February 28, 1955

Report by the Measurement Lab of the USSR Academy of Science, 'On the Properties of the Atomic Bombs Detonated on the Marshal Islands in 1954'

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Summary:

Soviet scientific intelligence report on U.S. nuclear weapons testing on the Marshall Islands in 1954. This report concludes that the Ivy Mike and Castle nuclear detonations were thermonuclear based on gamma ray spectroscopy of fission fragments collected by Soviet aircraft over the USSR and PRC.

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Order of Lenin
The Laboratory of Measurement Tools, AS USSR [Lab No. 2]

Affirmed by,
Director of the Laboratory of Measurement Tools AS USSR
Member of the Academy-I.V. Kurchatov
28 February 1955

"On the Properties of the Atomic Bombs Detonated on the Marshall Islands in 1954"
Director of Sector No. 3 - I.V. Kurchatov.
Senior Scientific Associate- S.A. Baranov
Junior Scientific Associates - A.G. Zelenkov, R.I. Polevoi, L.V. Chistiakov

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A Report by the Measurement Lab of the USSR Academy of Science

"On the Properties of the Atomic Bombs Detonated
on the Marshall Islands in 1954"

Affirmed by, 28 April 1955
Director of Measurement Laboratory AS USSR, Top Secret
Member of the Academy- I. V. Kurchatov (Special File)

Abstract
In this report we present the results of the first systematic study of the American atomic bombs [tested in the Marshall Islands]. The study is based on a radiochemical analysis of samples of fission fragments collected from the atmosphere.
A detailed presentation of the experimental material is given in a separate report.

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The Goal of the Study

During the period March-June 1954, a comprehensive study of radioactive dust that was collected from the atmosphere took place in the USSR for the first time. The study was complemented by a radiochemical analysis of the materials that were collected.

This study was conducted with the goal of obtaining information about the properties of the atomic bombs tested by the United States on the Marshall Islands in 1954, as well as with the additional goal of evaluating the level of atmospheric contamination at the moment of the radioactive cloud's passing over the territory of the USSR.

A full isotopic and radiochemical analysis of the fission fragments enable us to obtain answers to the following questions: What type of bomb was tested, and was that bomb thermonuclear?

. What is the proportion of the thermonuclear yield compared to the fission yield?

. What heavy fissile isotopes were used in the bomb?

. What light elements were used?

A large quantity of radioactive material was collected for the purposes of this study.

Evaluation of Expected Activities

The work of collecting radioactive dust was based on preliminary reports, which in turn were based on Davidenko's evaluations (1), and on the first experimental results, obtained by Ushatski, Kirin and others (2), that address the issue of the capturing and the analysis of fission fragments released to the atmosphere in the aftermath of the American atomic test in the Marshall Islands on 1 November 1952 [Ivy Mike]. Based on the yield of the bomb at 17 million tons of TNT, as well as the assumption that most of the energy release resulted from the fission of heavy atoms, V.A Davidenko calculated the average concentration of expected radioactivity in the atmosphere at 10-9 Ci/L. This figure does not take into account the erosion of the radioactive material from the cloud, and that the volume of the clouds was specified rather arbitrarily at 0.001 of earth atmosphere. Therefore the cited figure 10-9 Ci/L may be slightly exaggerated.

The second of the said studies enables us to obtain the concentration of activities from the experimental data. In this case, radioactivity was measured to be about 0.5 micro-curies, corresponding to a concentration 5x10-16 Ci/m3 at the time of sampling.

This last figure should be corrected and increased, given that from the moment of the bomb's detonation 1 November 1952 to the moment of the capturing of the aerosols over the USSR (March 1953), a period of three and a half months had passed. That led to a decline in volume and to the scattering of the clouds throughout the entire atmosphere.

Introducing corrections to scattering and volume calculations may increase the concentration to 5×10-12 ten days after the explosion.

This last figure was used at the time of the program's initiation.

In order to produce a thorough isotopic analysis of the fissile materials, it is necessary to collect radioactive materials at levels of about 50 μCi. For a radiochemical analysis, which would enable us to identify the type of the e, a smaller number of [unclear] micro curie would suffice.

On the Sampling of Radioactive Materials

At the expected concentration 5×10-12 curieliter, activity at 10 μCi could have been collected with special filters that were installed on airplanes which travelled hundreds of kilometers inside a radioactive cloud.

At the time of the detonation of the atomic bomb, the radioactive cloud, which is

composed of radioactive particulate, is ejected into the upper atmosphere. At altitudes higher than 5000 meters, the cloud may be caught up in a permanent wind zone, moving predominantly from the west to the east at speeds of 50-150 km/h.

Under these circumstances, the radioactive cloud might, as it moves from west to east, circle the earth and appear first over the west of Europe, and then over the territory of the USSR as well. That is why flights over the USSR were conducted in the meridian direction (across the assumed direction of the radioactive cloud) from 60°N to 46°N. The airplanes were flying mostly over the route Poltava-Leningrad-Odessa-Poltava, at an altitude of between three to eight thousand meters. In order to collect the particles from the atmosphere, the airplanes were equipped with cone shaped Petryanov filters [P.F] which can capture 100% of the aerosols. The filters, placed in the in the nacelles of the TSAGI, which were strengthened underneath the plane. The evaluation of the activity which accumulated on the filters was made after each flight with the help of portable type PR-6 radiometers. The radiometers were pre-calibrated under controlled laboratory conditions.

When radioactive materials accumulated, the filters were dismantled and sent to the Laboratory of Measurement Tools at AS USSR for radiochemical analysis.

The first flights over the territory of the USSR did not detect increased radioactivity levels in the air up to 20 March 1954, although already on 10 March 1954 one could anticipate the appearance of a radioactive cloud over the territory of the USSR, resulting from the blast on 28 February 1954 [Castle Bravo]. Apparently the cloud passed over the southern part of the USSR.

Since the Marshall Islands are located at 10°N, it was essential to examine the radioactive air as close as to the equator as possible. With this goal in mind, flights were organized on the route Beijing-Canton-Beijing. This enabled us to control the "belt," running from 40°N to 23°N. Flights to the USSR continued as well, that is, control [samples] were taken from a significant part of the atmosphere of the earth's northern hemisphere.

The outcomes of our work demonstrate that sending the expedition to the PRC was a very appropriate decision. Conditions suitable for the identification of clouds and for the gathering of radioactive samples were much more favorable in the PRC than in the USSR, allowing for the collection of a much larger amount of radioactive material. The radioactive materials collected by the expedition enabled us to identify two explosions which would have been impossible to study if the materials were gathered over the territory of the USSR.

During the expedition's work, it was also discovered that layers of used oil covering the engine's nacelle contained significant radioactive activity, comparable to the radioactivity on the Petryanov filters. That is why the fuselage and wings of the airplane, which was on its way to its next trip, was covered by special glue which could be washed off and studied for radioactivity after each trip.

The varying levels of radioactivity in particles that were washed off after each trip enabled us to monitor the changes in the concentration of radioactive aerosols in the atmosphere over the Beijing-Canton routes, although we had to take into account the long duration of the flights.

The measurement of the rate of decay of the samples, obtained during the wash-out process, enabled [the team] to [identify the date of the explosion] and thereby to calculate the time it took the cloud to reach PRC. This time is 10-15 days. It was also possible, based on the expedition's data, to calculate the approximate area of the cloud at the moment of its passing over the PRC. It is 1/30 the area of the globe.

General activity, as collected by the filters, turned out to be small (approximately 1 μCi). The concentration of radioactivity in the cloud was estimated to be about 10-15 Ci/L over the USSR and 10-14 Ci/L over the PRC. Therefore, the concentration of fission products in the atmosphere turned out to be lower by two orders of magnitude than expected, a fact that significantly complicated the work.

Activities collected over the territory of the USSR during one flight (of about 4000 kilometers) were well within our radiometers' range of measurement. Also, they were mixed with activities produced during the [background] decay of radon, and with radioactive particulate from previous explosions. For the purpose of the sampling of

the materials necessary for a radiochemical analysis, it was necessary to conduct several flights, a fact that on several occasions led to the sampling by the same filter of activities from two separate explosions. On average, a plane concluded a flight of about 10-12 thousand kilometers, after which the filters were sent for analysis.

Ultimately, the collected activity levels were within the range of a radiochemical analysis of several important [chemical] elements.

As we can see, sampling conditions were significantly more adverse than anticipated, a fact that necessitated the continuation of flights. In total, the flights covered 3.9×105 km.

□□□e Results of the Radiochemical Analysis

□□

The identification of the bomb type used in the [Marshall Island] test is based on the following information. It is known that the higher the energy of fission-inducing neutrons, the smaller the minimum [point] of the two-peak product yield curve.

We have data at our disposal on the relative yields of some fission products (Ag111, Cd115). The yield is located at the minimum of the [graph describing] the fission of U235 and U238 by 14 MeV neutrons and other fission spectra neutrons. During the fission of U235 by fission spectrum neutrons, the ratio of the product yields situated at the minimum [point of the curve] to the yield of Ba140, corresponding with the maximum point of the curve, is about 0.01, whereas during fission by 14 MeV neutrons this ratio increases to 0.17.

In an ordinary explosion, the relative yields of the fission products will correspond to the yields induced by fission spectra neutrons. In a thermonuclear explosion, due to the additional input of 14 MeV neutrons, the mentioned yields ratio will be in-between the mentioned above ratios, and it may be used for the purpose of the calculation of the proportion of fission induced by neutrons that were produced in a thermonuclear reaction.

Out of the elements lying at or near the minimum of the [fission] fragments curve, Ag111, Cd115, Cd115m, Sb125, Sn125, Sn123 may be used.

Due to the ease with which they could be identified, and the absence of long lasting radioactivity, silver and cadmium are suitable for the purposes of our study. Antimony [Sb] and tin [Sn] were not used because of the difficulties associated with their chemical isolation and purification, as well as due to their presence as long-lived isotopes, the yield of which was distorted in the context of previous explosions.

Another indication that the blast resulted from a fusion process is the reaction of [unclear], the flux of which is enabled by energy measured to be at least 8 MeV. Since the primary simple component of the atomic bomb is U238, the [unclear] of the mentioned reaction of U237 can identify the type of the bomb. Thus, when our own hydrogen bomb was tested on 12 August 1953 [Joe 4] the yield ratio U237/Ba140 equaled 4.6, whereas when a regular atomic bomb was detonated (14 September 1954) the ratio was 0.16. Due to its high relative yield, U237 is a good indicator for the existence of a thermonuclear reaction, despite its short half-life (6-7 days).

A radiochemical analysis can also give us information about the composition of the fissile material. It is known that an increase in the mass of fissile material can lead to a decrease in the light particles' maximum point on the yield curve.

As a result of this offsetting, fragment yields on the left hand slope of the previously mentioned maximum point of Pu239 in relation to U235 decreases (for example, the relative yield of Sr89 decreases from 0.67 to 0.33), while the yield of products on the right-hand slope increases (In particular the yield of Ru103 with slow neutrons increases).

Such differences may be identified during the analysis. In this way, by analyzing the fission fragments Ru and Sr, one may be certain to receive results in which Pu239 or U235, U238 predominate the fissile material. Precise data can be obtained only through direct analysis. Of the possible four components (U233, U235, U238, and Pu239) identifying Pu239 would be the easiest, in light of its relatively short half-life. In order to identify Pu239 collecting fragments at the order of 10 μCi would suffice. Uranium isotopes, for the purpose of their identification by the energy of alpha particles, require a radioactivity 1,000 times larger.

An important property of the hydrogen bomb is its light element content-deuterium, lithium, and tritium. The detection of Li6 is possible with radiochemical methods, due to the formation of Be7 as a result of the reaction. Thus, the identification of Be7 was essential to the task of this study. In order to classify the bomb, it is essential to determine its radiochemical composition as comprehensively as possible. This allows us to control the results of the identification of the amount of fissile material that underwent fission based on [unclear], and also to present conclusions which are based on various indicators of the type of the explosion. Such control is important in light of the fact that the long distance (approximately 30,000 kilometers) could have changed the ratios of the fragments of the explosion ("separation"). Such possibility may arise in the context of an accumulation of fission fragments on the dust that is constantly extracted from the cloud.

During our work it was necessary to reach a compromise between the need to identify a maximum number of elements, and the necessity of conducting the analysis [unclear] of the values of the filters (around 30).

The analysis of the filters was made with the following radioactive isotopes: Ba140, Sr89, Sr90, Ag111, Cd115m, Zr95, Ce141, Y91, the sum of the remaining rare earth elements-U237, Be7. Ru103 and Ru106 were analyzed separately. These isotopes comprise approximately 90% of the beta radiation of nonvolatile fission fragments, 0.5-2 months after the explosion. In the 18 analyses that were made, the levels of radiation isolated during the analysis of the elements were compared to the level of general radiation in the sample. It turned out that the isolated radiation made up on average 86% of the total radiation in the sample. This value is crude [because] of the variations in the impact of the Beta radiation's self-absorption at the time of measurement. The obtained result shows that during the first approximation, activity in the filter appeared due to primary fission fragments. Secondary radioactive fragments, whose activity can be attributed to the absorption of neutrons by earth matter, do not play a significant role.

The radiation analyzed turned out to be not high, 0.05-05 μCi, that is, 106-107 times smaller than the radiation collected by the filters over ground. The low radiation levels of some isotopes necessitated the use of a single sample for the purpose of separating them. Due to the fact that the possibility of repeated analysis was limited because of the quantity of material that was available, as well as of the decay of elements with low half-life (Ag111, U237) the analysis was performed with maximum care.

In order to convert the results from radioactivity levels to numbers of radioactive atoms, additional work was undertaken in order to measure the counting efficiency of several isotopes (U237, Ce 141, Ce144, Zr95, Sr89, Y90, Ru103, Ru106), and in order to identify Ce141, Ce144, as well as Ru103 and Ru106 in a mixture of both isotopes. Details concerning calculation methods and the chemical analysis are given in the [Lab No.2] AS report no. 3 for the year 1955.

During the analysis, it was crucial to identify U237, Ag111, Cd115, and Be7, since they serve as indicators of a thermonuclear reaction. However, due to the low yield of Be7, and the relative short half-lives of the other three indicators, their radioactivity levels may be lowered given the long period (about 20 days) that passed from the time of the explosion to the time of the analysis. Therefore, we will briefly review the identification results only for these isotopes, since the other fragments, because they have sufficient radioactivity, do not cause difficulties during the identification process.

Uranium-237: The radioactivity of U237, measured by a type T-20 geiger counter, in optimal scenarios (fission fragments from the 4 May 1954 [Yankee 2] explosion) was 890 and 2960 CPM at counting efficiency 0.11. For the other two explosions, it had a value of 100-500 CPM. That allowed us to follow the decay curve for 14-40 days. In this case, the half-life turned out to be 6.5 to 7.1 days, which is in agreement with the values presented in the table (6.75)

Immediately after the isolation, the curve for the absorption of beta radiation into aluminum was [calculated], yielding an absorption coefficient of 6.2-8.6 CPM, approximately the same figure that is cited in the literature.

Silver-111. This isotope was found to have radioactivity ranging from 11 to 200 CPM

and was identified on the basis of the decay curve over a period of 7-30 days. The half-life ranged from 6 to 8 days, sufficiently close to the figure given in the table-7.5 days.

Cadmium-115. In light of the fact that the analysis was conducted after some time had passed, the isotope Cd115, which has a half-life of 2.3 days, was not detected in any of the filters. The isomer Cd115m was repeatedly identified. Only in one case (involving a filter travelling 43,000 km), radiation levels turned out to be sufficient (34 CPM) for the calculation of half-life, which came out to be 45 days. This value is in agreement with the number shown in the table. In all of the other cases radiation levels were between 4 to 12 CPM. [Unclear] the low value did not permit us to calculate the half-life. In all cases where cadmium was analyzed, the rate of decay in activity over time did not contradict the given identifications.

It should be noted that despite the very low levels of radiation, the relative yields of Cd115m measured by our filters, [unclear] with scattering that did not exceed 30%. This serves as further evidence for the purity of the separation and the validity of the identification.

Beryllium-7: 35 analyses of Be7 samples were conducted. The measurement of Beryllium-7 was undertaken by V.K Voitovetzki and Iu.P Liubaviny, who used a gamma ray spectrometer. Special measures were taken in order to limit interference. It was brought up to 4 CPM, which corresponded to the lower [unclear] of the sensitivity of the installation of 4×107 Be7 atoms. All Be7 samples were identified on the basis of the gamma ray spectrum.

It was observed that background filters, collecting radioactive materials before the appearance of the radioactive cloud over the territory of the USSR, will contain a significant amount of Be7. At the rate of 1m2 and 10,000 km, it made up [unclear] from 4.5×109 to 1.7×1010 atoms. Inside the filters that were collecting fragmentary activity, quantities of atoms were between 1.2×109 to 1.9×1010 atoms. Be7 content in both cases turned out to be of an equal order of magnitude.

The relationship between the amount of Be7 and the number of atoms of one of the fragmentary elements (Sr89) drastically changed as we switched from one filter to another.

All of these facts point to the identified radioactivity level of Be7 must be related to the testing of an atomic weapon.

Ia. A. Smorodinski proposed a hypothesis according to which Be7 appears in the atmosphere after the splitting of nitrogen and oxygen atoms by cosmic rays. The amount of Be7 was valued in relation to [unclear], from which we had reliable experimental data. It was assumed, moreover, that Beryllium-7, similarly to tritium, is washed out from the atmosphere by rain, creating a strong link between its maintenance inside the atmosphere and meteorological conditions.

Ia. A. Smorodinski found that the quantity of Beryllium-7 formed as a result of a nuclear reaction induced by cosmic rays-105 atoms Be7/m3-is in agreement with our experimental data. Therefore, the amount of Be7 formed as a result of atomic explosions could not have been identified on the basis of the element's content in our filters, due to its mixing with Be7 originating in outer space.

The measurement of Be7 content in the dust samples washed out from the airplanes gave us great results. Despite of its radioactive content, no Beryllium-7 was detected in any of the samples. In this way, the radiochemical analysis of ground and dust samples enabled us to obtain the extremely important ratio between [unclear] of Be7 atoms and Ba140 isotopes (the results are presented in the table below).

Relative Yields Table □□□

□□□□

Isotope

28 Feb 1954

[Castle Bravo]

26 Mar 1954

[Castle Romeo]

4 May 1954
[Castle Yankee 2]
12 Aug 1953
[RDS-6s]
U238 on the
fission spectrum □□□
 □□□□
1
2
3
4
5
6 □□□
 □□□□
Ba140
1
1
1
1
1 □□□
 □□□□
Sr89
0.58±0.06
0.59
0.7±0.05
0.73
0.47 □□□
 □□□□
Y91
0.7
0.92±0.03
0.72±0.08
0.7
- □□□
 □□□□
Zr95
0.37±0.08
1.0±0.1
1.15±0.2
0.7
0.82 □□□
 □□□□
Cd115m
(2±0.4)×10-3
~2×10-3
≥3×10-3
4.2×10-3
4.4×10-4 □□□
 □□□□

Ag111
0.073±0.01
0.045
0.044±0.004
0.06
0.011 □□□
□□□□
U237
0.9±0.2
1.65
1.9±0.2
4.6
- □□□
□□□□
Ce141
0.76±0.15
0.88±0.04
0.74±0.1
-
- □□□
□□□□
Ce144
0.5xx
1.4±0.1x
0.8±0.1
0.7
0.85 □□□
□□□□
Ru103
1.15
1.0
1.1
-
1.1 □□□
□□□□
Ru106
1.75xx)
0.93x)
0.6
1.18
0.5 □□□
□□□□
Be7
<1.5xx)
<0.4xxx)
<0.3xxx)
0.01
- □□ □□

x) Result is increased by background radiation

xx) Result obtained from an analysis of surface dust samples

xxx) Result obtained during the analysis of the wash-off.

The results of the analysis of the three explosions' fission fragments, captured in a relatively pure state, are presented in this table.

The table presents average values of the relative yields of the isotopes specified therein (Ba140 is given as 1). For comparison purposes, the table presents the yields of the same isotopes in the aftermath of the explosion from 12 August 1953 [RDS-6s] as well as the yields of the fragments after the fission of U238 by neutron spectra neutrons.

The mean values obtained from 3-4 analyses are associated with different filters. These results take into account mean errors. For the other cases, measurement errors are evaluated at 15% (with the exception of Cd115, where the error is likely to be of the magnitude of 50%).

The table shows that in terms of fragment composition, all three explosions studied are quite similar up to the explosion of the hydrogen bomb in 12 August 1953. Based on the content of U237, we concluded that they were clearly thermonuclear. Note the considerably smaller yield of U237 in all three explosions compared to the yield of U237 from the 12 August 1953 test. The yields of U237 in the first explosion were especially low, and the explosion from 28 February 1954 was more powerful. The differences may be attributed either to a lower U238 content in the bomb or to a lower flux of 14 MeV neutrons.

The conclusion concerning the thermonuclear nature of the three studied explosions can be also validated by the detection of the high yields of Ag111 and Cd115 compared to their yields during the fission of U238, as shown on the fission spectra.

A quantitative assessment of the duration of the fission process based on the examination of the neutrons of the thermonuclear reaction cannot be taken because of the [unreliability] of the data on the yields of Cd115m. Data on the yields of Ag111 are considerably more reliable. However, Ag111 is not a sufficiently strong indicator of a thermonuclear reaction, given the fact that its yield is heavily depended on the composition of [unclear] elements. Based on data from the [V.G Khlopin] Radium Institute, the relative yield of Ag111 after the fission of Pu239 by fission spectra neutrons was 0.09, while during the fission of U238 that quantity was 0.01.

Based on the analysis of the filters containing Ag111, it can be concluded that for the bomb [type] which does not contain plutonium, the duration of the fission induced by thermonuclear reaction neutrons during the explosions from 3.26 and 5.4 was somewhat lower than in the test from 12 August 1953 [RDS-6s], and was closer to the explosion from 28 February 1954 [Castle Bravo].

The results concerning the Cd115m from the 28 February 1954 explosion show that for this explosion, the share of fission due to 14 MeV neutrons was several times smaller than it was in the 12 August 1953 experiment.

When plutonium can be found inside the mass of fissile material, such an estimate of 14 MeV neutrons inducing fission would be exaggerated. Therefore, it is important for us to use this analysis to obtain new data on this question. An answer can be found with the help of Sr89, Ru103, and Ru106, as well as with a direct filter based analysis of plutonium. The last option, [unclear] can be ruled out due to the presence of plutonium in the air, left from previous explosions. The yields of Ru103 were distorted as a result of the presence of Ru 103 left in the atmosphere after the 12 August 1953 explosion [RDS-6s]. The result of the analysis allows us to conclude that Sr89 was absent from the composition of all of the three bombs' fissile elements.

The yields of Ru103 provides sufficient basis to assume an increased presence of heavy fissile elements (Pu239, U238) in the American bombs, although a definite conclusion is impossible at this time, given the absence of Ru103 at the time of the fission of various atoms by fast neutrons.

During the flights over the territory of the USSR, conducted in April, May and June 1954, the filters collected a range of samples, which, in the aftermath of an analysis, turned out to contain a mixture of fragments from two different explosions. Decay

analysis from the two explosions enabled us to evaluate the yields of U237 for the 26 April 1954 explosion [Castle Union] and the 13 May 1954 explosion [Castle Nectar]. These evaluations showed that these two explosions were associated with the same type of a thermonuclear bomb that was used in the previous three explosions.

Atmospheric Contamination by Fission Fragments

During a radiochemical analysis of the filters conducted in the first half of 1954, significant quantities of long-living isotopes were detected. These isotopes formed as a result of the fission of Ce144 (T=280 days) and Sr90 (T=20 years), and comparatively small quantities of Sr89 (T=53 years) and Y91 (T=61 days). Isotopes with shorter half-lives, Ce141 (T=33 days) and Ba140 (T=12.8 days), were not detected. The ratios of the quantities of isotopes in the samples indicated that most of the share of Sr89, Y91, and Ce144 is related to the 12 August 1953 explosion, while most of the Sr90 should be attributed to earlier explosions.

The presence of background radioactivity in the atmosphere, a result of [previous] atomic explosions, could be seen in evaluations of general radioactive decay made by [unclear] filters. 2.3 months after the explosion the samples' radioactivity began decreasing at a slower rate than could be expected for fission fragments, whose "fission law" is well known. During the filters' radiochemical analysis, background radiation was expressed in the significantly higher yields of the long-lived isotopes Sr90, Ce144 and Ru106 (T=1 year), in relation to the yield of Ba140.

The data obtained during the radiochemical analysis of the samples from the filters, which take on great significance because of the yields of the listed above long-lived isotopes, enabled us to evaluate the background radioactivity of Ce144 and Sr90.

It was shown that the numerical ratio between the isotopes Sr90 and Ce144 equals 3, and that the ratio did not vary from filter to filter. Based on the results of 17 experiments, the mean values of the number of atoms of background Ce144 and Sr90, collected on a 1 m2 filter over 10 thousand kilometers of flight [are] 2.4×109 Ce144 atoms and 8×109 Sr90 atoms. In some samples, the results diverge from these means by 2 or 3 times. Background Ru106, specified after a single analysis, turn out to be close to the background Ce144. We could not conclude that detected background radioactivity levels depended on location or the time of sampling.

The question of the comparison of the obtained data about atmospheric contamination with the number of total fragments released to the atmosphere as a result of nuclear weapons testing in the last ten years should be of particular interest. A suitable element to use for such a comparison would be Sr90 (T=20 years). Sr90 content, if we allow for a complete blending of all three explosions' fission fragments in the atmosphere, corresponds with fission of 15 kilograms of uranium. We roughly estimate that over the last few years, 100 kilograms of fission fragments were released to the atmosphere as a result of atomic explosions. We can see that the number we obtained (15 kg of fission fragments) is very large, and attest to the extremely slow rate of the removal of fragments from the atmosphere.

This important conclusion is based on the collection of radioactive materials over a rather short period of time (March-May 1954). In order to confirm this conclusion, it is necessary to receive experimental materials that focus on fission fragments that have long half-lives.

Conclusions

The collections of radioactive dust over the territories of the USSR and the PRC during the period of the testing of an atomic weapon in the Marshall Islands in the year 1954, enabled us to capture the fragments of three explosions and to preform radiochemical analysis on them.

As a result of the analysis, it is possible to conclude that the explosions from 28 February, 27 March, and 4 May1954 [Castle Bravo, Romeo, and Yankee 2] were thermonuclear. This conclusion is based on the high content of U237 in the fragments of the explosions.

Based on the composition of the fragments, we conclude that all three explosions were similar to the explosion from 12 August 1953 [RDS-6s].

One significant difference between the explosions was the lower U237 content in the fragments of the explosions, especially when compared to the more powerful explosion from 28 February 1954 [Castle Bravo].

In the three studied thermonuclear explosions, the share of fission that could be attributed to thermonuclear reactions was similar to that share in the 12 August 1953 [RDS-6s] explosion (or slightly lower). This conclusion was based on the analysis of the yields of Ag111 and Cd115m.

All of our conclusions on the properties of the American atomic bombs are made under the assumption that the fragments of the explosions would not undergo separation in the time which passed between the explosions and the sampling. An assessment of a range of fragments, Ba140, Sr89,Y91,Ce141,Ru103, that was made in relation to all three explosions correspond rather well to the fission yields curve. Thus [unclear] assumption was confirmed after the first approximation.

The results on Zr95 indicate that for this separation element [unclear] during the late periods of the sampling.

The behavior of such indicators as U237, Ag111, and Cd115m, in relation to the separation remains unknown. The study of this issue is of primary importance.

The development of fast and reliable chemical methods for separation of radioactive tin and antimony from fission fragments, which would serve as complementary indicators of a thermonuclear reaction, is also very important.

Detected levels of Ag111 and Cd115m were not high enough to satisfy the quantitative requirements for a thermonuclear reaction.

It was noted that the Petryovna filters are not appropriate sampling devices for Be7 particles, since they capture large quantities of Be7 that appeared in the atmosphere not as a result of a thermonuclear explosion, but because of cosmic-ray activity.

An analysis of atmospheric radioactive dust, as well as an analysis of dust collected from the planes' bodies, showed an absence of Be7 in the [unclear] activity and enabled us to set an upper limit for Be7 content in the fragments of the explosion.

Thus we find a way to get closer to accomplishing the difficult task of isolating weapons-related Be7 in an environment of significantly large quantities of Be7 that are permanently present in the atmosphere. Given that Be7 is an important indicator of the presence of Li6 in the bomb, further work on the development of methods that could be used in its detection is needed.

Specifically, it is important to develop a radioactive dust sampling device. The device should be attached to a plane, work without air filtration, and be protected from ground-based dust.

The infiltration of such dust into our samples precludes the possibility of conducting large scale analyses.

It is necessary to develop special detectors of radioactive clouds for airplanes. This would enable them to collect the necessary materials more efficiently, and will reduce the share of background [fission] fragments that could be attributed to older explosions in the samples.

The filters' radiochemical analysis confirmed that fission fragments which resulted from older explosions were present in the atmosphere. It evaluated the content of Sr90 and Ce144 to be respectively (4×102and 1.5×102 atoms/liter). The count of the overall number of Sr90 atoms in the atmosphere, and the comparison of the obtained quantity with the amount of fission atoms ignited during the testing of atomic weapons, show an unexpectedly large (10%) share of continually present fragmentary activity.

The specific levels of the radioactivity of the clouds passing over the territories of the USSR and the PRC turned out to be notably low 10-15, 10-14 Ci/L. At 10-9 curie/liter, V.A Davidenko's calculations of expected cloud radioactivity is exaggerated. [unclear] of a more realistic volume of the cloud (1/30 of the volume of earth's atmosphere) [unclear]. The inclusion of such corrections will [clarify] the observed concentration of 10-12 Ci/L, which is 100-1000 times larger than observed quantities.

This brings us to the following alternative conclusions: □The tested thermonuclear bombs do not satisfy the yield and type prerequisites, as presented in V.A Davidenko's report, for a thermonuclear reaction.

. The movement of air-masses across the atmosphere have peculiarities which are not accounted for during an estimate of a cloud's expected radioactivity levels.