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QUARTERLY SUMMARY REPORT

(December 1, 1972 through March 1, 1973)

Prepared by

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Environmental Studies Division

Preceding reports in this series:

Year	HASL Report Nos.
1958	42, 51
1959	65
1960	77, 84, 88, 95
1961	105, 111, 113, 115
1962	117, 122, 127, 131
1963	132, 135, 138, 140
1964	142, 144, 146, 149
1965	155, 158, 161, 164
1966	165, 171, 172, 173
1967	174, 181, 182, 183
1968	184, 193, 197, 200
1969	204, 207, 210, 214
1970	217, 224, 227, 237
1971	239, 242, 243, 245
1972	246, 249, 257, 259
1973	268

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ABSTRACT

This report presents current data from the HASL Fallout Program; The Laboratory of Radiation Ecology, University of Washington; and the EURATOM Joint Nuclear Research Centre at Ispra, Italy. The initial section consists of interpretive reports on radium daughter products and lead in marine organisms, inventories of radionuclides in the stratosphere, strontium-90 in diet, and the tropospheric baseline concentration of lead. Subsequent sections include tabulations of radionuclide levels in fallout, surface air, stratospheric air, foods, milk, and tap water. A bibliography of recent publications related to radionuclide studies, is also presented.

Table of Contents

List of Tables
Part II
HASL Fallout Program

List of Figures

Part II

HASL Fallout Program

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 Dec. 1, 1972 to Mar. 1, 1973. The next report is scheduled for publication July 1, 1973. Preceding reports in the series, starting with HASL-42, "Environmental Contamination from Weapons Tests", and continuing through HASL-273, (this report) may be purchased from the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U. S. Department of Commerce, Springfield, Virginia 22151. A complete listing of these Fallout Program Quarterly Summary Reports is given on the title page of this report.

To give a more complete picture of the current fallout situation and to provide a medium for rapid publication of radionuclide and trace element 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 HASL is identified as such and is gratefully acknowledged by the Laboratory. In this report, data from the Laboratory of Radiation Ecology - Univ. of Wash. and the EURATOM Joint Nuclear Research Centre at Ispra, Italy are given.

A portion of the radiochemical analyses either have been or are being carried out by commercial laboratories under contract to the HASL Environmental Studies Division. The results of these analyses are reported as part of HASL's regular fallout program. The contractor analytical laboratories which provided data are Nuclear Science and Engineering Corporation, Pittsburgh, Pa.; Isotopes, Inc., Westwood, N. J.; Radiochemistry Inc., Louisville, Ky.; LFE Environmental Analysis Laboratories Division, Richmond, Calif.; Controls for Radiation, Inc., Cambridge, Mass.; Hazleton-Nuclear Science Corp., Palo Alto, Calif. (now Isotopes Palo Alto Laboratories); Food, Chemical and Research Laboratories, Inc., Seattle, Washington; Custom Nuclear Co., Mountainview, Calif.; Ledoux and Company, Teaneck, N. J.; and U. S. Testing Co., Richland, Washington.

This report is divided into four main parts:

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

PART I

INTERPRETIVE REPORTS

AND

N O T E S

POLONIUM-210, LEAD-210 AND STABLE LEAD IN MARINE ORGANISMS

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ABSTRACT. The natural radiation environment of marine organisms has classically been attributed, in the main, to contributions from ^{40}K, which is ubiquitous in seawater, and to cosmic ray irradiations. More recently, however, evidence has accumulated which suggests that a significant component of the natural radiation dose to marine biota comes from internally deposited, naturally occurring alpha radionuclides. Of these, ^{210}Po appears to be the most predominant. This finding has important implications in the overall assessment of the introduction of artificial radioactivity to the marine environment. The fraction of the radiation dose experienced by marine biota from man-made sources is significantly lowered when the radiation dose rate from ^{210}Po as well as ^{40}K and cosmic rays are considered. The present paper summarizes the results of extensive measurements of ^{210}Po, ^{210}Pb and stable Pb in marine biota, with the aim of increasing the data base from which to make generalizations concerning the importance of these entities in the marine environment.

1. INTRODUCTION

To adequately assess the impact of artificial radioactivity on the biota of any ecosystem, it is first necessary to establish the natural radiation environment to which the biota are subject. While this statement may appear thoroughly simplistic when one considers the abundant literature that has come into being on the subject of radioactivity in the environment, the fact remains

that during the past half decade evidence has been mounting which indicates that previous estimates of the natural radiation environment of marine organisms were low. This underestimate results because previous estimates considered only cosmic ray irradiations and contributions from ^{40}K [1]. If account is taken of the contribution from internally deposited alpha emitters, the total radiation dose rate is much higher [2].

The levels of natural radioactivity in the marine environment have recently been summarized [3, 4]. Of these summaries, that of Woodhead [3] presents the most current information concerning the activity levels of alpha emitting radionuclides in marine biota. However, Bowen et al. [4] have cautioned, "that these high alpha exposures apply generally to marine organisms is not yet well established, while the low cosmic ray and ^{40}K background rest on much data". The present paper presents a summary of measurements for ^{210}Po, ^{210}Pb (the precursor of ^{210}Po) and stable Pb in marine organisms. The intent is to extend our understanding of the range of concentrations of these entities in the marine environment so that the part played by the alpha emitting radionuclides in contributing to the natural radiation dose rate of marine biota can be more properly assessed.

2. HISTORICAL REVIEW

It seems useful to give a brief review of the work which has led to our current understanding of naturally occurring ^{210}Po and ^{210}Pb in marine organisms. The first reports that sparked interest in ^{210}Po content of marine biota were those of Marsden [5], Cherry [6] and Hill [7], all in 1964. Hill [8] had earlier reported high levels of ^{210}Po in cockles, but the number of measurements were not sufficient to attach any generalities about the extent of accumulation of this radionuclide in marine biota. Rama, Koide and Goldberg [9] had shown as early as 1961 that zooplankton contained easily measurable quantities of ^{210}Pb, and that biological accumulation of this radionuclide could act as a

significant vector for its transport from the surface layers of the oceans to depth. Thus, all data to 1965 indicated that naturally occurring radionuclides that accumulated in marine organisms might significantly alter previous radiation dose rate estimates.

Little appeared in the open literature on the subject of natural α-radioactivity in marine biota until 1966. Beasley and Palmer [10] and Folsom, Pillai and Beasley [11] reported a limited number of measurements of ^{210}Po in selected marine organisms taken from higher trophic levels than those reported by earlier workers. Easily measurable quantities of the radionuclide were found which extended the conclusion of widespread incorporation of ^{210}Po into the tissues of marine vertebrates and invertebrates.

In 1966, one of us (TMB) had begun a systematic investigation of ^{210}Pb (with some ^{210}Po measurements included) to understand how the concentration of these radionuclides changed in marine organisms with respect to hydrography and season. During that investigation [12], Holtzmann [13] reported ^{210}Pb and ^{210}Po concentrations in a variety of both marine and freshwater animals collected from various geographical areas. The results of his measurements again showed that the radiation dose rate from ^{210}Po alone substantially altered previous estimates based only on ^{40}K and cosmic rays. In 1967, Shannon and Cherry [14] extended their measurements of ^{210}Po in marine plankton, confirming Cherry's earlier observations in 1964, again emphasizing the high alpha dose rate experienced by the first two trophic levels in the marine food chain.

With the data in hand by 1968, it was clear that marine organisms could serve as important vectors for inclusion of ^{210}Pb and ^{210}Po into the diet of man. Beasley, Osterberg and Jones [15] showed that marine protein concentrates, prepared from benthic fishes, which were under investigation as possible supplements to human food, contained significant quantities of ^{210}Pb and ^{210}Po. This initial work was recently extended by a second study of concentrates, prepared by surface feeding fishes, with essentially the same result [16].

These findings have interesting implications when one considers the increasing emphasis being placed on the world oceans as a source of protein for the world's population.

By early 1969 it seemed to us that there was a need to answer certain outstanding questions regarding ^{210}Pb and ^{210}Po in the marine environment. We needed to know, for example: 1) The concentrations of these radionuclides in water and how they varied in time ; 2) If seasonal effects were prominent in the input of these radionuclides in the water column, were there pronounced fluctuations in the concentrations of these entities in the biota; 3) What were the relationships between various trophic levels with regard to concentration processes; and 4) was there a correlation between the amounts of ^{210}Pb and stable Pb in marine organisms.

Until 1970, all of the investigations dealing with ^{210}Pb and ^{210}Po in organisms suffered from an adequate number of analyses for these radionuclides in seawater. In 1967, Kaufman [18] had reported measurements of ^{210}Po in surface waters in the Atlantic collected in 1966-67 from stations ranging from $20^{o}N$ to $20^{o}S$ at distances far from the continents. Kaufman's average value was 40×10^{-15} Ci/liter. In 1970, Shannon and Cherry [17] published their measured concentrations of these radionuclides in the surface waters around Cape Town, South Africa. The mean ^{210}Po activity was 30×10^{-15} Ci/liter. These figures are in agreement with a very limited number of measurements made by Folsom, Pillai and Beasley [11] on surface waters collected from the Scripps Institution of Oceanography pier in 1966. The values obtained for duplicate samples were 30×10^{-15} and 37×10^{-15} Ci/liter. The general agreement between the activity levels measured from widespread geographic areas gave some hope of being able to compare levels of these radionuclides in organisms collected from different oceans. Thus, generalizations concerning the radiation dose rate from the alpha emitting radionuclides appeared possible. In addition, the measurements of both Kaufman and Shannon and Cherry showed that ^{210}Pb and ^{210}Po were present in

about equal concentrations. Langford's measurements [19] of particulate ^{210}Po and ^{210}Pb in the surface waters of both the Pacific and Atlantic Oceans averaged approximately 9×10^{-15} Ci/liter (discounting one rather large value for a sample containing algae), which suggests that approximately 25 % of the ^{210}Po was present in a form retained by a 0.3 μmillipore filter.

While our own investigations were under way dealing with the trophic level relationships of these radionuclides in marine biota, Shannon and Cherry [20] and Shannon [21] presented the results of similar studies which they had completed in South African waters. Their results showed striking trophic level magnifications of ^{210}Po, with less accumulation for ^{210}Pb. Concentration factors for ^{210}Po in whole pelagic fishes approached 10^5, those for ^{210}Pb being less than 3×10^2. These findings did much to solidify the argument that these radionuclides do, in fact, provide the majority of the natural radiation dose rate to marine organisms.

The present paper is intended to compliment the findings of Shannon and Cherry while adding new data which includes the additional measurement of stable lead. Individual organ analyses have been performed where possible to more closely identify the individual sites of accumulation of the radionuclides.

3. METHODOLOGY

3.1. Sample Collection

The samples analyzed in this study were collected from different stations within the Strait of Juan de Fuca (Puget Sound, Washington State) from the M/V COMMANDO of the University of Washington and the northeast Pacific Ocean from the R/V YAQUINA of Oregon State University. Plankton samples were taken using one-half and one meter plankton nets of zero mesh size. Macroplankton samples and pelagic fishes were taken with an Isaacs-Kidd midwater trawl and a large commercial otter trawl. Samples were sorted on deck immediately after trawling and were quick frozen rather than formalin preserved.

3.2 Analytical Procedure

3.2.1. Polonium

At the home laboratory, samples were dissected (where necessary), weighed and dried to constant weight at 105°C. Known amounts of ^{208}Po were added to the samples prior to dissolution to trace the subsequent yield of ^{210}Po through processing. The samples were digested in redistilled, reagent grade concentrated nitric and perchloric acids until all organic matter was oxidized. The polonium isotopes were plated onto a 2.2 cm diameter pure Ag disc (coated on one side with an inert organic film) from a 0.5 N HCl solution containing approximately 100 mg of ascorbic acid. Spontaneous electrodeposition of the polonium isotopes was accomplished by suspending the Ag disc in the solution by a glass rod attached to the bottom of a watch glass [12]. The solution was warmed and agitated by placing a teflon coated magnet in the beakers which were placed on a large, stirring hot plate. Deposition times were normally 16 hours. Following the plating, the small Ag disc was removed from the solution, rinsed with distilled water and left to dry in air. Since the deposition of ^{210}Po on these small Ag-discs is not quantitative it was necessary to further strip the solution of polonium isotopes, to allow for the ingrowth of fresh ^{210}Po as an indication of the ^{210}Pb present. This was accomplished by adding another 100 mg of ascorbic acid to the solution, warming the mixture to 90°C and plating the remainder of the polonium onto a large Ag disc (4.92 cm diameter, uncoated). Plating times for this part of the separation were normally two hours.

3.2.2. Stable Pb

After the second stripping of polonium from the mixture, ^{212}Pb was added to the solution and allowed to equilibrate overnight with the stable Pb in solution. The solution was warmed to further ensure exchange. The Pb fraction was subsequently isolated by extracting the solution twice with 20 ml portions of a 1 % DDTC/chloroform mixture (diethylammonium diethyldiethiocarbamate). The organic extract was then transferred to a clean, 250 ml beaker containing a small

amount of 6 M HNO_3, and warmed to remove chloroform. The nitric acid phase was then evaporated to dryness, and traces of organic matter were destroyed by heating the beakers in a muffle furnace to 500°C for approximately one hour. The Pb isotopes and stable Pb were removed from the beaker by rinsing with 0.3 N HCl. The rinses were transferred to 25 ml tared volumetric flasks, and the yield of Pb was obtained by total gamma counting of the ^{212}Pb. Stable Pb in the solution was determined by atomic absorption spectrometry using the method of standard additions. Once the weight of solution had been determined, the absorbance of the solution at the 2833 Å line of Pb was recorded. The solution was reweighed, and 25 µg of Pb were added (10 µ liters of solution). The solution was well mixed and the absorbance again determined. This procedure was repeated until three data points were available to plot absorbance versus p.p.m. Pb in the solution. Such a plot when extrapolated through the zero addition ordinate gives an intercept on the abscissa corresponding to the Pb concentration of the solution. Multiplying by the original solution weight yields the total Pb in the sample. A computer programme was written to perform a least squares fit to the absorbance-concentration plot, and the final readout of the analysis reports the net p.p.m. of Pb in the specimen analyzed.

3.2.3. Lead-210

The solution remaining after the Pb determination was stored from 3 - 12 months to allow for ingrowth of fresh ^{210}Po. The determination of this "in-grown" ^{210}Po provides a determination of the ^{210}Pb in the sample at the time of analysis. Counting of the samples was done using surface barrier diodes whose background count rates ranged from 0.02 - 0.05 c.p.m. (0.1 - 0.3 d.p.m.) in the energy interval used to determine the ^{210}Po. Counting times for both the ^{210}Po and ^{210}Pb measurements were 1000 minutes. In the determination of the ^{210}Po which grew into the solution following the original ^{210}Po measurements, selected samples were plated on large Ag discs and the ^{210}Po determined by total α-counting [12]. The majority of the samples,

however, were analyzed by alpha spectrometry. The ^{210}Pb in the sample was calculated using standard equations for growth of daughter activities from initially pure parent isotopes. Reagent blanks were analyzed with each group of samples, the groups generally being comprised of from 8-12 samples.

The calibration of the alpha spectrometer system was performed and verified in several ways. First, the efficiency of the diodes was determined by counting an electrodeposited ^{239}Pu disc whose size was very nearly that of the Ag discs used in the experiments and whose source strength had been determined by a number of laboratories in the United States. Second, calibrated standard solutions of both ^{210}Po and ^{208}Po were stippled onto Ag discs and the efficiency of the diodes was compared with that determined by the ^{239}Pu standard. In each case, agreement was excellent. Finally, the total alpha counters were designed to be identical to those originally described by Hallden and Harley [22]. The efficiencies of our total alpha counters were 48, 48 and 46 percent, as determined using the calibrated ^{210}Po solutions which compares very well with the figure of 47 percent quoted by the above authors. The efficiency of each diode was checked periodically to ensure that no changes in detector efficiency was occurring. During the course of the research, no change was observed.

We were concerned at the outset that upon thawing our plankton specimens prior to analysis that some ^{210}Po and ^{210}Pb might be lost due to the lysis of cells during freezing. We considered this much less of a problem with our larger pelagic and benthic crustacea and fishes because they could be dissected for individual tissue analysis while still in the frozen state. To determine to what extent these radionuclides appeared in the liquor upon thawing, we analyzed zooplankton samples (principally euphausiids and mysiids taken from three separate tows) which were composed of the sample plus liquor, a sample without liquor, and a sample of liquor itself. Table I shows that at the precision of the analyses, small, but nonetheless measurable amounts of activity for ^{210}Po were present in the liquor. The variability between aliquots do not permit an

Table I. ^{210}Pc and ^{210}Pb loss from zooplankton upon thawing.

Sample	Aliquot + liquor (Total d.p.m.)		Aliquot − liquor (Total d.p.m.)		Liquor (Total d.p.m.)	
	^{210}Po	^{210}Pb	^{210}Po	^{210}Pb	^{210}Po	^{210}Pb
Zooplankton	29.8 ± 2.2	0.70± 0.04	28.2 ± 1.9	0.90± 0.06	0.9 ± 0.1	N.D.
Zooplankton	9.4 ± 0.8	0.70± 0.04	10.1 ± 0.9	0.80± 0.05	0.50± 0.06	N.D.
Zooplankton	13.5 ± 1.0	1.40± 0.07	13.1 ± 1.1	0.90± 0.06	1.4 ± 0.1	0.06 ± 0.03

N.D. Not detected. Errors are standard errors (1 σ) derived from radiometric measurements only.

assessment of the loss through simple difference, but the magnitude of the ^{210}Po activity in the liquor suggests that anywhere from 3 - 10 % of the activity may be lost in this fluid. For this reason, plankton samples were transferred frozen to tared beakers to prevent such loss.

3.2.4. Error analysis

In reducing all of the radiometric count rate data, account has been taken of the propagation of errors according to standard statistical techniques. The variability in the data reported here are of two kinds. In many cases, a single sample has been analyzed which was comprised of one or many individuals. In these cases, the errors which are shown for the radiometric data are those derived from a propagation of the errors associated with the count rates of the ^{210}Po and ^{208}Po radionuclides in each measurement which was made. The propagation of the error was based on the standard error ($1\ \sigma$) associated with each radiometric measurement. In other cases we have used number weighted averages of the radiometric measurements which were made by separate analysis on a number of individuals collected at the same time. In these cases, the error associated with the data is the standard deviation from the mean radiometric value. We have chosen to underline, in our tables, those data which were derived by averaging a number of individual analyses. For example, all but three of the measurements reported in Table II under Trophic Level II Pelagic invertebrates represents the mean activity level calculated by averaging the individual measurements of the number of hauls taken. The error associated with single Pb analyses was derived from a propagation of errors associated with the measurements of the ^{212}Pb yield determinant, and the error associated with the measurement of a number of samples to which known amounts of Pb had been added. In our experience, the detection of 0.4 p.p.m. Pb in our final solution was difficult. This required that our original sample contain 10 µg of Pb, which in many instances was not the case. Consequently, both the ^{210}Pb and Pb data have large errors associated with their measurement due to biological variability

and the fact that we were working very near the detection limit for both of these entities.

The radiometric data have been corrected for decay to time of catch, and correction has been made for ingrowth of ^{210}Po from ^{210}Pb in the samples between catch data and analysis data. Despite our efforts to successfully wet ash the samples to complete dissolution in hot, concentrated perchloric acid, specimens were lost due to the rapid and explosive reaction of the organic matter with this strong oxidant. We have chosen to include at least a description of these lost samples in our tables for completeness. In other cases, the activity level of one or the other of the radionuclides was below our detection limit, as was the Pb. Those samples that were lost in analyses appear as lines in the tables whereas those measurements which were below our detection limit are shown as N.D.

4. RESULTS AND DISCUSSIONS

4.1. General findings

Tables II-VII contain the results of our measurements which began in 1969. We have chosen to order the organisms in trophic levels following the example of Osterberg, Pearcy and Curl [24] since many of the organisms analyzed were identical to those used by the above authors to study trophic level relationships of artificially produced radionuclides.

The data of Table II show that the variability within the microzooplankton does not permit a definitive statement about seasonal trends in ^{210}Po, ^{210}Pb or Pb concentrations within this group. Polonium-210 and Pb concentrations appear to be higher during winter months, decreasing to lower values during summer and fall, yet the same trend is not observed for ^{210}Pb. In the case of euphausiids, the levels of ^{210}Pb and Pb appear to show an increase in concentration during winter months (presumably due to increased input from rainfall (12)) but again the confidence limits associated with the averaged results are large. By contrast,

Table II. Lead-210, polonium-210 and stable Pb in marine organisms.
[activities are recorded as d.p.m./g dry weight; stable Pb as µg Pb/g dry weight]

	Date	Location	Organ	No. of hauls	^{210}Po	^{210}Pb	Pb	$^{210}Pb/Pb$
Trophic Level II								
Pelagic Invertebrates								
Microzooplankton (Acarcia, sp. Calanus finmarchicus, amphipods, zoea)	January 70	JDF	entire	(1)	15.0 ± 1.1	0.5 ± 0.1	12.5 ± 0.6	0.04 ± 0.01
	April 70	JDF	entire	(7)	3.8 ± 0.8	0.7 ± 0.3	6 ± 3	0.10 ± 0.07
	July 70	JDF	entire	(4)	6.9 ± 0.6	0.5 ± 0.1	1.5 ± 0.9	0.3 ± 0.2
	October 70	JDF	entire	(2)	2.7 ± 0.8	0.04± 0.01	0.9 ± 0.2	0.04 ± 0.01
Euphausiids (Euphausia pacifica)	October 69	JDF	entire	(3)	2.6 ± 0.3	0.2 ± 0.1	0.60± 0.06	0.3 ± 0.2
	January 70	JDF	entire	(6)	3.0 ± 0.6	0.9 ± 0.3	1.5 ± 0.7	0.6 ± 0.3
	March 70	NH-25	entire	(1)	8.8 ± 0.6	0.80± 0.06	1.2 ± 0.1	0.70 ± 0.08
	April 70	JDF	entire	(5)	3.2 ± 0.2	0.5 ± 0.3	0.6 ± 0.2	0.8 ± 0.5
	July 70	JDF	entire	(3)	2.0 ± 0.1	0.2 ± 0.1	0.3 ± 0.1	0.7 ± 0.4
Mysids (Acanthomysis sculpus)	October 69	JDF	entire	(4)	3.9 ± 0.9	0.7 ± 0.3	1.7 ± 1.0	0.4 ± 0.3
	January 70	JDF	entire	(7)	21.1 ± 3.3	0.3 ± 0.2	1.4 ± 1.0	0.2 ± 0.2
	April 70	JDF	entire	(4)	24.8 ± 3.9	0.2 ± 0.1	0.6 ± 0.2	0.3 ± 0.2
	October 70	JDF	entire	(1)	3.9 ± 0.3	0.10± 0.02	0.20± 0.02	0.5 ± 0.1

JDF = Straits of Juan de Fuca

NH = Newport Hydrographic Line. A series of stations seaward from Newport, Oregon. Numerical citations represent nautical miles offshore.

Table III. Lead-210, polonium-210 and stable Pb in marine organisms.

[activities are recorded as d.p.m./g dry weight; stable Pb as μg Pb/g dry weight]

Trophic Level III	Date	Location	Organs	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb
Pelagic Invertebrates								
Shrimp (Sergestes similis)	May 69	off Oregon Coast	entire	(*)	10	25.4 ± 1.9	0.20± 0.02	0.50± 0.05
	October 69	JDF	entire	(51)	10	12.2 ± 2.5	1.0 ± 0.6	0.30± 0.08
	January 70	JDF	entire	(100)	8-11	49.5 ± 7.6	0.5 ± 0.3	1.2 ± 0.5
	March 70	NH-25	entire	(20)	8-11	40.4 ± 2.9	-	5.0 ± 0.1
	April 70	JDF	entire	(78)	5-16	27.0 ± 2.0	0.4 ± 0.5	0.50± 0.05
	July 70	JDF	entire	(*)	*	16.7 ± 1.2	0.6 ± 0.1	0.90± 0.09
(Pasifea pacifica)	October 70	JDF	entire	(8)	5- 9	18.8 ± 1.3	0.8 ± 0.1	N.D.
				(42)	16-21	5.3 ± 1.1	0.20± 0.02	2.2 ± 1.7
	January 70	JDF	entire	(20)	10-16	4.2 ± 0.01	0.03± 0.01	N.D.
	April 70	JDF	entire	(200)	14-24	5.9 ± 0.5	0.6 ± 0.1	0.70± 0.07
	July 70	JDF	entire	(200)	*	2.3 ± 0.2	N.D.	0.40± 0.04
(Pandalus jordani)	October 69	JDF	entire	(144)	5-22	23.0 ± 5.0	0.4 ± 0.2	1.6 ± 1.0
	November 69	NH-25	entire-eggs	(11)	21-23	17.3 ± 1.1	0.90± 0.04	2.2 ± 0.1
			eggs	(11)		1.1 ± 0.1	0.40± 0.06	0.10± 0.01
			entire	(6)	6-10	36.5 ± 2.0	2.2 ± 0.1	7.6 ± 0.2
	January 70	JDF	entire	(34)	8-30	38.4 ± 4.0	0.7 ± 0.4	2.2 ± 0.8
	April 70	JDF	entire	(38)	8-18	20.9 ± 3.5	0.3 ± 0.1	0.5 ± 0.2
	July 70	JDF	entire	(5)	11-25	13.1 ± 0.9	0.5 ± 0.1	0.9 ± 0.1
			hepatopancreas	(14)	20-40	201 ±12	3.4 ± 0.6	2.20± 0.03
			G.I. contents	(14)	20-40	41.8 ± 2.3	8.9 ± 0.5	20.7 ± 0.4
			muscle	(14)	20-40	2.0 ± 0.2	N.D.	0.10± 0.02
			remains	(14)	20-40	6.6 ± 0.4	0.40± 0.05	0.50± 0.01

* not recorded

Table IV. Lead-210, polonium-210 and stable Pb in marine organisms.

[activities are recorded as d.p.m/g dry weight; stable Pb as µg Pb/g dry weight]

Trophic Level III	Date	Location	Organ	No. of individuals	Size (fork length-mm)	^{210}Po	^{210}Pb	Pb
Pelagic Vertebrates								
Smelt (Thaleichthys pacificus)	October 69	JDF	entire	(86)	50-145	1.3 ± 0.2	0.13± 0.07	0.4 ± 0.2
			eviscerated	(86)	50-145	1.0 ± 0.2	0.09± 0.05	0.4 ± 0.1
			viscera	(86)	50-145	4.9 ± 1.8	1.1 ± 0.7	3.0 ± 1.0
	November 69	NH-25	entire	(1)	152	1.1 ± 0.1	0.10± 0.02	0.60± 0.04
			eviscerated	(1)	152	0.30± 0.04	0.08± 0.02	0.40± 0.04
			viscera	(1)	152	10.9 ± 0.7	1.4 ± 0.1	2.8 ± 0.1
	January 70	JDF	entire	(102)	35-110	1.4 ± 0.8	0.20± 0.05	1.0 ± 0.3
			eviscerated	(102)	35-110	1.3 ± 0.4	0.06± 0.03	0.4 ± 0.2
			viscera	(102)	35-110	4.8 ± 1.8	0.9 ± 0.1	5.1 ± 2.0
	April 70	JDF	entire	(73)	48- 70	1.4 ± 0.2	0.40± 0.04	1.0 ± 0.3
			eviscerated	(73)	48 -70	0.9 ± 0.1	0.3 ± 0.1	0.8 ± 0.4
			viscera	(73)	48- 70	3.4 ± 0.5	1.0 ± 0.7	1.0 ± 0.3
	May 70	46°-23.8' 124°-15.4'	entire	(9)	86-110	4.7 ± 0.3	N.D.	1.30± 0.03
			eviscerated	(9)	86-110	3.4 ± 0.3	N.D.	1.30± 0.03
			viscera	(9)	86-110	23.3 ± 2.3	0.30± 0.07	0.4 ± 0.1
	July 70	JDF	entire	(33)	70-152	1.5 ± 0.1	0.10± 0.05	0.20± 0.02
			eviscerated	(33)	70-152	0.60± 0.06	0.10± 0.01	0.20± 0.02
			viscera	(33)	70-152	3.70± 0.02	0.10± 0.01	0.20± 0.02
	October 70	JDF	entire	(15)	42- 55	1.6 ± 0.1	0.20± 0.07	1.2 ± 0.1
			eviscerated	(16)	65-145	0.5 ± 0.1	0.02± 0.008	0.40± 0.04
			viscera	(16)	65-145	-	-	-

Table V. Lead-210, polonium-210 and stable Pb in marine organisms.

[activities are recorded as d.p.m./g dry weight; stable Pb as μg Pb/g dry weight]

	Date	Location	Organ	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb
Trophic Level III-V								
Pelagic Vertebrates								
Whiting (Theragra chalcogrammus)	October 69	JDF	entire	(9)	87-115	3.4 ± 0.2	0.07± 0.01	0.40± 0.02
			eviscerated	(9)	87-115	1.80± 0.02	0.05± 0.01	0.10± 0.01
			viscera	(9)	87-115	15.1 ± 1.1	0.20± 0.04	2.9 ± 0.1
		JDF	muscle	(1)	266	0.60± 0.04	0.05± 0.01	0.70± 0.01
			liver	(1)	266	4.3 ± 0.3	-	-
			viscera	(1)	266	8.5 ± 0.6	0.05± 0.03	N.D.
			bone	(1)	266	0.5 ± 0.1	0.3 ± 0.1	N.D.
	January 70	JDF	entire	(1)	135	4.1 ± 0.2	0.40± 0.04	0.90± 0.02
			eviscerated	(1)	135	1.40± 0.09	0.08± 0.02	0.90± 0.03
			viscera	(1)	135	19.5 ± 1.4	2.4 ± 0.2	0.60± 0.08
		JDF	muscle	(6)	225-350	0.20± 0.02	N.D.	0.30± 0.03
			liver	(6)	225-350	1.1 ± 0.1	0.20± 0.02	1.20± 0.02
			viscera	(6)	225-350	4.3 ± 0.2	N.D.	0.30± 0.01
			stomach contents	(6)	225-350	22.1 ± 1.1	0.20± 0.02	0.70± 0.05
			bone	(6)	225-350	0.10± 0.02	0.10± 0.02	0.80± 0.08
	April 70	JDF	entire	(3)	275-300	2.3 ± 0.2	0.20± 0.05	0.60± 0.06
			eviscerated	(3)	275-300	1.0 ± 0.1	0.10± 0.02	0.5 ± 0.2
			viscera	(3)	275-300	20.9 ± 2.0	0.90± 0.05	0.8 ± 0.3
		JDF	muscle	(2)	283-340	0.50± 0.05	0.02± 0.01	0.10± 0.01
			liver	(2)	283-340	9.2 ± 0.6	0.20± 0.02	0.30± 0.01
			bone	(2)	283-340	0.30± 0.02	0.10± 0.04	0.05± 0.01
	July 70	JDF	muscle	(4)	350-400	0.10± 0.03	N.D.	N.D.
			bone	(4)	350-400	0.10± 0.01	0.04± 0.01	0.20± 0.02
Salmon (Oncorhynchus tshawytscha)	October 69	U. of Wash.	muscle	(17)	66- 86 (cm)	0.10± 0.05	0.03± 0.01	0.20± 0.10
			liver	(17)	66- 86 (cm)	1.8 ± 0.9	0.4 ± 0.1	0.8 ± 0.3
			muscle	(1)	80 (cm)	0.05 ±0.02	0.02± 0.005	0.06± 0.01
			liver	(1)	80 (cm)	1.40± 0.01	N.D.	-
			kidney	(1)	80 (cm)	2.6 ± 0.5	0.40± 0.08	0.60± 0.02
			bone	(1)	80 (cm)	0.30± 0.03	0.30± 0.03	4.20± 0.05

Table VI. Lead-210, polonium-210 and stable Pb in marine organisms.
[activities are recorded as d.p.m./g dry weight; stable Pb as μg Pb/g dry weight]

	Date	Location	Organ	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb
Trophic Level II-V								
Demersal Fishes	October 69	JDF	muscle	(9)	158-395	0.3 ± 0.1	0.03± 0.01	0.10± 0.05
Flounders			liver	(9)	158-395	8.0 ± 0.8	0.20± 0.05	1.0 ± 0.2
(Atheresthes stomiasis)			viscera	(9)	158-395	14.8 ± 3.0	0.20± 0.05	2.0 ± 0.1
(Eopsetta jordani)			bone	(9)	158-395	0.10± 0.05	0.10± 0.05	10.0 ± 2.0
(Glyptocephalus zachirus)			skin	(9)	158-395	1.2 ± 0.1	0.10± 0.02	0.50± 0.07
(Lyopsetta exilis)	January 70	JDF	muscle	(3)	300-470	0.20± 0.07	0.03± 0.01	0.3 ± 0.1
(Parophrys vertulus)			liver	(3)	300-470	-	-	-
(Lepidopsetta bilineata)			bone	(3)	300-470	0.10± 0.05	0.10± 0.04	1.6 ± 1.0
	March 70	NH-25	muscle	(19)	200-400	0.6 ± 0.2	0.10± 0.05	0.10± 0.03
			liver	(19)	200-400	7.0 ± 0.4	0.30± 0.03	0.20± 0.02
			viscera	(19)	200-400	13.8 ± 2.0	1.00± 0.07	1.0 ± 0.3
			bone	(19)	200-400	0.3 ± 0.1	0.40± 0.07	0.5 ± 0.1
	April 70	JDF	muscle	(8)	320-450	0.3 ± 0.1	0.04± 0.01	0.10± 0.03
			liver	(8)	320-450	2.9 ± 0.8	1.7 ± 1.0	0.5 ± 0.2
			viscera	(8)	320-450	20.8 ± 7.0	2.5 ± 1.0	1.5 ± 0.7
			bone	(8)	320-450	0.20± 0.07	0.4 ± 0.1	0.7 ± 0.2
	July 70	JDF	muscle	(7)	210-400	0.4 ± 0.2	0.02± 0.005	0.4 ± 0.1
			liver	(7)	210-400	19.3 ± 8.0	-	10.1 ± 5.0
			bone	(7)	210-400	0.5 ± 0.1	0.7 ± 0.1	4.0 ± 1.0
Hake								
(Merluccius productus)	May 69	46°21.2'	muscle	(12)	350-560	0.60± 0.04	0.004±0.001	N.D.
		124°14.0'	Liver	(12)	350-560	4.3 ± 0.3	-	-
			viscera	(12)	350-560	10.1 ± 0.5	0.20± 0.01	N.D.
			bone	(12)	350-560	0.20± 0.04	0.20± 0.02	2.50± 0.02
			gonads	(12)	350-560	2.8 ± 0.3	0.04± 0.02	0.10± 0.02
			spleen	(12)	350-560	7.1 ± 0.8	0.40± 0.07	-
			heart	(12)	350-560	5.6 ± 0.4	0.10± 0.02	-
			gills	(12)	350-560	2.2 ± 0.4	0.20± 0.04	0.20± 0.01
			skin	(12)	350-560	0.07± 0.01	0.07± 0.01	0.30± 0.01
			eyes	(12)	350-560	0.10± 0.06	0.02± 0.007	N.D.
			kidney	(12)	350-560	13.1 ± 1.0	0.10± 0.04	N.D.

Table VI. (ctd.)

	Date	Location	Organ	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb
Hake (ctd.) (Merluccius productus)	June 70	Wash.-Ore. coast	muscle	(19)	*	0.40± 0.04	0.01± 0.002	0.30± 0.03
			liver	(19)	*	2.0 ± 0.2	-	-
			bone	(19)	*	0.20± 0.02	0.20± 0.02	0.80± 0.08
Rockfish (Sebastodes melanops)	November 69	NH-25	eviscerated	(3)	75- 78	2.7 ± 0.2	0.30± 0.04	0.50± 0.01
			viscera	(3)	75- 78	41.4 ± 2.4	1.5 ± 0.3	9.6 ± 0.2
(Sebastodes flavidus) (Sebastodes elongatus) (Sebastodes crameri) (Sebastodes alutus) (Sebastolobus alascanus)	January 70	JDF	muscle	(3)	290-400	-	-	-
			liver	(1)	290-400	6.4 ± 2.0	0.3 ± 0.1	2.8 ± 1.0
			viscera	(1)	290-400	4.6 ± 0.3	0.10± 0.05	1.10± 0.02
			+G.I. contents	(1)	290-400	27.1 ± 1.7	0.10± 0.01	3.70± 0.05
			bone	(3)	290-400	0.4 ± 0.1	0.10± 0.05	3.40± 0.05
	March 70	NH-25	muscle	(3)	420	0.4 ± 0.1	N.D.	0.20± 0.02
			liver	(3)	420	13.1 ± 5.0	0.8 ± 0.5	2.2 ± 0.5
			viscera	(3)	420	16.8 ± 2.0	0.30± 0.04	0.10± 0.03
			bone	(3)	420	1.7 ± 0.7	1.7 ± 0.7	2.2 ± 0.5
	April 70	JDF	muscle	(4)	235-250	0.10± 0.05	N.D.	0.20± 0.02
			liver	(4)	235-250	4.2 ± 0.3	0.20± 0.05	0.30± 0.03
			bone	(4)	235-250	0.07± 0.02	0.07± 0.03	0.30± 0.04
	July 70	JDF	muscle	(3)	*	0.10± 0.05	0.02± 0.01	0.10± 0.05
			liver	(3)	*	8.0 ± 0.6	N.D.	0.60± 0.06
			bone	(3)	*	0.13± 0.05	0.13± 0.06	-
Sablefish (Anoplopoma fimbria)	January 69	JDF	muscle	(3)	300-400	1.10± 0.06	0.01± 0.005	0.20± 0.02
			liver	(3)	300-400	80.0 ± 5.0	-	0.40± 0.04
			viscera	(3)	300-400	101 ± 3	0.10± 0.01	0.70± 0.01
			stomach contents	(3)	300-400	18.6 ± 1.0	0.10± 0.01	1.10± 0.02
			muscle	(2)	375-460	-	-	-
			liver	(2)	375-460	25.3 ± 1.2	0.20± 0.01	0.40± 0.01
			viscera	(2)	375-460	-	-	-
			G.I. contents	(2)	375-460	118 ± 6	3.7 ± 0.2	5.4 ± 0.1
			bone	(2)	375-460	0.40± 0.07	0.20± 0.02	0.70± 0.02
	March 70		muscle	(3)	280-300	0.70± 0.06	-	-
			liver	(3)	280-300	100	1.6 ± 0.1	1.00± 0.01
			viscera	(3)	280-300	47 ± 2	0.50± 0.01	0.30± 0.01
			bone	(3)	280-300	0.70± 0.07	0.06± 0.01	-

* not recorded
+ comprised mostly of mysids

Table VI. (ctd.)

	Date	Location	Organ	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb
Sablefish (ctd.) (Anoplopoma fimbria)	April 70	JDF	muscle	(3)	410–420	0.8 ± 0.3	0.05± 0.01	0.20± 0.02
			liver	(3)	410–420	36.0 ± 3.0	0.7 ± 0.1	0.40± 0.04
			bone	(3)	410–420	0.5 ± 0.1	0.20± 0.05	1.00± 0.08
	July 70	JDF	muscle	(2)	465–490	0.10± 0.01	N.D.	N.D.
			liver	(2)	465–490	40.0 ± 2.5	-	1.40± 0.04
			bone	(2)	465–490	0.7 ± 0.1	0.3 ± 0.1	0.40± 0.04
Ratfish (Hydrolagus colliei)	October 69	JDF	muscle	(3)	430–550	0.10± 0.01	0.10± 0.03	0.30± 0.03
			liver	(3)	430–550	1.4 ± 0.3	0.06± 0.03	0.10± 0.01
			viscera	(3)	430–550	26.1 ± 1.8	0.30± 0.03	N.D.
			notochord	(3)	430–550	0.5 ± 0.2	0.50± 0.05	N.D.
			skin	(3)	430–550	0.50± 0.06	0.20± 0.04	0.40± 0.01
	January 70	JDF	muscle	(3)	570	0.40± 0.04	0.08± 0.02	0.20± 0.04
			liver	(3)	570	0.60± 0.06	0.08± 0.02	-
			viscera	(3)	570	20.4 ± 6.0	0.6 ± 0.1	0.6 ± 0.3
			notochord	(3)	570	0.8 ± 0.1	0.70± 0.05	2.2 ± 0.1
			G.I. contents	(3)	570	30.6 ± 6.0	1.00± 0.05	3.8 ± 1.0
	March 70	JDF	eviscerated fish	(1)	280	0.40± 0.01	-	0.30± 0.03
	April 70	JDF	muscle	(7)	420–540	0.4 ± 0.1	0.20± 0.02	0.2 ± 0.1
			liver	(7)	420–540	4.3 ± 1.1	0.40± 0.04	0.4 ± 0.1
			bone	(7)	420–540	0.7 ± 0.1	0.6 ± 0.1	1.3 ± 0.1
	July 70	JDF	muscle	(5)	350–500	0.30± 0.03	-	-
			liver	(5)	350–500	0.80± 0.06	-	-
			bone	(5)	350–500	1.00± 0.09	0.9 ± 0.1	1.70± 0.02

Table VII. Lead-210, polonium-210 and stable Pb in marine organisms.

[activities are recorded as d.p.m./g dry weight; stable Pb as μg Pb/g dry weight]

	Date	Location	Organ	No. of individuals	Size (mm)	^{210}Po	^{210}Pb	Pb	$^{210}Pb/Pb$
Benthic Organisms									
Sea Urchins (Strongylocentrotus drabachensis)	November 69	NH-25	test	(7)	60	2.0 ± 0.1	1.5 ± 0.1	1.2 ± 0.1	1.3 ± 0.1
			viscera	(7)	60	15.0 ± 1.1	3.5 ± 0.2	15.0 ± 0.6	0.20± 0.01
			gonad	(7)	60	8.2 ± 0.7	0.8 ± 0.2	-	-
(Allocentrotus fragilis) (Brisaster, sp.) (Strongylocentrotus palidus)			test	(16)	20	3.5 ± 0.3	0.9 ± 0.1	0.9 ± 0.1	1.0 ± 0.2
			viscera	(16)	20	48.2 ± 3.3	12.7 ± 3.3	14.6 ± 0.4	0.9 ± 0.2
	January 70	JDF	test	(2)	43	1.9 ± 0.1	0.80± 0.05	0.9 ± 0.1	0.9 ± 0.1
			viscera	(2)	43	21.0 ± 1.5	6.9 ± 0.5	5.2 ± 0.1	1.3 ± 0.1
			test	(2)	60	1.1 ± 0.1	0.60± 0.06	0.7 ± 0.1	0.9 ± 0.2
			viscera	(2)	60	28.2 ± 1.8	9.4 ± 0.2	8.4 ± 0.1	1.10± 0.03
	March 70	NH-25	test	(11)	*	1.5 ± 0.2	0.8 ± 0.3	1.4 ± 0.1	0.6 ± 0.2
			viscera	(11)	*	36.2 ± 2.8	22.3 ± 2.0	15.1 ± 0.4	1.5 ± 0.1
	April 70	JDF	test	(3)	70- 80	0.6 ± 0.3	0.5 ± 0.1	-	-
			viscera	(1)	70- 80	41.3 ± 4.0	-	-	-
	July 70	JDF	test	(1)	*	0.9 ± 0.1	-	-	-
			viscera	(1)	*	4.1 ± 0.3	-	-	-
Sea Cucumbers (Stichopus, sp. Scotoplanes, sp.)	November 69	NH-25	eviscerated	(1)	360	3.5 ± 0.2	0.20± 0.01	1.4 ± 0.2	0.14± 0.02
		NH-65	eviscerated	(2)	*	5.0 ± 2.8	3.2 ± 1.0	1.1 ± 0.1	2.9 ± 0.9
			viscera	(2)	*	47.7 ± 4.4	5.7 ± 0.5	5.0 ± 1.0	1.1 ± 0.2
	March 70	NH-25	eviscerated	(1)	*	3.7 ± 0.2	0.6 ± 0.1	0.9 ± 0.1	0.7 ± 0.1
Polychaetes (Ophelia travisia) (Aphrodite aculeata)	November 69	NH-25	entire	(5)	24- 35	42.2 ± 2.5	5.3 ± 1.0	15.7 ± 2.0	0.30± 0.07
Snails (Thais, sp.) (Fusitriton)	April 70	JDF	shell	(16)	*	2.5 ± 0.2	-	0.90± 0.05	-
			soft parts	(16)	*	8.8 ± 0.6	-	0.40± 0.04	-

Table VII. (ctd.)

	Date	Location	Depth (meter)	^{210}Po	^{210}Pb	Pb	$^{210}Pb/Pb$
Sediments	March 70	NH-25	201	16.1 ± 2.1	16.1 ± 2.1	12.5 ± 0.1	1.3 ± 0.2
		NH-65	2800	24.7 ± 2.7	24.7 ± 2.7	12.5 ± 0.2	2.0 ± 0.2
		TH-8	190	23.6 ± 2.5	19.4 ± 1.3	12.0 ± 0.2	1.6 ± 0.1
		TH-35	695	28.2 ± 1.9	28.2 ± 2.1	13.5 ± 0.2	2.1 ± 0.2
		TH-65	1975	19.5 ± 2.3	18.9 ± 1.3	12.5 ± 0.2	1.5 ± 0.1

* = not recorded

TH = Tillamook Hydrographic Line. A series of stations seaward from Tillamook, Oregon. Numerical citations represent nautical miles offshore.

the ^{210}Po data for the euphausiids from within Puget Sound seem reasonably constant. The mysids, however, show decidedly higher ^{210}Po concentrations in winter and early spring. Little can be deduced about seasonal trends in the ^{210}Pb and Pb data for mysids again due to variability. The pelagic shrimp data of Table III do show pronounced seasonal changes in ^{210}Po and Pb for both Sergestes similis and Pandalus jordani, yet the ^{210}Pb data does not follow these trends. Moreover, there seems to be no detectable seasonal trends in either the ^{210}Po, ^{210}Pb or Pb concentrations in Pasiphea pacifica. Assuming that the seasonal variations of ^{210}Po in the mysids account in part for the seasonal increases of this radionuclide in S. similis and P. jordani, we conclude that mysids did not comprise a large portion of the food web of P. pacifica in our collections. It is interesting to note the internal distribution of these entities within the various tissues and organs of P. jordani collected in July, 1970. The hepatopancreas shows unusual concentrations of ^{210}Po which exceed 30,000 pCi/kg wet weight which is twice as high as that reported by Cherry, Shay and Shannon for the hepatopancreas of a rock lobster taken in South African waters [24].

A surprising finding to us was the generally low levels of ^{210}Po in the smelt specimens, Table IV. These fishes feed at trophic level II (small crustacea) and we had anticipated that the reasonably high levels of ^{210}Po in the small crustacea would be amplified in fishes feeding at this trophic level. This does not appear to be the case, and is in contrast to data which we have observed for anchovy and saury [16]. These fishes also feed at trophic level I and II, and they have been shown to have high levels of ^{210}Po. The ^{210}Po levels are comparable to those observed by Beasley [12] for Myctophids taken from the north east Pacific, which also feed at trophic level II. We can offer no explanation for this apparent contradiction. Equally interesting is the fact that no seasonal trends are evident in the ^{210}Po, ^{210}Pb or Pb concentrations for those smelt specimens taken from within Puget Sound. There does appear to be a

difference in the concentration of these products in the sample of smelt taken offshore in May, but we cannot attach a particular significance to this finding since lower trophic level specimens collected at the same time were unavailable for analysis.

The data in Table V and VI deal with much larger fishes and therefore contain results of organ analyses. It is clear that the internal organs of these animals contain the highest concentrations of ^{210}Po, ^{210}Pb and Pb and that in some cases, the levels of ^{210}Po can be very high. In particular the liver and viscera of these larger carnivores are shown to be sites of accumulation for ^{210}Po and ^{210}Pb. Stable Pb appears elevated in these tissues in addition to being high in the bone of the majority of the demersal fishes analyzed. We realize that the measurements for 'viscera' are less descriptive than they might be and that they include other organs of interest. However our purpose was to compare internal distribution in a large number of samples and consequently more definitive sites for accumulation within 'viscera' should now be sought based on the high concentration of ^{210}Po, ^{210}Pb and stable Pb that have been found there.

Table VI contains our measurements for demersal fishes which show essentially the same trends we have observed in pelagic fishes. We have chosen to group species of flounders and rockfishes rather than report individual species data, accepting the fact that differences might exist. However, we did not consistently trawl any single species that permitted us to discern any trend within members of the family Pleuronectidae. Accepting this shortcoming, the concentrations and distributions of ^{210}Po, ^{210}Pb and Pb in all of the larger fish species appear comparable.

Finally, Table VII lists our radiometric and stable element results for benthic organisms and some offshore sediments. While an attempt was made to remove sediments which was contained in the visceral mass of these organisms, the organic digest frequently contained small amounts of siliceous residue.

Thus, the values reported for viscera should not be viewed as being entirely derived from systemically deposited ^{210}Po, ^{210}Pb and Pb. By contrast, the shells and tests of the organisms were free from sediment. Again, we have grouped data, since there appear to be no significant differences between species even though certain organisms live at the sediment surface (Allocentrotus fragilis) while others live in the sediments (Brisaster, Sp.). There does not appear to be a large increase in the concentrations of any of the radionuclides or Pb over that observed for sediment. Indeed, the eviscerated sea cucumbers show quite low values for all three entities as do the values for snails. The sediment values for ^{210}Pb and ^{210}Po fall within the range of the average concentration ranges reported for ^{226}Ra [25], the precursor of ^{210}Pb. We have not, however, measured ^{226}Ra in these samples and therefore we have no information as to whether or not the ^{210}Po and ^{210}Pb activities reported here are in secular equilibrium with their ^{226}Ra parent. Carey [26] has characterized the composition of the sediments off the Oregon coast, at the stations sampled, as grading from well-sorted fine sands on the inner shelf to silty clays at depths of 2800 m on the Cascadia Abyssal Plain. The sediments reported here were collected by means of a Smith-McIntyre bottom grab sampler from this general area and we analyzed only the top 1 cm of sediment. Chow and Patterson [27] have reported Pb concentrations of 14 μg/g dry sediment for sediments whose composition approximate those measured here, and considering the variability of Pb concentrations with sediment type which was observed by these investigators, our average value for Pb in sediments of 12.6 ± 0.4 μg/g dry sediment agrees favourably with their findings.

4.2. Trophic level relationships of ^{210}Po, ^{210}Pb and Pb

The relationships between ^{210}Po, and ^{210}Pb concentrations in organisms from different trophic levels are quite similar to those observed by Shannon and Cherry [20]but some significant differences are noted. Table VIII shows a comparison of the data reported by these authors with that measured here.

We have converted our dry weight values to wet weight concentrations by dividing the dry weight activity values by the average wet/dry ratios observed during the preparation of the specimens. Since we did not analyze whole fish of the larger species, we have weighted the ^{210}Po, and ^{210}Pb values reported for individual tissue analyses by the contribution each tissue makes to the total fish weight. Welander [28] has tabulated the weight percentage of tissues from carnivorous fishes, and has shown that, on average, the skin, muscle, bone, liver and viscera comprise 8 - 9, 66, 18, 2, and 5 - 7 percent of the total body weight, respectively. Using these data, we have calculated whole body concentrations of selected fish from the organs we measured. While we find general agreement for ^{210}Pb values, certain fishes measured here appear to have much lower concentrations of ^{210}Po than those reported by Shannon and Cherry. Either there are indeed concentration differences of approximately an order of magnitude between species, feeding at similar trophic levels or other organs within the fishes we analyzed had high concentrations of ^{210}Po which we have failed to note (i.e. kidney, gills, etc.). Stomach content can play an important part in contributing to high levels of whole body ^{210}Po, and this possibility cannot be discounted.

The low levels of ^{210}Po in smaller fishes from trophic level III (smelt) should be more thoroughly investigated since these fishes form the basis of a large commercial fishery which can serve as an important vector for transporting ^{210}Po, ^{210}Pb and Pb to human populations. Data are needed for concentrations of these entities in several such species taken from the same waters, and where possible, stomach contents need to be identified.

4.3. Variability

One shortcoming of the present work is the uncertainty which results from averaging individual measurements. As discussed previously, these uncertainties arise both within the measurements themselves and because of biological variability. At the time we began our measurements, there was not a large literature

Table VIII. Polonium-210 and lead-210 concentrations in marine organisms

[pCi/kg wet wt.]

Trophic Level	Sample	Shannon and Cherry		Present work	
		^{210}Po	^{210}Pb	^{210}Po	^{210}Pb
	Seawater	0.020	0.038	0.038	0.045 +
I	Phytoplankton	76	27	-	-
II	Zooplankton	380	31	237	18
III	Fishes (pelagic)	-	-	140	19 *
III	Large crustacea	-	-	2256	64 **
III-V	Fishes (pelagic)	1260	8	340	7 ***
	Fishes (demersal)	-	-	1063	3 ****
				160	19 *****
				157	7 ******
				106	7 *******

+ ^{210}Po values of Folsom, Pillai and Beasley [11]; ^{210}Pb values of Rama, Koide and Goldberg [9].
* Average of all smelt data
** Average of all S. similis and P. jordani
*** Whiting, October, 69
**** Sablefish, January, 69
***** Patfish, October 69
****** Flatfish, October, 69
******* Hake, May, 69

available concerning contemporary levels of Pb in marine biota, and consequently, the choice of sample size had to be a compromise between that amount of sample which would hopefully yield a reasonable concentration of ^{210}Pb and Pb, but which could also be readily digested by HNO_3 and $HClO_4$ acids. Our experience has shown that the levels of these two entities are very low and that large samples, especially for muscle tissue, are required for accurate analysis. It is possible to improve the measurement of Pb by atomic absorption spectrometry using the newer flameless technique, but this does not obviate the serious problem of contamination both of samples and blanks during sample preparation and analysis. Such difficulties were encountered in some of our analyses; blank values did not lie within a population distribution which had been reasonably well defined by repeated measurements on reagents used in the analysis, and certain biological samples contained uncommonly high Pb concentrations which greatly exceeded values for the same species taken at the same time. This condition applied generally to plankton specimens, where contamination by particulate Pb could most readily occur. Our analyses of dissected specimens were much less troublesome in this respect. Nevertheless, we conclude that at least part of the variability in the Pb data must be attributed to these problems. The specific activity of contemporary Pb is low, ~25 nCi/kg [29], so that radiometric contamination of ^{210}Pb resulting from stable Pb contamination is believed to be negligible.

An equally difficult problem exists in trying to judge how biological variability itself has contributed to the range of concentration values reported here. We are uncertain as to the magnitude of its effect, yet some discussion on the reasons for this variability seems warranted. As such our ideas must be considered highly speculative until further evidence is accumulated from which to draw firmer conclusions. First, if we compare the Pb measurements of Tatsumoto and Patterson [31] with those of Langford [19] for open ocean surface water in the northeast Pacific the agreement is reasonably good. Values range from 0.2 - 0.3 μg/kg of seawater. Langford's value was derived by measuring

the Pb retained by a 0.3 μ millipore filter, while Tatsumoto and Patterson and Chow and Patterson measured Pb in unfiltered, acidified seawater using isotope dilution techniques. It would appear that Pb in seawater is present, therefore, in 'particulate' form. However, the ^{210}Pb values reported by various investigators suggest a pronounced partitioning of ^{210}Pb between 'soluble' and'particulate' forms. Rama, Koide and Goldberg [9] analyzed filtered seawater (pore size of the filter unspecified) and reported concentrations of 0.1 d.p.m./liter in surface waters off California. Lead-210 activity on the filter itself was not detectable. Tsunogai and Nozaki [32] have recently reported an extensive series of measurements in the Pacific in which total ^{210}Pb analyses were performed on the water samples taken at different latitudes. The values for samples between 40 - 50°N confirm the values measured by Rama et al. By contrast, the values reported by Langford for 'particulate' ^{210}Pb show average concentrations of only 0.016 d.p.m./liter or approximately 1/6 that reported for total ^{210}Pb by Rama et al. and by Tsunogai and Nozaki. Moreover, Schell, Jokela and Eagle [33] in a continuation of the present work, have presented data in agreement with particulate ^{210}Pb concentrations reported by Langford. Thus, while the data are not abundant, the possibility that differential solubility exists in seawater for ^{210}Pb and Pb cannot be entirely discounted. The kinetics of this speciation and the biological availability of the different chemical species could lead to marked concentration variations within marine organisms.

Once metabolized, individual tissues of marine organisms might be expected to show significant differences in the rates of turnover for lead; when the specific activity of the water or food changes, those tissues whose lead turnover times are fast will more nearly reflect the prevailing specific activities present in the food on which the organism feeds or the water mass in which it resides. Without definitive measurements on the magnitude of these turnover rates in marine organisms it is difficult to assess their contributions to variability, but it must be assumed that they play some part.

A less obvious, but important factor in the variability of our data, at least with respect to ^{210}Po, is the change observed in concentration with size of organism. Table III clearly shows this to be the case of P. pacifica taken in October, 1969 and for P. jordani taken in November, 1969. In these cases, the ^{210}Po concentration per unit dry weight is higher in the smaller members of the species. This trend does not seem to hold with higher carnivores, however, where a comparison of eviscerated smelt with eviscerated whiting show comparable levels of ^{210}Po. There does seem to be generally higher muscle concentrations in larger fish within species, but the trend is not pronounced. Thus, in an effort to assess general levels of these entities within organisms, the pooling of different sized organisms must always be done judiciously.

4.4. Competition

Our results suggest that Pb does not act as a diluent for ^{210}Pb in organisms. In tissues where both entities have been metabolized, elevated levels of ^{210}Pb are generally accompanied by elevated levels of Pb. Schell et al. [33] have reported data which tend to confirm these findings, with the notable exception of filter feeding organisms such as barnacles and oysters. These authors reported particulate ^{210}Pb, ^{210}Po and Pb values from both fresh and saline water systems which showed a pronounced increase in particulate Pb in winter and spring months which was not accompanied by a parallel trend in either particulate ^{210}Po or ^{210}Pb. The increased concentration of Pb in the water during these months was reflected in increased concentrations of Pb in oysters, but again, no parallel increase in either ^{210}Po or ^{210}Pb concentrations was observed. Accepting the uncertainty as to the concentration of 'soluble' ^{210}Pb, ^{210}Po and Pb in the water, these data suggest no influence of Pb on ^{210}Pb uptake by oysters. However, such an interpretation rests heavily on the assumption that the ^{210}Pb and Pb are

systemically deposited, which may be far from the case when the whole oyster is analyzed. The shellfish concentrations may largely reflect gut contents of ^{210}Pb and Pb, which permit no interpretation about competition.

4.5. Lead specific activities in marine organisms

We have included a limited number of calculations of lead specific activities in Tables II and VII, to indicate the range of values we have encountered in this research. Because of the large deviations observed, we cannot accurately discuss any clear trophic level relationships that would suggest ^{210}Pb and Pb are being metabolized differently at trophic level II or III. The lead specific activities of S. similis and P. jordani, while not shown, fall within the range of values observed for copepods, euphausiids, and mysids. Similarly, lead specific activities for smelt do not show pronounced differences from those observed for crustacea in trophic level II.

The lead specific activities of benthic organisms approximates the lead specific activities measured for sediments, with some notable exceptions. All of the tests of the sea urchins which were analyzed have lead specific activities which fall within the 2 σ value (1.7 ± 0.6 d.p.m. ^{210}Pb/μg Pb) observed for sediments collected offshore. All but one viscera sample from these same organisms lie within the sediment value, the notable exception being the specimen collected in November, 1969. By contrast, two specimens of eviscerated sea cucumbers and the one specimen of polychaete worms analyzed have specific activities which are lower than those observed for sediments at the 2 σ level. Thus, while the sea urchin data would indicate no discrimination in metabolizing Pb and ^{210}Pb from sediments and detritus, the sea cucumber and polychaete analyses suggest preferential uptake of Pb. We have no explanation for this contradictory finding, the resolution of which must rest on a far more extensive series of measurements than have been attempted here.

4.6. Radiation dose rate to marine organisms from ^{210}Po

Table IX contains the range of dose rates experienced from the concentrati

Table IX. Approximate dose rates (mrads/yr) to marine organisms from ^{210}Po and other sources.

Trophic Level		Organism or tissue	Range for ^{210}Po	All external sources plus internal ^{40}K +
II	Invertebrates	Copepods, small crustacean	10 - 60	39
		Euphausiids	15 - 70	
		Mysids	3 -160	
III	Invertebrates	Shrimp		
		S. similis	100 -400	64
		P. pacifica	20 -150	
		P. jordani	120 -350	
III	Vertebrates	Smelt -- eviscerated	3 - 34	64
		viscera	40 -240	
III-V	Vertebrates	Pelagic fishes		
		muscle	1 - 5	64
		liver	16 -140	
		viscera	40 -210	
		bone	1 - 5	
		Demersal fishes		
		muscle	1 - 9	39
		liver	9 -1500	
		viscera	46 -1000	
		bone	1 - 17	
	Detrital Feeders	Sea urchins		
		test	10 - 60	40 - 620
		viscera	20 -190	
		Polychaetes (entire)	270	40 - 620
		Snails		
		shell	90	40 - 620
		soft parts	84	
		Sea cucumber		
		eviscerated	14 - 20	
		viscera	123	

+ Previous estimates by Folsom and Harley [1]. Maximum values have been quoted for all species. Dose rates can be lowered for microzooplankton and fishes depending upon depth of residence in the water column.

of ^{210}Po measured. Such a calculation assumes uniform distribution of the ^{210}Po within the organism or tissue analyzed, and as such is highly conservative. Energy deposition is shown without the inclusion of the usual quality factor of 10 used in expressing alpha dose rates. We have chosen to do so in order that our data will be consistent with previous reports [2, 12], and for easy comparison with the recent summary of dose rates to marine organisms presented by Woodhead [3].

In general, the dose rates listed in Table IX compare favourably with those listed by Woodhead. Our measured values for whole crustacea (shrimp) tend to be higher and our range of dose rates to fish liver shows a much larger value owing principally to unusual ^{210}Po concentrations in sablefish liver. The data do support the contention that ^{210}Po contributes a major portion of the natural radiation dose rate to marine organisms. Unfortunately, the concentrations of ^{210}Po show marked variability within trophic levels and within organisms from the same trophic level and species. Thus, while the dose rates to marine biota from ^{40}K can be reasonably well generalized, based on the near constancy of this radionuclide in seawater, the same can not be said for ^{210}Po. In cases where dose rates from artificially produced radionuclide are calculated from measured concentrations of radionuclide in marine organisms (for example near nuclear power plants or fuel reprocessing plants), a separate analysis for ^{210}Po (and other alpha radionuclides) should be performed, if a comparison is to be made between natural and man-made sources of radiation.

5. CONCLUSIONS

We have attempted here to provide more data from which to assess the role played by ^{210}Po in contributing to the natural radiation dosimetry of marine organisms. Our results show that the variability between trophic levels can be pronounced, and that organisms from within trophic levels, especially lower trophic levels, show seasonal changes in their ^{210}Po concentrations.

We have confirmed that ^{210}Po concentrations are amplified through successive food chains, but that at higher trophic levels, the ^{210}Po is largely deposited in internal organs such as liver and viscera rather than muscle tissue. Lead-210, the radiogenic precursor of ^{210}Po does not show an increasing concentration through successive food chains, nor does Pb. Again, of the ^{210}Pb and Pb found in higher trophic levels, the highest concentrations occur in internal organs.

The question of whether or not high alpha exposures apply generally to marine organisms appears less equivocal to us, despite the range of values we have observed for ^{210}Po in marine biota. Our measurements, and those of other investigators which preceeded us, have demonstrated that ^{210}Po is present in marine organisms taken from every depth in the oceans and no sample analyzed in the present work contained undetectable activities of ^{210}Po. Since ^{210}Po occurs naturally in the decay of primordial radionuclides in the earth's crust, we conclude that ^{210}Po has been a component of the natural radiation environment of marine organisms over geological time. As such, it should be considered as one of the more important radionuclides present in the ocean.

[Note added in preparation: It has come to our attention, that Folsom, Wong and Hodge have recently reported data for ^{210}Po in a wide variety of marine organisms. (The Natural Radiation Environment II Symposium, Houston, Texas, USA. 1972 - In press). Their results are in general agreement with findings presented here and contain further refinements as to tissue distribution of ^{210}Po in internal organs.]

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Updating Stratospheric Inventories to March 1972

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ABSTRACT

The stratospheric inventories of Sr^{90}, Zr^{95}, Cs^{137} and SNAP-9A Pu^{238} are reported up to March 1972. Sr^{90} inventories react to recent large atmospheric tests while SNAP-9A Pu^{238} decreases with a half residence time of about 14 months. Cs^{137}/Sr^{90} inventory ratios are close to the theoretical production value of 1.44. The French test of August 14, 1971 injected about 130 kCi of Sr^{90} into the Southern Hemisphere stratosphere.

This is the seventh in a series of reports (1, 2, 3, 4, 5, 6) which updates the Sr^{90}, Zr^{95}, Cs^{137} and SNAP-9A Pu^{238} stratospheric inventories through March 1972. The method of calculating these inventories has been described in reference (6).

CONCENTRATION CONTOURS AND INVENTORIES

The stratospheric concentration contours of SNAP-9A Pu^{238} from February 1971 and of Sr^{90}, Zr^{95} and Cs^{137} from October 1971 through March 1972 are illustrated in Figures 1 through 15. The SNAP-9A Pu^{238} concentrations represent only the Pu^{238} remaining from the re-entry burn-up of the SNAP-9A power generator which occurred in 1964. (7) These contours are constructed from data obtained

by the AEC's aircraft and balloon sampling programs in the stratosphere. If the balloon launches did not occur in the same month as the aircraft mission, the balloon data were corrected to the aircraft timing by the appropriate nuclide decay and by a stratospheric half residence time of 10 months (8).

The inventories of each nuclide which are calculated from these contours are given in Table 1. Figures 16 and 17 illustrate the hemispheric and total stratospheric burdens of Sr^{90} (from 1963) and of SNAP-9A Pu^{238} (from 1964) to early 1972. The response of the stratospheric Sr^{90} inventory in Figure 16 to the large atmospheric nuclear tests since 1967 contrasts to the generally smooth decline of the SNAP-9A Pu^{238} since 1966. As indicated earlier (5), the apparent half residence time of SNAP-9A Pu^{238} in the stratosphere is about 14 months which is somewhat longer than the 10 month half residence time expected for Sr^{90} (8).

At times the maximum nuclide concentrations occur at or above the altitude range of the aircraft sampling program. Unfortunately for reasons of economy, the balloon sampling program was reduced in July 1971 to essentially one annual flight series per launch site in the Northern Hemisphere. As a result, data are sometimes unavailable to objectively describe the concentration

gradients above 19.2 km. A large measure of subjectivity is then required which makes the ultimate contours and inventories somewhat uncertain.

In the Southern Hemisphere the poleward thrust into Antarctica is restrained at 51°S latitude because of the operational limitations of the aircraft. This allows a relatively large region of the Southern Hemispheric atmosphere to go unsampled. From these considerations, we estimate that the reported inventories are accurate to within ±25 to 50%.

Cs^{137}/Sr^{90} INVENTORY RATIO

The Cs^{137}/Sr^{90} ratio is an important parameter of nuclear weapons debris because it represents an index of comparison among fallout research programs in which only one of these two nuclides is measured. Table 2 gives the stratospheric inventory ratios of these nuclides for 1971 and 1972 and the cumulative ratio since Cs^{137} inventories were made beginning in May 1970. Although there is some scatter in the data, the averages agree reasonably well with the theoretical production ratio of 1.44 (9).

FRENCH TEST OF AUGUST 14, 1971

The Republic of France conducted a large atmospheric nuclear weapon test at Mururoa Atoll, 22°S latitude on August 14, 1971.

The cloud from this event penetrated the Southern Hemisphere stratosphere, and its impact can be seen in the concentration contours of the fission products beginning with the October 1971 sampling flights (Figure 4). Debris from this test can also be seen to penetrate the Northern Hemisphere stratosphere in January and March 1972. (Figures 8 thru 10 and 12 thru 14).

To calculate the Sr^{90} injected into the stratosphere by this test, the Sr^{90} inventory of the Southern Hemisphere just prior to the test (July 1971, 144 kCi) is corrected for stratospheric fallout to subsequent sampling dates after the test. A stratospheric half residence time of 10 months is used (8). These decay corrected inventories represent the Sr^{90} remaining in the stratosphere at sampling time from earlier detonations. The difference between the measured inventory and the remnant from earlier tests is the contribution from the August 14, 1971 test. This difference is then corrected back to shot date with a 10 month half residence time to give the Sr^{90} injected by the test. Table 3 shows the results of these calculations for the October 1971 and January 1972 missions.

Similar calculations can be made with the Zr^{95} inventories. The July 1971 inventory of 6160 kCi Zr^{95} must also be corrected for

radioactive decay in addition to stratospheric fallout. The Sr^{90} injected into the stratosphere by the August 14, 1971 test can be estimated by dividing the Zr^{95} injected at shot time by the theoretical production ratio of 226 (9). Table 3 also shows the results of these calculations.

The estimates derived from the Sr^{90} analyses in Table 3 show a fairly wide range with an average of about 130 kCi. The Zr^{95} analyses give a much more precise injection of only 70 kCi. The calculation using the Zr^{95} data assumes that the debris entering the stratosphere from this test is representative of a theoretical fission product mixture, i.e., no fractionation, and that the Zr^{95}/Sr^{90} ratio of 226 applies.

Samples from the October 1971 mission which contained the highest concentrations of fresh fission products were adjusted for remnants of earlier nuclear tests. The adjusted Zr^{95}/Sr^{90} ratios of these samples corrected to August 14, 1971 were about ½ the theoretical ratio of 226. Consequently, it appears that the debris from this French test which entered the stratosphere was highly enriched in Sr^{90} with respect to Zr^{95}.

If this fractionation factor of 2 were accepted, the injection estimate derived from the Zr^{95} analyses would agree reasonably well with the estimate from the Sr^{90} analyses. Our best assignment is that the August 14, 1971 test injected 130 kCi of Sr^{90} into the Southern Hemisphere stratosphere.

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Table 1

Stratospheric Inventories, kCi

Date	Northern Hemisphere				Southern Hemisphere			
	Sr-90	Zr-95	Cs-137	SNAP-9A Pu-238	Sr-90	Zr-95	Cs-137	SNAP-9A Pu-238
2/23/71				0.30				0.49
5/25/71				0.22				0.38
7/21/71				0.25				0.35
10/6/71	84	425	141	0.19	258	10,400	363	0.37
1/11/72	82	206	114	0.16	171	2,880	194	0.26
3/27/72	82	152	139	0.18	99	901	144	0.18

Table 2

Cs-137/Sr-90 Stratospheric Inventory Ratios

Date	Northern Hemisphere	Southern Hemisphere
2/23/71 (a)	1.59	1.58
5/25/71 (a)	1.39	1.33
7/21/71 (a)	1.50	1.35
10/6/71	1.68	1.41
1971 mean	1.54±0.12	1.42±0.11
1/11/72	1.40	1.13
3/27/72	1.70	1.45
Inclusive mean since 5/8/70 (9 cases)	1.49±0.14	1.41±0.14
Inclusive mean of total stratosphere since 5/8/70		1.45±0.14

(a) Reported earlier in reference 5.

Table 3

Stratospheric Injection Sr-90 (kCi) from French Test of Aug. 14, 1971

Sampling Mission	Estimate Derived From Sr-90 Analyses	Estimate Derived From Zr-95 Analyses
10/6/71	155	72
1/11/72	104	69

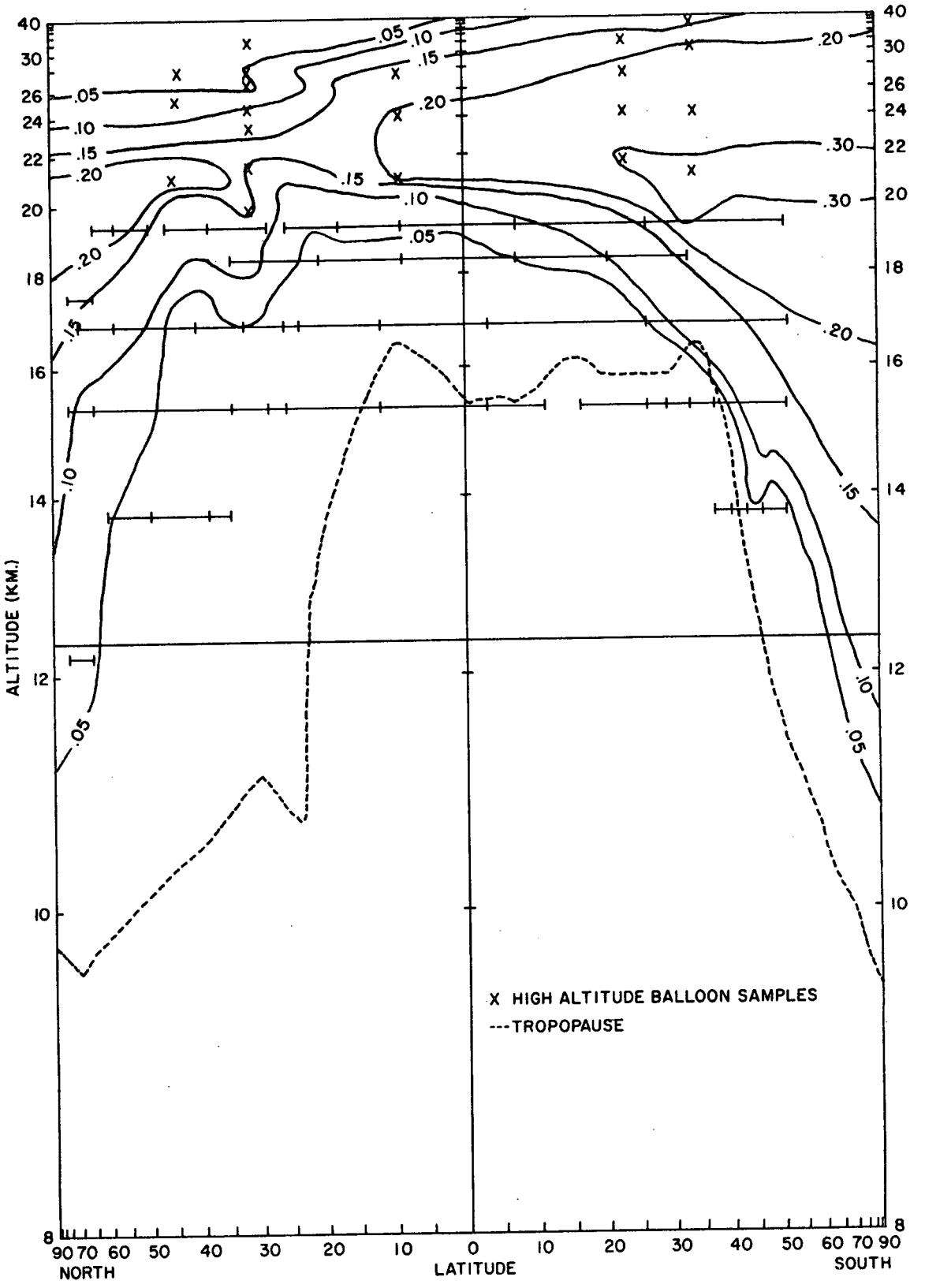

Fig. 1

CONCENTRATIONS OF SNAP-9A Pu-238
(PCi/100SCM)
FEBRUARY 1971

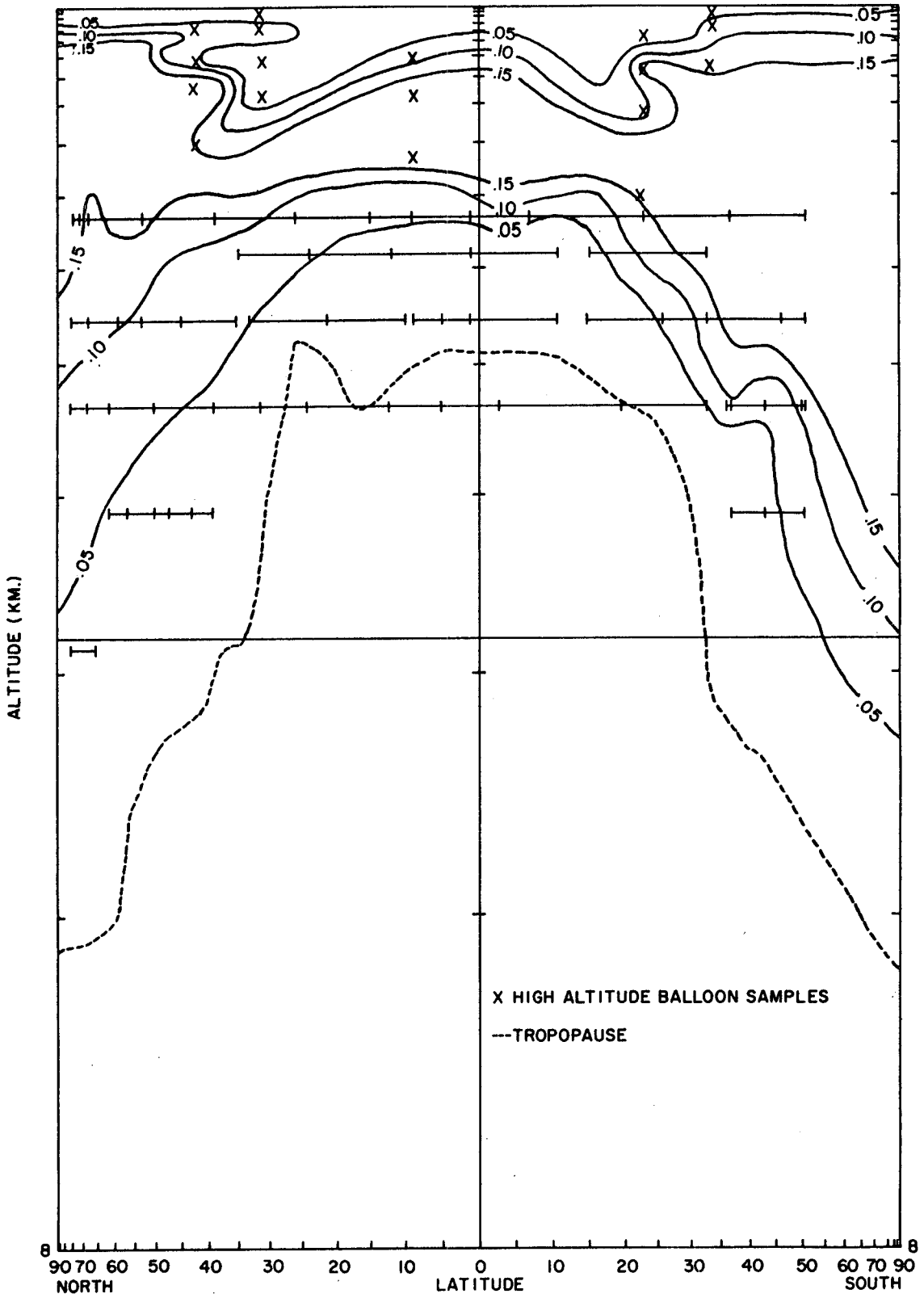

Fig. 2 CONCENTRATIONS OF SNAP-9A Pu-238
(PCI/100SCM)
MAY 1971

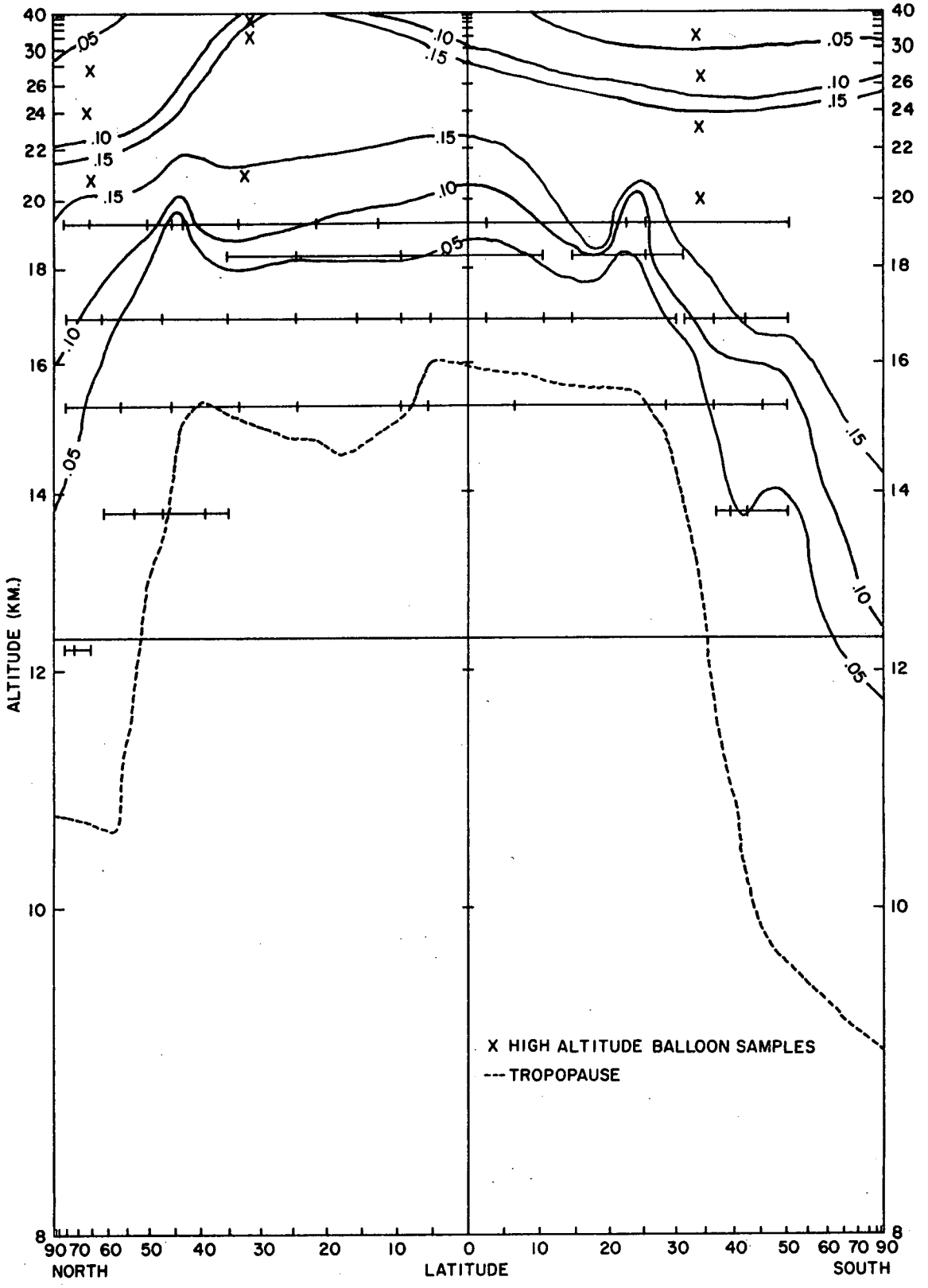

Fig. 3 CONCENTRATIONS OF SNAP-9A Pu-238
(PCi/100SCM)
JULY 1971

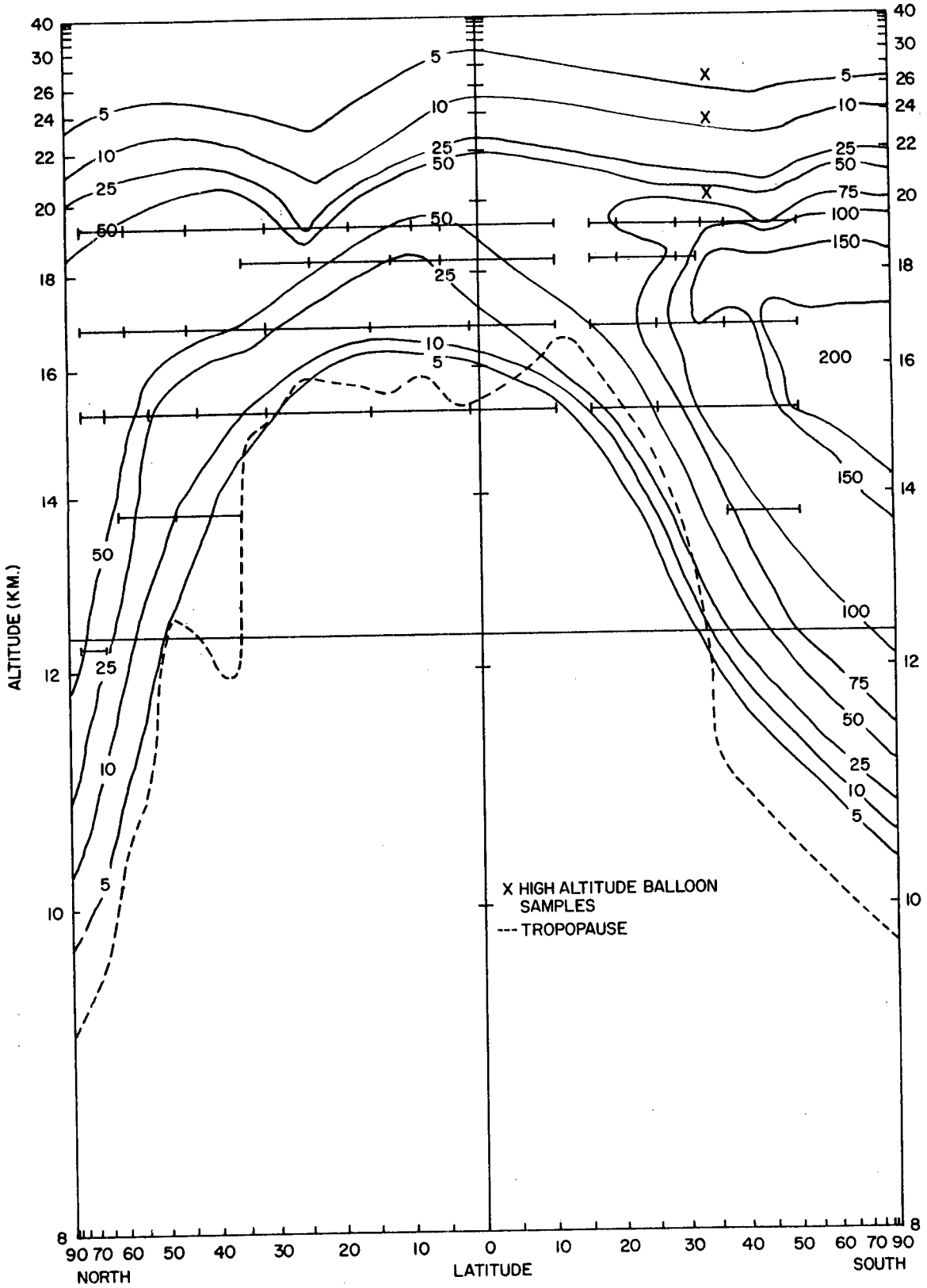

Fig. 4 CONCENTRATION OF Sr 90 IN STRATOSPHERIC AIR
(PCi/100SCM)
OCTOBER 1971

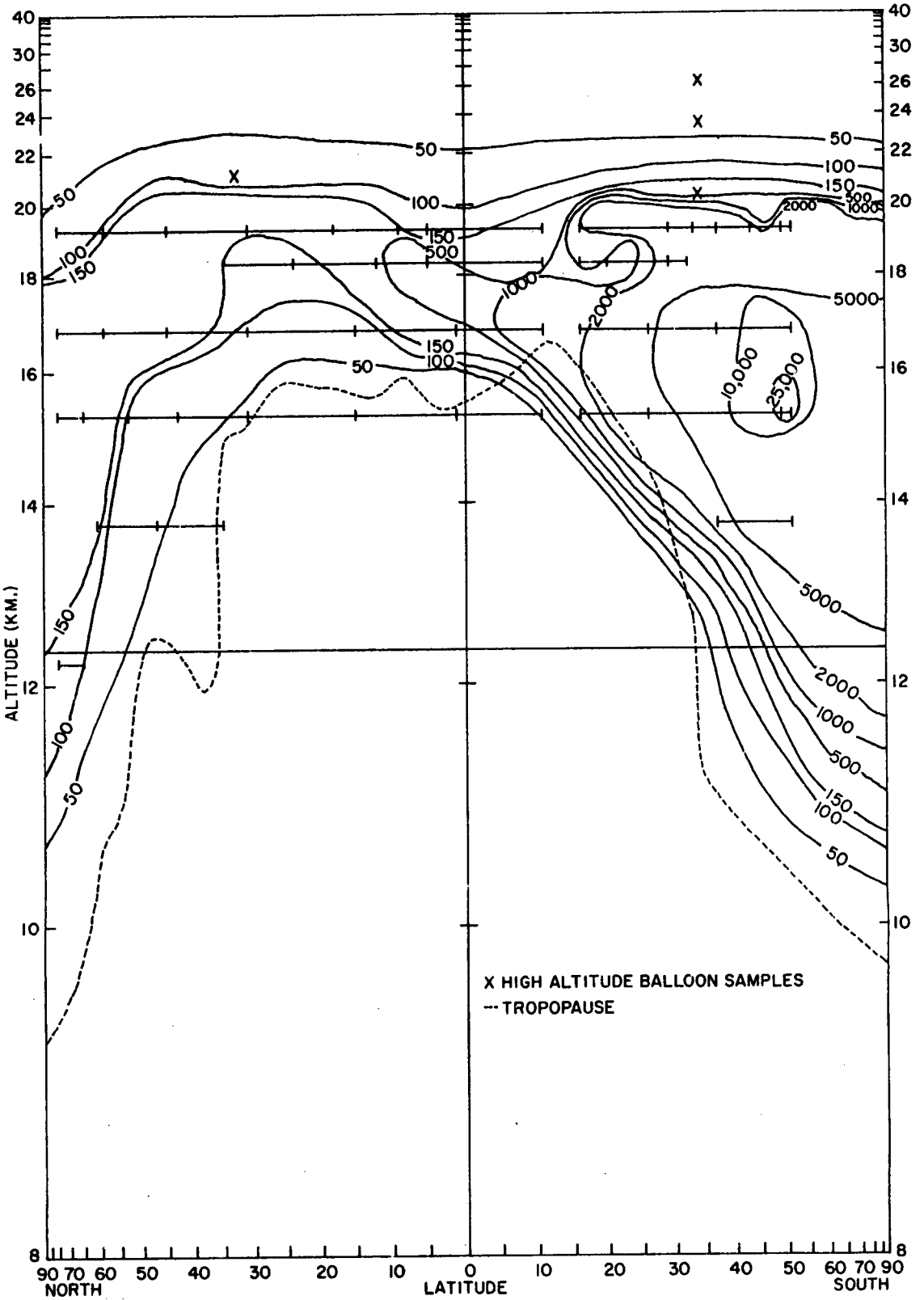

Fig. 5 CONCENTRATION OF Zr-95 IN STRATOSPHERIC AIR
(PCi/100SCM)
OCTOBER 1971

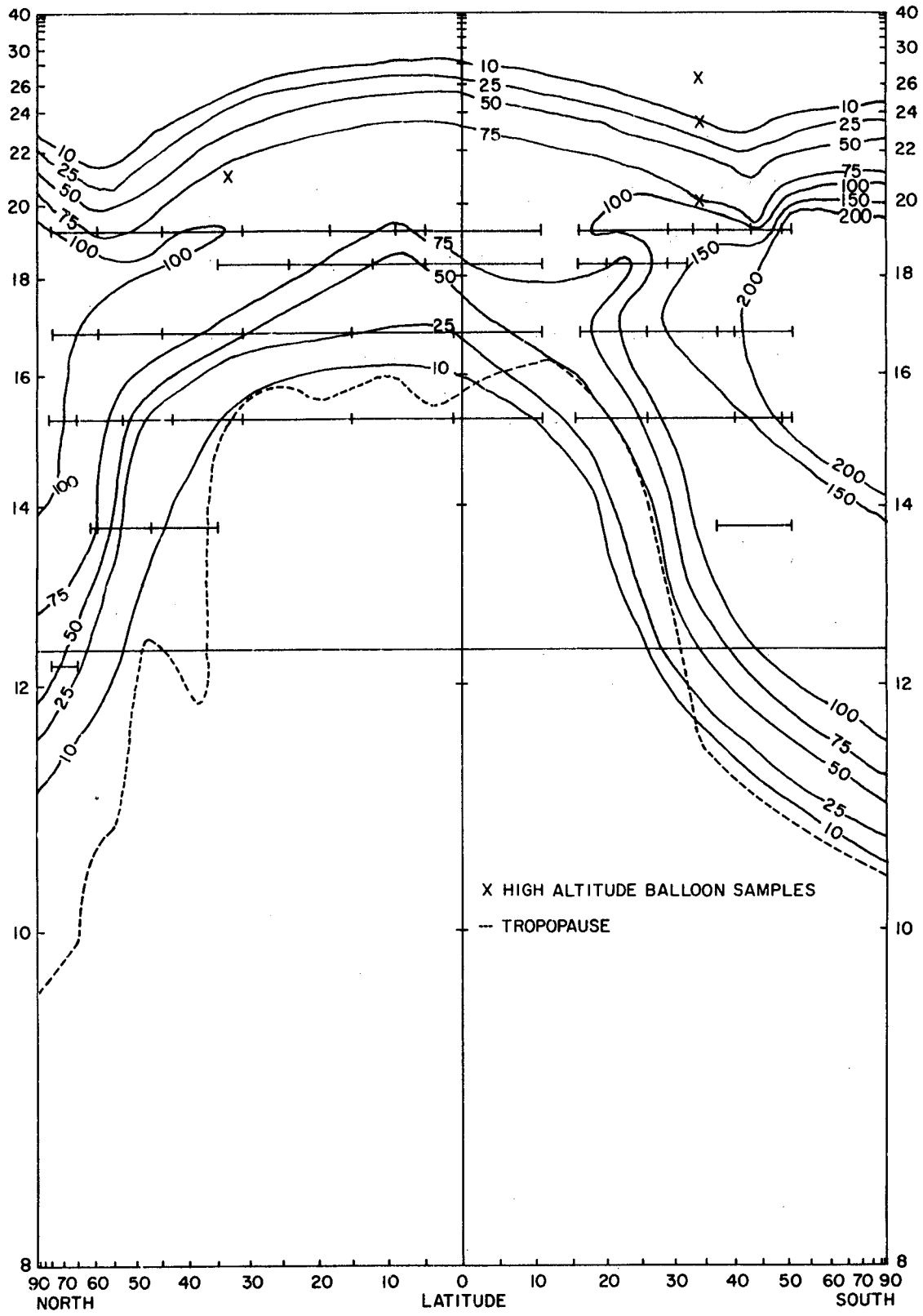

Fig. 6 CONCENTRATATION OF Cs-137 IN STRATOSPHERIC AIR
(PCi/100SCM)
OCTOBER 1971

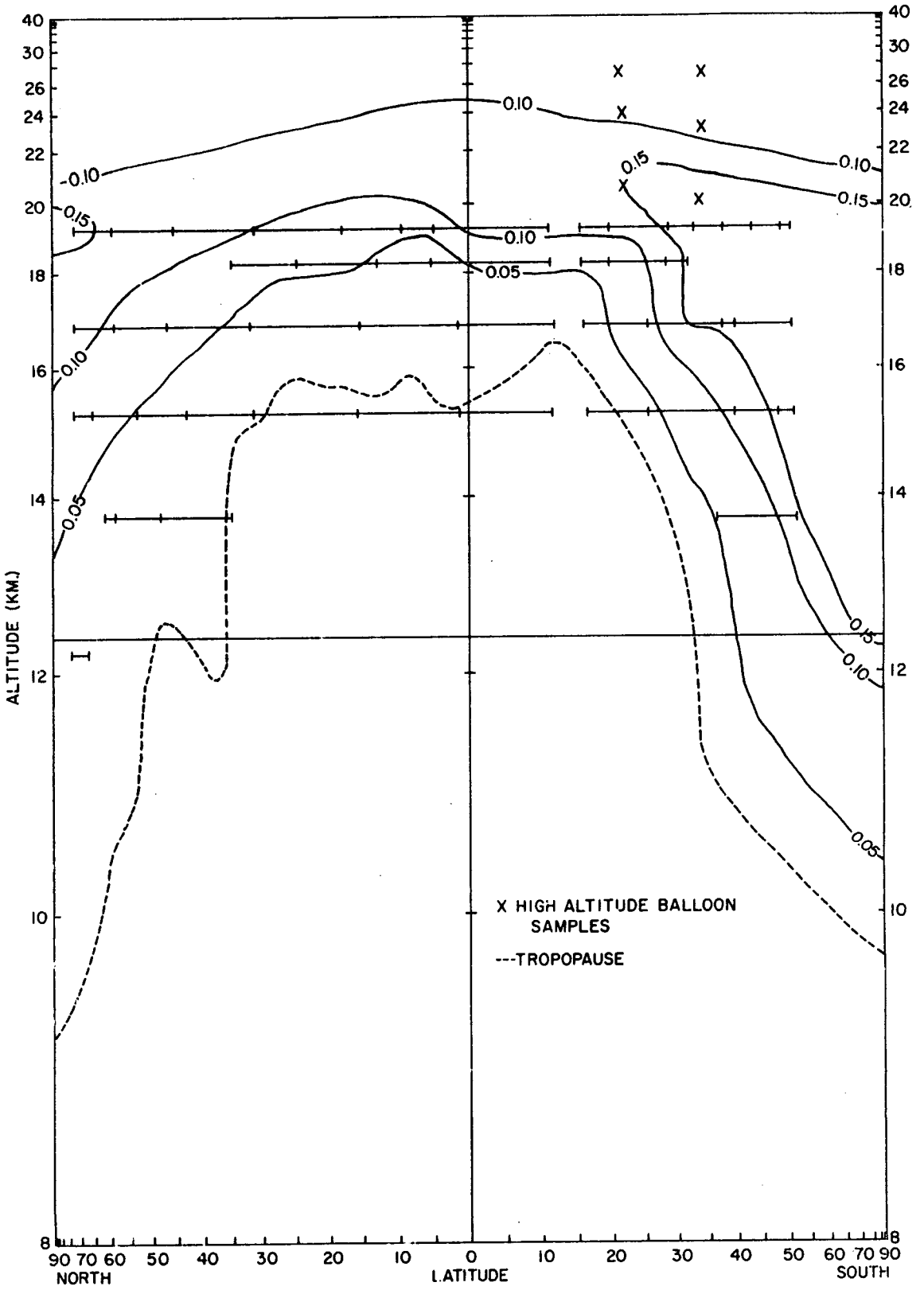

Fig. 7

CONCENTRATIONS OF SNAP-9A Pu-238
(PCi/100SCM)
OCTOBER 1971

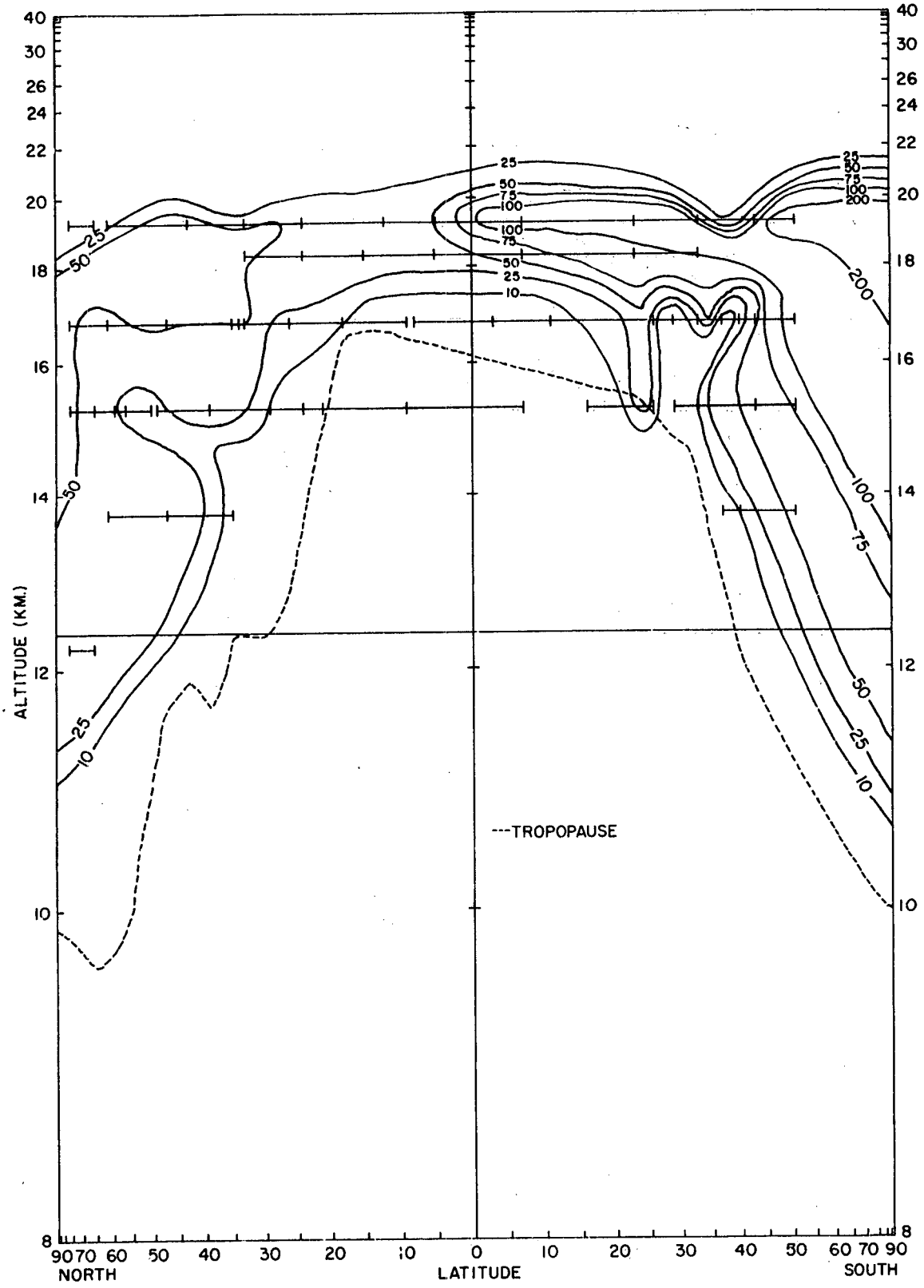

Fig. 8 CONCENTRATION OF Sr 90 IN STRATOSPHERIC AIR
(PCi/100SCM)
JANUARY 1972

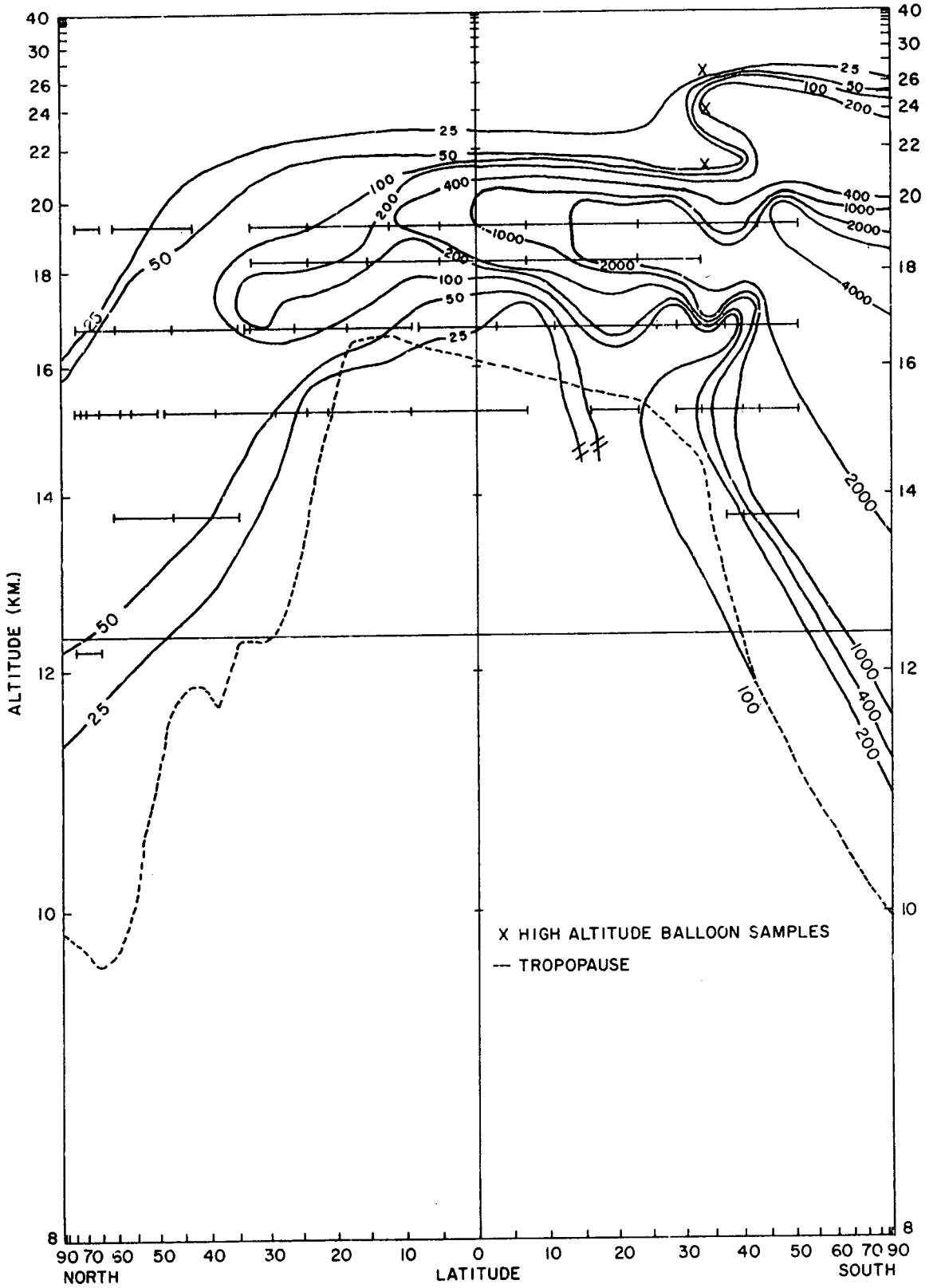

Fig. 9 CONCENTRATION OF Zr-95 IN STRATOSPHERIC AIR
(PCi/100SCM)
JANUARY 1972

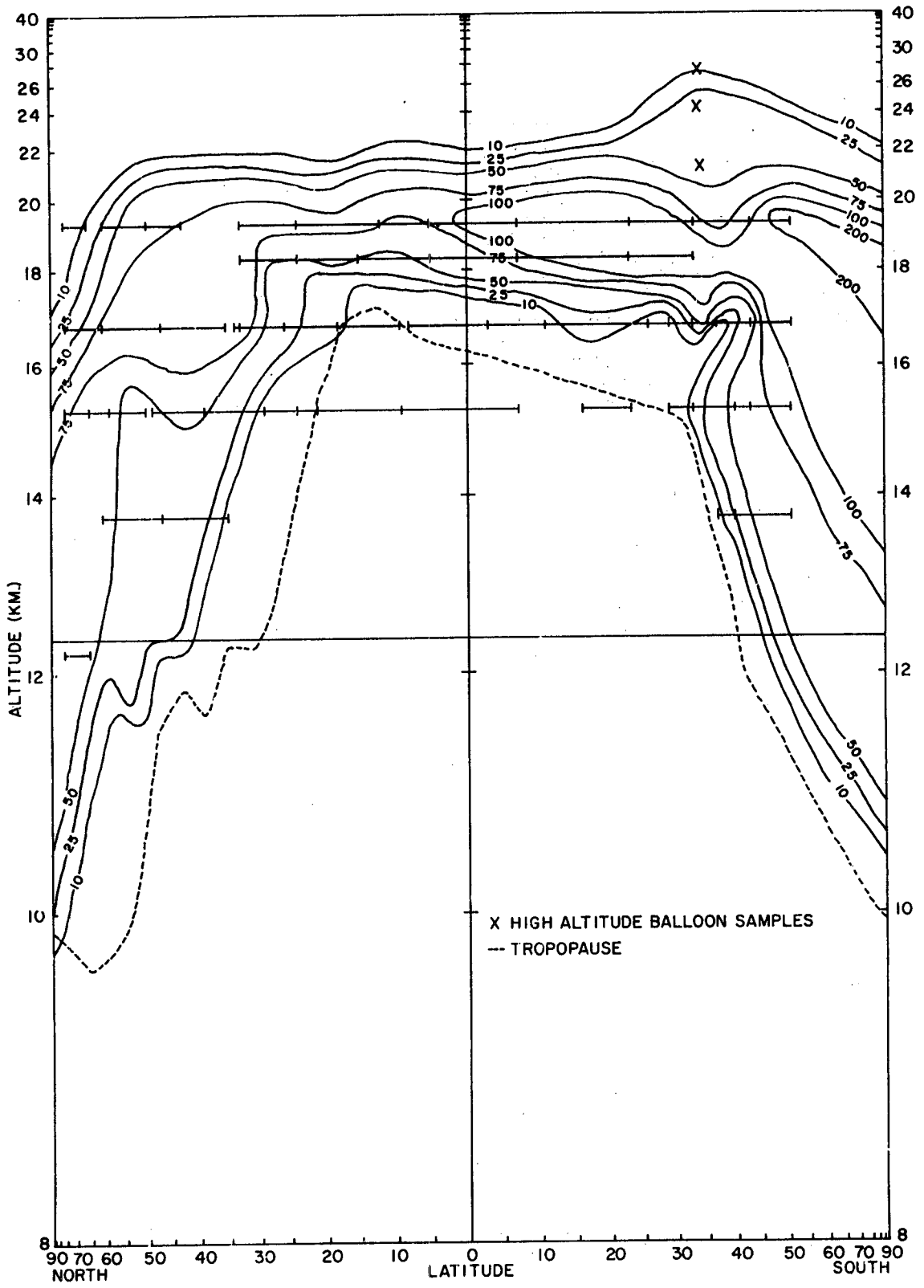

Fig. 10 CONCENTRATION OF Cs-137 IN STRATOSPHERIC AIR
(PCI/100SCM)
JANUARY 1972

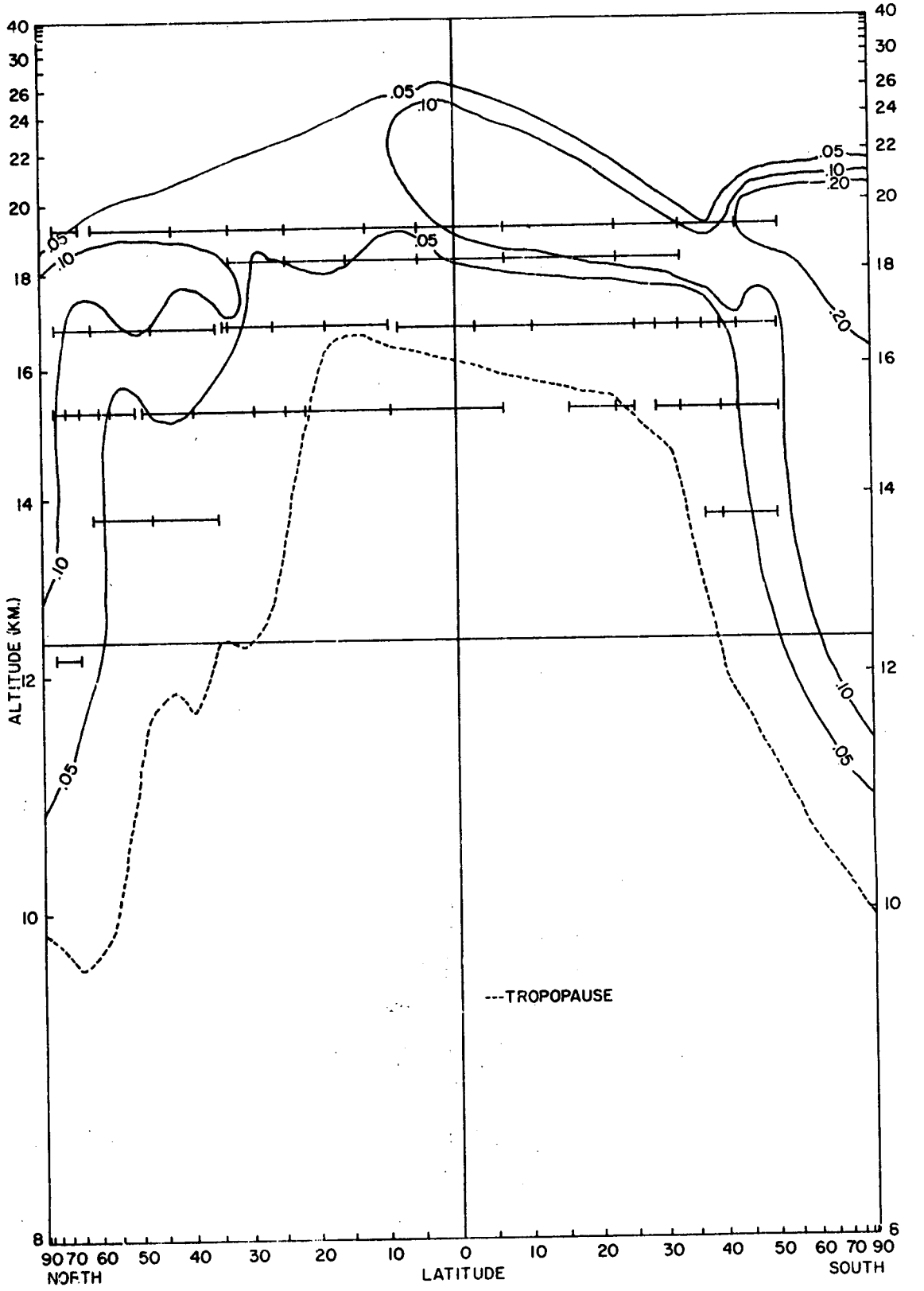

Fig. 11 CONCENTRATIONS OF SNAP-9A Pu-238
(PCi/100SCM)
JANUARY 1972

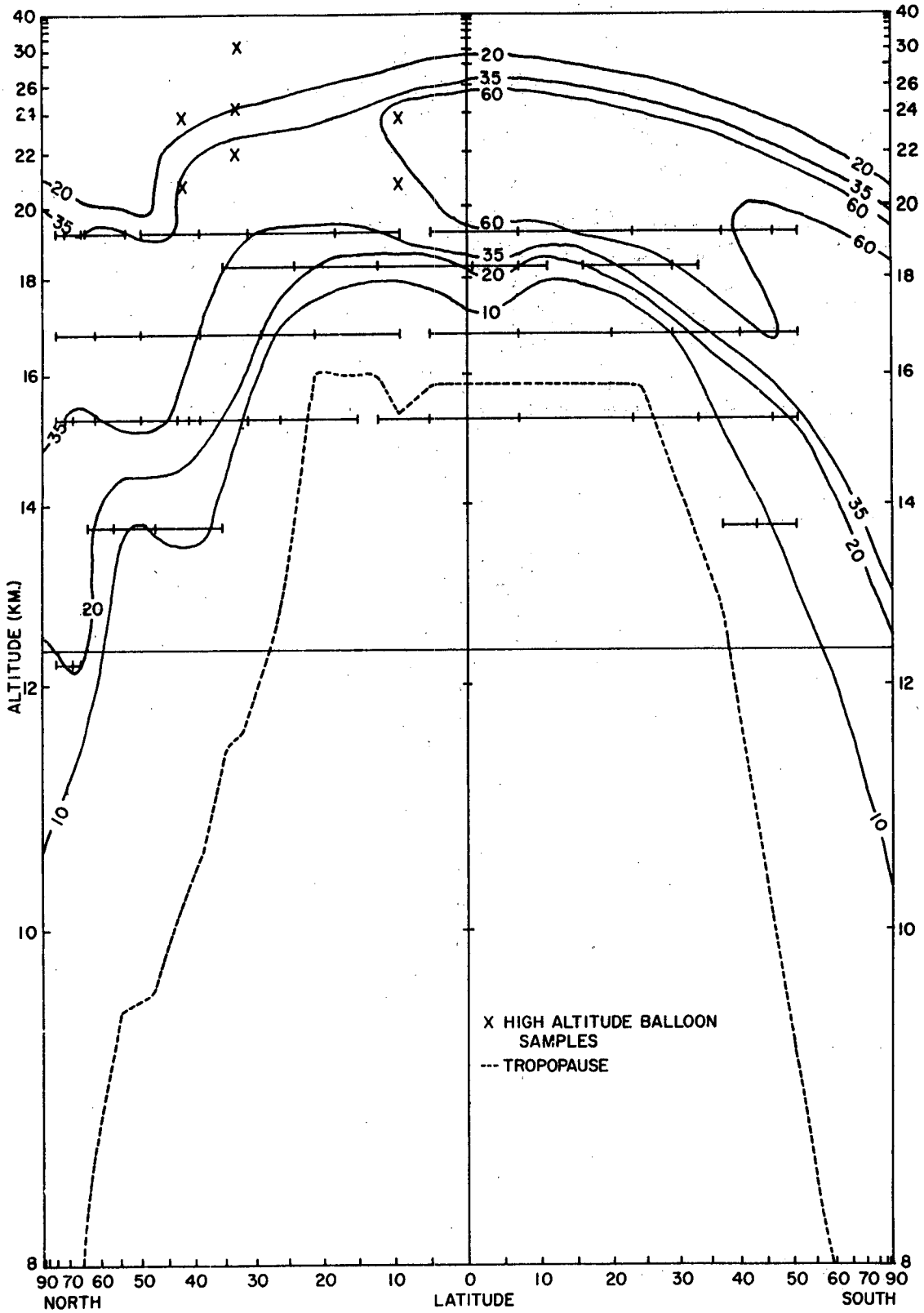

Fig. 12 CONCENTRATION OF Sr-90 IN STRATOSPHERIC AIR
(PCi/100SCM)
MARCH 1972

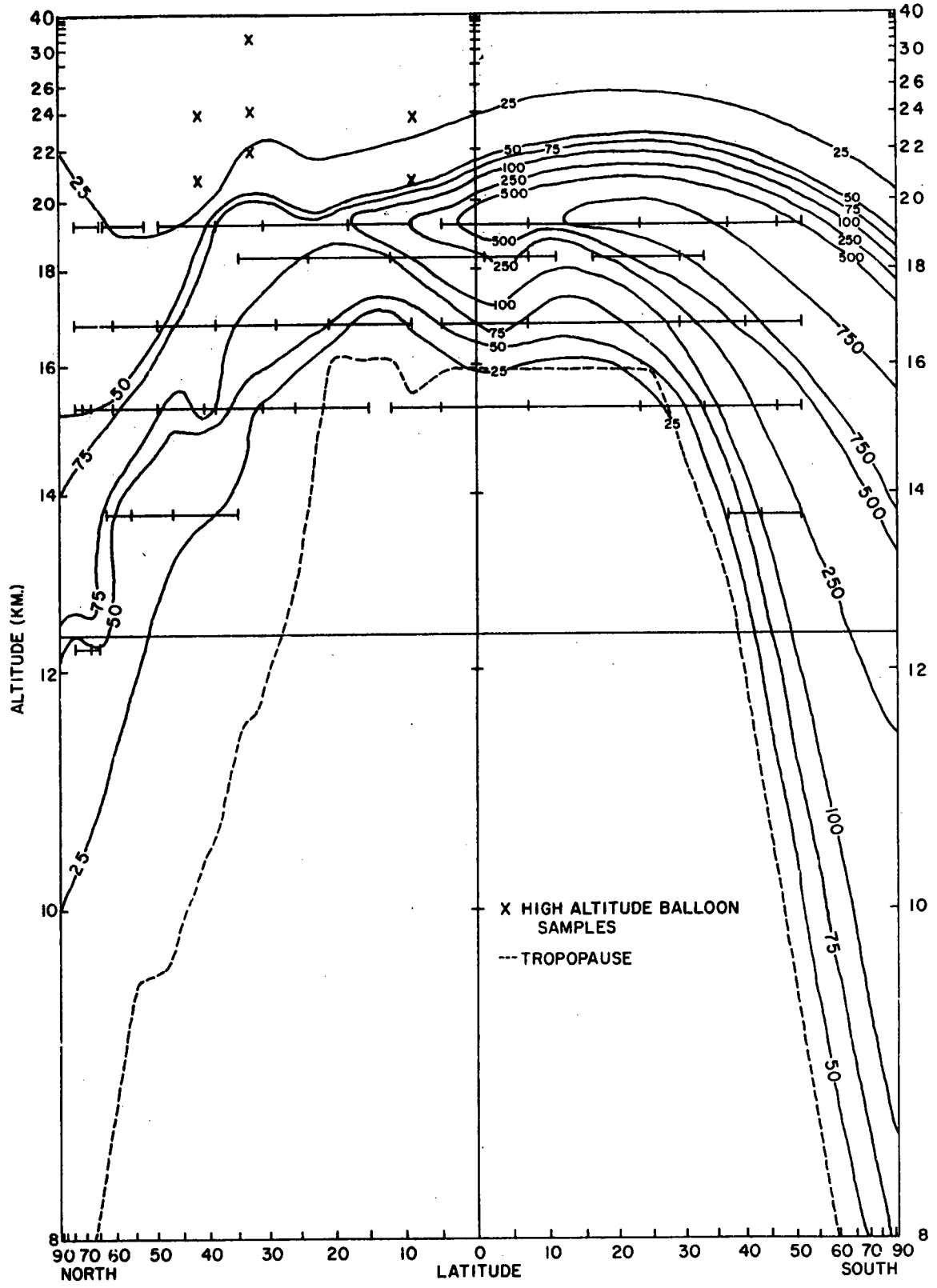

Fig. 13 CONCENTRATION OF Zr-95 IN STRATOSPHERIC AIR
(PCI/100SCM)
MARCH 1972

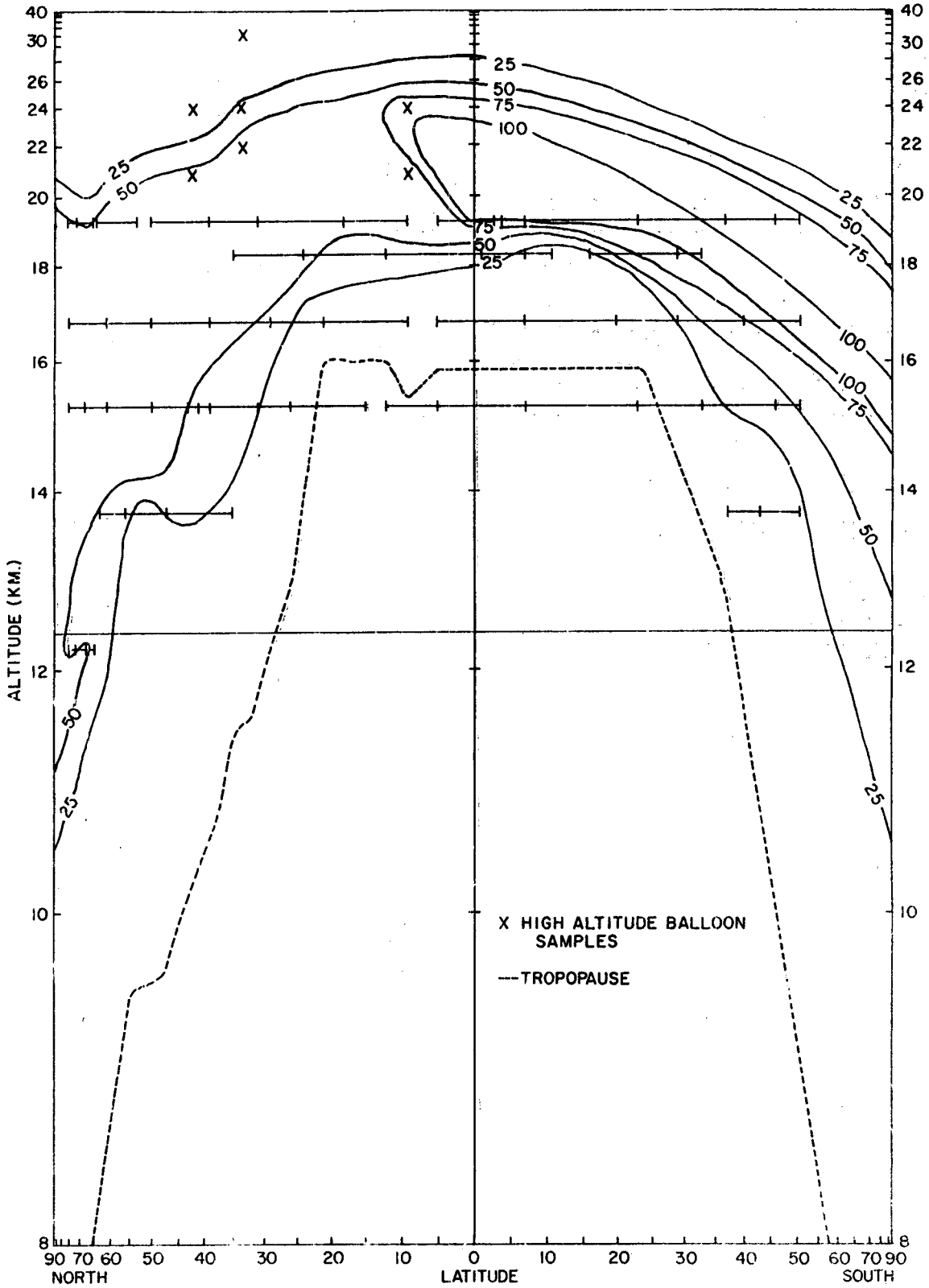

Fig. 14 CONCENTRATION OF Cs-137 IN STRATOSPHERIC AIR
(PCi/100SCM)
MARCH 1972

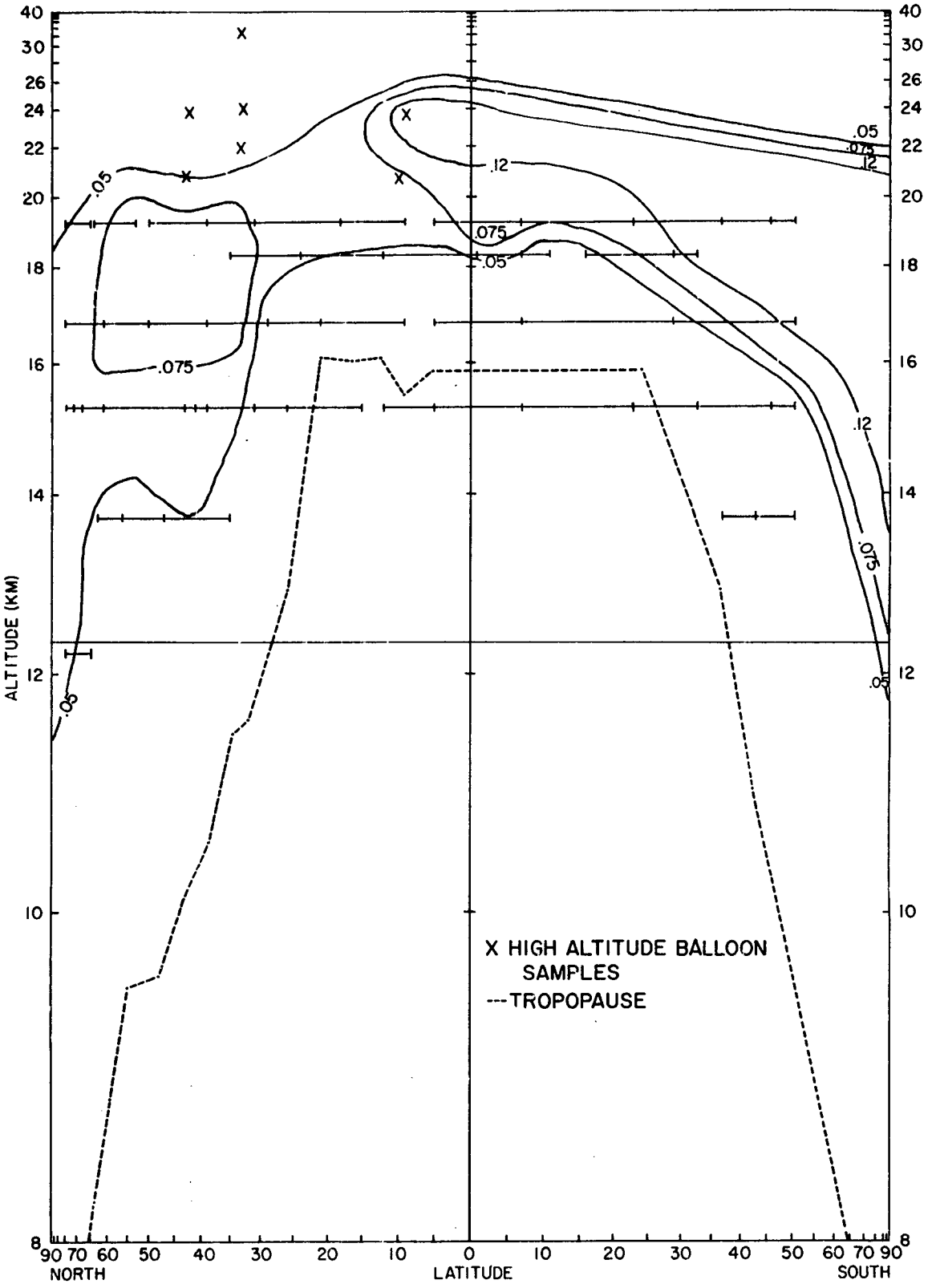

Fig. 15 CONCENTRATIONS OF SNAP-9A Pu-238
(PCi/100SCM)
MARCH 1972

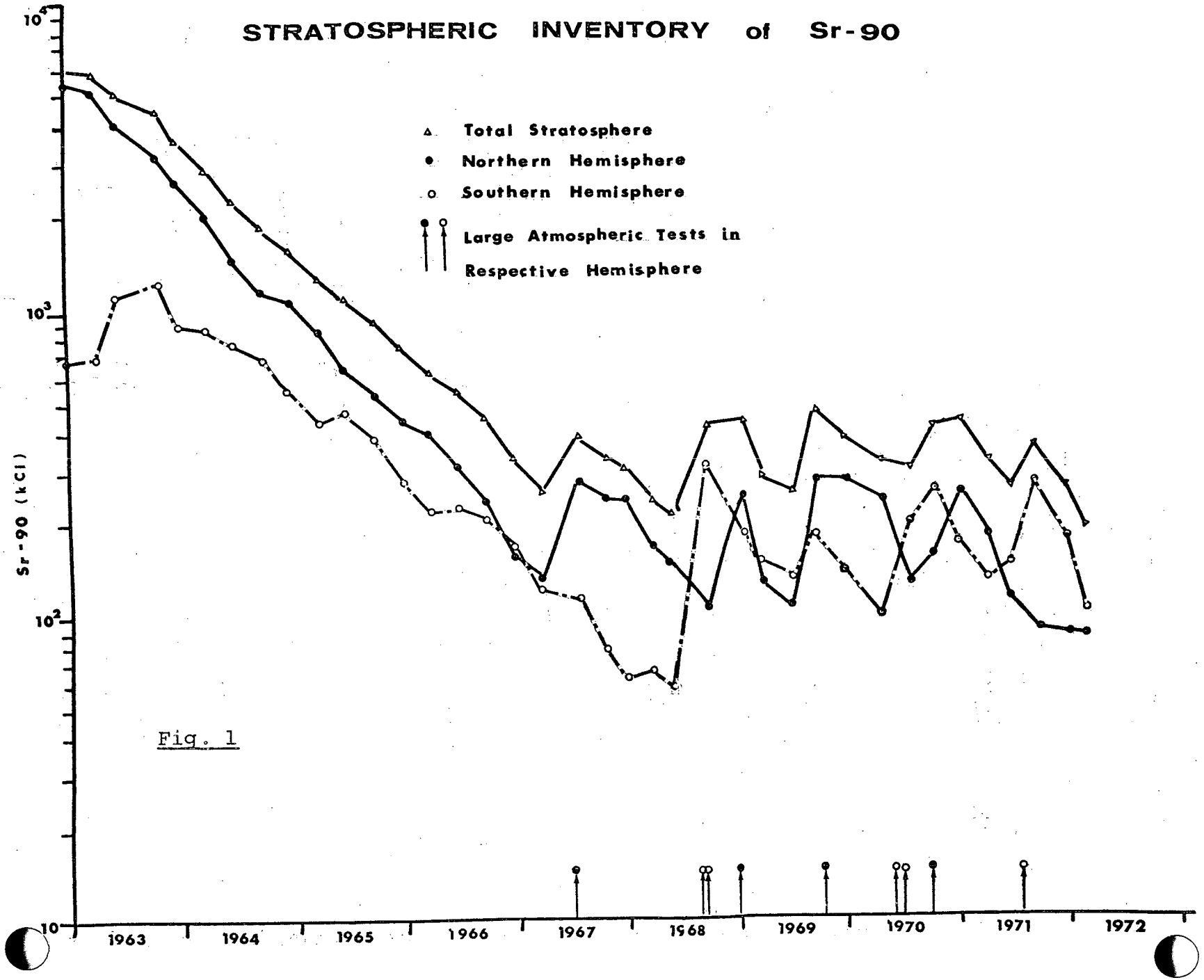
STRATOSPHERIC INVENTORY of Sr-90
Total Stratosphere
Northern Hemisphere
Southern Hemisphere
Large Atmospheric Tests in Respective Hemisphere
Sr-90 (kCi)
10⁴
10³
10²
10
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972

Fig. 1

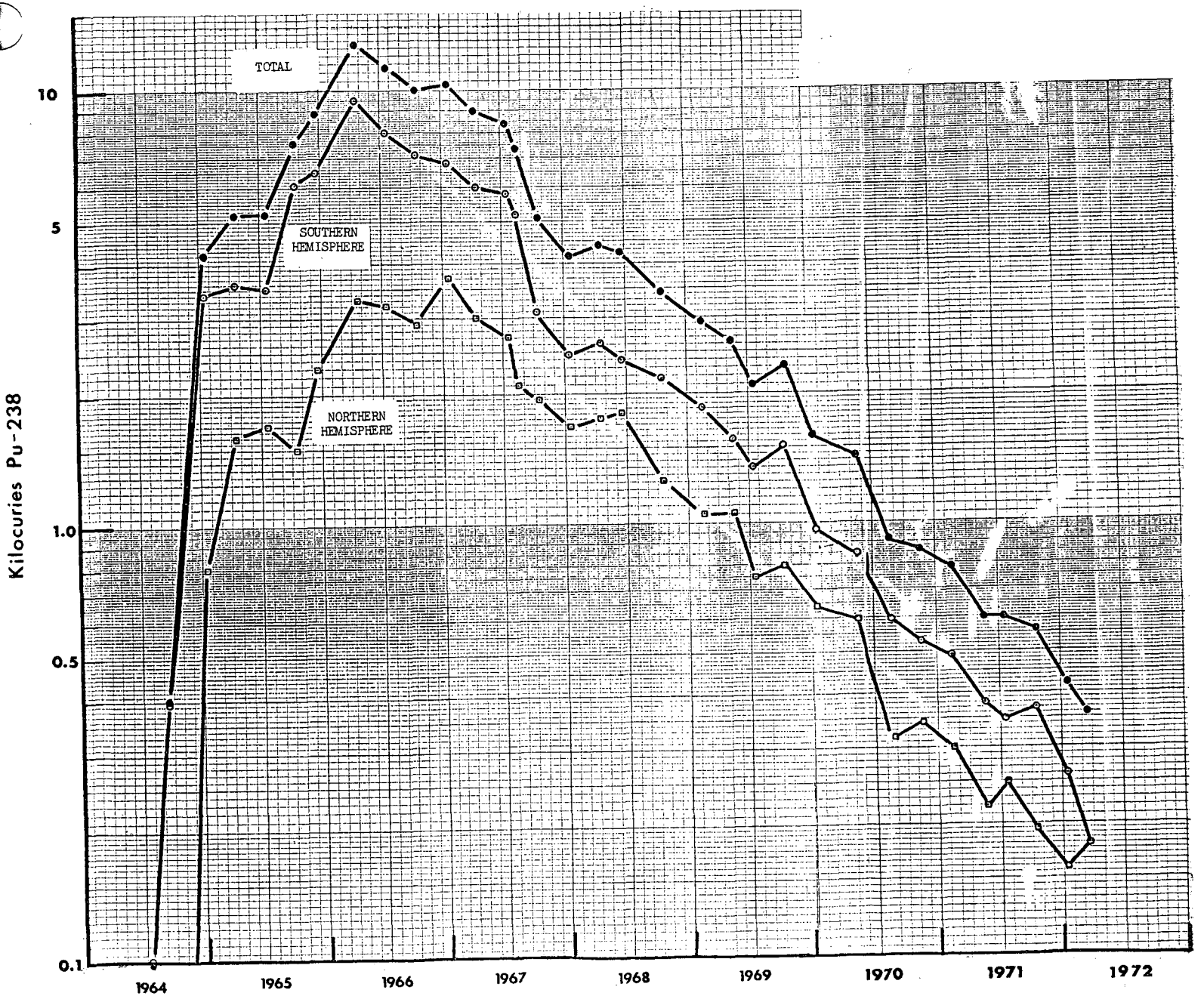

Fig. 17 - Stratospheric Inventory of SNAP-9A Pu-238

STRONTIUM-90 IN THE DIET

RESULTS THROUGH 1972

by B. G. Bennett (HASL)

ABSTRACT

Estimates of Sr-90 intake via the total diet in New York City and San Francisco have been made since 1960 from quarterly food samplings and average consumption statistics. The dietary intakes of Sr-90 have decreased from the maximum levels attained during 1963-64, but the declines have become more gradual in recent years due to the continuing small amounts of Sr-90 deposition and the little changing cumulative deposit of Sr-90 in soil. The annual intake in 1972 averaged 10.7 pCi/day in New York and 3.6 pCi/day in San Francisco, slight decreases from the previous year. Further gradual reductions in Sr-90 intake are anticipated during 1973.

Quarterly samplings of representative food items in New York City and San Francisco have been conducted by the Health and Safety Laboratory since 1960. Results of Sr-90 analyses and estimates of average consumption of these food items yield estimates of the total dietary intakes of Sr-90 for residents of these cities.[1] This information has been used to study the transfer mechanisms of Sr-90 fallout through the food chain to man and to relate to observed variations in Sr-90 body burdens.

Results for the third and fourth quarters of 1972 and a figure illustrating the quarterly results for the entire sampling period are presented on pages II-4 to II-7 of this report. The average Sr-90 concentration in each diet item and estimates of Sr-90 and Ca intakes for the entire year 1972 are listed in Table 1. It is noted that the calcium intake is estimated to be 370 g per year. Thus, Sr-90 intakes expressed as pCi/day or pCi/g Ca are almost equivalent.

Results for 1972

In New York City the annual Sr-90 intake during 1972 was estimated to be 3900 pCi, an average of 10.7 pCi/day. This is a decrease of 16% from the Sr-90 intake in the previous year, though the decrease over the past two years averages 6% per year. These changes reflect, to some extent, the continuing declines in Sr-90 deposition. In New York the annual Sr-90 deposition was .75 mCi/km^2 in 1972 compared to 1.41 mCi/km^2 in 1971. The contributions to Sr-90 intake decreased for all food categories. The largest percentage declines (30-50%) were for poultry, shell fish, meat, dry beans, rice and flour. Declines of 15-25% were recorded for eggs, fresh fish, whole grain products, milk, fresh vegetables, and fruit juice.

Table 1

Strontium-90 in the Diet During 1972

Diet Category	kg/yr	gCa/yr	% of yearly intake of Ca	New York City pCi Sr^{90}/kg	New York City pCi Sr^{90}/yr	% of yearly intake of Sr^{90}	San Francisco pCi Sr^{90}/kg	San Francisco pCi Sr^{90}/yr	% of yearly intake of Sr^{90}
Dairy Products	200	216.0		6.9	1370		1.5	291	
			58			35			22
Fresh Vegetables	48	18.7		14.0	671		2.9	139	
Canned Vegetables	22	4.4		7.2	158		3.3	73	
Root Vegetables	10	3.8		7.2	72		4.7	47	
Potatoes	38	3.8		6.6	251		2.1	81	
Dry Beans	3	2.1		12.4	37		14.2	43	
			9			30			29
Fresh Fruit	59	9.4		10.1	594		2.7	159	
Canned Fruit	11	0.6		1.3	14		1.0	12	
Fruit Juices	28	2.5		3.1	87		2.3	65	
			3			18			18
Bakery Products	44	53.7		5.5	242		3.0	133	
Flour	34	6.5		6.0	203		3.6	123	
Whole Grain Products	11	10.3		10.9	120		5.5	60	
Macaroni	3	0.6		4.3	13		3.9	12	
Rice	3	1.1		1.5	5		1.5	5	
			20			15			25
Meat	79	12.6		0.4	32		0.4	35	
Poultry	20	6.0		0.5	10		0.5	10	
Eggs	15	8.7		1.6	24		1.3	19	
Fresh Fish	8	7.6		0.3	3		N.D.	-	
Shellfish	1	1.6		0.9	1		0.2	-	
			10			2			5
Yearly Intake		370.0g			3907 pCi			1307 pCi	
Daily Intake					10.6 pCi/gCa			3.5 pCi/g Ca	
					10.7 pCi/day			3.6 pCi/day	

N.D. = not detectable

Slight decreases (5-15%) were noted for canned fruit, bakery products, macaroni, fresh fruit, and canned vegetables. The smallest changes (≤ 5%) were for potatoes and root vegetables, reflecting uptake from the little-changing cumulative deposit of Sr-90 in soil. Milk and other dairy products accounted for 35% of the total Sr-90 intake in New York during 1972. The contribution from vegetables remained at 30%. Fruit contributed 18%, grain products 15%, and the combined category of meat, fish, and eggs 2%.

In San Francisco the Sr-90 intake during 1971 was estimated to be 1300 pCi, an average of 3.6 pCi/day, compared to 4.0 pCi/day in 1971. Decreases occurred in contributions from grain products, meat, poultry, eggs, fish, and milk, while contributions from fresh vegetables and potatoes increased slightly. Unchanged were fruits, macaroni, rice, flour, dry beans, canned vegetables, and root vegetables. The relative contributions to the total Sr-90 intake in San Francisco during 1972 were dairy products 22%, grain products 25%, vegetables 29%, fruit 18%, and meat, fish, and eggs 5%.

Table 2 shows how the Sr-90 intake varied during each quarter in 1972 in New York and San Francisco. The numbers

in parentheses are the results for 1971.

Table 2

Sr-90 Intake in 1972 (pCi/day)

Quarter	New York	San Francisco
1	12.0 (13.4)	4.4 (5.0)
2	11.4 (13.8)	3.5 (4.5)
3	9.8 (11.7)	2.7 (3.5)
4	9.6 (12.3)	3.8 (3.0)
Yearly Average	10.7 (12.8)	3.6 (4.0)

Sr-90 intake declined throughout the year in New York, and in all but the last quarter in San Francisco.

Sr-90 Intake, 1960-1972

The estimates of annual intakes since 1960 of Sr-90 in the total diet and the major food categories in New York and San Francisco are illustrated in Figure 1. The total diet Sr-90 levels in New York have been consistently higher than in San Francisco because of less fallout deposition in the San Francisco food-producing region. The declines in Sr-90 intake in 1960-61 followed the nuclear testing moratorium in 1959-60. Maximum levels of Sr-90 in the diet were recorded in 1963-64 following the period of most active nuclear testing from September 1961 until late 1962, following which the Test

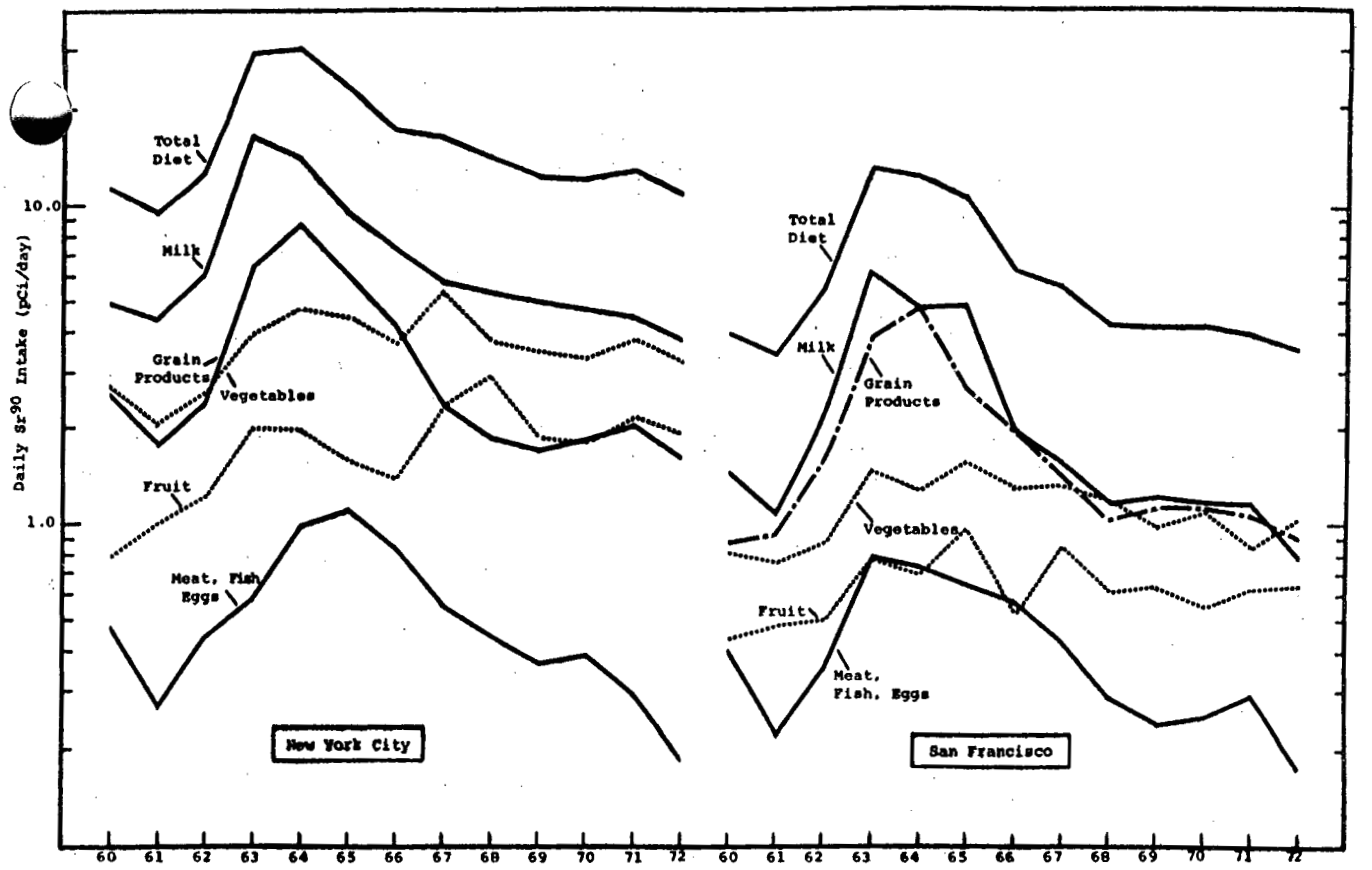

Figure 1. Strontium-90 intake in New York City and San Francisco.

Ban Treaty was signed. The rapid declines in Sr-90 intake following the peak values in 1963-64 became more gradual after 1966-67 as uptake from the little changing cumulative deposit of Sr-90 in soil became the dominant factor contributing to Sr-90 levels in food. The resumption of atmospheric testing by the French and Chinese in 1966, resulting in a relatively constant low fallout rate of Sr-90, has also been a factor in maintaining the dietary intakes of Sr-90 at about constant levels since 1968. The decreased deposition during 1972 is

reflected by the slightly lower dietary intakes of Sr-90.

The relative importance of the major food categories to the total Sr-90 intake can be seen in Figure 1. Milk, including other dairy products, is the most important contributor to Sr-90 intake. Grain products are the second greatest contributors during periods of heavy deposition, but vegetables and, to a lesser extent, fruit become more important in later years. Meat, fish, and eggs are minor contributors.

The variations in the relative contributions of the major food categories to the total Sr-90 intake are listed in Table 3. In general, the contributions from dairy products to the total in New York have been around 40%, with somewhat greater relative contributions occurring during periods of heavy deposition. Grain products contribute from 30% in periods of heavy deposition to 15% in later years. For vegetables the range is similar to grain products, but the greatest relative contribution occurred in more recent years, due in part to more rapid declines in the other food categories. In San Francisco, milk has contributed closer to 30% of the total yearly Sr-90 intake with increased contribution during periods of heavy deposition. Grain products have usually accounted for 20 to 30% with a

Table 3

Contributions of Major Food Categories to Average Daily Sr^{90} Intake

	% Contribution					Daily Intake pCi Sr^{90}/day
	Dairy Products	Grain Products	Vegetables	Fruit	Meat Fish, Eggs	
New York City						
1960	43	22	24	7	4	11.3
61	47	19	22	11	3	9.6
62	48	19	20	10	4	12.7
1963	56	22	13	7	2	29.6
64	46	28	16	7	3	30.3
65	42	27	20	7	5	22.9
1966	42	24	21	8	5	17.5
67	35	14	33	14	3	16.4
68	37	13	26	20	3	14.3
1969	40	14	28	15	3	12.4
70	39	15	27	15	3	12.1
71	35	16	30	17	2	12.8
1972	35	15	30	18	2	10.7
San Francisco						
1960	36	22	21	11	10	4.0
61	31	27	22	14	6	3.5
62	40	29	16	9	6	5.5
1963	47	30	11	6	6	13.3
64	39	39	10	6	6	12.5
65	46	25	15	9	6	10.8
1966	31	31	20	8	9	6.4
67	28	26	23	15	8	5.7
68	27	24	28	15	7	4.3
1969	29	27	23	15	6	4.2
70	28	27	26	13	6	4.2
71	29	27	21	16	7	4.0
1972	22	25	29	18	5	3.6

maximum contribution of 39% in 1964, one year after the peak milk contribution. Vegetables have increased their contribution from 10% in 1964 to over 20% in recent years. The contributions from fruit in both New York and San Francisco have behaved similarly to vegetables but by a factor of 2 less. Meat, fish and eggs have accounted for 5% or less of the total intake in New York and slightly higher relative amounts in San Francisco.

Prediction Methods

A useful model for correlating Sr-90 deposition with Sr-90 levels in milk and a procedure for using milk concentrations to predict total diet Sr-90 intake were discussed in the report HASL-246.[2] The deposition-milk model is given by the following formula

$$M_n = p_1 F_n + p_2 F_{n-1} + p_3 \sum_{m=1} F_{n-m} e^{-m\lambda}$$

M_n (pCi/g Ca) is the average Sr-90/Ca ratio in milk in the year n, and F_n (mCi/km^2) is the Sr-90 fallout deposition during the year n. The proportionality constant p_1 includes the rate and deposit effects of the current year's deposition; p_2 is the lag factor for the previous year's deposition; and $p_3 e^{-m\lambda}$ is the deposit factor with exponential removal due to reduced uptake availability of the deposition in each of the preceding years. The results of least squares fits to the average yearly Sr-90 concentrations in milk in New York through 1970 and 1971 were reported previously.[2,3] No parameter changes were required by the addition of the 1971 data. Inclusion of the 1972 fallout and milk data (Figure 2), results in yet the identical parameter values, which are $p_1 = .69$ $p_2 = .21$

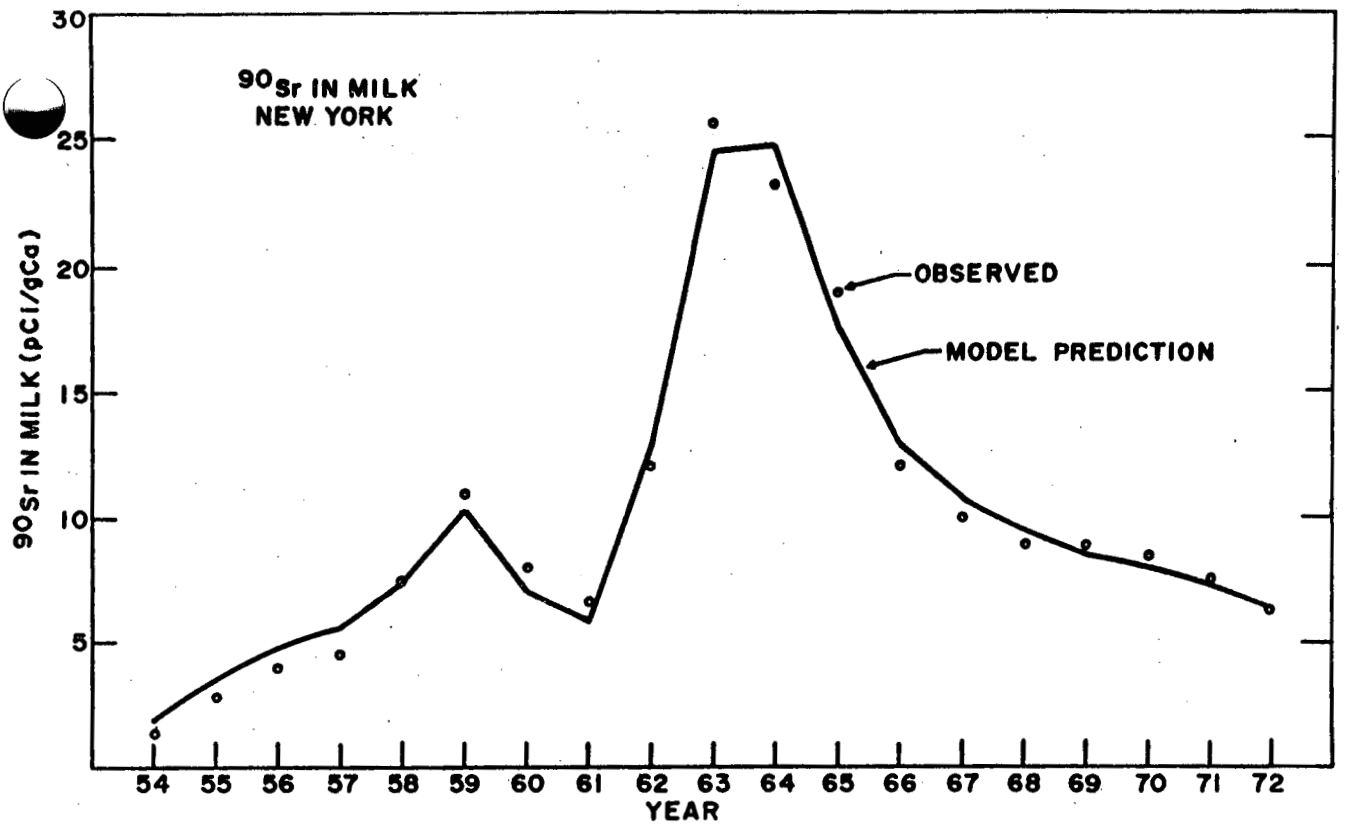

Figure 2. Average annual Sr-90 concentration in milk in New York City.

$p_3 = .20$ $\lambda = .14$. Such stability of the parameter values with fits to additional data reflects the appropriateness of the model formulation. The mean residence time of Sr-90 in soil inferred from the exponential removal term is 7.1 years after the initial deposition year. This corresponds to 11% per year removal of Sr-90 in addition to the 2.4% radioactive decay. A similar deposition-milk model has been used previously by Bartlett and Russell.[4] Their results for the U.K. are in general agreement with the results reported here.

Table 4

Sr^{90} Deposition and Contamination of Milk in New York

Year	Deposition (mCi/km^2)	Sr-90/Ca Ratio in Milk (nCi/g Ca) Observed	Sr-90/Ca Ratio in Milk (nCi/g Ca) Calculated	Percentage of Sr^{90} in milk attributable to uptake from soil
1954	2.76	1.4	1.9	0
55	3.97	2.8	3.5	13
56	4.43	3.9	4.8	21
57	4.44	4.5	5.6	29
58	6.16	7.6	7.4	30
59	8.68	11.0	10.3	29
60	1.58	8.0	7.0	58
61	2.43	6.7	5.9	66
62	12.33	12.1	12.8	29
63	23.79	25.6	24.4	22
64	15.85	23.2	24.7	36
65	5.53	19.1	17.6	59
66	2.43	12.1	12.9	78
67	1.64	10.0	10.8	85
68	1.32	9.0	9.5	87
69	1.43	9.0	8.7	85
70	1.48	8.4	8.0	84
71	1.41	7.6	7.4	83
72	0.75	6.2	6.3	87

Table 4 shows the measured annual Sr-90 deposition and the Sr-90/Ca ratio in milk in New York and the milk Sr-90/Ca ratio calculated by the above model using the given proportionality factors. Also shown is the percentage of the Sr-90/Ca ratio attributable to uptake of Sr-90 from soil. Since 1965, contamination of milk has been primarily due to uptake of Sr-90 from the cumulative deposit in soil. In 1972 this source accounted for 87% of the Sr-90 contamination of milk.

The procedure for estimating total diet Sr-90 intake from milk levels during periods of low fallout deposition is given by the following formula.[2]

$$D_n = \tfrac{1}{4} [.8\ M_o + 1.4\ (M_1 + M_2 + M_3) + .6\ M_3]$$

Where D_n is the average yearly Sr-90/Ca ratio in total diet, M_i is the Sr-90/Ca ratio in milk during the final quarter of the previous year (i = o) and the four quarters of the current year (i = 1,2,3,4). The formula gives 8.7 pCi/g Ca in total diet in New York during 1971, somewhat lower than the measured ratio. Somewhat higher values for the proportionality factors would be appropriate in the most recent years, however, as average factors, they apply quite well to the milk data obtained since 1960, as is shown in Figure 3. The proportionality factors were modified slightly in the few quarters when Sr-90 deposition was greater than 3 mCi/km^2 per quarter (see ref. 2). The annual total diet Sr-90 intakes estimated from the quarterly milk data are usually within 10% of the observed values.

The common procedure of multiplying the average Sr-90/Ca ratio in milk by 1.4 yields less appropriate estimates of the total diet Sr-90/Ca ratios over periods of varying Sr-90 deposition. The measured diet-milk ratio for New York in 1972

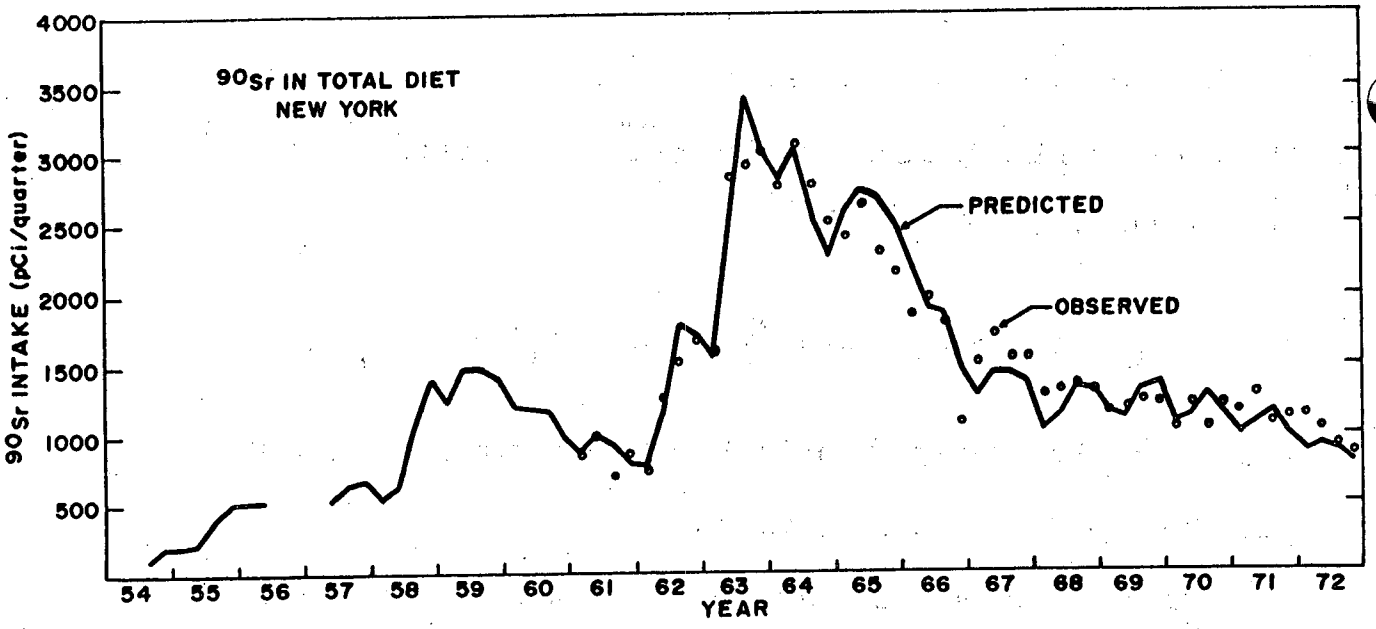

Figure 3. Quarterly intake of Sr-90 in total diet in New York City.

is 1.7, reflecting greater relative contribution to Sr-90 intake by non-dairy food items.

Anticipated Sr-90 Intake in 1973

Atmospheric nuclear testing activity in recent years in the Northern Hemisphere has included one Chinese test of estimated total yield of 3 MT in each of 1968, 1969, and 1970. Low yield tests were conducted by the Chinese in November 1971 and in January 1972 and an intermediate test (20-200 kT) in March 1972. There were 5 French tests of varying yields in the South Pacific in 1968, 8 in 1970, and 3 of low yield in 1972. The absence of large scale atmospheric tests in the

Northern Hemisphere for the past two years resulted in reduced Sr-90 deposition during 1972. The large contribution to diet attributed to uptake from the relatively constant cumulative deposit of Sr-90 in soil, however, precludes large variations in Sr-90 intake from one year to the next. If atmospheric testing activity remains at a low level or ceases in the future, one would expect the New York and San Francisco diets to show further slight reductions in Sr-90 concentrations during 1973. Based on variations in recent years, one would qualitatively estimate Sr-90 intakes in 1973 to be 9.8 ± .4 pCi/day in New York and 3.2 ± .2 pCi/day in San Francisco.

References

1. A description of the sampling methods and further details of the diet studies are given in:

Rivera, J. and Harley, J. H.
HASL Contributions to the Study of Fallout in Food Chains
USAEC Report HASL-147, July (1964)

The consumption statistics are obtained from:

Food consumption of Households in the United States - Spring 1965
A Preliminary Report, USDA, ARS 62-16, August (1967)

2. Bennett, B. G.
Estimation of Sr-90 Levels in the Diet
USAEC Report HASL-246, January (1972)

3. Bennett, B. G.
Strontium-90 in the Diet - Results through 1971
USAEC Report HASL-249, April (1972)

4. Bartlett, B.O. R.Scott, Russell, and W.Jenkins
Improved Relationship Between the Deposition of Strontium-90 and the Contamination of Milk in the United Kingdom
Nature, 238, No. 5358, pp 46-48, July 7, 1972

The Tropospheric Baseline Concentration for Lead

by H. L. Volchok, (HASL)

ABSTRACT

Much of the published data on lead concentrations in air from remote sampling stations on the earth's surface suggest that the baseline concentration may not be much greater than the value estimated from natural sources. An average value of about 1 ± 0.5 ng/m^3 as the global tropospheric Pb baseline is indicated.

INTRODUCTION

The concept of baseline concentration of any particular substance, while not rigorously defined, appears to be generally accepted as referring to the "background", and implies insulation from local sources of contamination. Both Chow et al (1, 2) and Simpson (3) recognized the necessity for establishing the baseline concentration of lead (or any pollution suspect) as a prerequisite to understanding the regional and perhaps global aspects of urban pollution. The actual geographic extent of a tropospheric baseline has also not been defined. Chow (2) referred to the "continental lead aerosol baseline concentration", while Simpson (3) discussing "aged" aerosols, suggested their use in evaluating urban pollution on a hemispheric scale.

There is little doubt that through man's activities even the most remote regions of the earth's surface have been affected; current snow falls in Greenland are at least 2 orders of magnitude higher in Pb concentration than those prior to extensive industrial Pb usage (4). However, with the increasing general awareness of the impact of pollution on the quality of life, significant programs have been initiated to decrease the contamination. For Pb, severe limitations in its use in paints and other consumer products as well as in automobile fuels has resulted, for example, in a measurable decrease in the surface air concentration in New York City (5). It seems pertinent at this time, therefore, to summarize the available low level lead concentration data in tropospheric air and if possible define the baseline level.

HASL SURFACE AIR DATA

The Health and Safety Laboratory (HASL) has continuously measured Pb concentrations in surface air, at about 20 stations, since mid 1967. This program, originally set up by the Naval Research Laboratory in 1957, was designed to study surface air concentrations of radioactive debris from nuclear weapons tests. The sampling sites were oriented, for the most part, about the 80th

meridian (West); along the east coast of North America and the west coast of South America. The sampling and analytical procedures as well as complete data summaries are published quarterly (6). The quality of the data in this program is intensively monitored and also regularly reported (7).

Obviously, the sampling stations in this project were set up to satisfy criteria of global fallout research. The source was mainly stratospheric and local contamination was a negligible problem. In many respects these criteria are quite opposed to those which might be suggested for studies of environmental lead - especially baseline Pb. However, we have found that some of the surface air data, for Pb, may in fact prove useful in circumscribing the baseline.

In units of nanograms per cubic meter of air sampled (ng/m^3) the urban sites in recent years range between a few hundred and a few thousand. Suburban surface air generally contain lower mean monthly concentrations very much dependent upon the proximity to urban centers and prevailing wind directions.

There are however, within the HASL network, five stations which are quite remote from highways and power generating equipment.

These are:

Thule, Greenland - (latitude 76°36'N). The station is located on a hill about 4 miles northeast of the air base The prevailing wind is from the south, hence the station is not ideally located for baseline studies.

Mauna Loa, Hawaii - (latitude 19°28'N). This station, as described by Simpson (3) could be perhaps one of the best baseline stations on the earth's surface. The site at 11,300 ft. is normally above the trade wind inversion, 300 km downwind of Honolulu and tens of kilometers from any of the coastal towns on the island of Hawaii. Unfortunately, the location of our sampler was, until recently within 25 feet of a parking lot which from time to time, accommodated numerous automobiles of both staff and sightseers.

Puerto Montt, Chile (latitude 41°27'S). Through 1969, the sampler at Puerto Montt was located about 20 km. outside of the town and several hundred meters off a sparsely used road. For convenience, but shortsightedly, in 1970 the sampler was moved to the local airport, resulting in markedly increased Pb concentrations.

Antarctica - (Chilean owned islands - latitude ~64°S).

The sampler here has been moved a number of times but never has varied by more than 2° of latitude or longitude. We believe that the sampler is powered by gasoline generators which probably are responsible for the variability of the concentrations observed.

South Pole (90°S). The equipment at the South Pole is operated for us by NOAA personnel. Here again, we believe that the variability reflects the proximity to and the wind direction from, polluting sources.

The results of all of the Pb concentrations data from these stations are summarized in Table 1.

Table 1

Mean Monthly Pb Air Concentration Data from HASL Remote Stations

Station	Latitude	Pb-Monthly Concentrations (ng/m^3) Median	Lowest Value
Thule, Greenland	75°36'N	9.2	0.9
Mauna Loa, Hawaii	19°28'N	5.3 (A)	0.7 (B)
Puerto Montt, Chile	41°27'S	5.6	0.5
Antarctica, Chile	~64°S	9.5	1.4
South Pole	90°S	4.3	1.6

(A) Simpson[3] sampled at Mauna Loa from Aug. thru Dec. 1970. The median of his data is 2.5 and the lowest was about 1.

(B) One extremely low value (0.07 ng/m^3) was eliminated as being analytically suspect.

OTHER PERTINENT DATA

Chow, et al (2) admirably summarized most of the other available low level Pb air concentrations. These are listed in Table 2. Included also in Table 2 is the White Mountain, Calif.

Table 2

Pb Aerosol Concentrations in Marine & Arctic Atmosphere [Afer Chow (3)]

Site Sampled	Concentrations (ng/m^3)	Original Reference
North-Central Pacific Ocean	1.0	(1)
Windward Oahu - Hawaii	1.7	(8)
South Indian Ocean	1.0	(9)
North Indian Ocean	4.5	(9)
Novaya Zemlya	0.3	(9)
Greenland	0.5	(4)
White Mountain, California	8.0	(2)

data from the same article. Note, for comparison with some of the other results, that the lowest monthly average concentation at White Mountain was 1.2 ng/m^3.

Moyers et al (10) reported the average concentration of Pb in air in 111 samples on the windward shore of Oahu, Hawaii (evidently an update of reference (8)) as 3.0 ± 2.8 ng/m^3.

DISCUSSION

In light of the number of different laboratories and the lack of information concerning accuracy and precision of the reported results, there appears to be a gratifying degree of consistency in the surface air Pb concentration data, summarized in the preceding two sections. Considering only the lowest month's concentration for the HASL sites, Oahu and White Mountain, except for the North Indian Ocean data, the 11 sites vary by only about a factor of 6; from 0.3 ng/m^3 at Novaya Zemlya to 1.7 at Hawaii. I hesitate to interpret this range as a latitudinal effect as suggested by Egorov et al (9) without much more information on the analytical standardization and quality control of the laboratories involved. However, it does not seem reasonable to expect complete homogeneity of the global troposphere when one considers the heterogeneity of the Pb source.

Patterson (11) estimated that the natural sources of lead on the earth would contribute about 0.5 ng/m^3 to the atmosphere. This value is of course a global mean, but it is, interesting to note that at this particular time, probably at the peak in

the earth's history of atmospheric Pb contamination, some of the remote sites may actually be almost pollution free. To pursue this particular subject further, a study of the Pb aerosol at these sites by isotopic means, would be extremely useful.

In summary, I have attempted here to define a baseline range for the Pb concentration in the troposphere. The conditions at the sampling stations were less than ideal for this purpose and the quality of much of the reported data is unknown. Nevertheless, representing both hemispheres and a wide range of latitudes, over land and over ocean, the data strongly suggest that the baseline concentration of Pb in most of the troposphere is probably 1 ± 0.5 ng/m^3.

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PART II

HASL FALLOUT PROGRAM DATA

1. Fallout Deposition

1.1 Monthly Precipitation

1.11 Sr^{90} and Sr^{89} in Monthly Deposition at World Land Sites

Precipitation and dry fallout are collected over monthly periods at stations in the United States and overseas. The samples are analyzed for Sr-90 and prior to 1971 for Sr-89 whenever possible. A description of the sampling network and available data for each site are given in the Appendix, Section A.

1.12 Other Isotopes at Selected Sites

At a number of stations in the United States, monthly deposition collections were analyzed for radiostrontium and other nuclides of interest to the Atomic Energy Commission. Multinuclide analyses were discontinued as of July 1967 and the complete data reported in HASL-193, p. II-4 thru II-25.

Plutonium analyses of monthly deposition were carried out at New York City, Melbourne, Seattle, Honolulu, Salisbury, Durban, and Rio de Janeiro. This program has been terminated and the complete data are given in HASL-237 on pages II-4 thru II-13.

1.2 Sr^{90} and Sr^{89} Deposition at Atlantic Ocean Weather Stations

Measurements of radiostrontium in precipitation and dry fallout collections at four U. S. Coast Guard Stations in the North Atlantic Ocean were carried out for comparison with land stations in the same latitude band. A description of the stations and available data are given in the Appendix, Section B.

2. Surface Air Sampling Program

The Health and Safety Laboratory has been collecting surface air particulate samples at stations in the Western Hemisphere since January 1963. The filters are analyzed for a number of fission and activation product radionuclides as well as stable lead. A description of the program and available data are given in the Appendix, Section C.

3. Project Airstream
The Health and Safety Laboratory measures radioactivity in the lower stratosphere employing the RB-57F aircraft as a sampling platform. The aircraft are flown by the 58th Weather Reconnaissance Squadron under the direction of the 9th Weather Wing of the Air Weather Service. The missions are scheduled quarterly and the coverage extends from 75°N to 51°S latitude in the Western Hemisphere. Air filter samples are collected from 12 to 19 km altitude and analyzed for a number of radionuclides. A more complete description of the program and available data are given on pages II-8 to II-90 of this report.

4. High Altitude Balloon Sampling Program
Balloon borne filtering devices are used to collect nuclear debris at altitudes from 21-32 km. Balloon launchings are conducted annually at Fairbanks, Alaska, 65°N; Sioux City, Iowa, 42°N; Alamagordo, N.M., 33°N; and Panama C.Z., 9°N and quarterly at Mildura, Australia, 34°S. Filters are analyzed for a number of radionuclides. A more complete description of the program and available data are given on pages II-161 to II-200 of HASL-259.

5. Radiostrontium in Milk and Tap Water
Strontium-90 levels in both powdered and fresh milk distributed in New York City and tap water sampled at the Health and Safety Laboratory, have been measured on a monthly basis since 1954. These data are summarized in tabular and graphical form in the Appendix, Section D.

6. Strontium-90 in Diets
Quarterly estimates of the annual dietary intake of Sr-90 of New York City and San Francisco residents have been made based on analyses of foods purchased at these cities every three months since 1960. Sampling in Chicago was discontinued in 1967. The program is described and available data reported on p. II-4 to II-7 of this report.

7. Strontium-90 in Human Bone
Specimens of human vertebrae from New York City and San Francisco have been made available for Sr-90 analysis since 1961. The results for 1971 were evaluated beginning on page I-51 of HASL-257.

6. HASL Diet Studies: Third and Fourth Quarters 1972

Results of the measurements of the Sr^{90} content of foods purchased in New York City and San Francisco in the third and fourth quarters of 1972 are given in the following tables. Estimates of the daily intake of Sr^{90} based on these measurements and on the revised consumption statistics given in the most recently available U. S. Department of Agriculture Report[1], are also listed.

The estimates of daily Sr^{90} intake are a continuation of the HASL Tri-City diet studies which were started in March of 1960. Results of the earlier measurements along with those made during 1972 are shown graphically in the figure on page II-7. A complete description of the sampling methods and philosophy of the HASL diet studies was given in HASL-147[2]. A discussion of the reasons for changes in the Tri-City diet studies made in 1968 was given in HASL-200[3].

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STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS

- Third Quarter 1972 -

				New York City - August			San Francisco - September		
Diet Category	kg/yr	gCa/yr	% of yearly intake of Ca	pCi ^{90}Sr/kg	pCi ^{90}Sr/yr	% of yearly intake of ^{90}Sr	pCi ^{90}Sr/kg	pCi ^{90}Sr/yr	% of yearly intake of ^{90}Sr
Dairy Products	200	216.0		5.9	1173		1.2	240	
			58			33			24
Fresh Vegetables	48	18.7		13.0	623		1.1	53	
Canned Vegetables	22	4.4		5.6	122		2.2	49	
Root Vegetables	10	3.8		6.0	60		3.8	38	
Potatoes	38	3.8		7.4	281		1.3	48	
Dry Beans	3	2.1		14.5	44		4.4	13	
			9			31			20
Fresh Fruit	59	9.4		7.0	413		2.1	121	
Canned Fruit	11	0.6		1.5	16		0.8	9	
Fruit Juices	28	2.5		3.5	98		2.1	59	
			3			15			19
Bakery Products	44	53.7		6.6	292		2.5	111	
Flour	34	6.5		6.8	232		3.4	115	
Whole Grain Products	11	10.3		11.6	128		4.3	48	
Macaroni	3	0.6		4.7	14		4.1	12	
Rice	3	1.1		1.7	5		1.8	6	
			20			19			30
Meat	79	12.6		0.5	40		0.5	36	
Poultry	20	6.0		0.5	10		0.4	8	
Eggs	15	8.7		2.8	41		1.4	22	
Fresh Fish	8	7.6		0.4	3		N.D.	-	
Shell Fish	1	1.6		0.2	-		N.D.	-	
			10			3			7
Yearly Intake	370				3595			988	
Daily Intake - pCi per gCa					9.7			2.7	

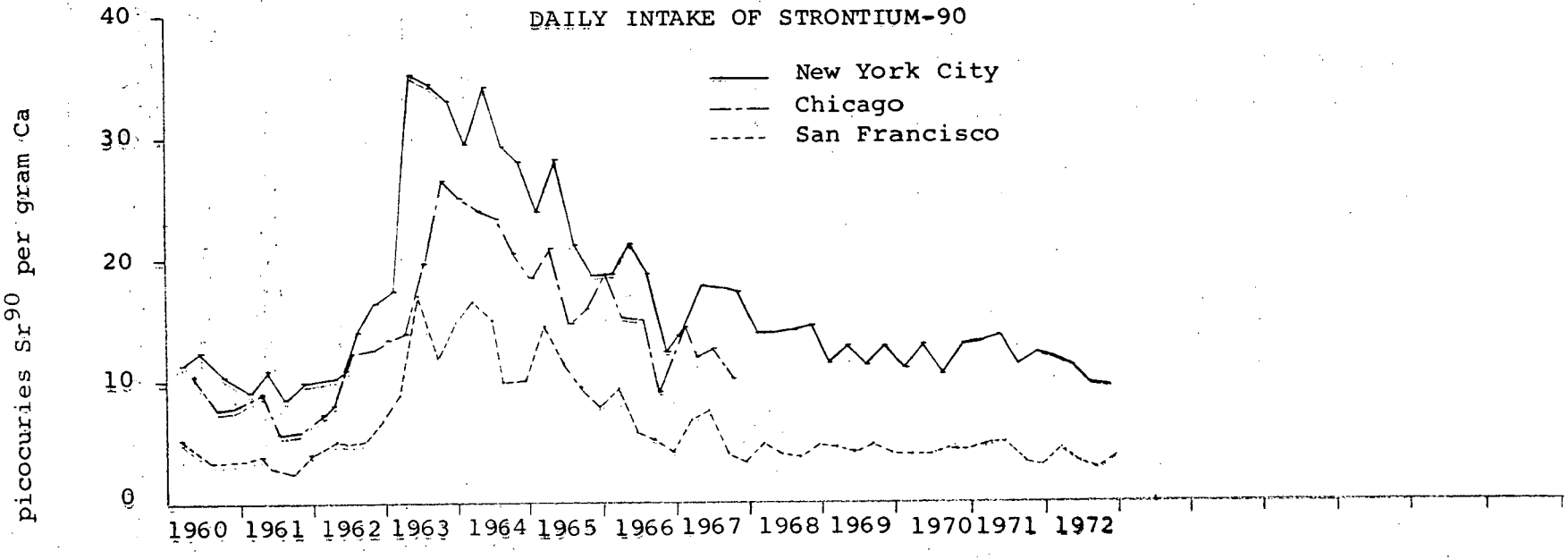
N.D. = not detectable

STRONTIUM-90 IN NEW YORK CITY AND SAN FRANCISCO DIETS

- FOURTH QUARTER 1972 -

Diet Category	kg/yr	gCa/yr	% of yearly intake of Ca	New York City - November			San Francisco - December		
				pCi ^{90}Sr / kg	pCi ^{90}Sr / yr	% of yearly intake of ^{90}Sr	pCi ^{90}Sr / kg	pCi ^{90}Sr / yr	% of yearly intake of ^{90}Sr
Dairy Products	200	216.0		6.7	1331		1.5	290	
			58			38			21
Fresh Vegetables	48	18.7		14.1	678		2.4	113	
Canned Vegetables	22	4.4		7.6	166		3.1	69	
Root Vegetables	10	3.8		6.3	63		5.7	57	
Potatoes	38	3.8		4.1	155		3.8	143	
Dry Beans	3	2.1		10.4	31		29.9	90	
			9			31			34
Fresh Fruit	59	9.4		8.0	475		2.3	137	
Canned Fruit	11	0.6		1.2	13		1.2	13	
Fruit Juices	28	2.5		2.8	80		2.1	60	
			3			16			15
Bakery Products	44	53.7		3.4	150		3.2	141	
Flour	34	6.5		6.4	216		3.5*	118	
Whole Grain Products	11	10.3		9.8	108		5.0	55	
Macaroni	3	0.6		4.2	13		4.4	13	
Rice	3	1.1		1.3	4		1.3	4	
			20			14			24
Meat	79	12.6		N.D.	-		0.5	40	
Poultry	20	6.0		0.6	11		0.8	16	
Eggs	15	8.7		0.3	4		1.1	16	
Fresh Fish	8	7.6		N.D.	-		N.D.	-	
Shell Fish	1	1.6		1.0	1		N.D.	-	
			10			1			5
Yearly Intake 370					3499			1375	
Daily Intake - pCi per gCa					9.5			3.7	

N.D. = not detectable
* = estimated


DAILY INTAKE OF STRONTIUM-90
New York City
Chicago
San Francisco
picocuries Sr^{90} per gram Ca
40
30
20
10
0
1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970 1971 1972

3. PROJECT AIRSTREAM

by Philip W. Krey (HASL)
Lawrence E. Toonkel (HASL)
Mindy Schonberg (HASL)

Project Airstream is HASL's study of radioactivity in the lower stratosphere employing the RB-57F aircraft as a sampling platform. The aircraft are flown by the 58th Weather Reconnaissance Squadron under the direction of the 9th Weather Wing of the Air Weather Service. This project is a continuation of the Defense Atomic Support Agency's Project Stardust except that Airstream's sampling missions are limited to only one per season.

This report contains the radiochemical data from the missions flown in March, July and October 1972. Previous reports containing results from this program are given in references 1 through 16.

FLIGHT SCHEDULE

Airstream missions are now scheduled for January, April, July and October with a ± one month slippage. However, each mission must be completed within a nine day interval. The first Airstream mission was flown in August 1967. The flight trajectory and altitude coverage of an Airstream mission are shown in Figures 3a and 3b, respectively. Because of operational difficulties, some of the altitudes in the July 1972 mission varied from the projected profile shown in Figure 3b.

The coverage in Figure 3b extends almost continuously at the indicated altitudes from 75°N to 51°S latitude except for a slight discontinuity between 10°S to 16°S. Each mission is accomplished by conducting return flights northward and southward from each of the four Air Force Bases of operation:

Eielson AFB	64°40'N	147°06'W
Kirtland AFB	35°03'N	106°36'W
Albrook AFB	08°57'N	79°34'W
Mendoza AFB	32°49'S	68°47'W

AIR FILTER SAMPLES

Air filter samples are collected along the flight tract at latitude increments of approximately 3 to 4° at each of the prescribed altitudes using the U-1 foil system. This system permits the sequential insertion of up to 13 IPC No. 1478 filter papers (diameter 16-3/8") into the sampling duct near the bomb bay on the right side of the aircraft. The volume of air sampled by each filter is calculated by the methods developed under Project Stardust and updated by Krajewski (17), and are reported as standard cubic meters (SCM) under the ICAO standard atmosphere (760 mm Hg and 15°C).

Beginning with the July 1972 mission, a cooperative program was initiated with the National Center for Atmospheric Research (NCAR) in which the filters from the Airstream missions will be shared.

NCAR is investigating the concentrations of stable tracers in the stratosphere with emphasis on water soluble stable tracers. To minimize the background contamination of these tracers in the filter material, NCAR washes each filter prior to exposure in the aircraft and special precautions are then taken in their installation and recovery. Tests conducted by NCAR and HASL show no demonstrable difference in collection efficiency between washed and unwashed filters (16).

TOTAL GAMMA AND GAMMA SPECTRUM MEASUREMENTS

Prior to July 1972 the filters were sent directly to HASL where they were coded, logged and quartered. The entire sample (or a representative fraction if the activity is too high) was folded and placed in a plastic box, 8 cm x 6.5 cm x 3.1 cm deep, for a gross gamma measurement on an 8" x 4" NaI (Tl) crystal. The total gamma activity was integrated between 100 Kev and 2.0 Mev, and the gamma concentration was reported as counts per minute (cpm) per 100 SCM on the counting date.

After July 1972 the filters are sent to NCAR where they are cut into thirds under "clean room" conditions. One third is analyzed by NCAR; one third is analyzed by HASL; and one third is reserved for the HASL library of stratospheric samples. To minimize the

impact of any heterogeneity of debris on the filter, each one third is a composite of opposite sixths of the original filter.

Based upon the gamma measurements, opposite quadrants or the one-third sections of each filter are usually combined into appropriate composite samples which are submitted to gamma spectral analysis at HASL by lithium drifted germanium diode detectors. It has been shown that opposite quadrants of the filter are representative of the entire filter. The composite samples are compressed into a 6 cm diameter by 3.5 cm depth aluminum can. The detectors are closed-end coaxial diodes of approximately 50 cm^3 volume with the following characteristics for the 1.33 Mev photon of Co-60:

Point Source efficiency at diode face: 1.2 - 1.7%

Resolution: 2.1 - 2.6 Kev

Peak-to-Compton: about 30 to 1

The diode responses are stored in 3000 channels of a computer based pulse height analyzer. A computer program resolves and reduces these spectra data by least squares fitting and has a sub routine which adjusts for the density of the sample. Presently the nuclides of interest from the diode spectrometry are

Be-7, Zr-95, Cs-137 and Ce-144. The germanium diode systems have been calibrated with standard solutions prepared at HASL. An efficiency versus energy curve has been prepared (shown in Fig. 3c) which illustrates the interrelation between standards and which lends greater reliability to the individual photon energy efficiencies.

RADIOCHEMICAL ANALYSIS

After the gamma measurements are completed, the composite samples are sent to contractor laboratories for detailed radiochemical analyses including some of the following nuclides:

Sr-89	Pb-210	Pu-238
Sr-90	Po-210	Pu-239,240

At the present time, Laboratory for Electronics Environmental Analysis Laboratory formerly Trapelo Division/West, Richmond, California is performing these analyses. Nuclide concentrations from radiochemical analyses are reported as picocuries per 100 standard cubic meters of air (pCi/100 SCM) at collection time. To convert pCi/100 SCM to disintegrations per minute per 10^3 standard cubic feet multiply by 0.629.

One standard deviation of the counting error for all data in this report is less than ±20% and usually less than ±10% unless annotated with the symbols:

A. One standard deviation of the counting error is between ±20 - 50%.

B. One standard deviation of the counting error is between ±51 - 100%.

*: Activity is not detectable. This designation is applied to data when one standard deviation of the counting error is greater than ±100%.

?: The nuclide concentration of a specific sample is considered suspect because it is inconsistent with the concentration of the same nuclide in adjacent samples in space and time or because it is inconsistent with other nuclides in the same sample.

The nuclide activity for each sample is corrected for the normal radiochemical parameters such as chemical yield and detection efficiency.

Po-210 is analyzed as rapidly as possible after the samples are received in the laboratory. The Po-210 data are reported as concentrations at collection time, and are corrected for the Po-210 which grew in from Pb-210 during the interval between collection and analysis of the filter. If the Po-210 at the time of analysis exceeds the Pb-210, the excess is corrected with a 138 day half life to collection and added to the equilibrium value of the Pb-210. This rarely happens, and the data is likely to be considered suspect when it does.

Beginning with the August 1970 mission, Pb-210 is analyzed by measuring the Po-210 ingrowth during a four month interval from a purified lead fraction to provide a greater sensitivity of analysis. Because of this ingrowth interval, the Pb-210 and Po-210 results are reported at a later time than the other radionuclides.

QUALITY CONTROL

To evaluate HASL's gamma ray spectrometry and the contractor's radiochemistry, blind blanks, standards and duplicates are routinely submitted for analysis. Prior to July 1972, the blanks were unexposed filters of IPC-1478 paper selected from the Air Force supply in current use. When sample sharing with NCAR began in July 1972, the blanks represented pre-washed filters exposed at altitudes for 5 seconds in filter position number 4 or 7 of the U-1 foil system.

For the March 1972 mission, the duplicates were identical composites of quadrants, not halves as was the practice earlier, with different code numbers. This reduction in the aliquot was initiated to preserve some fraction of each filter for possible future studies. Beginning with the July 1972 mission, the duplicates were identical composites of one sixth of each filter. To reduce the

effect of heterogeneity of debris on the filter and thereby improve the quality of the duplicate, each one sixth was made up of opposite one twelfths of the original filter.

Standards for radiochemistry are unwashed and unexposed filters of IPC-1478 paper on to which calibrated solutions of various nuclides have been evaporated. These calibrated solutions are available from a number of sources (i.e. Radiochemistry Center, IAEA, Nuclear Chicago) and are recalibrated at HASL. Generally, the agreement between HASL's value and the reported value is very good.

For gamma ray spectrometry specially prepared standards were made by mixing calibrated solutions of gamma emitting radionuclides with a 1% solution of Agar-Agar. These were found to be a reliable index of quality control for spectrometry because of the uniform distribution of radioactivity within the sample can (15). Starting with the July 1972 mission Agar standards are used exclusively to evaluate the quality of the gamma ray spectrometric analyses. The sample numbers of the standards are changed after each analysis so that they can be re-used many times.

R E S U L T S

The total gamma concentrations from the October 1972 mission are given in Table 3a. The gamma spectral and radiochemical analyses of the March 1972 composite samples are reported in Table 3b. The gamma spectral analysis of the July and October composite samples are reported in Tables 3c and 3d. The samples in these tables are grouped according to altitude of collection beginning with 19.2 km. Within each altitude group, the samples are then listed with decreasing latitude. The fractions of each individual filter making up the composites are listed immediately below the composite sample number. The collection parameters of the composite sample and the contractor laboratory performing the analysis are given prior to the nuclide concentrations.

Starting in July 1972 where the composites are made up of the one third sections reserved for radiochemistry, no fraction is reported. In the case of duplicates, the ½ fraction reported in the tables is one half of the reserved 1/3 section and in reality is 1/6 of the exposed filter.

The results of the quality control program are given in Tables 3e and 3f. The analyses of the blank samples in Table 3e indicate that the contamination inherent in the filter or introduced during

normal handling and laboratory operations is either not detectable or relatively unimportant to the activities encountered in the samples for the nuclides analyzed.

The results of the analyses of the standard samples for radiochemistry in Table 3e demonstrate high accuracy for the plutonium isotopes. However the Sr isotopes indicate an apparent bias of about -25%. Additional strontium standards are being analyzed to verify and correct this bias.

The analyses of the Agar standards for gamma ray spectrometry are reported in Table 3f. Each Agar standard was assayed blind as a routine sample from the July and October 1972 missions. Table 3f gives not only the % deviation of the analytical result from the expected value of each standard for each mission but also the average % deviation from all earlier measurements. It also lists the average % deviation of all the Agar standards for each nuclide for each mission.

Generally the % deviation reported for each standard agrees reasonably well with the average % deviation of earlier measurements. This consistency attests to the precision of analysis. The average deviation for all gamma emitting nuclides for both

the July and October 1972 missions is less than ±10% except for Zr-95 which indicates an apparent bias of about -15 to -20%.

The percent deviation between the analyses of duplicate samples is also shown in Table 3e and represents the range between duplicates divided by the mean. For most nuclides this deviation averages less than ±15% for each mission except for Be-7 and Sr-89 which can be as high as twice that amount. This greater imprecision of Be-7 and Sr-89 data is probably due to analytical problems rather than the result of heterogeneous aliquoting of the filter because the other nuclides show lesser deviations between duplicates.

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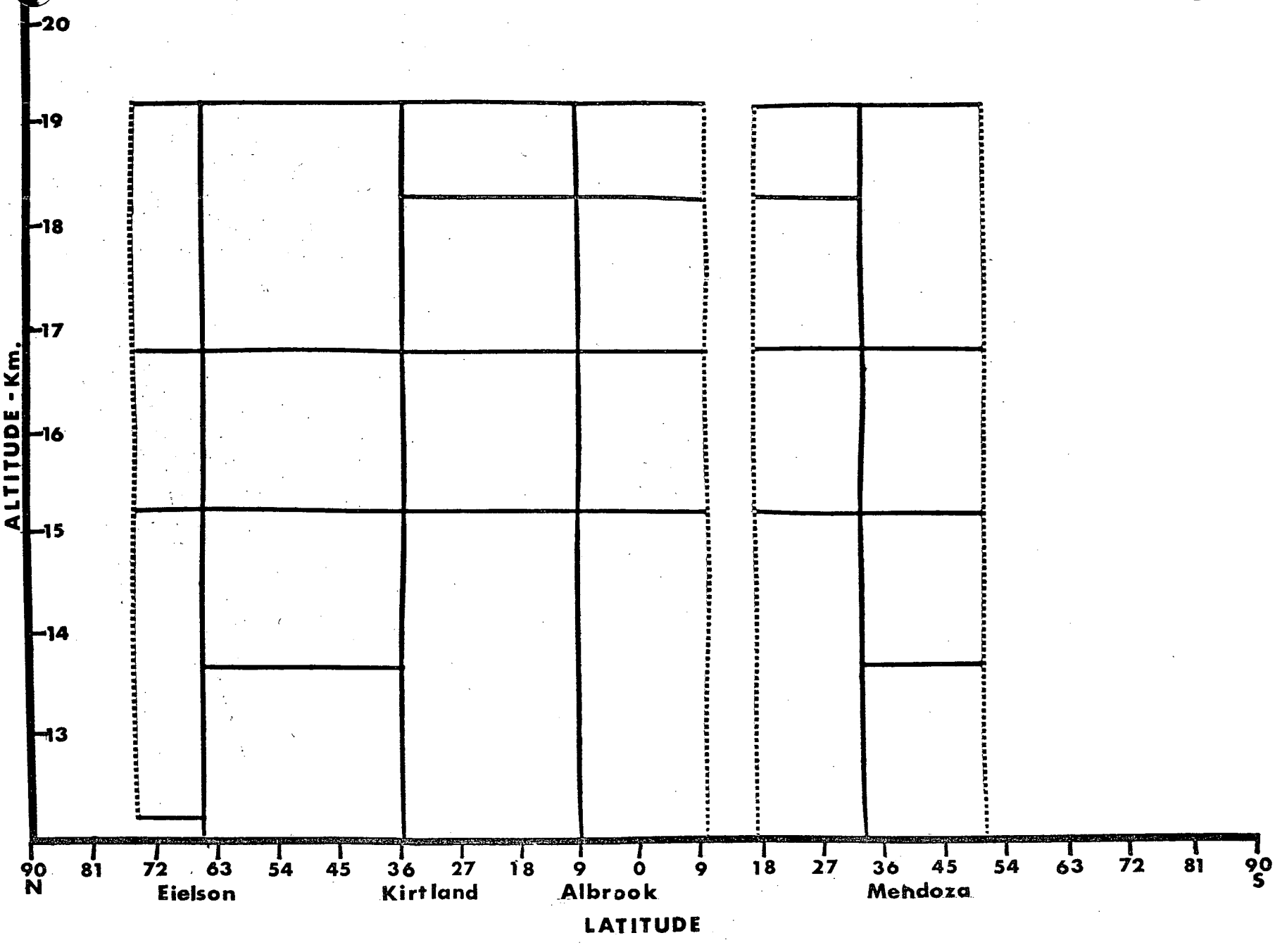
USAEC Report HASL-211, July (1969)

Figure 3b - Airstream Altitude Coverage



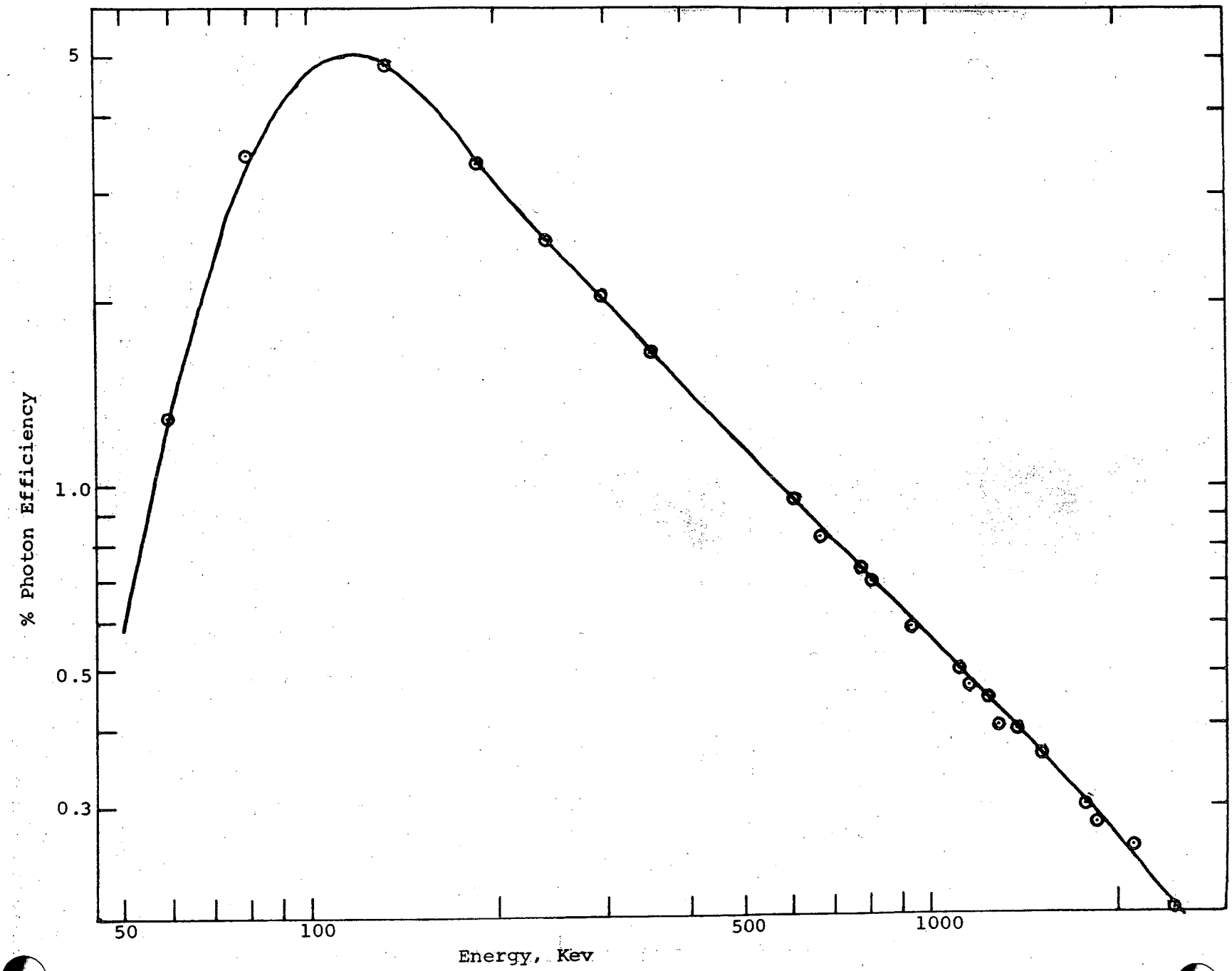


Fig. 3c - Calibration Curve of Germanium (Li) Diode Spectrometer

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 19.2 KM

SAMPLE NO.	6427	6428	6429	6430	6312
FLIGHT NO.	289	289	289	289	289
DATE	10/23/72	10/23/72	10/23/72	10/23/72	10/20/72
TIME	2132-2158	2158-2227	2227-2248	2248-2308	2148-2238
LAT.	75N-72N	72N-69N	69N-67N	67N-65N	65N-62N
LONG.	143W-143W	144W-143W	145W-144W	146W-145W	147W-138W
VOL. OF AIR (100 SCM)	0.73	0.81	0.59	0.56	1.33
GROSS GAMMA/ M/100 SCM	137.	185.	102.	107.	195.
COUNT DATE	12/12/72	12/12/72	12/12/72	12/12/72	11/30/72

SAMPLE NO.	6311	6309	6308	6306	6305
FLIGHT NO.	289	289	289	289	289
DATE	10/20/72	10/20/72	10/20/72	10/20/72	10/20/72
TIME	2105-2148	2027-2105	1951-2027	1905-1951	1833-1905
LAT.	62N-59N	59N-56N	56N-53N	53N-49N	49N-46N
LONG.	138W-131W	131W-125W	125W-121W	121W-117W	117W-114W
VOL. OF AIR (100 SCM)	1.15	1.01	0.98	1.26	0.87
GROSS GAMMA/ M/100 SCM	174.	208.	163.	198.	230.
COUNT DATE	11/30/72	11/30/72	11/30/72	11/30/72	11/30/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 19.2 KM

SAMPLE NO.	6437	6439	6440	6441	6477
FLIGHT NO.	289	289	289	289	298
DATE	10/24/72	10/24/72	10/24/72	10/24/72	10/26/72
TIME	0539-0609	0609-0638	0638-0708	0708-0736	1923-2022
LAT.	49N-46N	46N-43N	43N-40N	40N-37N	34N-31N
LONG.	117W-114W	114W-112W	112W-110W	110W-108W	106W-100W
VOL. OF AIR (100 SCM)	0.85	0.82	0.84	0.79	1.80
GROSS GAMMA/ M/100 SCM	176.	159.	119.	114.	156.
COUNT DATE	12/12/72	12/12/72	12/12/72	12/12/72	12/12/72

SAMPLE NO.	6476	6484	6486	6487	6488
FLIGHT NO.	298	298	298	298	298
DATE	10/26/72	10/18/72	10/18/72	10/18/72	10/18/72
TIME	1836-1923	1915-1945	1945-2016	2016-2045	2045-2115
LAT.	31N-28N	23N-20N	20N-17N	17N-14N	14N-11N
LONG.	100W- 95W	87W- 86W	86W- 83W	83W- 82W	82W- 80W
VOL. OF AIR (100 SCM)	1.42	0.91	0.96	0.91	0.94
GROSS GAMMA/ M/100 SCM	169.	132.	104.	99.	160.
COUNT DATE	12/12/72	12/12/72	12/12/72	12/12/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 19.2 KM

SAMPLE NO.	6489	6357	6356	6355	6354
FLIGHT NO.	298	290	290	290	290
DATE	10/18/72	10/24/72	10/24/72	10/24/72	10/24/72
TIME	2115-2138	2006-2039	1931-2006	1859-1931	1825-1859
LAT.	11N- 9N	8N- 5N	5N- 1N	1N- 3S	3S- 7S
LONG.	80W- 79W	79W- 79W	79W- 79W	79W- 79W	79W- 79W
VOL. OF AIR (100 SCM)	0.73	1.08	1.15	1.06	1.13
GROSS GAMMA/ M/100 SCM	137.	139.	130.	142.	142.
COUNT DATE	12/12/72	12/06/72	12/06/72	12/06/72	12/06/72

SAMPLE NO.	6352	6448	6450	6451	6452
FLIGHT NO.	290	298	298	298	298
DATE	10/24/72	10/21/72	10/21/72	10/21/72	10/21/72
TIME	1747-1825	1611-1640	1640-1708	1708-1743	1743-1821
LAT.	7S-11S	15S-18S	18S-21S	21S-25S	25S-29S
LONG.	79W- 78W	77W- 76W	76W- 75W	75W- 73W	73W- 72W
VOL. OF AIR (100 SCM)	1.22	0.92	0.87	1.09	1.17
GROSS GAMMA/ M/100 SCM	131.	272.	149.	9. ?	9. ?
COUNT DATE	12/06/72	12/12/72	12/12/72	12/12/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 19.2 KM

SAMPLE NO.	6501	6500
FLIGHT NO.	298	298
DATE	10/22/72	10/22/72
TIME	1827-1920	1801-1827
LAT.	32S-36S	36S-39S
LONG.	68W- 65W	66W- 65W
VOL. OF AIR (100 SCM)	1.59	0.76
GROSS GAMMA/ M/100 SCM	195.	303.
COUNT DATE	12/13/72	12/13/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 18.9 KM

SAMPLE NO.	6475	6499
FLIGHT NO.	298	298
DATE	10/26/72	10/22/72
TIME	1750-1836	1725-1801
LAT.	28N-25N	39S-43S
LONG.	95W- 89W	67W- 66W
VOL. OF AIR (100 SCM)	1.48	1.08
GROSS GAMMA/ M/100 SCM	122.	148.
COUNT DATE	12/12/72	12/13/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 18.3 KM

SAMPLE NO.	6405	6480	6481	6483	6472
FLIGHT NO.	294	298	298	298	298
DATE	10/19/72	10/18/72	10/18/72	10/18/72	10/26/72
TIME	1915-2002	1703-1748	1748-1817	1817-1846	1654-1723
LAT.	35N-32N	32N-29N	29N-27N	27N-25N	23N-20N
LONG.	106W-101W	102W- 96W	96W- 93W	93W- 90W	87W- 86W
VOL. OF AIR (100 SCM)	1.79	1.70	1.07	1.07	1.13
GROSS GAMMA/ M/100 SCM	123.	147.	168.	112.	18.
COUNT DATE	12/08/72	12/12/72	12/12/72	12/12/72	12/12/72

SAMPLE NO.	6471	6469	6468	6392	6513
FLIGHT NO.	298	298	298	298	298
DATE	10/26/72	10/26/72	10/26/72	10/24/72	10/23/72
TIME	1623-1654	1555-1622	1536-1555	1813-1843	1844-1908
LAT.	20N-17N	17N-14N	14N-12N	12N- 9N	7N- 5N
LONG.	86W- 83W	83W- 82W	82W- 81W	81W- 79W	79W- 79W
VOL. OF AIR (100 SCM)	1.20	1.07	0.76	1.17	0.95
GROSS GAMMA/ M/100 SCM	17.	9.	40.	77.	84.
COUNT DATE	12/12/72	12/12/72	12/12/72	12/07/72	12/13/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 18.3 KM

SAMPLE NO.	6512	6511	6510	6508	6376
FLIGHT NO.	298	298	298	298	298
DATE	10/23/72	10/23/72	10/23/72	10/23/72	10/19/72
TIME	1810-1844	1736-1810	1701-1736	1616-1701	1703-1748
LAT.	5N- 1N	1N- 3S	3S- 7S	7S-12S	14S-19S
LONG.	79W- 79W	79W- 79W	79W- 74W	78W- 74W	77W- 75W
VOL. OF AIR (100 SCM)	1.38	1.41	1.38	1.81	1.77
GROSS GAMMA/ M/100 SCM	73.	43.	73.	133.	113.
COUNT DATE	12/13/72	12/13/72	12/13/72	12/13/72	12/07/72

SAMPLE NO.	6378	6379	6380	6381
FLIGHT NO.	298	298	298	298
DATE	10/19/72	10/19/72	10/19/72	10/19/72
TIME	1749-1816	1816-1843	1843-1920	1920-2009
LAT.	19S-22S	22S-25S	25S-29S	29S-33S
LONG.	75W- 74W	74W- 73W	73W- 71W	71W- 68W
VOL. OF AIR (100 SCM)	1.07	1.05	1.40	1.81
GROSS GAMMA/ M/100 SCM	234.	238.	179.	221.
COUNT DATE	12/07/72	12/07/72	12/07/72	12/07/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 16.8 KM

SAMPLE NO.	6425	6424	6422	6421	6433
FLIGHT NO.	289	289	289	289	289
DATE	10/23/72	10/23/72	10/23/72	10/23/72	10/24/72
TIME	2048-2116	2023-2048	1957-2023	1919-1957	0300-0344
LAT.	75N-72N	72N-69N	69N-66N	66N-63N	63N-60N
LONG.	143W-143W	144W-143W	145W-144W	145W-141W	142W-133W
VOL. OF AIR (100 SCM)	1.32	1.18	1.22	1.77	2.08
GROSS GAMMA/ M/100 SCM	174.	212.	139.	175.	139.
COUNT DATE	12/12/72	12/08/72	12/08/72	12/08/72	12/12/72

SAMPLE NO.	6434	6436	6329	6331	6328
FLIGHT NO.	289	289	289	289	289
DATE	10/24/72	10/24/72	10/19/72	10/19/72	10/19/72
TIME	0344-0417	0417-0500	1903-1933	1933-2001	1828-1903
LAT.	60N-57N	57N-53N	43N-40N	43N-40N	40N-36N
LONG.	133W-127W	127W-127W	112W-110W	112W-110W	110W-108W
VOL. OF AIR (100 SCM)	1.58	2.06	1.44	1.34	1.78
GROSS GAMMA/ M/100 SCM	171.	214.	181.	149.	96.
COUNT DATE	12/12/72	12/12/72	12/01/72	12/01/72	12/01/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 16.8 KM

SAMPLE NO.	6332	6404	6345	6344	6343
FLIGHT NO.	289	294	290	290	290
DATE	10/19/72	10/19/72	10/25/72	10/25/72	10/25/72
TIME	2001-2035	1804-1824	0113-0215	0021-0113	2333-0021
LAT.	40N-36N	37N-35N	35N-31N	31N-28N	28N-25N
LONG.	110W-108W	108W-106W	106W-100W	100W- 95W	95W- 90W
VOL. OF AIR (100 SCM)	1.62	1.01	3.15	2.72	2.55
GROSS GAMMA/ M/100 SCM	160.	119.	70.	70.	90.
COUNT DATE	12/01/72	12/08/72	12/15/72	12/15/72	12/15/72

SAMPLE NO.	6364	6366	6367	6368	6369
FLIGHT NO.	290	290	290	290	290
DATE	10/18/72	10/18/72	10/18/72	10/18/72	10/18/72
TIME	1929-2009	2010-2043	2046-2113	2113-2142	2142-2202
LAT.	23N-20N	19N-16N	16N-14N	14N-10N	10N- 9N
LONG.	88W- 86W	85W- 83W	83W- 82W	82W- 80W	80W- 79W
VOL. OF AIR (100 SCM)	2.09	1.74	1.47	1.59	1.10
GROSS GAMMA/ M/100 SCM	34.	29.	34.	25.	27.
COUNT DATE	12/07/72	12/07/72	12/07/72	12/07/72	12/07/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 16.8 KM

SAMPLE NO.	6391	6388	6348	6349	6350
FLIGHT NO.	298	298	290	290	290
DATE	10/24/72	10/24/72	10/24/72	10/24/72	10/24/72
TIME	1718-1734	1657-1716	1507-1545	1545-1616	1616-1651
LAT.	9N- 7N	7N- 5N	5N- 0S	0S- 3S	3S- 7S
LONG.	79W- 79W	79W- 79W	79W- 79W	79W- 79W	79W- 79W
VOL. OF AIR (100 SCM)	0.89	1.05	2.11	1.68	1.93
GROSS GAMMA/ M/100 SCM	23.	29.	12.	18.	21.
COUNT DATE	12/07/72	12/07/72	12/15/72	12/15/72	12/15/72

SAMPLE NO.	6351	6447	6446	6445	6444
FLIGHT NO.	290	298	298	298	298
DATE	10/24/72	10/21/72	10/21/72	10/21/72	10/21/72
TIME	1651-1729	1524-1555	1447-1524	1400-1447	1326-1400
LAT.	7S-11S	15S-19S	19S-23S	23S-28S	28S-31S
LONG.	79W- 78W	77W- 75W	75W- 74W	74W- 72W	72W- 69W
VOL. OF AIR (100 SCM)	2.05	1.68	1.93	2.48	1.82
GROSS GAMMA/ M/100 SCM	34.	30.	83.	81.	93.
COUNT DATE	12/15/72	12/12/72	12/12/72	12/12/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 16.8 KM

SAMPLE NO.	6465	6464	6463	6462
FLIGHT NO.	290	290	290	290
DATE	10/21/72	10/21/72	10/21/72	10/21/72
TIME	1844-1846	1757-1841	1712-1757	1628-1712
LAT.	31S-33S	31S-36S	36S-41S	41S-46S
LONG.	68W- 66W	66W- 65W	66W- 65W	67W- 66W
VOL. OF AIR (100 SCM)	0.10	2.12	2.02	2.00
GROSS GAMMA/ M/100 SCM	200.	142.	173.	210.
COUNT DATE	12/12/72	12/12/72	12/12/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 16.5 KM

SAMPLE NO.	6460
FLIGHT NO.	290
DATE	10/21/72
TIME	1547-1628
LAT.	46S-51S
LONG.	69W- 67W
VOL. OF AIR (100 SCM)	1.95
GROSS GAMMA/ M/100 SCM	323.
COUNT DATE	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 15.2 KM

SAMPLE NO.	6413	6416	6417	6418	6302
FLIGHT NO.	289	289	289	289	289
DATE	10/22/72	10/22/72	10/22/72	10/22/72	10/21/72
TIME	2305-2343	2343-0010	0010-0036	0036-0054	2248-2336
LAT.	75N-71N	71N-68N	68N-65N	65N-63N	63N-60N
LONG.	143W-143W	144W-143W	146W-144W	147W-146W	142W-133W
VOL. OF AIR (100 SCM)	2.30	1.67	1.61	1.11	2.94
GROSS GAMMA/ M/100 SCM	200.	162.	99.	117.	238.
COUNT DATE	12/08/72	12/08/72	12/08/72	12/08/72	11/30/72

SAMPLE NO.	6301	6299	6298	6396	6395
FLIGHT NO.	289	289	289	294	294
DATE	10/21/72	10/21/72	10/21/72	10/18/72	10/18/72
TIME	2210-2248	2129-2210	2113-2129	1726-1811	1643-1726
LAT.	60N-57N	57N-54N	54N-52N	51N-47N	47N-43N
LONG.	133W-127W	127W-122W	122W-120W	119W-115W	115W-112W
VOL. OF AIR (100 SCM)	2.40	2.60	1.01	3.04	2.90
GROSS GAMMA/ M/100 SCM	171.	173.	277.	23.	38.
COUNT DATE	11/30/72	11/30/72	11/30/72	12/08/72	12/07/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 15.2 KM

SAMPLE NO.	6517	6516	6402	6401	6360
FLIGHT NO.	294	294	294	294	290
DATE	10/18/72	10/18/72	10/19/72	10/19/72	10/18/72
TIME	1613-1643	1553-1613	1729-1751	1657-1729	1709-1756
LAT.	43N-40N	40N-38N	37N-35N	35N-33N	33N-30N
LONG.	112W-110W	110W-109W	108W-106W	106W-103W	104W- 98W
VOL. OF AIR (100 SCM)	1.98	1.31	1.51	2.22	2.32
GROSS GAMMA/ M/100 SCM	101.	115.	20.	18.	35.
COUNT DATE	12/08/72	12/08/72	12/08/72	12/08/72	12/07/72

SAMPLE NO.	6361	6363	6340	6339	6337
FLIGHT NO.	290	290	290	290	290
DATE	10/18/72	10/18/72	10/25/72	10/25/72	10/25/72
TIME	1756-1841	1848-1921	2236-2306	2203-2236	2132-2203
LAT.	30N-27N	26N-24N	23N-20N	20N-17N	17N-14N
LONG.	98W- 93W	93W- 89W	87W- 85W	85W- 83W	83W- 82W
VOL. OF AIR (100 SCM)	3.06	2.32	2.17	2.34	2.14
GROSS GAMMA/ M/100 SCM	16.	9.	55.	68.	42.
COUNT DATE	12/07/72	12/07/72	12/15/72	12/01/72	12/01/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 15.2 KM

SAMPLE NO.	6336	6384	6385	6387	6372
FLIGHT NO.	290	298	298	298	298
DATE	10/25/72	10/24/72	10/24/72	10/24/72	10/19/72
TIME	2111-2132	1537-1609	1609-1629	1630-1649	1411-1446
LAT.	14N-12N	12N- 9N	9N- 7N	7N- 5N	5N- 1N
LONG.	82W- 81W	81W- 79W	79W- 79W	79W- 79W	79W- 79W
VOL. OF AIR (100 SCM)	1.52	2.29	1.44	1.39	2.60
GROSS GAMMA/ M/100 SCM	40.	9.	7.	7.	8.
COUNT DATE	12/01/72	12/07/72	12/07/72	12/07/72	12/07/72

SAMPLE NO.	6373	6374	6375	6507	6506
FLIGHT NO.	298	298	298	298	298
DATE	10/19/72	10/19/72	10/19/72	10/23/72	10/23/72
TIME	1446-1530	1530-1557	1557-1638	1510-1547	1431-1510
LAT.	1N- 4S	4S- 7S	7S-11S	15S-19S	19S-23S
LONG.	79W- 79W	79W- 79W	79W- 78W	77W- 75W	75W- 74W
VOL. OF AIR (100 SCM)	3.27	1.99	2.99	2.64	2.79
GROSS GAMMA/ M/100 SCM	9.	10.	7.	4.	7.
COUNT DATE	12/07/72	12/07/72	12/07/72	12/13/72	12/13/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 15.2 KM

SAMPLE NO.	6505	6504	6492	6493	6494
FLIGHT NO.	298	298	298	298	298
DATE	10/23/72	10/23/72	10/22/72	10/22/72	10/22/72
TIME	1351-1431	1303-1351	1350-1427	1427-1453	1453-1529
LAT.	23S-27S	27S-31S	33S-37S	37S-40S	40S-44S
LONG.	74W- 72W	72W- 69W	65W- 65W	66W- 65W	67W- 66W
VOL. OF AIR (100 SCM)	2.76	3.42	2.50	1.74	2.32
GROSS GAMMA/ M/100 SCM	4.	50.	40.	75.	91.
COUNT DATE	12/13/72	12/13/72	12/13/72	12/13/72	12/13/72

SAMPLE NO.	6495	6496
FLIGHT NO.	298	298
DATE	10/22/72	10/22/72
TIME	1529-1548	1548-1624
LAT.	44S-46S	46S-50S
LONG.	67W- 67W	68W- 67W
VOL. OF AIR (100 SCM)	1.15	2.17
GROSS GAMMA/ M/100 SCM	113.	166.
COUNT DATE	12/13/72	12/13/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 13.7 KM

SAMPLE NO.	6293	6294	6295	6296	6397
FLIGHT NO.	289	289	289	289	294
DATE	10/21/72	10/21/72	10/21/72	10/21/72	10/18/72
TIME	1810-1920	1920-2001	2001-2033	2033-2110	1816-1900
LAT.	64N-61N	61N-58N	58N-55N	55N-52N	51N-47N
LONG.	148W-135W	135W-129W	129W-124W	124W-120W	119W-115W
VOL. OF AIR (100 SCM)	5.30	3.08	2.40	2.83	3.49
GROSS GAMMA/ M/100 SCM	76.	211.	183.	78.	12.
COUNT DATE	11/29/72	11/29/72	11/29/72	11/30/72	12/08/72

SAMPLE NO.	6321	6320	6318	6317	6456
FLIGHT NO.	291	291	291	291	290
DATE	10/19/72	10/19/72	10/19/72	10/19/72	10/21/72
TIME	1725-1759	1656-1725	1620-1654	1557-1620	1256-1338
LAT.	47N-44N	44N-41N	41N-38N	38N-35N	34S-38S
LONG.	115W-112W	112W-110W	110W-109W	109W-107W	66W- 65W
VOL. OF AIR (100 SCM)	2.62	2.29	2.69	1.84	3.36
GROSS GAMMA/ M/100 SCM	4.	4.	4.	11.	45.
COUNT DATE	12/01/72	12/01/72	11/30/72	11/30/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 13.7 KM

SAMPLE NO.	6457	6458	6459
FLIGHT NO.	290	290	290
DATE	10/21/72	10/21/72	10/21/72
TIME	1338-1417	1417-1455	1455-1543
LAT.	38S-42S	42S-46S	46S-51S
LONG.	66W- 66W	67W- 66W	69W- 67W
VOL. OF AIR (100 SCM)	3.12	2.92	3.63
GROSS GAMMA/ M/100 SCM	80.	82.	80.
COUNT DATE	12/12/72	12/12/72	12/12/72

TABLE 3A
TOTAL GAMMA CONCENTRATIONS IN OCTOBER 1972

ALTITUDE 12.2 KM

SAMPLE NO.	6412	6410	6409
FLIGHT NO.	289	289	289
DATE	10/22/72	10/22/72	10/22/72
TIME	2215-2255	2143-2215	2108-2143
LAT.	75N-71N	71N-68N	68N-65N
LONG.	143W-143W	144W-143W	146W-144W
VOL. OF AIR (100 SCM)	3.53	2.82	3.09
GROSS GAMMA/ M/100 SCM	88.	71.	100.
COUNT DATE	12/08/72	12/08/72	12/08/72

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

19.2 KM

SAMPLE NO.	5948	5949	5950	5951	5952
COMPOSED OF:	1/2:5929	1/2:5930 5931	1/2:5945 5944 5943 5942	1/2:5660 5661 5662 5663 5664	1/2:5665 5714
MIDPOINT OF COLLECTION					
DATE	3/27/72	3/27/72	3/29/72	3/27/72	3/27/72
LAT.	75N-71N	71N-65N	64N-53N	50N-39N	39N-31N
LONG.	143W-143W	146W-143W	147W-129W	125W-108W	108W- 98W
VOL. OF AIR (100 SCM)	1.420	2.550	5.440	5.880	3.210
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1340.000	1200.000	1050.000	1230.000	804.000
SR-89	13.900B	*	22.900A	26.100A	73.300A
SR-90	42.400	25.000	38.300	24.600	54.800
ZR-95	4.187B	6.624A	27.200A	21.400	150.000
CS-137	58.400	38.900	69.800	62.300	90.100
CE-144	302.000	200.000	337.000	336.000	610.000
PU-238	0.069A	0.079	0.125	0.101	0.128
PU-239	0.665	0.505	0.833	0.744	1.087

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

19.2 KM

SAMPLE NO.	5953	5954	5955	5956	5957
COMPOSED OF:	1/2:5713 5712 5711 5763 5764	1/2:5765 5766 5767	1/2:5727 5726 5725	1/2:5724 5807 5808	1/4:5809 5810 5811 5836
MIDPOINT OF COLLECTION					
DATE	3/28/72	3/29/72	3/27/72	3/27/72	3/27/72
LAT.	31N-18N	18N- 9N	5N- 7S	7S-23S	23S-37S
LONG.	98W- 84W	84W- 79W	81W- 80W	80W- 74W	78W- 68W
VOL. OF AIR (100 SCM)	7.680	4.140	4.640	5.280	3.200
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	584.000	572.000	677.000	717.000	902.000
SR-89	24.200A	53.700A	309.000	360.000	392.000
SR-90	30.100	33.800	61.100	61.900	60.300
ZR-95	80.900	151.000	652.000	804.000	783.000
CS-137	54.200	57.100	108.000	103.000	105.000
CE-144	340.000	378.000	1200.000	1240.000	1170.000
PU-238	0.071	0.072	0.128	0.118	0.150
PU-239	0.618	0.586	1.151	1.042	1.071

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6001	5958	5959
COMPOSED OF:	1/4: 5809, 5810, 5811, 5836	1/2: 5835, 5834, 5833	1/2: 5832, 5831
MIDPOINT OF COLLECTION			
DATE	3/27/72	3/27/72	3/27/72
LAT.	23S-37S	37S-46S	46S-51S
LONG.	78W- 68W	68W- 67W	67W- 67W
VOL. OF AIR (100 SCM)	3.200	3.380	1.820
			PC/100 SCM
LAB:	LFE	LFE	LFE
BE-7	968.000	1360.000	1650.000
SR-89	288.000	183.000	204.000
SR-90	58.700	40.600	55.900
ZR-95	874.000	565.000	522.000
CS-137	96.400	78.200	88.900
CE-144	1210.000	801.000	864.000
PU-238	0.122	0.149	0.158
PU-239	1.063	0.924	0.978

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

18.3 KM

SAMPLE NO.	5960	5961	5962	5963	5964
COMPOSED OF:	1/2:5671 5707 5708 5709 5710	1/2:5746 5747 5748 5749	1/2:5750 5755 5720	1/2:5721 5722	1/2:5723
MIDPOINT OF COLLECTION					
DATE	3/27/72	3/23/72	3/26/72	3/27/72	3/27/72
LAT.	35N-24N	24N-12N	12N- 1S	1S- 7S	7S-11S
LONG.	106W- 89W	88W- 81W	81W- 79W	81W- 80W	80W- 79W
VOL. OF AIR (100 SCM)	8.420	6.830	5.810	4.140	2.050
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	781.000	706.000	316.000	341.000A	122.000
SR-89	41.500	17.000B	72.000	128.000	62.300
SR-90	30.200	19.700	18.600	31.500	12.700
ZR-95	99.500	58.700	148.000	300.000	133.000
CS-137	57.200	42.900	38.200	45.300	23.100
CE-144	354.000	264.000	326.000	498.000	207.000
PU-238	0.090	0.061	0.049	0.073	0.018B
PU-239	0.617	0.466	0.393	0.534	0.204

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

18.3 KM

SAMPLE NO.	5965	5966
COMPOSED OF:	1/2:5806 5805 5804 5803	1/2:5865
MIDPOINT OF COLLECTION		
DATE	3/27/72	3/28/72
LAT.	16S-29S	29S-33S
LONG.	76W- 71W	69W- 68W
VOL. OF AIR (100 SCM)	6.940	1.840
		PC/100 SCM
LAB:	LFE	LFE
BE-7	746.000	1210.000
SR-89	211.000	408.000
SR-90	42.600	78.800
ZR-95	624.000	862.000
CS-137	85.700	110.000
CE-144	954.000	1330.000
PU-238	0.076	0.156
PU-239	0.595	1.098

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

16.8 KM

SAMPLE NO.	5967	5968	5969	5970	5971
COMPOSED OF:	1/2:5928 5927 5926 5925	1/2:5937 5938 5939 5940	1/2:5891 5890 5889 5888 5887	1/2:5670 5689 5688 5687	1/2:5686 5685 5774
MIDPOINT OF COLLECTION					
DATE	3/27/72	3/29/72	3/25/72	3/28/72	3/27/72
LAT.	75N-61N	61N-50N	50N-39N	39N-29N	29N-21N
LONG.	146W-139W	138W-125W	125W-108W	108W- 94W	94W- 86W
VOL. OF AIR (100 SCM)	9.420	7.820	10.050	11.170	8.310
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1450.000	1240.000	1540.000	1140.000	484.000
SR-89	*	*	*	13.600A	14.400A
SR-90	35.500	39.400	40.200	32.400	8.039
ZR-95	43.700	41.200	61.900	63.300A	57.500
CS-137	83.200	72.600	78.900	64.900	17.200
CE-144	440.000	399.000	489.000	391.000	116.000
PU-238	0.097	0.116	0.106	0.083	0.022
PU-239	0.794	0.789	0.832	0.652	0.171

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

16.8 KM

SAMPLE NO.	5972	6006	5974	5975	5976
COMPOSED OF:	1/2:5775 5776 5777 5778	1/2:5738 5737 5736 5816	1/2:5817 5818 5819	1/2:5820 5821 5822	1/4:5860 5864 5826
MIDPOINT OF COLLECTION					
DATE	3/26/72	3/27/72	3/25/72	3/25/72	3/28/72
LAT.	21N- 9N	5N- 7S	7S-20S	20S-29S	29S-40S
LONG.	86W- 79W	81W- 80W	80W- 75W	75W- 71W	71W- 68W
VOL. OF AIR (100 SCM)	10.270	11.510	10.850	6.770	4.250
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	161.000	314.000	222.000	310.000	1220.000
SR-89	7.597	16.800A	23.000	24.700	246.000
SR-90	2.150	8.766	4.484	5.413	41.400
ZR-95	16.500	82.600	53.100	80.500	497.000
CS-137	4.233	14.600	7.680	9.581	63.200
CE-144	37.800	144.000	79.300	108.000	744.000
PU-238	*	0.026	0.009A	0.013A	0.077
PU-239	0.035	0.148	0.068	0.095	0.638

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6002	5977
COMPOSED OF:	1/4:5860 5864 5826	1/2:5827 5828 5829 5830
MIDPOINT OF COLLECTION		
DATE	3/28/72	3/27/72
LAT.	29S-40S	40S-51S
LONG.	71W- 68W	68W- 67W
VOL. OF AIR (100 SCM)	4.250	6.650
		PC/100 SCM
LAB:	LFE	LFE
BE-7	844.000	1610.000
SR-89	167.000	373.000
SR-90	31.700	77.100
ZR-95	460.000	1210.000
CS-137	55.700	133.000
CE-144	677.000	1680.000
PU-238	0.071	0.156
PU-239	0.555	1.216

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

15.2 KM

SAMPLE NO.	5978	5979	5980	5981	5982
COMPOSED OF:	1/2:5916	1/2:5917	1/2:5918 5883	1/2:5908 5907 5906 5905	1/2:5698 5697 5696 5695
MIDPOINT OF COLLECTION					
DATE	3/27/72	3/27/72	3/29/72	3/25/72	3/28/72
LAT.	75N-71N	71N-68N	68N-61N	61N-50N	50N-41N
LONG.	143W-143W	144W-143W	147W-138W	135W-118W	125W-111W
VOL. OF AIR (100 SCM)	3.110	2.510	8.060	12.190	11.530
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1010.000	*	743.000	1300.000	1450.000
SR-89	*	*	*	33.300A	11.300B
SR-90	39.400	0.567	29.200	33.700	39.800
ZR-95	47.800	14.200A	47.600	83.100	56.600
CS-137	58.100	2.710A	41.500	62.100	70.300
CE-144	349.000	4.343A	273.000	388.000	395.000
PU-238	0.089	*	0.084	0.079	0.081
PU-239	0.679	0.010A	0.533	0.661	0.636

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

15.2 KM

SAMPLE NO.	5983	5984	5985	5986	5987
COMPOSED OF:	1/2:5901	1/2:5900	1/2:5669 5668 5681	1/2:5682 5683	1/2:5795 5796 5797 5798
MIDPOINT OF COLLECTION					
DATE	3/25/72	3/25/72	3/29/72	3/28/72	3/25/72
LAT.	43N-41N	41N-39N	39N-31N	31N-26N	26N-15N
LONG.	112W-111W	111W-109W	108W- 98W	98W- 91W	91W- 82W
VOL. OF AIR (100 SCM)	2.040	2.000	12.010	7.000	12.400
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1120.000	768.000	1010.000	241.000	132.000
SR-89	69.600	978.000	14.700A	5.645	5.489
SR-90	31.000	30.000	25.400	3.656	1.104
ZR-95	175.000	935.000	37.500	19.600	18.500
CS-137	43.100	48.000	46.500	6.017	2.336
CE-144	287.000	414.000	260.000	47.300	19.700
PU-238	0.086	0.047A	0.072	0.007B	*
PU-239	0.565	0.698	0.538	0.079	0.021

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

15.2 KM

SAMPLE NO.	5988	5989	5990	6000	5991
COMPOSED OF:	1/2:5753 5754	1/2:5731 5732 5733	1/2:5734 5855 5854	1/2:5853 5852 5851 5863	1/2:5849 5848 5847 5846
MIDPOINT OF COLLECTION					
DATE	3/29/72	3/27/72	3/28/72	3/28/72	3/29/72
LAT.	12N- 5N	5N- 7S	7S-23S	23S-33S	33S-46S
LONG.	81W- 79W	81W- 80W	80W- 74W	74W- 68W	68W- 67W
VOL. OF AIR (100 SCM)	7.520	10.930	12.300	13.770	11.450
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	68.900	122.000	94.100	204.000	696.000
SR-89	0.872A	3.497	2.679A	10.800	78.900
SR-90	0.490	0.855	0.906	1.876	15.700
ZR-95	47.700 ?	8.036	10.600	26.500	238.000
CS-137	1.384A	2.279	1.472	3.762	32.100
CE-144	14.700	15.800	16.000	41.200	371.000
PU-238	*	*	*	0.007A	0.032
PU-239	0.012	0.020	0.013	0.040	0.249

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

15.2 KM

SAMPLE NO. 5992

COMPOSED OF:1/2:5845
5844

MIDPOINT OF COLLECTION	
DATE	3/29/72
LAT.	46S-51S
LONG.	67W- 67W
VOL. OF AIR (100 SCM)	4.090

PC/100 SCM

LAB:	LFE
BE-7	769.000
SR-89	160.000
SR-90	21.900
ZR-95	338.000
CS-137	39.300
CE-144	492.000
PU-238	0.046
PU-239	0.410

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

13.7 KM

SAMPLE NO.	5993	5994	5995	5996	5997
COMPOSED OF:	1/2:5874 5875 5876	1/2:5877 5878 5699	1/2:5700 5701 5702 5703 5704	1/2:5839 5840	1/2:5841 5842 5843
MIDPOINT OF COLLECTION					
DATE	3/30/72	3/29/72	3/28/72	3/29/72	3/29/72
LAT.	63N-56N	56N-47N	47N-35N	37S-43S	43S-51S
LONG.	142W-132W	132W-121W	121W-108W	68W- 67W	67W- 67W
VOL. OF AIR (100 SCM)	8.960	11.160	17.040	7.090	10.220
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	583.000	626.000	1120.000	449.000	621.000
SR-89	12.700A	18.900A	19.200A	30.100	63.800
SR-90	12.800	9.719	18.000	7.618	10.700
ZR-95	41.300	30.600	39.100	97.200	163.000
CS-137	26.000	19.600	45.500	13.500	20.700
CE-144	171.000	132.000	267.000	153.000	246.000
PU-238	0.039	0.035	0.063	0.022	0.022
PU-239	0.311	0.240	0.535	0.128	0.183

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3B

RADIOCHEMICAL ANALYSIS OF MARCH 1972 COMPOSITES

12.2 KM

SAMPLE NO.	5998	5999
COMPOSED OF:	1/2:5915 5914	1/2:5913
MIDPOINT OF COLLECTION		
DATE	3/27/72	3/27/72
LAT.	75N-68N	68N-65N
LONG.	144W-143W	146W-144W
VOL. OF AIR (100 SCM)	8.090	3.370
		PC/100 SCM
LAB:	LFE	LFE
BE-7	646.000	1230.000
SR-89	33.100A	21.500A
SR-90	15.900	28.000
ZR-95	37.900	80.200
CS-137	29.800	50.400
CE-144	185.000	314.000
PU-238	0.047	0.077
PU-239	0.354	0.620

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6224	6225	6226	6227	6228
COMPOSED OF:	6208 6209 6081 6195	6197 6198 6199 6200	6156 6095	6094 6093 6092	6173 6175 6176 6177
MIDPOINT OF COLLECTION					
DATE	7/27/72	7/25/72	7/29/72	7/28/72	7/27/72
LAT.	39N-21N	21N- 9N	9N- 1S	1S-10S	14S-29S
LONG.	108W- 86W	86W- 80W	80W- 79W	79W- 79W	76W- 72W
VOL. OF AIR (100 SCM)	3.800	3.680	2.270	3.130	3.840
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1320.000	673.000	431.000	505.000	502.000
ZR-95	34.900	73.800	72.000	100.000	167.000
CS-137	49.300	52.800	46.600	51.800	86.800
CE-144	218.000	291.000	268.000	397.000	736.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6229	6230	6278	6231
COMPOSED OF:	6178 6117	1/2:6116 6115	1/2:6116 6115	6114 6112
MIDPOINT OF COLLECTION				
DATE	7/28/72	7/28/72	7/28/72	7/28/72
LAT.	29S-37S	37S-43S	37S-43S	43S-51S
LONG.	72W- 68W	69W- 69W	69W- 69W	69W- 69W
VOL. OF AIR (100 SCM)	2.560	0.780	0.780	2.120
		PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE
BE-7	948.000	1670.000A	1120.000	2190.000
ZR-95	119.000	166.000A	146.000	97.700
CS-137	67.000	83.200	84.300	40.200
CE-144	507.000	687.000	641.000	297.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

18.9 KM

SAMPLE NO.	6232	6233
COMPOSED OF:	6023 6139	6138 6137
MIDPOINT OF COLLECTION		
DATE	7/28/72	7/26/72
LAT.	71N-61N	61N-53N
LONG.	147W-134W	134W-121W
VOL. OF AIR (100 SCM)	2.340	2.540
		PC/100 SCM
LAB:	LFE	LFE
BE-7	1940.000	1700.000
ZR-95	*	*
CS-137	34.300	36.700
CE-144	131.000	134.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

18.6 KM

SAMPLE NO.	6234	6235
COMPOSED OF:	6022	6136
MIDPOINT OF COLLECTION		
DATE	7/30/72	7/26/72
LAT.	73N-71N	53N-50N
LONG.	143W-143W	121W-118W
VOL. OF AIR (100 SCM)	0.520	1.100
		PC/100 SCM
LAB:	LFE	LFE
BE-7	2160.000	1380.000
ZR-95	*	*
CS-137	38.500	48.700
CE-144	120.000	192.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

18.3 KM

SAMPLE NO.	6236	6237	6238	6239	6240
COMPOSED OF:	6021	6210 6222 6221 6220 6219	6125 6126 6127 6128	6154 6035 6155	6034 6033
MIDPOINT OF COLLECTION					
DATE	7/30/72	7/30/72	7/24/72	7/29/72	7/29/72
LAT.	75N-73N	35N-24N	24N-12N	12N- 1N	1N- 7S
LONG.	143W-143W	106W- 92W	88W- 81W	81W- 79W	79W- 79W
VOL. OF AIR (100 SCM)	0.550	6.460	4.830	3.770	2.740
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	2430.000	1390.000	620.000	459.000	429.000
ZR-95	*	56.800	59.600	58.300	55.400
CS-137	52.900A	50.200	35.300	31.500	27.900
CE-144	159.000	248.000	187.000	189.000	181.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

18.3 KM

SAMPLE NO.	6241	6242	6279
COMPOSED OF:	6032 6186 6187	1/2:6188 6189 6013	1/2:6188 6189 6013
MIDPOINT OF COLLECTION			
DATE	7/27/72	7/27/72	7/27/72
LAT.	7S-21S	21S-33S	21S-33S
LONG.	79W- 75W	75W- 68W	75W- 68W
VOL. OF AIR (100 SCM)	3.410	1.850	1.850
			PC/100 SCM
LAB:	LFE	LFE	LFE
BE-7	645.000	1110.000	1030.000
ZR-95	117.000	175.000	182.000
CS-137	62.600	92.500	88.900
CE-144	543.000	789.000	750.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

18.0 KM

SAMPLE NO.	6243
COMPOSED OF:	6073
MIDPOINT OF COLLECTION	
DATE	7/30/72
LAT.	40N-37N
LONG.	110W-108W
VOL. OF AIR (100 SCM)	1.180

PC/100 SCM

LAB:	LFE
BE-7	1230.000
ZR-95	49.200A
CS-137	43.900
CE-144	209.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

17.7 KM

SAMPLE NO.	6244
COMPOSED OF:	6072
MIDPOINT OF COLLECTION	
DATE	7/30/72
LAT.	43N-40N
LONG.	112W-110W
VOL. OF AIR (100 SCM)	1.230

PC/100 SCM

LAB:	LFE
BE-7	1300.000
ZR-95	63.700
CS-137	37.400
CE-144	196.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

17.4 KM

SAMPLE NO.	6245
COMPOSED OF:	6071
MIDPOINT OF COLLECTION	
DATE	7/30/72
LAT.	46N-43N
LONG.	114W-112W
VOL. OF AIR (100 SCM)	1.280

PC/100 SCM

LAB:	LFE
BE-7	1150.000
ZR-95	65.500
CS-137	39.100
CE-144	194.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6246	6247	6284	6248	6249
COMPOSED OF:	6019 6018 6016	6141 6146	6145 6134 6133	6131 6206 6205	6191 6192 6194
MIDPOINT OF COLLECTION					
DATE	7/30/72	7/28/72	7/27/72	7/27/72	7/25/72
LAT.	75N-61N	61N-53N	53N-44N	44N-33N	33N-24N
LONG.	146W-142W	135W-121W	121W-112W	112W-102W	104W- 89W
VOL. OF AIR (100 SCM)	7.710	2.640	4.360	5.220	7.250
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1640.000	1410.000	1140.000	1030.000	1030.000
ZR-95	24.200	56.600	37.900	68.900	88.200
CS-137	52.700	51.400	36.600	31.200	29.800
CE-144	238.000	234.000	172.000	174.000	175.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6250	6251	6252	6253	6254
COMPOSED OF:	6079 6078 6076 6075	6152 6151 6180	6181 6183 6184	6030 6029 6027	6012 6026
MIDPOINT OF COLLECTION					
DATE	7/29/72	7/28/72	7/26/72	7/29/72	7/29/72
LAT.	23N-12N	12N- 1N	1N-12S	15S-25S	25S-33S
LONG.	88W- 81W	81W- 79W	79W- 78W	76W- 73W	73W- 68W
VOL. OF AIR (100 SCM)	5.970	5.480	6.140	4.860	3.640
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	428.000	268.000	270.000	361.000	540.000
ZR-95	40.900	22.900	16.400	25.300	50.900
CS-137	15.500	8.384	6.368	9.259	26.600
CE-144	89.800	49.400	47.800	68.500	214.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6255	6256
COMPOSED OF:	6010 6108	6109 6110 6111
MIDPOINT OF COLLECTION		
DATE	7/29/72	7/28/72
LAT.	33S-40S	40S-51S
LONG.	70W- 68W	69W- 69W
VOL. OF AIR (100 SCM)	3.670	5.890

PC/100 SCM

LAB:	LFE	LFE
BE-7	1130.000	1200.000
ZR-95	125.000	104.000
CS-137	73.300	57.700
CE-144	592.000	480.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6257	6258	6259	6260	6261
COMPOSED OF:	6048 6049	6050 6051	6097 6098	6100 6101	6103 6104 6105
MIDPOINT OF COLLECTION					
DATE	7/29/72	7/29/72	8/ 1/72	8/ 1/72	8/ 1/72
LAT.	75N-71N	71N-65N	65N-57N	57N-50N	50N-41N
LONG.	143W-143W	147W-143W	148W-127W	127W-118W	118W-110W
VOL. OF AIR (100 SCM)	2.160	3.560	7.290	3.940	5.810
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1850.000	1170.000	1610.000	418.000	703.000
ZR-95	58.400A	50.000	77.200	*	60.000
CS-137	49.800	36.800	48.700	13.900	21.400
CE-144	261.000	180.000	247.000	72.800	122.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6262	6263	6264	6265	6266
COMPOSED OF:	6106 6202 6119 6203	6120 6123 6217 6122	6216 6214 6213	6148 6149 6086	6087 6089 6090
MIDPOINT OF COLLECTION					
DATE	7/27/72	7/26/72	7/31/72	7/29/72	7/28/72
LAT.	41N-31N	31N-21N	21N-12N	12N- 1N	1N-10S
LONG.	110W-100W	100W- 85W	85W- 81W	81W- 73W	79W- 78W
VOL. OF AIR (100 SCM)	9.380	11.340	6.700	8.290	7.850
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	543.000	307.000	286.000	85.300	110.000
ZR-95	37.900	23.900	20.800	*	2.112A
CS-137	11.400	5.879	5.486	2.087	0.694A
CE-144	68.700	38.500	33.000	8.150A	5.446

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6267	6268	6269	6270
COMPOSED OF:	6172 6171 6170	6169 6009	6062	6060 6059 6057
MIDPOINT OF COLLECTION				
DATE	7/27/72	7/28/72	7/28/72	7/28/72
LAT.	15S-25S	25S-33S	33S-37S	40S-51S
LONG.	77W- 73W	73W- 68W	69W- 68W	69W- 67W
VOL. OF AIR (100 SCM)	6.880	5.930	2.310	6.160
			PC/100 SCM	
LAB:	LFE	LFE	LFE	LFE
BE-7	74.000A	302.000	926.000	1210.000
ZR-95	4.354B	12.300	68.100	118.000
CS-137	1.323A	5.522	34.700	60.600
CE-144	6.272A	48.600	287.000	522.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

13.7 KM

SAMPLE NO.	6271	6272	6273	6274	6275
COMPOSED OF:	6064 6065 6066 6067	6068	6164 6165 6166	6167	6053 6054 6055
MIDPOINT OF COLLECTION					
DATE	7/30/72	7/30/72	7/25/72	7/25/72	7/28/72
LAT.	64N-52N	52N-49N	47N-39N	39N-35N	37S-47S
LONG.	145W-120W	120W-117W	121W-108W	108W-106W	69W- 67W
VOL. OF AIR (100 SCM)	12.030	1.020	8.910	3.450	7.690
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	970.000	1560.000A	308.000	77.600	685.000
ZR-95	73.000	162.000	33.700	*	66.800
CS-137	25.500	31.600	6.774	0.790	33.000
CE-144	150.000	261.000	43.900	5.601	292.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

13.7 KM

SAMPLE NO.	6276
COMPOSED OF:	6056
MIDPOINT OF COLLECTION	
DATE	7/28/72
LAT.	47S-51S
LONG.	69W- 67W
VOL. OF AIR (100 SCM)	3.390

PC/100 SCM

LAB:	LFE
BE-7	978.000
ZR-95	93.300
CS-137	47.700
CE-144	399.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

TABLE 3C

GAMMA SPECTRAL ANALYSES OF JULY 1972 COMPOSITES

12.2 KM

SAMPLE NO.	6277
COMPOSED OF:	6046 6045 6043 6042
MIDPOINT OF COLLECTION	
DATE	7/29/72
LAT.	75N-65N
LONG.	146W-143W
VOL. OF AIR (100 SCM)	9.390

PC/100 SCM

LAB:	LFE
BE-7	907.000
ZR-95	90.700
CS-137	26.300
CE-144	159.000

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6518	6519	6520	6521	6522
COMPOSED OF:	6427 6428	6429 6430	6312 6311 6309	6308 6306 6305	6439 6440 6441 6477
MIDPOINT OF COLLECTION					
DATE	10/23/72	10/23/72	10/20/72	10/20/72	10/25/72
LAT.	75N-69N	69N-65N	65N-56N	56N-46N	46N-31N
LONG.	144W-143W	146W-144W	147W-125W	125W-114W	114W-100W
VOL. OF AIR (100 SCM)	1.540	1.150	3.490	3.110	4.250
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	2430.000	1910.000	1820.000	2290.000	1520.000
ZR-95	*	*	*	*	20.300A
CS-137	24.700	24.800	47.500	54.000	48.400
CE-144	68.200	49.700A	146.000	193.000	174.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6523	6524	6525	6526	6527
COMPOSED OF:	6476 6484	6486 6487	6488 6489 6357 6356	6355 6354 6352	6448 6450
MIDPOINT OF COLLECTION					
DATE	10/22/72	10/18/72	10/21/72	10/24/72	10/21/72
LAT.	31N-20N	20N-14N	14N- 1N	1N-11S	15S-21S
LONG.	100W- 86W	86W- 82W	82W- 79W	79W- 78W	77W- 75W
VOL. OF AIR (100 SCM)	2.330	1.870	3.900	3.410	1.790
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1180.000	335.000	417.000	453.000	692.000
ZR-95	16.100	15.100A	24.400	25.500	41.000
CS-137	40.600	37.800	44.000	37.600	61.900
CE-144	177.000	178.000	225.000	209.000	393.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

19.2 KM

SAMPLE NO.	6528	6529
COMPOSED OF:	6451 6452	6501 6500
MIDPOINT OF COLLECTION		
DATE	10/21/72	10/22/72
LAT.	21S-29S	32S-39S
LONG.	75W- 72W	68W- 65W
VOL. OF AIR (100 SCM)	2.260	2.350

PC/100 SCM

LAB:	LFE	?	LFE
BE-7	*	?	1110.000
ZR-95	*	?	36.200A
CS-137	*	?	54.800
CE-144	*	?	335.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

18.9 KM

SAMPLE NO.	6530	6531
COMPOSED OF:	6475	6499
MIDPOINT OF COLLECTION		
DATE	10/26/72	10/22/72
LAT.	28N-25N	39S-43S
LONG.	95W- 89W	67W- 66W
VOL. OF AIR (100 SCM)	1.480	1.080
		PC/100 SCM
LAB:	LFE	LFE
BE-7	874.000	1140.000
ZR-95	18.600	15.600B
CS-137	17.100	50.900
CE-144	82.500	302.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

18.3 KM

SAMPLE NO.	6532	6533	6534	6535	6536
COMPOSED OF:	6405 6480 6481 6483	6472 6471 6469	6468 6392	6513 6512	6511 6510
MIDPOINT OF COLLECTION					
DATE	10/18/72	10/26/72	10/25/72	10/23/72	10/23/72
LAT.	35N-25N	23N-14N	14N- 9N	7N- 1N	1N- 7S
LONG.	106W- 90W	87W- 82W	82W- 79W	79W- 79W	79W- 74W
VOL. OF AIR (100 SCM)	5.630	3.400	1.930	2.330	2.790
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1570.000	162.000	525.000	404.000	417.000
ZR-95	19.200	4.849A	5.298A	17.900	12.900A
CS-137	47.700	2.928B	9.873	18.100	19.500
CE-144	180.000	3.961A	68.600	92.600	90.400

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

18.3 KM

SAMPLE NO.	6537	6538	6574
COMPOSED OF:	6508 6376	1/2:6378 6379 6380 6381	1/2:6378 6379 6380 6381
MIDPOINT OF COLLECTION			
DATE	10/21/72	10/19/72	10/19/72
LAT.	7S-19S	19S-33S	19S-33S
LONG.	78W- 74W	75W- 68W	75W- 68W
VOL. OF AIR (100 SCM)	3.580	2.660	2.660
			PC/100 SCM
LAB:	LFE	LFE	LFE
BE-7	569.000	1110.000	921.000
ZR-95	22.500	45.600A	42.500
CS-137	37.500	73.800	58.400
CE-144	232.000	450.000	373.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6539	6541	6542	6543	6544
COMPOSED OF:	6425 6424 6422 6421	6331 6332 6404	6345 6344 6343	6364 6366 6367	6368 6369 6391 6388
MIDPOINT OF COLLECTION					
DATE	10/23/72	10/19/72	10/25/72	10/18/72	10/21/72
LAT.	75N-63N	43N-35N	35N-25N	23N-14N	14N- 5N
LONG.	145W-141W	112W-106W	106W- 90W	88W- 82W	82W- 79W
VOL. OF AIR (100 SCM)	5.490	3.970	8.420	5.300	4.630
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1700.000	1240.000	610.000	543.000	289.000
ZR-95	10.200A	12.600	*	7.445	*
CS-137	51.900	32.000	23.500	7.692	3.230
CE-144	176.000	130.000	92.600	41.900	12.600

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

16.8 KM

SAMPLE NO.	6545	6546	6547	6548
COMPOSED OF:	6348 6349 6350	6351 6447	6446 6445 6444	6464 6463 6462
MIDPOINT OF COLLECTION				
DATE	10/24/72	10/23/72	10/21/72	10/21/72
LAT.	5N- 7S	7S-19S	19S-31S	31S-46S
LONG.	79W- 79W	79W- 75W	75W- 69W	67W- 65W
VOL. OF AIR (100 SCM)	5.720	3.730	6.230	6.140
			PC/100 SCM	
LAB:	LFE	LFE	LFE	LFE
BE-7	179.000	252.000	569.000	998.000
ZR-95	*	*	15.100A	38.500
CS-137	2.378	4.734	21.000	52.500
CE-144	9.765	34.200	140.000	335.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

16.5 KM

SAMPLE NO. 6549

COMPOSED OF: 6460

MIDPOINT OF COLLECTION	
DATE	10/21/72
LAT.	46S-51S
LONG.	69W- 67W
VOL. OF AIR (100 SCM)	1.950

PC/100 SCM

LAB:	LFE
BE-7	1380.000
ZR-95	52.000
CS-137	79.900
CE-144	487.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6550	6551	6552	6575	6553
COMPOSED OF:	6413 6416	6417 6418	1/2:6302 6301 6299 6298	1/2:6302 6301 6299 6298	6396 6395
MIDPOINT OF COLLECTION					
DATE	10/22/72	10/22/72	10/21/72	10/21/72	10/18/72
LAT.	75N-68N	68N-63N	63N-52N	63N-52N	51N-43N
LONG.	144W-143W	147W-144W	142W-120W	142W-120W	119W-112W
VOL. OF AIR (100 SCM)	3.970	2.720	4.470	4.470	5.940
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	1510.000	853.000	1580.000	1470.000	312.000
ZR-95	15.400	21.400	18.600	15.300	5.263A
CS-137	42.700	26.300	40.400	38.100	5.035
CE-144	167.000	113.000	158.000	157.000	22.100

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6554	6555	6556	6557	6558
COMPOSED OF:	6517 6516	6402 6401 6360	6361 6363	6340 6339 6337 6336	6384 6385 6387 6372
MIDPOINT OF COLLECTION					
DATE	10/18/72	10/19/72	10/18/72	10/25/72	10/23/72
LAT.	43N-38N	37N-30N	30N-24N	23N-12N	12N- 1N
LONG.	112W-109W	108W- 98W	98W- 89W	87W- 81W	81W- 79W
VOL. OF AIR (100 SCM)	3.290	6.050	5.380	8.170	7.720
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	993.000	255.000	140.000	313.000	74.100
ZR-95	8.475A	4.914B	2.143A	10.900	4.475B
CS-137	19.900	1.794	1.264	16.000	*
CE-144	90.100	12.700	6.372	65.600	1.581A

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT
*:NOT DETECTABLE

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

15.2 KM

SAMPLE NO.	6559	6560	6561	6562	6563
COMPOSED OF:	6373 6374 6375	6507 6506 6505	6504 6492	6493 6494	6495 6496
MIDPOINT OF COLLECTION					
DATE	10/19/72	10/23/72	10/23/72	10/22/72	10/22/72
LAT.	1N-11S	15S-27S	27S-37S	37S-44S	44S-50S
LONG.	79W- 78W	77W- 72W	72W- 65W	67W- 65W	68W- 67W
VOL. OF AIR (100 SCM)	8.250	8.190	5.920	4.060	3.320
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	97.700	124.000	397.000	539.000	756.000
ZR-95	*	1.634A	9.359	15.400	26.100A
CS-137	0.494A	1.216A	10.900	22.100	39.300
CE-144	2.730A	6.435	70.300	141.000	263.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

13.7 KM

SAMPLE NO.	6564	6565	6566	6567	6568
COMPOSED OF:	6293	6294 6295	6296	6397 6321 6320 6318 6317	6456 6457 6458 6459
MIDPOINT OF COLLECTION					
DATE	10/21/72	10/21/72	10/21/72	10/19/72	10/21/72
LAT.	64N-61N	61N-55N	55N-52N	51N-35N	34S-51S
LONG.	148W-135W	135W-124W	124W-120W	119W-107W	69W- 65W
VOL. OF AIR (100 SCM)	5.300	5.480	2.830	12.930	13.030
			PC/100 SCM		
LAB:	LFE	LFE	LFE	LFE	LFE
BE-7	749.000	1490.000	672.000	64.400	650.000
ZR-95	10.600A	21.100	*	*	15.600
CS-137	17.000	32.100	13.000	0.596A	19.900
CE-144	70.600	129.000	47.800	3.470A	132.000

A:COUNTING ERROR IS 20-50 PERCENT *:NOT DETECTABLE
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

TABLE 3D

GAMMA SPECTRAL ANALYSES OF OCTOBER 1972 COMPOSITES

12.2 KM

SAMPLE NO.	6569
COMPOSED OF:	6412 6410 6409
MIDPOINT OF COLLECTION	
DATE	10/22/72
LAT.	75N-65N
LONG.	146W-143W
VOL. OF AIR (100 SCM)	9.440

PC/100 SCM

LAB:	LFE
BE-7	835.000
ZR-95	11.100
CS-137	13.600
CE-144	59.600

A:COUNTING ERROR IS 20-50 PERCENT
B:COUNTING ERROR IS 51-100 PERCENT
?:DATA SUSPECT

*:NOT DETECTABLE

Table 3e

Quality Control Results

dpm ± % Standard Deviation

Sample No.	Reference	Date	Be-7	Sr-89	Sr-90	Zr-95	Cs-137	Ce-144	Pu-238	Pu-239
Blanks										
6003	3/28/72		*	*	0.8±73	*	7±2	*	0.06±98	0.04±45
6004	3/27/72		*	*	*	*	*	*	*	*
6005	3/26/72		*			6±2	*	*		
6280	7/14/72		*			*	9±33	39±15		
6281	7/14/72		*			*	14±21	32±45		
6570	10/22/72		411±30			54±40	4±50	66±78		
6571	10/22/72		*			16±67	5±40	*		
Standards										
6007	3/26/72	added		1147	172				8.37	15.5
		found		738±4	121±2				8.01±4	15.7±4
		% deviation		-36	-30				-4.3	+1.4
6008	3/26/72	added		810	132				6.40	11.1
		found		633±7	105±3				6.55±4	11.0±3
		% deviation		-22	-20				+2.4	-1.1
Avg. dev. for March 1972 mission				-29	-25				-1.4	-0.2
			pCi/100 SCM ± % Standard Deviation							
Duplicates										
5957	3/27/72		902±6	392±6	60.3±1	783±4	105±7	1170±1	0.150±9	1.07±4
6001	3/27/72		968±10	288±13	58.7±6	874±2	96.4±5	1210±2	0.122±9	1.06±3
		% deviation	±7.0	±31	±2.7	±11	±8.5	±3.4	±21	±0.7
5976	3/28/72		1220±7	246±7	41.4±3	497±4	63.2±5	744±1	0.077±10	0.638±3
6002	3/28/72		844±5	167±5	31.7±2	460±3	55.7±3	677±1	0.071±11	0.555±4
		% deviation	±36	±40	±27	±7.7	±13	±9.4	±8.0	±14
Avg. dev. for March 1972 mission			±22	±36	±15	±9.4	±11	±6.4	±14	±7.4
6230	7/28/72		1670±21			166±25	83.2±13	687±3		
6278	7/28/72		1120±4			146±8	84.3±2	641±1		
		% deviation	±41			±13	±1.3	±6.9		
6242	7/27/72		1110±7			175±6	92.5±2	789±1		
6279	7/27/72		1030±4			182±5	88.9±3	750±2		
		% deviation	±7.5			±3.9	±4.0	±5.1		
Avg. dev. for July 1972 mission			±24			±8.4	±2.6	±6.0		
6538	10/19/72		1110±3			45.6±21	73.8±2	450±2		
6574	10/19/72		921±2			42.5±2	58.4±1	373±2		
		% deviation	±19			±7.0	±24	±19		
6552	10/21/72		1580±2			18.6±17	40.4±4	158±3		
6575	10/21/72		1470±1			15.3±16	38.1±4	157±3		
		% deviation	±7.2			±20	±5.8	±0.6		
Avg. dev. for October 1972 mission			±13			±14	±15	±10		

Table 3f

Gamma Spectroscopy Quality Control Results

Sample No.	Reference Date		Be-7	Zr-95	Cs-137	Ce-144
July Mission						
6289	7/14/72	added	0	539	126	2560
		found	483±28	488±6	127±5	2820±2
		% deviation		-9.4	+0.7	+10
% dev. from 4 earlier meas.				-6.0	-2.2	+7.9
6290	7/14/72	added	0	484	166	2490
		found	*	336±10	164±4	2660±2
		% deviation		-31	-0.9	+6.8
% dev. from 4 earlier meas.				-12	-5.6	+7.1
6291	7/14/72	added	0	513	155	2920
		found	*	416±11	167±7	3070±2
		% deviation		-19	+8.0	+5.1
% dev. from 4 earlier meas.				-11	+4.2	+8.0
6285	7/27/72	added	249,000	30,700	345	6680
		found	242,000±1	26,900±1	291±8	7580±3
		% deviation	-2.6	-12	-16	+13
6286	7/27/72	added	204,000	32,000	378	7090
		found	199,000±1	28,300±2	356±11	7750±2
		% deviation	-2.7	-12	-5.8	+9.3
6287	7/27/72	added	237,000	30,500	413	6480
		found	229,00±1	26,700±1	357±8	7170±2
		% deviation	-3.7	-12	-14	+11
6288	7/27/72	added	238,000	30,700	453	6440
		found	232,000±1	26,700±2	424±11	7040±1
		% deviation	-2.9	-13	-6.3	+9.3
Average dev. for July 1972 mission			-3.0	-15	-4.9	+9.2
October Mission						
6285	10/22/72	added	80,700	12,100	343	5410
		found	79,100±2	10,500±2	346±5	5820±2
		% deviation	-2.0	-13	+0.9	+7.5
% dev. from 1 earlier meas.			-2.6	-12	-16	+13
6286	10/22/72	added	66,300	12,700	376	5740
		found	62,700±1	10,500±1	367±3	6200±1
		% deviation	-5.4	-17	-2.3	+8.0
% dev. from 1 earlier meas.			-2.7	-12	-5.8	+11
6287	10/22/72	added	77,100	12,100	411	5240
		found	74,500±1	10,600±1	398±2	5770±1
		% deviation	-3.4	-12	-3.0	+10
% dev. from 1 earlier meas.			-3.7	-12	-14	+11

Table 3f (cont'd)

Gamma Spectroscopy Quality Control Results

Sample No.	Reference Date		Be-7	Zr-95	Cs-137	Ce-144
6288	10/22/72	added	77,400	12,200	450	5210
		found	72,000±1	10,400±1	423±3	5610±1
		% deviation	-7.0	-14	-6.1	+7.6
% dev. from 1 earlier meas.			-2.9	-13	-6.3	+9.3
6289	10/22/72	added	0	185	125	2010
		found	*	154±13	130±3	2150±2
		% deviation		-17	+3.5	+6.9
% dev. from 5 earlier meas.				-6.7	-1.6	+8.3
6290	10/22/72	added	0	167	165	1950
		found	*	81±32	172±4	2020±2
		% deviation		-51	+4.5	+3.8
% dev. from 5 earlier meas.				-16	-4.7	+7.0
6291	10/22/72	added	0	177	154	2290
		found	*	195±17	146±6	2460±2
		% deviation		+10.2	-5.3	+7.3
% dev. from 5 earlier meas.				-13	+5.0	+7.4
Average dev. for October 1972 mission			-4.4	-23	-1.1	+7.5

Part III

DATA FROM SOURCES OTHER THAN HASL

Numerous fallout studies are conducted by other organizations in the United States and abroad. Some of these 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.

Global Atmospheric Plutonium-239 and Plutonium Isotopic Ratios for 1959-1970

Introduction:

A program of atmospheric sampling and radiochemical analysis was undertaken from 1959 through 1970 to determine the distribution of nuclear debris by means of filter collection of airborne radioactive particulate matter on IPC-1478 paper carried by aircraft (1). The analytical results of fission products derived from the analysis of samples associated with this program have been published in the Health and Safety Laboratory Quarterly Summary Reports (2-10). This report deals exclusively with the isotopic concentrations of plutonium-239 and the plutonium isotopic ratios Pu-240/Pu-239, Pu-241/Pu-239 and Pu-242/Pu-239 obtained from these samples. These data have not been reported previously.

Aircraft sampling was normally conducted in the vicinity of four latitudes: 70°N, 35°N, 10°N and 40°S. Altitudes sampled varied from approximately 15,000 to 70,000 feet. The analysis of these samples was by Government laboratories.

These data were collected as part of a cooperative effort by the U. S. Department of Defense, Atomic Energy Commission and National Oceanic and Atmospheric Administration.

Description of Tables:

Date	Date (GCT) on which the filter was extracted from the aircraft, immediately after landing.
Altitude	Pressure altitude (in thousands of feet) at which sampling was performed.

Tropopause Height of tropopause (in thousands of feet) as reported by a nearby radiosonde station.

Isotopic Data The plutonium-239 concentrations are reported in units of picocuries per 100 standard cubic meters of air. The following table lists the isotopic half-life used in correcting the data to the date of collection.

Isotope	Half-life (years)
Pu-239	24,300
Pu-240	6,760
Pu-241	13
Pu-242	397,000

Unless otherwise indicated, the precision of the analysis is within 10%. Standard errors in the analysis greater than 10% are indicated by a letter following the value in accordance with the following code:

A	11-20%
B	21-40%
C	41-100%
D	> 100%

NR indicates the isotope was not detected in resolvable amounts.

References:

1. The Institute of Paper Chemistry, A Study of the Filtration and Permeability Characteristics of IPC-1478 Filter Paper, DASA 1168, February 13, 1960.

2. Fallout Program, Quarterly Summary Report, Health and Safety Laboratory New York Operations Office, U. S. A. E. C., HASL-115, October 1, 1961, pp. 177-183.

3. _____, HASL-117, December 30, 1961, pp. 225-229.

4. _____, HASL-142, January 1, 1964, pp. 272-276.

5. _____, HASL-165, January 1, 1966, pp. 301-311.

6. _____, HASL-172, July 1, 1966, pp. 164-171.

7. _____, HASL-182, July 1, 1967, pp. III30-III47.

8. _____, HASL-193, April, 1, 1968, pp. I208-I216.

9. _____, HASL-214, October 1, 1969, pp. III12-III43.

10. _____, HASL-227, July 1, 1970, pp. III12-III21.

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 1 1959

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1	-2	-3
REGION	~70N	~155W		X10	X10	X10
10-9	15	32	0.0104	2.34B	NR	NR
10-14	15	32	0.0114	1.41	0.906B	NR
8-24	18	38	0.0394	1.45	< 1.01	NR
9-3	18	32	0.0158	1.52A	< 1.14	NR
10-3	18	34	0.0112	1.70A	NR	NR
10-2	18	33	0.0131	1.57A	1.82C	5.22
11-5	18	33	0.0088	1.52	1.17B	NR
11-19	18	30	0.0108	1.58	0.905A	4.96C
12-9	18	25	0.0201	1.69A	NR	NR
12-28	18	23	0.0094	1.62	1.28A	3.57B
2-27	20	33	0.0771	2.09	NR	NR
3-4	20	29	0.201	1.40	0.694A	NR
10-2	25	34	0.0181	1.88B	NR	NR
10-9	25	32	0.0174	1.44A	NR	NR
10-14	25	32	0.0606	1.73A	1.53B	< 5.24
2-26	35	30	5.76	1.54	0.957B	NR
3-5	35	25	5.26	1.69	0.969	2.85B
5-14	37	23	5.62	1.72	0.927	2.85B
5-14	38	30	4.10	1.71	0.963	2.25
5-14	38	28	4.93	1.69	0.979	1.94
5-14	39	26	4.27	1.73	0.968A	< 1.61
1-21	40	35	3.52	1.55	0.844A	1.72B
1-27	40	36	6.52	1.66	0.891	1.87
2-18	40	33	7.89	1.71	1.17A	3.94A
3-6	40	24	5.44	1.82	1.03	2.48A
3-18	40	29	6.77	1.84	1.20A	2.53A
4-3	40	29	4.10	1.69	0.994	2.13A
5-7	40	31	2.33	1.65	1.07A	2.39A
5-14	40	22	3.76	1.72	1.20B	< 2.74
6-30	40	35	1.63	1.68	1.01A	2.58B
7-22	40	35	1.26	1.69	1.04	2.34A
8-12	40	38	0.886	1.66A	NR	NR
8-26	40	38	0.690	1.46	0.729A	2.19A

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 1 1959

DATE	ALT	TROP HT	PU-239	PU-240/PU-239	PU-241/PU-239	PU-242/PU-239
MO-DAY	KFT	KFT	PCI/100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~155W				
9-3	40	32	0.829	1.43	1.12	4.48B
9-22	40	30	0.598	1.31	0.581A	NR
10-2	40	34	0.543	1.63	0.823	2.86B
10-10	40	32	0.540	1.58	<0.962	<4.57
10-15	40	30	0.630	1.57	1.15B	4.26B
10-21	40	33	0.416	1.57A	0.829A	2.13
11-5	40	33	0.574	1.62	0.957	2.49
11-18	40	30	0.929	1.59	0.871A	3.26
12-31	40	20	0.574	1.78A	1.09A	4.26C
2-4	45	30	6.03	1.74	0.999	2.01A
2-27	45	33	7.92	1.74	0.992	NR
3-12	45	25	3.94	1.54	NR	NR
5-20	45	31	1.14	1.99	1.36A	<3.40
6-17	45	33	1.35	1.61A	1.02	3.37A
7-8	45	32	1.30	1.48	0.801	2.16
4-10	50	28	2.37	1.72	1.12A	2.93A
4-17	50	27	2.36	1.63	1.06A	3.44A
10-2	50	34	1.22	1.54A	0.842A	2.82A
10-10	50	37	1.20	1.85A	0.908A	2.86
10-14	50	32	1.72	1.51	1.04B	3.32B
4-10	60	28	2.12	1.59	1.15	NR
4-17	60	27	2.24	1.83	1.02A	2.95
10-3	60	34	2.56	1.65	1.04A	6.07B
10-10	60	37	2.42	1.82	1.18	3.91
10-14	60	32	2.40	2.02A	<1.42	NR
10-3	64	34	3.69	1.75	1.05	3.79
4-14	65	33	2.71	1.63	1.00A	2.51
10-10	65	37	2.41	1.78A	<2.07	NR
10-15	65	30	1.29	2.06	NR	NR
REGION	~35N	~110W				
10-2	60	44	1.50	1.67	1.04	3.55A
10-8	60	44	1.57	1.67	0.958	2.76
10-2	64	44	2.08	1.62A	1.02A	2.78A
10-9	67	44	2.13	1.65	0.939	3.52B

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 1 1959

DATE	ALT	TROP HT	PU-239	PU-240/PU-239	PU-241/PU-239	PU-242/PU-239
MO-DAY	KFT	KFT	PCI/100 SCM	-1 X10	-2 X10	-3 X10
REGION	~15N	~160W				
4-8	10	40	0.0264	1.62A	<1.31	<1.31
5-12	10	42	0.0611	1.63A	0.932B	3.50B
6-16	10	45	0.0197	1.77A	1.35A	6.90A
7-17	10	46	0.0036	<1.76	NR	NR
REGION	~40S	~60W				
5-15	40	32	0.126	1.62	1.11	3.49
6-12	40	32	0.101	1.75A	1.20A	7.02B
7-10	40	38	0.123	1.78	1.63B	NR
8-4	40	36	0.0998	1.89	1.33A	<4.03
4-3	50	30	0.215	1.82	<1.48	NR
5-15	50	32	0.243	1.91	1.26A	4.78A
6-2	50	32	0.121	1.76B	1.68B	NR
7-10	50	38	0.180	1.75	1.47A	4.14
8-4	50	36	0.123	2.21A	1.06A	5.88
4-10	60	34	0.315	1.89A	1.28A	4.15A
5-8	60	32	0.388	1.86	1.26	4.35
8-6	60	34	0.555	1.87	1.20A	4.37A
5-8	66	32	0.411	1.91	1.22A	4.23
4-10	68	34	0.421	1.84	2.75A	<7.14
7-16	68	36	0.589	1.73	1.13A	NR
8-6	70	34	0.744	1.58A	1.40B	5.50

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 2 1960

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~155W				
5-17	15	34	0.0134	1.79	1.16B	NR
5-24	15	39	0.0127	1.54B	2.74C	3.85C
5-17	25	34	0.0290	1.83	1.09A	3.65
5-24	25	39	0.0125	1.82	0.979B	2.17
11-1	25	34	0.0307	1.45A	0.924A	2.14B
11-15	25	29	0.0197	1.88	NR	NR
1-26	40	34	0.937	1.67	0.926	--
2-16	40	34	1.41	1.72	1.02	--
3-17	40	30	1.16	1.73	1.06	--
4-19	40	29	1.51	1.75	1.05	--
5-17	40	33	0.729	1.78	1.07	--
5-17	40	34	0.869	1.89B	1.02A	3.42A
5-24	40	39	0.175	1.75	1.03A	3.48B
6-20	40	32	0.798	1.80	1.06	--
7-18	40	35	0.525	1.80	1.05	--
8-16	40	34	0.369	1.79	1.05	--
9-20	40	34	0.467	1.75	1.49A	--
10-17	40	33	0.274	1.82	1.07	--
11-1	40	34	0.432	2.29A	NR	NR
11-10	40	32	0.538	1.79	1.04	2.82
11-16	40	29	0.292	1.86	1.27A	NR
11-17	40	33	0.306	1.77	1.01	--
12-19	40	31	0.853	1.76	1.02	--
5-18	50	33	1.16	1.78	1.09	2.95
5-20	50	33	1.35	1.79	1.18	NR
5-25	50	39	1.27	1.82	1.40A	5.80A
11-10	50	32	2.98	1.84A	1.00A	2.54A
11-15	50	29	2.65	1.82	1.09	NR
5-18	60	33	3.86	1.76A	1.05A	1.96A
5-20	60	33	4.15	1.81	1.36A	NR
5-25	60	39	4.33	1.85	1.00	2.43A
11-1	60	34	3.02	1.80	0.989A	2.57A
11-10	60	32	2.75	1.85A	1.04A	2.35A
11-15	60	29	3.52	1.84	1.12	NR

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 2 1960

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~155W				
5-18	63	33	5.28	1.68A	0.979A	1.82B
5-20	63	33	5.93	1.80	1.05	NR
11-10	63	32	4.35	2.06	0.951	2.49
5-25	64	39	4.41	1.85A	1.13	2.50A
11-1	64	34	3.66	1.79	0.601A	1.99A
11-15	64	29	4.02	1.87	1.07	NR
REGION	~35N	~110W				
5-20	15	39	0.0173	1.73A	1.03B	2.32B
5-24	15	42	0.0074	1.59	2.03C	NR
6-1	15	39	0.0142	1.70	NR	NR
5-20	25	39	0.0081	1.37A	NR	NR
5-24	25	42	0.0057	1.66	NR	NR
6-1	25	39	0.0206	1.72	NR	NR
5-20	40	39	0.0815	1.84A	1.20A	3.78A
5-24	40	42	0.243	1.71	1.13A	3.40
6-1	40	39	0.533	1.76	NR	NR
11-10	40	37	0.0501	1.61	0.986	2.18A
11-15	40	36	0.0955	1.78	1.14	NR
5-20	50	39	0.255	1.82	1.11A	3.07B
5-24	50	44	0.244	1.77	0.620B	NR
6-1	50	41	1.01	1.80	1.14	NR
11-1	50	54	0.146	0.965A	NR	NR
11-10	50	39	0.138	1.81	1.00	3.04A
11-15	50	36	0.538	1.87	1.08	NR
5-20	60	39	2.13	1.81	1.08	2.98A
5-24	60	44	1.88	1.35A	0.717A	2.13A
6-1	60	41	1.93	1.73	1.21A	NR
11-1	60	54	1.97	1.72	0.987	2.46
11-10	60	39	3.47	1.88A	1.08A	4.03C
11-16	60	44	1.80	1.86	1.13	NR
5-20	65	39	3.43	1.76	0.353C	2.58
6-1	65	41	3.54	1.79	<2.33	NR

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 2 1960

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~35N	~110W				
5-24	66	44	4.03	1.76	0.838	3.05D
11-1	66	54	3.35	1.80	0.990A	2.80A
11-10	66	39	2.71	2.03	1.09A	2.48B
11-15	66	44	2.98	1.85	1.17	NR
REGION	~10N	~55W				
5-20	50	52	0.0071	1.55B	NR	NR
5-20	60	53	0.214	1.95	1.87C	NR
5-24	60	53	0.304	1.91B	1.11B	5.44A
6-1	64	53	1.21	1.61	1.16	NR
5-24	65	53	1.13	1.69	1.01B	2.24A
REGION	~10N	~160W				
11-19	60	53	0.735	1.80	1.08	3.49
11-21	60	55	0.595	1.22	1.15B	2.01D
11-18	66	53	1.22	1.73	1.12A	3.11A
11-22	66	52	0.946	1.82	1.07	3.50
11-24	67	55	1.43	1.75	NR	NR
REGION	~40S	~60W				
5-19	15	32	0.0096A	1.82B	NR	NR
5-23	15	32	0.0145	0.651A	NR	NR
5-19	25	32	0.0225	1.37A	0.882A	2.68B
5-19	40	32	0.235	1.61A	1.05A	1.17B
5-23	40	32	0.0459	1.21A	1.04C	NR
6-2	40	44	0.0843	1.47	0.979	NR
5-19	50	32	0.336	1.62A	0.880	3.86A
6-2	50	44	0.588	1.78	1.11	NR
5-19	60	32	1.18	1.95A	1.02A	4.28C
5-23	60	32	0.831	1.78	1.11A	2.35A
6-2	60	44	0.626	1.77	1.19	NR

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 2 1960

DATE	ALT	TROP HT	PU-239	PU-240/PU-239	PU-241/PU-239	PU-242/PU-239
MO-DAY	KFT	KFT	PCI/100 SCM	-1 X10	-2 X10	-3 X10
REGION ~ 40S		~ 60W				
5-19	64	32	2.59	1.68A	0.940A	2.19B
5-23	65	32	2.15	1.78	1.02	2.22A
6-2	70	44	3.27	1.76	1.07	NR
REGION ~ 40S		~ 145E				
11-2	15	34	0.0144	1.58B	2.16C	NR
11-10	15	39	0.0049	1.50A	1.18B	2.75B
11-15	15	33	0.0091	1.73	NR	NR
11-2	25	34	0.0137	2.11C	NR	NR
11-15	25	33	0.0188	1.24	NR	NR
11-2	40	34	0.0493	1.85	1.53A	6.92B
11-10	40	39	0.160	1.64A	1.06A	3.12A
11-15	40	33	0.347	2.05A	NR	NR
11-2	50	34	0.332	2.09	NR	NR
11-8	50	30	0.336	1.77	1.04	4.19A
11-2	60	34	2.44	2.00A	1.08B	2.60A
11-8	60	30	2.49A	1.78B	1.02B	3.12A
11-15	60	33	2.11	1.79	NR	NR
11-8	63	30	2.37	1.75	1.03	2.66A
11-2	64	34	1.99	1.75B	1.00C	2.65A
11-15	65	33	2.28	1.82	NR	NR

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 3 1961

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
5-2	15	35	0.0556	1.83	1.01	2.59
5-12	15	32	0.0250	1.92A	1.26A	3.95B
5-16	15	32	0.0373	1.71A	NR	NR
5-2	25	35	0.0679	1.80	1.00	2.60
5-16	25	32	0.0294	1.79	1.31	NR
5-2	40	35	0.808	1.90	1.11A	2.80A
5-13	40	32	0.989	1.84	1.06	2.45
5-16	40	32	1.07	1.80	1.17	NR
5-2	50	35	1.33	1.89	1.05	2.40
5-13	50	32	0.903	1.82	0.962	2.43
5-16	50	32	1.20	1.81	NR	NR
5-2	60	35	2.16	1.81	0.984	2.38
5-12	60	32	2.03	1.68	0.826	2.26
5-16	60	32	2.38	1.81	NR	NR
5-16	62	32	2.40	1.82	1.04	NR
5-2	65	35	2.35	1.71	0.857	2.33
5-12	65	32	2.18	1.80	1.00	2.45
REGION	~35N	~110W				
5-4	15	37	0.0416	1.77	0.983	2.44
5-11	15	44	0.0100	1.53A	0.940A	2.27
5-16	15	42	0.0125	1.75	1.01	NR
5-4	25	37	0.0338	1.82A	1.30B	2.98B
5-11	25	44	0.0050	1.33A	0.808B	3.27B
5-16	25	42	0.0068	1.61	0.991A	NR
5-4	40	37	0.256	1.79	1.02	2.60
5-16	40	42	0.0703	1.82	1.04	NR
5-4	50	39	0.459	1.55A	0.951A	3.00B
5-11	50	50	0.0388	1.84	1.06A	4.90A

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 3 1961

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~35N	~110W				
5-4	60	39	0.894	1.82	0.940	2.63
5-11	60	50	1.30	1.79	1.00	2.63
5-16	60	42	1.98	1.80	1.08	2.53A
5-4	66	39	2.84	1.81	0.982	2.56
5-11	67	50	2.21	1.82	0.992	2.48
5-16	67	42	3.06	1.82	0.983	2.37
REGION	~10N	~160W				
6-6	50	49	0.0089	1.86A	1.21B	5.95A
6-15	50	51	0.390	1.82	1.00	2.53
6-6	60	49	1.05	1.64	0.782	2.27
6-15	60	51	0.527	1.84	1.12A	3.13A
6-20	60	50	0.685	1.83	1.01	NR
6-15	64	51	0.877	1.80	1.00	2.69
6-6	65	49	1.13	1.82	0.916A	3.01A
6-20	66	50	1.35	1.78	0.962	NR
REGION	~40S	~145E				
5-8	15	32	0.0050	1.56A	0.905A	2.14A
5-8	25	32	0.0154	1.60	NR	--
5-8	40	32	0.133	1.77	1.01	2.77
5-15	40	42	0.0150	1.56	1.13B	3.98C
5-23	40	37	0.208	1.77	1.20	NR
5-8	50	34	0.576	1.87	1.04	2.73A
5-15	50	42	0.628	1.81	0.971	2.68
5-23	50	37	0.702	1.81	0.984	2.72C
5-8	60	34	2.39	1.83	0.989	2.43
5-15	60	42	2.50	1.90	0.890	2.34
5-23	60	37	2.05	1.83	1.00A	NR
5-9	65	34	2.21	1.76	0.996	2.41
5-15	65	42	2.49	1.64	0.745	2.10
5-23	66	37	3.30	1.79	1.15	NR

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 4 1963

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
8-28	15	32	0.0808A	1.82B	--	--
11-6	15	28	0.0411	2.40	6.23C	22.5C
6-19	40	29	10.3	2.45	1.97	6.33
8-28	40	32	4.34	2.41	1.94	6.47
11-20	40	29	5.81	2.24	1.68	5.16
8-27	50	31	11.3	2.03	1.48	4.25
11-5	50	30	10.6	2.13	1.63	7.72B
8-28	60	31	15.7	2.40	1.84	5.89
11-5	60	30	19.0	1.88	1.37	4.59A
8-27	63	34	17.5	1.77	1.15	2.99
11-5	66	30	17.4	1.73	1.12	3.29
REGION	~35N	~110W				
8-13	65	--	25.4	1.93	1.37A	3.62B
11-19	67	40	18.7	1.82	1.38	4.82B
REGION	~10N	~80W				
8-13	67	52	5.50	2.13	1.76A	7.57B
11-5	69	54	14.9	2.07	1.56	4.73
REGION	~40S	~145E				
8-27	15	33	0.0972A	1.79A	1.32B	--
11-19	15	34	0.0138	1.81	0.776A	--
8-27	64	34	2.12	1.86	1.14	4.17A
11-19	65	34	3.16	1.72	1.05A	6.53C

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 5 1964

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
2-12	15	--	0.245	2.23	1.68	5.94
5-18	15	30	0.342	2.01	1.47	6.38
11-2	15	30	0.0227	2.05A	--	--
2-25	40	32	11.4	1.84	1.30	3.84A
5-18	40	30	6.85	1.94	1.31	4.03
8-24	40	33	2.64	1.89	1.26	3.67
11-3	40	26	3.46	1.90	1.23	3.90
2-11	50	28	10.1	1.87	1.26	3.69
5-19	50	30	7.90	1.85	1.25	3.82
8-24	50	33	4.33	1.94	1.24	3.63
11-3	50	26	5.46	1.83	1.11A	2.93
2-25	60	30	7.80	1.77A	1.05A	2.65B
5-18	60	30	9.80	1.73	1.16	3.49
8-11	60	35	7.23	1.76	1.15	3.40
11-2	60	30	2.26	1.47	0.966	2.38B
11-2	63	30	2.45	1.47	0.893	2.86
5-5	64	25	4.65	1.57	1.06	2.67
8-11	65	35	5.97	1.64	1.07	3.02
2-25	67	30	5.91	1.55	0.984	2.79
REGION	~35N	~110W				
2-25	50	36	4.06	1.87	1.28	3.87
5-20	50	44	1.96	1.90	1.29	4.89
8-25	50	50	1.38	1.91	1.46	4.73
2-25	60	36	10.6	1.88	1.27	3.68
5-19	60	45	9.98	1.86	1.31	4.40
8-11	60	53	6.92	1.83	1.29	4.15
11-30	60	43	4.79	1.75	1.23	3.53A
8-11	66	53	15.5	1.74	1.08	2.82
5-19	67	45	9.03	1.69	0.971B	4.74
2-25	69	36	10.9	1.86	1.26	3.74

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 5 1964

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~10N	~80W				
5-19	67	55	9.20	2.01	1.48	5.25
8-25	68	49	8.00	1.89	1.26	3.82
11-17	68	56	6.76	1.93	1.38	4.20
2-25	69	55	8.13	2.05	1.45	4.56
REGION	~40S	~145E				
2-25	15	--	0.0133	1.73A	ND	ND
5-6	15	--	0.0122	1.92	2.80	--
5-5	64	39	0.912	1.89	1.53	7.78A
8-25	65	34	1.36	1.83	1.20A	5.22B
11-3	65	33	1.36	1.80A	1.24	4.00
2-27	66	38	2.00	1.82	1.18A	3.50

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 6 1965

DATE	ALT	TROP HT	PU-239	PU-240/PU-239	PU-241/PU-239	PU-242/PU-239
MO-DAY	KFT	KFT	PCI/100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
5-18	15	32	0.0292	1.78	1.03	3.89
2-10	40	27	2.24	1.82	1.24	4.09
5-19	40	34	2.78	1.82	1.10	3.19
8-27	40	32	1.08	1.90	1.20	3.27A
11-16	40	32	0.449	1.77	1.08B	2.85
2-9	50	25	4.63	1.80	1.17	4.05
5-4	50	27	0.203	1.79A	1.23B	2.96
8-27	50	32	2.35	1.72A	1.38A	--
11-15	50	34	2.70	1.72	1.05	3.10A
2-8	60	23	3.25	1.68	1.24A	7.05B
5-3	60	30	4.24	1.70	1.05A	2.93
2-8	62	34	4.20	1.75	1.35	7.68
5-3	62	30	2.79	1.70	1.05A	2.90A
8-27	64	32	1.66	1.65	1.00	3.32C
11-16	64	30	1.36	1.70	1.04A	3.25A
REGION	~35N	~110W				
8-22	40	47	0.0164B	1.78C	--	--
5-3	50	44	2.17	1.68A	1.18	3.03A
8-9	50	53	0.322	1.78	1.41B	--
11-15	50	45	0.361	1.78	1.11	3.03A
2-8	60	38	4.02	1.80	1.18	4.24
5-18	60	41	2.53	1.76	1.10	3.74A
11-16	60	45	2.63	1.74	1.06	3.79A
5-18	63	41	2.70	1.68	1.05	2.66A
8-22	65	48	2.28	1.68	1.00A	3.51C
11-29	65	40	1.37	1.70	1.01	2.92
2-22	70	37	6.45	1.85	1.26	4.06

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 6 1965

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~10N	~80W				
5-18	52	52	0.718	1.74A	1.13	--
5-22	60	57	1.81	1.87	1.17	3.81
8-25	60	52	2.05	1.95	3.89B	3.53
11-15	64	56	1.22	1.80	1.12	3.33B
2-9	65	54	12.0	1.84	1.32	4.62B
5-22	66	57	4.76	1.88	1.24	3.78
8-10	67	49	3.22	1.90	1.93A	7.65C
REGION	~40S	~145E				
2-10	40	39	0.470	1.94	1.45	6.10A
5-19	40	32	0.661	1.90	1.20	3.50B
11-17	40	36	0.320	1.86	1.15A	3.11A
8-24	60	37	1.34	1.82	1.12	3.64B
11-18	60	36	1.08	1.75	1.50A	6.76C
8-24	63	37	1.28	1.79	1.34	3.98
11-18	65	36	0.989	1.77	1.12	2.81
5-4	66	40	0.989	1.82	1.14	3.77A
2-9	67	38	0.903	1.70	1.40A	4.49

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 7 1966

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~ 70N	~ 145W				
2-24	40	29	1.72	1.11	1.08	3.20
2-22	50	24	1.38	1.70	1.10	3.12
2-24	50	29	1.38	1.65	1.16A	--
2-22	60	24	1.49	1.79	1.10	3.12
2-22	64	24	1.45	1.75	--	--
REGION	~ 35N	~ 110W				
2-8	40	37	1.14	1.73	1.05	3.00B
6-14	40	47	0.0200	1.75	5.78B	--
2-20	50	33	0.430	1.71	1.24	--
2-23	50	37	0.350	1.76	1.04	2.67
6-28	50	52	0.231	1.51	0.865	2.51
6-29	50	50	0.0845	1.31A	0.909A	4.36B
2-23	60	37	2.04	1.77	1.08	3.11
6-14	60	49	1.45	1.72	1.08	3.21
6-27	60	51	1.55	1.72	1.09	3.38
6-14	64	45	1.47	1.75	1.06	2.47
6-27	65	51	1.58	1.75	1.09	3.20
REGION	~ 10N	~ 80W				
6-20	40	--	0.0025A	1.53A	4.54B	--
6-27	40	51	0.0159B	1.89B	5.04B	--
6-28	50	50	0.0440B	1.44B	2.01B	16.3C
2-11	60	56	0.381	1.78	1.21	3.54
6-27	60	50	0.833	1.68	1.00A	3.31B
6-27	62	50	1.13	1.83	1.10	3.56A
2-11	65	56	1.29	1.76	1.12A	--

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 7 1966

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~40S	~70W				
2-23	40	37	0.353	1.85	1.14	4.26B
7-2	40	36	0.111	1.79A	1.09A	6.71B
2-22	50	37	0.526	1.82	1.12	3.85
2-24	50	40	0.584	1.78	1.09	3.41A
7-3	50	38	0.586	1.77	1.05	2.67
7-3	50	38	0.531	1.82	1.33	4.46
2-23	60	39	0.912	1.76	1.29B	9.64C
7-2	60	35	0.721	1.78	1.07	2.81
7-2	60	35	0.685	1.81	1.11	4.80C
7-2	63	35	0.811	1.81	1.05A	4.13A
7-2	64	35	0.628	1.87	6.74B	8.14A

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 8 1967

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
1-19	40	36	0.211	1.69	0.930	2.78
1-24	40	--	0.438	1.73	0.926	2.60
7-18	40	31	0.242	1.88	1.69A	--
8-1	40	32	0.304	1.77	1.08A	--
1-10	50	27	1.22	1.86	1.07A	2.99A
1-10	50	27	0.912	1.78	1.04	3.81
7-18	50	31	0.598	1.85	1.35	3.45A
1-9	60	34	0.963	1.72	1.07	3.56
1-23	60	34	0.618	1.93	1.35	4.65
7-17	60	37	0.556	1.74	0.953A	--
7-24	60	34	0.445	1.76	1.02	3.47
1-9	63	29	0.781	1.80	1.04	3.00
1-9	63	28	0.325	1.86	--	--
7-17	63	37	0.437	1.77	1.06	3.93
REGION	~35N	~110W				
1-17	40	39	0.0764	1.67	1.10	--
1-25	40	--	0.210	1.65	0.965	3.08
7-19	40	51	0.0040	1.44B	--	--
8-1	40	52	0.0086	1.84B	1.09C	--
1-10	50	39	0.556	1.49	2.26B	6.90
1-17	50	39	0.320	1.73	--	--
8-1	50	52	0.0187	1.72A	--	--
1-9	60	37	1.08	1.72	0.966	2.66
1-16	60	42	0.903	1.76	1.01	3.43
7-24	60	52	3.90	1.90	1.32	2.60
1-16	63	42	1.08	1.72	1.04	3.49
7-24	63	52	3.31	1.92	1.41	2.83
7-31	63	53	1.73	1.97	1.33	2.79
1-23	64	40	0.821	1.75	1.03	3.45

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 8 1967

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~10N	~80W				
1-9	40	55	0.0094B	0.673B	0.631B	--
1-23	40	53	0.0154	1.77	1.15	--
7-18	40	48	0.0265	1.68	1.61	--
1-16	50	54	0.0075A	1.70A	--	--
1-23	50	53	0.0231B	1.03B	1.54B	7.26B
7-18	50	46	0.0058	1.64A	--	--
7-25	50	47	0.140	0.664A	0.207C	--
1-10	60	55	0.441	1.74	1.09	3.41
1-17	60	56	0.599	1.89	7.25B	9.23B
7-19	60	52	0.383	1.76	1.17	3.50A
1-17	63	53	1.14	1.77	1.03	3.26
1-17	63	56	0.869	1.82	1.08	3.27
7-19	64	52	0.989	1.85	1.01	3.60A
REGION	~40S	~70W				
1-9	40	36	0.163	1.41A	1.56B	5.66B
7-18	40	34	0.309	1.74	1.07A	3.37A
7-24	40	36	0.247	1.66	0.948	2.60
1-11	50	38	0.140	1.49	1.85	5.28
1-17	50	38	0.420	1.55	0.992	2.82
7-17	50	36	0.308	1.75	5.40C	6.93
7-17	50	36	0.432	1.69	1.08	3.18A
1-10	60	41	0.615	1.72	1.00A	3.29A
7-24	60	35	0.436	1.78	1.82C	--
7-24	60	34	0.490	1.67	1.02	2.62A
7-24	63	34	0.499	1.72	1.08A	--
1-10	64	41	0.654	1.77	1.08A	3.18
7-24	64	34	0.446	1.87	0.999A	3.66A

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 9 1968

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
1-11	40	29	0.877	1.78	1.15	2.66
1-23	40	28	0.0096	1.66	1.05A	--
6-2	40	35	1.17	1.88	1.12	1.68
6-8	40	33	1.20	1.93	1.35	2.98
1-15	50	--	2.46	1.88	1.42A	2.66
1-15	50	--	3.20	1.87	1.12	2.80
6-1	50	30	1.05	1.99	1.27	4.02
1-10	60	29	3.33	1.91	1.30	2.78
1-16	60	33	1.53	1.92	1.34	2.83
6-1	60	30	1.04	1.92	1.32	3.35
6-8	60	33	0.458	1.82	1.34	--
1-10	63	29	1.42	1.91	1.27	2.71
6-1	63	30	0.598	1.89	1.30	3.07
1-22	64	32	1.01	1.89	1.24	3.27
6-8	64	33	1.31	1.92	1.39	2.96
REGION	~35N	~110W				
1-9	40	37	1.09	1.81	1.18	3.20
1-16	40	36	0.0632	1.79	1.11	2.85
1-9	50	37	0.703	1.88	1.25	3.03
1-15	50	--	0.0518	1.83	1.35A	3.98
1-8	60	38	1.40	1.89	1.29	2.76A
1-15	60	--	3.31	1.91	1.28	3.00
1-15	62	--	2.06	1.93	1.28	3.64
1-8	66	38	2.89	1.90	1.34	2.66
REGION	~10N	~80W				
1-16	40	--	0.0632	1.79	1.11	2.85
6-1	40	52	0.0015C	1.20C	1.48C	1.83C
6-8	40	46	0.0121A	1.95A	--	--

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 9 1968

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION ~ 10N		~ 80W				
1-8	50	--	0.0124B	1.77B	1.49B	--
1-15	50	52	0.0024C	1.71C	--	--
6-8	50	47	0.0937	2.87	1.20	2.92
1-22	60	51	0.507	1.79	1.06	2.80
6-1	60	49	0.989	1.87	1.20	2.92
6-8	60	47	1.03	1.91	1.33	3.45
6-1	66	49	1.35	1.86	1.23	2.67
6-8	66	47	0.963	1.95	1.24	4.84
1-15	67	53	2.06	1.93	1.28	3.64A
REGION ~ 40S		~ 70W				
1-9	40	37	0.105	1.46	0.825	2.96A
1-16	40	40	0.0150	1.55	1.00A	--
6-2	40	39	0.0415	1.71	0.947	3.00
6-16	40	44	0.0705	1.74	--	--
1-9	50	37	0.171	1.63	1.19	--
1-23	50	40	0.122A	1.64A	0.959A	--
6-1	50	39	0.123	1.70	1.00	3.35
6-8	50	37	0.193	1.73	0.991	3.18A
1-10	60	36	0.306	1.70	0.961A	3.27A
1-16	60	40	0.249	1.72	0.975	3.19
6-3	60	38	0.211	1.69	0.916	3.12
6-8	60	37	0.180	1.90	1.09	--
1-8	63	37	0.249	1.72A	1.07A	--
1-22	63	50	0.417	1.72	0.987	--
6-8	63	37	0.197	1.70	1.06	--

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 10 1969

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~70N	~145W				
2-4	40	27	0.529	1.88	1.20	2.85A
2-19	40	30	0.492	1.76	1.04	2.53
2-3	50	27	4.19	1.74	1.12	2.05
2-17	50	30	2.68	1.72	1.03	1.55
2-3	60	27	0.427	1.77	1.08	2.32A
2-4	60	27	0.599	1.74	1.03	2.66
2-3	62	27	2.03	1.73	1.17	2.20
2-4	62	27	0.639	1.77	1.02	2.83
REGION	~35N	~110W				
2-5	40	45	0.0157	1.81	1.20	--
2-12	40	35	0.0530	1.80	1.18	2.91
2-4	50	37	0.242	1.81	1.09	2.19
2-12	50	38	0.0249A	1.71A	1.20A	2.88A
2-4	60	37	1.38	1.76	1.06	2.26
2-10	60	36	0.972	1.77	1.09	2.37
2-4	68	37	1.05	1.75	1.08	2.30
2-18	68	37	0.730	1.71	0.990	1.88
REGION	~10N	~80W				
2-10	40	--	0.0060D	1.57D	3.22D	10.4D
2-4	50	53	0.0065C	0.873C	0.562C	1.41C
2-17	50	52	0.0036A	1.78A	--	--
2-3	60	49	0.0955A	1.65A	0.988A	2.40A
2-10	60	52	0.384	1.72	1.07	--
2-4	64	53	0.572	1.57	0.938	2.24
2-10	65	52	0.555	1.64	1.09	--

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 10 1969

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~ 40S	~ 70W				
2-3	40	44	0.0243A	1.26A	0.729A	3.08B
2-11	40	36	0.0421	1.19	0.644	--
2-3	50	44	0.0808	1.21	0.663A	1.56C
2-10	50	37	0.775	1.02	0.466	0.751
2-18	60	48	2.77	0.951	0.436	0.501
2-18	63	48	2.35	0.963	0.707	0.780

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 11 1970

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~ 70N	~ 145W				
1-2	40	27	0.704	1.53	0.835	1.84
1-20	40	29	0.989	1.80	0.988	2.50A
1-13	50	33	2.56	1.92	1.14	1.86
1-13	50	29	3.31	1.95	1.15	2.84A
1-5	60	31	1.42	1.89	1.16	ND
1-12	60	33	1.72	1.91	1.12	1.89
1-12	62	33	0.972	1.88	1.05	2.02
1-19	62	31	0.848	1.74	1.08	2.61
REGION	~ 35N	~ 110W				
1-6	40	35	0.436	1.78	1.06	2.14
1-20	40	40	0.0366	1.77	1.77	2.42A
1-5	50	37	0.999	1.84	1.07	2.66
1-19	50	37	0.970	1.85	1.08	1.92
1-5	60	37	1.72	1.86	1.08	2.02
1-12	60	34	1.49	1.88	1.19	1.84
1-12	63	34	2.61	1.94	1.17	2.18
1-19	63	37	2.02	1.80	1.05	1.46
REGION	~ 10N	~ 80W				
1-20	40	53	0.142	1.58A	0.720A	ND
1-10	60	52	0.531	1.78	1.20	2.56B
1-19	60	53	0.941	1.60	1.09	2.67
1-13	64	52	0.765	1.73	1.03	1.70
1-5	66	52	0.775	1.63	1.11	2.24

PLUTONIUM-239 CONCENTRATIONS AND PLUTONIUM RATIOS

TABLE 11 1970

DATE	ALT	TROP HT	PU-239	PU-240 / PU-239	PU-241 / PU-239	PU-242 / PU-239
MO-DAY	KFT	KFT	PCI / 100 SCM	-1 X10	-2 X10	-3 X10
REGION	~ 40S	~ 70W				
1-6	40	37	0.0140	1.03	0.590	ND
1-19	40	52	0.129	1.06	0.541	0.876A
1-5	50	37	1.61	1.74	1.03	1.78
1-13	50	36	0.288	1.01	0.682A	1.10A
1-19	60	52	0.624	1.11	0.698	2.89
1-19	60	52	0.553	0.874	0.478	ND
1-12	62	36	0.636	1.06	0.514	0.936
1-12	63	36	0.670	1.13	0.573	ND

EURATOM JOINT NUCLEAR RESEARCH CENTRE

ISPRA ESTABLISHMENT

Protection Service

Site Survey and Meteorology Section

QUARTERLY REPORT

EUR/C-IS/394/70e.

The Euratom Ispra Establishment is located in Northern Italy 58 Km NW from Milan and 14 Km W from Varese.

The activity levels shown in this report represent world wide fallout, and do not reflect any contamination from the site.

SAMPLE COLLECTION

a. Air

Air is drawn by pumps through paper filters at the rate of, at least, 500 m^3/day, measured by gas meter.

The single daily filters are measured for gross beta radioactivity and then pooled to give monthly samples, for gamma spectrometry and radiochemical analyses.

b. Wet and dry deposition

These samples are collected monthly by means of four 1 m^2 stainless steel funnels, with the bottom always covered with deionized water. Water in excess of a pre-fixed level drains through a filter and a double (cationic and anionic) ion-exchange column. The eluate of the resins and the filters are submitted to the analyses. This procedure is described in detail in the paper by M.C. de Bortoli and P. Gaglione : "Sampling of radioactive deposition through ion-exchange resins", Giornale di Fisica Sanitaria, 13, 219-224 (1969).

c. Milk

Milk is collected twice a week in four small local dairies to give 8 liters / month. About six liters are dried and submitted to gamma spectrometry and two liters ashed for radiochemical determination of strontium-90.

CHEMICAL PROCEDURES AND COUNTING TECHNIQUES

a. Strontium-90 is separated by the fuming nitric acid precipitation and then purified through hydroxides and chromates precipitations. The activity of the final strontium carbonate and yttrium oxalate precipitates is measured in low level anticoincidence beta counters.

b. Cesium-137 is measured by direct gamma spectrometry on the unprocessed or dried samples and, whenever it is necessary, by gamma spectrometry after chemical separation. This is performed by filtration of the solution, obtained dissolving the sample, through a thin AMP (ammonium molybdophosphate) layer, by which cesium is retained. Details of this procedure may be found in the paper by E. Van der Stricht issued on "Radiochimica Acta" 3, 193-199 (1964).

c. Gamma emitting nuclides are measured by direct gamma spectrometry, using, also the spectrum stripping technique.

d. Plutonium isotopes are separated by anion exchange and electrodeposition ; details of the procedure may be found in the paper by M.C. de Bortoli : "Radiochemical determination of plutonium in soil and other environmental samples", Anal. Chem. 39, 375 (March 1967).
The activity is measured in a Frish grid ionisation chamber connected to a multichannel analyser.

EXTRAPOLATION OF THE DATA

Except when otherwise stated, the data presented in this report are extrapolated to the last day of the collecting period.

AIR RADIOACTIVITY

1972

SITE : I S P R A LAT. 45° 49' N LONG. 8° 37' E ALT. 250 m

Month	Gross beta pCi/m^3	^{90}Sr $10^{-3}pCi/m^3$	^{89}Sr $10^{-3}pCi/m^3$	^{137}Cs $10^{-3}pCi/m^3$	^{239}Pu $10^{-5}pCi/m^3$	^{238}Pu $10^{-5}pCi/m^3$
September	0.06	0.6	2.8	0.7	1.4	0.14
October	0.06	0.6	1.3	0.6	1.4	0.14
November	0.06	0.4	0.3	0.4	0.8	0.05
December	0.06	0.3	0.5	0.5	1.0	0.10

FALLOUT DEPOSITION

1 9 7 2

SITE : I S P R A LAT. 45° 49' N LONG. 8° 37' E ALT. 250 m

Month	Gross beta (1)		^{90}Sr	^{89}Sr	^{137}Cs	^{239}Pu	^{238}Pu	Precipitation
	mCi/Km^2	date (2)	mCi/Km^2	mCi/Km^2	mCi/Km^2	$\mu Ci/Km^2$	$\mu Ci/Km^2$	mm
September	4.0	12-10	0.095	0.38	0.13	-	-	315.8
October	0.82	16-11	0.016	0.033	0.021	0.25	0.02	109.0
November	0.29	7-12	0.007	0.003	0.008	0.11	0.007	22.2
December	0.49	17-1-73	0.013	0.010	0.018	0.25	0.02	114.0

(1) Potassium-40 equivalent (40 mg/cm^2).

(2) Day and month of the gross beta measurement.

\- Sample lost.

PART IV

RECENT PUBLICATIONS RELATED TO RADIONUCLIDE STUDIES

Recent Publications Related to Radionuclide Studies

Barker, D. R. and H. Zeitlin
Metal-Ion Concentrations in Sea-Surface Microlayer and Size-Separated Atmospheric Aerosol Samples in Hawaii
J. Geophys. Res., 77, No. 27, pp 5076-5086, Sept. 20, 1972

Blum, F. A.
Tunable Infrared Laser Spectroscopy of Atmospheric Water Vapor
Science, 177, No. 4050, August 25, 1972

Borak, T. B., et al
The Underground Migration of Radionuclides Produced in Soil Near High Energy Proton Accelerators
Health Physics, 23, No. 5, November 1972

Brandon, W. F., et al
Chromosome Aberrations in Uranium Miners Occupationally Exposed to ^{222}Radon
Radiation Research, 52, 204-215 (1972)

Cambray, R.S., et al
Radioactive Fallout in Air and Rain - Results to the Middle of 1972 -
AERE R7245, Health Physics & Medical Div., AERE, Harwell, Berkshire, 1972

Chattopadhyay, A. and R.E. Jervis
Determination of Nanogram Quantities of Lead by Photon Activation Analysis
Radiochem. Radioanal. Letters, 11, 6, pp 331-341, 1972

Chow, T. J., et al
Pb Aerosol Baseline: Concentration at White Mountain and Laguna Mountain
Science, 178, No. 4059, October 27, 1972

Clanet, F., et al
Determination du plutonium urinaire par analyse radio-chimique sur filtres echangeurs d'ions
Health Physics, 23, No. 2, August 1972

Czosnowska, W., et al
Long-term Study of the Urinary Sr^{90} and Calcium in Children
Health Physics, 23, No. 2, August 1972

DeGraf, H., et al
Relationships between Outdoor and Indoor Air Pollution
Atmospheric Environment, 6, No. 9, September 1972

Diethorn, W.S. and W.L. Stockho
The Dose to Man from Atmospheric ^{85}Kr
Health Physics, 23, No. 5, pp 653-662, November 1972

Druilhet, A., et al
Study of Radon-220 Emanation Deduced from Measurement
J. Geophys. Res., 77, No. 33, pp 6508 - 6514, Nov. 20, 1972

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Radioactivite Ambiante Dans Les Pays De La Communaute
Bulletin Trimestriel
No. 1/72, Juillet 1972
No. 2/72, Octobre 1972

EURATOM
Levels of Radioactive Contamination of the Environment and the Food Chain - Annual Report 1971
EUR 4885 f

Ettinger, H.J., et al
Size Selective Sampling for Plutonium-238
Health Physics, 23, No. 1, July 1972

FRANCE
Rapport D'Activite
September, October and November 1972
SCPRI B.P. n°35, 78 LeVesinet

FRANCE
Annexe Au Rapport Mensuel
Detail des Resultats de Mesure
September, October and November, 1972

FRANCE
Surveillance De La Radioactivite De La Chaine Alimentaire
2eme Trimestre 1972

FRANCE
Surveillance De La Radioactivite De L'Atmosphere Et Des Eaux
2eme Trimestre 1972

Foot, R.S.
Mercury Vapor Concentration Inside Buildings
Science, 177, No. 4048, August 11, 1972

Gopalakrishnan, S. and C. Rangarajan
The Role of the Indian Monsoons in the Interhemispheric Transport of Radioactive Debris from Nuclear Tests
J. Geophys. Res., 77, No. 6, pp 1012-1016, Feb. 20, 1972

Gudiksen, P. H.
The Activity of W-181 as a Function of Time within a Nuclear Cratering Cloud
Health Physics, 23, No. 3, September 1972

Hales, J. M.
Fundamentals of the Theory of Gas Scavenging by Rain
Atmospheric Environment, 6, No. 9, September 1972

Harkness, D.D. and Walton, A.
Further Investigations of the Transfer of Bomb ^{14}C to Man
Nature, 240, No. 5379, December 1, 1972

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