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STREAM-SIMULATION EXPERIMENTS FOR WASTE-REPOSITORY INVESTIGATIONS

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by

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ABSTRACT

The potential for radionuclide migration by groundwater flow from a breached--waste repository depends on the leaching process and on chemical changes that might occur as the radionuclide moves away from the repository. Therefore, migration involves the interactions of leached species with 1) the waste and canister, 2) the engineered barrier, and 3) the geologic materials surrounding the repository. Rather than attempt to synthesize each species and study it individually, another approach is to integrate all species and interactions using stream-simulation experiments. Interactions identified in these studies can then be investigated in detail in simpler experiments.

INTRODUCTION

Disposal of radioactive waste in geologic formations offers a practical method of permanently isolating the waste from the biosphere. Even if groundwater infiltrates a repository, leaches radionuclides from the solid waste, and transports them into fissures and pores of the surrounding geologic structure, the radionuclides can react with the rock and, again, become immobile. Both the solid waste and the geologic structure (together with any engineered barriers or canisters) prevent the dispersal of radioactivity into the biosphere.

A comprehensive technical treatment of potential radionuclide dispersal from a repository is not simple. In a generalized approach to understanding nuclide migration by groundwater flow, there are enormous numbers of solution and sorbed species that would have to be considered over a large range of element concentration, temperature, radiation field, groundwater flow velocity, and other conditions. Materials extraneous to a geologic structure that will be introduced as part of a nuclear waste repository complicate migration beyond that which occurs in the natural, undisturbed formation.

Most experimental work to evaluate the potential for dispersal of radioactivity has either examined the leach resistance of solid wastes or has investigated the adsorption of nuclides by rock. Both approaches investigate potentially very complex processes. Details of the chemical species at the solid-solution interface are sought in a particular leaching experiment to establish a mechanism of leaching. In qualified cases (Inoue 1963), results of adsorption experiments can be related to nuclide migration by flowing groundwater. However, the results of these experiments give little guidance to predict leaching or migration under general conditions. In fact, the species and concentration of nuclides formed during leaching can affect migration so that the migration is not independent of leaching (Seitz 1979).

Migration also depends on the chemical changes that might occur as the radionuclide moves away from the repository. So migration involves the interactions of leached species with 1) the waste and canister, 2) the engineered barrier, and 3) the geologic materials surrounding the repository. Some of these interactions would occur in the radiation and thermal gradients centered on the solidified waste. There is little hope of identifying from studies of individual repository components all important interactions that exist in a breached repository.

AN APPROACH

Rather than work with a part of a repository with the hope that the findings of each part will be integrated by computer model, our approach in the Waste Rock Interactions Technology (WRIT) Program has been to integrate repository components in laboratory experiments under conditions expected for a breached repository. The work has combined leaching and migration in a single groundwater stream (Seitz 1978, Seitz 1980). The experiments have used waste solids containing actinide elements, fission products and activation nuclides. Cores of both porous rock and impermeable rock containing fresh or old fissures have been used as the geologic medium. The experiments have identified relations between leaching and migration that were then studied in simpler adsorption tests (Seitz 1979A). Leach-migration experiments are being planned by other (Coles 1980).

Experiments, termed stream-simulation experiments, are now in progress that combine engineered barriers, canisters and rock cores in a single flowing groundwater stream. The objective and design basis for these experiments is described in the following section.

STREAM-SIMULATION EXPERIMENTS

The objective of the stream-simulation experiments is to reproduce the essential processes that occur in a breached repository. In a breached repository, groundwater may flow through the disrupted engineered barrier and canister, and contact the solid waste. The groundwater may leach radionuclides and stable elements from the waste and the altered groundwater may again flow through the breached canister and engineered barrier into the geologic structure surrounding the repository. The radiation and thermal fields are centered on the solid waste but are influenced by heat and radiation from surrounding waste packages.

An assembly of a stream-simulation experiment that reproduces the essential processes along the groundwater stream is shown in Figure 1. In the apparatus, groundwater is pumped through engineered barrier, contacts the solid waste and then exits through more of the engineered barrier. This part of the groundwater stream is maintained at elevated

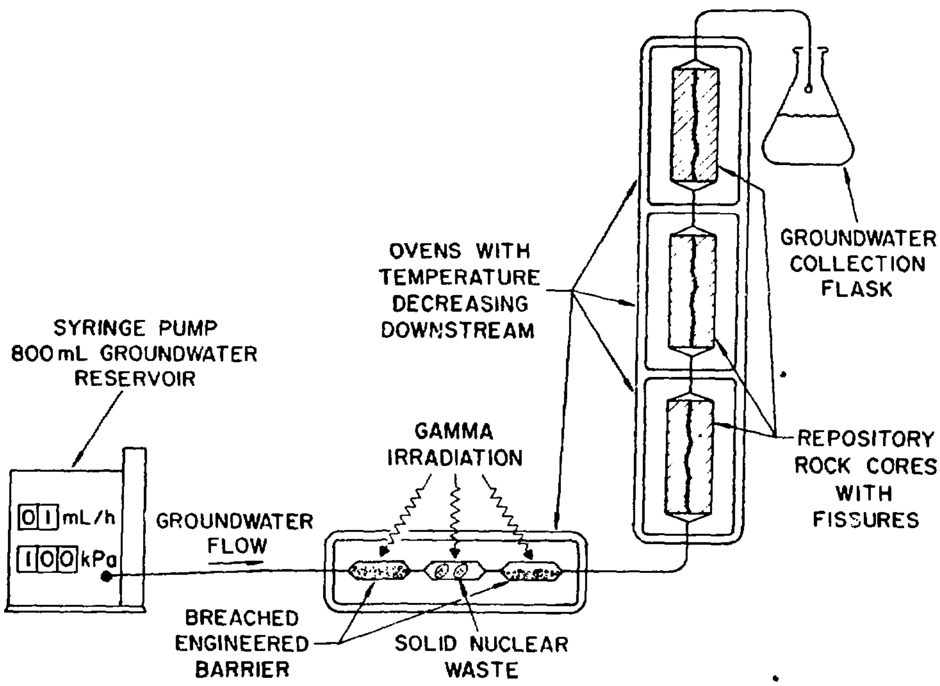

Figure 1. Schematic of the Components Used in a Stream Simulation Experiment

temperature in a radiation field. The groundwater then passes through rock cores held at temperatures that would occur at increasing distances from the repository. By monitoring the groundwater exiting from the apparatus for chemical changes (of both stable and radioactive species) and by analyzing the rock and engineered barrier after an experiment the behavior of the radionuclides can be established.

APPARATUS CONSTRUCTION

The entire apparatus defining the groundwater stream is made of Hastelloy C-276 or Teflon materials. The Hastelloy alloy shows excellent corrosion resistance in groundwater and brines and has been tested as a candidate metal for waste canisters (Braithwaite and Molecke 1980). The Teflon is used to prevent water from bypassing the rock cores (of 9.5-cm diameter by 23-cm long) and as seals in the solution metering pump.

The apparatus is assembled with tube fittings and valves so that groundwater can be sampled at several points along the groundwater stream. The stream is monitored with pressure transducers and thermocouples. The radiation field is provided by the waste solid itself and may be augmented by a cobalt-60 gamma source.

SUMMARY

The stream-simulation experiments are an elaboration of the leach-migration experiments conducted for the WRIT program in which solid waste at elevated temperature and geologic media were combined into one groundwater stream. Using the stream-simulation experiments, we are attempting to consider all potential interactions that occur when repository components are combined. The interactions, once they are identified, can then be studied in detail using simpler experiments.

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