

A Tale of Two "Nuclear" Cities.

Plutonium Contamination in an American and a Soviet Early Plutonium Worker

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In the 1940's, two "nuclear" cities were constructed, one in the US and one in the Soviet Union (USSR) for the purpose of developing fission nuclear weapons. Both cities were top-secret and only identified by post office box (POB) numbers. POB "1665" later became Los Alamos and was the site for the construction and deployment of the first atomic bomb in the US. The counterpart in the USSR was initially referred as a POB "40" in the Chelyabinsk region. This was changed in the early 1990's to POB "65" and in the mid-1990's to "Ozorysk". Ozorysk is located about 70 km north of the city of Chelyabinsk in the Southern Urals region of Russia.

Plutonium was discovered in 1941 and was soon found to have suitable fission and neutron capture properties for a fission weapon. In the US, plutonium for weapons was produced at Hanford, WA and sent to Los Alamos where purification and fabrication into weapons were completed ("Project Y"). Mankind was introduced to nuclear weapons with the explosion of a ²³⁹Pu device on July 16, 1945 at the Trinity site in New Mexico followed soon by detonations over Hiroshima and Nagasaki, Japan. The enterprise formed by the USSR to produce plutonium was the Mayak Production Association (MPA) and construction of the plant and reactor complex was started at Chelyabinsk-40 in 1945. The first reactor became fully powered in 1948 with the first finished ²³⁹Pu produced in 1949 (1).

In the 1940's, longer-term health consequences of exposures to various types of radiation on human health were not well known. At both "secret" cities, the initial work on fissionable, radioactive materials was hazardous and the technology was being developed as the work continued. While there were contamination events, including criticality accidents in the early years at both sites, it is now apparent that these events at Chelyabinsk-40 were common and often severe (2). In the initial years of plant operation, 1949-1953, plutonium workers at the MPA were routinely exposed to contaminated aerosols and the exposures to many were substantial, in some cases leading to "plutonium pneumosclerosis" (3), a condition not known outside of the USSR. Once plutonium is incorporated into the body and systemically distributed, it concentrates in the liver and skeleton and is capable of producing cancers in these organs (4). The carcinogenicity of

the plutonium alpha emission is well known from experimental studies and there is almost an obsessive public fear of this nuclide.

The purpose of this study was to compare the relative concentrations of plutonium that might be found in bones of early US and Soviet workers. Vertebral cancellous bone samples were obtained from archived materials. The vertebral column is a site with a higher propensity for plutonium-induced sarcomas (5). The Los Alamos worker had one of the higher documented industrial exposures to ^{239}Pu in the US whereas the exposures to the Mayak worker were “routine” for this period. Both workers were exposed during a period from the late 1940’s to mid-1950’s and both lived into their 7th decade of life. The US worker died of cardiovascular disease and the Mayak worker died from lung cancer, but both lived at least 3 decades beyond their exposures.

The tissues were prepared for neutron-induced autoradiography (NIAR). For this, sections were sandwiched between plastic detectors and all sections were placed in one container and irradiated with neutrons. The sections illustrated in Fig. 1 were identically exposed. After irradiation, the detectors were developed and the original tissue section stained such that the histology could be compared with the NIAR. The plutonium fission fragments create holes in the detector that appear as dark tracks.

The density of plutonium fission fragments in the bone from the “routinely” exposed early Soviet worker is dramatically greater than those observed in the “highly” exposed US counterpart. This initial study demonstrates large concentrations of ^{239}Pu in the bone of the USSR worker relative to the US worker, and both were decades beyond their initial exposures. The unfortunately high plutonium exposures to the early plutonium workers in Chelyabinsk-40 were indeed tragic. From this population, however, we may finally begin to understand the toxicity and health consequences of the one of mankind’s most feared and politically charged substances.

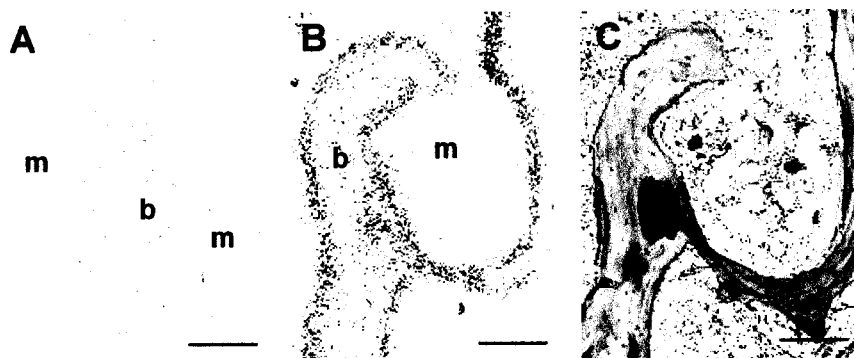


Fig. 1. (A) An NIAR from vertebral cancellous bone from an early “highly” contaminated US plutonium worker. Plutonium tracks are observed in the bone (b) with few in the marrow (m). (B) Histological section from vertebral cancellous bone from an early Soviet plutonium worker. Extensive plutonium fission tracks are located in areas corresponding to the bone (b) tissue but few in the marrow (m). (C) Histological detail of the section used for the NIAR image in (B). Bar: 0.25 mm.

References and Notes

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Supporting Online Material

Materials and Methods

References