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RG 189 National Academy of Sciences
Archives/Comms. on BEAR
Adm: ORG: NAS: Comms. on BEAR Effects of Strontium-90
Articles: Murayama N, 1960

A COMPARISON BETWEEN SPRING 1959 FALLOUT AND STRATOSPHERIC AIR CONTENT

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In a note by R. J. List in an earlier report (HASL 77, pages 39-43), it was noted that rainfall at Westwood, N. J. and Pittsburgh, Pennsylvania after about January 1959 contained Sr-90 which was highly dominated by debris which dated from the Soviet tests in October 1958. Taken literally, over 75% of the Sr-90 could be attributed to the date of October 18, 1958.

A similar and more extensive analysis is made of the fission products collected by Project Ash Can in the stratosphere since November 1958. In this case, several short lived isotopes were used to determine an apparent "age" and a fraction of October 18th Sr-90 (Soviet debris). These results are presented in Table 1. The ratios of radioactivity at formation and the half-lives of the radioisotopes were taken from (1) and are the same as were employed by List for the fallout calculations.

Table 1 shows that the origin of the bulk of the stratospheric Sr-90 after November 1958 is more likely Hardtack or earlier than the October 1958 Soviet test series. Further, it shows that (except for the Ce-144/Sr-90 results which will be discussed below), much less than 75% of the Sr-90 was attributable to October 1958.

We shall first discuss some of the possible sources of error in comparing the apparent age and fraction of Sr-90 from October 1958 in fallout and stratospheric samples. We will then describe a meteorological interpretation resulting from this difference.

The computation of apparent age from a pair of fission product radioisotopes is subject to several sources of potential error.

First, fractionation of the isotopes is known to take place. Thus, the assumed thermonuclear fission yield ratio for Cs-137/Sr-90 is usually exceeded by a significant factor in the stratospheric samples. This departure from the ratio might also be due to erroneous estimates of fission yield of either radioisotope or due to differing efficiency of collection by the fallout or stratospheric sampling procedures.

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6

It should be noted that irrespective of which of the three suggested explanations account for the higher Cs-137/Sr-90 ratio, the Sr-90 in the stratosphere is most likely depleted compared to the expected production. This means that a true sample of the radioactive debris (had the depletion not taken place) would contain a smaller ratio of short lived isotopes to Sr-90 giving an older apparent age and a smaller fraction of October 18th debris.

We have no knowledge concerning fractionation or other depletion effects for any of the shorter-lived isotopes. If there were fractionation or other depletion effects, the apparent age would be shortened and the fraction of October 18th debris increased. It should be noted that fractionation or depletion of an isotope within the first few days or weeks is irrelevant because it will affect both fallout and the stratospheric samples. The most likely source of error, if indeed there is an error, in the comparison of apparent age of fallout and stratospheric samples is due to the sampling devices themselves.

At the moment, it appears unlikely that the difference in apparent age or fraction of October 18th Sr-90 can be attributed to these kinds of artifacts.

The results of the Ce-144/Sr-90 ratios show an appreciably larger percentage of October 1958 Sr-90 than was found from the Sr-89 and Zr-95 radioisotopes. The determination of the percentage of debris assigned to a given date of origin implies that <u>all</u> of the short-lived radioisotopes originate at this time. When test series are widely spaced relative to the half life of the short-lived isotope, this assumption is reasonably correct. In each of the cases (using either Sr-89, Zr-95 or Ce-144) the fraction of October 1958 debris must be a maximum for this reason but in the case of Ce-144, with its 275-day half life, the maximum may greatly exceed the true value. The Panama percentage values indicate this feature since it is very unlikely that any U.S.S.R. Sr-90 (from October 1958) was actually present at Panama in November and December 1958.

The Ce-144/Sr-90 ratio results, in a few cases, in impossible apparent ages (formation later than sampling) and percentage contributions (>100%). If the radiochemical analysis is accepted as valid, the implication is again that Sr-90 is depleted relative to Ce-144 (as it may be relative to Cs-137). If the Sr-90 depletion is true for all samples, then the apparent time of formation, again, is earlier and the percentage of October 18th Sr-90 is smaller than shown in Table 1.

Another possible source of error in the treatment of the data may result from errors in the radiochemical analysis. A comparison of samples between laboratories reveals good agreement in all isotopes except Zr-95 according to Dr. J. Harley. However, the results derived from the Zr-95 are similar to those derived from Sr-89 suggesting random rather than systematic errors in the Zr-95. Further it should be noted that a systematic error in the analysis of Sr-89 or Sr-90 (the two isotopes common to both the U. S. fallout and stratospheric samples); will affect the apparent ages and percentages of October 18th Sr-90 in analogous fashions.

The sense of the difference in apparent age and fraction of October 18th long-lived fission products between fallout and stratospheric samples noted above was also reported in a recent U.N.S.C. meeting by the U. K. using aircraft over England up to about 50,000 feet. In this case gamma spectroscopy rather than radiochemical analysis was employed and tropospheric samples were also collected by aircraft.

The difference in age and proportions of October debris has an interesting implication in the likely location of exit of the Soviet October 1958 debris from the stratosphere.

First, it appears that the Sr-90 in fallout or in the troposphere in the first half of 1959 has a different proportion of Soviet October 1958 debris than appears in the stratosphere in the same latitudes as the fallout observations. Thus, debris is entering the troposphere from a reservoir other than directly over the 30-50°N latitude band. Since most of the Sr-90 found in fallout in the first half of 1959 originated in the Arctic and is not found in the temperate latitude stratosphere, it is unlikely that it has passed south of say, 50°N. Its probable exit from the stratosphere is, therefore, farther north than 50°N, or closer to its original latitude.

One reasonable interpretation of the fallout and stratospheric apparent age determination indicates that debris initially in the Arctic leaves the stratosphere in Arctic latitudes. Since we have only looked at this comparison in the first half of 1959, the location of exit cannot be generalized to

8

other parts of the year or to debris initially located outside the Arctic.

Reference

(1) Holland, J. Z. (ed), T.I.D. #5555, May 1959, p. B-15.

9

TABLE 1

Sioux City, Iowa
(42° 24' N 96° 23' W)

Date Of Observation	Altitude x 10^3 (ft.)	Apparent Date of Origin $\frac{Sr\text{-}89}{Sr\text{-}90}$	Apparent Date of Origin $\frac{Zr\text{-}95}{Sr\text{-}90}$	Apparent Date of Origin $\frac{Ce\text{-}144}{Sr\text{-}90}$	% Contributions 18 October 1958 $\frac{Sr\text{-}89}{Sr\text{-}90}$	% Contributions 18 October 1958 $\frac{Zr\text{-}95}{Sr\text{-}90}$	% Contributions 18 October 1958 $\frac{Ce\text{-}144}{Sr\text{-}90}$
27 Dec. 58	49.3	2 Sep. 58	5 Jun. 58	10 Jul. 58	54	24	78
31 Dec.	81.8	9 Jul. 58	15 May 58	6 Dec. 57	26	20	47
28 Feb. 59	48.5	4 Aug. 58	4 May 58	15 Dec. 57	38	14	48
1 Mar.	91	5 Aug. 58	25 Apr. 58	10 May 58	38	16	67
30 Mar.	65.8	29 Apr. 58	25 Mar. 58	---	9	11	--
1 Apr.	48.5	30 Jul. 58	---	21 Apr. 58	34	--	65
9 Apr.	65.3	3 Jul. 58	14 May 58	14 May 58	24	19	68
13 Apr.	90.5	22 Jul. 58	28 Apr. 58	10 Sep. 58	31	16	92
21 Apr.	80.8	17 Mar. 58	7 Dec. 57	30 Jul. 57	5	4	34
11 May	48.9	20 Feb. 58	22 Mar. 58	17 Mar. 58	4	10	60
15 May	91.5	30 Apr. 58	20 Apr. 58	14 Jul. 58	9	14	79
24 May	65.5	24 Apr. 58	28 Feb. 58	22 Aug. 57	9	8	36
25 Jul.	87.8--90	15 Mar. 58	13 Apr. 58	27 Jun. 58	5	13	76
6 Jul.	79.8	9 Jan. 58	13 Feb. 58	15 Nov. 57	2	7	44
9 Jul.	80.5	5 Jan. 58	15 Jan. 58	6 Oct. 57	2	5	41
11 Jul.	65.3	28 Mar. 58	28 Dec. 57	20 Aug. 57	6	12	36
3 Aug.	49.5	25 Apr. 58	30 Apr. 58	6 Nov. 57	10	16	44
7 Aug.	90:5	4 Apr. 58	24 Apr. 58	29 May 58	2	15	72
8 Aug.	65.3	26 Mar. 58	30 Jan. 58	27 Sep. 57	6	6	39
9 Aug.	80	oo	17 Dec. 57	17 Oct. 57	0	4	41
2 Sep.	49.3	4 Aug. 58	9 Feb. 58	1 Dec. 57	38	7	46
3 Sep.	89.3	15 Jul. 58	---	28 Oct. 58	27	--	(103)
4 Sep.	64.5	---	27 Jan. 58	8 Aug. 57	--	6	35
10 Sep.	78.5	---	---	27 Apr. 58	--	--	67

NAS

10

San Angelo, Texas (cont.)
(31° 21' N 100° 30' W)

Date Of Observation	Altitude x 10^3 (ft.)	Apparent Date Of Origin Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90	% Contributions 18 October 1958 Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90
7 Aug.	50.4	17 Aug. 58	---	31 Oct. 57	43	--	43
4 Sep.	65	---	1 Jul. 58	4 Oct. 57	--	29	40
5 Oct.	91.5	---	---	14 Oct. 57	--	--	44
6 Oct.	80	---	---	20 Mar. 58	--	--	60

NAS

San Angelo, Texas
(31° 21' N 100° 30'W)

Date Of Observation	Altitude x 10^3 (ft.)	Apparent Date Of Origin Sr-89/Sr-90	Apparent Date Of Origin Zr-95/Sr-90	Apparent Date Of Origin Ce-144/Sr-90	% Contributions 18 October 1958 Sr-89/Sr-90	% Contributions 18 October 1958 Zr-95/Sr-90	% Contributions 18 October 1958 Ce-144/Sr-90
1 Nov. 58	88.3	>12 Jan. 58	30 Nov. 57	27 Oct. 56	.2	3	18
1 Dec.	88.5	15 Apr. 58	19 Jun. 58	*	8	27	(225)
5 Dec.	63.5	4 Jun. 58	26 Jan. 58	9 Jan. 58	16	6	50
11 Dec.	80.0	5 Apr. 58	9 Sep. 58	*	7	73	(246)
15 Feb.	50.5	9 Aug. 58	11 Apr. 58	21 Jan. 58	39	14	52
16 Feb.	65.8	16 Jun. 58	15 Dec. 57	7 May 57	21	4	28
3 Mar.	47.2	10 Aug. 58	24 Apr. 58	8 Dec. 57	<40	16	46
7 Mar.	81.2	>15 Feb. 58	7 Feb. 58	14 Aug. 57	< 4	7	35
9 Mar.	80.7	18 Apr. 58	26 Feb. 58	12 Feb. 58	8	8	53
12 Mar.	64.2	5 Jul. 58	21 May 58	26 Jan. 58	25	18	52
17 Mar.	82.0	1 May 58	6 May 58	24 Aug. 58	10	18	87
2 Apr.	80.1	12 Apr. 58	12 Apr. 58	2 Apr. 58	10	13	63
4 Apr.	65	23 Jul. 58	14 May 58	6 Apr. 58	26	19	53
6 Apr.	90	30 Jun. 58	10 Jul. 58	*	23	36	(402)
13 Apr.	65.2	24 Jun. 58	2 Feb. 58	2 Feb. 57	20	6	23
14 Apr.	50.4	13 Jun. 58	20 Mar. 58	2 Aug. 57	18	10	34
6 May	65.5	6 May 58	21 Jan. 58	26 Apr. 57	11	6	27
7 May	80.1	21 Feb. 58	13 Dec. 57	26 Jun. 57	4	4	31
17 Jun.	66	7 Jul. 58	14 Mar. 58	15 Sep. 58	17	10	93
1 Jul.	90	27 Jan. 58	16 Feb. 58	26 Feb. 58	3	9	56
2 Jul.	50.6	oo	2 Jul. 58	11 Aug. 57	0	29	35
7 Jul.	80.1	29 Mar. 58	24 Dec. 57	6 Aug. 57	6	4	35
8 Jul.	65.6	6 Jul. 58	4 May 58	29 Apr. 58	20	16	66
1 Aug.	91.7	8 Jan. 58	9 Mar. 58	19 Dec. 57	2	9	48
2 Aug.	80.7	oo	9 Jan. 58	1 Sep. 57	0	5	37
3 Aug.	65.7	4 Jun. 58	9 Feb. 58	2 Sep. 57	16	7	38

12

Lowry, Colorado
(39° 46' N 104° 53' W)

Date Of Observation	Altitude x 10^3 (ft.)	Apparent Date Of Origin Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90	% Contributions 18 October 1958 Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90
10 Apr. 59	92	14 Jun. 58	26 Mar. 58	15 Jan. 58	15	10	52
3 Jun.	94	29 May 58	28 Feb. 58	29 May 58	13	8	70
3 Jun.	94	3 Jun. 58	14 May 58	18 Jul. 58	15	10	80
4 Jun.	93.5	30 May 58	10 May 58	3 Aug. 58	13	17	83
4 Jun.	93.5	30 May 58	10 May 58	20 May 58	14	16	69
11 Jun.	96.2_5	6 Jun. 58	28 Mar. 58	22 May 58	15	11	69
11 Jun.	96.2_5	12 May 58	28 Mar. 58	16 Jun. 58	11	10	74

Panama, Canal Zone
(08° N 58' N 79° 33' W)

Date Of Observation	Altitude x 10^3 (ft.)	Apparent Date Of Origin Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90	% Contributions 18 October 1958 Sr-89/Sr-90	Zr-95/Sr-90	Ce-144/Sr-90
7 Nov. 58	65.2	30 Jul. 58	5 Mar. 58	18 Oct. 57	32	10	41
16 Nov. 58	89.0	31 Dec. 57	14 Oct. 57	20 May 57	2	2	29
19 Nov. 58	81.8	8 May 58	29 Dec. 57	14 Mar. 58	11	5	59
2 Dec. 58	65:8	15 Aug. 58	17 Jun. 58	23 Oct. 58	44	26	(101)
12 Dec. 58	92.6	22 Dec. 57	7 Mar. 58	3 Sep. 57	2	10	37

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NOTES:

---, --; no observation.
oo ; the isotope amount of numerator = 0.
( ) ; percentage values greater than 100%.
* ; date later than sampling time.

13