Are Portions of the Urals Really Contaminated?

W. Stratton, D. Stillman, S. Barr, H. Agnew

In 1958 rumors surfaced in Western Europe that a radiation release accident had occurred in the Soviet Union and that the location of the release was in the area of the southern Ural Mountains. This incident was first mentioned in the technical literature in 1962, in *Progress in Nuclear Energy*, but the entry offered only the date, the country, and the statement, "Unconfirmed report of a major reactor incident" (*1*). Until recently, only occasional newspaper articles reported on rumors and allegations, usually from unidentified sources. However, in 1976, Zhores Medvedev, a refugee from the Soviet Union, and a distinguished biologist in his own right, mentioned this matter in *The New Scientist* (*2*). In this and two subsequent articles (*3, 4*), in his books *Soviet Science* (*5*), and in colloquia at Oak Ridge National Laboratory and recently at Los Alamos Scientific Laboratory (LASL) (*6*) he presented arguments that an area in and near the southern Ural Mountains was contaminated by radioactive material sometime in late 1957 or early 1958. His discussion followed the earlier word-of-mouth rumors that a large area was contaminated and many persons—into the thousands—were injured, more or less seriously.

In order to establish the location of the contaminated area and to estimate its size and contamination intensity, Medvedev conducted a search of Soviet open literature (biological and ecological) to find any scientific articles that might have made use of the uniqueness of such a large contaminated area for in situ research programs. This limited search revealed the presence of contaminated lakes, one of which was between 10 and 20 square kilometers in area and may have contained between 5,000 and 50,000 curies of strontium-90 and land areas that had as much as 3.4 millicuries of strontium-90 per square meter and lesser amounts by factors up to 500 of cesium-137. By identification of the biological species found in these lakes and contaminated soil areas, Medvedev believes the contamination area is located east of the city of Kyshtym, on the eastern slope of the Ural Mountains (see Fig. 1). Medvedev asserts that Kyshtym is near the site at which the first military plutonium production reactors were constructed.

The strontium remaining in the lake in about 1963 or 1964 was estimated by Medvedev from the strontium concentration cited in the literature and his estimate of the volume of the lake (the depth is not given). The extent of ground area contaminated was estimated by Medvedev by taking the maximum migratory distance per generation of mice, voles, and rabbits and the foraging distance of deer; the actual distribution is not given in the literature cited. The only radioactive isotopes mentioned in these Soviet publications are those of strontium and cesium—each with a half-life of about 29 years.

Medvedev then postulated the cause of this contamination (*2-4*). On the basis of his belief that the Soviets constructed high-power reactors near Kyshtym to create plutonium for use in the production of nuclear weapons, he assumed that radioactive waste material must surely have been stored or buried in a nearby area.

He further postulated that, after a large amount of this radioactive waste material was buried nearby, and after a considerable period of time, some sort of explosion or volcanic-like eruption occurred such that this highly radioactive material was vaporized and dispersed by the prevailing westerly winds. A period of time in storage is required to allow, per Medvedev's account, for the decay of short-lived isotopes, because only strontium-90 and cesium-137 are mentioned in the Soviet biological literature. The assumed manner of storage or burial, amounts and volumes of fission products, chemical form, water content, terrain, and nearby drainage patterns are not mentioned (*2-4*). No aspects of the physical nature of the release are discussed.

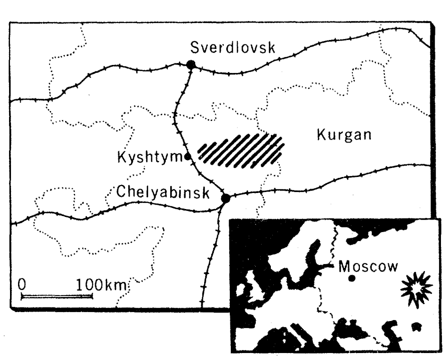

Fig. 1. Location of contaminated area (per Medvedev).

Any high-level radioactive waste storage area would, presumably, be designed to accommodate a large amount of radioactivity and concomitant heat generation; such activity could derive from plutonium military reactors and the associated chemical-processing plants. A limited-term military storage system probably would be similar to that used in the United States, United Kingdom, and France. It is reasonable to assume that if the waste products were in a convenient solutions form, a number of steel tanks would be used for containment. A steam explosion of one tank is not inconceivable but is most improbable, because the heat generation rate from a given amount of fission products is known precisely and is predictable. Means to dissipate this heat would be a part of the design and could be made highly reliable.

In one paper (*3*) Medvedev postulates that highly radioactive solutions with small concentrations of plutonium were poured into a trench; the concentration of plutonium accumulated slowly until a critical mass was created; and this unintended reactor caused an eruption. We find this theory to be unacceptable for several reasons; for example, plutonium production is the objective and it is unlikely that critical amounts would have been discarded; however, should this have been done, the fission rate would have been too slow to disturb the ground more than trivially. The case of the prehistoric Oklo reactor in Gabon is cited as the only known example of an in situ reactor. The fission products associated with this ancient reactor remained firmly fixed in place (*1*). We find that the physical problems associated with widespread dispersal of large amounts of strontium-90 and cesium-137 from a plutonium ground-storage criticality event are so monumentally difficult that this

Drs. Stratton, Stillman, and Barr are staff members at the Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544. Dr. Agnew is president of General Atomic Company, Post Office Box 81608, San Diego, California 92093.

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postulate cannot be considered seriously. There is also no report of any plutonium contamination in the references cited by Medvedev.

In his publications and during his colloquium at LASL, Medvedev made no mention of any other possible cause of this presumed contaminated area east of Kyshtym. Another possibility, more plausible than Medvedev's, is that the contaminated area is simply the result of localized fallout of radioactive material from a Soviet atmospheric nuclear weapons test at Novaya Zemlya (see Fig. 2). If, indeed, the area east of Kyshtym was contaminated in late 1957 or early 1958, there were several candidate multimegaton nuclear weapons tests conducted by the Soviets in the atmosphere during that period in the Novaya Zemlya area. In addition, this is said to have been one of the test series during which especially "dirty" (high fission product content) nuclear devices were tested by the Soviets. We call attention to the fact that for each megaton yield, about 10^5 curies of strontium-90 are created. The radioactivity created would thus be sufficient to account for the reported effects.

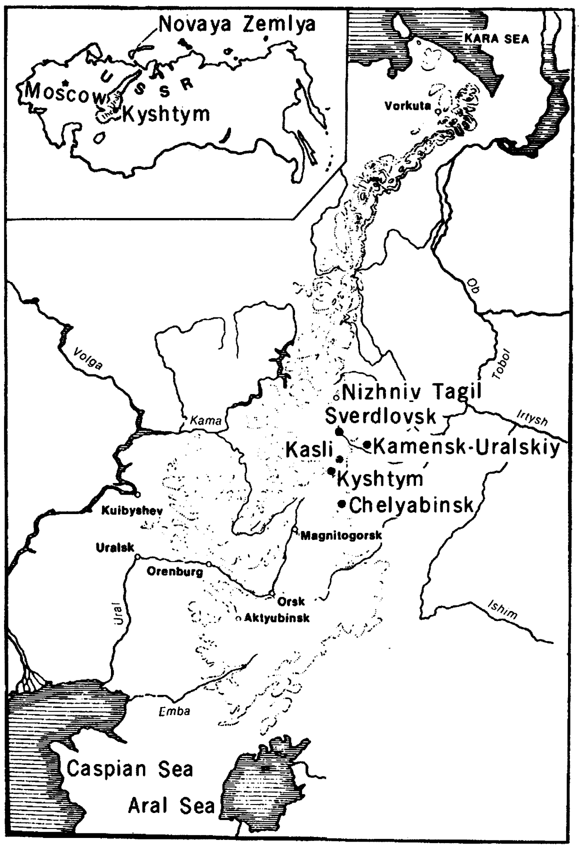

Fig. 2. Relation of Novaya Zemlya to contaminated area.

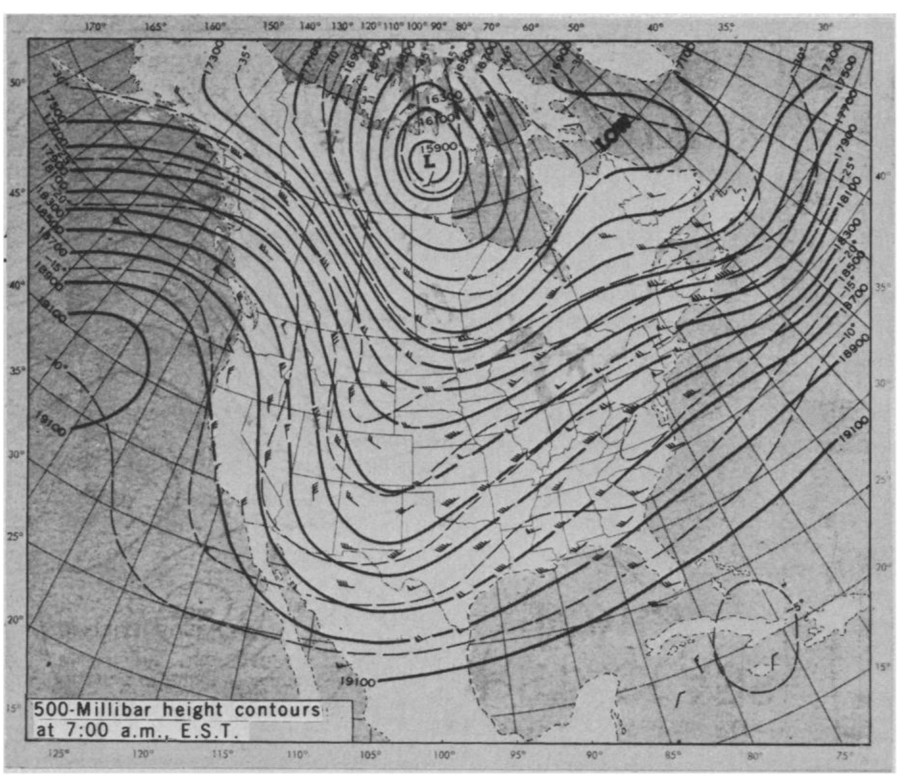

Fig. 3. Circulation pattern at 500-millibar height over North America on 6 December 1976. Winds flow parallel to the height contours at this altitude.

A critical matter, of course, is the weather pattern necessary for movement of the radioactive cloud or clouds from the Novaya Zemlya area to the area east of Kyshtym. Wintertime trajectories from Novaya Zemlya to the contaminated site, although not the climatic norm, have a reasonable chance of occurring. A survey of one season's circulation patterns in the upper troposphere over North America revealed several instances in which airborne material from above 70°N latitude could have been transported southward to 50°N with very little net east-to-west transport (*8*). The most common pattern producing this type of trajectory is an upper-level closed cyclonic circulation system that is slowly moving and centered at 60° to 65°N. Winds around the back of such a low-pressure center are northeasterly in the northern 400 miles. They recurve to northwesterly at lower latitudes and describe an arc that crosses 75° and 55°N at nearly the same longitude. Figure 3 shows an example of such a circulation. These weather patterns are expected to be at least as common over Asia as North America.

Another characteristic of the wind pattern described above is its association with major low-pressure (storm) systems, which implies the high probability of some precipitation. Scavenging of nuclear debris can produce spots of significant local ground-level contamination in any area along the path of the debris that precipitation is encountered. Figure 4 illustrates a 72-hour trajectory originating at 75°N based on wind patterns for early February 1976 over North America (*8*). The occurrence of observed precipitation along the trajectory is indicated by an asterisk. At 36 hours from the trajectory initiation the tracked parcel of air is located such that, if the release were made at Novaya Zemlya, the parcel would be over the postulated contaminated area east of Kyshtym. Figure 4 also shows that precipitation occurs in that area of the trajectory. The presence of the Ural Mountains would enhance the opportunity for precipitation and, therefore, for scavenging.

If the area east of Kyshtym had been contaminated in the 1961 to 1962 time periods rather than during the 1957 to 1958 test series, the same logic would apply: the contaminated area could simply be the result of localized fallout of radioactive material from Soviet atmospheric nuclear weapons tests at Novaya Zemlya. When the Soviets elected to resume atmospheric nuclear weapons testing on 1 September 1961, they were at times actually exploding large nuclear devices at the rate of one to two per day, often in the multimegaton range. The haste with which these tests were conducted was not conducive to careful consideration of wind and precipitation patterns.

In conducting atmospheric nuclear weapons tests the United States was scrupulously careful about the danger of "rainout." In the few recorded cases of rainout that occurred in the United States, only very low levels of contamination occurred. Thus the United States has little experience in this regard, but the possibility was recognized early and precautions taken. The haste with which the Soviets conducted the 1957 to 1958 tests and the later atmospheric test series would not have been consistent with such prudent precautionary measures.

To provide additional support that such events are within the realm of possibility and, indeed, may have caused the observed contamination, we quote from *The Effects of Nuclear Weapons* by Samuel Glasstone (*9*):

In a high-yield air burst, essentially all the radioactive debris would generally be carried above the rain-bearing layer and there would be little or no early fallout. An important exception could arise if the airborne debris were to encounter thunderstorms, since precipitation may then originate as high as 60,000 feet. Should such an encounter take place within a few hours after the burst, localized hot spots of very high intensity might develop due to rainout. Although radioactive decay, wind shear, and diffusion all tend to reduce the concentration of activity in the cloud, thunderstorm scavenging of the weapon residues could still conceivably produce serious contamination of the ground many hours after detonation and hundreds of miles downwind from the point at which the air burst occurred.

The foregoing discussion of the distribution of the early fallout may be supplemented by a description of the observations made of the contamination of the Marshall Islands area following the high-yield explosion (BRAVO) at Bikini Atoll on March 1, 1954. The total yield of this explosion was approximately 15-megatons TNT equivalent. The device was detonated on a coral reef and the resulting fallout, consisting of radioactive particles ranging from about one-thousandth to one-fiftieth of an inch in diameter, contaminated an elongated area extending over 330 (statute) miles downwind and varying in width to over 60 miles. In addition, there was a severely contaminated region upwind extending some 20 miles from the point of detonation. A total area of over 7,000 square miles was contaminated to such an extent that avoidance of death or radiation injury would have depended upon evacuation of the area or taking protective measures.

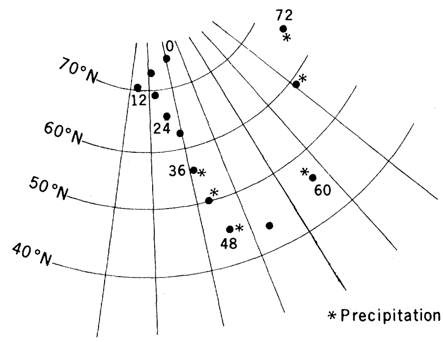

Fig. 4. A 72-hour trajectory originating at 75°N based on wind patterns for early February 1976 over North America.

Some of the reports released by the Central Intelligence Agency (*10*) mention radiation problems in Kamensk-Uralskiy; Medvedev mentioned severe anxiety in the city of Kasli (see Figs. 1 and 2). These cities are about 65 miles apart; fallout from a distant weapons test could contaminate an area this large fairly uniformly while a point source such as a reactor or waste storage tank would produce a most nonuniform fallout pattern. In addition the weapons test would have created intense activity early in time, evidence of which (health physics monitors, for example) could have caused the widespread anxiety, even panic, that is suggested by some of the reports. If the average contamination were not high, the people's concern would have faded at about the same rate at which the short-lived activities disappeared.

Thus Medvedev has offered no evidence that a waste repository was involved or that an explosion caused spread of the contamination or that any human life or property was put at risk. His biological data, however, provide convincing evidence that something happened, but the extent of ground and water contamination (except for one or two lakes) is poorly documented. The rumors of casualties consist only of hearsay evidence and should be treated as such except for providing corroboration of the biological evidence that some radioactive contamination was in the environment.

We suggest that the observed data can be satisfied by postulating localized fallout (perhaps with precipitation) from explosion of a large nuclear weapon, or even from more than one explosion, because we have no limits on the length of time that fallout continued. Finally, without additional evidence the intensity of contamination at any one point does not fix the areal extent and intensity. We can only conclude that, though a radiation release incident may well be supported by the available evidence, the magnitude of the incident may have been grossly exaggerated, the source chosen uncritically, and the dispersal mechanism ignored. Even so we find it hard to believe that an area of this magnitude could become contaminated and the event not discussed in detail or by more than one individual for more than 20 years.

References and Notes

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9. S. Glasstone, *The Effects of Nuclear Weapons* (U.S. Department of Defense and U.S. Atomic Energy Commission, Washington, D.C., April 1962), p. 460.
10. Statements released by the Central Intelligence Agency, 11 November 1977.