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RADIOCARBON

Senior Editor: MINZE STUIVER
Editors: J GORDON OGDEN, III—IRVING ROUSE—STEPHEN C PORTER
Managing Editor: RENEE S KRA

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INSTRUCTIONS TO CONTRIBUTORS

Manuscripts of radiocarbon papers should follow the recommendations in *Suggestions to Authors,* 5th ed.* All copy (including the bibliography) must be typewritten in *double space.* Manuscripts for vol 20, no. 2 must be submitted in *duplicate* before January 1, 1978, for vol 20, no. 3 before May 1, 1978.

General or technical articles should follow the recommendations above and the editorial style of the *American Journal of Science.*

Descriptions of samples, in date lists, should follow as closely as possible the style shown in this volume. Each separate entry (date or series) in a date list should be considered an *abstract,* prepared in such a way that descriptive material is distinguished from geologic or archaeologic interpretation, but description and interpretation must be both brief and informative, emphasis placed on significant comments. Date lists should therefore not be preceded by abstracts, but abstracts of the more usual form should accompany all papers (eg, geochemical contributions) that are directed to specific problems.

Each description should include the following data, if possible in the order given:

1. Laboratory number, descriptive name (ordinarily that of the locality of collection), and the date expressed in years BP (before present, ie, before AD 1950). The standard error following the date should express, within limits of $\pm 1\sigma$, the laboratory's estimate of the accuracy of the radiocarbon measurement, *as judged on physicochemical (not geologic or archaeologic) grounds.*

2. Substance of which the sample is composed; if a plant or animal fossil, the scientific name if possible; otherwise the popular name; but not both. Also, where pertinent, the name of the person identifying the specimen.

3. Precise geographic location, *including latitude-longitude coordinates.*

4. Occurrence and stratigraphic position in precise terms; use of metric system exclusively. Stratigraphic sequences should *not* be included. However, references that contain them can be cited.

5. Reference to relevant publications. Citations within a description should be to author and year, with specific pages wherever appropriate. References to published date lists should cite the sample no., journal (R for Radiocarbon), years, vol, and specific page (eg, M-1832, R, 1968, v 10, p 97). Full bibliographic references are listed alphabetically at the end of the manuscript, in the form recommended in *Suggestions to Authors.*

6. Date of collection and name of collector.

7. Name of person submitting the sample to the laboratory, and name and address of institution or organization with which submitter is affiliated.

8. Comment, usually comparing the date with other relevant dates, for each of which sample numbers and references must be quoted, as prescribed above. Interpretive material, summarizing the significance and implicity showing that the radiocarbon measurement was worth making, belongs here, as do technical matters, *eg,* chemical pretreatment, special laboratory difficulties, etc. Calendar estimates, reported in AD/BC may be included, citing the specific calibration curve used to obtain the estimate.

Illustrations should not be included unless absolutely essential. They should be original drawings, although photographic reproductions of line drawings are sometimes acceptable, and should accompany the manuscript in any case, if the two dimensions exceed 30cm and 23cm.

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* Suggestions to authors of the reports of the United States Geological Survey, 5th ed, Washington, DC, 1958 (Government Printing Office, $1.75).

NOTICE TO READERS

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 8th International Conference on Radiocarbon Dating, Wellington, New Zealand, 1972. 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 AD/BC, citing the specific calibration curve used to obtain the estimate.

Meaning of $\delta^{14}C$. In Volume 3, 1961, we indorsed 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.

Citations. A number of radiocarbon dates appear in publications without laboratory citation or reference to published date lists. We ask that laboratories remind submitters and users of radiocarbon dates to include proper citation (laboratory number and date-list citation) in all publications in which radiocarbon dates appear.

Radiocarbon Measurements: Comprehensive Index, 1950-1965. This index, covering all published ^{14}C measurements through Volume 7 of

RADIOCARBON, and incorporating revisions made by all laboratories, has been published. It is available to all subscribers to RADIOCARBON at $10.00 US per copy.

Publication schedule. Beginning with Volume 15, RADIOCARBON has been published in three numbers: Winter, Spring, and Summer. The next deadline is January 1, 1978. Contributors who meet our deadlines will be given priority but not guaranteed publication in the following issue.

List of laboratories. The comprehensive list of laboratories at the end of each volume now appears in the third number of each volume.

Index. All dates appear in index form at the end of the third number of each volume.

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EDITORIAL STATEMENT TO 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. An increasing number of ^{14}C dates, however, appear in more general articles and are never published in a datelist. Inclusion in Radiocarbon of some of the articles containing scientific knowledge derived from ^{14}C data should broaden the scope of the journal and increase its readership. The editors of Radiocarbon are now considering such articles for publication. The content of these articles can be either general or technical. For instance, the type of article considered suitable for inclusion in th Journal would contain subject matter normally presented at International Radiocarbon meetings.

All correspondence and manuscripts should be sent to the Managing Editor, Radiocarbon, Box 2161, Yale Station, New Haven, Connecticut 06520.

The Editors

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Radiocarbon

1977

DISCUSSION

REPORTING OF ^{14}C DATA

MINZE STUIVER* and HENRY A POLACH**

INTRODUCTION

Count rates, representing the rate of ^{14}C decay, are the basic data obtained in a ^{14}C laboratory. The conversion of this information into an age or geochemical parameters appears a simple matter at first. However, the path between counting and suitable ^{14}C data reporting (table 1) causes headaches to many. Minor deflections in pathway, depending on personal interpretations, are possible and give end results that are not always useful for inter-laboratory comparisons. This discussion is an attempt to identify some of these problems and to recommend certain procedures by which reporting ambiguities can be avoided.

1. RADIOCARBON DATING STANDARD

It is widely recognized that all laboratories should report their results either directely related to NBS oxalic acid or indirectly by using a substandard which is directly related to the NBS oxalic acid (Olsson, 1970). The internationally accepted radiocarbon dating reference value is 95 percent of the activity, *in* AD *1950,* of the NBS oxalic acid normalized to $\delta^{13}C = -19$ per mil with respect to (wrt) PDB (Olsson, 1970; R, 1961, v 3). Although the ^{14}C activity of oxalic acid is changing with time, the activity of the international standard defined above does not change. It will be named the *absolute international standard activity* (AISA) in further discussion.

Most laboratories, in their calculations, use an activity value A_{ON} that is 95 percent of the measured net oxalic acid activity (count rate) A_{Ox} today, normalized for ^{13}C fractionation according to

$$A_{ON} = 0.95A_{Ox}\left(1 - \frac{2(19 + \delta^{13}C)}{1000}\right).$$

Measurements of $\delta^{13}C$ are relative to the PDB standard. The activity A_{ON} depends on the year of measurement (y) and has to be corrected for decay between 1950 and year (y) of actual counting date. The *absolute international standard activity* is given by

$$A_{abs} = A_{ON}e^{\lambda(y-1950)} \qquad \text{where } \lambda = \frac{1}{8267}\ yr^{-1},$$

eg, the measured A_{ON} is today about 0.3 percent lower than A_{abs}.

* University of Washington, Seattle, Washington 98195
** Australian National University, Canberra, Australia

2. ISOTOPIC FRACTIONATION CORRECTION

It is strongly desirable that all workers report $\delta^{13}C$ values, either measured or estimated relative to PDB. By convention, the ^{13}C isotopic fractionation in all samples, irrespective of environment, is taken into account by normalizing to −25 per mil wrt PDB, the postulated mean value of terrestrial wood. The normalized sample activity A_{SN} relates to the measured sample activity A_S as follows:

$$A_{SN} = A_S \left(1 - \frac{2(25 + \delta^{13}C)}{1000}\right),$$

where $\delta^{13}C$ is measured or estimated in per mil wrt PDB. This equation is a generally used approximation of the more precise $A_{SN} = A_S 0.975^2/(1 + \delta^{13}C/1000)^2$ (Stuiver and Robinson, 1974).

3. RADIOCARBON AGE CALCULATION

The radiometric age of a sample is calculated by assuming a time-independent atmospheric ^{14}C level in all past times. The specific activity (activity per gram C) of this hypothetical atmospheric carbon level, after normalizing to −25 per mil for ^{13}C, is by definition equal to the specific *activity of the absolute international standard* A_{abs}. For a Libby half-life of 5568 yrs, and when measured in 1950, the age (t) of a sample before 1950 AD is therefore given by

$$t = -8033 \ln \frac{A_{SN} \text{ (in 1950)}}{A_{ON} \text{ (in 1950)}}$$

The actual measurements of sample and oxalic acid activities were, of course, not made in 1950. The measured ratio A_{SN}/A_{ON}, however, does not change with time. It stays equal to the 1950 ratio because both sample and oxalic acid lose their ^{14}C at the same rate. Thus the calculated age (t), given by $t = -8033 \ln A_{SN}/A_{ON}$, is a fixed number independent of the year of measurement. It always implies an age prior to AD 1950 (ie, AD 1950 equals 0 yrs BP).

Ages (yrs) calculated in the above manner ($t = -8033 \ln A_{SN}/A_{ON}$) are called *conventional radiocarbon ages* (years BP). This term implies:

A. the use of the 5568 yr half-life (mean life 8033 y),
B. the assumption of constancy of ^{14}C atmospheric level during the past,
C. the use of oxalic acid (direct or indirect) as a standard,
D. isotopic fractionation normalization of all sample activities to the base of $\delta^{13}C = -25$ per mil (relative to the $^{13}C/^{12}C$ ratio of PDB),
E. the year 1950 is automatically the base year, with ages given in years BP (*ie,* present is AD 1950).

4. RESERVOIR EFFECT

The calibration of the oxalic acid standard (in 1958) was based on the age corrected ^{14}C activity of AD 1890 tree-rings in equilibrium with 1890 atmospheric CO_2. When reservoirs differ in specific ^{14}C content from the atmosphere, an age adjustment is needed. A *conventional radiocarbon age,* as defined in section 3, does take into account ^{13}C fractionation but not differences in ^{14}C specific activity of reservoirs which arise from effects other than isotopic fractionation. It is recommended that a *conventional radiocarbon age* is always reported without adjustment; a *reservoir corrected age* BP should be given separately. The adopted reservoir corrections should be given (and referenced) with the sample description.

The above procedure necessitates a reservoir correction, for example, for marine shell ages because the *conventional radiocarbon age* takes only ^{13}C fractionation into account. The corrections for ^{13}C fractionation and reservoir ^{14}C deficiency cancel each other more or less for shells from non-polar regions and many laboratories have adopted the convenient practice of forgetting — and not mentioning — the two corrections. The recommended procedure should eliminate possible ambiguity: all *conventional radiocarbon ages* are to be ^{13}C corrected, and estimates of reservoir corrections, when needed, are to be given separately.

5. STATISTICAL UNCERTAINTY OF AGE DETERMINATION

The *conventional ^{14}C age* is accompanied by a standard error, based on the number of accumulated counts of the sample, oxalic acid, and background, plus additional errors caused by inaccuracies in voltage, pressure, temperature, dilution, et cetera. The standard error should include the error in ^{13}C ratios. For measured $^{13}C/^{12}C$ ratios the contribution to the standard error is small, but it may be significant for estimated isotope ratios. The spread in isotope ratios, and the influence on standard errors when $\delta^{13}C$ ratios are estimated, are given in figure 1 (reproduced by permission from Polach, 1976). The error in the conventional ^{14}C half-life should NOT be included in the standard error. The statistical uncertainty of the age determination, the standard error of the *conventional ^{14}C age,* is given as ± one *standard deviation.*

6. DEPLETION OR ENRICHMENT wrt STANDARD

To give the relative differences between either uncorrected or ^{13}C corrected sample activity (count rate) and measured oxalic acid activity, one can define

$$d^{14}C = \left(\frac{A_S - A_{ON}}{A_{ON}}\right) 1000 \text{ per mil} = \left(\frac{A_S}{A_{ON}} - 1\right) 1000 \text{ per mil}$$

and

$$D^{14}C = \left(\frac{A_{SN} - A_{ON}}{A_{ON}}\right) 1000 \text{ per mil} = \left(\frac{A_{SN}}{A_{ON}} - 1\right) 1000 \text{ per mil.}$$

Thus the *conventional radiocarbon age,* as defined in section 3, is given by

$$t = -8033 \ln\left(1 + \frac{D^{14}C}{1000}\right).$$

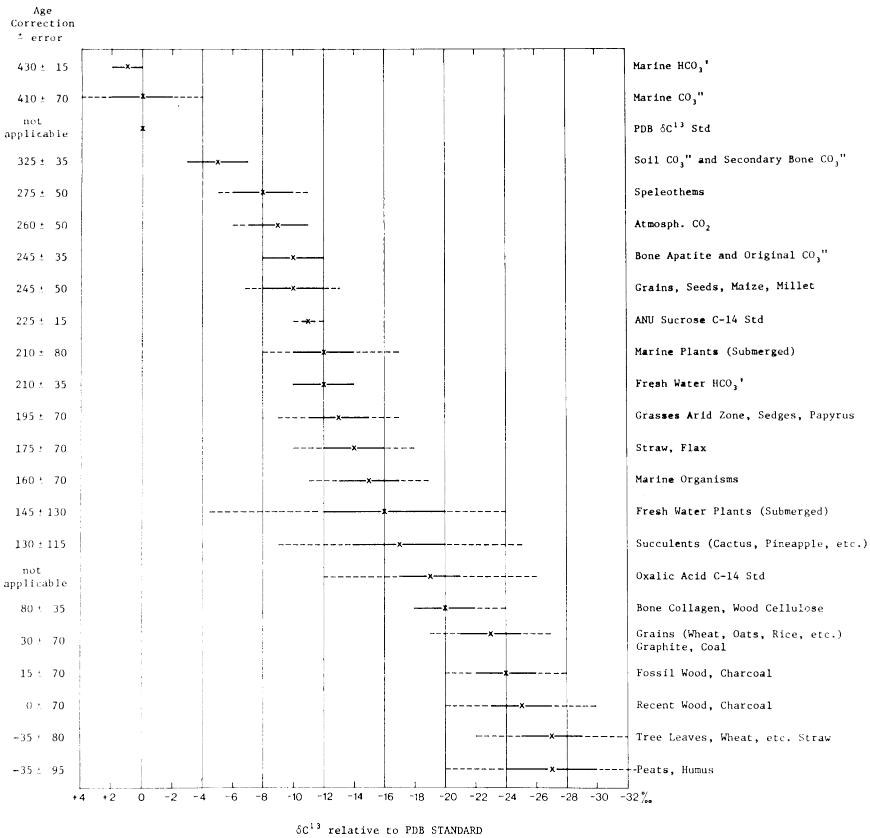

Fig. 1. C variation in nature. The suggested mean values, to be used when estimating $\delta^{13}C$ of samples are given as (x) and the suggested appropriate error of estimation (never less than ± 2‰) is given by solid lines. The variations in ^{14}C standard are due to laboratory fractionation only. The large range in $\delta^{13}C$ of some datable materials does not always allow to apply effectively a correction based on an estimate of the mean value. Note that the ± error of the *age correction* due to spread of $\delta^{13}C$ values is often of the same order of magnitude or larger than the common statistical uncertainty (± *error*) of the age determination. When a measured $\delta^{13}C$ correction is not applied, the *AGE CORRECTION* is to be added (arithmetically) to the isotopic fractionation uncorrected radiocarbon age determination and the error of estimation of mean $\delta^{13}C$ value (due to their spread in nature) must be correctly combined with the statistical uncertainty of the age determination. The isotopic fractionation corrected age is therefore the *sum* of the *radiocarbon age* and its *error* (A ± a) and the isotopic fraction *age correction* and its error (B ± b). The corrected age (A ± a) + (B ± b) equals $(A + B) \pm (a^2 + b^2)^{1/2}$. This correction, within limits given by solid lines, is necessary when valid comparison of reported ages of a variety of organic materials is sought. (After Polach, 1976, reproduced by permission of the editor).

As discussed, the measured activity ratios A_S/A_{ON} and A_{SN}/A_{ON} do not change with time because both sample and oxalic acid lose ^{14}C at the same rate. As a result $d^{14}C$ and $D^{14}C$ values are independent of the year of measurement.

7. PERCENT MODERN

Percent Modern is seldom used in chronological studies, and it is now recommended that in such studies only the $\delta^{13}C$ ratio and the *conventional ^{14}C age* BP be given. The 8th International Conference on Radiocarbon Dating (Proceedings, 1972) accepted the replacement of $D^{14}C$ per mil by *percent Modern,* equated to the activity ratio A_{SN}/A_{ON} $\times$ 100 percent. We consider this term superfluous. However, for geochemical and ^{14}C equilibria (distribution of ^{14}C in nature) studies, the new term "absolute" *percent Modern* (pM) is desirable. It is defined as follows

$$pM = \frac{A_{SN}}{A_{abs}} \times 100 \text{ percent} = \frac{A_{SN}}{A_{ON}e^{\lambda(y-1950)}} \times 100 \text{ percent},$$

where (y) is the year of Oxalic measurement, and $\lambda = 1/8267$ yr^{-1} is based on the 5730 yr half-life. When the years of collection and measurement are not identical, A_{SN} has to be corrected for the decay that took place between year of collection and measurement (table 1).

The measured and $\delta^{13}C$-normalized oxalic acid activity A_{ON} declines with age, and if the reservoir activity has remained constant, then the measured activity ratio A_{SN}/A_{ON} is dependent upon the year of measurement of Oxalic acid. The "absolute" *percent Modern* makes this ratio constant and meaningful for many specialized studies.

When relating a *conventional radiocarbon age* to "absolute" *percent Modern* (pM) as defined above, the year of measurement (y) becomes important. Thus,

$$t + \frac{y - 1950}{1.03} = -8033 \ln \frac{pM}{100}\ .$$

8. AGE CORRECTION, $\delta^{14}C$, Δ, AND $\Delta^{14}C$

When comparing sample ^{14}C activities with oxalic acid activity, an age correction may be needed. For instance, for a tree-ring grown in year (x) and measured during year (y), the age corrected activity is $A_S e^{\lambda(y-x)}$. The age correction is based on the 5730 yr half-life ($\lambda = 1/8267$ yr^{-1}). In the first proposed use of $\delta^{14}C$ and its associated $\Delta^{14}C$ (Broecker and Olson, 1959), it was also clearly stated that the comparison of sample activity should be with the activity of an age corrected international standard. As the actual intercalibration measurements of wood/oxalic were made in 1958, it was in the first instance suggested by Broecker and Olson (1959) that the oxalic activity should be corrected back to AD 1958. Since then it has become the custom to use the year 1950 as the base year for all radiocarbon measurements (Godwin, 1962). The age correction of oxalic acid standard has been made to the base year of 1950 for the calculation of the activity of the *absolute international standard* (Olsson, 1970), referred to in section 1.

TABLE 1

Calculation procedure for ^{14}C ages and geochemical parameters

	SAMPLE	OXALIC ACID
NET ACTIVITY; NORMALIZED FOR COUNTING VOLUME, MASS CHANGE, DILUTION, IMPURITIES, ETC. ACTIVITY IN COUNTS PER MINUTE	A_S	A_{Ox}
NORMALIZATION FOR ISOTOPE FRACTIONATION. ALL $\delta^{13}C$ VALUES WITH REGARD TO PDB	$A_{SN} = A_S\left[1 - \frac{2(25 + \delta^{13}C)}{1000}\right]$	$A_{ON} = .95A_{Ox}\left[1 - \frac{2(19 + \delta^{13}C)}{1000}\right]$
ABSOLUTE INTERNATIONAL STANDARD ACTIVITY (OXALIC ACID ACTIVITY) CORRECTED FOR DECAY SINCE 1950		$A_{ABS} = A_{ON}e^{\lambda(y-1950)}$
x = YEAR OF GROWTH y = YEAR OF MEASUREMENT	λ in Table always $\frac{1}{8267}yr^{-1}$	

	GEOCHRONOLOGICAL SAMPLES	GEOCHEMICAL SAMPLES WITHOUT AGE CORRECTION	GEOCHEMICAL SAMPLES WITH AGE CORRECTION
PER MIL DEPLETION OR ENRICHMENT WITH REGARD TO STANDARD	$d^{14}C = \left[\frac{A_S}{A_{ON}} - 1\right] 1000\ ^o/oo$	$\delta^{14}C = \left[\frac{A_S}{A_{ABS}} - 1\right] 1000\ ^o/oo$ *	$\delta^{14}C = \left[\frac{A_S e^{\lambda(y-x)}}{A_{ABS}} - 1\right] 1000\ ^o/oo$
Equivalent equation			$\delta^{14}C = \left[\frac{A_S e^{\lambda(1950-x)}}{A_{ON}} - 1\right] 1000\ ^o/oo$
PER MIL DEPLETION OR ENRICHMENT RELATIVE TO TO STANDARD NORMALIZED FOR ISOTOPE FRACTIONATION	$D^{14}C = \left[\frac{A_{SN}}{A_{ON}} - 1\right] 1000\ ^o/oo$	$\Delta^{14}C = \left[\frac{A_{SN}}{A_{ABS}} - 1\right] 1000\ ^o/oo$ *	$\Delta = \left[\frac{A_{SN} e^{\lambda(y-x)}}{A_{ABS}} - 1\right] 1000\ ^o/oo$
Equivalent equation			$\Delta = \left[\frac{A_{SN} e^{\lambda(1950-x)}}{A_{ON}} - 1\right] 1000^o/oo$
APPROXIMATE RELATIONSHIP	$D^{14}C = d^{14}C - 2(\delta^{13}+25)\left(1 + \frac{d^{14}C}{1000}\right)$	$\Delta^{14}C = \delta^{14}C - 2(\delta^{13}C+25)\left(1 + \frac{\delta^{14}C}{1000}\right)$	$\Delta = \delta^{14}C - 2(\delta^{13}+25)\left(1 + \frac{\delta^{14}C}{1000}\right)$
Conventional radiocarbon age BP, based on 5568 yr. half life $\lambda = \frac{1}{8033}yr^{-1}$	$t = -8033 \ln \frac{A_{SN}}{A_{ON}}$		
ALWAYS REPORT	$\delta^{13}C$ and conventional radiocarbon age	$\Delta^{14}C$, $\delta^{14}C$ and $\delta^{13}C$	Δ, $\delta^{14}C$ and $\delta^{13}C$
OPTIONAL	$d^{14}C$ and $D^{14}C$	$p.M = \frac{A_{SN}}{A_{ABS}}\ 100\ ^o/oo$ *	

When year of collection z differs from year of measurement y, either A_S or A_{SN} should be replaced by respectively $A_S e\lambda^{(y-z)}$, $A_{SN} e\lambda^{(y-z)}$, or A_S and A_{SN} kept unchanged but oxalic acid corrected for decay between year of collection and 1950 only. This procedure is applicable only when marked in the table by an asterisk.

Thus $\delta^{14}C$ is here defined as the relative difference between the *absolute international standard* and sample activity corrected for age, but not for $\delta^{13}C$.

$$\delta^{14}C = \left(\frac{A_S e^{\lambda(y-x)}}{A_{abs}} - 1\right) 1000 \text{ per mil,}$$

where (y) is the year of measurement and (x) the year of growth.

The $\delta^{14}C$ term has also often been used in instances where sample age correction is not possible. According to the 8th International Radiocarbon Conference in Wellington, New Zealand, the $\delta^{14}C$ (and its associated Δ term) should be used only when samples have been age corrected (Proc., 1972). When age correction is impossible, one can use $d^{14}C$ and $D^{14}C$, as defined in the previous section. However, $\delta^{14}C$, Δ, and $\Delta^{14}C$ values have been and are used extensively in oceanography where age corrections are not possible. Both age-corrected and non-age corrected $\delta^{14}C$, Δ, and $\Delta^{14}C$ values seem to be with us for an indefinite period, and therefore the radiocarbon dater must clearly define their meaning each time he uses these terms. Age corrected oxalic acid activity (the *absolute international standard activity* A_{abs}) should always be used when calculating the $\delta^{14}C$, $\Delta^{14}C$ values. For oceanographic samples

$$\delta^{14}C = \left(\frac{A_S}{A_{abs}} - 1\right) 1000.$$

When the years of collection and measurement are not identical, A_S has to be corrected for the decay that took place between year of collection and measurement (table 1).

After normalization for $\delta^{13}C$, the relative difference between age corrected sample activity $A_{SN}e^{\lambda(y-x)}$ and the absolute standard is

$$\Delta = \left(\frac{A_{SN} e^{\lambda(y-x)}}{A_{abs}} - 1\right) 1000 \text{ per mil}$$
$$= \left(\frac{A_{SN} e^{\lambda(1950-x)}}{A_{ON}} - 1\right) 1000 \text{ per mil.}$$

For oceanographic samples,

$$\Delta^{14}C = \left(\frac{A_{SN}}{A_{abs}} - 1\right) 1000 \text{ per mil.}$$

$D^{14}C$ and $d^{14}C$, as well as $\Delta^{14}C$ and $\delta^{14}C$, can be tied to each other through the following expressions:

$$D^{14}C = d^{14}C - 2(\delta^{13}C + 25)\left(1 + \frac{d^{14}C}{1000}\right) \quad (1)$$

and

$$\Delta^{14}C = \delta^{14}C - 2(\delta^{13}C + 25)\left(1 + \frac{\delta^{14}C}{1000}\right). \quad (2)$$

These are the expressions commonly used for the calculation of $D^{14}C$ and $\Delta^{14}C$ values. They are, however, only approximations derived from a combination of the equations in sections 6 and 8. The precise relationship

$$\Delta^{14}C = 1000\left(\left(1+\frac{\delta^{14}C}{1000}\right)\frac{0.975^2}{\left(1+\frac{\delta^{13}C}{1000}\right)^2}-1\right)$$

is given in Stuiver and Robinson (1974). As it has been customary so far to use relationships (1) and (2) in making corrections for isotopic fractionation, their continued use is recommended.

9. REPORTING OF AGES CLOSE TO MODERN

Chronological samples can be reported as *MODERN* when the reservoir-corrected, *conventional radiocarbon* age is less than 200 yrs; > *MODERN* when A_{SN} is greater than A_{ON}. However, in these instances, $D^{14}C$ must also be reported in addition to the required $\delta^{13}C$ value.

10. REPORTING OF AGES CLOSE TO BACKGROUND

In order to retain maximum possible information when reporting ages close to *background*, the following procedures are recommended:

When sample activity A_{SN} is less than twice the standard deviation σ of A_{SN} the resulting age should be reported as ">x," where the minimum age x is the conventional ^{14}C age calculated for an $A_{SN} + 2\sigma$ sample activity. $A_{SN} = 0$ has to be substituted for negative A_{SN} values. When the sample activity differs less than one σ from the background, the statement, "Sample activity not distinguishable from background," should be given. When measured sample activity is between 1 and 2σ, an "apparent" age can be added.

$D^{14}C$ values should also be reported in all the above cases because their error ($\pm$ $sD^{14}C$) is normally distributed round the value of $D^{14}C$, whilst the $\pm$ *error* of the *AGE* is log-normally distributed round the age BP, making it inappropriate for error weighted (pooled mean) calculations (Polach, 1969).

11. ROUNDING OFF

The magnitude of the standard error determines the rounding off of a conventional ^{14}C age. It is standard practice in the physical sciences to give one more digit than can be accurately accounted for. In reporting the standard error, the first two digits should be retained. For instance, 8234 ± 256 and 42,786 ± 2322 are rounded, respectively, to 8230 ± 260 and 42,800 ± 2300. When the standard error is less than 100 yrs, rounding off to the nearest multiple of ten is recommended between 50 and 100 yrs, and rounding off to the nearest multiple of five below 50 yrs.

RECOMMENDATIONS

For chronological studies, *ie*, geological, archaeological, et cetera samples, where the measurement of age is the most important aspect, the following quantities based on the 5568 yr half-life ($\lambda = 1/8033\ yr^{-1}$) are critical and should be reported:

A. $\delta^{13}C$ ratio — actual measured or estimated value wrt PDB.
B. The *conventional radiocarbon age* BP, as defined in section 3, with its ± *error* expressed as ± one standard deviation.
C. The estimate of "reservoir" correction (sec. 4) when a *reservoir corrected age* is given in addition to the *conventional radiocarbon age*.
D. An optional parameter for reporting is $D^{14}C$: The per mil *depletion* or *enrichment* wrt 0.95 Oxalic, (normalized for isotopic fractionation of both Oxalic and sample).

For geochemical samples, dendrochronological samples, reservoir equilibria, and diffusion models, the following quantities, with age corrections based on 5730 yr half-life ($\lambda = 1/8267$ yr^{-1}) are critical and should be reported:

A. $\delta^{13}C$ ratio — actual measured or estimated value wrt PDB,
B. *Percent modern*, as defined in section 7, (if applicable) or
C. $\delta^{14}C$ and $\Delta^{14}C$ or Δ (depending on the user's past preferences), as given in sections 8 and 9, with clear indication if an age correction has been applied to any of these terms.

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MINERALOGICAL STUDIES ON BONE APATITE AND THEIR IMPLICATIONS FOR RADIOCARBON DATING

AFIFA A HASSAN*, JOHN D TERMINE**, and C VANCE HAYNES, JR***

ABSTRACT. Infrared (IR) spectrophotometry and X-ray diffraction (XRD) were conducted on modern and fossil bone material from archaeological sites in the U S to determine post-mortem changes in bone apatite and to evaluate the effect of these changes on radiocarbon dating. IR absorption bands, XRD peak-broadening parameters, and XRD unit cell measurements indicated that during fossilization, bone apatite, a mineral similar to dahllite, was partially or completely recrystallized to francolite. Post-mortem changes involved then removal of some of the endogenous crystal carbonate both at surfaces and at internal OH-sites and introduction of exogenous carbonate into internal crystal PO_4 sites. Increased fluorine content accompanied carbonate substitution.

Both the carbon isotopic composition and the amount of exogenous carbonate introduced into the apatite structure will affect the radiocarbon dating of bone apatite. Special sample pre-treatment may remove most of the substituted carbonate in some cases. Simulated experiments are suggested for a better understanding of the nature and mechanism of carbonate substitution in bone apatite for the removal of the exogenously substituted carbon and the improvement of radiocarbon dates.

INTRODUCTION

Despite the abundance of bone material at archaeological sites, only a few radiocarbon dates have been obtained from them. Many workers regard bone dating with suspicion because of the inaccurate ages often obtained. The organic fraction in bone, namely collagen, does not exchange carbon with the bone post-mortem environment. Accordingly, inaccurate collagen dates are caused by physical contamination with other organic material, which has led many investigators to devise new techniques for separating pure collagen (Berger, Horney, and Libby, 1964; Krueger, 1965; Sellstedt and others, 1966; Berger and others, 1971; Longin, 1971; and Hassan, 1976). In many cases, however, the amount of collagen separated is insufficient for dating. Haynes (1968) used the bone mineral, apatite, as an alternative.

Many investigators are skeptical of radiocarbon dates obtained from bone apatite because of possible post-mortem exchange of carbon with the surrounding medium (Tamers & Pearson, 1965; Sellstedt and others, 1966). One of us (CVH), in collaboration with Austin Long, University of Arizona (unpub), demonstrated this exchange by radiocarbon analysis of about 2 my old bone from the Curtis Ranch locality in Arizona and obtained apparent ages of 21,000 ± 1000 BP (A-1028) on apatite CO_2 and 16,180 ± 300 BP (A-1027) on CO_2 from secondary carbonate. The mechanism and magnitude of such exchange had not been studied before. In the present study, modern and fossil bone apatites were subjected to X-ray and infrared investigation to trace the changes which might have

* Department of Geology, Washington State University, Pullman, Washington 99164

** Laboratory of Biological Structure, NIDR, National Institute of Health, Bethesda, Maryland 20014

*** Department of Anthropology, The University of Arizona, Tucson, Arizona 85721

TABLE 1

Frequency for IR absorption bands (in cm^{-1}) for the carbonate in dahllite, francolite, aragonite, calcite and bone apatite

Samples	ν_1	ν_2	ν_3	ν_4
Dahllite (Carlström, in press)		873	1416 1455	
Francolite (Carlström, in press)		866	1425 1455	
Aragonite (LeGeros and others, in press)	1080	842 852	1445 1485	700 710
Calcite (LeGeros and others, in press)		872	1420	710
Protein-free rat tibia, untreated (Termine and Lundy, 1973)		868 877*	1417 1441* 1476	
Protein-free rat tibia, air, 24 hr (Termine and Lundy, 1973)		870 876	1413 1457 1485*	

* Shoulder

occurred during fossilization and their possible effects on radiocarbon dating. The fossil bone specimens are from Folsom site, New Mexico; Murray Springs Clovis Level, Arizona; Blackwater Draw Clovis Level, New Mexico; Domebo Clovis Level, Oklahoma; and Boney Springs and Trolinger Bog, Missouri. They belong to *B bison antiquus, Mammuthus columbi, Mammuthus, imperator,* and *Mammut americanum.* The modern equivalents used in the study consist of buffalo (bison), cow, and elephant (*E indictus*)[1]. The elephant bones belong to two individuals; one died in 1967 and was left in open air while the other died in 1964 and was buried for 6 years prior to re-excavation.

INFRARED SPECTROSCOPY

Infrared (IR) absorption spectra from bone are usually composites of both protein and mineral absorption bands. The spectra of bone apatite are characterized by vibration bands produced by H_2O, OH, PO_4, and CO_3 groups. The characteristic vibrational bands of the CO_3 group in spectra of bone apatite are different from those observed in spectra of simple carbonate (table 1). The CO_3 IR bands of fresh bone apatite (table 1) are more complex than those of dahllite (carbonate hydroxyapatite with less than 1 percent F^-) and francolite (carbonate fluorapatite with more than 1 percent F^-).

Generally CO_3 exists in bone apatite at three different positions: (1) absorbed on the crystal surface, (2) at OH-, and (3) at PO_4-sites

[1] The elephant bones were obtained from Charles McNulty, University of Texas at Arlington.

TABLE 2

Chemical analysis of fresh, modern, and fossil bone apatite*

Sample description	Ca%	PO_4%	CO_3%	F%
Fresh cow	36.18	53.96	—	.074
Fresh buffalo	36.06	52.93	5.75	.035
Modern elephant	35.04	49.13	—	.076
Modern buried elephant	34.94	48.93	6.50	.055
Folsom bison	39.08	50.24	5.80	1.404
Murray Springs mammoth	37.46	49.28	—	1.467
Blackwater Draw mammoth	37.59	49.89	6.56	1.830
Blackwater Draw mammoth III	37.16	45.24	—	3.958
Domebo mammoth	36.67	48.44	9.78	1.659
Boney Springs mastodon	38.70	49.35	—	1.561
Trolinger bog mastodon	38.88	50.50	5.52	1.781

* From Hassan (1976)

(LeGeros and others, 1967; LeGeros and others, 1969; Carlström, in press; and Elliott, in press). About one-third to two-thirds of the total carbonate occurs at the surface (Neuman & Mulryan, 1967; Termine & Eanes, 1972; Termine & Lundy, 1973). The remainder is distributed between PO_4- and OH-sites with the vast majority in PO_4-sites.

The spectra of bone apatite were made with a Perkin-Elmer Model 621 Spectrophotometer, purged with dry air from pellets of 300mg kBr and 2mg protein- and calcite-free samples.[2] Some samples were treated with triammonium citrate and acetic acid to test the effect of these chemicals on carbonate removal. Machine adjustment was as follows: slit program 1x, gain 4.5, attenuator 11.00, scan time 10×4.5, suppression 6, and source 0.8 amp. The infrared splitting function SP, which is proportional to percentage crystallinity as determined by XRD, was calculated according to Termine and Posner (1966). The carbonate percentage was calculated from the ratio A_1/A_2, the ratio of the areas under the peaks of the carbonate ion asymmetric stretching frequency (1550-1350 cm^{-1}) and the phosphate ion antisymmetric bending frequency (800-450 cm^{-1}), and a standard whose CO_3 content is known (Greenfield & Eanes, 1972). The standard used in the present study is the modern buried elephant femur in which the CO_3 content was previously determined by wet chemistry (Hassan, 1976). Some of the chemical analysis on the bones investigated appear in table 2.

The spectra (fig 1) and frequencies (table 3) for IR linear absorbance for bone indicate that during fossilization bone apatite had experienced some changes. The absorption at 1495 cm^{-1}, attributed to surface and/or amorphous carbonate, is absent or very weak in the fossil bone. The intensities of IR bands at 1542, 1445, and 880 cm^{-1}, which stand for CO_3-OH substitution, decrease while an increase occurs at the 1418 and 873 cm^{-1} bands, which stand for CO_3-PO_4 substitution, with fossilization. Despite these changes, the fossil bone apatites were still close to the dahllite-type of apatite with the exception of the bone of the Blackwater Draw Mammoth III, a francolite-type. It is noteworthy that this sample

[2] See Hassan (1976) for sample pretreatment.

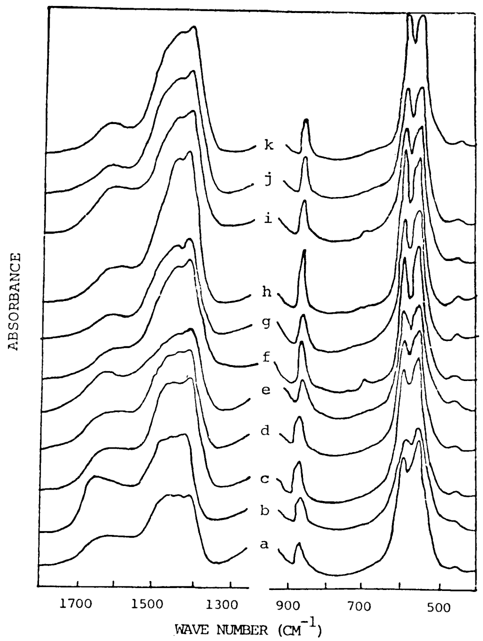


Fig. 1. Linear absorbance IR spectra from the bone of (A) fresh cow, (B) fresh buffalo, (C) modern elephant, (D) modern buried elephant, (E) Folsom bison, (F) Murray Springs mammoth, (G) Blackwater Draw mammoth, (H) Blackwater Draw mammoth III, and (K) Trolinger bog mastodon.

has an abnormally high F^- concentration (3.96 percent) whereas the rest of the fossil bones have less than 1.9 percent and the fresh and modern bones contain less than 0.1 percent flouride (table 2). The fact that bone mineral dahllite may be converted into francolite because of fossilization, has been reported previously by Stevenson (1966).

The relative carbonate content of fossil bone apatite decreases sharply with triammonium citrate and acetic acid treatments (table 4). Prior to these chemical treatments, calcite was removed mechanically (Hassan, 1976). Any calcite remaining was below the detection limit of the IR, about 2 percent. The decrease in CO_3 after the above treatments may well result from the weakening effect of the post-burial-substituted carbonate on bonds within the apatite structure. This is in agreement with the explanation of LeGeros and others (1967) for the observed increase in rates of dissolution and solubility of apatites with carbonate substitution.

X-RAY STUDIES

X-ray diffraction (XRD) broadening analysis has been extensively employed in the study of biological apatite (Carlström, 1955; Carlström and Glas, 1959; Posner and others, 1963, 1965; Harper and Posner, 1966; Termine and Posner, 1967; LeGeros and others, 1967; Posner, 1969;

TABLE 3

Frequency for IR absorption bands (in cm^{-1}) for the carbonate in modern and fossil bone apatite

Sample description	No treatment		Triammonium citrate		Acetic acid	
	ν_2	ν_3	ν_2	ν_3	ν_2	ν_3
Fresh cow	873	1417	—	—	—	—
	880*	1445	—	—	—	—
		1470		—		—
		1495*		—		—
		1512*		—		—
Fresh buffalo	873	1418	—	—	—	—
	880*	1445	—	—	—	—
		1470		—		—
		1495*		—		—
		1512*		—		—
Modern elephant	873	1418	—	—	—	—
	880*	1445	—	—	—	—
		1470		—		—
		1500*		—		—
Modern buried elephant	873	1418	873	1418	—	—
	880*	1445	880*	1445	—	—
		1470		1470		—
		1495*		1495*		—
		1510*		1510*		—
Folsom bison	868	1417	—	—	—	—
	878*	1450	—	—	—	—
		1495*		—		—
Murray Springs mammoth	873	1423	873	1423	873	1423
	880**	1453	880***	1453	880***	1453
		1495***		1495*		1495*
Blackwater Draw mammoth	873	1423	873	1423	—	—
	880**	1453	880**	1453	—	—
		1495***		1495*		—
Blackwater Draw mammoth III	866	1427	866	1429	—	—
		1455		1455		—
Domebo mammoth	873	1420	873	1420	873	1420
	880***	1453	880*	1453	880***	1453
		1495*		1495*		1495*
Boney Springs mastodon	873	1420	—	—	—	—
	880***	1453	—	—	—	—
		1495*		—		—
Trolinger bog mastodon	873	1422	—	—	—	—
	880***	1453	—	—	—	—
		1495*		—		—

* Shoulder
** Very weak shoulder
*** Weak shoulder

Lundy and Eanes, 1973; and Russell, Termine, and Arcoli, 1973). Crystallite size can be deduced from the broadened X-ray diffraction peaks using Scherrer's equation (Klug and Alexander, 1954). However, the figures for bone apatite crystallite dimensions and its crystallographic orientation are controversial (Carlström and Glas, 1959; Posner and others, 1963; and Höhling, Themann, and Vahl, 1966) which suggests that the validity of accurate crystallite size determination for bone apatite has not been settled. However, it is generally agreed that the crystals are extremely minute with the smallest dimension less than 50 Å and the largest dimension much less than 1000 Å, paralleling the c-axis (Eanes, 1973).

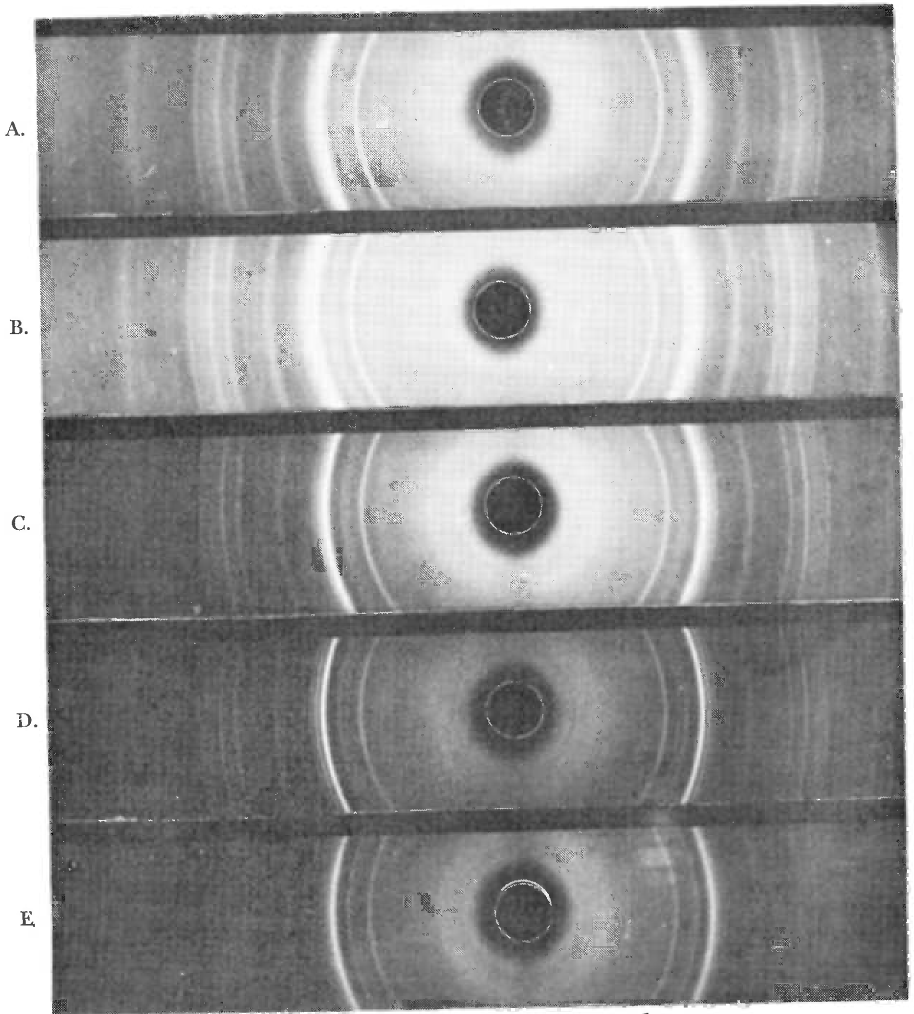
Variability in unit cell dimensions of biological apatites resulting from chemical substitution and the mechanism of such substitution has also been a matter of controversy. Among the substitutions which may occur in the apatite structure is that of carbonate. Carbonate substitution was investigated by McConnell (1938, 1952a and b, 1959, 1962, 1965), Borneman-Starinkevich and Belov (1953), Trautz (1960), McClellan and Lehr (1969), Elliott (1965, in press), LeGeros (1965), LeGeros and others (1967), LeGeros and others (1968, in press), Simpson (1972), and Carlström (in press). Generally agreed is that in francolite, one carbonate and one fluorine substitute together for one phosphate in the apatite structure resulting in a nonlinear decrease in the a-axis. Experimental studies on bone powder and on synthetic apatite by Neuman and Mulryan (1949, 1967), Neuman and others (1949), Neuman (1950), Neuman and Weikel (1954), and Simpson (1967) indicate that surface exchange, ionic and isotopic, as well as recrystallization, may also occur in bone apatites.

TABLE 4

Splitting functions (SP), the ratio A_1/A_2, and carbonate percentage calculated from A_1/A_2 using the wet chemical analysis for the modern buried elephant as a standard

Sample description	No treatment			Triammonium citrate			Acetic acid		
	SP	A_1/A_2	CO_3%	SP	A_1/A_2	CO_3%	SP	A_1/A_2	CO_3%
Fresh cow	0.042	0.880	4.3	—	—	—	—	—	—
Fresh buffalo	0.033	1.350	6.6	—	—	—	—	—	—
Modern elephant	0.036	1.314	6.4	—	—	—	—	—	—
Modern buried elephant	0.023	1.327	6.5	0.023	1.296	6.3	—	—	—
Folsom bison	0.047	1.345	6.6	—	—	—	—	—	—
Murray Springs mammoth	0.086	1.568	7.7	0.057	1.064	5.2	0.076	0.708	3.5
Blackwater Draw mammoth	0.059	1.327	6.5	0.047	1.067	5.2	—	—	—
Blackwater Draw mammoth III	0.075	1.947	9.5	0.054	1.643	8.0	—	—	—
Domebo mammoth	0.057	1.515	7.4	0.038	1.048	5.1	0.049	0.870	4.3
Boney Springs mastondon	0.039	1.452	7.1	—	—	—	—	—	—
Trolinger bog mastodon	0.032	1.525	7.5	—	—	—	—	—	—

PLATE 1



$4\theta = 51{\cdot}85$

Exact positives of X-ray films of (A) fresh cow bone, (B) modern buried elephant bone, (C) Folsom bison bone, (D) Blackwater Draw Mammoth III bone, and (E) Domebo mammoth bone.

XRD peak broadening analyses were obtained from protein-free finely hand-ground samples[3] adapting the method and experimental conditions of Russell, Termine, and Arcoli (1973). The apatite c-axis (002) and a-axis (310) reflections were step-scanned between 23.60-27.60° 2θ and 36.00-44.00° 2θ, respectively. Russell, Termine, and Arcoli (1973) ob-

[3] See Hassan (1976) for sample pre-treatment.

TABLE 5
X-ray diffraction broadening and intensity parameters

Sample description	$B^{1/2°}_{002}$ 2θ	$B^{1/2°}_{310}$ 2θ	$B^{I°}_{002}$ 2θ	$B^{I°}_{310}$ 2θ	$\Sigma B^{I°}$ 2θ	I_{002} (area)	I_{310} (area)	Brass Count	I/Brass 002	I/Brass 310	I_{xin}	$D\AA_{002}$	$D\AA_{310}$
Fresh cow	0.41	1.29	0.54	1.60	2.14	21,251	29,372	5,851	3.632	5.020	8.652	371	91
Fresh buffalo	0.39	1.31	0.49	1.66	2.15	20,372	31,663	5,844	3.486	5.418	8.904	408	89
Modern elephant	0.40	1.28	0.52	1.56	2.08	21,575	29,739	5,821	3.706	5.109	8.815	388	92
Modern buried elephant	0.39	1.23	0.49	1.53	2.02	21,705	30,390	5,874	3.695	5.174	8.869	408	97
Folsom bison	0.35	1.02	0.45	1.33	1.78	23,750	34,306	5,776	4.112	5.939	10.051	510	128
Murray Springs mammoth	0.32	0.95	0.39	1.09	1.48	25,144	34,615	5,867	4.286	5.890	10.176	628	143
Blackwater Draw mammoth	0.32	0.96	0.40	1.20	1.60	30,884	35,419	5,831	5.297	6.074	11.371	628	141
Blackwater Draw mammoth III	0.29	0.49	0.36	0.97	1.33	28,006	39,081	5,818	4.814	6.717	11.531	816	650
Boney Springs mastodon	0.35	1.11	0.43	1.36	1.79	29,932	34,787	5,794	5.166	6.004	11.170	510	113
Trolinger bog mastodon	0.36	1.20	0.45	1.48	1.93	31,473	36,354	5,921	5.316	6.140	11.456	480	101
Fluor-apatite[a] Standard	0.19	0.36	—	—	—	—	—	—	—	—	—		

[a] obtained from Mr. B. O. Fowler at NIH.

tained a precision in half-width (B 1/2) and integral breadth (B^I = peak area/peak height) values within ±1.5 percent. Debye-Scherrer, 114.6mm diameter powder cameras were used for study of unit cell dimensions. With Ni-filtered Cu radiation (CuK_2 = 1.542 Å), XRD patterns were recorded at 35 kv and 20 ma. The exposure time was 2 hrs. The 002 and 300 X-ray diffraction lines were used to calculate c Å and a Å dimensions, respectively.

The crystallite dimensions, D $Å_{002}$ and D $Å_{310}$, of modern bone apatite obtained in the present study (table 5) have their small dimension parallel to the a-axis, in agreement with Carlström and Glas (1959). The crystallite size of bone apatite and/or the percent crystallinity increases with fossilization. The XRD lines (pl. 1) are sharper in fossil than modern bones which most probably results from crystallite enlargement. The calculated unit cell dimensions (table 6), even though not very accurate, show a distinction between modern and fossil bone apatite. The slight decrease in the a-axis with fossilization is consistent with the observed increase in fluorine and carbonate content detected with fossilization (tables 2 and 4).

CONCLUSIONS AND PROBLEMS

Fossil bone apatite undergoes a number of post-mortem changes which distinguishes it from its biological predecessor. Among those changes critical for radiocarbon dating is carbonate substitution. The present study reveals a definite change in the mode and amount of carbonate contained within bone apatite upon fossilization which suggests post-mortem exchange with exogenous carbon. Whether the exchange is ionic and/or isotopic is still unclear. Chemical treatments with triammonium citrate and/or acetic acid remove some of the carbonate in the apatite structure. Carbon isotopic studies (Hassan, 1976) indicate that the carbonates thus removed are contaminants. Hydrochloric acid leaching of the finely ground samples (fractional hydrolysis technique) removes more of the contaminated carbonate which then may improve the radiocarbon dates (Hassan, 1976).

TABLE 6

Unit cell measurements

Sample description	θ_{002}	θ_{300}	d_{002}	d_{300}	c Å	a Å
Fresh cow femur	12.9500	16.5750	3.4371	2.7001	6.87	9.35
Modern buried elephant femur	13.0125	16.6000	3.4215	2.6961	6.84	9.34
Folsom bison bone	13.0000	16.6125	3.4241	2.6945	6.85	9.33
Murray Springs mammoth bone	13.0250	16.6250	3.4176	2.6922	6.84	9.33
Blackwater Draw mammoth III bone	12.9625	16.6500	3.4345	2.6882	6.87	9.31
Domebo mammoth bone	12.9625	16.6500	3.4345	2.6882	6.87	9.31
Boney Springs mastodon bone	13.0250	16.6750	3.4176	2.6843	6.84	9.30
Trolinger bog mastodon bone	12.9825	16.6250	3.4393	2.6922	6.86	9.33
Francolite*	—	—	—	—	6.881	9.356
Dahllite*	—	—	—	—	6.890	9.391
Bone**	—	—	—	—	6.88 ± 0.01	9.38 ± 0.01

* Trautz, 1955
** Posner and others, 1963

In order to evaluate the magnitude and mechanism of post-mortem exchange of carbon in bone apatite, simulated lab experiments are essential. Carbonate substitution in both very old and fresh bone powder using either active or dead carbon should be investigated. Data derived from such studies test the validity of the above mentioned fractional hydrolysis and demonstrate the limitations of its applicability to this problem.

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AN IMPROVED PROCEDURE FOR WET OXIDATION OF THE ^{14}C NBS OXALIC ACID STANDARD

S VALASTRO, JR*, L S LAND**, and A G VARELA*

ABSTRACT. An improved procedure for wet combustion of ^{14}C NBS oxalic acid standard has been devised which gives consistent high carbon yields and average $\delta^{13}C$ values of −19.1‰. The principal cause of fractionation in earlier attempts to prepare CO_2 by the wet oxidation method was the inexact nature of the end-point. The new procedure employs a chocolate-brown end-point by adding 5ml more of the sulfuric acid-potassium permanganate solution after the initial reddish brown end-point is reached. The sulfuric acid-potassium permanganate solution is added to the NBS oxalic acid in a steady drop-wise flow, heat is applied to the generating apparatus, and a cycling technique is utilized to collect the CO_2.

Fifteen samples of the NBS oxalic acid were processed. The per cent carbon yields range from 98.8 to 100.9% with an average of 99.7% and an average $\delta^{13}C$ of −19.12‰. The results obtained by this procedure are much more consistent than previous results obtained in several laboratories by direct combustion.

WET OXIDATION OF OXALIC ACID

Wet oxidation of the ^{14}C NBS oxalic acid standard to carbon dioxide is an accepted technique used by most radiocarbon laboratories. The procedure is simple and straightforward. After some years of use, however, investigators have discovered that fractionation does occur during CO_2 evolution because of difficulty in determining the proper end-point of the reaction.

Fractionation during this chemical reaction has been documented by several investigators. Lindsay (1949) reported as much as 3.5% change in the ^{13}C concentration in the CO_2 during the decomposition of oxalic acid, and Bernestein (1957), working with formic acid decomposition by sulfuric acid, stated that as much as 53% variations occurred. Grey *et al* (1969), in preparing CO_2 from the ^{14}C oxalic acid standard, reported a $\delta^{13}C$ value of −25.5‰ relative to PDB due to incomplete reaction.

Fractionation during oxidation of the NBS oxalic acid standard is of concern because it may offset counting rates, resulting in systematic errors in age determinations.

Craig (1961) determined the $^{13}C/^{12}C$ ratio of the standard gas samples from several laboratories, prepared by both wet oxidation and direct combustion in oxygen. $\delta^{13}C$ values by direct combustion with oxygen ranged from −17.15 to −22.72‰ with an average of −19.3‰ (10 samples), while the wet oxidation values ranged from −18.37 to −31.37‰. Rejection of the four most depleted values gave an average of −19.6‰ (6 samples). According to Craig, depleted values are to be expected if the oxidation has not gone to completion.

Since the primary ^{14}C standard for the University of Texas Radiocarbon Laboratory is NBS oxalic acid (as it should be for all laboratories), the personnel of the laboratory were compelled to improve the wet oxidation procedure so that no significant fractionation would occur.

* Radiocarbon Laboratory, University of Texas at Austin, Balcones Research Center, 10100 Burnett Rd, Austin, Texas 78758

** University of Texas at Austin, Dept of Geological Sciences, Austin, Texas 78712

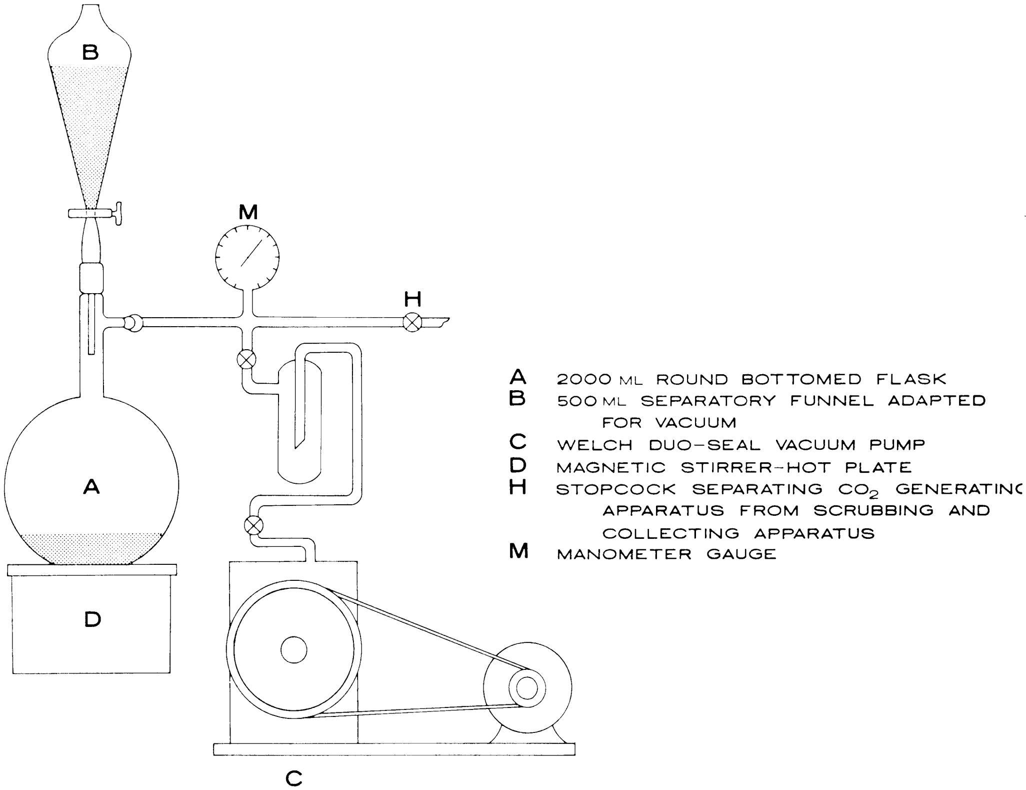

Fig 1. Schematic of the CO_2 generating apparatus for the preparation of NBS oxalic acid standard.

Thus, a new technique, which gives high yields and consistent $\delta^{13}C$ values that are close to the average value obtained by Craig (1961), is described.

PROCEDURE

For the generation of approximately 6.77L of CO_2 at STP from 3.31gm carbon, 17.35gm ^{14}C NBS oxalic acid standard $(CO_2H)_2 \cdot 2H_2O$, is weighed on an analytic balance and transferred to a 2000ml round-bottomed flask adapted for vacuum conditions. Degassed distilled H_2O is added to the sample to immerse the contents. A separatory funnel with a 24/40 joint adapted for vacuum is attached to the flask (fig 1). Vacuum is applied by a Welch Duo-Seal mechanical pump. All pumps used in the system are trapped, and the traps are refrigerated by a dry ice/acetone bath. A pressure of 0.01 Torr is normally achieved in approximately 15 min. The separatory funnel is filled with sulfuric acid-potassium permanganate solution containing 16.25gm $KMnO_4$, 40ml concentrated H_2SO_4, and 250ml degassed distilled H_2O. This solution is prepared by stirring and gently heating the contents until the $KMnO_4$ dissolves.

Vacuum is also applied to the scrubbing and collecting apparatus, which consists of three gas wash bottles in series containing potassium-permanganate ($KMnO_4$), silver nitrate ($AgNO_3$) and potassium dicromate-sulfuric acid [$(K_2Cr_2O_7) + (H_2SO_4)$] solutions respectively, a double water trap (E) cooled by dry ice/acetone mixture, and two CO_2 collecting traps (F & G) (fig 2). One of the CO_2 collecting traps is a 10-ft glass coil (G) placed purposely at the end of the collection train to insure total CO_2 removal. The gas wash-bottles are used to scrub the CO_2 free of impurities. Gas scrubbing is applied to all samples, whether background, unknown, or NBS standard.

When both the generating apparatus and the collecting apparatus are evacuted to 0.01 Torr pressure, the sulfuric acid-potassium permanganate solution is added to the NBS oxalic acid sample in a steady drop-wise flow, while the contents of the flask are continuously agitated by a magnetic stirrer. When enough CO_2 is generated to register approximately 38cm Hg pressure on a monometer, the stopcok (H), which separates the generating apparatus from the scrubbing and collecting apparatus, is opened and the CO_2 is collected and frozen at liquid nitrogen temperature in the straight (F) and coiled (G) traps while the system is closed to the vacuum pump (I). The steady drop-wise flow of the sulfuric acid-potassium permanganate solution and the continuous stirring of the contents are maintained throughout the entire procedure.

The "apparent" end-point of the reaction between the sulfuric acid-potassium permanganate solution and the NBS oxalic acid sample is reached when the solution in the flask changes from clear to reddish-brown. This particular end-point apparently does not satisfactorily insure total evolution of CO_2 from the sample according to Grey *et al* (1969). Thus, to the contents of the flask, 5ml more sulfuric acid-potassium permanganate solution is added until the color of the solution changes to a chocolate-brown tint. At this point, heat from a stirrer-hot plate is applied and the solution is gently warmed which serves to drive out additional CO_2 that may be trapped in the solution.

After the chocolate-brown end-point is reached a cycling procedure is started. The stopcock valve (J) separating the scrubbing from the collecting apparatus is closed and the collecting apparatus is then evacuated for five min through the spiral trap (G) by pump (I). After five min, the system is closed to the pump (I) and the stopcock (J) separating the collecting apparatus from the generating and scrubbing apparatus is re-opened for five min, allowing the remaining CO_2 to expand from the round bottomed flask (A) to the traps (F & G) where it is frozen out at liquid nitrogen temperature. This cycling is continued for 30 min to insure that all the CO_2 generated from the NBS sample is trapped. At the end of the cycling procedure, when the pressure in the entire system is typically close to 0.02 Torr, the stopcock (J) is closed, isolating the collecting apparatus from the scrubbing apparatus, and the collecting system is evacuated through the spiral trap (G) to a pressure

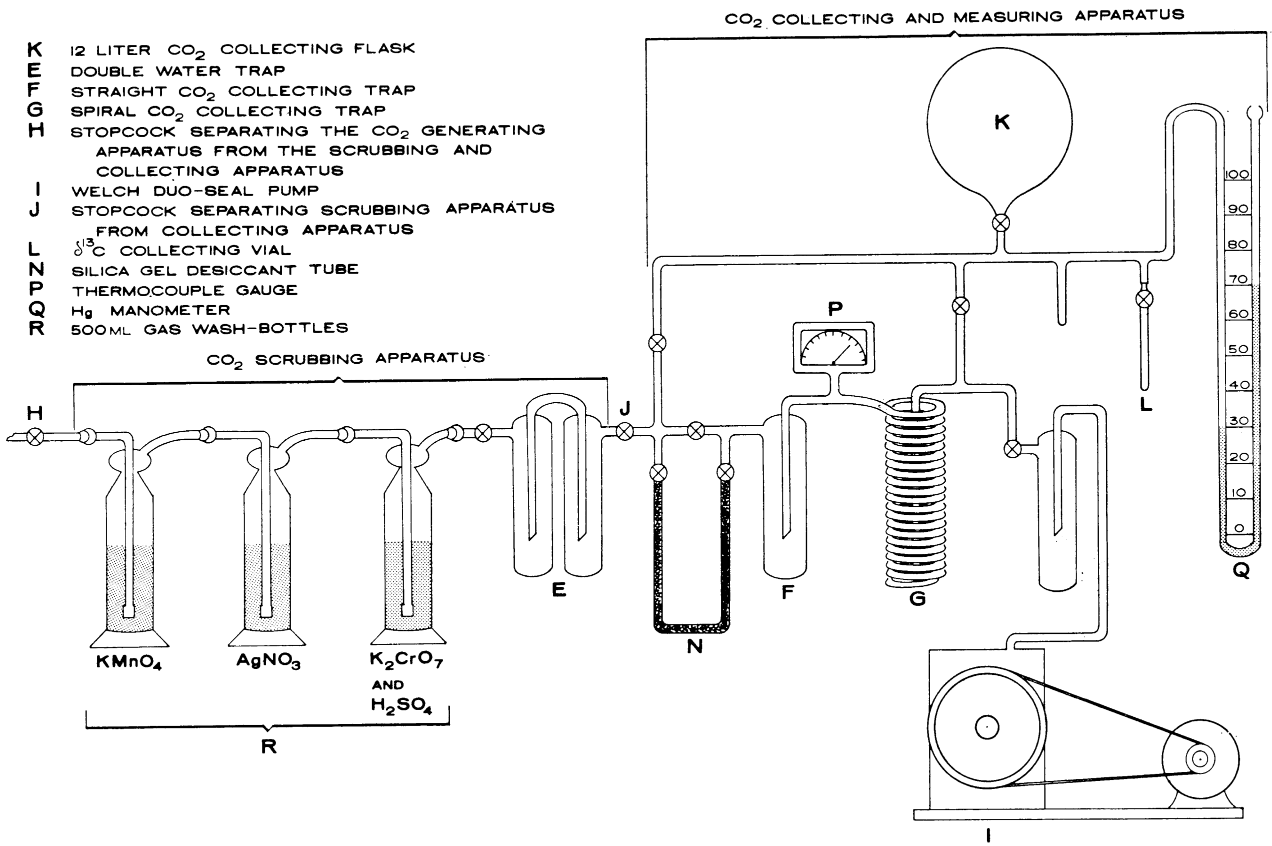

Fig. 2. Schematic of the chemical line for scrubbing, collecting, and measuring CO_2 during the preparation of NBS oxalic acid standard.

of 0.01 Torr. Finally, the CO_2 collected is expanded into a measuring flask (K) and into a collecting vial (L) for the measurement of the $\delta^{13}C$.

RESULTS

Fifteen consecutive NBS oxalic acid samples were processed by the method above, and then analyzed for $\delta^{13}C$ by a dual collector mass-spectrometer. The results of these samples are presented in Table 1.

TABLE 1

Yield in grams of carbon, per cent carbon, and $\delta^{13}C$ relative to PDB obtained by wet oxidation.

Sample No.	Yield in gm Carbon	% Carbon Yield	$\delta^{13}C$ in ‰ relative to PDB
NBS-1	3.34	100.9	−19.11
NBS-3	3.32	100.3	−19.51
NBS-4	3.28	99.1	−19.05
NBS-5	3.27	98.8	−18.65
NBS-6	3.29	99.4	−19.01
NBS-7	3.29	99.4	−19.15
NBS-8	3.28	99.1	−18.71
NBS-9	3.34	100.9	−19.34
NBS-10	3.31	100.0	−19.31
NBS-11	3.33	100.6	−19.13
NBS-12	3.30	99.7	−19.30
NBS-13	3.28	99.1	−18.93
NBS-14	3.33	100.6	−19.35
NBS-15	3.27	98.8	−19.14
NBS-16	3.28	99.1	−19.08
	Av = 3.30	Av = 99.7 ± .8	Av = −19.12 ± .23

The average of −19.12‰ for the 15 NBS oxalic acid samples processed by wet oxidation is close to the average value of −19.3‰ obtained by Craig (1961) by direct combustion.

To test the yields obtained by our wet oxidation procedure *vs* those obtained by direct combustion, we prepared six samples by direct combustion, utilizing a micro-combustion system with a moderate vacuum, and a micro-furnace containing CuO maintained between 800-900°C. During combustion, the generated gases are recycled with excess oxygen via a Toepler pump to insure total conversion to CO_2. The products are collected in a liquid nitrogen cooled trap, and transferred through dry-ice traps prior to analysis.

The average of −18.69‰ obtained from the six samples combusted in a stream of oxygen is significantly enriched relative to the average value of −19.12‰ obtained by the new wet oxidation procedure (Table 2).

TABLE 2

CO_2 and $\delta^{13}C$ in ‰ relative to PDB obtained by combustion in oxygen

Sample No.	CO_2 yields in mm Hg/mg oxalic acid	$\delta^{13}C$ in ‰ relative to PDB
5234	16.00	−18.65
5231	17.00	−18.87
5727	15.50	−18.45
5728	15.90	−18.71
5729	16.10	−18.84
5731	15.30	−18.59
		Av = −18.69 ± .16

A plot of the CO_2 yield *vs* the $\delta^{13}C$ ratio of the six samples processed by direct combustion, suggests that the depleted $\delta^{13}C$ values correlate with the larger CO_2 yields (fig 3). This observation suggests that during the evacuation of the system prior to combustion, depleted oxalic acid preferentially sublimates. For this reason, our $\delta^{13}C$ values for oxalic acid obtained by combustion are enriched relative to those obtained by wet oxidation. Thus, combustion of large samples of oxalic acid causes sublimation and isotopic fractionation.

The new wet oxidation technique differs from the normal accepted wet oxidation technique (Kim, 1970; Kolthoff & Sandell, 1952; Polach, 1972; Polach & Krueger, 1972) in the following ways: 1) The sulfuric acid-potassium permanganate solution is added to the NBS oxalic acid in a steady drop-wise flow while the contents of the flask are continuously stirred and the system is closed to the vacuum pump. 2) The chocolate-brown end-point is employed after adding 5ml more sulfuric acid-potassium permanganate when the initial "apparent" reddish-brown end-point is reached. 3) Heat is applied to gently warm the sample to drive off all the CO_2 that may be trapped in solution or trapped in the flask or generating apparatus. 4) A cycling technique is used by pumping

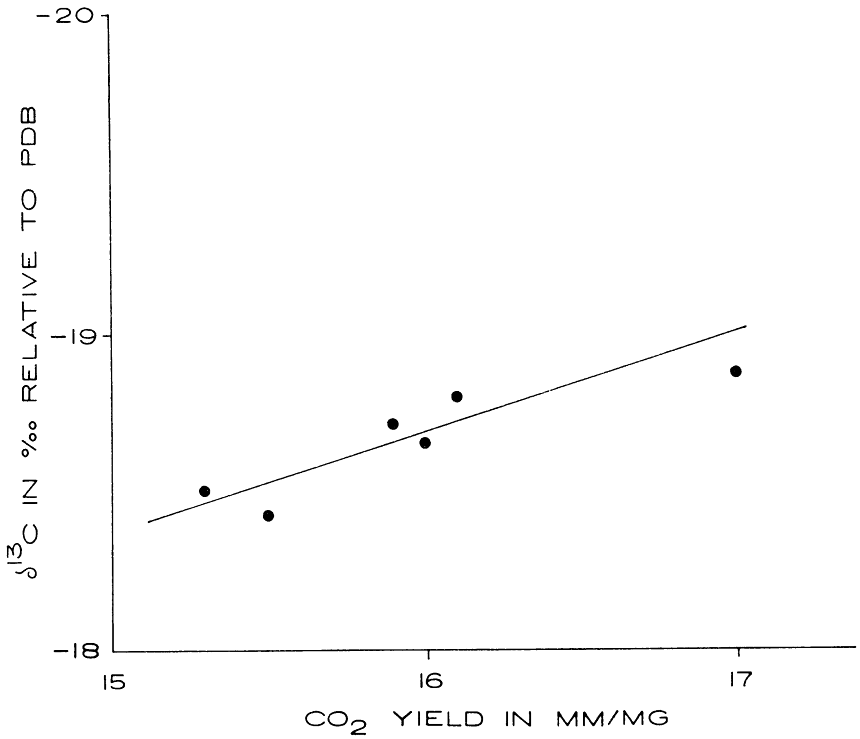

Fig 3. CO_2 yield in MM/MG vs $\delta^{13}C$ direct combustion of NBS oxalic acid standard.

the collecting apparatus while the generating apparatus is sealed for 5 min, and then closing the system to the vacuum pump and re-opening the generating apparatus.

This action allows the remaining CO_2 to expand from the flask into the liquid nitrogen traps where it is frozen out. The process is carried out for 30 min on an alternating basis.

Although this investigation is directly concerned with fractionation in the preparation of CO_2 by the wet oxidation procedure of ${}^{14}C$ NBS oxalic acid, it is also of interest to investigate whether further fractionation occurs when the CO_2 obtained by wet oxidation is converted to the counting liquid, benzene, via lithium-carbide and acetylene trimerization (Tamers, 1965).

Therefore, six NBS oxalic acid samples were prepared and converted to benzene and the product analyzed for $\delta^{13}C$ (Table 3). The average $\delta^{13}C$ of $-19.42 \pm .12‰$ is slightly different from our average value of $-19.12 \pm .23‰$ obtained by analyzing the CO_2 prepared from oxalic acid by wet oxidation. Correction for the activity of the counting liquid utilizing the formula proposed by Broecker and Olson (1961) accounts for a correction of approximately five radiocarbon years. These analyses substantiate that carbon isotope fractionation during the acetylene and benzene syntheses is negligible (Noakes *et al*, 1967; Hubbs *et al*, 1967).

TABLE 3

Per cent yield and $\delta^{13}C$ in ‰ relative to PDB of benzene obtained by wet oxidation

Sample No.	Over-all % yield from CO_2	$\delta^{13}C$ of benzene in ‰ relative to PDB
NBS-1	98.3	−19.59
NBS-2	96.4	−19.48
NBS-3	96.0	−19.40
NBS-4	99.8	−19.44
NBS-5	99.7	−19.35
NBS-7	99.5	−19.23
		Av = −19.42 ± .12

CONCLUSIONS

The new oxidation technique is easily carried out and minimizes the chances of sublimation while oxalic acid is under vacuum to expel air from the system.

Since ^{13}C fractionation by the wet method is insignificant, ^{14}C counting errors must also be insignificant.

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[RADIOCARBON, VOL. 19, No. 3, 1977, P. 383-388]

ANTWERP UNIVERSITY RADIOCARBON DATES II

R VANHOORNE and M VAN STRYDONCK

Department of General Botany, State University Centre, Antwerp, Groenenborgerlaan 171, B-2020 Antwerp, Belgium

The following list contains most of the measurements made during 1976, since our last list (R, 1976, v 18, p 151-160). Wood and charcoal samples were prepared as previously described (R, 1976, v 18, p 151). Peat samples were treated with cold N/10 NaOH and hot N/10 HCl, washed and dried.

With regard to trimerization of acetylene into benzene we have tested the Vanadium-activated catalyst (V-0701 T 1/8″ Harlow Chemicals) against the Chromium-activated catalyst (KC-Perlkator, Kalichemie, Hannover) which has been in use up to the present time. We found that, although trimerization with the Vanadium-activated catalyst was more rapid, higher yields were obtained with the chromium-activated catalyst. For this reason it seemed unnecessary to change our catalyst. To improve the efficiency of the trimerization, acetylene is now purified in a P_2O_5-Ascarite column.

As a result of the resolutions passed at the Ninth International Radiocarbon Conference, we no longer use AD/BC in our lists of age determinations.

ACKNOWLEDGMENTS

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Belgium

ANTW-154. Dobbelaere-Maldegem DOB-MA-133-13 940 ± 102

Peat from Layer L5, 110 to 120cm below surface (51° 12′ 05″ N, 3° 26′ 08″ E). Coll 1973 by I Heyse. *Comment* (CV): high percentage of *Secale*-pollen found in layer agrees with medieval age.

Paal series

The following series completes the previously pub list (R, 1976, v 18, p 158). Palynologic analysis of these sites are in preparation. (51° 03′ 23″ N, 5° 08′ 22″ E). Coll 1975 by L Beyens.

ANTW-147. Paal 2 5070 ± 190

Peat from layer 25 to 45cm below surface.

ANTW-148. Paal 3 5150 ± 115

Peat from layer 40 to 60cm below surface.

ANTW-161. Paal 1-b, Sample 1 11,870 ± 185

Peat from layer 100 to 105cm below surface.

ANTW-164. Paal 1-b, Sample 2 4660 ± 114

Wood from oak trunk embedded in peat layer 50cm below surface.

Lommel series

ANTW-155. Lommel 1-b, Sample 1 11,760 ± 175

Peat from layer 90 to 100cm below surface (51° 11′ 05″ N, 5° 17′ 31″ E). Coll 1975 by L Beyens.

ANTW-156. Lommel 1-b, Sample 2 2540 ± 115

Peat from layer 25 to 35cm below surface. Coll 1975 by L Beyens.

ANTW-160. Overpelt 3 4520 ± 115

Peat from layer 80 to 100cm below surface (51° 11′ 42″ N, 5° 21′ 46″ E).

Lampernisse series

ANTW-163. Lampernisse 98a point 189, Sample 1 3550 ± 36

Wood from a pine stump in upper part of peat layer 110 to 160cm below surface (51° 01′ 20″ N, 2° 49′ 50″ E). Coll 1951 by R Vanhoorne. *Comment* (RV): date compiled from age determinations of 4 samples from same stump (see Table 1).

TABLE 1
Age determination of 4 samples from the same pine stump

Activity cpm/gC samples	Date: year BP	$x-\bar{x}$	$(x-\bar{x})^2$
5.352 ± 0.042	3520 ± 110	30	900
5.357 ± 0.043	3520 ± 110	30	900
5.345 ± 0.043	3530 ± 110	20	400
5.284 ± 0.043	3630 ± 110	80	1600

$$\text{Mean value: } \bar{x} = \frac{\Sigma x}{n} = 3550 \text{ yr}$$

$$\Sigma(x-\bar{x})^2 = 3800$$

Activity cpm/gC modern standard = 8.298 ± 0.040

$$\text{one standard deviation: } s = \sqrt{\frac{\Sigma(x-\bar{x})^2}{n-1}} = 36 \text{ yr}$$

Comment (RV): pollen diagram from same coastal site (Stockmans & Vanhoorne, 1954, p 136) suggests a Sub-Atlantic age. This date seems to be 1000 yr too old.

ANTW-191. Lampernisse 98a point 189, Sample 2 2340 ± 54

Wood in upper part of peat layer 110 to 160cm below surface (51° 01′ 20″ N, 2° 49′ 50″ E). Coll 1951 by R Vanhoorne. *Comment* (RV):

date agrees with Sub-Atlantic age, suggested by pollen diagram (Stockmans & Vanhoorne, 1954, p 136), characterized by high percentages of *Fagus* (3.9% at 160cm to 27.5% at 110cm depth) and *Carpinus* (4.6% at 150cm to 11.2% at 140cm depth).

ANTW-188. Rijkevorsel R_2 **660 ± 58**

Charcoal from base of a plaggen epipedon 70cm below surface (51° 20′ 39″ N, 4° 45′ 34″ E). Coll May 1976 by C Verbruggen and J Maes. *Comment* (CV & JM): ref age determination for pollen analysis: trees 10%, herbs 90% (Gramineae nat 49%; Gramineae cult 20%; Ericaceae 4%; *Spergula* 5%; *Fagopyrum* 2.7%). This pollen spectrum shows a landscape after the great medieval land declamation and validates date.

B. Scotland

Cairngorm Estate series

Wood samples from Cairngorm Estate. All specimens originate from a belt 3.7km long. Sites represent some of highest spots in Cairngorm Estate at which pine stumps are still found. It was assumed that age determinations would fall within a fairly limited period of time, establishing a date for the maximum vertical extension of pine within the area. However, the picture is more complicated than originally assumed. The older dates (Sites 6-9, 20) are from more exposed slopes in W of area, while stands were present in more sheltered areas (Sites 5, 15) well into Sub-Boreal.

ANTW-171. Site 15, Sample 3 **3410 ± 80**

Pine wood recovered from eroded blanket bog between Creagan Dubh and Allt Clais a' Mhèirlich; alt, + 710m (57° 08′ 28″ N, 3° 38′ 28″ W). Coll 1975 by L Beyens and D K Ferguson. *Comment* (DKF): Sample represents only piece of wood found at this alt in this valley. A systematic search for wood at higher levels in the same valley proved negative.

ANTW-176. Site 7, Sample 4 **6400 ± 98**

Wood from pine root recovered from eroded blanket bog 120cm thick, close to lowermost ski tow; alt, + 640m (57° 07′ 58″ N, 3° 40′ 17″ W). Coll 1974 by D K Ferguson and M De Keersmaecker. *Comment* (DKF): pine stumps are common at this alt (see R, 1976, v 18, p 158).

ANTW-177. Site 7, Sample 5 **4470 ± 105**

Wood from pine root recovered from eroded blanket bog 120cm thick, close to the lowermost ski tow; alt, + 640m (57° 07′ 58″ N, 3° 40′ 17″ W). Coll 1974 by D K Ferguson and M De Keersmaecker.

ANTW-192. Site 5-1, Sample 6 **3780 ± 60**

Wood from pine stump recovered from eroded blanket bog between Creagan Dubh and Allt Clais a' Mhèirlich; alt, + 705m (57° 08′ 30″ N, 3° 38′ 22″ W). Coll 1975 by D K Ferguson, J and P D'hondt. *Comment* (DKF): pine stumps are still relatively common at this alt.

ANTW-193. Site 5-2, Sample 7 **3320 ± 55**

Wood from pine stump recovered from eroded blanket bog between Creagan Dubh and Allt Clais a' Mhèirlich; alt, + 705m (57° 08′ 30″ N, 3° 38′ 22″ W). Coll 1975 by D K Ferguson, J and P D'hondt. *Comment* (DKF): sample shows 40 growth rings. Of these, only 16 central rings were used in dating.

ANTW-194. Site 5-3, Sample 8 **4090 ± 62**

Wood from pine stump recovered from eroded blanket bog between Creagan Dubh and Allt Clais a' Mhèirlich; alt, + 705m (57° 08′ 30″ N, 3° 38′ 22″ W). Coll 1975 by D K Ferguson, J and P D'hondt.

ANTW-199. Site 6, Sample 9 **5140 ± 69**

Pine wood in blanket bog 70 to 80cm thick close to Allt Coire an t-Sneachda; alt, + 710m (57° 07′ 24″ N, 3° 40′ 33″ W). Coll 1975 by L Beyens & D K Ferguson. *Comment* (DKF): sample was discovered by chance while sounding the area. Thus, it is not certain whether pine trees were common at this site.

ANTW-200. Site 5-4, Sample 10 **4410 ± 54**

Wood from pine trunk recovered from eroded blanket bog between Creagan Dubh and Allt Clais a' Mhèirlich; alt, + 705m (57° 08′ 30″ N, 3° 38′ 22″ W). Coll 1975 by D K Ferguson, J and P D'hondt. *Comment* (DKF): fragment used in dating had 60 growth rings. Judging from fragment, trunk must have been at least 10cm in diam with growth rings averaging no more than 0.65mm wide.

ANTW-202. Site 20-1, Sample 11 **6620 ± 68**

Pine wood recovered from eroded blanket bog between Allt Creag an Leth-choin and Allt Coire an t-Sneachda; alt, + 730m (57° 07′ 16″ N, 3° 41′ 11″ W). Coll 1975 by L Beyens and D K Ferguson. *Comment* (DKF): while blanket bog is relatively well-eroded, wood remains seem rare at this alt. A fairly thorough search yielded no more than 2 samples (ANTW-202, -203).

ANTW-203. Site 20-2, Sample 12 **7060 ± 97**

Pine wood recovered from eroded blanket bog between Allt Creag an Leth-choin and Allt Coire an t-Sneachda; alt, + 730m (57° 07′ 16″ N, 3° 41′ 11″ W). Coll 1975 by L Beyens and D K Ferguson.

ANTW-218. Site 8, Sample 13 **5790 ± 80**

Trunk from pine stump in eroded blanket bog close to Allt a' Choire Chais; alt, + 620m (57° 08′ 01″ N, 3° 40′ 26″ W). Coll 1975 by L Beyens and D K Ferguson. *Comment* (DKF): 14 stumps were found in quadrat 10m × 10m. Since only ca ½ area included in quadrat was exposed by erosion, growth was probably dense. More dates are needed. Trees did not appear to have attained large dimensions (trunks vary between 6.5 and 22cm in diam at ground level) and growth rings in present sample indicate that growth in 1st 40 yr was very slow (mean width of growth rings 0.3mm). In the next 10 yr ring width averaged 1.25mm, a 4-fold increase over previous yr. The tree with trunk 6.5cm in diam, excluding the bark, seemed to have lived some 60 yr. Poor preservation of periphery prevents a more accurate estimation. Age determination is based on cross-section covering complete time span.

ANTW-219. Site 9, Sample 14 **5990 ± 63**

Trunk from pine stump in eroded blanket bog close to Allt a' Choire Chais; alt, + 590m (57° 08′ 06″ N, 3° 40′ 38″ W). Coll 1975 by L Beyens and D K Ferguson. *Comment* (DKF): sample is similar to ANTW-218 not only in age, but also in its slow rate of development. Trunk, 10cm in diam excluding bark, has 105 growth rings. In 1st 37 yr, growth was slow, averaging 0.5mm/yr, some indication of its difficulty in becoming established. In next 10 yr, growth more than doubled to 1.2mm/yr, followed by a sharp decrease to 0.5mm/yr in final 60 odd yr. Date is based on material from 1st 50 yr.

C. The Netherlands

ANTW-162. Aardenburg **26,510 ± 680**

Sample from loamy detrital peat 200 to 230cm below surface near top of Weichselian cover sands and underlying Sub-Atlantic marine clay (51° 15′ 25″ N, 3° 27′ 10″ E). Coll 1974 by M T Demuynck and C Verbruggen. *Comment* (CV): pollen analysis indicates a treeless full-glacial landscape. Date agrees with GrN-6116: 25,680 ± 175 BP.

II. ARCHEOLOGIC SAMPLES

A. Israel

ANTW-223. Tell Fara, Site K 1 and 2 **24,780 ± 573**

Charcoal samples found 900cm below surface (31° N, 34° E). Coll 1976 by J Prior. *Comment* (K L Alvin): Site K assigned to Upper Paleolithic. Sample combusted without pretreatment. Dilution: 80% sample. Date agrees with expected age.

B. Belgium

ANTW-195. Ranst R28 **1480 ± 49**

Burned wood at 80cm below surface (51° 11′ 7″ N, 4° 34′ 13″ E). Coll 1976 by F Lauwers.

ANTW-180. Edegem Ed 75/1 WP **750 ± 41**

Birch from bottom of a well 550 to 600cm below surface (51° 09′ 15″ N, 4° 27′ 30″ E). Coll Oct 1975 by F Brenders.

ANTW-182. Wichelen Lansschoen 9909 No. 49 **2380 ± 57**

Ash wood from lance shaft from bed of Schelde R near Wichelen (51° 00′ 50″ N, 3° 58′ 15″ E). Coll 1910 by J Maertens de Noordhout. *Comment* (CV): by adding the maximum correction for secular ^{14}C variations, a date of 2770 can be obtained. Date corresponds with youngest one proposed by archeologists, *ie*, ± 9th century BC.

ANTW-185. Ekeren E75 W1 h13 **2320 ± 64**

Sample from wooden shaft of a well 144 to 185cm below surface (51° 17′ 14″ N, 4° 25′ 01″ E). Coll April 1975 by W Ibens. *Comment* (WI): construction method suggests early Roman or Iron age well.

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[RADIOCARBON, VOL. 19, No. 3, 1977, P. 389-391]

BRATISLAVA RADIOCARBON MEASUREMENTS II

S USAČEV, J CHRAPAN, J ORAVEC, and B SITÁR

Department of Nuclear Physics, Comenius University,
Bratislava, Czechoslovakia

Radiocarbon dating facilities were built at the Department of Nuclear Physics, Comenius University in 1967 (Usačev *et al*, 1973). Initially, sample pretreatment and combustion systems for a proportional counter filled with CO_2 were installed (Chrapan, 1966). One group adopted methods based on the use of methane (Usačev *et al,* 1973), a second group continued radiocarbon dating using an Oeschger-type proportional counter filled with CO_2 (Chrapan, 1968). Later a modified Oeschger-type proportional counter with 1L active volume and with a background of approximately 8.10^{-2} bq was built (Schmidt and Chrapan, 1970). The pressure used in this counter is 10^5 Pa. 0.95 NBS oxalic acid is used as a standard of the present biosphere and the year 1950 refers to the zero year. Calculated radiocarbon ages are based on a 5568 ± 30 year half-life as recommended by the 8th International Radiocarbon Dating Conference. Statistical errors are calculated as a combination of the 3σ standard deviations of the sample count and the background. Samples were treated by HCl, NaOH or other chemicals according to their initial conditions.

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I. PEDOLOGIC SAMPLES

Komiatice series

Samples were prepared from recent soils of the Komiatice dist (48° 9′ N, 18° 10′ E), Nitra, S Slovakia. Coll and subm 1968 by E Vaškovská, Štur's Geol Inst, Bratislava.

Ba-221. Komiatice T **5330 ± 265**

Sample from recent soil from Komiatice-tehel'na.

Ba-222. Komiatice 1 **11,500 ± 1100**

Sample from humus underlying soil at depth 2.5m.

Ba-324. Pukanec No. 2 **800 ± 80**

Sample was prepared from recent soil underlying border hill, 2.3m below surface, 0.5km E of Pukanec (48° 21′ N, 18° 42′ E) Levice dist, middle Slovakia. Coll and subm by J Klinko, MNV Pukanec.

II. ARCHAEOLOGIC SAMPLES

Ba-223. Medvedia jaskyňa **17,700 ± 800**

Bones (*Ursus speleus* Rosnm & Heinr mandibula) from Medvedia jaskyna (Bear Cave) in Slovakian Paradise region (49° 5′ N, 20° 22′ E) at depth between 0.25 to 0.45m from top of cave sediment in Bludisko sec of cave. Coll and subm 1969 by Z Schmidt, Štur's Geol Inst, Bratislava.

Pukanec series

During excavation for a new building damaged wooden cellars were found 3m below surface in center of Pukanec (48° 21′ N, 18° 42′ E) Levice dist, middle Slovakia. Coll 1974 by J Chrapan.

Ba-224. Pukanec No. 1 **390 ± 50**

Wood from a supporting beam, Sec A-1.

Ba-225. Pukanec No. 1 **380 ± 50**

Wood from a supporting beam, Sec B-2.

Ba-235. Pukanec No. 3 **450 ± 40**

Fragment of excavated wood from 2.5m below surface near old mine W of Pukanec. Coll 1974 by J Chrapan.

Vodná veža series

During excavations a water tower was found on left bank of Danube at Bratislava (48° 10′ N, 17° 10′ E), SW Slovakia. Coll and subm 1974 by K Klinčoková, Pamiatkový ústav mesta Bratislavy.

Ba-226. Vodná veža A2 **1670 ± 70**

Charcoal fragments from tower structure at depth of 6m, Sec S-12.

Ba-227. Vodná veža A3 **1818 ± 60**

Charcoal fragments from tower structure at depth of 8m, Sec S-9.

Ba-228. Vodná veža A8 **320 ± 60**

A piece of wood from depth of 9.3m, Sec S-16.

Ba-229. Vodná veža A6 **2120 ± 180**

Charcoal fragments from construction parts at depth of 7.7m, Sec S-9.

Ba-230. Vodná veža A7 **18,090 ± 3500**

Charcoal mixed with humus and calcite gravel from depth of 2.7m, Sec P-1.

Ba-231. Vodná veža All **600 ± 60**

Wood from damaged structure of wall.

Šášov series

Wooden beams from Šášov castle (48° 31′ N, 18° 55′ E) 25km W of Zvolen, middle Slovakia. Coll 1974 by P Lesay, Comenius Univ, Bratislava.

Ba-232. Šášov III-1 **540 ± 50**

Wooden beam from castle.

Ba-233. Šášov III-2 **270 ± 20**

Wood from castle window.

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DALHOUSIE UNIVERSITY NATURAL RADIOCARBON MEASUREMENTS II

J GORDON OGDEN, III and W C HART

Department of Biology, Dalhousie University,
Halifax, Nova Scotia

The following list includes determinations completed since publication of our last date list (R, 1976, v 18, p 43-49). Sample preparation and counting configuration remains the same as for DAL-I. Age determinations are based on at least two counter fillings (except as noted for very small samples) for a total of 3000 minutes and are calculated from at least 5000 minutes modern and background counts updated weekly by alternating modern and background samples in the counters over weekends. Age calculations are based on the Libby half-life of 5568 y and includes 1 σ statistical uncertainties of sample, modern, and background activity. Reference age is AD 1950 and is determined from .95 oxalic acid activity or age-corrected 1850 wood.

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I. GEOLOGIC SAMPLES—LAKE SEDIMENTATION

Halifax Lake series

Short core samples were studied to determine sedimentation rates in Halifax lakes as part of a study on the stratigraphic distribution of mercury in culturally influenced and primitive lakes in various soil types in Halifax Co. Details are in Underwood (unpub MSc thesis, Biology Dept, Dalhousie Univ). Coll and subm J K Underwood, NS Dept Environment.

DAL-111. Duncan's Lake **1240 ± 50**

Core DL-1: 75 to 79cm. Shallow pond .5 km W of Atlantic coast shoreline (44° 30′ N, 63° 33′ W).

DAL-152. Lovett Lake **2060 ± 80**

Core LVT-4: 51 to 56cm. A 15ha pond adjacent to an industrial park. *Ambrosia* horizon at 18cm, Sr-90 horizon at 10cm (44° 39′ N, 63° 42′ W).

DAL-161. Otter Lake **3380 ± 160**

Core OL-1: 80 to 90cm. Water supply lake, 94ha, ca 15km W of Halifax, NS (44° 36′ N, 63° 45′ W). No *Ambrosia* horizon as lake is remote from habitation.

General Comment (JGO): with exception of culturally influenced lakes (eg, Lovett, DAL-152), sedimentation in the Halifax area lakes is ca 4 mm/yr.

DAL-53A. Lawrence Lake, Michigan **105 ± 80**

Organic fraction of marl-rich core from Lawrence Lake, Michigan (44° 26′ N, 85° 21′ W). Sample from *Ambrosia* pollen horizon (16.5 to 20.5cm in core) to calibrate organic and marl dates previously reported (R, 1976, v 18, p 47). Coll by R O Kapp and R G Wetzel, subm by R G W. *Comment* (B A Manny): approx correct date for *Ambrosia* horizon (ca AD 1830) implies little paleozoic lime contribution to organic dates.

Wintergreen Lake series

Sediment core from central basin of Wintergreen Lake, Kalamazoo Co, Michigan (42° 24′ N, 85° 23′ W). Intensive studies on palaeolimnology, including sedimentation rates of carbon, nitrogen, phosphorus, pigments, and pollen are reported in Manny & Wetzel (1976). 4 core segments were dated independently by Wisconsin Radiocarbon Lab. No correction for marl carbonate has been applied to the determinations. Least square power curve regression [$\hat{x}$ (age) = ay^b (depth)] gives a mean error of estimate of 148 yr, excluding DAL-202 (see Lab comments below). Coll and subm by R E Bailey and R G Wetzel.

Laboratory Comment (JGO): lab suspicion of gas quality for DAL-202 confirmed by least squares regression as grounds for rejection of sample

TABLE 1

Radiocarbon and Estimated Age of Sediments, Wintergreen Lake, Michigan

Lab no.	Mean depth cm (y)	Radiocarbon* age ± σ ($\bar{x}$)	Estimated age† ($\hat{x}$)	Difference $\lvert \bar{x} - \hat{x} \rvert$	Sedimentation rate (mm/yr)
DAL-175A	2.5	125 ± 90	0	130	
DAL-175B	2.5	135 ± 95	0		
DAL-177	196	2320 ± 135	2371	51	8.27
WIS-668	233.5	3245 ± 60	3008	237	5.89
DAL-201	366	5370 ± 175	5542	172	5.23
[DAL-202**	441	5585 ± 125]	—	—	—
WIS-670	504	8820 ± 90	8563	257	4.57
DAL-203	541	9610 ± 600	9429	181	4.27
WIS-672	614	11,295 ± 110	11,120	175	4.12
DAL-205	651	11,790 ± 770	12,127	337	3.99
WIS-676	676	13,065 ± 125	12,765	300	3.92

* Core radiocarbon determinations corrected by subtracting mean surface age (−130 yr)
** DAL-202 excluded from regression
† Regression equation $\hat{x}$ (age) = ay^b (depth)
a = 1.81128
b = 1.35975 r^2 = .999

determination. Excellent agreement between independent determinations by 2 labs is reassuring confirmation of results.

Cedar Lake series

Sediment core from central basin of Cedar Lake, Lake Co, Indiana (41° 22′ N, 87° 26′ W). Part of general study of pollen stratigraphy and chronology of central Great Lakes region. Coll and subm by R E Bailey. See Table 2. *Comment* (REB): dates correspond well with established chronology and pollen sequences from central Great Lakes region. Inversion of DAL-126 and -127 are puzzling, but similar inversions are known from other sequences in region. Basal date (DAL-132) is older than expected for a sequence on the Valaraiso moraine, believed to be ca 14,500 yr BP.

Laboratory Comment (JGO): least squares power curve regression [$\hat{x}$ (age) = ay^b (depth)] shows a mean error of estimate of 1468 yr, indicating that function does not describe the sedimentary history of the system. Inspection of the results indicates a major change in sedimentary processes 8000 to 10,000 yr ago.

Everitt Lake, Digby Co, N S series

Sediment core from central basin of (9.1 m) Everitt Lake, Digby Co, NS, ca 12km E of Weymouth, NS (44° 27′ N, 65° 52′ W). Lake is headwater system, surface area 40ha with a watershed of ca 200ha and a flushing time (period for runoff and rainfall input to equal basin volume) of 18 mos. Pollen stratigraphy (at ca 50 yr intervals reported in Green (1976). Coll and subm by D Green.

DAL-207. EL-2.1:0.10cm — 104.1 ± 1.3% above modern

DAL-208. EL-2:50-60cm — 1065 ± 195

TABLE 2

Radiocarbon and Estimated Age of Sediments, Cedar Lake, Indiana

Lab no.	Mean depth cm (y)	Radiocarbon age ± σ ($\bar{x}$)	Estimated age* ($\hat{x}$)	Difference $\mid \bar{x} - \hat{x} \mid$	Sedimentation rate (mm/yr)
DAL-123	313	1410 ± 95	999	411	31.3
DAL-126	573	2820 ± 65	3505	685	10.4
DAL-127	628	2775 ± 130	4239	1464	7.5
DAL-128	718	4840 ± 160	5599	759	6.6
DAL-129	813	6270 ± 105	7247	977	5.8
DAL-130	908	11,255 ± 230	9116	2139	5.1
DAL-131	1013	12,610 ± 400	11,441	2169	4.5
DAL-132	1118	17,190 ± 400	14,041	3144	4.0

* Regression equation $\hat{x}$ (age) = ay^b (depth)
a = .006569
b = 2.07643
r^2 = .91

DAL-209. EL-2:150-160cm **3340 ± 175**

DAL-212. EL-2:450-460cm **7030 ± 340**

Curry Pond, Yarmouth, N S series

Sediment core from central basin of Curry Pond, Yarmouth Co, NS, ca 10.5km NE of Tusket, NS (43° 53′ N, 65° 51′ W). Headwater lake, 9m maximum depth, surface area 22ha. Watershed is ca 120ha and lake has flushing time of ca 7 mos. Pollen stratigraphy is reported in Green (1976).

DAL-229. CT-1:5-15cm **3770 ± 180**

DAL-232. CT-1:180-190cm **8130 ± 380**

DAL-233. CT-1:240-255cm **10,810 ± 475**

Collins Lake, Port Elgin, New Brunswick series

Sediment core from central basin of Collins Lake, 8km NW Port Elgin, New Brunswick (46° 6′ N, 64° 6′ W). Headwater Lake, 6m maximum depth with a surface area of 75ha. Watershed area is ca 225ha and flushing time is ca 12 mos. Pollen stratigraphy is reported in Green (1976).

DAL-234. CL-1:34-45cm **905 ± 90**

DAL-235. CL-1:70-84cm (28% dilution) **1150 ± 255**

DAL-236. CL-1:122-122cm **2175 ± 195**

DAL-237. CL-1:177-183cm **905 ± 170**

DAL-238. CL-1:242-256cm **5500 ± 170**

DAL-239. CL-1:306-332cm **10,215 ± 270**

Comment (JGO): review of sample preparation and gas quality does not resolve anomalous age for DAL-237.

Lake Quexil, Guatemala series

First report of a broad series of archaeological, microfossil, and biogeochemical investigations of environmental history of Guatemala. The Peten is a country of karsted limestone in which lake basins are sealed to some extent by residual clay, perhaps the result of former forest clearance, and are probably influenced to variable extent by fossil carbonate from ground water. Samples to evaluate possible carbonate error are being investigated. Without measurements in Lake Quexil of the ^{14}C content equivalent to zero age, interpretation of stratigraphic dates must be provisional. Core from Lago Quexil (16° 55′ N, 89° 48′ W). Coll and subm E S Deevey, Jr and H Vaughan, Florida State Mus, Gainesville, Florida.

DAL-223. Lake Quexil 250-255cm **2440 ± 90**

Algal gyttja. *Comment* (ESD): an acceptable date which allows correlation of this core with results from Lake Petenxil and Mayan archaeologic sequence.

DAL-224. Lake Quexil 300-305cm **4535 ± 115**

Algal gyttja. *Comment* (ESD): regardless of absolute age, this sample and DAL-223 show sec from 2.5 to 3m as one of slow sedimentation. This is consistent with results found in neighboring Lake Petenxil and is inferred to be due to an extremely low or widely fluctuating lake level.

DAL-225. Lake Quexil 520-525cm **4855 ± 120**

Algal gyttja. This date suggests anomalously low sedimentation during the period represented by the section of the core from 5.5 to 5.2m. Sedimentation rates have varied widely throughout the history of this lake because of Mayan agriculture in upper secs and of changing lake levels in secs below 2.5m. Contributions of fossil carbon from carbonates may have varied with degree of perching of water table. Without correction for carbonate, we cannot decide whether this sample is too young or DAL-226 is too old, or both.

DAL-226. Lake Quexil 550-555cm **8390 ± 260**

Algal gyttja. Small sample, counted at 38cm counting pressure. *Comment* (ESD): less than a desirable amount of carbon was available for this date; see comment for DAL-225.

DAL-227. Lake Quexil 610-615cm **13,160 ± 560**

Algal gyttja. Small sample, counted at 38cm pressure. *Comment* (ESD): lacking any indication of a possible inversion of sediments in gross stratigraphy, or in pollen record, which below this level clearly indicates a successional development of aquatic macrophytes, this date would seem erroneous due to failure to separate autocthonous organic carbon from clastic carbonate material.

DAL-198. Lake Quexil 623-624cm **8410 ± 180**

Algal gyttja and wood fragments. *Comment* (ESD): this date, from sec of sediments high in woody fragments, fungal hyphae, and other apparently allocthonous materials, apparently represents an initial postglacial filling of basin. Most other lakes of approx equal depth in Central America and Florida show a similar age for oldest sediment; we anticipated a similar case here.

II. GEOLOGIC SAMPLES—OCEAN SEDIMENTATION

Black Sea series

Continuation of series reported in OWU-V (R, 1976, v 18, p 363). Sequences compare marl and organic fraction determinations from Kasten cores.

DAL-70. Core 1464K: 45-51cm **550 ± 145**

Organic fraction of core sample previously dated as marl fraction, OWU-456A, 1410 ± 110 (43° 00′ N, 35° 28′ E).

DAL-71. Core 1464K: 74-79.5cm **55 ± 135**

Organic fraction of core sample previously dated as marl fraction, OWU-457A, 880 ± 90.

DAL-79. Core 1463K: 5-15cm **215 ± 95**

Marl sample previously dated as OWU-462A, 100.1 ± 1.3% modern (43° 00′ N, 33° 00′ E). *Comment* (WC): marl carbonate ages ca 800 yr younger than organic carbon determinations.

Mid-Atlantic Ridge series

Core samples from Mid-Atlantic Ridge locations taken during 1971 "Deep Drill" cruise of *CSS Hudson*. Coll and subm by C Stehman.

DAL-142. Core 377 **32,430 ± 4100**

Foraminiferal ooze. Sample at 580cm from 1160cm core raised from 2631m water (45° 31.8′ N, 27° 25.6′ W). Small sample, single count.

DAL-187. Core 328 **12,500 ± 250**

Formaniferal ooza from 380cm in 1070cm core raised from 2328m water (45° 36.7′ N, 27° 27.0′ W).

DAL-189. Core 464 **>39,900**

Foraminiferal ooze from 220cm in 545cm core raised from 2805m water (45° 43.7′ N, 27° 14.5′ W). *Comment* (CS): dates substantiate chronology obtained from analysis of planktonic foraminifera in 9 cores from Mid-Atlantic Ridge. Details in Stehman (1975).

Chaleur Bay series

DAL-191. Central Chaleur Bay, Core 34-5B **9480 ± 315**

Fragments of *Mytilus* and *Mya* shell from 34 to 94cm in Core 35-5B (47° 55′ N, 65° 30′ W).

DAL-192. Central Chaleur Bay, Core 34-5B **10,360 ± 450**

Samples from conspicuous shell fragment layers (*Mytilus* and *Mya*) in Core 34-5B from central Chaleur Bay (47° 55′ N, 65° 30′ W). Coll and subm by C Schaffer, Bedford Inst Oceanog.

Grand Banks Seamount series

Samples are from a long core of pelagic sediment overlying seamount in 3780m water (Piper, 1975) SW of Grand Banks (40° 28.8′ N, 51° 30.0′ W). Coll and subm by B Piper.

DAL-195. Core 72-021-6: 5-10cm **16,280 ± 320**

Globigerina ooze.

DAL-196. Core 71-021-6: 44-53cm **>35,000**

Globigerina ooze.

General Comment (DP): dates establish stratigraphy of top of core and indicate that carbonate rich interval with warm water foram assemblage at ca 1m depth corresponds to Sangamon Interglacial. Core can be correlated with other seamount cores further N for which Alam (1976) has made detailed paleoclimatic and sedimentologic analysis. Plio-Pleistocene climatic history from this suite of cores is reviewed by Alam and Piper (ms in preparation).

III. MISCELLANEOUS GEOLOGIC SAMPLES

DAL-81. Buried wood, Dovercourt, England **585 ± 115**

Wood (*Ulmus* spp) id by J G Ogden from tree trunk at Dovercourt near Harwich, Essex, England (51° 56.6′ N, 1° 16.5′ E). Sample from stump ca 50m offshore from brick and concrete retaining wall ca 5.5m below present high tide. Coll and subm by K H Mann. *Comment* (KHM): weathering of exposed trunk makes it unclear if trees are in growth position. Regularity of spacing implies planting, thinning, or emplacement as early sea wall. Date indicates very rapid submergence in this region.

DAL-240. Buried woodland, Yarmouth, N S **615 ± 85**

Wood (*Picea* spp) from stump rooted in till and surrounded by thin veneer of woody peat near Lighthouse Beach, Yarmouth, NS (43° 39′ N, 66° 10′ W). One of several stumps exposed by recent beach retreat showing root crowns ca 30cm below datum (HHWL—Higher High Water Line). Coll and subm by J G Ogden.

DAL-241. Freeport log canoe, N S **102 ± 1.2%**

From outer rings of axe-hewn log canoe exposed in dike wall breached by a severe coastal storm near Digby, NS (44° 30′ N, 66° 00′ W). Canoe was cut from log ca 61cm diam, and was ca 4m long. Coll and subm by NS Mus. *Comment* (JGO): evidence of metal axe shaping and contemporary date suggest Acadian origin.

IV. ARCHAEOLOGIC SAMPLES

DAL-116. Seid Mound, Columbus, Ohio **1720 ± 80**

Charcoal deposit (burnt stick) from Unit D, Sq 20L2, Midden layer, S central portion of sq at Seid Mound (State Memorial Park Excavation). From 0.54m below Stake 30. Coll and subm by R S Baby, Ohio State Mus.

DAL-141. Incinerator Village site **295 ± 100**

Storage pit charcoal from Fort Ancient House site, Sec 17, Harrison twp, Montgomery Co, Ohio (39° 43′ N, 84° 14′ W). Sample id as ring-porous angiosperm (not oak, G W Burns). Coll by B J Smith, and subm by R S Baby. *Comment* (RSB): date is in line with UGa determination

(270 ± 120) for 46Pu31, the Buffalo site, a late Fort Ancient village site in West Virginia.
Laboratory Comment (JGO): sample is re-run of OWU-397 (R, 1973, v 15, p 365) which indicated post-1950 AD. Extensive leaching with hot 5% KOH apparently removed modern contamination.

DAL-242. Truro fireplace **440 ± 90**

Charcoal in Fireplace #10, 38 to 46cm below present land surface stripped by housing development (ca 30cm removed), at crest of hill, +70m, near Truro, Colchester Co, NS (41° 22′ N, 63° 17′ W). Coll and subm by C M Shipley. *Comment* (CMS): one of several fireplaces constructed of rock with apparent mortaring of joints.

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[RADIOCARBON, VOL. 19, NO. 3, 1977, P. 400-423]

HARWELL RADIOCARBON MEASUREMENTS II

R L OTLET

Nuclear Physics Division, Atomic Energy Research Establishment, Harwell, Oxfordshire, England

Since publication of Harwell I (R, 1974, v 16, p 178-191) the laboratory has been officially set up to operate a commercial radiocarbon dating service. To accommodate an increased number of samples the combustion and benzene synthesis rigs have been rebuilt as simultaneously-operated twin-line systems.

Detail modifications in the techniques of combustion and benzene synthesis have enabled a faster throughput while maintaining reliable yields. On the combustion rig, platinized catalyst pellets, Engelhard type 'M', are now used in the after-burner in place of copper oxide wire. The catalyst is particularly efficient in the oxidation of volatile hydrocarbons (Griffen *et al*, 1973). Improved combustion is demonstrated by the absence of deposit in the glass outlet lines and by the reproducibility of $\delta^{13}C$ test samples from product CO_2. Examination of the $\delta^{13}C$ results from 16 sets of paired replicate burns on a variety of wood/charcoal samples showed an average difference of less than 0.3‰ between attempts. In dry combustion of NBS oxalic acid the mean of all samples to date (15) is 19.25 $\pm$ 0.19‰ (1σ, standard deviation).

The acquisition of a VG Micromass model 602C has enabled $\delta^{13}C$ measurements to be made on all samples dated in this laboratory.

Since Sept 1973 we have also been using a new catalyst base material, obtained from J A Heslop, Petrochemicals Division, ICI, England, for the benzene synthesis. The catalyst, activated with V_2O_5, can be used in the trimerization stage exactly as before. Apart from giving a slightly higher and more reliable yield, ca 96%, two important advantages are:

(a) the acetylene can be applied very quickly (125g catalyst at 0°C will take 5L C_2H_2 down to less than 1 torr in ca 20 mins) and

(b) it can be used repeatedly with no apparent fall-off in yield even after 12 months of daily use. Memory effects are minimized by treating the catalyst to ca 300°C under vacuum, overnight, between samples. Care is also taken to remove any signs of visible aromatic deposit (Coleman *et al*, 1972, p 165) which appears around the neck of the containing vessel after repeated usage. Polach *et al* (1972, p 150), although not mentioning this deposit, have reported similarly for repetitive use of their catalyst.

Sample make up, using the proprietory benzene based scintillator (NE231A) and the method of sealing using specially ground vial tops with an indium washer, as described in HAR I, has continued to be employed.

As before, ages are calculated using the Libby half-life of 5568 years and 0.95 NBS oxalic modern standard with AD 1950 as reference year.

Errors quoted are the 1σ estimate of the accuracy of the full laboratory measurement, *ie*, based on the expected replicate sample reproducibility — not merely counting statistics. The procedure by which the estimates are assessed will be described elsewhere (Otlet, 1977, mss in preparation).

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I. ARCHAEOLOGIC SAMPLES

A. British Isles

HAR-233. WC 1970, Pit 8, H2 **5680 ± 120**

$\delta^{13}C = -26.1‰$

Charcoal from upper of 2 hearths within basal filling of Mesolithic pit at Wakefords Copse, Havant, Hampshire, England (50° 52′ 38″ N, 0° 58′ 10″ W, NGR: SU72780914). Coll 1970 by E Lewis; subm 1972 by R J Bradley, History Dept, Univ Reading, England (Bradley & Lewis, 1974). *Comment* (RJB): dates lower filling of 1 of at least 9 Mesolithic pits recorded in salvage excavation and interpreted as bases of winter shelters. Pit 8 produced a few flints fitting a later Mesolithic date.

HAR-234. Hog Cliff Hill, E 105 & E 121 **2490 ± 70**

$\delta^{13}C = -25.0‰$

Charcoal, from pit ca 45cm deep containing black soil and charcoal (E 105, AML 60471) and from base of posthole ca 30cm deep, below soil and flints (E 121, AML 60472), from Hog Cliff Hill, Maiden Newton, Dorset, England (50° 44′ 58″ N, 2° 31′ 47″ W, NGR: SY625966). Coll June 1960 by P A Rahtz; subm Dec 1972 by S Limbrey, Ancient Monuments Lab, London. *Comment* (PAR): date confirms relationship of site to others in Dorset, notably Maiden Castle sequence, and supports generally 'early' date assigned to pottery which includes classic haematite wares.

HAR-235. Woodbury Castle WDC 71 58-35 **1930 ± 200**

$\delta^{13}C = -24.0‰$

Charcoal, AML 710069, from pit in old land surface beneath hillfort rampart at Woodbury, Devon, England (50° 40′ 33″ N, 3° 21′ 52″ W, NGR: SY033875). Pit was apparently cut immediately before rampart construction and was sealed by rampart material to ca 45cm. Coll Sept 1971 by H Miles; subm Dec 1972 by S Limbrey. *Comments*: small sample accounts for large error term. (HM): on evidence from pottery and nature of earthwork, a construction date ca 200 BC was expected. Further dates may fix true date more precisely but this result is not inconsistent with expected age.

Carn Euny series

Charcoal samples from Carn Euny site, Sancreed Parish, West Penwith, Cornwall, England (50° 6′ N, 5° 38′ W, NGR: SW403288) (Christie, 1965-70, 1973). Coll Aug 1970 & Aug 1972 by P M Christie; subm Dec 1972 by S Limbrey.

HAR-237. F122 **1740 ± 70**
$\delta^{13}C = -25.3‰$

Charcoal (*Quercus* sp) AML 700191, from base of thick charcoal layer below soil and stones. Pit ca 53cm deep cut into subsoil, sealed by ca 50cm accumulation of soil. *Comment* (PMC): younger than expected but acceptable, confirms suspected late date of pit from which sample came.

HAR-238. F140 **2370 ± 70**
$\delta^{13}C = -26.2‰$

Charcoal (*Quercus* sp) AML 725418, from trench cut into subsoil, above ash layer, sealed by ca 45cm of humic soil beneath paving stones, with further accumulation of soil above pavings. *Comment* (PMC): sample, which comes from a pre-courtyard house phase, is surprisingly early. In view of context and its assoc with decorated potsherds of a type so far unknown on site, there is good reason for accepting it as earliest Iron age occupation.

Grindale Barrow series

Grindale Barrow I (54° 07′ 0″ N, 0° 14′ 31″ W, NGR: TA151707) is 1 of 3, plough-levelled, round barrow sites in Grindale parish and adjoining Boynton parish, Bridlington, Humberside, England (Manby, 1977). Dating was to confirm 2 phases of construction indicated by ditch system surrounding a central pit feature. Phase I ditch, a deep oval enclosure, had apparently silted up almost to its top before burnt timber structure collapsed into hollow Phase II ditch. Samples subm 1972 by T G Manby, Doncaster Mus & Art Gallery.

HAR-266. Grindale Barrow I, Sample 1 **4510 ± 90**
$\delta^{13}C = -26.5‰$

HAR-267. Grindale Barrow II, Sample 2 **4470 ± 120**
$\delta^{13}C = -22.5‰$

Charcoal samples from burnt and fallen timber feature resting on silted up inner ditch, Phase II of site.

HAR-269. Grindale Barrow I, Sample 3 **4910 ± 120**

$\delta^{13}C = -25.0‰$

Antler of red deer resting on floor of inner ditch, probably contemporary with digging. *Comment*: attempt was made to remove all traces of PVA with which antler had been painted before submission for dating.

General Comment (TGM): date for Phase I (Sample 3) compares well with previous date of Willerby Wold A, long barrow 2950 ± 150 BC (BM-188, R, 1969, v 11, p 287). Phase II dates (Samples 1 & 2) are closely contemporary and place monument in Neolithic period. Depth of Phase I ditch silting supports considerable duration before Phase II event.

HAR-268. Boynton Barrow 1, High Easton Farm **4840 ± 80**

$\delta^{13}C = -27.2‰$

Charcoal from in-filling of a central 'henge' type feature with opposed entrances at above site, Boynton, Nr Bridlington, Humberside, England (54° 07′ 02″ N, 0° 13′ 50″ W, NGR: TA159708). Coll & subm 1973 by T G Manby (1977). *Comment* (TGM): site is round barrow levelled by cultivation, early date indicated by fragments of Peterborough Ware vessels high up in silting of surrounding quarry ditch. Unweathered state of sides of trench shows it could not have stood open for more than a few weeks. Date of inner trench comparable with dating from Kilham long barrow, 2880 ± 125 BC (BM-293, R, 1971, v 13, p 293) if not as old as Grindale Barrow I, Phase I, ditch.

Milton Keynes series

Samples from several sites excavated under aegis of Milton Keynes Development Corp at Milton Keynes, Buckinghamshire, England (Green, 1974a, b). Unless otherwise noted, all samples coll 1972; subm 1973 by H S Green.

HAR-339. Pit 1 (MK23) **2790 ± 70**

$\delta^{13}C = -23.3‰$

Charcoal from Pit 1, N W quad of Hartigans Gravel Pit (52° 02′ 18″ N, 0° 43′ 05″ W, NGR: SP88183864). *Comment* (HSG): satisfactorily dates assoc Late Bronze age pottery.

HAR-340. Primary Burial (MK24) **3670 ± 80**

$\delta^{13}C = -24.0‰$

Human bone, crouched inhumation of elderly female from grave pit centrally placed in ring ditch at Little Pond Ground, Wolverton (52° 03′ 18″ N, 0° 50′ 10″ W, NGR: SP80124053). *Comment* (HSG): satisfactorily dates grave group consisting of Step 3 beaker and 1 double pointed copper awl.

HAR-341. Secondary burial (MK13) **2990 ± 80**

$\delta^{13}C = -21.2‰$

Human bone from secondary crouched inhumation of female placed on ditch silt under cairn at Warren Farm, Wolverton (52° 03′ 23″ N, 0° 49′ 55″ W, NGR: SP80334074). *Comment* (HSG): post-dates clearance horizon represented by charcoal spread 10cm below skeleton and dated to 1500 ± 90 BC (I-7148 not pub in *Radiocarbon* up to 1976). Date is acceptable.

HAR-471. (MK21-39) **3290 ± 160**
$\delta^{13}C = -26.8‰$

Charcoal from Cotton Valley Farm (52° 03′ 30″ N, 0° 42′ 45″ W, NGR: SP88504091). Samples taken from possible clearance horizon, or hearth, represented by a charcoal spread at depth 0.90m, 0.07m above floor of ring ditch. Coll 1971 by A Sandford. *Comment* (HSG): stratigraphy of sample suggests it is virtually contemporary with construction of ring ditch. Provides *terminus ante quem* for central (primary) cremation in a Collared Urn of Longworth's Primary series. Date is acceptable.

Rackham series

Rackham Common, Rackham, West Sussex, England (50° 55′ 30″ N, 0° 30′ 10″ W, NGR: TQ04901520) (Holden & Bradley, 1975, Dimbleby & Bradley, 1975). Coll by E W Holden; subm 1973 by R J Bradley.

HAR-359. Rackham 1970 Area I **2300 ± 100**
$\delta^{13}C = -24.6‰$

Charcoal. Bulked sample from charcoal spread assoc with flint industry of late Neolithic (Beaker) character. Included contents of one small hearth.

HAR-360. Area II **3950 ± 140**
$\delta^{13}C = -22.1‰$

Charcoal. Bulked sample from hearths assoc with flint industry of late Neolithic character.

General Comment: both samples should date a flint industry of late Neolithic character apparently in a forest clearing assoc with sub-Boreal pollen. HAR-359 appears substantially too young, not compatible with HAR-360 which conforms well with expected date. HAR-359 was probably contaminated, in fact both samples contained large quantities of modern rootlets. The hearth might also reflect later re-occupation in Iron age.

Crickley Hill series

Samples from Crickley Hill, Gloucestershire, England (51° 50′ 33″ N, 2° 6′ 20″ W). Coll 1973 by C Anderson unless otherwise stated; subm Sept 1973 by P W Dixon, Classical Archaeol Studies Dept, Univ Nottingham, England (Dixon, 1976).

HAR-391. Cl-366 **2520 ± 90**

Charcoal from Posthole 10: Oak gate post, 20 to 25cm diam originally, from final entrance to hillfort, Period 3B (Dixon, 1972).

HAR-392. C2-A1X9 **2590 ± 60**
$\delta^{13}C = -24.6‰$

Charcoal from lowest tier, small brushwood sample (raft in timber lacing) of timber-laced ramparts, of 1st hillfort, Period 2.

HAR-393. C3A1X9 **2310 ± 70**
$\delta^{13}C = -23.4‰$

Charcoal adjacent to HAR-392 and of identical character.

HAR-394. C4AXIV15 **2350 ± 80**
$\delta^{13}C = -23.1‰$

Charcoal from same layer as HAR-392 and -393. Coll Aug 1973 by A Pandrich.

Fengate 1973 series

Samples from an extensive Neolithic/BA site at Fengate, Peterborough, England (52° 34′ 58″ N, 0° 13′ 12″ W, NGR: TL212987). Coll and subm by F M M Pryor, Field Dir, Royal Ontario Mus/Nene Valley Research Comm Fengate excavations.

HAR-397. B24(1) **3980 ± 100**
$\delta^{13}C = -25.4‰$

Carbonized wood from small pit filled with domestic refuse, directly beneath top soil, cut into C soil horizon; contained many sherds of later Neolithic Grooved Ware and flint work.

HAR-399. B61(1) **3970 ± 70**
$\delta^{13}C = -24.4‰$

Carbonized wood from small domestic refuse pit, stratigraphically as HAR-397, above; contained many sherds of Grooved Ware and contemporary flint work.

HAR-404. Y12(1) **3880 ± 80**
$\delta^{13}C = -24.9‰$

Carbonized wood from another small refuse pit, stratigraphically as HAR-399, above, and containing similar finds.

HAR-409. W32(1) **3810 ± 150**
$\delta^{13}C = -24.6‰$

As HAR-399 above, but different pit.

HAR-401. Y4(1) **3960 ± 90**
$\delta^{13}C = -21.9‰$

Carbonized wood from large back-filled pit containing domestic refuse; sherds of Grooved Ware and numerous flint scrapers and waste flakes, together with leg bones of *Bos taurus* and *Bos primigenius*.

HAR-406. 1VW17(5) **3290 ± 80**
$\delta^{13}C = -21.3‰$

Waterlogged wood, dried before submission, from part of a stake from base of large pit assoc with ring ditch.

HAR-400. W2 **3410 ± 120**
$\delta^{13}C = -19.6‰$

Carbonized/burnt wood sample taken from charcoal separated from calcined bone fragments found inside a plain Secondary Series Collared Urn within a secondary turf mound in the center of a ring-ditch.

HAR-398. 11B3(5) **3000 ± 70**
$\delta^{13}C = -28.4‰$

Waterlogged wood twigs, dried before submission, taken from wattle lining at bottom of a well.

General Comment (FMMP): dates for carbonized wood samples, HAR-397, -399, -401 and -409 fall well within age range expected and are consistent with other dates for this ceramic style in Great Britain. HAR-400, together with HAR-406 provides dating for latest phase of late Neolithic/BA settlement. Since wells probably remained in use after main settlement had moved elsewhere, HAR-398 result should provide a sound *terminus ante quem* for settlement dated by other samples in this series.

HAR-395. Shelford **3480 ± 70**
$\delta^{13}C = -25.9‰$

Charcoal from Shelford, Nottinghamshire, England (52° 58′ 5″ N, 1° 1′ 35″ W, NGR: SK658419) from an unurned cremation at center of a ring ditch in a pit dug into gravel sub-soil with no trace of barrow mound (Revill, 1974). Coll and subm by S Revill, Archaeol Sec, Thoroton Soc Nottinghamshire. *Comment* (SR): date agrees with interpretation of assoc flint artifacts and is important because of absence of pottery.

Hereford Castle series

Charcoal and human bone from Saxon burial ground underneath Hereford Castle Bailey, Hereford, England (52° 03′ N, 2° 42′ 30″ W, NGR: SO512395). Coll and subm by R Shoesmith.

HAR-413. Sample A **960 ± 70**
$\delta^{13}C = -25.6‰$

Charcoal from Burial S80.

HAR-414. Sample B **1030 ± 80**
$\delta^{13}C = -26.0‰$

Comment (RS): two charcoal samples taken from charcoal bed underlying burials — similar types of burial from Winchester, York, Exeter and Oxford.

HAR-985. S85 **1250 ± 70**
$\delta^{13}C = -20.1‰$

Human bone from E-W burial underneath charcoal burial S80. *Comment* (RS): possibly earliest burial on site.

HAR-986. S46 **890 ± 80**
$\delta^{13}C = -19.8‰$

Human bone from E-W burial on bed of charcoal sealing foundations of E-W building with stone footings which could be St Guthlac's Church.

HAR-988. S10 **820 ± 70**
$\delta^{13}C = -19.5‰$

Human bone from E-W burial in stone cist. *Comment* (RS): one of latest burials on site but burial ground possibly still in use within Castle.
General Comment (RS): stratigraphic and historic sequence fits well with measured dates of this series.

All Saints series

Samples from All Saints Church, Oxford, England (51° 44′ 43″ N, 1° 15′ 22″ W, NGR: SP51500625) (Hassall & Durham, 1974). Coll and subm by B G Durham.

HAR-418. Sample 196 **920 ± 70**
$\delta^{13}C = -27.2‰$

Human bone, long bones, of earlier burial related to medieval church; found laid across a back-filled domestic cellar pit which was still actively subsiding. *Comment* (BGD): burial was thought to be stratigraphically later than an Edward the Confessor coin (1042-66).

HAR-419. Sample 184 **980 ± 70**
$\delta^{13}C = -27.2‰$

Charcoal from charred wattle fence, from layer which sealed HAR-466, and was itself sealed by further Saxon domestic layers and by the medieval church. *Comment* (BGD): result agrees well with provisional dating of site.

HAR-466-I. Sample 205 **1060 ± 70**
$\delta^{13}C = -21.9‰$

HAR-466-II. **1070 ± 80**
$\delta^{13}C = -22.1‰$

Charred grain (largely wheat, *Triticum aestiuum*) mixed with loam overlying original top soil. Sealed by Saxon domestic layers and medieval church. *Comments*: HAR-466-II analyzed as completely separate replicate sample check. (BGD): results agrees well with provisional date of site.

Balksbury Camp series

Site of Iron age hillfort, Balksbury Camp, Andover, Hampshire, England (51° 11′ 55″ N, 1° 30′ W, NGR: SU351446). Coll by G J Wainwright; subm Oct 1973 by H Keeley, Ancient Monuments Lab, London.

HAR-442. BCI-10 **2740 ± 170**
$\delta^{13}C = -22.9‰$

Antler pick, AML 736655, from base of Phase 1 rampart which should relate to construction of defenses.

HAR-443. 500-5/8 **1310 ± 100**
$\delta^{13}C = -25.3‰$

Charcoal, AML 736656, bulked sample from bell-shaped storage pit. *Comment* (GJW): age was expected to compare with HAR-442; contamination of bulked sample is suspected.

HAR-444. 36/6 **2140 ± 80**
$\delta^{13}C = -25.2‰$

Charcoal, AML 736657, from a bell-shaped storage pit assoc with pottery of Middle Iron age type.

HAR-445. 182/4 **2000 ± 80**
$\delta^{13}C = -24.1‰$

Charcoal, with mud, AML 736657, from storage pit as HAR-444.

HAR-446. 106/4 **2180 ± 150**
$\delta^{13}C = -25.1‰$

Charcoal, with mud, AML 736657, from storage pit as HAR-444.

HAR-461. RH 1973 (on base of 1.25) **2980 ± 70**
$\delta^{13}C = -24.6‰$

Charcoal immediately sealed by large chalk rubble in filling (interpreted as demolished facing of earlier rampart) of the BA enclosure ditch at Rams Hill, Kingston Lisle, Oxfordshire, England (51° 34′ 23″ N, 1° 32′ 55″ W, NGR: SU315864). Coll by R J Bradley and A Ellison; subm 1973 by R J Bradley (Bradley & Ellison, 1975). *Comment* (RJB): this is the 6th date for Rams Hill sequence (*cf* R, 1974, v 16, p 181-82). It provides a *terminus ante quem* for digging and early silting of 1st BA enclosure ditch and may be correlated with reconstruction of rubble rampart to site in timber. It agrees well with HAR-232: 3010 ± 70 BP (R, 1974, v 16, p 182) for charcoal assoc with material packing posts of this rebuilt rampart.

Breiddin hillfort series

Samples from Breiddin hillfort, Montgomery, Powys, Wales (52° 43′ 15″ N, 3° 2′ 45″ W, NGR: SJ292144). Coll and subm by C R Musson, Clwyd-Powys Archaeol Trust (Musson, 1970, 1972).

HAR-467. H1 **2410 ± 100**

$\delta^{13}C = -24.4‰$

Charcoal throughout postholes of Roundhouse B37 porch inside hillfort, from collapsed packing and post-pipes.

HAR-468. H2 **2190 ± 80**

$\delta^{13}C = -25.1‰$

Charcoal from combination of small samples from 13 postholes belonging to the 4-posted Bldgs B31, B36, B37 and B50 inside hillfort. Samples were drawn from collapsed packing and post-pipes. *Comment* (CRM): probably attributable to same occupation phase as HAR-469.

HAR-469. H3 **2120 ± 70**

$\delta^{13}C = -26.0‰$

Charcoal from post-pipe of posthole belonging to a 'pair' of posts in B36 inside hillfort.

HAR-474. Sample 3 **3260 ± 70**

$\delta^{13}C = -25.4‰$

Wood, tree roots (*Pinus sylvestris*) probably corresponds to sub-Boreal or late Atlantic pine woodland from Shieldaig, Wester Ross, Scotland (57° 30′ 50″ N, 5° 39′ 50″ W, NGR: NG81625231). Roots occur in superficial peat unit (Layer 2) and underlying sand unit (Layer 3). Coll and subm Oct 1973 by M J Walker, Dept Anthropol, Univ Sydney, New South Wales, Australia. *Comment* (MJW): date required to give better age estimate for layer in which prehistoric lithic artifacts were found. Previous results (R, 1974, v 16, p 185). HAR-163, 3720 ± 525 BP, from same stratigraphic unit, had excessive error margin and HAR-157, 4030 ± 120 BP from a surface wood sample was less securely stratified. Over-all, dates are acceptable for period of pine forest cover at site, they are later than underlying battered-back quartz microliths among a unit characterized by river pebbles in dunar sand corresponding to maximal marine transgression of post glacial times, perhaps ca 6500 BP or slightly later.

Llanstephan Castle series

Llanstephan Castle, Carmarthen, Dyfed, Wales (51° 45′ 45″ N, 4° 22′ 40″ W, NGR: SN351101) stands on a promontory cut off by a complex series of earth-works thought to be of prehistoric origin. Samples coll 1971-73; subm Nov 1973 by G Guilbert, Clwyd-Powys Archaeol Trust (Guilbert & Schweiso, 1972; Guilbert, 1974).

HAR-475. L1042 **2450 ± 90**

$\delta^{13}C = -25.3‰$

Charcoal from shallow trench/ditch at front of Bank C probably relating to original timber-revetted construction of that bank.

HAR-476. L1068 **2460 ± 70**
$\delta^{13}C = -25.0‰$

Charcoal from primary silt in deep U-shaped Ditch X, which possibly antedated timber-fronted rampart assoc with HAR-475.

HAR-477. L7115 **2470 ± 70**
$\delta^{13}C = -25.8‰$

Sample from charcoal-laden occupation soil with postholes sealed beneath primary earthwork of 12th century AD ring and bailey Castle.

General Comment (GG): dates for 3 charcoal samples, HAR-475-477, demonstrate that castle stands within Iron age hillfort and are invaluable to excavation in view of total absence of dateable artifacts in these levels. 6th to 5th century BC dates of HAR-475 and -476 are consistent with assoc Iron age timber-fronted form of rampart.

HAR-478. Ascot 1973, Sample I **3430 ± 70**
$\delta^{13}C = -27.8‰$

Charcoal of scattered ash from surface of turf line, under a bell barrow, sealing a series of possible furrows in buried soil and assoc with a phase of high cereal pollen. From Heatherwood Hospital, Ascot, Berkshire, England (51° 24′ 30″ N, 0° 41′ 30″ W, NGR: SU914687). Coll and subm 1973 by R J Bradley (Bradley & Keith-Lucas, 1975). Comment (RJB): gives *terminus post quem* for bldg of EBA-type bell barrow. *Terminus ante quem* for episodes of clearance and cultivation beneath or close to mound.

Brixworth series

Samples from excavations at Brixworth vicarage garden, some 70m W of church, Brixworth, Northamptonshire, England (52° 20′ 8″ N, 0° 54′ 17″ W, NGR: SP74607125). Coll July 1972 by P Everson; subm by H Keeley (Everson, 1973).

HAR-483. Major Ditch,
Samples BX72JB and BX72JT **1250 ± 80**
$\delta^{13}C = -21.5‰$

Animal bone from primary fill. *Comment* (PE): date, even as corrected to AD 700-720 on MASCA recalibration (Ralph *et al*, 1973), confirms excavator's opinion that feature was Saxon rather than pre-Roman and was boundary ditch of Saxon monastic precinct. Date also tends to support traditional late 7th century date for foundation of monastery.

HAR-484. Skeleton 10, BX72JF **1150 ± 70**
$\delta^{13}C = -19.8‰$

Human bone buried in natural sub-soil, W-E orientation, with no grave goods, stratified below 12th century and later medieval deposits. *Comment* (PE): corrects on MASCA recalibration (Ralph *et al*, 1973) to AD 830-850. Significance same as HAR-485, below.

HAR-485. Skeleton 1, BX72BM **1200 ± 80**
$\delta^{13}C = -20.0‰$

Human bone buried in natural sub-soil, W-E orientation with no grave goods. *Comment* (PE): date corrected on MASCA recalibration (Ralph *et al*, 1973) to AD 770-790, confirms relationship of burials to boundary ditch and establishes that they belong to a monastic period rather than later parochial burial ground.

HAR-486. Samples 1 & 2 **3720 ± 90**
$\delta^{13}C = -26.2‰$

Result of combination of 2 charcoal samples, a few cm apart, from original ground surface beneath remains of mound of round barrow at Harpley, Norfolk, England (52° 49′ 30″ N, 0° 36′ 10″ E, NGR: TF762279). Coll Oct 1973 by A J Lawson; subm Nov 1973 by H Keeley. *Comment* (AJL): charcoal found in same horizon as Collared Urn sherds and both offer a *terminus post quem* for construction of barrow.

Brenig series

Samples from a principally Bronze age site at Brenig, Glyndwr, Clwyd, Wales (53° 05′ N, 3° 30′ W, NGR: SH983572), threatened by construction of a new reservoir (Lynch *et al*, 1974). Coll 1973 by F Lynch & F A Hibbert; subm Jan 1974 by F A Hibbert.

General Comment (FAH): samples were from Ring Cairn, Brenig 44, believed to have had 3 periods of major activity lasting about 400 yr. Its use for burials may have been secondary.

HAR-500. 295 **3490 ± 70**
$\delta^{13}C = -25.6‰$

Charcoal from central cremation. *Comment* (FAH): burial dated here appears later than the first phase of construction, HAR-501, suggesting its secondary use for burial. Second phase of activity.

HAR-501. 328 **3630 ± 100**
$\delta^{13}C = -25.8‰$

Charcoal from F47. *Comment* (FAH): dates charcoal spread on original pared ground surface. Dates 1st of charcoal pits dug against face of ring in 1st phase of major activity.

HAR-502. 314 **3470 ± 70**
$\delta^{13}C = -25.7‰$

Charcoal from plank incorporated in outer bank. *Comment* (FAH): 2nd phase of activity.

HAR-503. 234 Brenig 44 **3230 ± 70**
$\delta^{13}C = -25.9‰$

Charcoal from F20 surrounding urns.

HAR-504. 154 **3290 ± 80**

$\delta^{13}C = -26.2‰$

Charcoal from F6; dug into top of inner bank. *Comment* (FAH): dates last burial at close of major activity at site. Third phase of activity.

HAR-505. 162 **3470 ± 80**

$\delta^{13}C = -25.8‰$

Charcoal from Layer 2 of inner bank. *Comment* (FAH): sample dates 2nd period of activity on outer bank.

Beacon Hill series

Human bone taken from Beacon Hill Cemetery, M40, Site 12, Beacon Hill, Nr Lewknor, Oxfordshire, England (51° 40′ 13″ N, 0° 57′ 14″ W, NGR: SU722972) from grave pits cut into chalk ca 0.8m from top soil (Chambers, 1973). Coll May 1972 & subm 1974 by R A Chambers.

HAR-506. Grave 14 **1130 ± 70**

$\delta^{13}C = -19.9‰$

HAR-507. Grave 33 **1090 ± 90**

$\delta^{13}C = -20.7‰$

Wicken Bonhunt series

Anglo-Saxon settlement (Wade, 1974) at Wicken Bonhunt, near Newport, Essex, England (51° 58′ 55″ N, 0° 12′ E, NGR: TL511335). Planks, up to 2.7m long and 0.3 wide, from lining of shaft, which contained Middle Saxon pottery, of Well 2/Phase 1. Samples coll 1972 by R Carr and S Dunmore; subm Oct 1973 and Jan 1974 by J M Fletcher, Research Lab for Archaeol & Hist Art, Oxford Univ. Growth allowances estimated from tree-ring examination by JMF.

HAR-512. Sample 1 **1195 ± 63**

$\delta^{13}C = -25.8‰$

Wet heartwood oak covering 15 annual rings from plank East 1, growth allowance 65 ± 10 yr.

HAR-513. Sample 2 **1200 ± 70**

$\delta^{13}C = -26.7‰$

Heartwood oak, dried before submission, covering 15 annual rings from plank East 2, growth allowance 40 ± 10 yr.

General Comment (JMF): after calibration (Damon *et al*, 1972) and application of growth allowance, corrected values are AD 845 ± 70 and AD 815 ± 75, respectively. The mean, AD 830 ± 50, places construction of well in Middle Saxon period. The planks, having been cut 'through and through', had insufficient growth rings for dating by dendrochronology.

Coed-y-Bwnydd series

Samples from excavations at the hillfort Coed-y-Bwnydd, Bettws Newydd, Gwent, Wales (51° 45′ 30″ N, 2° 55′ 10″ W, NGR: SO365068).

Two samples are charcoal from carbonized remains of wattle wall framework, wattle and daub structure, of 2nd phase of same Roundhouse L15 (Babbidge, 1970-71). Coll Aug 1971 & subm March 1974 by A V Babbidge.

HAR-546. Sample 1 **2390 ± 70**
$\delta^{13}C = -25.9‰$

HAR-547. Sample 2 **2350 ± 90**
$\delta^{13}C = -25.8‰$

Lloyds Bank site, Pavement, series

Three samples, from 50-yr intervals of 180-yr tree-ring sequence based on 3 oak (*Quercus* sp) planks, from early Medieval site beneath Lloyds Bank extension at Pavement, York (53° 57′ 30″ N, 1° 4′ 30″ W, NGR: SE604518). Site has also been studied for its fauna and flora (Anon, 1973; Buckland *et al*, 1974). All samples coll by York Archaeol Trust, winter 1972/73, and subm by R A Morgan, March 1974.

HAR-548. Sample 1 **1090 ± 60**
$\delta^{13}C = -26.2‰$

From planks at Level 23, Rings 40 to 60 (AML 740628).

HAR-549. Sample 2 **1170 ± 80**
$\delta^{13}C = -26.2‰$

From planks at Level 23, Rings 90-110 (AML 740629).

HAR-550. Sample 3 **1130 ± 80**
$\delta^{13}C = -26.4‰$

From 3 planks at Levels 23(2) and 21(1), Rings 140-160 (AML 740630).

General Comment: R A Morgan accepts that all 3 dates fit expected site chronology. Originally, possible reversal of Samples 1 and 3 was suggested but was considered unlikely. Such an explanation is unnecessary since extreme values are not inconsistent with dendrochronology when quoted standard deviations are properly analyzed.

Colwick Hall series

Wood from excavations of medieval weir (Salisbury, 1974) at gravel pit at Colwick Hall, Colwick, Nottingham, England (52° 56′ 40″ N, 1° 06′ 20″ W, NGR: SK604388). Coll and subm 1974 by C R Salisbury, Nottingham Historical Arts Soc.

HAR-552. Sample 1 **820 ± 70**
$\delta^{13}C = -26.8‰$

Wood (oak), AML 741282, from one of several hundred posts averaging 2m long and 10 to 15cm diam from 5m below gravel pit surface.

HAR-846. Sample 2 **860 ± 60**
$\delta^{13}C = -28.6‰$

Wood, AML 748280, probably willow (wattle) from ca 3m below gravel pit surface.

General Comment (CRS): v-shaped alignment of posts and wicker work in buried water course of River Trent was possibly a weir and/or fish trap.

HAR-560. Pile Sample **860 ± 80**
$\delta^{13}C = -26.8‰$

Wood (*Fagus sylvatica*) from piles adjacent to Bramber Medieval Bridge, West Sussex, England (50° 53′ 55″ N, 0° 18′ 5″ W, NGR: TQ18971062) found 3m below surface of alluvium (Holden, 1975). Coll & subm by E W Holden. *Comment* (EWH): archaeologically, piles should be late Saxon or early Norman. Radiocarbon date very satisfactory.

General Comment: timber sample dendrochronologically examined by J M F Fletcher. No growth allowance was deemed necessary for actual sample analyzed for Carbon-14.

Moel-y-Gaer series

Samples from excavations on Iron age hillfort site Moel-y-Gaer, Rhosesmor, Clwyd, North Wales (53° 12′ 45″ N, 3° 11′ W, NGR: SJ212691). Coll June 1973; subm May 1974 by G Guilbert.

HAR-603. MO476 **2190 ± 80**
$\delta^{13}C = -27.2‰$

Soil, brown silt containing charcoal, from deposit of twigs sealed beneath tail of 2nd rampart.

HAR-604. MO3 Front Gully **2530 ± 90**
$\delta^{13}C = -26.3‰$

Charcoal from packing of foundation trench for front revetment timbers of 1st timber-framed rampart of hillfort.

HAR-605. MO467 **3590 ± 80**
$\delta^{13}C = -25.6‰$

Charcoal from occupation dirt within rectilinear area sealed beneath Iron age rampart.

HAR-606. MO468 **2570 ± 70**
$\delta^{13}C = -26.0‰$

Charcoal from occupation soil of Post-Ring Round-House sealed under 1st rampart.

General Comment (GG): taking dates in order, HAR-605, 1640 BC, is no surprise, since there is a scatter of late Neolithic to EBA artifacts (notably flint arrow heads) across the whole ~6000 sq m area excavated. HAR-604, 580 BC, and HAR-606, 620 BC, are compatible within themselves and with dates from similar rampart excavations. HAR-603 provides *terminus post quem* for construction of 2nd rampart and is acceptable stratigraphically.

Somerset Levels series

The Somerset Levels comprises an area of low-lying land between Quantock Hills and Mendips in Somerset, England. Archaeol area, described by Coles (1975), covers 14 × 5km where Levels comprise stratified peats resting upon a more or less uniformly marine clay. Peat deposits began ca 3500 BC and continued throughout ca 4000 yr. Man's presence during this period has been successively discovered in recent yr from workings of commercial peat companies, with whose cooperation, comprehensive investigations in archaeol, palaeobot, and dendrochronol have been possible. The 10 dates fit into a set of 70 dates listed by Coles & Coles (1975) and refer principally to wood from newly discovered trackways. Unless otherwise stated, samples were coll during 1969-1974 and subm 1974 by J M Coles, Dept Archaeol, Cambridge.

HAR-649. SLP74.4 (Chilton 1-2) **4760 ± 80**
$\delta^{13}C = -28.2‰$

Wood (*Betula*), AML 744082, from horizontal timbers under 0.5m peat in large series of trackways leading to important Neolithic settlement at Chilton Moor (51° 11′ N, 2° 53′ 30″ W, NGR: ST387428) (Coles *et al*, 1970). Coll 1969 by J M Coles and F A Hibbert. *Comment* (JMC): sample from adjacent trackway dated BP 4760 ± 65 refers to unusual bifurcation in trackway construction.

HAR-650. SLP74.5 (Skinners Wood) **2630 ± 70**
$\delta^{13}C = -25.9‰$

Wood (*Fraxinus*), AML 744084, from vertical peg under ~1m peat at Skinners Wood, Shapwick Heath (51° 09′ 40″ N, 2° 50′ W, NGR: ST415404). *Comment* (JMC): Skinners Wood contains a series of trackways built during flooding conditions and assoc with unique wooden objects. Site now totally destroyed.

HAR-651. SLP74.2 (Honeydew G VII.1) **4460 ± 90**
$\delta^{13}C = -26.9‰$

Wood (*Betula*), AML 744083, from trackway under ~1m peat at Westhay Level (51° 11′ N, 2° 50′ W, NGR: ST416428). *Comment* (JMC): date exactly fits peat stratigraphy.

HAR-652. SLP74.3 (Honeycat G VI.5) **4370 ± 80**
$\delta^{13}C = -28.5‰$

Wood (*Corylus*), AML 744081, from horizontal timbers under ~2m peat in track complex at Westhay Level. *Comment* (JMC): date suitable for stratigraphic position and matches HAR-653.

HAR-653. SLP74.1 (Honeycat G V.I) **4440 ± 70**
$\delta^{13}C = -29.1‰$

Wood (*Betula*), AML 744080, from trackway under 1.5m peat at Westhay Level. *Comment* (JMC): date helps resolve horizontal and vertical stratigraphic problems of multiple trackways in this area of Levels.

HAR-680. SLP74.7 (Eclipse 1) **3460 ± 60**
$\delta^{13}C = -29.0‰$

Wood, AML 744086, from trackway under 0.4m, sphagnum peat at Meare Heath (51° 09′ 45″ N, 2° 47′ 10″ W, NGR: ST449406). *Comment* (JMC): date earlier than presumed, early 1st millennium BC, but agrees with detailed pollen analyses subsequently made.

HAR-681. SLP74.9 (Tinney's 18.7) **3040 ± 70**
$\delta^{13}C = -27.7‰$

Wood, AML 744088, from trackway under 0.75m *Eriophorum sphagnum* peat at Sharpham (51° 08′ 30″ N, 2° 45′ 20″ W, NGR: ST470382). *Comment* (JMC): sample from area where multiple tracks were built leading from promontory settlement towards Glastonbury Tor.

HAR-682. SLP74.8 (Garvin's) **4380 ± 70**
$\delta^{13}C = -28.3‰$

Wood, AML 744086, from trackway in terminal position under 0.4m peat at Walton Heath (51° 08′ 40″ N, 2° 46′ 50″ W, NGR: ST453385). *Comment* (JMC): date exactly suits peat stratigraphy.

HAR-683. SLP74.6 (Meare Lake 1-3) **3290 ± 70**
$\delta^{13}C = -27.0‰$

Wood, AML 744085, from trackway under 1m peat at Meare Heath (51° 09′ 45″ N, 2° 47′ 30″ W, NGR: ST444406). *Comment* (JMC): sample from area hitherto without traces of human activity. Trackway is multiple-layered in construction and contains wooden equipment and materials from another site yet to be discovered. Sample from large timber possibly 1 or 2 centuries old when incorporated in track.

HAR-684. SLP74.10 (Tinney's 17.7) **3020 ± 70**
$\delta^{13}C = -28.9‰$

Wood, AML 744089, from a complex of multiple structures beneath 0.75m *Eriophorum sphagnum* peat at Sharpham (51° 68′ 30″ N, 2° 45′ 20″ W, NGR: ST470382).

Watch Hill Barrow series

Charcoal from Watch Hill Barrow, St Austell, Cornwall, England (50° 21′ 40″ N, 4° 51′ 0″ W, NGR: SW974544). Coll & subm Aug 1973 by H Miles, Dept Extra-mural Studies, Univ Exeter, England (Miles, 1973). Samples are from pit dug in base of barrow ditch, carefully repacked with clay and charcoal, and thus relate to primary use of site, which was added to over a long period.

HAR-654. 162-29 **3470 ± 70**
$\delta^{13}C = -26.5‰$

HAR-655. 149-60 **3420 ± 70**
$\delta^{13}C = -27.2‰$

General Comment (HM): Watch Hill Barrow has been placed, on palynologic evidence, 2nd in series of recently excavated on St Austell granite.

It produced Food Vessel sherds likely to be some years later than primary, ^{14}C, context. On grounds of general similarities to other Cornish barrows, Watch Hill was expected to fall fairly early within Cornish EBA and dates provide good confirmation.

HAR-674. NEII Sample **4970 ± 80**
$\delta^{13}C = -21.5‰$

Human bone from Pen-y-Wyrlod (Talgarth) Long Cairn, Brecknock, Powys, Wales (51° 58′ 30″ N, 3° 14′ 20″ W, NGR: SO151316) in charnel deposit in chamber NEII (Savory, 1973). Coll & subm by H N Savory, Keeper, Natl Mus Wales, Cardiff. *Comment* (HNS): date is well within range established for long barrows and cairns in England and Scotland, but is 1st pub for a Welsh laterally-chambered long cairn. This particular group may have originated earlier than usually observed on purely archaeologic grounds.

HAR-744. Cefn Glas Hut floor **4110 ± 70**
$\delta^{13}C = -26.1‰$

Charcoal, from floor make up material in NE corner of hut at Cefn Glas Hut site (Craig-y-Llyn), Blaenrhondda, Mid-Glamorgan, Wales (51° 42′ 45″ N, 3° 32′ 45″ W, NGR: SN932024). Coll June & July 1974 by D Clayton; subm Aug 1974 by H N Savory. *Comment* (HNS): this date for construction of hut is consistent with late Neolithic character of flints also found on hut floor.

HAR-715. CC73V Stake 13 **1450 ± 70**
$\delta^{13}C = -26.6‰$

Wooden stake, AML 744070, probably part of animal pen, from Cainhoe Castle, Bedfordshire, England (52° 1′ 30″ N, 0° 24′ 15″ W, NGR: TL098373) (Taylor & Woodward, 1976). Coll & subm 1974 by P J Woodward, Bedfordshire Co Council. *Comment* (PJW): date acceptable although early since stake was assoc with motte and bailey castle. Occupation material found with stakes, however, comprised Roman pot, Early Medieval pot and flint tools.

North Elmham Park 1969 series

Bone samples from North Elmham Park, Norfolk, England (52° 45′ 15″ N, 0° 56′ 15″ E, NGR: TF987215). Subm Sept 1974 by P Wade-Martins (1969-1972).

HAR-759. 966 **1310 ± 70**
$\delta^{13}C = -24‰$

Animal bones, AML 748126, from Middle Saxon ditch (Period I), Ditch A, Feature 950.

HAR-760. 216 **1080 ± 70**
$\delta^{13}C = -22.7‰$

Animal bones, AML 748128, from Late Saxon cesspit (Period II), Pit Feature 44a.

HAR-763. 820 **1210 ± 80**
$\delta^{13}C = -23.4‰$

Animal bones, AML 748127, from Middle Saxon ditch (Period I, Ditch D, Feature 1018 (1).

B. Spain

HAR-358. Sample 7 **3600 ± 80**
$\delta^{13}C = -21.6‰$

Burnt bone from Copper age burial in cave at Cueva de los Tiestos, Murcia, Jumilla (38° 29′ 48″ N, 1° 22″ 13″ W). Coll Aug 1969 by Molina; subm Oct 1973 by M J Walker. *Comment* (MJW): date agrees well with Sample 7, HAR-160, 3790 ± 115 (R, 1974, v 16, p 187) on burnt barley from same burial cave and is acceptable in terms of Chalcolithic burial assemblage containing painted as well as 'Argaric" pottery and a copper point. Bristlecone pine corrected date (eg, Suess, 1970) for HAR-160 of ca 2100 BC seems correct for earliest manifestations of 'Argaric' cultural phenomenon in SE Spain.

HAR-520. Sample 1 **12,220 ± 130**
$\delta^{13}C = -4.2‰$

Shells (*Otala alonensis, Spincterochila candidissima*) id by D Heppel, Royal Scottish Mus, surface material from river terrace by water course at Rambla del Agua, Amarga, Murcia (38° 06′ 0″ N, 1° 7′ 22″ W). *Comment* (MJW): material was from surface of river terrace that also yielded fresh flint artifacts of generalized Upper Palaeolithic type. Terrace can probably be correlated to erosional stage of fluvial geomorphology observable downstream in terms of a gravel zone in a terrace sequence, that in the latter situation corresponds well to similar zones of other river terraces in the region and which pre-dates a layer of aeolian sand carbon-dated at other sites to 9000 to 7000 BP. Date therefore is acceptable.

HAR-521. Sample 1 **4350 ± 80**
$\delta^{13}C = +2.5‰$

Shells, id by D Heppel, from wide area of ground surface (also prehistoric pottery and samples of copper slag) near Ramonete, Lorca, Murcia (37° 31′ 52″ N, 1° 26′ 12″ W). *Comments* (MJW): corresponding to an absolute date of ca 3000 BC, this is a most interesting result in light of 19th century excavation of site, incorrectly called "Parazuelos", of flat-based, flared rim vessels of composite shape similar to Egyptian forms, and in light of copper slag at site from nearby copper vein. The site, now a few km inland, was formerly an island, as traces of estuarine sediments with marine sea-shells demonstrate, with a sea-level some 15m higher than today.

C. Sudan

Sudan series

Charcoal from domestic refuse in 1 of mounds at ancient site of Meroe, Sudan (16° 52′ N, 33° 41′ E). Coll Dec 1967-Mar 1968, Dec 1969-

Mar 1970 and subm May 1973 by P L Shinnie, Dept Archaeol, Univ Calgary, Canada.

HAR-346/I. MR10 **2410 ± 100**
$\delta^{13}C = -21.9‰$

HAR-346/II. MR10 **2590 ± 100**
$\delta^{13}C = -21.9‰$

HAR-346/III. MR10 **2480 ± 80**
$\delta^{13}C = -23.3‰$

Charcoal, treated separately, from J.50, Level 9.

HAR-347/I. MR11 **2020 ± 80**
$\delta^{13}C = -22.3‰$

HAR-347/II. MR11 **2090 ± 90**
$\delta^{13}C = -22.3‰$

Charcoal, treated separately from J/K50 Spit 11.

HAR-348/I. MR-1-120 **1670 ± 70**
$\delta^{13}C = -24.6‰$

HAR-348/II. **1740 ± 80**
$\delta^{13}C = -24.6‰$

Charcoal, treated separately from slag heap, Trench 1, Level 7a. *Comment* (PLS): in every case, date agrees with archaeol evidence.

II. GEOLOGIC SAMPLES

A. Sweden

HAR-390. PW-STR1/1 **2710 ± 70**
$\delta^{13}C = -22.0‰$

In situ stump *(Pinus* sp) exposed by peat digging at Strumasund, Vasterbottenlän, N Sweden (66° 05′ N, 14° 55′ E) (Lundqvist 1962, Worsley 1974a). Coll & subm July-Aug 1973 by P Worsley, Dept Geog, Univ Reading. *Comment* (PW): welcome confirmation that pine survived later than 3000 BP in this part of S Lapland. Previous dates (BP) from site: 4485 ± 80 (St-541), 2690 ± 80 (St-621), 3660 ± 80 (St-1454).

B. Norway

Engabreen series

Samples from Engabreen, Holandsfjord, Nordland, N Norway (66° 42′ N, 13° 45′ E) (Liestol, 1962; Worsley & Alexander, 1976). Coll & subm July-Aug 1973 by P Worsley.

General Comment (PW): dates HAR-385-389 are internally consistent. Time span is expected for fluvioglacial environment. Helga Sand Member subsequently buried by advance of Engabreen.

HAR-385. PW/ENGA/1 **1060 ± 80**
$\delta^{13}C = -26.8‰$

In situ root (*Alnus* sp) at present-day land surface Sta 27.7m. *Comment* (PW): date reported by Liestol (1962) incorrect, BP/AD values transposed. Worsley (1974b) gives correct Norwegian date: BP 1600 ± 100, T-263 not previously reported in *Radiocarbon,* obtained from *in situ* (*Betula odorata*) stump at same locality.

HAR-386. PW/ENGA/2 **1230 ± 80**

In situ stump, outermost layers of lower trunk, (*Salix* sp) ca 1m below present surface within Helga Sand Member of Svartis Gravel Formation Sta 39.4m.

HAR-387. PW/ENGA/3 **1480 ± 80**
$\delta^{13}C = -23.2‰$

Detrital wood fragments — litter, from surface organic accumulation at base of (*Salix*) stump of PW/ENGA/2 (HAR-386).

HAR-388. PW/ENGA/4 **1420 ± 80**
$\delta^{13}C = -22.3‰$

Wood from outermost layers of 4m-long detrital log (*Alnus* sp), Sta 18.3m. Depth ca 1m within Helga Sand Member.

HAR-389. PW/ENGA/5 **1160 ± 80**
$\delta^{13}C = -23.4‰$

Wood sample from small detrital log (*Alnus* sp), Sta 8.5m. Depth ca 0.5m within Helga Sand Member.

C. England and Wales

HAR-463. Hill Farm, Burtle **4280 ± 70**
$\delta^{13}C = -28.0‰$

Unburnt wood (*Corylus*) branch, trunk, or root at Hill Farm Burtle, Somerset, England (51° 11′ N, 2° 51′ 20″ W, NGR: ST399430). Sample from junction between Lias and Burtle clay with overlying sands (Kellaway, 1971; Kidson & Haynes, 1972; Hawkins & Kellaway, 1973). Coll Sept 1973 by A Heyworth; subm Oct 1973 by C Kidson. *Comment* (CK): sample is of either driftwood or *Corylus in situ* and indicates marine activity at site in late Flandrian. Interglacial age was expected since controversy over origin of Burtle Beds within which *Corylus* was found, was between those who suggested an Ipswichian interglacial and those who suggested a Wolstonian glacial age. A Flandrian date can mean either that Burtle Beds resulted from the Flandrian transgression or that the Flandrian transgression reworked earlier deposits. Samples from similar horizons will be dated from elsewhere in Somerset Levels.

HAR-324. Marks Tey 2 **>36,000**
$\delta^{13}C = -26.1‰$

Peat from Marks Tey brick pit, Marks Tey, Essex, England (51° 53′ 15″ N, 0° 47′ E, NGR: TL912242), between 2 and 2.25m under sloping surface. Probably early glacial Ho IV stage of Hoxnian interglacial (Turner, 1970). Coll & subm May 1973 by N R Page, Dept of Economics & Geography, Middlesex Polytechnic. *Comment*: age is minimum estimate.

HAR-327. 675 (with 674 & 673) **3910 ± 220**
$\delta^{13}C = -22.6‰$

Charcoal fragments from buried paleosol exposed in quarry sec across small combe valley at foot of Chilterns, Pitstone, Buckinghamshire, England (51° 49′ 20″ N, 0° 38′ 35″ W, NGR: SP939149). Deposits above and below paleosol highly calcareous chalky materials (Valentine, 1973). Coll Dec 1972 & subm May 1973 by K W Valentine, Dept Soil Sci, Univ Reading. *Comment*: small sample size accounts for larger than usual error term for this age. *Comment* (KWV): > 100kg paleosol sampled to obtain charcoal for this sample. Retained particles (3) id as ash (*Fraxinus* sp) by B Seddon, Univ Reading. Samples could represent clearing of original vegetation in which case ^{14}C age dates first cultivation by Neolithic man.

HAR-558. Yew Tree **3700 ± 90**
$\delta^{13}C = -23.5‰$

Wood from yew tree at Arundel, West Sussex, England (50° 51′ 55″ N, 0° 31′ 40″ W) in blue-gray clay at ca 4.3m. Site of former mill leat. Coll 1972; subm 1974 by M G Hay-Will. *Comment* (MGH-W): tree was dug out completely but with evidence that branches were broken off, possibly in fast running water. Tree could have been carried downstream in Arun R and into estuary now forming coastal plains S and E of Arundel.

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[RADIOCARBON, VOL. 19, No. 3, 1977, P. 424-441]

UNIVERSITY OF LUND RADIOCARBON DATES X

SÖREN HÅKANSSON

Radiocarbon Dating Laboratory, Department of Quaternary Geology
University of Lund, Sweden

INTRODUCTION

Most of the ^{14}C measurements reported here were made between October 1975 and October 1976. Equipment, measurement, and treatment of samples are the same as reported previously (R, 1968, v 10, p 36-37; 1976, v 18, p 290).

Age calculations are based on a contemporary value equal to 0.950 of the activity of NBS oxalic acid standard and on the conventional half-life for ^{14}C of 5568 yr. Results are reported in years before 1950 (years BP). Errors quoted ($\pm 1\sigma$) include standard deviations of count rates for the unknown sample, contemporary standard, and background.

Corrections for deviations from $\delta^{13}C = -25.0‰$ in the PDB scale are applied for all samples; also for marine shells, because apparent age of recent marine shells is not always just counterbalanced by the effect of isotopic fractionation (see e g, Mangerud & Gulliksen, 1975). $\delta^{13}C$ values quoted are relative to the PDB standard.

The remark, "undersized; diluted", in *Comments* means the sample did not produce enough CO_2 to fill the counter to normal pressure and "dead" CO_2 from anthracite was introduced to make up the pressure. "% sample" indicates amount of CO_2 derived from the sample present in the diluted counting gas; the rest is "dead" CO_2. Organic carbon content reported for bone samples is calculated from yield of CO_2 by combustion of gelatine remaining after treatment. Organic carbon lost during treatment is not included in calculated percentage.

The description of each sample is based on information provided by the submitter.

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SAMPLE DESCRIPTIONS

I. CHECK SAMPLES

Check sample series

Lu-1224:I. Ruds Vedby **10,900 ± 110**
$\delta^{13}C = -26.1‰$

New preparation from rest of wood sample dated 1966 as Lu-3; 10,840 ± 120 (R, 1968, v 10, p 38). *Comment:* no pretreatment (2 1-day counts in Counter I.)

Lu-1224:II. Ruds Vedby **10,910 ± 110**
$\delta^{13}C = -26.1‰$

Same preparation as Lu-1224:I. *Comment:* (2 1-day counts in Counter II.)

Lu-1240:I. Angelsta, Småland **2570 ± 55**
$\delta^{13}C = -22.5‰$

New preparation from rest of wood sample dated 1966 as Lu-2; 2510 ± 60 (R, 1968, v 10, p 38). *Comment:* no pretreatment (2 1-day counts in Counter I.)

Lu-1240:II. Angelsta, Småland **2460 ± 55**
$\delta^{13}C = -22.5‰$

Same preparation as Lu-1240:I. *Comment:* (2 1-day counts in Counter II.) Average value 2515 ± 40 for Lu-1240.

General Comment: good agreement with dates from 1966.

II. GEOLOGIC SAMPLES

A. Sweden

Hunneberg series

Sediment from lakes Domsjön (58° 18′ N, 12° 27′ E), Grågåsen (58° 17′ N, 12° 27′ E), Igelsjön (58° 18′ N, 12° 26′ E), Kvarnsjön (58° 18′ N, 12° 26′ E), and Kyrkesjön (58° 17′ N, 12° 29′ E) on Mt Hunneberg, NW Västergötland. Coll 1975 and 1976 and subm by G Digerfeldt, Dept Quaternary Geol, Univ Lund. Dating is part of study of highest sea shoreline in area. Isolation of lakes established by diatom analysis. Depths refer to sediment surface. All samples pretreated with HCl. Some samples undersized; diluted. Amount of CO_2 from sample is given in *Comments* below as "% sample".

Grågåsen

Lu-1125. Grågåsen, 522.5 to 526.5cm **11,440 ± 90**
$\delta^{13}C = -20.2‰$

Clay gyttja. *Comment:* (3 1-day counts.)

Lu-1126. Grågåsen, 527.5 to 531.5cm **11,450 ± 110**
$\delta^{13}C = -19.8‰$

Kyrkesjön

Lu-1127. Kyrkesjön 1, 685 to 690cm **10,770 ± 105**
$\delta^{13}C = -17.1‰$

Clay gyttja. Ca 10cm above isolation level.

Lu-1128. Kyrkesjön 2, 352 to 356cm **11,290 ± 110**
$\delta^{13}C = -14.9‰$

Clayey gyttja. Ca 15cm above isolation level.

Lu-1129. Kyrkesjön 2, 357.5 to 362.5cm **11,120 ± 110**
$\delta^{13}C = -15.7‰$

Clayey gyttja. Ca 10cm above isolation level.

Kvarnsjön

Lu-1130. Kvarnsjön, 507 to 511cm **12,210 ± 120**
$\delta^{13}C = -16.9‰$

Clay gyttja. Ca 25cm below isolation level.

Lu-1131. Kvarnsjön, 479.5 to 483.5cm **11,110 ± 110**
$\delta^{13}C = -17.7‰$

Clay gyttja. At isolation level.

Lu-1253. Kvarnsjön, 482 to 484cm **11,110 ± 75**
$\delta^{13}C = -17.2‰$

Clay gyttja. Underlying isolation level. *Comment:* (2 2-day counts).

Lu-1252. Kvarnsjön, 479 to 481cm **10,890 ± 75**
$\delta^{13}C = -17.9‰$

Clay gyttja. Overlying isolation level. *Comment:* (2 2-day counts).

Lu-1132. Kvarnsjön, 453 to 457cm **10,140 ± 100**
$\delta^{13}C = -22.2‰$

Clayey gytta. At *Empetrum* max near Pleistocene/Holocene Boundary.

Lu-1133. Kvarnsjön, 432.5 to 437.5cm **9460 ± 95**
$\delta^{13}C = -24.9‰$

Detritus gyttja. At rational *Corylus* limit.

Lu-1134. Kvarnsjön, 367.5 to 372.5cm **8330 ± 85**
$\delta^{13}C = -25.6‰$

Detritus gyttja. Overlying rational *Alnus* limit.

Igelsjön

Lu-1211. Igelsjön, 686 to 690cm **11,750 ± 120**
$\delta^{13}C = -24.9‰$

Clay gyttja.

Lu-1212. Igelsjön, 680 to 684cm **11,570 ± 135**
$\delta^{13}C = -26.5‰$

Clay gyttja. *Comment:* 65% sample. (3 1-day counts).

Domsjön

Lu-1213. Domsjön, 647 to 651cm **12,780 ± 175**
$\delta^{13}C = -17.9‰$

Clay gyttja. Ca 35cm below isolation level. *Comment:* 67% sample.

Lu-1214. Domsjön, 637 to 641cm **12,610 ± 130**
$\delta^{13}C = -17.7‰$

Clay gyttja. Ca 25cm below isolation level. *Comment:* 95% sample.

Lu-1215. Domsjön, 627 to 631cm **12,780 ± 145**
$\delta^{13}C = -18.0‰$

Clay gyttja. Ca 15cm below isolation level. *Comment:* 83% sample.

Lu-1216. Domsjön, 618 to 620cm **12,020 ± 130**
$\delta^{13}C = -18.5‰$

Clay gyttja. Underlying isolation level. *Comment:* 91% sample.

Lu-1217. Domsjön, 613 to 615cm **12,020 ± 130**
$\delta^{13}C = -20.5‰$

Clay gyttja. Underlying isolation level. *Comment:* 86% sample.

Lu-1218. Domsjön, 605 to 607cm **11,490 ± 155**
$\delta^{13}C = -20.6‰$

Clay gyttja. Overlying isolation level. *Comment:* 66% sample.

Lu-1219. Domsjön, 603 to 605cm **11,320 ± 135**
$\delta^{13}C = -21.3‰$

Clay gyttja. Overlying isolation level. *Comment:* 78% sample.

Ljungsjön series

Sediment from Lake Ljungsjön, Central Västergötland (57° 45′ N, 13° 19′ E). Alt +300m. Coll 1975 and subm by A Hilldén, Dept Quaternary Geol, Univ Lund. Dating of oldest organic sediment was part of study of ice recession in area. Depths refer to water surface. Pretreated with HCl.

Lu-1191. Ljungsjön, 854 to 858cm **12,410 ± 150**
$\delta^{13}C = -20.5‰$

Clay gyttja. *Comment:* undersized; diluted; 61% sample. (3 1-day counts.)

Lu-1198. Ljungsjön, 840 to 844cm **11,400 ± 110**
$\delta^{13}C = -19.3‰$

Clay gyttja.

Fjällsjön series

Sediment from Lake Fjällsjön, Central Västergötland (57° 45′ N, 12° 51′ E). Alt +285m. Coll 1975 and subm by A Hilldén. Dating is part of same study as Ljungsjön series, above. Depths refer to water surface. Pretreated with HCl.

Lu-1192. Fjällsjön 1, 843.5 to 848.5cm **12,240 ± 120**
$\delta^{13}C = -21.3‰$

Clay gyttja.

Lu-1193. Fjällsjön 2, 646 to 650cm **12,550 ± 125**
$\delta^{13}C = -21.4‰$

Clay gyttja. *Comment:* undersized; diluted; 76% sample. (3 1-day counts.)

Lu-1199. Fjällsjön 2, 633 to 637cm **11,070 ± 105**
$\delta^{13}C = -20.5‰$

Clay gyttja.

Dalaholmssjön series

Sediment from Lake Dalaholmssjön, 10km N of town of Skara, Västergötland (58° 28′ N, 13° 27′ E). Alt +116.5m; area 0.018sq km. Coll 1974 and subm by Th Persson, Dept Quaternary Geol, Univ Lund. Dated as part of study of Postglacial vegetational history of surrounding landscape. Depths refer to sediment surface. Water depth at sampling point, 5.3m. All samples consist of detritus gyttja, and were pretreated with HCl.

Lu-1139. Dalaholmssjön, 765 to 772cm **8630 ± 90**
$\delta^{13}C = -26.6‰$

Lu-1140. Dalaholmssjön, 745 to 750cm **6650 ± 75**
$\delta^{13}C = -31.0‰$

Slightly above rational limit of *Tilia*.

Lu-1141. Dalaholmssjön, 720 to 725cm **5970 ± 70**
$\delta^{13}C = -31.6‰$

Lu-1142. Dalaholmssjön, 710 to 715cm **5060 ± 65**
$\delta^{13}C = -31.0‰$

Distinct decrease of *Ulmus*.

Lu-1143. Dalaholmssjön, 695 to 700cm **4240 ± 60**
$\delta^{13}C = -32.1‰$

Beginning of further decrease of *Ulmus*.

Lu-1144. Dalaholmssjön, 675 to 680cm **3840 ± 60**
$\delta^{13}C = -29.2‰$

Lu-1145. Dalaholmssjön, 650 to 655cm **2990 ± 55**
$\delta^{13}C = -32.3‰$

Lu-1146. Dalaholmssjön, 630 to 635cm **2610 ± 45**
$\delta^{13}C = -28.9‰$

Comment: (3 1-day counts).

Lu-1147. Dalaholmssjön, 575 to 580cm **2620 ± 45**
$\delta^{13}C = -26.7‰$

Comment: (3 1-day counts).

Lu-1148. Dalaholmssjön, 525 to 530cm **2130 ± 50**
$\delta^{13}C = -27.6‰$

Picea reaches 1%.

Lu-1204. Dalaholmssjön, 475 to 480cm **1450 ± 50**
$\delta^{13}C = -28.5‰$

Lu-1205. Dalaholmssjön, 420 to 425cm **1360 ± 50**
$\delta^{13}C = -25.0‰$

Lu-1206. Dalaholmssjön, 375 to 380cm **1300 ± 50**
$\delta^{13}C = -25.7‰$

Lu-1207. Dalaholmssjön, 325 to 330cm **1310 ± 50**
$\delta^{13}C = -25.8‰$

Lu-1208. Dalaholmssjön, 275 to 280cm **1340 ± 50**
$\delta^{13}C = -25.3‰$

Lu-1209. Dalaholmssjön, 225 to 230cm **840 ± 50**
$\delta^{13}C = -26.1‰$

Lake Striern series

Sediment from Lake Striern, Östergötland (58° 05′ N, 15° 47′ E). Coll 1966 and 1972 and subm by H Göransson, Dept Quaternary Geol, Univ Lund. All samples consist of fine detritus gyttja. Depths are below sediment-water interface. For other dates from Lake Striern, see R, 1970, v 12, p 541-543; 1975, v 17, p 181-182. All samples pretreated with HCl.

Lu-1220. Striern I, 290 to 300cm **5050 ± 70**
$\delta^{13}C = -23.1‰$

Atlantic-Sub-Boreal Chronozone Boundary. Coll 1966; water depth at sampling point: 0.85m. *Comment*: undersized; diluted; 83% sample.

Lu-1221. Striern I, 265 to 275cm **4340 ± 60**
$\delta^{13}C = -23.1‰$

Upper part of *Quercus–Tilia–Ulmus* sub-zone. Coll 1966. *Comment*: diluted; 86% sample.

Lu-1194. Striern II, 497.5 to 501.5cm **8650 ± 90**
$\delta^{13}C = -28.6‰$

Rational *Alnus* limit. Coll 1972; water depth 0.63m.

Harplinge ristipp series

Shells (*Hiatella arctica*) from clay grading upwards into sandy and gravelly beach deposits and underlain by glaciofluvial material in deserted gravel pit used as brushwood dump (*Sw ristipp*) at Särdal, Harplinge, Halland (56° 45′ 03″ N, 12° 39′ 15″ E). Coll 1974 (Lu-1104) and 1975 (Lu-1165) and subm by E Lagerlund, Dept Quaternary Geol, Univ Lund. Dated as part of extensive study of deglaciation (Berglund, B E, The deglaciation of southern Sweden — a tentative radiocarbon chronology; Rept 10, Dept Quaternary Geol, Univ Lund [In cooperation with Bjelm, L, Digerfeldt, G, Hilldén, A, Knutsson, G, Lagerlund, E, and Ringberg, B], ms in preparation).

Lu-1104. Harplinge, Sample 1 **13,930 ± 135**
$\delta^{13}C = +0.3‰$

Comment: outer 14% removed by acid leaching.

Lu-1165. Harplinge, Sample 2 **13,860 ± 140**
$\delta^{13}C = +0.2‰$

Comment: many shell pairs were still articulated. Outer 40% removed by acid leaching.

General Comment: corrections for deviations from $\delta^{13}C = -25‰$ PDB are applied also for shell samples. No corrections are made for apparent age of shells of living marine mollusks. For apparent age of recent shells in area, see R, 1975, v 17, p 183-184, and Håkansson (1975b).

Marine shells series

Marine subfossil shells from Halland and Bohuslän, W Sweden. Coll 1975 and subm by Å Hillefors, Dept Phys Geog, Univ Lund. Dated as part of study of deglaciation of this area (Hillefors, 1975).

Lu-1171. Fjärås bräcka, *Mytilus* **13,030 ± 130**
$\delta^{13}C = -2.2‰$

Shell fragments (*Mytilus* sp) from varved clay overlain, successively, by nonvarved clay, glaciofluvial material, clay, and wave-washed material at S part of Fjärås bräcka, Halland (57° 25′ 30″ N, 12° 13′ 07″ E). Coll in same gravel pit as shells dated as Lu-165: 13,090 ± 130 and Lu-167: 12,850 ± 130 (R, 1969, v 11, p 439-440; Wedel, 1969). *Comment*: outer 37% removed by acid leaching.

Lu-1172. Fjärås bräcka, *Balanus* **13,120 ± 130**
$\delta^{13}C = +0.1‰$

Small shells (*Balanus* sp) from same deposit as Lu-1171. *Comment*: outer 54% removed by acid leaching.

Lu-1174. Ågård, Sample 2:1 **13,160 ± 130**
$\delta^{13}C = +0.8‰$

Shells (*Hiatella arctica*) from clay underlain by sand in clay pit at Ågård, E of town of Falkenberg, Halland (56° 54′ 07″ N, 12° 33′ 12″ E). Coll ca 20 cm above transition sand/clay. Mollusk shells from this site were studied previously (Asklund, 1936, p 8-9; Mörner, 1969, p 168-169). *Comment*: outer 41% removed by acid leaching.

Lu-1175. Ågård, Sample 2:2 **12,870 ± 125**
$\delta^{13}C = -0.4‰$

Shells (*Balanus hammeri*) from same deposit as Lu-1174. *Comment*: outer 59% removed by acid leaching.

Lu-1176. Ågård, Sample 3 **12,730 ± 130**
$\delta^{13}C = +0.6‰$

Shells (*Hiatella arctica*) from same site as Lu-1174 and -1175 but coll ca 1m above transition sand/clay. Some shell pairs still articulated. *Comment*: outer 18% removed by acid leaching. Undersized; diluted; 73% sample. (3 1-day counts.)

Lu-1173. Fagerfjäll, Sample 1 **12,140 ± 120**
δ¹³C = +0.9‰

Thick shells (*Mya truncata* and *Hiatella arctica*) from lower part of gray silty-sandy late-glacial clay underlain by sand (10 to 30cm) and ? till at Fagerfjäll, Tjörn, Bohuslän (57° 59′ 10″ N, 11° 39′ 23″ E). *Comment*: outer 52% removed by acid leaching.

General Comment: corrections for deviations from $\delta^{13}C = -25‰$ PDB are applied also for shell samples. No corrections are made for apparent age of shells of living marine mollusks. For apparent age of recent shells in area, see R, 1975, v 17, p 183-184 and Håkansson (1975b).

Lu-606. Fjärås bräcka, mixed shells **12,910 ± 125**
$\delta^{13}C = -1.5‰$

Shells (*Balanus balanus*) id by G Digerfeldt, and shell fragments (*Mytilus* sp & *Pecten* sp) from clay underlain by stratified sand and overlain by wave-washed gravel in deserted gravel pit at Fjärås bräcka (57° 25′ 45″ N, 12° 12′ 50″ E). Dated shells are from layer enriched in shells ca 25cm above transition sand/clay. Sample also contained 2 small shells of *Hiatella arctica* and 1 of *Macoma calcarea*. Coll 1971 by S Håkansson. *Comment*: outer 37% removed by acid leaching.

B. Norway

Angsnes series

Marine shells from submarine formed end moraine at Angsnes, Finnmark, N Norway (70° 09′ 42″ N, 28° 45′ 25″ E). Alt ca +10m. Coll 1975 and subm by B Malmström and O Palmér, Dept Phys Geog, Univ Lund. Dated as part of study of deglaciation of Varanger Peninsula. For other dates from area, see Varanger Peninsula series, R, 1974, v 16, p 317-318. Stratigraphic sequence from surface and down: 0.5m ablation till, 0.7m gray clay, and >0.4m red clay.

Lu-1201. Angsnes I **8510 ± 80**
$\delta^{13}C = +0.3‰$

One pair of large shells (*Mya truncata*), 0.5m below surface, from transition gray clay/ablation till. *Comment*: outer 37% removed by acid leaching.

Lu-1202. Angsnes II **9640 ± 160**
$\delta^{13}C = +0.2‰$

Shell fragments (*Mya truncata*), 1.2m below surface, from transition red clay/grey clay. *Comment*: undersized; diluted; 49% sample. Outer 15% removed by acid leaching.

Lu-1203. Angsnes III **10,480 ± 315**
$\delta^{13}C = +0.1‰$

Shell fragments, 1.4m below surface, from red clay. A few fragments id as (*Pecten sp, Hiatella arctica,* and *Mya truncata*). *Comment*: very small sample; no superficial leaching; diluted; 20% sample. (3 1-day counts.)

General Comment: corrections for deviations from $\delta^{13}C = -25‰$ PDB are applied also for shell samples. No corrections are made for apparent age of shells of living maine mollusks. For apparent age of recent shells in area, see Mangerud & Gulliksen (1975, p 269, fig 4).

C. Iceland

Mosfell series

Peat from cultivated hill-side bog (*Icel* Hallamýri) ca 300m S of Mosfell farm, Grímsnesi, S Iceland (64° 08′ N, 20° 36′ W). Coll 1975 and subm by M Hallsdóttir, Dept Quaternary Geol, Univ Lund. Dated to determine age of volcanic ash layer VII a+b, the so-called "landnám" layer (Thorarinsson, 1944; 1970, p 305-308, 323-324) in connection with pollen-analytic study of peat profile. Samples are from wall of 2m deep drainage ditch. Lu-1168 ca 15×15×1cm; all others ca 10×10×1cm each. Depths refer to surface of bog. All samples received mild pretreatment with NaOH and HCl.

Lu-1166. Mosfell, 88 to 89cm **1100 ± 45**
$\delta^{13}C = -26.0‰$

Comment: sample charred in nitrogen atmosphere prior to combustion. Undersized; diluted; 77% sample. (3 1-day counts.)

Lu-1167. Mosfell, 89 to 90cm **1190 ± 50**
$\delta^{13}C = -25.5‰$

Lu-1168. Mosfell, 90 to 91cm **1180 ± 50**
$\delta^{13}C = -25.3‰$

Peat containing main part of Ash Layer VII a+b.

Lu-1169. Mosfell, 91 to 92cm **1150 ± 50**
$\delta^{13}C = -22.2‰$

Lu-1170. Mosfell, 92 to 93cm **1290 ± 50**
$\delta^{13}C = -21.9‰$

III. FAUNAHISTORICAL SAMPLES

Lu-1223. Arrie, *Alces alces* **10,960 ± 110**
$\delta^{13}C = -19.5‰$

Collagen from 3rd cervical vertebra of *Alces alces*, id by J Lepiksaar, from gravel pit at Arrie, Scania (ca 55° 32′ N, 13° 07′ E). Coll 1962 by O Persson; subm by R Liljegren, Dept Quaternary Geol, Univ Lund. *Comments*: organic carbon content: 7.3%. (RL): pollen study not possible.

Lu-1059. Arrie, *Rangifer tarandus* **11,170 ± 110**
$\delta^{13}C = -18.3‰$

Collagen from subfossil antler of *Rangifer tarandus* (Liljegren, 1975, p 80) from gravel pit at Risebjär, Arrie, Scania (55° 31′ 15″ N, 13° 06′ 10″ E). Subm by B E Berglund, Dept Quaternary Geol, Univ Lund. *Comment*: organic carbon content: 5.4%. *Cf* date Lu-1223, above.

Lu-1060. Börringe, *Rangifer tarandus* **9810 ± 95**

$\delta^{13}C = -18.4‰$

Collagen from subfossil antler of *Rangifer tarandus* (Liljegren, 1975, p 82) from unspecified site in Börringe area, Scania (ca 55° 30′ N, 13° 21′ E). Subm by B E Berglund. *Comment*: organic carbon content: 7.7%.

Lu-1236. Östergötland, *Cervus elaphus* **2400 ± 55**

$\delta^{13}C = -22.0‰$

Collagen from subfossil antler of *Cervus elaphus* coll with part of skull in unspecified site in Östergötland (ca 58.5° N, 15.5° E). Subm by E Dahl, Dept Zool, Univ Lund. *Comment*: organic carbon content: 7.7%.

Lu-1237. Nävlinge, *Alces alces* **8920 ± 100**

$\delta^{13}C = -20.4‰$

Collagen from subfossil antler of *Alces alces* probably coll 1930 with skull E of Vinne peat bog, Nävlinge, Scania (ca 56° 2.5′ N, 13° 50′ E). Cat no. LUZM 135 (Liljegren, 1975, p 76). Subm by E Dahl. *Comment*: organic carbon content: 7%. Undersized; diluted; 80% sample.

Lu-1238. Sövestad, *Alces alces* **9160 ± 100**

$\delta^{13}C = -20.2‰$

Collagen from subfossil skull of *Alces alces* coll 1830 with both antlers at ca 1.5m depth in "Broma" peat bog, Sövestad parish, Scania (ca 55° 29′ N, 13° 48′ E). Cat no. LUZM 27 (Liljegren, 1975, p 77). Subm by E Dahl. *Comment*: organic carbon content: 6.9%. Diluted; 66% sample. (3 1-day counts.) Shellac preservative removed by 2 days repeated extraction with alcohol.

Lu-1260. Göteborg, St Förö, *Bos primigenius* **3940 ± 60**

$\delta^{13}C = -21.1‰$

Collagen from bone fragment of *Bos primigenius* from 108cm depth in peat bog in central part of isle of St Förö, Göteborg (57° 37′ 45″ N, 11° 51′ E). Coll 1975 and subm by S Mathiasson, Göteborg Mus Nat Hist. Cat no. GNM 1975-14142. *Comment*: organic carbon content: 5.3%.
General Comment: collagen extracted from all faunahistorical samples as described previously (R, 1976, v 18, p 290).

IV. ARCHAEOLOGIC SAMPLES

A. Sweden

Östanön-Kvalmsö-Helgeö-Almö series

Wood from artificial blockings at 2 to 5m depth in Listerby-Förkärla Archipelago, Blekinge. Coll 1972 to 1974 by Blekinge Mus; subm by B E Berglund. Other dates from similar blockings in area reported previously (R, 1974, v 16, p 327). Wood id by Th Bartholin. All samples pretreated with HCl and NaOH.

Lu-988. Almö-Kvalmsö **950 ± 50**
$\delta^{13}C = -25.7‰$

Wood from alder pile from blocking between Almö and Kvalmsö (56° 10′ 05″ N, 15° 26′ 20″ E).

Lu-1137. Östanön-Kvalmsö **920 ± 50**
$\delta^{13}C = -26.6‰$

Wood from ash pile from blocking between Östanön and Kvalmsö (56° 09′ 45″ N, 15° 25′ 25″ E). *Comment*: cf Lu-769, 940 ± 50 (*op cit*, above).

Lu-1138. Helgeö-Kvalmsö **1010 ± 50**
$\delta^{13}C = -25.8‰$

Wood from ash pile from blocking between Helgeö and Kvalmsö (56° 10′ N, 15° 24′ 55″ E). *Comment*: *cf* Lu-770, 1050 ± 50 (*op cit*, above).

Lu-1136. Helgeö-Östanön **950 ± 75**
$\delta^{13}C = -27.0‰$

Wood from lime pile from blocking between Helgeö and Östanön (56° 09′ 50″ N, 15° 24′ 45″ E). *Comment*: *cf* Lu-771, 960 ± 50 (*op cit*, above). Sample undersized; diluted; 50% sample.

Lu-987. Östanön-Stutaflåtarna **990 ± 50**
$\delta^{13}C = -26.8‰$

Wood from aspen pile from blocking between Östanön and Stutaflåtarna (56° 09′ 40″ N, 15° 24′ 55″ E).

Lu-986. Torkö-Helgeö **150 ± 45**
$\delta^{13}C = -25.8‰$

Wood from alder pile from blocking between Torkö and Helgeö (56° 09′ 40″ N, 15° 24′ 40″ E).

Lu-1008. Almö-Tromtö 1 **140 ± 45**
$\delta^{13}C = -25.6‰$

Wood from pine pile from blocking between Almö and Tromtö (56° 09′ 30″ N, 15° 27′ 50″ E).

Lu-1135. Almö-Tromtö 2 **940 ± 50**
$\delta^{13}C = -28.6‰$

Wood from birch pile from blocking between Almö and Tromtö (56° 09′ 30″ N, 15° 27′ 50″ E).

General Comment (BEB): new dates confirm older ones from this archipelago, *ie*, blockings apparently built ca AD 1000. Two dated piles have given too low ages; they probably belong to fishing tools.

Eketorp Fen series

Samples from 1m deep open sec in fen deposits E of Eketorp fortress, Gräsgård parish, S Öland, S Sweden (56° 17′ 45″ N, 16° 29′ 30″ E). Coll 1974 and subm by B E Berglund. Archaeol conditions described by

Stenberger (1966). Since deposits are calcareous, only fragments of bone and wood were used for dating. A pollen diagram covers entire sec.

Lu-1150. Eketorp Fen 1 **1100 ± 55**
$\delta^{13}C = -20.7‰$

Collagen from fragment of lower jaw of horse, id by R Liljegren, 50cm below surface in upper part of clay gyttja layer. *Comment*: collagen extracted as described previously (R, 1976, v 18, p 290). Organic carbon content: 3.1%. Undersized; diluted; 53% sample. (3 1-day counts.)

Lu-1149. Eketorp Fen 2 **1190 ± 50**
$\delta^{13}C = -27.6‰$

Wood from twig of *Malus* sp, id by Th Bartholin, ca 90cm below surface in bottom layer of limestone debris. *Comment*: pretreated with HCl and NaOH.

Ingelstorp series

Charcoal and bone from sites in Ingelstorp parish, Scania (55° 25′ N, 14° 03′ E). Coll 1975 and subm by M Strömberg, Hist Mus, Univ Lund. For other dates from area, see R, 1975, v 17, p 192-193; 1976, v 18, p 313-314. Charcoal pretreated with HCl and NaOH. Bone treated as described previously (R, 1976, v 18, p 290).

Lu-1151. Ingelstorp 10, Sample 1:HT75 **2540 ± 55**
$\delta^{13}C = -23.3‰$

Charcoal from hearth near lime pit. *Comment* (MS): older than expected from find circumstances.

Lu-1152. Ingelstorp 10, Sample 2:HT75 **1850 ± 50**
$\delta^{13}C = -25.1‰$

Charcoal from lime pit (*cf* Lu-1151, above). Assoc with bones, webweights, and iron objects.

Lu-1153. Ingelstorp 10, Sample 3:HT75 **1380 ± 50**
$\delta^{13}C = -20.5‰$

Collagen from mandible fragment, probably from young animal of cattle, from same lime pit as Sample 2:HT75. *Comment*: organic carbon content: 7%.

Lu-1177. Ingelstorp 31, Sample 4:HT75 **3020 ± 55**
$\delta^{13}C = -24.5‰$

Charcoal from charred wooden coffin in Grave 51. Assoc with helical bronze-ring and flint objects.

Lu-1188. Ingelstorp 32[5], Sample 5:HT75 **1960 ± 50**
$\delta^{13}C = -25.8‰$

Charcoal from cremation grave. Assoc with pottery, bronze buckle, and burnt bones.

Lu-1189. Ingelstorp 31[6], Sample 6:HT75 **1840 ± 65**

$\delta^{13}C = -19.6‰$

Collagen from human skull fragment from skeleton grave (No. 50). Assoc with unusual pottery and bronze buckle. *Comment*: organic carbon content: 1.7%. Undersized; diluted; 62% sample.

Lu-1196. Ingelstorp 32[8], Sample 7:HT75 **3090 ± 60**

$\delta^{13}C = -23.9‰$

Charcoal from coffin in skeleton grave (No. 5). Assoc with fragment of bronze fibula.

Lu-1210. Ingelstorp 32[5], Sample 9:75-76 **2730 ± 55**

$\delta^{13}C = -25.5‰$

Charcoal from cremation grave (No. 18). Assoc with pottery.

General Comment (MS): all dates except Lu-1151 agree well with archaeol estimates based on assoc artifacts.

Lu-1200. Stendala **1310 ± 50**

$\delta^{13}C = -23.8‰$

Charcoal from bottom of pit house at Stendala, Järrestad parish, Scania (55° 32′ N, 14° 17′ E). Coll 1975 and subm by M Strömberg. Assoc with brittle-burnt stones. In pit house were also iron objects, mold fragment, bone, and pottery. *Comment*: date agrees with assoc finds.

Ageröd series (II)

Charcoal and bark from Site Ageröd VI in Mesolithic settlement area at raised bog Ageröds mosse, Munkarp parish, Scania (55° 56.5′ N, 13° 25′ E). Coll 1975 and subm by L Larsson, Hist Mus, Univ Lund. Dated as complement to Ageröd series (R, 1976, v 18, p 304-308).

Lu-1156. Ageröd VI, Sample 1 **7320 ± 80**

$\delta^{13}C = -24.9‰$

Bark (? *Alnus* sp) from lowest part of occupation layer. *Comment*: normal pretreatment with HCl and NaOH.

Lu-1157. Ageröd VI, Sample 2 **5240 ± 65**

$\delta^{13}C = -25.3‰$

Charcoal from stratum just above occupation layer. *Comment*: mild pretreatment with NaOH and HCl; small sample.

Lu-1158. Ageröd VI, Sample 3 **6810 ± 75**

$\delta^{13}C = -25.6‰$

Charcoal from occupation layer. *Comment*: mild pretreatment with NaOH and HCl; small sample.

Lu-1195. Spjälkö **2890 ± 55**

$\delta^{13}C = -23.7‰$

Charcoal (*Fraxinus excelsior*) id by Th Bartholin, from Test-pit 5 on Pitted Ware culture site at Spjälkö, Ronneby parish, Blekinge (56°

10′ N, 15° 13′ E). Coll 1975 and subm by S Welinder, Hist Mus, Univ Lund. *Comment*: pretreated with HCl and NaOH.

B. Denmark

Lu-1222. Svendborg, Site 263 IV, C391/75 **650 ± 50**
$\delta^{13}C = -24.1$‰

Charcoal (*Corylus avellana*) id by Th Bartholin, from fire-stratum in excavation N of monastery church in town of Svendborg, Fyn (55° 03′ N, 10° 36′ E). Coll 1976 by J Bech; subm by H M Jansen, Inst Hist & Soc Sci, Univ Odense, Denmark. Dated as complement to Svendborg series (R, 1976, v 18, p 318-319). Pretreated with HCl and NaOH.

V. GEOCHEMICAL SAMPLES

Results are given as a difference, Δ, from our radiocarbon standard (95% activity of NBS oxalic acid standard, age corrected to 1958):

$$\Delta = \delta^{14}C - (2\delta^{13}C + 50)\left(1 + \frac{\delta^{14}C}{1000}\right)$$

where $\delta^{14}C$ is observed deviation from radiocarbon standard in per mil and $\delta^{13}C$ deviation from PDB standard in per mil.

Submerged plants series

Recent submerged plants from various S Swedish lakes coll 1974 and 1975. Aim of study was to compare ^{14}C activities in different kinds of lakes in order to acquire information about possible hard-water effects. Details about lakes and discussion of results were presented elsewhere (Håkansson, S, Radiocarbon activity in submerged plants from various South Swedish lakes; 9th internatl radiocarbon conf, Los Angeles and San Diego, June 1976, ms in preparation.) All samples except Lu-1162 and -1187 pretreated with HCl.

Lu-1184. Ämmern 1975, *Elodea* **Δ = 264.9 ± 6.5‰**
$\delta^{13}C = -17.2$‰

Elodea canadensis from Lake Ämmern, Östergötland (58° 07′ 30″ N, 15° 43′ 30″ E). Coll Sept 6, 1975 by H Göransson, Dept Quaternary Geol, Univ Lund.

Lu-1186. Ämmern 1975, *Potamogeton* **Δ = 263.9 ± 6.2‰**
$\delta^{13}C = -17.4$‰

Potamogeton perfoliatus from Lake Ämmern. Coll Sept 6, 1975 by H Göransson.

Lu-1011. Striern 1974, *Myriophyllum* **Δ = 297.8 ± 6.7‰**
$\delta^{13}C = -20.0$‰

Myriophyllum spicatum from Lake Striern, Östergötland (58° 05′ N, 15° 47′ E). Coll Sept 7, 1974 by H Göransson.

Lu-1185. Striern 1975, *Myriophyllum* $\Delta = 284.7 \pm 6.3‰$
$\delta^{13}C = -19.8‰$

Myriophyllum spicatum from Lake Striern. Coll Sept 6, 1975 by H Göransson.

Lu-1015. Vån 1974, *Elodea* $\Delta = 287.9 \pm 6.2‰$
$\delta^{13}C = -17.6‰$

Elodea canadensis from Lake Vån, Östergötland (58° 11′ N, 15° 47′ E). Coll Sept 30, 1974 by H Göransson.

Lu-1187. Vån 1975, *Elodea* $\Delta = 260.3 \pm 7.1‰$
$\delta^{13}C = -18.2‰$

Elodea canadensis from Lake Vån. Coll Sept 6, 1975 by H Göransson. *Comment*: sample undersized; diluted; 78% sample.

Lu-1181. Hinnasjön 1975, *Myriophyllum* $\Delta = 270.4 \pm 6.3‰$
$\delta^{13}C = -24.3‰$

Myriophyllum alterniflorum from Lake Hinnasjön, Småland (56° 53′ N, 14° 56′ E). Coll Sept 21, 1975 by Th Persson.

Lu-1009. Odensjön 1974, *Myriophyllum* $\Delta = 153.2 \pm 6.0‰$
$\delta^{13}C = -18.7‰$

Myriophyllum alterniflorum from Lake Odensjön, NW Scania (56° 00′ 15″ N, 13° 16′ 45″ E). Coll Sept 17, 1974 by S Håkansson.

Lu-1183. Odensjön 1975, *Myriophyllum* $\Delta = 123.4 \pm 5.8‰$
$\delta^{13}C = -20.4‰$

Myriophyllum alterniflorum from Lake Odensjön. Coll Sept 20, 1975 by H Göransson.

Lu-1162. Håkulls mosse 1975 $\Delta = 247.7 \pm 6.1‰$
$\delta^{13}C = -25.9‰$

Submerged brown-mosses from water-filled peat-cutting at Håkulls mosse, NW Scania (56° 17′ 20″ N, 12° 31′ 20″ E). Coll Sept 6, 1975 by S Håkansson.

Lu-1019. Börringesjön 1974, *Sium* $\Delta = 283.4 \pm 6.4‰$
$\delta^{13}C = -29.5‰$

Sium sp from rivulet connecting N and S part of Lake Börringesjön, S Scania (55° 30′ 10″ N, 13° 19′ 10″ E). Coll Oct 12, 1974 by S Håkansson.

Lu-1026. Åmossen 1974, *Ceratophyllum* $\Delta = 287.4 \pm 6.4‰$
$\delta^{13}C = -24.5‰$

Ceratophyllum sp from small lake at Åmossen, S Scania (55° 27′ 10″ N, 13° 15′ 30″ E). Coll Oct 26, 1974 by S Håkansson.

Lu-1178. Åmossen 1975, *Ceratophyllum* $\Delta = 255.9 \pm 6.2‰$
$\delta^{13}C = -22.4‰$

Ceratophyllum sp from same lake as Lu-1026. Coll Oct 12, 1975 by S Håkansson.

Terrestrial plants series

Sedges and grass coll near some lakes, above, to determine corresponding atmospheric ^{14}C activity. All samples pretreated with HCl.

Lu-1012. Striern 1974, *Carex* $\Delta = 426.3 \pm 6.6‰$
$\delta^{13}C = -26.3‰$

Carex sp from shore of Lake Striern. Coll Sept 7, 1974 by H Göransson.

Lu-1014. Ämmern 1974, *Carex* $\Delta = 425.3 \pm 6.6‰$
$\delta^{13}C = -27.7‰$

Carex sp from shore of Lake Ämmern. Coll Sept 7, 1974 by H Göransson.

Lu-1016. Vån 1974, *Carex* $\Delta = 425.8 \pm 6.6‰$
$\delta^{13}C = -27.4‰$

Carex elata from shore of Lake Vån. Coll Sept 30, 1974 by H Göransson.

Lu-1182. Hinnasjön 1975, *Molinia* $\Delta = 388.8 \pm 6.5‰$
$\delta^{13}C = -27.9‰$

Molinia caerulea from shore of Lake Hinnasjön. Coll Sept 21, 1975 by Th Persson.

Lu-1010. Odensjön 1974, *Carex* $\Delta = 426.8 \pm 6.5‰$
$\delta^{13}C = -27.4‰$

Carex sp from shore of Lake Odensjön. Coll Sept 17, 1974 by H Göransson.

Lu-1027. Åmossen 1974, *Carex* $\Delta = 415.9 \pm 6.5‰$
$\delta^{13}C = -27.4‰$

Carex sp from shore of lake at Åmossen. Coll Oct 26, 1974 by S Håkansson.

Lu-1179. Åmossen 1975, *Carex* $\Delta = 393.1 \pm 6.8‰$
$\delta^{13}C = -29.4‰$

Carex sp from shore of lake at Åmossen. Coll Oct 12, 1975 by S Håkansson.

Lu-1180. Måryd 1975, *Juncus* $\Delta = 390.2 \pm 6.5‰$
$\delta^{13}C = -28.0‰$

Juncus sp from shore of pond at Måryd, S Scania (55° 42′ 05″ N, 13° 22′ 25″ E). Coll Oct 11, 1975 by S Håkansson.

Surface sediment series

Since ^{14}C activity was abnormally low in submerged plants from Lake Odensjön (*cf* Lu-1009 and -1183, above), surface sediment samples from deepest part of this lake were assayed for ^{14}C content. Coll with 1m Mackereth corer (Mackereth, 1969) Sept 17, 1974 by G Digerfeldt. Depths given are below sediment surface measured in core tube after settling. No pretreatment; small samples; diluted. Amount of CO_2 from sample is given in *Comments* below as "% sample".

Lu-1241. Odensjön, 0 to 1cm $\Delta = -135.8 \pm 12.8‰$
$\delta^{13}C = -29.4‰$

Comment: 20% sample. Activity corresponds to a ^{14}C age of 1170 ± 120 BP.

Lu-1242. Odensjön, 1 to 3cm $\Delta = -150.7 \pm 10.8‰$
$\delta^{13}C = -29.0‰$

Comment: 31% sample. ^{14}C age 1310 ± 105 BP.

Lu-1243. Odensjön, 3 to 5cm $\Delta = -164.6 \pm 9.3‰$
$\delta^{13}C = -29.4‰$

Comment: 28% sample. (3 1-day counts.) ^{14}C age 1440 ± 90 BP.

Lu-1244. Odensjön, 5 to 7cm $\Delta = -159.9 \pm 9.9‰$
$\delta^{13}C = -29.0‰$

Comment: 27% sample. (3 1-day counts.) ^{14}C age 1400 ± 95 BP.

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QUEBEC RADIOCARBON MEASUREMENTS II

L BARRETTE, P LASALLE* and C SAMSON

Centre de Recherches Minérales
Ministère des Richesses Naturelles
Gouvernement du Québec, Québec

INTRODUCTION

Experimental procedures and calculation remain almost as previously described in R, 1977, v 19, p 326-331. The only difference is in the counting equipment. We now use a Beckman LS-230 counter where samples are counted for a total count of about 30,000.

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I. GEOLOGIC SAMPLES

A. Quebec, Canada

Richmond Gulf series

These samples were coll 1972 and subm by D Lagarec (except QU-140 coll by H Samson).

QU-140. Richmond I **4960 ± 120**

Wood and peat from contact between silt and peat on a palsa E of Richmond gulf (56° 08′, N, 75° 55′ W), +132m. *Comment* (DL): date is minimum for emergence since a lagoon occupied site after marine stage and since time must also be allowed for peat growth.

QU-141. Richmond II **1950 ± 90**

Basal peat from bog N of Richmond gulf (56° 32′ N, 76° 25′ W), +12m.

QU-142. Richmond III **4720 ± 120**

Roots from contact between silt and peat in a palsa S of Richmond gulf (56° 7′ N, 76° 28′ W), +84m.

QU-143. Nastapoka River **7760 ± 130**

Basal peat of a palsa near mouth of Nastapoka R (56° 48′ N, 76° 13′ W), +186m.

QU-144. Boniface River **4870 ± 180**

Wood from base of 255cm peat layer of palsa near Boniface R (57° 47′ N, 76° 17′ W), +135m.

General Comment (DL): from above dates we can expect that deglaciation is much older than 7500 BP as proposed by Prest (1970). On the other hand, taking into account time differences between site emergence and

* Exploration Géologique, Ministère des Richesses naturelles.

peat growth and differences between dates from shells and organic samples, uplift curve based on these dates agrees with those of Walcott (1972). N of Poste-de-la-Baleine.

QU-145. Mont Jacques-Cartier **1420 ± 150**

Wood underlying a non-sorted stripe at lower limit of occurrence of phenomenon on Mont Jacques-Cartier (49° 00′ N, 65° 57′ W), +1110m. Coll 1973 by F Boudreau and subm by DL. *Comment* (DL): minimum for non-sorted stripe period of activity in that area.

Lake Mimi series

QU-54. Lake Mimi I **7700 ± 310**
400 to 410cm

QU-70. Lake Mimi II **9460 ± 280**
425 to 435cm

QU-56. Lake Mimi III **10,180 ± 330**
455 to 460cm

QU-67. Lake Mimi IV **9770 ± 260**
470 to 480cm

QU-55. Lake Mimi V **11,050 ± 460**
500-515cm

Five samples of gyttja coll by P Poulin with a Livingstone sampler in 1971, from site ca 4km NW of village of Les Eboulements, Quebec (47° 29′ 50″ N, 70° 22′ 35″ W). *Comment* (PP): QU-55 give a minimum age for ice retreat in Mont des Eboulements area. QU-56 dates inversion of AP-NAP curve in pollen diagram (Richard & Poulin, 1976) and suggests slight climatic deterioration for the time. The 3 other dates help confirm the others, and also help to estimate rate of sedimentation for that lake.

Baie-des-Sables/Trois-Pistoles series

Samples of present series coll and subm by J Locat, Baie-des-Sables/Trois-Pistoles region (Locat, 1976).

QU-261. Price **11,100 ± 370**

Shells (*Mytilus edulis* dominant but assoc with *Macoma balthica, Hiatella arctica, Mytilu edulis, Balanus* sp *Mya arenaria*) coll in gravelly sand layer. Site (48° 36′ 38″ N, 68° 06′ 20″ W), +62m, in littoral sands and gravels below Price delta (+76m). Sea level assoc with these fossils was between 62 and 76m above present sea level. Shorelines at this site are very well-defined, and disappear at +70m. *Comment* (JL): date is maximum for marine water level assoc with position of present +62m contour line.

QU-262. Mont-Joli **11,380 ± 410**

Shells (*Mytilus edulis & Balanus* sp) coll in coarse sand overlain by oxidized fine sand. At this site (48° 35′ 35″ N, 68° 12′ 32″ W), +75m, 1.5km W of Mont-Joli, littoral sediments form a terrace in which sec was cut. *Comment* (JL): result dates maximum of sea level at +75m.

QU-263. St-Anaclet **12,220 ± 450**

Shels (*Mya* sp separated from several species) from fresh ditch in clayey sand overlain by thin littoral fine to medium sand, W of St-Anaclet (48° 29′ 00″ N, 68° 22′ 40″ W), +82m. Sediments may be closely related to St-Anaclet delta (+125m) to the S. *Comment* (JL): age is maximum for position of sea level at +82m.

QU-264. St-Donat **13,360 ± 320**

Shells (*Hiatella arctica, Mya truncata & Balanus hameri*), bivalves well-preserved, from marine clay grading upward into lacustrine varved sediments (48 couplets), in turn overlain by fluvial sand and gravel (48° 30′ 11″ N, 68° 15′ 55″ W), ca +90m. *Comment* (JL): result is close to time of deglaciation, ca 13,500 BP, as suggested by Elson (1969) for Rivière-du-Loup/Trois-Pistoles area. It also dates time of maximum marine inundation in Luceville/St-Donat area and must be related to Luceville delta at +126m.

QU-265. Baie-des-Sables **2240 ± 140**

Shells (*Mesodesma arctica*) from littoral sediments made of gravelly sand near village of Baie-des-Sables on Ste-Flavie terrace (48° 43′ 37″ N, 67° 53′ 00″ W), +4m. Species encountered has never been found in higher deposit. Only unbroken valves (ca 50% were used. *Comment* (JL): result dates marine level (+4m) coinciding with terrace surface.

QU-266. Luceville **10,400 ± 320**

Shells (*Mytilus edulis*) from gravel pit in littoral sediments at ca 3km SW of Luceville (48° 30′ 21″ N, 68° 21′ 30″ W), +70m. Gravel pit extends ca 50m into marine terrace lying at ca +73m in area. *Comment* (JL): result dates marine level assoc with +73m terrace.

QU-267. Grand Métis **11,590 ± 430**

Shells (*Macoma balthica,* unbroken valves, and gastropods and *Mya* sp) coll near Grand Métis, ca 10km E of Mont-Joli, on Bic terrace, near SE edge of old channel (48° 36′ 47″ N, 68° 06′ 00″ W), +30m. *Comment* (JL): date seems too old; possible reworking of higher and older deposits suggested by location of site within erosion channel. Main sea level assoc with this site is ca +53m, corresponding to adjacent shorelines. Shells may also have been contaminated by humic acid or carbonate fertilizers.

QU-268. St-Octave **11,360 ± 290**

Shells (*Mytilus edulis*) from medium sand to medium gravel near village of St-Octave-de-Métis (48° 36′ 48″ N, 68° 06′ 22″ W). Top of sec ca 2.4m above fossiliferous layer and is crest of a emerged beach deposit. *Comment* (JL): result dates marine level assoc with present position of +62m contour line.

QU-271. St-Fabien I **13,390 ± 690**

QU-272. St-Fabien II **12,300 ± 260**

Shells (*Hiatella arctica* for QU-271 assoc with *Balanus hameri, Macoma balthica* and *Mya arenaria* for QU-272) coll in fossiliferous till inclusion incorporated into ice-contact sediments in St-Fabien delta near St-Fabien (48° 18′ 25″ N, 68° 51′ 12″ W), +138m. Delta reaches maximum alt of 155m which corresponds to maximum sea level. This very interesting site is highest Quaternary marine macrofossil locality in Gaspe. Dates come from shells coll from 2 different inclusions; QU-271 is more reliable. *Comment* (JL): results date marine level assoc with position of present +138m contour line.

James Bay series

All samples in this group were coll 1973-5 by L Hardy.

QU-248. Fort George I **4470 ± 170**

Shells (*Hiatella arctica* and probably *Clinocardium ciliatum*) in sandy silt, 16km E of Fort George (53° 45′ 30″ N, 78° 52′ 30″ W), +16m.

QU-121. Fort George II **4110 ± 120**

Shells (*Hiatella arctica*) in beach gravel 22km E of Fort George (53° 44′ 25″ N, 78° 45′ 10″ W). *Comment* (LH): dates position of Tyrrell sea at present +40m contour line.

QU-256. Fort George III **5080 ± 180**

Shells (*Hiatella arctica*) in coarse beach gravel 50km E of Fort George (53° 40′ N, 78° 20′ W), +99m. *Comment* (LH): dates position of Tyrrell sea at present 99m contour line.

QU-119. Fort George IV **5560 ± 130**

Shells (*Hiatella arctica* and debris of probable *Pecten* sp) in shore deposits of Tyrrell sea 65km E of Fort George (53° 43′ N, 77° 58′ W), +172m. *Comment* (LH): dates position of Tyrrell seat at present 172m contour line.

QU-247. Fort George V **6910 ± 350**

Shells (*Hiatella arctica*) in beach gravel, 85km E of Fort George (53° 44′ N, 77° 52′ W), +183m. *Comment* (LH): dates position of Tyrrell sea at present 183m contour line.

QU-245. Fort George VI **7110 ± 180**

Shells (*Hiatella arctica*) in nearshore sandy silt deposit 85km E of Fort George (53° 42′ N, 77° 52′ W), +166m. *Comment* (LH): maximum age for retreat of water plane of Tyrrell Sea at position of present 166m contour line. From field relations, it dates approx position of Tyrrell sea at present 185m contour line.

QU-246. Mattagami-La Grande Road, Mile 363 **7220 ± 330**

Shells (*Hiatella arctica*) coll in reworked fluvio-glacial gravelly sand, (53° 34′ 40″ N, 77° 40′ W), +171m. *Comment* (LH): minimum age for deglaciation and arrival of sea at this point.

QU-249. Mattagami-La Grande Road, Mile 356 **6660 ± 190**

Shells (*Hiatella arctica*) in nearshore deposit of Tyrrell sea (53° 28′ N, 77° 30′ W), +164m. *Comment* (LH): from field relations dates position of Tyrrell sea at present 175m contour line.

Mattagami-La Grande Road, Mile 344

QU-122. **7880 ± 160**

(*Chlamys islandicus*), +162m

QU-124. **7750 ± 180**

(*Hiatella arctica* and other broken shells), +162.1m

Shells from 2 different levels in glacio-marine sandy silt underlying beach gravel and overlying Sakami moraine material, 4.5km W of Mile Post 344 (53° 21′ N, 77° 34′ W). *Comment* (LH): these 2 dates should give approx time of marine invasion in James bay lowlands.

QU-250. Mattagami-La Grande Road, Mile 292 **6930 ± 190**

Shells (*Hiatella arctica* and probably *Chlamys islandicus*) in nearshore sandy and pebbly silt (52° 46′ 30″ N, 77° 18′ 00″ W), +195m. *Comment* (LH): dates position of Tyrrell sea at present 195m contour line.

QU-253. Mattagami-La Grande Road, Mile 275 **6950 ± 210**

Shells (*Hiatella arctica* and *Mya truncata*) in beach sand (52° 34′ N, 77° 20′ W), +200m. *Comment* (LH): dates position of Tyrrell sea at present 200m contour line.

QU-258. Mattagami-La Grande Road, Mile 263 **7440 ± 210**

Shells (*Hiatella arctica*) in nearshore sandy silt (52° 25′ N, 77° 55′ W), +200m. *Comment* (LH): from field relations, dates position of Tyrrell sea at present 215m contour line.

QU-368. Eastmain River **7440 ± 180**

Shells in silty clay at base of marine (Tyrrell sea formation) N bank of Eastmain R, 7.3km upstream from its junction with Opinaca R (52° 13′ 20″ N, 77° 55′ W), +9m. *Comment* (LH): dates approx time of marine invasion (Tyrrell sea in James bay lowlands). Also a minimum age for deglaciation at this point.

QU-254. Eastmain River **7140 ± 210**

Shells (*Hiatella arctica*) in beach gravel. 1km S of Eastmain R along Matagami-La Grande Rd (52° 18′ 30″ N, 77° 05′ W), +218m. *Comment* (LH): dates position of Tyrell sea at present 225m contour line.

QU-252. Mattagami-La Grande Road, Mile 236 7030 ± 210

Shells (*Hiatella arctica*) in nearshore sandy silt (52° 13′ N, 77° 08′ W), +222m. *Comment* (LH): dates position of Tyrrell sea at present 230m contour line.

B. Spitzbergen, Svalbard

West Spitzbergen series

These 2 samples were coll 1973 and subm by J Fabiszewski and K Pekala, Polish Spitsbergen Expedition.

QU-156. Ralstranda bog 450 ± 90

Basal part of peat bog, 1.7m under surface, containing remains of tundra plants, accumulated on 3rd marine terrace at Ralstranda (77° 0′ 50″ N, 15° 19′ 55″ E), ca +25m. *Comment* (JF): result indicates fast peat accumulation in polar conditions and dates older Salix tundra, existing during previous glacier readvance.

QU-157. Eimfiellet nunatak 560 ± 90

Organic layer under 60cm of morainic material around Glacier Werenskioldbreen nunatak (77° 03′ 45″ N, 15° 20′ 15″ E), ca +370m. *Comment* (JF): age of tundra growing on nunatak before deposition of morainic material; also maximum age for recent glacial activity in area.

II. SOIL SAMPLES

A. Quebec, Canada

All soil samples were pretreated by collectors and subm as strontium carbonate. Ages when present are only apparent ages. ^{14}C concentrations are given as % modern relative to 0.95 NBS oxalic acid.

Horizon A series

Samples coll 1974 and subm by Y A Martel and P LaSalle. Bulk samples were taken from 0 to 18cm topsoil, Ap horizon, of a cultivated clay loam soil classified as Kamouraska series and in Gleysolic order (47° 20′ N, 70° 02′ W). *Comment* (YAM): studied to determine stability of soil organic matter in cultivated topsoil.

QU-131. Kamouraska, topsoil 117 ± 2% modern

Total soil organic matter. Roots were removed by water flotation and carbonates by 1N HCl treatment.

QU-129. Kamouraska, humic acids 1220 ± 150
86 ± 2% modern

Fraction of QU-131 extracted with 0.5N NaOH and precipitated at pH 2 with 1N HCl.

QU-130. Kamouraska, Humin I 113 ± 2% modern

Fraction of QU-131 unextractable with 0.5N NaOH.

QU-185. Kamouraska, Humin II **180 ± 100**
98 ± 1% modern

Fraction of topsoil, different from QU-131, unextractable with 0.5N NaOH.

QU-132. Kamouraska, nonhydrolizable **1530 ± 110**
83 ± 1% modern

Total soil was hydrolyzed using 0.5N and 6N HCl (Martel Paul, 1974). Nonhydrolyzable residue is dated.

Horizon C series

Soil samples, coll 1975 and subm by YAM and PL, were taken below root zone and total soil organic matter was dated after carbonates were removed with 1N HCl. *Comment* (YAM): studied to determine utility of such dates in estimating age of soil formation in zone of Champlain sea. QU-310 is shell sample related to corresponding soil.

QU-188. De L'Anse **1850 ± 90**
79 ± 1% modern

Soil coll at 210 to 240cm below surface, on De L'Anse soil series, Micmac terrace, at La Pocatière (47° 22′ N, 70° 03′ W), +6m.

QU-232. Kamouraska **11,730 ± 310**
23 ± 1% modern

Soil coll at 240 to 270cm below surface, on Kamouraska soil series at La Pocatière (47° 20′ N, 70° 02′ W), +115m.

QU-312. Fouquette **10,180 ± 270**
28 ± 1% modern

Soil coll at 150 to 180cm below surface on Fouquette soil series at St-Hélène de Kamouraska (47° 35′ N, 69° 45′ W), +140cm.

QU-313. Ste-Rosalie **16,170 ± 230**
13 ± 1% modern

Soil col at 300 to 330cm below surface on Ste-Rosalie soil series at L'Acadie (45° 19′ N, 73° 16′ W), +150m.

QU-311. St-Rédempteur **12,340 ± 340**
22 ± 1% modern

Soil coll at 260cm below surface at St-Rédempteur (46° 43′ N, 71° 17′ W), +60m.

QU-310. St-Rédempteur, shells **9210 ± 130**
32 ± 1% modern

Shells coll at same location and depth as QU-311.

III. ARCHAEOLOGIC SAMPLES

All archaeologic samples were coll within prov of Quebec and subm by people from Provincial Cultural Affairs Dept.

A. Quebec, Canada

Rivière-au-Bouleau series

Samples from Rivière-au-Bouleau, Quebec (50° 17′ N, 65° 30′ W). Coll and subm by D Chevrier.

QU-114. Rivière-au-Bouleau I **1770 ± 110**

QU-115. Rivière-au-Bouleau II **2870 ± 180**

QU-116. Rivière-au-Bouleau III **3220 ± 240**

Charcoal assigned to Middle Woodland because of archaeol assemblage. Two periods of occupation postulated, not separated by a long time. *Comment* (DC): QU-114 seems post probable date; other 2 dates are too old. Last 2 samples very small. Benzene obtained was minimal.

QU-234. Rivière-au-Bouleau IV **1280 ± 170**

Charcoal from site which should have had 2 periods of occupation; opinion based on pedol, geomorphol, and bot reasons. *Comment* (DC): dates 1st occupation.

QU-236. Rivière-au-Bouleau V **1620 ± 340**

Charcoal from site which should have been occupied before 5000 BP. *Comment* (DC): date too young. Probable contamination by rootlets or humic acids.

QU-237. Rivière-au-Bouleau VI **310 ± 70**

Charcoal from site which should have been occupied between 1000 and 1500 BP. *Comment* (DC): sample was not directly linked to archaeol levels; date tends to confirm that sample does not belong to prehistoric occupation.

QU-238. Rivière-au-Bouleau VII **1140 ± 210**

Charcoal from site which should have been occupied certainly before 6000 BP. *Comment* (DC): date too young, probably contaminated by rootlets or humic acids.

QU-117. Chambly I **1130 ± 90**

QU-118. Chambly II **1160 ± 110**

Charcoal from a site (45° 23′ 36″ N, 73° 15′ 30″ W) which clearly should have been occupied during Archaic period. Coll by G Frenette and N Clermont. *Comment* (NC): dates should be 1500 yr older. Small rootlets present in zone of coll together with fertilization of topsoil could have contaminated samples.

QU-235. Lotbinière **1630 ± 310**

Charcoal from a site (46° 31′ 00″ N, 71° 53′ 30″ W) which seems to correspond to same assemblage of artifacts as those of Owasco culture, New York (Ritchie, 1965) coll by R Ribes. *Comment* (RR): date does not agree with opinion expressed above, but seems to agree with that obtained on charcoal at a site near Trois-Rivières, Bourassa site, which corresponds to Middle Woodland.

St-André-de-Kamouraska series

Samples coll by P Dumais near St-André.

QU-357. Rivière-des-Caps **3670 ± 90**

Charcoal from prehistoric hearth (47° 43′ 29″ N, 69° 40′ 21″ W). *Comment* (PD): date agrees well with late Archaic typological and lithic assemblage.

QU-358. St-André I **630 ± 80**

Fragmented charcoal from test pits (47° 40′ 22″ N, 69° 44′ 38″ W). *Comment* (PD): site considered to be from Archaic period so date appears too young. Sample may have been contaminated by later human activities at site.

QU-359. St-André II **370 ± 90**

Fragmented charcoal from test pits (47° 43′ 26″ N, 69° 40′ 36″ W). *Comment* (PD): date seems too young as material recovered bore no sign of European occupation. Sample may have been contaminated and not even related to archaeol site.

Lanoraie series

Samples coll by G Barré.

QU-218. Lanoraie I **660 ± 100**

QU-220. Lanoraie III **810 ± 160**

Wood and charcoal from a site (45° 57′ N, 73° 13′ W) whose occupation has been assigned to early stage of Iroquois prehistory. *Comment* (GB): dates confirm interpretation given above.

QU-219. Lanoraie II **1610 ± 160**

QU-221. Lanoraie IV **1790 ± 280**

Wood and charcoal from pit and post mold in Iroquois long house (45° 59′ 15″ N, 73° 8′ 50″ W). *Comment* (GB): based on artifacts and other features found at site, dates do not seem to correspond with occupation of sites which should have been somewhere in 14^{th} century.

Tracy series

Samples coll by J Mandeville near Tracy (45° 59′ 5″ N, 73° 8′ 50″ W) and subm by G Barré.

QU-222. Tracy I **410 ± 120**

Charcoal from carbonized habitation post assoc with Iroquois artifacts dated archaeol ca 1500 AD. *Comment* (GB): date confirms interpretation given above.

QU-223. Tracy II **710 ± 130**

Charcoal from carbonized piece of wood separating 2 skeletons in Iroquois burial. *Comment* (GB): date, which should be ca 1500 AD, appears slightly too old.

N Gaspe Peninsula series

Samples coll 1974 by J Benmouyal from 3 archaeol sites on N shore of Gaspe peninsula.

QU-347. Ste-Anne **5960 ± 100**

Charcoal assoc with probable hearth. Habitation site (49° 07′ 35″ N, 66° 27′ 32″ W) on a +45m terrace which has given remains of late Paleo-Indian tradition. *Comment* (JB): age estimate, one of earliest dates for a prehistoric site, in Quebec, seems acceptable, although an older one would not have been surprising.

QU-373. Cap-au-Renard, B-10 **5270 ± 90**

QU-227. Cap-au-Renard, B-1 **4940 ± 170**

QU-228. Cap-au-Renard, B-2 **4170 ± 150**

QU-229. Cap-au-Renard, B-4 **3750 ± 180**

QU-372. Cap-au-Renard, B-7 **2500 ± 80**

Five charcoal samples, thought to belong to local "Middle-Archaic" tradition, coll on a +25m terrace (49° 11′ 51″ N, 66° 13′ 16″ W). This living site has yielded lithic remains in podzol, in A_2 and B horizons but mainly underlying humic level, overlying leached (A_2) soil. *Comment* (JB): results range rather widely in time; problem cannot be solved by assoc material. Some samples may represent forest fires, or may be contaminated. However, 2 samples, QU-228 and -229 are assoc with hearth; they were deeply buried in A_2 horizon, 27 to 32cm below surface. They probably best date human occupation.

QU-226. Cap-au-Renard, A-12 **3030 ± 470**

QU-225. Cap-au-Renard, A-6 **2280 ± 230**

QU-374. Cap-au-Renard, A-5/7 **1880 ± 110**

QU-224. Cap-au-Renard, A-1 **1490 ± 210**

Four charcoal specimens coll on small, badly drained terrace at +18m, underlying QU-373 group one. Material remains were under dark humic layer, in dark sand rich in decaying organic matters. *Comment* (JB): 2 samples, QU-225 and -374, drawn from hearth with fire-cracked rocks, faunal, and other cultural remains, must be favored.

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UNIVERSITY OF MIAMI RADIOCARBON DATES X

D PIEPGRAS, M A ALLISON, T DLUGOS
and J J STIPP

Department of Geology, University of Miami, Coral Gables, Florida 33124

The following dates are a partial list of archaeologic and geologic samples measured since spring of 1976. The method used is described by (Stipp *et al*, 1976). Errors reported are one standard deviation and include only the counting errors on the unknown sample, background, and modern standard. No corrections have been made on these dates. Sample descriptions and comments are based on information supplied by the submitters.

ARCHAEOLOGIC SAMPLES

Wightman series

Shell and charcoal from Wightman site, Sanibel I., Florida (26° 30′ N, 82° 10′ W). Continuation of a study on the occupation of this site (R, v 18, p 211; Fradkin, 1976). *Comment* (DP): this 1st series of 7 shell samples was coll from a cleaned, exposed W wall profile from Trench A. Coll and subm 1975 by J T Milanich, Florida State Mus, Gainesville, Florida.

UM-727. Zone "C" 70cm **1900 ± 90**
Upper zone of constructed shell mound.

UM-728. Zone "D" 80cm **1630 ± 65**
Crushed shell, sand and ash layer between strata of constructed mound.

UM-729. **1810 ± 210**
Duplicate run of UM-728.

UM-730. Zone "E" 160cm **1690 ± 60**
Lower zone of constructed shell mound.

UM-731. Zone "F" 190cm **1480 ± 95**
Shell midden underlying constructed mound.

UM-732. **2060 ± 70**
Duplicate run of UM-731.

UM-733. Zone "G" 220cm **2820 ± 80**
Tidally deposited sand, shell, and humus stratum.

UM-734. Zone "H" 250cm **1610 ± 70**
Intertidal oyster bar.

UM-735. Zone "I" 270cm **1740 ± 70**
Shell layer under oyster bed.

UM-736. **2080 ± 50**
Duplicate run of UM-735.

General Comment (DP): the following 18 shell and charcoal samples come from several locations within site. Sample locations are indicated by a coordinate system. Coll 1976 by J J Stipp; subm 1976 by C Wilson, Sanibel-Captiva Conservation Foundation.

UM-919. Sample #1 **1890 ± 110**

3m quad (129-132N, 123-126E). Charcoal from beneath barren, storm driven shell layer, SW corner.

UM-920. Sample #2 **2210 ± 110**

Same as UM-919 except from NE corner.

UM-921. Sample #3 **1805 ± 75**

Charcoal from S wall of trench (123N, 129E) at same level as UM-919.

UM-922. Sample #4 **2300 ± 85**

Charcoal from top of oyster bed directly below UM-921.

UM-860. Sample #5 **1895 ± 65**

Oyster shell from top of oyster bed and directly below UM-922.

UM-861. Sample #6 **1950 ± 65**

Shell from top of oyster bed at same location as UM-920.

UM-862. Sample #7 **1675 ± 60**

Oyster shell from middle of oyster bed at same location as UM-861.

UM-863. Sample #8 **1885 ± 70**

Mixed shell from middle clay floor in E wall profile of a N-S trench (125N, 129E).

UM-864. Sample #9 **1730 ± 70**

Shell from above storm driven layer and below UM-863.

UM-865. Sample #11 **2400 ± 180**

Shell between 2 ash layers in E wall profile of quad (129N, 129E).

UM-866. **2510 ± 130**

Duplicate run of UM-865.

UM-923. Sample #12 **1220 ± 125**

Charcoal coll side by side with UM-866.

UM-867. Sample #14 **2295 ± 85**

Oyster shell from hole in both sides of trench running N from quad of UM-919 (136N, 126E).

UM-868. Sample #15 **2855 ± 95**

Shell from storm layer in S wall of quad at same location as UM-919.

UM-869. Sample #16 **3395 ± 80**

Shell from storm layer in S wall of E-W trending trench (123N, 129E).

UM-924. Sample #17 **2045 ± 70**
Charcoal from same location as UM-869 overlying storm layer.

UM-870. Sample #19 **1690 ± 70**
Oyster shell from same location as UM-867 at base of oyster bed.

UM-871. Sample #20 **2055 ± 80**
Oyster shell from same quad as UM-919 and at same level as UM-870.

UM-872. **1655 ± 80**
Oyster shell from highest level of living site at Wightman site.

GEOLOGIC SAMPLES

A. United States

Corkscrew Swamp Sanctuary series

A piston core containing peat and marl from Corkscrew Swamp Sanctuary, Central Marsh, Naples, Florida (ca 26° 20′ N, 81° 45′ W). Samples taken to determine rate of peat growth and paleo-environment. Coll 1976 by M Duever, Corkscrew Swamp Sanctuary, and W Kropp, Univ Miami; subm 1976 by W Kropp. *Comment* (DP): basal peat from Corskscrew Swamp Sanctuary, UM-635, was dated, 4720 ± 90, R, v 19, p 123.

UM-952. CS6 (1)-1: 0 to 10cm **575 ± 140**
Peat.

UM-953. CS6 (1)-2: 33 to 46cm **1190 ± 120**
Peat.

UM-954. CS6 (1)-3: 69 to 81cm **3065 ± 85**
Peat.

UM-955. CS6 (2)-4: 106 to 121cm **5715 ± 210**
Peat.

UM-956. CS6 (2)-5: 116 to 127cm **6620 ± 105**
Marl.

UM-957. CS6 (2)-5X: 116 to 127cm **7065 ± 235**
Helisoma gastropod shell.

UM-958. CS6 (2)-6: 195 to 203cm **10,600 ± 180**
Marl.

Cluett Key series

Various piston core samples of peat and carbonate sediments from Cluett Key, Dildo Mud Bank in Florida Bay, S Florida (25° 03′ N, 80° 52′ W). Cluett Key is a mangrove island with a central lagoon. The following peat samples underlay carbonate sediments and are being used to determine if dolomite is forming at present. Coll 1976 by B Halley, USGS, Fisher I.; subm 1976 by M Calvert, Univ Miami. *Comment* (DP): UM-980 and -983 contain no dolomite, and were dated as controls.

UM-980. Cluett 14 **2025 ± 70**

Carbonate sediment.

UM-983. Cluett Δ1 **1735 ± 70**

Carbonate sediment.

UM-981. Dolomite I (Cluett) **4240 ± 90**

Carbonate sediment containing dolomite, HCl wash to 55% of original weight.

UM-982. Dolomite I (Cluett) **3440 ± 80**

Same sediment as UM-981, but sample was washed with EDTA to 72% of original weight to concentrate dolomite.

UM-986. Δ14: 279cm **3795 ± 90**

Peat of mangrove roots.

UM-987. Δ1: 213 to 238cm **4500 ± 100**

Peat of mangrove roots.

General Comment (DP): next 2 peat samples were coll to determine if peat from Cluett Key is same age as peat from a mud flat extending away from island.

UM-984. Cl 14: 219 to 238cm **4600 ± 95**

Peat of mangrove roots from mud bar covered by 46cm water.

UM-985. Δ32: from 122cm **595 ± 65**

Peat of mangrove roots from intratidal zone on Cluett Key.

Long Reef series

Coral from core taken from Long Reef, Dry Tortugas (24° 37′ N, 82° 45′ W). Dates to determine growth rates of *Montastrea annularis.* Coll 1976 by E Shinn, USGS, Mimai, Florida; subm 1976 by D Puppolo, Univ Miami.

UM-973. P-16 **3615 ± 95**

4.88m below reef surface.

UM-974. P-30 **4760 ± 85**

9.14m below reef surface.

UM-975. P-43 **5915 ± 225**

13.11m below reef surface.

UM-976. P-45 **5940 ± 90**

13.72m below reef surface.

UM-977. P-50 **$34,270 \begin{smallmatrix}+1300 \\ -1560\end{smallmatrix}$**

15.24m below reef surface. Unid Pleistocene material at base of coral reef.

UM-1019. P-50 **36,060 $^{+1725}_{-2200}$**

Duplicate run of UM-977.

UM-978. P-57 **35,160 $^{+1000}_{-1145}$**

17.37m below reef surface. Unid Pleistocene material below coral reef.

New York Bight Apex series

Marine shells from 7 cores taken as a part of NOAA's Marine Eco Systems Analysis program (MESA) on New York Bight (40° 25′ N, 73° 50′ E). Samples represent inner shelf clastic sediments. Dated to determine stratigraphy of area. Coll 1972 by S J Williams, CERC; subm 1976 by G L Freeland, NOAA-AOML, Miami, Florida.

UM-909. UC-5, 0.3m **7665 ± 100**

Coll 1974 by G L Freeland.

UM-911. C-60, 0.49m **2230 ± 100**

UM-912. C-59, 1.1m **1510 ± 75**

UM-913. C-58, 2m **2955 ± 90**

UM-914. C-53, 0.3m **430 ± 75**

UM-915. C-44, 0.33m **3740 ± 85**

UM-910. C-42, 0.9m **8380 ± 115**

B. West Indies

Mt Pelée series

Charcoal from pyroclastic sediments near Mt Pelée, Martinique, West Indies. Dated to determine frequency of cyclic eruptions on Mt Pelée, and stratigraphy of Mt Pelée. This is a continuation of earlier series of dates from Mt Pelée, see R, v 18, p 210-220. Coll and subm 1976 by A L Smith and M J Roobol, Univ Puerto Rico at Mayaguez.

UM-855. MP 507 **9175 ± 110**

Charcoal from pumiceous crystal groundsurge deposit, from lowest bed exposed in a 43m sec from lower part of Riviere des Peres, W Pelée (14° 45′ 12″ N, 61° 11′ 03″ W). *Comment* (DP): UM-430, 310 ± 60 yr is 4.5 from top of sec.

UM-935. MP 506 **615 ± 75**

Charcoal, 15m below top of 45m sec from lower part of Riviere des Peres, W Pelée (14° 45′ 12″ N, 61° 11′ 03″ W). Sample is a nuée ardente of Pelean type. *Comment* (DP): UM-430 (310 ± 60 yrs) is 4.5m from top of sec.

UM-936. MP 506 **575 ± 70**

Duplicate run of UM-935.

UM-856. MP 564 **21,185 ± 420**

Charcoal from rd cut near Riviere Laggarde, near Macouba, E Mt Pelée (14° 52′ 0″ N, 61° 9′ 20″ W). Sample is only carbon obtained from this type of deposit, a nuée ardente deposit of St Vincent type.

Soufriere Volcano series

Charcoal from various locations around Soufriere, West Indies. Coll with a mason's trowel. Dated to establish approx date of eruption, and to correlate stratigraphy of region. Coll and subm 1976 by K Rowley, Seismic Research Unit, St Augustine, Trinidad.

UM-873. SV 761 **4335 ± 95**

Charcoal, carbonized tree trunk from base of a nuée ardente flow in Rabacca R bank (13° 18′ 10″ N, 61° 07′ 30″ W) ca 12m above water level.

UM-874. SV 764 **4325 ± 95**

Wood, angiosperm twig from volcanic mudflow in Rabacca R bank (13° 18′ 12″ N, 61° 8′ 10″ W).

UM-875. SV 778 **2700 ± 90**

Charcoal, carbonized tree trunk from basaltic andesite nuée ardente flow near Waribishy R (13° 18′ 45″ N, 61° 07′ 15″ W).

UM-876. SV 781 **2480 ± 70**

Charcoal, carbonized twig and bark from partially welded "ash flow" deposit near Overland Village.

UM-877. SV 840 **635 ± 65**

Charcoal, carbonized tree trunk from pyroclastic flow of block and ash material from Wallibou Dry R (13° 19′ 00″ N, 61° 13′ 35″ W).

UM-878. SV 841 **555 ± 70**

Charcoal, carbonized tree trunk from a pyroclastic flow deposit in coastal cliff sec of Wallibou Beach (13° 19′ 15″ N, 61° 13′ 45″ W).

UM-879. SV 843 **615 ± 60**

Charcoal, carbonized branch of Angiosperm tree from a lithic groundsurge deposit on the East Soufriere Trail (13° 19′ 10″ N, 61° 10′ 10″ W).

UM-880. SV 844 **1045 ± 70**

Charcoal, carbonized branch of Angiosperm tree from fossil soil horizon in lithic groundsurge deposit on East Soufriere Trail (13° 19′ 10″ N, 61° 10′ 10″ W).

UM-881. SV 846 **4165 ± 70**

Charcoal, carbonized branch of Angiosperm tree from a pyroclastic flow deposit in Rabacca Valley (13° 17′ 50″ N, 61° 07′ 15″ W).

C. Bahamas

Joulters Cays series

Ooids retrieved from 2 cores 152m apart. Continuation of a study on stratigraphy and sedimentation rates on Joulters Cays, Bahamas (25° 17.5′ N, 78° 07′ W) (R, v 19, p 00). Coll and subm 1976 by P M Harris, RSMAS, Miami, Florida, and R Erlich, Univ Miami.

General Comment (DP): ages represent ca 25% dissolution of whole ooids unless otherwise noted.

UM-965. 76-9-5B **615 ± 105**

30cm below surface.

UM-966. 76-9-5D **625 ± 90**

91cm below surface.

UM-967. 76-9-5F **495 ± 120**

122cm below surface.

UM-968. 76-9-5I **735 ± 90**

183cm below surface.

UM-969. 76-9-5J **3185 ± 115**

457cm below surface.

UM-970. 76-9-5K **3755 ± 100**

488cm below surface. 47% dissolution of whole ooids.

UM-971. 76-9-5L **23,130 ± 490**

732cm below surface. 100% dissolution of whole ooids.

UM-972. 76-8-1A **1895 ± 65**

30cm below surface. 100% dissolution of whole ooids.

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[RADIOCARBON, VOL. 19, No. 3, 1977, P. 460-464]

US GEOLOGICAL SURVEY, MENLO PARK, CALIFORNIA, RADIOCARBON MEASUREMENTS I

STEPHEN W ROBINSON

US Geological Survey, Menlo Park, California 94025

A radiocarbon laboratory at the US Geological Survey Western Regional Headquarters in Menlo Park, California was established in temporary rooms in March, 1976. In August, 1976 the laboratory was dismantled and moved into a new building that was designed specifically for the facility. This list contains results of operations in the temporary laboratory, which was located in the basement of a two-story building. The counter shield was 15cm lead and 5cm borated paraffin with an additional 5cm of lead above the counters. The anticoincidence ring consisted of copper tubes, 5cm in diameter, mounted around a copper tube with an inside diameter of 15cm. Installed in the anticoincidence ring were the four sample counters, whose characteristics are shown in Table 1. The counting electronics unit, which is designed to service five sample counters, follows the design of Gulliksen (1972) in most respects. The sample counters were constructed of copper and quartz; their design is described in detail by Robinson (1977). The CO_2 counting gas was purified by recirculation over copper and silver at ca 450°C. Wood samples were typically pretreated by leaching for 24 hours alternately in 1N sodium hydroxide and hydrochloric acid solutions at 70°C.

Samples were counted for at least 2,400 min, and ages calculated using the Libby half-life of 5570 years. The age dating limits are stated for samples whose activity was measured as less than 4σ, where σ is the standard deviation due to counting statistics. The stated age limit is the age calculated for an activity of 4σ.

To provide an interlaboratory comparison, two samples previously dated at the Teledyne Isotopes laboratory were remeasured (Table 2). The apparent discrepancy for USGS-28 may indicate that the pretreatment used at the Teledyne laboratory is not sufficient for complete removal of humic-acid contamination, a problem also suggested by Stuiver *et al* (1975). Unless otherwise indicated, the collectors and submitters are US Geological Survey personnel.

SAMPLE DESCRIPTIONS

Colville River, Alaska series

Sec of dune sands and channel sands exposed in bank of Nechelik Channel distributary near its divergence from Colville R (70° 13.4′ N, 150° 52.0′ W). Coll and subm by L D Carter.

USGS-32. **1110 ± 65**

Detrital wood from channel sands ca 4.9m above river level.

USGS-39. 1280 ± 70

Wood in growth position in dune sand overlying channel sands. Ca 5.5m above river level.

USGS-73. 4290 ± 570

Wood fragments from 42m depth in core taken near Portage, Alaska (60° 49′ N, 148° 59′ W). Coll and subm by A T Ovenshine, S Bartsch-Winkler, R Kachadoorian. Undersized sample.

USGS-44. Galbreath Lake Moraine, Alaska 1850 ± 85

Peat from headwall of active earthflow 5km NW of Galbreath Lake (68° 29′ N, 149° 34′ W). Dates interval of slope stability that preceded late Holocene solifluction. Coll and subm by T Hamilton.

USGS-42. Galbreath Lacustrine Plain, Alaska 4800 ± 100

Wood from E bank Atigun R 7.5km S of Galbreath Lake (68° 23.5′ N, 149° 21′ W). Dates high-water phase, ca +10 to +15m, of Galbreath Lake. Coll and subm by T Hamilton.

Blakely Harbor, Washington series

Dates from marine terrace deposits exposed near Blakely Harbor, Bainbridge I., Washington (47° 35.7′ N, 122° 30.7′ W).

USGS-6. 4530 ± 90

Wood from S side of Blakely Harbor ca 2.7m above mean high tide. Coll and subm by K Marcus and H Gower.

USGS-7. 3260 ± 80

Marine shells from S side of Blakely Harbor ca 4.5m above mean high tide. Sampling site ca 25m W of USGS-6 and ca 100m E of USGS-65. Coll and subm by K Marcus and H Gower.

TABLE 1

Counter characteristics

Counter volume (L)	Filling pressure (atm)	Net modern count rate (cpm)	Background count rate (cpm)
0.74	2.04	9.3	1.91
1.02	2.04	12.7	2.52
1.22	2.72	20.9	3.01
2.48	2.04	30.5	5.49

TABLE 2

Interlaboratory check samples

Sample material	USGS results		Teledyne Isotopes' results	
Peat	USGS-27	2610 ± 110	I-7586	2475 ± 85
Wood	USGS-28	>39,400	I-7555	30,400 ± 1200

USGS-65. **5880 ± 70**

Marine shells from base of marine terrace sec ca 1m above mean high tide. Marine sec is ca 3m thick. Coll and subm by J Yount.

USGS-64. Double Bluff, Widbey Island, Washington **12,670 ± 90**

Marine shells in slightly oxidized sandy till, ca 100m ENE of most S point of Double Bluff (47° 58.1′ N, 122° 32.7′ W), ca 3m above present sea level. Till appears to be deposited against older Double Bluff drift ca 300m to E. Date agrees with other dates on glaciomarine drift in N Puget Lowland, 10,370 ± 300 BP to 13,100 ± 170 BP (Easterbrook, 1969). Coll and subm by J Yount.

USGS-54. Alta Coulee, Washington **430 ± 80**

Freshwater snail shells from surface sediments. Dates episode of ponding on floor of Alta Coulee (47° 58′ N, 119° 56′ W) in depression at least partly closed because of accumulation of Antoine Creek fan. Ponding records either neoglacial pluvial event or interval when Antoine Creek discharged across N sec of fan rather than across S sec as it does today. Coll and subm by R B Waitt.

USGS-80. Gas Line Flow, Newberry Craters, Oregon **6150 ± 65**

Charcoal from tree mold in lava, 16km S of Bend, Oregon (43° 50′ N, 121° 21′ W). Dates eruptions from NW rift of Newberry Volcano. Coll by N V Peterson, Oregon Dept Geol & Min Resources, and E A Groh; subm by D Champion, California Inst Tech and USGS.

USGS-38. Bakersfield, California **14,100 ± 200**

Wood, 12 to 15m below surface of Kern R alluvial fan (35° 21′ N, 119° 02′ W). Dates major phase of late Modesto (Modesto formation, upper member) glacial outwash, presumably correlative with major phase of Tioga glaciation of Sierra Nevada. Coll by S Soenke, US Dept Agr, subm by D Marchand.

USGS-62. Pixley, California **4600 ± 100**

Calcium carbonate- and silica-cemented hardpan horizon (Ccam). Fresno soil series (36° 58′ N, 119° 14′ W). Young apparent age demonstrates that hardpan was open to exchange with younger carbonate throughout Holocene time. Coll and subm by D Marchand.

USGS-87. Mule Creek, California **310 ± 45**

Wood from W side Mule Creek (122° 48′ 40″ W, 40° 52.07′ N). Sample from near base of foreset beds topographically higher than normal level by Clair Engle Reservoir, or Trinity Lake. Foreset beds may represent deposition in water body occupying present site of reservoir. Coll and subm by J Wolfe.

USGS-33A. Searles Valley, California **14,300 ± 200**

Tufa from compound gravel bar formed in ancient Searles Lake (35° 50.8′ N, 117° 18.4′ W). Grains picked from crustal tufa sample, washed in ultrasonic bath, and outer 10% dissolved in acid. Coll and subm by G I Smith.

USGS-33B. Searles Valley, California **12,800 ± 150**

Bulk sample not washed or picked, but with very short acid leach. Demonstrates that bulk sample contains significant contamination with younger carbon.

USGS-67. Searles Valley, California **7700 ± 75**

Green calcareous lacustrine silt. Contains ostracods dated at 9070 ± 300, W-1894 (R, 1969, v 11, p 213). Coll and subm by G I Smith.

Dumbarton West series, California

Samples from bore-hole drilled 0.5km N of W end of Dumbarton Bridge (37° 30′ 09″ N, 122° 07′ 49″ W). Coll and subm by M Bennett.

USGS-35. 6.6m depth **3070 ± 90**

Ostrea sp from upper part of Oyster mud.

USGS-36. 11.7m depth **4830 ± 130**

Ostrea sp from lower part of Oyster mud.

USGS-55. 16m depth **>37,600**

Wood fragment, near top of alluvial sand deposits. *Comment*: Oyster mud was deposited for ca 2000 yr with only 1 break in deposition. Alluvial sand is unconformably overlain by Holocene bay sediments.

Bolinas Lagoon Spit series, Marin Co, California

Shells from Borehole 3 on Bolinas Spit (37° 54′ 28.3″ N, 122° 40′ 39.5″ W). Coll and subm by J R Bergquist and B Atwater.

USGS-71. 7.9 to 8.2m depth **1160 ± 60**

Macoma nasuta and *Tresus* sp.

USGS-72. 15.2m depth **6450 ± 100**

Macoma nasuta, Tresus sp, *Clinocardium nuttalli,* and *Protothaca staminea.*

USGS-74. Burdell Mountain Landslide **>29,700**

Disseminated plant fragments from 23.6m below surface in large landslide mass (38° 7.5′ N, 122° 35′ W). Date is minimum for last activity of Burdell Mt slide. Coll by Cooper-Clark Assoc, Palo Alto, Calif and subm by S Ellen. Undersized sample.

USGS-90. Listvyanya Cove, Siberia, USSR **1750 ± 50**

Charcoal from 50cm depth in excavation at Listvyanya Cove (52° 14′ N, 107° 27′ E). Assoc with Bronze age pottery. Coll and subm by S L Troitskiy, Inst Geol & Geophys, Acad Sci, USSR, Novosibirsk, and D M Hopkins.

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[RADIOCARBON, VOL. 19, No. 3, 1977, P. 465-475]

RUDJER BOŠKOVIĆ INSTITUTE RADIOCARBON MEASUREMENTS IV

DUŠAN SRDOČ, ADELA SLIEPČEVIC*, BOGOMIL OBELIC, and NADA HORVATINČIC

Rudjer Bošković Institute, P O B 1016, 41001 Zagreb, Yugoslavia

The following list contains dates of samples measured since our previous list (R, 1975, v 17, p 149-155). As before, age calculations are based on the Libby half-life 5570 ± 30 yr and reported in years before 1950. The modern standard is 0.950 of the activity of NBS oxalic acid.

Sample pretreatment, combustion, and counting technique are essentially the same as described in R, 1971, v 13, p 135-140. A new technique was introduced for soil sample preparation (Srdoč Sliepčević, 1975) consisting of combustion of bulky samples of soil having very low carbon content in a large stainless steel cylinder, heated by an electric oven. The sample is distributed in several dishes; the total capacity of the furnace is ca 1kg of soil per combustion. A stream of purified oxygen flows through the tube and combustion products are trapped in cooled stainless steel traps. Carbon dioxide is subsequently purified by vacuum distillation and condensed in stainless steel cylinders. The synthesis of methane is performed in a similar furnace containing ruthenium catalyst. Statistical processing of data has been computerized (Obelić Planinić, 1975). Sample descriptions were prepared with collectors and submitters. The errors quoted correspond to 1σ variation of sample net counting rate and do not include the uncertainty in ^{14}C half-life. Data are not corrected for isotopic fractionation.

Ages of speleothems (dripstones) are calculated using 65% (subtracting 3461 yr) and 85% (subtracting 1305 yr), respectively, of NBS standard of contemporary ^{14}C values. The initial ^{14}C content in groundwaters depends namely upon the geology of the catchment area (Münnich & Vogel, 1959; Geyh, 1972).

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I. PALEOLITHIC AND MESOLITHIC SAMPLES OF CENTRAL AND EASTERN EUROPE

Z-321. Donja Cerovačka pećina **>40,000**

Crystalline calcite coating on animal bones (*Ursus spelaeus*), Cave Donja Cerovačka pećina near Gračac, Lika, S Croatia. Coll and subm 1972 by M Malez, Yugoslav Acad Sci & Arts, Zagreb.

Z-324. Hijenska pećina **7810 ± 150**

Calcite coating on animal bones (*Ursus spelaeus, Crocuta spelaea*) from Cave Hijenska pećina in Plovunija limestone quarry near Buje,

* Faculty of Veterinary Medicine, Univ Zagreb, Yugoslavia

Istria, W Croatia. Coll and subm 1973 by M Malez (1956). *Comment*: 65% modern.

Z-325. Pisana Stina Cave **4840 ± 100**

Calcite coating on animal bones and teeth (*Ursus spelaeus, Capra ibex, Leopardus pardus*), Cave Pisana Stina, Opor Mt near Trogir, S Croatia. Coll and subm 1969 by M Malez (1961). *Comment*: 65% modern.

Z-326 Kamenika Cave **1660 ± 100**

Porous calcite coating on animal bones (*Bison priscus*), Cave Kamenika near Srednji Lipovac, Slavonia, E Croatia. Coll and subm 1969 by M Malez (1971). *Comment* (MM): date younger than expected (Upper Pleistocene). 85% modern.

Medvjedja pećina series

Calcite deposits and stalagmites from cave Medvjedja pećina near Lučice, Lošinj I., Croatia. Coll and subm 1974 by M Malez. *Comment* (MM): samples containing fossil faunae from time when Lošinj I. was part of mainland. Dates indicate period of North Adriatic transgression (Malez Božičević 1964); 65% modern.

Z-338.	**Medvjedja pećina 2**	**>40,000**
Z-339.	**Medvjedja pećina 3**	**>40,000**
Z-340.	**Medvjedja pećina 4**	**>40,000**
Z-341.	**Medvjedja pećina 5**	**>40,000**
Z-328.	**Medvjedja pećina 1**	**12,830 ± 300**
Z-343.	**Medvjedja pećina 6**	**>40,000**
Z-346.	**Medvjedja pećina 7**	**>40,000**
Z-347.	**Medvjedja pećina 8**	**26,000 ± 1100**
Z-348.	**Medvjedja pećina 9**	**121% modern**
Z-349.	**Medvjedja pećina 10**	**128% modern**

Z-329. Pećina near Ličko Lešće **>40,000**

Travertine with embedded snail shells and animal bones from cave near Ličko Lešće, Lika, S Croatia. Coll and subm 1959 by M Malez. *Comment* (MM): expected age: Upper Pleistocene; 65% modern.

Z-330. Druška peć **17,000 ± 250**

Bone breccia in rock shelter near Mošćenička Draga, Istria, W Croatia. Coll and subm 1972 by M Malez (1971). *Comment* (MM): agrees with expected age: Upper Pleistocene; 85% modern.

Z-331. Djurkovina Cave **14,630 ± 400**

Calcite deposit on animal bones (*Ursus spelaeus*) from cave near Grebci, Hercegovina. Coll and subm 1958 by M Malez (1957). *Comment* (MM): date agrees with expected age: Upper Pleistocene; 65% modern.

Z-333. Kuvija or Megara Cave **3730 ± 110**

Porous stalagmite, Deposit b, Sonda I from cave on Bjelašnica Mt, Bosnia. Coll and subm 1971 by M Malez (1971). *Comment* (MM): dates sedimentation of speleothems in high alt, 1290m, and occurrence of faunae. The cave was a bear hole. 85% modern.

Z-335. Banić Cave or Čampari Cave **10,100 ± 600**

Stalagmite deposited on animal bones (*Ursus arctos priscus*) in Banić Cave near Petrići, Cres I. Coll 1973 by B Jalžić and subm by M Malez, both Yugoslav Acad Sci & Arts, Zagreb (Malez, 1975). *Comment* (MM): dates appearance of fossil bear. Agrees with expected age: Lower Holocene; 65% modern.

Zelena pećina series

Calcite deposit, remains on the right wall of cave hall, Buna R, spring near Blagaj, Bosnia. Coll and subm 1974 by M Malez. *Comment*: 85% modern.

Z-390. Zelena pećina 5 **32,600 +2400 −2300**

Z-391. Zelena pećina 6 **27,400 ± 1900**

Z-394. Donji Miholjac **11,700 ± 500**

Loess dolls from Donji Miholjac (45° 45′ N, 18° 10′ E) Slavonia. Profile 398,70; 120cm depth. Coll and subm 1974 by M Malez. *Comment*: 85% modern.

Z-406. Vindija **2770 ± 190**

Porous stalagmite with embedded Neolithic animal bones and ceramics from Cave Vindija, Gornja Voća near Ivanec, N Croatia. Coll and subm 1974 by M Malez. *Comment* (MM): expected period: Upper Pleistocene — Holocene; 65% modern.

Savudrija series

Calcareous concretions in loess profile from Savudrija (45° 29′ N, 13° 30′ E) Istria, W Croatia. Sample assoc with gastropod shells. Coll and subm 1975 by M Malez. *Comment* (MM): expected age: Upper Pleistocene; 85% modern.

Z-488. Savudrija (No. 4) **11,160 ± 210**

Middle layer.

Z-489. Savudrija (No. 6) **7190 ± 150**

Lower layer.

II. GEOLOGIC SAMPLES

Z-449. Leskovica **2530 ± 120**

Peat from boring hole in moor, depth 60 to 70cm, near Leskovica (46° 08′ 40″ N, 11° 44′ 20″ E) Slovenia. Coll and subm by A Šercelj, Slov

Acad Sci & Arts. *Comment* (AŠ): expected period: Middle Holocene (Šercelj, 1975). Dates period shortly before human influence in area. Date confirms palynologic data.

National Park Plitvička jezera series

Calcareous tufa, National Park Plitvice Lakes (44° 50′ N, 15° 35′ E), Lika, Croatia. Samples from various places and depths should indicate chronology of tufa formation. Coll and subm 1974 by M Malez, A Brnek, A Sliepčević and D Srdoč. *Comment*: Ages are only approximate due to possibility of isotopic exchange between ^{14}C atoms between tufa porous surface and air.

Z-396. Plitvički Ljeskovac 1 **>40,000**

Calcareous tufa barrier above present lake surface.

Z-398. Plitvički Ljeskovac 3 **>40,000**

Same as Z-396, crystalline structure.

Z-400. Gradinsko jezero 5 **103% modern**

Calcareous tufa under water, surface layer.

Z-403. Gradinsko jezero 8 **1065 ± 80**

Calcareous tufa above water, surface layer.

Z-405. Gavanovac jezero 10 **2850 ± 100**

Calcareous tufa deposited on limestone above present water level.

III. SOIL SAMPLES

Z-361. Rajhenavski Rog **235 ± 70**

Charcoal in soil profile, 15 to 20cm depth from Rajhenavski Rog Mt (45° 40′ 55″ N, 15° 1′ 5′ E) Kočevska, Slovenia. Dated to estimate forest age for vegetational map of Yugoslavia. Coll 1974 by I Puncer, Biol Inst, Slov Acad Sci & Arts, Ljubljana and subm by A Šercelj. *Comment* (AŠ): expected period: Holocene.

Snežnik series

Humus horizons A_1 of forest soil from various places of Snežnik Mt (45° 35′ N, 14° 24′ E) Slovenia. Coll 1973 by M Župančić, Biol Inst "Jovan Hadži" Ljubljana and subm by A Šercelj. *Comment*: modern rootlets removed. Soil samples measured to date sequence of forest vegetation, to correlate dates with pollen analyses, and to elucidate origin of forest phytocenoses, partly as a result of transhumance.

Z-308. Sežanje **2145 ± 80**

Soil léssivé, A_1 horizon, 5 to 15cm depth; forest: *Piceetum subalpinum dinaricum.*

Z-309. Medvedova draga **101% modern**

Soil léssivé, A_1 horizon, 8 to 15cm depth; vegetation: *Arnico-Nardetum.*

Z-310. Medvedova draga **545 ± 70**

Soil léssivé, $A_{1,2}$ horizon, 5 to 15cm depth; forest: *Piceetum montanum dinaricum.*

Z-311. Leskova dolina **70 ± 45**

Brown soil, A_1 horizon, 8 to 15cm depth; forest: *Abieti-Fagetum dinaricum.*

Trnovski gozd series

Humus horizons A_1 from Mt Trnovski gozd (45° 57′ N, 13° 52′ E). Coll by M Župančić and subm 1973 by A Šercelj. *Comment* (AŠ): expected age: 500 to 1000 yr. Modern rootlets removed.

Z-312. Smrečje **925 ± 70**

$A_{1,2}$ horizon, 7 to 18cm depth; forest: *Luzulo-Piceetum.*

Z-356. Smrekova draga 1 **460 ± 80**

A_1 horizon, 10 to 15cm depth; forest: *Piceetum subalpinum.*

Z-357. Smrekova draga 2 **1450 ± 100**

$A_{1,2}$ horizon, 20 to 25cm depth; forest: same as above.

Slatnik series

Forest humus Mali Slatnik near Novo Mesto (45° 48′ 40″ N, 15° 13′ 30″ E), E Slovenia. Dates forest succession. Coll 1974 by L Marinček, Biol Inst, Slov Acad Sci & Arts and subm by A Šercelj. *Comment*: modern rootlets removed.

Z-369. Slatnik A **112% modern**

Upper horizon, 5 to 10cm depth.

Z-370. Slatnik B **112% modern**

Lower horizon, 10 to 20cm depth.

National Park Plitvička jezera series

Soil samples from comparative lots (forest, ploughland) of National Park Plitvice lakes (44° 50′ N, 15° 35′ E), Lika, Croatia anthropogenic period of soil development and characteristic of A horizons of soils on limestone. Coll and subm 1974 by J Martinović, Inst Forest Sci, Jastrebarsko. *Comment*: modern rootlets removed.

Z-371. Korenička kapela 1 **265 ± 70**

Rendzina on dolomite, 5% C, A horizon, forest soil, 0 to 20cm depth.

Z-373. Jezerce 3 **106% modern**

Brownearth (Cambisol) on cretaceous limestone, 3% C, A horizon, forest soil, 0 to 12cm depth.

Z-374. Jezerce 4 **940 ± 110**

Brownearth on cretaceous limestone, 1% C, B horizon, forest soil, 20 to 40cm depth.

Z-375. Jezerce 5 **107% modern**

Brownearth on cretaceous limestone, 2% C, A horizon, plough-land, 0 to 15cm depth.

Z-376. Jezerce 6 **1140 ± 70**

Brownearth on cretaceous limestone, 1% C, B horizon, plough-land, 20 to 45cm depth.

Z-377. Jezerce 7 **570 ± 70**

Rendzina on Triassic dolomite, 5% C, A horizon, forest soil, 0 to 20cm depth.

Z-378. Jezerce 8 **100% modern**

Rendzina on Triassic dolomite, 2% C, A horizon, plough-land, 0 to 20cm depth.

Z-379. Bigina Poljana 9 **102% modern**

Brownearth on Triassic dolomite, 3% C, A horizon, forest soil, 0 to 13cm depth.

Z-380. Bigina Poljana 10 **480 ± 130**

Brownearth on Triassic dolomite, 1% C, B horizon, forest soil, 20 to 45cm depth.

Z-381. Bigina Poljana 11 **103% modern**

Brownearth on Triassic dolomite, 2% C, A horizon, plough-land, 0 to 15cm depth.

Z-382. Bigina Poljana 12 **1835 ± 80**

Brownearth on Triassic dolomite, 0,5% C, B horizon, plough-land, 20 to 45cm depth.

Z-383. Draga 13 **111% modern**

Luvisol on Triassic dolomite, 2% C, A horizon, forest soil, 0 to 10cm depth.

Z-384. Draga 14 **680 ± 80**

Luvisol on Triassic dolomite, 0,5% C, E horizon, forest soil, 15 to 30cm depth.

Z-385. Draga 15 **1770 ± 80**

Luvisol on Triassic dolomite, 0,5% C, B horizon, forest soil, 50 to 75cm depth.

Oborovo series

Samples of peat and clay from boring hole at Oborovo (45° 41′ N, 16° 16′ E) near Zagreb, Croatia. Coll and subm 1975 by Ana Sokač, Fac Min, Geol & Petrol Eng, Univ Zagreb. *Comment* (AS): dating Quaternary sediments to determine tectonic dislocations. Expected period: Upper Pleistocene.

Z-478. OS-1 **>45,000**

Peat, 27.6 to 29m below surface.

Z-479. OS-1 **>45,000**

Carbonaceous clay, 69.6 to 69.8m below surface.

Z-480. OS-1 **>45,000**

Peat, 86.8 to 87.1m below surface.

Z-482. OS-3 **>45,000**

Peat, 31.1 to 31.4m below surface.

Z-485. OS-4 **20,000 ± 1000**

Brown, sandy clay, containing organic material 5.1 to 5.2m below surface.

IV. ARCHAEOLOGIC SAMPLES

Z-300. Podgorač **3410 ± 100**

Charcoal mixed with earth, 0.80 to 1.90m depth, scattered in cultural pit of settlement Podgorač (Breški) (45° 27′ N, 18° 13′ E) near Našice, E Croatia. Coll and subm by Nives Majnarić-Pandžić, Archaeol Inst, Fac Arts & Sci, Zagreb.

Ljubljansko Barje series I

Palynol and archaeol studies from a basin 20km long and 10km wide S and SW of Ljubljana, Slovenia. Ancient moor filled with Quaternary deposits and alluvium of clay, sand, and peat. Peat and sediment samples.

Z-301. Ljubljansko Barje – Črna Vas **2850 ± 100**

Peat mixed with earth, 1m depth, Črna Vas (46° 0′ N, 14° 29′ E), Slovenia. Coll and subm 1973 by A Šercelj. *Comment* (AŠ): age younger than expected: 4000 yr.

Z-302. Ljubljansko Barje – Bevke **9710 ± 170**

Lake chalk mixed with organic matter, 3.40 to 3.60m depth, Bevke (45° 59′ N, 14° 21′ E). Coll and subm 1973 by A Šercelj. *Comment* (AŠ): expected age: 8000 to 10,000 yr.

Ljubljansko Barje series II

Fragments of wood from Eneolithic lake pile-dwelling. Coll 1974 by Tatjana Bregant, Fac Arts & Sci, Ljubljana; subm by A Šercelj. Dates estimate archaeol chronology (Bregant, 1975).

Z-351. Ljubljansko Barje — Maharski Kanal XLI 5080 ± 110

Wood, 80cm below surface embedded in gyttja and lake chalk deposit at Maharski Kanal, a drainage channel near Ig (45° 58′ 25″ N, 14° 32′ 20″ E). *Comment* (AŠ): corresponds to earlier measurements, Z-314 and Z-315 (R, 1975, v 17, p 149).

Z-353. Ljubljansko Barje — Maharski Kanal S-4 4330 ± 120

Comment (AŠ): corresponds to previous measurement, Z-305 (R, 1975, v 17, p 149).

Z-354. Ljubljansko Barje — Resnik Kanal 5850 ± 150

Wood, 50cm below surface in carbonaceous clay in Notranje Gorice (45° 59′ 30″ N, 14° 24′ 40″ E).

Z-336. Divostin A 6000 ± 180

Charcoal from Feature 121 ca 35cm below Level 7 at Divostin, village near Kragujevac (44° 00′ N, 26° 55′ E), Serbia. Coll 1969 by Ruth Tringham, Dept Anthropol, Harvard Univ, Cambridge, Masachusetts. Subm by A McPherron, Dept Anthropol, Univ Pittsburgh, Pennsylvania. *Comment* (AMcPh): sample was divided into 3 portions and dated in 3 labs: (Bln-898:3910 BC, BM-574: 3297 BC and Z-336: 4050 BC) (McPherron & Srejović, 1971).

Kranj series

Charcoal from hearth under recent church at Kranj (46° 14′ 25″ N, 14° 21′ 40″ E) from 80cm depth. Coll 1973 by A Valič, Gorenjski Mus, Kranj, subm by A Šercelj.

Z-358. Kranj IV 2160 ± 100

Z-359. Kranj XIX 1160 ± 80

Z-360. Barje Kaznarice near Pišece 7760 ± 600

Peat from core, 170cm depth from Kaznarice peat bog, near Pišece (46° 30′ N, 15° 40′ E), Slovenia. Dated to estimate chronology of lateglacial and postglacial vegetation. Coll and subm 1974 by A Šercelj. *Comment* (AŠ): expected age: end of Pleistocene, beginning of Holocene.

Tumba series I

Excavation in Crnobuki village, near Bitola (41° 04′ N, 21° 25′ E), Macedonia. Coll and subm 1974 by B Kitanosli, Naroden Mus, Prilep, Macedonia.

Z-362. Tumba 5390 ± 180

Cockle (?) from Sonda II, Horizon 1. *Comment* (BK): older than expected: 2000 BC.

Z-363. Tumba 5310 ± 180

Charcoal or soot (?) from Sonda I, Level 26-31.

Excavation in Karamani village, near Bitola, Macedonia. Coll and subm by B Kitanosli.

Z-364. Tumba **3600 ± 175**

Cockle from Sonda I, Horizon 1. *Comment* (BK): expected age: Bronze age, ca 1800 BC.

Z-365. Tumba **3660 ± 150**

Charcoal from Sonda I, Horizon 2.

Z-367. Tumba **3820 ± 150**

Wheat from Sonda I, Horizon 2.

Z-408. Goričan **2110 ± 90**

Fragments of charred wooden beam, tumulus, 1.1m depth, Goričan near Čakovec (46° 22′ N, 16° 40′ E). Col and subm 1974 by Ksenija Vinski, Archaeol Mus, Zagreb.

Odmut series

Charcoal samples from Odmut rock shelter (45° 12′ N, 18° 50′ E), Piva R spring, 12km downstream, Montenegro. Coll and subm 1974 by D Srejović, Fac Arts & Sci Archaeol Dept, Belgrade.

Z-409. Odmut 1 (No. 37) **4280 ± 120**

Charcoal from Eneolithic, Block V, Level III.

Z-410. Odmut 2 (No. 40) **4390 ± 150**

Charcoal from Late Neolithic, Block V, Level VI.

Z-411. Odmut 3 (No. 72) **7440 ± 150**

Charcoal from Late Neolithic, Block V, Level XV.

Z-412. Odmut 4 (No. 61) **6730 ± 160**

Charcoal from Early Mesolithic, Block V, Level XI.

Z-413. Odmut 5 (No. 78) **7350 ± 160**

Charcoal from Late Mesolithic, Block V, Level XXI.

Z-457. Odmut 6 (No. 24) **7030 ± 160**

Charcoal from Mesolithic, Block I, Level XIX.

Comment: significant archaeol loc of more layers (from Mesolithic to Eneolithic). Dates prehistory of Piva R region. Settlement excavated during construction of hydroelectric power plant, Mratinje.

Z-416. Spilia (No. 8) **4880 ± 110**

Charcoal from Spilia rockshelter at 300m alt above Perast (42° 30′ N, 18° 43′ E), Montenegro. Late Neolithic, Block C, Level VII. Coll and subm 1974 by D Srejović.

Most na Soči series

Charcoal samples from charred wooden wall of a Hallstatt house. Sonda 2, P1 5, 140cm depth. Munih's garden, Most na Soči (45° 15′ N, 11° 15′ E) SW Slovenia. Systematic archaeol excavation to study Hallstatt culture and architecture. Coll and subm 1974 by D Svoljšak, Mus Nova Gorica. Expected age: 6th century BC.

Z-429. Most na Soči 1 **2330 ± 100**

Z-430. Most na Soči 2 **2390 ± 100**

Z-431. Most na Soči 3 **2440 ± 80**

Sudjuradj, Šipan Island series

Samples found in sunken ship, near Sudjuradj, Šipan I. (42° 20′ N, 17° 55′ E). Coll and subm 1975 by J Luetić, Centre Sci Work, Yugoslav Acad Sci & Arts, Dubrovnik. *Comment* (JL): expected age: 16th to 17th century.

Z-452. Sudjuradj **410 ± 90**

Charcoal from gun powder.

Z-453. Sudjuradj **440 ± 90**

Fragment of wood from same ship.

Beran Krš series

Samples of charcoal from excavation at Beran Krš near Ivangrad (42° 45′ N, 19° 50′ E), Montenegro. Coll and subm 1975 by D Srejović. *Comment* (DS): expected age: Early Neolithic — Vinča culture.

Z-491. Beran Krš (No. 11) **6030 ± 160**

Charcoal from Sonda III, Excavation Layer 7.

Z-492. Beran Krš (No. 14) **5870 ± 150**

Charcoal from Sonda III, Base of Excavation Layer 13.

Čuka series

Charcoal assoc with pottery fragments from excavation site at Topolčani village (41° 16′ N, 21° 28′ E) Macedonia. Coll and subm 1975 by Dragica Simoska, Naroden Mus, Prilep. *Comment* (DS): expected period: Neolithic.

Z-494. Čuka 1 **7680 ± 160**

Charcoal from Sonda I, Layer 15-16.

Z-495. Čuka 2 **7010 ± 190**

Charcoal from Sonda I, Layer 22.

Tumba series II

Charcoal from excavation near Mogila village (41° 07′ 03″ N, 21° 07′ 02″ E) Macedonia. Coll and subm by Dragica Simoska. *Comment* (DS): expected period: Neolithic.

Z-496. Tumba I, 1 **6110 ± 170**

Charcoal from Sonda I, Excavation Layer 11, Horizon I.

Z-497. Tumba I, 2 **1480 ± 80**

Charcoal from Sonda I, Excavation Layer 14-25, Horizon II.

Z-498. Tumba I, 3 **7010 ± 190**

Charcoal from Sonda I, Excavation Layer 28, Horizon III.

Lijevče Polje series

Excavation in marshy plain between Sava R and Vrbas R (45° 07′ 30″ N, 17° 27′ 50″ E) N Bosnia. Coll and subm 1975 by B Refik, Geoinžinjering, Inst Geol, Ilidža. *Comment* (BR): expected period: Pleistocene — Holocene.

Z-502. Lijevče Polje, No. 1919 **1725 ± 80**

Charred wood of tree trunk from left bank of Jablanica R, Čatrnja near Bosanska Gradiška.

Z-503. Lijevče Polje, No. 2287 **6210 ± 70**

Charcoal, possibly trunk, in bed of Sava R, right bank, Bajina near Srbac.

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LABORATORIES

* Inactive Laboratories have been removed from this list. They are available, separately, upon request from the Managing Editor.

[1] The ^3H—Laboratorium of this institute (directed by Klaus Fröhlich) should be addressed separately.

[1a] Lists from this laboratory have not been submitted to RADIOCARBON. See Gdansk I, Acta Physica Polonica, vol 22, p 189, 1962 Gdansk II, *ibid,* vol 32, p 39, 1967.

[2] This designation Gif supersedes both Sa (Saclay) and Gsy (Gif-sur-Yvette). The only Gsy date list to be published is Gsy I (Coursaget and Le Run, RADIOCARBON, v 8).

[3] From January 1, 1961 the Gro numbers have been replaced by GrN numbers. "New" dates are referred to the NBS oxalic-acid standard.

[4] Early dates from this laboratory were given a code designation that represents the name of the sponsoring institution, e g, I (AGS) for American Geographical Society (Heusser, RADIOCARBON SUPPLEMENT, v 1).

[5] Formerly Hazelton Nuclear: code designation HNS has been dropped.

[6] Some dates from this laboratory were published with the code designations S (Pringle *et al,* 1957, Science, v 125, p 69-70).

[7] See SM.

[8] See Gif.

A ARIZONA
Dr Austin Long
Laboratory of Isotope Geochemistry
Geosciences Department
University of Arizona
Tucson, Arizona 85721

ALG ALGIERS
O Rahmouni
Bd Frantz Fanon
BP 1147
Algiers, Algeria

ANL ARGONNE NATIONAL LABORATORY
Mr James Gray, Jr
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439

ANTW ANTWERP UNIVERSITY
Prof R Vanhoorne
Dept of General Botany
State University Centre Antwerp
Groenenborgerlaan 171
B-2020 Antwerp, Belgium

ANU AUSTRALIAN NATIONAL UNIVERSITY
Mr H A Polach
ANU Radiocarbon Dating Laboratory
c/-Research School of Earth Sciences
The Australian National University
Canberra ACT, Australia 2600

AU UNIVERSITY OF ALASKA
William S Reeburgh and M Springer Young
Institute of Marine Science
University of Alaska
Fairbanks, Alaska 99701

B	BERN Prof H Oeschger Physikalisches Institut Universität Bern Sidlerstrasse 5 Bern, Switzerland
Ba	BRATISLAVA Prof S Usacev and Dr P Povinec Department of Nuclear Physics Comenius University Mlynská dolina F1 816 31 Bratislava Czechoslovakia
BC	BROOKLYN COLLEGE Prof Evan T Williams Department of Chemistry Brooklyn College Brooklyn, New York 11210
Birm	BIRMINGHAM R E G Williams Department of Geological Sciences, PO Box 363 University of Birmingham Birmingham B15 2TT, England
Bln	BERLIN Dr Günther Kohl Akademie der Wissenschaften der DDR Zentralinstitut für Alte Geschichte und Archäologie 1199 Berlin, Rudower Chaussee 6 German Democratic Republic
BM	BRITISH MUSEUM Mr Richard Burleigh Research Laboratory The British Museum London WC1B 3DG, England
CRCA	CAIRO Dr Shawki M Nakhla Cairo Carbon-14 Dating Laboratory Center of Research and Conservation of Antiquities Organization of Egyptian Antiquities Midan El Tahrir Cairo, Egypt
CSM	COSMOCHEMISTRY LABORATORY A K Lavrukhina and V A Alexeev VI Vernadsky Institute of Geochemistry and Analytical Chemistry USSR Academy of Sciences Moscow, USSR
Dak	DAKAR Dr Cheikh Anta Diop Directeur du Laboratoire de Radiocarbone IFAN Université de Dakar République du Sénégal
DAL	DALHOUSIE UNIVERSITY J Gordon Ogden, III Department of Biology Dalhousie University Halifax, Nova Scotia, Canada B3H 3J5

DE UNITED STATES GEOLOGICAL SURVEY
Coordinator, Nuclear Hydrology Program
U S Geological Survey
Mail Stop 416
Denver Federal Center, Box 25046
Denver, Colorado 80225

DIC DICAR CORPORATION
DICARB Radioisotope Laboratory
I C Stehli
16432 Stone Ridge Rd
Chagrin Falls, Ohio 44022

F FLORENCE
Dr C M Azzi, L Bigliocca, and F Gulisano
Radiocarbon Dating Laboratory
Istituto di Antropologia
Università di Firenze
Via del Proconsolo 12
50122, Florence, Italy

Fr[1] FREIBERG
Dr Klaus Fröhlich
Sektion Physik
Bergakademie Freiberg
DDR 92 Freiberg

GaK GAKUSHUIN UNIVERSITY
Prof K Kigoshi
Gakushuin University
Mejiro, Toshima-ku
Tokyo, Japan

Gd[1a] GDANSK
Prof W Mościcki, Gliwice
Politechnika Slaska
Katedra Fizyki
Zaklad Fizyki Technicznej
C-14 Laboratory
Poland

Gif[2] GIF-SUR-YVETTE
Dr J Labeyrie or Mme G Delibrias
Centre des Faibles Radioactivités
Laboratoire mixte CNRS-CEA
91190-Gif-sur-Yvette, France

Gro[3]
GrN GRONINGEN
Dr W G Mook
Natuurkundig Laboratorium der Rijks Universiteit
Westersingel 34
Groningen, Netherlands

GSC OTTAWA
Mr J A Lowdon
Radiocarbon Dating Laboratory
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario, Canada

GU GLASGOW UNIVERSITY
Dr M S Baxter
Department of Chemistry
The University
Glasgow G12 8QQ, Scotland

GX GEOCHRON LABORATORIES
Harold W Krueger
Geochron Laboratories Division
Krueger Enterprises, Inc
24 Blackstone Street
Cambridge, Mass 02139

H HEIDELBERG
Prof K O Münnich, D Berdau, and M Münnich
Institut für Umweltphysik der Universität Heidelberg
D-69 Heidelberg, Im Neuenheimer
Feld 366, West Germany

HAM UNIVERSITY OF HAMBURG
Prof Dr H W Scharpenseel
Ordinariat für Bodenkunde
University of Hamburg
2057 Reinbek, Schloss
Germany

HAR HARWELL
R L Otlet
Carbon-14/Tritium Measurements Laboratory
Bldg 10.46 AERE, Harwell
Oxfordshire
OX11 ORA, England

HIG HAWAII INSTITUTE OF GEOPHYSICS
Robert W Buddemeier
Hawaii Institute of Geophysics
University of Hawaii
2525 Correa Road
Honolulu, Hawaii 96822

Hv HANNOVER
Dr M A Geyh
Niedersächsisches Landesamt
für Bodenforschung
D-3000 Hannover-Buchholz, Postf 510153
West Germany

I^4 TELEDYNE ISOTOPES
James Buckley
Teledyne Isotopes
50 Van Buren Avenue
Westwood, New Jersey 07675

IRPA INSTITUT ROYAL DU PATRIMOINE ARTISTIQUE
M Dauchot-Dehon and J Heylen
Institut Royal du Patrimoine Artistique
1 Parc du Cinquantenaire
Brussels 4, Belgium

ISGS ILLINOIS STATE GEOLOGICAL SURVEY
Dr Dennis D Coleman
Section of Analytical Chemistry
Illinois State Geological Survey
Natural Resources Building
Urbana, Illinois 61801

K COPENHAGEN
Dr Henrik Tauber
Geological Survey of Denmark and National Museum
DK-1220 Copenhagen K, Denmark

KAERI KOREA ATOMIC ENERGY RESEARCH INSTITUTE
Dr Kyung Rin Yang
Radioanalytical Division
Korea Atomic Energy Research Institute
PO Box 7, Cheong Ryang
Seoul, Korea

KI KIEL
Dr H Willkomm and Dr H Erlenkeuser
Institut für Reine und Angewandte Kernphysik
Universität Kiel
Olshausenstrasse 40-60
23 Kiel, Germany

KN KÖLN
Dr J C Freundlich
Universität Köln, Institut für Ur-und Frühgeschichte
C^{14}-Laboratorium
Köln-Lindenthal Weyertal 125, W Germany

L LAMONT
Manik Talwani, Director
Lamont-Doherty Geological Observatory
of Columbia University
Palisades, New York 10964

LAR LIEGE STATE UNIVERSITY
Prof Dr Jean Govaerts
Lab d'application des radioéléments
9 Place du XX Aout
Liège, Belgium

LE LENINGRAD
Radiocarbon Laboratory
Institute of Archaeology (Leningrad Section)
Dvortsovaya Nab 18
Leningrad 192041, USSR

LJ UNIVERSITY OF CALIFORNIA, SAN DIEGO
Dr H E Suess
Mt Soledad Radiocarbon Laboratory S-003
University of California, San Diego
La Jolla, California 92093

LP LA PLATA
Laboratorio de Tritio y Radiocarbono
Facultad de Ciencias Naturales y Museo
Paseo del Bosque
La Plata, Argentina

Lu LUND
Prof Björn Berglund and Mr Sören Håkansson
Radiocarbon Dating Laboratory
University of Lund
Tunavägen 29
S-22363 Lund, Sweden

Lv LOUVAIN LA NEUVE
Prof P C Capron and Mr E Gilot
Laboratoire de Carbone 14
Chemin du Cyclotron 2
1348 Louvain la Neuve, Belgium

Ly UNIVERSITY OF LYON
M J Evin
Laboratoire de Radiocarbone
Centre de datations et d'Analyses Isotopiques
Université Claude Bernard—Lyon I
43, Boulevard du II Novembre 1918
69621, Villeurbanne-Lyon France

MC MONACO
Dr J Thommeret or Dr J L Rapaire
Laboratoire de Radioactivité Appliquée
Centre Scientifique de Monaco
Avenue Saint Martin
Monaco

ML MIAMI
Dr H G Östlund
Rosenstiel School of Marine and Atmospheric Science
University of Miami
Miami, Florida 33149

Mo VERNADSKI INSTITUTE OF GEOCHEMISTRY
Vernadski Institute of Geochemistry
Academy of Sciences of the USSR
Moscow, USSR
Address: Prof V L Barsukov
Vorobevskoye shosse,d47-A
Moscow, USSR

MP[7] MAGNOLIA PETROLEUM

MRRI MARINE RESOURCES RESEARCH INSTITUTE
Thomas D Mathews
Marine Resources Research Institute
P O Box 12559
Charleston, South Carolina 29412

N RIKEN (TOKYO)
Dr F Yamasaki
The Institue of Physical and Chemical Research
Wako-shi, Saitama Pref
Japan 351

NSTF NUCLEAR SCIENCE AND TECHNOLOGY FACILITY
C C Thomas, Jr, Director Radiocarbon Laboratory
Nuclear Science and Technology Facility
State University of New York at Buffalo
Rotary Road
Buffalo, New York 14214

NSW NEW SOUTH WALES
D J Carswell, Assoc Prof
Department of Nuclear and Radiation Chemistry
University of New South Wales
PO Box 1
Kensington, New South Wales, 2033, Australia

NTU NATIONAL TAIWAN UNIVERSITY
Yuin-Chi Hsu
Department of Physics
National Taiwan University
Taipei, Taiwan, China

Ny NANCY
Pr René Coppens et Dr Pierre Richard
Centre de Recherches Radiogéologiques
ENS de Géologie Appliquée et de Prospection Minière
Institut National Polytechnique de Lorraine
BP 452
54001 Nancy Cedex, France

NZ NEW ZEALAND
Dr T A Rafter
Institute of Nuclear Sciences
DSIR, Private Bag
Lower Hutt, New Zealand

P PENNSYLVANIA
Dr Elizabeth K Ralph and Barbara Lawn
Radiocarbon Laboratory
University of Pennsylvania
Department of Physics, DRL/E1
Philadelphia, Pennsylvania 19104

Pi PISA
Prof E Tongiorgi
Laboratorio di Geologia Nucleare dell'Università
Via S Maria, 22
Pisa, Italy

Pr PRAGUE
Alois Dubansky
Laboratory for Isotopes
Geochemistry and Geochronology
Geological Institute
Czechoslovak Academy of Sciences
Prague-8
Na Hrazi 26

PRL PHYSICAL RESEARCH LABORATORY
D Lal and D P Agrawal
Physical Research Laboratory
Navrangpura
Ahmedabad-380009, India

Pta PRETORIA
Dr J C Vogel
Natural Isotopes Division
National Physical Research Laboratory
CSIR
PO Box 395
Pretoria, South Africa

Q CAMBRIDGE
Dr V R Switsur
University of Cambridge
Godwin Laboratory
Free School Lane
Cambridge, England CB2 3RS

QC QUEENS COLLEGE
Richard R Pardi
Radiocarbon Laboratory
Queens College, CUNY
Flushing, New York 11367

QL QUATERNARY ISOTOPE LABORATORY
Minze Stuiver
Quaternary Research Center
University of Washington Ak-60
Seattle, Washington 98195

QU QUEBEC
Dr Louis Barrette and Claude Samson
Centre de Recherches Minérales
Complexe Scientifique du Québec
2700 rue Einstein
Ste-Foy, Québec
Canada, GIP 3W8

R ROME
Dr F Bella, Istituto di Fisica
and
Dr C Cortesi, Istituto di Geochimica
Radiocarbon Dating Laboratory
University of Rome
Città Universitaria
00100-Rome, Italy

RL RADIOCARBON, LTD
Charles S Tucek
Radiocarbon, Ltd
Route 2, Box 21E
Lampasas, Texas 76550

RT REHOVOT GEOISOTOPE LABORATORY
Dr A Kaufman and Mr I Carmi
Geoisotope Laboratory
Department of Isotope Research
Weizmann Institute of Science
Rehovot, Israel

RU RICE UNIVERSITY
J A S Adams
Department of Geology
Rice University
Houston, Texas 77001

S SASKATCHEWAN
Mr A Rutherford
Saskatchewan Research Council
University of Saskatchewan
Saskatoon, Saskatchewan, Canada

SI SMITHSONIAN INSTITUTION
Dr W H Klein, Director
Radiation Biology Laboratory
Dr Robert Stuckenrath
C^{14} Laboratory
12441 Parklawn Drive
Rockville, Maryland 20852

SMU SOUTHERN METHODIST UNIVERSITY
Dr Herbert Haas
Institute for the Study of Earth and Man
Southern Methodist University
Dallas, Texas 75275

SR	SALISBURY, RHODESIA Dr J G Sheppard Gulbenkian Radiocarbon Dating Laboratory Department of Chemistry University of Rhodesia PO Box MP 167 Salisbury, Rhodesia
SRR	SCOTTISH UNIVERSITIES RESEARCH AND REACTOR CENTRE Dr D D Harkness and Prof H W Wilson Scottish Universities Research and Reactor Centre East Kilbride Glasgow G75 0QU, Scotland
St	STOCKHOLM Dr Eric Welin Laboratory for Isotope Geology Swedish Museum of Natural History S-104 05 Stockholm 50, Sweden
Su	FINLAND Aulis Heikkinen, Lic Phil Geological Survey of Finland SF-02150 Espoo 15, Finland
SUA	SYDNEY UNIVERSITY, AUSTRALIA Assoc Prof R B Temple or Dr R Gillespie Dept of Physical Chemistry The University of Sydney Sydney NSW 2006, Australia
T	TRONDHEIM Dr Reidar Nydal, S Gulliksen, and K Lövseth Radiological Dating Laboratory The Norwegian Institute of Technology 7034 Trondheim, Norway
TA	TARTU E Ilves and A Liiva Geo-biochemistry Laboratory Institute of Zoology and Botany Academy of Sciences of the Estonian SSR Vanemuise St 21 202400 Tartu, Estonia, USSR
TAM	TEXAS A & M UNIVERSITY Dr William M Sackett Dept of Oceanography Texas A & M University College Station, Texas 77843
TB	TBILISI Dr A A Burchuladze Radiocarbon Laboratory Tbilisi University 1 Chavchavadze Avenue Tbilisi, USSR 380028
TK	UNIVERSITY OF TOKYO Dr Naotune Watanabe Carbon Dating Laboratory c/o Department of Anthropology Faculty of Science University of Tokyo Hongo, Bunkyo-ku, Tokyo, Japan

Tln TALLINN
J M Punning
Institute of Geology
Academy of Sciences of the Estonian SSR
Tallinn, Estonia puiestee 7 ESSR

TUNC TEHRAN UNIVERSITY NUCLEAR CENTRE
Dr A Mahdavi
Tehran University Nuclear Centre
PO Box 2989
Tehran, Iran

Tx TEXAS
Mr S Valastro, Jr or Dr E Mott Davis
Radiocarbon Laboratory
Balcones Research Center, 10,100 Burnet Rd
University of Texas at Austin
Austin, Texas 78758

U UPPSALA
Dr Ingrid U Olsson
Institute of Physics
University of Uppsala
Box 530
S-751 21 Uppsala, Sweden

UB BELFAST
Mr G W Pearson or Dr J R Pilcher
Palaeoecology Laboratory
The Queen's University
Belfast, BT7 1NN
Northern Ireland

UCLA UNIVERSITY OF CALIFORNIA, LOS ANGELES
Dr Rainer Berger and Dr W F Libby
Institute of Geophysics
University of California
Los Angeles, California 90024

UCR UNIVERSITY OF CALIFORNIA, RIVERSIDE
Dr R E Taylor
Department of Anthropology
Institute of Geophysics and Planetary Physics
University of California
Riverside, California 92512

UGa THE UNIVERSITY OF GEORGIA
John E Noakes, Betty Lee Brandau
The University of Georgia
4 GGS Bldg
Geochronology Laboratory
Athens, Georgia 30601

UM UNIVERSITY OF MIAMI
Dr J J Stipp and Peggy M Calvert
Geochronology Laboratory
Department of Geology
University of Miami
Coral Gables, Florida 33124

USGS US GEOLOGICAL SURVEY
MENLO PARK, CALIFORNIA
Dr Stephen W Robinson
US Geological Survey
345 Middlefield Road
Menlo Park, California 94025

UW UNIVERSITY OF WASHINGTON
Dr A W Fairhall
Department of Chemistry
University of Washington
Seattle, Washington 98195

VRI VIENNA RADIUM INSTITUTE
Dr H Felber
Institut für Radiumforschung und Kernphysik
Boltzmanngasse 3
A-1090 Vienna, Austria

W US GEOLOGICAL SURVEY
Dr Meyer Rubin
US Geological Survey
National Center, 971
Reston, Virginia 22092

WIS WISCONSIN
Dr Margaret Bender
Radiocarbon Laboratory of the Center for Climatic Research
Institute for Environmental Studies
University of Wisconsin
1225 W Dayton St
Madison, Wisconsin 53706

WRD US GEOLOGICAL SURVEY, WATER RESOURCES DIVISION
Dr F J Pearson, Jr
US Geological Survey
Isotope Hydrology Laboratory
National Center, MS 432
Reston, Virginia 22092

WSU WASHINGTON STATE UNIVERSITY
Dr John C Sheppard
Department of Chemical and Nuclear Engineering
Washington State University
Pullman, Washington 99164

X WHITWORTH COLLEGE
Dr Edwin A Olson
Department of Earth Science
Whitworth College
Spokane, Washington 99218

Ya YALE
Prof Karl K Turekian
Department of Geology and Geophysics
Yale University
New Haven, Connecticut 06520

Z ZAGREB
Dr Adela Sliepcevic and Dr Dušan Srdoc
Institute "Ruder Boškovic"
41001 Zagreb, POB 1016, Yugoslavia

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