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# HANNOVER RADIOCARBON MEASUREMENTS IV

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## INTRODUCTION

This date list covers a selection of $C^{14}$ results of archaeologic, hydrologic and speleologic samples that have been investigated in the period from March 1963 until July 1966. Dates of geologic samples will be presented in the following list.

The ages were calculated on a $C^{14}$ half-life of 5568 yr and 0.95 of the activity of the NBS oxalic-acid standard, and are quoted in the years before 1950. The age errors encompass the "true $C^{14}$ ages" with a probability of 68%. Included in the error calculations are the standard deviations of the background and of the NBS standard, which are each 3‰, and the counting error of sample. $C^{13}$ corrections have not been carried out. Infinite ages are stated on a criterion of $2\sigma$ above background.

The recent activity of water and calcareous sinter is assumed to be 85% modern. According to the model for age determination of water (Münnich, 1957; Münnich and Vogel, 1959) the $\delta C^{13}$ value of the precipitated free and fixed carbonic acid (Pearson, 1965; Geyh and Wendt, 1965) would be given by the equation:

$$\delta C^{13}{}_{M} = \frac{\frac{1}{2}\,[HCO_3] + [CO_2]}{[HCO_3] + [CO_2]}\ \delta C^{13}{}_{org}$$

$[HCO_3]$ and $[CO_2]$ are the concentrations of the fixed and free carbonic acid in mM/L, and $\delta C^{13}{}_{org}$ is the $C^{13}$-ratio of organic material, approximately equal to −25‰. Owing to the low precision of $CO_2$ and $HCO_3$ determinations, $\delta C^{13}{}_{M}$ can only be determined with an error of ± 2‰. By comparison of the measured $\delta C^{13}$ value of the precipitated free and fixed carbonic acid from a sample, with $\delta C^{13}{}_{M}$, it can be checked whether carbon dioxide other than that which is biogenic and recent contributed to the carbonic acid equilibrium.

The method is essentially the same as that used for the work described in the previous lists (Hannover I, II, III). For the preparation of the counting gases $C_2H_2$ and $C_2H_6$, a new apparatus was constructed, by help of which one technician can prepare four samples per day.

After extensive general tests, five new counters were set in operation with the result that the number of samples to be dated per year could be increased to 600. Technical data of these counters are covered in the following table:

| Name | Type | Vol L | p | $n_0$ cpm | $n_s$ cpm | $Age_{max}$ yr | Time hr | Ref. |
|---|---|---|---|---|---|---|---|---|
| GZR | Oeschger | 4.57 | 1 | 4.26 | 48.75 | 50,500 | 2 x 20 | Geyh, 1965a |
| | | | 3 | 7.75 | 146.00 | 62,000 | 7 x 24 | Houtermans & Oeschger, 1958 |
| BZR | | 1.50 | 1 | 1.52 | 17.30 | 46,000 | 2 x 20 | |
| PZR | | 1.50 | 1 | 1.22 | 16.84 | 46,000 | 2 x 20 | |
| MZR | Copper quartz | 0.87 | 1 | 1.69 | 7.59 | 39,000 | 2 x 20 | de Vries and others, 1959 |
| LZR | tube | 0.22 | 1 | 1.05 | 2.32 | 33,000 | 2 x 20 | |
| SZR | Scint. plastic | 0.04 | 1 | 0.15 | 0.30 | 19,000 | 2 x 20 | Geyh, 1965a |

(Abbreviations: p = filling pressure in atm; $n_0$ = background; $n_s$ = .95 x net counting rate of NBS oxalic-acid standard; max $age_{max}$ = measured infinite age; time = counting time; Vol is effective volume.)

The measurements are done with a vacuum-tube apparatus tested for its stability, without $\alpha$-discriminator. Each sample is measured twice in different counters. In those cases where the sample sizes are too small for the filling of one counter with 1 atm, background gas is admixed (Geyh, 1966). For checking the constancy of the $C^{14}$ time-scale, a dendrochronologically dated wood sample was measured monthly. Routine operating conditions are fixed according to methods already described (Geyh, 1965a).

Sample descriptions have been prepared in collaboration with collectors and submitters.

Abbreviations in the following text are: N.L.f.B. for Niedersächsisches Landesamt für Bodenforschung, Hannover (Germany); B.f.B. for Bundesanstalt für Bodenforschung, Hannover (Germany); and G.L. for Geologisches Landesamt.

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## SAMPLE DESCRIPTIONS

### I. ARCHAEOLOGIC SAMPLES

### *A. Germany*

**Tarmstedt series, Niedersachsen**

Charcoal from excavation of prehistorical circular burial with vault near Tarmstedt (53° 14′ 43″ N Lat, 9° 4′ 21″ E Long). Covered with sandy soil. Coll. 1966 and subm. by Joachim Deichmüller, Niedersächsisches Landesverwaltungsamt für Bodendenkmalspflege, Hannover. Samples date a unique grave, presumably of Bronze age.

**Hv-1391. Tarmstedt, 0.4 m depth** — **2800 ± 85 / 850 B.C.**
Sample of tree coffin.

**Hv-1392. Tarmstedt, 0.5 m depth** — **2950 ± 80 / 1000 B.C.**
Sample of tree coffin.

**Hv-1393. Tarmstedt, 0.3 m depth** — **2955 ± 80 / 1005 B.C.**
Wall remains of a vault.

**Hv-1395. Tarmstedt, 0.2 m depth** — **2870 ± 135 / 920 B.C.**
Remains of a wooden peg from the vault.

**Hv-1396. Tarmstedt, 0.3 m depth** — **2980 ± 155 / 1030 B.C.**
Remains of the vault entrance.

**Hv-1397. Tarmstedt, 0.8 m depth** — **2910 ± 130 / 960 B.C.**
Remains of a tree coffin. *Comment:* according to the manner of grave arrangement, age of 3500 B.P. was assumed. $C^{14}$ results show that in N Germany cremations with circular grave arrangements were performed even later.

**Hv-827. Ohlenstedt, Niedersachsen** — **3400 ± 105 / 1450 B.C.**
Chacoal from excavation of lower grave, 0.2 to 0.3 m depth, near Ohlenstedt (53° 17′ 39″ N Lat, 8° 45′ 39″ E Long), imbedded in sand. Coll. 1963 and subm. by J. Deichmüller. *Comment:* according to layout of grave and to ceramics, assignment was to older Bronze age.

**Hv-821. Gräpel, Niedersachsen** — **2650 ± 75 / 700 B.C.**
Charcoal from excavation of hill grave, 0.2 m depth, near Gräpel (53° 33′ 10″ N Lat, 9° 11′ 6″ E Long), imbedded in sand. Coll. 1961 and

subm. by J. Deichmüller. *Comment:* agrees with archaeologic dating of a cremation urn.

**6010 ± 100**

**Hv-366. Billerbeck, Niedersachsen** **4060 B.C.**

Charcoal from excavation of hill grave, 0.6 m depth, near Billerbeck (52° 52′ 42″ N Lat, 10° 52′ 15″ E Long). Coll. 1960 and subm. by J. Deichmüller. *Comment:* sample dates an ornamented pottery.

**4100 ± 140**

**Hv-369. Bullenburg, Niedersachsen** **2150 B.C.**

Charcoal from hill grave with circular trench, 1.3 m depth, near Bullenberg (53° 4′ 3″ N Lat, 9° 40′ 43″ E Long), imbedded in natural soil. Coll. 1957 and subm. by J. Deichmüller. *Comment:* sample dates a hill grave type, with a form of burial that so far could not be classified chronologically.

**Deinste series, Niedersachsen**

Charcoal from excavation of large stone grave near Deinste (53° 30′ 45″ N Lat, 9° 27′ 24″ E Long), overlain by natural soil. Coll. 1959 and subm. by J. Deichmüller. Sample date large Neolithic stone grave and ceramics.

**4170 ± 80**

**Hv-345. Deinste, 1.6 m depth** **2220 B.C.**

Charcoal from fireplace near a vault.

**4040 ± 110**

**Hv-348. Deinste, 1.4 m depth** **2090 B.C.**

Charcoal from a cult fireplace.

**3470 ± 80**

**Hv-824. Deinste, 1.6 m depth** **1520 B.C.**

Charcoal from the stone chamber.

**3410 ± 100**

**Hv-825. Deinste, 1.5 m depth** **1460 B.C.**

Charcoal from stone settlement beside the main burial place. *Comment:* in contrast to the archaeologic assumption, i.e. that the stone grave and the cult fireplace are of same age, results prove that stone grave was built during Bronze age.

**Goldbeck series, Niedersachsen**

Charcoal from excavation of circular burial with wooden vault near Goldbeck (53° 24′ 12″ N Lat, 9° 38′ 10″ E Long), overlain by debris. Coll. 1962 and subm. by J. Deichmüller. Sample date Stone age burial place, which was later used for a burial during Bronze age.

**1735 ± 100**

**Hv-752. Goldbeck, 0.45 m depth** **A.D. 215**

Charcoal from upper burial place.

**4085 ± 80**

**Hv-753. Goldbeck, 0.80 m depth** **2135 B.C.**

Plank of vault.

**4110 ± 85**

**Hv-759. Goldbeck, 1.30 m depth** **2160 B.C.**

Charcoal from circular trench.

**4020 ± 75**

**Hv-810. Goldbeck, 1.20 m depth** **2070 B.C.**

Charcoal from the chief burial. *Comment:* pottery findings of the old burial place date them to 2000 B.C. Discovery of a flint spearhead suggests Bronze age date for younger burial place.

**2355 ± 75**

**Hv-804. Effeln, Nordrhein-Westfalen** **405 B.C.**

Charcoal from excavation of urn cemetery of Hallstatt age near Effeln (51° 32′ 54″ N Lat, 8° 22′ 59″ E Long), overlain by "parabraunerde." Coll. 1964 and subm. by E. von Zezschwitz, G. L. Nordrhein-Westfalen, Krefeld. *Comment:* dating of an urn, ornamented with a delicate comb-like line, which according to H. Beck, Landesmuseum für Vor- und Frühgeschichte, Münster, was assigned to Hallstatt D or C (2600 B.P.) (Henneböle, 1959).

**3660 ± 70**

**Hv-773. Luttum, Niedersachsen** **1710 B.C.**

Charcoal of hill grave excavation, 0.9 m depth, near Luttum (52° 53′ 48″ N Lat, 9° 18′ 18″ E Long), overlain by sand. Coll. 1964 and subm. by R. Schünemann, Heimatmuseum, Borstel. *Comment:* dating of a cup, from a single grave, with scratched angular band-decoration; age of 1800 B.C. was assumed (Schünemann, 1965).

**3420 ± 60**

**Hv-587. Walkemühle, Niedersachsen** **1470 B.C.**

Charcoal from excavation of hill burial place of Bronze age, 0.5 to 0.7 m depth, at Walkemühle (51° 31′ 25″ N Lat, 9° 55′ 49″ E Long). Coll. 1963 and subm. by R. Maier, Seminar für Vor- und Frühgeschichte der Universität Göttingen. *Comment:* according to earlier dates (Meyer and others, 1963) of similar fragments from hill graves, should be Bronze age (approx. 1400 B.C.) or younger (Maier, 1964).

**1440 ± 75**

**Hv-1394. Tarmstedt, Niedersachsen** **A.D. 510**

Charcoal from exposure of an ancient iron smelting plant, 0.5 to 0.7 m depth, at Tarmstedt (53° 13′ 48″ N Lat, 9° 4′ 21″ E Long), overlain by sand. Coll. 1966 and subm. by J. Deichmüller. *Comment:* owing to absence of artifacts, no clues for age estimation.

**Isernhagen series, Niedersachsen**

Charcoal from excavation of ancient slag hills, 0.2 to 0.3 m depth, near Mellendorf (52° 35′ 31″ N Lat, 9° 48′ 40″ E Long). Coll. 1963 and subm. by H. Lang, N.L.f.B.

**Hv-523. Isernhagen** **600 ± 50** **A.D. 1350**

**Hv-524. Isernhagen** **660 ± 50** **A.D. 1290**

*Comment:* samples originate from the time when bog-iron smelting was carried out in Niedersachsen. According to pottery, end of this period is near A.D. 1200 to 1300 (Lang, 1962).

**Hv-722. Steinkart, Niederbayern** **1480 ± 70** **A.D. 470**

Charcoal from a hitherto unknown, collapsed mining shaft, 7.7 m depth, near Griesbach (45° 28′ 30″ N Lat, 13° 12′ 22″ E Long), overlain by forest soil. Coll. 1964 and subm. by H. Lang, Geograph. Inst. der Univ., München. *Comment:* sample dates an old mining site which, according to type of its construction and to quality of the ore, may have been established between 500 B.C. and A.D. 1000.

**Dümmer series, NW-Germany**

Samples of Neolithic settlement in vicinity of Dümmer lake at Hüde (52° 29′ 10″ N Lat, 8° 18′ 42″ E Long), imbedded in forest-bog peat, underlain by gyttja. Coll. 1962 to 1964 and subm. by Deichmüller. Samples date the unique Stone age settlement in NW Germany (Deichmüller, 1965a; Deichmüller, 1965b), the excavation of which produced many interesting and unique finds, i.a. a complex foreign ceramics.

**Hv-317. Dümmer, 1.2 m depth** **5430 ± 80** **3480 B.C.**
Wood of house post.

**Hv-374. Dümmer, 0.7 m depth** **5420 ± 50** **3470 B.C.**
Charcoal; dates an ornamented pottery.

**Hv-814. Dümmer, 0.9 m depth** **5565 ± 85** **3615 B.C.**
Bearing pile of dwelling.

**Hv-816. Dümmer, 0.5 m depth** **5425 ± 350** **3475 B.C.**
Charcoal from earthen vessel.

**Hv-1220. Dümmer, 0.7 m depth** **5170 ± 90** **3220 B.C.**
Wooden bow, presumably from a mill.

**Hv-1230. Dümmer, 0.5 m depth** **5175 ± 155 / 3225 B.C.**
Charred food remains on braided pottery.

**Hv-349. Dümmer, 0.5 m depth** **4710 ± 90 / 2760 B.C.**
Stump of tree that crushed the log canoe.

**Hv-373. Dümmer, 0.6 m depth** **4840 ± 130 / 2890 B.C.**
Charcoal; dates fragment of braided pottery.

**Hv-813. Dümmer, 0.4 m depth** **4740 ± 70 / 2790 B.C.**
Bark of a house post.

**Hv-1221. Dümmer, 0.5 m depth** **4800 ± 85 / 2850 B.C.**
Log canoe overlain by tree.

**Hv-318. Dümmer, 0.3 m depth** **2970 ± 80 / 1020 B.C.**
Charcoal from lower habitation layer.

**Hv-455. Dümmer, 0.7 m depth** **2580 ± 80 / 630 B.C.**
Charcoal from habitation layer, 7 m distant from Hv-1318.

**Hv-817. Dümmer, 0.4 m depth** **2840 ± 95 / 890 B.C.**
Bearing pile of dwelling.

**Hv-819. Dümmer, 0.4 m depth** **2770 ±85 / 820 B.C.**
Bearing pile of dwelling. *Comment:* age determinations by means of stratigraphic and pollen-analytic investigations were difficult owing to unevenness of the terrain. Comparisons of pottery (Knoll, 1959) confirm the $C^{14}$ dates. Pollenanalytic investigations by J. Schüttrumpf, Köln, indicate a period around 4500 B.P. (Upper Neolithic). $C^{14}$ dates provided proof of four phases of settlement and revealed many hitherto unknown relations in the field of Stone-age research of N Germany.

**Hv-1061. Ottmarsbocholt, Nordrhein-Westfalen** **1125 ± 60 / A.D. 825**
Wooden plank from excavation of old bridge, 2 to 3 m depth, near Ottmarsbocholt (51° 53′ 48″ N Lat, 7° 39′ 46″ E Long), overlain by high-flood loam. Coll. 1965 and subm. by H. C. Poeschel, Geograph. Inst. of Univ., Münster. *Comment:* samples dates bridge over Emmer river which, according to archival studies (Krusch, 1933), existed in A.D. 851.

**Madeburg series, Niedersachsen**

Charcoal from excavation of castle of Madeburg (51° 24′ 19″ N Lat, 9° 56′ 00″ E Long), overlain by humic soil. Coll. 1964 and subm. by H. G. Peters, Seminar für Früh- und Urgeschichte der Univ., Göttingen.

**Hv-707. Madeburg, 1.35 m depth** **1350 ± 115** **A.D. 600**

**Hv-710. Madeburg, 0.7 m depth** **1010 ± 80** **A.D. 940**

**Hv-711. Madeburg, 0.4 m depth** **930 ± 100** **A.D. 1020**

**Hv-712. Madeburg, 0.1 m depth** **800 ± 100** **A.D. 1150**

*Comment:* according to fragments of pottery, age of A.D. 900 to 1100 assumed (Peters, 1965).

**Hv-586. Rosdorf, Niedersachsen** **6350 ± 70** **4400 B.C.**

Charcoal of settlement midden, 0.3 to 0.9 m depth, near Rosdorf (51° 30′ 21″ N Lat, 9° 54′ 8″ E Long), overlain by loess. Coll. 1964 and subm. by H. G. Peters. *Comment:* according to older line-band ceramics found, age of 4500 to 4400 B.C. assumed (Maier and Peters, 1965; Meyer and others, 1963; Behrens, 1962).

**Hv-709. Wittenburg, Niedersachsen** **835 ± 80** **A.D. 1115**

Charcoal, 0.7 m depth, from excavation of castle Wittenburg (51° 36′ 9″ N Lat, 9° 58′ 3″ E Long), overlain by shell limestone. Coll. 1964 and subm. by H. G. Peters, *Comment:* archaeologic dating was not possible because of absence of specimens (Peters, 1965).

**Hv-1040. Möllenbeck, Niedersachsen** **1205 ± 105** **A.D. 745**

Charcoal from post, 0.1 to 0.6 m depth, in foundation of former "Stiftskirche" Möllenbeck (52° 10′ 23″ N Lat, 9° 1′ 45″ E Long), overlain by clay and gravel. Coll. 1965 and subm. by K. Maier, Landeskonservator, Hannover. *Comment:* older than A.D. 900, according to Carolingian pottery; $C^{14}$ age proves that the apsides-foundations of the crypt are the oldest unit of the church. Therefore occupancy of this region must have taken place prior to the founding of the monastery (Hentger, 1962; Maier, 1966).

**Lengderburg series, Niedersachsen**

Charcoal from trench, 0.4 m deep, into bulwark of castle Lengderburg (51° 30′ 29″ N Lat, 10° 3′ 56″ E Long), overlain by thin humus layer and weathered shell limestone. Coll. 1965 and subm. by H. G.

Peters. Samples serve to establish different building phases of prehistoric fortresses.

**Hv-931. Lengderburg** **5190 ± 115**
**3240 B.C.**

**Hv-932. Lengderburg** **5305 ± 85**
**3355 B.C.**

*Comment:* until now, three phases of castle construction were known in Niedersachen: in the 7th to the 5th century B.C. and in the Middle ages. The new discovery is surprising.

**Hedemünden series, Niedersachsen**

Charcoal from rampart near Hedemünden (51° 23′ 52″ N Lat, 2° 43′ 42″ E Long), overlain by humus and loess. Coll. 1965 and subm. by H. G. Peters. Samples date different building phases of a prehistoric fortress.

**Hv-928. Hedemünden, 0.3 m depth** **2135 ± 75**
**185 B.C.**

**Hv-929. Hedemünden, 0.5 m depth** **2190 ± 75**
**240 B.C.**

*Comment:* pottery findings imply age of 100 B.C.

**Hv-567. Seelenhof Ried, Württemberg** **8075 ± 65**
**6125 B.C.**

Wood from prehistoric dam, 1.05 m depth in Seelenhof Ried (48° 5′ 2″ N Lat, 27° 15′ 32″ E Long), overlain by 0.4 m humic soil and 0.6 m sand. Coll. 1961 and subm. by K. H. Göttlich, Wasserwirtschaftsamt Sigmaringen, Württemberg. *Comment:* discovery of Mesolithic tools confirms the $C^{14}$ dating (Göttlich, 1965). Thus, dam represents one of the oldest manmade trackways in Europe.

**Hv-637. Büderich, Nordrhein-Westfalen** **1525 ± 80**
**A.D. 425**

Wood from bearing pile of castle, 2 m depth, near Büderich (51° 16′ 7″ N Lat, 6° 40′ 36″ E Long), overlain by peat. Coll. 1963 and subm. by J. Braun, G. L. Nordrhein-Westfalen, Krefeld. *Comment:* according to construction as investigated by A. Herrnbroth, Rhein. Landescuseum, Bonn, foundation should originate from ca. A.D. 900.

*B. Foreign Countries*

**Hv-1098. Lüderitz, SW Africa** **9960 ± 390**
**8010 B.C.**

Bone of rhinoceros from watering place, depth 80 cm, on Lüderitzbucht (26° 43′ S Lat, 15° 14′ W Long), imbedded in sand. Coll. 1965 and subm. by H. Kazmaier, Lüderitz Mus., Lüderitzbucht. *Comment:* postglacial watering place of wild animals in the Nambi desert (Heinz, 1933). Contamination of sample is unlikely.

**1425 ± 80**

**Hv-556. Embouchure du Loa, Chile** **A.D. 525**

Charcoal from excavation of Indian grave near embouchure (21° 27′ S Lat, 70° 5′ W Long). Coll. 1963 and subm. by J. C. Spahni, Genf. *Comment:* according to pottery fragments of Atacaman culture, 6th to 7th century A.D. was assumed. Date shows extension of Atacaman culture as far as the Pacific coast (Bennet, 1946; Bird, 1946).

**1735 ± 100**

**Hv-557. Embouchure du Loa, Chile** **A.D. 215**

Charred human bone from excavation of Indian grave near Embouchure du Loa (21° 27′ S Lat, 70° 5′ W Long). Coll. 1963 and subm. by J. C. Spahni. *Comment:* same period as Hv-556.

**1180 ± 60**

**Hv-298. Tulán, Chile** **A.D. 770**

Charcoal from grotto near Tulán (23° 48′ S Lat, 68° 2′ W Long). Coll. 1962 and subm. by J. C. Spahni. *Comment:* cave paintings of men and lamas, and also an abundance of geometric symbols, point to time of main Atacaman culture ca. 10th century A.D.

**10,280 ± 120**

**Hv-299. San Lorenzo, Chile** **8330 B.C.**

Charcoal from fireplace in grotto of San Lorenzo (23° 15′ S Lat, 67° 25′ W Long). Coll. 1962 and subm. by J. C. Spahni. *Comment:* cave paintings of hunting ceremony with dancing people point, as does the date, to preceramic phase.

**Moquegua series, Peru**

Samples from Indian graves near Chen-Chen (17° 11′ 56″ S Lat, 70° 45′ 42″ W Long), imbedded in volcanic ash. Coll. 1965 and subm. by H. D. Disselhoff, Deutsche Forschungsgemeinschaft, Berlin. Dates should prove migration of the Tiahuanaco culture from Bolivian uplands.

**1040 ± 65**

**Hv-1076. Chen-Chen, 1.5 m depth** **A.D. 910**

Cotton tissue from stone grave.

**930 ± 65**

**Hv-1077. Chen-Chen, 0.9 m depth** **A.D. 1020**

Charcoal from grave, 70 m distant from Hv-1076. *Comment:* according to decorated pottery, approx. A.D. 900.

**Toro Grande series, Peru**

Samples from Indian graves near Toro Grande (16° 15′ 16″ S Lat, 72° 29′ 29″ W Long), imbedded in volcanic ash. Coll. 1965 and subm. by H. D. Disselhoff. Datings facilitate correlation of styles of ceramics.

**995 ± 90**

**Hv-1078. Toro Grande, 1.0 m** **A.D. 955**

Wood from exposure.

**960 ± 60**

**Hv-1079. Toro Grande, 0.6 m to 1.0 m** **A.D. 990**

Cotton textiles from exposure, 10 m distant from Hv-1078. *Comment:* according to pottery, A.D. 850 was assumed.

**Cabezas Achatadas series, Peru**

Samples from Indian graves near Cabezas Achatadas (16° 36′ 00″ S Lat, 72° 45′ 6″ W Long), imbedded in sand. Coll. 1965 and subm. by H. J. Disselhoff. Samples serve style classification of textiles.

**1805 ± 85**

**Hv-1101. Cabezas Achatadas, 1.9 m** **A.D. 145**

Wood sample.

**1855 ± 95**

**Hv-1155. Cabezas Achatadas, 1.5 m** **A.D. 95**

Rush mat, picked up 7 m SE of Hv-1101.

**1530 ± 70**

**Hv-1102. Cabezas Achatadas, 1.8 m** **A.D. 420**

Textiles, picked up 7 m away from Hv-1101. *Comment:* according to style comparison, possibly 2000 B.P.

**Loreto Viejo series, Peru**

Samples from burial places at Loreto Viejo (17° 36′ 50″ S Lat, 71° 14′ 18″ W Long), imbedded in sand. Coll. 1965 by H. J. Disselhoff; subm. by G. S. Vescelius, Am. Mus. of Nat. Hist., New York. Samples date Loreto complex, a derived Tiahuanaco culture, and correlate textile styles.

**470 ± 235**

**Hv-1080. Loreto Viejo, 1.0 m depth** **A.D. 1480**

Coca leaves from looted cave.

**750 ± 60**

**Hv-1081. Loreto Viejo, surface** **A.D. 1200**

Human hair and tissue from a mummy, found beside Hv-1080.

**980 ± 70**

**Hv-1091. Loreto Viejo, 0.7 m depth** **A.D. 970**

Cloth, found 10 m away from Hv-1080. *Comment:* according to associated ceramics, ca. A.D. 900.

**Punta Islay series, Peru**

Charcoal from dwelling site, immediately below surface at Punta Islay (17° 00′ 41″ S Lat, 72° 6′ 30″ W Long), overlain by waste layer

with shells. Coll. 1965 and subm. by G. S. Vescelius. Samples date different phases of Islay culture.

**1710 ± 95**

**Hv-1087. Punta Islay** **A.D. 240**

Sample from Stratum I (Level A).

**1685 ± 80**

**Hv-1082. Punta Islay** **A.D. 265**

Sample from Stratum II (Level B).

**1960 ± 100**

**Hv-1088. Punta Islay** **10 B.C.**

Sample from Strata XII to XIII (Level M-N). *Comment:* according to associated ceramics, samples originate from fairly late, intermediate and early phases of Islay culture or Episode B 5, A 6 and A 2/3 of Punta Islay sequence. Estimated ages 200 B.C., 300 B.C., 600 B.C. No absolute dating was performed before in this area.

**8190 ± 130**

**Hv-1083. Cueva de Caru, Peru** **6240 B.C.**

Charcoal from exposure, 1.5 m depth, at Cueva de Caru (17° 27′ 20″ S Lat, 70° 00′ 30″ W Long), overlain by sand. Coll. 1965 by R. Ravines; subm. by G. S. Vescelius. *Comment:* sample serves to date preceramic assemblage with projectile points of Pampa Colorada type.

**Puyenca series, Peru**

Charcoal from undisturbed middens, immediately below surface at Puyenca (16° 13′ 2″ S Lat, 73° 40′ 5″ W Long). Coll. 1965 and subm. by G. S. Vescelius. Dates late preceramic site at Punta Atico.

**8070 ± 145**

**Hv-1084. Puyenca** **6120 B.C.**

Sample from one of outlying middens.

**7855 ± 150**

**Hv-1086. Puyenca** **5905 B.C.**

Sample from one of central middens. *Comment:* because evidently preceramic, age of 1200 B.C. was assumed.

**8765 ± 160**

**Hv-1090. Playa Chira, Peru** **6815 B.C.**

Carbonaceous soil from shell heap, alt. 55 m above sealevel, at Playa Chira (16° 31′ 10″ S Lat, 72° 54′ 25″ W Long). Coll. 1965 and subm. by G. S. Vescelius. *Comment:* preceramic culture, estimated age 2250 B.C.

**730 ± 90**

**Hv-1089. Puyenca II, Peru** **A.D. 1220**

Charcoal from Stratum IV (Level B) of large dwelling site at Puyenca (16° 12′ 40″ S Lat, 73° 39′ 50″ W Long). Coll. 1965 and subm.

by G. S. Vescelius. *Comment:* should date the pre-ultimate phase of occupation at Puyenca II, ca. A.D. 1525 according to ceramics.

**Hv-1085. El Gentilar, Peru** **670 ± 70 A.D. 1280**

Textile fragments from Stratum X (Level J) of midden below surface, at El Gentilar (17° 41′ 45″ S Lat, 71° 22′ 15″ W Long). Coll. 1965 and subm. by G. S. Vescelius. *Comment:* should date earliest phase of culture sequence at El Gentilar, estimated age A.D. 1150.

**Hv-1151. Totimelmacau, Mexico** **2150 ± 125 200 B.C.**

Charcoal from excavation, 1.8 m depth, near Totimelmacau on uplands of Puebla (18° 54′ N Lat, 98° 11′ W Long), imbedded in calcareous bituminous layers. Coll. 1965 and subm. by Bodo Spranz, Museum für Völkerkunde, Freiburg, Württemberg. *Comment:* from pre-classic pyramid, age between 600 B.C. and A.D. 300 was assumed (Piña Chan, 1958).

## II. WATER SAMPLES

**Arnold series, Nordrhein-Westfalen**

Fixed and free carbonic acid, precipitated from water of several lysimeters at Arnold (52° 13′ 8″ N Lat, 7° 22′ 47″ E Long). Coll. June 1965 and subm. by Heinrich Fauth, B.f.B.

**Hv-1015. Heath lysimeter** **100.7 ± 1.4 % modern**

Stale water sample from lysimeter filled with calcareous sand and gravel, which is overgrown by heath. $\delta C^{13} = -21.7‰$; $\delta C_M^{13} = -17.8‰$.

**Hv-1016. Deciduous-forest lysimeter** **90.4 ± 2.2 % modern**

Stale water sample from lysimeter filled with gravelly calcareous sand and overgrown by deciduous forest. $\delta C^{13} = -18.0‰$; $\delta C_M^{13} = -14.4‰$.

**Hv-1017. Deciduous-forest lysimeter** **89.1 ± 1.8 % modern**

Directly extracted water sample from same lysimeter as Hv-1016. $\delta C^{13} = -18.2‰$; $\delta C_M^{13} = -14.0‰$.

**Hv-1018. Coniferous-forest lysimeter** **91.5 ± 4.2 % modern**

Stale water sample taken from lysimeter filled with calcareous sand and overgrown by coniferous forest. $\delta C^{13} = -18.3‰$; $\delta C_M^{13} = -14.4‰$. *Comment:* $C^{14}$ activity of recent waters exceeds that found earlier (Münnich, 1957), owing to atom bomb-tests. Higher activity of Hv-1015 may have been produced by larger pore volume in the extraction lysimeter (Wendt and others, 1967). It is remarkable that the computed $\delta C_M^{13}$ values exceed the measured ones.

**Valley of Elbe river series, Norddeutschland**

Fixed and free carbonic acid, precipitated by $Ba(OH)_2$ from water taken from some deep and some shallow groundwater near valley of Elbe river. Coll. 1964 and subm. by H. Fauth.

**Hv-681. Schutschur, 5.5 to 10.5 m 56.2 ± 1.1 % modern**

Water from 1st aquifer below surface (53° 13′ 6″ N Lat, 10° 55′ 42″ E Long). $\delta C^{13} = -10.7‰$; $\delta C_M{}^{13} = -13.1‰$; apparent age 3325 yr.

**Hv-684. Elstorf, 34 to 42 m 54.6 ± 0.9 % modern**

Water from 2nd aquifer below surface (53° 25′ 24″ N Lat, 9° 46′ 44″ E Long). $\delta C^{13} = -13.2‰$; $\delta C_M{}^{13} = -15.3‰$; apparent age 3555 yr.

**Hv-685. Sinstorf, 42 to 54 m 55.2 ± 0.8 % modern**

Water from 2nd aquifer below surface (53° 25′ 32″ N Lat, 9° 57′ 24″ E Long). $\delta C^{13} = -15.8‰$; $\delta C_M{}^{13} = -15.8‰$; apparent age 3615 yr.

**Hv-506. Niedermarschacht, 65 to 77 m 43.5 ± 0.9 % modern**

Water from 4th aquifer below surface (53° 25′ 8″ N Lat, 10° 21′ 46″ E Long). $\delta C^{13} = -10.9‰$; $\delta C_M{}^{13} = -14.0‰$; apparent age 5380 yr.

**Hv-682. Ashausen, 59 to 89 m 42.5 ± 1.0 % modern**

Artesian water from 3rd aquifer below surface (53° 21′ 54″ N Lat, 10° 9′ 6″ E Long). $\delta C^{13} = -15.3‰$; $\delta C_M{}^{13} = -13.9‰$; apparent age 5570 yr. *Comment:* plotting of apparent ages of these samples against depth of extraction shows strong linear dependence. Slope of relationship is steeper than that of the sealevel curve, so filling of aquifers seems unconnected to sealevel rise nor does theory of age distribution of groundwater in open aquifers (Vogel, 1965) provide satisfactory explanation. The calculated $\delta C^{13}$ values correspond to measured ones within limits of error, proving that no biogenic $CO_2$ has entered the system.

**Niedersachsen series, Norddeutschland**

Fixed and free carbonic acid from water samples, precipitated by $Ba(OH)_2$ from some deep and some shallow ground-waters in N Germany. Coll. 1965 and subm. by Heinrich Fauth.

**Hv-1180. Wittingen, 108 to 120 m 14.8 ± 1.4 % modern**

Water from 3rd aquifer below surface (52° 42′ 52″ N Lat, 10° 43′ 36″ E Long). $\delta C^{13} = -11.5‰$; $\delta C_M{}^{13} = -13.0‰$; apparent age 14,050 yr.

**Hv-1171. Schwarmstedt, 10 to 18 m 74.3 ± 3.1 % modern**

Sample from 2nd aquifer below surface (52° 40′ 18″ N Lat, 9° 37′ 12″ E Long). $\delta C^{13} = -17.7‰$; $\delta C_M{}^{13} = -20.4‰$; apparent age 1080 yr.

**Hv-1122. Lüneburg, 98 to 126 m** **54.9 ± 1.2 % modern**

Water from 4th aquifer below surface (53° 16′ 31″ N Lat, 10° 24′ 7″ E Long). $\delta C^{13} = -12.2‰$; $\delta C_M^{13} = -13.3‰$; apparent age 3510 yr.

**Hv-1013. Adendorf, 146 to 166 m** **50.3 ± 1.1 % modern**

Sample from 4th aquifer below surface (53° 16′ 40″ N Lat, 10° 28′ 00″ E Long). $\delta C^{13} = -10.5‰$; $\delta C_M^{13} = -13.0‰$; apparent age 4215 yr.

**Hv-1186. Eckerde, 8 to 18 m** **61.0 ± 1.3 % modern**

Water from 2nd aquifer below surface (52° 19′ 60″ N Lat, 9° 31′ 36″ E Long). $\delta C^{13} = -11.0‰$; $\delta C_M^{13} = -13.4‰$; apparent age 2660 yr.

**Hv-1010. Elstorf, 34 to 42 m** **53.4 ± 0.7 % modern**

Sample from 2nd aquifer below surface (53° 25′ 58″ N Lat, 10° 3′ 24″ E Long). $\delta C^{13} = -13.2‰$; $\delta C_M^{13} = -16.1‰$; apparent age 3735 yr.

**Hv-996. Nordhorn, 19 to 44 m** **39.1 ± 0.9 % modern**

Water from 2nd aquifer below surface (52° 25′ 32″ N Lat, 7° 4′ 25″ E Long). $\delta C^{13} = -11.7‰$; $\delta C_M^{13} = -14.6‰$; apparent age 6240 yr.

**Hv-730. Soltau, 32 to 42 m** **69.6 ± 1.5 % modern**

Sample from 1st aquifer below surface (52° 59′ 22″ N Lat, 9° 51′ 12″ E Long). $\delta C^{13} = -18.7‰$; $\delta C_M^{13} = -19.8‰$; apparent age 1600 yr.

**Hv-729. Tütsberg, 42 to 49 m** **76.1 ± 1.7 % modern**

Sample from 4th aquifer below surface (53° 6′ 55″ N Lat, 9° 54′ 54″ E Long). $\delta C^{13} = -22.1‰$; $\delta C_M^{13} = -22.1‰$; apparent age 890 yr. *Comment:* in most cases, the $C^{14}$ values were confirmed on remeasurment. Of interest is the age of sample Hv-1180 of more than 12,000 yr. Even if $C^{14}$ activity of recent water is very much lower than assumed (85% of NBS standard), calculated age is still older than postglacial. Contribution of biogenic $CO_2$ seems ruled out by high $\delta C^{13}$ values.

**West-Niedersachsen series, Norddeutschland**

Fixed and free carbonic acid, precipitated by $Ba(OH)_2$ from some deep and some shallow groundwaters, lying in sandy and gravelly layers. Coll. 1965 and subm. by Heinrich Fauth.

**Hv-1004. Aurich, 67 to 82 m** **76.8 ± 1.3 % modern**

Water from 2nd aquifer below surface (53° 28′ 53″ N Lat, 7° 29′ 24″ E Long). $\delta C^{13} = +3.2‰$; $\delta C_M^{13} = -21.7‰$; apparent age 820 yr.

**Hv-1003. Marienhafe, 37 to 64 m** **54.9 ± 0.9 % modern**

Mixed water from 2nd and 3rd aquifer from waterwork (53° 29′ 55″ N Lat, 7° 17′ 17″ E Long). $\delta C^{13} = +4.6‰$; $\delta C_M^{13} = -16.8‰$; apparent age 3510 yr.

**Hv-1007. Zwischenahn, 15 to 34 m** **59.2 ± 1.8 % modern**

Water from 2nd aquifer below surface (53° 11′ 12″ N Lat, 8° 2′ 6″ E Long). $\delta C^{13} = -8.3‰$; $\delta C_M^{13} = -16.3‰$; apparent age 2910 yr.

**Hv-1008. Westrhauderfeen, 44 to 45 m** **70.3 ± 0.9 % modern**

Water from 2nd aquifer below surface (53° 8′ 39″ N Lat, 7° 32′ 27″ E Long). $\delta C^{13} = +5.9‰$; $\delta C_M^{13} = -22.1‰$; apparent age 1525 yr. Sample from same place as Hv-385 (Hannover III).

**Hv-1006. Westerstede, 43 to 60 m** **62.3 ± 1.1 % modern**

Mixed water from 2nd and 3rd aquifer below surface (53° 16′ 28″ N Lat, 7° 58′ 15″ E Long). $\delta C^{13} = -9.7‰$; $\delta C_M^{13} = -15.1‰$; apparent age 2490 yr.

**Hv-997. Wietmarschen, 29 to 37 m** **52.5 ± 0.7 % modern**

Water from 3rd aquifer below surface (52° 33′ 39″ N Lat, 7° 6′ 56″ E Long). $\delta C^{13} = -5.6‰$; $\delta C_M^{13} = -14.8‰$; apparent age 3870 yr.

**Hv-995. Veldhausen, 69 to 79 m** **48.1 ± 0.7 % modern**

Water from 4th aquifer below surface (52° 35′ 54″ N Lat, 6° 51′ 44″ E Long). $\delta C^{13} = -8.3‰$; $\delta C_M^{13} = -15.3‰$; apparent age 4575 yr.

**Hv-999. Neermoor, 20 to 66 m** **57.1 ± 0.8 % modern**

Mixed water from 2nd and 3rd aquifer below surface (53° 20′ 26″ N Lat, 7° 22′ 35″ E Long). $\delta C^{13} = -4.2‰$; $\delta C_M^{13} = -16.9‰$; apparent age 3200 yr. *Comment:* the upper layers down to 1 m depth contain a large quantity of humous peat. This fact renders the application of the simple model for water age determination (Münnich, 1957; Münnich and Vogel, 1959) impossible, for the apparent ages will certainly be wrong. The deviations of the $\delta C_M^{13}$ from the measured $\delta C^{13}$ values confirm the participation of $CO_2$—produced by humic acid from limestone—in the carbonic acid-water-chemistry (Vogel and Ehhalt, 1963; Geyh, 1965b).

### III. CALCAREOUS SINTER

**Spilkerhalle series, Niedersachsen**

Recent calcite samples from Langenfeld cave, situated in Malm fm. of Jurassic age (52° 12′ N Lat, 9° 18′ E Long). Coll. 1965 and subm. by Bodo Schillat, Hamburg.

**Hv-1036. Spilkerhalle** **89.6 ± 1.6 % modern**

Recent sinter tubes of young stalactites; $\delta C^{13} = -7.6‰$.

**Hv-1038. Spilkerhalle** **93.7 ± 1.4 % modern**

Recent sinter leaf from a sinter basin; $\delta C^{13} = -7.1‰$. *Comment:* $C^{14}$ activity of recent sinter from an active sinter basin exceeds values

established earlier (Franke and others, 1959). It is probably wrong to consider natural exchange effects to be responsible for this, because water samples taken from lysimeters also show an increase of $C^{14}$ activity (Hv-1015 to Hv-1018) due to atom bomb tests.

**Langenfeld I series, Niedersachsen**

Calcite samples from broken stalagmites of Langenfeld cave (52° 12′ N Lat, 9° 18′ E Long), situated in the Malm fm. of Jurassic age (Schillat, 1959). The samples are to delineate the period where intensive sinter growth was possible.

**Hv-1071. Atlantishalle** **35.2 ± 1.9 % modern**

Regenerated sinter layer above first break-off of a stalagmite; $\delta C^{13} = -2.4‰$; apparent age 7080 yr.

**Hv-1073. Atlantishalle** **51.8 ± 1.7 % modern**

Regenerated sinter layer above second break-off of the regenerated stalagmite, from the same object as Hv-1071; $\delta C^{13} = -5.6‰$; apparent age 4000 yr.

**Hv-1074. Spilkerhalle** **56.3 ± 1.1 % modern**

Regenerated sinter layer above break-off of a stalagmite; $\delta C^{13} = -5.0‰$ apparent age 3310 yr.

**Hv-1063. Sinter basin** **53.4 ± 1.1 % modern**

Calcite cap of a stalagmite in an old sinter basin without water; $\delta C^{13} = -8.0‰$; apparent age 3740 yr.

**Hv-1066. Sinter basin** **54.0 ± 1.1 % modern**

Chalky base zone of a stalagmite, from same object as Hv-1063. Sample was corroded by water in earlier times. $\delta C^{13} = -8.0‰$; apparent age 3660 yr. *Comment:* age of Hv-1071 fixes beginning of the period of intensive sinter growth. After an abnormally strong growth of 4 mm/100 yr, the regeneration of stalagmites ended ca. 4000 to 3300 B.P. (Hv-1073, Hv-1074, Hv-1063 and Hv-1066); (Geyh and Schillat, 1966).

**Langenfeld II series, Niedersachsen**

Calcite from stalagmite fragments of Langenfeld cave (52° 12′ N Lat, 9° 18′ E Long), situated in the Malm fm. of Jurassic age. Coll. 1965 and subm. by B. Schillat. Samples date periods of growth of calo-sinter and serve to check the model of calc-sinter dating (Franke and others, 1959; Franke, 1951).

**Hv-1029. Langenfeld** **4.8 ± 1.6 % modern**

Calcite from stalagmite, 0 to 1 cm below surface; $\delta C^{13} = -6.0‰$; apparent age 23,000 yr.

**Hv-1030. Langenfeld** **4.1 ± 1.5 % modern**

Calcite from same stalagmite as Hv-1029, 1 to 2 cm below surface; $\delta C^{13} = -5.4‰$; apparent age 24,350 yr.

**Hv-1033. Langenfeld** **< 1.4 % modern**

Calcite from same stalagmite as Hv-1029, 4 to 5 cm below surface; $\delta C^{13} = +1.0‰$; apparent age >33,000 yr.

**Hv-1035. Langenfeld** **< 1.5 % modern**

Calcite from same stalagmite as Hv-1029, 6 to 7 cm below surface; $\delta C^{13} = -10.1‰$; apparent age >32,600 yr.

**Hv-1028. Biwakhalle** **5.5 ± 1.5 % modern**

Calcite from regenerated cap of broken-off stalagmite (No. 3); $\delta C^{13} = -5.0‰$; apparent age 22,000 yr.

**Hv-1068. Atlantishalle** **1.9 ± 0.8 % modern**

Calcite from regenerated cap of broken-off stalagmite (No. 20); $\delta C^{13} = -0.1‰$; apparent age 30,350 yr.

**Hv-1069. Atlantishalle** **20.4 ± 1.2 % modern**

Calcite from regenerated cap of broken-off stalagmite (No. 16); $\delta C^{13} = -1.7‰$; apparent age 11,500 yr.

**Hv-1075. Spilkerhalle** **2.7 ± 0.8 % modern**

Calcite from regenerated cap of broken-off stalagmite (No. 10); $\delta C^{13} = -4.6‰$; apparent age 27,700 yr. *Comment:* assuming correctness of calculated apparent age sinter grew also during interstadials and interglacials. The $\delta C^{13}$ values were commonly found to be lower in cold periods than in warm periods. To explain this result simply by temperature dependence of isotopic fractionation during lime precipitation is not possible. Other isotopic exchange processes must play a part as well (Geyh and Schillat, 1966).

## IV. NATURAL CONTAMINATED SAMPLES

**Hv-801. Hohes Holz, Niedersachsen** **218.0 ± 2.8 % modern**

Fixed and free carbonic acid precipitated by $Ba(OH)_2$ from water of 2nd aquifer in 30 to 60 m depth below surface near Wunstorf (52° 26′ 33″ N Lat, 9° 23′ 12″ E Long). Coll. and subm. by Heinrich Fauth. $\delta C^{13} = -12.1‰$. *Comment:* the extreme $C^{14}$ activity cannot be explained. Laboratory contamination can be excluded.

**Hv-639. Schalchen, Bayern** **175.3 ± 1.4 % modern**

Unpreserved mammoth bone, depth 4.0 to 6.0 m, near Schalchen (47° 53′ 44″ N Lat, 12° 25′ 48″ E Long), overlain by sand and limestone gravel above groundwater level. Coll. 1938 and subm. by Ortwin Ganss,

G. L. Bayern, München. *Comment:* date expected to correlate with "overthrust moraines" (Ganss, 1953) from the Würm glacial. The preparation of counting gas was made by combustion. Laboratory contamination can be excluded.

**Hv-1104. Hannover, Niedersachsen 179.8 ± 3.7 % modern**

$CO_2$ from air, precipitated by bubbling through $Ba(OH)_2$ during a time of one week in Hannover (52° 24′ 24″ N Lat, 9° 49′ 25″ E Long). Coll. June 1965 and subm. by Heinrich Fauth. *Comment:* increase of $C^{14}$ activity of carbon dioxide due to atom bomb tests corresponds to values measured elsewhere (Nydal, 1964).

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