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Yale Natural Radiocarbon Measurements III

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Earlier papers from our laboratory have reported measurements of natural radiocarbon made by Libby's solid-carbon method (*1, 2*) and by Suess' acetylene method (*3*). In this article, we give results obtained between July 1955 and March 1957 (*4*), mainly by the carbon dioxide method of de Vries and Barendsen (*5*), which we have had in operation since December 1955. Work with acetylene is never entirely free from danger of explosion, as we know from experience. Moreover, the yield of acetylene is less than 100 percent, so that larger samples are required and isotopic fractionation is possible. In extending the range and accuracy of radiocarbon dating by use of larger samples, we intend to take advantage of the fact that carbon dioxide can be compressed under many atmospheres without attendant risk.

Technique

A counting system including a high-pressure proportional counter and appropriately high voltages is being installed for full realization of the advantages of the carbon dioxide method. Meanwhile, we have conducted routine dating in the same counters that were previously used for acetylene. These counters were not designed for use at high pressures. Thus, when counter 1 is filled with carbon dioxide to a pressure of 137 millimeters of mercury, it shows a background of 8.8 disintegrations per minute, and counter 2 (which has no shielding inside the ring of anticoincidence counters) has a background of 10.1 disintegrations per minute; the net activity of the modern reference standard (hemlock wood laid down between A.D. 1840 and 1850) is close to 20.0 disintegrations per minute in each counter.

We have made no important changes in the system for purification of carbon dioxide that was developed by de Vries and Barendsen. Final purification, primarily for removal of radon, is accomplished by permitting the gas to react at 800°C with calcium oxide that has been prepared from ancient calcite to insure radiochemical purity. After gaseous products are pumped away at 400°C, the carbon dioxide is liberated by increasing the temperature of the carbonate to 900°C.

Corrections of several sorts have increased the stability of the background and modern counting rates, and thus the accuracy of the dates. Changes in room temperature are compensated for during filling of the counters; the purity of the filling gas is tested before and after a run by examination of the relation between over-all counting rate and voltage in the region where this relation is linear and steep; changes in barometric pressure (with which the meson component of the over-all counting rate is inversely correlated) are corrected for when necessary. Application of these various corrections may change the observed counting rate of a sample by as much as 2 percent; corrected counting rates for anthracite and for "modern" wood then prove to be extremely stable over periods of several months, with occasional fluctuations that are attributed to neutrons (associated with solar flares). We have also observed slow, systematic but unexplained changes in background counting rate, which do not affect the calculated dates because of the frequency with which calibration runs are made.

The routine practice in dating is to make duplicate 24-hour runs, one in each counter. Calibration runs are made over weekends. The net sample/net modern wood ratios for duplicate determinations normally agree within the statistical error, so that the two can be combined into a single date. Such dates are listed in Table 1; we make no distinction between dates obtained by the acetylene method and those obtained by the carbon dioxide method.

Results

Calcareous samples have been entirely avoided because of uncertainty about the modern carbon-14 assay with which they should be compared and because of the possibility of carbon exchange between lime and atmosphere or ground water. A few preliminary studies of the radiocarbon content of modern wood from Guatemala and Yucatan have confirmed the existence of the Suess effect (*6*) (decreased radioactivity since A.D. 1900, owing to admixture of "dead" carbon from combustion of coal and petroleum); they give no support to the suspicion that forest trees in the Maya area might incorporate an appreciable amount of old carbon from a limestone substratum. Further studies of the modern assay have been deferred until mass-spectrometric studies of carbon-13 can be conducted simultaneously.

Of the major projects represented by dates in Table 1, three are essentially complete. The Alaskan Little Ice Age is

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discussed in a paper by E. S. Deevey, D. B. Lawrence, and K. B. Bengtson (*7*). Caribbean archeology is discussed by Irving Rouse, J. M. Goggin, and J. M. Cruxent (*8*). A separate paper is not planned for the third project, on European Paleolithic to Neolithic, but a summary of the new dates, together with previously published dates of significance to the pollen chronology of northwestern Europe, is given for ready reference in Fig. 1; Table 2 is a check list of these dates. Studies are being continued on North American geology (with R. F. Flint), including the pollen-stratigraphic section for which E. S. Deevey is primarily responsible, and on the Southern Hemisphere (with various collaborators).

Table 1. Radiocarbon dates obtained by the acetylene and carbon dioxide methods. All ages are given in years before A.D. 1955. "Modern" means that the radiocarbon assay did not differ significantly from that of the reference standard.

Description	Sample No.	Age
I. *Alaskan Little Ice Age and related samples*		
Bengtson 46. Wood from 4-ft log imbedded in till, below the upper limit of till deposition at the end of a spur projecting into the east side of the south part of Brady Glacier, Glacier Bay district, at 1600-ft altitude at the location of sample Y-37 (*3*). Collected in 1950 and submitted by K. B. Bengtson. *Comment*: samples Y-37 and Y-32 were remains of alpine timber in similar stratigraphic positions; both were dated "modern." The large log reported here was transported to the locality by a glacier, but does not prove to be significantly older.	Y-36	Modern
Lawrence F55-1. Transported log, found on top of varved clay exposed in north wall of valley of Goose Cove Creek about 1/10 mi east of entrance of creek, east shore of Muir Inlet, Glacier Bay. Collected in 1955 and submitted by D. B. Lawrence.	Y-301	2265 ± 80
Lawrence F55-2. Stump, rooted in place, top torn by ice moving from north, exposed at north margin of valley of Goose Cove Creek about 1/10 mi east of entrance of creek, east shore of Muir Inlet, Glacier Bay. After its death, the tree was buried by 35 ft of varved clay, on top of which sample Y-301 was found. Collected in 1955 and submitted by D. B. Lawrence.	Y-302	4330 ± 80
Lawrence F55-3. Hemlock (?) stump, about 36 ft above high-tide level, rooted in place on varved clay 4 ft thick, overlain by 10 ft of sand and gravel, about 60 ft of varved clay, and 26 to 30 ft of sand and gravel, in the upper part of which sample Y-304 was found rooted in a buried soil horizon. The section is exposed at W. S. Cooper's station 20 (*9,* p. 119, Fig. 12, lower right), on the west shore of Muir Inlet, Glacier Bay. Collected in 1955 and submitted by D. B. Lawrence.	Y-303	3290 ± 55
Lawrence F55-4. Hemlock stump about 136 ft above high-tide level, rooted in a buried soil horizon overlying outwash, varved clay, and the fossil forest bed from which sample Y-303 was taken, at W. S. Cooper's station 20 (see Y-303). Collected in 1955 and submitted by D. B. Lawrence.	Y-304	1765 ± 50
Lawrence F55-5. Stump, rooted in soil on bedrock at 200-ft altitude and exposed by stream erosion at W. S. Cooper's station 20 (see Y-303). The forest zone is the uppermost zone exposed at this locality. Collected in 1955 and submitted by D. B. Lawrence.	Y-305	850 ± 100
Lawrence F55-6. Stump, rooted in soil on bedrock at 180-ft altitude and exposed by stream erosion (20 ft below sample Y-305) at W. S. Cooper's station 20 (see Y-303). Collected in 1955 and submitted by D. B. Lawrence.	Y-306	1710 ± 60
Lawrence F55-7. Stump, rooted in place about 10 ft below high-tide level, eroded from outwash by wave action, west of the north end of Willoughby Island, on the west shore of Glacier Bay. Collected in 1955 and submitted by D. B. Lawrence. *Comment*: this sample essentially duplicates sample Y-8 (4050 ± 150 yr) (*3*), which was collected by Bengtson at a nearby locality.	Y-307	3745 ± 100
Lawrence F55-8. Hemlock stump, rooted in place in intertidal zone on southern point of Lester Island at the north entrance of Bartlett Cove, Glacier Bay. Collected in 1955 and submitted by D. B. Lawrence. *Comment*: this sample essentially duplicates samples Y-132-83 and Y-132-86 (*3*), both of which were dated "modern."	Y-308	Modern
Helm Glacier, British Columbia. Wood from forest tree killed by advance of Helm Glacier to its recent maximum and exposed by its retreat since A.D. 1940, east tongue of Helm Glacier (*10,* locality 1, p. 366), Mount Garibaldi map area, southwestern British Columbia. Collected in 1955 and submitted by W. H. Mathews.	Y-346	Modern
Sphinx Glacier, British Columbia. Wood from forest tree killed by advance of Sphinx Glacier to its recent maximum and exposed by its retreat since A.D. 1940, north edge of Sphinx moraine (*10,* locality 4, p. 366), Mount Garibaldi map area, southwestern British Columbia. Collected in 1955 and submitted by W. H. Mathews.	Y-347	460 ± 40
II. *European Paleolithic to Neolithic*		
A. *British Isles*		
Clonsast recurrence horizon. Pine stump from about 75-cm depth in Clonsast bog, county Offaly, Eire. The pollen zone is that of the second elm maximum, associated with a recurrence horizon that is correlated with RY II, A.D. 400, in Sweden. Collected and submitted by G. F. Mitchell. *Comment*: a portion of the same stump (sample GRO-271) was dated 1485 ± 150 yr by the Groningen Laboratory (*11,* p. 202).	Y-94	1610 ± 80
Clonsast, early sub-Boreal. Pine root from 220-cm depth, overlying temporarily dried fen peat, overlain by highly humified *Sphagnum* peat, Clonsast bog, county Offaly, Eire. The decline of elm pollen (beginning of agriculture) lies at a depth of 250 cm, and a maximum of oak pollen that is contemporary with early Bronze Age objects lies at 180-cm depth in the same bog (*11,* p. 203).	Y-93	4170 ± 80

Description	Sample No.	Age
Collected in 1951 and submitted by G. F. Mitchell. *Comment*: sample C-358, peat from a level in Clonsast bog corresponding to a depth of about 275 cm in the same pollen diagram (*11*, p. 204), was dated 5824 ± 300 yr by Arnold and Libby (*12*). The horizon has been placed as early Atlantic by Mitchell (*13*).		
Toome Bay Mesolithic. Charcoal from hearth in Section D/6, 1951, Toome Bay, county Londonderry, Northern Ireland. Late Mesolithic culture underlying peat of pollen zone VIb, late Boreal (*14*). Submitted in 1951 by G. F. Mitchell.	Y-95	7680 ± 110
Upton Warren. Organic sediment from near the base of a 30-ft sand-and-gravel fill constituting a terrace of the river Salwarpe near Droitwich, Worcestershire, England. The fill is correlated with the Main Terrace of the river Severn, in turn a correlative of the Irish Sea ("Newer Drift") glacier. The deposit contains a "cold" mammal fauna. Collected in 1955 and submitted by F. W. Shotton, whose designation was band 2. *Comment*: the sample was measured five times in two counters, each time with results slightly but not significantly above background, but collectively suggesting an age only slightly in excess of 40,000 yr. It was therefore submitted to the Groningen laboratory, where it gave the measurement of 42,300 ± 1300 yr (sample GRO-595) (*15*).	Y-311A	> 38,350
Penkridge. Peat from the lowermost 5 cm of a peat deposit 250 cm thick, overlying sand, Penkridge, near Wolverhampton, England. The deposit fills a kettle in drift of the Irish Sea ("Newer Drift") glacier, at least 20 mi south of the outermost position reached by younger glaciers. Postglacial pollen zones (zone IV to VII) begin at a height 105 cm above the base of the deposit; the late-glacial pollen sequence is receiving further study. Collected and submitted by F. W. Shotton.	Y-464	10,670 ± 130
B. *Netherlands*		
Usselo Alleröd. Sandy peat from a depth of 160 to 165 cm, at base of Alleröd zone, profile IV Usselo A, Overijssel Province. The section was described with complete pollen analysis by van der Hammen (*16*). Submitted in 1951 by R. D. Crommelin.	Y-139-1	12,500 ± 180
Usselo culture. Sandy peat from a depth of 127 to 132 cm, at base of culture-influenced part of Alleröd zone, in the same locality and profile as sample Y-139-1. Submitted in 1951 by R. D. Crommelin.	Y-139-2	10,880 ± 160
Usselo, Upper Dryas. Sandy peat from a depth of 107 to 113 cm at base of Upper Dryas zone, in the same locality and profile as sample Y-139-1. Submitted in 1951 by R. D. Crommelin. *Comment*: the age of this sample is obviously too great, but the reason is not known.	Y-139-3	11,350 ± 150
Vriezenveen, below recurrence horizon. Eriophorum peat immediately below recurrence horizon (*Grenzhorizont* of C. A. Weber), Vriezenveen, Overijssel Province. Submitted in 1951 by R. D. Crommelin.	Y-139-5	3525 ± 200
Vriezenveen, above recurrence horizon. Base of *Sphagnum cuspidatum* peat immediately above the recurrence horizon in the same locality and profile as sample Y-139-5. Submitted in 1951 by R. D. Crommelin. *Comment*: the wide difference in age between the two samples reflects the fact that samples collected in 1951 for measurement by the solid-carbon method were undesirably large; with the closer spacing now possible, the Groningen laboratory (*17*) reports much closer agreement between samples collected from above and below recurrence horizons. If the Vriezenveen recurrence horizon is not that of Weber, RY III in the Swedish series, 600 B.C., it is an older one—for example, RY IV, 1200 B.C. Measurements made at the University of Chicago on a similar pair of samples from Melbeck in northern Germany (samples C-449, 1129 ± 115 yr and C-450, 1449 ± 200 yr) (*12*) are confirmed by the Heidelberg Laboratory (H-163-156, 1240 ± 60 yr; H-164-160, 1500 ± 80 yr) (*18*) but are now believed on stratigraphic as well as radiocarbon evidence to date RY II, A.D. 400; see sample Y-94 for an Irish correlative of RY II. The problem is being studied in the Heidelberg laboratory (*18*); of nine horizons so far measured in seven bogs, two prove to date RY II, three to date RY III, and four date a distinct horizon of intermediate age, about 100 B.C.	Y-139-6	2720 ± 90
Oud-Loosdrecht, above recurrence horizon. Young *Sphagnum* peat immediately above recurrence horizon, Oud-Loosdrecht, Utrecht Province. Submitted in 1951 by R. D. Crommelin.	Y-139-10	2190 ± 90
Oud-Loosdrecht, below recurrence horizon. Older *Sphagnum* peat (with *Eriophorum*), immediately below recurrence horizon in the same locality and profile as sample Y-139-10. Submitted in 1951 by R. D. Crommelin. *Comment*: this pair of samples agrees with that from Vriezenveen in proving that the recurrence horizon is not RY II; it does not distinguish between RY III and RY IV.	Y-139-11	3630 ± 90
C. *Germany*		
Rissen. Fragments of charcoal from various parts of the late Magdalenian culture layer, Rissen, near Hamburg. Collected in 1948 by H. Schwabedissen and submitted by Hallam Movius. *Comment*: sample Y-157A, being charcoal and all of one age, is believed to provide the best available date for this important horizon.	Y-157B	9280 ± 290
Rissen Magdalenian. Charcoal from hearth, late Magdalenian culture, Rissen, near Hamburg. Pollen age, Alleröd, at transition to Younger Dryas. Collected in 1948 by H. Schwabedissen and submitted by Hallam Movius. *Comment*: the Rissen culture is identical with that of Usselo (see sample Y-139-2), and the age of both agrees	Y-157A	10,560 ± 200

Description	Sample No.	Age

closely with the most accurate dating of late Alleröd time (samples K-101, K-102, K-103, mean 10,830 ± 200 yr; sample K-110, 10,770 ± 300 yr) (*19*). The dates obtained by the Washington laboratory are slightly younger, though not by a significant margin (samples W-82 and W-84, mean 10,400 ± 160 yr) (*20*). The Heidelberg date for charcoal of the Rissen culture (H-75-68, 11,450 ± 180 yr) (*18*) must therefore be regarded as too old, although the dates for the underlying wood and gyttja are consistent with that for charcoal.

Meiendorf Hamburgian. Antler from late Upper Paleolithic (Hamburgian) culture layer, Meiendorf, near Hamburg. Pollen age, Oldest Dryas (zone I). Submitted by H. Schwabedissen through Hallam Movius. *Comment*: because the antler appeared fresh and moderately organic, it was burned after acid-washing, giving an obviously false date (sample Y-158). Separation into acid-soluble or carbonate (sample Y-158-1 and acid-insoluble or organic (sample Y-158-2) fractions showed that the carbonate fraction is young and that carbonate infiltrated the specimen after deposition. A similar experiment with Meiendorf antler by Rubin and Suess (*21*) showed no difference in age between acid-insoluble (sample W-264, 11,790 ± 200 yr) and the merely acid-rinsed fraction (sample W-281, 11,870 ± 200 yr). However, a more elaborate study by Münnich (*18*) at the Heidelberg laboratory confirms the fact that the infiltrated carbonate of antler, including specimens from Meiendorf (H-38-121), is younger by several thousand years. Organic-carbon fractions of this antler (H-38-121A, H-38-121B) gave ages of 12,000 ± 300 yr and 12,300 ± 300 yr, but these are still too young for Oldest Dryas. The slightly younger culture from Poggenwisch in the same region gave dates about a thousand years older (H-31-67, organic fraction of antler, 13,050 ± 270 yr; H-136-116, wood, 12,980 ± 370 yr). On the other hand, gyttja samples from Meiendorf (sample W-172, 15,750 ± 800 yr) (*22*) and Poggenwisch (sample W-93, 15,150 ± 350 yr) (*20*) seem to be too old, presumably because of the "hard-water lake" effect (*2*). The Heidelberg laboratory (*18*) obtained a similar result for the organic fraction of gyttja from Poggenwisch (sample H-32-60, 15,700 ± 350 yr), but found the calcareous fraction to contain an older component (sample H-32-118a, 17,100 ± 560 yr) that was removable by dialysis (sample H-32-118c, 12,850 ± 500 yr).

Antler, burned after acid washing.	Y-158	9540 ± 130
Acid-soluble fraction of antler.	Y-158-1	7060 ± 400
Acid-insoluble fraction of antler.	Y-158-2	10,760 ± 250

Stellmoor Ahrensburg. Reindeer antler from the Ahrensburg (early Mesolithic) culture layer at Stellmoor, near Hamburg. Pollen age, Younger Dryas (zone III). Submitted by H. Schwabedissen through Hallam Movius. *Comment*: procedures identical to those used for sample Y-158 confirm the infiltration by younger carbon as carbonate. The date of the organic fraction seems entirely reasonable for a zone III culture, but as long as it rests on antler it must be treated with reserve.

Antler, burned after acid washing.	Y-159	9310 ± 260
Acid-soluble fraction of antler.	Y-159-1	5340 ± 200
Acid-insoluble fraction of antler.	Y-159-2	10,320 ± 250

Lieth Alleröd. Peat from dune sand of late glacial age, Lieth, near Elmshorn, Kreis Pinneberg, Schleswig-Holstein. Pollen age, Alleröd (zone II of Firbas) (*23*). Collected by E. Kolombe; submitted in 1955 by H. Schwabedissen. Y-442 11,220 ± 350

Duvensee Mesolithic. Decomposed hazel nuts (Nussmüll) from Mesolithic culture layer (upper Duvensee stage) at Duvensee, Schleswig-Holstein. Pollen age, early Boreal, zone VIa of Overbeck (*24*) (equivalent to zone V of Firbas, *23*; for correlation, see Schmitz, *25*). Submitted in 1951 by H. Schwabedissen. *Comment*: Heidelberg dates for this culture layer are in agreement: sample H-23-22, birch wood, 9200 ± 300 yr; H-26-23, hazel nuts, 9030 ± 350 yr (*18*). The culture is slightly younger stratigraphically than the Mesolithic culture of Star Carr in Yorkshire (sample C-353, 9488 ± 350 yr) (*12*). Y-161 8760 ± 70

Rüde Mesolithic. Wood from culture layer, about 50 cm thick, of Ertebölle/Ellerbek (Mesolithic or proto-Neolithic) culture in Satrup Moor, Rüde, near Schleswig, Schleswig-Holstein. Pollen age, Atlantic, zone VIIIb of Overbeck (*24*) (equivalent to zone VII of Firbas, *23*). Submitted by H. Schwabedissen.

Carbonized wood from upper part of culture layer, 1955 excavation, Fläche F, quadrat 78 a/b, Sch. 96c, between bark floors of a house. Y-471 5620 ± 50

Carbonized wood from lower part of culture layer, 1955 excavation, quadrat 121-c, Kies, Sch. 82. Y-441a 5620 ± 200

Wood from 1951 excavation. Y-160 5690 ± 70

Ellerbek Mesolithic. Worked wood from the Ertebölle/Ellerbek culture at Ellerbek, near Kiel, Schleswig-Holstein. Submitted by H. Schwabedissen; his designation: Sch. 56h. Y-440 6060 ± 200

Südensee-Damm Neolithic. Log, sharpened by stone ax, from base of layer, about 20 cm thick, of early Neolithic culture in Satrup Moor, Südensee-Damm near Schleswig, Schleswig-Holstein. Pollen age, early sub-Boreal, zone IX of Overbeck (*24*) (equivalent to zone VII-VIII of Firbas, *23*). The log lay in horizontal position at 156-cm depth, Fläche C, quadrat 34b, Sch. 94c, under a funnel-beaker, at the top of a layer of fine-detritus gyttja; remains of the Ertebölle/Ellerbek (Mesolithic) culture lay in peat, pollen-dated to zone VIIIb of Overbeck, between 165- and 185-cm depth in the same section. Submitted by H. Schwabedissen. Y-472 4960 ± 50

Heidmoor Neolithic. Wood and charcoal from the Neolithic site of Heidmoor, Gem. Berlin, Kreis Segeberg,

Description	Sample No.	Age
Schleswig-Holstein. Pollen age, late Atlantic or early sub-Boreal. A sample of wood (Y-162), submitted in 1951, gave an obviously erroneous date for the Neolithic culture; it may have come from the older Ertebölle/Ellerbek culture, which is present on the site (see samples Y-160, Y-441-a, Y-471, Y-440). New excavations in 1955 permitted subdivision into upper and lower culture levels within the Neolithic deposit. Submitted by H. Schwabedissen.		
Charcoal from lower level, Field A1, Sch. 75.	Y-443b	4530 ± 170
Charcoal from lower level, Field E, Sch. 81.	Y-443h	4210 ± 80
Charcoal from upper level, Field D, Sch. 78.	Y-443e	4400 ± 170
Wood, submitted in 1951.	Y-162	5940 ± 100
D. *Denmark*		
Herning. Gyttja from the upper (post-Middle-Bed) gyttja layer at Herning, Jutland. (Jessen and Milthers, *6*, layer F). Content of older pollen (for example, from the underlying interglacial gyttja) slight or negative, according to studies by S. T. Andersen. Collected in 1954 and submitted by S. T. Andersen; his sample number: 2812. *Comment*: this sample was evidently contaminated by younger carbon, as shown by the next two dates.	Y-257	19,580 ± 730
Herning. Gyttja, in the form of dark lumps in lighter-colored material, from the upper gyttja layer at Herning (layer F, see sample Y-257). Pollen studies of the lumps and the matrix show no differences, providing no support for the view that the gyttja as a whole was redeposited from older (interglacial) deposits. The gyttja, however, contains a certain proportion of redeposited interglacial pollen. Collected in 1954 and submitted by S. T. Andersen; his sample number: 2737.	Y-258-3	> 30,000
Rodebaek. Gyttja from the upper gyttja horizon at Rodebaek, Jutland. According to pollen studies by S. T. Andersen (*27*) the deposit is somewhat older than the gyttja horizon at Herning (see sample Y-257), but there is some possibility of admixture of older material. Collected in 1954 and submitted by S. T. Andersen; his sample number: 2542. *Comment*: in view of the possibility that the underlying Middle Bed corresponds to the Würm I glaciation, the gyttja may yet give a finite date, and new samples are being obtained for the purpose.	Y-259-1	> 40,000
E. *Finland*		
Varrassuo bog. Peat from near point 2 (*28*, Fig. 9) in Varrassuo bog, near Lahti, formed in a lake dammed by the Salpausselkä moraine system, thus immediately postdating the maximum glacial advance of the Fennoscandian subage. The pollen diagram has been published by Donner (*28*, Fig. 13). Collected and submitted in 1956 by Joakim Donner. *Comment*: the dates are about 3000 yr too young, presumably because the peat has undergone postdepositional exchange with younger carbon. Alkali washing of the material left no woody residue that could be used for a new measurement.		
Equisetum brown moss peat from depth of 389 to 399 cm (top of zone III, Younger Dryas), overlying silt and sand; Donner's sample A.	Y-482	8030 ± 140
Sphagnum-Carex peat from depth of 375 to 385 cm (zone IV, pre-Boreal); Donner's sample B.	Y-483	7470 ± 130
III. *North American geology and archeology*		
A. *Glacial geology*		
Bellevue Whittlesey. Spruce wood fragments imbedded in beach sediments of glacial Lake Whittlesey, 4.5 mi southeast of Bellevue, Ohio. Collected in 1953 and submitted by R. P. Goldthwait. *Comment*: this critical sample dates the Lake Whittlesey beach in the Lake Erie basin, a stage that resulted from readvance of the ice margin to the Port Huron moraine. It should therefore be of the same age as sample W-140 (12,650 ± 350 yr) (*22*), which dates the Glenwood phase of Lake Chicago. Sample W-33 (13,600 ± 500 yr) (*20*) should be slightly older because it dates the transition from Lake Arkona to Lake Whittlesey.	Y-240	12,800 ± 250
Opasatika River, Ontario. Organic portion of shell-and-wood sample from depth of 6 ft in 14-ft section of marine silty sand, overlying marine clay, described previously (*3*) as dating the post-glacial marine overlap in the James Bay region. *Comment*: the shell date (sample Y-271, 17,000 ± 370 yr) was obviously false; the organic-carbon date also appears to be too old, possibly because at least part of the organic material was older than the deposit in which it was stranded.	Y-271B	11,440 ± 450
Bald-Headed Hills, Manitoba. Wood from vertical stump, rooted in a fossil soil with a 12-in. humified zone and found in sand of active dunes, on Assiniboine delta of Lake Agassiz, 28 mi east and 12 mi south of Brandon. The dunes have been active since A.D. 1740 at least, and the fossil soil is believed to represent an earlier interval of humid climate. Collected in 1955 by R. D. Bird and submitted by J. A. Elson; his number: C-55-3. *Comment*: there are at least two buried soils in the district, and the date suggests that this sample came from a younger horizon than was supposed.	Y-410	Modern
Lavenham, Manitoba. Wood, buried at 12- to 13-ft depth, overlying clayey sand and overlain by 8 to 9 ft of stratified sand and silt containing snails and wood fragments, at about 1050-ft altitude on Lonsbury farm, NW¼ sec. 22, T.9, R.10, W Prin., 2 mi south and 1.2 mi west of Lavenham. The deposit is interpreted as alluvium, laid down in a ravine during the rising stage of Lake Agassiz II. Collected in 1955 by J. A. Elson, Alan Mozley, and R. D. Bird, and submitted by J. A. Elson; his number: C-55-4. *Comment*: this date is reasonably consistent with that of sam-	Y-411	10,550 ± 200

Description	Sample No.	Age
ple Y-165 (12,400 ± 420 yr) (*3*) as a date for Lake Agassiz II, confirming its correlation with the Valders advance.		
Treesbank, Manitoba. Wood from base of 15-ft layer of silty sand containing bones (bison?) and wood, underlain by till and by 8 to 10 ft of gravel and sand deposited on eroded surface of till; overlain by about 25 ft of sand containing a fossil soil horizon and eolian at the surface. Section exposed at 1100- to 1125-ft altitude on the north bank of the Assiniboine River about 1 mi east of (down-stream from) the mouth of the Souris River, NE¼ sec. 15, T.8, R.16, W. Prin., 2 mi north and 2 mi east of Treesbank. The wood-bearing sand was tentatively interpreted as part of the Assiniboine delta laid down in Lake Agassiz I. Collected in 1955 by J. A. Elson, S. Criddle, and R. D. Bird, and submitted by J. A. Elson; his number: C-55-13a.	Y-415	9110 ± 110
Stockton, Manitoba. Peat with wood fragments from a 4-ft bed, underlain by till and by 17 ft of sand and gravel, overlain by 25 ft of sand containing fossil soil horizons. Section exposed at about 1140-ft altitude on the north bank of the Assiniboine River, NE¼ sec. 36, T.7, R.15, W. Prin., 2 mi north and 2 mi east of Stockton. The sand inclosing the peat bed was interpreted as part of the Assiniboine delta laid down in Lake Agassiz I, and should be approximately contemporary with sample Y-415. Collected in 1955 and submitted by J. A. Elson; his number: C-55-11. *Comment*: samples Y-415 and Y-416 are consistent with each other, as expected. Field evidence permits the alternative interpretation, supported by the post-Valders-maximum dates, that the alluvium was graded to a high stage of Lake Agassiz II.	Y-416	8020 ± 100
Ashville, Manitoba. Peat from 4-in. layer at the base of a shallow bog, overlying stony clay in a lagoon behind a beach ridge of Lake Agassiz, at about 1260-ft altitude 51°10'N latitude, 100° 15'W longitude, 5 mi south of Ashville. The bog is believed to postdate Lake Agassiz I because of its altitude (above the highest level of Lake Agassiz II). Collected in 1955 and submitted by J. A. Elson; his number: C-55-14. *Comment*: the date, although disappointingly remote from that of Lake Agassiz I, may be of value in current studies of pollen stratigraphy. Contamination by rootlets is distinctly possible.	Y-418	1400 ± 80
Parker, S.D. Spruce wood (identified by W. L. Stern) from 26-ft depth in a well, NW¼NW¼ sec. 28, T99N, R53W, near Parker. The inclosing sediment is Wisconsin till that had been mapped by R. F. Flint as of late Cary age. Collected by H. A. Mateer and C. A. Avery; submitted by R. F. Flint. *Comment*: the date agrees with dates of samples from similar stratigraphic positions in Iowa (samples C-596, 11,952 ± 500 yr, and C-653, 12,200 ± 500 yr) (*29*).	Y-452	12,330 ± 180
Meriden Airport, Conn. Tamarack wood (identified by W. L. Stern) from a 3½-ft log imbedded in till at the base of a section overlying bedrock at Meriden Airport, near Meriden. Collected by Penelope Hanshaw; submitted by R. F. Flint. *Comment*: although this is the oldest sample yet given a finite date by our laboratory, there is little doubt that its radioactivity is real; of eight measurements on two separate preparations, only one differed from the average background by less than 4 times the standard error of the background.		
Untreated wood.	Y-451A	32,300 ± 4000
Wood, boiled in alkali.	Y-451B	32,000 ± 3000
		Average 32,000 ± 2800
B. *Pollen stratigraphy*		
Shady Valley, Tenn. Sandy peat from 5½- to about 5-ft depth in the spruce-pollen zone of a bog at Shady Valley, Johnson County. Seven peat-borer samples were taken between 4½- and 5½-ft depths, and their lower portions were combined. The pollen diagram (*30*) shows that this level is at the top of a zone of abundant spruce pollen and that it underlies the hemlock-oak zone. It coincides with a minimum in the curves for oak and hemlock, and with maxima in the curves for spruce, fir, and birch. Collected in 1955 by Frank Barclay and submitted by Paul B. Sears.	Y-287	9500 ± 150
Totoket Bog, Conn. Gyttja samples from a boring made with a 2-in. Livingstone borer through the lower part of Totoket bog, North Branford. The pollen stratigraphy was studied by Deevey (*31*) and correlated with the sequence of Leopold (*32*). Of four 1-m cores sampled, one (second from bottom, 7.0 to 8.0 m) incorporated anomalously young material, as proved by radiocarbon dates as well as by pollen, and has been rejected pending further study. Sample Y-285 (13,550 ± 460 yr) (*3*) came from zones A 1 and 2 in another boring at this locality (*32*). Collected in 1956 by E. S. Deevey, R. F. Flint, and Donald MacVicar, and submitted by Deevey.		
Gyttja from zone B (pine pollen maximum), 5.98 to 6.09 m.	Y-446g	9650 ± 90
Gyttja from zone A 4 (upper part of Durham spruce zone) 6.40 to 6.50 m.	Y-446f	12,080 ± 300
Gyttja from zone A 3 (pine-oak-spruce), 6.65 to 6.75 m.	Y-446e	13,870 ± 210
Gyttja from zones A 1 and 2 (lower part of Durham spruce zone), 7.00 to 7.10 m.	Y-446d	14,790 ± 160
Gyttja from zone T 1 (older herb zone), 8.25 to 8.30 m, overlying sand.	Y-446a	15,090 ± 160
Red Maple Swamp, Conn. Gyttja samples from a complete boring made with a 2-in. Livingstone borer through Red Maple Swamp, Connecticut Arboretum, Connecticut College, New London. Pollen stratigraphy was studied by Beetham (*33*) and correlated with the Totoket sequence of Leopold (*32*). The lowermost zones (T 1 to 3) contained too much inorganic material		

Description	Sample No.	Age
for dating. Collected in 1956 and submitted by Nellie Beetham and W. A. Niering.		
Gyttja from zone A 4 (upper part of Durham spruce zone) 4.00 to 4.10 m.	Y-447e	10,480 ± 140
Gyttja from zones A 1 and 2 (lower part of Durham spruce zone) 5.20 to 5.30 m.	Y-447d	13,290 ± 120
Lake Irene, Quebec. Gyttja from 5.75- to 6.00-m depth, overlying clay, in section through deposits of Lake Irene, Chibougamau district, west-central Quebec. Pollen zone 2a of Ignatius (*34*) (birch-spruce, correlated with pine-pollen zone of more southern localities). Collected in 1952 and submitted by Heikki Ignatius. *Comment*: sample Y-222 (6730 ± 200 yr) (*3*) also came from Ignatius' zone 2a in a bog in the Cochrane district, Ontario.	Y-223	6960 ± 90
C. *Five-Mile Rapids archeologic site, Oregon*		
Five-Mile Rapids, pre-Condor level. Charcoal from "Early I" culture layer, containing stone tools, mostly percussion-flaked, overlying fill of Columbia River at the head of Five-Mile Rapids, about 5 mi east of The Dalles (site WS-4). The sampled layer is partly waterlaid and ranges from sterile fill to the condor-bone level, 87.30 to 89.37 m (arbitrary datum, 100 m); it contained deer, carnivore, rodent, and fish bones, and shells of snails including *Lymnaea palustris* (Muller) and *Gyraulis parvus vermicularis* (Gould). Excavated in 1955 and submitted by L. S. Cressman; his sample number: I.	Y-340	9785 ± 220
Five-Mile Rapids, Condor level. Charcoal from "Early II" culture layer, 89.37 to 90.47 m, at the Five-Mile Rapids site. The artifacts are more numerous and more diversified than they are in layer I, including bola stones, atlatls, burins, and retouched lamellar flakes, as well as flaked stone tools; the fauna includes many birds, including condor and the extinct vulture *Coragyps occidentalis* Miller, as well as fish and terrestrial and marine mammals, but no mollusks. Sedimentation was cultural and subaerial, not fluviatile. Excavated in 1955 and submitted by L. S. Cressman; his sample number: II.	Y-341	7675 ± 100
Five-Mile Rapids, bottom of hardpan. Charcoal from "Transitional" culture layer, 90.80 to 91.08 m, at the Five-Mile Rapids site. Human occupation was less intensive than before and shows evidence of culture change, including pressure flaking; the fauna includes a few birds and fish and more terrestrial mammals. Noncultural sedimentation of the immediately preceding fill was subaerial and rapid. A layer of hardpan caps the latter, between 91.08 and 93.27 m at the measured section. Excavated in 1955 and submitted by L. S. Cressman; his sample number: III.	Y-342	7875 ± 100
Five-Mile Rapids, top of hardpan. Charcoal from "late" culture layer, in top of and immediately above hardpan, 93.27 to 93.80 m, at the Five-Mile Rapids site. Human occupation was more intensive than during the period represented by the hardpan stratum or that immediately preceding it, but bones were evidently no longer discarded in the site. The undisturbed surface of site at this point was approximately 4 m higher. Excavated in 1955 and submitted by L. S. Cressman; his sample number: IV.	Y-343	6090 ± 80
Five-Mile Rapids, 1953, pit 2. Charcoal from between 93.16 and 92.76 m, pit 2, 1953, at the Five-Mile Rapids site. Submitted by L. S. Cressman for purposes of cross-dating with materials from the 1954 and 1955 excavations; his sample number: 1953/II.	Y-345a	2395 ± 80
D. *Mexico*		
La Fragua. Organic fraction of marl-gyttja from 20.80 to 21.00 m depth in core 141/I/1L6, La Fragua, D. F. This level is tentatively correlated with the same level (about 20 m) in the Bellas Artes core (*35*). Collected in 1955 by Leonardo Zeevaert and submitted by Paul B. Sears. *Comment*: if the correlation between Bellas Artes and La Fragua cores is accepted, either the date of sample W-50 (4900 ± 250 yr) (*20*) is too young, or the date of sample Y-291 is too old. Sample W-50 was calcareous and may be less reliable than the present measurement. On the other hand, the subsidence of strata under Mexico City introduces serious difficulties of correlation, and the conflict cannot be resolved without further work.	Y-291	> 30,900
Lagunas de Zempoala. Peat from base of 3-m deposit, overlying gravel, at Las Lagunas de Zempoala, D.F. Pollen stratigraphy (*36*, Fig. 3) shows that the level represents a dry phase preceding the last moist phase, which is correlated with that of post-Classic (Toltec, Nahua) time. Predicted date, A.D. 500–1200. Collected in 1955 and submitted by Paul B. Sears.	Y-292	1040 ± 70
E. *Miscellaneous.*		
Follins Pond, Mass. Wood from post, suspected to be shoring for a Viking ship, excavated by Massachusetts Archaeological Society at Follins Pond, Cape Cod. Submitted in 1954 by Frederick J. Pohl. *Comment*: a sample of this wood was found to be modern by the Lamont laboratory (*37*), but since it was measured by the solid-carbon method, the possibility of radioactive contamination could not be excluded.	Y-268	Modern
IV. *Caribbean and South American archeology*		
A. *Paleo-Indian*		
El Jobo, Venezuela. Charcoal from surface deposits of refuse at El Jobo, Sanjón Malo, Estado Falcón. Collected in 1956 by J. M. Cruxent and submitted by Irving Rouse. *Comment*: this is the first Paleo-Indian type of culture discovered in northern South America (*38*). The obviously intrusive nature of the samples is attributed to deposition of charcoal on the eroded refuse by modern inhabitants. A more accurate idea of the probable age of the El Jobo		

Description	Sample No.	Age
culture can be obtained from the following date (Sample Y-228), since the El Jobo projectile points appear to be similar to those at Intihuasi Cave.		
Charcoal from locality CX391.	Y-438	Modern
Charcoal from locality CX348.	Y-439	Modern
Intihuasi Cave, Argentina. Burned bone from a hearth in layer 4, quadrat E, associated with implements of the Ayampitín culture, the older of two preceramic occupations in Intihuasi Cave, 76 km north of San Luis, San Luis Province. The underlying layers (layers 5 to 7) include volcanic ash, cemented gravel and sand, and Pampean loess, with mammal bones but no artifacts; the overlying layers (layers 1 to 3) are cultural refuse from two preceramic cultures (Ayampitín and Ongamirense) and the protohistoric San Luis culture, plus some volcanic ash, and are capped by recent guano (layer 0). Excavated in 1951 and submitted by A. R. Gonzalez.	Y-228	7970 ± 100
B. *Neo-Indian: east coast of Venezuela.*		
La Aduana. Charcoal from La Aduana site 1, Cubagua Island, Estado Nueva Esparta. Manicuare culture, period I. Collected in 1955 by I. Rouse and J. M. Cruxent and submitted by Rouse. *Comment*: the two La Aduana samples agree with those previously obtained for the Ortoire culture (samples Y-260-1, 2750 ± 130 yr, and Y-260-2, 2760 ± 130 yr) (*3*) in providing dates for period I (the preceramic period) on the east coast of Venezuela and in Trinidad.		
Charcoal from 2.00- to 2.75-m depth in sections A1 to A3.	Y-295	3570 ± 130
Charcoal from northern third of hearth 1, 1.50- to 1.75-m depth, section A1.	Y-296g	3050 ± 80
El Mayal, site 2. Charcoal from 0.50- to 0.75-m depth in test excavation at El Mayal site 2, Carúpano, Estado Sucre. El Mayal style, period II. Collected in 1955 by Irving Rouse and J. M. Cruxent and submitted by Rouse. *Comment*: a date of 1800 yr had been predicted for this sample, on the assumption that it corresponds to the time when the Island Arawak separated from the mainland Arawak language, which had been calculated as A.D. 150 by the method of glottochronology (*39*). The correspondence is remarkably close.	Y-297	1795 ± 80
El Mayal, site 1. Charcoal from 0.25- to 0.50-m depth in test excavation at El Mayal site 1, Carúpano, Estado Sucre. Chuare style, period III. Collected in 1955 by Irving Rouse and J. M. Cruxent and submitted by Rouse.	Y-300	1355 ± 80
El Morro. Charcoal from 0.20- to 0.80-m depth in test excavation at El Morro site, Rio Caribe, Estado Sucre. El Morro style, period IV. Collected in 1955 by Irving Rouse and J. M. Cruxent and submitted by Rouse.	Y-298	715 ± 70
Calle de la Marina. Charcoal from 0.40- to 0.75-m depth in test excavation on Calle de Marina, Rio Caribe, Estado Sucre. El Morro style, period IV. Collected in 1955 by Irving Rouse and J. M. Cruxent and submitted by Rouse. *Comment*: all the dates in the east-coast group agree nicely with the relative chronology previously established for this part of Venezuela (periods I to IV); they are in the proper order and fairly well spaced (*8*, Fig. 2).	Y-299	290 ± 70
C. *Neo-Indian: Orinoco basin, Venezuela*		
Saladero. Charcoal from 0.75- to 1.25-m depth in test pit at the western end of the Saladero site, Barrancas, Estado Monagas. Barrancas style, period II to III. Collected in 1955 by Irving Rouse and J. M. Cruxent and submitted by Rouse.	Y-294	2800 ± 150
Saladero. Charcoal from 1.25- to 1.50-m depth, excavation 6, Saladero site, Barrancas, Estado Monagas. Barrancas style, period II to III. Collected in 1950 by Irving Rouse and J. M. Cruxent and submitted by Rouse. *Comment*: a previous date for the Barrancas style (sample Y-40, 2850 ± 120 yr) (*3*) was questioned because it conflicted with the relative chronology. The Barrancas style had been placed in the latter part of period II and the first half of period III in the relative time scale, but this radiocarbon date made it contemporaneous both with the preceramic, period I sites on the coast and in Trinidad (see comment on samples Y-295 and Y-296g) and with the Saladero style of pottery on the lower Orinoco, which was supposed to date from the first half of period II. Because of these discrepancies, Rouse and Cruxent obtained a new sample for the Barrancas style (Y-294) and submitted another sample previously obtained (Y-316). The dates for the two new samples confirm the original date and indicate that both the Saladero and Barrancas styles of pottery were on the lower Orinoco at a time when the Indians of the east coast of Venezuela were still preceramic. In other words, both the Saladero and the Barrancas styles must be assumed to go back to the latter part of period I in the coastal chronology (*8*, Fig. 3).	Y-316	2820 ± 80
D. *Neo-Indian: miscellaneous*		
Chaviña, Peru. Textile from a mummy, found in an adobe-box grave at Chaviña, on the southern coast, and assigned on basis of pottery styles to the end of the Nazca (late Classic) culture. Predicted date, A.D. 700–800. Collected and submitted by S. K. Lothrop.	Y-126	1320 ± 60
V. *Southern Hemisphere*		
A. *Australia*		
Mowbray Swamp, Tasmania. Peat and marl from deposit of Mowbray Swamp, Shoobridge farm, Mella, near Smithton, northwestern Tasmania. The deposit contains ostracods, gastropods, and lamellibranchs, as well as extinct vertebrates (*Nototherium*), and was suspected to be a correlative of Pyramid Valley Swamp, New Zealand (*1*). However, more recent study of the pollen shows that the climatic conditions		

Description	Sample No.	Age
were those of open country, and assignment to an interglacial stage (Sangamon?) is now considered possible (*40*). Collected in 1952 and submitted by E. D. Gill. *Comment*: the peat was expected to give a younger apparent age than the marl, as at Pyramid Valley, but the great age of both leaves the difference between them unspecified.		
Marl from about 2-ft depth.	Y-148-1	> 37,760
Peat from 2- to 4-ft depth, underlying wood.	Y-148-2	> 37,760
Pulbeena Swamp, Tasmania. Peat and marl in a drain through deposit of Pulbeena Swamp, near Pulbeena railroad station, northwestern Tasmania. Pollen studies show vegetation indicative of climate as moist as or moister than that of the present; fossil mollusks and ostracods indicate no important difference between the deposit and that of Mowbray Swamp, 2 mi away. Collected in 1952 and submitted by E. D. Gill. *Comment*: the greater age of the marl may be real, but probably reflects in part the incorporation of older carbon from limestone in the vicinity.		
Peat from 2-ft to 2-ft 7-in. depth, underlying 1 ft 5 in. of marl.	Y-229-1	13,690 ± 550
Marl from 5½-ft depth in the same section.	Y-229-2	27,900 ± 2000
Lake Colongulac, Victoria. Coxiella (inland water) shells from the type locality of *Thylacoleo carnifex* Owen, underlying loess and volcanic tuff on east shore of Lake Colongulac, western Victoria. The deposit contains fossils of several extinct gigantic marsupials; a bone of one of these, believed to have been worked by man, was found *non in situ,* but has the same fluorine index as the extinct marsupials (*41, 42*). Collected in 1952 and submitted by E. D. Gill.	Y-170	13,700 ± 250
Lake Corangamite, Victoria. Coxiella shells sifted from fossil dune 40 ft above the eastern shore of Lake Corangamite, near Cundare, western Victoria (military map 1959, Beeac sheet, grid references 628, 956). The dune was formed during Australia's "Great Arid Period," postdating the deposits containing gigantic marsupials. Although the aquatic snails were not contemporary with the desiccation, but were blown into the deposit from dried-up pools on the floor of the basin, it was hoped that the difference in age would not be great. Collected in 1953 and submitted by E. D. Gill. *Comment*: redeposition of the shells makes this an impossible date for the arid phase.	Y-230	28,240 ± 1100
Yarra Delta, Victoria. Eucalyptus wood from 63-ft depth below low water, Spencer Street Bridge, Melbourne. The black marine silt in which the wood was imbedded overlies yellow clay, oxidized subaerially during the last low stand of the sea, and extends above present sea level. The wood dates an early stage in the postglacial marine transgression, which is believed to have been eustatic (*42, 43*). Collected in 1951 and submitted by E. D. Gill. *Comment*: another portion of this specimen (sample W-95) was dated 8720 ± 200 yr (*20*).	Y-151	8300 ± 210
Goose Lagoon, Victoria. Charcoal from an aboriginal midden on the 25-ft emerged shoreline, Goose Lagoon, site B, western Victoria. Collected in 1951 and submitted by E. D. Gill. *Comment*: a similar sample (C-600) was dated 1177 ± 175 yr (*44*).	Y-150-1	1855 ± 85
B. *Africa*		
Nok, Nigeria. Wood from the youngest and oldest alluvium exposed in the Main Paddock (tin mine) on Nok River, near Jos. The youngest alluvium is stratified, with tin-bearing gravels at the base, overlying an erosion surface cut in the older alluvium and overlain by sand and then by clay. The basal gravel of the youngest body contains pottery and figurines and some evidence of metal-working; hence the deposit is thought (*45*) to date from the Nakuran moist phase, which was provisionally dated (*46*) at 850 B.C. The next older alluvium contains Middle Stone Age tools, and is thought to be of Gamblian age, though Leakey (*47*) suggests that it is Makalian. The oldest alluvium contains Acheulian artifacts. Collected by Bernard Fagg and submitted through Hallam Movius. *Comment*: the oldest specimen was expected to be too old for radiocarbon dating, and was measured to test the possibility of infiltration of younger carbon into wood from alluvium at this tropical locality. The first sample of wood from the basal gravel (sample Y-142-3, Nok C), which was measured twice to insure against mixture of samples, is too old to be Nakuran, and must have been redeposited from older (presumably Makalian) sediments. This conclusion is supported by the similar age of the Zenebi sample (Y-142-7) and suggests that the Middle Stone Age may have survived into the Makalian interval in this part of Africa. The three younger samples confirm the belief that the Nok figurine culture began within the Nakuran moist phase and bracket its date between about 2000 B.C and A.D. 200, with the most probable date being that of Y-142-4, about 900 B.C.		
Nok G, wood with bark adhering, from black clay overlying sand and gravel of the youngest alluvial body, 1956 excavation.	Y-474	1750 ± 50
Nok D, wood from sand overlying basal gravel of the youngest alluvial body, 1951 excavation.	Y-142-4	2875 ± 70
Nok H, carbonized wood from sand and gravel at the main figurine horizon, overlying basal gravel of the younger alluvial body, 1956 excavation.	Y-475	4060 ± 140
Nok C, wood from basal tin-bearing gravel, at main figurine horizon, overlying erosion surface cut in older alluvium, 1951 excavation.	Y-142-3	5490 ± 85
Nok C, another portion of the same specimen, sent separately.	Y-142-3′	5660 ± 90
Average age of Nok C.		5575 ± 65
Nok E, carbonized wood from oldest	Y-142-8	> 39,000

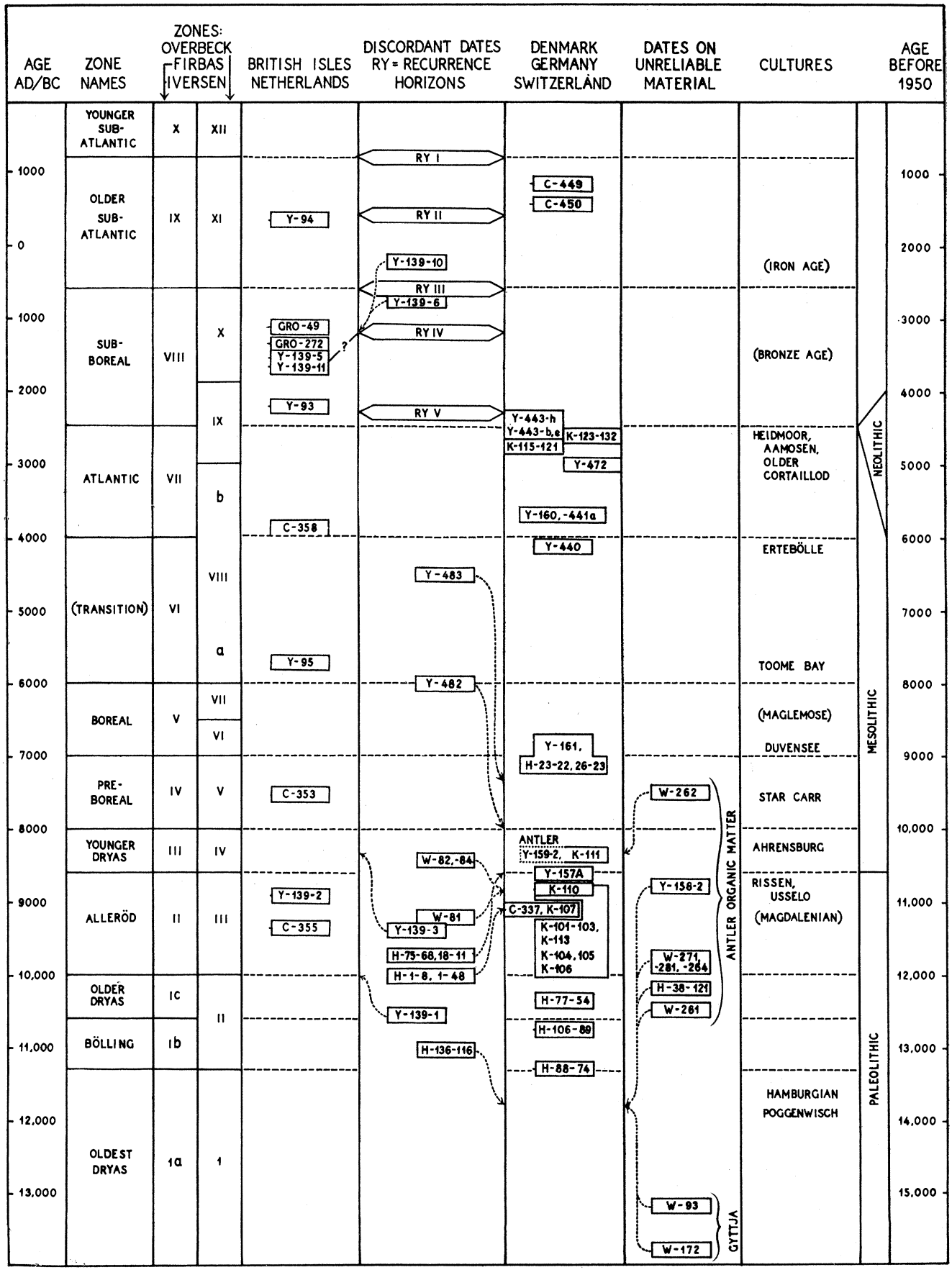

Fig. 1. Summary of radiocarbon-calibrated pollen chronology and archeology of northwestern Europe. Pollen zones are given according to Schmitz (*25*), with chronologic boundaries as modified by radiocarbon dates. Y, Yale dates (this article); C, Chicago dates (*12*); K, Copenhagen dates (*19, 52*); W, Washington dates (*20–22*); H, Heidelberg dates (*18, 53*); GRO, Groningen dates (*54, 55*). Samples are listed by number and name in Table 1.

Description	Sample No.	Age
alluvium, associated with Acheulian artifacts, 1951 excavation.		
Zenebi, Nigeria. Wood from a large log imbedded in older tin-bearing alluvium in Zenebi No. 1 Paddock, associated with a Middle Stone Age industry, on Zenebi River near Jos. The deposit is cut by an erosion surface, above which lies the younger alluvium. It is tentatively correlated (*45*) with the Gamblian pluvial age on the evidence of the artifacts. Collected in 1948 by Bernard Fagg and Geoffrey Bond and submitted through Hallam Movius; Fagg's specimen Z. *Comment*: the date suggests that the deposit is Makalian, not Gamblian. There is no reason to suspect that the artifacts were redeposited from older alluvium.	Y-142-7	5440 ± 110
Njoro Cave, Kenya. Charcoal from several graves at the Neolithic crematorium site, Njoro rock shelter, Kenya (*48*). Collected and submitted by L. S. B. Leakey through W. F. Libby. *Comment* (by L. S. B. Leakey): "It is uncertain whether the rock shelter was formed during the first part of the Nakuran wet phase or before it, but certainly any archaeological content in it would have been removed had it been in position before the maximum of the Nakuran moist climatic phase. Consequently, the culture found in the graves and cremations must postdate the peak of the Nakuran wet phase. This had been provisionally dated as 850 B.C. In view of the carbon dating the maximum of the wet phase is probably earlier than originally thought."	Y-91	2920 ± 80
Cape Flats, Cape Province, Union of South Africa. Podocarp wood from 20 ft below the surface of a sandy deposit, forming part of Cape Flats, the low-lying area separating the Cape Peninsula from the mainland. Submitted in 1951 by the South African Museum, Capetown.	Y-49	> 38,000
Crawford, Cape Province, Union of South Africa. Podocarp wood from 27 ft below the surface of a 70-ft terrace (*49*) forming part of Cape Flats, near Crawford. Collected in 1951 and submitted by E. M. van Zinderen Bakker. *Comment*: the 70-ft terrace is probably older than the last interglacial age. The two measurements cast no doubt on the supposition that the wood belongs to the terrace, but do not provide an adequate date for the last separation of the Cape Peninsula from the mainland.	Y-106	> 36,300
Florisbad, Orange Free State, Union of South Africa. Peat from layer I, 600 cm, inclosing a skull of Florisbad man, the oldest of four peat layers overlying bedrock in the cave of Florisbad, near Bloemfontein. Collected in 1951 and submitted by E. M. van Zinderen Bakker. *Comment*: this level has been dated (sample C-850) as > 41,000 yr (*50*) and (sample L-271B) as > 35,000 yr (*51*).	Y-103	> 44,000

Table 2. Checklist of European radiocarbon dates shown in Fig. 1.

Sample No.	Name	Location
	Yale dates (this article)	
Y-93	Clonsast, early sub-Boreal	Eire
Y-94	Clonsast recurrence horizon	Eire
Y-95	Toome Bay, Mesolithic	Northern Ireland
Y-139-1	Usselo, Alleröd	Netherlands
Y-139-2	Usselo culture	Netherlands
Y-139-3	Usselo, upper Dryas	Netherlands
Y-139-5	Vriezenveen, below recurrence horizon	Netherlands
Y-139-6	Vriezenveen, above recurrence horizon	Netherlands
Y-139-10	Oud-Loosdrecht, above recurrence horizon	Netherlands
Y-139-11	Oud-Loosdrecht, below recurrence horizon	Netherlands
Y-157A	Rissen, Magdalenian hearth	Germany
Y-158-2	Meiendorf, organic fraction of antler	Germany
Y-159-2	Stellmoor, Ahrensburg culture, organic fraction of antler	Germany
Y-160	Rüde, Mesolithic, 1951	Germany
Y-161	Duvensee, Mesolithic	Germany
Y-440	Ellerbek, Mesolithic	Germany
Y-441a	Rüde, Mesolithic, 1955, lower part	Germany
Y-442	Lieth, Alleröd	Germany
Y-443b,h	Heidmoor, Neolithic, lower level	Germany
Y-443e	Heidmoor, Neolithic, upper level	Germany
Y-471	Rüde, Mesolithic, 1955, upper part	Germany
Y-472	Südensee-Damm, Neolithic	Germany
Y-482	Varrassuo, post-Salpausselkä, zone III	Finland
Y-483	Varrassuo, post-Salpausselkä, zone IV	Finland
	Chicago dates (12)	
C-337	Wallensen, Alleröd, gyttja	Germany
C-353	Star Carr, Mesolithic, wood	England
C-355	Knocknacran, Alleröd, gyttja	Eire
C-449	Melbeck, above recurrence horizon	Germany
C-450	Melbeck, below recurrence horizon	Germany
	Copenhagen dates (19, 52)	
K-101–103	Ruds Vedby, end of Alleröd, gyttja	Denmark
K-104,105	Ruds Vedby, Alleröd, gyttja	Denmark
K-106	Ruds Vedby, lower Alleröd, gyttja	Denmark
K-107	Wallensen, Alleröd, checks sample C-337	Germany
K-110	Bölling, end of Alleröd, gyttja	Denmark
K-111	Bölling, younger Dryas, gyttja	Denmark
K-113	Ruds Vedby, Alleröd, between K-101-103 and K-104, gyttja	Denmark
K-115, 116, 118	Wauwilermoos, Neolithic, Egolzwil 3 site, wood	Switzerland
K-121	Wauwilermoos, Neolithic, Egolzwil 3 site, charcoal	Switzerland
K-123	Aamosen, Neolithic, Mul. I site, peat	Denmark
K-124–126	Aamosen, Neolithic, Mul. I site, bark	Denmark
K-127	Aamosen, Neolithic, Mul. I site, peat	Denmark
K-128,129	Aamosen, Neolithic, Mul. I site, hazelnuts	Denmark
K-131,132	Aamosen, Neolithic, Mul. I site, charcoal	Denmark
	U.S. Geological Survey dates (20–22)	
W-81	Ruds Vedby, Alleröd, same as sample K-102	Denmark
W-82,84	Ruds Vedby, Alleröd, same as sample K-101	Denmark
W-93	Poggenwisch, Hamburgian culture, marl-gyttja	Germany
W-172	Meiendorf, Hamburgian culture, marl-gyttja	Germany

Sample No.	Name	Location
W-261	Stellmoor, Hamburgian culture, antler	Germany
W-262	Stellmoor, Ahrensburg culture, antler, same as sample Y-159-2	Germany
W-264	Meiendorf, Hamburgian culture, antler	Germany
W-271	Poggenwisch, Hamburgian culture, antler	Germany
W-281	Meiendorf, Hamburgian culture, organic fraction of antler, same as sample Y-158-2	Germany
	Heidelberg dates (18, 53)	
H-1-8, 1-48	Wallensen, Alleröd, checks samples C-337 and K-107	Germany
H-18-11	Rissen, Magdalenian, wood	Germany
H-23-22	Duvensee, Mesolithic, birchwood	Germany
H-26-23	Duvensee, Mesolithic, hazelnuts	Germany
H-38-121	Meiendorf, Hamburgian culture, organic fraction of antler, same as samples W-281 and Y-158-2	Germany
H-75-68	Rissen, Magdalenian, charcoal, same as sample Y-157A	Germany
H-77-54	Gaterslebener See, 280 to 290 cm, beginning of older Dryas, zone Ic, wood	Germany
H-88-74	Gaterslebener See, 370 to 380 cm, beginning of Bölling, zone Ib, wood	Germany
H-106-89	Gaterslebener See, 367 to 377 cm, beginning of Bölling, zone Ib, wood	Germany
H-136-116	Poggenwisch, Hamburgian culture, wood	Germany
	Groningen dates (54, 55)	
GRO-272	Corlona, Bronze Age trackway, wood	Eire
GRO-49	Halve-Mijl-Toterfout, tumulus 8, Bronze Age, charcoal	Netherlands

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