Groningen Radiocarbon Dates II

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The first series of radiocarbon dates obtained at the University of Groningen has been published previously (*1*). This list (*2*) covers the measurements made during the period from August 1954 to March 1956. During part of this period, three counters were in operation, and in the course of time various improvements were introduced. These resulted in a simplification of the chemical procedure and in a reduction of the background (*3–6*).

The present characteristics of the counters can be summarized as follows. The counters are normally filled with carbon dioxide at a pressure of 3 atmospheres. The first counter has a background of 2.4 counts per minute and a net recent carbon count of 5.64 per minute. For the second counter, the corresponding figures are 0.91 and 14.6 counts per minute. The large counter, finally, has a background of 2.4 counts per minute and a recent carbon count of 37.0 per minute. The variation of its background per centimeter change in barometric pressure is 0.05 count per minute. The samples numbered between 500 and 600 were measured in this counter. The samples numbered above 900 were measured in the second counter, whereas the samples numbered below 500 and between 600 and 900 were measured in the small counter.

Various pretreatments for the samples were used (*7*). As a rule, the samples reported in this article were given the following pretreatment. Peat was washed only with hot, diluted hydrochloric acid in order to remove carbonates, if present. Charred material was boiled first with hydrochloric acid, then with sodium hydroxide (5 percent) in order to remove humic acids, and finally washed again at a *p*H below 5. Since the charred wood is never completely elementary carbon, often less than half of the initial amount of material is left. Consequently, this treatment was not applied in cases where only a small amount of material was available. In a few cases the various fractions of the samples were dated separately, and generally the difference between the fractions was not significant. Wood was always boiled with hydrochloric acid, and sometimes it was given the same treatment as charred material.

The errors given are the standard deviations (σ) as calculated from the statistics of the counted particles. It was checked that the fluctuations did not exceed the normal fluctuations. The contributions of the background and of the calibration sample of recent carbon to the final statistical error are also included, though they are very small and are not of interest for a comparison of data obtained by the same counter. Our error does not include the possible error in the half-life of carbon-14 (5570 years). We have used a number of calibration samples of recent carbon which did not give a significant difference. Because of the combustion of fossil oil and coal, the activity of these samples may have been too low ("Suess effect"). All the ages given may therefore be too low, but a correction will be applied as soon as all stations have agreed on its value. A preliminary measurement on charred wheat from 1648 gave a correction of about 250 years. This large effect was not due to isotopic fractionation since the C^{12}/C^{13} ratio was identical for this sample and for our recent calibration sample. Finally, the possible error introduced by isotopic fractionation by the plant (or animal) has not been taken into account. For a few samples this fractionation has been determined by measuring the C^{12}/C^{13} ratio.

A large number of samples pertaining to the problem of the lowering of the Dutch coast relative to sea level were dated. These samples provided a very complex set of data (*8*). Another group of samples related to geological problems of the Gulf of Paria (see our first dating results, *1*) is still being studied.

The remaining dates are given here in three groups (Tables 1–3). The first group contains some individual samples related to special geologic problems. The second group consists of a series of geologic samples from northwestern Europe, ranging in age from about 50,000 years ago to the present. This group includes some standard sections and datings of pollen zones. The third group deals with archeological samples from Europe, Africa, and America. As far as possible, the samples have been arranged in chronological order. Descriptions of the samples and short comments on the dates have been provided by those who were responsible for collecting the samples.

For the sake of clearness one of us (H.T.W.) standardized descriptions and comments to some extent. Wherever possible, related samples have been commented upon jointly. Unless explicitly mentioned, nothing has been added to the conclusions arrived at by the scientists responsible.

Table 1. Geological samples (special problems). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
Demarara (British Guiana). Charcoal from Demarara. Expected age, Tertiary (*9*).	Gro-416 Gro-501	> 29,000 > 50,000
Onverdacht (Surinam). Charcoal encountered in laminated bauxite at Onverdacht, Surinam. The quantity available was small. Since the sea level must have been considerably lower during the time when the bauxite was formed, a Pleistocene age was considered probable. These samples were collected and submitted by J. F. van Kersen, Geologisch Instituut, Leiden. For further details see Van Kersen's thesis (*9*).	Gro-371	> 10,000

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Table 2. Radiocarbon dates obtained on geologic samples, including samples from pollen zones (from "standard profiles"). All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
I. *Pleistocene.*		
De Voorst. Five samples from a well-exposed profile near De Voorst in Northeastern Polder, previously Zuiderzee, which is commonly considered as typical for the lower part of the Eemian interglacial (Jessen and Milthers' zones b, c, d, and e). A new pollen diagram of the site has been prepared by W. van Zeist, Biological Archeological Institute, Groningen. These samples have been measured in the large counter several times in the course of 2 years. The results of the first series were the same as the results obtained with the improved apparatus, with its lower background and barometric effect. We therefore give only the average results, together with our station number of the last measurement made on each sample. Depths below sample XI are given; activities are given in counts per minute.		
Sample XI: peat; depth, 0 cm; activity, 0.27 ± 0.03.	Gro-564	39,480 ± 800
Sample XIa: peat; depth, 0 cm; activity, 0.133 ± 0.02.	Gro-597	45,200 ± 1300
Sample II: peat; depth, 18 cm; activity, 0.26 ± 0.03.	Gro-567	39,790 ± 800
Sample VIII: peat; depth, 75 cm; activity, 0.13 ± 0.015.	Gro-1210	45,360 ± 1000
Sample VIIIa: peat; depth, 75 cm; activity, 0.10 ± 0.02.	Gro-1209	47,470 ± 1500
Sample IX: wood; depth, 85 cm; activity, 0.01 ± 0.02.	Gro-1201	> 57,000
Sample IX corresponds to the earliest phase of the Eem, lying nearly on the boulder clay; it represents the climatic optimum. The upper layers, about 15 cm above sample XI, were partly eroded off, probably during the formation of the Zuiderzee, and partly removed by a machine that dug a canal through this area of Eemian peat (*10*). Sample numbers marked *a* indicate that the sample was given a thorough washing with HCl and NaOH solution. For the upper layer (XI), this gave a pronounced decrease of activity, indicating that recent material had infiltrated, for recent material may be washed out more readily than original material. This effect is appreciable for the upper sample. For sample VIII it is not significant. This would be expected from the fact that the sample was well preserved. The sample consisted of *Hypnum* peat, which was still unoxidized (yellow) when excavated. Samples II and XI were more sandy and thus could have been more readily infiltrated, though they were still very compact and heavily compressed. The result, at least for sample VIII, seemed to be reliable. Nevertheless, the recent measurement of Eem samples from the type locality, which is protected by a layer of at least 8 meters of sand, gave a very high age even for the upper layers of the Eem. Something therefore has been wrong with the preservation of the samples described above; this presents a good example of the difficulties involved in the dating of very old layers. Collected by F. Florschütz, A. J. Wiggers and two of us (H. T. W. and H. de V.).		
Northeastern Polder (former Zuiderzee). Pure *Hypnum* peat, situated between loamy coversand and fluviatile sediments at a depth of 8.00 to 8.20 m near Emmeloord (*11*, p. 30, Figs. 1, 9). According to the pollen diagram by Florschütz, the age would be pleniglacial (more than 90 percent nonarboreal pollen). Collected and submitted by A. J. Wiggers, Dienst Noord-Oostpolderwerken, Kampen.	Gro-390	29,000 ± 5000
Wouw (province of Noord Brabant, Netherlands). Lower part of peat layer at a depth of 90 to 120 cm (sample 110 to 120 cm) near farm "De Grote Plas," municipality of Wouw. The peat is overlain by loamy sand and rather coarse sand. The pollen diagram by Florschütz shows 90 percent nonarboreal pollen, which would suggest a pleniglacial age. The peat, however, contains remains of *Carex*. Collected and submitted by L. van Dorsser, Geographical Institute, Utrecht.	Gro-931	28,500 ± 540
Breda (province of Noord Brabant). Peat layer in the Ganzeweide, municipality of Breda. Alternating peaty and loamy layers occur at a depth 120 to 220 cm. Grain-size analyses have shown that the loam probably consists of loess mixed with sand. Below 220 cm the material mainly consists of peat. The sample was taken at a depth of 2.80 to 3.00 m. The pollen diagram points to a pleniglacial age. Sample collected and submitted by L. van Dorsser.	Gro-936	32,000 ± 900
Samples Gro-390, 931, and 936 all refer to peat of pleniglacial age (*12*) overlain by loamy coversand. Sample Gro-936 antedates a previously unknown loess sediment in the North Brabant area.		
Usselo (province of Overijsel). A new excavation of the Usselo site in 1955 by C. C. W. J. Hijszeler of the Rijksmuseum Twenthe, Enschede, made it possible to collect a series of samples especially for dating purposes. The section corresponds to Van der Hammen's profile B (*12*, p. 117; *13*). The material consisted of moss peat more or less mixed with dune sand. In view of local irregularities in the lamination—mostly due to cryoturbation—the samples were collected at three different places. These three sections could be correlated by means of a number of clearly visible key layers. The samples given below are listed in order from top to bottom. The zone indications are based on the detailed pollen diagram by Van der Hammen. The samples were taken in the presence of S. Hansen and H. Krog (Danish Geological Survey), H. T. Waterbolk and A. Bohmers (Biological-Archeological Institute, Groningen) and W. H. Zagwijn (Geological Survey, Haarlem). A few check pollen analyses of the dated samples were carried out by W. van Zeist.		
Sample BC-1: upper peat (*Pinus* phase of Alleröd).	Gro-925	11,065 ± 120
Sample BC-III: upper peat (*Betula* phase of Alleröd).	Gro-933	11,875 ± 120
	Gro-948	11,515 ± 120
		Average 11,700 ± 90

Description	Sample No.	Age
Sample BC-III: combusted again.	Gro-947	11,470 ± 90
Sample BB-II: sandy intercalation with thin *Hypnum* layers (*Betula* phase of Alleröd).	Gro-921	11,560 ± 100
Sample BA-I: lower peat (older Dryas or top of Bölling).	Gro-926	11,825 ± 120
Sample BA-III: lower peat (Bölling).	Gro-927	12,355 ± 170
Sample BA-V: lower peat (Bölling).	Gro-1104	12,300 ± 100
Sample BA-VI: thin organic layer below lower peat (oldest Dryas or beginning of Bölling).	Gro-928 Gro-935	12,200 ± 100 12,380 ± 130
A detailed discussion of the results must be postponed until full palynological data are available and the ages of more samples have been determined. It seems clear, however, that the Bölling period precedes the Alleröd period by a very short interval. The same was observed in Germany (*14*). The Alleröd dates agree with those obtained in Denmark (*15*).		
Ruds Vedby (Denmark). Wood from the boundary Alleröd/Younger Dryas, dated in Copenhagen (sample K-101) to 10,890 ± 240 yr (*15*) and in Washington (sample W-82) to 10,260 ± 200 and 10,510 ± 180 yr (*16*). Submitted by H. Tauber, Copenhagen. The present result agrees with that obtained in Copenhagen; the Washington dates seem somewhat too young.	Gro-454	10,995 ± 250
Bergen op Zoom (province of Noord Brabant). Lower part of gyttja sediment in a depression east of the Zoom. Depth 1.60 m. Supposed age, Alleröd or Younger Dryas. Sample collected and submitted by L. van Dorsser. The result suggests formation in the Younger Dryas time. This date is very reasonable: the lakes were formed in the Alleröd valleys, which were locally blocked up by Younger coversand deposits.	Gro-419	10,345 ± 275
Northeastern Polder (former Zuiderzee). Two samples from a late glacial peat layer (*11*, p. 38, Fig. 13) at a depth of about 1.50 m. On the basis of a pollen analytical investigation by Florschütz, the layer would be of Alleröd (lower part) age.		
The upper sample (A-19-I) consists of clayey peat.	Gro-343	12,165 ± 350
Sample A-19-II: remeasured.	Gro-410	11,200 ± 320
The lower sample (number of submitter A-19-II) consisted of peat.	Gro-373	10,500 ± 300
Sample A-19-II: remeasured.	Gro-413	11,560 ± 260
A third sample came from a peat layer below late-glacial river loam and overlying coversand (Parcel E-155). It gives the expected age of the transition between the Alleröd and the Younger Dryas (*11*, pp. 40–42, Figs, 16, 17).	Gro-375	10,500 ± 280
These samples were submitted and collected by A. J. Wiggers. The difference between the duplicate measurement of samples A-19-I and A-19-II is somewhat larger than the statistical error. It has not been possible to explain this. The final results are according to expectation. For details see Wiggers (*11*, p. 38, Fig. 13; pp. 40–42, Figs. 16, 17).		
Wychense Ven (municipality of Wychen, province of Noord Brabant). Four samples from a gyttja sediment covered by fen peat in the Wychense Ven. According to pollen analysis (Florschütz) the gyttja could either comprise older Dryas, Bölling, and Alleröd time, or belong wholly to the Younger Dryas time. The samples were collected and submitted by L. J. Pons, Stichting Bodemkartering, Bennekom.		
Sample WVD-A (2.85 to 2.90 m).	Gro-660	9255 ± 180
Sample WVD-B (2.95 to 3.00 m), light brown gyttja with many plant remains, much humus, and little clay.	Gro-625	9260 ± 185
Sample WVD-C (3.32 to 3.36 m), peaty gyttja layer with clay gyttja.	Gro-627	10,580 ± 240
Sample WVD-D (3.70 to 3.90 m), humic gyttjalike loam passing into grey loam with plant remains and black spots.	Gro-632	10,640 ± 220
The results prove that the gyttja sedimentation took place mainly in the Younger Dryas period. For further details see Pons (*17*).		
Charcoal from Usselo layers. The following five samples belong to one series of charcoal samples, found in the *Usselo* layer, from different localities in the Netherlands. To this series may be added samples Gro-498, 603, and 607 in Table 3. They all refer to a thin charcoal-containing layer in coversand. In most cases this layer is clearly a part of a soil profile (Usselo layer) which is roughly contemporaneous with the Alleröd period. At the type locality, the charcoal itself could be followed by Van der Hammen (*12*) into the peat and thereby could be dated to the uppermost part of the Alleröd period. The samples from Deelen, Ugchelen, and Hilversum were collected and submitted by G. C. Maarleveld, Stichting Bodemkartering, Bennekom; those from Velzen and Lemele by H. D. M. Burck, Geologische Dienst, Haarlem.		
Deelen (province of Gelderland). Charcoal from a layer below sand ridge (pseudoås) (*18*) near Deelen. Depth 2.10 m. It is supposed that the ridge dates from Younger Dryas time and the charcoal from the Alleröd time.	Gro-909	11,025 ± 120
Ugchelen (municipality of Apeldoorn, province of Gelderland). Charcoal from cryoturbate layer, depth 1.30 to 1.40 m. A peat layer overlying the charcoal layer dates according to pollen analysis from the Younger Dryas time. Two samples were taken at a short distance from one another.	Gro-907 Gro-937	10,770 ± 120 10,555 ± 130
Hilversum (province of Noord Holland). Charcoal from a layer below a sand ridge near the Craylo bridge at Hilversum. Depth 3.00 m. Expected age, Alleröd.	Gro-920	10,660 ± 90
Velzen (province of Noord Holland). Charcoal from the Usselo layer in the tunnel pit. The quantity of charcoal was so small that no NaOH treatment could be applied. Infiltrated humus might therefore be present, giving rise to a lower age.	Gro-646	10,365 ± 200
Lemele (province of Overijsel). Charcoal from the Usselo layer. Also in this case the quantity was too small for NaOH treatment.	Gro-647	11,230 ± 400
The dates so far obtained closely agree. The mean value is about 10,800 yr—that is, it falls exactly in the transitional period between Alleröd and Younger Dryas time (see above). It is tempting to see a connection between		

Description	Sample No.	Age
these widespread and apparently synchronous forest fires and the declining climate. As Hijszeler recently suggested, volcanic ash from Eifel eruptions might have set the dying forest on fire (see below). It is of interest to emphasize the small scatter between the different samples. The weighted average of the ages, including the samples Gro-498, 603, and 607 mentioned above, is 10,800 yr, and the average value of the square of the deviation of individual results from this average, divided by the standard deviation given, is 1.8. If we had made repeated measurements on one sample, this average should have been 1. The difference is significant, but if sample Gro-646 is left out (this sample may have contained younger contamination) the average mentioned becomes 1.1. This means that the statistics do not exclude the same age for all our samples, especially since there should be an extra scatter due to the fact that not all the trees would have been of the same age at the moment they were set on fire.		
Schalkenmehrener Maar (Eifel, Germany). Gyttja from the East crater of the Schalkenmehrener "Doppelmaar" (Vulkaneifel), directly above tuff-sand layer from the middle of the Younger Dryas time (*19*). Depth 4.20 to 4.30 m. Expected age about 10,500 yr. Collected and submitted by H. Straka, Botanical Institute, Kiel, Germany. The second measurement has a much smaller error. It was undertaken to get a better basis for comparison with the dates of the Usselo layer (mean value, 10,800 yr). If we take into account a possible tree age of 100 to 200 yr and some 50 yr for the time of formation of 10 cm of gyttja after the tuff sedimentation, the difference does not seem to be large enough to exclude the possibility suggested above. Moreover, there were larger eruptions in the Eifel region that occurred before the eruption corresponding to the sample considered here.	Gro-458 Gro-961	10,770 ± 250 10,550 ± 100
II. *Holocene.*		
Emmen (province of Drente). Nine samples from a profile east-northeast of Emmen, in the former vast raised bog (Burtanger Moor) on the border between the Dutch province of Drente and Germany. The samples have been chosen at pollen levels which, according to earlier investigations in the same bog (*20*), have a regional value. The section was as follows: 0 to 44 cm, fresh-to-rather-fresh *Sphagnum* peat; 44 to 185 cm, highly humified *Sphagnum* peat; 185 to 252 cm, wood peat; 252 to 299 cm, fen peat; 299 to 314 cm, gyttja; 314 to 330 cm, moss peat; below 330 cm, sand. Samples collected and submitted by W. van Zeist.		
Emmen VI (− 17 cm): immediately above the beginning of the first important increase of *Fagus*.	Gro-479	2600 ± 140
Emmen VII (− 24 cm): immediately below the first important increase of *Fagus*.	Gro-480	2870 ± 140
Emmen I (− 42 cm): last *Corylus* maximum (C4 of Overbeck and Schneider).	Gro-426	3095 ± 150
Emmen II (− 62 cm): the point where *Fagus* reaches a value of about 1 percent.	Gro-424	3350 ± 140
Emmen III (− 119 cm): increase of *Plantago lanceolata*.	Gro-428	4185 ± 140
Emmen IV (− 171 cm): last high *Ulmus* value.	Gro-431	4965 ± 135
Emmen IV (− 171 cm): humic acid.	Gro-432	5120 ± 190
Emmen IV (− 171 cm): material extracted by HCl. Obviously there is no significant difference between these fractions.	Gro-487	4830 ± 400
Emmen V (− 250 cm): intersection of the lines for *Pinus* and *Alnus*.	Gro-429	7085 ± 210
Emmen IX (− 260 cm): considerable increase of *Alnus*.	Gro-667 Gro-676	7745 ± 135 7880 ± 110
Emmen VIII (− 280 cm): increase of *Corylus*. The pollen diagram, sample selection, and dates are dealt with by Van Zeist in a separate paper (*21*). Some important points are the following: the *Ulmus* fall at about 3000 B.C. (the same as in the profiles Vriezenveen and Tannenhausen; see below); the increase of plantain at about 2200 B.C.; the increase of *Fagus* to about 1 percent, corresponding to the transition from Neolithic to Bronze Age, at about 1400 B.C.	Gro-481	8630 ± 180
Vriezenveen (province of Overijsel). Seven samples from two partly overlapping sections in the large raised bog of Vriezenveen (*22*). Collected and submitted by F. Florschütz, Velp.		
Section I: Vriezenveen VI (28 to 30 cm); increase of *Carpinus*.	Gro-495	1260 ± 120
Section I: Vriezenveen VII (96 to 98 cm); increase of *Fagus*.	Gro-496	2370 ± 110
Section II: Vriezenveen V (20 to 25 cm); increase of *Fagus*.	Gro-491	2520 ± 100
Section II: Vriezenveen III (46 to 48 cm); immediately above the *Grenzhorizont*.	Gro-489	3540 ± 140
Section II: Vriezenveen IV (48 to 50 cm); immediately above the *Grenzhorizont*.	Gro-490	3425 ± 140
Section II: Vriezenveen II (53 to 55 cm); beginning of the continuous *Fagus* curve.	Gro-485	3365 ± 140
Section II: Vriezenveen I (90 to 92 cm); *Ulmus* fall.	Gro-484	4985 ± 140
The dates are in agreement with those from the other standard sections. The *Grenzhorizont* in this section appears to be very early; there is no significant difference between the dates on samples obtained below and above the *Grenzhorizont*.		
Tannenhausen (near Aurich, Ost Friesland, Germany). Five samples from a profile in a drained, raised bog about 5 km north of Aurich. The profile is considered as a standard profile to be used for the dating of submerged peat layers in the East Frisian coastal region (*23*). Collected and submitted by U. Grohne, Institut für Marschenforschung, Wilhelmshaven.		
Sample 5 (25 to 30 cm): fresh *Sphagnum imbricatum* peat; relatively high values for *Fagus* (± 10 percent) and *Carpinus* (5 to 6 percent); *Tilia* is absent.	Gro-321	1295 ± 130
Sample 4 (55 to 60 cm): fresh *Sphagnum imbricatum* peat; *Fagus* for the first time surpasses 4 to 6 percent; *Carpinus* remains below 1 percent; the *Tilia* curve is no longer continuous.	Gro-258	2395 ± 170

Description	Sample No.	Age
Sample 3 (81 to 87 cm): fresh *Sphagnum imbricatum* peat; *Fagus* exceeds 1.5 percent in this sample, and gradually increases toward the top.	Gro-259	2705 ± 120
Sample 2 (91 to 95 cm): humified *Sphagnum cuspidatum* peat; beginning of the continuous *Carpinus* curve, immediately above the last *Corylus* maximum (C4 of Overbeck and Schneider).	Gro-232	3075 ± 100
Sample 1 (155 to 160 cm): humified, *Calluna*-containing *Sphagnum* peat; last high *Ulmus* value at the transition from Atlantic to Subboreal.	Gro-231	4985 ± 120
From these dates one may conclude that the Atlantic-Subboreal boundary and the beginning of Neolithic agriculture, as shown by the presence of a few grains of *Plantago* and *Cerealia,* must be placed at about 3000 B.C. The transition from humified *Sphagnum cuspidatum* peat to fresh *S. imbricatum* peat took place shortly before 750 B.C. The dates closely correspond to those obtained in the Emmen standard section.		
Hilgenrieder Bucht (Ost Friesland, Germany). Two samples from a clay-covered, raised bog, about 10 km northeast of Norden. Distance to present coast marsh, about 1 km. Collected and submitted by U. Grohne.		
Sample 7 (section B3, 1.95 to 2.04 m): transition of humified *Sphagnum* peat to clay-containing *Sphagnum* peat. Beginning of continuous *Carpinus* curve, immediately above the fourth *Corylus* maximum.	Gro-324	3480 ± 120
Sample 6 (section B3, 2.43 to 2.48 m): Ubergangsmoor with monocotyledons, *Eriophorum,* Ericaceae, and *Sphagnum*; last high *Ulmus* value.	Gro-342	5360 ± 100
Sample Gro-342 is somewhat older than might be expected on the basis of the Tannenhausen results. Sample Gro-324 is about 500 years older than the corresponding sample from Tannenhausen. In this case, however, the deviation may have been caused by the redeposition of older peat material.		
Northeastern Polder (former Zuiderzee). Two samples from peat layers which have been correlated with a marine clay sediment (*Cardium* clay). This clay used to be considered as Atlantic, but nowadays a date of about 1800 B.C. is accepted.		
One sample is from Schokland (P.6); it consists of a clayey peat.	Gro-377	3315 ± 90
The other sample is from Urk (D 135); it is from the peat layer immediately below the clay and indicates the beginning of the transgression.	Gro-378	3505 ± 120
These dates prove the supposed subboreal age of the *Cardium* clay. For a detailed discussion, reference may be made to Wiggers (*11,* pp. 63–65, Fig. 24), who collected and submitted these samples.		
Hauwert (West Friesland, province of Noord Holland). Four samples from a profile at Hauwert; the profile is of importance for the study of marine transgressions in the area. The pollen analysis of the section has been made by Florschütz. The samples were collected and submitted by P. Ente and L. J. Pons, Stichting Bodemkartering, Bennekom.		
Sample HZS-a: depth, 1.10 to 1.35 m; shells.	Gro-617	3240 ± 140
Sample HZS-b: depth, 1.45 to 1.55 m; reed peat.	Gro-609	3750 ± 120
Sample HZS-c: depth, 3.35 to 3.45 m; sedge-reed peat.	Gro-610	4090 ± 120
Sample HZS-e: depth, 3.85 to 3.95 m; reed-containing sedge peat.	Gro-605	4690 ± 140
The results agree well with what was anticipated on the basis of palynological and geological considerations.		
Giersbacher Moor (Schwarzwald, Germany). Two samples from a peat profile in the southern part of the Black Forest (*24*). Collected and submitted by G. Lang, Karlsruhe.		
Sample 1 (68 to 75 cm): end of *Abies* period.	Gro-319	3015 ± 120
Sample 3 (155 to 163 cm): beginning of *Abies* period.	Gro-273	4465 ± 140
The dates confirm the view that the *Abies* period in the Black Forest should fall within the Subboreal. Formerly it was thought to belong to the Atlantic.		
Derrybrien North (county Galway, Eire). Peat containing amber bead. A group of several hundred amber beads of Late Bronze Age type were found at the base of a shallow blanket bog at Derrybrien North. Above the level of the beads the pollen sequence was marked by a fall in *Ulmus* to low values. The expected age was in the last centuries of the Pre-Christian Era. Collected and submitted by G. F. Mitchell, Trinity College, Dublin. The date is a little younger than was anticipated, but there is no reason why such necklaces should not still have been in use at the beginning of the Christian Era.	Gro-650	1870 ± 90
Corlona (county Leitrim, Eire). Wood (oak) from a trackway in Corlona Bog (*25*). Depth about 0.95 m. Collected by P. Tohall and submitted by W. van Zeist. According to the pollen diagram by Van Zeist as interpreted by G. F. Mitchell (*26*), the level of the trackway would fall in the beginning of Mitchell's revised zone VIII^{b}.	Gro-272	3395 ± 170
Clonsast (county Offaly, Eire). Wood from *Pinus* stump at a depth of about 75 cm in the raised bog at Clonsast (*26,* pp. 202–206, Fig. 6). The stump was immediately below a recurrence surface. At a slightly higher level the pollen sequence was marked by an abrupt fall in *Ulmus* to low values. The expected age was in the first centuries of the Christian Era. A piece of wood from the same stump was also submitted to the Yale Geochronometric Laboratory. The Yale determination was (Y-94) 1610 ± 80 yr. The results, which overlap very satisfactorily, suggest that the recurrence surface may perhaps be equated with RY-II of Granlund, which was dated at Yale to A.D. 400.	Gro-271	1485 ± 150
Wood from trackway embedded in upper fresh peat in the same raised bog at Clonsast (*26,* pp. 202–206, Fig. 7). Values for *Ulmus* pollen at the level of the trackway were low. The expected age was about A.D. 900. The date of the track is a little younger than was anticipated, but the age is a very reasonable one. These two samples were collected and submitted by G. F. Mitchell.	Gro-651	975 ± 80

Table 3. Archeological samples. All ages are given in radiocarbon years before the present.

Description	Sample No.	Age
I. *Europe.*		
Waskemeer (province of Friesland). Charcoal from culture layer with flint artifacts of the Tjonger culture ("Federmesser Gruppe") at Waskemeer. The layer was situated in coversand at a depth of 120 cm, about 30 cm below the Usselo horizon. Collected and submitted by A. Bohmers.	Gro-607	10,800 ± 230
Horn-Haelen (province of Limburg). Charcoal from Usselo horizon with artifacts from the Tjonger culture at Horn-Haelen. Collected by Brother A. Wouters, submitted by A. Bohmers.	Gro-497 Gro-498	11,000 ± 320 10,950 ± 300
Leende (province of Noord Brabant). Collected in the Usselo horizon, which locally was very rich in charcoal. In the coversand, immediately above this layer, artifacts of the Ahrensburg culture were found.	Gro-603	11,020 ± 230
Charcoal from the culture layer has recently been dated. Both samples collected and submitted by Brother A. Wouters and A. Bohmers.	Gro-1059	10,720 ± 85
Nederweert (province of Limburg). Charcoal from culture layer with artifacts from the Tjonger culture at Nederweert. This layer was situated at a depth of about 40 cm in a coversand deposit. Collected and submitted by A. Bohmers.	Gro-908	9315 ± 110
Lommel (Belgium). Charcoal found in coversand with artifacts from the Tjonger culture. Depth about 40 cm. Collected and submitted by H. T. Waterbolk and A. Bohmers.	Gro-911	7550 ± 90
This is a series of charcoal samples found in connection with Paleolithic cultures. A preliminary survey of the Dutch Paleolithic has been published by Bohmers (*27*), who is now preparing a survey of all Paleolithic finds in the Netherlands. The charcoal samples from Donderen and Een, the dates of which have previously been published, may be commented upon in this connection as well.		
Hamburgian of Donderen.	Gro-216	7365 ± 400
Tjongerian of Een.	Gro-236	7030 ± 140
At Horn-Haelen and Leende (sample Gro-603) the charcoal has no relation to the human occupation of the sites; the dates refer primarily to the Usselo layer which, on the basis of stratigraphic evidence, was expected to be of Alleröd age. Other dates of the Usselo layer are given in Table 2. They all appear to lie at the transition between the Alleröd and the Younger Dryas period. The ages of the other samples (Waskemeer, Nederweert, Lommel, Donderen, Een) are not in accord with expectation. At Waskemeer, the charcoal, although clearly below the Usselo layer, still has the same age. In the other cases the difference is even greater and in contradiction to other radiocarbon dates, if we accept well-founded geological and archeological synchronizations. At Donderen, Lommel, and Nederweert the charcoal was present in the form of diffusely spread small particles at a relatively small depth (less than 50 cm). The possibility may perhaps be considered that the presence of charcoal in these cases is due to the action of the soil fauna and plant roots. This matter needs further investigation. The date of Een cannot, however, be explained in this way.		
Schussenquelle (Bavaria-Württemberg, Germany). Marly moss peat and reindeer antler from the well known Magdalenian site at the Schussenquelle. The peat sample (layer D, No. 27) was collected by G. Lang, who made a new pollen profile. The thickness of the moss peat is 77 cm; the sample came from the lower part (10 to 20 cm above the base) and belongs to pollen zone Ia. The antler is from the 1867 excavation. At that time the objects from the find horizons were not separated; the antler might therefore also come from the upper layer of moss peat, which probably belongs to pollen zone Ib. The antler might have been sized. Submitted by H. Gross, Bamberg.		
Moss peat.	Gro-468	14,470 ± 385
Antler.	Gro-469	11,580 ± 290
After our pretreatment it is unlikely that the antler should have been rejuvenated by the sizing. Even if it should have come from the upper layer (zone Ib, that is, Bölling) the date obtained could hardly be correct. Washington dates from Meiendorf and Stellmoor would point to a consistent error inherent in antler. This matter is under further investigation. The peat date is a very reasonable one, though the high carbonate content might suggest a possible uptake of older carbonate by the mosses and the other constituents of the peat. Gross does not believe this to be a serious error, for the mosses would have taken up CO_2 from the air.		
Pesse (municipality of Ruinen, province of Drente). Wood (*Pinus*) from a dugout canoe found at a depth of 2 to 2.50 m in a small bog near Pesse. According to pollen analysis, the canoe would be of middle Boreal age (alder only 0.1 percent). Collected and submitted by W. van Zeist. The sample was submitted because the possibility could not entirely be excluded that the dugout had sunk into the peat at a later date. The radiocarbon date, however, agrees well with the pollen determination. This is the oldest dugout canoe now known.	Gro-486	8270 ± 275
Waskemeer (municipality of Ooststellingwerf, province of Friesland). Charcoal from a fireplace belonging to a Mesolithic settlement at the surface of the Younger coversand at Waskemeer. In the same section Paleolithic finds (see Gro-607) occurred. Collected and submitted by A. Bohmers. The artifacts belong to the same Mesolithic stage (Halterner Stufe, according to Schwabedissen) as those from the nearby settlement of Haule. From the latter place charcoal has been dated (*1*) at 7525 ± 200 yr (Gro-128). A Chicago measurement yielded 7900 ± 300 yr. According to pollen analysis, Haule would be of late Boreal age. The radiocarbon dates agree well with this determination.	Gro-615	7455 ± 120
Sittard (province of Limburg). Charcoal from a pit ("Wohngrube") at Sit-	Gro-320	6100 ± 140

Description	Sample No.	Age
tard, which was investigated in 1949 (*28*). It yielded, among other shards, a fragment of a beaker-with-a-protruding-foot, which, according to Sangmeister, would indicate a late stage of the *Bandkeramik*. Collected and submitted by W. Glasbergen.		
Sittard (province of Limburg). Two charcoal samples from the 1953 excavation (*29*) of a large Danubian settlement on the Stadswegske, Sittard. On the basis of archeological evidence, sample Gro-423 was expected to be the younger one. Glasbergen's pit is situated in the younger part of the settlement as well. Collected and submitted by P. J. R. Modderman, Rijksdienst voor Oudheidkundig Bodemonderzoek, Amersfoort. Samples Gro-320 and 423 agree with each other; against expectation, Gro-422 is somewhat younger. However, the difference is small. The present results confirm the unexpectedly great age of the *Bandkeramik*, which had appeared in the dates (*1*) of Westeregeln (Gro-147, charred wheat, 6200 ± 200 yr) and Wittislingen (Gro-265, charred wood, 6030 ± 110 yr). This differs from current views by about 1500 years!	Gro-422 Gro-423	5790 ± 190 6200 ± 150
Wahlitz (Kreis Burg, East Germany). Charred grain from culture layer belonging to the Rössen culture at Wahlitz (*30*). The sample number is 181/8 (find complex 37). Submitted by W. Rothmahler, Institut für Agrobiologie, Greifswald. In the light of the *Bandkeramik* dates, the age is very reasonable: the Rössen culture is commonly considered as early Neolithic, though younger than *Bandkeramik*.	Gro-433	5300 ± 200
Burgliebenau (near Merseburg, East Germany). Charred grain from a storage pit 1.75 m deep, excavated in 1916 (*31*). The sample is pure and reliable. Expected age, late Neolithic. Submitted by W. Rothmaler. This date agrees well with the current conception of the beginning of the Bronze Age in Middle Germany (about 1800 B.C.).	Gro-434	3900 ± 150
Durrington Walls (Wiltshire, England). Charcoal from the excavation of Durrington Walls. Collected and submitted by Stuart Piggot, Edinburgh, Scotland. Sample Gro-901a was an earlier measurement. According to Piggott, the date is much older than was expected and contrary to archeological evidence. The site must be approximately contemporary with the first stage of Stonehenge, for which a Chicago date of 3800 ± 275 yr is available. More determinations are needed.	Gro-901 Gro-901a	4584 ± 80 4575 ± 50
Hekelingen (Isle of Putten, province of Zuid-Holland). Charcoal from a Neolithic settlement in the alluvial coastal region at Hekelingen. The settlement was situated on a creek bank (*32*). According to Glasbergen, the pottery is identical with that found at Zandwerven, below a layer containing beakers-with-a-protruding-foot. It would correspond to that of the Seine-Oise-Marne culture of France and Neolithic coastal cultures in Belgium. Collected and submitted by P. J. R. Modderman.	Gro-254	4200 ± 120
Schaarsbergen (municipality of Arnhem, province of Gelderland). Charcoal from central grave of tumulus I at Schaarsbergen. In the grave, an early beaker-with-a-protruding-foot, a flint axe, and a flint blade were found. The quantity of charcoal was small.	Gro-318	4435 ± 320
Ede (province of Gelderland). Charcoal from central grave of tumulus I at Hotel Bosbeek (*33*). The grave contained an early beaker-with-a-protruding-foot, a faceted battle-axe, and a flint blade. Collected by P. J. R. Modderman and submitted by W. Glasbergen.	Gro-330	4195 ± 120
Bennekom (province of Gelderland). Charcoal from central grave and corresponding post circle in Oostereng (*34*). The grave contained two bell beakers of the Veluwe type. Collected and submitted by A. E. van Giffen, Biological Archeological Institute, Groningen.		
Charcoal from grave.	Gro-374	3560 ± 130
Charred post.	Gro-326	3865 ± 180
Witrijt (municipality of Bergeijk, province of Noord Brabant). Charcoal from foundation trench around the central grave of a tumulus at Witrijt. In the grave a beaker with herringbone ornamentation and a knife of Grand Pressigny flint. Collected and submitted by G. Beex and P. J. R. Modderman.	Gro-381	3965 ± 150
Eext (municipality of Anlo, province of Drente). Charcoal covering central grave of Neolithic barrow. During the 1956 excavation only part of the grave was found intact; it contained a battle axe. However, amateurs had collected from this barrow, most probably from the same grave, a beaker and a dagger of Grand Pressigny flint. Sample collected and submitted by one of us (H. W.) A more detailed discussion of the Dutch radiocarbon dates from the Neolithic and Bronze Age has been prepared by Glasbergen (*35*). The following comment is mainly based on the manuscript Dr. Glasbergen kindly put at our disposal. The dates of Schaarsbergen and Ede are of great importance. They refer to typical beakers-with-a-protruding-foot, a type which appears to start at an earlier date than hitherto accepted. The new dates, however, are in agreement with the views expressed by Van der Waals and Glasbergen in their recent study of Dutch beakers (*36*). According to expectation, the Hekelingen date is somewhat earlier. Finally, we may point to the date of the increase of plantain in the standard profile of Emmen (4185 ± 140 yr). This increase seems to be effected by the "protruding-foot-beaker" culture. Whenever such beakers and bell beakers in the Netherlands occur in a stratigraphical context, the latter appear to be the younger. The Bennekom dates are in agreement with this. The beaker of Witrijt, a bell beaker influenced by the "protruding-foot-beaker" culture, appears to be somewhat older than was expected. *Ermelo* (province of Gelderland). Charcoal from a burnt beam, found at the foot of tumulus VII (Elspeetse Heide) (*33*, pp. 21–33). Such charred	Gro-939 Gro-946	3645 ± 65 3640 ± 50

Description	Sample No.	Age
beams were found encircling two other barrows in the same area. Although no datable objects were found, these barrows were expected to date from the Early or Middle Bronze Age.		
Sample No. 38.	Gro-447	3375 ± 150
Charcoal samples from cremations, which, on the basis of archeological and pedological considerations, were expected to belong to the earliest part of the Bronze Age.		
Tumulus IV.	Gro-445	2840 ± 140
Sample No. 30, tumulus XIVa.	Gro-446	2995 ± 120
Sample No. 47, tumulus VII.	Gro-448	2820 ± 140
Charcoal from a burnt palisade around tumulus V in the Speuldersveld (Sample No. 84).	Gro-451	2935 ± 140
The Ermelo samples were collected and submitted by P. J. R. Modderman. The age of Gro-447 and 451 is according to expectation. Samples Gro-445, 446, 448 are much younger than was anticipated. Apparently the previous view, mainly based on pedological grounds, is wrong; the cremations date rather from the Middle Bronze Age.		
Myon (municipality of Myon, Doubs, France). Charcoal from a ditch at Bra, near the plateaux of Alaise. This ditch was found in 1861 by A. Castan and identified with the oppidum of Alesia, mentioned by Caesar. In 1954 the ditch was found again. The sample was collected at a depth of 2 to 2.20 m; no datable objects were found. If Castan's suppositions were correct, the date would fall between 50 B.C. and A.D. 50. Submitted by Professor J. Berard and collected by L. Déroche, University of Nancy, France. Apparently the charcoal layers originated long before the Roman occupation; the sample cannot be identified with Alesia.	Gro-369	2605 ± 130
Ermelo (province of Gelderland). Charred wheat and barley, found in a pit together with some Iron Age shards, in the vicinity of Ermelo. So far the largest find of prehistoric grain in the Netherlands. Owing to earlier diggings at the site, the contemporaneity of shards and grains was not certain. Collected and submitted by H. T. Waterbolk and W. van Zeist. The date confirms the supposed age.	Gro-652	2295 ± 100
Nijmegen (province of Gelderland). Charcoal found at a depth of about 2 m in a layer containing traces of a destruction (NS 54). It is thought that this devastation was due to the Norse raid in 880. In the same layer, pottery from the 9th to the 12 century was found, including Pingsdorf ware and ware with early glaze. Collected and submitted by H. Brunsting, Rijksmuseum, Leiden. The date agrees well with the assumption.	Gro-649	1050 ± 80
II *America, Africa.*		
Mayapan (Yucatan, Mexico). Charcoal, apparently from burned roof beams, on the floor of structure Q-142 in the main ceremonial group at Mayapan. The sample is from a building that seems to have been erected late in the life of the city. Expected age, approximately 500 yr.	Gro-450	355 ± 90
Charcoal from lower levels of a trench at the foot of the north stairway of the principal temple, the Castillo (structure Q-162) at Mayapan. Sample is associated with pottery and construction apparently marking the earliest phase of the principal period of occupation of the city. Expected age, approximately 700 yr. Submitted and commented on by H. E. D. Pollock, Carnegie Institution of Washington.	Gro-452	700 ± 95
Historical and archeological evidence indicates that the principal period of occupation of the city of Mayapan must have occurred between approximately A.D. 1200 and 1460. The two samples were selected with the idea of dating as nearly as possible the beginning and end of the period. The date of Gro-452 (sample B) bears out the archeological and historical evidence. The date of Gro-450 (sample A) is 160 years later than the date of the traditional destruction of the city and falls in post-Columbian times. The discrepancy may partly be due to "Suess effect" (see introduction).		
Uxmal (Yucatan, Mexico). A piece of sapote heartwood from the lintel of a door in the ape house at Uxmal. Sample collected by Buz l'Huiller, submitted and commented on by R. A. M. Bergman, Koninklijk Instituut voor de Tropen, Amsterdam. Uxmal is considered the oldest settlement of the Mayas in Yucatan after the end of the "old empire" in Honduras and Guatemala, which was left between A.D. 750 and 950. Then the "New Empire" was founded in Yucatan; this was taken by the Toltec between the years A.D. 1000 and 1100. The style of Uxmal is older than the one in Chichenitza and Mayapan, where Toltec influences are discernible. The dating found by the C^{14} method is in excellent agreement with these observations.	Gro-613	1065 ± 100
Irazu (Costa Rica). Sample of charcoal found under a lava stream during the construction of a road. Collected by Mrs. Doris Stone, submitted and commented on by R. A. M. Bergman. This charcoal belongs to a layer showing pottery of the Guetar culture, an Indian people of which no dating is known. Neither is the date known of the volcano eruption which covered the site. For both reasons the dating with C^{14} is very welcome, first because the Guetar culture can now be dated, second because it brings to our knowledge the date of this eruption of the Irazu.	Gro-614	960 ± 100
Paracas. A piece of wood found about 1 m under sand together with shards of pottery, fragments of tissue of the kind used for wrapping mummies, and a skull presenting a markedly elongated deformation. The site is a grave, probably opened previously. Collected and submitted by H. Feriz, commented on by R. A. M. Bergman. The oldest layer of this necropolis has been dated at 600 ± 180 B.C. According to Bird, the elongated deformation appeared at about 400 B.C. The Nasca culture, which is considered to follow the Pa-	Gro-618	1765 ± 155

Description	Sample No.	Age
racas culture, is thought to start at A.D. 100. The present find, which pertains to the younger layers of the Paracas culture, is very interesting, for it suggests that the elongated cranial deformation was practised until the end of the Paracas culture, and that the change from Paracas to Nasca culture was indeed rather an abrupt one.		
Saqqara (Egypt). Piece of wood from a mastaba (Saqqara 3505). End of the First Dynasty (reign of Ka). Accepted age about 4800 yr before the present).	Gro-902	4145 ± 70
A second sample from the same locality, tomb 3507 (Saqqara 1955–56). Post of wooden roller across a big niche, embedded in the brickwork. Middle of the First Dynastry (reign of Den). Accepted age about 4900. Unfortunately the sample did not contain enough material for measurement in the medium-sized counter. These samples were collected and submitted by A. H. Klasens, Rijksmuseum, Leiden. In our first report (*1*) a dating of a Badari sample was given (Gro-223, age 5110 ± 160 yr). Both the samples from the First Dynasty and this Badarian sample come out "too young." The interval between the two periods is not unreasonable. Further measurements are planned.	Gro-689	4450 ± 100

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