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BONN RADIOCARBON MEASUREMENTS I

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The laboratory started dating in 1966 using liquid scintillation techniques. Considerable effort has been expended on improvements in both sample preparation and detection (Pietig and Scharpenseel, 1964 and 1966). Yields now approach 100% and 4 to 6 samples are completed each week. A solution of 3 cc synthesized benzene and 1 cc "dead" commercial toluene is employed for ordinary measurements. Toluene contains PPO and POPOP scintillators that give final concentrations of 0.4% and 0.01%, respectively, when diluted with sample benzene. The counting arrangement with normal shielding gives a net modern count rate of 25.6 cpm (78% efficiency) with a background of 9.7 cpm. A special counter equipped with 5 cm mercury and 10 cm lead shielding as well as an anti-coincidence "umbrella" of polystilbeneplastic scintillator has considerably better characteristics. In addition to reduced background, samples as large as 100 cc can be accommodated. The exceptional performance obtained here is presently reserved for natural radioactivity measurements, such as T-3 and Cl-36.

Periodic checks are made to verify constant efficiency of the counter and the scintillation liquid. The instrument is monitored every time a sample is changed by a sealed standard and the scintillation characteristic is observed, using the channels ratio method. Both of these factors are sufficiently reproducible so as not to introduce a significant error in measurements. Routine procedures used for radiocarbon dating with benzene have been described previously (Tamers, 1965).

Radiocarbon dates in this list are based on 95% activity of NBS oxalic acid as modern standard and were calculated using 5568 yr as the half-life of C^{14}. Errors quoted are standard deviations originating from the statistical nature of the radioactive disintegration process, including modern and background counting errors.

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SAMPLE DESCRIPTIONS

I. GROUND WATER SAMPLES

Radiocarbon concentrations of dissolved carbonate in subsurface waters in deposits W and N of Cologne are being investigated. Samples

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were obtained from observation wells in the Sand 07 deposit and pumped wells from the shallower Sand 2 aquifier. Study of these ground waters is not complete and, therefore, only unadjusted (for limestone dilution) data is presented here. Carbonate species extraction method and the procedure we prefer for estimating ages from radiocarbon measurements has been described previously (Tamers, 1967). Samples coll. 1967 and subm. by members of Radiocarbon Dating Lab.

Sand 07 Wells

	C^{14} (% of modern)
BONN-201. Widdersdorf (50° 58′ N Lat, 6° 50′ E Long), 100 m deep.	**69.8 ± 0.5**
BONN-202. Ingendorf (51° 1′ N Lat, 6° 44′ E Long), 50 m deep.	**85.1 ± 0.7**
BONN-203. Sinthern (50° 58′ N Lat, 6° 47′ E Long), 89 m deep.	**78.9 ± 0.6**
BONN-204. Dansweiler (50° 57′ N Lat, 6° 46′ E Long), 111 m deep.	**34.8 ± 0.5**
BONN-205. Glessen (50° 58′ N Lat, 6° 45′ E Long), 81 m deep.	**102.8 ± 0.7**
BONN-206. Buschbell (50° 56′ N Lat, 6° 48′ E Long), 144 m deep.	**62.8 ± 0.6**
BONN-207. Königsdorf (50° 56′ N Lat, 6° 46′ E Long), 137 m deep.	**6.76 ± 0.35**
BONN-208. Bottenbroich (50° 55′ N Lat, 6° 44′ E Long), 233 m deep.	**7.46 ± 0.43**
BONN-209. Herbertskarl 50° 54′ N Lat, 6° 48′ E Long), 256 m deep.	**5.63 ± 0.76**
BONN-211. Marsdorf (50° 55′ N Lat, 6° 52′ E Long), 198 m deep.	**3.87 ± 0.29**

Sand 2 Wells

BONN-210. Efferen (50° 54′ N Lat, 6° 56′ E Long), 72 m deep.	**16.7 ±0.4**
BONN-212. ROW, Brunnen 2 (50° 48′ N Lat, 7° 1′ E Long), 74 m deep.	**61.6 ± 0.6**
BONN-213. Wasserwerk Bersdorf (50° 49′ N Lat, 6° 56′ E Long), 76 m deep.	**68.1 ± 0.6**

BONN-214. Degussa, Kalscheuren, Brunnen 2 71.0 ± 0.6

(50° 50′ N Lat, 6° 56′ E Long), 110 m deep.

General Comment: Sand 07 and Sand 2 are main aquifiers in Basin of Cologne and highly depleted by drainage pumping of brown coal industry. From dates speed of water movement (K_f-value) and time of exhaustion of water reserves are calculated. Work is repeated in 1968 and supplemented by T-3 measurements.

II. SOIL SAMPLES

Radiocarbon measurements of buried relic soils as well as dating on the basis of charcoal inclusions or other organic relics found adjacent to the test solum are applicable to chronologic problems of soil genetics. Age determinations of surface epipedons, whose organic matter is possibly subjected to translocation and rejuvenation are still infrequent with the exception of bog soils (humists, fibrists, lenists) and subhydric formations such as Gyttja, Dy, and Sapropel (limnists) (Mückenhausen, 1962, German Soil Classification, Smith, 1960, 1967, US Soil Classification). The few terrestric soils so far dated belong almost exclusively to the types of chernozem-like and other steppe soils: udolls, ustolls, xerolls, to the plaggen soils: plaggepts, and to podzols: orthods, humods, ferrods. In these cases humic matter containing A horizons or pronounced humus accumulation B_h horizons possess the required carbon contents.

Two principal difficulties of soil dating are: 1) presence of roots, unhumified organic debris; and 2) turnover and rejuvenation of humic matter in different strata of the A horizon due to translocation by earth living animals and percolating water.

Removal of roots and other organic debris from soil samples is achieved by special preliminary treatments. The soil is suspended in water and homogenized by a propeller-stirrer for 1 hr. Sand and silt are removed by settling and decanting the remaining clay suspension through a 0.5 mm mesh sieve. Most of the humified organic material of the soil exists in organo-mineralic complexes with clay minerals. The clay suspension, free from roots and organic debris, separated by centrifugation, and dried at 110°C, yields lumps of clay with black crusts of humic substance. This technique provides carbon enrichments of 2 to 10 times compared to the original soil material. Acid treatment of this smaller quantity of material for the removal of carbonates poses no problem.

Humic matter turnover rates and rejuvenation of organic matter in the different strata of A horizons are not exactly determinable. Estimates given by pedologists are usually based on the belief that within mollic and umbric A horizons the organic substance of different depth layers is nearly equal in age due to mixing action of soil animals and leaching. The following radiocarbon measurements indicate that the effect of mixing is less dramatic than anticipated.

Dating of 10- or 15-cm thick subhorizons shows age heterogeneity within the A horizon. Since it is reasonable to assume that the principal contamination of any one layer comes from the layer directly above. it can be shown that the net errors in the deepest organic matter containing subhorizon are not very large. A model situation is illustrated in Table 1.

TABLE 1

Examples of corrections that might be applied to radiocarbon-dated soil profiles for organic matter turnover as a result of rejuvenation. Extreme turnover assumes that the carbon in a particular layer represents contamination of 40%, 20%, 10%, 5%, and 2% from the succeeding upper layers; carbon in the 75 to 90 cm layer, for example, would be only 23% original material. The average turnover assumes 20%, 10%, 5%, 2%, and 1%.

Layer (cm)	C^{14} Date (yr B.P.)	Extreme Turnover Error (yr)	Average Turnover Error (yr)
0-15	1000	——	——
15-30	2000	400	200
30-45	3000	850	400
45-60	4000	1200	600
60-75	5000	1400	700
75-90	6000	1500	800

A. Chernozems (Vermudolls, Hapludolls)

These are soils of high fertility developed chiefly during post-glacial warm period on calcareous loess under steppe vegetation (Artemisia, Stipa). Black A horizons with 2 to 6% organic matter have developed in the loess. The most important subtypes are degraded (brunified) chernozem due to extensive agriculture utilization, pseudogley chernozem, with AC and C horizons mottled and under inhibited drainage conditions, grayish prairie soil like chernozem with disturbed drainage, and low humic chernozem transitional to brown earth. In W. Germany there are 4 notable regions of occurrence: S of Brunswick (Söllingen, Jerxheim), N of Hildesheim (Adlum, Asel), Pfalz/Rheinhessen (Wallertheim, Frankenthal), E Holstein (Grossenbrode, Ile of Fehmarn). Also relic chernozems occur as scattered buried patches under loess parabrown earth, also under trachyt tuff near Ochtendung, Michelsberg (Rheinland-Pfalz).

Origin of chernozem soils is generally assumed to be 5000-8000 B.P., in Boreal and Atlantikum, with a maximum during warm Atlantikum (Laatsch, 1934, 1957; Scheffer und Schachtschabel, 1956; Mückenhausen, 1962; Hohnvehlmann, 1963; and Zakosek, 1962). However, other soil scientists believe in an earlier, extended pararendzina stage or an origin during Late Glacial time (Wilhelmy, 1950). Some dates of Smonica as well as brown and gray steppe soils have been pbulished (Zakosek and Cow, 1962a, 1962b). Kohl and Quitta (1966) obtained 6045 ± 120 B.P. (Bln-250) for extracted humic acid from chernozem of Köttichau/Hohenmölseu in E. Germany. Similarly, Geyh (pers. commun.) determined from a chernozem at 60- to 70-cm depth, near Lehrte an age of 6050 ± 80 B.P. (Hv-254) and from a buried chernozem "Oingelbe" in 100- to 120-cm depth an age of 7260 ± 120 B.P. (Hv-570). Two degraded chernozems from Mooringen proved to be younger at 3615 ± 80 B.P. and 3270 ± 60 B.P. (Hv-422 and Hv-424). Östlund and Engstrand (1963) dated a degraded chernozem between Harsum and Clausen, near Hildesheim at 3170 ± 65 B.P. (St-682).

BONN-26. Söllingen A, 10 to 20 cm — **1210 ± 70**, **A.D. 740**

BONN-27. Söllingen A, 20 to 30 cm — **2070 ± 80**, **120 B.C.**

BONN-28. Söllingen A, 30 to 40 cm — **2560 ± 90**, **610 B.C.**

BONN-29. Söllingen A, 40 to 50 cm — **2310 ± 90**, **360 B.C.**

BONN-30. Söllingen A, 50 to 60 cm — **2830 ± 80**, **880 B.C.**

BONN-31. Söllingen A, 60 to 70 cm — **3020 ± 80**, **1070 B.C.**

BONN-32. Söllingen A, 70 to 80 cm — **4800 ± 100**, **2850 B.C.**

Samples of chernozem soil in Würm loess from town of Söllingen, S of Brunswick, W. Germany (52° 5′ N Lat, 10° 59′ E Long). From uncultivated area adjacent to "Old Windmill". Coll. 1966 and subm. by members of Radiocarbon Dating Lab. This profile and Söllingen C situated in slightly elevated position. *Comment:* no indication of water logging within A and AC horizons and age increase with depth is continuous. Slow development from pararendzina stage is suggested.

BONN-98. Söllingen C, 10 to 20 cm — **1340 ± 80**, **A.D. 610**

BONN-99. Söllingen C, 20 to 30 cm — **1920 ± 80**, **A.D. 30**

BONN-100. Söllingen C, 30 to 40 cm — **1760 ± 70**, **A.D. 190**

BONN-101. Söllingen C, 40 to 50 cm — **1780 ± 80**, **A.D. 170**

BONN-102. Söllingen C, 50 to 60 cm — **2470 ± 90**, **520 B.C.**

BONN-103. Söllingen C, 60 to 70 cm — **2680 ± 70**, **730 B.C.**

BONN-104. Söllingen C, 70 to 85 cm **3310 ± 70**
1360 B.C.

BONN-105. Söllingen C, 85 to 100 cm **5300 ± 80**
3350 B.C.

Samples of Chernozem soil from town of Söllingen, W. Germany (52° 5′ N Lat, 10° 5′ E Long), taken ca. 50 m from Söllingen A pit and in uncultivated area. Coll. 1967 and subm. by members of Radiocarbon Dating Lab. *Comment:* no indication of water logging effect and dates are similar to those of Söllingen A.

BONN-33. Söllingen B, 10 to 20 cm **2270 ± 110**
320 B.C.

BONN-34. Söllingen B, 20 to 30 cm **360 ± 50**
A.D. 1590

BONN-35. Söllingen B, 30 to 40 cm **2450 ± 80**
500 B.C.

BONN-36. Söllingen B, 40 to 50 cm **3120 ± 80**
1170 B.C.

BONN-37. Söllingen B, 50 to 60 cm **3470 ± 80**
1520 B.C.

BONN-38. Söllingen B, 60 to 70 cm **4060 ± 80**
2110 B.C.

BONN-39. Söllingen B, 70 to 80 cm **4320 ± 80**
2430 B.C.

BONN-40. Söllingen B, 80 to 90 cm **4050 ± 80**
2100 B.C.

Samples of pseudogley chernozem soil SE of Söllingen, W. Germany, in poplar orchard on border of E. Germany (52° 5′ N Lat, 10° 59′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment*: this profile, as well as Söllingen D and Hildesheim A and B, is strongly influenced by logging water, which explains relatively small differences in ages of top 60 cm (except for BONN-34, which must be contaminated with modern material). Apparently there was rapid accumulation of organic matter in initial stages of soil formation under wet conditions.

BONN-106. Söllingen D, 20 to 30 cm **1740 ± 70**
A.D. 210

BONN-107. Söllingen D, 30 to 40 cm **2040 ± 70**
90 B.C.

BONN-108. Söllingen D, 40 to 50 cm **3010 ± 70**
1060 B.C.

BONN-109. Söllingen D, 50 to 60 cm **3790 ± 80**
1840 B.C.

BONN-110. Söllingen D, 60 to 70 cm **4720 ± 80**
2870 B.C.

BONN-111. Söllingen D, 70 to 80 cm **5290 ± 80**
3340 B.C.

BONN-112. Söllingen D, 80 to 90 cm **5550 ± 80**
3600 B.C.

BONN-113. Söllingen D, 90 to 100 cm **5470 ± 80**
3520 B.C.

Samples of pseudogley chernozem soil near town of Söllingen, W. Germany (52° 5′ N Lat, 10° 59′ E Long), in open cultivated field next to old deserted railway track and station shelter on E. German border. Coll. 1967 and subm. by members of Radiocarbon Dating Lab. Surface is plowed annually to average depth of 30 cm. *Comment:* rapid initial accumulation of organic matter in wet environment accounts for same age of 3 deepest humus-carrying layers.

BONN-114. Hildesheim A, 20 to 30 cm **350 ± 60**
A.D. 1650

BONN-115. Hildesheim A, 30 to 40 cm **1590 ± 70**
A.D. 360

BONN-116. Hildesheim A, 40 to 50 cm **1700 ± 60**
A.D. 250

BONN-117. Hildesheim A, 50 to 60 cm **2560 ± 70**
610 B.C.

BONN-118. Hildesheim A, 60 to 70 cm **2870 ± 70**
920 B.C.

BONN-119. Hildesheim A, 70 to 80 cm **3130 ± 70**
1180 B.C.

BONN-120. Hildesheim A, 80 to 90 cm **3090 ± 50**
1140 B.C.

Pseudogley chernozem soil samples from town of Adlum, near Hildesheim, W. Germany (52° 15′ N Lat, 10° 2.5′ E Long), developed in Würm loess, superimposed on cretaceous clay. From open cultivated field (W of street, Adlum — Hildesheim). Coll. 1967 and subm. by members of Radiocarbon Dating Lab. Age of 3090 B.P. agrees with Hildesheim date of Östlund and Engstrand (1963). Almost identical age throughout the zone from 60 to 90 cm depth indicates fast initial accumulation of organic substance in wet environment (cf. Söllingen B and D).

BONN-121. Hildesheim B, 20 to 30 cm **1040 ± 60**
A.D. 910

BONN-122. Hildesheim B, 30 to 40 cm **1690 ± 70**
A.D. 260

BONN-123. Hildesheim B, 40 to 50 cm **1920 ± 70**
A.D. 30

BONN-124. Hildesheim B, 50 to 60 cm **2260 ± 70**
310 B.C.

BONN-125. Hildesheim B, 60 to 70 cm **2770 ± 70**
820 B.C.

BONN-126. Hildesheim B, 70 to 85 cm **3010 ± 70**
1060 B.C.

BONN-127. Hildesheim B, 85 to 100 cm **4000 ± 80**
2050 B.C

BONN-128. Hildesheim B, 100 to 110 cm **2510 ± 60**
560 B.C.

Pseudogley chernozem soil samples from town of Adlum, near Hildesheim, W. Germany (52° 15′ N Lat, 10° 3′ E Long), in Würm loess over cretaceous clay. In cultivated field near main drainage canal. Coll. 1967 and subm. by members of Radiocarbon Dating Lab. *Comment:* lowest level, 100 to 110 cm, contained very little carbon. Date is probably on intrusive material. Clear age gradient towards greater depth coincides with only light pseudogley characteristics in this profile.

BONN-4. Soest I, 130 to 140 cm **4170 ± 80**
2220 B.C.

BONN-3. Soest II, 110 to 135 cm **4000 ± 80**
2050 B.C.

Buried "Fliesserde" chernozems under parabrown earth of Würm loess on top of upper cretaceous marl near Soest, W. Germany (51° 35′ N Lat, 8° 5′ E Long). Taken from excavations ca. 8 km apart, they contain only 1 to 2% organic matter. Several authors have associated them with wet Tundra soils (Wortmann, 1960) or with black soils possibly formed in Alleröd or Bölling, described by Brunnacker (1957) for Bavaria. More recent reports consider them wet chernozem deposits from postglacial warm stages, e.g., Boreal (Hohenvehlmann, 1963; Wichtmann, 1965). Coll. 1966 and subm. by H. Wichtmann, NRW State Geological Survey, Krefeld, and H. W. Scharpenseel. *Comment*: above dates, adjusted as described in General Comment below suggest their origin 4500 to 6000 B.P. in the Atlantikum.

BONN-22. Wallertheim an Ziegelgrube **2560 ± 60**
610 B.C.

Sample taken 45 to 65 cm below surface in dark brown steppe soil from Wallertheim in Rhinehessen, W. Germany (49° 53′ N Lat, 8° 4′ E Long). Soil was 2% organic. Calcareous Würm loess overlays fine sandy alluvial loam that in turn is spread over calcareous young diluvial fine sand. Coll. 1966 and subm. by A. Beckel, Dept. of Agriculture of Rhineland-Pfalz, Mainz. *Comment:* this soil was already dated (Zakosek, 1962) and reported to correspond to Adlerbergzeit, ca. 3000 B.P. Brown and gray steppe soils farther S near Pfeddersheim and Frankenthal were slightly older, 3610 ± 120 and 3780 ± 140 B.P., respectively. Wallertheim steppe soil is younger than chernozems of Brunswick and Hildesheim areas.

BONN-96. Loess-pararendzine, Michelsberg **9130 ± 100** **7180 B.C.**

Sample from 0 to 12 cm of buried loess-pararendzine in Michelsberg, 2 km N of Ochtendung, Rhineland-Pfalz, W. Germany (50° 21′ N Lat, 7° 19′ E Long). Soil relic lies under Alleröd time mantle of trachyt pumice. Estimated age, 10,000 to 12,000 B.P. Coll. 1967 and subm. by W. Th. Stöhr, Rhineland-Pfalz, Geological Survey, Mainz. *Comment:* age falls 1000 yr short of estimate, which may be accounted for by leaching of young organic matter. Sample is important for explanation of chernozem origin.

BONN-156. Ostholstein A, 2 to 10 cm **630 ± 60** **A.D. 1320**

BONN-157. Ostholstein A, 10 to 20 cm **Modern**

BONN-158. Ostholstein A, 20 to 30 cm **910 ± 60** **A.D. 1040**

BONN-159. Ostholstein A, 30 to 40 cm **1850 ± 70** **A.D. 100**

Slightly pseudogleiey chernozem-like soil of prairie soil character near steep shore line of E Holstein, adjacent to island of Fehmarn (54° 23.5′ N Lat, 11° 7′ E Long), in Grossenbrode Fähre, Feriendorf. Soil has 40 to 50 cm deep black humus developed on clay facies of Würmien moraine marl. Coll. 1967 and subm. by members of Radiocarbon Dating Lab. *Comment*: this soil formation is younger than other chernozems tested. Date is older Sub-Atlantic.

BONN-161. Ostholstein B, 2 to 10 cm **520 ± 60** **A.D. 1430**

BONN-162. Ostholstein B, 10 to 20 cm **420 ± 50** **A.D. 1530**

BONN-163. Ostholstein B, 20 to 30 cm **1000 ± 60** **A.D. 950**

BONN-164. Ostholstein B, 30 to 40 cm **1390 ± 70** **A.D. 560**

BONN-165. Ostholstein B, 40 to 50 cm **1080 ± 60** **A.D. 870**

Slightly pseudogleiey chernozem-like soil from same area as Ostholstein A, but E of Grossenbrode. Soil has dark epipedon of 40- to 50-cm depth. Parent rock Würmien marl. Coll. 1967 and subm. by members of the Radiocarbon Dating Lab. *Comment:* like Ostholstein A, dated black soil is younger than classic chernozems.

General Comment for Chernozems: dates of 4000 to 5000 B.P. for chernozem representatives should be considered minimum. Differences between dendrochronologic and radiocarbon dates for samples approx. 5000 yr old indicate radiocarbon dates could be 1000 yr too recent (Damon and Cow, 1966). Organic substance rejuvenation due to translocation in deeper horizons can produce an error of 1000 yr (see table 1). With these considerations, radiocarbon dates reported here do not contradict general correlation of chernozem formation with Boreal and Atlantikum, 4500 to 8500 B.P. Uncertainty lies rather in the fact that during Oldest, Older, and Younger Dryas time calcareous dry steppe with Artemisia and Stipa was common. Veils of eolic loess sediments could have built up pararendzine chernozem profile, while after Alleröd time during moist Boreal and Atlantikum forest covered gravel plains and prevented further transport of loess. Also black relic of Michelsberg below Alleröd trachyt pumice (BONN-96) shows pararendzina chernozem development 10,000 to 12,000 yr B.P. Thus, the younger chernozems of Söllingen and Hildesheim areas could be possibly influenced by erosion and not entirely autochthonous. Older chernozem patches in these typical chernozem areas are however still to be found. If dates of different subhorizons are plotted against depth, the resulting curves are almost asymptotic to the age axis, when the soil profile developed in dry milieu, indicating a long lasting pararendzina stage. When the soil profile developed in a wet milieu the curve is throughout the deepest 2 or 3 subhorizons almost vertical to the age axis, indicating a fast initial organic matter accumulation up to considerable thickness in wet milieu. Thus, from the shape of the depth vs. age curve one can draw information on the mode of milieu during profile development. Great age differences within subhorizons devaluate common opinion that chernozem organic matter is homogeneously mixed due to high biological activity and ample population of soil animals, as indicated by typical crotovins.

B. Plaggen Soils (Plaggepts)

These anthropogenic soils are developed on poor sandy podzols (humods, orthods) and gley podzols (aquods) from man-made deposits of heath plaggen (gray variety) or grass plaggen (brown variety). Depth of organic cover superimposed on podzol ranges up to 90 cm. Some radiocarbon dates reported by Niemeier (1959) indicated maximum plaggen soil age of 1800 to 2400 B.P. Fastabend and v. Raupach (1962) obtained radiocarbon dates of plaggen soils which placed them in the 6th to 8th century A.D.

BONN-9. Greven, Albachtenesch, 55 to 70 cm depth **1300 ± 80**
A.D. 650

BONN-10. Greven, Marktesch, 60 to 70 cm depth **1235 ± 80**
A.D. 715

BONN-11. Greven, end of Main St. Direction Schmedehausen, 60 to 70 cm depth **980 ± 80**
A.D. 970

BONN-12. Greven, behind Schmedehausen, direction Ladbergen, 60 to 70 cm depth **980 ± 80**
A.D. 970

BONN-13. Greven, Kroner Heide, 60 to 70 cm depth **1030 ± 90**
A.D. 920

Samples of gray plaggen soils, vicinity Greven, N of Münster, Westfalen, W. Germany 52° 8′ N Lat, 7° 40′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* results for Westfalien plaggen soils agree well with dates reported by Fastabend and v. Raupach for several Low Saxonian plaggen soils.

BONN-43. Albachtenesch, 10 to 20 cm **580 ± 50**
A.D. 1370

BONN-44. Albachtenesch, 20 to 30 cm **990 ± 60**
A.D. 960

BONN-45. Albachtenesch, 30 to 40 cm **710 ± 50**
A.D. 1240

BONN-46. Albachtenesch, 40 to 50 cm **790 ± 60**
A.D. 1160

BONN-47. Albachtenesch, 50 to 60 cm **730 ± 80**
A.D. 1220

BONN-48. Albachtenesch, 60 to 70 cm **1220 ± 80**
A.D. 730

Gray plaggen soil profile near Greven, N of Münster, W. Germany (52° 8′ N Lat, 7° 40′ E Long). Coll. and subm. by members of Radiocarbon Dating Lab. *Comment:* radiocarbon date of upper layer is recent due to contamination with modern organic material. Date of lowest humus layer agrees with BONN-9, at 200-m distance.

BONN-49. Rheine, 20 to 30 cm **660 ± 60**
A.D. 1290

BONN-50. Rheine, 30 to 40 cm **1170 ± 60**
A.D. 780

BONN-51. Rheine, 40 to 50 cm **1260 ± 60**
A.D. 690

BONN-52. Rheine, 50 to 60 cm **1020 ± 60**
A.D. 930

BONN-53. Rheine, 60 to 70 cm **900 ± 60**
A.D. 1050

BONN-54. Rheine, 70 to 80 cm **810 ± 60**
A.D. 1140

Brown plaggen soil profile, developed on sandy-gravel of Ems River, S of Rheine, W of street in direction of Greven, W. Germany (52° 16′ N Lat, 7° 26′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* this profile shows same maximum age of about 1250 yr observed in BONN-9, 10, and 48. Phenomenon of oldest soil material underlain by younger organic material can possibly be explained by vertical transport, or different age of plaggen at moment of deposition (the total plaggen horizon is the result of repeated deposition of plaggen throughout generations).

BONN-129. Lengerich, 20 to 30 cm **860 ± 60**
A.D. 1090

BONN-130. Lengerich, 30 to 40 cm **910 ± 60**
A.D. 1040

BONN-131. Lengerich, 40 to 50 cm **1190 ± 70**
A.D. 760

BONN-132. Lengerich, 50 to 60 cm **940 ± 60**
A.D. 1010

BONN-133. Lengerich, 60 to 70 cm **860 ± 60**
A.D. 1090

BONN-134. Lengerich, 70 to 80 cm **860 ± 60**
A.D. 1090

BONN-135. Lengerich, 80 to 90 cm **3960 ± 80**
2010 B.C.

Gray plaggen soil on old pleistocene sand 4 km S Lengerich, W. Germany (52° 14.5′ N Lat, 7° 56′ E Long). Coll. 1967 and subm. by members of Radiocarbon Dating Lab. *Comment:* maximum age is again about 1200 yr except for BONN-135. Considerably greater age of layer 80 to 90 cm is indicative of older buried A horizon (probably of underlying podzol) and does not represent maximum age of sample profile.

C. Podzols (Orthods, Humods)

Migration of intact or degraded clay minerals, sesquioxides, and humus matter under strongly acid conditions in preferentially sandy material leads to formation of podzol profiles. Their $B_{h,s}$ horizon is so far favored for radiocarbon dating of podzol development (Lüders, 1964). A number of British podzols, dated by Godwin and Willis (1964) vary between 500 and 3000 yr old. Lappland podzols, dated by Östlund and Engstrand (1963) ranged from 460 to 1260 B.P. The following dates are part of a program of age determination of podzols in different parts of Germany and on various geological materials.

BONN-14. Sennesand **930 ± 80**
A.D. 1020

Podzol B_h horizon sample 60 to 70 cm below surface. In Sennesand near autobahn crossing of Teutoburger Wald Mountains (51° 57′ N Lat, 8° 31′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* podzol relatively young, expectedly due to narrowness of dark B_h horizon.

BONN-19. Irrel **810 ± 50**
A.D. 1140

Podzol B_h horizon in Lias sand of Irrel bei Echternach, on top of hill and 70 to 85 cm below surface (49° 52′ N Lat, 6° 20′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* recent date is probably due to erosion of elevated area.

BONN-20. Darlaten A **1220 ± 60**
A.C. 730

Podzol B_h horizon in diluvial sand 80 to 95 cm below surface in Darlaten, Niedersachsen (52° 32′ N Lat, 8° 51′ E Long). Fully developed podzol with thick B_h horizon. Coll. 1966 and subm. by G. Golisch, Dept. of Agriculture of State of Niedersachsen, Hannover. *Comment:* see BONN-21.

BONN-21. Darlaten B **1165 ± 60**
A.C. 785

Podzol B_h horizon from same pit as Bonn 20, but 95 to 110 cm below surface. *Comment:* ages of the 2 substrata are statistically indistinguishable. Podzol younger than expected from large size of B_h horizon.

BONN-90. Scherpenseel A **2960 ± 70**
1010 B.C.

Podzol A_h horizon from mixture of diluvial and cretaceous sand, 10 to 25 cm below surface on Maas River terrace near Dutch border Scherpenseel, close to Geilenkirchen (50° 56.5′ N Lat, 6° 0.5′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* see BONN-91.

BONN-91. Scherpenseel B **2570 ± 70**
620 B.C.

Podzol B_h horizon from same pit as BONN-90, but 65 to 85 cm below surface. *Comment:* this well-developed podzol is among oldest reported. Greater age of A_h horizon could be due to more soluble, younger humic substance preferentially migrating to B_h horizon.

BONN-41. Wilsede **1140 ± 60**
A.D. 910

Podzol B_h horizon in diluvial moraine sand and gravel 60 to 70 cm below surface in Wilsede, Lüneburger Heide heath sanctuary, 35 km S of Hamburg (53° 11′ N Lat, 9° 57′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* see BONN-42.

BONN-42. Oberhaverbeck **940 ± 50**
A.D. 1010

Podzol B_h horizon, 55 to 70 cm below surface, in Oberhaverbeck, 8 km SW of Wilsede (53° 11′ N Lat, 9° 57′ E Long). Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* because the B_h horizons are shallow young ages expected.

BONN-16. Flaesheim A **1940 ± 50**
A.D. 10

Podzol A_h in sand from upper cretaceous layers, 15 to 35 cm below surface in Flaesheim bei Haltern, Westfalia (51° 43′ N Lat, 7° 14′ E Long). Sandpit with well-developed double layer podzol. Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* see BONN-17.

BONN-15. Flaesheim B, upper layer **2220 ± 90**
70 B.C.

Podzol B_h horizon from same pit as BONN-16, but 80 to 95 cm below surface. *Comment:* see BONN-17.

BONN-17. Flaesheim B, lower layer **2420 ± 80**
470 B.C.

Podzol B_h horizon from same pit as BONN-16 and 15, but 135 to 170 cm below surface. *Comment:* upper and lower layers of B_h are interconnected and dates are statistically indistinguishable, as expected. *General Comment for Podzols:* small age difference between A_h and B_h horizons indicates profile differentiation occurs in fairly short period of time from mutual humus pool after acidity and colloid chemical con- established. Migration of organic matter seems to continue in strongly developed podzols, indicated by close resemblance of A_h and B_h horizon ditions for enhanced sesquioxide and humus migration have been dates. In consequence radiocarbon dating of podzol B_h horizons produces minimum ages. Age of podzol formation could be twice as high.

D. Parabrown Earth (Hapludalf)

These soils are often developed in alluvial, or Würm-loess materials and are typical for wide areas of the Netherrhine district on nether or middle terraces. Parabrown earth is genetically related to gray-brown podzolic (hapludalf) soils in USA, dernopodzols in USSR, and sol brun lessivé in France. Beginning of main phase of development is either nearly contemporary with black chernozem steppe soils, (under forestation), or later, in Sub-Boreal to older Sub-Atlantic.

BONN-92. Frimmersdorf, 5 to 25 cm **1060 ± 70**
A.D. 890

BONN-93. Frimmersdorf, 25 to 50 cm **500 ± 69**
A.D. 1450

BONN-94. Frimmersdorf, 50 to 75 cm **900 ± 70**
A.D. 1050

BONN-95. Frimmersdorf, 75 to 100 cm **1880 ± 80** **A.D. 70**

Parabrown earth taken at rim of brown coal pit of Frimmersdorf, 35 km WNW Cologne, W. Germany (51° 2.5′ N Lat, 6° 34′ E Long). Deposit overlays several m of Würm and possibly Riss loess. Coll. 1967 and subm. by members of Radiocarbon Dating Lab. *Comment:* parabrown earth profile seems to stem from older Sub-Atlantic, but more samples of this widely distributed soil type must still be dated.

E. Rendzina (Rendoll)

BONN-97. County Clare **1600 ± 70** **A.D. 350**

Rendzina relic under peaty podzol-gley with basal clay layer from County Clare, Ireland (53° 7′ N Lat, 9° 14′ W Long). Coll. 1967 by local associate of submitter, G. Jaritz, Institut für Bodenkunde, Univ. Bonn. Estimated age, minimum 4000 to 5000 yr as chernozem relic. *Comment* (G.J.): age too recent. Sample may have been improperly taken.

F. Half Bog Soils (Fibrist, Anmoor, Flaches Niedermoor)

BONN-24. Trhové Myto **2460 ± 60** **510 B.C.**

Buried anmoor soil under young holocene flood plain deposit along small Danube in middle part of Schüttisland, near Bratislava, Czechoslovakia (48° 0′ N Lat, 17° 45′ E Long). Sample covered by alluvial rambla soil of loamy sand. Coll. 1966 and subm. by Juraj Hrasko, Soil Survey Center of Slovakia, Bratislava. *Comment* (J.H.): date reasonable.

BONN-82. Kalkarer Moor I, 20 to 40 cm **2130 ± 50** **180 B.C.**

BONN-83. Kalkarer Moor I, 40 to 60 cm **6740 ± 80** **4790 B.C.**

BONN-84. Kalkarer Moor I, 60 to 80 cm **7240 ± 80** **5290 B.C.**

BONN-85. Kalkarer Moor I, 80 to 100 cm **7790 ± 110** **5840 B.C.**

Profile taken near rim of moor area. Half bog transitional to shallow low moor. Local phenomenon near Billig, S Euskirchen, W. Germany (50° 36′ N Lat, 6° 46′ E Long). Moor area is sanctuary of natural plant association growing on heavy loamy alluvium on tertiary clay. Date of half bog material could be pertinent to age of surrounding alluvial soils. Coll. 1966 and subm. by members of Radiocarbon Dating Lab. *Comment:* see Kalkarer Moor II profile.

BONN-86. Kalkarer Moor II, 20 to 40 cm **1210 ± 60** **A.D. 740**

BONN-87. Kalkarer Moor II, 40 to 60 cm **1830 ± 140**
A.D. 120

BONN-88. Kalkarer Moor II, 60 to 80 cm **2760 ± 80**
810 B.C.

BONN-89. Kalkarer Moor II, 80 to 100 cm **3160 ± 50**
1210 B.C.

Profile taken from center of Kalkarer Moor ca. 30 m from Kalkarer Moor I profile. Coll. same time as Kalkarer Moor I. *Comment:* great age differences between 2 profiles indicate slow process of low moor development from periphery towards center of basin. Boreal age of moor shows that moisture regime has been quite liberal since, in these small river valleys.

III. ARCHAEOLOGIC SAMPLES

A. West Germany

BONN-1. Inden-Lamersdorf **4800 ± 80**
2850 B.C.

Buried black soil layer in parabrown earth (Hapludalf) profile, 60 cm below surface near town of Inden-Lamersdorf in W. Germany 50° 51′ N Lat, 6° 20′ E Long). Preliminary treatment removed intrusive rootlets (see Soil Samples section, this date list). Archaeologic excavations in Hildesheim area indicate that Rössener culture is concentrated on chernozem patches. Coll. 1965 and subm. by Gustel Strunk, Univ. Bonn. *Comment:* date agrees with other chernozem profiles discussed previously; however, a connection with Rössener culture is still under discussion.

BONN-18. Gellep **1050 ± 100**
A.D. 900

Small charcoal particles in humic matter containing sand. From nether terrace of Rhine River in Sprilberg, W. Germany (51° 20′ N Lat, 6° 41′ E Long). Roots and other debris removed and charcoal concentrated by flotation. Charcoal is apparently culture relic estimated from Roman occupation. Coll. 1965 and subm. by Gustel Strunk. *Comment:* sample is younger than expected and seems to come from medieval settlement.

BONN-23. Rimberg **1900 ± 80**
A.D. 50

Soil sample with high organic content, apparently decayed wood of ancient structure, from town of Rimberg, near Aachen, W. Germany (50° 55′ N Lat, 6° 5′ E Long). Archaeologic evidence suggests sample should date from Roman times. Coll. 1966 and subm. by Gustel Strunk. *Comment:* date in agreement with submitter's estimate.

BONN-25. Neuss **1730 ± 90**
A.D. 220

Wood charcoal from excavations of Novaesium Roman camp near the town Neuss, W. Germany (51° 12′ N Lat, 6° 41′ E Long). A portion of sample previously dated at 1900 ± 120 B.P. (KN-3, Köln I). Coll. 1958 by G. Müller, Rheinisches Landesmuseum, Neuss; subm. by J. Freundlich, Univ. Köln, as check sample. *Comment:* agrees with Köln measurement.

B. Iraq

BONN-78. Aqur Quf **2160 ± 50**
210 B.C.

Dried reeds from ancient Kassite city of Kurigalzu (Dur-Kurigalzu), 33 km W of Baghdad, Iraq (44° N Lat, 33° E Long). Excavations by Dept. of Antiquities of Iraq indicate habitation starting from 15th century B.C. (Baquir, 1959). Predominant structure is stepped tower of "Ziggurat." This great mass of brick work is only denuded core, 57 m high at present, and has an approx. square base, 69 x 67 m. It is fortified by horizontal layers of reed matting which represents original material of tower. Coll. 1963 from ground level and subm. by Lothar von Erichsen, Univ. Bonn, W. Germany. *Comment* (L.v.E.): younger than expected.

C. Libya

BONN-145. Garamantes Grave **1950 ± 60**
A.D. 0

Human femur bones from stone burial mound in dry sand on slope of a wadi in N high plateau of Libya (26° 30′ N Lat, 13° 7′ E Long). Desert region with little possibility of contamination by plant matter. Site of Garamantes people who left Libya in the 1st to 2nd century B.C. and settled in Central Africa. Coll. 1967 and subm. by Ulrich Hallier, Univ. Bonn. Bones completely dissolved in hydrochloric acid to insure complete removal of carbonates before combustion. *Comment* (U.H.): date points to late Garamantes period in Libya and is reasonable.

IV. MODERN SAMPLES

Radiocarbon from nuclear weapon contamination is being monitored extensively in atmospheric CO_2. To make use of variations for our studies of soil and ground water dynamics, increased activity levels and extent of fluctuations in vegetation are more pertinent. Several different types of reliably documented plant materials from Rhineland region of W. Germany have been measured. The program is being continued with some 50 samples from the Darmstadt area.

Winter rye series, 1957-1967

BONN-56. Winter rye, 1957 **97.0 ± 0.7% modern**

Winter rye grown at Meckenheim fertilizer test site, 15 km SW of Bonn (50° 37.5′ N Lat, 7° 1′ E Long). Seeds were sown in Sept., 1956, main growth from April to June of following year. Coll. end of July, 1957 by Inst. of Agricultural Chemistry, Univ. Bonn. *Comment:* no nuclear weapon contamination, rather 3% lowering due to fossil fuel burning (Suess effect) which should be great in this highly industrialized region.

BONN-57. Winter rye, 1958 **234.5 ± 2.4% modern**

Winter rye from Meckenheim fertilizer test site coll. end of July, 1958. *Comment:* large amount of contamination is surprising, but there seems to be no possibility of introduction of tracer C^{14} either in our lab or at Meckenheim. Sample was run 3 times on separate batches of material. Results were 234.0 ± 1.1, 232.4 ± 1.8, and 237.1 ± 1.2% modern, which are statistically indistinguishable.

BONN-58. Winter rye, 1959 **125.6 ± 0.8% modern**

Winter rye from Meckenheim fertilizer test site coll. end of July, 1959.

BONN-59. Winter rye, 1961 **125.3 ± 0.9% modern**

Winter rye, Meckenheim, coll. end of July, 1961.

BONN-60. Winter rye, 1962 **143.0 ± 0.9% modern**

Winter rye, Meckenheim, coll. end of July, 1962.

BONN-61. Winter rye, 1963 **166.1 ± 1.3% modern**

Winter rye, Meckenheim, coll. end of July, 1963.

BONN-79. Winter rye, 1966 **176.3 ± 0.9% modern**

Winter rye, Meckenheim, coll. end of July, 1966.

BONN-143. Winter rye, 1967 **168.1 ± 0.9% modern**

Winter rye from Poppelsdorf (Bonn), (50° 44′ N Lat, 7° 8′ E Long) Experimental Field. Seeds put into ground Sept. 1966, green plant sample taken May 20, 1967 by H. W. Scharpenseel.

Winter wheat series, 1959-1966

BONN-62. Winter wheat, 1959 **139.1 ± 0.9% modern**

Winter wheat grown at Meckenheim fertilizer test site 15 km SW of Bonn (50° 37.5′ N Lat, 7° 1′ E Long). Seeds were sown in October 1958, but had only limited growth until April to July, 1959, when main development occurred. Coll. early Aug. 1959 by Inst. of Agricultural Chemistry, Univ. Bonn.

BONN-63. Winter wheat, 1960 **125.2 ± 0.6% modern**

Winter wheat from Meckenheim fertilizer test site coll. early Aug., 1960.

BONN-64. Winter wheat, 1962 **141.6 ± 0.7% modern**

Winter wheat, Meckenheim, coll. early Aug., 1962.

BONN-65. Winter wheat, 1963 **180.2 ± 1.0% modern**

Winter wheat, Meckenheim, coll. early Aug., 1963.

BONN-66. Winter wheat, 1964 **200.6 ± 1.6% modern**

Winter wheat, Meckenheim, coll. early Aug., 1964.

BONN-67. Winter wheat, 1965 **270.5 ± 1.8% modern**

Winter wheat, Meckenheim, coll. early Aug., 1965. *Comment:* contamination is higher than previously seen for plant materials. Sample run twice on separate batches with results 272.2 ± 1.4 and 268.8 ± 1.2% modern, which are statistically indistinguishable. There was no inclusion of tracer C^{14} either in Meckenheim or in lab.

BONN-80. Winter wheat, 1966 **173.0 ± 0.9% modern**

Winter wheat, Meckenheim, coll. early Aug., 1966.

Grass series, 1962-1965

BONN-68. Grass, 1962 **149.7 ± 0.9% modern**

Leaves of perennial grass plant from Meckenheim fertilizer test site. Maximum growth was from May to June. Coll. early June, 1962 by Inst. of Agricultural Chemistry, Univ. Bonn.

BONN-69. Grass, 1963 **195.4 ± 1.0% modern**

Grass from Meckenheim fertilizer site. Coll. early June, 1963.

BONN-70. Grass, 1964 **185.2 ± 1.0% modern**

Grass, Meckenheim, coll. early June, 1964.

BONN-71. Grass, 1965 **172.1 ± 1.0% modern**

Grass, Meckenheim, coll. early June, 1965.

Sugar and fodder beets leaves series, 1958-1966

BONN-72. Sugar beet leaves, 1958 **145.0 ± 0.8% modern**

Sugar beet leaves from Meckenheim fertilizer test site. Planted in April, maximum growth from June to Sept. Coll. Nov., 1958 by Inst. of Agricultural Chemistry, Univ. Bonn.

BONN-73. Sugar beet leaves, 1960 **136.3 ± 1.0% modern**

Sugar beet leaves from Meckenheim fertilizer test site. Coll. Nov., 1960.

BONN-74. Sugar beet leaves, 1962 **146.0 ± 0.9% modern**

Sugar beet leaves, Meckenheim, coll. Nov., 1962.

BONN-81. Sugar beet leaves, 1966 **186.8 ± 1.0% modern**

Sugar beet leaves, Meckenheim, coll. Nov., 1966.

BONN-75. Fodder beet leaves, 1960 **162.6 ± 0.8% modern**

Fodder beet leaves from Meckenheim fertilizer test site. Planted in April 1960, maximum growth from June to Sept. Coll. Nov., 1960 by Inst. of Agricultural Chemistry, Univ. Bonn.

BONN-76. Fodder beet leaves, 1964 **190.4 ± 0.8% modern**

Fodder beet leaves, Meckenheim, coll. Nov., 1964.

BONN-77. Fodder beet leaves, 1965 **177.3 ± 1.0% modern**

Fodder beet leaves, Meckenheim, coll. Nov., 1965.

BONN-144. Winter raps, 1967 **159.2 ± 0.9% modern**

Winter raps from Poppelsdorf (Bonn) Experimental Field. Seeds sown Sept., 1966 and coll. green May 20, 1967 by H. W. Scharpenseel.

German Wine series, 1958-1966

BONN-146. German Wine, 1958 **126.2 ± 0.8% modern**

Alcohol distilled from verified pure Riesling white wine grown in Mussbacher Heide vineyard of Staatsweingut in Rheinpfalz (49° 23′ N Lat, 8° 11:5′ E Long). This is "Spätlese," where grapes were excessively ripened on the vine. Coll. Nov., 1958 by members of Staatsweingut.

BONN-147. German Wine, 1959 **124.2 ± 0.8% modern**

Alcohol distilled from Riesling white wine grown in Haardter Herrenletten vineyard of Staatsweingut in Rheinpfalz (49° 22.5′ N Lat, 8° 11′ E Long). Coll. Oct. 1959 by members of Staatsweingut.

BONN-148. German Wine, 1960 **126.2 ± 0.8% modern**

Coll. Oct., 1960.

BONN-149. German Wine, 1961 **119.2 ± 0.8% modern**

Coll. Oct., 1961.

BONN-150. German Wine, 1962 **134.2 ± 0.8% modern**

Coll. Oct., 1962.

BONN-151. German Wine, 1963 **182.0 ± 1.0% modern**

Coll. Oct., 1963.

BONN-152. German Wine, 1964 **184.0 ± 1.0% modern**

Coll. Oct., 1964.

BONN-153. German Wine, 1965 **169.4 ± 0.9% modern**

New variety of vine, same location, coll. Oct., 1965.

BONN-155. German Wine, 1954 **95.5 ± 0.7% modern**

Coll. Oct., 1954.

BONN-154. German Wine, 1966 **170.8 ± 0.9% modern**

Alcohol distilled from Mosel white wine grown in Mehringer Hohlensberg vineyard (49° 46′ N Lat, 6° 48′ E Long). Bottled by Adam Schmitt Weingut in Bonn. Coll. Oct., 1966.

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