health and safety laboratory

FALLOUT PROGRAM

QUARTERLY SUMMARY REPORT

October 1, 1961

UNITED STATES ATOMIC ENERGY COMMISSION
NEW YORK OPERATIONS OFFICE

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HEALTH AND SAFETY LABORATORY

FALLOUT PROGRAM
QUARTERLY SUMMARY REPORT

(June 1, 1961 through September 1, 1961)

Prepared by

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Analytical Division

Preceding reports in this series:

HASL-42, -51, -65, -69, -77, -84,
-88, -95, -105, -111, and -113.

October 1, 1961

UNITED STATES ATOMIC ENERGY COMMISSION

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ABSTRACT

This report presents current data from the HASL Fallout Program, the High Altitude Sampling Program, the U. S. Naval Research Laboratory, and the Canadian Department of National Health and Welfare. Radionuclide levels in deposited fallout, air, water, and milk are given in tabular form. Interpretive reports and notes dealing with atmospheric and fallout radioactivity levels, strontium-90 in U. S. diets, tap water, grains, and miscellaneous samples of biological interest, are included. Also presented are results of a seven year survey of strontium-90 levels in soil, herbage, and animal bone at selected pasture sites in the United States, and a summary of the strontium-90 quality control program carried out at one of the AEC's contractor laboratories. Groups submitting notes and interpretive material include the Electronics Group of General Mills, Inc., the U. S. Weather Bureau, Hazleton-Nuclear Science Corporation, Tracerlab, Inc., Isotopes, Inc., and the Health and Safety Laboratory. A bibliography of recent literature pertinent to fallout studies is given at the end of the report.

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Introduction

Every three months, the Health and Safety Laboratory issues a report summarizing current information obtained at HASL pertaining to fallout. This report, the latest in the series, contains information that became available during the period from June 1, 1961 to September 1, 1961. The next report is scheduled for publication on January 1, 1962. Preceding reports in the series, starting with HASL-42, "Environmental Contamination from Weapons Tests", and continuing through HASL-51, -65, -69, -77, -84, -88, -95, -105, -111, -113, and -115 (this report), may be purchased from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

To give a more complete picture of the current fallout situation and to provide a medium for rapid publication of fallout data, these quarterly reports often contain information from other laboratories and programs, some of which are not part of the general AEC program. To assist in developing, as rapidly as possible, provisional interpretations of the data, special interpretive reports and notes prepared by scientists working in the field of fallout are also included from time to time. Many of these scientists are associated in some way with the general AEC program. Information developed outside of HASL is identified as such and is gratefully acknowledged by the Laboratory. In this report, data from the U. S. Naval Research Laboratory, the Canadian Department of National Health and Welfare, General Mills, Inc., the U. S. Weather Bureau, Hazleton-Nuclear Science Corporation, Tracerlab, Inc. and Isotopes,Inc. are included.

A portion of the radiochemical analyses are carried out by commercial laboratories under contract to the HASL Analytical Division. The results of these analyses are reported as part of HASL's regular fallout program. The contractor analytical laboratories are Nuclear Science and Engineering Corporation, Pittsburgh, Pennsylvania; Isotopes, Incorporated, Westwood, New Jersey; Radiochemistry, Incorporated, Louisville, Kentucky; Tracerlab, Incorporated, Richmond, California; and Controls for Radiation, Incorporated, Cambridge, Massachusetts. Data obtained by the New Zealand Department of Scientific and Industrial Research, under contract to the Division of Biology and Medicine, are also included as part of the Health and Safety Laboratory fallout program.

This report is divided into four main parts:

1. HASL Fallout Program Data,
2. Data from Sources Other Than HASL,
3. Interpretive Reports and Notes, and
4. Recent Publications Related to Fallout.

FALLOUT PROGRAM

Quarterly Summary Report

October 1, 1961

Part I - HASL Fallout Program Data

1. Fallout Deposition Collections

Fallout deposition rates are measured in monthly and individual precipitation collections. There are 40 monthly monitoring sites in the United States and 86 in foreign countries. These collections are made using either stainless steel pots with exposed areas of 0.82 square feet, or funnels with exposed areas of 0.77 square feet to which are attached ion-exchange columns. A map showing the fallout monitoring sites is presented as Figure 1, page 4.

Individual precipitation collections are carried out at four sites, namely Westwood, New Jersey, Pittsburgh, Pennsylvania, Richmond, California, and Lower Hutt, New Zealand. These collections commence immediately after a rainfall and terminate either after the next rainfall or after a week of dry weather. The collection vessels range in area from 10 to 80 square feet.

1.1 1960-61 Monthly and Bi-Monthly Data

In late 1958 and 1959, the monthly samples were analyzed for strontium-89, tungsten-185, and strontium-90, but the strontium-89 and tungsten-185 measurements were discontinued in 1960 at most sites. Analyses for strontium-89 will be resumed starting with the September 1960 collections. Starting with the 1960 May and June collections, the monthly samples were combined on a two-month basis since strontium-90 levels had dropped considerably. The September 1961 and later collections will be analyzed as individual monthly samples.

Laboratories at Richmond, California, Westwood, New Jersey, Louisville, Kentucky, Pittsburgh, Pennsylvania and Houston, Texas have analyzed duplicate monthly collections for strontium-89, plutonium-239, and cerium-144, in addition to strontium-90 and tungsten-185. The strontium-89 and tungsten-185 analyses were discontinued in July 1960 but strontium-89 assays have been resumed for September 1961 collections. In addition, analyses will be made for barium-140, cerium-141, and zirconium-95. Ruthenium-106 analysis began at Pittsburgh in July 1960.

The monthly collection data are shown in tables 1a and 1b, pages 5 through 52. Monthly strontium-90 levels for New York City since 1954 are shown in graph form in Figure 2, page 14.

1.2 1960-61 Individual Precipitation Collection Data

Individual precipitation samples collected at four sites are analyzed for strontium-90 in all cases, and cerium-144, cesium-137, and barium-140 at selected stations. Starting in September 1961, samples collected at all sites will be analyzed for barium-140 and strontium-89 as well as strontium-90. Results are given in Tables 1e, 1f, 1g, and 1h, on pages 53 through 60.

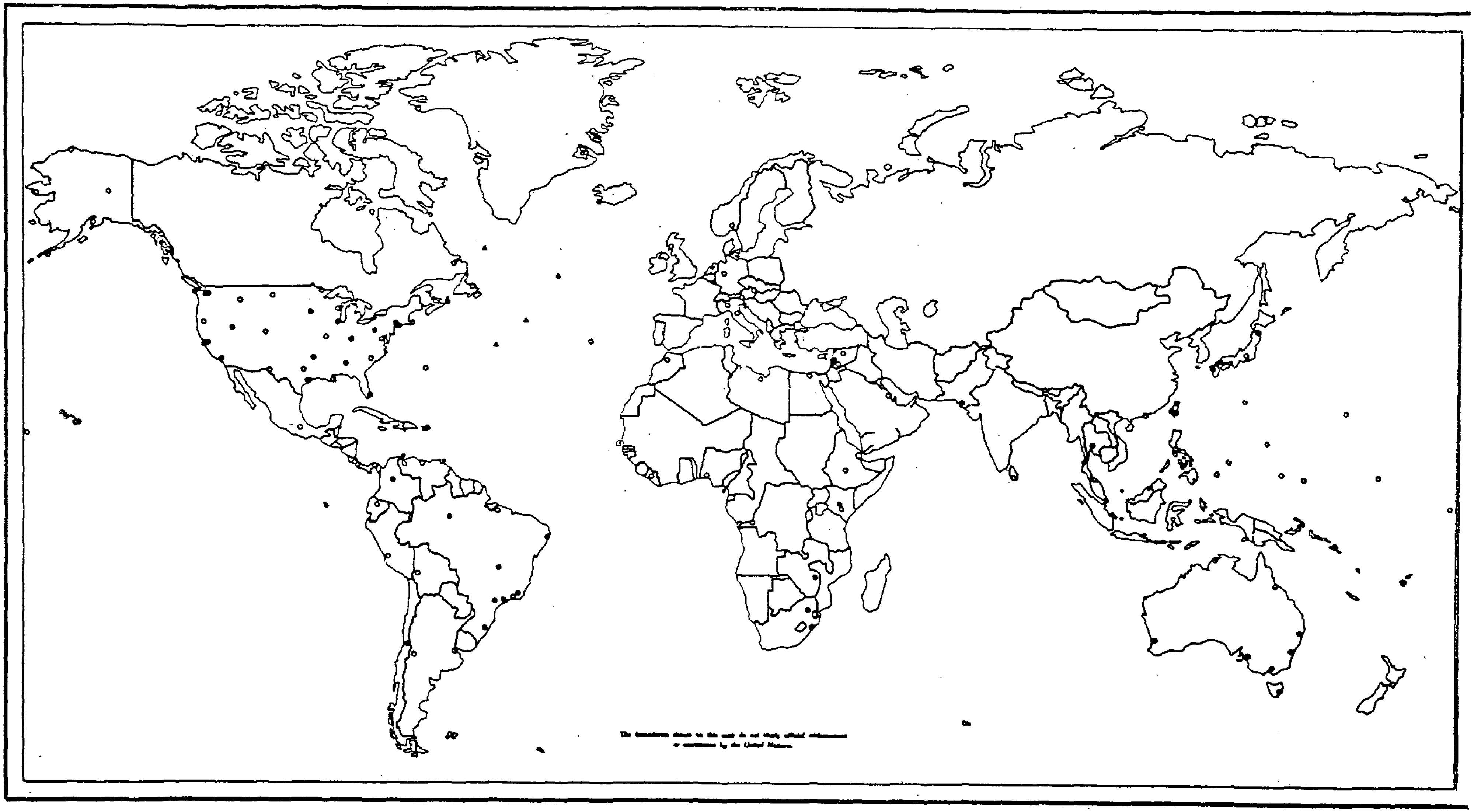


FIGURE 1 Sr^{90} MONTHLY SAMPLING NETWORK

- • POT
- ∘ FUNNEL
- ▴ RAIN GAUGE

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES

ALABAMA. BIRMINGHAM (began: 4/57)
cum. mc Sr^{90}/mi^2 thru 12/60- 39.79--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }		0.60	
March } April }		1.34	
May			
June			
July			
August			
September			
October			
November			
December			

ALASKA, ANCHORAGE (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-6.84--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/Mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	1.57 / 0.46	0.44	0.22
March } April }	1.72	0.15	0.09
May } June }	0.47 / 1.48	0.15	0.08
July			
August			
September			
October			
November			
December			

ALASKA. BARROW (began: 1/59)
cum. mc Sr^{90}/mi^2 thru 12/60-3.35--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	0.27 / 0.07	0.65	2.2
March } April }	0.22 / 0.15	0.16	0.43
May } June }	0.01 / 0.08	0.08	0.89
July			
August			
September			
October			
November			
December			

ALASKA. COLD BAY (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60- 15.61--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/Mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	1.95 / 1.62	0.16	0.04
March } April }	1.73 / 1.68	0.40	0.12
May } June }	0.95 / 0.12	0.03	0.03
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

ALASKA, FAIRBANKS (began: 3/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.11-- Column

Sampling Period 1961	precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January	0.27	0.00	
February	0.17		
March	0.47	0.20	0.24
April	0.37		
May	0.24	0.48	0.42
June	0.89		
July			
August			
September			
October			
November			
December			

ALASKA, NOME (began 2/60)
mcu. mc Sr^{90}/mi^2 thru 12/60-0.78--Column

Sampling Period 1961	Percip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January		not received	
February		not received	
March	0.18	0.00	
April	2.15		
May			
June			
July			
August			
September			
October			
November			
December			

ALASKA, JUNEAU (began: 3/59)
cum. mc Sr^{90}/mi^2 thru 12/60-16.37--Column

Sampling Period 1961	precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January	3.76	0.46	0.06
February	4.07		
March	2.67	1.21	0.18
April	3.92		
May	4.75	0.98	0.12
June	3.22		
July			
August			
September			
October			
November			
December			

CALIFORNIA, WEST LOS ANGELES (began 12/56)
cum. mc Sr^{90}/mi^2 thru 12/60-17.35--Pot

Sampling Period 1961	Percip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January		0.17	
February			
March		0.20	
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period Sr^{89}	Sr^{90}	Pu^{239}	Ce^{144}	W^{185}	on 6-1-58 W185	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	mc/sq. mile
California, Richmond (began: 3/20/58) - Pot												
1/4-2/2	5.50	0.206 ± 0.016 0.229 ± 0.031	0.230 ± 0.003 0.227 ± 0.006	≤0.0076 0.0044 ± 0.0004	2.18 ± 0.03 5.68 ± 0.04	0.112 ± 0.010 0.144 ± 0.007	24.9 ± 2.2 32.0 ± 1.6	0.90 1.00	9.48	0.041	3-25 3-25	7.39 ± 0.10 14.3 ± 0.10
2/3-3/1	4.63	0.195 ± 0.020 0.232 ± 0.039	0.241 ± 0.003 0.217 ± 0.005	≤0.0040 0.0037 ± 0.0002	1.91 ± 0.02 1.86 ± 0.02	0.055 ± 0.004 0.059 ± 0.003	16.2 ± 1.2 17.4 ± 0.9	0.81 1.07	9.71	0.049	3-25 3-25	6.80 ± 0.10 8.08 ± 0.10
3/1-4/1	2.45	1.46 ± 0.02 1.65 ± 0.02	0.255 ± 0.005 0.291 ± 0.005	0.0043 ± 0.0007 0.0058 ± 0.0005	2.16 ± 0.03 2.31 ± 0.03	0.044 ± 0.004 0.044 ± 0.004	16.9 ± 1.5 16.9 ± 1.5	0.10 0.12	9.98	0.111	4-25 4-25	10.7 ± 0.10 11.4 ± 0.10
4/1-5/2	1.05	0.030 ± 0.004 0.033 ± 0.004	0.052 ± 0.002 0.055 ± 0.002	0.0014 ± 0.0002 0.0018 ± 0.004	0.391 ± 0.013 0.394 ± 0.013	0.012 ± 0.002 0.016 ± 0.002	6.3 ± 0.2 8.4 ± 0.3	0.58 0.60	10.03	0.051	5-16 5-16	1.51 ± 0.02 1.45 ± 0.02
5/2-6/1	0.33	0.014 ± 0.003 0.010 ± 0.003	0.043 ± 0.001 0.044 ± 0.001	0.0013 ± 0.0002 0.0014 ± 0.0002	0.309 ± 0.005 0.309 ± 0.005	0.013 ± 0.005 0.010 ± 0.004	8.7 ± 3.3 6.7 ± 2.7	0.33 0.23	10.07	0.131	7-8 7-8	0.90 ± 0.01 0.95 ± 0.01
6/1-7/1	0	<0.0016 0.006 ± 0.002	0.007 ± 0.001 0.006 ± 0.001	0.0024 ± 0.0003 0.0025 ± 0.0002	0.075 ± 0.003 0.030 ± 0.003	<0.0077 <0.0092	--- ---	-- 1.00	10.08	--	7-25 7-25	0.52 ± 0.01 0.57 ± 0.01
7/1-8/1*	Trace		0.025 ± 0.003 0.020 ± 0.002	0.0025 ± 0.0006 0.0020 ± 0.0006	0.154 ± 0.006 0.146 ± 0.006				10.10	--		
8/1-9/1*	0		0.022 ± 0.001 0.020 ± 0.001	0.0049 ± 0.0006 <0.0033	0.218 ± 0.006 0.110 ± 0.005				10.12	--		
9/1-10/1*	0		0.011 ± 0.001 0.013 ± 0.001	0.0006 ± 0.0005 <0.0016	0.072 ± 0.008 0.122 ± 0.005				10.14	--		
10/1-11/1*	0.28		0.020 ± 0.001 0.020 ± 0.001	0.0011 ± 0.0002 0.0011 ± 0.0002	0.400 ± 0.008 0.338 ± 0.008				10.16	0.046		
11/1-12/1*	5.06		0.111 ± 0.003 0.125 ± 0.003	0.0067 ± 0.0008 0.0067 ± 0.0008	0.533 ± 0.008 0.517 ± 0.016				10.27	0.015		
12/1-1/1*	0.77		0.098 ± 0.005 0.088 ± 0.005	0.0020 ± 0.0002 0.0019 ± 0.0002	0.28 ± 0.01 0.32 ± 0.01				10.37	0.120		
1961												
1/1-2/1			Data not reported									
2/1-3/1	1.18		0.059 ± 0.001 0.058 ± 0.001	0.0021 ± 0.0003 0.0024 ± 0.0004	0.23 ± 0.01 0.26 ± 0.01					0.049		

* These data have been calculated on the basis of a collection area of 3.14 square feet. All previous results were calculated on the assumption that the collection area was 4.92 square feet. This latter area was recently found to be in error. All previously reported data from Richmond, California is being recalculated and corrected results will be reported in a subsequent quarterly report.

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

CALIFORNIA, SAN FRANCISCO (began: 2/59)
cum. mc Sr-90/mi² thru 12/60-3.47--Column

Sampling Period 1961	Precip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January		sample lost	
February	1.18	0.33	0.28
March	3.39	0.50	0.11
April	1.25		
May	0.60	0.32	0.46
June	0.10		
July			
August			
September			
October			
November			
December			

COLORADO, DENVER (began 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-17.28--Column

Sampling Period 1961	Precip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.07	0.63	0.86
February	0.66		
March	2.51	0.57	0.16
April	1.06		
May	4.12	1.15	0.22
June	1.11		
July			
August			
September			
October			
November			
December			

FLORIDA, CORAL GABLES (began: 4/57)
cum. mc Sr^{90}/mi^2 thru 12/60-39.53--Pot

Sampling Period 1961	Precip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.
January	5.00	0.19	0.03
February	0.63		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

HAWAII, HILO (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-22.16--Column

Sampling Period 1961	Precip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	2.34	3.07	0.15
February	20.50		
March	5.75	0.93	0.08
April	5.52		
May	8.12	1.51	0.11
June	5.78		
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont d

HAWAII, LIHUE (began: 5/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.52--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	2.19	0.36	0.16
March } April }	3.42 4.99	0.41	0.05
May } June }	1.02 0.07	0.00	
July			
August			
September			
October			
November			
December			

HAWAII, MAUNA LOA (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-3.06--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	0.17 1.26	0.15	0.10
March } April }	0.63 0.77	0.28	0.20
May } June }	1.02 0.07	combined sample lost	
July			
August			
September			
October			
November			
December			

HAWAII, OAHU (began: 6/57)
cum. mc Sr^{90}/mi^2 thru 12/60-33.40--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	4.17 0.79	0.84	0.17
March } April }	0.43 0.71	0.59	0.52
May			
June			
July			
August			
September			
October			
November			
December			

ILLINOIS, LEMONT (began: 12/56)
cum. mc Sr^{90}/mi^2 thru 12/60-45.36--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February }	0.28 0.91	0.14	0.12
March } April }	2.95 3.27	1.25	0.20
May			
June			
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Pu^{239}	Ce^{144}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	Total Beta Activity mc/sq. mile
Kentucky, Louisville (began: 9/58) - Pot												
January	2.55	1.00 ± 0.05	0.41 ± 0.02	*	*	0.29 ± 0.01	63 ± 2	2.4	19.23	0.160	2-3	5.91 ± 0.02
		lost	1.41 ± 0.70	*	*	0.23 ± 0.01	50 ± 2	--		0.552	--	lost
February	4.31	1.45 ± 0.11	1.32 ± 0.04	0.02 ± 0.01	0.16 ± 0.02	0.84 ± 0.05	237 ± 14	1.1	20.45	0.306	3-3	42.39 ± 3.0
		1.86 ± 0.06	1.12 ± 0.05	0.01 ± 0.005	0.30 ± 0.03	0.35 ± 0.01	99 ± 3	1.7		0.259	3-3	40.42 ± 2.91
March	2.42	1.73 ± 0.08	0.34 ± 0.02	0.01 ± 0.005	0.49 ± 0.02	0.28 ± 0.02	104 ± 7	5.1	20.82	0.140	4-1	8.59 ± 0.19
		1.35 ± 0.06	0.41 ± 0.02	0.01 ± 0.005	0.85 ± 0.04	0.50 ± 0.03	198 ± 13	3.0		0.169	4-1	7.74 ± 0.17
April	1.17	0.22 ± 0.01	0.56 ± 0.02	0.04 ± 0.004	1.97 ± 0.07	0.20 ± 0.02	100 ± 10	0.4	21.40	0.478	5-5	5.04 ± 0.17
		0.20 ± 0.01	0.60 ± 0.02	0.04 ± 0.004	2.36 ± 0.08	0.05 ± 0.01	25 ± 5	0.3		0.512	5-5	5.32 ± 0.18
May	3.52	0.16 ± 0.01	1.07 ± 0.04	0.016 ± 0.002	0.24 ± 0.011	0.46 ± 0.04	307 ± 27	0.1	21.88	0.303	6-3	11.09 ± 0.21
		0.25 ± 0.01	1.31 ± 0.05	0.025 ± 0.003	0.24 ± 0.011	0.51 ± 0.04	340 ± 27	0.2		0.372	6-3	11.35 ± 0.22
June	10.11	0.116 ± 0.005	1.32 ± 0.03	0.011 ± 0.002	0.56 ± 0.03	0.26 ± 0.02	217 ± 17	0.1	23.18	0.131	7-8	17.1 ± 0.3
		0.25 ± 0.01	1.27 ± 0.03	0.012 ± 0.002	0.60 ± 0.04	0.36 ± 0.03	300 ± 25	0.2		0.126	7-8	17.7 ± 0.3
July	1.99	0.078 ± 0.009	0.185 ± 0.017	0.003 ± 0.0008	2.895 ± 0.072	0.057 ± 0.026	63 ± 29	0.4	25.09	0.093	8-10	2.895 ± 0.072
		0.115 ± 0.011	0.197 ± 0.015	0.001 ± 0.0002	2.784 ± 0.074	0.066 ± 0.025	73 ± 28	0.6		0.099	8-10	2.784 ± 0.074
August	1.79		0.155 ± 0.009	0.001 ± 0.0007	2.77 ± 0.01**				25.23	0.037	9-12	1.842 ± 0.062
			0.131 ± 0.008	0.002 ± 0.0008	0.785 ± 0.013**					0.073	9-12	1.989 ± 0.070
September	3.00		0.108 ± 0.009	0.001 ± 0.001	0.602 ± 0.013				26.02	0.036	10-7	2.45 ± 0.045
			0.081 ± 0.008	0.001 ± 0.001	0.714 ± 0.013					0.027	10-7	1.99 ± 0.046
October	1.58		0.175 ± 0.010	0.004 ± 0.0008	0.524 ± 0.035				26.19	0.111	11-4	2.69 ± 0.07
			0.166 ± 0.009	0.002 ± 0.0007	0.571 ± 0.033					0.105	11-4	2.25 ± 0.06
November	3.35		0.118 ± 0.009	0.002 ± 0.0005	0.862 ± 0.132				26.32	0.035	12-7	2.81 ± 0.08
			0.142 ± 0.010	0.006 ± 0.001	0.585 ± 0.072					0.042		---
December	2.04		0.07 ± 0.01	0.002 ± 0.009	0.34 ± 0.17**				26.33	0.03	1-5-61	2.46 ± 0.71
			0.07 ± 0.01	0.002 ± 0.008	0.32 ± 0.17**					0.03	1-5-61	3.10 ± 0.08
1951												
January	2.41		0.130 ± 0.010	0.009 ± 0.002	0.661 ± 0.036				26.47	0.034	2-7	2.44 ± 0.08
			0.156 ± 0.010	0.017 ± 0.003	0.577 ± 0.197					0.065	2-7	2.46 ± 0.08
February	5.24		0.302 ± 0.014	0.007 ± 0.002	1.07 ± 0.04				26.81	0.058	3-7	6.25 ± 0.12
			0.380 ± 0.013	0.008 ± 0.003	1.04 ± 0.05					0.072		4.63 ± 0.10
March	7.63		0.51 ± 0.02	0.007 ± 0.002	1.68 ± 0.13				27.33	0.07	4-5	8.10 ± 0.14
			0.53 ± 0.02	0.016 ± 0.003	1.85 ± 0.16					0.07	4-5	9.00 ± 0.14
April	4.83		1.14 ± 0.02	0.027 ± 0.003	3.70 ± 0.10				28.38	0.236	5-10	15.5 ± 0.2
			0.97 ± 0.02	0.045 ± 0.005	3.61 ± 0.14					0.200	5-10	14.6 ± 0.2
May	9.00		1.32 ± 0.03	0.033 ± 0.004	3.92 ± 0.14				29.60	0.146	6-6	14.8 ± 0.2
			1.13 ± 0.02	0.025 ± 0.004	4.00 ± 0.18					0.125	6-6	12.9 ± 0.2
June	3.59		0.48 ± 0.02	0.009 ± 0.003	1.41 ± 0.04				30.04	0.133	7-6	5.30 ± 0.10
			0.39 ± 0.01	0.004 ± 0.002	1.42 ± 0.05					0.108	7-6	5.13 ± 0.10

* No analysis made

** Low chemical yield

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS; UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Pu^{239}	Ce^{144}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	Total Beta Activity mc/sq. mile
Kentucky, Louisville (began: 9/58) - Ion exchange column												
January	2.55	2.18 ± 0.78	0.28 ± 0.02	*	*	1.06 ± 0.03	230 ± 7	7.8	13.15	0.138	2-3	4.05 ± 0.03
		0.78 ± 0.03	1.05 ± 0.30	*	*	0.23 ± 0.01	50 ± 2	0.7		0.412	2-3	9.37 ± 0.05
February	4.31	1.93 ± 0.16	0.78 ± 0.03	0.01 ± 0.005	0.25 ± 0.01	0.24 ± 0.02	68 ± 6	2.5	14.03	0.180	3-3	8.92 ± 0.17
		0.76 ± 0.03	0.99 ± 0.03	0.01 ± 0.005	0.23 ± 0.01	0.94 ± 0.09	265 ± 25	0.8		0.229	3-3	12.62 ± 0.21
March	2.42	1.28 ± 0.05	0.59 ± 0.02	0.01 ± 0.005	0.62 ± 0.03	0.36 ± 0.03	133 ± 11	2.2	14.53	0.243	4-1	7.62 ± 0.17
		0.30 ± 0.02	0.41 ± 0.02	0.01 ± 0.005	0.36 ± 0.02	0.56 ± 0.04	207 ± 15	0.7		0.169	4-1	7.00 ± 0.15
April	1.17	0.37 ± 0.02	0.56 ± 0.02	0.04 ± 0.004	0.89 ± 0.04	0.13 ± 0.01	65 ± 5	0.7	15.03	0.478	5-5	11.6 ± 0.4
		0.35 ± 0.02	0.44 ± 0.02	0.04 ± 0.004	0.59 ± 0.03	0.19 ± 0.02	93 ± 10	0.8		0.376	5-5	4.63 ± 0.15
May	3.52	0.19 ± 0.01	1.66 ± 0.06	0.016 ± 0.002	0.24 ± 0.013	0.36 ± 0.03	240 ± 20	0.1	16.47	0.471	6-3	2.65 ± 0.05
		0.28 ± 0.01	1.23 ± 0.04	0.017 ± 0.002	0.18 ± 0.011	0.54 ± 0.06	360 ± 40	0.2		0.349	6-3	1.56 ± 0.03
June	10.11	0 ± 0.001	1.42 ± 0.03	0.009 ± 0.002	0.59 ± 0.03	0.14 ± 0.01	117 ± 7	~0	17.74	0.140	7-8	14.7 ± 0.2
		0 ± 0.001	1.11 ± 0.03	0.011 ± 0.002	0.58 ± 0.03	0.29 ± 0.02	242 ± 17	~0		0.110	7-8	7.68 ± 0.11
July	1.99	0.150 ± 0.012	0.07	0.001 ± 0.0002	0.938 ± 0.017	0.023 ± 0.026	26 ± 29	0.5	17.81	0.04	8-9	3.230 ± 0.030
		0.170 ± 0.011		0.001 ± 0.0002	0.268 ± 0.011	0.024 ± 0.024	27 ± 27	0.5			8-9	3.405 ± 0.033
August	1.79		0.12	0.001 ± 0.0008	0.700 ± 0.011**				17.93	0.07	9-12	3.63 ± 0.49
				0.001 ± 0.0007	0.160 ± 0.013**						9-12	2.90 ± 0.49
September	3.00		0.00	0.003 ± 0.001	0.460 ± 0.020				17.93	0.00	10-7	2.46 ± 0.30
				0.002 ± 0.001	0.964 ± 0.014						10-10	2.55 ± 0.23
October	1.58		0.12	0.009 ± 0.005	0.626 ± 0.029				18.05	0.07	11-4	3.42 ± 0.31
				0.005 ± 0.001	0.455 ± 0.024						11-4	2.92 ± 0.39
November	3.35		0.06	0.002 ± 0.0007	1.204 ± 0.263				18.11	0.02	12-7	2.35 ± 0.28
				0.008 ± 0.002	0.782 ± 0.088						12-7	3.13 ± 0.27
December	2.04		0.08	0.003 ± 0.001	0.45 ± 0.07**				18.19	0.04	1-4-61	2.81 ± 0.35
				0.010 ± 0.002	1.15 ± 0.02**						1-5-61	2.87 ± 0.38
1961												
January	2.41		0.14	0.004 ± 0.001	0.641 ± 0.037				18.33	0.06	2-6	3.85 ± 0.45
				0.011 ± 0.002	0.567 ± 0.054						2-3	3.09 ± 0.30
February	5.24		0.28	0.004 ± 0.002	1.02 ± 0.04				18.61	0.05	3-7	4.45 ± 0.45
				0.002 ± 0.0007	0.93 ± 0.04						3-7	4.73 ± 0.42
March	7.63		1.45	0.031 ± 0.005	4.82 ± 0.13				20.06	0.12	5-10	22.4 ± 0.9
April	4.83			0.064 ± 0.005	4.52 ± 0.11						5-10	20.5 ± 0.7
May	9.00		0.97 ± 0.02	0.017 ± 0.003	3.13 ± 0.21				21.20	0.107	6-6	8.50 ± 0.38
			1.32 ± 0.03	0.029 ± 0.004	3.37 ± 0.09					0.146	6-5	10.5 ± 0.4
June	3.59		0.45 ± 0.02	0.007 ± 0.002	1.48 ± 0.05				21.65	0.125	7-5	4.66 ± 0.33
			0.44 ± 0.01	0.009 ± 0.003	1.43 ± 0.05					0.122	7-5	4.64 ± 0.32

* No analysis made.

** Low chemical yield.

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Con t

LOUISIANA, NEW ORLEANS (began 5/60)
cum. mc Sr^{90}/mi^2 thru 12/60-0.65--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	6.94	0.34	0.02
February	9.00		
March	8.53	1.21	0.11
April	2.88		
May	7.27	1.42	0.09
June	8.01		
July			
August			
September			
October			
November			
December			

MINNESOTA, INTERNATIONAL FALLS (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-15.73-Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.46	0.36	0.27
February	0.85		
March	0.68	1.01	0.33
April	2.39		
May	1.76	1.15	0.47
June	0.70		
July			
August			
September			
October			
November			
December			

MISSOURI, COLUMBIA (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-23.03--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January		not received	
February		not received	
March	4.68	1.38	0.15
April	4.70		
May	6.33	1.81	0.16
June	5.26		
July			
August			
September			
October			
November			
December			

MONTANA, HELENA (began 2/59)
cum.mc Sr^{90}/mi^2 thru 12/60-9.30--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.09	0.13	0.87
February	0.06		
March	1.03	0.47	0.25
April	0.87		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1a

Sampling Period (1961)	Precip. (inches)	mc Sr^{90}/mi^2	Sr^{89}/Sr^{90} at Sampling Midpoint	mc Sr^{90}/mi^2 per inch of precip.
New York, New York				
(began 2/54: cum. mc Sr^{90}/mi^2 thru 12/60 - 76.09) - steel funnel-12.5 ft^2				
January	3.19	0.12		0.037
		0.10		0.031
February	4.09	0.18		0.044
		0.16		0.039
March	5.12	0.64		0.125
		0.72		0.140
April	7.36	0.83		0.112
		1.11		0.150
May	3.98	0.82		0.206
		0.83		0.208
June	2.76	0.42		0.152
		0.43		0.155

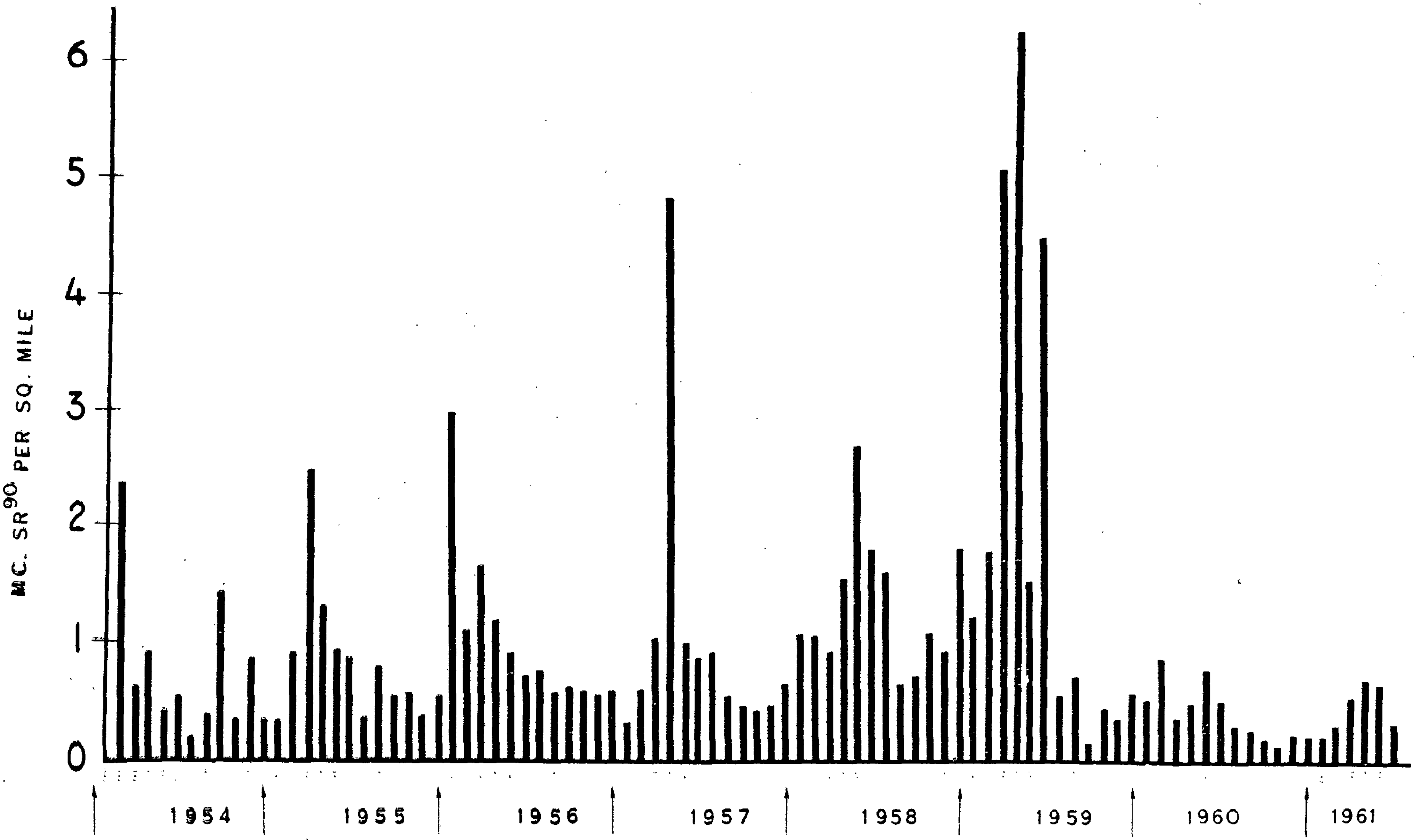


FIGURE 2 MONTHLY SR-90 NEW YORK CITY

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Pu^{259}	Ce^{144}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	Total Beta Activity mc/sq. mile
New Jersey, Westwood (began: 8/57) - Pot												
January	3.13	≤0.030	0.253 ± 0.010	lost	2.00 ± 0.08	≤0.089	---	--	44.55	0.080	2-17	7.31 ± 0.13
		≤0.048	0.254 ± 0.015	lost	2.16 ± 0.04	≤0.085	---	--		0.031	2-17	5.96 ± 0.11
February	4.89	1.24 ± 0.05	0.860 ± 0.022	≤0.0021	1.43 ± 0.03	≤0.103	---	1.44	45.22	0.175	3-9	30.5 ± 0.2
		1.11 ± 0.03	0.476 ± 0.013	lost	1.22 ± 0.03	≤0.077	---	2.33		0.037	3-9	27.2 ± 0.2
March	2.14	0.254 ± 0.043	0.427 ± 0.021	0.0033 ± 0.0024	1.12 ± 0.02	≤0.19	---	0.6	45.59	0.200	5-17	6.12 ± 0.16
		0.273 ± 0.032	0.311 ± 0.007	≤0.0025	1.11 ± 0.02	≤0.14	---	0.1		0.145	5-17	3.54 ± 0.50
April	3.99	≤0.010	1.06 ± 0.01	0.0110 ± 0.0029	4.07 ± 0.05	≤0.12	---	--	46.34	0.267	6-1	20.7 ± 0.4
		≤0.003	0.513 ± 0.009	0.0084 ± 0.0033	1.75 ± 0.03	≤0.068	---	--		0.129	6-1	9.70 ± 0.22
May	2.70	≤0.036	0.789 ± 0.015	0.0097 ± 0.0019	3.58 ± 0.04		---	--	47.14	0.232	7-5	16.7 ± 0.3
		≤0.036	0.809 ± 0.012	0.0074 ± 0.0027	3.51 ± 0.05		---	--		0.300	7-5	19.3 ± 0.3
June	1.50	≤0.034	0.476 ± 0.013	0.0036 ± 0.0027	2.00 ± 0.04		---	--	47.62	0.317	7-22	11.3 ± 0.2
		≤0.034	0.489 ± 0.011	0.0033 ± 0.0025	1.92 ± 0.04		---	--		0.326	7-22	10.3 ± 0.2
July	8.33		0.586 ± 0.014	0.0051 ± 0.0001	lost				48.20	0.070		
			0.578 ± 0.019	0.0028 ± 0.0000	lost					0.069		
August	6.73		0.334 ± 0.016	≤0.00346	1.26 ± 0.05				48.53	0.050		
			0.328 ± 0.017	≤0.00149	1.31 ± 0105					0.049		
September	6.93		0.283 ± 0.008	≤0.00420	1.03 ± 0.04				48.81	0.041		
			0.277 ± 0.007	lost	1.27 ± 0.05					0.040		
October	2.59		0.121 ± 0.009	≤0.00149	0.545 ± 0.032				48.93	0.047		
			0.128 ± 0.009	≤0.00149	0.498 ± 0.040					0.049		
November	2.96		0.118 ± 0.010	≤0.00149	0.326 ± 0.025				49.06	0.040		
			0.143 ± 0.018	≤0.00198	0.408 ± 0.033					0.048		
December	2.06		0.032 ± 0.004		0.341 ± 0.053				49.14	0.040		
			0.086 ± 0.009		0.394 ± 0.033					0.042		
1961												
January	*		0.193 ± 0.016		0.571 ± 0.022				49.32	0.132		
			0.189 ± 0.012		0.697 ± 0.032					0.121		
February	**		0.235 ± 0.010		0.714 ± 0.035				49.57	0.136		
			0.265 ± 0.010		0.709 ± 0.018					0.153		

* 1.46" rain and 15" snow.

** 1.73" rain and 18" snow.

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS; UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at Midpoint of sampling period: Sr^{89}	Sr^{90}	Pu^{239}	Ce^{144}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	Total Beta Activity mc/sq. mile
New Jersey, Westwood (began: 4/59) - Ion exchange column												
January	3.13	0.131 ± 0.053 0.082 ± 0.052	0.333 ± 0.014 0.334 ± 0.012	0.0030 ± 0.0015 0.0053 ± 0.0023	2.02 ± 0.04 3.26 ± 0.07	≤0.145 ≤0.090	--- ---	0.4 0.2	13.56	0.106 0.106	2-17 2-17	8.22 ± 0.29 8.28 ± 0.29
February	4.89	0.473 ± 0.029 0.900 ± 0.043	0.270 ± 0.012 0.711 ± 0.018	≤0.0022 ≤0.0019	0.790 ± 0.021 lost	≤0.096 ≤0.118	--- ---	1.8 1.3	14.05	0.055 0.145	3-9 3-9	12.2 ± 0.3 31.2 ± 0.6
March	2.14	0.08 ± 0.05 ≤0.06	0.374 ± 0.014 0.389 ± 0.016	≤0.0042 0.0054 ± 0.0016	0.352 ± 0.014 1.08 ± 0.02	≤0.24 ≤0.16	--- ---	0.2 --	14.43	0.175 0.182	5-21 5-21	9.84 ± 0.34 12.7 ± 0.5
April	3.99	≤0.408 ≤0.038	0.688 ± 0.027 0.692 ± 0.012	0.0039 ± 0.0025 ≤0.0042	2.41 ± 0.03 2.09 ± 0.03	≤0.068 ≤0.087	--- ---	-- --	15.12	0.172 0.173	6-1 6-1	13.5 ± 0.4 16.6 ± 0.5
May	2.70	≤0.034 ≤0.034	0.755 ± 0.011 0.768 ± 0.013	0.0058 ± 0.0015 0.0072 ± 0.0016	3.46 ± 0.04 3.12 ± 0.04		--- ---	-- --	15.74	0.280 0.284	7-5 7-5	15.3 ± 0.2 12.5 ± 0.2
June	1.50	≤0.037 ≤0.039	0.545 ± 0.014 0.634 ± 0.016	≤0.0031 0.0057 ± 0.0031	2.79 ± 0.05 3.19 ± 0.07		--- ---	-- --	16.33	0.363 0.423	8-10 8-10	7.42 ± 0.42 10.5 ± 0.2
July	8.33		0.41	0.0033 ± 0.0000 0.0033 ± 0.0003	1.98 ± 0.06 1.35 ± 0.07				16.74	0.05		
August	6.73		0.18	≤0.00155 ≤0.00155	1.36 ± 0.06 1.23 ± 0.05				16.92	0.03		
September	6.95		0.22	≤0.00440 ≤0.00440	0.956 ± 0.043 lost				17.14	0.03		
October	2.59		0.18	≤0.00200 ≤0.00243	lost 0.680 ± 0.094				17.32	0.07		
November	2.96		0.10	≤0.00155 ≤0.00155	0.312 ± 0.035 0.512 ± 0.036				17.42	0.03		
December	2.06		0.00		0.251 ± 0.022 lost				17.42	0.00		
1961												
January	*		0.29		1.30 ± 0.02 in process				17.71	0.20		
February	**		0.22		0.597 ± 0.033 0.803 ± 0.045				17.93	0.13		

* 1.46" rain and 15" snow.

** 1.73" rain and 18" snow.

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNTIED STATES SITES - Cont

NORTH DAKOTA, WILLISTON (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-8.49--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	0.09	0.90	0.67
February }	1.25		
March }	0.12	0.59	0.24
April }	2.39		
May }	0.58	0.35	0.35
June }	0.43		
July			
August			
September			
October			
November			
December			

OREGON, MEDFORD (began : 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-9.31--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	1.12	1.06	0.27
February }	2.74		
March }	3.05	0.33	0.08
April }	0.96		
May }	1.86	0.60	0.27
June }	0.34		
July			
August			
September			
October			
November			
December			

OKLAHOMA, TULSA (began: 1/58)
cum. mc Sr^{90}/mi^2 thru 12/60-44.97--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }		0.57	
February }			
March }		1.42	
April }			
May			
June			
July			
August			
September			
October			
November			
December			

SOUTH CAROLINA, COLUMBIA (began : 4/59)
cum. mc Sr^{90}/mi^2 thru 12/60- 10.90--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	2.93	1.54	0.13
February }	8.95		
March }	0.29	0.51	1.70
April }	0.01		
May }	2.98	0.34	0.07
June }	1.95		
July			
August			
September			
October			
November			
December			

MONTHLY FALLOUT DEPOSITION COLLECTIONS; UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Ce^{144}	Pu^{239}	Ru^{106}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on D-date (1959)	Total Beta Activity mc/sq. mile
Pittsburgh, Pennsylvania (began: 7/57) - Pot													
January*	2.89	0.11 ± 0.07	0.201 ± 0.040**				0.5 ± 0.2	109 ± 43	0.5	30.29	0.069	2-12	8.3 ± 0.9
		0.01 ± 0.06	0.300 ± 0.017				0.4 ± 0.2	87 ± 43	0.03		0.103	2-26	9.7 ± 1.0
February	2.07	0.44 ± 0.12	0.420 ± 0.016	2.71 ± 0.18	0.003 ± 0.004		0 ± 0.08	---	1.0	30.67	0.202	3-10	12.2 ± 0.8
		0.55 ± 0.18	0.343 ± 0.036	lost	lost		0.02 ± 0.09	---	1.6		0.165	3-17	15.2 ± 0.9
March	1.61	0.66 ± 0.9	0.321 ± 0.022	2.20 ± 0.12	0.020 ± 0.005		0.01 ± 0.03	---	2.0	30.99	0.199	4-30	8.9 ± 0.6
		0.52 ± 0.8	0.336 ± 0.023	2.28 ± 0.15	0.012 ± 0.003		0 ± 0.03	---	1.6		0.208	4-30	9.8 ± 0.7
April	1.59	0.21 ± 0.7	0.587 ± 0.035	3.24 ± 0.16	0.003 ± 0.005		0.01 ± 0.03	---	0.36	31.51	0.369	5-25	9.3 ± 0.6
		0.23 ± 0.9	0.431 ± 0.033	2.39 ± 0.25	0.008 ± 0.012		0 ± 0.03	---	0.53		0.271	5-21	16.1 ± 0.9
May	4.71	0 ± 0.09	0.784 ± 0.037	3.75 ± 0.20	0 ± 0.004		0.03 ± 0.10	20 ± 67	--	32.32	0.166	6-16	15.3 ± 0.8
		0.22 ± 0.20	0.843 ± 0.040	3.63 ± 0.25	0.009 ± 0.0008		0.08 ± 0.11	53 ± 73	0.26		0.179	6-16	17.0 ± 0.9
June	3.51	0.06 ± 0.08	0.803 ± 0.036	3.48 ± 0.30	0.010 ± 0.015		0.09 ± 0.11	75 ± 91	0.07	33.12	0.229	7-26	10.2 ± 0.6
		0.17 ± 0.12	0.803 ± 0.035	3.80 ± 0.45	0.003 ± 0.025		0.34 ± 0.15	283 ± 125	0.21		0.229	7-26	16.9 ± 0.9
July	2.89		0.478 ± 0.042	1.41 ± 0.42	0.022 ± 0.022	1.63 ± 0.07				33.59	0.165		
			0.459 ± 0.019	1.81 ± 0.12	0.014 ± 0.004	2.25 ± 0.10					0.159		
August	2.50		0.250 ± 0.023	1.04 ± 0.35	0.020 ± 0.013	9.01 ± 0.35				33.83	0.100		
			0.226 ± 0.022	1.02 ± 0.08	0.034 ± 0.003	3.96 ± 0.15					0.090		
September	3.08		0.182 ± 0.021	0.66 ± 0.20	0.019 ± 0.013	0.63 ± 0.05				34.01	0.059		
			0.165 ± 0.017	0.79 ± 0.08	0.012 ± 0.005	0.97 ± 0.06					0.054		
October	1.93		0.15 ± 0.04	0.54 ± 0.06	0.005 ± 0.002	2.98 ± 0.15				34.14	0.077		
			0.14 ± 0.02	0.59 ± 0.08	0.007 ± 0.004						0.072		
November	1.38		0.10 ± 0.02	0.40 ± 0.04	0.014 ± 0.003	0.51 ± 0.03				34.26	0.072		
			0.14 ± 0.02	0.46 ± 0.05	0.009 ± 0.003	0.80 ± 0.04					0.101		
December	2.76		0.19 ± 0.02	0.58 ± 0.06	0.014 ± 0.002	0.40 ± 0.04				34.46	0.068		
			0.20 ± 0.02	0.61 ± 0.06	0.025 ± 0.005	1.06 ± 0.04					0.072		
1961													
January	0.90		0.11 ± 0.02	0.31 ± 0.04	0.044 ± 0.010	0.31 ± 0.03				34.58	0.122		
			0.14 ± 0.02	0.40 ± 0.04	0.043 ± 0.009	0.26 ± 0.02					0.155		
February	3.01		0.54 ± 0.04	1.53 ± 0.10	0.039 ± 0.008	1.12 ± 0.04				35.16	0.179		
			0.63 ± 0.04	1.77 ± 0.09	0.062 ± 0.012	0.87 ± 0.07					0.209		
March	3.68		0.74 ± 0.04	2.42 ± 0.10	0.119 ± 0.018	1.61 ± 0.05				35.93	0.201		
			0.80 ± 0.04	2.36 ± 0.10	0.028 ± 0.016	1.40 ± 0.04					0.217		
April	3.44		1.16 ± 0.04	3.32 ± 0.08	0 ± 0.001	2.32 ± 0.06				37.05	0.337		
			1.08 ± 0.04	3.52 ± 0.08	0.009 ± 0.004	0.34 ± 0.06					0.313		
May	3.39		0.92 ± 0.04	2.19 ± 0.17	0 ± 0.001	2.26 ± 0.05				37.99	0.271		
			0.97 ± 0.03	2.21 ± 0.08	0 ± 0.002	1.92 ± 0.05					0.286		
June	4.23		0.83 ± 0.03	2.18 ± 0.07	0 ± 0.002	1.76 ± 0.04				38.83	0.195		
			0.86 ± 0.03	1.97 ± 0.07	0 ± 0.001	1.79 ± 0.04					0.203		

* This sample and all hereafter were reported after January 1, 1960. See note below.

** Sr^{90} data reported after January 1, 1960 are calculated from a recalibration based on HASL standards of Sr^{90} in strontium carbonate. These data reflect a 15 percent decrease in the overall counting efficiency. *Data reported prior to January 1, 1960, therefore, should be multiplied by a factor of 1.15 to be consistent with current data.*

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

Sampling Period (1960)	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Ce^{144}	Pu^{239}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity: on C-date (1960)	mc/sq. mile
Pittsburgh, Pennsylvania - Ion exchange column											
February	2.06	2 ± 3	0.144 ± 0.016			0.09 ± 0.27	26.5 ± 79.4	13.9	0.070	8-19	5.1 ± 0.6
		5 ± 4	0.220 ± 0.060			0.16 ± 0.25	47.1 ± 73.5	22.7	0.107	8-19	7.7 ± 0.7
March	1.61	0.7 ± 0.8	0.179 ± 0.025	1.19 ± 0.09	0 ± 0.003	0.24 ± 0.21	92.3 ± 80.8	3.9	0.111	8-18	4.6 ± 0.6
		0.5 ± 0.7	0.191 ± 0.016	1.08 ± 0.12	0.006 ± 0.008	0.04 ± 0.18	15.4 ± 69.2	2.6	0.119	8-18	5.4 ± 0.6
April	1.59	0.6 ± 0.4	0.257 ± 0.021	1.94 ± 0.12	0 ± 0.004	0.13 ± 0.16	65.0 ± 80.0	2.3	0.162	8-18	6.8 ± 0.7
		0.6 ± 0.6	0.422 ± 0.022	2.03 ± 0.15	0.004 ± 0.006	0.41 ± 0.24	205.0 ±120.0	1.4	0.265	8-18	6.2 ± 0.7
May	4.71	0.3 ± 0.4	lost	3.01 ± 0.16	0.018 ± 0.008	0.08 ± 0.10	53.3 ± 66.7	--	--	8-18	6.8 ± 0.7
		lost	lost	2.13 ± 0.20	0.006 ± 0.010	0.10 ± 0.11	66.7 ± 73.3	--	--	8-18	7.1 ± 0.7
June	3.87	0 ± 0.2	0.489 ± 0.025	2.33 ± 0.20	0.008 ± 0.014	0.06 ± 0.10	52.2 ± 87.0	0.0	0.126	8-18	5.9 ± 0.6
		0.5 ± 0.3	0.459 ± 0.039	1.52 ± 0.12	0 ± 0.005	0.06 ± 0.10	52.2 ± 87.0	1.1	0.119	8-18	6.4 ± 0.7
July	2.89		0.006 ± 0.002	1.32 ± 0.16	0.028 ± 0.010				0.002		
			0.020 ± 0.004	1.57 ± 0.15	0.030 ± 0.012				0.006		
August	2.50		0.51 ± 0.17	0.91 ± 0.06	0.037 ± 0.007				0.204		
			6.84 ± 2.32	0.98 ± 0.07	0.027 ± 0.008				2.74		
September	3.08		0.26 ± 0.05	0.28 ± 0.05	0.024 ± 0.006				0.084		
			0.27 ± 0.03	0.28 ± 0.05	0.051 ± 0.008				0.087		
October	1.93		0.35 ± 0.06	0.28 ± 0.04	0.001 ± 0.002				0.181		
			0.57 ± 0.05	0.80 ± 0.07	0.004 ± 0.004				0.295		
November	1.38		0.32 ± 0.02	0.14 ± 0.03	0.005 ± 0.005				0.231		
			0.37 ± 0.04	0.10 ± 0.02	0.014 ± 0.005				0.269		
December	2.76		0.36 ± 0.02	0.10 ± 0.03	0.003 ± 0.003				0.131		
			0.35 ± 0.02	0.28 ± 0.04	0.025 ± 0.005				0.126		
1961											
January	0.90		0.24 ± 0.02	0.19 ± 0.04	0.014 ± 0.010				0.266		
			0.26 ± 0.02	0.13 ± 0.04	0.012 ± 0.006				0.288		
February	3.01		0.57 ± 0.02	0.32 ± 0.03	0.013 ± 0.006				0.189		
			0.53 ± 0.02	0.21 ± 0.03	0.015 ± 0.006				0.176		
March	3.68		0.50 ± 0.02	0.16 ± 0.03	0.006 ± 0.005				0.135		
			0.38 ± 0.02	0.07 ± 0.02	0.003 ± 0.004				0.103		
April	3.44		0.32 ± 0.03	0.69 ± 0.07	lost				0.093		
			0.42 ± 0.02	lost	0 ± 0.003				0.122		
May	3.86		0.19 ± 0.02	0.36 ± 0.03	0 ± 0.003				0.049		
			0.60 ± 0.03	0.28 ± 0.03	0 ± 0.002				0.155		
June	3.76		0.15 ± 0.02	0.27 ± 0.03	0 ± 0.002				0.039		
			0.26 ± 0.02	0.50 ± 0.04	0 ± 0.001				0.069		

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont

SOUTH DAKOTA, VERMILLION (began: 4/57)
cum. mc Sr^{90}/mi^2 thru 12/60-37.26--Pot

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February		0.07	
March } April		0.56	
May			
June			
July			
August			
September			
October			
November			
December			

TEXAS, EL PASO (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-5.42--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	0.41		
February	T	0.84	2.05
March }	0.29		
April	0.01	0.39	1.30
May }	T		
June	0.27	0.10	0.37
July			
August			
September			
October			
November			
December			

TEXAS, DALLAS (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-16.79--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	3.39		
February	3.21	0.56	0.08
March }	4.90		
April	1.66	0.98	0.15
May }	1.31		
June	7.85	0.72	0.08
July			
August			
September			
October			
November			
December			

TEXAS, HOUSTON (began : 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-24.83--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	4.44		
February	3.88	1.74	0.21
March }	1.84		
April	2.42	0.66	0.15
May }	3.59		
June	11.11	0.52	0.04
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont'd.

Sampling Period 1960	Precip. (inches)	millicuries per square mile at midpoint of sampling period: Sr^{89}	Sr^{90}	Pu^{239}	Ce^{144}	W^{185}	on 6-1-58 W^{185}	Sr^{89}/Sr^{90} at Sampling Midpoint	Cumulative mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip.	Total Beta Activity on C-date (1960)	Total Beta Activity mc/sq. mile
Texas, Houston (began: 5/58) - Pot (HASL Contractor Site)												
1/4-2/1	1.95	0.083 ± 0.013	0.158 ± 0.006	≤0.0000 ± 0.0015	2.71 ± 0.06	0.104 ± 0.017	27 ± 4	0.5	21.67	0.081	3-3	7.01 ± 0.09
		0.058 ± 0.011	0.140 ± 0.005	≤0.0000 ± 0.0034	2.32 ± 0.05	0.117 ± 0.061	30 ± 6	0.4		0.072	3-3	6.23 ± 0.09
2/1-3/1	3.99	2.13 ± 0.06	0.620 ± 0.015	lost	5.48 ± 0.12	0.284 ± 0.032	84 ± 9	3.44	22.29	0.155	3-25	27.0 ± 0.3
		lost	lost	lost	lost	lost	- -	--		--		
3/1-4/1		lost	lost	lost	lost	lost	- -	--	--	--		
		lost	lost	lost	lost	lost	- -	--		--		
4/1-5/1	0.85	0.540 ± 0.021	0.221 ± 0.014	0.0056 ± 0.0006	2.59 ± 0.06	0.147 ± 0.027	74 ± 14	2.4	22.54	0.260	6-21	7.79 ± 0.14
		0.597 ± 0.043	0.278 ± 0.028	0.0051 ± 0.0003	3.11 ± 0.08	0.148 ± 0.032	74 ± 16	2.1		0.327	6-21	8.76 ± 0.14
5/1-6/1	0.88	0.018 ± 0.010	0.090 ± 0.004	0.0060 ± 0.0016	1.34 ± 0.04	0.042 ± 0.014	28 ± 9	0.2	22.62	0.102	6-22	4.23 ± 0.06
		0.022 ± 0.011	0.077 ± 0.004	0.0093 ± 0.0039	1.15 ± 0.08	0.065 ± 0.012	43 ± 8	0.3		0.088	6-22	3.80 ± 0.05
6/1-7/1	14.38	<0.049	0.601 ± 0.014	0.0115 ± 0.0008	3.62 ± 0.03	0.076 ± 0.013	101 ± 17	0.1	23.20	0.042	8-4	13.2 ± 0.2
		<0.011	0.564 ± 0.015	0.0119 ± 0.001	2.64 ± 0.03	0.054 ± 0.012	72 ± 16	0.02		0.039	8-4	11.5 ± 0.2
7/1-8/1	5.48		0.104 ± 0.004	0.0049 ± 0.0008	1.50 ± 0.03				23.30	0.019		
			0.103 ± 0.005	0.0098 ± 0.0013	1.37 ± 0.03					0.019		
8/1-9/1	7.42		0.327 ± 0.006	0.020 ± 0.002	2.65 ± 0.05				23.62	0.044		
			0.322 ± 0.006	0.016 ± 0.002	2.68 ± 0.03					0.043		
9/1-10/1	1.86		0.079 ± 0.006	0.0059 ± 0.0007	0.81 ± 0.02				23.69	0.042		
			0.072 ± 0.006	lost	0.97 ± 0.02					0.039		
10/1-11/1	10.85		0.241 ± 0.005	0.0051 ± 0.002*	0.336 ± 0.017				23.92	0.022		
			0.229 ± 0.01	0.0078 ± 0.0007*	0.334 ± 0.012					0.021		
11/1-12/1	4.73		0.110 ± 0.005	0.0043 ± 0.0006	0.55 ± 0.03				24.03	0.023		
			0.106 ± 0.005	0.0029 ± 0.0005	0.65 ± 0.03					0.022		
12/1-1/1	6.72		0.181 ± 0.008	0.0042 ± 0.0008	0.55 ± 0.04				24.20	0.026		
			0.160 ± 0.008	0.0053 ± 0.0007	0.58 ± 0.04					0.023		
1961												
1/1-2/1	4.44		0.253 ± 0.009	0.0050 ± 0.0008	0.88 ± 0.04				24.45	0.056		
			0.247 ± 0.009	0.0040 ± 0.0005	0.70 ± 0.02					0.055		
2/1-3/1	6.46		0.482 ± 0.014	<0.009	1.26 ± 0.04				24.92	0.074		
			0.452 ± 0.020	0.010 ± 0.003	1.13 ± 0.05					0.069		

* Low chemical yield

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont

UTAH, SALT LAKE CITY (began:12/56)
cum. mc Sr^{90}/mi^2 thru 12/60-57.18--Pot

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per-inch of precip
January	0.07	0.88	0.42
February	2.05		
March	1.85	1.13	0.40
April	0.94		
May			
June			
July			
August			
September			
October			
November			
December			

WASHINGTON, NEAH BAY (began :12/59)
cum. mc Sr^{90}/mi^2 thru 12/60-3.57--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	14.99	1.80	0.05
Frbruary	21.16		
March		Lost	
April	5.36	1.68	0.31
May	3.45	1.08	0.21
June	1.76		
July			
August			
September			
October			
November			
December			

WASHINGTON, SEATTL (began: 4/58)
cum. mc Sr^{90}/mi^2 thı 12/60-27.97--Pot

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per-inch of precip
January		0.82	
February			
March		1.02	
April			
May			
June			
July			
August			
September			
October			
November			
December			

VIRGINIA, STERLING (began: 2/59
cum. mc Sr^{90}/mi^2 thru 12/60-16.82--Column
COLLECTOR # 1

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.20	0.39	0.05
February	4.13		
March	4.05	1.53	0.21
April	3.22		
May	3.50	1.02	0.15
June	3.46		
July			
August			
September			
October			
November			
December			

Table 1a

MONTHLY FALLOUT DEPOSITION COLLECTIONS: UNITED STATES SITES - Cont

VIRGINIA, STERLING (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-16.82--Column
COLLECTOR # 2

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.20	0.23	0.03
February	4.13		
March	4.05	1.21	0.17
April	3.22		
May	3.50	1.32	0.19
June	3.46		
July			
August			
September			
October			
November			
December			

WISCONSIN, GREEN BAY (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-15.81--Column

Sampling Period 1961	Percip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 perinch of precip
January	0.31	0.20	0.16
February	0.93		
March	2.12	0.92	0.24
April	1.67		
May	1.42	2.09	0.36
June	4.31		
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES

ARGENTINA, BUENOS AIRES (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-2.16--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	7.80	0.70	0.06
February }	3.82		
March }	2.80	0.08	0.08
April }	3.23		
May	5.24		
June	1.48		
July	1.89		
August			
September			
October			
November			
December			

ARGENTINA, FORMOSA (began 6/61)

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February			
March			
April			
May			
June	3.46		
July			
August			
September			
October			
November			
December			

ARGENTINA, MALARGÜE (began: 11/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.21--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	0.09	0.60	0.74
February }	0.72		
March }	0.14	0.15	0.15
April }	0.85		
May	0.48		
June			
July			
August			
September			
October			
November			
December			

AUSTRIA, KLAGENFURT (began: 8/57)
cum. mc Sr^{90}/mi^2 thru 12/60-32.23--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	2.04	0.20	0.08
February }	0.43		
March }	1.20	0.44	0.20
April }	1.05		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

AUSTRIA, VIENNA (began: 6/57)
cum. mc Sr^{90}/mi^2 thru 12/60-36.09--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.35	0.42	0.14
February	2.68		
March	1.40	0.00	
April	2.55		
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, ADELAIDE (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-5.57--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.19	0.18	0.35
February	0.32		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, ADELAIDE (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-3.67--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.38	0.08	0.21
February	1.88	0.03	0.02
March	0.84	0.11	0.13
April	2.19	0.14	0.06
May	4.77	0.15	0.02
June	1.60		
July	1.42	0.24	0.08
August	1.58		
September	3.64	0.58	0.13
October	0.86		
November	3.80	0.57	0.14
December	0.11		

AUSTRALIA, BRISBANE (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-4.62--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.21	0.16	0.05
February	4.55	0.22	0.05
March	3.25	0.16	0.05
April	0.74	0.07	0.09
May	1.65	0.24	0.09
June	1.12		
July	1.49	0.07	0.04
August	0.46		
September	1.20	0.28	0.12
October	1.20		
November	4.68	0.81	0.09
December	4.56		

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

AUSTRALIA, BRISBANE (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-6.22--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	6.30	0.49	0.04
February }	7.09		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, DARWIN (began 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-5.89--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	10.36	0.10	
February }	14.50		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, DARWIN (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-4.78--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	22.36	0.06	0.00
February	16.30	0.20	0.01
March	17.56	0.24	0.01
April	3.20	0.07	0.02
May }	0.52	0.07	0.13
June }	0.00		
July }	0.00	0.03	--
August }	0.00		
September }	0.08	0.17	0.22
October }	0.76		
November }	3.02	0.27	0.04
December }	4.11		

AUSTRALIA, HOBART (began 6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-4.47--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	2.46	0.21	0.08
February	0.49	0.07	0.14
March	0.59	0.06	0.10
April	9.75	0.32	0.03
May }	3.81	0.11	0.03
June }	1.99	0.06	0.03
July }	2.13	0.12	0.04
August }	1.03		
September }	3.29	0.22	0.04
October }	2.57		
November }	2.76	0.22	0.07
December }	0.39		

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE OF UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
AUSTRALIA, HOBART (began 6/58)			
cum. mc Sr^{90}/mi^2 thru 12/60-5.86--Pot			
January	1.14		
February	1.20	0.30	0.13
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
AUSTRALIA MELBOURNE (began: 6/58)			
cum. mc Sr^{90}/mi^2 thru 12/60-6.25--Pot			
January	1.32		
February	1.48	0.28	0.10
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
AUSTRALIA, MELBOURNE (began: 6/58)			
cum. mc Sr^{90}/mi^2 thru 12/59-4.04--Pot			
January	1.80	0.19	0.10
February	2.41	0.12	0.05
March	0.38	0.16	0.42
April	7.67	0.25	0.03
May	3.75		
June	0.78	0.10	0.02
July	2.04		
August	2.79	0.29	0.06
September	3.64		
October	1.53	0.55	0.11
November	5.43		
December	2.52	0.88	0.11
AUSTRALIA, PERTH (began: 6/58)			
cum. mc Sr^{90}/mi^2 thru 12/59-2.91--Pot			
January	1.06	0.05	0.05
February	0.22	0.07	0.32
March	2.27	0.08	0.04
April	0.72	0.05	0.07
May	5.33		
June	4.44	0.23	0.02
July	7.38		
August	2.54	0.45	0.04
September	2.55		
October	1.06	0.25	0.07
November	0.30		
December	0.34	0.13	0.17

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

AUSTRALIA, PERTH (began 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-4.22--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.44	0.21	0.28
February	0.32		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, SYDNEY (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-8.72--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	2.46	0.54	0.09
February	3.37		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AUSTRALIA, SYDNEY (began:6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-6.16--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	2.27	0.14	0.06
February	3.68	0.21	0.06
March	2.08	0.12	0.06
April	1.16	0.17	0.15
May	4.28	0.23	0.03
June	3.56		
July	5.58	0.14	0.02
August	1.77		
September	2.68	0.65	0.05
October	11.03		
November	2.81	0.90	0.07
December	9.65		

AUSTRALIA, TOWNSVILLE (began 6/58)
cum. mc Sr^{90}/mi^2 thru 12/59-2.08--Pot

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	5.48	0.25	0.04
February	22.03	0.18	0.01
March	14.39	0.05	0.00
April	0.34	0.03	0.09
May	1.78	0.05	0.02
June	0.29		
July	0.05	0.02	0.22
August	0.04		
September	0.14	0.10	0.17
October	0.45		
November	5.32	0.34	0.04
December	3.53		

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

AUSTRALIA, TOWNSVILLE (began: 6/58)
cum. mc Sr^{90}/mi^2 thru 12/60-3.11--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	1.34		
February	8.69	0.11	0.01
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

AZORES, LAJES FIELD (began: 10/59
cum. mc Sr^{90}/mi^2 thru 12/60-2.70-- Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	4.78		
February	5.86	0.92	0.09
March	6.16		
April	3.62	0.46	0.14
May	1.41		
June	1.79	Lost	
July			
August			
September			
October			
November			
December			

BOLIVIA, LA PAZ (began: 2/60)
cum. mc Sr^{90}/mi^2 thru 12/60-0.67--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.54		
Febuary		0.00	
March	1.57		
April	1.18	0.11	0.04
May			
June			
July			
August			
Septamber			
October			
November			
December			

BRAZIL, BELÉM (began: 11/59)
cum. mc Sr^{90}/mi^2 thru 12/60-0.93--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February		Lost	
March	34		
April	1.40	0.34	0.01
May			
June			
July			
August			
September			
October			
November			
December			

Table ib

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, BRASILIA (began: 7/59) cum.mc Sr^{90}/mi^2 thru 12/59-0.36--Pot				**BRAZIL, BRASILIA** (began 7/59			
January		0.01		January }		0.02	
February		0.03		February }			
March		0.02		March			
April		lost		April			
May }		lost		May			
June }				June			
July		not received		July			
August		not received		August			
September }		0.08		September			
October }				October			
November }		0.06		November			
December }				December			
BRAZIL, MANAUS (began: 1/59) cum. mc Sr^{90}/mi^2 thru 12/59-3.01--Pot				**BRAZIL, MANAUS**			
January		not received		January }		0.16	
February		not received		February }			
March		not received		March			
April	0.55	0.51		April			
May }	0.24			May			
June }	5.91	lost		June			
July		0.02		July			
August		not received		August			
September				September			
October				October			
November }	9.45			November			
December }	11.81	0.09	0.00	December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, NOVA FRIBURGO (began: 8/58)			
cum. mc Sr^{90}/mi^2 thru 12/59-4.02--Pot			
January		0.03	
February			
March	13.65	0.13	0.01
April		0.00	
May	0.47	0.04	
June			
July		0.26	
August	2.24		
September		0.24	
October			
November		0.37	
December		not received	
BRAZIL, RECIFE (began: 9/59)			
cum. mc Sr^{90}/mi^2 thru 12/59-0.27--Pot			
January		0.06	
February		0.04	
March		0.55	
April		0.12	
May	0.79	0.56	0.71
June		not received	
July		0.22	
August		not received	
September		not received	
October		not received	
November		not received	
December		not received	

Sampling Period 1961	Precip. (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, NOVA FRIBURGO			
cum. mc Sr^{90}/mi^2 thru 12/60-5.09--Pot			
January	15	0.28	0.01
February	9.6		
March		0.16	
April			
May			
June			
July			
August			
September			
October			
November			
December			
BRAZIL, RECIFE			
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS :OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, RIO DE JANEIRO (began: 4/60)			
January			
February			
March			
April	9.84	0.01	0.00
May	7.83	0.18	0.02
June	1.57		
July	1.18	0.03	0.01
August	1.97		
September	3.35	0.04	0.01
October	1.05		
November	5.06	lost	
December	6.76		
BRAZIL, SÃO JOSÉ DOS CAMPOS, SÃO PAULO (began: 7/58)			
Cum. mc Sr^{90}/mi^2 thru 12/59-3.90--Pot			
January		not received	
February	12.21	0.04	0.00
March		0.08	
April	2.76	0.04	0.01
May	4.72	0.12	0.02
June		not received	
July		not received	
August	0.79	0.03	0.04
September		0.33	
October	6.30		
November		lost	
December			

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, RIO DE JANEIRO			
cum. mc Sr^{90}/mi^2 thru 12/60-0.33--Column			
January	6.88	0.24	0.02
February	3.70		
March	5.01	0.52	0.04
April	6.80		
May			
June			
July			
August			
September			
October			
November			
December			
cum. mc Sr^{90}/mi^2 thru 12/60-8.14			
January		0.28	
February			
March		0.16	
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, SÃO LEOPOLDO (began: 8/59)- - Pot							
cum. mc Sr-90/mi^2 thru 12/59- 0.93				cum. mc Sr-90/mi^2 thru 12/60 - 3.94			
January		0.12		January }		0.27	
February		0.12		February }			
March		0.24		March }		0.22	
April	0.87	0.15	0.17	April }			
May }		0.79		May			
June }				June			
July }		0.77		July			
August }				August			
September }		0.40		September			
Ocotber }				October			
November }		0.42		November			
December }				December			
BERMUDA, KINDLEY AFB (Began:9/59) --1961 data							
cum. mc Sr^{90}/mi^2 thru 12/60-3.52--Column							
January }	4.30	0.40	0.15				
February }	2.71						
March }	1.71	0.74	0.09				
April }	6.64						
May }		0.09					
June }	6.00						
July							
August							
September							
October							
November							
December							

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
BRAZIL, ITAICI, SÃO PAULO (began: 8/58)							
January				January		0.17	
February				February			
March				March			
April				April			
May				May			
June				June			
July		0.01		July			
August				August			
September		0.20		September			
October				October			
November		0.35		November			
December				December			
1961							
CANAL ZONE (began: 9/59)				**CANTON ISLAND** (began: 2/59)			
cum. mc Sr^{90}/mi^2 thru 12/60-1.82--Column				cum. mc Sr^{90}/mi^2 thru 12/60-1.76--Column			
January	0.19	0.09	0.08	January	0.68	0.18	0.18
February	0.86			February	0.30		
March		not received		March	0.71	0.26	0.16
April	1.79	0.16		April	0.90		
May				May	2.60	0.00	0.00
June				June	5.41		
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
CEYLON, COLOMBO (began: 9/59)			
cum. mc Sr^{90}/mi^2 thru 12/60-1.02--Column			
January } February }		0.00	
March } April } May }	11 18	0.21	0.01
June			
July			
August			
September			
October			
November			
December			
COLUMBIA, BOGOTA (began: 8/57) - 1960 data			
cum. mc Sr^{90}/mi^2 thru 12/59-2.35--Pot			
January			
February			
March		0.29	
April		0.04	
May } June }		0.04	
July } August }		0.01	
September		not received	
October		not received	
November		not received	
December		not received	

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
CHILE, SANTIAGO (began: 6/58)			
cum. mc Sr^{90}/mi^2 thru 10/60-3.05--Pot			
1960data			
November } December }	0 0	0.02	
January } February }	0 0	0.03	
March } April }	0.39 0	0.08	0.20
May			
June			
July			
August			
September			
October			
November			
December			
COLUMBIA, BOGOTA			
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

CONGO, LEOPOLDVILLE-Site #1 (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.70--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	4.56		
February	6.92	0.00	0.00
March	3.82		
April	13.97	0.16	0.01
May			
June			
July			
August			
September			
October			
November			
December			

Site #2 (began: 4/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.68--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

COSTA RICA, TURRIALBA (began: 8/59)
Cum. mc Sr^{90}/mi^2 thru 12/60-1.71--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.35		
February	0.20	0.02	0.01
March	1.67		
April	2.24	0.04	0.01
May			
June			
July			
August			
September			
October			
November			
December			

ECUADOR, QUITO (began: 7/59) - 1960 data
cum. mc Sr^{90}/mi^2 thru 12/59-o.14--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January		0.14	
February		0.13	
March		0.12	
April		0.12	
May		0.11	
June		not received	
July			
August		0.06	
September		not received	
October		not received	
November		not received	
December		not received	

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
ECUADOR, QUITO (began: 7/59)			
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			
ETHIOPIA, ADDIS ABABA (began: 1/60)			
cum. mc Sr^{90}/mi^2 thru 12/60-0.78--Column			
January }		0.21	
February }			
March }		0.23	
April }			
May }		0.67	
June }			
July			
August			
September			
October			
November			
December			

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
ETHIOPIA, ADDIS ABABA (began : 1/60)			
January		0.01	
February		0.23	
March		0.17	
April		lost	
May		lost	
June		lost	
July }		0.00	
August }			
September }		0.03	
October }			
November		0.05	
December		0.10	
GERMANY, RHEIN MAIN AFB (began:10/59) - 1961 data			
cum. mc Sr^{90}/mi^2 thru 12/60-2.16--Column			
January }	2.44	0.21	0.06
February }	1.27		
March	0.06	0.70	
April	2.40	0.33	0.14
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

FIJI ISLANDS, SUVA (began: 8/59)
cum mc Sr^{90}/mi^2 thru 12/60-2.36--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February	10.54	0.11	
March	4.20		
April	13.6	0.39	0.02
May			
June			
July			
August			
September			
October			
November			
December			

GUAM (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.98--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	4.79		
February	3.74	0.12	0.01
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

GREENLAND, THULE (began: 10/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.38--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.16		
February	T	0.02	0.12
March	0.08		
April	0.16	0.00	0.00
May			
June			
July			
August			
September			
October			
November			
December			

FRENCH WEST AFRICA, DAKAR (began: 7/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.22--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSTION COLLECTIONS: OUTSIDE UNITED STATES SITES- Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
HONG KONG (began: 1/60) --Column			
January	0.39	0.12	0.32
February	T	lost	--
March	9.84	0.17	0.02
April	1.57	lost	--
May	9.84	0.24	0.02
June	27.56	not received	
July	6.30	not received	
August	21.26	not received	
September	12.24	not received	
October	10.23	not received	
November	5.43	not received	
December	0.05	not received	
ICELAND, KEFLAVIK (began: 12/59) cum. mc Sr^{90}/mi^2 thru 12/60-2/03--Column			
January	4.13	0.28	0.03
February	5.44		
March	7.07	0.62	0.06
April	3.29		
May			
June			
July			
August			
September			
October			
November			
December			

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
HONG KONG			
January	approx.	0.15	
February	1 in.		
March	5.0	0.48	0.04
April	6.78		
May	5.00	0.19	0.01
June	8.3		
July			
August			
September			
October			
November			
December			
ITALY, FLORENCE (began: 9/59) cum. mc Sr^{90}/mi^2 thru 12/60-5.81--Column			
January	4.51	0.39	0.07
February	1.09		
March	0	0.97	0.23
April	4.16		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

ITALY, MILAN (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-4.18--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	1.22	0.13	0.05
February }	1.45		
March }	0	0.84	0.16
April }	5.34		
May			
June			
July			
August			
September			
October			
November			
December			

KOROR ISLAND (began: 1/60)
cum. mc Sr^{90}/mi^2 thru 12/60-0.81--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	16	0.21	0.01
February }	9.5		
March }	6.21	0.17	0.01
April }	6.71		
May			
June			
July			
August			
September			
October			
November			
December			

LIBERIA, MONROVIA (began: 7/59) - 1960 data
cum. mc Sr^{90}/mi^2 thru 12/59-0.76--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	1.18	0.01	0.01
February	1.01	lost	--
March	5.01	lost	--
April	1.45	0.17	0.12
May	11.07	0.14	0.00
June	57.18	0.21	0.00
July }	19.30	0.07	0.00
August }	23.41		
September }	25.75	0.14	
October }			
November }		0.14	
December }			

1961 data **LEBANON, BEIRUT** (began 10/59)
cum. mc Sr^{90}/mi^2 thru 12/60-2.94--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	6.43	1.39	0.08
February }	10.56		
March }	3.66	0.55	0.14
April }	0.11		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
LIBYA, WHEELUS AFB (began 9/59) cum. mc Sr^{90}/mi^2 thru 12/60-1.99--Column				**IWO JIMA** (began: 8/59) cum. mc Sr^{90}/mi^2 thru 12.60-2.57--Column			
January	2.04	0.53	0.21	January	2.71	0.43	0.07
February	0.46			February	3.65		
March	1.11	0.70	0.27	March	6.88	0.93	0.10
April	1.50			April	2.85		
May				May	2.87	0.43	0.07
June				June	3.12		
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			
JAPAN, HIROSHIMA (began: 8/56) cum. mc Sr^{90}/mi^2 thru 12/60-46.98--Pot				**JAPAN, MASAWA** (began: 9/59) cum. mc Sr^{90}/mi^2 thru 12/60-2.38--Column			
January	2.16	0.24	0.06	January	2.38	0.40	0.07
February	1.57			February	3.34		
March	3.31	1.06	0.11	March	0.79	0.88	0.25
April	6.69			April	2.75		
May				May			
June				June			
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			

Table 1b

MONTHLY FALLOUT DEPOSITION COOLECTIONS: OUTSIDE UNITED STATES SITES - Cont

JAPAN, NAGASAKI (began: 8/56)
cum. mc Sr^{90}/mi^2 thru 12/60-47.09--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	3.46	0.43	0.08
February	1.85		
March	4.17	0.05	0.01
April	4.21		
May			
June			
July			
August			
September			
October			
November			
December			

KENYA, KIKUYU (began: 1/57)
cum. mc Sr^{90}/mi^2 thru 12/60-6.48--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.26		
February		0.32	
March			
April	6.62	0.10	
May			
June			
July			
August			
September			
October			
November			
December			

JAPAN, TACHIKAWA (began: 10/59)
cum. mc Sr^{90}/mi^2 thru 12/60-4.38--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.68	0.89	0.44
February	1.34		
March	3.46	0.93	0.10
April	5.91		
May			
June			
July			
August			
September			
October			
November			
December			

KENYA, NAIROBI (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.26--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.33	0.00	0.00
February	0.62		
March	2.98	0.37	0.04
April	6.18		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90} / mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90} / mi^2	mc Sr^{90}/mi^2 per inch of precip
JOHNSTON ISLAND (began 2/60)							
cum. mc Sr^{90}/mi^2 thru 12/60-1.30--Column							
January }	0.64						
February }	1.10	0.12	0.07				
March							
April							
May							
June							
July							
August							
September							
October							
November							
December							

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

MAJURO ISLAND (began: 2/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.73--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	22	combined sample lost	
February	6.5		
March	3.84		
April	8.50	0.30	0.02
May	22		
June	6.50	0.00	0.00
July			
August			
September			
October			
November			
December			

MEXICO, MEXICO CITY (began: 8/59)
cum. mc Sr^{90}/mi^2 thru 12/60-1.64--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.29		
February	T	0.16	0.55
March	3.0		
April	6.2	0.41	0.04
May			
June			
July			
August			
September			
October			
November			
December			

MOROCCO, SIDI SLIMANE (began : 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-3.46--Column

Sampling Period 1961	Precip (inches	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	2.23	0.25	0.11
February	0.06		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

NEWFOUNDLAND, ERNEST HARMAN AFB (began: 8/59)
cum. mc Sr^{90}/mi^2 thru 12/60-4.02--Column

Sampling Period 1961	Precip (inches	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January			
February	2.99	0.39	
March			
April	0.46	0.98	
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
NEWFOUNDLAND, GOOSE AFB (began: 10/59) cum. mc Sr^{90}/mi^2 thru 12/60-1.55--Column				**NEW ZEALAND, WELLINGTON (began: 9/59)** cum. mc Sr^{90}/mi^2 thru 12/60-4.67-- Column			
January }	2.88	0.08	0.02	January }	3.9	0.27	0.04
February }	0.51			February }	2.67		
March				March }		0.42	
April				April }	2.01		
May				May			
June				June			
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			
NIGERIA, LAGOS (began: 8/59) cum. mc Sr^{90}/mi^2 thru 12/60-1.53--Column				**NORWAY, OSLO (began: 7/59)** cum. mc Sr^{90}/mi^2 thru 12/60-9.23--Column			
January }	1.18	0.11	0.08	January }	2.01	0.43	0.11
February }	0.12			February }	1.73		
March }	5.90	0.64	0.04	March }	1.34	0.44	0.05
April }	11.42			April }	7.01		
May				May			
June				June			
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip	Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
PAKISTAN, KARACHI (began: 2/58)				**PAKISTAN, KARACHI**			
cum. mc Sr^{90}/mi^2 thru 12/59-4.06--Column				cum. mc Sr^{90}/mi^2 thru 12/60-5/88			
January	0.16	0.38	2.40	January		0.11	
February	0	0.02	--	February			
March	1.18	0.13	0.11	March			
April	0.00	0.02	--	April			
May	0.00	lost	--	May			
June	T			June			
July	1.18	0.02	0.01	July			
August	0.20			August			
September	0.00	0.08	--	September			
October	0.00			October			
November	0.00	0.08	--	November			
December	0.00			December			
PERU, LIMA (began: 7/59) - 1961 data				**PHILIPPINE ISLANDS, CLARK AFB** (began: 11/59)			
				cum. mc Sr^{90}/mi^2 thru 12/60-1.10--Column			
January	T	0.06		January	0.01	0.13	0.92
February	0			February	0.13		
March	0	0.19		March	0.39	0.08	0.04
April	0			April	1.44		
May				May			
June				June			
July				July			
August				August			
September				September			
October				October			
November				November			
December				December			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

PONAPE ISLAND (began: 2/60)
cum. mc Sr^{90}/mi^2 thru 12/60-2.00--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	17	0.48	0.01
February	18		
March	17	0.39	0.01
April	12		
May	22	0.38	0.01
June	18		
July			
August			
September			
October			
November			
December			

SAUDI ARABIA, DHAHRAN (began: 12/59)
cum. mc Sr^{90}/mi^2 thru 12/60-2.18--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.50	0.31	0.27
February	0.65		
March	0.50	0.44	0.34
April	0.78		
May			
June			
July			
August			
September			
October			
November			
December			

PUERTO RICO, SAN JUAN (began: 2/60)
cum. mc Sr^{90}/mi^2 thru 1/61-2.69--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
December and	20.87	0.27	0.01
January	3.51		
February		0.60	0.10
March	2.95		
April	2.82		
May			
June			
July			
August			
September			
October			
November			
December			

SCOTLAND, PRESTWICK (began: 8/59)
cum. mc Sr^{90}/mi^2 thru 12/60-4.94--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	1.73	0.52	0.11
February	2.9		
March	2.02	0.17	0.03
April	2.98		
May	0.90	0.62	0.25
June	1.57		
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEOPSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

SINGAPORE (began: 9/59)
cum. mc Sr^{90}/mi^2 thru 12/60-2.73--Column

Sampling period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	6.05	0.00	0.00
February }	5.25		
March }	12	0.24	0.01
April }	5.44		
May			
June			
July			
August			
September			
October			
November			
December			

TAIWAN, TAIPEI (began: 2/58)
cum. mc Sr^{90}/mi^2 thru 12/60-23.62--Pot

Sampling period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }		0.49	
February }			
March }		0.06	
April }			
May			
June			
July			
August			
September			
October			
November			
December			

SOUTHERN RHODESIA, SALISBURY (began: 11/57)
cum. mc Sr^{90}/mi^2 thru 12.60-5.26--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	6.25	0.46	0.04
February }	5.66		
March }	4.04	0.07	0.01
April }	4.56		
May			
June			
July			
August			
September			
October			
November			
December			

TAIWAN, TATUNG (began: 4/58)
cum. mc Sr^{90}/mi^2 thru 12/60-6.04--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }		0.19	
February }			
March }		0.49	
April }			
May }			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEOPSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

TAIWAN, TAINAN (began: 1/58)
cum. mc Sr^{90}/mi^2 thru 12/60-7.74--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February		0.07	
March } April		0.04	
May			
June			
July			
August			
September			
October			
November			
December			

THAILAND, BANGKOK (began: 3/57)
cum. mc Sr^{90}/mi^2 thru 12/60-4.93--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January } February	0	0.11	
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

TRUK ISLAND (began: 12/59)
cum. mc Sr^{90}/mi^2 thru 12/60-0.94--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	9.12	0.28	0.02
February }	7.62		
March }	6.13	1.07	0.06
April }	11.3		
May			
June			
July			
August			
September			
October			
November			
December			

UNION OF SOUTH AFRICA, DURBAN (began: 6/57)
cum. mc Sr^{90}/mi^2 thru 12/60-9.69--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	4.72	0.60	0.08
February }	2.76		
March }	5.12	0.61	0.04
April }	10.63		
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEOPSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

UNION OF SOUTH AFRICA, PRETORIA (began: 7/57)
cum. mc Sr^{90}/mi^2 thru 12/60-7.11--Pot

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	4.33	0.37	0.06
February	1.97		
March	3.15	0.22	0.03
April	4.33		
May			
June			
July			
August			
September			
October			
November			
December			

UNITED ARAB REPUBLIC, EL QUAMISHLYIE (SYRIA)
(began 2/60)- 1960 data

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	T	0.71	--
February			
March		not received	
April		not received	
May		not received	
June		not received	
July		not received	
August		not received	
September	0.22	0.01	
October	2.45		
November			
December			

UNITED ARAB REPUBLIC, ALEXANDRIA (EGYPT) (began:12/59)

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 perinch of precip
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

UNITED ARAB REPUBLIC, EL QUAMISHLYIE (began 2/60)
1961 data cum. mc Sr^{90}/mi^2 thru 12/60-1.84--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 perinch of precip
January			
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

Table 1b

MONTHLY FALLOUT DEOPSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

UNITED ARAB REPUBLIC, ALEXANDRIA (EGYPT) (began 12/59)

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.39	0.03	0.08
February	0	0.18	--
March	1.18	0.18	0.15
April	0.00	0.26	--
May	0.00	0.00	--
June	0.00		
July	0.00		
August	0.00		
September	T		
October	T		
November	2.36		
December	1.97		

UNITED ARAB REPUBLIC, DAMASCUS (SYRIA) 1961 data

Sampling Period	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January		0.50	
February		0.02	
March		not received	
April	0.39	0.04	0.10
May			
June			
July			
August			
September			
October			
November			
December			

UNITED ARAB REPUBLIC, DAMASCUS (SYRIA) (began 1/60)

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January		not received	
February	T	0.15	--
March	5.19		
April			
May			
June			
July			
August			
September			
October			
November }		0.07	
December }			

VENEZUELA, CARACAS (began: 1/60) - 1960 data

Sampling Period 1960	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January	0.79	0.11	0.14
February		0.07	
March		0.02	
April		0.24	
May }		0.76	
June }	6.45		
July }	6.02	0.27	0.02
August }	4.87		
September }	3.42	0.13	0.02
October }	1.90		
November }		0.24	
December }			

Table 1b

MONTHLY FALLOUT DEPOSITION COLLECTIONS: OUTSIDE UNITED STATES SITES - Cont

VENEZUELA, CARACAS (began: 1/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.84--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	0.37	0.17	0.31
February }	0.17		
March }		0.00	
April }	4.17		
May			
June			
July			
August			
September			
October			
November			
December			

YAP ISLAND (began: 1/60)
cum. mc Sr^{90}/mi^2 thru 12/60-1.93--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	11.65	0.31	0.02
February }	5.67		
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

WAKE ISLAND (began: 2/59)
cum. mc Sr^{90}/mi^2 thru 12/60-5.64--Column

Sampling Period 1961	Precip (inches)	mc Sr^{90}/mi^2	mc Sr^{90}/mi^2 per inch of precip
January }	0.83	0.48	0.34
February }	0.56		
March }	3.47	0.62	0.14
April }	1.09		
May }	0.50	0.23	0.14
June }	1.09		
July			
August			
September			
October			
November			
December			

Table 1e

Strontium-90 in Individual Precipitation

Collections: California, Richmond

(Large collector - 25.0 ft^2)

Sampling Period[1] from	to	mc Sr^{90}/mi^2 at Midpoint of Sampling Period	Precip. (inches)
1961			
1/10, 1530	1/12, 1530	0.022 ± 0.0006 0.025 ± 0.0006	0.01
1/12, 1530	1/19, 1520	0.0035 ± 0.0004 0.0035 ± 0.0004	trace
1/19, 1520	1/24, 1525	0.018 ± 0.0006 0.018 ± 0.0004	0.15
1/24, 1525	1/27, 1110	0.030 ± 0.0006 0.036 ± 0.0006	1.81
1/27, 1110	1/30, 0905	0.023 ± 0.0004 0.024 ± 0.0004	0.47
1/30, 0905	2/3, 1530	0.032 ± 0.0004 0.034 ± 0.0004	0.45
2/3, 1530	2/7, 1400	0.0058 ± 0.0002 0.0042 ± 0.0003	0.06
2/7, 1355	2/10, 0920	0.016 ± 0.0002 0.018 ± 0.0003	0.34
2/10, 0920	2/14, 1525	0.025 ± 0.0004 0.022 ± 0.0003	0.41
2/14	3/3	data for these collections have not been reported by Analytical Lab.	
3/3, 1420	3/7, 1115	0.0165 ± 0.0004 0.0158 ± 0.0004	0.30
3/7, 1115	3/9, 1400	0.0088 ± 0.0006 0.0067 ± 0.0005	0.27
3/9, 1400	3/13, 1530	0.0114 ± 0.0005 0.0102 ± 0.0005	0.06
3/13, 1530	3/16, 1130	0.061 ± 0.001 0.061 ± 0.002	0.96
3/16, 1130	3/23, 1530	0.0032 ± 0.0002 0.0037 ± 0.0003	0.11

(1) Sampling began March 20, 1958

Table 1f

Strontium-90 and Cerium-144 in Individual Precipitation

Collections: New Jersey, Westwood

(Large funnel collector - 78.2 ft^2)

Sampling Period[1] from	to	At Midpoint of Sampling Period mc Sr^{90}/mi^2	mc Ce^{144}/mi^2	Precip. (inches)
Corrections and additions to collections reported in HASL-113				
1960				
11/23, 1600	11/30, 1330	0.0228 ± 0.0017	0.0382 ± 0.0010[2]	0.70
12/8, 1530	12/13, 1400	0.0062 ± 0.0002[3]	0.158 ± 0.008	0.28
1961				
2/14, 1430	2/16, 1530	0.0310 ± 0.0004	0.139 ± 0.004[2]	0.12
2/16, 1530	2/19, 0730	0.0395 ± 0.0004	0.0993 ± 0.0009[2]	0.34
2/24, 1545	2/26, 0730	0.0689 ± 0.0006	0.104 ± 0.001[2]	0.66
New data since HASL-113				
1961				
3/6, 1430	3/7, 1530		0.0522 ± 0.0014	0.30
3/7, 1530	3/9, 1400	0.0774 ± 0.0005	0.122 ± 0.002	0.93
3/7, 1530	3/9, 0930[4]	0.0771 ± 0.0011	0.101 ± 0.003	"
3/9, 1400	3/10, 1430	0.0018 ± 0.0001		0.03
3/10, 1430	3/15, 1430	0.528 ± 0.003	0.917 ± 0.009	1.28
3/15, 1300	3/20, 1400		0.148 ± 0.002	0.52
3/20, 1400	3/24, 1500	0.253 ± 0.001	0.141 ± 0.002	1.04
3/24, 1500	3/29, 1100		0.134 ± 0.002	0.28
3/29, 1100	11/3, 0730			
4/3, 0730	4/12, 1400		0.435 ± 0.003	0.96
4/12, 1400	4/14, 1130	0.267 ± 0.001	0.711 ± 0.011	1.21
4/14, 1130	4/20, 1530		0.891 ± 0.004	2.46

(1) Sampling began February 4, 1958
(2) Ce^{144} result had not been reported previously for this collector
(3) Sr^{90} result was not reported correctly in HASL-113
(4) This sample was collected from a polyethylene sheet in front of the laboratory in order to compare the efficiency of this type of collection with that of the large collector for a snow undisturbed by wind effects.

Table 1g

Strontium-90 in Individual Precipitation

Collections: Pennsylvania, Pittsburgh

(Collection area - 3.05 ft^2)

Sampling Period from	to	mc Sr^{90}/mi^2 at Midpoint of Sampling Period	Precip. (inches)
1960			
12/19, 1400	12/21, 1830	0.142 ± 0.006 0.060 ± 0.005	0.50
12/21, 1830	12/26, 1000	0.006 ± 0.004 0.009 ± 0.003	0.03
12/26, 1000	12/27, 2000	0.005 ± 0.002 0.005 ± 0.003	0.01
12/27, 2000	12/30, 0915	0.019 ± 0.003 0.018 ± 0.006	0.22
1961			
12/30, 0915	1/1, 1600	0.041 ± 0.004 0.038 ± 0.005	0.66
1/1, 1600	1/3, 1600	0.008 ± 0.002 0.013 ± 0.003	trace
1/3, 1600	1/9, 1200	0.007 ± 0.004 0 ± 0.003	trace
1/9, 1200	1/17, 1530	0.028 ± 0.004 0.026 ± 0.004	0.37
1/17, 1530	1/20, 0930	0.015 ± 0.003 0.012 ± 0.002	0.22
1/20, 0930	1/22, 1000	0 ± 0.003 0 ± 0.002	0.00
1/22, 1000	1/26, 0900	0.008 ± 0.002 0.008 ± 0.003	0.05
1/26, 0900	1/27, 0930	0.011 ± 0.003 0.015 ± 0.003	0.16
1/27, 0930	2/1, 1000	0.034 ± 0.004 0.031 ± 0.004	0.10
2/1, 1000	2/5, 1000	0.078 ± 0.005 0.089 ± 0.005	0.79

Table 1g cont'd.

Strontium-90 in Individual Precipitation

Collections: Pennsylvania, Pittsburgh - Cont'd.

Sampling Period from	to	mc Sr^{90}/mi^2 at Midpoint of Sampling Period	Precip. (inches)
1961			
2/5, 1000	2/9, 1030	0.027 ± 0.004 0.022 ± 0.004	0.81
2/9, 1030	2/16, 1430	0.024 ± 0.004 0.025 ± 0.004	dry
2/16, 1430	2/19, 1600	0.043 ± 0.004 0.044 ± 0.005	0.13
2/19, 1600	2/23, 1000	0.013 ± 0.002 0.014 ± 0.003	0.13
2/23, 1000	2/25, 1515	0.039 ± 0.006 0.042 ± 0.004	0.43
2/25, 1515	2/26, 1330	0.284 ± 0.016 0.268 ± 0.008	0.48
2/26, 1330	3/1, 1000	0.023 ± 0.004 0.024 ± 0.006	0.24
3/1, 1000	3/2, 0915	0 ± 0.003 0 ± 0.004	trace
3/2, 0915	3/5, 1200	0.063 ± 0.005 0.065 ± 0.004	0.93
3/5, 1200	3/6, 1430	0.018 ± 0.004 0.023 ± 0.003	0.35
3/6, 1430	3/8, 1025	0.035 ± 0.004 0.037 ± 0.004	0.36
3/8, 1025	3/10, 1315	0.108 ± 0.007 0.088 ± 0.006	0.39
3/10, 1315	3/15, 1545	0.237 ± 0.008 0.216 ± 0.008	0.35
3/15, 1545	3/17, 1115	0.009 ± 0.002 0.009 ± 0.003	trace
3/17, 1115	3/20, 1445	0.076 ± 0.005 0.071 ± 0.005	0.15
3/20, 1445	3/22, 1445	0.028 ± 0.003 0.026 ± 0.003	0.25

Table 1g cont'd.

Strontium-90 in Individual Precipitation

Collections: Pennsylvania, Pittsburgh - Cont'd.

Sampling Period from	to	mc Sr^{90}/mi^2 at Midpoint of Sampling Period	Precip. (inches)
1961			
3/22, 1445	3/25, 0900	0.039 ± 0.004 0.029 ± 0.004	0.05
3/25, 0900	3/29, 1515	0.034 ± 0.008 0.040 ± 0.004	0.10
3/29, 1515	4/1, 1345	0.067 ± 0.005 0.079 ± 0.005	0.75

Table 1h

Report No. 23

RADIOISOTOPES IN RAINWATER

Period: 2nd March to 3rd April 1961

Station: Gracefield, Lower Hutt, New Zealand. S.41°14' E.174°55'

POLYTHENE COLLECTOR 10.1 sq.ft.

Sampling Period		Activity: Microcuries/sq.mile			Ba^{140}/Sr^{90}	Cs^{137}/Sr^{90}	Cumulative Sr^{90}	Rain	Remarks
Start	Finish	Sr^{90}	Ba^{140}	Cs^{137}			Millicuries/Sq. Mile	Inches	
3 - 2	3 - 7	61 ± 1	Not detected	139 ± 5		2.16 to 2.40	0.41	1.37	
3 - 7	3 - 15	170 ± 2		279 ± 7		1.58 to 1.70	0.58	2.29	
3 - 15	3 - 27	47 ± 1		89 ± 6		1.73 to 2.06	0.63	0.96	
3 - 27	4 - 3	26 ± 1		56 ± 5		1.89 to 2.44	0.65	0.19	
3 - 2	4 - 3	393 ± 8	Not detected	714 ± 71		1.60 to 2.04		4.81	Monthly sample
Monthly total or average		304		563		1.85	0.304	4.81	
Accumulated total or average for 1961		654		1273		1.95	0.654	9.40	

Table 1h cont'd.

RADIOISOTOPES IN RAINWATER

Report No. 24

Period: 3 April to 1 May 1961

Station: Gracefield, Lower Hutt, New Zealand. S.41°14' E.174°55'

POLYTHENE COLLECTOR 10.1 sq.ft.

Sampling Period		Activity: Microcuries/sq.mile			Ba^{140}/Sr^{90}	Cs^{137}/Sr^{90}	Cumulative Sr^{90}	Rain	Remarks
Start	Finish	Sr^{90}	Ba^{140}	Cs^{137}			Millicuries/Sq. Mile	Inches	
4 - 3	4 - 13	41 ± 2		34 ± 5		0.68 to 1.0	0.69	0.17	
4 - 13	4 - 20	50 ± 1		93 ± 4		1.75 to 1.98	0.74	1.55	
4 - 20	5 - 1	37 ± 1		75 ± 5		1.84 to 2.22	0.78	0.33	
Monthly Total or Average		128		202		1.58	0.128	2.05	
Accumulated Total or Average for 1961		782		1475		1.89	0.782	11.45	
4 - 3	5 - 1	117 ± 4	Not detected	267 ± 50		1.8 to 2.8		2.05	Monthly sample

Table 1h cont'd.

Report No. 25

RADIOISOTOPES IN RAINWATER

Period: 1 May to 1 June 1961

Station: Gracefield, Lower Hutt, New Zealand. S.41°14' E.174°55'

POLYTHENE COLLECTOR 10.1 sq.ft.

Sampling Period		Activity: Microcuries/sq.mile			Ba^{140}/Sr^{90}	Cs^{137}/Sr^{90}	Cumulative Sr^{90}	Rain	Remarks
Start	Finish	Sr^{90}	Ba^{140}	Cs^{137}			Millicuries/Sq. Mile	Inches	
5 - 1	5 - 9	18 ± 1		40 ± 4			0.80	0.69	
5 - 9	5 - 15	46 ± 1	Not detected	88 ± 4			0.85	1.15	
5 - 15	5 - 25	19 ± 1	Not detected	30 ± 4			0.87	0.20	
5 - 25	6 - 1	43 ± 1	Not detected	86 ± 4			0.91	0.68	
Monthly Total or Average		126		244		1.94	0.126	2.72	
Accumulated Total or Average for 1961		908		1719		1.89	0.908	14.17	

2. Strontium-90 in Milk and Tap Water

In 1954 the Health and Safety Laboratory began monitoring milk in New York City for strontium-90 in order to estimate the potential hazard resulting from the contamination of foods by fallout. Subsequently, bread and tap water were also sampled on a routine basis and milk monitoring was started at Mandan, North Dakota, Perry, New York, and Honolulu, Hawaii.

Although a more complete study of the strontium-90 content of U. S. diets has since been started, milk and tap water analyses have been continued so that a detailed and continuous history of the contamination levels of these staples will be available for studies of possible mechanisms of contamination of food chains by fallout.

To further elucidate some of these problems, some food samples obtained since the recent Soviet test series will be analyzed for strontium-89 as well as strontium-90.

2.1 Milk

Prior to July of 1960, milk from New York City (liquid); Perry, New York (powdered); Mandan, North Dakota (powdered buttermilk); and Honolulu, Hawaii (liquid) was monitored for strontium-89, strontium-90, and calcium. Because of the low strontium-89 levels since July 1960, analysis for this nuclide was discontinued, but will be resumed again in September 1961 collections. Available data for 1961 collections are shown on pages 62 and 63. The data since the inception of the programs are graphed in Figures 3, 4, 5, and 6 on pages 65 through 68.

2.2 Tap Water

At Richmond, California and New York City, tap water has been collected and analyzed for strontium-90. The available data for 1961 are listed on page 64. A graphical presentation of all available results is shown in Figure 7, page 69.

Table 2a

Strontium-90 and Calcium in Milk

Year	Sampling Month	g Ca/liter	$\mu\mu c$ Sr^{90}/liter	$\mu\mu c$ Sr^{90}/g Ca
New York City - liquid				
1959	Average			11
1960	Average			8.0
1961	January	1.11	7.5	6.7
	February	1.08	7.8	7.3
	March	1.15	9.4	8.1
	April	1.31	8.6	6.5

Honolulu, Hawaii - liquid

Year	Sampling Month	g Ca/liter dairy #1	g Ca/liter dairy #2	$\mu\mu c$ Sr^{90}/liter dairy #1	$\mu\mu c$ Sr^{90}/liter dairy #2	$\mu\mu c$ Sr^{90}/g Ca dairy #1	$\mu\mu c$ Sr^{90}/g Ca dairy #2
8/59 - 12/59	Average					- 5.0 -	
1960	Average					- 3.2 -	
1961	January	1.12	1.12	2.0	3.0	1.8	2.7
	February	0.88	1.03	2.1	3.6	2.4	3.5
	March	1.01	1.03	1.9	3.2	1.9	3.1
	April	0.96	1.00	1.9	2.8	2.0	2.8

Table 2a - Cont'd

Strontium-90 and Calcium in Milk

Year	Sampling Month	g Ca / kg powder	$\mu\mu c\ Sr^{90}$ / kg powder	$\mu\mu c\ Sr^{90}$ / g Ca
Perry, New York - powdered				
1959	Average			8.0
1960	Average			6.5
1961	January	10.1	65	6.5
	February	9.27	65	7.0
	March	9.04	59	6.5
	April	9.01	65	7.2
Mandan, North Dakota - powdered buttermilk				
1959	Average			25.7
1960	Average			15.0
1961	January	11.0	114	10.4
	February	10.5	122	11.6
	March	11.2	122	10.9
	April	11.5	140	12.2

Table 2b

Strontium-90 in Tap Water

Year	Sampling Month	$\mu\mu c$ Sr^{90}/liter New York, N. Y.[1]	$\mu\mu c$ Sr^{90}/liter Richmond, Calif.[2]
1959	Average	0.40	0.29
1960	Average	0.47	0.26
1961	January	0.36	0.29
	February	0.31	0.32
	March	0.37	0.33
	April	0.34	
	May	0.32	
	June	0.33	

(1) From 100 - 200 liters per sample - Sampling began August 1954

(2) Approximately 40 liters per sample - Sampling began April 1958

Note: March through June samples for New York City analyzed for calcium and stable strontium. Average values are 6.0 ppm Ca and 0.03 ppm Sr

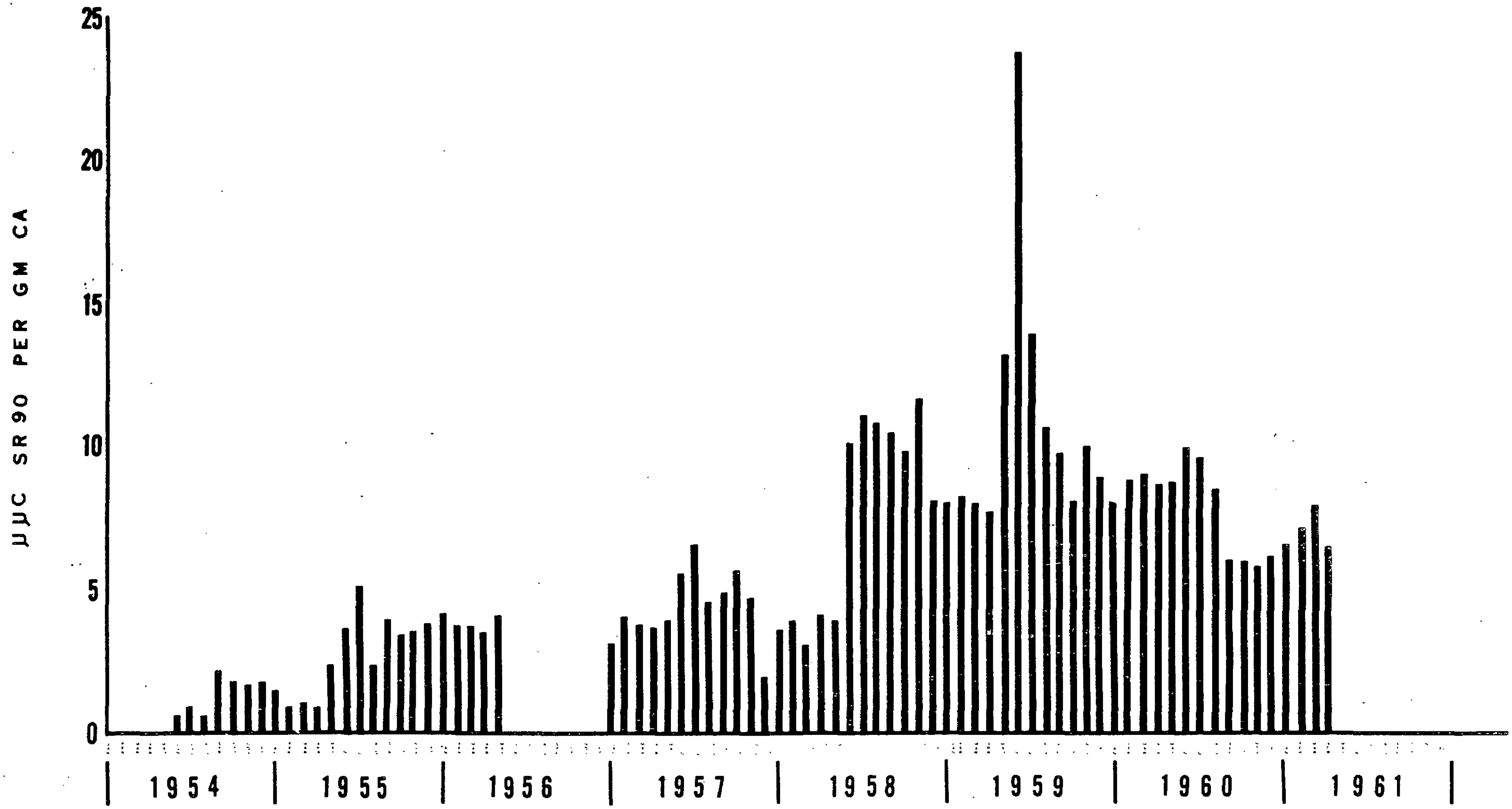


FIGURE 3 SR 90 IN MILK — NEW YORK CITY

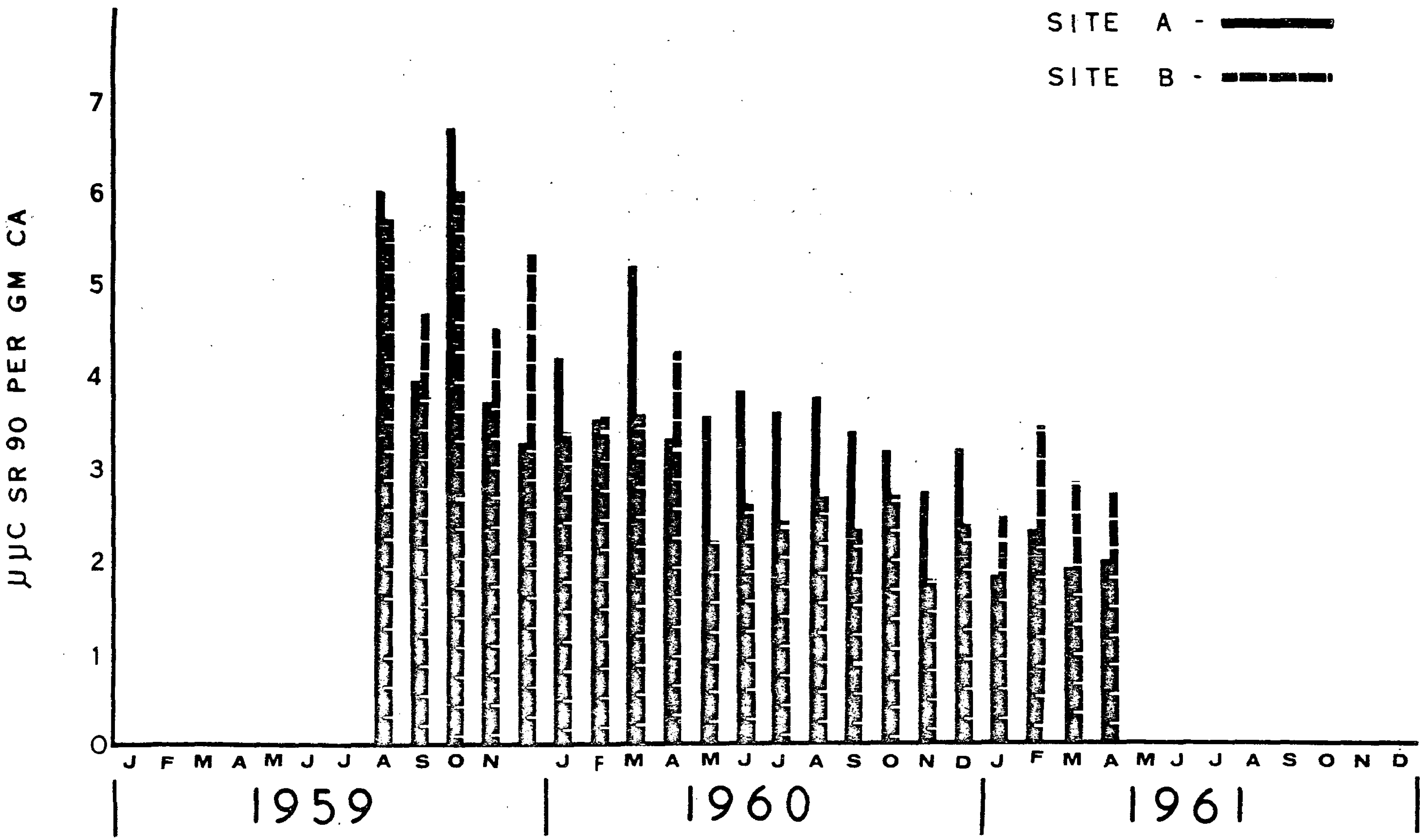
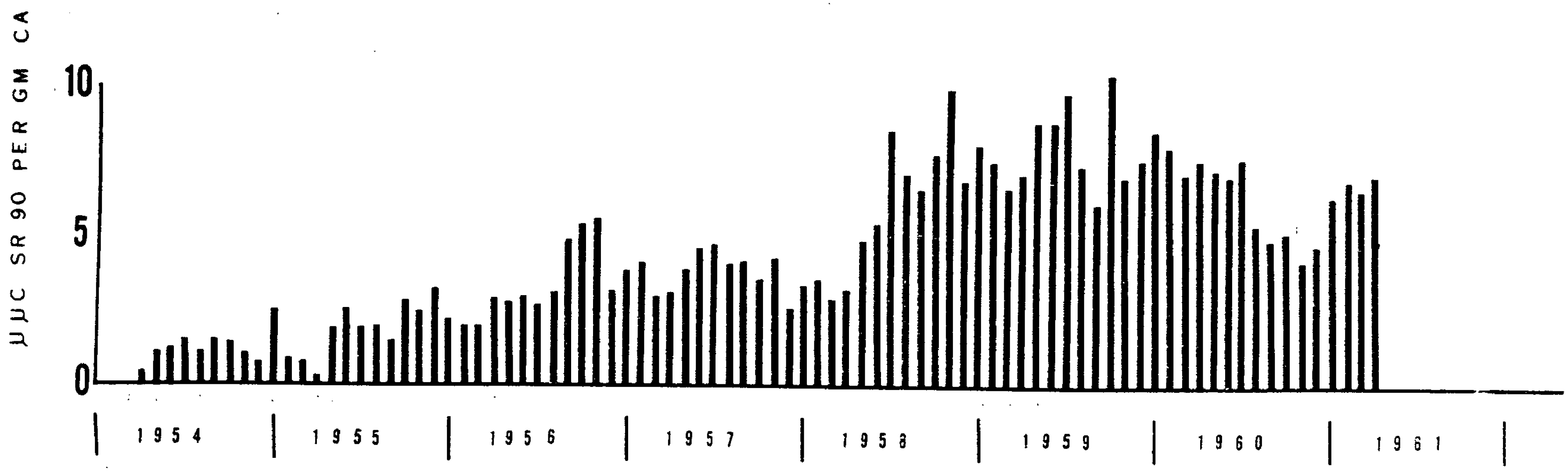
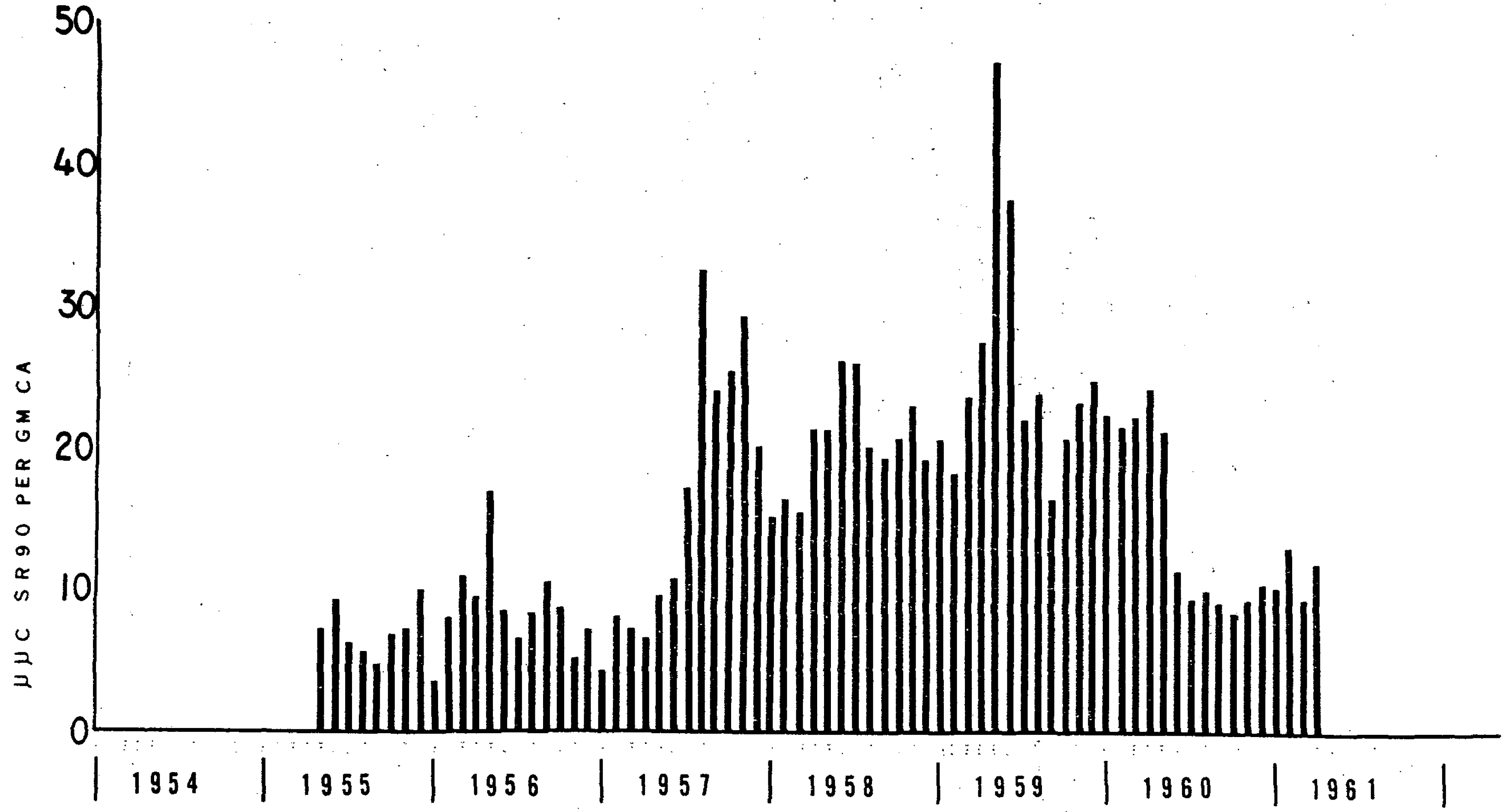


FIGURE 4

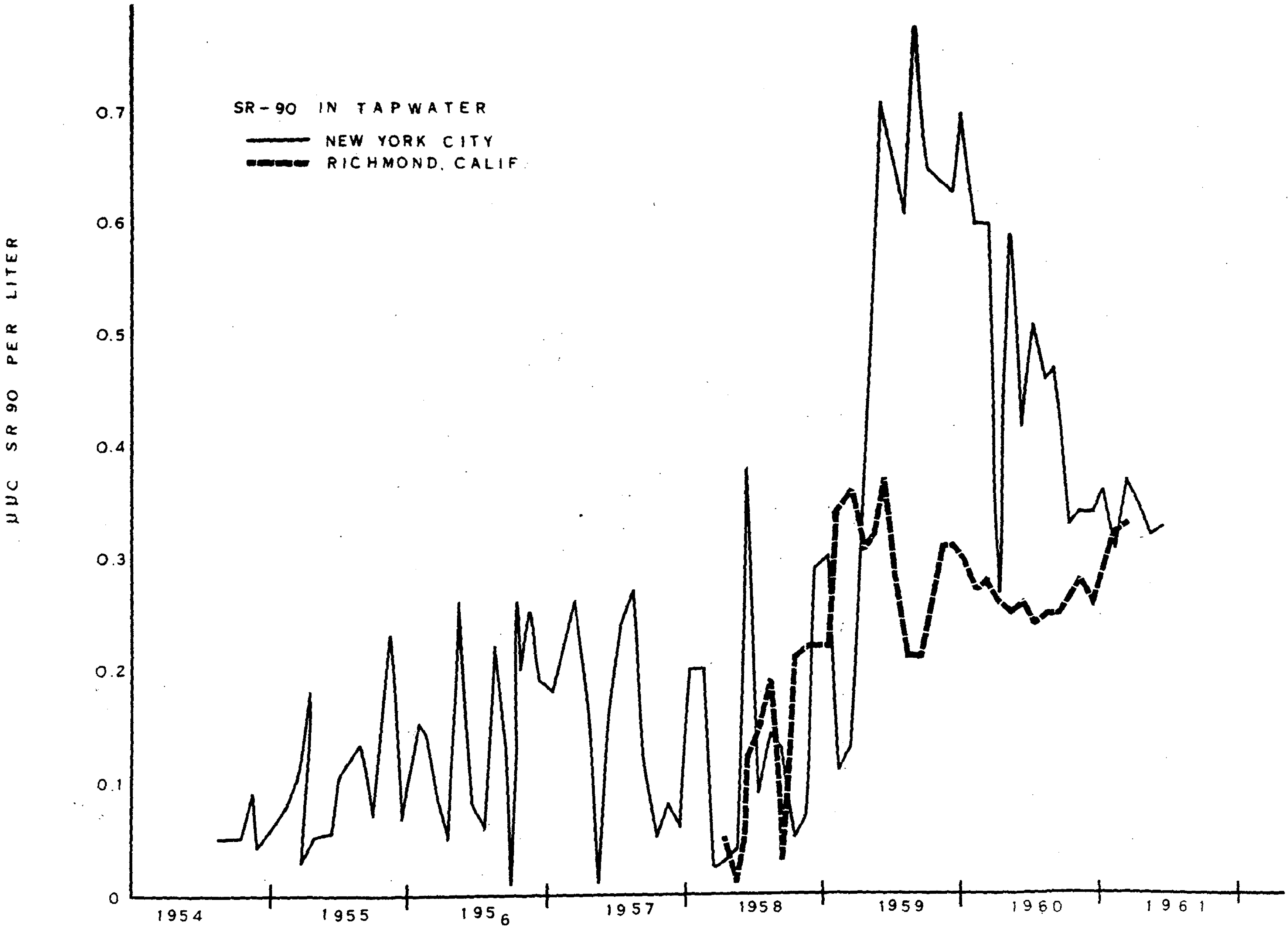
SR 90 IN MILK: HONOLULU, HAWAII



HASL FIGURE 5 SR 90 IN MILK — PERRY N.Y.



HASL FIGURE 6 SR90 IN MIL — MANDAN N.D.



SR-90 IN TAPWATER
NEW YORK CITY
RICHMOND, CALIF
μμC SR 90 PER LITER
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1954
1955
1956
1957
1958
1959
1960
1961

FIGURE 7

3. High Altitude Sampling Program (Project Ash Can)

Since November 1956 samples of particulate matter in the high atmosphere have been collected by means of balloon-borne filtering devices and analyzed for radioactivity. Data collected in this program are listed in the accompanying tables.

Explanation of Tables

Site

The following sampling sites have been used:

Site	Lat.	Long.	Established	Terminated
Minneapolis, Minnesota	45°N	93°W	November 1956	June 1958*
Sioux City, Iowa	42°N	96°W	August 1958	December 1959
San Angelo, Texas	31°N	100°W	November 1956	
Panama Canal Zone	9°N	80°W	December 1956	December 1958
Sao Paulo, Brazil	23°S	46°W	November 1956	February 1959
Mildura, Australia	34°S	143°E	December 1960	

* Non-routine experimental flights have continued at this site.

HASL

Number assigned by Health and Safety Laboratory to individual samples.

Flight

Number assigned to flight by balloon operations organization. More than one sample is often collected on a given flight.

Type

Identification of the devices used to collect the sample. Originally the project used a sampling device (referred to as "Ash Can" because of its shape) employing a large filter (5 square feet) and a relatively low face velocity of the air stream. Since early 1960, an improved sampler (termed the "Direct Flow Sampler") using a smaller filter (1 square foot) and a higher face velocity has been used. Two types of blower fans have been used, the Torrington 403 (used with both the Ash Can and Direct Flow Samplers) and the Torrington 704 (used only with the Direct Flow Sampler). The following code is used:

A-4: Ash Can Sampler/Torrington 403 blower
D-4: Direct Flow Sampler/Torrington 403 blower
D-7: Direct Flow Sampler/Torrington 704 blower

When two identical samplers were flown simultaneously, they are designated as #1 and #2.

(For a detailed discussion of the sampling units see article by Rex C. Wood in this HASL quarterly).

Nominal Altitude

Intended altitude (in thousands of feet) of collection. Prior to January 1960, samples were normally collected once a month at each of four altitudes: 50,000 feet, 65,000 feet, 80,000 feet and 90,000 feet. Since January 1960, five collection altitudes have been used, 50,000 feet, 60,000 feet, 70,000 feet, 80,000 feet and 90,000 feet.

Predominant Altitude

Altitude at which most of the sample was collected.

Altitude Range

Range of altitudes over which the collection occurred.

(Note: All altitude data are obtained from barometric readings and refer to pressure-altitude in the ICAO Standard Atmosphere).

Volume Determination

In the determination of the volume of air sampled, methods used prior to April 1961 depended upon the blower speed and the fan laws and employed radiotelemetry (which gives the instantaneous speed of the blower) or the Veedor Root counter (which gives the total revolutions of the blower). The method currently in use consists of a flowmeter which measures directly the quantity of air passing through the sampling unit. The method used in determining the volume is designated by the following letters:

F: Flowmeter
VR: Veedor Root Counter
T: Radiotelemetry
E: Estimated

Volume

The volume of air sampled is reported in standard cubic feet (SCF) of air, computed at 1013 mb and 59°F. 1 SCF = 0.346 kg of air.

An estimate of the reliability of the air volume sample is given in the NOTES at the bottom of each page. Whenever the volume has been listed as doubtful, the radioactivity data is listed in parentheses. While such data is not reliable as a measure of the concentration of radioactivity in the atmosphere, it may be used to compute ratios of activities of the different isotopes. For a more complete discussion of the volume data, see article by Rex C. Wood in this HASL quarterly.

The data collected since 1958 has been reevaluated using the latest available (August 1960) information on flow rates as a function of blower speed and is given here. The remaining data will appear in future reports.

Analytical Data

Radionuclide values are reported in disintegrations per minute per thousand standard cubic feet of air at date of sampling, and the total beta activity as of counting date. Error terms for total beta identified by (P) are counting errors. For other values after March 1959, error terms represent standard deviations of replicate analyses.

Table 3a

SAMPLING MONTHS: JANUARY TO MARCH 1958

Analytical Labs: NSEC - Tracerlab (W)

Site Minneapolis, Minnesota

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft3	Counting Date	d/m/1000 SCF Sr89	d/m/1000 SCF Sr90	d/m/1000 SCF Zr95	d/m/1000 SCF Cs137	d/m/1000 SCF Ba140	d/m/1000 SCF Ce144
7514	2309	A-4	1-10-58	65	64.2	64.2	T	2950	2860 ± 322	2-1-58	415 470	47.5 95.0	616 636	159 94.9	130 118	376 395
7518	2310	A-4	1-12-58	90	88.7	90.0-86.2	T	1230	770 ± 455	2-1-58	40 35	22.4 23.5	134 85	62 62	< 6.8 <8.4	210 209
7554(c)	2311	A-4	1-22-58	80	78.1	78.1	T	1290	914 ± 447	4-2-58	32 ± 3 20 ± 3	16.7 ± 0.8 18.2 ± 0.8	33 ± 12	40.6 ± 1.6 41.4 ± 1.6	9450 ± 99 10200 ± 131	169 ± 7 161 ± 7
7623(c)	2325	A-4	2-5-58	90	89.9	90.5-88.6	T	1090	286 ± 89	5-2-58	10.0 ± 4.2 230 ± 11.7 123 ± 4.5	11.2 ± 1.0 26.4 ± 0.8	91.5 ± 6.3 106 ± 7.4	25.7 ± 1.7 17.8 ± 0.5	6440 ± 203 5970 ± 184	114 ± 6 125 ± 7
7624(c)	2326	A-4	2-7-58	80	78.1	78.1	T	1250	1350 ± 96	4-28-58	76 ± 3 54 ± 3	18.8 ± 0.7 8.0 ± 0.7	186 ± 13 218 ± 11	87.1 ± 1.6 77.5 ± 0.8	8730 ± 287 6730 ± 287	355 ± 11 361 ± 1
7643(c)	2327	A-4	2-13-58	50	46.3	46.3(a)	T	3900	2390 ± 57	5-4-58	337 ± 10 371 ± 10	27.7 ± 1.3 35.4 ± 1.3	860 ± 17 899 ± 38	78.9 ± 1.8 74.9 ± 1.8	696 ± 29 886 ± 33	728 ± 2 726 ± 1
7653(c)	2328	A-4	2-20-58	65	64.7	64.7	T	3190	405 ± 143	4-17-58	45.0 ± 5.0 38.5 ± 4.2	27 ± 1 27 ± 1	34.6 ± 1.2 35.1 ± 1.2	29 ± 1 29 ± 1	2380 ± 32 2560 ± 32	198 ± 8 198 ± 8
7712	2329	A-4	3-6-58	50	48.7	48.7(b)	T	5370	2350 ± 174	3-13-58	164 159	26.5 23.5	406 432	19.4 22.5 34.2	4.4 7.6	451 480
7713(c)	2330	A-4	3-12-58	65	63.5	63.7-63.4	T	3340	1720 ± 12	5-25-58	Lost Lost	Lost Lost	650 ± 11 329 ± 18	111 ± 2 115 ± 2	1600 ± 27 1540 ± 54	717 ± 16 682 ± 16
7740(c)	2331	A-4	3-20-58	80	77.8	78.1-74.4	T	1450	293 ± 19	5-14-58	62.5 ± 2.0 68.5 ± 2.5	13.4 ± 0.6 15.6 ± 0.7	52.3 ± 2.2 57.9 ± 3.0	42.5 ± 1.4 44.8 ± 1.5	804 ± 33 442 ± 20	161 ± 4 162 ± 4
7778(c)	2335	A-4	3-26-58	90	92.8	92.8	T	910	651 ± 17	4-1-58	122 ± 5 164 ± 6	0.08 ± 0.01 0.02 ± 0.03	111 ± 8 138 ± 8	23.7 ± 0.8 30.6 ± 2.3	3560 ± 464 2520 ± 77	370 ± 8 144 ± 4

(a) Tropopause height - 35 kilofeet.
(b) Tropopause height - 34 kilofeet.
(c) Isotopic analyses - Tracerlab.

Table 3a - cont'd

SAMPLING MONTHS: APRIL TO JUNE 1958

Site: Minneapolis, Minnesota

Analytical Labs: NSEC - Tracerlab (W).

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}
7805 (d)	2336	A-4	4-7-58	90	90.1	90.1	T	1100	136 ± 9	5-8-58	36.2 ± 1.4 66.9 ± 1.4	14 ± 1 20 ± 1	78 ± 3 68 ± 3	30 ± 1 30 ± 1	3320 ± 50 3020 ± 50	150 ± 4 148 ± 5
7806 (d)	2337	A-4	4-8-58	80	77.7	77.9-77.4	T	1270	267 ± 8	6-29-58	106 ± 2 55 ± 2	17.0 ± 0.4 21.0 ± 0.5	151 ± 7 140 ± 5	56 ± 1 53 ± 1	380 ± 30 378 ± 30	
7807 (d)	2338	A-4	4-9-58	50	46.9	47.3-46.5 (a)	T	3660	2130 ± 27	6-29-58	608 ± 24 555 ± 23	27.6 ± 0.8 24.6 ± 0.5	3990 ± 38 4020 ± 38	48.4 ± 1.1 48.1 ± 1.1	1480 ± 53 1390 ± 53	1520 ± 20 1300 ± 11
7862 (d)	2339	A-4	4-16-58	65	64.4	64.7-64.1	T	3070	772 ± 16	7-11-58	291 ± 8 238 ± 4	50 ± 1 45 ± 1	540 ± 8 532 ± 8	124 ± 1 124 ± 1	256 ± 11 278 ± 11	247 ± 3 230 ± 3
8005	2347	A-4	5-8-58	50	48.3	48.3 (b)	T	3750	2210 2160	8-19-58 8-20-58	265 287	13 13	1480 1460	34.7 35.4	192 181	599 566
8008	2348	A-4	5-9-58	90	90.6	90.6	T	1140	790 436 608	8-8-58 8-7-58 8-7-58	57 108	13.6 14.9	97 168	38 38	264 133	172 131
8034	2350	A-4	5-15-58	80	77.8	77.8	T	1280	546 624	8-1-58 8-1-58	24 32	0 ± 1.8 0 ± 1.4	78 70	92.9 80.5	38 29	54 54 90
8033	2352-2	A-4	5-16-58	65	64.5	64.5	T	2070	2660 2760	8-7-58 8-7-58	300 321	76.5 74.3	432 508	116 91.8	34 105	1180 1170
8176	2364	A-4	6-6-58	90	91.0	91.4-90.7	T	1090	1190 827	7-18-58 7-18-58	25 19	10.3 8.3	112 90 120	1.9 ± 0.4 0.9 ± 1.9	21 31	99 100
8177	2365	A-4	6-11-58	50	46.1	46.1 (c)	T	3820	2990 2750	7-17-58 7-17-58	331 356	19 16	528 673	14 13	83 74	536 500
8188	2367	A-4	6-17-58	80	76.9	76.9	T	1440	274 481 208	10-11-58 10-7-58 10-2-58	50 51	16.6 20.0	25 40	36 33 35	8.9 14	81 106 36
8302	2372-4	A-4	6-27-58	65	62.9	66.0-53.0	T	3300	4730 ± 268 2940 ± 242 3030 ± 242	7-10-58 10-22-58 10-22-58	482 ± 50 589 ± 56	49 ± 2 43 ± 2	574 ± 26 413 ± 24 446 ± 24	100 ± 7.6 76.6 ± 4.3	137 364	715 ± 21 632 ± 21

(a) Tropopause height - 34 kilofeet.
(b) Tropopause height - 32 kilofeet.
(c) Tropopause height - 37 kilofeet.
(d) Isotopic analyses - Tracerlab.

Table 3b

SAMPLING MONTHS: JANUARY to JUNE 1958

Site: Panama Canal Zone

Analytical Labs: NSEC - Tracerlab (W)

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	Sr^{89} (d/m/1000 SCF)	Sr^{90} (d/m/1000 SCF)	Zr^{95} (d/m/1000 SCF)	Cs^{137} (d/m/1000 SCF)	Ba^{140} (d/m/1000 SCF)	Ce^{144} (d/m/1000 SCF)
7491	P-216	A-4	1-5-58	80	80.7	81.1-78.9	T	1430	900 ± 412	2-1-58	97 <164	87.6 97.2		29 24	75 78	548 543
7522	P-217	A-4	1-13-58	90	91.3	91.3-88.4	T	570	2270 ± 1150	2-1-58	<121 <250	41 42		59 64	47.6 59.6	358 374
7642	P-226[a]	A-4	2-10-58	80	81.0	81.0-79.6	T	1540	1270 ± 76	5-4-58	57 ± 12 99 ± 9	56.8 ± 2.6 56.6 ± 2.0	41.8 ± 3.6 50.9 ± 2.5	196 ± 5 204 ± 5	3410 ± 50 3030 ± 50	518 ± 9 518 ± 9
7684	P-229[a]	A-4	3-1-58	80	80.7	80.7-80.5	T	1530	1450 ± 396	4-2-58	30 ± 8 162 ± 8	54 ± 1 56 ± 1	106 ± 6 Lost	138 ± 4 161 ± 3	7600 ± 212 9100 ± 178	358 ± 4 379 ± 1
7826	P-241[a]	A-4	4-1-58	90	93.5	93.5-91.5	T	640	345 ± 14	7-11-58	0 15.5 ± 7.8	62 ± 1 58 ± 1	56 ± 4 55 ± 4	134 ± 3 132 ± 3	742 ± 106 706 ± 116	326 ± 9 336 ± 10
7863	P-244[a]	A-4	4-14-58	65	65.0	65.0	T	1630	582 ± 13	7-11-58	174 ± 3 159 ± 3	38 ± 1 42 ± 1	656 ±16 664 ±16	77 ± 1 79 ± 1	158 ± 21 172 ± 23	215 ± 5 241 ± 5
7984	P-245	A-4	5-1-58	65	64.4	64.4-64.1	T	1740	2560 2880	6-16-58 6-16-58	<157 <226	49 49		73.0 71.8		588 676
7985	P-247	A-4	5-4-58	90		94.2-72.9	T	1160	2060 1980	6-27-58 5-16-61	<226 <246	54 58		103 90		533 472
8031	P-248	A-4	5-9-58	80	80.5	80.5-77.3	T	1470	8210 5980	8-8-58 8-7-58	720 721	122 133		163 191	559 391	1460 1460
8072	P-251	A-4	6-2-58	65	64.8	64.8-64.5	T	1700	5940 6470	8-7-58 8-6-58	1210 1090	52 51		36.4 36.4	1030 1300	1290 1220 1240
8178	P-252	A-4	6-6-58	80	81.7	81.7-79.5	T	1180	8730 7120	7-17-58 7-17-58	695 674	117 117		46 28 33	168 196	1860 1612 1840

(a) Isotopic analyses by Tracerlab (W).

Table 3b - cont'd

SAMPLING MONTHS: JULY to DECEMBER 1958

Site: Panama Canal Zone

Analytical Labs: NSEC - Tracerlab (W)

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet: Nominal	Predominant	Range	Volume: Determination	S.C.F.	Beta Activity d/m/1000 ft3	Counting Date	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
		No	successful	flights in July 1958.													
8397	P-258	A-4	8-1-58	65	64.5	65.1-64.2	T	1660	$(45.2 \pm 0.3) \times 10^4$ $(141 \pm 6.6) \times 10^4$ $(130 \pm 6.0) \times 10^4$	8-15-58 10-11-58 10-11-58	32900 ± 1430 109000 ± 3540 55400 ± 2050	886 ± 42 858 ± 83		1280 ± 54 1240 ± 60	32900 ± 4100 138000 ± 12300	7340 ± 148 7160 ± 143	4580 ± 154
		No	successful flights	in September 1958.													
8809	P-264	A-4	10-5-58	65	66.1	66.1-64.2	T	1500	63700 ± 940	11-5-58	18600 ± 1030 17800 ± 960	347 ± 13 341 ± 14			<5260 <6400	3180 ± 78 3360 ± 78	4580 ± 154 3740 ± 157
8990	P-266	A-4	11-7-58	65	65.2	65.2-64.8	T	1590	80000 ± 1040	12-11-58	17800 ± 700 16600 ± 710	389 ± 15 388 ± 18			<4290 <6440	7020 ± 158 7040 ± 155	25000 ±1140 31400 ±1500
9017	P-269	A-4	11-16-58	90	89.0	90.8-88.3	B	900(a)	36400 ± 1070	1-7-59	414 ± 72 377 ± 152	189 ± 7 173 ±		432 ± 27	<81 <166	2240 ± 83 2230 ± 103	102 ± 38 542 ± 103 193 ± 88
9036(c)	P-270	A-4	11-19-58	80	81.8	82.4-81.8	T	1340	15100 ± 840	1-5-59	4280 ± 69 4150 ± 49	331 ± 9 331 ± 9	2440 ± 57 2520 ± 57	660 ± 24 729 ± 25	677 ± 69 766 ± 122	8360 ± 156 8290 ± 161	165 ± 4 164 ± 4
9066(c)	P-274	A-4	12-2-58	65	65.8	65.8	T	1560	33300 ± 961	1-5-59	8190 ± 80 8168 ± 80	193 ± 4 195 ± 4	7490 ± 132 7290 ± 119	508 ± 132 468 ± 119	1600 ± 30 1600 ± 30	7780 ± 152 8540 ± 152	9290 ± 178 9518 ± 178
9092	P-277	A-4	12-12-58	90	92.6	92.6-91.0	T	650	3330 ± 818	2-12-59	80 ± 39 95 ± 41	62.6 ± 5.4 63.9 ± 5.1		164 ± 17 156 ± 19	<792 <2500	874 ± 36 1020 ± 39	1590 ± 199 201 ± 67 204 ± 84

(a) Volume estimated for total collection time of 77 minutes based on 22 minutes of telemetry.
(b) Termination of sampling site.
(c) Isotopic analyses - Tracerlab.

Table 3c

SAMPLING MONTHS: JANUARY TO MARCH 1958

Site: Sao Paulo, Brazil

Analytical Lab: Tracerlab

BASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Altitude - kilofeet Predominant	Altitude - kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft3	Counting Date	Sr89 (d/m/1000 SCF)	Sr90 (d/m/1000 SCF)	Zr95 (d/m/1000 SCF)	Cs137 (d/m/1000 SCF)	Ba140 (d/m/1000 SCF)	Ce144 (d/m/1000 SCF)
7556	B-244	A-4	1-8-58	90	90.1	92.0-90.1	T	760	0 ± 613	4-2-58	27.9 ± 2.0 31.2 ± 2.0	2.8 ± 0.2 3.0 ± 0.2	63.9 ± 4.6 Lost	106 ± 4 105 ± 4	30700 ± 1550 25500 ± 1790	64 ± 4 74 ± 4
7557	B-246	A-4	1-10-58	65	65.2	65.2-64.4	T	1530	166 ± 333	4-2-58	27.8 ± 5.9 35.8 ± 2.0	12.9 ± 1.0 11.7 ± 0.4	51.2 ± 1.9 55.5 ± 1.9	39.8 ± 1.8 27.7 ± 1.3	5500 ± 3790 5070 ± 1070	81.2 ± 1.6 72.3 ± 2.3
7645	B-248	A-4	2-3-58	65	65.8	66.0-65.4	T	1380	202 ± 333	4-17-58	90 ± 8 66 ± 8	25 ± 1 28 ± 1	186 ± 34 Lost	125 ± 4 Lost	26600 ± 951 35200 ± 951	183 ± 8 261 ± 10
7646	B-251	A-4	2-9-58	80	79.2	79.4-79.2	T	1700	374 ± 17	5-14-58	30.0 ± 2.6 23.6 ± 2.3	16.6 ± 0.6 15.7 ± 0.4	34.3 ± 4.4 36.9 ± 2.5	44.6 ± 2.0 53.3 ± 2.3	4730 ± 207 4750 ± 179	102 ± 3 109 ± 3
7647	B-252	A-4	2-10-58	90	92.0	92.0-91.4	T	640	0 ± 763	4-2-58	14.3 ± 2.8 10.8 ± 2.1	7.7 ± 0.8 7.2 ± 0.5	61.2 ± 13.3 96.2 ± 9.2	14.0 ± 0.5 13.3 ± 0.5	11400 ± 191 9130 ± 110	52.4 ± 3.1 53.1 ± 2.5
7714	B-255	A-4	3-4-58	90	91.7	92.0-91.4	T	630	374 ± 1	4-1-58	0	33.4 ± 3 30.0 ± 4	302 ± 43 302 ± 129	34.4 ± 3.9 29.7 ± 1.1	93 ± 6 77 ± 1	4700 ± 110 5060 ± 73
7715	B-257	A-4	3-6-58	90	89.2	89.5-88.9	T	800	0 ± 651	4-17-58	32.8 ± 4.6 47.0 ± 4.7	9.6 ± 0.8 10.9 ± 0.8	22.8 ± 4.2 31.2 ± 4.0	10.0 ± 0.5 9.6 ± 0.5	69 ± 4 74 ± 3	4640 ± 61 5060 ± 61
7716	B-258	A-4	3-7-58	80	78.6	79.1-78.1	T	1760	352 ± 11	5-14-58	< 54.2 21.6 ± 8.7	16.3 ± 2.5 15.3 ± 1.1	< 434 < 247	44 ± 1 48 ± 1	1570 ± 21 2010 ± 31	89 ± 3 86 ± 3

Table 3c - cont'd

SAMPLING MONTHS: APRIL TO JUNE 1958

Analytical Labs: NSEC - Tracerlab.

Site Sao Paulo, Brazil

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}
7808(b)	B-263	A-4	4-3-58	65	65.5	65.5	T	1800(a)	(83.8 ± 3.4)	6-29-58	(25 ± 2) (26 ± 2)	(6.4 ± 0.2) (6.0 ± 0.2)	(66.5 ± 3.4) (78.9 ± 3.4)	(11.3 ± 0.5) (12.3 ± 0.5)	(237 ± 29) (244 ± 26)	(68.8 ±2.2) (71.6 ±2.2)
7809(b)	B-265	A-4	4-4-58	80	79.3	79.5-79.1	T	1680	263 ± 6	7-9-58	23 ± 4 33 ± 4	37 ± 1 34 ± 1	53.5 ± 1.8 54.1 ± 1.8	144 ± 2 144 ± 2	201 ± 29 361 ± 26	352 ±2.4 246 ±2.4
7810(b)	B-266	A-4	4-5-58	90	92.7	92.7	T	600	64 ± 10	7-9-58	0 5.2 ± 2.4	20 ± 1 14 ± 1	64 ± 1 40 ± 1	40 ± 1 40 ± 1	785 ± 68 470 ± 68	94.2 ±3.9 94.2 ±3.9
8037	B-268	A-4	5-9-58	65	64.6	64.6	T	1960(a)	(306) (253)	8-4-58 8-5-58	(<41) (<41)	(6.92) (6.15)	(54) (48)	(30) (30)	(< 47) (< 62)	(79) (90)
8038	B-271	A-4	5-11-58	90	88.2	88.2-85.5	T	880	460 338	8-19-58 8-20-58	<64 <58	7.8 8.2	139 136	31 ± 9 5 ±14 38 ± 5	< 77 <126	58 66
8039	B-275	A-4	5-17-58	80	79.4	79.4-78.8	T	1720	401 177 472	8-6-58 8-1-58 8-6-58	< 21 <22	5.7 8.8	295 268	22 27	32 60	39 44
8183	B-277	A-4	6-4-58	65	64.1	64.1-63.1	T	1710	1180 1060	10-16-58 10-10-58	78 120	38.3 39.0	261 289	93.0 90.0	< 23 <48	456 448
8185	B-279	A-4	6-8-58	80	79.1	79.1	T	1580	251 383	10-15-58 10-11-58	<51 <12	5.1 7.3	32 15	13 26 16	< 19 <14	32 26
8187	B-281	A-4	6-13-58	80	78.6	78.6-78.1	T	1450	< 142 <212 212	10-18-58 10-11-58 10-18-58	< 25 <16	11.4 13.1	24 34	27 26 21	< 16 <18	56 52

(a) Blower speed above normal - volume doubtful.
(b) Isotopic analysis - Tracerlab.

Table 3c - cont'd

SAMPLING MONTHS: JULY TO SEPTEMBER 1958

Analytical Labs: NSEC - Tracerlab

Site Sao Paulo, Brazil

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Altitude - kilofeet Predominant	Altitude - kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
8327[a]	B-283	A-4	7-7-58	65	69.7	70.2-69.1	T	1170	-	-	133 ± 17 121 ± 10	38 ± 2 36 ± 2	68 ± 6 841 ± 90	42 ± 1 47 ± 1	160 ± 12 249 ± 18	498 ± 21 496 ± 12	
8329[a]	B-285	A-4	7-9-58	90	89.7	89.7-89.4	T	760	-	-	35 ± 10 20 ± 10	34 ± 1 35 ± 3	593 ± 34 186 ± 17	51 ± 1 51 ± 1	261 ± 20 271 ± 20	226 ± 8 253 ± 7	
8330[a]	B-286	A-4	7-10-58	65	62.7	63.5-62.7	T	1770	290 ± 10	9-19-58	51.6 ± 1.9 44.0 ± 1.9	26.6 ± 1.2 27.0 ± 1.5	177 ± 8 174 ± 5	35 ± 1 39 ± 1	90 ± 5 56 ± 10	338 ± 2 331 ± 11	
8331[a]	B-287	A-4	7-11-58	80	79.6	79.6	T	1640	353 ± 11	9-19-58	57 ± 9 53 ± 5	36 ± 2 32 ± 1	136 ± 4 123 ± 4	54 ± 2 56 ± 2	78 ± 10 71 ± 6	306 ± 15 313 ± 16	
8600	B-290	A-4	8-5-58	90	93.0	93.8-93.0	T	610	770 770	10-25-58 10-25-58	<609 <52	28.5 ± 7.3 47.0 ± 9.4 25.2 ± 2.5	2180 ± 110 2610 ± 132	33 ± 33 102 ± 12	<96 <237	187 ± 19 191 ± 19	
8601	B-291	A-4	8-7-58	80	80.7	80.7-78.5	T	1470	2040 ± 272 1840 ± 272	10-21-58 10-21-58	26 ± 11 29 ± 18	7.7 ± 2.0 11.3 ± 4.8	1410 ± 63 1390 ± 63	35.3 ± 7.6 74.8 ± 6.8 38.1 ± 4.8	<36 66	63 ± 15 73 ± 6	
8602	B-293	A-4	8-9-58	65	65.2	65.2-64.6	T	1610	8200 ± 559	10-8-58	1310 ± 82 1280 ± 82	85 ± 3 83 ± 3	92 ± 30 76 ± 33	162 186	231 231	1420 ± 40 1490 ± 52	
8700[a]	B-294	A-4	9-2-58	90	95.4	96.0-94.5	T	510	1830 ± 1230	9-26-58	78 ± 2 88 ± 6	33 ± 2 33 ± 2	<128 <159	53 ± 2 41 ± 2	<454 <363	795 ± 22 795 ± 22	35 <48
8702[a]	B-295	A-4	9-3-58	80	83.2	83.2-82.7	T	1290	269 ± 403	9-26-58	<25 <25	32.2 ± 1.8 35.8 ± 4.1	<37 <45	41 ± 1 44 ± 1	<113 <113	388 ± 8 549 ± 15	13 14
8701[a]	B-298	A-4	9-6-58	65	65.7	65.9-65.3	T	1520	1980 ± 394	9-26-58	120 ± 3 152 ± 3	40 ± 2 36 ± 2	322 ± 4 356 ± 6	65 ± 2 66 ± 1	174 ± 10 169 ± 10	1620 ± 30 1670 ± 35	90 ± 2 75 ± 2

(a) Isotopic analyses - Tracerlab.

Table 3c - cont'd

SAMPLING MONTHS: OCTOBER TO DECEMBER 1958

Analytical Labs: NSEC - Tracerlab.

Site: San Paulo, Brazil

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr89	Sr90	Zr95	Cs137	Ba140	Ce144	W185
8817	B-300	A-4	10-6-58	65	66.7	67.0-66.5	T	1410	3200 ± 366	11-5-58	301 ± 98 469 ± 50	48 ± 3 60 ± 3	454 ± 97 611 ± 161	-	< 4390 < 7690	717 ± 26 694 ± 27	89 ± 48 116 ± 62
8819	B-301	A-4	10-7-58	90	94.5	94.5-89.7	T	590	0 ± 1140	11-5-58	< 95 < 96	7.8 ± 5.1 16.0 ± 3.4	1600 ± 78 2200 ± 105	51 ± 25 31 ± 15	< 1850 < 4490	70 ± 42 72 ± 29	< 85 < 57
8820	B-302	A-4	10-8-58	80	83.5	83.5-82.5	T	1220	10600 ± 646	11-5-58	505 ± 151 613 ± 69	14.3 ± 3.1 223 ± 10 203 ± 8	< 55 < 82	226 ± 41 516 ± 24	< 385 < 4060	3120 ± 123 3200 ± 118	< 55 307 ± 112
9013	B-304	A-4	11-4-58	80	83.8	83.8-83.0	T	1570(a)	2250 ± 419	12-11-58	103 ± 48 165 ± 34	48 ± 4 40 ± 2	609 ± 30 634 ± 36	107 ± 10 57 ± 19	< 231 < 153	645 ± 25 694 ± 26	154 ± 47 72 ± 36 80 ± 45
9014	B-305	A-4	11-5-58	90	95.5	95.5-92.4	T	550	937 ± 1280	12-11-58	< 8 < 6	102 ± 8 119 ± 9	337 ± 64 614 ± 98 525 ± 130	264 ± 64 382 ± 30	< 234 < 391	822 ± 40 935 ± 45	138 ± 68 186 ± 70 414 ± 127
9015	B-309	A-4	11-9-58	65	66.6	66.6-66.0	T	1450	260 ± 453	12-11-58	84 ± 30 67 ± 37	24.1 ± 1.9 32.1 ± 4.1	212 ± 123 121 ± 48	-	< 2480 < 827	285 ± 11 258 ± 12	69 ± 35 < 58
9073(b)	B-312	A-4	12-4-58	65	67.8	68.2-67.3	T	1230	1650 ± 455	1-5-59	514 ± 26 466 ± 26	25.5 ± 1.4 24.1 ± 1.4	554 ± 49 606 ± 42	103 ± 5 103 ± 5	93 ± 14 126 ± 15	994 ± 29 Lost	276 ± 13 276 ± 11
9071	B-315	A-4	12-6-58	80	81.0	81.0-78.4	T	1490	481 ± 548	1-5-59	51.2 ± 1.8 89.7 ± 3.1	25.6 ± 2.0 18.4 ± 3.1	176 ± 7 167 ± 7	48.3 ± 0.7 46.0 ± 0.7	< 41 < 21	416 ± 15 446 ± 20	< 64 < 24
9072	B-316	A-4	12-7-58	90	92.1	92.1-88.1	T	700	3190 ± 834	1-5-59	152 ± 4 122 ± 4	96 ± 4 106 ± 5	956 ± 48 1130 ± 53	168 ± 3 170 ± 3	< 90 < 74	1930 ± 37 2020 ± 40	< 15 < 74

(a) Blower speed above normal - volume doubtful.
(b) Isotopic Analyses - Tracerlab.

Table 3c - cont'd

SAMPLING MONTHS: JANUARY TO FEBRUARY 1959

Site: Sao Paulo, Brazil

Analytical Labs: NSEC - AFCRL

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Zr^{95}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}	d/m/1000 SCF W^{185}
9362(c)	B-320	A-4	1-16-59	80	79.3	79.3-77.0	T	1890(a)	(0 ± 383)	2-24-59	(50 ± 49)	(14 ± 0.6)	-	-	(281 ± 26)	-
9363	B-322	A-4	1-20-59	65	64.4	64.4	T	1670	1530 ± 382	2-24-59	73 ± 22 90 ± 39	48.0 ± 4.4 25.2 ± 2.2	200 ± 45 118 ± 39	86.3 ± 10.9 87.5 ± 12.9	235 ± 12 218 ± 18	373 ± 33 172 ± 28 192 ± 38
9364	B-324	A-4	1-22-59	90	91.6	91.6-87.0	T	680	1520 ± 528	2-24-59	1200 ± 1480	128 ± 25	-	-	1620 ± 148	-
9532	B-325	A-4	2-3-59	65	65.7	66.0-65.4	T	1690(a)	(0 ± 248)	3-23-59	-	-	-	-	-	-
9533	B-326	A-4	2-4-59	80	80.1	80.1-79.2	T	1580	1360 ± 404	3-23-59	421 ± 24 294 ± 50	140 ± 7 147 ± 6	690 ± 52 664 ± 48	353 ± 17 383 ± 18	1910 ± 75 2370 ± 60	75 ± 26 < 41
9534	B-328(b)	A-4	2-7-59	90	92.0	92.0-89.3	T	710	1413 ± 651	3-23-59	< 88 < 90	68 ± 7 58 ± 4	266 ± 61 261 ± 67	128 ± 23 150 ± 27	521 ± 28 514 ± 30	< 72 < 54

(a) Blower speed above normal - volume doubtful.
(b) Termination of sampling site.
(c) Isotopic Analyses - AFCRC.

Table 3d

SAMPLING MONTHS: AUGUST TO DECEMBER 1958

Site: Sioux City, Iowa

Analytical Labs: NSEC - Tracerlab (W)

				Altitude - kilofeet			Volume		Beta		d/m/1000 SCF						
HASL#	Flight#	Type*	Flight Date	Nominal	Predominant	Range	Determination	S.C.F.	Activity d/m/1000 ft^3	Counting Date	Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
8384(f)	I-11	A-4	8-2-58	90	90.0	90.2-88.0	T	810	91 ± 8	9-27-58	295 ± 6 336 ± 17	10 ± 1 28 ± 3	Lost	20 ± 1 18 ± 1	411 ± 25 4960 ± 236	80 ± 4 94 ± 4	
8385(f)	I-12	A-4	8-3-58	60	65.5	65.8-65.5	T	1830	879 ± 21	9-24-58	265 ± 4 265 ± 4	28 ± 1 27 ± 1	390 ± 16 379 ± 8	95 ± 4 99 ± 4	47 ± 2 49 ± 2	629 ± 19 615 ± 19	
8425	I-14	A-4	8-7-58	50	48.5	48.5(a)	T	2450(b)	(368 ± 236) (<161) (<161)	8-15-58 10-22-58 10-22-58	(28 ± 8) (28 ± 9)	(0.22 ± 0.47) (0.47 ± 0.71)	(40 ± 11) (53 ± 11	(10.6 ± 4.9) (5.7 ± 1.6) (4.9 ± 2.5)	(<29) (53)	(18 ± 5) (20 ± 3)	
8426	I-15	A-4	8-9-58	80	80.0	80.0	T	1650	1110 ± 341 232 232	8-15-58 10-22-58 10-22-58	35 ± 11 21 ± 8	15 ± 6 16 ± 3	31 ± 14 38 ± 17	37 ± 18 35 ± 5	<39 <36	97 ± 6 94 ± 6	
8681	I-17	A-4	9-1-58	50	49.5	49.5(c)	T	2810	Sample	lost.							
8667	I-18	A-4	9-7-58	80	79.5	80.0-78.8	T	1480	305 ± 367	9-26-58	<56 <85	18.5 ± 1.9 19.4 ± 2.8	<172 < 96		20,000 34,900	106 ± 9 106 ± 9	83 ± 62 84 ± 63
8687	I-19	A-4	9-8-58	65	61.8	61.8-61.5	T	2550(b)	(304 ± 193)	9-26-58	(<18) (<43)	(0.23 ± 0.16) (0.23 ± 0.46)	<191 < 96		(<13,300) (<24,100)	(20 ± 3) (18 ± 3)	(72 ± 48) (48 ± 36)
8811	I-23	A-4	10-14-58	65	64.5	64.5-64.2	T	1630	2090 ± 318	11-5-58	<98 109 ± 62	44 ± 2 42 ± 4	211 ± 104 141 ± 42		<3710 <9030	463 ± 20 502 ± 20	455 ± 102 586 ± 117
8823	I-27	A-4	10-18-58	90	90.0	90.0-89.5	T	800	607 ± 595	11-5-58	<70 <50	18.6 ± 3.7 24.7 ± 6.4	71 ± 27 111 ± 54	86 ± 14 77 ± 25	< 342 <603	117 ± 13 131 ± 44	56 80
9165	I-40	A-4	12-27-58	50	49.3	49.3-48.8(d)	E	2200(e)	5870 ± 281	2-12-59	1040 ± 57 974 ± 81	25 ± 1 31 ± 1	1710 ± 78 1340 ± 92 1710 ± 96	88.7 ± 12 91.6 ± 22	<156 <274	935 ± 31 784 ± 34	1930 ± 102 1640 ± 84
9230	I-42	A-4	12-31-58	80	81.8	81.8-80.5	T	1410	1870 ± 341	2-12-59	386 ± 43 392 ± 38	18.6 ± 2.3 28.3 ± 3.0	1050 ± 67 928 ± 59	42 ± 5.7 43 ± 5.7	<327 <276	438 ± 19 415 ± 16	509 ± 46 279 ± 38

Table 3d - cont'd

SAMPLING MONTHS: JANUARY TO MARCH 1959

Site: Sioux City, Iowa

Analytical Labs: NSEC - AFCRC - Tracerlab (W)

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Altitude - kilofeet: Predominant	Altitude - kilofeet: Range	Volume: Determination	Volume: S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
9270(b)	I-44	A-4	1-8-59	90	89.0	89.0	T	850	1610 ± 738	2-24-59	1530 ± 906	60 ± 13			824 ± 130	
9313(b)	I-45	A-4	1-22-59	80	80.3	81.0-78.8	T	1440	3800 ± 453	2-24-59	1250 ± 299	111 ± 2			904 ± 69	
9666	I-48	A-4	2-28-59	50	48.5	48.5-48.0(a)	T	2090	2520 ± 257	3-29-59	363 ± 17 378 ± 22	33.6 ± 3.3 34.6 ± 1.7	626 ± 30 473 ± 32 637 ± 30	86.1 ± 5.7 93.8 ± 6.6	512 ± 20 494 ± 29	665 ± 48 716 ± 50
9667	I-49	A-4	3-1-59	90	91.0	91.0-89.5	T	620	1250 ± 698	3-23-59	270 ± 147 489 ± 152	24.6 ± 4.5 39.4 ± 5.2	643 ± 74 560 ± 74	50.0 ± 22.5 62.8 ± 40.3	696 ± 50 754 ± 35	475 ± 100 165 ± 64 264 ± 67
9787(c)	I-51	A-4	3-27-59	65	65.8	66.3-65.3	T	1550	2820 ± 774 1960 ± 45	4-14-59 5-28-59	339 ± 6 323 ± 6	94.2 ± 1.3 104 ± 1	880 ± 24 890 ± 22	153 ± 5 191 ± 4	Lost	64 ± 5 66 ± 4

(a) Tropopause height - 31 kilofeet.
(b) Isotopic Analyses - AFCRC.
(c) Isotopic Analyses - Tracerlab.

Table 3d - cont'd

SAMPLING MONTHS: APRIL TO JUNE 1959

Analytical Labs: NSEC - Tracerlab (W)

Site: Sioux City, Iowa

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Predominant	Range	Volume: Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
9833[d]	I-54	A-4	4-1-59	50	48.5	49.0-48.5[a]	T	1630	1720 ± 729 1540 ± 79	4-23-59 5-6-59	334 ± 7 322 ± 7	52.7 ± 0.8 47.4 ± 0.8	Lost	102 ± 2 97.6 ± 1.8	1000 ± 18 1000 ± 15	494 ± 7 495 ± 7
9873[d]	I-55	A-4	4-9-59	65	65.3	65.5-65.3	T	1580	2480 ± 2160 2630 ± 8	4-14-59 5-8-59	468 ± 14 506 ± 14	124 ± 7 118 ± 7	832 ± 31 878 ± 51	235 ±120 246 ±120	2530 ± 21 2510 ± 21	111 ± 2 116 ± 2
9948	I-56	A-4	4-13-59	90	90.5	91.3-88.0	T	890	8630 ± 3080 7570 ± 258	5-6-59 7-21-59	530 ± 64 530 ±113	107 ± 6 109 ± 10	1320 ±106 1120 ± 79	263 ± 24 297 ± 25	3070 ± 527 2870 ± 154	82 98 ± 44
9970	I-57	A-4	4-21-59	80	80.8	81.2-80.8	T	1570	5990 ± 1010 3340 ± 114	4-29-59 7-28-59	172 ± 87 161 ± 58	211 ± 12 212 ± 9	523 ± 43 521 ± 50	441 ± 24 427 ± 21	2060 ± 110 2200 ± 120	32 43
10359	I-59	A-4	5-11-59	50	48.0	-(b) (c)	T	1740	698 ± 838	7-20-59	0 ± 29 24 ± 33	22.3 ± 1.6 24.2 ± 1.3	121 ± 28 132 ± 52	45 ± 6 39 ± 5	524 ± 19 257 ± 13	165 ± 53 130 ± 49
10472	I-61	A-4	5-15-59	90	91.5	91.5-87.0	T	730	484 ± 603	6-8-59	60 ± 29 0 ± 64	28.6 ± 3.2 34.6 ± 3.6	244 ±109 207 ±118	56 ± 8 60 ± 10	668 ± 29 718 ± 31	0 ± 92 0 ±139
10502	I-63	A-4	5-24-59	65	65.0	65.5-65.0	T	1590	2240 ± 751	7-20-59	112 ± 72 60 ± 66	107 ± 4 105 ± 3	540 ± 51 288 ± 27	204 ± 10 228 ± 10	1060 ± 35 1030 ± 45	60 ± 34 99 ± 32
10642	I-64	A-4	6-1-59	50	49.7	50.0-49.3[b]	T	1790			709	21.3	95.4		370	
10643	I-65	A-4	6-2-59	90	90.0	90.5-89.5	T	870			110	89.8	296		1340	
10644	I-66	A-4	6-2-59	80	80.8	81.3-80.0	T	1320			224	79.7	1000		1920	
10736	I-67	A-4	6-12-59	65	65.8	65.8-65.5	T	1500			300	259	756		990	

(a) Tropopause height - 34 kilofeet.
(b) " " - 37 kilofeet.
(c) Altitude range unknown due to telemetering failure.
(d) Isotopic analyses - Tracerlab.

Table 3d - cont'd

SAMPLING MONTHS: JULY TO SEPTEMBER 1959

Site: Sioux City, Iowa

Analytical Labs: NSEC - Tracerlab (W)

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr89	Sr90	Zr95	Cs137	Ce144	W185
10849	I-68	A-4	7-2-59	50	49.0	49.0(a)	T	2280(b)	0 ± 28	7-24-59	No other analyses.					
10850	I-69	A-4	7-5-59	90	90.0	90.0-87.8	T	890	6000 ± 1290	7-20-59	61 ± 50 0 ± 78	116 ± 6 106 ± 4	466 ± 76 451 ± 97	258 ± 12 186 ± 17	2060 ± 66 2100 ± 67	20 ± 47 20 ± 51
10851	I-70	A-4	7-6-59	80	79.8	80.3-79.8	T	1650	1610 ± 642	7-20-59	19 ± 29 0 ± 42	75.9 ± 4.2 95.6 ± 3.4	178 ± 42 194 ± 37	125 ± 6 140 ± 7	900 ± 35 883 ± 27	86 ± 22 161 ± 47
10871	I-71	A-4	7-9-59	80	80.5	80.5-80.0	T	1480	2730 ± 906	7-20-59	20 ± 31 0 ± 44	120 ± 4 117 ± 4	242 ± 58 119 ± 39	243 ± 14 283 ± 12	1130 ± 48 1230 ± 40	0 ± 18 0 ± 24
10890	I-72	A-4	7-11-59	65	65.2	65.3-65.0	T	1530	2520 ± 922	7-20-59	22 ± 32 32 ± 40	94 ± 3 95 ± 2	62 ± 30 166 ± 23	223 ± 10 203 ± 9	793 ± 25 863 ± 34	33 17
11038	I-73(c)	A-4	8-3-59	50	49.5	49.5(d)	T	2580(b)	(0 ± 193)	8-18-59	(1.3 ± 2.6) (3.3 ± 3.3)	(6.5 ± 0.6) (7.3 ± 1.0)	(26 ± 10) (20 ± 9)	(16.3 ± 2.3) (12.4 ± 2.0)	(68 ± 3) (68 ± 3)	(8 ± 12) (19 ± 13)
11046	I-74	A-4	8-7-59	90	90.5	90.5	T	790	2020 ± 410	9-15-59	5.1 ± 20.6 4.7 ± 23.6	82 ± 4 92 ± 7	264 ± 61 303 ± 114	142 ± 23 141 ± 19	1400 ± 43 1440 ± 57	0 ± 16
11047	I-75	A-4	8-8-59	65	65.6	65.8- 65.3	T	1510	1790 ± 508	9-15-59	42 ± 31 0 ± 34	119 ± 3 101 ± 5	162 ± 16 128 ± 13	275 ± 12 249 ± 11	1030 ± 32 924 ± 25	0 ± 6
11048	I-76	A-4	8-9-59	80	80.0	80.3-80.0	T	1480	2220 ± 779	9-15-59	0 ± 19 0 ± 20	110 ± 3 127 ± 4	94 ± 22 99 ± 34	270 ± 12 266 ± 12	1080 ± 27 1110 ± 41	11 ± 12
11198	I-77	A-4	9-2-59	50	49.3	49.3(e)	T	2200(b)	(437 ± 267)	9-15-59	(9 ± 7) (12 ± 7)	(12.3 ± 0.9) (11.7 ± 1.0)	(14 ± 9) (11 ± 9)	(29 ± 3) (34 ± 4)	(119 ± 4) (117 ± 6)	(20 ± 10) (28 ± 13)
11199	I-78	A-4	9-3-59	90	89.3	89.3	T	890	1670 ± 984	9-15-59	21 ± 26 30 ± 15	44.5 ± 2.4 35.7 ± 2.7	93 ± 37 140 ± 50	94 ± 11 97 ± 12	954 ± 35 803 ± 32	0 ± 12 32 ± 26
11213	I-79	A-4	9-4-59	65	64.5	64.5-64.3	T	1680	1310 ± 505	10-12-59	26 ± 18 9 ± 18	85.3 ± 3.0 88.0 ± 7.1	84 ± 27 78 ± 25	158 ± 24 192 ± 9	631 ± 38 646 ± 26	39 ± 14 82 ± 20
11228	I-80	A-4	9-10-59	90	87	87.0-86.3	T	1020	280 ± 363	10-12-59	-	23.9 ± 3.2	-	-	-	-
11289	I-81	A-4	9-11-59	80	78.5	78.8-78.5	T	1730	1783 ± 330	10-13-59	16 ± 19 20 ± 28	58.8 ± 4.0 57.2 ± 2.9	67 ± 21	92 ± 10 92 ± 6	690 ± 64 925 ± 33	12 ± 12 14 ± 12

(a) Tropopause height - 50 kilofeet.
(b) Blower speed above normal-volume doubtful.
(c) Exhaust duct first used at Sioux City.
(d) Tropopause height - 48 kilofeet.
(e) Tropopause height - 46 kilofeet.

Table 3d - cont'd

SAMPLING MONTHS: OCTOBER TO DECEMBER 1959

Analytical Labs: NSEC - Tracerlab (W).

Site: Sioux City, Iowa

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
11448	I-82	A-4	10-3-59	50	49.0	49.0 (a)	T	1960	818 ± 469	10-20-59	-	25.4 ± 3.1 23.2 ± 5.4	-	-	-	-
11449	I-83	A-4	10-5-59	65	65.8	65.8-65.3	T	1650	573 ± 430	10-20-59	-	23.8 ± 0.6 20.4 ± 3.4	-	-	-	-
11498	I-85	A-4	10-14-59	90	87.0	87.8-87.0	T	950	2740 ± 1910	11-16-59	136 ± 136 0 ± 128	92 ± 6 98 ± 9	155 ± 66 145 ± 66	190 ± 15 177 ± 18	1240 ± 88 1390 ± 74	41 ± 27 68 ± 35
11524	I-86	A-4	10-17-59	80	78.3	78.3	T	1820	2640 ± 718	11-16-59	66 ± 89 250 ± 100	86 ± 6 80 ± 4	82 ± 25 116 ± 52	196 ± 9 190 ± 10	1350 ± 60 1260 ± 52	9 ± 11 17 ± 20
11587	I-88	A-4	11-3-59	50	49.2	49.2-48.6 (b)	T	1720	0 ± 110	11-16-59	-	1.7 ± 1.0 0 ± 0.8	-	-	-	-
11647	I-89	A-4	11-10-59	65	65.3	65.3-64.8	T	1790 (c)	(844 ± 610)	12-21-59	-	(21.2 ± 2.0) (22.8 ± 2.0)	22 ± 15 15 ± 19	(62 ± 7) (48 ± 7)	(143 ± 21) (121 ± 21)	(0 ± 6) (18 ± 15)
11697	I-90	A-4	11-19-59	65	-	-	E	1500 (d)	1820 ± 912	12-16-59	7 ± 9 14 ± 12	101 ± 5 96 ± 5	133 ± 32 109 ± 27	182 ± 8 206 ± 8	622 ± 43 605 ± 33	12 ± 11 14 ± 11
11766	I-93	A-4	12-2-59	65	64.0	64.3-64.0	T	1630	1400 ± 1940	12-18-59	16 ± 22 7 ± 8	55 ± 5 63 ± 4	30 ± 12 48 ± 15	116 ± 7 123 ± 10	368 ± 38 337 ± 30	0 ± 4 12 ± 10
11765	I-94	A-4	12-3-59	80	77.5	78.0-77.5	T	1900 (c)	(1520 ± 606)	12-21-59	(1 ± 4) (11 ± 13)	(32.8 ± 4.0) (32.2 ± 2.0)	(55 ± 16) (66 ± 11)	(67 ± 7) (58 ± 7)	(487 ± 32) (506 ± 26)	(0 ± 6) (24 ± 17)
11819	I-95	A-4	12-16-59	50	48.5	48.5-48.0	T	1860	187 ± 264	2-8-60	-	-	-	-	-	-

(a) Tropopause height - 45 kilofeet.
(b) Tropopause height - 32 kilofeet.
(c) Blower speed above normal - volume doubtful.
(d) No altitude telemetring received. Volume based on as assumed altitude of 67 kilofeet.
(e) Sampling site terminated December 1959.

Table 3e

SAMPLING MONTHS: JANUARY TO MARCH 1958

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft3	Counting Date	Sr^{89} (d/m/1000 SCF)	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}
7492	T-244	A-4	1-7-58	80	81.1	81.1-79.6	T	1450	827 ± 531	2-1-58	45 105	11.6 9.8	79.1 89.5	46 47	< 14 < 19	103 103
7493	T-245	A-4	1-8-58	90	90.0	90.0	T	860	1630 ± 825	2-1-58	< 52 < 104	17.6 18.5	250 231	75 70	< 21 < 21	136 217
7526	T-248	A-4	1-15-58	65	65.1	65.1	T	980	12600 ± 754	2-1-58	1200 1290	87.7 89.9	2450 2440	234 245	284 308	1650 1560
FEBRUARY 1958 - no successful flights																
7686	T-255	A-4	3-3-58	90	91.9	91.9-87.6	T	1060	1510 ± 506	4-2-58	11.5 ± 1.3 22.5 ± 1.4 7.2 ± 0.1 13.1 ± 0.3	8.2 ± 0.4 24.6 ± 0.6 4.8 ± 0.1 13.2 ± 1.0	Lost	56 ± 3 59 ± 1	1280 ± 22 935 ± 18	184 ± 8 218 ± 8
7727	T-257	A-4	3-9-58	65	65.1	65.1	T	1740	2740 ± 265	4-17-58	0	16 ± 2 14 ± 2	Lost	149 ± 5 127 ± 5	12000 ± 240 11800 ± 300	786 ± 13 805 ± 19

Table 3e - cont'd

SAMPLING MONTHS: APRIL TO JUNE 1958

Site: San Angelo, Texas

Analytical Labs: NSEC - Tracerlab.

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Altitude - kilofeet: Predominant	Altitude - kilofeet: Range	Volume: Determination	Volume: S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF: Sr^{89}	d/m/1000 SCF: Sr^{90}	d/m/1000 SCF: Zr^{95}	d/m/1000 SCF: Cs^{137}	d/m/1000 SCF: Ba^{140}	d/m/1000 SCF: Ce^{144}
7793[c]	T-259	A-4	4-1-58	90	90.7	90.7-90.2	T	820	586 ± 24	6-20-58	43.4 ± 4.9 11.2 ± 4.9	25 ± 1 34 ± 1	154 ± 4 164 ± 8	73 ± 1 74 ± 1	685 ± 18 755 ± 22	308 ± 13 282 ± 13
7794[c]	T-260	A-4	4-2-58	80	79.9	79.9	T	1590	106 ± 5	6-20-58	17.9 ± 1.7 13.0 ± 1.7	10.6 ± 0.5 10.6 ± 0.5	17.1 ± 1.5 20.9 ± 1.5	36 ± 1 37 ± 1	56 ± 6 53 ± 6	118 ± 5 107 ± 5
7795[c]	T-261	A-4	4-3-58	65	64.7	64.7	T	1860	1760 ± 43	6-28-58	276 ±13 282 ±13	38 ± 1 35 ± 1	946 ±13 952 ± 8	136 ± 3 131 ± 3	71 ± 7 121 ± 3	374 ± 7 288 ± 6
7804[c]	T-263	A-4	4-8-58	50	49.4	49.4[a]	T	1780	320 ± 11	6-28-58	68.5 ± 2.0 69.1 ± 2.0	3.9 ± 0.2 4.7 ± 0.2	473 ± 6 441 ± 6	9.2 ± 0.3 9.2 ± 0.3	158 ± 8 138 ± 9	183 ± 3 189 ± 3
7988	T-266	A-4	5-4-58	65	65.4	66.0-65.4	T	1630	2700 3120	6-27-58 6-27-58	290 310	48 58 61	594 637	72.4 58	-	695 691
7989	T-267	A-4	5-5-58	90	92.0	92.8-88.7	T	690	577 577	6-27-58 6-30-58	120 243 132	13.4 ± 4 6.7 ± 8.0 0 ± 2.7	99 94	12 ± 9 20 ±12 32 ± 7	-	48 46
7990	T-271	A-4	5-10-58	50	49.1	49.3-48.3[b]	T	1430	3000 3700	6-27-58 6-27-58	377 263 161	28 25	587 711	36 25	-	676 668
8036	T-273	A-4	5-19-58	80	80.2	80.3-79.7	T	1490	801 671	7-25-58 7-25-58	38 41	16.6 17.7	106 130	127 121	52 58	171 184
8098	T-275	A-4	6-3-58	80	80.3	80.3-79.9	T	1630	6140 8590	7-22-58 7-19-58	24.9 46.2	16.0 15.0	48 75	62.0 60.0	21 51	134 110 127
8099	T-277	A-4	6-5-58	90	88.8	89.5-88.8	T	850	2350 3090	7-19-58 7-18-58	122 108	23.0 26.1	193 206	48 45	204 193	Lost
8175	T-278	A-4	6-7-58	65	65.0	65.3-65.0	T	1300	1840 1930	7-18-58 7-18-58	254 260	12.8 9.5	425 442	60.7 59.3	76 51	209 340 348

(a) Tropopause height - 41 kilofeet.
(b) Tropopause height - 42 kilofeet.
(c) Isotopic Analyses - Tracerlab.

Table 3e - cont'd

SAMPLING MONTHS: JULY TO SEPTEMBER 1958

Site: San Angelo, Texas

ANALYTICAL LABS: Tracerlab - NSEC

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
8323	T-280	A-4	7-2-58	80	81.5	81.7-81.5	T	1320	303 303	10-18-58 10-18-58	80 168	23.2 ± 1.5 23.2 ± 2.9	31 70 ± 31	34 ± 8 29 ± 9	190 278	116 ± 8 127 ± 8	-
8324	T-281	A-4	7-3-58	65	67.0	67.0	T	1370	1970 ± 292 2340 ± 365	10-18-58 10-18-58	529 ± 42 556 ± 37	54 ± 2 53 ± 2	583 ± 37 598 ± 44	61 ± 25 57 ± 8	173 254	692 ± 24 714 ± 25	-
8367(b)	T-287	A-4	7-18-58	90	83.5	89.2-86.5	T	800	288 ± 9	9-24-58	66 ± 4 84 ± 4	13.7 ± 1.3 12.8 ± 0.5	89 ± 3 104 ± 3	61 ± 5 62 ± 3	244 ± 11 234 ± 11	172 ± 9 133 ± 5	-
8393(b)	T-289	A-4	8-1-58	50	49.5	49.5(a)	T	1880	3880 ± 90	9-26-58	1480 ± 29 1920 ± 32	19 ± 1 20 ± 1	2390 ± 82 2390 ± 93	34 ± 1 37 ± 1	2230 ± 71 2950 ± 71	773 ± 24 779 ± 9	-
8394	T-290	A-4	8-2-58	90	91.8	91.8-91.0	T	740	1410 ± 741 536	8-15-58 10-17-58	52 ± 26 45	23.5 ± 2.8 27.6 ± 4.5	42 ± 25 127 ± 31	111 ± 40 78 ± 16	65 138	153 ± 12 133 ± 14	-
8396	T-293	A-4	8-5-58	80	81.0	81.0-80.5	T	1480	814 ± 379 338 266	8-15-58 10-17-58 10-23-58	59 37 ± 12 28	35 ± 2 30 ± 2	27 ± 12 52 ± 17	64 ± 10 65 ± 6	40 764	191 ± 10 181 ± 10	-
8679	T-295	A-4	9-3-58	80	80.0	80.5-79.8	T	1560	925 ± 328	9-26-58	97 114	56 ± 3 50 ± 3	182 194	-	35600 86400	452 ± 20 491 ± 20	.164 .331 .152

(a) Tropopause height - 50 kilofeet.
(b) Isotopic analyses - Tracerlab.

Table 3e - cont'd

Sampling Months: OCTOBER TO DECEMBER 1958

Site: San Angelo, Texas

Analytical Labs: NSEC - Tracerlab.

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Predominant	Range	Volume: Determination	S.C.F.	Beta Activity d/m/1000 ft^3	Counting Data	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
8825	T-301	A-4	10-16-58	80	79.0	79.5-78.5	T	1870(a)	(0 ± 329)	11-5-58	(35 ± 27) (< 27)	(12.7 ± 1.8) (15.2 ± 1.6)	(34 ± 16) (69 ± 23)	(44 ± 7) (40 ± 16)	(< 136) (< 2580)	(108 ± 9 (90 ± 10	(< 25) (138 ± 86) (158 ± 67)
8824	T-302	A-4	10-17-58	65	65.8	65.8-65.3	T	1520	3560 ± 338	11-5-58	188 ± 85 288 ± 47	63 ± 2 55 ± 2	195 ± 88 365 ± 61	-	9030 9890	644 ± 25 724 ± 25	142 ± 55 246 ± 69
8927	T-303	A-4	11-1-58	90	88.3	88.3-87.5	T	870	560 ± 862	12-11-58	92 78 ± 38	32.0 ± 5.6 21.8 ± 2.3	327 ± 42 392 ± 50	52 ± 23 82 ± 11	369 908	226 ± 13 202 ± 22	60 107 ± 46
9070(b)	T-307	A-4	12-1-58	90	88.5	89.8-88.5	T	950	1170 ± 730	1-5-59	140 ± 6 129 ± 6	15.1 ± 1.2 18.0 ± 1.4	649 ± 50 648 ± 52	14.2 ± 1.0 15.5 ± 1.2	224 ± 21 232 ± 21	1700 ± 69 1410 ± 61	34 ± 3 43 ± 4
9069(b)	T-311	A-4	12-5-58	65	63.5	63.9-63.2	T	1850	4730 ± 490	1-5-59	1100 ± 16 1090 ± 18	72.4 ± 4 74.6 ± 4	633 ± 22 629 ± 28	162 ± 7 180 ± 8	163 ± 19 165 ± 16	1500 ± 26 1560 ± 26	340 ± 14 541 ± 26
9081(b)	T-312	A-4	12-11-58	80	80.0	80.5-80.0	T	1670	3150 ± 395	1-5-59	110 ± 2 117 ± 2	18.6 ± 0.8 19.2 ± 1.2	1780 ± 76 1860 ± 63	27.6 ± 1.3 27.1 ± 1.4	186 ± 10 172 ± 10	1850 ± 35 1940 ± 35	50 ± 5 41 ± 2

(a) Blower speed above normal - volume doubtful.
(b) Isotopic analyses - Tracerlab.

Table 3e - cont'd

SAMPLING MONTHS: JANUARY TO MARCH 1959

Site: San Angelo, Texas

Analytical Labs: NSEC - AFCRC - Tracerlab.

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Altitude - kilofeet Predominant	Altitude - kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{89}	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Zr^{95}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}	d/m/1000 SCF W^{185}
9312(d)	T-313	A-4	1-2-59	90	95.0	95.5-95.0	T	430	1010 ± 152	2-24-59	2860 ± 232	768 ± 6	-	-	3250 ± 232	-
9272(d)	T-316	A-4	1-10-59	80	80.1	80.6-79.3	T	1900(a)	(1540 ± 326)	2-24-59	(111 ± 58)	(17.2 ± 0.5)	-	-	(279 ± 26)	-
9455	T-317	A-4	2-4-59	90	89.5	90.5-89.5	T	840	SAMPLE LOST.							
9456(d)	T-318	A-4	2-6-59	80	81.4	81.8-81.4	T	1410	6870 ± 480	2-24-59	1700 ± 298	191 ± 2	-	-		-
9530	T-320	A-4	2-15-59	50	50.5	50.5-49.4(b)	T	2110	2230 ± 206	3-24-59	379 ± 23 410 ± 23	28.9 ± 2.3 30.0 ± 1.7	512 ± 25 604 ± 30	79.1 ± 5.2 66.3 ± 7.1	568 ± 22 493 ± 18	531 ± 37 698 ± 33
9531	T-321	A-4	2-16-59	65	65.8	65.8-65.3	T	1530	4150 ± 373	3-23-59	826 ± 37 868 ± 38	122 ± 6 107 ± 4	415 ± 28 691 ± 33 590 ± 31	343 ± 15 304 ± 15	1110 ± 40 1100 ± 64	299 ± 26 252 ± 22
9665	T-323	A-4	3-3-59	50	47.2	49.8-47.2(c)	T	2200	1300 ± 200	3-23-59	<276 145 ± 24	22.9 ± 3.2 14.6 ± 2.5	359 ± 17 292 ± 17 348 ± 17	36.8 ± 4.1 35.9 ± 4.1	313 ± 13 259 ± 14	352 ± 28 347 ± 30
9688	T-325	A-4	3-7-59	80	81.2	81.2-80.8	T	1150	2010 ± 404	3-23-59	82 ± 27 <59	72 ± 7 77 ± 3	545 ± 47 497 ± 28	165 ± 26 148 ± 69	735 ± 48 958 ± 43	162 ± 20 89 ± 32
9686	T-326	A-4	3-9-59	80	80.7	81.1-80.7	T	1480	3820 ± 416	3-23-59	198 ± 43 152 ± 34	99.5 ± 5.4 64.5 ± 3.2	767 ± 35 648 ± 33 646 ± 49	324 ± 31 266 ± 22	1470 ± 49 1480 ± 42	152 ± 30 44 ± 19
9738(e)	T-327	A-4	3-12-59	65	64.2	64.7-63.8	T	1760	129 ± 568	4-14-59	98.8 ± 1.8 116 ± 2	13.3 ± 0.5 21.6 ± 0.4	155 ± 2 163 ± 2	24.4 ± 0.6 24.9 ± 0.6	293 ± 4 300 ± 5	32 ± 1 21 ± 1
9739(e)	T-328	A-4	3-17-59	80	82.0	82.0-80.8	T	1450	3340 ± 721 2280 ± 97	4-14-59 5-7-59	208 ± 20 271 ± 20	106 ± 3 103 ± 3	879 ± 17 855 ± 17	182 ± 3 186 ± 3	2960 ± 31 2920 ± 31	39 ± 1 39 ± 3

(a) Blower speed above normal - volume doubtful.
(b) Tropopause height - 39 kilofeet.
(c) Tropopause height - 40 kilofeet.
(d) Isotopic analyses by Cambridge Research Center.
(e) Isotopic analyses by Tracerlab.

Table 3e - cont'd

SAMPLING MONTHS: APRIL TO JUNE 1959

Site: San Angelo, Texas

Analytical Labs: NSEC-Tracerlab

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Predominant	Range	Volume: Determination	S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
9835(d)	T-329	A-4	4-2-59	80	81.1	81.5-81.1	T	1450	2790 ± 736 2340 ± 76*	4-14-59 5-12-59	127 ± 1 194 ± 1	141 ± 2 87 ± 1	561 ± 12 654 ± 13	197 ± 4 201 ± 2	2170 ± 13 2220 ± 15	12.4 ± 0.7 10.4 ± 0.7
9867(d)	T-331	A-4	4-4-59	65	65.0	65	T	1270	3840 ± 803 3940 ± 157*	4-14-59 5-24-59	462 ± 4 468 ± 4	94.4 ± 2.3 90.5 ± 2.3	627 ± 9 716 ± 40	199 ± 4 193 ± 4	1500 ± 52 1510 ± 52	591 ± 11 437 ± 8
9868(d)	T-332	A-4	4-6-59	90	90.0	91.0-90.0	T	800	1740 ± 975 1450 ± 68*	4-14-59 5-12-59	162 ± 1 206 ± 4	44.2 ± 1.3 45.6 ± 1.0	623 ± 31 616 ± 29	76.4 ± 3.5 81.8 ± 3.5	4200 ± 204 5550 ± 191	< 34 39 ± 3
9949	T-333	A-4	4-13-59	65	65.2	65.6-64.8	T	1650	3940 ±1100 3860 ± 191*	5-8-59 7-28-59	302 ± 96 400 ± 46	106 ± 6 112 ± 6	492 ±168 457 ± 52	270 ± 15 223 ± 17	579 ± 73 896 ± 50	533 ± 39 531 ± 45
9950	T-334	A-4	4-14-59	50	50.4	50.4(a)	T	1510	1660 ± 509 1320 ± 73* 1440 ± 119*	5-8-59 7-28-59 7-28-59	160 ± 3.8 164 ± 3.8	53.3 ± 3.8 61.8 ± 3.8	436 ± 31 382 ± 29	117 ± 10 102 ± 10	594 ± 34 589 ± 28	480 ± 66 534 ± 69
10337	T-335	A-4	5-1-59	90	89.6	90.4-88.5	T	940(c)	(0 ± 551)	No other analyses.						
10340	T-336	A-4	5-6-59	65	65.5	65.8-65.2	T	1500	3080 ±1000 2080 ± 100* 2290 ± 106*	6-8-59 7-29-59 7-29-59	66 ± 20 196 ±102	103 ± 4 103 ± 4	363 ± 32 319 ± 42	218 ± 16 207 ± 11	883 ± 51 713 ± 53	210 ± 24 198 ± 31
10357	T-337	A-4	5-7-59	80	80.1	80.1-79.7	T	1610	8140 ±1130 6960 ± 310* 7830 ± 310*	6-8-59 7-29-59 7-29-59	64 ± 20 190 ± 99	288 ± 12 268 ± 12	712 ± 38 500 ± 28	584 ± 26 537 ± 23	2310 ± 142 2650 ± 104	98 ± 53
10358	T-338	A-4	5-11-59	50	52.5	52.6-52.5(b)	T	2000(c)	(0 ± 246)	No other analyses.						
10775	T-344	A-4	6-17-59	65	66.0	66.3-65.5	T	1530	2430 ± 482	7-20-59	75 ± 16 57 ± 20	31 ± 2 52 ± 5	73 ± 33 238 ± 31	222 ± 20 248 ± 11	1010 ± 41	Lost

(a) Tropopause height - 44 kilofeet.
(b) Tropopause height - 49 kilofeet.
(c) Blower speed above normal - volume doubtful.
(*) One standard deviation due to counting - analyses by contractor.
(d) Isotopic analyses - Tracerlab.

Table 3e - cont'd

Sampling Months: JULY TO SEPTEMBER 1959

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet: Nominal	Altitude - kilofeet: Predominant	Altitude - kilofeet: Range	Volume: Determination	Volume: S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF: Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
10847	T-345	A-4	7-1-59	90	90.0	90.0	T	810	3440 ± 2270	7-20-59	0 ± 56 43 ± 76	154 ± 9 137 ± 13	721 ± 131 268 ± 78	254 ± 16 288 ± 16	2070 ± 73 2020 ± 56	0 ± 22 0 ± 42
10848	T-346	A-4	7-2-59	50	50.6	51.5-50.6(a)	T	1660	235 ± 208	7-20-59	0 ± 10 0 ± 11	5.8 ± 1.0 5.4 ± 1.4	53 ± 28 53 ± 21	7.2 ± 4.8 9.6 ± 4.2	44 ± 4 52 ± 6	25 32
10870	T-347	A-4	7-7-59	80	80.1	80.5-79.6	T	1590	3420 ± 1860	7-20-59	46 ± 39 46 ± 39	148 ± 7 156 ± 7	193 ± 49 202 ± 45	284 ± 11 296 ± 11	1360 ± 37 1280 ± 38	17 ± 20 0 ± 26
10889	T-348	A-4	7-8-59	65	65.6	65.6-65.3	T	1850(b)	(333 ± 135)	7-20-59	(11 ± 5) (13 ± 19)	(10.3 ± 2.3) (10.8 ± 1.9)	(50 ± 17) (50 ± 15)	(42 ± 4) (34 ± 4)	(198 ± 17) (144 ± 44)	Lost
11039	T-349	A-4	8-1-59	90	91.7	91.7-91.0	E	700(c)	925 ± 707	8-18-59	0 ± 14 14 ± 24	104 ± 10 90 ± 8	205 ± 96 208 ± 64	194 ± 23 221 ± 36	978 ± 48 1140 ± 51	0 ± 18 0 ± 20
11040	T-350	A-4	8-2-59	80	80.7	80.7-80.1	T	1580	2920 ± 696	8-18-59	0 ± 25 0 ± 38	143 ± 4 160 ± 5	181 ± 48 167 ± 34	294 ± 12 342 ± 13	1310 ± 44 1290 ± 38	0 ± 11 0 ± 35
11041	T-351	A-4	8-3-59	65	65.7	65.7-65.5	T	1500	2210 ± 1820	8-18-59	24 ± 8 48 ± 14	67 ± 3 67 ± 2	111 ± 22 102 ± 24	168 ± 13 173 ± 8	563 ± 23 587 ± 21	76 ± 22 87 ± 36
11063	T-352	A-4	8-7-59	50	50.4	50.4(d)	T	1750	274 ± 336	9-15-59	5 ± 10 6 ± 10	4.2 ± 1.4 4.6 ± 0.6	15 ± 9 13 ± 6	12.6 ± 4.6 10.3 ± 3.4	44 ± 7 41 ± 8	0 ± 10 3 ± 17
11226	T-355	A-4	9-4-59	65	65.0	65.0-64.5	T	1670(b)	(921 ± 467)	10-12-59	(0 ± 11) (0 ± 14)	(10.3 ± 2.2) (8.2 ± 1.4)	(46 ± 24) (42 ± 24)	(44 ± 10) (22 ± 6) (34 ± 6)	(86 ± 14) (75 ± 8)	(0 ± 6) (0 ± 10)
11227	T-356	A-4	9-5-59	50	49.9	49.9(e)	T	1820	128 ± 162	10-12-59		3.1 ± 1.8 0 ± 2.2	No other analyses.			

(a) Tropopause height - 46 kilofeet.
(b) Blower speed above normal - volume doubtful.
(c) Telemetry not received - volume estimated from past performance of sample type.
(d) Tropopause height - 51 kilofeet.
(e) Tropopause height - 48 kilofeet.

Table 3e - cont'd

SAMPLING MONTHS: OCTOBER TO DECEMBER 1959

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude - kilofeet Nominal	Altitude - kilofeet Predominant	Altitude - kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	Sr^{89} (d/m/1000 SCF)	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
11463	T-358	A-4	10-5-59	90	91.5	91.5	T	710	2040 ± 1960	10-20-59	5 ± 16 20 ± 27	162 ± 12 158 ± 12	78 ± 39 137 ± 56	292 ± 18 280 ± 16	1380 ± 56 1420 ± 56	41 ± 29 0 ± 15
11464	T-359	A-4	10-6-59	80	80.1	80.7-80.1	T	1560	2230 ± 827	10-19-59	17 ± 23 22 ± 28	80.5 ± 3.2 76.8 ± 4.5	1760 ± 52 2030 ± 69	154 ± 9 139 ± 9	857 ± 25 991 ± 34	0 ± 5 3 ± 8
11601	T-364	A-4	11-6-59	90	90.0	90.0	T	810	1780 ± 904	11-16-59	0 ± 94 257 ± 257	111 ± 8 109 ± 6	37 ± 29 80 ± 58	169 ± 17 412 ± 32 193 ± 18	883 ± 65 996 ± 65	19 ± 26 9 ± 22
11602	T-365	A-4	11-7-59	65	65.4	65.7-64.7	T	1540	1500 ± 1080	11-16-59	138 ± 78 22 ± 67	95 ± 6 69 ± 6 78 ± 6	21 ± 39 16 ± 46	165 ± 13 132 ± 19	550 ± 34 473 ± 34	44 ± 20 16 ± 17
11645	T-366	A-4	11-9-59	80	80.7	81.2-80.7	T	1460	2680 ± 543	12-15-59	16 ± 10 25 ± 16	172 ± 8 163 ± 7	85 ± 36 123 ± 43	321 ± 15 281 ± 13	953 ± 53 1050 ± 44	0 ± 5 29 ± 21
11646	T-367	A-4	11-12-59	50	51.7	51.7[(a)]	T	1540	234 ± 273	12-15-59		2.9 ± 1.5 0.93 ± 0.93	No other analyses.			
11768	T-368	A-4	12-1-59	90	90.0	90.7-90.0	T	780	3700 ± 2020	12-16-59	113 ± 90 84 ± 107	83.6 ± 5.7 84.3 ± 5.3	60 ± 49 71 ± 117	191 ± 16 149 ± 18	1140 ± 62 1090 ± 62	0 ± 13 9 ± 21
11770	T-370	A-4	12-2-59	50	50.0	50.0[(b)]	T	2380(c)	(207 ± 252)	12-21-59		(3.3 ± 0.4) (2.8 ± 1.3)	No other analyses.			
11771	T-372	A-4	12-5-59	80	79.8	79.8-75.5	T	460	3020 ± 3310	12-21-59	1.2 ± 1.8 1.2 ± 1.8	218 ± 11 221 ± 12	210 ± 116 246 ± 130	382 ± 37 364 ± 35	1870 ± 133 1820 ± 80	34 ± 28 11 ± 30
11809	T-374	A-4	12-9-59	65	65.5	65.5-65.2	T	1190	394 ± 272	2-5-60	No other analyses.					

(a) Tropopause height - 53 kilofeet.
(b) Tropopause height - 46 kilofeet.
(c) Blower speed above normal - volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: January 1960

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft3	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}	W^{185}
12008	T-377	D-4	1-3-60	90	90.8	90.8	T	180	4060 ± 960	2-5-60	-	112 ± 5	No other analyses.			
12009	T-378	D-4	1-7-60	80	81.0	81.5-80.5	E	600(b)	6140 ± 860	2-8-60	52 ± 103	172 ± 5	52 ± 30	213 ± 10	2400 ± 88	30 ± 40 38 ± 48
12066	T-379	D-4	1-8-60	70	67.5	67.8-67.5	T	550	3570 ± 524	2-5-60	42 ± 84 0 ± 81	157 ± 5 146 ± 6	27 ± 33 15 ± 30	270 ± 18 308 ± 16	643 ± 79 885 ± 46	22 ± 30 28 ± 36
12069	T-380	D-4	1-13-60	70	70.8	70.8-70.5	T	1110	3350 ± 298	2-5-60	20 ± 119 0 ± 131	249 ± 6 237 ± 6	43 ± 27 47 ± 34	498 ± 22 464 ± 20	739 ± 30 1070 ± 41 918 ± 49	41 ± 44 86 ± 43
12070	T-381	D-4	1-18-60	50	51.6	51.6-50.8(a)	T	2490	50 ± 75	2-5-60	-	7 ± 2 3 ± 2	No other analyses.			
12071	T-381	A-4	1-18-60	50	51.6	51.6-50.8(a)	T	2760	143 ± 191	2-5-60	-	14 ± 2 18 ± 4	No other analyses.			
12110	T-382	D-4	1-19-60	70	70.1	70.3-70.1	T	750	3050 ± 355	2-8-60	96 ± 56 95 ± 82	143 ± 6 149 ± 8	26 ± 22 16 ± 22	312 ± 15 299 ± 14	935 ± 35 964 ± 37	6 ± 23 3 ± 24
12111	T-383	D-4	1-20-60	60	67.0	67.0	T	660	7230 ± 971	2-8-60	0 ± 134 126 ± 126	277 ± 12 274 ± 7	46 ± 23 43 ± 43	567 ± 27 555 ± 26	2160 ± 122 2120 ± 58	8 ± 26 0 ± 24
12139	T-385	D-4	1-22-60	60	63.8	63.8	T	980	3120 ± 306	2-8-60	22 ± 104 135 ± 96	215 ± 8 215 ± 10	27 ± 27 0 ± 17	416 ± 20 436 ± 19	1323 ± 52 1290 ± 46	108 ± 58 17 ± 26

Notes:

(a) Tropopause height - 37 kilofeet.
(b) Volume estimated for total collection time of 80 minutes based on 3 minutes of telemetry.
(c) Blower speed slightly above normal, data appear acceptable.

Table 3e - cont'd

SAMPLING MONTH: February 1960

Analytical Lab: [illegible]SEC

Site: San Angelo, Texas

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}	W^{185}
12193	T-386	D-4	2-1-60	90	94.0	94.0	T	95	6010 ± 2450	2-25-60	-	116 ± 13 116 ± 19	No other analyses.				
12221	T-387	D-4	2-3-60	80	81.4	81.9-81.4	T	630	2830 ± 149	2-25-60	48 ± 48 16 ± 48	82 ± 5 89 ± 8	0 ± 24 10 ± 31	149 ± 19 155 ± 18	-	884 ± 131 998 ± 36	0 ± 21 0 ± 24
12301	T-388	D-4	2-5-60	70	68.6	71.0-67.9	T	770	4690 ± 452	2-25-60	18 ± 98 24 ± 119	254 ± 11 246 ± 11	32 ± 18 38 ± 22	465 ± 20 456 ± 20	-	1440 ± 50 1800 ± 48	34 ± 25 50 ± 31
12302	T-389	D-4	2-6-60	60	63.2	63.5-63.2	T	1050	1910 ± 292	2-25-60	22 ± 27 83 ± 103	128 ± 5 108 ± 5	10 ± 16 7 ± 15	281 ± 14 258 ± 15	-	699 ± 32 754 ± 24	21 ± 38 10 ± 27
12303	T-390	D-4	2-7-60	50	51.4	52.3-51.4[(a)]	T	2650	417 ± 129	2-25-60	0 ± 27 36 ± 54	73 ± 6 67 ± 4	14 ± 11 6 ± 13	138 ± 8 168 ± 10	-	416 ± 40 460 ± 16	8 ± 33 0 ± 26
12304	T-390	A-4	2-7-60	50	51.4	52.3-51.4[(a)]	T	3630	261 ± 333	2-25-60	-	50 ± 2 44 ± 6	No other analyses.				
12396	T-392	D-4	2-18-60	70	71.8	71.8	T	710	4440 ± 598	3-8-60	99 ± 124 11 ± 49	178 ± 7 193 ± 10	19 ± 21 26 ± 19	294 ± 15 352 ± 17	57 ± 71 0 ± 42	1510 ± 42 1580 ± 42	13 ± 19 0 ± 20
12393	T-393	D-4	2-25-60	50	53	53[(b)]	T	2790	306 ± 136	3-8-60	16 ± 24	62 ± 6	0 ± 2	132 ± 6	0 ± 4	238 ± 48	0 ± 9
12394	T-393	B-4	2-25-60	50	53	53[(b)]	T	3640	128 ± 204	3-8-60	0 ± 8	25 ± 2	0 ± 1	56 ± 5	2 ± 5	Lost	0 ± 8
12395	T-394	D-4	2-25-60	70	67.3	67.3	T	500	4480 ± 662	3-8-60	103 ± 129 11 ± 51	186 ± 7 201 ± 10	4 ± 12 5 ± 14	309 ± 14 265 ± 28	20 ± 20 36 ± 72	1050 ± 31 1060 ± 31	33 ± 41 4 ± 26

Notes:

(a) Tropopause height - 39 kilofeet.
(b) Tropopause height - 33 kilofeet.

Table 3e - cont'd

Sampling Month: March 1960

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}
12559	T-395	D-4	3-3-60	90	91.1	92.2-90.0	T	190	4030 ± 1450	3-25-60	36 ± 50	98 ± 7	0 ± 20	205 ± 16	0 ± 219	1040 ± 36
12560	T-396	D-4	3-9-60	50	49.2	49.2(a)	T	3710	199 ± 80	3-25-60	9 ± 9	39 ± 2	0 ± 5	85 ± 4	0 ± 6	206 ± 7
12561	T-396	A-4	3-9-60	50	49.2	49.2(a)	T	4520	112 ± 104	3-25-60	-	24 ± 1	-	-	0 ± 5	-
12562	T-397	D-4	3-9-60	70	71.6	71.6-71.2	T	670	4960 ± 660	3-25-60	0 ± 27 4 ± 29	151 ± 6 154 ± 6	10 ± 11 4 ± 12	319 ± 13 355 ± 16	0 ± 15 0 ± 24	1420 ± 41 1590 ± 41
12636	T-398	D-4	3-16-60	70	67.4	67.5-66.5	T	910	3840 ± 490	3-25-60	40 ± 56 5 ± 49	314 ± 14 309 ± 14	21 ± 16 14 ± 16	694 ± 31 654 ± 30	0 ± 14 0 ± 17	2060 ± 78 2430 ± 62
12687	T-399	D-4	3-18-60	65	61.8	61.8	T	1230	2840 ± 277	3-28-60	8 ± 26 36 ± 51	177 ± 6 214 ± 8	1 ± 9 8 ± 9	368 ± 17 411 ± 18	0 ± 7 0 ± 9	1190 ± 58 1290 ± 69
12689	T-400	D-4	3-19-60	50	49.3	49.3-48.7(b)	T	3200	358 ± 58	3-28-60	12 ± 10 8 ± 13	56 ± 10 72 ± 4	2 ± 8 0 ± 5	157 ± 8 145 ± 10	15 ± 19 19 ± 7	368 ± 12 419 ± 16
12690	T-400	A-4	3-19-60	50	49.3	49.3-48.7	T	4430	111 ± 42	3-28-60	-	31 ± 2	-	-	0 ± 2	-
12688	T-401	D-4	3-19-60	80	82.5	82.5-81.8	T	580	3520 ± 1410	3-28-60	0 ± 24 10 ± 26	169 ± 12 167 ± 10	19 ± 15 8 ± 15	318 ± 20 284 ± 26	0 ± 12 27 ± 20	1310 ± 36 1290 ± 41

Notes:

(a) Tropopause height - 40 kilofeet.
(b) Tropopause height - 39 kilofeet.

Table 3e - cont'd

SAMPLING MONTH: April 1960

Site: San Angelo, Texas

Analytical Lab: NSEC

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	Sr^{89} (d/m/1000 SCF)	Sr^{90}	Zr^{95}	Cs^{137}	Ba^{140}	Ce^{144}
12740	T-402	A-4	4-1-60	50	48.2	49.1-48.2(a)	T	2250(c)	(0 ± 28)	4-14-60	No other analyses.					
12741	T-402	D-4	4-1-60	50	48.2	49.1-48.2(a)	T	1560	85 ± 60	4-14-60	-	5 ± 1	-	-	0 ± 6	-
12738	T-403	D-7	4-1-60	90	93.2	94 -90.0	T	730	3160 ± 589	4-14-60	79 ± 38	198 ± 12	44 ± 22	397 ± 19	0 ± 27	1610 ± 41
12739	T-405	D-7	4-3-60	60	60.5	60.8-60.5	T	1860	2850 ± 325	4-14-60	40 ± 25	167 ± 3	33 ± 66	362 ± 12	0 ± 6	1134 ± 27
12769	T-406	D-7	4-4-60	80	80.5	80.9-80.5	T	1820	3770 ± 27	4-14-60	20 ± 30	176 ± 3	16 ± 16	335 ± 13	0 ± 4	1540 ± 37
12839	T-408	D-7	4-5-60	70	73.3	73.5-72.8	T	1240	4610 ± 449	4-14-60	52 ± 52	227 ± 5	38 ± 16	439 ± 16	0 ± 5	1630 ± 54
12840	T-409	D-7	4-7-60	70	67.2	67.4-66.8	T	1950	4540 ± 286	4-14-60	106 ± 89	213 ± 4	44 ± 16	422 ± 14	0 ± 3	551 ± 31
12870	T-411	A-4	4-9-60	50	49.3	49.3(b)	T	5070	153 ± 67	4-29-60	-	11 ± 1	-	-	0 ± 3	-
12871	T-411	D-4	4-9-60	50	49.3	49.3(b)	T	3250	170 ± 155	4-29-60	-	5 ± 1	-	-	0 ± 5	-
12872	T-412	D-7	4-9-60	90	93.7	93.7-90.6	T	640	3410 ± 270	4-29-60	13 ± 27	179 ± 5	11 ± 11	331 ± 19	0 ± 51	1310 ± 44

Notes:

(a) Tropopause height - 34 kilofeet.
(b) Tropopause height - 38 kilofeet.
(c) Blower speed above normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: May 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASI#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}
13029	T-413	D-7	5-1-60	90	90.7	92.3-90.0	T	810	3410 ± 376	6-1-60	12 ± 23	149 ± 2	170 ± 72	314 ± 6	1200 ± 26
13028	T-414	D-7	5-2-60	80	81.6	81.6-81.0	T	1430	6240 ± 898	6-1-60	0 ± 38	244 ± 2.8	179 ± 37	597 ± 9.8	1920 ± 30
13082	T-415	D-7	5-5-60	90	91.5	92.4-91.5	T	770	2730 ± 240	6-1-60	0 ± 45	144 ± 3	260 ± 62	273 ± 6	1150 ± 25
13083	T-417	D-4	5-7-60	50	50.2	51.0-50.2[a]	T	3510	103 ± 94	6-1-60		9.1 ± 0.34	No other analyses.		
13084	T-417	A-4	5-7-60	50	50.2	51.0-50.2[a]	T	4610	23 ± 36	6-1-60	0 ± 6.6	2.84 ± 0.24	0 ± 10	6.38 ± 0.52	17.44 ± 1.1
13085	T-418	D-7	5-7-60	60	61.1	61.2-61.0	T	2170	1330 ± 317	6-1-60	0 ± 19	73.2 ± 1.4	0 ± 48	125 ± 2.3	437 ± 8.8
13169	T-419	D-7	5-19-60	70	71.6	71.9-71.2	T	1510	4610 ± 432	6-2-60	0 ± 22	164 ± 2	0 ± 81	358 ± 7	1530 ± 36
13198	T-420	D-7	5-21-60	70	70.0	70.3-70.0	B	1800(b)	47 ± 59	6-2-60		0 ± 0.63	No other analyses.		

Notes

(a) Tropopause height - 40 kilofeet.
(b) Volume estimated for total collection time of 40 minutes based on 6 minutes of telemetry.

Table 3e - cont'd

SAMPLING MONTH: June 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Zr^{95}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
13261	T-422	D-7	6-2-60	90	91.3	91.3-96.0	T	840	2880 ± 357	7-13-60	0 ± 27	143 ± 2.4	0 ± 111	256 ± 3.6	1110 ± 17
13262	T-423	D-4	6-3-60	50	50.4	50.4(a)	T	3560	284 ± 268	7-13-60	0 ± 4.7	17.5 ± 0.4	0 ± 34	42.1 ± 0.84	106 ± 5.6
13263	T-423	A-4	6-3-60	50	50.4	50.4(a)	T	4740	23 ± 6	7-13-60		4.22 ± 0.46	No other analyses.		
13305	T-424	D-7	6-3-60	80	81.0	81.8-81.0	T	1470	2150 ± 318	7-13-60	0 ± 21	115 ± 1.4	217 ± 21	312 ± 3.4	748 ± 10
13306	T-425	D-7	6-3-60	60	60.3	60.5-60.0	T	2340	2620 ± 679	7-13-60	0 ± 56	99.1 ± 0.9	0 ± 56	206 ± 2.1	863 ± 6
13410	T-426	D-7	6-14-60	70	67.6	68.0-67.4	T	2690(b)	(328 ± 108)	7-13-60	(0 ± 5.5)	(18.4 ± 0.6)	(0 ± 44)	(85.5 ± 1.5)	(126 ± 2.6)
13411	T-427	D-7	6-15-60	70	69.5	69.5-69.1	T	1650	3280 ± 320	7-13-60	0 ± 20	160 ± 1	238 ± 27	344 ± 4.2	1270 ± 6.5
13560	T-428	D-7	6-21-60	70	71.2	71.5-70.6	T	1580	3050 ± 342	8-5-60	-	116 ± 1.3	-	216 ± 3.2	882 ± 8

Notes

(a) Tropopause height - 46 kilofeet.
(b) Blower speed above normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: JULY 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
13454	T-429	D-7	7-1-60	70	70.3	70.3-70.1	T	2470(d)	(310 ± 206)	8-5-60	(22.9 ± 0.9)	(100 ± 1.6)	(159 ± 3)
13500	T-430	D-7	7-1-60	90	92.1	94.8-91.7	T	930(d)	(1040 ± 232)	8-5-60	(46.2 ± 1.9)	(104 ± 1.8)	(486 ± 10)
13546	T-431	D-7	7-7-60	60	60.9	60.9-60.7	E	2200(b)	55 ± 93	8-5-60	No other analyses.		
13547	T-432	A-4	7-7-60	50	51.5	51.5(a)	T	4640	127 ± 253	8-5-60	5.13 ± 0.34	8.1 ± 0.39	29.8 ± 1.7
13548	T-432	D-4	7-7-60	50	51.5	51.5	T	3490	228 ± 54	8-5-60	12.7 ± 0.37	39.2 ± 1.1	92.9 ± 2.3
13549	T-433	D-7	7-8-60	80	80.5	80.5-80.0	E	900(c)	272 ± 253	8-5-60	3.0 ± 0.29	No other analyses.	
13559	T-434	D-7	7-12-60	90	91.8	91.8-88.5	E	700(b)	3040 ± 323	8-5-60	No other analyses.		

Notes

(a) Tropopause height - 45 kilofeet.
(b) No telemetry received. Volume estimated from past performance of sampler type.
(c) Volume estimated for total collection time of 78 minutes based on 43 minutes of telemetry.
(d) Blower speed above normal. volume doubtful.

Table 3e (cont'd)

SAMPLING MONTH: AUGUST 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet: Nominal	Altitude - Kilofeet: Predominant	Altitude - Kilofeet: Range	Volume: Determination	Volume: S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF: Sr^{89}	d/m/1000 SCF: Sr^{90}	d/m/1000 SCF: Zr^{95}	d/m/1000 SCF: Cs^{137}	d/m/1000 SCF: Ce^{144}
13855	T-435	D-7	8-1-60	90	92.9	92.9	T	830(b)	(1620 ± 477)	8-5-60	(0 ± 11)	(83.8 ± 2.3)	(0 ± 72)	(155 ± 3.6)	(478 ± 12)
13856	T-435	A-4	8-1-60	90	92.9	92.9	T	700(b)	(2200 ± 686)	8-19-60	(0 ± 8.1)	(9.71 ± 2.0)	(328 ± 78)	(20 ± 2.9)	(60 ± 2.8)
13860	T-437	D-7	8-2-60	75	77.5	77.5-77.0	T	2320	3160 ± 620	8-19-60	0 ± 5.9	136 ± 1.3	19.1 ± 4.8	312 ± 3.0	1010 ± 5.2
13861	T-437	A-4	8-1-60	75	77.5	77.5-77.0	T	2400(b)	(271 ± 625)	8-19-60	(0 ± 3.4)	(5.41 ± 0.83)	(0 ± 34)	(9.83 ± 0.75)	(40.8 ± 1.4)
13862	T-441	D-7	8-4-60	70	69.1	69.3-69.1	T	3100(b)	(529 ± 129)	8-19-60	(2.6 ± 3.0)	(21.5 ± 0.6)	(0 ± 3.2)	(51.6 ± 1.3)	(146 ± 2.6)
13863	T-441	A-4	8-4-60	70	69.1	69.3-69.1	T	2030(b)	(1650 ± 286)	8-19-60	(70 ± 11)	(65.0 ± 1.5)	(80 ± 14)	(169 ± 2)	(508 ± 4)
13934	T-443	D-7	8-5-60	60	60.2	60.2	T	2960	1350 ± 126	10-3-60	332 ± 36	42.9 ± 0.7	0 ± 15	144 ± 1.4	355 ± 3
13935	T-443	A-4	8-5-60	50	51.8	51.8-51.2(a)	T	1490	50 ± 32	10-3-60		0.80 ± 0.3	No other analyses.		

Notes

(a) Tropopause height - 49 kilofeet.
(b) Blower speed above normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: SEPTEMBER 1960

Site: San Angelo, Texas

ANALYTICAL LAB: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{89}	Sr^{90}	Zr^{95}	Cs^{137}	Ce^{144}
14014	T-450	D-7	9-1-60	90	90.0	90.0-89.3	T	1390	3020 ± 506	10-3-60	0 ± 20	135 ± 2	53.2 ± 15.2	284 ± 2.9	1020 ± 9
14015	T-450	A-4	9-1-60	90	90.0	90.0-89.3	T	1440	1990 ± 483	10-3-60	0 ± 111	76.4 ± 7.6	0 ± 50	190 ± 2.8	634 ± 8
14016	T-452	D-7	9-2-60	80	79.5	79.5-79.0	T	2040	2850 ± 165	10-3-60	0 ± 19	165 ± 2	29.3 ± 6.9	318 ± 2.4	1120 ± 6
14017	T-452	A-4	9-2-60	80	79.5	79.5-79.0	T	1980	1640 ± 236	10-3-60	0 ± 12	70.7 ± 1.0	0 ± 15	118 ± 2.0	628 ± 8
14018	T-454	D-7	9-6-60	70	71.4	71.4-71.0	T	2020	3670 ± 425	10-3-60	0 ± 16	175 ± 2	34.1 ± 8.5	307 ± 2.5	931 ± 6
14019	T-454	A-4	9-6-60	70	71.4	71.4-71.0	T	2360(c)	(946 ± 1010)	10-4-60	(0 ± 9.7)	(6.06 ± 0.68)	(0 ± 9)	(8.81 ± 0.34)	(28 ± 2)
14051	T-456	D-4	9-1-60	50	51.6	58.3-50.8(a)	T	1920	103 ± 34	10-3-60		7.7 ± 0.57	No other analyses.		
14052	T-456	D-7	9-7-60	60	58.2	60.0-47.0	T	5120(c)	(104 ± 26)	10-4-60	(0 ± 2.4)	(7.0 ± 0.35)	(0 ± 7.9)	(14.6 ± 0.45)	(35.3 ± 0.9)
14053	T-460	D-4	9-9-60	50	52.0	52.0-51.5(b)	T	2940(c)	(224 ± 45)	10-4-60	(0 ± 5.0)	(0 ± 0.88)	(0 ± 18)	(0.91 ± 0.15)	(5.32 ± 0.93)
14054	T-460	D-7	9-9-60	60	60.8	60.8-60.4	T	2890	1550 ± 205	10-4-60	42.1 ± 0.6	63.3 ± 0.7	0 ± 20	167 ± 1.7	413 ± 4

Notes

(a) Tropopause height - 50 kilofeet.
(b) Tropopause height - 50 kilofeet.
(c) Blower speed above normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: October 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet: Nominal	Altitude - Kilofeet: Predominant	Altitude - Kilofeet: Range	Volume: Determination	Volume: S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF: Sr^{90}	d/m/1000 SCF: Cs^{137}	d/m/1000 SCF: Ce^{144}
A0001	T-461	D-7	10-1-60	90	-	86.0 surface	B	~10000(b)	15.5 ± 3.3	10-21-60	28.2 ± 0.3	41.0 ± 0.5	118 ± 0.9
A0002	T-461	A-4	10-1-60	90	-	86.0 surface	B	~10000(b)	17.5 ± 10.2	10-21-60	10.4 ± 0.2	16.5 ± 0.5	51.5 ± 0.9
A0003	T-467	D-7	10-4-60	70	70.3	70.3	B	3700(c,d)	(0 ± 92)	10-21-60	No other analyses.		
A0004	T-467	A-4	10-4-60	70	70.3	70.3	B	2400(c,d)	(202 ± 182)	10-24-60	(44.0 ± 0.7)	(194 ± 0.7)	(73.6 ± 2.2)
A0005	T-469	D-4	10-5-60	50	50.0	50.0(a)	T	2520	102 ± 95	10-24-60	6.67 ± 0.48	No other analyses.	
A0006	T-469	D-7	10-5-60	60	60.0	60.0	T	3070	629 ± 182	10-24-60	49.8 ± 0.7	144 ± 1.6	304 ± 3.5
A0007	T-471	D-7	10-6-60	90	87.2	87.2	T	2130(d)	(1240 ± 175)	10-24-60	(66.7 ± 0.9)	(130 ± 2.8)	(502 ± 5.0)
A0008	T-471	A-4	10-6-60	90	87.2	87.2	T	1650	1100 ± 442	10-24-60	141 ± 2.4	Lost	561 ± 6.5
A0009	T-473	D-7	10-7-60	80	78.0	78.0-77.5	T	3800(d)	(27 ± 32)	10-24-60	(1.89 ± 0.26)	No other analyses.	
A0010	T-473	A-4	10-7-60	80	78.0	78.0-77.5	T	2410(d)	(513 ± 202)	10-24-60	(2.07 ± 0.58)	(2.41 ± 0.33)	(14.3 ± 0.7)

Notes

(a) Tropopasue height - 45 kilofeet.
(b) Approximately 90% of the sample was collected below 86 kilofeet. No telemetry received below 86 kilofeet.
(c) Volume estimated for total collection time of 47 minutes based on 24 minutes of telemetry.
(d) Blower speed above normal, volume doubtful.

Table 3e - cont'd

Sampling Month: November 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Altitude - Kilofeet Predominant	Altitude - Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
A0011	T-476	D-7	11-2-60	90	90.7	90.7	T	1240	1510 ± 484	12-5-60	104 ± 1.6	210 ± 2.4	520 ± 6.1
A0012	T-476	A-4	11-2-60	90	90.7	90.7	T	1180	2320 ± 803	12-5-60	166 ± 2.5	268 ± 3.4	817 ± 8.4
A0014	T-478	D-7	11-3-60	80	78.5	78.5	T	2090	2220 ± 62	12-5-60	146 ± 1.9	289 ± 2.4	784 ± 6.2
A0013	T-478	A-4	11-3-60	80	78.5	78.5	T	1940	1243 ± 754	12-5-60	135 ± 2.1	238 ± 2.6	588 ± 6.5
A0016	T-480	D-7	11-4-60	70	70.7	72.9-70.7	T	3550(c)	(86 ± 37)	12-5-60	(0.90 ± 0.11)	No other analyses.	
A0015	T-480	A-4	11-4-60	70	70.7	72.9-70.7	T	1960(c)	(794 ± 331)	12-5-60	(44.3 ± 0.97)	(67.3 ± 1.0)	(316 ± 5.4)
A0017	T-482	D-4	11-10-60	50	50.0	50.0-49.5(a)	T	2570	10.7± 21	12-5-60	No other analyses.		
A0018	T-482	D-7	11-10-60	60	60.0	60.5-60.0	B	2900(b)	(431 ± 107)	12-5-60	(40.0 ± 0.7)	(83.4 ± 1.0)	(161 ± 2.5)

Notes

(a) Tropopause height - 37 kilofeet.
(b) No telemetry received, volume estimated from past performance of sampler type.
(c) Blower speed above normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: December 1960

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{90}	Cs^{137}	Ce^{144}	Zr^{95}
A0024	T-486	D-7	12-2-60	80	79.3	79.3	T	2020	2720 ± 177	1-16-61	138 ± 0.15	296 ± 2.5	821 ± 6.5	0 ± 3.9
A0025	T-486	A-4	12-2-60	80	79.3	79.3	T	2170(d)	(217 ± 122)	1-16-61	(6.22 ± 0.46)	(11.2 ± 0.7)	-	-
A0026	T-488	D-7	12-15-60	90	87.5	87.5	E	1730(b)	28 ± 25	1-16-61	No other analyses.			
A0027	T-488	A-4	12-15-60	90	87.5	87.5	E	1620(e)	200 ± 69	1-16-61	No other analyses.			
A0028	T-491	D-7	12-16-60	70	71.4	73.7-71.4	T	2650(d)	(207 ± 51)	1-17-61	Lost	(42.6 ± 0.8)	(100 ± 2.4)	(0 ± 1.9)
A0029	T-491	A-4	12-16-60	70	71.4	73.7-71.4	T	2290(d)	(108 ± 109)	1-17-61	(2.44 ± 0.57)	(4.05 ± 0.23)	-	-
A0030	T-493	D-4	12-17-60	50	50.2	50.2(a)	T	2500	71 ± 53	1-17-61	0 ± 0.76	1.96 ± 0.52	-	-
A0031	T-493	D-7	12-17-60	60	60.6	60.6	T	2770	988 ± 191	1-17-61	74 ± 1.1	143 ± 1.4	294 ± 2.7	0 ± 2.3
A0032	T-497	D-7	12-19-60	90	95.0	95.0-94.0	VR	300(e)	(1140 ± 360)	1-18-61	Lost	(101 ± 5.3)	-	-
A0033	T-497	A-4	12-19-60	90	95.0	95.0-94.0	E	1000(c)	1742 ± 408	1-18-61	70.5 ± 1.7	143 ± 3	350 ± 5.1	0 ± 0.7
A0039	T-501	D-7	12-22-60	90	72.2	86.0-66.0	T	660	2340 ± 541	1-23-61	No other analyses.			
A0036	T-501	A-4	12-22-60	90	72.2	86.0-66.0	T	610	122 ± 244	1-23-61	No other analyses.			

Notes

(a) Tropopause height - 38 kilofeet.
(b) Doubtful that motor operated, no telemetry received.
(c) No telemetry received, volume estimated from past performance of sampler type.
(d) Blower speed above normal, volume doubtful.
(e) Blower speed below normal, volume doubtful.

Table 3e - cont'd

SAMPLING MONTH: January 1961

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude - Kilofeet: Nominal	Predominant	Range	Volume: Determination	S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF: Sr^{90}	Cs^{137}	Ce^{144}	Zr^{95}
A0037	T-502	D-7	1-3-61	60	60	60.0-59.7	T	2790	809 ± 97	1-18-61	45.9 ± 0.7	118 ± 1.4	245 ± 2.3	0 ± 1.9
A0038	T-502	D-4	1-3-61	50	48.3	48.3(a)	T	2730	289 ± 32	1-18-61	16.4 ± 0.4	38.5 ± 0.7	85.3 ± 1.8	0 ± 2.1
A0050	T-504	D-7 #1	1-9-61	70	69.5	72.1-69.0	T	2030	2180 ± 699	2-2-61	135 ± 1.5	253 ± 2	512 ± 5.5	-
A0051	T-504	D-7 #2	1-9-61	70	69.5	72.1-69.0	T	2030	2020 ± 113	2-2-61	162 ± 1.5	260 ± 2	649 ± 6.0	-
A0052	T-507	D-7 #1	1-10-61	80	78.2	78.2-76.4	T	2060	2100 ± 338	2-2-61	120 ± 0.97	329 ± 2.4	752 ± 6.1	-
A0053	T-507	D-7 #2	1-10-61	80	78.2	78.2-76.4	T	1990	2800 ± 230	2-2-61	121 ± 1.0	271 ± 2.5	777 ± 6.2	-
A0054	T-514	D-7	1-15-61	90	90.5	90.5	T	1430	1040 ± 106	2-2-61	52.3 ± 0.98	138 ± 2.1	166 ± 2.5	-
A0055	T-514	A-4	1-15-61	90	90.5	90.5	T	1270	738 ± 945	2-2-61	37.0 ± 1.0	76.1 ± 1.3	260 ± 5.7	-

Notes

(a) Tropopause height - 34 kilofeet.

Table 3e - cont'd

SAMPLING MONTH: February 1961

Site: San Angelo, Texas

Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
A0058	T-516	D-7 #1	2-2-61	90	88.0	88.0	T	1700	874 ± 157	2-15-61	18.2 ± 0.9	93.5 ± 2.4	277 ± 6.1
A0059	T-516	D-7 #2	2-2-61	90	88.0	88.0	VR	1440	543 ± 187	2-15-61	Lost	56.6 ± 3.2	171 ± 10
A0060	T-518	D-4	2-3-61	50	50.0	50.0(a)	T	2540	594 ± 40	2-15-61	5.71 ± 0.7	10.7 ± 1.0	21.8 ± 2.1
A0061	T-518	D-7	2-3-61	60	61.0	61.0-60.5	VR	2640	1120 ± 241	2-20-61	72.3 ± 0.8	137 ± 1.1	302 ± 3.8
A0064	T-520	D-7 #1	2-4-61	80	78.1	78.1-77.7	E	2060(c)	1190 ± 87	2-20-61	105 ± 1.4	188 ± 1.9	453 ± 11
A0065	T-520	D-7 #2	2-4-61	80	78.1	78.1-77.7	VR	1910	1360 ± 69	2-20-61	91.1 ± 1.6	52.3 ± 1.0	376 ± 8
A0068	T-524	D-7 #1	2-8-61	70	70.7	72.0-70.7	E	1960(d)	758 ± 130	3-7-61	63.3 ± 0.5	117 ± 1.0	235 ± 3.5
A0069	T-524	D-7 #2	2-8-61	70	70.7	72.0-70.7	VR	2410(b)	(1560 ± 23)	2-20-61	(102 ± 0.8)	(188 ± 1.2)	(416 ± 6.8)

Notes

(a) Tropopause height - 36 kilofeet.
(b) Blower speed above normal, volume doubtful.
(c) Volume estimated for total collection time of 93 minutes based on 79 minutes of telemetry.
(d) Volume estimated for total collection time of 49 minutes based on 38 minutes of telemetry.

Table 3e - cont'd

SAMPLING MONTH: March 1961

Analytical Lab: Isotopes, Inc.

Site: San Angelo, Texas

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft^3	Counting Date	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
A0093	T-527	D-7	3-1-61	60	49.5	49.5[a]	TR	1680	265 ± 76	4-3-61	27.8 ± 0.4	55.1 ± 0.4	94.4 ± 0.8
A0094	T-527	D-4	3-1-61	50	49.5	49.5[a]	T	2660	287 ± 28	4-5-61	32.9 ± 0.6	42.1 ± 0.8	84.9 ± 1.9
A0089	T-528	D-7 #1	3-4-61	90	89.5	89.5	E	1400[b]	878 ± 171	4-6-61	72.1 ± 2.0	95 ± 2	267 ± 6
A0090	T-528	D-7 #2	3-4-61	90	89.5	89.5	VR	1370	1050 ± 118	4-8-61	75.9 ± 1.4	138 ± 2	354 ± 6
A0091	T-530	D-7 #1	3-6-61	80	80.0	80.5-80.0	T	1780	1350 ± 94	4-4-61	151 ± 2	234 ± 2	442 ± 7
A0092	T-530	D-7 #2	3-6-61	80	80.0	80.5-80.0	TR	1610	1540 ± 113	4-7-61	134 ± 2	234 ± 1	488 ± 5
A0097	T-532	D-7 #1	3-7-61	60	62.5	63.0-62.5	T	2440	1170 ± 134	3-30-61	91.8 ± 0.8	154 ± 2	340 ± 3
A0098	T-532	D-7 #2	3-7-61	60	62.5	63.0-62.5	VR	2330	1450 ± 35	4-3-61	98.7 ± 0.8	198 ± 2	360 ± 4
A0101	T-534	D-7 #1	3-8-61	70	70.5	73.0-70.5	T	1850	1590 ± 7.8	4-20-61	153 ± 0.7	299 ± 2	525 ± 4
A0102	T-534	D-7 #2	3-8-61	70	70.5	73.0-70.5	T	1820	2180 ± 162	3-30-61	162 ± 1	265 ± 1	524 ± 4

Notes

(a) Tropopause height - 38 kilofeet.
(b) Volume estimated for total collection time 129 minutes based on 115 minutes telemetry.

Table 3e - cont'd

SAMPLING MONTH: May 1961

Site: San Angelo, Texas | Analytical Lab: Isotopes, Inc.

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Altitude-Kilofeet Predominant	Altitude-Kilofeet Range	Volume Determination	Volume S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{90}	d/m/1000 SCF Cs^{137}	d/m/1000 SCF Ce^{144}
A0134	T-551	D-7 #1	5-15-61	70	70.1	70.9-70.1	F	1880	1160 ± 83	5-25-61	123 ± 2	199 ± 5	411 ± 6
A0135	T-551	D-7 #2	5-15-61	70	70.1	70.9-70.1	VR	1620	1290 ± 73	5-29-61	154 ± 1	296 ± 2	422 ± 4
A0136	T-552	D-7 #1	5-16-61	90	87.0	87.9-87.0	F	2080	600 ± 7	5-29-61	52.4 ± 0.5	91 ± 1	170 ± 3
A0137	T-552	D-7 #2	5-16-61	90	87.0	87.9-87.0	VR	850	593 ± 212	6-1-61	64.1 ± 1.2	112 ± 2	205 ± 4
A0140	T-553	D-7 #1	5-22-61	80	76.8	77.3-76.8	F	1020	1410 ± 245	6-7-61	177 ± 2	338 ± 3	537 ± 4
A0141	T-553	D-7 #2	5-22-61	80	76.8	77.3-76.8	VR	1570(a)	(274 ± 66)	6-7-61	(27.3 ± 0.8)	(44.3 ± 0.6)	(67.1 ± 2.5)
A0143	T-554	D-4 #1	5-24-61	50	50.0	50.0(b)	T	1630(a)	66 ± 61	6-8-61	18.5 ± 0.7	21.8 ± 0.6	43.0 ± 3.1
A0144	T-554	D-7 #2	5-24-61	60	50.0	50.0(b)	F	3190	126 ± 23	6-8-61	17.9 ± 0.4	19.7 ± 0.4	29.6 ± 0.8
A0145	T-555	D-7 #1	5-25-61	60	60.8	60.8	T	2480(a)	(208 ± 34)	6-12-61	(12.6 ± 0.04)	(17.2 ± 3.6)	(30.2 ± 1.5)
A0146	T-555	D-7 #2	5-25-61	60	60.8	60.8	VR	1850	802 ± 166	6-12-61	77.8 ± 1	123 ± 1	220 ± 3

Notes

(a) Blower speed above normal, volume doubtful.
(b) Tropopause height - 38 kilofeet.

Table 3e - cont'd

SAMPLING MONTH: April 1961

Analytical Lab: Isotopes, Inc.

Site: San Angelo, Texas

HASL#	Flight#	Type*	Flight Date	Altitude-Kilofeet Nominal	Predominant	Range	Volume Determination	S.C.F.	Beta Activity d/m/1000 ft³	Counting Date	d/m/1000 SCF Sr^{90}	Cs^{137}	Ce^{144}
A0109	T-539	D-7 #1	4-7-61	80	79.0	79.0	F	1720	1110 ± 68	5-9-61	119 ± 2	214 ± 2	450 ± 5
A0110	T-539	D-7 #2	4-7-61	80	79.0	79.0	F	1660	1100 ± 45	5-2-61	105 ± 1	170 ± 2	466 ± 4
A0120	T-541	D-4	4-12-61	50	50.0	50.0(a)	T	2510(b)	(332 ± 56)	5-9-61	39.8 ± 0.6	72.5 ± 0.8	195 ± 2
A0121	T-541	D-7	4-12-61	60	60.5	60.5-60.0	F	3620	515 ± 73	5-10-61	(44.5 ± 0.6)	(101 ± 0.6)	(114 ± 2)
A0117	T-543	D-7 #1	4-14-61	70	69.0	70.5-69.0	F	2440	1220 ± 47	5-8-61	132 ± 0.8	234 ± 1	390 ± 3
A0118	T-543	D-7 #2	4-14-61	70	69.0	70.5-69.0	F	1400	1500 ± 130	5-8-61	128 ± 1	270 ± 1	544 ± 5
A0111	T-545	D-7 #1	4-18-61	90	88.0	88.0	F	1420	683 ± 211	5-3-61	53.4 ± 0.7	112 ± 1	232 ± 4
A0112	T-545	D-7 #2	4-18-61	90	88.0	88.0	F	1400	870 ± 243	5-3-61	63.7 ± 0.8	152 ± 2	273 ± 3

Notes

(a) Tropopause height - 47 kilofeet.
(b) Blower speed above normal, volume doubtful.

Part II - Data from Sources Other Than HASL

Numerous fallout studies are conducted by other organizations in the United States and abroad. Some of these data are sent to the editors for dissemination in these HASL quarterly reports. Submitted data are reproduced essentially as received and no interpretation by HASL is attempted.

Reported in this quarterly are Fission Product Beta Activity data from the U. S. Naval Research Laboratory for the months of April, May, June and July 1961 (pages 113 through 128). Results of Naval Research Laboratory radiochemical analyses of composite monthly air filter samples collected in 1960 are also presented on pages 129 through 133. These data will appear in NRL report 5692 entitled "Fission Product Radioactivity in the Air Along the 80th Meridian (West) During 1960" by L. B. Lockhart, Jr., R. L. Patterson, Jr., A. W. Saunders, Jr. and R. W. Black.

A report on "Residual Radioactivity in Canadian Foods" from the Canadian Department of National Health and Welfare is presented on pages 134 through 153. This is an outcome of a study to obtain data on past and current levels of beta radioactivity (minus the contribution from potassium-40) in the various types of food found on the Canadian market. It is planned to extend this survey to other types of food and obtain strontium-90 and calcium data for a number of samples of each type.

U. S. NAVAL RESEARCH LABORATORY
WASHINGTON 25, D. C.

IN REPLY REFER TO

6110-164A:LBL:em

6 June 1961

1.1 Subj: Fission product radioactivity of the air along the 80th meridian (west) during April 1961; NRL Problem A02-13; Project No. RR-004-02-41; interim report on

Figure: (1) Daily Record of Fission Product β-Activity Collected by Air Filtration
(2) Radioactivity Profile for April 1961

1. Radioactivity measurements of air-filter samples collected at various sites along the 80th meridian (west) during the month of April 1961 are presented in Figure (1). The radioactivity profile for April 1961 is shown in Figure (2). All radioactivity concentrations are given in disintegrations per minute per cubic meter of air at the collecting site.

2. These measurements are being carried out as part of the U. S. Naval Research Laboratory program of atmospheric radioactivity studies. Partial financial support is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

L. B. Lockhart, Jr.

L. B. LOCKHART, JR.

FIGURE 1

DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

April 1961

Day	Punta Arenas	Puerto Montt	Santiago	Antofa-gasta	Chacal-taya	Lima	Guaya-quil
	disintegrations/minute per cubic meter of air						
1	0.02	-	-	0.06	0.01	0.02	0.05
2	0.02	-	-	0.06	0.01	0.02	0.04
3	0.02	-	-	0.06	0.01	0.02	0.06
4	0.02	-	-	-	0.05	0.04	0.05
5	0.02	-	-	-	0.05	0.04	0.03
6	0.02	-	-	0.05	0.03	0.04	0.04
7	0.02	-	-	0.05	0.03	0.04	0.04
8	0.02	-	-	0.16	0.03	0.04	0.05
9	0.02	-	-	0.16	0.03	0.04	0.07
10	0.02	-	-	0.16	0.03	0.04	0.11
11	0.03	-	-	0.04	0.05	0.03	0.03
12	0.03	-	-	0.04	0.05	0.03	0.05
13	0.03	-	-	0.07	0.02	0.03	0.05
14	0.03	-	-	0.07	0.02	0.03	0.05
15	0.04	-	-	0.07	0.01	0.01	0.04
16	0.04	-	-	0.07	0.01	0.01	0.06
17	0.04	-	-	0.07	0.01	0.01	0.03
18	0.06	-	-	0.05	0.02	0.05	0.03
19	0.06	-	-	0.05	0.02	0.05	0.03
20	0.06	-	-	0.05	0.04	0.02	0.03
21	0.06	-	-	0.05	0.04	0.02	0.03
22	0.03	-	-	0.07	0.03	0.03	0.05
23	0.03	-	-	0.07	0.03	0.03	0.04
24	0.03	-	-	0.07	0.03	0.03	0.04
25	-	-	-	0.07	0.02	0.06	0.08
26	-	-	-	0.07	0.02	0.06	0.05
27	-	-	-	0.09	0.07	0.03	0.04
28	-	-	-	0.09	0.07	0.03	0.06
29	-	-	-	0.10	0.03	0.04	0.05
30	-	-	-	0.10	0.03	0.04	0.05
Mean Value	0.03	-	-	0.08	0.03	0.03	0.05

FIGURE 1 (Cont'd)

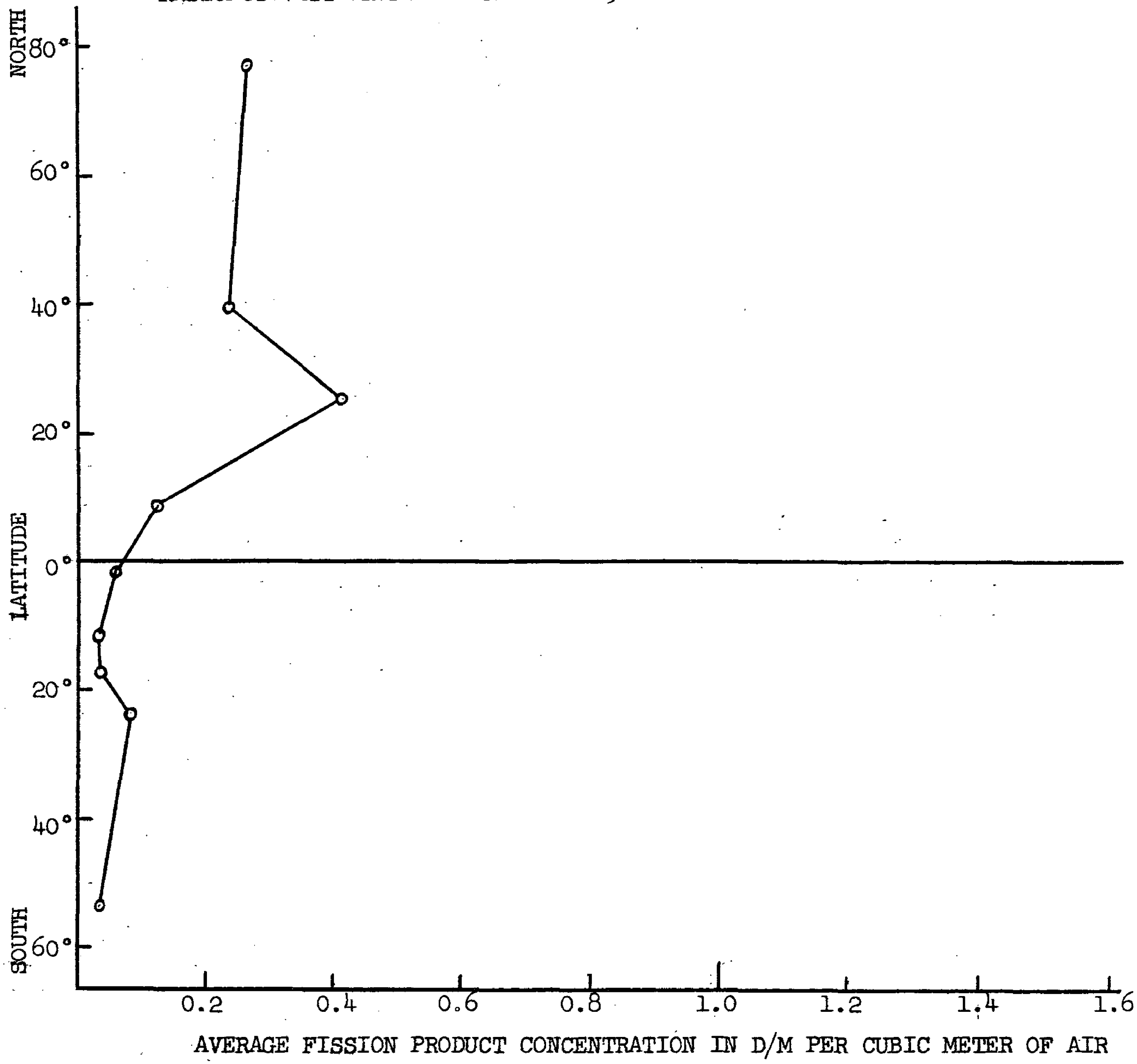
DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

April 1961

Day	Mira-flores	San Juan	Mauna Loa	Miami	Washington	Moosonee	Thule
	disintegrations/minute per cubic meter of air						
1	0.06	-	0.18	0.30	0.26	-	0.25
2	0.06	-	0.18	0.30	0.26	-	0.25
3	0.06	-	0.18	0.30	0.26	-	0.25
4	0.06	-	0.25	0.47	0.19	-	0.08
5	0.06	-	0.25	0.47	0.19	-	0.08
6	0.12	-	0.14	0.55	0.17	-	0.20
7	0.12	-	0.14	0.55	0.17	-	0.20
8	0.13	-	0.06	0.29	0.19	-	0.31
9	0.13	-	0.06	0.29	0.19	-	0.31
10	0.13	0.08	0.06	0.29	0.19	-	0.17
11	0.14	0.08	0.06	0.24	0.08	-	0.17
12	0.14	0.08	0.06	0.24	0.08	-	0.17
13	0.12	0.16	0.28	0.28	0.10	-	0.43
14	0.12	0.16	0.28	0.28	0.10	-	0.43
15	0.14	0.09	0.13	0.24	0.31	-	0.34
16	0.14	0.09	0.13	0.24	0.31	-	0.34
17	0.14	0.09	0.13	0.24	0.31	-	0.34
18	0.15	0.11	0.12	0.47	0.18	-	0.22
19	0.15	0.11	0.12	0.47	0.18	-	0.22
20	0.14	0.13	0.13	0.46	0.22	-	0.21
21	0.14	0.13	0.13	0.46	0.22	-	0.21
22	0.11	0.12	0.39	0.53	0.22	-	0.33
23	0.11	0.12	0.39	0.53	0.22	-	0.33
24	0.11	0.12	0.39	0.53	0.22	-	0.33
25	0.12	0.16	0.33	0.63	0.45	-	0.26
26	0.12	0.16	0.33	0.63	0.45	-	0.26
27	0.12	0.05	0.39	0.50	0.28	-	0.30
28	0.12	0.05	0.39	0.50	0.28	-	0.30
29	0.11	0.21	0.12	0.48	0.29	-	0.23
30	0.11	0.21	0.12	0.48	0.29	-	0.23
Mean Value	0.12	0.12	0.20	0.41	0.23	-	0.26

FIGURE 2

RADIOACTIVITY PROFILE FOR APRIL 1961



U. S. NAVAL RESEARCH LABORATORY
WASHINGTON 25, D. C.

IN REPLY REFER TO

6110-199A:LBL:em

5 July 1961

1.1 Subj: Fission product radioactivity of the air along the 80th meridian (west) during May 1961; NRL Problem A02-13; Project No. RR-004-02-41; interim report on

Figure: (1) Daily Record of Fission Product β-Activity Collected by Air Filtration
(2) Radioactivity Profile for May 1961

1. Radioactivity measurements of air-filter samples collected at various sites along the 80th meridian (west) during the month of May 1961 are presented in Figure (1). The radioactivity profile for May 1961 is shown in Figure (2). All radioactivity concentrations are given in disintegrations per minute per cubic meter of air at the collecting site.

2. No rise in radioactivity was observed at any site which could be attributed to the French nuclear test reported to have taken place in the Sahara Desert in late April 1961.

3. These measurements are being carried out as part of the U. S. Naval Research Laboratory program of atmospheric radioactivity studies. Partial financial support is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

LB Lockhart Jr
L. B. LOCKHART, JR.

FIGURE 1

DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

May 1961

Day	Punta Arenas	Puerto Montt	Santiago	Antofa-gasta	Chacal-taya	Lima	Guaya-quil
	disintegrations/minute per cubic meter of air						
1	0.02	-	0.03	0.10	0.05	0.04	0.05
2	0.01	-	0.09	0.08	0.05	0.05	0.04
3	0.01	-	0.09	0.08	0.05	0.05	0.04
4	0.04	-	0.18	0.06	0.04	0.05	0.04
5	0.04	-	0.07	0.06	0.04	0.05	0.04
6	0.02	-	0.07	0.10	0.03	0.02	0.03
7	0.02	-	0.07	0.10	0.03	0.02	0.03
8	0.02	-	0.07	0.07	0.03	0.02	0.03
9	-	-	0.07	0.07	0.03	0.02	0.04
10	-	-	0.07	0.07	0.03	0.02	0.04
11	-	-	0.02	0.08	0.02	0.05	0.04
12	-	-	0.02	0.08	0.02	0.05	0.04
13	-	-	0.10	0.10	0.02	0.07	0.01
14	-	-	0.10	0.10	0.02	0.07	0.01
15	-	-	0.10	0.10	0.02	0.07	0.01
16	-	-	0.05	0.12	0.02	0.09	-
17	-	-	0.05	0.12	0.02	0.09	-
18	-	-	0.05	0.02	0.02	0.04	-
19	-	-	0.05	0.02	0.03	0.04	0.07
20	-	-	0.07	0.08	0.03	0.05	0.07
21	-	-	0.07	0.08	0.03	0.05	-
22	-	-	0.07	0.08	0.03	0.05-	-
23	-	-	0.14	0.07	0.03	0.06	-
24	-	0.02	0.14	0.07	0.03	0.06	0.06
25	-	0.02	0.09	0.08	0.03	0.05	0.06
26	-	0.02	0.09	0.08	0.03	0.05	0.06
27	-	0.05	0.07	0.06	0.04	0.03	-
28	-	0.05	0.07	0.06	0.04	0.03	-
29	-	0.05	0.07	0.06	0.04	0.03	-
30	-	0.05	-	0.08	0.05	0.07	-
31	-	0.05	-	0.08	0.05	0.07	-
Mean Value	0.02	0.04	0.08	0.08	0.03	0.05	0.04

FIGURE 1 (Cont'd)

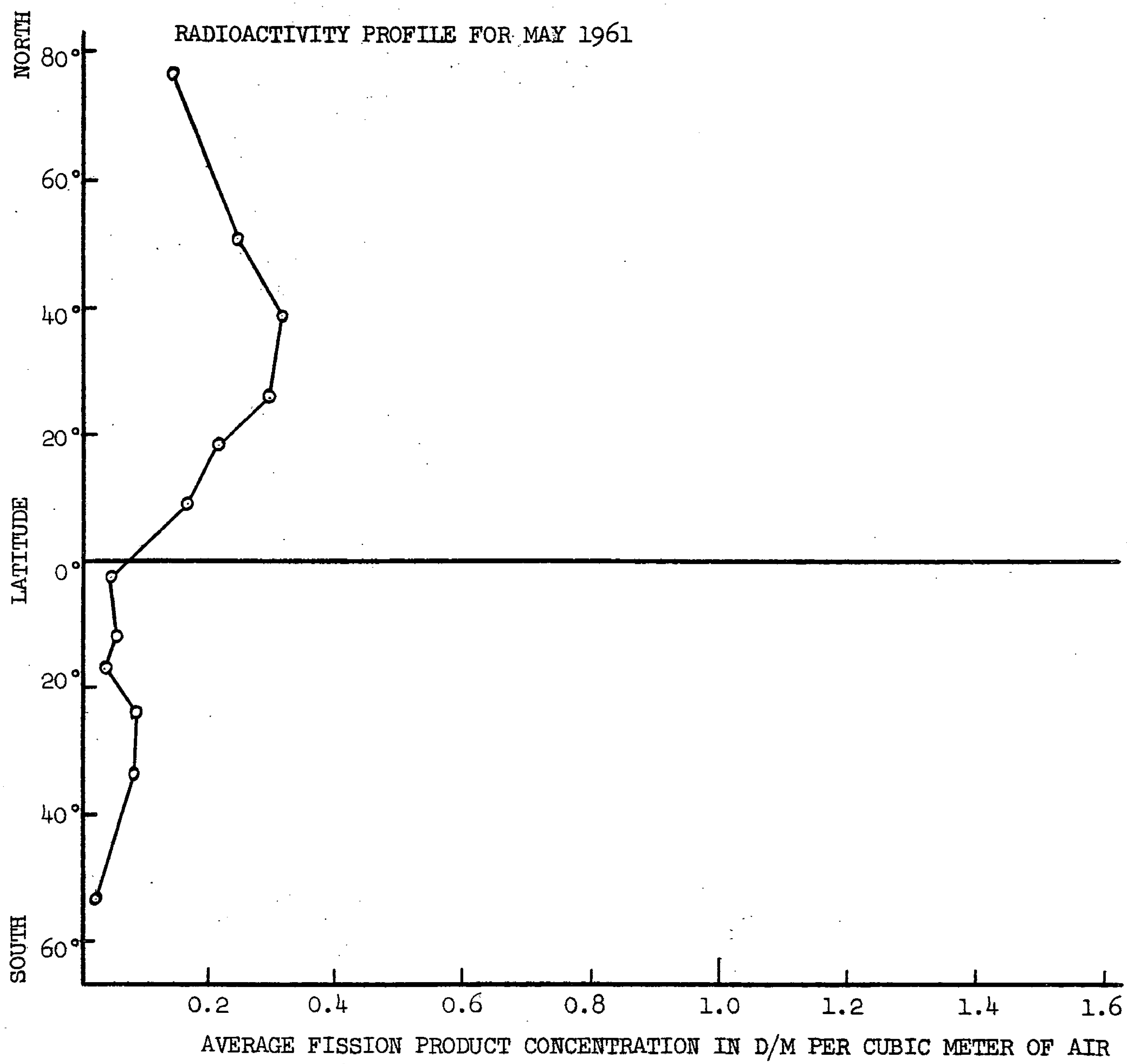
DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

May 1961

Day	Mira-flores	San Juan	Mauna Loa	Miami	Washington	Moosonee	Thule
	disintegrations/minute per cubic meter of air						
1	0.11	0.21	0.12	0.48	0.28	-	0.23
2	0.12	0.30	0.10	0.33	0.33	0.18	0.14
3	0.12	0.30	0.10	0.33	0.33	0.18	0.14
4	0.25	0.22	0.14	0.21	0.18	0.18	0.13
5	0.25	0.22	0.14	0.21	0.18	0.26	0.13
6	0.19	0.19	0.26	0.32	0.28	0.41	0.21
7	0.19	0.19	0.26	0.32	0.28	0.41	0.21
8	0.19	0.19	0.26	0.32	0.28	0.41	0.21
9	0.19	0.11	0.31	0.29	0.22	0.27	0.19
10	0.19	0.11	0.31	0.29	0.22	0.27	0.19
11	0.15	0.22	0.30	0.36	0.14	0.34	0.16
12	0.15	0.22	0.30	0.36	0.14	0.34	0.16
13	0.13	0.20	0.13	0.29	0.11	0.15	0.17
14	0.13	0.20	0.13	0.29	0.11	0.15	0.17
15	0.13	0.20	0.13	0.29	0.11	0.15	0.17
16	0.14	0.21	0.14	0.37	0.31	0.19	0.14
17	0.14	0.21	0.14	0.37	0.31	0.19	0.14
18	0.16	0.19	0.19	0.42	0.52	0.31	0.14
19	0.16	0.19	0.19	0.42	0.52	0.31	0.14
20	0.15	0.22	0.21	0.33	0.41	0.25	0.09
21	0.15	0.22	0.21	0.33	0.41	0.25	0.09
22	0.15	0.22	0.21	0.33	0.41	0.25	0.09
23	0.17	0.20	0.22	0.31	0.31	0.18	0.13
24	0.17	0.20	0.22	0.31	0.31	0.18	0.13
25	0.09	0.20	0.33	0.13	0.63	0.18	0.12
26	0.09	0.20	0.33	0.13	0.63	0.06	0.12
27	0.13	-	0.26	0.13	0.24	0.21	0.13
28	0.13	-	0.26	0.13	0.24	0.21	0.13
29	0.13	-	0.26	0.16	0.24	0.21	0.13
30	0.18	-	0.12	0.20	0.51	0.30	0.11
31	0.18	-	0.12	0.20	0.51	0.30	0.11
Mean Value	0.16	0.21	0.20	0.29	0.31	0.24	0.14

FIGURE 2

RADIOACTIVITY PROFILE FOR MAY 1961



U. S. NAVAL RESEARCH LABORATORY
WASHINGTON 25, D. C.

IN REPLY REFER TO

6110-227A:LBL:ht

2 August 1961

1.1 Subj: Fission product radioactivity of the air along the 80th meridian (west) during June 1961; NRL Problem A02-13; Project No. RR-004-02-41; interim report on

Figure: (1) Daily Record of Fission Product β-Activity Collected by Air Filtration
(2) Radioactivity Profile for June 1961

1. Radioactivity measurements of air-filter samples collected at various sites along the 80th meridian (west) during the month of June 1961 are presented in Figure (1). The radioactivity profile for June 1961 is shown in Figure (2). All radioactivity concentrations are given in disintegrations per minute per cubic meter of air at the collecting site.

2. These measurements are being carried out as part of the U. S. Naval Research Laboratory program of atmospheric radioactivity studies. Partial financial support is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

L.B. Lockhart, Jr.
L.B. LOCKHART, JR.

FIGURE 1

DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

June 1961

Day	Punta Arenas	Puerto Montt	Santiago	Antofagasta	Chacaltaya	Lima	Guayaquil
	disintegrations/minute per cubic meter of air						
1	0.04	0.05	-	0.07	0.09	0.07	-
2	0.04	0.05	-	0.07	0.09	0.07	-
3	0.02	0.05	-	0.02	0.06	0.06	-
4	0.02	0.02	-	0.02	0.06	0.06	-
5	0.02	0.02	-	0.02	0.06	0.06	-
6	0.03	0.07	-	0.05	0.04	0.07	-
7	0.03	0.07	-	0.05	0.04	0.07	0.05
8	0.03	0.03	-	0.04	0.04	0.03	0.05
9	0.03	0.03	-	0.04	0.04	0.03	0.05
10	-	0.03	-	0.03	0.04	0.04	0.02
11	-	0.03	-	0.03	0.04	0.04	0.02
12	-	0.03	-	0.03	0.04	0.04	0.02
13	-	0.04	-	0.06	-	0.06	-
14	-	0.04	-	0.06	-	0.06	-
15	-	0.01	-	0.09	-	0.07	-
16	-	0.01	-	0.09	-	0.07	-
17	-	0.02	-	0.09	-	0.06	-
18	-	0.02	-	0.09	-	0.06	-
19	-	0.02	-	0.09	0.03	0.06	0.04
20	-	0.03	-	0.09	0.03	0.10	0.04
21	-	0.03	-	0.09	0.03	0.10	0.04
22	-	0.02	-	0.21	0.03	0.06	0.04
23	-	0.02	-	0.21	0.03	0.06	0.04
24	-	0.02	-	0.05	0.03	0.08	-
25	-	0.02	-	0.05	0.03	0.08	-
26	-	0.02	-	0.05	0.03	0.08	-
27	-	0.01	-	0.10	-	0.06	-
28	-	0.01	-	0.10	-	0.06	-
29	-	0.02	-	0.05	-	0.10	-
30	-	0.02	-	0.05	-	0.10	-
Mean Value	0.03	0.03	-	0.07	0.04	0.07	0.04

FIGURE 1 (Cont'd)

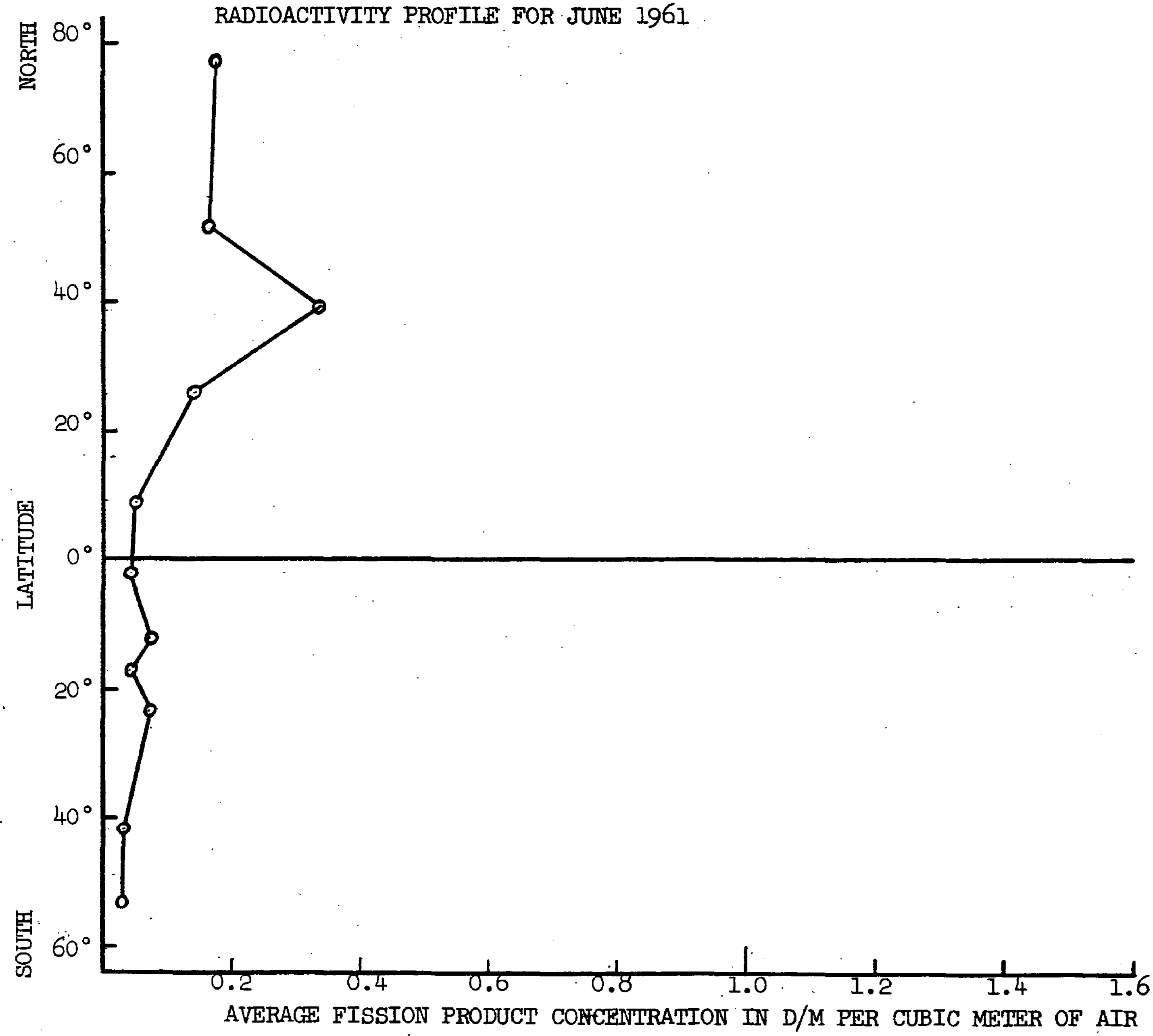
DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

June 1961

Day	Mira-flores	Mauna Loa	Miami	Washington	Moosonee	Thule
1	0.01	0.19	0.40	0.65	0.18	0.14
2	0.01	0.19	0.40	0.65	0.18	0.14
3	0.04	0.19	0.14	0.29	0.18	0.14
4	0.04	0.19	0.14	0.29	0.18	0.14
5	0.04	0.19	0.14	0.29	0.18	0.14
6	0.08	0.16	0.14	0.39	0.17	0.17
7	0.08	0.16	0.32	0.39	0.17	0.17
8	0.03	0.19	0.13	0.29	0.17	0.25
9	0.03	0.19	0.13	0.29	0.17	0.25
10	0.01	0.12	0.07	0.15	0.17	0.29
11	0.01	0.12	0.07	0.15	0.17	0.29
12	0.01	0.12	0.07	0.15	0.17	0.29
13	0.02	0.26	0.11	0.22	0.15	0.39
14	0.02	0.26	0.11	0.22	0.15	0.39
15	0.06	0.12	0.11	0.23	0.15	0.35
16	0.06	0.12	0.11	0.23	0.15	0.35
17	0.06	0.22	0.12	0.41	0.15	0.28
18	0.06	0.22	0.12	0.41	0.15	0.28
19	0.06	0.22	0.12	0.41	0.15	0.28
20	0.14	0.10	0.19	0.60	0.14	0.04
21	0.14	0.10	0.19	0.60	0.14	0.04
22	0.04	0.15	0.12	0.17	0.14	0.05
23	0.04	0.15	0.12	0.17	0.14	0.05
24	0.04	0.36	0.11	0.41	0.14	0.03
25	0.04	0.36	0.11	0.41	0.14	0.03
26	0.04	0.36	0.11	0.41	0.14	0.03
27	0.07	0.21	0.07	0.17	0.18	0.02
28	0.07	0.21	0.07	0.17	0.18	0.02
29	0.08	0.16	0.07	0.32	0.18	0.02
30	0.08	0.16	0.07	0.32	0.18	0.02
Mean Value	0.05	0.19	0.14	0.33	0.16	0.17

FIGURE 2

RADIOACTIVITY PROFILE FOR JUNE 1961



U. S. NAVAL RESEARCH LABORATORY
WASHINGTON 25, D. C.

IN REPLY REFER TO

6110-252A:LBL:ht

7 September 1961

1.1 Subj: Fission product radioactivity of the air along the 80th meridian (west) during July 1961; NRL Problem A02-13; Project No. RR-004-02-41; interim report on

Figure: (1) Daily Record of Fission Product β-Activity Collected by Air Filtration
(2) Radioactivity Profile for July 1961

1. Radioactivity measurements of air-filter samples collected at various sites along the 80th meridian (west) during the month of July 1961 are presented in Figure (1). The radioactivity profile for July 1961 is shown in Figure (2). All radioactivity concentrations are given in disintegrations per minute per cubic meter of air at the collecting site.

2. These measurements are being carried out as part of the U. S. Naval Research Laboratory program of atmospheric radioactivity studies. Partial financial support is provided by the Division of Biology and Medicine, U. S. Atomic Energy Commission.

L. B. Lockhart, Jr.

L. B. LOCKHART, JR.

FIGURE 1

DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

July 1961

Day	Punta Arenas	Puerto Montt	Santiago	Antofa-gasta	Chacal-taya	Lima	Guaya-quil
		disintegrations/minute per cubic meter of air					
1	0.03	-	-	0.04	0.03	-	-
2	0.03	-	-	0.04	0.03	-	-
3	0.03	-	-	0.04	0.03	-	-
4	0.03	-	-	0.06	0.06	-	0.01
5	0.03	-	-	0.06	0.06	-	0.01
6	0.02	0.04	-	0.06	0.06	-	0.01
7	0.02	0.04	-	0.06	0.06	-	0.01
8	0.05	0.05	-	0.06	0.06	0.15	0.01
9	0.05	0.05	-	0.06	0.06	0.15	0.01
10	0.05	0.05	-	0.06	0.06	0.15	0.01
11	0.06	0.03	-	0.07	0.09	0.02	0.01
12	0.06	0.03	-	0.07	0.09	0.02	0.01
13	0.02	0.01	-	0.07	0.09	0.02	0.01
14	0.02	0.01	-	0.07	0.09	0.02	0.01
15	0.03	0.02	-	0.07	0.09	0.02	0.01
16	0.03	0.02	-	0.07	0.09	0.02	0.01
17	0.03	0.02	-	0.07	0.09	0.02	0.01
18	0.02	0.03	-	0.09	0.04	0.05	0.01
19	0.02	0.03	-	0.09	0.04	0.05	0.01
20	0.02	0.05	-	0.09	0.04	0.05	0.01
21	0.02	0.05	-	0.09	0.04	0.05	0.01
22	0.02	0.02	-	0.09	0.04	0.05	0.01
23	0.02	0.02	-	0.09	0.04	0.05	0.01
24	0.02	0.02	-	0.09	0.04	0.05	0.01
25	0.02	0.03	-	0.07	0.05	0.07	0.02
26	0.02	0.03	-	0.07	0.05	0.07	0.02
27	0.02	0.06	-	0.07	0.05	0.07	0.02
28	0.02	0.06	-	0.07	0.05	0.07	0.02
29	0.02	0.09	-	0.07	0.05	0.07	0.02
30	0.02	0.09	-	0.07	0.05	0.07	0.02
31	0.02	0.09	-	0.07	0.05	0.07	0.02
Mean value	0.03	0.04	-	0.07	0.06	0.06	0.01

FIGURE 1 (Cont'd)

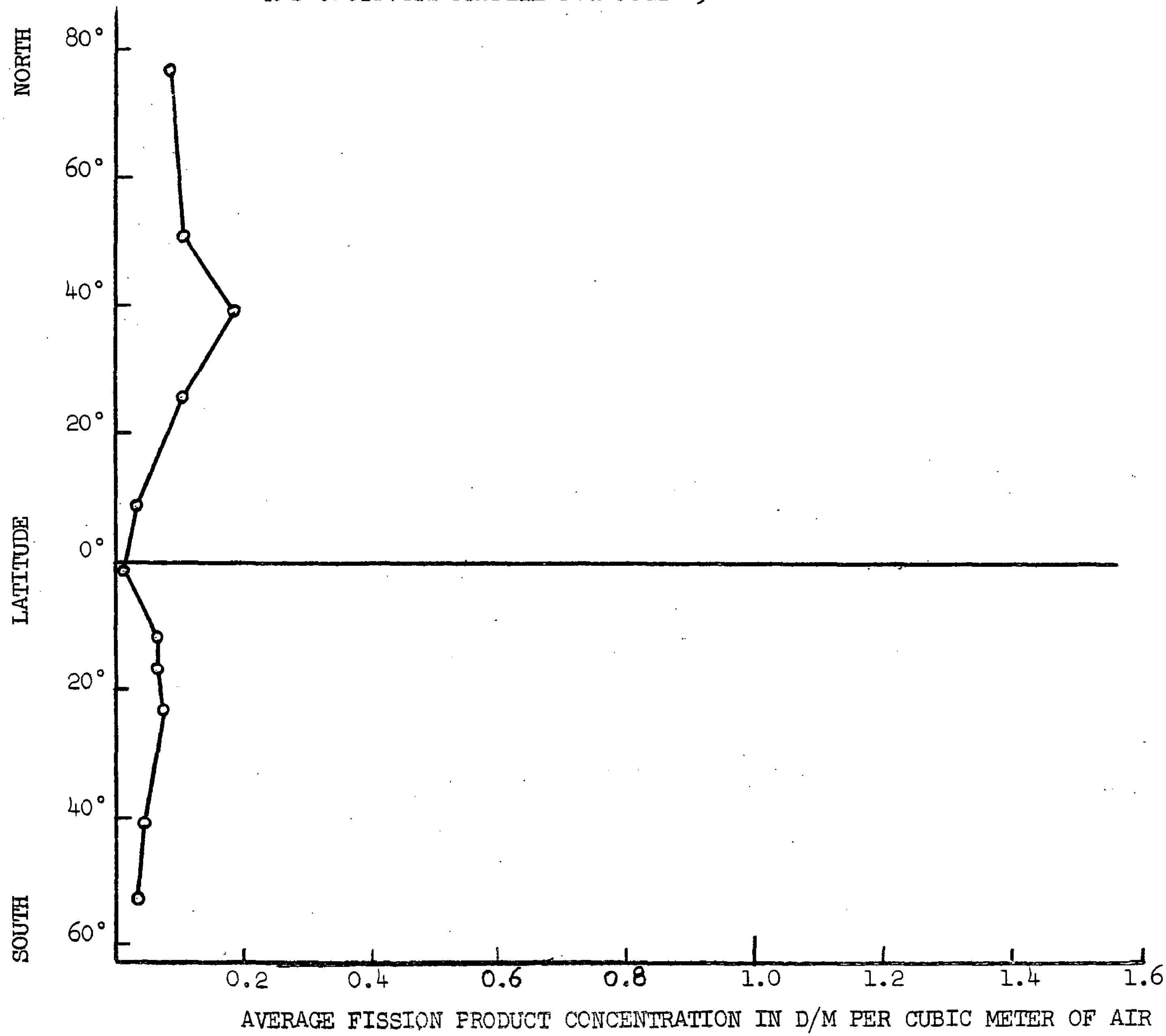
DAILY RECORD OF FISSION PRODUCT β-ACTIVITY
COLLECTED BY AIR FILTRATION

July 1961

Day	Mira-flores	Mauna Loa	Miami	Washington	Moosonee	Thule
	disintegrations/minute per cubic meter of air					
1	0.04	0.07	0.08	0.19	0.18	0.02
2	0.04	0.07	0.08	0.19	0.18	0.02
3	0.04	0.07	0.08	0.19	0.18	0.02
4	0.02	0.11	0.15	0.22	0.09	0.02
5	0.02	0.11	0.15	0.22	0.09	0.08
6	0.02	0.11	0.15	0.22	0.09	0.08
7	0.02	0.11	0.15	0.22	0.09	0.08
8	0.02	0.10	0.15	0.22	0.09	0.08
9	0.02	0.10	0.15	0.22	0.09	0.08
10	0.02	0.10	0.15	0.22	0.09	0.08
11	0.03	0.15	0.08	0.19	0.10	0.08
12	0.03	0.15	0.08	0.19	0.10	0.08
13	0.03	0.15	0.08	0.19	0.10	0.06
14	0.03	0.15	0.08	0.19	0.10	0.06
15	0.03	0.15	0.12	0.19	0.10	0.06
16	0.03	0.15	0.12	0.19	0.10	0.06
17	0.03	0.15	0.12	0.19	0.10	0.06
18	0.04	0.18	0.11	0.15	0.12	0.06
19	0.04	0.18	0.11	0.15	0.12	0.12
20	0.04	0.18	0.07	0.15	0.12	0.12
21	0.04	0.18	0.07	0.15	0.12	0.12
22	0.04	0.18	0.07	0.15	0.12	0.12
23	0.04	0.18	0.07	0.15	0.12	0.12
24	0.04	0.18	0.07	0.15	0.12	0.12
25	0.03	0.10	0.09	0.14	0.06	0.12
26	0.03	0.10	0.09	0.14	0.06	0.10
27	0.03	0.10	0.09	0.14	0.06	0.10
28	0.03	0.10	0.09	0.14	0.06	0.10
29	0.03	0.10	0.10	0.14	0.06	0.10
30	0.03	0.10	0.10	0.14	0.06	0.10
31	0.03	0.10	0.10	0.14	0.06	0.10
Mean Value	0.03	0.13	0.10	0.18	0.10	0.08

FIGURE 2

RADIOACTIVITY PROFILE FOR JULY 1961



1.2

RADIOCHEMICAL ANALYSES OF COMPOSITE MONTHLY AIR FILTER COLLECTIONS

Month 1960	Activity (dis/min per 100 std. cubic meters of air)+										Activity Ratios					
	Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	W^{185}#	Pb^{210}	Sr^{90}/Gross β	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	Pb^{210}/Gross β
Thule, Greenland - Lat. 76°35'N Long. 68°35'W Elev. 259 m																
Jan.	29	*	*	*	5.02	1.97	0.616	1.29	0.255	-	0.021	2.55	8.15	2.09	-	-
Mar.	36	*	(0.17)	*	5.61	3.27	0.908	1.33	0.139	-	0.025	1.72	6.18	1.46	-	-
May	22	*	(0.07)	*	3.65	1.83	0.710	1.42	0.050	-	0.032	1.99	5.14	2.00	-	-
July	18	*	*	*	2.74	1.74	0.615	1.20	0.043	-	0.034	1.57	4.46	1.95	-	-
Sept.	7	*	*	*	0.934	0.546	0.233	0.417	-	0.570	0.033	1.71	4.01	1.79	2.5	0.08
Nov.	6	*	*	*	0.795	0.616	0.219	0.386	-	2.20	0.037	1.29	3.63	1.76	10.0	0.37
Moosonee, Ontario, Canada - Lat. 51°16'N Long. 80°39'W Elev. 10 m																
Jan.	20	*	*	*	2.86	1.15	0.353	0.775	0.130	-	0.018	2.49	8.10	2.20	-	-
Mar.	42	*	(0.37)	*	5.72	2.36	0.856	1.68	0.173	-	0.020	2.42	6.68	1.96	-	-
May	29	*	(0.08)	*	5.74	3.00	1.09	2.19	0.055	-	0.038	1.91	5.27	2.01	-	-
July	27	*	*	*	4.53	2.76	0.994	1.86	0.038	-	0.037	1.64	4.56	1.87	-	-
Sept.	12	*	*	*	1.44	1.06	0.343	0.684	-	2.10	0.029	1.36	4.20	1.99	6.1	0.18
Nov.	8	*	*	*	0.660	0.459	0.178	0.323	-	2.72	0.022	1.44	3.71	1.81	15.3	0.34
Washington, D. C.**- Lat. 38°50'N Long. 76°57'W Elev. 88 m																
Jan.	25	*	(0.13)	*	3.93	1.48	0.486	1.04	0.177	-	0.019	2.66	8.09	2.14	-	-
Mar.	43	*	(0.43)	*	6.28	2.90	0.940	2.03	0.158	-	0.022	2.17	6.68	2.16	-	-
May	49	*	(0.13)	*	8.59	4.40	1.68	3.41	0.10	-	0.034	1.95	5.11	2.03	-	-
July	34	*	*	*	6.73	4.51	1.53	2.96	0.045	-	0.045	1.49	4.40	1.93	-	-
Sept.	18	*	*	*	2.16	1.77	0.543	1.00	-	4.85	0.030	1.22	3.98	1.84	8.9	0.27
Nov.	14	*	*	*	1.38	0.812	0.353	0.733	-	6.30	0.025	1.70	3.91	2.08	17.8	0.45

See last page for footnotes.

RADIOCHEMICAL ANALYSES OF COMPOSITE MONTHLY AIR FILTER COLLECTIONS (cont'.d)

Month 1960	Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	W^{185}#	Pb^{210}	Sr^{90}/Gross β	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	Pb^{210}/Gross β
	Activity (dis/min per 100 std. cubic meters of air)+										Activity Ratios					
Miami, Florida - Lat. 25°49'N Long. 80°17'W Elev. 4 m																
Jan.	42	*	(0.49)	*	8.37	3.54	1.06	1.31	0.425	-	0.025	2.36	7.90	1.24	-	-
Mar.	97	8.24	4.77	3.04	10.1	4.41	1.51	1.55	0.230	-	0.015	2.29	6.69	1.03	-	-
May	53	*	(0.02)	*	8.98	4.93	1.74	2.56	0.101	-	0.033	1.82	5.16	1.47	-	-
July	13	*	*	*	2.28	1.50	0.481	0.628	0.029	-	0.037	1.52	4.74	1.31	-	-
~~Sept.~~	~~7~~	~~*~~	~~*~~	~~*~~	~~0.811~~	~~0.483~~	~~0.178~~	~~0.243~~			~~0.800~~	~~0.025~~	~~1.67~~	~~4.56~~	~~1.3~~	
Sept.	7	*	*	*	0.811	0.483	0.178	0.243	-	0.800	0.025	1.67	4.56	1.37	4.5	0.11
Nov.	14	*	*	*	1.89	1.43	0.506	0.517	-	1.57	0.036	1.32	3.74	1.02	3.1	0.11
Mauna Loa, Hawaii - Lat. 19°28'N Long. 155°36'W Elev. 3394 m																
Jan.	34	*	*	*	6.87	2.85	0.930	1.86	0.330	-	0.027	2.41	7.39	2.00	-	-
Mar.	115	13.3	14.2	6.29	8.45	3.62	1.39	2.54	0.163	-	0.012	2.33	6.08	1.83	-	-
May	32	*	(0.23)	*	6.07	3.28	1.24	2.32	0.077	-	0.039	1.85	4.90	1.87	-	-
July	32	*	-	-	5.68	3.42	-	-	0.072	-	-	1.66	-	-	-	-
Sept.	14	*	*	*	1.86	1.10	0.408	0.808	-	1.28	0.029	1.69	4.56	1.98	3.1	0.09
Nov.	10	*	*	*	1.38	1.07	0.383	0.726	-	1.62	0.038	1.29	3.60	1.90	4.2	0.16
Miraflores, Panama Canal Zone - Lat. 9°00'N Long. 79°35'W Elev. 10 m																
Jan.	17	*	*	(0.10)	2.52	1.37	0.323	0.423	0.127	-	0.019	1.84	7.80	1.31	-	-
Mar.	555	112	51.2	42.0	15.1	4.45	0.858	1.55	0.083	-	0.0015	3.39	17.6	1.81	-	-
May	6	*	(0.03)	*	0.633	0.349	0.138	0.253	0.019	-	0.023	1.81	4.59	1.83	-	-
July	5	*	*	*	0.565	0.355	0.120	0.192	0.010	-	0.024	1.59	4.71	1.60	-	-
Sept.	3	*	*	*	0.104	0.090	0.042	0.057	-	0.485	0.014	1.16	2.48	1.36	11.5	0.16
Nov.	3	*	*	*	0.161	0.118	0.042	0.061	-	0.723	0.014	1.36	3.83	1.45	17.2	0.24

See last page for footnotes.

RADIOCHEMICAL ANALYSES OF COMPOSITE MONTHLY AIR FILTER COLLECTIONS (cont'd.)

Month 1960	Activity (dis/min per 100 std. cubic meters of air)+										Activity Ratios					
	Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	W^{185}#	Pb^{210}	Sr^{90}/Gross β	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	Pb^{210}/Gross β
Guayaquil, Ecuador - Lat. 2°10'S Long. 79°52'W Elev. 7 m																
Jan.	6	*	*	*	0.781	0.347	0.118	0.244	0.044	-	0.020	2.25	6.62	2.07	-	-
Mar.	47	18.3	10.3	6.50	2.48	0.760	0.170	0.432	0.023	-	0.0036	3.26	14.6	2.54	-	-
May	7	*	(0.02)	(0.20)	0.396	0.229	0.086	0.169	-	2.88	0.012	1.73	4.60	1.97	33.5	0.41
July	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sept.	4	*	*	*	0.275	0.172	0.074	0.159	-	0.820	0.019	1.60	3.72	2.15	11.1	0.21
Nov.	6	*	*	*	0.788	0.540	0.278	0.521	-	1.35	0.046	1.46	2.83	1.87	4.9	0.23
Lima, Peru - Lat. 12°06'S Long. 77°01'W Elev. 134 m																
Jan.	4	*	*	*	0.618	0.300	0.098	0.208	0.042	-	0.025	2.06	6.31	2.12	-	-
Mar.	5	(0.44)	0.23	0.144	0.646	0.301	0.115	0.214	0.030	-	0.023	2.15	5.62	1.86	-	-
May	2	*	*	*	0.129	(0.108)	0.032	0.056	-	0.732	0.016	1.19	4.03	1.75	22.9	0.37
July	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sept.	6	*	*	*	0.785	0.503	0.215	0.375	-	0.385	0.036	1.56	3.65	1.74	1.8	0.06
Nov.	5	*	*	*	0.652	0.490	0.201	0.370	-	0.730	0.040	1.33	3.24	1.84	3.6	0.14
Chacaltaya, Bolivia - Lat. 17°10'S Long. 68°15'W Elev. 5220 m																
Jan.	3	*	*	*	0.225	0.130	0.040	0.135#	0.123	-	0.013	1.73	5.60	3.38	-	-
Mar.	10	(0.38)	(0.17)	*	0.687	0.416	0.131	0.255	0.039	-	0.013	1.65	5.24	1.95	-	-
May	9	*	*	*	0.571	0.327	0.148	0.223	-	1.85	0.016	1.75	3.86	1.51	12.5	0.21
July	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sept.	9	*	*	*	0.765	0.502	0.201	0.390	-	2.60	0.022	1.52	3.81	1.94	12.9	0.29
Nov.	9	*	*	*	0.607	0.468	0.187	0.382	-	2.38	0.021	1.30	3.25	2.04	12.7	0.26

See last page for footnotes.

RADIOCHEMICAL ANALYSES OF COMPOSITE MONTHLY AIR FILTER COLLECTIONS (cont'd.)

Month 1960	Activity (dis/min per 100 std. cubic meters of air)+ Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	$W^{185\#}$	Pb^{210}	Activity Ratios Sr^{90}/Gross β	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	Pb^{210}/Gross β
Antofagasta, Chile - Lat. 23°37'S Long. 70°16'W Elev. 519 m																
Jan.	10	*	*	*	1.46	0.655	0.221	0.528#	0.105	-	0.022	2.23	6.61	2.39	-	-
Mar.	13	*	(0.20)	(0.11)	1.55	0.777	0.303	0.650	0.060	-	0.023	1.99	5.12	2.15	-	-
May	7	*	*	*	0.794	0.470	0.178	0.334	-	2.95	0.025	1.69	4.46	1.88	16.6	0.42
July	10	*	*	*	1.36	0.797	0.364	0.667	-	1.36	0.036	1.71	3.74	1.83	3.7	0.14
Sept.	14	*	*	*	1.86	1.22	0.520	0.650	-	0.301	0.037	1.52	3.58	1.25	0.6	0.02
Nov.	11	*	*	*	1.51	1.12	0.455	0.884	-	1.13	0.041	1.35	3.32	1.94	2.5	0.10
Santiago, Chile - Lat. 33°27'S Long. 70°42'W Elev. 520 m																
Jan.	12	*	*	*	1.70	0.931	0.286	0.585	0.118	-	0.024	1.83	5.94	2.05	-	-
Mar.	14	*	*	*	1.73	0.907	0.360	0.522	0.076	-	0.026	1.91	4.81	1.45	-	-
May	8	*	*	*	0.689	0.392	0.150	0.293	-	2.85	0.019	1.76	4.59	1.95	19.0	0.36
July	8	*	*	*	0.981	0.594	0.254	0.362	-	1.66	0.032	1.65	3.86	1.43	6.5	0.21
Sept.	13	*	*	*	1.65	1.02	0.468	0.934	-	0.980	0.036	1.62	3.53	2.00	2.1	0.08
Nov.	11	*	*	*	1.68	1.20	0.528	1.07	-	1.33	0.048	1.40	3.18	2.03	2.5	0.12
Puerto Montt, Chile - Lat. 41°27'S Long. 72°57'W Elev. 5 m																
Jan.	9	*	*	*	1.65	0.845	0.284	0.448	0.152	-	0.032	1.95	5.81	1.58	-	-
Mar.	10	*	*	*	1.52	0.756	0.311	0.542	0.049	-	0.031	2.01	4.89	1.74	-	-
May	5	*	*	*	0.816	0.458	0.176	0.288	-	0.654	0.035	1.78	4.64	1.64	3.7	0.13
July	2	*	*	*	0.359	0.223	0.092	0.159	-	0.275	0.046	1.61	3.90	1.73	3.0	0.14
Sept.	5	*	*	*	0.696	0.390	0.223	0.283	-	0.299	0.045	1.78	3.12	1.27	1.3	0.06
Nov.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

See last page for footnotes.

RADIOCHEMICAL ANALYSES OF COMPOSITE MONTHLY AIR FILTER COLLECTIONS (cont'd.)

Month 1960	Activity (dis/min per 100 std. cubic meters of air)+										Activity Ratios					
	Gross β	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	W^{185}#	Pb^{210}	Sr^{90}/Gross β	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}	Pb^{210}/Sr^{90}	Pb^{210}/Gross β
	Punta Arenas, Chile - Lat. 53°08'S Long. 70°53'W Elev. 3 m															
Jan.	3	*	*	*	0.612	0.350	0.134	0.253	0.06	-	0.045	1.75	4.57	1.89	-	-
Mar.	4	*	*	*	0.770	0.405	0.163	0.267	0.05	-	0.041	1.90	4.72	1.64	-	-
May	5	*	*	*	0.626	0.423	0.147	0.299	-	0.452	0.029	1.48	4.26	2.03	3.1	0.09
July	2	*	*	*	0.307	0.214	0.080	0.148	-	0.159	0.040	1.43	3.84	1.85	2.0	0.08
Sept.	3	*	*	*	0.529	0.364	0.157	0.293	-	0.383	0.052	1.45	3.37	1.87	2.4	0.13
Nov.	2	*	*	*	0.283	0.256	0.099	(0.224)	-	0.132	0.050	1.11	2.86	2.26	1.3	0.07

Footnotes:

\+ All activities (except Gross β) corrected for decay to midpoint of collection period. Counting error less than ±1% (standard deviation) unless otherwise indicated.

\- No analytical results reported due to non-receipt of sample or its loss during processing.

\# Counting error estimated to be in range of 1-5% (standard deviation).

( ) Counting error exceeds ±5% (standard deviation).

** Equipment moved to Sterling, Virginia (Lat. 38°59'N Long. 77°29'W Elev. 82m) in September 1960.

* Activity too low for measurement.

FOOD AND DRUG DIRECTORATE

CANADA

DEPARTMENT OF
NATIONAL HEALTH AND WELFARE

2. RESIDUAL RADIOACTIVITY IN CANADIAN FOODS

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May, 1961

INTRODUCTION

This study was initiated to obtain data on past and current levels of residual radioactivity in the various types of food found on the Canadian market. Analytical work on samples already on hand, some of which were obtained as far back as 1945, was initiated in December, 1959. The beta activity determinations were completed in August, 1960. The results presented in this report do not lend themselves to a time-correlation study, since most of the samples were either passed to this laboratory by other agencies or obtained in a non-systematic way. A detailed outline of the experimental methods and standardization and calculation procedures are given in the following sections.

INSTRUMENTAL

The following systems were employed:

(A) Automatic Beta Counting System. Detector: Tracerlab TGC-14, thin-window flow counter. Background: 11 cpm.

(B) Low-Level Beta Counting System. Detector: Amperex 18515, end-window halogen quenched G.M. Background: 1.1 cpm.

EXPERIMENTAL

A - Ashing of the Samples

Wet samples were dried overnight at 100°C. All samples were slowly and completely charred over an open flame without allowing them to catch fire. This was followed by two overnight ashings at 500°C, after which most samples showed no trace of residual carbon. The ashes were ground to a fine powder and weighed.

B - <u>Chemical Treatment of the Ash</u>

In order to eliminate K-40 corrections on the total beta radioactivity determinations and increase significantly the sample counting rate per unit volume, it was decided that the oxalate method of separation of potassium would be applied on all the ashed samples. The procedure employed was as follows:

1 - A known amount of ash was transferred to a 400 ml. beaker and 48.3 mgm of strontium nitrate (20 mgm of strontium) was added.

2 - Concentrated nitric acid (25 ml.) was carefully added. The sample was taken to near dryness on a steam bath, with precautions against mechanical loss.

3 - Step 2 above was repeated.

4 - Concentrated hydrochloric acid (10 ml.) was added and the sample was heated on the steam bath. When there was no further reaction, 190 ml. of water were added and as much as possible of the sample was brought into solution.

5 - The insoluble material was filtered off with a No. 12 or No. 30 Whatman filter paper. The residue was washed with water and discarded.

6 - The filtrate was adjusted to pH 1.5 using dilute ammonium hydroxide.

7 - The filtrate was heated on a steam bath to near boiling; a saturated solution of ammonium oxalate was added until no further precipitation occurred as shown by a spot test on the supernatant solution. Then 10 ml. of additional oxalate was added.

8 - The beakers were left on the steam bath for a further 15 minutes.

9 - Ethanol, 60 ml. was then added and the solution was allowed to cool down to about 40°F.

10 - The oxalate precipitate was filtered off, within 2 hours from precipitation, on a No. 12 or No. 30 Whatman filter paper coated with paper pulp from digested Whatman No. 42 filter paper. The residue was carefully washed 5 times with a 9:1 water-ethanol solution containing 1% of the saturated ammonium oxalate solution.

11 - The precipitate was transferred to a porcelain crucible and dried under an infrared lamp until the paper was well charred.

12 - The dried precipitate was ignited at 500°C for roughly 18 hours. It was then cooled, weighed, ground and bottled.

The foregoing procedure is essentially that proposed by Volchok et al. (1), except that it has been slightly modified to increase the strontium recovery. The efficiency of this procedure for the separation of potassium was checked using a mixture of 2.0 gm. of $CaCO_3$ and 1.0 gm. of K_2CO_3 as starting material. A flame photometric potassium determination on the final residue gave a value of 0.65 mgm. of potassium per gm. The amount of potassium in the same residue was also determined using a sodium tetraphenyl boron method (2). A value ranging between 0.5 to 1 mgm. of potassium per gm. was obtained.

Suttle and Libbie (3) have published the absolute beta-gamma activity of K^{40} as 1.776 dis./min./mgm. of potassium. In practice, a residual amount of 0.65 mgm. of potassium per gm. of carbonate residue, taking into account Suttle and Libbie's value and our experimental data on the solid geometry of the detector, absorption, scattering, and efficiency of the detector for K^{40} betas, gives a calculated counting rate of 0.13 count per minute for a planchet containing 1 gm. of carbonate residue. This correction, being smaller by at least a factor 3 than the expected statistical errors on the counting rates, was felt to be negligible. Elimination of K-40 corrections has the immediate effect of increasing the accuracy of the total beta activity determinations by decreasing the experimental errors. However, the total beta radioactivity thus determined must be interpreted to exclude any contribution from Cs^{137} which would be largely eliminated along with the other alkali metals during the chemical separation of potassium.

C - Preparation of Planchets for Counting

Atomic accessories, Inc., pyrex planchets, one inch x 5/16" model PP-13, were used. Several methods of preparation were investigated. The following was found most satisfactory.

A sample weight of either 0.5 gm. or 1.0 gm. was used. This amount of carbonate residue was weighed directly into the planchet. The planchet was tapped lightly to distribute the powder evenly. A 96 gm. stainless steel plunger, of diameter matching closely that of the inside of the planchet, was used to press down the powder. This operation required some skill. However, it was found that, if the planchet was rotated only when the pressure was lessened, an evenly packed volume and a smooth surface could be obtained without any of the powder escaping along the edge of the planchet. Finally, the surface was sprayed with amyl acetate using a Research Specialties Chromatography Sprayer and allowed to dry before counting.

Planchets, thus prepared, were kept many months without showing any sign of surface damage. The compactness of the sample, as related to internal absorption and emitting geometry is easily reproduced if planchet preparation is carried out by the same individual.

D - Preparation of Standards and Calculation of Sample Activity

A Nuclear-Chicago strontium - Yttrium-90 standard (Type RS-90, serial 4657) was used to prepare the standard planchets. A volume of this solution corresponding to a given number of disintegrations per second was added to 3 gm. of $CaCO_3$ and 0.3 gm. of Sr $(NO_3)^2$. The mixture was dissolved in HCl and water and the pH of the solution was adjusted to 1.5. The solution was then processed according to paragraphs 7 to 12, section B. Several replicates were prepared. The average recovery of the initial calcium and strontium was 99.5%.

Carbonate residues corresponding to initial specific activities of 6.71, 13.4 and 20.0 m.m.c. of Sr^{90} + Y^{90}/gm. were prepared. Standard planchets of 0.1, 0.2, 0.3, 0.4, 0.5, 1.0 and 1.5 gm. of carbonate were prepared as already outlined for each of the above specific activities. These standard planchets were used to calibrate the two beta counting systems. Two of the calibration curves are reproduced in Figures 1 and 2. The linearity of the response as a function of the specific activity for a given weight of the standard, Figure 1, is a strong evidence for the reliability of the chemical procedure used in this survey. Further, it shows that the sample preparation technique for counting was adequate. However, Figure 2 indicates that even with the largest amount of carbonate residue employed, 1.5 gm., which can be easily introduced into a one inch x 5/16" pyrex planchet, the infinite thickness condition for the Sr-Y-90 betas was not reached. Therefore, special care was exercised to keep sample preparation as uniform as possible.

In actual determinations, the counting rates of standards of matching weight, to those of the samples were obtained. The counting rates of the standards were used to make overall detector sensitivity corrections on the observed sample counting rates. The observed sample counting rates were then converted into micromicrocuries with the use of the proper conversion factors listed in Tables I and II. Duplicate activity determinations done on the same sample using the two beta counting systems gave values which agreed within statistical errors.

Figure 1.

COUNTING RATE AS A FUNCTION OF SPECIFIC ACTIVITY

Sample Weight Constant

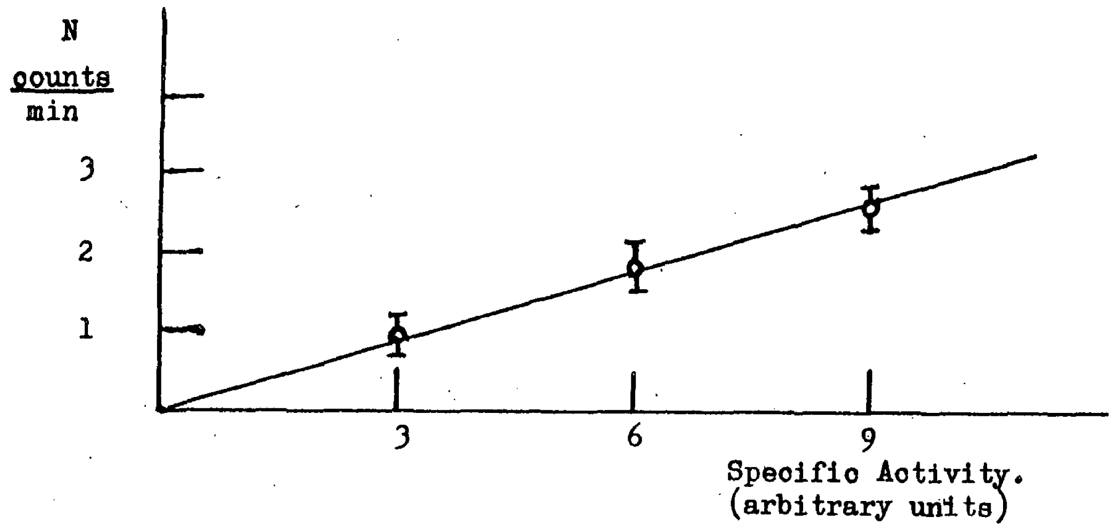

Figure 2.

COUNTING RATE AS A FUNCTION OF SAMPLE WEIGHT

Specific Activity Constant

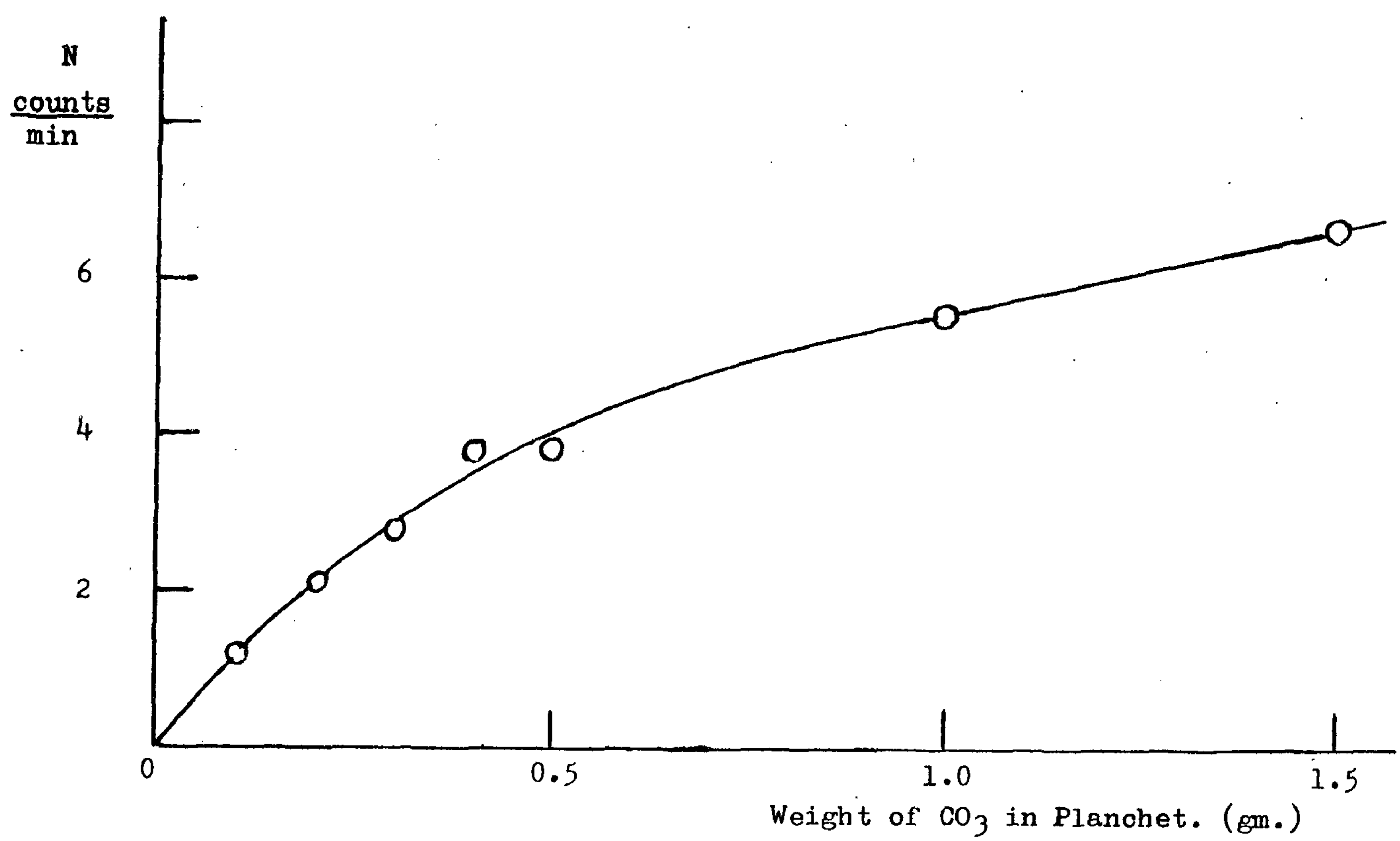

Table I

AUTOMATIC BETA COUNTING SYSTEM: SENSITIVITY AND CALIBRATION FACTOR

Weight of CO_3 in planchet	Standard Planchets Standardized counts.		Calibration factor
	(1)	(2)	
gm.	counts/min.	counts/min.	mmc/c.p.m.
1.5	7.2	4.8	4.17
1.0	5.7	3.8	3.51
0.5	3.3	2.2	3.03
0.4	3.0	2.0	2.66
0.3	2.7	1.8	2.22

Table II

LOW LEVEL BETA COUNTING SYSTEM: SENSITIVITY AND CALIBRATION FACTOR

Weight of CO_3 in planchet	Standard Planchets Standardized counts.		Calibration factor
	(1)	(2)	
gm.	counts/min.	counts/min.	mmc/c.p.m.
1.5	3.40	2.27	8.82
1.0	2.60	1.73	7.69
0.5	1.70	1.13	5.88
0.4	1.40	0.93	5.70

(1) Code (9 cc.); initial specific activity: 20.0 mmc of Sr^{90} + Y^{90}/gm. CO_3

(2) Code (6 cc.); initial specific activity: 13.4 mmc of Sr^{90} + Y^{90}/gm. CO_3

The standards were carried through the same chemical procedure as the food sample ashes so that corrections would be automatically made for the inevitable loss of some Sr-Y-90 during the chemical separation of potassium from the ashes. Further, the method of calibration selected for the two beta counting systems, takes into account the geometry of the detector, the sensitivity of the detector and the effect of the planchet material on the observed counting rates.

E - Calculation of the Statistical Error due to Counting

The following formula was used:

$$N/\text{unit time} = \bar{A} - \bar{B} \pm \sqrt{\frac{\bar{A}}{m\bar{t}_A} + \frac{\bar{B}}{n\bar{t}_B}}$$

where:

A = number of counts per minute as determined in t_A minutes (sample + background)

B = number of counts per minute as determined in t_B minutes (background)

m = number of determinations of A

n = number of determinations of B

$$\bar{A} = \frac{A_1 + A_2 + A_3 + \cdots\cdots + A_m}{m}$$

$$\bar{B} = \frac{B_1 + B_2 + B_3 + \cdots\cdots + B_n}{n}$$

$$\bar{t}_A = \frac{t_{A_1} + t_{A_2} + t_{A_3} + \cdots\cdots + t_{A_m}}{m}$$

$$\bar{t}_B = \frac{t_{B_1} + t_{B_2} + t_{B_3} + \cdots\cdots + t_{B_n}}{n}$$

RESULTS

Average values for each variety of foods included in this initial survey are given in Table III. In general, results are in line with those published from other countries. Bran cereals were the highest for the cereal foods. Processed vegetables and fruits were all noticeably low. Apricots and figs ranked highest for the dried fruits. The medium red cohoe salmon variety showed a higher average than other sea foods. It will be noted that salmon packed in Japan, when compared to similar types packed in Canada, had activity values of the same order of magnitude. The only exception was the red cohoe variety. Values for bone flour were high. However, due to its high calcium contents, the reported activities measured in S.U. units would be expected to be below 10. Tea, when compared to other beverages such as cocoa, coffee and the cereal beverages, yielded activity values which ran from 2 to 30 times higher. It was found, however, that only 10 to 16% of this activity passed into water solution under normal conditions, as shown in Table IV. The average activity was 1.05 mmc per cup of tea for 6 different varieties. The average values for each type of food have been summarized in Table V.

Table III

TOTAL[1] BETA RADIOACTIVITY OF ASHED MATERIAL FOLLOWING TREATMENT WITH AMMONIUM OXALATE

Variety	Year of Packing	Year of Purchasing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
Cereals for babies.						
Barley		1959	3		N.S.	
Corn		1959	1		N.S.	
Mixed		1959	3	N.S.	17	28±19
Oat		1959	2	46±25	83	120±33
		1961	10	N.S.	41	65±21
Rice		1959	3		N.S.	
Wheat		1959	4	N.S.	50	130±20
		1961	5	24±17	50	74±17
Cereals for adults.						
Barley		1960	1		48±4.2	
Bran		1960	6	52±3.8	150	250±15
		1961	11	44±5.2	150	200±10
Corn		1960	5	N.S.	11	25±4.3
Oat		1960	7	25±3.5	49	75±8.1
Rice		1960	3	9.6±3.2	14	20±3.1
Wheat		1960	17	4.9±2.0	57	200±11
		1961	1		110±52	
Others		1960	19	9.4±5.9	53	180±15
Processed vegetables and fruits for babies						
Apple and raspberry	1950		1		N.S.	

This does not include the contribution of potassium 40 and other alkali metals.

Values given refer to the weight of one liter of the commercial preparation.

N.S. : not significant. Activity below the sensitivity of the detector used.

Table III (continued).

Variety	Year of Packing	Year of Purchasing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
Processed vegetables and fruits for babies.[2] (continued).						
Beets	1945		1		10±6	
	1951		1		N.S.	
	1956		3	N.S.	6.0	17±6.2
Celery	1949		1		N.S.	
	1951		1		21±4.1	
	1956		3	N.S.	3.9	6.4±5.4
Mixed vegetables	1947		1		N.S.	
	1949		5		N.S.	
	1950		3		N.S.	
	1951		3		N.S.	
	1957		3	6.4±5.1	16	22±4.7
Mushroom	1948		1		8.4±4.4	
	1950		1		N.S.	
Peas	1949		3	N.S.	6.4	12±8.1
	1950		2		N.S.	
	1951		1		5.1±4.1	
	1956		3	N.S.	5.3	16±8.8
Peas and carrots	1949		1		N.S.	
	1950		1		N.S.	
Spinach	1945		1		22±11	
	1948		1		10±6.8	
	1949		1		N.S.	
	1956		3	N.S.	13	21±9.5
Squash	1949		1		N.S.	
Miscellaneous Processed foods for babies.[2]						
Orange custard	1949		2	N.S.	8.0	16±8.1
	1951		1		N.S.	

2 Values given refer to the weight of one liter of the commercial preparation.

Table III (continued).

Variety	Year of Packing	Year of Purchasing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
Meat broth.[2]						
	1947		1		N.S.	
	1948		2	3.1±3.0	6.0	8.8±7.1
	1949		2		N.S.	
	1950		1		N.S.	
	1951		5	N.S.	2.6	5.1±3.4
Fruit Juice.[2]						
Tomato	1949		11	N.S.	14	33±3.5
Processed fruits.[2]						
Tomatoes	1949		4	N.S.	18	57±4.5
Apricots	1961		5	8.1±1.4	24	64±3.4
Dried fruits.						
Apples		1960	2	25±5.3	34	43±9.3
Apricots		1960	2	93±9.3	220	350±18
		1961	5	140±7.5	150	160±5.9
Dates		1960	3	50±7.3	60	88±12
Figs		1960	8	84±16	140	220±18
Prunes		1960	2	29±2.9	39	49±4.4
Raisins		1960	5	49±7.8	83	130±8.0
Sea foods.						
Chicken haddies		1957	1		14±8.1	
Clams		1957	3	20±5.1	29	43±5.3
Crab meat		1957	6	N.S.	33	82±8.2

2 Values given refer to the weight of one liter of the commercial preparation.

Table III (continued).

Variety	Year of Packing	Year of Purcha-sing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
Sea foods. (continued).						
Fish cakes		1957	2	20±4.9	22	24±5.7
Lobster		1957	4	9.9±6.3	14	15±6.0
Oyster		1957	2	N.S.	20	39±24
Sardines		1957	3		N.S.	
Sea trout		1957	1		N.S.	
Shrimps		1957	3	N.S.	8.3	25±10
Tuna		1957	11	N.S.	18	50±94
Salmon:						
Keta						
-Canada		1957	8	N.S.	40	110±21
-Japan		1957	0		--	
Medium red cohoe						
-Canada		1957	2	62±6.2	91	120±17
-Japan		1957	2	40±11	80	120±15
Pink						
-Canada		1957	13	N.S.	14	36±7.5
-Japan		1957	7	N.S.	27	50±10
Red cohoe						
-Canada		1957	5	N.S.	5.0	15±3.4
-Japan		1957	10	N.S.	30	93±11
Red sockeye						
-Canada		1957	27	N.S.	22	82±15
-Japan		1957	13	N.S.	19	53±11
Bone flour.						
	1959		10	3100±1200	5700	9400±1200
	1960		2	3000±1200	5900	8800±1500

Table III (continued)

Variety	Year of Packing	Year of Purchasing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
Beverages.						
Cereal		1961	8	58±28	160	250±13
Cocao		1961	5	230±8.7	270	320±9.0
Coffee		1961	2		140±12	
Coffee (instant)		1961	1		200±8.7	
Tea:						
Broken orange pekoe						
-Ceylon	1958		2	980±82	1200	1400±74
-Formosa	1959		1		3900±90	
-Iran	1958		1		2900±150	
-Japan	1958		1		1600±58	
Broken pekoe						
-Ceylon	1958		4	670±28	1300	1700±64
	1959		2	780±46	1300	1900±64
-Kenya	1959		1		1700±76	
Black						
-Ceylon	1958		1		580±65	
-Formosa	1958		1		2200±10	
-Mozambique	1959		1		790±49	
Black broken						
-Amaravilla	1958		1		600±20	
-Japan	1958		1		780±28	
Black fannings						
-Ceylon	1958		1		1900±68	
	1959		4	980±54	2000	3500±150
-Kasaky	1958		1		750±22	
-Kenya	1959		1		2300±110	
-Nyasaland	1958		1		440±40	

Table III (continued)

Variety	Year of Packing	Year of Purchasing	Number of samples	Lowest mmc/kgm (fresh wt)	Average mmc/kgm (fresh wt)	Highest mmc/kgm (fresh wt)
<u>Beverages.</u> (continued).						
Tea: (continued).						
Green						
-Japan	1958		3	4000±150	4600	5000±190
	1959		1		7900±220	
Green siftings						
-Japan	1958		1		9500±280	
	1959		1		7400±200	
Green pan-fired						
-Japan	1958		2	830±71	2600	4400±76
Tea mixture						
-Ceylon	1958		2	460±49	830	1200±44
	1959		3	440±46	870	1600±74
-Iran	1958		2	750±55	790	830±33
Broken mixture						
-Ceylon	1959		3	1300±71	1500	1700±82
Mixed fannings						
-Ceylon	1958		5	1500±76	3500	6100±250
	1959		7	890±44	1800	5200±230
Tea dust						
-Ceylon	1959		1		1500±57	
-Uganda	1958		1		490±25	
Tamella broken						
-Ceylon	1959		1		990±35	

Table IV

DETERMINATION OF THE PERCENTAGE OF THE ORIGINAL BETA ACTIVITY PASSING INTO SOLUTION WITH DIFFERENT VARIETIES OF TEA

Original Solid	Solid Residue	Solution		
mmc/kgm (fresh weight)	mmc/kgm(1)	mmc/kgm(1)	mmc/cup	% of original solid activity
2400±72	2200±59	350±22	0.80±.05	14.6%
4400±76	3200±71	440±68	1.20±.08	10.0%
3900±90	3200±69	390±42	1.10±.10	10.0%
1700±76	1400±57	270±31	0.90±.10	15.9%
1600±74	1300±62	260±46	0.70±.10	16.6%
7400±200	5800±160	650±40	1.60±.10	8.8%

(1) refers to kilogram of original solid used to prepare the solution. Recipe: one teaspoon of tea per cup of boiling water. Standing time before filtering: 30 minutes.

Table V

TOTAL[1] BETA RADIOACTIVITY OF ASHED MATERIAL FOLLOWING TREATMENT WITH AMMONIUM OXALATE

Type of food	No of samples	Lowest mmc/kgm. (fresh wt)	Average mmc/kgm. (fresh wt)	Highest mmc/kgm. (fresh wt)
Meat broth[2]	11	N.S.	1.5	8.8±7.1
Miscellaneous processed foods for babies[2]	3	N.S.	5.3	16 ±8.1
Processed vegetables and fruits for babies[2]	46	N.S.	5.9	22 ±4.7
Fruit juice[2]	11	N.S.	14	33±3.5
Processed fruits[2]	9	N.S.	21	64±3.4
Sea foods	123	N.S.	23	120±15
Cereals for babies	31	N.S.	38	130±20
Cereals for adults	70	N.S.	73	250±15
Dried fruits	27	25±5.3	110	350±18
Coffee	3	140±6.5	160	200±8.7
Cereal beverages	8	58±28	160	250±13
Cocoa	5	230±8.7	270	320±9.0
Tea	58	440±40	2200	9500±280
Bone flour	12	3000±1200	5700	9400±1200

(1) This does not include the contribution of potassium 40 and other alkali metals.
(2) Values given refer to the weight of one liter of the commercial preparation.
N.S. : not significant. Activity below the sensitivity of the detector used.
Sampling dates: from 1945 to 1961.
Beta counting: 1960-1961.

FUTURE SCOPE OF THE SURVEY

It is planned to extend this survey to other types of food. Some of those listed in Table III are being checked with further samples. Absolute strontium-90 and calcium determinations will be conducted on a number of samples from each type.

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Part III - Interpretive Reports and Notes

"Development of Sampling Equipment Used in the Upper Atmosphere Monitoring Program" - by Wood, R. C., the Electronics Group of General Mills, Inc.

"Re-evaluation of Ash Can Volume Data" - by Telegadas, K., U. S. Weather Bureau.

"Global Atmospheric Radioactivity, May-June 1960 and November 1960" - U. S. Weather Bureau.

"Distribution of Radioactivity with Respect to Tropopauses and Jet Streams" - by Giles, K. C., U. S. Weather Bureau.

"Global Integrals of Monthly Strontium-90 Fallout, January 1958 - December 1960" - by Telegadas, K., U. S. Weather Bureau.

"A Simple Correlation Analysis Between Strontium-90 from Fallout and Precipitation Rates" - by Ong, L. D. Y., Health and Safety Laboratory.

"Ce^{144}/Sr^{90} Ratios in Precipitation and in Air" - by Frankel, R. and Salter, L., Health and Safety Laboratory.

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"Strontium-90 Concentration in the Palo Alto Water Supply" - by Kruger, P. and Hamada, G., Hazleton-Nuclear Science Corporation.

"Tri-City Diet Studies - Fourth Sampling" - by Rivera, J., Health and Safety Laboratory.

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August 15, 1961

DEVELOPMENT OF SAMPLING EQUIPMENT USED IN THE UPPER ATMOSPHERE MONITORING PROGRAM

by

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Development of Sampling Equipment
Used in the Upper Atmosphere Monitoring Program

by

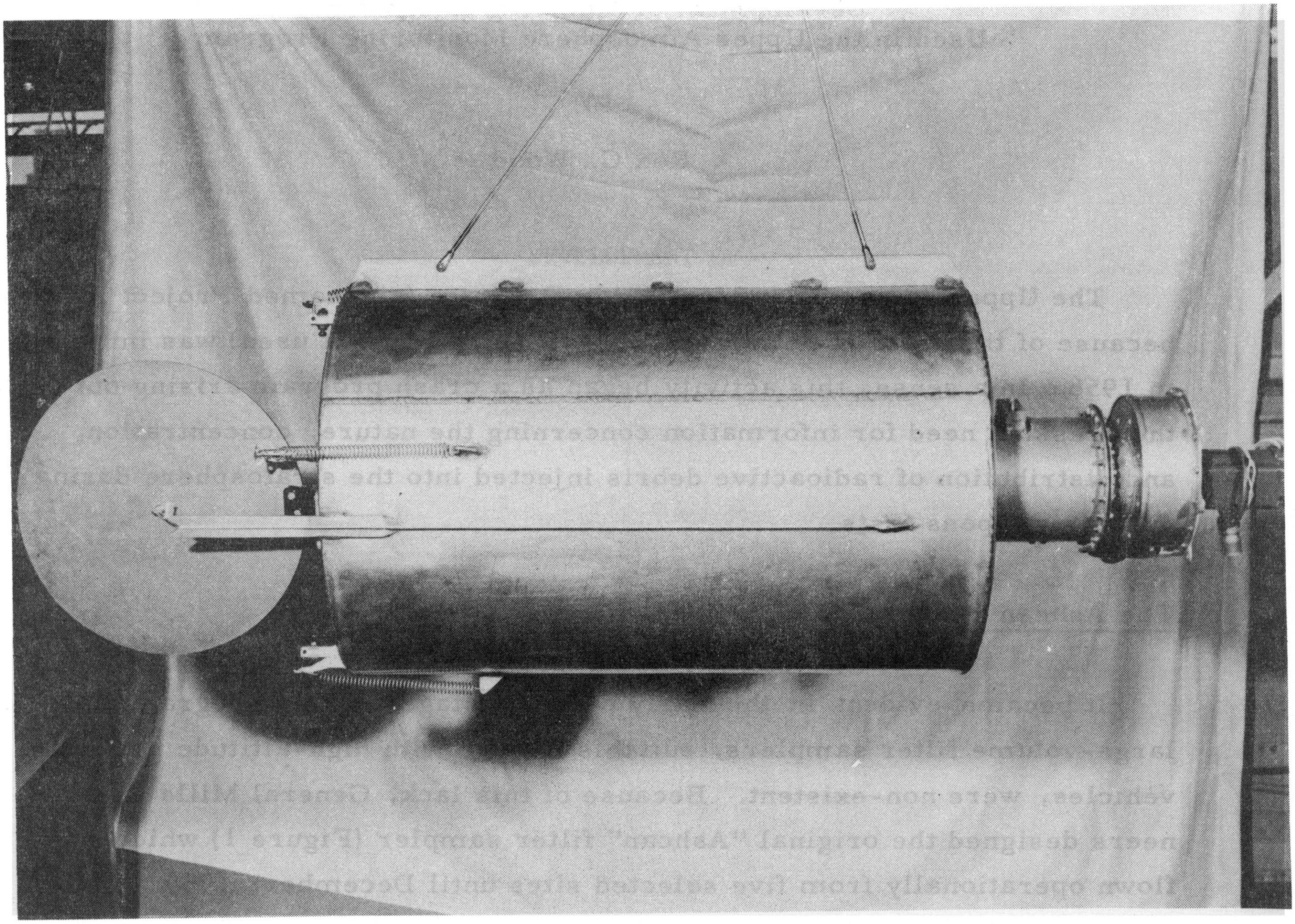
Rex C. Wood

The Upper Atmosphere Monitoring Program (nicknamed Project Ashcan because of the classical shape of the first sampling unit used) was initiated in 1956. In a sense, this activity began as a crash program arising out of the pressing need for information concerning the nature, concentration, and distribution of radioactive debris injected into the stratosphere during nuclear weapons tests.

The Ashcan Sampler

It became evident in the early planning stages of this program that large-volume filter samplers, suitable for use with high-altitude balloon vehicles, were non-existent. Because of this lack, General Mills engineers designed the original "Ashcan" filter sampler (Figure 1) which was flown operationally from five selected sites until December, 1959. This sampler utilized a Torrington 403 blower to pull air through five square feet of low background, low pressure drop filter paper, manufactured by the Institute of Paper Chemistry. Sampling rate depended upon altitude and voltage applied, but averaged between 500 and 600 cfm. Because there were no means for measuring air flow directly, volumes were extracted from a table in which sampling rate was related to telemetered blower rpm and altitude. This table was derived from the experimentally determined pressure drop characteristics of an average filter mat, and from performance curves furnished by the blower manufacturer.

Early in 1957, a critical re-examination of the Ashcan system was undertaken by General Mills, Inc. in a research program supported by the AEC. One outcome of this was the introduction of 40-foot exhaust ducts



Ashcan Aerosol Sampler
(Watertight version used at Panama)

Weight,	Sampler	45 pounds
	Batteries and aux. equip.	120 pounds
Blower		Torrington - 403, .25 hp
Filter		5 ft^2, IPC paper
Sampling Rate		500-600 cfm @ 65,000'
Sampling Efficiency		30-70% depending upon altitude, particle size, particle density
Volume Determination		From telemetered blower rpm
Dates Used		November 1956 to December 1959

Figure 1

with a view toward preventing re-entrainment of sampled air. Comparative flight tests of ducted and unducted samplers were performed at Minneapolis during 1958[1], and ducts were subsequently added to all operational flights beginning January, 1959. It should be pointed out, however, that comparative flight tests had not yielded conclusive evidence of any significant differences between sample activities obtained from ducted and unducted systems.

The most serious deficiency of the Ashcan system was revealed by S. C. Stern[2] and others at GMI through laboratory tests which indicated that the filtering efficiency of the unit was quite low, and a function of the following variables:

1) Air velocity through the filter (blower speed).

2) Air density (altitude).

3) Particle size.

4) Particle density.

(It is, of course, possible to go back and adjust past Ashcan data on the basis of a calculated filtering efficiency, but this must involve assumptions as to the size distribution of the aerosol and particle mass.)

<u>The Direct Flow Filter Sampler</u>

As laboratory tests provided increased knowledge of factors involved in high-altitude particle collection by filtration, it became apparent that there were two approaches by which higher filtering efficiency could be achieved:

1) By increasing the air velocity through the IPC filter mat (shift operation into the impaction regime).

2) By changing to a filter mat of higher density.

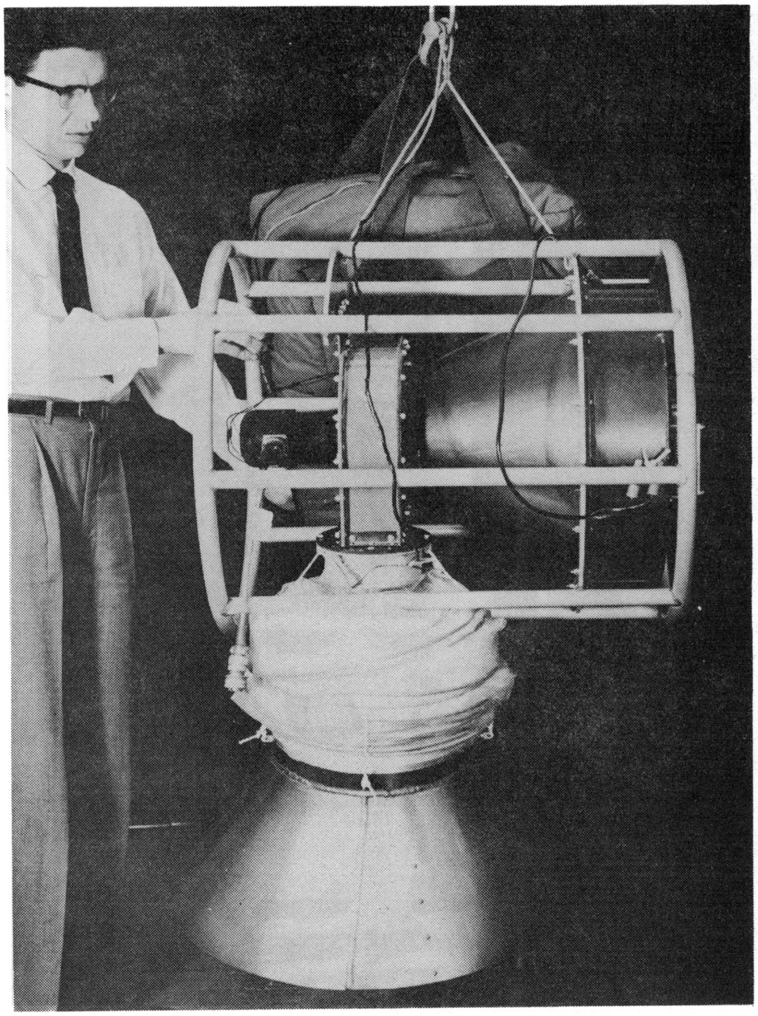
Stern chose the first option and developed the Direct Flow Filter Sampler shown in Figure 2. This unit utilizes one square foot of IPC filter paper instead of the five square feet used by the Ashcan sampler. Flow rates of 500 to 800 cubic feet per minute are achieved through use of a Torrington 704 blower, powered by a 0.52 hp Westinghouse aircraft motor. This unit presented a number of advantages with respect to weight, ease of handling, etc., but most important was the higher efficiency (90 - 97%) achieved through use of face velocities of 500 to 800 feet per minute.

A flight test program performed at Minneapolis during 1958 - 1959, demonstrated this rather conclusively[(3)], showing that two to three times as much activity per thousand standard cubic feet was obtained by the Direct Flow Samplers than was obtained by standard Ashcan units flown on the same balloon. As a result, the Direct Flow Sampler replaced the Ashcan filter sampler at San Angelo on January first, 1960. (Units initially flown at San Angelo were powered by surplus Torrington 403 blowers at some sacrifice in performance. All units flown after April 1, 1960 used the larger, Torrington 704 blower.)

Improved Direct Flow Filter Sampler

Under the present extension to Contract AT(11-1)-401 with the AEC, General Mills, Inc., is redesigning the Direct Flow Filter Sampler with a view toward increased utility and reliability in operational field use. While retaining the same proven blower, and the one square foot of filter area, the new unit is considerably more compact and utilizes aluminum spinnings in its construction. See Figure 3. Elimination of the 40-foot collapsible duct; formerly used and substitution of a short, thin wall, vertical exhaust stack, should increase system reliability and reduce the possibility of air flow blockage as suggested by Telegadas[(4)] in this HASL quarterly.

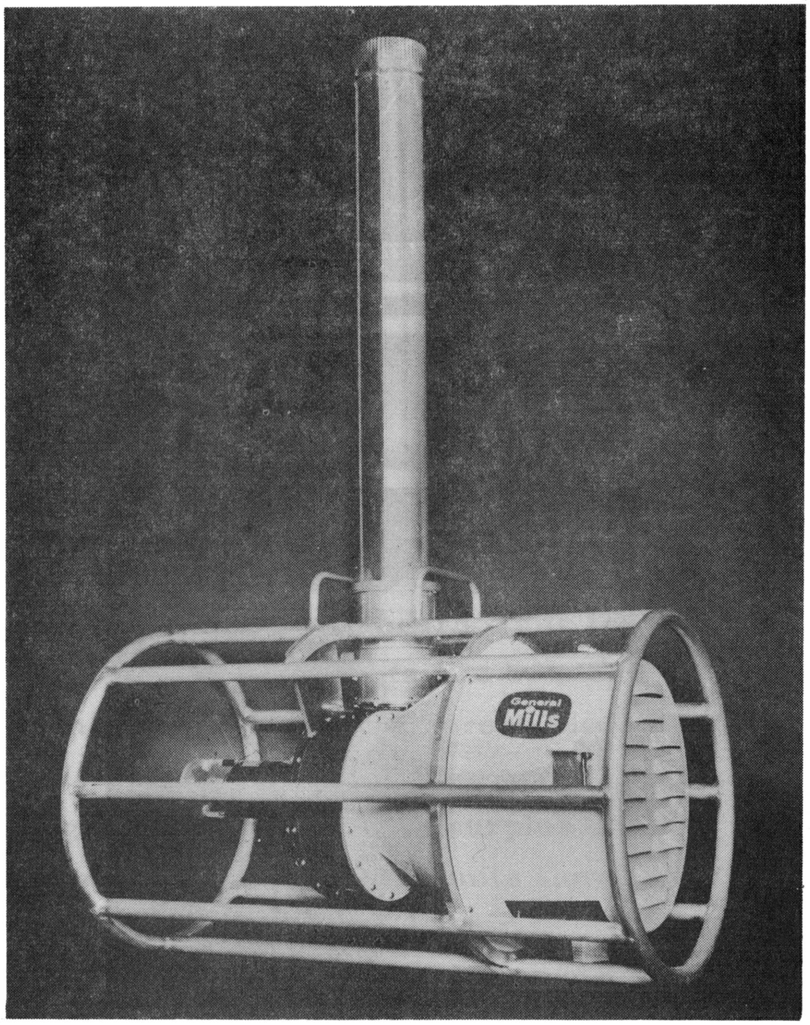
To date, two units have been flown successfully for 3-1/2 hours at 106,000 feet. See Figure 4. An additional flight to 110,000 feet is planned as a test of the blower's ability to withstand sustained operation at high rpm.



Direct Flow Aerosol Sampler
(with exhaust duct)

Weight, Sampler	40 pounds
Batteries and aux. equip.	120 pounds
Blower	Torrington - 704, .52 hp
Filter	1 ft^2, IPC paper
Sampling Rate	600-800 cfm @ 65,000'
Sampling Efficiency	90-97%
Volume Determination	From telemetered blower rpm, totalizing veeder-root counter, and/or PR-2 flowmeter
Dates Used	January 1960 to present

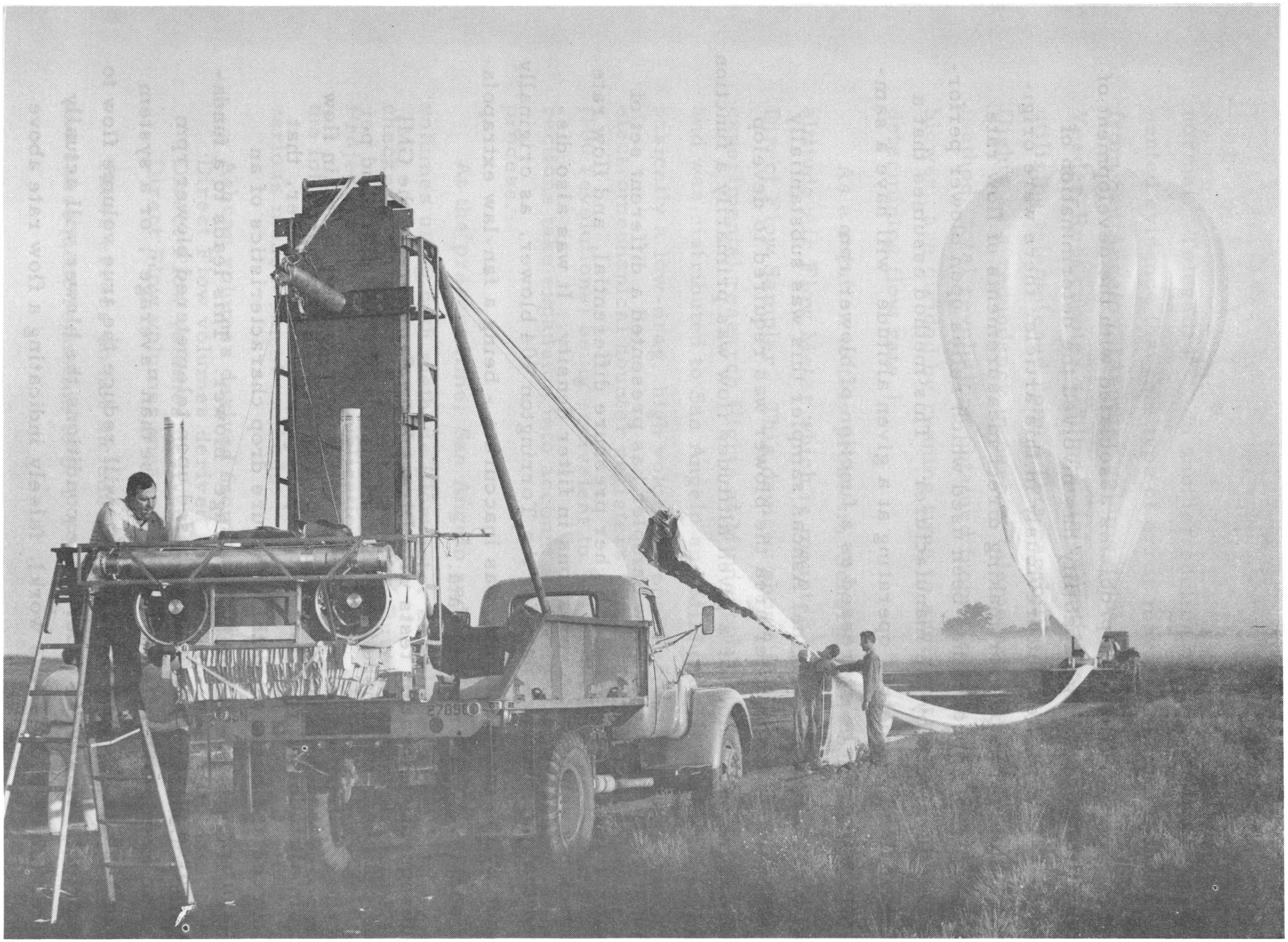
Figure 2



Improved Direct Flow Aerosol Sampler
(for operational field use)

Weight, Sampler	35 pounds
Batteries and aux. equip.	110 pounds
Blower	Torrington - 704, .52 hp
Filter	1 ft^2, IPC paper
Sampling Rate	600-800 cfm @ 65,000'
Max. Operating Altitude (est.)	120,000 ft (at reduced power)
Sampling Efficiency	90-97%
Volume Determination	From telemetered blower rpm and/or from PR-2 flowmeter.
Dates Used	Experimental tests began July 1961

Figure 3



Experimental Flight Train Before Launch of Improved Direct Flow Filter Units and Electrostatic Precipitator

Figure 4

Volume Determinations

One of the most difficult problems associated with the development of the high altitude sampling capability has involved the determination of volume flow. As pointed out previously in this article, there were originally no suitable methods for making direct measurements of flow rate, hence an indirect approach has been used which relies upon blower performance data furnished by the manufacturer. This method assumes that a sampler of fixed geometry, operating at a given altitude, will have a sampling rate which can be expressed as a function of blower rpm.

With respect to the original Ashcan sampler this was substantially true, since with a large filter area the blower was required to develop little pressure drop and, for a given altitude, flow was primarily a function of motor speed.

Adoption of the Direct Flow Sampler has presented a different set of problems since it operates at a higher pressure differential, and flow rate is appreciably sensitive to variations in filter density. It was also discovered that performance data for the Torrington 704 blower, as originally furnished by the manufacturer, was inaccurate - being a fan-law extrapolation of sea-level performance data.

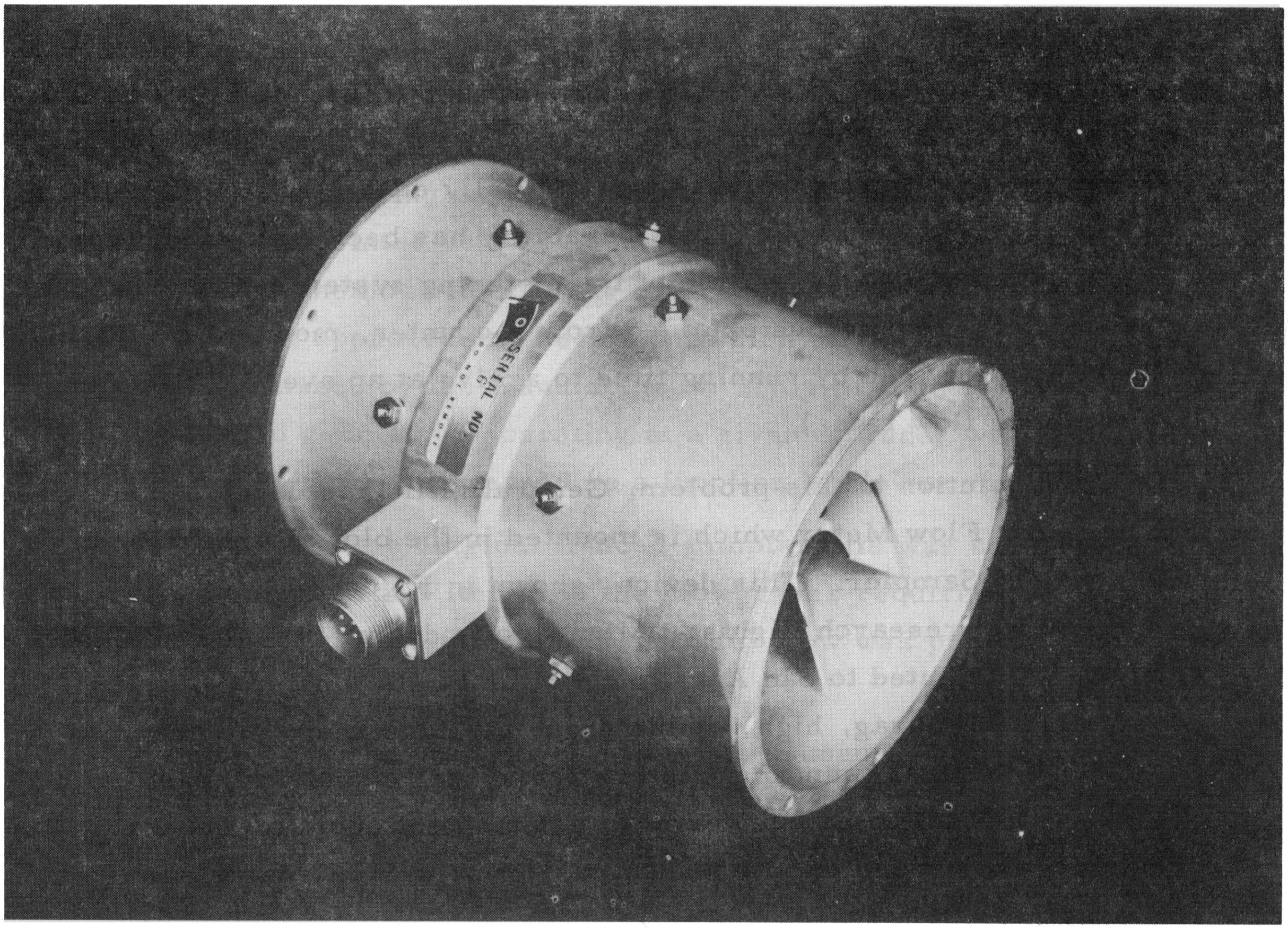
Subsequent calibration tests with Direct Flow Samplers in the GMI altitude chamber, established the characteristics of these units and permitted the construction of curves which are presently used to obtain flow rate from altitude and rpm data. It may be pointed out, however, that these curves are based upon the pressure drop characteristics of an "average" IPC filter mat and an "average" blower. This leads to a fundamental source of error in volumes based upon telemetered blower rpm data. For example: a filter mat more dense than "average", or a system blockage such as a fouled exhaust duct, will reduce the true volume flow to below normal. However, under these conditions the blower will actually run faster (since it does less work), falsely indicating a flow rate above normal. Telegadas[4], in another section of this HASL quarterly, has presented evidence that this type of error may be present in balloon flight data from San Angelo. (Another volume determination method, based upon Veeder-Root counter readings, is essentially equivalent to the method utilizing telemetered rpm. This capability has been included on some flights as a redundancy in case of telemetering system failure. In the V-R method, total revolutions obtained from a counter, mounted on the motor-blower, are divided by running time to arrive at an average rpm used in determining flow rate.)

As a solution to this problem, General Mills has developed a high-altitude Air Flow Meter which is mounted in the blower exhaust duct of the Direct Flow Sampler. This device, shown in Figure 5, was tested on experimental research flights at Minneapolis during the latter half of 1960 and was distributed to San Angelo and Mildura stations early in 1961. It is basically a low-drag, high volume propeller-type anemomenter. An electromechanical counter registers propeller revolutions, each count (100 revolutions) being equivalent to 9.5 ambient cubic feet of air. Corrections take expansion into account as air is warmed in the sampling process.

At the present time, San Angelo and Mildura stations are calculating volumes using both methods (flowmeter and blower rpm). These are checked critically by the U.S. Weather Bureau Meteorological Research Projects Branch before publication in HASL. In the opinion of this author, the following error limits are considered reasonable with respect to the various measurement methods:

Ashcan volumes derived from telemetered rpm data	± 20%
Direct Flow volumes derived from telemetered rpm data	± 20%
Direct Flow volumes derived from Veeder-Root counter data	± 20%
Direct Flow volumes measured by PR-2 flowmeters	± 5%

These errors do not include uncertainties involving sampling altitude and subsequent reduction to S. T. P.



PR-2 High Altitude Air Flow Meter

Figure 5

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REEVALUATION OF ASH CAN VOLUME DATA

Kosta Telegadas
U. S. Weather Bureau

The determination of volumetric air flow rates through balloon-borne particulate air samplers is necessary for the evaluation of the concentration of radioactive particles in the atmosphere. The volume has been determined from knowledge of blower speed and the fan laws. A reevaluation of earlier balloon volume data from AEC sponsored programs has been instituted. Preliminary results indicate that the blower speed can be used as a criteria in assessing the reliability of the sampling equipment.

Recently General Mills, Inc., who has been actively engaged in developing, improving, and testing air sampling equipment from the beginning of the AEC balloon program, issued their latest, and supposedly final, flow rate curves as a function of altitude and blower speed. Since the U. S. Weather Bureau was given the job of management and operational control of the AEC balloon program at San Angelo, Texas, it was decided to recompute all of the balloon sample volumes, using the latest flow rate curves and original in-flight data.

To date, the data from San Angelo, Texas; Sioux City, Iowa; São Paulo, Brazil; Minneapolis, Minnesota; and Panama Canal Zone, have been recomputed for the period from January 1958 to the present (or whenever the balloon station terminated). In the course of this work it became apparent that the blower speed was a function of altitude and had little variability at any one altitude. Since abnormally high and low blower speeds were encountered on several occasions, it was decided to see if there was any relationship between the reported radioactivity concentrations and the blower speeds. Two different blower/motor combinations, Torrington 403 blower/Eemco motor (used with both Ash Can and Direct Flow Samplers) and Torrington 704 blower/Westinghouse motor (used only with the Direct Flow Sampler) have been used during this program. The Sr-90 activity (d/m/1000 SCF of air) was plotted as a function of altitude, blower speed, and blower/blower motor combination and is shown in Figures 1 and 2. For a detailed discussion of the various sampling units, blower and volume determination techniques, see article by Rex C. Wood in this HASL quarterly.

Figure 1 shows Sr-90 activity as a function of blower speed and altitude for the Ash Can and the Direct Flow sampling units which used a Torrington 403 blower with an Eemco motor. Figure 2 shows similar data for the Direct Flow sampling units which used a Torrington 704 blower/Westinghouse motor combination. It is clearly seen that the blower speed on the average, groups about an average value which is a function of altitude. The dashed line represents what is believed to be the upper limit of blower speeds for sampling equipment that is functioning properly with the following applied voltages: 50,000 feet, 24 volts; 60,000 and 65,000 feet, 24-30 volts; 70,000 feet, 24-30 volts; 80,000 and 90,000 feet, 22.5-24 volts. The probable significance of blower speed variations is discussed below:

<u>Normal Blower Speed</u>

As has been stated previously, there is little variability of the blower speed about the average at any one altitude. The variability can probably be attributed to non-uniformity in the filter paper from one flight to another (2) and blowers of the same model may not have identical characteristics (3).

Blower Speed Above Normal

A blower speed above normal could probably be attributed to a closed sampling door or a constriction in the exhaust duct system.

If the sampling door was closed during the sampling period, the blower would do less work in moving the air and therefore, its speed would increase. This also means that since virtually no air has passed through the sampling system the activity should be almost zero.

In 1957 GMI proposed (2) using a collapsible duct made of polyethylene approximately 50 feet long suspended below the air mover so that the possibility of resampling exhaust air would be at a minimum. A malfunction in the extension or a constriction in the exhaust duct would cause the air to exhaust at a slower than normal rate, or not at all. If this occurs the blower would have to do less work and therefore, increase in speed. During one of GMI's experimental flights (4) the exhaust duct was visually observed to extend about half its normal length. The blower speed during this flight was reported to be about 50 cycles per second above normal. A pressure differential gauge to measure the pressure drop across the filter paper was available during this flight and indicated a pressure drop of almost zero. This confirmed the fact that the exhaust duct had malfunctioned and restricted the flow of air through the system. Exhaust ducts were first used at San Angelo and Sioux City in August 1959.

Blower Speed Below Normal

Three reasons come to mind that may cause a blower speed to operate below normal, these are: A hole in the sampling filter paper, a voltage drop across the blower motor and faulty blower motor.

No case has been reported to date, to this writer's knowledge, of the filter paper having holes in it. In a recent report (1) the below normal blower speed was attributed to either a poor battery cell or poor battery inter-cell connection which may have dropped the voltage 2 or 3 volts during the period of high current drain. This type of low blower speed should not affect the computed volume although it may affect the collection efficiency of the sampler which is presumably a function of the face velocity on the filter paper. Erratic blower speeds could be caused by a faulty blower motor. This condition would have little bearing on the volume as long as a continuous record of the blower speed is available during the collection period.

In order to verify that the reported Sr-90 activity per unit volume is in error for cases where the blower speed is apparently above normal, the trend in the activity as a function of time has been plotted for the period January 1959 - February 1961 for San Angelo and Sioux City and is shown in Figure 3.* The Sr-90 activity values are in units of d/m/1000 SCF of air using the recomputed volumes. Whenever the volume was computed for a blower speed which apparently was above normal, the activity value has been placed in parenthesis. As can be seen from Figure 3 for all cases except one where the blower speed was above normal the activity per 1000 SCF appears to be abnormally low. The one case which appears at 70,000 feet for January 1960 appears to be normal and it is not known why this is an exception to the rule.

The 50,000-foot level is not included in this figure as a much greater variability is expected in the activity due to the sampling altitude being so close to the tropical tropopause. Special mention should be made of the 50,000-foot balloon samplers. For San Angelo flights, prior to August 1960, Ash Can and Direct Flow Samplers which use the Torrington 403 blower and Eemco

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* Samples with a Cs-137/Sr-90 activity ratio lower than 1.0 and higher than 3.0 probably suffer from analytical errors (5). Eight samples were eliminated for this reason.

motor were flown with 24 volts applied to the samplers. The average blower speed for these flights, as seen from Figure 1, was about 130 cycles per second. Beginning in August 1960, step flights at 50,000 and 60,000 feet were flown with 30 volts applied to the samplers. The increased voltage increased the average blower speed at 50,000 feet to 170 cycles per second (not shown in Figure 1).

It is not known quantitatively how any malfunction in the sampling system, such as a closed sampling door, malfunction in any of the mechanical components of the system or malfunction in the exhaust duct is related to the air that actually passes through the filter medium. All that can be said is that when the blower speed appears to be above normal, the sampling system may not be operating normally and therefore, the computed volume which is based on blower speed is most likely in error. Isotopic activity ratios are not affected by the volume of air sampled even though the blower speed is above normal. In Figures 1 and 2 the line which is supposed to delineate normal and above normal blower speeds is subjective and is only meant as a guide in determining if a volume is suspect when no other information is available.

During the latter part of 1960 a series of flights were made in which the Ash Can and Direct Flow sampling units were flown simultaneously. These intercomparison tests were not too successful since in 9 out of 14 cases either one or both units operated at a blower speed which was above normal. The intercomparison program is continuing.

As an independent check on the validity of the blower speed line in Figure 2 the data which has been collected at Mildura, Australia since December 1959 will be used. The original in-flight data has been requested for all Australian flights so as to get an insight to any malfunctioning in the system that may have been reported. At present only a limited amount of Sr-90 data are available for this site and when more become available from both Mildura and San Angelo, they will be used to see if a less subjective delineation of acceptable blower speeds may be made.

A new volume measuring device, called the PR-2 air flow meter has been developed to measure directly the quantity of air passing through the sampling unit. This measuring device is now in operation at both sampling sites and should give more accurate volume data. The blower speed is also being telemetered and therefore this data together with the flowmeter data should give us a better idea of the orientation of the blower speed line.

In addition to the improved volume measuring device, one other source of trouble that was encountered during these flights, possible malfunction of the exhaust ducts, will be eliminated in the near future by redesign of the sampling unit.

Future plans call for a continuation of the recomputation of balloon volume data for the period prior to 1958 and reporting the new data in future HASL reports.

ACKNOWLEDGMENTS

Grateful acknowledgment is due the 1110th Balloon Activities Squadron, Headquarters Command,USAF, Goodfellow Air Force Base, Texas, for not only flying the balloons but also assisting in the compilation of this data.

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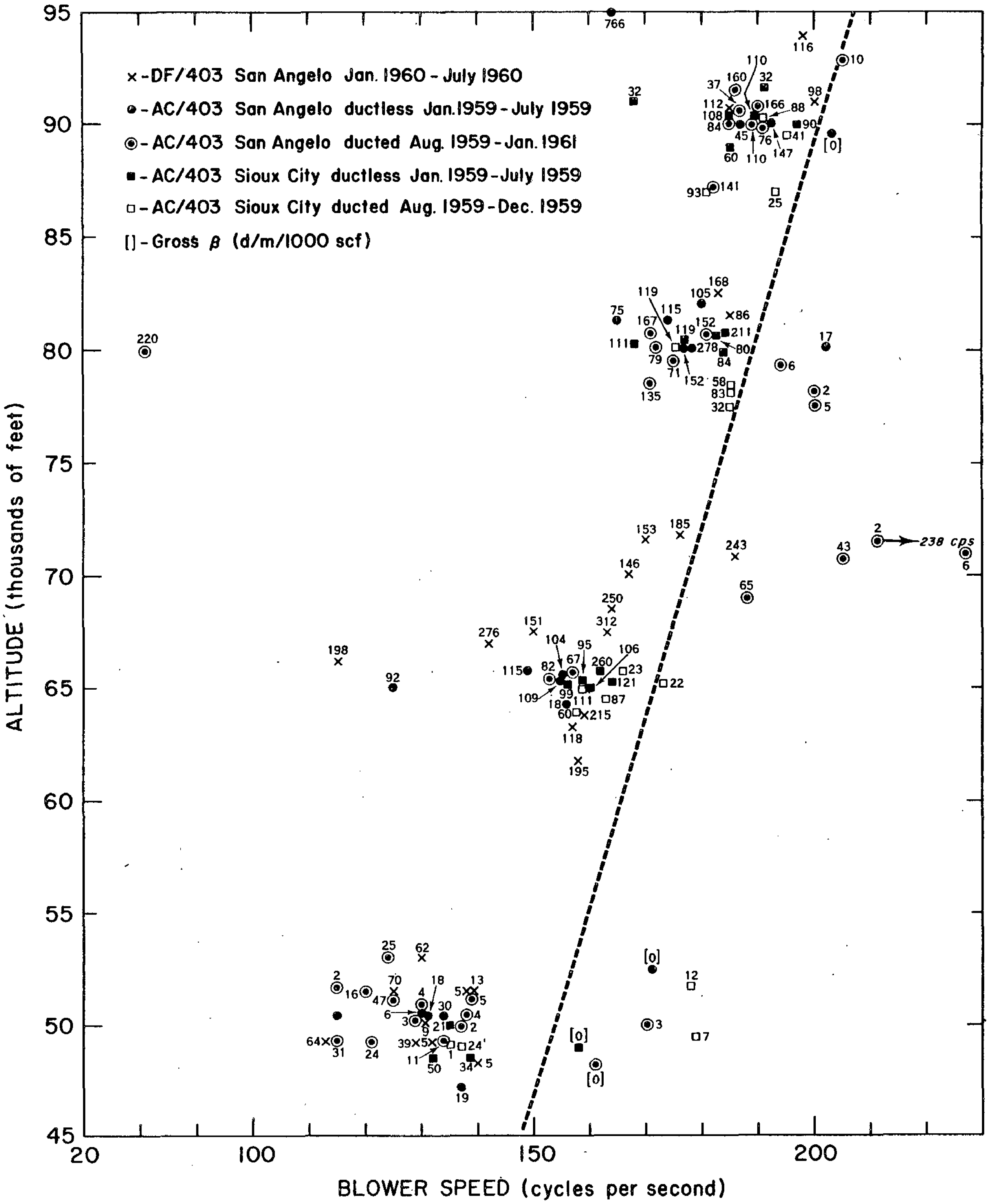

Figure 1. Sr-90 (d/m/1000 scf) as a function of altitude and Torrington-403 blower speed

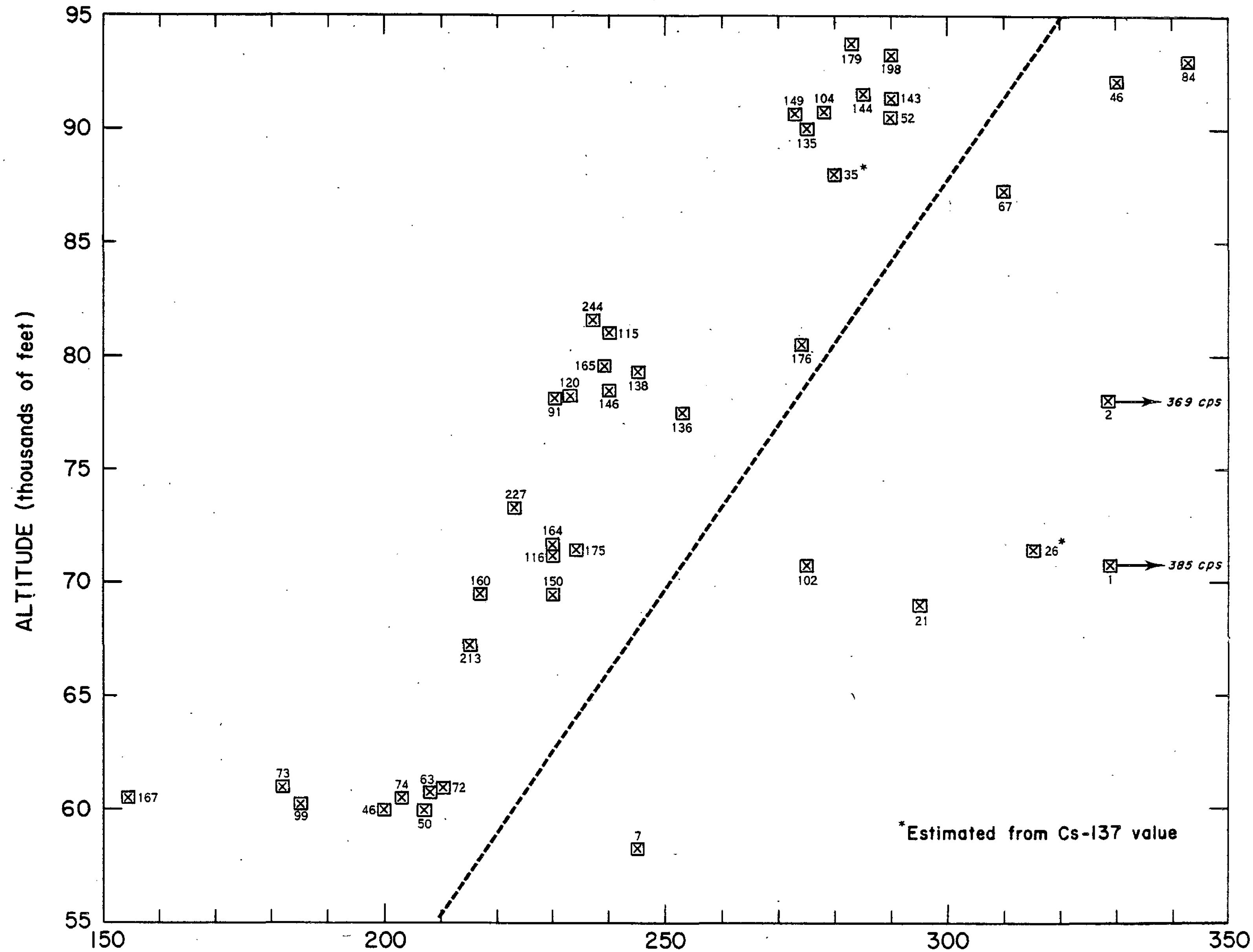

Figure 2. Sr-90 (d/m/1000 scf) as a function of altitude and Torrington 704 blower speed-San Angelo, Texas

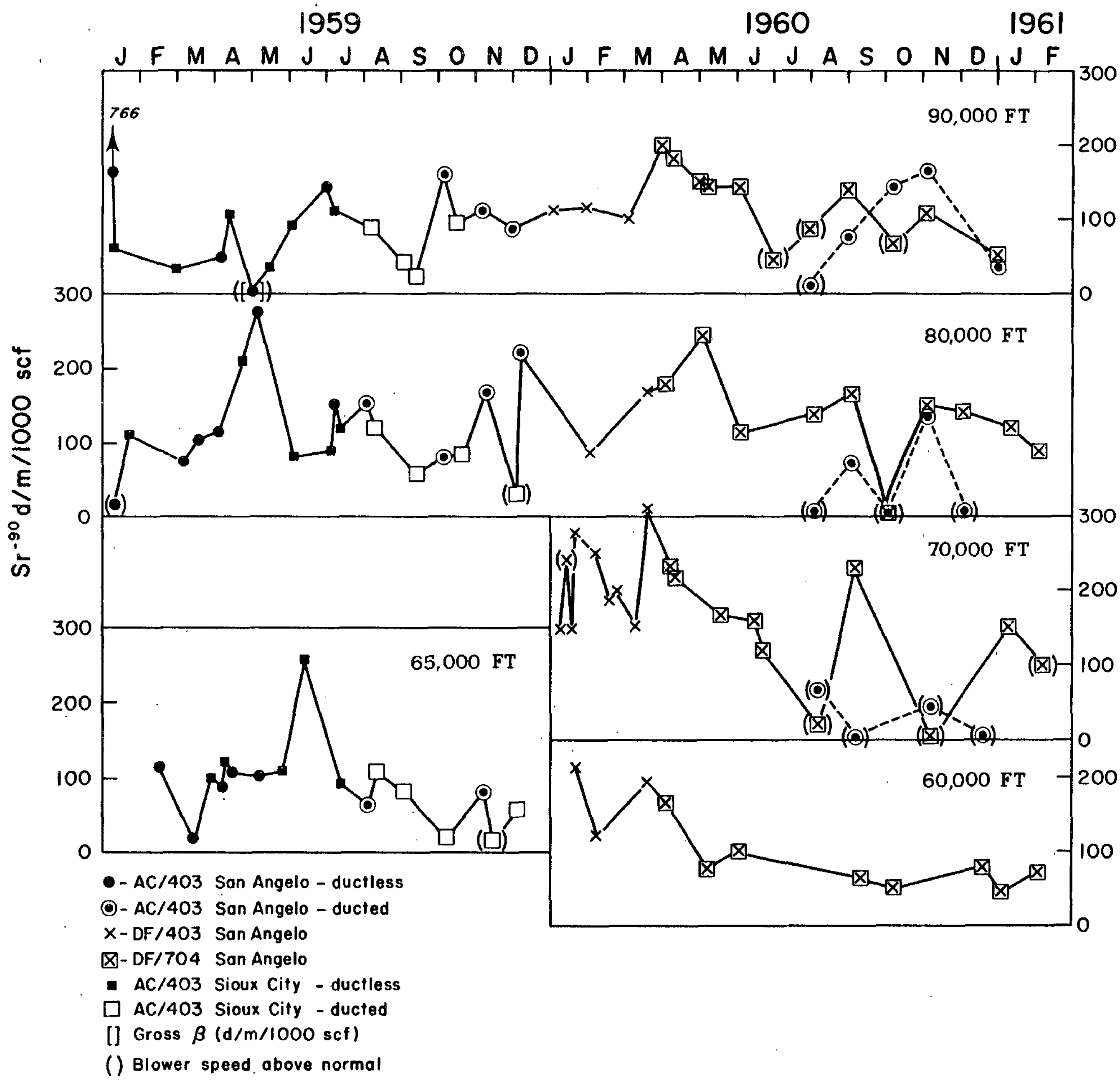

Figure 3. Varibility of Sr-90 with time

GLOBAL ATMOSPHERIC RADIOACTIVITY, MAY-JUNE 1960 and NOVEMBER 1960

U. S. Weather Bureau

Introduction

In late May 1960 and again in November 1960 USAF aircraft were deployed to make a series of vertical profiles of particulate radioactivity in the atmosphere. These were made in the vicinity of four latitudes: 70°N, 35°N, 10°N and 40°S. Longitudes depended on operational exigencies. Altitudes sampled were 15,000 feet, 25,000 feet, 40,000 feet, 50,000 feet, 60,000 feet, and a layer near 65,000 feet. B-57 aircraft were used for the lower altitudes, U-2 aircraft for the upper. Radiochemical analysis was by a government laboratory.

These data were collected as part of a cooperative effort by the U.S. Department of Defense, Atomic Energy Commission and Weather Bureau, and is a continuation of similar sampling programs conducted in the past by the Department of Defense. Preliminary results from the May-June 1960 program have already been given (1) and are repeated here with corrections where applicable. (Significant changes from the earlier data are underlined in the tables.)

Sampling Equipment

The B-57 aircraft were equipped with wing-tip filter tanks having an exposed filter area of 1.75 square feet. The U-2 aircraft used hatch samplers with a filter area of 1.38 square feet. Volume calibration of the samplers was made on the basis of theoretical aerodynamic properties of the samplers and by wind-tunnel and flight tests. U-2 volume data is based on a recent recalibration (2). It is estimated that the overall volume error is no more than 20%. The filter media (3) was IPC-1478, an impregnated porous paper with low resistance to air flow and a high retentivity for sub-micron particles at the flow rates employed.

Data

A summary of the data collected is given in the tables.

Date	Day (GCT) on which the filter was extracted from the aircraft, immediately after landing.
Latitude Longitude	Region of flight to nearest whole degree.
Altitude	Pressure altitude at which sampling was performed. At the highest altitude, sampling was performed during a slow climb to attain maximum possible altitude.
Exposure	Time period (minutes) over which the sample was collected.
Volume	Reported in units of 1000 standard cubic feet (SCF) of air, computed at 1,013 mb. and 59°F. 1000 SCF = 34.6 kg of air.
Tropopause height	Height of tropopause as reported by a nearby radiosonde station.
Isotopic data	All data are reported in units of disintegrations per minute per 1000 SCF. Data for Be-7, Sr-90, Zr-95, Cs-137, and Ce-144 are corrected to day of extraction of the filter, Rh-102 to Aug. 12, 1958, and W-181 and W-185 to Aug. 15, 1958. Pb-210 data represent the beta measurements of the Bi-210 daughter, corrected to equilibrium with Pb-210 at time of separation. In addition to the nine isotopes listed, most filters were also examined for Sr-89 and Ba-140, neither isotope was detected in resolvable amounts. The following decay constants were used:

Isotope	Half-Life Days	Decay Constant $Days^{-1}$
Be-7	53.0	0.0131
Sr-90	10104	0.0000686
Zr-95	63.8	0.0109
Rh-102	210	0.00330
Cs-137	9708	0.0000714
Ce-144	278	0.00245
W-181	120	0.00578
W-185	76.2	0.00910
Pb-210	8030	0.0000863

Unless otherwise indicated, the precision of the radiochemical analysis is within 3%. Standard errors in the analysis greater than 3% are indicated by a lower case letter following the value in accordance with the following code:

a	3-10%
b	10-20%
c	20-40%
d	40-100%

Lost indicates the isotope was lost in the radiochemical analysis.

N.R. indicates the isotope was not detected in resolvable amounts.

NOTE: Underlined data indicates a change of more than 5% in previously reported values.

ACKNOWLEDGMENTS

This program would not have been possible without the cooperation of the governments of Argentina and Australia.

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TABLE I

ATMOSPHERIC RADIOACTIVITY DATA, MAY-JUNE 1960

Date 1960	May 17	May 20	May 24	May 20	May 24	June 1	May 20	May 24	May 19	May 23
Latitude	70°N	70°N	70°N	34-36°N	35-36°N	36°N	10°N	10°N	40°S	40°S
Longitude	154°W	154°W	154°W	105°W	105°W	105°W	122°E	122°E	62°W	62°W
Altitude (Ft.)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	120	120	120	120	120	120	120	120	120	120
Volume (1000SCF)	294	262	286	542	538	523	267	260	378	362
Tropopause (Ht., Ft.)	33,600	30,800	34,600	38,500	41,500	38,600	60,000	56,000	34,000	32,000
Isotope										
Be-7	12.5a	29.7a	7.94a	12.6	9.73	12.6a				
Sr-90	0.775a	1.65	0.767	1.28b		0.894	0.143b	0.073a	0.367	0.172a
Zr-95	0.105	0.188b	0.100b	0.105	0.053a	0.073c				
Rh-102	0.561a	NR	NR	1.20a	NR	NR				
Cs-137	1.50	3.13	1.33	2.03	0.800	0.906	0.236	0.114a	0.588	0.326
Ce-144	4.31	7.50	3.87	5.78	2.17	3.87		0.293		0.794
W-181	16.2	36.3	NR	20.1	NR	14.3a				
W-185	21.1b	NR	25.1a	26.0a	NR	16.9c				
Pb-210	0.785		0.264	0.276	1.16					

Date 1960	May 17	May 20	May 24	May 20	May 24	June 1	May 20	May 24	May 19	May 23
Latitude	70°N	70°N	70°N	33-36°N	35-36°N	34°N	10°N	10°N	40°S	40°S
Longitude	154°W	155°W	154°W	105°W	105°W	105°W	122°E	122°E	62°W	64°W
Altitude (Ft.)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	120	120	120	120	120	120	120	121	120	120
Volume (1000 SCF)	279	267	292	428	428	437	237	238	405	351
Tropopause (Ht., Ft.)	33,600	30,800	34,600	38,500	41,500	38,600	60,000	56,000	34,000	32,000
Isotope										
Be-7	19.1a	26.1a	8.65b	6.24a	10.7	NR		11.5a	42.5b	
Sr-90	1.89a	1.65	0.814	0.357	0.321	1.08	0.032c	0.495	1.21a	NR
Zr-95	0.204b	0.196c	0.090a	NR	NR	0.090c		NR	0.090a	
Rh-102	NR	NR	NR	NR	NR	NR		NR	NR	
Cs-137	3.67	2.31	1.31	0.658	0.560	1.95	0.053a	0.860	Lost	0.373
Ce-144	9.62	7.79	3.95	1.64	1.49	5.31		2.15	4.76	0.830
W-181	33.1	31.6a	NR	NR	NR	17.5a		NR	37.7a	
W-185	47.9	NR	24.3a	9.87	NR	20.5c		NR	52.6a	
Pb-210			0.275	0.262	0.479			0.641	0.134a	

Date 1960	May 17	May 20	May 24	May 20	May 24	June 1	May 20	May 24	May 19	May 23	June 2
Latitude	70°N	70°N	72°N	34-36°N	35-36°N	35-36°N	10°N	10°N	40°S	40°S	40°S
Longitude	154°W	154°W	154°W	105°W	105°W	105°W	122°E	122°E	62°W	62°W	62°W
Altitude (Ft.)	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	120	120	130	120	120	120	120	120	120	120	120
Volume (1000SCF)	229	214	222	229	229	229	190	189	214	189	197
Tropopause (Ht., Ft.)	33,600	30,800	34,600	38,500	41,500	38,600	60,000	56,000	34,000	32,000	44,000
Isotope											
Be-7	339a	239	153a	90.1	154	248a			370	64.4	205a
Sr-90	47.9a	23.0	10.6	5.02	14.6	25.2	Lost	0.057a	15.1a	1.72	3.86
Zr-95	4.76a	2.15b	0.882a	0.444	1.06	1.29a			1.24b	0.147b	NR
Rh-102	16.0a	4.95c	3.64b	NR	3.55a	NR			NR	NR	NR
Cs-137	74.5a	42.2	18.3	9.33	25.6	54.1	0.294a	0.098a	28.0	3.02	6.83
Ce-144	242	125	51.2	24.6	74.7	133		0.263	66.0	7.03	18.6
W-181	541a	299a	129	67.7a	166a	320a			467	44.7b	127b
W-185	784	447a	178a	103a	235a	399a			631a	NR	157a
Pb-210	0.324		0.440	0.455	0.599a				0.350	0.253	

TABLE I

ATMOSPHERIC RADIOACTIVITY DATA, MAY-JUNE 1960

Date 1960	May 18	May 20	May 25	May 20	May 24	June 1	May 22	May 24	June 1	May 19	May 23	June 2
Latitude	70°N	70-73°N	70°N	34°N	32°N	32°N	5-10°N	5-10°N	10-15°N	40°S	40°S	40°S
Longitude	157°W	157°W	157°W	105°W	105°W	105°W	54°W	54°W	62°W	63°W	64°W	63°W
Altitude (Ft.)	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Aircraft Type	U-2	U-2	U-2	B-57	U-2	U-2	U-2	U-2	U-2	U-2	B-57	U-2
Exposure (Minutes)	287	318	315	120	376	325	232	224	314	352	120	336
Volume (1000SCF)	173	271	236	130	302	251	108	104	145	396	122	264
Tropopause (Ht., Ft.)	33,600	30,800	36,900	38,500	44,000	41,000	52,000	53,000	53,000	32,000	32,000	44,000
Isotope												
Be-7	370a	455	397	161	167	398			105b	326a	181	485b
Sr-90	67.5	76.6	70.3	14.7	13.7	58.8	0.246b	0.364	5.55	28.1a	7.77	31.8
Zr-95	7.10b	3.30a	5.09	1.36a	1.26	4.80a			0.510b	1.58a	0.933a	2.22c
Rh-102	26.1a	33.4b	51.0	5.22	7.49a	14.0b			NR	5.70a	NR	3.83c
Cs-137	119	116	121	24.9	23.8	107	0.385a	0.468	7.99	49.1	14.5	51.8
Ce-144	379	402	445	77.3	77.5	324		1.16	27.5	123	40.8	135
W-181	609	705a	462	167	171a	644			135b	474	275	822a
W-185	719b	1226	NR	279b	227	NR			NR	613	NR	1039a
Pb-210	0.319a		0.259	0.474a	0.367					0.204	0.208a	

Date 1960	May 18	May 20	May 25	May 20	May 24	June 1	May 21	May 24	May 31	May 19	May 23	June 2
Latitude	70-73°N	70°N	70-73°N	32°N	32°N	32°N	5-10°N	10°N	7-12°N	40°S	40°S	40°S
Longitude	157°W	157°W	157°W	105°W	105°W	105°W	54°W	56°W	60°W	63°W	63°W	63°W
Altitude (Ft.)	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Aircraft Type	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2
Exposure (Minutes)	395	364	406	427	402	256	257	272	368	352	380	318
Volume (1000 SCF)	171	158	177	186	175	111	111	118	160	205	165	138
Tropopause (Ht., Ft.)	33,600	30,800	36,900	38,000	44,000	41,000	53,000	53,000	53,000	32,000	32,000	44,000
Isotope												
Be-7	648	764a	695b	391	485	420b	162	121	265	585	493	385a
Sr-90	163a	171	171a	102	88.6	83.1	17.4	15.5	33.1	100	67.3	63.8
Zr-95	15.3	19.0a	11.1	8.60	4.38b	6.73a	1.46	1.73a	2.28a	10.1a	6.74	4.47c
Rh-102	171	274	223	76.4a	64.5	37.1c	NR	NR	7.42b	75.9a	29.1a	22.7b
Cs-137	288	270	274	177	164	136	29.4	21.3	NR	173	127	104
Ce-144	1113	1087	1314	636	525	445	78.3	93.3	128	529	344	271
W-181	822a	913a	417	796a	446	553a	512	NR	538a	888	1106	857b
W-185	1132	1032a	NR	1086	589a	679c	699	NR	NR	1226	1519	1052a
Pb-210	0.225		0.208a	0.320a	0.439a		0.343	0.273a		0.241a	0.314	

Date 1960	May 18	May 20	May 25	May 20	May 24	June 1	May 21	May 23	June 1	May 19	May 23	June 2
Latitude	70°N	70°N	70°N	32°N	32°N	32°N	5-10°N	5-10°N	10-15°N	40°S	40°S	40°S
Longitude	157°W	157°W	157°W	105°W	105°W	105°W	54°W	54°W	62°W	63°W	63°W	63°W
Altitude (Ft.)	61,500-64,000	62,000-64,400	63,000-65,500	63,000-66,000	64,000-68,700	64,000-66,500	66,500-69,000	64,000-66,000	63,200-64,700	63,500-65,000	64,500-66,500	70,000
Aircraft Type	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2
Exposure (Minutes)	404	403	398	430	463	425	236	255	372	193	354	360
Volume (1000 SCF)	139	136	123	133	126	124	56.9	76.1	119	61.7	103	73.1
Tropopause (Ht., Ft.)	34,600	30,800	36,900	38,000	44,000	41,000	54,000	53,000	53,000	32,000	32,000	44,000
Isotope												
Be-7	962	1186a	981	563	786b	885a	298b	368c	273b	1037	866	1966c
Sr-90	175	185	173	162	180	187	101	72.7	68.1	213	175	229
Zr-95	18.5	26.7a	14.3	15.2	6.68a	15.3	5.31b	6.67a	3.83b	NR	17.0a	19.1a
Rh-102	366	443	331b	118a	209a	126a	25.9	18.0b	NR	164a	176	125b
Cs-137	263a	317	287a	282	311	296	177	119	132	343	293	349
Ce-144	1480	1339	1341	1007	1246	1013	486	342	336	1177	910	1113
W-181	301a	418a	315	715a	496	604a	1780	1415a	1065	1192	1121b	1511a
W-185	421	522c	557a	992	786a	886b	2418	1998a	NR	1685	1519a	1845b
Pb-210	0.139a		0.136a	0.266a	0.231a		0.475a	0.568a		0.424a	0.341a	

TABLE II

ATMOSPHERIC RADIOACTIVITY DATA, NOVEMBER 1960

Date 1960	Nov 1	Nov 10	Nov 1	Nov 10	Nov 18	Nov 20	Nov 2	Nov 10	Nov 15
Latitude	70°N	71°N	35°N	34°N	9°N	8°N	42°S	40°S	40°S
Longitude	144°W	144°W	105°W	105°W	122°E	122°E	147°E	147°E	147°E
Altitude (Ft.)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	120	120	120	120	120	120	120	120	120
Volume (1000 SCF)	286	344	521	559	302	302	397	433	433
Tropopause (Ht., Ft.)	34,100	32,300	45,400	37,300	50,000	50,500	34,000	39,000	33,000
Isotope									
Be-7	26.9a	13.7a	12.8	8.94b	2.68	2.24c	16.8a	17.7	19.0
Sr-90	0.678	0.272a	0.164a	0.104a	0.023a	0.015c	0.459a	0.369a	0.651
Zr-95									
Rh-102	0.545b	0.234c	0.118c	0.111c	0.067d	0.025d	0.307c	0.289a	NR
Cs-137	1.10	NR	0.286	0.175		0.026a	0.762	0.566	0.955
Ce-144	2.34	1.03	0.595	0.394	0.085b	0.062c	1.35	1.15	1.81a
W-181	7.19d								9.66
W-185	17.1a								NR
Pb-210	0.713	0.940a	0.629	0.447a	0.050c	0.030	0.305	0.111a	

Date 1960	Nov 1	Nov 10	Nov 16	Nov 1	Nov 10	Nov 18	Nov 20	Nov 2	Nov 10	Nov 15
Latitude	70°N	71°N	71°N	35°N	34°N	8°N	8°N	41°S	41°S	40°S
Longitude	144°W	144°W	144°W	105°W	105°W	122°E	122°E	147°E	147°E	147°E
Altitude (Ft.)	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	120	121	120	120	120	120	120	120	120	120
Volume (1000 SCF)	336	301	323	405	443	231	231	310	260	298
Tropopause (Ht., Ft.)	34,100	32,300	27,200	45,400	37,300	50,000	50,500	34,000	39,000	33,000
Isotope										
Be-7	53.5	34.5a	108	26.7a	12.9a	2.68	2.35	22.5a	22.3a	26.7
Sr-90	1.35a	0.757	0.811	0.041a	0.085b	0.049b	0.011c	0.636a	0.561a	0.668
Zr-95		NR								
Rh-102	0.664a	0.570b	2.08	0.050c	0.058c	0.191d	0.066d	0.309b	0.195b	NR
Cs-137	2.30	1.22	1.25	0.072	0.143	0.084	0.021a	1.04	0.870	1.12a
Ce-144	4.65	2.84	3.30a	0.121a	0.336	0.229	NR	2.00	1.55	2.02
W-181	13.3c	24.6c	14.0d					15.4d		12.8
W-185	29.2a	47.9c	NR					19.0b		NR
Pb-210	0.378	0.486		0.324	0.269	0.032a	0.035	0.263	0.424a	

Date 1960	Nov 1	Nov 10	Nov 16	Nov 1	Nov 10	Nov 15	Nov 18	Nov 20	Nov 2	Nov 10	Nov 15
Latitude	70°N	71°N	71°N	35°N	34°N	38°N	8°N	8°N	42°S	41°S	41°S
Longitude	144°W	144°W	144°W	105°W	105°W	105°W	122°E	122°E	147°E	147°E	147°E
Altitude (Ft.)	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000	40,000
Aircraft Type	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57	B-57
Exposure (Minutes)	122	120	120	120	120	120	120	125	120	120	120
Volume (1000 SCF)	193	216	190	265	244	244	164	171	267	229	205
Tropopause (Ht., Ft.)	34,100	32,300	27,200	45,400	37,300	36,700	50,000	50,500	34,000	39,000	33,000
Isotope											
Be-7	361	437	321	21.0b	187	56.6	3.85c	2.65b	103a	248	505
Sr-90	18.0	26.2	14.0a	0.115a	2.35	4.42a	0.051b	0.034b	3.20a	10.4	24.7
Zr-95	0.397b	0.314a	NR							0.130b	NR
Rh-102	10.9a	17.4a	8.79a	0.052c	1.29a	NR	0.056d	0.291c	1.66a	4.81a	12.1
Cs-137	32.1	48.1	21.9	0.158	3.70	7.72	0.105a		6.17	18.7	39.4
Ce-144	75.8	103a	53.7	0.281a	8.18	16.9	0.192b	0.150a	11.4	35.7	68.9a
W-181	324c	244	119		22.8c	53.7			50.9b	122b	335
W-185	313a	335a	NR		NR	NR			91.3a	200a	NR
Pb-210	0.503	0.461		0.111	0.446a			0.019a	0.316	0.421	

TABLE II

ATMOSPHERIC RADIOACTIVITY DATA, NOVEMBER 1960

Date 1960	Nov 1	Nov 10	Nov 15	Nov 1	Nov 10	Nov 15	Nov 18	Nov 21		Nov 2	Nov 8	Nov 15
Latitude	71°N	72°N	71°N	34°N	33°N	34°N	8°N	9°N		43°S	42°S	42°S
Longitude	144°W	144°W	144°W	105°W	105°W	105°W	158°W	158°W		147°E	147°E	147°E
Altitude (Ft.)	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000		50,000	50,000	50,000
Aircraft Type	U-2	U-2	U-2	U-2	U-2	B-57	U-2	U-2		U-2	U-2	B-57
Exposure (Minutes)	294	368	300	159	313	129	305	312		360	354	111
Volume (1000 SCF)	224	282	229	133	263	149	220	224		237	287	121
Tropopause (Ht., Ft.)	34,100	32,300	29,000	54,000	39,000	36,700	53,000	54,500		34,000	29,500	33,000
Isotope												
Be-7	379	698a	758	65.8a	201a	559c	42.6a	20.7b		302	333	636
Sr-90	35.5	111	99.5	1.66a	9.90	25.5	0.740a	0.205b		26.8	26.3	41.5
Zr-95	0.593b	1.82a	1.50			NR				0.381a	0.326a	NR
Rh-102	20.8a	116	39.8a	1.59c	5.15	15.7a	0.376b	0.109d		14.0a	9.59a	20.8
Cs-137	64.5	190	155	2.82	16.9	36.4a	1.19	0.349a		47.7	45.9	59.3a
Ce-144	143	529	410a	5.41	35.6	80.4	2.79	0.886		89.5	87.3	120
W-181	341a	351a	454b		111b	133a				420a	375b	518
W-185	368a	584	NR		176	NR				NR	525a	NR
Pb-210	0.520	0.225a		0.309	0.512a		0.286a	0.152a		0.293	0.326	

Date 1960	Nov 1	Nov 10	Nov 15	Nov 1	Nov 10	Nov 16	Nov 19	Nov 21	Nov 24	Nov 2	Nov 8	Nov 15
Latitude	71°N	71°N	72°N	34°N	34°N	33°N	9°N	8°N	9°N	43°S	41°S	41°S
Longitude	144°W	144°W	144°W	105°W	105°W	105°W	158°W	158°W	158°W	147°E	147°E	147°E
Altitude (Ft.)	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000	60,000
Aircraft Type	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2
Exposure (Minutes)	238	361	366	345	342	287	316	351	347	360	184	339
Volume (1000 SCF)	103	156	159	150	148	124	127	142	140	148	78.5	147
Tropopause (Ht., Ft.)	34,100	32,300	29,000	54,000	39,000	44,000	53,000	54,500	54,600	34,000	29,500	33,000
Isotope												
Be-7	597a	698b	1116	553a	797	557a	324a	185	251	724	711a	939
Sr-90	129	111	145	85.1	130	84.4	37.2		26.8a	138	137a	150a
Zr-95	2.19b	2.19a	1.55	1.52	2.28a	1.02	0.920a			2.71a	2.96a	NR
Rh-102	112	203a	134	72.2	150	316a	24.0a	19.8b	9.94	178	159	46.6c
Cs-137	221	190	212	135	211	127	67.5	38.8	44.7	246	217	226a
Ce-144	586	602	626	358	624	324a	157	78.8	96.0a	583	536	416
W-181	512b	88.3c	366	414c	432b	563	378d	305c	NR	741a	857b	456
W-185	859a	234d	NR	649a	637b	NR	475b	576	NR	1079a	1239a	NR
Pb-210	0.301a	0.090a		0.356	0.271a		0.566	0.617a		0.233a	0.312b	

Date 1960	Nov 1	Nov 10	Nov 15	Nov 1	Nov 10	Nov 15	Nov 18	Nov 22	Nov 24	Nov 2	Nov 8	Nov 15
Latitude	71°N	72°N	71°N	32°N	33°N	32°N	9°N	8°N	9°N	40°S	40°S	40°S
Longitude	144°W	144°W	144°W	105°W	105°W	105°W	158°W	158°W	158°W	147°E	147°E	147°E
Altitude (Ft.)	63,900-65,600	62,000-64,000	61,900-64,600	65,000-67,300	65,000-67,400	66,000	65,900-68,600	64,500-67,900	65,700-68,900	60,000-64,000	62,000-64,000	62,000-67,000
Aircraft Type	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2	U-2
Exposure (Minutes)	352	387	367	373	436	459	308	310	320	421	326	404
Volume (1000 SCF)	107	133	123	101	119	126	77.0	84.2	80.0	156	111	124
Tropopause (Ht., Ft.)	34,100	32,300	29,000	54,000	39,000	44,000	53,000	51,500	54,600	34,000	29,500	33,000
Isotope												
Be-7	655a	845	1462b	792	591	563	267	220	296b	553a	727	797
Sr-90	148	147	168	142	136	139a	71.8	62.3	83.1	137	157	173a
Zr-95	1.86b	2.04a	1.50	2.94a	1.89a	NR	NR	1.37b	NR	2.50	2.34	NR
Rh-102	186	242b	261b	178	133	737a	47.3	55.3b	NR	151	206a	240
Cs-137	258	239	245	239	227	231a	138	112	145	235	276	285a
Ce-144	748	822	744	726	614	578	265	217	261a	549	652	589
W-181	193c	93.3b	254a	428b	385a	436	974	928a	1131	543b	NR	402a
W-185	403b	NR	NR	779a	635a	NR	1266	NR	NR	846a	753a	NR
Pb-210	0.214a	0.111a		0.243a	0.271a		0.436a	0.407a		0.166a	0.234a	

THE DISTRIBUTION OF RADIOACTIVITY WITH RESPECT TO TROPOPAUSES AND JET STREAMS

by

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Introduction

The mechanism of stratospheric-tropospheric exchange has long been an uncertainty, although several models have been proposed. In 1928 Dobson et al. (4), studying ozone, suggested a meridional circulation consisting of a slow poleward drift in the lower stratosphere and a slow descent near the pole. Brewer (1), who was concerned with water vapour, proposed a rising of air at the equator, poleward motion in the lower stratosphere and then descending motion into the troposphere in temperate and polar regions. From observations of strontium-90, Stewart (8) surmizes that the bulk of the material is returned from the stratosphere into the troposphere in a periodic manner and the transfer takes place in middle and high latitudes. Spar (6) has suggested that there is mixing through the so-called tropopause gap, wherein stratospheric radioactive debris enters the troposphere.

The existence and structure of a break in the tropopause has been the subject of many studies. The current concepts of the tropopause realize more than one break, and in general associate a break with a jet stream. Defant and Taba (3) have made a study of hemispheric soundings and conclude that the multiple tropopauses are a real phenomena. Danielsen (2) has worked with detailed analyses of soundings and has concluded that the tropopause is not a real barrier but rather there is an organized system of stratospheric-tropospheric exchange.

In order to gather data which might increase our knowledge as to the exchange mechanism, a series of special B-57 aircraft flights was made during March 1960. These flights, made from Kirtland Air Force Base, Albuquerque, New Mexico, collected samples of radioactive debris which were used as a tracer material. The actual mechanics of the sampling procedures and the variety of radiochemical analyses carried out on the samples have been fully described by Telegadas and List (10) and will be briefly summarized here. Generally the aircraft were vectored to fly parallel to the wind flow in order to obtain a homogeneous sample, since it was assumed that the gradient of radioactivity is perpendicular to the flow. In a few cases, due to other operational activities of the aircraft, the samples were obtained from cross-wind missions. Although several radioactive nuclides were measured, only the strontium-90 data were used for this study. This was done primarily for simplicity and because strontium-90 is a long-lived nuclide (about 28 year half-life) which has probably been considered more often than any other. Since the B-57 aircraft had an effective ceiling of 50,000 feet, additional unpublished data were utilized from the High Altitude Sampling Program, which employed U-2 aircraft. The U-2 flights were all cross-wind flights along the 98th meridian. The compatibility of the samples collected by the B-57 and by the U-2 aircrafts has been shown in other studies (9). The B-57 aircraft samples were taken primarily in the vicinity of the jet stream, whereas the U-2 data covers additional areas.

It should be pointed out that due to the exigencies of such an operation, the B-57 data are severely restricted both in location and in time. The mean pressure and mean latitude at which the B-57 samples were taken are 211 mb and 36.4°N, respectively. The pressure ranged from 385 to 116 mb and the latitudes ranged from 31.0 to 47.5°N. From Figure 1 (taken from Defant and Taba) one can see that the B-57 samples were probably taken above and below a mean middle tropopause but not above the mean tropical tropopause.

Method

For the meteorological analysis, vertical cross sections above 500 mb were constructed from original adiabatic charts of stations along a line normal to the upper wind flow in the area of sampling. The potential temperature,* in particular, was analyzed so that the tropopause could be picked out not only from the reported tropopause level, but from a consideration of highly stable layers, i.e., large vertical potential temperature gradients. Only one vertical cross section is reproduced for each sampling mission (Figures 2 through 29). Shown in these figures are the potential temperature lines (thin solid lines), the lowest reported tropopause ☒, the position of the sample (depicted as a point or a line depending upon whether the sample was taken normal to or in the plane of the cross section), the sample number (which, incidentally, is the same as used by Telegadas and List), and the isotachs of the reported winds (dashed lines). Wherever samples were taken simultaneously and an average activity value was used, this fact is indicated by having the sample numbers enclosed by a bracket. The 200 mb constant pressure charts, derived from the National Weather Analysis Center of the U.S. Weather Bureau, are reproduced, in part, in Figures 30 through 54. On these charts are indicated contour lines, isotherms, the primary jet stream, the position of the samples and the sample numbers. It should be emphasized that the sample is not necessarily at the 200 mb pressure level. From these two sets of charts (and those for intervening times) plus the Maximum Wind and Wind Shear Analyses Charts, which are transmitted over the facsimile circuit, the following data were assembled.

Table I: B-57 Samples Taken Parallel to Wind Flow

1. Sample number: Taken from Telegadas and List. Multiple sample numbers indicate that these samples were taken simultaneously and the activity values were averaged. (1/3 indicates an average from samples 1 and 3.)

2. Date and time: Mid-point of sampling period (GCT).

3. Latitude of sample: To nearest one-half degree.

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* The potential temperature is the temperature which an air parcel assumes when brought adiabatically to a pressure of 1000 mb.

4. Longitude of sample: To nearest one-half degree.

5. Pressure at which sample was taken: Since the aircraft altimeters were set at 29.92 inches of mercury, the standard atmosphere was used in converting the heights reported by the aircraft into millibars.

6. Strontium-90 activity values: These values have been rounded off to the nearest whole number and reported in disintegrations per minute per 1000 standard cubic feet of air (dpm/1000 SCF).

7. Latitude and pressure at level of maximum wind: Where maximum wind intersects cross-section at time of sample. Since the samples were generally taken between radiosonde observation times and sites, linear interpolation was used.

8. Tropopause pressures at time and geographical location of sample: Time and space linear interpolation was used, considering the lowest reported tropopause value given at the radiosonde stations and the packing of the potential temperature lines.

Table II: B-57 Samples Taken Normal to Wind Flow

Similar to Table I except that because the sample positions are not represented by points but by lines on the cross-section, the tropopause pressures are for the mid-point of the sample position.

Table III: U-2 Samples Taken Normal to Wind Flow

Similar to Table II except that longitude values are not listed since the U-2 flights were all along the 98th meridian.

Results

The total number of B-57 samples available, as given by Telegadas and List, is 134. Of these, 5 of the strontium-90 samples were lost in the chemical analysis. Theoretically the cesium-137 to strontium-90 activity ratio of a sample should be 1.65 (5). As a check on the quality of the radiochemical data a frequency distribution of the actual ratios was prepared, Figure 55. As pointed out by Stebbins (8), samples with ratios lower than 1.0 and higher than 3.0 probably suffer principally from analytical errors. Using this criteria 21 samples were eliminated as doubtful. Of the remaining 128 samples, 13 were taken simultaneously with others and were combined, and 2 were below the 500 mb pressure level. Of the remaining 93 samples, 80 were taken parallel to the wind flow, and 13 were taken normal to the wind flow. There were 54 U-2 samples available but because of loss in chemical analysis and simultaneity of samples, the number was reduced to 44. Therefore the total number of cases available for this study was 137.

Figure 56 shows the results of plotting the strontium-90 activity values with respect to their horizontal distance from the vertical jet axis and their vertical distance with respect to the tropopauses. Using the nomenclature of Defant and Taba, the mean middle tropopause was found to be at 219 mb and the mean tropical tropopause at 102 mb. The lines of equal Sr-90 radioactivity concentrations, as the data indicate, are quite subjective but do present a broad picture. The isolines of strontium-90 activity, in the layer between the two tropopauses, show a horizontal gradient near the jet axis. The figure clearly shows that air to the south of the jet and reported as stratospheric (between the middle and tropical tropopauses) actually has low values of strontium-90 radioactivity, in fact the same order of magnitude as the tropospheric values. The stratospheric values to the north of the jet and between the two tropopauses are larger by a factor of about 5. The values above the tropical tropopause are even larger and show little horizontal variation through the jet axis, the activity isolines tending to follow the tropical tropopause. Thus it appears in the mean that the tropical tropopause, including its northward extension acts as a semi-barrier to the vertical transfer of radioactivity.

Conclusions

Since the samples were taken over a short period of time and were restricted geographically, the results of this program cannot be conclusive. While the exact shape of the activity isolines in Figure 56 may not be significant, nevertheless, the broad scale features do stand out. Above the tropical tropopause there is little difference in the activity magnitude on either side of the jet axis with practically no horizontal gradient. This indicates that any vertical transfer of activity downward through the northward (with respect to the jet axis) extension of the tropical tropopause is of the same magnitude as that through the tropical tropopause to the south of the jet axis and also that the northward extension of the tropical tropopause is just as real and important a phenomenon as it is to the south of the jet axis. The middle tropopause seems to be something different again. That is, the activity values to the south of the jet axis and between the tropical and middle tropopauses are the same as the values in the troposphere while the values to the north of the jet axis and between the tropical and middle tropopauses lie somewhere between those in the troposphere and those above the tropical tropopause. The lack of a horizontal gradient in the activity isolines above the middle tropopause and to the north of the jet axis indicate that this tropopause acts as a semi-barrier in the same manner as does the tropical tropopause, but probably not as great a barrier. In effect then, to the south of the jet axis some sort of turbulent mixing seems to take place through the reported middle tropopause up to the tropical tropopause, while to the north of the jet axis this mixing is inhibited at the middle tropopause.

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Table I

B-57 SAMPLES TAKEN PARALLEL TO WIND FLOW

	Sample					Maximum Wind		Tropopauses	
No.	Date/Time (GCT) Mar.1960	Latitude (°N)	Longitude (°W)	Pressure (mb)	SR-90 (dpm/10^3SCF)	Latitude (°N)	Pressure (mb)	Pressure (mb)	Pressure (mb)
1/3	02/1812	35.0	106.5	188	29	36.0	238	232	105
6/8	2322	35.0	106.5	148	6	36.0	238	221	96
9	03/1755	32.5	109.0	188	<1	42.5	325	233	109
10	1841	32.5	109.0	127	2	42.5	328	232	108
11	1917	44.0	104.0	239	43	43.0	330	270	118
12	2000	44.0	104.0	148	45	43.0	333	267	110
13	2202	38.5	105.0	239	3	43.5	342	223	100
14	2246	38.5	105.0	148	5	43.5	345	224	101
15	07/1708	35.5	107.5	208	<1	39.5	209	186	88
16	1747	35.5	107.5	188	1	39.5	208	186	88
17	1708	35.5	107.5	170	1	39.5	209	186	88
18	1747	35.5	107.5	155	1	39.5	208	186	88
19	2300	35.5	107.5	119	10	39.5	201	185	89
20	2215	35.5	107.5	141	3	39.5	202	185	89
21	2355	44.0	103.5	239	2	39.5	200	231	100
22	08/0030	44.0	104.0	148	56	39.5	200	231	100
23	1735	35.0	107.0	170	18	39.0	211	192	83
27	09/1402	31.0	99.0	117	18	41.5	282	212	81
29	1845	33.5	105.0	188	4	41.5	277	200	91
35	1922	32.5	109.0	188	3	41.5	276	204	92
36	2006	32.5	109.0	116	5	41.5	275	203	93
37	2257	40.0	105.5	188	4	41.5	271	201	95
38	2347	40.0	105.5	125	67	41.5	270	202	93
39	10/1905	44.0	104.0	217	46	39.0	207	227	89
40	1937	44.0	102.5	300	6	39.0	205	228	89
41	2034	41.0	105.5	217	53	39.0	201	250	115
42	2105	41.0	105.5	300	5	39.0	198	250	115
43	1753	39.0	109.5	217	18	39.0	213	210	120
44	1824	39.0	109.5	300	1	39.0	211	211	119
46	11/1912	41.0	104.0	275	2	42.0	280	216	104
47	1855	38.5	105.5	188	32	42.0	282	216	93
48	1933	38.5	105.5	300	2	42.5	277	216	95

Table I (Con't)

B-57 SAMPLES TAKEN PARALLEL TO WIND FLOW

	Sample					Maximum Wind		Tropopauses	
No.	Date/Time (GCT) Mar.1960	Latitude (°N)	Longitude (°W)	Pressure (mb)	SR-90 (dpm/10^3SCF)	Latitude (°N)	Pressure (mb)	Pressure (mb)	Pressure (mb)
49	14/1848	41.0	101.5	208	35	33.0	195	236	102
50	1919	41.0	101.5	262	7	33.0	196	237	102
51	2127	33.5	103.0	239	3	33.0	202	220	100
52	2158	33.5	103.0	300	1	33.0	203	220	100
53	15/1717	35.0	102.0	239	58	33.0	225	238	104
54	1750	35.0	102.0	188	74	33.0	223	240	105
57	16/0135	35.0	104.5	300	3	32.5	215	202	118
59	1840	37.0	100.0	262	47	33.0	291	318	209
62	2222	33.5	102.5	251	21	32.0	297	222	98
63	17/2133	35.5	111.0	170	13	35.5	345	184	90
64	2205	35.5	111.0	316	1	35.5	346	184	90
68	1825	35.5	109.0	275	1	35.5	338	190	102
69/70	1830	35.0	106.5	188	40	35.0	339	221	110
71	2225	34.0	106.5	239	2	34.0	347	198	110
72	2306	34.0	106.5	148	45	34.0	348	194	110
75	18/1813	36.5	101.0	179	23	37.0	250	216	99
76	1845	36.5	101.0	275	3	37.0	250	217	99
77	1823	35.0	106.5	163	5	37.0	250	194	115
79	2214	37.0	101.0	300	2	37.0	250	222	101
81	2230	36.5	101.0	208	35	37.0	250	226	101
82	2302	36.5	101.0	239	8	37.0	250	228	102
87/88	22/1827	35.0	106.5	188	18	32.0	198	198	112
89/90	2151	35.0	106.5	148	15	32.0	199	178	106
99	23/1920	32.0	107.5	188	1	31.5	203	161	112
100	1958	32.0	107.5	239	5	31.5	204	162	113
101	1825	40.0	106.5	188	34	31.0	203	200	113
102	1857	40.0	106.5	251	2	31.0	203	200	114
107	24/1815	32.0	112.0	208	41	27.0	188	201	100
110	1912	35.0	110.5	300	3	27.0	188	203	104
111	1809	33.5	109.5	208	45	27.0	188	215	99
112	1735	33.5	109.5	300	5	27.0	188	215	99
113	2144	33.0	108.0	170	33	26.5	188	215	103

Table I (Cont't)

B-57 SAMPLES TAKEN PARALLEL TO WIND FLOW

	Sample					Maximum Wind		Tropopauses	
No.	Date/Time (GCT) Mar.1960	Latitude (°N)	Longitude (°W)	Pressure (mb)	SR-90 ($dpm/10^3SCF$)	Latitude (°N)	Pressure (mb)	Pressure (mb)	Pressure (mb)
114	24/2215	33.0	108.5	239	29	26.5	188	217	103
115	1545	35.0	107.5	188	54	27.5	188	211	107
119	25/1735	32.0	108.0	239	33	25.0	188	244	92
122	1758	32.0	104.0	269	4	25.0	188	244	92
125	2158	32.0	107.0	208	47	25.0	188	243	91
126	2229	32.0	107.0	385	3	25.0	188	242	91
139	30/1730	34.5	100.0	170	38	35.5	186	175	90
140	1801	34.5	100.0	228	1	35.5	185	175	90
141	1815	37.0	99.0	170	51	35.5	185	200	94
142	1849	37.0	99.0	228	6	35.5	184	199	94
143/144	2347	33.5	102.5	251	31	35.5	175	180	92
	Apr.1960								
145/146	01/1410	31.5	99.5	125	5	26.0	200	250	94
147/148	2015	34.5	103.5	228	47	30.5	203	300	100
151	1732	32.0	105.0	188	8	31.0	211	256	102
152	1805	31.5	104.5	148	47	31.0	210	257	101
153/154	09/1335	30.5	100.0	125	14	41.0	250	200	103

Table II

B-57 SAMPLES TAKEN NORMAL TO WIND FLOW

	Sample					Maximum Wind		Tropopauses	
No.	Date/Time (GCT) Mar.1960	Latitude (°N)	Longitude (°W)	Pressure (mb)	SR-90 (dpm/10^3SCF)	Latitude (°N)	Pressure (mb)	Pressure (mb)	Pressure (mb)
83	21/1937	37.0-40.0	105.0	188	1	45.0	262	243	109
84	2006	40.0-43.0	104.5	185	1	46.0	244	234	108
85	2037	43.0-46.0	103.5	173	2	47.0	250	231	111
86	2058	46.0-47.5	102.5	170	3	50.0	250	212	111
93	22/1909	39.5-46.5	104.0	188	14	51.0	262	227	111
96	2222	38.0-43.0	104.0	228	8	48.0	250	217	107
123	25/1927	33.5-35.0	105.5	208	30	25.0	188	210	88
129/130/131/132	28/1800	37.5-44.5	104.0	188	55	30.0	190	203	111
133/134	29/1621	39.0-46.0	100.0	188	54	34.0	250	234	95
135	1935	44.0-47.0	100.5	148	80	34.0	250	242	106
136	2005	40.5-44.0	100.5	148	77	34.0	250	237	91
137	1747	32.5-38.0	100.0	188	66	34.0	250	239	108
138	1857	32.5-38.0	100.0	135	47	34.0	250	232	109

Table III

U-2 SAMPLES TAKEN NORMAL TO WIND FLOW

No.	Sample: Date/Time (GCT) Mar. 1960	Sample: Latitude (°N)	Sample: Pressure (mb)	SR-90 (dpm/10^3SCF)	Maximum Wind: Latitude (°N)	Maximum Wind: Pressure (mb)	Tropopauses: Pressure (mb)	Tropopauses: Pressure (mb)
3418	04/1538	27.5-33.0	62-58	186	38.5	291	238	101
3419	1628	33.0-38.5	58	186	38.0	286	231	83
3420/3422	1716	39.0-44.0	58	204	37.5	282	221	94
3421/3423	1804	44.5-49.5	58	220	37.0	277	230	112
3424	1850	49.5-46.0	58-67	208	36.5	273	239	113
3425	1948	44.0-39.0	67-74	194	36.0	268	219	92
3435	10/2101	44.5-40.5	148	65	36.0	241	242	116
3436	2145	40.0-36.0	148	39	36.0	241	228	116
3437	2225	36.0-32.0	148	4	36.0	241	219	95
3438	2300	31.5-27.5	148	4	35.5	240	234	81
3440	1807	30.5-33.5	192	1	36.5	242	220	100
3441	1839	33.5-36.0	192	<1	36.5	242	216	94
3442	1914	36.0-39.0	192	40	36.5	242	212	115
3443	1948	39.0-41.5	192	59	36.5	242	238	120
3444	2018	41.5-44.5	192	73	36.5	242	241	120
3445	1808	27.0-32.5	116	1	36.5	242	228	86
3446	1900	33.0-37.5	116	43	36.5	242	216	94
3447/3449	1949	37.5-42.5	116	82	36.5	242	238	120
3448/3450	2039	42.5-48.0	116	120	36.0	241	248	121
3451	2131	48.0-43.0	92	136	36.0	241	249	120
3452	2214	42.5-38.0	92	123	36.0	241	240	126
3453	2256	37.5-33.0	92	73	35.5	240	219	99
3454	2348	32.5-27.5	92	47	35.5	240	235	80
3483	24/1545	27.5-35.0	70-59	151	29.5	167	203	84
3484	1635	35.0-38.5	59	180	29.0	165	204	102
3486/3488	1810	44.5-49.5	58-56	220	29.0	163	227	95
3487	1720	39.0-44.0	59-58	221	29.0	163	204	106
3489	1855	49.5-44.5	56-53	212	29.0	162	229	96
3490	1945	44.0-39.0	53-51	248	28.5	160	206	104
3491	2030	38.5-33.5	51-49	242	28.5	157	207	100
3492	2120	33.0-27.5	49-47	206	28.5	155	212	106
3504	29/1533	27.5-33.0	72	86	29.0	195	189	83
3505	1620	33.5-38.5	72	107	29.5	198	264	110

Table III (Con't)

U-2 SAMPLES TAKEN NORMAL TO WIND FLOW

	Sample				Maximum Wind		Tropopauses	
No.	Date/Time (GCT) Mar.1960	Latitude (°N)	Pressure (mb)	SR-90 (dpm/10^3SCF)	Latitude (°N)	Pressure (mb)	Pressure (mb)	Pressure (mb)
3506/3508	29/1707	39.0-44.0	72	134	29.5	201	209	98
3507/3509	1756	44.5-49.5	72	144	29.5	205	233	97
3510	1849	49.5-44.5	57	218	30.5	208	232	98
3511	1936	44.0-39.0	57	203	30.5	212	213	97
3512	2022	38.5-33.5	57	184	31.0	215	272	105
3513	2109	33.0-27.5	57	158	31.0	218	186	83
3523	31/1546	29.5-34.5	116	33	27.5	199	203	108
3524	1652	34.5-41.5	116	51	27.5	201	220	110
3525	1758	41.5-48.0	116	73	27.5	205	230	118
3526	1704	48.0-41.5	92	82	27.5	208	229	117
3527	2002	41.5-34.5	92	67	27.5	210	233	103

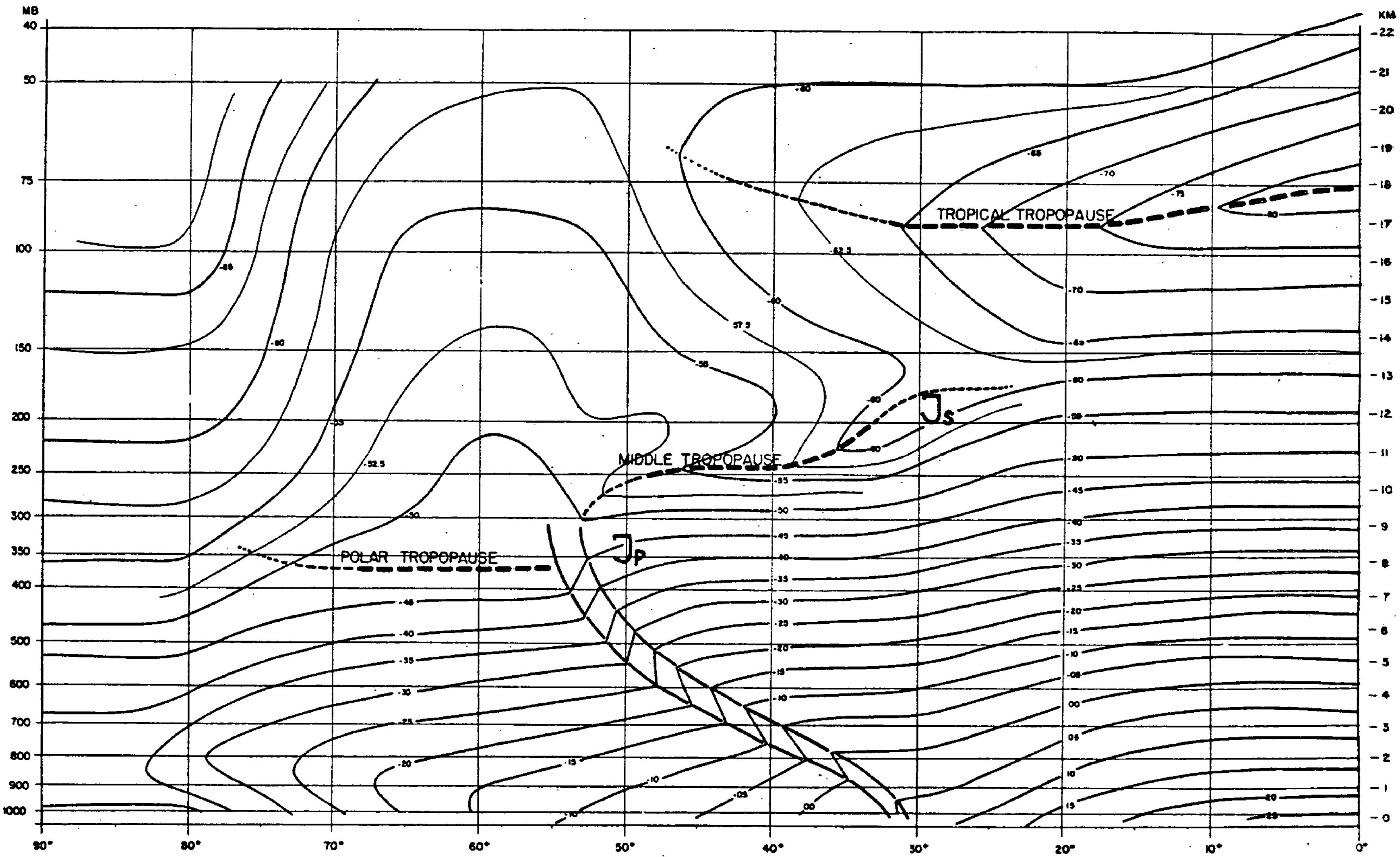


Figure I. Mean meridional cross sectin for Jan. I, 1956 (Defant and Taba)

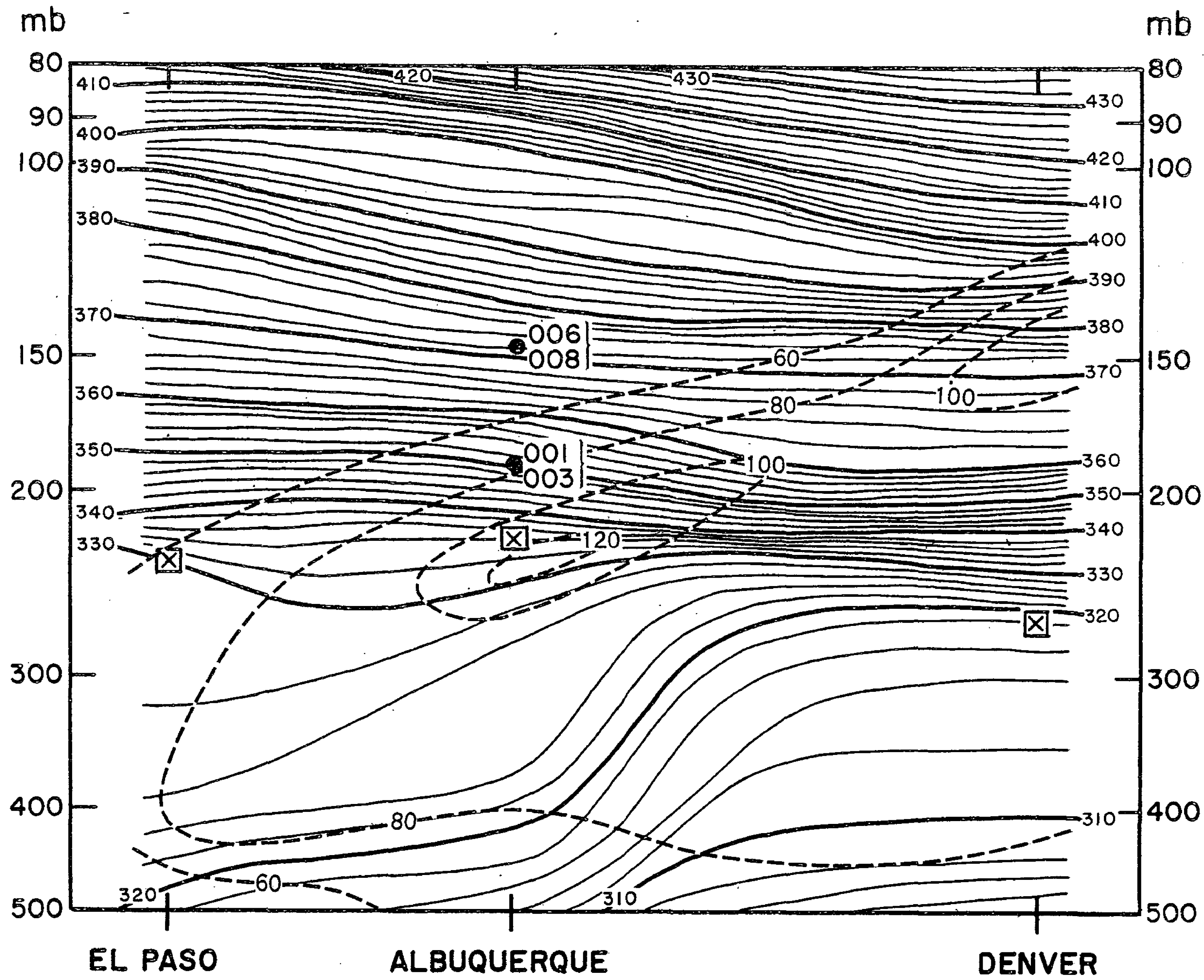


Figure 2. Vertical cross-section for 0000 GCT 3 March 1960

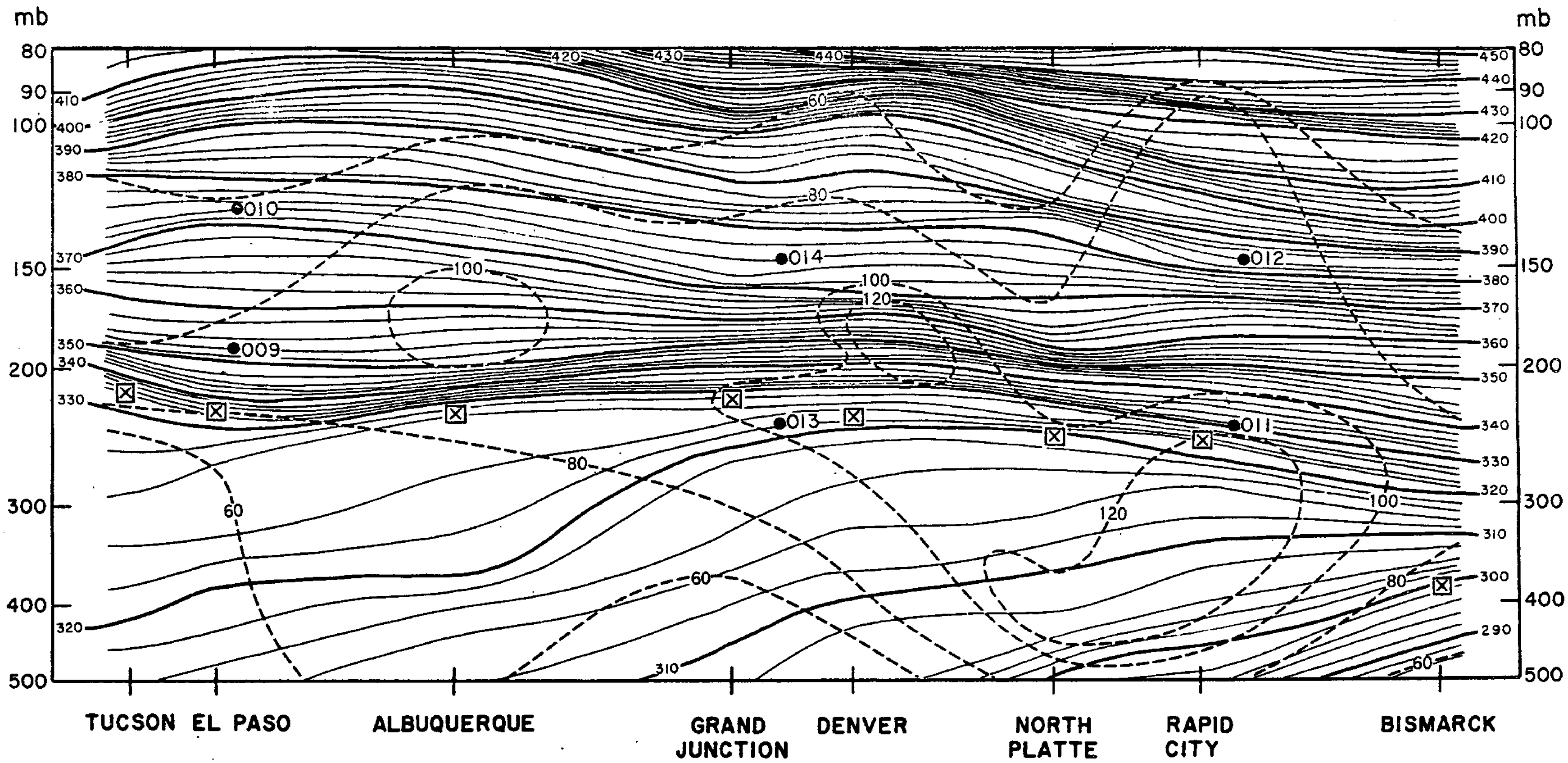


Figure 3. Vertical cross-section for 0000 GCT 4 March 1960

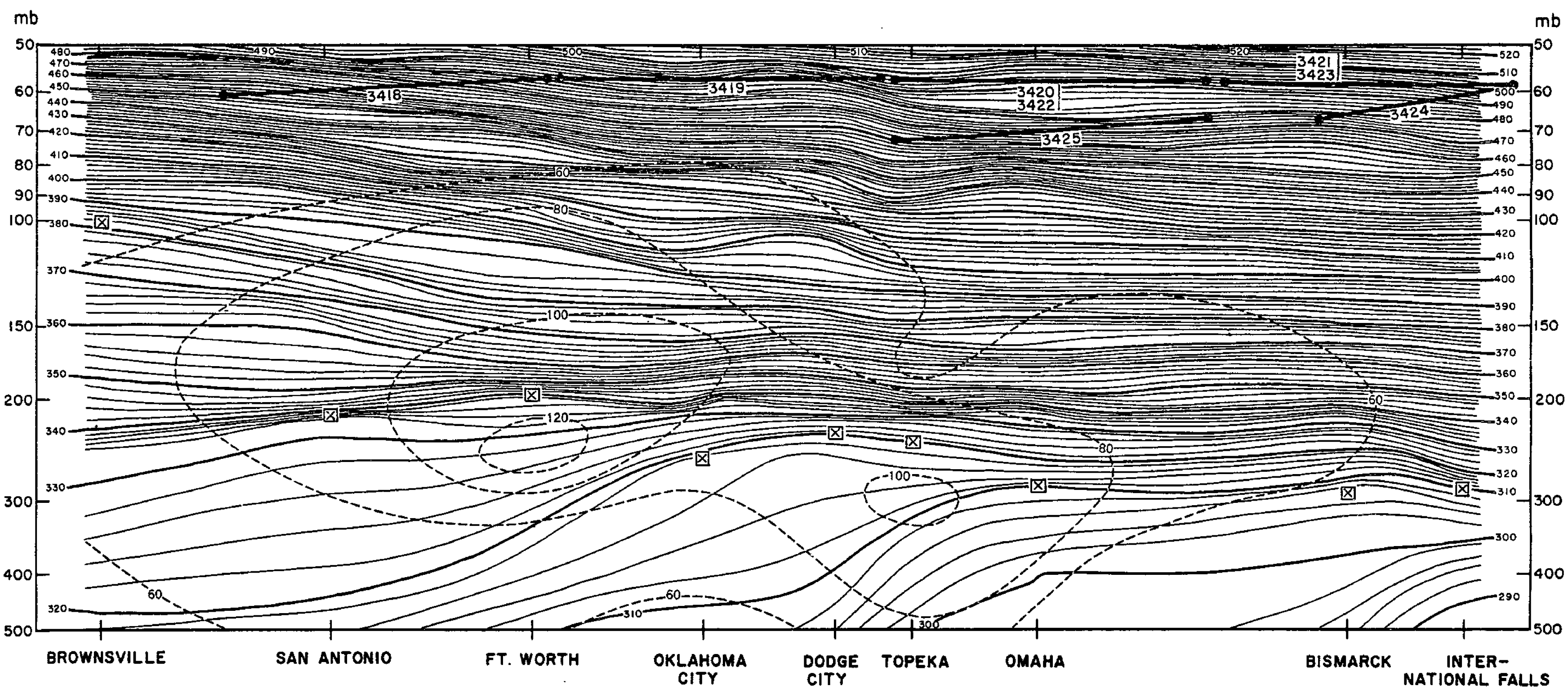


Figure 4. Vertical cross-section for 0000 GCT 5 March 1960

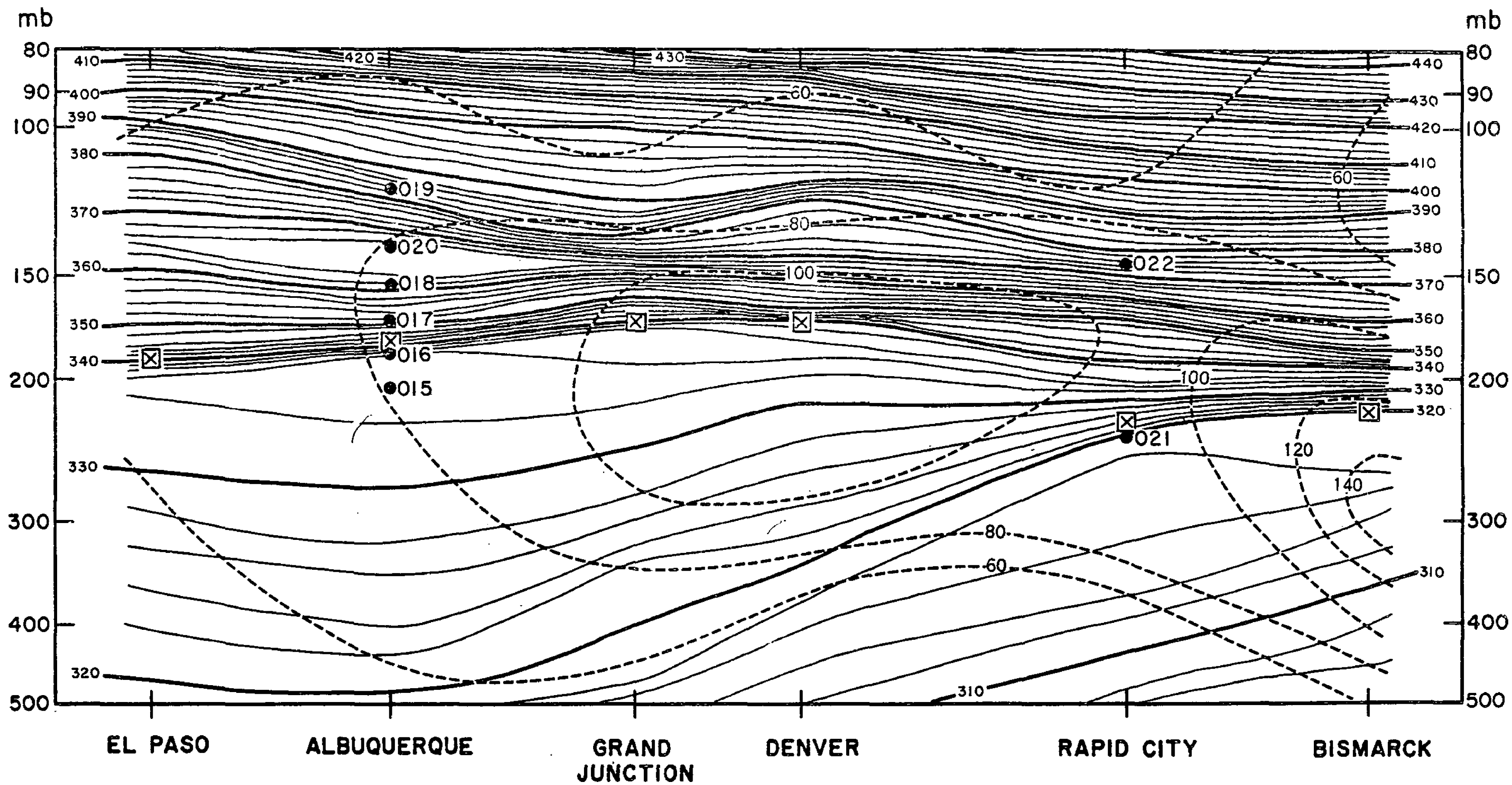


Figure 5. Vertical cross-section for 0000 GCT 8 March 1960

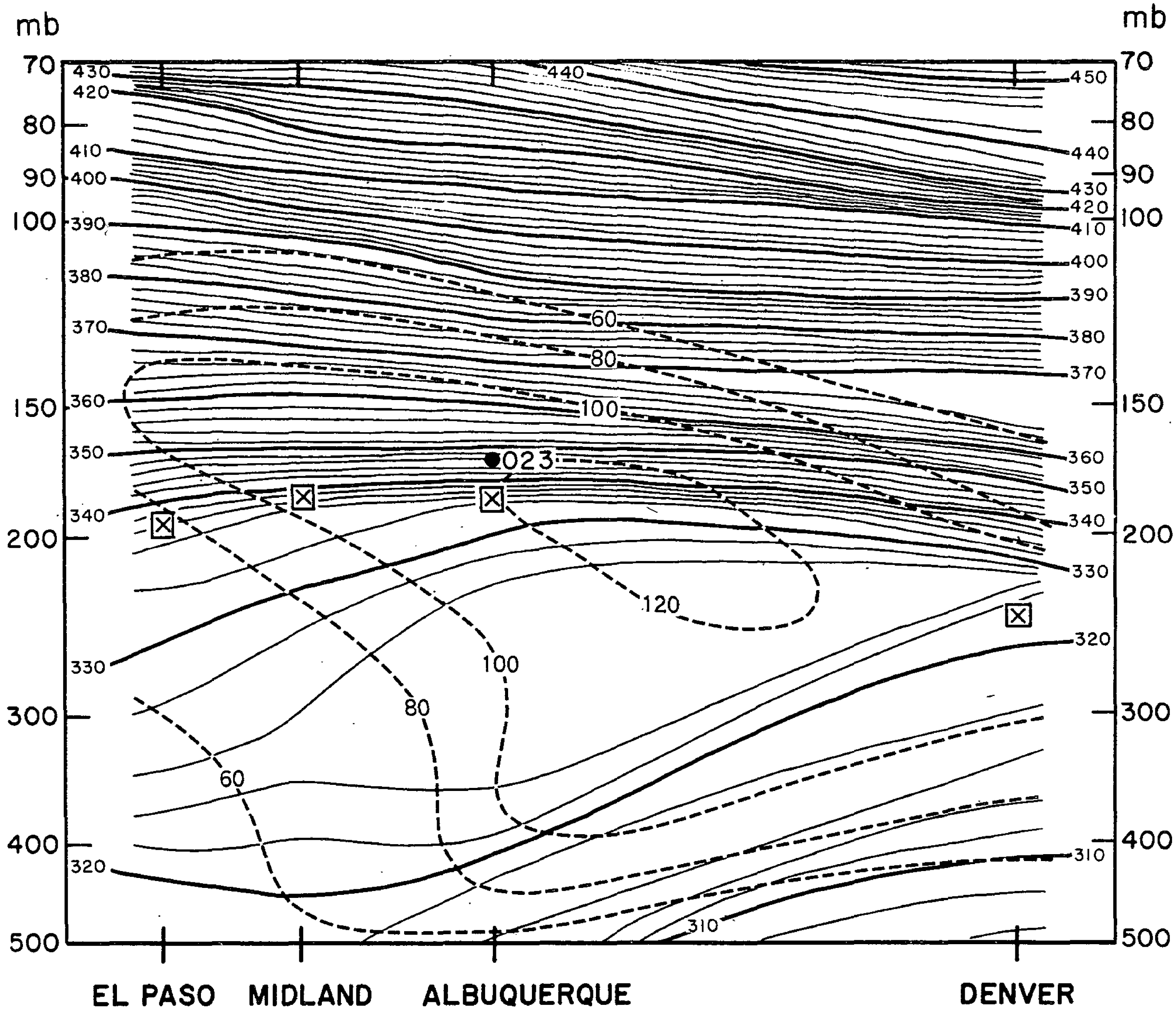


Figure 6. Vertical cross-section for 0000 GCT 9 March 1960

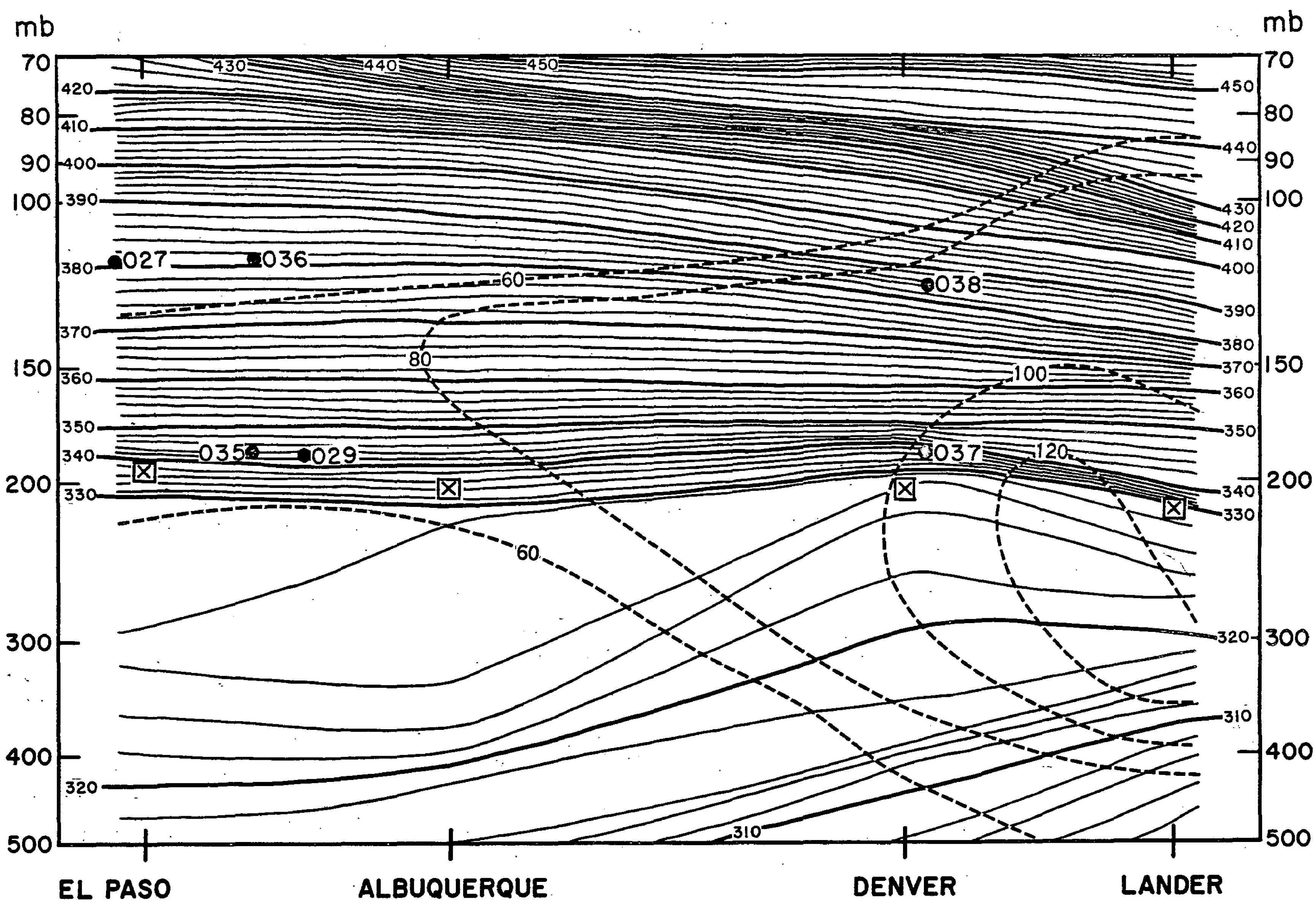


Figure 7. Vertical cross-section for 0000 GCT 10 March 1960

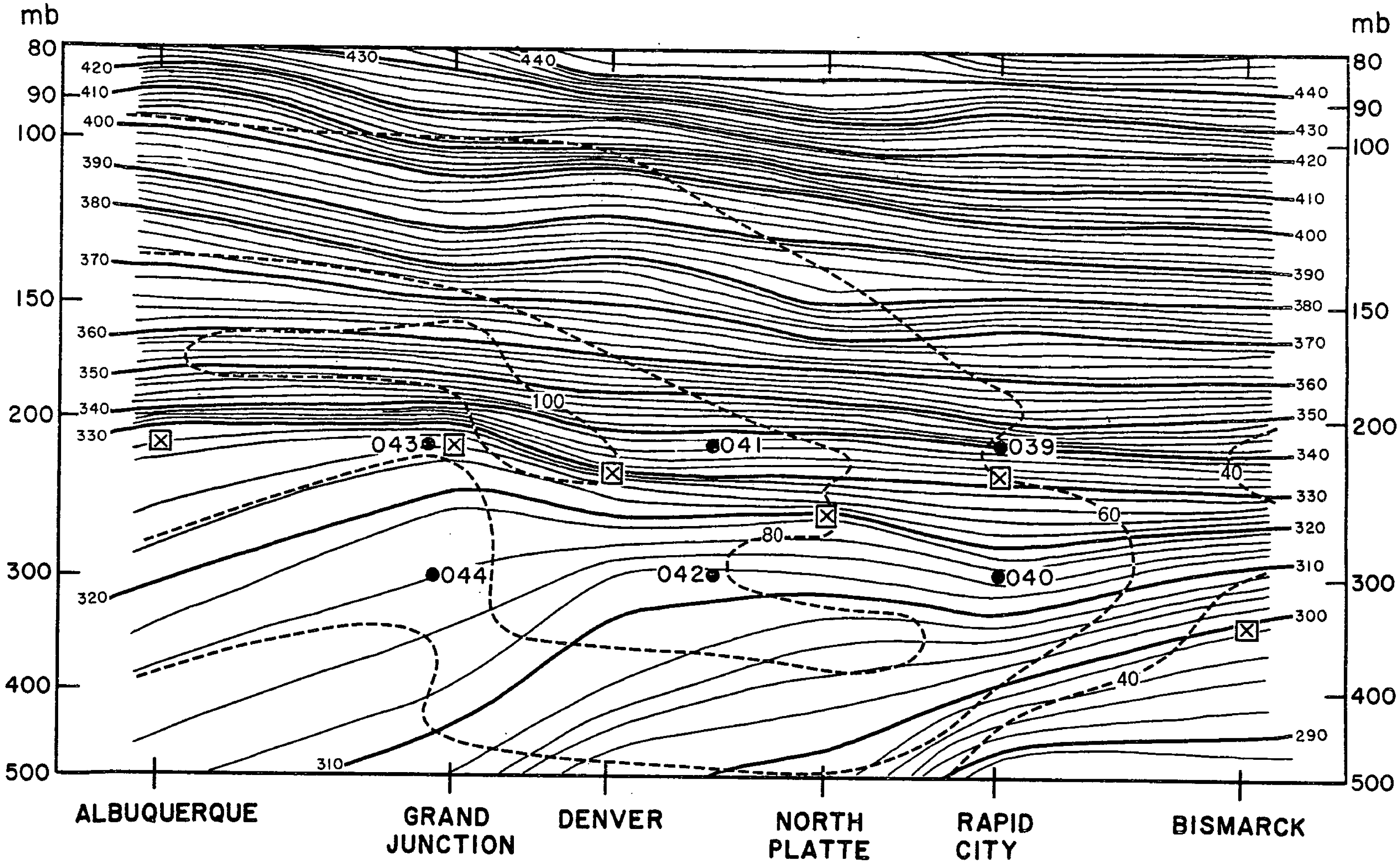


Figure 8. Vertical cross-section for 0000 GCT 11 March 1960

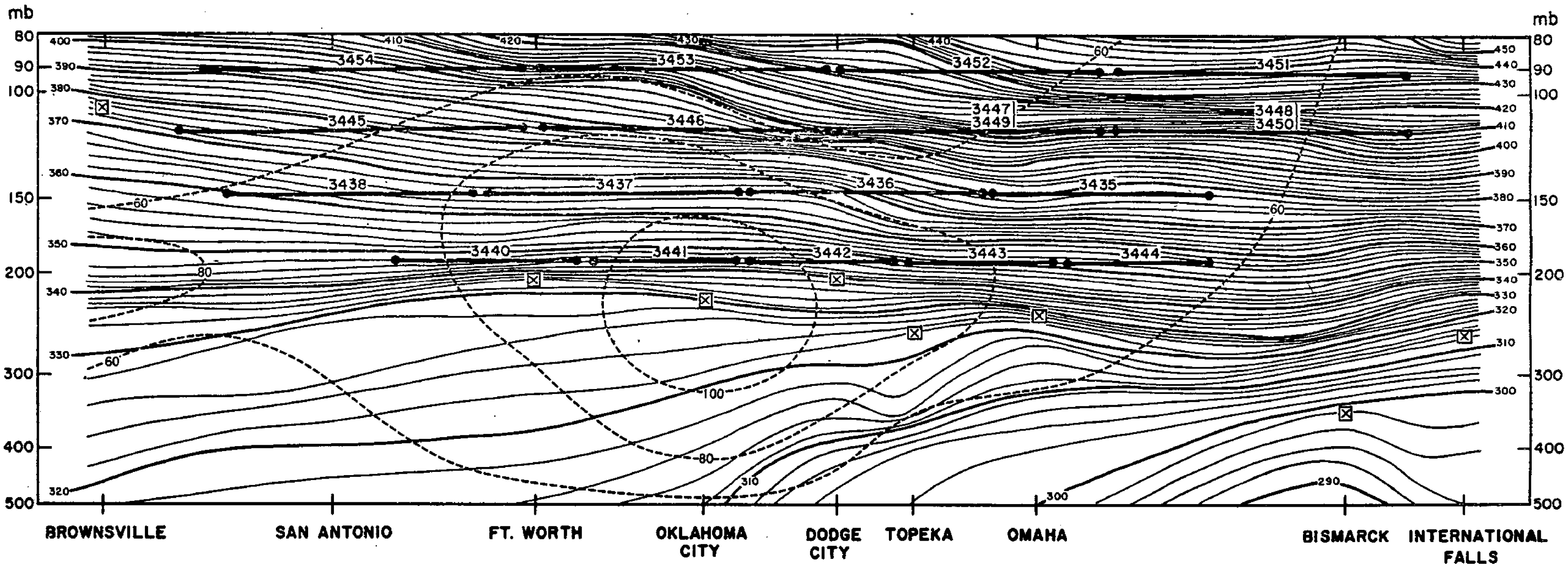


Figure 9. Vertical cross-section for 0000 GCT 11 March 1960

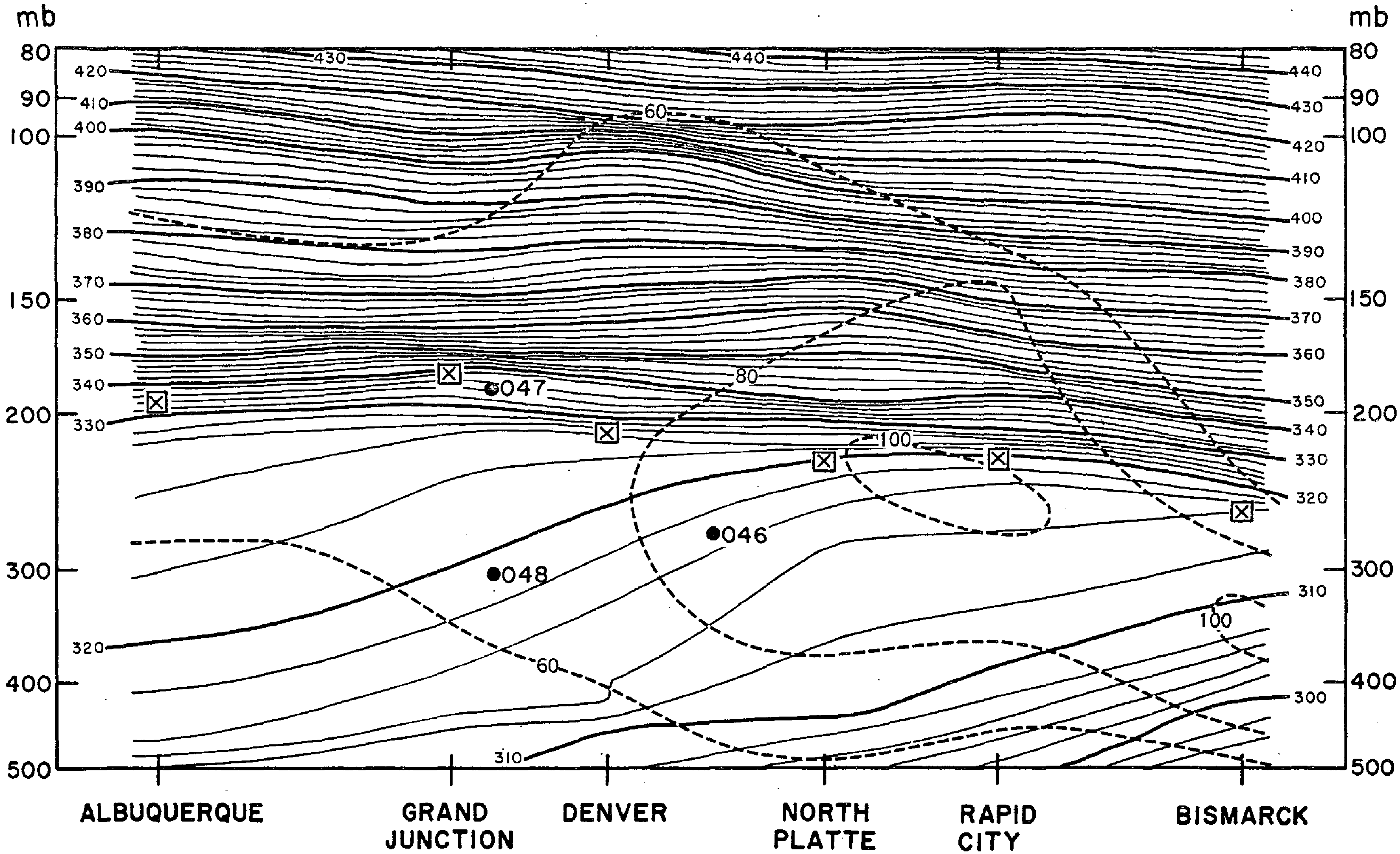


Figure 10. Vertical cross-section for 0000 GCT 12 March 1960

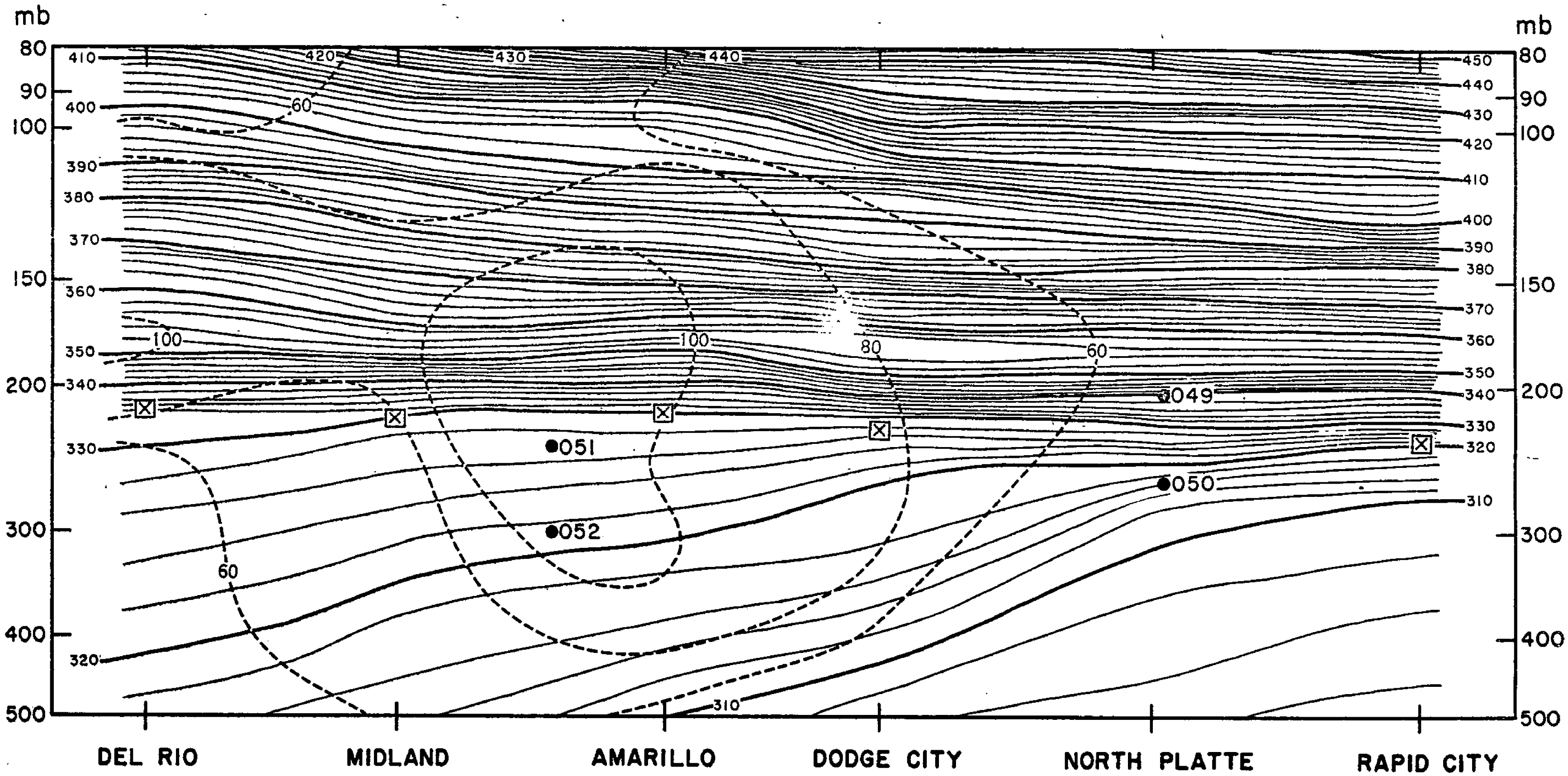


Figure II. Vertical cross-section for 0000 GCT 15 March 1960

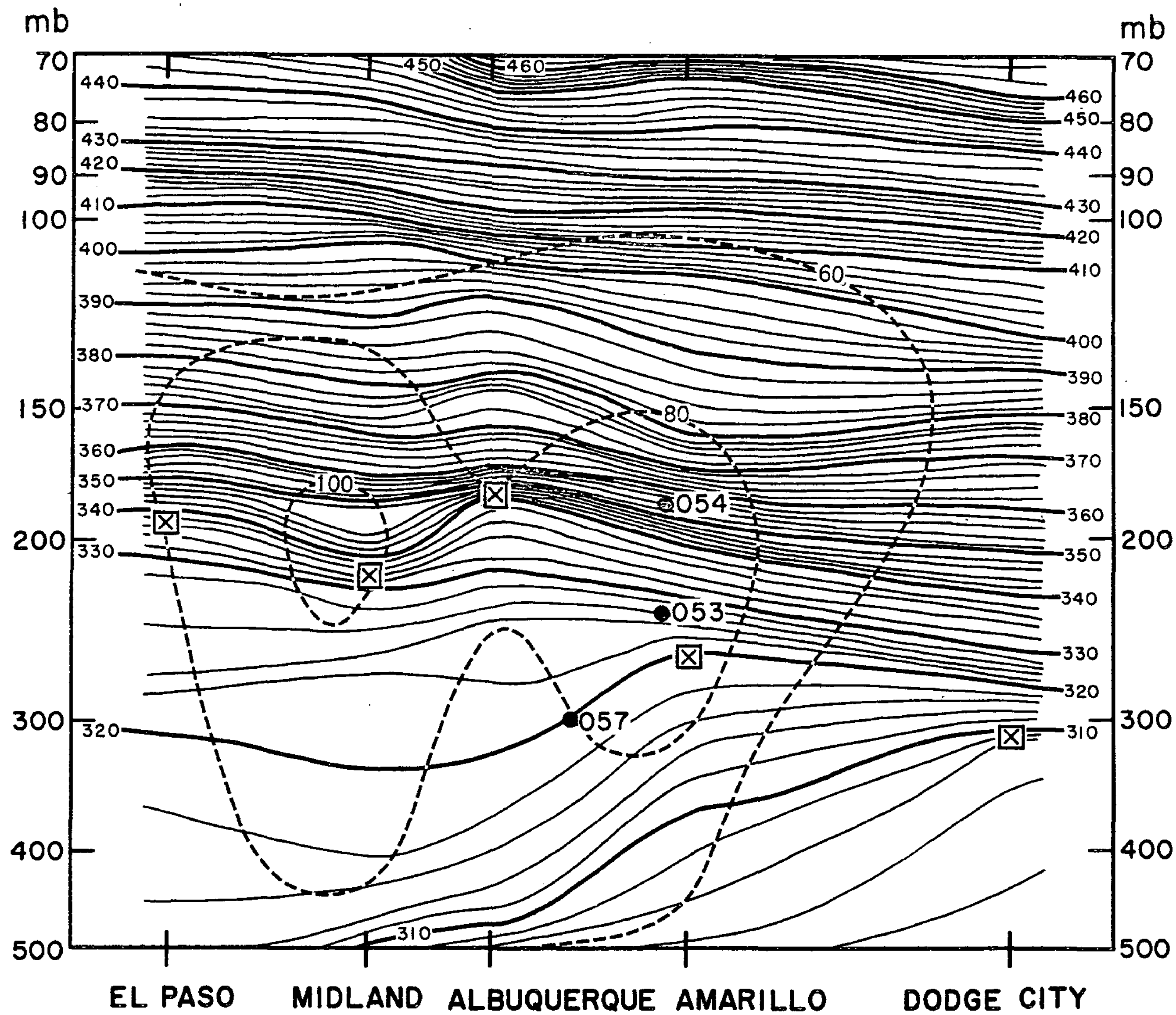


Figure 12. Vertical cross-section for 0000 GCT 16 March 1960

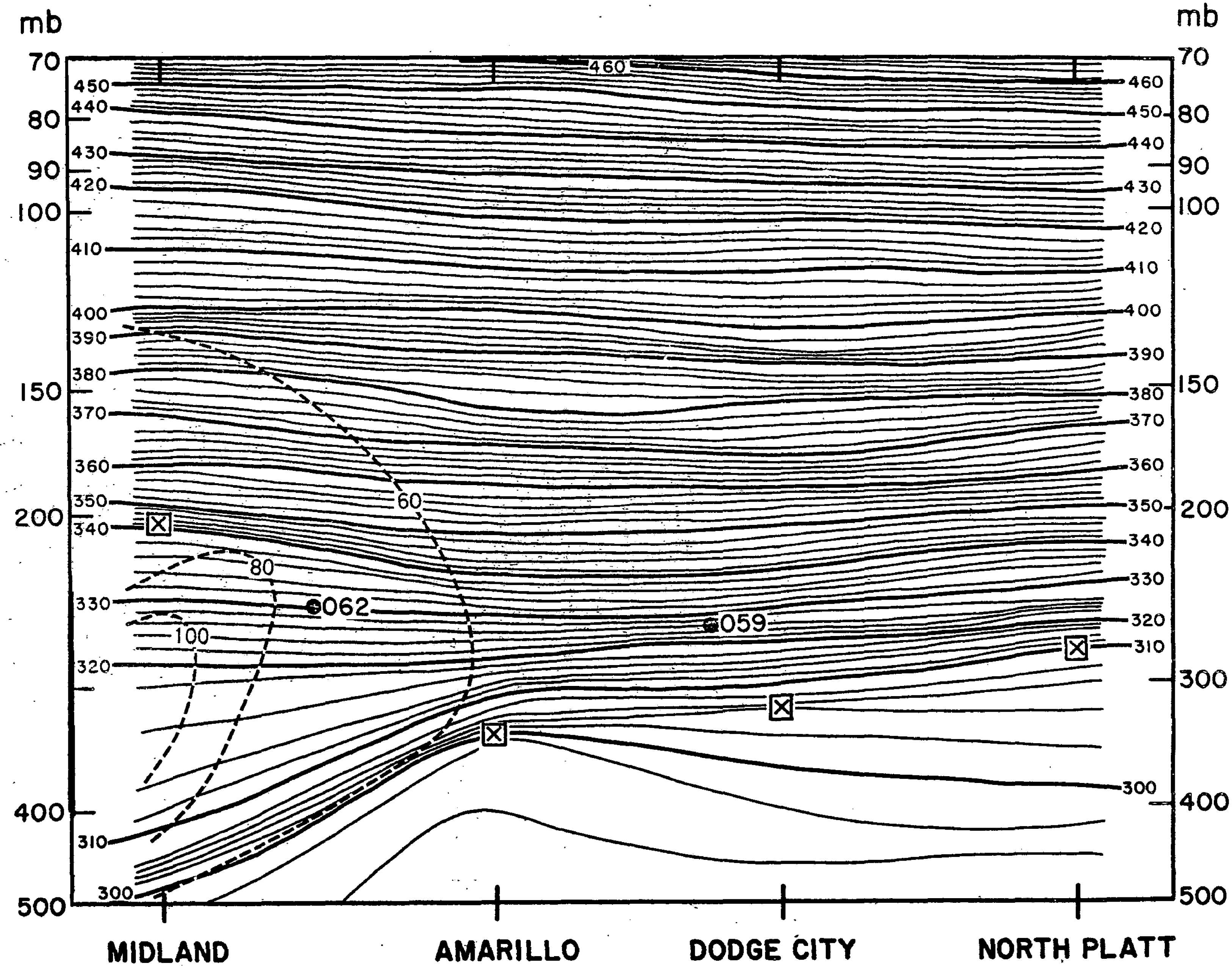


Figure 13 Vertical cross-section for 0000 GCT 17 March 1960

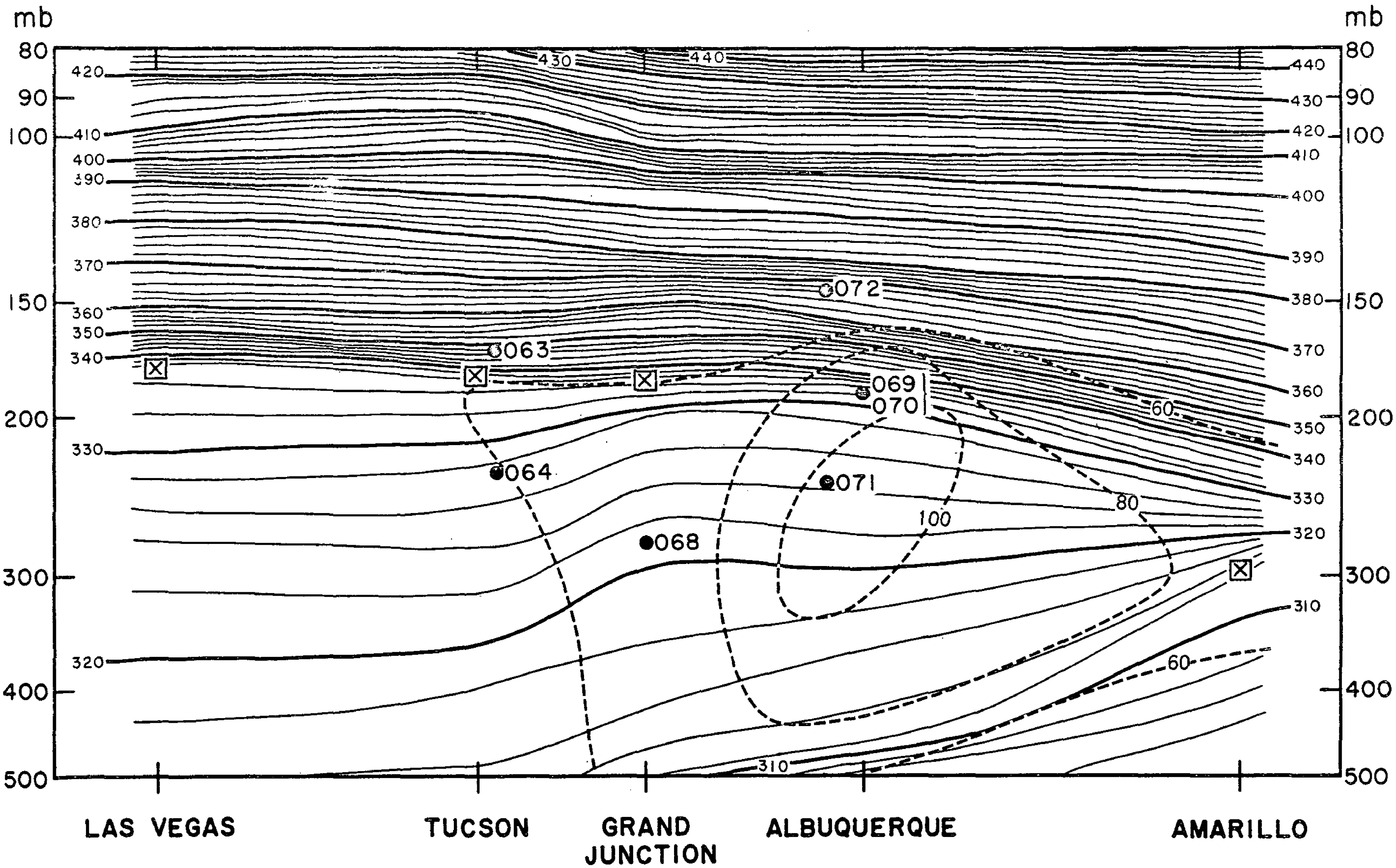


Figure 14. Vertical cross-section for 0000 GCT 18 March 1960

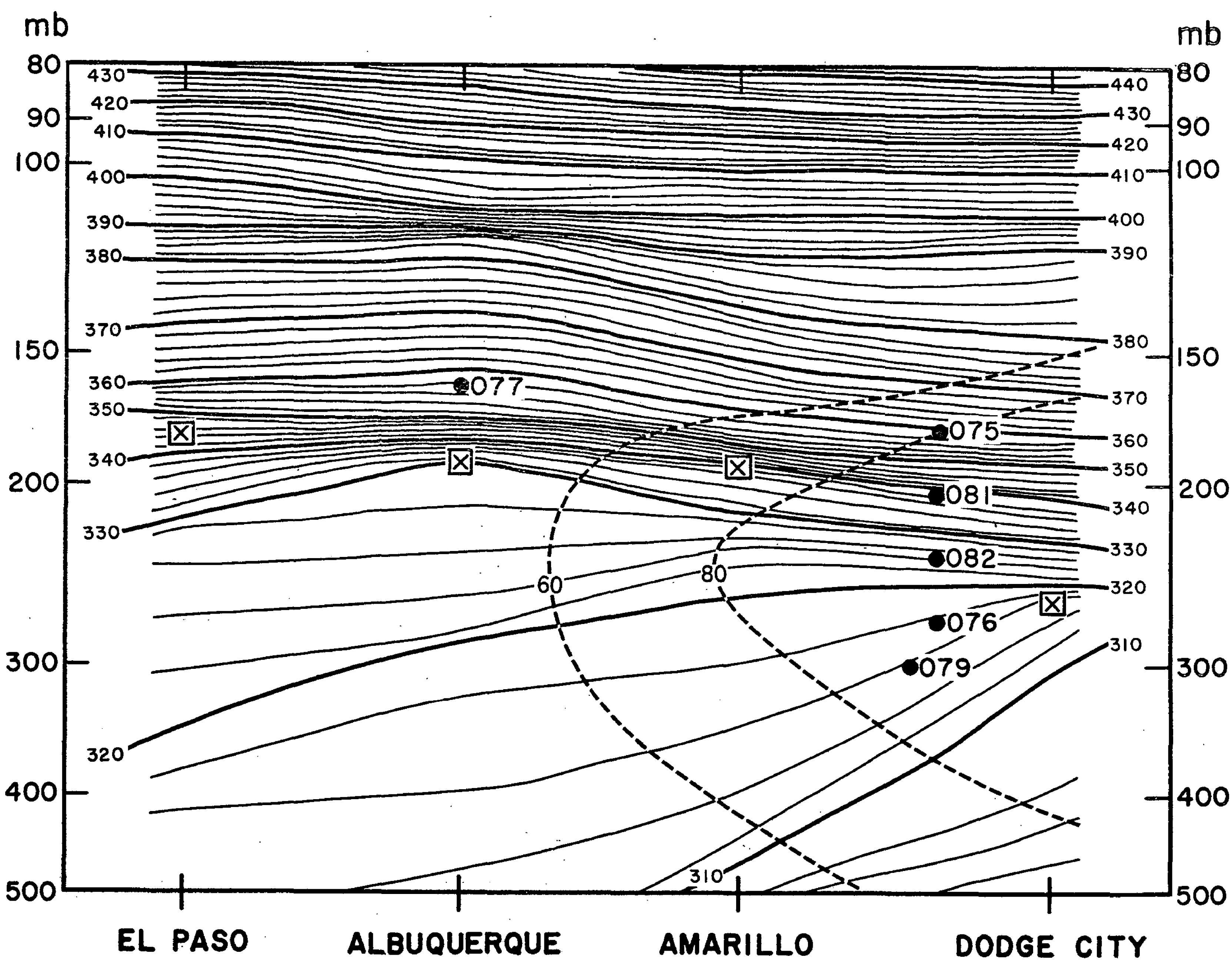


Figure 15. Vertical cross-section for 0000 GCT 19 March 1960

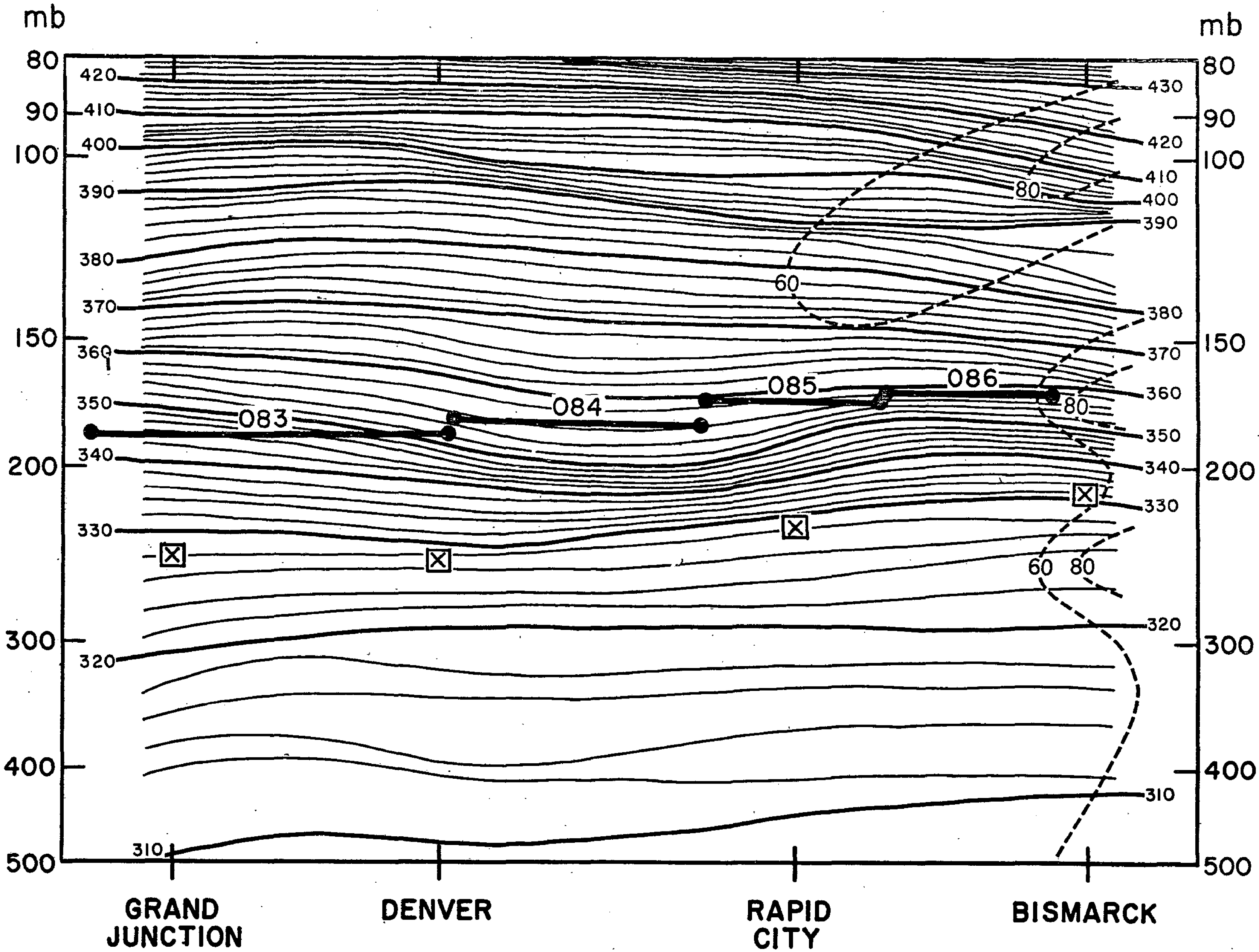


Figure 16. Vertical cross-section for 0000 GCT 22 March 1960

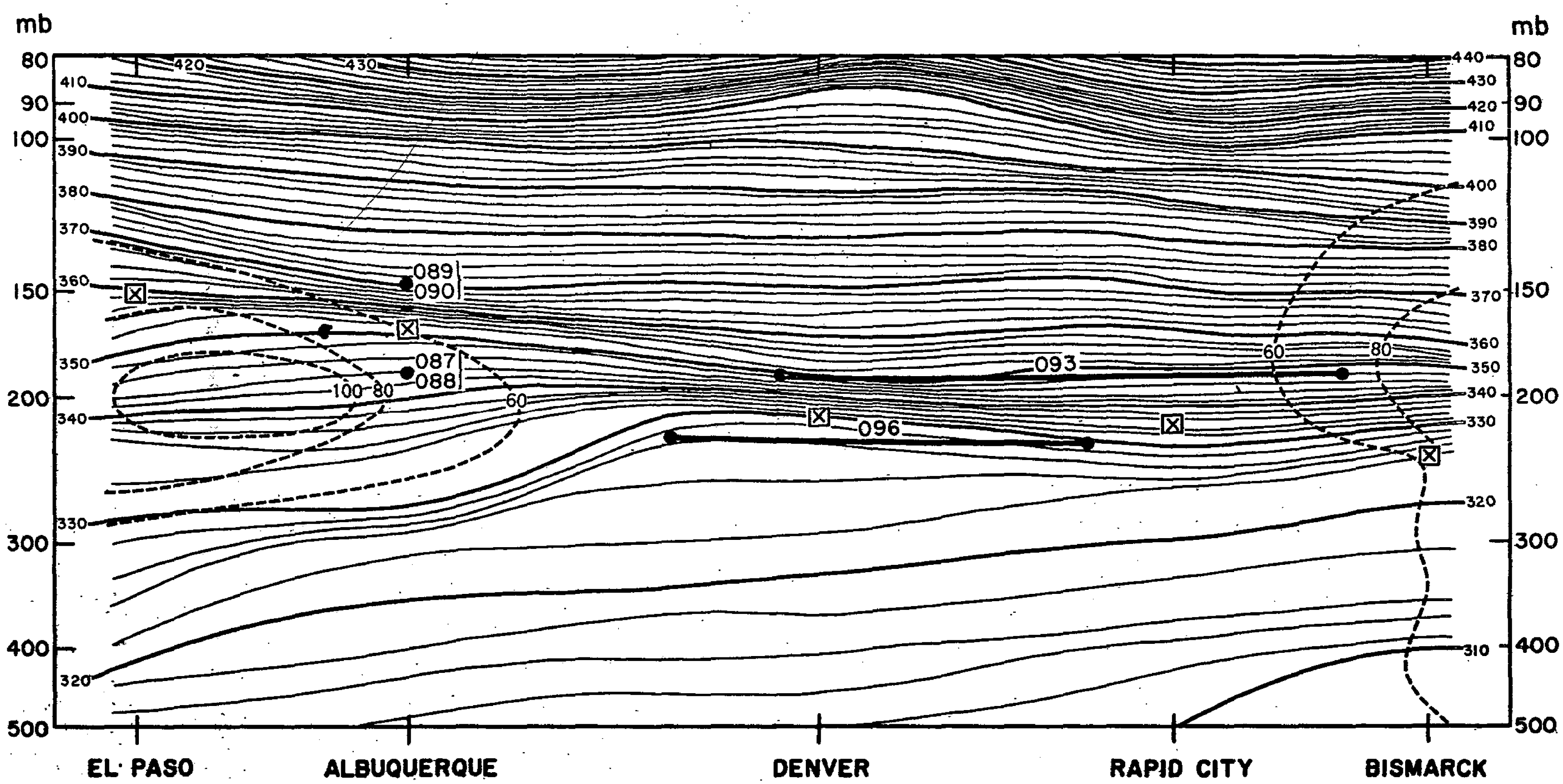


Figure 17. Vertical cross-section for 0000 GCT 23 March 1960

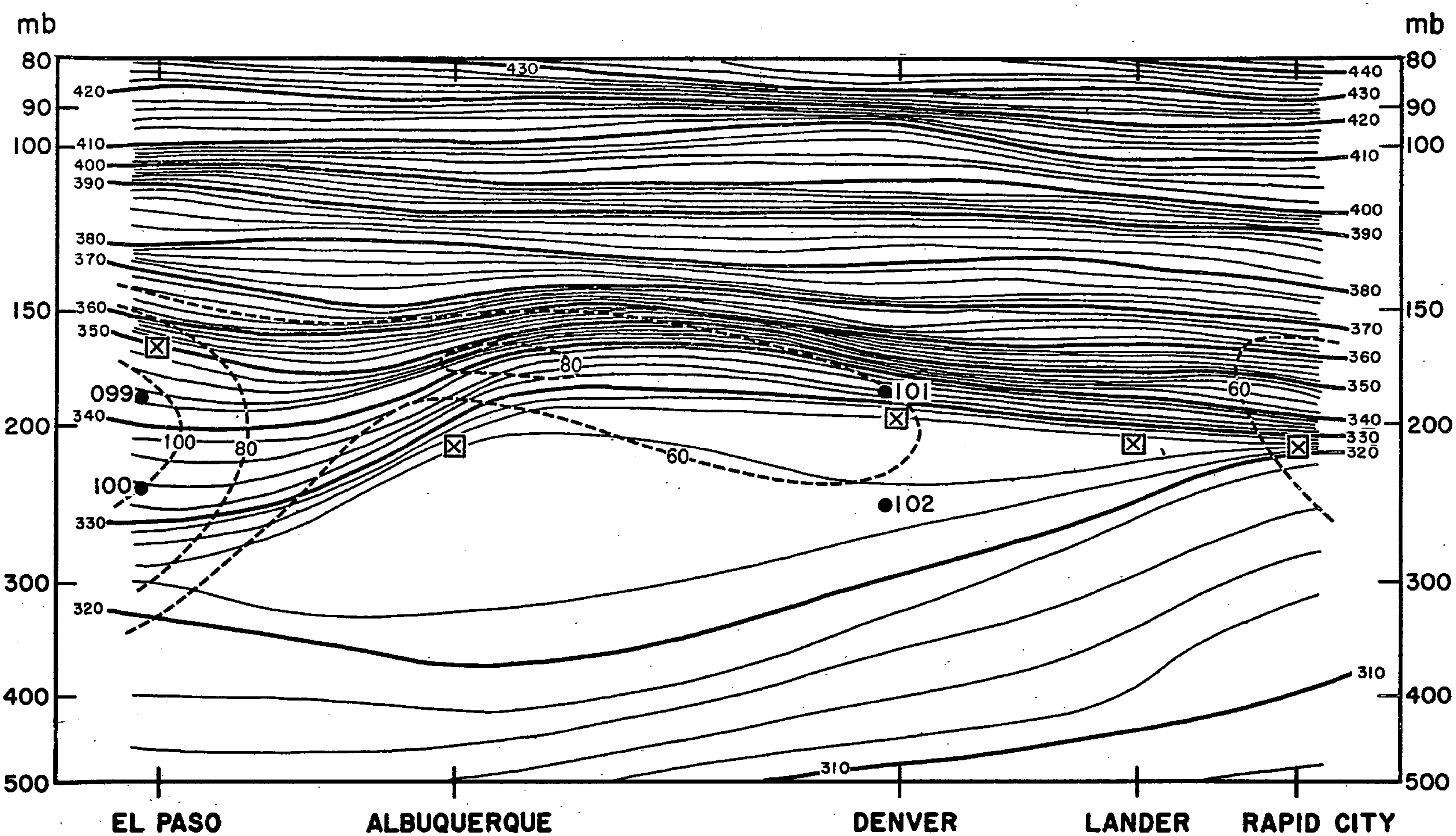


Figure 18. Vertical cross-section for 0000 GCT 24 March 1960

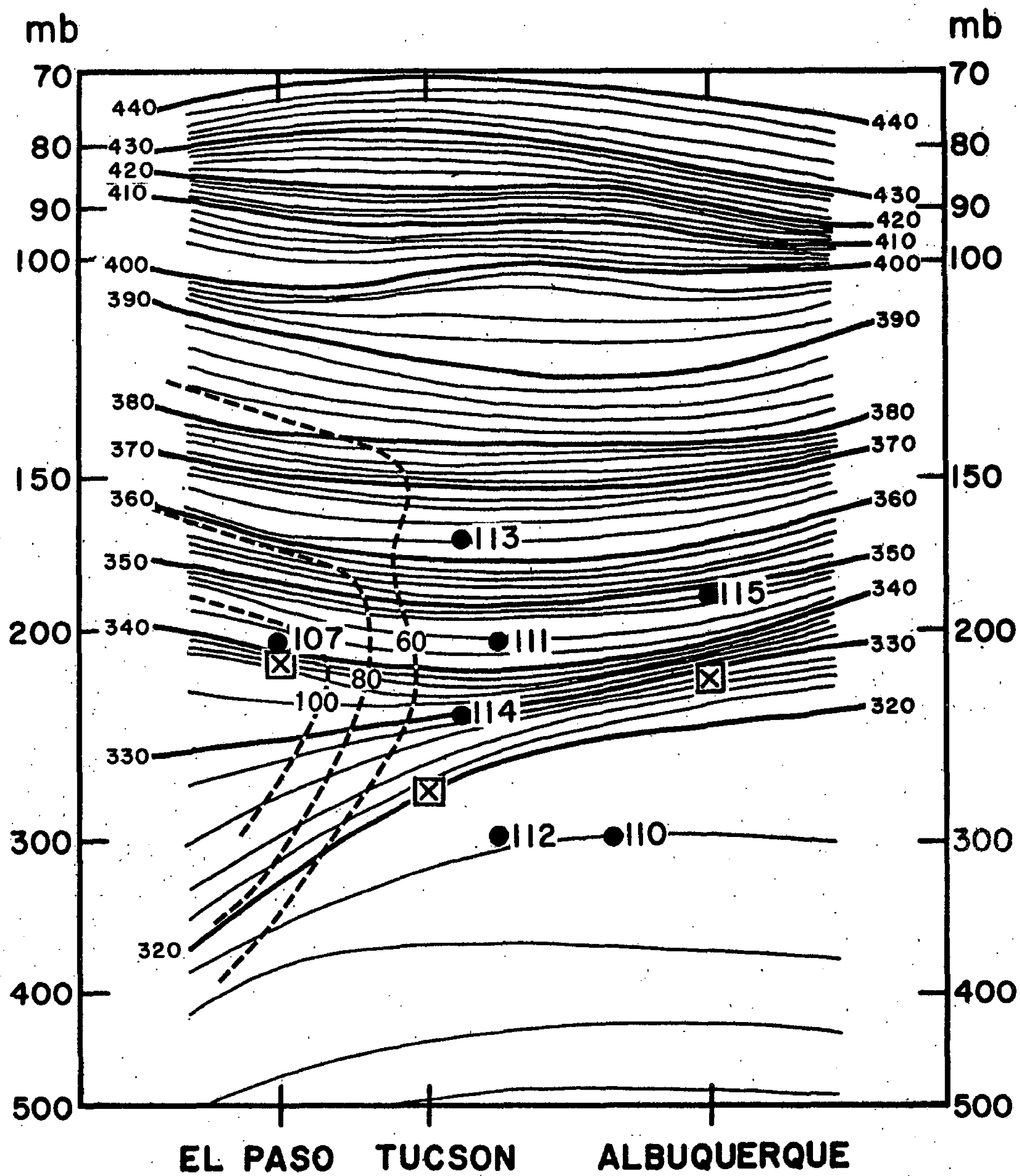


Figure 19. Vertical cross-section for 0000 GCT 25 March 1960

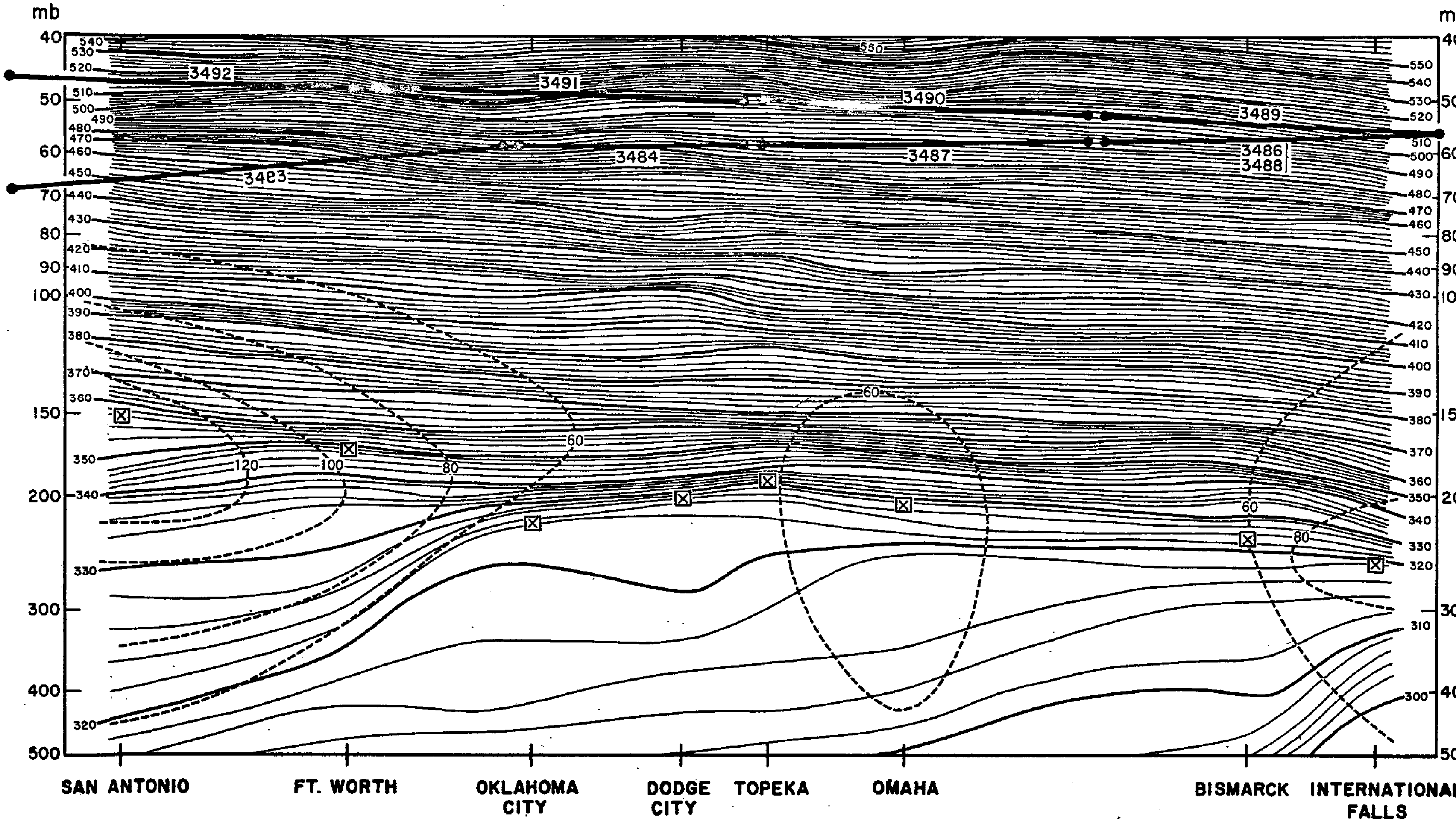


Figure 20. Vertical cross-section for 0000 GCT 25 March 1960

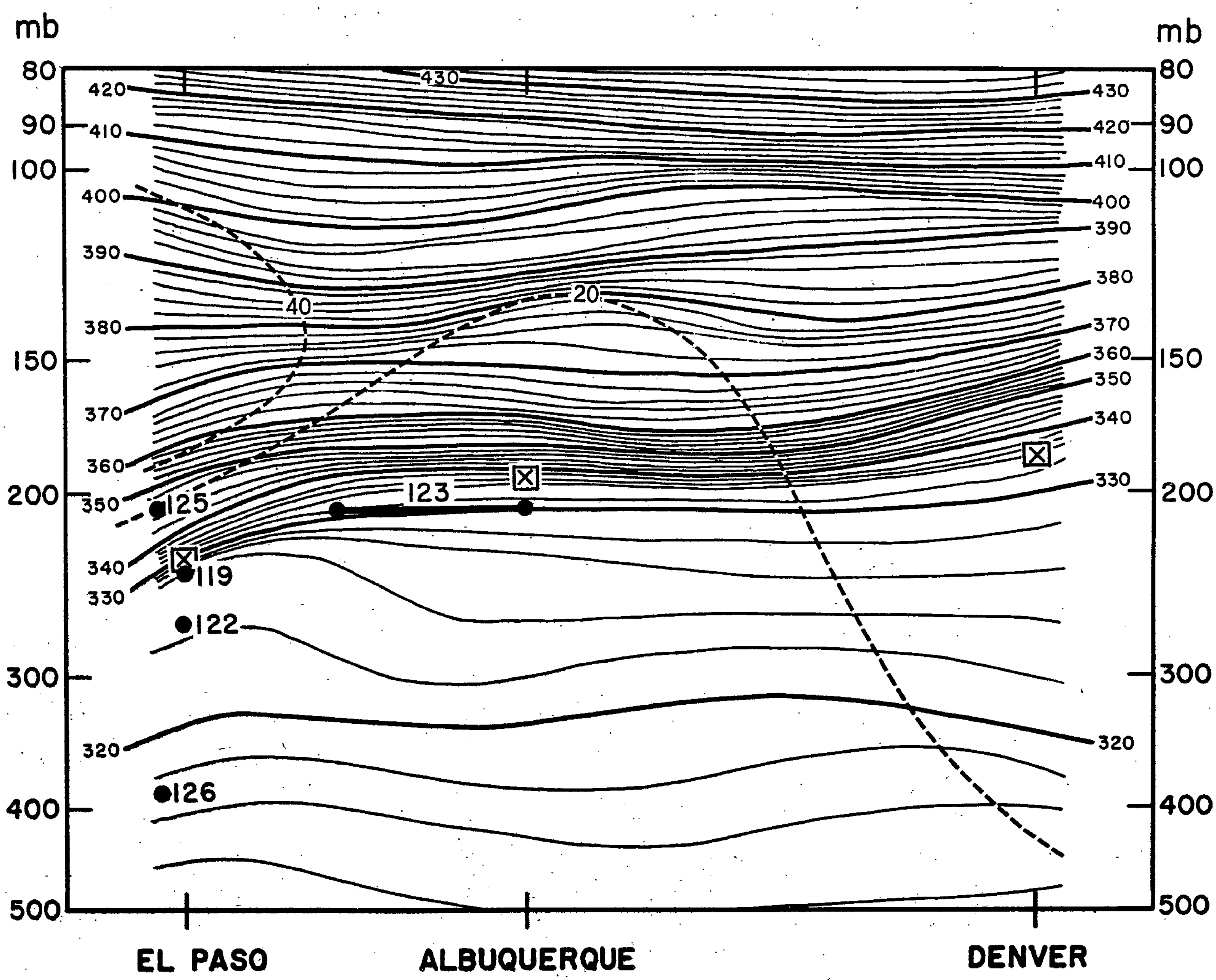


Figure 21. Vertical cross-section for 0000 GCT 26 March 1960

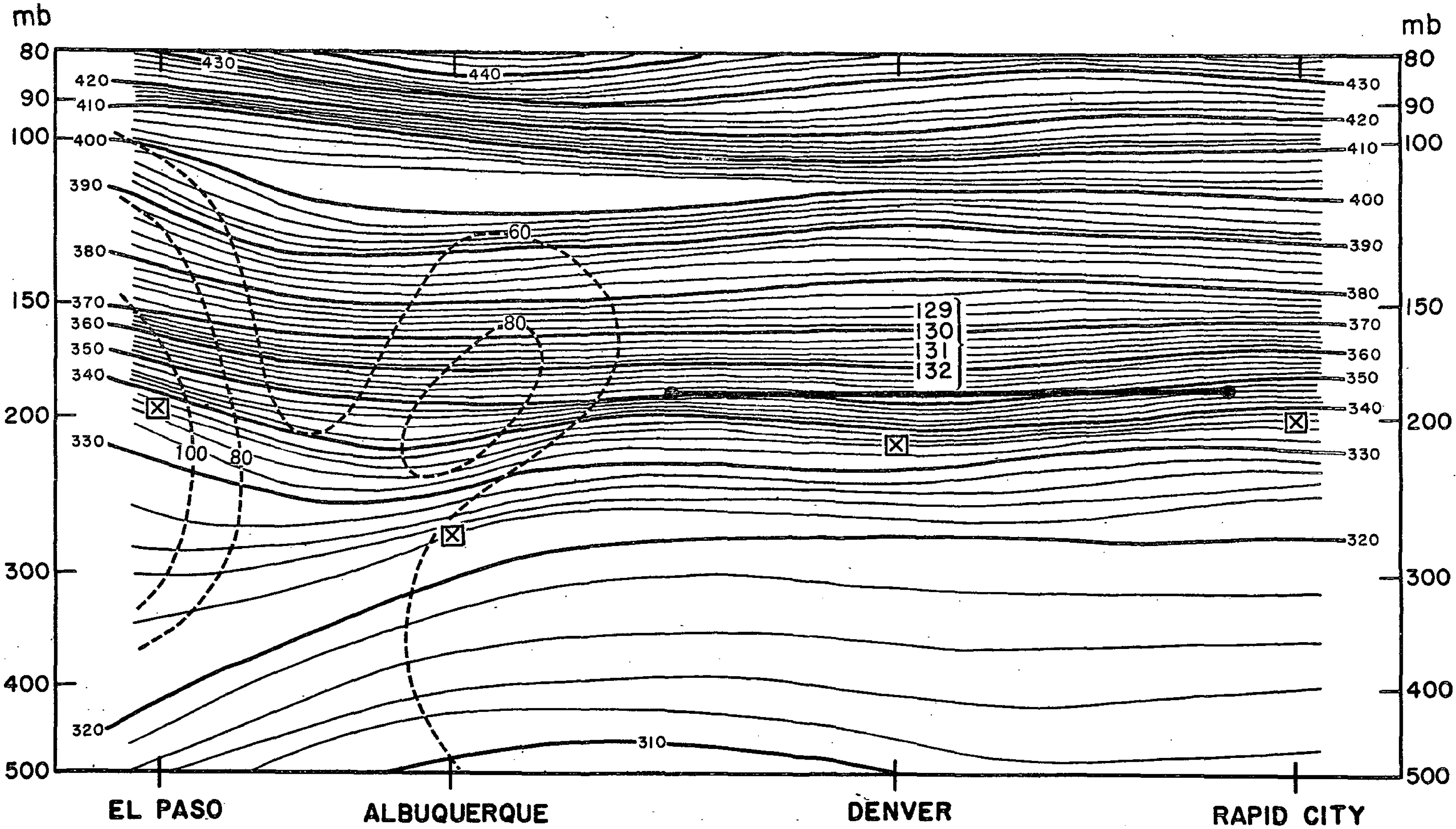


Figure 22. Vertical cross-section for 0000 GCT 29 March 1960

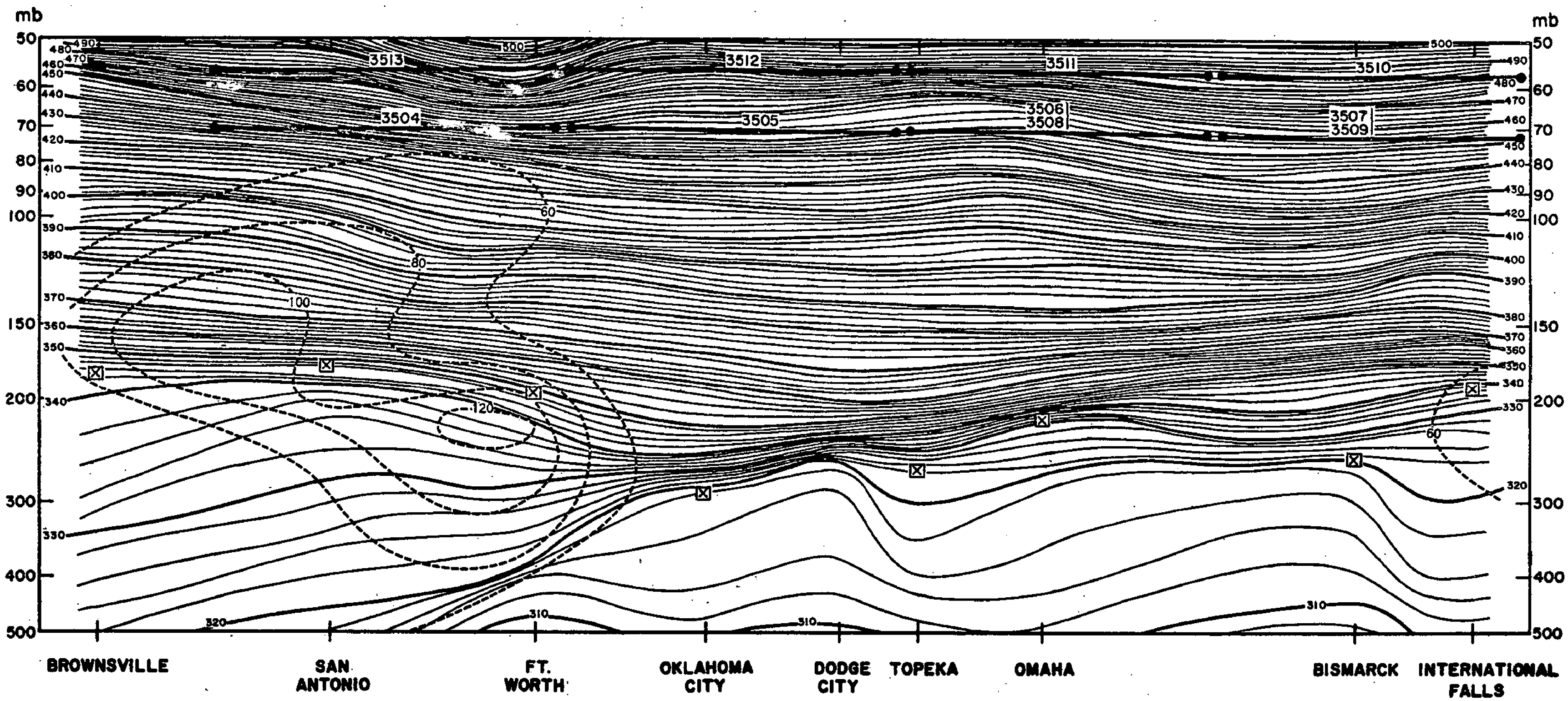


Figure 23. Vertical cross-section for 0000 GCT 30 March 1960

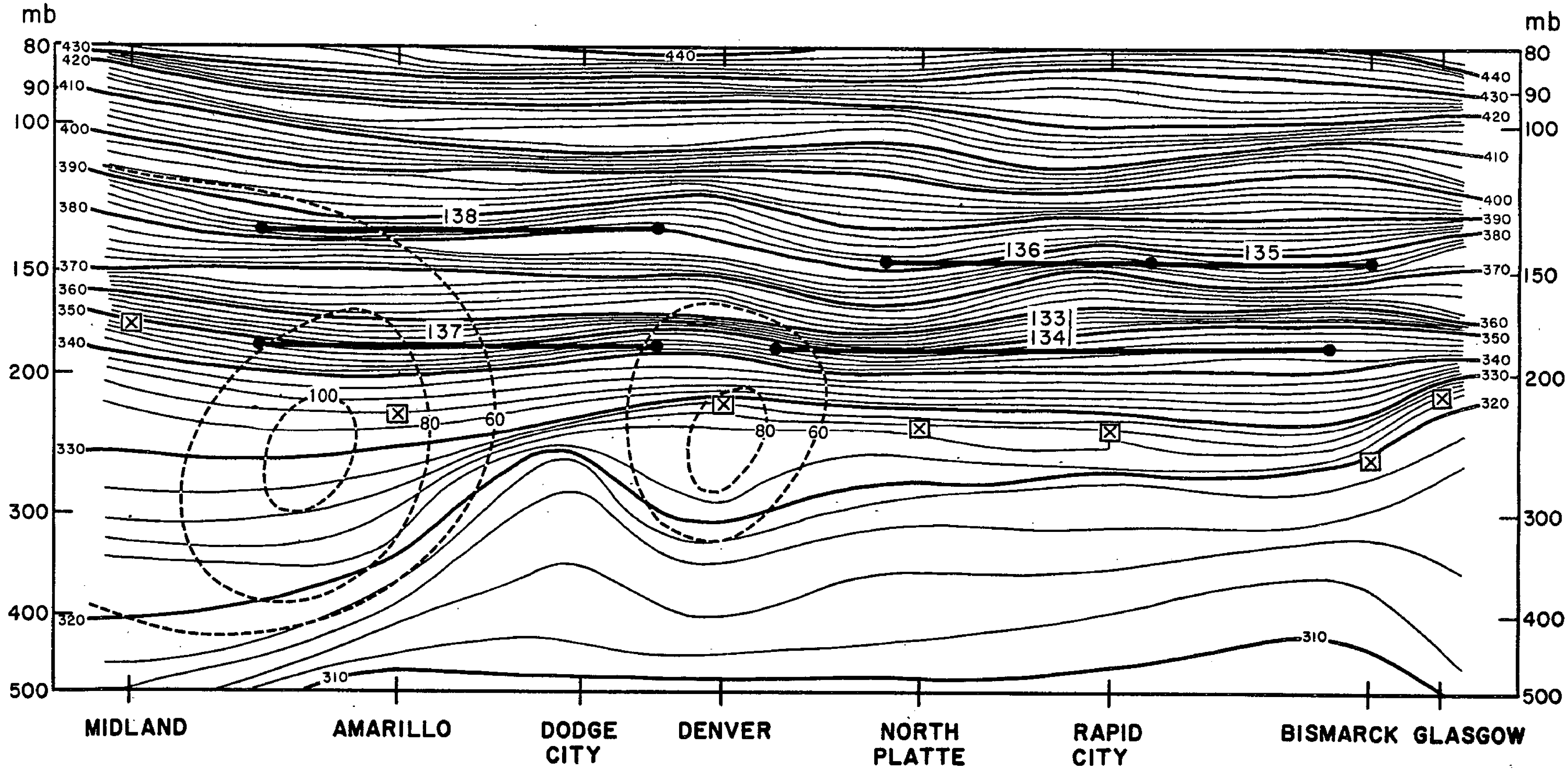


Figure 24. Vertical cross-section for 0000 GCT 30 March 1960

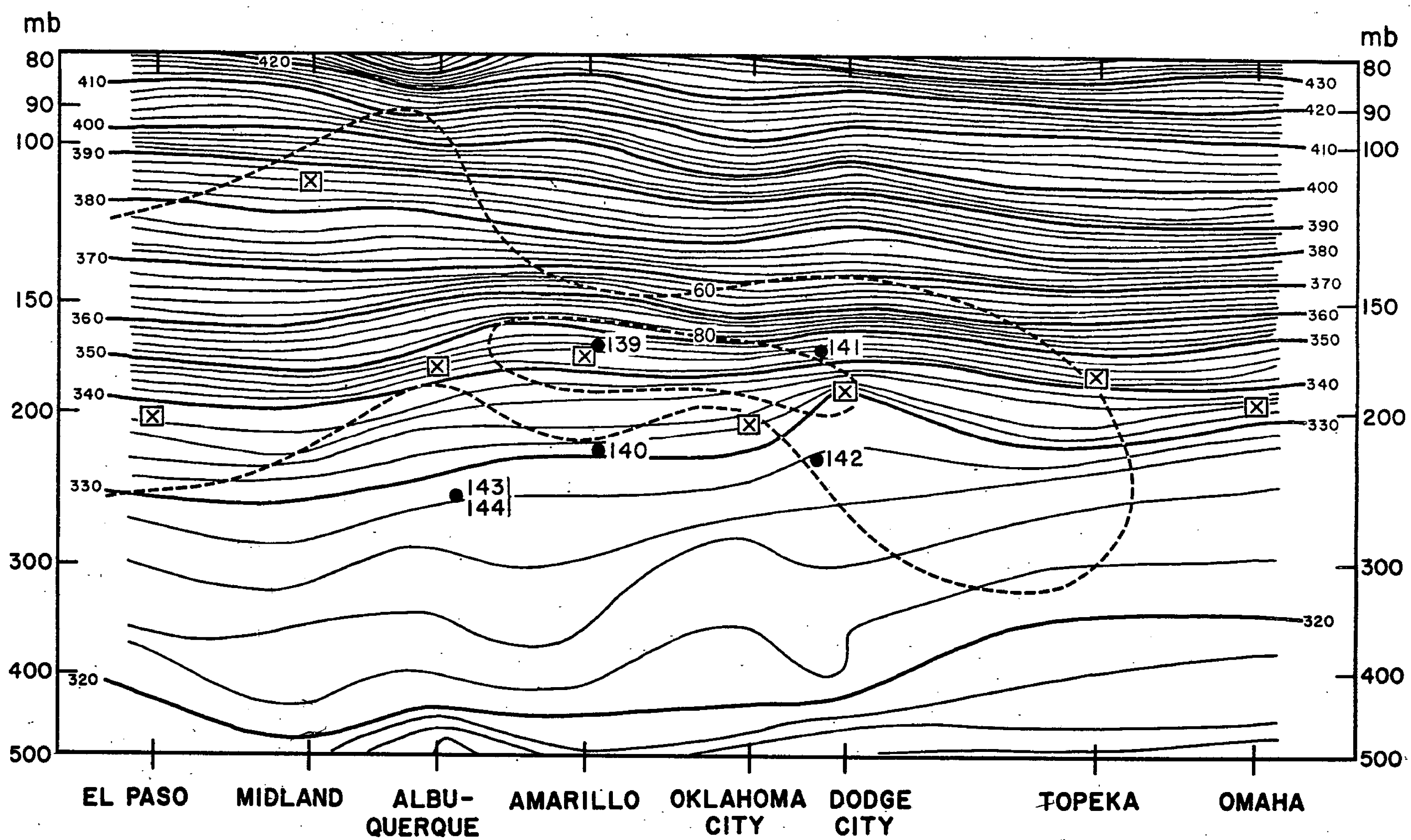


Figure 25. Vertical cross-section for 0000 GCT 31 March 1960

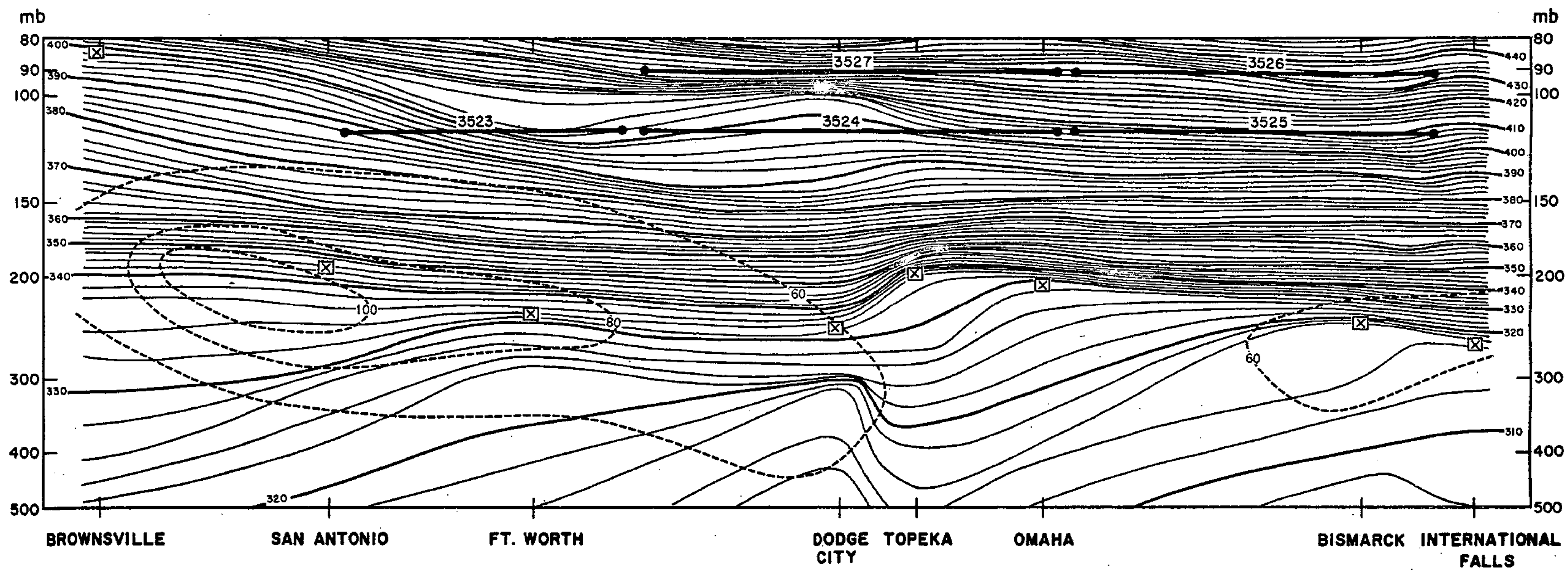


Figure 26. Vertical cross-section for 0000 GCT 1 April 1960

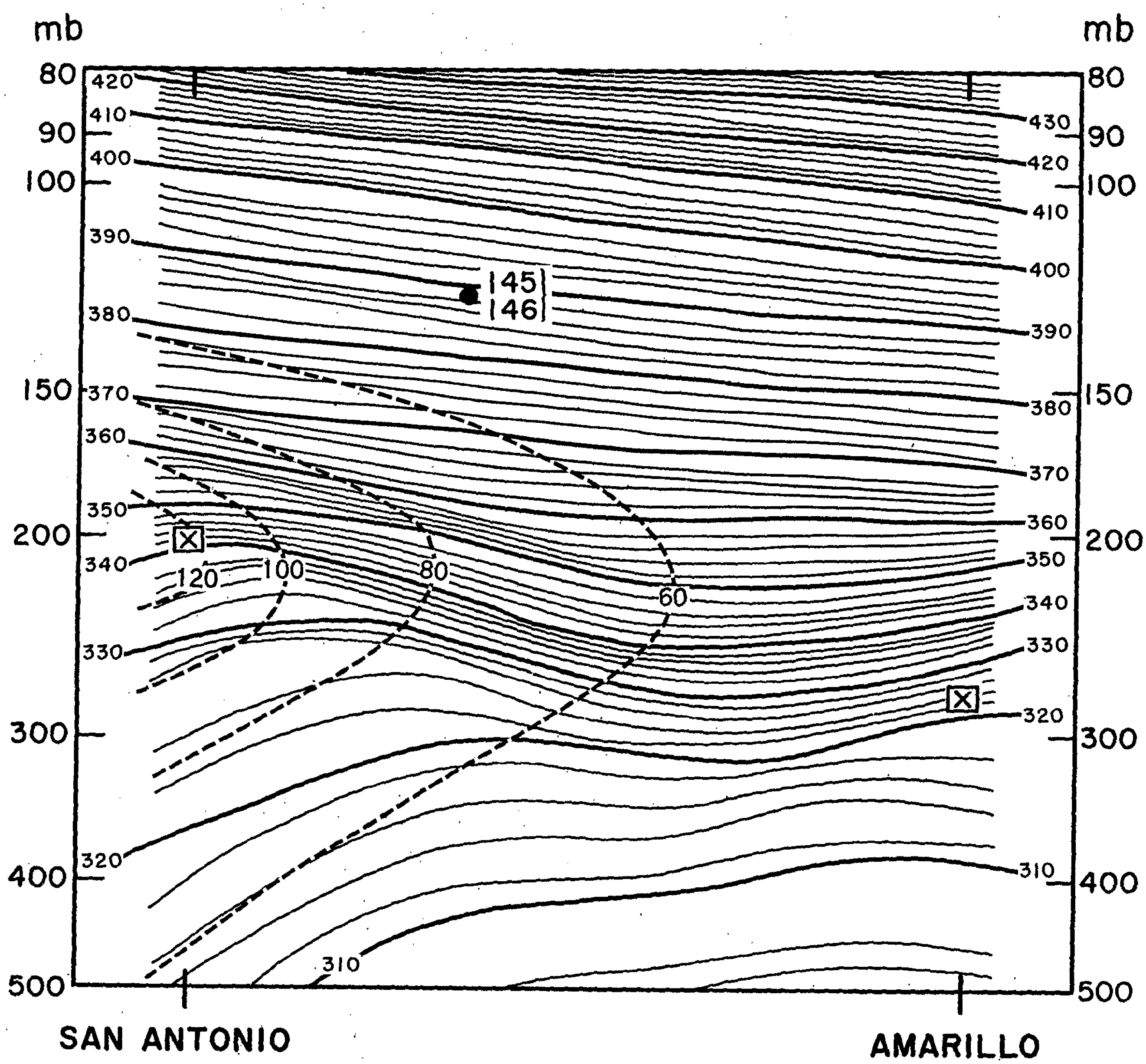


Figure 27. Vertical cross-section for 1200 GCT 1 April 1960

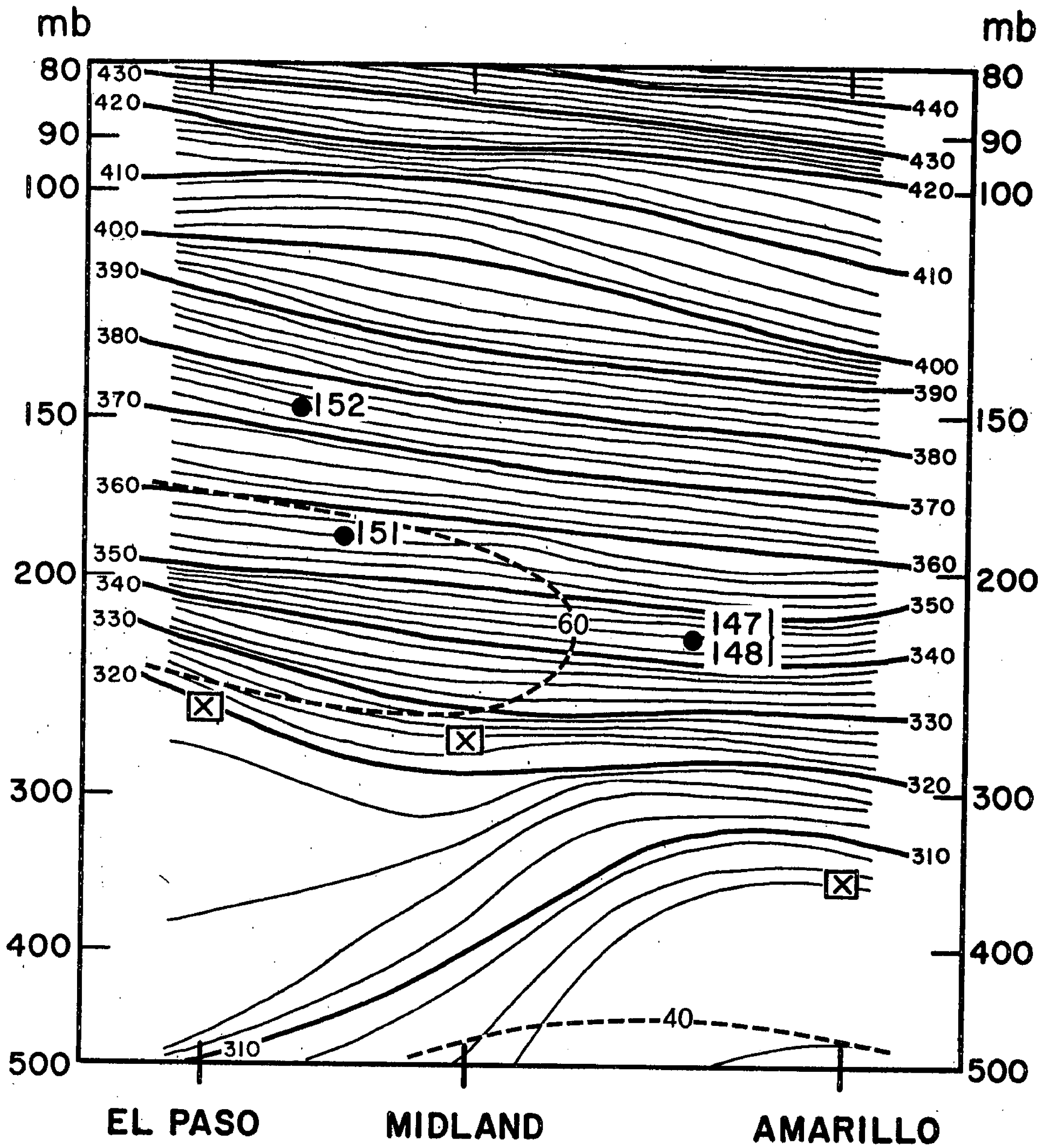


Figure 28. Vertical cross-section for 0000 GCT 2 April 1960

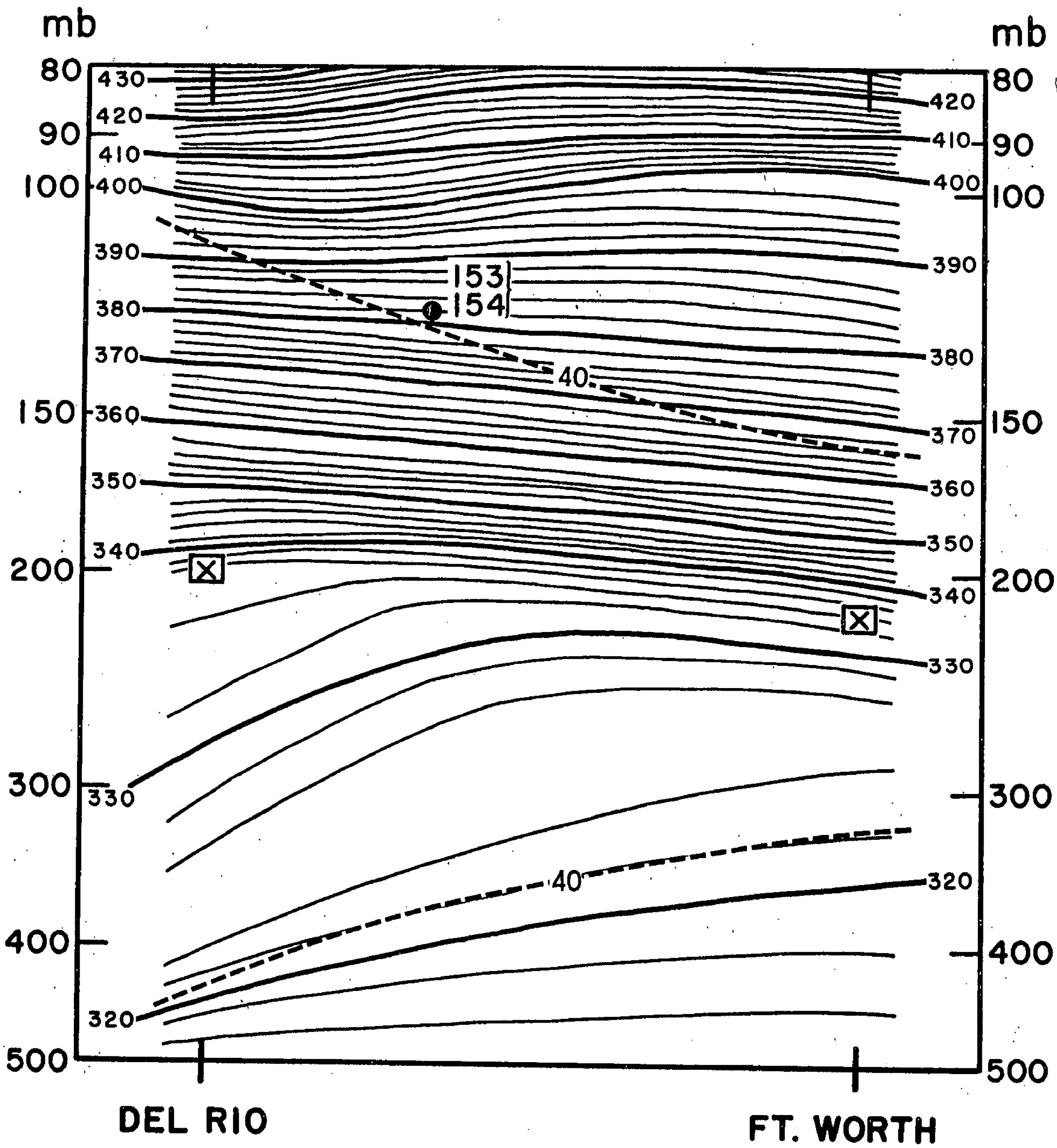
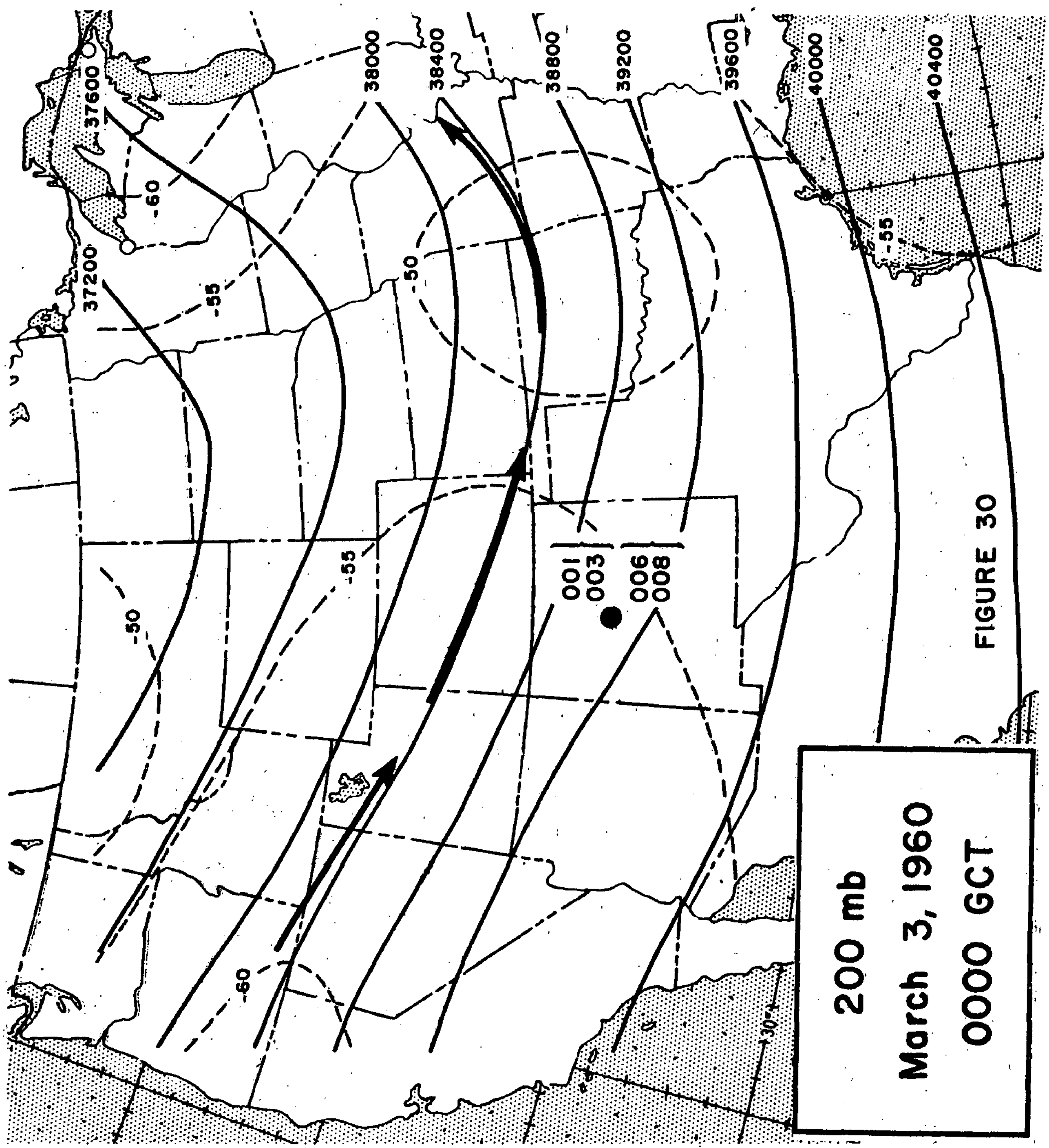


Figure 29. Vertical cross-section for 1200 GCT 9 April 1960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37600
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38400
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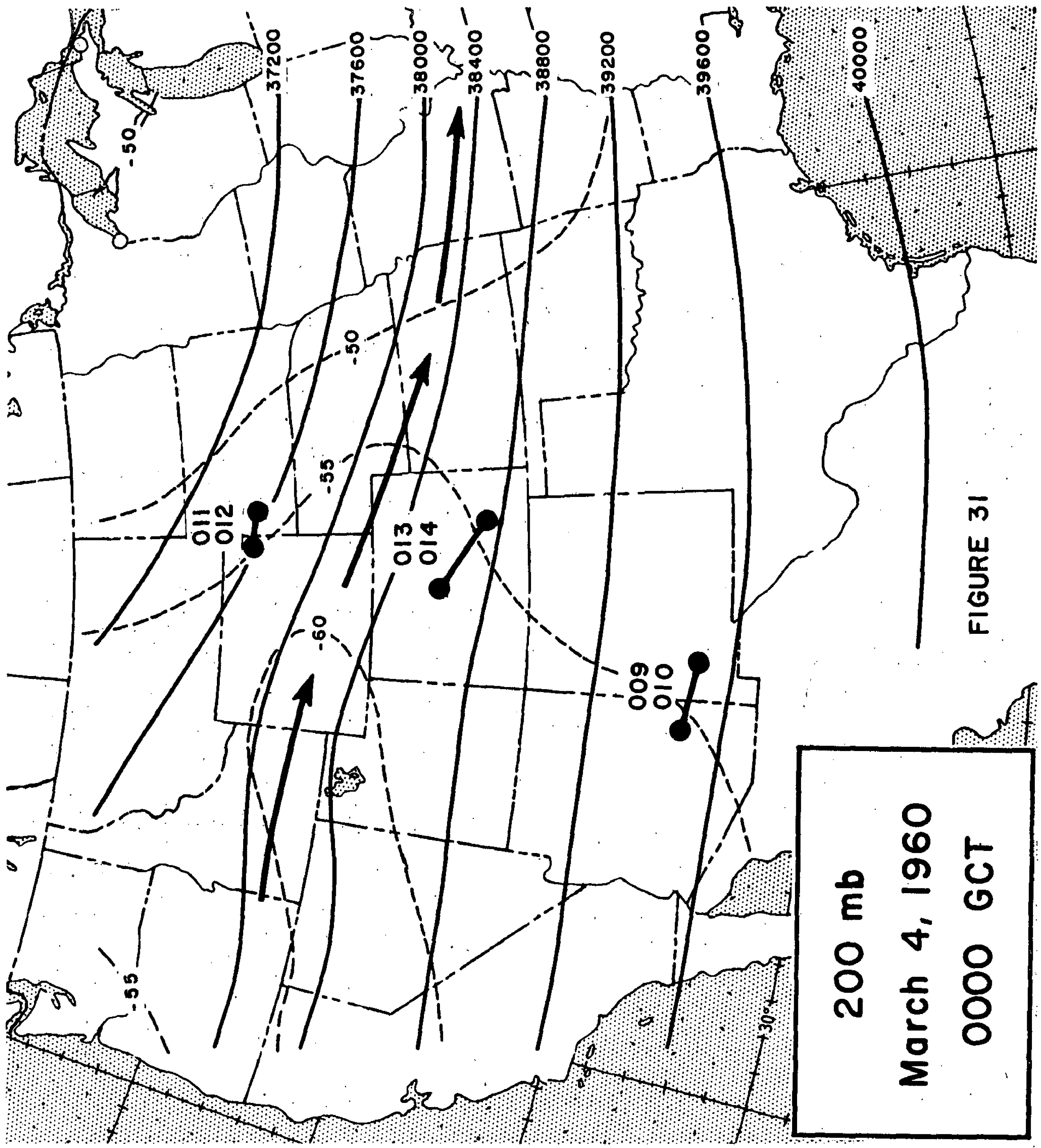
39600
40000
40400
-60
-55
-50
001
003
006
008
30

FIGURE 30


200 mb
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39600
40000
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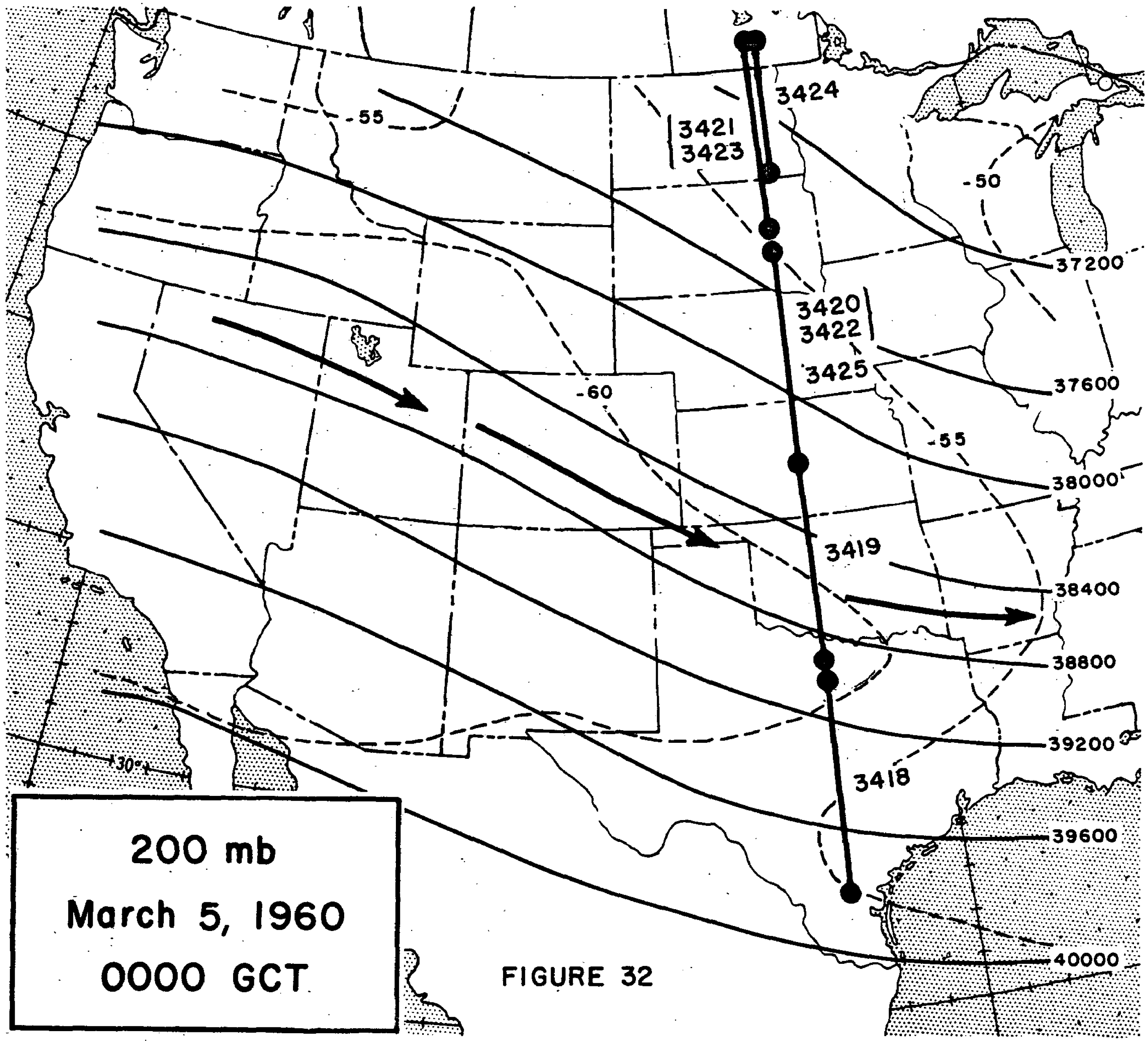
-55
-60
011
012
013
014
009
010
30°

FIGURE 31



-55
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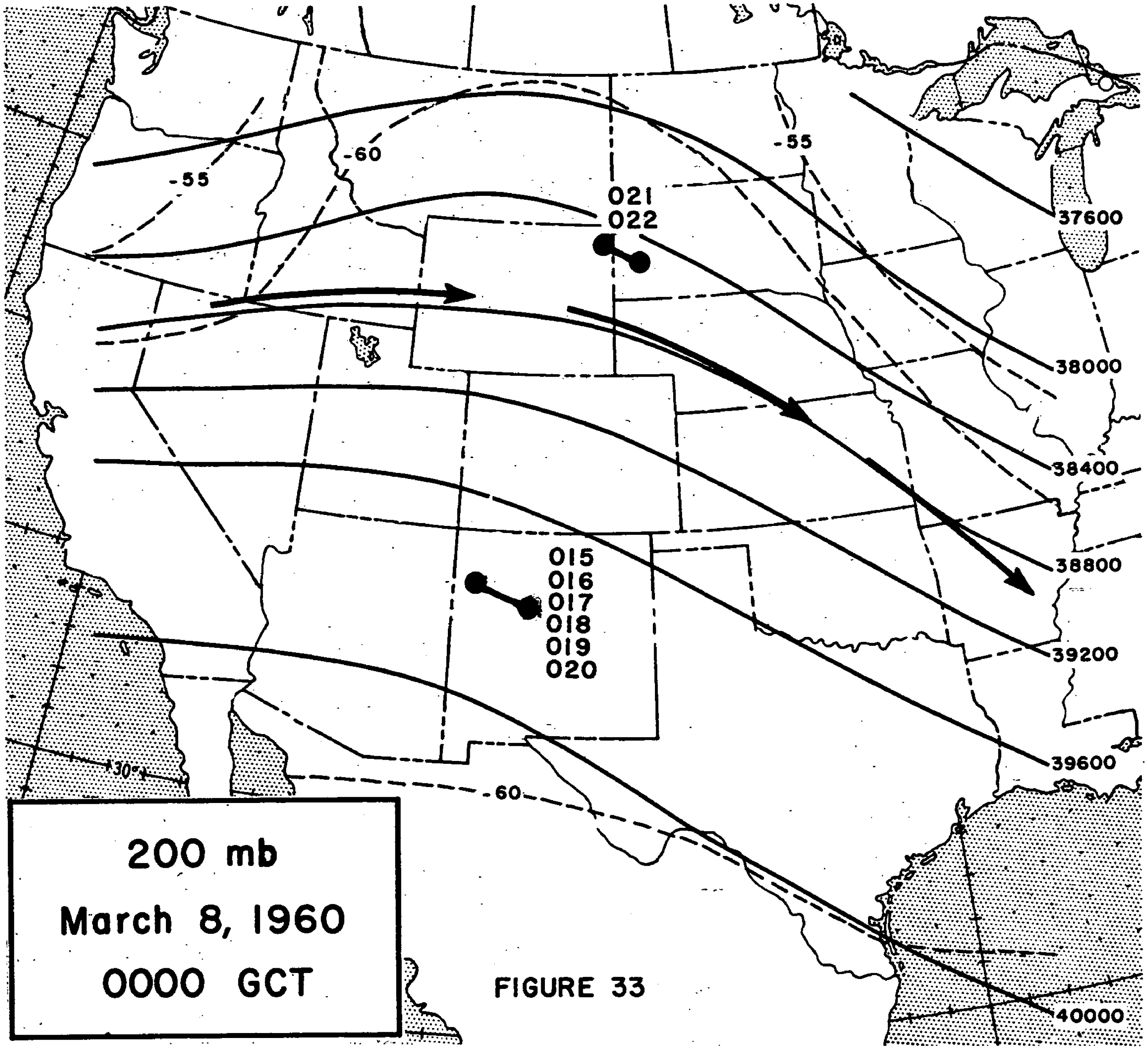
3421
3423
-50
37200
3420
3422
3425
37600
-60
-55
38000
3419
38400
38800
39200
3418
39600
40000
30°
200 mb
March 5, 1960
0000 GCT

FIGURE 32



200 mb
March 8, 1960
0000 GCT
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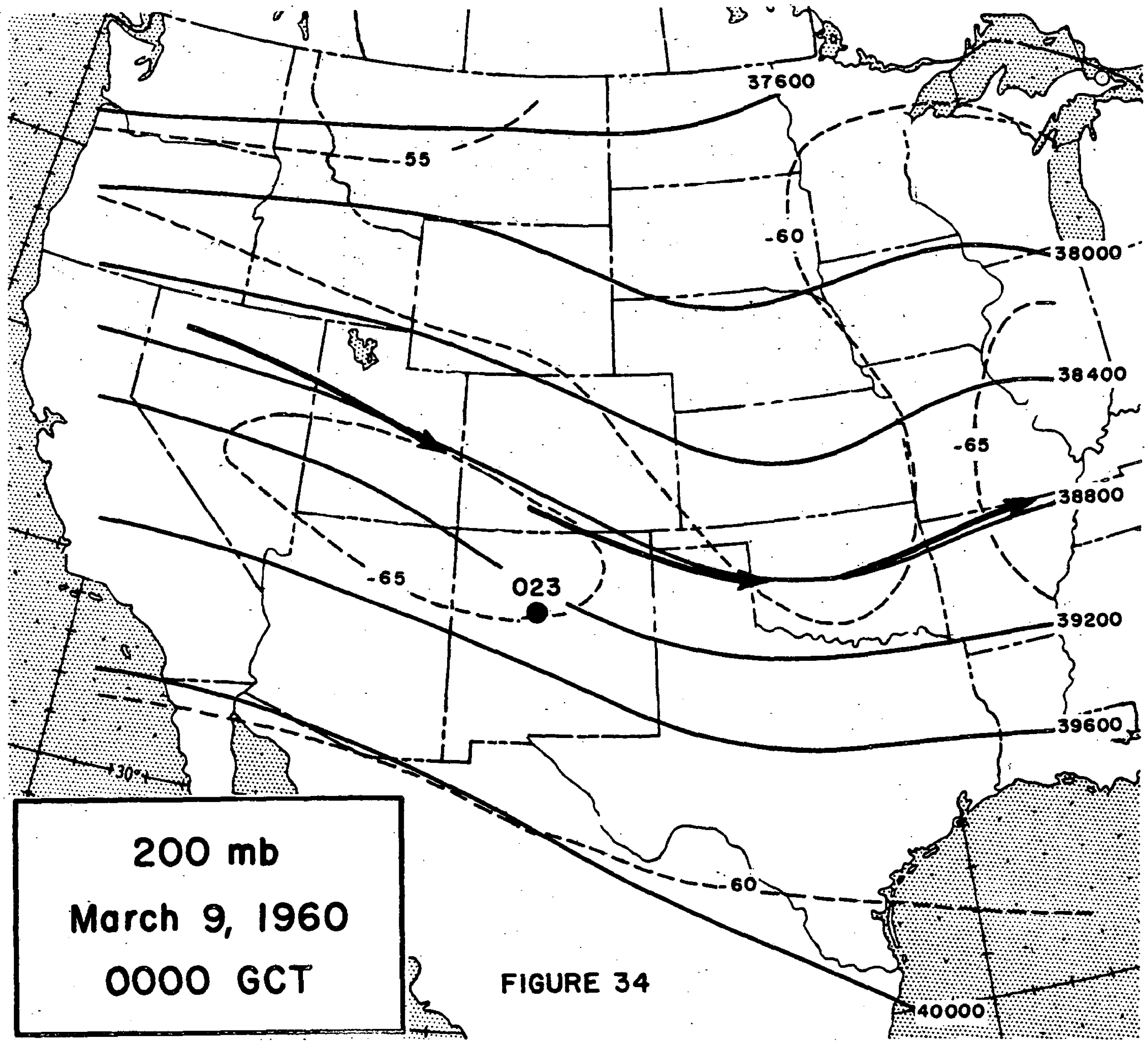
38000
38400
38800
39200
39600
40000
-55
-60
-55
-60
021
022
015
016
017
018
019
020
30°

FIGURE 33


200 mb
March 9, 1960
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38400
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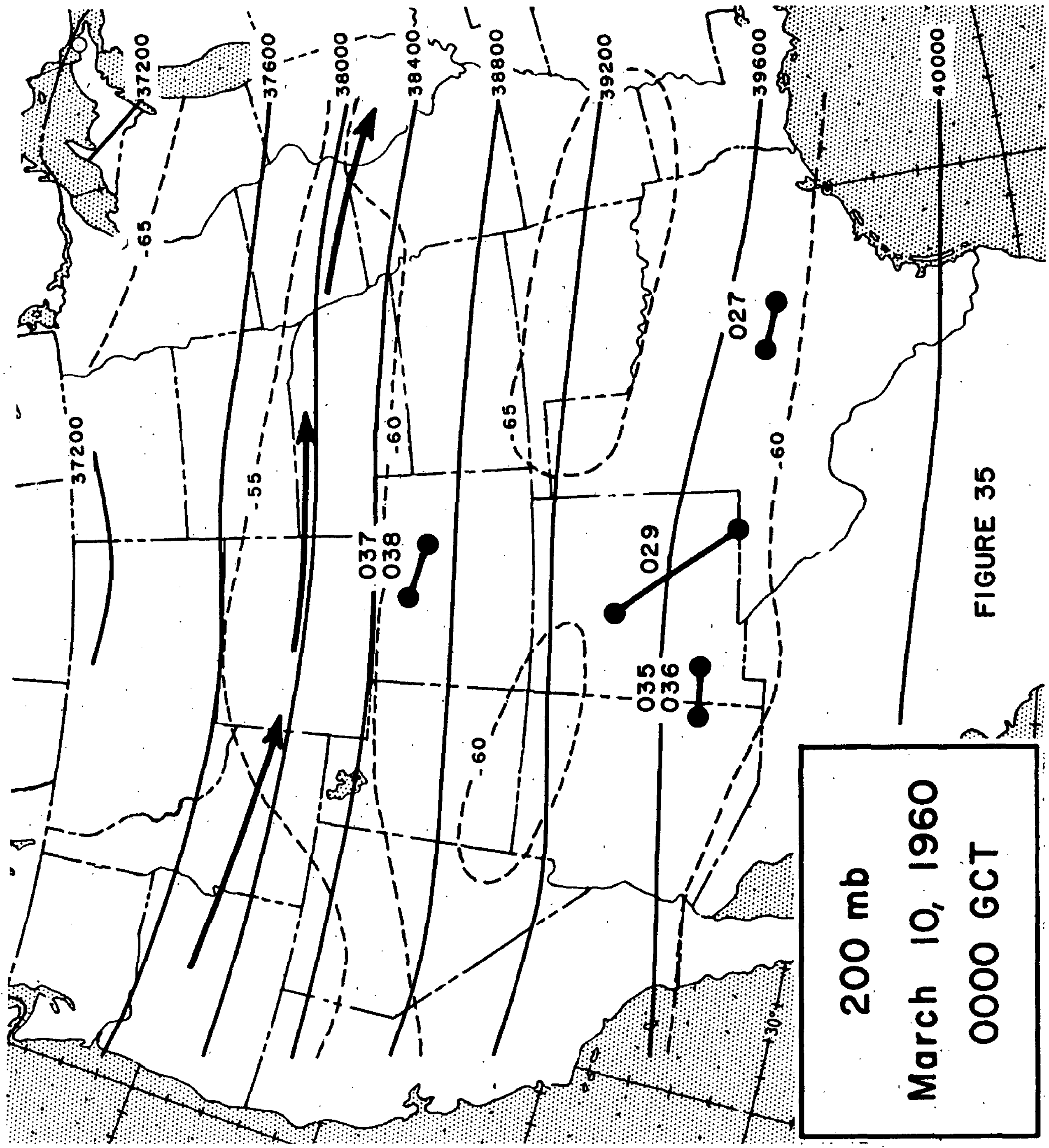
39600
40000
-55
-60
-65
-65
-65
-60
023
30°

FIGURE 34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38400
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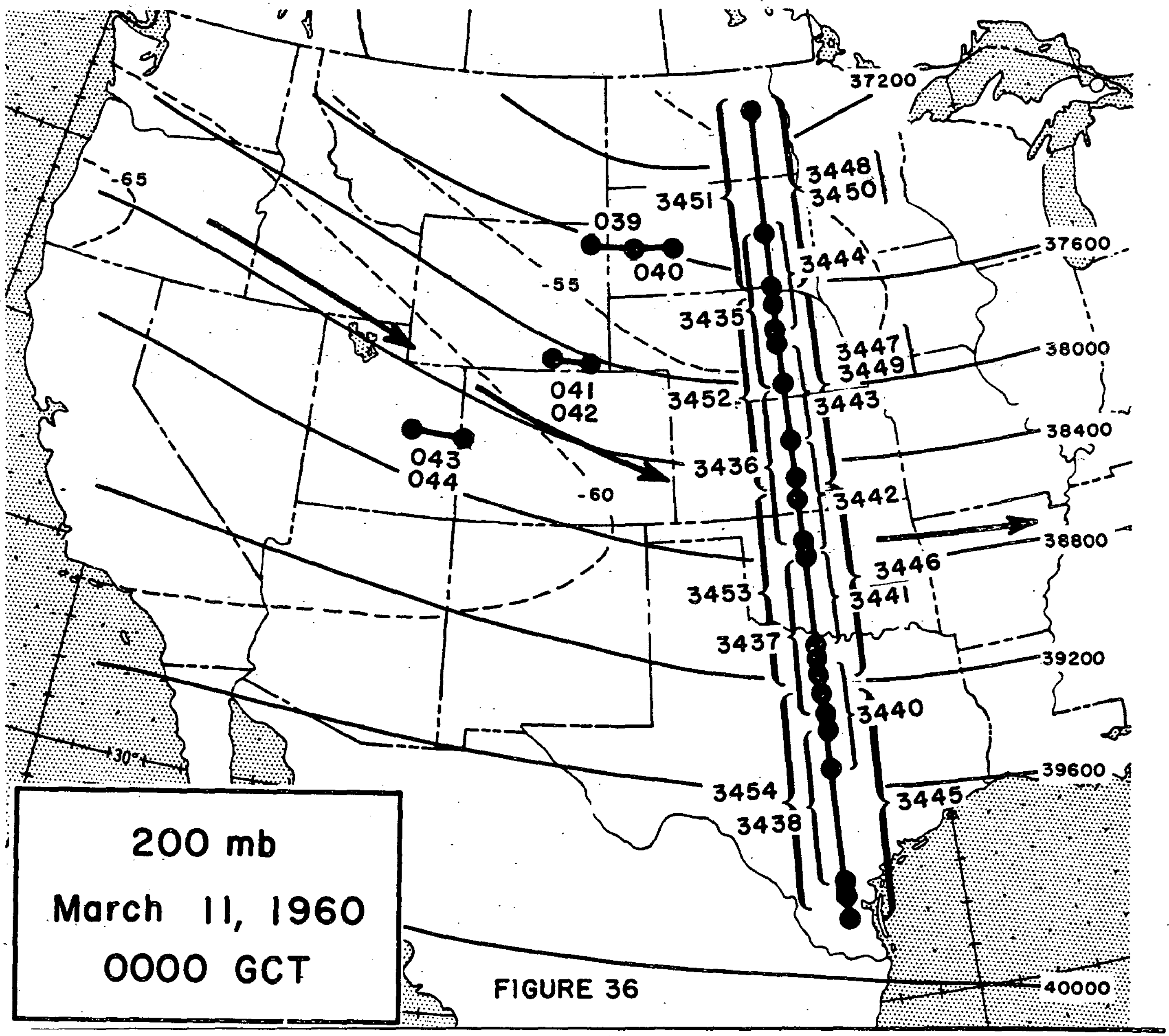
39600
40000
-65
-55
-60
-65
-60
-60
037
038
035
036
029
027
30°
200 mb
March 10, 1960
0000 GCT

FIGURE 35


200 mb
March 11, 1960
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38000
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39200
39600
40000
-65
-55
-60
30°
039
040
041
042
043
044
3448
3450
3451
3444
3435
3447
3449
3452
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3436
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3446
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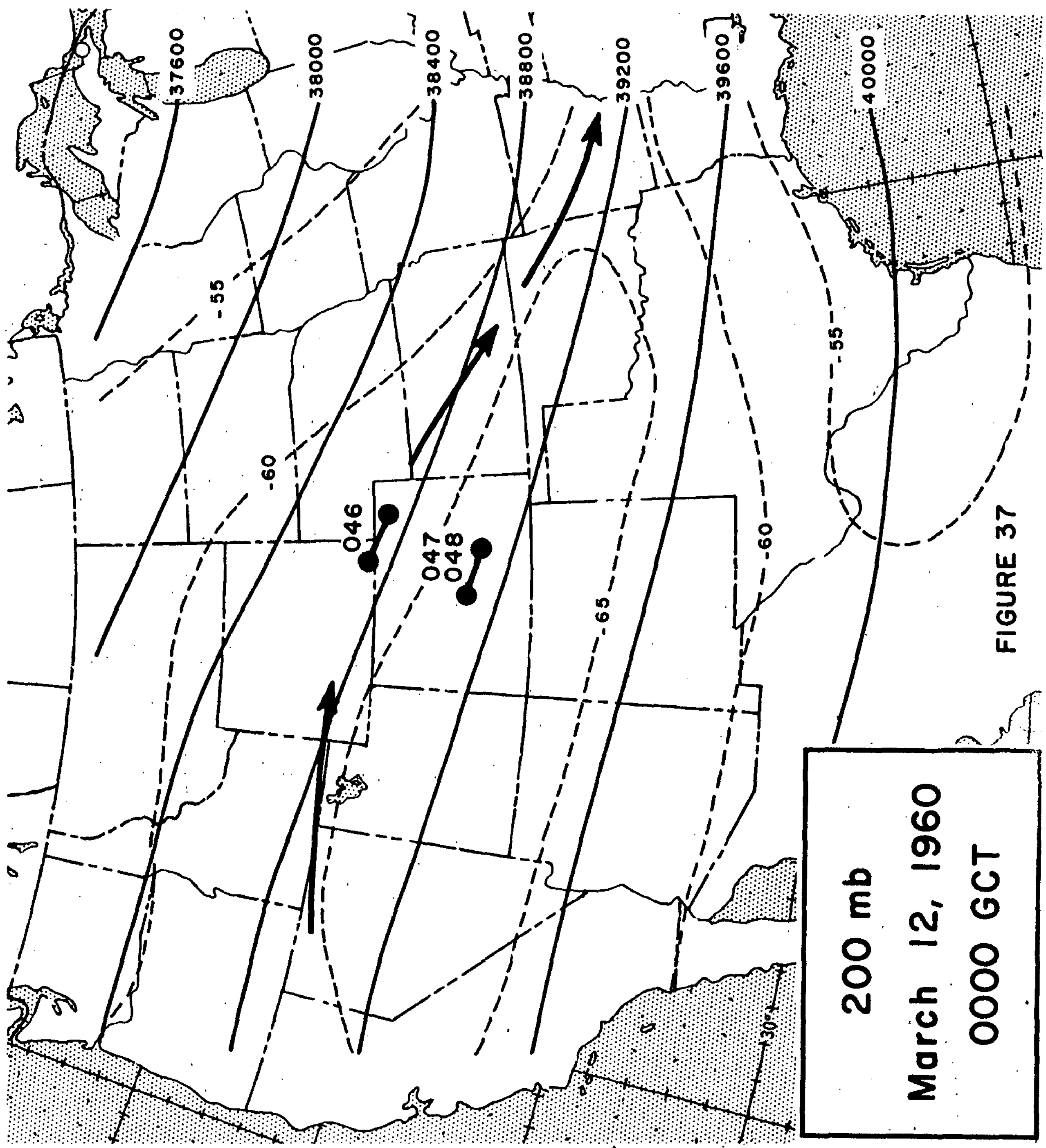
3437
3440
3454
3438
3445

FIGURE 36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38800
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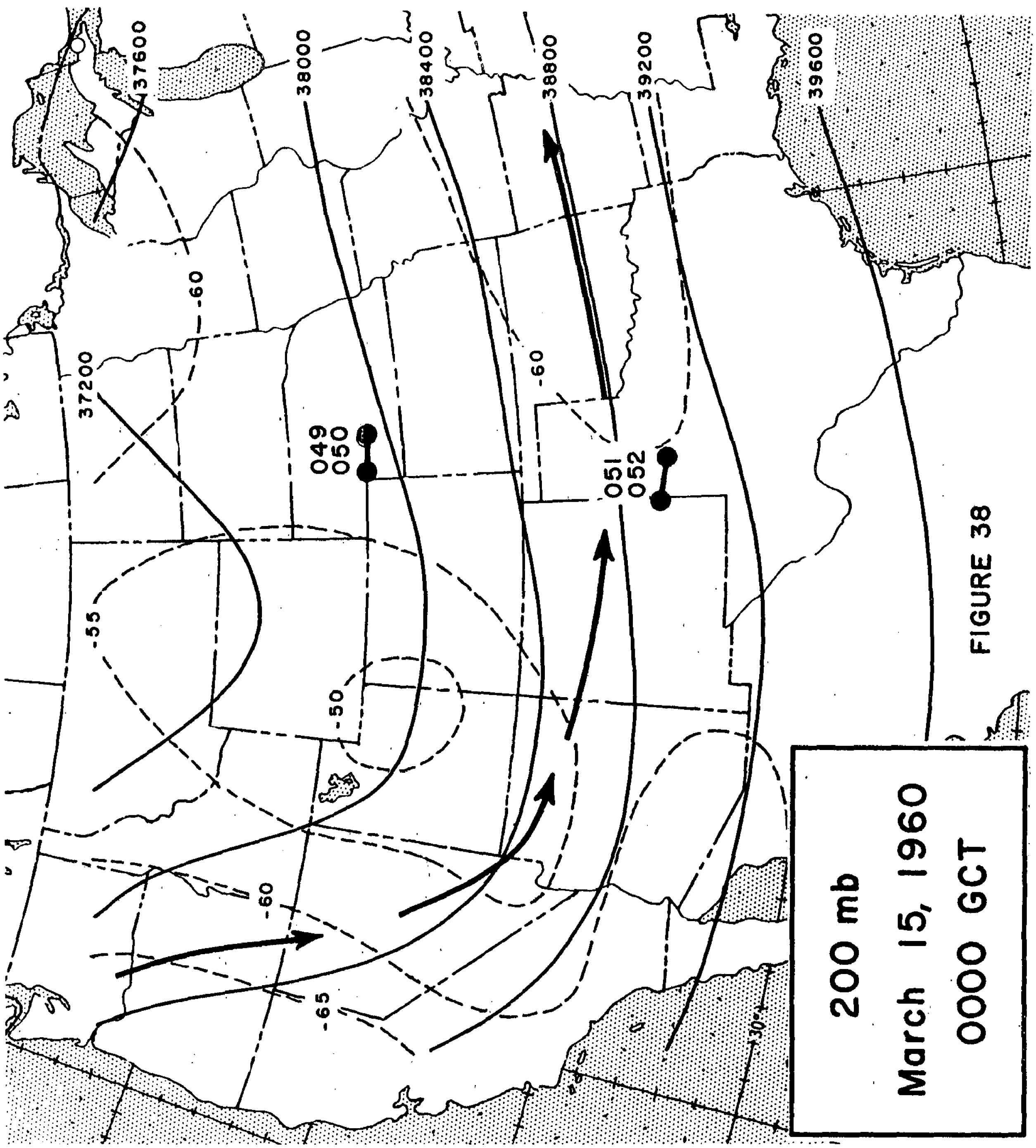
39600
40000
-55
-60
046
047
048
-65
-60
-55
30°
200 mb
March 12, 1960
0000 GCT

FIGURE 37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39600
37200
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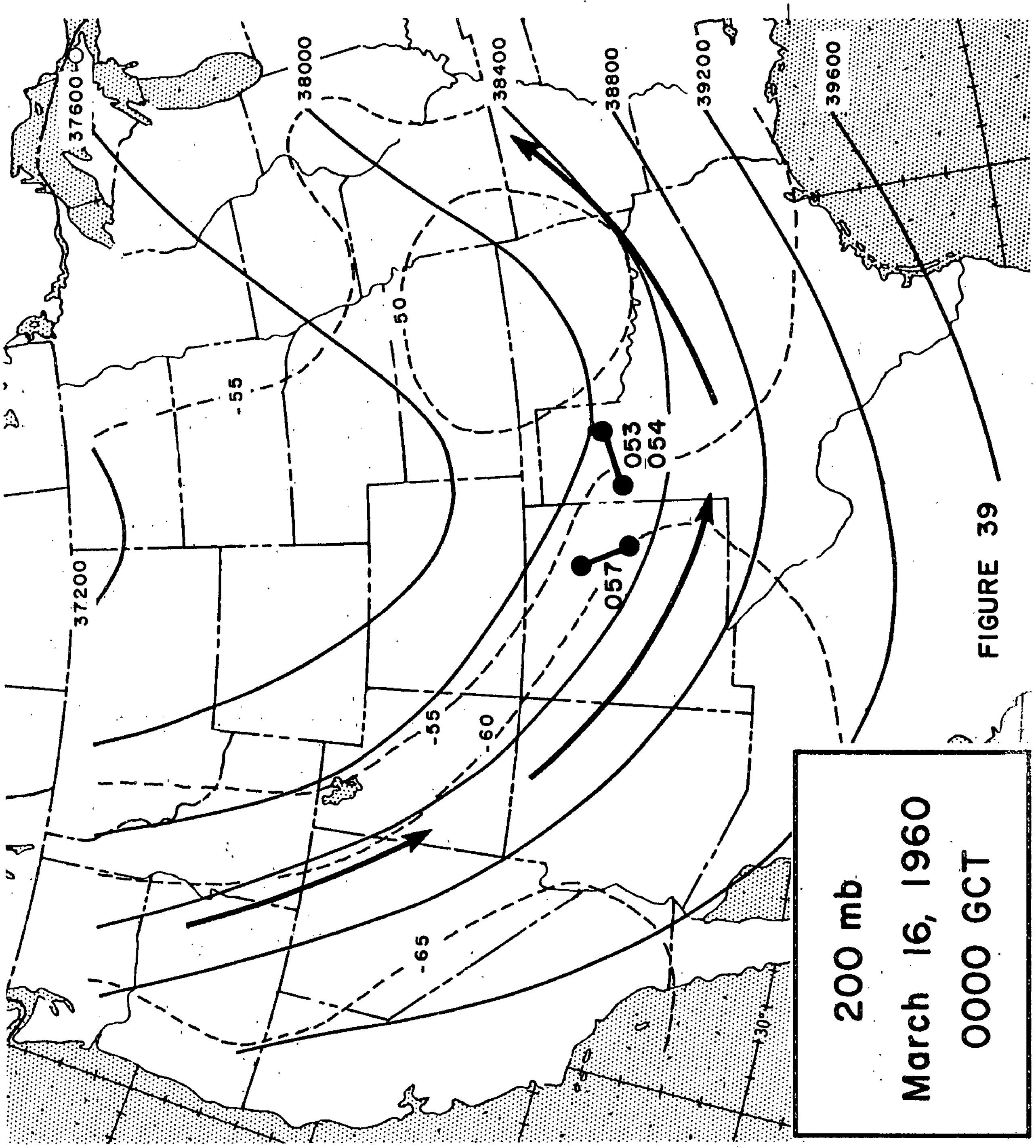
-55
-50
-60
-65
-60
049
050
051
052
30°
200 mb
March 15, 1960
0000 GCT

FIGURE 38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March 16, 1960
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38000
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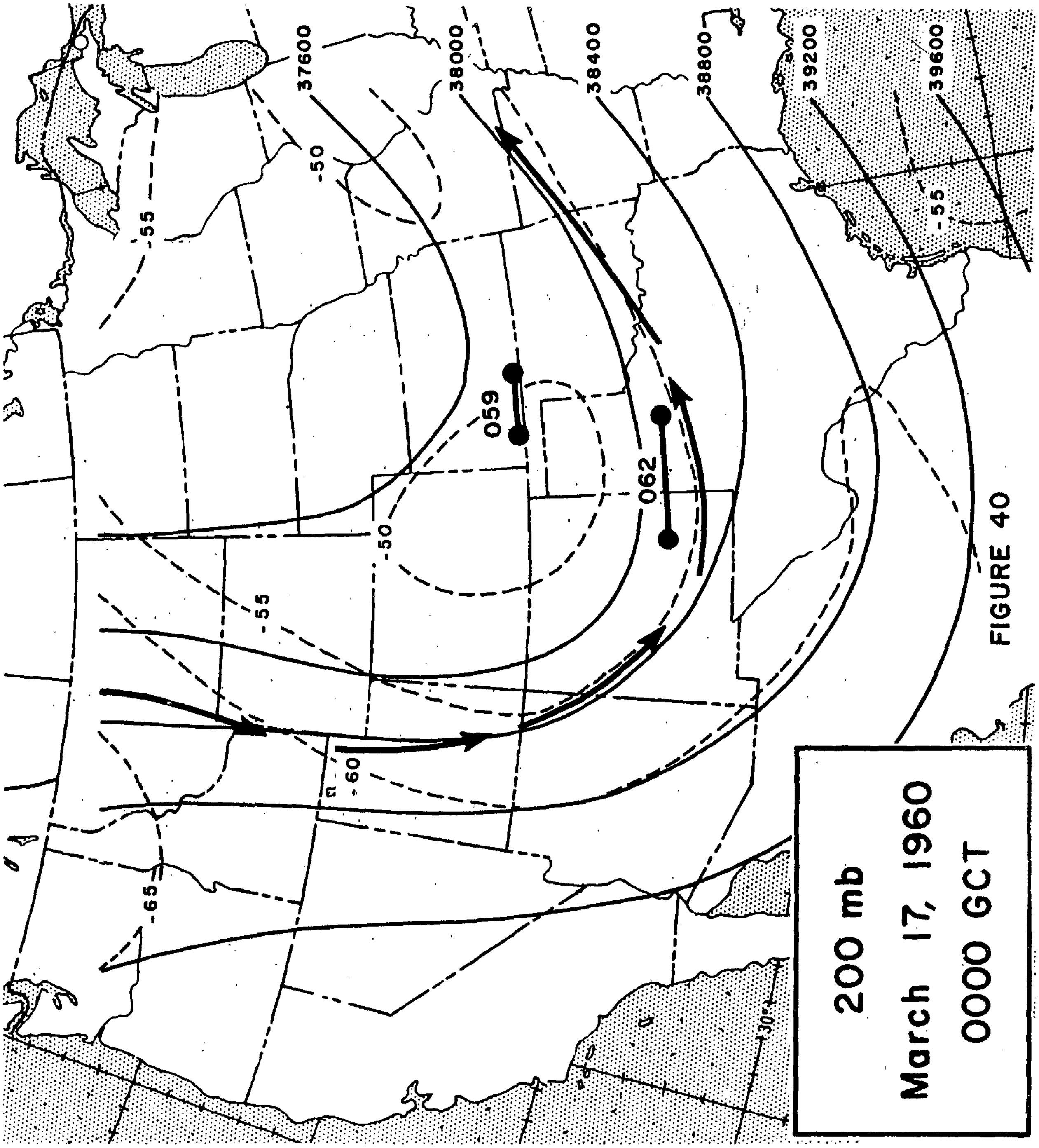
39200
39600
-50
-55
-55
-60
-65
053
054
057
30°

FIGURE 39


200 mb
March 17, 1960
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38000
38400
38800
39200
39600
-50
-55
-60
-65
059
062
30°
FIGURE 40

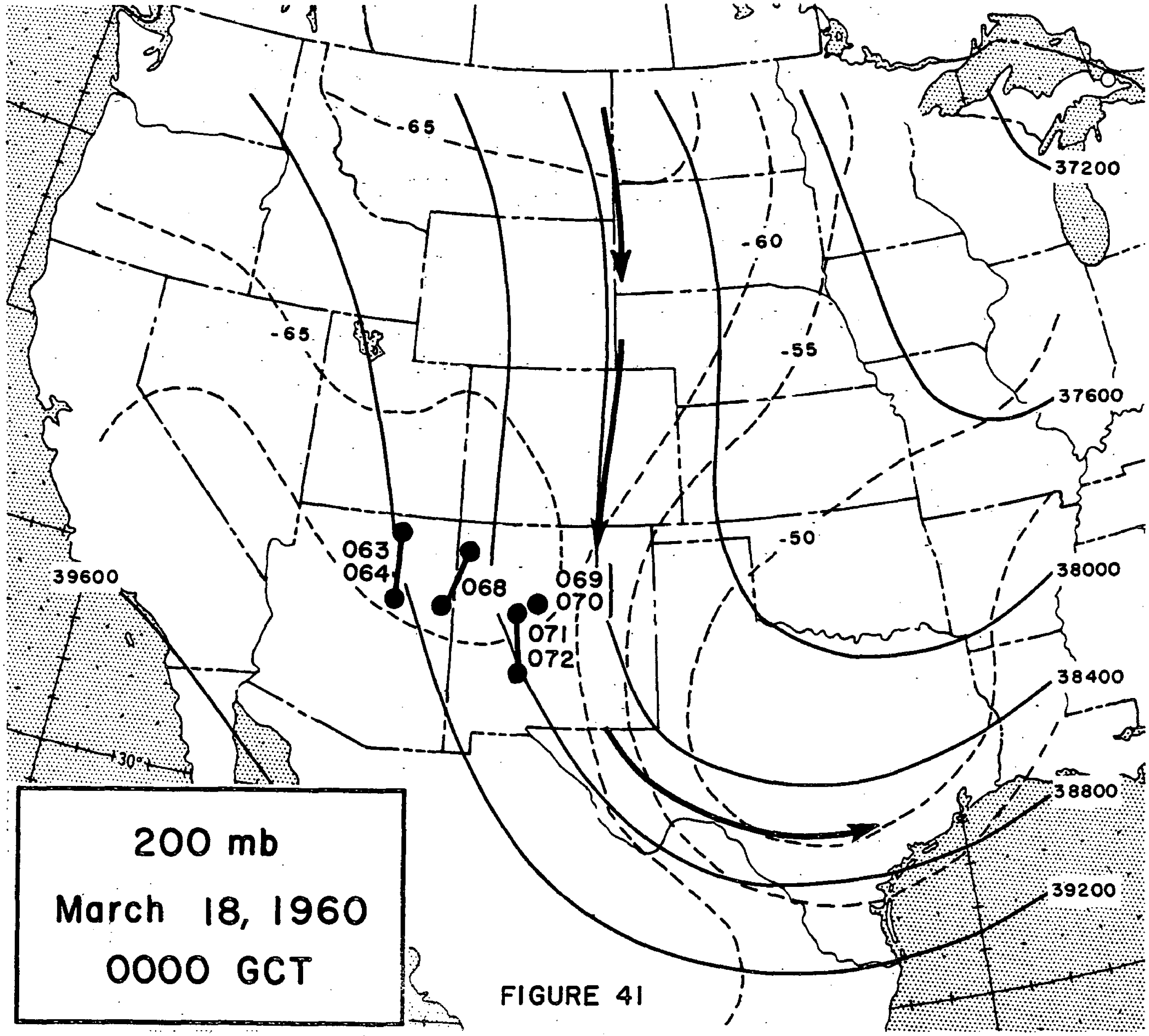
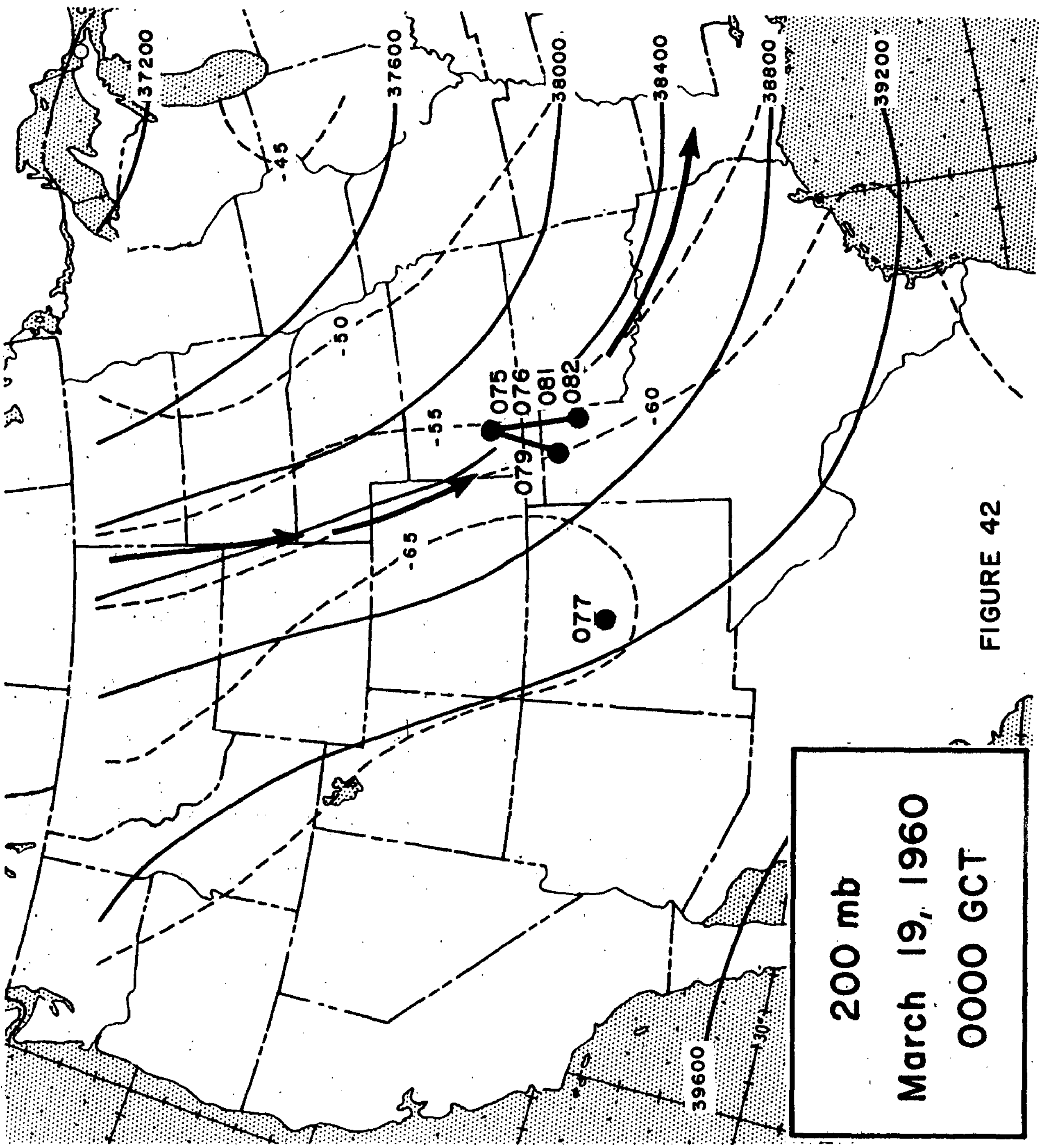
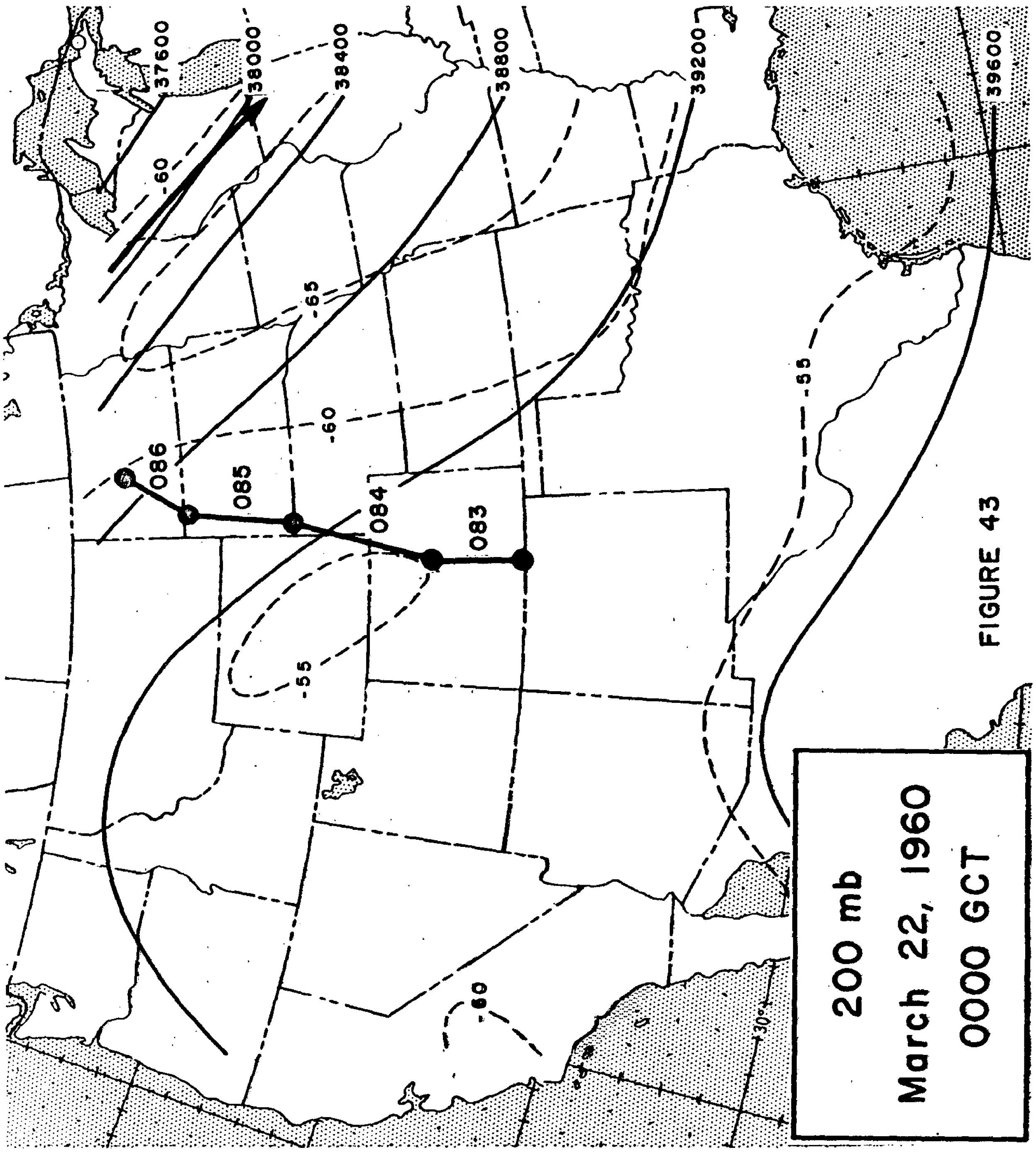

-65
-65
-60
-55
-50
37200
37600
38000
38400
38800
39200
39600
063
064
068
069
070
071
072
30°
200 mb
March 18, 1960
0000 GCT

FIGURE 41



37200
37600
38000
38400
38800
39200
39600
-45
-50
-55
-60
-65
075
076
081
082
079
077
30°
200 mb
March 19, 1960
0000 GCT

FIGURE 42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38800
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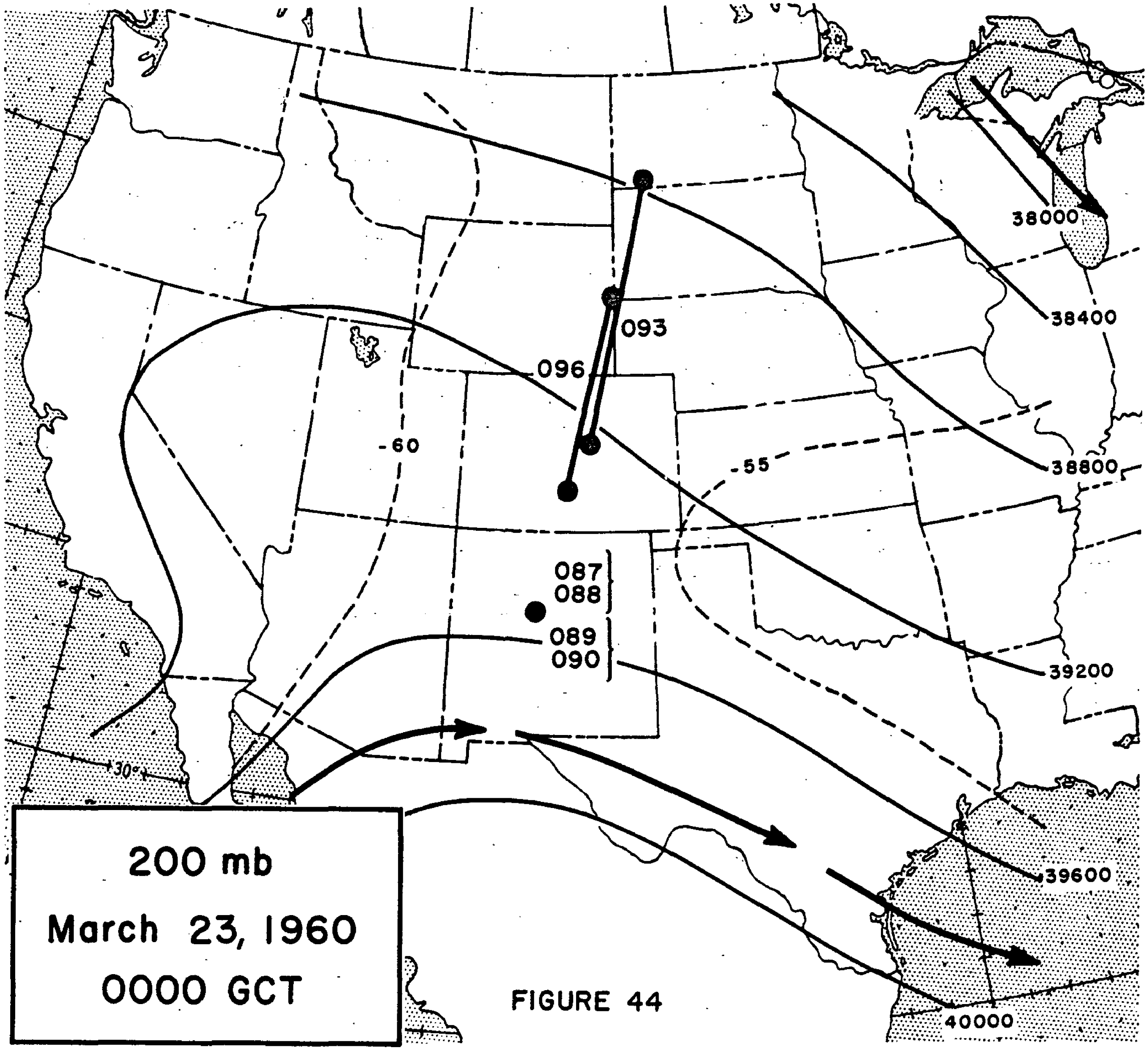
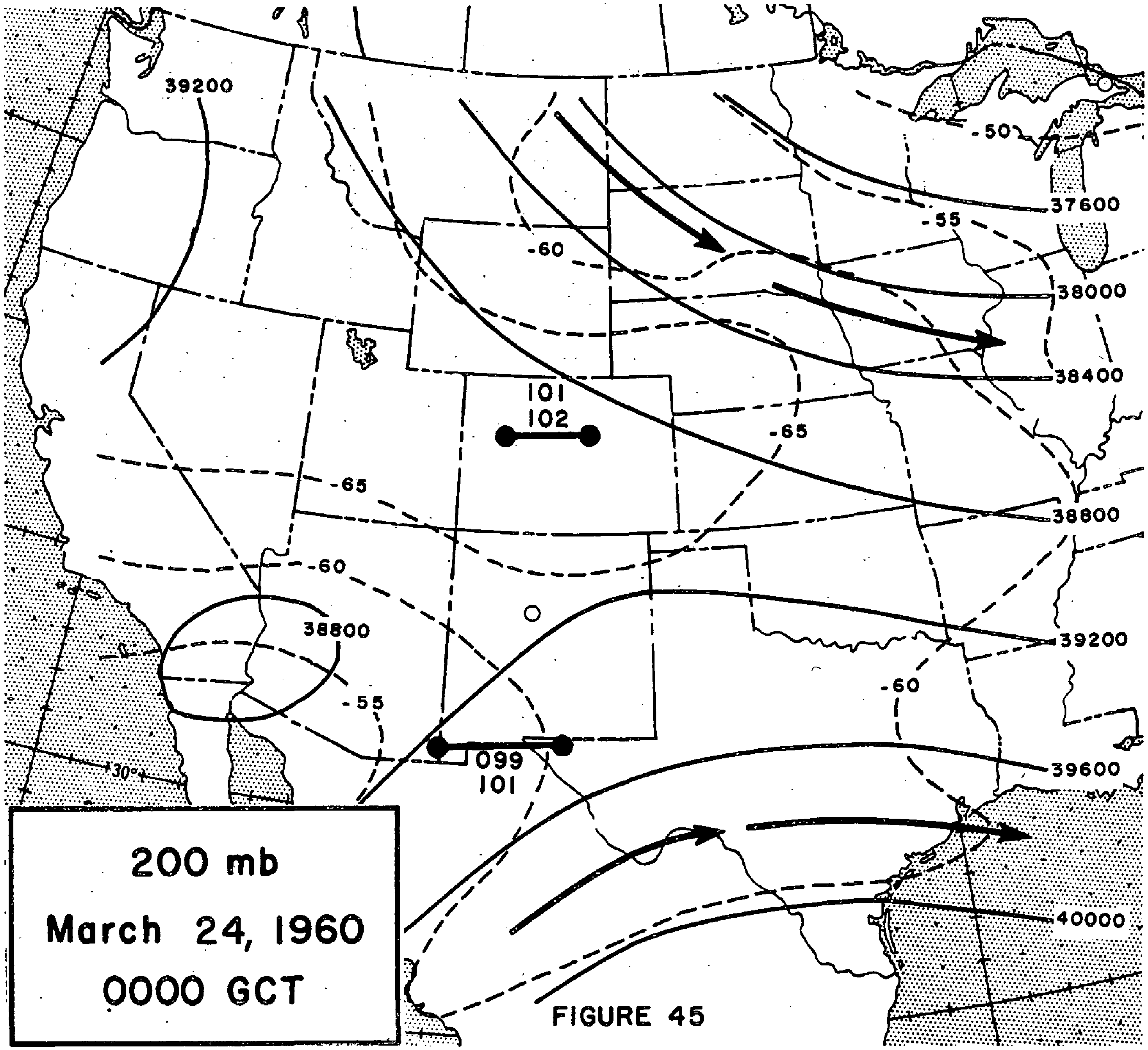
-60
-65
-60
-55
-55
-60
086
085
084
083
30°
200 mb
March 22, 1960
0000 GCT

FIGURE 43


200 mb
March 23, 1960
0000 GCT
38000
38400
38800
39200
39600
40000
093
096
087
088
089
090
-60
-55
30°
FIGURE 44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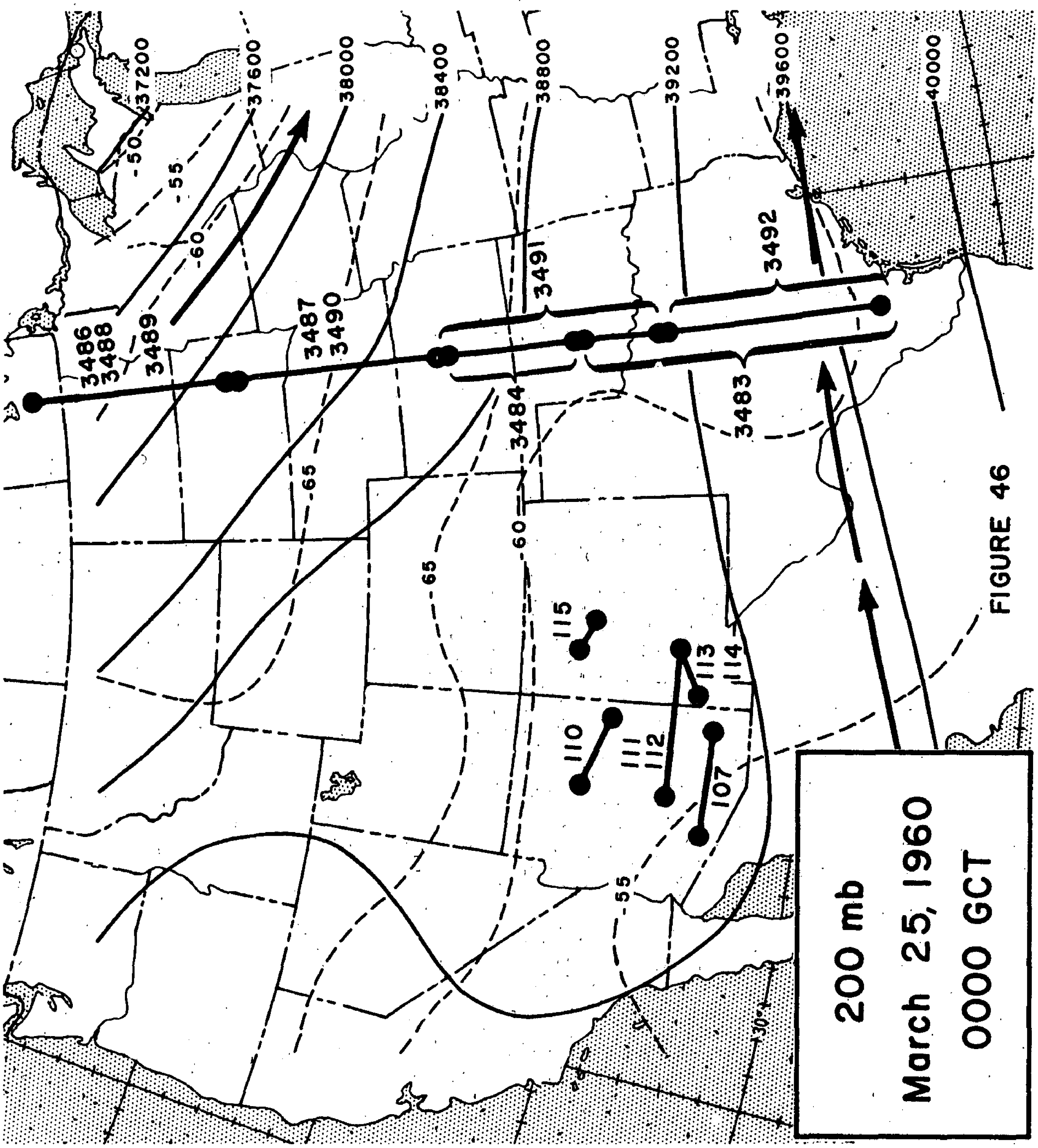
38000
38400
101
102
-65
38800
-60
38800
-55
099
101
39200
-60
39600
40000
30°
200 mb
March 24, 1960
0000 GCT

FIGURE 45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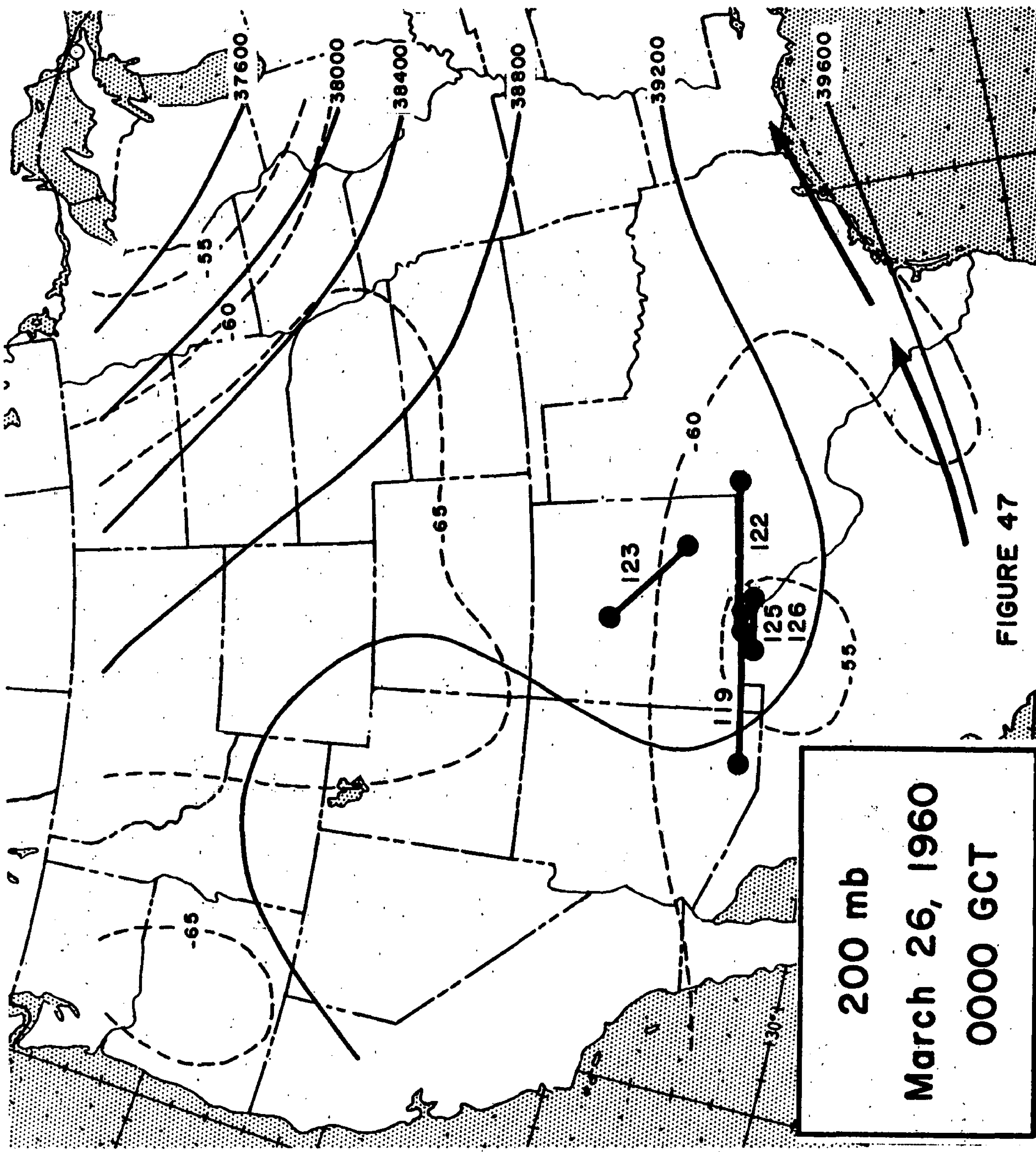
40000
-50
-55
-60
-65
65
60
55
3486
3488
3489
3487
3490
3491
3492
3484
3483
115
110
111
112
113
114
107
30°

FIGURE 46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-60
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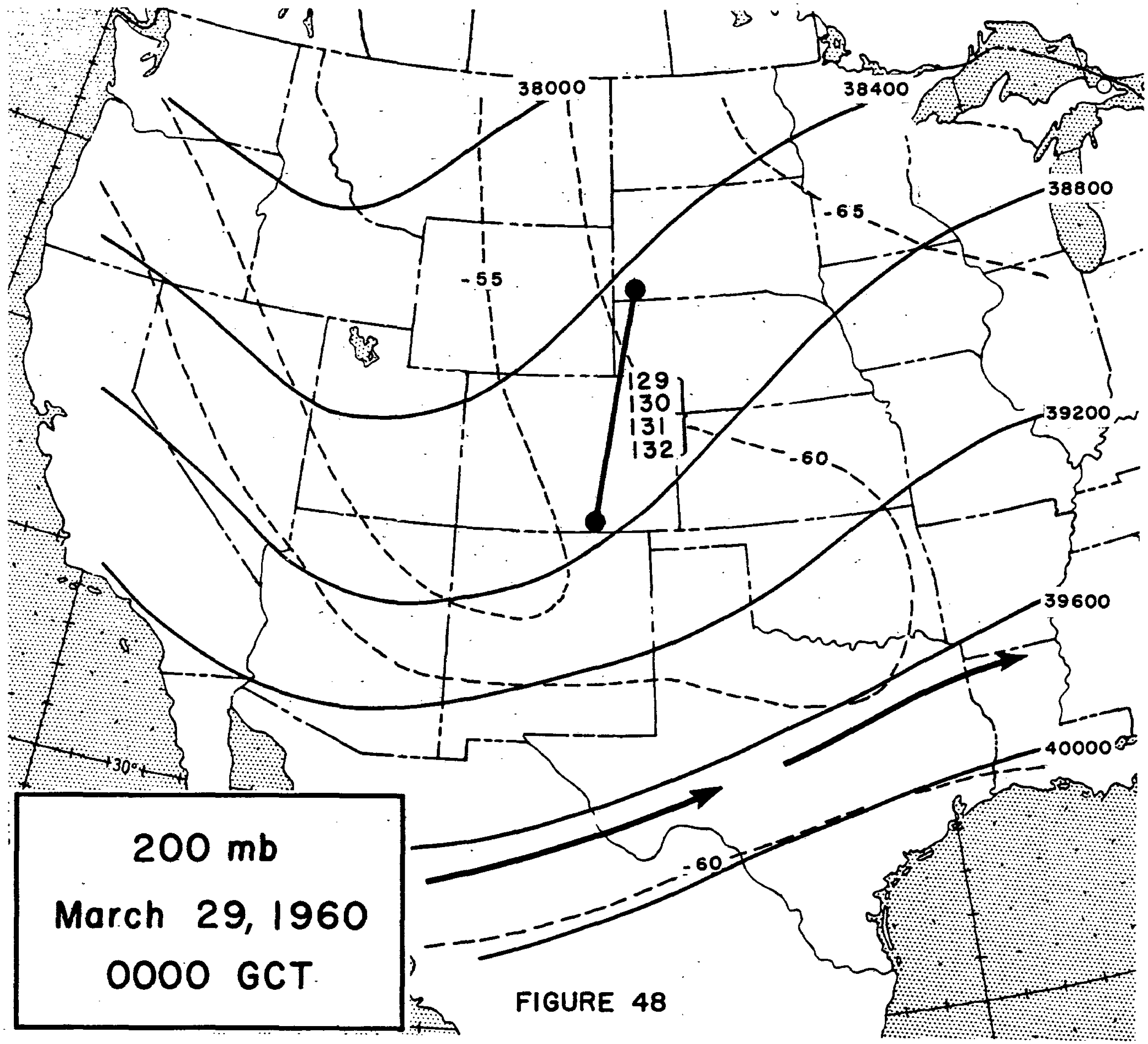
-60
-65
-55
-65
123
122
125
126
119
30°
200 mb
March 26, 1960
0000 GCT

FIGURE 47


200 mb
March 29, 1960
0000 GCT
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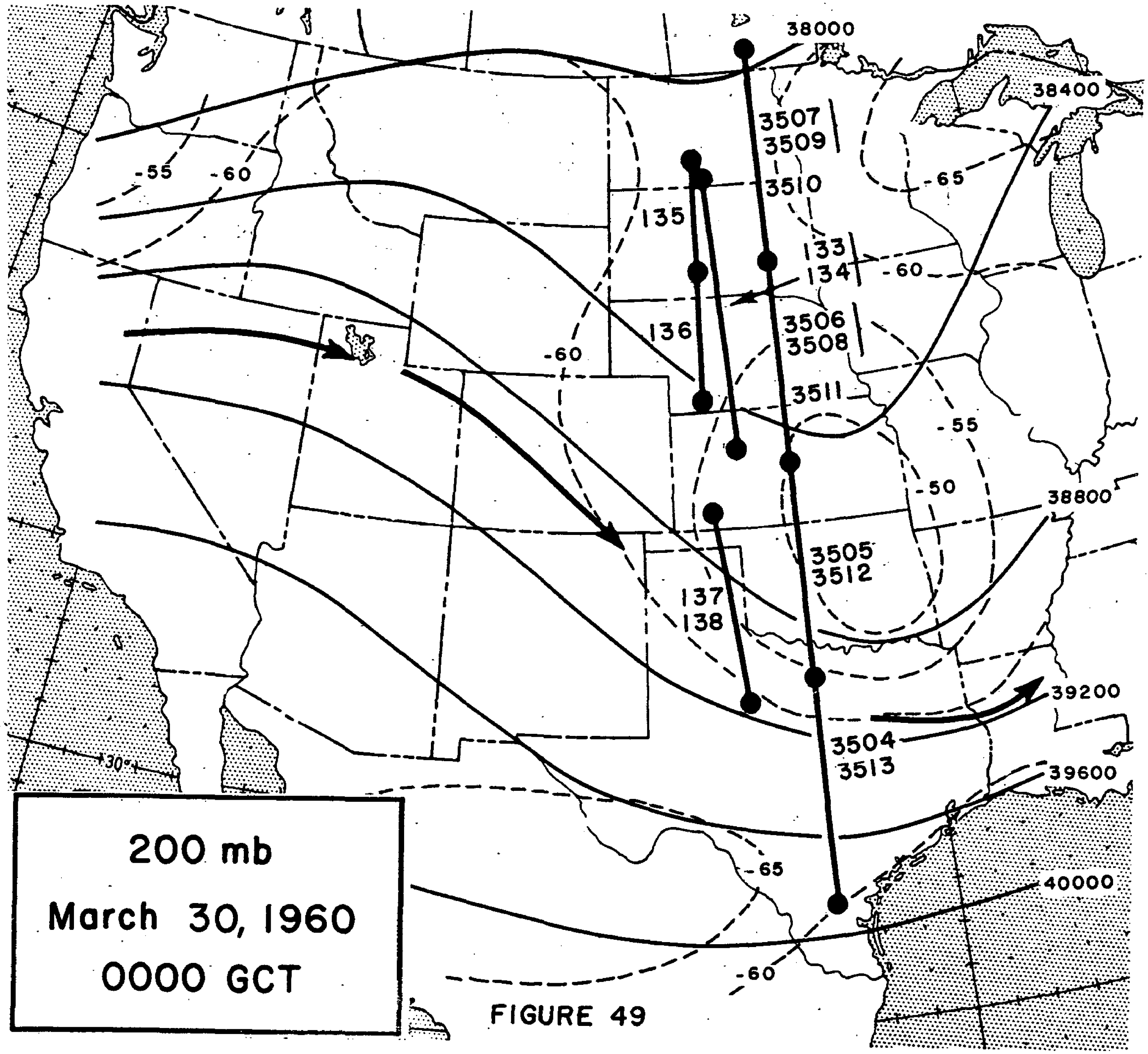
39200
39600
40000
-55
-60
-65
129
130
131
132
30°

FIGURE 48



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133
134
136
3506
3508
3511
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-60
-65
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-55
-50
38800
3505
3512
137
138
39200
3504
3513
39600
-65
40000
-60
30°
200 mb
March 30, 1960
0000 GCT

FIGURE 49

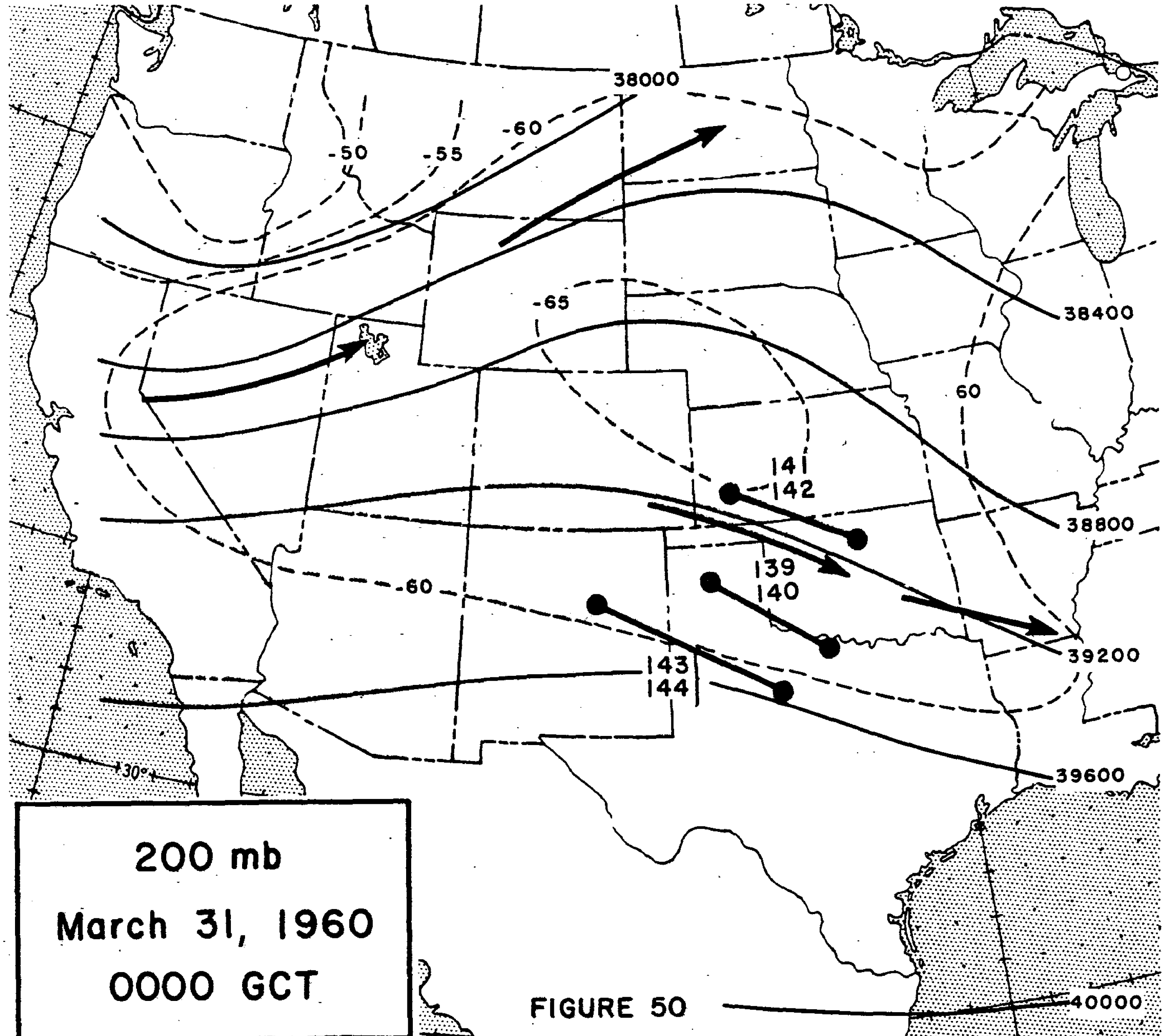
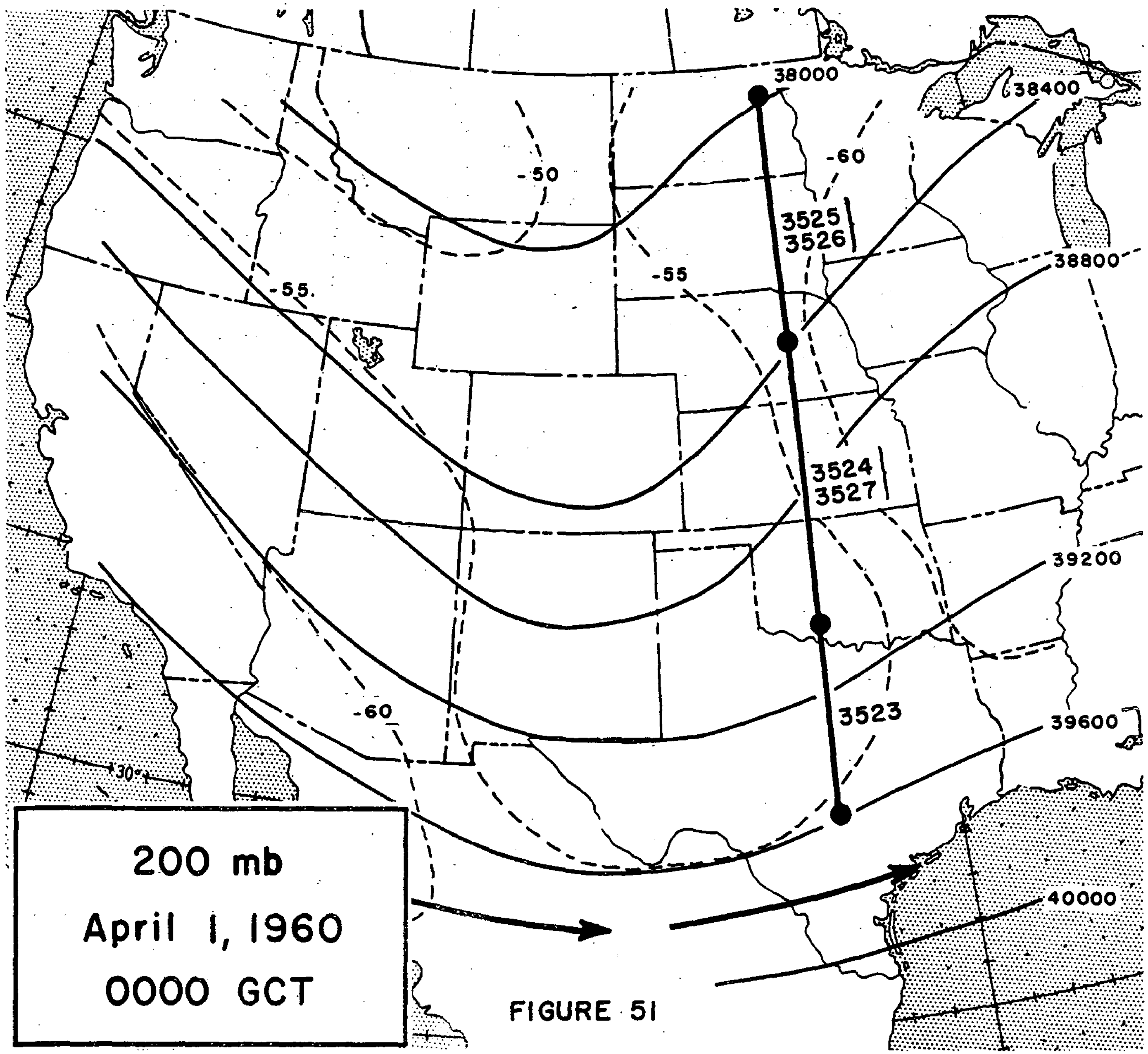
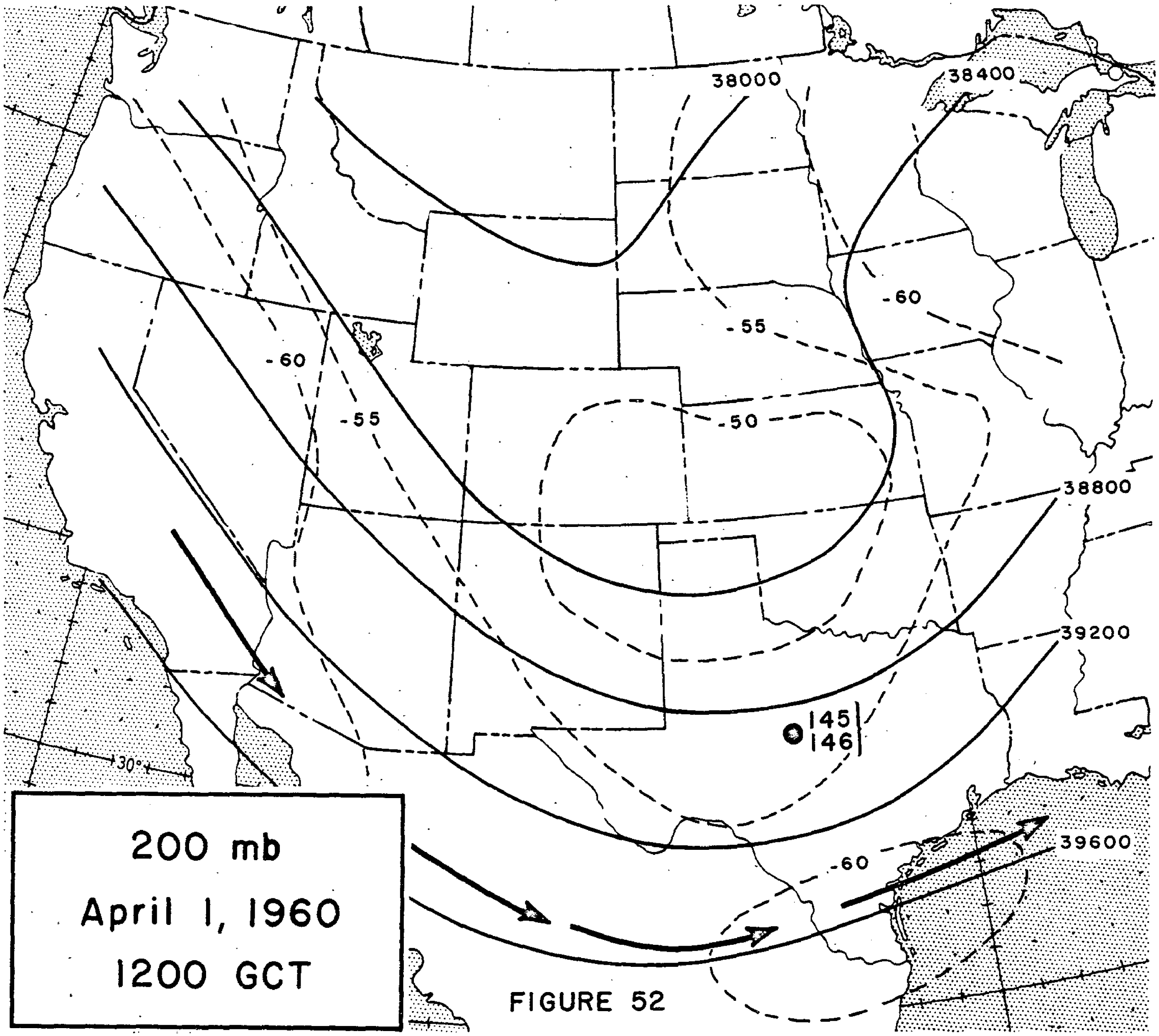

38000
38400
38800
39200
39600
40000
-50
-55
-60
-65
60
-60
141
142
139
140
143
144
30°
200 mb
March 31, 1960
0000 GCT

FIGURE 50



38000
38400
38800
39200
39600
40000
-50
-55
-55.
-60
-60
3525
3526
3524
3527
3523
30°
200 mb
April 1, 1960
0000 GCT

FIGURE 51



200 mb
April 1, 1960
1200 GCT
38000
38400
38800
39200
39600
-60
-55
-50
-55
-60
-60
145
146
30°

FIGURE 52

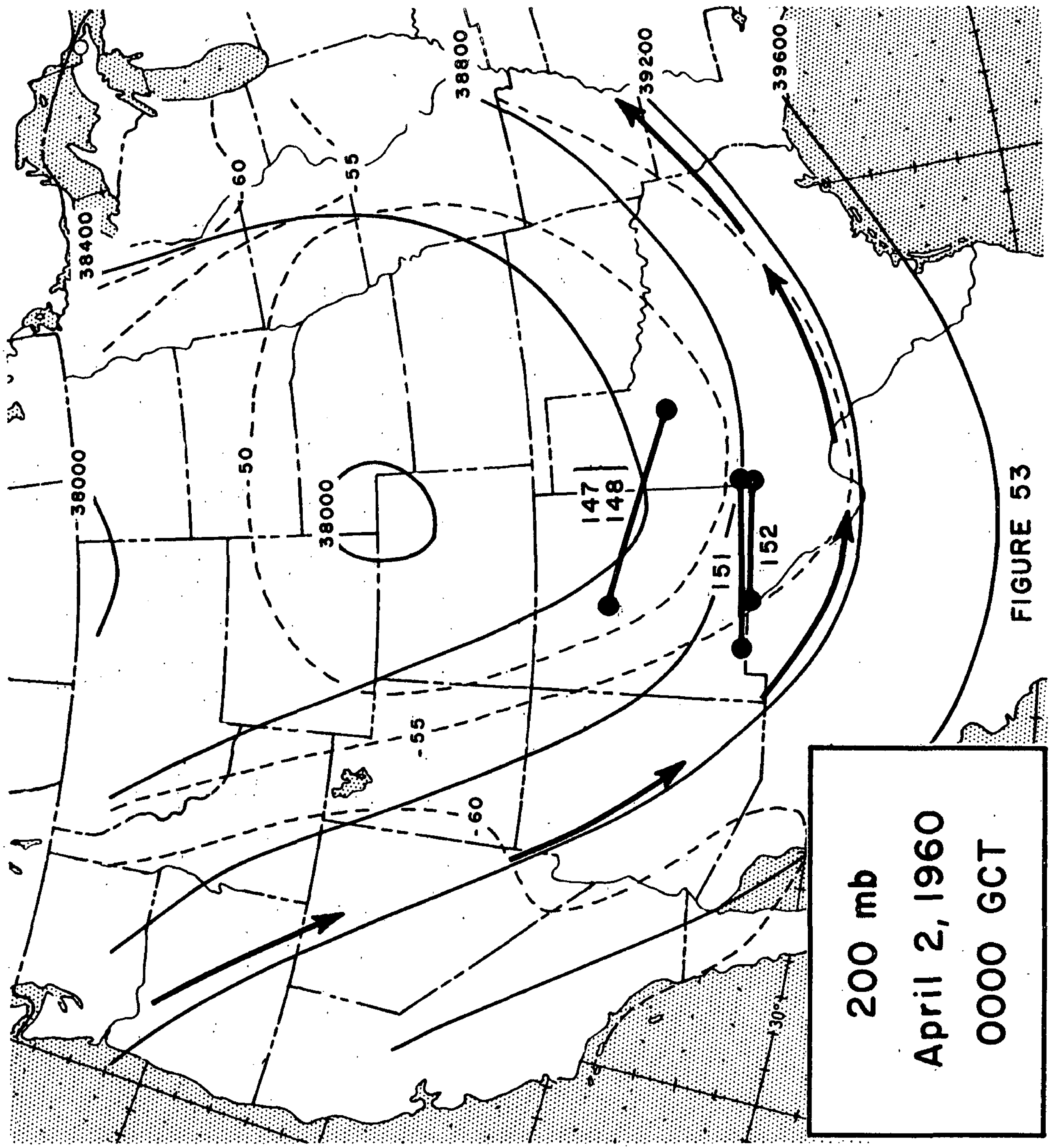
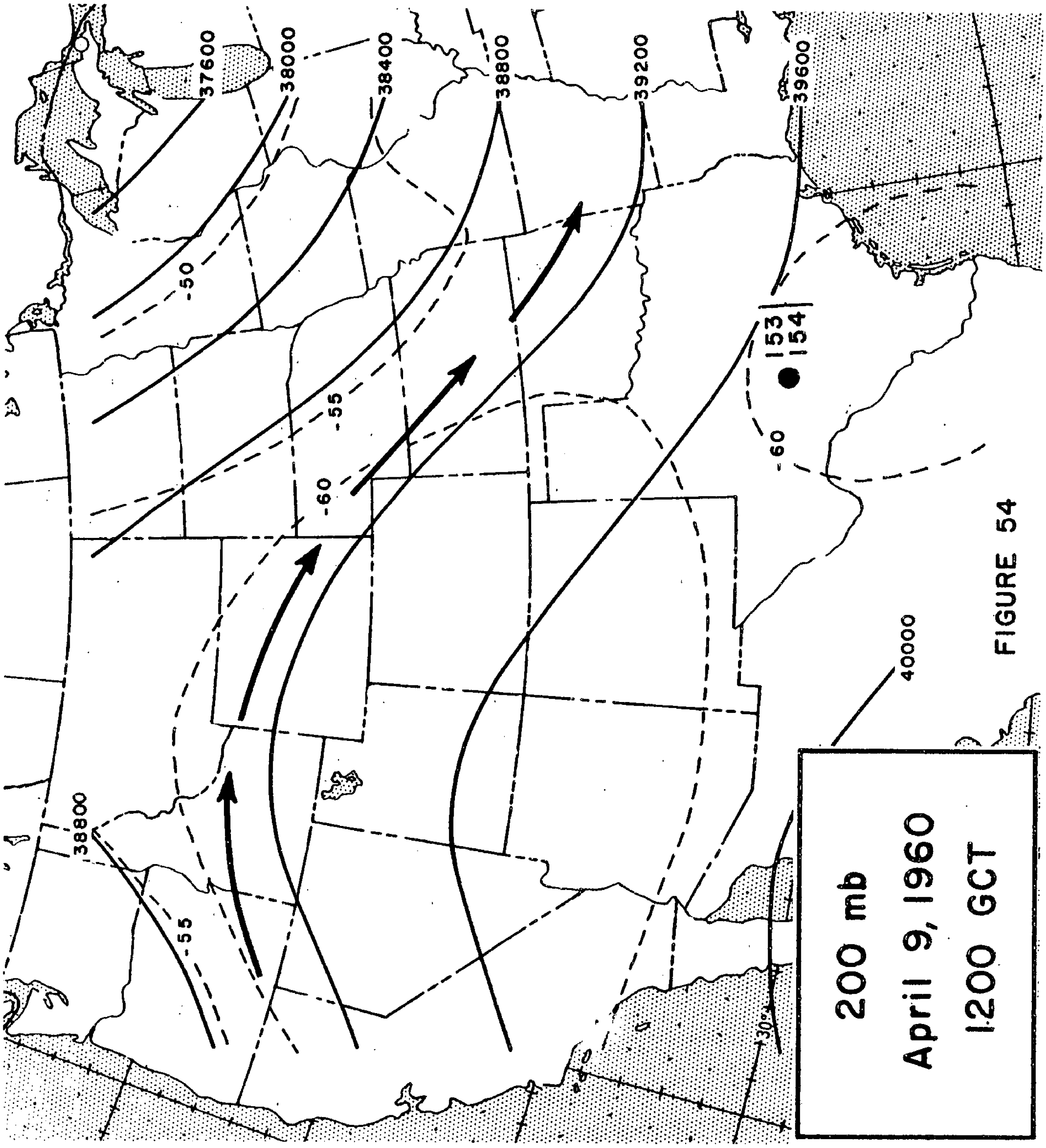

200 mb
April 2, 1960
0000 GCT
38000
38000
38400
38800
39200
39600
50
55
60
-55
60
147
148
151
152
30°

FIGURE 53



200 mb
April 9, 1960
1200 GCT
37600
38000
38400
38800
39200
39600
40000
-50
-55
-60
153
154
30°

FIGURE 54

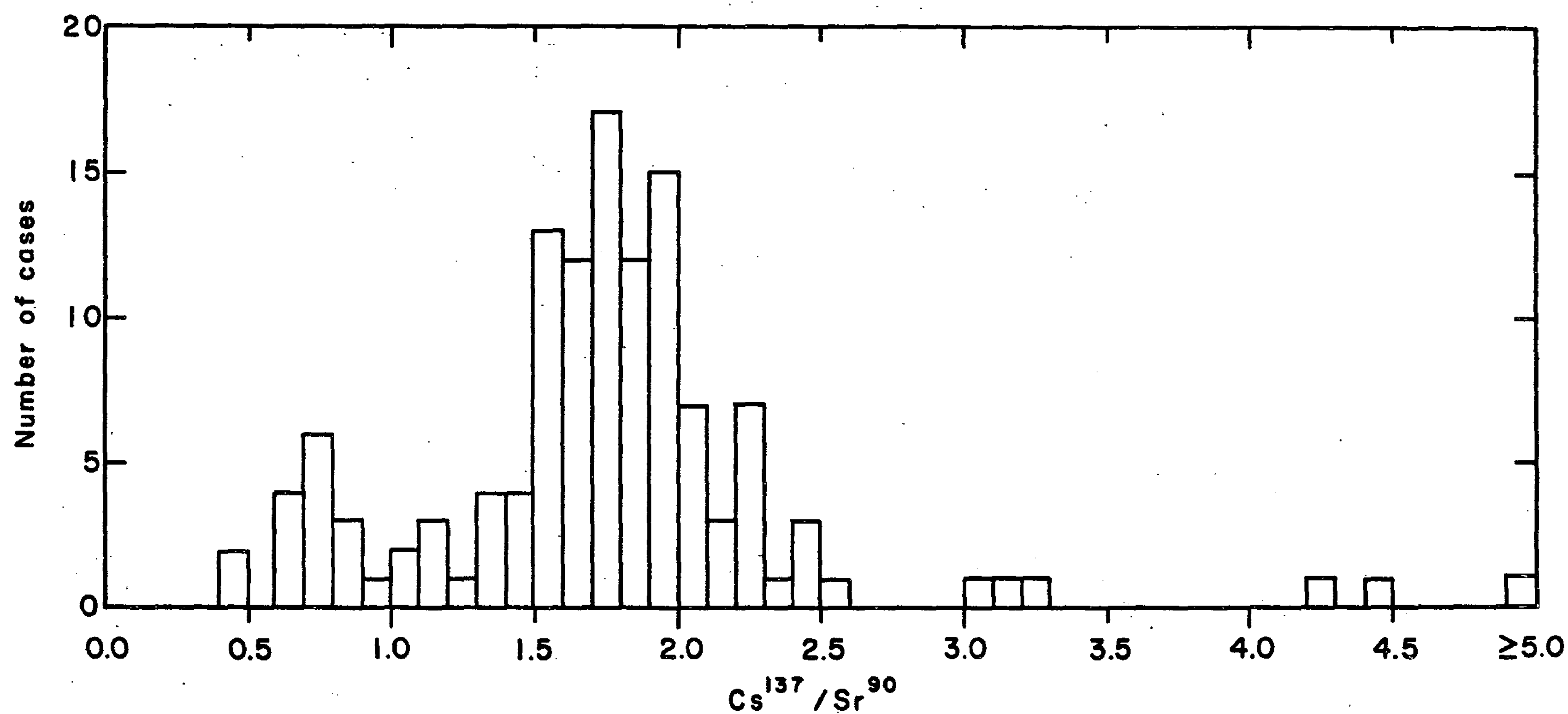


FIGURE 55. FREQUENCY DISTRIBUTION OF ACTIVITY RATIO FOR B-57 SAMPLES

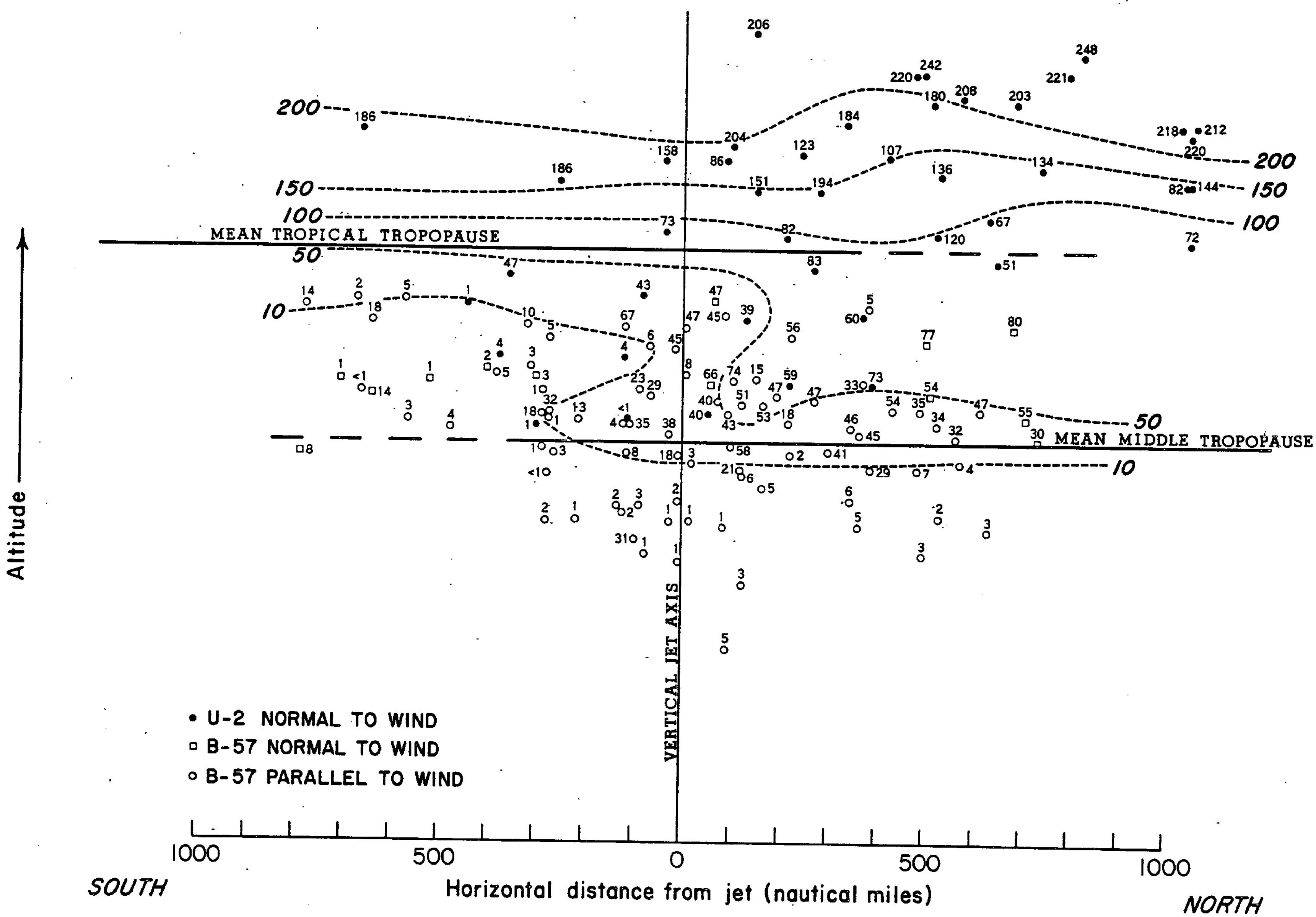


FIGURE 56. Sr-90 ACTIVITY (dpm/10^3 scf) WITH RESPECT TO TROPOPAUSES AND THE JET AXIS

GLOBAL INTEGRALS OF MONTHLY SR-90 FALLOUT, JANUARY 1958 - DECEMBER 1960

by

Kosta Telegadas
U.S. Weather Bureau

The monthly world-wide Sr-90 fallout for the period June 1958-May 1960 as determined from the pot and ion-exchange collectors has been reported in earlier HASL reports (1,2,3). This paper is an expansion of those reports to cover a 3 year period, January 1958-December 1960.

The monthly latitudinal distribution of Sr-90 fallout in millicuries per square mile (mc/mi^2) for the period January 1958-May 1958 is plotted in Figures 1-5 and bi-monthly data from May to December 1960 are given in Figures 6-9. Monthly collections are continuing, but as of May 1960, because of the low levels of activity, the samples were combined on a two month basis at most sites (4). As in earlier reports, two techniques were used in smoothing the data. The first consists of determining the arithmetic average of the Sr-90 deposition for each 10 degrees latitude band and drawing a smooth curve through these values. The second tries to compensate for the climatic differences by using the average rainfall in a latitude band.

Smoothed seasonal or bi-monthly latitudinal curves of deposition by the two techniques and for the periods under consideration in this paper are shown in Figures 10-12. The curves in these figures were integrated to give the fallout in megacuries of Sr-90. The results are shown in Table 1 together with those from the periods investigated in earlier papers.

It has been reported (4) that at four collection sites where the pot and ion-exchange collectors sampled simultaneously a systematic difference was observed starting with the July 1960 samples. The pot collectors showed a decline in the monthly deposition of Sr-90 while the ion-exchange collectors did not. This systematic difference was attributed to contamination of the resin with Sr-90 in the ion-exchange collector and therefore, a constant value of 0.24 mc/mi^2 was subtracted from the observed values of the ion-exchange sample starting in July 1960. It can be seen from Figures 6 and 7 (May-June 1960 and July-August 1960) that in the latter period where the constant correction was applied to the ion-exchange collectors more samples were reported as having zero activity than in the earlier period. It may be that the ion-exchange correction is not applicable to all columns and therefore, in this report the analysis from July 1960 on was essentially based on the pot data.

No attempt is made to estimate the reliability of the analysis. It should be pointed out that the uncertainties in assuming that the arithmetic average of selected stations as representative of the average value for the whole latitude band and in assuming that the average latitudinal rainfall is the same as that which occured for the time period under consideration are difficult to evaluate. In the estimation of the total Sr-90 deposition, it should be mentioned that in addition to the uncertainties mentioned above, virtually no samples were taken north of 60 degrees north latitude or south of 40 degrees south latitude. In estimating deposition in these latitude bands a subjective analysis was used where essentially the trend of activity at other latitude bands was extrapolated to higher latitudes.

Since the cessation of large scale nuclear testing, a number of papers have been written on the distribution of fallout on the earth's surface. One feature of the surface fallout which has been observed by many is the seasonal variation in the rate of fallout, a maximum in the spring and a minimum in the fall. This seasonal variation has been attributed principally to the seasonal changes in the atmosphere. To show this seasonal variation of surface fallout the bi-monthly and seasonal Sr-90 deposition for the northern and southern hemisphere listed in Table 1 was plotted on a time scale and shown in

Figure 13. It can be seen that in the northern hemisphere the spring maximum and fall minimum are clearly indicated. The southern hemisphere seasonal effect is not as well marked,which can probably be attributed to several causes. There are few sampling sites in the southern hemisphere with virtually no observations south of 40° latitude. If more sampling sites were available the seasonal changes may show up more clearly. Another factor which may help mask seasonal effect are the low levels of activity in the southern hemisphere. Also there may be a real difference in the meteorology of the two hemispheres.

For comparison purposes the Naval Research Laboratory hemispheric ground level air concentrations, which were arrived at by averaging the monthly ground level air concentrations taken along the 80°W meridian (5,6,7) are also shown in Figure 13. In general both the surface deposition and air concentration data shows that the northern and southern hemisphere are out of phase, the levels of activity in the northern hemisphere are greater than in the southern hemisphere and that beginning in late 1960 the levels of activity in the southern and northern hemispheres are about equal. It can be speculated that the seasonal effect will show up in the 1961 surface data but since the levels of activity are getting to be so low the effect may be masked by the variability in the data.

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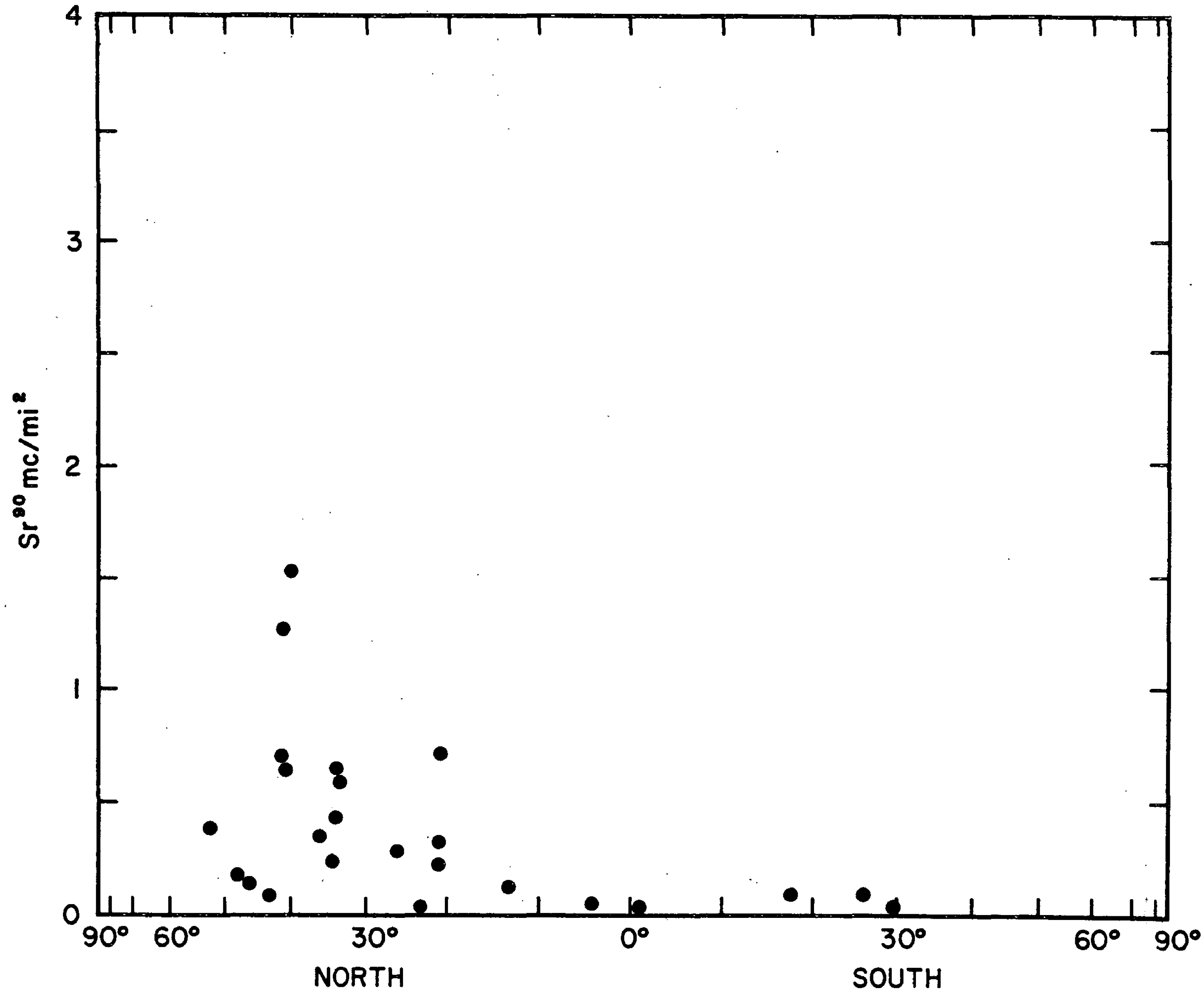
TABLE I. TOTAL WORLD FALLOUT OF SR-90 (MEGACURIES) FROM JANUARY 1958 TO DECEMBER 1960

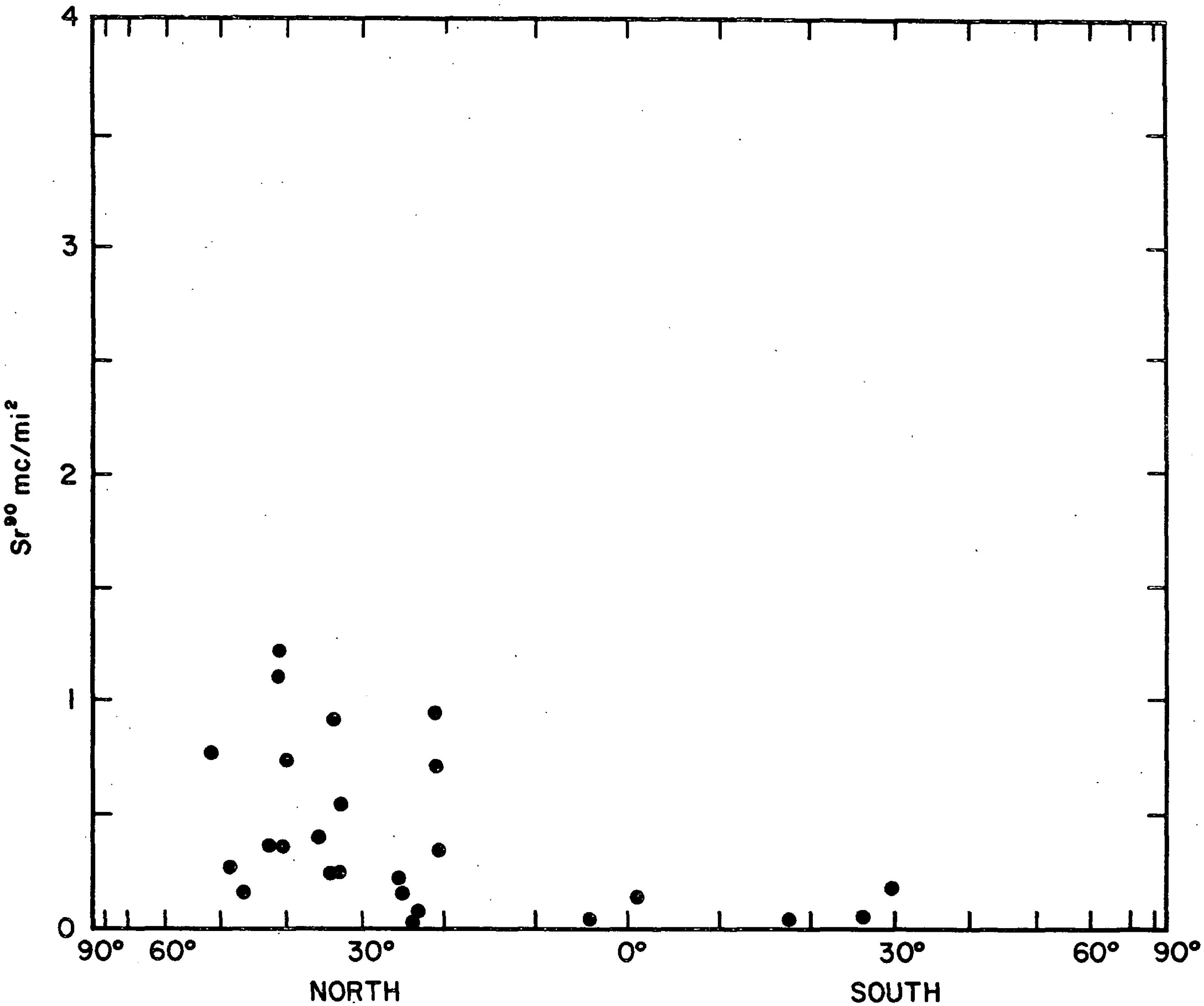
		30-90°N	0-30° N	Northern Hemisphere	Southern Hemisphere	Total	Average
Jan-Feb.'58	A	0.04	0.02	0.06	0.02	0.08	0.09
	B	0.05	0.02	0.07	0.02	0.09	
Apr-May '58	A	0.15	0.05	0.20	0.06	0.26	0.29
	B	0.18	0.06	0.24	0.08	0.32	
June-Aug.'58	A	0.13	0.05	0.18	0.04	0.22	0.26
	B	0.19	0.03	0.22	0.07	0.29	
Sept-Nov.'58	A	0.06	0.04	0.10	0.07	0.17	0.19
	B	0.09	0.02	0.11	0.09	0.20	
Dec-Feb.'59	A	0.15	0.06	0.21	0.07	0.28	0.29
	B	0.16	0.06	0.22	0.07	0.29	
Apr-May '59	A	0.34	0.12	0.46	0.05	0.51	0.52
	B	0.37	0.08	0.45	0.07	0.52	
June-Aug.'59	A	0.16	0.04	0.20	0.03	0.23	0.25
	B	0.16	0.04	0.20	0.06	0.26	
Sept-Nov.'59	A	0.06	0.03	0.09	0.03	0.12	0.12
	B	0.04	0.03	0.07	0.05	0.12	
Dec-Feb.'60	A	0.037	0.026	0.063	0.041	0.104	0.110
	B	0.042	0.026	0.068	0.047	0.115	
Mar-Apr.'60	A	0.039	0.029	0.068	0.023	0.091	0.104
	B	0.057	0.028	0.085	0.031	0.116	
May-June '60	A	0.034	0.017	0.051	0.019	0.070	0.072
	B	0.033	0.018	0.051	0.022	0.073	
July-Aug.'60	A	0.017	0.010	0.027	0.013	0.040	0.042
	B	0.018	0.008	0.026	0.018	0.044	
Sept-Oct.'60	A	0.010	0.007	0.017	0.025	0.042	0.047
	B	0.015	0.006	0.021	0.030	0.051	
Nov-Dec.'60	A	0.011	0.008	0.019	0.021	0.040	0.044
	B	0.016	0.007	0.023	0.024	0.047	
			Total January 1958-December 1960				2.43

A: Actual Deposition
B: Deposition Weighted by Rainfall



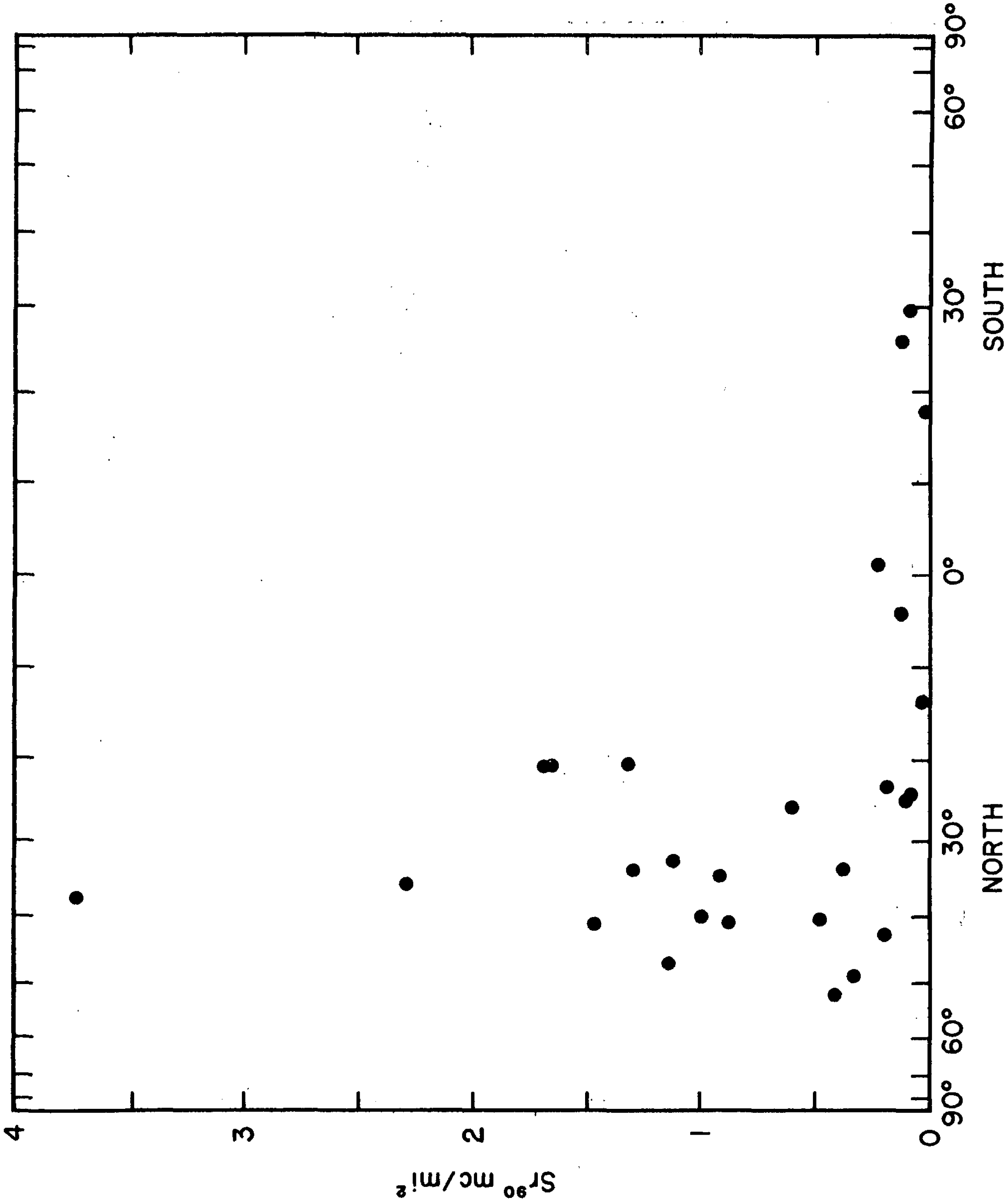
January 1958

FIGURE 1

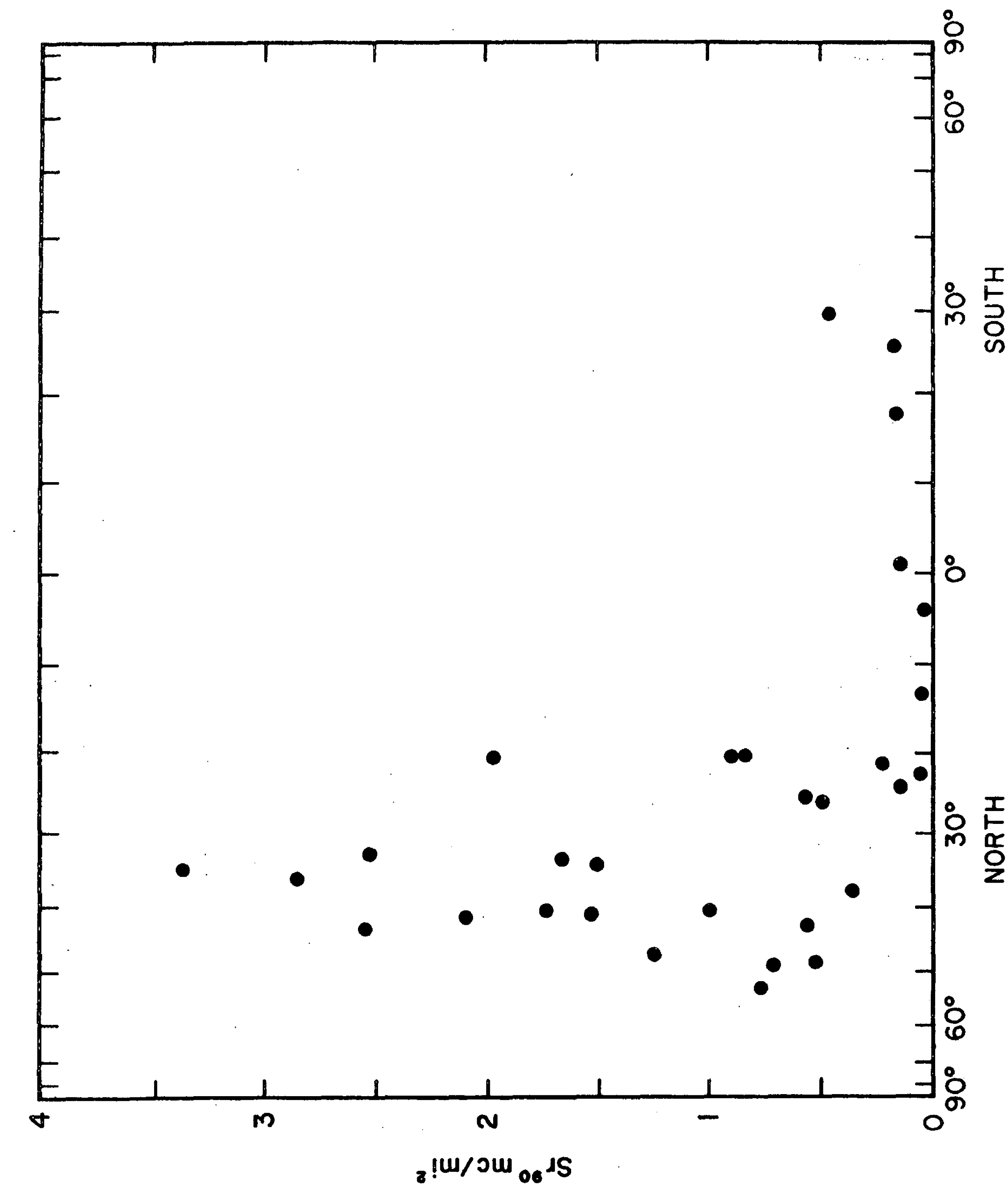


February 1958

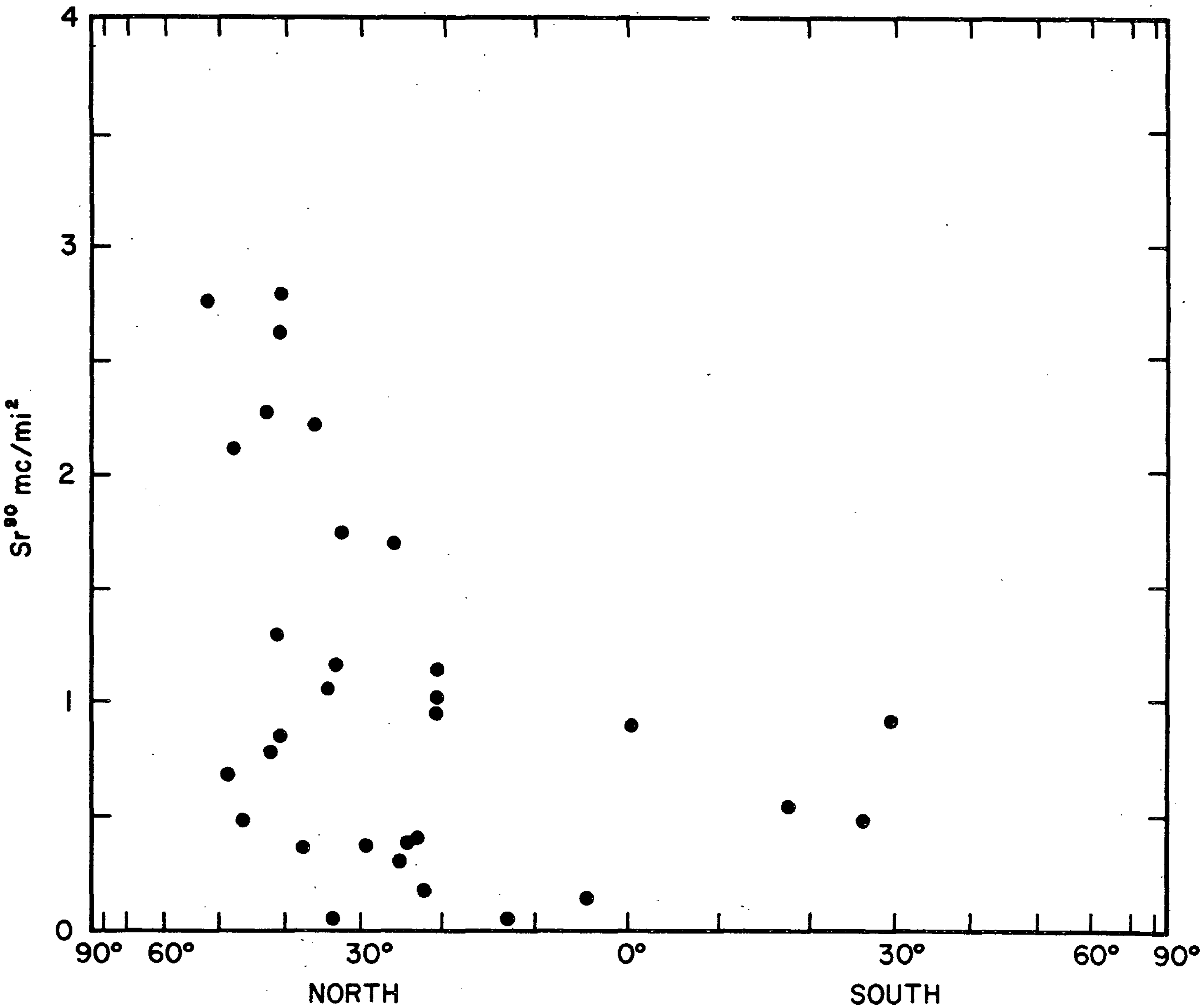
FIGURE 2



March 1958
FIGURE 3

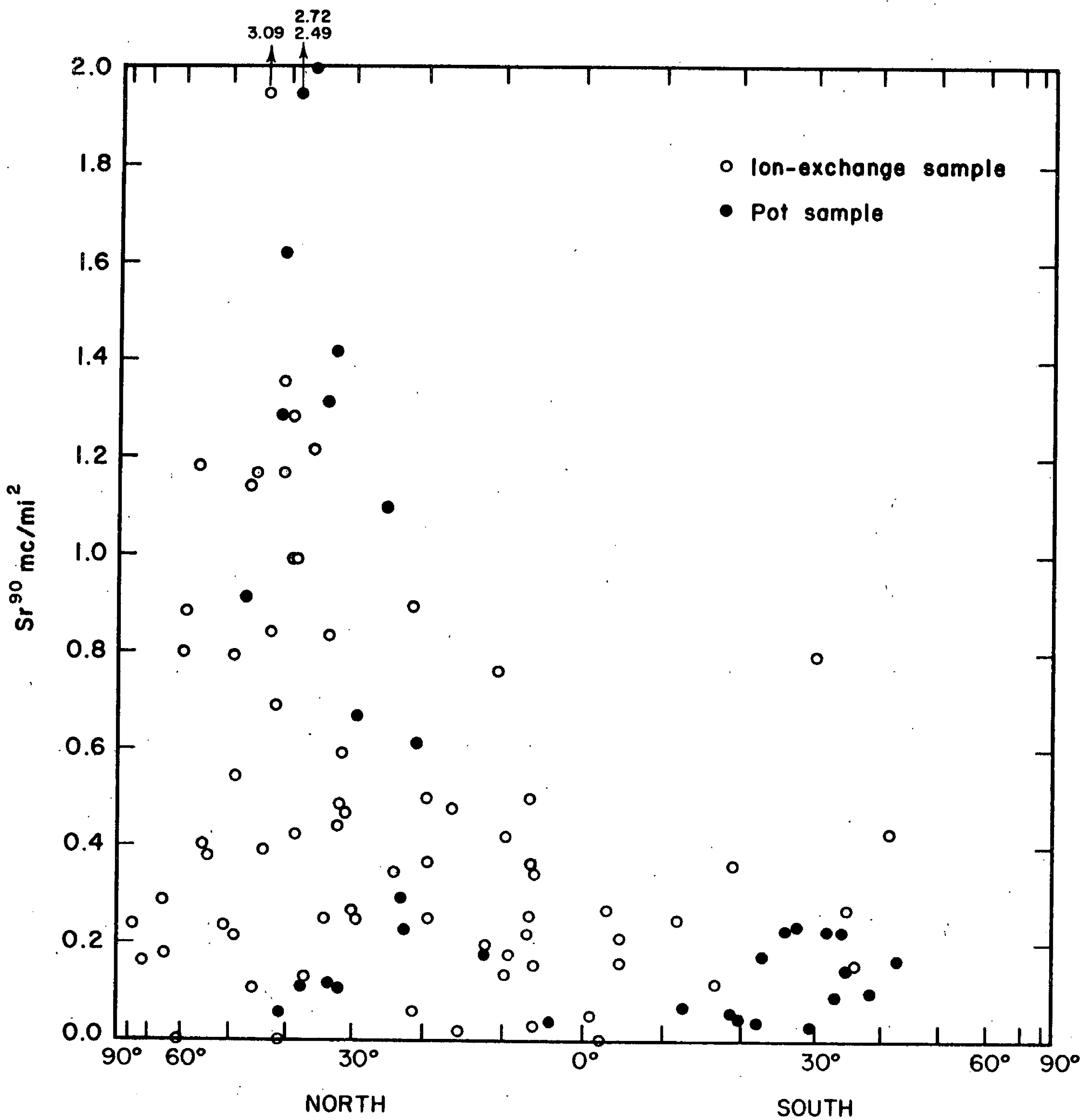


April 1958
FIGURE 4



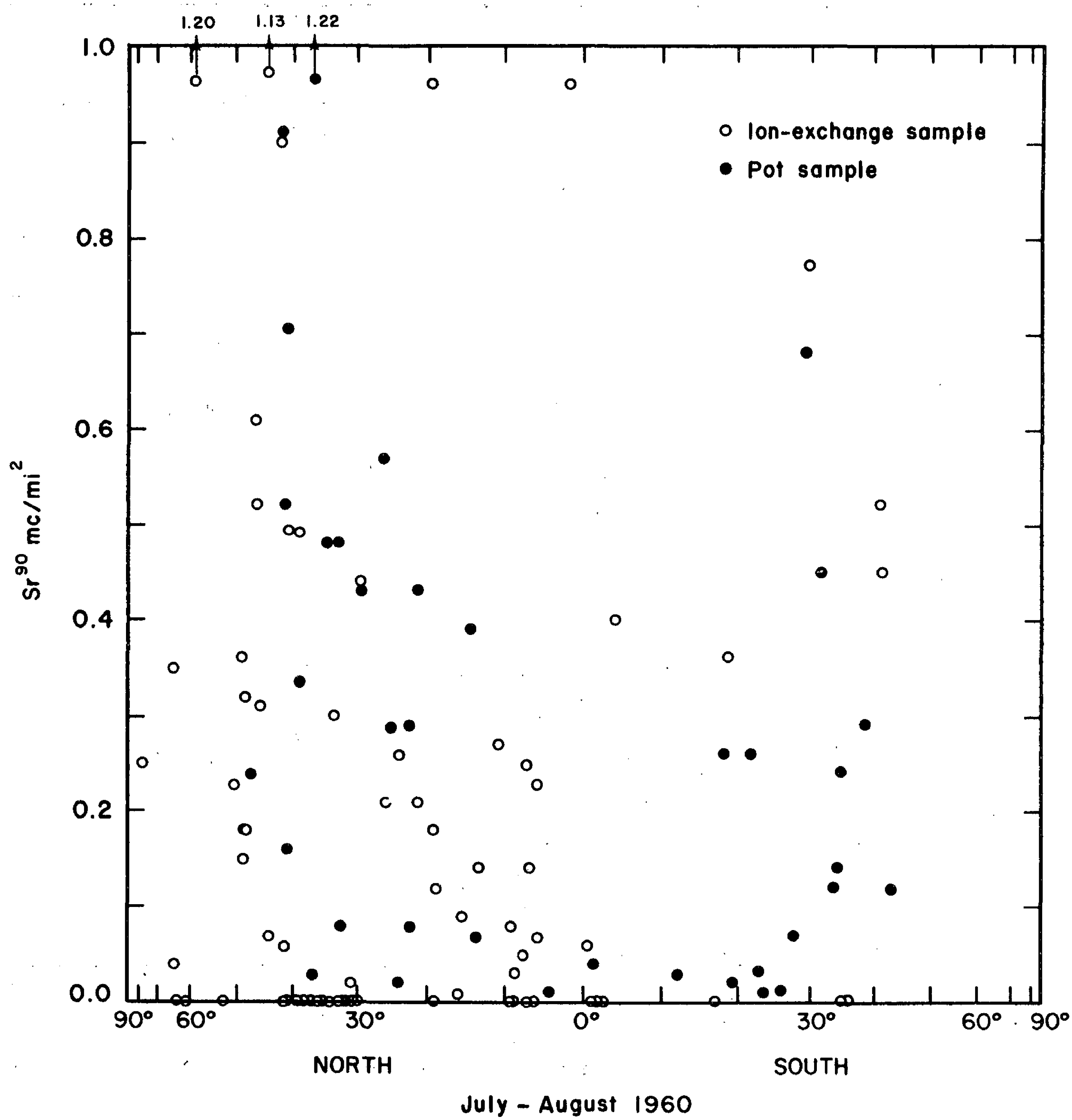
May 1958

FIGURE 5



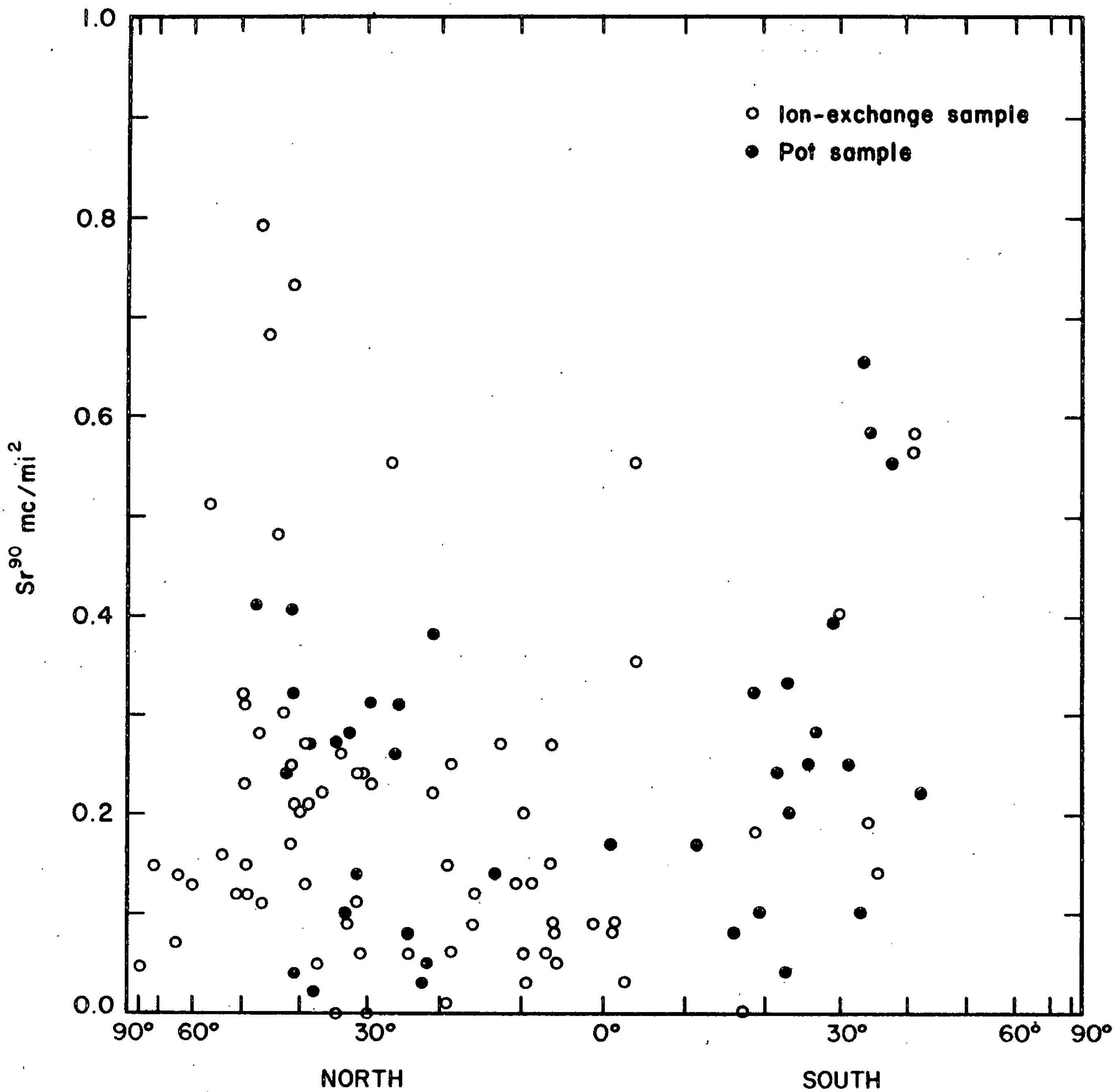
May – June 1960

FIGURE 6



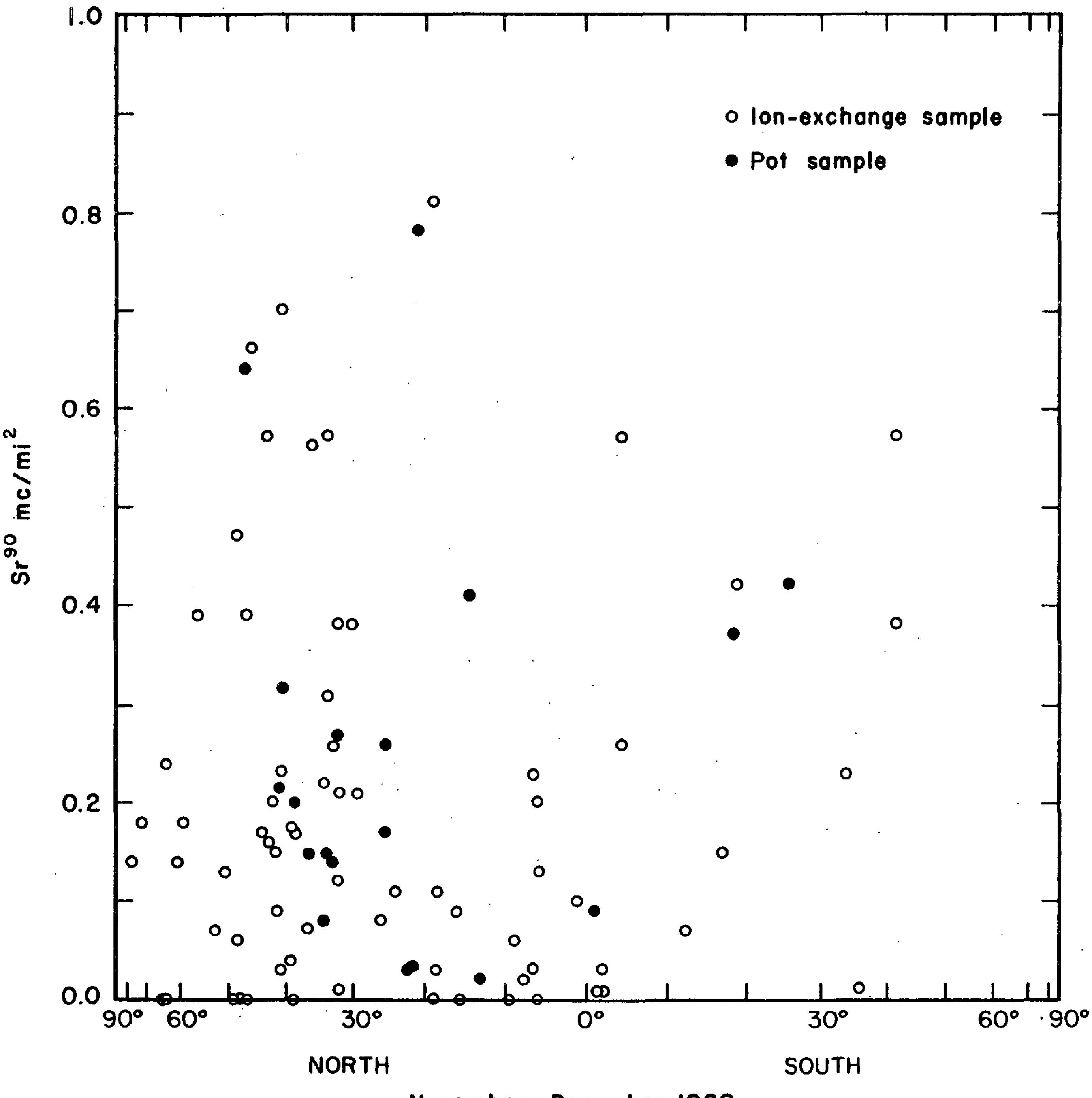
1.20
1.13
1.22
1.0
0.8
0.6
0.4
0.2
0.0
Sr^{90} mc/mi^2
Ion-exchange sample
Pot sample
90°
60°
30°
0°
30°
60°
90°
NORTH
SOUTH
July – August 1960

FIGURE 7



September-October 1960

FIGURE 8



1.0
0.8
0.6
0.4
0.2
0.0
Sr^{90} mc/mi^2
○ Ion-exchange sample
● Pot sample
90° 60°
30°
0°
30°
60° 90°
NORTH
SOUTH
November—December 1960

FIGURE 9

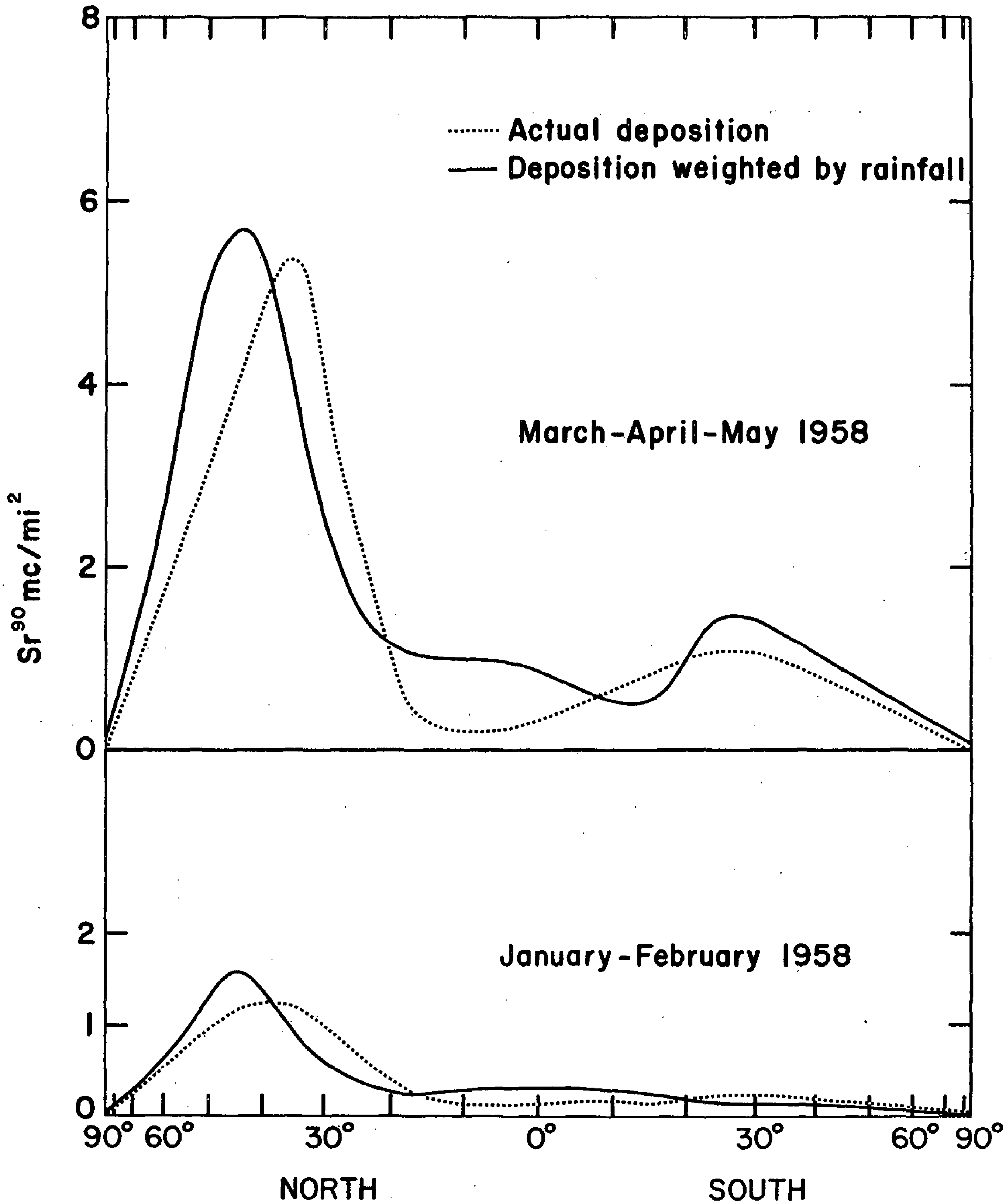

8
6
4
2
0
2
1
0
Actual deposition
Deposition weighted by rainfall
March-April-May 1958
January-February 1958
Sr^{90} mc/mi^2
90° 60°
30°
0°
30°
60° 90°
NORTH
SOUTH

FIGURE 10

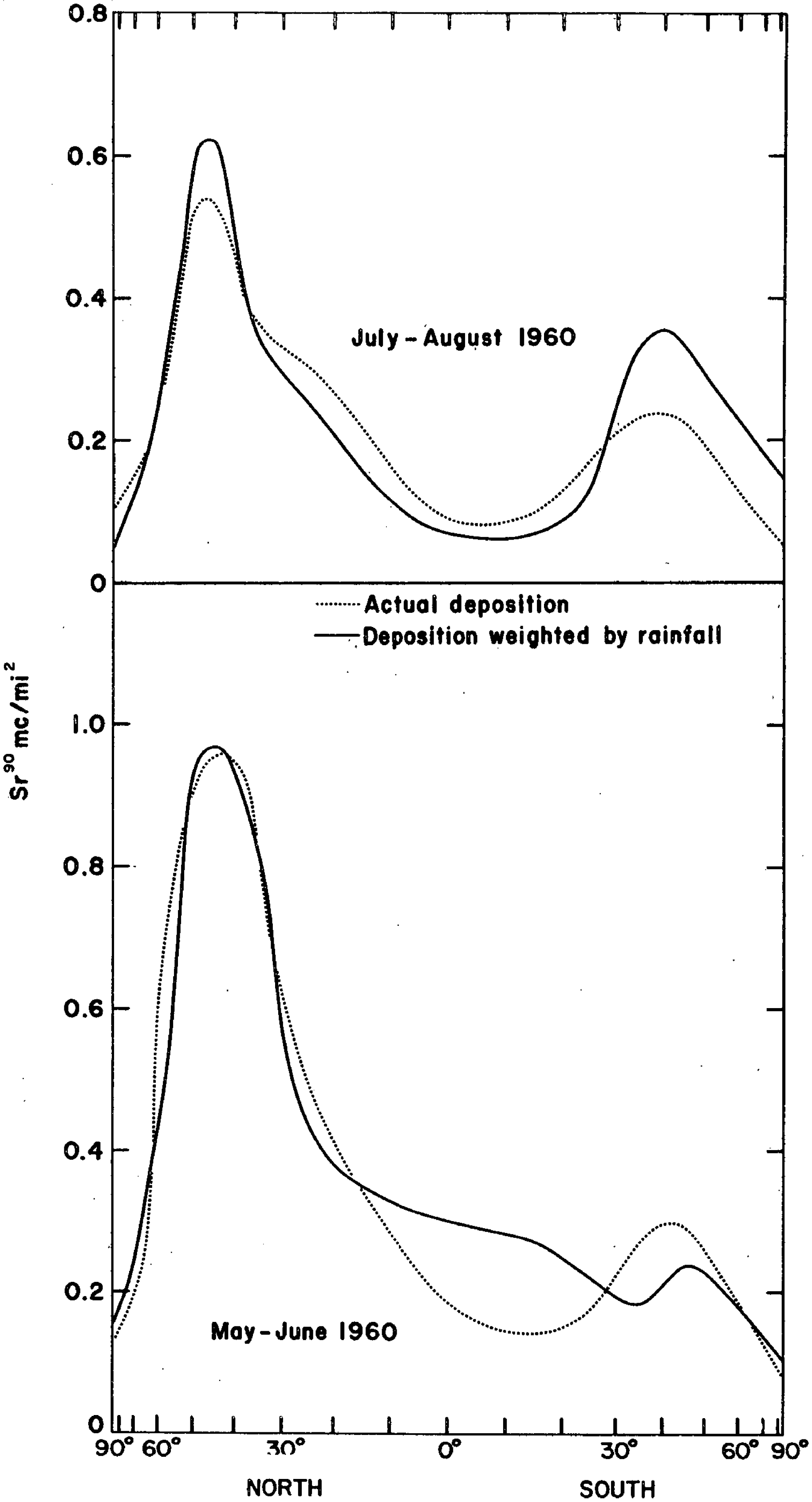

0.8
0.6
0.4
0.2
0
July - August 1960
Actual deposition
Deposition weighted by rainfall
Sr^{90} mc/mi^2
1.0
0.8
0.6
0.4
0.2
0
May - June 1960
90° 60°
30°
0°
30°
60° 90°
NORTH
SOUTH

FIGURE 11

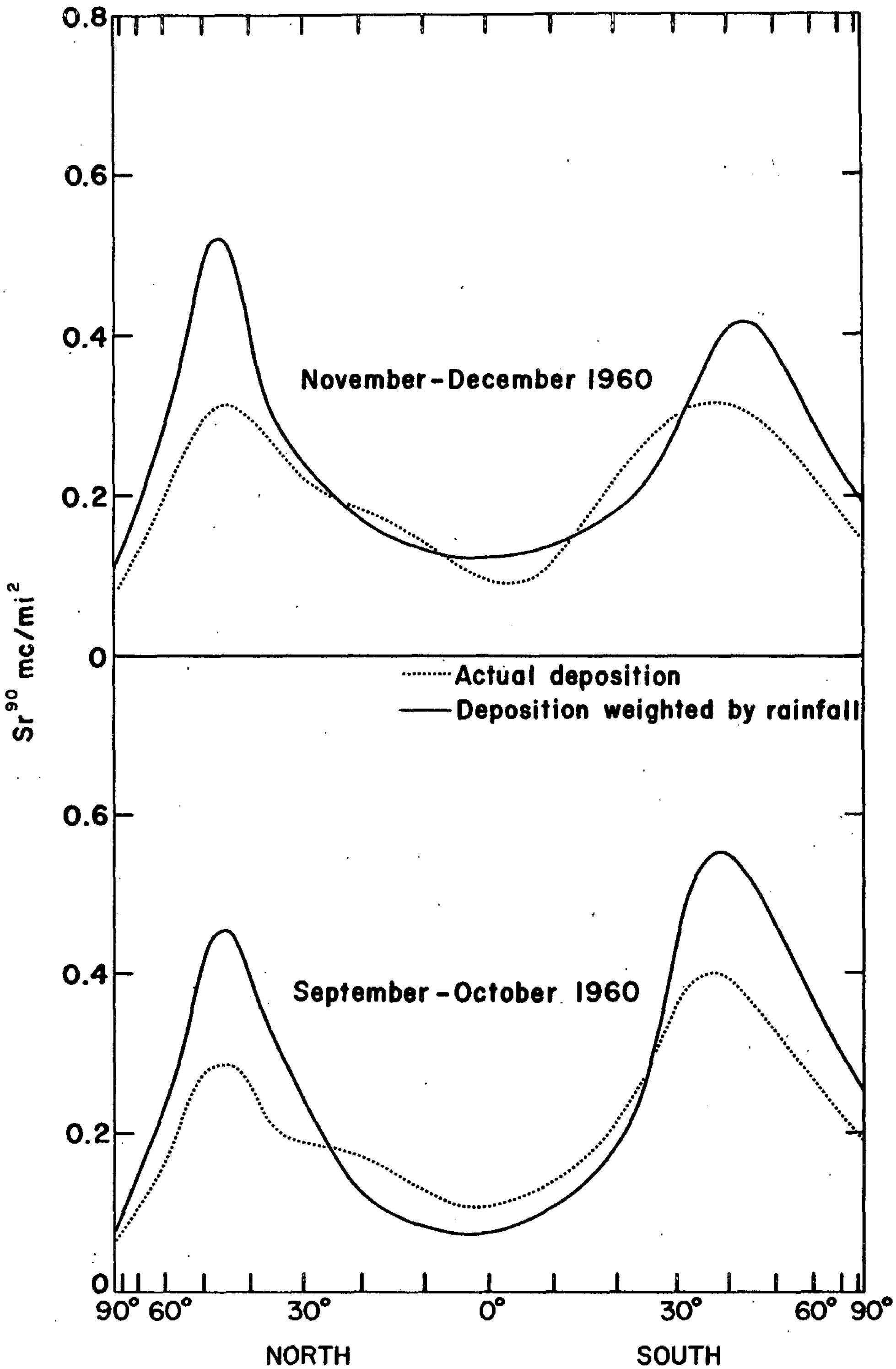

0.8
0.6
0.4
0.2
0
0.6
0.4
0.2
0
November - December 1960
September - October 1960
Actual deposition
Deposition weighted by rainfall
Sr^90 mc/mi^2
90° 60°
30°
0°
30°
60° 90°
NORTH
SOUTH

FIGURE 12

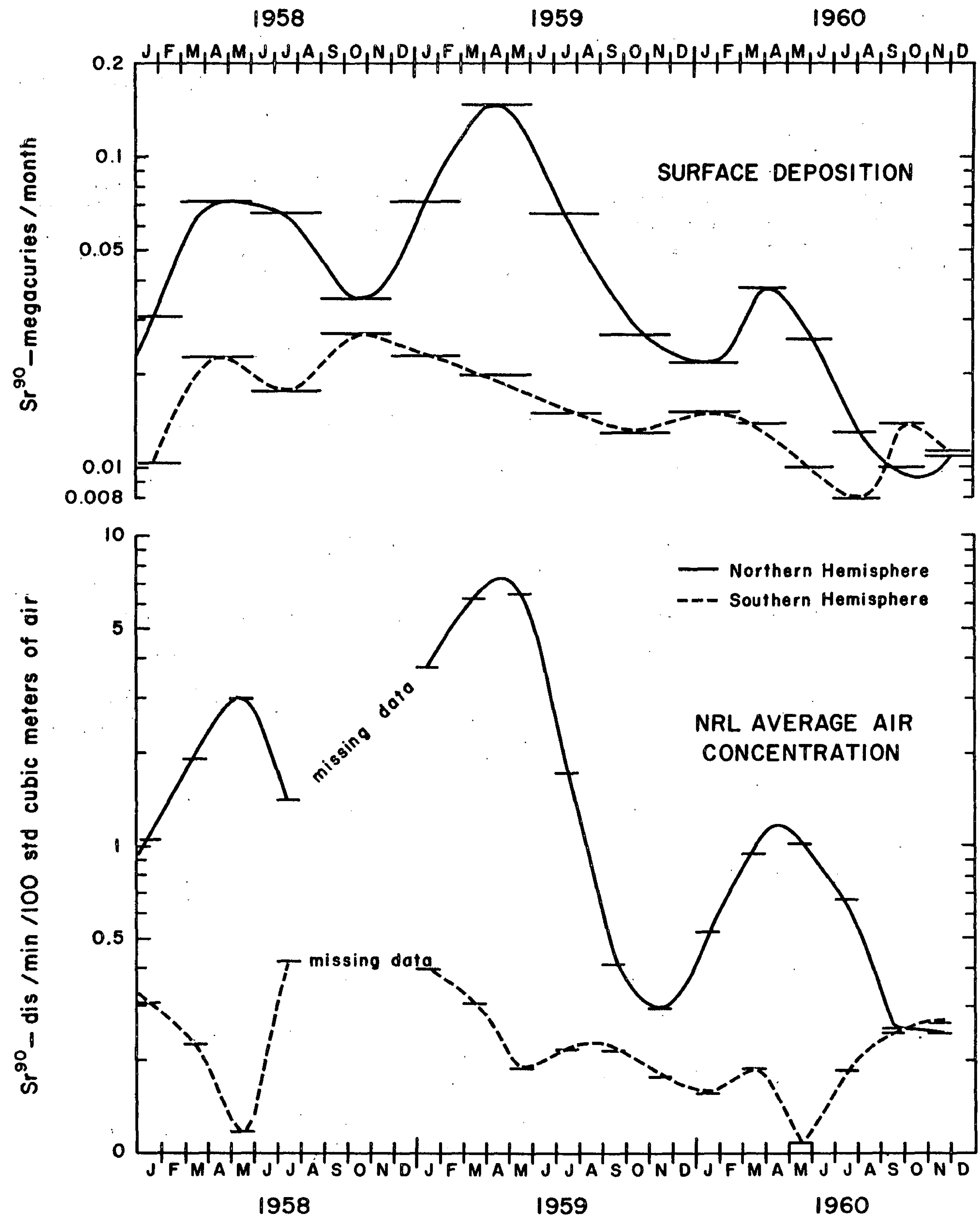

1958
1959
1960
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
0.2
0.1
0.05
0.01
0.008
Sr90—megacuries/month
SURFACE DEPOSITION
10
5
1
0.5
0
Sr90—dis/min/100 std cubic meters of air
Northern Hemisphere
Southern Hemisphere
missing data
missing data
NRL AVERAGE AIR CONCENTRATION
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1958
1959
1960

FIGURE 13

A Simple Correlation Analysis Between Strontium-90

From Fallout and Precipitation Rates

by L. D. Y. Ong (HASL)

Introduction

A simple correlation analysis has been performed to investigate whether there exists a relationship between the observed time distribution of strontium-90 deposition measured in pots and the time distribution of precipitation. The study has attempted to quantitatively answer on an average basis:

1. What direct measured relationship exists between the deposition rates of strontium-90 and volume of precipitation, and

2. What direct measured relationship exists between the deposition rates of strontium-90 and frequency of precipitation.

Geographical Stratification of Data

Strontium-90 levels estimated from pot samples collected monthly in the HASL's world-wide monitoring network during 1959 were stratified into five arbitrary 20-degree latitudinal bands as indicated below.

Band No.	Latitudinal Class Interval	No. of Stations
1	50° N - 30° N	45
2	30° N - 10° N	25
3	10° N - 10° S	20
4	10° S - 30° S	17
5	30° S - 50° S	9

Because of incomplete data, stations in latitudes greater than 50 degrees were not included in the study.

Strontium-90 Latitudinal Band Averages

Average monthly strontium-90 levels, a_{ij}, for each latitude band were computed at each point in time. This arithmetic mean may be expressed by:

$$a_{ij} = \frac{\sum_{K=1}^{N_{ij}} O_{ijk}}{N_{ij}} \qquad \begin{array}{ll} 1 \leq i \leq 5, & \Delta i = 1 \\ 1 \leq j \leq 12, & \Delta j = 1 \\ 1 \leq k \leq N_{ij}, & \Delta k = 1 \end{array} \tag{1}$$

where

N_{ij} = number of stations in the ith latitudinal band at the jth point in time

O_{ijk} = strontium-90 level observed at the kth station in the ith latitudinal band at the jth point in time

a_{ij} = average strontium-90 level in the ith latitudinal band at the jth point in time

The computed a_{ij} values may be expressed as elements of a 5 x 12 latitude-time matrix, α_s.

Precipitation Latitudinal Band Averages

Using monthly precipitation data corresponding to the strontium-90 measurements, a volume of precipitation - time matrix α_{pv} was computed with the method used to compute α_s where,

O_{ijk} = volume of precipitation observed at the kth station in the ith latitudinal band at the jth point in time

a_{ij} = average volume of precipitation per month at the ith latitudinal band at the jth point in time

Similarly, a frequency of precipitation-time matrix α_{pf}, was computed using data obtained from "Monthly Climatic Data for the World" (available from Supt. of Documents, Government Printing Office, Washington, D. C.) on the number of days per month for which the recorded precipitation was $\geq$ 1 mm. For this case we have:

O_{ijk} = frequency of precipitation observed at the kth station in the ith latitudinal band at the jth point in time

a_{ij} = average frequency of precipitation per month at the ith latitudinal band at the jth point in time

Correlation Coefficients

An index for measuring the mutual relationship between two independent variables, X and Y, is the population correlation coefficient, ρ, which may be estimated with the sample correlation coefficient, r. For perfect correlation r = ±1. This statistic is analytically expressed by

$$r = \frac{\sum_{i=1}^{N} (X_i - \bar{X})(Y_i - \bar{Y})}{N\, s_x\, s_y} \tag{2}$$

Confidence limits for ρ, given r, may be computed from the variable

$$Z = .5 \ln \frac{1 + r}{1 - r} \tag{3}$$

which has a normal sampling distribution with a standard deviation of $1/\sqrt{N - 3}$. Thus, the computed confidence limit allows for variation in sample sizes.

Statistical Analysis

Correlation coefficients measuring the relationship between the time distributions of strontium-90 and volume of precipitation for each latitudinal band were computed by treating the corresponding elements of α_s and α_{pv} with equations (2) and (3). Similarly, the correlation coefficients comparing the time distributions of strontium-90 and frequency of precipitation were computed using α_s and α_{pf}.

α_s Versus α_{pv}

Band No.	r	95% Confidence Interval for ρ
1	.58	.4 to .7
2	.37	.2 to .4
3	.15	.0 to .4
4	.81	.7 to .9
5	.44	.2 to .6

α_s Versus α_{pf}

Band No.	r	95% Confidence Interval for ρ
1	.11	-.1 to .3
2	.09	-.1 to .3
3	.31	.1 to .5
4	.47	.3 to .7
5	.06	-.1 to .3

Conditions of Statistical Analysis

Before evaluating the results, it is important to consider a number of conditions:

1. All computed correlation coefficients are really indices of "average" stations for each latitudinal band.

2. All averages for each band are biased since stations are not uniformly distributed within their respective latitude strata.

3. The results are correlation coefficients computed from 1959 pot data only. Data collected during another period with a different sampling system could yield completely different values.

4. Errors in either the strontium-90 or precipitation data would bias the coefficients.

5. The class intervals for latitude were arbitrarily selected. For example, areas with common environmental conditions could have been selected.

Inferences from Computations

Except for the equatorial band, "fair to good" correlation exists between monthly strontium-90 deposition and monthly volume of precipitation. Highest correlation exists in band 4, where the expected ρ is between 0.7 and 0.9. Bands 1 and 5 showed "considerable" correlation.

Little correlation appears to exist between the deposition rates of strontium-90 and frequency of precipitation. As in the volume of precipitation study, band 4 has the highest coefficient, with a 95% confidence interval of 0.3 to 0.7.

Conclusions

Correlation coefficients describing the mutual relationship between rates of strontium-90 deposition and precipitation as observed by HASL pot stations have been presented. Quick reference to the computed results could provide the fallout analyst with a general appreciation of this numerical index throughout the world.

The latitudinal distribution of ρ in both studies appears to be non-uniform with considerable variance in r existing among the bands. Perhaps the method of averaging data was a too general approach to take for analyzing variables with contributing individual variances. Also, as indicated by Table 1, variances in the distribution of r within the bands exist. Thus, the concept of using "average" stations to represent the behavior of their respective latitudes should be reinvestigated. To do this, the Health and Safety Laboratory has initiated a more detailed study to compute r values for each individual station and, where data are available, over a wider range of time. The results, when plotted on a latitude versus longitude scatter diagram, will yield a more efficient evaluation of the correlation present, since important variances and patterns of r within each latitude will be considered. Individual correlation coefficients for each station that collected pot samples during 1959 and 1960 are now being computed and all results will be presented in the next HASL quarterly report.

Table 1

Computed r for 1959 Australian Pot Stations

Sampling Station	Sample Size	r	Latitude Band	Latitude
Australia, Hobart	8	.25	5	42° 53' S
Australia, Adelaide	7	.68	5	34° 47' S
Australia, Sydney	7	.56	5	33° 52' S
Australia, Perth	8	.92	5	31° 57' S
Australia, Brisbane	7	.80	4	27° 23' S
Australia, Darwin	8	.12	4	12° 26' S

Overall Australian Mean	.56
Australian Standard Deviation	.31
Australian Range	.12 to .92
10°S - 50°S - Worldwide Mean	.63
30°S - 50°S - Australian Mean	.60 (Range .25 to .92)
30°S - 50°S - Worldwide Mean	.81
10°S - 30°S - Australian Mean	.46 (Range .12 to .80)
10°S - 30°S - Worldwide Mean	.44

Acknowledgement

I wish to thank D. K. Kahaner of the Statistical Branch who compiled most of the data and performed many of the computations.

On the Cerium-144/Strontium-90 Ratio in Precipitation

by R. Frankel and L. P. Salter (HASL)

Introduction

The Health and Safety Laboratory fallout program has included analysis of precipitation and stratospheric air samples for cerium-144 and strontium-90. Because of their relatively long half-lives of 285 days and 27.7 years, respectively, these two nuclides are useful in studying debris which may be from a few months to several years old.

In an isolated system storing nuclear debris, the ratio of Ce-144/Sr-90 will decrease with time exponentially, with a decay constant of 0.86 yr^{-1}, which corresponds to a half-period of 293 days. This is true even though the radioactivity came from material injected into the system at different times prior to its isolation. Extrapolation back to a production time ratio yields an apparent date of origin which is a weighted function of the various true injection times. Changes of the Ce-144/Sr-90 ratio with time in a component of the system in any other manner indicates (1) mixing of debris of a different apparent date of origin within the system, or (2) preferential removal of one of the nuclides from the component, i.e. fractionation. If fractionation is taking place only on a small scale relative to the size of the component, the ratio in the component will not deviate noticeably from an exponential decrease. The ratio of the material which is differentially removed, however, will vary from the ratio of the component.

The general features of the model defining the fate of radioactive debris injected into the atmosphere from high energy nuclear weapons testing are well known. In this model, the stratosphere is a storage system for radioactive debris several months after the cessation of tests; altitude bands within a latitude belt are the components of the system; and precipitation represents the material differentially removed from the low altitude component. For a given latitude, the ratio of Ce-144/Sr-90 in precipitation should be the same as that in the lower stratosphere unless the fractionation phenomenon is occurring.

It is the object of this paper to observe the trends of the Ce-144/Sr-90 ratio in monthly precipitation collections and relate them to age, mixing, and fractionation of nuclear debris by comparing them to the ratios observed in the stratosphere at the same time.

Trend of Ce-144/Sr-90 Ratios in Precipitation

Four AEC contractors have conducted analyses for cerium-144 and strontium-90 in 1960 and early 1961 precipitation collections at the following sites: (1) Westwood, New Jersey (Isotopes, Inc.); (2) Pittsburgh, Pennsylvania (Nuclear Science and Engineering Corp.); (3) Louisville, Kentucky (Radiochemistry, Inc.); (4) Houston, Texas (Tracerlab, Inc.); and (5) Richmond, California (Tracerlab, Inc.). These data have been published earlier in this quarterly report.[1] The Ce-144/Sr-90 ratios for these sites as determined from the monthly stainless steel pot collections, are shown in Figure 1. Although some of these sites collected samples using both stainless steel pots and ion exchange columns, only data from the former were used since some of the resin used for the ion exchange collections during part of this period are known to have been contaminated with small amounts of strontium-90. Data obtained by Collins, et al.[2] for New York City by averaging the analysis from replicate ion exchange columns collections in 1959, are also included and plotted with the Westwood data because of the geographical proximity of the sites. Because of known analytical problems with the early 1960 cerium-144 assays of the Louisville samples,[3] these data are shown from late 1960 only.

The best fitting line through the late 1960 and 1961 points for Westwood having the slope dictated by the 293 day half-period is shown on the plots for each of the sites. If this line is extrapolated back to an estimated production ratio of 45, obtained by using the fission product data presented by Holland[4] and the half-lives mentioned earlier, the apparent date of origin for the debris is December 1957. Since comparatively little testing was performed at this time, extrapolation to such a date indicates that debris deposited after mid-1960 contained material from 1958 tests mixed with pre-1958 debris from which cerium-144 had been depleted as the result of radioactive decay. Fractionation of these nuclides at the time of detonations or in the interval between their injection into the stratosphere and deposition via precipitation would modify this interpretation as would extrapolation to a different ratio.

The most prominent divergences of the Ce-144/Sr-90 ratios in these samples of monthly precipitation from a common 293 day half-period slope are (1) high values for the first half of 1959 in New York, (2) low values for the winter of 1959-1960 in New York and Westwood, and (3) the difference in the levels of the ratios after mid-1960 in Westwood and Pittsburgh as compared to Louisville, Houston and Richmond.

A trend similar to the low ratios observed for New York-Westwood was noted[5] for selected individual storms collected in Pittsburgh during the late winter and spring of 1960, but is not clearly discernible in the monthly pot collections from that site as shown in the second section of Figure 1.

Another feature of the data is the scatter around a 293 day half-period slope, especially for Houston. It may be noted that comparatively large amounts of total precipitation were observed at this site during the months for which the Ce-144 to Sr-90 ratios were relatively low (June, October and December 1960). Neither this effect nor its converse were apparent, however, in the data for the other sites.

There is considerable spread between replicate analysis for some months at the Richmond site, but this may reflect in some cases, notably August and September, sampling differences or larger analytical errors due to low quantities of activity from the reduced precipitation levels.

<u>Trend of Ce-144/Sr-90 Ratios in the Atmosphere</u>

Air sampling data are available from the AEC's Project Ash Can, presented earlier in this quarterly report.[6] For this project, stratospheric air samples are collected by balloons at altitudes ranging from 50,000 to 90,000 feet. Ce-144/Sr-90 ratios also have been obtained in the U. S. Naval Research Laboratory's (USNRL) studies of ground level air,[7,8] and in samples taken in the North Temperate and Polar stratosphere as part of the Defense Atomic Support Agency's High Altitude Sampling Program (HASP).[9]

Project Ash Can data for 1959-1961 from Sioux City, Iowa and San Angelo, Texas are shown in the first two sections of Figure 2. Dark symbols representing the Ce-144/Sr-90 ratios at different altitudes have been used for averages of two or more ratios in close agreement, and open symbols used where the spread between duplicates was greater than twenty percent or only a single ratio was available. The 293 day half-period slope extrapolated from a ratio of 45 in December 1957 is shown.

The data for Sioux City have been presented previously.[5] In summary, it was noted[10] that the ratios at 90,000 feet were decidedly higher than those at 65,000 feet, and extrapolation back to an initial ratio of 45 gave apparent dates of origin of August 1958 and December 1957, respectively.[11] The ratios at 80,000 feet were about the same as those at 65,000 feet during the summer. They increased during the fall, however, to the level of the ratios at 90,000 feet. This pattern indicates that the upper stratosphere contained relatively larger amounts of fresher debris which mixed vertically downward during the year. From the HASP data, reproduced in Figure 3, it may be observed that the ratios at 60,000 to 70,000 feet also changed from relatively low to higher values in the same period.

The San Angelo data may be divided into two periods: (1) thru February 1960 the ratios are characterized by large scatter around the 293 day half-period slope, and (2) from March 1960 the ratios show less scatter while decreasing with a 293 day half-period slope, which is above that extrapolated from an origin of December 1957. In neither period is a consistent difference in the ratios at each altitude clearly discernible.

The Ce-144/Sr-90 ratios from USNRL ground level air at six sites in the latitude belt from 9°N to 76°N are shown in the bottom section of Figure 2 with the 293 day half-period slope extrapolated from December 1957. The range of ratios observed for the six sites are shown.[12] These data agree remarkably well with the HASP data for 30,000 to 55,000 feet in the Northern Temperate and Polar atmosphere which are shown in Figure 3, and the data for monthly precipitation in the eastern sites, except for the low ratios for the latter during the winter of 1959-1960.

Discussion

Comparison of the Ce-144/Sr-90 ratios in precipitation with atmospheric data permits an exploration of the causes for the prominent divergences from a common 293 day half-period slope.

The high Ce-144/Sr-90 ratios during the first half of 1959 observed for New York precipitation, USNRL ground level air and the HASP measurements at 30,000 - 55,000 feet are consistent with the pattern of nuclear debris described in other papers.[13,14] These studies have concluded that through the spring, 1959 fallout in the North Temperate zone was composed primarily of 1958 Russian debris injected into the lower polar stratosphere with a short residence time. The smaller Ce-144/Sr-90 ratios in New York precipitation and the air observed in the latter part of 1959 probably reflected a lower stratosphere which contained relatively older test debris after the fresher Russian material had been removed.

The large scatter in the 1959 Ce-144/Sr-90 ratios at San Angelo makes their interpretation difficult, but from a consideration of the Sioux City ratios and the other data, the following picture of the 1959 North Temperate stratosphere emerges. At the beginning of the year, an intermediate layer at 60,000 to 80,000 feet of relatively older debris was sandwiched between mixtures containing newer material from 1958 Russian tests at lower altitudes, and Teak and Orange at higher altitudes. As the year progressed, the short residenced Russian debris fell out and slow vertical mixing brought the high altitude material to lower levels with the result that Ce-144 to Sr-90 ratios at 30,000-50,000 decreased, those around 60,000 feet remained unchanged, and those at 70,000-80,000 feet increased. The collection of stratospheric air samples at Sioux City ceased at the end of 1959, but one might conjecture that they would have reflected a continuation of the downward mixing trend, increasing the Ce-144/Sr-90 ratios in the lower stratosphere during 1960 to the level of those observed for San Angelo.

The cause of the other two divergences in the precipitation data remain substantially unresolved. While the New York-Westwood ratios qualitatively follow the trend predicted by the 1959-1960 model of the stratosphere given at Sioux City, the values for the winter 1959-1960 ratios at these sites are much smaller than found in the lower stratosphere. Nor do they have a counterpart in the data from USNRL ground level sampling networks and the other precipitation sites, except as noted earlier for individual storms in Pittsburgh. The hypothesis that the effect was a seasonal one must be rejected since the pattern was not repeated during the following winter. These data remain anomalous although the following possibilities cannot be ruled out: (1) debris in the precipitation during this period reflected an unusual source of relatively older stratospheric material, (2) an unparalleled fractionation phenomenon occurred, and (3) unique errors existed in the collections or radioassays of these samples.

For all the sources discussed in this paper, the Ce-144/Sr-90 ratios from mid-1960 decrease with a 293 day half-period slope on a line that extrapolates back to an apparent date of origin (1) of late 1957 or (2) of mid-1958. The data for Westwood and Pittsburgh precipitation and USNRL ground level air follow the former pattern; the data for Louisville, Houston, and Richmond precipitation and San Angelo stratospheric air follow the latter pattern. These differences cannot be dismissed entirely on the basis of differences in calibration of radioassay methods at the several laboratories since the San Angelo Ash Can samples, whose ratios decreased from mid-1958, were analyzed during this period by Isotopes, Inc. and Nuclear Science and Engineering Corp., whose precipitation data at Westwood and Pittsburgh, respectively, decreased from late 1957.

One may further note that extrapolation of the Sioux City 65,000 feet slope for 1959 agrees with the Westwood-Pittsburgh-USNRL data, but extrapolation based on additional downward mixing of newer debris as predicted for 1960 would yield closer agreement with the other sources.

Several hypotheses based on mixing, fractionation and calibration phenomena may be proposed to explain this difference in the extrapolated dates, but the study of additional data is required to resolve this problem adequately.

References and Notes

1. Fallout Program Quarterly Summary Report, USAEC Report HASL-115, p. 6, October 1, 1961.

2. Collins, Jr., W. R., Welford, G. A., and Morse, R., "Fallout from 1957 and 1958 Nuclear Test Series", Science (in press).

3. Private communication from Dr. James E. Lewis, Radiochemistry, Inc., Louisville, Kentucky.

4. Holland, J. Z. (ed.), Stratospheric Radioactivity Obtained by Balloon Sampling, USAEC Report TID-5555, p. B-15, May 1959.

5. Salter, L. P., Evaluation of Radioactive Fallout, NSEC-30, September 30, 1960.

6. Fallout Program Quarterly Summary Report, USAEC Report HASL-115, p. 73, October 1, 1961.

7. Ibid 6, p. 129.

8. Fallout Program Quarterly Summary Report, USAEC Report HASL-95, p. 116, October 1, 1960.

9. Isotopes, Inc., Studies of Nuclear Debris in Precipitation, NYO-9529, January 31, 1961.

10. This analysis included the data from samples assayed at one site only to eliminate effects due to laboratory intercalibrations.

11. A production ratio of 50 was used in NSEC-30, which gave slightly earlier apparent date of origin for the debris.

12. One very high ratio for 9^{o}N in March 1960 was excluded.

13. List, R. J. and Telegadas, K., "The Pattern of Global Atmospheric Radioactivity - May 1960", HASL-111, p. 186, April 1, 1961.

14. Martell, E. A. and Drevinsky, P. J., "Atmospheric Transport of Artificial Radioactivity", Science 132, 1523 (1960).

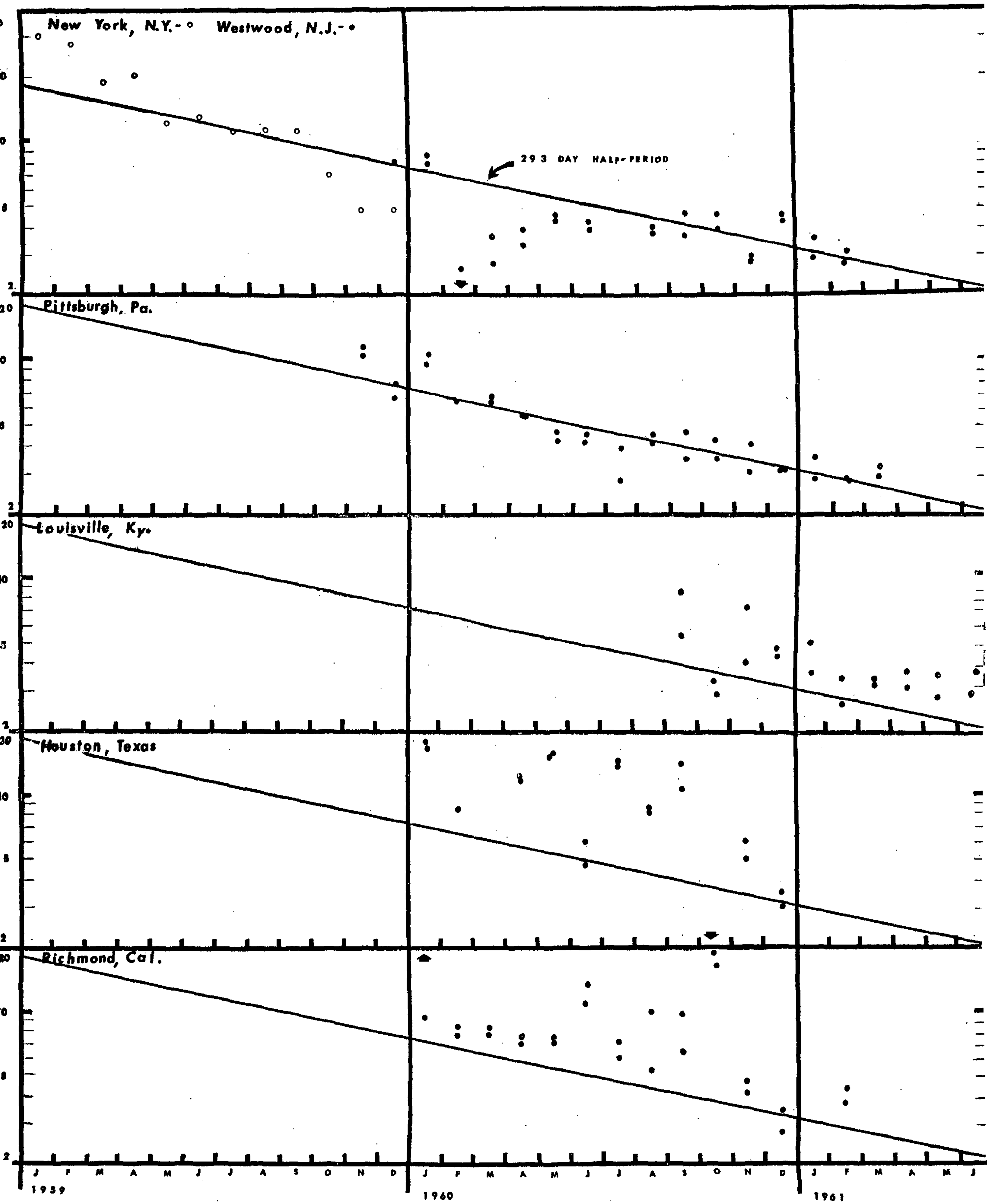


Figure 1   Cerium^{144}/Strontium^{90} in Monthly Precipitation Collections

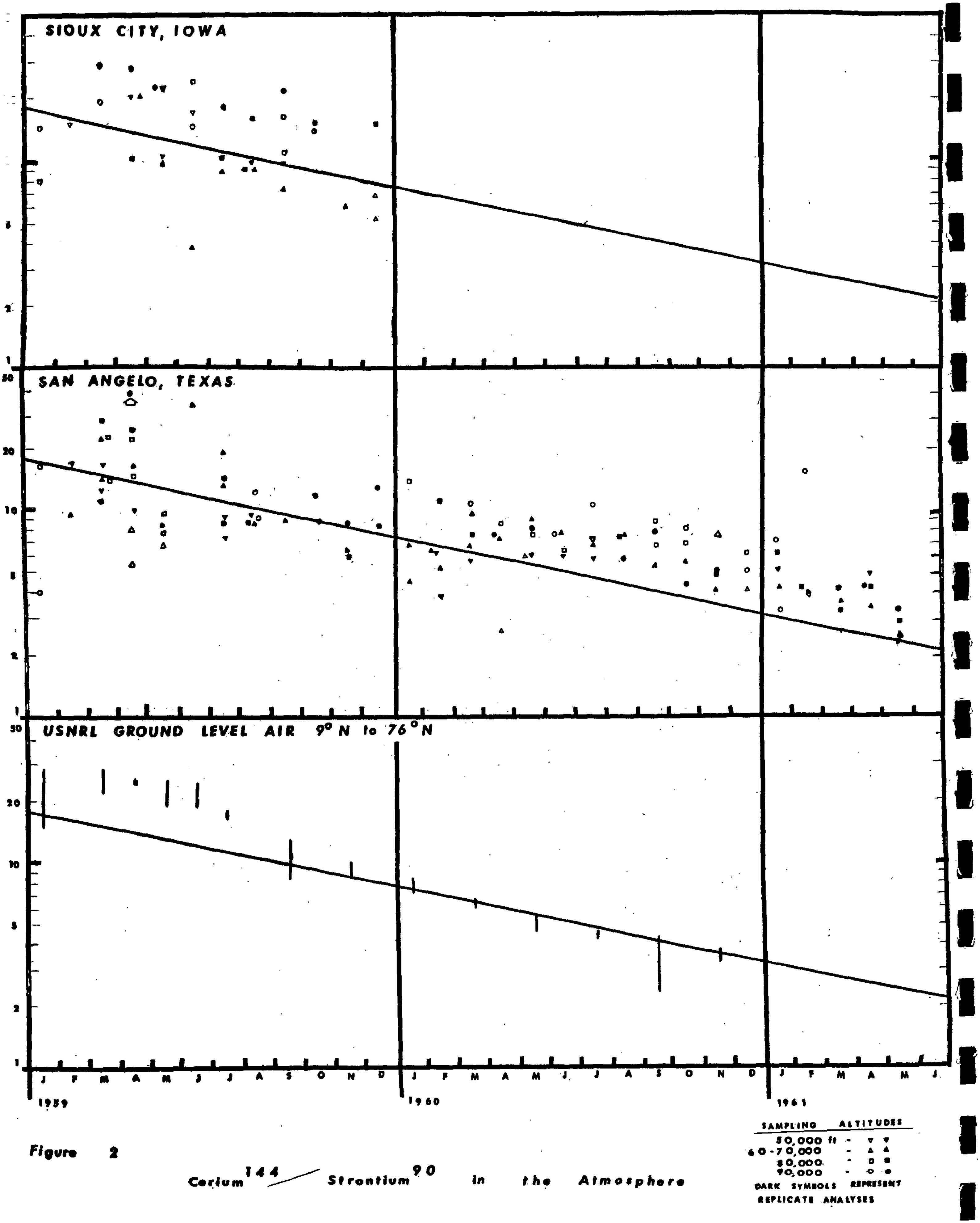


Figure 2

Cerium^{144} / Strontium^{90} in the Atmosphere

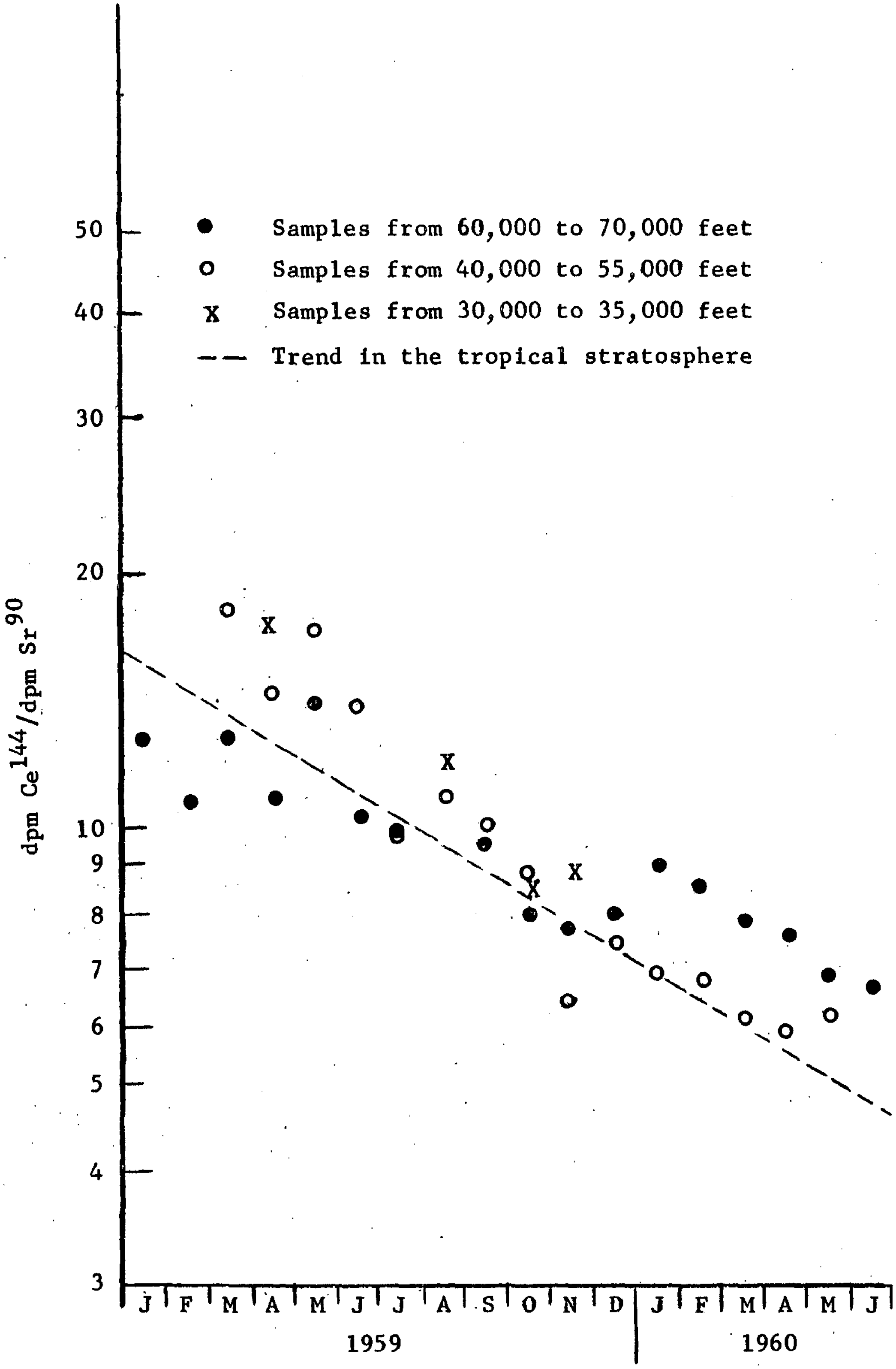


FIGURE 3 Variation With Time of the Monthly Average for Ce^{144}/Sr^{90} in Samples Collected in the Northern Polar Stratosphere (30°N - 90°N). (Copied from reference 10.)

Beryllium-7 and Phosphorus-32 in Precipitation

by Alan Walton, Isotopes, Inc.

The radioisotopes beryllium-7 and phosphorus-32 are two of several nuclides produced by cosmic-ray reactions in the atmosphere which have possible applications to studies of gross circulation patterns in the atmosphere. Such studies are particularly important in attempts to understand fully the mechanisms involved in the deposition of radioactive fallout from nuclear detonations. To aid these investigations a moderate program of measurement of beryllium-7 and phosphorus-32 in precipitation at Westwood, N. J. has been performed over the past several months. This report presents only the preliminary results of this study with a brief discussion of the implications of these data. The main objective of this study was to determine whether significant quantities of stratospheric air were contained in the air masses yielding precipitation over the Westwood area. This can be investigated by observations of the beryllium-7 to phosphorus-32 ratios in precipitation at Westwood since air of recent stratospheric origin would be expected to possess higher beryllium-7 to phosphorus-32 ratios than air which had spent its time between successive cleansing by rain exclusively within the troposphere. For example, according to recent theoretical calculations,(1,2) stagnant polar stratospheric air should possess a minimum ratio of about 350 while average tropospheric air which had been irradiated for a period of about 40 days should show a maximum ratio of about 200. Table I shows the results of beryllium-7 and phosphorus-32 analyses of precipitation samples collected in our large receiver (catch area = 78.2 ft^2) during late 1960 and the first half of 1961.

With the exception of sample S-295 our results are consistent with the conclusion that the air masses, from which the activities were removed, contained relatively small fractions of stratospheric air. The observed data can be satisfactorily explained by irradiation of the air masses concerned within the troposphere. Sample S-295 yielded a beryllium-7 to phosphorus-32 ratio which is slightly higher than would be predicted from irradiation exclusively within the troposphere but is not sufficiently large for us to conclude that large contributions of stratospheric air had been made to this particular air mass.

For comparison the results obtained by Lal, et al(4) for rains occurring during the monsoon season in Bombay during 1958 and shown in

(1) Lal, D., Malhotra, P. K., and Peters, B., "On the Production of Radioisotopes in the Atmosphere by Cosmic Radiation and Their Application to Meteorology, J. Atmos. and Terr. Phys. 12, 306, 1958.

(2) Lal, D., Arnold, J. R., and Holda, J., "Cosmic-ray Production Rates of Be^7 in Oxygen, and P^{32}, P^{33}, S^{35} in Argon at Mountain Altitudes, Phys. Rev. 118, No. 6, 1626, 1960.

(4) Lal, D., Rama, and Zutshi, P. K., "Radioisotopes P^{32}, Be^7 and S^{35} in the Atmosphere, J. Geophys. Res. 65, 669-673, 1960.

Table II. The good agreement between the two sets of data apparently provides supporting evidence for the hypothesis that the predominant source of beryllium-7 and phosphorus-32 in rains is irradiated tropospheric air. The hypothesis that the stratosphere is stagnant is, however, subject to great uncertainties and hence the ratio assumed for stratospheric air must be questioned. If the stratosphere is not stagnant the ratio of 350 should be somewhat lower for the northern polar regions. Indeed beryllium-7/phosphorus-32 ratios recently measured in stratospheric air samples[(5)] lie between 120 and 312 and hence tend to confirm that previously postulated values, based on theoretical considerations, were too high. It appears that further work is necessary to clarify the range of beryllium-7/phosphorus-32 ratios in both stratospheric air-filter samples and in tropospheric samples.

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(5) Friend, J. P., Feely, H. W., Krey, P. W., Spar, J., and Walton, Al, The High Altitude Sampling Program, Final Report DASA 1300, in press (1961).

Table I

Concentrations of Beryllium-7 and Phosphorus-32 in Precipitation

Collected at Westwood, N. J.(3)

Sample No.	Volume (liters)	Date of Collection	Beryllium-7 dpm/liter	Phosphorus-32 dpm/liter	Be^7/P^{32} atoms/atom
S-289	84	12-11-60	17.6 ± 0.83	0.72 ± 0.02	89.3
S-294	99	12-30-60	44.6 ± 2.02	1.70 ± 0.04	95.9
S-295	146	1-2-61	67.6 ± 1.57	1.16 ± 0.04	213.0
S-306	102	2-26-61	71.9 ± 1.18	2.07 ± 0.11	126.9
S-311	221	3-9-61	33.9 ± 0.59	0.95 ± 0.03	130.4
S-314	99	3-18-61	67.7 ± 2.23	2.21 ± 0.19	112.0
S-318	182	4-7-61	50.4 ± 1.16	2.52 ± 0.19	73.1
S-320	434	4-17-61	20.7 ± 0.33	0.49 ± 0.03	154.4
S-323	88	4-26-61	76.6 ± 0.14	2.00 ± 0.13	140.0
		Averages	50.1	1.54	126.1

(3) Latitude 40° 59' N, Longitude 74° 02' W.

Table II

Comparison of Beryllium-7 and Phosphorus-32 Concentrations in Rains at Bombay, India,[4] and Westwood, N. J.

Station		Nuclide Concentrations (atoms/ml)	
		Be^7	P^{32}
Bombay, India	(1958)	4.4×10^3	43.5
Westwood, N. J.	(1960-61)	5.5×10^3	46.3

(4) Lal, D., Rama and Zutshi, P. K., "Radioisotopes P^{32}, Be^7 and S^{35} in the Atmosphere, J. Geophys. Res. 65, 669-673, 1960.

Strontium-90 in New York City and Richmond, California Tapwater

by R. Frankel (HASL)

Introduction

As a part of the Health and Safety Laboratory's fallout monitoring program, tapwater from Richmond, California and New York City has been analyzed for strontium-90. The New York collections commenced in August 1954, and the Richmond collections in April 1958. In addition, August 1961 tapwater samples from Chicago and San Francisco have been obtained so that the contribution of water to the total intake of strontium-90 can be estimated in connection with the Tri-City Diet Study.(1) This is the first in a series of reports concerning the levels of strontium-90 detected in tapwater. Future reports will attempt to deal with the effectiveness of filtration processes by comparing strontium-90 levels in several components of selected water supply systems.

To evaluate the data, it is desirable to have some knowledge of the sources of the water, and how the water is supplied to the cities.

Description of Richmond and New York City Water Supply Systems

Richmond, California

Richmond, which is about twelve miles northeast of San Francisco, is in the East Bay Municipal Utility District, a service area which covers two hundred square miles in Alameda and Contra Costa Counties, but does not include San Francisco.(2) About 90% of the water is drawn from the Sierra Nevada Mountains, where snow and rain from a five hundred seventy-five square mile watershed form the Mokelumne River, which flows westerly to the Pacific Ocean. About 10% is drawn from local watersheds in the East Bay Hills. At times only one of the sources is available to an area, but at other times mixtures of the sources may be supplied. The average daily consumption in the district is 145 million gallons.

Richmond's water is purified at the San Pablo Filter Plants in the hills above El Cerrito, which is fed by a tunnel from the San Pablo Reservoir. The water is aerated, coagulated, sedimentized, filtered, and disinfected. It has been proposed that a sample of the sand used in the filtration be analyzed to determine the effectiveness of ion exchange processes in removing strontium-90. The results of any such analyses will be reported in the future.

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(1) HASL-113 - Fallout Program Quarterly Summary Report, July 1, 1961, p. 86

(2) Pamphlet "Water" Available from the East Bay Municipal Utility District, Oakland, California

The reservoirs which store the rain and snow waters for domestic use are large enough to provide long periods of retention. An accurate estimate of the period between the precipitation in the mountains and usage is difficult, since the supply can be added to at many points by ensuing rainfalls. For the New York City System, described below, an estimate of 6 months to a year has been made.[3]

New York City

New York receives its water supply from two main sources: approximately 85% comes from the Catskill-Delaware System, and 15% comes from the Croton System. Neither system uses any filtration (although at times the water is aerated), and virtually no pumping is necessary, since the water travels downhill from the Catskill watershed (75 - 125 miles northwest of New York), and the Croton watershed (25 - 60 miles northeast of New York). The twenty-six reservoirs hold a total of 514.5 billion gallons[4], and daily consumption totals 1,820 million gallons. The water analyzed by HASL should have come mainly from the Catskill system, although the two supplies are sometimes used interchangeably. Two samples, representing the different systems were collected in August 1961, in order to determine if any significant difference in strontium-90 content existed. One sample was taken from a supply shaft in the city and represents Catskill water. The other, from the Jerome Park Reservoir in the Bronx, represents Croton water. The results will be reported when available.

Discussion of the Data

Figures 1 and 2 show the strontium-90 content of the New York City and Richmond tapwater together with the results of the fallout deposition collections for the corresponding months. These data were reported in previous quarterly reports (HASL-42 through HASL-113). The strontium-90 concentration in the Richmond tapwater increases noticeably through 1958. A sharp increase occurs in February 1959, which is one month after the rise in fallout deposition levels. The deposition levels are highest during the early months of the year since the rainfall in Richmond drops off to almost zero from May through November. The June tapwater peak could also conceivably reflect the January-February precipitation, however, to assign a direct relationship between the tapwater and rainwater in periods of less than a year is probably not possible. If the tapwater taken is a representative sample, it should reflect the average concentration of strontium-90 in the reservoir, which may be storing water of widely varying age. The sample taken may have been recently rained into the reservoir, or at the other extreme, it may represent melted snow of considerably older "age".

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(3) Personal communication with Mr. Benjamin Nesin, Mt. Prospect Laboratory, New York City Board of Water Supply

(4) Pamphlet "1,820,000,000 Gallons Per Day" - Available from the New York City Board of Water Supply (1955)

Throughout 1960 the Richmond tapwater exhibited a remarkable constancy which is reflected in the deposition levels for 1960. The leveling off occurs at higher activities than those in 1958, and just below the 1959 peaks. In the first three months of 1961 there is a slight rise in the tapwater results. This will be interesting to follow as further data is received.

Since collections from New York began in 1954, it is possible to see a much broader picture. The outstanding feature is the marked increase in the tapwater strontium-90 content in mid 1959, which is the same period as the peak fallout observed in precipitation collections. The tapwater levels in New York City are about twice those in Richmond. This may be attributed to the higher New York fallout rate as well as the lack of artificial filtration processes (which may have provided opportunities for ion exchange processes to take place). As in Richmond, the leveling off of strontium-90 concentrations for New York in 1960 occurs at activities higher than in years previous to 1959.

If one compares the $\mu\mu c$ Sr^{90}/liter of both rainwater and tapwater for both sites, one finds the tapwater levels in 1960 range from one-fifth the precipitation levels in Richmond to one-third the precipitation levels in New York. A possible reason for this might be that the flow of the water through the river beds as well as artificial filtration processes which may be employed, provide opportunities for ion exchange processes, as mentioned earlier.

A study in Great Britain was conducted which showed the strontium-90 concentrations in rivers, lakes, reservoirs, and wells(5). The averaged results are shown below. The difference between the rivers and lakes is striking, with the lakes over 80% higher in strontium-90 than the rivers. The wells, as expected are very low. The comparatively high value recorded in the second quarter of 1959 was attributed to surface water that entered the well. Comparing the British levels with the two U. S. sites, one finds the British values somewhat higher for corresponding periods, especially those for the lakes and reservoirs. Since the British data extends only to mid 1959, a full comparison is not possible. However, the value of 0.71 $\mu\mu c$ Sr^{90}/liter recorded for the first quarter of 1959 in the British lakes and reservoirs seems to correspond with the high in New York tapwater in mid 1959.

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(5) Radiostrontium and Radiumcesium in Drinking Water in U. K.: Results up to mid 1959, Crooks, Osmond, Owers, et al. AERE-R-3127

Strontium-90 in Great Britain Drinking Water

µµc/liter

1957	Rivers	Lakes, Reservoirs	Wells
4th	0.23 (3)	0.42 (3)	0.01 (2)
1958			
1st	0.19 (3)	0.43 (6)	0.01 (2)
2nd	0.33 (3)	0.56 (1)	0.02 (1)
3rd	0.33 (3)	0.59 (6)	0.01 (2)
4th	0.38 (3)	0.65 (6)	0.02 (2)
1959			
1st	0.39 (3)	0.71 (7)	0.02 (2)
2nd	0.47 (7)	1.00 (8)	0.14 (1)

( ) Indicates the number of sites.

NEW YORK CITY

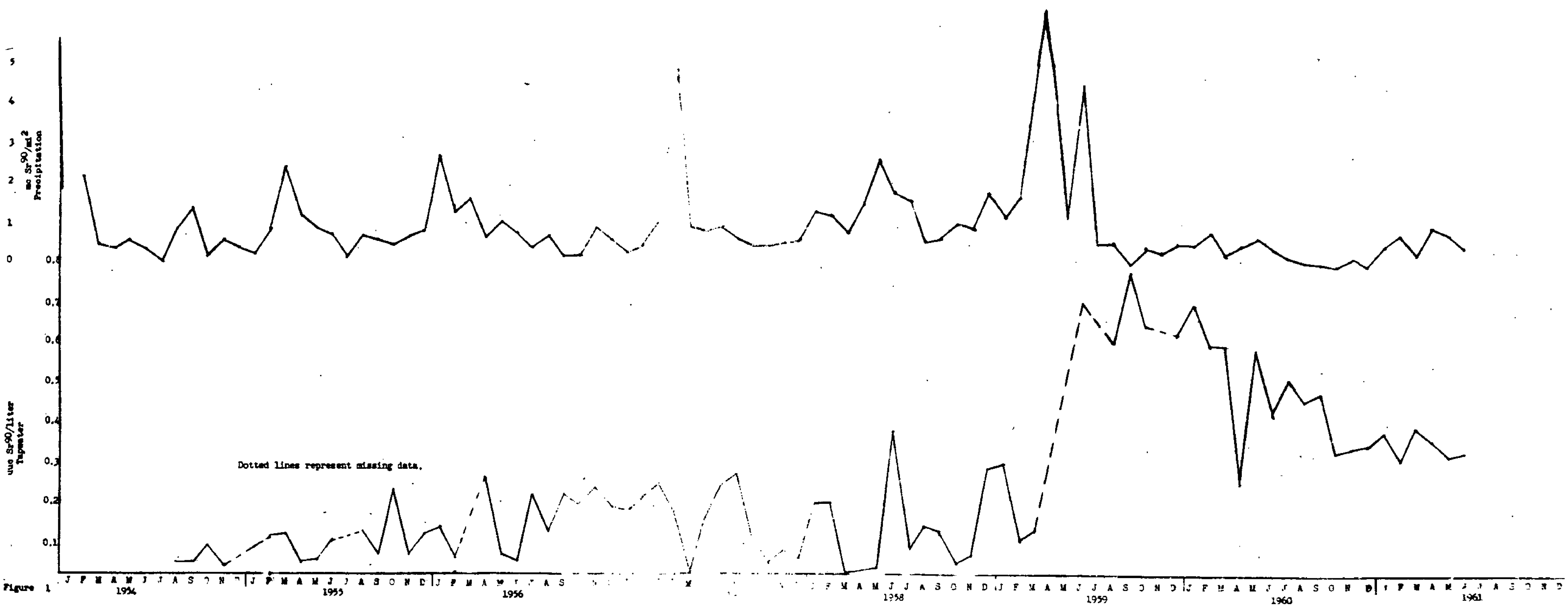
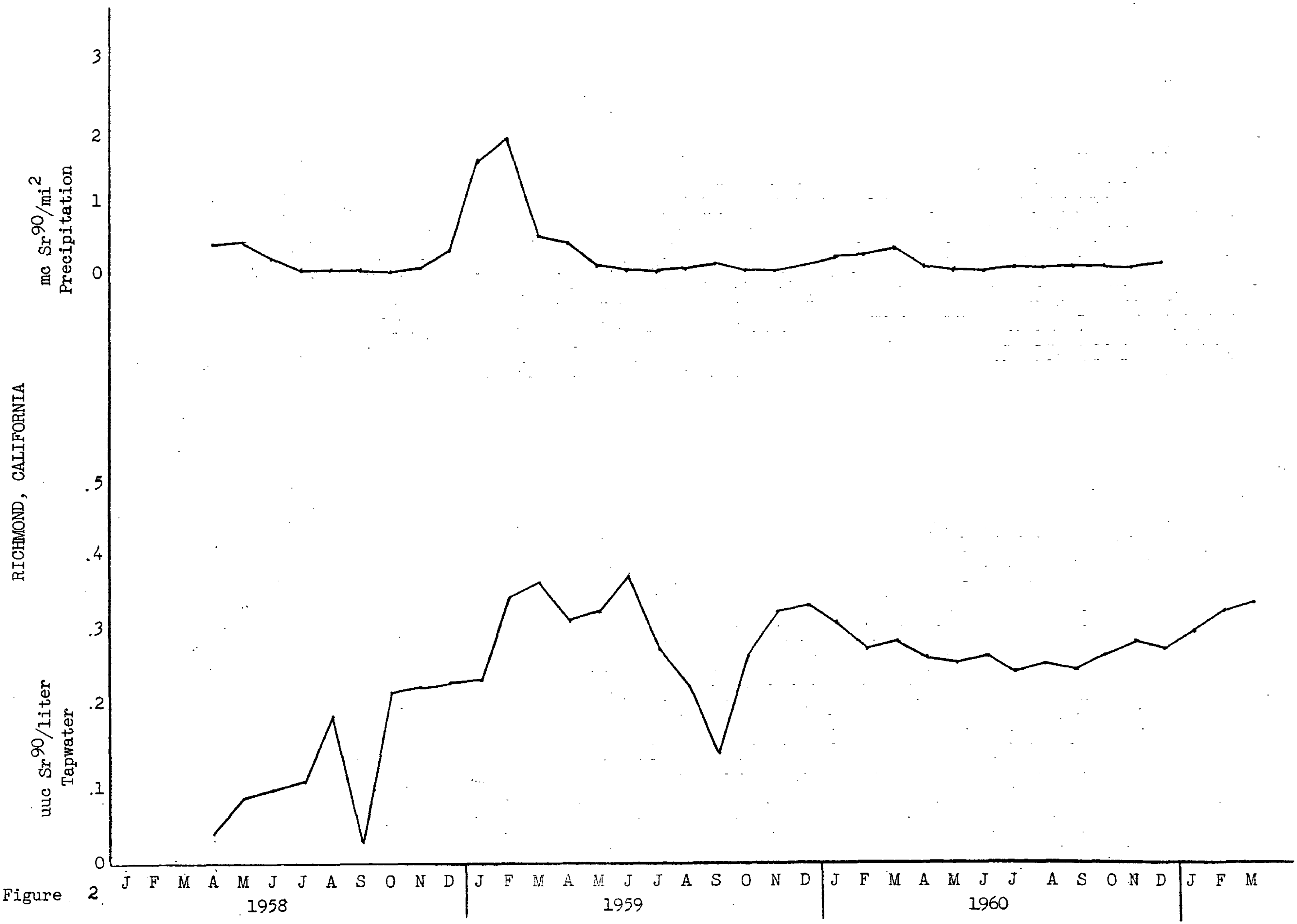


Figure 1



RICHMOND, CALIFORNIA
mc Sr90/mi2
Precipitation
uuc Sr90/liter
Tapwater
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M
1958
1959
1960

Figure 2

Sr^{90} CONCENTRATION IN THE PALO ALTO WATER SUPPLY

Paul Kruger and Gerald Hamada

September, 1961

Hazleton-Nuclear Science Corporation
Palo Alto, California

Sr^{90} CONCENTRATION IN THE PALO ALTO WATER SUPPLY

Paul Kruger and Gerald Hamada
Hazleton-Nuclear Science Corporation
Palo Alto, California

A program has been initiated at Hazleton-Nuclear Science Corporation to determine the concentration of Sr^{90} in the Palo Alto water supply. This water supply is of interest for Sr^{90} fallout measurement since the supply consists of water from two different sources. About 60 per cent of the Palo Alto water supply originates from twelve underground wells.[1] This water has percolated through alluvial deposits comprising the ground water basin and should be relatively cleaned of Sr^{90} by the ion-exchange process. The remaining 40 per cent of the water supply is purchased from the San Francisco network, which contains water primarily of surface runoff origin. Thus, the average Sr^{90} concentration in tap water should be equal to about 40 per cent of the average Sr^{90} concentration in the reservoirs. The concentration values for the Palo Alto water may be compared to those determined for the water supply[2] at Richmond, California, an East Bay community, whose water supply is predominantly of the surface runoff type.[1] The Sr^{90} concentration has been shown to be fairly constant over one year with an average value of about 0.26 $\mu\mu c$/liter.[2]

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(1) Harold L. May, Chief Water Engineer, Palo Alto, private communication.

(2) HASL - 113, Fallout Program, Quarterly Summary Report, HASL, USAEC, July 1, 1961.

If the value 0.26 μμc/liter for the East Bay area water is taken as the surface runoff water concentration for the Peninsula area, and it is assumed that the underground well water of Palo Alto is essentially free of Sr^{90}, then the average monthly value of Sr^{90} concentration should be a measure of the relative amount of surface water in the total Palo Alto water supply during the month. Since the underground water supply in Palo Alto is replenished during the rainy season, November through March, it is expected that the Sr^{90} concentration would be low in the Winter and Spring months and increase in the Summer and Fall months as increased quantities of surface runoff water are added during the hotter periods.

During the months of June through August, 1961, samples of cold water were taken daily from a tap in the H-NSC laboratories and combined on a monthly basis. These monthly samples were then analyzed for Sr^{90} content by radiochemical techniques used for fallout analysis. The percent of surface runoff water in the total water supply was obtained from the Palo Alto Water Department. The expected concentration, based upon the assumption that the surface water Sr^{90} concentration was of the same value as that for Richmond, was computed and compared with the observed values. These data are given in Table I.

It is noted that the Sr^{90} concentration in Palo Alto tap water increased markedly over the three month period, although not in proportion to the percent of surface runoff water in the total supply. Further, the correlation of measured concentration with that computed for the assumed surface water concentration is poor. These data indicate that the surface water concentration may vary from month to month or that because of the incomplete mixing of the two water sources, the transport properties of the Sr^{90} in the water network may be the determining factor for the average concentration of Sr^{90} in tap water at any particular location.

A more comprehensive program is suggested to study the transport of Sr^{90} through the Palo Alto water network. Simultaneous measurements of Sr^{90} concentration in surface runoff water entering the system, in water from several of the wells, and in tap water at several locations throughout Palo Alto would enable several kinds of data to be procured: (1) the current levels of Sr^{90} in the surface runoff water, (2) the distribution of this Sr^{90} in the water supply network, and (3) information on the mixing characteristics of the two sources in the network.

TABLE I

Sr^{90} CONCENTRATION IN PALO ALTO TAP WATER

Month (1961)	Volume Collected (liters)	Surface Water in Total Supply* (Per cent)	Sr^{90} Content (dpm)	Sr^{90} Concentration ($\mu\mu c$/liter)	
				Expected**	Found
June	30	49.06	1.54 ± 0.33	0.128	0.023 ± 0.005
July	30	61.23	6.30 ± 0.54	0.159	0.095 ± 0.008
August	60	56.09	22.6 ± 0.9	0.146	0.169 ± 0.007

*Data supplied by the Palo Alto Water Department.

**Based on assumed concentration of 0.26 $\mu\mu c$/liter determined for Richmond, California.

Tri - City Diet Studies - Fourth Sampling

Joseph Rivera

Estimates of the total Sr^{90} and Ca intake of adults living in New York City, Chicago and San Francisco, computed using the results of analyses of foods purchased in the first quarter of 1961, are presented in table 1. The data indicate that there has been no substantial change in the relative contributions of the various foods to the total intakes, or, in the total intakes of these elements since the last sampling. Contributions to the diet of Sr^{90} and Ca from tapwater were not included in this table; however, measurements recently computed show the contributions to have been 132, 176, and 132 uuc of Sr^{90} per year, and 2.6, 15.2, 7.0 gCa/yr. at New York, Chicago and San Francisco respectively. It is assumed in making these estimates that the average daily intake of tapwater is 1.2 liters. Details of the sampling procedure and method of estimation of the yearly intakes of other foods were reported in HASL- 113.

A summary of the data obtained from the first four samplings at the three cities is presented in table 2. No seasonal effect on the Sr^{90} levels of foods can be seen as yet. Due to the resumption of atmospheric testing of nuclear weapons, it will be difficult to determine how the levels might have varied with season had the testing moratorium been continued. However, an attempt will be made to estimate contributions to the dietary intake of Sr^{90} resulting directly from the recent Soviet test series, by analyzing some of the foods in the next samplings for Sr^{89} as well as Sr^{90}.

Variations with time of the Sr^{90}/Ca ratio in the total diet, and that of the milk, and non-milk fractions of the diet, are presented in table 3. The milk and non-milk fractions of the diet seem to be equally variable and no pattern in their variation can as yet be seen. The Sr^{90}/Ca ratio of milk is about 2/3 that of the total diet, and continues to be a reasonably good indicator of the Sr^{90}/Ca ratio of the total diet.

Table 1

Tri-City Diet Studies

(Fourth Sampling)

Food Category	kg/yr	N. Y. 2/61 μμc/kg	N. Y. 2/61 μμc/yr	Chicago 4/61 μμc/kg	Chicago 4/61 μμc/yr	S. F. 4/61 μμc/kg	S. F. 4/61 μμc/yr
Bakery Products	37	8.7 ± 0.9	322	9.7 ± 1.4	358	6.5 ± 0.0	242
Whole Grain Products	11	6.4 ± 0.1	70	16.6 ± 1.1	183	12.5 ± 1.2	138
Eggs	16	1.3 ± 0.9	21	1.7 ± 0.1	26	2.0 ± 0.1	33
Fresh Vegetables	43	3.5 ± 0.3	151	9.5 ± 0.4	416	2.4 ± 0.3	103
Root Vegetables	17	4.4 ± 0.4	75	9.5 ± 0.6	155	3.6 ± 0.3	61
Milk	221	7.9 ± 0.7	1735	5.3 ± 0.0	1164	2.1 ± 0.4	464
Poultry	17	0.3 ± 0.0	6	0.6 ± 0.1	11	0.6 ± 0.0	11
Fresh Fish	8	0.7 ± 0.2	5	0.4 ± 0.0	28	0.1 ± 0.1	1
Flour	43	5.8 ± 0.3	251	8.2 ± 0.3	351	0.5 ± 0.2	23
Macaroni	3	3.6 ± 0.3	11	4.0 ± 0.4	12	3.5 ± 0.3	10
Rice	3	0.1 ± 0.2	0	1.9 ± 0.2	6	1.7 ± 0.2	5
Meat	73	0.7 ± 0.1	47	0.3 ± 0.1	23	0.3 ± 0.1	21
Shellfish	1	0.9 ± 0.2	1	0.5 ± 0.1	4	3.9 ± 0.1	4
Dried Beans	3	19.4 ± 1.7	58	20.4 ± 1.8	61	1.3 ± 0.2	4
Fresh Fruit	68	6.5 ± 0.3	442	4.1 ± 0.5*	279	2.3 ± 0.4	157
Potatoes	45	4.6 ± 0.5	207	4.2 ± 0.6	189	2.8 ± 0.6	126
Canned Fruit	26	2.2 ± 0.2	58	1.1 ± 0.1	29	9.4 ± 1.4	25
Fruit Juices	19	2.3 ± 0.2	43	3.5 ± 0.3	66	2.0 ± 0.2	38
Canned Vegetables	20	2.5 ± 0.5	50	6.6 ± 1.4	132	0.9 ± 0.1	16
Annual Intake			3553		3493		1482
Strontium-90 to Calcium ratio (383 gms of Ca per yr.)			9.3		9.1		3.9

* Estimated from 11/60 sampling

Table 2a

Estimates of Annual Intake of Sr^{90} and Ca

New York City

Food Category \ Sampling Date	kg/yr	g Ca/yr	3/60 μμc	6/60 μμc	10/60 μμc	2/61 μμc
Bakery Products	37	37.0	352	377	211	322
Whole Grain Products	11	10.0	228	310	187	70
Eggs	16	9.1	170	32	51	21
Fresh Vegetables	43	15.0	237	585	757	151
Root Vegetables	17	6.1	90	88	82	75
Milk	221	234.3	2100	2431	1370	1735
Poultry	17	9.2	27	12	14	6
Fresh Fish	8	10.8	2	2	1	5
Flour	43	8.6	447	397	215	251
Macaroni	3	0.7	22	14	21	11
Rice	3	1.1	7	3	7	0
Meat	73	10.9	73	66	66	47
Shellfish	1	0.8	2	1	1	1
Dried Beans	3	2.9	6	7	25	58
Fresh Fruit	68	13.6	20	129	537	442
Potatoes	45	5.8	441	144	248	207
Canned Fruit	26	1.3	39	47	34	58
Fruit Juices	19	1.7	29	57	61	43
Canned Vegetables	20	4.2	84	58	106	50
Total Annual Intake	674	383	4376	4760	3992	3553

Table 2b

Estimates of Annual Intake of Sr^{90} and Ca

Chicago

Food Category \ Sampling date	kg/yr	g Ca/yr	5/60 μμc	9/60 μμc	11/60 μμc	4/61 μμc
Bakery Products	37	37.0	485	337	185	358
Whole Grain Products	11	10.0	219	180	168	183
Eggs	16	9.1	51	30	22	26
Fresh Vegetables	43	15.0	474	237	271	416
Root Vegetables	17	6.1	116	58	51	155
Milk	221	234.3	1348	1238	1392	1164
Poultry	17	9.2	22	43	15	11
Fresh Fish	8	10.8	8	1	21	28
Flour	43	8.6	486	340	237	351
Macaroni	3	0.7	29	23	15	12
Rice	3	1.1	5	4	3	6
Meat	73	10.9	73	73	44	23
Shellfish	1	0.8	1	1	1	4
Dried Beans	3	2.9	5	22	48	61
Fresh Fruit	68	13.6	408	109	279	279*
Potatoes	45	5.8	131	126	58	189
Canned Fruit	26	1.3	49	23	29	29
Fruit Juices	19	1.7	67	38	57	66
Canned Vegetables	20	4.2	94	108	116	132
Total Annual Intake	674	383	4074	2991	3012	3493

*Estimated from November 1960 sampling.

Table 2c

Estimates of Annual Intake of Sr^{90} and Ca

San Francisco

Food Category \ Sampling date	kg/yr	g Ca/yr	3/60 μμc	8/60 μμc	1/61 μμc	3/61 μμc
Bakery Products	37	37.0	95	167	144	242
Whole Grain Products	11	10.0	32	121	16	138
Eggs	16	9.1	47	37	37	33
Fresh Vegetables	43	15.0	98	129	86	103
Root Vegetables	17	6.1	98	12	48	61
Milk	221	234.3	928	420	398	464
Poultry	17	9.2	13	24	36	11
Fresh Fish	8	10.8	2	2	2	2
Flour	43	8.6	156	172	86	23
Macaroni	3	0.7	11	12	9	10
Rice	3	1.1	5	6	5	5
Meat	73	10.9	139	37	44	21
Shellfish	1	0.8	1	1	1	4
Dried Beans	3	2.9	19	11	13	4
Fresh Fruit	68	13.6	46	68	122	157
Potatoes	45	5.8	198	27	166	126
Canned Fruit	26	1.3	37	49	91	25
Fruit Juices	19	1.7	45	38	49	38
Canned Vegetables	20	4.2	37	16	24	16
Total Annual Intake	474	383	2007	1349	1378	1482

Table 3

Sr^{90} to Ca Ratios in Tri - City Diet Components

	Time of Sampling															
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A
					1960									1961		
San Francisco																
Milk			4					2					2	2		
Non-Milk			7					6					7	7		
Total Diet			5					4					4	4		
Chicago																
Milk					6				5		6					6
Non-Milk					18				12		11					16
Total Diet					11				8		8					9
New York City																
Milk			9			10				6				7		
Non-Milk			15			16				18				12		
Total Diet			11			12				10				9		

Sr^{90} in Various types of Grains

(HASL)

Samples of wheat, barley, oats and rye were collected at one site and all but rye at another during two harvest periods, and analyzed for strontium-90 to ascertain whether correlations exist among grain types and between sites.

From the data in table 1 there appears to be no correlation between the strontium-90 level in a particular type of grain grown in Warsaw, Virginia and the same type grown in Lafayette, Indiana. Furthermore there is considerable variability among grain types at a site with regard to strontium-90 activity per unit weight of grain as well as the strontium-90 activity per gram of calcium. Finally, no trend can be observed in the data between the two harvest periods.

It would be extremely difficult to isolate one factor as the predominant contributor to the variability among grain types, between sites, and between harvest periods.

Table 1

Comparison of Sr^{90} and Ca Levels in Different Grains at Two Sites for Two Harvest Periods

$\mu\mu c\ Sr^{90}/g\ Ca$

Site	Year	Wheat	Barley	Oats	Rye
Warsaw, Va.	1959	92	156	103	232
" "	1959-60	104	151	97	158
Lafayette, Ind.	1959	130	46	23	
" "	1960	155	129	29	

$\mu\mu c\ Sr^{90}/kg$ orig. mat.

Site	Year	Wheat	Barley	Oats	Rye
Warsaw, Va.	1959	28	53	86	80
" "	1959-60	35	54	81	58
Lafayette, Ind.	1959	45	25	17	
" "	1960	53	59	24	

g Ca/kg orig. mat.

Site	Year	Wheat	Barley	Oats	Rye
Warsaw, Va.	1959	0.31	0.34	0.83	0.35
" "	1959-60	0.34	0.36	0.84	0.36
Lafayette, Ind.	1959	0.35	0.54	0.74	
" "	1959-60	0.34	0.46	0.83	

SURVEY OF FALLOUT STRONTIUM-90 AT SELECTED PASTURE SITES - 1953-1960

USAEC, Health and Safety Laboratory, New York City

USDA, Soil Survey Laboratory, Beltsville, Maryland

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SURVEY OF FALLOUT STRONTIUM-90 AT SELECTED PASTURE SITES - 1953-1960

1. Introduction

In 1953 the Health and Safety Laboratory first became involved in the measurement of fission product radionuclides resulting from weapons testing. In collaboration with the U. S. Department of Agriculture Soil Survey Laboratory in Beltsville, Maryland, a long term sampling program was outlined which involved the collection of soil, herbage and bones of grazing animals from selected experimental pasture areas. These samples were to be analyzed for strontium-90 and calcium because of the biological significance of these two elements. It was hoped that definitive relationships could be established with regard to strontium-90 and calcium levels in the three sample types, which would elucidate the behavious of strontium-90 in the biosphere.

Originally, five experimental pasture areas were selected where the soil types and exchangeable calcium levels represented the gamut of conditions that would be encountered in most forms of agricultural production. Later on it became advisable to add two additional sites for reasons which will be subsequently discussed. A map showing the location of all the sites is presented in Figure 1 and identification of the experimental areas is given in Table 1.

The original sites first sampled in 1953 were located at Alapaha, Georgia, Raleigh, North Carolina, New Brunswick, New Jersey, Ithaca, New York and Logan, Utah. Since routine monitoring of powdered buttermilk from Mandan, North Dakota had shown higher levels of strontium-90 than milk from other areas, a pasture site was selected in this region and sampled first in 1956. When it became obvious through other studies that precipitation played an important role in the scavenging of atmospheric nuclear debris to the earth's surface, it was decided to sample in an area where rainfall was not principally depended upon for growing crops. The Imperial Valley region of California was selected since rainfall is very slight in this area and irrigation is the primary means of watering the land. Sampling was started here in 1956 also, and continued on a yearly basis as was done for the other sites. The selection of the original five sites was based mainly on the productivity of the area, the soil type and the level of exchangeable calcium in the soil. The mean annual rainfall eventually became an important consideration, also. Table 2 presents information and data pertinent to these area characteristics. Alapaha, for example, is a sandy loam soil area of low cation exchange capacity and exchangeable calcium, whereas Logan has very calcareous soil. The remaining sites fall between these two extremes.

2. Methods of Sample Collection

The soil cores were taken from undisturbed pasture or meadow areas which fulfilled the conditions for measuring the cumulative deposition of strontium-90.[1] The area was flat, uncultivated and not subject to run-off. Unlike studies which have been carried out in the United Kingdom,[2] no attempt was made to investigate sloping terrains or anomalous grazing conditions. The soil was sampled to a depth which was sufficient to include the total amount of strontium-90 that had fallen out and leached into the ground.

The herbage samples consisted of both legumes and grasses.

Shank or leg bone specimens were taken from slaughtered lambs or calves that had been born during the sampling year and had grazed the pasture from which soil and herbage samples had been collected.

3. Limitations of the Pasture Survey

The pasture survey was never intended to be a controlled scientific experiment although it was hoped that relationships could be demonstrated for the strontium-90 levels found in herbage, soil and animal bone. Calcium measurements were made as well for the three sample types since the chemical and metabolic similarity of strontium and calcium were well known. Initially, it was impossible to determine the degree of refinement in sampling that would be necessary to obtain certain kinds of information, and as time went on it became increasingly apparent that the study had very definite limitations.

Each sampling took place during a single day a year at each site and consequently it was impossible to obtain samples of herbage representing each cutting during the growing season. Thus, it was not possible to relate herbage contamination in any direct way to cumulative soil measurements. Furthermore, the herbage samples did not represent the diet of the grazing animals and could only be used to approximate how much strontium-90 and calcium the animals ingested over a relatively small part of the year. At some sites, herbage samples were not available from the grazing pastures under study and in addition, samples of the same kind of herbage from the same site from one year to the next could not always be obtained. The main reason for continuing the herbage collection was to see how much variability could be expected under these conditions and whether there was any discernible time effect or difference among the sites.

Samples of soil were taken only from undisturbed pasture or meadow areas and the effect of plowing and cultivation was not studied. The vertical penetration of strontium-90 was studied to some extent but detailed information was only obtained at Alapaha where the sandy type soil would be expected to facilitate the downward movement of this isotope. In this soil it was found that 94% of the strontium-90 was retained in the upper six inches.[3]

The bone samples were available from lambs or calves that ranged from 200 days to a year old at the time of slaughter, but had grazed on the pasture areas of interest. Information as to the grazing period was not available nor was it possible to determine how much and what kinds of herbage the animal had eaten while on pasture.

4. Analytical Reproducibility

The quality control program at HASL includes the submission of blind duplicates to the analytical laboratory. Table 3 presents the results of these duplicate analyses on samples related to the pasture study. The percent difference between duplicates is less than 10 for the three kinds of materials which is in accord with replicate data obtained on many other samples.

5. Strontium-90 Deposition as Determined by Soil Analyses

Results of consecutive yearly cumulative strontium-90 in soil measurements are available at the original five sites since 1953 and at the two remaining sites, Mandan and the Imperial Valley (Brawley and El Centro) since 1956. From precipitation and soil data presented in Tables A, B, and C, located in the Appendix, the summary data in Table 4 were derived. The cumulative and yearly strontium-90 deposition values from Table 4 for all sites,except the Imperial Valley, are plotted as a function of time in Figures 2a and 2b, respectively (the solid lines). The strontium-90 deposition values per inch of cumulative and yearly precipitation are also plotted as a function of time in Figures 2a and 2b, respectively (the broken lines). These latter curves actually represent the variation in concentration of strontium-90 in precipitation with time, assuming that the strontium-90 measured in soil was brought down entirely by rain. Data from the Imperial Valley were excluded from these tabulations and plots, since this area received so little rainfall and most of the strontium-90 found here is believed to have deposited in the dry state. From Figure 2 it can be seen that the peak deposition occurred between 1957 and 1958 and that the general pattern of deposition with time is the same as that of the concentration in rain. This indicates that rain is a primary process by which strontium-90 falls out.

When the cumulative strontium-90 deposition values for 1960 are plotted against the mean annual rainfall, a reasonably good straight line relation can be drawn through all points except that representing Mandan, North Dakota (Figure 3). The position of this point indicates that an unusually high rate of fallout at this site, occurred at some time in the past. It is possible that this resulted from an exaggerated deposition of tropospheric debris from one of the Nevada tests and that the other sites were not affected in this way. One of the most interesting things about Figure 3 is that at zero rainfall, about 18 millicuries of strontium-90 per square mile was on the ground at the end of 1960. Percentage-wise, the contribution from dry deposition must be very high in an area such as the Imperial Valley and cannot be considered negligible at any site in the continental United States.

6. Strontium-90 in Herbage, Bone and Soil as a Function of Time

Figures 4a through 4g show the strontium-90 levels in herbage, animal bone and soil plotted as functions of the sampling time, for each site. The herbage and bone values are expressed in micro micro curies of strontium-90 per gram of calcium, while the soil values are in millicuries of strontium-90 per square mile.

The cumulative soil levels follow essentially the same trend with time for all sites. Furthermore, the cumulative levels are about the same for those sites with approximately the same rainfall (Alapaha, Raleigh, New Brunswick and Ithaca), while they are somewhat less for Mandan and Logan where rainfall is not as abundant. Although the amount of strontium-90 in soil is considerably less in the Imperial Valley area due to the very small amount of rainfall, the same trend in time is observed. It would appear as though the cumulative strontium-90 reached a peak in 1959 and in the absence of atmospheric testing would level off and begin to decrease presumably with the half-life of strontium-90.

A more striking observation is the fact that the strontium-90 levels in animal bone follow the same trend with time as the soil strontium-90. This would indicate that bones of young grazing animals reflect the amount of directly deposited strontium-90 during any one year as well as the cumulative total in the soil. The bone levels reached a peak in 1959 and appear to have fallen off in 1960 since the fallout deposition between 1959 and 1960 was relatively small. If the moratorium on atmospheric testing had continued, the bone levels would have been expected to decrease until the measured strontium-90 in bone was due only to that which entered the herbage by way of the soil alone.

The herbage data (expressed as the ratio of strontium-90 to calcium) show considerably more variability with time than either bone or soil data. This is probably due to the effect of direct foliar and floral deposition which is influenced by the fallout rate. Nevertheless, higher values occurred more frequently during 1958 and 1959 and there is strong indication of a decrease in 1960 as might be expected in view of the decreased fallout rate. In Figure 5 the herbage values have been expressed as micro micro curies of strontium-90 per kilogram of dry material and the same general trend with time can be observed.

7. Calcium in Herbage as a Function of Cutting Period

Occasionally, it was possible to collect samples of two different cuttings during a single growing season. The early cutting results are shown in Figures 4 and 5 as black dots and the late cutting results as circles.

In Figure 4, where the strontium-90 to calcium ratio is used, it would appear that the early cutting values were higher than those for late cuttings, especially in the area of New Brunswick and Ithaca. When the data are expressed as activity per kilogram of dry herbage, this distinction is not evident at any site. Upon closer examination of the data found in Tables E 1 to 7 in the Appendix, the calcium levels in the late cutting are found to be higher than those in the early cutting by about a factor of 2. This difference is most evident at New Brunswick and Ithaca. Since calcium is not added at any time at any location during the growing season, this condition probably reflects a lush but low mineral content growth during the spring season.

8. <u>Strontium-90 in Different Bones of a Single Animal</u>

At the New Brunswick site, the entire carcass of an animal was obtained each year and different bones were analyzed to determine the strontium-90 variability. The data in Table D-3 are indicative of the expected uniform distribution of strontium-90 in the skeleton of young animals. The variability is not greater than 10%, on the average, and hence the mean is taken to be representative of the entire bone structure of the animal.

9. <u>Strontium-90 in the Same Bone Type of Animals from the Same Breed</u>

Three lambs from the same breed were slaughtered each year at Ithaca and leg bones made available for analysis. These data are presented in Table D-4. The variability here is small enough to warrant the use of the average as a suitable value for representing the strontium-90 level in the bones of animals from the same breed at the same site.

10. <u>Strontium-90 in the Same Bone Type of Animals from Different Breeds</u>

It was possible to obtain leg bone specimens from two breeds of lambs at Logan during 1959 and 1960. There is a significant difference between the average strontium-90 level for the Rambouillets and the Southdowns grazed in 1959, as can be seen from the data in Table D-6. According to information obtained from the experimental station,[4] both breeds were raised under the same conditions and, in fact, were separated only during the breeding period. Furthermore, there is little difference between the amount and kinds of forage eaten from the pasture by these two breeds. There is a difference in the grazing habits however; the Rambouillets are quite gregarious as a group, while the Southdowns are more or less independent of one another. Nevertheless, differences like this would hardly be expected to account for differences in accumulation of strontium-90. At the moment, it would appear that the possibility of there being differences in bone strontium-90 levels associated with differences of breed, cannot be neglected.

11. Strontium-90 in the Same Bone Type of Different Animal Species

A marked difference in the strontium-90 level in bones from two species of animals was first noticed in leg bone samples from lambs and pigs collected at Ithaca in 1956 (see Table D-4). Subsequently, a controlled experiment was devised to study the comparative utilization of dietary strontium-90 and calcium in these two animals.(5) Here the composition of the diet and the amount consumed were well known. It was concluded from this work that the higher values found for sheep were due to the fact that most of their bones had been formed on pasture which must have had a strontium-90 to calcium ratio about the same as the experimental ratios, whereas the pig bone had been formed mainly from supplements having a lower strontium-90 to calcium ratio than the current pastureage.

12. Strontium-90 in Bones of Animals Grazed on Native and Improved Pastures

Calves were grazed separately on native and improved pasture areas at Alapaha, Georgia. In neither area was the soil disturbed by plowing or cultivation during the experiments, but calcium amendments had been added to the soil in the pasture which is called the improved area. A plot of the strontium-90 levels in bone as a function of time is shown in Figure 4a. The fact that the strontium-90 to calcium ratios are always higher in bones of animals grazed on the native area indicates a relationship between exchangeable calcium in soil and strontium-90 concentration in bones. From Table F-1, it can be seen that calcium amendments substantially increase the exchangeable calcium level in the improved pasture area soil. An inverse relationship between the concentration of strontium in bone and the exchangeable calcium in soil is certainly indicated. If the diet of the animals grazing on both pastures were known, more information could be gleaned from this study.

13. Bone to Soil Observed Ratios: Effect of Exchangeable Calcium in Soil on the O.R.

As previously pointed out, the herbage sampled is not necessarily representative of the diet of the grazing animals. Furthermore, at low soil calcium sites such as Alapaha, unknown amounts of calcium are taken by the animal as a mineral supplement making it impossible to determine with certainty the strontium-90 to calcium ratio of the dietary intake from the herbage level alone. Since the bone and soil strontium-90 values seem to follow about the same trend with time, the strontium-90 to calcium ratios in the soil were compared to the strontium-90 to calcium ratios in the bone for each site. Alapaha was included despite the fact that animals at this site receive much supplementary calcium in their diets. It can be seen from Table 5 that the bone to soil observed ratios are distinctly different for each site and do in fact bear some relationship to the exchangeable calcium in the soil. This becomes clearer when the two parameters are graphically presented as in Figure 6. It is expected that this relationship becomes more significant when the herbage and feed contamination by strontium-90 occurs via uptake from the soil alone.

14. Strontium-90 in Herbage vs. Exchangeable Calcium in Soil

During periods of relatively high fallout rate, the contamination of herbage results to a considerable extent from direct deposition. Nevertheless, on the average, the exchangeable calcium in soil does exert an influence on the strontium-90 to calcium ratio in the herbage, particularly when the soil calcium content is low. This can be seen in Figure 7. The strontium-90 content per unit weight of herbage does not show any relationship to the exchangeable calcium in the soil, however. In the United Kingdom,[2] it was concluded that the direct contamination period and weight of herbage were both associated with slower growth in low exchangeable soil calcium areas.

15. Special Areas: Mandan, North Dakota and the Imperial Valley, California

Milk strontium-90 to calcium ratios have been observed at Mandan, North Dakota since 1955. The ratios have generally been found to be higher than other areas by about a factor of two.[6] The strontium-90 levels in animal bones from Mandan were higher in 1958 and 1959 than those at other sites even though the cumulative soil values were not markedly different from other areas. (See Figure 4e and Table D-5) It is possible that sometime during the latter part of 1957 and the beginning of 1958, the herbage and/or feed were exposed to a relatively heavy fallout of tropospheric debris, and that this material was placed in storage and used throughout 1959. This would explain in part the higher strontium-90 to calcium ratios found in bone. Less rainfall occurred at Mandan than in the other pasture areas in the eastern part of the United States despite the quantitative similarity in cumulative soil levels. As a result, the concentration of strontium-90 in rain, assuming all of the radioactive material came down with rain, is higher here than it is at the other sites. This may add weight to the speculation that more fallout, in proportion to rainfall, did in fact occur at Mandan.

The situation in the Imperial Valley of California where there is very little rainfall is quite interesting. From soil measurements, it is ascertained that about 16 to 19 millicuries of strontium-90 per square mile fell out on this area by the end of 1960 (Figure 4g). Since the mean annual rainfall is between one and two inches, it is certain that the majority of the strontium-90 came down as dry deposition. The bone strontium-90 to calcium ratios, although much lower than at the other sites, show a similar trend with time i.e., a steady increase from 1956 to 1959 followed by a decrease between 1959 and 1960.

16. Pasture Surveys in a Limited Geographical Area: The Chicago Milkshed

In 1953, the University of Chicago arranged through the U. S. Department of Agriculture at Beltsville, Maryland for the collection of samples of milk and other biological materials from farms in the Chicago milkshed area. In an attempt to study the mechanism by which milk becomes contaminated with strontium-90, samples of herbage, soil and animal bone from these same farms were also collected. A map showing the counties where the farms are located is presented in Figure 8 and a listing which includes the exchangeable calcium levels in the soil is given in Table 6.

The University of Chicago reported the analytical data for samplings carried out in 1953, 1954 and 1955(7) after which time the project became the responsibility of HASL and the USDA. Samples collected in 1956 were analyzed by newly formed contractor laboratories and the data are not considered reliable due to the fact that these laboratories were beset with analytical and calibration difficulties. Samples collected in 1957 and 1958 were analyzed at HASL by reliable methods and are reported here mainly for documentation purposes. Soils were collected at each of the original twelve sites but herbage sampling was sparse due to the unavailability of suitable samples at collection time. The soil and herbage data are presented in Tables G and H in the Appendix.

These sites were deliberately selected to cover the widest possible range in soil exchangeable calcium (2.3 to 22 meq Ca per 100 g soil) within this limited geographical area, as can be seen from Table 6. The five original pasture sites for the HASL study were also purposely selected to cover the range of soil exchangeable calcium levels that one would expect to encounter in agricultural production. For comparison, the range for these sites was 0.2 to 28 meq Ca/100 g soil.

The 1957 and 1958 soils were sampled during the month of October and a summary of the strontium-90 data is presented in Table 7. The average cumulative deposition was 31 mc Sr^{90}/mi^2 in 1957 and 44 mc Sr^{90}/mi^2 in 1958 compared with values of 28 and 40, respectively, for the HASL pasture sites during the same years. The average increment between 1957 and 1958 was 12 mc Sr^{90}/mi^2 compared with the same value determined for the HASL pasture sites. The error terms associated with the averages are standard deviations and one can see that even in a relatively small area, a yearly increment as measured can be in error by as much as 42 percent. The errors associated with average cumulative values are, of course, much less, but still variable.

Since very few herbage samples were collected in 1957 and only one in 1958, the data have little value. It is interesting, however, that the Sr^{90}/Ca ratios for the first, second, and third alfalfa cuttings at the Blomberg farm in 1957 are about the same while the Sr^{90}/kg dry herbage is quite variable. These herbage values and the ones for the Austin and Lewke farms are similar to Sr^{90}/Ca ratios found in herbage sampled at high exchangeable soil calcium areas in connection with the HASL pasture study.

17. Conclusions

Yearly strontium-90 measurements of soil, herbage and animal bone collected at undisturbed pasture sites have shown noticeable trends with time. The bone and soil results, in particular, indicate that there has been a steady increase in strontium-90 concentration since 1953 which continues through 1959. Between 1959 and 1960 a decrease in bone strontium-90 is evident while the cumulative soil vaues level off as one would expect. The herbage data, although showing considerable variability, indicate that strontium-90 concentrations were highest in 1957, 1958 and 1959.

Rainfall scavenging is the predominant mechanism by which atmospheric debris containing strontium-90 is deposited at these sites, except in a dry area such as Imperial Valley, California. A large fraction of the strontium-90 measured on the ground at this site must have fallen out in the dry state. A higher strontium-90 activity in soil per inch of rainfall was observed at Mandan. Furthermore, strontium-90 concentrations in animal bone were higher at Mandan than at the other sites under investigation. It is thought possible that sometime during the latter part of 1957 and the beginning of 1958, the herbage and feed were exposed to a relatively heavy fallout of tropospheric debris and that this material was placed in storage and used throughout 1959.

There is a relationship between the strontium-90 concentration in bone of yearling grazing animals and the total amount deposited on the ground as well as the increment deposited during any one year. When the Sr^{90}/Ca ratio found in bone is compared to the Sr^{90}/Ca ratio in soil, significantly different values for the bone to soil observed ratio are found among sites. These differences are inversely related to the amount of exchangeable calcium in the soil.

The concentration of strontium-90 is the same throughout the skeleton of a yearling grazing animal and does not vary significantly for different animals of the same breed during any one sampling period. Possible breed differences in bone strontium-90 concentration have been noted for the same animal type but no explanation is offered. Strontium-90 bone levels at a given location are markedly different between some animal species, such as lambs and pigs, but these differences are due to the source and kind of feed. Higher strontium-90 concentrations have been found in the bones of animals grazed on unlimed native pastures than on improved pastures within the same general area where calcium has been added. This points out the influence of soil calcium on the uptake of strontium-90 by herbage and the eventual deposition in bone through the food chain.

The calcium levels in herbage at any one site vary by as much as a factor of two from one cutting to the next during a single growing season. A similar variation is observed in the Sr^{90}/Ca ratio although the strontium-90 concentration in herbage per unit weight of original material does not show this variability. When the exchangeable calcium in soil is low, the Sr^{90}/Ca ratio in herbage, on the average, is higher than in other areas and varies inversely with the soil calcium level.

Pasture surveys conducted in the Chicago milkshed area have shown that strontium-90 measurements in soil and herbage are subject to errors of the same magnitude as those observed for strontium-90 measurements at more widely scattered sites. The average cumulative strontium-90 in soil values for the limited area sites were in agreement with those average values obtained for sites located at much larger distances from one another.

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(1) Hamada, G. H., Hardy, E. P., and Alexander, L. T., A Procedure for the Acid Extraction and Analysis of Strontium-90 in Soil. USAEC Report HASL-33 (Rev.) 1960.

(2) United Kingdom Agricultural Research Council Radiobiological Laboratory Reports, Nos. ARCRL 1, 2, and 4.

(3) Fallout Program Quarterly Summary Report, USAEC, HASL-113, July 1, 1961, pp. 101-105.

(4) Communication from Dr. James P. Thorne, Soil Scientist, U.S. Department of Agriculture Soils Laboratory, Logan, Utah.

(5) Hogue, D. E., Pond, W. G., Comar, C. L., Alexander, L. T., and Hardy, E. P., "Comparative Utilization of Dietary Calcium and Strontium-90 by Pigs and Sheep", J. Anim. Sci. 20, #3 (August 1961).

(6) HASL Fallout Program Quarterly Summary Reports, HASL-42, -51, -65, -69, -77, -84, -88, -95, -105, -111, and -113.

(7) Martell, E. A., Project Sunshine Bulletin No. 12, August 1, 1956, The Enrico Fermi Institute for Nuclear Studies, University of Chicago.

HASL PASTURE SITES

Figure 1

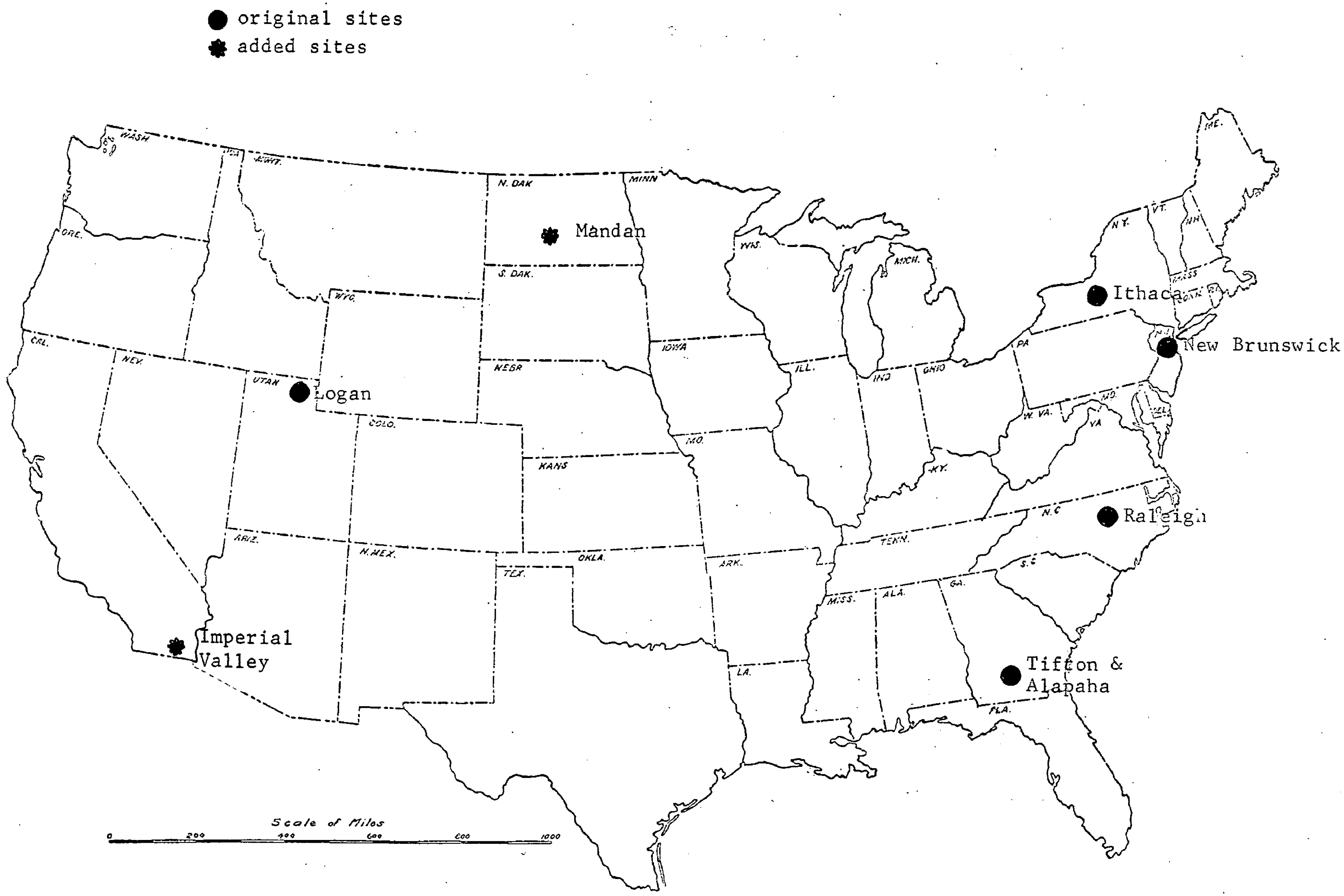


Table 1

HASL PASTURE PROGRAM

SAMPLING LOCATIONS

Site	Location
Alapaha, Georgia	Coastal Plains Experiment Station (a) improved pasture area (b) native pasture area
Raleigh, North Carolina	North Carolina State College Animal Husbandry Farm
New Brunswick, New Jersey	Rutgers University Animal Husbandry Farm
Ithaca, New York	Cornell University Animal Husbandry Farm
Mandan, North Dakota	(a) Northern Great Plains Field Station (b) Willard Griffin Farm
Logan, Utah	Utah State University Animal Husbandry Farm
Imperial Valley, California	(a) Irrigation Field Station at Brawley (b) Meloland Experiment Station at El Centro

Table 2

HASL PASTURE PROGRAM

SAMPLING SITES

Mean Annual Rainfall and Soil Characteristics

Site	Field Texture	Depth in inches	CEC(1) meq/100g	Exchangeable Ca meq/100g	Exchangeable Ca g/kg	Mean Annual Rainfall in inches(2)	pH
Alapaha							
unimproved	loamy sand	0-6	3.5	0.20	0.04	45	5.0
improved		0-10	3.3	1.2	0.25		5.3
Raleigh	sandy clay loam	0-8	8.3	3.0	0.58	49	5.6
New Brunswick	loam	0-8	12	6.3	1.3	43	5.8
Ithaca	silty clay	0-8	14	13	2.5	35	6.6
Mandan	loam	0-8	20	14	2.8	16½	7.5
Logan	clay loam	0-8	20	28	5.6	14½	7.6
Imperial Valley	silty clay loam	0-8	24	28	5.8	1½	7.8

(1) Cation exchange capacity determined by NH_4Ac leach.

(2) 8 year period --- 1953 through 1960.

Table 3

HASL PASTURE PROGRAM

Analytical Reproducibility

BONE

Site	Year	Animal	HASL#	d/m Sr^{90} / g ash	% Ca in ash
New Brunswick, N. J.	1957	lamb	8264	12.9	37.8
			8915	11.9	37.6
Mandan, N. D.	1957	lamb	8382	56.0	38.9
			8916	58.8	37.4
Mandan, N. D.	1957	steer	8917	25.0	37.6
			8918	25.2	38.0
Alapaha, Ga.	1958	calf	9505	41.8	37.2
			9513	43.8	36.2
Brawley, Calif.	1959	lamb	13141	2.28	37.6
			13604	2.46	37.7
			13605	2.43	37.5
Alapaha, Ga.	1960	calf	B0132	31.2	36.4
			B0151	29.5	36.8

HERBAGE

Site	Year	HASL#	d/m Sr^{90} / g ash	% Ca in ash
Raleigh, N. C.	1958	9504	24.7	5.20
		9629	25.1	4.98
Alapaha, Ga.	1958	9501	42.1	5.39
		9630	40.2	5.62

Table 3 cont'd.

HASL PASTURE PROGRAM

Analytical Reproducibility

SOIL

Site	Year	HASL#	d/m Sr^{90}/kg
Ithaca, N. Y.	1960	13314	152
		S0112	138
Alapaha, Ga.	1960	S0048	618
		S0131	567
Logan, Utah	1960	S0057	105
		S0150	115
New Brunswick, N. J.	1960	S0014	185
		S0146	188

Table 4

HASL PASTURE SITES

Summary of Sr^{90} in Soil

	1953	1954	1955	1956	1957	1958	1959	1960
mc Sr^{90}/mi^2/inch ppt'n. determined as a summation of the yearly values for all sites, excl. Imp. Val.	0.06	0.09	0.12	0.13	0.17	0.20	0.21	0.20
mc Sr^{90}/mi^2 determined as an average of the yearly values for all sites, excl. Imp. Val.	2	7	13	18	28	40	50	54
mc Sr^{90}/mi^2/inch ppt'n. yearly increment determined as a summation of all sites, excl. Imp. Val.		0.13	0.19	0.13	0.29	0.34	0.27	0.12
mc Sr^{90}/mi^2 yearly increment determined as an average of all sites, excl. Imp. Val.		4	6	5	10	12	10	4

Figure 2

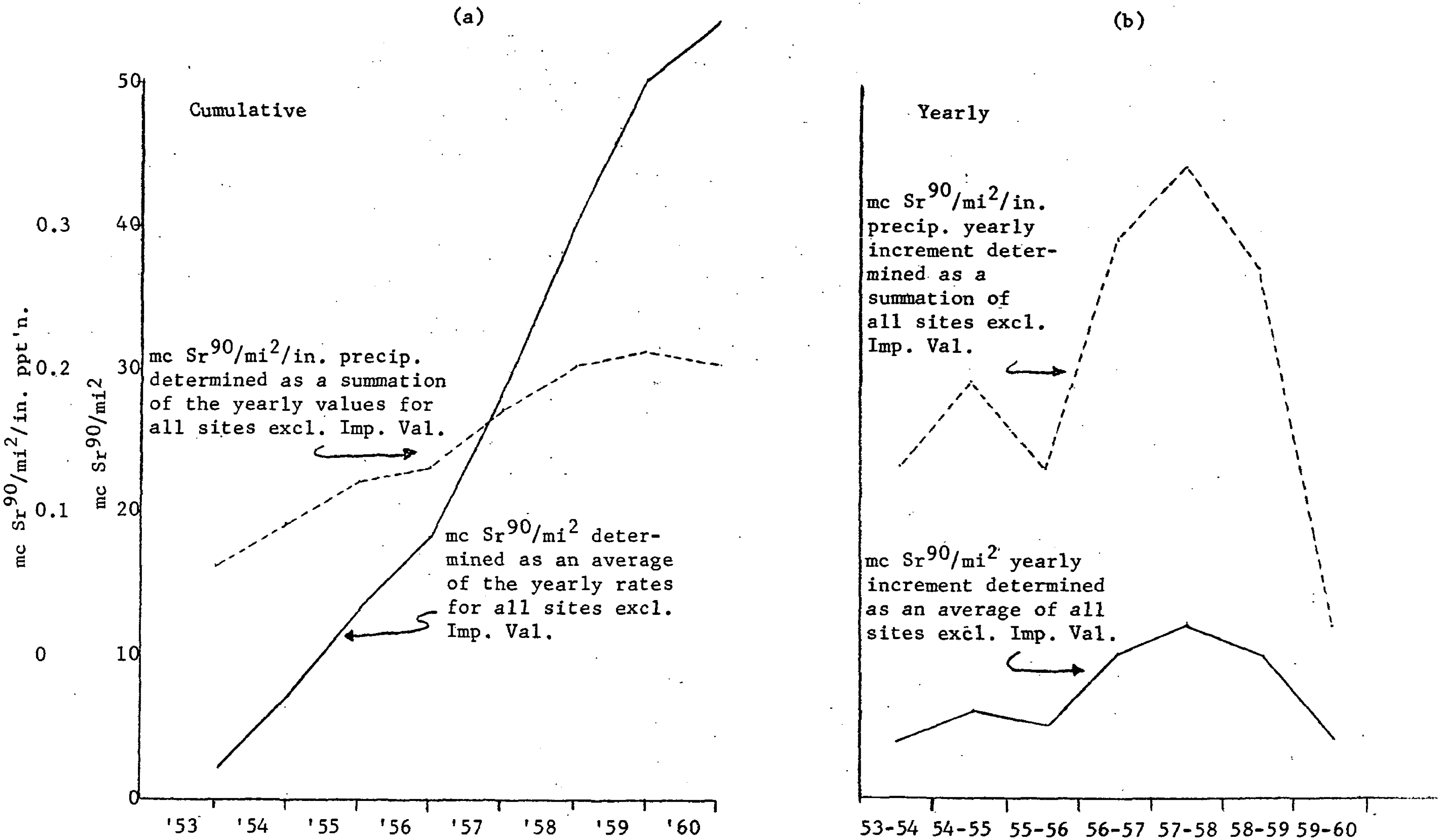
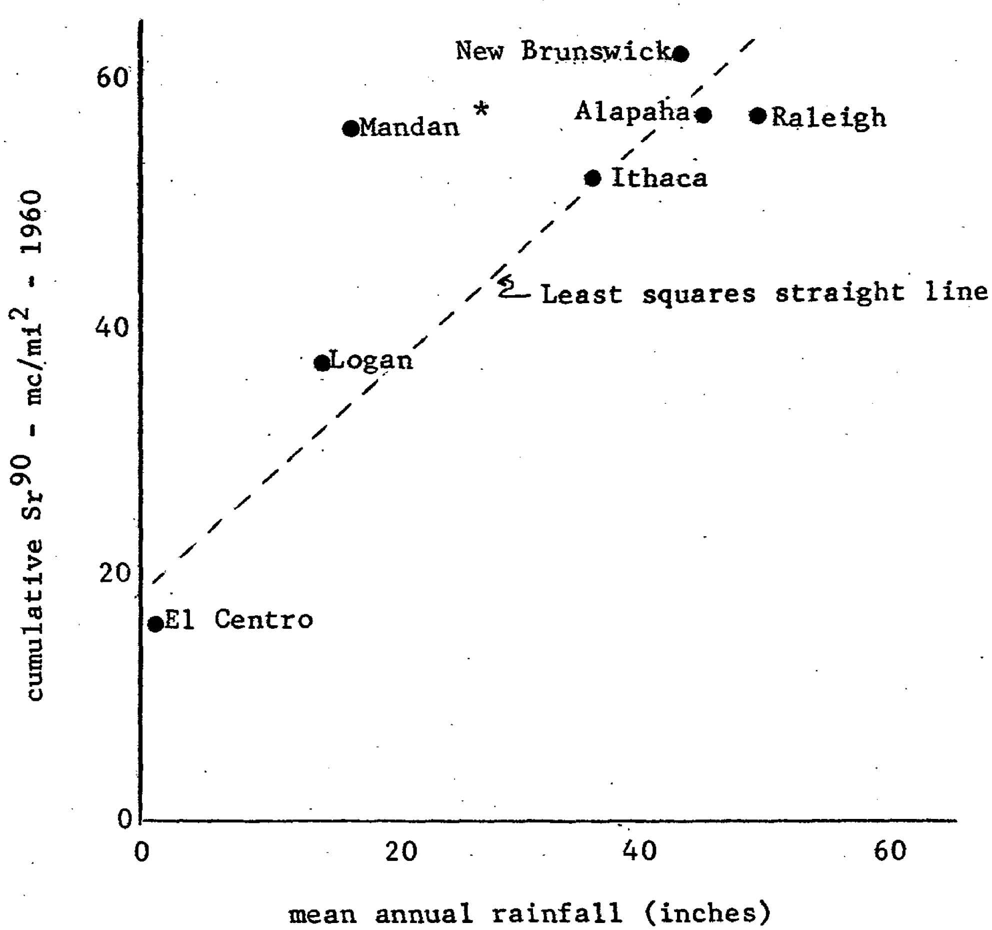

(a)
(b)
Cumulative
Yearly
mc Sr90/mi2/in. ppt'n.
mc Sr90/mi2
0.3
0.2
0.1
0
50
40
30
20
10
0
mc Sr90/mi2/in. precip. determined as a summation of the yearly values for all sites excl. Imp. Val.
mc Sr90/mi2 determined as an average of the yearly rates for all sites excl. Imp. Val.
'53 '54 '55 '56 '57 '58 '59 '60
mc Sr90/mi2/in. precip. yearly increment determined as a summation of all sites excl. Imp. Val.
mc Sr90/mi2 yearly increment determined as an average of all sites excl. Imp. Val.
53-54 54-55 55-56 56-57 57-58 58-59 59-60

Figure 3

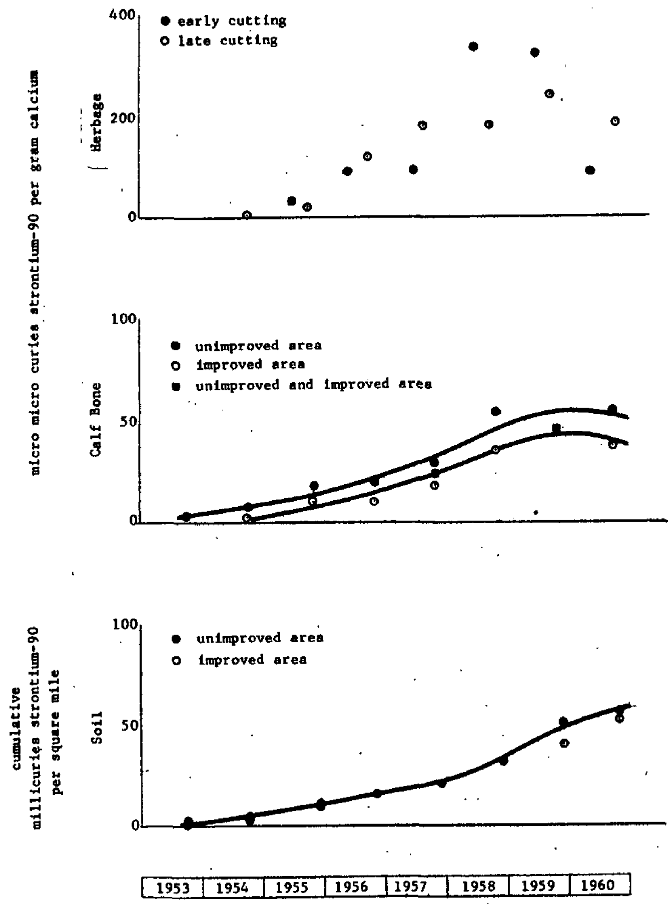
HASL PASTURE SITES

Relationship Between Rainfall and Cumulative Strontium-90 Deposition

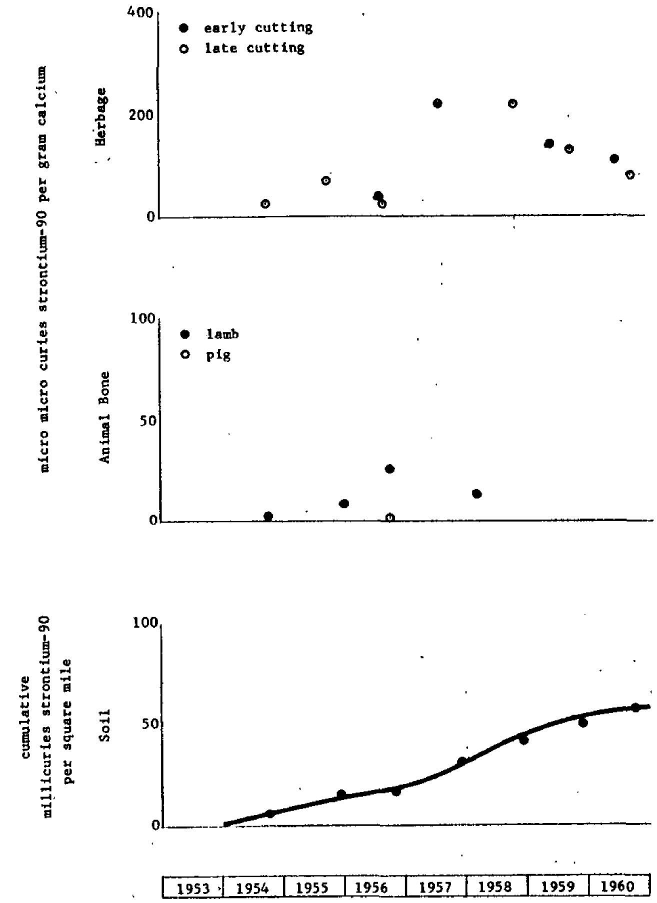


* Value for Mandan not included in computing least squares line

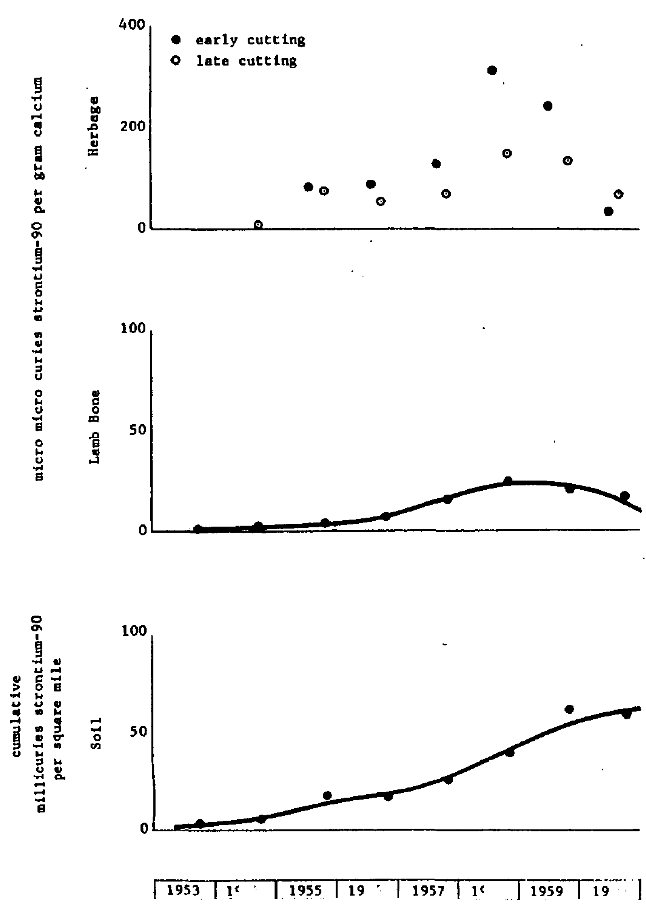
Site: ALAPAHA, GEORGIA Figure 4a



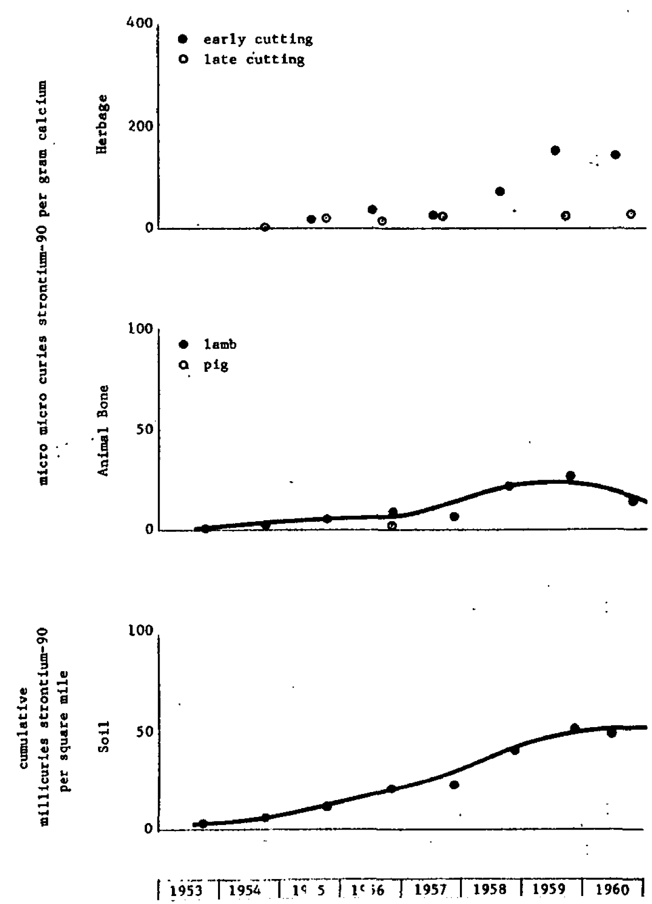
Site: RALEIGH, NORTH CAROLINA Figure 4b



Site: NEW BRUNSWICK, NEW JERSEY Figure 4c

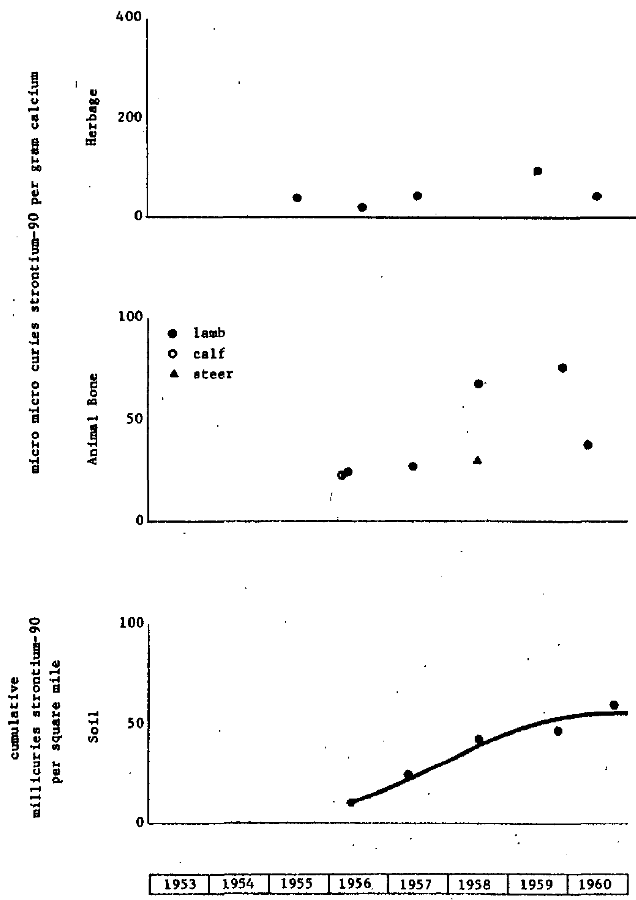


Site: ITHACA, NEW YORK Figure 4d



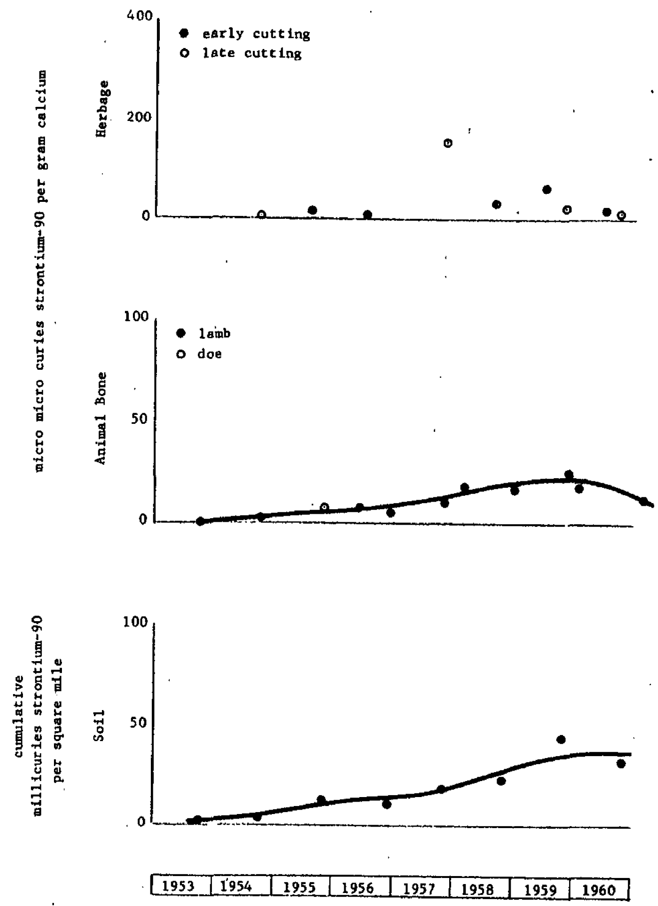
Site: MANDAN, NORTH DAKOTA

Figure 4e



Site: LOGAN, UTAH

Figure 4f



Site: IMPERIAL VALLEY, CALIFORNIA

Figure 4g

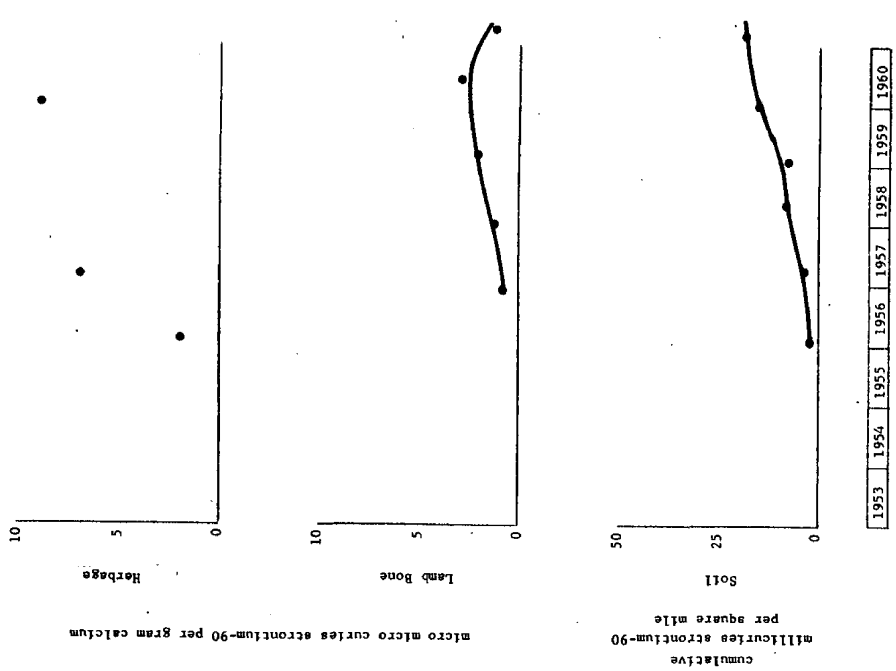


Figure 5

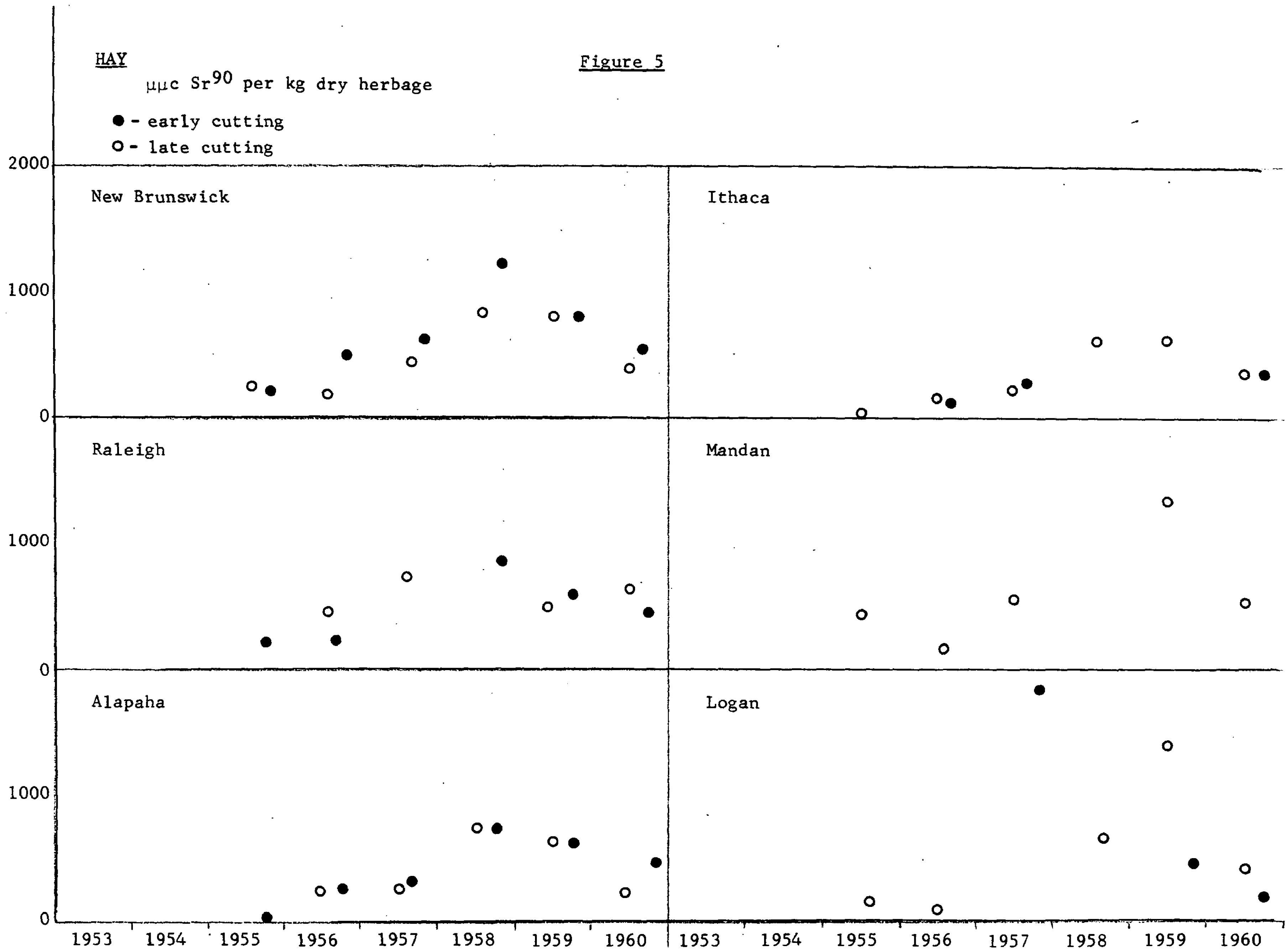

HAY
μμc Sr90 per kg dry herbage
● - early cutting
○ - late cutting
New Brunswick
Ithaca
Raleigh
Mandan
Alapaha
Logan
2000
1000
0
1000
0
1000
0
1953
1954
1955
1956
1957
1958
1959
1960
1953
1954
1955
1956
1957
1958
1959
1960

Table 5

Average Observed Ratios Bone : Soil

and Exchangeable Calcium in Soil

Site	O. R.	meq Ca / 100g soil
Alapaha	0.05 ± 0.02	0.20
Raleigh	0.54 ± 0.32	3.0
N. Brunswick	0.21 ± 0.03	6.3
Ithaca	0.67 ± 0.33	12
Mandan	1.5 ± 0.3	14
Logan	2.1 ± 0.6	28

Figure 6

Relationship Between the Bone/Soil Observed Ratio

and the Exchangeable Calcium in the Soil

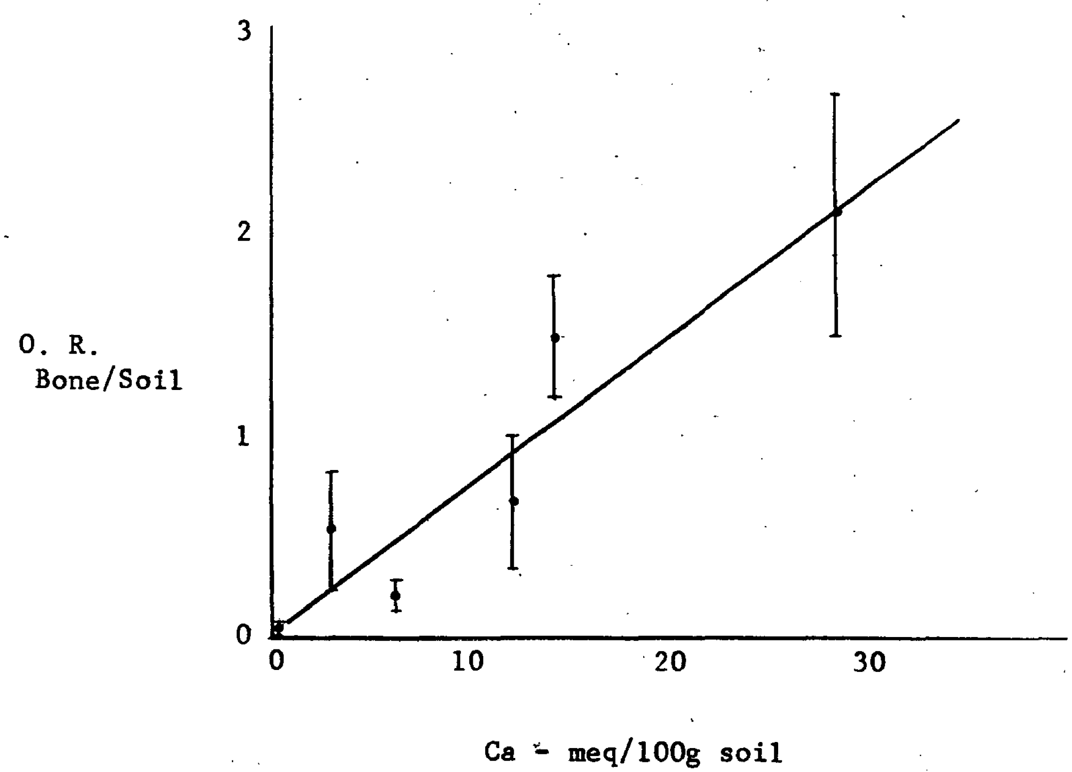


Figure 7

Relationship Between the Ratio of Strontium-90 to Calcium in Herbage Per Unit Deposition and Exchangeable Calcium in the Soil

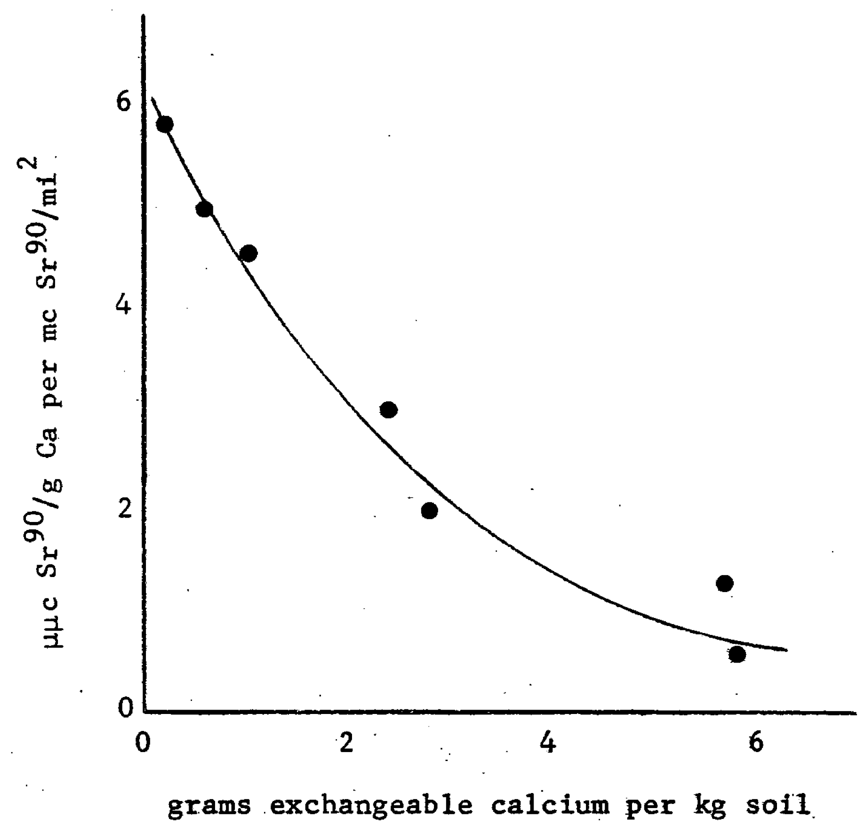


Figure 8

CHICAGO MILKSHED AREA

SAMPLING SITES

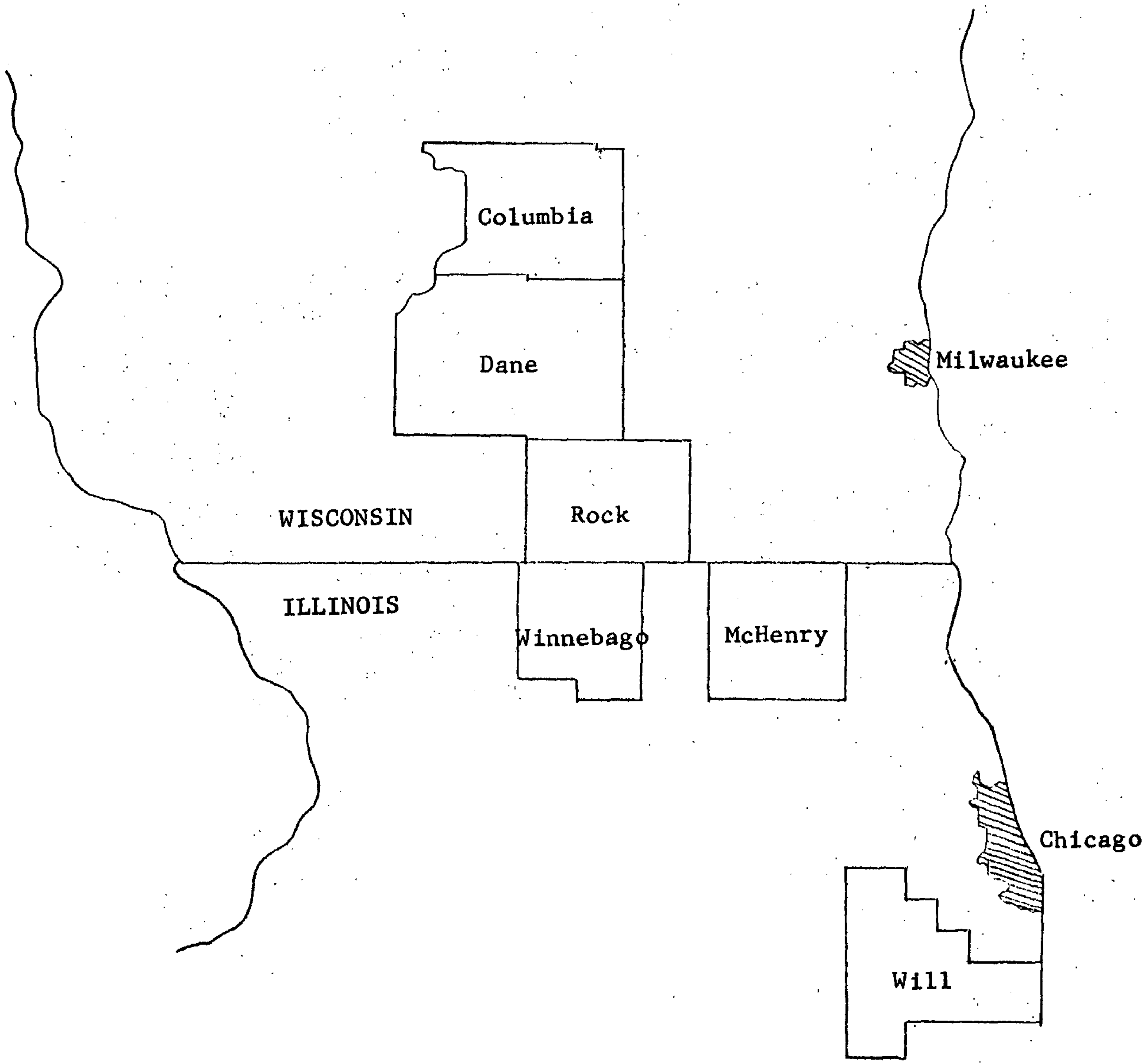


Table 6

CHICAGO MILKSHED AREA

SAMPLING SITES

State	County	Farm	Sampling depth in inches	Soil Exchangeable Ca meq/100g	g/kg
Illinois	Will	Van Winkle	0-6	4.2	0.86
Illinois	Will	Carver	0-12	2.3	0.47
Illinois	McHenry	Kurpeski	0-8	3.1	0.62
Illinois	McHenry	Blomberg	0-8	22	4.5
Illinois	McHenry	McKee	0-8	3.1	0.62
Illinois	McHenry	Austin	0-6	4.6	0.92
Illinois	Winnebago	Swanson	0-8	12	2.4
Wisconsin	Rock	Holcomb	0-6	9.2	1.8
Wisconsin	Rock	Grabow	0-9	5.4	1.1
Wisconsin	Rock	Swain	0-8	14	2.9
Wisconsin	Columbia	Premo	0-9	8.0	1.6
Wisconsin	Dane	Lewke	0-9	13	2.6

Table 7

CHICAGO MILKSHED SOILS

October Sampling

	Cumulative 1957	mc Sr^{90}/mi^2 1958	Increment '57-'58
Will Co., Ill.			
Van Winkle Farm	27.1	41.7	14.6
Carver Farm	32.4	47.3	14.9
McHenry Co., Ill.			
Kurpeski Farm	28.5	48.6	20.1
Blomberg Farm	28.5	36.7	8.2
McKee Farm	34.0	49.1	15.1
Austin Farm	29.8	36.5	6.7
Winnebago Co., Ill.			
Swanson Farm	32.5	65.2*	32.7
Rock Co., Wisc.			
Holcomb Farm	30.6	37.6	7.0
Grabow Farm	27.9	37.1	9.2
Swein Farm	37.2	46.8	9.6
Columbia Co., Wisc.			
Premo Farm	33.0	40.1	7.1
Dane Co., Wisc.			
Lewke Farm	34.4	37.4	3.1
Avg.	31.3 ± 2.9 (9.1%)	43.7 ± 8.4 (19.2%)	12.4 ± 5.2 (41.9%)

* suspected of being too high.

APPENDIX

Table A

HASL PASTURE PROGRAM

Cumulative and Yearly Precipitation

	1953	1954	1955	1956	1957	1958	1959	1960
cumulative precipitation in inches								
Alapaha	59.82	86.30	120.73	169.09	215.48	257.57	316.80	357.78 (1)
Raleigh	42.08	88.67	130.68	181.39	240.04	297.52	346.88	395.28 (1)
New Brunswick	45.77	88.17	129.21	172.79	208.06	257.87	299.19	342.86 (1)
Ithaca	30.05	66.64	100.25	138.16	170.19	217.06	255.50	283.66 (1)
Mandan	21.76	41.93	60.15	76.90	92.22	104.86	116.71	131.82
Logan	13.59	27.24	46.66	57.48	74.45	88.03	103.03	115.87 (2)
Brawley }	T	1.46	3.16	3.25	4.93	7.30	9.25	10.79
El Centro }	0.45	2.49	5.99	6.24	9.93	12.83	14.73	15.60
yearly increment precipitation in inches								
Alapaha	59.82	26.48	34.43	48.36	46.39	42.09	59.23	40.98 (1)
Raleigh	42.08	46.59	42.01	50.71	58.65	57.48	49.36	48.40 (1)
New Brunswick	45.77	42.40	41.04	43.58	35.27	49.81	41.32	43.67 (1)
Ithaca	30.05	36.59	33.61	37.91	32.03	46.87	38.44	28.16 (1)
Mandan	21.76	20.17	18.22	16.75	15.32	12.64	11.85	15.11
Logan	13.59	13.65	19.42	10.82	16.97	13.58	15.00	12.84 (2)
Brawley }	T	1.46	1.70	0.09	1.68	2.37	1.95	1.54
El Centro }	0.45	2.04	3.50	0.25	3.69	2.90	1.90	0.87

(1) Through October 1960.
(2) Through November 1960.

Table B

HASL PASTURE PROGRAM

Cumulative and Yearly Increment Sr^{90} Values for Soil[1]

	1953	1954	1955	1956	1957	1958	1959	1960
cumulative millicuries Sr^{90} per mi^2								
Alapaha	2	5	11	16	22	35	48	57
Raleigh	1	7	14	20	32	45	54	57
New Brunswick	3	8	15	19	30	45	56	62
Ithaca	4	7	14	21	31	44	51	52
Mandan				17	32	45	54	56
Logan	2	6	11	14	20	28	36	37
Brawley }			2	3	7	8		
El Centro }	—	—	—	—	—	—	14	16
Avg.[2]	2	7	13	18	28	40	50	54
yearly increment millicuries Sr^{90} per mi^2								
Alapaha		3	6	5	6	13	13	9
Raleigh		6	7	6	12	13	9	3
New Brunswick		5	7	4	11	15	11	6
Ithaca		3	7	7	10	13	7	1
Mandan					15	13	9	2
Logan		4	5	3	6	8	8	1
Brawley }				1	4	1		
El Centro }		—	—	—	—	—	6	2
Avg.[2]		4	6	5	10	12	10	4

(1) The cumulative Sr^{90} values were determined from the smooth curve drawn through a plot of the analytical values. The interpolated result was determined as of the end of the year.

(2) Excluding Imperial Valley.

Table C

HASL PASTURE PROGRAM

Sr^{90} Levels in Soil per inch of Cumulative and Yearly Precipitation

	1953	1954	1955	1956	1957	1958	1959	1960
cumulative mc Sr^{90}/mi^2/in. ppt'n.								
Alapaha	0.03	0.06	0.09	0.09	0.10	0.14	0.15	0.16
Raleigh	0.02	0.08	0.11	0.11	0.13	0.15	0.16	0.14
New Brunswick	0.06	0.09	0.12	0.11	0.14	0.17	0.19	0.18
Ithaca	0.13	0.10	0.14	0.15	0.18	0.20	0.20	0.18
Mandan				0.22	0.35	0.44	0.46	0.42
Logan	0.15	0.22	0.24	0.24	0.26	0.31	0.35	0.32
Brawley }			0.63	0.92	1.42	1.10		
El Centro }							0.95	1.02
yearly increment mc Sr^{90}/mi^2/in. ppt'n.								
Alapaha		0.11	0.17	0.10	0.13	0.31	0.22	0.22
Raleigh		0.13	0.17	0.12	0.20	0.23	0.18	0.06
New Brunswick		0.12	0.17	0.09	0.31	0.30	0.27	0.14
Ithaca		0.08	0.21	0.18	0.31	0.28	0.18	0.04
Mandan					0.98	1.03	0.76	0.13
Logan		0.29	0.26	0.28	0.33	0.59	0.53	0.08
Brawley }				11.11	2.38	0.42		
El Centro }							3.16	2.30

Table D-1

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	avg. % Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca	avg. $\mu\mu c\ Sr^{90}$ / g Ca
ALAPAHA, GEORGIA								
Coastal Plains Experiment Station								
unimproved pasture area								
	1953	calf	--	9/53	—		3.8	
	1954	calf	--	9/54	—		7.0	
	1955	calf	2/8/55	10/55	37		17.6	
	1956	calf	4/12/56	10/24/56	37.4		18.9	
	1957	calf	2/16/57	10/23/57	37.6		29.2	
	1958	calf	2/58	10/16/58	36.7		53.9	
	1959	calf	unimproved and improved					
	1960	calf	1/31/60	9/27/60	36.6		54.0	
improved pasture area								
	1953		no specimen collected					
	1954	calf	--	9/54	—		2.7	
	1955	calf	3/8/55	10/55	39		12.0	
	1956	calf	3/14/56	10/24/56	36.9		9.7	
	1957	calf	1/31/57	10/23/57	38.4		18.4	
	1958	calf	3/58	10/16/58	38.4		35.2	
	1959	calf	unimproved and improved					
	1960	calf	2/29/60	9/27/60	36.6		37.3	
unimproved and improved area								
	1957	calf*	2/8/57	10/23/57	36.2		24.0	
	1959	calf**	3/59	10/16/59	37.2	37.1	45.7	44.2
	"	" **	"	"	37.1		42.8	

* grazed on unimproved pasture from 3/15 to 7/1 and improved pasture from 7/1 to 10/15.
** grazed on unimproved pasture from 3/24 to 6/30 and improved pasture from 6/30 to 9/15.

Table D-2

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca
RALEIGH, NORTH CAROLINA						
North Carolina State College Animal Husbandry Farm						
	1953		no specimen collected			
	1954	lamb	--	9/54	—	2.1
	1955	lamb	--	12/14/55	37	8.6
	1956	lamb	--	9/19/56	36.9	26.2
		pig	3/15/56	9/24/56	--	1.9
		pig	3/15/56	9/24/56	36.4	1.6
	1957	lamb	11/23/56	2/13/58	38.4	13.8
	1958		no specimen collected			
	1959		no specimen collected			
	1960		no specimen collected			

Table D-3

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	avg. % Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca	avg. $\mu\mu c\ Sr^{90}$ / g Ca
NEW BRUNSWICK, NEW JERSEY								
Rutgers University Animal Husbandry Farm								
	1953	lamb	--	9/53	—		1.1	
	1954	lamb	--	9/9/54	—		2.7	
	1955	lamb	2/14/55	10/14/55	39		4.1	
	1956	lamb	9/10/55	10/11/56				
		leg			38.0		5.6*	
		vert.			—		7.5	
		femur			—		7.2	
		pelvic			—		7.5	7.6
		ribs			—		7.7	
		shoulder blade			—		8.4	
		shoulder			—		7.4	
	1957	lamb	3/57	10/15/57				
		leg			37.7		14.8	
		vert.			37.0		17.2	
		hip			37.7	37.8	17.4	15.8
		rib			37.8		16.0	
		ankle			38.7		13.4	
	1958	lamb	3/6/58	10/7/58				
		leg			37.2		21.9	
		vert.			36.0		26.0	
		shoulder			37.2	36.8	24.8	24.7
		rib			36.3		26.8	
		ankle			37.1		23.8	
	1959	lamb	9/11/58	10/7/59				
		leg			39.1		19.5	
		vert.			39.4	39.0	22.0	21.4
		rib			38.4		22.1	
		hip			39.0		21.9	
	1960	lamb	2/18/60	9/10/60	37.5		17.5	

* value suspect and not used in computing average.

Table D-4

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	avg. % Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca	avg. $\mu\mu c\ Sr^{90}$ / g Ca
ITHACA, NEW YORK								
Cornell University Animal Husbandry Farm								
	1953	lamb	--	9/53			1.1	
	1954	lamb	--	9/20/54			2.6	
	1955	lamb	3/55	9/20/55	36	38	5.4	5.4
		lamb	3/55	9/20/55	39		6.0	
		lamb	3/55	9/20/55	39		4.9	
	1956	lamb	--	10/20/56	37.2	37.4	8.8	9.1
		lamb	--	10/20/56	37.6		7.8	
		lamb	--	10/20/56	37.5		10.6	
		pig	--	10/20/56	36.6	37.2	2.7	2.5
		pig	--	10/20/56	37.5		2.2	
		pig	--	10/20/56	37.5		2.6	
	1957	lamb	1/12/57	10/8/57	36.8	37.4	8.4	6.7
		lamb	1/8/57	10/8/57	38.0		5.5	
		lamb	1/12/57	10/8/57	37.4		6.2	
	1958	lamb	--	Fall '58	37.2	37.5	21.1	22.0
		lamb	--	Fall '58	37.6		21.5	
		lamb	--	Fall '58	37.6		23.3	
	1959	lamb	--	Fall '59	37.3	37.5	25.0	27.4
		lamb	--	Fall '59	37.4		29.0	
		lamb	--	Fall '59	37.7		28.2	
	1960	lamb	2/29/60	9/21/60	36.6	37.0	13.1	14.4
		lamb	3/27/60	9/21/60	37.2		13.6	
		lamb	2/13/60	9/28/60	37.3		16.4	

Table D-5

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca
MANDAN, NORTH DAKOTA 1. Northern Great Plains Field Station 2. Farm						
	1953	no specimen collected				
	1954	no specimen collected				
	1955	no specimen collected				
	1956	calf	3/55	3/27/56	38	23
		lamb	4/55	3/27/56	39	24
	1957	lamb	3/56	5/57	33.3	26.8
	1958	lamb	4/10/57	6/58	38.2	67.8
		steer	--	6/12/58	37.2	29.7
	1959	lamb	4/15/59	11/18/59	37.5	75.2
	1960	lamb	4/1/60	11/3/60	36.3	37.7

Table D-6

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	avg. % Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca	avg. $\mu\mu c\ Sr^{90}$ / g Ca
LOGAN, UTAH								
Utah State University Animal Husbandry Farm								
	1953	lamb	2/53	9/53	—		0.6	0.9
		lamb	3/25/53	9/53	—		1.2	
	1954	lamb	--	9/54	—		1.7	3.0
		lamb	--	9/54	—		4.4	
	1955	doe	10/54	10/55	—		8.4	
	1956	lamb	spring '55	5/56	—		8.2	
		lamb	4/20/56	11/13/56	37.7		5.3	
	1957	lamb	2/57	10/57	37.1		10.8	
		lamb	3/24/57	1/27/58	38.4		15.2	
		lamb	3/24/57	1/27/58	38.2		18.1	
		lamb	3/31/57	1/27/58	38.6	38.1	15.9	18.7
		lamb	4/4/57	1/13/58	37.8		20.2	
		lamb	4/19/57	1/13/58	37.8		27.6	
		lamb	1/25/57	1/27/58	37.9		15.4	
	1958	lamb	2/7/58	11/21/58	37.2		17.7	
		lamb	2/13/58	12/11/58	38.5		17.8	
		lamb	2/6/58	12/11/58	37.2	37.3	18.7	17.7
		lamb	2/7/58	12/11/58	36.4		16.7	
	1959	Rambouillet lamb	1/25/59	11/11/59	37.9		32.5	
		Rambouillet lamb	1/27/59	11/11/59	39.7		28.1	
		Rambouillet lamb	1/28/59	1/10/60	36.5		20.9	
		Rambouillet lamb	1/29/59	11/14/59	36.2	37.5	25.1	25.8
		Rambouillet lamb	2/5/59	11/11/59	37.5		8.0*	
		Rambouillet lamb	2/23/59	11/11/59	37.1		22.5	
		So. Down lamb	2/9/59	1/18/60	37.3		24.4	
		So. Down lamb	2/14/59	1/21/60	37.3		15.3	
		So. Down lamb	2/16/59	1/10/60	36.4	37.1	19.7	18.8
		So. Down lamb	2/16/59	1/21/60	36.8		16.0	
		So. Down lamb	2/19/59	1/18/60	lost		lost	
		So. Down lamb	2/20/59	1/18/60	37.8		18.7	
	1960	So. Down lamb	1/26/60	2/27/61	37.7		11.8	
		So. Down lamb	2/21/60	2/27/61	36.6		13.4	
		Hampshire lamb	2/29/60	2/27/61	37.5	37.8	15.2	13.4
		Hampshire lamb	2/14/60	2/27/61	39.4		13.3	

* value suspect and not used in computing average.

Table D-7

HASL PASTURE PROGRAM

ANIMAL BONE

Site	Year	type	birth date	slaughter date	% Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca
BRAWLEY, CALIFORNIA Irrigation Field Station						
	1953		no specimen collected			
	1954		no specimen collected			
	1955		no specimen collected			
	1956	lamb	11 months old		37.9	0.7
	1957	lamb	1/11/57	12/23/57	37.2	1.3
	1958	lamb	1/30/58	2/59	37.1	2.2
	1959	lamb	2/21/59	3/23/60	37.6	2.9
	1960	lamb	--	--	37.0	1.3

Table E-1

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	μμc Sr^{90} per kg orig. mat.	μμc Sr^{90} per g Ca
ALAPAHA, GEORGIA						
Coastal Plains Experiment Station - improved area						
	1954	9/54	bermuda	—	—	4
	1955	6/55	bermuda			34
		9/55	bermuda	2.2 (green)	46 (green)	21
	1956	5/56	bermuda	2.4 (green)	216 (green)	90
		9/56	bermuda	1.9 (green)	228 (green)	120
	1957	6/57	bermuda	2.7 (green)	259 (green)	96
		8/57	bermuda	1.8 (green)	326 (green)	181
	1958	6/58	bermuda	2.2 (dry)	741 (dry)	337
		9/58	bermuda	4.1 (dry)	746 (dry)	182
	1959	6/18/59	bermuda	1.9 (dry)	608 (dry)	320
		9/15/59	bermuda	2.6 (dry)	627 (dry)	241
	1960	5/19/60	bermuda	2.7 (dry)	234 (dry)	88
		10/5/60	bermuda	2.6 (dry)	474 (dry)	185

Table E-2

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	$\mu\mu c$ Sr^{90} per kg orig. mat.	$\mu\mu c$ Sr^{90} per g Ca
RALEIGH, NORTH CAROLINA						
North Carolina State College Animal Husbandry Farm						
	1954	9/16/54	mixed			26
	1955	9/1/55	fescue	3.2 (green)	221 (green)	69
	1956	7/20/56	fescue	12.1 (dry)	472 (dry)	39
		8/4/56	fescue	9.5 (dry)	238 (dry)	25
	1957	7/57	fescue	3.3 (dry)	726 (dry)	220
	1958	10/1/58	fescue	4.0 (dry)	880 (dry)	220
	1959	5/25/59	orchard	3.6 (dry)	508 (dry)	141
		9/25/59	mixed	4.4 (dry)	581 (dry)	132
	1960	6/13/60	mixed	5.5 (dry)	613 (dry)	111
		9/5/60	mixed	5.8 (dry)	464 (dry)	80

Table E-3

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	$\mu\mu c\ Sr^{90}$ per kg orig. mat.	$\mu\mu c\ Sr^{90}$ per g Ca
NEW BRUNSWICK, NEW JERSEY						
Rutgers University Animal Husbandry Farm						
	1954	9/19/54	mixed	—	—	9
	1955	7/4/55	mixed	3.3 (green)	280 (green)	85
		10/55	mixed	3.2 (green)	246 (green)	77
	1956	7/3/56	mixed	2.3 (green)	202 (green)	88
		10/13/56	mixed	9.3 (green)	521 (green)	56
	1957	8/57	mixed	3.5 (green)	455 (green)	130
		10/16/57	mixed	9.1 (green)	628 (green)	69
	1958	7/58	mixed	2.7 (dry)	845 (dry)	313
		10/7/58	mixed	8.4 (dry)	1250 (dry)	149
	1959	6/23/59	mixed	3.3 (dry)	795 (dry)	241
		10/8/59	mixed	5.8 (dry)	795 (dry)	137
	1960	6/60	alfalfa	10.7 (dry)	394 (dry)	37
		8/60	alfalfa	8.1 (dry)	557 (dry)	69

Table E-4

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	μμc Sr^{90} per kg orig. mat.	μμc Sr^{90} per g Ca
ITHACA, NEW YORK						
Cornell University Animal Husbandry Farm						
	1954	9/10/54	--	—	—	0.2
	1955	6/15/55	mixed	1.6 (green)	30 (green)	19
		9/14/55	mixed			20
	1956	6/7/56	mixed	4.9 (dry)	186 (dry)	38
		8/25/56	alfalfa	8.8 (dry)	132 (dry)	15
	1957	6/15/57	alfalfa	7.7 (green)	223 (green)	29
		8/15/57	alfalfa	11.7 (green)	281 (green)	24
	1958	7/58	alfalfa	8.5 (dry)	620 (dry)	73
	1959	6/6/59	mixed	4.1 (dry)	627 (dry)	153
		8/5/59	mixed	11.2 (dry)	269 (dry)	24
	1960	6/60	mixed	2.7 (dry)	389 (dry)	142
		9/60	mixed	12.4 (dry)	372 (dry)	30

Table E-5

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	$\mu\mu c\ Sr^{90}$ per kg orig. mat.	$\mu\mu c\ Sr^{90}$ per g Ca
MANDAN, NORTH DAKOTA						
1. Northern Great Plains Field Station						
2. Farm						
	1954			no specimen collected		
	1955	6/55	alfalfa	11.6 (dry)	452 (dry)	39
	1956	7/1/56	alfalfa	9.3 (dry)	195 (dry)	21
	1957	6/57	alfalfa	12.5 (dry)	562 (dry)	45
	1958	6/7/58	alfalfa	—	—	?
	1959	6/25/59	alfalfa	13.8 (dry)	1325 (dry)	96
	1960	6/25/60	alfalfa	12.1 (dry)	531 (dry)	44

Table E-6

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	$\mu\mu c\ Sr^{90}$ per kg orig. mat.	$\mu\mu c\ Sr^{90}$ per g Ca
LOGAN, UTAH						
Utah State University Animal Husbandry Farm						
	1954	9/18/54	--		—	8
	1955	7/17/55	mixed	9.0 (green)	171 (green)	19
	1956	6/10/56	alfalfa	13.3 (green)	106 (green)	8
	1957	10/11/57	mixed	11.6 (green)	1830 (green)	158
	1958	8/30/58	alfalfa	18.7 (dry)	692 (dry)	37
	1959	6/59	alfalfa	21.0 (dry)	1390 (dry)	66
		10/10/59	alfalfa	18.7 (dry)	449 (dry)	24
	1960	6/60	alfalfa	20.6 (dry)	419 (dry)	20
		9/60	alfalfa	12.8 (dry)	194 (dry)	15

Table E-7

HASL PASTURE PROGRAM

HAY

Site	Year	Sampling date	type	g Ca / kg orig. mat.	$\mu\mu c\ Sr^{90}$ per kg orig. mat.	$\mu\mu c\ Sr^{90}$ per g Ca
BRAWLEY, CALIFORNIA Irrigation Field Station						
	1954			no specimen collected		
	1955			no specimen collected		
	1956	1/5/56	alfalfa			2
	1957	2/28/57	alfalfa	1.4 (wet)	9.8 (wet)	7
	1958			no specimen collected		
	1959	12/31/59	alfalfa	33.6 (dry)	302 (dry)	9
	1960			no specimen collected		

Table F-1

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
Alapaha, Georgia Coastal Plains Experiment Station										
unimproved pasture area										
	9/53	0-6	17.0	11.4	2.4	1.0	0.20	3.4		
	9-25-54	0-2	5.95	53.2	3.9	0.70	0.14	0.8		
		2-6	12.96	4.1	0.7	0.10	0.02	0.2		
		0-6	18.91		4.6	0.25	0.05	1.0		
	11-2-55	0-4	12.09	66.1	10.0	0.55	0.11	1.3		
		4-8	16.42	1.8	0.4	0.10	0.02	0.3		
		0-8	28.51		10.4	0.30	0.06	1.6		
	11-22-56	0-2	5.58	167	13.0	0.50	0.10	0.6		
		2-6	14.83	8.9	1.7	0.20	0.04	0.6		
		6-12	19.63	2.1	0.6	0.10	0.02	0.4		
		0-12	40.04		15.3	0.20	0.04	1.6		
	11-22-57	0-2	5.48	252	17.4	0.8	0.16	0.9		
		2-6	13.10	14.9	2.4	0.2	0.04	0.5		
		6-12	18.86	3.0	0.7	<0.1	0.02	0.4		
		0-12	37.44		20.5	0.25	0.05	1.8		
	11-3-58	0-2	3.72	454	21.2					
		2-6	13.71	46.5	8.1					
		6-12	23.02	9.4	2.7					
		0-12	40.45		32.5					
	11-11-59	0-2	4.54	630	35.9	0.54	0.11	0.49	4.3	4.6
		2-6	12.44	74.0	11.6	0.20	0.040	0.50	3.5	4.9
		6-12	19.30	10.5	2.5	0.04	0.008	0.15	1.6	5.5
		0-12	36.28		50.0	0.15	0.031	1.14		
	10-5-60	0-2	5.11	618	39.7	0.79	0.16	0.81	6.4	4.7
		2-6	12.19	88	13.5	0.27	0.054	0.66	4.2	4.8
		6-12	24.48	10.7	3.3	0.05	0.010	0.24	2.0	5.1
		0-12	41.78		56.5	0.20	0.041	1.71		

* NH_4Ac method.

Table F-1 cont'd.

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
Alapaha, Georgia										
Coastal Plains Experiment Station										
improved pasture area										
	9/53	0-1	2.5	32.5	1.0	0.60	0.12	0.3		
		1-6	15.0	2.2	0.4	0.80	0.16	2.4		
		0-6	17.5		1.4	0.75	0.15	2.7		
	9-25-54	0-2	6.26	44.0	3.4	3.7	0.74	4.6		
		2-6	13.30	2.4	0.4	0.70	0.14	9.1		
		0-6	19.56		3.8	3.5	0.70	13.7		
	11-2-55	0-2	6.98	101	8.5	2.9	0.58	4.0		
		2-6	16.33	6.7	1.4	0.80	0.16	2.7		
		0-6	23.31		9.9	1.4	0.29	6.7		
	1956		no sample collected							
	1957		no sample collected							
	1958		no sample collected							
	11-11-59	0-10	32.16	98.7	39.9	1.26	0.252	8.10	3.4	5.2
		0-2	7.41	384	35.7					
		2-4	6.95	77.7	6.79					
		4-6	8.31	30.3	3.16					
		6-8	9.68	9.4	1.15					
		8-10	7.86	5.3	0.53					
		10-12	7.71	3.9	0.38					
		0-12	47.92		47.7					
	10-5-60	0-10	37.95	108		1.23	0.246	9.34	3.2	5.4

* NH_4Ac method.

Table F-2

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
Raleigh, North Carolina										
North Carolina State College Animal Husbandry Farm										
	1953		no sample collected							
	9-23-54	0-2	4.72	68.8	4.1					
		2-6	16.37	7.1	1.4					
		0-6	21.09		5.5					
	11-1-55	0-6	22.76	54.0	15.4	5.5	1.1	26		
	10-23-56	0-2	3.55	275	12.6	10.0	2.0	7.0		
		2-6	14.01	20.8	3.6	4.6	0.92	12.9		
		0-6	17.56		16.2	5.6	1.1	19.9		
	11-16-57	0-6	15.81	163	32.4	7.3	1.47	23.1		
	11-5-58	0-2	2.88	697	25.2					
		2-6	13.20	103	17.2					
		0-6	16.08		42.4					
	11-9-59	0-8	24.61	162	50.1	3.2	0.64	16	8.7	5.6
	9-26-60	0-8	29.01	223	81.3	2.9	0.58	17	7.9	5.5

* NH_4Ac method.

Table F-3

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
New Brunswick, New Jersey										
Rutgers University Animal Husbandry Farm										
	9-2-53	0-1	2.5	34.8	1.1	5.5	1.1	2.7		
		1-6	15.0	5.9	1.1	4.8	0.96	14.4		
		6-12	20.0	6.5	1.6	3.0	0.60	12.0		
		0-12	37.5		3.8	3.9	0.78	29.1		
	9-11-54	0-2	6.37	56.6	4.5	4.1	0.82	5.2		
		2-6	12.86	5.0	0.8	3.8	0.76	9.8		
		0-6	19.23		5.3	3.9	0.78	15.0		
	10-17-55	0-2	7.59	108	10.2	3.9	0.78	5.9		
		2-6	17.94	32.4	7.3	3.9	0.78	14.0		
		0-6	25.53		17.5	3.9	0.78	19.9		
	10-13-56	0-6	15.50	78.9	16.6	3.3	0.66	10.2		
	10-16-57	0-6	15.36	134	25.9	2.4	0.48	7.4		
	10-7-58	0-6	18.62	174	40.8					
	10-8-59	0-8	25.39	196	62.5	6.3	1.3	32	11.5	5.8
	9-12-60	0-8	25.12	185	58.4	6.3	1.3	32	12.4	5.9

* NH_4Ac method.

Table F-4

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
Ithaca, New York Cornell University										
	9/53	0-1	2.5	32.4	1.1	10.0	2.0	5.0		
		1-6	15.0	4.9	0.9	11.5	2.3	33.9		
		6-12	20.0	3.3	0.8	8.5	1.7	34.4		
		0-12	37.5		2.8	10.0	2.0	73.3		
	9-10-54	0-2	4.62	62.7	3.6	15.5	3.1	14.5		
		2-6	12.90	9.4	1.5	17.0	3.4	43.6		
		0-6	17.52		5.1	16.5	3.3	58.1		
	9-14-55	0-2	3.94	174	8.6	12.0	2.4	9.4		
		2-6	16.25	16.7	3.4	10.0	2.0	32.2		
		0-6	20.19		12.0	10.5	2.1	41.6		
	10-12-56	0-2	4.54	232	14.1	13.0	2.6	12.0		
		2-6	13.40	43.6	7.3	13.5	2.7	36.8		
		0-6	17.94		21.4	13.5	2.7	48.8		
	10-5-57	0-2	2.78	370	13.0	10.0	2.00	5.56		
		2-6	11.10	69	9.6	8.4	1.68	18.6		
		0-6	13.88		22.6	8.7	1.74	24.2		
	10-27-58	0-2	3.56	579	25.9					
		2-6	12.19	98.2	14.9					
		0-6	15.75		40.8					
	10-7-59	0-8	26.23	157	51.7	12.2	2.44	64.0	13.7	6.4
	5-14-60	0-8	25.86	152	49.4	12.6	2.53	65.4	13.6	6.7

* NH_4Ac method.

Table F-5

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}	CEC* meq/100 g	pH
Mandan, North Dakota										
Northern Great Plains Field Station and Griffin Farm										
	1953	no sample collected								
	1954	no sample collected								
	1955	no sample collected								
	5/56	0-6 (Griffin)	23.43	33	10.1	11.5	2.3	55.6		
	4-20-57	0-6 "	13.40	143	24.0	16.2	3.2	43.4		
	6-7-58	0-6 "	15.64	228	44.8					
		0-6 (Expt.St.)	15.30	209	40.2					
	10-21-59	0-6 (Griffin)	19.13	192	46.1	9.0	1.80	34	14.1	6.6
		0-7 (Expt.St.)	16.75	225	47.3	13.5	2.70	45.2	20.3	7.6
	9-21-60	0-8 " "	22.31	212	59.4	14.3	2.86	63.8	20.2	7.4

* NH_4Ac method.

Table F-6

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil / ft.^{2}	d/m Sr^{90} / kg soil	mc Sr^{90} / mi^2	exchangeable Ca meq / 100 g	exchangeable Ca g / kg	exchangeable Ca g / ft.^{2}	CEC* meq / 100 g	pH
Logan, Utah										
Utah State University Animal Husbandry Farm										
	9/53	0-1	2.5	21.2	.0.7					
		1-6	15.0	7.9	1.5					
		0-6	17.5		2.2					
	9-18-54	0-2	4.72	21.9	1.3					
		2-6	11.77	15.6	2.3					
		0-6	16.49		3.6					
	10-29-55	0-2	6.57	121	9.9	26	5.2	34		
		2-6	14.89	19.9	3.7	27	5.5	82		
		0-6	21.46		13.6	27	5.4	116		
	11-9-56	0-2	3.22	149	6.0	27	5.4	17		
		2-6	15.71	29.7	5.4	24	4.9	78		
		0-6	18.93		11.4	25	5.0	95		
	10-25-57	0-2	4.22	201	9.2	30.3	6.06	22		
		2-6	12.83	55.8	8.9	29.4	5.89	88		
		0-6	17.05		18.1	32.2	6.45	110		
	10-10-58	0-2	4.06	258	13.2					
		2-6	13.54	62.1	10.5					
		0-6	17.60		23.7					
	10-14-59	0-8	24.04	150	45.3	29.3	5.87	141	20.8	7.5
	10-30-60	0-8	24.68	105	32.5	27.4	5.49	136	19.8	7.7

* NH_4Ac method.

Table F-7

HASL PASTURE PROGRAM

SOIL

Site	collection date	depth in inches	kg soil / ft.^{2}	d/m Sr^{90} / kg soil	mc Sr^{90} / mi^2	exchangeable Ca meq / 100 g	exchangeable Ca g / kg	exchangeable Ca g / ft.^{2}	CEC* meq / 100 g	pH
Brawley and El Centro, California										
Irrigation Field Station and Meloland Field Station										
	1953		no sample collected							
	1954		no sample collected							
	1955		no sample collected							
	1-5-56	0-6			2.5					
	3-8-57	0-6	18.51	14.6	3.4	31.1	6.22	115		
	4-30-58	0-6	21.16	25.1	8.1					
	1-27-59	0-8	27.93	21.9	7.7					
	12-31-59	0-7	19.80	62.2	15.5	27.1	5.43	108	24.2	7.8
	1-31-61	0-8	23.86	62	18.6	30.3	6.07	145	23.2	7.8

* NH_4Ac method.

Table G

CHICAGO MILKSHED AREA

HERBAGE

Site	Year	sampling date	type	g Ca / kg orig. mat.	$\mu\mu c\ Sr^{90}$ per kg orig. mat.	$\mu\mu c\ Sr^{90}$ per g Ca
McHenry County, Illinois						
Blomberg Farm						
	1957	7-11-57	alfalfa	10.5 (dry)	304 (dry)	29
		8-25-57	alfalfa	6.6 (dry)	172 (dry)	26
		9-15-57	alfalfa	9.1 (dry)	209 (dry)	23
	1958		no sample collected			
Austin Farm						
	1957	8-20-57	alfalfa	7.0 (dry)	336 (dry)	48
	1958	8-15-58	mixed	11.3 (dry)	610 (dry)	54
Dane County, Wisconsin						
Lewke Farm						
	1957	6-30-57	mixed	4.0 (dry)	392 (dry)	98
	1958		no sample collected			

Table H

CHICAGO MILKSHED AREA

SOIL

Site	collection date	depth in inches	kg soil / ft.^{2}	d/m Sr^{90} / kg soil	mc Sr^{90} / mi^2	exchangeable Ca: meq / 100 g	exchangeable Ca: g / kg	exchangeable Ca: g / ft.^{2}
Illinois, Will County, Van Winkle Farm								
	10-23-57	0-2	4.33	380	20.7	3.59	0.72	3.2
		2-6	8.53	59	6.4	4.79	0.96	8.2
		0-6	12.86		27.1	4.44	0.89	11.4
	10-31-58	0-8	25.05	133	41.7			
Illinois, Will County, Carver Farm								
	10-23-57	0-2	4.67	400	23.4	4.79	0.96	4.5
		2-6	12.46	49	7.7	2.79	0.56	7.0
		6-12	22.92	5	1.3	1.60	0.32	7.3
		0-12	40.05		32.4	2.34	0.47	18.8
	10-31-58	0-2	3.72	581	27.2			
		2-6	10.49	113	14.9			
		6-12	19.30	22	5.2			
		0-12	33.51		47.3			
Illinois, McHenry County, Kurpeski Farm								
	10-23-57	0-8	26.61	85	28.5	3.09	0.62	16.5
	10-30-58	0-8	28.44	136	48.6			

Table H cont'd.

CHICAGO MILKSHED AREA

SOIL

Site	collection date	depth in inches	kg soil / $ft.^2$	d/m Sr^{90} / kg soil	mc Sr^{90} / mi^2	exchangeable Ca meq / 100 g	exchangeable Ca g / kg	exchangeable Ca g / $ft.^2$
Illinois, Winnebago County, Swanson Farm								
	10-24-57	0-8	23.46	110	32.5	11.98	2.40	56.3
	10-30-58	0-8	26.07	199	65.2			
Wisconsin, Rock County, Holcomb Farm								
	10-24-57	0-2	4.43	380	21.2	9.53	1.91	8.5
		2-6	14.59	52	9.4	9.08	1.82	26.6
		0-6	19.02		30.6	9.18	1.84	35.1
	10-29-58	0-8	22.00	136	37.6			
Wisconsin, Rock County, Grabow Farm								
	10-24-57	0-9	30.77	72.1	27.9	5.39	1.08	33.2
	10-29-58	0-8	27.59	107	37.1			

Table H cont'd.

CHICAGO MILKSHED AREA

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}
Wisconsin, Rock County, Swain Farm								
	10-24-57	0-8	25.02	118	37.2	14.37	2.88	72.0
	10-29-58	0-8	22.17	168	46.8			
Wisconsin, Columbia County, Premo Farm								
	10-25-57	0-9	26.54	99	33.0	7.98	1.60	42.5
	10-29-58	0-8	22.85	140	40.1			
Wisconsin, Dane County, Lewke Farm								
	10-25-57	0-9	25.59	107	34.3	12.77	2.56	65.5
	10-29-58	0-8	24.71	120	37.4			

Table H cont'd.

CHICAGO MILKSHED AREA

SOIL

Site	collection date	depth in inches	kg soil/ft.^{2}	d/m Sr^{90}/kg soil	mc Sr^{90}/mi^2	exchangeable Ca meq/100 g	exchangeable Ca g/kg	exchangeable Ca g/ft.^{2}
Illinois, McHenry County, Blomberg Farm								
	10-23-57	0-8	22.34	102	28.5	22.36	4.48	100
	10-30-58	0-8	22.51	130	36.7			
Illinois, McHenry County, McKee Farm								
	10-23-57	0-8	23.87	114	34.0	3.09	0.62	14.8
	10-31-58	0-8	25.05	156	49.1			
Illinois, McHenry County, Austin Farm								
	10-23-57	0-2	5.08	355	22.6	5.99	1.20	6.1
		2-6	11.64	49	7.2	3.99	0.80	9.3
		0-6	16.72		29.8	4.59	0.92	15.4
	10-30-58	0-2	4.06	481	24.5			
		2-6	12.36	77	12.0			
		0-6	16.42		36.5			

MISCELLANEOUS BIOLOGICAL SAMPLES ANALYZED AT HASL SINCE 1956

USAEC, Health and Safety Laboratory, New York City
USDA, Soil Survey Laboratory, Beltsville, Maryland

In 1956, the first intensive worldwide sampling for cumulative strontium-90 levels in soils was undertaken by the Health and Safety Laboratory in cooperation with the U. S. Department of Agriculture. At some of the sampling sites, certain biological samples were available that might possibly have been of use as biological indicators of the fallout situation near the collection site. Where these samples were available, they were collected and analyzed for strontium-90 and calcium. No attempt was made to seriously seek biological indicators for a given locale but rather, different kinds of samples were obtained to see qualitatively what the effects of the fallout in the region were on the levels detected in the samples. Sampling of biological materials of this sort has continued on a very limited basis since then.

In general, the samples analyzed were animal bones, vegetation, and soil. It was felt that soil levels would indicate the total amount of strontium-90 that had fallen in the given area, vegetation levels would reflect the cumulative deposition as well as the recent deposition of strontium-90, and that the bone levels would indirectly reflect the levels in vegetation and soil. These impressions have since been verified to some extent by the results of the pasture survey in the United States (this quarterly) which was conducted concurrently. The sporadic nature of the sampling of the miscellaneous biological materials has made it impossible to come to any firm conclusions as to any further meaning of the results or their implications as far as fallout is concerned. The results are presented in Tables 1 through 7, mainly as matters of record for possible use by investigators in other fields who might possibly find them helpful in some other study.

Two sets of samples require some explanations; they are the snowy owl pellets obtained in Barrow, Alaska from 1956 to 1960 and the moss samples obtained at Ft. Chimo, Quebec in 1959 and 1960. The snowy owl pellets were collected because the strontium-90 and calcium levels reflect the levels in the bones of lemmings on which the owls fed. The two different kinds of moss sampled in 1959 and 1960 were obtained in connection with soil sampling. The strontium-90 that is deposited on and in the moss may be useful in place of soil measurements in determining the cumulative deposition of strontium-90 at a given site, where perhaps this information could not readily be obtained in any other way. This approach has been used in some of the work in Norway.

Table 1

Animal Bone, Soil, and Other Biological Samples Collected in Alaska

Sample type	Site		Sampling period	% Ca in ash	$\mu\mu c\ Sr^{90}$/g Ca
snowy owl pellets					
	Barrow		1956	34	21
			1957	13	7*
			1958	35	13
			1960	29	53
snowy owl skeletons (2)					
	Barrow		1960	32	20
pomarine jaeger chick skeletons (3)					
	Barrow		1960	32	22
yearling calf leg bones					
	Palmer		Nov. 1956	39	4
caribou bones					
	Eagle				
		fawn	Oct. 1956	37	50
		steer	Dec. 1956		112
	Mile-70				
		yearling	Oct. 1958	37	133

* Sample listed as being "old".

Soil

Site	sampling period	cumulative $mc\ Sr^{90}/mi^2$
Barrow	1956	3
	1958	4
	1959	11
	1960	9
Fairbanks	1956	4
	1958	12
	1959	19
	1960	25
Palmer	1956	6
	1958	11
	1959	22
	1960	28

Table 2a

Biological Samples Collected in Canada

Animal Bone

Sample type	Site	Sampling period	% Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca
reindeer leg bones				
	Reindeer Station, Northwest Territories			
	9 mo. old fawn	Jan. 1959	37	85
	2 yr. 9 mo. old steer	Jan. 1959	38	92
	8 mo. old fawn	Nov. 1959	39	98
	1 yr. 8 mo. old steer	Dec. 1959	39	121
sheep leg bones				
	Lacombe, Alberta			
	1 yr. old	1956		26
	Agassiz, British Columbia			
		Jan. 1957	38	32
	St. John's, Newfoundland			
		1956	37	63
	9 mo. old	Nov. 1958	38	128
	7 mo. old	Sept. 1959	37	173
	8 mo. old	Oct. 1960	37	114

Table 2b

Biological Samples Collected in Canada

Vegetation and Soil

Sample type	Site	Sampling period	g Ca / kg dry mat.	$\mu\mu c$ Sr^{90} per kg dry mat.	$\mu\mu c$ Sr^{90} per g Ca	mc Sr^{90} / mi^2
	Ft. Chimo, Quebec					
caribou moss		1959	1.31	740	565	11
		Sept. 1960	1.56	1470	940	21
sphagnum moss		1959	7.22	1630	226	26
		Sept. 1960	12.0	301	25	20
soil (undisturbed, 0-6")		June 1959				11
		Sept. 1960				14
	Reindeer Station, Northwest Territories					
soil		July 1957				5
		July 1959				5
		July 1960				13
	Lacombe, Alberta					
soil		Aug. 1956				8
		May 1958				24
		Sept. 1959				39
		Aug. 1960				44
	Agassiz, British Columbia					
soil		June 1957				35
		May 1958				49
		Sept. 1959				90
		Sept. 1960				91
	St. John's, Newfoundland					
soil		Oct. 1956				9
		Jan. 1959				50
		Sept. 1959				72
		May 1960				75

Table 3

Biological Samples Collected in Reykjavik, Iceland

Animal Bone

Sample type	Sampling period	% Ca in ash	$\mu\mu c\ Sr^{90}$ / g Ca
lamb leg	1960	37	41

Vegetation and Soil

Sample type	Sampling period	g Ca / kg dry mat.	$\mu\mu c\ Sr^{90}$ per kg dry mat.	$\mu\mu c\ Sr^{90}$ per g Ca	$mc\ Sr^{90}$ / mi^2
grass	June 1958	3.40	2940	864	3.2
soil	Aug. 1958				33
	June 1959				64
	Oct. 1960				60

Table 4

Biological Samples Collected in Chile

Site	Sample type	Sampling period	$\mu\mu c\ Sr^{90}$ / g Ca	mc Sr^{90} / mi^2
Punta Arenas				
	sheep leg bone	Jan. 1956	7	
	soil	Jan. 1956		1
		Mar. 1958		5
		Oct. 1959		8
		Dec. 1960		6
Antofogasta				
	cactus	Feb. 1956	1	
	pepper tree	Feb. 1958	2½	
	soil	Jan. 1956		0.1
		Feb. 1958		0.4
		Dec. 1960		0.9

Table 5

Biological Samples Collected in

Australia and New Zealand

Site	Sample type	Sampling period	$\mu\mu c\ Sr^{90}$/g Ca	mc Sr^{90}/mi^2
Adelaide, Australia				
	sheep leg bone 1 yr. old	May 1956	2½	
	soil	May 1956		5
		Mar. 1958		12
		June 1959		13
		Dec. 1960		14
Timaru, New Zealand				
	sheep leg bone			
	Farm A	1956	5	
	Farm B	1956	13	
	soil	Apr. 1956		2
		Mar. 1958		8
		Sept. 1959		10
		Jan. 1961		12

Table 6

Biological Samples Collected in Puerto Rico

Animal Bone

Sample type	Site	Sampling period	% Ca in ash	$\mu\mu c\ Sr^{90}/g\ Ca$
goat leg bones				
	Lajas Experiment Station			
	10 mo. old	Dec. 1957	36	5
	11 mo. old	Dec. 1958	36	7
	11 mo. old	Dec. 1959	38	9
	10 mo. old	Dec. 1960	36	4

Soil (undisturbed)

Site	Sampling period	$mc\ Sr^{90}/mi^2$
Lajas	Sept. 1957	17
El Younque, rain forest	Sept. 1957	44
San Juan	Nov. 1958	32
	July 1959	52

Table 7

Biological Samples Collected in

the Philippine Islands and Japan

Sample type	Site	Sampling period	$\mu\mu c\ Sr^{90}/g\ Ca$	$mc\ Sr^{90}/mi^2$
lamb leg bone	Manila			
	5 mo. old	Apr. 1956	2	
	11 mo. old	July 1956	4½	
goat leg bone	Hiroshima	1956	7	
	Nagasaki	1956	4½	
soil	Manila	Apr. 1956		6
		Feb. 1958		7
		June 1959		13
		Dec. 1960		18
	Fukuoka	Feb. 1958		25
		June 1959		48
		Dec. 1960		71

Strontium-90 in U. S. Wheat Harvested in 1960

by J. Rivera (HASL)

Preliminary results on the strontium-90 and calcium content of U. S. wheat harvested in 1960 are presented below. Data on wheat harvested in 1959 in the same state, previously reported, are presented alongside of the 1960 results to facilitate comparison.

State	μμc/kg		μμc/g Ca	
	1959	1960	1959	1960
California	17	4	49	11
Utah	21	6	45	15
Ohio	56	36	152	72
Nebraska	75	29	159	60
Colorado	46	22	71	45
Iowa	61	48	109	89
Washington	9	7	29	20
Missouri	121	21	272	50

The effects of the decreased fallout rate in 1960 as compared to that in 1959 are evident in the observed decreased strontium-90 levels in the 1960 wheat crop. The fallout rate in the United States in 1959 for the harvest months of May, June, July, and August is estimated to have been about 1.4 mc $Sr^{90}/mi^2/mo$, while in 1960 the rate was about 0.3 mc $Sr^{90}/mi^2/mo$. The increase in the cumulative strontium-90 in the soils on which the wheat was grown is estimated to have been from 66 mc/mi^2 at the end of 1959 to 70 mc/mi^2 at the end of 1960.

A more quantitative estimate of the relative importance of the fallout rate and the cumulative strontium-90 levels in the soil on the strontium-90 content of wheat will be attempted when the results of analyses on the 1960 wheat and milling products from seven additional states are available.

TRACERLAB, INCORPORATED
Reactor Monitoring Center
2030 Wright Avenue
Richmond, California

QUALITY CONTROL AT TRACERLAB

R. A. Wessman and L. Leventhal

Radiochemical analyses, at the Tracerlab Reactor Monitoring Center in Richmond, California, for the Sr^{90} program at HASL are performed in the low-level radiochemistry laboratory. The work comes under the direction of the Radiochemistry Group and the Radioactivity Measurements Group of the Technical Services Department.

A typical handling procedure for a sample received for low level Sr^{90} analysis would be as follows. The sample is received, logged and weighed. It is then ashed, ground and aliquots taken for Sr^{90} and Ca analysis. Stock Sr^{85} tracer and Sr carrier are added to the Sr sample which is dissolved and purified by a method suitable for that sample type. After a suitable in-growth period for Y^{90} growth, yttrium carrier precipitations are made, the yield is determined by weight of Y_2O_3 and submitted for counting. The Y^{90} is counted on a low background beta counter. Several decay points are taken over a period of time to check isotopic purity. The supernates from the Y^{90} milking are sampled and strontium yield determined by comparison counting of recovered Sr^{85} tracer and a Sr^{85} standard solution in a gamma scintillation well counter. The counting data are submitted to the calculations group. The completed results are reviewed by the measurements supervisor, the project leader and the head of radiochemistry. Approved results are then reported.

Some of the aspects of quality control are outlined below. Emphasis is placed upon maintaining quality on a day-to-day basis throughout the entire analysis.

COUNTERS. Probably the most important and difficult part of quality control in radiochemistry is maintaining the counters in top operating condition. These complex electronic instruments are subject to many ailments and must be continually checked. Even then, a counter may go out of order in the middle of a sample run and the erroneous results go undetected.

Chi-squared tests are taken to check malfunction after maintenance has been performed on an instrument. This checks the statistical behavior of the instrument. The instrument is acceptable if chi-square falls within the limits 0.1 and 0.9.

Individual beta counters are checked daily by taking overnight (if possible) background counts. On the low background CE-14 counters in use, the background ranges from 0.51 to 0.68 among 8 counters. The backgrounds on individual counters are quite stable and error limits are about ± 4%. A 5-day average background, recomputed daily, is used to correct counting results. A series of background measurements is shown in Table 1. A daily background check on CE-14 may be evaluated as a single observation by comparing it to the accumulated average, testing its deviation with Chauvenet's criterion. Normally, however, a background is suspect if it increases 0.1 cpm above normal. An additional background of 0.14 ± 0.02 cpm is introduced by the brass backed planchet, see Table 2.

The low background counters are isolated in a trailer about 100 yards from the laboratory to minimize the possibility of contamination or interference from external radiation sources.

A standard factor is determined daily for each beta counter by counting a long-lived Cl-36 standard on each counter. A standard is assigned to each counter. The standard factor is used to check constancy of measurements from day to day and year to year. The Cl-36 standard has a half-life of

4.4 x 10^5 years and its activity does not diminish by any observable amount and hence no decay correction need be made to counting rates or efficiencies. The standard factor is used to correct each counting measurement made on it. After the background and standard factor corrections are made, a corrected counting rate, say of Y^{90} in a sample, will be the same for any of the Tracerlab CE-14 low background chambers at the laboratory. The standard factor on CE-14 is obtained by counting standards of about 2,500 cpm for 10 minutes and this count must fall within approximately ± 2% of the preceding day or the counter is checked for malfunction. A series of standard factor measurements is shown in Table 1.

CALIBRATION IRRADIATIONS. Thermal neutron irradiations of normal and enriched uranium are performed once or twice a year to check on overall chemistry and counting measurements. For a given condition of irradiation the same relative concentrations of fission product activities are always obtained. Radiochemical analyses of the product mixture for the isotopes of interest give constant ratios of each isotope to some standard isotope whose fission yield is well known. By this means, fission product radiochemical analyses are checked from year to year.

On one recent calibration in 1960, CAL-1-60, Mo^{99} was used as the standard reference isotope and many nuclides, including Sr^{90}, were analyzed. Two technicians each performed quadruplicate analyses for each nuclide. The Mo^{99} count rates on each sample were about 10^4 cpm and the standard deviation of the disintegration rate of the solution was ± 1.8%. The Sr^{90} count rates on each sample were about 1,700 cpm and the standard deviation of the disintegration rate was ± 1.3%. Therefore, the ratio of Sr^{90}/Mo^{99} could be determined with good precision to check against previous irradiations.

MISCELLANEOUS CALIBRATIONS. Solutions of NBS standardized isotopes are obtained to check on counter calibrations and/or radiochemistry. In the case of isotopes which are beta-counted or gross- gamma counted, it is desirable to standardize for each isotope to be determined. In the case of isotopes counted on the gamma spectrometer, it is only necessary to check the efficiency versus energy curve.

The Sr^{90} analyses at Tracerlab are based on the fact that the radiochemical yield of the chemical procedure is the same as the chemical yield when exchange occurs between the added carrier and/or tracer and the microquantity of the element present in the radioactive form. This is true for Sr^{90} regardless of the composition of the sample analyzed providing the sample is put into complete aqueous solution. The number and types of steps intervening between the initial interchange and the final sample is not important providing the product is a pure sample of Y^{90} and strontium and yttrium chemical yields are accurately determined. Therefore, different chemical procedures may be used for different sample types without the necessity of running continuously standard samples of all these types.

The results of analyzing NBS Sr^{90} No. 4919-B are shown in Table 3. The values obtained by Tracerlab are in good agreement with the certified value, with the average value 2.3% higher than NBS.

Additional analyses of successive dilutions of this standard show the relation between count rate and disintegration rate is linear down to low count rate levels of less than 1 cpm Y^{90} which, by coincidence, in these samples, is also about 1 dpm Sr^{90}. The results of this dilution test are presented in Table 4.

Four-pi counting of isotopes employing a Tracerlab CE-10 counter is sometimes used for counter calibration checks or independent checks of values reported by standardizing laboratories.

Frequent intra-laboratory comparisons are also made. These may consist of analysis of mixtures for many isotopes or solutions of single isotopes. Intra-laboratory counting measurements on prepared samples have also been quite valuable. In the field of alpha counting both by gross counting methods and alpha pulse height analysis, periodic cross-counting of prepared samples has been used as a basis for maintaining primary alpha standards of high precision. Recently we have cross-checked our primary alpha standards at UCRL. They were counted several times over a period of time on the UCRL high precision, high geometry alpha counter.

STRONTIUM-90 STANDARD SAMPLES. Low level counting Sr^{90} standard samples prepared by HASL have been used to check overall procedural results on low level samples. The results of the analyses on a Standard Milk Ash Sample received from HASL in June 1959 are reported in Table 5. The unweighted average of recent analyses on this sample is 1.62 ± 0.16 dpm Sr^{90} per gram of ash. This is 3.2% higher than the HASL recommended value of 1.57 ± 0.14 dpm Sr^{90} per gram supplied. The recommended value was obtained from analyses of the sample by several laboratories. All of Tracerlab's analyses fall within the range of values (1.17 to 1.76 dpm/gm) reported previously by other laboratories and well within the limits of the HASL recommended value.

REPLICATE ANALYSES. Many replicate analyses have been performed at Tracerlab on many Sr^{90} samples. Table 6 shows the results of 5 different technicians on a Sr^{90} solution with a precision of ± 5.6%. Evaluation of results of the analyses of blind replicates submitted to Tracerlab have shown that the work is being done with a good degree of reproducibility. For instance, 8 milk ash samples, later found to be replicates, were analyzed for calcium and Sr^{90}. At a level of about 45 dpm per total sample and 13 $\mu\mu$c Sr^{90} per gram Ca, the range was 9.6% and standard deviation ± 3.4%. The results are given in Table 7. Calcium analyses show a good degree of reproducibility and the results of analyses on one quality control sample give a precision of ± 1.5%. Calcium analyses are reported in Table 8.

PROCEDURE BLANK. It is not feasible to check the radioactivity of each piece of equipment or reagent which goes into the low level laboratory.

Periodically blank samples are processed through the entire chemical and counting procedure to insure that there is no contamination which will contribute to specific analyses in progress.

Reagent contamination has not been a problem up to this time in the analyses of samples for low level Sr^{90}. Probably the largest uncertainty in the blank correction is the variable activity present in the planchet assembly and slight variations in counter backgrounds. Work is presently underway to lower these uncertainties. Variations of this type are significant in samples of less than one disintegration per minute. However, in Table 5, the standard sample measuring 1.55 dpm in the total sample analyzed is in good agreement with the larger samples containing up to 25 dpm when compared on a dpm per gram basis. Blank values are in the region of less than 0.2 cpm, the minimum detectable count rate of the CE-14 counters. When corrected for overall chemical yields, decay corrections, etc., blanks may vary from 0.4 to 1 dpm per total sample due to the leverage factors. Further blank studies are being performed to reduce this area of variation.

REPRODUCIBILITY OF LOW-LEVEL COUNTING SAMPLES. Figure 1 presents some data on the reproducibility of low-level counting samples. This is a preliminary plot of some data which should receive better statistical analysis.

The data was obtained in taking purity decay measurements on Rh^{102} samples. The observed count rates less background and blank on each sample were averaged without making appropriate decay corrections and plotted against the standard deviation of the average C_o (corrected count rate at reference time). The "curve" levels off rapidly in the region below 0.5 cpm and in the region of 0.2 cpm usually taken as the lower limit of detectability on our CE-14 counters, the error rapidly increases. The rapid increase in error at levels below 0.5 cpm is consistant with the results of Table 4.

COUNTING SAMPLES. The Y^{90} samples are usually counted to a smaller statistical error than required by specifications. Sample isotopic purity is checked where possible by decay measurements. Every bone or milk ash sample analyzed for Sr^{90} is counted on a low background beta counter two or three times over a period of decay of 2 or 3 half-lives. Figure 2 shows the decay of a Y-90 sample of initially 2 cpm to non-detectable levels over 6 half-lives. This procedure insures that measurements are being made on pure 2.67 day Y^{90}.

For other nuclides, depending on the extent and number of decontamination steps, it is possible to spot check the samples for purity of beta decay or absorption characteristics or gamma and alpha emitter spectral shape.

If there is any doubt about sample purity, recounting and/or rework to obtain constant specific activity are performed.

Table 9 contains a partial listing of the results of some of these re-milks and reworks. After these data were taken the counters became suspect due to erratic sample decay plots. From these data it is quite evident that counter problems not detectable by normal background and standard counting can produce very bad results.

When the sample was reworked it could not be definitely established that the counters in question were unreliable. In those cases where the original and reworks agreed it is probable that the counters became faulty after the first decay point, upon which the calculation is based, had been taken.

The quality control steps were able to detect erroneous results in these cases and to prove other results reliable.

TABLE 1. TYPICAL BACKGROUNDS AND STANDARD FACTORS ON A CE-14 LOW BACKGROUND COUNTER

Counter No. L-D

Day (1961)	Bkgd (cpm)[1] Daily	Bkgd (cpm)[1] 5 Day Av.	Std. Factor[2] Daily	Std. Factor[2] 5 Day Av.[3]
Feb. 6	0.540	0.524	0.995	0.995
7	0.505	0.525	1.004	0.997
8	0.562	0.540	1.002	1.000
9	0.545	0.540	0.991	0.998
10	0.565	0.544	1.008	1.000
Av.	0.54 ± 0.02	- -	1.000 ± 0.007	- -

1) Backgrounds counted caily (no planchet) for 300-3000 min. Brass planchet background is 0.14 ± 0.02 cpm.

2) Standard factor taken daily by counting Cl-36 standard of 2500 cpm for 10 min.

3) The consecutive 5 day average is used in correcting data.

TABLE 2. VARIATION OF COUNTER BACKGROUNDS WITH DIFFERENT COUNTERS AND PLANCHETS

TRACERLAB CE-14 COUNTERS

Counter No.	Counter Bkg (Air and Planchet) CPM	Planchet Bkg (Air and Plan.-Air) CPM	No. Planchets Counted (1)
A	0.680 ± 0.031	0.14 ± 0.03	9 (2)
B	0.657 ± 0.020	0.15 ± 0.04	9
C	0.754 ± 0.015	0.10 ± 0.03	8
D	0.714 ± 0.034	0.10 ± 0.04	8
E	0.630 ± 0.040	0.15 ± 0.05	9
F	0.706 ± 0.032	0.14 ± 0.06	9
G	0.654 ± 0.031	0.16 ± 0.03	7
H	0.703 ± 0.063	0.15 ± 0.07	7
Average	0.69 ± 0.063	0.14 ± 0.02	---

1) Brass planchet 24 mm diam. with aluminum ring. Total of 86 planchets counted.

2) Average of 8, one rejected by Q test.

TABLE 3 ANALYSES OF NBS SR^{90} STANDARD NO. 4919-B

All TLW Analyses Methane End Window Proportional Counting

SAMPLE	DATE	Sr^{90} Concentration dpm/ml x 10^{-5} Each	Average	Difference From NBS Per Cent
Sun-5	June 1959	(2.947)		
Sun-6	June 1959	2.844		
Sun-7	June 1959	2.791	2.818 ± 1.7%	+4.2
Sun-8	June 1959	2.872		
Sun-9	June 1959	2.853		
Sun-10	June 1959	2.826	2.850 ± 1.4%	+5.4
Sun-1	Nov. 1959	2.649		
Sun-2	Nov. 1959	2.584	2.617 ± 2.2%	-3.2
TLW-3	Jan. 1960	2.718		
TLW-4	Jan. 1960	2.799	2.759 ± 2.6%	+2.0
TLW-1[a)]	Jan. 1960	2.853		
TLW-2[a)]	Jan. 1960	2.874	2.864 ± 0.65%	+5.9
Average			2.782 ± 3.8%	+2.3
NBS Cert ($4\pi\beta$ Proportional)			2.704 ± 1.5%	

a) Analyses of a vial aliquoted and flame sealed at time of stock dilution

For all calculations at Tracerlab

$\lambda = 6.86 \times 10^{-5}$ days^{-1} $T_{\frac{1}{2}} = 27.65$ y.

Reference time of calculation day 329 in 1959

TABLE 4 ANALYSIS OF Sr^{90} AT DECREASING ACTIVITY LEVELS

Samples Obtained by Successive Dilutions of NBS No. 4919-B

SAMPLE NO.	COUNTER TYPE[a)]	ACTIVITY LEVEL NET MEASURED Y^{90}(cpm)[b)]	dpm Sr^{90} x 10^{-5}/ml[c)]	Difference from expected per cent
3	MEW	1160	2.718	+ 0.6
4	MEW	1234	2.799	+ 3.5
11	CE-14	126	2.600	- 3.8
12	CE-14	112	2.583	- 4.5
21	CE-14	11.92 ± 1.3%	2.549	- 5.7
22	CE-14	11.84 ± 1.3%	2.510	- 7.2
31	CE-14	1.31 ± 7.3%	2.688	- 1.0
32	CE-14	1.44 ± 7.0%	2.873	+ 6.3
33	CE-14	1.25 ± 7.0%	2.519	- 6.1
34	CE-14	1.25 ± 7.5%	2.71	- 0 -
41	CE-14	0.34 ±15. %	1.59	- 41.2
42	CE-14	0.48 ±10. %	2.23	- 17.5
43	CE-14	0.54 ± 9.1%	2.48	- 8.3
44	CE-14	0.63 ± 8.1%	2.83	+ 4.9
45	CE-14	0.38 ±14. %	2.89	+ 6.9
46	CE-14	0.48 ±10. %	3.73	+ 38.1
47	CE-14	0.31 ±19. %	2.71	- 0 -
48	CE-14	0.57 ± 7.8%	4.59	+ 69.4

a) MEW means Methane End Window proportional counter, CE-14 means Tracerlab low background counter

b) Counter and planchet backgrounds and carrier blank subtracted

c) NBS Value - 2.704 x 10^5 ± 1.5%

TABLE 5 QUALITY CONTROL MILK POWDER SAMPLES
STANDARD MILK ASH PREPARED BY HASL-NYOO
HASL RECOMMENDED VALUE 1.57±0.14 dpm/gm ASH

Date	Weight of Ash Analyzed GMS	DPM Sr-90 found in Sample Analyzed	DPM Sr-90 per GM of Sample	Average DPM per GM
Summer 1959	14.57	23.7	1.63 ± 0.03	
	15.04	25.2	1.68 ± 0.03	
	9.83	14.7	1.49 ± 0.05	
	9.45	14.6	1.54 ± 0.04	
	9.65	14.1	1.46 ± 0.05	
	9.82	14.0	1.43 ± 0.07	
	4.71	6.96	1.48 ± 0.07	
	4.56	6.84	1.50 ± 0.06	
	2.42	3.39	1.40 ± 0.12	
	2.36	3.23	1.37 ± 0.12	1.50 ± 0.03
Fiscal Year 1959-1960 NO MILK SAMPLES ANALYZED				
November 1960	7.48	12.12	1.62 ± 0.05	
" "	7.28	11.58	1.59 ± 0.03	
February 1961	1.00	1.55	1.55 ± 0.17	
" "	5.00	8.65	1.73 ± 0.06	1.62 ± 0.16

TABLE 6 REPLICATE Sr^{90} ANALYSES

DUPLICATE ANALYSES OF A SR-90 SOLUTION BY DIFFERENT TECHNICIANS

	DPM/ML[a)]
	120 ± 4
	122 ± 4
	124 ± 4
	130 ± 4
	110 ± 2
	125 ± 2
	(97 ± 1) b
	115 ± 3 b
	119 ± 4
	115 ± 1
AVERAGE	120 ± 7 ± 5.6%

a) True dpm value of solution not known.

b) New technician.

TABLE 7 REPLICATE ANALYSES OF MILK ASH SAMPLES

Sample Number	Per Cent Ca Found	dpm Sr^{90} per Gm of ash	$\mu\mu c$ Sr^{90} per gm of Ca
1728	20.62	5.90 ± 0.08	12.9 ± 0.2
1729	20.87	5.78 ± 0.07	12.5 ± 0.1
1730	20.74	6.07 ± 0.07	13.2 ± 0.1
1731	20.35	6.10 ± 0.08	13.5 ± 0.2
1732	20.59	5.71 ± 0.08	12.5 ± 0.2
1733	21.10	5.84 ± 0.08	12.5 ± 0.2
1734	20.40	6.20 ± 0.08	13.7 ± 0.2
1735	20.30	5.94 ± 0.06	13.2 ± 0.1
Average(1)	20.61 ± 0.28%	5.94 ± 0.17	12.7 ± 0.4
Std. Dev. (%)	± 1.4 %	± 2.8 %	±3.3%

(1) Standard deviation computed by range factor method.
ANAL. CHEM. 23 636 1951

TABLE 8 REPLICATE CALCIUM ANALYSES OF ASHED BONE MEAL (No. 1158)

SOLUTION NO.	PER CENT CALCIUM[1)] RUN No. 1	RUN No. 2	RUN No. 3
1160	36.96	37.69	
1161	37.90	37.99	
1162	37.64	37.45	
1163	38.26	37.89	38.64
1164	36.92	38.35	37.94
1165	36.75	37.86	
1166	37.06	38.05	
1167	38.12	38.44	
1168	37.51		
1169	37.60		
1170	38.96		
1171	37.00		

OVERALL AV.[2)] 37.77 ± 0.59%

RANGE 36.75 to 38.96%

PRECISION ±1.5%

1) Different Runs Usually by Different Technicians

2) Std. Deviation = $\sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$

TABLE 9 COMPARISON OF REMILKED Sr-90 RESULTS (a)

May - June 1961

Sample No.	dpm Sr-90 per sample Original	Remilk	Ratio Original/Remilk
B 11259	0.7 ± 0.1	0.8 ± 0.1	0.9
B 11262	1.37 ± 0.14	1.46 ± 0.24	0.94
B 11412	9.17 ± 0.43	9.25 ± 1.16	1.01
B 11452	<1.1	<1.1	--
M 1793	29.3 ± 0.08	24.8 ± 0.05	1.18
M 1795	10.83 ± 0.8	13.4 ± 0.5	0.81
B 1879	51.3 ± 0.07 (b)	47.5 ± 0.07	1.08
M 1889	6.16 ± 0.31 (b)	4.86 ± 0.30 (c)	1.27
M 1892	70.6 ± 0.6	75.7 ± 0.8	0.92

(a) Original counting data suspect due to later counter malfunction.

(b) Original B 1879 and M 1889 counted simultaneously on same pair of counters later found to be malfunctional.

(c) New sample aliquot taken.

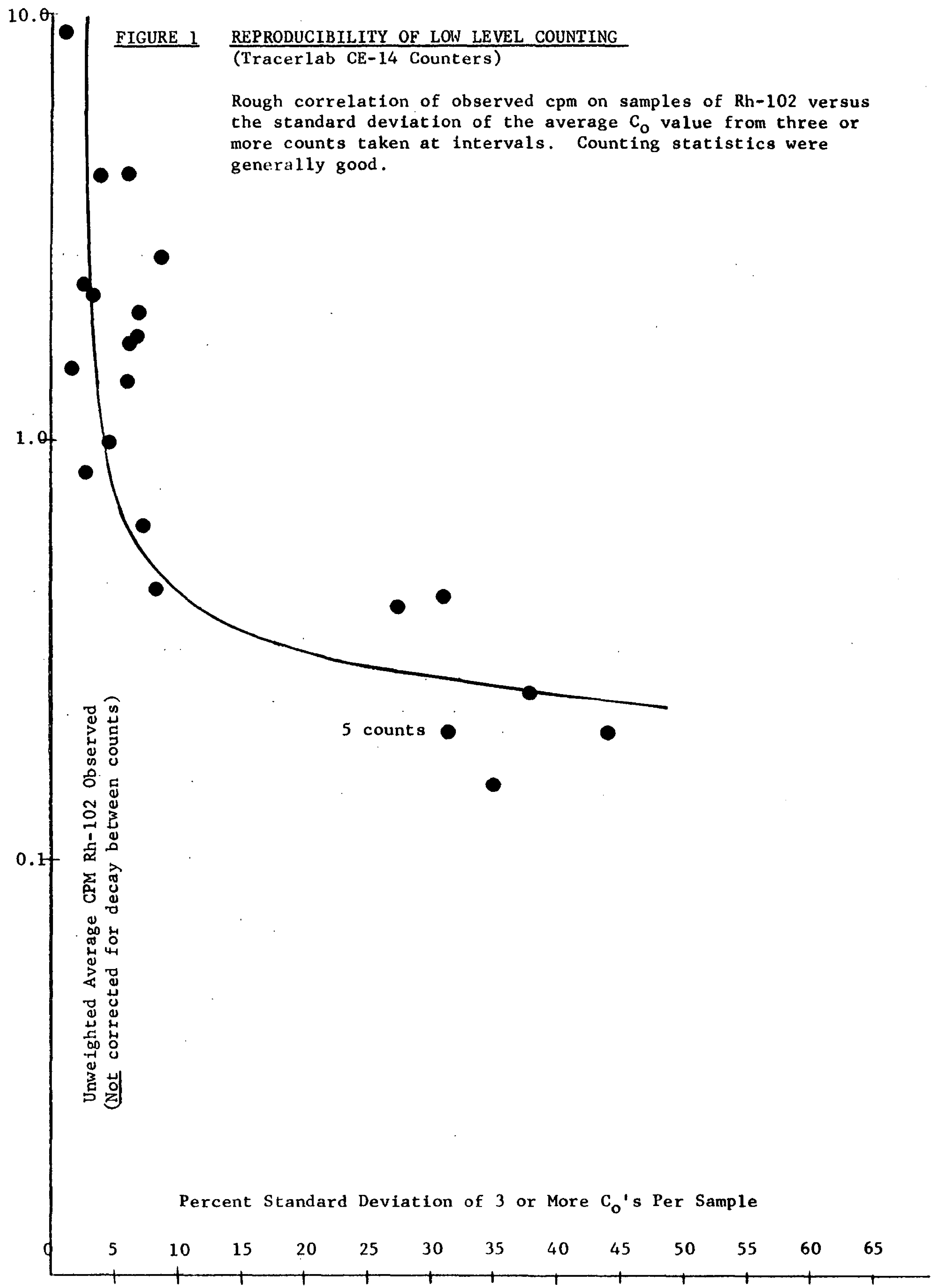


FIGURE 1 REPRODUCIBILITY OF LOW LEVEL COUNTING
(Tracerlab CE-14 Counters)

Rough correlation of observed cpm on samples of Rh-102 versus the standard deviation of the average C_o value from three or more counts taken at intervals. Counting statistics were generally good.

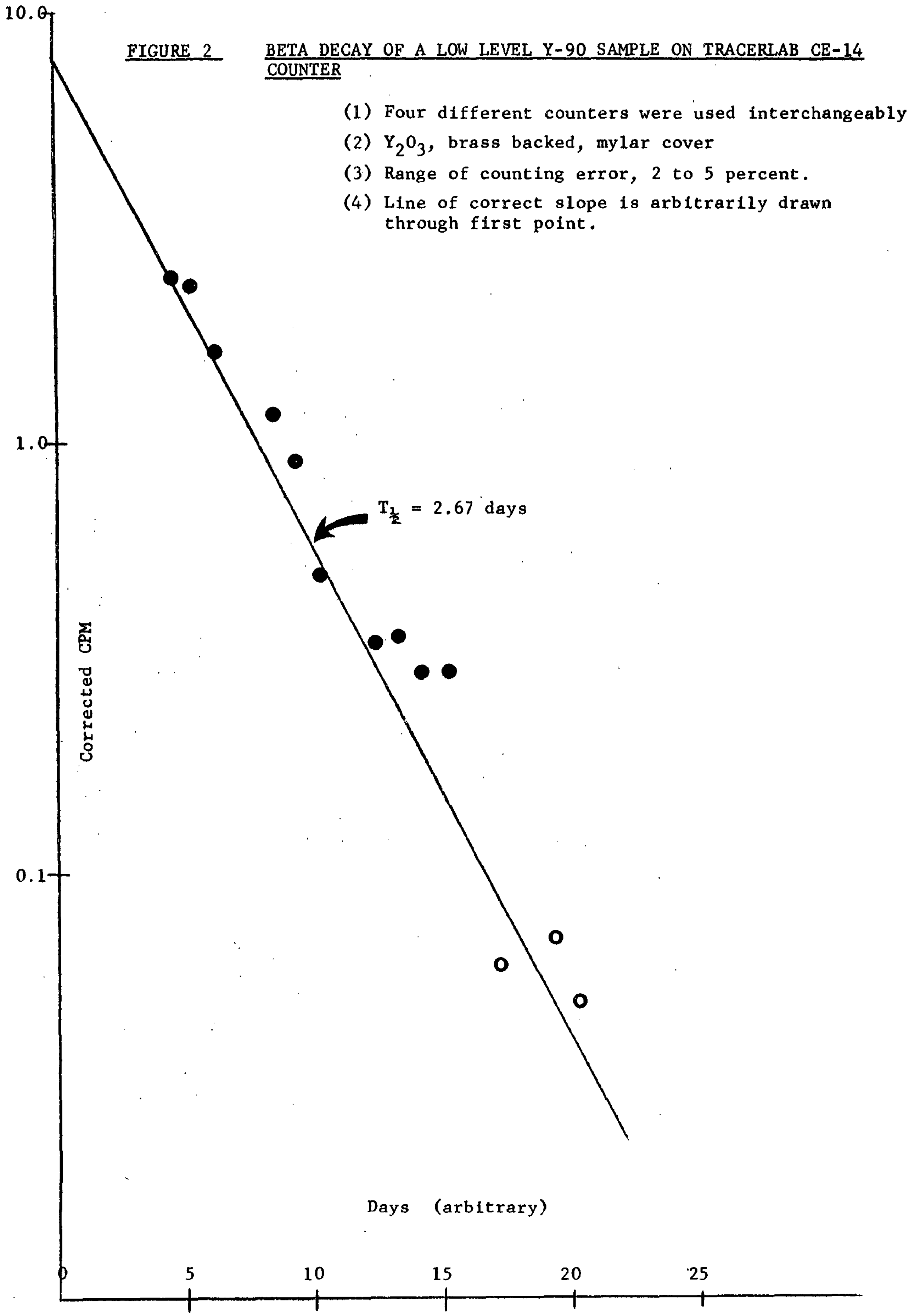


FIGURE 2 BETA DECAY OF A LOW LEVEL Y-90 SAMPLE ON TRACERLAB CE-14 COUNTER

(1) Four different counters were used interchangeably

(2) Y_2O_3, brass backed, mylar cover

(3) Range of counting error, 2 to 5 percent.

(4) Line of correct slope is arbitrarily drawn through first point.

Part lV - Recent Publications Related to Fallout

1. Anderson, E. C., et al., "Estimation of Total Body Fat from Potassium^{40} Content", Science 133, p. 1917 (June 16, 1961).

2. Baarli, J. et al., "Radiocesium and Potassium in Norwegians" Nature 191 p.436 (July 29, 1961).

3. Barreira, F., "Concentration of Atmospheric Radon and Wind Direction", Nature 190, p. 1092 (June 17, 1961).

4. Bartlett, B. O. et al., "Relationship Between the Deposition of Strontium^{90} and the Contamination of Milk in Britain During 1958-1960, July 1961, (To be summarized in ARCRL 5).

5. Bergh, H. et al., "Fallout in Norwegian Milk in 1959", FFIS Intern Rapport S-03, Reference 136 (December 1960).

6. Bodner, W. F., "Effects of Plant Nutrients on Uptake of Radiostrontium by Thatcher Wheat", Science 133, p. 1921 (June 16, 1961).

7. Bryant, F. J. and Loutit, F. J., "Human Bone Metabolism Deduced from Strontium Assays", AERE - R 3718, H. M. S. O. London 1961.

8. Catsch, A. and Schindewolf-Jordan, D., "Removal of Internally Deposited Radionuclides by Triethylenetetraamine-hezaacetic Acid", Nature 191, p. 715 (August 19, 1961).

9. Cohn, S. H., et al., "Diet Induced Changes in the Exchange and Accretion of Radiostrontium by Rat Skeleton", Radiation Research 15, p. 59 (January 29, 1961).

10. Cohn, S. H. and Robertson, J. S., "Determination of the Body Burdens of Marshallese Exposed to Fallout Utilizing a Portable Whole-Body Counter", BNL 5281.

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12. Cowan, G. A., "Scientific Applications of Nuclear Explosions", Science 133, p. 1739 (June 2, 1961).

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13. Fletcher, N. H., "Freezing Nuclei, Meteors and Rainfall", Science 134, p. 361 (August 11, 1961).

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Recent Publications Related to Fallout - cont'd.

15. Freiling, E. C., "Radionuclide Fractionation in Bomb Debris", Science 133, p. 1991 (June 23, 1961).

16. Gustafson, P. F. et al., " Comparison of Beryllium^{7} and Cesium^{137} Radioactivity in Ground-Level Air", Nature 191, p. 454 (July 29, 1961).

17. Hall, T., "X-ray Flourescence Analysis in Biology", Science 134, p. 449 (August 18, 1961).

18. Ichikawa, R., et al., "Evaluation of the Origins of Strontium^{90} Contained in Wheat Plant", Science 133, p. 2017 (June 23, 1961).

19. Kulp, J. L. et al., " Sr^{90} and Cesium^{137} in North American Milk", Science 133, p. 1768 (June 2, 1961).

20. Lee, C. C., "Effects of Plant Nutrients on Uptake of Radiostrontium by Thatcher Wheat", Science 133, p. 1921 (June 16, 1961).

21. Lillegraven, A., et al., "Fallout in Norwegian Milk in 1960", FFIS, Intern Rapport S-06, Reference 136 (May 1961).

22. Menzel, R. H., et al., "Foliar Retention of Sr^{90} by Wheat", Science 134, p. 559 (August 25, 1961).

23. "Atomic Radiation and Living Organisms", Nature 191, p.556 (August 5, 1961).

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26. Rama, et al., "Lead^{210} in Natural Waters", Science 134, p. 98 (July 14, 1961).

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