[Radiocarbon, Vol. 15, No. 1, P. 13-41]

UNIVERSITY OF BONN
NATURAL RADIOCARBON MEASUREMENTS V

H. W. SCHARPENSEEL and F. PIETIG
Institut für Bodenkunde, Universität Bonn
Bonn, Bundesrepublik Deutschland

Radiocarbon measurements, mainly on soil and water samples are being continued. Benzene samples are prepared as described earlier (Scharpenseel and Pietig, 1969). By adding another counting unit, the lab. now uses 3 liquid scintillation spectrometers and 4 benzene synthesis lines.

ACKNOWLEDGMENTS

The authors are indebted to E. Kruse, H. Tapp, Chr. Haupenthal, and H. Schiffmann for their technical help in sample preparation. An improved computer program was provided by H. Schiffmann. The Gesellschaft für Mathematik und Datenverarbeitung GmbH Bonn lent us their facilities for computer calculation of C^{14} ages. This work was supported by grants from the German Federal Department of Education and Science. Preparation of carbonate samples from aquifers in Tunisia was financed by the German Federal Department of Economic Cooperation. Travel funds for procurement of soil samples from outside Germany were provided by the German Foundation of Research (Deutsche Forschungsgemeinschaft).

SAMPLE DESCRIPTIONS

I. GROUND WATER SAMPLES

A. Tunisia series

Reported here are results of a 3rd yr of ground water dating in Tunisia; 47 carbonate samples from different wells were coll. C^{14} ages are indicated uncorrected and corrected for dead carbonate-C contribution (Tamers, 1967). Tritium concentrations were also measured. Samples coll. 1970 and subm. by H. W. Scharpenseel, F. Pietig, and Chr. Haupenthal, Inst. f. Bodenkunde, Bonn Univ., J. Ohling, HER-Econ. Coop. Proj., Tunis. This series is continuation of R., 1970, v. 12, p. 22-26 and R., 1971, v. 13, p. 190-193.

Sample	Measured C^{14} age	Corrected C^{14} age
	10,730 ± 130	8220 ± 840
BONN-580. Sidi Naji 10135/4 (36° 2′ N Lat, 10° 4′ E Long)	8780 B.C.	6270 B.C.
	5420 ± 60	3430 ± 660
BONN-581. Q. Khrioua 12620/4 (36° 4′ N Lat, 10° 4′ E Long)	3470 B.C.	1480 B.C.
	7190 ± 90	5310 ± 630
BONN-582. Q. El Ketam 9938/4 (36° 3′ N Lat, 10° 8′ E Long)	5240 B.C.	3360 B.C.
	2400 ± 70	580 ± 600
BONN-583. Tazoghrane 8 (36° 54′ N Lat, 10° 48′ E Long)	450 B.C.	A.D. 1370
	2960 ± 60	
BONN-584. Kherba 369/1 (36° 57′ N Lat, 9° 39′ E Long)	A.D. 1010	Modern
	4880 ± 90	1280 ± 1200
BONN-585. Ain Recoub 364/1 (37° 3′ N Lat, 9° 28′ E Long)	2930 B.C.	A.D. 670
	5830 ± 70	4510 ± 440
BONN-586. Al Kadrah 10933 (35° 29′ N Lat, 10° 8′ E Long)	3880 B.C.	2560 B.C.
	103.6 ± 0.2%	
BONN-587. Tazoghrane 9 (36° 54′ N Lat, 10° 47′ E Long)	Modern	Modern
	14,860 ± 200	10,360 ± 1500
BONN-588. M 'Halhal 5840/5 (33° 24′ N Lat, 9° 0′ E Long)	12,910 B.C.	8410 B.C.
	20,420 ± 460	18,320 ± 700
BONN-589. Fatnassa 2051/5 (33° 47′ N Lat, 8° 45′ E Long)	18,470 B.C.	16,370 B.C.
	21,020 ± 370	18,590 ± 810
BONN-590. Ksar Rhilane 7810/5 (32° 59′ N Lat, 9° 38′ E Long)	19,070 B.C.	16,640 B.C.
	2730 ± 70	840 ± 640
BONN-591. Grombalia 8955/2 (36° 35′ N Lat, 10° 30′ E Long)	780 B.C.	A.D. 1110
	16,510 ± 240	14,470 ± 680
BONN-592. O. Sohil 8464/2 (36° 29′ N Lat, 10° 42′ E Long)	14,560 B.C.	12,520 B.C.
	16,640 ± 180	14,690 ± 650
BONN-593. Sge. Belli 8979/2 (36° 34′ N Lat, 10° 34′ E Long)	14,690 B.C.	12,740 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

Sample	Measured C^{14} age	Corrected C^{14} age
	7300 ± 70	5080 ± 740
BONN-594. O. Sohil 7804/2 (36° 29′ N Lat, 10° 42′ E Long)	5350 B.C.	3130 B.C.
	8580 ± 80	6180 ± 300
BONN-595. O. Sohil 7384/2 (36° 28′ N Lat, 10° 42′ E Long)	6630 B.C.	4230 B.C.
	6200 ± 90	4640 ± 520
BONN-596. Mll. Mateur 5695/1 (37° 4′ N Lat, 9° 39′ E Long)	4250 B.C.	2690 B.C.
	400 ± 50	
BONN-597. Cge A. Koceine 1787/1 (37° 5′ N Lat, 9° 49′ E Long)	A.D. 1550	Modern
	3840 ± 60	
BONN-598. SGR 4$_b$ Elle Azib 5271/1 (37° 11′ N Lat, 9° 59′ E Long)	1890 B.C.	Modern
	5150 ± 80	3170 ± 660
BONN-599. SFR 1 M Bourguiba 5488/1 (37° 7′ N Lat, 9° 49′ E Long)	3200 B.C.	1220 B.C.
	2100 ± 60	630 ± 490
BONN-600. SGR 1 El Azib 5527/1 (37° 10′ N Lat, 9° 57′ E Long)	150 B.C.	A.D. 1320
	13,480 ± 150	10,980 ± 830
BONN-1201. Haffouz 3 (35° 38′ N Lat, 9° 40′ E Long)	11,530 B.C.	9030 B.C.
	2800 ± 60	1000 ± 600
BONN-1202. Cherichira 4 (35° 39′ N Lat, 9° 46′ E Long)	850 B.C.	A.D. 950
	3200 ± 80	1010 ± 730
BONN-1203. Bou Haffna 5 11564 (35° 39′ N Lat, 9° 38′ E Long)	1250 B.C.	A.D. 940
	5400 ± 80	3780 ± 540
BONN-1204. Bou Haffna 3 10927 (35° 41′ N Lat, 9° 39′ E Long)	3450 B.C.	1830 B.C.
	12,100 ± 110	9460 ± 880
BONN-1205. Haffouz 6 12215 (35° 38′ N Lat, 9° 40′ E Long)	10,150 B.C.	7510 B.C.
	160 ± 60	
BONN-1206. Ain Rhezala 1816 (35° 42′ N Lat, 9° 40′ E Long)	A.D. 1790	Modern
	860 ± 60	
BONN-1207. A. Cherichira 18/4 (35° 38′ N Lat, 9° 48′ E Long)	A.D. 1090	Modern

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

Sample	Measured C^{14} age	Corrected C^{14} age
BONN-1208. A. Bou Morra 41/4 (35° 54′ N Lat, 9° 53′ E Long)	860 ± 60 A.D. 1090	Modern
BONN-1209. Q. Mofrine 10653 (35° 57′ N Lat, 9° 54′ E Long)	1700 ± 50 A.D. 250	200 ± 500 A.D. 1750
BONN-1210. Sbiba 4 7133/4 (35° 31′ N Lat, 9° 2′ E Long)	2700 ± 70 750 B.C.	1080 ± 540 A.D. 870
BONN-1211. Sbiba 3 6821/4 (35° 29′ N Lat, 9° 0′ E Long)	3680 ± 60 1730 B.C.	2030 ± 550 80 B.C.
BONN-1212. A. Saboun 936/4 (35° 33′ N Lat, 9° 6′ E Long)	1800 ± 60 A.D. 150	Modern
BONN-1213. A. Kseiba 1229/3 (35° 45′ N Lat, 8° 52′ E Long)	3050 ± 70 1100 B.C.	1220 ± 610 A.D. 730
BONN-1214. A. Tsabet 1794/3 (36° 4′ N Lat, 9° 30′ E Long)	3000 ± 60 1050 B.C.	460 ± 880 A.D. 1490
BONN-1215. A. El Gharbi 4254/4 (35° 30′ N Lat, 9° 0′ E Long)	2250 ± 60 300 B.C.	120 ± 710 A.D. 1830
BONN-1216. A. El Abair 1426/3 (35° 52′ N Lat, 8° 47′ E Long)	2080 ± 70 130 B.C.	550 ± 510 A.D. 1400
BONN-1217. A. Hadia 933/4 (35° 36′ N Lat, 9° 17′ E Long)	3460 ± 50 1510 B.C.	1900 ± 520 A.D. 50
BONN-1218. A. Adjmi 1425/3 (35° 51′ N Lat, 8° 48′ E Long)	1640 ± 60 A.D. 310	Modern
BONN-1219. A. Afia (35° 52′ N Lat, 8° 53′ E Long)	4360 ± 60 2410 B.C.	2250 ± 750 300 B.C.
BONN-1220. Darchichou 8304/2 (37° 0′ N Lat, 10° 56′ E Long)	10,120 ± 110 8170 B.C.	7620 ± 860 5670 B.C.
BONN-1221. Mornag No. 1 9391/1 (36° 41′ N Lat, 10° 17′ E Long)	13,100 ± 150 11,150 B.C.	10,400 ± 900 8450 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

Sample	Measured C^{14} age	Corrected C^{14} age
BONN-1222. A. Gmatine 8072/2 (36° 56′ N Lat, 10° 58′ E Long)	18,630 ± 260 16,680 B.C.	14,910 ± 1240 12,960 B.C.
BONN-1223. Darchichou 8305/2 (36° 58′ N Lat, 11° 0′ E Long)	13,640 ±130 11,690 B.C.	11,870 ± 590 9920 B.C.
BONN-1224. El Ala 9739 (35° 38′ N Lat, 9° 34′ E Long)	3340 ± 60 1390 B.C.	1720 ± 540 A.D. 230
BONN-1225. O. Hallouf 11548 (35° 56′ N Lat, 9° 54′ E Long)	750 ± 60 A.D. 1200	Modern
BONN-1226. Cherichira 1 9276 (35° 38′ N Lat, 9° 48′ E Long)	11,100 ± 100 9150 B.C.	9420 ± 560 7470 B.C.

Comment: locations of above samples and those of already pub. samples (R., 1970, v. 12, p. 22-26 and R., 1971, v. 13, p. 190-193) are indicated in Fig. 1. They belong to 29 ground water regions; detailed evaluation is pub. elsewhere (Scharpenseel *et al.*, in press). The plain of Kairouan and the region of Chott el Djerid were intensively studied, and isochrones sufficiently concordant with the flow direction could be drawn. In the Kairouan plain and the region N of the Djerid, comparisons of radiocarbon ages with calculations based on water permeability (k_f) and slope values, obtained from pumping trials, as well as on estimated distance from the recharge area, were made and confirmed. Sample El Djazira (Bonn-290) could be compared with the estimated decay age due to natural chlorine-36 measurement (Tamers, Ronzani, and Scharpenseel, 1969), which with 19,400 yr, agreed well.

The oldest ground water samples approaching 30,000 B.P. are in the Kairouan plain (Draa Chouk, BONN-247), embedded in Quaternary sediments, and in ground water exits, such as Seftimi 1 a (BONN-552), C.F. 1 (BONN-558) or Dehibat (BONN-562), belonging to the reservoir of the "Continental Intercalaire", stored in the Neokom-Barrême of lower Cretaceous. Some samples from oases of the Algerian Sahara (BONN-564-567) compare well with the adjacent Tunisian lower Cretaceous samples of the "Continental Intercalaire".

II. SOIL SAMPLES

Pretreatment of soil samples follow the same procedures described (Scharpenseel and Pietig, 1969; Scharpenseel, 1971). Carbon analysis was performed according to Rauterberg and Kremkus (1951).

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

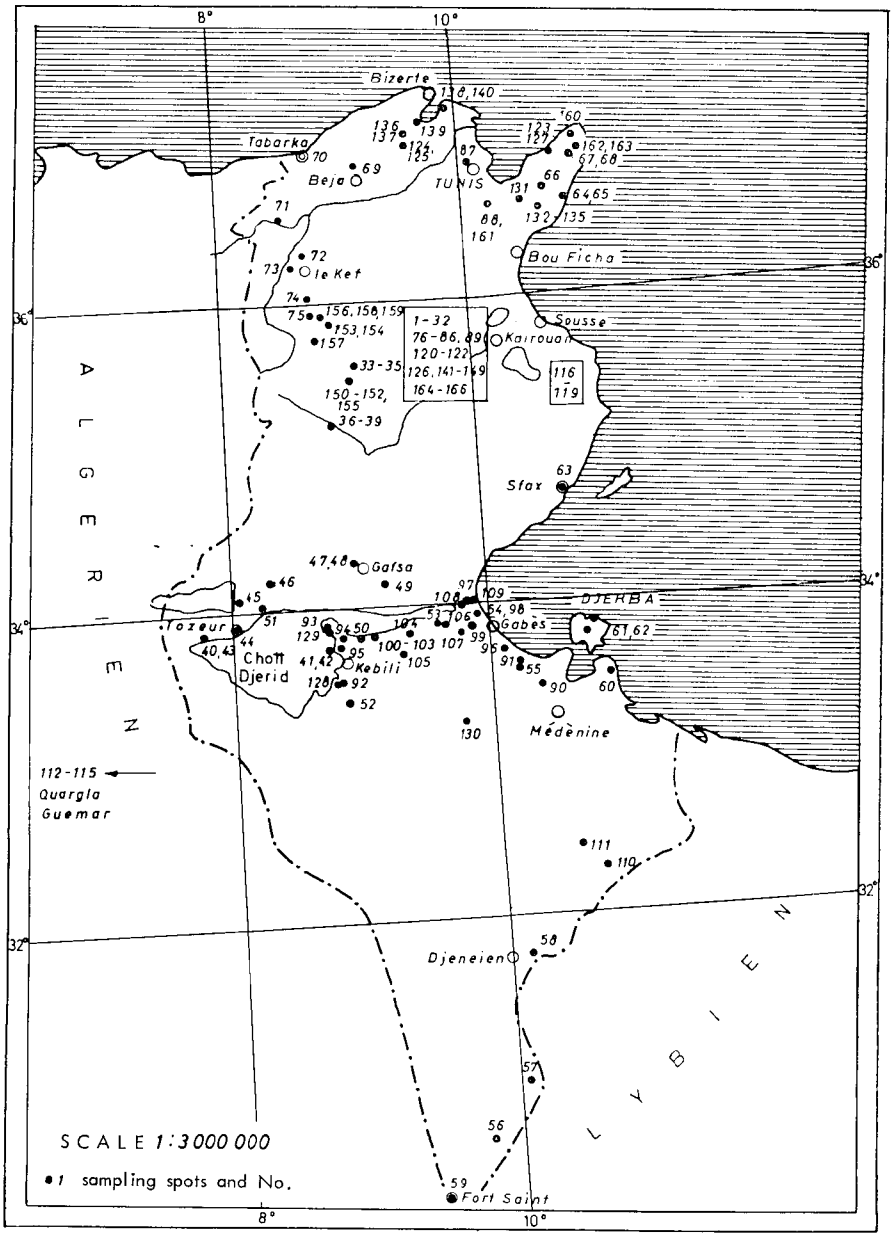

Fig. 1. Distribution of sampling spots in Tunisia.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

A. Israel series

These dates are part of study of natural radiocarbon concentration in vertisol profiles in various regions of the world. Vertisols and other soil formations were coll. in Israel with the cooperation of local pedologists.

Buried hydromorphic Hamra soil (red Mediterranean soil, Luvisol) under eolic dune material. It is a relic soil of an old land surface, emerging slowly ca. 25 m from sampling pit. Highway crossing N Tel Aviv, towards Haifa, corner Riohlon St. (32° 7′ N Lat, 34° 48′ E Long).

BONN-688. Soil under dune cover, 1.9% C, 180 to 200 cm — 14,740 ± 200 / 12,790 B.C.

BONN-689. Same location, 2.3% C, 200 to 220 cm — 10,130 ± 140 / 8180 B.C.

BONN-690. Same location, 0.7% C, 220 to 240 cm — 11,170 ± 100 / 9220 B.C.

BONN-691. Same location, 1.0% C, 240 to 260 cm — 12,700 ± 100 / 10,750 B.C.

BONN-692. Hamra in foot of slope, partially within root zone, 5.1% C, 10 to 30 cm — 8490 ± 110 / 6540 B.C.

BONN-693. Same location, 1.0% C, 30 to 50 cm — 7890 ± 110 / 5940 B.C.

BONN-694. Same location, 1.5% C, 50 to 70 cm — 7330 ± 150 / 5380 B.C.

BONN-695. Same location, 1.9% C, 70 to 90 cm — 10,470 ± 130 / 8520 B.C.

BONN-696. Hamra emerges in A horizon of recent profile. Surfacial erosion probable since already in 20 to 30 cm depth lime mycelia, 2.3% C, 10 to 30 cm. — 8340 ± 110 / 6390 B.C.

BONN-697. Same location, 1.0% C, 30 to 50 cm — 8590 ± 100 / 6640 B.C.

BONN-698. Same location, 2.0% C, 50 to 70 cm — 8550 ± 90 / 6600 B.C.

BONN-699. Same location, 0.5% C, 70 to 90 cm — 11,860 ± 150 / 9910 B.C.

BONN-700. Same location, 0.5% C, 90 to 100 cm. Very small sample of benzene only. — 23,030 ± 810 / 21,080 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

Hamra in 3 different positions: 1) covered and outside root zone, 2) just emerging into root zone, 3) within root zone. Coll. 1969 and subm. by H. W. Scharpenseel and H. Gewehr, Inst. Soil Sci., Bonn Univ., and G. Yaari Cohen, Div. Pedol. Dept. of Agric., Haifa. *Comment*: rejuvenation of carbon in root zone here in semi-arid climate not as strong as observed in more humid climate soils (Scharpenseel, 1971). This is only valid, if dune cover is rather old, compared with measured radiocarbon ages. Very high age of BONN-700 is doubtful. Sample was very small due to lack of carbon, which could be derived from some chance inclusion of charcoal instead of humus carbon.

Hamra soil embedded in dune material with lime concretions (Curcar), also particularly around roots as thick coatings, Wingate Inst. of Athletics near coastal hwy from Tel Aviv to Haifa (32° 24′ N Lat, 34° 53′ E Long).

BONN-701. Lime concretions in upper Curcar (not yet fully developed Curcar), on top of Hamra, 300 cm — 13,440 ± 160 / 11,490 B.C.

BONN-702. Lime concretion around root, upper Curcar, 300 to 350 cm — 13,640 ± 170 / 11,690 B.C.

BONN-704. Lime concretions in Hamra around root, 400 to 500 cm — 13,240 ± 140 / 11,290 B.C.

BONN-705. Lime concretions in lower Curcar, 500 to 750 cm — 15,410 ± 210 / 13,460 B.C.

BONN-706. Lime concretions around root in lower Curcar, 500 to 750 cm — 17,920 ± 180 / 15,970 B.C.

Hamra and Curcar in alternation, street to Ekron, (31° 51′ N Lat, 34° 48′ E Long).

BONN-709. Calcinated root in C-horizon of Hamra (II ?) — 16,930 ± 240 / 14,980 B.C.

Curcar-Hamra sequence, Rehovot, corner Main St. and Batia Markov (31° 53.5′ N Lat, 34° 49′ E Long).

BONN-711. Hamra (I ?), red color, 0.2% C, 180 to 200 cm — 14,920 ± 230 / 12,970 B.C.

Jashresh, Pseudogley from Hamra (Nazas), (31° 54.5′ N Lat, 34° 51′ E Long).

BONN-712. S_w-horizon, 0.2% C, 100 to 130 cm — 550 ± 50 / A.D. 1400

BONN-713. fAS_d-horizon, 0.3% C, 200 to 230 cm — 2960 ± 220 / 1010 B.C.

Samples coll. 1969 by H. W. Scharpenseel, H. Gewehr, and G. Yaari Cohen. *Comment*: unfortunately, C^{14} measurement of organic carbon of

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

some Hamra samples was impossible due to extremely low carbon content after HCl-treatment. Lime concretions in Hamra and Curcar horizons indicate ages between 13,000 and 18,000 yr. The Nazas (Pseudogley) could be contaminated by bomb carbon.

Soil assoc. on limestone (rendsina on soft limestone, calcareous brown earth on harder limestone, Terra rossa on very hard limestone).

Rendsina, Mitzpe Mesua, (31° 40′ N Lat, 34° 35′ E Long).

BONN-742. Rendsina on soft limestone, 1.1% C, A_h 30 to 45 cm — 580 ± 40 A.D. 1370

BONN-743. Same location, 0.5% C, AC 45 to 60 cm — 1500 ± 50 A.D. 450

Calcareous brown earth on harder limestone, only 150 m from Mitzpe Mesua (BONN-742); soil sometimes shows moderate B_v-horizon, (31° 40′ N Lat, 34° 35′ E Long).

BONN-744. Calcareous brown earth, 0.8 % C, A_h 50 to 60 cm — 2040 ± 60 90 B.C.

Terra rossa, Mattah on hard limestone (31° 43′ N Lat, 35° 03′ E Long).

BONN-745. Terra rossa on hard limestone, 0.2% C, B_t 100 to 120 cm — 2420 ± 70 470 B.C.

Samples coll. 1969 by H .W. Scharpenseel, H. Gewehr, and A. Singer, Fac. Agric., Univ. Jerusalem. *Comment*: although rejuvenation due to intrusion of roots exists to a certain extent, rather low residence times of humus-C are in accord with erosion-influenced sloping sampling site.

Husmas soils (Hamra soils with recalcification) and soils with petrocalcic horizon. Holocene Husmas soil, covered by Curcar-debris, 1 km W Argic. School Kanot, along street from Gedera to Ashdod (31° 48.5′ N Lat, 34° 45′ E Long).

BONN-748. Husmas W Kanot Agric. School, 0.3% C, B 80 to 100 cm — 830 ± 160 A.D. 1120

BONN-749. Same location, Hamra with $CaCO_3$-concretions, 0.2% C, 400 cm — 5050 ± 160 3100 B.C.

Dark brown loessic Burozem overlying Husmas with Ca-concretions, K Kibbutz Ruchama, (31° 30′ N Lat, 34° 42′ E Long).

BONN-751. Burozem Ruchama, traces of C, A_c 70 to 90 cm

BONN-752. Burozem Ruchama, traces of A_cB 190 to 210 cm

9000 ± 200 7050 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-753. Underlaying Husmas, traces of C, B_1 250 to 260 cm

BONN-754. Underlaying Husmas, traces of C, B_2 320 to 340 cm — 13,400 ± 190 / 11,450 B.C.

BONN-755. Underlaying Husmas, traces of C, C 470 to 500 cm

Husmas without loess cover, surfacial, Dorot 1, 8 km NW profile Ruchama (BONN-751), (31° 30.5′ N Lat, 34° 38′ E Long).

BONN-756. Husmas Dorot 1, traces of C, 70 to 80 cm — 90 ± 150 / A.D. 1860

Husmas overlaying fossil gray-green clay, Dorot 2, 9 km NW profile Ruchama (BONN-751), (31° 31′ N Lat, 34° 37′ E Long).

BONN-757. Fossil clay, bordering Husmas, traces of C, 300 to 320 cm — 19,920 ± 340 / 17,970 B.C.

Dark brown soil formed in calcareous dune sand, arid version of chestnut soil. Mafkiim, S Ashkalon, (31° 37′ N Lat, 34° 35′ E Long).

BONN-750. Calcareous B-horizon arid chestnut soil, 130 to 140 cm — 4760 ± 80 / 2810 B.C.

Burozem from Loess with caliche, near Shuval, Beer Shewa street for Tel Aviv, (31° 25′ N Lat, 34° 45′ E Long).

BONN-760. Burozem, near Shuval, 0.4% C, A_h 20 to 40 cm — 1090 ± 200 / A.D. 860

BONN-761. Same location, Caliche, 0.2% C, 100 to 120 cm — 6400 ± 130 / 4450 B.C.

BONN-762. Same location 0.2% C, BC 190 to 220 cm — 15,470 ± 230 / 13,520 B.C.

Sierozem from loess with caliche on top of petrified dune material, Eshel Hanassi, 14 km before Beer Shewa (31° 20′ N Lat, 34° 41.5′ E Long).

BONN-758. Sierozem Eshel Hanassi, 0.5% C, A 15 to 25 cm — 1410 ± 70 / A.D. 540

BONN-759. Same location, caliche, 0.2% C, 80 to 100 cm — 4020 ± 220 / 2070 B.C.

BONN-748-762 coll. and subm. 1969 by H. W. Scharpenseel, H. Gewehr, and H. Koyumdjisky, Volcani Inst. Agric. Res., Bet Dagan, Israel. *Comment*: soils with partly very low content of organic C besides high carbonate-C concentrations required very laborious sample preparation. Apparent mean residence time of organic carbon fraction in upper

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

100 cm of soil is rather low despite restricted conditions of rejuvenation due to root growth and percolation under prevailing semi-arid and arid climate conditions. Transport and reworking of top surface material is possible.

Vertisols with swelling and cracking clay, slickensides and self-mulching. Vertisol transition Zone E of Hamra-zone still under influence of colic fine sand transport from the W dunes. Plain of Barkai Afula St. to Hedera (32° 29′ N Lat, 35° 1′ E Long).

BONN-715. Vertisol plain of Barkai, 2.9% C, 20 to 40 cm — 960 ± 60 A.D. 990

BONN-716. Same location, 2.2% C, 40 to 60 cm — 1080 ± 80 A.D. 870

BONN-717. Same location, 0.7% C, 60 to 80 cm — 1600 ± 60 A.D. 350

BONN-718. Same location, 0.6% C, 80 to 100 cm — 1850 ± 70 A.D. 100

Vertisol Valley of Jesrael, W fringe, (32° 35′ N Lat, 35° 14′ E Long).

BONN-719. Vertisol, W Valley of Jesrael, 1.0% C, 30 to 50 cm — 960 ± 70 A.D. 990

BONN-720. Same location, 0.8% C, 50 to 70 cm — 1570 ± 70 A.D. 380

BONN-721. Same location, 2.3% C, 70 to 90 cm — 2640 ± 70 690 B.C.

BONN-722. Same location, 0.9% C, 90 to 110 cm — 2550 ± 80 600 B.C.

BONN-723. Same location, 0.6% C, 110 to 130 cm — 2760 ± 80 810 B.C.

Vertisol Valley of Jesrael, drain ditch, (32° 36′ N Lat, 35° 14′ E Long).

BONN-724. Vertisol, drainage ditch, 0.6% C, 80 to 100 cm — 4060 ± 80 2110 B.C.

BONN-725. Same location, 0.8% C, 100 to 120 cm — 3810 ± 50 1860 B.C.

BONN-726. Same location, 0.9% C, 120 to 140 cm — 6460 ± 60 4510 B.C.

BONN-727. Same location, 0.7% C, 140 to 160 cm — 7320 ± 120 5370 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-728. Same location, 0.4% C, 160 to 180 cm	7440 ± 80 5490 B.C.

Vertisol, El Hamma, high terrace with brown Vertisol under shallow young cover, (32° 42′ N Lat, 35° 40′ E Long).

BONN-729. Vertisol El Hamma, 0.7% C, 100 cm	3240 ± 80 1290 B.C.
BONN-730. Same location, 0.6% C, 200 cm	15,140 ± 120 13,190 B.C.
BONN-731. Same location, 0.7% C, 300 cm	18,710 ± 230 16,760 B.C.
BONN-732. Same location, 0.5% C, 400 cm	17,360 ± 580 15,410 B.C.
BONN-733. Same location, 0.6% C, 500 cm	18,600 ± 120 16,650 B.C.
BONN-734. Same location, 0.5% C, 600 cm	19,430 ± 350 17,480 B.C.

Vertisol near Kibbutz Kefar Menachem, old alluvium (32° 50′ N Lat, 35° 45′ E Long).

BONN-735. Vertisol Kefar Menachem, 0.5% C 40 to 60 cm.	3810 ± 70 1860 B.C.
BONN-736. Same location, 0.2% C, 60 to 80 cm. Sample too small to date.	
BONN-737. Same location, 0.5% C, 80 to 100 cm	4350 ± 220 2400 B.C.
BONN-738. Same location, 0.3% C, 100 to 120 cm	7140 ± 210 5190 B.C.
BONN-739. Same location, 1.1% C, 120 to 140 cm	8250 ± 170 6300 B.C.
BONN-740. Same location, 0.9% C, 140 to 160 cm	15,490 ± 280 13,540 B.C.
BONN-741. Same location, 0.9% C, 160 to 180 cm	16,100 ± 270 14,150 B.C.

Vertisol along st. to Syrian Quarantine Sta. and Jordan flow into Lake Genesareth (32° 55′ N Lat, 35° 39′ E Long).

BONN-773. Vertisol, st. to Quarantine Sta., 1.1% C, 20 to 40 cm	1000 ± 70 A.D. 950

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-774.	Same location, 1.0% C, 40 to 65 cm	1970 ± 70 20 B.C.
BONN-775.	Same location, 0.8% C, 65 to 90 cm	2280 ± 60 330 B.C.
BONN-776.	Same location, 1.0% C, 90 to 120 cm	2670 ± 100 720 B.C.

Samples coll. and subm. 1969 by H. W. Scharpenseel, H. Gewehr, and G. Yaari Cohen. *Comment*: below maximum depth of dry season cracks the rejuvenation in Vertisols is low due to high clay content, restrained root growth and low permeation (kf-value). In this range measured apparent mean residence time may approach true age of soil formation. But, theoretically it must be expected, that within range of dry season cracks and self-mulching dynamics, approx. equilibration of carbon residence time due to perfect mixing prevails. From above results it appears that only the profiles "Valley of Jesrael, drain ditch", (beginning at 120 cm), "El Hamma" (beginning at 200 cm), and "Kefar Menachem", (beginning at 100 till 140 cm) reach below crack boundaries. Thus, radiocarbon measurements in Vertisol profiles reveal soil genetic principles and profile dynamics.

B. Bulgaria series

At a guided tour of soil correlation among European classification systems, USA 7th Approximation and FAO–Soil Map of the World, systematic, soil profile samples were taken in *locus typicus* throughout Bulgaria.

Light gray, forest (pseudopodzolic) surface waterlogged soil, Eutric Planosol, Vertic Albaqualf (according to J. D. Rourke, U.S. Dept. Agr., Soil Conservation Service), Glavatsi, Danube valley, heavy loamy river deposits (43° 12′ N Lat, 23° 10′ E Long).

BONN-1071.	Vertic Albaqualf, Glavatsi, 1.1% C, Sd1, 35 to 40 cm	1170 ± 70 A.D. 780
BONN-1072.	Same location, 0.4% C, Sd2/BS, 55 to 65 cm	3310 ± 70 1360 B.C.
BONN-1073.	Same location, 0.3% C, SB 85 to 95 cm	5210 ± 90 3260 B.C.
BONN-1074.	Same location, 0.5% C, BC 115 to 125 cm	8050 ± 80 6110 B.C.

Leached Chernozem, Luvic Phaeozem, Udic Haplustoll, near village of Gorni Dubnik, loessic material (43° 27′ N Lat, 24° 13′ E Long).

BONN-1075.	Leached Chernozem, 2.6% C, Ah2 36 to 47 cm	940 ± 70 A.D. 1010

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-1076.	Same location, 1.2% C, BAh2 55 to 65 cm	2340 ± 70 390 B.C.
BONN-1077.	Same location, 0.9% C, AhB 85 to 95 cm	4130 ± 90 2180 B.C.
BONN-1078.	Same location, 0.5% C, Cl 120 to 130 cm	7040 ± 80 5090 B.C.
BONN-1079.	Same location, 1.1% C, ClfA 200 to 210 cm	11,100 ± 90 9150 B.C.

Calcareous Chernozem, Calcareous Phaeozem, Typic Calciustoll, NW Pleven, loessic material (43° 29′ N Lat, 24° 11′ E Long).

BONN-1080.	Calcareous Chernozem, 2.5% C, Al 28 to 32 cm	1480 ± 70 A.D. 470
BONN-1081.	Same location, 1.4% C, A2 37 to 43 cm	1480 ± 70 A.D. 470
BONN-1082.	Same location, 0.8% C, A3 66 to 73 cm	3140 ± 80 1190 B.C.
BONN-1083.	Same location, 0.3% C, A4 102 to 108 cm	4130 ± 70 2180 B.C.
BONN-1084.	Same location, 0.5% C, AC 145 to 155 cm	5760 ± 90 3810 B.C.
BONN-1085.	Same location, material of crotovines, 1.0%C, 100 to 150 cm	3460 ± 80 1510 B.C.

Gray Forest soil, Luvic Phaeozem, Udic or Udertic Paleustalf, 12 km S Pleven on reddish brown loess-like clay, (43° 22′ N Lat, 24° 35′ E Long).

BONN-1086.	Gray Forest soil, 1.3% C, A1 7 to 30 cm	470 ± 60 A.D. 1480
BONN-1087.	Same location, 1.0% C, A1B 30 to 37 cm	1980 ± 70 30 B.C.
BONN-1088.	Same location, 1.0% C, BtBv1 70 to 80 cm	4060 ± 100 2110 B.C.
BONN-1089.	Same location, 0.6% C, Bv 135 to 145 cm	4340 ± 120 2390 B.C.
BONN-1090.	Same location, 0.5% C, IIAh1 170 to 180 cm	6520 ± 110 4570 B.C.
BONN-1091.	Same location, 1.5% C, IIAh2 210 to 220 cm	11,140 ± 170 9190 B.C.

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-1092.	Same location, 0.8% C, HSB 250 to 265 cm	18,920 ± 340 16,970 B.C.

Gray Forest soil, Luvic Phaeozem, Udic Haplustalf, N Kozlevo village, dist. of Shoumen on loess-like clays, (43° 32′ N Lat, 27° 17.5′ E Long).

BONN-1093.	Gray Forest soil, 0.7% C, BA1 16 to 28 cm	1380 ± 70 A.D. 570
BONN-1094.	Same location, 0.3% C, Bt 35 to 44 cm	1510 ± 80 A.D. 440
BONN-1095.	Same location, 0.2% C, CBt, 60 to 70 cm	2180 ± 70 230 B.C.
BONN-1096.	Same location, 0.6% C, BC 80 to 90 cm	3370 ± 100 1420 B.C.
BONN-1097.	Same location, 0.6% C, BshC 98 to 106 cm	3010 ± 120 1060 B.C.

Strongly degraded Cinnamonic Forest soil, Planosol, Udertic Paleustalf, Karnobat, near Bourgas, Pliocene sandy clay (42° 36′ N Lat, 26° 58′ E Long).

BONN-1098.	Cinnamon Podzolic soil, 0.9% C, Bs1 30 to 40 cm	1780 ± 70 A.D. 170
BONN-1099.	Same location, 0.9%C, Bs2 50 to 60 cm	3340 ± 70 1390 B.C.
BONN-1100.	Same location, 0.5% C, Bsh? 74 to 82 cm	4950 ± 100 3000 B.C.
BONN-1101.	Same location, 0.6% C, fA 85 to 95 cm	10,730 ± 130 8780 B.C.
BONN-1102.	Same location, 0.6% C, ACca 105 to 115 cm	12,380 ± 280 10,430 B.C.
BONN-1103.	Same location, 0.8% C, SACca 155 to 168 cm	14,150 ± 240 12,200 B.C.
BONN-1104.	Same location, 0.5% C, BC 190 to 200 cm	14,140 ± 280 12,190 B.C.

Cinnamonic–Podzolized–Gleyey soil, Planosol, Vertic Albaqualf, Badeshte, Thracian plain on Pliocene sandy clay (42° 16′ N Lat, 25° 44′ E Long).

BONN-1105.	Cinnamonic soil, 1.2% C, Ah 25 to 35 cm	1840 ± 60 A.D. 110

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

BONN-1106.	Same location, 0.7% C, ABS1 40 to 50 cm	2940 ± 70 990 B.C.
BONN-1107.	Same location, 0.5% C, S2 60 to 70 cm	6970 ± 200 5020 B.C.
BONN-1108.	Same location, 0.3% C, SC 160 to 170 cm	9850 ± 240 7900 B.C.

Smonitsa-Vertisol, Vertisol, Typic Pellustert, Sredets, Thracian Plain on Pliocene redeposited clay (42° 10′ N Lat, 25° 40′ E Long).

BONN-1108.	Smonitsa-Vertisol, 3.0% S, Ah1 20 to 30 cm	990 ± 50 A.D. 960
BONN-1109.	Same location, 2.3% S, Ah2 40 to 50 cm	2050 ± 70 100 B.C.
BONN-1110.	Same location, 7.5% C, Ah3 75 to 85 cm	2940 ± 70 990 B.C.
BONN-1111.	Same location, 1.0% C, BtAh 115 to 125 cm	3890 ± 80 1940 B.C.
BONN-1112.	Same location, 0.3% C, CB 140 to 150 cm	4590 ± 90 2640 B.C.
BONN-1113.	Same location, 0.4% C, BC 170 to 180 cm	11,110 ± 200 9160 B.C.
BONN-1114.	Same location, 0.7% C, C 240 to 250 cm	16,140 ± 460 14,190 B.C.

Cinnamonic Forest soil, Chromic Luvisol, Udic Rhodustalf, Koren, alluvium upon orthogneiss (41° 47′ N Lat, 25° 50′ E Long).

BONN-1115.	Cinnamon soil, 1.1% C, Ah 15 to 20 cm	101.0 ± 0.4% Modern
BONN-1116.	Same location, 0.4% C, AlBt 30 to 40 cm	940 ± 60 A.D. 1010
BONN-1117.	Same location, 1.1% C, Bt1 55 to 65 cm	1550 ± 80 A.D. 400
BONN-1118.	Same location, 0.7% C, Bt2 85 to 95 cm	6620 ± 240 4670 B.C.
BONN-1119.	Same location, 0.4% C, BC 140 to 170 cm	8480 ± 140 6530 B.C.

Samples coll. and subm. 1970 by H. W. Scharpenseel and W. Kerpen, Inst. Bodenkunde, Bonn. *Comment*: contrary to N European conditions, where soils in equilibrium with present-day environmental conditions are mainly formed during Holocene on glacially or periglacially in-

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

fluenced parent material, most soils of Bulgaria are older and pre-Holocene in origin. The Smonitsa-Vertisol shows rather uniform C-residence time values within main zone of summer cracks till 85 cm, an older, but also rather uniform age level from 85 to 150 cm, zone of occasional cracks and self mulching during extended periods of extreme draught. Below 150 cm lack of cracks avoids influx of surface material. In consequence, age is rising sharply. (Cf. Vertisols of Israel, BONN-724 to 741 above). Descriptive terms of 7th Approximation were provided for all tested profiles by J. D. Rourke.

C. Sardinia series

Samples of Vertisol profiles in typical locations of Sardinia coll. with local pedologists. Vertisol, formed in phreatic milieu, Aquert, rather shallow, rich in montmorillonite, Plane de Cuga, Ittiri, 20 km SW Sassari (40° 34′ N Lat, 3° 26′ W Long).

BONN-1154.	Vertisol Ittiri, 2.2% C, Ah1 10 to 25 cm	410 ± 90 A.D. 1540
BONN-1155.	Same location, 1.9% C, Ah2 25 to 40 cm	420 ± 90 A.D. 1530
BONN-1156.	Same location, 1.3% C, Ah3 40 to 60 cm	460 ± 70 A.D. 1490
BONN-1157.	Same location, 1.2% C, AhC 60 to 80 cm	570 ± 50 A.D. 1380

Shallow Vertisol, Ustert, Campo Mela, 20 km S Sassari (40° 40′ N Lat, 3° 48.5′ W Long).

BONN-1158.	Vertisol, Campo Mela, 4.5% C, Ah1 10 to 25 cm	220 ± 60 A.D. 1730
BONN-1159.	Same location, 1.8% C, Ah2 25 to 40 cm	1520 ± 70 A.D. 430
BONN-1160.	Same location, 1.3% C, Ah3 40 to 60 cm	1700 ± 70 A.D. 250

Vertisol, Chromoxerert in recent alluvium of Basalt decomposition, typical slickensides, developed on river terrace of Rio Mannu di S. Vero. Below 90 cm buried horizon, St. Vero Milis, Molino Meloni (40° 2′ N Lat, 3° 52′ W Long).

BONN-1161.	Vertisol St. Vero Milis, 0.3% C, Ah1 10 to 30 cm	280 ± 70 A.D. 1670
BONN-1162.	Same location, 0.5% C, SwAh2 30 to 50 cm	3240 ± 110 1290 B.C.
BONN-1163.	Same location, 0.3% C, SwAh3 50 to 70 cm	3370 ± 110 1420 B.C.

BONN-1164.	Same location, 0.8% C, SdAh4 70 to 90 cm	3870 ± 130 1920 B.C.

Vertisol, Pelloxerert, black clay plain of marl, underneath Miocene sandstone, Arziadas, Arenadas, Tuvoi (39° 18′ N Lat, 3° 33′ W Long).

BONN-1167.	Vertisol Arziadas, 1.5% C, Ah1 40 to 60 cm	730 ± 60 A.D. 1220
BONN-1168.	Same location, 0.8% C, Ah2 60 to 80 cm	1490 ± 60 A.D. 460
BONN-1169.	Same location, 1.3% C, Ah3 80 to 100 cm	1770 ± 70 A.D. 180
BONN-1170.	Same location, 0.9% C, Ah4 100 to 120 cm	2060 ± 90 110 B.C.
BONN-1171.	Same location, 0.4% C, Ah5 120 to 140 cm	3470 ± 80 1520 B.C.
BONN-1172.	Same location, 0.5% C, Ah6 140 to 160 cm	4740 ± 80 2790 B.C.
BONN-1173.	Same location, 0.4% C, Ah7 160 to 180 cm	4990 ± 90 3040 B.C.
BONN-1174.	Same location, 0.3% C, AC 180 to 200 cm	5430 ± 100 3480 B.C.

Vertisol, Chromoxerert, formed in weathered trachyt/andesit-tuff of Oligocene volcanism, Monastir, along hwy. 20 km N Cagliari (39° 23′ N Lat, 3° 24.5′ W Long).

BONN-1175.	Vertisol Monastir, 6.2% C, Ah1 20 to 40 cm	107.7 ± 0.5% Modern
BONN-1176.	Same location, 4.9% C, Ah2 40 to 60 cm	670 ± 60 A.D. 1280
BONN-1177.	Same location, 0.6% C, Ah3 60 to 80 cm	2270 ± 70 320 B.C.
BONN-1178.	Same location, 0.3% C, Ah4 80 to 100 cm	1920 ± 100 A.D. 30

Vertisol, Pellustert, formed on weathered calcareous marne, Nurallao (39° 47′ N Lat, 3° 23′ W Long).

BONN-1180.	Vertisol Nurallao, 1.9%, Ah1 0 to 20 cm	40 ± 70 A.D. 1910
BONN-1181.	Same location, 2.6% C, Ah2 20 to 40 cm	410 ± 70 A.D. 1540

BONN-1182.	Same location, 1.5% C, Ah3 40 to 60 cm	1490 ± 60 A.D. 460
BONN-1183.	Same location, 1.3% C, Ah4 60 to 80 cm	1490 ± 80 A.D. 460
BONN-1184.	Same location, 1.3% C, Ah5 80 to 100 cm	1900 ± 80 A.D. 50
BONN-1185.	Same location, 2.1% C, Ah6 100 to 120 cm	2410 ± 70 560 B.C.
BONN-1186.	Same location, 0.8% C, Ah7 120 to 140 cm	3090 ± 80 1140 B.C.
BONN-1187.	Same location, 0.5% C, AC 140 to 160 cm	3220 ± 80 1270 B.C.

Samples coll. and subm. 1970 by H. W. Scharpenseel with local pedologists, A. Pietracaprina and P. Baldaccini. *Comment*: residence times of humus-C measured are partly rather young, although most vertisols are expected to be Holocene in origin. Except for Arziadas (BONN-1167 to 1174) and Nurallao (BONN-1180 to 1187), shallow pedon and fact that sampling horizons were still in self-mulching zone of crack depth are probably responsible. Continuous age increase in deeper profiles of Arziadas and Nurallao supports view that even throughout these deeper profiles younger surface material was transported downwards until the AC-horizon.

D. Sicily series

Typical Vertisol profiles of W Sicily were studied with assistance of local pedologists. Vertisol, typical Chromoxerert, Scalilli, formed in colluvium upon an old terrace, near Corleone (37° 48.5′ N Lat, 1° 8′ W Long).

BONN-1326.	Vertisol Scalilli, 1.9% C, Ah1 0 to 20 cm	860 ± 70 A.D. 1090
BONN-1327.	Same location, 2.3% C, Ah2 20 to 40 cm	1340 ± 70 A.D. 610
BONN-1328.	Same location, 1.1% C, Ah3 40 to 60 cm	1560 ± 70 A.D. 390
BONN-1329.	Same location, 1.9% C, Ah4 60 to 80 cm	2000 ± 80 50 B.C.
BONN-1330.	Same location, 1.9% C, Ah5 80 to 100 cm	2970 ± 70 1020 B.C.
BONN-1331.	Same location, 1.9% C, IIA 100 to 110 cm	3030 ± 90 1080 B.C.

Vertisol, Pelloxerert, mainly colluvial on terrace gravel, below 100 cm depth transition into fossil horizon, Plana di Scala, Corleone (37° 49′ N Lat, 1° 7′ W Long).

BONN-1332.	Vertisol Plane di Scala, 2.4% C, Ah1 0 to 20 cm	530 ± 70 A.D. 1420
BONN-1333.	Same location, 1.5% C, Ah2 20 to 40 cm	1800 ± 60 A.D. 150
BONN-1334.	Same location, 1.5% C, Ah3 40 to 60 cm	1650 ± 70 A.D. 300
BONN-1335.	Same location, 0.9% C, Ah4 60 to 80 cm	2160 ± 60 210 B.C.
BONN-1336.	Same location, 0.6% C, Ah5 80 to 100 cm	2430 ± 70 480 B.C.
BONN-1337.	Same location, 0.6% C, fAh1 100 to 120 cm	3670 ± 100 1720 B.C.
BONN-1338.	Same location, 0.5% C, fAh2C 120 to 140 cm	16,210 ± 360 14,260 B.C.

Vertisol, Pelloxerert, formed in Pliocene clay, underground sandy, *Aziena Sporacia*, experimental farm, Univ. Palermo, Inst. Agronomy (cammarata), Profile 1, (37° 49′ N Lat, 1° 7′ W Long).

BONN-1339.	Vertisol *Az. Sporacia* (1), 1.3% C, Ah1 0 to 20 cm	890 ± 70 A.D. 1060
BONN-1340.	Same location, 1.9% C, Ah2 20 to 40 cm	890 ± 70 A.D. 1060
BONN-1341.	Same location, 1.3% C, Ah3 40 to 60 cm	1080 ± 70 A.D. 870
BONN-1342.	Same location, 1.1% C, Ah4 60 to 80 cm	1460 ± 70 A.D. 490
BONN-1343.	Same location, 1.1% C, Ah5 80 to 100 cm	2160 ± 90 210 B.C.
BONN-1344.	Same location, 1.9% C, Ah6 100 to 120 cm	1430 ± 60 A.D. 520
BONN-1345.	Same location, 0.6% C, Ah7 120 to 140 cm	1700 ± 60 A.D. 250
BONN-1346.	Same location, 0.9% C, Ah8 140 to 160 cm	2910 ± 90 960 B.C.
BONN-1347.	Same location, 0.8% C, Ah9 160 to 180 cm	3990 ± 90 2040 B.C.

BONN-1348.	Same location, 0.7% C, Ah10 180 to 200 cm	4040 ± 120 2090 B.C.
BONN-1349.	Same location, 0.7% C, Ah11 200 to 220 cm	4360 ± 140 2410 B.C.
BONN-1350.	Same location, 0.7% C, AC1 220 to 240 cm	4950 ± 110 3000 B.C.
BONN-1351.	Same location, 0.4% C, AC2 240 to 260 cm	5470 ± 120 3520 B.C.

Vertisol, Chromoxerert, (ca. 10% Na^+ on base exchange complex), *Aziena Sporacia*, experimental farm, Univ. Palermo, Profile 2, (37° 49′ N Lat, 1° 7′ W Long).

BONN-1352.	Vertisol, *Az. Sporacia* (2), 1.2% C, Ah1 0 to 25 cm	113.3 ± 0.4% Modern
BONN-1353.	Same location, 1.1% C, Ah2 25 to 45 cm	990 ± 80 A.D. 960
BONN-1354.	Same location, 0.9% C, Ah3 45 to 65 cm	910 ± 70 A.D. 1040
BONN-1355.	Same location, 0.8% C, Ah4 65 to 85 cm	1600 ± 70 A.D. 350
BONN-1356.	Same location, 0.6% C, Ah5 85 to 105 cm	1970 ± 70 20 B.C.
BONN-1357.	Same location, 0.8% C, Ah6 105 to 125 cm	4990 ± 140 3040 B.C.
BONN-1358.	Same location, 0.3% C, Ah7 125 to 145 cm	9890 ± 240 7940 B.C.
BONN-1359.	Same location, 0.2% C, AC1 145 to 165 cm	9790 ± 160 7840 B.C.
BONN-1360.	Same location, 0.1% C, C2 165 to 185 cm	11,510 ± 310 9560 B.C.
BONN-1361.	Same location, 0.5% C, C3 185 to 205 cm	15,160 ± 370 13,210 B.C.
BONN-1362.	Same location, 0.7% C, C4 205 to 225 cm	12,830 ± 330 10,880 B.C.
BONN-1363.	Same location, 0.3% C, C5 225 to 245 cm	14,720 ± 330 12,770 B.C.

Samples coll. and subm. 1970 by H. W. Scharpenseel with local pedologist, G. Fierotti. *Comment*: in 1st profile, Scalilli, apparent depth limit of summer cracks is ca. 80 cm. Below, no rejuvenation due to sur-

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

face material occurs, and mean carbon residence time becomes markedly higher. In 2nd profile, Plame di Scala, age break is noticeable between 100 to 120 cm and deeper. A fossil A-horizon produces a sharp increase of carbon mean residence time. Above 100 cm natural radiocarbon values are rather uniform, indicating, that due to summer cracks of about this depth there is a constant rejuvenation within upper 100 cm blanket, caused by droppings of surface material.

Among the 2 profiles within boundaries of the experimental farm, Univ. Palermo, the deeper, darker Profile 1 reveals lower mean residence time values of humus carbon, than the shallower, browner, less humus containing and more sodic Profile 2. The latter lies across a creak, several 100 m apart, but is different in color as in base inventory.

E. Romania series

Soil samples with humus from underneath Danube alluvium in karstic landscape with annual overflooding (winter, spring), when Danube River rises (44° 40′ N Lat, 22° 20′ E Long).

BONN-1379.	Sample 4, 0.9% C, 90 cm	5830 ± 120 3880 B.C.
BONN-1383.	Sample 3, 0.7% C, 120 cm	7660 ± 110 5710 B.C.
BONN-1381.	Sample 2, 0.6% C, 160 cm	8070 ± 130 6060 B.C.
BONN-1385.	Sample 1, 0.6% C, 200 cm	8070 ± 130 6120 B.C.

Samples coll. and subm. 1970 by A. Conea, Inst. Geol. Bucharest. *Comment*: samples from epipaleolithic period, proven by flintstone tools and art objects in same strata. Simple plant cultivation indicated. Estimated age: Atlantic to Boreal time. Results confirm expected age.

E. Local (German) series

Pseudogley–Humus–Iron–Podzol, Aqualfic Fragiorthod formed in sand layer on top of basal moraine of Drenthe-Saale glaciation, Amelsbüren (51° 51′ N Lat, 7° 38′ E Long).

BONN-1364.	Podzol Amelsbüren, 30.3% C, OH1 5 to 0 cm	700 ± 60 A.D. 1250
BONN-1365.	Same location, 31.1% C, OH2 0 to 25 cm	1450 ± 60 A.D. 500
BONN-1367.	Same location, 3.8% C, Aeh 45 to 70 cm	1910 ± 60 A.D. 40
BONN-1368.	Same location, 1.5% C, Bh 70 to 100 cm	1980 ± 80 30 B.C.
BONN-1369.	Same location, 2.0% C, Bsh 100 to 120 cm	1900 ± 70 A.D. 50

BONN-1663. Dark transition zone to Drenthe-Saale basal moraine below 160 cm, 0.5% C — 15,170 ± 230 / 13,220 B.C.

Samples coll. and subm. 1970 and 1971 by H. Butzke, Geol. Landesamt NRW, Krefeld and H. W. Scharpenseel Inst. Bodenkunde, Bonn. *Comment*: deep and strong podzolization was expected to be among oldest of this type, so far, showing apparent carbon residence times of ca. 3000 yr. (BONN-90, R., 1968, v. 10, p. 20). Because of extreme percolation, measurements in humus-podzols are not closely related to age of soil formation. Measured age is minimum. Transition zone to moraine represents fossil A-horizon, now superimposed by Holocene podzol formation.

Bändchenpodzol of Black Forest, Placorthod, Grindenschwarzwald, Gemsbach (48° 14′ N Lat, 8° 35′ E Long).

BONN-1371. Bändchenpodzol 1, 1.9% C, Ahe 25 cm — 720 ± 60 / A.D. 1230

BONN-1372. Same location, 0.3% C, Bb 70 cm — 1790 ± 60 / A.D. 160

BONN-1373. Bändchenpodzol 2, 3.7% C, AhAeg 35 cm — 1670 ± 60 / A.D. 280

BONN-1374. Same location, 1.6% C, Bb 85 cm — 2550 ± 70 / 600 B.C.

BONN-1375. Bändchenpodzol 3, 1.4% C, AhAe 35 cm — 1600 ± 60 / A.D. 350

BONN-1377. Bändchenpodzol 4, 1.4% C, AhAe 38 cm — 2000 ± 60 / 50 B.C.

BONN-1378. Same location, 0.9% C, Bb 85 cm — 2090 ± 70 / 140 B.C.

Samples coll. and subm. 1970 by K. Stahr, Inst. Pedol. Stuttgart-Hohenheim. *Comment*: results resemble previous measurements at nearby Schliffkopfhaus (BONN-859 to 861, R., 1971, v. 13, p. 197/198). Results, prove, that soil was not formed by medieval deforestation as was previously contended.

III. ARCHAEOLOGIC SAMPLES

A. West Germany

BONN-1120. — **8420 ± 160** / **6470 B.C.**

Humus containing layer of possibly Neolithic settlement, Mayen/Eifel (50° 20′ N Lat, 7° 16′ E Long), 0.2% C, 180 to 195 cm.

BONN-1121. — **2060 ± 50** / **110 B.C.**

Humus containing layer, St. Stephanus church Kornelimünster, La

https://doi.org/10.1017/S0033822200058586 Published online by Cambridge University Press

Tène period, directly below pavement, (50° 44′ N Lat, 6° 11′ E Long), 0.7% C.

BONN-1152. **1840 ± 50** **A.D. 110**

Incineration grave, Xanten, estim. Roman, 1st century (51° 40′ N Lat, 6° 28′ E Long), 2.6% C, 150 cm.

Samples coll. and subm. 1970 by G. Strunck-Lichtenberg, Inst. f. Bodenkunde, Bonn. *Comment*: BONN-1120 and 1121 elucidate prehistoric chronology of settlements. BONN-1120 is older than expected. BONN-1152, dated by Roman ceramics to ca. 2000 B.P. Result agrees fairly well; 160 yr-gap probably due to humus percolation from above.

BONN-1556. **520 ± 60** **A.D. 1430**

Piece of log, used as support in mines. Sample 1, Müsen, Siegerland, 5.60 m (51° N Lat, 8° E Long).

BONN-1557. **800 ± 60** **A.D. 1150**

Same location, upright standing wooden board in house wall, 60 m.

BONN-1654. **1060 ± 70** **A.D. 890**

Same location, piece of log, 28 m.

BONN-1655. **1230 ± 70** **A.D. 720**

Same location, piece of wood, ore processing site, 28 m.

BONN-1656. **970 ± 70** **A.D. 980**

Same location, frame-wood of cellar basement, 28 m.

Samples coll. and subm. 1971 by Mining Museum Bochum. *Comment*: dates assess early mining in Siegerland; 200 to 300 yr older than expected.

B. Israel

BONN-746. **4200 ± 70** **2250 B.C.**

Ancient Jericho ruins (oldest, deepest ruins assessed at ca. 9000 B.P.), charcoal samples taken from 1/3 to 1/2 of total depth of pit, 250 cm, prehistoric, Sumeric, Akkadic, Caldeic period expected represented. (31° 52′ N Lat, 34° 35′ E Long).

BONN-747. **5110 ± 110** **3160 B.C.**

Same location, charcoal, 350 cm.

Samples coll. and subm. 1969 by H. W. Scharpenseel and H. Gewehr, Inst. f. Bodenkunde, Bonn. *Comment*: unfortunately no continuity of charcoal samples down to bottom of pit. Availability of organic C and charcoal at various depth levels makes site potentially important for humus-C versus charcoal age comparison.

C. Ecuador

2630 ± 80

BONN-1550. **680 B.C.**

High Andes Mts., Ambato, S Quito, on carstic hill, charcoal in soil, pit 80 to 100 cm deep. Few relics of Puruhá-style, dating of pre-Inca settlement (1° 14′ S Lat, 78° 42′ W Long).

990 ± 60

BONN-1551. **A.D. 960**

W part of house in Cashaloma style, hill of E Cordillera, some Inca ceramics, coal 10 to 100 cm, scattered in house. Dates fixation of Inca occupation of Ecuador (2° 32′ S Lat, 78° 53′ W Long).

1510 ± 80

BONN-1552. **A.D. 440**

Same location, coal, 20 to 60 cm.

690 ± 60

BONN-1553. **A.D. 1260**

High Andes, rock precipice E Cordillera W layer, 160 cm, coal in bits and pieces. Locally average Cashaloma ceramics. Attempts chronologic assessment of last pre-Inca as well as Inca cultural horizons (2° 32′ S Lat, 78° 53′ W Long).

750 ± 70

BONN-1554. **A.D. 1200**

Same location, charcoal, 135 cm.

700 ± 60

BONN-1555. **A.D. 1250**

Same location, charcoal, 150 cm.

Samples coll. and subm. 1971 by A. Meyers, Inst. Anthropol., Bonn Univ. *Comment*: results are slightly higher than expected. Age of wood, before conversion into charcoal, could be partly responsible.

D. Peru

Peru samples are part of current large scale study on pre-Spanish settlements and relics.

730 ± 60

BONN-1139. **A.D. 1220**

Wood, Huaycan, Lurín valley; to date pre-Spanish settlement (12° 5′ S Lat, 76° 10′ W Long).

420 ± 80

BONN-1140. **A.D. 1530**

Charcoal, Huaycan, same location; to date pre-Spanish settlement.

660 ± 60

BONN-1141. **A.D. 1290**

Wood, Túcume, Lambayeque; to date pre-Inca pyramid El Mirador (6° 30′ S Lat, 79° 40′ W Long).

BONN-1142. **680 ± 50**
A.D. 1270

Charcoal, Túcume, same location; to date pre-Inca pyramid El Mirador, NW-platform, 55 to 60 cm under surface.

BONN-1143. **940 ± 50**
A.D. 1010

Wood, Túcume, same location; to date pre-Inca pyramid de las Estacas, E part, 40 to 55 cm, 4. layer of wooden logs.

BONN-1144. **690 ± 50**
A.D. 1260

Wood, Túcume, same location; to date pre-Inca pyramid Huaca Alagarda. E wall 45 to 60 cm below top.

BONN-1145. **1430 ± 50**
A.D. 520

Charcoal, Apurlec, Lambayeque; to date pre-Spanish buildings (6° 20′ S Lat, 79° 40′ W Long).

BONN-1146. **420 ± 50**
A.D. 1530

Root wood, Aymara, Mala valley; 70 to 80 cm in house wall; to date pre-Spanish settlement (12° 35′ S Lat, 76° 30′ W Long).

BONN-1147. **660 ± 50**
A.D. 1290

Charcoal, Puyenca, S Chala, 85 cm below garbage pile; to date pre-Spanish settlement (16° 10′ S Lat, 73° 50′ W Long).

BONN-1148. **13,950 ± 130**
12,000 B.C.

Charcoal, Puyenca, in street lining, same location; to date pre-Spanish settlement.

BONN-1149. **2280 ± 80**
330 B.C.

Bamboo sticks, Amapaya, Sama valley, part of vertical house wall remnants; to date age of pre-Spanish buildings (18° 10′ S Lat, 70° 40′ W Long).

BONN-1150. **130 ± 50**
A.D. 1820

Wood, Fundus la Vitúna, Sama valley, Tacna, sowed hard wood, vertical position, 30 cm; to date age of pre-Spanish buildings (18° 12′ S Lat, 70° 40′ W Long).

BONN-1151. **710 ± 60**
A.D. 1240

Charcoal, Tocuco Alto, Tacna, fireplace 10 to 25 cm below terrace surface; to date pre-Spanish settlement (17° 45′ S Lat, 70° 15′ W Long).

BONN-1558. **6160 ± 120**
4210 B.C.

Charcoal, Sumbay, Arequipa, cave, 20 to 30 cm below surface; to date prehistoric settlement (16° 15′ S Lat, 71° 30′ W Long).

BONN-1559. **5350 ± 90**
3400 B.C.

Charcoal, Sumbay, cave bottom 30 to 40 cm below surface; to date prehistoric settlement, same location.

BONN-1560. **730 ± 60**
A.D. 1230

Llama dung, Alto Tocuco, Pachia, in bottom of inhabited terrace; to date pre-Spanish settlement (17° 45′ S Lat, 70° 15′ W Long).

BONN-1561. **900 ± 100**
A.D. 1050

Charcoal, Alto Tocuco, in bottom of inhabited terrace; to date pre-Spanish settlement, same location.

BONN-1562. **3260 ± 120**
1310 B.C.

Charcoal, hut in Pizacoma, Chucuito; Mesolithic ceramics exists; to date prehistoric settlement (16° 30′ S Lat, 70° 0′ W Long).

BONN-1563. **1500 ± 70**
A.D. 450

Cotton cloth, Chavina-valley, Acari, on bottom of garbage pile; to date layer of Nasca culture (15° 30′ S Lat, 74° 50′ W Long).

BONN-1564. **280 ± 70**
A.D. 1670

Relic of corn cob, Lluta, Pachia, in bottom of house relic, 30 to 40 cm below surface; to date pre-Spanish settlement (17° 45′ S Lat, 70° 15′ W Long).

BONN-1565. **770 ± 70**
A.D. 1180

Corn straw and fiber fabric from desert soil, La Vituna, Las Yaras, 40 cm below surface; to date pre-Spanish settlement (17° 45′ S Lat, 70° 45′ W Long).

BONN-1566. **390 ± 70**
A.D. 1560

Piece of wooden pole of house entrance, Lluta, Pachia, in bottom of former house; to date pre-Spanish settlement (17° 45′ S Lat, 70° 15′ W Long).

BONN-1567. **270 ± 70**
A.D. 1680

Piece of wooden pole of house entrance, in house bottom, 20 to 30 cm below surface; to date pre-Spanish settlement, same location.

BONN-1568. **290 ± 70**
A.D. 1660

Twigs and branches in basement of former house, Lluta, 20 cm below surface; to date pre-Spanish settlement, same location.

BONN-1569. **100.8 ± 0.8%**
Modern

Unknown plant grains, in basement of pre-Spanish storage house, Quebrada de la Vaca, Chala; to date pre-Spanish settlement (15° 48′ S Lat, 74° 24′ W Long).

BONN-1570. **1560 ± 70**
A.D. 390

Lower Part of wooden pole, in base of artificial hill, Cahuachi, Nazca valley 40 cm below surface; to date phase of Nazca culture (15° S Lat, 75′ W Long).

BONN-1664. **570 ± 80**
A.D. 1380

Remnant of wooden pole in bottom of former house (2), Lluta, Pachia, Tacna; to date pre-Spanish settlement (17° 45′ S Lat, 70° 15′ W Long).

BONN-1665. **260 ± 70**
A.D. 1690

Remnant of wooden pole in bottom of former house (1), Lluta; to date pre-Spanish settlement, same location.

BONN-1813. **1110 ± 70**
A.D. 840

Charcoal No. 5 and 6, ruin complex Apurlec, Motupe, Lambayeque, in wall material 20 to 45 cm below surface; to date pre-Spanish ruin complex (16° 20′ S Lat, 79° 40′ W Long).

Samples coll. and subm. 1970 to 1972 by H. Trimborn, Inst. Anthropol., Bonn Univ. *Comment*: project still pending, dates help validate assumptions based on stratigraphic estimates and fossil evaluation.

IV. MODERN SAMPLE

BONN-1337. Grass, Röttgen near Bonn, Oct. 1971 **145.8 ± 0.5%**
Modern

Sample coll. and subm. 1971 by H. W. Scharpenseel. Continues study of bomb carbon level since 1957 (R., 1969, v. 11, p. 13).

References

Rauterberg, E. and Kremkus, F., 1951, Bestimmung von Gesamt- und alkalilöslichen Huminstoffen im Boden: Z. Pflanzenernähr., Düng., Bodenkunde, v. 54, p. 240.

Scharpenseel, H. W., 1971, Radiocarbon dating of soils—problems, troubles, hopes, Paleopedology—Origin, Nature and Dating of Paleosols, ed. D. H. Yaalon, Int. Soil Sci. Soc., p. 77 to 88.

Scharpenseel, H. W., *et al.*, Analyses des eaux souterraines en Tunisie, par mesure des concentrations naturelles de radiocarbone et de tritium: Report to the Tunisian Government. (in German: Fortschr. Geol. in Nordrhein-Westfalen, in press).

Scharpenseel, H. W. and Pietig, F., 1968/69, Einfache Boden- und Wasserdatierung durch Messung der C^{14}-oder Tritiumkonzentration: Geoderma, v. 2, p. 273-289.

———— 1970, University of Bonn natural radiocarbon measurements III, v. 12, p. 19-39.

———— 1971, University of Bonn natural radiocarbon measurements IV, v. 13, p. 189-213.

Scharpenseel, H. W., Pietig, F., and Tamers, M. A., 1968, Bonn radiocarbon measurements I, v. 10, p. 8-28.

———— 1969, University of Bonn natural radiocarbon measurements II, v. 11, p. 3-14.

Tamers, M. A., 1967, Radiocarbon ages of ground water in arid zone unconfined aquifer: Am. Geophys. Union Mon., v. 11, p. 143.

Tamers, M. A., Ronzani, C., and Scharpenseel, H. W., 1969, Observation of naturally occurring chlorine Cl-36: Atompraxis, v. 15, p. 1-5.