BOOK REVIEWS

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Geological Disposal of Radioactive Waste *In Situ* Experiments in Granite

Publisher Nuclear Energy Agency, Organization for Economic Cooperation and Development, 2, rue Andre-Pascal, 75775 Paris-Cedex 16, France (1982)

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Reviewer Jaak J. K. Daemen

This volume contains the proceedings of a workshop that took place in Stockholm, Sweden, from October 25 to 27, 1982, organized by the Organization for Economic Cooperation and Development's Nuclear Energy Agency and the Swedish Nuclear Fuel Supply Company.

Emplacement in deep geologic formations remains the most probable method for the permanent disposal of the highly radioactive wastes produced by nuclear power generation. Even though the concept has been widely accepted, the safety and feasibility of the deep geological disposal approach remain to be demonstrated conclusively. The book being reviewed summarizes the extensive research that has been performed and proposed at the Stripa mine in Sweden on various aspects of high-level waste disposal in granite, as well as at other granite test sites in the United States, the United Kingdom, Canada, and France.

In addition to the introductory summarizing chapter, the book contains sections on rock mechanical, hydrological, geochemical migration, buffer, and backfill materials investigations, as well as a program of future *in situ* experimental work at Stripa and at the Canadian and proposed Swiss underground research laboratories in granite. This outline indicates the broad scope of the work already completed at Stripa and of the plans for the future.

The section on rock mechanical investigations includes papers on thermomechanical investigations and stress measurements at Stripa, on experimental and calculational results from the spent fuel test at the Climax, Nevada, Test Site experiments, and on the rock mechanics and hydrological investigations at the Colorado School of Mines/Office of Nuclear Waste Isolation (CSM/ONWI) site. The Stripa *in situ* heater tests have demonstrated the feasibility of predicting temperature distributions around heaters in jointed rock and have identified likely causes of difficulties in predicting heater-induced displacements, even though at the time of this publication, only a preliminary data analysis had been performed. Extensive comparisons of the results obtained for the *in situ* stress measurements performed by several of the most widely used methods indicate fair consistency in results, notwithstanding the considerable scatter in the results, and allow the authors to develop general recommendations for *in situ* stress measuring programs for repository site characterization. Full-scale repository simulations have been performed at the Climax facility, including emplacement of spent fuel assemblies, supplemented by conventional heaters. Displacement and temperature monitoring show excellent agreement between calculated predictions and measured values. At both the Climax and Stripa sites, considerable experience has been developed in the use of *in situ* instrumentation in a repository environment, and problems encountered are identified. Techniques are described, and a few results presented, of the investigation of the disturbance zone around an experimental room excavated by CSM for ONWI. Also described is an extensively instrumented heated block test performed at this facility.

Papers on the comprehensive fracture hydrology investigations at the Stripa site, on the interpretation of field experiments on the flow of water and tracers through crystalline rock, on borehole hydrogeological investigations at Stripa, and on the application of the sinusoidal pressure test to the measurement of hydraulic parameters of fissured porous media are presented in the section on hydrological investigations. The comprehensive fracture hydrology investigations at Stripa include extensive fracture geometry characterization, borehole injection test data, a macropermeability experiment on a large rock mass, geochemical and isotopic groundwater characterization, and surface pump tests. Interpretation of this extensive data basis leads the authors to generalized recommendations for hydrological repository site investigations. The paper on interpretation of field experiments on the flow of water and tracers through crystalline rock presents new models for tracer transport through single fractures and through fracture networks, models which include the effects

of radial advection, hydrological dispersion, kinetic sorption and diffusion, as well as a probabilistic fracture system representation. Testing, especially fracture and mineralization mapping, and hydraulic conductivity measurement results for four deep holes at Stripa are described, as well as calculated head distributions around the mine. A paper on the application of the sinusoidal pressure test includes several theoretical developments of line sources within rock masses and presents very encouraging results from an initial field test.

The section on geochemical and migration studies includes papers on isotope hydrology, groundwater chemistry, and migration experiments in a single fracture in the Stripa granite, as well as a paper on groundwater geochemistry and isotope hydrology at the French Auriat site. Isotope hydrology studies have identified several distinct groundwater systems at the Stripa site and suggest strongly that deeper groundwater systems are much older than shallower waters, even though considerable uncertainty remains about the detailed history of the systems. The geochemical elemental analysis of the deep groundwaters has been used to develop an argument for the case that the high salinity may be due to mixing of infiltrating water with brine or salt inclusions within the granite. Preliminary results of migration experiments in a single fracture in the Stripa granite indicate that flow along a natural fracture, even over relatively short distances of metres and less, occurs along quite complex paths and similarly that fissure width determinations are difficult. Geochemical and isotopic analyses of water sampled from the deep (1000-m) French hole at the Auriat site suggest that the water is a mix of drilling water and shallow groundwater.

Preliminary results from the buffer mass test of phase I, Stripa project, include comparisons between numerical predictions and measured results for temperature, water content, water pressure, and swelling pressure distributions within bentonite buffers surrounding heaters in holes and in the bentonite tunnel backfill above the holes.

The last section of the book presents programs for further *in situ* experimental work to be performed at Stripa, Sweden, at the Canadian underground research laboratory and at the proposed Grimsel laboratory in Switzerland.

The investigations proposed for phase II (1983–86) of the international Stripa project include detection and characterization of fracture zones by cross-hole geophysical and hydraulic methods, tracer experiments in fractured granite, diffusion experiments in highly compacted bentonite and mixtures of bentonite and sand, and sealing of boreholes and shafts with highly compacted bentonite. The Canadian facility in an undisturbed batholith representative of the Canadian Precambrian Shield is intended to assess and improve the ability to interpret geology, geochemistry, and hydrogeology of large volumes of plutonic rock. Additional objectives include study of the effects of excavation on the rock, development and assessment of shaft and drift seals and accuracy evaluation of mathematical models of the near-field response to heat. The Grimsel laboratory in the Swiss Alps is intended to allow testing the applicability of results obtained elsewhere, to study specific aspects of Swiss repository concepts, and to develop the expertise and experience for later experiments at an actual repository site. The paper describes the facility, as well as the geological, hydrological, and geomechanical test plans.

Clearly, the book covers a large number of repository projects. It is ideal, therefore, for anyone wishing to have a rapid overview of ongoing repository site characterization programs in granite. Although all papers of necessity are highly condensed program summaries, virtually all of them include extensive lists of references, primarily to reports prepared by the various organizations operating the sites or testing at the sites, thus greatly facilitating the task of obtaining more detailed information.

Although the book discusses *in situ* experiments in granite, its interest should not be limited only to people involved in granite repositories. The book provides more broadly applicable insight into general testing strategy and methods of approach, test design and implementation, data analysis and interpretation, problems encountered, etc.; hence, it should be of considerable value to anyone wishing a rapid overview of most of the ongoing major projects for repository development and research.

The book has been produced inexpensively from camera-ready copy, but even so, the number of errors is minimal and the presentation of the articles quite consistent in format. The text and virtually all figures are clear and easily readable.

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Quantum Electrodynamics of Strong Fields

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Reviewer	Howard R. Reiss

In general terms, an electromagnetic field is regarded as "strong" if the magnitude of the interaction energy between the field and a system with which it interacts is as large as a characteristic energy of the system. For instance, if the electromagnetic field term in the equation of motion is as large as the rest energy of the electron, then a quantum electrodynamical description of this problem has to be in terms of strong-field electrodynamics. The usually reliable perturbation theory is not to be trusted in these circumstances and can give answers that are totally misleading both qualitatively and quantitatively.

Quantum Electrodynamics of Strong Fields is a collection of papers presented at the NATO Advanced Study Institute held at Lahnstein-on-the-Rhine, Federal Republic of Germany, June 15–26, 1981. The main thrust of the contributions in this volume is much more specific than is suggested by the general definition of strong fields given above. The