

Radiocarbon

1974

UNIVERSITY OF BONN NATURAL RADIOCARBON MEASUREMENTS VII

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Radiocarbon measurements, mainly on soil and water samples are being continued. Benzene samples are prepared as described earlier (Scharpenseel and Pietig, 1969; 1970). Radioactivity is measured in a single quartz vial, and also with 13 specially manufactured, low background Teflon/Duraluminium vials, similar to the system described by Polach (1971, pers commun).

ACKNOWLEDGMENTS

The authors are indebted to E Kruse, A Lay, H Kirschey, and W Goebel for their technical help in sample preparation. H Schiffmann was responsible for computer evaluation of activity measurements. The Gesellschaft für Mathematik und Datenverarbeitung GmbH, Bonn helped us with their computer facilities. This work was financed by grants from the Federal Department of Research and Technology. Preparation of carbonate samples from aquifers in Taiwan was financed by the German Foundation of Research (Deutsche Forschungsgemeinschaft).

SAMPLE DESCRIPTIONS

I. GROUND WATER SAMPLES

A. Taiwan

Reported here are results of ground water dating in Taiwan; 84 carbonate samples from different wells were coll using an accelerator of precipitation (Scharpenseel, Pietig, and Kruse, in press). Tritium concentrations were also measured. Samples coll 1971 and subm by F Pietig and E Kruse, Inst f Bodenkunde, Bonn Univ.

Sample	¹⁴ C age
BONN-1237. Taipei, W Tanshui R, food co (25° 4' N, 121° 28' E)	4680 ± 90 2730 BC
BONN-1238. Taipei, W Tanshui R, chemical co (25° 1' N, 121° 26' E)	6930 ± 70 4980 BC
BONN-1239. Taipei, W Tanshui R, wire cable factory (25° 0' N, 121° 26' E)	102.5 ± 0.7% Modern

Sample	¹⁴ C age
BONN-1240. Ta Chiao (Kuo Hsiao) (25° 3' N, 121° 30' E)	7120 ± 150 5170 BC
BONN-1241. Yen Ping (25° 4' N, 121° 30' E)	6830 ± 180 4880 BC
BONN-1242. Ta Tung (25° 3' N, 121° 30' E)	6380 ± 180 4430 BC
BONN-1243. Cheng Yi (25° 4' N, 121° 29' E)	6440 ± 150 4490 BC
BONN-1244. Ta Tung Pei Lu (25° 3' N, 121° 29' E)	5030 ± 120 3080 BC
BONN-1245. Hsin Te (25° 4' N, 121° 28' E)	11,380 ± 230 9430 BC
BONN-1246. Kung 14 (25° 4' N, 121° 28' E)	13,200 ± 340 11,250 BC
BONN-1247. San Kuang (25° 3' N, 121° 29' E)	4160 ± 130 2210 BC
BONN-1248. San Chung (25° 4' N, 121° 29' E)	9200 ± 230 7250 BC
BONN-1249. Fu Te (25° 3' N, 121° 29' E)	4020 ± 150 2250 BC
BONN-1250. Lung Men (25° 4' N, 121° 29' E)	9530 ± 130 7580 BC
BONN-1251. Fe He (25° 1' N, 121° 29' E)	5350 ± 110 3400 BC
BONN-1251a. Miao Wei (25° 0' N, 121° 29' E)	3880 ± 90 1930 BC
BONN-1252. Electric factory (25° 0' N, 121° 29' E)	7340 ± 190 5390 BC
BONN-1253. Textile mill (25° 4' N, 121° 28' E)	9330 ± 160 7380 BC
BONN-1254. Water works (25° 0' N, 121° 27' E)	3840 ± 160 1890 BC
BONN-1255. New deep well of water works (25° 1' N, 121° 27' E)	4650 ± 150 2700 BC
BONN-1256. Paper mill Corp (25° 0' N, 121° 28' E)	4990 ± 270 3040 BC

Sample	^{14}C age
BONN-1257. Paper mill (25° 0' N, 121° 27' E)	4150 $\pm$ 270 2200 BC
BONN-1258. Fu Jen Univ (25° 2' N, 121° 25' E)	8270 $\pm$ 190 6320 BC
BONN-1259. Chang hua, No. 68 (23° 53' N, 120° 35' E)	109.6 $\pm$ 0.4% Modern
BONN-1260. Chang hua, No. 27 (23° 51' N, 120° 33' E)	2500 $\pm$ 60 550 BC
BONN-1261. Chang hua, No. 49 (23° 53' N, 120° 29' E)	3410 $\pm$ 60 1460 BC
BONN-1262. Chang hua, No. 12 (23° 57' N, 120° 27' E)	4980 $\pm$ 60 3030 BC
BONN-1263. Touliu, No. 383 (23° 43' N, 120° 31' E)	2270 $\pm$ 80 320 BC
BONN-1264. Touliu, No. 403 (23° 42' N, 120° 31' E)	2260 $\pm$ 70 310 BC
BONN-1265. Touliu, No. 378 (23° 41' N, 120° 13' E)	2750 $\pm$ 70 800 BC
BONN-1266. Touliu, No. 370 (23° 41' N, 120° 20' E)	5080 $\pm$ 110 3130 BC
BONN-1267. Touliu, No. 401, new well (23° 43' N, 120° 21' E)	5610 $\pm$ 70 3660 BC
BONN-1268. Tainan/Pingtung, No. 18, Dar Liao (22° 36' N, 120° 25' E)	100.7 $\pm$ 0.6% Modern
BONN-1269. Tainan/Pingtung, Dar Liao (22° 36' N, 120° 36' E)	104.7 $\pm$ 0.6% Modern
BONN-1270. Tser San (22° 36' N, 120° 36' E)	880 $\pm$ 90 AD 1070
BONN-1271. Sin Tso 5111-1 (22° 33' N, 120° 36' E)	350 $\pm$ 70 AD 1600
BONN-1272. Si Lin 5113-5 (22° 32' N, 120° 35' E)	3110 $\pm$ 90 1160 BC
BONN-1273. Lim Hon 5114-3 (22° 32' N, 120° 34' E)	3270 $\pm$ 70 1320 BC
BONN-1274. Wanlon 5113-7 (22° 31' N, 120° 35' E)	3350 $\pm$ 90 1400 BC

Sample	¹⁴ C age
BONN-1275. Nan An 5509-2 (22° 30' N, 120° 34' E)	3660 ± 100 1710 BC
BONN-1276. Gun Tan Men 5104-1 (22° 32' N, 120° 28' E)	102.3 ± 0.2% Modern
BONN-1277. Wan Tan 5103-1 (22° 35' N, 120° 28' E)	7460 ± 130 5510 BC
BONN-1278. Kan Din 5502-2 (22° 30' N, 120° 29' E)	7330 ± 130 5380 BC
BONN-1279. Hou Pi Tso 5505-1 (22° 31' N, 120° 30' E)	6720 ± 150 4770 BC
BONN-1280. Ta Hsiang Ying 5511-1 (22° 25' N, 120° 36' E)	1550 ± 90 AD 400
BONN-1281. Chan Lon 5510-5 (22° 26' N, 120° 33' E)	1820 ± 130 AD 130
BONN-1282. Tai Yuan No. 3 (22° 25' N, 120° 35' E)	1410 ± 100 AD 540
BONN-1283. Yuan Tan Tsz 5207-1 (22° 55' N, 120° 29' E)	190 ± 50 AD 1760
BONN-1284. Kin Cuar 5201-2 (22° 52' N, 120° 29' E)	4900 ± 100 2950 BC
BONN-1285. Peng Tso 5101-1 (22° 45' N, 120° 29' E)	490 ± 60 AD 1460
BONN-1286. Tung Hai Fong 5105-5 (22° 42' N, 120° 32' E)	730 ± 60 AD 1220
BONN-1287. Tson Lang 5102-1 (22° 43' N, 120° 28' E)	3190 ± 70 1240 BC
BONN-1288. Jen Wu 123 (?)	530 ± 70 AD 1420
BONN-1289. Hou Chin No. 17 (22° 43' N, 120° 17' E)	2270 ± 100 320 BC
BONN-1290. Jong San Tru 25 (22° 44' N, 120° 44' E)	2220 ± 90 270 BC
BONN-1291. E Chin Po, No. 17 (22° 44' N, 120° 18' E)	1100 ± 80 AD 840
BONN-1292. W Chin Po, No. 11 (22° 44' N, 120° 18' E)	2330 ± 70 380 BC

Sample	^{14}C age
BONN-1293. S Salun, No. 14 (22° 55' N, 120° 17' E)	101.1 ± 0.3% Modern
BONN-1294. N Salun, No. 28 (22° 56' N, 120° 17' E)	840 ± 80 AD 1110
BONN-1295. Kui Jen, No. 11 (22° 55' N, 120° 14' E)	2620 ± 80 670 BC
BONN-1296. Hu Shan, No. 15 (22° 56' N, 120° 12' E)	2480 ± 80 530 BC
BONN-1297. Hu Shan, No. 19 (22° 57' N, 120° 12' E)	2360 ± 90 410 BC
BONN-1298. Sin Yuan, No. 21 (22° 53' N, 120° 16' E)	4130 ± 90 2180 BC
BONN-1299. Lu Tzu, No. 15 (22° 50' N, 120° 14' E)	1120 ± 50 AD 830
BONN-1300. Pen Chau, No. 19 (20° 50' N, 120° 15' E)	1460 ± 50 AD 490
BONN-1701. Chiu Kui, No. 15 (22° 51' N, 120° 18' E)	2240 ± 60 290 BC
BONN-1702. Chin Jon Tza, No. 19 (22° 49' N, 120° 18' E)	3500 ± 60 1550 BC
BONN-1703. Tiou Chi Lin, No. 15 (22° 47' N, 120° 18' E)	2400 ± 50 450 BC
BONN-1704. N Kun Siu, No. 17 (22° 47' N, 120° 19' E)	2340 ± 60 390 BC
BONN-1705. S Kun Sui, No. 18 (22° 46' N, 120° 19' E)	1800 ± 70 AD 150
BONN-1706. Pai Shou Tze (22° 45' N, 120° 17' E)	1300 ± 50 AD 650
BONN-1707. Tainan, Wangliao, No. 11 (BONN-1707 -1718 all in S coastal plain, exact coordinates not available)	2480 ± 70 530 BC
BONN-1708. Tainan, Cheang, No. 2	7930 ± 80 5980 BC
BONN-1709. Taoyeh, No. 2	9500 ± 90 7550 BC

Sample		¹⁴ C age
BONN-1710.	Kanhse, No. 1	11,640 ± 160 9690 BC
BONN-1711.	Liufen Liao, No. 13	108.9 ± 0.3‰ Modern
BONN-1712.	Tseugwen, No. 15	1250 ± 70 AD 700
BONN-1713.	Sanhua, No. 11	3080 ± 70 1130 BC
BONN-1714.	Chiapo, No. 13	1530 ± 60 AD 580
BONN-1715.	Pantzeliao, No. 13	4960 ± 120 3010 BC
BONN-1716.	Pantzeliao, No. 14	6930 ± 170 4980 BC
BONN-1717.	Shinhua, No. 12	4540 ± 80 2590 BC
BONN-1718.	Chuochia, No. 13	1050 ± 70 AD 900

Comment: 84 ground water sources and wells are situated in 3 regions of W coastal plain of Taiwan, with heavy water consumption for irrigation and industry. Areas show alarming drop of water table as well as lowered land surface. Risk of penetration of recent percolates in well tubings, inherent to monsoon climate with much precipitation, had to be accepted, but is not estimated too great.

The basin of Taipei, BONN-1236 to -1258 harbors oldest water of region, recharged from the andesite heights in the N, Pleistocene sediments in the W, and the young Tertiary sediments in the S and E. Flow speed, calculated from isochrone distances is very low (< 1m/yr).

The coastal plain of the Choshui River Alluvial Fan, BONN-1259 to -1267 reveals 2 isochronous ground water lines of ca 2250 and 5250 yr ¹⁴C age, respectively. The NW-NE directed drainage shows a flow speed of ca 5m/yr.

The S tip of the coastal plain, BONN-1259 to -1718 (Chianan-Tainan-Pingtung-plain) is distinguished by the only slightly moving ground water of the depression in the Akungtien Reservoir region. Yet the SW flow (ca 3m/yr) of the water of the Pingtung plain syncline, in which NE-SW directed isochrones of ca 3300 and 7300 yr of ¹⁴C age can be distinguished. Dates may supply some new information for water management of the regions.

B. Eifel maar lake

These dates belong to water of volcanic maar lakes. Subhydric soil (gyttja) profiles of these lakes were also studied (R, 1973, v 15, p 267-271; see below: II. Subhydric soils).

	1730 $\pm$ 90 AD 220
BONN-1719. Schalkenmehrer Maar, S Eifel (50° 9.5' N, 6° 51' E)	13,560 $\pm$ 150 11,610 BC
BONN-1720. Laacher See, S Eifel (50° 25' N, 7° 16' E)	730 $\pm$ 90 AD 1220
BONN-1721. Meerfelder Maar, S Eifel (50° 6' N, 6° 45.5' E)	136.6 $\pm$ 0.5% Modern
BONN-1722. Pulvermaar, E Eifel (50° 8' N, 6° 55' E)	

Comment: volcanic maar lakes, except Pulvermaar, especially lake of Laach, seem to be influenced by dead CO₂ of volcanic origin. For lake of Laach estimates of Homann (1968) are 460 to 480 m³/day. The Pulvermaar contains largely modern surface water.

II. SUBHYDRIC SOILS, GYTTJA

A. Laach

Lake of Laach is not considered a typical maar lake, since craters of the huge gas explosion are numerous, scattered in the lake and the surrounding tuffaceous wall. Laach trachyt ashes are time marker of extraordinary importance for Alleröd age. Maximum depth of lake is 53m.

BONN-1572. Lake of Laach, Profile I, (Barschrücken) depth 10.30 to 12.80m, gyttja 12.1% C, 10 to 30cm.	10,710 $\pm$ 140 8760 BC
BONN-1573. 15.0% C, 30 to 48cm	11,930 $\pm$ 280 9980 BC
BONN-1574. 14.4% C, 48 to 62cm	11,820 $\pm$ 100 9870 BC
BONN-1575. 8.6% C, 62 to 70cm	17,550 $\pm$ 310 15,600 BC
BONN-1576. 3.6% C, 70 to 82cm	18,680 $\pm$ 250 16,730 BC
BONN-1578. 1.5% C, 90 to 100cm	21,520 $\pm$ 940 19,570 BC
BONN-1579. 1.2% C, 100 to 110cm	17,300 $\pm$ 490 15,350 BC

BONN-1580.	1.9‰ C, 110 to 120cm	17,470 ± 500 15,520 BC
BONN-1581.	1.7‰ C, 120 to 130cm	20,070 ± 410 18,120 BC
BONN-1582.	1.5‰ C, 130 to 140cm	19,070 ± 800 17,120 BC
BONN-1583.	0.7‰ C, 140 to 150cm	23,010 ± 460 21,060 BC
BONN-1584.	1.4‰ C, 150 to 160cm	21,780 ± 620 19,830 BC
BONN-1585.	1.7‰ C, 160 to 170cm	16,790 ± 640 14,840 BC
BONN-1586.	1.8‰ C, 170 to 180cm	19,230 ± 600 17,280 BC
BONN-1587.	1.6‰ C, 180 to 190cm	20,490 ± 910 18,540 BC
BONN-1588.	1.7‰ C, 190 to 200cm	18,650 ± 650 16,700 BC
BONN-1589.	0.5‰ C, 200 to 220cm	17,940 ± 380 15,990 BC
BONN-1590.	1.4‰ C, 220 to 240cm	22,530 ± 640 20,580 BC
BONN-1591.	Lake of Laach, Profile II (Alte Burg) depth 16.70 to 18.90m, gyttja, 12.5‰ C, 2 to 19cm	9000 ± 90 7050 BC
BONN-1592.	10.9‰ C, 19 to 30cm	9680 ± 130 7730 BC
BONN-1593.	11.3‰ C, 30 to 57cm	10,170 ± 140 8220 BC
BONN-1594.	7.8‰ C, 57 to 71cm	6770 ± 100 4820 BC
BONN-1595.	12.0‰ C, 71 to 89cm	8000 ± 90 6050 BC
BONN-1596.	13.5‰ C, 89 to 100cm	6970 ± 90 5020 BC
BONN-1597.	16.8‰ C, 100 to 108cm	7390 ± 100 5440 BC

BONN-1598.	15.5‰ C, 108 to 120cm	8170 ± 100 6220 BC
BONN-1599.	16.7‰ C, 120 to 131cm	8340 ± 140 6390 BC
BONN-1600.	16.4‰ C, 131 to 141cm	13,460 ± 180 11,510 BC
BONN-1601.	7.8‰ C, 141 to 147cm	17,390 ± 290 15,440 BC
BONN-1602.	11.8‰ C, 147 to 155cm	20,500 ± 380 18,550 BC
BONN-1603.	16.4‰ C, 155 to 163cm	17,720 ± 370 15,770 BC
BONN-1604.	1.7‰ C, 163 to 170cm	17,860 ± 610 15,910 BC
BONN-1607.	2.0‰ C, 190 to 200cm	19,410 ± 480 17,460 BC
BONN-1609.	Lake of Laach, Profile III ("Im Haferstück" near camping ground), depth 9.80 to 12.00m, gyttja, 8.2‰ C, 10 to 45cm	11,360 ± 220 9410 BC
BONN-1610.	10.1‰ C, 45 to 64cm	9880 ± 420 7930 BC
BONN-1611.	8.6‰ C, 64 to 80cm	10,230 ± 130 8280 BC
BONN-1612.	9.1‰ C, 80 to 90cm	9150 ± 240 7200 BC
BONN-1613.	13.6‰ C, 90 to 101cm	9810 ± 240 7860 BC
BONN-1614.	9.8‰ C, 101 to 113cm	9300 ± 120 7350 BC
BONN-1616.	3.0‰ C, 130 to 144cm	17,980 ± 320 16,030 BC
BONN-1617.	4.4‰ C, 144 to 155cm	18,900 ± 320 16,950 BC
BONN-1618.	3.4‰ C, 155 to 167cm	14,550 ± 290 12,600 BC
BONN-1619.	3.4‰ C, 167 to 180cm	22,070 ± 440 20,120 BC

BONN-1620.	2.6‰ C, 180 to 190cm	17,620 ± 410 15,670 BC
BONN-1621.	2.9‰ C, 190 to 200cm	18,780 ± 310 16,830 BC
BONN-1622.	7.3‰ C, 200 to 220cm	19,360 ± 370 17,410 BC
BONN-1623.	Lake of Laach, Profile IV ("Am Segelhafen"), depth 20 to 20.30m. gyttja, 5.1‰ C, 50 to 69cm	6090 ± 90 4140 BC
BONN-1624.	4.9‰ C, 69 to 86cm	6020 ± 90 4070 BC
BONN-1625.	7.3‰ C, 86 to 104cm	7830 ± 110 5880 BC
BONN-1626.	8.0‰ C, 104 to 117cm	9310 ± 140 7360 BC
BONN-1627.	8.4‰ C, 117 to 130cm	8710 ± 120 6760 BC
BONN-1628.	13.6‰ C, 130 to 144cm	10,450 ± 140 8500 BC
BONN-1629.	15.4‰ C, 147 to 160cm	10,240 ± 130 8290 BC
BONN-1630.	15.2‰ C, 160 to 170cm	10,700 ± 140 8750 BC
BONN-1631.	15.0‰ C, 170 to 180cm	6210 ± 70 4260 BC
BONN-1633.	14.0‰ C, 190 to 200cm	6540 ± 100 4590 BC
BONN-1634.	12.4‰ C, 200 to 220cm	7710 ± 90 5760 BC
BONN-1636.	13.3‰ C, 220 to 230cm	9180 ± 130 7230 BC
BONN-1637.	Lake of Laach, Profile V, (near bathing strip of monastery), depth 15.20 to 16.50m, gyttja, 10.5‰ C, 120 to 160cm	13,110 ± 140 11,160 BC
BONN-1638.	11.6‰ C, 160 to 170cm	17,790 ± 370 15,840 BC
BONN-1639.	10.4‰ C, 170 to 185cm	20,130 ± 300 18,180 BC

BONN-1640.	8.4% C, 185 to 200cm	18,760 $\pm$ 270 16,810 BC
BONN-1641.	6.8% C, 200 to 225cm	17,270 $\pm$ 330 15,320 BC
BONN-1643.	3.0% C, 225 to 250cm	19,770 $\pm$ 530 17,820 BC

Samples coll and subm 1971 by H W Scharpenseel, W Kerpen, H Gewehr, H Schiffmann, and C Hauptenthal, Inst Bodenkunde, Bonn Univ (50° 25' N, 7° 16' E). *Comment:* cores of gyttja sediment were taken with the aid of case lot of 250cm length. Sampling positions were selected, where echo sounder records indicated slightly thicker gyttja layers on top of the lacustrine clay and the underlying tuffaceous material. Very high ^{14}C ages necessitated check on ^{14}C age of water itself. Water sample, obtained near sampling spot of Profile V (this list, BONN-1720) was deficient in ^{14}C because of addition of dead CO_2 of volcanic origin. Maximum ^{14}C ages observed in Profiles I, II, III, V are >20,000 yr. Profile IV, showing highest ^{14}C age of 10,700 yr only, reveals heterogeneity of lake water with regard to dead carbon burden. Attempts at correcting gyttja age on basis of water date are futile due to inconsistency of dead, volcanic CO_2 supply throughout millennia after original gas explosions, as well as to formation of gyttja organics by surrounding terrestrial vegetation. Profile IV, W of ca 4km² lake surface, in nearly maximum distance from hitherto observed CO_2 exists, should come close to non-contaminated C-residence time of gyttja. Variation of age gradient with depth in gyttja sediments reflects mixing and translocation of subsurface currents, methane, and eventually CO_2 bubbles.

B. Meerfelder Maar

The lake, Meerfelder Maar, owes its maar-like shape to a combination of gas eruption and, particularly, the following collapse of the crater zone into the present day deeper valley with a rather shallow maar lake in the center. Its maximum depth is only 17m. Rich aquatic vegetation has produced a muddy, rapidly growing cover a gyttja over the sandstone bedrock.

BONN-1820.	Meerfelder Maar, Profile I, SW part of lake, depth 14.00 to 15.60m, gyttja, 6.8% C, 0 to 14cm	1740 $\pm$ 70 AD 210
BONN-1821.	8.6% C, 14 to 32cm	2920 $\pm$ 80 970 BC
BONN-1822.	3.8% C, 32 to 42cm	2170 $\pm$ 80 220 BC
BONN-1823.	6.8% C, 42 to 59cm	2380 $\pm$ 80 430 BC

		2550 ± 80
BONN-1824.	11.5% C, 59 to 68cm	600 BC
		2010 ± 90
BONN-1825.	4.8% C, 68 to 74cm	60 BC
		2670 ± 110
BONN-1826.	5.0% C, 74 to 83cm	720 BC
		1870 ± 70
BONN-1827.	6.5% C, 83 to 97cm	AD 80
		6800 ± 100
BONN-1828.	21.8% C, 97 to 106cm	4850 BC
		2280 ± 80
BONN-1829.	7.5% C, 106 to 117cm	330 BC
		2440 ± 110
BONN-1830.	9.8% C, 117 to 128cm	490 BC
		4520 ± 100
BONN-1831.	13.8% C, 128 to 132cm	2570 BC
		3770 ± 80
BONN-1832.	22.8% C, 132 to 150cm	1820 BC
		5630 ± 90
BONN-1818.	12.7% C, 150 to 160cm	3680 BC
BONN-1833.	Meerfelder Maar, Profile 2, WSW part of lake, depth 15.00 to 16.20m, gyttja, 18% C, 0 to 20cm	2980 ± 80 1030 BC
		2840 ± 70
BONN-1834.	19.5% C, 20 to 40cm	890 BC
		3440 ± 110
BONN-1835.	25.9% C, 40 to 60cm	1490 BC
		3510 ± 120
BONN-1836.	29.7% C, 60 to 80cm	1560 BC
		3530 ± 100
BONN-1837.	30.4% C, 80 to 100cm	1580 BC
		9140 ± 120
BONN-1838.	21.3% C, 100 to 120cm	7190 BC
BONN-1839.	Meerfelder Maar, Profile 3, W part of lake, depth 14.00 to 15.70m, gyttja, 15.0% C, 0 to 12cm	2900 ± 70 950 BC
		3100 ± 110
BONN-1840.	27.3% C, 12 to 26 cm	1150 BC

BONN-1841.	34.4‰ C, 26 to 43cm	3480 ± 60 1530 BC
BONN-1842.	30.4‰ C, 43 to 55cm	3400 ± 70 1450 BC
BONN-1843.	23.7‰ C, 55 to 64cm	3380 ± 80 1430 BC
BONN-1844.	36.8‰ C, 64 to 83cm	3140 ± 70 1190 BC
BONN-1845.	17.5‰ C, 83 to 101 cm	5060 ± 70 3110 BC
BONN-1846.	21.3‰ C, 101 to 109cm	5410 ± 90 3460 BC
BONN-1847.	17.5‰ C, 109 to 120cm	6150 ± 90 4200 BC
BONN-1848.	18.7‰ C, 120 to 140cm	6210 ± 90 4260 BC
BONN-1849.	14.5‰ C, 140 to 170cm	7380 ± 90 5430 BC
BONN-1850.	Meerfelder Maar, Profile 4, NW part of lake, depth 10.00 to 11.75m, gyttja, 13.5‰ C, 0 to 18cm	2100 ± 70 150 BC
BONN-1851.	11.0‰ C, 18 to 38cm	2260 ± 70 310 BC
BONN-1852.	19.7‰ C, 38 to 56cm	2470 ± 70 520 BC
BONN-1853.	30.0‰ C, 56 to 72cm	3340 ± 110 1390 BC
BONN-1854.	28.5‰ C, 72 to 92cm	4150 ± 80 2200 BC
BONN-1855.	27.5‰ C, 92 to 105cm	4060 ± 110 2110 BC
BONN-1856.	27.0‰ C, 105 to 130cm	4480 ± 80 2530 BC
BONN-1857.	28.0‰ C, 130 to 137cm	4770 ± 100 2820 BC
BONN-1858.	18.8‰ C, 137 to 145cm	5020 ± 80 3070 BC

		5550 $\pm$ 90 3600 BC
BONN-1859.	17.5% C, 145 to 175cm	
BONN-1860.	Meerfelder Maar, Profile 5, N part of lake, 10.00 to 11.60m depth, gyttja, 11.0% C, 0 to 30cm	2440 $\pm$ 70 490 BC
BONN-1861.	8.2% C, 30 to 47cm	1720 $\pm$ 70 AD 230
BONN-1862.	8.5% C, 47 to 62cm	1990 $\pm$ 70 40 BC
BONN-1863.	3.7% C, 62 to 70cm	2240 $\pm$ 70 290 BC
BONN-1864.	7.3% C, 70 to 90cm	2080 $\pm$ 140 130 BC
BONN-1865.	12.5% C, 90 to 110cm	2440 $\pm$ 70 490 BC
BONN-1866.	25.8% C, 110 to 130cm	2620 $\pm$ 70 670 BC
BONN-1867.	25.0% C, 130 to 160cm	3520 $\pm$ 80 1570 BC
BONN-1868.	Meerfelder Maar, Profile 6, E part of lake, 7.00 to 8.40m depth, gyttja, 23.0% C, 0 to 6cm	2630 $\pm$ 110 680 BC
BONN-1869.	20.5% C, 6 to 21cm	2800 $\pm$ 70 850 BC
BONN-1870.	9.5% C, 21 to 35cm	2640 $\pm$ 70 690 BC
BONN-1871.	7.8% C, 35 to 51cm	1290 $\pm$ 70 AD 660
BONN-1872.	11.5% C, 51 to 67cm	1810 $\pm$ 60 AD 140
BONN-1873.	7.8% C, 67 to 88cm	2390 $\pm$ 70 440 BC
BONN-1874.	9.7% C, 88 to 98cm	2480 $\pm$ 70 530 BC
BONN-1875.	14.3% C, 98 to 111cm	2630 $\pm$ 80 680 BC
BONN-1876.	36.7% C, 111 to 140cm	4050 $\pm$ 80 2100 BC

Samples coll and subm 1972 by H W Scharpenseel, H Gewehr, and K Kirschey, Inst Bodenkunde, Bonn Univ (50° 6' N, 6° 45.5' E). *Comment*: organic matter, adjacent to underlying tuffaceous material, from deep bore holes, produced radiocarbon dates of 10,950 yr; palynologic evaluation suggested 11,350 yr for the volcanic event (Erlenkäufer *et al*, 1970). Lake water, itself, produces a radiocarbon age of 730 yr (this list, BONN-1721), may be caused by some volcanogenic, dead CO₂ or by influx of older, fossil water from the bottom through underground cleaves, traceable with the echosounder. Still, the oldest ages of core fractions lag considerably behind the dates of Erlenkäufer *et al*. During the summer, water gets highly turbid, caused by intensive growth of green and red algae and aquatic plants. Most of the upper 30 to 60cm of gyttja were quite muddy and soft, while some of the deeper lying substance had a rather compact or almost peaty character. Relics of beach leaves, found in some of the middle samples indicated rather young age of corresponding material. Gaps between maximum dates of gyttja fractions (Profile 1 = 6800 yr; 2 = 9140 yr; 3 = 7380 yr; 4 = 5550 yr; 5 = 3520 yr; 6 = 4050 yr); and dates of organic material on top of tuff and bedrock, dated by Erlenkäufer *et al*, could be attributed to the organic matter, embedded in the rather impervious lacustrine clay, between gyttja and tuffaceous material or bedrock. This clay was partly quite compacted; penetration of the case lot was so difficult, that under pressure of lead weight, the case became twisted and inclined, losing its vertical position. Particularly in the shallower parts of the maar, eg, in the sectors of Profiles 5 and 6, (N and E part of lake) the softer gyttja in the earlier phase of sedimentation, must have slipped into deeper ground. This could explain the young age throughout Cores 5 and 6. Results are part of a joint program for over-all exploration of Meerfelder Maar's properties.

C. Pulvermaar (Gillenfelder Maar)

The Pulvermaar is an ideal maar kettle with an almost circular maar lake in the center. The Pulvermaar lake is the deepest of all Eifel maars and the deepest German lake outside the Alp region. Its depth is 74m in most of the lake area. The water is very clear with little aquatic vegetation. Completely wooded surroundings assures a certain supply of leaf droppings from terrestrial vegetation to the lake ground.

BONN-1877.	Pulvermaar, Profile 1, in front of parking lane, between camping ground and official beach, 62 to 64m depth, gyttja, 10.5% C, 0 to 27cm	2120 ± 70 170 BC
		2500 ± 100
BONN-1878.	6.0% C, 27 to 38cm	550 BC
		3240 ± 80
BONN-1879.	8.3% C, 38 to 48cm	1290 BC

BONN-1880.	22.0% C, 48 to 62cm	3470 $\pm$ 110 1520 BC
BONN-1881.	19.0% C, 62 to 75cm	3820 $\pm$ 80 1870 BC
BONN-1882.	32.3% C, 75 to 81cm	3780 $\pm$ 80 1830 BC
BONN-1883.	34.0% C, 81 to 95cm	4700 $\pm$ 80 2750 BC
BONN-1884.	38.7% C, 95 to 99cm	4140 $\pm$ 100 2190 BC
BONN-1885.	25.5% C, 99 to 113cm	5100 $\pm$ 120 3150 BC
BONN-1886.	26.1% C, 113 to 129cm	5200 $\pm$ 110 3250 BC
BONN-1887.	28.0% C, 129 to 148cm	4720 $\pm$ 80 2770 BC
BONN-1888.	31.2% C, 148 to 150cm	7610 $\pm$ 230 5660 BC
BONN-1889.	33.8% C, 150 to 169cm	6640 $\pm$ 150 4690 BC
BONN-1890.	21.7% C, 169 to 180cm	7470 $\pm$ 150 5520 BC
BONN-1891.	21.0% C, 180 to 200cm	8040 $\pm$ 120 6090 BC
BONN-1892.	Pulvermaar, Profile 2, between camping ground and sandbank, 72 to 74m, gyttja, 7.3% C, 0 to 24cm	1440 $\pm$ 70 AD 510
BONN-1893.	28.7% C, 24 to 37cm	2140 $\pm$ 70 190 BC
BONN-1894.	11.7% C, 37 to 51cm	2440 $\pm$ 70 490 BC
BONN-1895.	13.2% C, 51 to 62cm	2390 $\pm$ 80 440 BC
BONN-1896.	6.0% C, 62 to 68cm	2940 $\pm$ 100 990 BC
BONN-1897.	13.2% C, 68 to 81cm	4580 $\pm$ 80 2630 BC

BONN-1898.	32.6‰ C, 81 to 95cm	4800 ± 100 2850 BC
BONN-1899.	30.0‰ C, 95 to 115cm	5360 ± 90 3410 BC
BONN-1900.	28.5‰ C, 115 to 126cm	4940 ± 90 2990 BC
BONN-1901.	35.5‰ C, 126 to 138cm	4710 ± 80 2760 BC
BONN-1902.	33.8‰ C, 138 to 146cm	5660 ± 90 3710 BC
BONN-1903.	28.8‰ C, 146 to 176cm	6720 ± 110 4770 BC
BONN-1904.	Pulvermaar, Profile 3, in front of quarry, 72 to 74m depth, gyttja, 10.9‰ C, 0 to 10cm	1870 ± 90 AD 80
BONN-1905.	28.8‰ C, 10 to 21cm	1560 ± 70 AD 390
BONN-1906.	13.9‰ C, 21 to 30cm	1960 ± 90 10 BC
BONN-1907.	10.1‰ C, 30 to 45cm	2080 ± 70 130 BC
BONN-1908.	10.9‰ C, 45 to 56cm	1720 ± 70 AD 230
BONN-1909.	11.3‰ C, 56 to 65cm	2400 ± 70 450 BC
BONN-1910.	9.7‰ C, 65 to 71cm	2530 ± 70 580 BC
BONN-1911.	5.3‰ C, 71 to 79cm	2600 ± 70 650 BC
BONN-1912.	13.1‰ C, 79 to 91cm	2410 ± 70 460 BC
BONN-1913.	29.6‰ C, 91 to 111cm	3440 ± 70 1490 BC
BONN-1914.	23.2‰ C, 111 to 140cm	3400 ± 70 1450 BC
BONN-1915.	28.5‰ C, 140 to 170cm	5360 ± 180 3410 BC

		6420 $\pm$ 180 4470 BC
BONN-1916.	31.5% C, 170 to 185cm	
BONN-1917.	Pulvermaar, Profile 4, lake center, 74 to 76m depth, gyttja, 5.7% C, 0 to 18cm	1650 $\pm$ 100 AD 300
BONN-1918.	9.8% C, 18 to 24cm	730 $\pm$ 70 AD 1220
BONN-1919.	7.0% C, 24 to 39cm	880 $\pm$ 150 AD 1070
BONN-1920.	39 to 49cm	890 $\pm$ 70 AD 1060
BONN-1921.	49 to 64cm	730 $\pm$ 70 AD 1220
BONN-1922.	64 to 81cm	1310 $\pm$ 70 AD 640
BONN-1923.	81 to 88cm	1730 $\pm$ 60 AD 220
BONN-1924.	88 to 106cm	2210 $\pm$ 70 260 BC
BONN-1925.	106 to 121cm	2610 $\pm$ 70 660 BC
BONN-1926.	121 to 127cm	3690 $\pm$ 70 1740 BC
BONN-1927.	19.1% C, 127 to 142cm	3000 $\pm$ 70 1050 BC
BONN-1928.	26.7% C, 142 to 153cm	3310 $\pm$ 70 1360 BC
BONN-1929.	22.9% C, 153 to 163cm	3760 $\pm$ 90 1810 BC
BONN-1930.	3.5% C, 163 to 200cm	4980 $\pm$ 80 3030 BC
BONN-1931.	Pulvermaar, Profile 5, in front of public beach (Badeanstalt), 72 to 74m depth gyttja, 7.9% C, 0 to 27cm	1280 $\pm$ 60 AD 670
BONN-1932.	5.6% C, 27 to 42cm	1300 $\pm$ 60 AD 650
BONN-1933.	6.4% C, 42 to 53cm	1860 $\pm$ 70 AD 90

BONN-1934.	10.2‰ C, 53 to 60cm	1040 ± 70 AD 910
BONN-1935.	14.7‰ C, 60 to 67cm	1150 ± 70 AD 800
BONN-1936.	23.2‰ C, 67 to 78cm	1810 ± 60 AD 140
BONN-1937.	12.4‰ C, 78 to 95cm	2090 ± 60 140 BC
BONN-1938.	13.2‰ C, 95 to 105cm	2490 ± 70 540 BC
BONN-1939.	7.5‰ C, 105 to 109cm	3090 ± 70 1140 BC
BONN-1940.	8.3‰ C, 109 to 114cm	2910 ± 80 960 BC
BONN-1941.	21.0‰ C, 114 to 131cm	2750 ± 70 800 BC
BONN-1942.	18.8‰ C, 131 to 135cm	3450 ± 90 1500 BC
BONN-1943.	23.7‰ C, 135 to 144cm	4240 ± 100 2290 BC
BONN-1944.	35.7‰ C, 144 to 156cm	4050 ± 80 2100 BC
BONN-1945.	32.5‰ C, 156 to 160cm	5170 ± 180 3220 BC
BONN-1946.	27.4‰ C, 160 to 173cm	4860 ± 100 2910 BC
BONN-1947.	33.8‰ C, 173 to 203cm	5140 ± 80 3190 BC

Samples coll and subm 1972 by H W Scharpenseel, H Gewehr, and K Kirschey (50° 8' N, 6° 55' E). *Comment:* ^{14}C dates of deepest organic matter in contact with tuff and bedrock, publ by Erlenkäufer *et al* (1970; 1972) date maar producing volcanic events to 11,300 yr, with palynologic estimates of 10,150 yr. Lake water in Pulvermaar, based on surface near sample, taken close to site of Profile 5, is modern (this list, BONN-1722). From local rainfall and evaporation, the water balance is positive and no visible influx nor outflow exists. Failure of the water level to rise correspondingly suggests subterranean water losses. All profiles are taken in deep water. Due to steep lake bottom, >70m depth,

- BONN-1957.** **720 ± 70**
AD 1230
Wood, Huaca Chotura, dist Lambayeque, to date pre-Spanish pyramid (6° 30' S, 79° 40' W).
- BONN-1958.** **590 ± 70**
AD 1360
Wood, Huaca Chotuna, dist Lambayeque, to date pre-Spanish pyramid (6° 30' S, 79° 40' W).
- BONN-1959.** **960 ± 80**
AD 990
Charcoal, Quebrada de la Vaca, dist Chala, to date pre-Spanish settlement (15° 48' S, 74° 24' W).
- BONN-1960.** **1090 ± 70**
AD 860
Charcoal, Quebrada de la Vaca, dist Chala, to date pre-Spanish settlement (15° 48' S, 74° 24' W).
- BONN-1961.** **820 ± 100**
AD 1130
Charcoal, Quebrada de la Vaca, dist Chala, to date pre-Spanish settlement (15° 48' S, 74° 24' W).
- BONN-1962.** **150 ± 100**
AD 1800
Charcoal, Pampa de Taimara, dist Chala, to date pre-Spanish settlement (15° 48' S, 74° 24' W).
- BONN-1963.** **490 ± 100**
AD 1460
Charcoal, Quebrado de Mocca, dist Chala, to date pre-Spanish settlement (15° 48' S, 74° 24' W).
- BONN-1964.** **860 ± 60**
AD 1090
Wood, Inclán, Sama Grande, prov Tacna, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1965.** **700 ± 70**
AD 1250
Charcoal, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1966.** **220 ± 100**
AD 1730
Wood, Lluta, dist Pachia, to date pre-Spanish settlement in Caplina valley, S Peru (17° 45' S, 70° 15' W).
- BONN-1967.** **900 ± 100**
AD 1050
Charcoal, Challatita, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).

- BONN-1968.** **200 ± 100**
AD 1750
Wood, Alto de Sama, dist Inclán, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1969.** **1560 ± 200**
AD 390
Wood, Alto de Sama, dist Inclán, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1970.** **390 ± 100**
AD 1560
Wood, Alto de Sama, dist Inclán, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1971.** **110 ± 100**
AD 1840
Wood, Cantalloc, Nazca-Tal, dist Nazca, to date pre- or post Columbian drainage canals (15° S, 75° W).
- BONN-1972.** **140 ± 100**
AD 1810
Wood, Majore, Nazca-valley, dist Nazca, to date pre- or post Columbian drainage canals (15° S, 75° W).
- BONN-1975.** **104.8 ± 0.5%**
Modern
Wooden cane, relics of house wall, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1976.** **350 ± 100**
AD 1600
Relics from house wall of wooden cane. Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1977.** **520 ± 70**
AD 1430
Relics of wooden pole, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1978.** **104.0 ± 0.4%**
Modern
Relics of wooden pole, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1979.** **140 ± 120**
AD 1810
Relics of wooden house wall made of wooden cane, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).
- BONN-1980.** **210 ± 100**
AD 1740
Relics of wooden pole, Lluta, dist Pachia, to date pre-Spanish settlement (17° 45' S, 70° 15' W).

BONN-1981.

1610 ± 110

AD 340

Charcoal, Bermejo, dep Ancash, to date pre-Spanish settlement (10° 30' S, 78° W).

2450 ± 110

BONN-1982.

AD 500

Charcoal, Bermejo, dep Ancash, to date pre-Spanish settlement (10° 30' S, 78° W).

Samples coll and subm 1972 by H Trimborn, Inst Anthropol, Bonn Univ. *Comment:* submitter uses dates within framework of book on pre-Spanish settlements in S Peru. For evaluation of dates, see H Trimborn (1972).

REFERENCES

- Erlenkäufer, H, Frechen, J, Straka, H, and Willkomm, H, 1972, Das Alter einiger Eifelmaare nach neuen petrologischen, pollenanalytischen und Radiocarbon-Untersuchungen: *Decheniana*, v 125, p 113-129.
- Erlenkäufer, H, Straka, H, and Willkomm, H, 1970, Neue ¹⁴C-Datierungen zum Alter der Eifelmaare: Eiszeitalter und Gegenwart, v 21, p 177-181.
- Homann, W, 1968, Tauchen in den Eifelmaaren, *Z Delphin*, v 10, p 9-10.
- Okrusch, M, Strunk-Lichtenberg, G, and Gabriel, B, 1973, Vorgeschichtliche Keramik aus dem Tibesti (Sahara), *Berichte der Deutschen Keramischen Gesellschaft*, v 50, p 261-296.
- Scharpenseel, H W and Pietig, F, 1969, Einfache Boden-und Wasserdatering durch Messung der ¹⁴C-oder Tritiumkonzentration: *Geoderma*, v 2, p 273-289.
- 1970, Alterbestimmung mit dem Flüssigkeits-Szintillations-Spektrometer—Vereinfachte Benzolsynthese, auch aus kleinen CO₂-Mengen: *Atompraxis*, v 16, p 1-2.
- 1973, University of Bonn natural radiocarbon measurements V, v 15, p 13-41.
- 1973, University of Bonn natural radiocarbon measurements VI, v 15, p 252-279.
- Scharpenseel, H W, Pietig, F, and Kruse, E, Radiocarbon dating of ground water samples in Taiwan: *Fu Jen Sci News* (in press).
- Trimborn, H, 1973, Nueva fechas radiocarbónica para algunos monumentos y sitios prehispánicos de la costa peruana: 40th internatl cong Americanists, proc, 1972, Rome-Genova.

**RADIOISOTOPES LABORATORY
RADIOCARBON DATE LIST I**

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INTRODUCTION

The Radioisotopes Laboratory was established in January 1972, in order to supply radiocarbon measurements of various samples to several institutions. Active analyses commenced in June following the testing and evaluation of equipment and known samples for accuracy and reproducibility. During this time, data was accumulated for the statistical establishment of counting accuracy, particularly for background activity.

The laboratory utilizes liquid scintillation counting techniques for radiocarbon analysis through conversion of sample carbon to benzene. The underlying principles in the synthesis techniques are those developed by Noakes *et al*, (1965; 1967; 1971) without major modifications. A vanadium-alumina catalyst (Task) is used at reduced temperature for the acetylene to benzene conversion.

The radiocarbon-containing benzene sample is mixed with the scintillator solution and counted in one of 3 Picker Nuclear Corporation Liquimat 220 liquid scintillation spectrometers. Counting time is dependent on estimates sample age and is usually 4000-5000 mins. Age calculations are routinely performed on a Wang Model 450 programmable electronic calculator.

LABORATORY OPERATIONS

Samples are routinely inspected under 20X illuminated magnification for obvious impurities (rootlets, leaves, bush bristles, etc) and are prepared for chemical removal of contaminants. Unless otherwise indicated, all samples are routinely pretreated even when no contamination is evident.

A charcoal or wood sample free of rootlets is broken into fragments 2 to 3cm long and 5 to 6mm thick, treated with 2.0N NaOH at room temperature and stirred for 24 hrs, filtered, washed and treated in boiling 2.0N NaOH for 3 hrs. Filtering and boiling are repeated with the sample receiving an additional final base soak at room temperature for 48 hrs. The sample is then stored in 2.0N HCl for 48 hrs for carbonate removal and minimization of atmospheric carbon dioxide uptake. Washing to neutrality with distilled water completes the procedure.

If rootlet contamination is suspected, the standard base treatment is augmented by slightly modified procedures (Michael and Ralph, 1970). The charcoal is placed in concentrated HCl (18M) followed by slow addition, with stirring, of NaOCl, and remains in solution overnight. Next follows thorough washing and nitration in a 1:1 mixture of concentrated HNO_3 , H_2SO_4 for 2 hrs at room temperature. The residue is