – | – | – | – | |
| " | " | G ruber | – | – | – | – | – | – | |
| " | " | M benth | – | – | – | – | – | – | |
| 30–33 | 6.8 | G sacc | 215 | 14.9 | 194 | 13.5 | April 86 | 15,100 ± 250 | 15,16 |
| " | " | G ruber | 526 | 10.1 | 453 | 8.7 | " | 15,450 ± 260 | 15,16 |
| " | " | P obliq | 5.7 | 0.36 | – | – | – | – | |
| " | " | N duter | 61.7 | 3.7 | 186 | 11.1 | April 86 | 15,170 ± 260 | 15,16 |
| " | " | M benth | 6.7 | 0.21 | 298 | 9.3 | " | 16,350 ± 280 | 16 |
| 33–35 | 9.2 | G sacc | – | – | – | – | – | – | |
| " | " | G ruber | – | – | – | – | – | – | |
| " | " | M benth | – | – | – | – | – | – | |
| 35–38 | 7.4 | G sacc | 216 | 16.3 | 163 | 12.3 | Jan 87 | 16,090 ± 320 | 15,16 |
| " | " | G ruber | 496 | 8.7 | 400 | 7.0 | " | 15,870 ± 290 | 15,16 |
| " | " | P obliq | 1.6 | 0.08 | – | – | – | – | |
| " | " | N duter | 58.2 | 3.5 | 229 | 13.7 | July 86 | 16,060 ± 200 | 15,16 |
| " | " | M benth | 4.7 | 0.11 | 187 | 4.4 | July 86 | 16,130 ± 240 | 16 |
| 36–38 | 7.9 | G sacc | 96.2 | 9.4 | 157 | 15.3 | March 87 | – | |
| " | " | G ruber | – | – | – | – | – | – | |
| " | " | M benth | 3.4 | 0.24 | 58 | 4.1 | March 87 | – | |
| 38–40 | 9.1 | G sacc | – | – | – | – | – | – | |
| " | " | G ruber | – | – | – | – | – | – | |
| " | " | M benth | – | – | – | – | – | – | |
| 40–43 | 8.9 | G sacc | 220 | 15.5 | 183 | 13.0 | June 86 | 16,710 ± 250 | 15,16 |
| " | " | G ruber | 458 | 13.2 | 548 | 15.8 | " | 17,040 ± 250 | 15,16 |
| " | " | P obliq | 1.4 | 0.07 | – | – | – | – | |
| " | " | N duter | 86.7 | 6.3 | 181 | 13.2 | June 86 | 17,610 ± 280 | 15,16 |
| " | " | M benth | 4.5 | 0.23 | 193 | 10.2 | " | 17,870 ± 370 | 16 |
| 43–45 | 10.1 | G sacc | – | – | – | – | – | – | |
| " | " | G ruber | – | – | – | – | – | – | |
| " | " | M benth | – | – | – | – | – | – | |
| 45–48 | 8.6 | G sacc | 186 | 22.8 | 86 | 9.5 | Jan 87 | 17,780 ± 360 | 15,16 |
| " | " | G ruber | 766 | 14.0 | 500 | 12.7 | " | 17,430 ± 340 | 15,16 |
| " | " | P obliq | 4.2 | 0.22 | – | – | – | – | |
| " | " | N duter | 52.5 | 3.4 | 199 | 12.9 | July 86 | 17,660 ± 260 | 15,16 |
| " | " | M benth | 4.5 | 0.23 | 155 | 5.8 | " | 17,900 ± 640 | 16 |

*Publication no. in which radiocarbon date has been published (see references cited)
**Archive core
†Working core

## SIERRA LEONE RISE

EN 066 39GGC
EN 066 21GGC
EN 066 32GGC

Study of the dependence of core top ages for *G menardi* and *G sacculifer* on water depth in cores of low sedimentation rate (~2cm/$10^3$ yr). The study was initiated by Lisa Dubois of Brown University on cores originally studied by Curry and Lohmann of Woods Hole Oceanographic (see Table 2).

### References

Curry, W B and Lohmann, G P, 1983, Reduced advection into Atlantic Ocean deep eastern basins during last glaciation maximum: Nature, v 306, no. 5943, p 577–580.

———— 1986, Late Quaternary carbonate sedimentation at the Sierra Leone Rise (Eastern Equatorial Atlantic Ocean): Marine Geology, v 70, p 223–250.

TABLE 2

EN 066 39GGC Equatorial Atlantic Sierra Leone Rise
Location (5°04'N, 20°52'W) Depth 2818m

| Depth (cm) | Coarse fraction (%) | Foram Sp | Abund (no./gm) | Abund (mgm/gm) | No. tests Anal. | Weight Anal. (mgm) | Date of AMS Analysis | Age (yr) |
|---|---|---|---|---|---|---|---|---|
| 2-3 | - | G menardi | - | - | - | 1.2 | Sept 85 | 1860 ± 120 |
| " | - | G sacc | - | - | - | 12.1 | " | 4510 ± 170 |
| " | - | M benth | - | - | - | 9.0 | " | 5180 ± 180 |
| 10-11 | - | G menardi | - | - | 100 | 10.3 | July 86 | 3920 ± 90 |
| 11-12 | - | G menardi | - | - | - | 10.1 | Sept 85 | 4100 ± 160 |
| " | - | G sacc | - | - | - | 8.0 | " | 7720 ± 260 |
| " | - | M benth | - | - | - | 10.9 | " | 10,430 ± 350 |
| 13-14 | - | G menardi | - | - | 66 | 3.0 | Aug 86 | 7510 ± 200 |
| 16-17 | - | G sacc | - | - | 208 | 10.5 | Jan 87 | 15,130 ± 280 |
| 23-24 | - | G sacc | - | - | - | 11.6 | Sept 85 | 19,290 ±1080 |
| " | - | G infla | - | - | - | 5.5 | Feb 86 | 16,900 ± 250 |
| " | - | M benth | - | - | - | 5.7 | " | 20,430 ± 360 |
| EN 066 21GGC Equatorial Atlantic Sierra Leone Rise Location (4°14'N, 20°38'W) Depth 3995m | | | | | | | | |
| 2-3 | - | G menardi | - | - | - | 11.8 | Sept 85 | 2280 ± 130 |
| " | - | G sacc | - | - | - | 8.0 | " | 3800 ± 160 |
| EN 066 32GGC Equatorial Atlantic Sierra Leone Rise Location (2°28'N, 19°44'W) Depth 5003m | | | | | | | | |
| 2-3 | - | G menardi | - | - | - | 10.9 | Sept 85 | 2840 ± 130 |
| " | - | G sacc | - | - | - | 8.1 | " | 4070 ± 160 |

## WESTERN EQUATORIAL ATLANTIC

V14-05TW
V25-59TW
V16-200TW
V14-06TW
V15-17TW

The study of these whole shell, shell fragment pairs from trigger weight cores from the western equatorial Atlantic was initiated by Alan Mix (see Table 3).

### References

Damuth, J, (ms) 1973, The western equatorial Atlantic: Morphology, Quaternary sediments, and climatic cycles: PhD dissert, Columbia Univ, 602 p.

Mix, A, (ms) 1986, Late Quaternary paleoceanography of the Atlantic Ocean: Foraminiferal faunal and stable isotopic evidence: PhD dissert, Columbia Univ, 738 p.

Mix, A and Ruddiman, W, 1985, Structure and timing of the last deglaciation: Oxygen-isotope evidence: Quaternary Sci Rev, v 4, p 59–108.

TABLE 3

V14-05TW Equatorial Atlantic
Location (00°15'N, 32°51'W) Depth 3255m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) |
|---|---|---|---|---|---|---|---|---|
| 5-10 | - | G menardi | - | - | - | 9.9 | Sept 85 | 4050 ± 210 |
| " | - | G men frag | - | - | - | 5.5 | " | 3360 ± 220 |
| | | V25-59TW Equatorial Atlantic<br>Location (01°22'N, 33°29'W) Depth 3824m | | | | | | |
| 5-10 | - | G menardi | - | - | - | 7.5 | Sept 85 | 4740 ± 230 |
| " | - | G men frag | - | - | - | 7.9 | " | 5010 ± 210 |
| | | V16-200TW Equatorial Atlantic<br>Location (01°58'N 37°04'W) Depth 4093m | | | | | | |
| 0-10 | - | G menardi | - | - | - | 10.3 | Sept 85 | 2950 ± 180 |
| | | V14-06TW Equatorial Atlantic<br>Location (00°50'N, 34°20'W) Depth 4429m | | | | | | |
| 0-10 | - | G menardi | - | - | - | 9.8 | Sept 85 | 7760 ± 330 |
| " | - | G men frag | - | - | - | 8.6 | " | 7610 ± 330 |
| | | V15-17TW Equatorial Atlantic<br>Location (06°59'N, 41°04'W) Depth 4768m | | | | | | |
| 0-10 | - | G menardi | - | - | - | 5.0 | Sept 85 | 6420 ± 280 |
| " | - | G men frag | - | - | - | 9.9 | " | 5800 ± 230 |

## NORTHERN ATLANTIC

### V23-81

The study of this northern Atlantic core was undertaken to establish the chronology of surface water temperature changes in the northern Atlantic from 40,000 years ago to present (see Figs 3, 4; Table 4).


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Broecker, W S, Andrée, M, Bonani, G, Wolfli, W, Oeschger, H and Klas, M, 1988, in press, Can the Greenland climatic jumps be identified in records from ocean and land?: Quaternary Research.

Broecker, W S, Andrée, M, Wolfli, W, Oeschger, H, Bonani, G, Kennett, J and Peteet, D, in press, The chronology of the last deglaciation: Implications to the cause of the Younger Dryas event: Paleoceanography.

Ruddiman, W F and McIntyre, A, 1981, The North Atlantic Ocean during the last deglaciation: Paleogeog, paleoclimatol, paleoecol, v 35, p 145–214.

Ruddiman, W F, Sancetta, C D and McIntyre, A, 1977, Glacial/interglacial response rate of subpolar North Atlantic waters to climatic change: the record in ocean sediments: Royal Soc [London] Philos Trans, v B280, p 119–142.

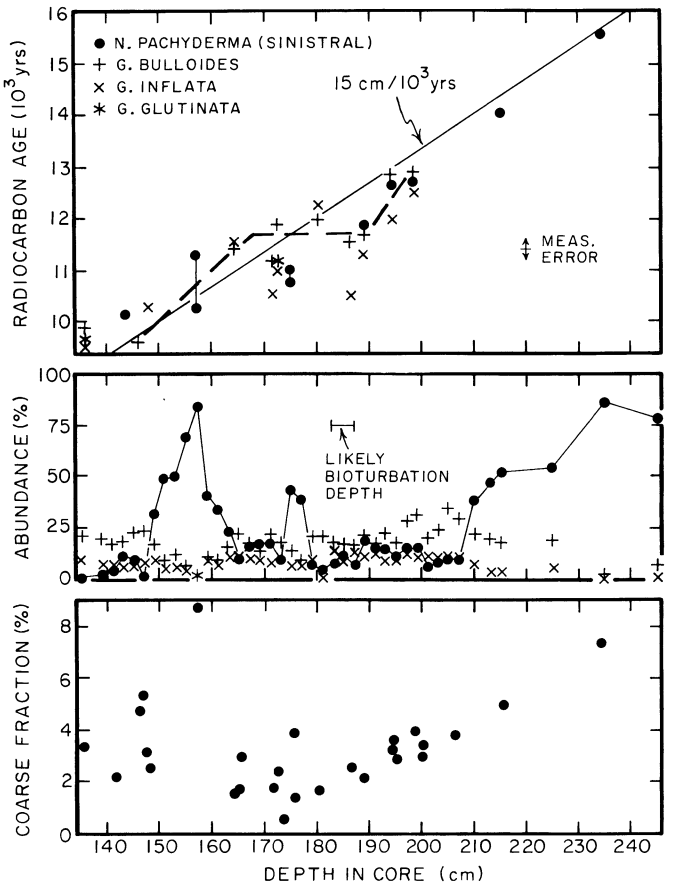


Fig 3. Plot of $^{14}C$ ages, relative abundances, and coarse fractions *vs* depth for the deglacial interval in core V23-81. As the coarse fraction is made up almost entirely of planktonic shells, the product of the coarse fraction percentage and the relative abundance percentage provides a measure of the absolute abundance of a given shell type (*ie*, gm shell/gm sediment). We do not graph this product for two reasons: 1) the abundances and coarse fractions were not done on the same samples, 2) the abundances are for shell number rather than shell weight. The $^{14}C$ ages are uncorrected for the $^{14}C/C$ ratio difference between atmospheric $CO_2$ and surface ocean $\Sigma CO_2$. The reference line shows the expected trend in age if the sedimentation rate and the $^{14}C/C$ ratio in surface ocean water remained constant with time.

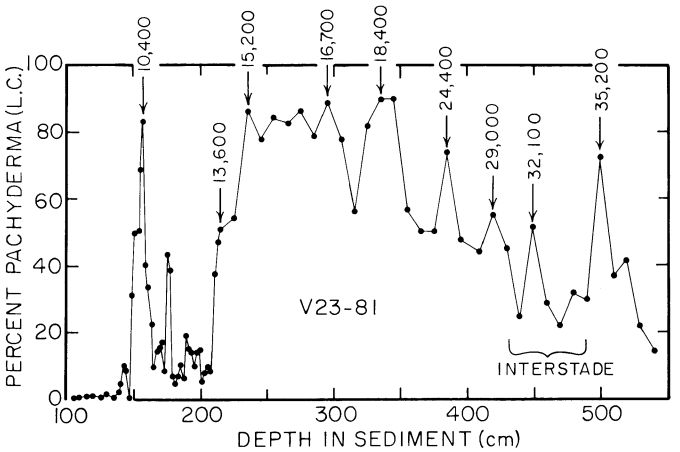


Fig 4. $^{14}C$ ages on the shells of *N pachyderma(s)* in northern Atlantic core V23-81

TABLE 4

V23-81 North Atlantic
Location (54°18'N, 16°48'W) Depth 2393m

| Depth (cm) | Coarse fraction (%) | Foram Sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 0-3TW | 5.0 | G infla | 309 | 6.31 | 270 | 5.5 | Aug 86 | 2070 ± 90 | 12 |
| 7-8 | 10.0 | G glut | 72.8 | - | - | - | - | - | |
| " | " | G quin | 65.5 | - | - | - | - | - | |
| " | " | G bull | 328 | 3.34 | 542 | 5.5 | Aug 86 | 2410 ± 100 | 12,15 |
| " | " | G infla | 386 | 9.04 | 410 | 9.6 | " | 1820 ± 90 | 12,15 |
| " | " | M benth | 14.1 | - | - | - | - | - | |
| 61-63 | 11.7 | G bull | 312 | 4.76 | 531 | 8.1 | Nov 87 | 6930 ± 170 | 12 |
| " | " | G infla | 277 | 9.41 | 376 | 12.8 | Mar 87 | 6260 ± 150 | 12 |
| " | " | M benth | 35.0 | 1.01 | 276 | 8.0 | " | 6990 ± 170 | 12 |
| 112.5-113.5 | 4.2 | - | - | - | - | - | - | - | |
| 122.5-123.5 | 7.0 | - | - | - | - | - | - | - | |
| 131-132 | 3.6 | - | - | - | - | - | - | - | |
| 135-136 | 3.4 | G glut | 107 | 0.55 | 1000 | 5.2 | Aug 86 | 9610 ± 150 | 12 |
| " | " | G quin | 70.5 | 0.13 | 1570 | 3.0 | - | - | |
| " | " | G bull | 212 | 3.94 | 530 | 9.9 | Aug 86 | 9890 ± 160 | 12,15 |
| " | " | G infla | 112 | 2.86 | 339 | 8.7 | " | 9490 ± 200 | 12,15 |
| " | " | M benth | 8.05 | - | - | - | - | - | |
| 143-144 | 2.2 | N pach(s) | 92.9 | 0.82 | 817 | 7.2 | Jan 87 | 10,120 ± 180 | 12 |
| " | " | G infla | 71.2 | 1.76 | 304 | 7.5 | Nov 87 | 10,450 ± 200 | 12 |
| 146.0-146.5 | 4.8 | N pach(s) | 138 | - | - | - | - | - | |
| " | " | G bull | 436 | 8.30 | 462 | 8.8 | Mar 87 | 9600 ± 210 | 12 |
| " | " | G infla | 142 | - | - | - | - | - | |

TABLE 4 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 147.5-148.0 | 2.6 | N pach(s) | 209 | - | - | - | - | - | |
| " | " | G bull | 232 | - | - | - | - | - | |
| " | " | G infla | 105 | 3.18 | 296 | 9.0 | Mar 87 | 10,260 ± 190 | 12 |
| 157-158 | 8.7 | N pach(s) | 4130 | 25.0 | 1370 | 8.3 | July 85 | 11,300 ± 140 | 12,13 |
| " | " | " | 4130 | 32.7 | 1400 | 11.1 | Jan 87 | 10,230 ± 200 | 12,13 |
| 164-165 | 1.8 | N pach(s) | 167 | - | - | - | - | - | |
| " | " | G bull | 155 | 2.76 | 548 | 9.8 | Mar 87 | 11,500 ± 210 | 12,15 |
| " | " | G infla | 97.3 | 2.16 | 316 | 7.0 | " | 11,500 ± 200 | 12,15 |
| 171-172 | 1.8 | G bull | 113 | 1.61 | 500 | 7.1 | Aug 86 | 11,170 ± 180 | 12,15 |
| " | " | G infla | 64.0 | 1.39 | 350 | 7.6 | " | 10,530 ± 160 | 12,15 |
| " | " | N pach(d) | - | - | - | - | - | - | |
| 172-173 | 2.4 | G glut | 103.4 | 0.57 | 777 | 4.3 | Aug 86 | 11,140 ± 190 | 12 |
| " | " | G quin | 207 | 0.47 | 1100 | 2.5 | - | - | |
| " | " | G bull | 219 | 3.64 | 479 | 8.0 | Aug 86 | 11,860 ± 170 | 12,15 |
| " | " | G infla | 52.7 | 1.02 | 429 | 8.3 | " | 10,960 ± 200 | 12,15 |
| " | " | N pach(d) | 71.1 | 0.49 | 583 | 4.0 | - | - | |
| 173-174 | 0.6 | G bull | 31.2 | - | 100 | - | - | - | |
| " | " | G infla | 41.8 | - | 183 | - | - | - | |
| 175-176 | 3.9 | N pach(s) | 647 | 6.31 | 862 | 8.4 | Aug 86 | 10,990 ± 190 | 12,13 |
| " | " | " | 647 | 7.34 | 837 | 9.5 | Jan 87 | 10,780 ± 190 | 12 |
| 175-176 | 1.4 | N pach(s) | 43.2 | - | 133 | - | - | - | |
| 180-181 | 1.7 | N pach(s) | 38.5 | - | - | - | - | - | |
| " | " | G bull | 191 | 3.42 | 250 | 4.7 | Mar 87 | 11,990 ± 280 | 12,15 |
| " | " | G infla | 78.6 | 1.90 | 300 | 7.2 | " | 12,240 ± 220 | 12,15 |
| 186-187 | 2.8 | G bull | 169 | - | - | - | - | - | |
| " | " | G infla | 109 | 2.96 | 294 | 8.0 | Mar 87 | 10,500 ± 230 | 12,15 |
| 186-187 | 2.5 | G bull | 254 | 5.64 | 450 | 10.0 | Mar 87 | 11,540 ± 210 | 12,15 |
| " | " | G infla | 109 | - | - | - | - | - | |
| 188-190 | 2.4 | N pach(s) | 185 | 1.69 | 900 | 8.2 | Jan 87 | 11,850 ± 200 | 12,13 |
| 188-190 | 2.1 | G bull | 114 | 1.35 | 715 | 8.5 | Mar 87 | 11,650 ± 210 | 12,15 |
| " | " | G infla | 75.3 | 1.13 | 535 | 8.0 | " | 11,330 ± 230 | 12,15 |
| 194.0-195.5 | 3.2 | N pach(s) | 289 | 3.41 | 687 | 8.1 | Jan 87 | 12,660 ± 240 | 12 |
| " | " | G bull | 282 | 3.20 | 724 | 8.2 | Mar 87 | 12,840 ± 230 | 12,15 |
| 194.0-195.5 | 3.5 | G infla | 145 | 3.17 | 474 | 10.4 | Mar 87 | 11,940 ± 210 | 12,15 |
| 194.5-195.0 | 3.5 | N pach(s) | 353 | - | - | - | - | - | |
| " | " | G bull | 283 | - | - | - | - | - | |
| " | " | G infla | 180 | - | - | - | - | - | |

TABLE 4 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 195.0-195.5 | 3.6 | N pach(s) | 499 | - | 568 | - | - | - | |
| " | " | G bull | 251 | - | 269 | - | - | - | |
| " | " | G infla | 145 | - | 160 | - | - | - | |
| 195.5-196.0 | 2.9 | N pach(s) | 193 | - | 438 | - | - | - | |
| " | " | G bull | 304 | - | 294 | - | - | - | |
| " | " | G infla | 87.0 | - | 184 | - | - | - | |
| 198-199 | 3.6 | - | - | - | - | - | - | - | |
| 198-199 | 4.1 | N pach(s) | 366 | 3.84 | 905 | 9.5 | Jan 87 | 12,270 ± 220 | 12,13 |
| " | " | G bull | 423 | 7.49 | 593 | 10.5 | Mar 87 | 12,910 ± 240 | 12,15 |
| " | " | G infla | 168 | 4.06 | 327 | 7.9 | " | 12,530 ± 220 | 12,15 |
| 200.0-200.5 | 3.0 | G bull | 255 | - | - | - | - | - | |
| " | " | G infla | 131 | - | - | - | - | - | |
| 201-202 | 2.9 | G bull | 272 | 5.24 | 451 | 8.7 | Nov 87 | 12,860 ± 240 | 12 |
| " | " | G infla | 118 | 4.31 | 335 | 12.2 | Nov 87 | 12,390 ± 240 | 12 |
| 206-207 | 3.8 | G bull | 277 | 5.34 | 550 | 10.6 | Nov 87 | 13,180 ± 240 | 12 |
| " | " | G infla | 97.7 | 2.60 | 432 | 11.5 | Nov 87 | 13,240 ± 310 | 12 |
| " | " | N pach(s) | _ | - | - | - | - | - | |
| 215-216 | 5.0 | N pach(s) | 789 | 8.66 | 930 | 10.2 | Aug 86 | 14,060 ± 210 | 12,13 |
| 234-235 | 4.5 | N pach(s) | 1860 | 20.7 | 771 | 8.6 | July 85 | 15,600 ± 190 | 12,13 |
| 293-294 | 6.7 | N pach(s) | 2610 | 32.9 | 706 | 8.9 | July 85 | 17,140 ± 240 | 12,13 |
| 313-315 | 1.9 | N pach(s) | 105 | - | - | - | - | - | |
| " | " | G bull | 39.6 | - | 400 | - | - | - | |
| " | " | G infla | 8.40 | - | 113 | - | - | - | |
| 335-336 | 7.7 | N pach(s) | 2130 | 23.7 | 845 | 9.4 | July 85 | 18,790 ± 280 | 13 |
| 384-385 | 5.6 | N pach(s) | 1230 | 15.0 | 813 | 9.9 | Sept 85 | 24,820 ± 870 | 13 |
| 385-386 | 6.8 | N pach(s) | 898 | 11.2 | 900 | 11.2 | Aug 86 | 24,400 ± 540 | 13 |
| 418-419 | 9.2 | N pach(s) | 1780 | 21.3 | 916 | 10.9 | Aug 86 | 29,400 ± 960 | 13 |
| 449-450 | 5.4 | N pach(s) | 328 | 3.56 | 810 | 8.8 | Aug 86 | 32,540 ±1240 | 13 |
| 499-500 | 9.8 | N pach(s) | 1480 | 18.0 | 861 | 10.5 | Aug 86 | 35,640 ±1810 | 13 |

*Publication no. in which radiocarbon date has been published.

## II. CORES FROM BASINS ADJACENT TO THE ATLANTIC OCEAN

### V28-122

The study of this core was undertaken to measure the benthic-planktonic age difference for the "Boyle water" of glacial time in the Caribbean Sea (see Figs 5, 6; Table 5).


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Boyle, E A and Keigwin, L D, 1987, North Atlantic circulation during the last 20,000 years linked to high-latitude surface temperature: Nature, v 330, p 35–40.

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Broecker, W S, Andrée, M, Bonani, G, Wolfli, W, Oeschger, H, Klas, M, Mix, A and Curry, W, ms in preparation, The radiocarbon age of deep water in the glacial ocean.

Oppo, D W and Fairbanks, R, 1987, Variability in the deep and intermediate water circulation of the Atlantic Ocean during the past 25,000 years: Northern Hemisphere modulation of the southern ocean: Earth & Planetary Sci Letters, v 86, no. 1, p 1–15.

———— in press, Carbon isotope composition of tropical surface water during the past 22,000 years: Paleooceanography.

Prell, W L, 1978, Upper Quaternary sediments of the Colombia Basin: Spatial and stratigraphic variation: Geol Soc America Bull, v 89, p 1241–1255.


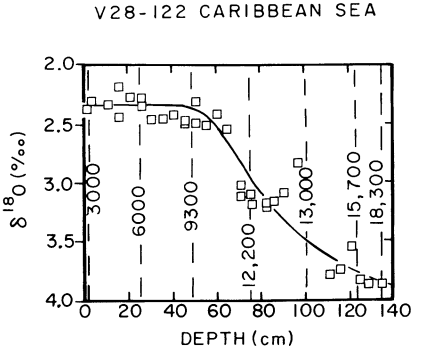


Fig 5. Oxygen isotope record for benthic foraminifera (Oppo & Fairbanks, in press)

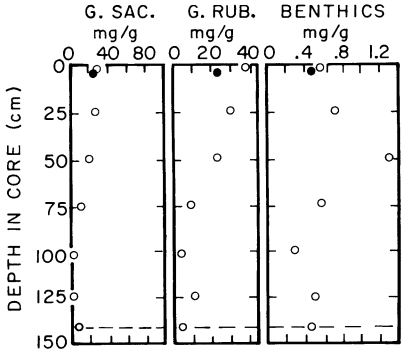


Fig 6. Abundance *vs* depth planktonic and mixed benthic foraminifera shells for V28-122

TABLE 5

V28-122 Caribbean Sea Columbia Basin
Location (11°56'N, 78°41'W) Depth 3623m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 2- 5TW | 23.1 | G sacc | 437 | 25.7 | 241 | 14.2 | Mar 87 | 3180 ± 160 | |
| " | " | G ruber | 1210 | 23.6 | 554 | 10.8 | - | - | |
| " | " | M benth | 19.6 | 0.47 | 172 | 4.2 | - | - | |
| 1- 3 | 30.3 | G sacc | 612 | 29.0 | 194 | 9.2 | Mar 86 | 2930 ± 120 | 15,16 |
| " | " | G ruber | 2300 | 38.7 | 493 | 8.3 | " | 3040 ± 130 | 15,16 |
| " | " | M benth | 27.2 | 0.57 | 530 | 11.1 | " | 3280 ± 140 | 16 |
| 24- 25 | 24.9 | G sacc | 595 | 27.0 | 205 | 9.3 | - | 5940 ± 130 | 15 |
| " | " | G ruber | 1780 | 30.7 | 610 | 10.5 | - | 6170 ± 190 | 15 |
| " | " | M benth | 22.5 | 0.73 | 130 | 4.2 | - | - | |
| 48- 49 | 21.4 | G sacc | 368 | 20.4 | 222 | 12.3 | - | 9230 ± 150 | 15,16 |
| " | " | G ruber | 1600 | 23.4 | 607 | 8.9 | - | 9390 ± 160 | 15,16 |
| " | " | M benth | 32.2 | 1.32 | 207 | 8.5 | - | 10,120 ± 200 | 16 |
| 74- 75 | 13.8 | G sacc | 177 | 9.9 | 193 | 10.8 | - | 12,040 ± 220 | 15,16 |
| " | " | G ruber | 628 | 9.4 | 500 | 7.5 | - | 12,410 ± 230 | 15,16 |
| " | " | M benth | 31.2 | 0.69 | 367 | 8.1 | - | 12,620 ± 210 | 16 |
| 98-104 | 4.1 | G sacc | 16.6 | 1.1 | 205 | 13.9 | Mar 87 | 12,650 ± 250 | 15,16 |
| " | " | G ruber | 183 | 3.3 | 545 | 9.8 | - | 13,240 ± 240 | 15,16 |
| " | " | M benth | 6.50 | 0.29 | 227 | 10.3 | Mar 87 | 15,200 ± 300 | 16 |
| 123-124 | 6.0 | G sacc | 38.3 | 2.2 | 174 | 10.1 | - | 15,860 ± 260 | 15,16 |
| " | " | G ruber | 549 | 10.6 | 525 | 10.1 | - | 15,540 ± 270 | 15,16 |
| 123-128** | " | M benth | 17.0 | 0.51 | 302 | 8.2 | - | 16,550 ± 270 | 16 |
| 129-139 | 8.0 | G sacc | 59.2 | 4.0 | 121 | 8.2 | Mar 87 | 17,910 ± 400 | 16 |
| " | " | G ruber | 374 | 7.1 | 582 | 11.1 | - | 18,730 ± 480 | 16 |
| " | " | M benth | 16.3 | 0.46 | 505 | 15.3 | Mar 87 | 18,530 ± 420 | 16 |
| 145-146 | - | G sacc | 28.4 | 1.5 | - | - | - | - | |
| " | - | G ruber | 274 | 4.2 | - | - | - | - | |
| 157-158 | - | G sacc | 20.3 | 1.1 | - | - | - | - | |
| " | - | G ruber | 268 | 4.7 | - | - | - | - | |

*Publication no. in which radiocarbon date has been published (see references cited)
**55.3% from 123-124cm
26.2% from 125cm
18.5% from 128cm

## GULF OF MEXICO
## ORCA BASIN

### EN32-PC6

The study of this core was undertaken in cooperation with James Kennett. The purpose was to establish the chronology of the Mississippi River melt water record (see Figs 7, 8; Table 6).


REFERENCES

Broecker, W S, Andrée, M, Wolfli, W, Oeschger, H, Bonani, G, Kennett, J and Peteet, D, in press, The chronology of the last deglaciation: Implications to the cause of the Younger Dryas event: Paleoceanography.

Kennett, J P, Elmstrom, K and Penrose, N, 1985, The last deglaciation in Orca Basin, Gulf of Mexico: High-resolution planktonic foraminiferal changes: Paleogeog, Paleoclimatol, Paleoecol, v 50, p 189–216.

Leventer, A, Williams, D F and Kennett, J P, 1982, Dynamics of the Laurentide ice sheet during the last deglaciation: Evidence from the Gulf of Mexico: Earth & Planetary Sci Letters, v 59, p 11–17.

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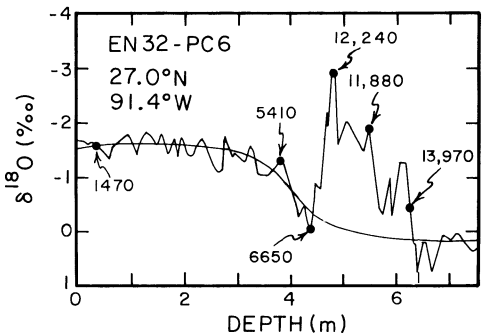


Fig 7. The $^{18}O/^{16}O$ record obtained on the shells of the planktonic species *G ruber* from a Gulf of Mexico deep-sea core raised in the Orca Basin (Leventer, Williams & Kennett, 1982). The smooth curve shows the record expected was the core from the open ocean. The large anomaly to more negative $\delta^{18}O$ values is attributed to the discharge of glacial melt water from the Mississippi River. The $^{14}C$ analyses were carried out on hand-picked planktonic shells.

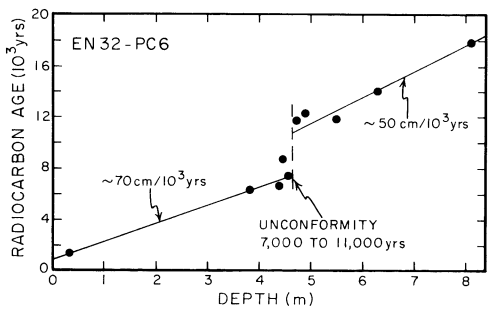


Fig 8. $^{14}C$ age *vs* depth in Gulf of Mexico core EN32-PC6. The results suggest that a section of the record from ca 7000 BP to ca 11,000 BP is missing. The $^{14}C$ ages have not been corrected for the air-surface-sea age difference.

TABLE 6

EN32-PC6 Gulf of Mexico Orca Basin
Location (26°57'N, 91°21'W) Depth 2280m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 23- 29 | - | M plank** | - | - | - | 10.2 | Mar 87 | 1470 ± 120 | 12 |
| 380-382 | - | M plank | - | - | - | 14.5 | Mar 87 | 5410 ± 130 | 12 |
| 437-438 | - | M plank | - | - | - | - | Sept 85 | 6650 ± 110 | 12 |
| 442-443 | 0.41 | M plank | - | - | - | - | Oct 86 | 8780 ± 180 | 12 |
| 456-458 | - | M plank | - | - | - | 7.2 | Mar 87 | 7360 ± 160 | 12 |
| 470-472 | - | M plank | - | - | - | 13.4 | Mar 87 | 11,690 ± 210 | 12 |
| 485-487 | - | G ruber | - | - | - | - | May 85 | 12,240 ± 150 | 12 |
| 547-548 | - | G ruber | - | - | - | 8.0 | Jan 87 | 11,880 ± 210 | 12 |
| 627-629 | - | M plank | - | - | - | - | Aug 86 | 13,970 ± 410 | 12 |
| 808-810 | - | M plank | - | - | - | 7.7 | Mar 87 | 17,860 ± 370 | 12 |

*Publication no. in which radiocarbon date has been published (see Refereces cited)
**M plank = mixed planktonic species

## ARCTIC OCEAN

### FL-124

This study was undertaken in cooperation with David Clark of the University of Wisconsin in order to confirm the previous estimates of low sedimentation rates in the Arctic Basin (see Table 7).

#### References

Clark, D L, Andrée, M, Broecker, W S, Mix, A, Bonani, G, Hofmann, H J, Morenzoni, E, Nessi, M, Suter, M and Wolfli, W, 1986, Arctic Ocean chronology confirmed by accelerator $^{14}C$ dating: Geophysical Research Letters, v 13, no. 4, p 319–321.

TABLE 7

FL-124 Arctic Ocean
Location (78°14'N, 174°42'W) Depth 1517m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (years) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 0-1 | - | N pach(s) | - | - | - | - | May 85 | 9130 ± 120 | 8 |
| 2-3 | - | " | - | - | - | - | " | 15310 ± 210 | 8 |
| 4-5 | - | " | - | - | - | - | " | 31720 ± 1280 | 8 |
| 8-9 | - | " | - | - | - | - | " | >41100 | 8 |

*Publication no. in which radiocarbon date has been published (see References cited)

## III. CORES FROM THE OPEN PACIFIC

### EAST PACIFIC RISE

### TT154-10

This study was carried out in cooperation with Steve Emerson of the University of Washington. The purpose was to obtain benthic-planktonic and planktonic-planktonic age differences on hand-picked foraminifera shells. Material was taken from two separate subcores from the primary 50cm$^2$ box core (see Tables 8, 9).

TABLE 8

TT154-10 (Core 5) East Pacific Rise
Location (10°17.5'N, 111°20'W) Depth 3225m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 0- 1 | 35.7 | BULK $CaCO_3$ | - | - | - | - | - | 5100 ± 200** | 15 |
| " | " | G sacc | 885 | - | - | 7.2 | July 84 | 5920 ± 100 | 15 |
| " | " | P obliq | 612 | - | - | 10.2 | " | 5770 ± 120 | 15 |
| " | " | M benth | 32.0 | 0.56 | 537 | 9.4 | - | - | |
| 1- 2 | 41.0 | G sacc | - | - | - | 9.9 | July 84 | 5930 ± 100 | 15 |
| " | " | P obliq | - | - | - | 7.7 | " | 5580 140 | 15 |
| 2- 3 | 40.4 | G sacc | 767 | - | 187 | 7.4 | July 84 | 6110 ± 100 | 15 |
| " | " | P obliq | 787 | - | 192 | 7.2 | " | 5020 ± 130 | 15 |
| " | " | M benth | 26.0 | 0.35 | 607 | 8.1 | - | - | 15 |
| 3- 4 | 34.9 | BULK $CaCO_3$ | - | - | - | - | - | 5100 ± 200** | 15 |
| " | " | G sacc | 657 | - | - | 12.4 | Mar 84 | 5160 ± 140 | 15 |
| " | " | P obliq | 743 | - | - | 9.1 | July 84 | 4750 ± 110 | 15 |
| " | " | M benth | 36.0 | 0.38 | 920 | 9.7 | - | - | |
| 4- 6 | 37.5 | BULK $CaCO_3$ | - | - | - | - | - | 5600 ± 200** | 15 |
| " | " | G sacc | 786 | - | - | 8.7 | July 84 | 6770 ± 150 | 15 |
| " | " | P obliq | 643 | - | - | 12.6 | " | 5500 ± 90 | 15 |
| " | " | M benth | 27.0 | 0.37 | 496 | 6.8 | - | - | |
| 6- 8 | 37.8 | G sacc | - | - | - | 12.2 | July 84 | 5880 ± 100 | 15 |
| " | " | P obliq | - | - | - | 10.9 | " | 5530 ± 100 | 15 |
| " | " | M benth | 28.0 | 0.31 | 570 | 6.4 | - | - | |
| 7- 8 | - | BULK $CaCO_3$ | - | - | - | - | - | 6100 ± 250** | 15 |
| 8-10 | 34.5 | G sacc | 675 | - | - | 8.7 | July 84 | 6500 ± 110 | 15 |
| " | " | P obliq | 532 | - | - | 11.5 | " | 6180 ± 100 | 15 |
| " | " | M benth | 30.0 | 0.42 | 591 | 8.3 | - | - | |
| 9-10 | 45.2 | BULK $CaCO_3$ | - | - | - | - | - | 5700 ± 150** | 15 |
| 11-12 | - | BULK $CaCO_3$ | - | - | - | - | - | 6700 ± 250** | 15 |
| 10-14 | - | M benth | 25.0 | 0.34 | 537 | 7.4 | - | - | |
| 13-14 | - | BULK $CaCO_3$ | - | - | - | - | - | 8100 ± 300** | |
| 14-16 | 48.8 | BULK $CaCO_3$ | - | - | - | - | - | 8800 ± 100** | |
| " | " | G sacc | 648 | - | - | - | - | - | |
| " | " | P obliq | 800 | - | - | - | - | - | |
| " | " | M benth | 31.0 | - | - | - | - | - | |

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Emerson, S, Stump, C, Grootes, P M, Stuiver, M, Farwell, G W and Schmidt, F H, 1987, Estimates of degradable organic carbon in deep-sea surface sediments from $^{14}C$ concentrations: Nature, v 329, p 51–53.


TABLE 8 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 16–18 | 49.6 | BULK $CaCO_3$ | – | – | – | – | – | 9400 ± 100** | |
| " | " | M benth | 31.0 | – | – | – | – | – | |
| 18–20 | 46.5 | M benth | 36.0 | – | – | – | – | – | |
| 20–22 | 50.1 | M benth | 31.0 | – | – | – | – | – | |
| 22–24 | 43.5 | G sacc | 511 | – | – | 13.0 | July 84 | 11,640 ± 130 | |
| " | " | P obliq | 481 | – | – | – | – | – | |
| " | " | M benth | 35.0 | 0.48 | 530 | 7.3 | – | – | |
| 24–26 | 52.3 | M benth | 39.0 | – | 587 | – | – | – | |
| 26–28 | 51.2 | G sacc | – | – | – | – | Jan 87 | 12,200 ± 230 | 15 |
| " | " | P obliq | – | – | – | 11.6 | " | 13,350 ± 250 | 15 |
| " | " | M benth | 37.0 | 0.44 | 562 | 6.7 | " | 16,220 ± 300 | |
| 28–30 | 53.8 | M benth | 55.0 | – | – | – | – | – | |
| 30–32 | 47.3 | – | – | – | – | – | – | – | |
| " | " | P obliq | – | – | – | 12.8 | Jan 87 | 16,320 ± 310 | 15,16 |
| " | " | M benth | 83.0 | 1.14 | 656 | 9.0 | " | 17,500 ± 380 | 16 |
| 30–32 | 46.9 | G sacc | 120 | 9.4 | 150 | 11.8 | Mar 87 | 15,770 ± 330 | 15,16 |
| " | " | P obliq | – | – | – | – | – | – | |
| " | " | M benth | – | – | – | – | – | – | |
| 32–34 | 46.6 | M benth | 34.0 | – | – | – | – | – | |
| 34–36 | 47.5 | G sacc | – | – | 161 | 10.7 | Jan 87 | 16,600 ± 340 | 15,16 |
| " | " | P obliq | – | – | 200 | 14.2 | " | 16,530 ± 340 | 15,16 |
| " | " | M benth | 57.0 | 0.62 | 809 | 8.8 | " | 19,170 ± 420 | 16 |
| 36–38 | 46.6 | M benth | 72.0 | – | – | – | – | – | |
| 36–38 | 46.1 | G sacc | – | – | 150 | 10.6 | Mar 87 | 16,320 ± 370 | 15,16 |
| " | " | P obliq | – | – | 113 | 8.1 | " | 17,390 ± 370 | 15,16 |
| " | " | M benth | – | – | 137 | 6.8 | " | 20,180 ± 610 | 16 |
| 40–42 | 46.9 | G sacc | 362 | – | – | 10.5 | July 84 | 20,110 ± 220 | 16 |
| " | " | M benth | 44.0 | 0.73 | 484 | 8.0 | " | 21,980 ± 640 | 16 |

*Publication no. in which radiocarbon date has been published (see References cited)
**Ages obtained at LDGO by conventional decay counting

TABLE 9

TT154-10 (Emerson Frozen Subcore) East Pacific Rise
Location (10°17.5'N, 111°20'W) Depth 3225m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) |
|---|---|---|---|---|---|---|---|---|
| 0-1.2 | 49.9 | G sacc | 487 | - | - | - | - | - |
| " | " | P obliq | 683 | - | - | - | - | - |
| " | " | M benth | 38.0 | 0.48 | 657 | 8.3 | May 85 | 6700 ± 100 |
| 1.2-2.4 | 49.9 | G sacc | 411 | - | - | - | - | - |
| " | " | P obliq | 679 | - | - | - | - | - |
| " | " | M benth | 36.0 | 0.41 | 653 | 7.5 | Jun 85 | 6780 ± 110 |
| 2.4-3.6 | 48.6 | G sacc | 531 | - | - | - | - | - |
| " | " | G ruber | - | - | 754 | 8.2 | - | - |
| " | " | P obliq | 742 | - | - | - | - | - |
| " | " | N duter | - | - | 300 | 12.1 | - | - |
| " | " | M benth | 35.0 | 0.39 | 704 | 7.9 | Dec 84 | 6930 ± 110 |
| 3.6-4.8 | 42.0 | G sacc | 403 | 33.7 | 140 | 11.7 | - | - |
| " | " | P obliq | 597 | 43.5 | 147 | 10.7 | - | - |
| " | " | M benth | 37.0 | 0.51 | 705 | 9.8 | Jun 85 | 6960 ± 100 |
| 4.8-6.0 | 44.8 | G sacc | 485 | 33.3 | 150 | 10.3 | - | - |
| " | " | P obliq | 624 | 48.5 | 148 | 11.5 | - | - |
| 5.0-6.0 | 44.8 | M benth | 34.0 | 0.47 | 641 | 8.8 | Jun 85 | 6610 ± 110 |
| 6.0-7.2 | 47.5 | G sacc | 462 | 32.8 | 163 | 11.2 | - | - |
| " | " | P obliq | 657 | 55.6 | 124 | 10.5 | - | - |
| " | " | M benth | 41.0 | 0.51 | 784 | 9.7 | Jun 85 | 6550 ± 90 |
| 7.2-8.4 | 45.0 | G sacc | 434 | 40.7 | 130 | 12.2 | - | - |
| " | " | P obliq | 590 | 52.2 | 113 | 10.0 | - | - |
| " | " | M benth | 32.0 | 0.39 | 747 | 9.0 | Jun 85 | 7410 ± 110 |
| 8.4-9.6 | 44.0 | G sacc | 335 | 23.9 | 168 | 12.0 | - | - |
| " | " | P obliq | 573 | 43.8 | 157 | 12.0 | - | - |
| " | " | M benth | 35.0 | 0.38 | 707 | 7.6 | - | - |

Table 9 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) |
|---|---|---|---|---|---|---|---|---|
| 9.6- | | | | | | | | |
| 10.8 | 37.1 | G sacc | 527 | 40.9 | 152 | 11.8 | - | - |
| " | " | P obliq | 598 | 48.6 | 144 | 11.7 | - | - |
| 10.8- | | | | | | | | |
| 12.0 | 37.4 | G sacc | 490 | 32.2 | 166 | 10.9 | - | - |
| " | " | P obliq | 562 | 48.8 | 137 | 11.9 | - | - |
| 12.0- | | | | | | | | |
| 13.2 | 39.0 | G sacc | 447 | 31.7 | 162 | 11.5 | May 85 | 6950 ± 110 |
| " | " | G ruber | - | - | 552 | 7.5 | - | - |
| " | " | P obliq | 625 | 47.0 | 145 | 10.9 | May 85 | 6480 ± 100 |
| " | " | N duter | - | - | 326 | 12.2 | - | - |
| " | " | M benth | 28.0 | 0.38 | 644 | 8.6 | May 85 | 9400 ± 120 |
| 13.2- | | | | | | | | |
| 14.4 | 39.6 | G sacc | 470 | 36.8 | 152 | 11.9 | - | - |
| " | " | P obliq | 582 | 44.0 | 152 | 11.5 | - | - |
| 20.4- | | | | | | | | |
| 21.6 | 44.2 | G sacc | 569 | 44.0 | 163 | 12.6 | - | - |
| " | " | P obliq | 382 | 30.8 | 150 | 12.1 | - | - |
| " | " | G ruber | 973 | 22.6 | 543 | 12.6 | - | - |
| " | " | N duter | 181 | 7.6 | 300 | 12.6 | - | - |
| 25.2- | | | | | | | | |
| 26.4 | 50.3 | G sacc | 405 | 21.6 | 205 | 10.9 | - | - |
| " | " | P obliq | 560 | 34.0 | 283 | 17.2 | - | - |
| 31.2- | | | | | | | | |
| 32.4 | 49.0 | G sacc | 188 | 9.9 | 61 | 3.2 | - | - |
| " | " | P obliq | 448 | 28.7 | 145 | 9.3 | - | - |
| 34.8- | | | | | | | | |
| 36.0 | 47.9 | G sacc | 231 | 15.6 | 120 | 8.1 | - | - |
| " | " | P obliq | 448 | 35.0 | 233 | 18.2 | - | - |
| 39.6- | | | | | | | | |
| 40.8 | 50.1 | G sacc | 148 | 13.0 | 67 | 5.9 | - | - |
| " | " | P obliq | 532 | 38.4 | 241 | 17.4 | - | - |
| 44.4- | | | | | | | | |
| 45.6 | 43.7 | G sacc | 110 | 7.8 | 45 | 3.2 | - | - |
| " | " | P obliq | 509 | 34.1 | 209 | 14.0 | - | - |
| 49.2- | | | | | | | | |
| 50.4 | 45.9 | G sacc | 242 | 14.8 | 100 | 6.1 | - | - |
| " | " | P obliq | 363 | 35.8 | 150 | 14.8 | - | - |

## OONTONG-JAVA PLATEAU

### V28-238
### RC17-176

These cores were chosen for our initial effort because they typified normal open ocean conditions (see Fig 9; Tables 10, 11).


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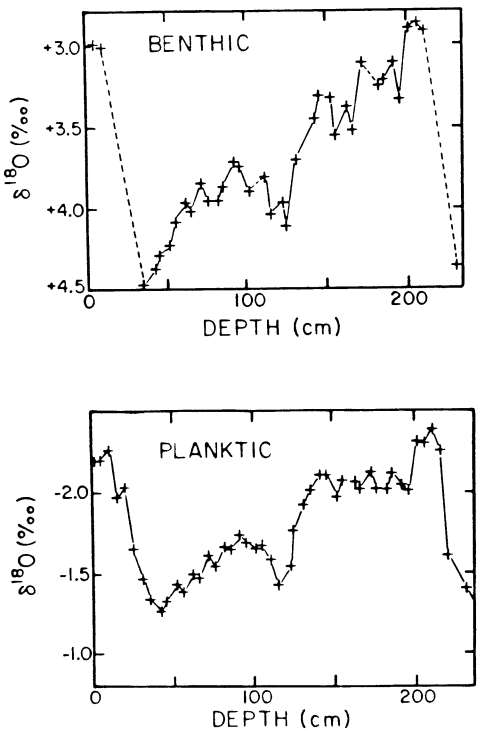


Fig 9. Oxygen isotope records for core V28-238 (Shackleton & Opdyke, 1973)

TABLE 10

V28-238 Equatorial Pacific Oontong-Java Plateau
Location (01°01'N, 160°29'E) DEPTH 3120m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 3. 8TW | 30.8 | G sacc | 632 | - | - | - | Dec 83 | 4640 ± 160 | 4,6 |
| " | " | sacc frag | - | - | - | - | Mar 84 | 4650 ± 100 | 4,6 |
| " | " | G ruber | 2067 | 19.1 | - | - | " | 5680 ± 90 | 4,6 |
| " | " | P obliq | 685 | - | - | - | Dec 83 | 4760 ± 160 | 4,6 |
| " | " | N duter | 385 | 17.8 | - | - | Mar 84 | 5410 ± 80 | 4,6 |
| " | " | M benth | - | - | - | - | Dec 83 | 6150 ± 180 | 4,6 |
| 2.5-4.5 | - | G sacc | - | - | - | - | July 84 | 5500 ± 230 | 6 |
| " | " | P obliq | - | - | - | - | " | 4330 ± 100 | 6 |
| 10-12 | 39.0 | G sacc | 535 | - | - | - | Feb 83 | 5880 ± 100 | 4,6 |
| " | " | G ruber | 1433 | 1.9 | - | - | Mar 84 | 7670 ± 100 | 4,6 |
| " | " | P obliq | 1604 | - | - | - | Dec 83 | 6390 ± 160 | 4,6 |
| " | " | N duter | 92.0 | 0.3 | - | - | Mar 84 | 9070 ± 120 | 4,6 |
| " | " | M benth | - | - | - | - | Feb 83 | 9530 ± 80 | 4,6 |
| " | " | <25 microns | - | - | - | - | " | 6320 ± 60 | 4,6 |
| " | " | 25-63 microns | - | - | - | - | " | 6620 ± 70 | 4,6 |
| " | " | >63 microns | - | - | - | - | Mar 84 | 6870 ± 140 | 4,6 |
| 12-15 | - | BULK $CaCO_3$ | - | - | - | - | - | 8010 ± 150 | |
| 13-14 | 40.3 | G sacc | 249 | 12.3 | - | 9.4 | Mar 84 | 8350 ± 100 | 4,6 |
| " | " | G ruber | 1907 | - | - | - | - | - | |
| " | " | P obliq | 613 | 27.4 | - | 10.5 | Mar 84 | 8620 ± 100 | 4,6 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 25.0 | 1.0 | 152 | 6.2 | Mar 84 | 12,080 ± 120 | 4,6 |
| 15-16 | 38.6 | G sacc | 716 | - | - | - | Feb 85 | 8190 ± 120 | |
| " | " | G ruber | 2339 | - | - | - | - | - | |
| " | " | P obliq | 1200 | - | - | - | Feb 85 | 8450 ± 110 | |
| " | " | N duter | 143 | - | - | - | - | - | |
| " | " | M benth | 40.0 | - | 189 | 3.2 | - | - | |
| 18-20 | 45.3 | G sacc | 662 | - | - | - | Dec 83 | 9730 ± 220 | 4,6 |
| " | " | G sacc | 955 | - | 662 | 17.8 | Mar 84 | 8490 ± 150 | 4,6 |
| " | " | G ruber | 1079 | 11.8 | - | - | " | 9580 ± 110 | 4,6 |
| " | " | P obliq | 1486 | - | 515 | 41.2 | Dec 83 | 9300 ± 220 | 4,6 |
| " | " | P obliq | - | - | - | - | Mar 84 | 9680 ± 170 | 4,6 |
| " | " | N duter | 107 | 4.4 | - | - | " | 11,230 ± 130 | 4,6 |
| " | " | M benth | 49.0 | - | 540 | 8.1 | Dec 83 | 11,660 ± 260 | 4,6 |
| 21-22 | 37.0 | G sacc | 270 | - | 208 | - | Feb 85 | 10,230 ± 120 | |
| " | " | G ruber | 1862 | - | - | - | - | - | |
| " | " | P obliq | 719 | - | 60 | - | Feb 85 | 10,470 ± 160 | |
| " | " | N duter | 195 | - | - | - | - | - | |
| " | " | M benth | 60.0 | - | - | - | - | - | |
| 25-26 | 33.1 | G sacc | 529 | - | 233 | - | - | - | |
| " | " | G ruber | 1114 | - | - | - | - | - | |
| " | " | P obliq | 935 | - | 75 | - | - | - | |
| " | " | N duter | 166 | - | - | - | - | - | |
| " | " | M benth | 61.0 | - | - | - | - | - | |
| 29-30 | 30.0 | G sacc | 138 | - | 208 | - | Feb 85 | 11,880 ± 140 | |
| " | " | G ruber | 634 | - | - | - | - | - | |
| " | " | P obliq | 795 | - | 85 | - | Feb 85 | 12,950 ± 140 | |
| " | " | N duter | 108 | - | - | - | - | - | |
| " | " | M benth | 69.0 | - | - | - | - | - | |

TABLE 10 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 30-31 | 25.7 | G sacc | 392 | - | 464 | 16.4 | Dec 83 | 11,650 ± 260 | 4,6 |
| " | " | P obliq | 1069 | - | 315 | 21.7 | " | 12,680 ± 460 | 4,6 |
| " | " | M benth | 76.0 | - | 715 | 8.7 | " | 16,140 ± 390 | 4,6 |
| 34-35 | 21.6 | G sacc | 96 | 3.40 | 241 | 8.54 | Mar 84 | 13,560 ± 220 | 4,6 |
| " | " | G ruber | 768 | - | - | - | - | - | |
| " | " | P obliq | 340 | 23.5 | 80 | 8.0 | Feb 85 | 14,340 ± 130 | |
| " | " | N duter | 225 | - | - | - | - | - | |
| " | " | M benth | 87.0 | 1.00 | - | - | - | - | |
| 41-43 | 24.8 | G sacc | 93 | - | - | 11.0 | Apr 83 | 17,780 ± 390 | 4,6 |
| " | " | P obliq | 648 | - | - | 11.0 | July 83 | 19,620 ± 190 | 4,6 |
| " | " | N duter | 169 | - | - | - | - | - | |
| " | " | M benth | 81.0 | - | 781 | 6.0 | Apr 83 | 20,650 ± 220 | 4,6 |
| " | " | <25 microns | - | - | - | - | " | 17,800 ± 160 | 4,6 |
| " | " | 25-63 microns | - | - | - | - | " | 19,440 ± 260 | 4,6 |
| 44-45 | 21.2 | G ruber | 288 | - | - | - | - | - | |
| " | " | P obliq | 310 | - | - | - | - | - | |
| " | " | N duter | 149 | - | - | - | - | - | |
| " | " | M benth | 9.00 | - | - | - | - | - | |
| 45-47 | 28.8 | G sacc | - | - | - | - | Mar, 84 | 19,620 ± 240 | 4,6 |
| " | " | G ruber | 436 | 0.09 | - | - | " | 19,380 ± 260 | 4,6 |
| " | " | N duter | 180 | 6.4 | - | - | " | 21,000 ± 250 | 4,6 |
| " | " | M benth | - | - | - | - | " | 22,110 ± 350 | 4,6 |
| 50-51 | 25.9 | G sacc | 678 | 21.2 | 458 | 14.5 | Dec, 83 | 19,610 ± 620 | 4 |
| " | " | G sacc | 678 | - | - | - | Mar, 84 | 22,400 ± 1180 | 4 |
| " | " | G ruber | 504 | 5.20 | - | - | " | 21,030 ± 280 | 4 |
| " | " | P obliq | 1282 | 75.9 | 433 | 26.9 | Dec, 83 | 22,630 ± 1290 | 4 |
| " | " | P obliq | - | - | - | - | Mar, 84 | 22,180 ± 1090 | 4 |
| " | " | N duter | 182 | 0.50 | - | - | " | 22,890 ± 280 | 4 |
| " | " | M benth | 124 | 1.40 | 678 | 8.1 | Dec, 83 | 22,440 ± 690 | 4 |
| 1200 | 21.5 | G sacc | 124 | - | - | - | Mar, 84 | >40140 | 4 |
| " | " | P obliq | - | - | - | - | " | >41900 | |
| " | " | P obliq | - | - | - | - | Nov, 85 | >42840 | 4 |
| " | " | G sacc | - | - | - | - | " | >36400 | |

*Publication no. in which radiocarbon date has been published (see References cited

TABLE 11

RC17-176 Equatorial Pacific Ontong-Java Plateau
Location (03°45'N, 158°46'E) Depth 3156m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) |
|---|---|---|---|---|---|---|---|---|
| 4-6 | 49.0 | G sacc | 351 | - | - | - | Dec 83 | 6080 ± 190 |
| " | " | P obliq | 814 | - | - | - | " | 6710 ± 190 |
| " | " | N duter | - | - | - | - | " | - |
| " | " | M benth | 25.6 | - | - | - | " | 9400 ± 220 |

## IV. CORES FROM BASINS ADJACENT TO THE PACIFIC

### SOUTH CHINA SEA

V35-5
V35-6

This study was undertaken to determine the time history of the surface to deep $^{14}C/C$ ratio difference for the Pacific Ocean (see Fig 10; Tables 12, 13).

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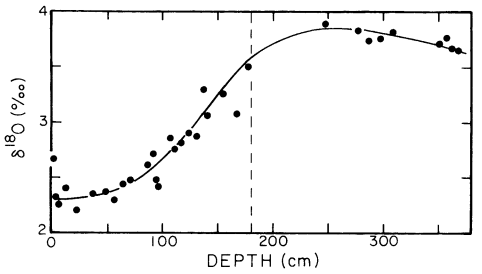


Fig 10. Oxygen isotope record for benthic foraminifera in core V35-05 (Oppo & Fairbanks, 1987)

TABLE 12

V35-05 South China Sea
Location (07°11.7'N, 112°4.6'E) Depth 1953m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 1- 4TW | 1.77 | G sacc | 32.5 | 0.52 | 255 | 4.1 | July 85 | 690 ± 150 | 9 |
| 0-20TW | 1.91 | G sacc | 31.8 | 1.19 | 404 | 15.1 | Sept 85 | 1930 ± 90 | 9,15 |
| " | " | G sacc | 31.8 | 1.43 | 348 | 15.7 | Apr 86 | 1810 ± 100 | 9,15 |
| " | " | P obliq | 10.5 | 0.29 | 376 | 10.4 | Sept 85 | 2090 ± 90 | 9,15 |
| " | " | P obliq | 10.5 | 0.34 | 250 | 8.1 | July 86 | 2160 ± 120 | 15 |
| " | " | M benth | 9.8 | 0.21 | 690 | 15 | Sept 85 | 3560 ± 100 | 9 |
| 0- 1 | 2.51 | G sacc | 9.0 | 0.24 | 74 | 2 | - | - | |
| 3- 6 | 3.86 | G sacc | 26.7 | 0.66 | 303 | 7.5 | Sept 85 | 1940 ± 120 | |
| " | " | P obliq | 8.1 | 0.17 | 87 | 1.8 | - | - | |
| 6- 7 | 3.65 | G sacc | 27.1 | 0.60 | - | - | - | - | |
| 7- 8 | 3.44 | G sacc | 4.9 | 0.18 | - | - | - | - | |
| 0-10 | 3.36 | G sacc | 23.2 | 0.86 | 387 | 14.3 | Sept 85 | 2010 ± 90 | 9,15 |
| " | " | G sacc | 23.2 | 0.74 | 320 | 10.2 | Apr 86 | 2100 ± 100 | 9,15 |
| " | " | P obliq | 30.9 | 0.92 | 294 | 8.8 | Sept 85 | 2620 ± 90 | 9,15 |
| " | " | P obliq | 30.9 | 0.87 | 269 | 7.6 | July 86 | 2250 ± 80 | 15 |
| " | " | M benth | 8.8 | 0.25 | 472 | 13.4 | Sept 85 | 3610 ± 100 | 9 |
| 10-15 | 3.54 | G sacc | 11.3 | 0.44 | - | - | - | - | |
| " | " | P obliq | 9.6 | 0.38 | - | - | - | - | |
| 25-30 | 2.72 | G sacc w/s | 29.8 | 1.05 | 165 | 6.4 | Nov 87 | 3380 ± 120 | |
| " | " | G sacc 0/s | 35.1 | 0.88 | 196 | 6.2 | Nov 87 | 1740 ± 110 | |
| " | " | P obliq | 14.9 | 0.48 | 151 | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 40-45 | 2.52 | G sacc | 23.5 | 0.87 | - | - | - | - | |
| " | " | P obliq | 10.8 | 0.27 | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 59-70 | 2.19 | G sacc | 39.5 | 1.46 | 373 | 13.8 | Apr 86 | 5750 ± 120 | 9,15 |
| " | " | P obliq | 17.2 | 0.53 | 253 | 7.7 | " | 6500 ± 130 | 9,15 |
| " | " | M benth | 5.7 | 0.17 | 232 | 7.4 | " | 7240 ± 120 | 9 |
| 60-70 | 2.41 | G sacc | 51.2 | 1.60 | 433 | 13.5 | Sept 85 | 5830 ± 110 | 9,15 |
| " | " | P obliq | 12.7 | 0.37 | 312 | 9.1 | " | 6190 ± 110 | 9,15 |
| " | " | M benth | 7.4 | 0.12 | 241 | 4 | " | 7110 ± 120 | 9 |
| 65- 70 | 1.80 | G sacc w/s | 9.6 | 0.45 | 202 | 9 | Nov 87 | 5750 ± 130 | |
| " | " | G sacc 0/s | 10.3 | 0.46 | 227 | 10.2 | Nov 87 | 5400 ± 150 | |
| " | " | P obliq | 6.2 | - | - | - | - | - | |

TABLE 12 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 70- 75 | 1.75 | G sacc | 49.7 | 1.57 | 308 | 9.8 | Oct 86 | 5990 ± 150 | 15 |
| " | " | P obliq | 22.9 | 0.82 | 256 | 9.2 | " | 6870 ± 150 | 15 |
| " | " | M benth | 4.1 | 0.09 | 260 | 6 | - | - | |
| 75- 80 | 1.81 | G sacc | 44.9 | 1.64 | 309 | 11.3 | Jan 87 | 6830 ± 190 | |
| " | " | P obliq | 28.5 | 1.11 | 273 | 10.6 | " | LOST | |
| " | " | M benth | 4.4 | 0.12 | 294 | 7.9 | - | - | |
| 80- 85 | 1.58 | G sacc | 34.5 | 1.20 | 414 | 14.4 | Apr 86 | 7670 ± 140 | 9,15 |
| " | " | P.obliq | 21.0 | 0.67 | 366 | 11.6 | " | 8350 ± 150 | 9,15 |
| " | " | M benth | 5.4 | 0.09 | 280 | 4.8 | - | - | |
| 85- 90 | 1.95 | G sacc | 37.5 | 0.99 | 586 | 14.5 | Apr 86 | 7500 ± 150 | 9,15 |
| " | " | P obliq | 29.5 | 0.46 | 481 | 14.8 | " | 7910 ± 150 | 9,15 |
| " | " | M benth | 6.0 | 0.14 | 475 | 11.1 | " | 8870 ± 160 | 9 |
| 90-100 | 2.20 | G sacc | 27.7 | 0.90 | 407 | 13.2 | Apr 86 | 8250 ± 140 | 9,15 |
| " | " | P obliq | 19.7 | 0.79 | 284 | 11.4 | July 86 | 9000 ± 130 | 9 |
| 90-100 | 1.28 | G sacc | 26.8 | 0.94 | 396 | 14 | Apr 86 | 8130 ± 140 | 9,15 |
| " | " | P obliq | 19.5 | 0.63 | 449 | 14.7 | " | 8820 ± 150 | 9,15 |
| 90-100 | 1.61 | M benth | 4.6 | 0.09 | 461 | 8.8 | July 86 | 10,930 ± 190 | |
| 96-104 | 1.21 | G sacc w/s | 13.0 | 0.58 | 224 | 8.6 | Nov 87 | 8700 ± 180 | |
| " | " | G sacc 0/s | 17.3 | 0.55 | 240 | 7.5 | Nov 87 | 8680 ± 200 | |
| " | " | P obliq | 14.0 | 0.61 | 155 | 6.8 | - | - | |
| 100-105 | 1.61 | G sacc | 35.2 | 1.22 | 382 | 13.3 | July 86 | 9050 ± 130 | 15 |
| " | " | P obliq | 17.6 | 0.66 | 320 | 12.1 | " | 9520 ± 130 | 15 |
| 105-110 | 1.33 | G sacc | 26.3 | 0.94 | 424 | 15.2 | July 86 | 8930 ± 150 | 15 |
| " | " | P obliq | 20.2 | 0.65 | 367 | 11.7 | " | 9980 ± 140 | 15 |
| 100-110 | 1.42 | M benth | 5.1 | 0.15 | 304 | 8.7 | July 86 | 11,430 ± 180 | |
| 110-115 | 1.34 | G sacc | 27.7 | 1.05 | 406 | 15.4 | Apr 86 | 9050 ± 160 | 9,15 |
| " | " | P obliq | 26.3 | 0.89 | 364 | 12.3 | " | 9800 ± 180 | 9,15 |
| " | " | M benth | 5.9 | 0.16 | 332 | 9.2 | " | 10,910 ± 180 | 9 |
| 115-120 | 1.51 | G sacc | 29.5 | 1.11 | 402 | 15.1 | Oct 86 | 9610 ± 200 | 15 |
| " | " | P obliq | 22.7 | 0.87 | 350 | 13.4 | " | 10,400 ± 220 | 15 |
| " | " | M benth | 6.2 | 0.11 | 300 | 5.7 | - | - | |
| 120-130 | 2.11 | G sacc | 46.8 | 1.64 | 405 | 14.2 | July 86 | 9520 ± 150 | 15 |
| " | " | P obliq | 32.0 | 1.00 | 359 | 11.2 | - | - | |

TABLE 12 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 120-126 | 1.60 | G sacc | 32.0 | 1.12 | 380 | 13.3 | July 86 | 9550 ± 130 | |
| 125-130 | 1.47 | G sacc | 35.4 | 1.34 | 372 | 14.1 | Jun 86 | 9910 ± 240 | 9 |
| 120-130 | 1.74 | P obliq | 37.3 | 1.17 | 319 | 10 | Jun 86 | 10,350 ± 120 | 9,15 |
| " | " | M benth | 5.4 | 0.11 | 446 | 9.1 | " | 11,690 ± 130 | 9 |
| 130-135 | 1.20 | G sacc | 20.7 | 0.68 | 248 | 8.1 | Jun 86 | 9670 ± 110 | 9 |
| 135-140 | 1.28 | G sacc | 25.9 | 0.84 | 361 | 11.7 | Jun 86 | 10,890 ± 130 | 9 |
| 140-145 | 2.05 | G sacc | 36.3 | 1.54 | 356 | 15.1 | Jun 86 | 11,300 ± 120 | 9 |
| 130-145 | 1.61 | P obliq | 35.8 | 1.24 | 331 | 11.5 | Jun 86 | 11,410 ± 190 | 9,15 |
| " | " | M benth | 4.5 | 0.10 | 490 | 10.8 | " | 11,960 ± 180 | 9 |
| 150-160 | 3.11 | G sacc | 29.7 | 1.19 | 388 | 15.5 | Jun 86 | 11,580 ± 200 | 9,15 |
| " | " | P obliq | 38.3 | 1.43 | 399 | 14.9 | " | 12,210 ± 190 | 9,15 |
| " | " | M benth | 8.7 | 0.25 | 308 | 8.7 | " | 12,620 ± 190 | 9 |
| 160-165 | 1.81 | G sacc | 20.5 | 0.72 | 242 | 8.5 | Nov 87 | 9820 ± 160 | |
| " | " | P obliq | 37.2 | 1.35 | 217 | 7.9 | Nov 87 | 12,920 ± 210 | |
| 160-165 | 1.54 | G sacc | 14.9 | 0.61 | - | - | - | - | |
| " | " | P obliq | 40.0 | 1.20 | - | - | - | - | |
| 165-170 | 1.06 | G sacc | 14.1 | 0.54 | - | - | - | - | |
| " | " | P obliq | 23.3 | 0.84 | - | - | - | - | |
| 170-175 | .83 | G sacc | 13.6 | 0.45 | 213 | 7 | Nov 87 | 11,860 ± 190 | |
| " | " | P obliq | 25.8 | 0.77 | 331 | 9.9 | Nov 87 | 13,170 ± 210 | |
| 170-175 | .98 | G sacc | 20.1 | 0.48 | - | - | - | - | |
| " | " | P obliq | 30.7 | 0.86 | - | - | - | - | |
| 175-180 | .70 | G sacc | 7.2 | 0.22 | 221 | 7.4 | May 88 | 12,980 ± 210 | |
| " | " | P obliq | 16.6 | 0.43 | 259 | 7.6 | May 88 | 13,600 ± 170 | |
| 180-195 | 1.43 | G sacc | 9.5 | 0.32 | 285 | 9.7 | Sept 85 | 13,240 ± 190 | 15,16 |
| " | " | P obliq | 5.5 | 0.17 | 270 | 8.5 | " | 15,160 ± 220 | 15,16 |
| " | " | M benth | 1.9 | 0.11 | 119 | 6.7 | " | 13,710 ± 190 | 16 |
| 180-195 | 1.35 | G sacc | 9.6 | 0.27 | 337 | 9.5 | Apr 86 | 13,220 ± 190 | 15,16 |
| " | " | P obliq | 5.8 | 0.16 | 232 | 6.6 | " | 14,780 ± 210 | 15,16 |
| 205-220 | .50 | G sacc | 6.2 | 0.15 | - | - | - | - | |
| " | " | P obliq | 1.4 | 0.07 | - | - | - | - | |

TABLE 12 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 210-220 | .89 | G sacc | 10.9 | 0.23 | 434 | 9 | Sept 85 | 1,3740 ± 190 | 15,16 |
| " | " | P obliq | 1.9 | 0.05 | 214 | 5.6 | " | 1,4340 ± 200 | 15,16 |
| " | " | M benth | 2.5 | 0.11 | 114 | 4.8 | " | 1,6330 ± 250 | 16 |
| 240-255 | 1.09 | G sacc | 2.8 | 0.08 | 218 | 6.1 | Sept 85 | 1,4570 ± 600 | 15 |
| " | " | P obliq | 12.4 | 0.34 | 444 | 12 | " | 1,6010 ± 440 | 15,16 |
| " | " | M benth | 1.3 | 0.04 | - | - | - | - | |
| 240-255 | .22 | G sacc | 3.0 | 0.07 | - | - | - | - | |
| " | " | P obliq | 5.6 | 0.22 | 300 | 11.4 | July 86 | 1,6130 ± 330 | 16 |
| 240-255 | .62 | M benth | 1.6 | 0.04 | 287 | 7.9 | July 86 | 1,7010 ± 230 | 16 |
| 270-285 | .45 | G sacc | 1.9 | 0.04 | - | - | - | - | |
| " | " | P obliq | 7.9 | 0.22 | - | - | - | - | |
| 270-285 | .38 | sac&30%rub | 2.5 | 0.06 | 387* | 8.8 | Aug 86 | 1,6170 ± 290 | 15,16 |
| " | " | P obliq | 10.4 | 0.28 | 498 | 13.5 | " | 1,7530 ± 330 | 15,16 |
| " | " | M benth | 2.5 | 0.05 | 435 | 10 | " | 1,7810 ± 350 | 16 |
| 300-318 | 1.12 | G sacc | 2.7 | 0.09 | 135 | 4.6 | Sept 85 | 1,6380 ± 590 | 15 |
| " | " | P obliq | 8.1 | 0.22 | 339 | 9.1 | " | 1,7300 ± 500 | 15 |
| " | " | M benth | 1.0 | 0.03 | - | - | - | - | |
| 300-319 | .24 | G sacc | 4.2 | 0.11 | 293 | 7.6 | Jun 86 | 1,7540 ± 260 | 15,16 |
| " | " | P obliq | 10.2 | 0.32 | 264 | 8.1 | " | 1,8440 ± 270 | 15,16 |
| 300-319 | .55 | M benth | 1.8 | 0.05 | 367 | 9.6 | Jun 86 | 1,9280 ± 290 | 16 |
| 318-330 | .41 | G sacc | 5.6 | 0.12 | 475 | 9.8 | Oct 86 | 1,7020 ± 390 | 15 |
| " | " | P obliq | 10.4 | 0.32 | 499 | 15.5 | " | 1,7840 ± 430 | 15 |
| " | " | M benth | 2.3 | 0.05 | 349 | 7 | " | 1,9040 ± 460 | |
| 330-350 | .27 | G sacc | 4.4 | 0.11 | 312 | 8 | Jun 86 | 2,1110 ± 340 | 16 |
| " | " | P obliq | 10.6 | 0.32 | 300 | 9.1 | " | 1,8890 ± 280 | 16 |
| " | " | P obliq | 10.6 | 0.32 | 472 | 15.1 | Oct 86 | 1,8770 ± 480 | 16 |
| " | " | M benth | 2.9 | 0.06 | 507 | 10.8 | Jun 86 | 1,6200 ± 220 | 16 |

*Publication no. in which radiocarbon date has been published (see References cited).
**30% G ruber added to reach desired size

TABLE 13

V35-06 South China Sea
Location (07°13'N, 112°09'E) Depth 2030m

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 1- 7TW | .80 | G sacc | 9.2 | 0.17 | 125 | 2.3 | July 85 | 1170 ± 170 | 7,9 |
| " | " | P obliq | 3.2 | 0.06 | 35 | 0.7 | - | - | |
| 7- 8TW | .83 | G sacc | 9.3 | 0.15 | - | - | - | - | |
| " | " | P obliq | 1.2 | - | - | - | - | - | |
| 8- 9TW | .68 | G sacc | 7.6 | 0.14 | - | - | - | - | |
| " | " | P obliq | 1.3 | 0.07 | - | - | - | - | |
| 9-10TW | .91 | G sacc | 5.8 | 0.13 | - | - | - | - | |
| " | " | P obliq | 1.2 | 0.12 | - | - | - | - | |
| 7-18TW | 1.80 | G sacc | 2.0 | 0.07 | - | - | - | - | |
| " | " | P obliq | 3.2 | 0.08 | - | - | - | - | |
| 18-22TW | 2.45 | G sacc | 18.4 | 0.55 | - | - | - | - | |
| " | " | P obliq | 4.8 | - | - | - | - | - | |
| 37-41TW | 2.95 | G sacc | 23.6 | 0.91 | - | - | - | - | |
| " | " | P obliq | 7.0 | 0.15 | - | - | - | - | |
| 0- 1 | 2.35 | G sacc | 2.0 | 0.29 | - | - | - | - | |
| " | " | P obliq | 3.2 | - | - | - | - | - | |
| " | " | M benth | 4.4 | - | - | - | - | - | |
| 1- 2 | 3.26 | G sacc | 16.2 | 0.51 | - | - | - | - | |
| " | " | P obliq | 2.5 | - | - | - | - | - | |
| 2- 3 | 2.28 | G sacc | 10.1 | - | - | - | - | - | |
| " | " | P obliq | 2.2 | - | - | - | - | - | |
| 1- 2 | 2.14 | G sacc | 33.8 | 0.24 | - | - | - | - | |
| 2- 4 | 2.22 | G sacc | 43.1 | 1.13 | 347 | 9.1 | July 85 | 3580 ± 80 | 7,9 |
| " | " | P obliq | 2.7 | 0.15 | 32 | 1.8 | - | - | |
| " | " | M benth | 4.9 | 0.14 | 58 | 1.6 | - | - | |
| 4- 5 | 2.04 | G sacc | 18.2 | 0.32 | 52 | 0.9 | - | - | |
| 5- 6 | 4.30 | G sacc | 69.2 | 1.99 | 251 | 7.2 | - | - | |
| 6- 7 | 2.37 | G sacc | 26.4 | 0.50 | 64 | 1.2 | - | - | |

TABLE 13 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 8-13 | 3.07 | G.sacc | 41.9 | - | 100 | 9.4 | May 85 | 4860 ± 90 | 7,9,15 |
| " | " | G.ruber | - | - | - | - | - | - | |
| " | " | P.obliq | 24.6 | - | 155 | 13.4 | May 85 | 5140 ± 90 | 7,9,15 |
| " | " | N.duter | - | - | - | - | - | - | |
| " | " | M.benth | 7.8 | - | 271 | 4.9 | May 85 | 6420 ± 100 | 7,9 |
| Unknown* | 2.16 | G.sacc w/s | 24.9 | 1.02 | 192 | 7.9 | Nov 87 | 5210 ± 170 | |
| " | " | G.sacc O/s | 19.7 | 0.60 | 269 | 8.1 | Nov 87 | 5470 ± 170 | |
| " | " | P.obliq | 15.7 | 0.53 | - | - | - | - | |
| 13-16 | 1.19 | G.sacc | 15.2 | 0.47 | - | - | - | - | |
| " | " | P.obliq | 19.7 | 0.51 | - | - | - | - | |
| " | " | M.benth | - | - | - | - | - | - | |
| 16-22 | 1.84 | G.sacc w/s | 19.5 | 0.76 | 130 | 5.1 | Nov 87 | 6350 ± 160 | |
| " | " | G.sacc O/s | 15.9 | 0.51 | 185 | 5.9 | Nov 87 | 6370 ± 170 | |
| " | " | P.obliq | 16.2 | 0.50 | - | - | - | - | |
| " | " | M.benth | - | - | - | - | - | - | |
| 17-24 | 2.38 | G.sacc | 28.9 | - | 128 | 10.0 | May 85 | 6040 ± 100 | 7,9,15 |
| " | " | G.ruber | - | - | - | - | - | - | |
| " | " | P.obliq | 13.7 | - | 161 | 12.3 | May 85 | 6060 ± 100 | 7,9,15 |
| " | " | N.duter | - | - | - | - | - | - | |
| 18-20 | - | M.benth | - | - | 273 | 4.0 | Jun 85 | 7200 ± 110 | 7,9 |
| 22-28 | - | M.benth | 7.6 | - | 237 | 4.8 | May 85 | 7660 ± 130 | 7,9 |
| 27-30 | 2.75 | G.sacc | 44.0 | - | - | 10.0 | May 85 | 6420 ± 100 | 7,9,15 |
| " | " | G.ruber | - | - | - | - | - | - | |
| " | " | P.obliq | 15.0 | - | - | 12.4 | May 85 | 6810 ± 100 | 7,9,15 |
| " | " | N.duter | - | - | - | - | - | - | |
| " | " | M.benth | 8.8 | - | - | - | - | - | |
| 37-45 | 2.46 | G.sacc | 51.0 | - | - | 10.0 | May 85 | 7890 ± 110 | 7,9,15 |
| " | " | G.ruber | - | - | - | - | - | - | |
| " | " | P.obliq | 24.0 | - | - | 13.5 | May 85 | 8030 ± 110 | 7,9,15 |
| " | " | N.duter | - | - | - | - | - | - | |
| " | " | M.benth | 8.6 | - | 480 | 8.4 | Jun 85 | 9210 ± 130 | 7,9 |
| 42-47 | 1.52 | G.sacc | 20.9 | 0.70 | - | - | - | - | |
| " | " | P.obliq | 17.7 | 0.59 | - | - | - | - | |
| " | " | M.benth | - | - | - | - | - | - | |
| 45-53 | 1.61 | G.sacc | 29.0 | - | - | 9.5 | May 85 | 8780 ± 120 | 7,9,15 |
| " | " | G.ruber | - | - | - | - | - | - | |
| " | " | P.obliq | 23.0 | - | - | 11.7 | May, 85 | 9020 ± 120 | 7,9,15 |
| " | " | N.duter | - | - | - | - | - | - | |
| " | " | M.benth | 7.9 | - | 476 | 7.0 | Jun, 85 | 9760 ± 130 | 7,9 |

TABLE 13 (cont'd)

| Depth (cm) | Coarse fraction (%) | Foram sp | Abund (no./gm) | Abund (mgm/gm) | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | Age (yr) | Ref* |
|---|---|---|---|---|---|---|---|---|---|
| 52-60 | 1.41 | G sacc | 16.5 | 0.47 | - | - | - | - | |
| " | " | P obliq | 22.6 | 0.80 | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 54-61 | 1.79 | G sacc w/s | 17.7 | 0.56 | 267 | 8.4 | Nov 87 | 9600 ± 210 | |
| " | " | G sacc 0/s | 18.5 | 0.65 | 216 | 7.7 | Nov 87 | 9500 ± 90 | |
| " | " | P obliq | 28.5 | 0.95 | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 57-64 | 0.96 | G sacc | 24.0 | - | - | 9.4 | May 85 | 9550 ± 120 | 7,9,15 |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | P obliq | 20.0 | - | - | 11.0 | May 85 | 9630 ± 120 | 7,9,15 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 6.6 | - | 362 | 6.5 | Jun 85 | 1,0810 ± 150 | 7,9 |
| 68-72 | 1.48 | G sacc | 20.0 | - | - | - | Jun 85 | 1,0130 ± 120 | 7,9,15 |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | P obliq | 51.0 | - | - | - | Jun 85 | 1,0070 ± 120 | 7,9,15 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 7.5 | - | 408 | 7.3 | Jun 85 | 1,1290 ± 150 | 7,9 |
| 78-82 | 1.72 | G sacc | 24.0 | - | - | - | May 85 | 9740 ± 130 | 7,9,15 |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | P obliq | 30.0 | - | - | - | May 85 | 1,0370 ± 130 | 7,9,15 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 9.2 | - | - | - | May 85 | 1,1180 ± 140 | 7,9 |
| 89-92 | 2.17 | G sacc | 23.0 | - | - | - | July 85 | 1,1590 ± 140 | 7,9,15 |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | P obliq | 21.0 | - | - | - | July 85 | 1,1820 ± 140 | 7,9,15 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 9.2 | - | 386 | 5.8 | July 85 | 1,2950 ± 160 | 7,9 |
| 98-102 | 1.81 | G sacc | 23.0 | - | - | - | July 85 | 1,2540 ± 160 | 7,9,15 |
| " | " | G ruber | - | - | - | - | - | - | |
| " | " | P obliq | 50.0 | - | - | - | July 85 | 1,2700 ± 160 | 7,9,15 |
| " | " | N duter | - | - | - | - | - | - | |
| " | " | M benth | 12.8 | - | - | - | July 85 | 1,3550 ± 170 | 7,9 |
| 103-108 | 1.03 | G sacc | 11.0 | 0.38 | - | - | - | - | |
| " | " | P obliq | 30.9 | 0.95 | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 145-155 | 1.03 | G sacc | 4.5 | 0.18 | - | - | - | - | |
| " | " | P obliq | 1.5 | - | - | - | - | - | |
| " | " | M benth | - | - | - | - | - | - | |
| 196-200 | 0.21 | G sacc | 0.2 | - | - | - | - | - | |
| " | " | P obliq | 0.1 | - | - | - | - | - | |
| " | " | M.benth | - | - | - | - | - | - | |

*Publication no. in which radiocarbon date has been published (see References cited).

## V. SEDIMENT TRAP SAMPLES

### MANOP SITE C

This project was initiated by Alan Mix working in cooperation with Jack Dymond. It involves measurements of one size fractions and hand-picked foraminifera shells from material caught in sediment traps deployed in the equatorial Pacific Ocean (see Tables 14, 15).

TABLE 14

MPC-2 SOUTAR

Location (01°2.4'N, 138°56.4'W) Depth 2695m

| OSU # | Coll date From | Coll date To | Material analyzed | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | $\Delta^{14}C$ (‰) |
|---|---|---|---|---|---|---|---|
| 1 | 12/16/82 | 02/29/84 | P obliq | 192 | 7.6 | Feb 86 | 112 ± 12 |
| 2 | " | " | N duter | 210 | 8.4 | " | 90 ± 12 |
| 3 | " | " | Pteropods | - | 9.6 | " | 70 ± 12 |
| 4 | " | " | 63-150µm | - | >8.6 | " | 79 ± 12 |
| 5 | " | " | <63µm | - | >9.6 | " | 50 ± 11 |
| 6 | " | " | G sacc w/s | 407 | 11.7 | " | 131 ± 12 |
| 7 | " | " | G sacc O/s | 572 | 10.4 | " | 133 ± 13 |
| 8 | " | " | G congl | 235 | 11.2 | " | 110 ± 11 |
| 9 | " | " | G ruber wh | 1490 | 9.0 | " | 98 ± 11 |
| 14(Rep5) | 12/16/82 | 02/29/84 | - | - | 53.5 | - | - |
| | | | MPC-2 Lower Trap | | | | |
| | | | Location (01°2.4'N, 138°56.4'W) Depth 3495m | | | | |
| 15 | 12/23/82 | 04/03/83 | <63µ $CaCO_3$ | - | 31.9 | - | - |
| 16 | 04/03/83 | 07/12/83 | " | - | 21.2 | Mar 87 | 204 ± 17 |
| 17 | 07/12/83 | 10/20/83 | " | - | 50.7 | - | - |
| 18 | 10/20/83 | 02/29/84 | " | - | 46.3 | - | - |
| 56(Repl6) | - | - | " | - | 25.0 | - | 243 ± 13 |
| | | | MPC-1 Middle Trap | | | | |
| | | | Location (01°3.6'N, 138°57.6'W) Depth 4295m | | | | |
| 19 | 12/18/82 | 03/29/83 | " | - | 37.0 | - | - |
| 20 | 03/29/83 | 07/07/83 | " | - | 38.5 | Mar 87 | -142 ± 14 |
| 21 | 07/07/83 | 10/15/83 | " | - | 46.0 | - | - |
| 22 | 10/15/83 | 02/08/84 | " | - | 34.5 | - | - |

TABLE 15
MPC-2 MIDDLE TRAP
Location (01°2.4'N, 138°56.4'W) Depth 1895m

| OSU # | Coll date From | To | Material analyzed | No. tests analyzed | Weight analyzed (mgm) | Date of AMS analysis | $\Delta^{14}C$ (o/oo) |
|---|---|---|---|---|---|---|---|
| 10 | 12/23/82 | 04/03/83 | <63μ $CaCO_3$ | - | 33.4 | - | - |
| 11 | 04/03/83 | 07/12/83 | " | - | 44.8 | Mar 87 | 119±15 |
| 12 | 07/12/83 | 10/20/83 | " | - | 32.4 | - | - |
| 13 | 10/20/83 | 02/29/83 | " | - | 52.5 | - | - |
| 27 | 12/23/82 | 04/03/83 | G ruber | 1290 | 7.9 | - | - |
| 28 | " | " | P obliq | 185 | 6.2 | Sept 87 | 109 ± 12 |
| 29 | " | " | G sacc w/s | 206 | 7.1 | Sept 87 | 153 ± 12 |
| 30 | " | " | G sacc O/s | 279 | 6.0 | - | - |
| 31 | 04/03/83 | 07/12/83 | G ruber | 1112 | 7.6 | - | - |
| 32 | " | " | P obliq | 272 | 6.3 | Sept 87 | 106 ± 12 |
| 33 | " | " | G sacc w/s | 344 | 9.6 | Sept 87 | 151 ± 12 |
| 34 | " | " | G sacc O/s | 309 | 5.6 | - | - |
| 35 | " | " | N duter | 161 | 5.4 | Sept 87 | 96 ± 12 |
| 36 | 07/12/83 | 10/20/83 | P obliq | 184 | 5.0 | Sept 87 | 80 ± 12 |
| 37 | " | " | N duter | 171 | 6.5 | Sept 87 | 102 ± 12 |
| 38 | 10/20/83 | 02/29/84 | P obliq | 220 | 8.2 | Sept 87 | 90 ± 13 |
| (39+40) | " | " | G sacc w/+O/s | 326 | 6.8 | Sept 87 | 93 ± 13 |
| 41 | " | " | N duter | 219 | 8.5 | Sept 87 | 48 ± 14 |
| | | | MPC-3 | | | | |
| | | | Location (01°3.6'N, 138°56.8'W) Depth 2895m | | | | |
| 23 | 02/25/84 | 04/01/84 | <63μ $CaCO_3$ | - | 12.8 | - | - |
| 24 | 04/01/84 | 07/10/84 | " | - | 22.4 | - | - |
| 25 | 07/10/84 | 10/18/84 | " | - | 47.0 | - | - |
| 26 | 10/18/84 | 02/22/84 | " | - | 33.2 | - | - |
| 42 | 04/01/84 | 07/10/84 | G ruber | 912 | 6.6 | - | - |
| 43 | " | " | P obliq | 371 | 9.7 | Sept 87 | 116 ± 12 |
| 44 | " | " | G sacc | 365 | 7.2 | Sept 87 | 121 ± 12 |
| 45 | " | " | N duter | 257 | 8.0 | Sept 87 | 77 ± 12 |
| 46 | 07/10/84 | 10/18/84 | G ruber | ≈1400 | 9.1 | - | - |
| 47 | " | " | P obliq | 231 | 8.3 | Sept 87 | 102 ± 12 |
| 48 | " | " | G sacc w/s | 347 | 9.6 | Sept 87 | 80 ± 13 |
| 49 | " | " | G sacc O/s | 511 | 9.8 | - | - |
| 50 | " | " | N duter | 278 | 9.4 | Sept 87 | 62 ± 12 |
| 51 | 10/18/84 | 02/22/85 | G ruber | ≈1300 | 8.4 | - | - |
| 52 | " | " | P obliq | 285 | 8.2 | Sept 87 | 70 ± 13 |
| 53 | " | " | G sacc w/s | 237 | 8.3 | Sept 87 | 118 ± 12 |
| 54 | " | " | G sacc O/s | 303 | 6.0 | - | - |
| 55 | " | " | N duter | 264 | 8.0 | Sept 87 | 78 ± 12 |

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# HARWELL RADIOCARBON MEASUREMENTS VI

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## INTRODUCTION

This is the first of a series of new lists of English archaeological dates commissioned for measurement by the Historic Buildings and Monuments Commission within prescribed contractual periods. This list, containing 121 dates, refers to the measurement period, April 1985 to March 1986, and results are reported irrespective of whether the associated projects are completed or ongoing.

All three measuring systems of the Isotope Measurements Laboratory were used—standard liquid scintillation counting (Otlet & Warchal, 1978) to a precision of ±1%, miniature gas proportional counting (Otlet *et al*, 1983, Otlet, Huxtable & Sanderson, 1986), and the larger sample, higher precision (±0.5%) liquid scintillation system brought into operation in 1985. In all cases, the error term quoted is the 1 sigma standard deviation estimate of the full replicate sample reproducibility (Otlet, 1979). Following further software developments, the basic text of the reports is now routinely prepared automatically from database entries using an in-house microcomputer and no longer requires a mainframe.

Calculations are based on the Libby half-life of 5568 years, using NBS oxalic acid standard (×0.95) as "modern," both values treated as constants with AD 1950 as the reference year. All results are corrected for fractionation according to the quoted $\delta^{13}C$ (wrt PDB) values measured in this laboratory.

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## ARCHAEOLOGIC SAMPLES

### *England*

### Thirlings series

Four charcoal samples taken from different features at Thirlings, Northumberland (55° 35′ 7″ N, 2° 4′ 11″ W, NGR: NT 956324).

**4270 ± 100**

**HAR-1450. F71** $\delta^{13}C = -26.5‰$

Ca 20% id. as hawthorn type (*Crataegus/Pyrus/Sorbus/Malus* sp), hazel (*Corylus avellana* L) and probably cf blackthorn (*Prunus* sp), AML 757514, from late Neolithic pit containing pottery, organic material, and saddle quern. Coll and subm Dec 1975 by R Miket, Arbeia Roman Fort and Museum.

**2060 ± 150**

**HAR-6240. I1467** $\delta^{13}C = -26.7‰$

AML 850836, from post hole of building foundation. Coll and subm Jan 1984 by C F O'Brien, Univ Newcastle-upon-Tyne.

**4450 ± 100**

**HAR-6658. F72** $\delta^{13}C = -26.1‰$

Ca 50% id. by C A Keepax as hawthorn, hazel, from fairly large branches and timbers, AML 757515, from pit containing bucket-shaped vessel. Subm Dec 1975 By R Miket.

**4530 ± 130**

**HAR-6659. F25** $\delta^{13}C = -26.4‰$

AML 757517, from circular timber structure within settlement. Subm Dec 1975 by R Miket.

**3460 ± 140**

**HAR-1923. HA76AV** $\delta^{13}C = -26.7‰$

Charcoal, id. by C A Keepax as mainly willow/poplar from large timbers plus cf blackthorn and gorse/broom both mainly twiggy, from deposit of burned material, including sand, on bedrock floor of circular building at Harlyn Bay Iron Age Cemetery, North Cornwall. Coll and subm Sept 1976 by R P Whimster, Royal Comm Historical Monuments of England. *Comment* (RPW): sample came from excavation of occupation layers antedating use of area for burial and apparently belongs to final destruction phase of building (Whimster, 1977).

**Mucking series**

**2920 ± 130**

**HAR-2337. 21958996** $\delta^{13}C = -25.6‰$

Wood, carbonized twig, AML 776299, from pit partly obliterated by Saxon sunken hut at Mucking, Essex (51° 29′ 47″ N, 0° 24′ 38″ E, NGR: TQ 673803). Coll and subm May 1977 by M U Jones.

**2440 ± 100**

**HAR-2651. R17-1476** $\delta^{13}C = -23.0‰$

Animal bone, AML 7716309, from Feature 5JJ, Layer 7063, primary silt of Early Iron Age enclosure ditch at MARC 3 R17, Winnall Down. Coll

and subm May 1977 by P J Fasham, Trust for Wessex Archaeol. *Comment* (PJF): assoc with hematite-coated pottery. Other dates are included in site report (Fasham, 1985).

**MVW79-4611 series**

**HAR-3521. SLP7917** **2830 ± 100**
$\delta^{13}C = -25.2‰$

Soil, AML 794484, from charred plant beneath stone slab on central hearth, N mound at Meare Village West, Somerset (51° 10′ 33″ N, 2° 47′ 38″ W, Natl Grid Ref ST 445422). Coll and subm Sept 1979 by J M Coles, Somerset Levels Project. *Comment* (JMC): dating material from this context was sparse; this date varies with others from comparable strata yielding dates from 2050 to 2250 BP (Orme *et al,* 1981).

**HAR-4490. HYMD781** **2820 ± 80**
$\delta^{13}C = -25.7‰$

Charcoal, id. as oak and ash, from beneath bank around Iron Age enclosure at Mingie's Ditch, Hardwick, Oxon (51° 45′ 00″ N, 1° 26′ 01″ W, Natl Grid Ref SP 391059). Coll and subm May 1981 by M Robinson, Oxford Univ Mus. *Comment* (MR): this charcoal layer probably resulted from late Bronze Age clearance, also represented on site by tree-clearance pit dated to 2800 ± 90 BP (HAR-4489).

**Wharram Percy series**

Samples from Site 30, Wharram Percy, North Yorkshire. All samples coll and subm by J G Hurst, Historic Buildings and Monuments Commission, London.

**HAR-4649. 30/1640A** **1080 ± 100**
$\delta^{13}C = -21.1‰$

Bone, AML 812982, from below carbonized grain layer. Coll and subm Aug 1981. *Comment* (JGH): sample came from bottom-most excavated layer.

**HAR-4650. 30/1640B** **1060 ± 100**
$\delta^{13}C = -22.1‰$

Bone, AML 812983, from below carbonized grain layer (?Middle Saxon). Coll and subm Aug 1981. *Comment* (JGH): sample came from bottom-most excavated layer.

**HAR-4652. 30/1642** **750 ± 90**
$\delta^{13}C = -29.2‰$

Wood, AML 812985, part of line of wattle, possibly part of lowest down feature on site. Coll and subm Aug 1981. *Comment* (JGH): sample from different line of wattle from 30/1641 (HAR-4651) dated to 860 ± 70.

**1120 ± 100**

**HAR-5624. 59/149** $\delta^{13}C = -26.7‰$

Charcoal, AML 826043, from fill of small bowl-shaped hearth of Saxon smithy. Subm June 1983. *Comment* (JGH): hearth was well-defined cut feature, probably of short life, and is one of three assoc within timber post-built structure. Whole complex is very similar to that at Ramsbury (Wiltshire). Assoc pottery suggests early-mid-Saxon date.

**660 ± 90**

**HAR-6787. 1569/120** $\delta^{13}C = -25.5‰$

Wood, AML 811624A, from unid. item at base of waterlogged silt deposits. Coll and subm Aug 1981.

**Lincoln series**

One of series of samples from single-celled church or chapel at St Paul-in-the-Bail, Lincoln, coll and subm July 1982 by B Gilmour, Lincoln Archaeol Trust.

**HAR-5098. 33BQH533** **1730 ± 110**

Human bone, AML 812976.

**Castle Farm series**

Charcoal from Iron Age Fort at Castle Farm Shifnal, Shropshire. Coll and subm Oct 1981 by A Roe, Birmingham Univ Field Archaeol Unit.

**3810 ± 110**

**HAR-5116. CF802238** $\delta^{13}C = -27.2‰$

AML 815098, from clay layer, possibly first disuse phase of Late Iron Age or Roman inner ditch (F100).

**2290 ± 100**

**HAR-5118. CF808007** $\delta^{13}C = -27.2‰$

AML 815103, from gray sandy layer producing VCP pottery within feature (F800) on Site L, E side of enclosure.

**730 ± 140**

**HAR-5279. 230-41** $\delta^{13}C = -25.0‰$

Charcoal, AML 8210221, from old land surface beneath bank around probable Dark Age Burgh at Daws Castle, Watchet, Somerset. Coll and subm Nov 1982 by N D Balaam, Ancient Monuments Lab, London.

**Trelan series**

Charcoal from Bronze Age barrow site, Trelan 2, subm by N D Balaam.

**3890 ± 120**

**HAR-5280. 41-062** $\delta^{13}C = -26.9‰$

AML 8110749, from stakehole beneath barrow. Coll June 1981 by G Smith and subm Nov 1982.

**HAR-5510. 41-062** **3530 ± 80**
$\delta^{13}C = -26.5‰$

AML 8110716, from primary fill of first phase ditch of barrow. Coll June 1981 by G Smith and subm March 1983.

### Claydon Pike series

One of series of bone and charcoal samples from Claydon Pike, Gloucestershire. Coll and subm Jan 1983 by D Miles, Oxford Archaeol Unit.

**HAR-5407. FCP1** **2380 ± 120**

Animal bone from low levels of enclosure ditch. *Comment* (DM): on pottery evidence, enclosure ditch is Late Iron Age.

### Rough Ground Farm series

Bone from Rough Ground Farm, Lechlade, Gloucestershire. Coll and subm March 1983 by T G Allen, Oxford Archaeol Unit.

**HAR-5498. RGF784** **4100 ± 100**
$\delta^{13}C = -23.8‰$

From grooved-ware rubbish pit.

**HAR-5499. RGF1260** **3710 ± 100**
$\delta^{13}C = -22.6‰$

From domestic rubbish pit, Beaker culture.

**HAR-5505. RGF1280** **1760 ± 100**
$\delta^{13}C = -23.9‰$

From basal fill of early Iron Age pit.

### Cowleaze series

Charcoal from bowl barrow at Cowleaze, Winterbourne Stepleton, Dorset (50° 41′ 55″ N, 2° 32′ 54″ W, Natl Grid Ref SY 61288898). Coll and subm June 1983 by P J Woodward, Trust for Wessex Archaeol. For full details of site, see Woodward (1988).

**HAR-5617. 968** **3390 ± 100**
$\delta^{13}C = -24.5‰$

Id. as *Quercus* sp, AML 831127, from clay-enriched soil at base of accumulated soil profile in barrow ditch (850). *Comment* (PJW): date must be compared with further samples from this soil development profile in barrow ditch; result is of right order and compares with construction data for neighboring enclosure (HAR-5622, 3410 ± 80).

**HAR-5620. 1281** **3140 ± 130**
$\delta^{13}C = -26.3‰$

Id. as *Quercus* and *Carpinus* spp, AML 831132, from Cremation 2 assoc with jet toggle and bronze awl.

**2670 ± 150**

**HAR-5623. 1150** $\delta^{13}C = -26.2‰$

Id. as *Pomoideae,* AML 831136, from primary fill of field/cemetery boundary.

### Westward Ho series

Samples from Westward Ho, North Devon coll and subm by N D Balaam.

**6580 ± 150**

**HAR-5632. 8311026** $\delta^{13}C = -27.1‰$

Charcoal, AML 8311026, from upper levels of Mesolithic midden. Subm June 1983.

**1560 ± 80**

**HAR-6513. 8311353** $\delta^{13}C = -24.6‰$

Animal bone, AML 8311353, from extensive midden-like deposit contained within silted-up estuarine channels. Subm March 1985. *Comment* (NDB): size of bones of some of domesticates suggests late prehistoric/Romano-British date.

### Manor Farm, Borwick series

Bone samples from Bronze Age burial monument at Manor Farm, Borwick, Lancashire (54° 08′ 45″ N, 2° 44′ 44″ W, Natl Grid Ref SD 513725). Coll and subm by A C H Olivier, Dept Archaeol, Univ Lancaster, July 1983. For details of site, see Olivier (1983).

**2580 ± 110**

**HAR-5659. MF82SF52** $\delta^{13}C = -22.4‰$

Scatter of human bone, AML 831223, recovered during removal of main cairn (002) which overlay limestone enclosure. *Comment* (ACHO): result indicates possible Iron Age re-use of monument.

**3450 ± 70**

**HAR-5661. MF82SF55B** $\delta^{13}C = -21.0‰$

Animal bone, AML 831792, id. as cat, from amongst human bone of central inhumation (HAR-5658, 3270 ± 80 BP).

### Lizard series

**5470 ± 130**

**HAR-5668. 235-220** $\delta^{13}C = -24.5‰$

Charcoal, id. as mainly *Quercus* sp, AML 8211180, from charcoal-rich Mesolithic feature at Windmill Farm, Lizard, Cornwall. Coll and subm July 1983.

**Ardleigh series**

Charcoal from cremations in Bronze Age cemetery at Ardleigh, Essex (51° 54′ 34″ N, 0° 59′ 1″ E, Natl Grid Ref TM 052277). Coll and subm Sept 1983 by N D Balaam.

**HAR-5744. 29-7249** **2880 ± 70**
$\delta^{13}C = -27.6‰$

Id. by N D Balaam as *Alnus glutinosa,* mature wood, AML 8319351, from cremation.

**HAR-5745. 29-7270** **2810 ± 120**
$\delta^{13}C = -25.6‰$

AML 8319352.

*General Comment* (NDB): results help establish date of cemetery.

**Bantham Ham series**

Two samples from same context, suggested post-Roman hearth, at Bantham Ham, Devon (50° 16′ 35″ N, 3° 52′ 38″ W, Natl Grid Ref SX 66254357). Subm Oct 1983 by Frances Griffith, Devon County Council.

**HAR-5775. BANTH02** **1690 ± 80**
$\delta^{13}C = -23.0‰$

Bone.

**HAR-5776. BANTH01** **1440 ± 90**
$\delta^{13}C = -24.0‰$

Charcoal, AML 823530.

**HAR-6136. A6F125A** **4270 ± 110**
$\delta^{13}C = -21.0‰$

Animal bone, AML 832756, from butchery deposit stratified late in Neolithic sequence of Runnymede Bridge, Egham, Surrey. Coll and subm Sept 1983 by S P Needham.

**Cannington series**

One of series of human bone samples from cemetery at Cannington, Somerset. Coll and subm Aug 1984 by S M Hirst and S M Wright.

**HAR-6259. 374** **1680 ± 130**
$\delta^{13}C = -22.6‰$

AML 841014, from grave assoc with slab-marked grave mound. *Comment* (SMW): grave is on N periphery of main concentration of graves, is later than path (FT 23), and is potentially one of latest graves.

**Somerset Levels series**

Wood samples from 1984 and 1985 excavations at Somerset Levels site, Somerset. For more data on project, see Harwell II (Otlet, 1977,

p 360–364), Harwell IV (Otlet & Walker, 1979, p 77–80) and Harwell V (Walker, Keyzor & Otlet, 1987, p 87–92).

**3470 ± 90**

**HAR-6263. SLP8402** $\delta^{13}C = -27.0‰$

Id. as oak, from plowed field at Fordgate, Sedgemoor (51° 4′ 54″ N, 2° 58′ 32″ W, Natl Grid Ref ST 31673187). Coll and subm Aug 1984 by J M Coles, Somerset Levels Project. *Comment* (JMC): plowed field in area undergoing drainage and cultivation has yielded various prehistoric surface finds. Oak trunk used for this sample was 1 of 6 from same source used for tree-ring studies and chronology building. Original context and approximate date was unknown. Actual sample dated came from outermost 50 sapwood rings of tree ca 160 years old (O'Hare, 1985).

**3220 ± 80**

**HAR-6606. SLP8501** $\delta^{13}C = -29.0‰$

AML 852173, from area assoc directly with foundation deposit of Bronze Age trackway, in peats closely linked to flooding horizon at Meare Heath (51° 09′ 31″ N, 2° 47′ 48″ W, Natl Grid Ref ST 443403). Coll April 1985 by A G Brown, subm April 1985 by J M Coles, Somerset Levels Project.

**3120 ± 80**

**HAR-6607. SLP8502** $\delta^{13}C = -29.0‰$

AML 852174, from same context as HAR-6606.

**Haseley Manor series**

One of series of samples from cores taken from features of multi-period building, Haseley Manor, Arreton, Isle of Wight. Samples coll and subm by D Haddon-Reece, Ancient Monuments Lab, London.

**580 ± 100**

**HAR-6353. HM83H** $\delta^{13}C = -24.5‰$

Wood, id. as oak (*Quercus* sp) by D Haddon-Reece, AML 841018, from N arch brace. *Comment* (DHR): one end is outer face of beam. Sample taken to date arch-braced collar truss which is included in earliest discernible part of building.

**Beeston Castle series**

All charcoal samples id. as oak (*Quercus* sp) from Beeston Castle, Bunbury, Cheshire (53° 7′ 43″ N, 2° 41′ 26″ W, Natl Grid Ref SJ 538593). Coll and subm July 1984 by P Hough.

**2490 ± 100**

**HAR-6459. BC0323** $\delta^{13}C = -27.7‰$

AML 834993, from beneath one of series of very large boulders which collapsed out of early phase of rampart to seal latest pre-castle road surface. *Comment* (PH): sample dates sealing of final phase of prehistoric castle road system.

**HAR-6462. BC0546** **5140 ± 90**
$\delta^{13}C = -27.8‰$

AML 834997, from lowest fill of earliest cut of N prehistoric ditch, sealed in part by colluvial sands.

**HAR-6464. BC0621/D** **2300 ± 80**
$\delta^{13}C = -25.1‰$

AML 834974, from structural timbers of rampart. *Comment* (PH): sample contains 40 to 50 rings.

**HAR-6468. BC0621/B** **2290 ± 70**
$\delta^{13}C = -25.3‰$

AML 834991, from timbers of rampart. *Comment* (PH): sample contains 20 to 30 rings of small diameter and probably represents most of radius of young tree.

**HAR-6469. BC0621/C** **2370 ± 80**
$\delta^{13}C = -24.4‰$

AML 834992, from timbers of rampart. *Comment* (PH): sample contains many rings.

**HAR-6503. BC0621/Q** **2350 ± 70**
$\delta^{13}C = -26.0‰$

AML 834977, from structural timber of rampart. *Comment* (PH): sample contains ca 40 rings and comes from mature tree.

**HAR-6504. BC0234** **2310 ± 70**
$\delta^{13}C = -25.3‰$

AML 834996, sample sealed into roadway leading into hill-fort entrance. *Comment* (PH): roadway seals ditch from which Sample 86 (HAR-6462, 5140 ± 90) was taken. Material is possibly result of site clearance.

### Barton-on-Humber series

Wood samples from St Peter's Church, Barton-on-Humber, Humberside (53° 40′ 59″ N, 0° 25′ 58″ W, Natl Grid Ref TA 035219). Coll July 1981 and subm July 1984 by W Rodwell. For details of site, see Rodwell and Rodwell (1982).

**HAR-6476. BH08** **1010 ± 80**
$\delta^{13}C = -27.6‰$

Id. as oak (*Quercus* sp), AML 841591, from lid of coffin F4181.

**HAR-6501. BH07** **900 ± 70**
$\delta^{13}C = -26.8‰$

Id. as oak (*Quercus* sp), AML 841275, from part of coffin (F3564), shaped in dug-out manner. *Comment* (WR): sample contains ca 7 rings of

average width (ca 3mm), from curvature of sample and coffin's construction. It is possible that rings were near outside of tree.

**HAR-6838. BH09** **900 ± 100**
$\delta^{13}C = -28.1‰$

Id. by Jacqui Watson as *Salix/Populus* sp, AML 800554, from part of wicker basket handle found in putlog hole on inside of tower wall. *Comment* (WR): basket presumed contemporary with building of tower.

### Drayton Cursus series

Bone from Drayton Cursus, Abingdon, Oxfordshire. Subm Aug 1984 by R Chambers, Oxford Archaeol Unit.

**HAR-6477. ABDC821** **4990 ± 100**

**HAR-6478. ABDC822** **4780 ± 100**
$\delta^{13}C = -19.0‰$

### Wenlock Priory series

Bone samples from Wenlock Priory, Much Wenlock, Shropshire (52° 35′ 49″ N, 2° 33′ 13″ W, Natl Grid Ref SJ 625001), coll June 1982 and subm July 1982 by H Woods.

**HAR-6496. 822562** **1290 ± 70**

Animal bone, AML 822562, from midden layer 62 into which burials are cut and which is sealed by early Medieval layer 56. Layer 62 overlies and layer 69 contains alluvial silt which was limit of excavation. Layer 62 was earliest deposit on site.

**HAR-6553. 53822545** **950 ± 80**
$\delta^{13}C = -23.5‰$

Human bone, AML 822545, from burial 53, sealed by ground surface 48 which cuts ground surface 56 and burials 57 and 58.

**HAR-6554. 59822548** **890 ± 70**

Human bone, AML 822548, from burial 59, sealed by ground surface 48, cutting ground surface 56, but cut by burial 57.

**HAR-6555. 58822547** **890 ± 80**

Human bone, AML 822547, from burial 58, sealed by ground surface 48, cutting ground surface 56, but cut by burial 53. Wooden base of coffin rests on midden layer 62.

**HAR-6556. 68822549** **960 ± 890**
$\delta^{13}C = -23.7‰$

Human bone, AML 822549, from burial 68, which is cut by construction trench 51 for wall 63, and which cuts into wall 52 and layers 62, 66, and 69.

**1020 ± 70**

**HAR-6609. 57822546** $\delta^{13}C = -22.1‰$

Human bone, AML 822546, from burial 57, sealed by ground surface 48, cutting ground surface 56 and burial 59, but cut by burial 53.

*General Comment:* $^{14}C$ results were intended to date stratigraphically closely related sequence of burials 53 (latest), 57, 58, 59, and 68 (earliest). However, dates obtained show that time span for whole sequence was small and thus, it is not possible to differentiate between phases. Layer 62 (HAR-6496) was earliest at site and burial sequence provides *terminus* for this (Wood, 1987).

**2280 ± 80**

**HAR-6497. SL835AJ** $\delta^{13}C = -28.5‰$

Wood, id. as *Populus* sp (Poplar) by D Haddon-Reece, AML 840002, from base of waterlogged ditch at Swarkestone Lows, Parish of Swarkestone, Derbyshire (52° 51′ 41″ N, 1° 27′ 17″ W, Natl Grid Ref SK 367295). Coll and subm Dec 1983 by S Losco-Bradley, Trent and Peak Archaeol Trust. For descriptions of site, see Greenfield (1956, 1960) and Posnansky (1956).

**8210 ± 150**

**HAR-6498. SCK** $\delta^{13}C = -30.8‰$

Wood, id. as *Salix/Populus* sp by J Watson, AML 832976, possibly only surviving remnant of late Mesolithic arrow shaft, found embedded in peat at Seamer Carr, North Yorkshire (54° 13′ 23″ N, 00° 24′ 55″ W, Natl Grid Ref TA 033820). Coll and subm Nov 1984 by A David, Historic Buildings and Monuments Comm, London. *Comment* (AD): sample was one of series of dates from Seamer Carr project; peat in which wood was embedded was previously dated to 8020 ± 90 BP (HAR-5789).

**7170 ± 80**

**HAR-6500. BLF/01/0014** $\delta^{13}C = -26.8‰$

Charcoal from soft dark brown soil lying on base of bowl-shaped pit, but probably not burned *in situ*. Upper part of pit was filled with brown clay and stone material. Charcoal was found 0.5 to 0.6m below modern turf at Lismore Fields, Buxton, Derbyshire (53° 15′ 17″ N, 1° 55′ 30″ W, Natl Grid Ref SK 050731). Coll Sept 1984 by P Losco-Bradley, subm Dec 1984 by G C Guilbert, Trent and Peak Archaeol Trust. *Comment* (GCG): sample defines chronology of broad late Mesolithic/Neolithic date indicated by flint work from 1984 trial excavation. 1985 excavations have shown discrete areas of Mesolithic and Neolithic occupation and structures.

**4130 ± 120**

**HAR-6505. N80/15** $\delta^{13}C = -25.3‰$

Charred wood and hazelnut shells forming middle layer in fill of small feature (15), probably post hole, 1 of 9 forming roughly trapezoidal setting or structure at Newton Cliffs, Lincolnshire (53° 14′ 41″ N, 0° 45′ 49″ W, Natl Grid Ref SK 825727). Coll and subm Aug 1983 by D Garton, Trent

and Peak Archaeol Trust. *Comment* (DG): date was required to distinguish between two possible contexts for putative structure because pit (11), containing Late Beaker pottery and Mesolithic flint knapping area, coincided with posthole setting (Garton, 1983).

**Heslerton Parish series**

Four results from series of samples subm from multi-phase site at Heslerton Parish, Vale of Pickering (54° 10′ 33″ N, 0° 35′ 42″ W, Natl Grid Ref SE 917765). Site covers 80km$^2$ with evidence of activity from Neolithic to Anglian periods. Samples dated include all phases of site and are intended to establish fundamental chronology both for sites, themselves, and Eastern Yorkshire as a whole. All samples coll between 1977 and 1982 and subm Oct 1984 by D J Powlesland, Heslerton Parish Project.

**HAR-6516. HP00003C** — **1690 ± 70**; $\delta^{13}C = -21.0‰$

Human bone, AML 841203, context 2B00055, from burial in pit alignment boundary of Anglian cemetery. *Comments:* $\delta^{13}$C measurement assumed (DP): iron object was apparently lodged in spine of skeleton.

**HAR-6517. HP00001C** — **2280 ± 80**; $\delta^{13}C = -23.3‰$

Human bone, AML 841201, context 1A00018, from prone burial in Anglian cemetery, originally thought to be Late Saxon insertion into pagan cemetery.

**HAR-6519. HP00008C** — **1650 ± 100**; $\delta^{13}C = -21.0‰$

Charcoal, AML 841208, from context 2R00012, from second SFB fill in Anglian settlement, 250m to SW of site 2M. *Comment* (DP): sample gives weight to hypothesis that cemetery and settlement are contemporary.

**HAR-6630. HP00016C** — **4060 ± 80**; $\delta^{13}C = -21.0‰$

Human bone, AML 841216, from primary burial within Early Bronze Age barrow. *Comments:* $\delta^{13}$C measurement assumed (DP): bones in this burial were disturbed for insertion of secondary burial IR304, HAR-6631 (3510 ± 80).

**HAR-6690. HP00012C** — **3840 ± 40**; $\delta^{13}C = -26.4‰$

Charcoal, AML 841212, context 1L00034, from large deposit sealed by preserved barrow mound and adjacent to cremation burial 1L00065 in Early Bronze Age barrow cemetery.

**Everley Water Meadow series**

Charcoal samples from Everley Water Meadow, Hambledon Hill, Dorset (50° 54′ 8″ N, 2° 11′ 52″ W, Natl Grid Ref ST 86101151). Coll and subm Jan 1985 by R J Mercer, Univ Edinburgh.

**HAR-6529. EWM8361** **3160 ± 70**
$\delta^{13}C = -26.0‰$

AML 850037, from trench 2, layer 1A, sec 2.

**HAR-6530. EWM84292** **3090 ± 80**
$\delta^{13}C = -25.4‰$

AML 850038, from trench 3, layer 4, sec 6.

**HAR-6531. EWM84331** **3070 ± 70**
$\delta^{13}C = -25.7‰$

AML 850039, from trench 3, layer 4, sec 6.

**Bromfield Quarry series**

Charcoal from Bromfield Quarry, Shropshire (52° 23′ 37″ N, 2° 45′ 35″ W, NGR: SO 483776). Coll and subm Sept 1984 by S C Stanford. For description of site, see Stanford (1980, 1982).

**HAR-6544. S168** **2400 ± 80**
$\delta^{13}C = -25.7‰$

AML 841437, from post socket (F410), of single phase four post structure within single-ditched farm enclosure, but only 1.6m from lip of ditch. *Comment* (SCS): result indicates open Iron Age settlement and gives *terminus post quem* for enclosure (E2). Pottery from this is dated Iron Age but enclosure could be Roman.

**HAR-6545. S175** **2130 ± 70**
$\delta^{13}C = -25.3‰$

AML 841438, from upper filling of shallow pit (F480). *Comment* (SCS): with HAR-6544 qv this result strengthens case for open Iron Age settlement preceding enclosure.

**HAR-6546. S182 and 183** **1800 ± 70**
$\delta^{13}C = -25.9‰$

AML 841439, from upper filling of enclosure (E2), ditch F401. *Comment* (SCS): sample should relate to extramural activities after abandonment of enclosure for which it provides *terminus ante quem.* With only 800mm gravelly filling beneath, in ditch only 2m wide at sample level, it must be unlikely that ditch was dug before first century AD.

**HAR-6547. S228 and 230** **3460 ± 90**
$\delta^{13}C = -24.4‰$

AML 841440, from well-preserved pyre base on old ground surface below few centimeters of preserved barrow material. Charcoal layer of pyre was cut by primary grave F266. *Comment* (SCS): sample dates barrow B15 within Bromfield funerary sequence and provides *terminus ante quem* for preceding Beaker use of site.

**3450 ± 70**

**HAR-6560. S231** $\delta^{13}C = -24.1‰$

AML 841441, from primary cremation grave F266 in center of barrow B15, below barrow turf but cut through pyre layer. *Comment* (SCS): result supports HAR-6547 qv with which it should be contemporary.

**3540 ± 70**

**HAR-6561. S232** $\delta^{13}C = -26.5‰$

AML 841442, from satellite cremation grave F267 within area of barrow B15, but probably below barrow material. *Comment* (SCS): it is not known whether satellite cremation was buried at same time as funeral pyre or was placed between pyre phase and barrow construction. Date confirms that primary and satellite burials were broadly contemporary.

**3090 ± 70**

**HAR-6566. S233** $\delta^{13}C = -25.2‰$

AML 841443, from cremation grave F272, in small cemetery of which other graves contained sherds of either Late Beaker or Early Bronze Age pottery.

**Cairn 38 series**

Charcoal samples from cairn site at Chysauster, CEU site 267, Carnaquidden Farm, Ludgvan, Cornwall (50° 9′ 50″ N, 5° 32′ 25″ W, NGR: SW 472354). Coll by G H Smith and subm Feb 1985 by N Balaam.

**3650 ± 80**

**HAR-6548. 8410209** $\delta^{13}C = -25.2‰$

Id. as *Quercus* sp by N D Balaam, AML 8410209, from top of old land surface sealed beneath cairn. *Comment* (GHS): charcoal was scattered over fairly wide area and was not just result of small fire but possibly of clearance of woodland prior to construction of cairn. Sample provides date for construction of kerb enclosure, which may have been ceremonial and which antedates insertion of first burials and building of cairn mound.

**3790 ± 120**

**HAR-6549. 8410212** $\delta^{13}C = -26.1‰$

Id. as *Quercus* sp and *Corylus avellana* by N D Balaam, AML 8410212, from fill of pot containing cremation burial. Pot was contained in pit under small cist outside kerb of cairn.

**3680 ± 80**

**HAR-6651. 8410213** $\delta^{13}C = -25.9‰$

Id. as *Quercus* sp by N D Balaam, AML 8410213, from fill of pot containing cremation burial, which was from pit outside kerb of cairn.

**Dubby Sike series**

Charcoal from complex site at Dubby Sike, Cowgreen Reservoir, Upper Teesdale, County Durham (54° 40′ 28″ N, 2° 19′ 5″ W, NGR: NY

795311). Coll and subm Oct 1984 by D Coggins, The Bowes Mus, Barnard Castle.

**HAR-6551. DS842P** **2110 ± 90**
$\delta^{13}C = -26.2‰$

AML 843341, from small bowl-shaped pit in natural subsoil of ring cairn which covered flat stones.

**HAR-6552. DS843GH** **2170 ± 100**
$\delta^{13}C = -26.4‰$

AML 843342, from beneath paving just outside entrance to large sub-circular building at S W edge of site.

**Bawsey series**

Charcoal, id. as oak, from Mintlyn Wood, Bawsey, Norfolk (52° 45′ 0″ N, 0° 27′ 56″ E, NGR: TF 66381981). Coll and subm Nov 1984 by P Murphy.

**HAR-6569. SML33** **3560 ± 80**
$\delta^{13}C = -26.7‰$

AML 842808, from context 1304, secondary cremation inserted into mound of barrow with primary grave containing broken beaker and stain of bier. *Comment* (PM): sample assoc with pot and spoon-like artifact.

**HAR-6614. SML17** **2810 ± 80**
$\delta^{13}C = -26.3‰$

AML 842807, in deposit of burned flint, calcined bone, and pottery fragments, context 1002. *Comment* (PM): date interpreted as secondary cremation in mound of barrow with primary grave containing broken beaker and stain of bier.

**Sandon series**

Wood samples from valley sediments, in valley close to Neolithic cursus at Sandon Culvert, Springfield, Chelmsford, Essex (51° 42′ 41″ N, 0° 31′ 44″ E, NGR: TL 747045). Coll and subm Nov 1984 by P Murphy.

**HAR-6570. SANDTOP** **860 ± 70**
$\delta^{13}C = -26.6‰$

AML 842811.

**HAR-6580. SANDBASE** **1770 ± 70**
$\delta^{13}C = -28.3‰$

AML 842812. *Comment* (PM): sample provides date for base of pollen and macro-column samples from sec.

**Towcester Church series**

Wood, id. as *Quercus* sp, from two cores taken from head of effigy of Archdeacon Sponne at Towcester Church, Northamptonshire. Coll and subm July 1984 by D Haddon-Reece.

**290 ± 70**
$\delta^{13}C = -26.0‰$

**HAR-6574. TOW1**

AML 840108.

**240 ± 70**
$\delta^{13}C = -24.3‰$

**HAR-6575. TOW2**

AML 840109.

**Hullbridge series**

Samples taken from peat at sites on N bank of River Crouch opposite Hullbridge, Essex (52° 31′ 41″ N, 0° 39′ 24″ E, Natl Grid Ref TL 802956). Coll June and subm July 1984 by P Murphy.

**1420 ± 70**
$\delta^{13}C = -27.7‰$

**HAR-6581. H52WOOD**

Wood, AML 841420, from brushwood trackway in upper peat at Site 52. *Comment* (PM): trackway thought to be Late Roman or Early Saxon.

**HAR-6589. H4UPEATT** **1380 ± 80**

Peat, id. as *Phragmites* sp, AML 841421, from top 5cm of peat layer at Site 4. *Comment* (PM): sample provides date for top of upper peat, indicating change from freshwater to estuarine conditions (Murphy & Wilkinson, 1982).

**3990 ± 70**
$\delta^{13}C = -24.6‰$

**HAR-6604. STL7/43**

Charcoal, id. as mostly oak, AML 841422, from site 7, St Lawrence, Essex. Coll May 1984 and subm July 1984 by P Murphy, Centre for East Anglian Studies, Norwich. *Comment* (PM): sample probably relates to phase of forest clearance.

**1330 ± 80**
$\delta^{13}C = -26.9‰$

**HAR-6605. BRD0/83**

Charcoal, AML 841427, from 25 to 40cm below Middle Saxon occupation layer, but above humified peat layer at Stanch Meadow, Brandon (BRD 018), Suffolk (52° 26′ 46″ N, 0° 36′ 59″ E, Natl Grid Ref TL 778864). Coll May 1984 and subm July 1984 by P Murphy. *Comment* (PM): sample appears to be related to clearance, by burning, of vegetation on site. Date defines beginning of site and is relevant to dating Ipswich Ware in general.

**Bradwell series**

Charcoal, id. as *Quercus* sp from beneath peat on head surface at site 8, Bradwell-on-Sea, Essex (51° 44′ 36″ N, 00° 53′ 50″ E, Natl Grid Ref TM000090). Coll and subm July 1984 by P Murphy.

**HAR-6617. BRA8/32** **4690 ± 70**
$\delta^{13}C = -25.2‰$

**HAR-6618. BRA8/31** **4000 ± 70**
$\delta^{13}C = -24.5‰$

*General Comment* (PM): results provide date for Middle Neolithic site.

**Springfield series**

Charcoal from Late Bronze Age site at Springfield Lyons, Chelmsford, Essex (51° 44′ 46″ N, 0° 30′ 49″ E, Natl Grid Ref TL 735083). Coll and subm Nov 1984 by P Murphy.

**HAR-6621. SB3558** **3760 ± 70**
$\delta^{13}C = -24.9‰$

Id. as oak, AML 842809, from pit. *Comment* (PM): result provides *terminus post quem* for enclosure.

**HAR-6622. SB3666** **2830 ± 70**
$\delta^{13}C = -24.1‰$

Id. as oak, ash and hazel/alder, AML 842810, from post hole of round house.

**HAR-6623. MAY341** **4190 ± 80**
$\delta^{13}C = -26.2‰$

Wood, id. as oak, AML 841423, from peat overlying head surface at site 3, Maylandsea, Essex (Natl Grid Ref 915046). Coll June and subm July 1984 by P Murphy.

**Sproatley series**

Two samples from series of bog oaks excavated in 1984 during drainage in Carr land at Sproatley, Humberside (Natl Grid Ref TA 205347). Samples coll and subm May 1985 by D Crowther, City of Kingston upon Hull, Museum and Art Gallery.

**HAR-6626. SPRTLY1A** **6310 ± 80**
$\delta^{13}C = -25.6‰$

**HAR-6627. SPRTLY1B** **6300 ± 80**
$\delta^{13}C = -26.1‰$

*General Comment:* bog oaks were found in peat at depth ca 5m. One showed signs of having been chopped apart ca 2m from root bole. How long after death that tree was chopped is not known, although angle of chopped surface and distance from root bole point to possibility of tree leaning in rising bog. $^{14}C$ results suggest Neolithic felling and toolmark studies are awaited.

**Bushmead Priory series**

Wood from Bushmead Priory, Eaton Socon, Bedfordshire (Natl Grid Ref TL 108108) (Hughes, Milson & Leggett, 1981). Coll 1981 and subm May 1985 by D Haddon-Reece.

**630 ± 40**

**HAR-6628. 16N1B** $\delta^{13}C = -24.9‰$

Id. as oak (*Quercus* sp) from rings 11 to 20 of 30-year sequence of timber 16N1.

**680 ± 40**

**HAR-6629. 16N1C** $\delta^{13}C = -25.4‰$

Id. as oak (*Quercus* sp) from rings 1 to 10 of timber 16N1.

**Davidstow Moor series**

Charcoal from separate barrows at Davidstow Moor, Cornwall. Coll 1941 and 1942 and subm Dec 1984 by P Christie, Inst Archaeol, London.

**3520 ± 70**

**HAR-6634. DM147** $\delta^{13}C = -25.2‰$

Id. by C R Cartwright as including *Corylus, Calluna, Quercus, Carpinus, Betulus,* and *Leguminosae* spp, AML 851366, from fires 1 and 2 in Barrow 1 (50° 38′ 23″ N, 04° 37′ 33″ W, Natl Grid Ref SX 14358560).

**3580 ± 70**

**HAR-6635. DM24** $\delta^{13}C = -26.8‰$

Id. by C R Cartwright as including *Calluna, Quercus,* and *Leguminosae* spp, AML 851364, from miniature cairn outside kerb on axis of SE quad of Barrow 2 (50° 37′ 54″ N, 04° 36′ 28″ W, Natl Grid Ref SX 15608465). *Comment* (PMC): result relates satisfactorily to early collared urn tradition.

**3740 ± 90**

**HAR-6640. DM82** $\delta^{13}C = -26.0‰$

Id. by C R Cartwright as including *Calluna* and *Leguminosae* spp, AML 851365, from center of old turf in Barrow 8 (50° 38′ 21″ N, 04° 37′ 20″ W, Natl Grid Ref SX 14608550).

**4130 ± 70**

**HAR-6643. DM223** $\delta^{13}C = -25.6‰$

Id. by C R Cartwright as including *Corylus, Calluna, Quercus, Leguminosae,* and *Salix/Populus* spp, AML 851367, from pit 16 in Barrow 22 (50° 38′ 59″ N, 04° 37′ 38″ W, Natl Grid Ref SX 14308670). *Comment* (PMC): result is unsatisfactory as sample is believed to relate to pre-barrow (Grooved Ware) occupation of site.

*General Comment* (PMC): $^{14}C$ dating is sole way of dating barrows more precisely and establishing relationship between them. It is fortunate that charcoal was retained from 1940s excavations.

**Ham Hill series**

**HAR-6653. 252/84** **2160 ± 90**

Charcoal, id as *Alnus* sp, AML 8312852, from Iron Age pit at Ham Hill. Coll and subm April 1985 by N Balaam.

**Greyhound Yard, Dorchester series**

Two antler samples, id. as *Cervus elaphus* L sp, from primary contexts of large Neolithic monument in SE corner of Roman town of Dorchester (Durnovaria), Greyhound Yard site (50° 42′ 49″ N, 2° 26′ 4″ W, Natl Grid Ref: SY 69349060). Samples coll Aug and subm Nov 1984 by P J Woodward. For description of excavations, see Woodward, Davies and Graham (1984).

**HAR-6663. W67.4947** **4020 ± 80**
$\delta^{13}C = -23.8‰$

Frontal bone and skull attached to antler from mature stag, AML 843338, from Late Neolithic post-pit.

**HAR-6664. W67.4166** **4070 ± 70**
$\delta^{13}C = -23.6‰$

Base and shaft of mature shed antler, AML 843339, from post pipe.

*General Comment* (PJW): two results are consistent with each other and also with HAR-5508 (4060 ± 90 BP) and provide date in late Neolithic slightly earlier than those of two neighboring sites, shafts at Mammbury Rings (BM-2281, 3650 ± 70 and -2282, 3640 ± 70) (Bradley & Thomas, 1985) and palisade at Mount Pleasant (Wainwright, 1979).

**Chelmer Bridge series**

Wood taken from detritus mud at Chelmer Bridge (51 43′ 48″ N, 0° 31′ 32″ E, NGR: TL 74390655). Coll and subm May 1985 by P Murphy.

**HAR-6682. CBBASE** **3710 ± 80**
$\delta^{13}C = -29.2‰$

AML 852732, from base of detritus mud.

**HAR-6683. CBTOP** **3200 ± 70**
$\delta^{13}C = -28.4‰$

AML 852733, from top of detritus mud.

**Asheldham Camp series**

Charred grain samples, id. as wheat (*Triticum* sp), from Asheldham Camp, Essex (51° 40′ 28″ N, 0° 51′ 9″ E, Natl Grid Ref TL 972012). Coll April 1985 by O Bedwin, Essex County Council and subm July 1985 by P Murphy. For report on site, see Essex County Council (1985).

**HAR-6700. AC8563** **1980 ± 80**
$\delta^{13}C = -24.4‰$

AML 852765, from lower fill of pit 62 in trench F.

**HAR-6701. AC8538** **2190 ± 70**
$\delta^{13}C = -24.8‰$

AML 852764, from fill of context 37.

**2280 ± 80**

**HAR-6702. AC8534** $\delta^{13}C = -24.4‰$

AML 852763, from lower fill of pit 62 in trench F.

*General Comment* (OB): all samples were assoc with middle Iron Age pottery.

**Dalton Parlours series**

Two samples from series of six from occupation site at Dalton Parlours, Collingham Parish, Near Wetherby, West Yorkshire (53° 53′ 42″ N, 1° 23′ 18″ W, Natl Grid Ref SE 402445). Site is multi-phase Iron Age occupation site of several acres and comprises a complex of linked irregular single-ditched enclosures within which were round houses and other typical Iron Age structures. After a break in occupation, a large Roman Villa existed and thereafter some Anglo-Saxon activity is suspected. All samples coll 1976 to 1978 by A B Sumpter and subm March 1985 by J D Hedges.

**1780 ± 80**

**HAR-6714. DP5005** $\delta^{13}C = -20.7‰$

Human bone, AML 852634, from burial.

**2090 ± 80**

**HAR-6716. DP0032** $\delta^{13}C = -21.0‰$

Animal bone, AML 852636. *Comment:* $\delta^{13}C$ value is assumed.

**Moss Mire series**

Peat from Moss Mire, Barnard Castle, Co Durham. Coll and subm Jan 1979 by A M Donaldson.

**2170 ± 110**

**HAR-6804. MM220** $\delta^{13}C = -29.5‰$

AML 790084, from forested period preceding first major clearance.

**4720 ± 130**

**HAR-6805. MM260** $\delta^{13}C = -30.9‰$

AML 790085, lowest datable sample from forested period preceding first major clearance.

**Aldwark series**

**680 ± 80**

**HAR-6887. EBR5556** $\delta^{13}C = -21.3‰$

AML 777855, bone, fragmentary skull of man 25–35 years old, with widespread ulceration of external surface of both parietals and frontal bone, possibly from syphilis (Dawes & Magilton, 1980). From context 1162, described as 'late medieval level,' NW (*ie*, on liturgical N side) of church of St Helen-on-the-Walls, Ebor Cemetery, Aldwark, York (53° 57′ 41″ N, 1° 4′ 31″ W, Natl Grid Ref SE 60665212). Coll April 1974 by J D Dawes and subm Aug 1977 by H K Kenward, York Archaeol Trust.

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# HARWELL RADIOCARBON MEASUREMENTS VII

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## INTRODUCTION

The results presented in this list are mostly from our earlier years of operation, the most recent of which were measured in 1984. It is the second of a series of special lists being prepared hopefully to clear the backlog of unpublished dates of this laboratory. All samples are of archaeological origin from the United Kingdom; most have originated from "rescue" type excavations and all were sponsored by the Ancient Monuments Laboratory of the Historic Buildings and Monuments Commission.

All samples were measured by liquid scintillation counting (Otlet & Warchal, 1978), and the error term quoted is the 1 sigma standard deviation estimate of the full replicate sample reproducibility (Otlet, 1979). The list was produced, as was the last one, from computer-prepared data using procedures described in Otlet and Walker (1983). Calculations are based on the Libby half-life of 5568 years, using NBS oxalic acid standard (×0.95) as "modern," both values treated as constants, with AD 1950 as the reference year. All results are corrected for fractionation according to the quoted $\delta^{13}C$ (wrt PDB) values measured in this laboratory.

## ACKNOWLEDGMENTS

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## ARCHAEOLOGIC SAMPLES

### *England*

#### St Aldates series

Wood and charcoal, from St Aldates, Oxford (51° 44′ 46″ N, 1° 15′ 20″ W, Natl Grid Ref SP 514058). Coll and subm by B G Durham, Oxford Archaeol Unit. See Durham (1977, 1983, 1984) for report on site at 65 St Aldates; for other dates from area, see Harwell I (R, 1974, v 16, no. 2, p 179–180).

**HAR-717. SPL319** **870 ± 70**
$\delta^{13}C = -25.7‰$

Charcoal, id. as charred twigs, from 79–80 St Aldates (Durham, 1977).

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**1150 ± 90**

**HAR-718. SPL406** $\delta^{13}C = -25.4‰$

Wood from 79–80 St Aldates (Durham, 1977).

**830 ± 70**

**HAR-5339. OX65A313** $\delta^{13}C = -28.5‰$

Wood, AML 826484, from early silting after abandonment of ford, trench III (1981), at 65 St Aldates. Coll Dec 1981 and subm Dec 1982. *Comment* (BGD): result of AD 1100 expected for this material which is from first 0.3m silting above abandoned 'Oxen Ford'; this is confirmed by $^{14}C$ result.

**1020 ± 70**

**HAR-5340. OX65A317** $\delta^{13}C = -28.7‰$

Wood, AML 826485, from core of stone ford, trench III (1981), at 65 St Aldates. Coll Dec 1981 and subm Dec 1982. *Comment* (BGD): 'Oxen Ford' is thought to have existed from ca AD 800; this result presumably relates to repair or general widening of upstream edge.

**1080 ± 70**

**HAR-5341. OX65A402** $\delta^{13}C = -29.3‰$

Wood, AML 826486, from waterfront at rear of tenement fronting 65 St Aldates, (trench IV, 1982). Coll June 1982 and subm Dec 1982. *Comment* (BGD): topographically, this feature was assumed to be 13th century AD, however, result is one of earliest dates in Oxford and at that time area was assumed to be broad, forded river channel. Sample came from salvage operation so no other evidence is available.

**1080 ± 80**

**HAR-5343. OXTMS31** $\delta^{13}C = -27.4‰$

Wood, AML 826488, from stake at base of gully in S trench at 89–91 St Aldates. Coll Dec 1981 and subm Dec 1982.

**980 ± 70**

**HAR-5346. OXTMS35** $\delta^{13}C = -27.9‰$

Wood, AML 826491, from wooden fender in front of gravel waterfront at 89–91 St Aldates. Coll July 1982 and subm Oct 1982.

**Wetwang series**

Samples from sites VI, VII, IX and XII at Wetwang Slack, East Yorkshire. All samples coll by J S Dent or J D Dawes and subm by J S Dent, Humberside Co Council, Beverley, North Humberside. For descriptions of different aspects of site, see Dent (1978, 1978, 1982); for summary of excavations, 1964–1980, see Dent (1983).

**2110 ± 80**

**HAR-1665. WE1 AF** $\delta^{13}C = -22.0‰$

Human bone, AML 760801, from woman's skeleton, burial 155, in Iron Age grave at site VII (54° 1′ 41″ N, 0° 33′ 20″ W, Natl Grid Ref SE

946601). Coll April 1976 and subm May 1976. *Comment* (JSD): two bronze bracelets, bronze brooch, bronze earring, and glass bead necklace were found with sample.

**HAR-1878. WSVI F1AK** **3450 ± 90**
$\delta^{13}C = -25.0‰$

Wood, AML 760784, ca 50% id. by C A Keepax as oak and hawthorn type, probably mature wood, from remains of coffin at site VI (54° 1′ 41″ N, 0° 33′ 15″ W, Natl Grid Ref SE 947601). Coll April 1975 and subm Sept 1976. *Comment* (JSD): coffin was from grave thought to be Bronze Age although among Iron Age square barrows; latter is confirmed by $^{14}C$ result. Inhumation was assoc with animal shoulder blade, possibly deer, and grave fill clearly cut cremation (assumed to be Bronze Age also).

**HAR-1879. WSVI F455NS** **3160 ± 90**
$\delta^{13}C = -26.0‰$

Wood, AML 760783, from post pipe of circle of nine large posts (54° 1′ 44″ N, 0° 33′ 20″ W, Natl Grid Ref SE 946602). Coll Sept 1975 and subm Sept 1976. *Comment* (JSD): post circle, ca 9m diam, more probably from ritual or funerary monument than domestic structure.

**HAR-2771. WT 125CR** **2140 ± 80**
$\delta^{13}C = -21.6‰$

Human bone, AML 781193, burial 236, from grave in Iron Age cemetery at site IX (54° 1′ 38″ N, 0° 33′ 31″ W, Natl Grid Ref SE 944600). Coll June 1977 and subm May 1978. *Comment* (JSD): bronze bracelet, iron brooch, and glass bead necklace found with burial.

**HAR-2776. WSVI F334MD** **1790 ± 70**
$\delta^{13}C = -23.1‰$

Human bone, AML 781194, burial 117, from grave in Iron Age cemetery at site VI (54° 1′ 44″ N, 0° 33′ 20″ W, Natl Grid Ref SE 946602). Coll Oct 1975 and subm May 1978. *Comment* (JSD): iron brooch and pig bones were found with burial.

**HAR-2777. WSV1 F292JU** **2080 ± 80**
$\delta^{13}C = -21.6‰$

Human bone, AML 781196, burial 98, from Iron Age grave at Site VI (54° 1′ 44″ N, 0° 33′ 20″ W, Natl Grid Ref SE 946602). Coll Aug 1975 and subm May 1978. *Comment* (JSD): burial contained sword and shield.

**HAR-4425. WG218EC** **2270 ± 100**
$\delta^{13}C = -26.0‰$

Charcoal, id. as oak (*Quercus* sp) and blackthorn (*Prunus* sp) from mature timbers, also hawthorn (*Rosaceae* subfamily *Pomoideae*) and hazel/alder (*Corylus/Alnus* sp) from twigs or branches, found in post hole in early Iron Age round house at Site XII (54° 1′ 41″ N, 0° 33′ 38″ W, Natl Grid Ref SE 94286010). Coll May 1980 and subm Feb 1981. *Comment* (JSD): sample from one of many round houses representing, with post squares, buildings

of early Iron Age linear settlement. Other assoc features include linear ditches, trackways, and large cemetery.

**3780 ± 70**

**HAR-4427. WG7AX** $\delta^{13}C = -25.4‰$

Wood, id. by C A Keepax as oak (*Quercus* sp) from mature timbers, from timber lining of burial cist, burial 12, in early Bronze Age grave at Site XII (54° 1′ 38″ N, 0° 33′ 37″ W, Natl Grid Ref SE 943600). Coll May 1980 and subm Feb 1981. *Comment* (JSD): grave contained crouched burial with pig bones and very fine battle axe. Only Yorkshire battle axe burial found since advent of $^{14}C$ dating.

**4260 ± 80**

**HAR-4428. WE47IUW** $\delta^{13}C = -25.6‰$

Wood, id. by C A Keepax as oak, (*Quercus* sp) from mature timbers, from pit at center of interrupted circular ditch at site VII (54° 1′ 41″ N, 0° 33′ 26″ W, Natl Grid Ref SE 945601). Coll Feb 1977 and subm Feb 1981. *Comment* (JSD): no bone was recovered from central pit, but monument is probably ritual or funerary; for comparable examples, see Allen (1981).

*General Comment* (JSD): Wetwang Slack is dry valley in Yorkshire Wolds containing many prehistoric burial and settlement sites. $^{14}C$ dating has proved useful in identifying second millennium BC features. However, it has not been possible to provide absolute dates for various stages of development of Iron Age cemetery as time-span of its use is short in comparison with precision of $^{14}C$ dates (see HAR-1665, -2771, -2776, -2777). This is where precision $> \pm$ 1% is needed for effective archaeological interpretation.

**Hereford series**

Wood from Saxon sites in City of Hereford, Hereford and Worcester. Coll by R Shoesmith, City of Hereford Archaeol Comm. For other results in series, see Harwell III (R, 1979, v 21, no. 3, p 373).

**750 ± 70**

**HAR-1735. HE741** $\delta^{13}C = -27.6‰$

Wood, AML 753184, from part of timber structure of unknown nature in disused Saxon defensive ditch at City Arms site (52° 3′ 22″ N, 2° 42′ 58″ W, Natl Grid Ref SO 50913999). Coll 1974 and subm May 1976 by R Shoesmith. *Comment* (RS): result shows ditch stayed open and was re-used (Shoesmith, 1982).

**980 ± 70**

**HAR-5066. SAMPLF** $\delta^{13}C = -24.9‰$

Wood, AML 813956, from timber 'corderoy' road 2m below present level in King St (52° 3′ 14″ N, 2° 43′ 1″ W, Natl Grid Ref SO 50853981). Coll Oct 1980 and subm June 1982 by D Haddon-Reece, Ancient Monuments Lab, London. *Comment* (DHR): sample came from point where road

crossed marshy area some 50m wide to W of Cathedral. King St appears to be original E-W rd of Saxon town and may have provided W limit of original cathedral nucleus (Shoesmith, 1980). $^{14}C$ result is of value in considering origin of street plan of Hereford.

**3520 ± 80**

**HAR-4399. EXG027** $\delta^{13}C = -22.1‰$

Human bone, from possible Bronze Age inhumations at Exning, Suffolk (52° 14′ 45″ N, 0° 23′ 18″ E, Natl Grid Ref TL 63036357). Coll by E Martin and subm Feb 1981 by P Murphy. *Comment* (PM): result confirms Bronze Age date for burials.

**1540 ± 80**

**HAR-4525. 575C-IV** $\delta^{13}C = -28.4‰$

Wood and peat, AML 811641, from humidified peat and very humic silt mud with occasional wood fragments at 1.20m OD (51° 29′ 47″ N, 0° 16′ 35″ E, Natl Grid Ref TQ 580800). Coll and subm June 1981 by T J Wilkinson. *Comment* (TJW): same level as scatter of charcoal fragments in peats (possible clearance or human influence).

**1470 + 80**

**Brixworth series**

Wood from All Saint's Church, Brixworth, Northamptonshire (52° 20′ 0″ N, 0° 54′ 13″ W, Natl Grid Ref SP 747712). Coll Nov 1981 by N Wilson and subm April 1982 by M Audovy.

**HAR-4945. BX81705** **1130 ± 70**
$\delta^{13}C = -27.8‰$

AML 822326, from base courses of jamb of nave arcading.

**HAR-4946. BX81600** **1270 ± 80**
$\delta^{13}C = -24.2‰$

AML 822325, from just below a thin layer of mortar. *Comment* (MA): sample from probable construction layer and thus assoc with building of church.

**Raunds series**

Samples from Anglo-Saxon site at Raunds, Northamptonshire (52° 20′ 54″ N, 0° 32′ 0″ W, Natl Grid Ref SP 999733). All samples except HAR-4903 subm April 1982 by A Boddington, Northamptonshire Co Council. For description of site, see Boddington and Cadman (1981).

**HAR-4903. 223** **1480 ± 90**
$\delta^{13}C = -25.4‰$

Charcoal, AML 813690, from fill of possible pit oven, Site 77. Coll by S A Power and C Addison-Jones and subm Sept 1981 by G Cadman. *Comment* (GC): sample from 1st phase of Saxon occupation. Forms part of earliest period, represented by scatter of isolated features (Cadman, 1983).

**HAR-5010. 5222-111** **970 ± 70**
$\delta^{13}C = -21.6‰$

Human bone, from Anglo-Saxon cemetery. Coll July 1979 and subm April 1982 by A Boddington. *Comment* (AB): sample contemporary with period IIC church.

**HAR-5011. 5299-136** **960 ± 60**
$\delta^{13}C = -22.1‰$

Human bone, from late Anglo/Saxon Christian cemetery. Coll July 1980 and subm April 1982 by A Boddington. *Comment* (AB): sample is contemporary with period II A/B church.

**HAR-5012. 5286-135** **1000 ± 70**
$\delta^{13}C = -22.1‰$

Human bone, from late Anglo/Saxon Christian cemetery. Coll July 1980 and subm April 1982 by A Boddington. *Comment* (AB): sample is contemporary with period II A/B church.

**1320 ± 70**

**HAR-5013. 5266-122** $\delta^{13}C = -21.0‰$

Human bone, from late Anglo-Saxon Christian cemetery. Coll Oct 1979 and subm April 1982 by A Boddington. *Comment* (AB): sample is contemporary with period II A/B church.

**1110 ± 90**

**HAR-5014. 5223-112** $\delta^{13}C = -22.4‰$

Human bone, from late Anglo-Saxon Christian cemetery. Coll July 1980 and subm April 1982 by A Boddington. *Comment* (AB): sample is contemporary with period II A/B church.

**1040 ± 70**

**HAR-5015. 5015-71** $\delta^{13}C = -26.0‰$

Charcoal from chancel of late Anglo/Saxon church. Coll July 1980 and subm April 1982 by A Boddington. *Comment* (AB): sample antedates period II C rebuilding.

**1080 ± 70**

**HAR-5016. 5254-119** $\delta^{13}C = -22.6‰$

Human bone, from late Anglo-Saxon cemetery. Coll Aug 1979 and subm April 1982 by A Boddington. *Comment* (AB): sample contemporary with period IIC church.

**930 ± 70**

**HAR-5019. 5178-113** $\delta^{13}C = -22.0‰$

Human bone, from late Anglo/Saxon Christian cemetery. Coll May 1979 and subm April 1982 by A Boddington. *Comment* (AB): sample is contemporary with period IIC church.

**1100 ± 80**

**HAR-5020. 5298-134** $\delta^{13}C = -22.8‰$

Human bone, from late Anglo-Saxon cemetery. Coll July 1979 and subm April 1982 by A Boddington. *Comment* (AB): sample contemporary with period IIA/B church.

*General Comment* (GC & AB): excavations at Raunds site "Furnells" include Saxon settlement, late Saxon church and cemetery and medieval manor house. Work on this began in 1977 and was completed in 1982 although excavation of surrounding sites continues to investigate nature and evolution of Saxon and Medieval landscape complex.

### Hullbridge series

Samples from survey at Hullbridge basin, Essex. Coll June 1982 and subm Aug 1982 by P Murphy, except where indicated, on behalf of Essex Co Council.

**2620 ± 70**

**HAR-5221. H11ROOT** $\delta^{13}C = -29.1‰$

Wood, AML 823047, from tree roots in exposed estuarine clay surface at Site 11 (51° 38′ 11″ N, 0° 36′ 26″ E, Natl Grid Ref TQ 80419634). *Comment* (PM): sample within area of prehistoric occupation exposed by machining (Murphy & Wilkinson, 1982).

**2730 ± 60**

**HAR-5222. H1WOOD14** $\delta^{13}C = -28.3‰$

Wood, AML 823048, from layer sealed by ca 2.0m of estuarine clay at site 1 (51° 38′ 15″ N, 0° 35′ 47″ E, Natl Grid Ref TQ 79649645). *Comment* (PM): sampled brushwood, exposed by erosion, assoc with probable prehistoric platform structure (Murphy & Wilkinson, 1982).

**3660 ± 70**

**HAR-5223. H4LPEATW** $\delta^{13}C = -28.0‰$

Wood, AML 823049, from top of Flandrian lower peat at site 4 (51° 37′ 48″ N, 0° 36′ 17″ E, Natl Grid Ref TQ 80269561). *Comment* (PM): agrees well with $^{14}C$ determination (HAR-5226) from base of lower peat at same loc (Murphy & Wilkinson, 1982).

**1500 ± 70**

**HAR-5224. H9UPEAT** $\delta^{13}C = -29.1‰$

Soil, AML 823050, from Flandrian upper peat at site 9 (51° 38′ 14″ N, 0° 39′ 34″ E, Natl Grid Ref TQ 84019657) described in Murphy and Wilkinson (1982).

**1610 ± 70**

**HAR-5225. H4UPEATB** $\delta^{13}C = -30.3‰$

Soil, AML 823051, from base of Flandrian upper peat at site 4 (51° 37′ 48″ N, 0° 36′ 17″ E, Natl Grid Ref TQ 80269561) described in Murphy and Wilkinson (1982).

**3760 ± 70**

**HAR-5226. H4LPEATB** $\delta^{13}C = -30.0‰$

Soil, AML 823052, from base of Flandrian lower peat at site 4 (51° 37′ 48″ N, 0° 36′ 17″ E, Natl Grid Ref TQ 80269561) described in Murphy and Wilkinson (1982).

**4100 ± 70**

**HAR-5227. H8ROOTS** $\delta^{13}C = -30.6‰$

Wood, AML 823053, id. as tree roots, from site 8, 40m S of shore of Crouch Estuary (51° 38′ 14″ N, 0° 39′ 2″ E, Natl Grid Ref TQ 83409653). Coll June 1978. *Comment* (PM): roots comprise part of currently exposed Flandrian submerged forest once sealed by estuarine clays, but sample measured was sub-aerially exposed (Murphy & Wilkinson, 1982).

**270 ± 80**

**HAR-5549. H44TWIGS** $\delta^{13}C = -28.5‰$

Wood, AML 831123, from context 44 of structure thought originally to be prehistoric (51° 37′ 54″ N, 0° 38′ 3″ E, Natl Grid Ref TQ 82299589). Coll Dec 1982 by T J Wilkinson and subm April 1983. *Comment* (PM): 2nd sample from same structure (post H45, HAR-5550, below) yielded similar post-Medieval date; it is evident structure was part of old sea wall or related to it (Wilkinson & Murphy, 1983a).

**300 ± 90**

**HAR-5550. H45POST** $\delta^{13}C = -25.2‰$

Wood, AML 831124, from context 44 of structure thought originally to be prehistoric (51° 37′ 54″ N, 0° 38′ 3″ E, Natl Grid Ref TQ 82299589). Coll Dec 1982 by T J Wilkinson and subm April 1983.

**180 ± 80**

**HAR-5732. H56/97** $\delta^{13}C = -29.4‰$

Peat, AML 832738, from river bank at site 56, Canewdon (51° 37′ 43″ N, 0° 46′ 51″ E, Natl Grid Ref TQ 92449591). Coll June 1983 by T J Wilkinson. *Comment* (PM): upper peat layer result of inning during last few hundred years (Wilkinson & Murphy, 1983b).

**3020 ± 90**

**HAR-5733. H2/91** $\delta^{13}C = -25.3‰$

Charcoal, AML 832739, from prehistoric salt working hearth at site 2, South Woodham Ferrers (51° 38′ 15″ N, 0° 36′ 16″ E, Natl Grid Ref TQ 80209646). Coll June 1983 by T J Wilkinson. *Comment* (PM): conforms well with late Bronze Age to early Iron Age pottery (Wilkinson & Murphy, 1983b).

**2950 ± 70**

**HAR-5734. H29/67** $\delta^{13}C = -25.9‰$

Wood, AML 832740, id. as *Quercus* sp and *Prunus* sp, brushwood platform in base of clays of Holocene marine transgression from site 29 (51° 38′ 27″ N, 0° 44′ 25″ E, Natl Grid Ref TQ 89599717). Coll April 1983 by T J Wilkinson. *Comment* (PM): from platform on edge of estuary after Neolithic occupation ceased (Wilkinson & Murphy, 1983b).

**3250 ± 90**

**HAR-5735. H29/68** $\delta^{13}C = -25.0‰$

Wood, AML 832741, id. as *Fraxinus* sp, from part of wooden trackway from site 29 (51° 38′ 27″ N, 0° 44′ 25″ E, Natl Grid Ref TQ 89599717). Coll April 1983 by T J Wilkinson. *Comment* (PM): from platform on edge of estuary after Neolithic occupation ceased (Wilkinson & Murphy, 1983a,b).

**HAR-5736. H22WOOD** **2800 ± 70** $\delta^{13}C = -25.4‰$

Wood, AML 832742, from group of timbers assoc with hurdles at site 22 (51° 38′ 21″ N, 0° 46′ 8″ E, Natl Grid Ref TQ 91579707). Coll April 1983 by T J Wilkinson. *Comment* (PM): from hurdle structure contained within marine transgression clays stratigraphically later than lower peats which have $^{14}C$ age 2000–1700 BC (Wilkinson & Murphy, 1983b).

**HAR-5737. H23WOOD** **3680 ± 70** $\delta^{13}C = -28.8‰$

Wood, AML 832743, id. as *Crataegus* sp, from post cutting lower peats at site 23 (51° 38′ 5″ N, 0° 46′ 42″ E, Natl Grid Ref TQ 92249660). Coll April 1983 by T J Wilkinson. *Comment* (PM): stratigraphically contemporary with lower peat, conforming with $^{14}C$ determinations on lower peat from elsewhere in basin (Wilkinson & Murphy, 1983a).

*General Comment* (PM): aim of survey is to locate and describe archaeol sites currently being eroded in valleys of R Crouch and R Blackwater and to relate these to sediment sequences. $^{14}C$ is used for main chronological framework. Results from Crouch estuary fall into 4 groups: 1) wood and other organic material in Lower Peat, ca 3660 to 4100 BP, 2) landing stage structures and salt-working sites assoc with Middle Clay, ca 2620 to 3250 BP, 3) Upper (*Phragmites*) Peat ca, 1500 to 1610 BP, and 4) deposits and structures assoc with reclamation following renewed sedimentation (Upper Clay), ca 270 to 180 BP.

## Canterbury series

Two charcoal samples, from floor of Late Saxon cellared building cut into natural at 69a Stour St, Canterbury, Kent (51° 16′ 38″ N, 1° 4′ 49″ E, Natl Grid Ref TR 148577). Coll 1981 by T Tatton-Brown and subm by D Haddon-Reece.

**HAR-5229. STOUR02** **1060 ± 70** $\delta^{13}C = -26.5‰$

AML 822359. *Comment* (TTB): excavators ref CBR V 246A.

**HAR-5230. STOUR03** **1170 ± 70** $\delta^{13}C = -27.0‰$

AML 822360. *Comment* (TTB): excavators ref CBR V 246B.

*General Comment* (TTB): samples overlay deposit of occupation loam, may be charred timber from destruction of building. Sample was sealed by dark loam infill, containing carbon, clay, and daub. One other sample, fragment of preserved and waterlogged timber (AML 822361), part of vertical post, produced date 1270 ± 70 (Bennett, Tatton-Brown & Blockley, 1980).

**Rowden series**

Samples from Neolithic and Bronze Age contexts at Rowden, Dorset. Coll Sept 1981 by P J Woodward and subm by D Haddon-Reece. See Woodward (1981) for description of site.

**HAR-5245. RD82287** **4690 ± 70**
$\delta^{13}C = -26.5‰$

Charcoal, AML 822635, from layer 287.

**HAR-5247. RD82571** **4940 ± 70**
$\delta^{13}C = -26.7‰$

Charcoal, AML 822637, from layer 571. Subm Oct 1982.

**HAR-5248. RD82634** **4860 ± 70**
$\delta^{13}C = -26.5‰$

Charcoal, AML 822638, from layer 634. Subm Oct 1982.

**HAR-5548. RD815773** **2940 ± 70**
$\delta^{13}C = -23.6‰$

Carbonized grain, AML 831125, from storage pit in Middle Bronze Age hut. Subm April 1983. *Comment* (PJW): result compares well with HAR-5698, from same pit.

**HAR-5698. RD815773** **2920 ± 80**
$\delta^{13}C = -23.2‰$

Charcoal, AML 831125, from storage pit in Middle Bronze Age hut. Subm April 1983. *Comment* (PJW): result as expected on archaeol evidence; site compares with Black Patch excavation, Sussex (Drewett, 1982).

*General Comment* (PJW): HAR-5245, -5247, -5248, assoc with large post pit, confirm early Neolithic date antedating Late Bronze Age hut and settlement complex.

**Winwick series**

Charcoal from Southworth Hall Barrow, Winwick, Cheshire (53° 26′ 15″ N, 2° 34′ 25″ W, Natl Grid Ref SJ 619936). Coll Sept/Oct 1980 and subm Oct 1981 by D Freke.

**HAR-5258. 14980112** **3390 ± 70**
$\delta^{13}C = -26.7‰$

AML 824012, from context 84, fill of cremation pit in fill of 2nd phase ditch of 2nd phase Barrow. Coll Oct 1980. *Comment* (DF): sample assoc with collared urn and accessory vessel.

**HAR-5259. 14980130** **4090 ± 80**
$\delta^{13}C = -27.2‰$

AML 824014, from context 327, large pit filled with burned stones, charcoal, and Bronze Age pottery fragments. *Comment* (DF): pit was 10m

outside outer ditch of 2nd phase Barrow. Earliest result from 1st phase of Barrow was HAR-5262, below.

**HAR-5260. 14980141** **3630 ± 70** $\delta^{13}C = -28.2‰$

AML 824015, from context 386, layer of charcoal at base of inner ditch of phase 2 Barrow. *Comment* (DF): sample not burned *in situ* but dumped, one of several patches.

**HAR-5261. 14980145** **3470 ± 70** $\delta^{13}C = -27.9‰$

AML 824016, from thick charcoal layer under 2nd phase mound. *Comment* (DF): interpreted as burned mortuary structure.

**HAR-5262. 14980159** **3690 ± 80** $\delta^{13}C = -27.6‰$

AML 824017, from context 921, small pit under 1st phase mound of 2nd phase Barrow. *Comment* (DF): earliest date for Barrow.

**Somerset Levels series**

Following 34 dates were coll during excavations between 1974 and 1984 from Somerset Levels sites, Somerset. Following general dates, main series was divided into sub-series (Meare Lake Village, East Moors, Eclipse Site, Sedgemoor, and Sweet Track). For introduction to project and other results, see Harwell II (R, 1977, v 19, no. 3, p 415–416); III (R, 1979, v 21, no. 3, p 360–364); IV (R, 1985, v 27, no. 1, p 77–80); V (R, 1987, v 29, no. 1, p 87–92). Except where noted, all samples coll and subm by J M Coles, Dept Archaeol, Cambridge.

**HAR-1490. SLP76-2** **3200 ± 130** $\delta^{13}C = -26.8‰$

Wood, AML 760302, from rings 68 to 80 of 118-year floating tree-ring sequence at Meare Lake track, Somerset. Coll 1974–5 and subm Jan 1976 by R Morgan. *Comments:* small sample due to experimental difficulties accounts for larger than normal error term. (JMC): 2nd sample in dendrochronologic series of 3. Includes sections of 4 timbers. Wood was distorted due to peat drying out, some root intrusion. Also see HAR-943, Harwell III (R, 1979, v 21, no. 3, p 360).

**HAR-2772. SLP7809** **3270 ± 70** $\delta^{13}C = -30.7‰$

Wood, from terminal of Bronze Age trackway at terminal site 1, Shapwick, Somerset. Coll and subm July 1978. *Comment* (JMC): complex of wood.

**HAR-3446. SLP7918** **2630 ± 80** $\delta^{13}C = -27.7‰$

Charcoal, AML 79476 from Withy Bed Copse, Shapwick, Somerset (51° 8′ 50″ N, 2° 48′ 20″ W, Natl Grid Ref ST 435394). Coll by C R Sturdy

and subm Aug 1979. Also see HAR-994, Harwell III (R, 1979, v 21, no. 3, p 361).

**3600 ± 70**

**HAR-3838. SLP8009** $\delta^{13}C = -29.8‰$

Wood from early Bronze Age hurdle structure at Eclipse track, Somerset. Coll by B J Orme and subm April 1980.

**4880 ± 100**

**HAR-4078. SLP8010** $\delta^{13}C = -27.4‰$

Wood, from newly discovered track structure in peat at Bisgrove, Somerset. Coll Sept 1980 and subm Oct 1980.

**4280 ± 70**

**HAR-4130. SLP8011** $\delta^{13}C = -28.0‰$

Peat from SF 80.37 at Decoy Pool Wood, Shapwick, Somerset. Coll Oct 1980 and subm Nov 1980. *Comment* (JMC): peat in direct assoc with Neolithic stone axe.

**5420 ± 70**

**HAR-4999. SLP8205** $\delta^{13}C = -28.0‰$

Peat, from West Edington Valley, Somerset (51° 10′ 41″ N, 2° 52′ 27″ W, Natl Grid Ref ST 389425). Coll and subm April 1982. *Comment* (JMC): sample used to date clay-peat interface in W Brue.

**Meare Lake Village series**

Samples from Meare Lake Village West, Somerset (51° 10′ 33″ N, 2° 47′ 38″ W, Natl Grid Ref ST 445422). For description of site, see Orme *et al* (1981). For other dates in series, see Harwell IV (R, 1985, v 27, no. 1, p 79–80).

**2200 ± 70**

**HAR-3489. SLP7918** $\delta^{13}C = -29.7‰$

Wood, AML 794485, from planking in gully between mounds. Coll and subm Sept 1979. *Comment* (JMC): series of stratified horizons of peat, wood occupation debris marking several periods of activity assoc with bone, wood, bronze, iron, lead, pottery, glass, etc.

**2130 ± 60**

**HAR-3492. SLP7910** $\delta^{13}C = -25.0‰$

Wood, id. as plank of elm (decayed), AML 794477, assoc with Iron Age site. Coll and subm Sept 1979. *Comment* (JMC): series of stratified horizons of peat with occupation debris marking several phases of activity assoc with bone, wood, bronze, iron, lead, pottery, glass, etc.

**2250 ± 70**

**HAR-3535. SLP7915** $\delta^{13}C = -26.8‰$

Peat, AML 794482, from beneath central floor, assoc with large storage vessel. Coll and subm Sept 1979.

**2410 ± 80**

**HAR-3546. SLP7911** $\delta^{13}C = -28.8‰$

Peat, AML 794478, from uppermost peat sealing site. Coll and subm Sept 1979.

**2700 ± 70**

**HAR-3633. SLP7913** $\delta^{13}C = -29.2‰$

Charcoal, AML 794480, from top of underlying peat surface, beneath occupation deposit. Coll and subm Sept 1979.

**2230 ± 60**

**HAR-3634. SLP7912** $\delta^{13}C = -27.6‰$

Peat, AML 794479, from black earth occupation deposit. Coll and subm Sept 1979.

**2170 ± 70**

**HAR-3693. SLP8004** $\delta^{13}C = -23.3‰$

Wood, id. as elm coll Sept 1979 and subm Feb 1980. *Comment* (JMC): assoc with hearth to NW of occupation floor.

**2190 ± 70**

**HAR-3719. SLP7918** $\delta^{13}C = -28.0‰$

Wood, AML 794481, from remains of wood under central floor of occupation site. Coll and subm Sept 1979.

**2810 ± 70**

**HAR-3740. SLP8002** $\delta^{13}C = -29.6‰$

Wood from peat surface, NW of main occupation floor. Coll Sept 1979 and subm Feb 1980.

**2280 ± 80**

**HAR-3744. SLP8003** $\delta^{13}C = -27.3‰$

Wood and peat, from occupation surface. Coll Sept 1979 and subm Feb 1980.

**2080 ± 60**

**HAR-3745. SLP8001** $\delta^{13}C = -28.5‰$

Soil, from central floor of occupation. Coll Sept 1979 and subm April 1980.

**2370 ± 70**

**HAR-3864. SLP8005** $\delta^{13}C = -28.6‰$

Peat, from monolith top 2.98 to 3.00m. Coll Sept 1979 by A E Caseldine and subm April 1980. *Comment* (JMC): a few very fine rootlets in samples.

**2210 ± 70**

**HAR-3891. SLP8006** $\delta^{13}C = -28.0‰$

Wood from monolith, 3.04 to 3.06m. Coll Sept 1979 by A E Caseldine and subm April 1980.

**1870 ± 80**

**HAR-3892. SLP8007** $\delta^{13}C = -28.3‰$

Charcoal, id. as peat/charcoal, from monolith 3.10 to 3.12m occupation deposit. Coll Sept 1979 by A E Caseldine and subm April 1980.

**2220 ± 90**

**HAR-3896. SLP8008** $\delta^{13}C = -27.8‰$

Wood, from monolith, 3.14 to 3.16m, occupation deposit. Coll Sept 1979 by A E Caseldine and subm April 1980.

**East Moors series**

Wood samples from East Moors, Ashcott Heath, Somerset. Coll by C R Sturdy and subm Aug 1979.

**3770 ± 70**

**HAR-3448. SLP7906** $\delta^{13}C = -30.8‰$

From site 3.

**3750 ± 70**

**HAR-3449. SLP7908** $\delta^{13}C = -29.3‰$

From area 10.

**3870 ± 80**

**HAR-3447. SLP7907** $\delta^{13}C = -29.0‰$

From area 6.

**Eclipse site series**

Peat samples from Eclipse track site, Meare Heath, Somerset (51° 9′ 41″ N, 2° 47′ 17″ W, Natl Grid Ref ST 449406). Coll Sept 1980 by A E Caseldine and subm Feb 1982. For description of zones, see Beckett and Hibbert (1979) and Orme (1982); for other dates in series, see Harwell V (R, 1987, v 29, no. 1, p 87–92).

**4780 ± 70**

**HAR-4866. SLP8110** $\delta^{13}C = -28.9‰$

From lower division of peat monolith, dating E1.E2 boundary and therefore, region A/B boundary.

**3840 ± 60**

**HAR-4867. SLP8111** $\delta^{13}C = -29.3‰$

From within zone E4, of local sequence, probably near or at regional zone D/E boundary (E80.54).

**HAR-4868. SLP8112** **3240 ± 70** $\delta^{13}C = -28.6‰$

From immediately below hurdle track, near top of monolith (E80.26). *Comment* ( JMC): possible modern rootlet contamination.

**Sedgemoor series**

Wood, from prehistoric structure, Sedgemoor, Somerset. Coll by K Campbell and subm April 1981.

**HAR-4374. SLP8101** **4510 ± 80** $\delta^{13}C = -28.6‰$

From site 81.6A.

**HAR-4375. SLP8102** **4690 ± 90** $\delta^{13}C = -28.3‰$

From site 81.6B.

**Sweet Track series**

Peat, from regional pollen assemblage zone boundaries from Sweet Track, Somerset. Coll Sept 1980 by A E Caseldine and subm Nov 1982. For other dates in series, see Harwell III (R, 1979, v 21, no. 3, p 363–364).

**HAR-5294. SLP8209** **4180 ± 70** $\delta^{13}C = -29.1‰$

From pollen boundary C/D.

**HAR-5295. SLP8208** **4510 ± 70** $\delta^{13}C = -28.1‰$

From pollen boundary B/C.

**HAR-5296. SLP8207** **4790 ± 80** $\delta^{13}C = -29.1‰$

From pollen boundary A/B.

**HAR-4540. 41-149** **3740 ± 110** $\delta^{13}C = -25.9‰$

Charcoal, AML 8110725, from Trelan 2, Cornwall. Coll by G H Smith and subm Aug 1981 by N D Balaam.

**Balksbury Camp series**

Samples from Iron Age hillfort at Balksbury Camp, Andover, Hampshire (51° 11′ 56″ N, 1° 29′ 51″ W, Natl Grid Ref SU 351446). Coll 1981 by K Smith and subm Aug 1982 by N D Balaam. *Comment:* for other dates in series, see Harwell II (R, 1977, v 19, no. 3, p 408).

**HAR-5124. 36-326** **3530 ± 80** $\delta^{13}C = -23.5‰$

Human bone, AML 8112901.

**2800 ± 70**

**HAR-5127. 36-1465** $\delta^{13}C = -25.9‰$

Charcoal, id. as mostly *Fraxinus* sp, with small quantities of *Populus* sp, *Fagus* sp, and *Quercus* sp, AML 8112890, from small pit in hillfort with early Iron Age pottery.

**Catterick series**

Human bone from Catterick (Natl Grid Ref SE 240972). Coll Oct 1981 by P Wilson and subm Oct 1982 by N D Balaam.

**1640 ± 70**

**HAR-5272. 46-941** $\delta^{13}C = -22.5‰$

AML 8111678.

**1660 ± 70**

**HAR-5273. 46-1742** $\delta^{13}C = -23.5‰$

AML 8111679.

**1870 ± 70**

**HAR-5275. 46-1732** $\delta^{13}C = -22.0‰$

AML 8111564.

**1500 ± 70**

**HAR-5276. 46-709** $\delta^{13}C = -21.9‰$

AML 8111254.

**1560 ± 70**

**HAR-5277. 46-3520** $\delta^{13}C = -22.5‰$

AML 8111950.

**1900 ± 80**

**HAR-5740. 46-1033** $\delta^{13}C = -23.6‰$

AML 8111316, from crouched burial pit with no artifacts. *Comment* (NDB): burial sealed by early Roman features.

**Ardleigh series**

Charcoal, from possibly Bronze Age site at Ardleigh, Essex. Coll by J Hinchliffe and subm by N D Balaam.

**3600 ± 80**

**HAR-3908. 29-750** $\delta^{13}C = -26.1‰$

AML 7911015, id. as *Quercus* sp, from mature timber and *Corylus avellana* nut shell, from Bronze Age cremation. Subm June 1980.

**2870 ± 80**

**HAR-5126. 29-1939** $\delta^{13}C = -25.8‰$

AML 7910872, id. as *Quercus* sp, from lower fill of ditch enclosure. Coll 1976 and subm Aug 1982. *Comment* (NDB): possibly late Bronze Age.

**2940 ± 70**

**HAR-5128. 29-1937** $\delta^{13}C = -26.0‰$

AML 7910865, id. as *Quercus* sp, from lower fill of ditch. Coll 1979 and subm Aug 1982. *Comment* (NDB): possibly late Bronze Age.

**3050 ± 70**

**HAR-5129. 29-7542** $\delta^{13}C = -27.1‰$

AML 7911015, id. as *Crataegus* sp, from ditch of possible cursus. Coll 1979 and subm Aug 1982.

### Queensford Mill Cemetery series

Human bone, from graves of late and sub-Roman cemetery at site I along rte of Dorchester By-Pass, Dorchester-on-Thames, Oxfordshire (51° 38′ 59″ N, 1° 9′ 32″ W, Natl Grid Ref SU 58189493). Coll Spring 1981 and subm Nov 1982 by R A Chambers. *Comment* (RAC): there was no stratigraphic relationship between graves of extra-mural cemetery to NE of Roman town.

**1480 ± 70**

**HAR-5323. DBPIF34** $\delta^{13}C = -22.3‰$

**1430 ± 70**

**HAR-5324. DBPIF64** $\delta^{13}C = -24.4‰$

**1550 ± 70**

**HAR-5350. DBPIF48** $\delta^{13}C = -21.8‰$

**1550 ± 80**

**HAR-5351. DBPIF75** $\delta^{13}C = -23.1‰$

### Church Lawton series

Charcoal from Church Lawton, Alsager, Cheshire. Coll by R McNeil and subm May 1983 by R McNeil, Rescue Archaeol Comm, Univ Liverpool.

**3600 ± 100**

**HAR-5533. 3551F12** $\delta^{13}C = -24.9‰$

AML 830768, from Bronze Age burial mound (53° 5′ 52″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808557). Coll Jan 1983. *Comment* (RMcN): sample from possible mortuary house, representing only evidence that mound was ever a burial ground.

**4100 ± 160**

**HAR-5534. 3551F14** $\delta^{13}C = -26.3‰$

AML 830769, from old ground surface sealed under barrow, (53° 5′ 52″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808557). Coll Jan 1983. *Comments:* small sample accounts for larger than normal error term. (RMcN): deposit assoc with previous and early phase of Barrow.

**3400 ± 80**

**HAR-5535. 3547F5** $\delta^{13}C = -27.3‰$

AML 830772, from fire pit used for cremating bones (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Aug 1982. *Comment* (RMcN): sample is sealed by turf and belongs to Phase 2 Barrow.

**3300 ± 80**

**HAR-5536. 3547F11** $\delta^{13}C = -26.9‰$

AML 830773, from fire pit (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Aug 1982. *Comment* (RMcN): sample assoc with Phase 2 Barrow.

**3490 ± 80**

**HAR-5537. 3547F12** $\delta^{13}C = -26.3‰$

AML 830774, from burial lid of primary insertion (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Aug 1982. *Comment* (RMcN): no skeleton present because soil was very acid; pit cuts old ground surface and is sealed by sand of Phase 1 Barrow.

**3560 ± 80**

**HAR-5538. 3547F13** $\delta^{13}C = -24.5‰$

AML 830775, from ditch surrounding barrow (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Aug 1982. *Comment* (RMcN): ditch antedates construction of phase I Barrow and is sealed by slumping from Barrow.

**3500 ± 100**

**HAR-5539. 3547F16** $\delta^{13}C = -26.6‰$

AML 830776, from inside accessory urn (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Sept 1982. *Comment* (RMcN): satellite burial, phase 1, feature sealed by sand of mound, no cremation present.

**3500 ± 80**

**HAR-5541. 3547F26** $\delta^{13}C = -25.6‰$

AML 830778, from pit containing accessory urn (53° 5′ 56″ N, 2° 17′ 12″ W, Natl Grid Ref SJ 808558). Coll Sept 1982. *Comment* (RMcN): satellite burial, phase 1, no cremation present.

**1940 ± 110**

**HAR-5614. MK117040** $\delta^{13}C = -27.7‰$

Wood, AML 823999, from four stakes at site MK117, context 95 at Mill Field site, Bow Brickhill Parish, Buckinghamshire (52° 0′ 25″ N, 0° 42′ 1″ W, Natl Grid Ref SP 89213511). Coll by M Petchey and subm June 1983 by D Haddon-Reece. *Comment* (MP): context is 2nd lowest fill of ditch 4 in sec F of blue-gray sticky clay. Each stake at least 1.5m long lying horizontally in base of ditch 4 (Loveday & Petchey, 1982).

**Coppergate Helmet series**

Wood from Coppergate Development, York, North Yorkshire (53° 57′ 28″ N, 1° 4′ 46″ W, Natl Grid Ref SE 604517). Coll May 1982 by N F Pearson and subm Sept 1983 by A K G Jones, Environmental Archaeol Unit, Univ York.

**HAR-5974. 82/22/68** **1160 ± 70**
$\delta^{13}C = -29.1‰$

AML 834741, id. as ash (*Fraxinus* sp), from stake fragments of pit lining. *Comment* (AKGJ): pit was overlain by modern building rubble and some Medieval layers and was a few meters away from pit containing helmet.

**HAR-5975. 82/22/72** **1250 ± 70**
$\delta^{13}C = -27.4‰$

AML 834742, id. as oak (*Quercus* sp), from same fills as helmet.

*General Comment* (AKGJ): samples came from area in which Coppergate helmet was found. Results suggest helmet was buried during Anglian period (Addyman, Pearson & Tweddle, 1982).

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# HIROSHIMA UNIVERSITY RADIOCARBON DATES II WEST AND SOUTH COASTS OF SRI LANKA

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## INTRODUCTION

Geologic samples for $^{14}C$ age measurements were collected from the west, southwest and south coasts of Sri Lanka during October and November 1986. Sample points were leveled based on the Colombo datum level. Results presented below were obtained by liquid scintillation counting of methanol for coral and shell samples. Ages were measured from December 1986 to May 1987, at the Department of Geography, Hiroshima University, Radiocarbon Dating Laboratory, using the laboratory procedure described by Fujiwara and Nakata (1984). Sample preparation techniques were similar to those mentioned in the first list (Katupotha, 1988). The results are expressed in radiocarbon years relative to AD 1950 based on the Libby half-life of 5568 ± 30 years, using the new oxalic acid standard (SRM 4900C) as 'modern' (Stuiver, 1983).

The tidal range on Sri Lanka coasts is small, ranging from the mean low water spring (MLWS) at −37cm to mean high water spring (MHWS) at +40cm from the mean sea level (MSL) (data based on the standard point of Colombo, datum level 38cm below MSL. Tide tables, vol 2, Pacific and Indian Oceans, 1982). However, high waves (height 5m or more) are seen along the southwest and south coasts and are related to the strong southwest monsoon season from May to September. The present living corals thrive from MLWS to 8m and 4m in depth in fringing reef and lagoon reef areas at Hikkaduwa, respectively (Mergner & Scheer, 1974).

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GEOLOGIC SAMPLES

**West Coast series**

**HR-235. Chilaw** **1680 ± 60**

Shell (*Corbidae*) from a dug well, SE of Chilaw Town, Chilaw dist (7° 33′ 40″ N, 79° 48′ 05″ E), depth 1.5m approx below msl. *Comment:* shell belonging to brackish form living in inter-tidal zone was covered from base to top by fine sand (wind blown), coarse sand with pebbles (terrestrial ?) ca 4.5m thick since Late Holocene (Early Subatlantic/Early Subboreal).

**HR-271. Fort-Colombo** **5790 ± 80**

Peat sample from pit at Fort in Colombo, Colombo dist, near Beira Lake (6° 55′ 00″ N, 79° 50′ 40″ E), depth ca 30cm below msl. *Comment:* fibrous dark-brown to black peat with soft dark-gray organic silty clay in part shows that brackish marsh developed in the area following Holocene transgression. Age, mid-Holocene (Main Atlantic), and level are similar to first age group on SW and S coast series (see *General Comment*).

**Southwest Coast series**

Samples from well-developed buried coral reef patches and emerged reef patches, Galle dist. Dates correlated with mid-Holocene (Main Atlantic) and Late Holocene (Late Subboreal). Upright branching (*Acropora*) and massive (*Porites*) corals of buried reef patches (coral quarries nos. 1 and 2) show that accumulation of materials was not caused by catastrophic events such as storm wave action. Dated corals from emerged reef patches also were in growth position.

**HR-236. Dimbulduwa (Akurala)** **5590 ± 80**

Coral (*Acropora*) from coral quarry no. 1 (6° 12′ 10″ N, 80° 03′ 00″ E), depth 1.7m below msl.

**HR-237. Dimbulduwa (Akurala)** **5840 ± 80**

Coral (*Acropora*) from coral quarry no. 1, at same loc as HR-236, depth 3.4m below msl.

**HR-238. Akurala** **5350 ± 80**

Coral (*Acropora*) from emerged reef patch (6° 10′ 30″ N, 80° 03′ 30″ E), elev 50cm above msl.

**HR-239. Akurala** **6170 ± 70**

Coral (*Platygyra*) from emerged reef patch (ca 75m N of HR-238), elev 10cm above msl.

**HR-240. Akurala (Telwatte)** **5840 ± 80**

Coral (*Acropora*) from emerged reef patch (6° 10′ 10″ N, 80° 03′ 50″ E), cemented with beach rock, elev 60cm above msl.

**HR-241. Akurala (Telwatte)** **5980 ± 70**

Coral (*Montipora*) from emerged reef patch, near and S of HR-240, cemented with beach rock, elev 60cm above msl.

**HR-242. Hikkaduwa** **3210 ± 70**

Coral (*Goniastrea*) from emerged reef patch (6° 07′ 45″ N, 80° 05′ 45″ E), N of HR-116 as mentioned previously (Katupotha, 1988), cemented with beach rock, elev 1.0m above msl.

**HR-243. Hikkaduwa** **2560 ± 60**

Coral (*Goniastrea*) from emerged reef patch, near and E of HR-116, cemented with beach rock, elev 1.0m above msl.

**HR-244. Dadalla** **5200 ± 70**

Coral (*Platygyra*) from emerged reef patch (6° 02′ 25″ N, 80° 11′ 35″ E), cemented with beach rock, elev 20cm above msl.

**HR-245. Dadalla** **5480 ± 70**

Coral (*Goniopora*) from emerged reef patch, near and E of HR-244, cemented with beach rock, elev 10cm above msl.

**HR-246. Mihiripenna** **5600 ± 70**

Coral (*Acropora*) from coral quarry no. 2 (6° 00′ 20″ N, 80° 15′ 50″ E), depth 70cm below msl.

**HR-247. Mihiripenna** **5630 ± 70**

Shell (*Tridacnidae*) from coral quarry no. 2, at same loc as HR-246, depth 1.2m below msl.

**HR-248. Mihiripenna** **5970 ± 70**

Coral (*Porites*) from coral quarry no. 2, at same loc as HR-246, depth 1.4m below msl.

**HR-249. Mihiripenna** **5910 ± 70**

Coral (*Acropora*) from coral quarry no. 2, at same loc as HR-246, depth 2.0m below msl.

**HR-250. Koggala** **5440 ± 70**

Coral (*Goniopora*) from emerged reef patch (5° 59′ 00″ N, 80° 19′ 25″ E), elev 40cm above msl.

*General Comment:* dated sequences of coral quarries nos. 1 and 2 reveal that corals developed in inland bays or lagoons where factors were well-fitted to growth of coral, and gradually formed reefs in many places on SW coast in mid-Holocene. In comparing levels of present-living corals with lowest and upper levels of dated coral samples of quarry nos. 1 and 2, it is estimated that msl was at least 50cm (10cm +37cm ≈50cm) higher at 6170 ± 80 BP than at present, and at least 1.0m (50cm +37cm ≈1.0m) at 5380 ± 80 BP.

Coral samples from emerged reef patches indicate two separate age groups: 1) from 6170 ± 70 BP to 5350 ± 80 BP; 2) from 3210 ± 70 BP to 2560 ± 60 BP. These ages also show that sea level was higher than at present during mid-Holocene phases.

**South Coast series**

Samples from emerged reef patches, buried coral reefs and shell beds. Dated corals of emerged reef patches and buried coral reef patches were in growth position. Dates correlated with mid-Holocene (Main Atlantic) and late Holocene (Early and Late Subboreal).

**HR-251. Aranwala** **2330 ± 60**

Coral (*Goniastrea*) from emerged reef patch, Aranwala, Galle dist (5° 58′ 00′ N, 80° 22′ 30″ E), elev 40cm above msl.

**HR-252. Aranwala** **5540 ± 70**

Coral (*Goniopora*) from emerged reef patch, near and E of HR-251, elev 30cm above msl.

**HR-253. Aranwala** **2250 ± 60**

Coral (*Goniastrea*) from emerged reef patch, near and E of HR-252, elev 10cm above msl.

**HR-254. Denuwala** **2540 ± 60**

Coral (*Acropora*) from emerged reef patch, Denuwala, Matara dist (5° 57′ 55″ N, 80° 23′ 10″ E) elev 70cm above msl.

**HR-255. Denuwala** **2580 ± 60**

Coral (*Galaxea*) from emerged reef patch, near and E of HR-254, elev 50cm above msl.

**HR-256. Denuwala** **2510 ± 60**

Coral (*Acropora*) from emerged reef patch, near and E of HR-255, elev 50cm above msl.

**HR-257. Denuwala** **2520 ± 60**

Coral *(Favites)* from emerged reef patch, near and E of HR-256, elev 40cm above msl.

*General Comment:* coral dates at Aranwala and Denuwala also indicate that there are two separate age groups, which are quite similar to age groups on Southwest Coast series.

**HR-258. Palalla-Weligama** **4420 ± 70**

Shell (*Veneridae*) from core coll with hand augur at Weligama, Matara dist (5° 59′ 50″ N, 80° 25′ 55″ E), elev from 1.8m to 1.9m above msl. *Comment:* sample composed of beach deposits.

**HR-259. Palalla-Weligama** **4560 ± 60**

Shell (*Veneridae*) from core coll with hand augur, ca 30m to W of HR-258, elev 1.3m above msl. *Comment:* bivalves were embedded in black-to-greenish lagoonal mud.

**HR-260. Madihe** **4330 ± 60**

Coral (*Acropora*) from coral quarry no. 3, Madihe, Matara dist (5° 56′ 10″ N, 80° 30′ 35″ E) elev 10cm above msl.

**HR-261. Madihe** **4850 ± 70**

Coral (*Acropora*) from coral quarry no. 3, at same loc as HR-260, depth 1.3m below msl.

**HR-262. Walgama (Madihe)** **4720 ± 60**

Coral (*Acropora*) from coral quarry no. 4, Walgama, Matara dist (5° 56′ 25″ N, 80° 30′ 45″ E), depth from 10cm to 30cm below msl.

**HR-263. Walgama (Madihe)** **4830 ± 70**

Coral (*Acropora*) from coral quarry no. 4, at same loc as HR-262, depth 2.3m below msl.

*General Comment:* regarding stratigraphic and deposition pattern of exposed quarries at Madihe and Walgama, upright branching *Acropora* and plate type were in growth position. HR-262 and -263 subm by N P Wijayananda.

**HR-269. Pallikkudawa** **5610 ± 70**

Coral (*Goniastrea*) from emerged reef patch, Hambantota dist (6° 01′ 00″ N, 80° 17′ 30″ E), elev 40cm above msl.

**HR-270. Pallikkudawa** **5470 ± 70**

Coral (*Platygyra*) from emerged reef patch, very near HR-269, elev 60cm above msl. *Comment:* ages and levels at Pallikkudawa coincide with first age group on SW coast.

**HR-264. Hatagala (Hungama)** **4440 ± 60**

Shell (*Veneridae*) from exposed deposits, Hambantota dist (6° 06′ 35″ N, 80° 56′ 50″ E), elev 80cm above msl. *Comment:* shells gathered in lagoon floors and were deposited *in situ* following coastal progradation since Late Subboreal. Sample subm by N P Wijayananda.

**HR-265. Kalametiya** **3570 ± 60**

Shell (*Veneridae*) from exposed shell deposit, Hambantota dist (6° 05′ 08″ N, 80° 56′ 45″ E) elev 1.10m above msl. *Comment:* shell was composed mainly of coarse sand and calcareous clay.

**HR-266. Kalametiya** **4460 ± 60**

Shell (*Veneridae*) from exposed shell deposit (6° 05′ 15″ N, 80° 57′ 08″ E), elev 2.2m above msl. *Comment:* shells were embedded in black-to-blue-

black mud and clay; it is assumed that HR-265 and -266 gathered (*in situ* ?) in lagoon floors following coastal progradation since Late Subboreal.

**HR-267. Kalametiya** **3960 ± 60**

Shell (*Veneridae*) from exposed shell deposit (6° 06′ 10″ N, 80° 57′ 15″ E), elev 2.0m above msl. *Comment:* shells and shell debris were composed of fine-to-coarse sand. Composition of materials shows that they were accumulated at rims of emerged coastal embayments by wave action.

**HR-268. Udamalala** **4650 ± 70**

Shell (*Veneridae*) from midden of lake margin, Hambantota dist (6° 10′ 15″ N, 80° 10′ 00″ E), elev ca 5.0m above msl. *Comment:* shell layer consists of uniform species of shell ca 20cm thick; presently being covered by reddish brown wind-blown sand. Shells were probably left by early inhabitants during daily activities.

*General Comment:* dated coral samples from emerged reef patches at Aranwala, Denuwala, and Pallikkudawa are quite similar to age groups on SW coast series. Dated sequences of coral quarries nos. 3 and 4 reveal that growth of corals were continued inland bays or lagoons (to W of Dondra Head) during Late Holocene (Early Subboreal).

Shell and coral debris at Palalla (HR-258) show that materials accumulated on backshore beaches by wave action, but bivalves, which were embedded in black-to-greenish lagoonal mud (HR-259), are probably *in situ*. Dates of deposits indicate that shell belonging to marine form lived in intertidal zone and were extended ca 4km inland from shore in mid-Holocene.

As for deposition pattern and composition of shell deposits in Hambantota dist, shells probably accumulated at rims of emerged coastal embayments or lagoon floors by three processes: 1) bulk of valves piled up by wave action on rims of coastal embayments following coastal progradation since Late Holocene (Late Subboreal); 2) shells gathered in lagoon floors of marine or brackish pools, and they were deposited (*in situ* ?) since Late Subboreal; 3) shells on coastal hills and dunes left by early inhabitants during daily activities.

These and previous dates (Katupotha, 1988) indicate that sea level was at least 1.0m or higher than present msl, from mid-Holocene (Main Atlantic) to Late Holocene (Early Subatlantic), with minor oscillations. It is assumed that local palaeo-sea level was not lower than at present during above-mentioned period.

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[RADIOCARBON, VOL 30, NO. 3, 1988, P 347–350]

# LA PLATA RADIOCARBON LABORATORY LIQUID SCINTILLATION COUNTING AND INTER-LABORATORY CHECK SAMPLES

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## INTRODUCTION

The development and improvement of benzene synthesis for radiocarbon dating by liquid scintillation counting was started at LATYR in 1981. The basic technique employed was described by Polach, Gower & Frazer (1972). The line of benzene synthesis is similar to that used by Coleman *et al* (1972). The pretreatment of the samples and transformation to $CO_2$ has been previously described (Figini *et al*, 1984). The conditions of measurement were partially determined according to Pearson (1979). Results of measurements of interlaboratory check samples using the technique described are given.

## MATERIAL AND METHODS

### *Benzene Synthesis*

The conversion of 0.26 moles of $CO_2$ to $Li_2C_2$ is carried out in a stainless steel reactor in which are placed 20g of lithium metal shot, low sodium grade (produced by Lithium Corp of America), maintained in ether of petroleum anhydrous. This quantity is 100% in excess of the stoichiometric amount needed. After the reactor is closed and evacuated, the reaction is carried out by heating to 650°C in a furnace, maintaining a pressure of $CO_2$ to be absorbed into molten lithium at 56cm Hg for 20 min. In order to assure the total transformation at $Li_2C_2$, the reactor is heated to 1000°C for 30 min. Any extraneous gases are removed with a vacuum pump. When the reactor reaches room temperature, the lower part is cooled by dipping in a bath at 0°C. Under these conditions the hydrolysis of lithium carbide is performed by slowly adding (one hour) of 1.5L of distilled water. When normal yields of $CO_2$ to $C_2H_2$ are obtained (98 to 100%) the alkaline solution is clear. Occasionally, when yields were low, the solution turned black, with a few carbonaceous particles and encrustations at the bottom of the reactor. This clearly demonstrated that the predominant reaction had been the transformation in C and $Li_2O$. In some cases, the solution was whitish, indicating the formation of $Li_2CO_3$ by a secondary reaction (Belluomini *et al,* 1978) and with a strong $NH_3$ odor. This implies that air was introduced into the system through a leak in the vacuum (Griffin & Druffel, 1985).

The following vanadium catalyzers (Harshaw Chemical Co) were tested for the trimerization of $C_2H_2$ to $C_6H_6$, according to Coleman *et al* (1972): V-0301, T1/8; V-0501, T1/8; V-0601, T1/8. Also used as catalyzer support of cracking HFZ, Houdei 310m$^2$ according to Noakes, Kim & Akers (1967). In all these cases, benzene production was negligible. When we used

V-0701, T1/8 (Harshaw Chemical Co), the first trials rendered unequal yields. The best results were obtained by leaving the catalyzer (40g) in the oven at 550°C for more than 48 hr and transferring it while hot to the catalyst column, evacuating up to $10^{-3}$torr. Following this procedure, the catalyzer was re-used effectively for more than 30 syntheses, with no evidence of memory effect. Trimerization was carried out at 0°C, maintaining a pressure of $C_2H_2$ of 76 ± 10cm Hg on the catalyzer. Thirty minutes were sufficient for a reaction of 0.13 moles of $C_2H_2$. The last trace of $C_2H_2$ was frozen into the column by submerging its end into liquid $N_2$. The column was then isolated and left standing at room temperature overnight. The recovery of benzene was carried out by heating the catalyst column in a furnace, under vacuum, at 125°C for 2 hr. Chemical conversion yields for the $CO_2$ to $C_6H_6$ is ≷85%.

*Measurement*

Analysis of the final benzene samples for radiocarbon activity was performed in a Beckman LS-100 liquid scintillation spectrometer, using commercial Packard vials (20ml) of low potassium glass. Thirty vials were selected for their similarity of weight (Harkness & Wilson, 1972). In order to minimize evaporative loss through the standard vial seal, new seals were made with viton O-rings, a specially fitted PTFE stopper and a plastic screw cap. The glass vial was masked with black paint on white above the level reached by the top of the scintillation liquid so as to reduce cross-talk between counter photomultiplier tubes (Pearson, 1979).

A fraction (2ml) of the benzene sample was weighed (1.758g) out accurately into the counting vial. To this was added 0.5ml of a scintillation solution, composed of PPO and POPOP in scintillation grade toluene, with final concentrations in the vial of 5g/L and 0.05g/L, respectively. The medium value of the background (5.4cpm) and standard (13.5cpm) was individually determined for each of the vials. No memory effect was noticed during the alternate measurement of background and standard. The measurement was made at intervals of 100 min, alternating background, sample, and standard. The energy window for the measurement of $^{14}C$ was adjusted placing the lowest limit at the end of the $^{3}H$ curve. The net counts were corrected for loss of weight and normalized to 1.758g. Benzene background was synthesized from acidification of $CaCO_3$ USP light (powder) TAC Mallinckrodt Art 4052. Benzene Merck Art 1783 was used for routine measurements. Standard benzene was synthesized from wet oxidation of the NBS oxalic acid (SRM 4990B), following the method of Valastro, Land and Varela (1977). For routine measurements, we used a standard prepared by dilution of benzene marked $^{14}C$ (supplied by Lab de Metrologie des Rayonnements Ionisants, Gif-Sur-Yvette, with an activity of $1.042 \times 10^{-6}$Ci/g), up to an activity equal to the standard of reference NBS oxalic acid. Date calculations were previously given (Figini *et al,* 1984). No $^{13}C/^{12}C$ ratios were measured and results are not corrected for $^{13}C$ fractionation.

Sample descriptions are based on information provided by submitters.

INTER-LABORATORY CHECK SAMPLES

*Norway*

**LP-72a.** **9340 ± 210**

Shells (*Mya truncata*) subm by Otto Salvigsen, Norsk Polarinst, dated at 9480 ± 140 (T-2919, OS, pers commun). *Comment:* another portion of the same sample was determined by gas counting at 9280 ± 250 (LP-72: R, 1984, v 26, no. 1, p 128).

*New Zealand*

**LP-73a. Hollyford Valley** **7890 ± 110**

Shells (*Amphiderma sp*) from lower Holly Ford valley, SW corner, S Island, New Zealand. Subm by H S Jansen, Inst Nuclear Sci, DSIR, New Zealand, dated at 7670 ± 70 (R-9048, internal no. New Zealand lab, HSJ, pers commun). *Comment:* another portion of same sample was determined by gas counting at 7460 ± 210 (LP-73: R, 1984, v 26, no. 1, p 128).

*France*

**LP-83. Le Grau du Roi 25644, Le Petit Travers, Hérault** **7250 ± 100**

Shells from oldest offshore bar, between Mangio pond and sea, at Le Grand Travers (43° 44′ N, 4° 03′ E). Subm by J Evin, CDAI, Lyon. Age reported was 7050 ± 100 (Ly-1511: R, 1979, v 21, no. 3, p 426).

*Sweden*

**LP-101. Southern Baltic 4** **9650 ± 90**

Wood from large pine stump coll at 52m depth (55° 43′ N, 14° 28′ E). Subm by S Håkansson, Lund. Age given was 9420 ± 95 (Lu-890: R, 1976, v 18, no. 3, p 293).

**LP-103. Kasi Mysuseter** **4500 ± 100**

Wood (*Pinus sp*) id by T Bartholin from bottom of unintentionally drained small lake near Kasi Mt, ca 1km N of Mysuseter (61° 49′ N, 9° 40′ E). Alt ca 1000m. Subm by S Håkansson. Age reported was 4890 ± 65 (Lu-995, SH, pers commun). *Comment:* both samples were pretreated in same manner as Lund lab (SH, pers commun).

*United States*

**LP-134. Wisconsin** **11,920 ± 140**

Wood from Two Creeks interstadial, on W shore of Lake Michigan (44° 19′ 40″ N, 87° 32′ W). Subm by A Long, Univ Arizona. Several dates between 11,700 to 12,200 BP (AL, pers commun).

## CONCLUSIONS

The methodology we employed to obtain benzene is efficient and produces a radiochemically pure product. The operative form of the vanadium catalyzer (V-0701, T1/8) produces good results with higher yields of benzene when longer in the oven at 550°C. The catalyzer prepared by LATYR did not produce the desired results, probably due to the catalyzer support employed. The $^{14}C$ results of the inter-laboratory check samples agree with those determined by other laboratories.

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# MIDDLE EAST TECHNICAL UNIVERSITY (METU) RADIOCARBON DATES I

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The Radiocarbon Dating Laboratory was established at the Middle East Technical University in the Physics Department with the equipment provided by the British Government through former CENTO auspices and financial support by the Ford Foundation. This list reports on $^{14}C$ dates measured up to July 1987.

The laboratory is built in the basement of a three-story building and uses $CO_2$ gas for proportional counting. The system is equipped with three high-purity copper proportional counters (Twentieth Century Electronics). Each counter has an active volume of ca 2L.

The proportional counters are protected against cosmic ray and surrounding ionizing radiation by a passive 10cm-thick shield made of old lead (James Girdler & Co, Ltd) and an active cylindrical plastic scintillator anticoincidence ring (Nuclear Enterprise NE 102A). Each copper proportional counter is separately placed inside a horizontal cylindrical cavity in the plastic scintillator which is viewed from both ends by two 30cm photomultipliers (EMI 945B) to detect any external radiation passing through the system. In between the passive and active shields there is a neutron moderator in the form of small pellets made of 70% paraffin wax, 20% boric acid, and 10% polythene. The signals from both photomultipliers are first fed into individual preamplifiers and then added in a mixing unit before going to the amplifier. Output signals from the proportional counters are fed into separate signal processing channels through charge-sensitive preamplifiers built into the counters. Anticoincident $^{14}C$ signals from the counter are also fed into a 256-channel pulse height analyzer (Tracor Northern NS633) to obtain beta spectrum of each sample counted.

Only one of the counters is used for dating purposes. The usual operating pressure of the counter is 120cmHg. Two other pressures, 100cmHg, and 80cmHg, are also used for smaller-sized samples. Counter plateaus are ca 700V long with slopes $<1\%/100V$ for cosmic rays at the operating pressure of 120cmHg. The operating voltage at this pressure is ca 4750V. Modern standard $CO_2$ is prepared by wet oxidation of NBS oxalic acid and background $CO_2$ is prepared by combustion of anthracite. At the operating pressure of 120cmHg, the background is $9.74 \pm 0.06$cpm and net modern (95% of NBS oxalic acid) corresponding to AD 1950 $^{14}C$ count rate is $15.92 \pm 0.10$cpm. Every sample is counted for >48 hours with 200 minute repeating periods. The background and the NBS oxalic acid standard are counted at least twice a month.

Samples are examined for contamination and a physical cleaning is followed by a standard acid-alkali-acid treatment. After each treatment the sample is rinsed with distilled water until neutralization is achieved, and is made slightly acidic before it is dried overnight at 100°C. Charcoal, wood,

charred grains, and anthracite for background are converted to $CO_2$ by controlled combustion in a quartz tube with a stream of commercial oxygen gas coming through washed bottles containing 1% NaOH solution. The combustion products of the sample are initially purified by passing over several $KMnO_4$ solutions and water traps cooled at −78°C. The $CO_2$ is collected with liquid nitrogen and further purification is achieved by circulating the $CO_2$ over 450°C hot CuO. The purified $CO_2$ is stored for about four weeks to ensure radon decay. Prior to each counter filling, the CuO furnace is reduced to Cu by passing hydrogen gas at 450°C and the $CO_2$ is routinely circulated several times over 450°C hot Cu and is vacuum distilled at −78°C. After this procedure, $CO_2$ quality is satisfactory for proportional counting and, therefore, the CaO purification furnace present in the system is not used.

Dates are expressed in years BP (AD 1950) using the half-life for $^{14}C$ of 5568 years (Stuiver & Polach, 1977). Errors quoted with dates are based only on counting statistics and correspond to $\pm 1\sigma$ of sample, background, and modern standard. No $\delta^{13}C$ values were measured and dates have not been corrected for isotopic fractionation. No corrections were made for natural $^{14}C$ variations.

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## ARCHAEOLOGIC SAMPLES

### *Turkey*

**Phrygian series**

Wooden beam from Gordion (39° 45′ N, 31° 55′ E), ca 110km SW of Ankara, in very good state of preservation. Beam was taken from tomb in Great Tumulus. NaOH pretreatment. *Comment:* series of dates for same site was pub previously (P-127, -128, -133 to -137: R, 1959, v 1, p 45–58). Another wooden sample from Great Tumulus, Phrygian site, Bahçelievler, Ankara. It contains too much humic acid. NaOH and HCl treatment.

**METU-3. Gordion** **2650 ± 200**

**METU-4. Bahçelievler** **2550 ± 200**

**Ikiztepe series**

Charcoal and charred grains from Ikiztepe Mound, ca 7km NW of Bafra, Samsun at Black Sea Coast. There are four distinct tumuli at site;

only Tumulus I and Tumulus II were excavated. Three main periods, Chalcolithic, Early Bronze Age, and Early Hittite (or Transition), were assigned to site on archaeol grounds. Six phases of Early Hittite period are present in Tumulus I, at 6m depth from surface. Upper levels of Tumulus II were eroded and seven phases of Early Bronze Age occur at 5m depth. Seven phases of Chalcolithic period occur at 5.5m depth. All samples coll and subm by late U Bahadir Alkim, Istanbul Univ. NaOH and HCl pretreatment.

**METU-5. Ikiztepe 6** **5170 ± 170**

Tumulus II, charcoal mixed with soil, Loc b 517, D-13/II-19.

**METU-6. Ikiztepe 8** **3690 ± 160**

Tumulus I, charred grains mixed with soil, Loc b 421, D-4/IV-11.

**METU-7. Ikiztepe 15** **4270 ± 100**

Tumulus I, charred grains mixed with soil, Loc b 422, D-4/IV-12.

**METU-8. Ikiztepe 18** **5550 ± 120**

Tumulus II, charcoal mixed with soil, Loc b 116, D-11/II-19.

**METU-9. Ikiztepe 22** **4030 ± 100**

Tumulus II, charcoal mixed with charred grains and soil, Loc b 506, D-13/II-1.

### Çayönü series

Charcoal from Çayönü Tumulus (38° 16′ N, 39° 43′ E), Diyarbakir in Turkey (Braidwood, Çambel & Shirmer, 1981; Çambel, 1981, p 151). Samples are mixed with soil. NaOH and HCl pretreatment. Samples coll and subm by Halet Çambel, Istanbul Univ. *Comment:* series of 20 dates for same site was pub previously (GrN-4458, -4459: R, 1967, v 9, p 107–155; GrN-5827, -5952 to -5954, -6241 to -6244, -8078, -8079, -8103, -8819 to -8821, -10358 to -10361: Çambel, 1984, p 20). GrN-8079, 9250 BP or GrN-8821, 9175 BP date beginning of site.

**METU-10. Çayönü 2** **9510 ± 100**

Charcoal mixed with soil. Excavation R-3/4-0.51.

**METU-11. Çayönü 3** **10,480 ± 220**

Charcoal mixed with soil. Excavation R-5/11/1.10.

**METU-12. Çayönü 4** **10,820 ± 220**

Charcoal mixed with soil. Excavation R-5/13-7.08 Tr-1.13.

**METU-13. Çayönü 5** **5940 ± 150**

Charcoal mixed with soil. Excavation R-4/10-0.74 Tr-0.82.

**Keban series**

Charcoal and charred grains coll from Tepecik Tumulus (38° 39′ N, 39° 26′ E) and Tülintepe Tumulus (38° 38′ N, 39° 24′ E) Altinova, Elaziğ, ca 30km E of Elaziğ. Both tumuli are now flooded as result of Keban Dam built in region. Tepecik Tumulus was assigned on archaeol grounds to beginning of Late Neolithic. Early and Late Chalcolithic, Early, Middle, and Late Bronze Ages, Iron Age, and Middle Ages cultural levels are present in Tepecik. Upper levels of Tülintepe Tumulus were destroyed and only Early and Late Chalcolithic cultural levels were excavated (Esin, 1982, p 95; Esin & Arsebük, 1982, p 127). All samples coll and subm by Ufuk Esin, Istanbul Univ.

**METU-14. Tepecik (K-15B)** **4000 ± 60**
Charcoal, Loc K, 74, 12K, 4.

**METU-15. Tepecik (K-19)** **4790 ± 60**
Charcoal, Loc A, 16A, 3, BT2.

**METU-16. Tepecik (K-22A)** **2890 ± 60**
Charcoal mixed with soil, Loc K, 70, 7K, 4,29.

**METU-17. Tülintepe (K-4)** **6160 ± 150**
Charred grains, Loc I, 531, 1, B, 10.

**METU-18. Tülintepe (K-6)** **5360 ± 180**
Charred grains, Loc L, 54L, 18.

**METU-19. Tülintepe (K-7)** **5730 ± 190**
Charred grains, Loc I, 71, 481, 2,2.


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# UNIVERSITÉ DU QUÉBEC A MONTRÉAL GEOTOP RADIOCARBON DATES I

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## INTRODUCTION

GEOTOP is the geochemistry and geochronology research center of the Université du Québec à Montréal (UQAM). The Radiocarbon Laboratory was established to meet the growing demand for radiocarbon dating in Québec. The laboratory was founded by Claude Hillaire-Marcel. The first measurements were completed in October 1978. The laboratory was managed by Pierre Pagé until May 1985. Serge Occhietti and Pierre Pichet are presently in charge. Technical maintenance is under the direction of Claude Jacob.

The laboratory is equipped with two liquid scintillation counters (Intertechnique) which are installed in sub-basement three of a seven-story building.

Carbonate samples (eg, shells) are cleaned by dissolving 10 to 20% weight with HCl. The $CO_2$ is released using phosphoric acid at room temperature. Collagen is extracted from bones, according to the method described by Longin (1971), and conversion to $CO_2$ is made by combustion bomb method (Switsur, 1974). Modern standard $CO_2$ is prepared by oxidation of NBS oxalic acid (SRM 4990C) with $KMnO_4$ in 2N $H_2SO_4$. $\delta^{13}C$ measurements are carried out at GEOTOP on $CO_2$ samples with a precision of $\pm 0.2‰$.

Carbon dioxide is purified by passing through acetone/dry-ice water traps and then reacted with lithium at 700°C. The $Li_2C_2$/Li mixture is cooled and $C_2H_2$ is obtained by adding water. The benzene is produced by trimerization of $C_2H_2$ on a $Cr^{+3}$ catalyst at 60°C and trapped with liquid nitrogen and acetone/dry-ice. The benzene samples are stored for at least three weeks to ensure complete $^{222}Rd$ decay. They are stored and counted in numbered bottles with lead caps and bottoms. It has been observed that the background values were reduced by half when using those bottles.

Each sample is counted at least 12 times for 100 minutes, at 6°C, alternating with 3 or 4 samples and commercial dead benzene used for background. The background values and the counting efficiencies are typically 4 cpm/58% and 2 cpm/53% for counters A and B, respectively. From these values a merit figure of 1400 and 900 is obtained. The modern standard $CO_2$ is regularly checked with a 100-year-old wood sample. Age calculations are based on the 5570 ± 30 yr Libby $^{14}C$ half-life and on a contemporary value equal to 0.95 of the activity of the NBS oxalic acid standard. No corrections are made for $^{14}C$ fractionation and/or reservoir effect. Deviations

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reported as $\pm 1\sigma$ include standard deviation of count rates on the background, the sample and modern standard. When the sample activity is below $2\sigma$, the age is expressed as greater than the minimum calculated age.

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INTER-LABORATORY CHECK SAMPLES

| Sample | GEOTOP date | Other lab no. | Other lab date | Ref |
|---|---|---|---|---|
| UQ-535 (wood) | 36,000 ± 2000 | GSC-3563 | >42,000 | Blake, pers commun |
| -555 (wood) | 25,200 ± 450 | GSC-1802-2 | 25,200 ± 260 | Lowdon & |
| | | WAT-199 | 25,320 ± 400 | Blake (1979) |
| | | BGS-303 | 25,620 ± 300 | |
| -133 (shell) | 7395 ± 80 | SI-4089 | 7500 ± 280 | England (1978) |
| -134 (shell) | 6790 ± 410 | SI-4029 | 6845 ± 70 | England (1983) |

GEOLOGIC SAMPLES

## Anticosti Island series

The Anticosti Island series (Gulf of St Lawrence), consists of 29 samples collected between 1981 and 1985 by members of a Univ de Sherbrooke research group. The main objectives of sampling program were to establish a sea-level curve for the island (Painchaud, 1984; Painchaud, Dubois & Gwyn, 1984) and chronologic framework for Late Quaternary glacial and non-glacial events (Gratton, Gwyn & Dubois, 1984). Detailed data and interpretations are pub in Bigras and Dubois (1987).

### UQ-493. Rivière du Brick

**12,400 ± 140**
$\delta^{13}C = +1.9‰$

Shell fragments and a few complete specimens in growth position *(Mya truncata ovata, Hiatella arctica)* subm 1982 by J M M Dubois and coll 1981 by D Gratton and QHJ Gwyn from 4m depth in prodeltaic sand and silt overlying marine silt and clay (49° 21′ 28″ N, 63° 23′ 22″ W). Alt of sample 18m asl; same unit as UQ-498, -499, -508 and same site as UQ-512. *Comment:* age of prodeltaic sediments of Goldthwait Sea.

**UQ-496. Côte Verte** **13,250 ± 400**

Shell fragments (*Hiatella arctica*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 8m depth in glaciomarine cobbly silts containing striated pebbles (49° 24′ 00″ N, 63° 34′ 48″ W). Alt of sample 4m asl; same site and same unit as UQ-502, same unit as UQ-505 and same sample as UQ-551. *Comment:* age for proximal glacio-marine sediments of Goldthwait Sea. In spite of low benzene volume used for counting, this date is more reliable than UQ-551.

**11,700 ± 270**

**UQ-498. Rivière Jupiter** $\delta^{13}C = +5.1‰$

Shell fragments and a few complete specimens in growth position (*Mya truncata ovata*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 5m depth in deltaic sand (49° 29′ 31″ N, 63° 31′ 53″ W). Alt of sample 23m asl; same unit as UQ-493, -499, -508. *Comment:* age of deltaic sediments of Goldthwait Sea.

**12,000 ± 190**

**UQ-499. Rivière Jupiter** $\delta^{13}C = +2.2‰$

Shell fragments and a few complete specimens in growth position (*Mya truncata ovata*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 2m depth in prodeltaic sand (49° 29′ 26″ N, 63° 32′ 20″ W). Alt of sample 18m asl; same unit as UQ-493, -498, -508 (same site). *Comment:* age of prodeltaic sediments of Goldthwait Sea.

**13,570 ± 200**

**UQ-502. Côte Verte** $\delta^{13}C = +3.6‰$

Shell fragments (*Balanus* sp) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 3m depth in glacio-marine cobbly silt containing striated pebbles (49° 24′ 00″ N, 63° 34′ 48″ W). Alt of sample 9m asl; same unit and same site as UQ-496, -551, and same unit as UQ-505. *Comment:* age of proximal glaciomarine phase of Goldthwait Sea.

**UQ-505. Côte Verte** **13,200 ± 200**

Shell fragments and a few complete valves (*Hiatella arctica*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 3m depth in glaciomarine sandy and cobbly silt with striated pebbles (49° 24′ 47″ N, 63° 34′ 42″ W). Alt of sample 15m asl; same unit as UQ-496, -502, -551. *Comment:* age of a proximal glaciomarine phase of Goldthwait Sea.

**12,080 ± 280**

**UQ-508. Rivière Jupiter** $\delta^{13}C = +7.7‰$

Shell fragments and a few complete specimens in growth position (*Balanus crenatus, Hiatella arctica*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 3m depth in prodeltaic sand and silt (49° 29′ 26″ N, 63° 32′ 20″ W). Alt of sample 17m asl; same unit as UQ-493, -498 and same site as UQ-499. *Comment:* age of prodeltaic sediments of Goldthwait Sea.

**UQ-509. Côte Verte** **28,100 ± 1200**

Shell fragments (*Buccinum, Balanus* spp) subm by 1982 J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 11m depth in glaciomarine cobbly sand containing striated pebbles (49° 24′ 36″ N, 63° 34′ 40″ W). Alt of sample 7m asl; same unit as UQ-553. *Comment:* this age for proximal glaciomarine phase agrees with UQ-510, -514 (obtained from shell material included in till).

**29,060 ± 1050**

**UQ-510. Pointe du Sud-Ouest** $\delta^{13}C = +4.1‰$

Unid. shell fragments subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 1m depth in silty clay till, 2m thick, containing Precambrian clasts and overlying bedrock (49° 24′ 08″ N, 63° 30′ 50″ W). Alt of sample 116m asl; same unit as UQ-514. *Comment:* max age for glacial advance assoc with Anticosti Island Till; this date agrees with UQ-514. Shells are probably derived from glacio-marine sediments in the Trois-Milles brook (NW of site) which are correlatives of glacio-marine sediments at Côte Verte (UQ-509).

**13,100 ± 150**

**UQ-512. Rivière du Brick** $\delta^{13}C = +1.5‰$

Shell fragments and a few complete specimens in growth position (*Mya truncata*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 8m depth in marine silt and clay overlain by prodeltaic sediments (49° 21′ 28″ N, 63° 23′ 22″ W). Alt of sample 14m asl; same unit as UQ-712 and same site as UQ-493. *Comment:* age of deepwater phase of Goldthwait Sea.

**UQ-514. Pointe du Sud-Ouest** **30,000 ± 1200**

Shells (*Hiatella arctica*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 2m depth in silty clay till containing Precambrian clasts (49° 23′ 47″ N, 63° 31′ 14″ W). Alt of sample 84m asl; same unit as UQ-510. *Comment:* same interpretation as UQ-510.

**UQ-515. Côte Verte** **11,950 ± 150**

Shell fragments and a few unbroken valves (*Mya truncata, Mya arenaria, Buccinum terrae-novae, Hiatella arctica*) subm 1982 by J M M Dubois and coll 1981 by D Gratton and Q H J Gwyn from 9m depth in glaciomarine silty and cobbly sand (49° 24′ 16″ N, 63° 34′ 38″ W). Alt of sample 3m asl; same unit as UQ-738. *Comment:* age of proximal glaciomarine phase assoc with readvance of Anticosti I. residual ice cap.

**14,500 ± 800**

**UQ-551. Côte Verte** $\delta^{13}C = +7.4‰$

Shell fragments (*Hiatella arctica*) subm 1982 by J M M Dubois and coll 1982 by D Gratton and Q H J Gwyn from 8m depth in glaciomarine cobbly silt containing striated pebbles (49° 24′ 00″ N, 63° 34′ 38″ W). Alt of sample 4m asl; same site as UQ-502, same unit as UQ-505 and same sample as UQ-

496. Same interpretation as UQ-496. *Comment:* this date may be less reliable than UQ-496 because of less benzene recovery.

**≥36,000**

**UQ-553. Baie Bonsecours** $\delta^{13}C = +0.6‰$

Shell fragments (*Balanus* sp) subm 1982 by J M M Dubois and coll 1982 by D Gratton and Q H J Gwyn from 5m depth in glaciomarine silty and cobbly sand containing striated pebbles (49° 28′ 45″ N, 63° 36′ 50″ W). Alt of sample 1–2m asl; same unit as UQ-509. *Comment:* oldest date on Anticosti I., age of proximal glaciomarine phase. Sample should be cross-checked on proportional counter because of less benzene recovery. Date was previously considered finite (36,000 ± 3500 BP; Gratton, Gwyn & Dubois, 1984), age seems consistent with available amino acid ratios (Bigras, Gwyn & Dubois, 1988).

**13,400 ± 140**

**UQ-712. Ruisseau Martin** $\delta^{13}C = +5.5‰$

Shell fragments and a few complete specimens in growth position (*Hiatella arctica*) subm 1983 by J M M Dubois and coll 1982 by D Gratton and Q H J Gwyn from 3m depth in cobbly glaciomarine silt overlying till and underlying littoral gravel (49° 10′ 34″ N, 62° 46′ 58″ W). Alt of sample 9m asl; same unit as UQ-512. *Comment:* same interpretation as UQ-512.

**UQ-719. Rivière à l'Huile** **9010 ± 60**

Shell fragments and a few unbroken valves (*Zirphaea crispata*) subm 1983 by J M M Dubois and coll 1981 by A Painchaud in cobbly matrix-dominated resedimented diamicton overlain by 6m of littoral sandy gravel (49° 50′ 12″ N, 63° 33′ 30″ W). Alt of sample 12m asl. *Comment:* located on distal side of Rivière à l'Huile Moraine, date is min for moraine.

**12,190 ± 170**

**UQ-738. Ruisseau Box** $\delta^{13}C = +0.7‰$

Shells (*Mya truncata, Hiatella arctica*) subm 1983 by J M M Dubois and coll 1982 by D Gratton and Q H J Gwyn from 2m depth in glaciomarine sandy and cobbly silt (49° 06′ 21″ N, 62° 24′ 00″ W). Alt of sample 2 to 3m asl; same unit as UQ-515. *Comment:* same interpretation as UQ-515.

**UQ-776. Baie Martin** **9450 ± 200**

Shell material (mainly *Mya truncata*) subm 1983 by J M M Dubois and coll 1981 by A Painchaud in glaciomarine sandy silt incorporated in till (49° 52′ 25″ N, 63° 52′ 10″ W). Alt of sample 10m asl. *Comment:* sample coll within Rivière à l'Huile Moraine. Date is considered suspect because of low sample weight and small benzene recovery.

**UQ-778. Rivière Sainte-Marie** **10,150 ± 100**

Shells in growth position (*Mya truncata*) subm 1983 by J M M Dubois and coll 1981 by A Painchaud at surface of till overlain by 1.5m of littoral gravel (49° 40′ 10″ N, 63° 54′ 48″ W). Alt of sample 5m asl; same unit as

UQ-1018 and QU-1262 (11,680 ± 190), -1263 (12,400 ± 230), -1264 (11,830 ± 180), -1265 (12,090 ± 210), -1268 (12,300 ± 180), -1269 (12,470 ± 170), -1270 (11,940 ± 190) and -1271 (12,200 ± 190) (Bigras & Dubois, 1987). *Comment:* age of regressive level of Goldthwait Sea at alt ca 35 to 50m asl according to mean depth range of this species.

**UQ-1018. Rivière aux Becs-Scie** **13,450 ± 300**
$\delta^{13}C = +1.06‰$

Unbroken shell valves (*Macoma calcarea*) subm and coll 1984 by J M M Dubois in thin till derived from glaciomarine sediments and overlain by 1 to 2cm of littoral sand and 1.5m of terrestrial peat (49° 42′ 09″ N, 64° 05′ 10″ W). Alt of sample 3.3m asl; same unit as UQ-778 and QU-1262 to -1265 and -1268 to -1271 (Bigras & Dubois, 1987). *Comment:* age of Goldthwait Sea proximal glaciomarine sediments deposited prior to fm of Sainte-Marie Moraine.

**UQ-1036. Baie du Petit Makasti** **470 ± 80**
$\delta^{13}C = +1.7‰$

Shells in growth position (*Mya arenaria*) subm and coll 1984 by J M M Dubois from veneer of Goldthwait Sea marine clay on modern intertidal rock-platform (49° 55′ 30″ N, 64° 22′ 15″ W). Alt of sample 0m asl; sampled in immediate vicinity of site of sample UQ-1376. *Comment:* this shallow-water species probably burrowed into older marine clay (UQ-1376) during Late Holocene phase of littoral erosion. Age of regressive level of Goldthwait Sea at site alt. Small benzene recovery.

**UQ-1056. Rivière aux Saumons** **10,200 ± 200**

Shell fragments (*Hiatella arctica, Macoma* sp) subm 1984 by L St-Pierre and coll 1984 by Q H J Gwyn, P Bigras and L St-Pierre from 13m depth at base of prodeltaic silt and sand overlying marine or glaciomarine silt and clay (49° 24′ 55″ N, 62° 15′ 05″ W). Alt of sample 6m asl. *Comment:* dates 42m asl surface of Rivière aux Saumons delta into receding Goldthwait Sea.

**UQ-1063. Port-Menier Airport** **11,600 ± 200**

Shell fragments (mainly *Mytilus edulis*) subm 1984 by L St-Pierre and coll 1984 by L St-Pierre and D Côté from 2m depth in prodeltaic sand and gravel (49° 50′ 05″ N, 64° 15′ 50″ W). Alt of sample 61m asl; same unit as QU-1272 (12,450 ± 190), -1273 (12,510 ± 200) and GSC-89 (12,940 ± 150) (Bigras & Dubois, 1987). *Comment:* date is youngest date for fm of Trois-Milles brook outwash plain; outwash body which formed during sea-level stand at site alt is contemporaneous with Sainte-Marie Moraine.

**UQ-1064. Pointe Carleton** **9500 ± 100**

Shell fragments (mainly *Mytilus edulis* and *Mya* sp) subm 1984 by L St-Pierre and coll 1984 by P Bigras, L St-Pierre and D Côté from 2m depth in littoral sand and gravel at surface of raised rock platform (49° 43′ 57″ N,

62° 58′ 47″ W). Alt of sample 26 to 29m asl. *Comment:* age of regressive level of Goldthwait Sea at site alt.

**UQ-1066. Rivière à la Patate** **10,600 ± 200**
$\delta^{13}C = +2.8‰$

Shell fragments and a few unbroken specimens (mainly *Mya truncata, Mya arenaria, Hiatella arctica*) subm 1984 by L St-Pierre and coll 1984 by J M M Dubois, P Bigras and L St-Pierre from depth 17m in marine silty clay overlain by 10m of deltaic sand and gravel (49° 42′ 20″ N, 62° 56′ 00″ W). Alt of sample 13 to 17m asl; same unit as QU-1375, -1376 (Bigras & Dubois, 1987). *Comment:* min age of deglaciation in E part of Jacques-Cartier Passage. Complete starfish (*Ophiuroida*) specimen, probably *Asterias vulgaris* or *Henricia sanguinolenta,* was also found at this site.

**UQ-1068. Pointe Carleton** **1300 ± 100**
$\delta^{13}C = +1.3‰$

Shell fragments (mainly *Buccinum undatum, Mytilus edulis*) subm 1984 by L St-Pierre and coll 1984 by P Bigras, L St-Pierre and D Côté from 2 to 3m depth in beach sand and gravel at surface of raised littoral rock platform (49° 43′ 58″ N, 62° 59′ 01″ W). Alt of sample 3 to 6m asl. *Comment:* dates regressive level of Goldthwait Sea at site alt.

**UQ-1082. Port-Menier Airport** **9850 ± 300**

Whale vertebra (restored and exposed in Mus Nat Sci, Ottawa) subm 1984 by J M M Dubois and coll 1984 by Q H J Gwyn in beach gravel overlying fluvio-deltaic sediments (49° 50′ 00″ N, 64° 17′ 30″ W). Alt of sample 49m asl. *Comment:* dates regressive level of Goldthwait Sea at site alt.

**UQ-1375. Baie du Petit Makasti** **9900 ± 100**

Shells (*Hemithyris psittacea, Mya truncata, Macoma balthica*) in growth position subm 1986 and coll 1985 by J M M Dubois at 6m depth in marine clay overlain by deltaic sand and gravel (49° 55′ 20″ N, 64° 21′ 30″ W). Alt of sample 3m asl; same unit as UQ-1066, -1376. *Comment:* same interpretation as UQ-1066, -1376. Site provides first recorded occurrence of *Crassostrea virginica* this far N of its modern distribution area, boundary of which now lies near 47° N.

**UQ-1376. Baie du Petit Makasti** **13,900 ± 300**

Shells in growth position (*Hiatella arctica, Mya truncata*) subm 1986 and coll 1985 by J M M Dubois from 25cm depth in marine clay in depression of modern littoral rock platform (49° 55′ 30″ N, 64° 22′ 15″ W). Alt of sample 0m asl; near UQ-1036 and same unit as UQ-1066, -1375. *Comment:* min age of deglaciation of W part of Jacques-Cartier Passage. Late Wisconsinan marine clays at surface of modern platform indicates platform was formed prior to Late Wisconsinan time, possibly during Sangamonian stage.

**Baie-Comeau series**

Baie-Comeau series (North Shore of St Lawrence estuary) consists of 15 samples coll 1985 and subm 1986 by J M M Dubois. Samples were dated

to document relative sea-level changes in this part of Goldthwait Sea (Dubois, 1979; Bigras & Dubois, 1987) and to date marine limit; thus to provide min age for deglaciation of area. Most samples were coll in two secs exposing thick coquina beds with minor sand and gravel. These deposits underlay well-defined offlap terraces in small bays of former Rivière aux Anglais estuary. Site 1 is Rivière des Anglais-A (49° 17′ 25″ N, 68° 09′ 45″ W); 60m asl; samples UQ-1229, -1230, -1360 and QU-573 (9600 ± 130) (Bigras & Dubois, 1987) were coll in coquina beds which has exposed thickness of 1.7m. Site 2 is Rivière des Anglais-B (49° 19′ 15″ N, 68° 09′ 20″ W) 76m asl; samples UQ-1231 to -1235, -1361 and QU-574 (9970 ± 130) (Bigras & Dubois, 1987) were coll in coquina beds thickness of which exceed 8m. Detailed data and interpretations are pub in Bigras and Dubois (1987).

**UQ-1229. Rivière des Anglais-A** **9350 ± 100**

Well-preserved shells (*Balanus crenatus*) from depth 40cm assoc with *Hiatella arctica, Mytilus edulis, Hemithyris psittacea* and foram, *Elphidium incertum. Comment:* age of regressive sea level at 60m asl; date agrees with GSC-1565 (9280 ± 140), QU-73 (10,000 ± 170) and QU-573 (9600 ± 130).

**UQ-1230. Rivière des Anglais-A** **8600 ± 100** $\delta^{13}C = +1.2‰$

Well-preserved shells (*Balanus crenatus*) from depth 0.4 to 1.7m; same faunal assemblage as UQ-1229. *Comment:* date slightly too young for regressive sea level at 60m asl (5 dates).

**UQ-1360. Rivière des Anglais-A** **11,600 ± 300**

*Comment:* this date, intended as cross-check of UQ-1230, same species, should be used with caution since only 0.947g benzene was used for counting. Date seems somewhat too old relative to other dates at same alt in area.

**UQ-1231. Rivière des Anglais-B** **9850 ± 100**

Well-preserved shells (*Mytilus edulis*) from depth 40 to 50cm assoc with *Balanus balanus, Balanus crenatus, Mya truncata, Natica clausa, Hiatella arctica, Buccinum tenue,* a few *Chlamys islandicus, Macoma balthica, Astarte montagui striata, Balanus hameri, Hemithyris psittacea* and one valve of *Zirphaea crispata. Comment:* age for regressive sea level stand at 76m asl. UQ-1231, -1232, -1233 show expected age increase with depth, but UQ-1234, -1235, -1361, at greater depth, are more problematic.

**UQ-1232. Rivière des Anglais-B** **10,000 ± 100**

Well-preserved shells (*Mytilus edulis*) from depth 2.2 to 2.4m. *Comment:* age for regressive sea level at 76m asl; age agrees with strat position.

**UQ-1233. Rivière des Anglais-B** **10,350 ± 100**
$\delta^{13}C = 0.4‰$

Well-preserved shells (*Mytilus edulis*) from depth 2.8 to 3.1m. *Comment:* age for regressive sea level at 76m asl; agrees with strat position.

**UQ-1234. Rivière des Anglais-B** **10,200 ± 100**
$\delta^{13}C = 0.1‰$

Well-preserved shells (*Mytilus edulis*) from depth 4m. *Comment:* age for regressive sea level at 76m asl; if stated errors ($\pm 1\sigma$) are considered, this date may be identical to or slightly older than UQ-1233.

**UQ-1235. Rivière des Anglais-B** **9600 ± 200**

Well-preserved shells (*Balanus crenatus*) often fixed on other shells from depth 4m; same sample as UQ-1234. *Comment:* this date is significantly younger than UQ-1233 and -1234; date may be suspect, particularly since low benzene volume was used for counting.

**UQ-1361. Rivière des Anglais-B** **12,600 ± 200**

*Comment:* this date was intended as cross-check of UQ-1235, but on mixed species (see assemblage UQ-1231); same problem as UQ-1360. Apparent antiquity of this date may be caused by reworked shells from older sediments; however, only small amount of benzene was used for counting; date should be used with caution.

**UQ-1236. Baie-Comeau** **9050 ± 100**
$\delta^{13}C = +0.4‰$

Shells (*Mya arenaria*) coll from depth 0 to 1m in silty marine sediment (49° 13′ 00″ N, 68° 11′ 40″ W). Alt of sample 60m asl; same site as GSC-1565 (Bigras & Dubois, 1987) and same unit as UQ-1237; thanacoenotic assemblage also contains *Balanus crenatus, Mytilus edulis, Hiatella arctica, Hemithyris psittacea* and a few *Astarte montagui, Macoma balthica, Venericardia borealis. Comment:* age slightly too young for regressive level of Goldthwait Sea at site alt; date is consistent with UQ-1229, -1237, QU-573 and GSC-1565.

**UQ-1237. Baie-Comeau** **10,000 ± 100**
$\delta^{13}C = +2.3‰$

Shells (*Mya truncata*) coll near surface in veneer of silty marine sediment on bedrock (49° 13′ 00″ N, 68° 11′ 40″ W). Alt of sample 56m asl; same unit as UQ-1236 and GSC-1565 (Bigras & Dubois, 1987); thanacoenotic assemblage also contains *Chlamys islandicus, Macoma calcarea, Balanus hameri* and a few *Cyrtodaria siliqua, Astarte montagui, Hemithyris psittacea, Venericardia borealis, Buccinum hancocki. Comment:* date is too old for regressive level of Goldthwait Sea at site alt, presumably because shells were reworked from sediments deposited earlier during marine invasion; min age for marine invasion in area.

**9950 ± 100**

**UQ-1238. Baie-Comeau (Pointe Saint-Gilles)** $\delta^{13}C = +1.6‰$

Shells (*Balanus crenatus*) coll near surface in marine silty and clayey sand containing pebbles and cobbles (49° 11′ 55″ N, 68° 10′ 25″ W). Alt of sample 30m asl; same unit as UQ-1239 and GSC-1746 (8890 ± 150); thanacoenotic assemblage also contains *Chlamys islandicus, Hemithyris psittacea* and a few *Astarte montagui, Macoma balthica, Mya truncata, Hiatella arctica, Buccinum hancocki, Natica clausa. Comment:* same interpretation as UQ-1237.

**7800 ± 500**

**UQ-1239. Chute-aux-Outardes** $\delta^{13}C = -1.6‰$

Thin, dwarf shells in growth position (*Macoma balthica*) coll at the base of 4.9m of compact marine sediment overlain by 4m of deltaic sand and gravel (49° 07′ 40″ N, 68° 22′ 20″ W). Alt of sample 21m asl; same unit as UQ-1238 and GSC-1746. *Comment:* age is mainly indicative because only 0.3g of benzene were recovered from this 5g sample; age for marine sediments underlying part of delta of Rivière aux Outardes ca 30m asl.

**UQ-1362. Baie-Comeau** **9900 ± 200**

Shells (*Balanus crenatus*) coll from depth 60cm in beach sand and fine gravel at the contact with underlying marine sediment (49° 12′ 00″ N, 68° 11′ 15″ W). Alt of sample 23m asl; probably same site GSC-1746 (8890 ± 150); assemblage also contains *Clinocardium ciliatum, Astarte montagui, Macoma balthica, Macoma calcarea. Comment:* age too old for regressive level of Goldthwait Sea at site alt. This date should be used with caution because of small benzene recovery.

**UQ-1363. Pointe-aux-Outardes** **7600 ± 150**

Shells in growth position (*Mya arenaria*) coll from depth 0.4m in compact marine sediment overlain by 3.7m of beach sand and 0.9m of aeolian sand (49° 02′ 30″ N, 68° 27′ 45″ W). Alt of sample 2m asl. *Comment:* same interpretation as UQ-1239. This date should be used with caution because of small benzene recovery.

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# UNIVERSITY OF WISCONSIN RADIOCARBON DATES XXV

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Procedures and equipment used in the University of Wisconsin laboratory have been described in previous date lists. Except as otherwise indicated, wood, charcoal, and peat samples are pretreated with dilute NaOH—$NA_4P_2O_7$ and dilute $H_3PO_4$ before conversion to the counting gas methane; when noted, marls and lake cores are treated with acid only. Very calcareous materials are treated with HCL instead of $H_3PO_4$. Pretreatment of bone varies with the condition of the bone sample; solid bone with little deterioration is first cleaned manually and ultrasonically. The bone is treated with 8% HCL for 15 minutes, then dilute NaOH—$Na_4P_2O_7$ for 3 hours at room temperature, washed until neutral, and the collagen extracted according to Longin (1971). Charred bone is treated with dilute HCL, NaOH—$Na_4P_2O_7$, and then dilute HCL again.

The dates reported have been calculated using 5568 yr as the half-life of $^{14}C$. The standard deviation quoted includes only $1\sigma$ of the counting statistics of background, sample, and standard counts. Background methane is prepared from anthracite, standard methane from NBS oxalic acid. The activities of the dated samples for which $\delta^{13}C$ values are listed have been corrected to correspond to a $\delta^{13}C$ value of $-25‰$; the activity of the standard methane has been corrected to $-25‰$.

Sample descriptions are based on information supplied by those who submitted samples.

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## ARCHAEOLOGIC SAMPLES

### *United States*

*Illinois*

**Bauer Branch phase series**

Wood charcoal coll 1981–82 from sites in upper Sugar Creek drainage (Schuyler Co) between villages of Littleton and Vermont by W Green, D Esarey, M Malpass, K Stevenson, K Sampson and subm by W Green, Dept Anthropol, Univ Wisconsin-Madison.

**1050 ± 70**

**WIS-1871. (11Sc264)** $\delta^{13}C = -26.4‰$

Sample from Feature 3 (40° 14′ 30″ N, 90° 34″ W), shallow basin-shaped pit directly assoc with Bauer Branch sherds and punctated pipe.

**1370 ± 70**

**WIS-1872. (11Sc268)** $\delta^{13}C = -26.5‰$

Sample from Feature 9 (40° 15′ N, 90° 35′ W), structure basin directly assoc with Bauer Branch vessels.

**1020 ± 70**

**WIS-1877. (11Sc348)** $\delta^{13}C = -26.2‰$

Sample from Feature 8 (40° 15′ N, 90° 35′ W), Bauer Branch pottery refits with Feature 13 sherds.

**1170 ± 70**

**WIS-1878. (11Sc348)** $\delta^{13}C = -26.3‰$

Sample from Feature 11 (same as WIS-1877, above), directly assoc with Bauer Branch sherds and triangular point.

**1120 ± 70**

**WIS-1879. (11Sc348)** $\delta^{13}C = -26.3‰$

Sample from Feature 13 (same as WIS-1877, above), directly assoc with notched, stemmed points and Bauer Branch pottery. Sherds refit with Feature 8 pottery.

**1050 ± 70**

**WIS-1880. (11Sc461)** $\delta^{13}C = -26.3‰$

Sample from features exposed in road cut (40° 14′ 30″ N, 90° 34″ W), Late Woodland pottery and stemmed points assoc. *Comment:* age 400 yr younger than artifacts indicate.

**1250 ± 70**

**WIS-1881. (11Sc466)** $\delta^{13}C = -26.2‰$

Sample from feature assoc with paleosol in Sugar Creek flood plain (40° 14′ 30″ N, 90° 30′ 30″ W), depth 100 to 110cm, Late Woodland assoc.

*General Comment:* occupation of Sugar Creek headwater area intensified after demise of Hopewell culture and ended just before Mississippian influence in region. Site density along intermittent streams indicates higher, more stable prehistoric stream flow level. Previous dates WIS-918 (R, 1979, v 21, no. 1, p 120; Esarey, 1982; Green, 1976, 1977, 1987).

*Massachusetts*

**Boylston Street Fish Weir site series**

Wood from Boylston Street Fish Weir site Suffork Co (42° 40′ N, 71° 00′ W) coll by E De'cima and M Roberts and subm by P Newby, Brown

Univ, Providence. Wooden stakes from area that was once inlet of Charles R (Johnson, 1942, 1949).

**WIS-1957.** **3890 ± 70**
$\delta^{13}C = -31.3‰$

Wood from 481cm below Boston City base; normal pretreatment.

**WIS-1958.** **4120 ± 70**
$\delta^{13}C = -31.1‰$

Sample treated to remove hydrocarbons, then normal pretreatment (same sample as WIS-1957).

**WIS-1959.** **5300 ± 70**
$\delta^{13}C = -26.9‰$

Sample from 550cm below Boston City base.

*Minnesota*

**WIS-1869. Yucatan Village site (21Hu26)** **220 ± 60**
$\delta^{13}C = -26.6‰$

Charred wood from Site 21Hu26, Houston Co (43° 40′ N, 91° 42′ W) coll May 1985 by R M Withrow and subm by E Johnson, Dept Anthropol, Univ Minnesota, Minneapolis. *Comment:* sample is assoc with Orr phase Oneota ceramics from deep bell-shaped pit. European trade items including glass beads and kettle brass were found on surface of site and in subsurface pits lacking Oneota ceramics.

**WIS-1870. Archaeological site (21Ml11)** **Modern**
$\delta^{13}C = -26.1‰$

Charred wood from Site 21Ml11, Mille Lacs Co (46° 07′ N, 93° 46′ W) coll and subm by E Johnson. House structure supporting timbers underlying 15 to 18cm mixed humic soil overburden.

*Ohio*

**WIS-1876. Sand Ridge site (33Ha17)** **560 ± 70**
$\delta^{13}C = -26.4‰$

Wood charcoal from Sand Ridge site (33Ha17) Hamilton Co (39° 06′ 05″ N, 84° 23′ 45″ W) coll 1948 by D Conover and subm by R E Riggs, Dept Anthropol, Univ Wisconsin-Madison. *Comment:* sample dates Fort Ancient tradition component of site. For previous dates from site, see R, 1987, v 29, no. 3, p 400.

*Oklahoma*

**Geren site (34Lf36) series**

Samples coll Jan-April 1941 from Geren site, LeFlore Co (34° 18′ 37″ N, 94° 35′ 09″ W) by K G Orr and subm by C L Rohrbaugh, Illinois State Univ, Normal (formerly Stovall Mus, Univ Oklahoma).

**460 ± 70**

**WIS-1859.** $\delta^{13}C = -25.5‰$

Wood charcoal from House 9, probably from central hearth of two-center-post rectangular house pattern.

**420 ± 70**

**WIS-1860.** $\delta^{13}C = -25.7‰$

Wood charcoal from House 2, probably from wall post of two-center-post rectangular house patterns with extended entrance.

**450 ± 70**

**WIS-1884.** $\delta^{13}C = -26.9‰$

Wood charcoal from House 10, probably from wall post or central hearth of two-center-post rectangular house.

**590 ± 70**

**WIS-1885.** $\delta^{13}C = -27.4‰$

Same as WIS-1860.

**330 ± 70**

**WIS-1889.** $\delta^{13}C = -25.9‰$

Wood charcoal from House 1, probably from one of exterior wall posts of two-center-post rectangular house.

**390 ± 60**

**WIS-1892.** $\delta^{13}C = -9.2‰$

Carbonized corn from refuse-filled pit in House 2. Same as WIS-1860.

**670 ± 50**

**WIS-1893.** $\delta^{13}C = -9.4‰$

Carbonized corn from one of several refuse-filled pits in circular House 3. Dates are first from circular houses in Arkansas R region of Caddoan area.

**660 ± 60**

**WIS-1894.** $\delta^{13}C = -9.4‰$

Same as WIS-1893.

*General Comment:* dates on contexts at Geren Site 34Lf35 are interesting because they are unexpected. Houses clearly belong to late part of Caddoan sequence in Arkansas Valley, but those believed to be early date to period of Fort Coffee phase. Circular houses, believed by many to be Fort Coffee features, date to earliest part of Spiro phase (Rohrbaugh, 1985a,b; R, 1981, v 23, p 147–148).

*Wisconsin*

**Fred Edwards site (47Gt377) series**

Wood charcoal coll Aug 1985 from Fred Edwards site 47Gt377, Grant Co (42° 43′ 30″ N, 90° 50′ 58″ W) by F Finney, C Arzigian, N Mills, C Pope, and subm by J B Stoltman, Dept Anthropol, Univ Wisconsin-Madison. Samples date Middle Mississippi/Late Woodland contact in SW Wisconsin (R, 1986, v 28, no. 3, p 1211; R, 1987, v 29, no. 3, p 403).

**WIS-1886.** **1010 ± 70**
$\delta^{13}C = -25.2‰$

Sample from Feature 51, rock-filled, 2.5 × 1.5m basin, possible sweat lodge or roast pit. Basin contained diagnostic Late Woodland ceramics.

**WIS-1887.** **810 ± 70**
$\delta^{13}C = -26.1‰$

Sample from Feature 73, rectangular, shallow, semi-subterranean structure containing Late Woodland and Middle Mississippian (including Ramey Incised) ceramics. *Comment:* WIS-1887 is in conformity with preponderance of dates from site; WIS-1886 is slightly older but is acceptable.

**Bachmann site (47Sb202) series**

Samples coll July 1986 from Bachmann site, Sheboygan Co (43° 43′ N, 87° 48′ W) and subm by L Rusch, State Hist Soc Wisconsin-Madison (Rusch & Penman, 1984; R, 1986, v 28, no. 3, p 1211; R, 1987, v 29, no. 3, p 402).

**WIS-1890.** **2050 ± 70**
$\delta^{13}C = -26.9‰$

Wood charcoal, sample no. 22, gathered from 40cm$^2$ of prehistoric living surface.

**WIS-1891.** **890 ± 50**
$\delta^{13}C = -26.2‰$

Wood charcoal, sample no. 30, coll from large fire pit containing a few chert flakes. This feature had no diagnostic artifacts.

*General Comment:* sample no. 22 dates Early Woodland habitation. This component represents previously unid. manifestation of Early Woodland. It is characterized by predominance of Durst points in lithic assemblage and ceramics which cannot be assoc with any previously defined type. Sample no. 30 dates Late Woodland component.

**WIS-1895. Oneota site (47Lc262)** **470 ± 70**

Wood charcoal coll Oct 1986 from Oneota site (47Lc262), LaCrosse Co (43° 56′ 30″ N, 91° 15′ 30″ W) by D M Stemper and N Meinholtz and subm by J T Penman, State Hist Soc. *Comment:* dated charcoal is from Fea-

ture 1, burial pit in Unit W98 S01. Burials include three individuals, one of which is extended. Grave goods, including Madison triangular projectile points and rolled copper beads, were found with all three burials. Oneota ceramics and bison scapula hoe were found above burial pit. Burials are probably assoc with large Oneota Tremaine village (47Lc95) W of 47Lc262.

**330 ± 60**

**WIS-1913. Kessler's Two site (47Cl18)** $\delta^{13}C = -27.1‰$

Wood charcoal coll Nov 1986 from Kessler's Two site (47Cl18), Clark Co (44° 34′ N, 90° 37″ W) by J H Broihahn and subm by J T Penman. Sample from Feature 1 contained no diagnostic artifacts (Broihahn, Penman & Rusch, 1987). *Comment:* Feature 1 is in cultivated field. Charcoal was coll 30 to 35cm below ground surface. Paste characteristics and formal attributes of ceramics taken from feature contiguous to Feature 1 exhibit parallels to Late Woodland pottery. Ceramics could not be assoc with any previously defined type.

### Gottschall Site (47Ia80) series

Wood charcoal coll from Gottschall Rockshelter (47Ia80), Iowa Co (43° 06′ 19″ N, 90° 21′ 01″ W) by R J Salzer, M Steinhauer, C Phannkuche and subm by R J Salzer, Beloit Coll. Previously dated (R, 1987, v 28, no. 3, p 402; Salzer, 1987).

**3060 ± 70**

**WIS-1911.** $\delta^{13}C = -25.5‰$

Charcoal from Feature 1, sample nol. 86Cl, Late Archaic hearth.

**3450 ± 70**

**WIS-1912.** $\delta^{13}C = -26.3‰$

Charcoal from Feature 1, sample no. 86C2, Late Archaic hearth.

### Whitefish Bay View site (47Dr167) series

Wood charcoal from Whitefish Bay View site, Door Co (44° 55′ 36″ N, 87° 11′ 55″ W) subm by V Dirst, Wisconsin Dept Nat Resources, Bur Parks & Recreation, Madison (Dirst, V, Archaeological research at Whitefish Dunes State Park, Door County, Wisconsin, ms in preparation).

**560 ± 60**

**WIS-1918.** $\delta^{13}C = -25.8‰$

Sample coll July 1986 by V Dirst and C Waggener from Feature 6, an Oneota trash pit that yielded Green Bay phase ceramics, chert flakes, a large quantity of faunal remains (mostly fish) and some floral remains, including corn.

**WIS-1919.** **1640 ± 70**
$\delta^{13}C = -24.6‰$

Sample coll Aug 1986 by J A Clark from Feature 8. Dates earlier of two Late Woodland occupations at site. Pottery includes Pt Sauble collared sherds and non-Pt Sauble Madison Ware vessels.

*General Comment:* WIS-1918 well within range of dates expected. Deflation appears to have resulted in misinterpretation of context of WIS-1919. It is now considered to date earliest occupation of site, which must be Middle Woodland. Sample was assoc with lithic debitage and floral remains (blackberry and bush honeysuckle), but no ceramics. Ceramics noted in initial description were in Late Woodland horizon separated from this sample by disconformity.

### "Brussels Hill" Cave series

Charcoal coll 1986 and 1987 from pit cave near Brussels, Door Co (44° 44′ 35″ N, 87° 35′ 21″ W) by N Kox, R Howe, M Schleis, C Schleis, G Soule, J Brazowski, K Brown, T Erdman and subm by R Howe, Univ Wisconsin-Green Bay. Cave is deep, irregular fissure of Silurian dolomite shaped somewhat like hour glass yielding much vertebrate skeletal remains (West & Dallman, 1980; Schleis, 1987). Presence of wetland spp below this upland site is particularly curious.

**WIS-1888.** **670 ± 70**
$\delta^{13}C = -26.1‰$

Date is min for underground deposit of fossil-bearing sediments.

**WIS-1965.** **1820 ± 70**
$\delta^{13}C = -25.6‰$

Sample from depth 28m.

*Belize*

### MAYA series

Wood charcoal coll Jan 1987 from Alabama site, Stann Creek Dist (16° 44′ N, 88° 31′ W) by J J MacKinnon, M Meyers and L Marten and subm by J J MacKinnon, Anthropol Dept, Univ Wisconsin-Madison.

**WIS-1914.** **1190 ± 80**
$\delta^{13}C = -27.3‰$

Sample from red-brown sandy clay, depth 173cm, in sealed context beneath intact lime plaster floor, Sq F, central trench, Structure 3. Beneath ceremonial platform of limestone, schist, and granite blocks atop Maya pyramid.

**1100 ± 70**

**WIS-1915.** $\delta^{13}C = -27.1‰$

Sample from dark red-brown sandy clay, beneath wall of S structure (Maya Palace) atop Structure 3 (main pyramid/acropolis) from profile trench no. 1. Wall is largely granite and schist with a few limestone blocks.

**1570 ± 70**

**WIS-1916. Rum Point Lime site** $\delta^{13}C = -25.5‰$

Wood charcoal coll Jan 1984 from Rum Point Lime site, Placencia Lagoon, Stann Creek Dist (16° 31′ N, 88° 21′ W) by S G Velzy and subm by J J MacKinnon. Sample PL-1-2 from sandy clay carbonate-rich soil. On ancient Maya site where lagoon shells were burned to produce lime. Heavy concentrations of broken pottery and lime concretions in midden on shore of brackish lagoon.

*Ecuador*

**Yumes site series (OG-BL-PL-18)**

Wood charcoal from Site OG-BL-PL-18 (01° 36′ S, 79° 59′ W), Recinto Yumes, Guayas Prov, coll July 1984 and subm by D M Stremper, Anthropol Dept, Univ Wisconsin-Madison (R, 1986, v 28, no. 3, p 1212–1213).

**WIS-1974.** **3960 ± 260**

Sample from 411 to 431cm below surface, assoc with late Valdivia sherds, one post mold, bone, and burned daub.

**WIS-1975.** **3530 ± 250**

Sample from 431 to 451cm below surface, assoc with probable late Valdivia midden.

*Peru*

**Cerro Azul site series**

Samples coll 1983–1984 from Cerro Azul site, Canete Valley (13° 01′ S, 76° 29′ W) and subm by J Marcus, Mus Anthropol, Univ Michigan, Ann Arbor (Marcus, 1987).

**420 ± 70**

**WIS-1936.** $\delta^{13}C = -26.0‰$

Small charcoal fragments from Feature 6 of Structure D, large mud-walled compound. *Comment:* feature was midden in courtyard of compound, presumed to represent refuse left behind when building was abandoned following Inca conquest of Cerro Azul, AD 1470.

**520 ± 70**

**WIS-1937.** $\delta^{13}C = -26.7‰$

Small charcoal fragments from floor of S Corridor of Structure D. *Comment:* charcoal assoc with large pile of corn cobs, presumed to have

been left behind when building was abandoned following Inca conquest of Cerro Azul, AD 1470.

**WIS-1938.** **1150 ± 70**
$\delta^{13}C = -24.0‰$

Sec of wooden post from 220cm depth in Terrace 9 of Quebrada 5a. *Comment:* matrix was brown, soft, sandy refuse midden, possibly assoc with wattle-and-daub structure. Overlying level was gray, hard, ashy midden. Previous date from same level (Beta-7796) was 1640 ± 120.

**WIS-1939.** **480 ± 60**
$\delta^{13}C = -26.7‰$

Small charcoal fragments from Feature 20 of Structure 9, mud-walled compound. Feature was midden adjacent to compound, presumed to represent refuse left behind when building was abandoned following Inca conquest of Cerro Azul, AD 1470.

## GEOLOGIC SAMPLES

### *United States*

*Alaska*

**Pleasant Island site series**

Core coll Sept 1984 from small lake in Tongass Natl Forest (58° 21′ N, 135° 39′ W) by D R Engstrom and subm by D R Engstrom and H E Wright, Jr, Univ Minnesota, Minneapolis. Lake elev, 150m. All depths in cm from lake surface, water depth 3.64m. Dated to provide stratigraphic pollen record.

**WIS-1945.** **3320 ± 80**

Fine detritus, 426 to 432cm.

**WIS-1946.** **6180 ± 90**

Fine detritus, 468 to 476cm.

**WIS-1947.** **10,110 ± 100**

Fine detritus, 548 to 556cm.

**WIS-1948.** **11,260 ± 120**

Light brown gyttja, 608 to 616cm.

**WIS-1949.** **11,950 ± 120**

Green-brown gyttja, 626 to 632cm. Sample overlies Edgecumbe tephra.

**WIS-1950.** **12,280 ± 120**

Mottled green-brown gyttja, 640 to 646cm. Sample underlies Edgecumbe tephra.

**WIS-1951.** **13,760 ± 120**

Gyttja with coarse detritus, 660 to 666cm. Basal date.

**WIS-1967.** **1940 ± 70**

Limnic sediment, 384 to 388cm.

**WIS-1968.** **8390 ± 80**

Limnic sediment, 508 to 514cm.

*Connecticut*

**Cedar Swamp series**

Cores coll June 1986 from Cedar Swamp, Pequot Indian Reservation (41° 27′ 30″ N, 71° 57′ 40″ W) by R S Webb and T Webb, III. Subm by R S Webb, Brown Univ, Providence, Rhode Island. Depths in cm below surface.

**WIS-1874.** **10,830 ± 110**

Fine grained, felty peat from Core B, 265 to 271cm.

**WIS-1875.** **12,690 ± 120**

Interbedded organic silt and clay from Core B, 311 to 319cm.

**WIS-1952.** **8960 ± 110**

Organic silt, rich in fine-grained peat from Core B, 154 to 160cm.

**WIS-1953.** **8990 ± 90**

Organic silt, rich in fine-grained peat from Core A, 155 to 160cm.

**WIS-1954.** **10,620 ± 100**

Fine-grained organic silt and detrital peat from Core A, 254 to 264cm.

*Florida*

**WIS-1943. Camel Lake** **>33,000**

Sandy gyttja coll March 1986 from Camel Lake, Appalachicola Natl Forest, Liberty Co (30° 15′ N, 84° 45′ W) by E Grimm, W Watts, D Poteet and subm by H E Wright, Jr, Univ Minnesota, Minneapolis. Sample from 1284 to 1294cm below water surface, water depth 4.0m. Part of ongoing study of vegetation and climate history of Florida and SE United States.

*Massachusetts*

**WIS-1917. Great Pond** **12,240 ± 120**
$\delta^{13}C = -28.5‰$

Livingstone core coll Sept 1986 from Great Pond, Truro, Barnstable Co (42° 00′ N, 70° 00 ′W) by M Winkler, R Webb, J Overpeck, J Portnoy, K

Gajewski and subm by M Winkler, Univ Wisconsin-Madison. Willow wood from 441 to 452 cm below water/sediment interface, water depth 9.88m.

*Minnesota*

**Carda site series**

Wood coll March 1987 from Carda site, Kanabec Co (45° 53′ 16″ N, 93° 26′ 05″ W) and subm by P L Hamilton, Sci Mus Minnesota, St Paul.

**WIS-1955.** **2230 ± 70**
$\delta^{13}C = -24.2‰$

Sample from water-saturated white pine log coll from 132cm depth in peat.

**WIS-1956.** **270 ± 60**
$\delta^{13}C = -24.6‰$

Sample from cross-section of white pine log unearthed during commercial peat excavations at site.

*North Dakota*

**WIS-1873. Rice Lake** **9240 ± 90**

Core coll Dec 1985 from Rice Lake, Ward Co (48° 00′ N, 98° 10′ W) and subm by E C Grimm, Univ Minnesota, Minneapolis. Spruce wood *(Picea)* from basal trash layer, 2028 to 2032cm below ice surface; water depth 863cm. Rice Lake is on transect of sites used for vegetation and climatic history study of N Great Plains.

**Paddock Creek series**

Samples coll Sept 1985 from terraces along Paddock Creek basin, Billings Co (46° 56′ 20″ N, 103° 22′ 53″ W) and subm by M A Gonzalez, Geog Dept, Univ Wisconsin-Madison. Dated to provide geochronology of terrace fm, gullying and soil fm (Gonzalez, 1987; Muhs, 1985; Clayton, Moran & Bickley, 1976). Acid treatment only. Depths in cm below terrace surface.

**WIS-1906.** **3240 ± 80**

Sample from second highest fluival terrace, 125 to 138cm. Paleosol is top of alluvial sediment buried by overbank, vertically accreted sediment.

**WIS-1907.** **3860 ± 70**

Sample from highest fluvial terrace, 160 to 172cm. Same as WIS-1906, above.

**WIS-1908.** **3830 ±70**

Sample from highest fluvial terrace, 238 to 255cm. Same as WIS-1906, above.

**WIS-1909.** **2960 ± 70**

Sample from second highest fluvial terrace, 155 to 165cm. Same as WIS-1906, above.

**WIS-1910.** **2280 ± 70**

Sample from third highest fluvial terrace, 200 to 220cm. Same as WIS-1906, above.

*Pennsylvania*

**Spring Lake series**

Samples coll 1983–1985 from Spring Lake, Bradford Co (41° 37″ N, 76° 20′ W) by A D Barnosky and subm by C W Barnosky, Carnegie Mus Nat Hist, Pittsburgh. Whole rib bone of mammoth and assoc sediment were dated (Barnosky *et al,* 1986).

**WIS-1925.** **15,910 ± 160**

Silt containing pollen, plant macrofossils, and fossil beetles surrounding mammoth bones.

**WIS-1935.** **14,240 ± 150**

Whole rib bone of Newton Mammoth from N end of kettle lake below Walter Newton house.

*South Dakota*

**Cottonwood Lake series**

Livingstone core, 5cm diam, from Cottonwood Lake, Sully Co (44° 28′ N, 99° 55′ W) coll and subm by E C Grimm, Limnol Research Center, Univ Minnesota, Minneapolis. Site is part of study of vegetation and climate history of Northern Great Plains. *Comment:* Cottonwood Lake is on Missouri Coteau in central South Dakota, nearest other sites of paleol studies are several hundred km away. All depths in cm from water surface; water depth 3.2m. Previously dated (R, 1986, v 28, no. 3, p 1220).

**WIS-1896.** **1300 ± 70**

Organic clay, 337 to 348cm.

**WIS-1897.** **4550 ± 80**

Organic clay, 403 to 418cm.

**WIS-1898.** **9810 ± 100**

Organic clay, 460 to 480cm.

**WIS-1899.** **11,430 ± 110**

Organic clay, 543 to 559cm.

**WIS-1900.** **9380 ± 100**

Organic clay, 615 to 626cm.

**WIS-1901.** **11,060 ± 110**

Organic clay, 689 to 700cm.

**WIS-1902.** **11,060 ± 110**

Organic clay, 759 to 770cm.

**WIS-1903.** **11,060 ± 110**

Organic clay, 835 to 846cm.

**WIS-1904.** **12,130 ± 110**

Organic clay, 903 to 914cm.

**WIS-1905.** **19,860 ± 210**

Organic clay, 986 to 977cm.

**WIS-1966. Medicine Lake** **7630 ± 80**

Livingstone core coll Feb 1980 from Medicine Lake, Codington Co (44° 59′ N, 97° 21′ W) by N J Radle and subm by H E Wright, Jr. Calcareous lake sediment from 2004 to 2012cm below water surface; water depth 12.94m. Acid treatment only. Previously dated (R, 1982, v 24, no. 1, p 94).

*Wisconsin*

**WIS-1944. Onion River site** **5020 ± 80**

Sample coll Aug 1986 from low terrace on Onion R, Sheboygan Co (43° 43′ N, 87° 48′ W) and subm by J C Knox, Geog Dept, Univ Wisconsin-Madison. Very dark grayish brown soil from 49 to 64cm below surface. Dates late middle Holocene (Nippissing) high level stage on Lake Michigan (Hansel *et al,* 1985).

**WIS-1964. Horicon Marsh** **2470 ± 70**
$\delta^{13}C = -27.2‰$

Core coll June 1987 from Horicon Marsh, Dodge Co (40° 31′ N, 88° 39′ W) and subm by J Battista, Dept Geol Geophysics, Univ Wisconsin-Madison. Plant fibers, seeds, and wood from ca 4.48m below 4.58m blue-gray clayey slit.

*Wyoming*

**Hedrick Pond series**

Core coll Aug 1986 from Hedrick Pond, Grand Teton Natl Park (43° 45′ N, 110° 31′ W) and subm by C W Barnosky. Depths in cm from water surface; water depth 5.5m. Glacier Peak B Ash (ca 11,200 yr BP) occurs at 11.52m below water surface.

**WIS-1920.** **2190 ± 60**

Organic clay, 700 to 710cm.

**WIS-1921.** **4210 ± 80**

Fine detritus gyttja, 880 to 890cm.

**WIS-1922.** **11,340 ± 100**

Fine detritus gyttja, 1090 to 1100cm.

**WIS-1923.** **14,580 ± 150**

Fine detritus gyttja, 1140 to 1152cm.

**WIS-1924.** **17,160 ± 210**

Organic silty clay, 1206 to 1221cm.

**WIS-1926. Emerald Lake** **4990 ± 70**

Core coll Aug 1985 from Emerald Lake, Teton Natl Forest (44° 04′ 30″ N, 110° 17′ W) and subm by C W Barnosky. Fine detritus gyttja from 800 to 815cm below water surface; water depth 5.9m. Previously dated (R, 1987, v 29, no. 3, p 410). Acid treatment only.

**WIS-1927. Lily Lake** **2720 ± 70**

Core coll Aug 1986 from Lily Lake, Teton Natl Forest (46° 12′ 50″ N, 110″ 19′ 30″ W) and subm by C W Barnosky. Fine detritus gyttja from 956 to 966cm below water surface; water depth 6.95m. Acid treatment only.

**Lily Lake Fen series**

Core coll Aug 1985 from Lily Lake Fen, Teton Natl Forest and subm by C W Barnosky. Depths in cm from surface. Previously dated (R, 1987, v 29, no. 3, p 411). Acid treatment only.

**WIS-1928.** **10,170 ± 100**

Fine detritus gyttja, 900 to 920cm. Increase in diploxylon pine pollen dates spread of lodgepole pine near site.

**WIS-1929.** **10,770 ± 110**

Fine detritus gyttja, 1002 to 1017cm.

**WIS-1930. Mariposa Lake** **9460 ± 90**

Core coll Aug 1985 from Mariposa Lake, Yellowstone Natl Park (44° 09′ N, 110° 17′ W) and subm by C W Barnosky. Fine detritus gyttja, 310 to 325cm depth from water surface; water depth 1.43m. Previously dated (R, 1987, v 29, no. 3, p 411). Acid treatment only.

**Fallback Lake series**

Core coll Aug 1986 from Fallback Lake, Teton Natl Forest (43° 58′ N, 110° 26′ 30″ W) and subm by C W Barnosky. Depths in cm from water surface; water depth 8.8m. Acid treatment only.

**WIS-1931.** **9510 ± 90**

Coarse detritus gyttja, 446 to 456cm.

**WIS-1932.** **12,070 ± 120**

Organic silty clay, 500 to 510cm.

**WIS-1933.** **15,640 ± 160**

Inorganic clay, 558 to 570cm.

**WIS-1934. Divide Lake** **3970 ± 80**

Core coll Aug 1985 from Divide Lake, Teton Natl Forest (43° 46′ 30″ N, 110° 14′ W) and subm by C W Barnosky. Fine detritus gyttja, 810 to 825cm depth from water surface; water depth 7.2m. Previously dated (R, 1987, v 29, no. 3, p 411). Acid treatment only.

*Canada*

**English Lake series**

Livingstone core, 5cm diam, coll Aug 1985 from English Lake (unofficial name), Labrador (53° 49′ N, 58° 34′ W) by G A King and H E Wright, Jr and subm by G A King, Univ Minnesota, Minneapolis. Dated for time of tree arrival, sediment accumulation rate, and pollen influx. Depths in cm from water surface, water depth 8.58m. Acid treatment only.

**WIS-1882.** **6080 ± 80**

Brown gyttja, 1099 to 1105cm; dates peak per cent organic matter since deglaciation.

**WIS-1883.** **7250 ± 80**

Silty gyttja, 1099 to 1105cm; date is min estimate of local deglaciation and time when lowland below Mealy Mts became ice free.

**WIS-1960. Traffic Lake** **6710 ± 80**

Core coll Aug 1985 from Traffic Lake (unofficial name), Labrador (53° 16′ N, 62° 27′ W) by G A King and H E Wright, Jr and subm by G A King. Lake elev 460m, water depth 2.52m. Silty gyttja from 538 to 543cm below water surface. Basal date, gives time of local deglaciation (King, 1985). Previously dated (R, 1987, v 29, no. 3, p 413). Acid treatment only.

**WIS-1961. Claude Lake** **8170 ± 80**

Core coll Aug 1985 from Claude Lake (unofficial name), Labrador (53° 35′ N, 58° 35′ W) by G A King and H E Wright, Jr and subm by G A King. Lake elev 480m, water depth 9.93m. Silty gyttja from 1339 to 1349cm below water surface. Basal date, gives time of local deglaciation (King, 1985). Previously dated (R, 1987, v 29, no. 3, p 413). Acid treatment only.

**WIS-1962. Cirrus Lake** **8290 ± 80**

Core coll Aug 1985 from Cirrus Lake (unofficial name), Labrador (52° 18′ N, 58° 22′ W) by G A King and D R Foster and subm by G A King. Lake elev 360m, water depth 102cm. Silty gyttja from 337 to 343cm below water

surface. Basal date, gives time of local deglaciation (King, 1985). Previously dated (R, 1987, v 29, no. 3, p 412). Acid treatment only.

**WIS-1963. Access Lake** **7410 ± 80**

Core coll Aug 1985 from Access Lake (unofficial name), Labrador (53° 27′ N, 60° 34′ W) by G A King and H E Wright, Jr and subm by G A King. Lake elev 200m, water depth 2.89m. Silty gyttja from 542 to 546cm below water surface. Basal date, gives time of local deglaciation (King, 1985). Previously dated (R, 1987, v 29, no. 3, p 414). Acid treatment only.

*Peru*

**WIS-1940. Laguna Tuctua** **11,310 ± 110**

Organic lake sediment coll Sept 1986 from Laguna Tuctua, Junin Prov (11° 34′ S, 74° 57′ W) and subm by H E Wright, Jr, Univ Minnesota, Minneapolis. Basal date, gives time of deglaciation of E cordillera in this area (Wright, 1983, 1984).

**WIS-1941. Tunsho site** **8430 ± 110**

Sample coll Sept 1986 from Tunsho site, Junin Prov (11° 50′ S, 75° 06′ W) and subm by H E Wright, Jr. Basal peat from 429 to 433cm depth. Peat growth at this site started as soon as early Holocene glacier retreated from moraine (Wright, 1983, 1984).

**WIS-1942. Laguna Paca** **2550 ± 80**

Organic lake sediment coll Sept 1986 from Laguna Paca, Junin Prov (11° 45′ S, 75° 30′ W) and subm by H E Wright, Jr. Dates lake basin believed to have formed as result of outwash fans from Pleistocene glaciers in W cordillera (Wright, 1983, 1984).

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## NOTES AND COMMENTS

# MICROWAVE OVEN PRETREATMENT OF CARBONATES FOR $^{14}C$ DATING BY ACCELERATOR MASS SPECTROMETRY

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ABSTRACT. A microwave oven is used to pretreat carbonate samples prior to graphitization and radiocarbon dating by accelerator mass spectrometry. The method reduces the risk of contamination of small carbonate samples and provides a fast and convenient method for the acid evolution of $CO_2$.

### INTRODUCTION

One of the major impacts of the accelerator mass spectrometry (AMS) method of radiocarbon dating has been to lower sample size requirements of 0.1 to 5mg of carbon. This has resulted in the development of various micro-chemical techniques for the pretreatment and subsequent graphitization of samples submitted for dating. In our laboratory, we have had a large demand for radiocarbon dates on various kinds of carbonates including shells, marine phosphorites, bone apatite, and starfish spicules. To liberate $CO_2$ from these species, we have traditionally used concentrated orthophosphoric acid with the samples in a glass apparatus heated to 100°C in a steam bath to dissolve the carbonates. During the last few months, however, we have used a conventional domestic microwave oven to quickly and conveniently dissolve the various carbonate species submitted to our laboratory for $^{14}C$ AMS analysis.

### EXPERIMENTAL PROCEDURE

The carbonate sample to be dated is placed in the main arm of a side-arm flask and 3ml of $CO_2$-free concentrated orthophosphoric acid are metered into the side arm of the pyrex apparatus (Fig 1) using a Socorex dispenser fitted with a teflon needle. In order to do this, the glass piston valve, fitted with a teflon "O" ring, is removed from the apparatus. Taking care not to tip the acid onto the carbonate, the valve is replaced and the apparatus carefully evacuated to a pressure of ca $10^{-3}$ Torr. After evacuation, the valve is closed, the acid mixed with the carbonate, and the apparatus is placed in a conventional domestic microwave oven. Concentrated acids are effective absorbers of microwave energy in the 2.45 GHz region (Mahan *et al*, 1987). Microwaving at 650 watts radiated power for 60 secs easily dissolves individual portions of carbonates like shell weighing 30 to 40mg.

After dissolution of the carbonate, $CO_2$ is extracted and purified by careful vacuum distillation over alcohol/dry ice and liquid nitrogen traps. Reaction yields are measured by expanding the $CO_2$ into a calibrated manifold and measuring the pressure with a pressure transducer. Carbon yields

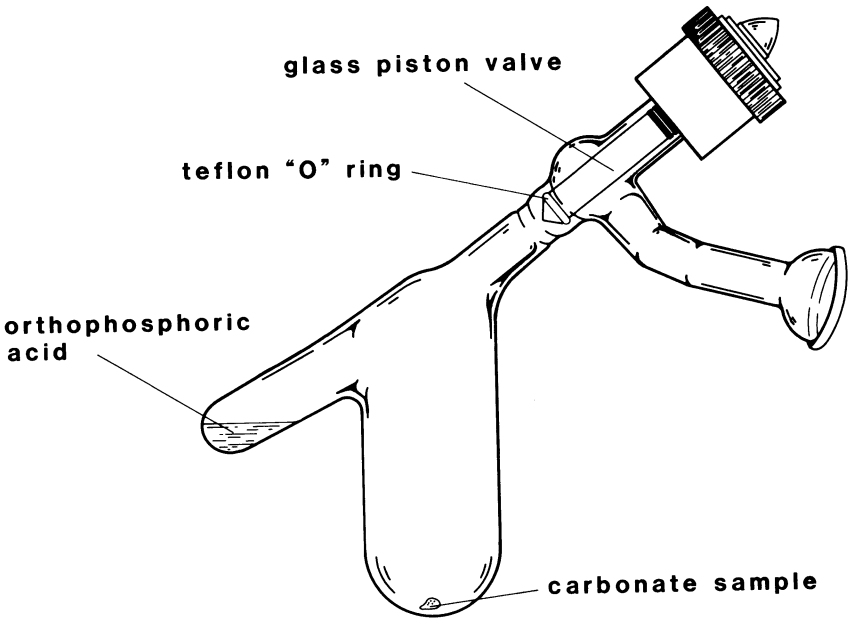


Fig 1. Side-arm flask used for microwave oven acid dissolution of carbonate samples

are always within ±2% of theoretical from calcium carbonate standards with the major error in the determination being in the pressure measurement.

When the yield has been calculated, the $CO_2$ is converted into a graphite target using the method of Lowe and Judd (1987) and $^{14}C$ AMS measurements are made using the New Zealand AMS facility (Wallace *et al,* 1987). We have used the technique for a wide variety of carbonate types including marine phosphorites, shells, bone apatite, and Crown of Thorns starfish spicules (Sparks, Wallace & Lowe, 1986).

## RESULTS AND DISCUSSIONS

Microwave oven pretreatment appears to have some major advantages over the traditional steam bath technique. At 100°C 30mg solid pieces of shell form a semi-impervious layer of calcium phosphate around the bulk of the carbonate and reaction times for complete dissolution can be several hours. To speed the reaction rate, most laboratories grind carbonates into a fine powder before adding acid. For $^{14}C$ AMS measurements in which samples are small, this process greatly increases the risk of sample contamination. In the microwave technique reported here, the orthophosphoric acid reaches a temperature of ca 140°C and a 30mg piece of shell dissolves typically in ca 1 minute. Hence, the need for initial powdering of carbonate sample is eliminated and the risks of sample contamination during pretreatment are greatly reduced. Using a 10ml apparatus (Fig 1), we have treated

samples containing as little as 0.2mg of carbon with the technique. For bigger samples, eg, 4mg of carbon, a larger, 30ml apparatus is used.

After an extensive series of tests, we have now adopted the microwave technique as part of our standard pretreatment technique for radiocarbon AMS measurement of carbonate samples.

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[RADIOCARBON, VOL 30, NO. 3, 1988, P 389–390]

# A STANDARD SAMPLE OF $^{14}$C-SPECIFIC $\beta$ ACTIVITY

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A standard sample (SS) of $^{14}$C-specific $\beta$ activity has been created based on benzene containing radioactive carbon diluted with "dead" benzene.

The SS activity determination has been made at several laboratories from the preparation activity measurements as compared to the activity of benzenes synthesized on the oxalic acid base (NBS standard, SRM-4990) and oak and pine tree rings of 1845–1855. Specific activity values of the sample age corrected back to 1950 are summarized in Table 1.

Non-parametric statistical methods have been applied to data processing (Table 1). We used a sampling median as a SS-certified characteristic, as well as sequential statistics with numbers 3 and 14 for the non-symmetrical distribution of measurement results as the limits of the confidence interval corresponding to the 0.95 probability. The determined value of SS-specific $\beta$ activity is 1129 Bk/kg (imp/s · kg) with an error not exceeding 15 Bk/kg corresponding to a five-fold carbon activity (4.996) referring to 1950. The present $^{14}$C-specific activity is assumed to be 226 Bk/kg (13.56 decay/g · min) (Karlen *et al*, 1964).

During SS certification, a number of methodologic problems have been solved. The identification of variations of radiocarbon concentrations with time in different trees and geographic areas is made by annual high-precision measurements (Bitvinskas, Metzkhvarishvili & Stupneva, 1984) of the $^{14}$C concentration in rings of Scotch pine, Siberian larch, Norwegian and Eastern spruce, English oak, and black poplar. The measured $^{14}$C concentration in pine and oak rings coincides within the limits of counting errors (Table 2).

Isotopic fractionation is demonstrated by the $\delta^{13}$C values which are $-24.1‰$ for benzene synthesized from oak rings, $-25.0‰$ from pine rings, $-22.6‰$ from NBS standard.

Homogeneity of SS in the process of its storage was checked by measuring the activity of samples from the total SS volume of 1983–1986. Data in Table 3 referred to in terms of count rates excluding background, confirm the SS material uniformity during storage.

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TABLE 1

The results of standard sample specific activity measurements

| Lab | Ref sample | Weight (g) | Specific activity (Bk/kg) | Remarks |
|---|---|---|---|---|
| 1 | Oak and pine rings | 2.0 | 1069 | |
| 2 | Pine rings | 5.7 | 1103 | |
| 3 | NBS standard | 8.8 | 1114 | |
| 4 | Pine rings | 6.2 | 1119 | |
| 4 | Pine rings | 7.7 | 1125 | Synthesis of 1984 |
| 5 | Pine rings | 4.4 | 1126 | Synthesis of 1986 |
| 6 | Pine rings | 9.4 | 1129 | |
| 7 | Pine rings | 8.8 | 1129 | |
| 7 | Oak rings | 8.8 | 1131 | |
| 6 | NBS standard | 19.4 | 1131 | Isotopic fractionation |
| 6 | NBS standard | 13.2 | 1131 | |
| 2 | Oak rings | 5.7 | 1138 | |
| 1 | Oak and pine rings | 8.8 | 1143 | |
| 2 | Oak rings | 6.2 | 1159 | |
| 4 | Oak rings | 7.7 | 1167 | |

TABLE 2

The results of 1845–1855 pine and oak ring measurements

| Lab | Sample count rate, imp/min | | Relative deviation (%) |
|---|---|---|---|
| | Pine rings | Oak rings | |
| AURISGG | 20.817 | 20.779 | 0.2 |
| Leningrad State Univ | 146.623 | 146.038 | 0.4 |

TABLE 3

The results of SS measurements in various years

| Lab | Sample count rate, imp/min | | | | Relative deviation (%) |
|---|---|---|---|---|---|
| | 1983 | 1984 | 1985 | 1986 | |
| AURISGG | | 116.700 | | 116.723 | 0.017 |
| Leningrad State Univ | 710.164 | | 710.128 | | 0.014 |

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Vol 30, No. 3 Radiocarbon 1988

# CONTENTS