1 Synthesis

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The RADiation from nuclear TEST explosions, or RADTEST, project is one of the Scientific Committee On Problems of the Environment (SCOPE) programmes. It falls within SCOPE's Health and Environment cluster.

The test-explosion of nuclear weapons has made a far larger impact on the world environment than all the operations and accidents with nuclear power generation. This study of the 2419 tests between 1945 and 1998 records the past and present understanding of the results as the weapons have been developed and tested. In sum the tests have yielded explosive energy equivalent to 550 million tons of TNT, with the USA and USSR accounting for 80% of the tests and 90% of the yields. Although there have been extensive global studies on fallout, publication on local effects, especially on human health, has been uneven. The RADTEST study provides much information that until now has been restricted or unavailable.

The areas for nuclear weapons testing were chosen for remoteness from human habitation and observation. Fallout affecting life and health has been studied extensively and publicized in such areas as Nevada, Australia and islands in the Pacific. That information is re-examined here, with new RADTEST studies of the Altai–Semipalatinsk and Novaya Zemlaya regions of the former Soviet Union (FSU) and of the Chinese testing ground at Lob Nor. The most recent tests there are covered as well as the series in French Polynesia. Limited information is available on the tests made by India and Pakistan in 1998.

Models for predicting short and long-term health effects require both meteorological data and population medical records at the time of the explosions and study of the changing patterns over the years until now. Poor medical records have to be interpreted and supplemented by the extensive knowledge from the Hiroshima and Nagasaki bombs and the tests in the Pacific. The object is to establish the pathways by which radionuclides reach human beings and the doses of radiation received by populations and individuals from initial and continuing exposure until the present. Differing systems of radiological protection and medical records in the countries studied have been compared in order to give firmer prediction for any future accidental or deliberate release.

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One result of RADTEST is a current inventory of radioactivity at or near test sites with potential for remediation or restoration. Activities are in general much lower than those experienced at Hiroshima and Nagasaki. Those at Altai are high enough to have significant health effects and to throw light on the controversial low-dose regimes. In particular, dose reconstruction from the effects on eyes and teeth are being assessed by individual and case-control studies as distinct from the assumptions for populations in cancer prediction. This is of current public and political interest.

The detailed information and discussion in the following chapters start with an introduction to the background of the Report and the contributions of the NATO Workshops in Vienna and Siberia, which included the visit to Semipalatinsk. General conclusions on human, animal and plant irradiation effects from the French case-studies in Polynesia follow, and then the comparable results from the USA, FSU and China.

In Chapter 3 the history of weapon developments opens with the simple fission bombs of World War II, yielding about 20 kt, to the later boosted-fission, hydrogen fusion, and combined fission–fusion–fission weapons. These led to national arsenals with a total of more than 25 000 warheads, mainly around 100 kt but with some up to 1 Mt. The varying yields from the testing of these weapon developments are discussed. The different sites and testing techniques are covered in detail, with summaries of the number of tests with their explosive and radionuclide yields, accurate figures for which have been released only recently. Of the total tests, 541 were in the atmosphere and 1878 underground.

Chapter 4 details the immediate environmental impacts following the formation of different radionuclide compounds and the aerosol transport in the atmosphere and the troposphere. These local, remote and global tropospheric patterns are expressed by mathematical models. These are then used with the actual data on which they are based for the reinterpretation of early tests in the atmosphere. It emerges clearly that the radioactive products from fission reactions vary with the process of detonation, and that firing conditions are of great importance. Contamination of geological formations, water and oil from underground tests is considered in this chapter.

Chapter 5 discusses pathways for external and internal exposure in the human body following inhalation and ingestion of contaminated foodstuffs, looking at specific test-sites and regions. The radioisotopes of iodine, strontium and caesium are of greatest interest because of the amounts released, their ready transfer to human beings via the foodchain and high relative activities because of short half-lives.

Chapter 6 summarizes the estimation of dose to human beings with reference to the test sites in Nevada, South Pacific, Semipalatinsk, Novaya Zemlaya, Lob Nor, Mururoa, Fangataufa and Australia. The variation of local and regional levels and of external and internal irradiation are discussed. Extensive

and detailed dose reconstruction from local fallout has so far been carried out only at Nevada. The estimated collective dose to the world's population is 50 times that from the Chernobyl accident. These global levels are of course a small fraction of the exposure to natural background radiation but local contamination can give far higher doses than the average.

Chapter 7 examines in detail the health consequences for exposed populations in the USA, FSU, French and Australian territories. Most fallout exposures of individuals near test sites from high local fallout have already been received. The most highly exposed cohorts face increased health risks and deterministic effects seem to be appearing. Evaluating risks of a stochastic nature requires long-term follow-up.

Chapter 8 discusses fallout models and tries to bring together the different approaches in earlier chapters. The discussion shows that further work is needed to establish models which are better for explanation and prediction.

Many of the differences arise because the capacity of modern computers is now much greater than at the time earlier models were developed. The rate of change is great and demonstrated in the advance between first and second volumes of *SCOPE 28: Environmental Consequences of Nuclear War* in the models of general circulation of the atmosphere. To these there are added the problems of particles, their relation to cloud formation and the special properties of nuclear aerosols, including multispecies with morphologies and properties unlike normal aerosols in the atmosphere.

The approximations made in early models were assessments covering fallout from hundreds of weapons and compromises. Recent developments in understanding microphysics, plume clouds and weather codes have yet to be applied. In particular, formation of particles can now be examined more closely, i.e. particles in the submicron range that were neglected earlier.

There are other difficulties because of the large proportion of material carried along with the small amount of nuclear materials. These difficulties need adding to the modelling of weather and fallout. The chapter ends with suggesting that an immediate jump in capability is now possible, with the elimination of many uncertainties.

The Appendix summarizes the releases of radioactivity from all atmospheric and vented underground tests. Recent tests deep underground have not added to natural radioactivity in the atmosphere or oceans.

This Report should help environmental understanding and guide the making of policy on the testing and control of nuclear weapons. It has been made possible by the commitment of scientists to seek out information previously kept secret for military security. This collaboration world-wide is one of the fruits of the ending of the Cold War. Publication should encourage the open discussion of steps now being considered for the control of nuclear weapon production, including the cessation of testing and targeting, and the detection of clandestine testing. Although the Comprehensive Test Ban Treaty has

lessened the fear of nuclear war, it is to be hoped that the international collaboration established by SCOPE-RADTEST will continue—and assist in the safeguarding and disposal of nuclear weapons material.