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LAMONT NATURAL RADIOCARBON MEASUREMENTS V*

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This article reports the radiocarbon age measurements made at the Lamont Geological Observatory between February 1957 and July 1958. For convenience the sample ages have been classified into the following categories:

Table	I	Geologic Samples—North American glacial geology
Table	II	Geologic Samples—Pluvial lake levels
Table	III	Geologic Samples—Relative sealevel changes
Table	IV	Geologic Samples—Oceanography
Table	V	Geologic Samples—Miscellaneous
Table	VI	Archaeologic Samples
Table	VII	Check Samples

Within each table are subdivisions according to geographic origin.

As an aid to those who do not care to scan the entire seven tables, the contents of each are summarized in the following paragraphs. Following this summary, three final items are discussed: (1) age calculations, (2) new methods of chemical pretreatment designed to detect and overcome possible sample contamination, and (3) the effect of material type on the reliability of a radiocarbon date.

Table I consists primarily of samples submitted by the Geological Survey of Canada and the United States Geological Survey. Of particular interest are the Quadra Beds in British Columbia (L-221A, B and L-424B, C, E: 25,000 to 30,000 yr), the Cook Inlet sea bluff exposure in Alaska (L-117L, L-163A, L-434: ages from 3650 to >44,000 including a finite age of 39,000) and the Port Talbot deposits on the north shore of Lake Erie (L-370A and L-440, both so old as to exceed the counter's sensitivity). For these and other sites, details are to be found in the references cited in the various sample descriptions. Other important samples are the Don interglacial beds near Toronto (L-409) and a buried soil near Richmond, Indiana (L-414), both exceeding 40,000 years in age.

Table II includes tufa samples from terraces surrounding Lake Bonneville (L-435 series) and Pyramid Lake (L-420). Shells from an elevated beach near Lake Kivu, Belgian Congo, are also listed (L-349).

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Table III is for samples which indicate times in the past when land and sea stood at different relative positions. The new relative positions have resulted from glacial rebound, melting of glaciers, or crustal movements. Included in Table III are samples from Alaska (L-297B, E, G), Hudson Bay (L-433A, L-441A), British Columbia (L-391D, E, F; L-441B), Lower California (L-438A), Madagascar (L-403C), and Morocco (L-398A).

Table IV consists entirely of ocean sediment cores except for a carbonate sample (L-389A) dredged from the top of the Atlantis seamount. Cores are from the Cariaco Trench in the Caribbean Sea (L-430C), from the Mediterranean Sea (L-392), and from the South Atlantic Ocean off the west coast of Africa (L-421). All samples were collected by the Lamont research vessel VEMA.

Among the miscellaneous geologic samples listed in *Table V* are three buried soils from Alaska (L-400A, B, C), oölite samples from the Bahama Banks (L-418 series), and wood buried by ash ejected from the Santorin volcano on the Greek Island of Thera (L-362).

Numerous archaeologic sites are reported in *Table VI*. These include the following:

Manakaway, Conn. (L-339)	Chiapa de Corzo, Mexico (L-427)
Castle Windy, Fla. (L-377, L-405)	Chanquillo Fortress, Peru (L-404A)
Modoc Rock Shelter, Ill. (L-381C)	Grotte du Renne, France (L-399D)
Twenhafel, Ill. (L-431C)	Grotte de la Garenne, France (L-340)
Signal Butte, Nebr. (L-385)	Grotte de Taforalt, Morocco (L-399E)
Midland, Texas (L-347)	Marquesas Islands (L-394, F, J)

Kalambo Falls, N. Rhodesia (L-395B; L-399A, B, C)

Those sites with radiocarbon ages indicating the greatest antiquity of man are Kalambo Falls (>40,000), Midland (20,400), and Grotte de la Garenne (14,200).

The final table (*VII*) contains several samples measured in order to obtain interlaboratory comparisons or checks with other methods of dating—namely, historic records and the ionium-uranium age method. Samples L-292 and L-432 are checks, respectively, with the Groningen and Michigan laboratories. In both cases there is agreement within the experimental error. Additional positive interlaboratory checks have resulted as byproducts of other studies and these are reported in Table I (L-369A, L-370A, L-440, L-397C, L-397E). Besides Lamont, the other laboratories involved are Washington (U. S. Geological Survey), Yale, and Saskatchewan; all employ gas counting. Several cases in which Lamont black-carbon dates have not been substantiated by subsequent gas-counting dates are included in the Table I descriptions of samples L-117L, L-163A, and L-434.

A valuable historical check included in Table VII is sample L-371E, charred bread remains found during excavation of ash-covered Pompeii. Destruction of the city took place in A.D. 79 or about 1880 years ago. The measured C^{14} age is 1830 ± 50; it is based on 1890 oak wood as the modern control material, corrections having been made both for radioactive decay and for the fact that 1956 Italian wheat shows a C^{13}/C^{12} isotopic ratio slightly different from the oak. Such corrections avoid the presently competing H-bomb and Suess effects which make today's organic materials unacceptable in fixing the modern control value.

Samples L-423A and L-423B in Table VII consist of calcium carbonate obtained from drill holes in Eniwetok atoll in the Pacific Ocean. Both have been dated by radiocarbon analysis and by the ionium-uranium age method (Sackett, 1958). Results are as follows:

Sample No.	Radiocarbon Age	Ionium Age
L-423A.	4900 ± 150	12,000 ± 4,000
L-423B.	23,500 ± 1000	132,000 ± 10,000

Most of the difference between the above results is probably due to younger secondary calcite cementing the original aragonitic material. Particularly is this important in sample L-423B which would require only 5.5 percent of modern calcite cement to drop its age from 132,000 to 23,500 years. Using cement-free carbonate material recently obtained, additional analyses will be made as a further check between the two dating methods.

Three final matters now to be discussed are age calculations, new methods of chemical pretreatment, and material type as it seems to affect reliability. Except where specifically mentioned in individual sample descriptions, the modern control value used to calculate ages is obtained from oak wood grown in 1890. Normalized to the same C^{13}/C^{12} ratio, this wood, after correction for 68 years of C^{14} decay, has a 3.7 ± 0.7 percent lower C^{14}/C^{12} ratio than the oxalic acid standard designated by the National Bureau of Standards. Details of the calculation methods and the gas counters used are to be found in a previous Lamont date list (Broecker, Kulp, and Tucek, 1956).

Because a radiocarbon age can be altered by the entrance of contaminating organic solutions into a sample from its environment, two chemical techniques have recently been employed in attempts to isolate a contaminant-free sample portion. These methods have been applied to wood, peat, charcoal, and burned bone and are described in detail by Olson and Broecker (1958). The first method is to employ an alkaline leach to remove so-called humic acid, the most logical contaminant in a soil environment. The second technique, limited to peat and wood, involves isolating cellulose and lignin fractions by appropriate chemical methods, the expectation being that the contaminant either will be eliminated or will follow one fraction or the other. A part of both chemical techniques is an acid leach to remove possible carbonate contamination.

At the Lamont radiocarbon laboratory, treatment for humic-acid removal is now standard practice in handling organic samples. In the course of this work, about a dozen samples have yielded sufficient humic acid for dating (in this date list, samples L-117L; L-163A; L-368; L-391B; I, L-397E; L-399C; L-400A, B, C; L-414A, B; L-424B). In only two cases—soil samples L-400A and L-400C (Table V)—has there been a significant difference between the treated sample and its humic acid, the latter being younger; hence, in the majority of cases the humic acid recovered is derived from the sample itself and is not a contaminant. In this date list, every sample treated for humic-acid removal is so specified.

When several hundred grams of a sample are available and that sample is expected to be old, cellulose or lignin isolation is desirable. Ages of cellulose and/or lignin fractions of the following samples are reported here: L-221A, B; L-369A, B; L-370A; L-399B: and L-409. In several cases, the value of the chemical treatment is clearly demonstrated.

Inasmuch as a given percentage of modern contamination is of greatest significance in the case of old samples, contamination studies must go hand in hand with efforts to extend the radiocarbon range through C^{14} isotopic enrichment and increased counter sensitivity. Cases in point are samples L-399C (Table VI, 43,000 yr) and L-163A (Table I, 39,000 yr). These were assigned finite ages only because both were pretreated and because the humic-acid fractions of both were datable and gave ages identical to the treated sample. Even so, such old ages should be used in a conservative manner.

The question is often asked, "What materials are best for radiocarbon dating?" Certain dates reported here contribute toward an answer, providing favorable evidence for shells and both favorable and unfavorable evidence for buried soils and bone. Because shells are chemically ionic, the possibility of carbon exchange with the atmosphere or ground water must be kept in mind. That this has not occurred in sample L-391E (Table III, 12,350 yr) is evidenced by a similar age for associated wood. In addition, the 25,000-yr age on shells of sample L-438A (Table III) indicates that any exchange that may have occurred was limited; nevertheless, the age must be considered a minimum. Another sample of carbonate material showing negligible exchange is L-403C (Table III), coral limestone with an age exceeding 30,000 years.

In the case of buried soils, samples L-414A (Table I) and L-400B (Table V) demonstrate that such soils can be sealed off for thousands of years without contamination. Soil samples L-400A and C (Table V), on the other hand, show that contamination has occurred. Similarly, the bone carbonate of sample L-431C (Table VI) is consistent with archaeologic evidence, but the two burned-bone samples from Signal Butte, Nebraska (L-385C, E; Table VI) are a thousand years younger than associated charcoal.

Thus, the following conclusions seem warranted: (1) shells are gaining in stature as more dates accumulate, (2) soils and bone are less desirable but often usable, particularly if pretreated, and (3) wood and peat are superior dating materials. The third conclusion is based on the consistent humic-sample checks reported here, on the ease with which possible carbonate contaminants can be removed, on the inherent chemical variety which allows fractions to be isolated, and on the non-ionic nature of wood and peat.

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SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES—NORTH AMERICAN GLACIAL GEOLOGY

A. Alaska

L-117L. Nikishka No. I, Kenai Lowland, Alaska **>44,000**

Abraded. lignitized log in lowest 1 ft of organic lake silt section, 8 ft thick, overlying iron-stained and contorted gravel exposed near base of Cook Inlet sea bluffs (60° 51′ N Lat. 151° 24′ W Long), 2.5 mi S of Naptowne end moraine at East Foreland, Alaska. The log is transported and could have been either derived from vegetation growing at the time of initial lake deposition or reworked from the subjacent older gravel unit of pre-Naptowne age. The antiquity and lignitized character of the sample suggest derivation from the underlying gravel. The geology of the area is described in a U. S. Geological Survey report now in preparation (T. N. V. Karlstrom, personal communication). Sample L-117L is part of a group of Cook Inlet C^{14} samples, including material collected from directly beneath Naptowne till, which were dated by the black-carbon method between 14,000 and 22,000 B.P. and suggested a late-Wisconsin age for the Naptowne glaciation (Karlstrom, 1952, and *in* Péwé and others. 1953). All these samples have been rerun by the more accurate gas-counting methods. All gave ages of >32,000 B.P., indicating that the early black-carbon results in this finite older age range were spuriously young. and requiring a revision in the correlation of the Naptowne glaciation of Cook Inlet with all, not just part, of the type Wisconsin deposits (Karlstrom, 1955, 1957). Coll. 1951 and subm. by T. N. V. Karlstrom, U. S. Geological Survey. *Comment*: sample L-117L was previously dated by the black-carbon method at 19,200 ± 1000 yr as reported by Kulp and others (1952). The sample reported here was treated for humic-acid removal.

L-117L. Residue after humic-acid removal **>44,000**
L-117L. Humic acid **>40,000**

Other related Cook Inlet samples dated by the black-carbon method include samples L-101B (14,300 ± 600) and L-117J (15,800 ± 400) as reported by Kulp and others (1951); L-117A (19,100 ± 900) as reported by Kulp and others (1952); and L-163A (22,000 ± 2000, previously unpublished black-carbon result). Reruns by the gas-counting methods of samples L-101B, L-117A, L-117J, and L-163A gave ages respectively of >38,000 (W-535; Robert Miller, U. S. Geological Survey, personal communication), >32,000 (W-76; Suess, 1954), >32,000 (W-77; Suess, 1954), and 39,000 ± 2000 (L-163A; this paper).

L-163A. Salamato Beach, Kenai Lowland, Alaska **39,000 ± 2000**

Iron-stained lignitized log collected from silt, sand, and gravel unit conformably overlain by coarse gravel, and unconformably overlying contorted gravel and silt unit as exposed in upper part of Cook Inlet sea bluffs (60° 40′ N Lat, 151° 23′ W Long) about 3.5 mi S of the Naptowne end moraine at East Foreland, Alaska. The sampled intermediate stratigraphic unit is traceable northward in the sea bluffs up to and beneath Naptowne till at East Foreland (Wisconsin till according to Karlstrom) and apparently represents in large part lacustrine and fluvial sedimentation during the advancing phases of an ice tongue from Alaska Range sources, across Cook Inlet into the vicinity of East Foreland during Naptowne time (Karlstrom, report in preparation). This sample is the first from Alaska to be finitely dated in this age range. Its stratigraphic position and apparent age give promise that the interval preceding the last major glaciation in Cook Inlet, Alaska may be datable in the extending 40,000 to 60,000-yr C^{14} range. Coll. 1951 and subm. by T. N. V. Karlstrom. *Comment*: sample L-137D (Broecker and others, 1956), collected near Kenai from a comparable stratigraphic position in the sea bluffs but closer to beach level, was dated by the black-carbon method at >24,000. Sample 163A itself was previously dated by the black-carbon method and gave an age of 22,000 ± 2000. The age reported here is based on two portions of the original sample: the residue after humic-acid removal and the humic acid itself. Of six measurements, only two differed from average background by less than four times the standard error of the background; and these two exceeded the background by twice its standard error.

L-163A.	Residue after humic-acid removal	**39,000 ± 2600**
L-163A.	Humic acid	**39,000 ± 2000**

L-434. Third Bay, Kenai Lowland, Alaska **3700 ± 150**

Wood from beaver-gnawed debris in a beaver-house pocket immediately beneath a 5 to 9-ft peat unit in a surface bog deposit exposed in Cook Inlet sea bluffs of Third Bay (60° 47′ N Lat, 151° 12′ W Long) within 1 mi, and E, of the Naptowne end moraine at Boulder Point, Alaska. The geology of the area and stratigraphy of the coastal bogs are described in a U. S. Geological Survey report now in preparation (T. N. V. Karlstrom, personal communication). Coll. 1950 and subm. by T. N. V. Karlstrom. *Comment*: this sample was treated for humic-acid removal. Under the number L-163C a portion of this sample was dated by the black-carbon method as 3100 ± 400. Related samples include L-117N (Kulp and others, 1952; 3800 ± 400) of spruce wood collected from the basal peat 1 ft above sample L-434; and L-163E and F (3550 ± 170 and 3950 ± 200; previously unpublished black-carbon results) of spruce and birch wood collected respectively 6 in. above and from along the contact of the same stratigraphic horizon in another coastal bog 6 mi E of the L-434 and L-117N-collecting locality. Results from these four samples, within statistics, are consistent with each other and with stratigraphic position.

Samples **L-163B** and **L-1170 (8650 ± 450** and **8200 ± 900;** previously unpublished black-carbon results) are wood and organic silt near the base of a lower 4-ft peat bed overlain by organic silt in the same bog and collected by Karlstrom about 9 ft below sample L-434. These results compare with wood and organic-silt samples L-137D and L-163D (9500 ± 600 and 9200 ± 600; Broecker and others, 1956) and wood samples W-602 and W-603 (8470 ± 300 and 8950 ± 280; Karlstrom, U. S. Geological Survey personal communication). Coll. by Karlstrom just beneath and along comparable stratigraphic horizons exposed in three bogs in the Turnagain Arm sea bluffs near Point Possession 40 mi NE of Boulder Point.

L-301. Kogosukruk River, Alaska **>36,000**

Larch wood from a bank in a cut of the Kogosukruk River (69° 45′ N Lat, 151° 40′ W Long), Alaska. Sample came from a gravelly layer in the zone of contact between the unconsolidated Gubik Formation and the Cretaceous Colville Formation. Probably of marine origin at this site, the Gubik is thought to be Pleistocene in age. Coll. 1953 by J. C. F. Tedrow; subm. by Boston University Physical Research Laboratory. *Comment*: sample was first given a finite age of 24,000 ± 2000. Since the geologic evidence suggested an age beyond the range of the Lamont counters, a new sample portion was measured; the above age of >36,000 was then obtained. Whether field or laboratory contamination caused the finite age has not been determined.

L-368. Nelchina River, Alaska **8450 ± 200**

Peat with high silt content from north bank of Nelchina River (61° 57′ N Lat, 146° 57′ W Long) 3 mi S of milepost 137, Glenn Highway, southwestern Copper River Basin, Alaska. Buried 8 ft below the surface, the sample provides a minimum date for (1) contorted gravel at base of the section, deposited as Nelchina Glacier retreated (its terminus now lies 14 mi S) and (2) stratified lacustrine sand and silt above the contorted gravel but below the dated material. Geologic report is in preparation. Coll. 1954 and subm. by J. R. Williams, U. S. Geological Survey. *Comment*: this sample was treated for humic-acid removal and enough humic acid was recovered for dating.

L-368.	Residue after humic-acid removal	**7550 ± 500**
L-368.	Humic acid	**8450 ± 200**

The humic-acid age is preferred because the amount of CO_2 recovered from the treated residue was quite small, requiring dilution with CO_2 from anthracite coal. A peat sample (L-237B, unpublished) collected by Williams in 1952 from the same section as L-368 but 16 ft below gave an anomalously young age which has not yet been explained. Three separate measurements were made:

L-237B.	Untreated (black-carbon method)	**600 ± 240**
L-237B.	Untreated (CO_2 method)	**950 ± 200**
L-237B.	Residue after humic-acid removal (CO_2)	**900 ± 300**

L-297A. Lemon Creek Glacier, Alaska **10,300 ± 600**

Basal ligneous peat from a depth of 18 ft in muskeg (58° 23′ 30″ N Lat, 134° 25′ 20″ W Long) 6 mi N of Juneau, Alaska. Sample was obtained at a 750-ft elevation, about 1000 ft from the position attained around A.D. 1750 by the lower tongue of Lemon Creek Glacier. The sample age is the earliest postglacial date thus far obtained in this district and indicates that the 1750 glacier position has not been exceeded for at least the past 10,000 years. Coll. 1955 and subm. by C. L. Heusser, American Geographical Society. *Comment*: the same age was obtained for basal sedge peat collected several miles away (L-297D; Broecker and Kulp, 1957).

B. Canada

L-391I. Avalon Peninsula, Newfoundland **7400 ± 150**

Basal peat from a bog (47° 29′ N Lat, 52° 46′ W Long), 17 ft thick, on Avalon Peninsula, Newfoundland. Sample gives a minimum age for deglaciation of the St. John's, Newfoundland area. Coll. 1956 by E. P. Henderson; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal and enough material was recovered for dating.

L-391I.	Residue after humic-acid removal	**7400 ± 150**
L-391I.	Humic acid	**7350 ± 300**

L-369A. St. Pierre les Becquets, Quebec >44,000

Wood from a peat bed exposed in a stream bank, 90 ft high, near St. Pierre les Becquets (46° 29′ N Lat, 72° 12′ W Long), Nicolet County, Quebec. The geology of the area is described by Gadd (1955). Coll. 1954 by N. R. Gadd; subm. by Geological Survey of Canada. *Comment*: this sample has been dated by three laboratories in the past (Rubin and Suess, 1955, W-189; Preston and others, 1955, Y-242; Broecker and Kulp, 1957, L-190A); all ages have exceeded counting range. The age reported here is for lignin isolated from wood.

L-369B. Missinaibi, Ontario >42,600

Wood from between two till sequences exposed in a bank cut by the Missinaibi River (50° 19′ N Lat, 82° 42′ W Long) about 6 mi upstream from its confluence with the Soweska River, 125 mi SW of James Bay, Ontario. Sample is from base of non-glacial beds, 17 ft thick, containing wood, peat, and organic silt and sand. The wood was separated from the remainder of the non-glacial sequence by a lens of till-like material, 3 ft thick, probably colluvium. The non-glacial beds overlie a complex of till and gravel and are overlain in turn by till. Sample probably dates a non-glacial interval with climate there much like that today. The geology of the area is described by McLearn (1926). Coll. 1954 by O. L. Hughes; subm. by Geological Survey of Canada. *Comment*: the above age supersedes the four finite ages (37,700 to 38,900) reported by Olson and Broecker (1957) for cellulose and lignin fractions of the wood and the peat above it. The age reported here is for a re-count of the wood cellulose. Untreated wood yielded an age of >40,500.

L-391A. Coulson Township, Ontario 3450 ± 300

Fresh peat from a depth of 8.65 to 8.80 ft at the base of a bog impounded behind a Lake-Barlow-Ojibway bay-mouth bar located in Coulson Township (48° 38′ N Lat, 80° 21′ W Long), Northern Ontario. Sample indicates the minimum age for the bay-mouth bar. Coll. 1956 by O. L. Hughes; subm. by Geological Survey of Canada.

L-391B. Cochrane, Ontario 4750 ± 250

Peat from a depth of 386 cm at the base of a bog (49° 2′ N Lat, 80° 59′ W Long) resting on gray silty clay 1.5 mi SE of Cochrane, Ontario, on the Ontario Northland Railway. Sample age indicates the beginning of peat formation following the close of the Lake Barlow-Ojibway episode. Coll. 1956 by J. Terasmae; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal and enough humic acid was recovered for dating.

L-391B.	Residue after humic-acid removal	**4750 ± 250**
L-391B.	Humic acid	**4650 ± 180**

L-433C. Cochrane, Ontario 5300 ± 120

Peat from a bog exposed on the south side of Highway 11 near Cochrane (49° 3′ N Lat, 81° 6′ W Long), Ontario, about 1.65 mi E of bridge over Frederick House River. Sample comes from the lowest 1 in. of the bog profile. Sample age indicates the time of earliest peat formation following the Lake

Barlow-Ojibway episode. Coll. 1957 by J. Terasmae; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal.

L-409. Don Valley, Ontario **>46,000**

Wood from an exposure of the Don Beds in the Don Valley Brick Yards near Toronto, Ontario (43° 41′ N Lat, 79° 22′ W Long). Sample was found 3 to 4 ft above the contact with the Dundas Ordovician shale and limestone. Sandwiched between two distinct tills above and one below, the Don sands contain warm-climate fossils. Watt (1954) judged the Don beds to be of Sangamon age; thus the age of the enclosed wood should exceed the range of the Lamont counters. Coll. 1957 and subm. by A. K. Watt, Ontario Water Resources Commission. *Comment*: cellulose and lignin fractions were isolated. Without such isolation, a finite age would have been given for the sample. The appearance of the younger contaminant in the cellulose rather than in the lignin is inconsistent with the postulate that the contaminant is humic acid.

L-409.	Wood lignin	**>46,000**
L-409.	Wood cellulose	**40,200 ± 1600**
L-409.	Untreated wood	**43,100 ± 3000**

L-370A. Port Talbot, Ontario **>40,000**

Gytta from lens in silt exposed on the shore of Lake Erie, abount 0.5 mi SW of Port Talbot, Ontario (42° 38′ N Lat, 81° 23′ W Long). Beneath the silt are varved clay and sandy till; above it are several tills and lacustrine deposits. Glacial geology is described by Dreimanis (1957, 1958) who considers the gyttja to have formed shortly after the Early Wisconsin sub-age. Coll. 1956 and subm. by A. Dreimanis and W. S. Broecker. *Comment*: other radiocarbon dates for the area are summarized by Dreimanis (1957); among them are ages of four samples correlative with L-370A, all of which exceed the radiocarbon-counting range of the three laboratories reporting the ages. In addition, L-440 (this date list) is the age of wood from the till above this sample. Gyttja sample reported here was measured in two ways:

L-370A.	Untreated	**33,000 ± 1500**
L-370A.	Cellulose	**>40,000**

L-440. Port Talbot, Ontario **>29,500**

Coniferous wood from gravelly till (no. 2 of Dreimanis, 1957) in the shore cliff of Lake Erie (42° 38′ N Lat, 81° 23′ W Long). Found with a mastodon tusk and beneath two other tills, the wood may indicate a glacial advance breaking up the big interstadial period between Early Wisconsin glacial time and the 25,000-year-old main Wisconsin glacial time. The geology of this area, with other radiocarbon dates and definitions of chronologic terms, is discussed by Dreimanis (1957, 1958). Coll. 1957 and subm. by A. Dreimanis, University of Western Ontario. *Comment*: this sample was a 13-gram piece of wood whittled clean of slightly moldy outside material. It was treated for humic-acid removal. There is a distinct possibility that the sample has a finite age. Five 1000-min counts were made, one of which was 0.1 cpm below background, each of the other four exceeding background by at least 0.4 cpm. If the single low count were excluded, the sample age would be 33,000 ± 3000. Even including the low count, the average net sample count equals twice its error. Because the same wood has been dated by the University of Saskatchewan as >34.000 (S-46: Dreimanis. 1958). it seems wise not to quote a finite age until a larger sample becomes available for further measurement. Below this sample in the stratigraphic column is L-370A (this date list) with an age exceeding 40.000; above it in the next-younger till are L-185B (28.200 ± 1500) and L-217B (24.000 ± 1600) (Broecker and Kulp. 1957).

L-391H. High River, Alberta **4200 ± 150**

Wood from 1 ft above the base of a 15-ft section (50° 35′ N Lat, 113° 52′ W Long) of floodplain silt overlying gravel near High River. Alberta. in the abandoned valley of Little Bow River. Sample age indicates the minimum time elapsed since diversion of Highwood River from Little Bow Valley to its present course northward from High River. Coll. 1955 by A. M. Stalker; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal.

Quadra Beds, British Columbia

In the Vancouver Island area. Quadra marine and fluvial beds unconformably underlie Vashon glacial sediments, the latter having been deposited during a single major Wisconsin glaciation. From field evidence alone it appeared that Quadra carbonaceous materials should have ages exceeding 40.000 years. However, the samples listed below indicate deposition 25,000 to 30.000 yr B.P. Geology is discussed in detail by Fyles (1956).

L-221. Dashwood Cliff, Vancouver Island, British Columbia

Wood and peat from the base of the Quadra sediments exposed at Dashwood (49° 22′ N Lat. 124° 31′ W Long) near Qualicum Beach on Vancouver Island. British Columbia. Both samples were from a peat bed. 40 in. thick. in sediments thought to correlate with similar deposits throughout the Georgia Basin. Coll. 1953 by J. G. Fyles; subm. by Geological Survey of Canada. *Comment*: both peat and wood were previously dated by the black-carbon method (Broecker and others. 1956) as >24.000 and >26.000 respectively. The dates reported here are for chemical fractions isolated according to techniques described by Olson and Broecker (1958).

L-221A.	Wood cellulose	**25,900 ± 300**
L-221A.	Wood lignin	**25,850 ± 500**
L-221B.	Peat cellulose	**23,450 ± 300**
L-221B.	Peat lignin	**25,050 ± 300**

L-424B. Denman Island, British Columbia **30,200 ± 1300**

Peat exposed in the lower part of the Quadra sediments in the northwestern part of Komas Bluff (49° 36′ N Lat. 124° 49′ W Long), Denman Island. British Columbia. Coll. 1957 by J. G. Fyles: subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal and sufficient humic acid was obtained for dating.

L-424B.	Residue after humic-acid removal	**30,200 ± 1300**
L-424B.	Humic acid	**32,300 ± 1800**

L-424C. Denman Island, British Columbia **29,300 ± 1400**

Wood from a sand lens in Komas Bluff (49° 36′ N Lat. 124° 49′ W Long), Denman Island, British Columbia. Lens forms part of the silt-gravel-peat unit located in lower Quadra sediments. Coll. 1957 by J. G. Fyles; subm. by Geological Survey of Canada.

L-424E. Denman Island, British Columbia 30,000 ± 1200

Wood from the silt-gravel-peat unit of the Quadra sediments, Komas Bluff (49° 36′ N Lat, 124° 49′ W Long), Denman Island, British Columbia. Coll. 1957 by J. G. Fyles; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal.

L-428. Thelon River, Northwest Territories 5500 ± 250

Leaves of *Ceratophyllum demersum* collected 3 ft below the surface in a gullied pingo (64° 19′ N Lat, 102° 41′ W Long), adjacent to the Thelon River, Northwest Territories, Canada. Numerous laminae of the plant material are encased in the silt, which probably accumulated in a small pond or on a flood-plain. Age of the sample sets a lower limit on the duration of postglacial time in this region. Coll. 1955 by B. G. Craig; subm. by Geological Survey of Canada.

L-300A. Mackenzie Delta, Northwest Territories >33,000

Driftwood from a pingo, 130 ft high (69° 27′ N Lat, 133° 04′ W Long), in the Mackenzie Delta, Northwest Territories, Canada. Sample was found below deposits of apparently glacial origin: these in turn were overlain by lake deposits containing mollusk shells. It was hoped that the sample age would provide better evidence concerning the maximum period for postglacial pingo formation, a period known to be less than the several thousand years since glacial retreat in the area, but the age is too great to be of value. Müller (in press) describes the pingos of the region. Coll. 1955 and subm. by F. Müller. *Comment*: another sample of driftwood from the same pingo and from the same stratigraphic section (10 ft higher but still below the glacial deposits) was dated by Dr. Oeschger, University of Berne, Switzerland, at 28,000 ± 2000 years (F. Müller, personal communication.)

C. United States

L-380. Worcester, Massachusetts >30,000

Peat from a road cut (42° 12′ N Lat, 71° 47′ W Long) exposed during construction of the Massachusetts Turnpike near Worcester. Having almost the consistency of lignite, the peat comprises a layer, 1 to 2 ft thick, interbedded between underlying shallow-lake sediments and about 65 ft of till above. No other till exists above the regional Paleozoic bedrock. Coll. 1956 and subm. by E. S. Barghoorn, Harvard University. He (personal communication) believes the till represents the last ice advance in the area. From his study of the peat microfossils, he concludes that the flora closely resembles that in Eastern Massachusetts today, representing possibly a slightly warmer climate. On this basis, he judges the peat to be interglacial. *Comment*: sample was treated for humic-acid removal.

L-397C. Dayton, Ohio 20,000 ± 500

Wood from within the Camden moraine (39° 39′ N Lat, 84° 11′ W Long), 6 mi S of Dayton, Montgomery County, Ohio. Sample was entirely encased in till and lay beneath 19 ft Cary till and sand. Coll. 1947 and subm. by R. P. Goldthwait. Ohio State University. *Comment*: sample was dated previously by Suess (1954, W-37) and gave an age of 20,700 ± 600. Lamont secured an additional portion for humic-acid removal and the treated sample age is that above. The check between the two laboratories indicates absence of humic-acid contamination in the original sample.

L-397E. Germantown, Ohio **>44,000**

Wood from a cut of the Twin Creek River (39° 37′ N Lat, 84° 21′ W Long) near Germantown, Montgomery County, Ohio. Sample came from a peat layer, 8 ft thick, overlying till and itself overlain by 60 ft of calcareous till. According to Goldthwait (1958), the peat layer antedates the upper till by a considerable time. Coll. by E. Orton; subm. by R. P. Goldthwait. *Comment*: sample was dated previously by Suess (1954, W-96) and gave an age of >34,000. Lamont secured an additional portion for humic-acid removal. The age given above was obtained on the humic acid extracted because the sample residue was too small for dating.

L-414. Darrah Farm, Indiana **>41,000**

Humus-rich humic-gley soil with included wood from the Darrah Farm (39° 47′ N Lat, 84° 59′ W Long) 5 mi SW of Richmond, Indiana. This buried soil, about 23 in. thick, is overlain by 28 in. of leached sand covered by calcareous till considered by both Gamble (1958) and by J. Thorp and A. Gooding (personal communication) to be of early Wisconsin age. Numerous buried soils in the area seem to correlate with the Darrah Farm soil but have not been C^{14}-dated as yet. Coll. 1957 by E. Gamble and A. Gooding; subm. by J. Thorp, Earlham College. *Comment*: both the soil and the included wood were treated for humic-acid removal. In each case enough humic acid was recovered for dating.

L-414A.	Soil residue after humic-acid removal	**>34,000**
L-414A.	Soil humic acid	**>41,000**
L-414B.	Wood residue after humic-acid removal	**>29,000**
L-414B.	Wood humic acid	**>33,000**

This site was previously dated by Broecker and others (1956) at 30,000 ± 8000, using calcium carbonate prepared from soil organic by the U. S. Dept. of Agriculture, Beltsville, Maryland Station.

II. GEOLOGIC SAMPLES—PLUVIAL LAKE LEVELS

A. North America

L-420. Pyramid Lake, Nevada **19,100 ± 700**

Crystals of thinolite tufa collected on the western shoreline of Pyramid Lake (39° 58′ N Lat, 119° 38′ W Long) about 3 mi N of Sutcliffe, Nevada. Samples were taken from the surface of an exposed mud flat about 3 ft from the water's edge; the crystals were oriented perpendicular to the surface. See Radbruch (1957) for a discussion of the origin of thinolite tufa. Coll. 1957 and subm. by D. H. Radbruch, U. S. Geological Survey. *Comment*: the age of this sample was calculated using the C^{14}/C^{12} ratio in dissolved bicarbonate from Pyramid Lake (Broecker and Walton, in press).

L-435. Provo Terrace, Utah

Tufa samples collected from Provo Terrace (alt. 4880 ft) at the north end of the Oquirrh Mountain Range (40° 42′ N Lat, 112° 20′ W Long) opposite Great Salt Lake. Presumably tufa was formed during high-water phases of Lake Bonneville. See Broecker and Orr (1958) for a radiocarbon chronology of Lakes Lahontan and Bonneville based in part on tufa samples. Coll. 1957 and subm. by W. S. Broecker and A. Walton, Columbia University. *Comment:* all samples were pre-treated with acid to remove a thin outer layer. The problem of tufa contamination by postdepositional exchange with atmospheric and water-dissolved CO_2 is discussed by Broecker and Orr (1958). Although they conclude that atmospheric contamination is not likely to occur to a significant degree, only limited data are presented for the case of exchange with water-dissolved CO_2. The modern control value recommended by them has been used in calculating the age of the L-435 series.

L-435D. Provo Terrace, Utah **14,800 ± 600**

Massive tufa directly overlying the bedrock into which the terrace was cut. The 4-in. tufa horizon from which the sample was taken is covered by a more recent layer of similar tufa.

L-435K. Provo Terrace, Utah **16,400 ± 400**

Tufa cementing gravel into which the Provo terrace was cut. This gravel is overlain by a layer of pure tufa with a radiocarbon age of 15,530 ± 280 yr (Broecker and Kulp, 1957; L-363E).

L-435G. Provo Terrace, Utah **11,300 ± 250**

Tufa cementing gravels that form part of the terrace.

L-435F. Provo Terrace, Utah **9150 ± 200**

Relatively pure tufa from beneath the gravels from which sample L-435G was taken. The material leached from this sample yielded an age of 8500 ± 200. The age is anomalously young, suggesting that it was contaminated by recent leaching of the gravels.

L-435C. Provo Terrace, Utah **10,600 ± 300**

Tufa from a 6-in. layer covering a portion of the Provo Terrace. The material leached from the surface of this sample yielded an age of 9050 ± 200 yr.

L-435B. Provo Terrace, Utah **13,100 ± 250**

Tufa cementing coarse gravel into which the terrace was cut.

B. Africa

L-349A. Lake Kivu, East Africa **12,450 ± 350**

Shells from a terrace 330 ft (100 m) above the level of Lake Kivu at Kisenyi (1° 42′ S Lat, 29° 16′ E Long), Ruanda. Sample was imbedded in a sandy-clay bed interstratified with coarse sand and volcanic ash at the former mouth of the Sebeya stream. Apparently the shells date a high level of the lake. Coll. 1955 by A. Meyer; subm. by the Director of Geological Survey of Belgian Congo. *Comment:* the age of the shells was calculated assuming that the C^{14}/C^{12} ratio in the lake is equal to that in the atmosphere. Sample L-349B (reported in this date list) was originally submitted as a control sample but appears to be fossil rather than recent. Since the C^{14}/C^{12} ratio in the lake may have been less than that assumed for the age calculated, the age should be considered a maximum.

L-349B. Lake Kivu, East Africa **14,000 ± 600**

Lamellibranch shells from Kirotshe beach, Belgian Congo (1° 36′ S Lat, 29° 02′ E Long) at the northwest corner of Lake Kivu. Originally, it was thought that the shells should be modern, but the old radiocarbon age is consistent with two facts pointing to the shells being ancient: (1) no living lamellibranch mollusks have been found in the vicinity, and (2) excavated pits in the area show a nearly continuous buried shell layer. Thus the shell age probably dates a former level of the lake close to the present level. Lake Kivu must have passed the present level before reaching the high level dated by sample L-349A. Coll. 1955 by A. Meyer; subm. by the Director of Geological Survey of Belgian Congo. *Comment*: the age is based on an initial C^{14}/C^{12} ratio equal to that in atmospheric CO_2 and hence must be considered maximum.

III. GEOLOGIC SAMPLES—RELATIVE SEALEVEL CHANGES

A. North America

L-189B. Coquille, Oregon **350 ± 150**

Charcoal buried under 7 ft of floodplain silt deposited by the meandering Coquille River about 1 mi S of Coquille, Oregon (43° 10′ N Lat, 124° 11′ W Long). Charcoal is associated with mussel shells, fireplaces, and artifacts. Since sample lies at a sharp sand-silt boundary, its age provides chronologic information as to the time when the velocity of the Coquille River decreased, perhaps owing to relative rise of sealevel. Coll. 1952 and subm. by L. S. Cressman, University of Oregon. *Comment*: because of the unexpectedly young sample age, additional charcoal (L-388A) from the same site was dated following treatment for humic-acid removal, and essentially the same age was obtained.

L-297G,E,B. Juneau, Alaska

This is a sequence of basal peats from muskegs situated at various elevations below the limit of late-glacial and early postglacial marine transgression. As a result of glacial rebound, this limit in the Juneau district is now elevated to as much as 500 ft above present sealevel. Since the sampling area has an annual rainfall of about 100 in., peat should begin forming almost immediately after emergence. On this basis the ages of basal peats at higher elevations should exceed those at lower elevations. The ages of the following samples show this to be so. Further support comes from the fact that pollen profiles at the 40-ft and 10-ft elevations (samples L-297E and B respectively) lack a basal section present in the profile at 150 ft (L-297G); this points to peat forming at higher elevations while the lower areas were inundated. Hence, this sequence of radiocarbon dates provides a chronology of both emergence and uplift. Samples coll. and subm. by C. J. Heusser, American Geographical Society.

L-297G. Montana Creek Road **7800 ± 300**

Ligneous peat from a 19.5-ft depth at site along Montana Creek Road 11 mi NW of Juneau, Alaska, elevation about 150 ft (58° 25′ 20″ N Lat, 134°

36′ 40″ W Long). The pollen record indicates the sample age to be early Hypsithermal (see Deevey and Flint, 1957). Till with marine fossils is present in the Upper Montana Creek valley at elevations up to 400 ft. showing that the sample site was once beneath the sea (Twenhofel, 1952). *Comment*: sample L-297D (Broecker and Kulp, 1957) is of basal sedge peat (elevation 750 ft) from another locality along the Montana Creek Road about 8 mi from L-297G. Since the pollen of L-297D is early pine, its age of 10,300 ± 400 gives an approximate date to the recession of the last area glacier. If this date is taken as the time when glacial rebound began, the average rate of emergence between elevations 400 ft and 150 ft was about 10 ft per century.

L-297E. Glacier Highway 6650 ± 250

Sedge peat at a 9.6-ft depth near milepost 11.5 along Glacier Highway NW of Juneau, Alaska, elevation about 40 ft (58° 22′ 30″ N Lat, 134° 36′ 40″ W Long). The sample age, together with the content and stratigraphy of pollen in the overlying section, indicates that muskeg formation began during the Hypsithermal interval. *Comment*: based on the ages of this sample and L-297G above, average rate of emergence between 150-ft and 40-ft positions approximates 10 ft per century.

L-297B. Sunny Point 6100 ± 300

Sedge peat from a 15.8-ft depth on Gastineau Channel at milepost 7.5 along Glacier Highway northwest of Juneau, Alaska, elevation about 10 ft (58° 21′ 35″ N Lat, 134° 31′ 40″ W Long). The sample age is also Hypsithermal. In combination with pollen content and stratigraphy of the overlying peat, the sample age indicates that sealevel has not risen above the present 10-ft elevation within the last 6100 years. *Comment*: based on the ages of this sample and L-297E above, average rate of emergence from elevation 40 ft to 10 ft approximates 5 ft per century. Within the last 6100 years, the rate has dropped to almost nothing, averaging about 2 in. per century.

L-391D, E. Parksville, Vancouver Island

Wood and shells from the bottomset sand and clay of a delta of the Englishman River near Parksville (49° 17′ N Lat, 124° 02′ W Long) on the east-central coast of Vancouver Island, Canada. The delta, thought to mark a marine stand, is now 170 ft above sealevel. Coll. 1956 by J. G. Fyles; subm. by Geological Survey of Canada.

L-391D. Wood **12,150 ± 250**

L-391E. Marine shells **12,350 ± 250**

Comment: the agreement between these two dates is evidence for the reliability of dates on marine shell.

L-391F. Fanny Bay, Vancouver Island 11,850 ± 300

Wood from bottomset sand of a delta of Wilfred Creek at Fanny Bay (49° 29′ N Lat, 125° 49′ W Long) near Courtenay on the east-central coast of Vancouver Island. The delta, thought to mark a marine stand, is now 70 ft above sealevel. Coll. 1956 by J. G. Fyles; subm. by Geological Survey of Canada.

L-433A. Fort George, Quebec 3700 ± 130

Wood from the bank of the Fort George River 36 mi E of Fort George (58° 44′ N Lat, 78° 11′ W Long), Quebec. Associated with marine shells, the wood lay beneath 15 ft of surface sands and 40 ft of stony clay. Since the top of the stony silt is now 175 ft above sealevel, this sample dates an ancient sea stand and indicates the magnitude of glacial rebound. Coll. 1957 by H. A. Lee; subm. by Geological Survey of Canada. *Comment*: sample was treated for humic-acid removal.

L-438A. El Pulmo, Mexico **25,400 ± 1000**

Shells of *Glycymeris maculata* taken from fossiliferous beds approximately 12 ft above sealevel at El Pulmo (23° 26′ N Lat, 109° 25′ W Long), Baja California, Mexico. Beds are thought to be of late Pleistocene age and to have been uplifted rather than deposited during a higher stand of sealevel. The basal portion of this sequence represents the foundation rock for the coral reef at El Pulmo reported by Ricketts *in* Steinbeck and Ricketts (1941). Coll. 1957 and subm. by D. F. Squires, American Museum of Natural History. *Comment*: shells were preleached with acid in order to remove possible contamination. Since there is no assurance that more recent carbonate was completely removed, the age must be considered a minimum.

L-441A. Great Whale River, Quebec **3020 ± 120**

Wood from terrace, elevation 20 ft, at settlement of Great Whale River (55° 16′ N Lat, 77° 43′ W Long), Quebec (Hudson Bay). The wood came from silt containing marine shells 6.5 ft beneath the surface of a terrace cut into the marine deposits by the river. The marine deposits enclosing the wood probably correlate with the 90-ft strandline found throughout the area. Coll. 1957 by H. A. Lee; subm. by Geological Survey of Canada.

L-441B. Denman Island, British Columbia **11,500 ± 200**

Marine shells from Komas Bluff (49° 35′ N Lat, 124° 49′ W Long), Denman Island, British Columbia (Strait of Georgia). The shells were collected from a postglacial beach 120 ft above sealevel. Coll. 1956 by J. G. Fyles; subm. by Geological Survey of Canada. *Comment*: samples L-391D, E, and F (reported in this date list) represent similar shoreline positions in the same region.

B. Africa

L-398A. Rabat, Morocco **800 ± 200**

Charcoal fragments imbedded in an alluvial terrace of the Bou Regreg Valley (34° 02′ N Lat, 6° 50′ W Long) near Rabat, Morocco. Sample was associated with Neolithic (or younger) pottery debris about 9 ft below the surface of the lowest alluvial terrace. The alluvium of that terrace unconformably overlies estuarine clay which is associated with fine-grained littoral shell sands and is believed to be of Flandrian age (Gigout, 1954). The date confirms that the last alluviation was post-Altithermal (3500 to 7500 B.P.), and, because the terrace is 7 ft above present mean sealevel, it points to a late Recent stage of high sealevel and/or high rainfall in Morocco. Mean sealevel 1000 yr B.P. was probably 3 ft above the present (see "Rottnest" terrace of Fairbridge, 1958), but contemporary fluvial deposits could, of course, build up higher Coll. 1956 by M. Gigout; subm. by R. W. Fairbridge, Columbia University.

L-403C. Ambanja, Madagascar **>30,000**

Coral limestone from a buried coral reef near Ambanja (13° 39′ S Lat, 48° 26′ E Long), Madagascar. The coral (madreporarian) grew in situ when sealevel stood somewhat below its present level. Specimen came from a well sunk in the innermost part of the Sambirano delta, from a depth of 55 to 60 ft beneath the delta plain, and about 5 to 10 ft below mean sealevel. A dating in the postglacial range would have indicated the mean rate of delta growth and also the time of a former sealevel in this rather stable region. Coll. 1957 by R. Battistini; subm. by R. W. Fairbridge.

IV. GEOLOGIC SAMPLES—OCEANOGRAPHY

A. Atlantic Ocean

L-421. Walvis Shelf, South Atlantic Ocean

Organic material from a diatomite layer in a core (V-12-64) taken in the South Atlantic Ocean off the west coast of Africa (22° 34′ 12″ S Lat. 14° 12′ 00″ E Long) along the continental shelf. The diatomite layer is underlain by a mixture of sand and coarse shell fragments. Coll. 1956 and subm. by R. Menzies, Columbia University. *Comment*: sample ages are computed using the C^{14}/C^{12} ratio measured for plankton that was collected in the same area in 1957. The Plankton has a C^{14}/C^{12} ratio 7.8% below that in age-corrected 1890 wood.

L-421B.	0 to 80 cm	**3380 ± 200**
L-421A.	240 to 300 cm	**4130 ± 200**

L-389A. Atlantis Seamount **8600 ± 350**

Lithified carbonate material (A152-Dr108) dredged from the surface of the Atlantis Seamount (34° 09′ N Lat. 30° 14′ W Long) at a depth of about 540 m. Sample was one of a large number of cobbles dredged up. Coll. 1948 by M. Ewing; subm. by B. C. Heezen, Columbia University.

B. Caribbean Sea

L-430C. Cariaco Trench, Atlantic Ocean **10,730 ± 250**

Organic material from a depth of 440 to 450 cm in a core (V-12-97) taken in the Cariaco Trench (10° 35′ N Lat. 65° 04′ W Long) N of Venezuela. Sample comes from just above contact between an organic-rich muck, which forms the upper portion of the core, and steel-gray organic-free clay. The sample should date the time of stagnation of the trench. Coll. 1957 and subm. by B. C. Heezen. *Comment*: a modern control value 3.2% less than age-corrected 1890 oak wood was used in the age calculation. This figure is based on the average C^{14}/C^{12} ratio for dissolved bicarbonate in Caribbean surface water together with a correction for an assumed 3.5% discrimination against carbon-14 during the formation of the organic material.

C. Mediterranean Sea

L-392. Mediterranean Sediment Core

Samples from a large-diameter (8 in.) core (V-10-LDC64) taken at a depth of 1167 fathoms in the Mediterranean Sea (34° 23′ 30″ N Lat. 24° 6′ 9″ E Long). The core contains a layer of organic-rich material overlain by several layers of organic fill-sediment. Coll. 1956 by M. Ewing; subm. by R. Menzies.

L-392A. 8 to 15 cm. fine **5650 ± 400**

Fine fraction ($<74\mu$) calcium carbonate from a depth of 8 to 15 cm.

L-392B. 8 to 15 cm, coarse **5870 ± 300**

Coarse fraction ($>74\mu$) calcium carbonate from a depth of 8 to 15 cm.

L-392C. 23.5 to 28.5 cm. coarse **8700 ± 1000**

Coarse fraction ($>74\mu$) calcium carbonate from a depth of 23.5 to 28.5 cm (the organic-rich layer).

L-392D. 23.5 to 28.5 cm. fine **7400 ± 200**

Fine fraction ($<74\mu$) calcium carbonate from a depth of 23.5 to 28.5 cm (the organic-rich layer).

L-392E. 23.5 to 28.5 cm. organic **8400 ± 250**

Organic material from a depth of 23.5 to 28.5 cm (the organic-rich layer).

V. GEOLOGIC SAMPLES—MISCELLANEOUS

A. North America

L-372A. Lake Washington, Washington **5150 ± 200**

Fibrous peat from a core taken in the northern part of Lake Washington (47° 45′ 02″ N Lat. 122° 16′ 07″ W Long) 0.5 mi S of the mouth of the Sammamish River in the State of Washington. Sample is from the base of a 5-ft fibrous-peat layer, which overlies stratified sand and gravel and is overlain by 2 ft of limnic peat: obtained from 7 ft beneath the lake bottom and 27 ft beneath the lake surface. Since fibrous peat is a marginal lake deposit, the sample dates a lake level about 26 ft lower than now. The subsequent rise in level has resulted chiefly from building up of the Cedar River delta at the south end of the lake: the delta separates the lake from Puget Sound. Coll. 1955 and subm. by H. R. Gould, Humble Oil Company.

L-400A. Point Barrow, Alaska **3000 ± 130**

Arctic brown soil collected 1 mi S of the Arctic Research Laboratory (71° 20′ N Lat. 156° 36′ W Long), Point Barrow, Alaska. Sample taken from the A_1 horizon, 1 to 5 in. thick. Tedrow and Douglas (1958) conclude that the soil was formed in place and that the great sample age indicates equilibrium with the environment; hence little likelihood of podzol development with time. Profile description is given by Drew and Tedrow (1957). Coll. 1956 by L. A. Douglas, subm. by J. C. F. Tedrow, Rutgers University. *Comment*: sample was treated for humic-acid removal. Enough humic acid was recovered for dating.

L-400A. Residue after humic-acid removal **3000 ± 130**
L-400A. Humic acid **2100 ± 180**

L-400B. Gubik Formation, Alaska **10,900 ± 350**

Upland tundra soil included in Pleistocene Gubik sediments 1 mi S of the Arctic Research Laboratory (71° 20′ N Lat. 156° 37′ W Long), Point Barrow, Alaska. The site is about 20 ft above sealevel. Sample taken from organic-rich layer, 23 to 24 in. thick, which is about 1 ft down in the permafrost. Drills and explosives were used in sample collecting. Tedrow and others (1958) and Tedrow and Douglas (1958) suggest some possible origins. Coll. 1956 by L. A.

Douglas, J. C. F. Tedrow, and J. O'Sullivan; subm. by Tedrow. *Comment*: sample was treated for humic-acid removal and enough humic acid was recovered for dating.

L-400B.	Residue after humic-acid removal	**10,700 ± 350**
L-400B.	Humic acid	**11,050 ± 350**

L-400C. Umiat, Alaska **8720 ± 200**

Organic matter from upland tundra soil profile located 2 mi N of the Umiat Air Strip (69° 23′ N Lat. 152° 11′ W Long). Alaska. Site is approximately 360 ft above the Colville River. Sample taken from a 46 to 48-in. layer which is permanently frozen, in which ground ice comprises over 50% of the volume, and below which organic matter is absent. Drills and explosives were used in sample collecting. Tedrow and others (1958) and Tedrow and Douglas (1958) suggest some possible origins. Coll. 1956 by J. C. F. Tedrow and L. A. Douglas; subm. by Tedrow. *Comment*: sample was treated for humic-acid removal and enough humic acid was recovered for dating.

L-400C.	Residue after humic-acid removal	**8720 ± 200**
L-400C.	Humic acid	**5400 ± 180**

L-418A, B. Sandy Cay, Bahama Islands

Oölite sand from an intertidal area 3.25 naut. mi N 7° E of Sandy Cay (79° 12′ N Lat. 25° 28′ W Long). Bahama Islands. The oölites average 0.42 mm in diameter and consist of cryptocrystalline aragonite nuclei surrounded by concentric layers of aragonite. Coll. 1957 by E. Purdy; subm. by N. Newell and J. Imbrie. Columbia University. *Comment*: D. Thurber of the Lamont staff isolated sample fractions by acid leaching. Ages were computed using the average C^{14}/C^{12} ratio in N. Atlantic surface water as a control. This is 1% above age-corrected 1890 oak wood.

L-418A. Surface **225 ± 100**

Surface layer (first 10% removed by acid leaching).

L-418B. Nucleus **2350 ± 100**

Nucleus (residual material after 80% had been removed by acid leaching).

L-418C. Great Bahama Bank, Bahama Islands **1650 ± 100**

Oölite sand from beneath 20 ft of water in the northwest lobe of the Great Bahama Bank about 22 mi SE of Orange Cay (78° 48′ N Lat. 24° 46′ W Long). Bahama Islands. The oölites average 0.3 mm in diameter and consist of cryptocrystalline aragonite nuclei surrounded by concentric layers of aragonite. Coll. 1957 by E. Purdy: subm. by N. Newell and J. Imbrie. *Comment*: ages were computed using as a control the average C^{14}/C^{12} ratio in N. Atlantic surface water. This is 1% above age-corrected 1890 oak wood.

L-418D, E. Andros Island, Bahama Islands

Aragonite ooze from a 30-in. core (A-3) taken on the west coast of Andros Island (78° 17′ N Lat. 24° 46′ W Long) in the Bahama Islands. Although now 2 ft above sealevel, the material was probably deposited in shallow water. Coll. 1957 by J. Imbrie; subm. by N. Newell and J. Imbrie. *Comment*: ages were computed using as a control the average C^{14}/C^{12} ratio in N. Atlantic surface water. This is 1% above age-corrected 1890 oak wood.

L-418D. 0 to 3 in. (top) **2330 ± 100**

L-418E. 27 to 30 in. (bottom) **2660 ± 100**

L-425. Labrador Iron Ore Deposit **>40,000**

Lignitized wood removed from iron-ore deposit in Ruth Lake Ore Body (54° 48′ N Lat. 66° 50′ W Long), Labrador, Canada. J. L. Usher believes wood to be either *Populus* or a member of the family Cupressaceae. Fossil leaves accompanying the wood identify it as late Cretaceous or early Tertiary, but well-preserved nature of the organic material first suggested a much younger age. Coll. 1956 by Iron Ore Company of Canada; subm. by J. L. Usher, Queen's University. *Comment*: sample was treated for humic-acid removal.

B. Europe

L-362. Thera Island, Greece **3370 ± 100**

Charred wood from beneath the bottom pumice layer in a quarry (36° 25′ N Lat, 25° 25′ E Long) at Fira, Thera Island, Greece. Found with the wood were human bones and teeth and ceramic art objects, the latter indicating a civilization stage of 1800 to 1500 B.C. On the basis that the pumice (which charred the wood) resulted from a volcanic explosion accompanying or preceding the formation of Santorin Caldera, the age of the charred wood gives a maximum age for the caldera. Coll. 1956 and subm. by A. G. Galanopoulos, University of Athens. *Comment*: sample was treated for humic-acid removal.

VI. ARCHAEOLOGIC SAMPLES

A. North America

L-339. Greenwich, Connecticut

Shells and charcoal (associated with potsherds and other cultural material) from the Manakaway shell midden, located on the southeastern tip of Greenwich Point (41° 0′ 9″ N Lat, 73° 34′ 2″ W Long), Greenwich, Conn. Archaeologic details are discussed by Suggs (1958) and a complete report of the excavations (Bull. 29 of the Connecticut Archaeological Society) is in press. Coll. 1955 and subm. by R. C. Suggs, American Museum of Natural History.

L-339A. Charcoal **750 ± 130**

Charcoal from Hearth no. 1 on sterile till at the base of the shell midden. Associated potsherds are of the East River tradition, probably variants of the Bowmans Brook Stamped type.

L-339B. Shell **730 ± 100**

Oyster and clam shells from the 6- to 9-in. level, Unit N30 E55. Associated with potsherds of both the East River and Windsor traditions.

L-273. Smithfield, Virginia **<100**

Shingle from Old St. Luke's Church in Smithfield, Va. Church, constructed in 1632, is the only original Gothic church remaining in the United States. During the planning of the restoration the question arose whether the roof shingles were the originals. The C^{14} measurements suggest that they were not. Coll. 1955 and subm. by J. G. Van Derpool, Columbia University.

L-377. Castle Windy, Florida **930 ± 100**

Charcoal from a depth of 10 ft in an Indian shell midden at the Castle Windy site (28° 53′ N Lat. 80° 48′ W Long) on the east side of Mosquito Lagoon 15 mi SE of New Smyrna Beach, Florida. Sample came from the base of the middle or "crushed coquina" zone. Associated pottery at all levels is of the St. Johns Check Stamped type. Regional chronology is described by Goggin (1952) and the site itself is described by Bullen and Sleight (in press). Coll. 1956 and subm. by R. P. Bullen and F. W. Sleight, Florida State Museum. *Comment*: other radiocarbon dates for the Castle Windy site are L-405A and B (this date list).

L-405. Castle Windy, Florida

Charcoal from each of two levels in the Castle Windy Shell Midden (28° 53′ N Lat. 80° 48′ W Long), Volusia County, Florida. Other archaeologic material found in the midden includes artifacts and shells together with animal, bird, and fish remains. The archaeology of this site is described by Bullen and Sleight (in press). Coll. 1957 by R. P. Bullen and F. W. Sleight, subm. by F. W. Sleight, Central Florida Museum.

L-405A. Charcoal from 18-in. level **650 ± 100**
L-405B. Charcoal from 14- to 17-ft level **910 ± 100**

Comment: another sample (L-377, this date list) from this site has been dated at 930 ± 100 years. Both the above charcoal samples were treated for humic-acid removal.

L-381C. Modoc Rock Shelter, Illinois **7000 ± 170**

Charcoal from a depth of 19 to 20 ft in the Modoc Rock Shelter (38° 3′ N Lat. 90° 4′ W Long) 2 mi N of the village of Modoc, Randolph County, south-western Illinois. This site has been excavated to a depth of 26.5 ft; some five zones, all containing implements, have been delineated. This sample comes from within the next-to-bottom zone (II). The archaeology of this site, including several radiocarbon dates, is described by Fowler and Winters (1956) and Deuel (1957). Coll. 1956 by M. L. Fowler; subm. by T. Deuel, Illinois State Museum. *Comment*: sample was treated for humic-acid removal. Other radiocarbon dates for the Modoc Rock Shelter are reported by Libby (1954) and Crane (1956).

L-431C. Twenhafel Site, Illinois **1440 ± 100**

Unburned bone and teeth from the Weber Mound of the Twenhafel Indian Site (37° 40′ N Lat. 89° 31′ W Long), Illinois. Contemporary artifacts indicate the site to be Hopewellian. Coll. 1957 by M. L. Fowler; subm. by T. Deuel. *Comment*: CO_2 released by acidification of the bone was used in the age determination. In the age calculation, the modern count was obtained by increasing the age-corrected 1890 oak wood count by 1.9% in accordance with slight C^{14} enrichment in bone as reported by Rafter (1955).

L-385. Signal Butte, Nebraska

Contemporaneous bone-charcoal pairs from the Signal Butte paleo-Indian site (41° 48′ N Lat, 103° 54′ W Long), Nebraska. All samples are from the lowest horizon, no. 1; within this horizon, level A is the lowest and level C the highest, while level B, separating them, is sterile. Kulp and others (1951) reported radiocarbon ages for other Signal Butte samples (L-104A,B) and gave several site references. Coll. 1956 by R. G. Forbis; subm. by W. D. Strong, Columbia University.

L-385B.	Horizon 1A, charcoal	**4550 ± 220**
L-385C.	Horizon 1A, burned bone	**3400 ± 150**
L-385D.	Horizon 1C, charcoal	**4170 ± 250**
L-385E.	Horizon 1C, burned bone	**2850 ± 350**

Comment: all samples except 385E were treated for humic-acid removal. The ages reported are consistent stratigraphically if the bone and charcoal samples are considered independently. But the difference between stratigraphically identical samples indicates that, despite pretreatment, one sample type is subject to ground contamination; owing to its porous nature, the bone is more likely to be in error.

L-347. Midland, Texas **20,400 ± 1200**

Carbon extracted from caliche found in the Scharbauer site (31° 55′ N Lat, 102° 12′ W Long) near Midland, Texas. Sample was buried 18 to 24 in. within the Gray Sand deposit which also contained fossil human remains. It appears that the caliche was used as fire bricks so that the included carbon was apparently produced by charring of fats and oils which seeped from food cooked by early man. Wendorf and others describe the site in *The Midland Discovery* (1955). Coll. 1955 and subm. by F. Wendorf, Museum of New Mexico. *Comment*: calcium carbonate from the caliche itself has an apparent age of 23,500 yr. Since the initial C^{14} concentration in caliche is difficult to estimate and since the caliche may be contaminated with more recent calcium carbonate, the caliche age is difficult to evaluate.

L-427. Chiapa de Corzo, Mexico **2730 ± 150**

Charcoal from an excavated pit outside Chiapa de Corzo (16° 42′ N Lat, 93° 01′ W Long), State of Chiapas, Mexico. Sample rested upon sterile sand at the base of a cultural deposit representing a mixture of the earliest and second earliest phases of the Early Pre-Classic at Chiapa de Corzo. Coll. 1956 by G. W. Lowe; subm. by T. S. Ferguson, New World Archaelogical Foundation. *Comment*: this sample was treated for humic-acid removal. Other portions of this sample were dated by the Groningen Laboratory as follows: GRO-1172, 2885 ± 60; GRO-1512, 2770 ± 50 (Ferguson, personal communication).

B. South America

L-404A. Chanquillo, Peru **2300 ± 80**

Wood (*Pithecellobium* sp.) from a lintel in the hilltop fortress of Chanquillo (9° 30′ S Lat, 78° 15′ W Long), Casma Valley, Peru. According to D. Collier, this elaborate stone-walled structure was formerly thought to date from the Coast Tiahuanaco period (ca. A.D. 900). But the ceramic collection made at the site in 1956 included a substantial number of sherds that were not of Tiahuanaco type. They resembled instead the plain ware of the Puerto Moorin period in Viru Valley, which dates at about 500 B.C. Present evidence suggests the reoccupation in the Tiahuanaco period of a structure first used during the late Formative stage. The lintel date indicates that the major construction occurred during the first occupation. Coll. 1956 and subm. by D. Collier, Chicago Natural History Museum.

C. Europe

L-340. Grotte du Renne Series, France

Charred-bone samples from an Upper Paleolithic cave (Grotte du Renne) near Arcy-sur-Cure (47° 37′ N Lat, 3° 43′ E Long) (Yonne), France. Coll. 1955 by A. Leroi-Gourhan; subm. by H. L. Movius, Jr., Harvard University.

L-340A.	Level V, Upper Périgordian	**11,400 ± 250**
L-340B.	Level VII, Aurignacian	**10,900 ± 250**
L-340C.	Level IX, Lower Périgordian (Châtelperronian)	**15,700 ± 400**
L-340D.	Level X, Lower Périgordian (Châtelperronian)	**15,350 ± 400**

Comment: Movius considers these ages too young. Samples L-340C and L-340D, he believes, should be greater than 35,000 yr in age, L-340B approximately 30,000 yr, and L-340A approximately 20,000 yr in age. Because of the small amount of material available, the samples were given no pretreatment. The C^{14} dates must thus be considered minimum ages.

L-399D. Grotte de la Garenne, France **14,200 ± 500**

Burned bone from a cave hearth (Foyer II) in Grotte de la Garenne, near Saint Marcel (46° 34′ N Lat, 1° 30′ E Long) (Indre), France. Sample found in an extension of the cave which had been separated from the main part by a rock sill; in the extension, conditions for preserving perishable materials were much better than in the main cave where the occupation layer was overlain by a thick rockfall. Since archaeologic materials are late Upper Paleolithic (Middle Magdalenian), the sample dating throws light on the age of the Magdalenian in Western Europe. Coll. by J. Allain; subm. by H. L. Movius, Jr. *Comment*: sample portions were treated in several ways for dating:

L-399D.	Bone carbonate	**9000 ± 220**
L-399D.	Untreated sample	**9000 ± 400**
L-399D.	Residue after removal of humic acid and bone carbonate	**14,200 ± 500**

Other dates from the Middle Magdalenian layer in this cave (main section) were obtained by Libby (1951) as follows: C-577, burned bone from a hearth, 11,109 ± 480; C-578, ashy material from same hearth as C-577, 15,847 ± 1200; C-579, burned bone originating outside above hearth, 12,986 ± 560. In addition, a date of the Late Magdalenian occupation at the Grotte de la Vache near Tarascon-sur-Ariège is relevant (L-336C, unpublished: 11,650 ± 200).

D. Africa

Kalambo Falls Series, Northern Rhodesia

In old lake beds adjacent to the Kalambo Falls (8° 35′ S Lat, 31° 15′ E Long) on the Kalambo River near the south end of Lake Tanganyika in Northern Rhodesia, Africa, Clark (1954, 1956) has discvovered a prolific archaeologic sequence extending from the Early Stone Age to historic times. Coll. J. D. Clark; subm. by H. L. Movius, Jr.

L-395B. Early Iron Age **1080 ± 180**

Charcoal with associated pottery from gray sands and clays near the middle of the Iron Age deposit (6.5 to 7.0 ft in depth) at Site A1. Since sherds throughout the deposit are essentially of the same type, the sample should roughly date the Channeled Ware culture. Because the date does not indicate the complete time range of the culture at this site. Clark's prediction (personal communication) that this culture extends back to between 1500 and 2000 B.P. is not inconsistent. *Comment*: date given above is for a sample portion treated for humic-acid removal. An untreated portion gave an age of 1010 ± 100.

L-399C. First Intermediate Culture—Sangoan
43,000 ± 3300

Wood from beneath the third occupation floor, i.e. under Middle Stone Age occupation and over Early Stone Age layers at Site A. Sample comes from the roots of a tree that apparently grew on a land surface developed on the lower levels of the Earlier Stone Age beds after the upper levels had been removed by erosion. The tree then was buried by material upon which the third or Middle Stone Age occupation floor developed. The sample is believed to date the time of the Sangoan Culture. *Comment*: sample was treated for humic-acid removal and enough was obtained for dating. The ages of the two fractions are based on three 1000-min measurements apiece. In both cases, all individual measurements exceed average background; in addition, both average net sample counts are three times the standard errors of the net counts. These ages are the oldest reported thus far by the Lamont Laboratory. Until additional fractions are isolated in an effort to study contamination further, these ages should be used in a conservative manner.

L-399C.	Residue after humic-acid removal	**43,000 ± 3300**
L-399C.	Humic acid	**42,000 ± 3000**

L-399A. First Intermediate Culture—Sangoan **>40,000**

Wood from a clay-filled gully cut in current-bedded sands and believed to be of approximately the same age as samples L-399C and L-399B. A finite date would fix the beginning of a rise in lake level provisionally identified by Clark (personal communication) as contemporary with the onset of the Gamblian Pluvial period. *Comment*: sample treated for humic-acid removal.

L-399B. First Intermediate Culture—Sangoan **>42,500**

Wood from the fourth occupation floor at Site B. Associated cultural material was sparse but sufficient (in the form of picks) to be sure that it is post-Chelles-Acheul and belongs with the Sangoan. The general agreement among samples L-399A, B, and C indicates a date in the region of >40,000 for the Sangoan Culture. In addition, if the beds containing the Acheulian Culture floors are of Kanjeran age rather than of early Gamblian age, the same date holds for the onset of the Gamblian Pluvial period. *Comment*: sample was first measured without treatment and a finite age was obtained. Sufficient material was available for isolation of cellulose and lignin, however, and the age was then shown to exceed the Lamont dating range.

L-399B. Untreated wood **32,500 ± 2800**
L-399B. Wood lignin **>38,000**
L-399B. Wood cellulose **>42,500**

Floor 5 (Acheulian) in the Kalambo sequence has been dated as >35,000 (L-271A, Broecker and others, 1956) and as >52,000 by the Groningen Laboratory (Clark, personal communication).

L-399E. Grotte de Taforalt, Morocco **11,900 ± 240**

Charcoal from a hearth in Grotte de Taforalt (34° 49′ N Lat, 2° 24′ E Long), Taforalt, Morocco. Sample came from the top level which, with the two below it, represents the Oranian culture of Upper Paleolithic-Early Mesolithic times. Materials of the Mousterian culture are also present in the cave. Subm. by H. L. Movius, Jr. *Comment*: Lamont radiocarbon dates for the Capsian culture (thought to be essentially contemporaneous with the Oranian culture) are reported by Kulp and others (1952, L-133B, L-134), Broecker and others (1956, L-240B) and Broecker and Kulp (1957, L-240A); all dates fall between 6800 and 8400 yr B.P. Samples above and below L-399E have been dated by Centre Atomique de Saclay (Movius, personal communication); the sample above gave an age of 10.800 ± 400, the sample below 12,070 ± 400.

E. Pacific Islands

L-394. Marquesas Islands, French Polynesia

Charcoal from fire pits in two sites in Uea valley or Bay Marquisien on the southwestern coast of Nuku Hiva (8° 56′ S Lat, 140° 11′ W Long). Both sites are small rock shelters, NBM-1 being situated at the base of the "Roche remarquable, 200 m. environ", shown on the south side of this valley on Map 3931, Service Hydrographique de la Marine. Paris, 1883, and NBM-5 being situated at the extreme south side of the beach. Archaeologic details are given by Shapiro (1958). Coll. 1956 by H. L. Shapiro and R. C. Suggs; subm. by Shapiro, American Museum of Natural History.

L-394F. Site NBM-1 Unit 55-5 **480 ± 100**

Charcoal resting on bedrock at a depth of 20 in. Simple and compound shank hooks are associated with the charcoal.

L-394J. Site NBM-5 Unit-X **270 ± 100**

Charcoal from base of large earth oven on bedrock at depth of 36 in. Associated with simple hooks.

VII. CHECK SAMPLES

L-292. Groningen, Netherlands **1250 ± 150**

Wood from the Walburg Church in Groningen (53° 12′ N Lat, 6° 36′ E Long), Netherlands. This sample has been used as a standard for interlaboratory comparison. The Groningen radiocarbon laboratory (de Vries and Barendsen, 1954) has obtained an average age about 1000 yr based on a large number of measurements. Coll. 1950 and subm. by Hl. de Vries, University of Groningen. *Comment*: the difference in the Lamont and Groningen ages results largely from the fact that no Suess-effect correction was applied to the Groningen age. According to de Vries, such a correction would raise his age to about 1200 yr (personal communication).

L-371E. Pompeii, Italy **1830 ± 50**

Carbonized bread from a storehouse of ancient Pompeii (40° 50′ N Lat, 14° 30′ E Long), Italy. Still retaining the appearance of a baker's roll that seemingly was overdone, the material was charred by the volcanic ash fall that buried the city in A.D. 79, roughly 1880 years ago. Although precise information is not available concerning how long grain was stored at that time, the consensus is that the period did not exceed 2 years. Hence, this sample provides an excellent historic check of the radiocarbon method of age determination. Supplied by A. Maiuri; subm. by J. Bird, American Museum of Natural History. *Comment*: in order to obtain the best possible modern control for use in the age calculation, freshly sprouted wheat and live poplar twigs were collected near Rome by L. Lodi on November 7, 1956. Identical radiocarbon contents and C^{13}/C^{12} ratios were found for the two materials. On this basis, it was concluded that the usual Lamont control, 1890 oak wood, was acceptable once a minor correction was made for a slight difference in C^{13}/C^{12} ratio between the oak and the twigs and wheat. As always, an additional 68 years were added to the calculated age in order to allow for the decay of radiocarbon in the 1890 oak wood.

L-423. Eniwetok Atoll, Marshall Islands

Carbonate material from drill holes in Eniwetok Atoll, Marshall Islands. Purpose of the radiocarbon age determinations was to provide a comparison with ages determined by the ionium-uranium method (Potratz, Barnes, and Lang, 1955).

L-423A. Parry Island **4900 ± 150**

Sample of cuttings from a 40- to 45-ft depth (no. E-1, 40-45) in drill hole on Parry Island (11° 24′ N Lat, 162° 22′ E Long), Eniwetok Atoll, Marshall Islands. Coll. 1952 by H. Ladd; subm. by H. Potratz, Washington University of St. Louis.

L-423B. Mujinkarikku Island **23,500 ± 1000**

Sample of cuttings from a 34 to 36-ft depth (no. Mu 7-13) in drill hole on Mujinkarikku Island (11° 39′ N Lat, 162° 15′ E Long), Eniwetok Atoll, Marshall Islands. Coll. 1950 by H. Ladd; subm. by H. Potratz. *Comment*: the corresponding ionium-uranium ages are 12,000 ± 4000 and 132,000 ± 10,000 respectively (Sackett, 1958). Most of the difference between the respective pairs is probably due to younger secondary calcite cementing the original aragonitic material. Recently obtained cement-free material will be run in the near future.

L-432. Interlaboratory Check **2200 ± 200**

Black-carbon sample sent by the Geochronology Laboratory of the University of Arizona. This had been dated by both Michigan and Arizona, and a 1500-yr difference obtained for the two measurements. Arizona's date was

3980 ± 160 (U.A. 21 and 22; Wise and Shutler. 1958). Michigan's date, 2400 ± 200 (M-540; Crane and Griffin, 1958). The Lamont measurement supports that of Michigan. Why Arizona's result was high is unknown. Fission-product contamination would produce the opposite effect; further, there seems to have been no overestimation of the sample carbon content. Currently, the Arizona laboratory is converting its system so as to measure CO_2 gas instead of solid carbon.

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