

UPPSALA NATURAL RADIOCARBON MEASUREMENTS IV

INGRID U. OLSSON and SERAP KILICCI*

Fysiska Institutionen, Uppsala Universitet, Uppsala, Sweden

The following list covers most of the samples measured at the Uppsala C¹⁴ laboratory since the last list (Uppsala III) except for all the samples utilized for determining the increase of the C¹⁴/C¹² ratio due to explosion of nuclear devices and the few samples measured with a new proportional counter.

The technique used is the same as previously described by Olsson (1958) and the pretreatment is that which has been used earlier (wood, charcoal, peat, gyttja and other organic sediments are boiled with HCl, 1 to 2%, washed with distilled water, kept in NaOH, 1 to 2%, at +80°C over night, washed with distilled water and finally acidified to pH about 3 before being dried) except for Foraminifera tests, see below.

The reference sample is 95% of the activity of the NBS oxalic-acid standard. Any corrections for apparent water ages are thus not included here, but will be discussed in later papers dealing with the marine samples. Corrections for deviations from the normal C¹³/C¹² ratio (-25.0‰ in the PDB scale) are applied for the unknown samples. Our oxalic acid was measured by Craig (1961) and has a C¹³/C¹² ratio of -18.97‰ and corresponds to the accepted standardized value, -19‰, which should be used for age determinations (Editorial Statement in Radiocarbon, v. 3). Two new combustions of oxalic acid have not shown any significant difference in their C¹³ content relative to the oxalic acid 1 sample measured by Craig.

The value 5570 yr has been used for the half-life of C¹⁴. Results are expressed in years before 1950 (B.P.). Errors include the standard deviations (σ) of the counted particles as well as the error in the δ C¹³ values. When the activity is very low, so that 2 σ corresponds to a possibility of infinite age, 2 σ has been used instead of σ .

Several samples had to be diluted with CO₂ from an old source to bring them to the normal working pressure of 3 atm.

ACKNOWLEDGMENTS

Descriptions of the samples are based on information provided by those responsible for collecting and submitting them. Before the final manuscript was ready, most contributors were kind enough to read the draft and suggest improvements. Sincere thanks are due to them. Special thanks are also due Dr. R. Ryhage and his co-workers for making the C¹³/C¹² determinations; Prof. K. Siegbahn, who has made it possible to do this work at the institute; and Statens Naturvetenskapliga Forskningsråd, which has given the laboratory financial support. The authors are indebted to Fil. kand. P. Kållberg for his assistance in programming the IBM 1620 for calculating ages and Fil. mag. Anders Ingemarsson for taking part in the dating during the autumn 1962, and to Miss

* On leave from the Middle East Technical University, Ankara, Turkey.

Birgitta Wallin and Miss Maud Söderman who began taking part in the work in February and April 1963 respectively.

One of us (S.K.) would like to acknowledge a fellowship from the Swedish Agency for International Assistance through the International Seminar for Research and Education in Physics.

SAMPLE DESCRIPTIONS

I. GEOLOGIC SAMPLES

A. Mediterranean Area

Western Mediterranean Sea series

Foraminifera tests from deep-sea cores. Coll. 1948 by Swedish *Albatross* Expedition (Pettersson); subm. by K. Gösta Eriksson, Kvartergeologiska Inst., Uppsala Univ., Uppsala, Sweden. All present and previous samples of sediment core No. 210 are described by Eriksson (1964) and samples from the other two sediment cores Nos. 209 and 211 will be described later by Eriksson. The Foraminifera analyses were made by Todd (1958). *Comment*: samples did not contain enough coarse fraction ($>74\mu$) for separate measurements as suggested by Rubin and Suess (1955) and Ericson and others (1956). An investigation has been initiated in order to determine the most suitable choice of fractions for C^{14} dating; so far, 2 samples have been investigated after the material was separated into three fractions ($>44\mu$, $4-44\mu$, and $<4\mu$). Results show that finer fractions may give erroneous results. Another important con-

TABLE 1
Contamination of "infinitely" old material with recent material
due to different dispersing media

Laboratory No.	Dispersing medium ^a	Apparent age ^c years	$\delta C^{13}\%$	Net counting rate (contamination) counts/min
U-287	Dist. H ₂ O	33,800 $\begin{smallmatrix} + 2400 \\ - 1900 \end{smallmatrix}$	-7.5	0.14 \pm 0.03
U-288	NH ₄ OH 0.1%	32,000 $\begin{smallmatrix} + 1600 \\ - 1400 \end{smallmatrix}$	-8.2	0.18 \pm 0.03
U-289	Dist. H ₂ O ^b	37,400 $\begin{smallmatrix} + 3600 \\ - 2500 \end{smallmatrix}$	-7.5	0.09 \pm 0.03
U-290	Boiled dist. H ₂ O	>40,000	-7.7	0.02 \pm 0.03
U-291	NH ₄ OH 0.1%	36,500 $\begin{smallmatrix} + 3100 \\ - 2300 \end{smallmatrix}$	-7.3	0.10 \pm 0.03
U-292	Dil. HCl (pH = 4.0)	>40,000	-7.5	0.05 \pm 0.03

^a) 1 L medium + 0.5 L wash liquid of same composition.

^b) Following filtration this sample was treated with 5 ml of dil. HCl (pH = 4.0) and dried in the oven at 105°C.

^c) The apparent ages are the results, within the limits of error, corresponding to the net counting rates, due to contamination. The errors given are the statistical errors. The accepted value of 5570 yr is used for the half-life of C^{14} . The δC^{13} values give the C^{13} enrichment relative to the Chicago PDB standard (Craig, 1961). 95% of the net counting rate of the NBS oxalic acid gives 9.31 counts/min in the proportional counter.

U-265. Abidjan CI 60/1 b **990 ± 70**
A.D. 960

Shell layer surrounding the part used for sample U-266. *Comment:* layer corresponds to 34% of the shells. $\delta C^{13} = -5.8\text{‰}$.

U-264. Abidjan CI 60/1 a **970 ± 110**
A.D. 980

Shell layer surrounding the part used for sample U-265. *Comment:* layer corresponds to 42% of the shells. 7% was removed by washing. $\delta C^{13} = -4.6\text{‰}$.

C. Asia

Sogho-nor series

Shells coll. by N. Hörner at the lake Sogho-nor (42° N Lat, 101° E Long) and at Camp H82 ($40^\circ 34'$ N Lat, $90^\circ 10'$ E Long) near the lake Lop-nor, Turkestan. Shells are probably freshwater but of unknown species. Finite ages may be too great, owing to recycling of carbonates, but age of two old samples is probably minimum if there has been atmospheric contamination. Measure-

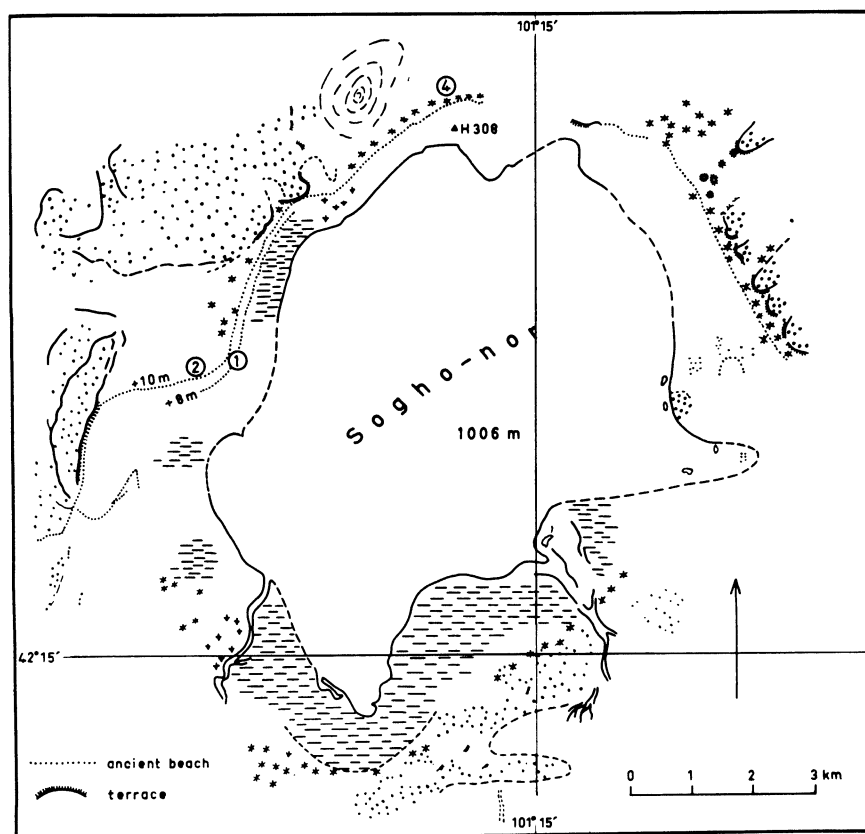


Fig. 1. Map showing the lake Sogho-nor and its beaches.

ments were undertaken in an effort to contribute some new information to an exceptionally interesting problem, described by Hörner and Chen (1935) and discussed anew by Norin (in preparation). The map (Fig. 1) shows Sogho-nor and its beaches.

U-281. Sogho-nor 040233 AB **33,700 +1400**
-1200
31,750 B.C.

Shells on surface of uppermost terrace, 15½ m above level of lake on collection day, Locality 4 on the map N of Camp H308. Coll. Febr. 4, 1933 by Hörner; subm. by Erik Norin, Mineralogisk-geologiska Inst., Uppsala Univ., Uppsala, Sweden. *Comment*: inner 86% was used. $\delta C^{13} = -5.1\%$.

U-280. Sogho-nor 270530 shell **34,200 +1400**
-1200
32,250 B.C.

Shells in ancient gravelly beach 8 m above level of lake on collection day, and in silt accumulated behind the ridge, Locality 1 on the map. Shells probably derived from adjoining terrace sediments. Coll. May 27, 1930 by Hörner; subm. by Norin. *Comment*: inner 57% was used. $\delta C^{13} = -4.8\%$.

U-286. Lop-nor b 230731 **3100 ± 110**
1150 B.C.

Shells from "yardang sediments" (erosional remains of ancient Tarim delta) at Camp H 82 E of ruined town of Lou-lan, Lop-nor. Coll. 1931 by Hörner. *Comment*: inner 25% was used. Diluted. $\delta C^{13} = -7.6\%$.

U-285. Lop-nor a **3020 ± 90**
1070 B.C.

Shell layer surrounding the part used for U-286. *Comment*: layer corresponds to 45% of the shells. 30% was removed by washing. $\delta C^{13} = -7.9\%$.

U-238. Avdat I, Israel **60 ± 80**
A.D. 1890

Pieces of wood from stone wall at Avdat (30° 45' N Lat, 34° 45' E Long), Israel. Wood was supposed to be either recent roots or to belong to construction of wall, which is ca. 2000 yr old. $\delta C^{13} = -11.6\%$.

D. Spitsbergen

Vestspitsbergen series

Peat and shells measured as a continuation of Vestspitsbergen series (Uppsala II and III; Feyling-Hanssen and Olsson, 1959-1960) and also to date pollen-analyzed peat. All altitudes are above mean sealevel.

U-206. Skansbukta 15 M h **3410 ± 230**
1460 B.C.

Humus exaracted by hot NaOH from peat used for sample U-185, Skansbukta 15 M p (78° 31.5' N Lat, 16° 03' E Long), Billefjorden, Spitsbergen, dated at 4800 ± 120 B.P. (Uppsala III). Diluted. $\delta C^{13} = -25.4\%$.

U-203. Anservika 334 b₁ **4500 ± 90**
2550 B.C.

Astarte borealis from Anservika (78° 28' N Lat, 16° 23' E Long) Billefjorden, Spitsbergen, 9.7 m alt (Feyling-Hanssen and Jørstad, 1950, p. 33

and Feyling-Hanssen, 1955, p. 58-65). Coll. 1950 and subm. by Rolf Feyling-Hanssen, Paleontologisk Mus., Oslo, Norway. *Comment*: inner 53% was used. $\delta C^{13} = +0.1\%$.

U-204. Anservika 334 a₁**4160 ± 170
2210 B.C.**

Shell layer surrounding the part used for U-203. *Comment*: layer corresponds to 16% of the shells; 31% was removed by washing. Diluted. δC^{13} assumed 0‰.

U-279. Anservika 334 c₂**5210 ± 90
3260 B.C.**

Astarte borealis from Anservika (78° 28' N Lat, 16° 23' E Long), Billefjorden, Spitsbergen, 9.7 m alt (Feyling-Hanssen and Jørstad, 1950, p. 33 and Feyling-Hanssen, 1955, p. 58-65). Coll. 1950 and subm. by R. W. Feyling-Hanssen. *Comment*: inner 25% was used. Sample was also dated in 1961, in fractions corresponding to those of U-203 and U-204 (this date list) but the fractions gave too large a difference in age at that time, and two new samples were selected, fractionated, and dated. The age difference may indicate a strong contamination. 700 years corresponds to 10% contamination with pre-bomb material. $\delta C^{13} = +0.9\%$.

U-278. Anservika 334 b₂**5250 ± 90
3300 B.C.**

Shell layer surrounding the part used for U-279. *Comment*: layer corresponds to 30% of the shells. $\delta C^{13} = +1.2\%$.

U-277. Anservika 334 a₂**5110 ± 140
3160 B.C.**

Shell layer surrounding the part used for U-278. *Comment*: layer corresponds to 33% of the shells; 12% was removed by washing. $\delta C^{13} = +1.9\%$.

U-424. Teltfjellbekken 357 c**9340 ± 140
7390 B.C.**

Astarte borealis, *Arctica* (= *Cyprina*) *islandica*, *Saxicava arctica*, *Macomma calcarea*, *Littorina littorea* from S of Teltfjellbekken (78° 38' N Lat, 16° 44' E Long), Brucebyen, Billefjorden, Spitsbergen, 23.0 m alt. Locality described by Feyling-Hanssen (1955, p. 82-86). Coll. 1950 and subm. by R. W. Feyling-Hanssen. *Comment*: inner 31% was used. $\delta C^{13} = +2.0\%$.

U-423. Teltfjellbekken 357 b**9490 ± 270
7540 B.C.**

Shell layer surrounding the part used for U-424. *Comment*: layer corresponds to 15% of the shells. Diluted. δC^{13} assumed +2.0‰.

U-422. Teltfjellbekken 357 a**9140 ± 190
7190 B.C.**

Shell layer surrounding the part used for U-423. *Comment*: layer corresponds to 18% of the shells. 36% was removed by washing. $\delta C^{13} = +2.3\%$.

U-261. Hornsund 1**1390 ± 70
A.D. 560**

Brown basal peat in bog, surface alt 12 m, 55 to 60 cm depth, among moraine boulders, Hornsund (77° 00' N Lat, 15° 28' E Long), Spitsbergen. Bog is described by Środoń (1960) and the dates are discussed by Blake,

Środoń, and Olsson (in preparation). Coll. 1957 by A. Środoń, Inst. Botaniki, Polska Akad. Nauk, Kraków; subm. by Weston Blake Jr., Geol. Survey of Canada, Ottawa 4, Ontario. *Comment*: another sample from nearly the same depth in the same bog gave two different ages, both younger, when fractionated (U-202, U-275, this date list). $\delta C^{13} = -23.8\%$.

U-262. Hornsund 2, p **620 ± 80**
A.D. 1330

Light-brown peat from same bog as U-261, 54 to 55 cm depth, Hornsund. Coll. 1957 by A. Środoń; subm. by W. Blake Jr. *Comment*: humus fraction (U-275, this date list) was dated at 260 ± 110 B.P. $\delta C^{13} = -24.9\%$.

U-275. Hornsund 2, h **260 ± 110**
A.D. 1690

Humus extracted from the peat used for sample U-262, Hornsund. Diluted. $\delta C^{13} = -27.4\%$.

U-210. Russekeila I, 55, p **4780 ± 120**
2830 B.C.

Peat from same peat bog as U-212, Russekeila ($78^{\circ} 05' N$ Lat, $13^{\circ} 47' E$ Long), Isfjord, Spitsbergen, 9.5 m above high tide level on a raised beach sloping from 12.5 to 7.5 m alt, 55 cm below surface, showing no frost cracks. Bog is pollen-analyzed by E. Norling. Coll. 1960 and subm. by E. Norling, Kvantärgeologiska Inst., Uppsala Univ., Uppsala. $\delta C^{13} = -28.3\%$.

U-211. Russekeila I, 55, h **5480 ± 130**
3530 B.C.

Humus extracted from the peat used for U-210, Russekeila, Isfjord, Spitsbergen. $\delta C^{13} = -26.0\%$.

U-212. Russekeila II, 55, p **1090 ± 80**
A.D. 860

Amblystegium peat from ca. 15 cm depth in same peat bog as U-210, Russekeila. Coll. 1960 and subm. by E. Norling. $\delta C^{13} = -29.6\%$.

U-205. Talavera O₄ h **3030 ± 290**
1080 B.C.

Humus extracted with hot NaOH from the peat used for sample U-186, Talavera O₄ p ($78^{\circ} 15' N$ Lat, $20^{\circ} 50' E$ Long), Barentsöya, Spitsbergen, dated at 6000 ± 400 B.P. (Uppsala III). Diluted. $\delta C^{13} = -22.0\%$.

Nordautlandet series

Shells, peat, and humus collected to confirm previously obtained results on land uplift (e.g. Olsson and Blake, 1961-1962), to get a measure of accumulation rate of sediments, and to date pollen-analyzed peat.

U-227. Trippvatnet H/I **4830 ± 120**
2930 B.C.

Limnic peat and algal mud from 59 to 68 cm above bottom of pollen-analyzed sediment core, Trippvatnet ($80^{\circ} 01' N$ Lat, $18^{\circ} 47' E$ Long), Nordautlandet, Spitsbergen, 5.2 m alt. Below sediment core was clay with pieces of schist. Described by Häggblom (1963). Coll. 1958 and subm. by Anders Häggblom, Geog. Inst., Stockholms Univ., Stockholm, Sweden. *Comment*: a sample from the same sediment and corresponding level was dated at

5290 \pm 400, U-93, corrected to oxalic acid (published as 5160 \pm 400, Uppsala II). Diluted. $\delta C^{13} = -26.3\%$.

U-228. Krystallvatnet H/28-58

4940 \pm 100
2990 B.C.

Limnic peat (*Fontinalis* type) from 98.5 to 104.5 cm above bottom of pollen-analyzed sediment core with total length of 130 cm, Krystallvatnet (79° 58' N Lat, 18° 40' E Long), Nordaustlandet, Spitsbergen, 62 m alt. Below bottom of core was firm clay. Described by Häggblom (1963). Coll. 1958 and subm. by A. Häggblom. *Comment*: a sample from same sediment, but coll. 10 cm above bottom of core, was dated at 10,030 \pm 550, U-92, corrected to oxalic acid (published as 9900 \pm 550, Uppsala II). $\delta C^{13} = -27.3\%$.

U-263. Lady Franklinfjorden 48

13,470 +530
-500
11,520 B.C.

Shells and calcareous algae (*Lithothamnion*, *Balanus*, and probably *Hiatella* and *Mya*) from 2 collecting points in till at Lady Franklinfjorden (80° 12' N Lat, 18° 42' E Long), Nordaustlandet, Spitsbergen, 1.5 to 2 m alt. Shells are part of matrix of till, and thus give a limiting date for the time of glacier advance. Beach gravel overlies the till, and in one place peat dated at 3960 \pm 100 B.P., U-276, occurs between the till and the beach gravel. Coll. 1958 by R. Bergström and W. Blake, Jr., and subm. by W. Blake, Jr. Pollen-analyzed by E. Norling (in preparation). *Comment*: only ca. 8 g was subm., too little to allow thorough pretreatment, and condition of shells was very poor, so result should be regarded as minimum age. Outer 22% was removed by washing. Diluted. $\delta C^{13} = -2.6\%$.

U-276. Lady Franklinfjorden 49

3960 \pm 100
2010 B.C.

Plant remains mixed with till (?) or mud above main till at Lady Franklinfjorden (80° 12' N Lat, 18° 42' E Long), Nordaustlandet, Spitsbergen, 2 m alt. Shells in underlying till dated at >13,000 B.P., U-263. Coll. 1958 and subm. by W. Blake, Jr. $\delta C^{13} = -23.1\%$.

General Comments: the results obtained from Spitsbergen confirm previous results in showing that land uplift for the last 8000 yr has been very slow.

As shown earlier, great care must be taken in pretreatment of samples. It is not sufficient to wash shells so that e.g. 10 to 20% of the shells are removed; samples must be carefully selected from bulk material and treated individually.

Large age discrepancies between peat and humus fractions of sediments in frozen ground (Olson and Broecker, 1958) have also been observed in 4 samples presented here. The reasons are still obscure, but one may be that cryoturbation causes vertical movement of soil and stones. Water-borne humus may be carried to various depths in such an environment. Wind-borne material may also easily contaminate the samples.

E. Åland

Åland series

Gyttja from Åland, Finland, pollen-analyzed to date immigration of spruce (*Picea*) and cultivation of rye (*Secale*) on the main island. Coll., subm.,

and pollen-analyzed by Magnus Fries, Växtbiologiska Inst., Uppsala Univ., Uppsala, Sweden.

U-231. Söderängsmossen 175 to 180 **1740 ± 120**
A.D. 210

Gyttja from the bog Söderängsmossen (60° 18' N Lat, 20° 7' E Long), Saltvik parish, Åland, Finland. Sample from the marked increase of *Picea*, at beginning of Pollen Zone IX (Jessen), 175 to 180 cm below the reference level. Coll. 1961. $\delta C^{13} = -26.0\%$.

U-232. Söderängsmossen 172.5 to 175 and 180 to 182.5 **2050 ± 120**
100 B.C.

Gyttja above and below sample U-231, from 172.5 to 175 cm and 180 to 182.5 cm level, measured to check the unexpectedly low date of U-231. $\delta C^{13} = -34.5\%$.

U-233. Dalkarbyträsk 575 to 580 **2530 ± 90**
580 B.C.

Gyttja from Dalkarbyträsk (60° 09' N Lat, 19° 57' E Long), Jomala parish, Åland, Finland. Sample from the marked increase of *Picea*, at beginning of Pollen Zone IX (Jessen), 575 to 580 cm below (frozen) lake surface. Coll. 1962. $\delta C^{13} = -28.2\%$.

U-234. Dalkarbyträsk 540 to 546 **1610 ± 90**
A.D. 340

Gyttja from Dalkarbyträsk (60° 09' N Lat, 19° 57' E Long), Jomala parish, Åland, Finland. Sample from a level indicating beginning of cultivation of rye, Pollen Zone IX (Jessen), 540 to 546 cm below (frozen) lake surface. Coll. 1962. $\delta C^{13} = -29.1\%$.

U-236. Dalkarbyträsk 500 to 506 **1540 ± 100**
A.D. 410

Gyttja from Dalkarbyträsk (60° 09' N Lat, 19° 57' E Long), Jomala parish, Åland, Finland, from a level indicating a possible decrease of cultivation of rye, Pollen Zone IX (Jessen), 500 to 506 cm below (frozen) lake surface. Coll. 1962. $\delta C^{13} = -28.7\%$.

U-235. Kvarnboträsk 174 to 180 **2080 ± 90**
130 B.C.

Gyttja from Kvarnboträsk (60° 17' N Lat, 20° 04' E Long), Saltvik parish, Åland, Finland, from the marked increase of *Picea*, at beginning of Pollen Zone IX (Jessen), 174 to 180 cm below sediment surface. Coll. 1962. $\delta C^{13} = -30.7\%$.

F. Sweden

U-445. Submarine peat, Laholm bay **10,060 ± 140**
8110 B.C.

Dark brown submarine peat, well humified and containing macrofossils of *Betula*, *Equisetum*, *Phragmites* and *Carex*, from bay outside Laholm (56° 31' N Lat, 12° 48' E Long), Halland, Sweden; water depth ca. 16 m. Pollen analysis (Magnus Fries) implies that peat is derived from a fen and belongs to Pollen Zone IV (Jessen). Peat appeared to be *in situ* when dredged, with no overlying sediment; judging from its altitude, locality should have been above

sealevel at time of date. Recent molluscs were removed before dating. Described by Wærn (1964). Coll. 1963 on the Sunbeam expedition by Mats Wærn and subm. by Mtgnus Fries, both Växtbiologiska Inst., Uppsala Univ., Uppsala, Sweden. $\delta C^{13} = -28.0\%$.

9830 ± 140

U-428. Levide

7880 B.C.

Wood from trunk of *Pinus silvestris* from Hallbåter, Levide (57° 16' N Lat, 18° 15' E Long), Gotland, Sweden, ca. 1500 m S of Ancyclus ridge below layer of sand and gravel about 1.9 m deep. Forest was destroyed by a transgression of the Baltic. Coll. 1961 and subm. by Bengt Pettersson, Växtbiologiska Inst., Uppsala Univ., Uppsala, Sweden. $\delta C^{13} = -25.1\%$.

2940 ± 90

U-429. Bunn, Bunge

990 B.C.

Charcoal of *Pinus silvestris* from Bunn, Bunge (57° 52' N Lat, 19° E Long), Gotland, Sweden, found with potsherds and mixed with sand. Supposedly from a dwelling-place buried by sand, ca. 2 m thick. Coll. 1957 and subm. by B. Pettersson. $\delta C^{13} = -24.2\%$.

1095 ± 80

U-427. Nyköping boat

A.D. 855

Pine wood, part of boat, in excavation for basement of Nyköping Town Hall (58° 45' N Lat, 17° 1' E Long), Södermanland, Sweden. Boat imbedded in *Phragmites* peat member of lake deposit, pollen-dated as lower Zone IX, underlain by mud and Baltic sediments. Diatom analysis by Maj-Britt Florin, pollen analysis by Thorolf Candolin; described by Florin and Olsson (1964). Coll. 1959 and subm. by Sten Florin, Kvartärgeologiska Inst., Uppsala Univ., Uppsala, Sweden. $\delta C^{13} = -25.7\%$.

Land Uplift series, Eastern Central Sweden

Sediments from eastern Central Sweden, coll. from ancient lakes developed by isolation from the sea, to determine time and rate of land uplift in this part of Sweden. Described by Maj-Britt Florin (1944) and Sten Florin (1944, 1947, and 1948).

8320 ± 140

U-218. Grässjön II

6370 B.C.

Clay-gyttja from the lake Grässjön (59° 10' N Lat, 14° 31' E Long), Nysund parish, Närke, Sweden; drainage threshold at 121.1 m alt. Sediment from level 200 to 207 cm below surface. Diatom and pollen analysis performed by Maj-Britt Florin (1944) and subsequent analysis performed by G. Piehl-Linnman and T. Candolin. Analyses imply that this sediment was deposited shortly after lake had been isolated from sea in early time of Zone IV (Jessen) before increase of *Corylus*. Coll. 1959 and subm. by Sten Florin. Diluted. $\delta C^{13} = -19.2\%$.

8770 ± 190

U-269. Grässjön I

5820 B.C.

Gyttja from the lake Grässjön (59° 10' N Lat, 14° 31' E Long), Nysund parish, Närke, Sweden, drainage threshold at 121.1 m alt, from level 190 to 198 cm below surface and taken above sample U-218. Diatom and pollen

analysis performed by Maj-Britt Florin and others (see U-218). Coll. 1959 and subm. by Sten Florin. *Comment*: this sample more organogenic than sample U-218. Diluted. $\delta C^{13} = -24.4\text{‰}$.

Late Pleistocene vegetational series, Eastern Central Sweden

Sediments from ancient lakes in W Kolmården, E Central Sweden, described by M.-B. Florin (1944) and S. Florin (1944, 1947, and 1948). Coll. by M.-B. and S. Florin; subm. by M.-B. Florin. Diatom and pollen analyses by M.-B. Florin.

U-217. Långa Getsjön III **9140 ± 260**
7190 B.C.

Detrital gyttja with fine sand from 415 to 419 cm below surface, Långa Getsjön (58° 42' N Lat, 16° 16' E Long), alt 120 m (MSL). Coll. 1962. Pollen analysis implies Pre-Boreal time, Pollen Zone IV (Jessen). Diluted. $\delta C^{13} = -31.7\text{‰}$.

U-426. Långa Getsjön II **10,210 ± 140**
8260 B.C.

Clay-gyttja from 440 to 445 cm below surface, Långa Getsjön (58° 42' N Lat, 16° 16' E Long). Coll. 1963. Pollen analysis implies Pollen Zone IV (Jessen). Sedimented in fresh water according to diatom analysis. $\delta C^{13} = -21.8\text{‰}$.

U-425. Långa Getsjön I **19,700 +1100**
-900
17,750 B.C.

Clay with one sandy layer from 455 to 465 cm below surface, Långa Getsjön (58° 42' N Lat, 16° 16' E Long). Coll. 1963. Pollen analysis implies late Pollen Zone III or early Pre-Boreal Pollen Zone IV (Jessen). Sedimented in fresh water according to diatom analysis. *Comment*: this sample and varved glacial clay samples from Lugnvik (U-213, U-214, and U-260, this date list), show that too high ages may be obtained if the clay contains allochthonous material. Diluted. $\delta C^{13} = -26.6\text{‰}$.

U-420. Stuggölen I **9930 ± 140**
7980 B.C.

Clay and clay-gyttja from 430 to 435 cm below surface, Stuggölen (58° 42.5' N Lat, 16° 22' E Long), alt 95 m. Coll. 1963. According to pollen analysis sample is correlated with Pollen Zone IV (Jessen), and diatoms show influence of the Yoldia Sea. $\delta C^{13} = -17.5\text{‰}$.

U-421. Stuggölen II **9300 ± 130**
7350 B.C.

Detrital gyttja from 425 to 430 cm below surface, Stuggölen (58° 42.5' N Lat, 16° 22' E Long), immediately overlying U-420. According to pollen and diatom analysis sample is correlated with Pollen Zone IV (Jessen) and sedimentation occurred in fresh water. $\delta C^{13} = -17.9\text{‰}$.

U-219. Dragby sedge bog 16 **2710 ± 100**
760 B.C.

Sedge dy and gyttja from Dragby (59° 59' N Lat, 17° 35' E Long),

Skuttunge parish, Uppland, Sweden. Bog is in a kettle, drainage level at 28.5 m alt. Sample from upper part of Pollen Zone VIII near boundary of Pollen Zone IX (Jessen), below the increase of *Picea*. Pollen analysis by T. Candolin. Sample near isolation contact according to diatom analysis by M.-B. Florin. Described by M.-B. and S. Florin (1960) and S. Florin (1963). Samples of archaeological interest from Dragby are given in Uppsala II and III, Stockholm IV and V, and this paper. Coll. 1962 and subm. by S. Florin. $\delta C^{13} = -25.0\%$.

Varved glacial clay series, Lugnvik

Organic material deposited in glacial varves +29 to +82, Borell-Offerberg's (1955) time-scale, at Lugnvik (62° 55' N Lat, 17° 55' E Long). Concentration of organic material was almost as high as 1%. Although organic material could be expected to be mainly allochthonous and thus probably old, pollen analysis (Hörnsten) proved that part of it is contemporaneous with the sediment. Samples were determined partly to give information about origin of deposited material and partly to prove that selection of samples is important. Only authigenic material in sediments may be used for dating. Dates given here by the varve chronology are not exact since there is some uncertainty concerning the extrapolation to present time. Samples are described by Hörnsten and Olsson (1964). Coll. 1962 and subm. by Åke Hörnsten, Kvartergeologiska Inst., Uppsala Univ., Uppsala. *Comment*: due to the low carbon content and the high ages a small contamination with modern material may change the result for U-213 and U-214 considerably so that the dates given should be regarded as lower limits. The insoluble (in hot NaOH) fractions are thus supposed to be older than 30,000 yr and 34,000 yr, respectively. A similar sample from Södermanland (U-425) has also been dated.

U-260. Lugnvik varves, +29 to +55 **≥37,000**

Varved clay dated by varved clay chronology at 6894 to 6868 yr B.C. Clay content about 43% ($<2\mu$). $\delta C^{13} = -28.6\%$.

U-213. Lugnvik varves, +56 to +82 (a) **30,000 +2500**
-2000
28,000 B.C.

Varved clay dated by varved clay chronology at 6867 to 6841 yr B.C. Clay content about 38% ($<2\mu$). $\delta C^{13} = -29.4\%$.

U-215. Lugnvik varves, +56 to +82 (ah) **9000 +1400**
-1200
7000 B.C.

Humus extracted with hot NaOH from clay used for U-213. Diluted.

U-214. Lugnvik varves, +56 to +82 (b) **34,000 +2200**
-1800
32,000 B.C.

Varved clay from same bulk material as U-213. Coll. 1962 and subm. by S. Florin.

II. ARCHAEOLOGIC SAMPLES

A. Iran

U-274. Takht-i-Suleiman **3810 ± 80**
1860 B.C.

Muck from Takht-i-Suleiman (36° 37' N Lat, 47° 14' E Long), Azerbaijan, Iran, found in pit with artifacts about 1500 yr old. Coll. 1962 and subm. by Carl Nylander and Lars Gezelius, Inst. för Klassisk Fornkunskap och Antikens Historia, Uppsala Univ., Uppsala, Sweden. $\delta C^{13} = -19.9\%$.

B. Italy

U-267. San Giovenale 62-183 b **2420 ± 80**
470 B.C.

Charcoal from San Giovenale (42° N Lat, 12° E Long), province of Viterbo, Italy, found in fill with sherds dating from 600 to 300 B.C. Coll. 1962 and subm. by C. Nylander. $\delta C^{13} = -22.9\%$.

U-268. San Giovenale 62-159 d **2390 ± B.P.**
440 B.C.

Charcoal from San Giovenale (42° N Lat, 12° E Long), di Viterbo, Italy, found in fill with sherds dating from 600 to 300 B.C. Coll. 1962 and subm. by C. Nylander. $\delta C^{13} = -24.7\%$.

C. Ireland

Raheennamadra series, Ireland

Wood and charcoal from a so-called ring-fort from Raheennamadra (52° 3' N Lat, 8° 3' W Long) near church of Knocklong in the Golden Vale, Co. Limerick, Ireland. The late Seán Ó Riordáin suggested collaboration with Swedish archaeologists and his intention was fulfilled in 1960-61 by Michael O'Kelly of Cork and Márten Stenberger of Uppsala. The ring-fort has total diam of 45 m including surrounding bank with an associated outer fosse. Diam of raised platform within the bank (the site) is 20 m and close to the bank at SW is souterrain house, 8.5 x 2.5 m, of 2 rooms with stone walls, 2 m high. In center of the site are faint traces of something believed to be a hut of wattle-work. Site is described in a preliminary report by Stenberger (1962). Sample coll. 1961 and subm. by Márten Stenberger, Inst. för Nordisk och Jämförande Fornkunskap, Uppsala Univ., Uppsala, Sweden.

U-240. Raheennamadra 1 a **1280 ± 120**
A.D. 670

Wood from wooden post supposed to have supported roof of souterrain house. $\delta C^{13} = -28.5\%$.

U-241. Raheennamadra 1 b **1430 ± 130**
A.D. 580

- U-243. Raheennamadra 2 b** **1260 ± 120**
A.D. 690
Same piece of wood as U-242 but new pretreatment and combustion. $\delta C^{13} = -24.9\%$.
- U-244. Raheennamadra 3 a** **1330 ± 110**
A.D. 620
Charcoal from log on hearth built of clay outside and above top of E gable-wall of souterrain. $\delta C^{13} = -23.6\%$.
- U-245. Raheennamadra 3 b** **1300 ± 120**
A.D. 650
Same charcoal sample as U-244 but new pretreatment and combustion. $\delta C^{13} = -24.6\%$.
- U-246. Raheennamadra 4 a** **1200 ± 110**
A.D. 750
Charcoal from hearth in E end of souterrain. $\delta C^{13} = -24.0\%$.
- U-247. Raheennamadra 4 b** **1360 ± 100**
A.D. 590
Same charcoal sample as U-246 but new pretreatment and combustion. $\delta C^{13} = -26.7\%$.
- U-248. Raheennamadra 5** **1840 ± 110**
A.D. 110
Charcoal from a dark layer, assumed to be a hearth, in a trial trench within what was supposed to be a hut, 114 cm below arbitrary datum. $\delta C^{13} = -26.7\%$.

*D. Sweden***Dragby series**

Resin and charcoal from Dragby (59° 59' N Lat, 17° 35' E Long), Skutunge parish, Uppland, Sweden. Results of the excavations and geological investigations are given by Stenberger (1960, 1961), M.-B. and S. Florin (1960), Olsson (1960), Gräslund (1961), Jaanusson and Silvén (1962), Rydh (1962), Damell and Sjögren (1962), Florin (1963), and Gejvall (1963). Coll. by students and subm. by M. Stenberger. Other samples have been dated previously (Uppsala II and III; Stockholm IV and V).

- U-201. Dragby 335 B** **2070 ± 100**
120 B.C.
Resin from Grave 335 B. Coll. 1960. $\delta C^{13} = -29.1\%$.
- U-403. Dragby 325** **2060 ± 80**
110 B.C.
Resin from Grave 325, attributed to Early Iron Age. Coll. 1963. $\delta C^{13} = -26.5\%$.
- U-400. Dragby 359 V** **2340 ± 170**
390 B.C.
Charcoal from Grave 359 V, attributed to Early Iron Age. *Comment:* diluted. $\delta C^{13} = -29.4\%$.

U-404. Dragby UO X, G3 **2830 ± 80**
880 B.C.

Charcoal from Pit No. 3 above layer of brittle burnt stones, 10 to 15 cm thick, on bottom of pit, one of several pits near Grave field, probably used for cooking. Sampled level consists of black clayey soil and black soil with gravel, both containing charcoal. Coll. 1963 by Per Kåks. $\delta C^{13} = -23.0\%$.

III. CROSS-CHECK SAMPLES

U-239. Lago di Nemi **2120 ± 80**
170 B.C.

Wood from Roman ships at Lake Nemi (41° 43' N Lat, 01° 34' E Long), Italy. Ships are attributed to Emperor Caligula (A.D. 37 to 41). Subm. by C. Cortesi and F. Bella, C¹⁴ Laboratory, Ist. di Geochim. dell Università Roma, Italy. *Comment:* for this determination the same gas was used as for U-68 (Uppsala I), published as 1980 ± 70 and $\delta C^{13} = +0.1\%$. These data, when recalculated to oxalic acid and PDB standards, give 2100 B.P. and -24.1%, i.e. are indistinguishable from measurements made after 5 years' storage. For reference to other determinations see U-68 (Uppsala I, p. 100). $\delta C^{13} = -23.1\%$.

REFERENCES

Date lists:

- | | |
|--------------|-----------------------------|
| Arizona III | Damon and Long, 1962 |
| Stockholm IV | Engstrand and Östlund, 1962 |
| Stockholm V | Östlund and Engstrand, 1963 |
| Uppsala I | Olsson, 1959 |
| Uppsala II | Olsson, 1960 |
| Uppsala III | Olsson and others, 1961 |
| USGS II | Rubin and Suess, 1955 |
- Borell, R., and Offerberg, J., 1955, Geokronologiska undersökningar inom Indalsälvens dalgång mellan Bergeforsen och Ragunda: Sveriges Geol. Undersökning, Ser. Ca, v. 31.
- Craig, Harmon, 1961, Mass-spectrometer analyses of radiocarbon standards: Radiocarbon, v. 3, p. 1-3.
- Damell, David, and Sjögren, Ingvar, 1962, Hjukorsgravar på Dragbyfältet: Tor, v. 8, p. 95-104.
- Damon, P. E., and Long, A., 1962, Arizona radiocarbon dates III: Radiocarbon, v. 4, p. 239-249.
- Engstrand, Lars G., and Östlund, H. Göte, 1962, Stockholm natural radiocarbon measurements IV: Radiocarbon, v. 4, p. 115-136.
- Ericson, D. B., Broecker, W. S., Kulp, J. L., and Wollin, Goesta, 1956, Late Pleistocene climates and deep-sea sediments: Science, v. 124, p. 385-389.
- Eriksson, K. Gösta, and Olsson, Ingrid U., 1963, Some problems in connection with C¹⁴ dating of tests of Foraminifera: Bull. Geol. Inst. Uppsala, v. 42, p. 1-13.
- Eriksson, K. Gösta, 1964, A Late-Pleistocene sediment sequence in the Western Mediterranean Sea. Studies of sediment core no. 210: Rept. Swedish Deep-Sea Exped., VIII, no. 7.
- Feyling-Hanssen, Rolf W., 1955, Stratigraphy of the marine Late-Pleistocene of Billefjorden, Vestspitsbergen: Norsk Polarinst., skr., no. 107, 186 p.
- Feyling-Hanssen, Rolf W., and Jørstad, F. A., 1950, Quaternary fossils from the Sassen-area in Isfjorden, West-Spitsbergen: Norsk polarinst. skr., no. 94, 85 p.
- Feyling-Hanssen, Rolf W., and Olsson, Ingrid, 1959-1960, Five radiocarbon datings of Post Glacial shorelines in Central Spitsbergen: Norsk Geog. Tidsskr., v. 17, p. 122-131.
- Florin, Maj-Britt, 1944, En sensubarktisk transgression i trakten av södra Kilsbergen enligt diatomacésuccesionen i områdets högre belägna fornsjölagerföljder: Geol. fören. Stockholm förh., v. 66, p. 417-448.
- Florin, Maj-Britt, and Florin, Sten, 1960, Naturhistorisk utveckling vid Dragby under bronsåldern. Från en påbörjad undersökning över områdets kvartärgeologi: Tor, v. 6, p. 87-121.

- Florin, Sten A., 1944, Havsstrandens förskjutningar och bebyggelseutvecklingen i östra Mellansverige under senkvartär tid. I. Allmän översikt: Geol. fören. Stockholm förh., v. 66, p. 551-634.
- 1947, Diskussion om senglacialens nivåförändringar och klimatutveckling: Geol. fören. Stockholm förh., v. 69, p. 221-232.
- 1948, Havsstrandens förskjutningar och bebyggelseutvecklingen i östra Mellansverige under senkvartär tid. II. De baltiska strandbildningarna och stenåldersboplatsen vid Dammstugan nära Katrineholm: Geol. fören. Stockholm förh., v. 70, p. 17-202.
- 1963, Skuttungesjön: Tor, v. 9, p. 47-84.
- Florin, Sten, and Olsson, Ingrid U., 1964, Ett båtfynd från vikingatiden i torvmark under Rådhuset i Nyköping: Geol. fören. Stockholm förh., v. 86, in press.
- Fries, Magnus, 1964, Kvartärbotanisk undersökning av submarine torv från Laholmsbukten. (Summary, A botanical investigation of the late Quaternary submarine peat from Laholm Bay, West Coast of Sweden): Svensk botan. tidskr., v. 58, p. 315-319.
- Gejvall, Nils-Gustav, 1963, Skelettmaterialet i Dragby hällkista: Tor, v. 9, p. 85-122.
- Gräslund, Bo, 1961, Den "södra gravslätten" i Dragby. Några gravtyper: Tor, v. 7, p. 205-219.
- Häggblom, Anders, 1963, Sjöar på Spetsbergens Nordostland: Ymer, p. 76-105.
- Hörner, Nils G., and Chen, Parker C., 1935, Alternating lakes: Geog. Ann. Stockholm, v. 17, p. 145-166.
- Hörnsten, Åke and Olsson, Ingrid U., 1964, En C^{14} -datering av glaciallera från Lugnvik, Angermanland: Geol. fören. Stockholm förh., v. 86, in press.
- Jaanusson, Hille, and Silvén, Ulla, 1962, Undersökningen av Dragbyröset 88: Tor, v. 8, p. 5-44.
- Norin, Erik, in preparation, Description to Sheet NK-46, HAMI. Sven Hedin Central Asia Atlas 1:1,000,000.-Sino-Swed. Exped., Pub. no. 47.
- in preparation, Description to Sheet NK-47, O-CHI-NA HO (EDSEN GOL). Sven Hedin Central Asia Atlas 1:1,000,000.-Sino-Swed. Exped., Pub. no. 47.
- Olson, E. A., and Broecker, W. S., 1958, Sample contamination and reliability of radiocarbon dates, New York Acad. Sci. Trans., ser. II, v. 20, no. 7, p. 593-604.
- Olsson, Ingrid, 1958, A C^{14} dating station using the CO_2 proportional counting method: Arkiv Fysik, v. 13, p. 37-60.
- 1959, Uppsala natural radiocarbon measurements I: Am. Jour. Sci. Radioc. Supp., v. 1, p. 112-128.
- 1960a, Uppsala natural radiocarbon measurements II: Am. Jour. Sci. Radioc. Supp., v. 2, p. 112-128.
- 1960b, C^{14} bestämningar på prover från gravfältet vid Dragby: Tor, v. 6, p. 122-124.
- Olsson, Ingrid U., and Blake, Weston, Jr., 1961-1962, Problems of radiocarbon dating of raised beaches, based on experience in Spitsbergen: Norsk Geog. Tidsskr., v. 18, p. 47-64.
- Olsson, Ingrid, Cazeneuve, Horacio, Gustavsson, John, and Karlén, Ingvar, 1961, Uppsala natural radiocarbon measurements III: Radiocarbon, v. 3, p. 81-85.
- Olsson, Ingrid U., and Eriksson, K. Gösta, 1964, Remarks on C^{14} dating of shell material in sea sediment: Deep-Sea Research, in press.
- Östlund, H. Göte, and Engstrand, Lars G., 1963, Stockholm natural radiocarbon measurements V: Radiocarbon, v. 5, p. 203-277.
- Rubin, Meyer, and Suess, Hans E., 1955, U. S. Geological Survey radiocarbon dates II: Science, v. 121, p. 481-488.
- Räydh, Stig, 1962, Dragbfältet kring röse 88: Tor, v. 8, p. 45-94.
- Šrodoň, A., 1960, Pollenspectra from Spitsbergen: Folia Quaternaria, v. 3, p. 1-17.
- Stenberger, Märten, 1960, Gravfältet vid sockenmötet. Dragby i Skuttunge, orientering och problem: Tor, v. 6, p. 63-86.
- 1961, Dragbyröset 88: Tor, v. 7, p. 184-190.
- 1962, Raheennamadra—"den lilla hundens gård": Tor, v. 8, p. 252-259.
- Todd, Ruth, 1958, Foraminifera from Western Mediterranean deep-sea cores: Rept. Swedish Deep-Sea Exped., v. 8a, no. 3, p. 167-217.
- Wærn, Mats, 1964, En algbevuxen torvbotten i Laholmsbukten. (Summary: A peat bottom with algal growth in Laholm Bay, West coast of Sweden): Svensk botan. tidskr., v. 58, p. 309-314.