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GLASGOW UNIVERSITY RADIOCARBON MEASUREMENTS III

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INTRODUCTION

The following list presents results obtained during 1968-69 on a series of samples chosen to investigate temporal variations of C^{14} concentrations in the atmosphere during the past century. Together with data presented previously (Radiocarbon, 1969, v. 11, p. 45-52) they constitute a study of annual variations of C^{14} activities at N temperate latitudes.

Procedures for the analysis of a variety of organic and inorganic materials were previously reported and these have remained virtually unchanged. In some instances C^{14} concentrations were revised slightly in view of mass spectrometric analyses for C^{13}/C^{12} ratios. All δC^{14} and Δ values of recent samples are decay-corrected, although this correction is very small.

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I. SPIRIT SAMPLES

The study of atmospheric C^{14} concentrations in past years through analyses of malt whiskies of known age has continued. Results pub. in Radiocarbon, 1969, v. 11, p. 43-52 established the reliability of malt whiskies as indicators of atmospheric C^{14} concentrations during barley growth periods.

Malt whisky, Scotland series

Sample no.	Barley coll. date	Distill. date	δC^{14}‰	δC^{13}‰	Δ‰
GU-228	1919	1920	-1.6 ± 0.6	-27.1	-1.2 ± 0.6
GU-229	1920	1921	-2.0 ± 0.6	-25.7	-1.8 ± 0.6
GU-230	1925	1926	-3.4 ± 0.6	-27.7	-2.8 ± 0.6
GU-231	1935	1936	-1.7 ± 0.5	-27.6	-1.2 ± 0.5
GU-232	1939	1940	-3.5 ± 0.6	-28.1	-2.9 ± 0.6
GU-233	1947	1948	-5.7 ± 0.5	-27.9	-5.2 ± 0.5
GU-234	1947	1948	-5.9 ± 0.7	-29.1	-5.1 ± 0.8

II. VINTAGE WINE SAMPLES

L'Orange and Zimen (1968) have shown that a good correlation exists between atmospheric C^{14} concentrations and those in vintage wine

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samples. To extend our knowledge of past atmospheric C^{14} concentrations a number of French and Portuguese wines were analyzed.

Sample no.	Sample site	Yr	δC^{14}‰	δC^{13}‰	Δ‰
GU-238	Portugal	1897	−1.7 ± 0.5	−30.2	−0.7 ± 0.5
GU-239	France	1906	−2.8 ± 0.6	−29.2	−2.0 ± 0.6
GU-240	France	1907	−4.7 ± 0.5	−38.3	−2.2 ± 0.5
GU-241	France	1907	−2.7 ± 0.5	−27.8	−2.2 ± 0.5
GU-242	France	1908	−3.3 ± 0.5	−29.9	−2.4 ± 0.5
GU-243	France	1914	−2.4 ± 0.5	−30.5	−1.3 ± 0.5
GU-244	France	1914	−1.0 ± 1.1	−29.4	−0.1 ± 1.1
GU-245	Portugal	1917	−4.0 ± 0.6	−31.6	−2.8 ± 0.6
GU-246	France	1918	+97.6 ± 1.7	−29.6	+99.4 ± 1.8

Comments: high Δ value indicative of 1963 sample. Since lab contamination of sample to such an extent would seem impossible, discrepancy appears due to mistaken identity of sample. The analysis, however, reveals the possibility of applying C^{14} analysis to dating of recent wines even though accuracy of age-assessment may be limited within certain time periods.

Sample no.	Sample site	Yr	δC^{14}‰	δC^{13}‰	Δ‰
GU-247	France	1920	−1.6 ± 0.5	−30.5	−0.5 ± 0.5
GU-248	France	1926	−3.3 ± 0.6	−28.7	−2.5 ± 0.6
GU-249	Portugal	1927	−4.6 ± 0.5	−31.6	−3.3 ± 0.5
GU-250	France	1928	−3.2 ± 0.6	−32.0	−1.8 ± 0.6
GU-251	France	1928	−2.2 ± 0.5	−28.4	−1.5 ± 0.5
GU-252	France	1929	−2.2 ± 0.5	−31.7	−1.0 ± 0.6
GU-253	France	1929	−2.8 ± 0.5	−31.4	−1.6 ± 0.5
GU-254	Portugal	1929	−2.1 ± 0.6	−29.8	−1.2 ± 0.6

III. TREE SEED SAMPLES

In a study of atmospheric C^{14} concentrations during the period 1959-1968 a number of tree seeds (subm. and id. by U. K. Forestry Comm.) have been analyzed. The seeds, stored in vacuum since collection, represent a variety of species and were coll. from Scotland and Oregon, U.S.A.

		δC^{14}‰	δC^{13}‰	Δ‰
GU-255.	Scotland	18.7 ± 0.6	−24.9	18.7 ± 0.7

Seeds (*Tsuga mertensiana*) coll. 1960 from SW Scotland (56° 30′ N Lat, 3° 30′ W Long).

		$\delta C^{14}‰$	$\delta C^{13}‰$	$\Delta‰$
GU-256.	Scotland	21.6 ± 0.6	−28.9	22.5 ± 0.6

Seeds (*Pinus mugo*) coll. 1961 from NW Scotland (57° 30′ N Lat, 4° 30′ W Long).

GU-257.	Scotland	29.4 ± 0.7	−26.2	29.8 ± 0.7

Seeds (*Pinus mugo*) coll. 1962 from NW Scotland (57° 30′ N Lat, 4° 30′ W Long).

GU-258.	Scotland	85.4 ± 1.2	−26.8	86.1 ± 1.2

Seeds (*Pinus sylvestris*) coll. 1963 from Moray (57° 30′ N Lat, 3° 30′ W Long).

GU-259.	Scotland	93.8 ± 1.2	−26.7	94.4 ± 1.3

Seeds (*Pinus sylvestris*) coll. 1964 from Moray (57° 30′ N Lat, 3° 30′ W Long).

GU-53.	Scotland	72.9 ± 1.0	−26.9	73.5 ± 1.0

Seeds (*Pinus sylvestris*) coll. 1965 from Moray (57° 30′ N Lat, 3° 30′ W Long).

GU-260.	Scotland	69.9 ± 0.8	−29.4	71.4 ± 0.8

Seeds (*Pinus sylvestris*) coll. 1966 from S Scotland (55° 30′ N Lat, 3° 30′ W Long).

GU-261.	Scotland	62.7 ± 0.7	−25.7	62.9 ± 0.7

Seeds (*Larix decidua*) coll. 1967 from Moray (57° 30′ N Lat, 3° 30′ W Long).

GU-262.	England	55.7 ± 0.7	−33.0	58.2 ± 0.8

Seeds (*Fagus sylvatica*) coll. 1967 from Cirencester (51° 40′ N Lat, 1° 57′ W Long).

GU-263.	Scotland	59.4 ± 0.7	−29.8	60.9 ± 0.7

Seeds (*Picea sitchensis*) coll. 1968 from N Scotland (58° N Lat, 4° 30′ W Long).

GU-264.	Oregon	33.4 ± 1.0	−28.0*	34.2 ± 1.0

Seeds (*Pseudotsuga taxifolia*) coll. 1959 (45° N Lat, 120° W Long).

GU-265.	Oregon	18.5 ± 0.5	−30.6	19.8 ± 0.6

Seeds (*Abies grandis*) coll. 1960 (45° N Lat, 120° W Long).

GU-266.	Oregon	19.9 ± 0.6	−26.5	20.3 ± 0.6

Seeds (*Picea sitchensis*) coll. 1961 (45° N Lat, 120° W Long).

GU-267.	Oregon	28.7 ± 0.8	−25.6	28.8 ± 0.8

Seeds (*Abies nobilis*) coll. 1962 (45° N Lat, 120° W Long).

* Estimated, as mass-spectrometric measurements were not available.

		δC^{14}‰	δC^{13}‰	Δ‰
GU-268.	Oregon	78.7 ± 1.1	−26.3	79.2 ± 1.1
	Seeds (*Pinus contorta*) coll 1963 (45° N Lat, 120° W Long).			
GU-269.	Oregon	89.2 ± 1.2	−29.6	90.9 ± 1.2
	Seeds (*Pinus contorta*) coll. 1964 (45° N Lat, 120° W Long).			
GU-270.	Oregon	67.6 ± 1.0	−23.9	67.2 ± 1.1
	Seeds (*Abies amabilis*) coll. 1966 (45° N Lat, 120° W Long).			
GU-271.	Oregon	70.3 ± 1.0	−26.1	70.7 ± 1.1
	Seeds (*Abies nobilis*) coll. 1967 (45° N Lat, 120° W Long).			
GU-272.	Oregon	58.7 ± 0.7	−28.4	59.8 ± 0.8
	Seeds (*Abies nobilis*) coll. 1968 (45° N Lat, 120° W Long).			

Comment: C^{14} activities of N hemispheric tree seeds accurately reflect atmospheric levels during seed growth periods. Rate of equilibration of atmospheric C^{14} concentrations since 1963 is approximated by the expression $\Delta_t = 97e^{-0.10t}$ where Δ_t is the tropospheric C^{14} concentration (‰) at time and yr after 1963. Discrepancies between the 2 seed series (Scotland and Oregon) although in part statistical, may also be due to slightly different growth periods and to minor disequilibrium in atmospheric C^{14} distribution in N Lats.

IV. FLAX SEEDS, CEREAL, AND WOOL SAMPLES

A variety of biospheric materials including flax seeds, and cereals coll. near Belfast, N Ireland (54° 35′ N Lat, 5° 50′ W Long) and English wool samples of known age were analyzed to permit estimation of past atmospheric C^{14} activities. Samples were provided by the N Ireland Ministry of Agriculture.

		δC^{14}‰	δC^{13}‰	Δ‰
GU-273.	Flax seeds	−3.5 ± 0.6	−33.2	−1.9 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1934.			
GU-274.	Oats	−2.4 ± 0.5	−30.3	−1.3 ± 0.5
	Seeds (*Avena sterilis*) coll. 1935.			
GU-275.	Barley	−4.0 ± 0.6	−30.0	−3.0 ± 0.6
	Seeds (*Hordeum distichum*) coll. 1936.			
GU-276.	Flax seeds	−4.3 ± 0.5	−29.9	−3.4 ± 0.5
	Seeds (*Linum usitatissimum*) coll. 1936.			
GU-277.	Flax seeds	−4.7 ± 0.7	−32.6	−3.2 ± 0.7
	Seeds (*Linum usitatissimum*) coll. 1938.			

		$\delta C^{14}‰$	$\delta C^{13}‰$	$\Delta‰$
GU-278.	Flax seeds	-4.5 ± 0.5	-30.7	-3.4 ± 0.5
	Seeds (*Linum usitatissimum*) coll. 1938.			
GU-279.	Flax seeds	-3.8 ± 0.5	-30.1	-2.8 ± 0.5
	Seeds (*Linum usitatissimum*) coll. 1940.			
GU-280.	Flax seeds	-3.8 ± 0.6	-32.1	-2.5 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1942.			
GU-281.	Flax	-4.4 ± 0.5	-30.7	-3.4 ± 0.6
	Straw (*Linum usitatissimum*) coll. 1943.			
GU-282.	Flax seeds	-5.3 ± 0.6	-32.6	-3.8 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1944.			
GU-283.	Flax seeds	-5.8 ± 0.5	-30.7	-4.7 ± 0.5
	Seeds (*Linum usitatissimum*) coll. 1945.			
GU-284.	Flax seeds	-6.1 ± 0.5	-32.0	-4.8 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1946.			
GU-285.	Flax	-6.0 ± 0.4	-30.7	-4.9 ± 0.4
	Straw (*Linum usitatissimum*) coll. 1947.			
GU-286.	Flax seeds	-6.1 ± 0.6	-31.0	-5.0 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1948.			
GU-287.	Flax seeds	-5.1 ± 0.6	-29.1	-4.3 ± 0.6
	Seeds (*Linum usitatissimum*) coll. 1950.			
GU-288.	Wool, 1962	20.4 ± 0.6	-30.7	21.7 ± 0.6
	Comment: wool sample has C^{14} content representative of 1961 atmospheric C^{14} levels.			
GU-289.	Wool	-3.0 ± 0.8	-31.8	-1.7 ± 0.8
	Wool coll. 1851 from NE England (54° N Lat, 1° W Long).			
GU-290.	Wool	-2.3 ± 0.7	-27.5	-1.8 ± 0.8
	Wool coll. 1851 from NE England (54° N Lat, 1° W Long).			
GU-291.	Wool	-4.1 ± 0.5	-30.5	-3.0 ± 0.6
	Wool coll. 1944 from NE England (54° N Lat, 1° W Long).			

Comment: results of analyses of malt whiskies, vintage wines, flax seeds, and other biospheric materials indicate that N hemisphere C^{14} activities have fluctuated significantly on an annual basis during the time period 1890-1950. The causes of these variations are to be discussed elsewhere.

V. ARCHAEOLOGIC SAMPLES

Mortar series

GU-292. Carlisle Castle mortar **1158 ± 57** **A.D. 792**

Mortar from "De Ireby's Tower" Carlisle Castle (54° 47′ N Lat, 2° 55′ W Long), from ground floor W room, Garderobe entrance, 9.5 ft from ground level, 2 ft from interior wall face, and 1.5 ft above lower side of stone lintel. Coll. and subm. 1967 by Ministry of Public Bldgs. and Works, Ancient Monuments Branch. *Comment*: true age is 580. Sample prepared from 1st CO_2 fraction during acid hydrolysis and contains less contaminant old carbon than GU-66 (2002 ± 58) prepared from the total CO_2 yield (Radiocarbon, 1969, v. 11, p. 51).

GU-293. Carlisle Castle mortar **2936 ± 72** **986 B.C.**

Same mortar sample as GU-292 (above) and GU-66 but prepared from the 2nd CO_2 fraction during hydrolysis. *Comment*: discrepancies between 1st, 2nd, and over-all fractions not due to fractionation since mass spectrometric measurements performed. Presumably non-crystalline carbonate (from atmospheric CO_2) is hydrolyzed preferentially to the carbonate of calcareous sands and/or limestone residues.

GU-294. **738 ± 52** **A.D. 1212**

Mortar from Projecting Garderobe Bay Hampton Court Palace (51° 25′ N Lat, 0° 24′ W Long), from top of wall immediately below courtyard paving cobbles. Coll. and subm. 1967 by Ministry of Public Bldgs. and Works, Ancient Monuments Branch. *Comment*: true age is 440. Contamination by old carbon evident.

GU-295. London Tower mortar

$\delta C^{14}‰$	$\delta C^{13}‰$	$\Delta‰$
7.09 ± 0.59	−17.09	5.39 ± 0.61

Mortar from Cold Harbour Tower, Tower of London (51° 32′ N Lat, 0° 05′ W Long), from NW drum of tower immediately above footing offset and present ground level. Repair mortar from 1953. Coll. and subm. 1967 by Ministry of Public Bldgs. and Works, Ancient Monuments Branch. *Comment*: Δ value representative of post-1953 nuclear era with same C^{14} content as 1956 atmosphere. Thus mortar "hardening" appears to have reached an advanced stage during the 1st 5 to 10 yr (since significant incorporation of 1963 atmospheric C^{14} would have been readily detectable).

GU-296. Orford Castle mortar **7370 ± 87** **5420 B.C.**

Mortar from W Tower Orford Castle (52° 05′ N Lat, 1° 35′ W Long), from W wall of tower 35 ft above ground level. Coll. and subm. 1968 by Ministry of Public Bldgs. and Works, Ancient Monuments

Branch. *Comment*: true age is 800. Sample appears contaminated to >50% by inactive carbon.

2012 ± 53

GU-297. Conway Town Wall mortar **62 B.C.**

Mortar from Conway Town Walls (53° 17′ N Lat, 3° 50′ W Long), from steps outside E tower 65 ft from end of tower and from 0.5 ft to 1.5 ft into wall. Coll. and subm. 1968 by Ministry of Public Bldgs. and Works, Ancient Monuments Branch. *Comment*: true age is 680 and thus contamination by old carbon is evident.

370 ± 31

GU-298. Hampton Court mortar **A.D. 1580**

Mortar from Apt 35, Wolsey Rooms Hampton Court Palace (51° 25′ N Lat, 0° 24′ W Long), from brickwork on internal wall ground floor. Coll. and subm. by Ministry of Public Bldgs. and Works, Ancient Monuments Branch. *Comment*: true age is ca. 420 and thus contamination by old carbon is not present.

General Comment: this series of data from mortar samples confirms inherent unreliability of this material for dating purposes in the U.K. (Baxter and Walton, 1970). Studies by Stuiver and Smith (1965) and Delibrias and Labeyrie (1965) suggest that conflicting opinions exist on the value of mortar for dating.

2370 ± 40

GU-299. Kilphedir hut circles, Sutherland, Scotland **420 B.C.**

Charcoal (birch and hazel) from Hut Circle III, 1 of 5 in locality just below turf at Kilphedir site, Sutherland, Scotland, 3.5 mi from sea at Helmsdale (58° 09′ N Lat, 3° 43′ W Long), 400 ft. Coll. and subm. 1968 by H. Fairhurst, Archaeol. Dept., Univ. of Glasgow. *Comment*: age (based on assumption of $\delta C^{13} = -28.10‰$, is in reasonable agreement with archaeologic assessment of ca. 300 B.C.

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