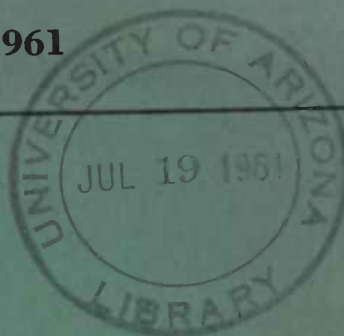


Volume 3 - 1961



RADIOCARBON

Published annually by
THE AMERICAN JOURNAL OF SCIENCE

Editors
RICHARD FOSTER FLINT — EDWARD S. DEEVEY

Managing Editor
HELEN J. ROLFE

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ROOM 5, STERLING TOWER
YALE UNIVERSITY
NEW HAVEN, CONNECTICUT

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INSTRUCTIONS TO CONTRIBUTORS

Manuscripts of radiocarbon papers should follow the recommendations in *Suggestions to Authors*, 5th ed.* All copy must be typewritten in *double space* (including the bibliography): manuscripts must be submitted in *duplicate*.

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. Date lists should therefore not be preceded by abstracts, but abstracts of the more usual form should accompany all papers (e.g. geochemical contributions) that are directed to specific problems.

1. Laboratory number, descriptive name (ordinarily that of the locality of collection), and date expressed in years B.P. (before present). 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.

5. Date of collection and name of collector.

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

7. Reference to relevant publications. Citations within a description should be to author and year, with specific pages wherever appropriate, except that references (e.g. to published date lists that are frequently repeated may be simplified by use of a code (e.g. Groningen III) that is explained in the bibliography. Full bibliographic references are listed alphabetically at the end of the manuscript, in the form recommended in *Suggestions to Authors*.

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 implicitly showing that the radiocarbon measurement was worth making, belongs here, as do technical matters, e.g. chemical pretreatment, special laboratory difficulties, etc.

Illustrations, in general, should be originals, but photographic reproductions of line drawings are sometimes acceptable, and should accompany the manuscript in any case, if the originals exceed 9 by 12 inches in size.

Reprints. Thirty separate copies of each article will be furnished to each paper, free of cost; these will be without a cover. Additional copies will be furnished at cost. Printed covers can be specially ordered.

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

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Radiocarbon

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EDITORIAL STATEMENT

RADIOCARBON, a new title. Though published by the AMERICAN JOURNAL OF SCIENCE, the RADIOCARBON SUPPLEMENT is a separate journal, edited and subscribed to independently of its parent. Because of confusion on this point, and in the belief that the word *Supplement* has contributed to the confusion, a new title, RADIOCARBON, has been agreed on by the editors of both journals, and becomes effective with Volume 3, 1961. We regret the inconvenience that may be caused to bibliographers and librarians, but doubt that there will be any for subscribers.

Half-life of C^{14} . Any change in the half-life will necessitate recalculation of all previously published radiocarbon dates. A recent announcement by the U. S. National Bureau of Standards indicates that the long-accepted value of 5568 ± 30 yr is probably incorrect. The correction will probably be small, but may exceed the quoted error of the original date. As it can be made by simple addition or subtraction, without authorization by any laboratory, there is danger that any recalculation will be inadvertently reduplicated as dates pass through the hands of several authors. To minimize confusion, as several other laboratories are known to be engaged in measurements of the half-life, we urge that producers and users of radiocarbon dates await international agreement on any new value. When such agreement is reached, probably when Volume 4 of RADIOCARBON is published, we will announce the magnitude of the correction, and will recommend a typographic convention to be followed when quoting recalculated dates and "new" dates together in lists and discussions. *All dates published in this volume (1961) are based on the half-life value of 5568 yr.*

Standards and modes of expression. As shown by Craig (RADIOCARBON, this volume), different laboratories may introduce different amounts of isotopic fractionation in preparing their reference gas samples from the National Bureau of Standards oxalic acid; slight discrepancies may result, in dates as well as in modern assays, if such "standard" samples are not identical in C^{14} activity. Mass-spectrometric measurement of the C^{13} in the C^{14} -counting gas gives the only reliable basis of uniformity between laboratories. By informal agreement among several laboratories, which we here indorse, the C^{13} content of the counting gas is assumed to correspond to the -19% deviation, observed as the (rounded) mean of several determinations by Craig, and rigorous accuracy requires that any departures from this value be taken into account when C^{14} assays are calculated. Thus,

$$0.95A_{\text{ox}} = 0.95A'_{\text{ox}} \left(1 - \frac{2(19 + \delta C^{13'}_{\text{ox}})}{1000} \right)$$

where A'_{ox} and $\delta C^{13'}_{\text{ox}}$ are based on the actual counts and mass-spectrometric

measurements made on a gas prepared from the oxalic-acid standard. The computed value $0.95A_{ox}$ then becomes the universal C^{14} standard activity from which δC^{14} values (below), and all dates, are calculated.

We also call attention to the mode of expression adopted by the Lamont laboratory (Lamont VIII, RADIOCARBON, this volume) when C^{14} assays are corrected (normalized) for isotopic fractionation by C^{13} measurement. In this notation, which we also indorse, a quantity Δ is substituted for ΔC^{14} , the definition of which (Lamont VI, RADIOCARBON SUPPLEMENT, v. 1, p. 114) has been found to contain a logical inconsistency. Thus,

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

where Δ is the per-mil deviation from the modern C^{14} standard (i.e. from $0.95A_{ox}$ as defined above), and δC^{14} and δC^{13} are the observed per-mil deviations from C^{14} and C^{13} standards. The matter is more important for modern C^{14} assays made for geochemical reasons than for routine dating. In this volume, the papers Lamont VIII and Yale VI follow the new notation, whereas Cambridge IV uses the older ΔC^{14} . Conversion can be made by the expression

$$\Delta = \Delta C^{14} - \frac{\delta C^{14}}{20}$$

RICHARD FOSTER FLINT
EDWARD S. DEEVEY

ERRATUM

In RADIOCARBON SUPPLEMENT, v. 2, 1960, in the reference to Kenya (W-749) on p. 175, the following words should be deleted from the reference: 'bore hole drilled' and also '(the Limuru trachytes)'.

Radiocarbon

1961

MASS-SPECTROMETER ANALYSES OF RADIOCARBON STANDARDS

HARMON CRAIG

Department of Earth Sciences, University of California, La Jolla

Twenty-four samples of CO_2 from combustion of the NBS oxalic-acid radiocarbon standard, submitted from 13 radiocarbon laboratories, were analyzed for C^{13} content in this laboratory in order to provide comparative data for normalizing the counting results. The samples were analyzed on Samson, a 60° sector, six-inch radius, McKinney-Nier type mass-spectrometer with magnetic switching between sample and standard gas feed to the instrument.

The CO_2 samples were received in sealed breakoffski flasks containing on the order of 100 cc of gas, except for the Lamont, Yale, Isotopes Inc., and La Jolla samples which were in sample tubes with stopcocks. Aliquots of 10-15 cc were taken for analysis by direct expansion of the gas into an evacuated gas pipette on a vacuum line. The Lamont, Isotopes Inc., and Socony Mobil samples contained small amounts of an impurity not condensable in liquid N_2 , and the wet combustion sample from the National Physical Laboratory contained some water; these samples were purified with liquid N_2 and dry-ice traps. The other samples contained no detectable impurities.

The samples were analyzed in series against a single gas standard which had previously been well calibrated against the PDB Chicago C^{13} standard. The following corrections were applied to the raw δC^{13} values:

- a. Valve mixing: $f = 1.006$
- b. Fraction of mass 44 tail falling on mass 45: $f = 1.0066$
- c. CO_2 background in source: $f = 1.0033$
- d. O^{17} content of standard and sample gas: correction as given by Craig (1957).

The raw δC^{13} values are multiplied by the indicated factors; samples were also analyzed for O^{18} to obtain the corrections for O^{17} in the individual samples. The instrumental corrections were minimized for inter-comparison of standards with each other by using a spectrometer gas standard chosen to have a C^{13} content close to the oxalic-acid value (-24.8% relative to PDB). The mass-spectrometer has been shown to be exactly linear (to 0.1%) over a range of 0 to -50% .

Table 1 presents the results in terms of C^{13} enrichment relative to the Chicago PDB standard ($\delta'\text{C}^{13}$), and also as enrichments ($\delta_w\text{C}^{13}$) relative to

TABLE 1

Isotopic composition of CO₂ from NBS oxalic-acid-radiocarbon standards. All samples represent the CO₂ which was actually counted except for La Jolla and Socony Mobil who do not use CO₂ as counter gas.

Laboratory ¹	$\delta^{13}\text{C}$	$\delta_{\text{w}}^{13}\text{C}$	$\delta^{18}\text{O}$	Oxalic Acid Combustion
Copenhagen				
K-301	-19.41	+5.73	-15.09	direct
K-302	-19.73	+5.40	-15.92	direct
	-19.72	+5.42	—	—
K-303	-19.51	+5.63	-11.67	wet
Groningen				
1st series	-18.77	+6.39	-12.42	direct
Duplicate sample	-18.73	+6.43	-12.44	—
2nd series	-19.24	+5.91	-13.82	direct
Duplicate sample	-19.21	+5.94	-13.82	—
Isotopes, Inc.	-21.57	+3.52	-12.68	wet
La Jolla ²				
170 A	-31.34	-6.50	-2.75	wet
170 B	-31.37	-6.53	—	—
145	-22.72	+2.34	(-5.3)	direct
197	-21.84	+3.24	(-5.3)	wet
Lamont				
L-456 D	-19.05	+6.10	-11.60	wet
National Physical Lab.				
A	-18.94	+6.21	-10.86	wet
B	-21.43	+3.66	-12.63	direct
New Zealand				
CR-929	-19.50	+5.64	-10.20	direct
Duplicate sample	-19.45	+5.69	-10.35	—
Pennsylvania				
P-263	-25.67	-0.67	-16.29	wet
	-25.70	-0.71	-16.36	—
Socony Mobil ³	-19.28	+5.87	-16.30	direct
Stockholm				
ST 532	-17.15	+8.05	-17.26	direct
Duplicate sample	-17.26	+7.94	-17.28	—
Trondheim				
T-200	-18.37	+6.80	-19.35	wet
Uppsala				
Oxalic acid-1	-18.97	+6.18	-13.24	direct
Yale	-20.01	+5.12	-12.22	wet

NOTES

¹ All sample numbers or letters denote separate combustions. "Duplicate sample" means duplicate flasks of gas from one combustion were received and analyzed. An analysis with no notation is a repeat analysis of the same gas, made as a check after the series was analyzed (K-302 and P-263).

² The samples are CO₂ from recombination of the C₂H₂ which was actually counted. The C₂H₂ samples were combusted with CuO and O₂ in a closed recycling system as described by Craig (1953), which prevents fractionation in this step. Samples 170A and 170B are duplicate recombinations of the same C₂H₂ from a single combustion. (The O¹⁸ value—5.3 is the average of several other combustions, as the last two samples were not analyzed for oxygen.)

³ The sample represents CO₂ produced from the combustion of oxalic acid. The CO₂ was then hydrogenated to CH₄ for counting; the isotopic analysis does not include any fractionation which may occur in the preparation of the CH₄.

the C^{13} content of average wood which is taken as $\delta = -25\%$ relative to PDB (Craig, 1953). The delta values are defined by:

$$\delta^t = 1000 [(R/R_{PDB}) - 1]; \delta_w = 1000 [(R/R_{wood}) - 1]$$

where $R = C^{13}/C^{12}$, and $R_{wood} \equiv 0.975 R_{PDB}$. The absolute values of the ratios are given by Craig (1957). The uncertainty in the δ values is $\pm 0.1\%$.

Table 1 also shows the measured O^{18}/O^{16} enrichments in per mil ($\delta^{18}O$) relative to PDB standard CO_2 , as it may be of some interest to record the range and variation of O^{18} content in the different combustions. The observed data are quite typical of values observed for carbon combustion with CuO and tank O_2 (Craig, 1957, p. 141) except for the C_2H_2 combustions which were done with CuO and tank O_2 and deviate for an unknown reason.

Average values for both "direct" combustion (with O_2) and wet combustion were computed by using only one value for direct or wet combustion for each laboratory; when duplicates or samples from more than one combustion of the same type were analyzed the average of these was used as one analysis. In order to compare combustions directly, the La Jolla data were not included, as these values include the effect of the additional step of making C_2H_2 from the CO_2 obtained from the combustion.

The average direct combustion value thus obtained (7 laboratories) is $\delta^{13}C = -19.3\%$. The average wet combustion value (excluding also the Pennsylvania value which seems clearly divergent; 6 laboratories) is -19.6% , indicating that wet oxidation is probably about as reliable as direct combustion with O_2 , at least for oxalic acid. A histogram of all the data appears markedly non-Gaussian, with a pronounced tendency for enrichment of C^{12} in the product CO_2 , as might be expected if some combustions are less complete than others.

δC^{14} values relative to any standard are given by:

$$\delta_{14} = 2\delta_{13} + 10^{-3}\delta_{13}^2 \quad (\delta \text{ values in per mil})$$

assuming that for any separation process $\alpha_{14} = \alpha_{13}^2$ (Craig, 1954, p. 133). The total C^{13} range, excluding the one very light La Jolla wet combustion value and the Pennsylvania value, is 5.5% , indicating that the probable spread among various laboratories for careful work will be of the order of only 1% variation in reported activity when fractionation is neglected, in the case of a single sample. The range of C^{13} variation in ancient and modern wood is of the order of 10% (Craig, 1953) and is thus a more important factor than most of the laboratory effects observed in the present study.

Thanks are due the Isotopes Inc., New Zealand, Socony Mobil, and Stockholm laboratories for their courtesy in indicating the pressures in their sample flasks. Construction and operation of Samson were supported by the Office of Naval Research, the Atomic Energy Commission, and the National Science Foundation.

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UNIVERSITY OF PENNSYLVANIA RADIOCARBON DATES IV

ELIZABETH K. RALPH and ROBERT E. ACKERMAN

Department of Physics and University Museum, University of Pennsylvania,
Philadelphia 4, Pennsylvania

With one exception, the radiocarbon dates in this list were reported previously by Rainey and Ralph (1959). For discussions of the reliability of the dates, of the materials dated, and of the correspondence of the dates with estimated arctic chronologies, the reader is urged to refer to the original publication. The radiocarbon determinations were made over a period of several years. Those processed before 1956 were dated by the solid-carbon method and are so labeled; others, by the carbon-dioxide method. The age calculations are based on the average of several samples dated archaeologically and by tree-rings, corrected to zero age (Rainey and Ralph, 1959, p. 365). By this means the errors due to atmospheric depletion (Suess effect) and to past changes in radiocarbon concentration (de Vries, 1958; Willis, Tauber, and Münnich, 1960) have been minimized. The B.P. dates are calculated from A.D. 1957 (solid-carbon) and A.D. 1958 (carbon dioxide).

The one exception, not included in the previous publication, is sample P-325 from St. Lawrence Island, Alaska (Okvik Period), a recount of C-505 (Chicago II) after conversion to carbon dioxide.

Ekseavik Site series, Tree-Ring-Dated Samples

Ekseavik site is along the Squirrel River, 8 mi N of the village of Kiana (67° 0' 0" N Lat, 160° 41' 18" W Long), which is on the Kobuk River, Alaska. Coll. 1947 and subm. by J. L. Giddings, Brown University, Providence, Rhode Island. From the distribution of the dendrochronological dates, Giddings (1952, p. 107) states that house 11 was constructed between 578 and 568 B.P., occupied and rebuilt during the following two decades and abandoned after 548 B.P. As the bark dates are the crucial ones for the archaeologist rather than the average age of the wood used for dating, these C¹⁴ dates do *not* date the time of occupation of the site. These tree-ring-dated samples serve only as a check on the C¹⁴ dating.

P-16. Ekseavik, no. 42 **780 ± 150**

Spruce wood from house 11, no. 42. Dated by tree-ring analysis, 874 to 571 B.P. *Comment:* dated by solid-carbon method, two counting runs.

P-29. Ekseavik, no. 33 **720 ± 200**

Spruce wood from house 11, no. 33. Dated by tree-ring analysis, 738 to 593 B.P. Portion used for this measurement had an average of 691. *Comment:* dated by solid-carbon method.

P-31. Ekseavik, no. 1 **820 ± 200**

Wood from house 11, no. 1. Dated by tree-ring analysis, 747 to 592 B.P.

Portion used for this measurement had an average age of 688. *Comment:* dated by solid-carbon method.

Kugusugaruk Site series

Kugusugaruk site consists of a group of middens located 10 mi S of the village of Utkiavik (Barrow village) (71° 12' N Lat, 156° 30' W Long), Point Barrow, Alaska. Coll. 1917-1919 by W. B. Van Valin (deceased); subm. by F. Rainey, University Museum, University of Pennsylvania, Philadelphia. This site was incorrectly labeled "Utkiavik" by Rainey and Ralph (1959) as it was believed that Van Valin had worked at Utkiavik. Ford (1959, p. 19) revealed that Van Valin's site is actually Kugusugaruk. According to Ford's (p. 21, fig. 34) classification, the Kugusugaruk site burials fall in the early part of the Birnirk Period. Artifacts from this site are similar to those of the Birnirk site (Ford, 1959; Mason, 1930; Van Valin, 1941).

P-73. Kugusugaruk (Birnirk Period), house 4 1430 ± 190

Wood from a light-weight coarse-grained oval-shaped cylindrical piece, from house 4 (University Mus. no. 29-90-608). Broken end gives the impression of having been hafted in something. *Comment:* dated by solid-carbon method; individual dates of two portions are 1620 ± 300 and 1320 ± 220.

P-97. Kugusugaruk (Birnirk Period) house 3 1146 ± 95

Wooden meat tray (University Mus. no. 29-90-293) from house 3, found near skeleton no. 12.

P-55. Anderson Point Site 1130 ± 200

Spruce wood from the Anderson Point site on the Arctic Sea coast between Barter and Flaxman Islands (70° 02' N Lat, 144° 27' W Long), Alaska. Coll. 1952 by J. L. Giddings and A. Ricciardelli; subm. by J. L. Giddings, Brown University, Providence, Rhode Island, who noted that the material seemed roughly equivalent to Birnirk culture. *Comment:* dated by solid-carbon method; individual dates of two portions are 1160 ± 240 and 1090 ± 310.

Kurigitavik Site series

Kurigitavik site is located just back of the present village of Wales (65° 36' N Lat, 168° 4' W Long), Cape Prince of Wales, Alaska. Birnirk-type pottery occurs in the midden from about the middle to bottom levels. Thule-Punuk harpoon heads occur from the surface of the midden to about the middle. Below the middle level the harpoon heads exhibit features suggestive of Birnirk. The one associated with sample P-65 was the only typical Birnirk head found at the site (Collins, 1937a; 1940, p. 561-562). Coll. 1936 and subm. by H. B. Collins, Smithsonian Institution, Washington, D. C.

P-68. Kurigitavik (Thule-Punuk Period), 20 in. 1350 ± 360

Wooden dish (piece of base) and shafts (17 small pieces) from cut 2, section 4, depth 20 in. *Comment:* dated by the solid-carbon method.

P-67. Kurigitavik (Thule-Punuk Period), 29 in. 1230 ± 240

Wooden dish (2 pieces) from cut 6, section 4, depth 29 in. Typical Thule-

Punuk harpoon heads and other artifacts occur at this level. *Comment:* dated by solid-carbon method.

P-65. Kurigitavik (Birnik Period), 88 and 90 in. 1320 ± 230

Wooden shafts (4 small pieces) from cut 3, sections 20 and 21, depth 88 and 90 in. (base). A Birnik harpoon head was found in this cut at a depth of 86 in. *Comment:* dated by solid-carbon method.

P-63. Beach Midden, Cape Prince of Wales 1480 ± 240

Wooden dish bottom from a large steeply sloping midden on a high beach located just south of the village of Wales ($65^{\circ} 36' N$ Lat, $186^{\circ} 4' W$ Long), Cape Prince of Wales, Alaska. Sample is from cut A, section 26, depth 101 in., from near the base (upper part of slope). A Birnik harpoon head was found in a nearby cut at about this level. The surface of the midden contains recent material (Collins, 1937a; 1940, p. 561-562). *Comment:* dated by solid-carbon method. This site was inadvertently placed under Kurigitavik site by Rainey and Ralph (1959).

St. Lawrence Island series

Ievoghiyoq, Miyowagh, and Hillside sites are located E of Gambell, near Cape Chibukak ($63^{\circ} 46' 30'' N$ Lat, $171^{\circ} 43' 20'' W$ Long), St. Lawrence Island, Alaska. Ievoghiyoq and Miyowagh are situated on a gravel spit, and Hillside at the foot of Cape Chibukak.

Ievoghiyoq Site

Ievoghiyoq site is representative of the Punuk period (Collins, 1937b, p. 181-182). Coll. 1930 and subm. by H. B. Collins, Smithsonian Institution, Washington, D. C.

P-69. Ievoghiyoq (Punuk Period), no. 354968 1070 ± 210

Wooden dish bottom (U. S. Nat. Mus. no. 354968) from cut 2, section 8, depth 52 in. (base). *Comment:* dated by solid-carbon method.

P-92. Ievoghiyoq (Punuk Period), no. 354971 910 ± 145

Wooden object (U. S. Nat. Mus. no. 354971) from cut 2, section 8, depth 52 in. (base).

Miyowagh Site

Miyowagh is a two-level site containing cultural material from the Old Bering Sea Period and the early phase of the Punuk Period. In some instances (Collins' house 3), Punuk house floors have been dug into areas of the midden that yield predominantly Old Bering Sea artifacts. Samples P-83, P-85, P-88, P-84 and P-80 coll. and subm. by H. Michael, University Museum, University of Pennsylvania, Philadelphia.

P-83. Miyowagh (Early Punuk Period), shaft 1013 ± 111

Wooden shaft from test pit 18 m SW by S of Collins' house 5 at depth 1.35 m below surface (2.5 m below house rim). Coll. 1952.

P-85. Miyowagh (Late Old Bering Sea Period) 1002 ± 108

Wood from test pit 25 m N of NE corner of Collins' cut 26 from the 0.8 to 1.0 m level, in association with ivory harpoon point. Coll. 1952.

P-88. Miyowagh (Early Punuk Period), log 1231 ± 108

Outer piece of large log found lying on flagstone floor of structure, Collins' house 3 entrance from 2.5-m level. Coll. 1952.

P-84. Miyowagh (Old Bering Sea Period), beam 1296 ± 108

Roof beam of passageway to house 4, 1.4 to 1.6 m level, in association with (OBS) whaling harpoon head. Coll. 1952.

P-80. Miyowagh (Old Bering Sea Period), wood 1398 ± 116

Piece of wood associated with OBS harpoon heads 0.8 m level, above P-88. Coll. 1952.

P-71. Miyowagh (Old Bering Sea Period), wood 1630 ± 230

Wooden objects, fire drills (U. S. Nat. Mus. nos. 353754 and 353769), from cut 7, levels 8 and 9, depths 46 and 51 in. Coll. 1930 and subm. by H. B. Collins, Smithsonian Institution, Washington, D. C.

P-93. Miyowagh (Old Bering Sea Period), wood 1700 ± 150

Wooden objects (U. S. Nat. Mus. no. 353744) from cut 7, section 7, depth 37 in. Coll. 1930 and subm. by H. B. Collins, Smithsonian Institution, Washington, D. C.

Hillside Site series

Collins (1937b) originally designated the more simplified art style at the Hillside site "Old Bering Sea Style I." It was not until Rainey (1941) and Rudenko (1947) established Okvik as a distinct period that the "Old Bering Sea Style I" of Collins was recognized as a form of Okvik design. Collins, Giddings and Larsen (Giddings, 1960, p. 123, 132, and 137) have considered Okvik to contain two to three separate art styles which may allow Okvik to be broken up into stages as has been done by Collins for Old Bering Sea. It has been assumed that Okvik preceded the Old Bering Sea Period. The following dates seemingly contradict this sequence. In light of continuing analyses of the Okvik and old Bering Sea culture, it has been noted by Levin (in Giddings, 1960) that the Okvik and Old Bering Sea periods overlap. An early phase of Old Bering Sea culture could thus be older than a late phase of Okvik culture, giving rise to an apparent contradiction in the sequence based upon single dates at some point in the culture's history rather than upon the total time span of the culture. Coll. 1930 and subm. by H. B. Collins (except P-325), Smithsonian Institution, Washington, D. C.

P-95. Hillside (Old Bering Sea Period) 1641 ± 106

Wooden objects (U. S. Nat. Mus. no. 352646) from house 1. *Comment:* 2 counting runs.

P-70. Hillside (Okvik Period), no. 352547 1420 \pm 230

Wooden object (U. S. Nat. Mus. no. 352547) from house 2, below floor stones. *Comment:* dated by solid-carbon method.

P-94. Hillside (Okvik Period), no. 352558 1429 \pm 121

Wooden object (U. S. Nat. Mus. no. 352558) from house 2, below floor stones. *Comment:* two counting runs.

P-325. Hillside (Okvik Period), Okvik house 1461 \pm 65

Carbon (Chicago solid-carbon sample C-505) derived from spruce log taken from Giddings' Okvik house (Rainey, 1941, p. 468-472). Coll. 1939 by J. L. Giddings, Brown University, Providence, Rhode Island; subm. to Chicago Laboratory 1951 by F. Rainey, Univ. Mus., Univ. of Pa. Carbon subm. in 1960 to Univ. of Pennsylvania laboratory by W. F. Libby, Institute of Geophysics, University of California, Los Angeles, and R. Ackerman, University of Pennsylvania, Philadelphia. *Comment:* Chicago solid-carbon date for this sample is 2258 \pm 230 (Chicago II). The date for P-325 is in agreement with the other two Okvik samples listed here.

P-98. Ipiutak Site, Point Hope 1619 \pm 210

Caribou antler from Ipiutak site, on the N shore of Point Hope Spit, approximately 1 mi from the village of Tigara (68° 19' N Lat, 166° 42' W Long). Point Hope, Alaska. The site extends 5 mi or more to the east. Sample consisted of 14 caribou antler arrowheads, Type I, one of the most typical artifacts found at Ipiutak. Coll. 1948 and subm. by F. Rainey, Univ. Mus., U. of Pa. This is the type site for the Ipiutak stage that H. Larsen and F. Rainey (1948) have described as the Paleo-Eskimo horizon in the arctic. *Comment:* other dates for Ipiutak culture are C-266, 912 \pm 170, and C-260, 973 \pm 170 (Chicago I).

P-225. Cape Krusenstern Site 1651 \pm 130

Charcoal from Cape Krusenstern site (67° 8' 33" N Lat, 163° 40' 0" W Long), located on a series of beach ridges between the villages or camp sites of Talikoot and Tikizat, Cape Krusenstern, Kotzebue Sound, Alaska. Coll. 1958 and subm. by J. L. Giddings, Brown University, Providence, Rhode Island. This is an extensive site of many cultural horizons that are located on a succession of beach ridges. Cultures earlier than Cape Denbigh Flint complex to the present are represented. This sample is representative of the Ipiutak period. *Comment:* sample was infested with rootlets which were removed as much as possible before processing.

Native Point Sites series

Native Point sites lie 40 mi S of Coral Harbor (64° 10' N Lat, 83° 15' W Long) on the SE coast of Southampton Island, Hudson's Bay, Canada. Site T 1, 1 mi E of the Sadlermiut site of Tunermit, extends over 20 acres, covering most of a plateau 70 ft high. T 3 site is 30 ft lower than T 1, on an old beach ridge, 40 ft high, at the base of the T 1 plateau. Coll. 1954 and 1955

and subm. by H. B. Collins, Smithsonian Institution, Washington, D. C. These are early Dorset period sites (Collins, 1956a, 1956b).

P-62. Native Point T 1 (Dorset Period), 14 in. 2060 \pm 200

Charred bones from Test Pit 6 on the NE end of T 1 plateau, on a gravel ridge ca. 50 yd from the Dorset midden. From a hearth 14 in. below the surface; hearth contained large quantities of burned mammal bones, blackened earth and gravel, and many bird bones. *Comment*: dated by solid-carbon method.

P-74. Native Point T 1 (Dorset Period), 12 in. 2183 \pm 122

Burned bones, soil, and a few small pieces of charcoal from hearth area in T 1 site, Test Pit 8, from depth 12 in. (base).

P-75. Native Point T 1 (Dorset Period), 6 in. 2508 \pm 130

Burned bones from T 1 site, trench A, square 1, level 2, depth 6 in. Trench A is 275 yards from Test Pit 8.

P-76. Native Point T 1 (Dorset Period), 6-10 in. 2632 \pm 128

Burned bones from T 1 site, trench A, square 5, levels 2 and 3, depth 6 to 10 in. *Comment*: on the basis of culture and stratigraphy, this sample is expected to be contemporaneous with P-75.

P-77. Native Point T 3 (Dorset Period), 8 in. 2191 \pm 120

Burned bones from T 3 site, squares 1 and 9, level 2, depth 8 in. *Comment*: 2 counting runs.

Yukon Island Site series

Yukon Island is in Kachemak Bay, E of the city of Seldovia (59° 27' N Lat, 151° 44' W Long) on the Kenai Peninsula of Alaska. Coll. 1932 and subm. by F. de Laguna, Bryn Mawr College, Bryn Mawr, Pennsylvania. De Laguna (1934) defined 5 periods at this site which are described as Kachemak Bay I, II, III, Sub-III, and IV.

P-138. Kachemak Bay III Period, layers 6-9 1369 \pm 102

Caribou antler (5 pieces) from layers 6-9.

P-139. Kachemak Bay I Period, layer 1 2706 \pm 118

Caribou antler (8 pieces) from level 1, the earliest.

Palugvik Site series

Palugvik site is on the western spit of Hawkins Island (60° 30' N Lat, 146° 30' W Long), Prince William Sound, Alaska. The site is a large midden consisting of 4 layers; the bottom (no. 1) began in the Kachemak Bay III or sub-III period whereas the top layer (no. 4) indicates that the site was abandoned before European contact (de Laguna, 1956). Coll. 1938 and subm. by de Laguna, Bryn Mawr College, Bryn Mawr, Pennsylvania. These samples represent the Kachemak Bay III Period. *Comment*: samples had been coated with paraffin. The suspicion that paraffin might have penetrated the wood was

prompted by the date of a contaminated sample, a wooden shovel blade from the same site (P-173, 2265 ± 112), which should have been contemporaneous with P-174. The core of the house post (P-192) was therefore counted. The fact that the dates of P-192 and P-174 are in agreement indicates either that this post did not have serious paraffin contamination or that the paraffin was removed by the cleaning process.

P-174. Palugvik (Katchemak Bay III Period) 1753 ± 105

Wood from the outer part of house post (University Mus. no. 33-37-476).

P-192. Palugvik (Katchemak Bay III Period) 1727 ± 105

Wood from core of house post (University Mus. no. 33-37-476). The C¹⁴ date has been corrected for age of 83 yr as determined by tree-ring count.

Choris Site series

Choris site is near the end of Choris Peninsula ($66^{\circ} 16' 24''$ N Lat, $161^{\circ} 52' 18''$ W Long), Kotzebue Sound, Alaska. Coll. and subm. by J. L. Giddings. Brown University, Providence, Rhode Island. The site is considered by Giddings (1957) to contain artifacts typologically closer to Norton forms than to those of the Denbigh Flint complex. *Comment*: samples were broken into small pieces and visible rootlets removed before processing.

P-96. Choris Period, wood 2635 ± 125

Wood, a partially disintegrated base log heavily infused with rootlets, from Oval House 1. Coll. 1956.

P-175. Choris Period, antler 2244 ± 133

Worked fragments of antler (with a few rootlets) from floor deposit of Oval House 1. Coll. 1956.

P-203. Choris Period, charcoal 2646 ± 177

Charcoal from below roof level at N end of house 2 pit. Coll. 1958.

P-228. Engigsteiak Site (Early Mountain Phase) 3208 ± 156

Antler from Engigsteiak site, located at foot of British Mountains, 16 mi from the Arctic Ocean, on the E side of Firth River, about 0.5 mi N of where the narrow steep canyon of the Firth River gives way to a relatively wide valley that becomes the Firth River Delta ($69^{\circ} 34' 18''$ N Lat, $139^{\circ} 22' 30''$ W Long), Yukon Territory, Canada. Sample from pit 32 (N. VK-1, S135W25), level 3-4, 1.7 ft beneath ceramics of Cordmarked and Dentate pottery. MacNeish, in a letter dated Oct. 6, 1958, stated that the culture typologically seems to be an early variant of Cape Denbigh. The site is described by MacNeish (1956). Coll. 1958 and subm. by R. S. MacNeish, National Museum, Ottawa, Ontario, Canada.

Igloolik Area series

The 3 sites of Alarnerk, Kapuivik, and Kaleruserk are located in the area of Igloolik ($69^{\circ} 10'$ N Lat, $83^{\circ} 59'$ W Long), Northwest Territory, Canada. Samples taken from house ruins found on raised gravel beaches. House ruins

were found on various sites on terraces up to 54 m above present sealevel, revealing 3 distinct Eskimo cultures: Thule (5- to 8-m terraces), Dorset (8- to 22-m terraces), and Sarqaq (23- to 54-m terraces) (Meldgaard, 1960). Coll. 1954 and 1957 and subm. by Jørgen Meldgaard, Danish National Museum, Copenhagen, Denmark. *Comment*: the dates for antler samples are consistently younger than those for ivory. Ivory is believed to be a more reliable material.

P-212. Alarnerk (Dorset Period, Stage I), antler **2404 \pm 137**

Antler from 22 m above sealevel. *Comment*: compare with P-213.

P-213. Alarnerk (Dorset Period, Stage I), ivory **2910 \pm 129**
Ivory from 22 m above sealevel.

P-211. Kapuivik (Late Sarqaq Period), antler **2354 \pm 135**
Antler from 24 m above sealevel.

P-210. Kapuivik (Early Sarqaq Period), antler **2898 \pm 136**
Antler from 44 m above sealevel.

P-208. Kaleruserk (Early Sarqaq Period), antler **3560 \pm 123**

Antler from 51 m above sealevel. *Comment*: this sample is identical to K-505, 3700 \pm 300 (Copenhagen IV) ; compare also with P-209.

P-209. Kaleruserk (Early Sarqaq Period), ivory, 51 m **3906 \pm 133**

Ivory from 51 m above sealevel.

P-207. Kaleruserk (Early Sarqaq Period), ivory, 52 m **3958 \pm 168**

Ivory from 52 m above sealevel.

Iyatayet Site series

Iyatayet site is on the W side of Cape Denbigh (64° 25' 42" N Lat, 161° 31' 30" W Long), on steep slopes flanking a fresh-water stream, Norton Sound, Alaska. Coll. 1948-1950 and subm. by J. L. Giddings, Brown Univ., Providence, R. I. There are three cultural levels at Iyatayet, an upper Neo-Eskimo (Nuklet), a middle Paleo-Eskimo (Norton culture), and a separated lower level defined as the Denbigh Flint complex (Giddings, 1949). Charcoal samples from the very thin layer of Denbigh Flint material were contaminated with roots of later date which were probably not removed successfully before processing. David Hopkins of the U. S. Geol. Survey, who made a study of this site, believed that geologic, paleobotanical, and radiocarbon evidence all point to an age of more than 5000 and less than 10,000 yr (Giddings, 1955).

P-13. Norton Culture (Paleo-Eskimo) **2213 \pm 110**

Charcoal from baseline timbers of W wall. *Comment*: this was a new portion of the same material as that used for C-563 (Chicago II), dated 2016 \pm 250 in 1951. Another portion of P-13 was dated by solid-carbon method,

average of 3 counting runs is 2360 ± 170 . Compare also with C-506 (Chicago I), 1460 ± 200 .

P-104. Above Denbigh Complex, sec. IYZ-5B 3000 ± 170

Peat and earth from second peat above Denbigh Flint complex, section IYZ-5B. *Comment:* dated by solid-carbon method; 3 counting runs. C-793 (Chicago IV), 3509 ± 230 , was taken from the same section.

P-108. Above Denbigh Complex, sec. IYZ-5A 3080 ± 210

Dry peat and earth from peaty layer next above Denbigh Flint complex, section IYZ-5A. *Comment:* dated by solid-carbon method; 2 counting runs.

P-105. Denbigh Complex, sec. IYZ-5B 4040 ± 280

Charcoal mixed with earth from soil above Denbigh Flint complex, but below peaty layer where peaty layer was covered with sterile sandy layer, section IYZ-5B. *Comment:* dated by solid-carbon method. Sample contaminated with roots.

P-103. Denbigh Complex, sec. IYZ-5D 3480 ± 200

Charcoal and charred twigs from 2 fireplaces, section IYZ-5D. *Comment:* dated by solid-carbon method, 2 counting runs. Sample contaminated with roots.

P-102. Denbigh Complex, sec. IYR 3310 ± 200

Charcoal, earth, and a few roots from fireplace from section IYR. *Comment:* dated by solid-carbon method; 2 counting runs. Compare this sample and P-105 and P-103 with C-793 (Chicago IV), 4658 ± 220 and with W-298 (USGS III), 3970 ± 600 . Sample contaminated with roots.

GENERAL COMMENT

Dates obtained by the CO_2 method are considered more reliable than those obtained by the solid-carbon method, and thus we have placed our major emphasis on those dates. One date worthy of comment, and not previously listed in the paper by Rainey and Ralph (1959), is P-325 from the Hillside site at Gambell, St. Lawrence Island, Alaska. Dated by the solid-carbon method (C-505, 2258 ± 30 , Chicago II), this sample was used by Giddings (1960, p. 123) as a basal date for the cultural sequence on St. Lawrence Island. The new date for this sample (1461 ± 65) by the CO_2 dating process places the Okvik house excavated by Giddings at Gambell within the time period of the Old Bering Sea culture. New samples are yet necessary for a firm dating of the Okvik culture in the Bering Sea region and until they are obtained, the claim of precedence for the Okvik culture will necessarily have to rest upon archaeological interpretation.

A tentative cultural chronology for the Arctic was attempted previously (Rainey and Ralph, 1959, p. 373) and found to be useful. This chronologic sequence reproduced below is, however, to be used with caution as it is for the most part based on too few samples.

Neo-Eskimo Horizon

Punuk Period	A.D. 1000
Birnirk	A.D. 800
Kachemak Bay III Period	A.D. 600
Okvik Period	A.D. 500
Old Bering Sea Period	A.D. 300

Paleo-Eskimo Horizon

Ipiutak Period	A.D. 300
Norton Period	300 B.C.
Dorset Period	200 to 700 B.C.
Kachemak Bay I Period	700 B.C.
Choris Period	700 B.C.

Ancient Arctic Horizon

Firth River	
(Early Mountain Phase)	1300 B.C.
Sarqaq	400 to 2000 B.C.
Denbigh Flint Complex	Earlier than 2000 B.C.

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BERN RADIOCARBON DATES II

CHR. GFELLER, H. OESCHGER and U. SCHWARZ

Physikalisches Institut, Universität Bern

This list covers measurements made at the Radiocarbon Dating Laboratory, Physics Department, University of Bern, from spring, 1959, until summer, 1960. We have now two low-level counters working (Houtermans and Oeschger, 1958).

The samples are converted into acetylene. The available amount of most samples was limited, and as peat, gyttja, and especially bone, contain only a few grams of carbon, they are measured routinely at a pressure of 500 mm Hg.

As background samples we use acetylene, produced either from coal or ethylene, derived from crude oil. Recently, we have taken as a modern reference source the activity of NBS-oxalic-acid-standard $\times 0.950$. It agrees, within statistics with our older standards, which were wood formed between A.D. 1850 and 1900. Errors given are the standard deviations derived from the number of counted particles and the statistical errors of background and modern standard. Results are calculated with a decay time of 5568 yr for C^{14} ; no C^{13} corrections are made.

Gytta, peat, wood and charcoal samples have been pretreated with hot dilute HCl. For peat samples, in which infiltration of humic acid is to be feared, additional treatment with hot KOH is applied. Bone samples are charred in a nitrogen atmosphere at 650° C and treated with hot dilute HCl afterwards. Bone and other samples are then converted into acetylene (Suess, 1954), which is stored for ca. one month before measurement. Each sample is then measured in both counters in turn, with an interval of one week to check radon contamination.

About twenty dates of samples from peat borings in the high-alpine region are not reported in this paper, because they are much too young; they have shown activities as much as 20 to 30% higher than our modern standard. We have excluded the possibility that these samples contain parts of actual living plants. Contamination with $CaC^{14}O_3$ can also be excluded, because the samples have been treated with hot acid. The source of this contamination is still under study.

Another group of dates left out of this paper is related to dating of the last glacial age. Measured dates lie between 30,000 and 45,000 yr, or are older than 50,000 yr. We expect to repeat some of the measurements, with better chemical pretreatment. Moreover, the geologic age of some of these samples is still under discussion.

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SAMPLE DESCRIPTIONS

I. QUATERNARY GEOLOGY AND VEGETATIONAL HISTORY

Grindelwald series, Switzerland

At several places in the village of Grindelwald, (ca. $46^{\circ} 37' 30''$ N Lat, $8^{\circ} 2' 30''$ E Long), alt ca. 1050 m, Bernese Oberland, stems have been excavated during the building of new houses. Some were found in drift of the Obere Grindelwald Glacier; others in prehistoric landslides. Both kinds are of unknown age. Coll. 1958 by Viktor Boss, Grindelwald; subm. by F. G. Houtermans, Univ. of Bern. *Comment* (by M.W.): samples not being accurately located, they can be discussed only as a group. The oldest are dated here as of Neolithic age. It is improbable that human influence is responsible for the burial of the three oldest stems. They may therefore be tentatively compared with B-254 (this date list) from Oberaar, by which an advance of the Oberaar Glacier at this time is proved. Younger (19th and 16th century) advances of the Obere Grindelwald Glacier did not quite reach the village, but are known to have alarmed the inhabitants. The younger stems probably were incorporated in landslides of unknown extent during the Bronze and Iron ages. Further investigations will be of more than local interest.

B-137.	Grindelwald, Kirche I	2500 \pm 120
B-138.	Grindelwald, Endweg	4700 \pm 160
B-139.	Grindelwald, Adlerstutz I	4400 \pm 120
B-140.	Grindelwald, Adlerstutz II	4400 \pm 120
B-141.	Grindelwald, Kirche II	3400 \pm 120

Khumbu Moraine series, Nepal

Plant remnants from a well-developed soil profile in alluvial sand and clay, Gorakshep Lake, near Khumbu Glacier, Mount Everest area ($27^{\circ} 59'$ N Lat, $86^{\circ} 50' 1''$ E Long). Coll. 1956 and subm. by Fritz Müller, now at McGill Univ., Montreal, Canada. *Comment*: Gorakshep Lake lies between two moraines which appeared comparable with the A.D. 1600 and A.D. 1850 moraines in the Alps. The plants must have grown on one or both moraines. Dates prove that both moraines are older than A.D. 1600 (Müller, 1958).

B-174.	Khumbu Moraine I, 70 cm depth	480 \pm 80
Plant remnants, several indistinguishable species.		
B-173.	Khumbu Moraine II, 130 cm depth	1150 \pm 80
Plant remnants, several indistinguishable species.		

Dalpe series, Switzerland

Peat and gyttja from a bog deposit, Bedrina-Dalpe, near Faido, Canton Ticino ($46^{\circ} 29' 08''$ N Lat, $8^{\circ} 46' 34''$ E Long), alt 1235 m. Coll. 1958 by Heinrich Zoller, Univ. of Zürich; subm. by Max Welten, Univ. Bern. *Comment*: B-179 dates the end of dominant *Abies* and immigration of *Picea abies*; B-176 dates immigration of *Abie alba* S of the Alps. B-177 dates a deterioration

of climate in the Preboreal, named "Piotino-Schwankung" by the author. B-178 dates the thermal maximum within the Allerød S of the Alps (Zoller, 1960).

B-179. Dalpe 1, 107 to 112 cm depth	5970 ± 160
Sedge peat.	
B-176. Dalpe 2, 225 to 250 cm depth	9500 ± 150
Sedge peat, with fragments of <i>Abies alba</i> wood.	
B-177. Dalpe 3, 295 to 300 cm depth	9900 ± 190
Peat of Hypnaceae.	
B-178. Dalpe 4, 422 to 427 cm depth	10,900 ± 250
Gyttja with clay.	

Lago Origlio series, Switzerland

Gytta from a lake and bog deposit at Lago d'Origlio, N of Lugano, Canton Ticino (46° 03' 07" N Lat, 8° 56' 55" E Long), alt 421 m. Coll. September 1958 and 1959 by Heinrich Zoller, Univ. of Zürich; subm. by Max Welten, Univ. of Bern. *Comment*: B-187 allows the inference that chestnut, *Castanes sativa*, was brought into this region by man in the Iron (and Roman) ages. B-188 dates first traces of culture of Neolithic man. B-189 dates the initial phase of the Allerød interstadial in low altitudes S of the Alps (H. Zoller, 1960).

B-187. Lago Origlio, 240 to 250 cm depth	2770 ± 120
B-188. Lago Origlio, 370 to 380 cm depth	4700 ± 100
B-189. Lago Origlio, 480 to 490 cm depth	12,000 ± 200

B-190. Lago Cadagno, Switzerland 3250 ± 100

Peat mixed with sand from 90 to 102 cm depth in a bog on the shore of Lago Cadagno, near Lago Ritom, Canton Ticino (46° 33' 05" N Lat, 8° 42' 54" E Long), alt 1925 m. Coll. September 1958 by Heinrich Zoller, Univ. of Zürich; subm. by Max Welten, Univ. of Bern. *Comment*: the sample dates a phase within the period of *Alnus-viridis* and *Picea* (Zoller, 1960).

Fuori Piora series, Switzerland

Peat from a bog, Cadagno Fuori, near Lago Ritom, Canton Ticino (46° 33' N Lat, 8° 42' 14" E Long), alt 1910 m. Coll. 1958 by Heinrich Zoller, Univ. of Zürich; subm. by Max Welten, Univ. of Bern. *Comment*: B-191 dates the first re-immigration of forest at this alt at the end of Preboreal time (Zoller, 1960).

B-191. Fuori Piora, 50 to 55 cm depth	5100 ± 100
B-192. Fuori Piora, 145 to 150 cm depth	8150 ± 130

Bitsch-Naters series, Wallis, Switzerland

Gyttja and peat from Bitsch-Naters, Canton Wallis, near Brig (46° 20' 24" N Lat, 7° 59' 26" E Long), alt 1039 m. Coll. September 1956 by Max

Welten and Otto Hegg; subm. by Welten, Univ. of Bern. *Comment*: the filling of this kettle by a thick deposit of pure organic matter after the retreat of the ancient Aletsch Glacier, gives crucially important data on the retreat and on the invasion of vegetation, as well as on later vegetational and climatic changes. Palynological details are unpublished, except for a preliminary note by Welten (1958). Two dates, determined earlier, are to be found in Oeschger, Schwarz and Gfeller (1959), (B-72, 7330 ± 180 ; B-73, 2600 ± 100). The series of 6 dates is fairly consistent internally.

B-197.	Bitsch-Naters III, 135 cm depth	1000 ± 120
B-196.	Bitsch-Naters III, 234 cm depth	1740 ± 200
B-195.	Bitsch-Naters III, 432 cm depth	4170 ± 120
B-194.	Bitsch-Naters III, 505 cm depth	5350 ± 100

Eggen series, Wallis, Switzerland

Peat of sedges and Hypnaceae from a bog deposit just behind a lateral moraine of the ancient Aletsch Glacier. The boggy plain behind the moraine is covered by grassland and fields, where rye was cultivated until recently. Locality is N of Blatten and Brig-Naters, Wallis ($46^{\circ} 22' 13''$ N Lat, $7^{\circ} 59' 22''$ E Long), alt 1650 m. Coll. September 1956 by Max Welten and Otto Hegg; subm. by Welten, Univ. of Bern. *Comment*: material taken from a single boring. The beginning of organic sedimentation after the retreat of Aletsch Glacier was of primary concern. Younger dates will give the chronology of vegetational history, demonstrated by pollen analyses, as yet unpublished. See preliminary note of Welten (1958). The series is fairly self-consistent, though all dates are ca. 1000 yr older than supposed on the basis of the first palynologic researches in 1957.

B-201.	Eggen, 60 cm depth	2500 ± 100
B-200.	Eggen, 140 cm depth	3970 ± 110
B-198.	Eggen, 320 cm depth	7080 ± 120

Belalp series, Wallis, Switzerland

Peat and gyttja from a lake-and-bog deposit above the present forest limit, near the Aletsch Glacier, N of Brig-Naters, Wallis ($46^{\circ} 23' 6''$ N Lat, $7^{\circ} 59' 2''$ E Long), alt 2330 m. Coll. September 1959 by Max Welten and Otto Hegg; subm. by Welten, Univ. of Bern. *Comment*: material taken from a single boring. The beginning of organic sedimentation was to be dated, as well as different stages of the pollen-sequence diagram, as yet unpublished. If the forest ever reached this alt, this event was to be dated, too. A preliminary note was published by Welten (1958).

B-205.	Belalp, 62.5 cm depth	1920 ± 90
B-203.	Belalp, 122.5 cm depth	5820 ± 120
B-202.	Belalp, 147.5 cm depth	6130 ± 110

B-254. Oberaar-Grimsel Reservoir, Switzerland 4600 \pm 80

Trunks of fir (*Pinus cembra*), excavated during construction of reservoir of Oberaar (46° 32' 46" N Lat, 8° 15' 55" E Long), alt 2240 m W of Grimsel Pass, Bernese Oberland. The wood, so well preserved that it was used as fuel, came from an end moraine of the Oberaar Glacier, now drowned by the reservoir; it was supposed to record one of the last advances of the glacier, in A.D. 1860 or 1808, or perhaps about A.D. 1600. Coll. 1952 by different persons, reported by Hugo Maler, Bern; subm. by Max Welten, Univ. of Bern. *Comment*: the result is surprising and of great interest in history of glaciation and of former treelines. Details of this and other local glacial advances and retreats are still not clear. B-138, B-139, and B-140 (this date list) give evidence of advance of the Oberer Grindelwald Glacier at about the same time.

Grächen series, Wallis, Switzerland

Sedge and moss peat from a boring in a small lake behind a lateral moraine of the ancient glacier of Nikolai valley, a little above the village of Grächen (46° 11' 48" N Lat, 7° 50' 43" E Long), alt 1720 m, near Visp and Stalden, Wallis. Coll. and subm. July 1951 by Max Welten, Univ. of Bern. *Comment*: Grächen being the driest locality in Switzerland, it is of special interest to investigate its vegetational history by means of palynology and C¹⁴ dating. A preliminary note was published by Welten (1958). The series is consistent with the exception of B-262, which is incomprehensible and will be repeated. The pollen profile shows unusually strong fluctuations of the larch curve, of which at least the older ones are considered to reflect climatic changes.

B-261. Grächen, 238 cm depth 2060 \pm 100

B-260. Grächen, 408 cm depth 4220 \pm 120

B-259. Grächen, 536 cm depth 4490 \pm 100

B-258. Grächen, 630 cm depth 4950 \pm 100

B-262. Grächen, 709 cm depth 3070 \pm 160

B-283. La Trelasse, Switzerland, 510 cm depth 8300 \pm 120

Peat in a well-developed sphagnum bog at La Trelasse, near St. Cergue (46° 26' 51" N Lat, 6° 5' 43" E Long), W part of Jura mountains, alt 1242 m. Sample was taken to complete a series taken in October 1956, two dates of which have been published (B-87 and B-88, Bern I). Coll. July 1959 by Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: sample dates end of the phase of hazel and the beginning of Quercetum mixtum.

B-284. Lac de L'Abbaye, France, 403.3 cm depth 9050 \pm 120

Gyttja, mixed with clay and chalk, from a boring in Lac de L'Abbaye, near St. Laurent (46° 31' 36" N Lat, 5° 54' 13" E Long), alt 871 m, in the French Jura. Coll. 1957 by Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: B-284 may date the invasion of hazel in the western Jura, if no redeposited carbonate contributed to the sample.

Lac de Narlay series, France

Gyttja mixed with chalk (B-285) and peat (B-286) from Lac de Narlay, near Le Frasnois, French Jura ($46^{\circ} 38' \text{ N Lat}$, $5^{\circ} 54' \text{ E Long}$), alt 748 m. Coll. July 1957 by Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: B-285 dates a time shortly after the beginning of invasion of *Abies* and *Fagus*. It is a very long phase. This dating does not contradict B-88 (5340 ± 100 , La Trelasse 340 cm, Bern I), because the 1957 studies refer to a different section. B-286 dates a later rise of *Abies* pollen after the long period of dominance.

B-285. Lac de Narlay, 673.3 cm depth **4720 ± 100**

B-286. Lac de Narlay, 95.2 cm depth **1050 ± 80**

B-287. Lac de Chalain, France, 75.5 cm depth **2700 ± 100**

Dry peat from the shore of Lac de Chalain, near Champagnole, French Jura ($46^{\circ} 40' \text{ N Lat}$, $5^{\circ} 47' \text{ E Long}$), alt 488.4 m. Coll. August 1957 by H. Balmer and Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: sample supposedly dates the end of the period of Quercetum mixtum, but seems to be too young. The reason for this is not known.

Les Cruilles series, Switzerland

Peat in a well-developed sphagnum bog at Les Cruilles, near Le Pont, Vallee de Joux ($46^{\circ} 39' 49'' \text{ N Lat}$, $6^{\circ} 18' 36'' \text{ E Long}$), alt 1040 m, western Jura. Coll. 1958 by Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: all dates are from a single peat profile and form a consistent and reasonable series from the beginning of the Quercetum mixtum phase in western Jura.

B-288. Les Cruilles, 324 cm depth **7060 ± 100**
The beginning of Quercetum mixtum phase.

B-289. Les Cruilles, 199.8 cm depth **5570 ± 120**
The end of the Quercetum mixtum phase.

B-290. Les Cruilles, 98.8 cm depth **4170 ± 140**
The first dominance of *Picea*.

B-292. Seche de Gimel, Switzerland, 380.3 cm depth **6360 ± 120**

Peat in a sphagnum bog (Sèche de Gimel), near Col de Marchairuz ($46^{\circ} 33' 05'' \text{ N Lat}$, $6^{\circ} 14' 00'' \text{ E Long}$), alt 1300 m, in western Jura. Coll. 1958 by A. Wasserfallen and Samuel Wegmüller; subm. by Max Welten, Univ. of Bern. *Comment*: sample dates the culmination of the Quercetum-mixtum phase in the western Jura and agrees very well with results of the series from Les Cruilles (B-288, B-289, this date list).

Fagne Wallonne series, Belgium

Fragments of wood found in a layer of peat, Fagne Wallonne, near Liège ($50^{\circ} 30' 56'' \text{ N Lat}$, $6^{\circ} 06' 38'' \text{ E Long}$). Coll. March 1960 by R. Schumacker; subm. by Prof. Duchesne, Liège University. *Comment*: samples were taken in

a peat pit. For palynology, see Florschütz and van Oye (1946), and Persch (1950).

B-297. Fagne Wallonne 1, 220 cm depth 6720 \pm 120

Fragments of trunks (*Betula pubescens*). Pollen zone: Atlantic.

B-298. Fagne Wallonne 2, 110 cm depth 4690 \pm 100

Fragments of branches (*Betula pubescens*, *Vaccinium uliginosum*). Pollen zone: Subboreal.

II. ARCHAEOLOGIC SAMPLES

Mottata series, Ramosch, Switzerland

Charcoal from Mottata, a cave inhabited from middle Bronze Age until late Iron Age, near Ramosch, Unter-Engadin, Canton Graubünden (46° 50' 15" N Lat, 8° 23' 20" E Long), alt 1524 m. Coll. July and August 1956 by Benedikt Frei; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the ages seem to be a little too high, but archaeological knowledge about these culture layers is poor (Frei, 1959).

B-145. Mottata 2 3060 \pm 100

Charcoal from upper "Melaunerhorizont" (Ceramic type Hallstatt C).

B-146. Mottata 5 2850 \pm 130

Charcoal from a rafter of a late-Iron-Age house (probably early phase of "Fritzens-Sanzenhorizont").

B-147. Mottata 9 3320 \pm 100

Charcoal from deeper layer of lower "Melaunerhorizont" (Urnenfelderzeit, probably Hallstatt A).

B-148. Mottata 13 3550 \pm 100

Charcoal from older "Melaunerhorizont" (Urnenfelderzeit).

B-149. Mottata 14 3570 \pm 160

Charcoal from middle Bronze Age.

B-163. Homberg-Kuettigen, Switzerland 500 \pm 100

Piece of burned oak found 60 cm below surface at Homberg, near Aarau (47° 25' 17" N Lat, 8° 04' 05" E Long). Coll. 1958 and subm. by Alfred Lüthi, Aarau. *Comment*: the result shows that the piece of wood comes from a fireplace of men who cleared this region, and does not originate from a prehistoric settlement.

Schiers series, Switzerland

Wood and charcoal samples from an early-medieval burial place near Schiers, Canton Graubünden (46° 58' 3" N Lat, 7° 21' 15" E Long). Coll. 1956 by Hans Erb; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the ages of the three samples are in agreement with archaeological chronology.

B-165. Schiers II 1680 \pm 100

Charcoal from level of skeleton, tomb II, in scree.

B-166. Schiers III **1430 ± 80**
Charcoal from fireplace above skeleton (above B-165), tomb II.

B-168. Schiers V **1640 ± 100**
Wood from level of skeleton, tomb III, in scree.

Ranggiloch-Boltigen series, Switzerland

Bones from two bear-bone layers and three pieces of wood stuck perpendicularly in these layers, in shelter-cave at Ranggiloch, near Boltigen, Bernese Oberland (46° 38' 20" N Lat, 7° 20' 27" E Long), alt 1845 m. Coll. 1933 and 1946 by David and Albert Andrist and Walter Flükiger; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: both layers are more or less disturbed and mixed. The upper layer contains material washed up from the deeper layer (Schmid, 1958). The wood samples (B-154, B-206, B-207) are younger than the bones, and therefore are supposed to have fallen from overhanging rocks, late in postglacial time, as is also implied by the ecology of the trees.

B-152. Ranggiloch **10,150 ± 200**
Bones from upper bear-bone layer (*Ursus arctos spelaeus*).

B-153. Ranggiloch **9500 ± 150**
Bones from lower bear-bone layer.

B-154. Ranggiloch **4800 ± 90**
Picea abies wood.

B-206. Ranggiloch **4920 ± 130**
Pinus cembra wood.

B-207. Ranggiloch **4700 ± 80**
Picea abies wood.

Podstrana series, Yugoslavia

Bones of man from old-Croatian grave-mounds, excavated at Podstrana-Omiš, near Split, province Hrvatska (43° 29' 20" N Lat, 16° 35' 5" E Long). Coll. August 1958 and subm. by Father Ante Skobalj of Krilo-Jesenice. *Comment*: B-216 and B-218 were very small samples, and could only be measured at half the normal pressure. Both dates seem to be too young, because the bones came from a pre-Christian, old-Croatian type of grave. B-217, originating from a medieval (Christian) old-Croatian grave, gives the expected age.

B-216. Podstrana 1 **500 ± 200**

B-217. Podstrana 2 **410 ± 80**

B-218. Podstrana 3 **600 ± 130**

B-233. Umtali, Southern Rhodesia **940 ± 110**

Charcoal found in a niche below an iron-furnace in a kraal (walled village) of Ingyanga culture, near the Zewa farm, Umtali, Southern Rhodesia (18° 55' S Lat, 32° 33' E Long). Coll. 1958 by F. O. Bernhard, Umtali;

subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the sample was taken in the deepest culture layer found, accompanied by pottery of a pre-Ingyanga culture.

Birmatten-Basishöhle series, Switzerland

Bone from Birmatten-Basishöhle cave-dwelling, with five Mesolithic culture layers, at Nenzlingen, near Laufen, Canton Bern (47° 25' 43" N Lat, 7° 33' 3" E Long). Coll. 1955 and 1956 and subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: errors given are relatively high, because samples were half the normal size.

B-234. Birmatten-Basishöhle 1 b **5350 ± 120**

Bones from layer 1 (Tardenoisian?).

B-235. Birmatten-Basishöhle 2 b **5310 ± 240**

Bones from layer 2 (Tardenoisian?).

B-236. Birmatten-Basishöhle 3 b **6970 ± 120**

Bones from layer 3 (Sauveterrian?).

B-238. Birmatten-Basishöhle 5 b **7460 ± 160**

Bones from layer 5 (Sauveterrian?).

B-232. St. Léonard, Switzerland **4750 ± 100**

Soil formed by decomposition of wood from a Neolithic culture layer, inhabited during the Cortaillod-Chassey-Lagozza-period, at St. Léonard, near Sierre, Wallis (46° 15' 28" N Lat, 7° 25' 36" E Long), alt 592 m. Coll. by M. R. Sauter, Univ. of Geneva; subm. by Max Welten, Bern. *Comment*: it is the first age determination of this kind in Canton Wallis (Sauter, 1959 and 1960), and no definite conclusion can be drawn out.

B-246. Alt-Landenberg, Switzerland **500 ± 100**

Fragments of shingle-wood, discovered by excavating bottom of moat at ruin of Alt-Landenberg castle, near Bauma, Canton Zurich (47° 22' 28" N Lat, 8° 52' 10" E Long). Coll. 1958 by P. Ziegler; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: result shows that the moat, now filled, must have been open until about A.D. 1500.

B-247. Tierberghöhle, Switzerland **2140 ± 80**

Charcoal from uppermost of three layers containing hearths, in the Tierberghöhle, a high-alpine cave near Lenk, Bernese Oberland (40° 23' 25" N Lat, 5° 28' 18" E Long), alt 2600 m. Coll. 1937 by David and Albert Andrist and Walter Flükiger; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the cave was used as shelter until the Iron Age. For excavation data see Andrist and Flükiger (1937).

B-244. Seeberg Burgaeschisee-Süd 1 (B-114 bis) **4790 ± 120**

Charcoal from a settlement of Younger Cortaillod culture, inhabited near the end of the "Vollneolithikum" of Switzerland, at Burgaeschisee, near Seeberg, Canton Bern (47° 11' N Lat, 7° 40' E Long). Coll. October 1957 from charcoal layer below a thin zone of loam, overlying a sequence of loam and

charcoal layers, by Hansjürgen Müller-Beck; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the result fits somewhat better with the archaeologic explanation (H. Müller-Beck, Oeschger and Schwarz, 1958) than did the original figure, 4390 ± 80 (Bern I). The reason for the discrepancy is not known.

B-245. Seeberg Burgaeschisee-Süd 5B (B-118B bis) 4630 ± 120

Bone fragments from a settlement of Younger Cortaillod culture, inhabited near end of "Vollneolithikum" of Switzerland, at Burgaeschisee, near Seeberg, Canton Bern ($47^{\circ} 11' N$ Lat, $7^{\circ} 40' E$ Long). Coll. November 1958 from the upper third of the culture layer, by H. Müller-Beck; subm. by H. G. Bandi, Historisches Museum, Bern. *Comment*: the result fits well with the first determination; see B-118B, 4630 ± 180 (Bern I), and Müller-Beck, Oeschger and Schwarz (1958). (Seeberg-Burgaeschisee-Süd 1 (B-114) and Seeberg-Burgaeschisee-Süd 5B (B-118B) have been re-run with better chemical pretreatment in our laboratory as samples B-244 and B-245, because both samples gave extreme ages of the first series).

B-271. Prins-Bois, Switzerland 1640 ± 100

Charcoal found with fragments of Roman bricks during excavation of primitive iron-working site, at Prins-Bois forest, near Orbe, Canton Waadt ($46^{\circ} 39' 55'' N$ Lat, $6^{\circ} 26' 46'' E$ Long), alt 725 m. Coll. 1959 by P. L. Pelet, Univ. of Lausanne; subm. by H. G. Bandi Historisches Museum, Bern. *Comment*: the date confirms the age inferred from archaeologic considerations (Pelet, 1960).

B-274. Arbon, Switzerland 1030 ± 120

Post wood from old harbor construction in Bodensee, near Arbon, Canton Thurgau ($47^{\circ} 30' 45'' N$ Lat, $9^{\circ} 26' 30'' E$ Long), taken at low-water level. Coll. 1959 and subm. by Willy Schädler, Arbon. *Comment*: the remains of this construction are described as Roman on old maps. The result shows that it is medieval.

Cape Krusenstern series, NW Alaska, U. S.

Wood and charcoal samples from archaeological sites, and peat in a similar situation, on old beach ridges at Cape Krusenstern, NW Alaska, U. S. ($67^{\circ} 7' N$ Lat, $163^{\circ} 40' W$ Long). Archaeologic samples coll. July 1959 under direction of J. L. Giddings, Brown University, Providence, Rhode Island, U. S. A.; subm. by H. G. Bandi, Historisches Museum, Bern; peat (B-265) coll. by G. W. Moore, U. S. Geol. Survey. *Comment*: the different places of archaeological excavation were expected to give different ages, corresponding to their distance from the modern seashore; house 25, medieval; houses 17 and 18, Ipiutak period; house 21, older than Ipiutak. The dates agree with expectation, and with other dates for these Eskimo cultures. However, the gravel underlying the peat collected by Moore is also beach ridge, deposited when sealevel stood ca. 3 to 4 m above its present level, and appears to be much older than the ridge-sites excavated by Giddings. At least the date of B-265 rules out the possibility that the 3 to 4 m high stand was occupied in Hypsithermal time.

B-281. Cape Krusenstern, house 25	770 ± 120
Remains of food from bowls.	
B-266. Cape Krusenstern, house 17	1450 ± 80
Charcoal.	
B-280. Cape Krusenstern, house 18	1250 ± 100
Charcoal.	
B-267A. Cape Krusenstern, house 21	2470 ± 150
Charcoal.	
B-267B. Cape Krusenstern, house 21	2530 ± 150
Fragments of wood.	
B-265. Cape Krusenstern, house 59	26,100 ± 400
Peat-like material overlying a former beach ridge (Ame/Tikizat-1-3).	

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DUBLIN RADIOCARBON DATES I

I. R. McAULAY and W. A. WATTS

Trinity College, Dublin

INTRODUCTION

A C^{14} -dating installation was operated in the Physics Department, Trinity College, Dublin, from early 1958 until early 1960, by I. R. McAulay. Construction and testing of the apparatus had occupied 15 months previous to this. Material for dating was selected and pretreated by W. A. Watts, who also collected and submitted the samples and carried out pollen analyses except where the contrary is stated in the text. The project was a short-term one with two main aims; to obtain a few key archaeologic dates, particularly in the Neolithic, to help orientate chronologic discussion; and to test the validity of the pollen zonation for the post-Atlantic of Mitchell (1956).

Operation of the machine has already been described (Delaney and McAulay, 1959). Scintillation techniques were used. Sample to be dated was converted to methyl alcohol and mixed with a liquid scintillator. The scintillator cell was of fused silica, in the form of a cylinder of volume 50 ml, 10 ml of methanol being added to 40 ml liquid scintillator. The scintillator cell was viewed by two photomultipliers working in coincidence. The background counting rate was reduced by massive screening and by pulse-height selection. Reference sample counting rate was 20.3 ± 0.18 counts/min. above a background of 13.6 ± 0.11 counts/min. For reference sample 120-yr-old oak wood was used. Counting period was 17 hours. Some of the samples were counted more than once, as a check on the consistency of the machine's running, but limited time made it unpractical to adopt this as a standard procedure for all samples. After the 1959 radiocarbon conference at Groningen, counts were carried out on the oxalic-acid reference sample issued by the U. S. Bureau of Standards (NBS), taking 95% of its activity to be the "recent standard." Our former reference sample had yielded a contemporary count rate lower by ca. 1% than the count rate from the oxalic acid. Our earliest datings (D-1, D-22, D-28 to D-32, D-34, D-46 and D-68 to D-70), most of which had already been published (Delaney and McAulay, 1959), are based on our old standard, the remainder are based on the new. The difference between the standards is, in any case, a small one and no substantial change of date would result from recalculating dates based on the former standard. Pretreatment was by successive boiling in acid, alkali and acid again, in the case of the archaeologic samples. Bog samples were untreated, in view of the evidence of Overbeck and others (1957) that no particular advantage was obtained by removing the humus fraction from raised-bog peat.

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NOTE: A detailed account of all the dates quoted here, together with the pollen diagrams referred to, will be offered to Proceedings of the Royal Irish Academy for publication during 1961.

SAMPLE DESCRIPTIONS

I. POLLEN-DATED BOG SAMPLES

The datings were made to test the scheme for pollen zoning the post-Atlantic period suggested by Mitchell (1956), with some minor modifications proposed by Watts (1961). The zone boundaries proposed are as follows:—zone VII (Atlantic)—VIII (Pagan) boundary, drawn where *Ulmus* (elm) curve falls suddenly in pollen diagrams and/or pollen of *Plantago lanceolata* (plantain) appears in quantities greater than single grains; zone VIII-IX (Christian period) boundary, drawn where *Ulmus* virtually disappears from pollen diagrams and *Fraxinus* (ash) suffers a simultaneous great decrease; zone IX-X (Afforestation period), dated historically to about A.D. 1700, when planting of exotic trees became widespread in Ireland. The appearance of their pollen, especially *Pinus* (pine) and *Fagus* (beech), in pollen diagrams defines the zone boundary. Suggested subdivisions of zone VIII are (1) at the first appearance of *Fraxinus* pollen in quantity early in the zone, (2) at the maximum value of *Quercus* (oak) reached in the middle of the zone, and (3) at a point where *Fraxinus* doubles its values late in the zone. Zone IX might be subdivided by (1) the rather sudden appearance of *Artemisia* (mugwort) pollen in abundance early in the zone, and (2) a conspicuous minimum for *Corylus* (hazel) which occurs slightly later. Boundaries were tested by dating slices of peat 2 cm thick from pollen-dated peat monoliths from raised bogs. Prominent recurrence surfaces in the bogs were also dated.

Redbog series

Peat samples from Redbog, County Louth (53° 58' N Lat, 6° 25' W Long). Monolith coll. 1958 by W. A. Watts and G. F. Mitchell, Trinity College, Dublin.

D-1. Redbog, 406 to 408 cm depth 6460 ± 200

2-cm slice of *Dryopteris thelypteris* peat, very humified. Sample dates zone VIb-VIc boundary, *sensu* Jessen (1949).

D-2. Redbog, 366 to 368 cm depth 6400 ± 200

2-cm slice of wood peat rich in wood of *Pinus* (pine) and *Betula* (birch). Sample dates zone VIc-VII boundary, *sensu* Jessen (1949). Compare Q-166, 6955 ± 131 (Cambridge I) which lies just above same boundary.

D-4. Redbog, 284 to 286 cm depth 5170 ± 190

2-cm slice of *Sphagnum-Calluna* peat, rich in *Eriophorum* fibre. Sample lies at beginning of *Ulmus* fall. Zone VII-VIII boundary is placed at 280 cm where *Ulmus* falls to its lowest level before beginning to recover.

D-5. Redbog, 264 to 266 cm depth 4430 \pm 140

2-cm slice of very humified *Sphagnum-Calluna* peat, rich in *Eriophorum* fibre. Sample lies at rise of *Ulmus* to abundance once more after its first fall.

D-3. Redbog, 239 to 241 cm depth 3570 \pm 170

2-cm slice of very humified *Sphagnum-Calluna* peat rich in *Eriophorum* fibre. Sample lies at first appearance of *Fraxinus* with moderate abundance. In interpreting the pollen diagram there was some doubt as to whether this slice should not be taken at 250 cm, which would have yielded a date ca. 2000 B.C.

D-6. Redbog, 174 to 176 cm depth 2625 \pm 130

2-cm slice of moderately humified *Sphagnum*-rich peat with lenses of fresh *Sphagnum*. Sample lies at highest value for *Quercus* pollen in middle of zone VIII.

D-7. Redbog, 109 to 111 cm depth 2220 \pm 130

2-cm slice of moderately humified *Sphagnum*-rich peat with lenses of fresh *Sphagnum*. Sample marks the point high in zone VIII where *Fraxinus* increases greatly in abundance.

D-8. Redbog, 69 to 71 cm depth 1725 \pm 130

2-cm slice of moderately humified *Sphagnum* peat. Sample dates VIII-IX boundary.

D-9. Redbog, 61 to 63 cm depth 1380 \pm 120

2-cm slice of fresh *Sphagnum* peat from immediately above well-marked recurrence surface.

D-10. Redbog, 49 to 51 cm depth 1450 \pm 130

2-cm slice of fresh *Sphagnum* peat. Dates appearance of *Artemisia* in abundance early in time of zone IX.

D-11. Redbog, 27 to 29 cm depth 500 \pm 130

2-cm slice of fresh *Sphagnum* peat. Dates a small peak in *Ulmus* curve lying midway between the *Corylus* minimum at 40 cm and the beginning of zone X at 8 cm.

D-12. Lomcloon Townland, County Sligo 5160 \pm 190

2-cm slice of highly-humified *Sphagnum* peat at depth 14 to 16 cm, from a short monolith obtained from peat exposed by drainage operations at Lough Gara, County Sligo (53° 56' N Lat, 8° 27' W Long). The peat represents basal remains of a destroyed raised bog. The slice dates the VII-VIII boundary. Coll. June 1958 by W. A. Watts and G. F. Mitchell, Trinity College, Dublin.

Treanscrabbagh Townland series

Samples from two peat monoliths from a large raised bog in this town-

land, County Sligo (54° 3' N Lat, 8° 23' W Long). Coll. May 1958 by W. A. Watts and F. M. Synge, Geol. Survey of Ireland, Dublin.

D-13. Treanscrabbagh 1, 386 to 388 cm depth 4970 ± 190

2-cm slice of very homogeneous fen mud peat with much fibre, probably of *Carices*. *Menyanthes* and mosses abundant. Fragments of wood, *Corylus* nuts and *Salix atrocinerea* leaves occur. Sample dates VII-VIII boundary.

D-14. Treanscrabbagh 1, 342 to 344 cm depth 4550 ± 180

2-cm slice of peat, similar to D-13. Dates first appearance of *Fraxinus* in quantity. A hearth of burnt stone and ash, but with no other finds, is buried in the bog at this level.

D-15. Treanscrabbagh 1, 294 to 296 cm depth 3665 ± 130

2-cm slice of peat, similar to D-13. Dates maximum of *Quercus* in middle of zone VIII.

D-17. Treanscrabbagh 1, 89 to 91 cm depth 1220 ± 120

2-cm slice of fresh *Sphagnum* peat with *Calluna* and *Eriophorum*. Dates appearance of *Artemisia* in quantity. There is a very striking recurrence surface at 98 cm and the zone VIII-IX boundary lies at 108 cm.

D-16. Treanscrabbagh 2, 36 to 38 cm depth 3120 ± 120

2-cm slice of yellow-brown moss peat. Dates point in zone VIII where the sediment passes from moss peat with twigs and leaves to thick *Eriophorum* peat.

D-25. Tullymackan Townland, 106 to 108 cm depth 2030 ± 130

2-cm slice of very humified peat with twigs of *Calluna* from a peat monolith in a small raised bog in this townland, County Clare (52° 59' N Lat, 8° 55' W Long). Sample dates the doubling of *Fraxinus* values late in zone IX.

D-26. Clonsast trackway 1910 ± 130

Corylus wood from a small, poorly-constructed trackway at the SW margin of this very large raised bog (53° 13' N Lat, 7° 13' W Long). The trackway underlies *Pinus* stump layer described by Mitchell (1956, p. 202). This layer (dated by D-29, 1620 ± 130, this date list), in turn immediately underlies the VIII-IX boundary. Coll. and subm. December 1958 by Dr. N. Murray, Trinity College, Dublin. Pollen diagrams in Murray (1957).

D-29. Clonsast stump 1620 ± 130

Pinus root wood from horizon of *Pinus* stumps growing on a recurrence surface at the SW corner of the bog. Stump layer lies from 65 to 75 cm below bog surface, from which top few cm have been removed. Parts of same root have been dated by Yale (Y-94, 1610 ± 80, Yale III) and by Groningen (Gro-271, 1485 ± 150; Groningen dates in this paper, which are not corrected for the Suess effect, are quoted from Mitchell (1958)). The trees, some of which reached an age of about 100 yr, must have been growing ca. A.D. 300. VIII-IX boundary lies at 58 cm and must be slightly younger. Coll. 1953

and subm. by G. F. Mitchell, Trinity College, Dublin. Pollen diagram in Mitchell (1956).

Agher Townland series

Samples from a small, much destroyed, raised bog in this townland, County Meath (53° 27' N Lat, 6° 45' W Long). Monolith coll. 1958 by W. A. Watts and G. F. Mitchell, Trinity College, Dublin.

D-18. Agher, 62 to 64 cm depth 1610 ± 120

2-cm slice of very fresh *Sphagnum* peat. Sample dates VIII-IX boundary.

D-20. Agher, 23 to 25 cm depth 1380 ± 120

2-cm slice of very fresh *Sphagnum* peat. Dates *Corylus* minimum early in IX.

D-21. Agher, 103 cm depth 1650 ± 120

Thin slice of very humified greasy amorphous peat lying immediately below a marked recurrence surface.

D-22. Agher, 101 cm depth 1200 ± 120

Thin slice of very fresh *Sphagnum* peat with leaves of *Andromeda* and *Oxycoccus* representing flooding of humified peat surface dated by D-21. *General Comment*: although separated by 40 cm of peat from D-18, there is probably not a very great age difference between D-18 and D-21, as the pollen diagram indicates very rapid bog growth at this stage. D-22, which should be of ca. the same age as D-21, appears to be too young.

Fallahogy Townland series

A raised bog in this townland, County Derry (54° 54' N Lat, 6° 33' W Long) has been investigated by A. G. Smith, Queen's Univ., Belfast (Smith, 1958). Samples are slices from a bog monolith coll. 1958 by Dr. Smith.

D-23. Fallahogy *Ulmus* fall 3290 ± 140

2-cm slice of *Eriophorum* peat with some *Calluna*. Corresponds to 285 cm level in Fallahogy Td. I pollen diagram (Smith, 1958). Sample dates zone VII-VIII boundary, sensu Mitchell (1956). Subm. 1958 by A. G. Smith, Queen's Univ., Belfast.

D-24. Fallahogy *Fraxinus* appearance 3070 ± 140

2-cm slice of *Eriophorum* peat with some *Calluna*. Corresponds to 255 cm level in Fallahogy Td. I pollen diagram (Smith, 1958). Sample dates rise of *Fraxinus* low in zone VIII (Mitchell, 1956). *General comment*: Fallahogy dates are self-consistent but appear too young in comparison with those already obtained for these horizons. Sources of discrepancy may be (1) that a pollen zonation which works for the Irish Central Plain may not be applicable to other regions of Ireland, (2) there may have been a technical error, though both datings were repeated with the same result, (3) the pollen diagram may have been misinterpreted. The Cambridge laboratory has agreed to recheck the dates and, pending this, further comment may be withheld.

General Comments on Pollen-Zone Datings

D-4, D-12 and D-13 suggest that the VII-VIII boundary lies about 3000 B.C. This agrees with other dates for this horizon, e.g. Q-171, 4932 ± 134 (Cambridge I). The VIII-IX boundary proposed by Mitchell (1956) seems well-founded at about A.D. 300. This is important, because this boundary is based on sharply-defined, easily-recognized features and is most valuable in subdividing the post-Atlantic. The *Quercus* maximum, which Mitchell used to subdivide zone VIII, is evidently unsuitable for the purpose. Compare also Gro-272, 3400 ± 170 (Mitchell, 1958) which dates this feature. The first appearance of *Fraxinus* in zone VIII in quantity D-3, 3570 ± 170 , D-14, 4550 ± 180 , (this date list) and Y-93, 4170 ± 80 (Yale III), which lies just after *Fraxinus* first appears, lies between 2500 and 2200 B.C., but as seen from the Redbog pollen diagram (see comment on D-3) it may be difficult to decide the exact point at which *Fraxinus* may be said to "appear in quantity". Evidently the appearance of *Fraxinus* is of considerable value for dating purposes, but is not suitable for defining a pollen zone. The doubling of *Fraxinus* values, which occurs high in zone VIII, appears to occur about 100 B.C. The point at which a great increase in *Fraxinus* is seen can be drawn sharply in some pollen diagrams, but not all. Therefore, this event has indicator value for age, but is not suitable as the basis of a zone boundary. The same observations apply to the appearance of *Artemisia* low in zone XI and the *Corylus* minimum which occurs slightly higher. The former increases its quantity about A.D. 600; the latter slightly later. Gro-651, 980 ± 80 (Mitchell, 1958) lies just above the *Corylus* minimum.

II. MISCELLANEOUS BOG DATES

D-28. Treanmacmurtagh, County Sligo 3670 ± 130

Charcoal from a hearth of burnt stone and ash without archaeological finds, embedded in raised-bog peat of zone VIII in this townland ($54^{\circ} 3' \text{ N Lat, } 8^{\circ} 24' \text{ W Long}$). Coll. 1956 and subm. by G. F. Mitchell, Trinity College, Dublin.

D-27. Timoney Bog, County Tipperary 550 ± 120

Bark and outer wood of *Taxus* (yew) stump bearing axe marks, buried 150 cm below bog surface in Timoney Townland ($52^{\circ} 55' \text{ N Lat, } 7^{\circ} 45' \text{ W Long}$). The stump dates an adjacent occupation site, 150 cm below the bog surface, marked by a floor of sandstone slabs covered by ashes and by two large wooden troughs. The site is unique in that the bog seems to have been severely eroded at one period; then the surface of the eroded peat was occupied; then the peat re-formed. More detailed archaeological and pollen-analytical work is still necessary. Coll. February 1959 by W. A. Watts and N. Murray at site indicated by A. Lucas, National Museum, Dublin.

D-30. Beaghmore, County Tyrone 1400 ± 120

At Beaghmore Townland ($54^{\circ} 42' \text{ N Lat, } 6^{\circ} 57' \text{ W Long}$) stone circles, stone alignments and old field boundaries are buried by blanket peat. Sample dates the base of the peat. Site is described by May (1953). A pollen diagram was prepared from the peat by G. F. Mitchell (May, 1953, p. 194) but was

uninformative. *Comment:* peat date can only provide a terminus ante quem for the site which, on archaeologic grounds, must be much older. A. G. Smith, Queen's Univ., Belfast, is re-investigating the site.

D-31. Sutton, County Dublin

3730 \pm 130

Estuarine peat (53° 23' N Lat, 6° 6' W Long) exposed under marine gravels at ca. 6 m above o.d. Gravels represent a retreat stage of marine transgression which had reached its maximum before 3000 B.C., in the Irish Sea area. See Q-120, 5412 \pm 130 (Cambridge I) which dates maximum of transgression.

D-32. Ballynaclash Townland, County Wexford

11,060 \pm 250

In this townland (52° 25' N Lat, 6° 20' W Long) black algal mud 3 cm thick, and covered by clay-rich peat 12 cm thick, is exposed on the seashore. The deposit is overlain by 2m of sand with clay lenses and small stones. It lies in a hummocky area, rich in kettles, which marks the end moraine of the last glaciation. Coll. March 1958 by W. A. Watts and F. M. Synge, Geol. Survey, Dublin. *Comment:* in spite of the surprisingly thick overburden the algal mud, which was used for dating, is obviously of Allerød age, agreeing with the numerous Allerød dates already published, e.g. in Cambridge I. The pollen diagram supports the date.

III. ARCHAEOLOGIC SAMPLES

Samples D-36 to D-49 and D-51 have already been published and discussed, (Watts, 1960) and will be treated briefly here.

D-36. Newferry, County Antrim

5290 \pm 170

Charcoal from hearth (54° 49' N Lat, 6° 27' W Long), containing Bann flakes and fragments of polished stone axes stratified in diatomite. Pretreatment: the charcoal, which was silicified, was reboiled in HF. Coll. August 1959 by W. A. Watts and G. D. Liversage, at site indicated by A. G. Smith, Queen's Univ., Belfast. Site description in Movius (1942).

D-37. Knockiveagh, County Down

5020 \pm 170

Charcoal from beneath large stone cairn (54° 17' N Lat, 6° 10' W Long). Charcoal was mixed with abundant sherds of Neolithic pottery. Site excavated and published by Collins (1957). Coll. 1956 and subm. by A. P. Collins, Archaeological Survey of North Ireland, Belfast.

D-38. Dalkey Island, County Dublin

5300 \pm 170

Charcoal from shell midden (53° 17' N Lat, 6° 5' W Long) where finds suggest a transition from Mesolithic to Neolithic economy. Coll. and subm. 1959 by the excavator, G. D. Liversage, Queen's Univ., Belfast. Site not yet published. *Comment:* D-36, D-37 and D-38 suggest that the Neolithic in Ireland began before 3000 B.C. This is supported by other dates, e.g. BM-73, 4910 \pm 150 (Smith, 1960).

D-39. Geroid Island, Lough Gur, County Limerick

4090 \pm 140

Charcoal from habitation site (52° 30' N Lat, 8° 32' W Long) associated

with Neolithic pottery. Described by Liversage (1958). Subm. 1959 by G. D. Liversage, Queen's Univ., Belfast.

D-34. Geroid Island, Lough Gur, County Limerick 3680 ± 140

Wood from *Quercus* stump overlying habitation layer described in D-39. Gives a terminus ante quem for the Neolithic occupation of the island. Consistent with D-39. Published as T.C.D./8 in Liversage (1958). Subm. 1958 by G. D. Liversage, Queen's College, Belfast.

D-40. Circle L, Knockadoon, Lough Gur 4410 ± 240

Charcoal from Neolithic house site (52° 32' N Lat, 8° 32' W Long). Dates early phase of Knockadoon occupation. Unpublished excavation, 1954, by late S. P. O'Riordain. Subm. 1959 by M. de Paor, University College, Dublin. Other similar sites at Knockadoon are described by O'Riordain (1954).

D-41. Circle L, Knockadoon, Lough Gur 4690 ± 240

Charcoal from posthole of house dated by D-40. *Comment:* D-40 and D-41 have large errors, due to the small quantities of charcoal available. Dates may be combined to give a date of ca. 2600 B.C. for the house.

D-42. Mound of the Hostages, Tara, County Meath 4080 ± 160

Charcoal infilling of a ditch (53° 35' N Lat, 6° 37' W Long), predating a passage grave of the Boyne culture. Coll. 1959 by W. A. Watts on behalf of the excavator, R. de Valera, University College, Dublin. Excavation not yet published.

D-43. Mound of the Hostages, Tara, County Meath 4260 ± 160

Fine charcoal fragments from burnt ground surface under stone cairn of Boyne culture passage grave. Details as D-42.

D-44. Mound of the Hostages, Tara, County Meath 3880 ± 150

Charcoal from fire on old ground surface of passage grave close to entry to the passage. Details as D-42.

D-45. Four Knocks 2, County Meath 3480 ± 140

Charcoal (53° 35' N Lat, 6° 17' W Long) from a cremation pit containing Loughcrew pottery associated with a Boyne culture passage grave. Coll. 1950 by the excavator, P. J. Hartnett, Bord Failte Office, Dublin. Site mentioned in Hartnett (1957). Subm. 1958 by National Museum, Dublin. *Comment:* D-42 to D-45 suggest that Boyne culture dates ca. and shortly after 2000 B.C.

D-46. Goodland, County Antrim 4150 ± 200

Very humified peat (55° 13' N Lat, 6° 7' W Long), rich in *Juncus* seeds. Base of blanket bog overlying Neolithic ritual site. Coll. 1954 and subm. by the excavator, H. Case, Ashmolean Museum, Oxford. Publication pending in Proceedings of the Prehistoric Society.

D-47. Island McHugh, County Tyrone 3380 ± 120

Charcoal (7° 25' N Lat, 7° 25' W Long) embedded in peat with late

Neolithic pottery of Sandhill type. Coll. and subm. August 1959 by W. A. Watts, G. D. Liversage and G. Eogan, Trinity College, Dublin. Site excavated and published by Davies (1950). Samples came from a part of the site which had been left unexcavated.

D-48. Ballyutoag, County Antrim **4120 \pm 300**

Charcoal (54° 39' N Lat, 5° 59' W Long) from the forecourt of horned cairn, associated with Neolithic pottery. Coll. 1935 by I. J. Herring, the excavator; subm. 1959 by Belfast Municipal Museum. Description of site in Herring (1938). *Comment*: small quantity of charcoal available makes a large error inevitable.

D-49. Island, County Cork **3110 \pm 140**

Charcoal (52° 4' N Lat, 8° 35' W Long) from around the bases of the orthostats of wedge-shaped gallery grave. Coll. 1957 and subm. by M. J. O'Kelly, University College, Cork (O'Kelly, 1958a). *Comment*: date is rather young on archaeological grounds, but not impossible.

D-50. Carn, County Mayo **3000 \pm 140**

Handle of halberd made of *Quercus* (oak) wood (54° 15' N Lat, 9° 19' W Long) found in a bog in County Mayo in 1941. Subm. by J. Raftery, National Museum, Dublin (Raftery, 1942).

D-51. Dundrum Sandhills, County Down **2860 \pm 140**

Charcoal (54° 14' N Lat, 5° 50' W Long) associated with Neolithic pottery forming an occupation horizon buried in dune sand. Coll. and subm. 1959 by A. P. Collins, Archaeological Survey of N Ireland, Belfast. *Comment*: date is too young. The error may lie in the difficulty associated with sand-dune sites, that material from several horizons may become mixed due to erosion of the dunes and sand movement.

D-52. Shanballyedmond, County Tipperary **2050 \pm 130**

Charcoal (52° 41' N Lat, 8° 14' W Long) from chamber of a horned cairn. Coll. and subm. 1958 by M. J. O'Kelly, University College, Cork. Site is described in O'Kelly (1958b). *Comment*: there was some doubt as to whether this charcoal was in primary position. Clearly it was not, for the date is far too young.

Lough Gara series

During 1955, Dr. J. Raftery, National Museum, Dublin, excavated "Crannog 61", one of a large group of artificial islands constructed as house sites which came to light as the water level of the lake fell due to drainage operations. The crannog (53° 56' N Lat, 8° 25' W Long) had occupation layers dating from the Late Bronze Age and Early Iron Age and gave an opportunity to date the transition between the two. Material subm. by National Museum, Dublin. Site has not yet been published.

D-53. Lough Gara S. 176 **2070 \pm 130**

Corylus twigs from fire basket. Late Bronze Age horizon.

D-54. Lough Gara S. 172 **2140 ± 130**

Corylus twigs from fire basket. End of Late Bronze Age. Sample should be slightly younger than D-53.

D-55. Lough Gara S. 177 **2150 ± 130**

Wood from the outermost circle of crannog piles. No archaeological evidence of age.

D-56. Lough Gara S. 174 **310 ± 120**

Wood from piles forming ultimate structure of crannog. *Comment:* Dr. Raftery suggests a date ca. A.D. 400 for this structure, but it appears to be much later.

D-57. Lough Gara S. 171 **2100 ± 130**

House posts of *Quercus* (oak) wood from the early Iron Age period.

D-58. Lough Gara S. 173 **1630 ± 130**

Wood from outer revetment piles of crannog. Early Iron Age period.

D-59. Lough Gara S. 175 **2150 ± 130**

Corylus twigs from fire basket. Late Bronze Age level. Should be of the same age as D-53, which comes from same horizon.

D-60. Lough Gara cereals **2160 ± 130**

Charred cereals. End of Late Bronze Age horizons. Should be more or less contemporary with D-54.

D-61. Lough Gara S. 39 **2250 ± 130**

Charcoal from clay near base of hearth under a large stone mass. Should be of Early Iron Age date. *General comment:* Lough Gara dates suggest that the crannog was constructed not earlier than 250 B.C. and was occupied until the early centuries A.D. Most archaeologists would think 250 B.C. a rather young date for the Late Bronze Age-Early Iron Age transition.

Drombeg Townland series

In this townland, County Cork (51° 34' N Lat, 9° 5' W Long) E. M. Fahy, Cork Public Museum, excavated a stone circle in 1958. Associated with the circle were a pit containing some pottery and an ancient cooking pit. Samples subm. by E. M. Fahy. Site is described in Fahy (1959).

D-62. Drombeg stone circle **1350 ± 120**

Charcoal associated with fragments of pottery in a soil-filled pit. The pottery was thought by the excavator to resemble Lough Gur Class 2 ware and would therefore be late Neolithic. This sample is described as T.C.D. 38 in Fahy (1959).

D-63. Drombeg cooking pit **1390 ± 120**

Charcoal from old ground surface of cooking pit.

D-64. Drombeg cooking pit **1520 ± 120**

Charcoal from base of cooking pit. *General comment:* both the pottery and the cooking pit date to about A.D. 500. The three dates agree so well that a

Neolithic date seems impossible. Whether stone circles of the Drombeg type, "recumbent stone circles", may also be of this age is still an open question. It is possible that there were two periods of occupation at the site.

D-65. Drumaroad, County Down 900 \pm 120

Charcoal (54° 18' N Lat, 5° 54' W Long) from a house site within a cashel (stone-built fort). Sample dates pottery of "souterrain ware" type associated with the house. Coll. 1953 and subm. by D. M. Waterman, Archaeological Survey of N Ireland, Belfast. Published by Waterman (1956).

D-66. Larne, County Antrim 1470 \pm 120

Charcoal (54° 55' N Lat, 5° 51' W Long) associated with "souterrain ware". Coll. 1957 and subm. by D. M. Waterman, Archaeological Survey of N Ireland. Publication: preliminary note (Anonymous, 1958). *Comment:* (D-65 and D-66) "souterrain ware" is associated in N Ireland with Early Christian stone- or earth-built habitation sites (cashels and raths respectively). Dates agree well with the archaeologic expectation.

D-68. Milmorane, County Cork 4040 \pm 150

Blanket bog peat (51° 52' N Lat, 9° 12' W Long) surrounding a necklace which, on archaeologic grounds, should be of Iron Age date. Coll. 1944 and subm. by G. F. Mitchell, Trinity College, Dublin. A pollen diagram of the site is available (Mitchell, 1951). *Comment:* pollen diagram and radiocarbon dates agree. Evidently the necklace was buried in the bog.

D-69. Ballingarry Downs 1200 \pm 120

Charcoal (52° 23' N Lat, 8° 21' W Long) from occupation debris of a large ring fort from this townland near Ballylanders, County Limerick. Excavated by J. Hunt, 1955. Subm. by G. F. Mitchell, Trinity College, Dublin. Photograph in O'Riordain (1953). The excavation is unpublished.

D-67. Garryduff, County Cork 250 \pm 120

Charcoal (52° 1' N Lat, 8° 7' W Long) from occupation debris of a ring fort in this townland. Site was rich in finds suggesting a date in the middle of the first millennium A.D. Coll. 1945 and subm. by M. J. O'Kelly, University College, Cork. Preliminary note of excavation in O'Kelly (1946). *Comment:* the charcoal is a secondary intrusion.

CHECK SAMPLE

D-70. Nabu Temple, Nimrud, Iraq 2506 \pm 140

Charred wood from Nabu Temple at ancient Nimrud (36° 11' N Lat, 43° 20' E Long). Coll. 1956 by M. E. L. Mallowan, Univ. of London. Archaeologic date of the specimen should be some decades before 612 B.C. *Comment:* sample has also been dated by the British Museum at 2400 \pm 150 (BM-59), (British Museum II). Date quoted above was obtained, using our old reference standard. A second dating, using the oxalic-acid standard, gives 2730 \pm 120.

MISCELLANEOUS SAMPLE

D-71. Kentmere boat**650 ± 120**

Wood from remains of a boat discovered at Kentmere, Westmoreland (54° 26' N Lat, 2° 21' W Long). Sample dated at suggestion of British Museum laboratory. *Comment*: age of boat was in doubt. Possibilities seemed to be either early centuries A.D., or much later. The latter view appears correct.

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BRITISH MUSEUM NATURAL RADIOCARBON MEASUREMENTS III

HAROLD BARKER and JOHN MACKEY

Research Laboratory, British Museum, London W.C.I.

The third series of radiocarbon measurements made at the British Museum Research Laboratory is reported in the following list. Equipment and method used are as described previously (British Museum I) and, as in previous lists, the error terms are not based solely on counting statistics, but are widened to include contributions of ± 80 years for possible isotopic fractionation effects and ± 100 years for the de Vries effect. Ages are calculated on a half-life of 5568 ± 30 years. NBS oxalic acid is now used as a reference standard in place of 100-yr-old oak. The latter gave an age-corrected value almost exactly 95% of the oxalic-acid activity and thus no corrections are required to our previous date lists to bring them into line with the new standard.

PRETREATMENT OF BONE AND ANTLER

One of the laboratory's long-term projects is an investigation into the reliability of bone and antler as source materials for dating. A number of measurements on such materials are reported here. In all cases, only the organic fraction of the sample was used as a source of carbon, and the procedure adopted was as follows: Sample was broken into small pieces, either by coarse grinding or pounding in a mortar, and was treated with cold dilute hydrochloric acid in order to remove carbonates and to decalcify the material. Resulting granular gel was washed thoroughly by repeated soaking with cold water and was finally dried, prior to combustion.

ACKNOWLEDGMENT

Thanks are due to the Director, Atomic Energy Research Establishment, Harwell, for electronic servicing facilities. Help and advice received from those members of the Establishment concerned with this service, is gratefully acknowledged.

SAMPLE DESCRIPTIONS

I. ARCHAEOLOGIC SAMPLES

A. Africa

BM-31. Magabengberg, N Transvaal 1020 \pm 150

Charcoal from bed 1 in Magabengberg cave, Magabengberg North Transvaal ($23^{\circ} 15' S$ Lat, $28^{\circ} 55' E$ Long). Found in association with Later Smithfield industry. Coll. December 1954 by Jean Humphries; subm. by Director, Archaeological Survey, Union of South Africa. *Comment*: the associated culture is similar to that found at Olieboompoort bed 3 (BM-42, 870 ± 150 , this date list). The two dates thus corroborate each other.

BM-42. Waterberg, W Transvaal 870 \pm 150

Charred bone from bed 3 in cave on W side of Olieboompoort, NW

Waterberg, Transvaal (23° 50' S Lat, 27° 40' E Long). Found in association with Later Smithfield industry. Coll. September and October 1954 by R. J. Mason; subm. by Director, Archaeological Survey, Union of South Africa. Relevant publication—Mason 1957, 1958. *Comment*: see BM-31.

B. Egypt

BM-82. Abu Sir

3950 ± 150

Wood from Pyramid of Neferirkare (29° 53' N Lat, 31° 11' E Long). Coll. 1839 by J. S. Perring and presented to British Museum in 1840 (ref. 38259). Subm. by Dept. of Egyptian Antiquities. Relevant publication—Vyse, 1842. *Comment*: the wood was found in a situation that indicated it must have been built into the masonry at the time of erection of the building and therefore must be at least as old as the pyramid. As the accepted date for Neferirkare is 2460 B.C. (4420 B.P.) this sample provides another instance of Egyptian material giving a radiocarbon age less than the accepted one (Pennsylvania III).

BM-79. Tura Caves

2130 ± 150

Papyrus rope found buried in debris in one of the Tura caves, which are old stone quarries (29° 56' N Lat, 31° 18' E Long). Collector not known but the find is described by A. Lucas (Lucas, 1948). Received in British Museum in 1955, but not incorporated into the collection. There was no firm archaeological evidence to suggest the age of the rope, but it obviously was not modern, and as the site has been used as a source of stone for a very long period, a date was of some interest.

C. Great Britain

BM-89. Blashenwell, Dorset

6450 ± 150

Bone, mainly ox, from the middle zone of layer of tufa, 8-ft thick at Blashenwell, Dorset, 1 mi SW of Corfe Castle (50° 29' 30" N Lat, 02° 04' W Long). Coll. ca. 1894 by Clement Reid and A. Wallace on field survey for the Geol. Survey. Mesolithic flints occur throughout the deposit. Subm. by W. F. Rankine (Great Austins, Farnham, Surrey, England). The culture is suspected to be Maglemosian, on evidence of marginal finds of tranchets. Relevant publications—Reid, 1896; Clark, 1938; Arkell, 1947; Bury, 1950. *Comment*: date puts Blashenwell tufa (Middle zone) into the Early-Atlantic period. Reviewing the date as compared with Oakhanger (Rankine and Dimbleby, 1960), and assuming that the industry is Maglemosian, a 200-yr lag behind the latter is what one would expect.

BM-68. Ehenside Tarn, Cumberland

3530 ± 150

Wood from an implement found at Neolithic settlement at Ehenside Tarn (54° 26' N Lat, 03° 33' W Long). Precise position unstated. Coll. 1869 by Rev. S. Pinhorne and now in the British Museum. Subm. by Sub-Dept. of Prehistoric and Roman Britain, British Museum. Relevant publication—*Archaeologia*, v. 44, p. 273 ff. *Comment*: charred wood from same site was dated earlier (C-462, 4964 ± 300, Chicago I). This present result is late for British Neolithic, but not impossibly so.

BM-86. Galley Hill**3310 ± 150**

Bone, fragments of the humeri of the Galley Hill skeleton (British Museum Natural History, ref. E. M. 255-6). Found in 1888 by Robert Elliot at a depth of 8 ft in gravel of the 100-ft terrace of River Thames in a gravel pit 180 yards NW of All Saints Church, Swanscombe, Kent (51° 27' N Lat, 00° 18' E Long). Subm. by K. P. Oakley, British Museum Natural History. Skeleton was originally thought to be contemporaneous with Paleolithic gravel, but this was later doubted. Fluorine dating in 1949 showed it to be an intrusive burial "prehistoric but probably post-Paleolithic." Relevant publications—Newton, 1895; Oakley and Montagu, 1949. *Comment*: the post-Paleolithic dating is confirmed.

Grimes Graves series

Two samples (BM-87 and BM-88) from the Grimes Graves flint mines (52° 25' 39" N Lat, 00° 38' 41" E Long). These were chosen as part of a program to check suitability of antler as a material for dating, since a number of antler samples from this site are available in the British Museum. Archaeologic evidence points to each pit having been filled within a relatively short time, so the difference in level between the two samples is not significant. Coll. 1937 and 1938 by A. L. Armstrong; subm. by Sub.-Dept. of Prehistoric and Roman Britain, British Museum. *Comment*: Grimes Graves flint mines are generally associated with the Windmill Hill British-Neolithic culture. Sufficient dates are not yet available for this, but at the present time the dating would appear to be rather late.

BM-87. Depth 14 ft**4270 ± 150**

Charcoal from pit 15.

BM-88. Depth 11 ft**4050 ± 150**

Antler from pit 15.

BM-80. West Hartlepool, Submerged Forest**8700 ± 180**

Antler from shore at West Hartlepool, County Durham (54° 41' N Lat, 01° 13' W Long). Coll. (date not recorded) and subm. by C. T. Trechmann, Castle Eden, County Durham. Antler was associated with Mesolithic flakes and implements and came from a bed of peat and trees which overlies hard, stony boulder clay and continues below low-tide mark to join the moorlog of the North Sea. It is the most northerly occurrence of coastal peat that has yielded implements. Relevant publications—Trechmann, 1936, 1947. *Technical matters*—Sample was in an unusually good state of preservation and in section presented (1) a dark, almost black, outer layer, (2) an intermediate light-colored zone, (3) a central spongy core, also light in color. Outer layer gave appearance of being fire blackened or charred and this and the intermediate zone were both composed of dense, compact material which was high in carbon (ca. 18%) and might be expected to be little affected by contamination from the environment. The central core, on the other hand, had a lower carbon content (ca. 7%) and, since its surface to volume ratio was much higher, might be expected to show effects due to contamination with younger organic material absorbed from its environment. Results tabulated below support these

ideas and also indicate that dialysis during the pretreatment has no effect on the result. Results obtained on outer and intermediate zones are in accord with archaeological and geologic estimates.

BM-81.	Dark outer layer, treated with HCl as described above.	8680 \pm 180
BM-80.	Light-colored intermediate zone. Treated as above.	8700 \pm 180
BM-90.	Spongy central zone. Treated as above.	8100 \pm 180
BM-83.	Spongy central zone. Digested with HCl and dialysed.	8110 \pm 180

Windmill Hill series

Three samples from Neolithic site at Windmill Hill, Avebury, Wiltshire (51° 26' 28" N Lat, 01° 52' 32" W Long). Sample A from the Neolithic (Windmill Hill) occupation surface, sealed beneath the bank of the Neolithic camp and is thus contemporary with first phase of the Neolithic settlement, prior to the construction of the camp. Associated Neolithic pottery and other artifacts are indistinguishable from those in use immediately after construction of the camp and there is no evidence of earlier (Mesolithic) occupation. Sample B, charcoal from the rapidly-forming primary silt of the camp ditches, (obtained from two cuttings in the outer ditch and one in the middle ditch). It can be shown that both middle and outer ditches were dug at the same time and that formation of the primary silt would have been complete by the end of 15 yr, at the most. This charcoal is therefore virtually contemporary with the construction of the camp. Sample E is from a well-preserved old turf line found in one of the outer ditch cuttings associated with Late Neolithic Beaker, Peterborough, and Rinyo-Clacton wares. Coll. June to August 1958 and subm. by I. F. Smith, Church Walk Cottage, Avebury, Marlborough, Wilts. Relevant publications—Smith, 1958, 1959. *Comment*: date range accords well with present expectations, in view of the series for comparable material from Ireland (D-36, D-37, D-38—Watts, 1960, and Dublin I).

BM-73.	Charcoal	Sample A	4910 \pm 150
BM-74.	Charcoal	Sample B	4530 \pm 150
BM-75.	Charcoal	Sample E	3500 \pm 150

D. India

BM-92.	Karle Caves	2240 \pm 150
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Wood from a pin holding together ceiling beams of middle third of main cave (Chaitya cave), Karle (ca. 18° 46' N Lat, 73° 28' E Long), above village of Vehergao. Coll. September 1956 and subm. by D. D. Kosambi, PO. Deccan Gymkhana, Poona 4. Relevant publications—Fergusson and Burgess, 1880; also Archaeological Survey of Western India, v. 4. *Comment*: date hitherto accepted is 150 B.C., or later (2100 B.P.). Pin appears to have been young

wood at the time of felling and only a few yr need be allowed for seasoning, prior to its use. Radiocarbon age thus agrees with accepted age.

E. Iraq

Ur series

Group of bone samples excavated by Sir Leonard Woolley during the period 1927 to 1930 at Ur (30° 56' N Lat, 46° 08' E Long), and now in British Museum. Subm. by Dept. of Western Asiatic Antiquities. All are from Period A of Predynastic cemetery (Predynastic = Pre-First Dynasty of Ur but is now designated Early-Dynastic Period). Relevant publication—Woolley, 1934. *Comment*: the Royal Tombs are usually considered to be earlier than 2350 B.C., which is the provisional date for the end of the Early Dynastic period. Agreement between the burned and unburned bone suggests that there is unlikely to be any major error due to contamination of the sample. The discrepancy between the radiocarbon and accepted ages is thus not explained. However, it may be significant that Egyptian material of about this age also gives radiocarbon results which are younger than the archaeologically accepted ones (Pennsylvania III).

BM-64. Skeleton of Mes-Kalam-Shar.	
Ref P.G. 755	3920 ± 150
BM-70. Burned bone from a clay coffin.	
Ref P.G. 1515	4030 ± 150
BM-76. Skeleton of Queen Shub-ad.	
Ref P.G. 800	3990 ± 150

F. Ireland

BM-78. Dalkey Island	4260 ± 150
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Fragments of human skeleton from Dalkey Island (53° 14' N Lat, 06° 06' W Long) County Dublin, Ireland. It was found in one of two shell middens, covered by later archaeologic material. Both middens contained a Larnian (Mesolithic) flint industry, limpet scoops and polished stone axes. Coll. (date not recorded) by G. D. Liversage; subm. by D. R. Brothwell, Duckworth Laboratory, Cambridge, England. Relevant publication—Watts, 1960. *Comment*: material from the second midden has given a date of 5300 ± 170 (D-38, Watts, 1960, and Dublin I). The finds suggest that southern midden, from which skeleton came, might well be younger than the northern one. There is no stratigraphic connection between the middens.

G. Spain

BM-85. Rio Tinto Mines	2400 ± 150
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Wood from a Romano-Spanish water wheel from the Rio Tinto mines, Spain (37° 41' N Lat, 06° 30' W Long). Coll. 1889 by Rinched Museum and now in Greek and Roman Dept., British Museum. Subm. by Greek and Roman Dept., after doubts had been cast as to its antiquity. *Comment*: other wheels of this type have been found in mines in Spain and Portugal; some in associa-

tion with Roman pottery. Allowing for probable age of timber before fabrication, radiocarbon result is quite consistent with a Romano-Spanish origin.

II. GEOLOGIC SAMPLE

BM-95. Schreckhorn

680 ± 150

Wood (*Pinus cembra*) from surface of old right lateral moraine, beside the path from Baregg to Schwarzegg, 1700 m above sealevel on right bank of Lower Grindelwald Glacier (47° 35' N Lat, 08° 05' E Long). Coll. July 1947 by the late Pastor Nil of Grindelwald; subm. by Sir Gavin de Beer, Director, British Museum Natural History. *Comment*: tree must have been killed by a deterioration in climate. Dating was undertaken as part of research to establish date of the onset of this deterioration which closed Alpine passes in the 16th century A.D. (see Bern II for other dates from the Grindelwald).

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(ABSTRACT) THE CO₂-CS₂ GEIGER COUNTER AND ITS USE IN C¹⁴ DATING

H. R. CRANE

Department of Physics, University of Michigan, Ann Arbor, Michigan

A complete description of the CO₂-CS₂ Geiger-counter system which is in operation at the University of Michigan Radiocarbon Dating Laboratory is available in mimeograph form, upon request to the author. It includes a report on research into the characteristics of the CO₂-CS₂ counter, as well as a full set of instructions and diagrams for the building of such a system for use in radiocarbon dating.

Some of the findings may be noted briefly as follows.

General characteristics: The electrons released by an ionizing particle become attached, probably to CS₂. The self-quenching action of the counter is excellent, in that no spurious counts are observed, in the absence of electronic quenching. However, a dead time of several milliseconds must be imposed electronically, because of the long interval during which the negative ions arrive at the anode.

Method: An electronic quench is used, which is triggered both by the CO₂-CS₂ counter and the anticoincidence ring. This serves to impose the required dead time, and also to prevent the firing of the CO₂-CS₂ counter by mesons.

Counter: The active part is 27/8 in. in diam. and 16 in. long, filled to 1 atmosphere, 95% CO₂ and 5% CS₂.

Experiments on characteristics: The plateau was measured to 1900 volts above threshold, and was found to be level to within 1% from 400 to 1600 volts above threshold. The maximum drift time of the negative ions was found to be about 9 milliseconds, with a sharp cutoff. Tests with various combinations of gas indicated, but did not prove, that the charge carrier was CS₂. The effects of common contaminants were determined. At voltages over 400 above threshold, 1% O₂ gave no detectable effect; 0.3% SO₂ gave a 2% to 3% reduction in counting rate. Extensive tests of the efficiency were made. Comparisons of the CO₂-CS₂ filling with an argon-ethane filling gave identical results within the experimental error. No basis was found for supposing that there was any failure of the CO₂-CS₂ counter to register counts.

Reliability, when used for dating: Data extending over a long period obtained with the system described have given no indication that there are variations in counting rate outside those expected on the basis of statistics.

Support: The laboratory is supported in part by the Michigan Memorial Phoenix Project.

ISOTOPES, INC. RADIOCARBON MEASUREMENTS I

ALAN WALTON, MILTON A. TRAUTMAN and JAMES P. FRIEND

Isotopes, Incorporated, Westwood, New Jersey

INTRODUCTION

Radiocarbon analyses have been performed at Isotopes, Inc. since 1957 using proportional-counting techniques. Carbon dioxide is employed as the counting gas at pressures up to two atmospheres. The counter presently in service is electrolytic copper and has an active volume of just under two liters. It is shielded by one in. of mercury, a ring of 23 G-M counters operated in anti-coincidence with the sample counter, 4 in. of paraffin wax, and 18 in. of hot-rolled steel. A background of 9.2 counts/min has been attained with this arrangement.

Prior to use of the NBS oxalic-acid standard, our modern standard was 1885 pine wood. Age corrected to 1960, this wood had an activity of $94.0 \pm 1.9\%$ of the NBS oxalic-acid standard. We are now using the NBS oxalic-acid standard as our modern value and $A_{ox} \times 0.95$ is 23.3 counts/min corrected to a standard temperature of 273°K. Shell dates reported below were calculated using the pine-wood standard, without correction for supposed fractionation of carbon isotopes.

Sample pretreatment consists of removal of rootlets and gross contaminants, leaching with 1% hot HCl or H_3PO_4 in all cases, and with hot 1% NaOH in those cases where humics are likely to be present. Final washings in distilled water are always given. Shells are scrubbed and leached to remove outer layers. Samples are then either burned or hydrolyzed and CO_2 evolved is purified according to standard procedures. Radon is removed during purification, and as a final check the radon content of the CO_2 is monitored by counting on the alpha plateau.

Samples with code numbers I(GSC)-1 through 12, I(OSU)-80, I(MI)-9 and 27, I(USG)-34, I(UW)-79, I(AMNH)-39,41,43,44,47 and 48, and I(RB)-46 were counted in a small counter of ca. 400 cc volume which is no longer in routine use. Counting and preparation procedures were similar to those now followed. The small counter had a background of 2 counts/min and a modern-standard activity of 3.5 counts/min.

Each sample is counted at least twice for 8 to 15 hours, several days apart. Errors quoted include uncertainties associated with the unknown, modern, and background-sample determinations. Also included is the error in the C^{14} half-life (5568 ± 30 years), but no account has been taken of the deVries effect (deVries, 1958).

ACKNOWLEDGMENTS

Data obtained at Isotopes, Inc. are the sole property of our clients, and up to now only a small number of results has appeared in print. However, during the past year we have endeavored to encourage our clients to submit full descriptions of their samples and these dates are published with their con-

sent. We wish to express, therefore, our deep gratitude for the descriptions, comments and continued cooperation of all those mentioned in the following date list. In addition, we are indebted to Shirley A. Rickert of Isotopes, Inc. for her excellent assistance in the laboratory work.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

The following series of samples, from many areas in Canada, was coll. by the staff of Geol. Survey of Canada and subm. over a period of 2.5 yr by Dept. of Mines and Technical Surveys, Geol. Survey of Canada, Ottawa, Ontario, Canada.

A. Western Canada

I(GSC)-1. Parksville, Vancouver Island $12,000 \pm 450$

Wood excavated from E bank of Englishman River, Vancouver Island, ca. 3 mi SE of Parksville ($49^{\circ} 17' N$ Lat, $124^{\circ} 12' W$ Long). Sample coll. ca. 60 ft below top of bank, 100 ft high, from bottomset sands of a marine delta with top surface 170 ft above present sealevel. Coll. 1956 by J. G. Fyles; subm. 1958. *Comment*: highest and earliest postglacial-marine level is at alt 470 ft. Above date relates to a younger level (Terasmae and Fyles, 1959). Sample is also a duplicate of L-391 D, $12,150 \pm 250$ (Lamont V).

I(GSC)-5. Oyster River, Vancouver Island $>35,000$

Wood taken from SE bank (80 ft high) of Oyster River, Vancouver Island ($49^{\circ} 53' N$ Lat, $125^{\circ} 11' W$ Long). Wood was dug from a 17-ft layer of silt, sand, and gravel ca. 35 ft below top of bank. Layer is underlain by till and overlain by two lithologically-distinct tills, as well as by postglacial marine- and deltaic deposits. Coll. 1957 by J. G. Fyles; subm. 1958. *Comment*: wood-bearing sediments such as these have been found in several places in Oyster River area of Vancouver Island and have yielded coniferous pollen recording a climate cooler than the present. Relation of these deposits to the more widespread Quadra sediments is not known.

I(GSC)-9. Courtenay, Vancouver Island, gravel pit $12,500 \pm 450$

Marine pelecypod shells from Marriots gravel pit. Cumberland Road, between Courtenay and Cumberland, Vancouver Island ($49^{\circ} 38' 40'' N$ Lat, $125^{\circ} 00' 20'' W$ Long). Shells coll. in floor of pit from stony clay which lies beneath thick gravels forming the front of an ice-contact delta with upper surface (alt ca. 500 ft) at highest marine level in vicinity. Coll. 1956 and 1957 by J. G. Fyles; subm. 1958. *Comment*: shell-bearing clay apparently accumulated at ca. same time as delta, shortly after deglaciation permitted influx of sea into this part of the Georgia depression. Sample was exceedingly small and collection site only fair, hence date is only approximate.

I(GSC)-10. Courtenay, Vancouver Island, kettle $11,780 \pm 450$

Peat sample from bog in kettle, 100 yd SW of Courtenay Sand and Gravel Co. pit, on Cumberland Road between Courtenay and Cumberland ($49^{\circ} 38' 30'' N$ Lat, $125^{\circ} 00' 10'' W$ Long). Dated material consists of basal peat from

two cores, taken 5 ft apart, at a depth of 6.4 to 6.5 m from kettle in marine ice-contact delta. Top surface alt is 500 ft. Coll. 1957 by J. G. Fyles; subm. 1958. *Comment*: delta is one of earliest marine deposits built at highest stand of sealevel by a river flowing off glacier ice during deglaciation. Date gives a minimum age for this delta (see I(GSC)-9).

I(GSC)-6. Lower Fraser Valley, British Columbia $12,625 \pm 450$

Marine pelecypods coll. from drainage ditch on E side of King George Highway, Sunnyside, near Whiterock, British Columbia ($\sim 49^\circ 01' \text{ N Lat}$, $122^\circ 50' \text{ W Long}$). Shells inclosed in stony clay beneath ca. 5 ft of marine sand at alt ca. 260 ft. Coll. 1957 by J. E. Armstrong; subm. 1958.

B. Eastern Canada

I(GSC)-11. Hamilton, Ontario $10,150 \pm 450$

Plant material from 203 to 204.5 ft below present level of Lake Ontario, beneath Burlington Bar, Hamilton, Ontario ($43^\circ 18' \text{ N Lat}$, $79^\circ 48' \text{ W Long}$). Sample taken from boring #F-1-36 (Ontario Hydroelectric Power Commission). Material lay near base of thick succession (~ 200 ft) of lake sediments lying upon glacial deposits. Coll. 1958 by Ontario Hydroelectric Power Commission for J. Terasmae; subm. 1958. *Comment*: date applies to an early stage of Lake Ontario when water level of W end of lake appears to have been lower than at present. Younger and higher samples from these deposits have been dated at 5240 ± 140 (Y-614A) and 2830 ± 160 (Y-613A; Yale V).

I(GSC)-14. Missinaibi River, Ontario 7875 ± 200

Marine pelecypod shells from top of N bank of Missinaibi River, 13.5 mi downstream from Bulls Bay ($50^\circ 13' \text{ N Lat}$, $82^\circ 54' \text{ W Long}$). Collection site is 115 ft above river, alt ca. 400 ft; shells from 3.5 ft of wavy-bedded silt and sand that rests upon laminated clay. Coll. 1954 by O. S. Hughes; subm. 1959. *Comment*: dated shells are believed to have formed during the earliest, highest stand of sea, S of James Bay, immediately following deglaciation of the locality (Terasmae and Hughes, 1960; Lee, 1960).

I(GSC)-29. Galt, Ontario $11,950 \pm 350$

Peat and gyttja from basal organic sediment at depth 295 to 305 cm, in Grieff Kettle Bog, 8 mi NE of Galt, Ontario ($43^\circ 25' \text{ N Lat}$, $80^\circ 11' \text{ W Long}$). Coll. 1959 by J. Terasmae; subm. 1959. *Comment*: dated material was formed at initial stage of bog development in a kettle on Galt Moraine. The date, therefore, provides a minimum age for deglaciation of the moraine.

I(GSC)-3. Little Current, Manitoulin Island 9450 ± 300

Peat taken from base of organic bog sediment, 188 to 198 cm below bog surface, alt ca. 1000 ft, SW of Little Current, Manitoulin Island ($45^\circ 56' \text{ N Lat}$, $82^\circ 00' 30'' \text{ W Long}$). Coll. 1957 by J. Terasmae; subm. 1958. *Comment*: sample site is above highest level of glacial Great Lakes; date indicates minimum time elapsed since area was deglaciated (Terasmae and Hughes, 1960).

I(GSC)-15. Guyer Lake, Quebec 5475 ± 160

Peat from depth of 4.2 to 4.4 ft below surface in bog near Guyer Lake,

Quebec (53° 35' N Lat, 74° 41' W Long). Coll. 1957 by H. A. Lee; subm. 1959. *Comment*: sample site is above limit of marine submergence; dated peat marks beginning of postglacial-bog development at site. Age indicates minimum time elapsed since deglaciation (Lee, Eade, and Heywood, 1960).

I(GSC)-12. Iris Station, Prince Edward Island 6600 ± 270

Peat dug from base of roadside 0.5 mi E and 1 mi S of Iris railroad station, Prince Edward Island (45° 59' N Lat, 62° 42' 30" W Long). Sample from depth of 5 ft at base of peat resting upon till. Coll. 1956 by L. Frankel; subm. 1958. *Comment*: palynological work by J. Terasmae indicates dated material accumulated during an early phase of postglacial-thermal maximum.

I(GSC)-23. Nicholas Point, Prince Edward Island 915 ± 90

Wood from one of several tree stumps rooted in peat on intertidal part of beach at Nicholas Point, 8 mi W of Wood Island on the SE coast of Prince Edward Island (45° 59' 30" N Lat, 62° 52' 30" W Long). Dated sample taken from tree rooted 5.4 ft below high tide level. Tree and peat rest upon marine deposits. Coll. 1957 by L. Frankel; subm. 1959. *Comment*: date indicates time of drowning of forest and peat bog and provides data on rate of submergence of this region. Submergence is believed to be still in progress.

I(GSC)-2. Green River, New Brunswick 10,220 ± 350

Peat coll. from basal 0.5 in. of a 1.4-ft thick bog layer which lies beneath clay and rests upon gravel on E bank of Green River ca. 2 mi N of its confluence with Saint John River (47° 19' N Lat, 68° 07' W Long). Coll. 1956 by H. A. Lee; subm. 1958. *Comment*: date indicates minimum age of the Grand Falls drift and disappearance of glacial ice from this part of New Brunswick (Lee, 1959b).

I(GSC)-7. Saint John, New Brunswick 13,325 ± 500

Marine molluscan shells collected from clay exposed on sea cliff at Smugglers, about 5 mi W of Saint John, New Brunswick (45° 13' N Lat, 66° 07' W Long). Clay lies beneath and intertongues with delta-outwash gravels. Coll. 1958 by H. A. Lee; subm. 1958. *Comment*: dated shells were formed during, or shortly after retreat of glacial margin from the vicinity.

I(GSC)-4. Whitbourne, Avalon Peninsula 8420 ± 300

Peat-gyttja taken at a depth of 4.85 to 5.00 m in transition zone from overlying peat to silt in a bog located at N end of Whitbourne, Avalon Peninsula, Newfoundland (47° 25' 30" N Lat, 53° 32' W Long). Coll. 1958 by E. P. Henderson; subm. 1958. *Comment*: date indicates minimum time elapsed since area was uncovered by last ice sheet.

C. Northern Canada

I(GSC)-8. Keewatin, NW Territories 6975 ± 250

Marine pelecypod shells from clay exposed on river bank 1 mi S of Carr Lake (62° 10' N Lat, 95° 41' W Long), alt 210 ft. Coll. 1952 by H. A. Lee; subm. 1958. *Comment*: shells coll. at base of hill that extended above marine

limit (560 ft above present sealevel). Date believed to represent time of maximum stand of Tyrell Sea (Lee, 1959a, 1960; Craig and Fyles, 1960).

I(GSC)-13. Port Epworth, Coronation Gulf, NW Territories

8290 \pm 330

Marine pelecypod shells from "mud-gravel of dolomite hills of S end of Port Epworth, Coronation Gulf, (Canadian Arctic Expedition—1924) alt 320 ft" (67° 41' N Lat, 110° 55' W Long). Coll. 1916 by J. J. O'Neill; subm. 1959. *Comment*: dated shells represent a sealevel 320 ft or more above present position and 300 ft or less below limit of marine submergence in vicinity. Date applies to middle of interval of rapid uplift of land that followed retreat of Laurentide ice sheet (Craig and Fyles, 1960; Craig, 1960) (cf. samples I(GSC) 16, 17, 22 and 25).

I(GSC)-16. Kugaryuak River, Coronation Gulf, NW Territories

9100 \pm 180

Marine pelecypod shells from S of Coronation Gulf, 495 ft above sealevel, from gullied surface of marine clay (67° 39' N Lat, 113° 19' W Long). Coll. 1959 by B. G. Craig; subm. 1959. *Comment*: shells coll. close to upper limit of marine submergence; date from early part of interval of marine submergence that followed retreat of Laurentide ice sheet (Craig and Fyles, 1960; Craig, 1960) (cf. samples I(GSC)-13, 17, 22 and 25).

I(GSC)-17. Tree River, Coronation Gulf, NW Territories

10,215 \pm 220

Marine pelecypod shells embedded in erosional remnants of marine clay, coll. in valley of Tree River, S of Coronation Gulf (67° 30' 15" N Lat, 112° 02' W Long), alt 282 ft. Coll. 1959 by B. G. Craig; subm. 1959. *Comment*: date from shells represents a time soon after retreat of Laurentide ice sheet from site when the sealevel was 300 ft or more above its present position and 300 ft or less below its maximum stand. (See samples I(GSC)-13, 16, 22 and 25 and Craig and Fyles, 1960; Craig, 1960).

I(GSC)-22. Asiatic River, Coronation Gulf, NW Territories

8275 \pm 220

Marine pelecypod shells from fine sand, alt ca. 425 ft, on outer face of an esker delta ca. 28 mi SE of Coppermine (67° 41' N Lat, 114° 27' W Long). Top surface alt of delta ca. 450 ft. Coll. 1959 by R. J. Fulton for B. G. Craig; subm. 1959. *Comment*: upper limit of marine submergence in vicinity is ca. 500 ft alt. Dated shells are inferred to have originated close to front of retreating Laurentide Ice Sheet or shortly after its retreat (cf. I(GSC)-13, 16, 17 and 25). Younger age of this sample was unexpected and older dates probably provide a more reliable indication of time of glacial retreat. (Craig and Fyles, 1960).

I(GSC)-25. Harding River, Dolphin and Union Strait, NW Territories

10,530 \pm 260

Marine pelecypod shells coll. at alt ca. 244 ft in very fine sand, S of Dolphin and Union Strait, near Harding River (68° 47' N Lat, 116° 56' W

Long). Coll. 1959 by B. G. Craig; subm. 1959. *Comment*: date represents a time soon after retreat of Laurentide ice sheet from site when the sealevel was within 100 ft of its earliest and highest stand (Craig and Fyles, 1960). (cf. samples I(GSC)-13, 16, 17 and 22).

I(GSC)-18. Peel Point, Victoria Island, NW Territories

12,400 \pm 320

Shells of *Yoldia arctica* (id. by F. J. E. Wagner, Geol. Survey of Canada) from 5 mi S of Peel Point at the NW extremity of Victoria Island, alt 220 ft (73° 18' N Lat, 114° 30' W Long). Shells inclosed in clay which rests upon stratified silt and sand. Coll. 1959 by J. G. Fyles; subm. 1959. *Comment*: dated shells occur within 50 ft of limit of marine submergence; are believed to have originated during deglaciation, in a narrow body of sea water bordering the glacial ice in Prince of Wales Strait and Viscount Melville Sound (Craig and Fyles, 1960).

I(GSC)-19. Banks Island, NW Territories (in silt)

>35,000

Wood coll. half way up a 100-ft cliff on W coast of Banks Island at Worth Point (72° 15' N Lat, 125° 40' W Long). Dated wood is representative of small trees and beaver-gnawed sticks, apparently embedded in pond silts resting upon till, which in turn overlies Beaufort formation. A younger till (?) may separate wood-bearing silts from uncompressed surface peat (see I(GSC)-26). Coll. 1959 by J. G. Fyles; subm. 1959. *Comment*: (see I(GSC)-28).

I(GSC)-26. Banks Island, NW Territories (in uncompressed peat)

>38,000

Wood (dwarf willow) from same site as I(GSC)-19 (72° 15' N Lat, 125° 40' W Long). Sample coll. from 6-ft bed of uncompressed moss peat at top of the exposure. Peat has yielded pollen of birch, in addition to that of plants now growing in the area. Coll. 1959 by J. G. Fyles; subm. 1959. *Comment*: uncompressed surface peat containing dated wood has accumulated since last glaciation of W part of Banks Island. This radiocarbon age supports the inference (based upon other features of the region) that W Banks Island was not glaciated during "classical" Wisconsin time.

I(GSC)-28. Bernard Island, near Banks Island, NW Territories

>38,000

Moss peat from shore cliff at SW end of Bernard Island which lies off the mouth of Bernard River on W coast of Banks Island (73° 40' N Lat, 124° 25' W Long). Moss peat occurs in lacustrine silts lying beneath till or colluvium and overlying till which in turn rests upon Beaufort formation. Pollen of conifers and tundra vegetation now found in area has been obtained from the moss. Coll. 1959 by J. G. Fyles; subm. 1959. *Comment*: lacustrine or pond silts containing dated moss and other similar deposits on W Banks Island (see I(GSC)-19), appear to record a sparsely forested interglacial period (Craig and Fyles, 1960).

I(GSC)-20. Holman Island, Victoria Island, NW Territories
8895 \pm 220

Marine pelecypod shells from wet clay on left bank of small river 0.25 mi. from its mouth and 1 mi NE of Holman Island Post, Victoria Island (70° 44' N Lat, 117° 46' W Long). Shells coll. ca. 25 ft above present sealevel from unoxidized fetid clay that appears to be bottomset part of small delta formed when the seashore stood about 30 ft above its present level. Coll. 1959 by J. G. Fyles; subm. 1959. *Comment*: limit of marine submergence in W Victoria Island is ca. 300 ft above present sealevel. In view of this date, most of this 300-ft uplift of the land relative to the sea occurred more than 9,000 yr ago (Craig and Fyles, 1960).

I(GSC)-30. Prince Albert Sound, Victoria Island, NW Territories
28,000 \pm 1500

Tundra plants dug from 200-ft river bank ca. 5 mi N of Prince Albert Sound on Victoria Island (70° 38' N Lat, 116° 35' W Long). Organic material occurs as a succession of thin-growth layers in a 20-ft section of silt, lying within ca. 150 ft of gravel and sand. These stratified deposits underlie till and glacial gravel and overlie till. Pollen derived from organic layers belongs entirely to tundra plants. Coll. 1959 by J. G. Fyles; subm. 1960. *Comment*: dated material is believed to record an interstadial interval. Deposits inclosing dated material are of local extent, but may correlate with similar materials (which so far have yielded no organic remains) that lie beneath till throughout large parts of NW Victoria Island and NE coast of Banks Island.

I(GSC)-21. Melville Island, NW Territories
8275 \pm 320

Marine pelecypod shells coll. ca. 175 ft above sealevel near Tingmisut Lake on Melville Island (75° 50' N Lat, 108° 00' W Long). Limit of marine submergence is ca. 270 ft above present sealevel. Coll. 1959 by E. T. Tozer for J. G. Fyles; subm. 1959. *Comment*: NW peninsula of Melville Island as yet has yielded no evidence of glaciation. This date indicates, however, uplift of land relative to sea during "normal" postglacial interval as if through isostatic rebound following the retreat of Wisconsin-age glaciers (Craig and Fyles, 1960).

I(GSC)-24. Loughheed Island, NW Territories
8200 \pm 180

Marine pelecypod shells from 75 to 100 ft above sealevel, 2.5 to 3 mi inland from NE coast of Loughheed Island (\sim 77° 33' N Lat, 105° W Long). Marine shells have been reported nearby up to alt of 400 ft. This particular sample coll. from shallow gully eroded in clay. Coll. 1916 by V. Stefansson, Canadian Arctic Expedition; subm. 1959. *Comment*: Loughheed Island has yielded no evidence of having been glaciated. Nonetheless, this datum indicates uplift of land, as does I(GSC)-21 (Craig and Fyles, 1960).

I(GSC)-27. Fort Selkirk, Yukon Territory
>38,000

Charred wood from steep right bank of Yukon River, 180 ft above river, 3 mi downstream from junction of Yukon and Pelly rivers (62° 41' N Lat, 137° 27' W Long). Wood was contained in a 12-in. lens of silt beneath 4 ft of sand and gravel and beneath lava flows of the Selkirk volcanics. Coll. 1959

by E. B. Owen; subm. 1959. *Comment*: dated materials belong to succession of gravel, sand, and silt that overlies till. Overlying lava flow bears glacial striae on its surface; hence deposits are inferred to be interstadial or interglacial.

D. United States—Alaska

The following results were obtained on a suite of samples from the Glacier Bay area, Alaska. Samples coll. and subm. by R. P. Goldthwait, Dept. of Geology, Ohio State Univ., Columbus. Ages ranging from 1400 ± 90 to 7075 ± 250 , mainly on wood samples, have been determined. The following discussion, subm. by R. P. Goldthwait, outlines the significance of these dates.

The 21 samples from Muir, Adams, and Wachusett inlets in the NE reaches of Glacier Bay were dated to determine the time zones in a common local stratigraphy. All samples are logs, most of which were in place. In every situation (except I(OSU)-122 and I(OSU)-90) sorted gravels and sands lie directly on the wood, and indeed trees were killed by this burial and accompanying stream erosion. Some of these trees are rooted in the outwash which was building in the valley. Others (I(OSU)-83, 84, 88, 124, 126, and 163) grew in a forest mat and soil on bed rock up the valley wall. Obviously the outwash grew from bottom to top, from old to young. However, it was not expected that dates would be so remarkably consistent, falling on a straight altitude-time line (Goldthwait, 1960) from sealevel to 61 m alt. This implies growth of outwash at 1.4 m per century for over 4000 yr in these several long inlet arms.

The only date inconsistent with this picture is that for I(OSU)-121 in sand right under the edge of Plateau Glacier. Being at sealevel it should come out about 6000 to 7000 yr old, but instead it is 2715 ± 120 yr. A nearby log sample in place on bed rock at sealevel (I(OSU)-163) does give the expected order of magnitude. Possibly sample I(OSU)-121 was transported in sand and redeposited under ice; its root system was not seen.

Specimens I(OSU)-86, 123, 162, and 164, as well as earlier specimens Y-303, 304 and Y-301, 302 (Yale III) help to date lacustrine silt beds which occur commonly in the upper part of the gravels. Ponding was common to all three inlets ca. the same time, 4000 to 3000 yr B.P.

Finally the whole area was invaded by the ice in a "Little Ice Age" advance. This is dated by I(OSU)-122, one of many prostrate logs and stumps in place in imbedding till (2735 ± 160 B.P.). Undoubtedly this time would be later at higher altitudes and further down the fiord inlets, but the only other relevant date is I(OSU)-90, a stump in McBride Glacier moraine which is not positively in place.

I(OSU)-81. Nunatak Cove 1, Muir Inlet 6335 \pm 220

Picea (spruce) stump (id. by G. W. Burns) coll. at Muir Inlet, Nunatak Cove, in lower forest bed 0.5 mi S of entrance ($58^{\circ} 58' N$ Lat, $136^{\circ} 07' W$ Long). Sample covered with 30 ft gravel plus till, 88 ft above tide.

I(OSU)-82. Nunatak Cove 2, Muir Inlet 5235 \pm 200

Picea (spruce) stump (id. by G. W. Burns) coll. at Muir Inlet, Nunatak Cove, in upper forest bed on S side of cove. ($58^{\circ} 58' N$ Lat, $136^{\circ} 07' W$ Long). Sample lay under 5 to 10 ft of gravel plus till, 57 ft above tide.

I(OSU)-83. Wachusett Inlet 1 **4215 ± 200**

Tsuga (hemlock) stump (id. by G. W. Burns) coll. at Wachusett Inlet (off Muir Inlet) on N side by creek, near 1959 camp, 1 mi NW of island (58° 57' N Lat, 136° 15' W Long). Sample was in place on bed rock at alt 90 ft.

I(OSU)-84. Westdahl Point, Muir Inlet **7075 ± 250**

Tsuga (hemlock) stump (id. by G. W. Burns) coll. at Muir Inlet on steep NE-facing shore of Westdahl Point, on W side of inlet (58° 59' N Lat, 136° 09' W Long). Sample rooted on bedrock, lay under ca. 100 ft of gravels at alt of 30 ft.

I(OSU)-80. Goose Cove, Muir Inlet **4775 ± 250**

Picea (spruce) log (id. by G. W. Burns) coll. at Muir Inlet, on E side at Goose Cove (58° 58' N Lat, 136° 06' W Long). Sample located under 20 ft of gray gravel and possible till, at alt ca. 50 ft.

I(OSU)-86. Geikie Inlet **3175 ± 220**

Tsuga (hemlock) log (id. by G. W. Burns) coll. at Geikie Inlet in slope N of bay head (58° 37' N Lat, 136° 31' W Long). Sample located 100 ft below top of terrace, in till-covered outwash gravel, 140 ft above tide.

I(OSU)-87. Charpentier Inlet **1825 ± 150**

Tsuga (hemlock) log (id. by G. W. Burns) coll. 0.5 mi upstream from Bulky Valley at head of Charpentier Inlet (58° 39' N Lat, 136° 27' W Long). Sample located near base of ca. 200 ft of cross-bedded sands, ca. 300 ft above sealevel.

I(OSU)-85. Adams Inlet 1 **1975 ± 150**

Picea (spruce) stump (id. by G. W. Burns) coll. at Adams Inlet on E side of Muir Inlet (58° 53' N Lat, 135° 52' W Long). Sample excavated in SE corner of a low island, located in central part of Adams Inlet, overlain by 5 ft of laminated clay and more silt and till, alt ca. 50 ft.

I(OSU)-88. Forest Creek, Muir Inlet **2175 ± 100**

Picea (spruce) stump (id. by G. W. Burns) coll. at Muir Inlet on middle of E side, where Forest Creek from Casement Glacier joins inlet (58° 57' N Lat, 136° 02' W Long). Sample located at least 200 ft above tide, in forest mat on bed rock, covered by 3 ft of recently-terraced gravel.

I(OSU)-90. McBride Glacier, Muir Inlet **1975 ± 200**

Taxus (?) stump (id. by G. W. Burns) coll. at upper E side of Muir Inlet (59° 01' N Lat, 136° 06' W Long). Sample in sharp N-lateral moraine of McBride Glacier at ca. 80 ft above sealevel.

I(OSU)-89. Queen Inlet **4755 ± 180**

Picea (spruce) stump (id. by G. W. Burns) coll. at Queen Inlet, Carrol Glacier (58° 58' N Lat, 136° 00' W Long) on outwash apron 1 mi NE of tide flats.

I(OSU)-91. Nunatak Cove 3, Muir Inlet 7025 ± 270

Forest mat (duff), needles and twigs coll. at Muir Inlet, 0.5 mi S of Nunatak Cove (58° 58' N Lat, 136° 07' W Long), on mid-east side of inlet. Sample taken from lower forest bed 20 ft above tide.

I(OSU)-124. Wachusett Inlet 2 4750 ± 160

Wood (stump) coll. at Wachusett Inlet off Muir Inlet (58° 56' N Lat, 136° 14' W Long) on N side, 1 mi NW of island, in creek bend near camp. Stump was rooted at alt of 80 ft in duff on lowest exposed bedrock, covered by gravel, forest beds, sand and till, totalling more than 30 ft.

I(OSU)-126. Wachusett Inlet 3 3650 ± 100

Wood (stump) from Wachusett Inlet (58° 56' N Lat, 136° 14' W Long), 1 mi NW of island on N shore. Stump, rooted in forest mat on bed rock at 135 ft alt, covered by sandy gravel (15 ft or more) and till.

I(OSU)-125. Wachusett Inlet 4 3900 ± 100

Wood (log) from Wachusett Inlet (58° 56' N Lat, 136° 14' W Long), 1 mi NW of island on N shore. Sample taken at alt of 113 ft from sandy gravel at lower forest horizon. Horizon was overlain by sand, forest, gravel, and till, with coarse gravel beneath it.

I(OSU)-123. Wachusett Inlet 5 3655 ± 100

Wood (log) from Wachusett Inlet N shore (58° 56' N Lat, 136° W Long), 1 mi NW of island. Sample taken at alt of 152 ft from upper forest layer or sand, overlain by gravel and till.

I(OSU)-121. Plateau Glacier 2715 ± 120

Wood (stump) from Wachusett Inlet (58° 56' N Lat, 136° 19' W Long) under edge of wasting Plateau Glacier on N shore, at head of bay. Wood was in place, projecting up through covering sand, ca. 5 ft above mean sealevel.

I(OSU)-122. Burroughs Glacier, Muir Inlet 2735 ± 160

Wood (log) from between Muir Inlet and Wachusett Inlet (58° 57' N Lat, 136° 11' W Long) on NW slope of hill, above wasting Burroughs Glacier. Wood half imbedded in surface till at alt of 658 ft.

I(OSU)-162. Adams Inlet 2 1400 ± 90

Wood from Adams Inlet (off Muir Inlet) (58° 53' N Lat, 135° 42' W Long), at head of bay on S shore. Sample was beneath ca. 150 ft sands, fine gravel, and till, near top of 60 ft of lacustrine clay.

I(OSU)-163. Wachusett Inlet 6 6650 ± 100

Wood from Wachusett Inlet (58° 56' N Lat, 136° 18' W Long) at head of bay on N side. Sample rooted in forest mat on weathered bedrock, covered by 5 ft sandy gravel, ca. 3 ft above mean tide and hence within reach of wave action. Burns locality 34; Goldthwait locality 13. Coll. 1956 by G. W. Burns, Ohio Wesleyan Univ. Delaware, Ohio.

I(OSU)-164. Adams Inlet 3 3710 ± 110

Wood (log) from Adams Inlet (58° 53' N Lat, 135° 42' W Long), at

head of bay on S shore. Log located under at least 60 ft lacustrine clay and 150 ft sands, sandy gravel and till.

E. Southern United States

I(MI)-27. Bellefontaine Marsh, Mississippi 2220 ± 180

Gray-green mud from a zone 125 to 140 cm depth, in Bellefontaine Marsh, W of Pascagoula, Mississippi ($30^{\circ} 21' N$ Lat, $88^{\circ} 41' W$ Long). This is a brackish coastal marsh, the sediments of which are slightly alkaline. Sampling area was N of long N to S loop of Graveline Bayou and Graveline Bay access to this area. Coll. and subm. 1957 by J. G. Erdman, Mellon Institute, Pittsburgh, Pennsylvania. *Comment:* sediment is recent deposit, well above eroded Pliocene interface. C^{14} age is consistent with ages of sediments in Mississippi Sound and on Gulf side of Horn Island (Erdman, 1961).

I(MI)-112. Okefenokee Swamp, Georgia 4475 ± 120

Peaty sediment from Okefenokee Swamp, Georgia ($30^{\circ} 52' N$ Lat, $82^{\circ} 19' W$ Long). Swamp is entirely fresh water and consists of marsh grasses and cypress, with "islands" on which pine and some oak are abundant. Sample taken at depth 115 to 130 cm, in cypress-marsh area below roots of cypress tree measuring 11 ft in circumference at shoulder height. Coll. 1957 and subm. 1959 by J. G. Erdman, Mellon Institute, Pittsburgh, Pennsylvania. *Comment:* C^{14} age is consistent with belief from tree-ring evidence that the tree, beneath the roots of which the sample was taken, is several thousand yr old. C^{14} age does not exceed probable age of the swamp.

F. Eastern United States

I(MI)-9. Tamarack Swamp, Corry 2820 ± 250

Brown, peaty sediment, 115 to 130 cm depth, at Tamarack Swamp, near Corry, Pennsylvania ($42^{\circ} N$ Lat, $80^{\circ} W$ Long). Tamarack Swamp is an acid, freshwater swamp or bog and represents a good example of a typical N swamp succession. Vegetation is largely tamarack and water-loving shrubs. Sphagnum moss is abundant. Coll. 1956 by J. G. Erdman; subm. 1957 by E. M. Marlett, Mellon Institute, Pittsburgh, Pennsylvania. *Comment:* radiocarbon age is consistent with the concept that bogs have developed in postglacial times.

I(USGS)-34. Borthwick Farm, Blackbird $15,100 \pm 600$

Slightly organic clay and siliceous silt coll. at Borthwick Farm near Blackbird, New Castle County, Delaware ($39^{\circ} 21' N$ Lat, $75^{\circ} 40' W$ Long). Sample taken from depth 9.33 to 9.63 ft in bottom of dark fill of undrained basin; a composite of 4 samples taken in the lower 4 in. of the hole, and part of a suite of 33 taken for pollen study. Sample from center of basin. Coll. 1957 by W. C. Rasmussen and O. J. Coskery, U. S. Geol. Survey, Newark, Delaware; subm. 1958 by W. C. Rasmussen. *Comment:* C^{14} -age fits pollen succession. A spruce-pine flora was determined for samples in lower 6 ft, followed by a mixed oak-hardwood flora. Date would indicate this basin began to fill in Late Wisconsin time.

II. ARCHAEOLOGIC SAMPLES

A. United States

I(UW)-79. Quimby, Iowa 8430 \pm 520

Charcoal from Quimby site (42° 38' N Lat, 95° 36' W Long), 17 ft below surface of bank of Little Sioux River, from hearths in which animals were believed to have been roasted. Extinct *Bison occidentalis* were found in association with side-notched points. Coll. 1958 by G. A. Agogino and W. D. Frankforter; subm. 1959 by G. A. Agogino, Univ. of Wyoming, Laramie.

I(UW)-141. Lindenmeier Site, Colorado 10,780 \pm 135

Charcoal from Folsom Level, Lindenmeier site, Ft. Collins, Colorado. Coll. 1959 by G. A. Agogino and C. V. Haynes, Jr.; subm. 1960 by G. A. Agogino, Univ. of Wyoming, Laramie. *Comment*: sample was first C¹⁴-date over 10,000 yr for Folsom. Estimated age of horizon from geologic evidence was ca. 10,000 yr (Libby, 1955).

I(TTC)-140. Lubbock Reservoir, Texas 70 \pm 70

Charred bone (*Bison bison*) from Lubbock Reservoir site, Lubbock, Texas (33° 35' N Lat, 101° 50' W Long). Lubbock Reservoir site is a well-known Folsom locality (Libby, 1955), but this sample is from a comparatively recent occupation, ca. 12 ft above the Folsom horizon. Bone was at base of small hearth that had been "sealed" after use, by a large rock. Coll. 1959 and subm. 1960 by F. E. Green, The Museum, Texas Technological College, Lubbock, Texas. *Comment*: hearth containing bone was in an occupation-level that should be of pre-pottery age, and should be several hundred yr older than indicated by radiocarbon date.

B. Pacific Islands

Haatuatua Bay series

Samples from site NHaa 1, Haatuatua Bay, Nuku Hiva, Marquesas (9° 48' S Lat, 140° 02' W Long). Coll. 1956-1958 and subm. 1958 by H. L. Shapiro and R. C. Suggs, The American Museum of Natural History, New York, N. Y. Site is an open dune fringing shoreline of Haatuatua Bay on Nuku Hiva, the main island of the N group in the Marquesas. Site had been used for burials and possibly ceremonial purposes and to one side lay house sites.

I(AMNH)-39. Haatuatua Bay, bone 1270 \pm 150

Charred bone from burial area 4.5 ft deep.

I(AMNH)-41. Haatuatua Bay, ash 1 1090 \pm 180

Ash from fire pit in habitation area 23 in. deep.

I(AMNH)-43. Haatuatua Bay, charcoal 2080 \pm 150

Charcoal in association with burials 4.5 ft deep.

I(AMNH)-48. Haatuatua Bay, ash 2 1910 \pm 180

Ash from fire lens in house floor 11 in. deep.

Bay Marquisien series

Samples from series of sites in Bay Marquisien (9° 25' S Lat, 140° 02' W Long) on W coast of Nuka Hiva. Coll. 1956 to 1958 and subm. 1958 by H. L. Shapiro and R. C. Suggs, The American Museum of Natural History, New York, N. Y.

I(AMNH)-44. Bay Marquisien, charcoal **760 ± 150**
Site NMB 1, charcoal from fire pit, 20.5 in. deep.

I(AMNH)-47. Bay Marquisien, leaves **484 ± 150**
Site 394 H, matted leaves from below fire bed at 5 to 10 in. below surface.

III. MISCELLANEOUS SAMPLES

I(RB)-46. Jenness Beach **3640 ± 230**

White pine stump from below tide at Jenness Beach, near Strows Point (42° 59' N Lat, 70° 46' W Long), on shore of Atlantic Ocean, Rye, New Hampshire. Mixed growth of pine and cedar in an area of two or more acres. Stumps are normally covered with sea sand and exposed only after a severe storm such as that of April 1958, and then only for a few weeks. Stumps are covered by 8 to 12 ft of water at high tide. Coll. 1958 by A. B. and P. S. Drake; subm. 1958 by A. B. Drake, Rye Beach, New Hampshire.

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CAMBRIDGE UNIVERSITY NATURAL RADIOCARBON MEASUREMENTS III

H. GODWIN and E. H. WILLIS

Cambridge University*

The dates and activity measurements given below have been obtained during the year 1960 (excepting only Q-9 held over from the previous year). They have been made with carbon dioxide at 3 atmospheres pressure in a proportional gas-counter similar to that used for the results given in Radiocarbon Supplement, volumes 1 and 2.

We have maintained our policy of directing our assays largely towards particular projects under investigation in the University Sub-department of Quaternary Research, and during 1960 particular attention has been given to problems of land-level and sealevel changes of British coastal areas.

We particularly wish to acknowledge the help of R. J. F. Burleigh, Technical Assistant in the Carbon Dating Laboratory.

SAMPLE DESCRIPTIONS

BRITISH ISLES

A. Coastal Series, Southwestern England and Wales

On the coasts of the British Isles there is abundant evidence of past changes in the relative positions of land level and sealevel: these take the form of submerged peat beds, raised beaches, and the alternation of freshwater and brackish-water deposits. Suitable samples, where possible formed close to the contemporary mean sealevel, have been collected from (A) areas of relative crustal stability in which it may be supposed eustatic changes of ocean level have prevailed; (B) areas (in the N) in which postglacial land elevation has taken place, presumably by isostatic recovery; (C) areas bordering the southern North Sea in which subsidence has occurred by some kind of tectonic movement.

Q-126. Tealham, Somerset, no. 2 5620 \pm 120

Clayey *Phragmites* peat (51° 13' N Lat, 2° 50' W Long). Sample taken from North Drain excavation at junction of lower estuarine clay and *Phragmites* peat close to present sealevel. This sample came from just above Q-120 (5412 \pm 130 B.P., Cambridge I), and was intended as a check on account of the importance of this horizon as marking the end of the main eustatic rise of ocean level (Godwin, Suggate and Willis, 1958). Coll. August 1955 by H. Godwin. *Comment*: the two determinations are in agreement.

Q-423. Shapwick Heath, Neolithic axe site, 284/7 cm 5510 \pm 120

Clayey *Phragmites* peat (51° 9' 13" N Lat, 2° 38' 37" W Long). This site marks the upper surface of the estuarine clay beneath the raised-bog de-

*Radiocarbon Dating Laboratory, 5 Salisbury Villas, Station Road, Cambridge, and University Sub-department of Quaternary Research, Botany School, Cambridge, England.

posits, and like Q-120 (5412 ± 130 , Cambridge I) and Q-126 (5620 ± 120 , this date list) should date the conclusion of the main eustatic rise in ocean level. The horizon is 1 or 2 ft above present-day sealevel. Coll. 1959 by H. Godwin. *Comment*: date confirms the view reached on stratigraphic and pollen-analytic grounds that the marine contact is of the same age in separate parts of the levels. About 1000 yr were occupied by sedge-peat and wood-peat formation before the development of ombrogenous peat in Neolithic time (Q-430, 4540 ± 130 , Cambridge II).

Q-35. Combwich, Somerset 6460 \pm 140

Wood ($51^{\circ} 10' 20''$ N Lat, $3^{\circ} 3' 25''$ W Long) from trees (*Alnus* and *Taxus*) growing on an 8-in. peat bed at ca. + 6 ft o.d. which is overlain clay. 14 ft of clay extending to present ground level, and underlain by marine clay. Coll. 1939 by H. S. L. Dewar, Bridport, Dorset (Godwin, 1941). *Comment*: the stratigraphy at the marginal site of Combwich has not been related to that of the adjacent levels, and the significance of the date is not clear at present.

Q-265. Margam, Glamorgans, 0 to 4 cm 3402 \pm 108

Phragmites (brushwood peat) ($51^{\circ} 32'$ N Lat, $3^{\circ} 46'$ W Long). Upper surface of a submerged peat bed, 2 ft 9 in. thick, overlain by gray sand and silty clays and underlain by gray silty clays. Clays are of marine origin. Level of sample: -7.7 ft o.d. Coll. November 1957 by Cementation Co. Ltd. *Comment*: dates the end of a considerable period of marine retrogression or standstill from about 6200 B.P. (Q-275, 6184 ± 143 , this date list).

Q-274. Margam, Glamorgans, 37 to 42 cm 5605 \pm 126

Aquatic pool peat of *Sphagna* and *Hypnaceae* ($51^{\circ} 32'$ N Lat, $3^{\circ} 46'$ W Long). From same borehole as Q-265 (3402 ± 108 , this date list) and same peat bed, this sample is close to the boundary between a lower ombrogenous *Sphagnum-Calluna* peat and an upper aquatic peat passing over into eutrophic fen peat. Coll. November 1957 by Cementation Co. Ltd. *Comment*: the change to eutrophic conditions after this date is indicative of rising ground-water.

Q-275. Margam, Glamorgans, 48 to 52 cm 6184 \pm 143

Gray silty clay ($51^{\circ} 32'$ N Lat, $3^{\circ} 46'$ W Long). From same borehole as Q-265 and Q-274 (5605 ± 126 , this date list), constituting the base of same peat bed where it is transitional from brackish- to freshwater conditions. Level: -10.5 ft o.d. (core compressed during drilling). Coll. November 1957 by Cementation Co. Ltd. *Comment*: the three dates from this peat bed indicate 3000 yrs of freedom from marine transgression: it seems probable that it corresponds with peat bed described from dock excavations at Port Talbot (closely adjacent) at a slightly higher level, and which contained a broken polished stone axe (cf. Q-430, 4540 ± 130 , Cambridge II). In comparison with data on the other side of the Bristol Channel in the Somerset Levels, Q-275 corresponds with the submerged peat at 15 ft below sealevel at Burnham-on-Sea (Q-134, 6262 ± 130 , Cambridge I), and Q-274 corresponds with the three Somerset date (Q-120, 5412 ± 130 , Cambridge I; Q-126, 5620 ± 120 , and Q-423, 5510 ± 120 ; this date list) for the close of the estuarine-clay deposition around 5400 B.P.

Q-380. Ynyslas, Cardigans, 38 cm 6026 \pm 135

Betula wood (52° 30' N Lat. 4° 3' W Long). Birch grown *in situ* in brushwood peat at base of submerged peat bed exposed on the foreshore of Cardigan Bay near the Dovey Estuary. Peat bed overlies blue silt and has been shown (Godwin, 1943) to extend conformably inland as the base of a large raised bog (Borth Bog). It falls within pollen zone VIIa and its growth indicates replacement of a period of marine deposition by one of standstill or marine retrogression. Coll. March 1959 by H. Godwin.

Q-382. Ynyslas, Cardigans, 65 cm 5898 \pm 135

Brushwood peat (52° 30' N Lat, 4° 3' W long) from same excavation as Q-380: a peat sample from the base of peat bed just overlying the marine silt at level assumed from earlier levelling to be about -1 to -2 ft o.d. Coll. March 1959 by H. Godwin. *Comment*: the basal wood-peat clearly grew very rapidly and it is not surprising that Q-380 (6026 \pm 135, this date list) and Q-382 give similar dates. Together they indicate the end of a considerable marine transgression in the area, for marine deposits extend to substantial depths in the Cardigan Bay estuaries.

General Comment on the A Coastal Series

The results of coastal series A from the region of assumed crustal stability confirm the view that the extensive and rapid eustatic rise in ocean level now generally agreed to have been proceeding in Boreal time (Godwin, Suggate and Willis, 1958), had reached its full extent by ca. 5500 B.P. and was within about 15 ft of this already by ca. 6200 B.P.

B. Coastal Series, Northern Britain

The most conspicuous evidence of land elevation in northern Britain is the so-called "25-foot beach" which is plausibly attributed to a period when the decelerating eustatic rise of ocean level was for a time approximately equalled by isostatic uplift. Continuance of the latter, when the former had ceased, brought the beach to its present position. We here report one date for the late stage of building of the beach in northern Ireland, and three dates for the beginning of formation of the Scottish Carse Clays, which are a deposit conceded to have been laid down in the raised-beach episode. There are also samples from three other coastal sites, in northwestern England, that lie well within the region of isostatic elevation.

Q-373. Cushendun, County Antrim 4740 \pm 110

Wood (55° 8' N Lat, 6° 2' W Long). In banks of river behind raised beach at Cushendun, a layer of wood overlies gray silts of the marine transgression and is covered by about 3 ft of coarse gravel. The level of these silts corresponds with that of the "upper lagoon silts" described by Jessen (1949) as forming behind the beach in its last stage of accumulation. Coll. June 1958 by H. Godwin and A. G. Smith, Queen's University, Belfast. *Comment*: the date is concordant with Jessen's estimate that raised-beach formation ended at the pollen-zone boundary VIIa/VIIb, and that the upper lagoon silts themselves were laid down late in zone VI. It agrees also with the Dublin radiocarbon

date (D-38, 5300 ± 170), cited by Watts, 1960, and Dublin I) for charcoal of transitional Mesolithic-Neolithic occupation on the surface of the raised beach further S on this coast at Dalkey.

Q-280. Airth Colliery, Sterlingshire, no. 1 **8421 ± 157**

Peat ($56^{\circ} 4' \text{ N Lat, } 3^{\circ} 47' \text{ W Long}$). Uppermost layer of a thin peat bed that lies between the deposits of the Scottish 100-ft raised beach and the overlying Carse Clay. Present level of base of Carse Clay is ca. 25.5 ft o.d. Coll. April 1958 by Geological Survey, Edinburgh. *Comment*: pollen analyses indicate that the peat formed early in zone VI, and on the basis of the Scaleby Moss pollen-zonation dates (Cambridge I) the date of 8421 ± 157 is acceptable.

Q-281. Airth Colliery, Sterlingshire, no. 2 **$11,024 \pm 199$**

Clay with peaty layers ($56^{\circ} 4' \text{ N Lat, } 3^{\circ} 47' \text{ W Long}$). This is the base of the same peat layer, 4 in. thick, assayed in Q-280 (8421 ± 157 , this date list), and directly above the deposits of the 100-ft raised beach. Coll. April 1958 by Geological Survey, Edinburgh. *Comment*: pollen analyses indicate that the peat may have begun to form in zone V, but the radiocarbon date is much too old for this. Pollen analyses, however, show very large amounts of derived organic detritus and of spores from more ancient geologic formations; the content of derived inactive carbon is presumably responsible for the erroneous date. High values of pollen of Chenopodiaceae and a seed of *Atriplex* sp. throughout the peat bed, indicate proximity of the sea and suggest that peat formation was due to response by rising ground water to the onset of marine incursion over the much older beach.

Q-421. Eastfield of Dunbarney (Bridge of Earn) Perthshire **8421 ± 157**

Peat with wood ($56^{\circ} 21' \text{ N Lat, } 3^{\circ} 25' \text{ W Long}$). From peat bed below the Carse Clay exposed in the banks of the River Earn. Coll. 1945 (probably by J. Simpson), Geological Survey, Edinburgh (sample U-2931). *Comment*: pollen analysis of a sample of this peat collected by H. Godwin in 1945, and of the carbon-dated sample itself, indicates formation during pollen zone VIa, as with Q-280 (8421 ± 157 , this date list) from Airth Colliery where, by chance, precisely the same radiocarbon date was obtained.

Q-422. Broombarns, near Forgandenny, Perthshire **8354 ± 143**

Quercus wood ($56^{\circ} 21' \text{ N Lat, } 3^{\circ} 29' \text{ W Long}$) from peat below Carse Clay exposed in S bank of the River Earn, 750 yd W 20° N of Broombarns. Coll. 1959 by Dr. Earp, Geological Survey, Edinburgh (sample U2934). *Comment*: pollen analysis of sample of peat from this bed, collected by H. Godwin in 1945, indicates formation during pollen zone VIa or VIb. The conformity of the three samples from separate sites, Q-280, Q-421 and Q-422 is striking; they are slightly older than Q-214 (8120 ± 135 , Cambridge II), the peat below the raised beach at Ballyhalbert in N Ireland which was referred to pollen zone VIc (Cambridge II). This site is probably identical with that sampled originally by Erdtman (1928), and referred to as Forgandenny: he described the peat as of Boreal age and this is of course now confirmed.

Q-398. Brighthouse Bay, Kirkcudbrightshire 9640 \pm 180

Wood (54° 47' N Lat, 4° 7' W Long) lying horizontally in the upper surface of a thin peat bed (2 in.) over what appears to be boulder clay, exposed on the foreshore. Pollen analyses show that the peat formed when pine-birch-hazel dominated the vegetation, i.e., zone V. Coll. July 1959 by Dr. Martin Jope. *Comment*: radiocarbon date suggests origin so early in the post-glacial period that peat deposit may well be the early infilling of an interdunal hollow. There is nothing to link it with former sealevel. The date, however, falls within the age attributed to zone V at Scaleby Moss, which lies no great distance eastwards (Cambridge I).

Q-256. Silverdale Moss, N Lancashire, no. 5 5734 \pm 129

Oxidized fen peat (54° 12' N Lat, 2° 50' W Long). At the eastern side of Silverdale Moss, a sequence of organic deposits extending from pollen zone IV to VIIa is interrupted by a bed of marine clay which is also recognized in the near neighborhood. From a monolith brought back to the laboratory, radiocarbon samples were taken at the upper and lower clay surfaces (Oldfield, 1960). Q-256 is immediately below the marine clay. Coll. August 1957 by Frank Oldfield, Univ. Leicester. *Comment*: date agrees with the determination that the peat below the clay formed in pollen zone VIIa.

Q-260. Silverdale Moss, N Lancashire, no. 9 6590 \pm 144

Phragmites peat (54° 12' N Lat, 2° 50' W Long). From same sequence as Q-256 (5734 \pm 129, this date list), immediately above upper surface of the marine clay. In main part of the Silverdale Moss basin surface of the marine clay lies at ca. + 15 ft o.d. Coll. August 1957 by Frank Oldfield, Univ. Leicester. *Comment*: pollen analyses show very similar character above and below the marine clay; both are referred to pollen zone VIIa, but the radiocarbon dates are inexplicably different.

Q-261. Silverdale Moss, N Lancashire, no. 10 5865 \pm 115

Alnus wood (54° 12' N Lat, 2° 50' W Long). From the same sequence as Q-256, 5734 \pm 129, and Q-260, 6590 \pm 144 (this date list), this alder wood was 30 cm above the upper surface of the marine clay, and still within pollen zone VIIa. Coll. August 1957 by Frank Oldfield, Univ. Leicester. *Comment*: all three samples can be referred pollen-analytically to levels 325 to 350 cm in the long continuous freshwater deposits at Haweswater, only 0.5 mi away, and these levels constitute only a small section in the middle of zone VIIa. This makes the big range of the three radiocarbon dates surprising. Stratigraphic studies show that only in its latest stages did the transgression bring clay over the outer rock bar into the Silverdale basin.

Q-85. Helsington Moss, Westmorland 5277 \pm 120

Phragmites peat (54° 17' 30" N Lat, 2° 49' W Long). The reed-swamp peat immediately above the estuarine clay that underlies the whole of the large raised bog, Helsington Moss, the stratigraphy of which has been described by Smith (1959). He refers the marine contact to early in pollen zone VIIa: its level he shows to be ca. + 16 or 17 ft o.d. Coll. July 1953 by A. G. Smith,

Queen's Univ., Belfast: multiple-shot sampling by Hiller borer. *Comment:* date is somewhat younger than might have been supposed from the palynological evidence, and from the Silverdale Moss dates. Method of sampling might have led to some introduction of younger peat, and this would therefore be a minimal age.

Q-88. High Foulshaw Moss, Westmorland 4616 ± 112

Peat ($54^{\circ} 15' \text{ N Lat, } 2^{\circ} 19' 30'' \text{ W Long}$). High Foulshaw Moss is alongside the upper reaches of the River Kent estuary and behind it lies Foulshaw Moss which has been investigated stratigraphically and pollen-analytically by Smith (1959): both are close to Helsington Moss, (Q-85, 5277 ± 120 , this date list). Under all these mosses, at about 12 ft to 15 ft o.d., is the surface of an estuarine clay, representing the end of the latest large marine transgression on this coast. Sample is from upper surface of the estuarine clay which in Foulshaw Moss (but not High Foulshaw itself) was shown to correspond with an early part of zone VIIa. Coll. July 1953 by A. G. Smith, Queen's Univ., Belfast. *Comment:* date is younger than would have been expected, but possibly lies too close to the estuary channel to be trustworthy as an index to the maximum of the transgression: the date is minimal.

General Comments on the B Coastal Series

The view supported by the dates of the A coastal series that the main eustatic rise of ocean level was almost ended by 6200 and quite finished by 5500 B.P. is not contradicted by evidence of deposits from within the region of isostatic uplift. Now raised to an elevation of about + 15 ft o.d., the surface of the marine clays of the last big transgression are shown to date from ca. 5800 years B.P. in Silverdale, N Lancashire, and from ca. 5300 years B.P. in Helsington Moss, Westmorland. The later date for High Foulshaw Moss is somewhat suspect.

Dates so far obtained for the deposits of the 25-ft raised beach suggest that it formed between ca. 8000 and 5000 B.P. It is interesting to find that the Carse Clays of lowland Scotland began to cover the valley peats also ca. 8000 B.P.; we do not yet know when deposition of the Carse Clays ceased. Both the beach and the Carse Clays represent a net transgression of some 10 or 15 ft during formation (ca. 0.5 ft per century). The net isostatic uplift of ca. 25 ft during the last 5000 yr (0.5 ft per century) is substantially less than the net rate of eustatic rise in the Late Boreal and Early Atlantic (of the order of 2.0 ft/100 yr). This latter figure would permit the necessary phase of first transgression and then equilibrium responsible for beach formation and Carse Clay deposition during the last stages of the eustatic rise of sealevel. Subsequently, of course, both features have been raised to their present heights by continued isostatic uplift.

C. Coastal Series, Fenland Basin

The shallow Fenland basin of East Anglia is filled with postglacial deposits of alternately freshwater and brackish-water origin. Their stratigraphy in the southern half of the basin was elucidated by the former Fenland Research

Committee during the 1930's (Godwin, 1940). Black fen peats that occupy the landward part of the basin are divided (save at the extreme margin) into an upper and a lower peat, by a "Fen Clay" or "Buttery Clay" laid down in brackish water. The upper peat, which contains Bronze Age remains in several places, is itself overlain on the seaward side by a deep deposit of silt laid down and occupied during the Romano-British period. Neolithic remains occur in the lower peat at one site (Shippea Hill). A broad general chronology for the postglacial evolution of the Fenland was derived from the convergent evidence of stratigraphy, archaeology and pollen analysis, and a scheme showing the changes of land level and sealevel in the area was related to that chronology (Godwin, 1940).

The present series of radiocarbon datings is designed to test and extend those earlier conclusions: in many instances the samples relate to geologic situations already explored in the earlier work. The enquiry essentially concerns the dating of the transgression that produced the "Fen Clay", and of the episode of marine retrogression (or less probably, of stability) that produced the "upper peat."

(i) *Fen margin sites*

Over much of the shallowest part of the Fenland basin peat formation only began when the Fen Clay transgression caused backing up of fresh water, and this was the time when the primeval forests of straight-boled giant oaks growing on the mineral soil were killed and entombed by the peat. At other places, although Fen Clay was not present, pollen analyses and stratigraphic studies indicate its horizon in the continuous peat deposition, by a pronounced turn towards local wetness.

Q-129. Adventurer's Fen, Wicken, Cambridgeshire, tree no. 1

4380 \pm 140

Quercus wood (52° 18' N Lat, 0° 17' E Long). Roots of an oak tree growing in Gault Clay beneath the black fen peat, exposed in excavations for artificial mere. Coll. August 1955 by H. Godwin.

Q-130. Adventurer's Fen, Wicken, Cambridgeshire, tree no. 2

4605 \pm 110

Quercus wood (52° 18' N Lat, 0° 17' E Long). Outer rings of prostrate oak from basal forest layer beneath fen peat, exposed alongside Q-129 (4380 \pm 140, this date list). Coll. August 1955 by H. Godwin. *Comment*: at sites nearby in Wicken Fen, Reach Fen and at Upware, pollen analyses proved that the basal forest peat was succeeded by *Cladium* sedge peat formed under much wetter conditions, and that this wet episode corresponded with the Fen Clay deposition at sites slightly more seaward.

Q-589. Queen Adelaide Bridge, Ely, Cambridgeshire 4495 \pm 120

Quercus wood (52°23' N Lat, 0° 15' 40" E Long). Outer rings of an oak tree 7 ft in girth and of 70 ft straight trunk, almost certainly from the basal forest bed, found in the Fen Clay during river-drainage improvement. Coll. 1960 by E. H. Willis and W. E. Doran. *Comment*: date corresponds strikingly

well with that of the trees from Wicken (Q-129, Q-130; this date list) only a few mi distant.

Q-544. Wood Fen, Ely, Cambridgeshire 4195 ± 110

Wood peat (52° 25' 40" N Lat, 0° 16' 40" E Long) from around roots of a pine tree (*Pinus sylvestris*) growing upon the fen peat at a site just beyond maximum extension of the Fen Clay. Pollen-analytic and stratigraphic studies showed the pine-tree layer to have grown immediately after deposition of the Fen Clay (Godwin, and Clifford, 1935). Coll. April 1934 by M. H. Clifford. *Comment*: in good agreement with Q-405 (4190 ± 130, Cambridge II) from Holme Fen, on the W fen margin, which also represents the resumption of wood-peat growth after a wet phase corresponding to the Fen Clay phase (Cambridge II).

Q-532. Flaggrass, March, Cambridgeshire, no. 2 4055 ± 110

Wood peat (52° 33' 14" N Lat, 0° 7' 8" E Long) from base of a peat bed resting upon the gravels of Island of March, slightly outside the range of the Fen Clay. Coll. August 1960 by H. Godwin and R. G. West from excavations organized by T. Potter. *Comment*: it seems likely that as at Wicken (Q-129, 4380 ± 140, and Q-130, 4605 ± 110, this date list) this sample represents the effects of general waterlogging induced by the Fen Clay incursion: the level of -1.5 ft o.d. accords with this.

Q-474. Glass Moor, Ramsey, Huntingdonshire 4345 ± 110

Cones of *Pinus sylvestris* (52° 31' N Lat, 0° 4' E Long) from a layer of wood peat with pine trees *in situ*, underneath a thin layer of Fen Clay and with shells of *Cardium edule* (cockle), growing upon the peat surface. Coll. ca. 1938 by H. Godwin and M. H. Clifford. *Comment*: in good agreement with the Wicken and Ely dates.

Q-545. Woodwalton Fen, Huntingdonshire 3415 ± 110

Thelypteris peat (52° 26' 40" N Lat, 0° 11' 40" W Long) from a monolith representing the initiation of ombrogenous peat growth from fen peat: sample includes the characteristic layer of rootlets of marsh fern (*Dryopteris thelypteris*). Must post-date the Fen Clay incursion which comes fairly close to this site. Coll. 1937 by H. M. Clifford (Godwin and Clifford, 1938).

Q-546. Ugg Mere, Green Dyke, Huntingdonshire 3260 ± 110

Droppings of elk (*Alces alces*) in aquatic *Sphagnum* peat (52° 27' 30" N Lat, 0° 10' 30" W Long) found between the top of the Fen Clay and the calcareous shell marl of Ugg Mere, a marl possibly laid down as a consequence of the Romano-British marine transgression. Coll. ca. 1937 by H. Godwin and M. H. Clifford (Godwin and Clifford, 1938). *Comment*: date falls satisfactorily into the series of dates for the upper peat and establishes a Bronze Age date for elk in Britain.

(ii) *Central and seaward sites*

In general, upper peat of the Fenland basin is now well preserved (and free from intrusive living roots) only in those seaward regions where it has

been covered by the silts of the Romano-British transgression. Recent deep excavations of a flood-relief channel of the River Great Ouse, through the courtesy of the chief engineer, W. E. Doran, yielded several opportunities to sample this bed.

Q-549. Saddle Bow, King's Lynn, Norfolk, 0 to 2 cm depth **1875 \pm 110**

Fen peat (52° 42' 40" N Lat, 0° 23' 10" E Long) from top of the upper peat bed that overlies Fen Clay, and just below the Romano-British silty clay. Exposed in new flood-relief channel of the River Great Ouse, about 0.5 mi N of Saddle Bow village. Nearby was the site from which bones of pelican were recovered from the peat (Forbes, Joysey, and West, 1958). Coll. 1955 by R. G. West and E. H. Willis.

Q-550. Saddle Bow, King's Lynn, Norfolk, 2 to 4 cm depth **2070 \pm 110**

Fen peat (52° 42' 40" N Lat, 0° 23' 10" E Long) from top of the upper peat just below Q-549. Coll. 1955 by R. G. West and E. H. Willis. *Comment*: dates of Q-546 (3260 \pm 110, this date list) and Q-550 agree quite well with one another and accord with the evidence that the upper silty clay was laid down in a marine transgression that began in the Romano-British period.

Q-489. Saddle Bow, King's Lynn, Norfolk, no. 1 **3905 \pm 120**

Fen peat (52° 42' 40" N Lat, 0° 23' 10" E Long) from the transition of the upper surface of the Fen Clay to the brown 2-ft peat bed above. Sample taken from just below Q-490 (3915 \pm 120, this date list). Coll. by R. G. West and E. H. Willis.

Q-490. Saddle Bow, King's Lynn, Norfolk, no. 2 **3915 \pm 120**

Fen peat (52° 42' 40" N Lat, 0° 23' 10" E Long) from the transition of the upper surface of the Fen Clay to the brown 2-ft peat bed above. Sample taken from just above Q-489 (3905 \pm 120, this date list). Coll. by R. G. West and E. H. Willis. *Comment*: dates for Q-489 and Q-490 are self-consistent and place the marine regression following the deposition of the Fen Clay at about 3910 B.P.

Q-547. Magdalene Bend, Runceton Holme, Norfolk **3305 \pm 120**

Fen peat (52° 39' 30" N Lat, 0° 21' 40" E Long) from top surface of the upper peat at contact with overlying sandy silt presumed to be of Romano-British age. Shells of *Cardium edule* with joined valves common on the peat surface: they must have lived *in situ* on the peat surface. Coll. Oct. 1957 by H. Godwin, Vishnu-Mittre, and R. P. Suggate. *Comment*: the fact that the age of the marine contact here is so much greater than at Saddle Bow (Q-549, 1875 \pm 110 and Q-550, 2070 \pm 110, this date list) suggests that the encroaching tidal water may have scoured away some of the upper peat.

Q-263. Denver Sluice, Norfolk, no. 1 **4390 \pm 120**

Wood (52° 35' N Lat, 0° 20' 40" E Long) from the upper peat bed be-

tween Fen Clay and Romano-British silt, taken from just above the Fen Clay. Coll. October 1957 by H. Godwin and others.

Q-264. Denver Sluice, Norfolk, no. 2 **4085 \pm 110**

Wood (52° 35' N Lat, 0° 20' 40" E Long) from the upper peat near site of Q-263. Tree stem 7 in. in diameter, lying horizontally 3 in. above the upper surface of the Fen Clay, here with much *Phragmites*. Coll. October 1957 by H. Godwin and others. *Comment*: results for Q-263 (4390 \pm 120, this date list) and Q-264 agree reasonably well; the "Bear's Muck" (i.e. tidal clay with *Phragmites*) defines the marine contact and represents the end of the Fen Clay transgression.

Q-31. Wighenhall St. Germans, King's Lynn, Norfolk **4690 \pm 120**

Oak wood (52° 41' N Lat, 0° 21' 35" E Long) from a tree grown *in situ* in the "lower" peat bed. This is peat-bed C, which lies below the Fen Clay at a present height of 17 ft below mean sealevel. Pollen analyses show that the oaks grew in fen woods late in the hydrosere succession represented by the peat bed, and were killed as wet conditions returned with the onset of the marine transgression (Godwin and Clifford, 1938). Coll. 1932 by H. Godwin. *Comment*: pollen analyses indicate an origin in zone VII that accords with the radiocarbon date. This date must imply a net subsidence of this coast of at least 17 ft in the last 4600 yr.

Q-81. Ingoldmells, Lincolnshire **2455 \pm 110**

Wood (53° 11' N Lat, 0° 22' E Long) from trees growing *in situ* in the upper peat exposed on the foreshore. This peat lies close to present mean sealevel and overlies a salt-marsh clay (*Triglochin* clay) with a brackish-water *Phragmites* peat transition. Halstatt-type (Early Iron Age) pottery was recorded from the upper peat by H. H. Swinnerton who described the stratigraphy of the deposits. On pollen-analytic and stratigraphic evidence Godwin and Clifford (1938) correlated this peat bed with the upper peat of the Fenland basin, but Smith (1958*b*) subsequently suggested that it was formed "in the period of the Roman occupation." Coll. March 1953 by A. G. Smith, Queen's Univ., Belfast. *Comment*: radiocarbon date accords with the date of the Halstatt-type pottery and falls within the range of dates covered by the upper peat of the main Fenland basin, to which Ingoldmells can be considered marginal.

Q-531. Flaggrass, March, Cambridgeshire, no. 1 **3065 \pm 110**

Peat (52° 33' 14" N Lat, 0° 7' 8" E Long) from upper surface of deep peat bed at contact with overlying silt of a roddon, i.e., tidal deposits of a channel dating from the Romano-British occupation. Coll. August 1960 by H. Godwin and R. G. West from pit 5 of archaeological excavations by T. Potter. *Comment*: the radiocarbon date is 1000 yr before the Roman occupation: probably the upper layers of the peat were removed by tidal water, and certainly the local stratigraphy shows abrupt transition between peat and overlying silt.

Q-401. Immingham, Lincolnshire **6681 \pm 130**

Alnus wood (53° 11' N Lat, 0° 22' E Long) from root crown of an alder

tree grown *in situ* in a peat bed exposed in excavation for the new Henderson graving dock. Peat bed was about 30 ft below present sealevel: it was ca. 4 in. thick and contained wood, frequent hazel nuts (*Corylus*) and *Phragmites*. The peat overlies brackish-water clay with *Phragmites* some 4-ft thick above gravelly sand, and is covered also by similar clay up to ground surface. Coll. August, 1959 by H. Godwin. *Comment*: peat bed appears to represent a brief halt in the progress of marine transgression. Site lies close to the zero isobase for the 25-ft raised beach and seems unlikely to have been much affected by post-glacial land movements. Nonetheless, Smith (1958b) has shown that there was a marine transgression in the Humber region between the Early Iron Age and the Roman period. The situation of the dated Immingham peat bed no doubt reflects in part this transgression and in part the terminal stages of the main eustatic rise in ocean level. We have to note from Smith's evidence that this area has behaved differently in its land- and sealevel relationships from the Fenland basin (see notes on Q-79, 2796 ± 100 , Q-78, 2784 ± 100 , this date list).

(iii) *The Shippea Hill site*

Shippea Hill ($52^{\circ} 26' 10''$ N Lat, $0^{\circ} 23' 52''$ E Long) was the site of important excavations made by the Fenland Research Committee and reported in a number of publications (Clark, G., 1933; Clark, Godwin, and Clifford, 1935; Godwin and Clifford, 1938). They showed that in Late-glacial time there existed a wide valley, cut down deeply below present sealevel and subsequently filled with alternating freshwater and brackish-water deposits. Consequently, at this site the lower peat beneath the Fen Clay was several ft thick and was shown pollen-analytically to have formed over a long period. One Mesolithic occupation and one Neolithic occupation of the sandy banks of the channel were traced outward into the fen peats of the channel, and referred to respective places in the pollen-zonation. In 1960 J. G. D. Clark reopened the site, and a column through the lower peat, secured by J. H. Dickson, was brought to Cambridge for pollen analysis, identification of macroscopic remains and selection of radiocarbon samples. In addition, charcoal from the Neolithic horizon was separately collected.

Q-499. Shippea Hill, Cambridgeshire, no. 100 4695 ± 120

Wood ($52^{\circ} 26' 10''$ N Lat, $0^{\circ} 23' 52''$ E Long) from tree growing in the wood peat not far below the Fen Clay. Coll. 1960 by J. H. Dickson and J. G. D. Clark, Cambridge. *Comment*: the sample gives a date for the time just before deposition of the Fen Clay and closely conforms to that of Q-31 (4690 ± 120 , this date list) from a comparable stratigraphic position. It is the uppermost and has the youngest date of the samples through the lower peat at this site.

Q-525/6. Shippea Hill, Cambridgeshire, nos. 1 and 2 4870 ± 120

Charcoal coll. from Neolithic culture layer in the lower peat: the amalgamation of two samples coll. at 18.55 W, 20.62 S and 18.49 W, 20.90 S respectively. Coll. 1960 by J. G. D. Clark.

Q-527/8. Shippea Hill, Cambridgeshire, nos. 3 and 11 4950 ± 120

Charcoal coll. from Neolithic culture layer in the lower peat: the amalgamation of two samples coll. at 18.37 W, 20.67 S and 18.71 W, 20.24 S respectively. Coll. 1960 by J. G. D. Clark. *Comment*: dates of Q-525/6 and Q-527/8 agree.

Q-580. Shippea Hill, Cambridgeshire, 4 to 5 cm depth 4800 ± 120

Clayey *Phragmites* peat, marking brackish-water transition from lower peat to Fen Clay: from top of monolith through lower peat.

Q-581. Shippea Hill, Cambridgeshire, 5 to 6 cm depth 5130 ± 120

Clayey *Phragmites* peat immediately below sample Q-580 and slightly less clayey. *Comment*: dates of Q-580 and Q-581 agree closely, and also with that of Q-499 (4695 ± 120 , this date list), a wood sample from the same stratigraphic horizon.

Q-582. Shippea Hill, Cambridgeshire, 35 cm depth 5310 ± 120

Black sedge peat with small wood from monolith through the lower peat and midway between the top of the lower peat and the Neolithic-culture layer. In the pollen diagram this level marks maxima in the curves of *Quercus*, *Fraxinus* and *Hedera*, and the end of the continuous curve for *Plantago lanceolata*.

Q-583. Shippea Hill, Cambridgeshire, 50 cm depth 5295 ± 120

Black fen peat with small wood and a little fine sand from monolith through the lower peat and at the top of the Neolithic-culture layer.

Q-584. Shippea Hill, Cambridgeshire, 65 cm depth 5465 ± 120

Black fen peat with small wood and a little fine sand, from monolith through lower peat at a level presumed to be the base of the Neolithic culture: the first *Plantago lanceolata* pollen occurs at this level.

Q-585. Shippea Hill, Cambridgeshire, 70 cm depth 5330 ± 120

Black fen peat with small wood and a little fine sand, from immediately below sample Q-584 (5465 ± 120 , this date list).

Comment on the Shippea Hill series

The 9 samples dated from the uppermost 70 cm of the lower peat bed at Shippea Hill form a generally self-consistent group within a space of only 750 yr. There is very close agreement between the 3 peat samples Q-583, 584 and 585 (this date list) that cover the Neolithic culture layer. In view of this, it is remarkable that the Neolithic charcoal samples Q-525/6 and Q-527/8 (this date list) (which agree reasonably well with one another) should be some 400 yr younger.

In both Britain and the continental mainland the opening of the Neolithic commonly corresponds with the *Ulmus* decline that indicates the pollen-zone boundary VIIa/VIIb, but at Shippea Hill this relation is not apparent. The Neolithic level is, however, marked by the earliest evidence of agricultural activity, in this instance by the consistent presence of pollen of *Plantago lan-*

ceolata. Although on present evidence it is impossible to choose between the charcoal dates of 4900 B.P., and the peat dates of about 5300 B.P., for the Shippea Hill Neolithic, they must be taken as confirming a much earlier date for the earliest Neolithic in Britain than had been supposed before the advent of radiocarbon dating. It is to be recalled that the palynologic evidence for the beginning of Neolithic clearance on the western margin of the Fenland at Holme Fen occurred at a level with a radiocarbon date of 5000 B.P. (Q-406, 4958 ± 130 , Cambridge II).

After the Neolithic occupation, the river valley was occupied by fen-woods and the radiocarbon dates indicate a rapid formation of peat. The coincidence of three dates (samples Q-499, 580 and 581, this date list) shows that at this site brackish water invaded the valley close to 4700 B.P.

It remains to complete dating the samples from the lower half of the peat monolith (including the Mesolithic culture layer, which lies very close to the pollen-zone boundary VI/VII).

General Comment on the C Coastal Series

The C series of samples has provided a group of dates which place the Fen Clay deposition within the period 3000 to 2300 yr B.C. This agrees with the archaeological evidence that Neolithic remains have been found below the Fen Clay, and that Early Bronze Age remains occur immediately above it. It seems as if the maximum extension was about 2400 B.C., at which time the buried-oak forests of the Fenland margin were destroyed.

At the same time, the series supplies a number of dates for the upper peat ranging between about 2400 B.C. and A.D. 100. It is noteworthy that in the Netherlands similar geologic and radiocarbon evidence points to a substantial marine transgression between 2900 and 2300 B.C., followed by a long period of marine retrogression.

If we consider the evidence from the Fenland in conjunction with that from southwestern England (series A) it will be seen that the radiocarbon dates support the conclusion already advanced on other grounds that since the end of the main eustatic rise in ocean level (ca. 3500 B.C.) there has been downward movement of the east of England. This agrees with the general picture already advanced of the southern North Sea basin as a region of post-glacial subsidence (Godwin, 1945).

From Shippea Hill we have the evidence of the first incidence of Neolithic agriculture in the area, close to 3000 B.C.

D. Archaeologic Samples

Q-79. Short Ferry, Fiskerton, Lincolnshire (boat) 2796 \pm 100

Wood ($53^{\circ} 13' N$ Lat, $0^{\circ} 22' W$ Long) from prehistoric dug-out canoe with separate stern board found in valley deposits of the old River Witham, near Lincoln. Coll. March 1953 by A. G. Smith. *Comment*: boat appears to belong to the Late Bronze Age, despite the suggestion of younger age deduced from the pollen analyses by Smith (1958a).

Q-78. Brigg, Lincolnshire (boat) 2784 ± 100

Wood ($53^{\circ} 33' \text{ N Lat, } 0^{\circ} 30' \text{ W Long}$) from prehistoric monoxylous boat with separate stern board found in deposits of the old River Ancholme. From the same site came a structure "now thought to be part of a boat similar to the 'sewn' boats from North Ferriby on the northern shore of the Humber opposite the outfall of the River Ancholme" (Smith, 1958a). The boats apparently lay within the brackish-water clay that fills the valley and the base of which covers a brushwood-peat surface carrying objects of the Late Bronze Age and Halstatt-type pottery, as well as the wooden trackway already dated to 2552 ± 120 (Q-77: Cambridge II). Coll. 1952 by E. H. Rudkin; subm. by A. G. Smith. *Comment:* like the Short Ferry boat and the 'sewn' boats from North Ferriby (2700 ± 150 , BM-58, British Museum II), the Brigg boat appears to be of Late Bronze Age construction. The clay in the valley must have been quickly deposited, not only because of the archaeological objects found below it, but because of the Brigg trackway, likewise below it, but with a scarcely separable radiocarbon date. It might be conjectured that the boats were lost by a sudden surge of tidal water into the valley.

Q-387. Mynnth Rhiw, Lleyn Peninsula, Caernarvons 3094 ± 90

Charcoal ($52^{\circ} 49' 40'' \text{ N Lat, } 4^{\circ} 37' 30'' \text{ W Lat}$) from quarry pits on Neolithic axe-factory site, excavated for the Royal Commission on Ancient Monuments, in Wales and Monmouthshire. Tools and industry stated to match those of Graig Llwyd and charcoal stated to be from a fire pit, hearth II, site B, in use during occupation and to have filled in during the same time. Coll. April 1959 by C. H. Houlder, Aberystwyth, and Judith Turner, Cambridge. *Comment:* date appears too young by several centuries for a Neolithic date, and one supposes either that the sample was contaminated by younger carbon in some manner not detected, or that the charcoals came from a secondary and much later occupation and hearth-building inside a Neolithic pit after it had become partly silted up. There is no trace of any distinct post-Neolithic-material culture to support the latter idea, however.

*E. Late-Glacial and Full-Glacial Deposits***Q-463. Dover Hill, Folkestone, Kent $11,944 \pm 210$**

Small charcoal ($57^{\circ} 5' 12'' \text{ N Lat, } 1^{\circ} 11' 20'' \text{ E Long}$) washed out from a dark gray band (residue of a fossil rendzina soil) in the cryoturbation layer which lies on the flank of the chalk downs between underlying Coombe Rock and overlying hill-wash of Roman or later date. Whereas molluscan evidence collected by M. P. Kerney indicates Late-glacial age for the cryoturbatic layer as a whole, the gray layer is characterized by molluscan species of entirely different character, indicative of warmer conditions, so that he tentatively identifies this phase with the mild Allerød period (Godwin, 1960). Coll. December 1959 by M. P. Kerney, Imperial College, London. *Comment:* radiocarbon date falls within the limits of zone II (the mild Allerød) as hitherto dated in western Europe. It confirms Dr. Kerney's expectation and demonstrates that freeze-thaw conditions were active in SE England in zones I and

III of the Late-glacial period. Fruit stones of *Empetrum* were present, a species prevalent in the British Late-glacial.

Q-473. Holborough, near Maidstone, Kent 13,190 \pm 230

Black organic material (51° 20' 30" N Lat, 0° 25' 40" E Long) washed out from the lower and thinner of two darker layers within thick chalky solifluxion material overlying Coombe Rock on the slope of the North Downs. Both dark layers have a molluscan assemblage of species indicating milder conditions than those of the cryoturbatic material that encloses them. Dr. Kerney tentatively equates the upper of the two layers here with the single dark layer of Allerød age recovered in similar circumstances at Dover Hill (Q-463, 11,944 \pm 210, this date list), and consequently regards the lower layer as indicative of minor interstadial oscillation in Late-glacial zone I, such perhaps as the Bølling. Coll. 1960 by M. P. Kerney. *Comment*: radiocarbon date confirms dating of this mild episode to the Late-glacial zone I.

Q-457. Loch Droma, Ross-shire 12,814 \pm 155

Plant remains (57° 44' N Lat, 4° 55' W Long), National Grid ref. 252752, from a dark layer relatively rich in organic material in deposits of glacial melt-water silts formed in the bed of the lake during excavations for hydroelectric project. Altitude 845 to 880 ft O.D. Carbon-dating sample was taken at 46 to 50 cm from a monolith transferred to Cambridge. Pollen analyses through the deposit show that it was laid down in conditions such as those now encountered in the low-alpine region of N Scandinavia, close to the sub-alpine birch forest and the pre-alpine pine forest. Macroscopic plant remains isolated from organic layers in the silts by Mr. Durno of the Macaulay Institute, Aberdeen, carry similar implications. Bryophyta identified by J. M. Dickson indicate local snow-patch vegetation. Coll. 1959 by W. Kirk, Univ. of Leicester. *Comment*: Late-glacial age indicated by the radiocarbon date accords very well with the biological evidence. At the same time it is to be noted that this date indicates a pre-Allerød (zone I) origin, and that the valley lies in the center of the Highland Readvance glaciation which Donner (1957) has rather convincingly referred to the post-Allerød zone III. If such soft deposits as these could not have escaped destruction during a zone III glaciation, then some modification of Donner's hypothesis seems to be called for.

F. Problematic Dates

Various samples throughout this date list, provide, incidentally, radiocarbon dates for the British postglacial-pollen zones, but the following samples were secured primarily to obtain a date for a pollen-zone boundary. In each instance, however, the result is problematical.

Q-9. Hockham Mere, Norfolk, DB 5, 330 to 350 cm 3880 \pm 90

Fine detritus nekron-mud (gyttja) (52° 30' 55" N Lat, 0° 50' E Long) collected by multiple-shot boring with Hiller peat sampler, between 330 to 350 cm depth in borehole DB 5. The filled-in lake, Hockham Mere, in the N of the East Anglian Breckland has yielded a very long and comprehensive palynologic

record through the Late-glacial and postglacial periods (Godwin, 1944; Godwin and Tallentire, 1951). This sample comes from the *Ulmus*-decline horizon that marks pollen-zone boundary VIIa-VIIb in the British sequence and also the first indications of Neolithic forest clearance. Coll. October 1949 by H. Godwin. *Comment*: date is 2000 yr younger than would be expected from other W European determinations (Godwin, 1960). As pollen diagrams indicate freedom from disturbance, possibly multiple-shot sampling in the soft material may have led to incorporation of young material from upper layers. Yet the error is so large that one is not fully convinced by this explanation: the same situation held with regard to the Late-glacial sample from Hockham Mere, dated by Libby, 1952 (C-349), which was several thousand yr too young (Godwin, 1951).

Q-247. Thrang Moss, North Lancashire, no. 9 4360 ± 130

Sphagnum-Calluna peat ($54^{\circ} 16' \text{ N Lat}, 2^{\circ} 47' \text{ W Long}$) from the relict raised bog in Lowland Lonsdale described by Oldfield (1960). Part of a monolith brought back to Cambridge for analysis and tied palynologically by check samples to a continuous pollen diagram. Q-247 (26 to 29 cm lower series) was chosen to date the first and strongest *Ulmus* decline, here associated with the commencement of a continuous curve for *Fraxinus* and the earliest indications of forest clearance. This corresponds with the pollen-zone boundary VIIa-VIIb and Oldfield's horizon UF. Coll. May 1957 by F. Oldfield, the Univ., Leicester. *Comment*: see notes on Q-249, 4360 ± 130 , this date list.

Q-249. Thrang Moss, North Lancashire, no. 11 4360 ± 130

Sphagnum-Calluna peat ($54^{\circ} 16' \text{ N Lat}, 2^{\circ} 47' \text{ W Lat}$) from same monolith as Q-247 (4360 ± 130 , this date list), but slightly higher (20 to 23 cm lower series). Intended also to date the same VF horizon, and VIIa-VIIb zone boundary. Coll. May 1957 by Frank Oldfield, Leicester Univ. *Comment*: age determinations of Q-247 and Q-249 are identical, but both are about 600 yr younger than would have been expected on the assumption of general synchronicity of the VIIa-VIIb boundary in N. Europe (Godwin, 1960). The samples, unfortunately, had certainly been partially penetrated by present-day living plant rootlets, and despite every effort by Oldfield to eliminate this source of error by picking out all fresh rootlets, the possibility remains that undetected recent rootlets have contributed to the samples and caused too recent dates to be obtained.

GREECE

Q-491. Acheron Valley, Preveza region, Greece 667 ± 110

Wood ($39^{\circ} \text{ N Lat}, 20^{\circ} 40' \text{ E Long}$) from the alluvial deposits of the Acheron valley. Coll. 1960 by the Greek Institute for Geology and Subsurface Research, Athens; subm. by T. Papadimitropoulos. *Comment*: date has been of value to the Institute as affording a measure of the rate of infilling of the valley by mineral sediments.

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CAMBRIDGE UNIVERSITY
NATURAL RADIOCARBON MEASUREMENTS IV
NUCLEAR-WEAPON TESTING AND THE
ATMOSPHERIC RADIOCARBON CONCENTRATION

H. GODWIN and E. H. WILLIS

Cambridge University

A. Annual Rings of Populus nigra, 1953-1959

In continuance of investigations upon successive annual crops of oats reported in RADIOCARBON SUPPLEMENT, Volume 2, we undertook the analysis of successive annual rings of a tree that had been growing throughout the period covered by the oat-crop assays, namely 1953 to 1959. The selected tree was a straight-boled specimen of *Populus nigra* from the Forestry Commission's plantations at Santon Downham, near Thetford, Norfolk. It had been planted in 1929 and was felled on 21 October, 1959. Shortly afterwards, it was brought into the laboratory and sawn into slices just over 1 in. thick. The surfaces having been smoothed, the annual-ring contacts were marked, and within each annual ring the inner (spring) wood was marked off from the outer (autumn) wood. The tree had been chosen as one exhibiting rapid growth and it proved fairly easy to dissect off with a chisel all the separate half-rings between spring 1953 and the end of 1959. In the event, activities were determined only upon four of the half or whole rings.

Since it was thought possible that some of the abundant starch present in the wood might have been directly translocated from the stored starch deposits of earlier years, in two instances starch was removed from the ring samples by acid hydrolysis before combustion and assay.

All activities are quoted as a percentage variation from the activity of the 100-yr-old oak standard. It must be remembered that the Suess effect accounts for a negative variation of about -3.3% between the standard and the 1953 samples, whilst the age correction is +1.2%, leaving a negative balance of about 2%.

Q-453	1953	Whole ring	-2.2% + 0.7%
Q-454	1953	Whole ring—destarched	-2.9% + 0.7%
Q-446	1958	Autumn half-ring destarched	+13.8% ± 1.0%
Q-447	1958	Spring half-ring	+14.5% ± 1.0%
Q-443	1959	Whole ring	+25.2% ± 1.3%
Q-444	1959	Whole ring—destarched	+23.1% ± 1.3%

Increase in activity of about 27% between wood grown in 1953 and that grown in 1959 is comparable with the increase of 32% in the activity of oat grains grown in these respective seasons.

In the two assays for autumn and spring wood of 1958, there is no evidence that the spring wood of one season might have been largely built from carbohydrate synthesized in the previous season, stored over the winter and mobilized in the spring.

Likewise, in the 1959 analyses there is no evidence that starch from an earlier season and with a different radiocarbon activity is present, stored in the wood of a given year.

In this tree it would appear that the year's growth of wood is largely the product of photosynthesis in that year: this does not, of course, exclude the possibility that it might be otherwise with other species or other conditions of growth.

B. Tropospheric Radiocarbon Activity in 1960

Measurements made upon the tropospheric radiocarbon activity since large scale nuclear weapon testing began, have all indicated a seasonal variation in concentration which reaches a peak level for any particular year in the early summer in the Northern Hemisphere (Münnich and Vogel, 1958). This is also characteristic of other fission products, particularly strontium 90, caesium 137, zirconium 95 and tungsten 185 (Pierson *et al.*, 1960). The seasonal peak was much in evidence in 1959, the first year after the moratorium on testing, when a large accumulation in the autumn of 1958 flushed into the northern hemisphere troposphere the following spring (Willis, 1960; Tauber, 1960; Broecker, 1960). It was of great importance to see whether this observation would be repeated in the 1960 season, for it would provide a valuable guide to mean residence and turnover times of the phases of the atmosphere.

A site to windward of the city of Cambridge, free from possible fuel-carbon contamination, was chosen for the collection of the samples. They were of two kinds, organic and inorganic. The organic samples were successive crops of mustard (*Sinapis alba*), grown from seed at regular intervals. The final dry weight after three weeks was greatly in excess of that of the seed, and no correction has been applied for initial carbon content of the seed. A sample of oats grown in a field nearby was also assayed, and the result was in general agreement with that given by the mustard plants. The inorganic sample was obtained as carbonate by exposing to the air 2 litres of N. sodium hydroxide for 3 or 4 days, usually during the last few days of growth of the mustard plants. Carbonate yields tended to vary around 60%, and C^{12}/C^{13} ratios in the precipitate might therefore be expected also to vary slightly from sample to sample. In the absence of mass-spectrometric facilities, Broecker's average C^{13} value of -21% , which had been observed for samples taken under comparable conditions, was taken as the correction to the C^{14} value. In the case of the organic material, C^{13} was taken as -25 , again an average of Broecker's measurements. One atmospheric sample from Gilleleje, Denmark ($56^{\circ} 7' N$ Lat, $12^{\circ} 19' E$ Long), collected by Tauber in June and July as part of a similar investigation, was measured and found to give close agreement with the British measurements.

The season's results appear to indicate that there has been no significant peak in the 1960 level of activity. In 1959, a concentration gradient existed between the northern and southern hemispheres, varying from C^{14} of about 310 in the N to about 180 in the S. In 1960 there are indications that the tropospheres of both hemispheres are approaching equilibrium at around 220. The question arises as to the fate of the inflow of radiocarbon from the northern

hemisphere stratosphere to the troposphere. The absence of any seasonal peak might indicate that the inflow was equal to the outflow down the concentration gradient to the southern hemisphere and into the oceans. Alternatively, it could mean that there has been little or no inflow of radiocarbon from the stratosphere this year. If the amount being taken up by the oceans is large, then this will be soon indicated by the decay time of the tropospheric activity which will provide an indication of the troposphere and surface ocean turnover rate.

Organic series, 1960

Q No.		δC^{14}	Estimated δC^{13}	(ΔC^{14})
500	March 10-30	202	-25	212 ± 9
501	April 1-21	175	-25	184 ± 9
502	April 22-May 12	185	-25	194 ± 9
511	Oats picked July 24	187	-25	196 ± 9

Carbonate series, 1960

504	May 16-19	213	-21	213 ± 9
505	May 31-June 3	205	-21	205 ± 9
506	June 21-27	218	-21	218 ± 9
508	July 15-18	209	-21	209 ± 9
513	Aug. 4-8	235	-21	235 ± 9
515	Aug. 29-Sept. 1	202	-21	202 ± 9
524	Oct. 1-Oct. 7	216	-21	216 ± 9
523	Nov. 10-13	181	-21	181 ± 9
520/521	June-July Gilleleje, Denmark	212	-21	212 ± 9

C. Other bomb-affected carbon samples

	δC^{14}	δC^{13}	ΔC^{14}
Q-471. Human testes	149	-25	158 ± 20

Submitted by the Medical Research Council, Radiobiological Research Unit, Harwell, England (J. F. Loutit), and obtained from a young healthy person, the victim of a road accident. The ΔC^{14} value represents the concentration of bomb-derived carbon in healthy genetical tissue in early 1960. The dry weight of the sample was small, and the result was obtained by a dilution technique.

	δC^{14}	δC^{13}	ΔC^{14}
Q-472. Horse hair			
Clipped September 1959.	148	-25	156 ± 8

This represents the summer growth of horse hair, while the animal was grazing on foodstuff containing the high summer activity of 1959.

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UPPSALA NATURAL RADIOCARBON MEASUREMENTS III

INGRID OLSSON, HORACIO CAZENEUVE, JOHN GUSTAVSSON,
and INGVAR KARLÉN

Uppsala Universitets Fysiska Institution, Uppsala, Sweden

The following list covers samples measured at the Uppsala radiocarbon laboratory during 1960. The technique used has been described by the senior author (Olsson, 1958). Pretreatment has not been changed since the last dating list was published (Uppsala II).

Reference sample is now 95% of the activity of the oxalic-acid standard from the National Bureau of Standards. Because this sample is used as if it were a wood standard, we have related our C^{13} values to the PDB Chicago C^{13} standard. The C^{13}/C^{12} ratios for samples were compared to that of our oxalic-acid 1 sample, which in turn was measured by Craig (1961) and related to the PDB Chicago C^{13} standard. The old Uppsala standard, which was 18th-century wood (Uppsala I and II), differs in C^{13} by $-24.2 \pm 1 \%$ from PDB Chicago, and this amount should be added algebraically to δC^{13} values given in previous papers. To convert the old Uppsala time-scale to the new one, 135 ± 35 yr should be added to previously published dates, because 95% of the NBS oxalic acid has a C^{14} activity of $15 \pm 4 \%$ more than the old Uppsala reference sample, which in turn differs in C^{13} content from other wood samples by only 0.8 %.

The value 5570 yr has been used for the half-life of C^{14} . Results are expressed in yr before 1950. Errors include the standard deviations (σ) of the counted particles for the unknown sample, reference sample, and background sample as well as the error in the δC^{13} values. When the activity is very low, so that 2σ corresponds to a possibility of infinite age, 2σ has been used instead of σ .

A few samples had to be diluted with CO_2 from an old source to bring them to the normal working pressure of 3 atmospheres.

ACKNOWLEDGMENTS

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

*A. Mediterranean Area***U-177. Core 20902, 105.5 to 111 cm depth 15,900 ± 300**

Shells of foraminifera from core 20902 (38° 31' N Lat, 3° 50' E Long), depth 105.5 to 111 cm; depth in sea 2596 m. This level corresponds to lower parts of a layer rich in iron. The content of *Globorotalia scitula* was low. Coll. 1948 by Swedish *Albatross* Expedition (Pettersson); subm. by K. Gösta Eriksson, Uppsala Universitets Kvartergeologiska Institution, Uppsala, Sweden. *Comment*: a fraction $>4\mu$ was used. $\delta C^{13} = -3.5\text{‰}$.

*B. Spitsbergen***Vestspitsbergen series**

Peat, wood, and shells measured as a continuation of the Vestspitsbergen series (Uppsala II; Feyling-Hanssen and Olsson, 1959-1960). All altitudes are above mean sealevel.

U-185. Skansbukta 15 M p 4800 ± 120

Peat, 1.5 m below surface of a marine terrace, NE side of Skansbukta (78° 31.5' N Lat, 16° 3' E Long), Billefjorden, Spitsbergen; peat at 16.2 m alt. Sample gathered in a peat lamina, 3 cm thick, in sandy soil with marine shells of *Astarte borealis*, *Astarte montagui*, *Mytilus edulis*, *Saxicava arctica*, and *Mya truncata* above and below the peat lamina. Sample was expected to date a postglacial transgression. The stratigraphy is discussed by Feyling-Hanssen (1955, p. 109-115). Coll. 1950 and subm. 1960 by R. W. Feyling-Hanssen, Norsk Polarinstitut and Norges Geologiske Undersøkelse, Oslo, Norway. *Comment*: the humus, which was extracted with NaOH will be dated later. $\delta C^{13} = -27.0\text{‰}$.

U-187. Gipshuken 6014 635 ± 90

Wood from Gipshuken (78° 27' N Lat, 16° 20' E Long), Isfjorden, Spitsbergen; ca. 5.5 m alt. Sample from a root (ca. 70 cm long and 25 cm thick), partly overgrown by vegetation and that left an imprint in the ground. A bone sample was collected at the same alt., a few m from this sample. Small pieces of wood, lying loose on the surface and showing traces of human activity, were found nearby. This sample was gathered in the area where Feyling-Hanssen and Jørstad (1950, p. 55-58) previously had observed grayish wood samples which they thought should be ancient. Coll. 1960 by R. W. Feyling-Hanssen, Norges Geologiske Undersøkelse, Oslo, Norway, and Ingrid Olsson. $\delta C^{13} = -24.4\text{‰}$.

U-188. Gipshuken 6015 1150 ± 100

Wood from Gipshuken (78° 27' N Lat, 16° 22' E Long), Isfjorden, Spitsbergen; ca. 6 m alt. Sample from root end of a split, partly buried log ca. 4 m long. The small bay below this location was exposed to the wind. Coll. 1960 by

R. W. Feyling-Hanssen, Norges Geologiske Undersökelse, Oslo, Norway, and Ingrid Olsson. $\delta C^{13} = -23.3\text{‰}$.

U-189. Ekholmvika 6018 b **21,300 \pm 500**

Fragments of *Mya truncata* and *Saxicava arctica* from Ekholmvika ($78^{\circ} 35' \text{ N Lat, } 16^{\circ} 40' \text{ E Long}$); Billefjorden, Spitsbergen; 84.5 m alt. Sample from surface layer at landward edge of marine terrace, 77.0 to 84.5 m alt, as determined by Feyling-Hanssen (1955, p. 76-81). Coll. 1960 by R. W. Feyling-Hanssen, Norges Geologiske Undersökelse, and Ingrid Olsson. *Comment*: condition of shells (small pieces) was such that one might expect contamination to produce a minimum age. Inner 60% was used. $\delta C^{13} = +0.6\text{‰}$.

U-190. Ekholmvika 6018 a **18,100 \pm 500**

Shell layer surrounding part used for sample U-189. *Comment*: layer corresponds to 35% of the shells; 5% was removed by washing. $\delta C^{13} = -1.9\text{‰}$.

U-186. Talavera O₄ p **6000 \pm 400**

Peat, 2.33 m below surface of a marine terrace, Talavera ($78^{\circ} 15' \text{ N Lat, } 20^{\circ} 50' \text{ E Long}$), Barentsöya, Spitsbergen; peat at 12.1 m alt. Sample gathered in a peat lamina, 3 cm thick, below fossil bearing sand and above fossil bearing sand and clayey silt. Sample was expected to date a postglacial transgression in Spitsbergen. Coll. 1960 by J. Büdel, Geographisches Institut, Würzburg, Germany; subm. by R. W. Feyling-Hanssen, Norges Geologiske Undersökelse, Oslo, Norway. *Comment*: before being subm. the sample was treated with H_2O_2 and CCl_4 , in order to separate any foraminifera that might be present. The humus, which was extracted with NaOH, will be dated later. Diluted. $\delta C^{13} = -27.0\text{‰}$.

C. North America

Sample of Special Palynologic Interest

U-176. Weber Lake, Minnesota, 720 to 740 cm depth **10,180 \pm 160**

Clay-gyttja from a sediment core from southern edge of Weber Lake, Lake County, Minnesota, 0.5 mi W of State Highway 2, 31 mi N of Two Harbors (or one mi S of Mount Weber Lookout Tower), in sec. 36, T 58 N, R 11 W ($47^{\circ} 28' \text{ N Lat, } 91^{\circ} 40' \text{ W Long}$). Sample from 720 to 740 cm below reference level (ice). A strong birch-pollen maximum and also the upper end of the late-glacial part of the profile rich in non-arboreal pollen (Fries) were found at the sampling level. Another sample (710 to 750 cm level) from same core (out of a split part of core), has been dated by the U. S. Geol. Survey Laboratory (W-873, $10,550 \pm 300$, USGS V). Two samples of same core taken 440 to 447 cm and 620 to 633 cm, respectively, below reference level, have been dated by Uppsala II: U-163, 7300 ± 140 ; U-164, 9150 ± 130 . Coll. 1959 by H. E. Wright, Jr., Univ. of Minnesota, Minneapolis, U. S. A. and Magnus Fries, Uppsala Universitets Växtbiologiska Institution, Uppsala, Sweden; subm. by Fries. $\delta C^{13} = -16.6\text{‰}$.

II. ARCHAEOLOGIC SAMPLES

*Sweden***U-168. Ö. Vemmerlöv no. 11 (LUHM 28568:18) 3085 ± 120**

Charcoal, from grave 18 at Ö. Vemmerlöv no. 11 ($55^{\circ} 35' \text{ N Lat}$, $13^{\circ} 14' \text{ E Long}$), Ö. Vemmerlöv parish, Skåne, Sweden. Charcoal was found with burnt bone in an urn, the type of which indicates fifth period of the Bronze Age (Montelius' system). Coll. 1939 by B. M. Vifot, Lunds Universitets Historiska Museum, Lund, Sweden; subm. by Berta Stjernquist, Lunds Universitets Historiska Museum, Lund, Sweden. *Comment*: $\delta\text{C}^{13} = -24.2 \text{ ‰}$.

U-184. Dragby 1¹:G:22 2045 ± 110

Resin from grave G from Dragby ($59^{\circ} 59' \text{ N Lat}$, $17^{\circ} 35' \text{ E Long}$), Skuttunge parish, Uppland, Sweden. Resin was found with burnt bone. Preliminary results of the excavation are discussed from different points of view by Stenberger (1960), Maj-Britt and Sten Florin (1960), Olsson (1960b) and Gräslund (1961). Coll. 1960 by Bo Gräslund, Uppsala Universitets Institution för Nordisk och Jämförande Fornkunskap; subm. by Mårten Stenberger, Uppsala Universitets Institution för Nordisk och Jämförande Fornkunskap, Uppsala, Sweden. This sample belongs to Dragby series for which the first 10 dates have already been published (Uppsala II). $\delta\text{C}^{13} = -26.0 \text{ ‰}$.

III. ATOMIC BOMB EFFECT

The values are related to the international reference standard sample (95% of the activity of oxalic acid) and corrected for deviation in the C^{13} content, according to Broecker's suggestion (Lamont VI). Results give the per mil excess over corrected reference sample. The C^{14} content of these samples, and those previously measured in Uppsala (I and II), agrees with the content measured by Broecker and others (1959 and 1960); Lamont VI; Bien and Suess (1959); Münnich and Vogel (1959); Tauber (1960); and Willis (1960).

U-191. Typha 60 $\Delta\text{C}^{14} = + 266 \pm 12 \text{ ‰}$

Typha latifolia from Ekensberg ($59^{\circ} 48.5' \text{ N Lat}$, $17^{\circ} 34.5' \text{ E Long}$), Uppsala, Sweden. The plant was gathered July 10, 1960 by Ingrid Olsson. $\delta\text{C}^{13} = -27.6 \text{ ‰}$.

U-192. Kvalöya, birch 6001 $\Delta\text{C}^{14} = + 252 \pm 12 \text{ ‰}$

Birch leaves from Kvalöya ($69^{\circ} 39' \text{ N Lat}$, $18^{\circ} 41' \text{ E Long}$), Troms, Norway. Leaves were gathered July 23, 1960 by Ingrid Olsson. $\delta\text{C}^{13} = -26.7 \text{ ‰}$.

U-193. Templet, grass 6010 $\Delta\text{C}^{14} = + 272 \pm 9 \text{ ‰}$

Grass from Templet ($78^{\circ} 24' \text{ N Lat}$, $16^{\circ} 47' \text{ E Long}$), Spitsbergen. Coll. July 29, 1960 by Ingrid Olsson. $\delta\text{C}^{13} = -26.5 \text{ ‰}$.

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U. S. GEOLOGICAL SURVEY RADIOCARBON DATES VI*

MEYER RUBIN and SARAH M. BERTHOLD

U. S. Geological Survey, Washington, D. C.

Dates in this list have been determined at U. S. Geological Survey radiocarbon laboratory, Washington, since our 1960 date list (USGS V). Procedures for the preparation of acetylene gas used in the counting, and the method of counting, (two days in two separate counters) remain unchanged. However, the modern standard used is no longer wood grown in the 19th century, but 95% of the activity of NBS oxalic-acid radiocarbon standard, as recommended at the 1959 Groningen Radiocarbon Conference. Measurement of the oxalic-acid standard at our laboratory indicates $6.2 \pm 1\%$ more C^{14} activity than our modern wood standard; so use of the new standard should make no appreciable difference when comparing samples computed by the old method. W. F. Libby's (1955) half-life average for C^{14} , 5568 ± 30 years, was used for the decay equation.

Pretreatment of wood, charcoal, and peat samples by boiling in acid, alkali, and acid again, is standard procedure. Ultrahigh frequency vibration cleaners are used on all shell samples. This process has proven extremely useful in removal of matrix from snail shells. In addition, shell samples are pretreated in weak acid to remove outer 20% of carbonate, a step which reduces the likelihood of contamination.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Eastern United States

W-910. New Sharon, Maine **>38,000**

Spruce fragments from brown sandy silt, underlying blue-gray till and overlying greenish-gray till, exposed (Caldwell, 1959) on N bank of Sandy River ($44^{\circ} 38' 30''$ N Lat, $70^{\circ} 00' 24''$ W Long), 0.6 mi NE of New Sharon, Maine. Coll. 1959 by D. W. Caldwell, Wellesley College, Wellesley, Massachusetts; subm. by R. L. Dow, Dept. of Sea and Shore Fisheries, Augusta, Maine. *Comment:* this is undoubtedly same horizon and locality as Y-689 (Yale V), dated at $>30,000$, and provides an excellent cross-laboratory check. Several dates on samples from beneath till now exist for localities in New England; all are outside our range of C^{14} dating.

W-883. Lewiston, New York **$12,080 \pm 300$**

Picea mariana (id. by D. Bierhorst) from laminated silt and clay deposits of Lake Iroquois, unearthed in excavation at Lewiston in connection with Niagara Power Project of New York State Power Authority, in spoil area in SE Lewiston ($43^{\circ} 10'$ N Lat, $79^{\circ} 02'$ W Long), New York. From 340 ft alt in gray silty clay, overlying till and underlying brown silty clay, obtained from

* Publication authorized by the Director, U. S. Geological Survey.

office of C. P. Benziger, of Uhl, Hall, and Rich, Lewiston, New York. *Comment*: two runs were made on a log coll. 1958 by C. P. Benziger; subm. by E. H. Muller, Syracuse Univ. Syracuse, New York, from same locality. W-813 (USGS V) gave age of 8520 ± 300 , and W-861 (USGS V), $12,660 \pm 400$. W-813 was believed to be incorrect due to erratic behavior of the counter. In order to verify W-861 date, another sample, coll. at same time, was requested. New date agrees with W-861; difference is considered insignificant. Because no till overlies lake beds in which wood was found, and because this locality is N of escarpment forming Niagara Falls, date of ca. 12,000 yr should date beginning of the Falls. In addition, this date, giving a minimum age for youngest till in New York, makes it unlikely that the continental ice sheet reached New York State during Valders time.

B. Central United States

W-917. Danville, Illinois **>40,000**

Wood from silt in a diversion drainage ditch dug for a strip mine in SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 2, T 19 N, R 12 W ($40^{\circ} 09' N$ Lat, $87^{\circ} 40' W$ Long), NW of Danville, Illinois. The section, originally described by Eveland (1952), consists of a series of tills interbedded with silt, sand, or gravel deposits. Recent erosion along ditch has exposed additional phenomena, and a revised, more detailed description and interpretation has been published by Ekblaw and Willman (1955). W-256 (USGS III), $>37,000$, was from this section from a till designated as of Illinoian age by Eveland. Sample (W-917) comes from a silt, higher in the section (unit IX of Ekblaw and Willman). Wood occurs in this till and in the silts above and below the till. Coll. 1959 by Ekblaw and Willman, Illinois State Geol. Survey. *Comment*: this till was interpreted as Farmdale till by Ekblaw and Willman. They now state "although the previous date ($>37,000$) makes a Farmdale age doubtful, it appears now that the till could be Wisconsin but pre-Farmdale in age. Wood from the silt above the till could be considerably younger than till and is at least a possibility for a Farmdale age" (W. B. Willman, written commun., 1959). Date allows placement of this silt and till in Altonian substage of Frye and Willman (1960), which is of Wisconsin, pre-Farmdale age.

W-882. Harrison County, Iowa **$11,600 \pm 200$**

Spruce log (id. by D. W. Benseid, Iowa State Univ.) from alluvium at depth 28.4 to 29.4 ft in W bank of Willow Drainage ditch, 100 ft N of tributary entering from W, in SW $\frac{1}{4}$ sec. 11, T 80 N, R 43 W ($41^{\circ} 45' N$ Lat, $95^{\circ} 47' W$ Long), Harrison County, Iowa. This is one of several dated-wood samples from Thompson Creek and Willow River watersheds (see Thompson Creek series, USGS V, p. 144-145). Alluvial fill represents a complex sequence of erosion, deposition and accumulation of organic matter. Deposits have been divided tentatively into 5 beds. Sample comes from 15 in. above base of bed 2, second from the bottom. Coll. 1959 by R. B. Daniels, U. S. Dept. of Agriculture, North Carolina State College, Raleigh. *Comment*: W-700 (USGS V), from top of basal bed 1 in Thompson Creek watershed, dated $11,120 \pm 440$. Either top of bed 1 in Thompson Creek area is younger than base of bed 2 in Willow

River area, or this detrital log was redeposited from underlying bed 1 (Daniels, and others, in preparation).

W-908. Big Bone Lick, Kentucky **<250**

Wood from blue clay in trench cut into bank of Gum Branch at junction with Big Bone Creek, near Big Bone Lick Salt Spring (38° 53' N Lat, 84° 45' W Long), Rising Sun and Union Quadrangles, Ohio-Kentucky. Section consists of dense blue clay underlying a Cary (?) terrace fill and a Recent terrace fill. Blue clay contains bones of bison, musk-ox reindeer and elephant (Jillson, 1936; Cooper, 1931). Coll. 1959 by F. C. Whitmore, Jr., U. S. Geol. Survey, Washington, D. C., and C. B. Schultze, Univ. of Nebraska State Museum, Lincoln. *Comment*: wood does not date the blue clay, but must have been deposited at a later date during recent scour by the stream.

W-919. Coopers Canyon, Nebraska **10,850 ± 300**

Mollusks from white cross-laminated sand exposed along W side of gully cutting into railroad embankment, and E side of Coopers Canyon in NW ¼ NW ¼ sec. 14, T 15 N, R 11 W (41° 17' N Lat, 98° 34' W Long), Howard County, Nebraska. Sample from upper 10 in. of sand, which underlies silt and a humic gley horizon. Humic gley soil and underlying silt had been considered by Scott (Miller and Scott, 1955) to be parts of the Sappa formation of late Kansan or Yarmouth age, and the underlying sand to be the Grand Island formation of Kansan age. Coll. 1959 and carefully cleaned by R. D. Miller, U. S. Geol. Survey, Denver, Colorado. *Comment*: W-752 (USGS V) 10,500 ± 250, was sample consisting of mollusks coll. by J. C. Brice, U. S. Geol. Survey, Lincoln, Nebraska, from beneath gley soil at Coopers Canyon. This sample was run to confirm the date on Brice's sample.

W-900. Grand Forks, North Dakota **10,080 ± 280**

Wood from N-flowing drainage ditch at jet airbase, 1.8 mi N of U. S. Highway 2, in NW ¼ sec. 31, T 152 N, R 52 W (47° 50' N Lat, 97° 20' W Long), 15 mi W of Grand Forks, North Dakota. Section from top to base consists of: soil, 1.8 ft; yellow sandy clay of glacial Lake Agassiz, 1.6 ft; tan crossbedded sand with a few pebbles, 6.5 ft; fossil wood (sample from here) in horizontal position in sand, branches up to 3 in. in diameter, 1.0 ft; gray, unoxidized sand at ditch level, 1.0 + ft. (Till probably underlies sand at shallow depth). Sample run as check on W-723 (USGS V), 10,960 ± 300, taken from E-flowing drainage ditch 0.5 mi S of this locality, at about the same stratigraphic horizon. The problem, discussed by Lemke and Colton (1958), is whether the ice sheet entered North Dakota in Valders time. The till inferred to underlie the fossil wood is believed to have been deposited by the ice lobe that formed the Edinburg and Holt moraines, and represents the last ice advance into North Dakota. This date, as well as from W-723, provides a minimum age for this till but does not preclude a Valders age. Coll. 1959 by R. W. Lemke, U. S. Geol. Survey, Denver, Colorado. *Comment*: if the wood gave a Two Creeks age or older (11,300 or more), last advance would have to be a pre-Two Creeks event. Because no till overlies the wood, the possibility of

Valders age till in North Dakota would be precluded, but with the present data, no conclusions of that nature can be made.

W-901. Waukesha, Wisconsin**30,800 ± 1000**

Spruce log (id. by B. F. Kukachka, Forest Products Laboratory, Madison) from depth of 60 ft in gravelly-sand outwash exposed in Johnson Sand and Gravel Co. pit in NW $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 36, T 7 N, R 19 E (43° 03' N Lat, 88° 12' W Long), 1 mi NE of Waukesha, Wisconsin. The log, 4 to 6 in. in diameter and 2 ft long, is one of many occurring in the pit. Site was mapped by Alden (1918) as ground moraine of Lake Michigan lobe, now regarded as of Cary age. Typical Cary stony till up to 40 ft thick lies unconformably on top of outwash, which is locally contorted. Folds seem in part to be due to overriding and in part to slump by melting of buried ice blocks. Coll. 1960 by E. R. Nelson, Public Museum, Milwaukee, Wisconsin; subm. by R. F. Black, Univ. of Wisconsin, Madison. *Comment*: local topography is similar to that studied by Black near Lake Geneva in Walworth County (sample W-638, USGS V, from Lake Geneva dated 31,800 ± 1200) in SE Wisconsin, where overriding of buried outwash by Cary ice is well established. Abundant large logs, which are obviously transported but not compressed like those in till, are supposed by Black to be part of a forest destroyed by stream action as the outwash was laid down, presumably during the deglaciation of SE Wisconsin just after Rockian advance (of Black) of some 30,000 B.P.

W-903. Elkhorn, Wisconsin**29,000 ± 900**

Spruce log (id. by B. F. Kukachka, Forest Products Laboratory, Madison) imbedded in outwash gravel at depth of 40 ft in gravel pit in NW $\frac{1}{4}$ SE $\frac{1}{4}$ sec. 1, T 3 N, R 16 E (42° 45' N Lat, 88° 33' W Long), 5 mi N of Elkhorn, Wisconsin. Occurrence is similar to W-901, this date list, (see also W-747, USGS V, Hammond, Wis., 29,000 ± 1000, and Y-572, Yale IV, 30,650 ± 1640). Gravel here is also contorted and overlain by thin till. Area is mapped as terminal moraine of Lake Michigan lobe (Alden, 1918); till is considered Cary in age (late Woodfordian of Frye and Willman, 1960) by the collector, R. F. Black, Univ. of Wisconsin. *Comment*: according to Black (written commun.) this outwash represents the retreat phase that followed the Rockian advance. Frye and Willman (1960) would correlate it with Winnebago drift of Shaffer (1956), a rock-stratigraphic unit within their Altonian substage. Leighton (1960) used similar dates from Wisconsin to date the Farmdale glacial drift of the Farmdale substage.

*C. Western United States***W-892. Searles Lake, California****12,390 ± 400**

Carbonaceous mud from core hole S-35, 0.25 mi W of NE corner of sec. 2, T 26 S, R 43 E (35° 42' 30" N Lat, 117° 19' 00" W Long), Searles Lake, California (Gale, 1914). Sample taken from base of Overburden Mud deposited after lake had desiccated to form the Upper Salt. Overburden Mud extends from 0 to 22.7 ft in this core and sample was taken from bottom 0.7 ft. None of the ca. 30 dated samples from Searles Lake (Flint and Gale, 1958) are from Overburden Mud. This segment of core varies in lithology from mud

with scattered pirssonite crystals, to muddy halite near the base. Sample consisted of organic portion of upper half. Coll. 1958 by F. J. Druzak, American Potash and Chemical Corp., Trona, California; subm. by G. I. Smith, U. S. Geol. Survey, Menlo Park, California. *Comment*: stratigraphically older samples elsewhere in the lake sediment have been dated as younger than the 12,390 yr of this sample. It is unlikely that this is the age of Overburden Mud. It is possible that sample consisted of some carbonaceous matter reworked from older lake sediments exposed around the edges. Additional dating will help clarify the anomaly.

W-898. Thatcher, Idaho

33,700 \pm 1000

Shells of freshwater mollusks taken from calcareous silt and clay from oldest exposed sediments of Lake Thatcher, exposed in road cut in center SW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 35, T 11 S, R 40 E (42° 26' N Lat, 111° 45' W Long), 1.5 mi NW of Thatcher, Idaho. Sample is 99% *Valvata* spp., remainder being *Carinifex* and *Pisidium* (id. by R. C. Bright). Lake Thatcher was formed by lava-damming of Bear River (Bright, 1960). Lake rose to 5484 ft alt and overflowed into Bonneville Basin to the S. This sample came from 4935 \pm 5 ft alt. Coll. 1959 by R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: two previous samples from Lake Thatcher sediments were from higher in section. W-704 (USGS V), 32,500 \pm 1000 yr was from 5290 \pm 5 ft alt; W-855 (USGS V), 27,500 \pm 1000 yr from 5170 \pm 5 ft alt.

W-899. Preston, Idaho

13,900 \pm 400

Shells of freshwater mollusks from cross-laminated sand within a series of sediments believed associated with Provo level of Lake Bonneville in N Cache Valley, Idaho. Section is exposed in road-cut, in NE $\frac{1}{4}$ NW $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 28, T 15 S, R 39 E (42° 06' N Lat, 111° 54' W Long), 1.3 mi W of Preston, Idaho. Sample alt, 4702 \pm 5 ft, ca. 10 ft below top of cut. Sample is 85% *Valvata utahensis* and *Stagnicola* spp.; remainder *Succinea*, *Gyraulus*, hydrobiids, and *Pisidium* (id. by R. C. Bright). Coll. 1959 by R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: all attempts to date the various stands of Lake Bonneville have been handicapped by lack of really good datable carbon from a definite stand or shoreline. Ages of the Provo-level samples range from ca. 11,600 to 40,000 yr. This large range is probably due to the reoccupation of the shorelines at various times, but it may reflect the unsatisfactory nature of materials dated.

W-902. Cascade, Montana

7460 \pm 250

Snail shells from undercut bank of Missouri River, 2 mi NE of Cascade, SE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 24, T 18 N, R 1 E (47° 20' N Lat, 111° 53' W Long), Montana. From buried soil horizon that may be Hypsithermal in age, with wide regional distribution. Soil, at depth 6 ft is overlain by ash (Galata ash of Horberg and Robie, 1955). Date gives age of buried soil, as well as a maximum age for ash. Underlying sample horizon are beds of clay, silt and sand. At 10 ft, in silt, a nearly complete bison skeleton was coll. and identified as *Bison antiquus*, Leidy. Clam shells from bison horizon were dated as 8800 \pm 300, W-594, (USGS V). Coll. 1958 and subm. by R. W. Lemke, U. S. Geol.

Survey, Denver, Colorado. *Comment*: shells were vibrated by an ultrasonic cleaner that removed adhering matrix.

W-918. Gallatin County, Montana **600 ± 250**

Charred wood from E wall of arroyo, in NE $\frac{1}{4}$ NE $\frac{1}{4}$ sec. 16, T 3 N, R 3 E (46° 01' N Lat, 111° 22' W Long), Clarkston Valley, Gallatin County, Montana. Charred wood is from stratum of silt a few in. thick, containing many large pieces of wood, ranging from unaltered through superficially charred, and the articulated backbone and ribs (but not head or limbs) of *Bison bison* (id. by G. E. Lewis, USGS, Denver). Stratum is 8 ft below surface of Quaternary alluvium and colluvium at least 20 ft thick. Surface has been stable long enough to develop thin soil and continuous grass cover. Coll. 1957 by G. D. Robinson, U. S. Geol. Survey, Denver, Colorado. *Comment*: locality is at head of latest arroyo cutting, probably dating from the 1870s. Wood, obviously from an occupation site, helps date time of alluviation of Clarkston Valley.

W-921. Toledo, Oregon **>40,000**

Wood embedded in silt and clay exposed in road cut along E side of Olallie Creek, 600 ft W, 2150 ft S, NE corner sec. 17, T 11 S, R 10 W (44° 38' N Lat, 123° 52' W Long), Toledo quadrangle, Oregon. Exposed Pleistocene sequence consists of 90 ft of poorly consolidated clay, silt, and sand, with thin gravel beds. Wood is abundant in lower part of section; this sample from 65 ft depth. Coll. 1958 by P. D. Snavely, Jr., U. S. Geol. Survey, Menlo Park, California. *Comment*: these sediments were believed to have been deposited in an embayment that formed in the vicinity of Toledo, Oregon, during a post-Wisconsin rise of sealevel.

W-922. Nisqually River, Washington **1640 ± 250**

Wood from a duff zone at top of a yellow pumice exposed by excavation of W approach to new Nisqually River bridge, 150 ft SW from bridge and directly beneath highest ridge of Nisqually Glacier moraine (1840 of Sigafos and Hendricks, in press) in Mount Rainier National Park (46° 47' N Lat, 121° 45' W Long), Washington. Section consists of surface till of 1840 moraine, a series of pumice layers (the sample horizon from above the uppermost pumice, a good stratigraphic marker), overlying till. Crandell and Waldron (1956) described a measured section of recent pyroclastics from Mount Rainier that is similar to that on Nisqually side of mountain. Coll. 1959 by R. D. Miller, U. S. Geol. Survey, Denver, Colorado. *Comment*: date gives minimum age for coarse yellow pumice widespread in the Mount Rainier region.

Mount Rainier series, Washington

Wood exposed on E wall of Kautz Creek during 1948 flood, ca. 0.75 mi upstream from Wonderland Trail crossing in the NE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 21, T 15 N, R 8 E (46° 47' N Lat, 121° 48' W Long), Mount Rainier National Park, Washington. Strong flood of 1948 cut channel 60 ft deep, exhuming a section consisting of (from top to base): flood deposits, 20 ft; buried forest 0 to 3 ft (sample W-926 from here); mudflow deposits, 33 ft; pumice slurry flood deposit, 3 to 15 ft; pumice ash fall, 1.5 to 2 ft; immature soil zone, 0.5 ft (W-

925 from here); mudflow deposits, less than 12 ft. W-925 was stump rooted in mudflow at base of section. Tree was killed by a 2-ft fall of lapilli from Mount Rainier or by a flood of pumice slurry and boulders that immediately followed ash fall and buried roots of tree to a depth of more than 10 ft. Still later it was buried under additional 50 ft of deposits. During this accumulation, there was a period of non-deposition, allowing a forest to grow. W-926 was from log, 10 in. in diameter, taken from this buried forest. Samples date last main eruption from Mount Rainier. Coll. 1960 by A. C. Waters, Johns Hopkins Univ., Baltimore, Maryland. *Comment*: two samples may have different ages; if so, this small difference is not detectable by C¹⁴ method.

W-925. Mount Rainier stump **350 ± 250**

Stump exposed at water level.

W-926. Mount Rainier log **350 ± 250**

Log taken from bluff 37 ft above stream bed.

W-914. Pinedale, Wyoming **11,330 ± 320**

Organic matter taken from near base of core obtained from an unnamed lake on top of left lateral moraine of Green River lobe, Pinedale in age, in NW ¼ sec. 9, T 36 N, R 110 W (43° 06' N Lat, 110° 00' W Long), 18 mi N of Pinedale, Fremont County, Wyoming. Sediment consists of dark, yellow-brown copropelic clay. Dated sample taken from 310 to 315 cm below top of core, coincident with a *Betula* maximum, below a *Pinus* minimum, and below a *Picea* maximum. Pollen analysis by R. C. Bright, Coll. 1959 by H. E. Wright, Jr. and R. C. Bright, Univ. of Minnesota, Minneapolis. *Comment*: two related samples are shells coll. from knob-and-kettle outwash of Pinedale age, 3 mi SE of Jackson Lake, Wyoming. W-392 and W-393 (USGS IV) dated 9580 ± 250 and 8800 ± 250 respectively.

D. Alaska

Sullivan Creek series, Alaska

Wood recovered from frozen silty sediments of late Pleistocene and Recent age exposed in mining excavations near Sullivan Creek, Tofty placer-mining district (65° 10' 45" N Lat, 150° 20' 15" W Long), central Alaska. Stratigraphic section is as follows: (A) massive, structureless silt, probably loess, 5 to 10 ft thick; (B) discontinuous lenses of fresh peat, large and uncompressed logs, 0 to 5 ft thick; (C) stratified organic silt, largely reworked loess, 10 to 30 ft thick; (D) pond sediments or fine fluvial gravel containing abundant bones of mammoth, bison, horse, ground squirrel, lemming and other microtine rodents, 0 to 7 ft thick, resting unconformably on underlying unit; (E) organic silt, stratified, but stratification extremely distorted, probably as consequence of having thawed out during deposition of overlying unit. Soil profile in upper 1 to 5 ft. Total thickness 10 to 20 ft; (F) pebble gravel overlying bedrock. Coll. 1956 by D. M. Hopkins, U. S. Geol. Survey, Menlo Park, California.

W-891. Wood from unit D 2520 ± 200

This appears to be much too young because beaver-gnawed wood from unit B has been dated as 6820 ± 200 (W-810, USGS V).

W-895. Wood from unit F >39,000**W-896. Omega Creek, Alaska 4100 ± 200**

Wood recovered from abandoned mining pit of Montana Mining Co. in Omega Creek opposite mouth of Montana Creek, Eureka placer-mining district ($65^{\circ} 10' 45''$ N Lat, $150^{\circ} 20' 15''$ W Long, central Alaska. Wood embedded in iron-stained but fresh gravel, 9 ft thick, overlain by gravelly peaty silt, 4 ft thick, and underlain by sequence of peat, silt, and gravel, 12 ft thick. Coll. 1956 by D. M. Hopkins, U. S. Geol. Survey, Menlo Park, California. *Comment*: age indicates specimen came from bed ca. correlative with units A and B at Sullivan Creek (see W-891, W-895).

*E. Miscellaneous***Waipahu series, Oahu**

Two samples of oyster shells were analyzed to date the 25-ft (Waimanalo) stand of sea in Hawaii. Stand is considered definitely eustatic and most probably formed during interglacial or interstadial period. A 25-ft stand is recognized in many parts of the world; in Europe it is termed by some Late Monastirian. Section consists of alluvium to the surface of an embankment at alt 20 ft with a bed of oyster shells 1 ft thick at 13 ft. Coll. 1959 by J. F. Mink; subm. by K. J. Murata, U. S. Geol. Survey, Hawaiian Volcano Observatory and Washington, D. C.

W-886. Waipahu 1 >38,000

Shells, densely packed but not cemented. Loose silty marl mixed with shells. Sample came from upper part of oyster bed at 14 ft above sealevel. Obtained from embankment at end of Awanui Street in Wailani Tract, Waipahu ($21^{\circ} 23' 13''$ N Lat, $158^{\circ} 00' 06''$ W Long), Oahu, Hawaiian Islands.

W-885. Waipahu 2 >38,000

Oysters from continuation of bed from which W-886 was taken. From embankment at end of Maikai Street in Wailani Tract, ca. 500 ft S of W-886 ($21^{\circ} 23' 10''$ N Lat, $158^{\circ} 00' 02''$ W Long), Oahu. *Comment*: activity of both samples was equivalent to age of 39,000 yr. However, as these were shells, definite possibility exists that enough modern carbon was added from atmosphere or ground water to make them look this young. They may actually be much older.

Pahala ash series, Hawaii

Pahala ash is considered only good marker bed in Hawaii. Much of the geology on the island of Hawaii is dated as pre-Pahala ash or post-Pahala ash, with age of ash itself known only as late Pleistocene. These two samples of carbonaceous ash, therefore, are extremely important to the geology of ca. 4000 square mi. The two dates, bracketing deposition of most of ash, show that fall occurred from climax of late Wisconsin glacial stage to its final retreat. Coll. 1959 by G. D. Fraser, U. S. Geol. Survey, Hawaiian Volcano Ob-

servatory, Hawaii National Park, Hawaii; subm. by K. J. Murata, U. S. Geol. Survey, Washington, D. C.

W-905. Kaone fault scarp, bottom 17,360 \pm 650

Carbonaceous ash from top of the lower bed of Pahala ash exposed on SE end of seaward-facing Kaone fault scarp (19° 20' N Lat, 155° 20' W Long), S slope of Kilauea Volcano, Hawaii. Section (Stearns and Macdonald, 1946) consists of 26 ft of upper part of Pahala ash, overlying 5 ft of pahoehoe basalt, 7 ft of lower part of Pahala ash and basalt. Carbon came from contact of lower part of Pahala ash with overlying pahoehoe. Tree molds in basalt have diameters of 10 in., proving more vegetation existed in Pahala time than at present in this desert area. This substantiates a pluvial climate here during glacial Wisconsin stage.

W-907. Maniania Pali, top 10,140 \pm 300

Carbonaceous volcanic ash exposed in sea cliff at Maniania Pali (19° 03' N Lat, 155° 35' W Long), S of Honuapo, Hawaii. Pahala ash just S is 25 ft thick (Stearns and Clark, 1930), 3 ft of ash overlain and underlain by basalt. Sample came from top of ash at its contact with overlying basalt.

W-913. Thjorsarbru, Iceland 8170 \pm 300

Peat lens, 30 cm thick, overlain by oldest Thjorsa lava flow, from Thjorsarbru, W bank of river (63° 55' N Lat, 20° 39' W Long), Arnessysla, S Iceland. Sample was taken from top of lens, within 5 cm of contact with the lava. Overlying lava flow is 130 km long, covering area of 800 square km; possibly greatest postglacial lava flow on the Earth. Coll. 1959 by G. Kjartansson, Museum of National History, Reykjavik, Iceland. *Comment:* W-482, 8065 \pm 400 (USGS IV) was peat sample from same locality, probably from same horizon.

W-909. Stokkseyri, Iceland 1910 \pm 250

Bottom layer of peat overlying oldest Thjorsa lava flow, from beach at Stokkseyri (63° 50' N Lat, 21° 06' W Long), Arnessysla, S Iceland. Sample taken from ca. 1 m below mean sealevel. Since the peat contains only fresh-water diatoms, sample antedates rise of sealevel that inundated the peat. Coll. 1954 by G. Kjartansson, Museum of Natural History, Reykjavik, Iceland. *Comment:* although peat overlies Old Thjorsa lava, date is not believed to give a close bracket (with W-913) to time of the flow. Rather, it is believed that a low-water table in the permeable lava prevented formation of peat until sea-level rose sufficiently.

W-911. Hnubbafossar, Iceland 5290 \pm 250

Plant remains, mostly of moss (*Amblystegium fluviatile*), contained in laminated clay as tough and coherent but very thin sheets. From Hnubbafossar (64° 08' N Lat, 18° 58' W Long), N bank of Tungnaa, central highlands of Iceland. Coll. 1959 by G. Kjartansson, Museum of National History, Reykjavik, Iceland. *Comment:* clay, containing organic matter, was deposited by glacial river Tungnaa in a short-lived lake dammed against edge of youngest Thjorsa

lava flow. Clay is rhythmically laminated. Sample was taken near base of clay overlying next-to-youngest Thjorsa lava flow.

W-912. Lake Thingvallavatn, Iceland **9130 \pm 260**

Carbonized plant stems from E bank of Efra-Sog River, outflow of Lake Thingvallavatn (64° 08' N Lat, 21° 02' W Long), Iceland. Plant remains are contained in surface layer of soil developed on eolian deposits, overlain by Thingvallahraun lava flow. Coll. 1957 by G. Kjartansson, Museum of Natural History, Reykjavik, Iceland. *Comment*: at contact, soil is blackened by carbonization of its organic matter by heat of lava. Thus sample precisely dates eruption of Thingvallahraun.

Saudi Arabian ground-water series

A series of samples consisting of bicarbonate and CO₂ extracted from deep water samples from Saudi Arabia was analyzed for C¹⁴ content to determine time since their precipitation as rainfall. Waters came from aquifers, at depths below well-head greater than 1200 ft. Distances from outcrop of aquifers to wells range from 24 to 250 km.

Water was coll. in large drums without air contamination. Shortly after collection, it was introduced into a solution of barium hydroxide for precipitation of CO₂ and bicarbonate. Precipitate was filtered and washed, and treated as a normal carbonate for C¹⁴ analysis. Ages of samples were computed on basis that initial C¹⁴ content was the same as that of contemporary wood, or more exactly 95% of the NBS oxalic-acid C¹⁴ standard. No C¹⁴ measurements were made here on shallow well water, to determine whether carbon in the water begins with a deficiency of C¹⁴ due to uptake of old carbon from limestone. Studies of this nature have been made in till plains of Germany by Brinkman, Munnich and Vogel (1959). Their age computations on deeper waters are based on an initial C¹⁴ content of 80 to 85% of modern wood. This subtracts ca. 2000 yr from their apparent dates. In Saudi Arabia, it is believed that infrequent and usually torrential rainfall adds water directly to sandstones and dunes above sandstones, without uptake of "dead" carbonate.

Samples coll. in 1959 and 1960 by the Arabian-American Oil Co.; subm. by Glen Brown, U. S. Geol. Survey, Washington, D. C. *Comment*: ages for deep artesian waters at Buraida, Riyadh, Khurais, and Abqaiq range from 20,400 to 24,630 yr. This is in fair agreement with a maximum estimate of 18,500 yr, the calculated time (based on gradient and permeability) for water to move from outcrop to Abqaiq; the most distant well-head. Climax of Wisconsin glacial stage occurred at this time, and high rainfall during this pluvial period must have charged the aquifers. Ages of greater than 33,000 for the water samples from the western Rub al Khali may be due to old carbonate taken up from carbonate rocks in Yemen highlands and calcareous loess E of the highlands; or the water there may actually have fallen during an earlier glacial age.

W-904. Buraida **20,400 \pm 500**

Water from town well of Buraida (26° 20' N Lat, 43° 58' E Long), Saudi Arabia, depth 1250 ft, from a flowing artesian well in Nubian-type sandstone

of Cambrian and Ordovician ages. Minimum distance to outcrop, 24 km; water, 100°F.

W-889. Riyadh 24,630 ± 500

Water from water well 180, 300 ft WSW of Shamasi powerhouse, Riyadh (24° 35' N Lat, 46° 45' E Long), Saudi Arabia, depth 3647 to 3974 ft from artesian well in Nubian-type sandstone of Triassic or Jurassic age. Distance to outcrop, 60 km.

W-897. Khurais 20,760 ± 500

Water from water well 8, in Khurais (25° 29' N Lat, 47° 58' E Long), Saudi Arabia, depth 1490 to 1693 ft, from artesian well in Nubian-type sandstone of Cretaceous age. Distance to outcrop, 70 km; water 80°F.

W-894 Abqaiq 22,500 ± 500

Water from water well 32, in Abqaiq (25° 58' N Lat, 49° 40' E Long), Saudi Arabia, depth 3003 to 3402 ft, from artesian well in same aquifer as W-897. Distance to outcrop, 250 km; water, 134°F.

W-888. Quad T-4, ST-7WW >33,000

Water from well ST-7WW in quad T-4 (17° 30' N Lat, 47° 08' E Long), depth 1617 to 3035 ft, from pumped well from a sandstone aquifer, with some calcareous beds, of Jurassic and Cretaceous age. Distance to outcrop, 75 km; water, 100°F.

W-887. Quad 0-5, ST-13WW >33,000

Water from well ST-13WW in quad 0-5 (18° 20' N Lat, 47° 08' E Long), depth 3435 to 3506 ft, from pumped well from sandstone aquifer with some calcareous beds, of Permian age. Distance to outcrop, 200 km; water, 98°F.

II. ARCHAEOLOGIC SAMPLES

W-915. Fell's Cave, Chile 10,720 ± 300

Charcoal from fire pit from oldest occupation layer of Fell's Cave, a shelter at North Arm Station (52° 04' S Lat, 69° 07' W Long), Chile, near Strait of Magellan. Shelter was formed by Rio Chico undercutting volcanic rock, leaving basal deposit of sand and clay, now 19.5 ft above stream. Hunters of the giant sloth and native horse camped on this fresh floor, building fires in depressions. Small shrubs were used for fuel, judging from some pieces of charcoal which retained their form. Area is treeless today and may have been then. A roof rock-fall interrupted the occupation, as the articulated foreleg, neck and skull of a horse were found directly beneath the slabs. Subsequent reoccupation was by people with different hunting equipment, after extinction of horse and sloth. Coll. 1959 by J. B. Bird, American Museum of Natural History, New York; subm. by Clifford Evans, U. S. National Museum, Washington, D. C. *Comment*: two related samples from Patagonia are the Mylodon Cave sloth dung (C-484, 10,832 ± 400, Chicago I), and Palli Aike Cave, burned bone (C-485, 8639 ± 450, Chicago I). Details of find, with its relation to changes in sealevel, recession of glacial Lake Laguna Blanca, and volcanic activity, were given by Bird (1938).

W-916. Tell Gat, Israel**4410 ± 250**

Carbonized grains of wheat, uncovered during excavations at Tell Sheikh Ahmed el Ureini, known as Tell Gat (31° 38' N Lat, 34° 48' E Long), Israel. Grains coll. by Israel Dept. of Antiquities, during its 1957 campaign, from debris of large building in Stratum IV. Subm. by Immanuel Ben-Dor, Emory Univ., Atlanta, Georgia. *Comment*: debris showed clear signs of conflagration, and judging from other material coll. at the same level, should belong to Early Bronze I age, 3100-2900 B.C. era. Grains were probably contained in large pottery jar, which had been crushed by destruction of building, as they were found accumulated in one spot. Jar was completely recovered. Level 131.00, locus 4001, no. 509, room 61.

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CARBON-14 DATING IN PISA—II

G. FERRARA, G. FORNACA-RINALDI and E. TONGIORGI

Istituto di Antropologia e Paleontologia Umana, Università di Pisa

CNEN*—Laboratorio di Geologia Nucleare—Pisa

Almost all radiocarbon measurements reported in the following list have been made with the same equipment and method used for the measurements reported in our previous work (Pisa-I). The sample used as contemporary standard for these samples is also charcoal obtained from *Arbutus unedo* wood grown near Pisa between 1948 and 1956. The value obtained from this standard has also been used for shell samples.

An Oeschger-Houtermans counter, manufactured in the Institute of Physics University of Bern, is now operating; this counter, shielded with 1.5 cm of lead and 30 cm of iron, has, with acetylene at a pressure of 530 mm, a background of 1.59 counts/min. With such conditions oak wood grown near Pisa between 1890 and 1900 has an activity of 13.49 counts/min. This wood is now used as standard. Samples Pi-119, Pi-153 and Pi-150 have been measured with the new counter; their ages have been calculated by comparison with the oak-wood standard and referred to 1950.

For evaluation of the magnitude of the Suess effect we are now measuring the two contemporary standards with the two counters.

SAMPLE DESCRIPTIONS

I. ARCHAEOLOGIC SAMPLES

Italy

Pi-119. Levanzo

9694 \pm 110

Shells (*Patella ferruginea*) from lower part of the deposit in the Cala Genovesi Cave, at Levanzo Island (38° 00' N Lat, 12° 20' E Long). Sample was taken by P. Graziosi during the 1953 excavation, at a depth of about 2 m. The age determined corresponds to the age of the first human habitation in this cave. It probably took place soon after a coastal economy developed. This economy was based on marine and terrestrial shell harvest. Later this food became of increasing importance and continued to be so until the beginning of the Neolithic. A stone engraved with a figure of a wild ox was found at the same depth where the sample was found. This stone appears to have been engraved in the same manner as human and animal figures engraved on the walls of the cave (Graziosi, 1950). Hence it is possible to correlate this prehistoric art with the age of the sample. Subm. by P. Graziosi, Istituto di Paleontologia dell'Università di Firenze.

La Punta series

The deposit in the La Punta Cave, 20 km SE of Avezzano (41° 57' N Lat, 13° 39' E Long), was excavated by Radmilli and Tongiorgi in 1959. Below

* Comitato Nazionale per l'energia Nucleare (National Committee for Nuclear Energy).

the Neolithic layers no cultural remains were found in a section of the deposit 2 m thick. The next 2 m below contained stone implements and a large number of bones of birds and small mammals which can be supposed to have been captured with traps.

Pi-153. Grotta La Punta 1

10,581 \pm 100

Charcoal from the lower part of the above described section. Underneath this section, a deposit of 1.50 m thickness was formed during a period in which cave was not inhabited. This period is represented in the nearby Ortucchio Cave by sample Pi-23, 12,619 \pm 410 (Pisa I).

Pi-152. Grotta La Punta 2

14,488 \pm 800

Charcoal from the lower part of a still deeper layer, also 1.50 m thick. A few bones found with this sample seem to indicate an economy different from that of the layer of Pi-153. This economy belonging to an Upper Paleolithic culture and based on the hunting of large mammals, is well represented by remains found in many nearby caves. A 10-cm bed of volcanic ash has been found in upper part of this layer. The ash is believed not to have been re-deposited after the eruption and provides a good base of correlation for this whole region.

Pi-101. Penne Di Pescara

6578 \pm 135

Charcoal from the central open hearth in a house-site of a prehistoric village 3 km from Penne di Pescara (42° 28' N Lat, 13° 56' E Long). Sample was collected by G. Leopardi during the 1958 excavation, one m below the surface. Two different kinds of pottery were found in association. One of these is the "impressed" pottery, persisting from a lower Neolithic culture; the other is a yellowish, unpainted and untempered ware indicating the beginning of middle Neolithic (Radmilli, 1959a). Subm. by G. Leopardi, Comitato per le Ricerche Preistoriche in Abruzzo, Soprintendenza alle Antichità di Chieti.

Grotta Piccioni series

Samples were taken from a cave (Grotta dei Piccioni) located on the rocky side of the valley of Orte River, 500 m ENE of Bolognano (42° 13' N Lat, 13° 58' E Long). Remains ranging from middle Neolithic to Iron Age have been found in the deposit excavated (1957-1960) by A. M. Radmilli, Istituto di Antropologia e Paleontologia Umana dell'Università di Pisa, who supplied the samples.

Pi-46. Grotta Piccioni 1

6247 \pm 130

Charcoal from an horizon where pottery belonging to an early phase of a middle Neolithic culture was found. At the same horizon both impressed and yellowish pottery were found. The latter was made from untempered clay and its surface was either unpainted or decorated with a red design, without a black outline.

Pi-49. Grotta Piccioni 3

4770 \pm 110

Charcoal from an upper horizon in the part of the deposit containing remains of an upper Neolithic culture. Some types of pottery are known only in

this cave; others are similar to those of the Ripoli culture; still others were evidently influenced by the Lagozza culture dated at 4794 ± 90 (Pi-34, this date list).

Pi-50. Grotta Piccioni 4

4306 ± 105

Charcoal from a layer containing, in this thicker part, remains of an Eneolithic culture clearly influenced by the Remedello culture.

Pi-47. Grotta Piccioni 2

9465

Earth, rich in carbonaceous matter, but without pieces of charcoal, from a lower horizon in the same upper Neolithic layer from which sample Pi-49 (4770 ± 110 , this date list) was obtained. The C^{14} age, clearly too old, was inexplicable until bitumen pieces (Fig. 1) were found in the same layer. Ex-



Fig. 1.

Piccioni Cave—Abruzzo—Italy
Upper Neolithic

Fig. 1. Bitumen piece found at the same level of sample Pi-47 (nat. size).

Fig. 2. Yellowish untempered ware repaired with bitumen (1/2).

Fig. 2.

traction of bitumen from limestones in this region was practiced also during the Roman period. Upper Neolithic inhabitants of Piccioni Cave used the bitumen to repair broken vessels, one of which (of the yellowish untempered ware) is shown in Fig. 2.

Pi-34. Lagozza

4794 \pm 90

Part of a wooden piling driven deep into the lacustrine deposit during the lake-dwelling phase represented by the archaeologic zone 15 to 30 cm thick at Lagozza di Besnate, 6 km NNW of Busto Arsizio (45° 42' N Lat, 80° 46' E Long). This locality, typical of the upper Neolithic Lagozza culture, was excavated by O. Cornaggia-Castiglioni in 1953 and 1954 (Cornaggia-Castiglioni, 1955), Soprintendenza alle Antichità-Milano, who submitted the samples.

Pi-100. Asciano

4248 \pm 115

Charcoal found by R. Peroni during the 1955 and 1956 excavation of the deposit under a rock ledge in the locality named "La Romita", near Asciano, 7 km NE of Pisa (43° 44' N Lat, 10° 29' E Long). Sample was collected at the horizon containing some of the cultural remains, which in central Italy are frequently found in burials of the Rinaldone type (related to the Remedello culture). Subm. by R. Peroni, Istituto di Antropologia e Paleontologia Umana dell'Università di Pisa.

Pi-87. Barche di Solferino

3341 \pm 115

Wood from lake dwelling of Barche di Solferino (Zorzi, 1940) 27 km NW of Mantova (45° 32' N Lat, 10° 34' E Long). Archaeologic findings belong to the Polada culture. Subm. by F. Zorzi, Museo Civico di Verona.

Pi-88. Ledro

3137 \pm 105

Part of wooden piling collected by R. Battaglia during the 1937 excavation of lake dwelling found in the Ledro lake, 7 km SE of Riva del Garda (45° 51' N Lat, 10° 43' E Long) (Battaglia, 1953). Sample is probably contemporaneous with Polada type of pottery, but, owing to the long occupation of the Ledro lake dwellings, this association is not entirely certain. Subm. by Cleto Corrain, Istituto di Antropologia dell'Università di Padova.

Pi-81. Lavagnone

3099 \pm 120

Wood from the inner part of piling underneath lake dwelling found during the extraction of peat in the Lavagnone marsh, 1 km SE of Desenzano del Garda (43° 28' N Lat, 10° 34' E Long). The abundant prehistoric pottery found by F. Fussi, belongs to the same culture as the Late Bronze Age finds in Isolone del Mincio (Pi-25, 3333 \pm 115; Pi-26, 3100 \pm 113; Pisa I). Subm. by F. Fussi, Museo Civico di Verona.

Pi-91. Castione Marchesi

2944 \pm 105

Wood from the Terramare of Castione dei Marchesi near Fidenza, 26 km from Parma (44° 54' N Lat, 10° 03' E Long). Subm. by Museo Nazionale di Antichità di Parma.

Pi-80. Fucino

3366 \pm 130

Charcoal coll. during S.M. Puglisi's 1958 excavation in a prehistoric vil-

lage in the Fucino plain near Ortucchio, 19 km SE of Avezzano (41° 57' N Lat, 13° 39' E Long). This village, on basis of shape and decoration of vessels, is considered to belong to the sub-Appennine culture (Late Bronze Age) (Radmilli, 1959a). The remains of this village were found 50 cm below the surface and were superimposed upon a habitation layer with remains of an older (Eneolithic) village (Radmilli, 1959b). Subm. by S. M. Puglisi, Museo Preistorico L. Pigorini di Roma.

Pi-53. Grotta del Farneto **3240 ± 110**

Charcoal from refuse deposit outside the Farneto Cave, 10 km SE of Bologna (44° 26' N Lat, 11° 23' E Long). Sample was coll. during the 1951 excavation (Bermond-Montanari and Radmilli, 1954 and 1955) in an horizon very rich in pottery and implements. In spite of some archaic types, these materials have been classified as belonging to the sub-Appennine culture (Late Bronze Age). Subm. by A. M. Radmilli, Istituto di Antropologia e Paleontologia Umana dell'Università di Pisa.

Pi-54. Grotta Misa **3030 ± 75**

Charcoal found during the 1947 excavation of Cardini, Rittatore and Tongiorgi in the Misa Cave, 16 km N of Montalto di Castro (42° 30' N Lat, 11° 38' E Long) (Rittatore, 1949). Sample was taken from a circle of charcoal within which wheat, beans, millet and flour were burned, probably ritually (Tongiorgi, 1947). Bronze objects and pottery found in the cave are representative of the sub-Appennine culture (Late Bronze Age). Subm. by E. Tongiorgi.

Pi-94. Ancona **2780 ± 95**

Charcoal from lower part of archaeological sequence found by D. Lollini (1956) in the "Colle dei Cappuccini" within the town of Ancona (43° 37' N Lat, 13° 31' E Long). First period of habitation, represented by this sample, occurred during the time of the proto-Villanovan culture. Subm. by D. Lollini, Soprintendenza alle Antichità di Ancona.

Pi-1. Grotta del Fauno **2318 ± 105**

Charcoal found in 1955 by A. M. Radmilli during an excavation under a rock ledge, 13 km SE of Pescasseroli (41° 44' N Lat, 13° 50' E Long). The deposit, 2.5 m thick, consists of rubble with beds of charcoal and ashes, which in the upper part are of the Roman period, and in the lower part contain pre-Roman pottery showing a local persistence of some Iron Age types. Sample was taken from upper part of pre-Roman deposit (Radmilli, 1956). Subm. by A. M. Radmilli, Istituto di Antropologia e Paleontologia Umana dell'Università di Pisa.

Pi-84. Canoe del Trasimeno **744 ± 100**

Wood from one of the dugouts found on shore of Trasimeno lake (43° 11' N Lat, 12° 8' E Long) during drainage operations in 1958. Sample was submitted by the Soprintendenza alle Antichità di Etruria di Firenze, because in the absence of any other kind of remains, it was impossible to confirm the supposed prehistoric age of the dugouts.

II. GEOLOGIC SAMPLES

*Italy***Pi-116. Lago di Massaciuccoli** **5646 \pm 220**

Shell (*Purpura haemastoma* Consul) found in silica-sands, extracted for industrial purposes between -12 and -26 m below sealevel, near Torre del Lago (Lago di Massaciuccoli), 15 km NNW of Pisa (45° 50' N Lat, 10° 19' E Long). Subm. by E. Tongiorgi.

Pi-150. Stagno **2991 \pm 115**

Posidonia fibres in a near-shore sediment found near Stagno, 16 km SSW of Pisa (43° 36' N Lat, 10° 24' E Long) 2 m below sealevel, during the excavation of a channel. The sediment was deposited at the end of the last period of open sea at this locality. Subm. by E. Tongiorgi.

Pi-75. Campi Flegrei **10,090 \pm 215**

Calcareous petrified wood found during drilling of tunnel through Vomero hill (40° 51' N Lat, 14° 21' E Long). The fossil wood was in a greenish-gray tufa, belonging to the yellow tufa formation at Naples. Subm. by P. Lucini, Istituto di Geologia Applicata di Napoli.

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UNIVERSITY OF MICHIGAN RADIOCARBON DATES VI

H. R. CRANE and JAMES B. GRIFFIN*

The University of Michigan, Ann Arbor, Michigan

The following is a list of radiocarbon dates obtained since the preparation of the manuscript for the publication of Michigan V, in December, 1959. The method of measurement and treatment of data are the same as those described in the introductions to Michigan lists III and IV. A full statement on the Michigan counter is referred to by Crane (p. 46) in this issue.

We acknowledge the help of Patricia Dahlstrom for the chemical preparation of the samples and of Alan L. McPherron and George J. Armelagos in the preparation of descriptions. We are indebted to the Michigan Memorial-Phoenix Project for the major part of the financial support of the laboratory.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Central U. S.

M-1138. Saginaw, Michigan 5280 \pm 300

Northern white-cedar log from floor of a buried forest, found in a clay pit being excavated to make a private fish pond (43° 25' N Lat, 84° 00' W Long), Saginaw County, Michigan. Sample, probably drowned by rising Lake Nipissing at alt 572 ft, was buried with other forest materials beneath 18 ft of silty clay, in an ancient erosion notch in the bank of Tittabawassee River. The overlying silt shows no clear indication of intervening dry periods and suggests continual filling of the pond. Coll. August 1960 and subm. by Mark Papworth, Museum of Anthropology, Univ. of Michigan. *Comment:* date suggests that Nipissing rose rapidly and evenly to 605-ft level. Nearby Andrews site has an occupation at 592.2 ft alt, dated 5300 \pm 300 (M-941, Michigan V, p. 34), which was covered by Nipissing water. The Andrews site was re-occupied at 3170 \pm 300 (M-659, Michigan V, p. 34) on what was probably a shore of Zumberge Zee, a Univ. of Michigan name for a large embayment of Lake Algoma time, SW of Saginaw Bay.

M-653. Williams Farm, Michigan >30,000

Wood, subm. by E. P. Gibson, Grand Rapids, Michigan, from the Williams farm, located ca. .25 mi from Flat River (43° 1' N Lat, 85° 17' W Long), Otisco Township, Ionia County, Michigan. The specimen, found in 1877 during digging of a well, was located at depth of 87 ft, below a layer of 50 ft of blue clay. *Comment:* a pre-Wisconsin tree fragment, deeply buried by drift.

M-855. Mackinaw City, Michigan 5270 \pm 300

Root end of hemlock log from 2400 ft W of the shore of Straits of Mackinac and 225 ft W of approach to Mackinac Bridge (45° 46' 35" N Lat, 84°

* The authors of this paper wish to register their protest at the editorial policy, common to most geologic journals, that dictates deletion, wherever possible, of *al* from such words as *geologic* and *archaeologic*.

44' 00" W Long), Emmet County, Michigan. Log lay horizontal in sandy gravel at alt 597 ft, covered with ca. 6 or 7 ft of sediment. Soil at this site mapped as Alpena Cobbly loam (Foster and Shearin, 1939). Gravel extends several ft below the log. Beneath gravel is gray silt and clay (possibly marly), underlain by red clay (possibly varved). Bedrock (limestone) appears to lie at 25-ft depth. Many other buried logs are reported ca. 4 or 5 ft lower than the log sampled. Coll. June 1957 and subm. by R. W. Kelley, Geol. Survey Div., Lansing, Michigan. *Comment*: sample was exposed for 6 yr.

M-855A. Mackinaw City, Michigan, fresh sample 5650 \pm 300

Fresh sample of log from which M-855 was taken. M-855A had not been exposed to the air. Coll. May 1958 and subm. by R. W. Kelley, Geol. Survey Div., Lansing, Michigan. *Comment*: much of original ground surface has been stripped and it is unlikely that much new information can be obtained in the field. A study of air photos and alt of the log give some credence to the idea that the feature was a beach of Lake Algoma. C¹⁴ date indicates this tree lived during the Stanley-Nissing transition. It appears likely that the hemlock inhabited the lacustrine plain abandoned by Lake Algonquin and was knocked down and buried by action of rising water, prior to Nipissing stage.

M-968. Stonington Peninsula, Michigan 5720 \pm 250

Wood from pit, ca. 500 ft from high-water line of Lake Michigan, along the E to W center line of sec. 33 (45° 49' 10" N Lat, 86° 46' 40" W Long), Stonington Peninsula, Delta County, Michigan. Log from which specimen was cut was uncovered at depth of 7 to 8 ft. Bottom of pit was limestone bedrock, overlain by 1 to 1.5 ft of gray clay. Clay was overlain by a dark soil, 1-ft thick, in which the wood was located. Soil zone was overlain by ca. 5 ft of sand. Surface elevation is 600 ft above sealevel. Dark soil is ca. 5 ft above present Lake Michigan, as measured by aneroid barometer. Coll. March 1959 and subm. by A. E. Slaughter, Geol. Survey Div., Escanaba, Michigan. *Comment*: location is ca. 25 ft below shoreline of Lake Nipissing (M-855, M-855A, M-1012 and M-1138, this list).

M-1012. Thompson's Harbor, Michigan 7250 \pm 300

Charred wood from two separate stumps *in situ* on lake bottom at depth of 15 ft below the surface in Lake Huron, 300 yd from the mouth of Thompson's Harbor, SE of Rodgers City (ca. 44° 23' N Lat, 83° 36' W Long), Michigan. This alt is ca. 175 ft below Algonquin beach. It is supposed that the trees were covered by water rising from the Chippewa-Stanley low level of the Huron basin and that fire had occurred before that time. Coll. by D. R. Brackenbury, Geol. Survey, Mt. Pleasant; subm. by J. H. Zumberge, Univ. of Michigan. *Comment*: see also M-834 (7850 \pm 350, Michigan V) for sample of drowned organic material in Lake Michigan basin, ca. 155 ft below Lake Algonquin.

M-694. Elkhart, Indiana 9320 \pm 400

Bone from American mastodon (*Mammot americanus* Kerr) found 2 mi due W of freight office at Elkhart (41° 44' N Lat, 86° 59' W Long), Indiana.

Sample found in marl below 16 ft of muck and peat. Coll. January 1957 by Scott Talbot; subm. by C. W. Hibbard, Univ. of Michigan. *Comment*: the date seems reasonable.

M-936. Val-Lor-Will Farm, Wisconsin **>30,000**

Log, id. as spruce by J. M. Dryn, from Val-Lor-Will farm ($42^{\circ} 32' 55''$ N Lat, $88^{\circ} 30' 30''$ W Long), Walworth County, Wisconsin, from morainal deposits on S side of Lake Geneva. Sample, probably transported by ice, lay depth of 18 to 20 ft in Darien terminal moraine of Cary age, as mapped by Alden (1918). Coll. September 1957 by Robert Schramski; subm. by R. F. Black, Univ. of Wisconsin, Madison. In spite of the mapping by Alden, the deposits seem to be older than Cary when weathering and surface expressions are compared with Valparaiso Moraine of Illinois or Kettle Interlobate Moraine of Wisconsin. *Comment*: sample of same log, W-638, was dated $31,800 \pm 1200$ (USGS V).

M-1067. Lloyd's Rock Hole, Pennsylvania **9540 ± 500**

Small mammal bones, mostly hare (*Lepus americanus*), from Lloyd's Rock Hole, 1.5 mi NE of New Paris ($40^{\circ} 7' N$ Lat, $78^{\circ} 37' W$ Long), Bedford County, Pennsylvania. Specimen found 17.5 to 21.5 ft below mouth of sink-hole. Coll. 1959 by A. D. McCrady and R. R. Bossart, Carnegie Museum, Pittsburgh, Pennsylvania; subm. by J. E. Guilday, Carnegie Museum. Should date an associated fauna of 53 vertebrates and 12 invertebrates (Guilday and Bender, 1958) and an associated pollen profile. Fauna and flora are boreal in character and late Pleistocene in age. Date should provide a minimum terminal date for the Pleistocene peccary, *Mylohyus*, and a basis for correlation with other Appalachian cave faunas, similar in species composition but unrelated to any particular stage of the late Pleistocene. The C^{14} run on this specimen was somewhat shorter than normal 48-hour period. *Comment*: the date is slightly later than expected.

M-1103. Jones local fauna, Kansas **>30,000**

Fossil snails from Jones local fauna ($37^{\circ} 14' N$ Lat, $100^{\circ} 16' W$ Long), Meade County, Kansas. Sample was from a 1-ft thick measured section taken from bed no. 5, Jones Sink, Vanhem Formation, Meade County, loc. 13. Coll. summer of 1955 and subm. by C. W. Hibbard, Univ. of Michigan. *Comment*: considered Late Wisconsin in age. See Downs (1949; 1954) and Tihen (1942) for description of the fauna.

M-832. Butler Spring, Kansas **40 ± 150**

Wood (cedar ?) from depth of 2 ft in Butler Spring ($37^{\circ} N$ Lat, $100^{\circ} 26' W$ Long), SW $\frac{1}{4}$ sec. 33, T 34S, R 29W, Meade County, Kansas. Coll. July 1941 by Henry Cochran and C. W. Hibbard; subm. by Hibbard, Univ. of Michigan. Specimen was coll. because there were no growing trees or stumps in this area when settled by Cochran in 1905.

M-854. Montague County, Texas **1350 ± 150**

Charcoal from base of terrace on N bank of Dye Creek, 6 mi S of St. Joseph ($33^{\circ} 35' N$ Lat, $97^{\circ} 30' W$ Long), Montague County, Texas. Found

with vertebrates, invertebrates and flint chips. Should help to interpret the terrace development and history of stream entrenchment. Coll. April 1958 by W. W. Dalquest, William Melton and C. W. Hibbard; subm. by Hibbard, Univ. of Michigan.

B. Colorado

Colorado lake-bed samples, dated in order to correlate with microfossils, the rate of sediment deposition, trophic changes in lake waters, vegetational history of areas immediately surrounding the three sites, and possibly with the last recession of valley glaciers of the Colorado Front Range. A comprehensive paper including these phases of the project is now in preparation at Univ. of Colorado. All samples were coll. and subm. by R. W. Pennak, Univ. of Colorado, Boulder.

Muskee Lake series, Colorado

Organic lake sediment from freshly exposed side of large test pit, dug in artificially drained lake, could be taken easily with no danger of contamination. Muskee Lake is a small lake with intermittent outflow, 2617 m alt ($39^{\circ} 59' N$ Lat, $105^{\circ} 30' W$ Long), Boulder County, Colorado. Coll. November 1954. *Comment*: deposits below these samples are sand, gravel and clay mixtures.

M-948.	60 cm depth	920 ± 150
M-950.	40 to 46 cm depth	3120 ± 200
M-951.	60 to 66 cm depth	3870 ± 250
M-952.	80 to 86 cm depth	4350 ± 400

Silver Lake Gate bog series, Colorado

Lake sediments from a filled-in pond formerly supplied with water from a stream now 40 m from edge of bog proper, alt 2980 m, ($40^{\circ} 1' N$ Lat, $105^{\circ} 35' W$ Long), Boulder County, Colorado. The bog vegetation is sedge and arctic willow. Samples taken September 1955 with Hiller peat borer. *Comment*: sampler could not be forced to a greater depth because of coarse gravel.

M-953.	From surface to depth of 25 cm	< 150
M-954.	Between depths of 50 to 75 cm	910 ± 150
M-955.	Between depths of 100 to 125 cm	3470 ± 250
M-956.	Between depths of 150 and 175 cm	6190 ± 300

Bedrock Lake series, Colorado

A small lake with intermittent outflow at alt of 3090 m, ($40^{\circ} 6' N$ Lat, $105^{\circ} 33' W$ Long), Boulder County, Colorado. Organic lake deposits coll. October 1953 with a Hiller peat borer. Lake was 1.6 m deep at sampling point in center of basin.

M-957.	Between mud-water interface and a depth of 10 cm	935 ± 150
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M-958.	Sediment 20 to 30 cm below mud-water interface	1525 \pm 200
M-959.	Sediment 40 to 50 cm below mud-water interface	2600 \pm 200
M-960.	Sediment 60 to 70 cm below mud-water interface	460 \pm 200
M-961.	Sediment 80 to 90 cm below mud-water interface	3330 \pm 200
M-962.	Sediment 100 to 110 cm below mud-water interface	2890 \pm 200
M-963.	Sediment 120 to 130 cm below mud-water interface	3020 \pm 200
M-964.	Sediment 140 to 150 cm below mud-water interface	5940 \pm 700
M-965.	Sediment 160 to 170 cm below mud-water interface	5560 \pm 300
M-966.	Sediment 180 to 190 cm below mud-water interface	6680 \pm 400

M-939. American Falls Lake Beds, Idaho **>30,000**

Charcoal from the American Falls Lake beds on SE shore of American Falls Reservoir (42° 56' N Lat, 112° 41' W Long), Bingham County, Idaho. Charcoal scattered through fossiliferous zone, upper limits lying ca. 14 in. below present beach surface, lower limits from 2 to 3 ft below beach surface. The zone is composed of sand, locally cemented by limonite. Site is ca. 10 yd out from cliff behind beach and 30 ft above nearby *Bison latifrons* horizons, dated W-358, at >32,000 (USGS IV). There is no reason to suppose the charcoal was left by man. Coll. August 1959 and subm. by M. L. Hopkins, Idaho State College, Pocatello. See Hopkins (1951; 1955) for report on fauna of this deposit.

M-1052. Clark Peninsula, Windmill Island, Antarctica **6040 \pm 250**

Coralline algae Archaeolithothamnion from Clark Peninsula, Windmill Island (66° 15.5' S Lat, 110° 31.2' E Long), Antarctica. Sample found 65 ft above present sealevel. Coll. by R. L. Cameron, Columbus, Ohio; subm. by J. H. Zumberge, Univ. of Michigan. *Comment*: raised beaches, indicating higher relative sealevel, exist up to 100 ft on Windmill Islands and are believed to have been formed during recent geologic period. The age of the algae should approximate the climax of the warming trend following the retreat of the Wisconsin-Würm ice.

II. ARCHAEOLOGIC SAMPLES

A. Upper Mississippi Valley and Great Lakes

M-790. Missaukee Mound 2, Michigan **750 \pm 150**

Bark from a layer 15 in long by 10 in. wide and 1.5 in. thick, over a copper axe (6.25 in. by 1.5 in. at the poll end, 2.5 in. at the bit end, and

0.375 in. thick). Axe had been inclosed in beaver(?) skin and tied, near bit end, with a 2-ply, 2-twisted, (counter clockwise) cord of bast fiber. Axe was associated with an adult-male burial in a small, low mound (44° 17' N Lat, 85° W Long) sec. 23, Aetna Township, Missaukee County, Michigan. *Comment*: excavated 1925 by E. F. Greenman (Greenman, 1926) and originally attributed to the Hopewell culture. Association of the mound with the Missaukee earthworks, burial characteristics, and the C¹⁴ date, A.D. 1270, indicates Late Woodland age.

M-1070. Dumaw Creek Site, Michigan 280 ± 150

Organic material with burial at Dumaw Creek (43° 50' N Lat, 86° 20' W Long), sec. 5, R17W, T16N, Oceana County, Michigan. Coll. 1917 by Carl Schruppf. Organic material composed of witches' brew of fur and hair from raccoon, beaver, elk, bear and buffalo, plus human hair and fragments of human and animal tissue, in direct association with skull of burial found beneath roots of white pine stump (*Pinus strobus*) 30 in. in diam. Tree probably was cut between A.D. 1870 and 1880. Cultural remains from this site are indicative of the very Late Woodland period. There is, however, no evidence of European contact. Copper artifacts are of Lake Superior copper. Subm. by G. I. Quimby, Chicago Natural History Museum, who is preparing a publication on the burial.

Juntunen Site series, Michigan

Charcoal from the Juntunen Site (20 MK 1), (45° 49' N Lat, 84° 35' W Long), Mackinac County, Michigan. Series should date time span of occupation of this Late Woodland site, as well as dating three separate occupations separated by wind-blown sand. Coll. August 1960 by A. T. Steegman, Univ. of Michigan; subm. by Alan McPherron for the Museum of Anthropology, Univ. of Michigan.

M-1140. Juntunen Site, 1.5 ft 890 ± 150

Sample from square 1880-1130 between square sheets 4 and 5 at a depth of 1.5 ft.

M-1141. Juntunen Site, 2.0 ft 1050 ± 150

Sample from square 1880-1130 between square sheets 6 and 7 at a depth of 2.0 ft. This level is a grey-black layer, separated by sand from the level above and below.

M-1142. Juntunen Site, 4.0 ft 1125 ± 150

Sample from square 1880-1130 between square sheets 10 and 11 at a depth of 4.0 ft. This is the lowest gray band containing cultural material. This layer is separated from the overlying zones by wind-blown sand.

M-907. Turpin Farm Site, Ohio 675 ± 150

Charcoal pieces from a single log found at Turpin Farm Site, 100 yd W of the Turpin house (ca. 39° 15' N Lat, 84° 25' W Long), Anderson Township, Hamilton County, Ohio, from bottom of a refuse pit which extends from 2 to 3 ft below the surface. Coll. December 1958 by J. H. Chapman, Cincinnati,

Ohio; subm. by J. B. Griffin. Fort Ancient pottery of the Madisonville Focus variety was found beside and underneath the wood. *Comment*: date seems satisfactory for a part of the time span of the Fort Ancient Aspect (Griffin, 1943; Oehler, 1950).

M-910. Haffner-Kuntz Site, Ohio 1375 \pm 150

Charcoal from Haffner-Kuntz Site (33 Ha 9), NE of Kellogg Avenue Bridge over Little Miami River (ca. 39° 15' N Lat, 84° 26' W Long), Anderson County, Ohio. Charcoal was found with shell and bone at 3 ft, 6 in. to 4 ft depth. Coll. 1958 by W. F. Starr, Cincinnati Museum of Natural History; subm. by J. B. Griffin. In this Fort Ancient site 540 shell-tempered sherds were found (Starr, 1960). Over three-fifths of the sherds are Madisonville Plain, the remainder being equally divided between cord-marked and smoothed-over cord-marked. One of the vessels was a long-necked water bottle. Two extended burials were also found, one with slab-lined tomb and a triangular projectile point. *Comment*: date is slightly greater than expected.

M-928. West Mound, Ohio 1830 \pm 200

Charcoal from N side of tomb 4 in a Hopewell mound N of Marshall and near Rocky Fork Lake (ca. 39° 11' N Lat, 83° 29' W Long), Highland County, Ohio. This is the same mound dated as M-650, 1890 \pm 200 (Michigan, III). This mound was excavated and a report published by Tom Porter and Don McBeth (1956; 1957); subm. by Don McBeth, Kingston, Ohio.

M-929. Clough Mound, Ohio 2120 \pm 200

Charcoal from burned house in Adena mound on N border of Waverly, Peepee Township (ca. 39° 9' N Lat, 82° 58' W Long), Pike County, Ohio. Mound partially excavated in the 1890s by Gerard Fowke (1902; 1928). It is listed as mound 17 by Greenman (1932) and as mound 192 by Webb and Baby (1957). Excavated in 1953 by McBeth and Porter who reported their observation in Porter and McBeth (1956); subm. by Don McBeth, Kingston, Ohio.

M-871. Beloit Mound Group, Rock County, Wisconsin 1460 \pm 150

Charcoal from mound 6 on Beloit College campus (42° 31' N Lat, 89° 1' W Long), Rock County, Wisconsin. Samples lay on floor of mound. Original humus layer had been removed before erection of the mound. This and other mounds are regarded as part of the Effigy Mound culture of Wisconsin. Date is apparently early in the life of the Effigy Mounds of the upper Mississippi Valley. Excavated 1958 and subm. by Tyler Bastian, Univ. of Utah.

Steuben Site series, Illinois

Mussel shell and charcoal from a Hopewell burial mound and a related village occupation at Steuben Site (40° 59' N Lat, 89° 26' W Long) Marshall County, Illinois. A report on this site will be published by Museum of Anthropology, Univ. of Michigan.

M-439. Steuben Site, Mound Ma° 202 2110 \pm 200

Mussel shell from mound containing Late Hopewell Zoned pottery and

other artifacts. Excavated in early 1950s by D. F. Morse and D. F. Morse, Jr., of Peoria. This date is probably somewhat too early, as mussel shell from the Illinois River tends to yield dates substantially earlier than true age. See also M-378, 1650 ± 350 (Michigan II) charred wood from the same site.

M-440. Steuben Village, level 4 1325 \pm 200

Charcoal from level 4 of strata pit excavated by D. F. Morse. Pottery sequence in this pit runs from Hopewell to early Late Woodland types.

M-441. Steuben Village, level 5 1275 \pm 200

Charcoal sample from level 5 of strata pit excavated by D. F. Morse. Pottery sequence in this pit runs from Hopewell to early Late Woodland.

M-545. Steuben Village, unit #2, 1.5 to 2 ft 1900 \pm 200

Charcoal sample from excavation unit #2, 1.5 to 2 ft in strata pit excavated by J. B. Griffin and D. F. Morse for Museum of Anthropology, Univ. of Michigan.

M-548. Steuben Village, unit #2, 2 to 2.5 ft 2010 \pm 200

Charcoal sample from 2 to 2.5-ft level of pit excavated by J. B. Griffin and D. F. Morse, Univ. of Michigan.

M-758. McDougal-Hartman Mound, Illinois 2270 \pm 200

Wood fragments from undisturbed log from the McDougal-Hartman Mound, located 0.25 mi S of the Dickinson site, N of Mossville ($40^{\circ} 50' N$ Lat, $89^{\circ} 31' 30'' W$ Long), Peoria County, Illinois. Mound was disturbed by amateurs in 1941. A central sub-floor log tomb and bundle burials at either end were undisturbed. A vessel of Havana Zoned Stamped cord-wrapped stick variety was associated with burials at W side of tomb. Sample coll. September 1957 by Elaine Bluhm and W. J. Beeson (Bluhm and Beeson, 1960); subm. by J. C. McGregor, Univ. of Illinois, Urbana.

M-759. Renschville Mound, Illinois 1990 \pm 200

Wood fragments from logs placed over burials in the Renschville Hopewell Mound ($40^{\circ} 50' N$ Lat, $89^{\circ} 31' 30'' W$ Long), Peoria County, Illinois. Associated with burials and a cache of bone awls, copper awl, flake knives, bear teeth and a wolf incisor. Coll. by Elaine Bluhm and W. J. Beeson (Bluhm and Beeson, 1960); subm. by J. C. McGregor, Univ. of Illinois, Urbana.

M-760. Caterpillar Mound, Illinois 2010 \pm 150

Wood from Caterpillar Mound, N of Mossville ($40^{\circ} 50' N$ Lat, $89^{\circ} 31' 30'' W$ Long), Peoria County, Illinois. Sample is from well-preserved log at N edge of Hopewell tomb, on top of bundle burials. Rectangular sub-floor tomb, dug into gravel, contained extended burials in center and bundle burials at N end. Copper wire wound spirally around a wooden staff, a flake knife, and a curved-base platform pipe were associated with burials. Coll. September 1957 by Elaine Bluhm and W. J. Beeson (Bluhm and Beeson, 1960); subm. by J. C. McGregor, Univ. of Illinois, Urbana. A sample of the same log was run at Univ. of Arizona as A-60A with a date of 1900 ± 350 and as A-80B with a date of 2080 ± 200 (Arizona II).

M-743. Harper's Ferry Mound group, Iowa 1730 \pm 150

Wood charcoal from Valley Mound in Harper's Ferry Mound group (42° 11' N Lat, 91° 10' W Long). The mound contained evidence of heavy firing in a shallow pit. No burials were found but very late rocker-stamped pottery and a Late Woodland vessel with cord-impressed, upper-rim design were recovered. Excavated in 1934. Collections of State Historical Society of Iowa; subm. by W. C. Logan, National Park Service, Washington, D. C.

M-744. French Town Mound group, Iowa 1720 \pm 150

Wood charcoal from mound of above group, located in Clayton County, Iowa (42° 49' N Lat, 91° 8' W Long). A charcoal stratum, 12 ft in diam. was found in a burial pit in this mound. Below charcoal layer was a small very late Hopewell vessel with plain rocker-stamping on the body. Material in collections of State Historical Society of Iowa; subm. by W. C. Logan, National Park Service, Washington, D. C.

Turin Site series, Iowa

Human and bison bones from Turin Site (42° 1' 24" N Lat, 95° 57' 55" W Long), Monona County, Iowa.

M-932. Turin Site, 13- to 14-ft level 4720 \pm 250

Most of skeleton no. 3, an adolescent found flexed on its left side, in burial pit sprinkled with red ochre and associated with a side-notched projectile point and a string of several gastropod shell beads. This and other pits were dug in sandy to silty loess. Coll. September 1955 by R. J. Ruppé and W. D. Frankforter; subm. by Ruppé, State Univ. of Iowa (Ruppé, 1956).

M-1071. Turin Site, 11-ft, 8 in.-level 6080 \pm 300

Lumbar vertebrae and sacrum from *Bison* sp. found in articulated position, lying horizontally in N face of excavation in loess valley fill which contained human skeleton (M-930, this date list). Bison bones were 30 ft SE in an horizon 8 ft below the human remains (11 ft, 8 in. below the surface, according to Frankforter). Stratification of site was continuous across this face. Bones coll. August 1955 and subm. by W. D. Frankforter, Sanford Museum, Cherokee, Iowa (Frankforter and Agogino, 1959). *Comment*: these dates offer an index of the rate of loess accumulation along E side of Mississippi River. Simonsen Site, which contained point of a type similar to the single point found with M-930, was dated 8430 \pm 520 by Isotopes, Inc. (I(UW)-79, Isotopes I). The Simonsen Site also contains bison (*Bison occidentalis*).

*B. Lower Mississippi Valley and Southeast***M-909. Gaines Site, Kentucky 2070 \pm 200**

Charcoal from Gaines Mound (39° 8' N Lat, 84° 44' W Long), Boone County, Kentucky. Sample is from top level, 5 to 6 ft above mound base. Cultural material is judged to be Late Adena. Coll. 1958 by Ellis Crawford, William H. Behringer Foundation; subm. by J. B. Griffin, Univ. of Michigan. Sample M-908, 1975 \pm 200 (Michigan V) came from base of mound. *Comment*: it is doubtful that Late Adena can be as late as some archaeologists have accepted.

M-600. Vaughn Site I, Missouri 890 \pm 150

Charred pieces of bone from Vaughn Site I, 23 SN 203, (36° 36' N Lat, 93° 19' W Long), Stone County, Missouri. Sample from deep combination-cremation-and-bundle burial at a depth of 4 to 6 ft below surface of terrace of White River. Specimen was associated with an engraved bowl and a gorget. Vessel appears to be from the Caddoan area and resembles middle-to-late Spiro types. Coll. July 1955 and subm. by C. H. Chapman, Univ. of Missouri, Columbia, who has given a preliminary report on this site (Chapman, 1957).

M-897. Creve Coeur Lake, Missouri 2070 \pm 200

Charred antler (originally B 277) from a bluff above Creve Coeur Lake Site (23 SL 20), Creve Coeur Lake (ca. 38° 40' N Lat, 90° 30' W Long), St. Louis County, Missouri. Sample from level XI, 34 to 37 in. below datum, associated with Middle and Late Hopewell sherds and worked stone. Coll. and subm. by L. W. Blake, St. Louis, Missouri.

M-918. Cherry Valley Site, Arkansas 1030 \pm 150

Charred bone from burial 86 at summit of primary mound 3 (11 N 17) in the Cherry Valley Mound group (35° 26' N Lat, 90° 45' W Long), Mitchell Township, Cross County, Arkansas. Found in association with seeds and cloth material. Coll. 1958 and subm. by Gregory Perino, Thomas Gilcrease Foundation, Tulsa, Oklahoma. *Comment:* M-917 (Michigan V, p. 37) from beneath mound 2 was dated 1250 \pm 150. This site yielded a new culture complex for NE Arkansas and is important because of a remarkable resemblance of some of the pottery vessels to the Tippet bean pot, found at Cahokia, in Illinois. May represent splinter group created by population increase at Cahokia.

M-729. Bowman Farm Site, Tennessee 760 \pm 150

Charred cane, thatch, and wood from Bowman Farm Site, mound 2 (36° 19' 30" N Lat, 84° 1' 45" W Long), Campbell County, Tennessee. From collapsed, burned arbor of small poles, earlier than mound 1 and disturbed by building on primary floor of mound 1. Coll. February 1934 and subm. by T. M. N. Lewis, Univ. of Tennessee, Knoxville. Should date Irvin Focus in Norris Basin area (see Webb, 1938, p. 10-25, for discussion of this site), and is probably slightly later than Hiwassee Island Focus.

M-730. Alford Site, Tennessee 930 \pm 150

Charred wood from the Alford Site, mound 4 (35° 50' 10" N Lat, 84° 33' W Long), Roane County, Tennessee. Specimen was from burned log associated with burial 6 ft, 7 in. below apex of mound. Coll. April 1941 by Wendell Walker; subm. by T. M. N. Lewis, Univ. of Tennessee, Knoxville. Should date the late Hamilton burial-mound culture. Pottery found at site is predominately Hamilton Plain (Lewis and Kneberg, 1946, p. 83).

M-731. De Armond Site, Tennessee 670 \pm 150

Charcoal from burned roof of Early Mississippi council house (distinguished by small posts) at de Armond Site, (35° 51' 10" N Lat, 84° 35' 5" W Long), Roane County, Tennessee. The house was first structure built on old humus beneath platform mound. Coll. May 1941 by John Alden; subm. by T.

M. N. Lewis, Univ. of Tennessee, Knoxville. *Comment*: sample should date a late variant of Hiwassee Island Red-on-Buff pottery. A wide-neck bottle with rayed-sun design lay on floor of structure. Sherds of earlier Red-on-Buff variant were present on the site.

Russell Cave series, Alabama

Charcoal from within Russell Cave ($34^{\circ} 58' \text{ N Lat}, 85^{\circ} 48' 32'' \text{ W Long}$), Doran Cove, Jackson County, Alabama. The cave, as described by Broyles (1958) and Miller (1958), has been excavated extensively. The excavation controls used by Miller are not the same as those of the earlier excavators. Coll. and subm. by C. F. Miller, Smithsonian Institution, Washington, D. C.

M-845. Russell Cave, 2.0 ft. 8750 ± 500

Charcoal from hearth in square 10, at depth of 2.0 ft. Sample associated with Middle Woodland cultural material. *Comment*: two dates attributed to this complex have been reported previously; M-557 (Michigan IV, p. 187) from the Middle Woodland level within the cave dated 1110 ± 200 years ago; M-765 (Michigan IV, p. 187), a Middle Woodland sample from a mound 100 yd. NNE of cave gave a date of 1560 ± 200 . M-845 is much too early to be attributed to any Woodland culture.

M-846. Russell Cave, 7.5 ft. 7970 ± 450

Charcoal from large shallow fire pit in square 12 at depth of 7.5 ft. Sample is attributed by the excavator to an Early Archaic context. *Comment*: M-591 (Michigan II, p. 1101) from the 5.5-ft level, attributed by the excavator to the Archaic, was dated 6300 ± 350 .

M-847. Russell Cave, 8.5 ft. 8350 ± 500

Charcoal blanket covering a typical Early Archaic semiflexed male burial in square 30 at a depth of 8.8 ft. *Comment*: M-766 (Michigan IV, p. 187) from earliest occupation level at a depth of 23 ft was dated at 9020 ± 300 . An adequate correlation of the dates with the cultural complexes and depth from datum will be provided in Miller's publication of his excavations.

M-995. Money's Bend Site, Alabama 550 ± 150

Charcoal from village site midway between the Coosa and Chatooga rivers, ca. 2.5 mi SW of Cedar Bluff (ca. $34^{\circ} 12' \text{ N Lat}, 85^{\circ} 38' \text{ W Long}$), Cherokee County, Alabama, from borrow trench of feature 1, a palisade. Site was interpreted as late Middle Woodland because of high proportion of plain limestone-tempered pottery. Excavated summer of 1959 and subm. by C. H. Fairbanks, Florida State Univ., Tallahassee (Keel, 1960). *Comment*: date seems to be too young but the charcoal may well be intrusive and associated with Mississippi pottery on the site.

M-1064. Etowah Site, Georgia 850 ± 150

Charcoal from Etowah Site ($34^{\circ} 5' \text{ N Lat}, 84^{\circ} 50' \text{ W Long}$), 3 mi S of Cartersville, Bartow County, Georgia. Sample (cat. #3459) from feature 19 of mound C. Coll. September 1958 and subm. by L. H. Larson, Atlanta, Georgia. *Comment*: this famous center of Mississippi culture is particularly

important for establishing the duration of the climax of southeastern ceremonial activities (Kelly and Larson, 1957). Other samples from mound C have been dated 725 ± 200 , 910 ± 200 and 500 ± 250 (M-402, M-542 and M-543, Michigan IV, p. 188). Archaeologic data also indicate that burial activities at mound C extended a considerable period of time.

Chauga Mound series, South Carolina

Charcoal from Chauga Mounds, Hartwell Basin Survey ($34^{\circ} 36''$ N Lat, $83^{\circ} 10' 02''$ W Long), Oconee County, South Carolina. Coll. 1958 by R. S. Neitzel; subm. by A. R. Kelly, Univ. of Georgia, Athens.

M-933. Chauga Mound, Feature 15 1120 \pm 150

Charcoal from N50-60, W60-70; Fd. no. 191 in feature 15, a hearth overlying burial 17. The burial was intrusive from the mound 3 phase into feature 14 of the mound 1 phase. *Comment*: according to Kelly, mound 3 and 4 stages at Chauga represent a composite Etowah-Savannah culture, and are approximately equivalent to Etowah 3 at the Etowah (type) site.

M-934. Chauga Mound, Feature 26 1070 \pm 150

From N60-70, W70-80, Fd. 178, feature 26, the pre-mound base. *Comment*: should be older than M-933 and M-935.

M-935. Chauga Mound, Feature 9 770 \pm 150

From N90-100, W70-80, Fd. 143, feature 9, adjacent to Fd. 144 (rock slab) on mound 3. Belongs with M-933 to about the mound 3 stage of Chauga mound.

C. Northeastern United States and Canada

Cresap Mound series, West Virginia

Charcoal from the Cresap Mound Site ($39^{\circ} 50'$ N Lat, $80^{\circ} 49'$ W Long), Marshall County, West Virginia. Coll. summer 1958 and subm. by D. W. Dragoo, Carnegie Museum, Pittsburgh, Pennsylvania. The series dates an Eastern Adena mound, exceptional in that good artifact types can be correlated with the dates. Dragoo has made preliminary reports on the site (1958; 1959a; 1959b).

M-976. Cresap Mound, below floor 2240 \pm 150

Charcoal (originally F. C. #3191) found in fill in sub-floor tomb (feature 28, burial 54). A fire had been built over the tomb, and with collapse of the logs the charcoal fell directly into the tomb. Sample was found 7.5 ft E and 210 ft S at depth of 0 to 0.8 ft below floor of mound.

M-975. Cresap Mound, 0.8 ft above floor 2190 \pm 200

Charcoal (originally F. C. #3187) from near edge of West Primary mound, 8 ft W and 9.2 ft N, at an elevation of 0.8 ft above floor of mound. Samples M-975 and M-976 are from widely separate features near the floor of the mound, and should date an early period in the construction of the mound.

M-974. Cresap Mound, 6.7 ft above floor 2020 \pm 150

Charcoal (originally F. C. #3185) from feature 24, burial 44, 13.1 to

16.1 ft E and 0 to 3.2 ft N at an elevation of 6.75 ft above floor of mound. Sample came from a large feature, near several other features, on a major level of activity about midway in the mound; should date the middle occupation of the mound.

Site 18 AN 18 series, Maryland

Charcoal and bark from Site 18 AN 18, along Chesapeake Bay (38° 53' N Lat, 76° 31' W Long). Site is a cremation and reburial cemetery of a culture with many similarities, especially in stone pipes, to Adena and Ohio artifacts (Ford, 1958).

M-927. Site 18 AN 18, crematory pit 2300 ± 200

Charcoal scattered through crematory pit and concentrated in fire pits located within crematory pit; also, bark on top of reburial in separate pit. Coll. 1955 to 1957 and subm. by T. L. Ford, Jr., Archaeological Society of Maryland, Buxton.

M-419B. Site 18 AN 18, excavation #7 1960 ± 200

Charcoal from excavation #7, specimen 7B. Coll. and subm. by John Witthoft, Historical Commission, Harrisburg, Pennsylvania, and T. L. Ford, Jr.

M-420B. Site 18 AN 18, excavation #8 2110 ± 200

Charcoal from excavation #8, specimen 8B. Coll. and subm. by John Witthoft, Historical Commission, Harrisburg, Pennsylvania, and T. L. Ford. *Comment*: other dates from this same site are: M-419C, 1700 ± 250 (Michigan I); M-416A, 2310 ± 200; M-417A, 1850 ± 200 (Michigan V).

M-911. Lamoka Lake Site, New York 4480 ± 300

Wood charcoal, mostly carbonized bark, from hearth 1 in test trench 2, Lamoka Lake Site (42° 25' N Lat, 77° 5' W Long), Tyrone Township, Schuyler County, New York. The hearth was found at base of a narrow subsoil pit, 8 in. wide and 8 in. deep. Overlying soil consisted, from above downward, of a 9-in. plow zone, a 7-in. white and gray ash layer and 8 in. of dark soil with bone refuse. Coll. 1958 and subm. by W. A. Ritchie, New York State Museum and Science Service, Albany, New York. *Comment*: this is the type site of the Lamoka culture of the Early Archaic in New York State. Another type Lamoka sample is M-912, 4410 ± 250 (Michigan V, p. 38); (see earlier summary in Michigan IV, p. 184).

M-969. Wapanucket Site #6, Massachusetts 4300 ± 250

Charcoal from burial no. 2 and 3 of Wapanucket Site #6, N shore of Lake Assawompsett (41° 51' 18" N Lat, 71° 54' 10" W Long), Plymouth County, Massachusetts. Burials were found at ca. 40 cm below present surface and extended to 85 cm below the present surface. Cremated human bone was present. Burial no. 2 contained a quantity of red ochre, four gouges, one plummet and two sharpening stones; burial no. 3 contained a semi-lunar knife and a sharpening stone. Coll. 1957 by A. C. Staples and Maurice Robbins; subm. by Robbins, Attleboro, Massachusetts. *Comment*: date confirms suspicion that this crematory pit and pit #29 near lodge floor #5 (M-764, 4250 ± 300, Michigan IV, p. 184) are from the same general period (Robbins, 1960).

*D. Western United States***M-946. The Pinnacles Site, South Dakota 1060 \pm 150**

Fragments of bone and charcoal from The Pinnacles site, Badlands National Monument (43° 52' N Lat, 102° 13' W Long), South Dakota. Sample was from the lowest of four occupation levels in the side of a gully and from 13 to 14 ft beneath the surface. Associated pottery was identified as Stanley Braced Ware. Coll. 1958 and subm. by D. C. Taylor, Montana State Univ., for the U. S. National Park Service. *Comment*: this date does not support a geologic interpretation of the overburden as having been deposited during Altithermal time.

M-947. Conata Basin Site, South Dakota 660 \pm 150

Bison bone from Conata Basin site, Dillon Pass area (ca. 43° 45' N Lat, 102° 06' W Long), Badlands National Monument, South Dakota. The bison bones were in a clay deposit, 3 to 3.5 ft below ground surface. The clay deposit was overlain by alluvial fill. Coll. June 1958, by John Clark, South Dakota School of Mines; subm. by D. C. Taylor, Montana State Univ., Missoula, for U. S. National Park Service. *Comment*: this date does not support an interpretation that the bison was Late Pleistocene or early recent in age.

Glendo Reservoir Site series, Wyoming

Wood samples from the Glendo Reservoir Site (48 Pl 24), Glendo Reservoir area, near town of Glendo (ca. 42° 30' N Lat, 105° 1' W Long), Platte County, Wyoming. Coll. and subm. by William Mulloy, Univ. of Wyoming, Laramie.

M-971. Glendo Reservoir Site, habitation #6, upper level 1325 \pm 150

Charred wood (originally #2) from upper level of habitation #6, associated with Late Middle period artifact complex. Mulloy estimated date ca. 3000 B.P. *Comment*: sample originally contained many rootlets.

M-972. Glendo Reservoir Site, hearth 2020 \pm 200

Wood (originally #3) from hearth 441 in same stratified area as M-971 but at a lower level, associated with Middle Period complex, expected to date near M-971.

M-973. Glendo Reservoir Site, above habitation #6 1025 \pm 150

Wood (originally #4) from a level stratigraphically above Late Middle Period occupation. Sample was associated with a somewhat scanty Late Period complex. Estimated age, A.D. 500, or later.

M-783. Thorne Cave Site, Jensen, Utah 4230 \pm 250

Charcoal from remains of a campfire found in lowest habitation layer in Thorne Cave, on Cliff Creek (40° 30' N Lat, 109° 15' W Long), Uintah County, Utah. Cave is 100 ft wide and 40 ft deep. Deposits showing human habitation are ca. 6 ft deep, overlain by 3 to 4 ft of sterile sand. Coll. November 1957 and subm. by R. C. Thorne, Jensen, Utah. *Comment*: charcoal dates

a non-ceramic complex, consisting of a notched scapula and a few flint pieces comparable to Danger Cave III (Jennings, 1957). Site is entirely sealed by alluvium, presumably of Altithermal age. Notched scapula is almost identical with one from Humboldt Cave, described by Heizer and Krieger (1956, p. 139). Age of material exceeds that of Humboldt Cave, but is slightly younger than expected by Jennings.

M-919. Stockhoff Ranch Site, Oregon **2600 \pm 200**

Wood charcoal from test square 197 + 96.8, level 5, Pacific Northwest Pipeline Archaeological Project, schedule 12, Stockhoff Ranch Site (45° 13' N Lat, 118° 1' W Long), Union County, Oregon. This level is composed of water-laid materials ranging from pea-sized gravel to fine sand. Sample was associated with chipping detritus occurring from the surface to a depth of 3.5 ft. Coll. 1955 by A. L. Bryan and D. R. Touhy; subm. by E. H. Swanson, Idaho State College Museum, Pocatello. *Comment:* site a basalt quarry and contained tools very similar to those found by Carter (1958) in Reno area of Nevada. Carter claimed that his implements date from Wisconsin I to Wisconsin II, 30,000 to 10,000 B.P.

M-942. Windy Spring Site, Washington **1080 \pm 200**

Turtle carapace from square 1211, 24- to 30-in. level, and bone fragments from square IV, 36- to 42-in. level. Samples are from levels 5 thru 7, the oldest culture-bearing strata, in yellow-gray part of "B" soil horizon at the Windy Spring Site (47° 21' N Lat, 119° 38' W Long), Grant County, Washington. Coll. August 1958 by B. R. Butler (1958); subm. by Douglas Osborne, Mesa Verde National Park, Colorado. *Comment:* the association is with polyhedral cores and microblades suggestive of northern influences and also with elements of plateau or desert culture, such as grinding slabs and manos.

M-937. Childers Site, California **610 \pm 150**

Charcoal from the 12- to 24-in. level in an unstratified midden found at Childers Site (39° 22' N Lat, 121° 3' 20" W Long), Nevada County, California. The midden has a total depth of ca. 36 in. The site is a manifestation of the "Martis complex" as described by Heizer and Elsasser (1953). Coll. July 1954 and subm. by R. F. Heizer, Univ. of California.

M-938. Gunther Island Shellmound Site, California **1050 \pm 200**

Marsh material (carbonized wood and vegetable detritus material mixed with dirt) from the Gunther Island Shellmound Site (40° 48' N Lat, 124° 9' 5" W Long), Humboldt Bay, California. Marsh material on which the mound or midden rests was sampled at 8 ft, 8 in. below the mound surface. Coll. 1913 by L. L. Loud (1913, p. 266-68); subm. by R. F. Heizer, University of California, Berkeley. *Comment:* it is hoped that this sample will establish a maximal date for the occupation on Gunther Island, as well as for the mound itself.

M-1066. Boarding School Site, Montana **360 \pm 150**

Charcoal which included rootlets from Blackfoot Indian reservation (48° 38' 18" N Lat, 112° 57' 27" W Long), Montana, taken from layer 21 in S

wall of square 25 W 1, in a bison-drive site with deep stratification (Kehoe and Kehoe, 1960). Coll. 1952 and subm. by T. F. Kehoe, Saskatchewan Museum of Natural History. *Comment:* (J.B.G.) this date may be somewhat too recent, because of the rootlets.

E. Mexico

Santa Marta Cave series, Chiapas, Mexico

Charcoal from Santa Marta Cave (16° 48' N Lat, 93° 23' W Long), Chiapas, Mexico. Coll. by R. S. MacNeish and F. A. Petersen; subm. by R. S. MacNeish, National Museum of Canada, Ottawa.

M-977. Santa Marta Cave, level 2 1870 ± 200

Charcoal from square N3E1, level 2, floor 6, zone A. *Comment:* sample should date the Classic period, remains of the Piedra Parada phase. This should have some relevance to the Maya Calendar problem.

M-978. Santa Marta Cave, level 5 3280 ± 200

Charcoal from square S1E2, level 5, zone C. *Comment:* should date Chiapa de Corzo, Period I, Early Formative.

M-979. Santa Marta Cave, level 7 7320 ± 300

Charcoal from square S1E2, level 7, floor 3, zone F. *Comment:* should date late Santa Marta pre-ceramic complex.

M-980. Santa Marta Cave, level 9 8730 ± 400

Charcoal from square N1E1, level 9, floor 2, zone G. *Comment:* should date the early Santa Marta complex in this cave.

F. Far East and Pacific

M-921. Rano Raraku Lake Site, Easter Island 100 ± 150

Totora reeds, *Scirpus riparius* L., living in freshwater lake of Rano Raraku (27° 10' S Lat, 109° 25' W Long), Easter Island. Coll. November 1955 to April 1956 by C. S. Smith, with Thor Heyerdahl; subm. by Smith, Univ. of Kansas, Lawrence. *Comment:* totora reeds (M-732, 1650 ± 250, Michigan IV) were used to date Ahu number 1, Ahu Tepeu Site (E-13), Easter Island (grave 2). Smith considers this too old. A sample of bone (M-870, 330 ± 110, Michigan V) was subm. from this same site. This specimen, M-921, was dated to determine the C¹⁴ age of modern reeds. Scientific reports of the Heyerdahl expedition are still in manuscript.

M-689. Eider Point, Aleutians 890 ± 150

Populus driftwood (id. by T. P. Bank, II) from Eider Point (53° 57' 35" N Lat, 166° 35' 40" W Long) a long, low spit forming the western entrance to Unalaska Bay, Unalaska Island, eastern Aleutians. Sample was from SE quad. sec. A, excavation unit #2, level 6, 2.5 ft below datum level which is 2 ft above the basal cobble beach underlying the site. Coll. August 1954 by F. Hadleigh-West; subm. by T. P. Bank, II, Ann Arbor, Michigan. *Comment:* the site, one of the deepest in the area (30 ft of cultural deposits), is quite dif-

ferent culturally from the Amaknak D Site (Bank, 1953a; 1953b), which is only 5 mi away. The first occupation of Eider Point (M-687, Michigan V, p. 44, from 2 ft above datum line was 740 ± 150) occurred later than Amaknak D (M-676, M-677, M-678, M-681 and M-682, Michigan IV, p. 193, with dates from 1880 to 1100 B.P.).

G. Continental Old World

Ereta del Pedregal series, Spain

Peat from Ereta del Pedregal ($39^{\circ} 00' \text{ N Lat, } 00^{\circ} 4' \text{ W Long}$), Valencia Province, Spain. The bog deposit, 80 cm thick, lies beneath 150 cm of clay and above rock. Coll. September 1957 by Josefa Menéndez Amor and F. Florschütz; subm. by Menéndez Amor, National Museum of Natural Sciences, Madrid, Spain.

M-753. Ereta del Pedregal, 160 cm level **3930 ± 250**
Bog material from the upper 10 cm of the deposit.

M-754. Ereta del Pedregal, 230 cm level **6130 ± 300**
Bog material from the 230 cm level of the deposit. *Comment:* samples date formation of bog, which occurred in Neolithic-Eneolithic-Bronze times. Pollen analysis has produced a diagram in which *Quercetum mixtum* is dominant, but with fairly high percentages of *Pinus*; other trees do not exceed 10%. The spectrum at 230 cm shows predominance of *Pinus*, followed by *Quercetum mixtum*, and low percentage of *Betula*.

M-994. Soto de Medinilla, Spain **2175 ± 200**

Charred wheat from Soto de Medinilla ($41^{\circ} 39' \text{ N Lat, } 4^{\circ} 44' \text{ W Long}$), a Celtic town in isthmus of a large meander of Pisuerga River, a tributary of the Duero, Valladolid, Spain. Specimen came from interior of round-house no. 1 and was found beneath a hearth of the latest Celtic level, which was covered by a Celto-Iberian level. Sample dates a Bronze Age "Celtic Population" which is associated with Celtic town Cortes de Navarra (Ebro). Uppermost Celto-Iberian level continues into layers showing Romanization which occurred in the 2nd century B.C. A comparable specimen of wheat was given to Hans Helbaek of Copenhagen, for study. Coll. October 1957 and subm. by Pedro de Palol, Univ. of Valladolid, Valladolid, Spain.

M-931. Holzhausen Site, Germany **3560 ± 250**

Charcoal from a barrow in the neighborhood of a mound of the single-grave culture, near Holzhausen ($52^{\circ} 49' 13'' \text{ N Lat, } 8^{\circ} 27' 52'' \text{ E Long}$), Gemeinde Wildeshausen, Landkreis Oldenburg, Germany. Charcoal was found within a horseshoe-shaped stone arrangement at the former ground surface. The find indicates a cremation, but no grave was discovered. Apparently the body was simply burned and only later mounded over. Two later burials, in the form of cremations, without grave goods, were intruded in the mound built over the burned body. As such bone beds are found primarily from Pre-Christian Iron Age, the funeral pyre beneath the mound must be still older,

i.e. Bronze-Iron Age. Coll. November 1957 and subm. by J. Pätzold, State Museum of Natural Science and Prehistory, Damm 40, Oldenburg, Germany.

M-932. Einen Site, Germany

2220 ± 150

Charcoal from Einen Site (52° 49' 13" N Lat, 8° 27' 52" E Long), Geimeinde Goldenstedt, Kreis Vecta, Germany, from a cremation at ground level at Point I. A small, round barrow was erected over this funeral pyre. An embankment was constructed over this mound and a further covering of earth extends over this embankment. Burned bones, and iron fittings from ornaments of a shield, were found between the pieces of charcoal. On the basis of these finds, the burial was thought to date around 500 B.C. The last covering over the mound has been dated (by secondary burials) between 500 and 200 B.C. This brackets the age of the embankment, the secondary burials being younger, and the original burial older.

Safadi Site series, Israel

Safadi Site is a subterranean village, dug in the alluvial sandy loam forming the upper part of the Wadi Sheba Terrace, near Beersheba (31° 13' 30" N Lat, 34° 46' 45" E Long), Israel. The culture discovered at Safadi is intrusive in Palestine and localized in Jordan Valley and the southern portion of the country. Samples coll. 1954 and 1955 and subm. by Jean Perrot, Directeur, Mission Archeologique Francaise en Israel.

M-864B. Safadi, 1.5-m level

5270 ± 300

Burnt wood (terebinth ?), (original sample 346), from locus 318, was associated with fireplace in open pit house, 1.5 m below present surface. From the same archaeological level as M-864A.

M-864C. Safadi, 1.8-m level

5120 ± 350

Burnt wood (terebinth ?), (original sample 320) from locus 325, a bell-shaped silo, 1.8 m below surface. May be later than samples 346 and 693, but total duration of the occupation of the site does not exceed 200 to 300 yr.

M-864A. Safadi, 3.0-m level

5420 ± 350

Burnt wood (terebinth ?), (original sample 693), from locus 309, on floor of a subterranean passage ca. 3 m below the surface. This is considered the best specimen, since at this level there was no possibility of contamination by roots. *Comment:* Perrot believes that the Beersheba people were the first Armenoids to make their appearance in the Middle East and that they introduced copper metallurgy into Palestine. His estimate for Beersheba culture at Safadi was 3500 to 3000 B.C. (Perrot, 1955; 1957).

Zimbabwe Acropolis series, Africa

Charcoal from acropolis on Zimbabwe Hill (20° 15' S Lat, 30° 56' E Long), Southern Rhodesia, Africa. Dates the Iron Age of Southern Rhodesia. Coll. 1958 by E. R. Robinson, National Museum of Southern Rhodesia; subm. by Roger Summers, National Museum, Bulawayo, Southern Rhodesia. Reported by Summers (1955).

M-913. Zimbabwe Acropolis, lowest level **1630 ± 150**

The deepest charcoal specimen (former no. 58452) dates the end of earliest Southern Rhodesia Iron Age cultures, and the beginning of Iron Age cultures associated with mining. Expected to date 1500 B.P.

M-914. Zimbabwe Acropolis, middle level **875 ± 150**

Charcoal from middle level (former no. 58403), associated with a change in ceramic style; provides the earliest possible date for walling at Zimbabwe. Estimated to date 1000 B.P.

M-915. Zimbabwe Acropolis, highest level **510 ± 150**

Charcoal from the highest level (former no. 58355) where a second change in ceramic style occurs; dates the end of early walling phase and beginning of the period associated with the best quality walling (Type Q). Expected to date 17th century A.D.

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YALE NATURAL RADIOCARBON MEASUREMENTS VI

MINZE STUIVER and EDWARD S. DEEVEY

Geochronometric Laboratory, Yale University, New Haven, Connecticut

The following list includes most of the measurements made since publication of Yale V; some measurements, such as a series collected in Greenland by A. L. Washburn, are withheld pending additional information or field work that will make better interpretations possible. In addition to radiocarbon dates of geologic and/or archaeological interest, we give in the third part of the paper, for the first time since 1954 (Deevey and others, 1954), recent assays of C^{14} in lake waters and other lacustrine materials, now normalized for C^{13} content. Some of these C^{13} values have been published separately (Oana and Deevey, 1960), but most have not. We follow the newly accepted convention (Lamont VIII) in expressing normalized C^{14} values as

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

where Δ is the per mil deviation of the C^{14} of the sample from any contemporary standard (whether organic or a carbonate) after correction of sample and/or standard for real age, for the Suess effect, for normal isotopic fractionation, and for deviations of C^{14} content of the age- and pollution-corrected 19th-century wood standard from that of 95% of the NBS oxalic-acid standard; δC^{14} is the measured deviation from 95% of the NBS standard, and δC^{13} is the deviation (measured on a Consolidated mass-spectrometer, Model 21-401) from the NBS limestone standard, both in per mil. These assays, made in 1958 and later, are of course variously affected by artificial C^{14} resulting from nuclear tests, and we withhold detailed or general comments until our studies have continued for at least another season.

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

Y-762. Port Hood Island, Nova Scotia 10,710 \pm 240

Populus (id. by W. L. Stern) wood and peat from between two tills, N shore of Port Hood Island (46° 01' 17" N Lat, 61° 33' 49" W Long), Nova Scotia. Section exposed in ancient sink in gypsum, transected by modern wave-cut cliff. It shows 4 ft of modern organic material overlying 7 ft of till. This till is underlain by a lens, 5.5 ft thick, of interbedded organic material and sand, and then by till, of which 20 ft is exposed. Coll. 1959 and subm. by

Charles F. Hickox, Jr., Colby College, Waterville, Maine. *Comment*: the sample appears to be of Two Creeks age, as expected. A pollen zone believed to be correlative with the Valders substage was dated at Gillis Lake, Nova Scotia (Y-524, $10,160 \pm 160$, Yale IV).

Y-773. Blue Hill Bay, Maine

2970 \pm 140

Birch (?) wood from a stump rooted in gray silty clay, now submerged at least 13.5 ft at high tide (as indicated by hand-levelling), E side of Trumpet Island ($44^{\circ} 14' 07''$ N Lat, $68^{\circ} 26' 05''$ W Long), Blue Hill Bay, Maine. Stump is rooted in firm substratum, probably postglacial marine sediment; thus subsidence due to compaction is considered unlikely. Coll. 1959 and subm. by A. L. Bloom, Yale University (now at Cornell University, Ithaca, N. Y.). *Comment*: similar dates of stumps in similar stratigraphic positions are: W-396, 2980 ± 180 , Wells, Maine (USGS IV) and W-508, 2810 ± 200 , Wells, Maine (USGS V). A younger date was given by W-509, 1280 ± 200 , Kennebunk Beach West, Maine (USGS V), and older dates were given by W-510, 3250 ± 200 , Kennebunk Beach East, Maine (USGS V), L-118, 4150 ± 200 , Sagadahoc Bay, Maine (Lamont II), and Y-156, 4190 ± 200 , Odiorne Point, New Hampshire (Yale IV). Y-773 shows greater submergence than any of the others, and was expected to be older than most of them; as it is not, the possibility of differential land movements along the Maine coast must be considered.

Y-840. Killam's Point, Connecticut

910 \pm 120

Cedar root, imbedded in growth position 32 in. below MHW, S end of Killam's Point Marsh ($41^{\circ} 15'$ N Lat, $72^{\circ} 50'$ W Long), Branford, Connecticut. Inclosing peat contained abundant fragments of stalks and culms of *Scirpus*, overlain by 4 in. of silty *Spartina alterniflora* peat and 22 in. of *S. patens* peat. Coll. 1960 and subm. by A. L. Bloom, Yale University (now at Cornell University, Ithaca, N. Y.). *Comment*: Killam's Point Marsh was the subject of a classic study by Knight (1934). The date, like that of Y-855 (this date list), indicates a recent marine transgression at a rate of about 3.5 in. per century.

Y-855. Guilford Point, Connecticut

1180 \pm 80

Oak log, imbedded in 14-in. layer of black freshwater peat, 45 in. below surface of tidal marsh (which is at MHW), W edge of Guilford Point ($41^{\circ} 16'$ N Lat, $72^{\circ} 40'$ W Long), Guilford, Connecticut. Log protruded from face of wave-cut bank of peat; the freshwater layer was overlain by 40 in. of gray muddy salt-marsh peat, and underlain by gray-brown medium sand. Coll. 1960 and subm. by A. L. Bloom, Yale University (now at Cornell University, Ithaca, N. Y.). *Comment*: see Y-840 (this date list) for a similar date showing a comparable rate of submergence at Killam's Point, 8.5 mi W.

Y-843. Stiles Brickyard, Connecticut

6810 \pm 170

Log, imbedded in well sorted cross-stratified gray medium sand, overlain by 2 ft of gray medium sand, 3.5 ft of gray silt, and 13 ± 1 ft of estuarine peat, SE corner of Stiles Brick Co. clay pit ($41^{\circ} 22'$ N Lat, $72^{\circ} 53'$ W Long),

North Haven, Connecticut. Section similar to that described by Brown (in Flint, 1930); the sand, interpreted as alluvium, unconformably overlies laminated New Haven clay. Coll. 1960 and subm. by A. L. Bloom, Yale University (now at Cornell University, Ithaca, N. Y.). *Comment*: forest trees from this alluvium (id. by Brown) included maple, hemlock, and two species of oak, and now are seen to prove the alluvium to be younger than the late-glacial age assigned it by Flint (1930). The date supports this revised interpretation, but gives only a maximum age for the beginning of marine submergence at this locality.

Y-727. Lloyd Rock Hole, Pennsylvania 11,300 \pm 1000

Charcoal from cave fill, level 83, 15 ft below surface, in Sink No. 4 or Lloyd Rock Hole (40° 07' N Lat, 78° 37' W Long), New Paris district, Bedford County, Pennsylvania; alt 1500 ft. Associated fauna includes boreal and subarctic mammals, such as *Microtus xanthognathus* (Leach) (Guilday and Bender, 1960); a complete skeleton of the extinct peccary *Mylohyus pennsylvanicus* was found at the same level, 14 to 15 ft below surface. Pollen flora from the cave matrix (id. by Paul S. Martin) is also boreal (dominated by small-pollen pine) or subarctic, but pollen flora from rodent droppings is temperate, dominated by oak, probably implying that some rodents burrowed into the deposit after its formation. Coll. 1958 by A. D. McCrady and Ralph Boissart; subm. by J. E. Guilday, Carnegie Museum, Pittsburgh 13, Pennsylvania. *Comment*: as the locality is 100 to 150 mi outside the limit of Wisconsin drift, a Two Creeks date is not surprising. Bones, mostly snowshoe hare (*Lepus americanus*), found at a slightly deeper level (17.5 to 21.5 ft), were dated at 9540 \pm 500 (M-1067, Michigan VI).

Y-841. Newman's Point, Virginia 3160 \pm 160

Ostrea and Littorina (?) shells from pocket in top 2 ft of clayey fine sand exposed in wave-cut cliff, Newman's Point (36° 52' 00" N Lat, 76° 30' 30" W Long), NE corner of Chuckatuck 7½ min quadrangle, on Nansemond River, Nansemond County, Virginia. Shells were coll. from 18 in. to 30 in. below surface. They appeared to have been washed into the pocket by natural processes; accumulation by human agency seemed less likely but was not excluded. Coll. 1960 and subm. by R. F. Flint and J. E. Sanders, Yale University. *Comment*: human agency appears to have been responsible, judging from the young age.

Anaktuvuk Pass series, Alaska

Wood fragments and organic matter from deposits related to glaciation in the Anaktuvuk Pass district, Alaska. Coll. 1959 and 1960 and subm. by Stephen C. Porter, Yale University.

Y-770. Summit Lake 6260 \pm 160

Wood fragments from perennially frozen lacustrine silt, 9 ft below present ground surface in an Eskimo cellar beside Summit (Eleanor) Lake (68° 09' N Lat, 151° 43' W Long). Coll. 1959. *Comment*: inclosing silt was deposited in a small temporary lake marginal to wasting ice during retreat of Echooka

glaciation. This glaciation was tentatively assigned an early Wisconsin age by Detterman, Bowsher, and Dutro (1958), but evidently should be considered late Wisconsin.

Y-771. Inukpasugruk Creek **2830 ± 120**

Wood fragments from base of 17.5-ft section of stratified gravel on Inukpasugruk Creek, 6.8 mi above its mouth (68° 02' N Lat, 151° 14' W Long). The gravel constitutes an outwash fan, which grades upstream into an end moraine that postdates the Echooka glaciation. Coll. 1959. *Comment*: see Y-873.

Y-772. Anivik Lake **1170 ± 120**

Organic matter from layer, 1 in. thick, underlying 15 in. of loess, 0.5 mi beyond terminal moraine of Echooka glaciation, near Anivik Lake (68° 12' N Lat, 151° 03' W Long). Organic layer overlies stratified sand and pebble gravel. Coll. 1959. *Comment*: dates the beginning of a period of eolian sedimentation that is younger than the outwash (Y-771, Y-871, Y-872, Y-873), and may be correlative with glacial events recorded by end moraines in cirque valleys near Anaktuvuk Pass.

Y-871. Anaktuvuk River **2760 ± 150**

Wood from outwash N of the Echooka end moraine in valley of Anaktuvuk River, 9 mi N of Anaktuvuk Pass (68° 15' N Lat, 151° 32' W Long). Coll. 1.0 ft from bottom of cutbank of river, exposing 8.5 ft of stratified sand, silt, and interbedded organic matter. Coll. 1960.

Y-872. Anaktuvuk River **1120 ± 90**

Wood from outwash N of Echooka end moraine, 1.5 mi N of Y-871 (68° 16' N Lat, 151° 30' W Long), 2 ft from base of cutbank exposing 11 ft of stratified sand, silt, clay, and interbedded organic matter. Coll. 1960.

Y-873. Anaktuvuk River **1045 ± 200**

Wood from outwash N of Echooka end moraine, 13 mi N of Anaktuvuk Pass and 4 mi N of Y-871 (68° 18' N Lat, 151° 29' W Long), 2.5 ft from base of cutbank exposing 20.5 ft of stratified sand, silt, clay, and interbedded organic matter. Coll. 1960. *Comment*: Y-771, younger than the Echooka glaciation and older than the cold period recorded by the loess (Y-772), dates an end moraine believed to be correlative with moraines of the Alapah Mountain glaciation that lie 17 mi E of Anaktuvuk Pass. These moraines were tentatively assigned a late Wisconsin age by Detterman, Bowsher, and Dutro (1958), but the glaciation dated here was post-Hypsithermal. The other outwash samples, coll. from a continuous body of sediment containing no marked unconformities, also appear to belong to the Alapah Mountain glaciation, and suggest that outwash deposition was continuous throughout the time from 2760 to 1045 B.P.

Lago di Monterosi series, Italy

Gyttja from cores under ca. 5 m of water, Lago di Monterosi (42° 12' N Lat, 12° 18' E Long), a small explosion crater N of Rome, believed to have

been formed during the second or main part of the Würm glacial age. Two cores were coll. in 1959 by Enrico Bonatti and W. T. Edmondson; core M-I has been used mainly for studies of pollen, diatoms, and C^{14} , core M-II for detailed chemistry; enough chemistry has been done on M-I for cross-correlation with M-II. Both cores show a great maximum of organic matter in the middle; above this, sedimentation was very fast, below it, very slow. Subm. by G. E. Hutchinson and Ursula Cowgill, Yale University.

Y-974. Monterosi M-I, 244 to 248 cm 24,460 \pm 1300

Bottom of core M-I. Pollen mainly *Artemisia*, practically all nonarbooreal. Organic C content 15.6%.

Y-913. Monterosi M-I, 128 to 148 cm 1573 \pm 77

Upper part of the zone of maximum organic N, now shown clearly to correspond to Roman settlement. Organic C content 10.3%.

Y-914. Monterosi M-I, 108 to 128 cm 1349 \pm 75

Above zone of maximum organic N. Organic C content 5.8%.

Y-915. Monterosi M-I, 73 to 88 cm 1003 \pm 76

Organic C content 5.7%.

Y-916. Monterosi M-I, 58 to 73 cm 984 \pm 72

Organic C content 5.6%. *Comment:* the region is believed never to have been inhabited by agricultural man until Roman times, and lake sediments accumulated very slowly. With the coming of the Romans the sedimentation rate was sharply accelerated, and the sediments became much more organic. Use of the land diminished in early medieval times, and more inorganic gyttja was deposited. Throughout the sedimentary record the dominant inorganic material is a noncrystalline clay-like substance, probably to be called allophane.

Lago de Petenxil series, Guatemala

Gyttja from cores under ca. 4 m of water, Lago de Petenxil (17° 55' N Lat, 89° 50' W Long), the first lake E of Flores in an E-W chain of lakes, Dept. of El Petén, Guatemala. Three cores were coll. in 1959 by George and Ursula Cowgill; none is yet proved to have reached the oldest sediments of the lake. Cores II and III have been subjected to chemical and clay-mineral analysis. Diatoms appear to be absent, and pollen studies are still incomplete. The dominant clay-mineral appears to be halloysite, its degree of hydration yet to be determined. The local bedrock is limestone, but no appreciable inorganic carbon was found in the cores studied. Both cores show series of maxima and minima of exchangeable K, but the relation between the two cores is not yet established. Subm. by G. E. Hutchinson and Ursula Cowgill, Yale University.

Y-987. Petenxil III, 85 to 92 cm 635 \pm 140

Core III, 85 to 92 cm depth, at greatest maximum of exchangeable K.

Y-988. Petenxil III, 145 to 149 cm 1305 \pm 140

Core III, 145 to 149 cm depth, at second-greatest maximum of exchangeable K.

Y-989. Petenxil III, 181 to 187 cm **1590 \pm 140**

Core III, 181 to 187 cm depth, at minimum of exchangeable K.

Y-990. Petenxil III, 225 cm **2170 \pm 85**

Bottom of core III, 225 to ca. 229 cm depth, at a maximum of exchangeable K.

Y-842. Petenxil II, 166 to 221 cm **2880 \pm 80**

Core II, 166 to 221 cm depth, sample disturbed during extrusion and therefore larger than desirable; maxima of exchangeable K occur above and below this sample. *Comment*: land clearance by burning in this region is known to increase the exchangeable-K content of soil (Cowgill, in press). On the assumption that some of this K, when leached from soils, is delivered to the lake, maxima of exchangeable K in the sediments record major episodes of burning, and hence of agricultural activity. The inference, from the dates, that some of these episodes are older than about 3000 B.P., is of interest to archaeologists, and warrants further detailed study.

Y-766. Ascension Island **1200 \pm 120**

Phosphatic dust, unaltered by percolating water, from near bottom of deposit, 18 in. thick, under overhanging rock, ca. 0.5 mi inland, in lava field S of S Gannet Hill (7° 57' S Lat, 14° 21' W Long), Ascension Island. The deposit contained fragments of feathers of tropic-birds (*Phaethon* spp.), two species of which breed elsewhere on the island today, but the large lava field in which the large deposit occurs is now entirely deserted by birds. Coll. 1958 and subm. by Philip Ashmole, Edward Grey Institute, Oxford University, through G. E. Hutchinson, Yale University. *Comment*: the large breeding-bird colony that produced the deposit probably became extinct some time after the discovery of the island in A.D. 1501, perhaps in the early 19th century when mammalian predators were introduced. The date confirms the impression, given by the lack of alteration in protected places, that even the older part of the deposit is relatively recent.

II. ARCHAEOLOGIC SAMPLES

Tazumal series, El Salvador

Charcoal from complex I of structure 1, Tazumal (13° 58' 52" N Lat, 89° 40' 35" W Long), near Chalchuapa, Dept. of Santa Ana, El Salvador. Excavated 1950 to 1955 and subm. 1958 by Stanley H. Boggs, Claypool, Indiana.

Y-682. Tazumal 3 **1480 \pm 120**

Pot 1, grave 16, structure 1; sample 3.

Y-684. Tazumal 5 **1780 \pm 140**

Below phase 6 stairs, central structure, W side; sample 5.

Y-685. Tazumal 6 **1520 \pm 120**

Pot 8, grave 13, structure 1; sample 6. *Comment*: no great difference in age was expected among the samples. Their dates confirm belief that archi-

tectural complex I, pertaining to the main period of construction, was contemporary with classic Maya culture. Certainly sample 5 (Y-684) and probably sample 6 (Y-685) refer to structural phases of that complex. The report on this site is in preparation.

Matapalo series, Costa Rica

Charcoal from midden, Matapalo site ($10^{\circ} 22' \text{ N Lat}$, $85^{\circ} 49' \text{ W Long}$), Guanacaste province, Costa Rica. The site is stratified, with Zoned Bichrome pottery, Monte Fresco phase, underlying polychrome pottery, Matapalo phase, of the Early Polychrome B period. Coll. 1959 and subm. by Michael D. Coe, Yale University.

Y-810. Matapalo, Monte Fresco, 2 1870 \pm 200

Sample no. 2 (G 11/2J), cut 2, 1.35 to 1.50 m depth; Monte Fresco phase.

Y-809. Matapalo, Monte Fresco, 1 1530 \pm 280

Sample no. 1 (G 11/1K), cut 1, 1.50 to 1.65 m depth; Monte Fresco phase. *Comment:* because some air may have been admitted during preparation of Y-809, Y-810 is believed to be more reliable as a date for the Zoned Bichrome period. The date of A.D. 90 is reasonable for a pottery phase with marked resemblance to late Formative wares (e.g. Utatlan) elsewhere in Middle America; Utatlan pottery of the Providencia phase at Kaminaljuyu (Y-370, 1850 ± 60 , Yale IV) is closely similar. The date of Y-809 seems a little late, though not impossibly so.

Y-811. Matapalo phase, 3 1395 \pm 90

Sample no. 3 (G 11/1E), cut 1, 0.60 to 0.75 m depth; Matapalo phase. *Comment:* this polychrome phase is stratigraphically higher than Y-809 and Y-810, and the date confirms this. The Early Polychrome B period, associated elsewhere in NW Costa Rica with Nicoya jade and carved metates, was equated on stylistic grounds with the end of the Early Classic and the beginning of the Late Classic in the Maya area. The date (A.D. 565) confirms this alignment.

Y-814. Miramar Site, Costa Rica 220 \pm 100

Charcoal from midden, sample no. 6 (G 10/3C), cut 3, 0.30 to 0.45 m depth, Miramar site ($10^{\circ} 17' \text{ N Lat}$, $85^{\circ} 50' \text{ W Long}$), Guanacaste province, Costa Rica. The site, on the margin of a mangrove swamp, is apparently of a single phase, but lacks polychrome pottery; it may be coeval with the Matapalo (Early Polychrome) or Tamarindo (Late Polychrome) phases. An alternative explanation is that the extremely thick, crude pottery represents the remains of a Chorotegan salt-making station of Conquest or even post-Conquest age. Coll. and subm. 1959 by Michael D. Coe, Yale University. *Comment:* although the sample lay close to the surface and may be either contaminated or intrusive, the very late date is not impossible.

Y-815. Huerta del Aguacate Site, Costa Rica 990 \pm 70

Charcoal from shell midden, sample no. 7 (G 2/2E), cut 2, 0.60 to 0.75 m depth, Huerta del Aguacate site ($10^{\circ} 19' \text{ N Lat}$, $85^{\circ} 49' \text{ W Long}$), Guana-

caste province, Costa Rica. The only phase represented is Tamarindo, Middle Polychrome period; many of the famous "Nicoya Polychromes" are associated. Coll. and subm. 1959 by Michael D. Coe, Yale University. *Comment*: confirms stratigraphic evidence from other sites that Middle Polychrome is later than Early Polychrome (e.g. Matapalo phase, Y-811, 1396 ± 90 , this date list), and confirms chronologic estimates based on external correlations.

Y-816. Chahuite Escondido Site, Costa Rica 840 \pm 70

Charcoal from shell midden, sample no. 8 (B 1/1B), cut 1, 0.15 to 0.30 m depth, Chahuite Escondido site ($10^{\circ} 55' N$ Lat, $85^{\circ} 43' W$ Long), Guanacaste province, Costa Rica. Associated pottery is of La Cruz phase, Late Polychrome period. This is the final prehistoric culture of the Guanacaste region, associated with Luna Polychrome, and probably dates from the Conquest or shortly before. Coll. and subm. 1959 by Michael D. Coe, Yale University. *Comment*: in satisfactory agreement with the archaeological sequence as inferred, though a little older than expected.

Y-850. Ortega Site, Costa Rica 1700 \pm 70

Charcoal from hearth, 1.70 m depth, Ortega site ($10^{\circ} 22' N$ Lat, $85^{\circ} 28' W$ Long), Guanacaste province, Costa Rica. Associated pottery is of Catalina phase, Zoned Bichrome period, and should be at least as old as the Monte Fresco phase found at the Matapalo site by Coe, which it is intended to check. Coll. 1960 by C. F. Baudez, Musée de l'Homme, Paris, and subm. by Michael D. Coe, Yale University. *Comment*: in satisfactory agreement with Y-810, 1870 ± 200 , Monte Fresco phase, Matapalo site (this date list).

La Mata series, Venezuela

Charcoal from house, built on Terrace 3 (third-youngest) above Lake Valencia, La Mata ($10^{\circ} 10' N$ Lat, $67^{\circ} 34' W$ Long), state of Aragua, Venezuela. The site was excavated by Bennett (1937), and re-examined by Cruxent because the associated pottery, of Valencia style, can be assigned to Period IV in the Rouse-Cruxent sequence, and because there has been doubt of the conclusion (Cruxent and Rouse, 1958-59, vol. 1, p. 164-168) that the whole terrace sequence above the lake, known since Humboldt's time, is protohistoric and historic. Coll. 1958 by J. M. Cruxent; subm. by Irving Rouse, Yale University.

Y-630. La Mata 1 1000 \pm 70

Mound 1, level 9, 2.00 to 2.25 m depth.

Y-631. La Mata 2 980 \pm 110

Mound 1, level 6, depth not stated.

Y-632. La Mata 3 1000 \pm 100

Mound 1, level 6, depth not stated. *Comment*: three floors were encountered in the new excavation, but no appreciable age difference between them was expected. The dates are slightly early for Period IV, which is placed at 400 to 800 B.P. As Kidder (1944, p. 36) showed, La Cabrera style antedates all the terraces of Lake Valencia; no date has yet been obtained for it, but El

Palito style at Aserradero (Y-579, Y-580, mean age A.D. 320, this date list) is comparable, as are other Period II dates in Yale II, Yale III, and Yale IV. The beginning of the terraces is therefore bracketed between about the 4th and the 10th centuries A.D., but their climatic implication, if any, is still obscure.

Aserradero series, Venezuela

Charcoal from Aserradero site (10° 28' N Lat, 68° 07' W Long), El Palito, state of Carabobo, Venezuela. Associated pottery is of El Palito style, late Period II and Period III, in the Rouse-Cruxent sequence. Coll. 1957 by students and subm. by J. M. Cruxent, Museo de Ciencias Naturales, Caracas.

Y-579. Aserradero B **1640 ± 120**

Section G-9, 0.25 to 0.50 m depth.

Y-580. Aserradero C **1615 ± 120**

Section and level not stated. *Comment*: the material appears to be all of one age, falling almost exactly on the boundary between Periods II and III, which is placed at 1600 B.P. (Cruxent and Rouse, 1958-59, p. 9, 83-88).

Nachikufu series, Northern Rhodesia

Charcoal from various culture levels in Nachikufu cave (12° 14' S Lat, 31° 15' E Long), near Mpika, Northern Rhodesia, the type-site of Nachikufan culture, and at the related rock-shelter site of Kasama (10° 13' S Lat, 31° 12' E Long). Excavations at Nachikufu in 1953 by J. Desmond Clark, Rhodes-Livingstone Museum, Livingstone, Northern Rhodesia, and at Nachikufu and Kasama in 1955 by Mrs. L. Hodges. Subm. 1958 by Clark (now at University of California, Berkeley) through Hallam L. Movius, Harvard University, Cambridge, Massachusetts.

Y-618. Nachikufu Iron Age N 1953 **300 ± 200**

1953 excavation, 0.5 to 1.0 ft depth.

Y-796. Nachikufu Iron Age N 1955 **200 ± 100**

1955 excavation, 2.0 to 3.0 ft depth.

Y-619. Nachikufu, Nachikufan III **5000 ± 200**

1953 excavation, 1.5 to 2.0 ft depth.

Y-619 bis. Nachikufu, Nachikufan III **4830 ± 320**

Recheck of Y-619, new preparation.

Y-805. Kasama, Nachikufan III or II

1955 excavation, 2.5 to 3.0 ft depth.

charcoal residue

7320 ± 200

alkali-soluble fraction

7200 ± 200

Y-791. Nachikufu, Nachikufan II **5630 ± 200**

1953 excavation, 2.5 to 3.0 ft depth. *Comment*: sample very small, not pre-treated with alkali.

Y-620B. Nachikufu, Nachikufan II 9720 \pm 550

1953 excavation, 3.0 to 3.5 ft depth. *Comment:* a mislabelled sample (Y-620), supposedly from this layer, gave 400 ± 130 and has been rejected.

Y-799. Nachikufu, Nachikufan II, N 1955 1060 \pm 100

1955 excavation, 5.0 to 7.0 ft depth. *Comment:* this sample presumably represents contaminating Iron Age material and is also rejected.

Y-625. Kasama, Nachikufan II 8640 \pm 240

1955 excavation, 3.0 to 3.5 ft depth.

Y-808. Kasama, Nachikufan II

1955 excavation, 4.5 to 7.0 ft depth.

charcoal residue

10,820 \pm 340

alkali-soluble fraction

11,700 \pm 280

Y-623-624. Nachikufu, Nachikufan I

1953 excavation, combined samples, 6.0 to 7.0 and 7.0 to 8.0 ft depth.

charcoal residue

3460 \pm 200

alkali-soluble fraction

7540 \pm 600

Comment: except for Y-791, all samples were pre-treated with alkali as usual. Samples believed to be bone charcoal (Y-805, Y-808, Y-623-624) were divided during pretreatment, and the alkali-soluble material was dated separately. Normally, as found by the Groningen Laboratory, the alkali-soluble fraction is at least slightly older, and, as the removal of soluble material is not 100% complete, doubt is thrown on both measurements. This series of dates, though reasonably consistent internally, is in serious conflict with archaeological evidence at several points. Nachikufan III contains pottery, and iron slag was found down to 1.5 ft, immediately overlying Y-619; its 5000-yr date is considered impossibly old. Nachikufan II contains polished stone axes, not known to be older than 6300 yr even in North Africa, whence the Neolithic presumably came, and while Y-791 (5630 ± 200) is reasonable, it is the least reliable on technical grounds, and the older dates (Y-620B, Y-625, Y-808) are much too old. Nachikufan I was dated at Chifubwa Rock Shelter as 6310 ± 250 (C-663, Chicago III), but if the alkali-soluble fraction of Y-623-624 is arbitrarily selected as consistent with this date, all dates for Nachikufan II and III must be rejected. As the gross error of Y-623-624 shows, there is clearly something wrong about bone charcoal, but bone was not a major constituent of most of the samples, and the direct tests do not suggest that error from this source is quantitatively sufficient to account for the discrepancies. Apart from archaeological difficulties, which can only be resolved by new excavations, sources of error are probably both geochemical (absorption of humic material after burial) and biologic (fractionation of carbon isotopes by food plants, by animals, and by the charring process).

III. GEOCHEMICAL SAMPLES

A. Linsley Pond, North Branford, Connecticut
(41° 19' N Lat, 72° 47' W Long)

Yale no.	Description	$\delta C^{14}\text{‰}$	$\delta C^{13}\text{‰}$	$\Delta\text{‰}$
Y-748.	Linsley Nuphar 1958	+189 ± 7	-22.0	+184 ± 7
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 19 September 1958 by E. S. Deevey.			
Y-750.	Linsley Nuphar 1959	+230 ± 11	-24.4	+229 ± 11
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 21 October 1959 by E. S. Deevey.			
Y-892.	Linsley Nuphar 1960	+210 ± 5	-23.5	+206 ± 5
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 5 October 1960 by E. S. Deevey.			
Y-749.	Linsley Potamogeton 1958			
	<i>Potamogeton</i> sp.; coll. 19 Sep- tember 1958 by E. S. Deevey.	+12 ± 7	-20.6	+3 ± 7
Y-893.	Linsley Potamogeton 1960			
	<i>Potamogeton</i> sp.; coll. 5 October 1960 by E. S. Deevey.	+56 ± 6	-17.6	+40 ± 6
Y-906.	Linsley terrestrial 1960	+210 ± 7	-29.5	+221 ± 7
	Sassafras leaves, on Twin Lakes Road on hill above Linsley Pond; coll. 20 October 1960 by E. S. Deevey.			
Y-742.	Linsley deep water 1958	-86 ± 5	-17.2*	-102 ± 5*
	Water, 14 m depth; coll. 20 Oc- tober 1958 by E. S. Deevey, S. Oana, and S. Horie.			
Y-746.	Linsley surface water 1959	-9 ± 11	-10.6*	-40 ± 11*
	Surface water; coll. 29 October 1959 by E. S. Deevey and S. Nankin.			
Y-825.	Linsley surface water early 1960	-21 ± 7	-8.1*	-56 ± 7*
	Surface water; coll. 22 March 1960 by E. S. Deevey and K. Elgmork.			

* δC^{13} * determined on aliquot of unpurified CO_2 from water sample; purification of the gas for C^{14} counting enriches the C^{13} content by an average of 1.2‰ (average of 5 samples). The Δ values for all water samples have been calculated on the assumption of 1.2‰ enrichment in C^{13} .

Yale no.	Description	$\delta C^{14}\text{‰}$	$\delta C^{13}\text{‰}$	$\Delta\text{‰}$
Y-908.	Linsley deep water late 1960	-36 ± 7	-14.1^*	$-59 \pm 7^*$
	Water, 13.5 m depth; coll. 1 October 1960 by E. S. Deevey and J. A. King.			
Y-909.	Linsley surface water late 1960	$+70 \pm 8$	-6.8^*	$+29 \pm 8^*$
	Surface water; coll. 5 October 1960 by E. S. Deevey and S. Nankin.			
	<i>B. Queechy Lake, Canaan, New York</i> (42° 24' N Lat, 73° 25' W Long)			
Y-899.	Queechy Potamogeton 1958	-131 ± 6	-17.3	-144 ± 6
	<i>Potamogeton</i> sp.; coll. 29 September 1958 by E. S. Deevey.			
Y-754A.	Queechy Potamogeton organic 1959	-125 ± 8	-12.6	-147 ± 8
	<i>Potamogeton</i> sp., organic carbon; coll. 12 July 1959 by E. S. Deevey.			
Y-754B.	Queechy Potamogeton inorganic 1959	-101 ± 10	-2.5	-141 ± 10
	Lime crust deposited on <i>Potamogeton</i> sp. in summer; coll. 12 July 1959 by E. S. Deevey.			
Y-857.	Queechy Potamogeton 1960	-118 ± 7	-15.1	-135 ± 7
	<i>Potamogeton</i> sp.; coll. 5 July 1960 by E. S. Deevey.			
Y-898.	Queechy Chara 1958	-143 ± 11	-19.7	-152 ± 11
	<i>Chara</i> sp. (calcareous alga); coll. 29 September 1958 by E. S. Deevey.			
Y-755.	Queechy Chara 1959	-135 ± 8	-18.1	-147 ± 8
	<i>Chara</i> sp. (calcareous alga); coll. 12 July 1959 by E. S. Deevey.			
Y-856.	Queechy Chara 1960	-137 ± 6	-19.1	-147 ± 6
	<i>Chara</i> sp. (calcareous alga); coll. 5 July 1960 by E. S. Deevey.			
Y-858.	Queechy Nymphaea 1960	$+218 \pm 4$	-23.0	$+213 \pm 4$
	<i>Nymphaea</i> sp. (white water-lily) leaves; coll. 5 July 1960 by E. S. Deevey.			

Yale no.	Description	$\delta C^{14}\text{‰}$	$\delta C^{13}\text{‰}$	$\Delta\text{‰}$
Y-745.	Queechy deep water			
	1959	-286 \pm 18	-11.4*	-307 \pm 18*
	Water, 12 m depth; coll. 27 September 1959 by E. S. and G. B. Deevey.			
Y-744.	Queechy surface water			
	1959	-275 \pm 9	-5.9*	-304 \pm 9*
	Surface water; coll. 12 July 1959 by E. S. Deevey.			
Y-907.	Queechy deep water			
	1960	-153 \pm 10	-13.6*	-174 \pm 10*
	Water, 12 m depth; coll. 2 October 1960 by E. S. Deevey.			
Y-910.	Queechy surface water			
	1960	-121 \pm 7	-9.0*	-151 \pm 7*
	Surface water; coll. 2 October 1960 by E. S. and G. B. Deevey.			

C. Lake Quassapaug, Middlebury, Connecticut
(41° 32' N Lat, 73° 09' W Long)

Y-896.	Quassapaug Nuphar			
	1958	+132 \pm 11	-22.9	+127 \pm 11
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 5 October 1958 by E. S. Deevey.			
Y-894.	Quassapaug Nuphar			
	1960	+225 \pm 6	-23.0	+220 \pm 6
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 12 October 1960 by E. S. Deevey.			
Y-897.	Quassapaug Myriophyllum			
	1958	-14 \pm 6	-27.4	-9 \pm 6
	<i>Myriophyllum</i> sp.; coll. 5 October 1958 by E. S. Deevey.			
Y-895.	Quassapaug Myriophyllum			
	1960	+43 \pm 8	-27.4	+48 \pm 8
	<i>Myriophyllum</i> sp.; coll. 12 October 1960 by E. S. Deevey.			

Yale no.	Description	$\delta C^{14}\text{‰}$	$\delta C^{13}\text{‰}$	$\Delta\text{‰}$
	<i>D. Lake Quonnipaug, Guilford, Connecticut</i> (41° 24' N Lat, 72° 42' W Long)			
Y-900.	Quonnipaug Nuphar			
	1958	+138 ± 6	-25.7	+140 ± 6
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 12 October 1958 by E. S. Deevey.			
Y-902.	Quonnipaug Nuphar			
	1960	+208 ± 7	-23.7	+205 ± 7
	<i>Nuphar</i> sp. (yellow water-lily) leaves; coll. 6 November 1960 by E. S. Deevey.			
Y-901.	Quonnipaug Potamogeton			
	1958	-32 ± 7	-12.6	-56 ± 7
	<i>Potamogeton</i> sp.; coll. 12 Oc- tober 1958 by E. S. Deevey.			
Y-903.	Quonnipaug Potamogeton			
	1960	+57 ± 9	-14.4	+35 ± 9
	<i>Potamogeton</i> sp.; coll. 6 Novem- ber 1960 by E. S. Deevey.			
	<i>E. Rogers Lake, Lyme, Connecticut</i> (41° 22' N Lat, 72° 18' W Long)			
Y-904.	Rogers Lobelia 1960	-15 ± 14	-28.8	-7.5 ± 14
	<i>Lobelia</i> sp.; coll. 20 September 1960 by E. S. Deevey and M. B. Davis.			
Y-905.	Rogers Nymphaea 1960	+213 ± 6	-22.6	+207 ± 6
	<i>Nymphaea</i> sp. (white water-lily) leaves; coll. 20 September 1960 by E. S. Deevey and M. B. Davis.			
Y-980.	Rogers deep water 1960	+20 ± 15	-21.4*	+10 ± 15*
	Water, 18.5 m depth; coll. 20 September 1960 by E. S. Deevey and J. A. King.			

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LAMONT NATURAL RADIOCARBON MEASUREMENTS VII*

EDWIN A. OLSON** and WALLACE S. BROECKER

Lamont Geological Observatory, Columbia University, Palisades, New York

INTRODUCTION

Radiocarbon-age measurements reported here were made at Lamont Geological Observatory between July 1958 and November 1960. Sample descriptions are classified as follows:

- I. Samples associated with glacial deposits
- II. Samples associated with marine coastal deposits
- III. Samples associated with marine coastal deposits uplifted by glacial rebound
- IV. Samples associated with pluvial-lake deposits
- V. Samples from deep-sea cores
- VI. Samples from cave deposits
- VII. Miscellaneous samples of geologic interest
- VIII. Samples of archaeologic interest

Equipment for age measurement and details of age calculation have been reported previously; see Broecker, Tucek, and Olson (1959) for a detailed description of sample processing and counting.

Unless otherwise stated in individual sample descriptions, every sample has received a standard pretreatment. Organic materials have been given successive acid and base leaches for removal of carbonates and humic acids; dilute HCl and 2% NaOH solutions are used. Note that alkali-soluble material is here referred to as "humic acids". For carbonate samples, predominantly shells, surface leaching for an unspecified time removes a portion of sample before the CO_2 to be counted is ultimately collected. Further details on pre-treating samples are given in an article by Olson and Broecker (1958).

Ages reported here are obtained by CO_2 gas-proportional counting at one or two atmospheres pressure in 2- or 5-liter counters. At best, finite ages between 40,000 and 45,000 yr are the upper limit, although no samples in this range are reported here.

As adopted at the Groningen Radiocarbon Conference of 1959, the contemporary activity used in age calculations is here taken as 95% of the activity of standard oxalic acid (distributed by NBS). Unless otherwise stated, all samples in this list are calculated on this basis. Thus, if any sample reported here is identical with that dated by another laboratory using the same contemporary value, ages should agree within experimental error.

Aside from chronologic applications listed here, basic studies in contamination are reported where they apply to samples described. Such studies involve isolation and dating of several fractions of a single sample or dating of

* Lamont Contribution No. 498.

** Present address: Division of Science, Whitworth College, Spokane, Washington.

stratigraphically-equivalent materials of different type. The following types of comparison are included:

1. Humic acids vs. residue remaining after humic acids have been removed (L-399G, L-399I, L-401A, L-433B, L-441C, L-455B, L-472B, L-473A, C,D, L-476A, L-478B, L-479A, L-480F, L-483EE, L-494B, L-502, L-511, L-550B, L-567). Seven of these samples are woods, three are charcoal, and the remaining eight are peat or decayed plant materials. All pairs, except three, show a check within the experimental error. One of these (L-478B) is wood that had definitely been contaminated with humic acids which were removed by alkali pre-treatment. The second one, also wood (L-479A), suggested just the reverse effect, but this needs verification by further work. The third one, charcoal (L-399G), showed slight discrepancies among the three fractions, suggesting a non-homogeneous sample.

2. Bone organic vs. bone carbonate (L-385A, L-406, L-431A). Without exception, the carbonate fractions are correspondingly younger, apparently as a consequence of ground-water-carbonate contamination.

3. Outside of carbonates vs. inside (L-475A,B, and L-4830). The three samples show identical ages for the two fractions, indicating absence of surface contamination, even though each was so old as to have no detectable radiocarbon.

4. Wood vs. shell in same stratigraphic position (L-514C,D). The shells have a significantly younger age, probably because of contamination with ground-water carbonate.

5. Charcoal vs. bone organic in same stratigraphic position (L-385A, L-406, L-431A). In these three pairs concordance was obtained, but such a situation is not universally found (L-385B,C,D,E in Lamont V).

6. Disseminated organic vs. disseminated carbonate (L-430D,E, L-435I, L-483EE,FF, and L-494C,D). Contamination effects are noted in three of the six pairs described here.

7. Disseminated organic vs. disseminated carbonate in varved clay (L-551B, L-563A,B,C). Organic and carbonate fractions show different ages, but there is no unequivocal explanation for the differences.

Judging from the pairs considered above, organic materials offer no contamination problem except when very old. Shells and disseminated carbonate are variable, depending much on the sealing quality of the host sediment. Bone carbonate is worthless. These conclusions, in essence, were reached in a previous Lamont date list (Lamont V).

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SAMPLE DESCRIPTIONS

I. SAMPLES ASSOCIATED WITH GLACIAL DEPOSITS

*Midwestern United States***L-605. Sand Island, Wisconsin 4800 \pm 150**

Compressed, air-dried fibrous peat with recognizable macroflora dredged from beneath 14 ft of sand at bottom of Lake Superior, (water depth 40 ft) ($46^{\circ} 57' N$ Lat, $91^{\circ} 00' W$ Long). Sample should date a low-water interval in Lake Superior basin, perhaps contemporary with Chippewa and Stanley low-water phases in Michigan and Huron basins. Coll. by J. Merrill; subm. by W. Farrand, Lamont Geol. Observatory. *Comment*: sample was previously dated using black-carbon method, as C-504 (3656 ± 640 , Libby, 1955).

L-550. Sunbeam Prairie Bog series, Indiana

Marl and peat from Sunbeam Prairie bog, 10 mi NE of Richmond, Indiana ($39^{\circ} 58' N$ Lat, $84^{\circ} 48' W$ Long). Bog, probably of ice-block origin, is located on Champaign till S of the Bloomington moraine. A pit dug almost 5 ft down exposes much of the bog sequence, while with an auger, samples all the way down to underlying calcareous till, have been obtained. Thus a record is available, presumably since Tazewell substage (Gooding, 1957). Pollen profile for the bog, determined by R. O. Kapp, Univ. of Michigan, resembles profiles published by Potzger (1946) for central Indiana. Coll. 1959 by R. O. Kapp and A. M. Gooding; subm. by Gooding, Earlham College, Richmond, Indiana.

L-550A. Basal marl 8600 \pm 500

The almost total absence of pollen in the sample, together with its position in the profile (81 to 85 in. deep), indicates formation soon after melting of ice block. However, the young age indicates ground-water contamination, not an unexpected situation in view of water seepage encountered in digging of bog pit.

L-550B. Peat from 14- to 16-in. level 10,600 \pm 150

Pollen analysis indicates peat was deposited at onset of Hypsithermal interval in this area (Deevey, 1957). *Comment*: humic acid isolated from sample gave an age of 9900 ± 200 .

Richmond series, Indiana

A. M. Gooding and E. Gamble of Earlham College have examined and sampled numerous Pleistocene exposures in vicinity of Richmond, Indiana. Exposed sediments include tills, stratified deposits of clay, silt, sand, and gravel (many of outwash origin), and humic zones that are probably buried soils. Of all the beds, two adjacent ones, till with pink inclusions of an older till, and an underlying buried soil, are most characteristic. The soil is thought to be of Sangamon age (Gamble, 1958). If so, overlying tills are Wisconsin, possibly within the range of the Lamont measuring equipment. The age of a sample of the buried soil exposed at the Darrah Farm, Indiana, has already been re-

ported as $>41,000$ (L-414A,B; Lamont V). Similarly, all samples described below are too old to be measured.

L-477B. Jones Farm $>41,000$

Wood from within a thin layer of calcareous silt directly overlying a presumed Sangamon buried soil, exposed on E bank of a creek on the Jones Farm, NW Fayette County, Indiana ($39^{\circ} 47' \text{ N Lat, } 85^{\circ} 12' \text{ W Long}$). The silt layer, only 2 in. thick, separates the overlying till with pink inclusions from the soil zone and appears to represent proglacial sediments laid down before the first advancing Wisconsin glacier. Coll. 1957 by A. M. Gooding and J. Rodgers; subm. by Gooding, Earlham College, Richmond, Indiana.

L-478B. American Aggregate Gravel Pit $>40,500$

Wood from organic-rich zone overlying till with pink inclusions at American Aggregate gravel pit, 3 mi NE of Richmond, Indiana ($39^{\circ} 50' \text{ N Lat, } 84^{\circ} 50' \text{ W Long}$). Peaty plant-remains and many snails occur in the same horizon, probably once a bog. At the pit, the presumed Sangamon soil is not exposed. Coll. 1957 by A. M. Gooding and J. Rodgers; subm. by Gooding, Earlham College, Richmond, Indiana. *Comment*: humic acid was isolated from two separate pieces of the wood sample. Both humic-acid portions were found to have measurable C^{14} , giving apparent ages of $31,800 \pm 2500$ and $23,100 \pm 1500$. Thus, the value of alkali pre-treatment in this case is demonstrated.

L-479. Smith Farm series

Wood-and-soil organic matter from exposures along several creeks just S of the Smith Farm, 2.2 mi S of Centerville, Indiana ($39^{\circ} 47' \text{ N Lat, } 84^{\circ} 59' \text{ W Long}$). Samples L-414A,B (Lamont V) were coll. only .75 mi from the Smith Farm. Coll. 1957 by A. Gooding and J. Thorp; subm. by Gooding.

L-479A. Wood in till $>43,000$

Wood, encased in till containing pink inclusions. *Comment*: the age quoted is for humic acid extracted from the wood. Alkali-treated wood gave $33,600 \pm 2800$. As a check on the validity of the latter age, an untreated portion of the wood is currently in process.

L-479B. Organic matter from buried soil under till $>37,500$

L-479C. Organic matter from second buried soil $>35,000$

Sample lies below L-479B, the two being separated by 2 to 3 ft of leached fine sand, silt, and clay. *Comment*: detectable C^{14} was found, equivalent to an apparent age of $39,500 \pm 3000$. In view of the greater ages found at higher levels, however, this finite age was not quoted.

L-239A. White Pine, Michigan 9800 ± 120

Log buried beneath 35 ft of clay ($46^{\circ} 45' \text{ N Lat, } 89^{\circ} 34' \text{ W Long}$). Coll. by W. S. White, U. S. Geol. Survey. *Comment*: result is somewhat lower than black-carbon age of $12,600 \pm 1200$ obtained previously (Lamont III), but agrees well with the result of 9500 ± 600 obtained for W-693 (USGS V).

L-467. Hamilton, Ohio **19,800 \pm 300**

Log 25 ft down in a 60-ft section of till exposed in Twomile Creek (39° 25' N Lat, 84° 34' W Long). Till is overlain by 2.5 ft of loess and underlain by Sangamon paleosol on Illinoian till. Subm. by R. P. Goldthwait, Ohio State Univ., Columbus.

*Eastern United States***L-551B. Haverstraw, New York** **>20,000**

Disseminated organic matter in varved clay, deposited in proglacial lake ca. 0.75 mi SSW of Grassy Point, Haverstraw, New York (41° 12' N Lat, 70° 58' W Long). According to Antev's varve chronology (1953) the varves were deposited ca. 24,000 yr ago. See L-564 (this list) for another varve sample in the Antevs series. Coll. 1959 by F. Wagner and E. A. Olson; subm. by Olson, Lamont Geol. Observatory. *Comment:* the actual age measured was finite (23,500 \pm 1500). However, sample contained modern rootlets which, although removed as completely as possible, still might have contributed the activity that gave the finite age. In addition, carbonate from the varved clay was dated, giving an age of >33,000. If the result is valid, it suggests that the varves were not deposited during the retreat of the Late Wisconsin ice sheet.

L-564. Hanover, New Hampshire **>21,400**

Disseminated organic matter in varved clay deposited in a proglacial lake just S of Hanover, New Hampshire (43° 38' N Lat, 72° 18' W Long). According to Antev's varve chronology (1953), the age of the Hanover varve series is ca. 19,500. Antevs correlates the Hanover retreat with the Two Creeks interval, dated at ca. 11,500 yr. Hence, sample age is in excess of that predicted from either chronology. Whether this indicates that the organic matter dated is not equivalent in age to the time of varve deposition remains to be determined. See L-551B (this list) for another varve sample in the Antevs series. Coll. 1959 by D. D. Smith, Dartmouth College, Hanover, New Hampshire, and requested by E. A. Olson. *Comment:* on a dry basis, the clay had ca. 0.5% organic carbon and almost twice as much carbonate carbon.

*Canada***L-563. Steep Rock Lake series, Ontario**

Varved clay from Steep Rock Lake, Ontario, 140 mi W of Fort William, Ontario (48° 49' N Lat, 91° 39' W Long). The clay, now being removed to obtain ore beneath it, was deposited in Glacial Lake Johnston, perhaps 100 ft higher than present Steep Rock Lake. By varve count, the high level persisted for more than 1250 yr. According to Antevs (1951), Lake Johnston probably was contemporaneous with early stages of Lake Agassiz, but he and Elson (1957) point out uncertainties in late Pleistocene history in such a little-explored area. Tentatively, an age between 9500 and 13,000 is most probable. Antevs (1925) described the mechanics of varve deposition in general, while

Eden (1955) discussed the varves. Coll. 1959 by W. J. Eden, National Research Council of Canada, and requested by E. A. Olson.

L-563A. Concretion carbonate **14,700 \pm 100**

Calcium carbonate from a single concretion found within the varved clay. Concretion was half CaCO_3 with remainder acid-insoluble. A contemporary-wood standard was used in the age calculation; as the concretion formed after the host varves, the initial C^{14} concentration is uncertain. Probably it exceeded 50% of the contemporary level, so that the true age is at least 9000 yr.

L-563B. Disseminated organic **15,700 \pm 900**

Organic matter converted to CO_2 gas by combustion that followed acidification of the clay for carbonate removal. According to J. Terasmae, Geol. Survey of Canada (personal communication), the organic matter in varved clay consists of pollen, spores, and other minute plant fragments, all probably wind blown. Old organic matter, pulverized by the glacier and deposited in Glacial Lake Johnston, might account for the old age. *Comment*: on a dry basis, the clay contained 0.11% carbon.

L-563C. Disseminated carbonate **10,000 \pm 1000**

Acidification released the CO_2 for this sample age. *Comment*: clay contained only 0.12% CaCO_3 . According to Eden (1955), the dark winter layers were devoid of carbonate. This indicates either that the carbonate was precipitated as a result of warmer water in the summer or that the particle size of all carbonate minerals was large enough to have permitted quick settling during summer melting. The first mechanism is postulated by Burwash (Legget and Bartley, 1953).

L-522B. Scarborough beds, Toronto, Ontario **>40,000**

Woody detritus from the seminary section of the Scarborough beds ca. 1000 ft E of the end of Undercliffe Drive, Scarborough, suburb of Toronto, Ontario (43° 42' N Lat, 79° 14' W Long). Sample exposure is a bluff ca. 240 ft high, the upper 100 ft consisting of Wisconsin till and the lower portion of Scarborough non-glacial sands and silts. Sample came from cross-laminated sand ca. 8 ft below base of till. Pollen analysis indicates the Scarborough beds were deposited when a boreal climate prevailed; the deposits have been classified as Sangamon interglacial or an intra-Wisconsin interstadial. For details of the geology, see Coleman (1933); Watt (1957), and Terasmae (1960). Coll. 1957 by V. K. Prest and J. Terasmae; subm. by Geol. Survey of Canada.

L-441C. Drummondville, Quebec **9500 \pm 300**

Gyttja from lowest 10 cm of a bog 0.6 mi W of St. Germain de Grantham village (45° 51' N Lat, 72° 35' W Long), SW of Drummondville, Quebec. Bog is ca. 260 cm thick, occupying a depression in the Drummondville moraine ca. 300 ft above present sealevel. Sample is tied in with the local pollen sequence and believed to have originated soon after retreat of the Champlain Sea (Terasmae, 1959a). Coll. 1957 by J. Terasmae; subm. by Geol. Survey of Canada. *Comment*: humic acid extracted from the wood gave an age of 9200 \pm 600.

L-433B. Oldman River, Alberta **>35,500**

Wood from a succession of sediments lying between two till sheets exposed along E bank of the Oldman River, Alberta; site is located in E half of sec. 18, township 9, range 22, W 4th meridian (49° 44' N Lat, 112° 58' W Long). Intertill sediments at the collection site consist of a 24-ft layer of grit, silt, and sand with the wood coming from 5 ft above the base. According to A. M. Stalker sediments are interstadial or interglacial materials. Apparently correlative samples from two nearby sites have been dated as >26,000 yr (L-221C; Lamont III) and >32,000 yr (S-65, Saskatchewan II). The intertill sediments are extensive, having been observed at intervals for 50 mi along the river. Coll. 1956 by A. M. Stalker; subm. by Geol. Survey of Canada. *Comment*: humic acid extracted from sample yielded an age of >33,500 yr.

Quadra beds series, Columbia

In Vancouver Island area, Quadra fluvial and marine beds unconformably underlie Vashon glacial sediments, the latter deposited during a single major Wisconsin glaciation. A previous Lamont date list (Lamont V) gave several dates for Quadra sites on Vancouver and Denman Islands, all falling roughly within the 25,000 to 30,000-yr range. Additional dates of horizons, thought by J. G. Fyles to be Quadra, are given below. See Fyles (1956) for description of the regional Pleistocene geology.

L-455B. Marina Island **35,400 ± 2200**

Pine wood from near base of a 120-ft sea cliff on Marina Island, Strait of Georgia, British Columbia (50° 05' N Lat, 125° 02' W Long), ca. .5 mi SE of Shark Spit. Although sample was from plant-bearing silts ca. 3 ft above high tide, the sediments exposed in the cliff are mainly sands that may or may not continue beneath the sampled silt horizon. J. G. Fyles, Geol. Survey of Canada, places the sands and silts in the Quadra sediments, correlating them with the upper sand unit. At Denman Island and at Dashwood on Vancouver Island (38 and 54 mi to the SE), peat beds beneath the sand unit have radiocarbon ages no older than 30,000 yr (L-221A, L-221B, L-424B, L-424C, L-424E, Lamont V). Coll. 1957 by J. G. Fyles; subm. by Geol. Survey of Canada. *Comment*: the age reported above is for alkali-treated material. Untreated wood gave an age of 36,500 ± 4000.

L-475A. Denman Island **>41,500**

Barnacle shells from a Quadra section exposed at Komas Bluff, Denman Island, British Columbia (49° 36' N Lat, 124° 29' W Long). Shells come from a marine stony clay forming base of Quadra sediments and lying beneath a silt-and-gravel layer containing wood and peat previously dated around 30,000 yr (L-424B, L-424C, L-424E; Lamont V). In the opinion of J. G. Fyles, the gradational nature of the "contact" between the stony clay and organic-bearing silt-gravel layer militates against the large spread in the radiocarbon ages. Instead of thousands of yr difference, he predicts time interval was only a few hundred yr. The problem is as yet unresolved. Coll. 1958, by J. G. Fyles; subm. by Geol. Survey of Canada. *Comment*: the age given is for inner por-

tions of barnacle shells; surface carbonate was leached off and also dated, giving an age of $>35,000$ yr.

L-475B. Dashwood Cliff, Vancouver Island $>35,600$

Mollusc shells from stony marine clay at base of a section of the Quadra sediments exposed in sea cliff at Dashwood, Vancouver Island, British Columbia ($49^{\circ} 22' \text{ N Lat, } 124^{\circ} 31' \text{ W Long}$). Just above the marine clay is a silt-to-gravel layer containing peat and wood, from a nearby locality, which gave ages around 25,000 yr (L-221A and L-221B; Lamont V). As the stratigraphy at Dashwood Cliff is identical with that at Komas Bluff (see L-475A above), J. G. Fyles thinks that the large difference between shell and wood ages is inconsistent with the field evidence. He sees nothing in the field evidence to indicate a break of more than a few hundred yr. The problem is as yet unresolved. Coll. 1958 by J. G. Fyles; subm. by Geol. Survey of Canada. *Comment*: the age given above is for surface carbonate leached off; inner carbonate was also dated, giving an age of $>34,000$ yr.

L-502. Spanish Banks, Vancouver Island $24,400 \pm 900$

Wood from a Quadra exposure in a sea cliff at Spanish Banks on Vancouver Island, British Columbia ($49^{\circ} 17' \text{ N Lat, } 123^{\circ} 13' \text{ W Long}$). Sample comes from a bed of silty-to-sandy clay containing peat and wood; beds, possibly correlative, at other Quadra sites have given ages between 25,000 and 30,000 yr (L-221A, L-221B, L-424B, L-424C, L-424E; Lamont V). Coll. 1958 by J. E. Armstrong; subm. by Geol. Survey of Canada. *Comment*: the age given above is for untreated material; humic acid isolated from the wood gave an age of $26,700 \pm 3000$.

L-514. Cowichan Head series, Vancouver Island

Wood and mollusc shells from Cowichan Head sea cliff, Vancouver Island, British Columbia ($48^{\circ} 03' \text{ N Lat, } 123^{\circ} 21' \text{ W Long}$). Samples occurred within a bed of marine stony clay forming base of a succession of sands similar to, and possibly correlative with the Quadra sediments. If correlation is correct, the ages of L-514 samples should be the same as those of L-475A and L-475B (see above). Coll. 1958 by J. G. Fyles; subm. by the Geol. Survey of Canada.

L-514C. Wood $>42,000$

L-514D. Shells $35,000 \pm 1600$

Comment: the shells were leached of surface carbonate, but the finite age of the shells in contrast to age of the wood suggests that some shell contamination existed and was not totally eliminated. On the other hand, absence of contamination in shell samples L-475A and L-475B (see above) indicates that shell contamination does not always occur.

England

L-387A. Chelford, England $>36,500$

Wood from a forest bed and organic mud lying within the Middle Sands formation. Collection site was a small sand pit at Chelford, Cheshire, England

(53° 15' N Lat, 02° 18' W Long). The deposit is underlain by the Lower Boulder Clay of the Geological Survey of Great Britain and is overlain by the Upper Boulder Clay. Although the Upper Boulder Clay is known to be pre-Allerød in this region it was thought that the sands might be as young as 18,000 yr or as old as Pliocene. For details of the geology, see Simpson and West (1958) and Poole and Whiteman (in press). Coll. 1956 and subm. by A. J. Whiteman, University of Khartoum, Sudan.

Antarctica

(Samples coll. and subm. by T. L. Péwé, U. S. Geol. Survey and Univ. of Alaska College, Alaska, unless stated otherwise)

L-462. Hobbs Valley, Antarctica series

Samples giving minimum ages for the latest glacial advance in the McMurdo Sound region and also for the last major glaciation (Koettlitz Glaciation) in the area (Péwé, 1960). In addition, they give length of time that stagnant ice has been present in the moraine.

L-462A. Peat 2480 ± 120

Algal peat from a 0.5 in.-thick layer buried 1 to 2 ft in glacial sand and gravel (ablation drift) which is the veneer of an ice-cored lateral moraine of Koettlitz Glacier (77° 59' S Lat, 164° 20' E Long).

L-462C. Sand 5900 ± 140

Algiferous sand from a slumped block of ablation drift on ice-cored moraine of Koettlitz Glacier in front of the terminus of Hobbs Glacier (77° 57' S Lat, 164° 42' E Long).

L-462B. Mount Nussbaum, Antarctica 1250 ± 100

Hide from remains of a seal lying on glacial drift at alt 1630 ft on Mount Nussbaum, ca. 5 mi from present shoreline (77° 41' S Lat, 163° 40' E Long). Apart from demonstrating the slow rate of decay processes in Antarctica, the age gives a minimum time since the area was deglaciated. *Comment:* the age was computed with assumption that seal hide had an initial Δ value equal to that measured for a contemporary seal from same area (L-570, Lamont VIII). If 0.95, the activity of the oxalic-acid standard, were used as the initial value, the age would have been 2550 ± 100 . The low activity in living seals results from low C^{14} concentration in Antarctic waters (Broecker and others, 1960). $\delta C^{13} = -28.7$. For a discussion of this result see Péwé and others (1959).

L-462E. Boney Lake, Antarctica >300

Fur from carcass of an old seal frozen in the ice of Boney Lake at upper end of Taylor Dry Valley (77° 42' S Lat, 162° 25' E Long) in the McMurdo Sound area. *Comment:* as for sample L-462B, contemporary Antarctic seal hide was used as a control. If the usual standard were used, the age would have been 1500 ± 150 . $\delta C^{13} = -23.5$. See Péwé and others (1959) for a discussion of this result.

L-462G. Taylor Dry Valley, Antarctica 4000 ± 200

Marine shells (mostly *Pecten*) lying on sand at high-tide mark on a beach

at the end of Taylor Dry Valley ($77^{\circ} 35' \text{ S Lat}$, $163^{\circ} 30' \text{ E Long}$), in the McMurdo Sound area. As in some cases both valves were intact, shells are assumed to be contemporary. *Comment:* the shells do not appear to be contemporary in age. They have 15% less C^{14} than the most C^{14} -deficient sea-water sample analyzed to date. The age given is based on the C^{14} concentration in Antarctic surface waters. If 0.95 oxalic acid were used, the age would be 4700 ± 200 . A separate analysis on a second batch of material sent by Péwé yielded the same result, eliminating the possibility of a laboratory error. The collector suggests the possibility that samples were mislabeled in the field and shells analyzed were from a 20-ft terrace and not from sealevel. The area has been free of ice for many thousands of yr (Péwé, 1960).

L-627. Davis Glacier, Antarctica 250 \pm 150

Flipper of a mummified crab-eater seal found 100 ft in front of Davis Glacier in the McMurdo Sound area at 1170 ft alt ($77^{\circ} 59' \text{ S Lat}$, $164^{\circ} 10' \text{ E Long}$). *Comment:* the age is based on the Δ value for contemporary seal (L-570). If the usual standard were used, the age would be 1450 yr. Further information and discussion of the area is given by Péwé (1960) and in press.

L-594. Marble Point, Antarctica 4450 \pm 150

Hide of an elephant seal buried under one ft of beach gravel on a beach at alt 44 ft ($77^{\circ} 26' \text{ S Lat}$, $163^{\circ} 46' \text{ E Long}$). As the seal must have been buried by wave action, its age should provide an estimate of rate of crustal uplift in this area. Coll. in 1960 and subm. by R. L. Nichols, Tufts Univ. Medford, Massachusetts. *Comment:* the Δ value for the contemporary seal from same area (L-570, Lamont VIII) was used as a control value for the age calculation. If the usual standard were used, the age would be 5650 ± 150 yr.

II. SAMPLES ASSOCIATED WITH MARINE COASTAL DEPOSITS

UPLIFTED BY GLACIAL REBOUND

Canada

L-604. Foster Sand Pit series, Ottawa

Marine shell from Foster sand pit ca. 0.5 mi NW of Uplands Airport ($45^{\circ} 20' \text{ N Lat}$, $75^{\circ} 42' \text{ W Long}$); ca. 300 ft above sealevel. Highest marine limit in Ottawa area is at 690 ft. The shells are associated with beach formed by the Champlain Sea. Coll. by J. Terasmae; subm. by Geol. Survey of Canada. *Comment:* 10% of sample was removed by acid leaching before analysis was performed.

L-604A. Mytilus 10,700 \pm 200

Mytilus from 40 ft below ground surface.

L-604B. Mixed shells 10,550 \pm 200

Hiatella, *Macoma*, and *Balanus* from 35 ft below ground surface.

L-571A. Somerset Island 7150 \pm 350

Marine shell (*Macoma*, *Cardium*, and *Hyatella arctica*) from terrace 100 ft alt, in Four Rivers Bay ($72^{\circ} 47' \text{ N Lat}$, $95^{\circ} 37' \text{ W Long}$). Coll. 1959 by J.

B. Bird; subm. by W. L. Donn, Lamont Geol. Observatory. *Comment*: 10% of sample was removed by slow acid leaching before it was prepared for analysis.

L-571B. Prince of Wales Island **9200 \pm 160**

Marine shell (*Mya*) from terrace 370 ft above sealevel near Transition Lake (72° 13' N Lat, 96° 38' W Long). Coll. by J. B. Bird; subm. by W. L. Donn, Lamont Geol. Observatory. *Comment*: 10% of sample was removed by slow acid leaching before it was prepared for analysis.

L-548. Ellesmere Island **19,500 \pm 1100**

Marine shells (mainly *Hiatella artica* and *Mya truncata*) from a terrace at 2000 ft alt on Hare Cape Ridge on Eureka Sound, near Slidre Fiord (79° 57' N Lat, 86° 22' W Long). Coll. by V. Sim; subm. by W. Newman, Lamont Geol. Observatory. *Comment*: as sample was small, it was given only a "quick" acid leach before hydrolysis. Although 10% recent carbonate would be required to give this age to an infinitely old sample, the result still should be considered a minimum.

III. SAMPLES ASSOCIATED WITH MARINE COASTAL DEPOSITS
IN AREAS UNAFFECTED BY GLACIAL REBOUND

Atlantic Coast

L-562. New York City **6500 \pm 100**

Juniper wood found during excavation for New York Telephone Company building at Barclay, Vesey, and Washington streets in New York City (40° 43' N Lat, 74° 00' W Long). Sample came from one of several prostrate trunks of juniper trees, some of which were 10 ft long with bark and branches still attached, evidence that the trees had grown *in situ*. They were found associated with an 18-in. layer of peat, ca. 25 ft above bedrock and 45 ft below present sealevel. According to Reeds (1927), the trees grew in postglacial time and indicate subsidence at the mouth of the Hudson River, in contrast to differential uplift farther N. Coll. 1925 by A. Hollick, New York Botanical Garden; New York, N. Y.; subm. by H. F. Becker at the request of E. A. Olson. For details on the trees see Hollick (1926).

L-617. Queens, New York **6600 \pm 700**

Peat, mixed with shell fragments from a boring at site of the Aquacade in Flushing Meadows (40° 45' N Lat, 73° 50' W Long). Sample is from 50 ft below sealevel, at base of the marine section, overlying sand and fine gravel thought to be outwash. Sample should date the marine transgression in this area, following the last deglaciation. Subm. by W. S. Newman, Lamont Geol. Observatory.

L-587A. Hudson River Canyon **>35,000**

Marine shell from 4 ft below top of core V 16-4, taken on shoulder of the Hudson River canyon at depth 450 ft (39° 34' N Lat, 72° 22' W Long). Coll. by J. I. Ewing; subm. by C. T. Fray, Lamont Geol. Observatory.

L-544. Charleston, South Carolina >31,700

Peat from top of the Pamlico formation, 9.4 ft below sealevel ($32^{\circ} 45' N$ Lat, $79^{\circ} 55' W$ Long). Subm. by W. S. Newman, Lamont Geol. Observatory. *Comment:* result is consistent with the Sangamon age usually attributed to this formation.

L-398B. Rabat, Morocco 5970 ± 130

Marine shell (*Mytilus africanus*, *Cardium edule*, and *Patella*) from 2 m above low tide in valley of Miramar Creek ($33^{\circ} 57' S$ Lat, $6^{\circ} 56' W$ Long). Shells were inclosed in marine sand overlying an erosional platform thought to be of late Sangamon age. Sample should record the first positive stand of the sea subsequent to the last glaciation. Coll. 1956 by M. Gigout; subm. by R. W. Fairbridge, Columbia Univ., New York, N. Y.

L-581. Argentine Shelf, 238 ft $16,350 \pm 300$

Marine shell from 2 to 3 ft below top of core V 15-149, coll. at depth of 238 ft ($38^{\circ} 30' S$ Lat, $56^{\circ} 53' W$ Long). Subm. by B. C. Heezen, Lamont Geol. Observatory. *Comment:* as the shell appears to be part of a beach deposit, the result should provide an estimate of the magnitude of sealevel lowering during Late Wisconsin time.

L-628. Argentine Shelf, 490 ft >35,000

Marine shells from 9 ft below sediment surface in core V 16-149 ($48^{\circ} 09' S$ Lat, $61^{\circ} 19' W$ Long) taken at depth of 490 ft. Subm. by C. T. Fray, Lamont Geol. Observatory.

*Pacific Coast***L-580D. Garanon Canyon, Santa Rosa Island, California >35,000**

Marine shell from sediments overlying the 25-ft platform exposed in Garanon Canyon on N Coast ($34^{\circ} 00' N$ Lat, $120^{\circ} 11' W$ Long). 10% of sample was removed by acid leaching prior to analysis. Subm. by P. C. Orr, Santa Barbara Museum of Natural History. *Comment:* as C^{14} dates on samples in the overlying dune- and alluvial sequence are infinite, this date should be infinite also. See Orr (1960a) for a discussion of Santa Rosa Island stratigraphy.

L-580E. Cluster Point, Santa Rosa Island, California >35,000

Marine shell from sediments overlying 25-ft platform exposed in sea cliff W of Cluster Point on S coast of the island ($33^{\circ} 55' N$ Lat, $120^{\circ} 10' W$ Long). Subm. by P. C. Orr, Santa Barbara Museum of Natural History. *Comment:* same as for L-580D.

L-482. Eniwetok Atoll series

Aragonitic coral from boring MU-7 on Mujinkarikku Island. Samples were selected to be free of alteration and secondary deposition. Subm. by S. Schlanger, U. S. Geol. Survey. *Comment:* the amount of calcite present was determined in each case by X-ray analysis. Because of the relatively young age of the first three samples, even if the calcite present were composed of recent

carbon, it could not measurably alter the results. However, as L-482E contains only 1.7 % of the C^{14} concentration of a contemporary coral, all the radiocarbon may be associated with the 2.1 % calcite present. Thus the true age of the sample may well lie beyond the range of the C^{14} method. Measurements of Th^{230} , Ra^{226} , and U^{238} in this sample (Potratz and Broecker, personal communication) support this hypothesis, suggesting an age in excess of 100,000 yr.

L-482A. 13 to 24 ft below sealevel **4100 \pm 200**
2.1% calcite.

L-482B. 24 to 26 ft below sealevel **5800 \pm 100**
2.9% calcite.

L-482C. 34 to 36 ft below sealevel **6050 \pm 100**
2.3% calcite.

L-482E. 64 to 69 ft below sealevel **33,000 \pm 1500**
2.1% calcite.

L-482G. 90 to 97 ft below sealevel **> 36,000**
1.0% calcite.

L-521. Brunei, Borneo **5800 \pm 200**

Arca and *Dosinia* from a shell bed 2 m above low-tide level (4° 50' N Lat, 114° 57' E Long). Result should provide a date for the first positive stand of the sea subsequent to the last glacial zone. Coll. by G. Wilford; subm. by R. W. Fairbridge, Columbia Univ., New York, N. Y.

IV. SAMPLES ASSOCIATED WITH PLUVIAL LAKE DEPOSITS

Lahontan Basin

L-596. Guano Cave, Lake Winnemucca, Nevada **6500 \pm 150**

Organic debris (insects, chitin, sticks, and fibers) from fine sand of habitation level in Guano Cave (40° 15' N Lat, 119° 17' W Long). Of the samples available, the pollen spectrum of this one indicated the most arid period in the sequence. Coll. by P. C. Orr and J. W. Calhoun, Western Speleological Institute, Carson City, Nevada; subm. by P. B. Sears, Yale Univ., New Haven, Connecticut.

L-437. Lithoid Terrace series, Lake Winnemucca, Nevada

Tufa samples coating rock outcrops. The deposits are among the highest to be found above Guano Cave and Crypt Cave (40° 15' N Lat, 119° 17' W Long). Coll. by P. C. Orr and J. W. Calhoun. *Comment:* the Δ value for the present day Pyramid Lake was used as a control in the age calculations.

L-437E. 570 ft **11,150 \pm 250**
570 ft above present level of Pyramid Lake.

L-437F. 546 ft **11,350 \pm 200**
546 ft above present level of Pyramid Lake.

L-364. Pyramid Lake series, Nevada

Samples coll. from a large tufa dome in the Needles area at N end of the lake (40° 08' N Lat, 119° 41' W Long). Samples were taken from a traverse across a spherical mass, 32 ft in diameter, partially destroyed by erosion showing numerous varieties of tufa in concentric layers (Broecker and Orr, 1958). Coll. by P. C. Orr and W. S. Broecker. *Comment:* results provide a clue to the mode of origin of thinolite crystals. As nonthinolite tufas show a progressive increase in age toward the center of the mass and these ages are consistent with the lake-level sequence of Broecker and Orr, the ages on the dendritic and lithoid tufas are considered reliable. If so, young ages on the thinolite samples could result from recrystallization of preexisting tufa into its present thinolite form. The Δ for Pyramid Lake was used as a control for the age calculations.

L-364CE. Depth 0 to 10 in. 8500 \pm 200

Massive lithoid tufa, 0 to 10 in. from surface of mass (previously published by Broecker and Kulp, 1957).

L-364CF. Depth 10 to 12 in. 12,150 \pm 150

Dense, highly-shattered tufa, 10 to 12 in. from surface.

L-364CG. Depth 10 to 15 in. 12,300 \pm 200

Dendritic tufa, 3-in.-thick layer 12 to 15 in. from surface.

L-364CI. Depth 17 to 19 in. 14,500 \pm 400

Dendritic tufa, 2-in.-thick layer 17 to 19 in. from surface (previously published by Broecker and Kulp, 1957).

L-364CJ. Depth 19 to 22 in. 15,500 \pm 350

Dendritic tufa, 3-in.-thick layer 19 to 22 in. from surface.

L-364CK. Depth 22 to 24 in. 15,350 \pm 400

Mammillary tufa, coating underlying radially-oriented thinolite crystals, 22 to 24 in. from surface.

L-364CL. Depth 24 to 28 in. 11,000 \pm 300

Radially-oriented thinolite crystals, 4 in. long, 24 to 28 in. from surface.

L-364CM. Depth 30 to 42 in. 11,400 \pm 250

Radially-oriented thinolite crystals, 12 in. long, 30 to 42 in. from surface.

L-364CN. Depth 150 in. 13,450 \pm 200

A randomly-oriented mesh of thinolite crystals, 3 in. long; these crystals make up entire core of the mass; ca. 150 in. from surface.

L-483. Carson Sink series, Nevada

Eleven samples, mainly of tufa and shell, deposited during various oscillations of Lake Lahontan, cover most of the stratigraphic sequence worked out by Morrison, U. S. Geol. Survey. Coll. by Morrison, P. C. Orr, Western Speleological Institute, and W. S. Broecker. *Comment:* samples are arranged in the order of increasing stratigraphic age. Unless stated otherwise, 25 to

50% of each tufa sample was removed by acid leaching before analysis was carried out. The C^{14} ages are consistent with the stratigraphic relationship of the samples.

Results on Wyemaha and Eetza samples lie so close to the limit of sensitivity of the method that more measurements must be made before the finite ages can be accepted. The Δ for Pyramid Lake was used for all samples deposited from the waters of the Lahontan lakes, yielding ages 400 yr lower than if the usual control value were used.

The stratigraphic names used below are provisional and subject to the approval of the U. S. Geological Survey.

L-483Q. Carson Lake Area—Fallon **<300**

Clam shells (*Anodonta californiensis*) from high shore of Morrison's third post-Lahontan lake, W side of U. S. Highway 95, S of Fallon, Nevada, SW $\frac{1}{4}$ sec. 6, T. 16N., R29E., alt 3920 ft (39° 16' N Lat, 118° 46' W Long).

L-483J. Carson Lake Area—Grimes Point **950 \pm 250**

Gastropod and pellicypod shells from highest beach of Morrison's second post-Lahontan lake, 1 mi S of Grimes Point, SW cor. sec. 29, T. 18N., R.30E., alt 3930 ft, (39° 23' N Lat, 118° 39' W Long).

L-483Z. Upsal Hogback Area **8600 \pm 200**

Lithoid tufa, probably from the upper member of the Seho formation (deposited by Morrison's third late Lahontan Lake), alt 3940 ft, 1.5 mi N of Upsal Hogback and 1.5 mi W of Nevada State Highway 1A, NW $\frac{1}{4}$ sec. 23, T.21N.,R.28E. (39° 40' N Lat, 118° 49' W Long).

L-483X. Third Seho Lake tufa **8850 \pm 150**

Lithoid tufa at base of the upper member of the Seho formation, deposited during the transgression of the third Seho lake, last of the Lahontan lakes, alt 3930 ft, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec.24,T.19N.,R.29E. (39° 30' N Lat, 118° 40' W Long).

L-483F. Wyemaha Valley, dendritic tufa **13,200 \pm 250**

Dendritic tufa (a characteristic radiating-algal variety found in several places in the Lahontan basin) in the dendritic member of the Seho formation, deposited during the transgression of the second late-Lahontan lake. Sample coll. from a fresh cut in a gravel pit at W end of Wyemaha Valley, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 22, T.18N.,R.30E., alt 4090 ft, (39° 25' N Lat, 118° 37' W Long). *Comment:* samples identical in appearance exposed in the Truckee River Valley at an alt of 4010 ft (L-289S and L-364AM) yielded ages of 12,900 \pm 350 and 12,700 \pm 300 respectively (Broecker and Orr, 1958).

L-483I. Churchill Valley **11,950 \pm 250**

"Coralline" tufa of either the lower member of the Seho formation, deposited during the transgression of the first Seho lake or the dendritic member deposited during the transgression of the second Seho lake, in Churchill Valley, 0.4 mi WSW from summit of Seho Mountain, SE $\frac{1}{4}$ SW $\frac{1}{4}$ sec. 15, T. 18N.,R.30E., alt 4180 ft, (39° 25' N Lat, 118° 37' W Long). *Comment:* tufa

blankets a gravel bed, several ft thick, which directly overlies the shell-bearing sand from which L-483H came.

L-483H. Sehoo Mountain 12,700 ± 300

Gastropod (*Parapholys nevadensis*) shells (showing no evidence of alteration) from lake sand of either the lower or the dendritic member of the Sehoo formation 1 ft below the surface. Sand in which shells were found is thought to have been deposited during rise of the first or the second Sehoo lake. Sample, coll. within 50 ft of L-483I, is stratigraphically older. *Comment*: the age of this sample and that of L-483I support a second rather than first post-Lahontan age for this sequence.

L-483D. Wyemaha Valley, "Coralline" tufa >33,000

"Coralline" tufa of lower member of Sehoo formation, deposited during rise of the first Sehoo lake. Coll. from horizon 5 ft below that containing L-483F, in the same gravel pit, and thus is definitely stratigraphically older than L-483F.

L-483DD. Fallon 33,500 ± 2000

Wood from black organic mud in the Wyemaha formation, at bottom of 51-ft drainage well drilled in 1948 at Univ. of Nevada Agricultural Experiment Station, 0.85 mi S of Fallon City limit (39° 27' N Lat, 118° 46' W Long). Black mud is ca. 31 ft below the top of the Wyemaha formation in the well, at 3907 ft alt. If formed during the low-water and desiccation interval between the Eetza and Sehoo lakes.

L-4830. Bunejug Mountains

Lithoid tufa of the Eetza formation, from a fresh exposure in gravel pit 1.5 mi S of U. S. Highway 50, at NW tip of the Bunejug Mountains, SE $\frac{1}{4}$ NW $\frac{1}{4}$ sec. 5, T.17N., R.30E. (39° 15' N Lat, 118° 49' W Long) alt 3950 ft, deposited during a comparatively low stand of one of the early Lahontan lakes.

First 10% removed during acid leaching >34,000

Residual material after 90% of sample was removed by acid leaching >32,000

L-483N. Bunejug Mountains, limestone >34,000

Cemented fine-grain CaCO from 1-in. layer of lacustrine limestone of the Eetza formation, several in. below sample L-4830, in the same gravel pit.

L-483Y. Seguspa Canal, Fallon, Nevada 1300 ± 150

Fine-grained calcium carbonate from the carbonate-accumulation horizon (Cca horizon) of a buried paleosol (Toyeh soil) formed during the latter part of the Altithermal Age (of Antevs). The soil is developed on sand of the upper member of the Sehoo formation (which records the 3rd late-Lahontan Lake cycle), overlain by lake sand in the lower part of the Fallon formation, deposited by the first post-Lahontan lake. Bank of Seguspa irrigation canal 5 mi NE of Fallon, 3935 ft alt, SW $\frac{1}{4}$ NW $\frac{1}{4}$ sec.3, T.19N., R.29E. (39° 32' N Lat, 118° 43' W Long). *Comment*: this analysis was undertaken to see how the C¹⁴ age on soil would compare with its stratigraphic age. Although the C¹⁴ age

L-483FF. Carbonate**9550 \pm 150**

Carbonate from light layer, immediately above layer from which L-483EE was taken.

L-485. Knolls, Utah**11,300 \pm 250**

Nearly-pure dolomite from 1 ft below the surface of the Great Salt Lake desert (40° 43' N Lat, 113° 27' W Long), alt 4217 ft. Coll. by D. Graf, Illinois State Geol. Survey and A. Eardley, Univ. of Utah, Logan. *Comment:* as primary dolomite is known to precipitate only from waters of very high Mg content, the deposition of this sample very likely occurred during the last desiccation of Lake Bonneville. The Δ value for contemporary Pyramid Lake was used as a control for this age calculation. $\delta C^{13} = 1.3$.

L-503A. Saltair, Utah**>32,300**

Fine $CaCO_3$ from 13-ft, 1-in. to 13-ft, 3-in. interval in 650-ft core taken on the shore of Great Salt Lake (40° 47' N Lat, 112° 12' W Long). A complete description of the core and its implications to climatic history of Lake Bonneville has been given by Eardley and Gvosdetsky (1960). Subm. by A. J. Eardley, Univ. of Utah, Salt Lake City.

V. SAMPLES FROM DEEP-SEA CORES

*Arctic***L-501. Arctic Ocean, dredge sample****9300 \pm 180**

Shells of foraminifera (largely *Globigerina pachyderma*) separated from sediment coll. with an Ekman dredge (84° 22' N Lat, 148° 51' W Long). Dredge is thought to have sampled only uppermost layer in the sediment which, as shown by Menzies and others (1959), is far richer in forams than underlying layer. Purpose of the measurement was to determine whether this layer is postglacial, as would ordinarily be expected, or Wisconsin, as postulated by Ewing and Donn (1956). Coll. and subm. by K. Hunkins, Lamont Geol. Observatory. *Comment:* result suggests that the rate of sedimentation is presently very low (not exceeding a few mm per 1000 yr).

L-508. Arctic Ocean, core samples**25,000 \pm 3000**

Foraminifera separated from the 7- to 10-cm level of 4 cores (Alpha 3, 84° 12' N Lat, 168° 33' W Long, 2409 m; Alpha 4, 84° 21' N Lat, 168° 49' W Long, 2041 m; Alpha 5, 84° 28' N Lat, 169° 04' W Long, 1934 m; Alpha 6, 85° 15' N Lat, 167° 54' W Long, 1842 m). In each case sample represents the base of zone rich in forams (see sample L-501). Subm. by D. Ericson, Lamont Geol. Observatory. *Comment:* as with L-501, the age implies an extremely slow rate of sedimentation. The base of the foram-rich zone (10 cm) apparently does not correspond to end of the Wisconsin but to some much earlier event.

L-565A. Arctic Ocean, trawl sample**4800 \pm 700**

The 74- to 200-microns-size fraction, from a dark-brown clay, coll. at depth of 269 m with a trawl which penetrated the bottom sediments to a depth

of ca. 5 cm (77° 52' N Lat, 163° W Long). Sample contained mainly *Globirgerine pachyderma* mixed with ca. 20%, by weight, shell fragments and insoluble particles. Subm. by W. Cromie, Lamont Geol. Observatory.

Caribbean

L-430. Cariaco Trench series, Venezuela

Sediment samples from cores taken in a stagnant marine basin in S Caribbean Sea (10° 35' N Lat, 65° 04' W Long). The uppermost 5 m of sediment in cores V 12-97 and 99 and uppermost 8 m in V 12-98 consisted of a laminated (possibly varved) dark-green, organic-rich, and highly-fossiliferous lutite, representing deposition in the present anaerobic environment. At the base of this layer there is a sharp contact with gray lutite containing fossil of benthic animals, demonstrating that the basin was not then stagnant. Coll. and subm. by B. C. Heezen, Lamont Geol. Observatory. *Comment:* the ages were computed using results on surface ocean-water samples from Caribbean Sea as control. Corrections were made for depletion of C^{14} resulting from fractionation during the photosynthetic cycle of marine plants. As extrapolation yields non-zero surface ages for both organic and inorganic material, incorporation of a small amount of reworked material is suggested. The true age of sediment may be ca. 700 yr younger than that indicated by the organic fractions and 1200 yr younger than that indicated by the carbonate fraction. If so, stagnation of the trench occurred $10,300 \pm 250$ yr ago. If, on the other hand, the organic material is assumed to be free of reworked material, the transition is dated at $11,000 \pm 250$.

L-430D. Core V 12-97

Organic-rich lutite, 0 to 20 cm below top of core.

Organic material — $\delta C^{13} = -23.1$

950 ± 100

Bulk $CaCO_3$ — $\delta C^{13} = -1.7$.

1350 ± 100

L-430E. Core V 12-97

Organic-rich lutite, 255 to 280 cm below top of core.

Organic material.

7350 ± 200

Bulk $CaCO_3$.

7930 ± 150

L-430C. Core V 12-99

$10,700 \pm 400$

Organic-rich lutite, 400 to 450 cm below top of core (immediately above steel-gray lutite).

L-528D. Core V 12-98

$20,200 \pm 900$

Shells from 1050 to 1060 cm below top of core (organic-rich layer terminates at 850-cm depth in this core).

Mediterranean

L-430G. Mediterranean Sea, Ionian Basin, I

$13,600 \pm 700$

Fine fraction of $CaCO_3$ from 40- to 70-cm depth in core V 10-67, taken at depth of 2890 m (34° 42' N Lat, 20° 43' E Long). Coll. and subm. by R. J.

Menzies, Lamont Geol. Observatory. *Comment*: as reworked material may have been present, the age should be considered a maximum.

L-430F. Mediterranean Sea, Ionian Basin, 2 $29,900 \pm 3000$

Fine fraction of CaCO_3 from 180- to 190-cm depth in core V 10-67 (see L-430G). Subm. by R. J. Menzies, Lamont Geol. Observatory. *Comment*: in this age range, contamination by recent carbon in such samples is probably a more important potential source of error than that resulting from reworked material; hence this result may represent only a minimum age.

Pacific

L-520. Equatorial Pacific series

Foraminifera, separated from core V 15-32, taken at depth of 2850 m ($03^\circ 15'$ S Lat, $82^\circ 30'$ W Long). The Worzel ash layer (Worzel, 1959; and Ewing and others, 1959) is found in this core at depth of 604 to 613 cm. Subm. by D. B. Ericson, Lamont Geol. Observatory. *Comment*: the results yield a sedimentation rate of 5.5 cm per 1000 yr. Assuming that this rate applies down to the depth of the ash layer, a date of 110,000 B.P. is obtained for the ash fall.

L-520A. 68 to 80 cm $13,300 \pm 300$

L-520B. 145 to 160 cm $27,400 \pm 1500$

VI. SAMPLES FROM CAVE DEPOSITS

United States

L-490A. Schoharie Caverns, New York $>30,000$

Upper 1 in. of a mass of flowstone ($42^\circ 39'$ N Lat, $74^\circ 20'$ W Long). Coll. by R. Gurnee, E. A. Olson, and W. S. Broecker. *Comment*: absence of measurable C^{14} in this sample strongly suggests that, despite its fresh appearance, significant deposition has not occurred during postglacial times. $\delta\text{C}^{13} = -8.3$.

L-500A. Onondaga Caverns, Missouri 6000 ± 150

Moist stalactites ca. 25 in. in diam. and several in. in length ($38^\circ 02'$ N Lat, $97^\circ 15'$ W Long). Coll. 1958 by W. S. Broecker and E. A. Olson. *Comment*: the age was computed using the Δ value of -137% obtained on recently formed dripstone from the same cave (L-500C, Lamont VIII). If rate of growth has been uniform, 3.3 gm per 1000 yr per stalactite is suggested. Growth in this case must have begun ca. 14,000 yr ago. $\delta\text{C}^{13} = -8.0$.

L-495B. Sheep Canyon Cave, Beaverhead County, Montana 5100 ± 140

Water-soluble portion of a black organic coating called "amberat" found on ceiling of cave located in Madison limestones ($45^\circ 00'$ N Lat, $113^\circ 00'$ W Long), known only in dry caves in W North America and Australia. "Amberat", sometimes confused with smoke and/or animal excrement, is known to

occur only in the vicinity of calcium-carbonate deposits, suggesting that it is the water-soluble portion of ancient organic materials, leached from surrounding rocks and deposited by evaporation. Coll. by P. C. Orr, Western Speleological Institute. *Comment*: "amberat" from Nevada (L-364BI, Lamont IV) dated at 4150 ± 150 B.P., was later found to be contaminated with numerous insect parts and plant fibers. The Montana sample was dissolved in distilled water and filtered, thus eliminating insoluble portion of contaminants. Thus, either soluble contaminants are present, or the theory is incorrect. Further discussion in Orr (1959).

L-530. Moaning Cave series, California

Speliothem, coating a human bone ($38^{\circ} 04' \text{ N Lat}$, $128^{\circ} 28' \text{ W Long}$). Microscopic examination revealed 1206 concentric growth rings with an estimated additional 200 rings obscured. Significance of the results and a complete description of samples have been published elsewhere (Orr, 1952; Orr, 1953; and Broecker, Olson, and Orr, 1960). Subm. by P. C. Orr, Western Speleological Institute, Carson City, Nevada. *Comment*: the ages were computed using a contemporary dripstone deposit from nearby Crystal Palace Cave as control (L-551A—Lamont VIII). If rate of growth was uniform, ages of 1400 ± 250 for onset of deposition and of <100 yr for cessation of deposition are obtained by extrapolation. Growth period of 1400 yr suggests that each concentric ring represents 1 yr.

L-530A. Moaning Cave, 6.1 to 8.8 cm **200 ± 150**
6.1 to 8.8 cm from outer edge of bone.

L-530B. Moaning Cave, 0.0 to 2.6 cm **1200 ± 150**
0.0 to 2.6 cm from outer edge of bone.

VII. MISCELLANEOUS SAMPLES OF GEOLOGIC INTEREST

Eastern and Central United States

L-534. Catskill series, New York

Limestone samples selected to determine whether a dense carbonate would be measurably contaminated during weathering processes ($42^{\circ} 13' \text{ N Lat}$, $73^{\circ} 53' \text{ W Long}$). Coll. by W. S. Broecker. *Comment*: results suggest that contamination during weathering is negligible for carbonates of low porosity.

L-534A. Moss-covered limestone fragments **$>37,000$**

Carbonate leached from surface of discolored chips of Becraft limestone, broken free from parent outcrop by weathering, and completely surrounded by soil and a thick moss.

L-534B. Water-etched limestone **$32,000 \pm 3200$**

Carbonate leached from surface of pieces of Becraft limestone from a water-worn surface. Vegetation-free outcrop from which the sample was taken was eroded into a series of parallel channels, 1 to 3 ft wide. The pieces were coated with grease so only the surfaces exposed to weathering were attacked by the acid during the laboratory preparation.

L-457. Horn Island series, Mississippi

Organic matter from two cores taken on opposite sides of Horn Island, Mississippi, in Gulf of Mexico. Ages of the samples are consistent with prevailing sedimentation rates, indicated by faunal-population ratios in the cores. Coll. 1953 by J. G. Erdman and J. C. Ludwick; subm. by W. E. Hanson, Mellon Institute, Pittsburgh, Pennsylvania. *Comment*: these two samples were combusted and converted to calcium carbonate before dating.

L-457A. Mississippi Sound side 1400 ± 100

Organic matter from 120- to 135-cm zone of a core taken in a lagoon in 16 ft of water (30° 14' N Lat, 88° 40' W Long). Core was dominantly clay, little sand, 1% CaCO₃, and 1.5% organic carbon.

L-457B. Gulf of Mexico side 3480 ± 140

Organic matter from 120- to 135-cm zone of a core taken in 38 ft of water (30° 12' N Lat, 88° 39' W Long). Core consisted of muddy sand with 5.9% CaCO₃ and 0.5% organic carbon. Sampled site has only a thin layer of recent sediments covering eroded Pliocene sediments. On the basis of its texture, analyzed material was of recent deposition.

L-480. Wayne County series, Indiana

Nuts, snails, and wood from shallow drag-line gravel pit 2 mi N of Fountain City, Wayne County, Indiana (39° 58' N Lat, 84° 54' W Long). Samples apparently were deposited in a postglacial-stream channel, cut into gravel. Based on the presence of beaver-gnawed wood fragments in sample horizon, sediments accumulated behind a beaver dam, first from 1 to 2 ft of organic-rich material (sample layer) and then about 4 ft of sand, silt, and clay. On the latter, there developed the present Eel silt-loam soil (Gooding, 1957). The spread in ages points to long interval of sediment accumulation.

L-480D. Walnuts 1000 ± 150

Coll. 1957 by A. M. Gooding, J. Thorp, E. Gamble, and E. A. Olson; subm. by Gooding, Earlham College, Richmond, Indiana.

L-480E. Snails 2350 ± 100

Coll. 1957 by A. M. Gooding and J. Thorp; subm. by Gooding.

L-480F. Wood 6800 ± 100

Coll. 1957 by A. M. Gooding, J. Thorp, E. Gamble, and E. A. Olson; subm. by Gooding. *Comment*: humic acid isolated from the wood gave age of 6700 ± 100.

*Southwestern United States***L-112B. bis Henry Mountains, Utah 1000 ± 100**

Wood from alluvium (38° 10' N Lat, 110° 05' W Long). Tree-ring studies indicate alluvium is more than 900 yr old. Subm. by C. B. Hunt, U. S. Geol. Survey. *Comment*: previously published black-carbon age of same sample was <100 yr (Lamont I). New result eliminates the anomaly.

L-494A. Monahans, Texas **19,200 \pm 500**

Snails (*Stagnicola palustris elodes*, id. by Leslie Hubricht) from a layer of calcareous sand exposed in a blowout 6 mi E of Monahans, Crane County, Texas (31° 37' N Lat, 102° 46' W Long). Sample age fixes a time when many perennial ponds existed in the Monahans dune area, and probably dates the last major Wisconsin pluvial maximum. In this latter respect, sample tends to confirm the validity of the Rich Lake samples (L-513 A, B; this list). Coll. 1958 by Mayrene Green; subm. by F. E. Green, Texas Technological College, Lubbock. *Comment*: Green provisionally placed the sample horizon below the basal unit at the Midland archaeologic site where snails have been dated at 13,400 \pm 1200 yr (L-304C, Lamont IV).

L-513. Rich Lake series, Texas

Freshwater limestone from the Tahoka formation exposed on W bluff of Rich Lake, 10 mi NE of Brownfield, Terry County, Texas (33° 17' N Lat, 102° 12' W Long). Rich Lake is the present remnant of a lake in which the Tahoka sediments were deposited. Except for the upper 4 ft of sand and two thin, freshwater limestone beds, the Tahoka sediments are clays which for the most part are calcareous. See Evans and Meade (1945) for a measured section and general description of the regional Quaternary history. Coll. 1959 and subm. by F. E. Green, Texas Technological College, Lubbock.

L-513A. Upper limestone (9 ft to 9 ft, 8 in.) **17,400 \pm 600****L-513B. Lower limestone (18 ft to 18 ft, 8 in.)** **26,500 \pm 800**

Comment: on stratigraphic grounds, Green thinks that the upper limestone should be older than L-494C, dated this list at 22,300 \pm 700. He suggests that the organic matter of L-494C may have included older reworked material that gave it an anomalously old age. On the other hand, Fred Wendorf (personal communication) considers it possible that the relative stratigraphy of the two sites (L-513 = Rich Lake, and L-494C = Arch Lake) has been misinterpreted and thinks that L-513A, and L-494C have consistent ages as reported in this list (see Wendorf's comment, L-494C, D, this list).

L-494B. Wolf Ranch, New Mexico **2850 \pm 100**

Carbonized plant remains from Wolf Ranch on the Penasco River, 14 mi E of Mayhill, Chaves County, New Mexico (32° 55' N Lat, 105° 15' W Long). Sample coll. from a carbon layer in a stream cut where 36 ft of sediments are exposed; the sample horizon, lying almost 11 ft below surface, is overlain and underlain by alternating layers of thin-bedded silt and clay. Presumably, the sediments accumulated in ponds (cienegas) caused by natural damming of a valley, although today the area is arid. As the sample layer contains pollen, a date is useful in calibrating the regional pollen chronology. Coll. 1958 by Ulf Hafsten; subm. by F. E. Green, Texas Technological College, Lubbock. *Comment*: humic acid isolated from sample was dated at 2900 \pm 100.

L-494. Arch Lake series, New Mexico

Organic matter, disseminated throughout layers of gypsiferous clay laid down in a former lake (now an alkaline remnant, Arch Lake), 22 mi E of

Portales, Roosevelt County, New Mexico, along State Highway 88 (34° 07' N Lat, 103° 03' W Long). Samples were obtained ca. 50 ft from present shoreline in a pit dug 4 ft down into wet clay, most of it containing gypsum. Pollen in the clay reflects a period when climate was cooler and more moist than at present. The lake sediments appear to extend from the Late Wisconsin almost to the present. See L-513A, B (this list) for other relevant samples. For a general reference concerning the Quaternary of this region, see Evans and Meade (1945). Coll. 1958 by F. E. Green, Texas Technological College, Lubbock; subm. by Fred Wendorf, Museum of New Mexico, Santa Fe.

L-494D. 8-in. level **1630 ± 100**

L-494C. 26- to 28-in. level **22,300 ± 700**

Comment: dates are for organic carbon. Carbonate carbon gave ages of 3800 ± 150 (L-494D) and 15,200 ± 500 (L-494C). The significant differences between carbonate and organic fractions probably result from two types of contamination: initial detrital limestone, which caused the great age of L-494D carbonate, and ground-water carbonate which caused the low age of L-494C. On the other hand, Green, on stratigraphic grounds, thinks that the 22,000-yr age of L-494C organic matter is too old and suggests the organic matter includes reworked older material (see discussion of L-513, this list). Wendorf believes that while the two dates are in proper stratigraphic order, the time separating them is far too great. Further, pollen associated with the upper sample (L-494D) indicates that it was contemporary with L-513A, dated at 17,400 ± 600 (this list). Also, the pollen flora associated with the lower sample (L-494C) closely resembles that found with L-513B, dated at 26,500 ± 800 (this list). Wendorf considers it possible that the relative stratigraphy of Arch Lake and Rich Lake was incorrectly interpreted because of the formation of gypsum. Owing to shallow depth of L-494D, it is possible that this sample was contaminated by recent rootlets and humic acids.

L-515A. Chuska Mountains, Northwestern New Mexico 3900 ± 300

Black mud 9 to 12 cm below surface in core (#5825B) near middle of Deadman Lake (36° 15' N Lat, 108° 55' W Long), in Tertiary sandstone at ca. 9100 ft alt. Pollen analysis shows dominant pine; an *Artemisia*-spruce zone in gray clay and silt is ca. 25 cm below. Subm. by H. E. Wright, Univ. of Minnesota, Minneapolis. *Comment:* the analysis was undertaken to determine whether the uppermost black mud, 12 cm thick, represented all of post-Wisconsin time or only the period subsequent to the onset of agriculture in the area; the date implies the former.

L-473. Rampart Cave series, Arizona

In Rampart Cave, located 3 mi E of Pierce Ferry in lower Grand Canyon, Mohave County, Arizona (36° 07' N Lat, 113° 58' W Long), Dick Shutler, Jr., then of Univ. of Arizona, coll. samples of dung of sloth *Nothrotherium shastense* from a deposit 60 in. thick. Paul Martin, Univ. of Arizona, made pollen analyses of the samples. Dung was laden with small undigested twigs which were used for dating. Coll. 1956 and subm. by Shutler.

L-473A. Surface material 9900 \pm 400

Pollen in sample indicates a hot, dry climate like that prevailing today. Because lower levels contain pollen of both dry and moist climates, it is thought that the postglacial change to an arid climate was not the reason for the sloth's departure from the region. Martin and others (1961) postulate that man was the cause of the sloth's extinction. *Comment*: humic acid isolated from sample gave an age of 10,000 \pm 200.

L-473C. 18-in. level 11,900 \pm 500

Pollen in sample indicates a climate cooler and more moist than that of today; pine, juniper, and sage were common. *Comment*: humic acid isolated from sample gave an age of 12,000 \pm 350.

L-473D. 60-in. level (base) >38,300

Pollen in sample indicates a dry climate much like that of today. *Comment*: humic acid isolated from sample gave an age of >32,600 yr.

*Alaska***L-601. Fairbanks, Alaska 21,300 \pm 1300**

Skin and flesh of baby elephant, probably *Mammuthus primigenius*, exposed during hydraulic mining of gravels along Fairbanks Creek (ca. 64° 50' N Lat, 147° 30' W Long). Coll. by O. Geist, American Museum of Natural History, New York, N. Y.; subm. by W. R. Farrand. Described by H. E. Anthony (1949). *Comment*: specimen was swabbed with glycerin and formalin upon collection and may be contaminated with modern carbon. Thus the age is minimum. Compare the Lena Delta woolly mammoth from Siberia, dated >30,000 B.P. (Y-633, Yale V). However, Soviet geologists place many woolly mammoths in an interstadial (Alleröd?) of the last glacial age (Saks and Strelkov, 1959, Table IV). See summary discussion of frozen woolly mammoths by Farrand (1961). Further attempts to evaluate contamination are planned.

L-567. Barrow, Alaska 3400 \pm 100

Partially decomposed organic matter from permafrost soil 8 mi S of Arctic Research Laboratory, Barrow, Alaska (71° 20' N Lat, 156° 45' W Long). Soil profile begins with a 2-in. surface mat of fresh organic material, below which is a gleyed soil with almost no organic matter; this extends downward to ca. 18-in. depth, where permafrost begins and organic matter reappears. Sample was coll. at depth of 32 to 34 in. In the lower organic zone the organic material is in the form of elongate fingers, as if mineral matter from below had been forced up through an organic layer. As with L-400B,C (Lamont V) and L-511B (this list), origin of sample is as yet uncertain. Coll. 1959 and subm. by L. A. Douglas, Rutgers Univ., New Brunswick, New Jersey. *Comment*: humic acid extracted from sample gave an age of 3400 \pm 200.

L-511. Franklin Bluffs series, Alaska

Organic matter from a soil profile near Franklin Bluffs, Northern Alaska (69° 50' N Lat, 148° 48' W Long). Soil is of the Upland Tundra type, prob-

ably of Quaternary age, and is perennially frozen below 17-in. depth. For areal geology, see Payne and others (1951). Coll. 1958 by L. A. Douglas; subm. by J. C. F. Tedrow, Rutgers Univ., New Brunswick, New Jersey.

L-511A. Surface plant litter (0 to 1 in.) **<200**

L-511B. Buried organic layer (19 to 21 in.) **8700 ± 200**

This organic layer lies within almost organic-free gray glei which begins at 18-in. depth and is overlain by brown sediments of blocky and crumb structure, having a carbonate content that increases with depth. It is uncertain whether the organic layer at depth of 19 to 21 in. represents a genetic soil process or was brought into position by later soil movement. Other samples coll. from similar profiles are L-400B and L-400C (Lamont V), which gave ages ca. 10,900 and 8700 yr respectively, and 511B (this list). See Tedrow and others (1958) and Tedrow and Douglas (1958) for several suggested origins of the buried layer. *Comment:* the age given above is an average of three fractions isolated from the buried organic layer: coarse fraction (>40 mesh) after humic-acid removal, 9000 ± 400; fine fraction (< 40 mesh) after humic-acid removal, 8200 ± 250; fine fraction, humic-acid portion, 8700 ± 200.

Canada

L-512. Edmonton, Alberta **4260 ± 260**

Humic (12%) and fulvic (88%) acids, from sediments 5 to 6 ft below surface in fractures of a fossil-soil polygon (53° 33' N Lat, 113° 41' W Long). Organic material (ca. 0.1% by weight) was isolated by extraction of 5 kg of sediment with 2% NaOH. Modern soil-forming processes are not thought to be active below 4 ft. The age should define the last period of permafrost activity in the area. Coll. and subm. by R. Taylor, Univ. of Alberta, Edmonton.

L-526. Ellesmere Island **3560 ± 150**

Organic rich dust blown from coast of N Ellesmere Island and deposited on the Ellesmere ice shelf (83° 03' N Lat, 76° 12' W Long). Sample comes from an unconformity which crops out near inner edge of the ice shelf. Dust was presumably concentrated during a period of ablation of the ice. The date should provide a basis for correlation with ice-island T-3, thought to have been originally part of the Ellesmere ice shelf. On a stratigraphic basis, the layer was thought to correspond to one on T-3 dated at 3050 ± 200 (L-213D, Lamont III). Coll. by E. Marshall; subm. by U. S. Army Snow Ice and Permafrost Research Estab., Wilmette, Illinois. *Comment:* no correction for the industrial CO₂ effect was applied to L-213D. Corrected age is 3300 ± 200.

L-522A. Mackenzie River, Northwest Territories **>42,000**

Peat from lower part of a succession of gravels, sands, and silts exposed on E bank of E Branch of the Mackenzie River, 20 mi N of Reindeer Station, Northwest Territories, Canada (68° 52' N Lat, 134° 30' W Long). The sediments are believed to have been overridden by glacier ice and are considered by Mackay (1956) to be part of an ancient delta of Mackenzie River.

Terasmae (1959c) studied pollen in apparently correlative peat from a nearby locality and inferred that inclosing sediments are interglacial. A possible finite date for the peat was suggested by a date of $28,000 \pm 2000$ on nearby drift-wood that lay beneath glacial deposits (L-300A, Lamont V). Coll. 1957 by J. R. Mackay; subm. by Geol. Survey of Canada.

Caribbean and Bahama Islands

L-401A. Guaracara Delta, Trinidad 3600 ± 120

Wood buried under 15 ft of alluvial silt in Guaracara Delta, 1 mi S of Pointe-a-Pierre railway station on Trinidad Island, British West Indies ($10^{\circ} 18' \text{ N Lat, } 61^{\circ} 23' \text{ W Long}$). Lying 12 ft below high-tide level, sample provides information on the history of the Gulf of Paria and on the average rate of delta sedimentation. Coll. 1957 by K. Rohr; subm. by H. G. Kugler, Trinidad Oil Co. *Comment*: humic acid extracted from the wood gave an age of 3700 ± 400 .

L-401C. San Fernando, Trinidad $>35,500$

Wood buried ca. 12 ft in alluvium of a filled-in Pleistocene river channel located ca. 10 mi SW of San Fernando, Trinidad Island, British West Indies ($10^{\circ} 18' \text{ N Lat, } 61^{\circ} 23' \text{ W Long}$). With the wood were various beetles and the bones of Glyptodon and Megatherium, permeated with oil that seeped into the alluvium from the Miocene sediments in which the channel was cut. It was hoped that the wood would date the buried mammals and thus fix a time when Trinidad and Venezuela were joined. Coll. 1957 and subm. by H. G. Kugler, Trinidad Oil Company. *Comment*: age is for wood treated several times with benzene in order to extract the oil. An untreated sample gave an age of $>29,000$ yr.

L-540A. Gold Cay, Great Bahama Bank, B. W. I. 700 ± 150

Unconsolidated grains (chiefly fecal pellets) from Gold Cay on the Andros Platform ($24^{\circ} 42' \text{ N Lat, } 78^{\circ} 38' \text{ W Long}$). Coll. and subm. by E. Purdy, Rice Univ., Houston, Texas.

L-540B. Little Stirrup Cay, Great Bahama Bank, B. W. I. 2500 ± 150

Unconsolidated grains (chiefly grapestone and cryptocrystalline aggregates) from Little Stirrup Cay, Andros Platform ($25^{\circ} 42' \text{ N Lat, } 78^{\circ} 09' \text{ W Long}$). Coll. and subm. by E. Purdy, Rice Univ., Houston, Texas.

L-366F. Bimini Cay, Bahamas $29,300 \pm 1500$

Partially cemented oolite rock from Entrance Point ($25^{\circ} 31' \text{ N Lat, } 79^{\circ} 10' \text{ W Long}$). Oolites were released from the matrix by light crushing and panning. Eight % of mechanically separated oolite was slowly leached away with acid. X-ray analysis demonstrated that the purified product contained less than 1% calcite. Coll. by K. K. Turekian, Yale Univ., New Haven, Connecticut, and N. D. Newell, American Museum of Natural History; separation by J. Corless. *Comment*: independent age estimates by the Ra-U method, as well as geologic considerations, strongly suggest that the true age of sample is well

beyond the range of C^{14} . As at least 2.5% secondary calcite would be required to supply the measured radiocarbon, some other mechanism besides cementation with calcite appears to be responsible for the finite age obtained. Perhaps exchange with surroundings by exposed carbonate ions is responsible. This would require a surface area of ca. 10 square m per gram of aragonite.

L-366G. Bimini Cay, Bahamas, oolite

Cemented oolite rock from crest of a low ridge near Entrance Point ($25^{\circ} 31' N$ Lat, $79^{\circ} 10' W$ Long). Sample, taken immediately below the case-hardened surface, was selected to see whether by mechanical separation into a fraction rich in oolite (largely aragonite) and into a fraction rich in cement (largely calcite), both the time of oolite formation and the time of cementation could be determined. Sample was finely ground and separated with bromoform. The aragonite-calcite ratio was determined by X-ray diffraction. Coll. by K. K. Turekian, Yale Univ., New Haven, Connecticut, and N. D. Newell, American Museum of Natural History; physical separations by D. Thurber. *Comment:* the assumption that all the aragonite is of one age and all the calcite of a single younger age must be rejected. Calcite is, as expected, younger than the aragonite, the former probably averaging less than 10,000 yr in age and the latter more than 20,600 yr. Bulk-material ages on such samples would obviously be quite misleading.

Fraction A—16% of total sample, 24% aragonite	13,300 \pm 500
Fraction B—48% of total sample, 38% aragonite	18,900 \pm 900
Fraction C—38% of total sample, 85% aragonite	20,600 \pm 900
Bulk sample (separate portion) 49% aragonite (age compares favorably with composite age of 18,000 \pm 1500 computed for fractions A, B, and C.)	19,700 \pm 900

L-593A. Bimini Cay, Bahamas, marine shell **> 32,000**

Marine shell (*Codakia orbicularis*) from a carbonate rock exposed near the Lyon's estate ($25^{\circ} 31' N$ Lat, $79^{\circ} 10' W$ Long). Subm. by A. McIntyre, Columbia Univ, New York, N. Y. *Comment:* result agrees with that obtained previously on the same formation L-321B (Broecker and Kulp, 1957). Ten % of sample was removed by acid leaching before proceeding with analysis.

L-524. Nassau, Bahamas **32,300 \pm 2500**

Land snails from Queen's Staircase ($25^{\circ} 05' N$ Lat, $77^{\circ} 20' W$ Long). Sample should date the period of formation of the dunes, responsible for most of the relief in the islands. As the dunes are not cut by high strandlines they probably postdate the last positive stand of the sea in this area. Subm. by N. D. Newell, American Museum of Natural History, New York, N. Y. *Comment:* despite removal of the surface of the shells by acid leaching, radiocarbon in the sample may be the result of contamination. Thus the age is minimum.

Europe and Africa

L-553A. Amersfoort, Holland **> 28,200**

Marine shells from 16.8 to 21.8 m below sealevel from Amersfoort Boring I ($52^{\circ} 17' N$ Lat, $05^{\circ} 25' E$ Long). Shells are from the marine Eemian. Subm.

by W. Zagwijn, Geol. Survey of the Netherlands. *Comment:* Haring and others (1958) have shown that the Eemian is $>64,000$ yr in age. The purpose of this analysis was to determine the level of contamination in this shell material. Fifty % of the shell was removed by acid leaching before analysis. Result suggests that 1 ± 1 % of carbon is recent.

L-599C. Amsterdam, Netherlands $>35,000$

Marine shells from Eemian sand directly overlying the Eemian clay in borings made for a proposed tunnel under the IJ River ($52^{\circ} 17' \text{ N Lat, } 5^{\circ} 05' \text{ W Long}$). Subm. by W. H. Zagwijn, Geol. Survey of the Netherlands. *Comment:* as in the case of L-553A, sample is beyond the range of C^{14} . Result measures the contamination level in these shells.

L-506. Sadd-El-Aali series, Egypt

Wood from borings in sediments deposited by the Nile River, near site proposed for the Aswan High Dam. Coll. by J. Keller; subm. by W. L. Donn, Lamont Geol. Observatory.

506B. Borehole no. D-2 at 38-ft depth 3500 ± 150

506A. Borehole no. 25 at 139-ft depth $>30,000$

VIII. SAMPLES OF ARCHAEOLOGIC INTEREST

United States

Twenhafel Site, Illinois 2900 ± 650

Charcoal dust from refuse pit below the Weber Mound of the Twenhafel Indian Site ($37^{\circ} 40' \text{ N Lat, } 89^{\circ} 31' \text{ W Long}$), Illinois. Contemporary artifacts indicate the site to be Hopewellian. Charcoal is a combination of two samples coll. from the same occupation level but at different places. Coll. 1957 by M. L. Fowler; subm. by Thorne Deuel, Illinois State Museum. *Comment:* carbonate from contemporaneous uncharred bone (L-431C) was reported in Lamont V to have an age of 1440 ± 100 . The organic fraction of this bone material has since been dated at 3450 ± 450 . Presumably the difference is another case of ground-water contamination of bone carbonate.

L-406. Modoc Rock Shelter, Illinois 7050 ± 220

Charred bone from a depth of 21 to 22 ft in the Modoc Rock Shelter ($38^{\circ} 04' \text{ N Lat, } 90^{\circ} 04' \text{ W Long}$) 2 mi SE of village of Prairie DuRocher, Randolph County, SW Illinois. This site has been excavated to a depth of 26.5 ft; some five zones, all containing implements, have been delineated. Sample comes from the top of the next-to-bottom zone (II). Charcoal from the same horizon dated 7000 ± 700 (L-381C; Lamont V). Archaeology of this site is described by Fowler and Winters (1956), Deuel (1957) and Fowler (1959). Coll. 1956 by M. L. Fowler; subm. by Thorne Deuel, Illinois State Museum. *Comment:* in addition to charred organic carbon described above, carbonate carbon was removed from both charred and uncharred bone fragments. The ages are as follows:

Carbonate from charred bone	4200 ± 100
Carbonate from uncharred bone (portion 1)	2900 ± 100
Carbonate from uncharred bone (portion 2)	2950 ± 200

These younger ages are not surprising in view of the collector's observation that there were "small amounts of (ground water) calcium carbonate on bones and artifacts at all levels in the site". No such deposits were visible in samples measured. Identical "ages" of the two portions of uncharred bone show identical degrees of contamination, suggesting that the surface area per gram and the degree of exchange, or deposition per square cm, were roughly uniform throughout the sample of uncharred bone.

L-385A. Signal Butte, Nebraska **2630 ± 100**

Charcoal from middle cultural horizon (II) at the Signal Butte site (41° 48' N Lat, 103° 54' W Long), Nebraska. The reported age is consistent with ages reported in Lamont V for the next horizon below (I), namely, L-385B, L-385C, L-385D, and L-385E. The above age is also somewhat younger than those of horizon I charcoals dated by Kulp and others (1951), L-104A and L-104B. The Signal Butte site is described by Strong (1935). Coll. 1956 by R. G. Forbis; subm. by W. D. Strong, Columbia Univ., New York, N. Y. *Comment:* charred bone contemporaneous with the charcoal was also dated:

Organic portion of charred bone	2400 ± 500
Carbonate portion of charred bone	820 ± 550

L-533B. Tule Springs, Nevada **>28,000**

Charcoal mixed with earth, coll. with Pleistocene camel bones and a man-made stone tool (scraper), in a clearly delimited deposit under 4 ft of overburden (36° 19' N Lat, 155° 09' W Long). See Simpson (1956) and Harrington and Simpson (in press) for further details. Subm. by R. Simpson, Southwest Museum, Los Angeles, California. *Comment:* result agrees with the Chicago black-carbon result of >23,000 yr (C-914, Libby, 1955). As almost all the organic material was dissolved during the routine NaOH leach, the soluble organics (humic fraction) were run, rather than the residual organic material.

L-446B. Santa Rosa Island, California **5370 ± 150**

Abalone shell (*Haliotis rufescens*) from bottom of midden, locality 131.43, pit M at depth of 18 to 24 in. (34° 00' N Lat, 120° 00' W Long). The Highland culture is not yet properly characterized, but appears to be confined to the high parts of the islands, occupying tops of slight knolls; in the later sites, culture still retains evidence of house pits. Burials, are oriented with head to the NW, flexed, and face-down or on the left side. A total of 96 Highland sites is recognized on Santa Rosa Island; they occur also on San Nicolas, San Clemente, San Miguel, Santa Cruz and Anacapa Islands. Coll. and subm. by P. C. Orr, Santa Barbara Museum of Natural History, Santa Barbara, California.

L-568A. Santa Rosa Island, California **10,400 ± 2000**

Charcoal-bearing earth surrounding human bone from a cienaga in the

alluvial fans at Arlington Canyon on N side of the island (120° 10' N Lat, 34° 00' W Long). Subm. by P. C. Orr, Santa Barbara Museum of Natural History, Santa Barbara, California. *Comment*: bone lay 37 ft below the surface in the Tecolote member of the Santa Rosa Island formation. The large error is due to the small amount (0.3g) of carbon in the sample. Sample also contained rootlets which would tend to give a younger-than-true age. See Orr (1960b) for further information. A second analysis on a larger sample (L-650) yielded an age of $10,000 \pm 200$ yr.

Central and South America

L-561. San José Island, Mexico 1100 \pm 80

Marine shell (*Lyropecten* (*Lyropecten*) *subnodosus*) from the surface of a large shell midden (24° 53' N Lat, 110° 35' W Long) (Emerson, 1960). Coll. by Puritan-American Museum Expedition to Western Mexico; subm. by W. K. Emerson, American Museum of Natural History, New York, N. Y.

L-384A. Ancon, Peru 1390 \pm 160

Tortora rope, in direct association with a storage olla of white-zoned type of Willey's White-on-Red style. Sample coll. inside an excavated clay dwelling (11° 45' S Lat, 77° 10' W Long) which contained sherds of Playa Grande I type. Thought to be ca. 1800 yr old. Coll. in 1952 by L. Stumer; subm. by W. Strong, Columbia Univ., New York, N. Y.

L-476A. Alumbreira, Argentina 1530 \pm 100

Charcoal from an inside hearth 2 mi SE of Alumbreira, Andalgalá Dept., Province of Catamarca, Argentina (27° 33' S Lat, 66° 05' W Long). Ceramics associated with the charcoal are of the Ciénaga-Condorhuasi phase of the Barreales culture. Coll. 1957 by A. R. González, Univ. of Córdoba; subm. by Junius Bird, American Museum of Natural History, New York, N. Y. *Comment*: humic acid isolated from the charcoal dated 1380 ± 220 . Sample Y-558 (Yale V) from same site was dated at 1630 ± 60 .

L-476B. Agua de las Palomas, Argentina 1250 \pm 100

Charcoal from near the surface of an inside hearth at Agua de las Palomas, Andalgalá Dept., Province of Catamarca, Argentina (27° 38' 5" S Lat, 66° 5' 55" W Long). Sample dates the Cienaga-Condorhuasi phase of the Barreales culture, one of the earliest agricultural and ceramic cultures in NW Argentina. Compare with L-476A above. Coll. 1957 by A. R. González, Univ. of Córdoba; subm. by Junius Bird, American Museum of Natural History, New York, N. Y.

L-476C. Cerrito Colorado, Argentina 400 \pm 100

Charcoal from floor of an ancient dwelling located in Cerrito Colorado, 1.5 mi W of town of La Ciénaga, Belén Department, Province of Catamarca, Argentina (28° 25' S Lat, 67° 09' W Long). Sample dates the Belén culture of the Late Period in the archaeologic sequence of NW Argentina. Coll. 1952 by A. R. González, Univ. of Córdoba; subm. by Junius Bird, American Mu-

seum of Natural History, New York, N. Y. *Comment*: another sample dating the Belén culture is Y-559 with an age of 590 ± 50 (Yale V).

Europe and Africa

L-472A. Antrim, Northern Ireland 2700 \pm 120

Charcoal from an undisturbed Late Neolithic pit ca. 5 mi E of Ballycastle, County Antrim, Northern Ireland ($55^{\circ} 12' \text{ N Lat}$, $6^{\circ} 07' \text{ W Long}$). Neolithic objects were found in the pit, which was cut almost 2 ft down into till; the pit was subsequently covered, first by at least 6 in. of clay, on which a soil developed, and then by 4 ft of Sphagnum peat. The charcoal age not only dates the Late Neolithic of Northern Ireland but provides estimate of rates at which the soil developed and peat accumulated. For a general review of the Neolithic of Northern Ireland, see Piggott (1954). Coll. 1955 and subm. by H. J. Case, Ashmolean Museum, Oxford, England. *Comment*: as the age of the charcoal turned out to be younger than a dated sample of basal peat, supposedly correlative with the peat that lay above the charcoal, a C^{14} age was obtained for a basal peat sample coll. at the pit. The age of the basal peat (L-472B) is 1380 ± 150 and the humic acid extracted from it 1460 ± 100 . Thus, at the pit, the C^{14} ages are stratigraphically consistent.

L-399G. Taforalt series, Morocco

Charcoal from the Oranian culture level (horizon C) in Grotte de Taforalt ($39^{\circ} 49' \text{ N Lat}$, $2^{\circ} 24' \text{ E Long}$). Coll. by Abbé Jean Roche; subm. by H. L. Movius, Harvard Univ., Cambridge, Massachusetts. *Comment*: the ages agree well with that of $11,900 \pm 240$ obtained on (L-399E) dating same culture but from slightly higher in sequence (horizon A) (Lamont V).

L-399G. Residual, after humic acid removal 12,100 \pm 200

L-399G. Humic acid 13,000 \pm 250

L-399G. Untreated portion of sample 13,900 \pm 250

L-395D. Abercorn, Northern Rhodesia 9550 \pm 210

Charcoal from a temporary land surface near base of a sequence of current-bedded sands ($8^{\circ} 35' \text{ S Lat}$, $31^{\circ} 13' \text{ E Long}$). Sample should date the Makalian wet phase and the Rhodesian Magosian culture. Coll. by J. D. Clark; subm. by H. L. Movius, Harvard Univ., Cambridge, Massachusetts.

L-399I. Kalambo Falls, Northern Rhodesia

Charcoal from the earlier of two Middle Stone age floors (Rhodesian Lupemban) in old lake beds adjacent to the falls ($8^{\circ} 35' \text{ S Lat}$, $31^{\circ} 15' \text{ E Long}$), near S end of Lake Tanganyika. See Lamont V, for other dates from the Kalambo Falls site. Coll. by J. D. Clark; subm. by H. L. Movius, Harvard University, Cambridge, Massachusetts.

Residue, after humic acid removal **30,500 \pm 2000**

Humic acid **27,500 \pm 2300**

South Pacific Islands

L-504B. Marquesas Islands

<200

Charcoal from site N Huu 1, in Ha's 'upa'upa, a small valley on W shore of Ha 'ata'i ve'a Bay, Nuku Hiva Island, Marquesas (8° 49' S Lat, 40° 02' W Long). N Huu 1 is an adze quarry or shop area, one of a complex of sites in Ha'ata'i ve'a, all of which are related to the large red tufa quarries on the E shore of that bay. Stratigraphy of N Huu 1 is as follows: 1.) An overburden containing remains of recent lime-burners fires, 1 ft, 3 in. in depth. 2.) Cultural strata about 2 ft thick, consisting of tightly packed debris of adze manufacture, unfinished adzes of Mouaka and Koma types (both used for stone cutting) and shop flakes. These strata were separated by a 5-in. sterile-layer wedging out of E end of the excavation. At the base of the lowest stratum a hearth was uncovered from which this sample was removed. 3.) Sterile stratum of erosion debris. Age of sample fixes the date at which the tufa quarries in the valley were worked to provide blocks and slabs for buildings, as well as large statues. Date can be extended to provide dates for Megalithic-architecture sites in which red tufa was used. Until this time, such sites could only be dated relatively, by reference to architectural characteristics developed stratigraphically. The date fits in well with von den Steinen's previous estimates of the age of the statues, made on the basis of a study of native historical traditions (Von den Steinen, 1928). For further information see Suggs (1960) and (in press).

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LAMONT RADIOCARBON MEASUREMENTS VIII

WALLACE S. BROECKER and EDWIN A. OLSON**

Lamont Geological Observatory, Columbia University, Palisades, New York

Like Lamont VI (Broecker and Olson, 1959), this list contains only results on samples of known age (most of which formed during the past ten years). The measurements were made largely in order to gain an understanding of the distribution of radiocarbon within the dynamic carbon reservoir. Again, the data are not reported primarily with the idea of drawing new conclusions but rather to bring together in one place information which is presently scattered throughout the literature or which otherwise might remain unpublished.

Although the system of data presentation is essentially the same as that adopted in our previous paper, a change has been made in the normalization formula:

previous relationship (Lamont VI)

$$\Delta C^{14} = \delta C^{14} - 2\delta C^{13} \left(1 + \frac{\delta C^{14}}{1000} \right) - 50.0$$

revised relationship (as suggested by K. C. Munnich and J. C. Vogel, personal communication)

$$\Delta = \delta C^{14} - 2\delta C^{13} \left(1 + \frac{\delta C^{14}}{1000} \right) - 50.0 \left(1 + \frac{\delta C^{14}}{1000} \right)$$

or

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

The symbol Δ has been substituted for ΔC^{14} in the revised formula in order to eliminate confusion between the two modes of normalization. The $\left(1 + \frac{\delta C^{14}}{1000} \right)$ term replaces unity as a multiplier of the constant term, 50.0, in order to yield Δ values which reflect the exact per-millage change in the fractionation-normalized C^{14} concentrations. That this was not precisely the case with the previous system can be most easily demonstrated by considering an example. Two plant samples identical in C^{13}/C^{12} ratio ($\delta C^{13} = -25.0$) but differing by a factor of 1.200 in C^{14}/C^{12} ratio ($\delta C_1^{14} = 0$ and $\delta C_2^{14} = 200$) would have ΔC^{14} values of 0 and 210 per mil respectively and Δ values of 0 and 200 per mil. Thus, the old scale (ΔC^{14}) would unnecessarily introduce an additional 10 per mil difference, while the corrected scale (Δ) would give a difference consistent with the measured C^{14} activities.

The convenience provided by the Δ scale should more than compensate for any confusion resulting from the change. ΔC^{14} results can be easily converted to Δ results by the following relationship:

$$\Delta = \Delta C^{14} - \frac{\delta C^{14}}{20}$$

* Lamont Geological Observatory Contribution no. 495.

** Present address: Division of Science, Whitworth College, Spokane, Washington.

It can be seen that the scale difference exceeds 5 per mil only for samples having C^{14} concentrations differing from 0.95 oxalic acid by more than 100 per mil.

The scale change in no way alters the method of computing δC^{13} and δC^{14} values or the use of .95 oxalic acid as a base for age calculations. One point concerning the use of the oxalic-acid standard warrants discussion, however. As shown by Craig (1961), considerable differences in δC^{13} value exist between gases prepared by different laboratories. These differences presumably result from isotope fractionation during chemical conversion of the oxalic acid to the compound used for the radioactivity assay. If corrections are not made, the activity of standards used by various laboratories (and even by the same laboratory at different times) will not be identical. To avoid this, it is proposed that all laboratories correct the activity of counting gas (or liquid) prepared from oxalic acid to the activity it would have had if its δC^{13} value were -19.0 . Thus,

$$.95A_{ox} = .95A'_{ox} \left(1 - \frac{2(19.0 + \delta C^{13'}_{ox})}{1000} \right)$$

where A'_{ox} and $\delta C^{13'}_{ox}$ are based on the actual counting and mass-spectrometer measurement made on a gas prepared from the oxalic-acid standard. If a further chemical conversion is required in order to convert the compound used for the radio assay into the compound (usually CO_2 gas) used for mass analysis, this conversion, of course, must be carried out without any additional isotopic fractionation.

A recalibration of the mass-spectrometer used for C^{13} analyses at Lamont indicates that the previous calibration was in error over the entire range by 1.7 per mil. Thus a δC^{13} result given previously as -16.9 per mil would become -18.6 . Although this change does not alter the relative values for any of the previously published Lamont results, it does introduce about a 3 per-mil error in comparing Lamont ΔC^{14} results with those from other laboratories. Because of this, Δ values in this paper are expressed in terms of the new calibration and should supersede results published elsewhere. In order to correct the results in Lamont VI, 1.7 per mil should be subtracted from each δC^{13} value and $3.4 (1 + .001 \delta C^{14})$ should be added to each ΔC^{14} value. Further conversion

to the Δ scale requires the subtraction of $\frac{\delta C^{14}}{20}$ from each result. Thus the results on the oxalic-acid standard (previously given as $\delta C^{14} = 53$, $\delta C^{13} = -16.9$, and $\Delta C^{14} = 39 \pm 2$) become $\delta C^{14} = 53$, $\delta C^{13} = -18.6$, $\Delta C^{14} = 42 \pm 2$ and $\Delta = 39 \pm 2$. It should be noted that as the result of the change in calibration the δC^{13} for the Lamont oxalic-acid CO_2 agrees within experimental error with that of -19.0 obtained by Craig (1961) for the same gas.

The CO_2 method for measuring C^{14} activities was used in all cases. Details of the Lamont procedure have been published by Broecker, Tucek, and Olson (1959).

As the results on the samples in section IID have not been published elsewhere, a brief discussion of their significance is appropriate. Four types of information can be derived from these analyses; 1) the relationship between

Δ for shells from open coastlines and Δ for surface water from the adjacent open ocean; 2) the magnitude of the Suess effect in the surface ocean; 3) the Δ value for areas of the surface ocean for which no direct measurements are available; 4) control values for age determinations on marine organisms.

The Δ values for coastal shells are compared with the average Δ values for the adjacent surface ocean in table 1. As would be expected, the agreement is satisfactory, the mean deviation (11 per mil) being only slightly greater than that expected from the experimental errors.

TABLE 1
Comparison of Δ values for coastal shells
with those for the adjacent surface ocean

Lamont No.	Shell Location	Shell Collection Date	Δ Shell	Average Δ Adjacent Open Ocean*
L-576B	Bahamas	1950	-51 ± 5	-49
L-593C	Bahamas	1958	$-25 \pm 7^\dagger$	-49
L-599A	Western France	1952	-58 ± 5	-49
L-576A	Jamaica	1930	-48 ± 5	-51
L-241A	Algeria	1954	$-43 \pm 10^{**}$	-49
L-576E	Tahiti	1957	-62 ± 5	-49
L-576C	Iceland	1946	-64 ± 6	-54^{***}

* see Broecker and others, 1960.

** see Broecker and Olson, 1959.

*** based on the results of Fonselius and Östlund, 1959.

† the relatively high C^{14} concentration probably reflects the presence of bomb-produced C-14.

TABLE 2
Estimates of the Suess effect in the surface ocean

Location	Lamont No.	Collection Date	Δ	Estimated Suess Effect in 1955
Jamaica	L-576F	1884	-43 ± 5	13 ± 17
	L-576A	1930	-48 ± 5	
Bahamas	L-576G	1885	-55 ± 7	≤ 8
	L-576B	1950	-51 ± 5	
Iceland	L-576I	1840	-72 ± 6	≤ 8
	L-576H	1900	-69 ± 6	
	L-576C	1946	-64 ± 6	
Tahiti	L-576K	1885	-58 ± 5	≤ 15
	L-576E	1957	-62 ± 5	

The magnitude of the Suess effect in the surface oceans has been estimated in four different localities by measuring pairs of gastropod shells collected at different times from each locality. The results as summarized in table 2 suggest that the decrease in Δ has been less than 10 per mil between 1880

and 1955. Since the atmosphere showed a decrease in Δ of about 25 per mil over the same time interval, the rate of vertical mixing in the oceans must be quite rapid. This is in agreement with the vertical distribution of Sr^{90} in the oceans as observed by Bowen and Sugihara (1960). Rapid vertical mixing is also consistent with the fact that the observed atmospheric Suess effect is only a small fraction of what it would be if a major portion of combustion CO_2 were not being taken into the ocean. A quantitative treatment of this problem will be published separately.

Very few surface-water samples were collected for radiocarbon analysis from the North Pacific prior to 1957. Because results on samples collected since that time are influenced by the presence of bomb-produced C^{14} , measurements on shells grown before bomb-testing will perhaps be the only way to establish the steady-state Δ for these waters. Three of the samples reported here provide estimates of this value; Oahu, Hawaii (L-576J) $\Delta = -62 \pm 6$; Eniwetok Atoll (L-584A) $\Delta = -76 \pm 5$; and Vancouver Island (L-595) $\Delta = -55 \pm 5$. Certainly many more such analyses are needed before any conclusions can be formulated.

The selection of a proper contemporary standard for radiocarbon dating of marine shells has always presented a serious problem. The results of this study suggest the following generalizations.

1) For age determinations on shells which formed on open-ocean coast lines in the latitude range from 40°N to 40°S , a control value of $\Delta = -55 \pm 10$ should be used. Since the C^{14} activity corresponding to this Δ value is almost the same as that of the usual standard for age determination of terrestrial organic materials (.95 oxalic acid), use of the latter standard seems justified for these shells. The additional error resulting from uncertainty in the initial $\text{C}^{14}/\text{C}^{12}$ ratio of mid-latitude shells will probably not increase the total error for such samples beyond that for terrestrial organic materials.

2) Because C^{14} -deficient deep-water horizons outcrop at high latitude, age determination on samples formed there presents greater difficulty. This is particularly true in the Antarctic. As demonstrated by the measurement on the living seal from McMurdo Sound (L-570, this date list), marine organisms in this region form with an abnormally low C^{14} concentration, so that at death they appear to have ages as great as 1200 yr. Low values of C^{14} concentration are also found for surface water samples from the Antarctic. On the other hand, the effect in the northern North Atlantic should be much smaller, perhaps equivalent to an "initial age" below 200 yr. There are three reasons why this is so: a) the deep waters of the North Atlantic have relatively high Δ values (approximating—100 per mil), b) the Gulf Stream is a significant contributor to North Atlantic waters, and c) Atlantic circulation may be cyclic (Broecker and others, 1960).

3) The most difficult problem is the evaluation of results on samples from lagoons, estuaries and other restricted parts of the ocean. In these cases the contribution of limestone-derived carbon from terrestrial drainage may cause a significant depression in the initial Δ . Whether this is the explanation for the low value of the Pearl Harbor sample (L-576D, this date list) is not certain; more probably, the result implies a finite age of the sample at the time of col-

lection. More work is needed before the magnitude of these local effects can be evaluated.

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SAMPLE DESCRIPTIONS

I. SAMPLES UTILIZING ATMOSPHERIC CO₂

A. Samples Defining the Atmospheric C¹⁴/C¹² Ratio Before 1900

	δC^{14}	δC^{13}	Δ
L-549A. Tokyo, Japan	-1±5	-25.8	1±5

Wood from the 1849 to 1853 growth rings of a *Quercus Glandulifera* tree growing in a forest near Iwaizumi (Akita-Ken) Japan (39° 48' N Lat, 141° 48' E Long). Coll. by K. Kigoshi, Gakushuin Univ., Tokyo.

L-549B. Stockholm, Sweden	9±6	-26.3	12±6
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Wood from the 1844 to 1856 growth rings of an oak tree from a resort area near Stockholm (59° 20' N Lat, 18° 08' E Long). This wood has been used as a radiocarbon standard by the Stockholm Laboratory which obtained a Δ value of 6±5 per mil. Subm. by G. Östlund for purposes of interlaboratory calibration.

B. Samples Defining the Atmospheric C¹⁴/C¹² Ratio During the Time of the Suess Effect (1900-1952)

L-458. Lower Hutt, New Zealand	-18±6	-25.4	-17±6
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Wood from pine lumber used by New Zealand Laboratory as a standard (exact age unknown but cut prior to 1950). Subm. by T. Rafter and G. Fergusson for purposes of an interlaboratory calibration. New Zealand Laboratory obtains a Δ value of -18±4 per mil.

L-539B. Palisades, New York	2±6	-23.7	-1±6
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Wood from the 1952 growth ring of an oak tree cut April 19, 1959 on the grounds of Lamont Geol. Observatory (41° 00' N Lat, 73° 55' W Long). Sample was run to determine whether it contained carbon photosynthesized subsequent to formation of the ring. The Δ value is 25±10 per

	δC^{14}	δC^{13}	Δ
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mil greater than that for similar age rings from trees cut prior to 1954, suggesting that a small amount of bomb-produced C^{14} was incorporated into the ring subsequent to its formation. Also compare Δ for this sample with -41 ± 15 for twigs coll. on Lamont grounds in 1952 (see L-184E, Broecker and Olson, 1959). The bulk sample was combusted without pretreatment. Coll. by the authors.

C. Samples Defining the Atmospheric C^{14}/C^{12} Ratio Since Large-scale Bomb-testing Began (1952-1960)

L-453. Stratosphere	225 ± 6	-7.2	181 ± 6
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Composite of several CO_2 samples separated from stratospheric air, distributed by L. Machta, U. S. Weather Bureau, for purposes of intercalibration between the various laboratories interested in bomb-produced C^{14} . Result obtained agrees well with those of the other participating laboratories.

L-493L. South Atlantic Ocean	118 ± 5	-7.4	79 ± 5
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Atmospheric CO_2 coll. on Columbia Univ. research vessel *Vema* by pulling air through CO_2 -free KOH (35° S Lat, 24° E Long). Coll. April 15 to 18, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).

L-493M. South Atlantic Ocean	125 ± 6	-7.1	85 ± 6
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Atmospheric CO_2 coll. on Columbia Univ. research vessel *Vema* by pulling air through CO_2 -free KOH (27° S Lat, 46° E Long). Coll. April 28 to May 2, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).

L-493N. South Atlantic Ocean	120 ± 5	-5.3	76 ± 5
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Atmospheric CO_2 coll. on Columbia Univ. research vessel *Vema* by pulling air through CO_2 -free KOH (13° S Lat, 65° E Long). Coll. May 13 to 17, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).

L-4930. Mediterranean Sea	214 ± 8	-6.8	170 ± 8
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Atmospheric CO_2 coll. on Columbia Univ. research vessel *Vema* by pulling air through CO_2 -free KOH (36° N Lat, 7° E Long). Coll. August 8 to 10, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).

	δC^{14}	δC^{13}	Δ
L-493P. North Atlantic Ocean	200\pm8	-7.5	158\pm8
Atmospheric CO ₂ coll. on Columbia Univ. research vessel <i>Vema</i> by pulling air through CO ₂ -free KOH (39° N Lat, 30° W Long). Coll. August 15 to 19, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-487M. Santa Barbara, California	109\pm6	-25.6	110\pm6
Sycamore leaves from grounds of Santa Barbara Museum of Natural History (34° 31' N Lat, 119° 41' W Long). Coll. September 9, 1958 by P. Orr.			
L-529A. North Atlantic Ocean	197\pm5	-6.8	153\pm5
Atmospheric CO ₂ coll. on Columbia Univ. research vessel <i>Vema</i> by pulling air through CO ₂ -free KOH (33° N Lat, 76° W Long). Coll. October 22 to 24, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-529M. North Atlantic Ocean	193\pm8	-8.3	153\pm8
Atmospheric CO ₂ coll. on Columbia Univ. research vessel <i>Vema</i> by pulling air through CO ₂ -free KOH (11° N Lat, 76° W Long). Coll. November 8 to 10, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-537A. Equatorial Pacific Ocean	176\pm9	-7.8	136\pm9
Atmospheric CO ₂ coll. on Columbia Univ. research vessel <i>Vema</i> by pulling air through CO ₂ -free KOH (1° N Lat, 84° W Long). Coll. December 1 to 4, 1958 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-528C. Palisades, New York	264\pm7	-18.6	248\pm7
Atmospheric CO ₂ coll. statically in KOH exposed 3 ft above ground in dense forest on the grounds of the Lamont Geol. Observatory (41° 00' N Lat, 73° 55' W Long). Coll. by W. S. Broecker (Broecker and Olson, 1960).			
L-516E. Carson City, Nevada	249\pm8	-25.5	250\pm8
Willow leaves from tree growing W of town (39° 07' N Lat, 119° 53' W Long). Coll. June 5, 1959 by J. Calhoun, Nevada State Museum (Broecker and Olson, 1960).			

	δC^{14}	δC^{13}	Δ
L-528F. Rockleigh, New Jersey	232\pm8	-27.5	238\pm8
Black-cherry leaves from tree growing on a golf course (41° 00' N Lat, 73° 58' W Long). Coll. June 9, 1959 by W. S. Broecker (Broecker and Olson, 1960).			
L-537L. South Pacific Ocean	144\pm7	-8.9	107\pm7
Atmospheric CO ₂ coll. on Columbia Univ. research vessel <i>Vema</i> by pulling air through CO ₂ -free KOH (49° S Lat, 75° W Long). Coll. January 28, 1959 by R. Gerard, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-519B. Lima, Peru	135\pm7	-11.8	105\pm7
Grass cut (12° S Lat, 77° W Long) March 6, 1959 by O. C. Johnson, U. S. Atomic Energy Commission (Broecker and Olson, 1960. Note: the ΔC^{14} given in this publication was incorrect).			
L-523. Tucson, Arizona	193\pm9	-22.4	187\pm8
Leaves from tree growing in residential area on outskirts of Tucson (32° N Lat, 111° W Long). Coll. April 4, 1959 by W. S. Broecker (Broecker and Olson, 1960).			
L-528A. Palisades, New York	178\pm6	-27.6	183\pm6
Maple leaves from the grounds of Lamont Geol. Observatory (41° 00' N Lat, 73° 55' W Long). Coll. May 16, 1959 by W. S. Broecker (Broecker and Olson, 1960).			
L-528B. Alpine, New Jersey	251\pm6	-20.6	240\pm6
Atmospheric CO ₂ coll. statically in KOH on top of a 400-ft radio tower (40° 57' N Lat, 73° 55' W Long). Coll. May 16, to June 7, 1959 by the authors (Broecker and Olson, 1960).			
L-528E. Palisades, New York	198\pm7	-27.9	205\pm7
Maple leaves from the grounds of Lamont Geol. Observatory (41° 00' N Lat, 73° 55' W Long). Coll. June 7, 1959 by W. S. Broecker (Broecker and Olson, 1960).			
L-547A. Alpine, New Jersey	236\pm6	-25.7	238\pm6
Atmospheric CO ₂ coll. statically in KOH on top of a 400-ft radio tower (40° 57' N Lat, 73° 55' W Long). Coll. October 12 to 18, 1959 by the authors.			

	δC^{14}	δC^{13}	Δ
L-547C. Alpine, New Jersey	220\pm6	-26.0	222\pm6
Atmospheric CO ₂ coll. statically in KOH on top of a 400-ft radio tower (40° 57' N Lat, 73° 55' W Long). Coll. October 25 to 28, 1959 by the authors.			
L-547F. Alpine, New Jersey	202\pm7	-26.5	206\pm7
Atmospheric CO ₂ coll. statically in KOH on top of a 400-ft radio tower (40° 57' N Lat, 73° 55' W Long). Coll. November 25 to 28, 1959 by the authors.			

D. Samples Defining the Amount of Bomb-produced C¹⁴ in Humans

L-371A. New York, New York	61\pm10	-16.4	43\pm10
Human-lung tissue and associated blood from autopsy performed June 1958; subm. by A. Schulert.			
L-505A. Rockland County, New York	106\pm8	-23.5	103\pm8
Respiratory CO ₂ from a local resident, coll. January 1, 1959 by respiration into CO ₂ -free KOH (Broecker, Olson and Schulert, 1959).			
L-505B. Rockland County, New York	115\pm8	-18.2	100\pm8
Blood from same person as L-505A; also coll. January 1, 1959.			
L-516A. Carson City, Nevada	118\pm7	-18.1	103\pm7
Blood from a local resident, coll. March 4, 1959; subm. by J. Calhoun, Nevada State Museum. (Broecker and Olson, 1960).			
L-519A. Lima, Peru	70\pm6	-18.9	57\pm6
Blood from a local resident, coll. March 6, 1959; subm. by O. C. Johnson (Broecker and Olson, 1960).			
L-516C. Ushuaia, Argentina	33\pm8	-20.9	25\pm8
Blood from a local resident, coll. March 15, 1959 by M. Ewing, Lamont Geol. Observatory (Broecker and Olson, 1960).			
L-516D. Carson City, Nevada	135\pm6	-19.7	123\pm6
Blood from same person as L-516A, coll. June 1, 1959; subm. by J. Calhoun (Broecker and Olson, 1960).			

	δC^{14}	δC^{13}	Δ
L-516G. Carson City, Nevada	183±6	-19.5	170±6
Blood from same person as L-516A, coll. December 17, 1959; subm. by J. Calhoun (Broecker and Olson, 1960).			
L-569B. Rockland County, New York	213±6	-19.9	201±6
Respiratory CO ₂ from a local resident, coll. January 13, 1960 by breathing into large plastic bag (Broecker and Olson, 1960).			
L-569A. Rockland County, New York	194±6	-18.4	178±6
Blood from same person as L-569B, coll. January 19, 1960 (Broecker and Olson, 1960).			
L-583A. New York, New York	156±10	-17.9	140±10
Composite of blood-free muscle tissue coll. during an autopsy on February 8, 1960; subm. by P. Hudson, Columbia Univ. (Broecker and Olson, 1960).			

E. Samples Defining the C¹⁴ Concentration in Soil-Organic Materials

L-528D. Palisades, New York	106±7	-24.9	106±7
CO ₂ given off by soil in dense forest on the grounds of Lamont Geol. Observatory (41° 00' N Lat, 73° 55' W Long). Coll. continuously from May 16 to June 7, 1959 by exposing a tray of CO ₂ -free KOH within an inverted barrel driven several in. into the soil. Total CO ₂ obtained indi- cated that 1.7 moles of CO ₂ were being given off per week from each square m of soil surface (Broecker and Olson, 1960).			
L-528K. Palisades, New York	-1±7	-26.1	1±7
Coarse organic material from composite sam- ple of soil (0 to 21 in.) coll. June 8, 1960 from same locality as L-528D. Sample, consisting of leaves, twigs, rootlets, etc., was obtained by sieving the soil through a window screen. Amount of ma- terial obtained corresponds to 4±2 gm of carbon per kg of soil (Broecker and Olson, 1960).			
L-528L. Palisades, New York	-123±9	-24.7	-124±9
Fine organic material from same soil as L-528K. A representative sample of that portion of the soil passing through the 40-mesh screen was combusted. Amount of CO ₂ obtained corresponds to 10±2 gm of carbon per kg of soil (Broecker and Olson, 1960).			

	δC^{14}	δC^{13}	Δ
L-528G. Palisades, New York	-25 ± 7	-25.9	-23 ± 7
Humic acid extracted from fine fraction of soil (L-528L) by boiling it in 2% NaOH. Ca. 35% of the organics was dissolved by this treatment (Broecker and Olson, 1960).			
L-528P. Palisades, New York	-218 ± 9	(-24.7)	(-218 ± 9)
Residual organics after treatment with NaOH. Ca. 55% of the organic material appeared in this fraction (Broecker and Olson, 1960).			
L-528R. Palisades, New York	-83 ± 20	(-24.7)	(-82 ± 20)
Acid-soluble humic material from sample L-528L. That portion of the NaOH-soluble organics which was not precipitated upon acidification of the NaOH with HCl. Ca. 10% of the carbon in the fine fraction appeared in this fraction (Broecker and Olson, 1960).			

II. SAMPLES UTILIZING CO₂ DISSOLVED IN SEA WATER

A. CO₂ obtained from acidified samples of sea water from Atlantic Ocean and adjacent seas. All samples in this group were coll. by the scientific staff of Columbia Univ. research vessel *Vema*, under direction of M. Ewing, R. Gerard, and B. Heezen. The techniques used in collecting and measuring samples have been published by Broecker, Tucek, and Olson (1959). The implications of the results have been discussed by Broecker, Gerard, Ewing, and Heezen (1960). The rather large variations in the δC^{13} ratios are the result of isotope fractionation during the processing of the sample and do not represent real variations within the ocean. The numbers in parentheses beside each laboratory number are the index numbers used by Broecker and others (1960). δC^{13} values in parentheses are estimated rather than measured. The corresponding Δ values are based on these estimates.

1) Surface water 0 to 50 m

L-326A.(1) Gulf Stream	-9 ± 7	0.1	-59 ± 7
Coll. October 30, 1955; 38° 22' N Lat, 71° 32' W Long; 1 m depth.			
L-287E.(2) North Atlantic Current	12 ± 8	(-3.7)	(-31 ± 10)
Coll. July 19, 1955; 37° 58' N Lat, 50° 53' W Long; 1 m depth.			
L-326B.(3) Sargasso Sea	-5 ± 6	-2.8	-49 ± 6
Coll. November 1, 1955; 36° 06' N Lat, 66° 06' W Long; 1 m depth.			
L-538P. Gulf Stream	28 ± 8	-1.0	-21 ± 8
Coll. July 10, 1959; 35° 20' N Lat, 74° 40' W Long; 1 m depth.			

	δC^{14}	δC^{13}	Δ
L-326C.(4) Sargasso Sea	4±6	(3.3)	(-53±8)
Coll. November 3, 1955; 34° 06' N Lat, 65° 06' W Long; 1 m depth.			
L-465Z.(5) Sargasso Sea	-1±5	-0.2	-51±5
Coll. November 13, 1957; 34° 05' N Lat, 65° 00' W Long; 1 m depth.			
L-367I.(6) Sargasso Sea	-5±5	0.5	-56±5
Coll. June 2, 1956; 33° 50' N Lat, 66° 18' W Long; 1 m depth.			
L-367K.(7) Sargasso Sea	-6±6	-1.0	-55±6
Coll. June 7, 1956; 33° 00' N Lat, 49° 48' W Long; 1 m depth.			
L-367J.(8) Sargasso Sea	9±6	-0.3	-41±6
Coll. June 5, 1956; 32° 38' N Lat, 57° 55' W Long; 1 m depth.			
L-367L.(9) Sargasso Sea	-13±7	(-0.7)	(-62±10)
Coll. June 12, 1956; 31° 45' N Lat, 34° 38' W Long; 1 m depth.			
L-464B.(10) Sargasso Sea	26±5	(3.3)	(-32±8)
Coll. November 16, 1957; 29° 57' N Lat, 61° 41' W Long; 1 m depth.			
L-464D.(11) Sargasso Sea	13±6	-3.5	31±6
Coll. November 17, 1957; 29° 13' N Lat, 60° 30' W Long; 46 m depth.			
L-326D.(12) Antilles Current	5±6	3.2	-51±6
Coll. November 5, 1955; 27° 05' N Lat, 73° 32' W Long; 1 m depth.			
L-416A.(13) Florida Current	-2±7	0.6	-49±7
Coll. June 24, 1957; 25° 42' N Lat, 79° 23' W Long; 1 m depth.			
L-326E.(14) Antilles Current	6±5	-0.9	-42±5
Coll. November 8, 1955; 25° 25' N Lat, 75° 13' W Long; 1 m depth.			
L-326G.(15) Antilles Current	10±10	0.3	-41±10
Coll. November 12, 1955; 20° 32' N Lat, 68° 30' W Long; 1 m depth.			
L-326F.(16) Antilles Current	14±7	5:8	-48±7
Coll. November 10, 1955; 19° 58' N Lat, 70° 53' W Long; 1 m depth.			

	δC^{14}	δC^{13}	Δ
L-326H.(17) Antilles Current	8±5	0.4	-43±5
Coll. November 14, 1955; 19° 07' N Lat, 67° 07' W Long; 1 m depth.			
L-529I.(165) West Caribbean	20±7	2.1	-35±7
Coll. November 6, 1958; 15° 51' N Lat, 75° 11' W Long; 1 m depth.			
L-4640.(18) North Equatorial Current	1±8	-2.7	-44±8
Coll. November 26, 1957; 15° 03' N Lat, 39° 48' W Long; 1 m depth.			
L-538I.(163) North Equatorial Current	19±6	2.4	-37±6
Coll. May 14, 1959; 10° 31' N Lat, 45° 02' W Long; 1 m depth.			
L-326R.(19) West Caribbean	-1±7 (1.3)	(-52±9)	
Coll. December 20, 1955; 19° 04' N Lat, 80° 48' W Long; 1 m depth.			
L-326P.(20) West Caribbean	-11±10	5.5	-71±10
Coll. December 10, 1955; 16° 17' N Lat, 79° 14' W Long; 1 m depth.			
L-326Q.(21) West Caribbean	-5±7	-2.8	-49±7
Coll. December 16, 1955; 17° 39' N Lat, 79° 04' W Long; 1 m depth.			
L-326O.(22) East Caribbean	9±6	0.6	-43±6
Coll. December 8, 1955; 12° 27' N Lat, 77° 25' W Long; 1 m depth.			
L-326L.(23) East Caribbean	9±7	3.8	-49±7
Coll. November 25, 1955; 17° 05' N Lat, 71° 36' W Long; 1 m depth.			
L-326J.(24) East Caribbean	4±7	2.9	-52±7
Coll. November 19, 1955; 16° 43' N Lat, 70° 38' W Long; 1 m depth.			
L-326I.(25) East Caribbean	-1±6	3.4	-58±6
Coll. November 17, 1955; 17° 11' N Lat, 68° 55' W Long; 1 m depth.			
L-326K.(26) East Caribbean	11±7	4.2	-48±7
Coll. November 22, 1955; 17° 47' N Lat, 68° 22' W Long; 1 m depth.			
L-367Y.(27) East Mediterranean	-4±7	2.5	-59±7
Coll. August 16, 1956; 34° 04' N Lat, 26° 21' E Long; 1 m depth.			

	δC^{14}	δC^{13}	Δ
L-367R.(28) Gulf of Corinth	-53 ± 7	-4.0	-93 ± 7
Coll. July 24, 1956; $38^{\circ} 06' N$ Lat, $22^{\circ} 54'$ E Long; 1 m depth.			
L-464R.(29) South Equatorial Current	-28 ± 6	-2.8	-71 ± 6
Coll. December 5, 1957; $00^{\circ} 51' N$ Lat, 32° $52' W$ Long; 49 m depth.			
L-334A.(30) South Equatorial Current	-2 ± 6	-0.3	-52 ± 6
Coll. February 15, 1956; $03^{\circ} 06' S$ Lat, 32° $26' W$ Long; 1 m depth.			
L-334E.(31) South Equatorial Current	-13 ± 7	(-0.7)	(-61 ± 10)
Coll. February 17, 1956; $03^{\circ} 34' S$ Lat, 31° $22' W$ Long; 1 m depth.			
L-410D.(32) South Equatorial Current	-24 ± 5	-2.1	-69 ± 5
Coll. January 9, 1957; $04^{\circ} 29' S$ Lat, $34^{\circ} 54'$ W Long; 1 m depth.			
L-419B.(33) North Benguela Current	-24 ± 7	-5.0	-63 ± 7
Coll. May 20, 1957; $05^{\circ} 41' S$ Lat, $10^{\circ} 39' E$ Long; 1 m depth.			
L-464T.(34) Brazil Current	-8 ± 7	(-2.7)	(-52 ± 9)
Coll. December 16, 1957; $09^{\circ} 38' S$ Lat, 34° $05' W$ Long; 1 m depth.			
L-410E.(35) Brazil Current	-11 ± 7	-5.9	-49 ± 7
Coll. January 19, 1957; $10^{\circ} 59' S$ Lat, 32° $28' W$ Long; 1 m depth.			
L-465D.(36) Brazil Current	7 ± 7	-3.8	36 ± 7
Coll. December 26, 1957; $23^{\circ} 12' S$ Lat, 37° $38' W$ Long; 1 m depth.			
L-410JJ.(37) Central South Atlantic	-10 ± 15	(-2.7)	(-54 ± 15)
Coll. May 12, 1957; $14^{\circ} 30' S$ Lat, $07^{\circ} 34'$ E Long; 1 m depth.			
L-410DD.(39) Central South Atlantic	-13 ± 5	-3.0	-56 ± 5
Coll. May 3, 1957; $25^{\circ} 31' S$ Lat, $12^{\circ} 26' E$ Long; 1 m depth.			
L-410AA.(40) Central South Atlantic	-2 ± 7	-2.6	-47 ± 7
Coll. April 29, 1957; $32^{\circ} 13' S$ Lat, $16^{\circ} 20'$ E Long; 1 m depth.			
L-465X.(41) Central South Atlantic	-8 ± 6	-2.9	-52 ± 6
Coll. April 6, 1958; $34^{\circ} 06' S$ Lat, $18^{\circ} 06' E$ Long; 1 m depth.			

	δC^{14}	δC^{13}	Δ
L-410Y.(42) West Benguela	-2±7	-6.8	-38±7
Coll. April 19, 1957; 34° 46' S Lat, 06° 29' E Long; 1 m depth.			
L-410S.(43) West Wind Drift	-2±5	-0.7	-51±5
Coll. April 6, 1957; 39° 03' S Lat, 41° 48' W Long; 1 m depth.			
L-410W.(44) West Wind Drift	-21±7	-8.3	-54±7
Coll. April 12, 1957; 40° 54' S Lat, 20° 29' W Long; 1 m depth.			
L-410X.(45) West Wind Drift	-14±7	-3.9	-56±7
Coll. April 15, 1957; 41° 15' S Lat, 06° 10' W Long; 1 m depth.			
L-410Q.(46) Falkland Current	-27±5	-1.1	-74±5
Coll. April 2, 1957; 40° 43' S Lat, 56° 32' W Long; 1 m depth.			
L-410R.(47) Falkland Current	-27±7	-3.3	-69±7
Coll. April 3, 1957; 41° 05' S Lat, 51° 09' W Long; 1 m depth.			
L-410P.(48) Falkland Current	-27±6	-1.4	-73±6
Coll. March 20, 1957; 45° 24' S Lat, 59° 13' W Long; 1 m depth.			
L-465S.(49) Antarctic Convergence	-28±6	3.9	-84±6
Coll. March 24, 1958; 51° 27' S Lat, 02° 38' E Long, 1 m depth.			
L-465M.(50) Drake Passage	-69±7	-5.9	-105±7
Coll. February 24, 1958; 55° 27' S Lat, 57° 10' W Long; 1 m depth.			
L-465R.(51) Antarctic Surface Water	-79±5	-6.6	-113±5
Coll. March 19, 1958; 57° 07' S Lat, 07° 15' W Long; 1 m depth.			

2) Subsurface water 200 to 400 m

L-334U.(52) North Atlantic Central Water	-11±7	1.2	-63±7
Coll. April 16, 1956; 25° 01' N Lat, 59° 12' W Long; 256 m depth.			
L-367EE.(53) North Atlantic Central Water	-15±5	2.5	-69±5
Coll. October 12, 1956; 23° 22' N Lat, 27° 14' W Long; 329 m depth.			

	δC^{14}	δC^{13}	Δ
L-334M.(54) North Atlantic Central Water	-29±6	-4.3	-69±6
Coll. April 11, 1956; 15° 49' N Lat, 47° 12' W Long; 229 m depth.			
L-334K.(55) Transition NACW-SACW	-49±9	-4.6	-88±9
Coll. April 7, 1956; 08° 15' N Lat, 37° 54' W Long; 274 m depth.			
L-464P.(56) Transition NACW-SACW	-41±6	-2.6	-84±6
Coll. December 3, 1957; 07° 22' N Lat, 29° 59' W Long; 240 m depth.			
L-419G.(57) South Atlantic Central Water	-18±7	-4.1	-59±7
Coll. June 9, 1957; 00° 19' S Lat, 24° 29' W Long; 201 m depth.			
L-334B.(58) South Atlantic Central Water	-35±7	-2.1	-79±7
Coll. February 16, 1956; 03° 17' S Lat, 32° 14' W Long; 274 m depth.			
L-419A.(59) Lower SACW	-38±7	-4.2	-78±7
Coll. May 19, 1957; 06° 25' S Lat, 11° 26' W Long; 366 m depth.			
L-464Y.(60) South Atlantic Central Water	-8±5	-3.6	-50±5
Coll. December 21, 1957; 14° 02' S Lat, 37° 32' W Long; 295 m depth.			
L-464Z.(61) South Atlantic Central Water	-4±6	-0.1	-54±6
Coll. December 21, 1957; 14° 10' S Lat, 37° 33' W Long; 300 m depth.			
L-410HH.(62) South Atlantic Central Water	-13±7	-3.2	-56±7
Coll. May 9, 1957; 21° 14' S Lat, 03° 22' E Long. 0-274 m depth.			
L-410BB.(63) South Atlantic Central Water	-4±7	-4.2	-45±7
Coll. May 2, 1957; 28° 26' S Lat, 08° 39' E Long; 201 m depth.			

3) Subsurface water 500 to 1200 m

L-287G.(64) Lower North Atlantic Central Water	7±13 (-3.7) (-35±13)
Coll. July 19, 1955; 38° 00' N Lat, 51° 37' W Long; 732 m depth.	

	δC^{14}	δC^{13}	Δ
L-367CC.(65) North Atlantic Undefined	-41 ± 10	6.8	-102 ± 10
Coll. October 11, 1956; $24^\circ 23'$ N Lat, $24^\circ 03'$ W Long; 1097 m depth.			
L-282M.(66) North Atlantic Undefined	-50 ± 13	(-3.7)	(-90 ± 13)
Coll. June 17, 1955; $23^\circ 28'$ N Lat, $65^\circ 56'$ W Long; 896 m depth.			
L-3340.(67) North Atlantic Undefined	-49 ± 6	(-3.7)	(-90 ± 8)
Coll. April 14, 1956; $22^\circ 22'$ N Lat, $54^\circ 19'$ W Long; 823 m depth.			
L-464H.(68) North Atlantic Undefined	-57 ± 6	-16.5	-73 ± 6
Coll. November 22, 1957; $20^\circ 44'$ N Lat, $49^\circ 24'$ W Long; 950 m depth.			
L-326U.(69) North Atlantic Undefined	-43 ± 7	-3.0	-85 ± 7
Coll. December 25, 1955; $19^\circ 09'$ N Lat, $76^\circ 59'$ W Long; 1097 m depth.			
L-334L.(70) North Atlantic Undefined	-50 ± 6	-1.7	-94 ± 6
Coll. April 11, 1956; $15^\circ 49'$ N Lat, $47^\circ 12'$ W Long; 823 m depth.			
L-464M.(71) North Atlantic Undefined	-73 ± 6	-8.8	-103 ± 6
Coll. November 26, 1957; $15^\circ 29'$ N Lat, $40^\circ 30'$ W Long; 823 m depth.			
L-334I.(72) North Atlantic Undefined	-60 ± 5	-1.8	-104 ± 5
Coll. April 7, 1956; $08^\circ 14'$ N Lat, $37^\circ 48'$ W Long; 823 m depth.			
L-464S.(73) Antarctic Intermediate Water	-63 ± 6	-3.0	-104 ± 6
Coll. December 5, 1957; $00^\circ 51'$ N Lat, $32^\circ 52'$ W Long; 799 m depth.			
L-334C.(74) Antarctic Intermediate Water	-76 ± 6	-1.9	-119 ± 6
Coll. February 16, 1956; $03^\circ 22'$ S Lat, $31^\circ 50'$ W Long; 732 m depth.			
L-419C.(75) Antarctic Intermediate Water	-64 ± 7	-14.4	-84 ± 7
Coll. May 26, 1957; $04^\circ 47'$ S Lat, $02^\circ 40'$ E Long; 732 m depth.			

	δC^{14}	δC^{13}	Δ
L-464U.(76) Antarctic Intermediate Water	-86\pm6	-2.4	-127\pm6

Coll. December 16, 1957; 10° 04' S Lat, 33°
52' W Long; 914 m depth.

L-410II.(77) Upper Antarctic Intermediate Water	-67\pm7	-3.8	-107\pm9
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Coll. May 9, 1957; 21° 09' S Lat, 03° 20' E
Long; 550 m depth.

L-410CC.(78) Lower Antarctic Intermediate Water	-92\pm7	-4.1	-130\pm7
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Coll. May 2, 1957; 28° 25' S Lat, 08° 36' E
Long; 1189 m depth.

4) *Subsurface samples 1200 to 2500 m*

L-450E.(80) Upper North Atlantic Deep Water	-22\pm5	-3.9	-63\pm5
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Coll. October 31, 1957; 39° 16' N Lat, 70°
46' W Long; 2323 m depth.

L-287F.(81) Upper North Atlantic Deep Water	-19\pm7	(-3.7)	(-62\pm13)
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Coll. July 19, 1955; 37° 58' N Lat, 50° 53'
W Long; 1944 m depth.

L-464E.(82) Upper North Atlantic Deep Water	-32\pm10	(-4.7)	(-74\pm10)
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Coll. November 17, 1957; 29° 13' N Lat,
60° 31' W Long; 1423 m depth.

L-282K.(83) Upper North Atlantic Deep Water	-20\pm13	-3.4	-62\pm13
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Coll. June 15, 1955; 25° 07' N Lat, 69° 57'
W Long; 1829 m depth.

L-538M.(158) Upper North Atlantic Deep Water	-59\pm7	(-0.7)	(-105\pm7)
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Coll. May 30, 1959; 21° 10' N Lat, 66° 37'
W Long; 2520 m depth.

L-529C.(84) Upper North Atlantic Deep Water	-5\pm6	-4.4	-46\pm6
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Coll. November 4, 1957; 20° 31' N Lat, 73°
22' W Long; 1230 m depth.

L-529E.(152) Upper North Atlantic Deep Water	-9\pm7	0.3	-59\pm7
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Coll. November 4, 1958; 20° 31' N Lat, 73°
22' W Long; 1783 m depth.

	δC^{14}	δC^{13}	Δ
L-529D.(154) Upper North Atlantic Deep Water			
	-34 ± 6	0.7	-84 ± 6
Coll. November 4, 1958; 20° 31' N Lat, 73° 22' W Long; 1863 m depth.			
L-529F.(160) Upper North Atlantic Deep Water			
	-32 ± 6	-2.8	-75 ± 6
Coll. November 5, 1958; 19° 31' N Lat, 74° 59' W Long; 1290 m depth.			
L-538L.(155) Upper North Atlantic Deep Water			
	-30 ± 6	0.2	-79 ± 6
Coll. May 25, 1959; 18° 58' N Lat, 65° 38' W Long; 1260 m depth.			
L-419J.(87) Upper North Atlantic Deep Water			
	-61 ± 7	-14.7	-80 ± 7
Coll. July 4, 1957; 11° 12' N Lat, 59° 19' W Long; 2305 m depth.			
L-419I.(88) Upper North Atlantic Deep Water			
	-43 ± 6	-7.3	-77 ± 6
Coll. July 4, 1957; 11° 12' N Lat, 57° 16' W Long; 1765 m depth.			
L-419H.(89) Upper North Atlantic Deep Water			
	-62 ± 6	-17.6	-76 ± 6
Coll. July 3, 1957; 10° 49' N Lat, 55° 41' W Long; 1262 m depth.			
L-367BB.(90) Upper North Atlantic Deep Water			
	-56 ± 5	-2.4	-99 ± 5
Coll. October 10, 1956; 25° 13' N Lat, 21° 23' W Long; 1463 m depth.			
L-367AA.(91) Upper North Atlantic Deep Water			
	-60 ± 6	-1.4	-104 ± 6
Coll. September 10, 1956; 25° 13' N Lat, 21° 23' W Long; 1829 m depth.			
L-334J.(92) Upper North Atlantic Deep Water			
	-53 ± 7	0.8	-102 ± 7
Coll. April 7, 1956; 08° 15' N Lat, 37° 53' W Long; 1463 m depth.			
L-419D.(93) Upper North Atlantic Deep Water			
	-47 ± 6	-2.5	-90 ± 6
Coll. May 27, 1957; 04° 23' S Lat, 00° 05' W Long; 1829 m depth.			

	δC^{14}	δC^{13}	Δ
L-464W (94) Upper North Atlantic Deep Water			
	-54 ± 8	-2.6	-96 ± 8
Coll. December 16, 1957; $10^{\circ} 06' S$ Lat, $34^{\circ} 54' W$ Long; 1829 m depth.			
L-464X (95) Upper North Atlantic Deep Water			
	-55 ± 9	-8.3	-87 ± 9
Coll. December 17, 1957; $12^{\circ} 37' S$ Lat, $35^{\circ} 00' W$ Long; 1829 m depth.			
L-465B (96) Upper North Atlantic Deep Water			
	-61 ± 7	-1.3	-106 ± 7
Coll. December 22, 1957; $15^{\circ} 17' S$ Lat, $36^{\circ} 00' W$ Long; 4369 m depth.			
L-410GG. (97) Antarctic Deep Water	-80 ± 10	-5.0	-117 ± 10
Coll. May 8, 1957; $22^{\circ} 40' S$ Lat, $03^{\circ} 16' E$ Long; 1646 m depth.			
L-410Z. (98) Antarctic Deep Water	-71 ± 10	-1.0	-116 ± 10
Coll. April 2, 1957; $35^{\circ} 20' S$ Lat, $10^{\circ} 42' E$ Long; 2195 m depth.			
L-410T. (99) Antarctic Deep Water	-100 ± 5	-6.0	-134 ± 5
Coll. April 7, 1957; $38^{\circ} 58' S$ Lat, $40^{\circ} 06' W$ Long; 1829 m depth.			
5) Subsurface samples 2500 to 4000 m			
L-287N. (100) North Atlantic Deep Water			
	-43 ± 10	(-3.7)	(-84 ± 10)
Coll. July 27, 1955; $34^{\circ} 55' N$ Lat, $57^{\circ} 11' W$ Long; 3488 m depth.			
L-334X. (101) North Atlantic Deep Water			
	-62 ± 6	-0.8	-107 ± 6
Coll. April 18, 1956; $28^{\circ} 41' N$ Lat, $60^{\circ} 19' W$ Long; 2560 m depth.			
L-367Z. (102) North Atlantic Deep Water			
	-62 ± 8	-1.1	-107 ± 8
Coll. September 9, 1956; $26^{\circ} 10' N$ Lat, $18^{\circ} 06' W$ Long; 3503 m depth.			
L-334S. (103) North Atlantic Deep Water	-56 ± 7	-0.8	-102 ± 7
Coll. April 16, 1956; $25^{\circ} 01' N$ Lat, $59^{\circ} 11' W$ Long; 2560 m depth.			
L-282R. (104) North Atlantic Deep Water			
	-50 ± 7	(-3.7)	(-90 ± 9)
Coll. June 22, 1955; $24^{\circ} 26' N$ Lat, $70^{\circ} 23' W$ Long; 2787 m depth.			

	δC^{14}	δC^{13}	Δ
L-464G.(105) North Atlantic Deep Water	-53 ± 6	-7.0	-87 ± 6
Coll. November 21, 1957; 22° 03' N Lat, 51° 27' W Long; 2700 m depth.			
L-464I.(106) North Atlantic Deep Water	-62 ± 6	-3.0	-103 ± 6
Coll. November 22, 1957; 20° 43' N Lat, 49° 26' W Long; 2926 m depth.			
L-464L.(107) North Atlantic Deep Water	-69 ± 7	-5.6	-105 ± 7
Coll. November 25, 1957; 16° 44' N Lat, 42° 38' W Long; 3840 m depth.			
L-410A.(108) North Atlantic Deep Water	-53 ± 5	-11.3	-79 ± 5
Coll. December 31, 1956; 15° 52' N Lat, 38° 03' W Long; 3840 m depth.			
L-334N.(109) North Atlantic Deep Water	-74 ± 7	1.4	-123 ± 7
Coll. April 11, 1956; 15° 49' N Lat, 47° 12' W Long; 2560 m depth.			
L-334F.(110) North Atlantic Deep Water	-49 ± 6	-2.7	-91 ± 6
Coll. February 18, 1955; 03° 48' S Lat, 30° 53' W Long; 2560 m depth.			
L-419E.(111) North Atlantic Deep Water	-62 ± 7	-3.0	-103 ± 7
Coll. May 27, 1957; 04° 23' S Lat, 00° 15' W Long; 2743 m depth.			
L-410J.(112) North Atlantic Deep Water	-71 ± 6	-10.0	-99 ± 6
Coll. January 22, 1957; 17° 03' S Lat, 28° 13' W Long; 2807 m depth.			
L-410FF.(113) North Atlantic Deep Water	-63 ± 7	-5.5	-98 ± 7
Coll. May 8, 1957; 22° 56' S Lat, 04° 52' E Long; 2560 m depth.			
L-465H.(114) North Atlantic Deep Water	-57 ± 6	-4.0	-96 ± 6
Coll. January 18, 1958; 38° 25' S Lat, 53° 11' W Long; 2770 m depth.			

6) *Subsurface samples greater than 4000 m*

L-287A.(115) North Atlantic Deep Water	-43 ± 7 (-3.7) (-84 ± 9)
Coll. July 16, 1955; 39° 27' N Lat, 56° 57' W Long; 4345 m depth.	
L-287C.(116) North Atlantic Deep Water	-58 ± 7 (-3.7) (-98 ± 9)
Coll. July 18, 1955; 39° 03' N Lat, 53° 29' W Long; 5281 m depth.	

δC^{14} δC^{13} Δ

L-287H.(117) North Atlantic Deep Water
 -40 ± 13 (-3.7) (-81 ± 13)

Coll. July 19, 1955; $38^{\circ} 00'$ N Lat, $51^{\circ} 37'$
 W Long; 5369 m depth.

L-287L.(118) North Atlantic Deep Water
 -73 ± 13 (-3.7) (-112 ± 13)

Coll. July 23, 1955; $37^{\circ} 23'$ N Lat, $53^{\circ} 22'$
 W Long; 5368 m depth.

L-287M.(119) North Atlantic Deep Water
 -53 ± 7 (-3.7) (-93 ± 9)

Coll. July 26, 1955; $35^{\circ} 28'$ N Lat, $55^{\circ} 48'$
 W Long; 5416 m depth.

L-287K.(120) North Atlantic Deep Water
 -58 ± 5 (-3.7) (-98 ± 9)

Coll. July 22, 1955; $35^{\circ} 43'$ N Lat, $53^{\circ} 15'$
 W Long; 5454 m depth.

L-287I.(121) North Atlantic Deep Water
 -76 ± 13 (-3.7) (-115 ± 13)

Coll. July 21, 1955; $34^{\circ} 46'$ N Lat, $52^{\circ} 46'$
 W Long; 5481 m depth.

L-282Y.(122) North Atlantic Deep Water
 -60 ± 13 (-3.7) (-100 ± 13)

Coll. June 27, 1955; $31^{\circ} 47'$ N Lat, $71^{\circ} 13'$
 W Long; 5360 m depth.

L-282Z.(123) North Atlantic Deep Water
 -56 ± 7 (-3.7) (-96 ± 9)

Coll. June 29, 1955; $31^{\circ} 21'$ N Lat, $66^{\circ} 39'$
 W Long; 4893 m depth.

L-282X.(124) North Atlantic Deep Water
 -52 ± 9 (-3.7) (-92 ± 10)

Coll. June 27, 1955; $31^{\circ} 17'$ N Lat, $71^{\circ} 03'$
 W Long; 5367 m depth.

L-282W.(125) North Atlantic Deep Water
 -33 ± 13 (-3.7) (-74 ± 13)

Coll. June 26, 1955; $29^{\circ} 14'$ N Lat, $69^{\circ} 55'$
 W Long; 5400 m depth.

L-282L.(127) North Atlantic Deep Water
 -53 ± 20 (-3.7) (-93 ± 20)

Coll. June 15, 1955; $25^{\circ} 07'$ N Lat, $69^{\circ} 57'$
 W Long; 5508 m depth.

	δC^{14}	δC^{13}	Δ
L-334T.(128) North Atlantic Deep Water	-88 ± 6	-9.0	-117 ± 6
Coll. April 16, 1956; 25° 01' N Lat, 59° 12' W Long; 6035 m depth.			
L-367DD.(129) North Atlantic Deep Water	-82 ± 5	-0.2	-128 ± 5
Coll. October 11, 1956; 24° 23' N Lat, 24° 03' W Long; 4921 m depth.			
L-282P.(130) North Atlantic Deep Water	-58 ± 8	(-3.7)	(-98 ± 8)
Coll. June 20, 1955; 24° 05' N Lat, 68° 23' W Long; 5584 m depth.			
L-282N.(131) North Atlantic Deep Water	-55 ± 13	(-3.7)	(-95 ± 13)
Coll. June 17, 1955; 23° 28' N Lat, 65° 56' W Long; 5788 m depth.			
L-334P.(132) North Atlantic Deep Water	-87 ± 6	-8.3	-118 ± 6
Coll. April 14, 1956; 22° 22' N Lat, 54° 19' W Long; 5698 m depth.			
L-410B.(133) North Atlantic Deep Water	-65 ± 7	0.6	-113 ± 7
Coll. December 31, 1956; 15° 52' N Lat, 38° 08' W Long; 5264 m depth.			
L-464N.(134) North Atlantic Deep Water	-83 ± 9	-5.7	-118 ± 9
Coll. November 26, 1957; 15° 29' N Lat, 40° 30' W Long; 4147 m depth.			
L-334D.(135) Antarctic Bottom Water	-99 ± 7	-1.1	-142 ± 7
Coll. February 16, 1956; 03° 26' S Lat, 31° 34' W Long; 4389 m depth.			
L-410H.(136) Antarctic Bottom Water	-105 ± 6	-4.2	-142 ± 6
Coll. January 22, 1957; 16° 34' S Lat, 28° 03' W Long; 5330 m depth.			
L-410N.(137) Antarctic Bottom Water	-88 ± 5	-5.0	-124 ± 5
Coll. February 1, 1957; 33° 43' S Lat, 45° 18' W Long; 4380 m depth.			
B. CO ₂ obtained from acidified samples of sea water from Pacific Ocean. Samples in this group coll. by Univ. of Washington research vessel <i>Brown Bear</i> , under the direction of S. El Wardani.			
L-470A. North Pacific Basin	-180 ± 7	0.3	-222 ± 7
Coll. August 15, 1957; 50° 55' N Lat, 177° 23' E Long; 5200 m depth.			

	δC^{14}	δC^{13}	Δ
L-470B. Aluetian Trench	-158 ± 8	-0.9	-199 ± 8
Coll. August 17, 1957; $51^{\circ} 08' N$ Lat, $174^{\circ} 41' E$ Long; 6200 m depth.			
L-470C. North Pacific Surface Water	-34 ± 5	0.6	-83 ± 5
Coll. August 14, 1957; $50^{\circ} 42' N$ Lat, $177^{\circ} 17' E$ Long; 1 m depth.			
L-470D. North Pacific Surface Water	89 ± 6	0.9	33 ± 6
Coll. August 30, 1957; $53^{\circ} 10' N$ Lat, $162^{\circ} 22' W$ Long; 1 m depth.			
C. CO_2 obtained from acidified samples of sea water from deep basins of the Caribbean Sea. Samples in this group coll. by the scientific staff of Columbia University research vessel <i>Vema</i> under the direction of M. Ewing, R. Gerard, and B. Heezen. These results are discussed in a paper by Broecker, Gerard, Heezen, and Ewing (in press). The numbers in parentheses beside each laboratory number are the index numbers used by Broecker and others in that paper.			
L-529J.(138) Columbia Basin	-53 ± 5	-0.6	-99 ± 5
Coll. November 7, 1958; $14^{\circ} 05' N$ Lat, $75^{\circ} 25' W$ Long; 2316 m depth.			
L-419P.(139) Columbia Basin	-49 ± 7	-5.6	-86 ± 7
Coll. July 29, 1957; $17^{\circ} 00' N$ Lat, $74^{\circ} 24' W$ Long; 2341 m depth.			
L-529K.(140) Columbia Basin	-43 ± 13	-0.8	-89 ± 13
Coll. November 7, 1958; $14^{\circ} 05' N$ Lat, $75^{\circ} 25' W$ Long; 3262 m depth.			
L-529L.(141) Columbia Basin	-49 ± 7	0.5	-98 ± 7
Coll. November 7, 1958; $14^{\circ} 05' N$ Lat, $75^{\circ} 25' W$ Long; 3790 m depth.			
L-326W.(142) Columbia Basin	-55 ± 7	-1.0	-100 ± 7
Coll. January 1, 1956; $17^{\circ} 31' N$ Lat, $73^{\circ} 22' W$ Long; 4265 m depth.			
L-529H.(143) Cayman Trough	-32 ± 5	-0.5	-79 ± 5
Coll. November 5, 1958; $19^{\circ} 31' N$ Lat, $74^{\circ} 59' W$ Long; 1647 m depth.			
L-529G.(144) Cayman Trough	-26 ± 5	-0.5	-74 ± 5
Coll. November 5, 1958; $19^{\circ} 31' N$ Lat, $74^{\circ} 59' W$ Long; 1893 m depth.			
L-326S.(145) Cayman Trough	-24 ± 5	2.7	-78 ± 5
Coll. December 23, 1955; $19^{\circ} 15' N$ Lat, $79^{\circ} 30' W$ Long; 2560 m depth.			

	δC^{14}	δC^{13}	Δ
L-326T.(146) Cayman Trough	-43 ± 7	-3.7	-84 ± 7
Coll. December 24, 1955; $19^{\circ} 10' N$ Lat, $78^{\circ} 00' W$ Long; 4755 m depth.			
L-419Q.(147) Cayman Trough	-28 ± 7	-5.9	-65 ± 7
Coll. July 30, 1957; $19^{\circ} 33' N$ Lat, $75^{\circ} 02' W$ Long; 4844 m depth.			
L-419K.(148) Granada Basin	-55 ± 7	-11.3	-81 ± 7
Coll. July 11, 1957; $12^{\circ} 45' N$ Lat, $63^{\circ} 06' W$ Long; 2468 m depth.			
L-419L.(149) Cariaco Trench	-23 ± 7	-16.6	-39 ± 7
Coll. July 13, 1957; $10^{\circ} 36' N$ Lat, $65^{\circ} 04' W$ Long; 550 m depth.			
L-419M.(150) Cariaco Trench	3 ± 7	-7.7	-32 ± 7
Coll. July 14, 1957; $10^{\circ} 39' N$ Lat, $65^{\circ} 43' W$ Long; 1152 m depth.			

D. Organisms deriving their organic and inorganic carbon from the dissolved CO_2 in sea water.

L-444.(38) Benguela Current **-64 ± 15 -17.7 -78 ± 15**

Organic material from plankton coll. at a depth of 73 m by the scientific staff of Columbia Univ. research vessel *Vema* on May 5, 1957 ($22^{\circ} 34' S$ Lat, $14^{\circ} 12' E$ Long; subm. by R. Menzies, Univ. of Southern California.

L-570. McMurdo Sound, Antarctica **-148 ± 7 -24.7 -149 ± 7**

Flesh from right rear flipper of freshly killed seal ($77^{\circ} S$ Lat, $165^{\circ} E$ Long). Coll. by J. Mulligan, U.S.A.R.P., December 17, 1959; subm. by T. Pewe, U. S. Geol. Survey. Result is in the same range as the Δ values obtained by Rafter and Fergusson (1958) for the dissolved CO_2 in surface waters adjacent to the Antarctic. The low C^{14} concentration in these waters results in an apparent radiocarbon age of 1300 yr for the marine organisms living in this area.

L-112D. Adak, Aleutian Islands **-79 ± 9 1.3 -127 ± 9**

Clam shells bearing dried meat from a lagoon ($51^{\circ} 40' N$ Lat, $176^{\circ} 30' W$ Long). Coll. July 1950 by H. Powers, U. S. Geol. Survey. Whether the low value results from freshwater drainage into the lagoon, the upwelling of deep

water, or a non-zero age for the shells is not known.

Living coral from a reef off Bogan Island (11° 30' N Lat, 162° 10' E Long). Coll. 1946 by J. Tracey, U. S. Geol. Survey.

Living barnacles (49° N Lat, 124° W Long).
Coll. 1959; subm. by J. Fyles, Geol. Survey of
Canada.

Pelecypods (*Cardium edule* L.) from Atlantic Ocean along the coast of Southwestern France (44° 35' N Lat, 01° 25' W Long). Coll. 1952; subm. by W. Zagwijn, Geol. Survey of the Netherlands.

Pelecypods (*Cardium edule* L.) from the North Sea coast (52° 30' N Lat, 04° 25' E Long). Coll. May, 1960 by W. Zagwijn.

Gastropods (*Liiona pica* L) coll. 1929 or 1930 (18° N Lat, 78° W Long); subm. by H. Rehder, National Museum, Washington, D. C.

Gastropods (*Liiona pica* L) coll. 1884 (18° N Lat, 78° W Long) ; subm. by H. Rehder.

Gastropods (*Strombus raninus*) coll. 1950
(26° N Lat, 78° W Long) ; subm. by N. Newell,
American Museum of Natural History.

Gastropods (*Strombus raninus*) coll. during the 1880s (26° N Lat, 78° W Long); subm. by H. Behder.

Pelecypods (*Codakia orbicularis*) coll. June 1958 at Bimini Cay (25° 45' N Lat, 79° 15' W Long); subm. by J. Imbrie and A. McIntyre, Columbia Univ.

	δC^{14}	δC^{13}	Δ
L-576C. Kollafjord, Iceland	-8±6	(3.4)	(-64±6)
Gastropods (<i>Nucella lapillus</i> L) coll. 1946 from Faxa Bay (22° N Lat, 64° W Long); subm. by H. Einarsson, Univ. Research Institute, Reykjavik, Iceland.			
L-576H. Kollafjord, Iceland	-13±6	3.4	-69±6
Gastropods (<i>Nucella lapillus</i> L) coll. 1900 from Faxa Bay (22° N Lat, 64° W Long); subm. by G. Thorson, Univ. of Copenhagen.			
L-576I. Kollafjord, Iceland	-16±6	3.4	-72±6
Gastropods (<i>Nucella lapillus</i> L) coll. 1840 from Faxa Bay (22° N Lat, 64° W Long); subm. by G. Thorson.			
L-576J. Oahu, Hawaii	-8±6	2.2	-62±6
Gastropods (<i>Trechus intertextus</i>) coll. 1840 or 1841 (22° N Lat, 158° W Long); subm. by H. Rehder.			
L-576D. Pearl Harbor, Hawaii	-380±12	2.9	-415±12
Gastropods (<i>Trechus intertextus</i>) coll. 1936 (22° N Lat, 158° W Long); subm. by H. Rehder.			
L-576E. Tahiti	-5±5	3.7	-62±5
Gastropods (<i>Turbo setosus</i>) coll. 1957 (18° S Lat, 149° W Long); subm. by H. Rehder.			
L-576K. Moorea	2±5	4.7	-58±5
Gastropods (<i>Turbo setosus</i>) coll. early 1880s (18° S Lat, 149° W Long); subm. by H. Rehder.			

III. SAMPLES UTILIZING CO₂ FROM TERRESTRIAL WATERS

A. Lake Samples

L-487J. Mono Lake, California	-105±15	4.0	-157±15
Dissolved CO ₂ coll. by passing lake waters through an anion exchange column (37° 59' N Lat, 119° 08' W Long). Coll. August 23, 1958 by O. Schaeffer, Brookhaven National Laboratory.			
L-415GGG. Great Salt Lake, Utah	-93±6	2.1	-142±6
Dissolved CO ₂ coll. by acidifying lake water and bubbling with N ₂ . Coll. (40° 50' N Lat, 112° 35' W Long) June 1958 by R. Cohenour, Salt Lake City, Utah (Broecker and Olson, 1960).			

	δC^{14}	δC^{13}	Δ
L-542. Great Salt Lake, Utah	-39±9	-16.7	-55±9
Brine shrimp (40° 50' N Lat, 112° 35' W Long); coll. August 1959 by C. Sanders, Ogden, Utah (Broecker and Olson, 1960).			

B. River Samples

L-487F. San Francisco Flycasting Club	-8±6	-4.8	-48±6
Pelecypods (<i>Margaritifera margaritifera falcata</i> (Gould)) living on a sandy shoal in Truckee River ca. 5 mi E of Truckee, California (39° 23' N Lat, 120° 07' W Long). Coll. August 25, 1958 by W. Broecker and O. Schaeffer (Broecker and Olson, 1960).			
L-487G. San Francisco Flycasting Club	-22±6	-22.0	-28±6
Meat from the above shells (L-487F) (Broecker and Olson, 1960).			
L-487H. San Francisco Flycasting Club	-1±7	-10.2	-31±7
Dissolved CO ₂ coll. by passing river water through an anion exchange column. From same locality as L-487F. Coll. August 25, 1958 (Broecker and Olson, 1960).			
L-415S. Ogden, Utah	-146±6	-33.9	-131±6
Plants growing within waters of Weber River near Rt. 91 bridge (41° 10' N Lat, 111° 50' W Long). Coll. September 1957 by A. Walton and W. Broecker (Broecker and Olson, 1960).			
L-4870. Ogden, Utah	-116±9	-25.4	-115±9
Plants growing within waters of Weber River near Rt. 91 bridge (41° 10' N Lat, 111° 50' W Long). Coll. September 10, 1958 by W. Broecker (Broecker and Olson, 1960).			

C. Ground Water Samples

L-500C. Onandaga Cave, Missouri	-90±15	-9.0	-119±15
Dripstone carbonate ca. 3 mm thick, removed from broken rock used to define a pathway through the cave (38° 02' N Lat, 97° 15' W Long). Coll. November 8, 1958 by W. Broecker and E. Olson.			
L-451C. Crystal Palace Cave, California	-63±8	-8.9	-93±8
Dripstone carbonate, coating and replacing a piece of lumber brought into the cave by miners			

δC^{14} δC^{13} Δ

ca. 1880. The recency of the wood was confirmed by a radiocarbon analysis ($\Delta = -5 \pm 10$.) Subm. by R. de Saussure, Berkeley, California.

D. Hot Springs Sample

L-487P. Bridgeport, California

— **-0.8** —

Carbonate forming a one-quarter-inch coating on a wooden bathtub fed by a hot spring ($38^\circ 08' N$ Lat, $119^\circ 10' W$ Long). Despite exposure to the atmosphere, sample contained only $2.0 \pm 0.8\%$ of the activity of the oxalic-acid standard. Coll. September 1958 by P. Orr and W. Broecker.

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LABORATORIES

Additions and changes since publication of list of laboratories in Volume 2, (1960).

New Laboratories

- GaK GAKUSHUIN UNIVERSITY
Prof. K. Kigoshi
Gakushuin University
Mejiro, Toshima-ku
Tokyo, Japan
- GSC OTTAWA
Mr. W. Dyck
Isotope and Nuclear Research Laboratories
Geological Survey of Canada
601 Booth Street,
Ottawa, Ontario, Canada
- Hv HANNOVER
Dr. Immo Wendt
Niedersächsisches Landesamt
für Bodenforschung
Hannover, Wiesenstr. 1
West Germany
- LP LA PLATA
Dr. Horacio Cazeneuve
Museo de La Plata
Paseo del Bosque
La Plata, Argentina
- ML MIAMI
Dr. H. G. Östlund
c/o Dr. Gene Rusnak
The Marine Laboratory
University of Miami
Miami 49, Florida
- UCLA
Prof. Gordon Fergusson and Dr. W. F. Libby
University of California
Los Angeles 24, California

Changes

- BM BRITISH MUSEUM
Mr. Harold Barker
Research Laboratory
The British Museum
London W.C. 1, England
- Gd GDANSK
Dr. Wi. Mościcki
Polska Akademia Nauk
Instytut Badan Jadrowych
Pracownia Geochronologii Bezwzględnej
Gdansk-Wrzeszcz, ul. Sobieskiego 18
Poland

- Gro
*GrN GRONINGEN
Prof. H. de Waard and Dr. J. C. Vogel
Natuurkundig Laboratorium der Rijks-Universiteit
Westersingel 34
Groningen, Netherlands
- LJ SCRIPPS
Dr. H. E. Suess
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, California
- N TOKYO
Dr. T. Yamasaki
The Institute of Physical and Chemical Research
Bunkyo-ku, Tokyo, Japan
- NZ NEW ZEALAND
Dr. T. A. Rafter
Institute of Nuclear Sciences
Lower Hutt, New Zealand
- R ROME
Dr. F. Bella, Istituto di Fisica
and
Dr. C. Cortesi, Istituto di Geochimica
Radiocarbon Dating Laboratory
University of Rome
Citta Universitaria
Rome, Italy
- Sa SACLAY
Monsieur J. Labeyrie or Mme. Georgette Delibrias
Service d'Electronique Physique
Centre d'Etudes Nucleaires de Saclay
B.P. no. 2
Gif-sur-Yvette (Seine-et-Oise), France
- SM SOCONY MOBIL
Mr. E. E. Bray
Socony Mobil Oil Company, Inc.
Field Research Laboratory
P. O. Box 900
Dallas 21, Texas
- St STOCKHOLM
Dr. H. G. Östlund or Mr. Lars Engstrand
Radioactive Dating Laboratory
Geological Survey of Sweden
Frescati, Stockholm 50, Sweden
- Su FINLAND
Dr. Esa Hyypä
Geological Survey of Finland
Otaniemi, Finland
- V VICTORIA
Dr. C. M. Focken
Radiocarbon Laboratory
Institute of Applied Science
Swanston Street
Melbourne, Victoria, Australia

* From January 1, 1961 the Gro numbers have been replaced by GrN numbers. "New" dates are referred to the NBS oxalic-acid standard.

Radiocarbon

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