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Characterisation of prompt and delayed atmospheric radioactivity releases from underground nuclear tests at Nevada as a function of release time

Martin B. Kalinowski*

Carl Friedrich von Weizsäcker Center for Science and Peace Research, University of Hamburg, Beim Schlump 83, 20144 Hamburg, Germany

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ABSTRACT

A database with information on about 500 cases of atmospheric radioactivity releases from underground nuclear tests is analysed. The data are statistically evaluated and systematically aggregated in order to characterise prompt uncontrolled as well as delayed operational releases of radioactivity into the atmosphere. The focus is put on the latter. The reported data compare well with theoretically derived xenon activities for reasonable nuclear test scenarios. Conclusions are drawn on the main features of releases that can be expected from underground nuclear tests as a function of release time. These findings are relevant for developing and validating methods to be applied in global monitoring of atmospheric radioactivity with respect to indications of an underground nuclear explosion.

1. The database

Atmospheric radioactivity release data from historic underground nuclear test explosions are valuable for developing and validating the methods for verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT). A yet untapped source is a large database that had been declassified as part of dose reconstruction efforts related to a compensation program for cancer patients in the United States of America.

The document by Schoengold et al. (1996) includes atmospheric radioactivity release information for 433 nuclear tests conducted on the Nevada Test Range from 15 September 1961 through 23 September 1992. Some tests had more than one release bringing the total number of releases above 500. Only 52, i.e. 6.3% of the 824 tests conducted in the period covered by the report, had been detected by ground or aerial measurements made off-site. It should be noted that all of these tests except for 7 Ploughshare or cratering tests were designed to remain fully contained. 105 tests had containment failures, operational releases followed 287 tests, and in two cases the release was described as a late-time seepage after operations in that area have ceased. Many of the operational releases were filtered. Usually, these resulted from purging of tunnels or sometimes shafts to minimise the exposure to personnel. Other operations that caused filtered or unfiltered releases are drill-back operations to recover samples for diagnostic purposes, gas sampling from sampling tanks or sealing the drill hole with a plug and backfilling with cement or grout.

For each test, radiation measurements began milliseconds after detonation, and continued until no apparent radiation hazard existed. The detailed information given in that report includes the activity, time information (delay and duration of release), explosive yield or yield range as well as depth of burial. For an uncontrolled release due to containment failure, the activity is normalised to the activity at release time plus 12 h. For operational releases, the activity is reported as measured at the time of the release. In general, the total released activity is given. Isotopic activities are reported as available. There are 102 cases for which the activity of three xenon isotopes is reported (^{135}Xe, ^{133m}Xe, ^{133}Xe). All activity data are reported to two significant figures.

Few data are available in the open literature on radioactive effluents from underground Soviet nuclear weapons tests. There is one source (Bazhenov, 1999) that provides for the first time detailed data on the radioactive releases from 39 underground nuclear explosions at the North Test Site on Novaya Zemlya for the period 1955–1990. This publication resulted from a cooperation of the Interagency Expert Commission on assessment of radiation and seismic safety of underground nuclear tests, the V.G. Khlopin Radium Institute, the Russian Nuclear Society and the Centre for Public Information on Nuclear Power. According to Andrianov and Vyskrebentsev (1999), only in two cases were considerable amounts of gaseous fission products recorded on the surface and in 60% of all underground tests insignificant amounts of radioactive

* Tel.: +49 40 42838 2870; fax: +49 40 42838 3052.
E-mail address: Martin.Kalinowski@uni-hamburg.de.

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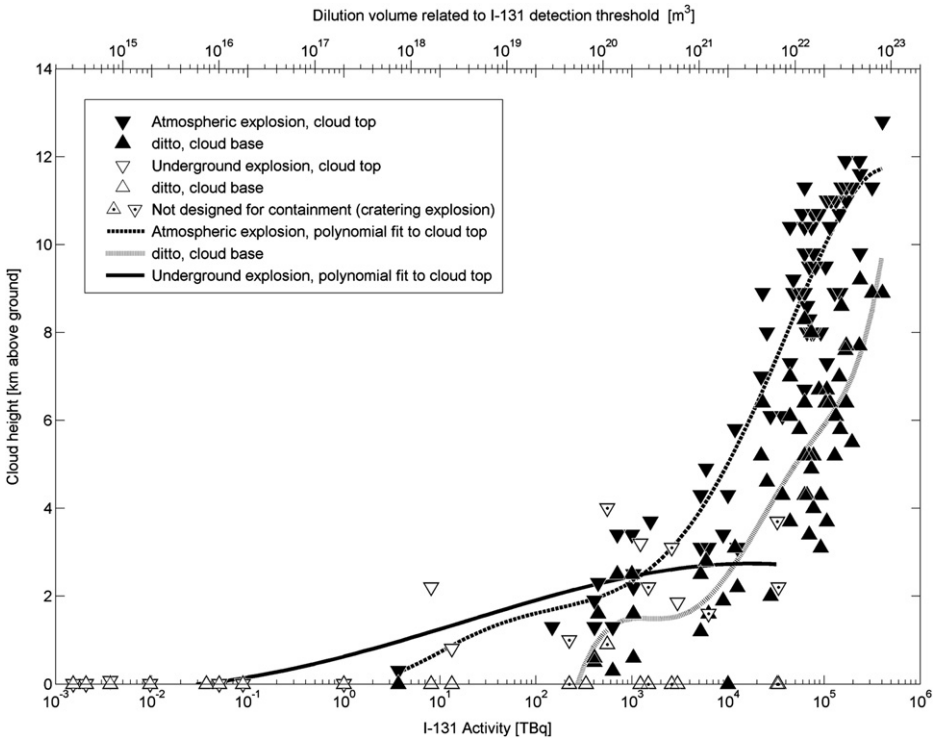

Fig. 1. Reported radioactive cloud heights versus released ^{131}I activity from atmospheric and from vented underground explosions.

noble gas isotopes (including ^{133}Xe, and ^{135}Xe) leaked to the surface some time after the explosion.

2. Geology and reported containment performance

Four different types of atmospheric effluents from nuclear weapons tests can be distinguished regarding their time-line and quantity of radionuclide release. These are:

- Unconstrained free distribution resulting from atmospheric explosions,
- Uncontrolled, typically rapid test release with constraints from covering material, including venting due to spontaneous or slowly developing containment failure of underground explosions, crater-forming eruptions of shallow underground tests as well as underwater explosions,
- Controlled release following operations at the site of a deep underground explosion,

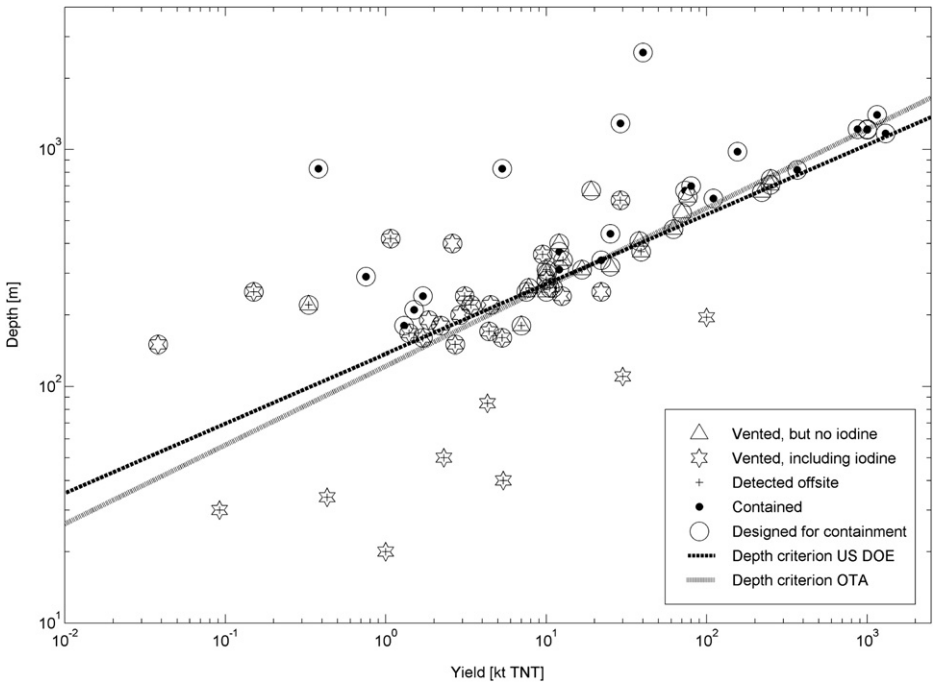

Fig. 2. Experience in containment performance of underground nuclear explosions with different yield and depth of burial.