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REHOVOT RADIOCARBON MEASUREMENTS I

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The Rehovot Radiocarbon Laboratory was established in 1968, as an extension of a low-level tritium laboratory, which has been in operation many years. Intended to be a supporting facility in geohydrological studies, the laboratory now offers general services in carbon dating.

For measurements, we use proportional gas counting of ethane, at 2100 torr. The sample counter is a modified RCL counter, of 1.1 L volume; it is operated at 5600 volts. The counter is surrounded, respectively, by a Johnston GRC-13 anticoincidence guard counter, 2 cm old lead, 10 cm boron loaded paraffin, and 25 cm pre-2nd-world-war steel. Samples are counted in four channels, in anticoincidence with the guard counter. The four channels count disintegrations between the following energies: channel 1: 1 to 18 keV, channel 2: 18 to 59 keV, channel 3: 59 to 155 keV, and channel 4: above 155 keV. C^{14} is counted in the two middle channels; channel 1 is rejected against possible tritium contamination, and channel 4 is used to detect Radon contamination. The working point is determined by coincidence counting of charged cosmic particles: the ratio of count rates in the two sample channels is adjusted to 1.

The acquisition and processing of counting data is done automatically by an on-line computer (Carmi and Ashkenazi, 1970).

Background samples are prepared from alabaster or from anthracite. The average of 21 background measurements was 3.77 ± .08 cpm. The calibration standard is the NBS oxalic acid standard. The average of 9 standard measurements was 24.40 ± 0.11 cpm (after multiplication by .95). According to convention, the half life used is 5568 years.

The chemical procedure is, first, to prepare the sample so that it can be converted to CO_2. Next, solid or dissolved carbonates are treated by acid, and organic matter is combusted in dry oxygen stream. The CO_2 is purified, and converted to ethane in the following steps: carbidization of lithium (Barker, 1953), hydrolysis to acetylene, and hydrogenation to ethane over palladium catalyst (Bainbridge *et al.*, 1961).

The facility was established with the aid of a grant by the Ford Foundation. C^{13} analyses are performed on an M-86 mass-spectrometer, donated by the Volkswagen Stiftung.

SAMPLE DESCRIPTIONS

I. ATMOSPHERIC SAMPLES

Atmospheric CO_2 is collected weekly at Rehovot, (1460-1315) local grid. Collection is by exposure of concentrated NaOH solution to the

* Left in 1969.

atmosphere. The results of 23 of the samples, collected between 1968 and 1970, are given below. Before 1968, several Rehovot samples were measured by R. Nydal of Trondheim. *Comment*: (I.C.) decrease in the concentrations, beginning in spring 1969, is definitely noticeable.

Sample no.	Exposure dates	$\delta C^{14}\%$
RT-122	March 18, 1968—March 22, 1968	62.2 ± 1.7
RT-123	March 25, 1968—March 31, 1968	58.1 ± 1.2
RT-124	April 15, 1968—April 21, 1968	57.1 ± 1.2
RT-125	April 29, 1968—May 5, 1968	57.1 ± 0.9
RT-126	July 7, 1968—July 12, 1968	55.7 ± 1.2
RT-127	July 22, 1968—July 28, 1968	61.1 ± 1.1
RT-157	Sept. 16, 1968—Sept. 20, 1968	60.7 ± 0.3
RT-158	Sept. 30, 1968—Oct. 4, 1968	67.1 ± 1.3
RT-159	Oct. 15, 1968—Oct. 18, 1968	59.6 ± 1.4
RT-160	Oct. 28, 1968—Nov. 1, 1968	58.8 ± 1.6
RT-161	Nov. 11, 1968—Nov. 17, 1968	60.4 ± 0.9
RT-162	Dec. 9, 1968—Dec. 13, 1968	57.9 ± 1.7
RT-163	Jan. 6, 1969—Jan. 10, 1969	58.7 ± 1.7
RT-164	Feb. 17, 1969—Feb. 21, 1969	59.1 ± 1.4
RT-166	April 14, 1969—April 20, 1969	60.4 ± 1.5
RT-199	June 16, 1969—June 22, 1969	61.2 ± 1.2
RT-200	July 21, 1969—July 25, 1969	59.3 ± 1.5
RT-201	Aug. 18, 1969—Aug. 22, 1969	57.2 ± 1.5
RT-202	Sept. 29, 1969—Oct. 1, 1969	57.8 ± 1.7
RT-203	Oct. 24, 1969—Oct. 24, 1969	57.6 ± 1.5
RT-204	Nov. 11, 1969—Nov. 21, 1969	53.4 ± 1.5
RT-205	Dec. 15, 1969—Dec. 19, 1969	55.4 ± 1.4
RT-206	Jan. 19, 1970—Jan. 23, 1970	45.5 ± 1.3

II. WATER SAMPLES

Water samples are collected for a preliminary survey of the C^{14} concentration distribution in Israel waters, and for possible age estimations. Samples are brought in fiberglass containers from field to laboratory, where the carbonates are precipitated as $BaCO_3$. The coordinates are given in the local grid.

Ages are calculated after Ingerson and Pearson (1964), with $\delta C^{13}{}_{ls} = 0$ in the mother rock. They should, therefore, be regarded with reservations. *Comment* (I.C.): in the 2 cases that the calculation gave more than 100% concentration, results are supported by tritium data, which shows that the samples contain water components, or are completely, of post-thermonuclear origin.

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Sample	Name	Type	Coordinates (local grid)	Depth (m)
	a. Northern Arava (S of the Dead Sea)			
RT-101	Tamar 7	well	0458-1805	345
RT-108	Zin 6	well	0440-1833	50
RT-117	Tamar 3	well	0433-1787	76
RT-131	Tamar 3	well	0433-1787	76
RT-156	Neot Hakikar	well	0388-1863	73
RT-193	Tamar 3	well	0433-1787	400
	b. Southern Arava (N of Eilat)			
RT-107	Yotvata 2	well	9225-1544	50
RT-112	Timna 5	well	9116-1517	116
	c. Negev			
RT-115	Dimona 1	well	0496-1624	89
RT-129	Dimona 1	well	0496-1624	89
RT-136	Beer Sheva 3	well	0716-1289	267
RT-137	Omer	well	0750-1348	539
RT-138	Hatzerim	well	0720-1270	238
RT-196	Makhtesh 3	well	0400-1710	763
	d. Sinai			
RT-140	Nahel	well	9260-0290	15
RT-195	Ein Fourtaga	spring	8290-7070	
	e. Dead Sea Coast (N)			
RT-157	Ein Feshcha	spring	1250-1940	
RT-155	Ein Feshcha	spring	1250-1940	
	f. Central Lowlands			
RT-152	Lod 23	well	1530-1420	276
RT-153	Lod 26	well	1540-1430	76
RT-194	Rosh Ha'ayin	well	1660-1425	119
	g. Tel-Aviv			
RT-167	Reading	well	1680-1290	32
RT-168	Gordon	well	1640-1280	60
	h. Lake Tiberias area			
RT-103	Ein Noon	spring	2497-1982	
RT-106	Hamat Gader	spring	2327-2129	
RT-109	Tiberias Hot Springs	spring	2414-2017	
RT-154	Kineret 8	well	2013-2517	715

Sampling date	Sampled by	δC^{13}‰	C^{14} (% modern)	Age (B.P.)
	a. Northern Arava (S of the Dead Sea)			
March 68	E. Mazor*	— 7.9	4.7± .5	15,300±900
April 68	E. Mazor	—11.3	4.2± .4	19,200±800
Nov. 68	E. Mazor	— 8.4	5.3±1.0	14,800±500
Jan. 69	E. Mazor	— 8.4	5.2± .4	14,900±600
July 69	E. Mazor	—10.4	36.9± .4	980±90
Jan. 70	E. Mazor	— 7.9	.9± .4	28,500±350
	b. Southern Arava (N of Eilat)			
April 68	E. Mazor	— 8.9	6.9± .5	13,200±600
March 68	E. Mazor	— 4.2	2.2± .6	16,300±2200
	c. Negev			
Nov. 68	E. Mazor	—11.8	24.0± .5	5500±150
Jan. 69	E. Mazor	—11.8	24.3± .4	5300±130
Feb. 69	E. Mazor	—13.7	20.0± .9	8100±350
Feb. 69	E. Mazor	—13.7	38.5± .4	2800±100
Feb. 69	E. Mazor	—13.7	18.2± .4	8900±200
July 69	E. Mazor	—14.3	3.9± .4	22,000±1000
	d. Sinai			
Feb. 69	E. Mazor	—12.2	44.8± .7	690±130
Dec. 69	A. Issar**	— 9.8	64.0±1.0	(163%±2.6)
	e. Dead Sea Coast (N)			
March 69	E. Mazor	—12.2	33.1±1.2	3100±300
May 69	R. Schlesinger*	—12.2	35.6± .4	2500±90
	f. Central Lowlands			
May 69	Tahal†	—16.6	45.0± .4	3100±70
May 69	Tahal	—16.6	33.0± .4	4700±90
Jan. 70	M. Ben-David*	—14.0	41.6± .6	2500±120
	g. Tel Aviv			
July 69	M. Ben-David		55.8± .7	
July 69	M. Ben-David		64.0± .9	
	h. Lake Tiberias area			
May 68	E. Mazor	—12.8	64.5±1.0	(126.0%±2.0)
May 68	E. Mazor	—15.2	19.4± .6	9200±250
May 68	E. Mazor	— 5.7	4.8± .5	12,500±900
May 69	Tahal	— 6.7	7.2± .3	11,000±250

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** Geological Survey of Israel, Jerusalem.
† Water Planning for Israel Ltd, Tel Aviv.

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III. GEOLOGIC SAMPLES

The coordinates are given in the local grid, and locations are shown in Fig. 1.

A. Secondary calcites

In secondary calcites, it is assumed that the carbon in the carbonate has been affected by interactions between water and country rock. It is possible, therefore to calculate the age of the sample, correcting for the δC^{13} value by the method of Ingerson and Pearson (1964), using the value of the country rock as $\delta C^{13}{}_{ls}$.

Qsalon series

Secondary calcites (Nari) on a dolomite in a Cenomenian stratum near Qsalon (1312-1532), in the Judean Mts., Region k in Fig. 1. Coll. and subm. Feb., 1970 by M. Magaritz, Weizmann Inst. of Sci. For age calculation, $\delta C^{13}{}_{ls} = +1‰$ in the dolomite. *Comment*: to avoid attacking the dolomite, a 4% HCl solution was used for liberating CO_2 from the samples.

Sample	Height above dolomite (cm)	C^{14} (% modern)	δC^{13}(‰)	Age B.P.
RT-211. Qsalon 2	0	7.5±.5	−10.0	13,700±850
RT-213. Qsalon 3	40	9.6±.5	− 9.6	12,480±350
RT-197. Qsalon 1	80	10.7±.4	−10.4	11,200±500
RT-217. Qsalon 4	120	17.0±.6	−10.4	6600±600

Hermon series

Coarse crystalline calcite in a karst in Jurassic rock on Mt. Hermon. Coll. and subm. April, 1970 by M. Magaritz.

RT-215. Hermon 1 **>38,000**
$C^{14} = 0.4\% \pm 0.8$
$\delta C^{13} = -11.4‰$

From limestone (2980-2210). For age determination, $\delta C^{13}{}_{ls} = -.5‰$ in the country-rock calcite.

RT-216. Hermon 2 **22,000 ± 1000**
$C^{14} = 3.5\% \pm 0.4$
$\delta C^{13} = -11.5‰$

From dolomite adjacent to a magmatic dike (2960-2203). For age determination, $\delta C^{13}{}_{ls} = +1.0‰$ in the country-rock dolomite.

Sha'ar Hagai series

Secondary calcite in a Cenomenian stratum near Sha'ar Hagai, on hwy. to Jerusalem (7925-0155), Region k on Fig. 1. Coll. and subm. March, 1970 by M. Magaritz. For age determination, $\delta C^{13}{}_{ls} = -1.0‰$ in the country rock.

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RT-195. Sha'ar Hagai 1

>40,000
$C^{14} = 1.1\% \pm 0.4$
$\delta C^{13} = -12.2‰$

RT-192. Sha'ar Hagai 2

29,000 ± 1000
$C^{14} = 1.1\% \pm 0.4$
$\delta C^{13} = -11.4‰$

10 cm from RT-195.

B. Precipitates and shells

These are reported as "per cent of modern" and δC^{13} in per mil. Ages are calculated only where there is an accepted method for the calculation.

RT-182. Qabri Aqueduct

$C^{14} = 71.4\% \pm 0.9$
$\delta C^{13} = -11.0‰$

Precipitate in an aqueduct near Qabri, in W Galilee (2660-1600), in use until late 1940's. Coll. and subm. 1969 by A. Issar.

RT-184. Feiran

$C^{14} = 4.3\% \pm 0.4$
$\delta C^{13} = -8.2‰$

Lacustrine precipitate from upper-mid-Pleistocene in Sinai (7025-0155), coll. and subm. 1969 by A. Issar.

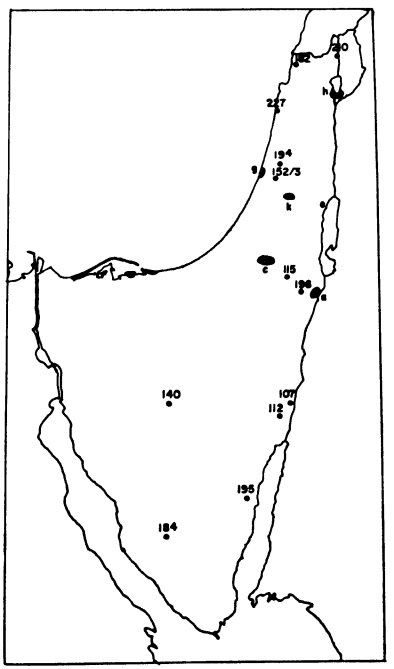

Fig. 1

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$C^{14} = 2.3\% \pm 0.4$

RT-187. Ein Moreh $\delta C^{13} = -3.3‰$

Travertine on limestone in Negev (0275-1270), coll. and subm. 1969 by A. Issar.

4600 ± 100

RT-210. Hula shells $C^{14} = 61.0\% \pm 0.8$

$\delta C^{13} = -14.3‰$

Shells (*Unio* sp.) from terrace of ancient Lake Hula, near Bnot Ya'aqov bridge in upper Galilee (2686-2083). Coll. and subm. March, 1970 by A. Horowitz, Geol. Survey of Israel, Jerusalem. *Comment* (A.H.): terrace was formed during last intrusion of Lake Hula into Bnot Ya'aqov region.

C. Organic matter

Dead Sea driftwood

Driftwood from localities higher than surface of Dead Sea (–398.5m). Subm. April, 1970 by Zipora Klein, Jerusalem. *Comment* (I.C.): it is assumed that samples were deposited when sea was at present sample level. Assuming wood was then fresh, it can date change of level of Dead Sea (based on information by Z. Klein).

200 ± 100

A.D. 1750

RT-220. Dead Sea driftwood ZK5 $C^{14} = 97.9\% \pm 1.1$

$\delta C^{13} = -23.5‰$

Driftwood from Nahal More (1858-0750), coll. April 1970 by Z. K. from alt –376.5m.

100 ± 100

A.D. 1850

RT-221. Dead Sea driftwood ZK1 $C^{14} = 100.0\% \pm 1.0$

$\delta C^{13} = -21.0‰$

Driftwood from Mezad Qidron (1920-1211, local coordinates). Loc. is 8th century B.C. Israeli fort; sample was deposited by later flooding. Coll. 1968 by Z. Klein from –385.7 m.

(corr. $C^{14} = 100\% \pm 1.0$)

RT-226. Dead Sea driftwood ZK3 $C^{14} = 98.9\% \pm 3.0$

$\delta C^{13} = -30.8‰$

Driftwood from delta of Nahal Haver (1866-0912) coll. 1967 by Z. Klein from alt –394 m. *Comment* (I.C.): sample resembles eroded beach stone. Large error is due to small amount of sample.

General Comment: samples were treated with HCl to remove inorganic deposits.

IV. ARCHAEOLOGIC SAMPLES

18,500 ± 300

RT-227. Khabara 14 $C^{14} = 9.5\% \pm 0.2$

$\delta C^{13} = -29.0‰$

Ash from prehistoric cave in Carmel Mts. (2183-1444, local coordi-

nates) from Layer 26 in stratigraphy which corresponds to Levantine Orignacian A. Coll. and subm. June 1970 by O. Bar-Yossef, Hebrew Univ., Jerusalem. *Comments* (I.C.): age determined on combusted residue of HCl and NaOH treated sample. (O.B-Y): archaeologic determination of ages is between 25,000 and 35,000 yr. B.P. Sample coll. from exposed ditch in excavation.

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