[RADIOCARBON, VOL. 3, 1961, P. 141-175]

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 pretreating 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).

ACKNOWLEDGMENTS

The authors were assisted in the laboratory by M. L. Zickl, J. E. Hubbard, F. J. Senn, and D. E. Kemerer. Financial support was provided by National Science Foundation Grant 4191 and through contributions from a number of those who submitted samples. This aid is deeply appreciated.

SAMPLE DESCRIPTIONS

I. SAMPLES ASSOCIATED WITH GLACIAL DEPOSITS

Midwestern United States

L-605. Sand Island, Wisconsin **4800 ± 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° 57′ N Lat, 91° 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° 58′ N Lat, 84° 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 calcerous 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 ± 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 ± 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 reported 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° 47′ N Lat, 85° 12′ 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° 50′ N Lat, 84° 50′ 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 ± 2500 and 23,100 ± 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° 47′ N Lat, 84° 59′ 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 ± 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 ± 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° 45′ N Lat, 89° 34′ W Long). Coll. by W. S. White, U. S. Geol. Survey. *Comment*: result is somewhat lower than black-carbon age of 12,600 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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 portions 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° 22′ N Lat, 124° 31′ 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 ± 900**

Wood from a Quadra exposure in a sea cliff at Spanish Banks on Vancouver Island, British Columbia (49° 17′ N Lat, 123° 13′ 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 ± 3000.

L-514. Cowichan Head series, Vancouver Island

Wood and mollusc shells from Cowichan Head sea cliff, Vancouver Island, British Columbia (48° 03′ N Lat, 123° 21′ 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 ± 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

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

at the end of Taylor Dry Valley (77° 35′ S Lat, 163° 30′ 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 ± 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° 59′ S Lat, 164° 10′ 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 ± 150**

Hide of an elephant seal buried under one ft of beach gravel on a beach at alt 44 ft (77° 26′ S Lat, 163° 46′ 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° 20′ N Lat, 75° 42′ 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 ± 200**

Mytilus from 40 ft below ground surface.

L-604B. Mixed shells **10,550 ± 200**

Hiatella, *Macoma*, and *Balanus* from 35 ft below ground surface.

L-571A. Somerset Island **7150 ± 350**

Marine shell (*Macoma*, *Cardium*, and *Hyatella arctica*) from terrace 100 ft alt, in Four Rivers Bay (72° 47′ N Lat, 95° 37′ W Long). Coll. 1959 by J.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 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 ± 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 ± 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 ± 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° 45′ N Lat, 79° 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° 57′ S Lat, 6° 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 ± 300

Marine shell from 2 to 3 ft below top of core V 15-149, coll. at depth of 238 ft (38° 30′ S Lat, 56° 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° 09′ S Lat, 61° 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° 00′ N Lat, 120° 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° 55′ N Lat, 120° 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

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 200**

2.1% calcite.

L-482B. 24 to 26 ft below sealevel **5800 ± 100**

2.9% calcite.

L-482C. 34 to 36 ft below sealevel **6050 ± 100**

2.3% calcite.

L-482E. 64 to 69 ft below sealevel **33,000 ± 1500**

2.1% calcite.

L-482G. 90 to 97 ft below sealevel **>36,000**

1.0% calcite.

L-521. Brunei, Borneo **5800 ± 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 ± 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 ± 250**

570 ft above present level of Pyramid Lake.

L-437F. 546 ft **11,350 ± 200**

546 ft above present level of Pyramid Lake.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 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 ± 150**

Dense, highly-shattered tufa, 10 to 12 in. from surface.

L-364CG. Depth 10 to 15 in. **12,300 ± 200**

Dendritic tufa, 3-in.-thick layer 12 to 15 in. from surface.

L-364CI. Depth 17 to 19 in. **14,500 ± 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 ± 350**

Dendritic tufa, 3-in.-thick layer 19 to 22 in. from surface.

L-364CK. Depth 22 to 24 in. **15,350 ± 400**

Mammillary tufa, coating underlying radially-oriented thinolite crystals, 22 to 24 in. from surface.

L-364CL. Depth 24 to 28 in. **11,000 ± 300**

Radially-oriented thinolite crystals, 4 in. long, 24 to 28 in. from surface.

L-364CM. Depth 30 to 42 in. **11,400 ± 250**

Radially-oriented thinolite crystals, 12 in. long, 30 to 42 in. from surface.

L-364CN. Depth 150 in. **13,450 ± 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, SW¼ sec. 6, T. 16N., R29E., alt 3920 ft (39° 16′ N Lat, 118° 46′ W Long).

L-483J. Carson Lake Area—Grimes Point **950 ± 250**

Gastropod and pellecypod 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 ± 200**

Lithoid tufa, probably from the upper member of the Sehoo 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, NW¼ sec. 23, T.21N.,R.28E. (39° 40′ N Lat, 118° 49′ W Long).

L-483X. Third Sehoo Lake tufa **8850 ± 150**

Lithoid tufa at base of the upper member of the Sehoo formation, deposited during the transgression of the third Sehoo lake, last of the Lahontan lakes, alt 3930 ft, SW¼ NW¼ sec.24,T.19N.,R.29E. (39° 30′ N Lat, 118° 40′ W Long).

L-483F. Wyemaha Valley, dendritic tufa **13,200 ± 250**

Dendritic tufa (a characteristic radiating-algal variety found in several places in the Lahontan basin) in the dendritic member of the Sehoo 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, SW¼ NW¼ 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 ± 350 and 12,700 ± 300 respectively (Broecker and Orr, 1958).

L-483I. Churchill Valley **11,950 ± 250**

"Coralline" tufa of either the lower member of the Sehoo formation, deposited during the transgression of the first Sehoo lake or the dendritic member deposited during the transgression of the second Sehoo lake, in Churchill Valley, 0.4 mi WSW from summit of Sehoo Mountain, SE¼ SW¼ sec. 15,T. 18N.,R.30E., alt 4180 ft, (39° 25′ N Lat, 118° 37′ W Long). *Comment*: tufa

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 (*Parapholyx 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, SE¼ NW¼ 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, SW¼ NW¼ sec.3,T.19N.,R.29E. (39° 32′ N Lat, 118° 43′ W Long). *Comment*: this analysis was undertaken to see how the C^{14} age on soil would compare with its stratigraphic age. Although the C^{14} age

L-483FF. Carbonate **9550 ± 150**

Carbonate from light layer, immediately above layer from which L-483EE was taken.

L-485. Knolls, Utah **11,300 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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 ± 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, 1 **13,600 ± 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.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 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° 15′ S Lat, 82° 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 ± 300

L-520B. 145 to 160 cm 27,400 ± 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° 39′ N Lat, 74° 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. $\delta C^{13} = -8.3$.

L-500A. Onondaga Caverns, Missouri 6000 ± 150

Moist stalactites ca. 25 in. in diam. and several in. in length (38° 02′ N Lat, 97° 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. $\delta C^{13} = -8.0$.

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° 00′ N Lat, 113° 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° 04′ N Lat, 128° 28′ 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° 13′ N Lat, 73° 53′ 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 ± 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.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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% $CaCO_3$, 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% $CaCO_3$ 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 ± 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 ± 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 ± 600**

L-513B. Lower limestone (18 ft to 18 ft, 8 in.) **26,500 ± 800**

Comment: on stratigraphic grounds, Green thinks that the upper limestone should be older than L-494C, dated this list at 22,300 ± 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 ± 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 ± 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 ± 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 ± 200.

L-473C. 18-in. level **11,900 ± 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 ± 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 ± 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 ± 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 ± 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, probably 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 gave 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 CO_2 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.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 2000 on nearby driftwood 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° 18′ N Lat, 61° 23′ 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° 18′ N Lat, 61° 23′ 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° 42′ N Lat, 78° 38′ 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° 42′ N Lat, 78° 09′ W Long). Coll. and subm. by E. Purdy, Rice Univ., Houston, Texas.

L-366F. Bimini Cay, Bahamas **29,300 ± 1500**

Partially cemented oolite rock from Entrance Point (25° 31′ N Lat, 79° 10′ 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° 31′ N Lat, 79° 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 ± 500**
Fraction B—48% of total sample, 38% aragonite	**18,900 ± 900**
Fraction C—38% of total sample, 85% aragonite	**20,600 ± 900**
Bulk sample (separate portion) 49% aragonite (age compares favorably with composite age of 18,000± 1500 computed for fractions A, B, and C.)	**19,700 ± 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° 31′ N Lat, 79° 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 ± 2500**

Land snails from Queen's Staircase (25° 05′ N Lat, 77° 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° 17′ N Lat, 05° 25′ E Long). Shells are from the marine Eemian. Subm.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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° 17′ N Lat, 5° 05′ 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° 40′ N Lat, 89° 31′ 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° 04′ N Lat, 90° 04′ 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:

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

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 ± 200 yr.

Central and South America

L-561. San José Island, Mexico **1100 ± 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 ± 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. Alumbrera, Argentina **1530 ± 100**

Charcoal from an inside hearth 2 mi SE of Alumbrera, 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 Cordoba; 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 ± 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 ± 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 Museum 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 ± 120**

Charcoal from an undisturbed Late Neolithic pit ca. 5 mi E of Ballycastle, County Antrim, Northern Ireland (55° 12′ N Lat, 6° 07′ 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° 49′ N Lat., 2° 24′ 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 ± 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 ± 200**

L-399G. Humic acid **13,000 ± 250**

L-399G. Untreated portion of sample **13,900 ± 250**

L-395D. Abercorn, Northern Rhodesia **9550 ± 210**

Charcoal from a temporary land surface near base of a sequence of current-bedded sands (8° 35′ S Lat, 31° 13′ 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° 35′ S Lat, 31° 15′ 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 ± 2000**
Humic acid **27,500 ± 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).

References

Date lists:

Chicago I	Arnold and Libby, 1951
Lamont I	Kulp, Feely and Tryon, 1951
Lamont III	Broecker, Kulp and Tucek, 1956
Lamont IV	Broecker and Kulp, 1957
Lamont V	Olson and Broecker, 1959
Lamont VIII	Broecker and Olson, 1961
Saskatchewan II	McCallum and Dyck, 1960
USGS IV	Rubin and Alexander, 1958
USGS V	Rubin and Alexander, 1960
Yale V	Stuiver, Deevey and Gralenski, 1960

Arnold, J. R., and Libby, W. F., 1951, Radiocarbon dates: Science, v. 113, p. 111-120.

Antevs, Ernst, 1925, Condition of formation of the varved glacial clay: Geol. Soc. America Bull., v. 36, p. 171-192.

———— 1951, Glacial clays in Steep Rock Lake, Ontario: Geol. Soc. America Bull., v. 62, p. 1223-1261.

———— 1953, Gechronology of the Deglacial and Neothermal ages: Jour. Geology, v. 61, p. 195-230.

Anthony, H. E., 1949, Nature's deep freeze: Nat. History, v. 58, p. 296-301.

Broecker, W. S., and Kulp, J. L., 1957, Lamont natural radiocarbon measurements IV: Science, v. 126, p. 1324-1334.

Broecker, W. S., Kulp, J. L., and Tucek, C. S., 1956, Lamont natural radiocarbon measurements III: Science, v. 124, p. 154-165.

Broecker, W. S., and Olson, E. A., 1961, Lamont radiocarbon measurements VIII: Radiocarbon, v. 3, p. 176-204.

Broecker, W. S., Olson, E. A., and Orr, P. C., 1960, Radiocarbon measurements and annual rings in cave formations: Nature, v. 185, p. 93-94.

Broecker, W. S., and Orr, P. C., 1958, Radiocarbon chronology of Lake Lahontan and Lake Bonneville: Geol. Soc. America Bull., v. 69, p. 1009-1032.

Broecker, W. S., Tucek, C. S., and Olson, E. A., 1959, Radiocarbon analysis of oceanic CO_2: Internat. Jour. Applied Radiation and Isotopes, v. 7, p. 1-18.

Coleman, A. P., 1933, The Pleistocene of the Toronto region: Ontario Dept. Mines 41st Ann. Rept., v. 41, pt. 7, 55 p.

Deevey, E. S., Jr., 1957, Radiocarbon-dated pollen sequences in eastern North America: Geobot. Inst. Rübel, Zürich, Veröffentl., no. 34, p. 30-37.

Deuel, Thorne, 1957, The Modoc shelter: Illinois State Mus. Rept. Inv. 7. [Reprinted (with revisions) from Nat. History, v. 66, no. 8, 1957.].

Eardley, A. J., and Gvosdetsky, Vasyl, 1960, Analysis of Pleistocene core from Great Salt Lake, Utah: Geol. Soc. America Bull., v. 71, p. 1323-1344.

Eden, W. J., 1955, A laboratory study of varved clay from Steep Rock Lake, Ontario: Am. Jour. Sci., v. 253, p. 659-674.

Elson, J. A., 1957, Lake Agassiz and the Mankato-Valders problem: Science, v. 126, p. 999-1002.

Emerson, W. K., 1960, Results of the Puritan-American Museum of Natural History expedition to western Mexico. 12. Shell middens of San Jose Island: Am. Mus. Novitates, no. 2013, 9 p.

Evans, G. L., and Meade, G., 1945, Quaternary of the Texas high plains: Texas Univ. Pub. 4401, p. 485-507.

Ewing, W. M., and Donn, W. L., 1956, A theory of the Ice Ages: Science, v. 123, p. 1061-1066.

Ewing, W. M., Heezen, B. C., and Ericson, D. B., 1959, Significance of the Worzel ash layer: Natl. Acad. Sci. Proc., v. 45, p. 355-361.

Farrand, W. R., 1961, Frozen mammoths and modern geology: Science, 1961, v. 133, p. 729-735.

Fowler, M. L., 1959, Summary report of Modoc rock shelter: 1952, 1953, 1955, 1956: Illinois State Mus. Rept., Inv. 8.

Fowler, M. L., and Winters, H., 1956, Modoc rock shelter: Prelim. Rept: Illinois State Mus. Rept. Inv. 4.

Fyles, J. G., 1956, Surficial geology of the Horne Lake and Parksville map areas, Vancouver Island, British Columbia: Ph.D. dissert., Ohio State Univ.

Gamble, R., 1958, Descriptions and interpretations of some Pleistocene sections in Wayne County, Indiana: Earlham Coll. Sci. Bull. 3.

Gooding, A. M., 1957, Pleistocene terraces in the upper Whitewater drainage basin, southeastern Indiana: Earlham Coll. Sci. Bull. 2.

Haring, A., deVries, A. E., and deVries, H., 1958, Radiocarbon dating up to 70,000 years by isotopic enrichment: Science, v. 128, p. 472-473.

Harrington, M. R., and Simpson, R. D., in press, Tule Springs, Nevada, Southwest Mus., paper 18.

Hollick, A., 1926, Report on a tree trunk and associated lignitic debris excavated in Manhattan Island: Am. Mus. Novitates, no. 213, p. 1-6.

Kulp, J. L., Feely, H. W., and Tryon, L. E., 1951, Lamont natural radiocarbon measurements I: Science, v. 114, p. 565-568.

Leggett, O. O., and Bartley, X. X., 1953, An engineering study of glacial deposits at Steep Rock Lake, Ontario [see appendix by Burwash]: Econ. Geology, v. 48, p. 513-540.

Libby, W. F., 1955, Radiocarbon dating, 2nd ed.: Chicago, Univ. Chicago Press, ix, 175 p.

McCallum, J. L., and Dyck, W., 1960, University of Saskatchewan radiocarbon dates II: Am. Jour. Sci. Radioc. Supp., v. 2, p. 73-81.

Mackay, J. R., 1956, Mackenzie deltas: a progress report: Canadian Geographer, no. 7, p. 1-11.

Martin, P. S., Sabels, B. E., and Shutler, Dick, Jr., 1961, Rampart Cave coprolite and ecology of the Shasta ground sloth: Am. Jour. Sci., v. 259, p. 102-127.

Menzies, R. J., Be, A. W. H., and Clarke, A. H., 1959, Biological aspects of Arctic deep-sea sedimentation: Rept. to Arctic Inst. of North America.

Olson, E. A., and Broecker, W. S., 1958, Sample contamination and reliability of radiocarbon dates: New York Acad. Sci. Trans., ser. II, v. 20, p. 593-604.

——— 1959, Lamont natural radiocarbon measurements V: Am. Jour. Sci. Radioc. Supp., v. 1, p. 1-28.

Orr, P. C., 1952, Excavations in Moaning Cave: Santa Barbara Mus. Nat. History, Dept. Anthropology Bull. 1, 19 p.

——— 1953, Speleothem Age dating: Texas Archaeol. Soc. Bull., v. 24, p. 7-17.

https://doi.org/10.1017/S0033822200020919 Published online by Cambridge University Press

———— 1959, Observations on new radiocarbon measurements: Western Speleological Inst. Observations no. 5, p. 1-3.

———— 1960a, Late Pleistocene marine terraces on Santa Rosa Island, California: Geol. Soc. America Bull., v. 71, p. 1113-1120.

———— 1960b, Radiocarbon dates from Santa Rosa Island, II: Santa Barbara Mus. Nat. History, Dept. Anthropology Bull. 3, 12 p.

Payne, T. G., and others, 1951, Geology of the Arctic slope of Alaska: U. S. Geol. Survey, Oil and Gas Inv. Map OM 126, sheet 1.

Péwé, T. L., 1960, Multiple glaciation in the McMurdo Sound area, Antarctic—a progress report: Jour. Geology, v. 58, p. 498-514.

Péwé, T. L., Rivard, N. R., and Lano, G. A., 1959, Mummified seal carcasses in the McMurdo Sound region, Antarctica: Science, v. 130, p. 716.

———— in press, Age of moraines in Victoria land, Antarctica: Jour. Geology.

Piggott, S., 1954, Neolithic cultures of the British Isles: (especially p. 152-192, 316-321).

Poole, E. G., and Whiteman, A. J., in press, The glacial drifts of the southern part of the Shropshire-Cheshire basin: Geol. Soc. London Jour.

Potzger, J. E., 1946, Phytosociology of the primeval forest in central-northern Wisconsin and upper Michigan and a brief post-glacial history of the Lake Forest formation: Ecol. Mons., v. 16, p. 211-250.

Reeds, C. A., 1927, Glacial lakes and clays near New York city: Nat. History, v. 27, p. 54-64.

Rubin, Meyer, and Alexander, Corrinne, 1958, U. S. Geological Survey radiocarbon dates IV: Science, v. 127, p. 1476-1487.

———— 1960, U. S. Geological Survey radiocarbon dates V: Am. Jour. Sci. Radioc. Supp., v. 2, p. 129-185.

Saks, V. N., and Strelkov, S. A., 1959, Quaternary deposits of the Soviet Arctic [in Russian]: Arctic Geol. Research Inst., Trans. [Moscow], v. 91.

Simpson, R. D., 1956, Finding the scraper at Tule Springs: The Masterkey, v. 30, 109 p.

Simpson, I. M., and West, R. G., 1958, On the stratigraphy and paleobotany of a late Pleistocene organic deposit at Chelford, Cheshire: New Phytologist, v. 57, p. 239-250.

Strong, W. D., 1935, An introduction to Nebraska archeology: Smithsonian Misc. Colln., v. 93, no. 10, p. 224-239.

Stuiver, Minze, Deevey, E. S., and Gralenski, L. J., 1960, Yale natural radiocarbon measurements V: Am. Jour. Sci. Radioc. Supp., v. 2, p. 49-61.

Suggs, R. C., 1960, The island civilizations of Polynesia: New York, Mentor Series, New American Library.

———— in press, The archeology of Nuku Hiva, Marquesas Islands, French Polynesia: Am. Mus. Nat. History Anthropol. Papers.

Tedrow, J. C. F., and Douglas, L. A., 1958, C^{14} dating of some Arctic soils: Rutgers Univ. Soils Dept., Mimeographed note.

Tedrow, J. C. F., Drew, J. V., Hill, D. E., and Douglas, L. A., 1958, Major genetic soils of the Arctic slope of Alaska: Jour. Soil Sci., v. 9, p. 33-45.

Terasmae, Jaan, 1959a, Notes on the Champlain Sea episode in the St. Lawrence lowlands, Quebec: Science, v. 130, p. 334-335.

———— 1959c, Paleobotanical study of buried peat from the Mackenzie River delta area, Northwest Territories: Canada Jour. Botany, v. 37, p. 715-717.

———— 1960, Contributions to Canadian palynology II. Part II. A palynological study of the Pleistocene interglacial beds at Toronto, Ontario: Canada Geol. Survey Bull. no. 56.

Von den Steinen, K., 1928, Die Marquesaner und ihre Kunst: Berlin, Dietrich Riemer Verlag, v. II, p. 84-86.

Watt, A. K., 1957, Pleistocene geology and ground water resources of the townships of North York, York County: Ontario Dept. Mines Ann. Rept., v. 64, pt. 7.

Worzel, J. L., 1959, Extensive deep sea subbottom reflections identified as white ash: Natl. Acad. Sci. Proc., v. 45, p. 349-359.